Volume 2

Environmental Report
Part I

Mt. Taylor Uranium Mill Project
New Mexico

Gulf Mineral Resources Co.
Denver, Colorado

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VOLUME 2

ENVIRONMENTAL REPORT
PART I

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Section 1.0

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1.0
PROPOSED ACTION

1.1 THE SITE

Gulf Mineral Resources Co. (GMRC) is planning to mine and mill uranium from deposits discovered in the Grants Mineral Belt in northwestern New Mexico. The Mt. Taylor Uranium Mill Project is located in northwestern New Mexico approximately 60 miles northwest of Albuquerque, and 30 miles northeast of Grants on the McKinley-Valencia County border (Figure 1.1-1). The purpose of this document is to identify and describe potential environmental effects resulting from the proposed milling activity.

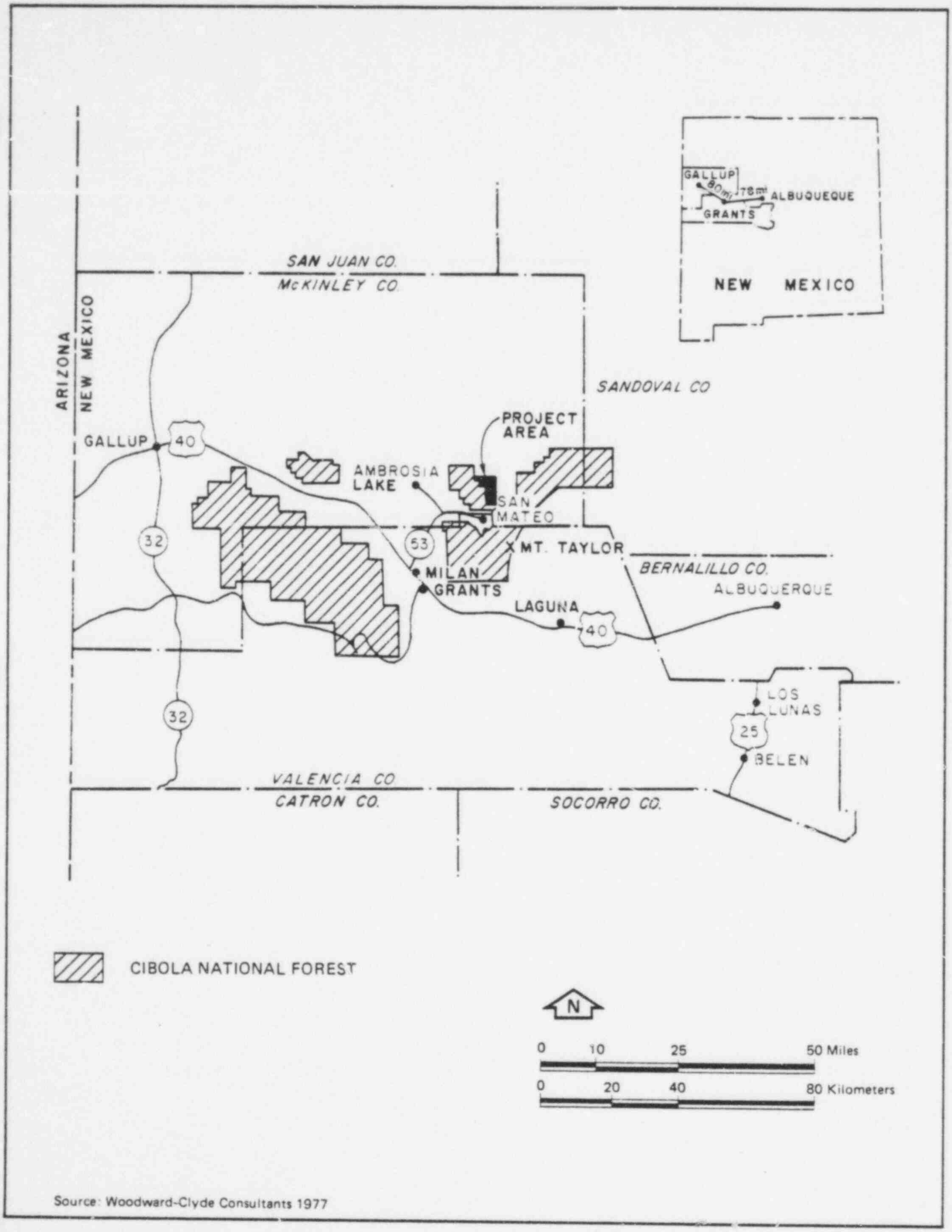

Figure 1.1–1.
PROJECT LOCATION

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1.2 THE MINE

The proposed mine-mill operation will extract uranium from a six-mile trend of orebodies lying at a depth of approximately 3200 feet along the northwest flank of Mt. Taylor. The orebody trend is northwest to southeast starting in Section 15, T13N, R8W, McKinley County, New Mexico and terminating in Section 5, T12N, R7W, Valencia County, New Mexico. The individual orebodies are basically flat lying tabular units with a high degree of irregularity in ore thickness and crosstrend width. The uranium mineralization occurs in the Westwater Formation, an arkosic sandstone member of the Morrison Formation of Late Jurrasic Age. The ore appears to be a typical Grants Belt occurrence with a black to brown mixture of coffinite and organic humates filling pore space and coating the sandstone grains. Exploration to date has delineated recoverable reserves containing over 100 million pounds of uranium as U_3O_8 equivalent. Sample concentrations of uranium range from 0.05 to 1.0 percent U_3O_8.

The planned mining rate of 1.4 million tons of ore per year will be attained by a work force of approximately 800. Proposed mining extraction methods are room and pillar and/or modified longwall/ shortwall retreat combined with a cemented backfill of the mined-out areas. The exact mining methods to be used will be finalized after pilot mining work verifies underground conditions. Since the mine is an underground operation, no overburden material will be generated. The ore will be transported to the mill via truck over a privately owned road. A discussion of mining activities is found in Section 3.6, Volume 3.

1.3 THE MILL

The mill facility will be located in lower San Lucas Canyon, Section 1, T13N, R8W, McKinley County, New Mexico. The site is in an area isolated from the public. A mill impoundment will preclude the release of any accidental process spills to watercourses in the area. Tall structures will support grinding equipment and the yellowcake washing, drying, and packaging. A series of single and two-story structures will house the offices, laboratory, boilers, shops, and warehousing. Process tankage will be of various sizes depending on the specific processes involved, and will be positioned in areas where required by the process. The entire mill site will be fenced and access to the facilities will be controlled.

The proposed mill will have the design capacity to process blended ore assaying between 0.05 and 0.50 percent uranium (U_3O_8) to a finished yellowcake product at a design rate of 4200 dry tons of ore per stream day. Coarse ore will be delivered to the mill via truck and placed in storage piles. A front-end loader will be used to feed coarse ore to the mill feed system.

The milling process begins with grinding the coarse ore to separate the sand grains from the interstitial cementing matrix. Uranium values are then leached from the solids in two stages of leach, followed with the leached sand/slime residue being separated from the uranium-rich leach solution by countercurrent washing in thickeners. Provision is made for the uranium-free residues to be classified into sand and slime fractions. The resulting sands after being washed, can be returned to the mine for backfill or used for tailings pond reclamation. The slime fraction and any sands not separated will be pumped to the tailings pond.

The subsequent steps of the milling process, which consist of recovery and purification of the uranium values from the acid leach solution, begin with clarification of the uranium-rich leach solution, followed by filtration to remove the fine suspended solids, and solvent extraction to recover and purify the uranium. In the solvent extraction process, the uranium is transferred to an organic phase consisting of an amine in a kerosene diluent. After solvent extraction, the uranium-free leach solution (raffinate) is recycled to the countercurrent decantation (CCD) circuit as a wash solution. The uranium is removed from the solvent with a sodium carbonate solution, and the solvent recycled to the solvent extraction circuit. The sodium carbonate solution, now containing the uranium, is acidified and then pumped to precipitation tanks where uranium is precipitated as uranyl peroxide ($UO_4 \cdot 2H_2O$) by digestion in a hydrogen peroxide solution. The uranyl peroxide is then washed in thickeners, centrifuged, and calcined in a multiple hearth furnace. The resulting yellowcake is packaged in drums for shipment via truck in accordance with Department of Transportation regulations.

A slurry pipeline (described in Section 3.4.1 of Volume 3) will transport the tailings to an impoundment located in La Polvadera Canyon approximately six miles north of the mill. The site is a natural canyon bordered on three sides by high bluffs, providing protection from both wind and storm damage as well as total isolation from the public. The tailings retention dam of the impoundment area will be a zoned earth and rockfill structure with a sloping upstream clay core. Tailings distribution into the impoundment area will be via a sand cell system for total tailings or a perimeter discharge system when only slime tailings are being impounded. Downstream of the tailings impoundment is a catch dam to provide containment of any minor spills. Both the impoundment and catchment areas will be completely fenced. The tailings impoundment area is fully described in Section 3.4.2 of Volume 3.

Based on current ore reserve and market assessments, the production life of the mill will be 20 years. At this time, no other outside source of ore is expected to be processed through this facility. The mill will run seven days a week, with three eight-hour shifts each day. Production capacity for the years 1981 through 1984 will be 2100 dry tons per stream day, which could yield a yellowcake product of 12,500 pounds of U_3O_8 equivalent per day (4.3 million pounds per year). Commencing in approximately 1985 production capacity will be increased to 4200 dry tons per stream day yielding a yellowcake product of 25,000 pounds of U_3O_8 equivalent per day (8.6 million pounds of U_3O_8 per year). Final yellowcake quality will assay greater than 85 percent U_3O_8.

When it has been determined that the useful life of the mill has been completed, all above ground facilities, with the exception of concrete foundations, will be removed. The mill site will be scanned with suitable counting equipment to isolate any areas containing residual radioactivity, and, where appropriate, sufficient earth will be removed to achieve background radioactivity levels. Excavated areas will be filled to finish grade with soil, seeded and protected until vegetative cover has become established. On the basis of the average annual precipitation rates in the area and, therefore, the capacity of the soil to sustain vegetation, it has been concluded that the land would best be utilized for livestock grazing as is most of the surrounding region. The reclamation plan more fully described in Section 9.0 of Volume 3 is designed with that objective in mind.

Surety arrangements for eventual reclamation of impacted areas is addressed in Section 9.3 of Volume 3.

1.4 THE SCHEDULE

In 1975, Woodward-Clyde Consultants was commissioned to do an expanded environmental study for development of baseline environmental information. The studies included ecology, geology, meteorology, hydrology, radiology, cultural resources and demography. The field work in these areas is now complete and reported herein.

In April of 1977, Jacobs Engineering Co. was selected as the contractor for definitive design and capital cost estimation of the mill. In June, 1977, W.A. Wahler & Associates was chosen to do definitive and detail design and capital cost estimation on the tailings impoundment facility.

Detailed design of the mill commenced in the second half of 1978, with site preparation and construction expected to start about the first half of 1980. The tailings facility will also commence construction in the first half of 1980. Both mill and tailings facilities are targeted to be in operation in the last half of 1981. Mine and mill are expected to be at nominal production rates in 1985.

Section 2.0

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2.1 SITE LOCATION AND LAYOUT

The Mt. Taylor project is located in northwestern New Mexico on the McKinley-Valencia County border. It lies in the eastern part of the Ambrosia Lake mining district, one of New Mexico's major uranium-producing areas. The project area is near the town of San Mateo, about 30 miles northeast of Grants, New Mexico, via Route 53 (Figure 1.1-1).

In order to conduct the proposed milling operation in a manner that provides maximum protection to the public and the environment, yet incorporates the soundest engineering practices, the mine, the mill and the tailings pond will be located in separate areas (Figure 2.1-1). The mine, located in Section 24, T13N, R8W, Valencia County, lies approximately one-half mile northeast of the town of San Mateo. The mill, situated in the Bartolome Fernandez Grant just below the San Lucas Dam in McKinley County, will lie approximately three miles north of the mine. The tailings pond will be constructed approximately six miles north of the mill in La Polvadera Canyon, T14N, R8W, McKinley County. When filled to capacity, the pond will lie within portions of Sections 10, 11, 14 and 15. Figure 2.1-1 also notes the exclusion area boundaries as well as the truck route between the mine and mill. This route is approximately three miles long, and will handle from 50 to 120 ore trucks per day at full mine production.

The status of land owned and leased by Gulf in the project area, and the ownership of surrounding property, is shown on Figure 2.1-2.

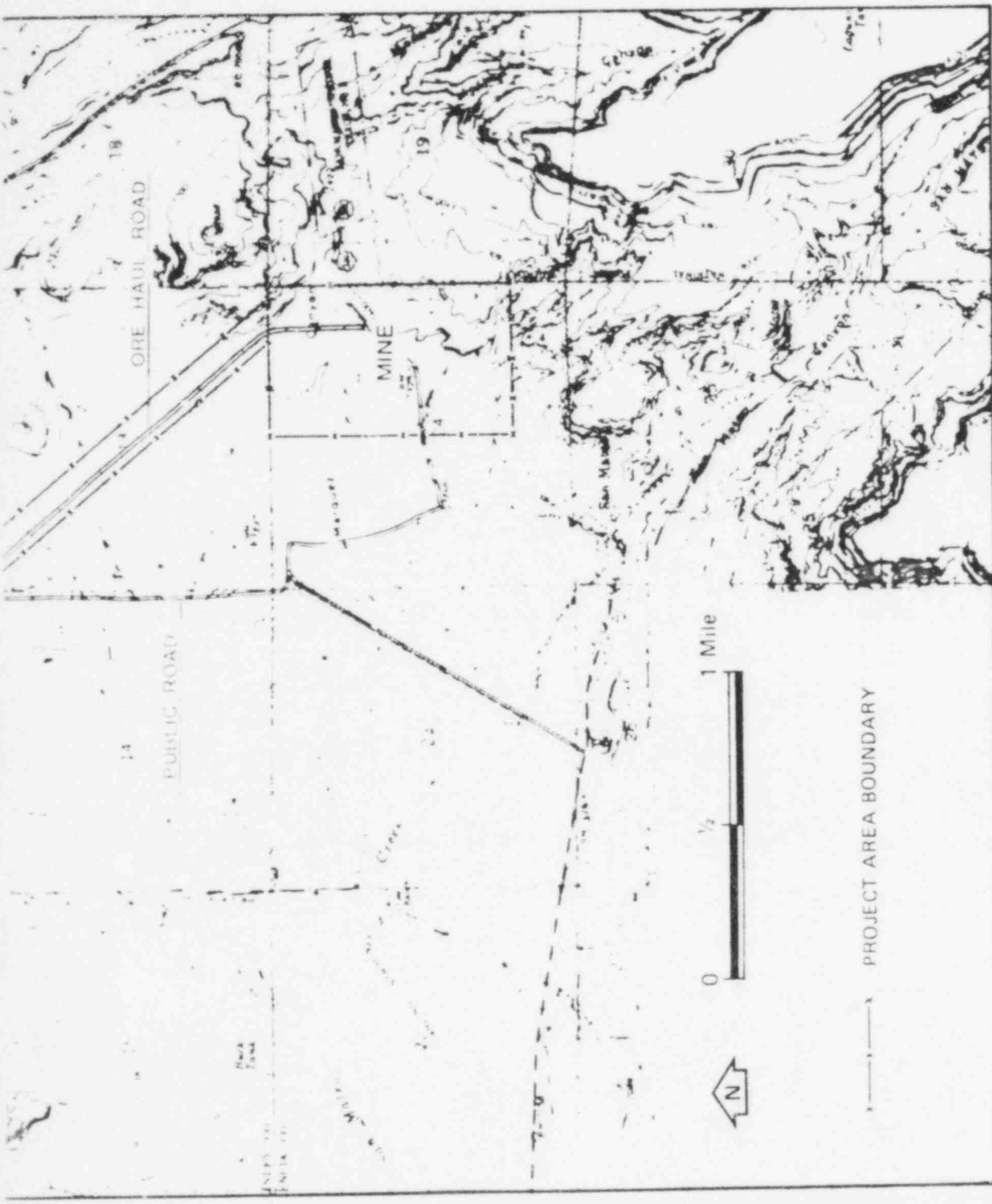
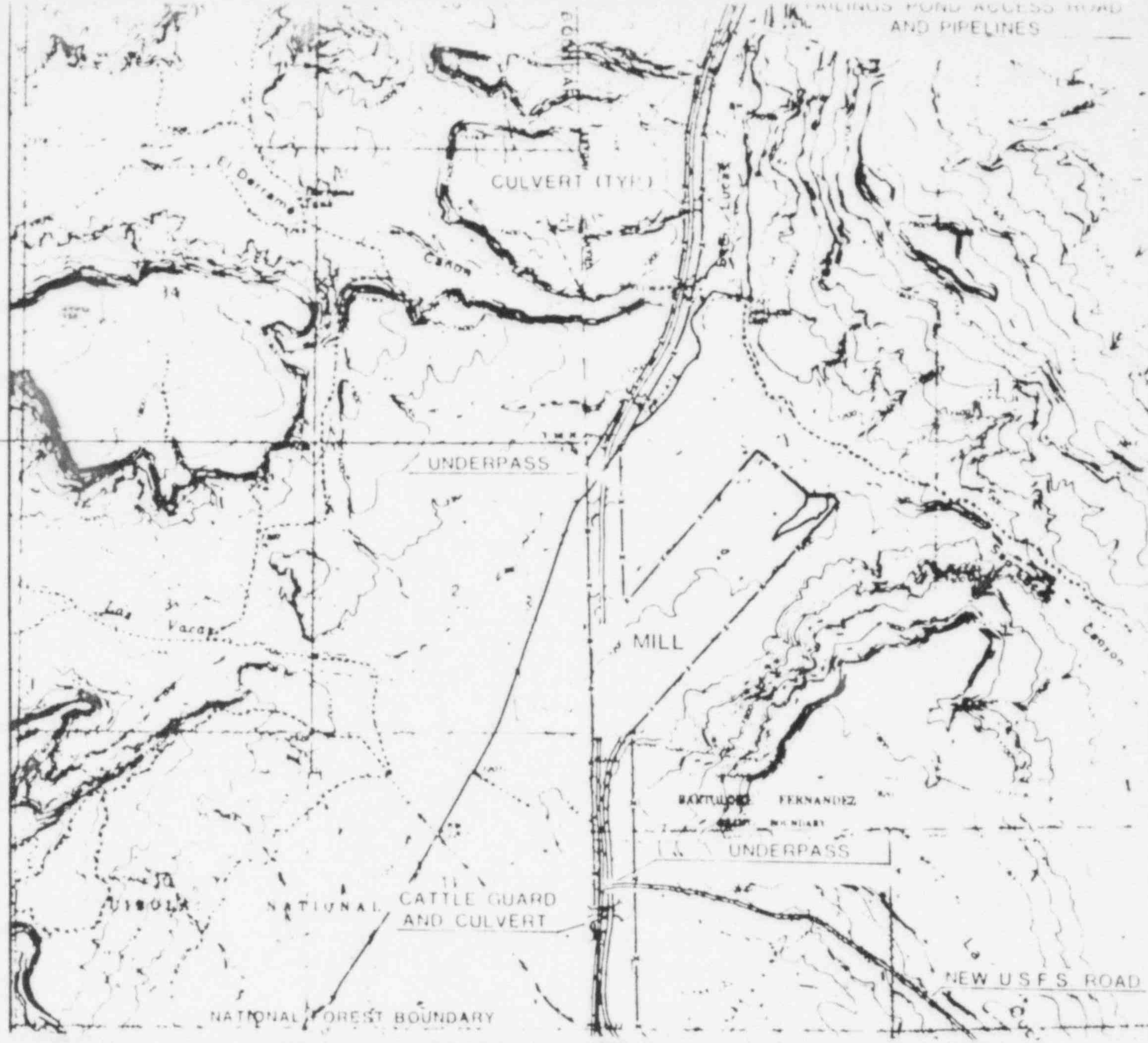
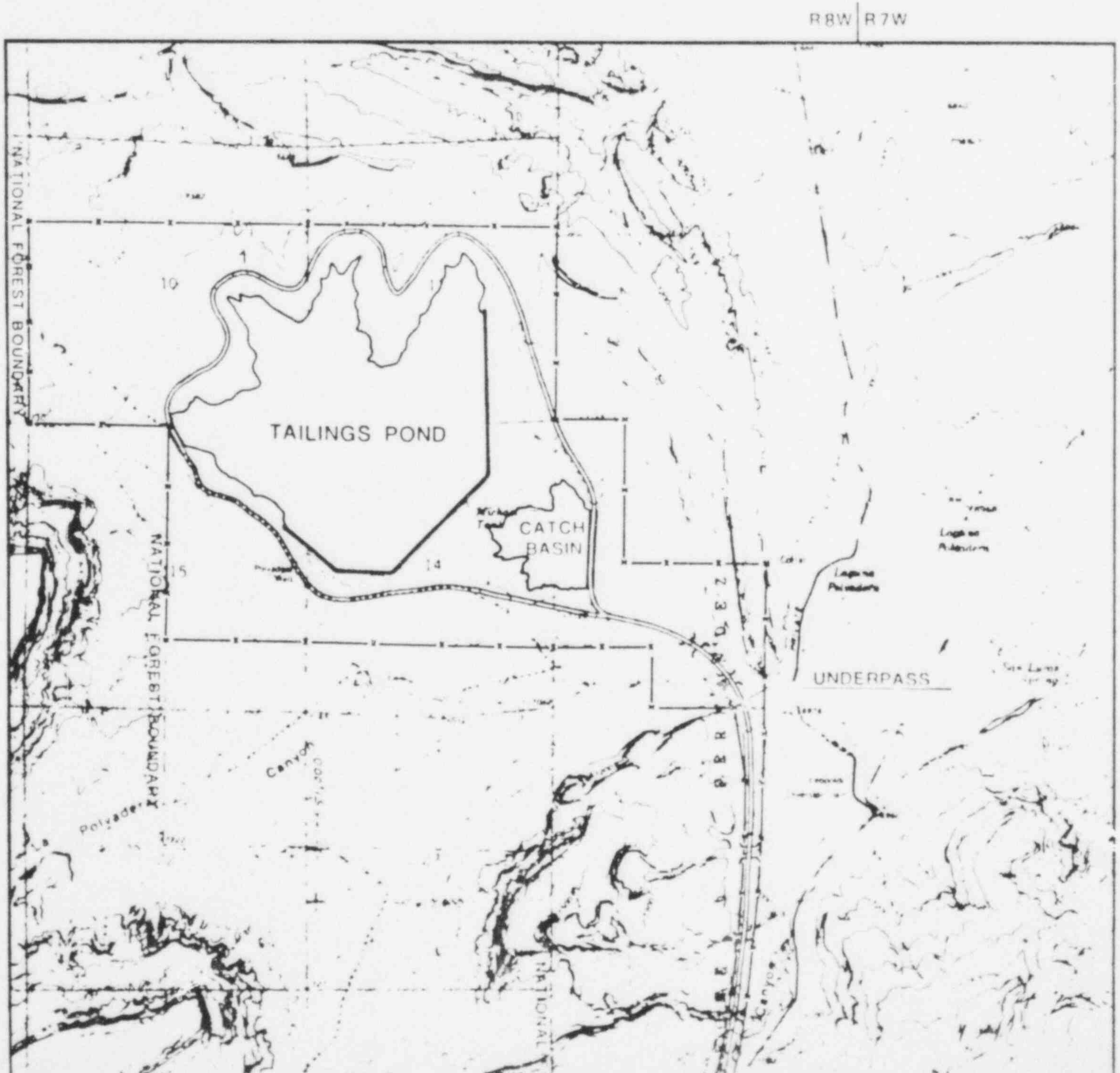


Figure 2.1–1.
PROJECT LAYOUT


TAILINGS POND ACCESS ROAD
AND PIPELINES
CULVERT (TYP)
BOUNDARY
T14N
T13N
UNDERPASS
MILL
BARTOLOMÉ FERNANDEZ
GRANT BOUNDARY
UNDERPASS
CATTLE GUARD
AND CULVERT
CIBOLA NATIONAL
NATIONAL FOREST BOUNDARY
NEW U.S.F.S. ROAD
T14N
T13N
Canyon
Las Vacas
El Dorado



Source: Gulf Mineral Resources Co. 1978

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POOR ORIGINAL

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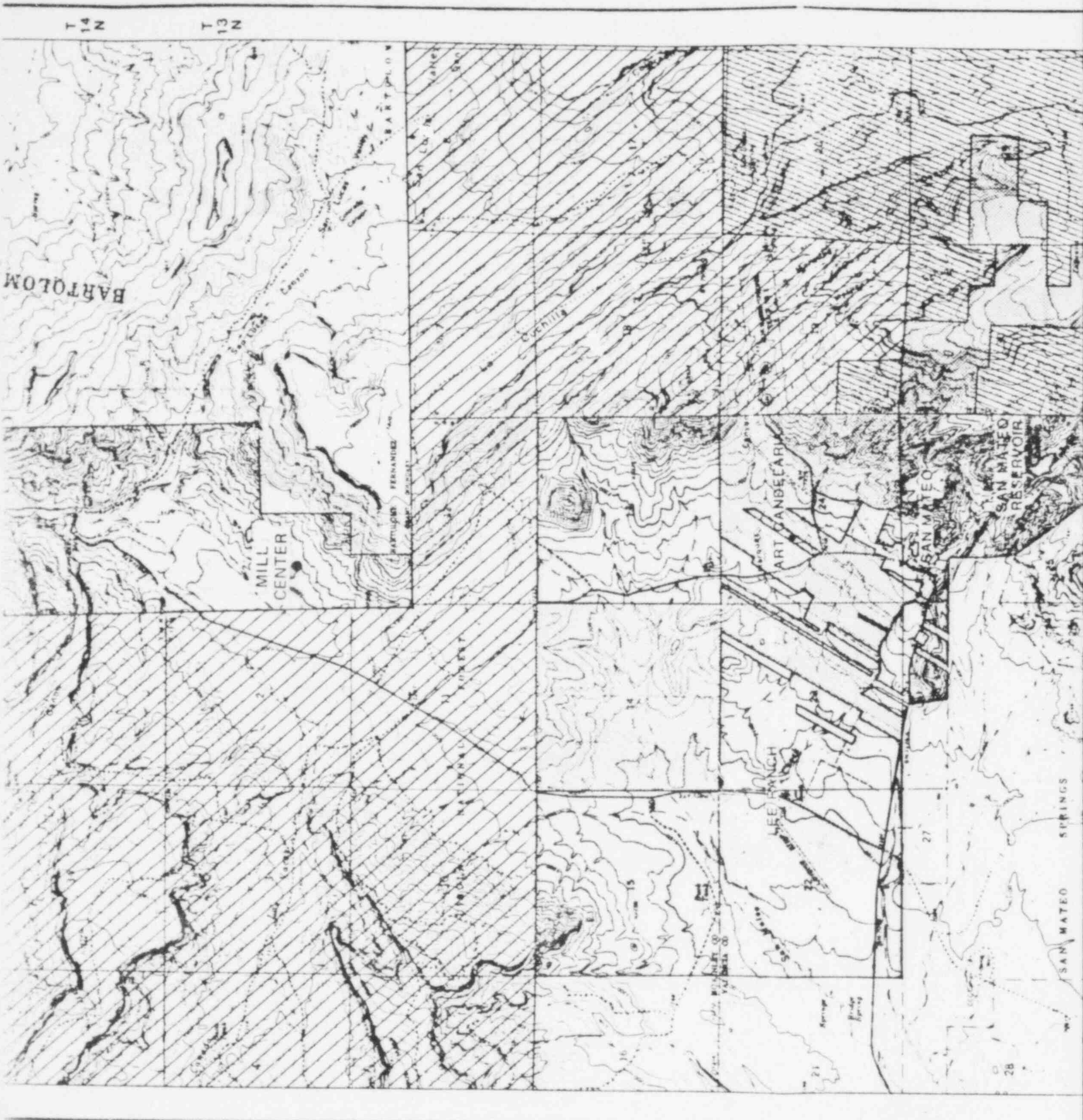
Figure 2.1-2.
MT. TAYLOR LAND STATUS FOR MC KINLEY AND VALENCIA COUNTIES, NEW MEXICO



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POOR ORIGINAL

MT. TAYLOR
AND VAL

Source: Gulf Mineral Resources Co.

POOR ORIGINAL

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Provisions have been made, and will continue to be made for Gulf, or any assignee, to enter the premises after operations are terminated for the purpose of monitoring or maintenance, in accordance with federal and/or state law.

Gulf owns or leases approximately 8,800 acres. Approximately 650 acres will be temporarily modified by construction of the mill and tailings pipeline (see Section 9.0 for reclamation plans), and approximately 1,000 acres, where the tailings impoundment is located, will be removed from use as grazing land.

The two water bodies in the project area, San Mateo Reservoir and Laguna Polvadera, are also noted on Figure 2.1-2. It should be pointed out that the presence of the "lake" at Laguna Polvadera is due principally to the discharge of treated mine water from the Gulf Mt. Taylor Mine.

The most prominent topographic feature in the project area is Mt. Taylor, a Miocene volcano surrounded by basalt-capped plateaus such as Mesa Chivato. The broad valleys of the region are separated from the mesa tops by steep slopes abruptly dissected by arroyos. The uplands of the Mt. Taylor volcanic plateau and San Mateo Mesa are part of the Cibola National Forest, which crosses the center of the project area.

2.2 SOCIOECONOMICS AND LAND USE

This section describes the regional and local, demographic, land use and socioeconomic characteristics of the area around the Gulf Mt. Taylor project. The following topics were selected to describe the elements of the present socioeconomic environment that may be affected by the proposed project:

- demography
- housing
- employment and income
- public facilities and services
- public finance
- land use

The region discussed here is known as the Grants Uranium Belt. The description of local socioeconomic characteristics focuses on the Grants-Milan area. Grants and Milan are the largest communities in the immediate area and are the major centers of uranium related urbanization in New Mexico.

2.2.1 General Description of Region

The Grants Uranium Belt is an area about 100 miles long by 20 miles wide and extends from Gallup on the west to Rio Puerco on the east. It is located in one of the most diversified major energy-producing regions in the United States. Within or adjacent to the area are large oil and gas fields, and abundant accessible coal deposits. Several electric generation facilities have also been proposed for this area. The Grants region is the major producer of uranium in the United States and contains more than half of the nation's economically recoverable uranium reserves. At the end of 1975, the Grants Uranium Belt had produced more than 52 million tons of ore containing 112,700 tons of U_3O_8. Six mills and

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approximately 36 mines are in operation in the mining area (Figure 2.2-1, Tables 2.2-1 and 2.2-2). Approximately 3300 people are employed in uranium exploration and production within the district, with a total yearly income of roughly $36 million.

Expansion of the uranium industry in the area depends on national demand and policy. The U.S. Energy Research and Development Administration (ERDA) has projected that a fourfold increase in uranium production will be needed by 1985. Estimates range from double to triple the present level of development in the area in the next 10 years, with an expected increase of employment to roughly 8500 persons during the same time period (New Mexico State Planning Office, 1976; MRGCOG, 1977). This growth trend is already noticeable in light of the present high level of exploration activity and development. Plans are underway for the construction of additional mines and mills. Moreover, recent discoveries have indicated that the Grants Uranium Belt may be much wider (45 to 50 miles wide rather than 20 miles wide) and point to the possibility of uranium resources far in excess of current estimates.

The uncertainties of the energy and mineral industry and the lack of all but the most general data on future expansion within the area have made adequate planning to accommodate population growth increasingly difficult for the communities of Grants and Milan. The larger communities within the area (particularly Albuquerque) could more easily provide adequate public facilities and services to support energy-related population increases; previous population growth in these cities has been accommodated with minimum disruption. Expansion of the mineral and energy industry in the Grants Uranium Belt has historically placed major increased demand on the communities of Grants and Milan and on the immediate surrounding areas. The magnitude of community impacts that have already occurred in these towns and the potential for sustained intensive mineral development have prompted a number of studies by regional, state, and federal agencies.

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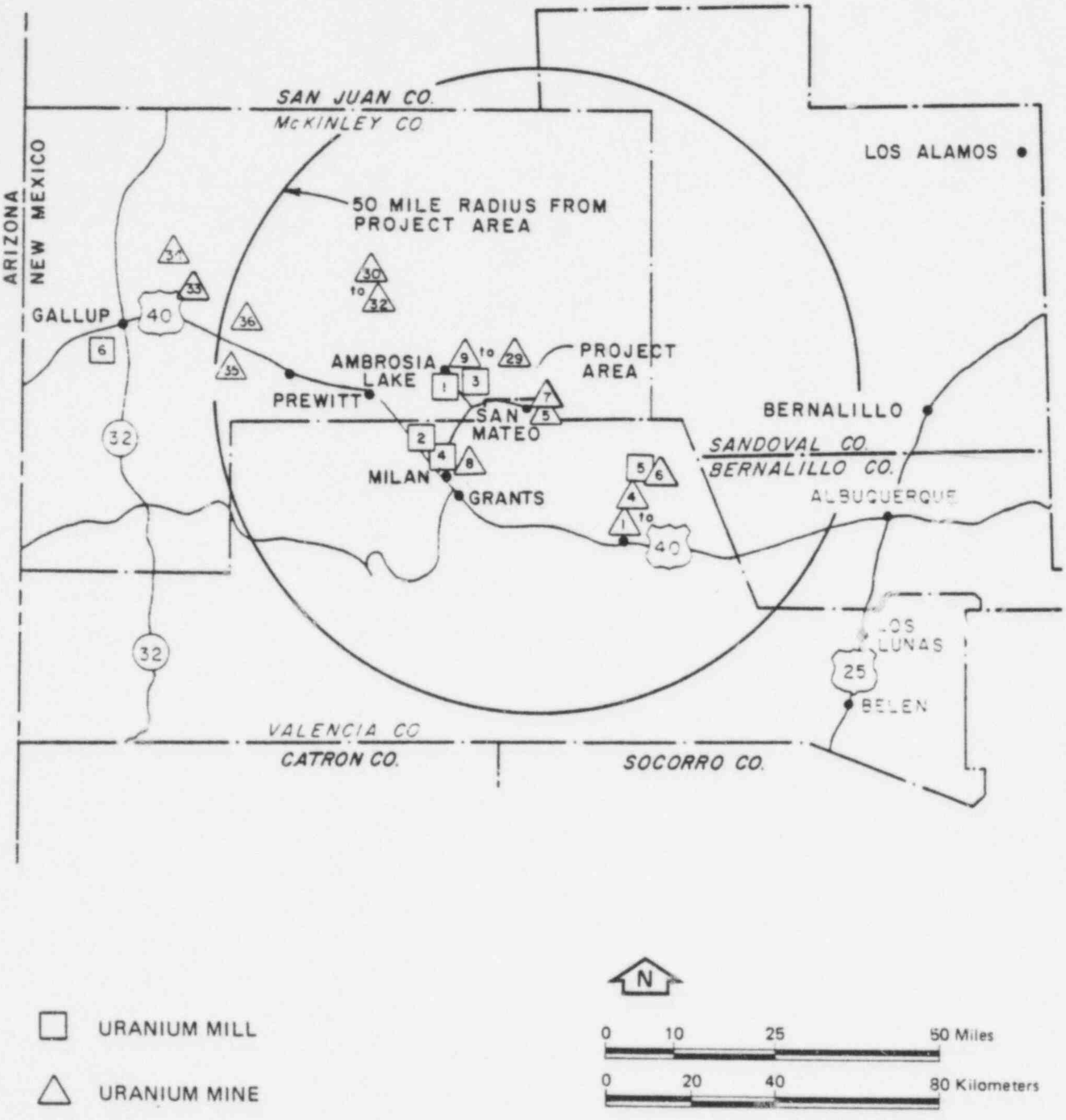

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Source: Woodward-Clyde Consultants 1977

Figure 2.2–1.
NUCLEAR FUEL CYCLE FACILITIES
WITHIN 50 MILES OF PROJECT AREA

Table 2.2-1. URANIUM MINES IN THE REGION

Valencia County	
1 Jackpile-Paguate Mine Anaconda Company 2 open pits, operational	In Paguate Purchase, Laguna Reservation, Sec. 33, 34, 35, 36 T. 11 N., R. 5W., N.M.B. & P.M.[a]
2 Alpine Miner Test Mine Anaconda Company inactive	Jackpile-Paguate on Laguna Reservation, Sec. 1, 2, 3, 4, T.10N., R. 5W.
3 P-10, P-9-2 Anaconda Company underground, operational	Jackpile-Paguate on Laguna Reservation
4 Housing, H-1 Anaconda Company open pit, operational	Portion of Jackpile-Paguate directly west of Alpine Miner Test Mine
5 San Mateo Mine United Nuclear Corp. underground, inactive	East of San Mateo, T. 13N., R. 8W.
6 L-Bar SOHIO-Reserve Minerals underground, operational	Approximately 15 miles north of Laguna, T.11N., R.5W.
7 Gulf Mt Taylor Mine Gulf Mineral Resources Co. underground, under development	1/2 mile northeast of San Mateo, Sec. 24, T.13N., R.8W.
8 F-33 Mine Homestake Mining Company underground, operational	2 miles east of Homestake Mill, N. of Grants, SW1/4, Sec. 33, T.12N., R.9W.
McKinley County	
9 Ann Lee Mine United Nuclear Corporation underground, operational	Ambrosia Lake, NW1/4, Sec.28, T.14N., R.9W.
10 Dog Mine Four Corners Exploration Company underground, inactive	Ambrosia Lake

[a]New Mexico Baseline and Principal Meridian.

Table 2.2-1. (continued)

McKinley County (cont.)

11 Johnny M. Mine Ranchers Explorations & Development Corporation underground, operational	Ambrosia Lake, 2 miles southeast of Sec. 36 Mine
12 Kerr-McGee Sec. 17 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, SW1/4, Sec. 17, T.14N., R.9W.
13 Kerr-McGee Sec. 19 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, Sec. 19, T.14N., R.10W.
14 Kerr-McGee Sec. 22 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, Sec. 22, T.14N., R.10W.
15 Kerr-McGee Sec. 24 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, SW1/4, Sec. 24, T.14N., R.10W.
16 Kerr-McGee Sec. 30 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, Sec. 30, T.14N., R.9W.
17 Kerr-McGee 30 West Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, W1/2, Sec. 19, T.14N., R.10W.
18 Kerr-McGee Sec. 33 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, Sec. 33, T.14N., R.9W.
19 Ker-McGee Sec. 35 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, Sec. 35, T.14N., R.9W.
20 Kerr-McGee Sec. 36 Mine Kerr-McGee Corporation underground, operational	Ambrosia Lake, Sec. 36, T.14N., R.9W.
21 Sandstone Mine United Nuclear Corporation underground, operational	Ambrosia Lake, Sec. 34, T.14N., R.9W.
22 Sec. 25 Mine Bailey & Fife underground, operational	Ambrosia Lake, Sec. 25, T.14N., R.9W.

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Table 2.2-1. (continued)

23 Sec. 27 East Mine United Nuclear Corporation underground, operational	Ambrosia Lake, Sec. 27, T.14N., R.9.
24 Spencer Mine Kerr-McGee Corporation undergound, inactive	Ambrosia Lake, 4 miles south of Kerr-McGee Mill
25 UN-HP Sec. 15 Mine United Nuclear-Homestake Partners underground, operational	Ambrosia Lake. Sec. 15, T.14N., R.10W.
26 UN-HP Sec. 23 and Mine General United Nuclerar-Homestake Partners underground, operational	Ambrosia Lake, Sec. 23, T.14N., R.10W.
27 UN-HP Sec. 25 Mine United Nuclear-Homestake Partners underground, operational	Ambrosia Lake, Sec. 25, T.14N., R.10W.
28 UN-HP Sec. 32 Mine United Nuclear-Homestake Partners underground, operational	Ambrosia Lake, Sec. 25, T.14N., R.9W.
29 Haystack Mine Todelite Exploration and Development Company open-pit, operational	Approximately 5 miles east of Prewitt, T.13N., R.10W.
30 Evelyn Mine Clark & Company underground, inactive	Smith Lake Area, 12 miles north of Prewitt, 20 miles west of Ambrosia Lake
31 Mac No. 1 Mine, Grants United Nuclear-Homestake Partners underground, inactive	Smith Lake Area, 18 miles north of Thoreau
32 Westranch Mine Hydro Nuclear Corporation underground, inactive	Smith Lake Area, 16 miles north of Prewitt, 20 miles west of Ambrosia Lake
33 N.E. Churchrock Mine United Nulcear Corporation underground, operational	Approximately 13 miles northeast of Gallup, Sec. 35, T.17N., R.16W.
34 Navaho Mine Kerr-McGee Nuclear Corporation underground, operational	Approximately 13 miles northeast of Gallup, Sec. 35, T.17N., R.16W.

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Table 2.2-1. (concluded)

35 Western Nuclear Mine Western Nuclear Corporation underground, operational	Smith Lake Area, 9 miles west of Thoreau, T.15N., R.13W.
36 Mariano Lake Mine Gulf Mineral Resources Co. underground, operational	11 miles northwest of Thoreau, Sec. 12, T.15N., R.14W.

Sources: New Mexico Dept. of Development 1976.
New Mexico State Inspector of Mines 1976.

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Table 2.2-2. URANIUM MILLS IN THE REGION

1	Kerr-McGee Nuclear Corp. Mill, Kerr-McGee Nuclear Corp.; P. O. Box 218, Grants, New Mexico, 87020; Bill Stevens, Manager. This mill is located in the Ambrosia Lake district approximately 23 miles north of Grants, on state route 509. The mill and related activities spread over the entire square mile of Sec. 31, T.14N., R.9W., N.M.B. & P.M. This is approxiately 16 miles northwest of the proposed project site.
2	Anaconda Bluewater Mill, The Anaconda Company, New Mexico Operations; P. O. Box 638, Grants, New Mexico, 87020; A. J. Fitch, Manager. Uranium ore from the Jackpile-Paguate mine is shipped by rail to the Bluewater Mill. Located approximately 12 miles northwest of Grants on Interstate 40 in T.12.N, R.11W., N.M.B. & P.M. This is approximately 20 miles southwest of the proposed project site.
3	United Nuclear/Phillips Petroleum Ambrosia Mill, in the Ambrosia Lake district, approximately 2 miles from the Kerr-McGee Mill. It is in Sec. 28, T.14N., R.9W., N.M.B. & P.M. The mill is closed.
4	United Nuclear-Homestake Partners Mill; P. O. Box 98, Grants, New Mexico, 87020; Paul M. Price, General Manager. Located 9 miles north of Grants by Route 66; it is 15 miles southwest of the proposed project. It is in Sec. 26, T.12N., R.10W., N.M.B. & P.M.
5	L-Bar Uranium Mill, SOHIO Petroleum Company and Reserve Oil and Minerals Corp., located about 10 miles north of Laguna by route 279. It is in T.11N., R.6W., 25 miles southeast of the proposed project area.
6	United Nuclear Churchrock Mill, located in western McKinley Co. in Sec. 2, T.16N., R.16W.

Mills are shown by number on Figure 2.2-1.

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A singular concern of many of these studies is the ability of Grants and Milan to cope with massive changes in population, land use, and demand for public facilities and services.

2.2.2 Demography

Population change in the Grants-Milan area and in Valencia County is due almost entirely to developments in the uranium industry. Early exploration for mining and milling of uranium during the 1950s created numerous job opportunities in Grants and Milan. During that decade, population in Grants more than quadrupled and population in the county nearly doubled (Table 2.2-3). Milan was incorporated in 1957 with a population of 540, and by 1960 the population had increased to 2658. The Grants-Milan area registered a population decrease of 15 percent for the period 1960-1970, while the county experienced a slight increase of 0.04 percent. The growth of Grants-Milan and Valencia County since 1970 can be generally attributed to renewed expansion in the uranium industry.

Grants and Valencia County share similar racial and ethnic characteristics (Table 2.2-5). Grants has a higher percentage of minorities than the state. More than half of the residents within the community are of Spanish descent. Approximately 13 percent of the residents within the community and 15 percent of the residents within the county are American Indian. Indian groups and Indian lands within the county include the Acoma, Isleta, Laguna, Zuni, Canoncito, and Ramah Navajo.

Population distribution in the vicinity of the proposed mill site is shown in Table 2.2-4. In 1970, there were approximately 240 people within 10 km (6.3 miles) of the site and another 1,366 people with 20 km (12.5 miles). Population projections for the area (by sector) are not available from either local or state agencies. There are no significant transient or seasonal populations near the project area, although Lee Ranch employs about 20 to 25 seasonal workers.

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Table 2.2-3. POPULATION CHANGES, 1950-1976

	Grants-Milan	Valencia County	New Mexico
Total population			
1950	2,251*	22,481	684,300
1960	12,932	39,085	951,023
1970	10,953	40,539	1,016,000
1976	18,800**	47,200	1,173,100
Percent change, 1960-1970	+45	+21	+23
Total families, 1970	3,317	9,217	242,740

Source: University of New Mexico, 1975, 1976 (except as noted).
*Grants only; Milan was not incorporated until 1957.
**Middle Rio Grande Council of Governments, 1977b.

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Table 2.2-4. POPULATION DISTRIBUTION[a]

Kilometers	N 0.0	NNE 22.5	Ne 45.0	ENE 67.5	E 90.0	ESE 112.5	SE 135.0	SSE 157.5	S 180	SSW 202.5	SW 225.0	WSW 247.5	W 270.0	WNW 292.5	NW 315.0	NNW 337.5
0-.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.1-.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.5-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4-5	0	0	0	0	0	0	0	0	6[b]	25[c]	0	0	0	0	0	0
5-10	0	0	0	0	0	0	0	0	200[d]	0	0	10[e]	0	0	0	0
10-20	0	487	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-30	0	0	0	0	0	0	0	0	1366	0	0	0	0	0	0	0
30-40	0	0	0	0	0	0	335	0	125	0	12,667	1102	1205	0	0	0
40-50	0	0	0	0	0	0	969	726	2111	0	0	0	624	557	0	0
50-60	1474	0	0	3329	0	0	145	0	0	0	787	0	0	0	972	1314
60-70	0	0	0	0	0	842	0	0	0	0	0	0	0	1761	1196	0
70-80	0	0	0	0	0	0	0	0	341	0	0	0	274	0	0	0

[a]1977 population data.
[b]Candelaria Residence; population estimates provided by Gulf Mineral Resources Co.
[c]Lee Ranch; population estimates provided by Gulf Mineral Resources Co.
[d]San Mateo; 1970 population data.
[e]Marcus Ranch; population estimates.
[f]San Fidel; 1970 population data.

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Table 2.2-5. RACIAL DISTRIBUTION (percent of 1970 population)

	White	Spanish Heritage*	Indian	Negro	Other
Grants	34.2	51.3	13.1	0.7	0.7
Valencia County	28.0	56.0	15.0	0.4	0.6
New Mexico	50.0	40.1	7.2	1.9	0.8

Source: Middle Rio Grande Council of Governments, 1976.
*Persons of Spanish language or surname.

Population projections have been prepared for the Grants-Milan area by the Middle Rio Grande Council of Governments (MRGCOG) and for Valencia County by the University of New Mexico's Bureau of Business and Economic Research (Table 2.2-6). The MRGCOG estimates are based on current and planned energy and resource development (particularly uranium) in the region. The projections assume that uranium production will peak in 1990. It is projected that the population of Valencia County will increase by 41 percent until 1991, with most of the growth occurring in the Grants-Milan area. By 1990, approximately 70 percent of the county population will reside in the Grants-Milan area, compared with 40 percent in 1976.

2.2.3 Housing

Rapid energy development has historically exerted pressure on the Grants-Milan area housing stock. A total of 4116 housing units was reported for the Grants-Milan area in 1976, an increase of 39 percent since 1970 (Table 2.2-7). Approximately 58 percent of all housing units are single-family dwellings. Because of the high cost of construction of conventional single-family homes in the Grants-Milan area ($24-$30 per square foot) and the lack of units suitable for rehabilitation, much of the housing needs in the two communities are being met by mobile homes. Additional

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Table 2.2-6. POPULATION PROJECTIONS, 1976-1995

	Grants-Milan Area	Grants-Milan Area with Accelerated Uranium Production	Valencia County	New Mexico
Projected population				
1976	18,800	18,800	47,200	1,173,000
1980	25,100	31,500	52,300	1,277,600
1985	37,500	43,000	62,100	1,413,700
1990	48,100	47,500	66,700	1,561,900
1995	46,500	45,600	—	—
Percent change, 1976-1990	+156	+153	+41	+33

Sources: University of New Mexico, 1976; Middle Rio Grande Council of Governments, 1977b.

Table 2.2-7. HOUSING STOCK IN THE GRANTS-MILAN AREA, 1970-1976

Total Housing Units			Type of Housing Units (1970)			Housing Construction (1970-1976)		
1970	1975	% Change, 1970-1975	Single-Family	Multiple -Family	Mobile Homes	Single-Family	Multiple -Family	Mobile Homes
2953	4116	39	2099	322	532	308	139	716

Source: Middle Rio Grande Council of Governments, 1977a.

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mobile homes in the community exceeded the construction of single-family units by a rate of 2.3:1 for the period 1970-1976.

The MRGCOG (1977a) reported that vacancy rates in the Grants-Milan area approach 0 percent, with only the most dilapidated homes vacant. Rents are reported as high as $250-$350 per month for either conventional or mobile homes. The MRGCOG (1977b) also reported that vacancy rates in Valencia County in 1975 were approximately 10 percent. This indicates that Grants-Milan, the area that is most likely to receive the highest housing demands as a result of increased uranium production, will not be able to provide for projected needs with the housing units presently available. In view of the forecasted population growth and current housing shortages, a marked increase in mobile homes can be expected for the Grants-Milan area.

2.2.4 Employment and Income

The Grants-Milan area is a relatively poor area within a significantly poor county and region. Valencia County has been designated as a Redevelopment Area within a four-county Economic Development District (EDD). The other designated Redevelopment Areas in the EDD include Torrance, Sandoval, and Bernalillo counties. The Redevelopment Areas are eligible for federal Economic Development Administration (EDA) financial assistance under the Public Works and Economic Development Act of 1965.

The primary function of EDA is the long-range economic development of areas that have severe unemployment and low family income. The EDA program includes public works grants and loans; economic adjustment assistance grants; business loans for industrial and commercial facilities; guarantees of leases for private industry and private loans for industrial and commercial facilities; and technical, planning, and research assistance to provide information on and demonstrate possible solutions to severe unemployment or underemployment.

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Employment data for the Grants-Milan area indicate that the uranium industry continues to play a key role in the local economy (Table 2.2-8). Almost half of the workers residing in Grants-Milan were employed by the mining industry in 1970 and 1976. This trend is significantly greater in Grants than in other parts of the county, region, or state. The State Planning Office cites that in 1960 the U.S. Census estimated that 56 percent of all uranium workers in New Mexico resided in Grants-Milan (New Mexico State Planning Office, 1976), and current estimates may be higher. Between 1970 and 1976, the number of residents in Grants-Milan who were employed in the miing industry increased by 84 percent.

Wholesale and retail trade, government, and services contribute the next highest employment. Although Grants-Milan is the trade center for western Valencia County and the service center for Interstate 40 travelers, the relative size of the nonbasic industries is small (47 percent of the total in 1976). The proximity to metropolitan Albuquerque may account for this, since uranium workers spend a sizable portion of their disposable income in Albuquerque and mining companies purchase much of their materials there.

The Grants-Milan area is thought to have substantial unemployment, although recent unemployment figures are not available for the community level (New Mexico State Employment Security Commission, 1974). Unemployment in the county (8.8 percent) in 1976 was slightly lower than the rate recorded for the state (9.1 percent).

Employment in the Grants-Milan area is expected to increase through 1990 (Table 2. -9). Growth is expected to be most rapid during the first half of the 1980s. The MRGCOG projects that employment will peak in 1990 (20,820 workers), which will be more than triple the 1976 level (6790 workers). Grants-Milan area residents who are employed in the mining industry are expected to increase from approximately 3300 in 1976 to about 4890 by 1980, and then increase by 58 percent to 8430 in 1985. The MRGCOG

Table 2.2-8. GRANTS-MILAN AREA EMPLOYMENT, NUMBER AND PERCENT, BY INDUSTRY

	1970	Percent	1976	Percent
Agriculture	65	2	40	1
Mining	1798	49	3300	49
Construction	80	2	170	2
Manufacturing	72	2	80	1
Transportation, communications, utilities	104	3	230	3
Trade	591	16	1220	18
Finance, insurance, real estate	138	4	190	3
Services	679	18	620	9
Government	158	4	940	14
Total	3685	100	6790	100

Source: Middle Rio Grande Council of Goverments, 1977a.

Table 2.2-9. GRANTS-MILAN AREA PROJECTED EMPLOYMENT, NUMBER AND PERCENT, BY INDUSTRY

	1976	%	1980	%	1985	%	1990	%	1995	%
Agriculture	40	1	30	-	30	-	20	-	20	-
Mining	3300	49	4890	52	8430	52	10,710	51	10,000	49
Construction	170	2	410	4	470	3	490	2	500	3
Manufacturing	80	1	80	1	80	-	100	1	130	1
Transportation, communications, utilities	230	3	300	3	520	3	700	3	710	3
Trade	1220	18	1540	16	2730	17	3600	17	3690	18
Finance, real estate, insurance	190	3	240	3	430	3	570	3	580	3
Services	620	9	790	8	1410	9	1850	9	1890	9
Government	940	14	1190	13	2100	13	2780	14	2850	14
Total	6790	100	9470	100	16,200	100	20,820	100	20,370	100

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anticipates that roughtly 10,710 workers (over half of the total work force and over one-fifth of the total population) will be associated directly with the mining industry.

General family income characteristics of the Grants-Milan area in relation to the county and the EDD are summarized in Table 2.2-10. Of particular interest are the Grants-Milan area median income (17 percent higher than the county median and 33 percent higher than the EDD median); the number of families in Grants with social security income (4.4 percent, compared with 16.2 percent for the county and 15.3 percent for the EDD); the number of families in the Grants-Milan area receiving public assistance funds (2.6 percent, compared with 7.8 percent for the county and 5.6 percent for the EDD); and the number of families in the Grants-Milan area that are below the poverty level (11.9 percent, compared with 18.5 percent for the county and 14.8 percent for the EDD).

2.2.5 Public Services and Facilities

Water Supply. Grants and Milan have individual systems that supply water to residences and businesses within their respective municipal boundaries from wells that can supply more than 7000 gallons per day (Table 2.2-11). Both systems are looped and metered and both use the gas chlorine purification process. Grants has recently drilled and equipped a new well that will be connected to its water system in the near future.

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Table 2.2-10. GENERAL INCOME CHARACTERISTICS

	Grants-Milan	Valencia County	Economic Development District (four-county region)	New Mexico
Total families (1970)	3377	9217	91,866	242,740
Median family income (1970)	9178*	7610	6165	7849
Per capita income (1974)	3364	3391	3580	4299
Total families with social security income (1970)	124*	1492	14,031	39,772
Total families receiving public assistance funds (1970)	89	715	5382	15,223
Total families below poverty level (1970)	402	1708	13,665	44,906
Per capita income of families below poverty level (1970)	—	2105	2121	2077

Source: University of New Mexico, 1977.

*Grants only.

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Table 2.2-11. GRANTS-MILAN WATER SUPPLY SYSTEM

	Source	Maximum Capacity	Peak Load	Storage Capacity
Grants	2 wells	5.472 mgpd*	3.3 mgpd	4,500,000 gallons
Milan	3 wells	1.700 mgpd	0.5 mgpd	700,000 gallons

Source: Middle Rio Grande Council of Governments, 1977a.
*mgpd = million gallons per day.

Water storage is provided by supply tanks located on the slopes of Black Mesa. Water is initially pumped into storage tanks and then boosted to tanks that feed each community's system. In recent years Milan's storage tank has proven inadequate. High water usage has significantly depleted the storage and affected the community's water pressure. Local public officials have considered the addition of a larger 1,000,000-gallon storage tank to solve the problem and provide for additional capacity for future growth. The rehabilitation of existing transmission lines, the looping of existing water distribution lines, and the replacement of undersized water mains in the Lobo Canyon area of Grants are also under consideration. The Lobo Canyon area, a prime area for future development, presently receives insufficient water supply at unacceptable pressure; the construction and completion of the storage tank will satisfy present needs and allow for anticipated growth.

<u>Sewerage</u>. Grants has an activated sludge plant that is operating near its rated capacity of 2.0 million gallons per day. Improvements have been proposed to increase the plant's capacity. The effluent is discharged into the Rio San Jose and the sludge is used as landfill and fertilizer. The Milan wastewater is collected and pumped through the Santa Fe Avenue wastewater interceptor in northwestern Grants and is then treated at the Grants facility. The interceptor capacity to handle wastewater for Milan and

the areas it serves in Grants has already been exceeded. Officials in Milan have indicated a need to increase the line capacity by rehabilitating the interceptor and two lift stations and constructing two additional lift stations. Officials in Grants also want to improve their wastewater collection system. Plans have been proposed for: a new Lobo Canyon sewer interceptor to serve new development in northeastern Grants, a new wastewater interceptor and pump station to serve the portion of the community south of Interstate 40, an interceptor to serve 160 acres near the city's eastern boundary, an extension of the Roosevelt Avenue interceptor, and new lines to serve the Galbaden Hill area.

Only five percent of the streets in Grants have storm sewers (Santa Fe Avenue and High Street), and Milan presently has no storm sewers. Both communities are subject to periodic runoff, particularly from the slopes of the Black Mesa, and infrequent flooding from Rio San Jose, Bluewater Creek, and major arroyos. Construction of detention and diversion structures and channel improvements are under consideration.

<u>Solid Waste Management</u>. A private firm collects solid wastes from Grants up to four times weekly (depending on the type of establishment or unit). Solid wastes are hauled to a 20-acre sanitary landfill site. The disposal site is expected to last until about 1985.

Milan's solid wastes are collected as frequently as six times a week. Service is provided by the community. Solid wastes are transported to a 15-acre landfill site, which is expected to last until about 1985.

<u>Energy Supply</u>. The communities of Grants and Milan receive electricity from the Continental Divide Electric Cooperative, which purchases its power from Plains Electric Generation and Transmission Cooperative. Natural gas is supplied by the Southern Union Gas company.

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Communications. Telephone service is provided to the area by the Mountain Bell Company, an affiliate of AT&T. The Grants Daily Beacon, the Uranium Empire Reporter, and several Albuquerque papers provide news to area residents. Numerous radio broadcasts from regional stations and cable television programs from Albuquerque and Los Angeles can be received throughout the area.

Police Services. The communities of Grants and Milan receive police protection from their respective municipal police departments, the county sheriff's office, and the state police. The Grants Police Department has 17 officers and maintains 14 vehicles. Milan's police department has four officers and four patrol cars. Three deputies are assigned by the Valencia County Sheriff to patrol western Valencia County (including Grants and Milan); 6 state police officers are also assigned to the area. The county and state police both have offices in Grants. The police staff in the area, especially at the local level, is expected to grow moderately over the next 10 years (in response to recent and projected population growth and to increasing needs for service).

Fire and Emergency Services. Grants has two fire stations staffed with 10 paid and 29 volunteer firemen. The community owns two 750-gallon and two 1000-gallon fire trucks and one car. Milan has two fire stations operated by a part-time firechief and 18 volunteer firemen. The community owns two pumper trucks with 750- and 1000-gallon tanks, a 1000-gallon tanker truck, and one car. Officials in both communities have indicated the need to expand and improve existing fire protection service with additional stations and equipment.

The Grants-Milan area is served by the Grants Ambulance Company, which owns several ambulances. Additional limited ambulance service is provided to uranium mining employees by the individual mining companies

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Health Care. The Cibola General Hospital is located in Grants. The 45-bed hospital, which is currently understaffed, has a staff of 61 members, including five medical doctors, one osteopath, four registered nurses, four licensed practical nurses, and EKG and X-ray technicians (MRGCOG, July 1977). The five M.D. general practitioners who treat their patients at the hospital also have offices in Grants or Milan. In addition, one opthamologist, three dentists, and five chiropractors have practices in the area. Plans are currently underway for the construction of a nursing home in Grants.

Valencia County operates a public health clinic and a public dental clinic in Grants. Mental health services are provided by the Community Mental Health Center, the Grants Counseling Service, the United Counseling Service, and the Grants Youth Outreach Center. Alcoholism problems are treated by the Western Valencia Alcoholism Program and by private nonprofit organizations. Other services are provided by the Grants First Offenders Program, the Paisano Senior Citizens Group, and the New Mexico Family Planning Council.

Recreation, Parks. The Cibola National Forest provides a variety of recreational activities near Grants and Milan. Recreational sites include Coal Mine Canyon and Lobo Canyon (picnicking), and Mount Taylor (hiking, seasonal hunting, sightseeing). Recreational facilities within Grants include several parks, numerous baseball fields and tennis courts, an outdoor swimming pool, and the New Mexico State University branch campus basketball courts and gymnasium. The city has plans for the development of four additional parks. The Grants Park and Recreation Department administers a wide range of recreational programs throughout the year. Milan maintains three parks (Josephine Elkins Park, Skytop Community Park, Sylvester Mirabal Park) that offer a limited range of recreational opportunities. At present, the only organized recreational program in the community is Little League baseball.

Transportation, Access, Mobility. Access to the Grants-Milan area is provided by a major highway, Interstate 40 (U.S. 66), which connects the communities with Albuquerque to the east and Gallup to the west. State Highway 53 also passes through Grants, running north and south. Rail transportation is provided by the Atchison, Topeka and Santa Fe Railway, which runs parallel with Interstate 40 in the area. Regional bus service is provided by Greyhound Lines and Continental Trailways, and two local bus lines make daily runs from Grants to the mines. Taxi service is available from a small operator in Grants. Four commercial trucking companies provide shipping service to the area.

The Grants-Milan Municipal Airport, located approximately three miles northwest of Grants, provides limited air service (single-engine charter, patrol flights, instruction, surveying, advertising) to the communities. The facility is under the joint responsibility of Grants and Milan.

Education. The Grants Municipal School System serves western Valencia County and is the largest of three school districts in the county. School enrollment in Grants has been increasing at a rapid rate (Table 2.2-12). At the present time the school system is using temporary modular classrooms to manage the increase. Two additional elementary schools and an additional junior-senior high school have been proposed.

Table 2.2-12. GRANTS SCHOOL DISTRICT ENROLLMENT, 1970-1977

	1970-1971	1971-1972	1972-1973	1973-1974	1974-1975	1975-1976	1976-1977	% Change, 1970-1977
Total enrollment	4032	4797	4713	4579	4837	4896	5330	+32.2

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The New Mexico State University branch college in Grants is currently undergoing new construction. Enrollment in the past few years has ranged from 230 to 250 students.

2.2.6 Summary of Existing Needs

The resources needed to satisfy preliminary needs and allow for incremental development within the two communities are estimated by the MRGCOG at roughly $32 million for 1977 (Table 2.2-13). Water supply and sewerage projects are serious present needs.

2.2.7 Public Finance

The sale of general obligation and revenue bonds or the use of transfer payments from other governmental units are the primary methods for municipalities in New Mexico to finance large capital improvements. The maximum amount that may be raised through general obligation bonds is equal to four percent of the taxable property valuation for municipalities and counties and six percent of the taxable property valuation for school districts. No statutory limit is placed on general obligation bonds used for water and sewer capital improvments. General obligation bonds are paid through levies against all property owners. Revenue bonds are paid by income from waste and sewer systems, gas and electric utilities, and sale tax.

A review of the total revenue, average annual revenues, total bonded indebtedness, and average annual capital resources needed for Grants and Milan indicates that the bonding capacity of Grants and Milan will not cover the costs of needed services (Table 2.2-14). Approximately $32 million is required to meet current needs, and both communities are near their bonding capacity. MRGCOG reports that even if bonded indebtedness in Grants and Milan were tripled the increased resources would account for less than 10 percent of the total capital resources needed. Though money is available from federal and state water, sewer, and recreation grants, and through the FHA, EDA, HUD, and the Four Corners Regional Commission, Grants and Milan

Table 2.2-13. REQUIRED CAPITAL RESOURCES FOR GRANTS-MILAN, 1977 (dollars)

	Grants	Milan	Grants-Milan (joint facilities)
Water supply	699,800	230,000	6,600,000
Sewerage	2,041,121	4,675,000	4,300,000
Police, fire services	255,450	95,600	-
Health care	-	-	500,000
Recreation, parks	805,000	39,000	-
Transportation, access, mobility	1,800,000	1,000,000	1,250,000
Education	-	-	7,500,000
Other	225,000	108,000	-
Total	5,826,371	6,147,600	20,150,000

Source: Middle Rio Grande Council of Governments, 1977a.

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will probably not be able to finance improvements entirely through bonding or grant funds, given the development that is projected in this area.

Table 2.2-14. GRANTS-MILAN RESOURCES AND ANNUAL CAPITAL NEEDS

	Grants	Milan
Total revenue (1975)	1,926,384	477,946
Average annual revenues (1970-1975)	1,470,568	461,978
Total bonded indebtedness (1975)	927,902	406,000
Grants-Milan annual capital resources needed (1977-1980)*	7,739,818	

Source: Middle Rio Grande Council of Governments, 1977a.
*Total capital resources needed spread evenly over the next four years.

The New Mexico legislature recently passed the Severance Tax Act (HTRC/ SFC/ SB137 - Laws of 1977, Chapter 102), which revises tax rates on the severance and production of uranium, coal, oil, and natural gas and their products produced in the state. The act provides, on a cumulative basis, millions of dollars in new tax revenues for the state. Some of these revenues will be specifically earmarked for redistribution to local communities affected by energy development.

