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Woodward-Clyde Consultants

November 20, 1978
60245A

Mr. R.Y. Salisbury
Coordinator, Environmental Programs
Union Oil Company of California
Union Oil Center
Los Angeles, California 90017

Dear Dick:

Enclosed are 20 copies of the Minerals Exploration Company Anderson Uranium Project Environmental Report.

At Terry Larson's request we are sending 5 copies of this report to him in Tucson plus an additional copy of Section 2.0 only that he asked for by phone on November 17, 1978.

If you have any questions, please call.

Sincerely,

C. Batra
Senior Project Manager
Energy-Related Industries

cc: Mr. Terrence L. Larson
Minerals, Tucson

Environmental Report

Anderson Uranium Project
Yavapai County, Arizona

For

Minerals Exploration Company

Woodward-Clyde Consultants
Three Embarcadero Center, Suite 700, San Francisco, CA 94111

60245A

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The proposed Anderson Uranium Project is located in southwestern Yavapai County, Arizona, approximately 100 air miles northwest of Phoenix and 43 air miles northwest of Wickenburg. Minerals Exploration Company (MINERALS), a wholly owned subsidiary of Union Oil Company of California, intends to mine uranium ore located primarily in Sections 9, 10, 11, 14, and 15 of T11N, R10W and process it at a mill to be constructed adjacent to the ore deposits.

Potentially economic reserves of uranium ore were first identified in the project area in 1955 by airborne scintillation. Mr. T. R. Anderson of Sacramento, California, drilled and surface mined a small quantity of this ore in 1958. The mine, located in Section 11, T11N, R10W, was abandoned within a few years. In 1968, MINERALS received a submittal on approximately 4260 acres encompassing the ore reserves. MINERALS purchased the property in 1975 following an exploratory drilling program.

The principal uranium mineral in the ore to be mined is tyuyamunite ($Ca(UO_2)(VO_4)_2 \cdot 5\text{-}8H_2O$) which generally occurs in carbonaceous material. The ore ranges in grade from 0.03 to more than 0.15 percent uranium oxide (U_3O_8) and has an average grade of 0.072 percent. It is estimated that the deposits on the property consist of 7.2 million tons of ore containing 10.3 million pounds of uranium oxide.

The ore will be recovered by continuous excavation of a series of open pit phases. Surface mining is the most appropriate method of recovering the ore on the property because of the relatively shallow depth of the deposits. Current plans call for initial overburden removal to begin in the fourth quarter of 1979. Within approximately 3 months, overburden removal will reach 2.43 million tons per month and remain at this rate for the first 5.75 years of stripping activity after which it will decrease to 1.73 million tons per month for the remaining life of the project. By March 1980, mining of ore will commence. Material removed from the mining zone will consist of 730,000 tons per year of ore and 2.71 million tons of associated "internal" waste for approximately 10 years, when presently known ore reserves are exhausted.

Excavation will begin at the northeast end of the ore deposit and progress south and west. Stripping will be done with two electric shovels on 50-foot benches. The approximate slope between each bench will be 0.5:1, with an overall pit slope varying between 0.4:1 and 1.0:1, depending on the height of the slope (this includes safety benches with a minimum width of 10 feet). Overburden material and internal waste will be hauled to either the waste dump areas located northeast and northwest of the ore body or to an exhausted pit area where it will be used as backfill.

Before the final overburden bench is excavated, additional holes will be drilled to determine the exact location of the individual ore lenses.

This information will be used to control the actual bottom elevation of the final bench and to determine final mining plans. After the overburden has been removed, tractors equipped with rippers will be used to loosen the ore. The ore will then be loaded into trucks and hauled to a probe tower where a sample will be analyzed to determine uranium content. Material containing less than 0.028 percent uranium oxide will either be hauled to a low-grade stockpile or to exhausted pit areas. Material with a higher uranium oxide content will be deposited in one of three mill stockpiles.

The mine will operate primary stripping crews for 18 shifts per week, 52 weeks per year. Mining crews will operate 15 8-hour shifts per week, 52 weeks per year.

Construction of the proposed uranium mill will begin in the third quarter of 1979. Milling operations will begin in the first quarter of 1981. The proposed mill will process an average of 2000 tons of ore per day (dry weight basis), 365 days per year. It is expected that the mill will have an overall uranium oxide recovery rate of 88.6 percent. Based on this anticipated recovery rate, the average mill throughput, and the average ore grade, the mill will produce about 2550 pounds per day of uranium oxide, or approximately 930,000 pounds per year.

The primary milling circuit involves grinding the siltstone ore, then dissolving the uranium from the particle surfaces using a sulfuric acid solution. The uranium-rich acid solution will be recovered in a five stage countercurrent decantation process. The leached silt will be discarded as tailings to an open impoundment. The uranium will be transferred from the aqueous acid phase to an organic phase by means of a solvent extraction process. The uranium will be removed from the organic phase by ammonium sulfate and will then be precipitated by the injection of ammonia gas. The final precipitate will be washed, dried, and packed into 55-gallon drums. The finished product will then be shipped to a uranium hexafluoride conversion plant and eventually turned into fuel for nuclear power plants.

A slurry pipeline will transport tailings from the mill to an impoundment located in exhausted pit areas. In order to contain the tailings, it will be necessary to construct a dam. This dam will be built in stages to prevent interference with mining operations and still provide adequate tailings storage capacity. The impoundment will be of sufficient size to store all of the solid tailings and entrained water discharged from the mill; however, it will be necessary to remove excess "free" water to prevent overtopping of the tailings dam. Standing water from the center of the impoundment will either be sprayed from the top of the