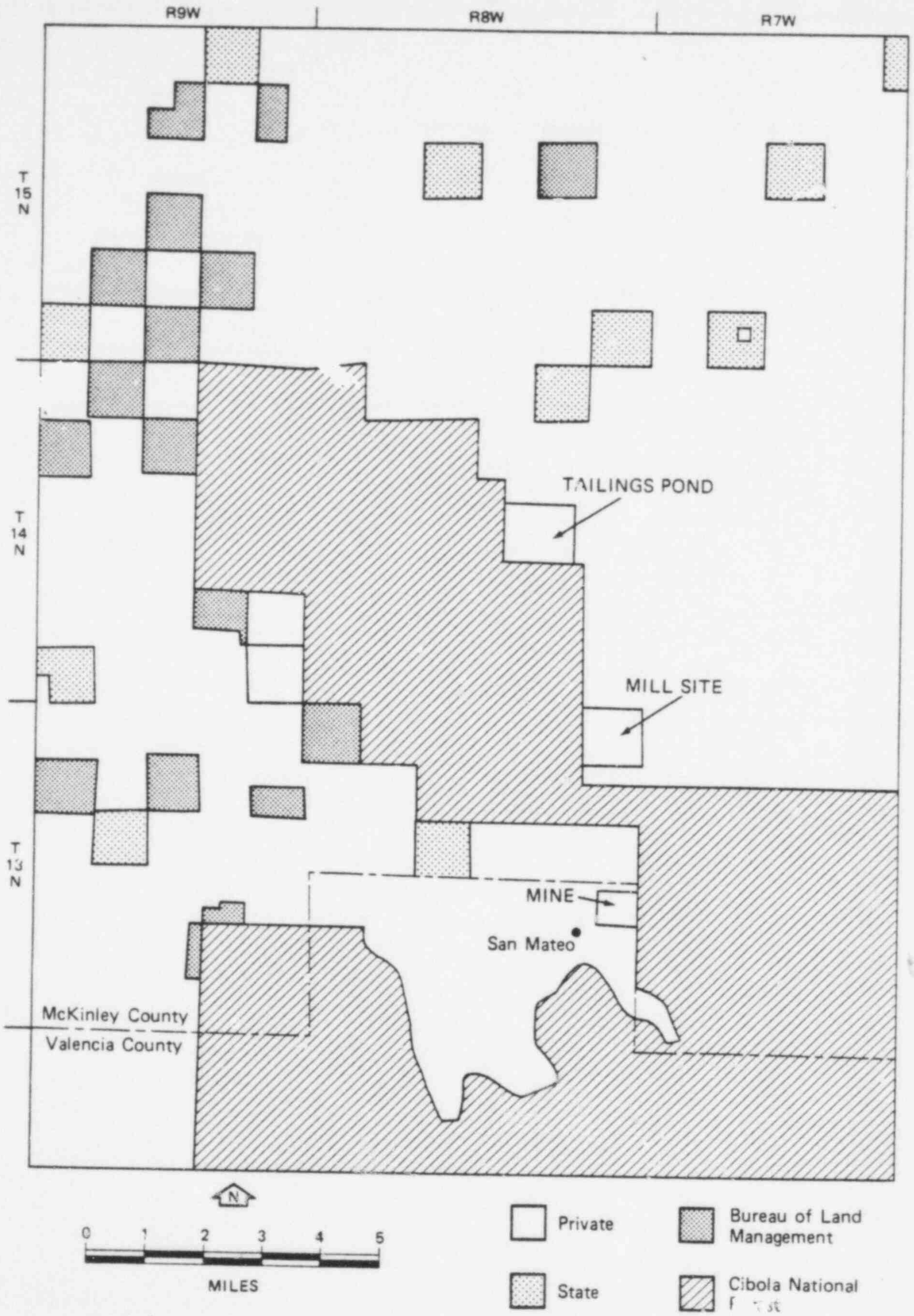
Recent energy-related state legislation has also set up a new state authority empowered to grant up to $10 million for technical and financial assistance to communities affected by energy or mineral resource development (Community Assistance Authority Act, SFC/SB165 and SB198 - Laws of 1977, Chapter 299). The purpose of the act is to provide state assistance to governmental units unable to cope with rapid population growth as a result of mineral and energy resource development. The act is considered a significant energy-related piece of legislation since it sets a precedent in state-local relationships and fiscal appropriations.

The grant funds will be committed within the next two years. It is expected that local jurisdictions within the Grants Uranium Belt and the San Juan Basin will receive most of the funds. Though $10 million provides some assurance of a minimal standard of public services to these areas, it should be recognized that the funds are inadequate for total financial requirements. In February 1977, the Governor's Energy Impact Task Force identified $119 million for capital projects requiring local funding over the next five years (Energy Impact Task Force, 1977). A longer-term solution beyond the $10 million grant program has generally been recognized by the Task Force and the State Legislative Energy Committee; however, an acceptable financial arrangement to meet these needs has not yet been established.

2.2.8 Land Use Management

The lands surrounding the incorporated communities of Grants and Milan are undergoing widespread and intensive mineral or residential development. The lands in the vicinity of the site and the unincorporated land around Grants-Milan is primarily a mixture of state-owned and private land, although small parcels of U.S. Bureau of Land Management (BLM) natural-resource lands are scattered throughout the area. BLM lands are managed under a multiple-use land management system. Currently, the BLM lands in the area are generally used for grazing purposes. This use is not likely to change in the near future as a result of resource development and urbanization.

As is indicated by in the land ownership map in Figure 2.2-2, no single, central agency is responsible for all land use decisions in the potential growth areas. Rather, several public agencies are engaged in planning, regulating, or otherwise managing land use with considerable variation in approaches to rapid growth management, levels of experience



Source: Public Service Company of New Mexico, 1978.

Figure 2.2–2.
LAND OWNERSHIP

and expertise, and enforcement controls. The assessment of land use impacts associated with the uranium mine project requires an understanding of the institutional framework for land use and growth management. The framework for land use decisions for each of the potentially affected land categories is discussed below.

National Forest Service Lands. The Forest Service administers National Forest Service lands under the Department of Agriculture. The West Cibola Division of the National Forest Service has jurisdiction over the Mount Taylor Ranger District of the Cibola National Forest, located in McKinley, Valencia, and Sandoval counties. The Division's responsibilities include general administration of those portions of the forest under its jurisdiction, management of timber resources, and development of specific land use management plans based on the Cibola National Forest Multiple Use Guide for National Forest Lands (U.S. Forest Service, 1975). Forest management activities are responsive to the Multiple-Use Sustained Yield Act directives of 1960. Planning obligations of the Forest Service are in response to the Wilderness Act, the Wild and Scenic Rivers Act, and the National Environmental Policy Act.

Grants-Milan. As incorporated communities in New Mexico, Grants and Milan can use a full range of land use controls within their respective corporate limits (zoning ordinances, planned unit development, subdivision controls mobile home park standards, growth boundaries, service areas for water and sewers). Until recently, they have not been fully engaged in such activities. The two communities are currently participating in the development of functional plans and programs with the assistance of the MRGCOG. The communities have recently considered for adoption the following growth policies:

- encourage development only in those areas most suitable for development as determined by physical constraints

- encourage development of areas that are easily and economically serviceable
- require developers to conform with local standards as a condition to subdivision plat approval
- require, as a condition of annexation, that improvements meet community standards with no cost to the rest of the community (through assessment districts, if warranted)
- ensure that new development be in conformance with local development policies through the enforcement of subdivision, zoning, and building code regulations
- provide utilities to designated Special Service Areas on the condition that the developer pays for the marginal cost of the improvement

Based on these policies, Grants and Milan have designated several service areas within the various geographic areas of the communities. The designated areas provide the communities with a preliminary base for land use decision making. Implementation and enforcement of these objectives would ensure that new development will not conflict with existing land use.

Unincorporated State and Private Lands. In New Mexico, state legislation authorizes county governments to engage in land use management (1973 New Mexico Subdivision Act). In recent years, McKinley and Valencia counties have become more active in planning and land use control, although the counties are still quite vulnerable to unregulated and unplanned development. Both counties have limited their authority to the regulation of subdivisions (adopted 1973); neither county has prepared any active or enforceable land use plans or policies, and neither has adopted any zoning regulations.

Several agencies, including the MRGCOG, the McKinley Area Council of Governments, the Four Corners Regional Planning Commission, and the State Planning Office (SPO) have all collected some land use data at the county level.

However, these agencies do not administer lands or exercise any land use regulatory functions in the counties. Their primary functions are to administer state and federal funds within their jurisdictions under the SPO and to act as advisory councils to the state legislature and the governor. The SPO is currently delineating areas of critical environmental concern throughout the state and is gradually moving to control land uses in these areas. Most of these areas of critical environmental concern are located within unincorporated areas where land is generally not presently subject to regulation or management. This is the state's first attempt to draw these areas into a comprehensive development plan. The SPO has identified the Grants-Milan area as a critical growth area.

2.2.9 Land Use and Economic Activity

The project area is sparsely populated, rural, and undeveloped. Characteristic vegetation on the site includes pinyon juniper, desert shrubs, and grasses. Predominant land uses in the area are mineral development, low-density grazing, some timber production, and approximately 500 acres of cultivation. The only urban development in the vicinity of the proposed site is the unincorporated community of San Mateo (population 225), located approximately three miles south of the proposed site. For many years, the livelihood of the residents of San Mateo depended primarily on livestock operations. Recently, the community has undergone a gradual shift from ranching to employment in the mining industry. Population has not increased significantly in the past few years, and it is expected to grow gradually in the near future. Recreational activity in the area includes general sightseeing, picnicking, hiking, and seasonal hunting (deer, elk, and wild turkey).

Uses of lands and waters within five miles of the proposed mill site are indicated on Figure 2.2-3. The predominant land use surrounding the project is low-density grazing. A portion of the grazing is conducted

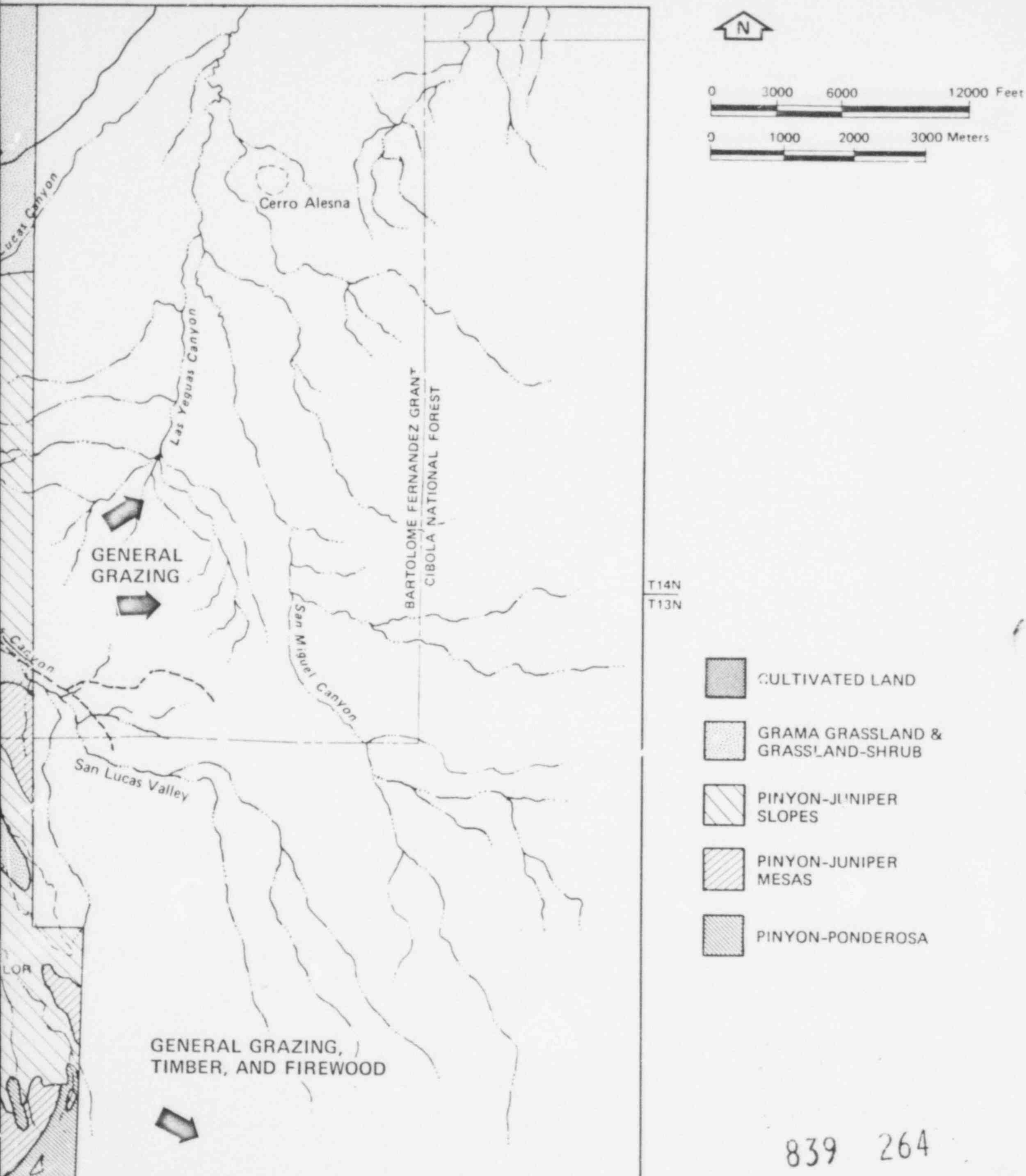


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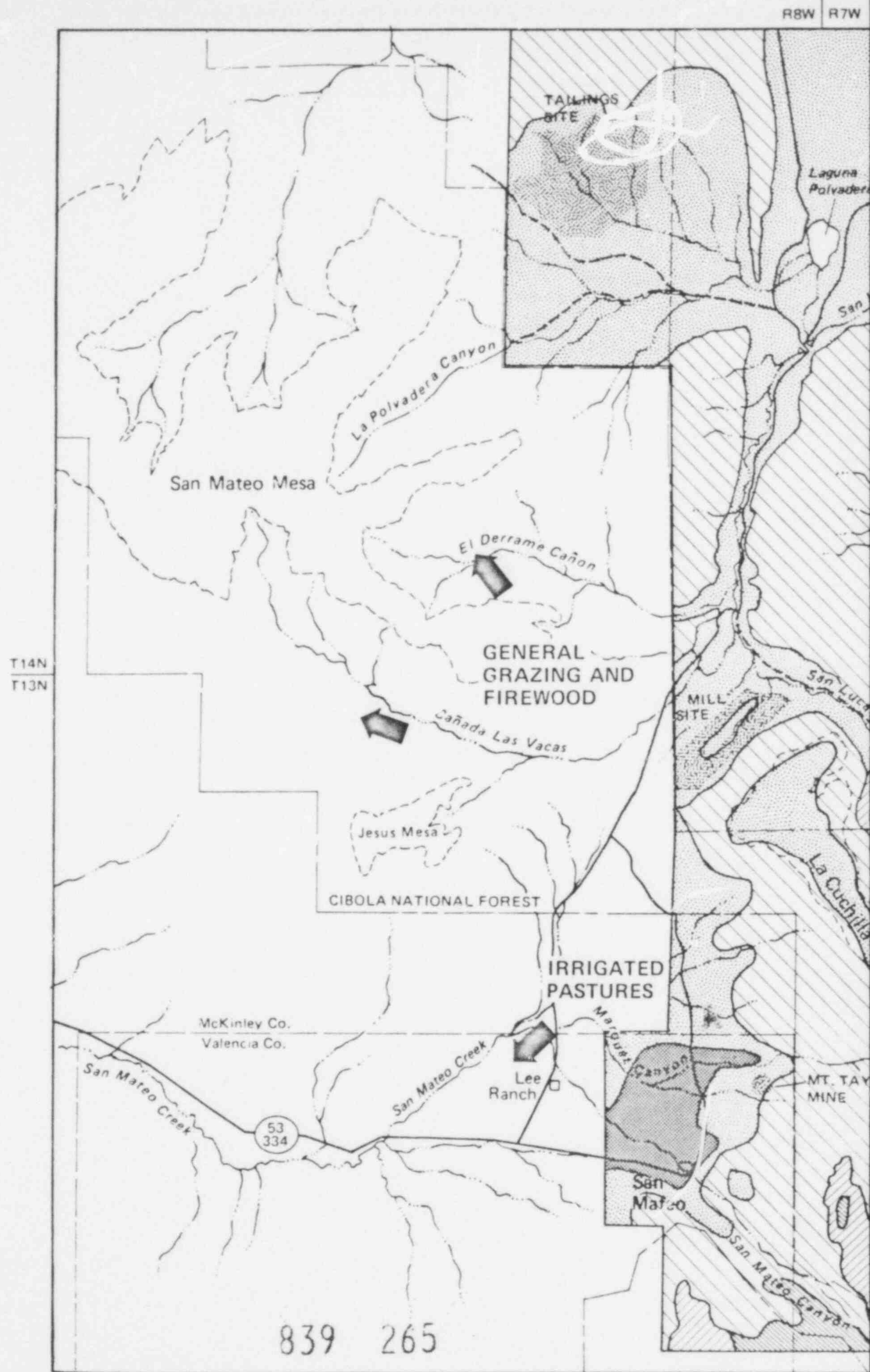
Figure 2.2-3.
LAND USE AND VEGETATION MAP OF PROJECT AREA



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Source: NMEI 1974; USGS 7½' Topographic Maps

POOR ORIGINAL

under the Federal Grazing Allotments shown on Figure 2.2-4. The other land uses as shown on Figure 2.2-3 are:

- Approximately 500 acres of cultivated land (gardens, pastures, orchards, etc.) located in the immediate vicinity of San Mateo. Production data are unavailable.

- Commercial logging activities conducted on the Northwest Flank of Mt. Taylor.

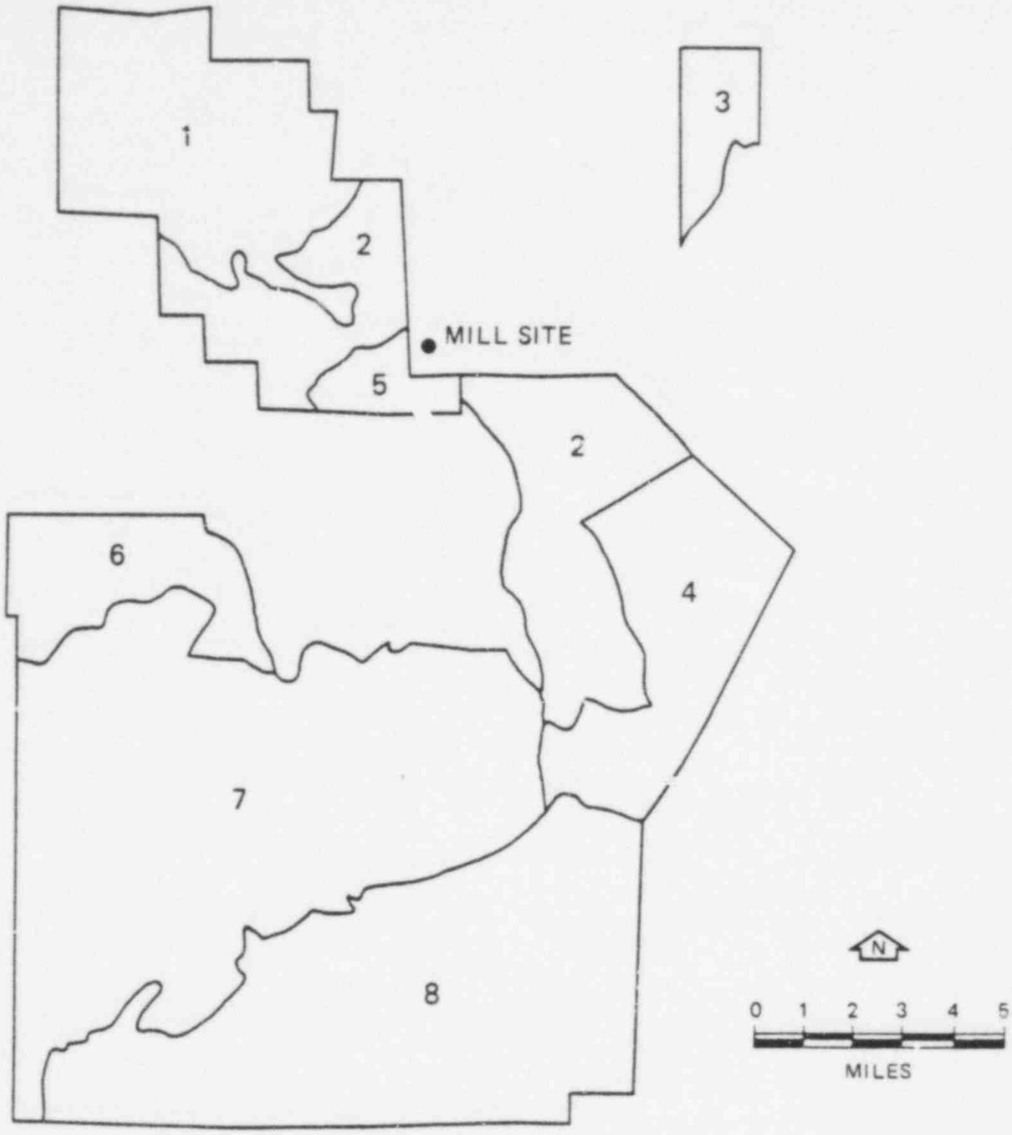
- Personal and commercial gathering of firewood is a prevalent land use in the pinyon-ponderosa forest.

Table 2.2-15 provides distance data for three types of land use: grazing, game animals, and vegetable gardens.

Nearest Residence. The proposed mill site is relatively remote from human residences. As shown in Table 2.2-16, the Candelaria Residence is located 4.4 km to the south of the mill site. The town of San Mateo, with a 1970 population of 200, and the Fernandez Ranch owned by the Lee family, are located approximately six kilometers to the south. There are no known residences within 20 km to the north and east.

Nearest Mill Site Boundary. The geographical boundaries of the proposed project are irregular. Generally, the property runs along a north-south axis (see Figure 2.1-2). Distances to the nearest mill site boundary were measured from the mill center (boiler stack).

Game Animals. According to the Grants Ranger District of the New Mexico Department of Fish and Game, a number of game species exist within five miles of the proposed mill site, primarily in Cibola National Forest to the south, east, and west. Game species include deer, elk, bear, turkey,



Grazing Allotment	Season	No. of Animals
1. Ortega	4/16 - 10/15	58 cattle
2. San Lucas		113 yearling cattle
Las Vacas Pasture	3/1 - 4/30	
Summer Pasture	5/1 - 7/31	
San Lucas Pasture	8/1 - 10/31	
Las Vacas Pasture	11/1 - 2/28	
3. Cerro Alesna	1/1 - 12/31	180 sheep
4. American Ranch	5/16 - 9/30	29 cattle
5. San Mateo Village		57 yearling cattle
Monte Pasture	3/1 - 4/30	
Banco Pasture	5/1 - 8/30	
Cuchilla Pasture	9/1 - 11/30	
Monte Pasture	12/1 - 2/28	
6. La Jara	4/16 - 7/15	100 cattle
7. El Rito	5/16 - 10/31	299 cattle
	11/1 - 1/31	199 cattle
8. Cubero	5/1 - 10/31	189 cattle

Source: U.S. Dept. of Agriculture, 1978.

Figure 2.2–4.
GRAZING PATTERNS AND SEASONS NEAR THE GULF MT. TAYLOR PROJECT SITE

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Table 2.2-15. DISTANCE TO LAND USES (LESS THAN TEN KILOMETERS) FROM THE CENTER OF THE MILL SITE

Direction	Grazing[a] Animal	Game[b] Animal	Vegetable Garden
N	3.5 km	9.7 km	-
NNE	-	5.5	-
NE	9.7	3.5	-
ENE	8.3	2.9	-
E	4.0	2.4	-
ESE	1.5	2.9	-
SE	1	3.3	-
SSE	1.0	4.2	-
S	0.9	9.0	4.0 - 5.0 km
SSW	1.0	0.5	4.0 - 5.0
SW	0.8	0.4	-
WSW	0.6	0.3	8.0
W	0.5	0.2	-
WNW	0.6	0.3	-
NW	0.7	0.4	-
NNW	1.0	0.5	-

Sources: [a]U.S. Forest Service, Cibola National Forest, Grants District Office, 1979.

[b]New Mexico Department of Fish and Game, Grants Ranger District, 1979.

Table 2.2-16. NEAREST RESIDENCES AND SITE BOUNDARIES

Receptors	Coordinates with respect to mill center X(km)	Y(km)	Z(m)
Candelaria Residence	0.24	-4.4	12.2
Lee Ranch	-1.87	-4.2	-33.5
San Mateo	-0.174	-5.7	24.5
Marcus Ranch	-8.74	-3.7	-94.5
Hospah	-9.54	39.1	-67.1
Albuquerque	96.71	-32.3	-646.2
North Site Boundary	0.00	3.6	48.77
South Site Boundary	0.00	-0.95	42.67
East Site Boundary	1.3	0.00	146.31
West Site Boundary	-0.31	0.00	-6.1
Grants - Milan	-19.54	-24.7	-225.5
Marquez	31.21	-7.5	-128.0
San Fidel	4.45	-33.2	-323.1

Source: Gulf Mineral Resources Co., 1978.

Note: Base elevation Z(m) = 2,194.39 m.

quail, dove, duck and rabbit. The annual harvest of deer and elk is fairly accurate, while the harvest of small game, which varies greatly due to predator-caused mortality and range and weather conditions, has been estimated by the Department. Harvest estimates are shown in Table 2.2-17. Illegal harvest of big game occurs, but is limited since the land around the site is privately owned and, thus, inaccessible. Approximate distances to nearby hunting areas are shown in Table 2.2-15.

Table 2.2-17. GAME ANIMALS WITHIN FIVE MILES OF PROJECT SITE

Game Animal	Annual legal harvest within 5 mi. radius of site	Total annual harvest estimated within 5 mi. radius of site
Deer	19	19-38
Elk	2	2-4
Bear	0	0
Turkey	0-5	0-5
Quail	0-25	0-25
Dove	0-50	0-50
Duck	0-25	0-25
Rabbit	0-100	0-100

Source: New Mexico Department of Fish and Game, Grants Ranger District, 1979.

Irrigated Grasslands and Annual Agricultural Production. There are three irrigated areas within 10 miles of the mill site as shown in Figure 2.2-5: 102 acres of surface irrigation along San Mateo Creek;[a] a second

[a]New Mexico Interstate Commission and the State Engineer Office, 1974, p.12.

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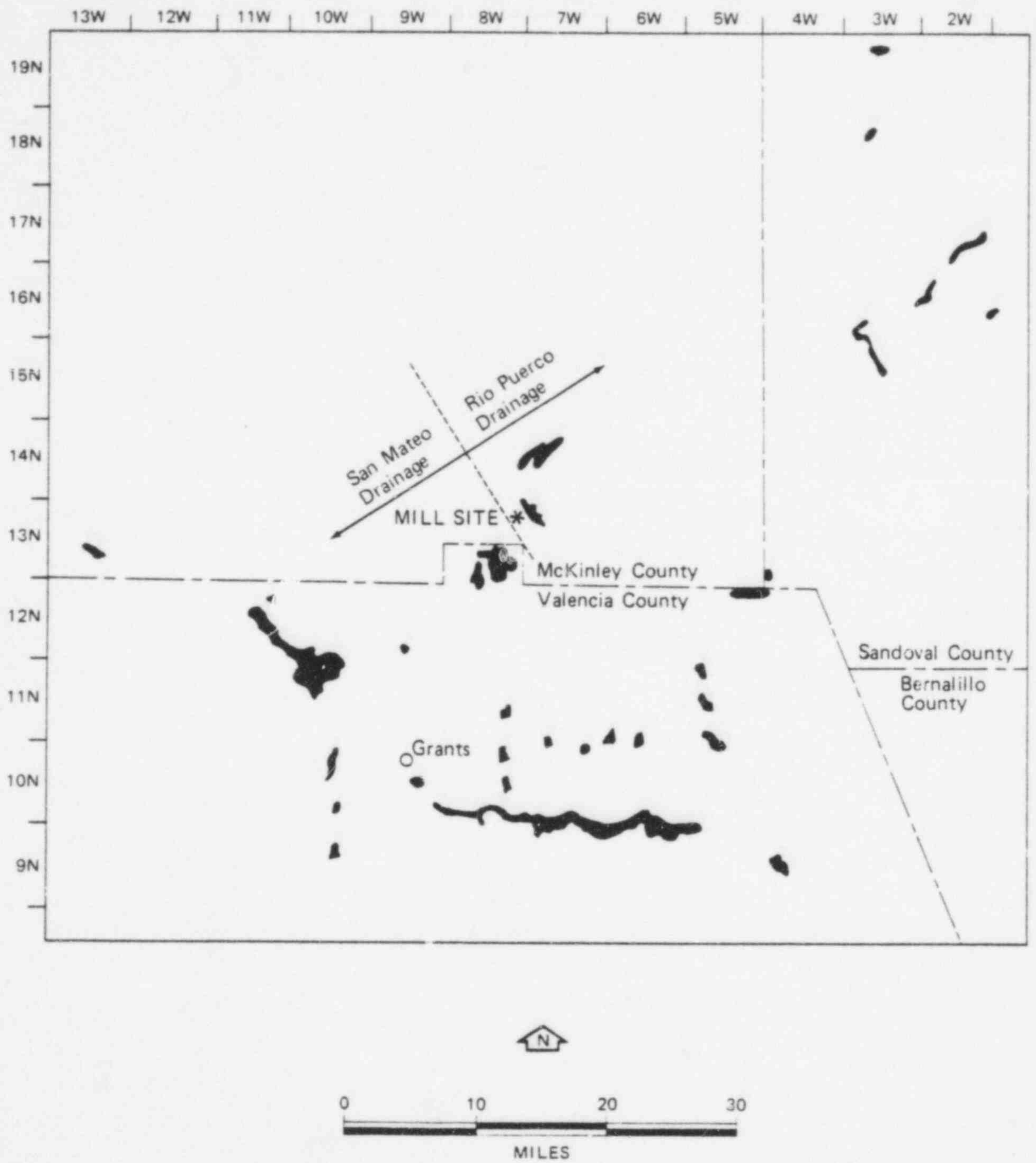

Source: New Mexico Interstate Stream Commission and State Engineer's Office, 1968.

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Figure 2.2–5.
IRRIGATED LANDS
NEAR PROJECT SITE

area in the San Lucas Canyon bordering the northeastern end of the project mill area; and a third area (run by the Fernandez Cattle Company) further downstream in the San Lucas Canyon. The San Mateo section, which is run by the Lee Ranch, produces vega (natural vegetation) and hay, and there are small plots of grazing land.[a] The project mill area primarily produces vega.[b] No information is available concerning agricultural production in the Fernandez section.

Virtually all of the irrigated land in this region occurs some 30 miles southwest of the proposed project site, Figure 2.2-5. Note that the site drainage is to the north, away from these lands. The Grants-Bluewater area has 5,880 acres of irrigated land, or 13 percent of the county total, while other areas to the east (e.g., Cebolleta, Acoma Pueblo, Isleta Pueblo, Laguna Pueblo) have a total of 7,454 acres, or 17.2 percent. These areas produce a mixture of crops, but the average county cropping pattern in 1969 was: corn (4 percent), small grains (19 percent), vegetables (6 percent), orchard (1 percent), alfalfa and other hay (65 percent), and irrigated pasture (5 percent).[c]

The approximate acreages of irrigated farmland and annual production yields are shown in Table 2.2-18. Valencia County is the largest producer of agricultural crops among the four counties within the 50 miles radius, with corn, wheat, hay and alfalfa constituting the major crops.

An inventory of the estimated livestock in the region is shown in Table 2.2-19. No data is available on the actual production of meat supplied from these animals.

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[a]U.S. Department of Agriculture, Economics Statistics and Cooperative Service, 1979.

[b]U.S. Soil Conservation Service, Grants Branch Office, 1979.

[c]New Mexico Interstate Stream Commission, 1974, p. 11-12.

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Table 2.2-18. IRRIGATED FARMLAND AND AGRICULTURAL PRODUCTION, BY CROP AND BY COUNTY, WITHIN 50 MILES OF THE PROJECT SITE (1977)

Estimated % of Farmland Within 50 Miles of the Mill (by County)	McKinley County 20%		Valencia County 30%		Sandoval County 5%		Regional Total	
Crop	Acres	Production	Acres	Production	Acres	Production	Acres	Production
Barley (bushels)	–	–	30	1,050	–	–	30	1,050
Apples (lbs.)	–	–	NA	600	NA	200	NA	800
Corn (bushels)	20	540	240	16,800	20	900	280	18,240
Sorghum (bushels)	–	–	45	2,700	–	–	45	2,700
Wheat (bushels)	–	16	660	33,000	–	4	660	33,000
All hay (tons)	130	170	4,200	14,700	260	760	4,590	15,630
Alfalfa (tons)	80	120	3,900	14,400	250	750	4,230	15,270
Lettuce-Spring (1975 CWT)	–	–	42	5,400	–	–	42	5,400
Onion-Summer (CWT)	4	460	6	700	–	–	10	1,160

Source: U.S. Department of Agriculture, New Mexico Crop and Livestock Reporting Service, 1977.

*Based on Figure 2.2-5. There are no irrigated lands in Bernalillo County within 50 miles of the project site.

Table 2.2-19. LIVESTOCK INVENTORY (JANUARY 1, 1978)

Estimated Percentage of Grazing Land Within 50 Miles	McKinley 50%	Valencia 80%	Sandoval 30%	Bernalillo 10%	Total
All Cattle	10,000	32,000	5,100	12,000	59,100
Milk Cows	50	2,700	300	1,100	4,150
Beef Cows	7,000	15,700	2,700	5,300	30,700
Other Cattle	3,000	13,600	2,100	2,600	21,300
All Hogs	200	1,700	30	400	2,330
All Sheep	39,800	28,400	1,300	2,400	71,900
All Chickens	1,000	3,200	300	157,100	161,600

Source: U.S. Department of Agriculture, New Mexico Crop and Livestock Reporting Service, 1977.

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Water Uses and Users. Water users in the vicinity of the project site may be categorized as follows: municipal (community water supply), domestic (individual household well), industrial, livestock watering, and wildlife watering. As shown in Table 2.2-20, the predominant users are single households in the township of San Mateo which draw water from individual wells for domestic purposes. Although withdrawal rates are not available for these wells and livestock watering wells, the State Engineering Office estimates they probably do not exceed three gallons per minute each (or approximately three acre feet per year).* The San Mateo township has three municipal wells, one which is being repaired and another which was recently dug. Withdrawal rates are approximately 25 gallons per minute.** Gulf Mineral Resources Co. owns several wells outside the mill site. One well is located near the mine (see S-1 on Figure 2.6-8 in Volume 2 of this report) and provides approximately 160 gallons per minute for domestic use. The other well is located north of San Mateo Canyon (#17 on Figure 2.6-5), and provides approximately 400 gallons per minute for industrial uses.

Aquifer identification is difficult for most of the regional wells due to the lack of drilling records. Many of the shallow wells in San Mateo are completed in discontinuous sand lenses within the Menefee formation. Table 2.6-4 tabulates those wells in the area for which aquifers can be identified.

Wells used for livestock watering are located in outlying areas away from San Mateo. The major users are the Lee, Candelaria, Michael, and Marquez ranches.

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*New Mexico State Engineer Office, 1979.

**New Mexico Interstate Stream Commission and State Engineer Office, 1974.

Table 2.2-20. LOCATION OF WELLS[a]

No.	Location[c]	Owner	Elevation[a] (ft)	Total[a] Depth (ft)	Depth to[a] Water Table (ft)	Distance to Mill (miles/km)	Withdrawal[b,f] Rate (gallons per minute)	Return[b,f] Rate	Type of[b] Water User
1	13.8.14.422	I. Michael	7,180	200	71.5 56	2.3/3.7	e	NA	Livestock
2	13.8.22.242	Lee Ranch	7,110	-	37.5 33.3 39.6	4.2/6.8	e	NA	Domestic/ Livestock
3a	13.8.23.343	Roman Marquez	NA	68	30.0		3	NA	Domestic
3b	13.8.23.431	H. Marquez	7,180	92	38.2 35 35	4.7/7.6	e	NA	Domestic
4	13.8.24.223	A. Candelaria	7,320	-	140.7 195 184.5	3.7/6.0	e	NA	Domestic/ Livestock
5	13.8.24.334B	N. Marquez	7,295	200	40	4.8/7.7	e	NA	Domestic
6	13.8.24.334	F. Gonzales	7,290	200	50	4.6/7.4	e	NA	Domestic
7	13.8.24.334A	N. Marquez	7,300	140	89.5	4.9/7.9	e	NA	Unused
8	13.3.25.112	J.T. Gonzales	7,320	150	43.0	5.0/8.0	e	NA	Domestic
9a	13.8.25.114	E. Michael(a)	7,310	120	35.9	5.1/8.2	e	NA	Domestic
9b	13.8.25.114	E. Michael(b)	7,310	250	80		e	NA	
10	13.8.25.111	P. Pena	7,295	21	19.5	5.0/8.0		NA	Domestic
11a	13.3.25.123	Community of San Mateo(a)	7,240	336	281	5.0/8.0	25	NA	Municipal
11c	13.8.26.221	Community of San Mateo(b)	7,240	600 being repaired	75.0	5.0/8.0	e	NA	Municipal
11d	13.8.26.212	Community of San Mateo(b) (12/27/72)	NA	707	686	5.0/8.0	e	NA	Municipal
12	13.8.26.211	P. Sandoval	7,215	40	33.2 34 32	5.1/8.2	e	NA	Domestic
13	13.9.24.221	N. Marquez	6,910	80	56.5	8.6/13.8	e	NA	Livestock

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14	13.9.24.221	Calumet Hecla, Inc.	6,910	80	56.6	8.7/14.0	e	NA	Industrial/ Domestic
15	13.8.25.114	J. Hope	7,290	35 broken	27	5.2/8.4	e	NA	Municipal
16	13.7.33.234	Gulf water well	8,400	1500 approx.	400 ±	8.7/14.0	e	NA	Industrial
17	13.7.30.432	Gulf		>1980	<300	6.5/10.5	400	NA	Industrial
SM2443	13.8.24.412	Gulf	7,350	800	260	2.8/4.5	160	NA	Domestic
18[d]	14.8.12.234	Lee Ranch	-	-	-	7.8/12.6	e	NA	Livestock
19[d]	14.8.15.433	Polvadera (Lee Ranch	7,180	1320	-	6.5/10.5	1-2	NA	Livestock
20[d]	13.8.17.241	Lee Ranch	-	-	-	5.1/8.2	e	NA	Livestock
21[d]	13.8.27.134	-	-	-	-	6.4/10.3	e	NA	Livestock
22[d]	13.8.33.234	Bita	-	600	-	7.9/12.7	e	NA	Livestock
	13.8.11.321	Cattlemen's Assoc.	7,190	192.3	76.90		e	NA	Livestock
	13.8.14.422	GMRC	7,180				NA	NA	Industrial
	14.7.19.221	Lee Ranch	6,930		Flowing	3.6/5.8	e	NA	Livestock
	14.8.4.334	Lee Ranch	7,210		>500		e	NA	Livestock
	13.8.24.144	C. Trujillo	7,280	160		2.7/4.3	e	NA	Domestic
	13.8.24.342	F. Candelaria	7,310	250	15	3.1/5.0	e	NA	Domestic
	13.8.23.413	H. Marquez	7,180	78.9	33.98		e	NA	Domestic
	13.8.24.141	A. Candelaria	7,260	285	-	2.5/4.1	e	NA	Domestic
	13.8.14.422	GMRC	7,190	-	-	1.8/2.9	NA	NA	Industrial
	13.7.30.421	GMRC	8,260	4,207	7,500		NA	NA	Industrial
	13.8.24.342	F. Candelaria				3.1/5.0	e	NA	Domestic
	13.8.25.121	San Mateo	7,320		269.35	3.3/5.3	e	NA	Municipal
	13.8.24.412	GMRC	7,350	2,000	700	2.9/4.7	NA	NA	Municipal

Sources: [a]Based on Tables 2.6-2 and 2.6-4, Volume 2.
[b]State Office of Engineering, Water Rights District Office, 1979.
[c]For explanation of well numbering system, see Figure B-1, Appendix B, Volume 4.
[d]Data supplied by Kerr-McGee Corporation.
[e]Estimated to be less than 3 acre-feet per year (approximately 0.19 liters per second).
[f]Withdrawal and return rates are not available, since the State Engineering Office, Water Rights Division (Albuquerque District Office) did not issue permits in the San Mateo area until 1976.

Based on withdrawal rates for the above wells, it is estimated that water usage in the vicinity of the project site is about 500 acre feet per year.

Springs and surface water sources are shown on Table 2.2-21 and Figure 2.6-5. The largest of the springs is San Mateo Springs which is located southeast of San Mateo township and provides an estimated 250 to 300 gallons per minute. This water feeds San Mateo Reservoir. Other springs include San Lucas Spring, Maruca Spring, Bridge Springs, South Bridge Springs, and San Lucas Valley Spring. These springs have a flow rate of less than 30 gallons per minute. Flow rates in the San Lucas Canyon and American Canyon are estimated at 50 gallons per minute.

Table 2.2-21. LOCATIONS OF LOCAL SPRINGS AND SURFACE WATERS[a]

No.	Location[c]	Owner or Name	Elevation (ft)	Yield		Type of Water Use[b]
				Flow (gpm)[d]	Date	
B	13.7.9.441	San Lucas Canyon	7,880	50E 25.7M 5M	10-23-62 10-24-72 5-31-73	Wildlife
C	13.7.9.433	American Canyon (west of B, above)	7,810	50E ≈2M >100M 5M	10-23-62 10-18-72 10-24-72 5-31-73	Wildlife
D	13.7.20.121	San Lucas Spring	7,850	20M 9.8M 15.3M 12.1M 14.9M	8-29-62 9-29-72 10-11-72 3-14-73 5-31-73	Wildlife
E	13.7.31.414	San Mateo Springs (See San Mateo Dam below)	8,120	230-300E	10-24-62	Municipal, Wildlife
F	13.7.19.242	Maruca Spring	7,850	Trace	9-29-72	Wildlife
S-18	13.7.28.131	Lee Ranch	7,908	--	--	--
G	13.8.21.424	Bridge Springs	7,035	18.9M 31.0M 11.3M	10-18-72 3-14-73 6-2-73	Domestic, Wildlife
H	13.8.28.141	South Bridge Springs	7,015	4.6M 26.7M 18.9M	10-17-72 3-14-73 6-2-73	Wildlife
I[e]	13.7.6.322	San Lucas Valley Spring	-	-	6-1-72	Wildlife
J[e]	13.8.25.414	San Mateo Dam	7,460	250-300E	6-1-72	Municipal, Wildlife

Sources: [a]Based on Table 2.6-3, Record of Historical Spring and Surface Water Sample Points.
[b]State Office of Engineering, Water Rights District Office, 1979.
[c]For explanation of location well-numbering system, see Figure B-1, Appendix B, Volume 4.
[d]E-Estimated; M-Measured.
[e]Data supplied by Kerr-McGee Corporation.

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2.3 CULTURAL RESOURCES

The history of the diverse groups that have settled in northwestern New Mexico is described in the report prepared by the New Mexico Environmental Institute (1974). The following discussion is excerpted from that account.

2.3.1 Archaeological Background

The Mt. Taylor area is situated in the archeological district designated the Acoma Culture Province. Numerous aboriginal habitations in west central New Mexico attest to a large prehistoric population, with human occupation of this area dating from the year 10,000 B.C. However, archeological surveys in the project area have been limited and have consisted primarily of excavations along pipeline and highway construction routes of the past twenty years. These surveys have uncovered approximately twenty-five prehistoric sites (personal communication, Mr. Stewart Peckham), evidence of occupation by pre-Pueblo hunting and gathering groups. Many campsites dating from 4000 B.C. to A.D. 500 were found in Grants Canyon and west and north of Grants Ridge.

Between 500 B.C. and A.D. 500 the culture of the area was transformed by the development of agriculture, pottery, and pueblos. The Anasazi cultures, comprised of two distinct complexes, evolved near the end of the long period. The earliest culture was the Basket Maker, first described from cave excavations of corpses which are accompanied by numerous detailed baskets. During the later Basket Maker stages advanced and more distinctive cultural traits appeared, such as living quarters, pottery design, and new agricultural crops.

The later Anasazi culture, the Pueblo, was initiated with the movement into the plateau of a new group of people who mixed physically and culturally with the Basket Makers, producing a distinctive group. The initial signs of Pueblo culture appeared in approximately A.D. 700, and continued to evolve and spread until about A.D. 1000. There is evidence of rapid development during this period of many small villages and a few sizeable pueblos, and the standardization of an economy based essentially on agriculture. Severe droughts caused people from southern areas to migrate to this portion of the Acoma Culture Province. Two archeological sites which were excavated northeast of Grants and dated at approximately A.D. 1050 contained remnants of this culture (Wendorf et al., 1956). This excavation revealed that corn, beans, and fruit trees were grown in the area with the aid of irrigation wells. The findings also support the contention that the advanced stages of Pueblo culture experienced an expansion of group or community living and produced corrugated pottery with designs over the entire surface of cooking vessels.

From A.D. 1100 to 1300 the Pueblo III culture began to dominate the plateau area. Characteristics of this culture which indicated advanced cultural attainment were large communities and developments in the arts and agriculture. The population of this culture tended to be concentrated in the relatively small areas at various points in time. This pattern indicated the evolution of the "human cycle," whereby an area was rendered unfit for residence after a certain duration of human occupancy.

Since this area was a considerable distance form the center of Spanish colonization in the Rio Grande Valley, it was not greatly affected by the early Spanish trade. Despite the Spanish and later American contacts, Acoma retained must of its original way of life. Acoma Pueblo is located about 25 miles southeast of the project area.

2.3.2 Spanish and American Settlements

Europeans first arrived in the region during the sixteenth century. Francisco Vasquez de Coronado, leading an expedition of explorers, crossed through this region in the 1540's. Thereafter, the Spanish

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made occasional trips into the region until 1598, when Juan de Onate's colonizing force marched through the area.

From 1598 until 1821 northwestern New Mexico was presided over by Spanish governors under jurisdiction of the Colonial Government of Mexico. The small rural communities that began to develop in this general area were patterned after both the older Indian pueblos and the feudal villages of medieval Europe. When Mexico obtained independence from Spain in 1821, this area became part of Mexican territory. As a result of the Mexican War in 1848, this land was ceded to the United States by the Treaty of Guadalupe Hidalgo. Thereafter Anglo-Americans migrated through this region in great numbers.

Historical information regarding specific communities in the Mt. Taylor area can be traced back to the early 1800's. At this time communities developed in the surrounding area of Valencia County as settlers capitalized on the physical advantages of the Rio Grande and Rio San Jose.

Grants, New Mexico, is approximately 30 miles southwest of the project area, and is a main center of population in the Mt. Taylor area. The town of Grants, originally named Los Alamitos, was homesteaded in 1872 by Jesus Blea and in 1873 by Ramon Baca. The economy of the Grants area was primarily agricultural until the 1950's. The history of the town and development of the surrounding area is discussed in the baseline report prepared by New Mexico Environmental Institute (1974).

The village of San Mateo, (Figure 1.1-1), is located about 30 miles northeast of Grants near the Valencia-McKinley county line. Founded in 1835 by Manuel Chaves to Honor St. Matthew, the village was later colonized by about 30 Mexican-American settlers. By 1875 these early colonists applied for private land claims and began ranching and agricultural activities in the area.

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San Mateo is also the headquarters for the Old Fernandez Ranch. In 1768 Pedro Fermin de Mindinueta, Capital General of the Province of New Mexico, acting under the authority of the Spanish crown, granted to Bartolome Fernandez and his ancestors a large tract of land near San Mateo. The grant was in consideration of services rendered by Fernandez to the King of Spain. This ranch is currently owned by Floyd Lee.

Since the original inhabitants of San Mateo were from a traditional Spanish background, Catholicism became the dominant religion of the community. A small, attractive chapel, constructed in the 1880's and currently in operation, reflects this strong Catholic heritage.

The Santa Fe to Prescott Stagecoach Route, which passes through the San Mateo area, is the only registered historic landmark in the area. La Posta, a stage stop of the route, still exists on the Floyd Lee Ranch. The town of San Mateo is not a registered site, but is recorded in the survey files of the Museum of New Mexico, Santa Fe, as an historic site.

2.3.3 Summary of Cultural Resources Within the Project Area

Inventory and reconnaissance survey in the San Lucas Canyon area has produced evidence of human occupation from four probable temporal/cultural horizons: Archaic, Pueblo, Navajo and Anglo. In addition, two areas of lithic debris were encountered which could not be dated.

Archaic period remains consist of lithic debris located on sandy knolls overlooking expanses of open grassland or specific geographical features (canyons). Within the survey area Pueblo period remains proved restricted either to locations conducive to agriculture, or access routes between known areas of Pueblo occupation. Navajo remains comprised the largest number of sites recorded in San Lucas Canyon proper. The rugged scarp

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bordering the drainage on the west appears to have supported a considerable Navajo population during the 1800's. However, habitation and livestock structures appear located with a preference for protection from visual as well as climatic exposure. Spanish herding enclosures were located in two areas associated with large expanses of grazing land. These features occur at lower elevations and in more exposed positions than the Navajo sites. The single feature attributed to Anglo uranium exploration is positioned relative to exposed geologic strata and testing areas rather than to overt vegetative or topographic features. For an expanded discussion, please see Appendix E.

The New Mexico State Planning Office has indicated that no sites presently entered in the National Register or which have been previously determined eligible for nomination to the Register are located in the project area. The planning office also has indicated concurrence with the findings and recommendations of Mr. John Beal, as presented in Appendix E.

2.4 GEOLOGY

2.4.1 Regional Setting and Topography

The project area lies in the eastern part of the Colorado Plateau geologic province near the southern boundary of the San Juan Basin. The site is about 35 miles west of the San Ignacio faulted monocline that forms the boundary between the Colorado Plateau and the Rio Grande Depression (Figure 2.4-1). It is in the southeastern part of the Ambrosia Lake mining district of the Grants Mineral belt.

Topographically, the project area is in mesa country that is typical of much of the Colorado Plateau province. The valley bottoms are relatively flat and are deeply incised by channels of intermittently flowing streams. The valley slopes typically are steep, and grade abruptly to flattopped crests.

2.4.2 Regional Geologic and Tectonic History

The San Juan Basin sediments, as much as 9,000 feet thick, were gently folded in Jurassic time (about 155 million years before the present), and tilted northwestward, in this sector of the basin, at a low angle (two to five degrees) toward the center of the basin. This tectonic activity subsided through Cretaceous time, but in early Tertiary time (50 to 60 million years before the present), tectonic activity began again. This activity resulted in the formation of the present general configuration of the San Juan Basin, in addition to several smaller structures (Madera anticline, Arch Mesa syncline) in the eastern part of the basin (Kelley, 1950). In late Tertiary time, (10 to 20 million years before the present) a regional east-west crustal extension resulted in the formation of the Rio Grande depression and also created major folding, accompanied by northeast-trending normal faulting to the east and northeast of the project area. During this same period, volcanic activity centered in the Mt. Taylor volcanic field, east of the project area.

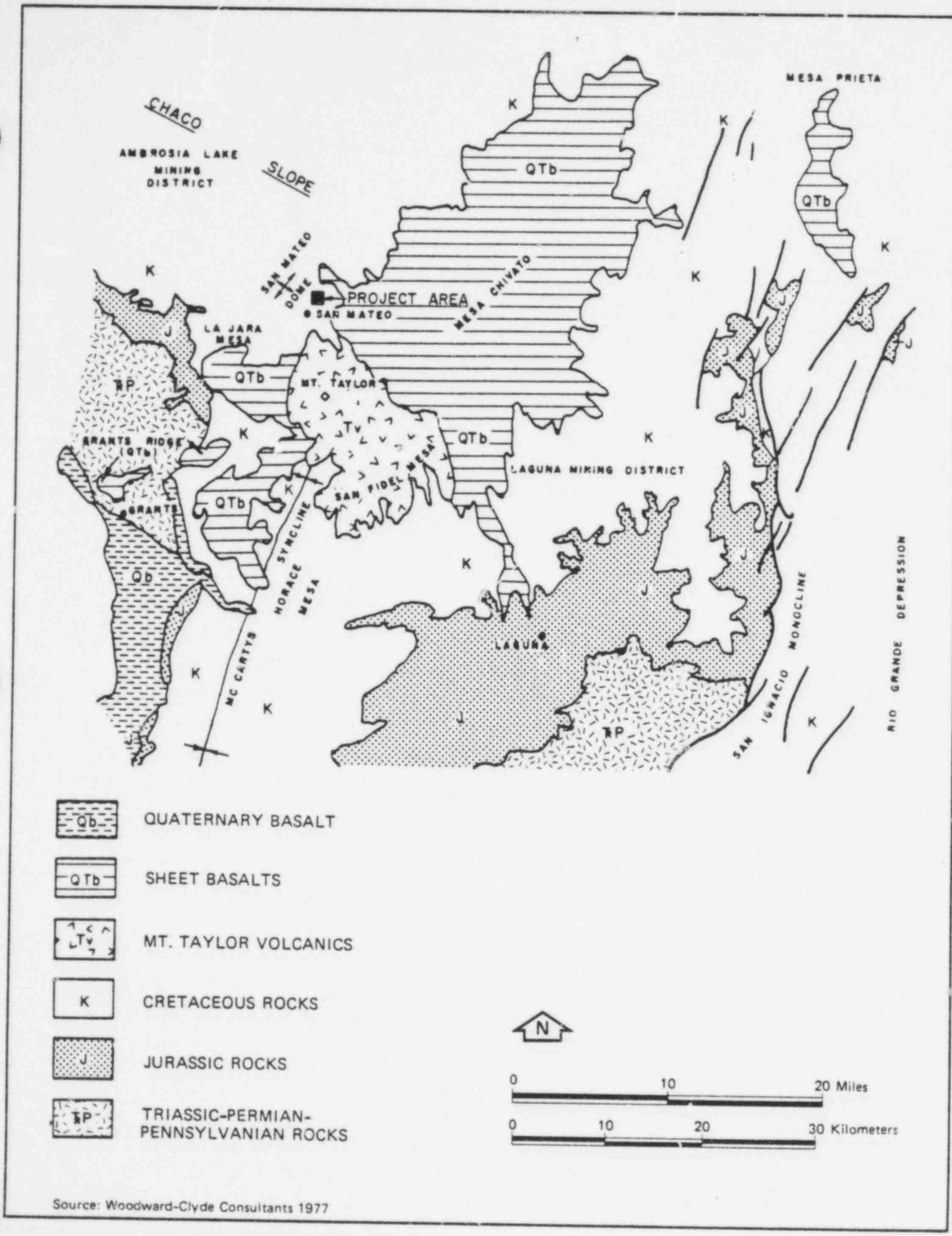

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Figure 2.4–1
REGIONAL GEOLOGIC FEATURES

Subsequently, thousands of feet of sediments have been eroded away to expose rocks of Cretaceous age and older (Kelley, 1963).

La Polvadera Canyon, the site of the proposed Mt. Taylor tailings disposal area, is at the northeast end of San Mateo Dome, an elongated structure that trends northeasterly. The flank of the dome coincides with a part of the west flank of the McCartys syncline. Contours drawn at the base of the Dakota Sandstone show that the San Mateo Dome retains its general structure at depths of 1,600 to 2,000 feet (Santos, 1968). The dome is cut by normal faults which can be traced for several miles and exhibit both horizontal and vertical displacement.

2.4.3 Stratigraphy

The generalized stratigraphic column shown in Figure 2.4-2 summarizes the rocks of the project area, and the geologic map of the project area is shown on Figure 2.4-3. Of interest to this project are the Morrison Formation and its overlying strata.

The Morrison Formation of Late Jurassic age overlies the Bluff Sandstone and crops out south and east of the project area along the margins of the San Juan Basin. About 300 to 500 feet thick, it comprises variegated shales, claystones, and discontinuous interbedded sandstones divided into three members. In ascending order, these are the Recapture, Westwater Canyon, and Brushy Basin members.

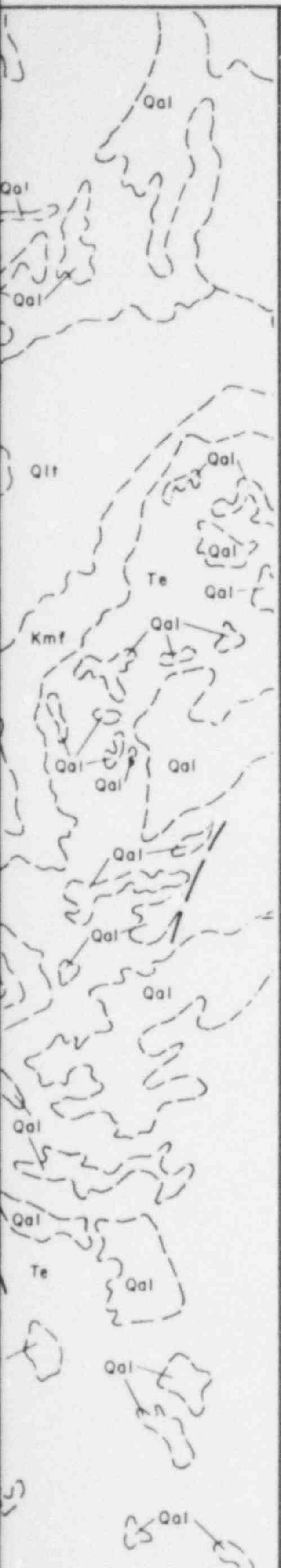
The lowest member of the Morrison Formation, the Recapture Member, is formed of red, maroon, and greenish-gray shales, claystones and sandy claystones. The Westwater Canyon Member consists of a light-colored, fine to coarse-grained sandstone that is areally discontinuous, and probably interfingers with the overlying Brushy Basin Member and the underlying Recapture Member.

SYSTEM		ROCK UNITS	LITHOLOGY	
QUATERNARY		ALLUVIUM	Qal	sand and gravel, poorly sorted and cemented
TERTIARY		VOLCANICS	Tb	basalt, andesite, rhyolite, lava flows and dikes
CRETACEOUS	MESA-VERDE GROUP	MENEFEE FORMATION	Kmf	gray, brown claystone and shale, sandstone, limestone and coal
		POINT LOOKOUT SANDSTONE	Kpl	dark orange to yellowish gray arkosic sandstone
		CREVASSE CANYON FORMATION		sandstone, claystone, shale
		Gibson Coal Member	Kca	
		Dalton Sandstone Member	Kcda	
		Mulatto Tongue (Mancos Shale)	Kmm	
		Dilco Coal Member	Kcdi	
		GALLUP SANDSTONE	Kg	brown sandstone
		MANCOS SHALE	Km	dark gray shale with interbedded sandstone
		Tres Hermanos Member		
		DAKOTA SANDSTONE	Kd	tan to gray quartz sandstone
JURASSIC		MORRISON FORMATION	Jm	
		Brushy Basin Member		sandstone
		Jackpile sandstone		mudstone and sandstone
		Poison Canyon sandstone		
		Westwater Canyon Member		sandstone and mudstone
		Recapture Member		sandstone and siltstone
		BLUFF SANDSTONE	Jb	pale red to brown sandstone
	SAN RAFAEL GROUP	SUMMERVILLE FORMATION	Js	pale brown sandstone and siltstone
		TODILTO LIMESTONE	Jt	limestone
		ENTRADA SANDSTONE	Je	fine-grained sandstone
		CARMEL FORMATION		red, fine-grained silty sandstone
		WINGATE FORMATION		red to tan sandstone
TRIASSIC		CHINLE FORMATION	℞c	red shale with interbedded red siltstone and sandstone
PERMIAN		SAN ANDRES FORMATION		limestone
		Glorieta Member	Pg	white to tan fine-grained, cross-bedded sandstone

Source: Modified from Hazlett and Kreek 1963

Figure 2.4–2.
STRATIGRAPHIC COLUMN

839 288



Qlt	LANDSLIDE AND TALUS MATERIAL
Qc	RESIDUAL DEPOSITS: BEDROCK DECOMPOSED TO CLAY, (MAPPED AS SAPROLITE BY USGS)
Qal	ALLUVIUM (SILT, CLAY WITH OCCASIONAL GRAVELLY LENSES)
Te	BASALT, ANDESITE AND OTHER INTRUSIVE ROCKS
Kmf	MENEFEE FORMATION (INTERBEDDED SILTSTONE AND FINE TO MEDIUM GRAINED SANDSTONE)
Kpl	POINT LOOKOUT SANDSTONE, MAIN BODY
Kplh	POINT LOOKOUT SANDSTONE, HOSTA TONGUE
Kcg	CREVASSE CANYON FORMATION, GIBSON COAL MEMBER (INTERBEDDED SANDSTONE, SILTSTONE, SHALE & COAL BEDS)
Kcda	CREVASSE CANYON FORMATION DALTON SANDSTONE MEMBER
Kcdi	CREVASSE CANYON FORMATION, DILCO COAL MEMBER (INTERBEDDED SANDSTONE, SHALE, AND COAL BEDS)
Kms	MANCOS SHALE, SATAN TONGUE (INTERBEDDED SANDSTONE, SILTSTONE, AND SHALE)
Km[illegible]	MANCOS SHALE, MULATTO TONGUE (INTERBEDDED SHALE AND SANDSTONE)

CONTACT BETWEEN GEOLOGIC FORMATION, APPROXIMATELY LOCATED

FAULT, DASHED WHERE LOCATED APPROXIMATELY; DOTTED WHERE CONCEALED

ANTICLINE, SHOWING CREST LINE AND PLUNGE

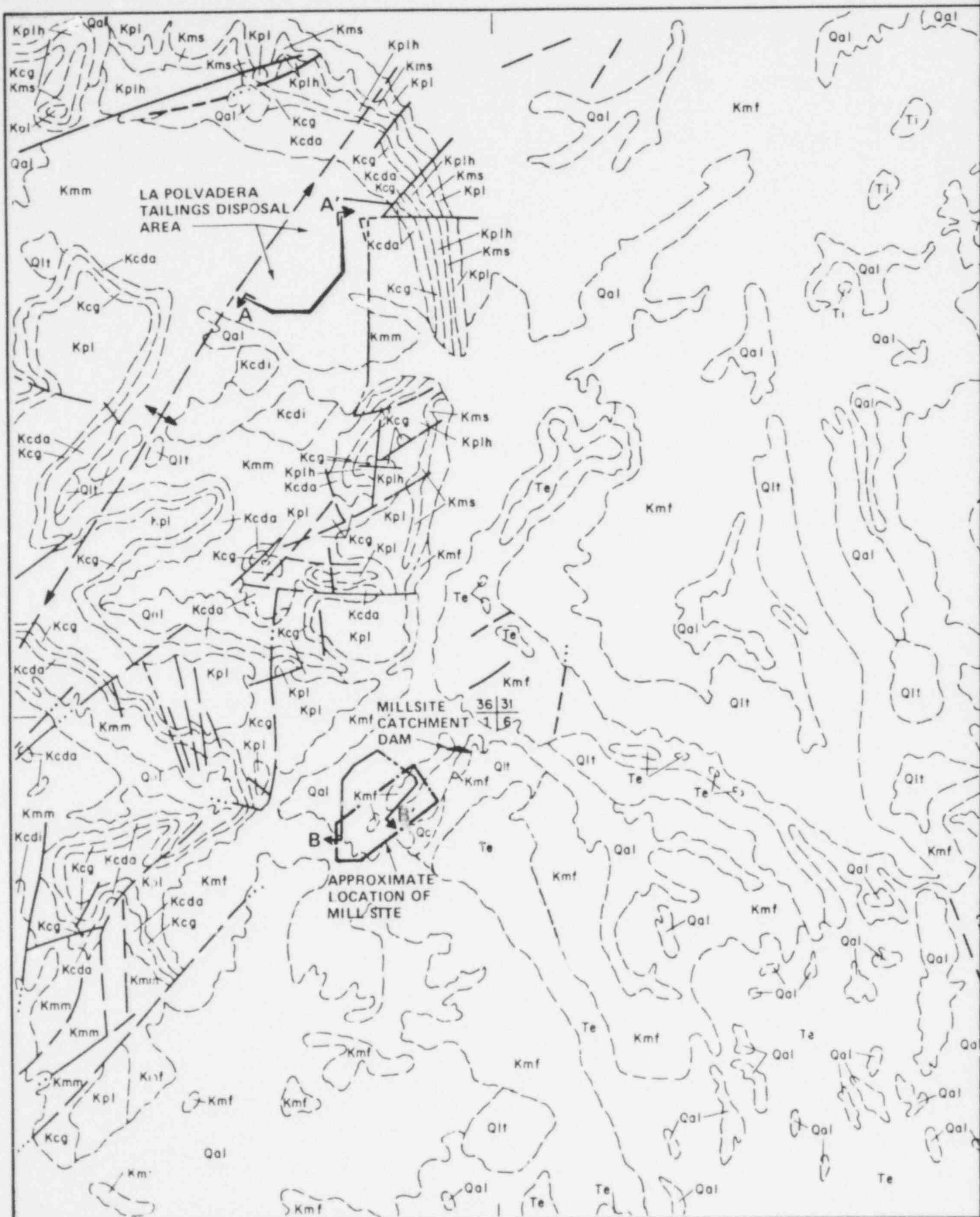
REFERENCED TAILINGS DAM SITE, APPROXIMATELY LOCATED

N

0 ½ 1 2 Miles

Figure 2.4–3.
GEOLOGIC MAP OF PROJECT AREA

839 289



Source: Modified from Cooper and John 1968; and from Santos 1966

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The Brushy Basin Member incorporates primarily greenish-gray shales, claystones, sandy claystones, and interbedded sandstones. The uppermost unit is a light-colored, fine to coarse-grained sandstone called the Jackpile Sandstone. Locally, it contains extensive deposits of uranium ore. The sandstone beds of the Morrison Formation generally range in thickness from a few inches to 120 feet.

The Dakota Sandstone of Early and Late Cretaceous age unconformably overlies the Morrison Formation. It comprises light-colored fine to medium-grained quartzose sandstones, and dark-gray to black carbonaceous shales, as well as a basal conglomerate at some places.

The Mancos Shale of Late Cretaceous age overlies the Dakota Sandstone and crops out near the tailings disposal site in La Polvadera Canyon. It is primarily a sequence of medium to dark-gray shales, but includes three beds of pale yellowish-brown, fine to medium-grained sandstone in the lower part. Those sandstones and the intervening beds of shale are believed to be equivalent to the Tres Hermanos Sandstone Member that has been mapped to the east and south of the project area. The Mancos Shale and overlying strata are mapped on Figure 2.4-3.

The Mesa Verde Group of Late Cretaceous age conformably overlies the Mancos Shale. The Mesa Verde includes alternating irregularly bedded sandstones, clays, and coals more than 1,500 feet thick. In the project area, the Mesa Verde is subdivided, in ascending order, into the Gallup Sandstone, Crevasse Canyon Formation, Point Lookout Sandstone, and Menefee Formation. The Gallup Sandstone, which conformably overlies and interfingers with the Mancos Shale, crops out locally in the northwestern corner of the project area. It locally comprises two sandstone units separated by about 90 feet of dark gray shale of the Mancos Formation. The lower unit below this tongue of the Mancos Formation is a gray fossiliferous fine to coarse-grained sandstone approximately 10 to 20 feet thick. The upper unit is a pale, reddish-brown and light gray, fine to medium-grained arkosic sandstone. It ranges from 80 to 100 feet thick northwest of San Mateo.

The Crevasse Canyon Formation of the Mesa Verde Group includes three members. In ascending order they are the Dilco Coal Member, Dalton Sandstone Member, and Gibson Coal Member. The Mulatto Tongue of the Mancos Shale locally separates the lower two members. All three members are exposed in the northwestern corner of the area.

The Dilco Coal Member is composed of 80 to 135 feet of interbedded, light-colored sandstones, siltstones, carbonaceous shales, and several lenticular coal beds. The Dalton Sandstone Member is generally a clean, white to buff, massive, fine to medium-grained sandstone. It is 40 to 70 feet thick in the area. The Gibson Coal Member is composed of interbedded sandstone, clay, shale and coal. It ranges from 180 to 250 feet thick in the project area.

The Point Lookout Sandstone is massive, cross-bedded, light gray and reddish-brown, fine to medium-grained, and arkosic. Well exposed three miles northwest of San Mateo, it ranges from 70 to 160 feet in the vicinity. The Menefee Formation, 400-1000 feet thick, conformably overlies the Point Lookout Sandstone and is widely exposed around the village of San Mateo. It incorporates interbedded pale yellowish-brown siltstones, fine to medium-grained sandstones, gray shales, carbonaceous shales, and thin coal beds.

Silicic tuffs and flows unconformably overlie the Menefee Formation. These volcanic rocks are believed to represent the earliest eruptions from the Mt. Taylor volcanic vent, the first stage in building the Mt. Taylor cone. The thickness of this sequence increases from about

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300 feet at La Jara Mesa to about 1500 feet under the central part of Mt. Taylor.

The final eruptions of Mt. Taylor consisted chiefly of porphyritic andesite. Continuous exposures of the andesite are present in the south central part of the area between El Rito Spring and San Mateo Canyon. Maximum observed thickness is about 500 feet. A series of dense, black basalt and basaltic andesite flows up to 300 feet thick covers the La Jara and Chivato Mesas in the southwestern and eastern parts of the area. Some of these sheet lavas preceded the youngest flows from Mt. Taylor, but most poured out on pediments after Mt. Taylor had ceased erupting, and now overlap the porphyritic andesite (Hunt, 1938).

Three types of unconsolidated surficial deposits obscure the bedrock geology over parts of the area. These deposits consist of unconsolidated talus, alluvial and eolian sediments and saprolite material. Talus and landslide blocks cover extensive areas on the slopes adjacent to the high basalt-covered mesas southwest and southeast of San Mateo. Clay, silt, sand and gravel (alluvial and eolian) underlie most of the valleys in the area. Soft, earthy, clay-rich, thoroughly decomposed rock (saprolite), formed in place by chemical weathering, covers several square miles of the area west and north of San Mateo.

2.4.4 Structural Geology

The strata beneath the project area are warped into two north-northeast trending folds on the Chaco Slope. The broad McCarty syncline under Mt. Taylor is the most prominent of the two. The southern end of the San Mateo Dome, the second fold, lies in the northwestern corner of the area. The eastern flank of the dome is highly fractured by a complicated fault system. Some of these faults have vertical displacements of up to 300 feet. The eastern flank coincides with a part of the western flank of the McCarty syncline, which has eastward dips of

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two to six degrees in the vicinity of San Mateo. Slight tilting possibly accompanied by very low amplitude warping is evidenced by the unconformity at the base of the Dakota Sandstone (Gordon, 1961).

2.4.5 Mineral Resources

The Gulf Mt. Taylor uranium deposits are in the Ambrosia Lake mining district, which is near the west end of the Southern San Juan Basin mineral belt.

Evidences of the roll-front type of uranium mineralization are widespread in the Morrison formation, but the reasons for its local concentration at levels of economic interest are not well understood. Mineralized and unmineralized specimens of Morrison sandstones are similar in texture and composition, and the ore deposits show no consistent relationship to structural or sedimentary features. The ore minerals, poorly crystallized coffinite and uraninite, occur intimately mixed with a dark brown to black humic material which apparently was the localizing agent for ore deposition. The mineralized material comprises pore fillings and grain coatings of the sandstone. In thin beds, concentration of U_3O_8 may exceed 1.0 percent but mostly the concentration is in the range of 0.10 to 0.50 percent U_3O_8.

Individual ore zones are tabular and roughly concordant with bedding. Thickness ranges from a feather edge to 30 feet. In the major deposits, a large number of these mineralized zones more-or-less coalesce over an area as large as 6000 feet long by 2000 feet wide. Isolated small mineral concentrations occur in the periphery of the main accumulations (Kelley, et al. 1968).

Although significant quantities of both molybdenum and vanadium are present in the ore, only molybdenum shows potential for economic recovery at this time.

2.4.6 Detailed Site Geology

Mill Site. The Lower San Lucas Valley deposits in the project area include alluvial, eolian, and alluvial fan soil deposits, over Menefee Formation siltstones and sandstones and the Point Lookout Sandstone. Terrace deposits and colluvium overlie Menefee Formation siltstones on the east side of the valley. A geologic cross-section is presented in Figure 2.4-4.

The Point Lookout Sandstone exposed on the west side of Lower San Lucas Valley and the younger Menefee Formation exposed intermittently in the valley strike approximately parallel to the valley and dip gently, about 10 degrees, to the east. The Point Lookout Sandstone is a fine- to medium-grained, moderately cemented sandstone. The sandstones form gently sloping surfaces broken by sharper relief outcrops spaced intermittently along their dip-slope surfaces.

The Menefee Formation, exposed or at very shallow depths on the east side of the valley, underlies most of the mill site area and is a moderately indurated siltstone interbedded with fine- to medium-grained, moderately cemented sandstones. Jointing in the siltstone of the Menefee Formation is not well developed; however, jointing in the interbedded sandstone units probably reflects those characteristics of the Point Lookout Sandstone. Pressure tests in the exploration holes indicate the fracture permeability in the Menefee Formation is low.

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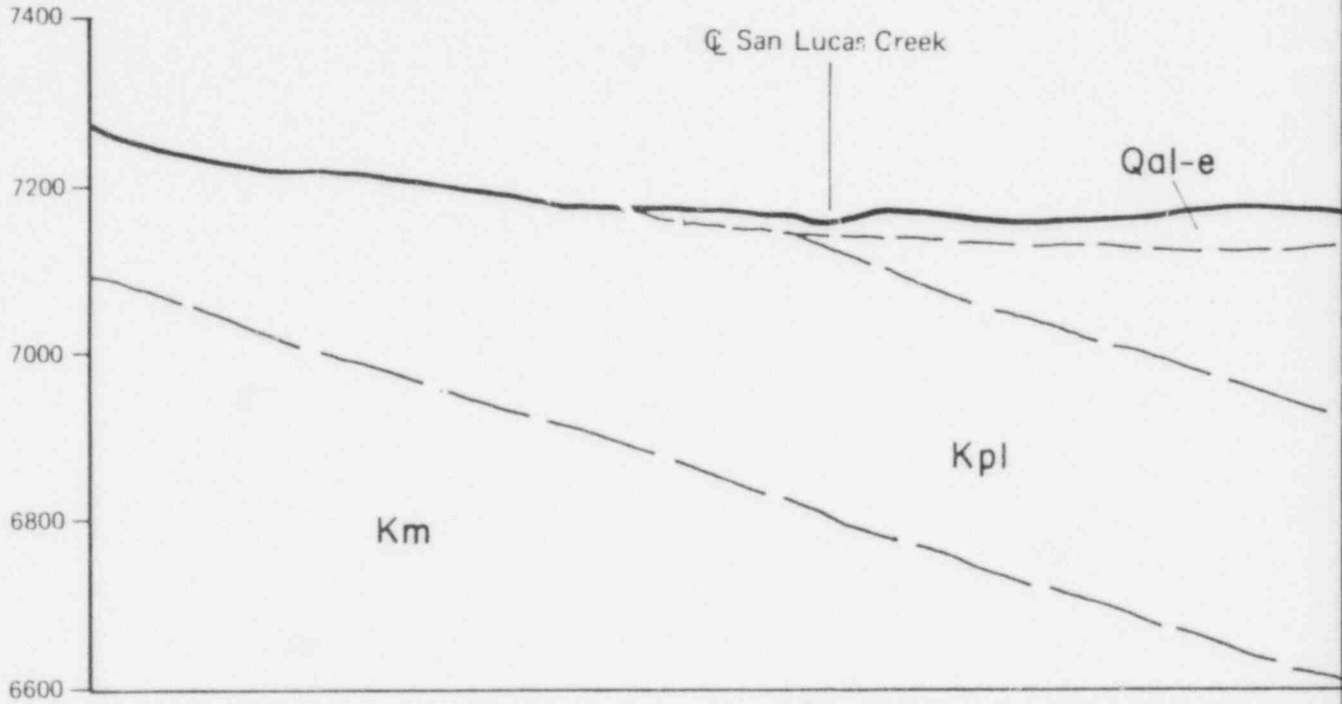
B

NORTHWEST



Qal-e	ALLUVIUM AND EOLIAN DEPOSITS: CLAYEY TO VERY CLAYEY SAND INTERMITTENTLY MANTLED BY WIND-BLOWN SILTS AND FINE GRAINED SILTY SANDS, POORLY STRATIFIED.
Qaf	ALLUVIAL FAN: SILTY TO CLAYEY SANDS WITH THIN GRAVEL LENSES DEPOSITED AT THE MOUTHS OF SMALL EPHEMERAL DRAINAGES; POORLY SORTED AND STRATIFIED.
Qc	COLLUVIUM: SILTY TO VERY SILTY SANDS DERIVED FROM WEATHERING AND TRANSPORTATION OF BEDROCK UNITS; MAY CONTAIN MASS TRANSPORTATION GRAVELS, COBBLES AND BOULDERS; NON-STRATIFIED.
Qls	LANDSLIDE: LARGE BLOCKS OF JUMBLED BEDROCK AND SURFICIAL MATERIALS; COMPOSITION IS VARIABL ; CHARACTERIZED BY HUMMOCKY, IRREGULAR TOPOGRAPHY; NON-STRATIFIED.

Km

Kp

Kr

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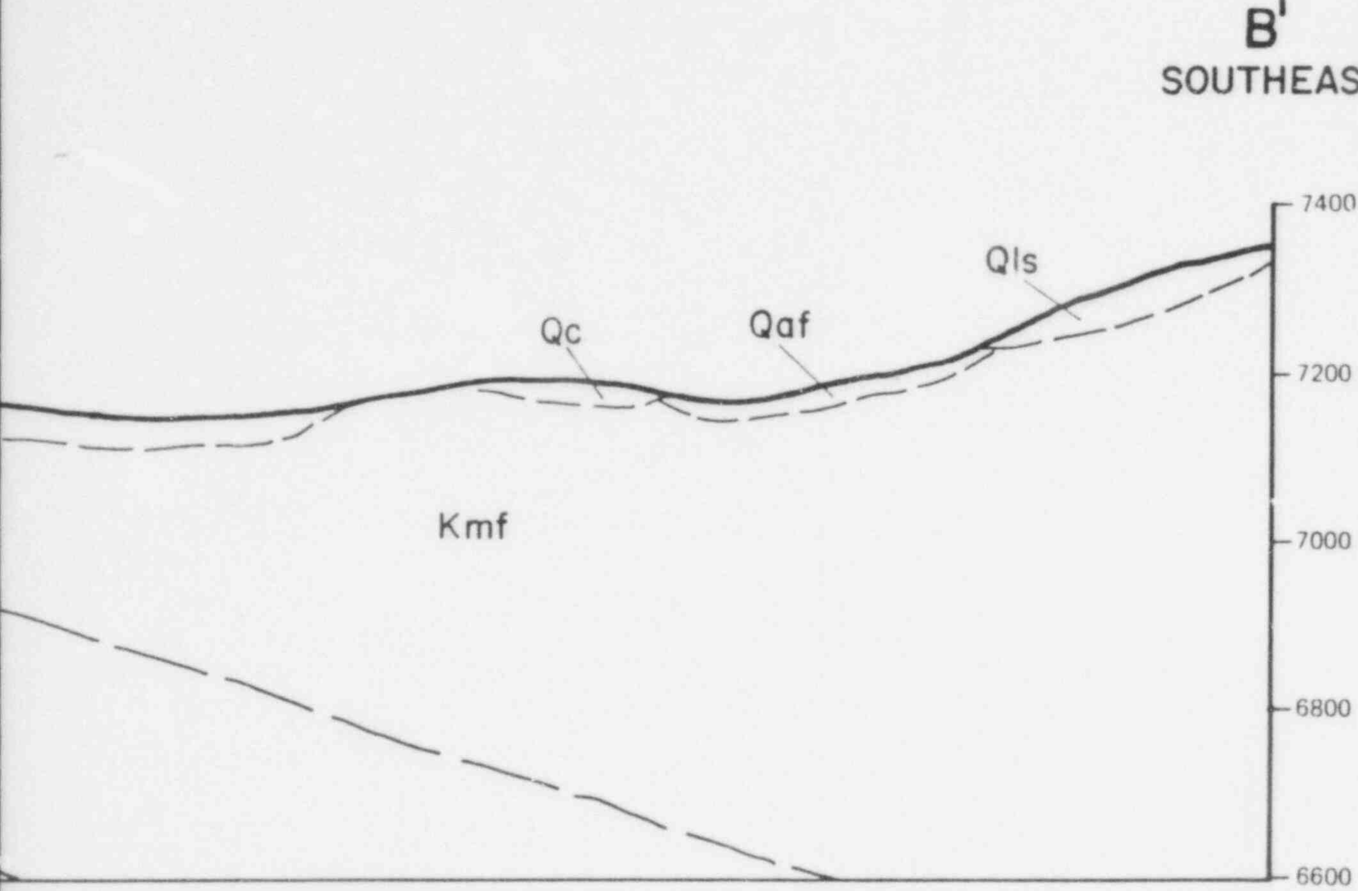
Source: Woodward-Clyde Consultants 1977



nf	MENEFEE FORM TION: SILTSTONES, INTERBEDDED WITH FINE TO MEDIUM GRAINED SANDSTONES; GENERALLY POORLY EXPOSED IN THE PROJECT AREA.
l	POINT LOOKOUT SANDSTONE: MEDIUM TO FINE GRAINED SANDSTONES; FORMS RESISTANT LEDGES AND CUESTAS.
n	MANCOS SHALE: GRAY CLAYSTONE ITH THIN BEDS OF YELLOWISH-GRAY FRIABLE SANDSTONES.
— —	GEOLOGIC CONTACT, APPROXIMATELY LOCATED.

Scale: 200' 400' 0

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Note: See Figure 2.4–3. for Location of Section.

Figure 2.4–4.
MILL SITE
GEOLOGIC CROSS SECTION

La Polvadera Tailings Impoundment Area. As a result of reconnaissance studies carried out by Woodward-Clyde Consultants and more detailed site selection studies performed by W.A. Wahler & Associates, the La Polvadera Canyon area was selected for disposal of mill waste. The site proposed during the reconnaissance phase was at the mouth of La Polvadera Canyon, where erosion has cut through a series of hogback ridges on the eastern flank of the San Mateo Dome. However, because of potential seepage along the truncated sandstone beds on the upstream side of the hogbacks and because of the unfavorable downstream-dipping strata, it was decided to avoid the canyon mouth area and investigate potential sites upstream. Two sites were selected, one on the northern branch and the other on the main drainage of the channel of La Polvadera Canyon. Both sites are located west of a north-south trending fault. They were the subjects of extensive subsurface exploration work. (The extent of the exploration program is shown on Figure 2.4-5). It was determined subsequently, after accurate site topography became available and the required storage volume was refined, that only one pond was required. The northern pond, which is the subject of the following discussion, was selected because it has a smaller drainage basin, which will make the runoff diversion and catch basin requirements less difficult, and because it will provide a smaller ratio of embankment volume to pond storage volume.

The canyon area is a broad, rolling, bowl-shaped basin drained by several washes that converge and drain through a series of low hogback ridges into San Lucas Canyon. The hogbacks are formed by resistant sandstone beds that dip 20 to 30 degrees east, or downstream, at the canyon outlet. These dipping beds form the eastern flank of the San Mateo Dome; north of the canyon outlet they curve westward, forming the northern flank of the dome and the northern rim of the La Polvadera drainage basin. The western and southern margins of the basin are formed by arms of the San Mateo Mesa. The axis of the dome bisects the central part of the canyon

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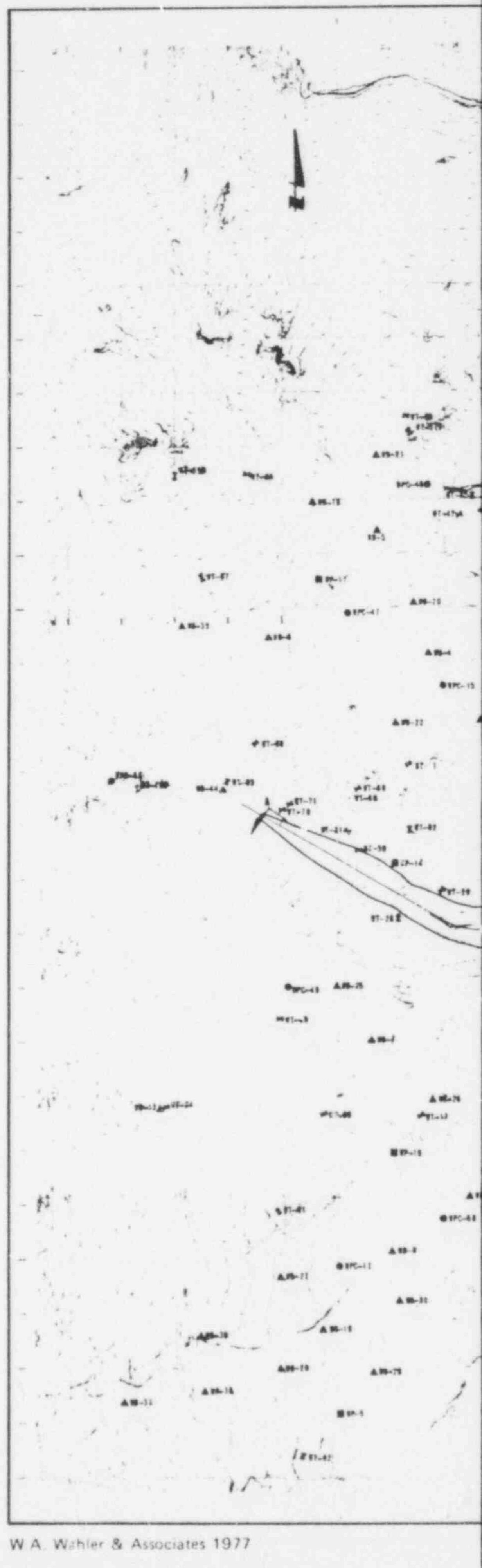

W.A. Wahler & Associates 1977

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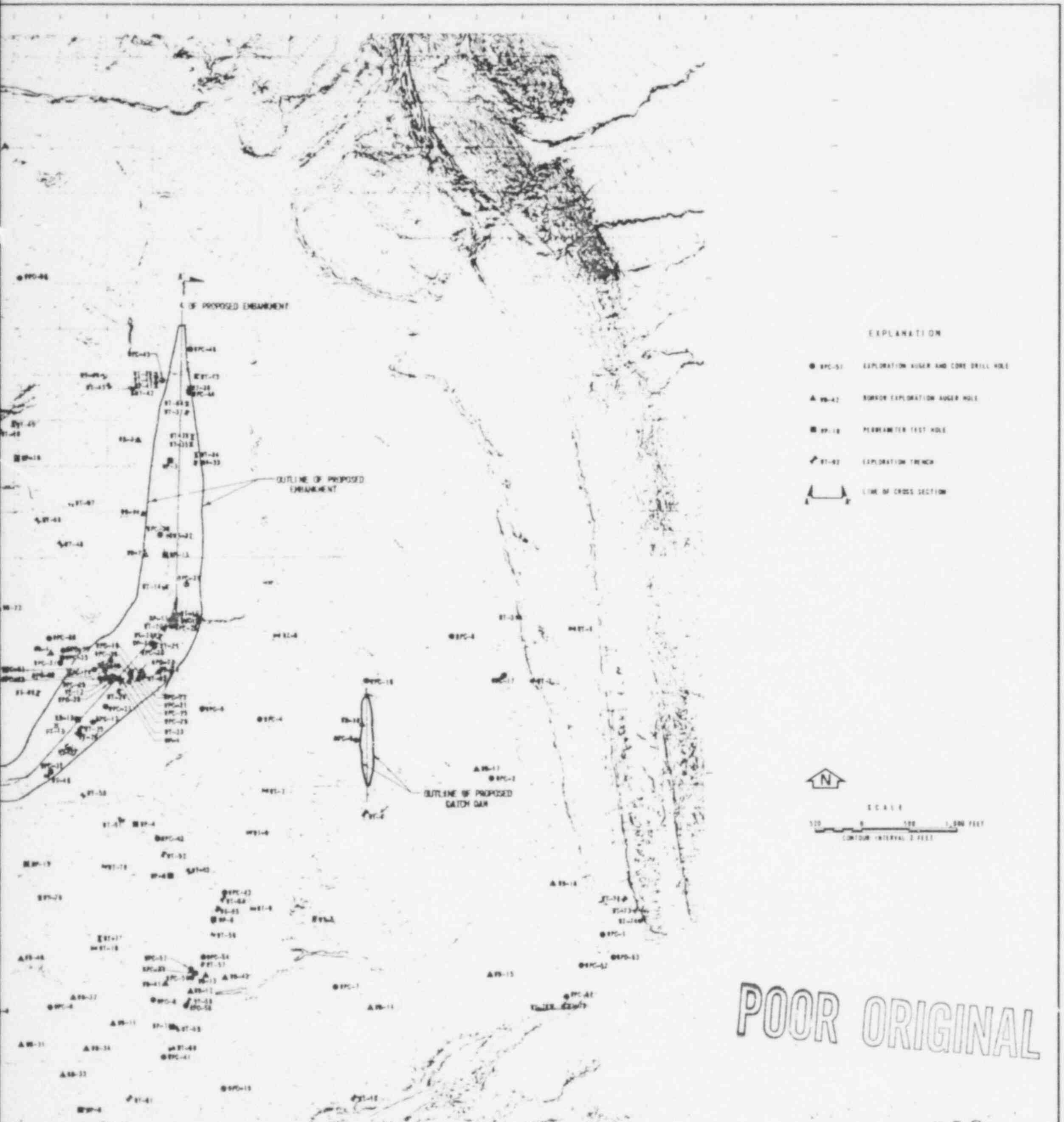


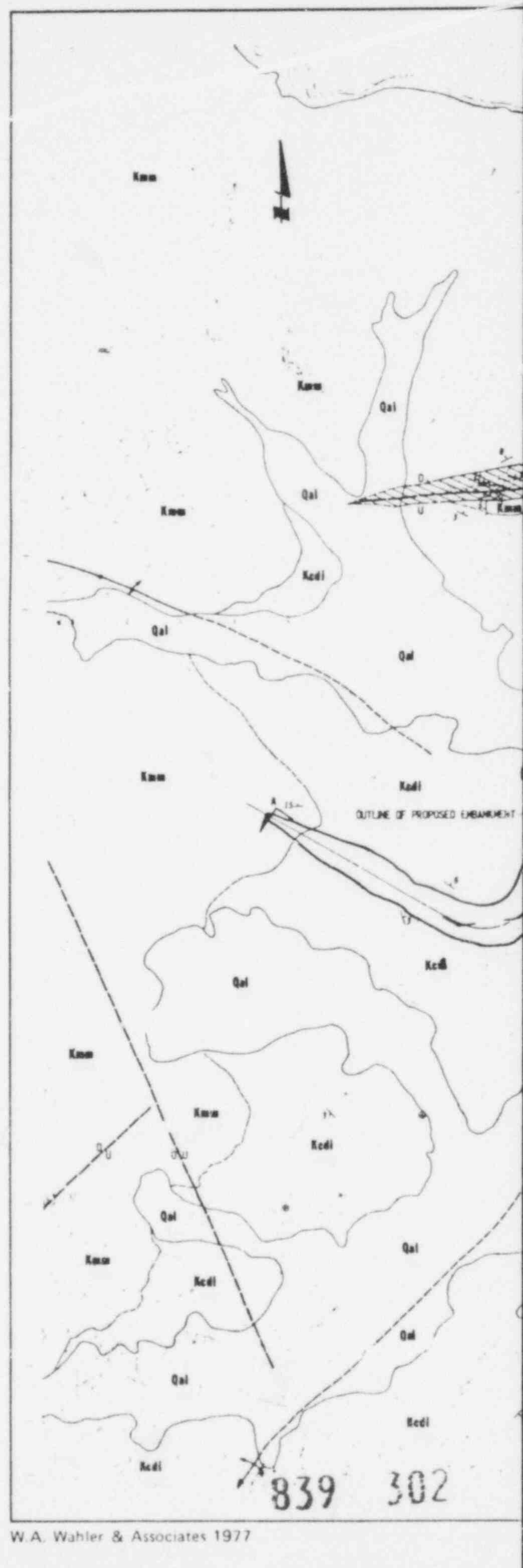
Figure 2.4–5.
EXPLORATION MAP
TAILINGS IMPOUNDMENT

area; thus bedrock units (consisting primarily of a thick sequence of interbedded sandstone and shales) are generally flat-lying or gently dipping in the broader parts of the basin. It is in this area that the proposed tailings disposal site is located.

Bedrock outcrops in the canyon include Cretaceous sandstone, siltstone, and shales of the Menefee Formation, Point Lookout Sandstone, Crevasse Canyon Formation, Gallup Sandstone, and Mancos Shale. Bedrock is well exposed in the canyon and on surrounding mesas and hogbacks. These formations intertongue in a complex manner as a result of cyclic marine transgression and regression. The geology of La Polvadera Canyon is illustrated on Figure 2.4-6. The explanation on the figure graphically represents the complex interbedding of the formations. The geologic formations cropping out in the proposed tailings pond consist of the Mulatto Tongue Member of the Mancos Shale, the Dilco Coal Member of the Crevasse Canyon Formation, and the Gallup Sandstone. These formations will constitute the bedrock foundation materials of the proposed tailings dam and reservoir. Surficial deposits of alluvial and eolian sand, silt, and clay blanket the bedrock along the valley bottom.

The Dilco Coal Member underlies a major portion of the proposed dam and about two-thirds of the pond area. The Mulatto Tongue Member, which overlies the Dilco Coal Member, is found on the northern and western ends of the proposed dam and in the retention pond at higher elevations. The Gallup Sandstone will be the foundation material along the channel section of the dam, except for a narrow section along the channel where the main body of the Mancos Shale lies buried beneath the alluvium. The Gallup Sandstone is also buried beneath the alluvium in the immediate area upstream of the proposed dam.

The tailings disposal area is near the crest of the San Mateo Dome, reflected by the gently dipping bedrock strata. The bedding generally



W.A. Wahler & Associates 1977

POOR ORIGINAL

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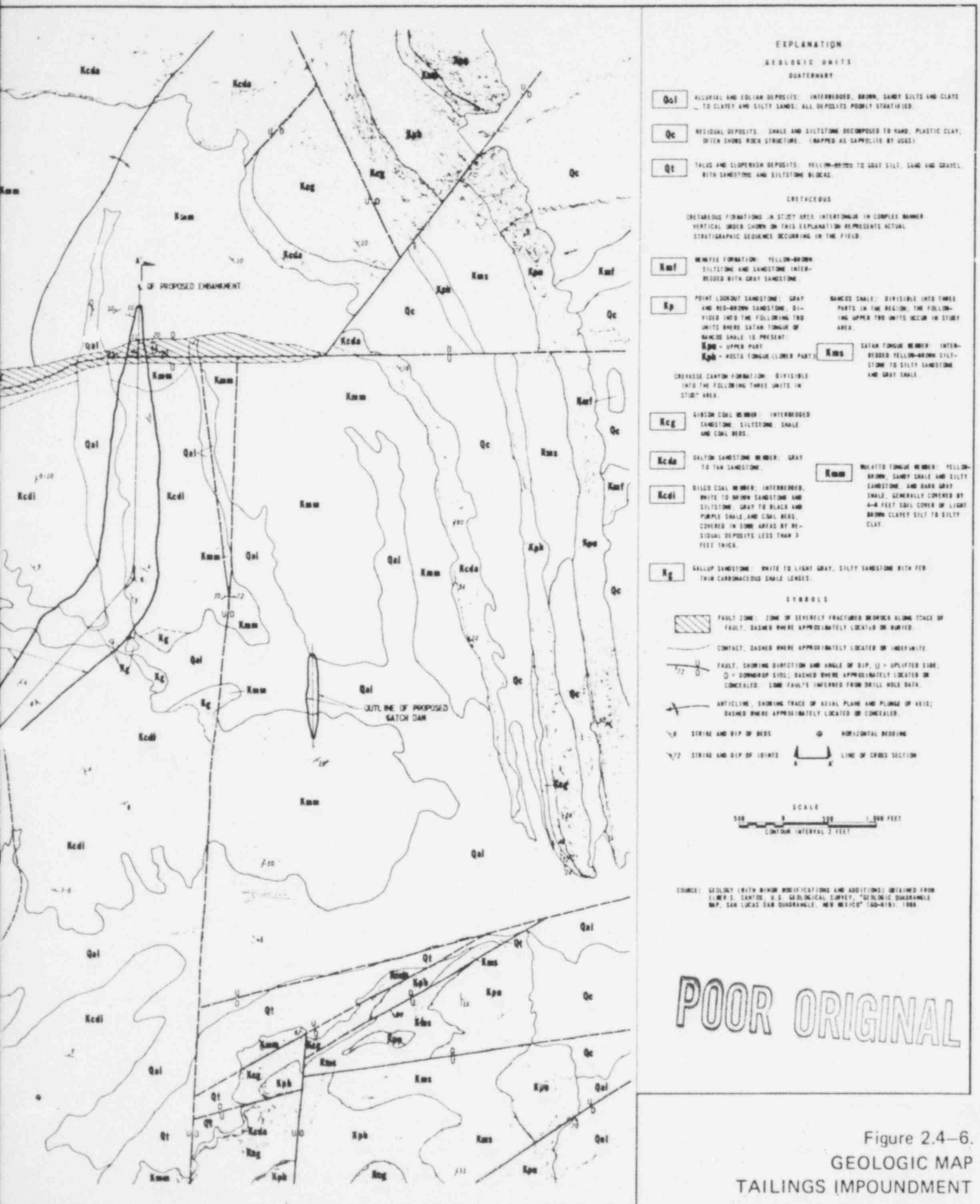

Figure 2.4–6.
GEOLOGIC MAP
TAILINGS IMPOUNDMENT

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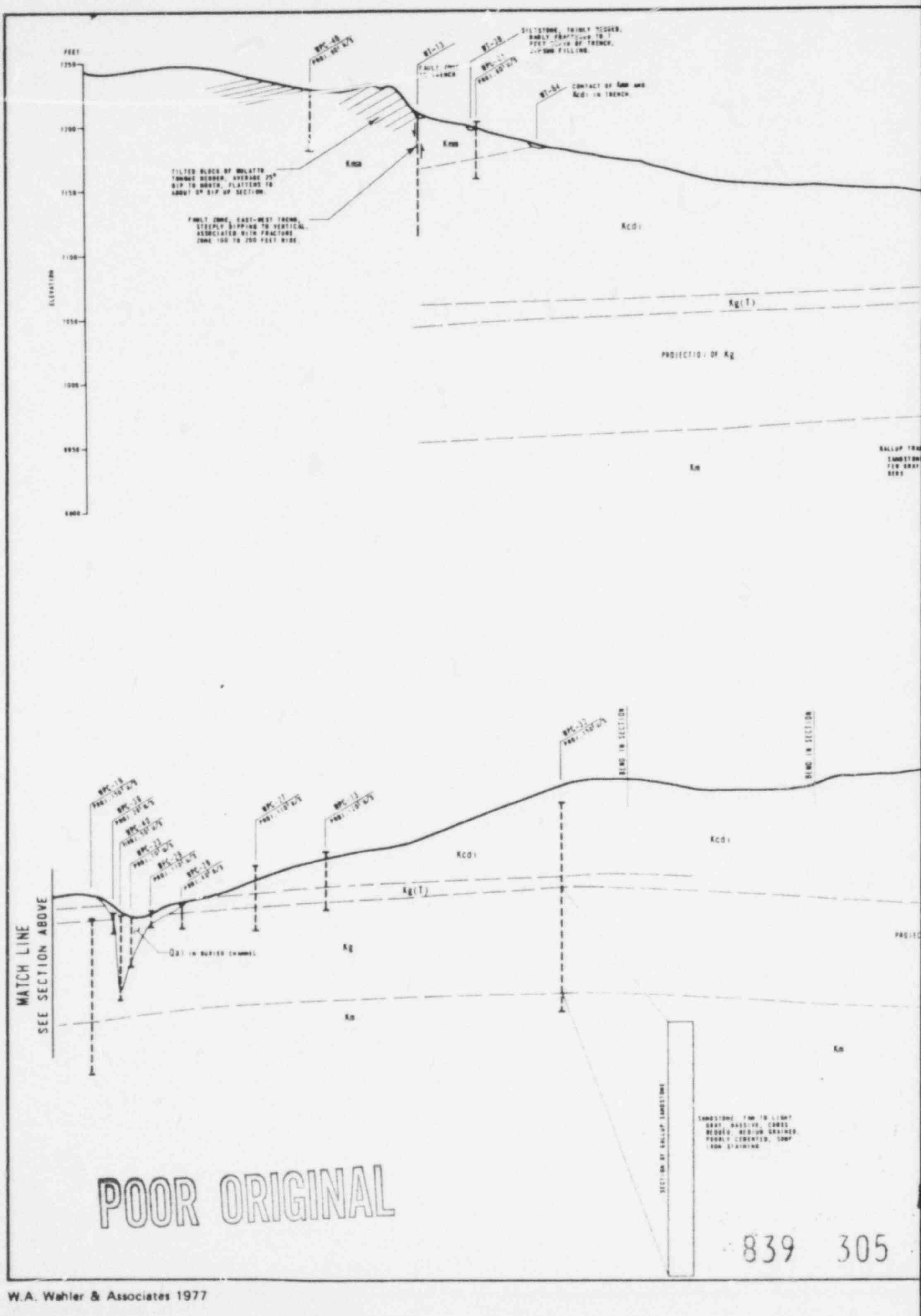
strikes northwest and dips gently (average five degrees) to the northeast. However, on the north side of the proposed tailings pond area, relatively steeper dips associated with a tilted and faulted block of Mulatto Tongue Member were noted.

A longitudinal section (Figure 2.4-7) shows the stratigraphy beneath the dam. For the most part, the dam abutments will be founded on the Dilco Coal Member. In the tailings disposal area, the Dilco Coal Member is about 120 feet thick in full section and consists of interbedded white to brown sandstone, brown to light gray siltstone, and gray to black and purple shale beds. Coal lenses up to six inches thick were encountered in some drill holes. The sandstone is fine to medium-grained and poorly cemented, and contains carbonaceous partings and some iron-oxide stain. The thickness of the sandstone beds ranges from six inches to three feet, although one massive sandstone bed in the upper part of the Dilco stratigraphic section is 15 feet thick. This thick bed forms the cliffs along the abutment ridges and knobs immediately upstream of the dam. Jointing in the sandstone is widely spaced, thus the rock weathers to large blocks and talus deposits are relatively small. To avoid contact of pond water with cliff exposures in the abutments, the proposed embankment will be positioned so that the impervious zone will lap over the upstream cliff slopes. The siltstone and shale are generally thinly bedded and iron-stained. The shale is gray to black, carbonaceous, fissile to flaky, and air slakes readily. Most of the shale is in the lower half of the stratigraphic section.

The Mulatto Tongue Member constitutes the bedrock foundation material on the west and north ends of the dam. On the west end, the Mulatto conformably overlies the Dilco Coal Member. On the northernmost end of the dam the Mulatto is in both conformable contact and fault contact with the Dilco Coal Member. This east-west trending fault was traced about 3,000 feet west of the dam axis and is topographically marked by



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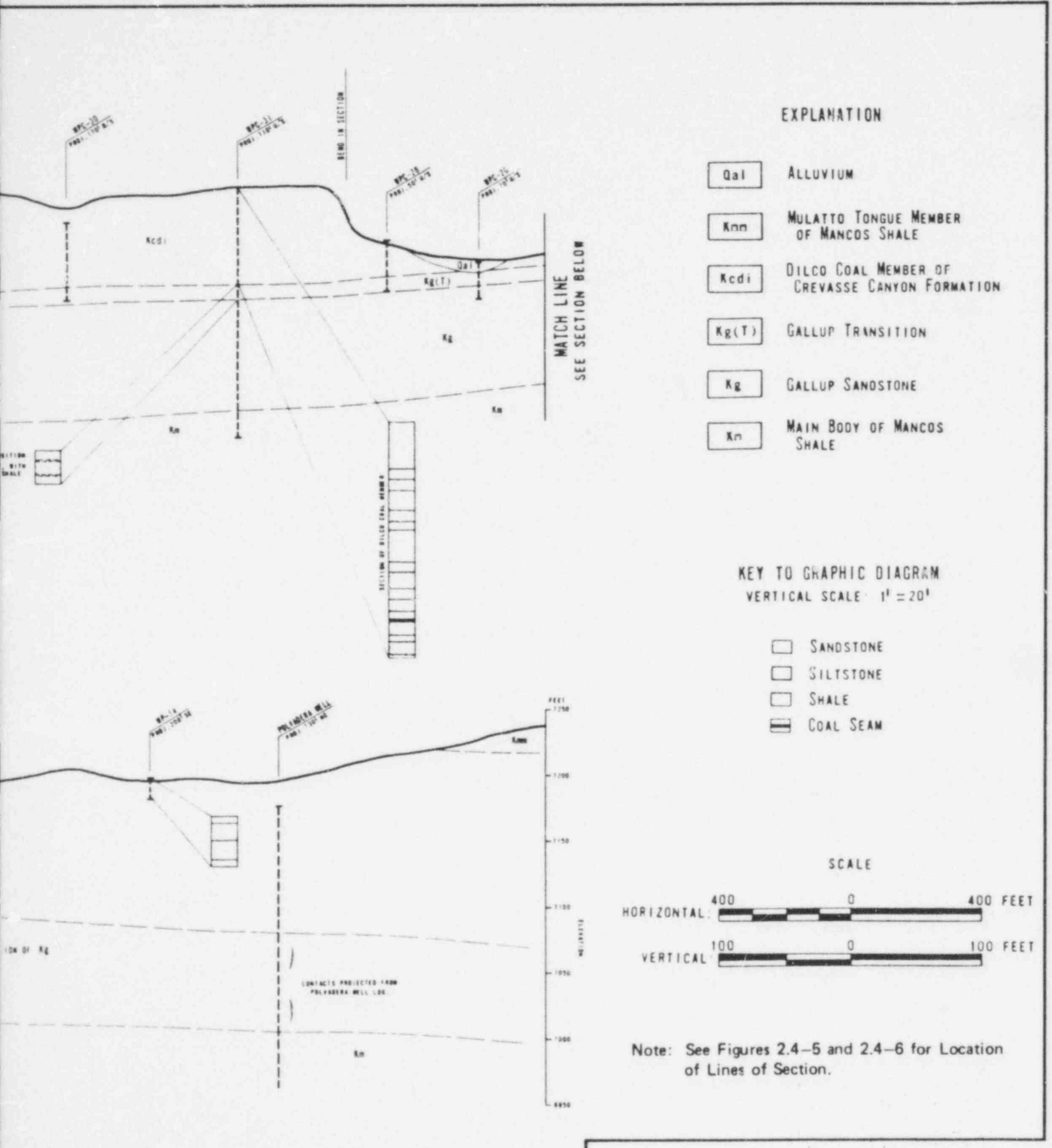

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Figure 2.4-7.
LONGITUDINAL SECTION A-A'
ALONG DAM AXIS

20-to 30-foot-high escarpments of tilted Mulatto on the downdrop side of the fault. The tilted Mulatto block has an average dip of 25 degrees to the north but gradually flattens to about eight degrees farther upslope and up the stratigraphic section. Trenches excavated across the fault zone indicate a 100-to 200-foot-wide zone of intensely fractured, faulted, and contorted Mulatto bedrock. Near the surface, several of these fractures are open and partly filled with gypsum; however, core hole data indicated that fracturing persists at depth but decreases in intensity below about 30 feet, and the fractures are both clay- and gypsum-filled. The fault zone will be blanketed with impervious material to preclude potential seepage through this zone. The Mulatto Tongue Member consists of thinly bedded, light tan, sandy shale and siltstone, with a few interbeds of sandstone and dark gray shale. Gypsum occurs as a filling in fractures and along bedding planes.

The Gallup Sandstone crops out in the channel section of the proposed dam. As indicated by drilling results, the Gallup ranges from 78 to 84 feet thick along the dam axis. It is massive, cross-bedded, white to light gray, fine- to medium-grained, poorly cemented, and it contains a few inclusions and thin streaks of carbonaceous material. Joints are steeply dipping to vertical and are spaced from 2 to 10 feet, as observed in outcrops.

The main body of the Mancos Shale lies beneath the Gallup Sandstone and thus is not exposed in the tailings pond area. However, it was penetrated by deep borings located along the dam axis. The Mancos Shale regionally is a thick lithologic unit composed predominantly of dark gray, calcareous, fissile clay-shale of marine origin. In La Polvadera Canyon, the Mancos Shale, as indicated by the geologic log of Polvadera Well, is 905 feet thick (Cooper and John, 1968). At the damsite deep drill holes penetrated 15 to 40 feet into the Mancos Shale. The recovered Mancos drill core consists of interbedded, thinly bedded, dark gray shale and siltstone with carbonaceous partings. The shale is tight and fissile; it air slakes readily, and breaks down to a very plastic clay when wetted.

The channel section of the proposed embankment will straddle the confluence of the main channel and its northern tributary. A deep-buried, channel along the alignment of the main channel was the subject of an extensive exploration program. The buried channel is 100 to 200 feet wide at ground surface, and is about 80 feet deep. It is filled with alluvial sandy clay to silty sand. The channel apparently was incised through the Gallup Sandstone and, at least in one area into the top of the Mancos Shale. Design considerations will require excavation and removal of the alluvium of the buried channel beneath the dam embankment.

Surficial deposits consisting of alluvial and eolian deposits blanket the valley areas. These soil deposits ranged from a moderate brown to moderate yellow-brown sandy clay to silty sand. At depth near the bedrock contact, the material is generally coarser, and consists of gravelly sand with varying amounts of fines. The near-surface soils tend to be collapsible, as indicated by the sink-type depressions that occur along stream bottoms.

The alluvium upstream from the proposed dam will be the source of impervious material for the dam. The Dilco Coal Member forming ridges within the retention pond area will provide material for the shell zone of the embankment. The Mulatto Tongue Member forming the ridges to the north and west above the ultimate reservoir level will be the reclamation material borrow source at the end of the project operations.

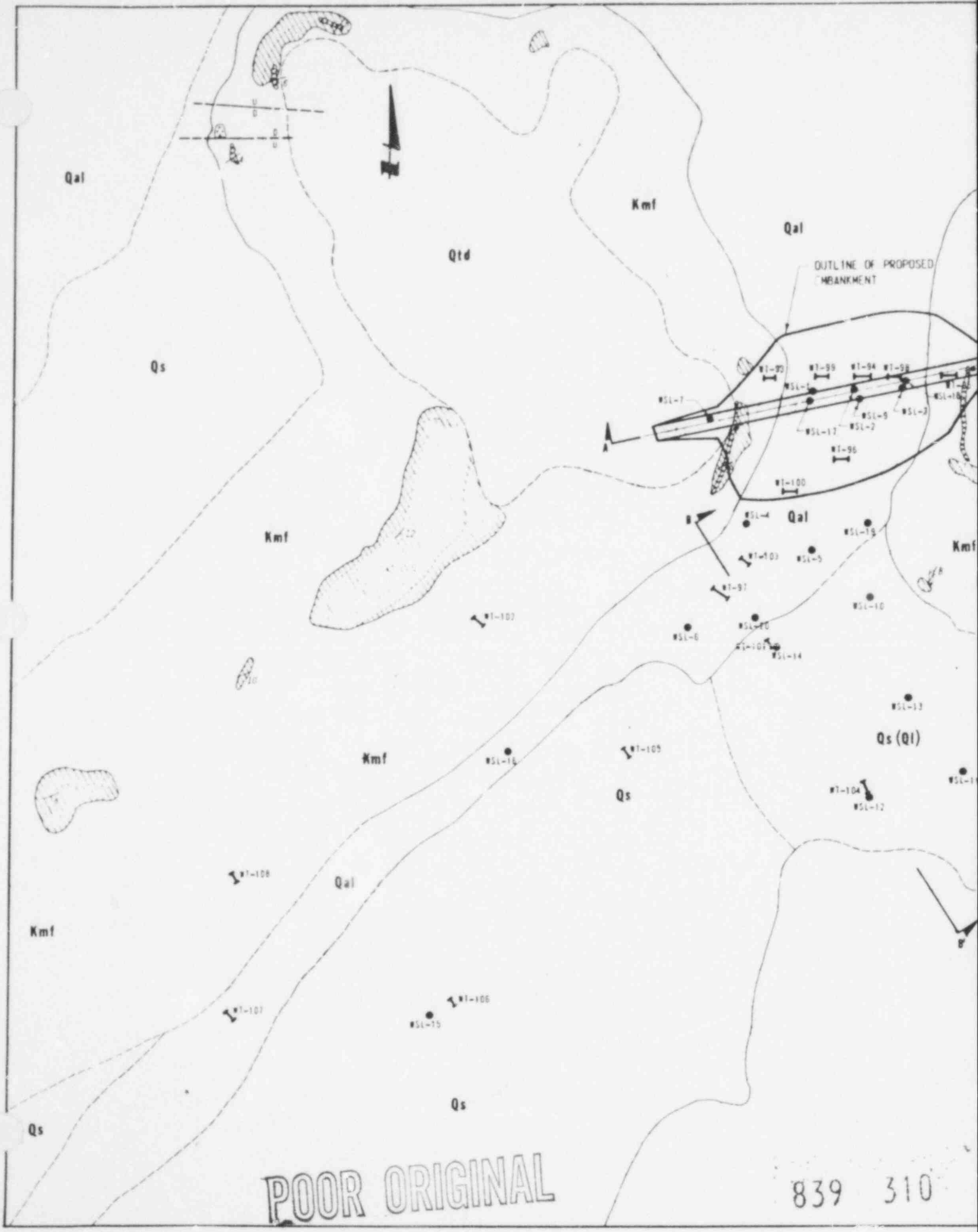
The only major fault structure mapped within the tailings disposal area is the east-west trending fault near the north margins of the pond (Figure 2.4-6). The fault is normal and near-vertical, with the north block downdropped. It displaces Mulatto bedrock near its contact with the

Dilco. The fault is considered inactive because it does not offset alluvial deposits in the area.

An extensive water testing program to assess bedrock permeability was conducted as part of the detailed exploration program. The mean permeability values calculated for bedrock types in the tailing disposal area are less than 10 feet per year, with the Gallup Sandstone showing the relatively higher average permeability of 8.8 feet per year and the upper part of the Mancos Shale showing a low average permeability of 0.05 foot per year. The fault zone near the northern margin of the pond is recognized as an area for potential pond seepage, although this potential is indeterminate. Lining of the fault zone within the tailings impoundment will be considered as part of the design. Groundwater conditions in the proposed tailings pond area, as well as hydraulic properties of the pond bedrock materials and pond seepage assessments, are discussed in Section 2.6.1, Groundwater.

Mill Site Impoundment Dam. Figures 2.4-8 and 2.4-9 present the geologic map and section for the mill site impoundment dam. The Cretaceous-age Menefee Formation underlies the impoundment dam and outcrops on both abutments. The Menefee Formation is interbedded, light brown to grayish orange siltstone and sandstone and light gray shale. Strata exposed on the abutment strike N45°-55°E and dip 6 to 10 degrees southeastward. The bedrock is strong and competent and will provide a sound foundation.

Alluvial and eolian deposits occurring in the channel consist of interbedded, light brown, sandy silt to silty sand with medium brown, clayey sand to sandy clay. The alluvium is 26 feet thick, as indicated by drilling in the center of the channel along the proposed dam axis, and is underlain by interbedded shale and siltstone of the Menefee Formation. Ground water was encountered in the alluvium in one



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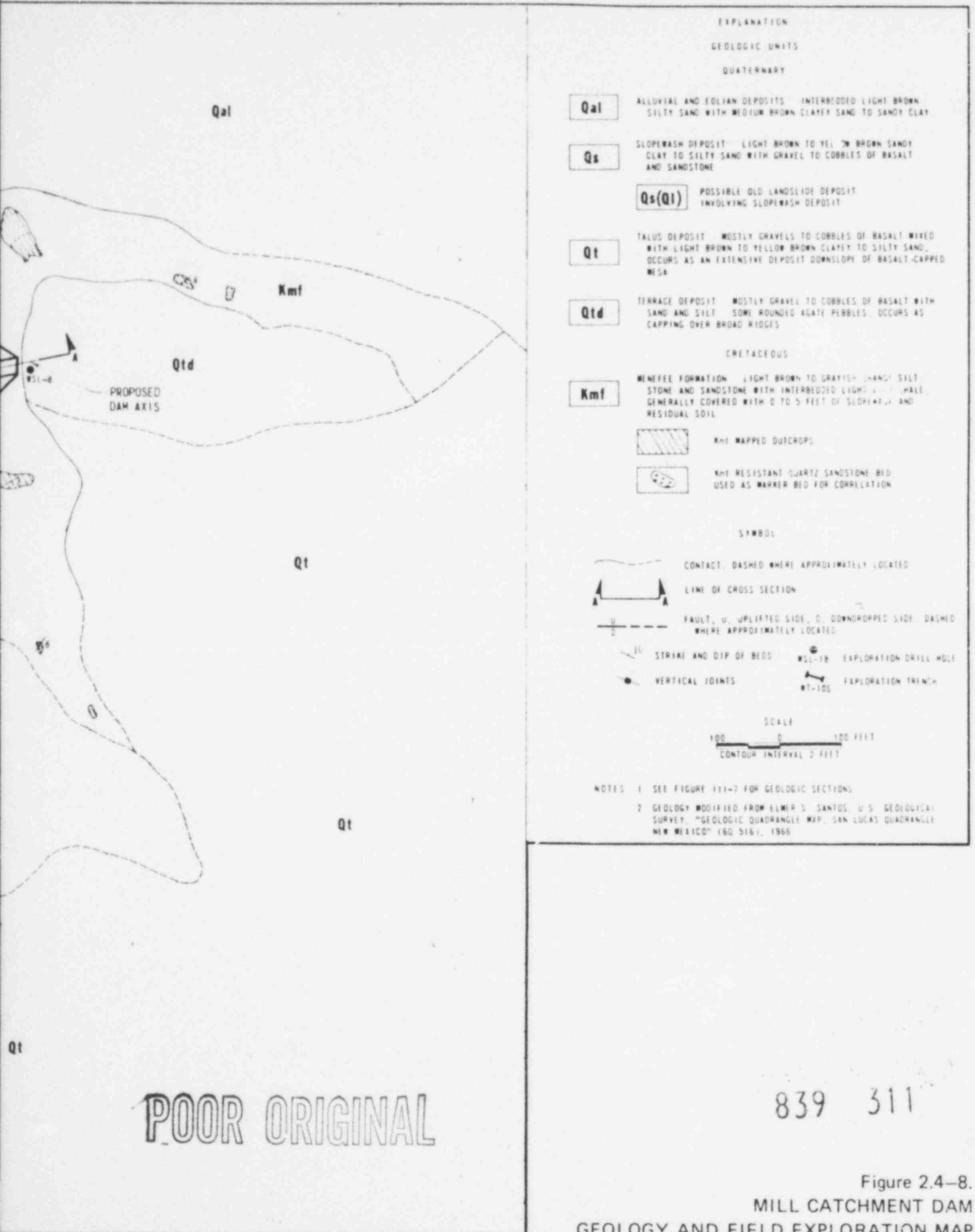
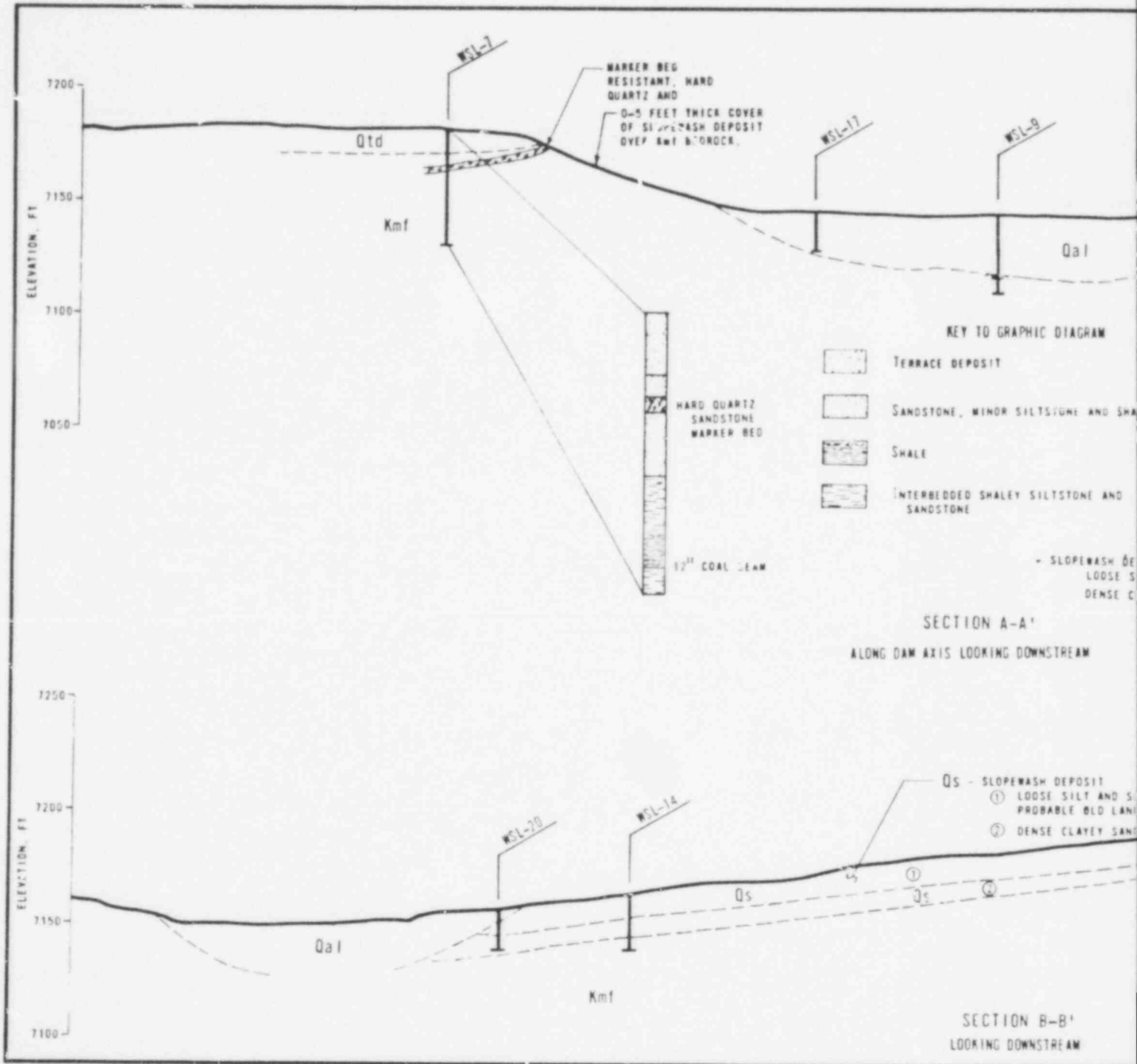


Figure 2.4–8.
MILL CATCHMENT DAM
GEOLOGY AND FIELD EXPLORATION MAP



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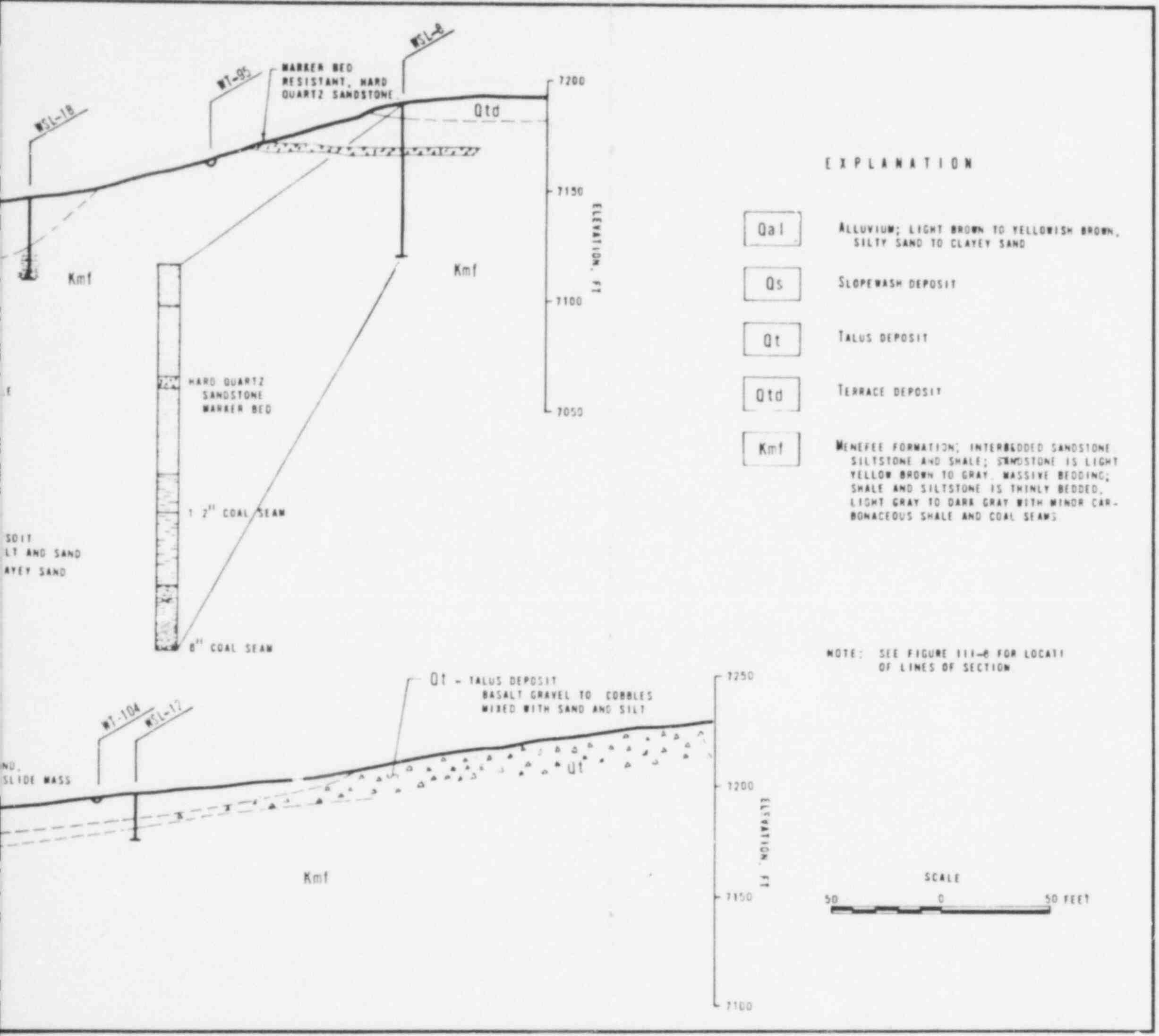
POOR ORIGINAL



POOR ORIGINAL

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Figure 2.4–9.
MILL CATCHMENT DAM
GEOLOGIC SECTIONS

of the exploration drill holes in the center of the stream channel. The ground water appears to be perched in the alluvium.

Slopewash deposits consisting of mixed sand, silt and clay, with some fragments of basalt and sandstone overlie the bedrock in the lower slopes of the proposed pond area. A portion of this slopewash deposit upstream of the right abutment is probably on old landslide deposit as evidenced by subdued hummocky topography and minor slumps at the toe of the slope. The slope ranges from 10 to 15 percent and extends about 700 feet upslope and high above the proposed reservoir level. The slopewash deposit is about 14 to 20 feet thick in the probable landslide area. Because of the potential for instability, no excavation work will be done within and downslope of the probable landslide area. The proposed dam is located downstream of the toe of the probable slide and any renewed activity should not endanger the dam facilities, but would contribute a significant amount of debris to the proposed reservoir.

An extensive talus deposit that occurs on steeper slopes high above the proposed reservoir to the east is comprised of fines and gravel- to boulder-sized basalt derived from the basalt caprock upslope and outside the mapped area. Minor terrace deposits overlie the bedrock on the broad ridgetop of both abutments.

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2.5 SEISMOLOGY

2.5.1 Earthquake Studies

New Mexico, eastern Arizona, southern Colorado, and southeastern Utah are not considered to be seismically active areas relative to the main earthquake belts of the world (Fig. 2.5-1). This is not to say the region is free from earthquake-induced ground tremors. However, historically recorded tremors in the region have almost always been mild, with reported damage slight and confined to localized areas. A general discussion of earthquake monitoring and measuring is provided in Appendix A.

Seismological events have been quantified only in the past 70 years. Most eyewitness reports for the western half of the United States, except the Pacific Coast area, postdate 1865, when the West had its first great impetus of population growth. Earthquakes undoubtedly have gone unrecorded in the more sparsely populated areas. However, in recent years a network of seismic recording stations has been established across most of the western United States (Coffman and Von Hake, 1973). This network affords the opportunity to record and locate seismic activity instrumentally without relying on the subjective reports of the general populace. Earthquakes with magnitudes too small for human beings to detect are easily recorded on a seismograph. The frequency of these smaller magnitude events may give an indication of the relative seismicity of an area using a short period of seismic records.

2.5.2 Earthquake History

Seismic evidence, both historical and instrumentally recorded, indicates that the Mt. Taylor project site is in an area of low seismic activity (Fig. 2.5-2). There is no reported historic record of earthquake damage in the area since 1887.

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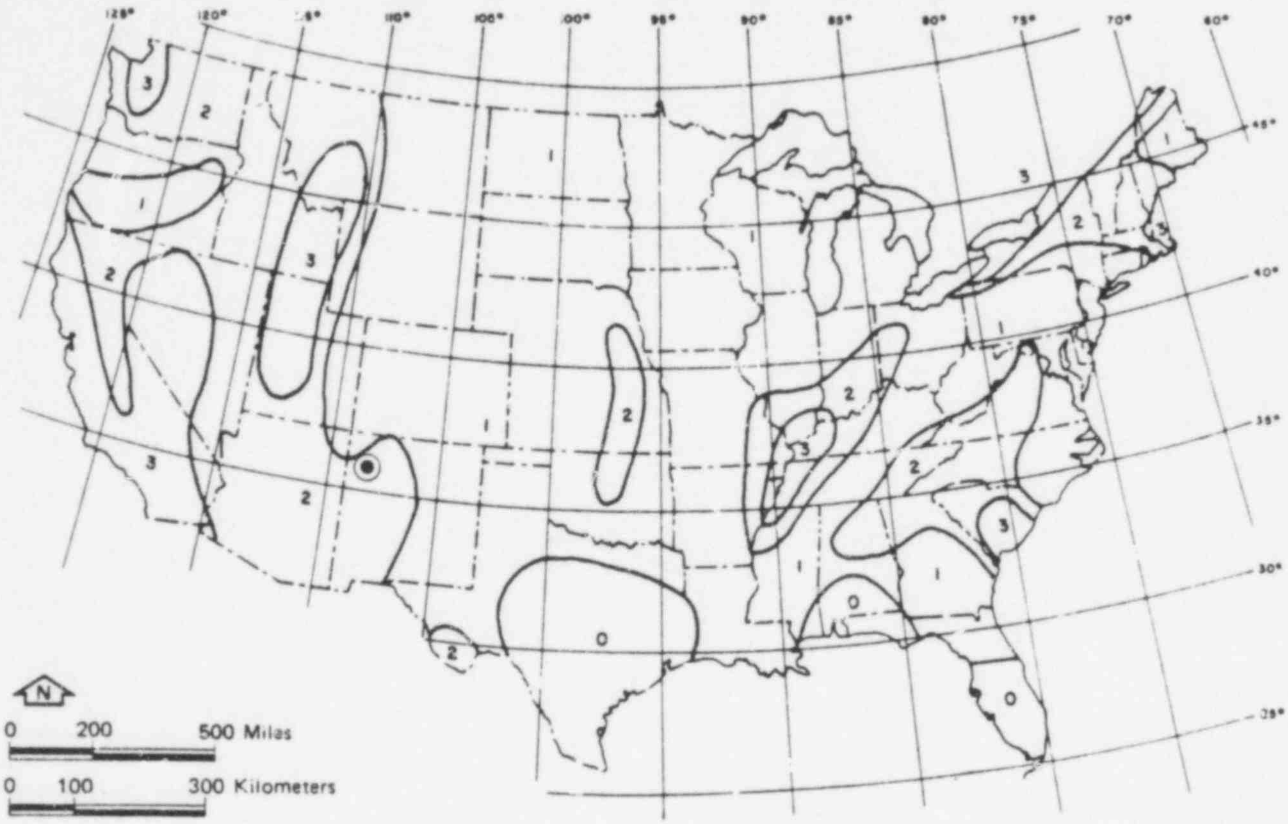

ZONE 0 – No Damage

ZONE 1 – Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 seconds; corresponds to intensities V and VI of the MM* Scale.

ZONE 2 – Moderate damage; corresponds to intensity VII of the MM* Scale.

ZONE 3 – Major damage; corresponds to intensity VIII and higher of the MM* Scale.

This map is based on the known distribution of damaging earthquakes and the MM* intensities associated with these earthquakes, evidence of strain release, and consideration of major geologic structures and provinces believed to be associated with earthquake activity. The probable frequency of occurrence of damaging earthquakes in each zone was not considered in assigning ratings to the various zones. See accompanying text for discussion of frequency of earthquake occurrence.

*Modified Mercalli Intensity Scale of 1931

◉ Project Area

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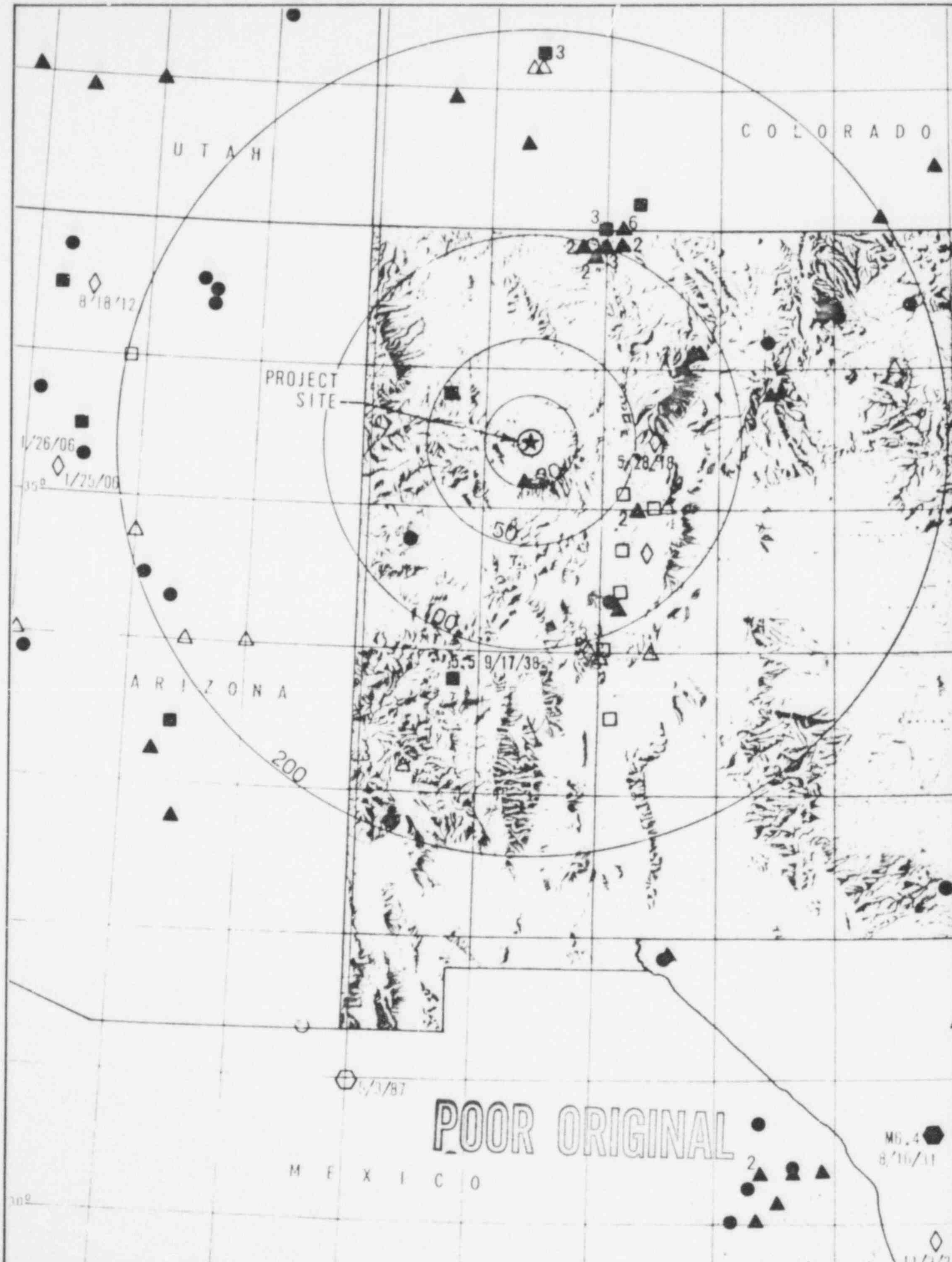
Figure 2.5–1.
SEISMIC RISK MAP
OF THE UNITED STATES



W.A. Wahler & Associates 1977

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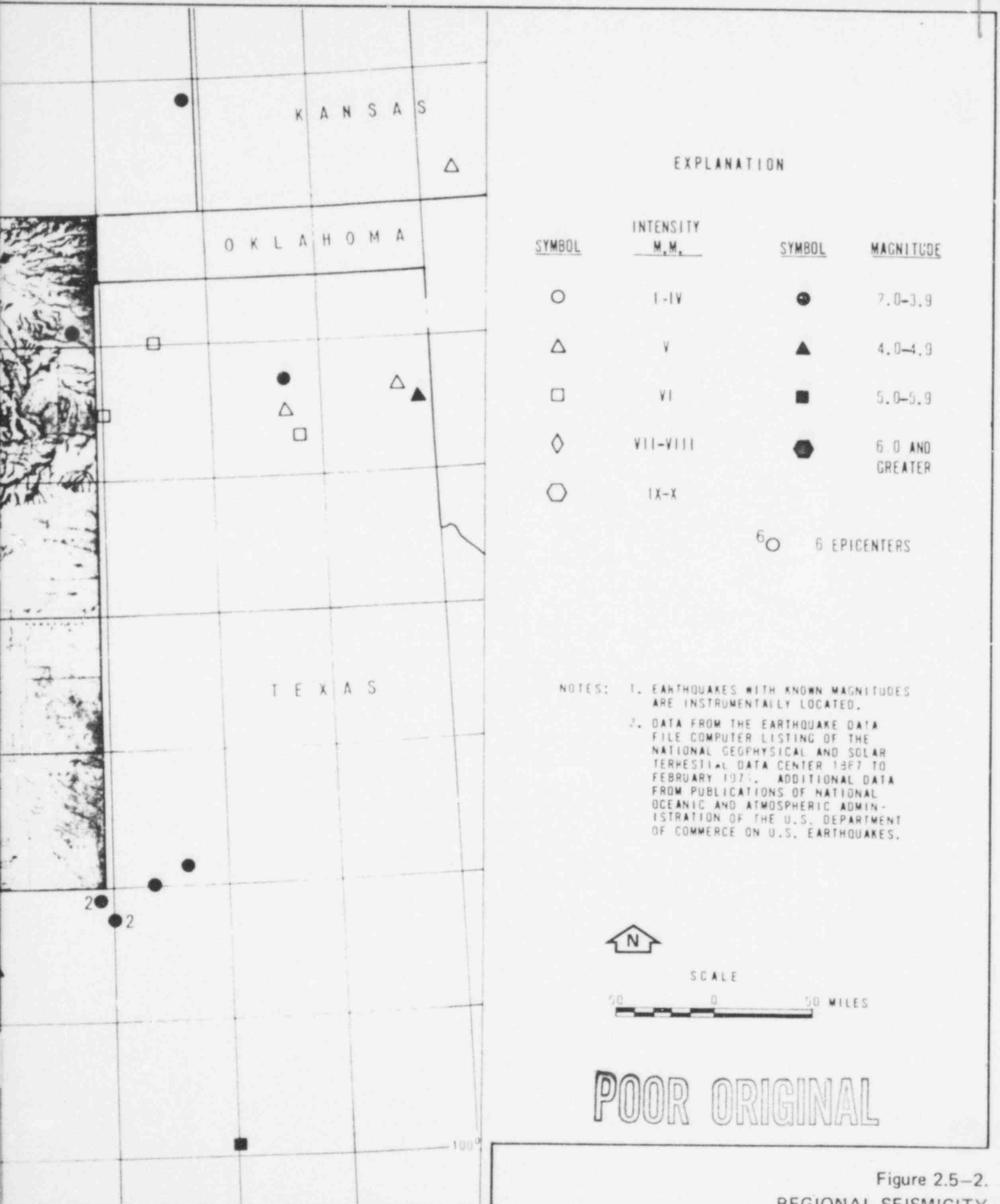

Figure 2.5–2.
REGIONAL SEISMICITY

There are two zones of moderate seismicity in the region of the Mt. Taylor project site; these zones are characterized as having a relatively large number of low to moderate seismic events, both historical and instrumentally recorded. Each zone corresponds to an area of known faulting. One seismic zone, about 170 miles from the project site at its closest distance, trends northwest and extends from the lower Rio Grande Valley near El Paso on the south through southwestern New Mexico into Arizona, terminating near Flagstaff. Several Modified Mercalli Intensity V to VI shocks have been recorded in the area--the largest earthquake, of Intensity VII, occurred at Flagstaff in 1906. The second zone coincides approximately with the Rio Grande Rift Zone, about 50 miles east of the project site. This roughly north-south trending zone begins south of Socorro and parallels the Rio Grande Valley north to Colorado. The Rio Grande Rift Zone is believed to be a tensional feature in the earth's crust incorporating large, down-dropped blocks of crustal material (grabens). This rift zone is bounded on the east and west by north-south trending faults. It is postulated that earthquakes with hypocenters located within the Rio Grande Rift Zone are the result of slight movements along these fault planes. Some of the smaller magnitude events, as well as a great deal of the microseismic activity within the rift zone, are believed to be associated with geothermal sources lying at moderate depths within the zone. Although most of the historical and instrumentally recorded earthquakes associated with the rift zone have been of low magnitude and intensity, a few larger magnitude events have been documented. The strongest recorded earthquake in New Mexico occurred in this zone, at Socorro, on July 16, 1906; it had a maximum intensity of VIII with a radius of perceptibility of 200 miles. This shock was part of a prolonged earthquake swarm that began in July 1906 and continued into the early part of 1907. The Mt. Taylor project site, about 100 miles northeast of the epicentral area, probably experienced an intensity of IV to V. Another shock of intensity VII to VIII about 60 miles east of the project site occurred in

Sandoval County, New Mexico on May 28, 1918, and probably subjected the project site to intensities similar to those of the 1906 shock. Although the effects of the earthquake were very localized and the damage was relatively minor, these events within the rift zone demonstrate the potential of faults within the zone to generate moderate to moderately large earthquakes.

An earthquake swarm epicentered on the Colorado-New Mexico border about 100 miles northeast of the project area occurred in January 1966. The largest event in this swarm had a Richter Magnitude of 5.5 and was felt over an area of about 15,000 square miles. Damage was reported in the small town of Dulce, New Mexico, near the epicentral area. This event was felt in Los Alamos but was reportedly not felt in Albuquerque; therefore, the event ws probably not felt in the project area.

Another significant event that may have affected the Mt. Taylor project site was the Sonora, Mexico earthquake of May 3, 1887, which had an intensity of VIII to IX at the epicenter (estimated Richter Magnitude 6.3 to 7.0). Its epicenter was probably about 20 miles south of the Arizona-New Mexico border, where faulting was reported on both sides of the Sierra Teras, a north-south range in southeastern Arizona. On the west side of the Sierra Teras the scarp followed a winding course over 35 miles, with a maximum threw of 26 feet. The shock was felt over a wide area and as far north as Albuquerque and Santa Fe. At Tucson, El Paso, and Albuquerque, 130 to 320 miles from the epicenter, "water tanks slopped over, cars were set in motion on tracks, chimneys toppled down," which indicates an intensity of V to VI (Heck and Eppley, 1958). The project site is about 320 miles northwest of the epicentral area, and therefore probably experienced the same intensity of shaking.

Only two earthquake events have occurred within 50 miles of the project area, but both have occurred in recent years. The nearest earthquake to the project site was a Magnitude 4.4 earthquake on December 23, 1973, with its epicenter near Grants, about 20 miles southwest of the site. The earthquake was felt in McKinley and Valencia counties and subjected Grants, where minor damage occurred, to a maximum intensity of VI. In San Mateo, near the site, the reported intensity ranged from I to IV. The most recent event was a Magnitude 5.0 shock on January 5, 1976, with the epicenter located 45 miles northwest of the site. The epicentral area experienced Intensity VI.

2.5.3 Earthquake Risk Evaluation

Available seismograph records for the project area are insufficient to permit statistical forecasting of the occurrence of large-magnitude earthquakes. Therefore, the evaluation of earthquake risk is based on historical records and on the assumption that the maximum earthquake of record is the worst likely to occur during a comparable period of time in the future. Historical and instrumentally recorded data were used; therefore, there is some statistical bias with respect to population density.

The seismic history of the area indicates that the largest tremors within 200 miles of the project site have been: (1) the 1906 Flagstaff earthquake (Intensity VIII), 170 miles west of the site; (2) the 1906 Socorro, New Mexico earthquake (Intensity VIII), 100 miles southwest of the site; and (3) the 1918 Sandoval County, New Mexico earthquake (Intensity VII-VIII), about 60 miles east of the site. The largest shock in the region was the 1887 northern Mexico earthquake of Intensity IX, 320 miles southsouthwest of the site; this earthquake may have subjected the site to a shock of Intensity V to VI. The most recent shocks, in 1973 and 1976, located 20 and 45 miles from the site, had reported maximum intensities of VI in the epicentral area and were probably felt at the project site with intensities of IV or less. The most significant earthquake that affected the area was the 1918

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Sandoval County earthquake in the Rio Grande seismic belt. The maximum intensity of VIII was the highest reported in the Rio Grande Rift Zone. It was probably felt at the project area with an intensity of VI, and would have been accompanied by peak ground acceleration of about 0.06g. Based on the historical record, the analysis indicates that an earthquake of Intensity VIII could occur at the Rio Grande Rift Zone about 60 miles to the east of the site. This earthquake would probably be felt at the project site with an intensity of VI. In terms of the Mt. Taylor tailings pond embankment stability, an earthquake with a maximum intensity greater than VII at the site cannot reasonably be expected. To generate such a shock would require an Intensity IX to X earthquake along the Rio Grande seismic belt, and in view of the available historical data this possiblity should be considered remote.

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2.6 HYDROLOGY AND WATER QUALITY

2.6.1 Ground Water Hydrology

The project area is located northwest of the Mt. Taylor volcanic field in the Bluewater and Rio Grande Underground Water Basins (Figure 2.6-1). Descriptions of the geologic formations in the project area and their hydrologic properties have been discussed in numerous publications (Titus Jr., 1963; McGlothlin, 1972; Gordon, 1961; West, 1961; Jacob, 1957; New Mexico Environmental Institute, 1974). The most important hydrogeologic units that occur beneath the project area include the following: (1) Cretaceous Dakota Sandstone, (2) Jurassic Westwater Canyon Member of the Morrison Formation, (3) Permian Glorieta Sandstone, and (4) Permian San Andres Limestone (Table 2.6-1 and Figure 2.4-2). Hydrogeologic units of lesser importance for water supply include: (1) Quaternary alluvial and volcanic deposits, (2) Cretaceous Mesa Verde Group, (3) Jurassic San Rafael Group, and (4) Triassic Chinle Formation. These units are classified as aquifers and, depending on their hydrologic characteristics, yield ground water to wells and springs. The following discussion is confined to descriptions of these aquifers.

Hydrogeologic Units.

Alluvial and Volcanic Deposits. The alluvial aquifer in the project area is comprised of unconsolidated, poorly stratified clays, silts, sands, and gravels. Since evapotranspiration exceeds precipitation, recharge is restricted to fluvial channels or other areas where surface water collects. Most of this recharge flows through the alluvium to deeper aquifers resulting in little potential for the development of alluvial ground water supplies. The volcanic aquifer generally consists of basalts, silicic tuffs and andesites. Most recharge to this aquifer probably is the result of infiltration of water downward through younger volcanic rocks high on the slopes of Mt. Taylor. Several low-yielding

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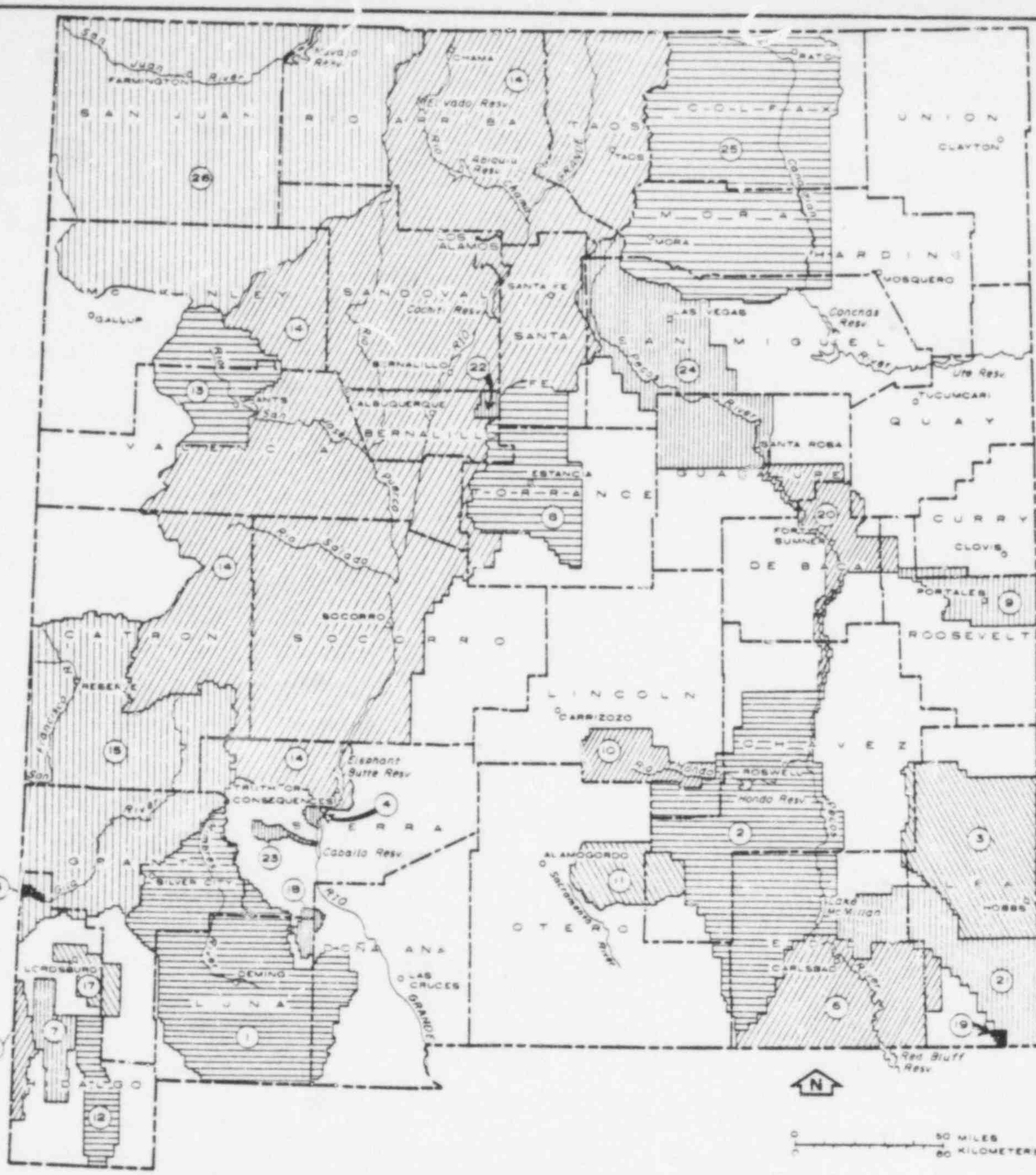

DECLARED UNDERGROUND WATER BASINS IN NEW MEXICO

BASIN	AREA IN SQUARE MI.
1. MIMBRES VALLEY	4,279
2. ROSWELL	4,281
3. LEA COUNTY	2,180
4. HOT SPRINGS	38
5. VIRDEN VALLEY	19
6. CARLSBAD	1,965
7. ANIMAS	426
8. ESTANCIA	1,724
9. PORTALES	628
10. HONDO	611
11. PEÑASCO	723
12. PLAYAS VALLEY	515
13. BLUEWATER	1,318
14. RIO GRANDE	24,144
15. GILA – SAN FRANCISCO	5,659
16. SAN SIMON	263
17. LORDSBURG VALLEY	329
18. NUTT - HOCKETT	133
19. JAL	15
20. FORT SUMNER	1,059
21. CAPITAN	1,550
22. SANDIA	73
23. LAS ANIMAS CREEK	75
24. UPPER PECOS	2,708
25. CANADIAN RIVER	5,825
26. SAN JUAN	9,591
TOTAL	70,131

Source: New Mexico State Engineer's Office 1976

Figure 2.6–1.
DECLARED UNDERGROUND WATER BASINS IN NEW MEXICO

POOR ORIGINAL

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Table 2.6-1. SUMMARY OF HYDROLOGIC UNITS IN THE PROJECT AREA

Geologic Age	Group	Hydrologic Unit	Estimated Thickness (ft)	Lithologic Characteristics	Hydrologic Characteristics
Holocene		Alluvium	0 - 150	Clays, silts, sands, and gravels; some slopewash material	Yields small quantities of water to wells.
Tertiary		Bidahochi Formation	0 - 100	Basalt, andesite and rhyolite lava flows and dikes	Low yielding springs discharge at favorable topographic positions on mesas.
Cretaceous	Mesa Verde Group	Menefee Formation	210 - 250	Claystone, shale, sandstone, limestone and coal	Yields small amounts of water to wells for stock supply.
	Mesa Verde Group	Point Lookout Sandstone	60 - 100	Arkosic sandstone	
	Mesa Verde Group	Crevasse Canyon Formation	200 - 250	Sandstone, claystone and shale	
	Mesa Verde Group	Gallup Sandstone	70 - 100	Sandstone	Yields moderate quantities of water to pumping and artesian wells.
		Mancos Shale	250 - 500	Shale and interbedded sandstone	Not known to yield water to wells in the area.
		Dakota Sandstone	40 - 85	Quartz sandstone	Yields small to moderate supplies of water to domestic and stock wells.
Jurassic		Morrison Formation	245 - 300	Mudstones, siltstones and sandstones	Westwater Canyon Member yield moderate to large quantities of water to wells.
	San Rafael Group	Bluff Sandstone	90 - 125	Sandstone	Yields small quantities of water to wells for stock supply.
	San Rafael Group	Summerville Formation	95 - 125	Sandstone and siltstone	
	San Rafael Group	Todilto Limestone	50 - 75	Limestone	
	San Rafael Group	Entrada Sandstone	200 - 250	Sandstone	
Triassic		Chinle Formation	300 - 500	Sandstones, siltstones and claystones	Yields small quantities of water to wells for stock supply.
Permian		San Andres Limestone	80 - 100	Limestone	Yields moderate to large quantities of water for irrigation, industrial and municipal supplies.
		Glorieta Sandstone	125 - 300	Sandstone	

Modified from:

Gordon (1961); West (1961); New Mexico Environmental Institute, 1974.

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springs discharge, particularly from the silicic tuffs, high on the slopes of mesas in the vicinity.

Mesa Verde Group. The Mesa Verde Group consists of alternating, irregularly bedded sandstone, clay, and coal, intertonguing with the underlying Mancos Shale. Rocks of this group are exposed on San Mateo Mesa and the western wall of San Lucas Canyon just south of Laguna Polvadera.

The Menefee Formation is not generally a major aquifer, but does yield about 5 gpm of good-quality water to wells near the community of San Mateo. The Point Lookout Sandstone is a massive sandstone unit that forms the caprock of San Mateo Mesa. Several miles north of the project area, wells completed in the Point Lookout Sandstone yield about 20 gpm, on the average, of good to fair quality water.

The Crevasse Canyon Formation consists of three members - the Gibson Coal Member Dalton Sandstone Member, and Dilco Coal Member, in descending order. The Dilco Coal Member is separated from the other two by the Mulatto Tongue of the Mancos Shale, and in many areas forms a single aquifer with the underlying Gallup Sandstone. Few wells tap the aquifers of the Crevasse Canyon Formation.

The Gallup Sandstone is the basal unit of the Mesa Verde Group. It yields water to a few wells northeast of the project area, but the quality is generally fair to poor and the water is suitable only for livestock use.

Dakota Sandstone. The Dakota Sandstone is a yellowish-gray, massive, well-cemented quartz sandstone. Locally, the sandstone is interbedded with carbonaceous shales and conglomerates. Thickness varies (40 to 85 feet) beneath the site due to lateral lithologic gradation and intertonguing with the overlying Mancos Shale. Locally, the Dakota aquifer is hydraulically connected to the Westwater Canyon Formation below. Wells that

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tap the Dakota for water supply generally yield 1 to 10 gallons per minute (gpm); however, depressurization wells of the mine site have been pumped in excess of 100 gpm.

Morrison Formation. The Westwater Canyon Member is the only member of the Morrison Formation known to be an aquifer beneath the site. The Westwater Canyon aquifer comprises fine to coarse, poorly sorted, felds-pathic sandstone. Its thickness ranges from approximately 50 to 200 feet. This aquifer probably is the second most important aquifer for water supply in the project area. Wells completed in the aquifer for stock water supply commonly yield 5 to 20 gpm. Dewatering wells for uranium mines, however, have pumped several hundred gpm from the Westwater Canyon aquifer.

San Rafael Group. Little is known of the water-bearing properties of the formations of the San Rafael Group. The Entrada and Summerville Formations probably are the aquifers with greatest potential for development within the group. These formations are fine-grained massive, cross-bedded sandstones containing lenses of claystone, siltstone and limestone. Wells tapping these aquifers for stock and domestic supplies generally yield as much as 20 gpm.

Chinle Formation. The Chinle Formation consists of 300 to 500 feet of varicolored clay and siltstone, interbedded silty sandstone and coarse-grained to conglomeratic sandstone. The sandstone and silty sandstone units generally yield low to moderate supplies of water (less than one gpm) to wells for stock and domestic supply. Locally, large water supplies for irrigation can be pumped from the lower units of the aquifer.

San Andres Limestone and Glorieta Sandstone. The San Andres Limestone and Glorieta Sandstone, formerly classified as a member of the San Andres, together comprise the most productive aquifer of the region. These

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formations consist of massive, dolomitic sandy limestone with interbedded sandstone and medium grained, well-sorted, hard to soft sandstone, respectively. The San Andres aquifer generally yields more water than the Glorieta aquifer, but the individual and/or combined yields are adequate for irrigation, industrial and municipal supplies. Well-connected cavernous zones and solution channels which help create relatively high transmissivities contribute to the resulting high yields of the San Andres aquifer.

Ground Water Use. With the exception of water wells and exploration boreholes drilled by Gulf, wells and springs in the region are widely scattered (Tables 2.6-2 and 2.6-3). Aquifers in which wells are completed include alluvial deposits, Menefee Formation, Point Lookout Sandstone, Gallup Sandstone, Dakota Sandstone and Westwater Canyon Member. The water is used primarily for watering livestock and wildlife. Domestic supply wells are located in the vicinity of San Mateo. Overall, however, the amount of ground water pumped for all these uses is relatively small.

Of those wells constructed by Gulf for industrial uses, only one (Sample No. 1, Table 2.6-4) has been used regularly for potable water supply. The present water production from this well is 160 gpm. Well No. SM 2443, completed in the Westwater Canyon Member, has been intermittently pumped at 400 gpm for industrial use. The remainder (approximately 15 wells) are to be used for testing of hydrologic properties of the aquifer.

Ground Water Occurrence and Movement. Of the aquifers described above, the Westwater Canyon Aquifer is of greatest potential importance to the proposed milling activities. The aquifer can yield relatively large amounts of water, as evidenced by the production from mine dewatering wells. The aquifer also yields water of relatively good quality (Table B-10 in Appendix B). In this area, water in the Westwater Canyon generally

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Table 2.6-2. RECORD OF HISTORICAL WELL SAMPLE POINTS

No.	Location[a]	Owner	Elevation (ft)	Total Depth (ft)	Depth to Water Table (ft)	Date Measured	Remarks
1	13.8.14.422	I. Michael	7,180	200	71.5 56	9-10-62 10-18-72	Stock well.
2	13.8.22.242	Lee Ranch	7,110	-	37.5 33.3 39.6	10-23-62 10-17-72 5-30-73	Ranch hdqrs. well; old Fernandez Co. W.L. measured 5-30-73 after 11 min recovery.
3	13.8.23.431	H. Marquez	7,180	92	38.2 35 35	9-11-62 10-17-72 6-2-73	
4	13.8.24.223	A. Candelaria	7,320	-	140.7 195 184.5	9-10-62 10-17-72 6-2-73	
5	13.8.24.334B	N. Marquez	7,295	200	40	before 1962	
6	13.8.24.334	F. Gonzales	7,290	200	50	before 1962	
7	13.8.24.334A	N. Marquez	7,300	140	89.5	9-10-62	
8	13.8.25.112	J.T. Gonzales	7,320	150	43.0	9-10-62	
9a 9b	13.8.25.114 13.8.25.114	E. Michael(a) E. Michael(b)	7,310 7,310	120 250	35.9 80	9-11-62 10-11-72	Water from gravel & sandstone. Well b, 3 yrs old.
10	13.8.25.111	P. Pena	7,295	21	19.5	9-11-62	Dug well (72" diameter).
11a	13.8.26.221	Community of San Mateo(a)	7,240	336	281		For well a, water was reported above 100' but was sealed off. Well b probably modified well a.
11b	13.8.26.221	Community of San Mateo(b)	7,240	200 being repaired	32.8	10-24-72	
12	13.8.26.211	P. Sandoval	7,215	40	33.2 34 32	9-11-62 10-18-72 6-2-73	Dug well (84" diameter).
13	13.9.24.221	N. Marquez	6,190	80	56.5	12-6-57	
14	13.9.24.221	Calumet & Hecla, Inc.	6,910	80	56.6	12-6-57	Exploratory drill hole.
15	13.8.25.114	J. Hope	7,290	35 broken	27	10-11-72 6-2-73	Shallow dug well.
16	13.7.33.234	Gulf water well	8,400	1500 approx.	400±	9-29-72	Located in Colorado Canyon.
17	13.7.30.432	Gulf		>1980	<300		
SM2443	13.8.24.412	Gulf	7,350			8-26-76	Abandoned well on San Mateo mesa. No data.
18[b]	14.8.12.234	Lee Ranch	-	-	-	6-1-72	
19[b]	14.8.15.433	Polvadera (Lee Ranch)	-	1320	-	9-2-71	Tapping Mancos.
20[b]	13.8.17.241	Lee Ranch	-	-	-	6-1-72	
21[b]	13.8.27.134	-	-	-	-	6-1-72	
22[b]	13.8.33.234	Bita	-	600	-	6-1-72	

Source: New Mexico Environmental Institute, 1974.

[a]For explanation of well-numbering system, see Figure B-1.

[b]Data supplied by Kerr-McGee Corporation.

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Table 2.6-3. RECORD OF HISTORICAL SPRING AND SURFACE WATER SAMPLE POINTS

No.	Location[a]	Owner or Name	Elevation (ft)	Yield		Remarks
				Flow (gpm)[b]	Date	
B	13.7.9.441	San Lucas Canyon	7,880	50E	10-23-62	
				25.7M	10-24-72	
				5E	5-31-73	
C	13.7.9.433	American Canyon (west of B above,	7,810	50E	10-23-62	
				≈2M	10-18-72	
				>100M	10-24-72	
				5E	5-31-73	
D	13.7.20.121	San Lucas Spring	7,850	20E	8-29-62	Series of small seeps.
				9.8M	9-29-72	
				15.3M	10-11-72	After 1-inch of rain.
				12.1M	3-14-73	
				14.9M	5-31-73	
E	13.7.31.414	San Mateo Springs	8,120	250-300E	10-24-62	5 springs of 25 gpm flow & many small springs (14°C 6-2-73).
F	13.7.19.242	Maruca Spring	7,850	trace	9-29-72	
Q	13.8.21.424	Bridge Springs	7,035	18.9M	10-18-72	
				31.0M	3-14-73	
				11.3M	6-2-73	
H	13.8.28.141	South Bridge Springs	7,015	4.6M	10-17-72	
				26.7M	3-14-73	
				18.9M	6-2-73	
I[c]	13.7.6.322	San Lucas Valley Spring	-	-	6-1-72	
J[c]	13.8.25.414	San Mateo Dam	-	-	6-1-72	Surface sample.

Source: New Mexico Environmental Institute, 1974.

[a] For explanation of well-numbering system, see Figure B-1.

[b] E-Estimated; M-Measured.

[c] Data Supplied by Kerr-McGee Corporation.

Table 2.6-4. RECORD OF MARCH AND DECEMBER 1976 WATER QUALITY SAMPLE POINTS

HIST. SAMPLE NO.	WCC SAMPLE NUMBER	LOCATION	WELL OWNER	SURFACE ELEV (FT)	DEPTH TO WATER (FT)	DEPTH OF WELL (FT)	AQUIFER	M… CONDU… µmho…
	WELLS							
-	S-1	13.8.24.412	GMRC	7,350	260	800	Point Lookout SS	3
2	S-4	13.8.22.242	Lee Ranch	7,110	48.39		Menefee Formation	3
	-	13.8.11.321	Cattlemen's Assoc.	7,190	76.90	192.3	Menefee Formation	
	-	13.8.14.422	GMRC	7,180			Menefee Formation	
	S-7	14.7.19.221	Lee Ranch	6,930	Flowing		Menefee Formation, Point Lookout SS	3
	-	14.8.4.334	Lee Ranch	7,210	>500		Menefee Formation	
	S-8	13.8.24.144	C. Trujillo	7,280		160	Menefee Formation	8
	S-9	13.8.24.342	F. Candelaria	7,310	15	250	Menefee Formation	7
	-	13.8.23.413	H. Marquez	7,180	33.98	78.9	Menefee Formation	
3	S-10	13.8.23.431	H. Marquez	7,180			Menefee Formation	2
12	S-11	13.8.26.211	P. Sandoval	7,215	33.41		Menefee FC., Alluvium	9
5	S-12	13.8.24.334B	N. Marquez	7,295	87.39		Menefee Formation	[illegible]
4	S-13	13.8.24.223	A. Candelaria	7,320			Menefee Formation	7
	S-14	13.8.24.141	A. Candelaria	7,260		285	Menefee Formation	1,0
9	S-15	13.8.25.114	E. Mitchell	7,290	103.87		Point Lookout SS	4
	S-16	13.8.14.422	GMRC	7,190			Menefee Formation	1,5
	-	13.7.30.421	GMRC	8,260	>500	4,207	Morrison Formation	
16	-	13.7.33.234	GMRC	8,400	>500			
	-	13.8.26.221	San Mateo	7,240			Point Lookout SS	
	S-19	13.8.24.342	F. Candelaria					
	S-20	13.8.25.121	San Mateo	7,320	269.35		Point Lookout SS, Menefee Formation	9
	S-22	13.8.24.412	GMRC	7,350	700	2,000		
	SPRINGS							
	S-5	13.7.20.121	Forest Service	7,850			Tertiary Volcanic	1
	S-6	13.7.9.441	Forest Service	7,880			Tertiary Volcanic	1
	S-17	13.7.19.242	Forest Service	7,850			Tertiary Volcanic	1
	S-18	13.7.28.131	Lee Ranch	7,908			Menefee Formation	4
Q	S-21	13.8.21.423	Lee Ranch	7,035			Menefee F., Alluvium	7
	S-28	13.7.9.441	Forest Service	7,880				
	SURFACE WATER							
	S-2	13.8.25.442		7,520				1
J	S-3	13.8.25.414		7,460				1
	S-27	13.8.21.433		7,290				

NOTES:

a TYPE OF CHEMICAL ANALYSES
(A) Standard Chemical and Heavy Metals
(B) Total Suspended Solids
(C) Molybdenum and Vanadium
(D) Radiochemical
(E) Lead - 210

b SOURCE OF ORIGINAL WELL DATA
(A) New Mexico Environmental Institute, 1974.
(B) Cooper and John, 1968.

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SAMPLING PERIOD								
…RCH, 1976		DECEMBER, 1976						
…TIVITY /cm	TEMP °C	CONDUCTIVITY µmhos/cm	TEMP °C	HCO_3 mg/l	pH (UNITS)	TYPE OF LABORATORY ANALYSES[a]	REMARKS	SOURCE OF ORIGINAL WELL DATA[b]
25	21	350	8.3	294	8.5	A,D	SPLIT SAMPLE (Dec. only)	
15	12	300	13.5	290	8.2	A	Gulf Water Supply	
							Windmill Broken	
							No Pump	A,B
75	16.5					A,D		
							Pump Not Working	B
60	9.5	850	12.5	486	9.7	A,C,D		
75	10					A		
70	5	400	9	340	7.5	A		A,B
00	8.5					A	No Pump	A,B
80	10	800	8	546	8.4	A		A,B
80	10.5	1,250	10	814	8.2	A		A,B
60	12.5					A,C	Split Sample (March only)	
55	12					A		A
00	11.5					A		
							No Pump	
							Pump House Locked	A
							Old Municipal Well, No Pump	
							Duplicate of Sample 9	A,B
15	13.5	1,000	12.5	812	8.9	A,C,D,E	Municipal Well, Split Sample (March only)	
		1,050	50	334	8.7		GMRC Hot water well	
70	9.5	180	5.5	152	7.8	A,B		A,B
60	5.5	800	3.5	902	7.6	A,B		A
60	5					A,B		A
55	9					A,B		
20	5					A,B		A
		800	[illegible]	930	8.1	A,B	Duplicate of Sample 6	
30	8					A,B,C,D	San Mateo Creek	
60	3.5	150	3	114	8.4	A,B,C	San Mateo Reservoir	A
		1,600	5	502	9.7	A,B,D	San Mateo Creek At Rt. 53	

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is under artesian pressure (confined). Th. ₒ:adient of the piezometric surface beneath the site appears to slope easterly; thus t.e overall direction of ground water flow is easterly.

Shallow aquifers in the region, particularly the Quaternary alluvium and volcanic deposits, contain water under water table (unconfined) conditions. This is evidenced by the occurrence of springs, many of which are intermittent, discharging from these deposits. Many of these springs probably represent local water table or perched ground water conditions, and are caused by impermeable shale-siltstone units that interrupt vertical water infiltration forcing water to move horizontally toward the valley walls.

The regional aquifers probably are recharged by infiltration of precipitation falling directly on their outcrop areas south and west of the project area. The main source of recharge is probably by infiltration of runoff in stream valleys where the alluvium has hydraulic connection with the aquifers or by direct percolation where streams cross outcrop areas.

Natural ground water discharge occurs principally from springs located in stream valleys. The discharged spring water generally flows a short distance downstream before evaporating or seeping back into the aquifer. Yields from domestic and stock wells account for relatively small quantities of ground water discharge.

Quantitative Hydrologic Testing. Gulf has collected detailed pump test and water level monitoring data in the area (Dames and Moore, 1972; McGlothlin, 1972). These data were primarily collected to determine geotechnical and ground water conditions beneath the site. Some data have also been collected related to depressurization for shaft sinking.

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The testing indicated that ground water occurs in each of the sandstone beds below a depth of 270 feet. The water in each sandstone layer is confined; however, in some instances, where the intervening shale layers are thin and jointed or fractured, the sandstone aquifers appear to be interconnected. In those cases, the entire thickness of the interconnected layers was considered to be a single aquifer with greater horizontal than vertical permeability. Estimates from available data indicate that the vertical permeabilities through the fractures in the shales are 1/10 to 1/50 of the horizontal permeabilities and only very small flows of water occur in vertical directions.

Based on laboratory and field permeability tests, it appears that a significant but highly variable portion of the total water flow occurs along fractures in the aquifers. This is particularly true in the lower portion of the Point Lookout, Gibson and Dakota Formations.

From the results of hydrologic testing, there is an apparent easterly slope in the pressure gradient in the Westwater Canyon aquifer.

Drill stem and injection tests were conducted on aquifers penetrated by the pilot hole for the mine shaft. The results show that sections of the Westwater Canyon Member have a permeability of up to 1300 millidarcys (md) (McGlothlin, 1972). This value agrees with similar data obtained from the Westwater Canyon in the Ambrosia Lake area, which yielded permeabilities on the order of 680 md (Jacob, 1957). Recent data suggest that the overlying Dakota Formation may locally have a permeability as high as 900 md (Gulf internal communication, May 6, 1977).

The Point Lookout Sandstone, with a permeability of 170 md, is the only other tested formation having a permeability greater than 50 md (Dames and Moore, 1972). Recent data suggest that the effective permeability of the Point Lookout Sandstone may be as high as 400 md (Gulf internal com-

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munications, May 6, 1977). The Menefee was not tested for permeability in the field, but laboratory tests indicate that the Menefee may contain thin sandstone beds with permeabilities of the same order of magnitude as the Point Lookout Sandstone.

A comparison of historical water level data (Cooper and John, 1968; New Mexico Environmental Institute, 1974) and data from Gulf files indicate that the water levels in wells completed in shallow aquifers have varied little with time even under pumping from deeper aquifers.

La Polvadera Canyon Tailings Impoundment Area.

Site Selection. The primary concern in selecting a tailings impoundment site was control of pond seepage. La Polvadera Canyon itself was selected as a desirable area because of its remoteness from water supply sources and other activities. Within the canyon, geologic structure is the controlling factor with respect to seepage and has served to limit the number of possible dam and pond sites. It is desirable to avoid the steeply dipping flanks of San Mateo Dome (Figure 2.4-1) because the rocks are more permeable and more sandstone units would be truncated and exposed to seepage. The most suitable area for tailings impoundment development is the central part of the canyon where beds are relatively flat-lying along the crest of the dome. Seepage analyses indicate that, with the exception of the fault zone on the north side of the pond, the proposed tailings area can be used without lining (See Seepage Evaluation in Section 3.4.2).

Existing Ground Water Conditions. Very little direct information is available on existing ground water conditions in La Polvadera Canyon or the immediate vicinity. However, the geologic mapping of the San Lucas Canyon Quadrangle published by the U.S. Geological Survey (Santos, 1966) permits extrapolation from other areas to the south where the

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same stratigraphic units occur. Well information in the area is very scarce and must be considered of questionable reliability. The Polvadera well is located in the canyon at Elevation 7,180 feet, southwest and outside of the proposed tailings pond. It was originally drilled as an oil and gas test hole 1,320 feet deep and the yield, reported to be 1 to 2 gpm, is used to water stock. According to Cooper and John (1968), this well taps the Mancos Shale, but the well may also penetrate the Dakota Sandstone and the Brushy Basin Member of the Morrison Formation. There are two other stock wells just outside of La Polvadera Canyon to the northwest (SW1/4, Sect. 4, T14N, R8W) and to the northeast about one mile north of Laguna Polvadera. The well to the northwest reportedly produces from the Dalton Sandstone and the well to the northeast probably produces from the Point Lookout Sandstone.

If the data from the Polvadera Well are correct, the depth to ground water beneath La Polvadera Canyon ranges from 500 feet at this well to an estimated 300 feet at the canyon mouth, where land surface is some 200 feet lower. The alluvial deposits in the canyon are unsaturated, except perhaps for some minor perched zones beneath intermittent stream channels. None of the test holes drilled during the geotechnical investigation encountered saturated soils or rocks and all of the materials penetrated appeared to be very dry, probably well below field capacity.

The principal aquifers beneath the canyon areas are the Dakota Sandstone and underlying sandstone members of the Morrison Formation. The top of the Dakota Sandstone occurs at a minimum depth of approximately 900 feet beneath the surface. It is separated from overlying alluvium sandstone units by over 800 feet of the Mancos Shale, which acts as an aquiclude. Along the flanks of the San Mateo Dome the Gallup, Dalton, and Point Lookout sandstones plunge beneath the surface to depths where they are saturated and probably act as aquifers outside the canyon area to the north and east.

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Geologic structure is expected to control ground water movement. The sandstone units are interbedded with shales which severely limit interconnection across bedding planes, especially beneath the main part of La Polvadera Canyon where beds are relatively flat-lying near the crest of the dome. Along the flanks of the dome, such as at the mouth of the canyon, the rock units are relatively intensely jointed and faulted, which may permit limited vertical seepage adjacent to these zones in some cases. It is doubtful that this fracturing would persist through a thick, relatively plastic shale unit such as the Mancos Shale.

There is no evidence of any ground-water recharge within La Polvadera Canyon except possibly near its mouth. The dry nature of the alluvial soils, which are up to 80 feet deep, suggests that there is not enough precipitation in excess of evapotranspiration even to develop a sizable perched water table, much less to penetrate to the saturated zone. However, along the flanks of the dome, fractured sandstones forming hogback ridges are exposed and there could be some recharge by direct penetration of precipitation in these outcrop areas.

As mentioned above, the three existing wells in or near La Polvadera Canyon are used for stock watering. There are no historic data available on the quality of ground water in the area, but presumably it is adequate for stock and domestic uses.

Field Permeability. Much of the exploration program effort was placed on obtaining reliable field permeability data for the pond seepage analysis. Three methods were used to perform field tests in bore holes. The water injection tests and the falling-head tests provided more reliable data for seepage estimates. The shallow (10 to 15 feet) field permeameter tests produced data with a wide scatter of results that reflected the higher permeabilities at these depths, where fractures are open. The injection and falling-head tests provided more useful data because they

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are more representative tests of the rock units involved in making seepage estimates and they are not limited to surficial materials.

Figure 2.6-2 shows the distribution of permeability data with relation to stratigraphic position for all field tests. Each point was selected at the midpoint of the test interval. There is a tendency for permeability to decrease with depth in the Dilco and Gallup units, and all of the anomalously high values are at shallow depths, either along ridge tops or in the Gallup Sandstone next to a deep, buried channel where stress relief and open fractures are at a maximum. Table 2.6-5 summarizes the injection and falling-head tests and Table 2.6-6 summarizes the shallow field permeameter tests.

Three field permeability testing methods were used because it is difficult to obtain consistent and reliable results for unsaturated materials with any one technique. Water-injection tests were particularly difficult, and standard procedures had to be adjusted substantially. Much longer than normal test periods were required before injection rates stabilized. Also, there was a tendency for the shales to hydrofracture along partings or for existing fractures to be forced open under pressure. This was indicated by sudden pressure drops and increased injection rates. The extent of hydrofracturing was apparently limited in most cases, because injection rates decreased within a short time and in some cases flow was reversed (possibly due to swelling clay shales). As a result, injection tests had to be evaluated carefully, and where definite indications of hydrofracturing occurred the test data were adjusted or eliminated. However, even with the adjustments, the results tend to indicate higher permeabilities than are actually the case.

The falling-head tests were run over much longer periods of time (24 hours or more) and are subject to fewer variables, although there is

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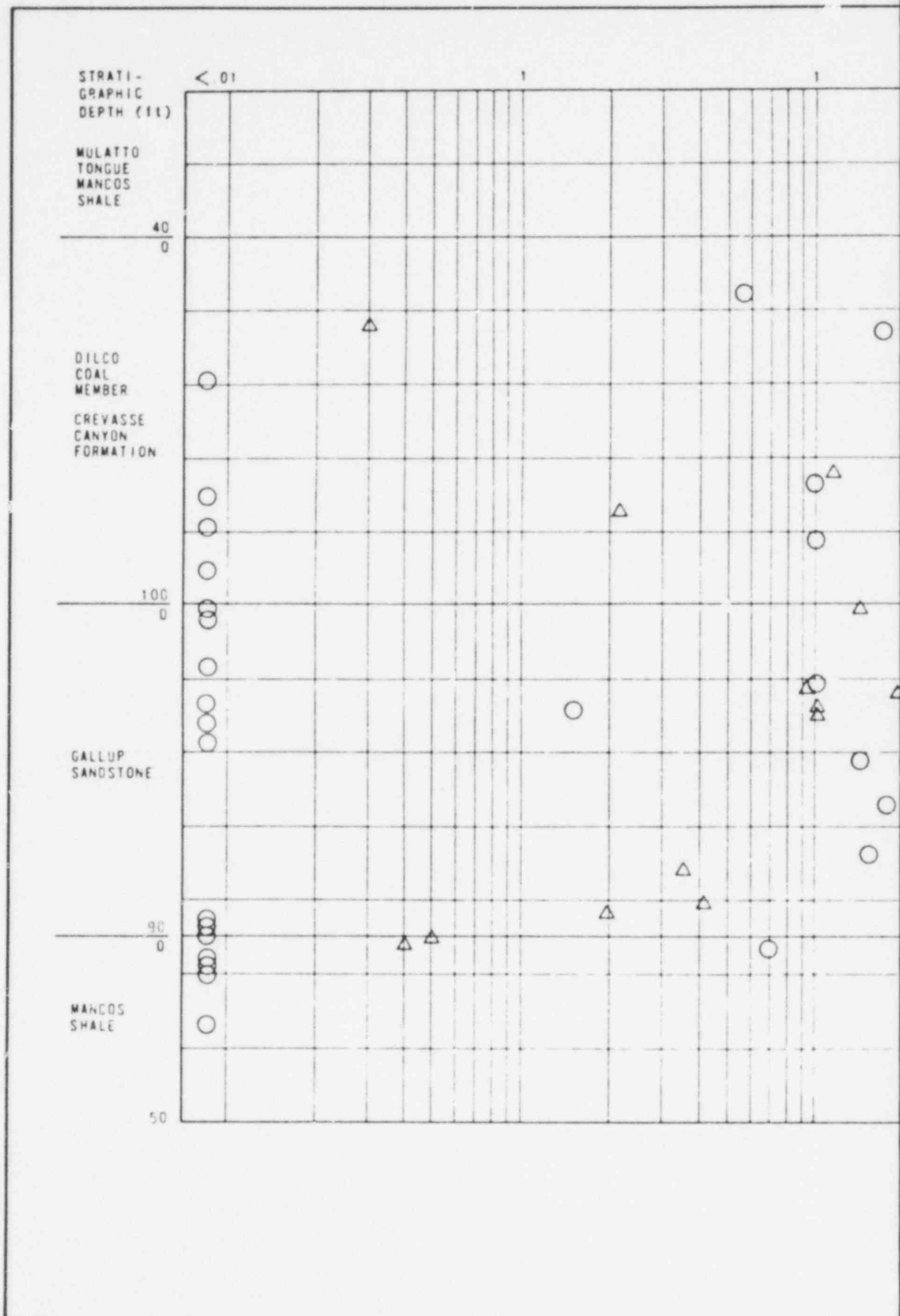

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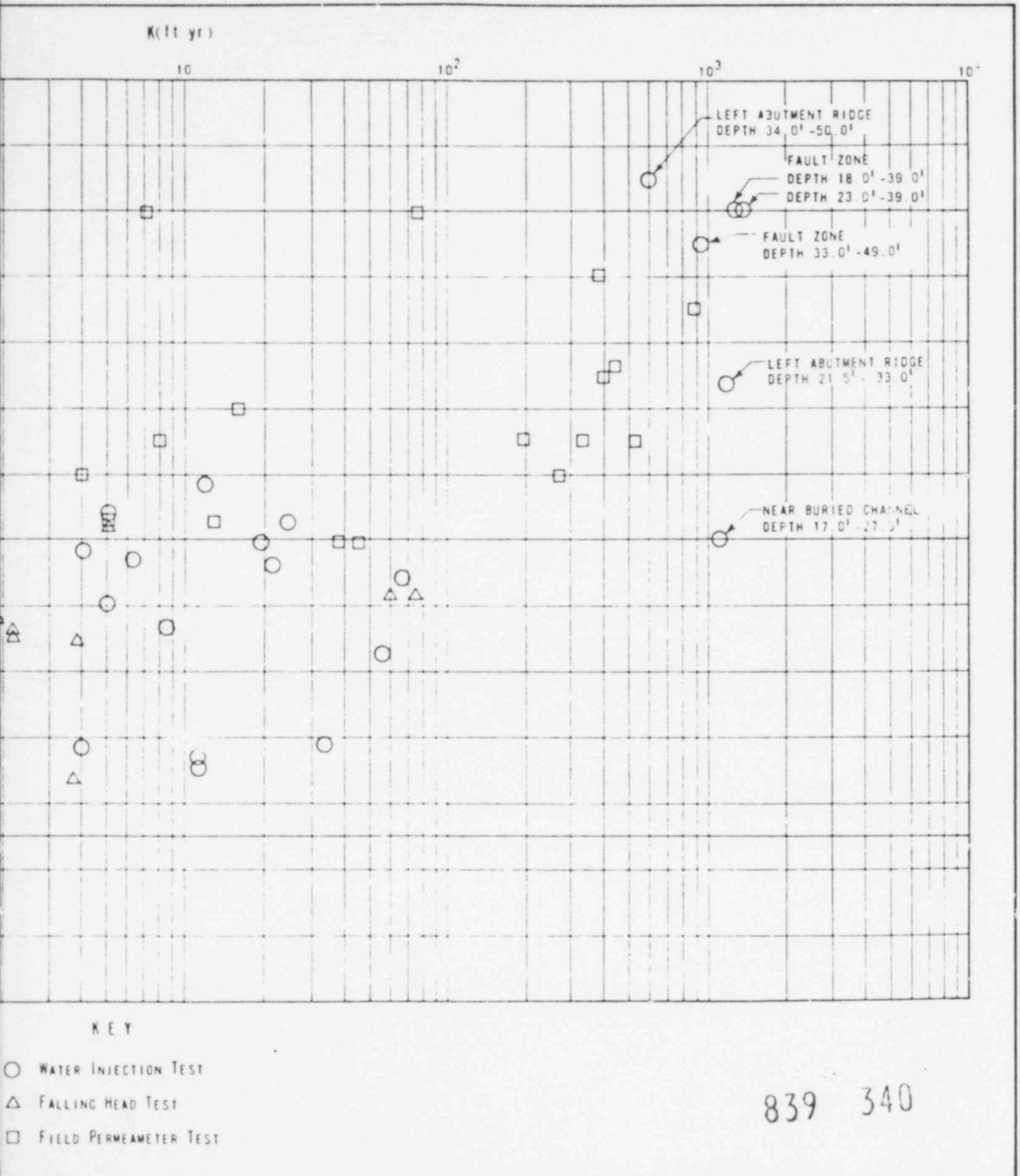

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Figure 2.6–2.
STRATIGRAPHIC DISTRIBUTION OF
FIELD PERMEABILITY VALUES

Table 2.6-5. SUMMARY OF WATER-INJECTION AND FALLING-HEAD TESTS

LA POLVADERA CANYON TAILINGS DISPOSAL AREA

Hole No.	Formation	Depth from Surface (ft)	Type of Test	Permeability (ft/yr)
19	Gallup and Mancos	61.25 - 86	Falling Head	0.18
	Gallup and Mancos	65 - 86	Injection	0
	Mancos	77 - 86	Injection	0.7
	Mancos	89 - 119	Injection	0
25	Gallup	23.3 - 39	Falling Head	1.87
	Gallup	28 - 39	Injection	0
	Gallup	29.5 - 39	Falling Head	2.15
	Gallup	30.7 - 39	Falling Head	1.72
26	Dilco-Gallup Transition	17 - 27.5	Injection	1,127
	Gallup	28 - 39	Injection	66
	Gallup	36.9 - 39	Falling Head	58.75
	Gallup	38 - 39	Falling Head	70.35
27	Dilco-Gallup Transition	22 - 33.5	Injection	0
	Gallup	45.5 - 58.5	Falling Head	0.15
	Gallup	36 - 47.5	Injection	5.0
	Gallup	44 - 58.5	Falling Head	2.17
	Gallup	48.3 - 58.5	Falling Head	3.77
	Gallup	47.5 - 58.5	Injection	0
30	Dilco	26 - 37.5	Injection	12
	Dilco	36 - 47.5	Injection	5
	Dilco and Dilco-Gallup Transition	33.3 - 59	Falling Head	5
	Dilco and Dilco-Gallup Transition	42.5 - 59	Falling Head	1.43
	Dilco-Gallup Transition	48 - 59	Injection	4

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Table 2.6-5. (continued)

Hole No.	Formation	Depth from Surface (ft)	Type of Test	Permeability (ft/yr)
31	Dilco	21.5 - 33	Injection	1,201
	Dilco	48.5 - 60	Injection	1
	Dilco	58.5 - 80	Injection	1
	Gallup	81.5 - 103	Injection	6.2
	Gallup	87 - 130	Falling Head	0.91
	Gallup	96.5 - 127.5	Injection	8.6
	Gallup	101.5 - 130	Falling Head	1.03
	Gallup	127 - 168.5	Injection	1.5
	Gallup and Mancos	115 - 190	Falling Head	0.35
	Gallup and Mancos	127.2 - 190	Falling Head	.42
	Gallup and Mancos	146.4 - 190	Falling Head	.04
	Mancos	168.5 - 190	Injection	0
32	Dilco-Gallup Transition	56.5 - 68	Injection	0
	Gallup	71.5 - 103	Injection	1
	Gallup	106.5 - 138	Injection	11.3
	Gallup and Mancos	136.5 - 148	Injection	0
	Mancos	149.5 - 160.5	Injection	0
33	Gallup and Mancos	89 - 120	Injection	0
	Mancos	104 - 120	Injection	0
34	Gallup and Mancos	59 - 160	Injection	4
	Gallup and Mancos	113.5 - 160	Falling Head	0.05
	Mancos	134 - 160	Injection	0
41	Dilco and Gallup	19 - 100	Injection	56
	Gallup	33 - 100	Injection	1.4
	Gallup	68 - 100	Injection	33
	Gallup	78 - 100	Injection	11
	Gallup	93 - 100	Falling Head	3.67
42	Dilco	18 - 39	Injection	0
	Dilco	25 - 39	Falling Head	0.23

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Table 2.6-5. (concluded)

Hole No.	Formation	Depth from Surface (ft)	Type of Test	Permeability (ft/yr)
43	Dilco and Gallup	18 - 69	Injection	24.5
	Dilco and Gallup	32 - 68	Injection	19
	Gallup	47 - 68	Injection	21
44	Mulatto and Dilco, near fault zone	18 - 39	Injection	1,135
	Fault Zone	23 - 39	Injection	1,400
45	Mulatto and Dilco, near fault zone	18 - 79	Injection	0.56
	Dilco, near fault zone	38 - 79	Injection	1.7
	Dilco, near fault zone	63 - 79	Injection	0
	Dilco, near fault zone	32.1 - 79	Falling Head	0.03
46	Mulatto	34 - 50	Injection	592
47	Dilco	39 - 60	Injection	0
	Dilco	14.5 - 60	Falling Head	1.14
48	Dilco, western extension of east-west fault zone	33 - 49	Injection	917
49	Dilco and Gallup	54 - 100	Injection	0
	Gallup	47 - 100	Injection	0
50	Gallup	41 - 58	Injection	0
	Gallup	59 - 70	Injection	1.76

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Table 2.6-6. SUMMARY OF FIELD PERMEAMETER TESTS[a]

Permeameter Hole Number	Location	Tested Interval (ft)	Formation	Permeability (ft/yr)	Comments
WP-1	Proposed dam axis[b]		Gallup Sandstone		Test not done to silting from runoff; replaced by WP-12.
WP-2	Proposed dam axis	4 - 13.5	Gallup Sandstone	38	Intake of water exceeded capacity of permeameter valve. Permeability valve based on valve capacity.
WP-3	Proposed dam axis	5 - 13	Dilco Coal Member	>890	
WP-4	Alternative dam axis[c]	5 - 13.5	Dilco Coal Member	16	
WP-5	Alternative pond	5 - 13.5	Dilco Coal Member	417	
WP-6	Alternative dam axis	5 - 13.5	Dilco Coal Member	4	
WP-7	Alternative dam axis	5 - 12.5	Dilco Coal Member	13	
WP-8	Alternative dam axis	5 - 13	Dilco Coal Member	5	
WP-9	Alternative dam axis	5 - 13.5	Dilco Coal Member	538	
WP-10	Proposed dam axis	5 - 13	Dilco Coal Member	448	
WP-11	Proposed dam axis	5 - 13	Dilco Coal Member	8	
WP-12	Proposed dam axis	9 - 18.5	Gallup Sandstone	46	Replaces Test WP-1.
WP-13	Proposed dam axis	5 - 13	Dilco Coal Member	272	
WP-14	Proposed dam axis	4 - 15	Dilco Coal Member	7	
WP-15	Alternative pond	5 - 17	Dilco Coal Member	199	
WP-16	Alternative pond	5 - 18	Dilco Coal Member	>334	Intake of water exceeded capacity of permeameter valve
WP-17	Proposed pond	5 - 18	Dilco Coal Member	>384	Intake of water exceeded capacity of permeameter valve.
WP-18	Proposed pond	5 - 15	Dilco Coal Member	76	

a. USBR Designation E-19, 1974, Earth Manual, U. S. Bureau of Reclamation. Tests conducted from July 26 to August 10, 1977.
b. Pond 6A.
c. Pond 8A.

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less flexibility in isolating zones for testing. In general, however, there was good agreement between falling-head tests and injection tests. The field permeameter test results (E-19 tests) are probably reliable, but they were limited to the upper 10 to 15 feet of weathered rock. In this zone joints were consistently more open, which resulted in generally higher permeabilities. Most of these tests were run along abutment ridges where stress relief resulting in open fractures is the greatest. Also, rocks in this shallow zone are more exposed to leaching of soluble cementing minerals (calcite and gypsum). These shallow, permeable zones will be blanketed by the tailings dam embankment, which will be designed to cover the upstream slope of abutment ridges with impervious fill material.

The measured field permeabilities probably reflect near-horizontal or bedding-plane directions. Observations of cores indicate that steeply dipping joints below 20 or 30 feet in depth do not persist across thick shale beds. This may not always be the case, but it is logical, since the sandstones are more brittle and subject to fracturing, whereas the shales tend to deform plastically. Fractures observed in shales of the Dilco unit at depth contain a solid filling of large gypsum crystals and appear to be very tight. No fractures were encountered in the Mancos Shale. Fracturing adjacent to fault planes may be more persistent with depth, but even this is questionable in the case of the main body of the Mancos Shale.

From the field permeability test weighted average permeability values were developed for use in pond seepage analyses. The field permeameter tests were not used because they represent only near-surface conditions. In addition, six exceptionally high pressure test values were eliminated because they represented either shallow tests along ridge tops or tests in fractured rocks along the east-west fault zone near the northern margin of the proposed tailings pond. (The fault zone area will be lined and the other locations will be covered with embankment material.) From the remaining data, weighted average permeabilities were calculated for the Dilco, Gallup, and Mancos units.

The weighted average permeability calculated for the Dilco Coal Member of the Crevasse Canyon Formation is 4.43 feet per year. The values recorded ranged from 0 to 56 feet per year. The weighted average permeability calculated for the Gallup Sandstone is 9.25 feet per year. The values used ranged from 0 to 70 feet per year. For the Mancos Shale, the calculated weighted average permeability is 0.05 foot per year. Table 2.6-7 gives a comparison of these weighted average values with permeability values obtained by Gulf for shaft dewatering at San Mateo.

Table 2.6-7. LA POLVADERA CANYON AND SAN MATEO FIELD PERMEABILITIES

(feet per year)

Geologic Unit	La Polvadera Canyon	San Mateo
Dilco	4.4	5.3
Gallup	8.8	31
Mancos	0.05	a

[a]The main body of the Mancos Shale was not tested, but the Upper Tres Hermanos Member had a permeability of 0.27 foot per year.

There is close agreement for the Dilco unit, and a range of 9 to 31 feet per year for the Gallup Sandstone is reasonably good. No attempts were made to average these numbers for purposes of seepage analysis, but these permeability values were simply used as an approximate range for the Dilco and Gallup units, and the Mancos shale was assumed to be essentially impermeable.

2.6.2 Surface Water

Surface water from the mill and tailings pond sites flows overland in an easterly direction into San Lucas Canyon, a tributary of San Miguel Creek.

Then the drainage trends generally in a northeast direction to Arroyo Chico and eventually merges with the Rio Puerco. The Rio Puerco joins the Rio Grande near Bernardo, approximately 45 miles south of Albuquerque, New Mexico. These drainage patterns are shown on Figures 2.6-3 and 2.6-4, which have been marked to indicate the course along which water from the project area would flow.

This region of New Mexico is arid to semiarid; precipitation ranges from approximately 10 to 12 inches per year in the project vicinity to about 20 inches per year near Mt. Taylor (New Mexico State Planning Office 1967; Juan et al., 1973). It should be noted that the Mt. Taylor region appears as an "island" of high precipitation. Much of the annual precipitation occurs from brief thunderstorms of high intensity which often cause flooding and extreme peak discharges. This has resulted in a land surface incised by many pronounced drainage channels, most of which are usually dry. Stream discharge records are sparse and often inaccurate and/or misleading. Average annual runoff varies from approximately 0.1 to 5 inches in the region (New Mexico State Planning Office, 1967). Typically, about 40 percent of the annual rainfall occurs in July and August when temperatures and evaporation rates are high and soil moisture is low. These factors are largely responsible for the low annual runoff rates.

The nearest gaging stations operated by the U.S. Geological Survey are approximately 30 miles from the project area. These include stations on the Rio Puerco above Arroyo Chico near Guadalupe, New Mexico, Arroyo Chico near Guadalupe, New Mexico, Rio San Jose at Grants, New Mexico,

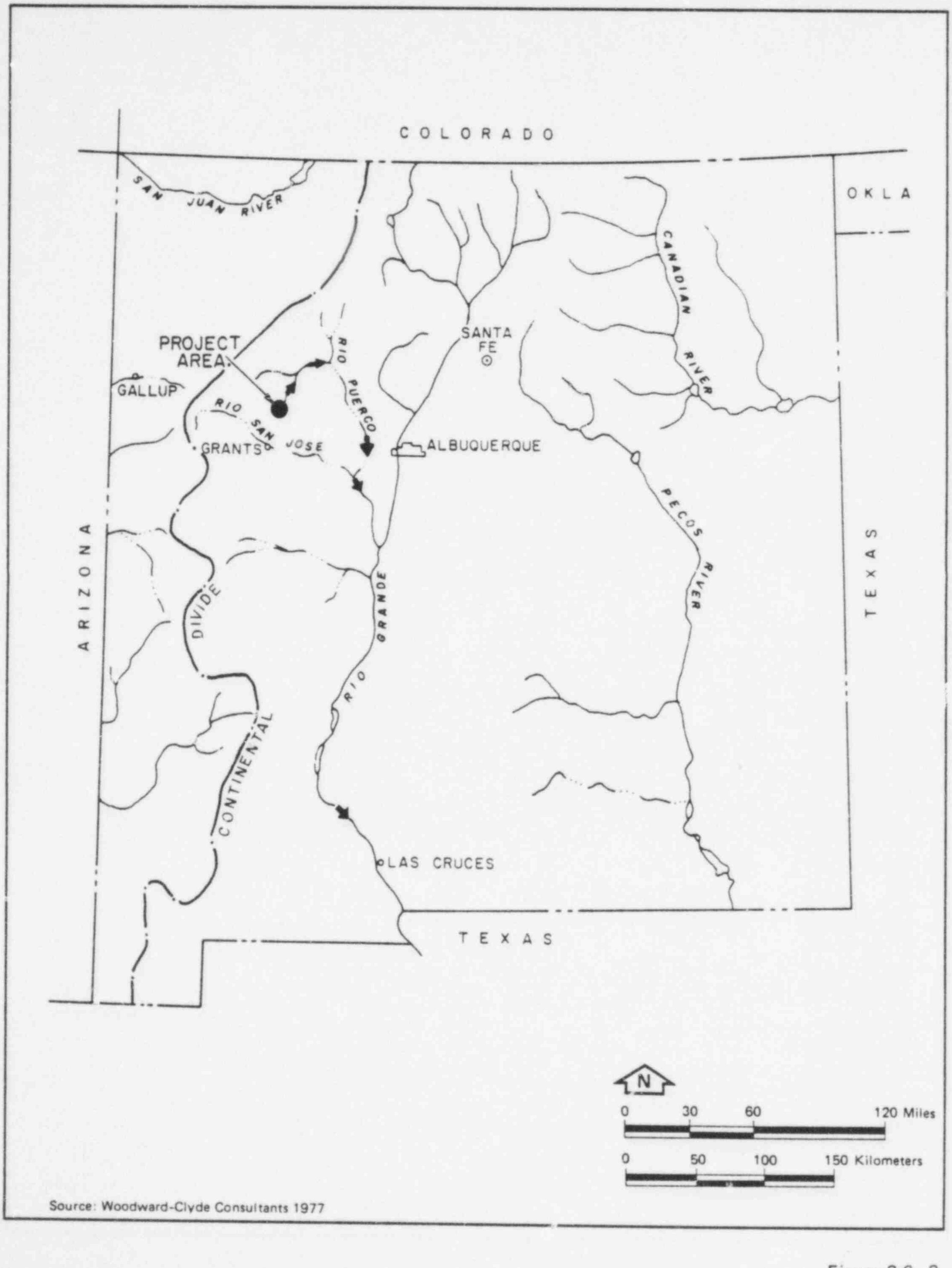

Figure 2.6–3.
DRAINAGE PATTERNS IN NEW MEXICO

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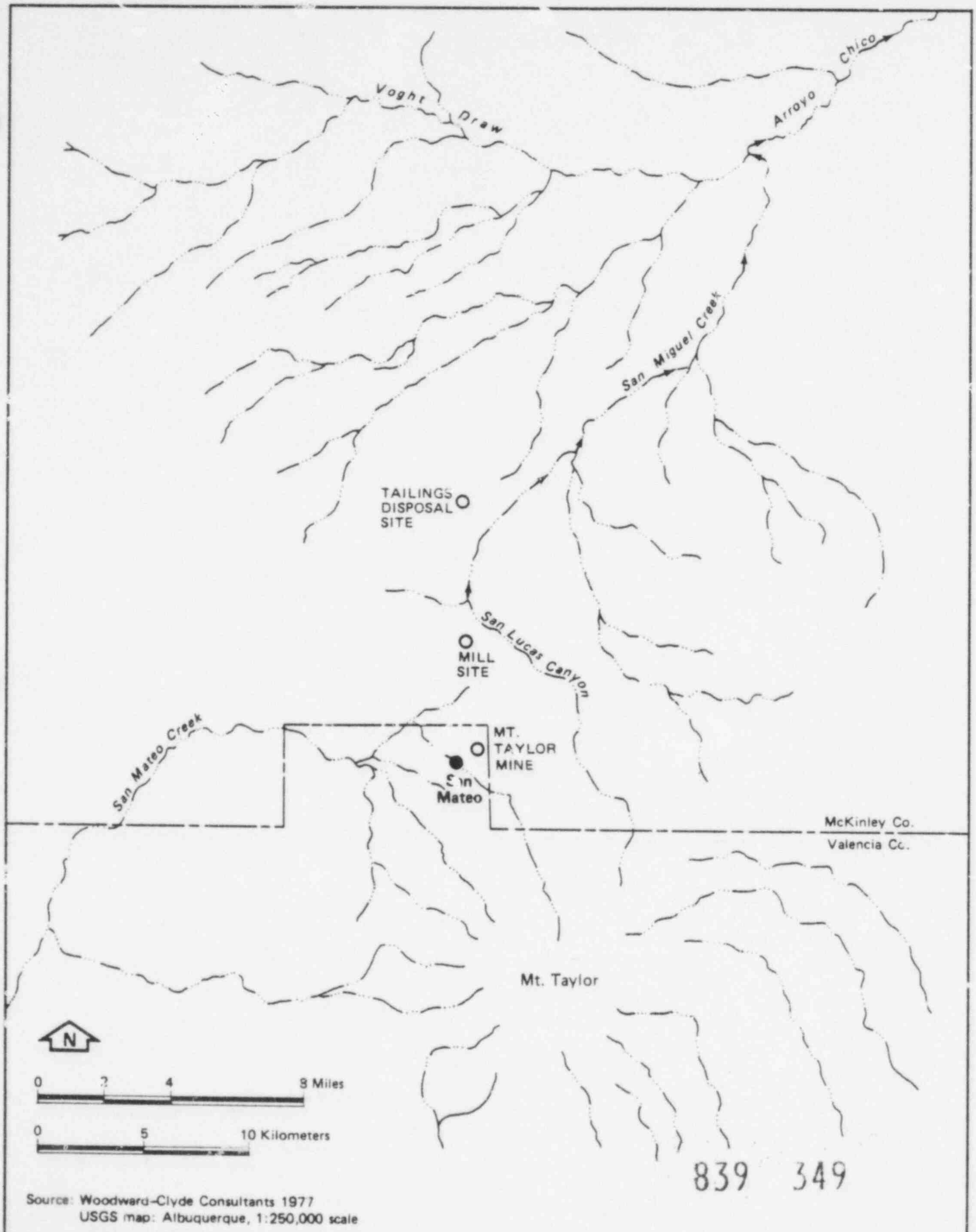

Figure 2.6–4.
REGIONAL DRAINAGE PATTERNS

and at Grants Canyon at Grants, New Mexico. Data for these stations over their periods of record showed an average annual runoff of less than 0.1 inches per year for the Rio San Jose to nearly 0.5 inch per year for the Rio Puerco (U.S. Geological Survey, 1976). Data collected by New Mexico Environmental Institute (1974) indic[illegible] that for San Mateo Creek, a perennial stream, the annual runoff is on the order of five inches per year. Colorado Canyon, an epher[illegible]al stream, has an estimated run-off of 2.5 inches per year. The mean annual runoff for the above two streams was estimated using relationships developed for California Streams which may not be representative of those in the Mt. Taylor area. The data cited above, however, do tend to confirm that runoff from the higher elevations of the Mt. Taylor area is greater than that from the lower elevations. We would expect average annual runoff at the project area to lie within the limits given by these data.

Hydrological investigations of the project area included the theoretical determination of volumes for the 100-year and probable maximum precipitation (PMP) storms. The PMP is the amount of rainfall resulting from the most critical meteorological conditions that are considered likely to occur. The magnitudes of the various storms are based on precipitation data from Miller, Frederick and Tracy (1973). The PMP estimated for the project area is 16.5 inches for a storm of 6 hours duration and 20 inches for a 24-hour duration storm. For these durations, the estimated 100-year precipitation values are 2.5 inches and 3.4 inches, respectively.

Predictions of peak flood discharges and volumes involve consideration of such factors as amount, intensity, and duration of rainfall, size and shape of the watershed, soil conditions, and vegetation. Estimates of the amount of runoff that could be expected from the 100-year and PMP storms were based on methods currently employed by the U.S. Soil Conservation Service (1972). In general, the upper watershed soils in the project area fall into Soil Conservation Service (SCS) hydrologic groupings B and C, while the lower watershed soils have been classified as soil groups C and D. The SCS hydrologic cover complex, or vegetative cover, falls into the juniper-grass category. These areas are usually mixed, with varying amounts of juniper, pinon, grass, and cholla cover, or they may be predominantly one of these types. Because of the higher annual precipitation, grass cover is generally heavier than in desert areas. Juniper grass is typical of mountain slopes and mesas of intermediate elevations.

2.6.3 Water Quality

Water quality sample locations within the project area are shown on Figures 2.6-5 and 2.6-8. Water quality data from the locations shown on Figure 2.6-5 and 2.6-8 are summarized on Figures 2.6-6 and 2.6-7, and on Figures 2.6-9 and 2.6-10, respectively. The individual analyses are presented in Appendix B, Tables B-1 through B-10.

Generally the wells sampled are completed into the Menefee aquifer and a few tap the deeper Point Lookout Sandstone. Other wells that were sampled in the vicinity of San Mateo tap alluvial deposits. Springs sampled in the highlands east of the area discharge from the Tertiary volcanic deposits while other springs discharge from the Menefee Formation. No aquifers were sampled below the Point Lookout aquifer.

The results of the chemical analyses indicate that there generally are two water types in the project area: (1) sodium bicarbonate, and (2) calcium bicarbonate. Total dissolved solids of these waters range from approximately 100 to 1500 mg/l.

It appears that no significant difference is present in water from wells penetrating different aquifers. Most well water is the sodium bicarbonate type. Water discharging from springs in the volcanic deposits, however, tends to be calcium rather than sodium bicarbonate type. Water discharging

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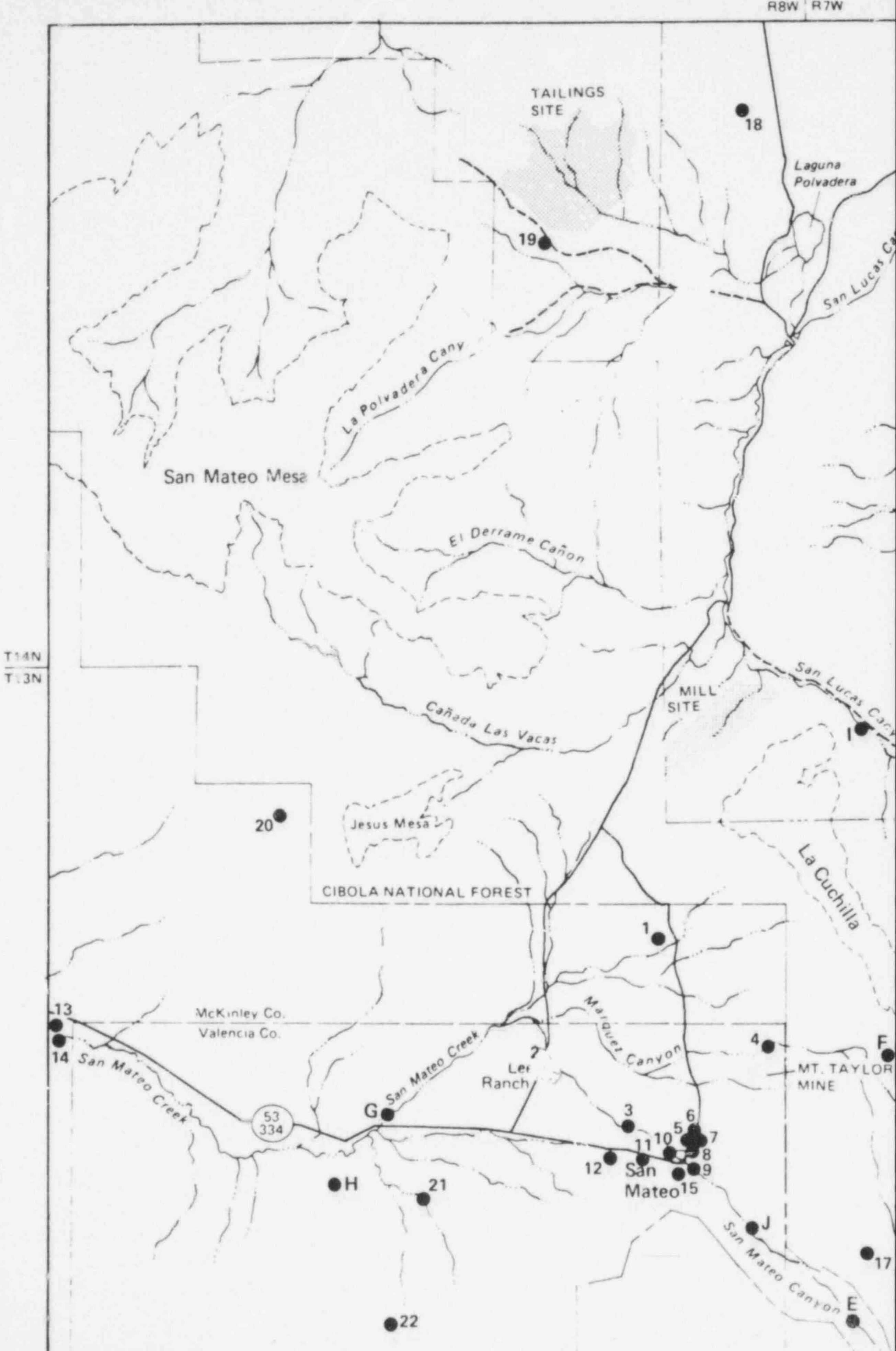
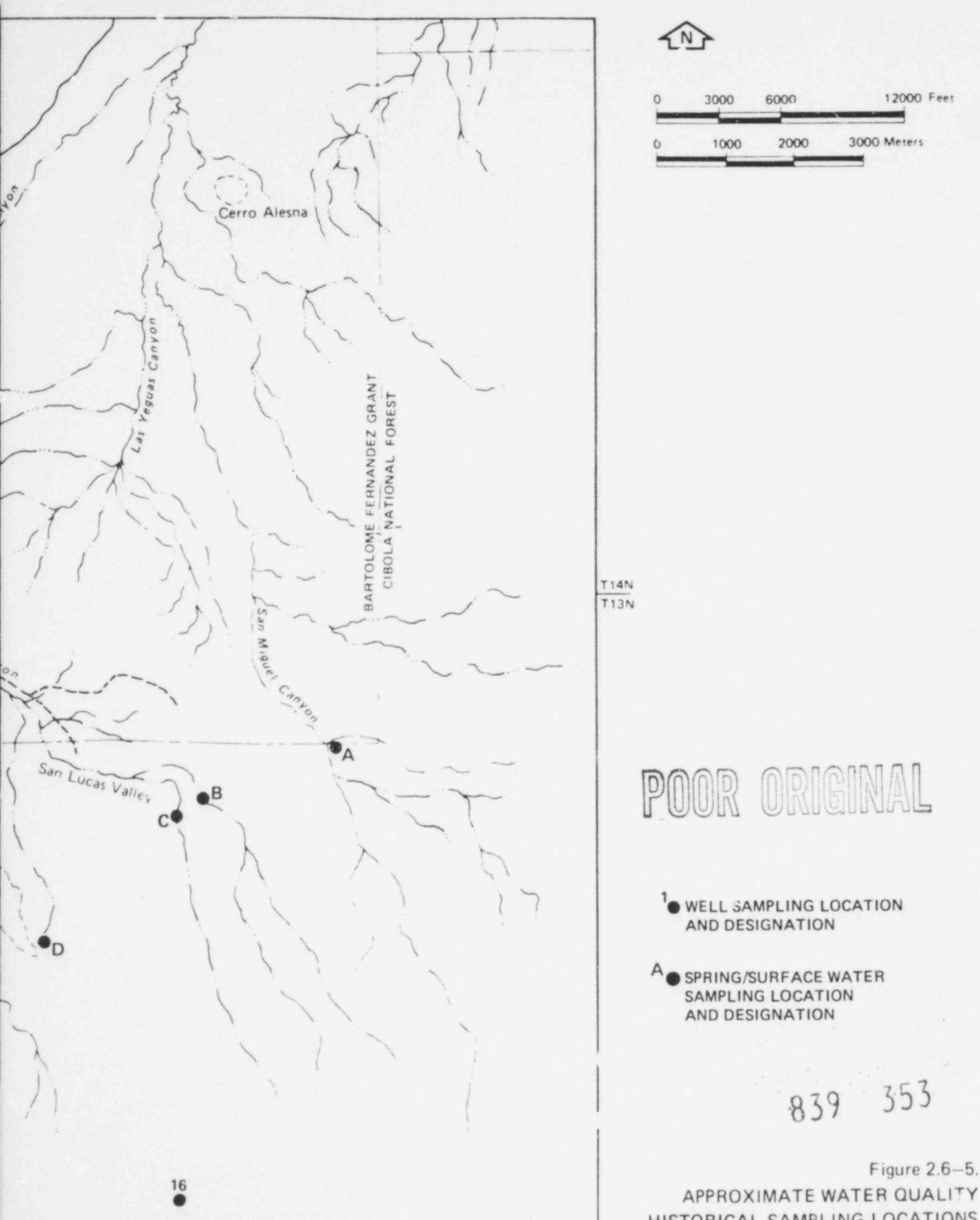


Source: Woodward-Clyde Consultants 1977

POOR ORIGINAL

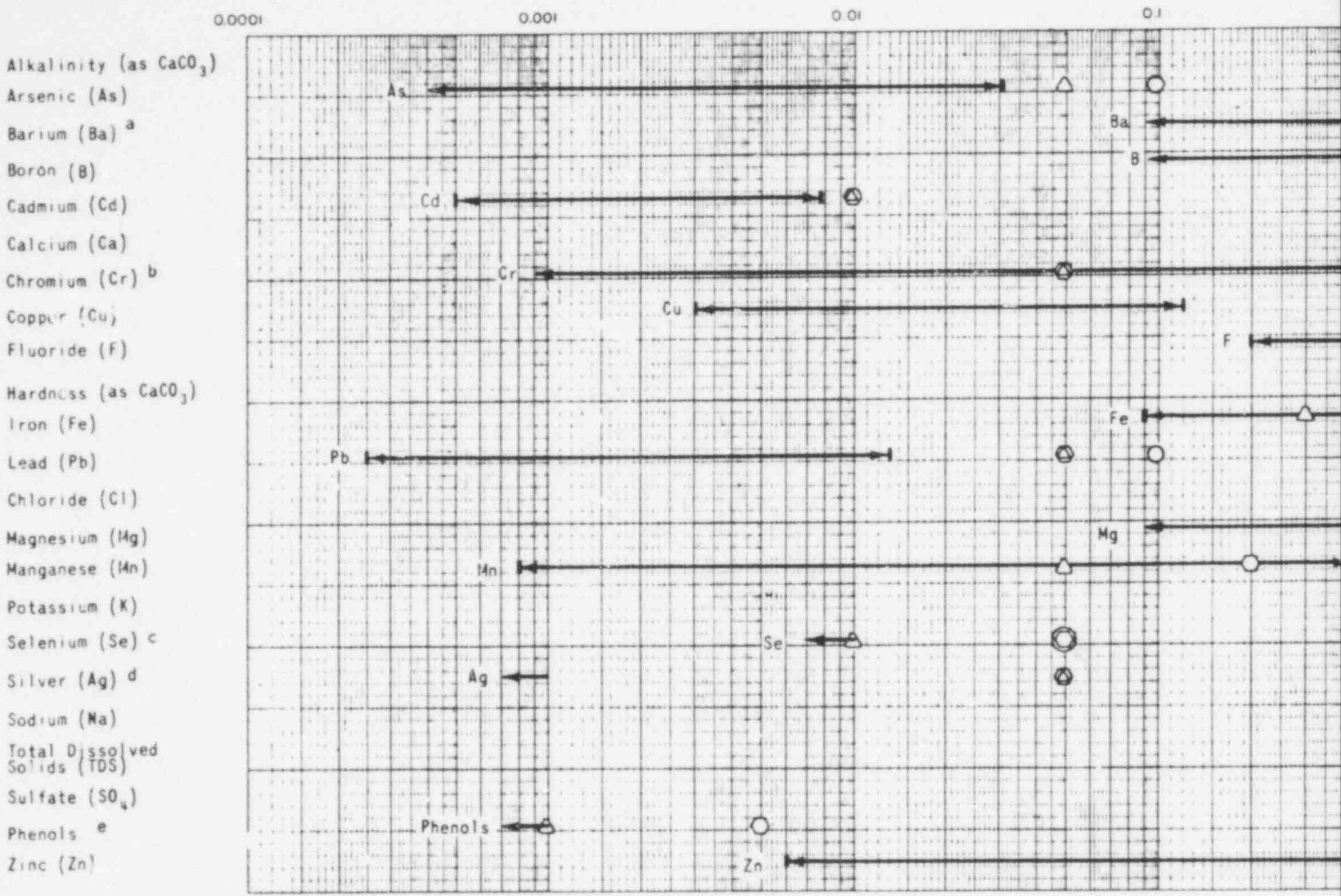
839 352



POOR ORIGINAL

839 353

Figure 2.6–5.
APPROXIMATE WATER QUALITY
HISTORICAL SAMPLING LOCATIONS



Range between these values.

Range less than value indicated when vertical line omitted.

[a]All samples analyzed for Barium were less than 1.0 mg/l

[b]All samples analyzed for Chromium were less than 1.0 mg/l

[c]One sample analyzed for Selenium was less than 0.01 mg/l

[d]One sample analyzed for Silver was less than 0.001 mg/l

[e]One sample analyzed for Phenols was less than 0.001 mg/l

[f]All samples analyzed for Bismuth were less than 0.0005 mg/l

[g]All samples analyzed

[h]All samples analyzed

[i]All samples analyzed

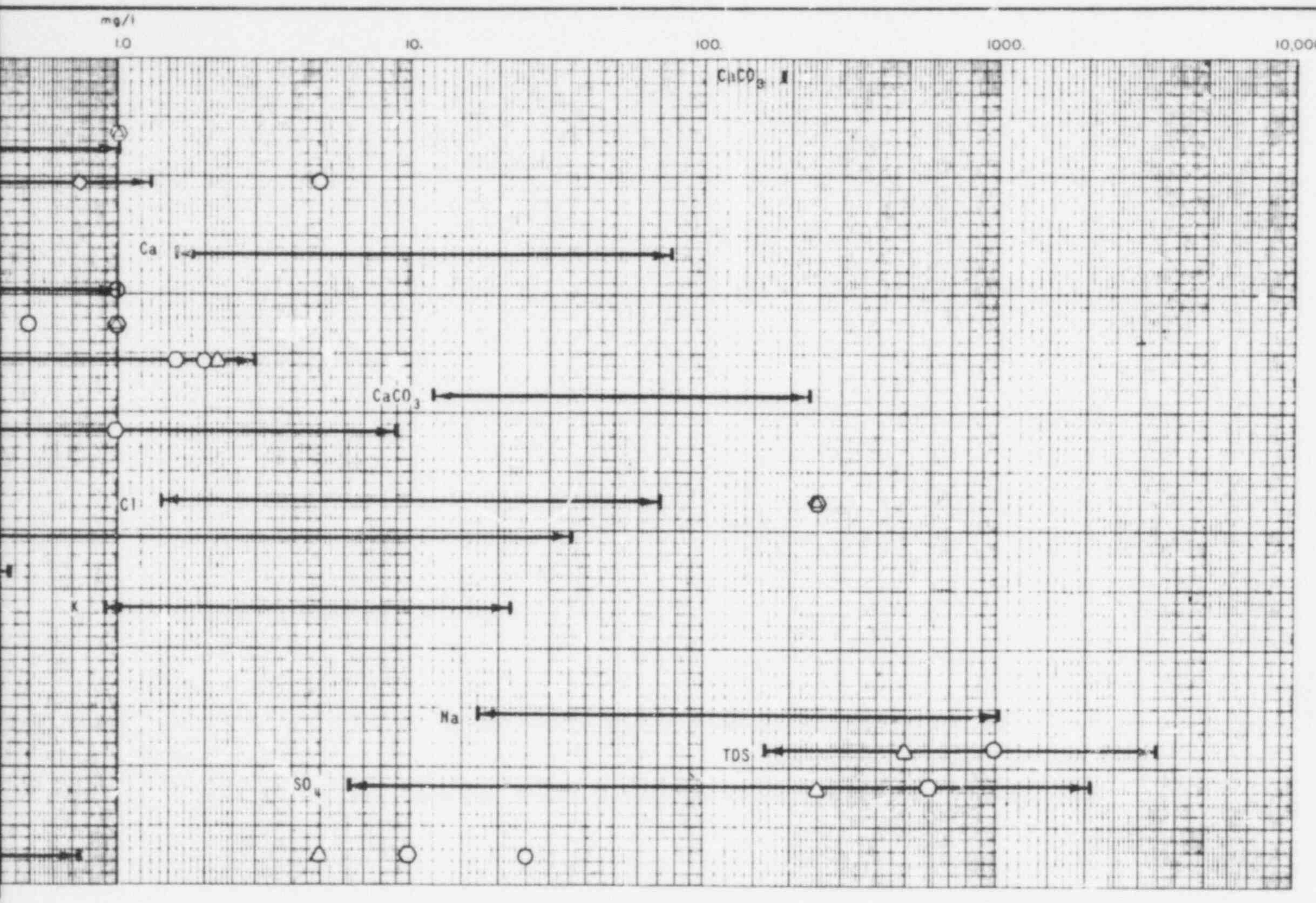
[j]All samples analyzed

[k]One sample analyzed

[l]One sample analyzed

[m]One sample analyzed

Source: Woodward-Clyde Consultants, 1977



for Cobalt were less than 0.001 mg/l

for Antimony were less than 0.0006 mg/l

for Molybdenum were less than 0.02 mg/l

for Mercury were less than 0.001 mg/l

for Carbonate was less than 0.1 mg/l

for Cyanide was less than 0.01 mg/l

for Strontium - 9^ was 0.0 ± 0.5 pCi/l

△ Maximum Permissible Concentration for Drinking Water, U.S. Public Health Service, 1962. Recommended Limit used where MPC not available.

○ Ground Water Quality Standards, New Mexico Environmental Improvement Agency (NMEIA), 1977.

○ Proposed EPA Criteria for Livestock.

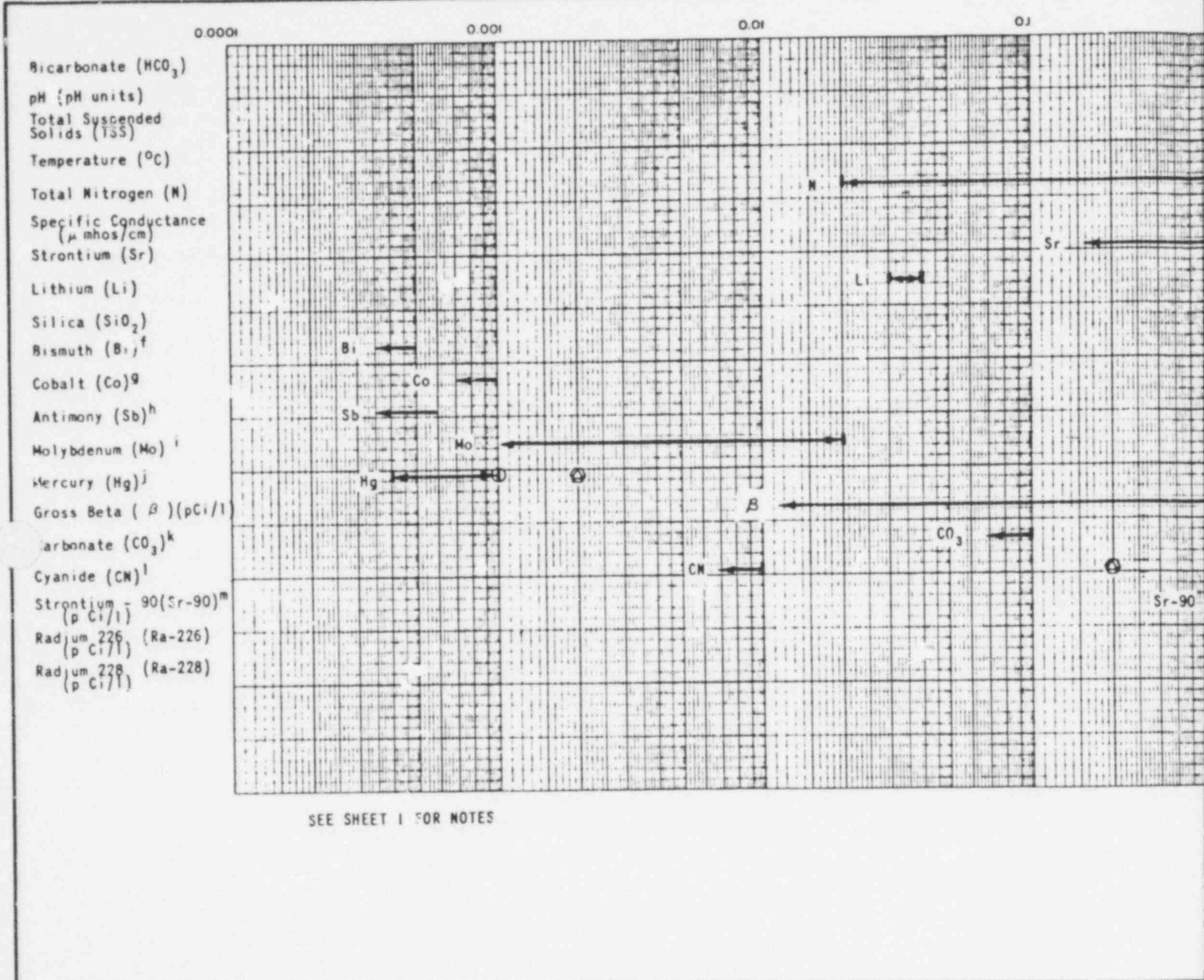
◇ Irrigation Standards for ground water, NMEIA, 1977.

Sheet 1 of 2

POOR ORIGINAL

837 353

Figure 2.6-6. SUMMARY, HISTORICAL WATER QUALITY ANALYSES, WELL SAMPLES

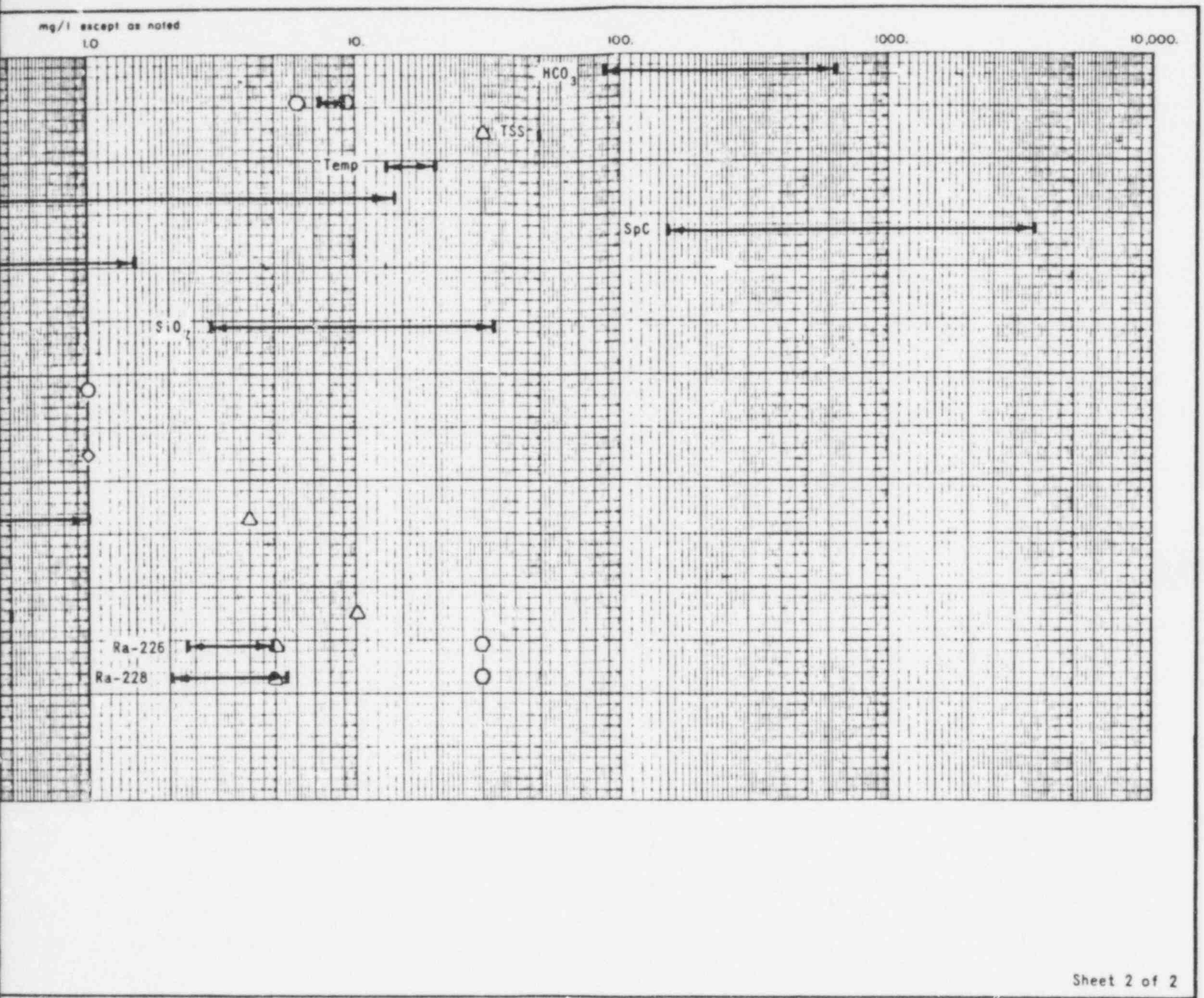


SEE SHEET 1 FOR NOTES

Source: Woodward-Clyde Consultants 1977

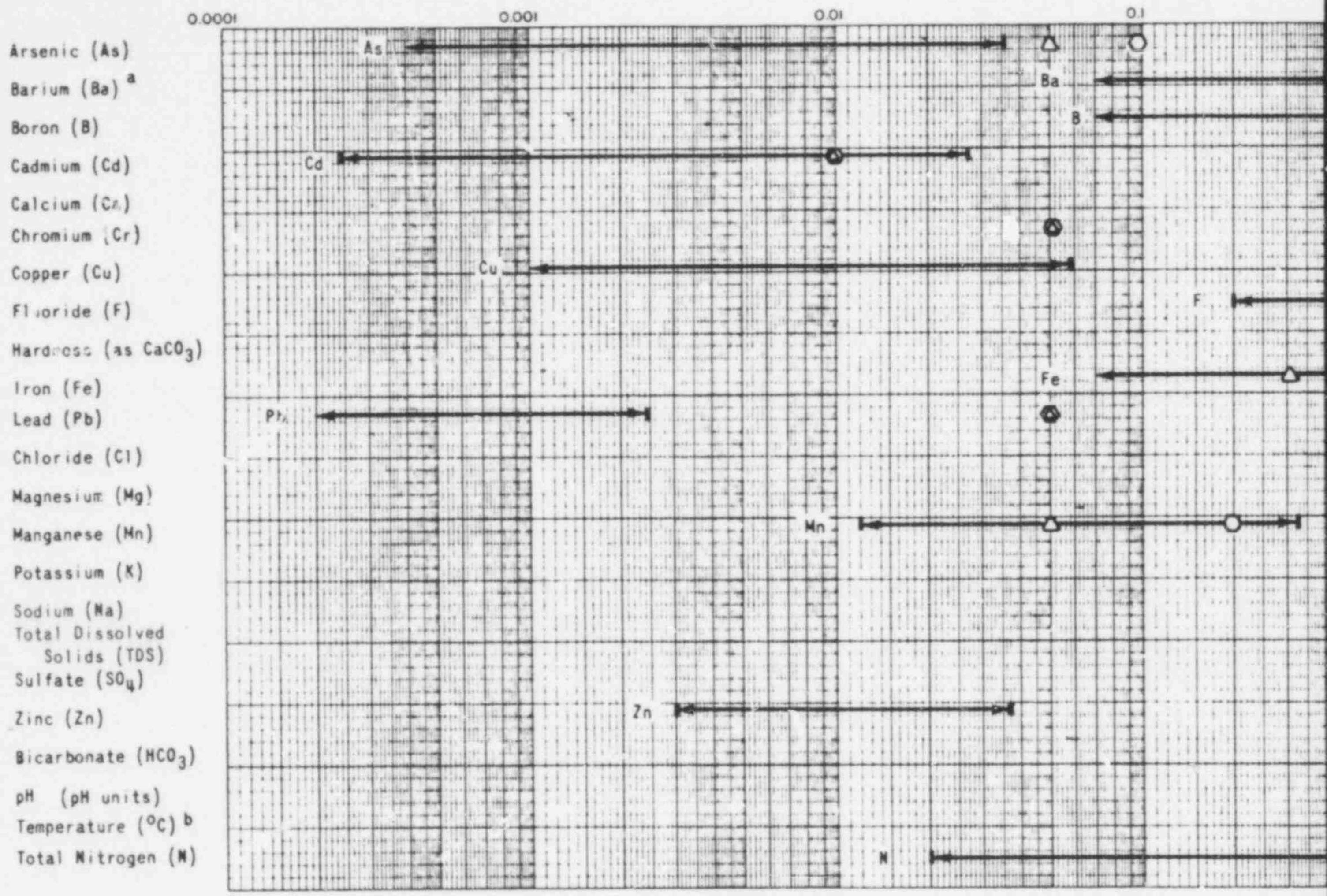
POOR ORIGINAL

839 356



839 357

Figure 2.6–6.
SUMMARY,
HISTORICAL WATER QUALITY ANALYSES,
WELL SAMPLES



Range between these values.

Range less than value indicated when vertical line omitted.

[a]All samples analyzed for Barium were less than 1.0 mg/l.

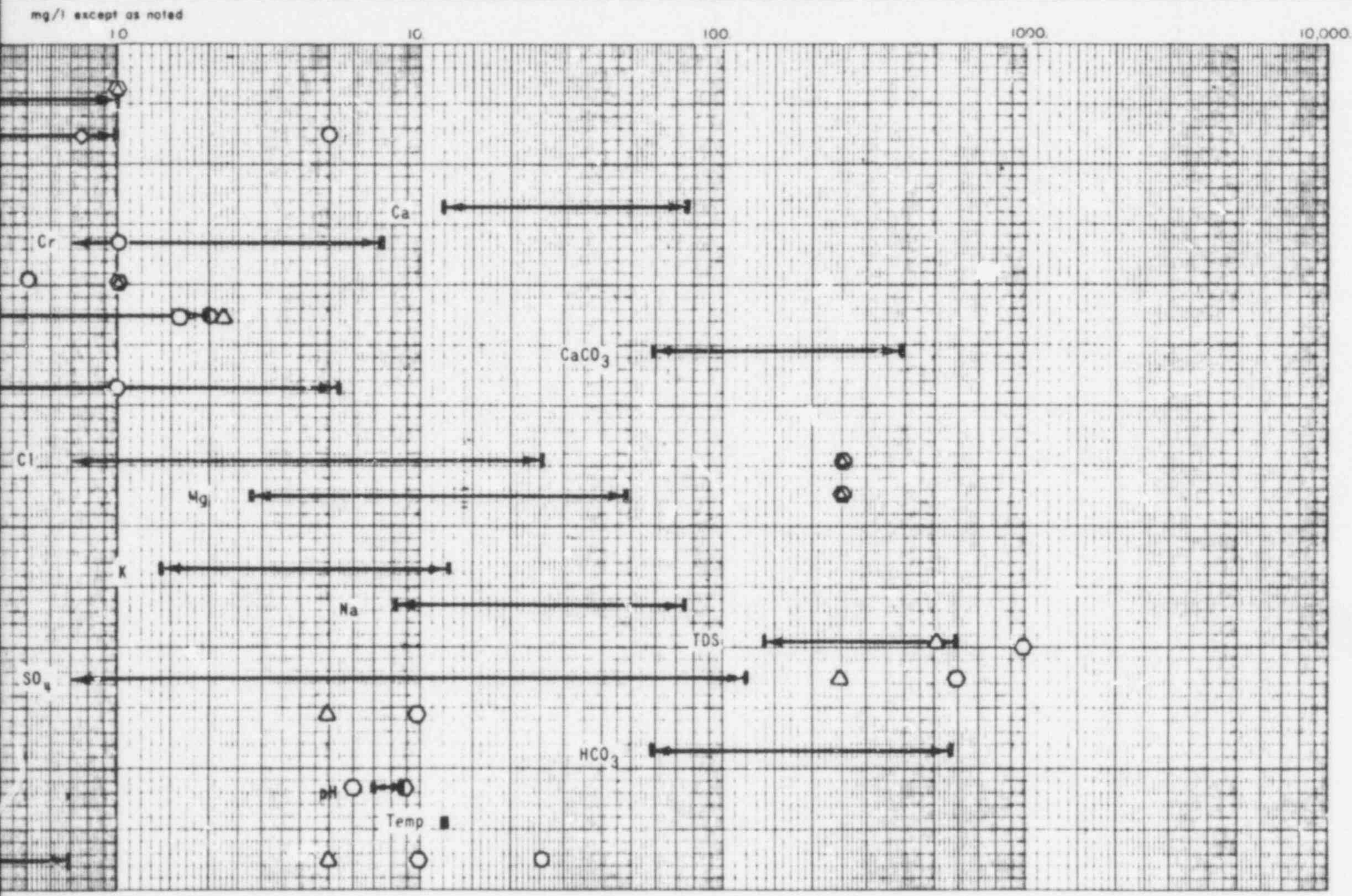
[b]Temperature ranges between 12° and 12.2°C.

△ Maximum Permissible Concentration for Drinking Water, U.S. Public Health Service, 1962. Recommended Limit used where MPC not available.

Source: Woodward-Clyde Consultants 1977

POOR ORIGINAL

839 358



round Water Quality Standards, New Mexico Environmental
mprovement Agency (NMEIA), 1977.

roposed EPA Criteria for Livestock.

rrigation Standards for ground water, NMEIA, 1977.

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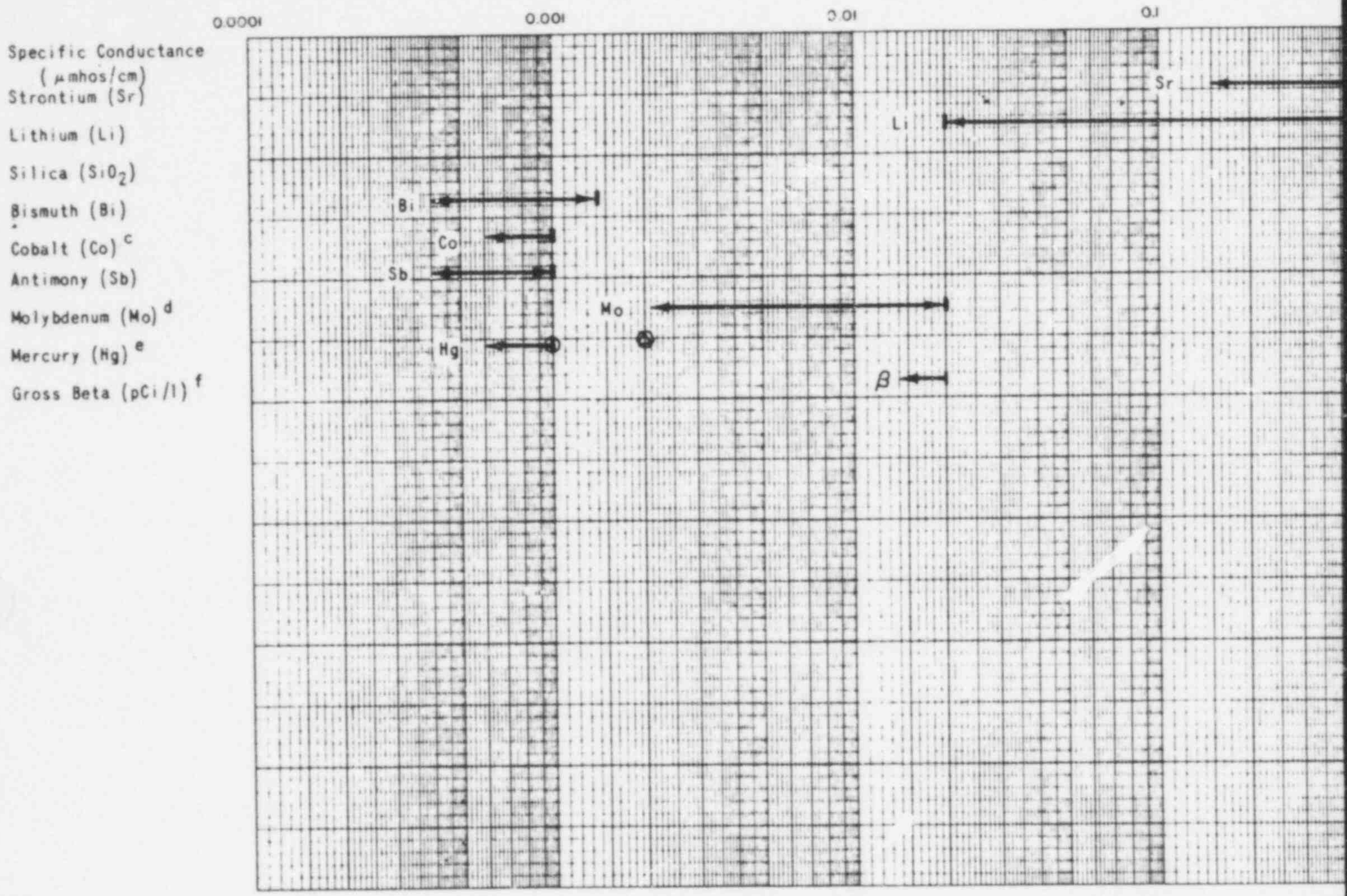
839 359

POOR ORIGINAL

Figure 2.6–7.
SUMMARY,
HISTORICAL WATER QUALITY ANALYSES,
SPRING AND SURFACE WATER SAMPLES



[c] All samples analyzed for Cobalt were less than 0.001 mg/l.

[d] All samples analyzed for Molybdenum were less than 0.02 mg/l.

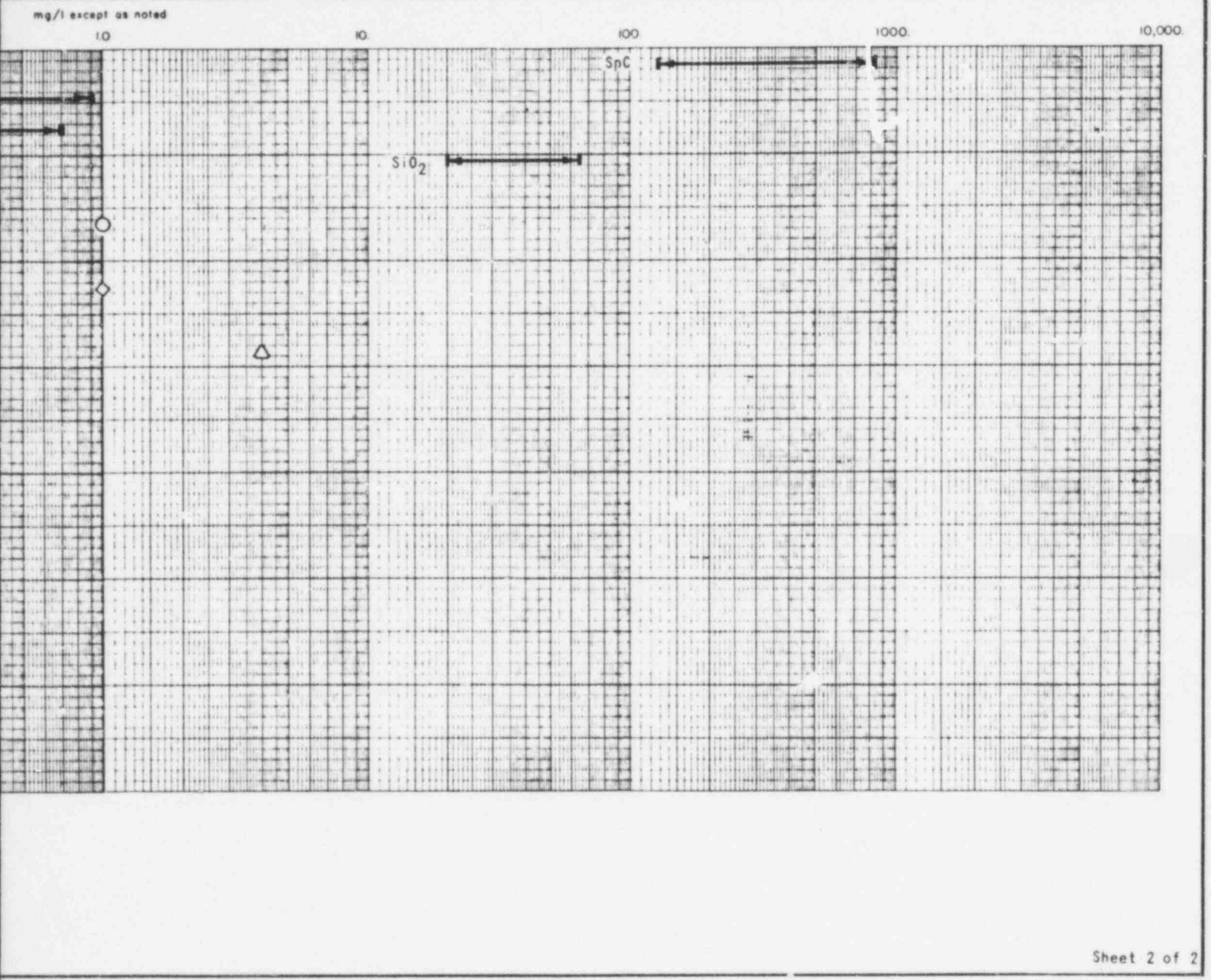
[e] All samples analyzed for Mercury were less than 0.001 mg/l.

[f] All samples analyzed for Gross Beta were less than 0.02 pCi/l.

Source: Woodward-Clyde Consultants :977

POOR ORIGINAL

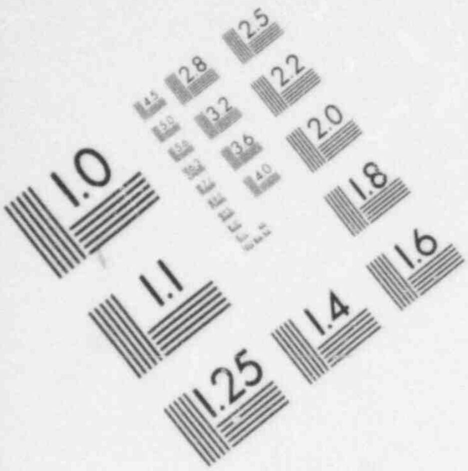
839 360



839 361

POOR ORIGINAL

Figure 2.6–7.
SUMMARY,
HISTORICAL WATER QUALITY ANALYSES,
SPRING AND SURFACE WATER SAMPLES



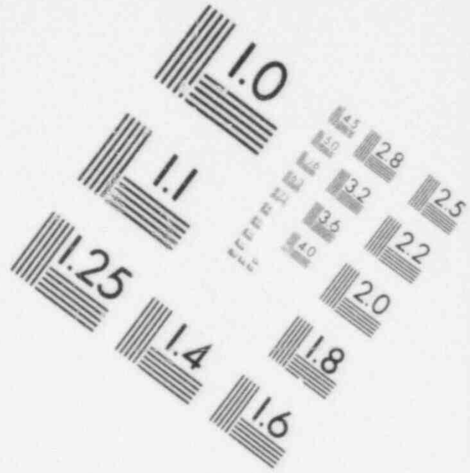
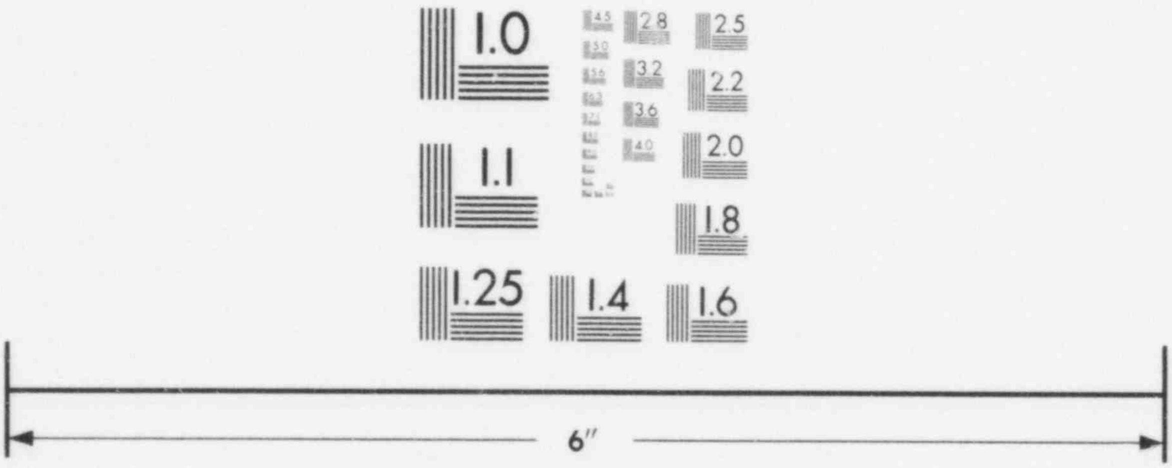
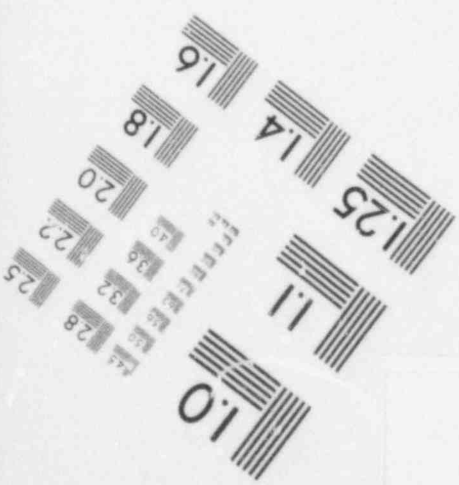
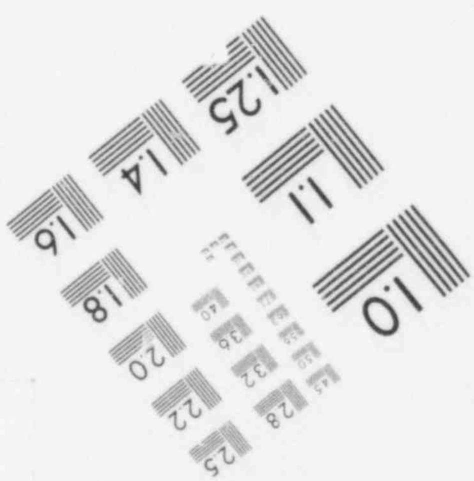
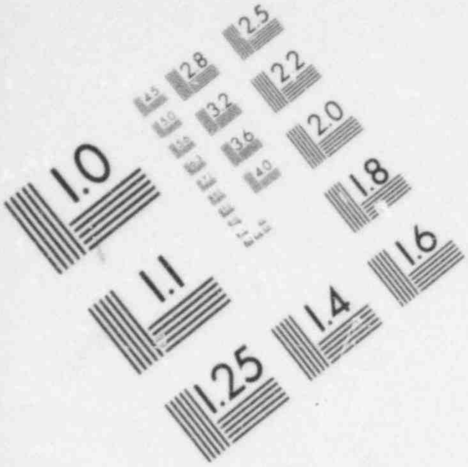


IMAGE EVALUATION TEST TARGET (MT-3)









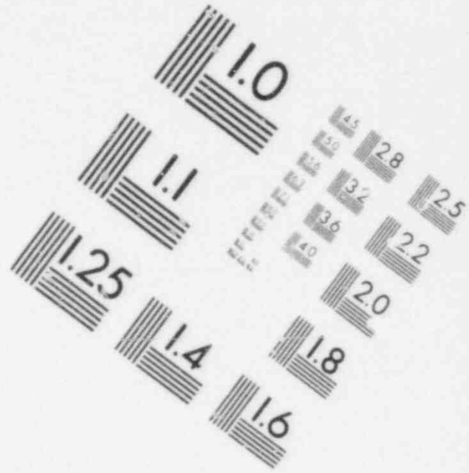
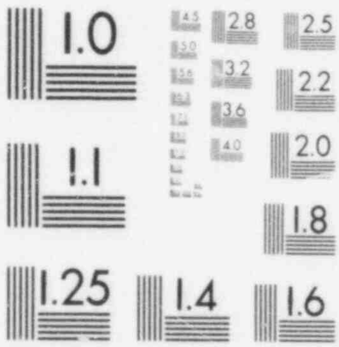
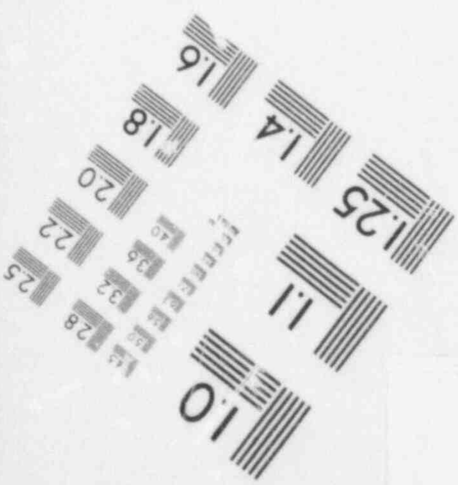
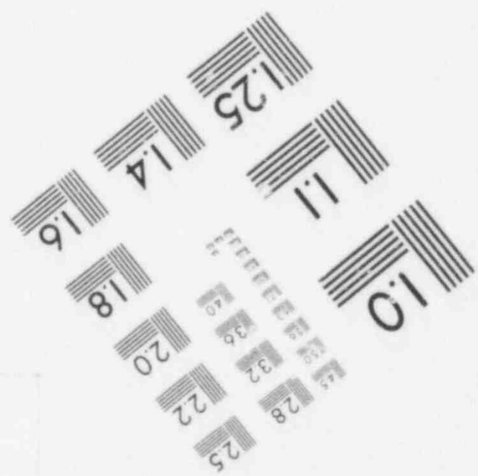


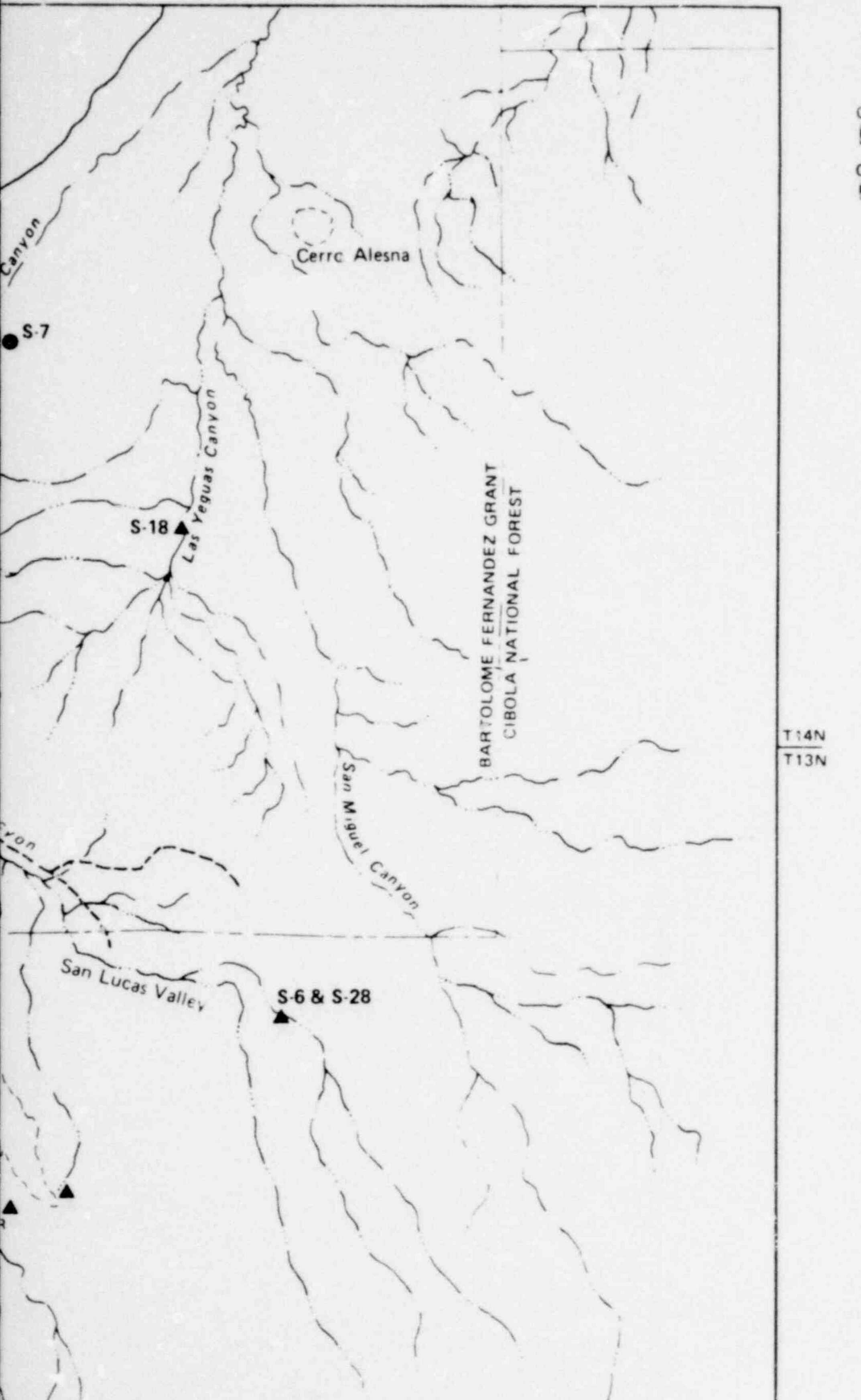
IMAGE EVALUATION TEST TARGET (MT-3)



6″



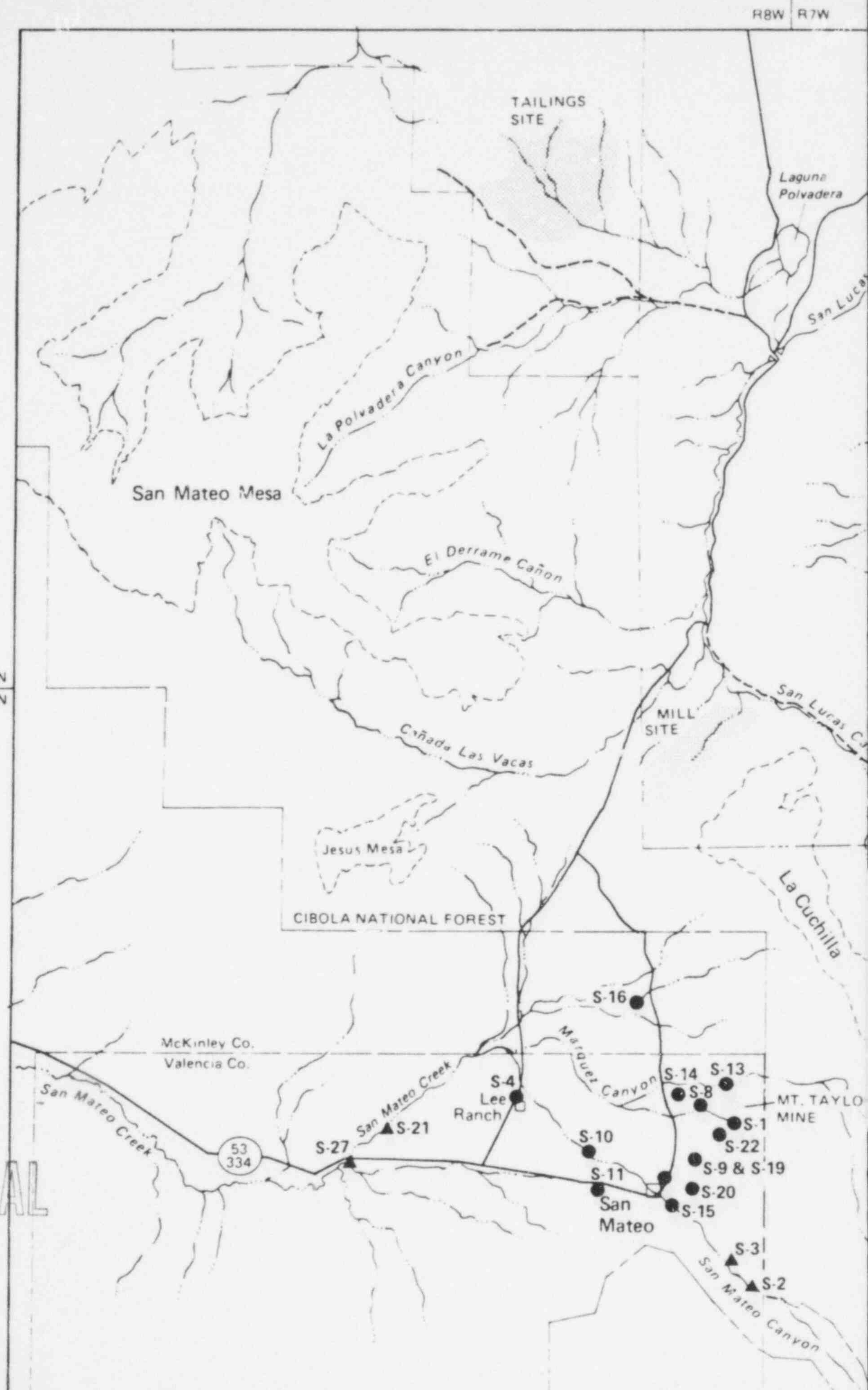




POOR ORIGINAL

840 001

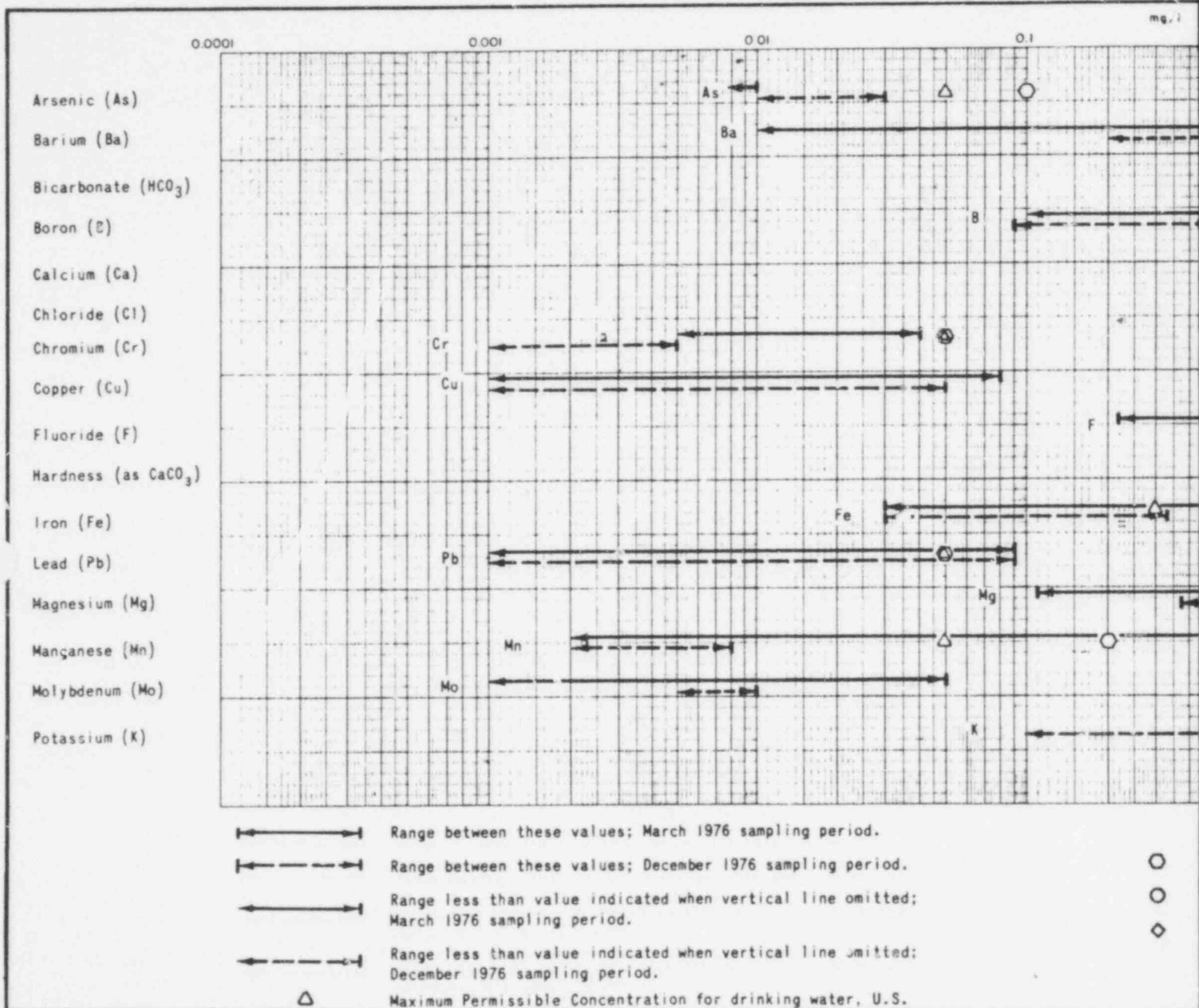
Figure 2.6–8.
APPROXIMATE WATER QUALITY SAMPLING LOCATIONS, MARCH AND DECEMBER 1976 SAMPLING PERIODS



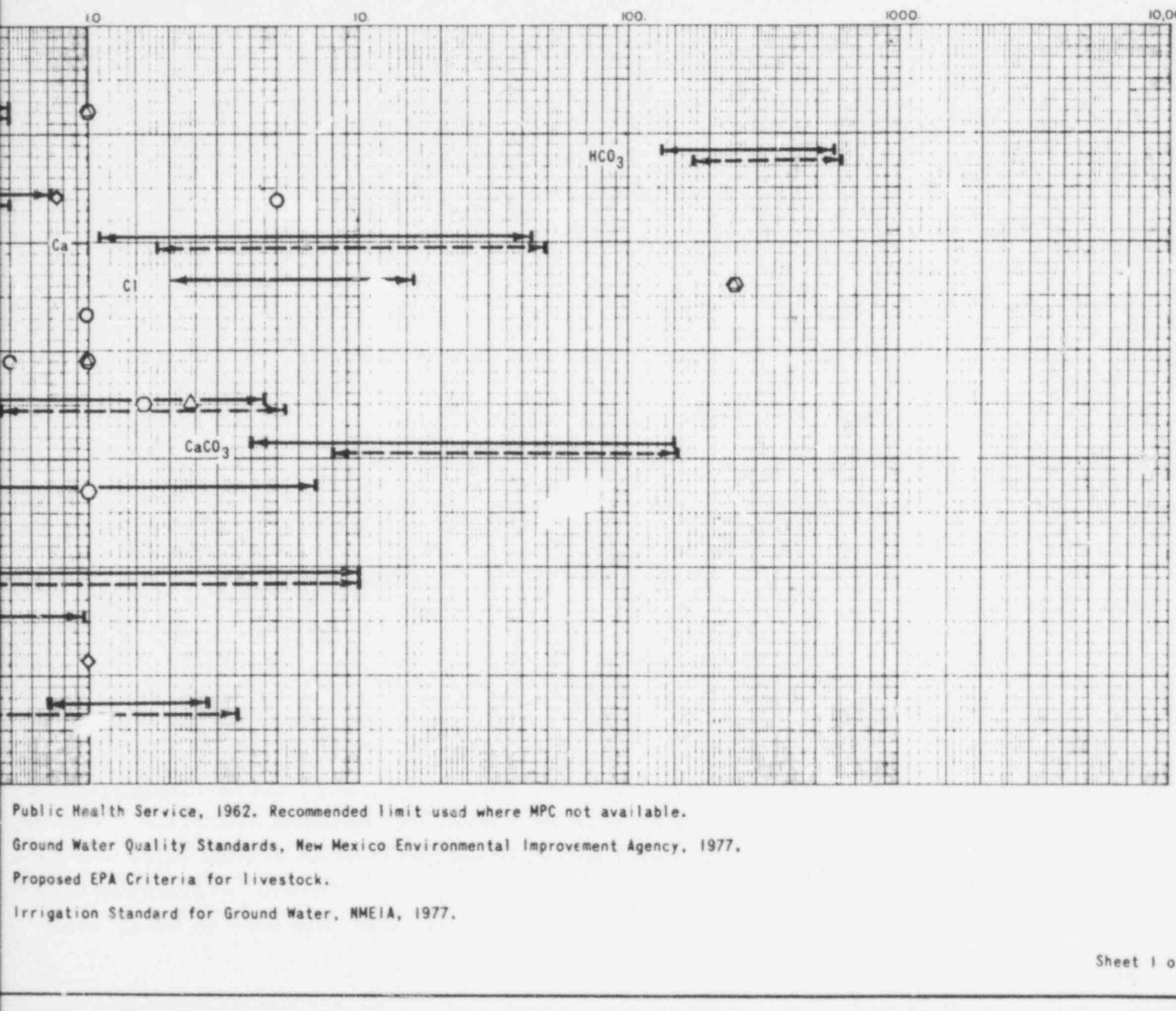
Source: Woodward-Clyde Consultants 1977

POOR ORIGINAL

840 002



Source: Woodward-Clyde Consultants 1977



Public Health Service, 1962. Recommended limit used where MPC not available.

Ground Water Quality Standards, New Mexico Environmental Improvement Agency, 1977.

Proposed EPA Criteria for livestock.

Irrigation Standard for Ground Water, NMEIA, 1977.

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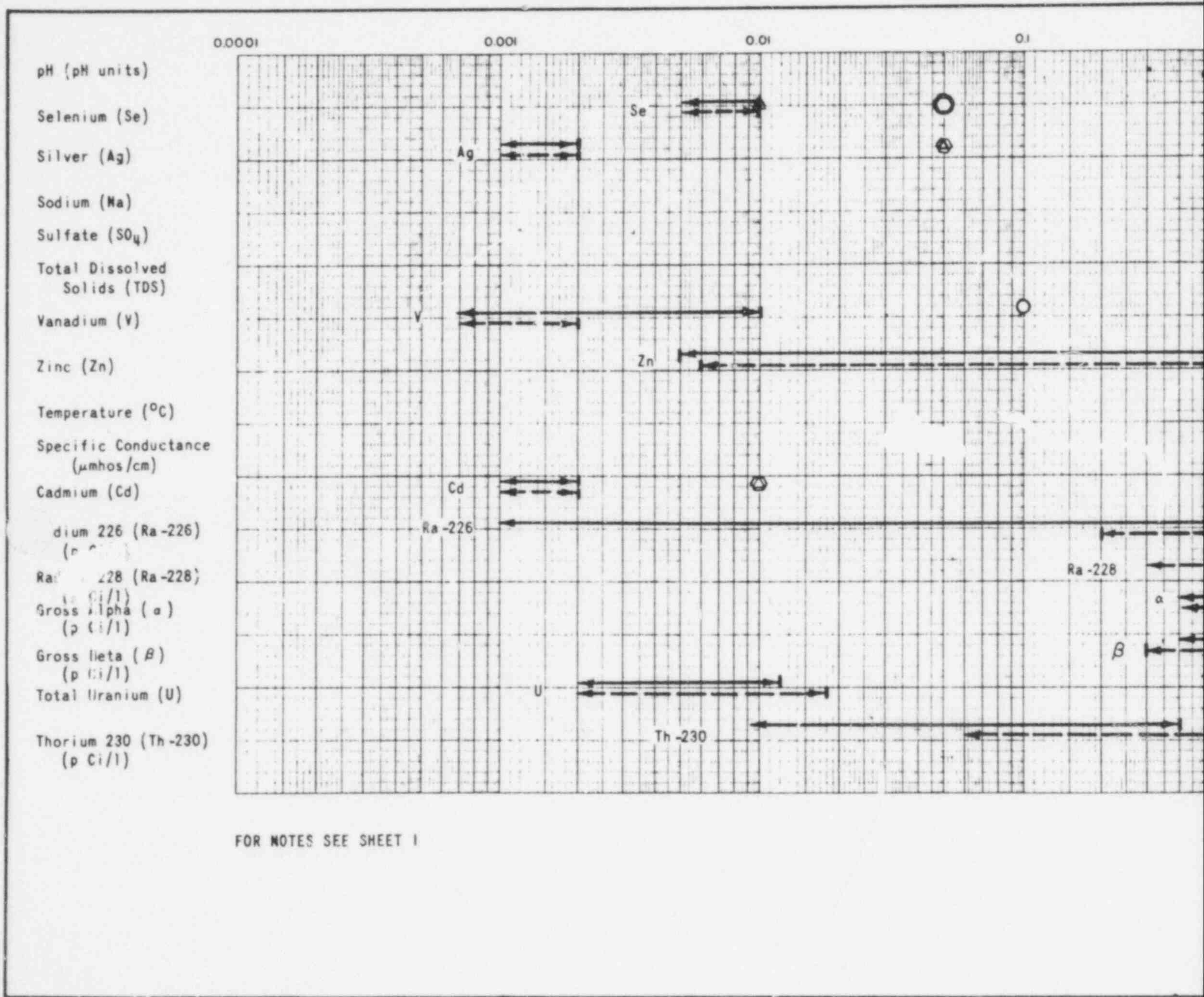
POOR ORIGINAL

840 004

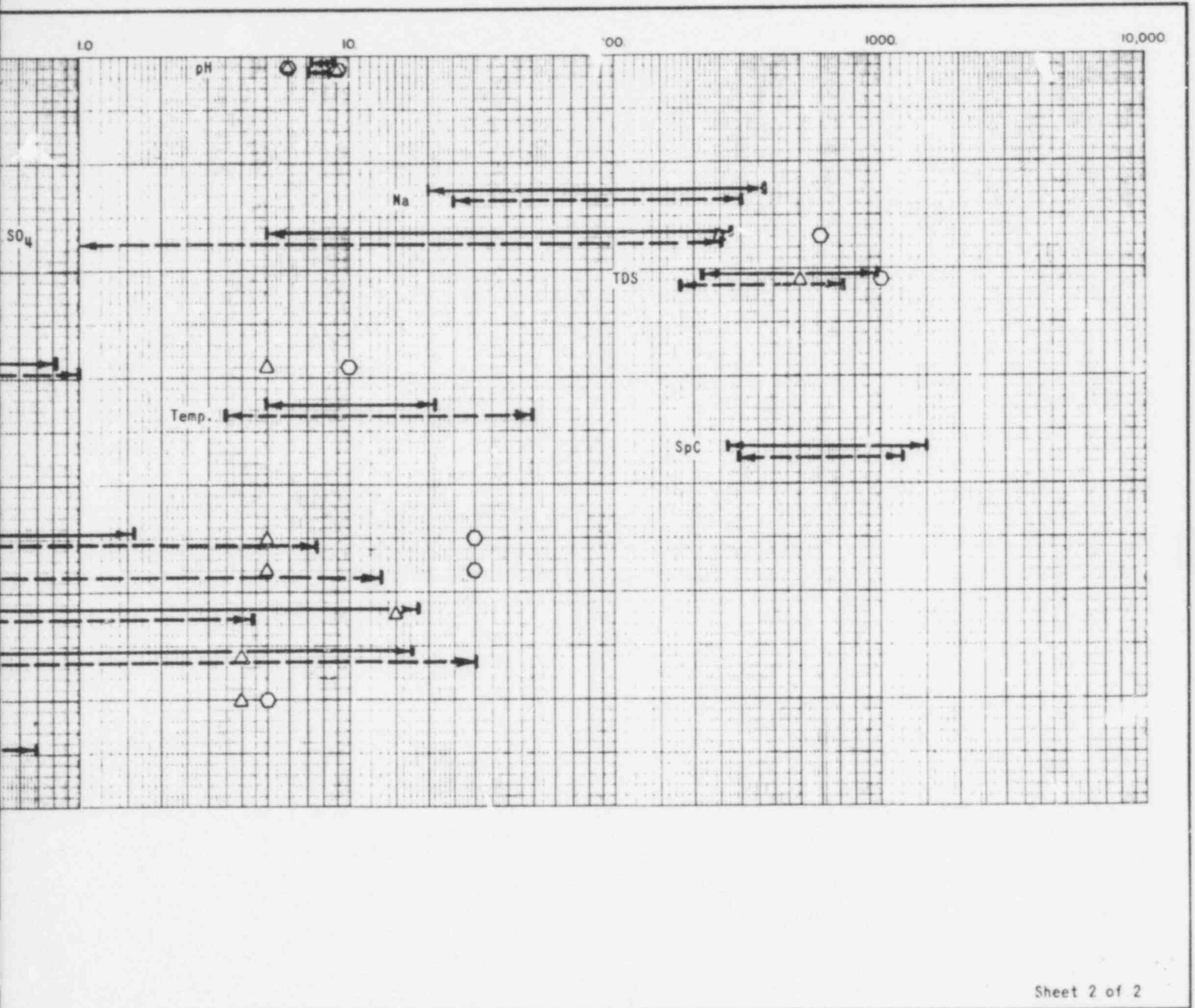
Figure 2.6–9.
SUMMARY,
WATER QUALITY ANALYSES,
WELL SAMPLES, MARCH AND
DECEMBER 1976 SAMPLING PERIODS



Source: Woodward-Clyde Consultants 1977

POOR ORIGINAL

840 005



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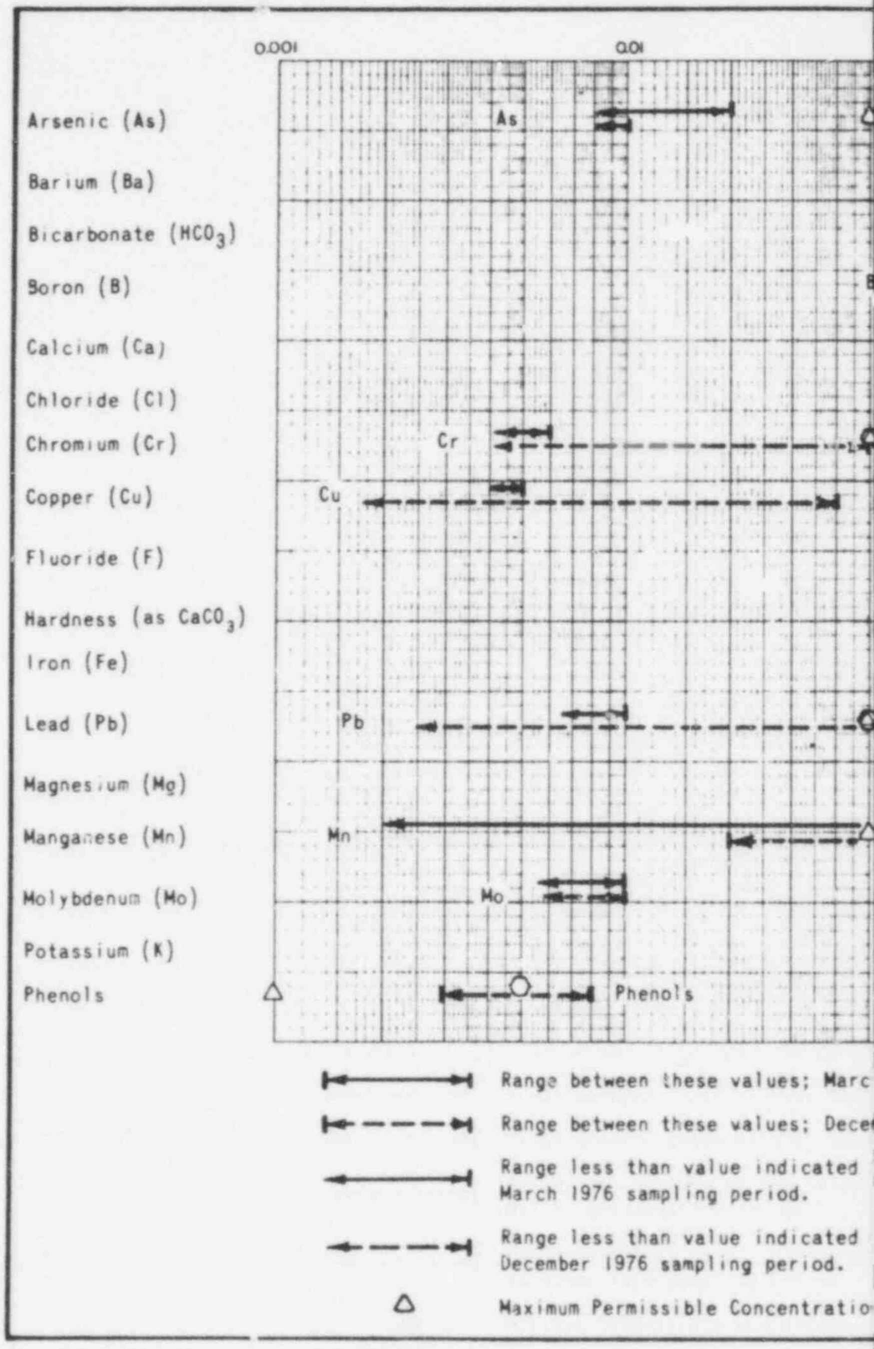
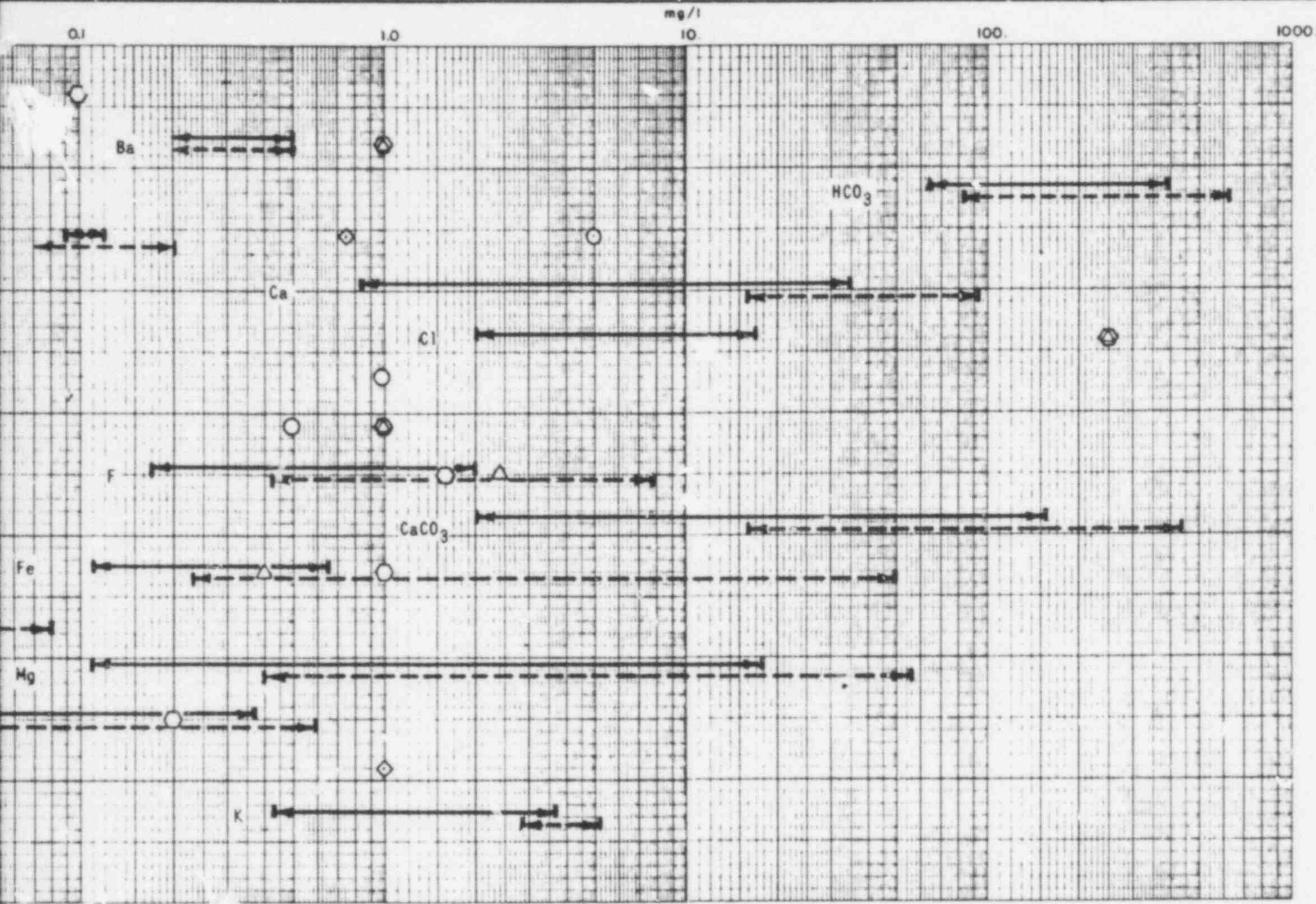
POOR ORIGINAL

Figure 2.6–9
SUMMARY,
WATER QUALITY ANALYSES,
WELL SAMPLES, MARCH AND
DECEMBER 1976 SAMPLING PERIODS



Source: Woodward-Clyde Consultants 1977

POOR ORIGINAL



1976 samp[illegible] period.

ber 1976 sampling period.

hen vertical line omitted;

hen vertical line omitted;

for drinking water. U.S. Public Health Service, 1962. Recommended limit used where MPC not avaliable.

○ Ground Water Quality Standards, New Mexico Environment Agency, 1977.

○ Proposed E.P.A. criteria for livestock consumption.

◇ Standards for ground water used for irrigation, New Mexico Environmental Improvement Agency, 1977.

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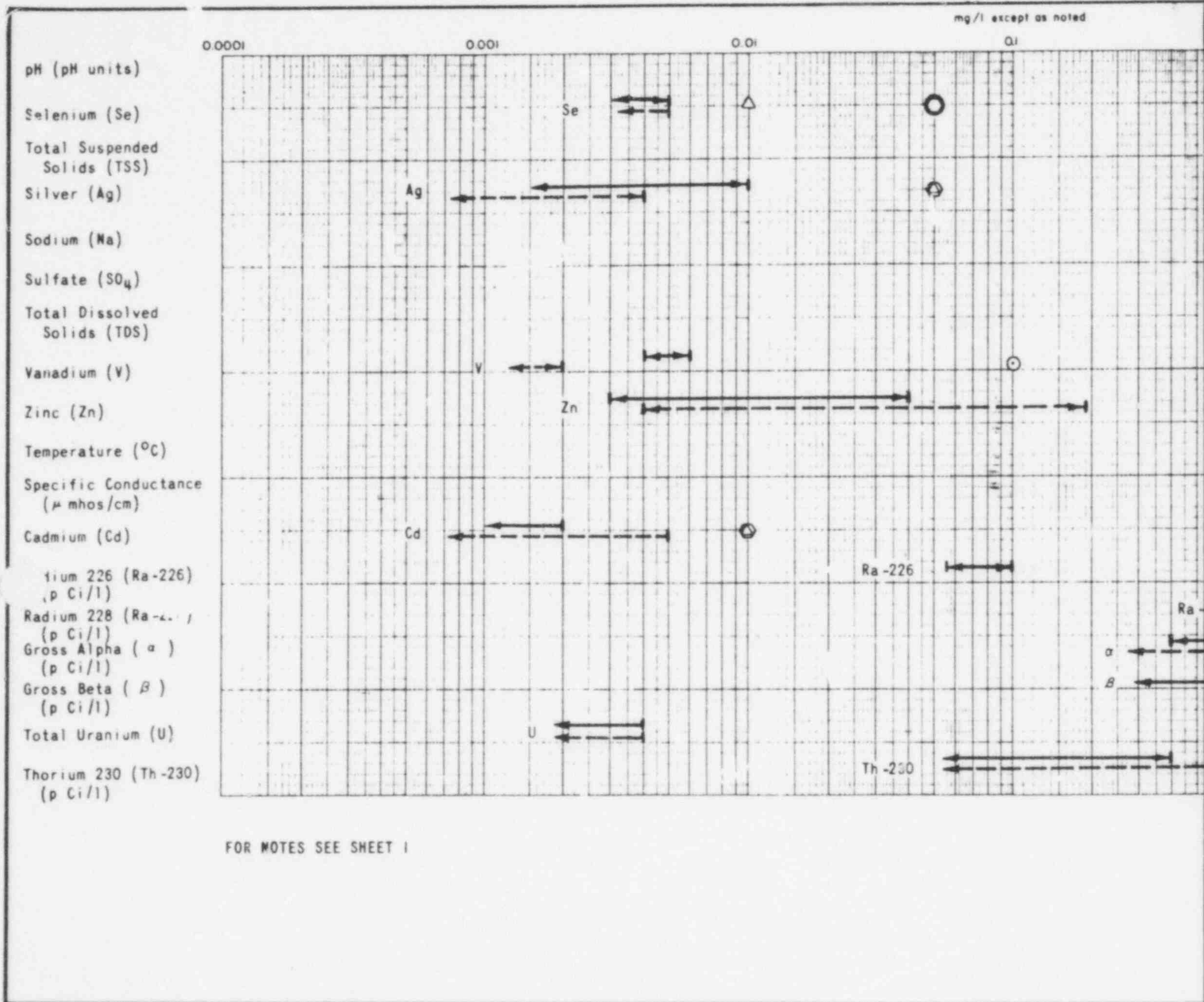
840 008

POOR ORIGINAL

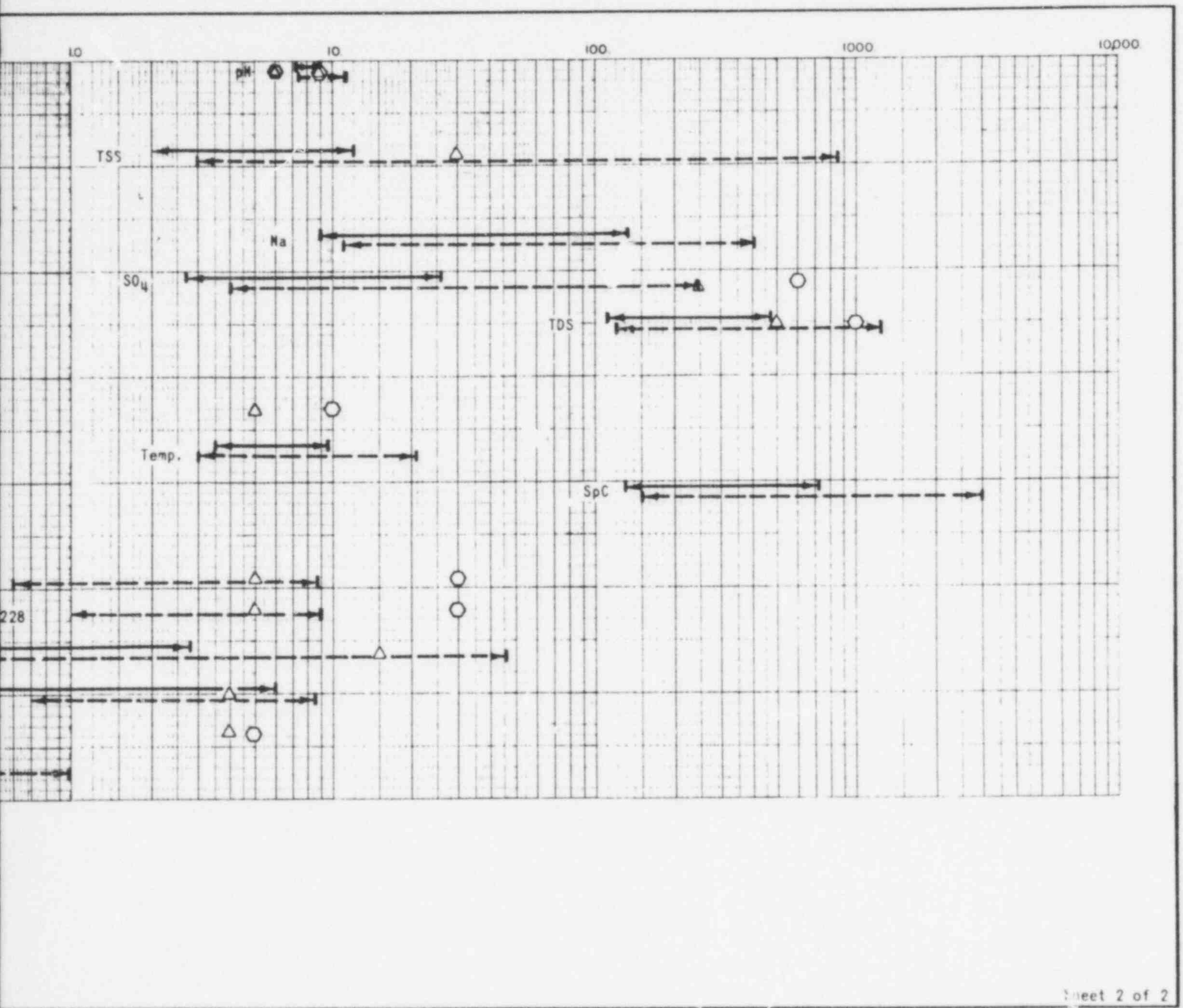
Figure 2.6–10.
SUMMARY,
WATER QUALITY ANALYSES,
SPRING AND SURFACE WATER SAMPLES,
MARCH AND DECEMBER 1976 SAMPLING PERIODS



Source: Woodward-Clyde Consultants 1977

POOR ORIGINAL

840 009



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POOR ORIGINAL

Figure 2.6–10.
SUMMARY,
WATER QUALITY ANALYSES,
SPRING AND SURFACE WATER SAMPLES,
MARCH & DECEMBER 1976 SAMPLING PERIODS

from springs in the Menefee aquifer is calcium bicarbonate. Some wells have high, but not dominant, sulfate concentrations. Comparison of the historical sampling with recent sampling indicates that the well and spring water have maintained the same relative concentrations of chemical parameters. The more recent water analyses, however, have shown lower total dissolved solids than in past years.

The quality of water in the Menefee aquifer is generally classified as good. The total dissolved solids concentration of this water is usually less than 1000 mg/l. Although a few parameters exceed water quality standards, the aquifer is a source of potable water supply.

Few water supply wells are drilled into the Westwater Canyon aquifer near the project area. Well water that was tested from this aquifer at a location (approximately four miles west of the site) contained 362 mg/l total dissolved solids. However, gross beta and radium-226 concentrations were 35 pCi/l and 8.5 pCi/l, respectively. Municipal water supply wells completed in the San Andres-Glorieta aquifer and springs discharging from the alluvial and volcanic aquifers all yield relatively good quality water.

As mentioned previously, ground water in the project area is primarily used for watering livestock and wildlife and it is anticipated that these uses will continue in the future. In addition, ground water will be used for human consumption and industrial process water. There are specific state and federal limitations applicable to drinking water (Table 2.6-8). In addition, the Environmental Protection Agency has published water quality criteria for a variety of uses, including livestock and wildlife consumption (EPA, 1976), and the New Mexico Environmental Improvement Division instituted irrigation standards in 1977 (Table 2.6-9). There are no criteria for industrial process water.

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POOR ORIGINAL

Table 2.6-8. WATER QUALITY STANDARDS

Chemical Constituents	Drinking Water Quality Standards[a] (total basis)			Ground Water Quality[b] (dissolved basis)	EPA Mine Effluent Limitations (mg/l)[c] (total basis)	
	Recommended Limit (mg/l unless noted otherwise)	Maximum Permissible Limit (mg/l)	Reason for Limit	Maximum Limit (mg/l)	Maximum for any 1 day	Ave[illegible]e Daily [illegible]al for 30 d[illegible] shall not [illegible]ed —
Arsenic	0.01	0.C5	Poisoning	0.1	1.0	0.5
Barium		1.0	Poisoning	1.0		
Cadmium		0.01	Poisoning	0.01	0.10	0.05
Chloride	250.0		Taste & laxative properties	250.0		
Chromium		0.05	Poisoning	0.05		
Copper	1.0		Taste	1.0		
Cyanide	0.01	0.2	Poisoning	0.2		
Fluoride	0.8 - 1.7	1.4 - 2.4	Mottling of teeth	1.6		
Iron	0.3		Staining, taste	1.0		
Lead		0.05	Poisoning	0.05		
Manganese	0.05		Staining, taste	0.2		
Mercury		0.002		0.002 (total)		
Nitrate (as N)		10.0	Methemoglobinemia in infants (blue babies)	10.0		
Phenols	0.001		Taste	0.005		
Strontium-90 (pCi/l)		10.0	Poisoning			
Selenium		0.01	Poisoning	0.05		
Sil[illegible]		0.05	Poisoning discoloration	0.05		
Sulfate		250.0	Taste & laxative properties	600.0		
Zinc	5.0		Taste	10.0	1.0	0.5
Total dissolved solids		500.0	Taste & Laxative properties	1000.0		
Suspended solids					30.0	20.0
Oil and grease						
Temperature (°F)						
pH (units)				6.0 - 9.0	6.0 - 9.0	
Radium-226 & radium-228 combined (pCi/l)		5.0	Poisoning	30.0		
Radium-226 (pCi/l)					10.0	3.0
Gross alpha (including radium-226 but excluding radon & uranium) (pCi)		15.0				
Gross beta radioactivity (total body or internal organ dose in millirem/year)		4.0				
Uranium				5.0	4.0	2.0
Chemical oxygen demand					200.0	100.0

[a] Drinking Water Quality Standards by U.S. Public Health Service and U.S. Environmental Protection Agency. Recommended limits should not be exceeded whenever more suitable water supplies are available at reasonable cost. Maximum permissible limits, if exceeded, are grounds for rejection of the water supply.

[b] New Mexico Environmental Improvement Agency Ground Water Quality Standards, 1977.

[c] U.S. Environmental Protection Agency, 40 CFR 440 - 41 FR 51722, Nov. 1975.

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Table 2.6-9. RECOMMENDED CRITERIA FOR SELECTED WATER USES[a] AND EXISTING NEW MEXICO STANDARDS[b]

Constitutent	Livestock[a] Consumption	Wildlife[a] Consumption	Irrigation Usage[b] of Ground Water
pH	-	6.0 - 9.0	-
Alkalinity	-	30 - 130	-
Al	5.0	-	5.0
As	0.2	-	-
Be	No Limit	-	-
B	5.0	-	0.75
Cd (μg/l)	50.0	-	-
Cr	1.0	-	-
Co	1.0	-	0.05
Cu	0.5	-	-
F	2.0	-	-
Fe	No Limit	-	-
Pb	0.1	-	-
Mn	No Limit	-	-
Hg - Inorganic (μg/l)	1.0	0.5μg/g in fish	-
Mo	No Limit	-	1.0
Ni	-	-	0.2
NO_3	100 combined NO_3 and NO_2	-	-
NO_2	10.0	-	-
Se	0.05	-	-
V	0.1	-	-
Zn	25.0	-	-
Microorganisms	500 coliforms/100 ml avg. of a minimum of 2 samples/month; 20,000/100 ml individual sample	2000/100 ml	-
Fecal Coliforms	1000/100 ml average of a minimum of 2 samples/ month; 4000/100 ml individual sample	2000/100 ml	-
Radioactivity	Same as Federal Drinking Water Standards	-	-

[a]Recommended criteria for these water uses are from U.S. Environmental Protection Agency (1973). The latest version of Water Quality Standards in U.S. EPA's Quality Criteria for Water (1976) does not deal with these water uses.

[b]New Mexico Environmental Improvement Agency, Ground Water Quality Standards, 1977.

Note: Criteria given in mg/l unless otherwise indicated.

Results of historical water quality analyses (Tables B-1 and B-2) show that several samples exceed limits recommended by EPA and NMEID (Tables 2.6-8 and 2.6-9). The maximum permissible concentration of 500 mg/l TDS in drinking water is exceeded by samples from eight wells and one spring. However, only Sample Nos. 1 (1445 mg/l) and 19 (3460 mg/l) exceed 1,000 mg/l, the maximum limit set by NMEID. The recommended limit of 0.3 mg/l for iron is exceeded by five ground-water samples and five spring samples. Samples Nos. 1, 9, 11, 12 and B exceed the NMEID limit of 1.0 mg/l for iron; sample No. 1 contained 9.0 mg/l, while the other four ranged between 1.5 and 5.4 mg/l. Sample Nos. 1, 9, 20, B and G exceeded the recommended limit of .05 mg/l for manganese, while only Sample Nos. 1, 9 and G exceeded the NMEID limit of 0.2 mg/l; Sample No. 9 had the maximum concentration of 0.43 mg/l. The maximum drinking water limit of 2.4 mg/l for fluoride was exceeded by two samples, No. 11 (3.0 mg/l) and No. 12 (2.8 mg/l). Sample Nos. 1, 19 and 20 exceeded the maximum limit of 250 mg/l for sulfate, but only sample No. 19 (2093 mg/l) exceeded 500 mg/l. Sample No. D exceeded drinking water limits for chromium and cadmium. Sample Nos. 1, 11, 12, 16, B and D, with concentrations of boron ranging between 0.8 and 1.3 mg/l, exceeded the NMEID limitation of 0.75 mg/l for irrigation usage of ground water. None of the historical water quality samples appear to exceed recommended EPA limitations for stock watering.

The water quality parameters analyzed during the March 1976 sampling period are consistent with the historical data. The drinking water limitation of 500 mg/l is exceeded by samples 8, 11, 12, 14, 16 and 20, which have TDS concentrations ranging from 534 to 978 mg/l. The drinking water limitation of 2.4 mg/l for fluoride is exceeded by Sample Nos. 11, 16 and 20, with fluoride concentrations ranging from 2.6 to 4.5 mg/l. The recommended limit for iron (0.3 mg/l) is exceeded by five ground-water samples, two surface water samples the one spring sample; however, only three samples, Numbers 1 (1.2 mg/l), 15 (5.0 mg/l) and 16 (6.9 mg/l)

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exceeded the NMEID limit of 1.0 mg/l. Samples 6, 15, 16 and 21 exceeded the recommended limit of 0.05 mg/l for manganese; Sample 15 had the maximum concentration of 0.95 mg/l. The drinking water limit of 0.05 mg/l of lead was exceeded by one sample, No. 8, with 0.08 mg/l. The drinking water limit of 250 mg/l of sulfate was exceeded by one sample, No. 16, with 277 mg/l.

Results of the December 1976 sampling are generally consistent with the March sampling and the historical data. Several samples (6, 8, 13, 20, 22, 27 and 28) exceed the drinking water limit of 500 mg/l TDS, but only one, Number 27, with 1230 mg/l, exceeds 1,000 mg/l. Four samples, Numbers 3, 13, 20 and 27, with fluoride concentrations ranging from 2.6 to 7.6 mg/l, exceed the drinking water limitation of 2.4 mg/l. Four samples (Numbers 6, 13, 27 and 28) exceeded the recommended limit for iron, and four samples (Numbers 5, 6, 27, and 28) exceeded the recommended limit for manganese. The drinking water limit of 0.05 mg/l lead was exceeded by two samples, Numbers 12 (.09 mg/l) and 27 (.08 mg/l). Sample Number 22, with a sulfate concentration of 257 mg/l, just exceeded the drinking water limit of 250 mg/l. All of the surface water and spring samples, with phenol concentrations ranging from 0.003 to 0.008 mg/l, exceeded the recommended limit of 0.001 mg/l. Samples S-20 and S-27 generally exceeded drinking water standards for radioactivity.

Several of the water quality samples from the project area exceed some of the limitations for drinking water. However, in general, the water quality parameters analyzed in this study were well below the suggested limits for livestock and wildlife consumption provided in the proposed EPA and NMEID criteria (including those for trace elements and radiochemical species).

840 015

2.7 METEOROLOGY AND AIR QUALITY

2.7.1 Regional Climatology and Topographical Influences

The project area is located in the "Southwestern Mountains" climatological subdivision of New Mexico, an area characterized by low (and highly variable) precipitation amounts, abundant sunshine, low relative humidity, and moderate temperatures with large diurnal and annual ranges. The regional climate may be considered as semi-arid, continental (BSw, or Steppe with a winter dry season, in the Köppen system) (Visher, 1966).

Synoptic scale meteorological influences are relatively weak; therefore, the regional and local topography play an important role in determining the climate. The project area is located east of the continental divide in broken mesa country at the base of the western foothills of the San Mateo mountains. These mountains, consisting of San Mateo Mesa to the immediate west, Mt. Taylor to the southeast and the Mesa Chivato to the east, range in peak elevation from about 8000 feet MSL to over 11,000 feet MSL. These topographical features present significant blocking influences to synoptic scale winds and modify the wind regime in the project area.

The mill site lies on relatively flat to gently sloping terrain, at an elevation of 7200 feet MSL, at the base of the northwest extremity of La Cuchilla Mesa. The mesa rises to a height of approximately 7800 feet MSL about one half mile to the east and southeast of the mill site. To the immediate north of the mill, the terrain is relatively flat. San Lucas Canyon, oriented north-south, lies approximately one mile north of the mill site with steeply rising topography on either side of the canyon; to the west, Jesus Mesa rises to an elevation of 7700 feet at two miles from the mill site; to the southwest the terrain is relatively flat and open.

840 016

These terrain factors suggest a strong diurnally controlled wind regime with nighttime winds draining down from the mesa walls and slopes located to the immediate east and south of the mill. During the daytime there is a reversal of this pattern, although some overriding synoptic-scale influences may be anticipated during the daytime mixing periods.

The tailings pond site lies in relatively flat terrain in the western third of the La Polvadèra Valley area, at an elevation of about 7200 feet MSL. San Mateo Mesa is one mile to the west and southwest of the proposed tailings area and rises steeply to an elevation of approximately 8000 feet MSL. Mesas and low ridges at elevations varying from 7500 to 8000 feet MSL are found at distances of 2 to 3 miles to the southwest, south, and southeast. The terrain is open and relatively flat in the north and east quadrants with the exception of ridges which rise to approximately 7300 to 7400 feet about two miles from the mill site. These terrain features at the tailings area indicate topographically controlled diurnal wind regime directly opposite to that of the mill site (4.5 miles to the south), with prevailing directions from the north through east during the daytime hours and from the south through west (down the La Polvadera Canyon) during the nighttime hours.

The diurnal wind patterns associated with the local topographical features described above have been substantiated by onsite data collected at specific site locations within the project area; these will be discussed in further detail in subsequent sections of this report.

Temperature, relative humidity, precipitation, and evaporation can be expected to be comparable to those found in other stations at similar altitudes in the region.

840 017

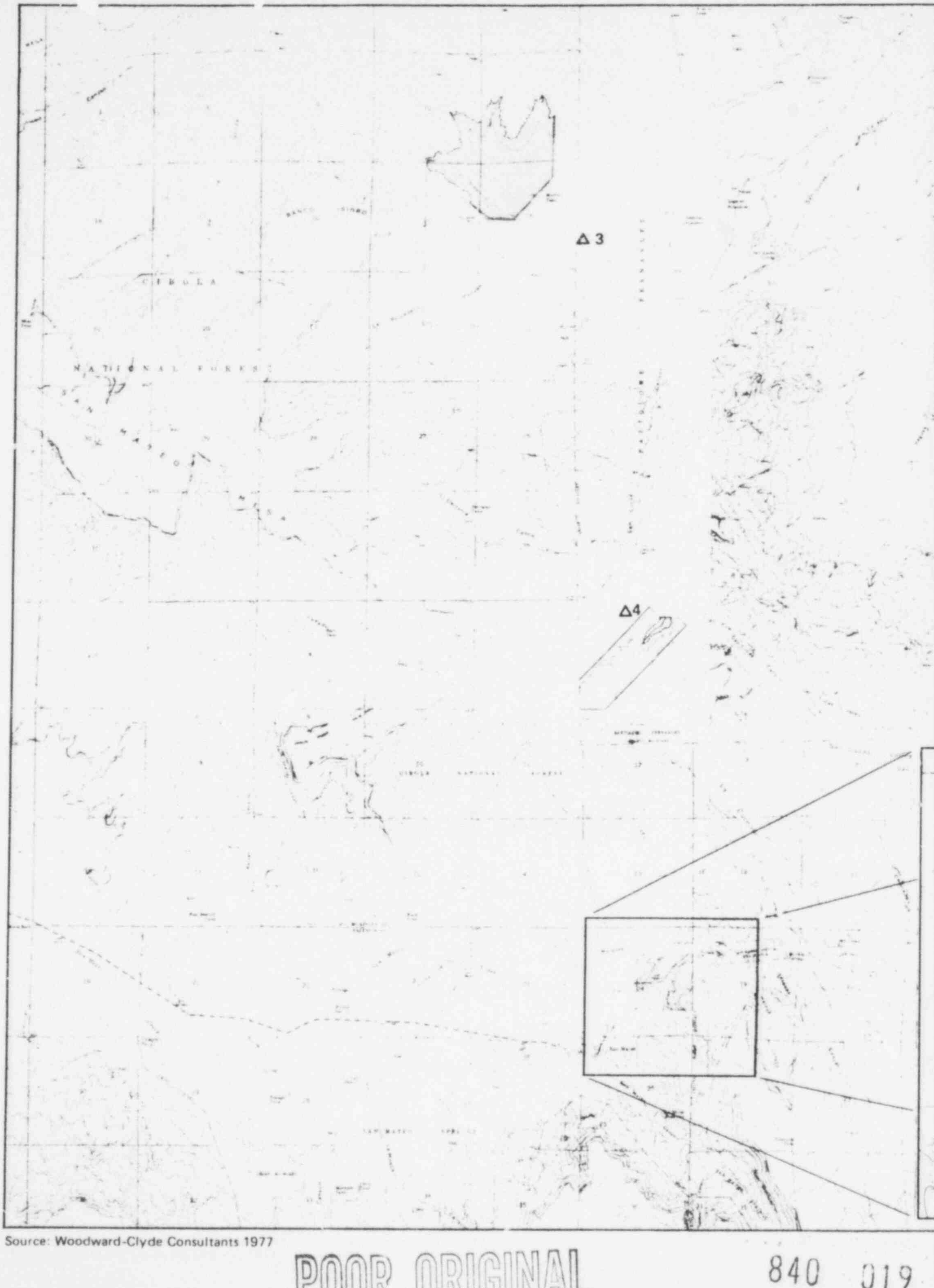
2.7.2 Local Climatology

There are no national weather observing stations in the immediate project vicinity. However, data which can be considered representative of the project site are available from surrounding stations, including San Mateo (6.5 miles south at 7250 feet MSL), Grants (18 miles south-southwest at 6470 feet MSL), Marquez (22 miles east-southeast at 7620 feet MSL), Laguna (30 miles southeast at 5812 feet MSL), and from the Albuquerque National Weather Service Station (approximately 65 miles east-southeast at 5311 feet MSL). Also meteorological monitoring stations were established at five locations in the general Mt. Taylor Uranium Mill project area (Figure 2.7-1) to provide data for comparison with surrounding local and regional long-term stations. The information on local climate presented here consists of a synthesis of the available project area data and the long-term regional data.

Temperature and Relative Humidity. Long-term temperature in the project area is best represented by data collected at San Mateo (Floyd Lee Ranch) during a period from 1962 through 1974 (Table 2.7-1). The mean annual temperature for the period of record was 49.2°F. The warmest month was July (average temperature 69.2°F) and the coldest month was January (28.9°F). The warmest temperature recorded during the period was 103°F on June 23, 1962; the coldest temperature recorded was -35°F on January 7, 1971. The site area exhibits a large diurnal range in temperature which is also conducive to nighttime inversion formations. Regional data for more extended periods of time are also available for Grants and Laguna (Table 2.7-1).

Data collected for a 12-month period at the Mt. Taylor project area at Monitoring Site #1 indicate a very close similarity to the San Mateo long-term temperature data. Project area data, including monthly and annual mean ranges and extremes, are shown in Table 2.7-2.

840 018



Source: Woodward-Clyde Consultants 1977

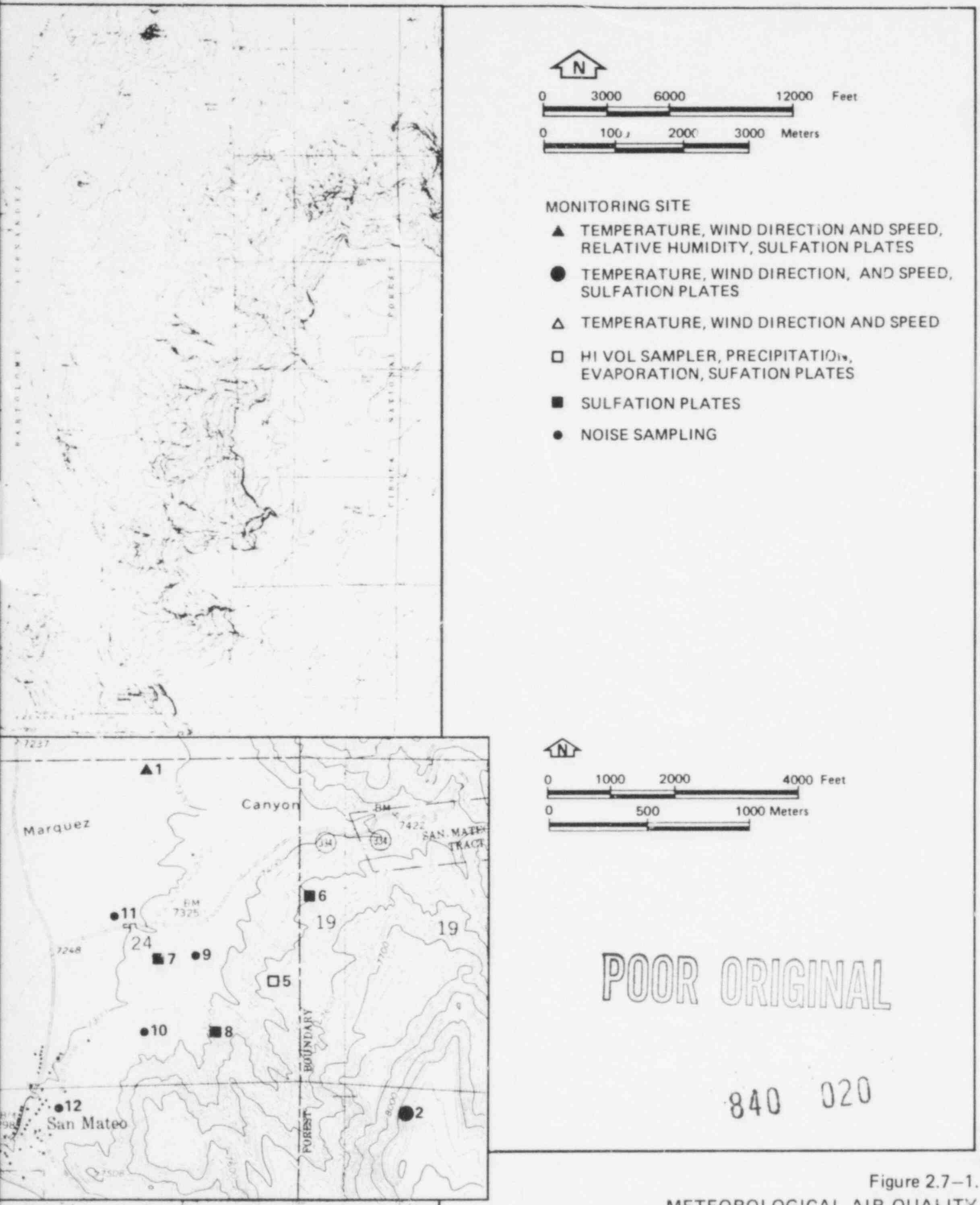


Figure 2.7–1.
METEOROLOGICAL AIR QUALITY
MONITORING STATIONS

Table 2.7-1. MONTHLY AND ANNUAL MEANS OF TEMPERATURE (°F) FOR SAN MATEO, GRANTS, AND LAGUNA, NEW MEXICO

Month	San Mateo[a]	Grants[b]	Laguna[c]
January	28.9	28.5	33.4
February	33.7	33.0	37.6
March	38.9	38.6	43.9
April	45.5	47.4	52.4
May	55.6	56.2	60.5
June	64.1	66.0	70.5
July	69.2	71.0	74.3
August	67.2	68.0	72.6
September	59.6	61.1	66.0
October	49.7	50.0	54.4
November	38.8	38.3	42.4
December	28.7	29.5	33.5
Annual Mean	49.2	49.0	53.4
Extreme Maximum	103 (June 23, 1962)		103
Extreme Minimum	-35 (January 7, 1971)		-20

[a]Elevation, 7250 feet MSL; period of record 1962-1974.
Source: U.S. Department of Commerce Annual.

[b]Elevation, 6480 feet; period of record 1946-1960.
Source: U.S. Forest Service 1973 in NMEI 1974.

[c]Elevation, 5840 feet; period of record 40 years to 1960.
Source: U.S. Department of Commerce 1965.

840 021

Table 2.7-2. MONTHLY AND ANNUAL MEANS AND EXTREMES OF TEMPERATURE (°F) RECORDED AT THE MT. TAYLOR URANIUM MILL PROJECT MONITORING SITE #1 ELEVATION, 7280 FEET MSL

Month	Mean	Mean Daily Maximum	Mean Daily Minimum	Extreme Maximum	Extreme Minimum
1976					
February	37.1	46.2	28.7	58.0	14.0
March	34.6	45.6	22.5	63.0	10.5
April	48.0	57.3	36.9	65.5	19.0
May	55.2	64.7	45.1	76.0	30.0
June	64.5	75.1	52.3	84.0	42.0
July	67.3	78.3	57.[illegible]	86.0	52.0
August	66.2	76.5	56.7	83.0	44.5
September	59.8	70.4	49.8	82.0	39.5
October	48.3	57.6	38.9	72.0	29.5
November	38.8	49.8	28.3	62.0	-5.0
December	31.9	43.8	22.4	58.0	10.0
1977					
January	28.5	38.3	20.3	48.0	3.0
Annual	48.4	58.7	40.3	86.0	-5.0

840 022

The frost-free season in the area averages approximately 150 days with the last freezing temperatures generally occurring around the middle of May and the first fall freezing temperatures occurring in early October (Tuan, et al., 1973). Variations in the length of the season are large from year to year with freezing temperatures ending as early as late April during some years, and extending into the middle of June during other years. Fall freezing temperatures have occurred as early as mid-September and as late as the end of October. During the onsite monitoring program, the last freezing temperatures occurred May 1, 1976 and the first freezing temperatures of the fall occurred October 19, 1976.

Relative humidity in the area over the long term is estimated to range from an average of 65 percent at sunrise to approximately 30 percent in midafternoon. Afternoon relative humidity on many occasions is less than 15 percent. Monthly and annual relative humidity for Albuquerque (where the longest regional record is available) are presented in Table 2.7-3. The data indicate an influx of moisture in July and August (the thunderstorm season) and then a gradual return to dry conditions during fall. Data collected at Monitoring Site #1 for a 12-month period are shown in Table 2.7-4. These data indicate the same general relative humidity pattern as Albuquerque with mean annual relative humidity approximately three percent higher at the project area during the study year than the long-term Albuquerque data.

Precipitation and Evaporation. Precipitation in the project area occurs primarily during the thunderstorm season, although total annual and monthly rainfall amounts vary considerably from year to year. Data for San Mateo (Floyd Lee Ranch) for a period from 1939 to 1974 and for other regional stations (Grants, Marquez, and San Fidel) are shown in Table 2.7-5. The annual average precipitation at San Mateo was 8.83 inches. The maximum annual rainfall recorded was 13.55 inches during 1956. Maximum monthly precipitation occurred in August with an average amount of 2.13 inches.

Table 2.7-3. RELATIVE HUMIDITY (%), ALBUQUERQUE, NEW MEXICO

	Mean Relative Humidity By Time of Day (LST)[a]				Monthly Percent Frequency of Relative Humidity Class[b]					
Month	05	11	17	23	0-29	30-49	50-69	70-79	80-89	90-100
January	68	49	37	58	11	33	38	11	4	3
February	63	43	32	52	22	37	28	7	3	2
March	54	32	23	42	42	32	16	5	4	3
April	45	25	17	33	56	25	13	3	2	1
May	43	22	16	30	57	24	14	3	1	<0.5
June	44	23	17	31	65	24	9	1	1	<0.5
July	61	35	28	49	35	35	21	6	3	1
August	65	39	30	52	24	36	25	8	4	2
September	59	40	31	52	50	30	14	3	2	1
October	59	37	29	48	37	31	17	7	5	3
November	64	42	35	53	21	38	28	8	3	2
December	70	51	43	61	11	34	35	11	7	3
Annual	58	37	28	47	36	32	21	6	3	2

[a]Period of record: 1961-1975. Source: U.S. Department of Commerce 1975.

[b]Period of record: 1951-1960. Source: U.S. Department of Commerce 1963.

Table 2.7-4 MONTHLY AND ANNUAL MEANS AND EXTREMES OF RELATIVE HUMIDITY (%) RECORDED AT THE MT. TAYLOR URANIUM MILL PROJECT MONITORING SITE #1

Month	Mean	Mean Daily Maximum	Mean Daily Minimum	Maximum	Minimum
1976					
February	34	48	21	59	11
March	47	70	28	100	8
April	37	56	22	100	4
May	43	60	30	98	12
June	34	45	25	90	15
July	45	61	30	88	5
August	49	70	31	98	8
September	48	71	24	96	5
October	52	68	38	100	19
November	51	65	38	100	29
December	51	66	36	100	7
1977					
January	63	79	46	100	18
Annual	46	63	31	100	4

Period of Record: February 11, 1976 to January 31, 1977.

840 025

Table 2.7-3. MONTHLY AND ANNUAL AVERAGE PRECIPITATION (INCHES) FOR SAN MATEO, GRANTS, MARQUEZ, AND SAN FIDEL, NEW MEXICO

Month	San Mateo[a]	Grants[b]	Marquez[c]	San Fidel[d]
January	.42	.36	.45	.37
February	.38	.39	.49	.46
March	.40	.45	.57	.44
April	.43	.36	.67	.65
May	.37	.43	.70	.79
June	.47	.69	.73	.79
July	1.72	1.81	1.79	1.65
August	2.13	2.18	2.71	2.02
September	1.14	1.17	1.20	1.43
October	.75	1.07	1.31	.61
November	.33	.33	.51	.41
December	.44	.62	.55	.47
ANNUAL	8.83[e]	10.04	11.68	10.09

[a]Elevation 7250 feet MSL; period of record 1939-1974. Source: U.S. Department of Commerce Annual, 1964, 1965.

[b]Elevation 6480 feet MSL; period of record 1946-1960. Source: U.S. Forest Service 1973 in NMEI 1974.

[c]Elevation 7620 feet MSL; period of record 1941-1970. Source: U.S. Department of Commerce, 1973a.

[d]Elevation 6160 feet MSL; period of record 1920-1954. Source: U.S.D.C., Weather Bureau, 1959.

[e]24 years data available for annual mean.

840 026

The maximum precipitation for a one-month period was 4.38 inches recorded in August 1948 (4.35 inches was recorded in July 1956).

One year's data collected at Monitoring Site 5 are shown in Table 2.7-6. Maximum monthly precipitation during the onsite monitoring program was 2.89 inches in July. The annual precipitation for the 12-month period of record was 8.18 inches. It is noted that the one-year onsite precipitation data approximated the long-term records for San Mateo with the exception that somewhat higher rainfall amounts were measured in the fall and winter. The coefficient of variation (annual rainfall standard deviation expressed as a fraction of the arithmetic mean) is large, estimated to be 0.3 (30 percent) in the general area (Tuan et al., 1973).

Much of the winter precipitation can be expected to fall as snow. Based on available mean snowfall measurements for surrounding locations (Crownpoint, Laguna), elevation considerations, and comparative precipitation amounts, the yearly average snowfall at the site is estimated to be 26 inches.

Mean annual lake evaporation in the project area is estimated from regional data to be 57 inches (U.S. Department of Commerce 1968). Evaporation data collected in the project area at Monitoring Site #5 for an 8-month period (non-freezing months only) are shown in Table 2.7-7.

Sunshine. Central New Mexico receives approximately 75 percent of possible winter sunshine and 80 percent of possible summer sunshine. The average for the year for Albuquerque is 77 percent. Similar figures can be expected to apply to the San Mateo area, except that the amount of sunshine is decreased on the slopes of Mt. Taylor by cumulus cloud buildup during the summer months (New Mexico Environmental Institute, 1974).

Wind Speed, Wind Direction, and Stability. Wind speed and wind direction were monitored at four locations in the project area (Figure 2.7-1).

840 027

Table 2.7-6. MONTHLY AND ANNUAL PRECIPITATION (INCHES) RECORDED AT THE MT. TAYLOR URANIUM MILL PROJECT MONITORING SITE #5

Month	Monthly Total	Number of Days with Precipitation	Maximum 24-Hour Amount
1976			
February	0.26	3	0.24
March	0.32	6	0.12
April	0.12	3	0.06
May	0.66	5	0.41
June	0.26	3	0.14
July	2.89	12	1.03
August	2.03	8	0.84
September	0.69	9	0.17
October	0.22	3	0.20
November	0.14	1	0.14
December	0.16	4	0.09
1977			
January	0.27	5	0.09
February	0.16	2	0.15
12-Month Total	8.18	66	1.03

Period of Record: February 11, 1976 to February 10, 1977.

840 028

Table 2.7-7 MONTHLY GROSS PAN EVAPORATION (INCHES) RECORDED AT THE MT. TAYLOR URANIUM MILL PROJECT MONITORING SITE #5

	Monthly Total
March	3.83
April	8.09
May	9.07
June	12.08
July	9.70
August	8.80
September	6.36
October	4.65
November	NR[a]
December	NR
January	NR
February	NR

[a]NR = No record due to freezing conditions.

Period of Record: March 13, 1976 to February 1977.

Monitoring Site #1 (in the broad valley one mile north of San Mateo at an elevation of 7280 feet) and Monitoring Site #2 (on top of the mesa one mile east of San Mateo at an elevation of 8,160 feet) were monitored for a 12-month period. Temperature measurements were taken concurrently with wind measurements; the temperature differences (for an elevation difference of 880 feet) were used in conjunction with regional data to determine atmospheric stability. The application of these data for dispersion calculations will be discussed in further detail in Section 2.7.3, Diffusion Climatology.

Wind measurements were also collected in the La Polvadera Valley adjacent to the proposed tailings site (Monitoring Site #3, elevation 7150 feet MSL), and in the San Lucas Valley (Monitoring Site #4, elevation 7200) approximately 0.5 miles north of the proposed uranium mill site.

Wind data collected at the San Lucas Valley monitoring station (Tables 2.7-8 and 2.7-9) substantiate the nighttime drainage of winds from south to north off the La Cuchilla Mesa slopes in the direction of the San Lucas Canyon. During the daytime hours, there is a broader distribution of wind directions reflecting both upslope heating effects (northerly winds) and an overriding synoptic mixing effect (mostly from the south-southwest). Winds were measured at the San Lucas Valley during two seasons (one summer month and one winter month). A continuing monitoring program is currently in progress at this site.

Winds collected at Monitoring Site #1, may also be considered representative of the mill area. This station is located approximately two miles south of the proposed mill but is in a very comparable position and configuration with respect to surrounding mesa slopes and walls. Higher topography surrounds the station from the south through the northeast, with open and gradual down-sloping terrain features to the northwest and west. Prevailing nighttime winds at this monitoring station are from the east reflecting

840 030

Table 2.7-8. DIURNAL WIND DIRECTION FREQUENCY AT SAN LUCAS VALLEY, MONITORING SITE #4

	Hour																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
N	1	0	0	0	1	1	1	0	0	1	1	2	4	2	2	1	2	0	1	1	1	1	0	1	24
NNE	0	0	1	0	1	0	0	1	1	2	5	4	7	4	1	1	0	0	0	0	1	1	0	0	30
NE	0	1	0	0	0	1	0	0	0	0	1	2	1	0	1	0	0	2	0	0	0	3	0	2	14
ENE	0	0	0	1	1	1	1	1	0	1	1	2	0	1	1	2	2	0	1	0	0	0	1	0	17
E	3	1	0	2	1	0	2	1	1	1	1	2	0	1	0	1	1	0	0	1	3	1	4	2	29
ESE	2	2	1	0	1	1	0	0	1	1	1	3	3	5	2	3	4	3	2	2	1	1	1	2	42
SE	3	2	4	6	4	2	1	2	2	0	1	0	2	3	6	2	2	4	3	3	6	4	4	2	68
SSE	2	4	2	0	6	4	5	6	0	0	0	0	0	1	1	1	2	6	9	8	2	5	4	4	72
S	1	1	3	4	1	7	4	2	1	2	1	1	0	2	2	2	3	1	0	3	4	0	2	4	51
SSW	3	5	5	2	3	2	3	9	12	7	4	3	3	3	3	3	0	1	4	1	1	3	5	3	88
SW	5	5	3	3	2	1	3	1	4	4	2	2	2	1	0	3	3	1	3	2	2	4	3	4	63
WSW	2	3	4	4	2	2	1	0	3	5	3	1	0	0	2	3	2	3	2	2	1	2	1	2	50
W	1	0	1	0	0	1	0	0	0	1	3	0	1	2	2	2	4	3	1	3	2	0	1	0	28
WNW	1	1	0	1	0	1	0	0	0	0	1	2	1	0	1	0	0	0	0	0	0	0	0	0	9
NW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	4
NNW	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	1	2	0	0	0	0	0	0	7
CALM	2	1	2	3		2	5	2	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	27
TOTL	26	26	26	26	[illegible]	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	25	26	26	623

Period of record: 7/6/76 - 7/31/76.

840 031

Table 2.7-9. DIURNAL WIND DIRECTION FREQUENCY AT SAN LUCAS VALLEY, MONITORING SITE #4

	Hour																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
N	2	2	1	1	1	0	0	2	0	0	1	6	9	10	11	14	13	6	0	1	1	1	1	1	84
NNE	0	0	0	0	0	0	3	1	1	0	1	1	3	3	2	3	4	2	4	1	1	0	0	0	30
NE	1	0	0	0	0	0	2	1	1	0	0	0	0	0	2	0	0	2	0	0	1	2	1	0	13
ENE	1	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0	3	1	0	0	1	1	13
E	0	0	0	1	0	1	0	1	0	2	1	1	0	0	0	0	0	0	5	4	0	1	0	0	17
ESE	1	0	2	0	2	1	2	0	2	1	0	0	0	0	2	0	3	1	2	1	3	4	2	3	32
SE	2	3	1	2	0	1	1	0	1	0	1	0	0	0	1	1	0	1	0	4	3	1	0	1	24
SSE	1	2	3	5	4	0	2	5	1	1	0	1	0	0	2	1	0	1	1	2	2	3	7	3	47
S	5	5	4	4	2	1	0	2	7	4	7	3	1	2	0	2	0	0	0	1	2	3	2	4	61
SSW	4	6	8	5	10	5	5	5	13	7	5	8	6	6	5	2	1	0	1	3	4	7	4	4	124
SW	7	6	5	5	4	6	4	8	1	3	3	3	5	1	1	3	3	3	2	2	3	3	2	6	89
WSW	1	0	1	4	1	2	4	1	0	1	1	0	4	4	1	1	0	1	1	1	1	0	0	2	32
W	0	1	1	0	0	2	1	2	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	0	13
WNW	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	3
NW	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	3	1	0	0	0	1	0	11
NNW	0	0	1	0	0	1	0	0	0	0	1	1	0	2	1	2	1	4	1	1	1	1	0	0	18
CALM	5	3	3	3	6	9	5	2	2	9	8	2	1	0	1	0	1	3	7	6	7	3	8	4	98
TOTL	30	30	30	30	30	30	30	30	30	30	30	29	30	30	30	29	29	29	29	28	29	29	29	29	709

Period of record: 11/24/76 - 12/23/76.

840 032

downslope drainage off the mesa; daytime winds again show a broader distribution (indicating both heating effects and synoptic influences) but are primarily from the southwest through west-northwest directions.

Data collected at both the San Lucas Valley monitoring site and Monitoring Site #1 have been used in providing dispersion calculations and assessments for the mill area.

The most representative data for dispersion calculations for tailings operations, were collected at La Polvadera Valley Site #3 approximately one mile west of the proposed tailings area. Data were collected at this site for four months (two summer months and two winter months). Diurnal distributions of winds collected at Monitoring Site #3 are shown in Tables 2.7-10 and 2.7-11 and indicate the dominant diurnal influences resulting from drainage from San Mateo Mesa and La Polvadera Canyon during the nighttime-evening hours and the upslope effects during the mid-day period.

The wind patterns obtained from the onsite collection program at the various monitoring sites are consistent and identifiable with respect to controlling wind circulation influences and can be considered to be representative of specific locations within the project area. Wind roses for a 12-month period at Monitor Site #1 and for the four-month period at Monitor Site #3 are shown in Figures 2.7-2 and 2.7-3 respectively. These wind roses may be compared with available long-term regional data from Albuquerque (Figure 2.7-4) which reflect similar synoptic influences and stability characteristics, but not the same site-specific topographical influences. For example, prevailing winds at Albuquerque are primarily from the north sector under stable (light wind) nighttime conditions; prevailing winds at Site #1 are from the east, and at La Polvadera, under similar conditions, from the southwest sector reflecting downslope drainage off the local mesa topography (Figure 2.7-1). Joint frequency distributions of wind speed, wind direction, and stability for Albuquerque, Monitoring Site #1, and

840 033

Table 2.7-10. DIURNAL WIND DIRECTION FREQUENCY AT LA POLVADERA VALLEY, MONITORING SITE #3

	Hour																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
N	0	1	0	0	1	2	1	4	2	4	5	6	6	10	7	4	2	2	2	[illegible]	1	2	0	0	64
NNE	1	0	0	1	1	2	1	0	3	7	7	8	5	2	3	2	2	4	1	1	2	0	3	0	56
NE	3	0	0	2	0	1	0	0	0	3	9	3	1	1	2	2	2	1	1	1	1	0	0	2	35
ENE	1	0	0	0	2	0	0	1	4	4	0	3	5	8	3	3	1	2	2	2	0	1	2	0	44
E	0	0	1	1	4	1	2	1	5	6	5	7	6	4	6	4	5	4	6	3	1	1	2	1	76
ESE	3	1	0	1	0	1	0	4	7	0	2	3	5	2	8	5	3	6	4	0	1	1	0	0	57
SE	4	1	2	1	1	1	2	2	0	3	1	1	1	4	1	1	4	2	10	8	7	5	4	5	71
SSE	5	4	4	2	1	2	2	5	3	3	1	1	2	1	0	0	3	5	0	6	4	5	7	3	69
S	10	12	10	11	4	8	9	7	17	10	5	2	2	5	1	5	6	3	8	10	13	10	9	14	191
SSW	12	15	10	15	20	11	12	10	5	2	7	6	5	4	5	4	5	4	4	3	6	9	8	13	195
SW	8	13	14	8	11	12	17	7	1	5	3	5	5	3	2	9	7	5	7	7	3	7	12	7	178
WSW	3	2	6	9	6	6	3	4	1	1	1	1	2	4	4	6	2	7	4	9	9	7	4	3	104
W	3	2	2	1	2	4	2	2	3	0	1	1	3	1	3	1	3	3	1	1	2	0	0	3	44
WNW	0	2	4	1	1	1	2	2	0	2	2	1	2	0	2	1	1	1	0	0	2	2	0	2	31
NW	1	0	0	0	0	1	0	2	1	2	3	3	1	2	3	4	3	2	1	0	2	2	1	0	34
NNW	0	1	1	1	0	1	1	2	2	3	2	3	3	3	4	3	5	3	3	1	0	1	1	0	44
CALM	0	0	0	0	0	0	1	2	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
TOTL	54	54	54	54	54	54	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	54	54	54	1311

Period of record: 7/8/76 - 9/3/76.

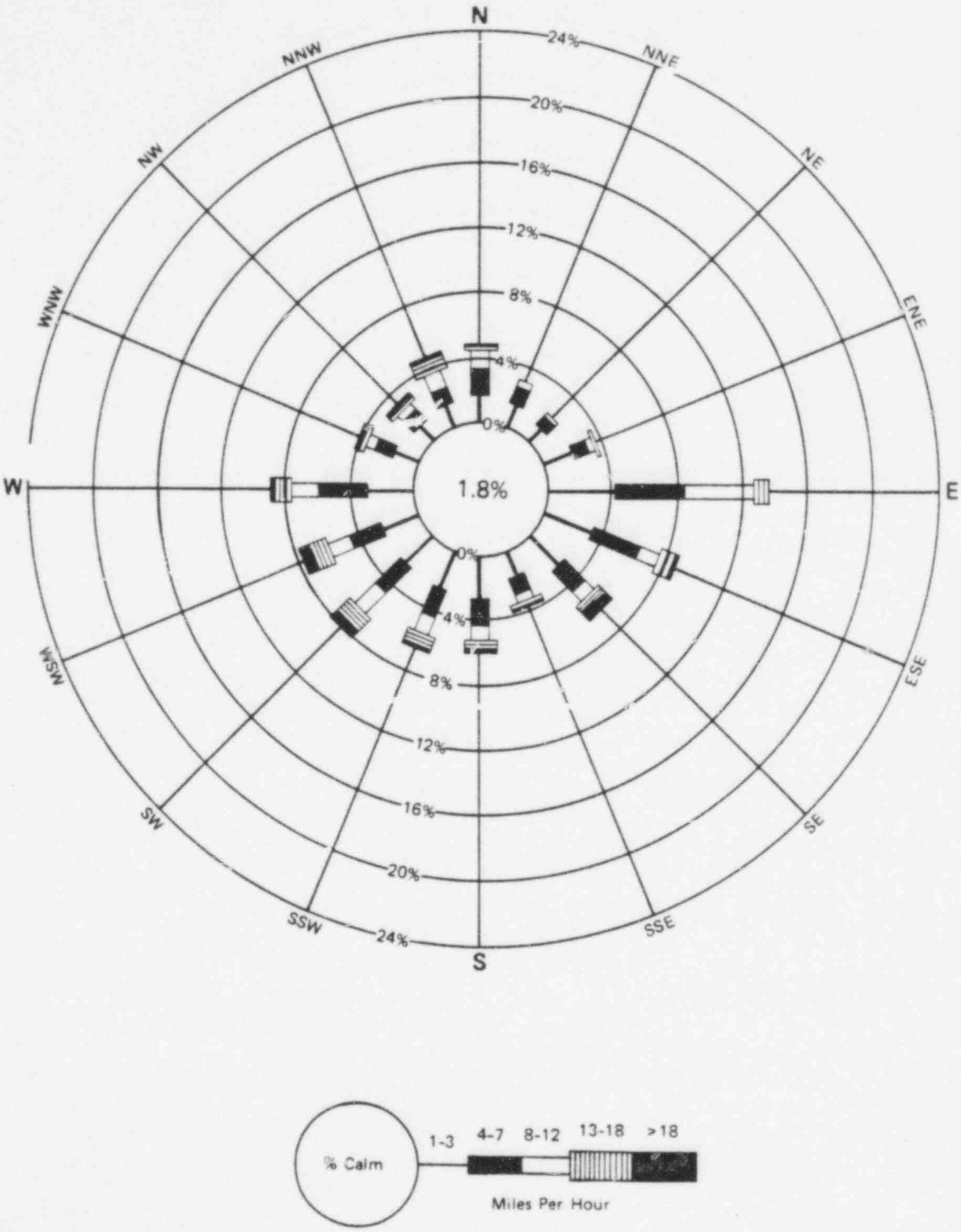
840 034

Table 2.7-11. DIURNAL WIND DIRECTION FREQUENCY AT LA POLVADERA VALLEY, MONITORING SITE #3

	Hour																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
N	0	2	0	1	1	1	2	2	1	0	10	7	4	5	1	5	6	4	2	1	1	1	2	2	61
NNE	2	0	0	0	0	0	0	1	0	0	3	1	2	3	3	5	1	2	1	0	1	0	0	0	25
NE	1	0	1	0	0	0	2	0	1	0	1	6	8	9	6	4	3	0	0	0	0	2	1	0	45
ENE	1	0	0	0	0	0	1	0	0	0	2	3	2	7	9	6	2	0	0	0	0	0	0	0	33
E	1	0	0	0	0	0	0	1	3	2	0	9	10	11	10	10	4	7	0	2	0	1	1	0	72
ESE	1	0	0	4	0	2	1	1	1	1	4	3	5	1	5	3	4	0	0	0	2	0	1	0	39
SE	0	0	0	0	0	0	1	0	1	2	0	1	0	0	0	2	4	1	0	0	1	0	1	1	15
SSE	1	2	2	0	0	1	2	2	0	1	1	2	1	1	0	0	3	2	0	1	0	2	0	2	26
S	1	1	2	1	2	2	1	2	1	2	3	3	1	2	1	0	3	4	3	0	1	1	1	2	40
SSW	3	2	5	6	3	2	1	1	4	11	12	5	3	3	3	3	2	3	4	3	3	0	4	1	87
SW	19	22	17	20	23	20	16	12	10	9	6	5	6	2	4	5	7	8	10	8	16	16	11	15	287
WSW	16	16	16	17	14	14	17	21	21	18	5	4	2	2	2	2	2	11	17	22	13	14	17	17	300
W	6	7	8	6	7	7	8	8	8	6	3	0	3	3	2	3	3	4	15	12	11	10	11	11	162
WNW	0	3	2	1	6	5	2	3	3	2	2	2	3	1	3	1	3	4	1	6	6	8	4	3	74
NW	2	2	2	1	0	2	2	2	2	2	4	5	3	4	3	6	6	3	3	2	2	0	2	2	62
NNW	1	0	2	0	0	1	1	1	1	1	0	1	4	4	6	2	4	2	1	0	0	1	1	0	34
CALM	2	1	1	1	2	1	1	1	1	1	2	1	1	0	0	1	1	3	1	1	1	2	1	2	29
TOTL	57	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	1391

Period of record: 11/24/76 - 1/20/77.

840 035

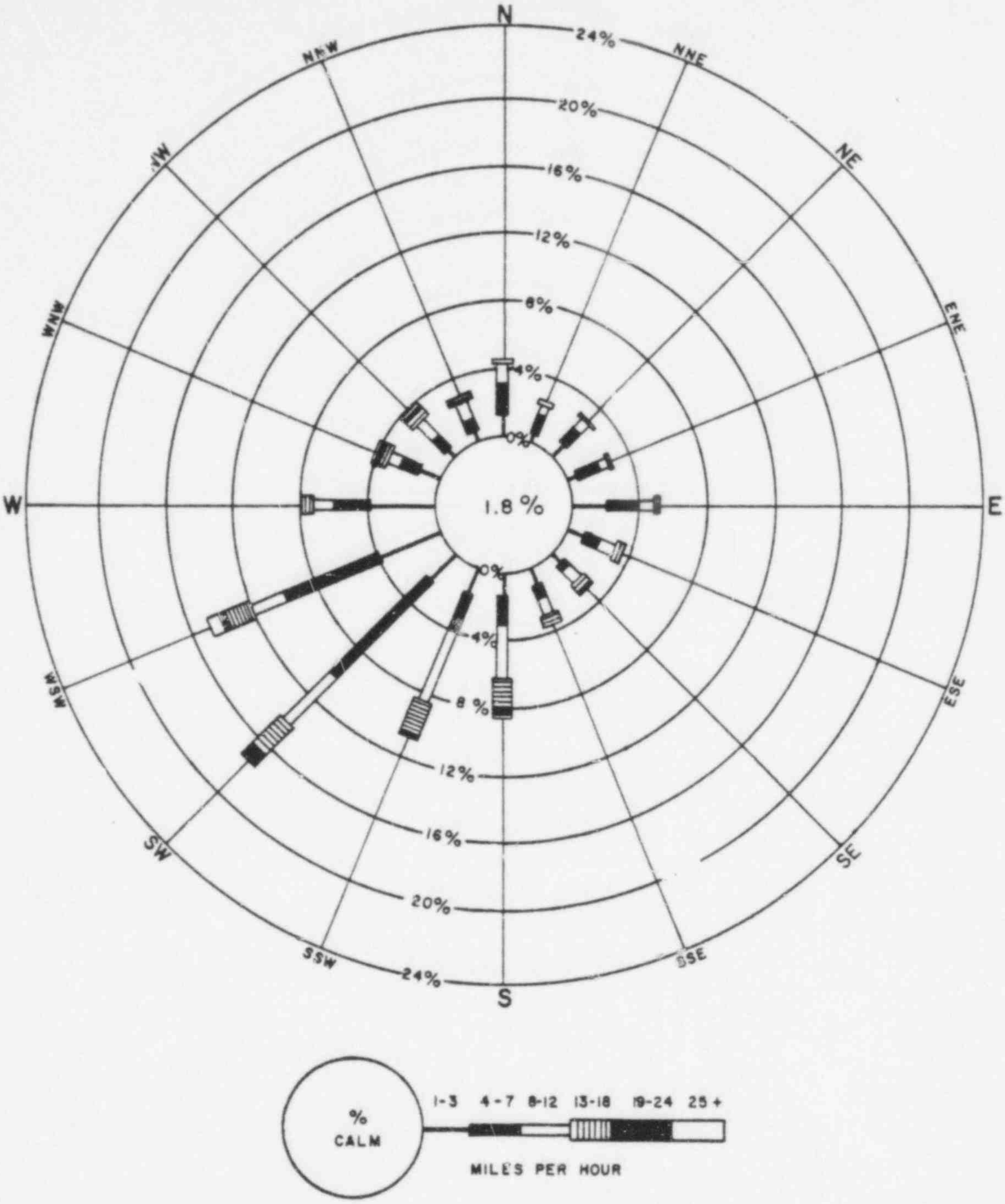


Monitoring Site No. 1
Period of Record
FEB. 1976 – FEB, 1977

840 036

Source: Woodward-Clyde Consultants 1977

Figure 2.7–2.
SAN MATEO VALLEY WIND ROSE

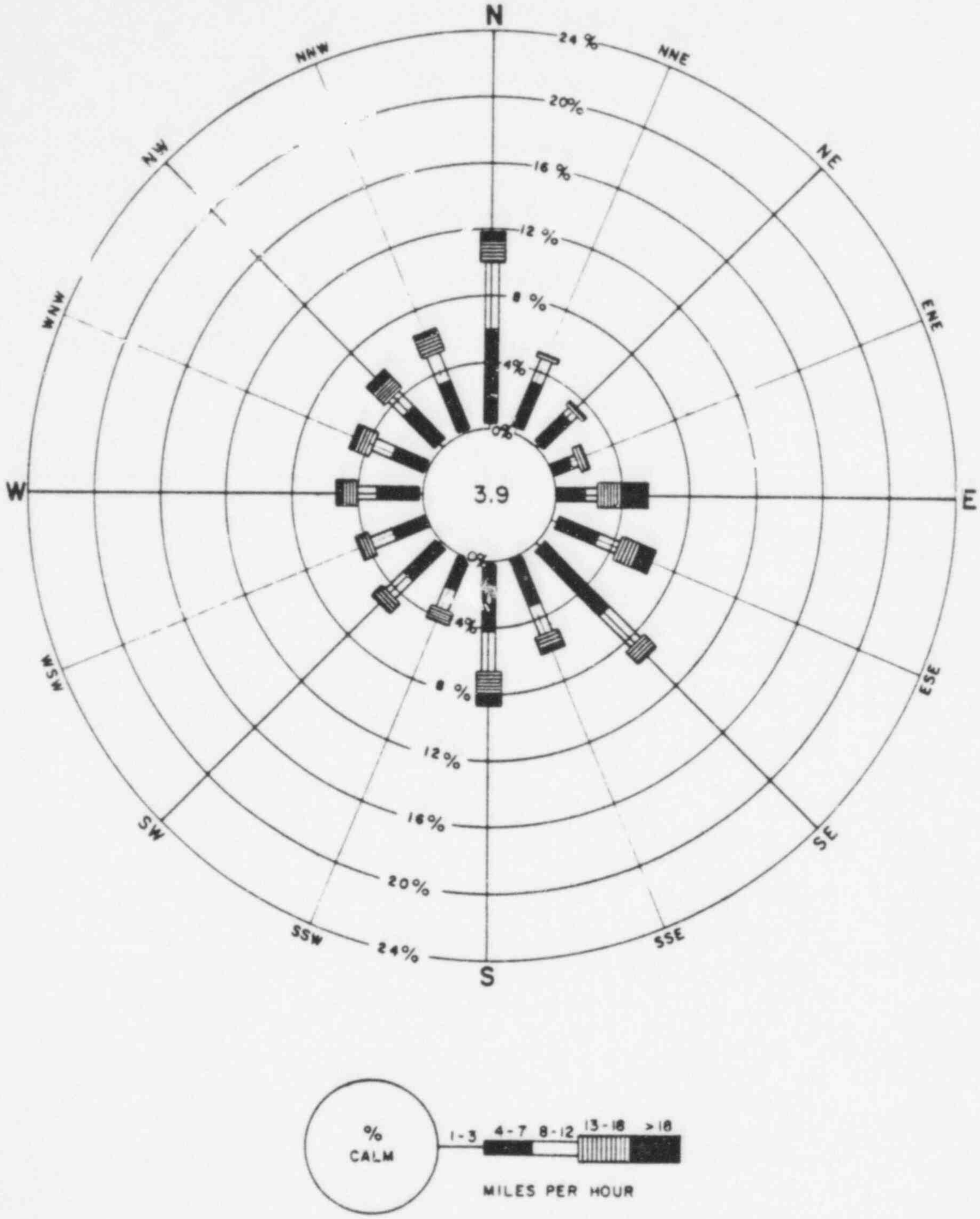


Monitoring Site No. 3
Period of Record
JULY 7 – SEPT. 3, 197?
NOV. 24 – JAN. ??, 1977

Source: Woodward-Clyde Consultants 1977

840 037

Figure 2.7–3.
LA POLVADERA VALLEY WIND ROSE



Period of Record: 1948 – 1968

840 038

Source: U.S. Dept. of Commerce 1973

Figure 2.7–4.
ANNUAL ALBUQUERQUE WIND ROSE

Monitoring Site #3 (La Polvadera) are shown in Appendix C and will be discussed in further detail in Section 2.7.3, Diffusion Climatology.

Severe Weather. Tropical cyclones are rare in New Mexico, particularly in the project area (Houghton 1972). Tornadoes are occasionally reported in New Mexico, most frequently during the afternoon and evening hours from May through August. However, only two tornadoes were reported in a one degree of latitude and longitude square (3880 square miles) that includes the project area during the period 1955-1967 (Markee, et al., undated). Thus, the probability of a tornado striking a specific point in any year in the project area is .00016 using these data and applying the methods developed by Thom (1963). The mean recurrence interval for a tornado striking a point within this square is 5991 years.

Thunderstorms are relatively frequent in the area during the summer months. Thunderstorms occur an average of 50 days per year, with two to four days per year reporting hail (Baldwin 1973). Extreme winds may occur as a result of these thunderstorms. In addition, strong winds may also occur in the area under certain pressure gradient configurations. Waters (1970) has defined areas of the United States that are often subjected to high winds because of the recurrence of certain synoptic features in the atmosphere. The project area is included in an area referred to as the "Dusty Box." During the winter and spring, low pressure weather systems approaching from the west can induce surface winds in excess of 60 mph. These strong winds, blowing from the south-southwest to west-southwest, pick up considerable dust while crossing the plains, thus giving the area its name.

The estimated maximum wind speeds (fastest mile) for the project area, 30 feet above ground level, for various recurrence intervals (Thom, 1968), are as follows:

840 039

Recurrence interval (years)	2	10	25	50	100
Maximum speed (mph)	57	68	73	80	87

Because of the relative protection of the project area from the west through southeast by towering mesas, these estimates may be slightly high for the project area.

Maximum short-duration rainfall in the area is generally caused by thunderstorms; maximum precipitation of longer duration is caused by the infrequent occurrence of tropical cyclones from the Gulf of Mexico or the Gulf of California. Table 2.7-12 presents estimated maximum precipitation at any point in the project area for various durations and recurrence intervals.

2.7.3 Diffusion Climatology

The ability of the atmosphere to disperse air pollutants emitted into it at a particular location depends on a number of atmospheric variables, the most important of which are stability characteristics, wind direction and speed frequency distributions, mixing depth and various combinations of these parameters.

Based on the input parameters of solar altitude, cloud cover, ceiling height and wind speed, atmospheric stability can be classified into several catagories (Pasquill Classes) ranging from extremely unstable (A) to extremely stable (G). The closest location with available long-term stability data for the Mt. Taylor project area is Albuquerque. Monthly and annual distributions of stability (for 20 years of record) are presented in Table 2.7-13. In general these data indicate that good diffusion conditions (Classes A through D) occurred 66.6 percent of the time.

Stability data calculated for the SOHIO L-Bar Ranch (25 miles east-southeast of the project site) for a one-year period between January 1973 and January

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Table 2.7-12. ESTIMATED MAXIMUM POINT PRECIPITATION (INCHES) FOR SELECTED DURATIONS AND RECURRENCE INTERVALS, MT. TAYLOR URANIUM MILL PROJECT AREA

Duration	Recurrence Intervals (years)				
	2	10	25	50	100
1 hour	0.7	1.1	1.5	1.7	1.9
12 hours	1.3	2.3	2.7	2.9	3.3
24 hours	1.4	2.4	2.9	3.3	3.7
2 days	1.7	2.7	3.3	3.6	4.3
7 days	2.3	3.5	3.8	4.9	5.2
10 days	2.4	3.6	4.5	5.0	5.5

Sources: Hershfield, 1961, and Miller, 1964.

840 041

Table 2.7-13. PERCENT FREQUENCY DISTRIBUTION OF PASQUILL STABILITY CLASSES: ALBUQUERQUE, NEW MEXICO

	A	B	C	D	E	F	G
	Extremely Unstable	Unstable	Slightly Unstable	Neutral	Slightly Stable	Stable	Extremely Stable
January	<0.05	7.4	13.9	36.5	15.6	17.4	9.2
February	0.4	11.2	12.7	38.6	14.3	15.3	7.5
March	0.4	11.4	11.3	45.7	13.7	12.2	5.3
April	2.9	12.4	13.7	44.6	12.4	9.7	4.2
May	4.3	14.6	15.1	40.4	12.4	9.2	4.0
June	8.0	17.5	14.8	36.2	11.3	8.8	3.3
July	8.6	19.2	13.2	37.2	11.3	7.9	2.6
August	6.7	19.1	14.7	30.4	12.7	11.3	4.5
September	1.3	19.1	13.6	31.7	13.9	13.4	6.8
October	0.8	15.3	13.5	29.9	14.9	16.9	8.7
November	<0.05	10.4	14.1	32.2	14.4	16.9	11.6
December	0.0	7.4	14.5	32.6	15.6	18.7	11.1
Annual	2.8	13.8	13.8	36.2	13.6	13.2	6.6

Period of record: 1948-1968.

Source: U.S. Department of Commerce, 1973.

840 042

1974 reflect similar distributions, with stability class A through D occurring 69.3 percent of the time.

Using temperature differences (ΔTs) obtained from the Mt. Taylor Uranium Mill project two-tower network (Monitoring Sites #1 and #2 in Figure 2.7-1), stability was classified for each hour of the day employing the following empirically adjusted criteria*.

Class	Temperature Lapse (°C) for 880 feet
A	<-3.8
B	-3.8 to -2.6
C	-2.6 to -2.2
D	-2.2 to -0.4
E	-0.4 to 0.7
F	0.7 to 2.7
G	>2.7

The distribution of onsite stability classes for the 12-month period is shown in Table 2.7-14. It is noted that these distributions closely match the long-term Albuquerque regional data and the SOHIO L-Bar Ranch data with good stabiity conditions (Stability Classes A through D) occurring 70.2 percent of time. Boundary layer inversion conditions (Stability Classes E, F and G) occurred approximately 29.8 percent of the time, primarily during nighttime and early morning hours, which is the normal Southwest Mountain condition. It is important to note that inversion conditions

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*These data are based on NRC "Safety Guide 23" 100-meter vertical lapse rate classes, empirically adjusted for terrain, tower configuration, and comparable regional stability data. Results were further adjusted and verified using $\sigma\theta$ comparisons (Slade, 1966).

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Table 2.7-14. PERCENT FREQUENCY DISTRIBUTION OF PASQUILL STABILITY CLASSES: MT. TAYLOR URANIUM MILL PROJECT

	A	B	C	D	E	F	G
	Extremely Unstable	Unstable	Slightly Unstable	Neutral	Slightly Stable	Stable	Extremely Stable
January	2.8	7.5	14.8	38.5	12.1	13.2	11.1
February	5.6	16.2	11.7	41.3	13.3	8.9	2.9
March	2.0	7.9	9.0	35.9	20.5	17.1	7.6
April	2.5	24.9	25.5	34.6	5.2	5.2	1.9
May	5.5	20.9	17.1	38.9	11.9	5.3	0.4
June	2.0	5.4	8.1	37.8	23.9	16.7	6.2
July	2.5	13.1	14.6	41.4	16.3	9.5	2.6
August	1.7	19.1	18.0	39.9	11.9	7.2	2.1
September	16.4	23.9	11.2	24.5	13.4	7.8	2.9
October	0.7	20.5	19.3	36.2	8.2	9.0	6.1
November	3.4	13.7	12.6	37.0	11.4	11.4	10.2
December	4.8	5.2	9.5	36.4	11.9	15.0	16.9
Annual	4.0	14.8	14.4	37.0	13.4	10.5	5.9

Period of record: 2/11/76 - 2/20/77.

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at the project site are almost exclusively associated with downslope drainage from the surrounding mesas. Consequently, poor dispersion conditions, which would be associated with highly stable air impacting on the mesa canyon slopes, are generally avoided.

Application of these data concurrently with hourly wind speed and direction enabled a site-specific joint frequency distribution of winds and stability data to be obtained. The distributions for Monitoring Sites #1 and #3, which are applicable for dispersion calculations for the mill and tailings operations, are shown in Appendix C, and are further discussed in Section 5.0.

Good dispersion conditions for the project site are also indicated by available "mixing depth" data. Mixing depth is a measure of the thickness of the layer of the lower atmosphere in which pollutants can disperse freely once daytime heating burns off the normal nocturnal temperature inversion (stable conditions). Therefore, the higher the afternoon mixing depth, the better the dispersion, assuming all other conditions are equal. Holzworth (1972) has studied mixing depths, as well as wind speeds, for 62 National Weather Service stations in the contiguous United States. His data, based on a five-year period of record, indicate that Albuquerque (and the project area) are in an area with the highest mean annual afternoon mixing heights in the country (Albuquerque averaged 2788 meters overall).

2.7.4 Existing Air Quality

Air Quality Standards. The project area is located in the Southwestern Mountains - Augustine Plains Intrastate Air Quality Control Region (AQRC 156). The regional air quality has been classified as an attainment area for all criteria pollutants (suspended particulates, sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone). This means that pollutant levels are believed to be below federal secondary standards, based on

840 046

actual measurements or certain estimation techniques. Federal ambient air quality standards (primary and secondary) are presented in Table 2.7-15; New Mexico ambient standards are presented in Table 2.7-16.

Maximum allowable increases in ambient pollutant concentrations (sulfur dioxide and particulate matter) which are applicable to mill operations under the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act Amendments of 1977, PL 95-95, are shown in Table 2.7-17. Under PSD provisions, Class II incremental standards are applicable.

Air Quality Data. Baseline air quality monitoring in the project area included high-volume sampling for particulate concentrations and sulfation plate analyses to determine background SO_2 concentrations.

Total suspended particulates were collected for continuous 24-hour periods, every sixth day, between February 10, 1976 and February 12, 1977 in the project area (Monitoring Site #5 in Figure 2.7.1). The geometric mean for the one-year sampling period was 40.8 $\mu g/m^3$. Several of fifty-five 24-hour particulate samples collected averaged above the 150 $\mu g/m^3$ state (and federal secondary) standard, and three of these were above the federal primary 24-hour standard. In most cases concurrent winds were moderate to strong with peak hourly speed reaching 20 miles per hour or higher (Appendix C, Table C-1). In the desert southwest, strong blowing winds and dust storms are a common natural occurrence resulting in high regional background concentrations. Table 2.7-18 presents ambient particulate data collected by the New Mexico Environmental Improvement Agency for San Mateo and five other communities within the general project region.

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Table 2.7-15. FEDERAL AMBIENT AIR QUALITY STANDARDS

Standard	Duration				
	1-hr	3-hr	8-hr	24-hr	Annual
Primary (intended to protect public health)					
Carbon monoxide (mg/m^3)	40[b]	--	10[b]	--	--
Photochemical oxidants ($\mu g/m^3$)	240[b]	--	--	--	--
Nonmethane hydrocarbons ($\mu g/m^3$)[a]	--	160[b]	--	--	--
Nitrogen dioxide ($\mu g/m^3$)	--	--	--	--	100
Suspended particulates ($\mu g/m^3$)	--	--	--	260[b]	75[c]
Sulfur dioxide ($\mu g/m^3$)	--	--	--	365[b]	80
Secondary (intended to protect public welfare)					
Carbon monoxide (mg/m^3)	40[b]	--	10[b]	--	--
Photochemical oxidants ($\mu g/m^3$)	240[b]	--	--	--	--
Nonmethane hydrocarbons ($\mu g/m^3$)[a]	--	160[b]	--	--	--
Nitrogen dioxide ($\mu g/m^3$)	--	--	--	--	100
Suspended particulates ($\mu g/m^3$)	--	--	--	150[b]	60[c,d]
Sulfur dioxide ($\mu g/m^3$)	--	1300[b]	--	--	--

[a]6 to 9 a.m., to be used as a guide in devising plans to achieve oxidant standards.

[b]Not to be exceeded more than once per year.

[c]Annual geometric means.

[d]To be used as a guide in achieving the 24-hr standard.

Source: U.S. Environmental Protection Agency, 1976a.

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Table 2.7-16. NEW MEXICO AMBIENT AIR QUALITY STANDARDS

Parameters[a]	Duration						
	1-hr	3-hr	8-hr	24-hr	7-day	30-day	Annual
Carbon monoxide (mg/m^3)	15	--	10	--	--	--	--
Photochemical oxidants	120	--	--	--	--	--	--
Nonmethane hydrocarbons	--	127	--	--	--	--	--
Nitrogen dioxide	--	--	--	188	--	--	94
Soiling index (COHs/1000 ft)	--	--	--	--	--	--	0.4
Suspended particulates	--	--	--	150	110	90	60[b]
Beryllium	--	--	--	--	--	0.01	--
Asbestos	--	--	--	--	--	0.01	--
Heavy metals (combined)	--	--	--	--	--	10.0	--
Sulfur dioxide	--	--	--	262	--	--	38
Hydrogen sulfide (ppm)	0.003	--	--	--	--	--	--
Total reduced sulfur (ppm)	0.003	--	--	--	--	--	--

[a]Values in $\mu g/m^3$ unless otherwise noted. Some values have been converted from ppm to $\mu g/m^3$ to facilitate comparison with federal standards.

[b]Annual geometric mean.

Source: New Mexico Environmental Improvement Agency, 1975.

Table 2.7-17. MAXIMUM ALLOWABLE INCREASES (in micrograms per cubic meter) UNDER PREVENTION OF SIGNIFICANT DETERIORATION PROVISIONS OF CLEAN AIR ACT AMENDMENTS OF 1977

	Class		
Particulate Matter	I	II	III
Annual geometric mean	5	14	37
24-hour maximum	10	37	75
SO_2			
Annual arithmetic mean	2	20	40
24-hour maximum	5	91	182
3-hour maximum	25	512	700

Table 2.7-18. REGIONAL SUSPENDED-PARTICULATE CONCENTRATIONS (ANNUAL GEOMETRIC MEAN - $\mu g/m^3$)

Station Name	1974	1975	1976
Kerr-McGee (Grants) -8B	—	--	79.9[a]
Grants -8C	52.6	--	--
Paguate -8D	—	42.5	87.7
Milan -8F	114.4	80	204.9
United Nuclear (Milan) 8G	--	--	71.3[b]
San Mateo -8H	--	—	44.2[c]

[a]Started monitoring June 1976.

[b]Started monitoring July 1976.

[c]Started monitoring August 1976.

Source: New Mexico Environmental Improvement Agency, 1975, 1976.

The San Mateo geometric mean was 44.2 $\mu g/m^3$ (very close to the project site mean) while other monitoring locations were considerably higher (above the New Mexico ambient standards). These lower particulate concentrations suggest that the San Mateo area is protected from strong winds. Four of the particulate samples were analyzed for selected trace metals by atomic absorption spectrometry. Results are presented in Table 2.7-19.

Sulfation plates were exposed at various sampling locations in the Mt. Taylor Uranium Mill project area (Figure 2.7-1). Analyses of these measurements (Table C-2, Appendix C) indicate that sulfation rates were generally less than the lower limit of detection by the method. The method can be used as a rough estimate of sulfur dioxide (Huey, 1968; Huey, et al., 1969); one may therefore conclude that baseline sulfur dioxide concentrations over the project area are very low (less than 0.005 ppm). Baseline concentrations of other primary pollutants (hydrocarbons, photochemical oxidants, carbon monoxide, etc.) are also expected to be very low in the project area because of the lack of anthropogenic sources.

2.7.5 Baseline Noise Levels

Most background noise at the site is attributed to natural sources. The normal level appears to be in the range of 30-40 dB(A)*. Near exploratory mining activities in the vicinity of the site, the sound levels may increase to approximately 70 db(A).

Background noise surveys were performed in the vicinity of the site on March 8-9, 1976 and August 4-5, 1976. Measurements were made at four sites

*dB(A) = decibels, A-weighted scale.

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Table 2.7-19. TRACE ELEMENT CONCENTRATIONS IN SUSPENDED-PARTICULATE SAMPLES

Metal	Apr. 30, 1976	Aug. 16, 1976	Sep. 16, 1976	Jan. 7, 1977	Urban[a] National Geometric Means	Nonurban[a] National Geometric Means
Arsenic	<0.0006	<0.0006	0.0098	<0.0012	--	--
Barium	0.31	0.012	<0.006	<0.0012	--	--
Boron	0.012	0.49	<0.006	<0.0012	--	--
Cadmium	0.019	0.00025	0.00012	<0.00012	LD[b]	0.0001
Chromium	0.0015	0.0143	<0.00006	0.0055	0.0054	LD
Copper	0.110	0.118	0.98	0.186	0.106	0.1264
Cyanide	0.149	0.143	0.00074	<0.012	--	--
Iron	5.5	0.418	0.053	0.390	1.17	0.248
Lead	0.043	0.0055	0.0086	0.066	0.886	0.0578
Magnesium	1.69	3.67	0.40	6.50	--	--
Manganese	0.082	0.0098	0.0031	0.024	0.032	0.0068
Mercury	<0.00018	0.00037	0.00080	<0.000006	--	--
Molybdenum	0.000031	0.00025	<0.00006	0.00025	--	--
Nickel	0.037	0.0025	<0.0006	<0.0012	0.0082	0.001
Selenium	<0.0006	<0.0006	<0.0006	<0.0012	--	--
Silver	<0.006	<0.006	<0.006	0.0006	--	--
Sodium	0.184	42.2	<0.006	6.99	--	--
Vanadium	0.012	0.0037	0.0049	<0.0012	0.0102	0.001
Zinc	0.59	0.053	0.013	0.036	--	--
Total Mass	190.6	37.6	57.9	14.5	--	--

[a]5-year average. Source: EPA, 1976b.

[b]LD = below level of detection.

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near the town of San Mateo (Figure 2.7-1)*. The measurement results are presented in Table 2.7-20.

The onsite ambient noise measurements indicate that mining** and residential activities near San Mateo, the closest town, are not excessively loud and should not be considered significant sources of noise. Figure 2.7-5 shows sound levels at various locations in differenct parts of the country on the EPA's (1974) day-night equivalent sound level scale (L_{dn}). The L_{dn} scale was developed to give a better indication of human response to long-term noise levels by emphasizing nighttime levels more than daytime levels. Figure 2.7-5 substantiates the fact that anticipated onsite baseline noise levels are low.

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*A General Radio Company Type 1933 precision sound level meter and type 1562-A permissive sound level calibrator (114 db at 1000 Hz) were used.

**Exploratory mining activities in the vicinity of this site were in progress during the ambient noise measurements.

Table 2.7-20. BACKGROUND NOISE LEVELS IN PROJECT AREA

Location	Noise Level	
	March 8-9, 1976	August 4-5, 1976
9	LEQ[1] = 66 dB(A)	63 dB(A)
	LDN[2] = 66.2 dB(A)	69 dB(A)
10	LEQ = 44 dB(A)	44 dB(A)
	LDN = 45 dB(A)	50 dB(A)
11	LEQ = 48 dB(A)	53 dB(A)
	LDN = 48 dB(A)	61 dB(A)
12	LEQ = 39 dB(A)	41 dB(A)
	LDN = 41 dB(A)	45 dB(A)

[1]LEQ = equivalent scale.

[2]LDN - day-night scale.

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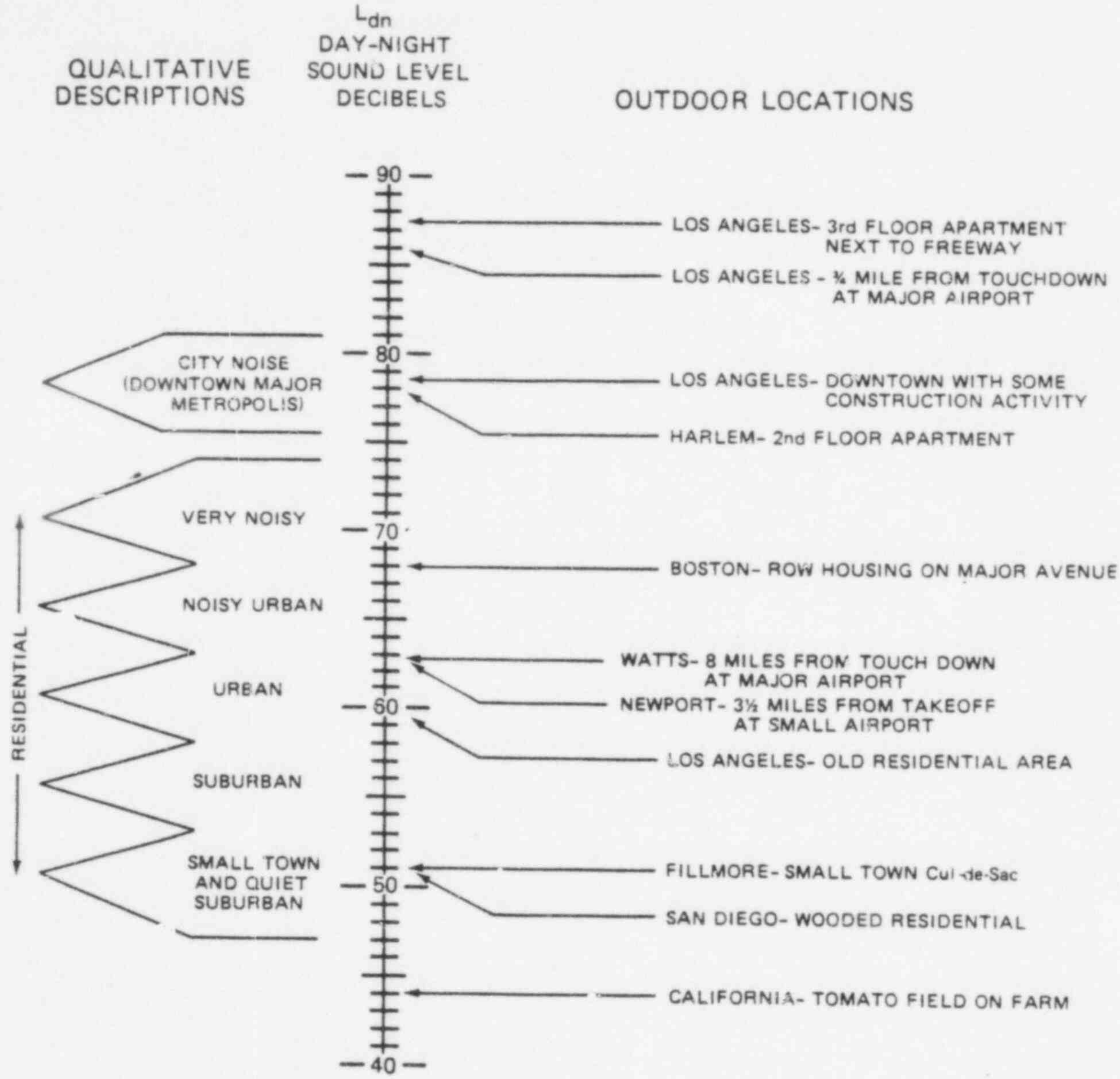

Source: Environmental Protection Agency 1974

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Figure 2.7–5.
SOUND LEVELS AT OUTDOOR LOCATIONS

2.8 ECOLOGY

2.8.1 Regional Setting

The project area is in the northwestern portion of the State of New Mexico on the northern flank of the Mt. Taylor volcanic complex. The elevation ranges from 7,000 feet near La Polvadera Canyon in the northwest of the project area to 8,480 feet in the southeastern portion. The ecological habitats vary from grassland in the lower elevations to the north and west, through pinyon-juniper slopes and uplands at the mid and higher elevations, to pinyon-ponderosa forest at the highest elevations to the south and east.

All habitats have been disturbed to varying degrees over the years as a result of both ranching and logging operations. No sites have been observed within the project area that could be considered pristine or natural; most have been heavily disturbed.

The area has been considered drier and warmer than similar mountain complexes in New Mexico (Osborn, 1962) and the life zones range to somewhat higher elevations in this area. The biotic life zones originally described by C. Hart Merriam (1890) for the San Francisco Mountains in northwestern Arizona, often modified and adapted, have been the basis of many ecological classifications and descriptions in the region since that time (Baily, 1913; Nichols, 1937). A general description of the vegetation of New Mexico with a map of the major types is given in Hunter (1937) and in Little (1950).

Osborn's account (1962) was the first to delineate the altitudinal life zones of major communities of Mt. Taylor and to show the xeric and depauperate nature of the vegetation of the area. Schroeder (1961) described the animal life on Mt. Taylor. Using these references as a basis, the New Mexico Environmental Institute

(NMEI 1974) described and mapped the baseline vegetation and animal species of a portion of the Mt. Taylor area, particularly in the forested types. Additional data on areas that could be affected by the proposed mill and tailings impoundment sites was obtained by Woodward-Clyde Consultants (WCC) in 1976 and 1977. Because Osborn's collections and data were not made from the project area specifically, the baseline data and interpretations that follow in the remainder of this report are based on the studies by NMEI (1974) and WCC (Locations shown in Figure 2.8-1). Considerable study activity, which will add to the available data, is preceding energy development programs in the region.

2.8.2 Vegetation

The major vegetation types in the project area include: (1) grassland, (2) pinyon-juniper slopes, (3) pinyon-juniper mesas (all three in the Upper Sonoran life zone), and (4) pinyon-ponderosa pine forests (in the Transition zone). These types are mapped on Figure 2.8-2 and general characteristics are shown on Table 2.8-1. Within each life zone, and particularly in the Upper Sonoran, the ecological variability produces several vegetation subtypes.

Grassland Type. Within the grassland type, variations in slope, soil, available water and amount of previous disturbance result in the local predominance of different species. We have differentiated the following subtypes: (a) disturbed grassland, (b) grama grassland, and (c) grassland-saltbush.

Generally, grassland vegetation occupies elevations between 7,000 and 7,500 feet over the project area. The soils are coarse sandy loam to sandy loam, with surface horizons 6 to 12 inches thick and a soil pH of 7.4 to 8.2.

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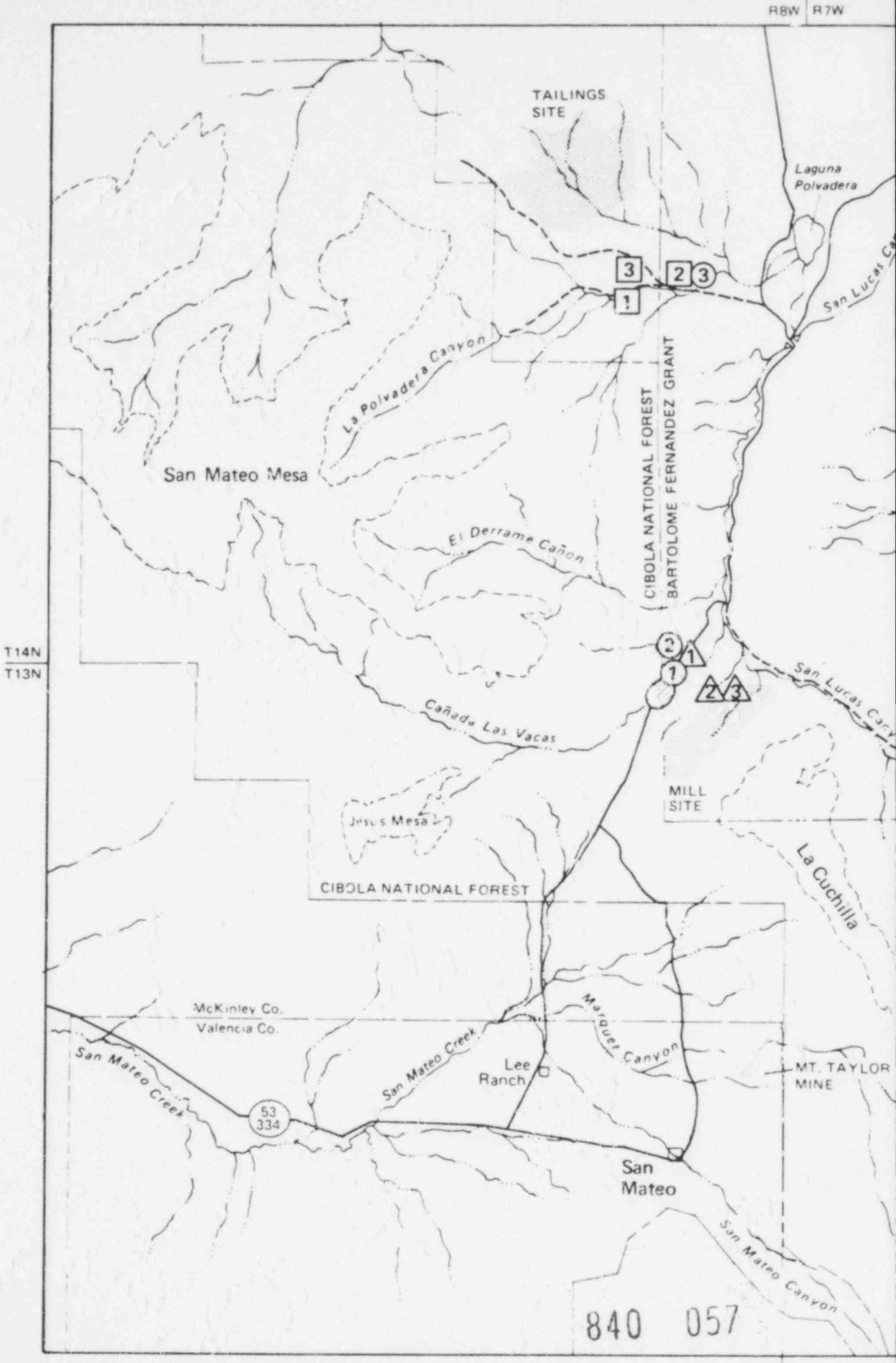

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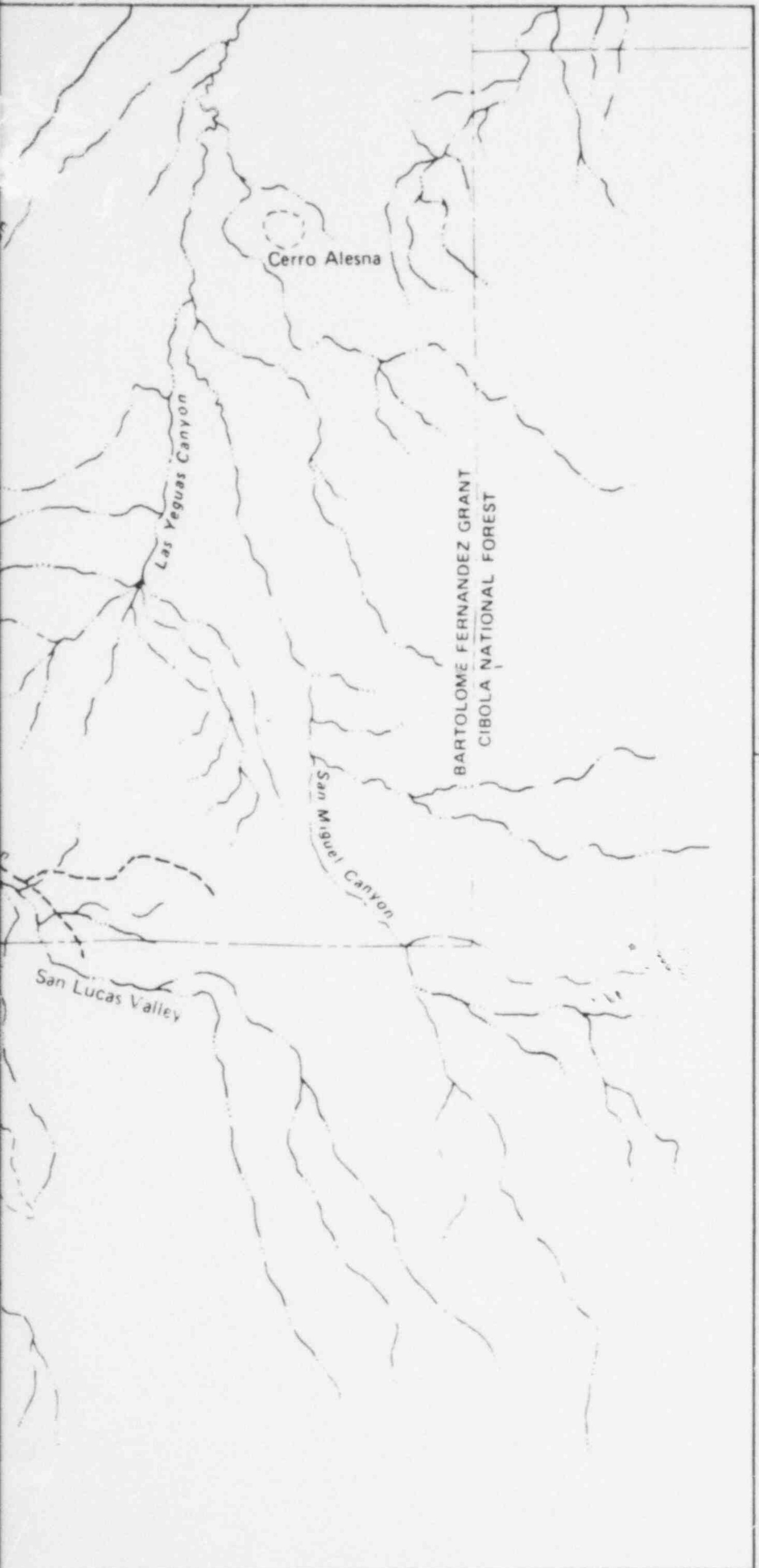
Source: Woodward-Clyde Consultants 1977



N

0 3000 6000 12000 Feet

0 1000 2000 3000 Meters

PRAIRIE DOG TOWN

MAMMAL TRAP LOCATIONS

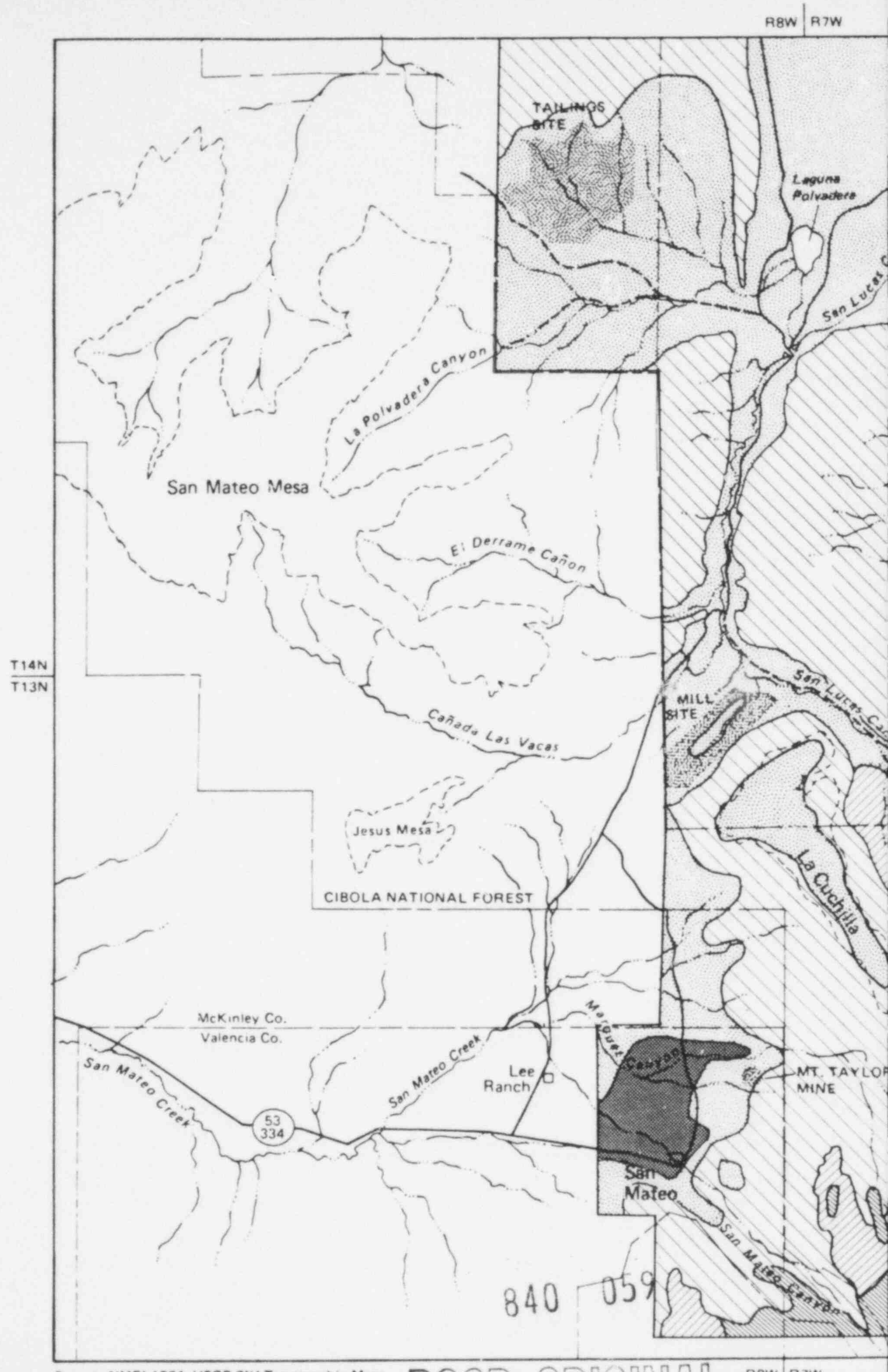
1. SAN LUCAS GRASSLAND
2. SAN LUCAS PINYON-JUNIPER
3. POLVADERA GRASSLAND

VEGETATION SAMPLING LOCATIONS

△ SAN LUCAS 1, 2, 3

□ POLVADERA 1, 2, 3

Figure 2.8–1
ECOLOGICAL SAMPLING STATIONS



Source: NMEI 1974; USGS 7½' Topographic Maps

POOR ORIGINAL

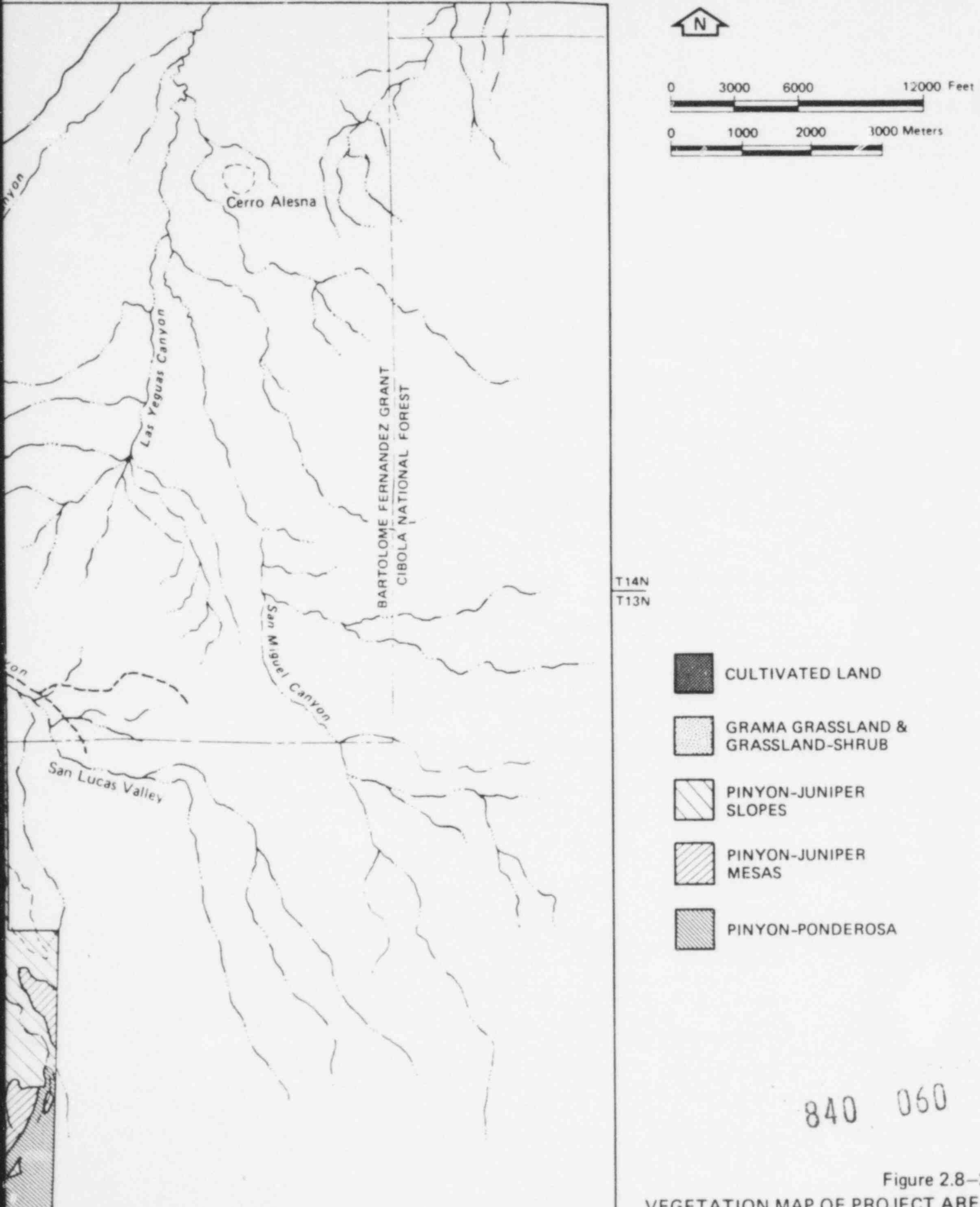


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Figure 2.8–2.
VEGETATION MAP OF PROJECT AREA

Table 2.8-1. CHARACTERISTICS OF VEGETATION TYPES IN THE MT. TAYLOR PROJECT AREA

	Vegetation Types				
	Disturbed Grassland	Grassland	Pinyon/ Juniper Slopes	Pinyon/ Juniper Mesas	Pinyon/ Ponderosa
Elevation (ft)	7160-7360	7100-7500	7400-8100	7900-8320	8300-9300
Slope (%)	0-4	0-20	>30	<30	20-100
Surface Composition[a], %					
Bare ground	76	56	40	26	14
Rocks	1	5	25	16	13
Litter and duff[b]	19	22	28	53	65
Basal Plant Cover, %					
Grasses	1	13	6	4	7
Forbs and Shrubs	3	4	1	1	1
Total	4	17	7	5	8
Tree canopy cover %	-	-	23	42	30

[a] Ground surface composition is given as percent of all surface area covered.

[b] Litter is all organic plant debris which has recently fallen to the ground Duff is well decomposed litter.

Source: Modified from NMEI 1974.

Disturbed Grassland. This type occurs primarily in previously irrigated or cultivated fields and includes areas that have been subjected to extreme disturbance, such as plowing, livestock pens, dumps, and severe overgrazing and erosion. In this type, grass cover has been severely reduced and forbs and low shrubs account for most of the relative cover. The vegetation covers from zero to less than 25 percent of the soil surface and there is little or no litter. Many of the forb species present are indicators of major disturbance, including annuals such as Russian thistle (*Salsola kali*), several species of the family Chenopodiaceae and careless weed (*Amaranthus palmeri*). If not heavily disturbed, and if sufficient time were allowed for revegetation, this subtype would approach either the blue grama grassland or the grass-saltbush types described next.

Grama Grassland. The most abundant plant species in the grassland type, and a species common in all four vegetation types, is blue grama (*Bouteloua gracilis*), a major forage grass. This perennial species has been heavily grazed and at the time of sampling formed mats with few or no flowering stems. The data (Table 2.8-2) show that this species forms about 5 to 22 percent actual cover while its relative cover varies from 22 to 88 percent. In some areas small perennial shrubs such as winter fat (*Eurotia lanata*) and horsebrush (*Tetradymia canescens*) are the major components of the type, although other shrubs such as snakeweed (*Gutierrezia* spp.) are also common in this type.

Grassland-Saltbush. This type occurs near dry washes where water is more available at certain seasons. Because of the high salt content of the soil, the most frequent plant is saltbush (*Atriplex canescens*). Individual site conditions determine the grass species found in association with the saltbush. Our data (Table 2.8-3) indicate that alkali sacaton (*Sporobolus airoides*) is present with considerable regularity,

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Table 2.8-2. CHARACTERISTICS OF THE BLUE-GRAMA GRASSLANDS TYPE

	La Polvadera-3 Cover, %[a]		San Lucas-2 Cover, %[a]		San Lucas-3 Cover, %[b]	
	Actual	Relative	Actual	Relative	Actual	Relative
Grasses and Forbs						
Aristida sp.	0.1	0.5	-	-	-	-
Bouteloua gracilis	4.7	22.2	18.0	63.2	21.8	87.2
Hilaria jamesii	-	-	-	-	1.6	6.4
Sporobolus airoides	0.4	1.9	-	-	-	-
Talinum parviflorum	-	-	-	-	0.6	2.4
Other	-	-	1.0	3.5	0.5	2.0
Shrubs						
Atriplex canescens	-	-	1.2	4.2	0.1	0.4
Chrysothamnus spp.	-	-	-	-	0.2	0.8
Eurotia lanata	9.3	43.8	-	-	0.1	0.4
Gutierrezia spp.	0.7	3.3	8.3	29.1	0.1	0.4
Tetradymia canescens[c]	6.0	28.3	+	-	-	-
Total	21.2	100.0	28.5	100.0	25.0	100.0

[a]Based on 2 line intercepts of 30 meters each.

[b]Based on 20 0.1 m^2 quadrats.

[c]A "+" refers to cover less than 0.1 percent.

Table 2.8-3. CHARACTERISTICS OF THE GRASSLAND-SALTBUSH VEGETATION TYPE

	La Polvadera-1 Cover, %[a]		La Polvadera-2 Cover, %[a]		La Polvadera-1 Cover, %[b]	
Species	Actual	Relative	Actual	Relative	Actual	Relative
Grasses & Forbs						
Sporobolus airoides	0.4	4.5	3.4	25.8	2.7	6.3
Bouteloua gracilis	-	-	4.2	31.8	1.3	3.0
Hilaria jamesii	3.0	34.1	0.3	2.3	-	-
Sitanion hystrix	0.7	8.0	1.8	13.6	-	-
Agropyron smithii	0.3	3.4	-	-	-	-
Muhlenbergia sp.	0.6	6.8	-	-	-	-
Amaranthus palmeri	-	-	-	-	15.7	36.3
Salsola kali	-	-	-	-	10.8	25.0
Talinum parviflorum	-	-	-	-	2.2	5.1
Ambrosia sp.	-	-	-	-	1.0	2.3
Others	+	-	+	+	1.5	3.5
Shrubs						
Atriplex canescens	3.8	43.2	3.5	26.5	6.0	13.9
Chrysothamnus nauseosus	-	-	-	-	2.0	4.6
Lycium pallidum	-	-	-	-	-	-
Gutierrezia sp.	-	-	-	-	-	-
Totals	8.8	100	13.2	100	43.2	100

[a]Based on line intercepts totaling 90 m.

[b]Based on ten 0.25 m^2 quadrats.

[c]A "+" refers to percentages less than 0.1 percent.

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while galleta grass (*Hilaria jamesii*) and blue grama occur more sporadically. A comparison of shrub densities in the grassland types is given in Table 2.8-4.

Pinyon-Juniper Slopes. Pinyon-juniper woodlands occupy the steep slopes between the lowlands and the mesa tops, from elevations of 7400 to 8100 feet. At the lower elevations, most of the trees are one-seed juniper (*Juniperus monosperma*). At higher elevations, Rocky Mountain juniper (*J. scopulorum*) and pinyon pine (*Pinus edulis*) are major components of the vegetation. Total tree canopy cover reaches 30 percent (Table 2.8-5). The predominant understory species, which is heavily grazed, is blue grama. The soil type is generally a brown gravelly loam, with shallow surface horizons containing about 30 percent rock. The soil pH is about 7.6. Soil type and slope (usually greater than 30 percent) distinguish this vegetation type from the pinyon-juniper mesas.

Pinyon-Juniper Mesas. The classic pinyon-juniper vegetation type predominates on the lower mesas of the project area. These mesas range from 7,900 to 8,320 feet in elevation. The majority of the soils are grayish to brown loams and gravelly loams with surface horizons 8 to 14 inches thick. The soil pH is between 7.0 and 8.4.

Canopy cover of all woody species in the sample areas is about 43 percent. The dominant species is pinyon pine, which constitutes over 80 percent of the total canopy cover (Table 2.8-5). As in the pinyon-juniper slopes, most of the basal ground cover is blue grama.

Pinyon-Ponderosa Type. This type is a forest type with considerable variation. The dominant trees are ponderosa pine (*Pinus ponderosa*) and pinyon pine, with patchy clumps of small oaks (*Quercus* spp.) occurring frequently. Grasses constitutre the bulk of the understory vegetation. This type occupies slopes varying from 20 to 100 percent and elevations above 8300

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Table 2.8-4. SHRUB DENSITY IN GRASSLAND VEGETATION TYPES

	Grassland-Saltbush Type			Blue Grama Grassland Type	
	La Polvadera-1	La Polvadera-2	San Lucas-1	San Lucas-2	San Lucas-3
Atriplex canescens	62±24[a]	72±54	493±305	21±38	20±37
Chrysothamnus greenii	-	-	-	137±198	7±19
Chrysothamnus nauseosus	-	-	93±139	-	20±37
Eurotia lanata	-	-	-	-	173±297
Gutierrezia spp.	-	-	5±23	3304±5000	127±148
Lycium pallidum	-	-	27±74	-	-
Mammillaria	-	-	-	10±33	-
Sphaeralcea	-	-	-	-	93±142
Area of transects sampled	$600 m^2$	$600 m^2$	$300 m^2$	$240 m^2$	$300 m^2$

[a]All densities are expressed as numbers per hectare.

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Table 2.8-5. CHARACTERISTICS OF THE WOODY VEGETATION TYPES

	Pinyon/Juniper Slopes				Pinyon/Juniper Mesas				Pinyon/Ponderosa			
	Density[a]		Cover[b]		Density		Cover		Density		Cover	
	#/ha	Rel.	%	Rel.	#/ha	Rel.	%	Rel.	#/ha	Rel.	%	Rel.
Pinus edulis	191	52.2	15	62.5	520	81.8	36	83.7	218	15.6	10	33.3
Pinus ponderosa	-	-	-	-	-	-	-	-	253	18.1	18	60.0
Juniperus monosperma	113	30.9	7	29.1	34	5.3	3	7.0	14	1.0	1	3.3
Juniperus scopulorum	11	3.0	1	4.2	28	4.4	3	7.0	28	2.0	1	3.3
Quercus spp.	-	-	-	-	-	-	-	-	871	62.4	+	
Shrubs[c]	51	13.9	1	4.2	54	8.5	1	2.3	12	.9	+	
Total Density	366				636				1396			
Total Canopy Cover			24				43				30	

[a]Density is given in numbers per hectare; relative density is density for a given species as a percent of the total density.

[b]Cover is canopy cover, or percent of transect intercepted by the canopy. Relative cover is cover for a given species as a percent of total canopy cover.

[c]Includes *Atriplex canescens*, *Cercocarpus montanus*, *Lycium pallidum*, *Opuntia imbricata* *Rhus trilobata*, *Ribes* spp., and *Yucca baccata*.

Source: NMEI 1974.

840 067

feet. The soils are brown loams, the surface horizons are up to 14 inches thick, and the pH is about 7.4. At the higher elevations, this type occupies gentle, open slopes, but at its lower range, it occurs on north-facing slopes and in deep canyons.

2.8.3 Wildlife

The diversity of vegetation types and topographic features in the project area provides a variety of habitat types for many wildlife species. Although most of these species are not restricted to single vegetation types, some species show an affinity for certain plant associations, soil types and topographic configurations, such as cliffs, bluffs, and canyons. The mule deer, for example, is found primarily in the ponderosa pine and pinyon-juniper areas, while the coyote ranges from the grasslands through the mountains. Other species, such as the kangaroo rat, are primarily associated with sandy soils in the grassland vegetation. Still others, such as the deer mouse, occur in nearly all habitat types. The major wildlife species and some of their more critical habitat requirements are briefly discussed below.

The wildlife of the project area has been the subject of two separate studies. The first, by NMEI (1974) studied the southern and eastern areas. Particularly intensive small mammal trapping and bird observation programs were recorded and are summarized in their report. The second, by WCC in 1976, emphasized the areas of San Lucas Valley and La Polvadera Valley, which were potential major activity sites at that time. No site-specific field work was conducted in the area which is now being considered for tailings impoundment. The NMEI report should be examined for data taken in the pinyon-juniper and ponderosa ecosystems, where that study is particularly intensive. Species lists presented in Appendix D of this report represent only those species for which on-site evidence is available. More detailed species lists for the area may be found in the NMEI (1974) report.

840 068

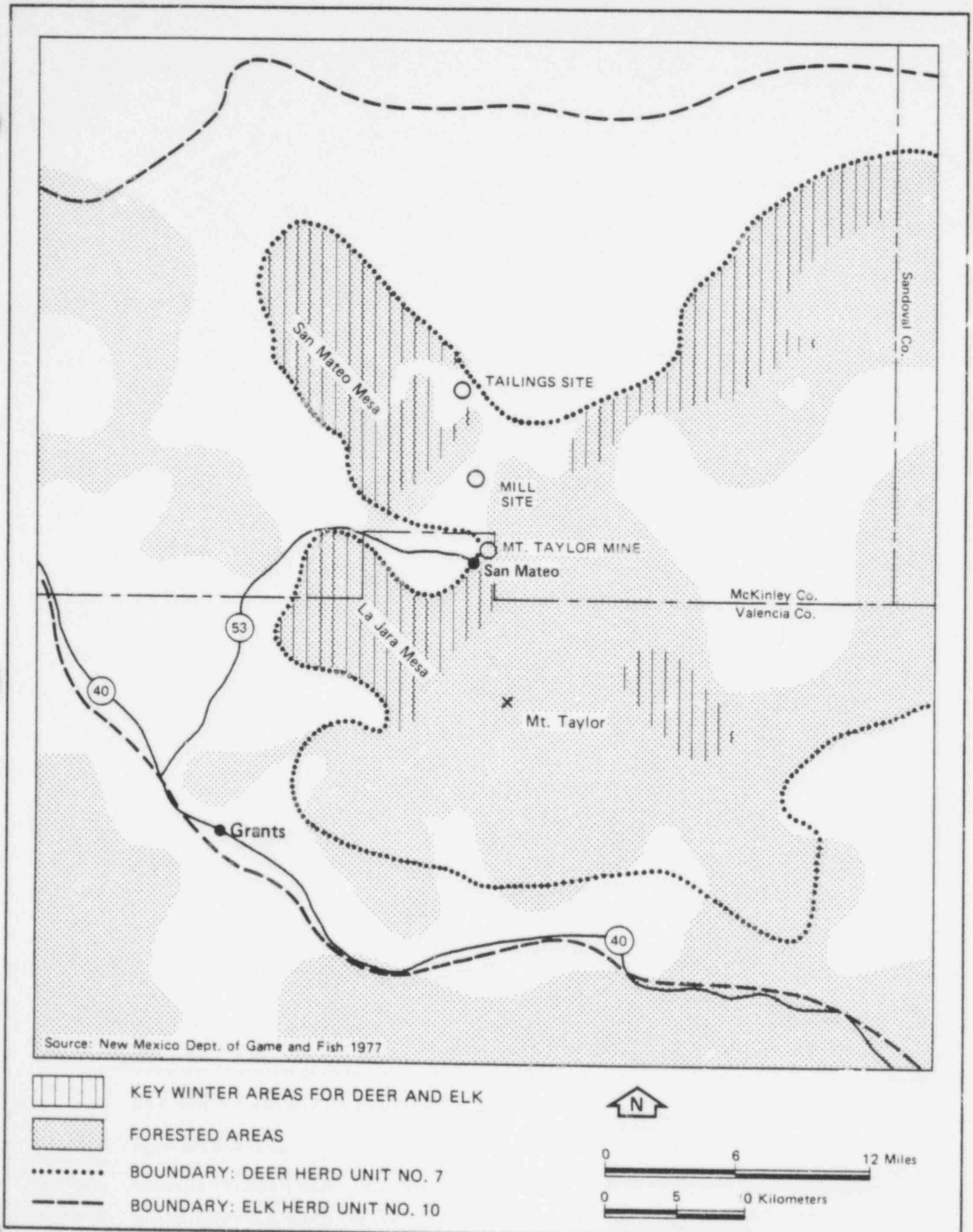
Large Mammals. Big game species that may occur in the project area include mule deer and elk. They are generally considered important species, because they are major herbivores in the food chain and because of their recreational value as big game animals.

In this region the mule deer is the most important big game species in terms of abundance and recreational value. Estimates of the annual deer harvest vary from 220 to 540 for the years 1970-1974 in Game Management Unit 27, which covers an area of 2,968 square miles, including the Mt. Taylor area. Current population estimates range from one deer per square mile in the grassland community to 18 per square mile in critical winter habitat on the higher mesas (Figure 2.8-3) (NMDG&F 1976).

Mule deer make extensive use of forest habitat in this region but may migrate to lower or higher elevations during fall and spring, due to seasonal changes in forage availability and snow cover. During the summer months (early June-early October), deer move to higher elevations, where cooler temperatures and greater precipitation provide sufficient forage. Forbs, shrubs, grasses and small trees are common in the diet. Migration to lower elevations where pinyon-juniper dominates may occur in winter, depending upon weather conditions. Heavy snow will occasionally force deer to lower elevations where grasslands predominate.

Elk in the vicinity of the project area are normally associated with the ponderosa pine forest. Key winter habitat includes the San Mateo Mesa and La Jara Mesa areas (Figure 2.8-3). The elk population apparently utilizes the eastern slopes more than they utilize the western side of Mt. Taylor (Hubbard, personal communication, 1977). This may be due to human encroachment along the west mesa rim and adjacent areas.

840 069



POOR ORIGINAL

Figure 2.8-3.
KEY WINTER AREAS FOR DEER AND ELK

840 070

Medium-sized Mammals. A variety of medium-sized mammals occurs in the project area (Appendix D, Table D-2). The greatest species diversity is expected to occur in the more heterogeneous pinyon-juniper habitat adjacent to the project area rather than in the grassland community. The kit fox, coyote and badger are among the carnivores expected to utilize the habitats in the region. Important herbivores in the food chain include the black-tailed jackrabbit, the desert cottontail and the white-tailed prairie dog.

The kit fox, a nocturnal predator, feeds primarily on small rodents in grasslands at lower elevations. Poison programs directed primarily at the coyote have resulted in a serious decrease in kit fox populations in some areas (Burt and Grossenheider, 1964). The kit fox population in the project area is not known.

The coyote was observed in the project area, but estimates of relative abundance are not available. The diet of the coyote includes rabbits, small rodents and birds. During periods of low rodent activity, the coyote may feed on various fruits and vegetable matter, such as juniper berries (Hoffmeister and Durham, 1971). Coyotes are chiefly nocturnal, but may occasionally be observed during daylight hours.

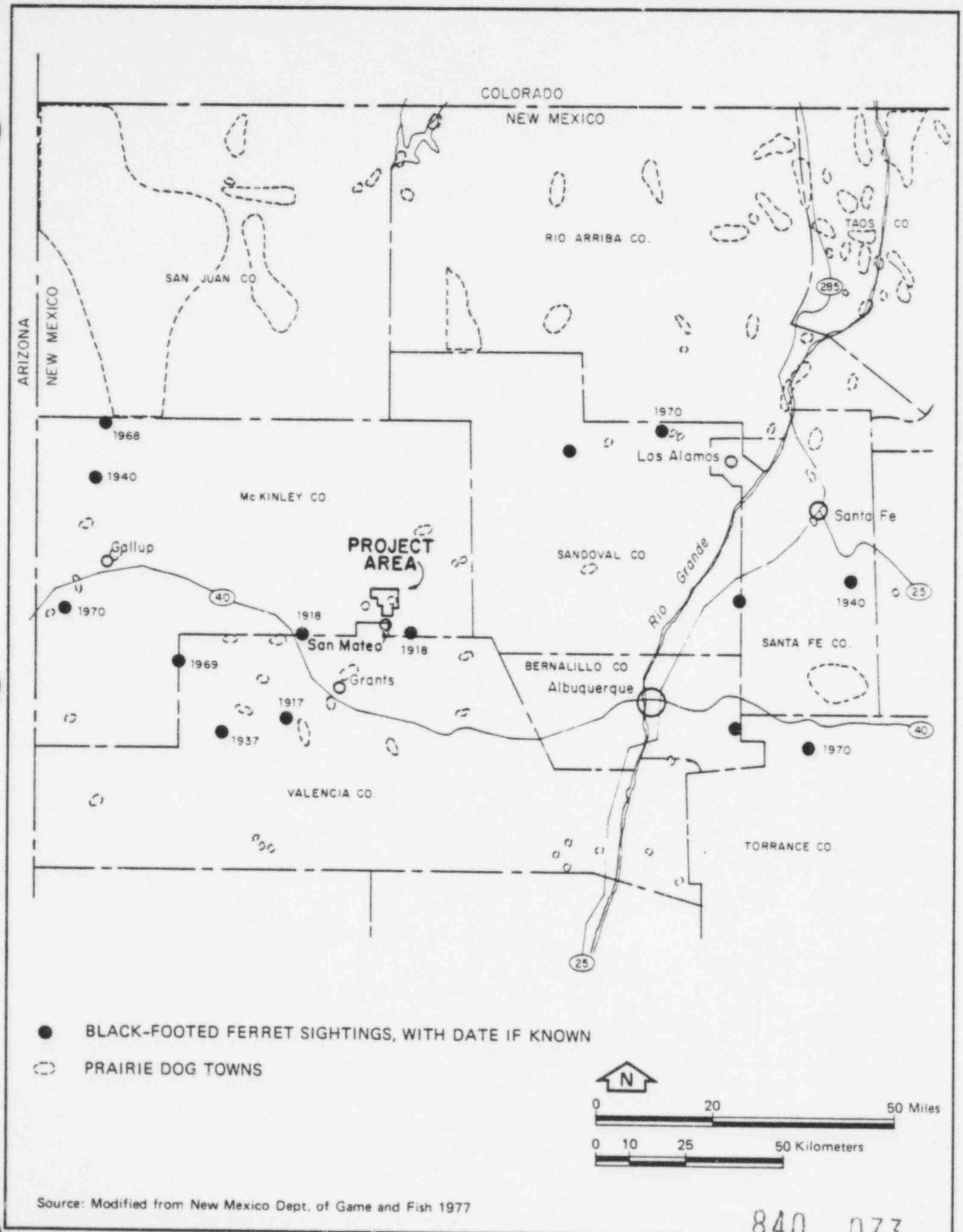
The badger is expected to occur in the project area, and may utilize pine, pinyon-juniper and grassland vegetation types. Its diet consists of various rodents and other small mammals. Three species of lagomorphs, the desert cottontail, eastern cottontail and blacktail jackrabbit, may occur in the project area. Although these often occupy overlapping habitats, the desert cottontail usually occurs in areas of dense vegetation such as sagebrush scrub interspersed with pinyon-juniper (Hoffmeister and Durham, 1971). It feeds primarily on fresh vegetation and bark.

The eastern cottontail inhabits forested areas with nearby open areas and heavy brush. It generally feeds on green vegetation. The major distribution of the species in the project area is expected to be in the pinyon-juniper vegetation and at the higher elevations.

The only whitetail prairie dog town observed within the project area is near the proposed access road at the San Lucas site. Several other towns have been observed in McKinley and Valencia Counties (Figure 2.8-4). The main diet of the whitetail prairie dog consists of grasses and forbs, although insects are consumed occasionally (Burt and Grossenheider, 1964). The presence of prairie dogs indicates a potential for the occurrence of the rare and endangered black-footed ferret. The black-footed ferret has been reported to be closely associated with prairie dog towns, and the majority of sightings have occurred near prairie dog towns (USDI, 1976; NMDG&F, 1976). However, no black-footed ferret sightings within 30 miles of the project area have been reported since 1918 (see Figure 2.8-4).

Small Mammals. Small mammals are the most numerous mammals that occur in the project area. Their abundance makes them important as herbivores and as prey for larger, predatory mammals and for raptors. The Ord kangaroo rat and the deer mouse were the most common small mammals live-trapped at the San Lucas and La Polvadera sites (Table 2.8-6). Other species that were relatively common include the silky pocket mouse and bannertail kangaroo rat.

Several small mammal species were common in the grassland habitat that occurs at both sites. These include the Ord kangaroo rat, silky pocket mouse, and the western harvest mouse (Table 2.8-6). Additional species such as the 13-lined ground squirrel and white-tailed antelope squirrel may also be expected to occur in these grasslands (NMEI, 1974). The white-throated woodrat was observed in pinyon-juniper habitat at the



840 073

Figure 2.8-4.
WHITETAIL PRAIRIE DOG TOWNS AND SIGHTINGS OF THE BLACK-FOOTED FERRET

POOR ORIGINAL

Table 2.8-6. MAMMALS TRAPPED AT THE SAN LUCAS AND LA POLVADERA SITES

Species Scientific Name Common Name	San Lucas Grassland No.	San Lucas Grassland % Comp.	San Lucas Pinyon-Juniper No.	San Lucas Pinyon-Juniper % Comp.	La Polvadera Grassland No.	La Polvadera Grassland % Comp.
Dipodomys ordi Ord kangaroo rat	12	54.5	1	9.0	4	18.3
Perognathus flavus Silky pocket mouse	6	27.4	5	45.5	5	22.7
Peromyscus maniculatus Deer mouse	2	9.1	4	36.5	5	22.7
Dipodomys spectabilis Bannertail kangaroo rat	0	0	0	0	5	22.7
Onychomys leucogaster Northern grasshopper mouse	1	4.5	0	0	2	9.0
Reithrodontomys megalotis Western harvest mouse	1	4.5	0	0	1	4.6
Neotoma albigula White throat woodrat	0	0	1	9.0	0	0
TOTALS	22	100.0%	11	100.0%	22	100.0%

840 074

San Lucas site. In addition, the rock mouse and pinyon mouse may be expected to utilize this habitat in the Mt. Taylor area (NMEI, 1974).

Birds. A variety of bird species were recorded in the project area (Table D-3). Some species of birds are permanent residents while others occur as seasonal migrants. Populations of some resident species may fluctuate due to the movement of individuals into and out of the resident populations during seasonal migrations. Resident species in the project vicinity include the golden eagle, sparrow hawk, scaled quail, scrub jay and lark sparrow.

Resident and migrant species utilize a variety of food sources and can be classified as herbivores (plant-eaters), granivores (seed-eaters), insectivores (insect-eaters), carnivores (meat-eaters), or omnivores (all foods). However, few bird species are limited to one classification and many species make use of food sources from more than one major feeding category, depending upon the relative availability of alternate food sources. Birds are therefore important in maintaining the stability in various food chains of the ecosystem.

Upland game birds observed in the area include the mourning dove and Gambel's quail. The mourning dove (seed-eater) occurs in a variety of habitats throughout its range, including the grassland and pinyon-juniper associations present at the proposed tailing dam site. Gambel's quail occurs primarily in the lower portions of the pinyon-juniper vegetation that have open spaces with low herbaceous plants, loafing sites, escape cover, and a nearby water source. The scaled quail is expected to be more common than Gambel's quail in the project area. Scaled quail primarily utilize grasslands and associated shrubs.

The most important upland game species in the Mt. Taylor region, in terms of recreational value, is the wild turkey. This species prefers mountain forests and broken woodland. Although turkeys have been observed south of the project area in San Mateo Canyon (NMEI, 1974), it is not likely that they utilize areas near the proposed tailings site.

Several raptor species utilize the two major vegetation associations (grassland and pinyon-juniper woodland) near the proposed La Polvadera tailings site. Raptor species observed during the field reconnaissance included the golden eagle, red-tailed hawk, and kestrel. Other raptors that may be expected to occur during the summer include the turkey vulture and Swainson's hawk. During winter months, the roughlegged hawk and harrier may be expected to migrate into the region (Peterson, 1961; Robbins et al., 1966). The peregrine falcon, an endangered species (USDI, 1976), may occur as a ra[illegible]nter migrant. Additional species which may occur as residents include the sharp-shinned hawk and the prairie falcon.

The main diet of raptors consists of small mammals ranging in size from mice to small rabbits. Species such as the golden eagle, because of their large size, require a greater number of small animals for survival and a relatively large hunting area is necessary to provide sufficient food (Welty, 1962). Their diet may consist of rabbits, ground squirrels, prairie dogs and carrion. Some species such as the prairie falcon have a variable diet ranging from small ground squirrels and jackrabbits to a variety of birds including mourning doves, meadowlarks and horned larks. Waterfowl habitat is provided by only a few small stock ponds and reservoirs in the project area. These ponds are primarily used as resting areas during migration. Few individuals would be expected to utilize the project area at any one time due to the lack of sufficient habitat. Species that may be observed in the area include the killdeer and spotted sandpiper.

Amphibians and Reptiles. Few amphibians are expected in the project area because of the lack of large, or permanent water bodies. However, the western spadefoot toad may occur in the small cattle watering ponds in the area. The most abundant species recorded in NMEI included the Great Basin spadefoot toad, the eastern fence lizard and the safebrush lizard. The most frequently observed lizard species may be more abundant because they are not completely dependent on moist habitats.

Invertebrates. Invertebrates (including insects, spiders and other arthropods) are extremely abundant in the vegetation types of the area in terms of both species and individuals. Although small in size and often unnoticed by man, except for a relatively few pest species (flies, wasps, etc.), this group represents one of the more important groups in the ecosystem. Invertebrates form a significant portion of the animal biomass in most habitats and function at almost every level in the food chain. They are especially important as a food source for amphibians and reptiles as well as for many species of birds and mammals. Our study did not obtain field data on this group.

2.8.4 Ecological Interrelationships

Dynamics. Succession, the natural progression of biotic communities through time, tends to develop a stable, or climax, community in equilibrium with environmental conditions. Activities such as grazing by domestic livestock and logging disrupt the successional trend and promote the development of a subclimax or, when disturbance is very severe, a pioneer community. In this area, disturbances occur when pinyon-juniper woodlands are chained to promote grass growth and eliminate the woody vegetation, or when severe overgrazing or heavy erosion eliminate even the perennial species. In the latter case, a pioneer community, in which most of the ground is bare and many of the plants are annual weeds, may become established. If such a community is not further

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degraded, and the topsoil remains, the vegetation may progress rapidly to a subclimax community and eventually to the climax. In this grassland type, the pioneer community described by NMEI (1974) includes an open assemblage of annual forbs such as Russian thistle, pigweeds, summer cypress (*Kochia scoparia*) and others.

In time, perennial grasses, such as blue grama and galleta, become established and the area is also invaded by shrubs such as snakeweed and, in the more saline habitats, four-wing saltbush. These plants invade the pioneer community to form a subclimax grassland that may be well-adapted to moderate or heavy grazing pressure.

With reduced grazing, or with deferred grazing (timing of grazing such that early season grazing is eliminated), a climax grassland that includes cool season grasses such as western wheat grass (*Agropyron smithii*) may predominate. Climax grassland may include more species diversity, with a higher percent cover and more litter, than subclimax grassland. The plant productivity of subclimax grassland may be greater than that of the climax vegetation because moderate grazing often stimulates productivity of grassland species.

Succession and Land Use. All of the lower portions of the project area have been intensively grazed since early settlement in the late 1700's. The grassland and woodland types are part of the San Mateo range allotment, still freely grazed by livestock, and have a history of intensive cattle grazing. The grama grassland may be in a state of accelerated erosion because of grazing pressure. According to NMEI (1974), this idea has been espoused by one U.S. Forest Service scientist who feels that the nitrogen cycle may have been disrupted as a result of heavy grazing in this area in the 1870's and 1880's. With present grazing pressure, it is anticipated that one-seed juniper will increase

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in the flat areas of the grassland and that a more luxuriant climax grassland, including cool season species, may never become reestablished.

Surveys by U.S. Forest Service personnel indicate that cool season grasses, such as western wheat grass, rarely occur in the project area. Such grasses are heavily impacted by grazing during the early portion of the year; and their absence in this area may be an indication of heavy grazing. The Mesa Chivato area (in the northwest corner of the Cibola National Forest) which has been only slightly grazed, contains an abundance of cool season grasses including western wheat grass (Mr. Wayne Patton, U.S. Forest Service, Cibola District Office, Albuquerque, personal communication NMEI, 1974, p. 185). These surveys would indicate that the present grama grassland is subclimax and that, although blue grama would be a major climax species, a greater diversity of grass species (including cool season grasses) would probably constitute the climax grassland vegetation.

The pinyon-juniper type appears to be in a stable subclimax state in the terms of plant composition; in terms of structure, the trees are relatively small, and an increased canopy cover can be expected as the stands mature. This would reduce the density of grasses and forbs. In the pinyon-ponderosa forest, logging has eliminated the large pines and the subclimax community now present includes only scattered ponderosa and young oaks. Maturation of these stands should again produce the typical large ponderosa pine forest, with some pinyon understory. The abundance of oak clumps is apparently a result of former disturbance by fire and logging (NMEI, 1974, p. 185).

2.8.5 Endangered or Threatened Species

Five wildlife species listed as endangered or threatened by the U.S. Fish and Wildlife Service and the State of New Mexico have ranges which include portions of the State of New Mexico. Endangered species are

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"those species in danger of extinction throughout all or a significant portion of their ranges" and threatened species are "those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range" (USDI, 1976). The bald eagle and peregrine falcon are considered migrants in the Mt. Taylor area (Hubbard, 1977). It is doubtful that these species would nest in the area because of the lack of adequate nesting habitat.

The black-footed ferret is extremely rare throughout its range; however, several sightings have been reported in McKinley and Valencia Counties by the New Mexico Department of Game and Fish (Figure 2.8-4).

Threatened species with distributions encompassing the Mt. Taylor/San Mateo region include the osprey and McCown's longspur (NMDG&F, 1976). The osprey may utilize a variety of habitats during migration, but it normally occurs along major streams and lakes. No such habitat occurs in the project area. McCown's longspur is a winter migrant in grassy plains and valleys of New Mexico and may utilize the grasslands in the region on a transient basis.

No endangered or threatened plant species have been found in the project area. The existing plant list has been compared with a list prepared by the Smithsonian Institution (1976). No unique vegetation types were observed in the region. None of the vegetation has a potential value for "benchmark" purposes or for inclusion in a natural areas system. The types which were found are typical of those which cover large sections of New Mexico and the southwest. All of the vegetation in the area has been disturbed and none is considered to be in natural condition. This disturbance has resulted from heavy grazing throughout the area and logging at the higher elevations in the forest types.

2.9 RADIOLOGICAL ENVIRONMENT

2.9.1 Natural Radiation Sources

The largest source of ionizing radiation exposure to the general population is the natural radiation environment. This exposure is not uniform for all individuals, but varies due to a number of factors including altitude, geological features, and living habits. Variations in exposure as a result of these factors often exceed exposure from sources which have received considerably more attention. For example, the dose from natural radiation to an individual in the United States ranges from 80 to 250 mrem*/yr. In addition, the average individual living in the United States in 1964 received a medical x-ray exposure of 55 mrem/yr. Other sources, such as nuclear reactors and fallout, account for less than 5 mrem/yr. (Oakley, 1972).

Exposure to natural radiation has not received the attention which has been accorded to sources of less magnitude and ubiquity, such as medical x-ray exposure and nuclear reactors. Several studies have shown no correlation of background radiation with health. However, background radiation exposure is less well defined than smaller sources of exposure, and may contribute to the deleterious effects which are speculated to be associated with other low levels of radiation. In order to determine the significance of the effects of small man-made increments of exposure, it is necessary to determine the larger component due to natural radiation.

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*One millirem (mrem) is defined as that quantity of any type of ionizing radiation which, when absorbed by man, produces an effect equivalent to the absorption by man of 0.001 of a roentgen of x-ray or gamma radiation (400 KV).

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External natural radiation sources include cosmic radiation and radioactive elements in the earth's crust and in building materials. An additional increment of external exposure, which accounts for less than 5 percent of the total, is due to the presence of radon isotopes and their radioactive decay products in the atmosphere.

One source of internal exposure is ingestion of natural radionuclides. Potassium-40 is the principal contributor to this internal dose; other significant internal emitters are carbon-14, radon-222 and progeny, radium isotopes and their daughter products. The retention of inhaled radioactive daughter products of radon isotopes is the primary source of lung dose to the general population. The inhalation of radon daughters requires special attention in the case of underground uranium miners (Federal Radiation Council, 1967). Exposure to occupants of residential dwellings can also be significant. A potential average lung dose of about 200 mrem/yr to occupants of unventilated wood dwellings and about 1800 mrem/yr to occupants of unventilated concrete buildings has been calculated.

The natural radiation environment has been relatively constant for at least 10,000 years and probably much longer. However, man's living habits have changed in such a way as to influence his exposure. Populations have tended to migrate inland from coastal areas. This migration increases the average elevation of the population and, hence its exposure to cosmic radiation. Outdoor agrarian society has largely been replaced by indoor work and life in urban centers. Man's exposure has thus been increased in some instances because of the natural radioactivity of building materials; in other instances, buildings attenuate exposure to the outdoor terrestrial sources, thereby reducing exposure.

Since the proposed project will release radioactive materials, it is important to establish baseline radiation levels and concentrations of

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radioactive materials. Periodic monitoring during project operation can then detect any significant increases by comparison with these baseline levels. To obtain the necessary information, a baseline radiological monitoring program was carried out by WCC personnel. Analyses were performed by Controls for Environmental Pollution, Inc. (CEP), an experienced firm located in Santa Fe, New Mexico and by Eberline Instrument Corporation, another well-established company located in Albuquerque, New Mexico. Field measurements were made of total background radiation levels. Soils, plants, air and water in the project area were analyzed for radioactivity. Results indicate that the project area, which is at a relatively high elevation (over 7,000 feet above sea level), receives more than the average level of cosmic radiation. Further, the rock and soil of this general locale contain a comparatively high concentration of radioactive materials (hence its exploitation as a source of uranium), which contributes to the increase in background radiation and accounts for the presence of traces of these radioactive materials in the local water, air, and biota. It is believed that the background radiation levels have changed little, if any, due to man's prior activities in the area.

2.9.2 Ambient Radiation Levels

Total natural background radiation from all sources (i.e., air, water, earth, and cosmic radiation, was measured in the field by means of thermoluminescent dosimetry. Special weatherproof thermoluminescent dosimeter (TLD) packets containing high-sensitivity lithium fluoride chips were placed at 15 monitoring points on and around the project area during two sets of measurement periods. Each set of measurements included dosimeters that were exposed for about one month and others that were exposed for an overlapping three month period. The periods of exposure are given in Table 2.9-1. Two sets of measurements (Periods 3 and 4) were made with one TLD at each monitoring point for each time interval, while the other sets were performed using duplicate TLD's at

Table 2.9-1. THERMOLUMINESCENT DOSIMETER MEASUREMENTS

Location[a]	Measured Dose (mrem/week) Period 1 2/9/76 3/15/76	Period 2 2/9/76 5/12/76	Period 3 8/4/76 9/10/76	Period 4 8/4/76 10/5/76	Period 5 10/21/76 1/26/77	Estimated Annual Dose[b] (mrem)
TLD-1	4.08	2.85	2.19	2.71	3.45	159
TLD-2	3.88	2.45	2.07	2.56	3.04	146
TLD-3	3.56	1.98	1.85	2.18	2.83	129
TLD-4	4.30	2.30	2.07	2.58	3.16	150
TLD-5	5.48	3.46	1.89	2.62	2.90	170
TLD-6	3.64	2.45	1.85	2.71	2.92	141
TLD-7	4.20	2.26	2.19	2.47	3.02	147
TLD-8	3.54	2.54	1.92	2.31	3.17	140
TLD-9	3.96	2.45	2.00	2.31	2.88	141
TLD-10	3.54	3.20	2.00	2.60	3.06	149
TLD-11	3.72	2.70	2.11	2.64	2.81	145
TLD-12	3.76	2.27	1.92	2.64	3.41	146
TLD-13	3.82	2.66	2.04	2.56	3.13	148
TLD-14	4.02	2.61	2.11	2.66	2.85	148
TLD-15	4.06	2.38	2.15	2.66	3.06	149
Average for the project area						147

[a]Dosimeter locations shown in Figure 2.9-1.

[b]Measured doses were summed and then multiplied by 52/5 to estimate annual dose.

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each point for each time interval. The locations of monitoring points are labeled TLD-1 through TLD-15 in Figure 2.9-1.

After collection, the TLD's were analyzed by Eberline to determine the amount of radiation exposure (dose). Dose data for the average of each simultaneously exposed TLD pair are presented in Table 2.9-1 for each location. The mean annual background radiation level in the area was calculated to be 147 mrem with an uncertainty of about 20 percent.

2.9.3 Radioactive Materials in the Environment

Air. Gaseous radon-222 and radioactive constituents of suspended particulate matter account for a majority of the background airborne radioactive matter at the project area. Surface soils and rock, which are the most significant existing sources of airborne particles in the area, contain traces of radioactive matter, as do most materials of the earth's crust. Gaseous radon-222, a radioactive decay product of radium-226 in the soil and rock, decays to radioactive daughter products which deposit on soil particles and airborne particles. These can be ingested by man and animals.

Baseline levels of airborne radioactivity and concentrations of selected radioactive materials in the air have been measured at the project area.

Suspended Particulate Matter. Suspended particulate samples were collected in the project area by WCC at location shown as HV in Figure 2.9-1. High-volume air samplers were used to collect these samples on filter material with an air flow rate of about 40 cubic feet per minute. One sample per month was subsequently analyzed by Controls for Environmental Pollution, Inc. (CEP) of Santa Fe, N.M. for gross alpha, beta and gamma activities, thorium-230, radium-226 and natural uranium by

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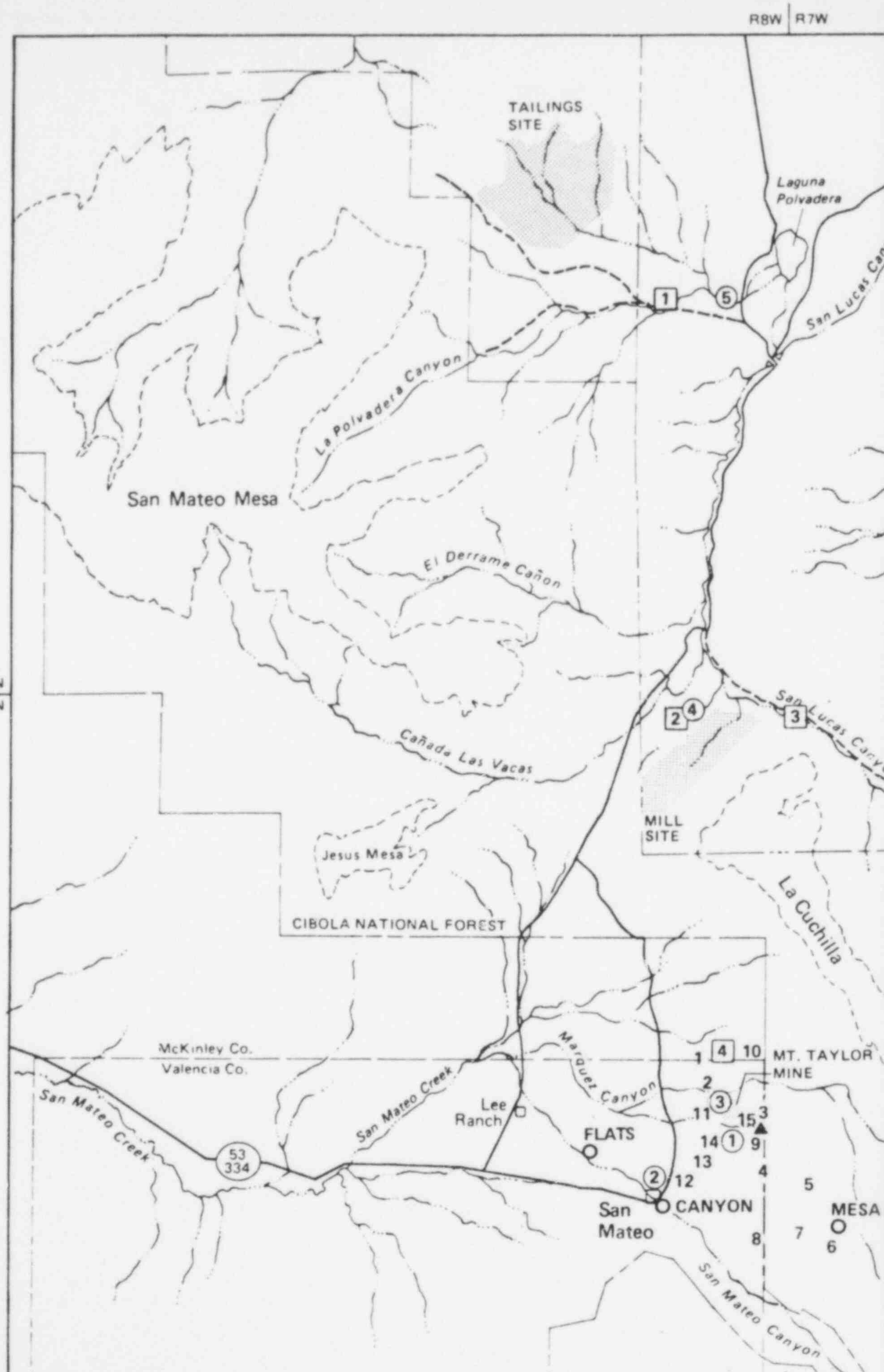

Source: Woodward-Clyde Consultants, 1977

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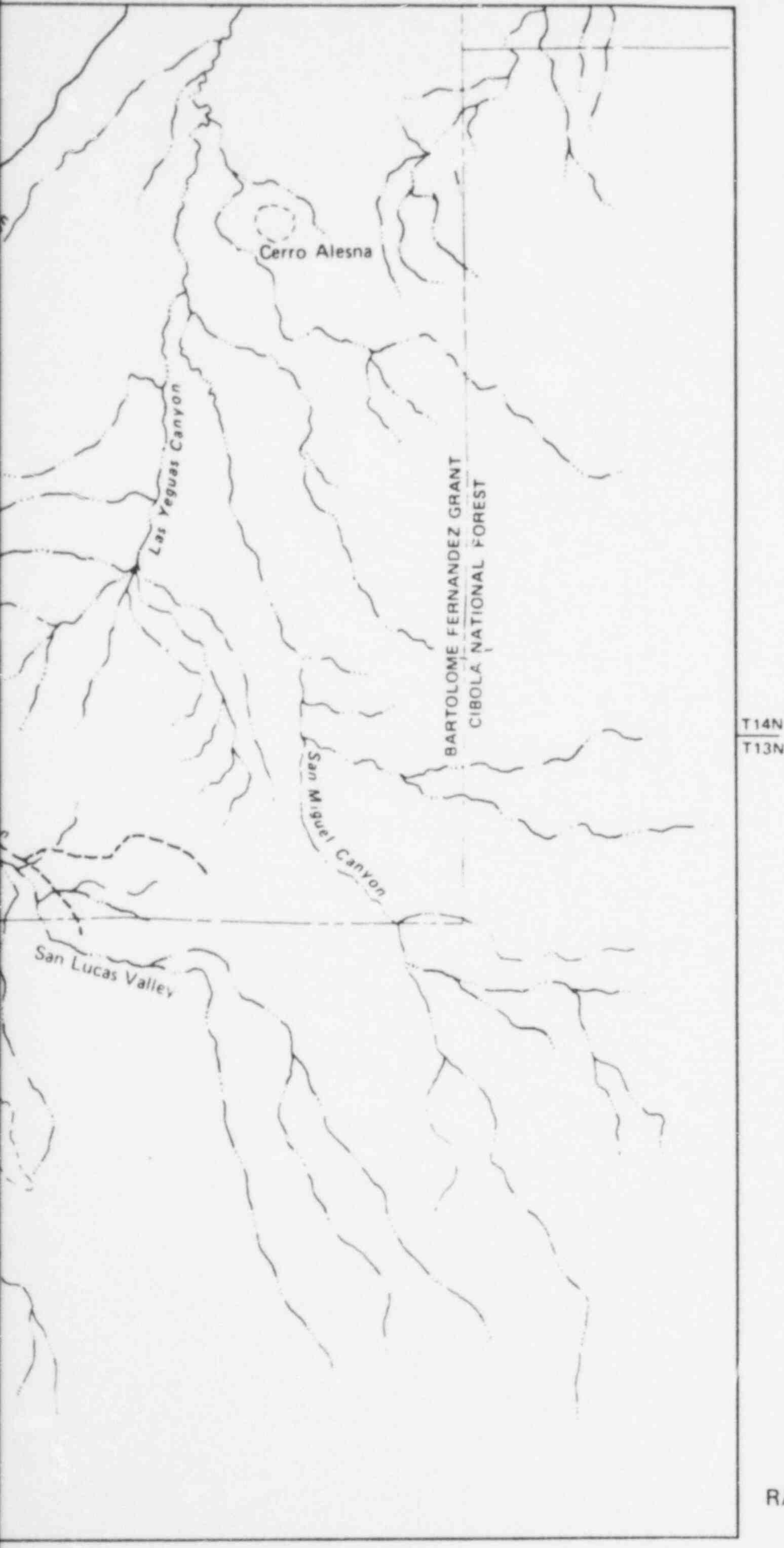

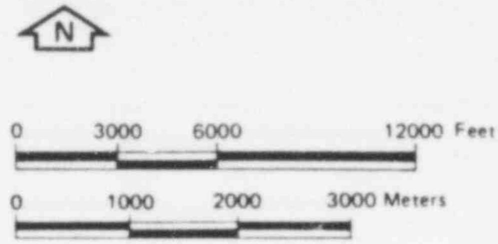

③ RADON (WCC) 1–5
O RADON (NMEI, 1974)
3 TLD 1–15
▲ HV SAMPLES

BIOLOGICAL AND SOIL SAMPLES

1 POLVADERA V1, V2, V7, V8, S1–6, SMALL MAMMAL TRAPS
2 SAN LUCAS V3, V4, V5, V6, V9, S7, S8 SMALL MAMMAL TRAPS
3 SAN LUCAS VII
4 LOWER MET. STATION V10, S9 SMALL MAMMAL TRAPS

Figure 2.9–1.
RADIOLOGICAL SAMPLING LOCATIONS

radiochemical techniques. The results of particulate sample analyses (Table 2.9-2) show normal levels of radioactivity for the majority of the year. High values of gross beta and gamma measurements are ascribed to fission product material from Chinese nuclear bomb debris in the atmosphere. The high value for Th-230 found in sample HV-10 is anomalous.

Radon-222 and Daughters. Ambient ground-level radon-222 gas and daughter concentrations were estimated at 5 locations in the project area (labeled "RADON (WCC) 1-5" in Figure 2.9-1). A series of radon-222 gas and radon daughter measurements was made over a two day period (September 16-17, 1976) by Eberline Instrument Corporation of Albuquerque, N.M. at the request of Woodward-Clyde Consultants.

Airborne radon daughters were determined by the industry standard method (American National Standard Institute, 1969), which is based on measuring the alpha particle emission rate from a filter sample 40 to 90 minutes after sampling. A battery operated sampler with a flow rate of about 15 liters/minute was used to collect aerosols on the filter. The flow rate of the sampler was measured with a rotameter. An Eberline Model SACR-5 detector, an Eberline Model MS-2 scaler, and ZnS tape were used to measure the alpha particle emission rate. The alpha counter was calibrated using a Th-230 alpha standard.

Airborne radon gas was measured using 2.5 and 4.5 inch diameter scintillation cells manufactured by Eberline. Filtered air was flushed through the cells using a battery operated pump. The cells were counted about two hours after sampling. An Eberline Model SACR-5 detector with an Eberline Model MS-2 scaler were used to count the 2.5 inch gas cells. Each cell was calibrated using Rn-222 gas flushed into the cell from a National Bureau of Standards Ra-226 solution standard.

Table 2.9-2. BASELINE GROUND-LEVEL AIRBORNE RADIOACTIVES AND CONCENTRATIONS OF SELECTED RADIOISOTOPES IN PARTICULATE MATTER

Sample[a]	Date	Gross Radioactivity (pCi/filter)[b,c] Alpha	Beta	Gamma	Concentration (pCi/filter)[b,c] Th-230	Ra-226	Uranium[d]
HV-1	3/13/76	47.3±28.3	45.3±4.1	157±58	0.00±0.02	21.9±0.8	1.80
HV-2	4/12/76	38.1±27.0	37.5±2.7	102±48	0.00±0.02	1.19±0.16	12.9
HV-3	5/12/76	22.5±16.2	2.04±1.63	97±30	0.19±0.05	3.61±0.30	16.9
HV-4	6/17/76	45.4±33.5	39.3±5.2	110±26	0.00±0.02	1.88±0.02	30.5
HV-5	7/17/76	47.3±25.5	41.2±3.6	41±39	2.25±0.23	16.4±1.6	6.3
HV-6	8/22/76	15.8±12.1	42.6±5.0	54±18	0.00±0.02	7.43±0.43	5.0
HV-7	9/15/76	23.6±12.7	23.9±4.2	49.5±32.4	0.00±0.02	20.8±10.7	0.46
HV-8	10/3/76	13.7±12.6	74.7±6.1	164±59	0.00±0.02	4.7±1.5	55.4
HV-9[e]	11/8/76	26.0±13.5	330±8	485±63	0.00±0.02	15.3±0.6	13.1
HV-10[e]	12/20/76	84.5±24.1	63.5±3.3	196±77	9.01±4.46	14.4±3.7	8.6
HV-11[e]	1/19/77	44.1±23.5	54.3±3.8	330±130	0.00±0.02	9.5±3.6	1.7
HV-12[e]	2/6/77	48.0±20.3	146±7	460±50	2.11±0.56	5.32±3.23	11.5

[a]Location is shown in Figure 2.9-1. Samples were taken for 24 hrs. at 40 scfm.

[b]pCi/filter = picocuries of radioactivity or radioisotope per filter ±2 σ (Poisson).

[c]Determined by Controls for Environmental Pollution, Inc.

[d]Uranium concentrations were determined by fluorometric analysis. This technique has an accuracy of 92-95%. A conversion factor of 0.68 pCi/μg uranium was used.

[e]This sample contained fission product material which is attributed to Chinese nuclear bomb tests.

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No significant differences in air concentrations were observed between sample site, sample times, or weather conditions (Table 2.9-3). Concentrations of radon daughters were very low, ranging from 0 to 3 x 10^{-4} working levels* (WL). Concentrations of radon gas were similarly low ranging from 0 to 0.08 pCi/liter. These air concentrations are approximately equal to world average radon concentrations for outdoor air (United Nations, 1966). The air concentrations observed were near the limit of instrument sensitivity with statistical counting errors at the 95% confidence level being about 2 x 10^{-4} WL for radon daughters and 0.1 pCi/liter for Rn-222 gas.

An extensive baseline study was performed in the Mt. Taylor region by the New Mexico Environmental Institute in 1972-73 for Gulf Mineral Resources Co. (New Mexico Environmental Institute, 1974). This study included measurements of radon and its daughter products in air samples taken three feet above ground level at three stations (shown in Figure 2.9-1) over a one year period. The results of the radon measurements, which are summarized in Table 2.9-4, ranged from 0.08 to 0.90 pCi/liter with an overall mean of 0.19 pCi/liter. Grouping the results by time of day showed a variation from morning to afternoon of about a factor of three. The radon daughter measurements gave variable results with an average of about 50 percent of the equilibrium amount of short-lived daughters present.

Aircraft soundings were used to obtain the variation of radon concentrations with respect to altitude for up to 13,500 feet above the San Mateo basin. Evidence was obtained that on many occasions air in the basin does not mix readily with the air at and above mesa top levels.

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*Working Level = daughters in equilibrium with 100 pCi of Radon-222 per liter of air

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2.9-3. BASELINE AIRBORNE CONCENTRATIONS OF RADON AND RADON DAUGHTERS

Sample Number[a]	Date and Time of Sampling		Radon Daughters $\times 10^{-4}$ WL[b,d]	Radon Gas pCi/liter[c,d]
RN-1	9/16/76	10:21	0±2	0.06±0.10
		14:52	0±2	
		15:58	2±2	
	9/17/76	11:23	1±2	
		11:33	2±2	
		15:33		0.06±0.10
RN-2	9/16/76	11:34	3±2	0.04±0.10
		15:08	1±2	
		16:38	1±2	
	9/17/76	11:45	0±2	
RN-3	9/16/76	11:52	2±2	
		15:24	0±2	
		16:24	1±2	0.04±0.10
	9/17/76	11:59	2±2	
		15:13	1±2	
RN-4	9/16/76	13:44	2±2	
	9/17/76	10:20	0±2	
		13:45	0±2	
		14:53	1±2	0.00±0.10
RN-5	9/16/76	13:27	2±2	
	9/17/76	10:03	0±2	
		13:25	1±2	0.08±0.10

[a]Locations shown on Figure 2.9-1.

[b]WL = Working Level = Daughters in equilibrium with a concentration of 100 pCi of radon-222 per liter of air.

[c]pCi/liter = picocuries of radon-222 per liter of air $\pm 2\sigma$ (Poisson).

[d]Determined by Eberline Instrument Co.

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2.9-4. MEAN SURFACE RADON CONCENTRATIONS AT PROJECT AREA STATIONS DURING SAMPLING PERIODS 1972-1973

Sampling Period	No. of Samples	Mean Rn-222 Concentration (pCi/l)		
		Flats[b]	Canyon[b]	Mesa[b]
September (28-29)	6	0.19	0.19	0.19
October (12-23)	21	0.18	0.19	0.C8
December (17-18)	7	0.59	0.36	0.16
February (23-24)	10	0.19	0.16	
May (3-4, 8-9)	37	0.20	0.17	0.12
June (18-19)	6	0.20	0.18	0.14
July-August (25, 26,30,31,1)	48	0.25	0.18	0.19
Mean		0.23	0.19	0.15
Total Samples	135			
		0.19 (Overall Mean)		

Source: New Mexico Environmental Institute 1974.

[a]The statistical error in counting and sampling is a standard deviation of ±12 percent.

[b]Locations are shown in Figure 2.9-1.

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A study of the concentrations of radon and radon daughters in the Grants Mineral Belt was performed by the Environmental Protection Agency during November 1975 (Eadie et al., 1976). This study showed that San Mateo had a significantly lower radon-222 concentration than all other locations sampled except Thoreau. The Radon-222 concentrations ranged from 0.062 to 0.90 pCi per liter. The average was 0.36 pCi per liter. Indoor measurements showed that radon daughters were 67 percent of the equilibrium levels.

Water. Samples of surface and well water were collected from a variety of points in the project area. Analyses for radiochemical constituents were performed, and the results are presented in Section 2.6 and Appendix B. According to these data, water in the area appears to be within the limits recommended for radiochemical constituents in drinking water.

Soils. Eighteen samples of soil from nine locations were collected in the project area during the environmental field program by WCC. These were analyzed by CEP for the following radiological parameters:

- Gross alpha
- Gross beta
- Total uranium
- Thorium-230
- Radium-226
- Lead-210

The samples were also analyzed for various radionuclides by gamma-ray spectrometry. The surface soil samples were obtained at several points and composited to make one sample near each vegetation sampling location. The 3 to 12 inch samples were taken from two soil auger holes. Samples were also taken at one, two and three foot depths. The samples were cleaned of roots and rocks. The soils were collected at the locations shown on Figure 2.9-1.

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The results of the analyses of soil are presented in Tables 2.9-5 and 2.9-6. In general, the levels measured were low and in the usual range for soils of this region.

Biota. The radiological properties of plants and small mammals in the project area were determined by collecting samples of species which were in abudance or are known to play important roles in the food web. Biological samples were collected during the field studies from the sites shown on Figure 2.9-1.

Analyses were performed for the following:

- Gross alpha
- Gross beta
- Total uranium
- Thorium-230
- Radium-226
- Lead-210

The vegetation samples were also analyzed for various radionuclides by gamma-ray spectometry. The results of vegetation analyses are presented in Tables 2.9-7 and 2.9-8, and animal analyses in Tables 2.9-9 and 2.9-10. The levels of radioactivity in species present are quite low.

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Table 2.9-5. BASELINE RADIOACTIVITY AND CONCENTRATIONS OF SELECTED RADIOISOTOPES IN PROJECT AREA SOILS

Location[a]	Depth (inches)	Concentration (pCi/g)[b,c]					
		Gross Alpha	Gross Beta	Th-230	Ra-226	Pb-210	Uranium[d]
S-1	0-1	8.26±1.80	5.90±0.71	0.71±0.13	9.05±0.48	2.40±0.17	0.75
S-3	0-1	16.7±2.7	7.11±0.75	0.08±0.02	2.23±0.22	5.41±0.29	2.3
S-5	0-1	10.9±1.9	6.97±0.74	0.73±0.02	3.44±0.29	4.98±0.27	1.6
S-7	0-1	6.84±1.33	3.60±0.61	0.21±0.06	1.94±0.21	2.37±0.9	1.0
S-8	0-1	12.9±1.8	4.95±0.67	0.26±0.07	0.96±0.14	1.42±0.14	0.75
S-9	0-1	18.0±2.2	5.90±0.71	0.97±0.15	4.91±0.35	2.31±0.19	1.0
San Lucas	12	3.1±0.9	1.73±0.54	0.07±0.02	0.94±0.14	0.32±0.5	0.27
San Lucas	24	2.8±0.9	1.61±0.54	0.05±0.02	0.36±0.08	0.22±0.05	0.20
San Lucas	36	2.3±0.8	1.50±0.53	0.0±0.1	0.44±0.08	0.26±0.05	0.27
Polvadera	12	5.4±4.5	1.51±0.53	0.0±0.1	0.84±0.13	0.26±0.05	0.54
Polvadera	24	13.5±9.5	1.22±0.52	0.27±0.07	1.34±0.18	0.48±0.06	1.1
Polvadera	36	13.7±4.8	2.11±0.56	0.22±0.06	1.03±0.15	0.52±0.07	3.4
Mt. Taylor - Lower Station	12	8.8±1.6	3.63±0.63	0.11±0.04	1.58±0.18	0.31±0.05	0.41
Mt. Taylor - Lower Station	24	5.6±1.3	3.83±0.64	0.33±0.08	1.67±0.19	0.42±0.06	0.54
Mt. Taylor - Lower Station	36	10.0±3.5	3.65±0.63	0.15±0.05	2.33±0.23	0.38±0.05	0.61

[a]Locations shown in Figure 2.9-1.

[b]pCi/g = picocuries of radioactivity or radioisotope per gram of dry soil ± 2σ (Poisson).

[c]Determined by Controls for Environmental Pollution, Inc.

[d]Uranium concentrations were determined by fluorometric analysis. This technique has an accuracy of 92-95%. A conversion factor of 0.68 pCi/μg uranium used.

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Table 2.9-6. BASELINE CONCENTRATIONS OF SELECTED RADIOISOTOPES IN PROJECT AREA SOILS

	Depth	Concentration (pCi/g)[b,c]						
Location[a]	(inches)	Pb-214	Bi-214	Pb-212	Tl-208	Ac-228	K-40	Cs-137
S-1	0-1	0.88±0.10	0.86±0.10	1.30±0.13	0.35±0.05	0.85±0.13	11.4±0.1	0.96±0.02
S-2	4-12	0.96±0.14	0.84±0.13	1.40±0.14	0.36±0.05	1.05±0.11	14.4±0.1	0.22±0.02
S-3	0-1	1.72±0.18	1.57±0.20	2.41±0.20	0.71±0.10	1.93±0.20	25.7±0.1	2.09±0 10
S-4	3-6	1.15±0.17	1.08±0.20	1.75±0.18	0.48±0.06	1.43±0.15	22.1±0.1	0.44±0.02
S-5	0-1	1.84±0.25	1.56±0.20	2.49±0.24	0.62±0.07	1.85±0.19	26.5±0.1	1.51±0.10
S-6	3-6	0.84±0.13	0.76±0.10	1.08±0.11	0.32±0.05	0.99±0.10	17.7±0.1	0.20±0.02
S-7	0-1	1.17±0.20	0.96±0.15	1.35±0.14	0.42±0.05	1.27±0.13	22.9±0.1	0.67±0.02
S-8	0-1	0.77±0.12	0.52±0.09	0.91±0.10	0.19±0.02	0.78±0.14	16.0±0.1	0.29±0.02
S-9	0-1	1.10±0.20	0.86±0.15	1.59±0.16	0.42±0.05	1.20±0.12	21.6±0.1	0.67±0.02
San Lucas	12	0.51±0.02	0.41±0.02	0.88±0.02	0.22±0.01	0.870±0.02	16.1±0.6	<0.02
San Lucas	24	0.52±0.02	0.54±0.02	0.93±0.02	0.26±0.01	0.93±0.02	18.5±0.6	<0.02
San Lucas	36	0.50±0.02	0.43±0.02	0.76±0.02	0.23±0.01	0.75±0.02	14.4±0.6	<0.02
Polvadera	12	0.83±0.02	0.77±0.02	0.83±0.02	0.30±0.02	0.77±0.02	12.7±0.6	<0.02
Polvadera	24	0.95±0.02	0.69±0.02	1.09±0.01	0.29±0.01	0.86±0.02	9.8±0.5	<0.02
Polvadera	36	1.28±0.01	1.08±0.01	1.50±0.01	0.42±0.01	0.99±0.02	13.0±0.6	0.03±0.01
Mt. Taylor - Lower Station	12	0.87±0.02	0.76±0.02	1.41±0.01	0.42±0.01	1.2[illegible]±0.02	24.6±0.6	<0.02
Mt. Taylor - Lower Station	24	0.89±0.02	0.72±0.02	1.35±0.01	0.42±0.01	1.38±0.02	20.4±0.6	<0.02
Mt. Taylor - Lower Station	36	0.99±0.02	0.99±0.02	1.88±0.01	0.54±0.01	1.68±0.02	20.8±0.6	0.03±0.01

[a]Locations shown in Figure 2.9-1.

[b]pCi/g = picocuries of radioisotope per gram of dry soil ± 2σ (Poisson). Determined by gamma-ray spectrometry.

[c]Determined by Controls for Environmental Pollution, Inc.

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Table 2.9-7. BASELINE RADIOACTIVITY AND CONCENTRATIONS OF SELECTED RADIOISOTOPES IN VEGETATION FROM THE PROJECT AREA

		Concentration (pCi/g)[b,c]					
Location[a]	Description	Gross Alpha	Gross Beta	Th-230	Ra-226	Pb-210	Uranium[d]
V-1	*Atriplex canescens*	4.89±2.98	32.9±1.4	0.00±0.05	0.80±0.12	0.67±0.10	0.17
V-2	Mixed grasses	2.79±0.96	6.17±0.72	0.09±0.05	0.35±0.07	1.72±0.14	1.05
V-3	*Gutierrezia*	1.50±0.77	15.6±0.7	0.00±0.05	0.25±0.03	0.66±0.10	1.63
V-4	Mixed grasses	0.97±10.5	20.7±0.8	0.00±0.05	0.26±0.05	0.18±0.17	0.40
V-5	Pinyon Pine	1.14±0.45	2.33±0.4	0.00±0.05	0.34±0.06	1.46±0.13	0.25
V-6	Juniper	1.67±0.45	4.41±0.65	0.19±0.03	0.36±0.07	0.86±0.11	1.80
V-7	*Eurotia*	3.81±1.48	12.6±0.7	0.15±0.04	0.56±0.10	0.83±0.11	0.61
V-8	*Hilaria*	2.59±0.77	7.75±0.55	0.04±0.03	0.54±0.09	0.98±0.11	1.26
V-9	*Chrysothamnus*	2.79±1.06	19.0±0.8	0.00±0.05	0.13±0.03	0.97±0.12	1.20
V-10	*Gutierrezia*	4.70±1.85	19.5±1.1	0.29±0.05	0.63±0.09	1.11±0.12	0.59
V-11	*Quercus*	1.79±0.65	6.38±0.52	0.00±0.05	0.07±0.05	0.48±0.09	0.64
V-12	Cow Dung	8.39±1.20	7.73±0.55	0.24±0.07	0.71±0.12	3.27±0.19	1.99

[a]Locations shown in Figure 2.9-1.

[b]pCi/g = picocuries of radioactivity or radioisotope per gram of dry vegetation ±2σ (Poisson).

[c]Determined by Controls for Environmental Pollution, Inc.

[d]Uranium concentrations were determined by fluorometric analysis. This technique has an accuracy of 92-95%. A conversion factor of 0.68 pCi/μg uranium was used.

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Table 2.9-8. BASELINE CONCENTRATIONS OF SELECTED RADIOISOTOPES IN VEGETATION FROM THE PROJECT AREA

Location[a]	Description	Concentration (pCi/g)[b,c]						
		Pb-212	Bi-214	Pb-214	Tl-208	Ac-228	K-40	Cs-137
V-1	Atriplex canescens	0.23±0.02	0.16±0.04	0.05±0.02	<0.01	0.39±0.04	52.7±0.3	<0.02
V-2	Mixed grasses	0.46±0.05	0.39±0.03	0.13±0.02	0.11±0.03	0.37±0.04	10.7±0.2	0.03±0.01
V-3	Gutierrezia	0.05±0.01	0.09±0.03	0.02±0.01	<0.01	<0.07	20.7±0.3	<0.02
V-4	Mixed grasses	0.14±0.03	0.09±0.03	<0.01	<0.01	<0.07	32.4±0.4	<0.02
V-5	Pinyon Pine	0.28±0.02	0.22±0.03	0.04±0.02	<0.01	0.07±0.03	6.76±0.15	0.12±0.02
V-6	Juniper	0.36±0.02	0.37±0.03	0.09±0.02	<0.01	<0.07	4.80±0.14	0.23±0.03
V-7	Eurotia	0.10±0.02	0.14±0.04	0.25±0.03	<0.01	<0.07	15.5±0.3	<0.02
V-8	Hilaria	0.16±0.02	0.29±0.04	0.06±0.03	<0.01	0.36±0.04	9.52±0.28	<0.02
V-9	Chrysothamnus	0.09±0.02	0.08±0.02	0.07±0.02	<0.01	0.06±0.02	22.9±0.13	<0.02
V-10	Gutierrezia	0.25±0.02	0.32±0.03	0.07±0.02	0.08±0.02	0.39±0.03	21.7±0.18	0.14±0.03
V-11	Quercus	0.13±0.02	0.14±0.03	0.06±0.02	<0.01	0.25±0.03	9.67±0.17	<0.02
V-12	Cow Dung	0.82±0.03	0.76±0.04	0.51±0.03	0.22±0.04	0.53±0.02	8.29±0.18	0.51±0.04

[a]Location identification numbers are the same as those used in Figure 2.9-1.

[b]pCi/g = picocuries of radioisotope per gram of dry vegetation ± 2σ (Poisson).

[c]Determined by Controls for Environmental Pollution, Inc.

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Table 2.9-9. BASELINE RADIOACTIVITIES AND CONCENTRATIONS OF SELECTED RADIOISOTOPES IN ANIMALS COLLECTED IN THE PROJECT AREA

		Concentration (pCi/g)[b,c]					
Location[a]	Sample Description	Gross Alpha	Gross Beta	Th-230	Ra-226	PB-210	Uranium[d]
San Lucas	Ord's Kangaroo Rats (#1)	0.54±0.72	1.94±0.15	0.0±0.1	0.05±0.06	0.20±0.12	0.64
San Lucas	Deer Mice (#2)	0.38±1.10	6.07±0.60	0.0±0.4	0.11±0.03	0.0±0.3	6.40
San Lucas	Silky Pocket Mice (#3)	1.06±1.63	7.33±1.28	0.0±0.8	0.30±0.06	0.0±0.7	3.25
San Lucas	Silky Pocket Mouse (#4)	2.30±2.30	6.78±1.93	0.0±1.5	0.41±0.08	0.0±1.1	7.41
San Lucas	Western Harvest Mouse (#5)	0.31±1.28	5.72±1.09	0.0±0.7	2.85±0.26	0.0±1.2	0.35
San Lucas	Deer Mouse (#6)	0.10±0.42	2.06±0.31	0.0±0.2	0.25±0.05	0.0±0.2	0.47
Polvadera	Deer Mice (#7)	1.22±1.33	3.39±0.27	0.0±0.1	0.19±0.03	0.18±0.10	0.20
Polvadera	Ord's Kangaroo Rats (#8)	0.89±0.97	5.06±0.26	0.0±0.1	0.09±0.05	0.22±0.15	0.37
Polvadera	Bannertail Kangaroo Rats (#9)	0.07±0.29	2.62±0.11	0.00±0.05	0.06±0.05	0.18±0.06	0.11
Polvadera	Silky Pocket Mice (#10)	1.37±1.11	6.04±0.68	0.0±0.4	0.12±0.04	0.0±0.3	1.58
Polvadera	Northern Grasshopper Mouse (#11)	0.75±1.34	5.49±0.53	0.0±0.3	0.61±0.11	0.0±0.2	0.65
Polvadera	Western Harvest Mouse (#12)	1.22±1.64	5.57±0.74	0.0±0.2	0.0±0.2	0.26±0.16	2.82

[a]Locations shown in Figure 2.9-1.

[b]pCi/g = picocuries of radiation or radioistope per gram of dry weight ± 2σ (Poisson).

[c]Determined by Controls for Environmental Pollution, Inc.

[d]Uranium concentrations were determined by fluorometric analysis. This technique has an accuracy of 92-95%. A conversion factor of 0.68 pCi/μg uranium used.

Table 2.9-10. BASELINE CONCENTRATIONS OF SELECTED RADIOISOTOPES IN ANIMALS COLLECTED IN THE PROJECT AREA

Location[a]	Sample Description	Concentration (pCi/g)[b,c]					
		Pb-214	Bi-214	Pb-212	Tl-208	Ac-228	K-40
San Lucas	Ord's Kangaroo Rat	1.22±0.15	0.72±0.10	<0.05	0.10±0.03	0.59±0.10	4.52±0.53
Polvadera	Deer Mouse	0.52±0.05	0.36±0.11	<0.05	<0.06	<0.2	7.64±0.58
Polvadera	Deer Mouse	1.00±0.09	2.26±0.18	<0.05	<0.06	1.82±0.18	8.62±0.40
Polvadera	Ord's Kangaroo Rat	<0.1	<0.1	0.13±0.05	<0.06	<0.2	6.83±0.43
Polvadera	Ord's Kangaroo Rat	0.43±0.04	0.42±0.07	<0.05	0.08±0.02	0.81±0.09	9.55±0.43
Polvadera	Bannertail Kangaroo Rat	0.11±0.02	0.10±0.04	<0.05	0.07±0.03	<0.2	2.67±0.20
Polvadera	Bannertail Kangaroo Rat	0.15±0.02	0.55±0.06	<0.05	<0.06	0.24±0.06	5.38±0.33
Polvadera	Bannertail Kangaroo Rat	0.11±0.02	0.32±0.06	<0.05	<0.06	0.48±0.10	3.30±0.20
San Lucas	Ord's Kangaroo Rat	0.28±0.03	0.32±0.09	<0.05	<0.06	0.44±0.10	11.1±0.5
San Lucas	Deer Mouse	0.64±0.10	2.01±0.24	0.52±0.17	0.24±0.10	1.07±0.26	19.9±0.08
Polvadera	Silky Pocket Mouse	0.62±0.20	0.41±0.10	<0.05	<0.06	<0.2	59.2±3.7
Polvadera	Western Harvest Mouse	0.77±0.15	0.94±0.18	<0.05	<0.06	<0.2	28.7±2.5
Polvadera	Plains Harvest Mouse	0.54±0.17	0.58±0.20	<0.05	<0.06	<0.2	41.7±1.0
San Lucas	Ord's Kangaroo Rat	0.12±0.04	0.48±0.09	0.12±0.06	0.11±0.04	1.33±0.12	7.09±0.56
San Lucas	Deer Mouse	2.18±0.10	1.[illegible]5±0.28	0.87±0.15	<0.06	0.43±0.13	21.4±1.4
San Lucas	Deer Mouse	0.64±0.11	0.65±0.26	<0.05	<0.06	6.02±0.42	5.99±1.9
Polvadera	Silky Pocket Mouse	0.64±0.07	0.69±0.15	<0.05	<0.06	1.39±0.22	11.4±1.1
San Lucas	Silky Pocket Mouse	2.29±0.12	2.76±0.37	<0.05	<0.06	1.26±0.33	14.5±1.7
San Lucas	Silky Pocket Mouse	2.53±0.39	2.00±0.40	<0.05	<0.06	5.48±0.97	53.0±5.3
San Lucas	Silky Pocket Mouse	0.94±0.34	1.16±0.30	<0.05	<0.06	6.82±0.63	59.2±3.2
San Lucas	Western Harvest Mouse	1.70±0.16	2.67±0.31	0.31±0.15	<0.06	2.64±0.35	31.5±1.9
Polvadera	Northern Grasshopper Mouse	0.51±0.07	0.24±0.12	<0.05	<0.06	1.00±0.13	10.7±0.6
Polvadera	Deer Mouse	1.89±0.10	1.31±0.26	0.30±0.13	<0.06	<0.2	19.5±1.3

[a]Locations shown in Figure 2.9-1. All samples collected 8/12/76.

[b]PCi/g = picocuries of radiation or radioisotope per gram of dry weight ± 2σ (Poisson).

[c]Determined by Controls for Environmental Pollution, Inc.

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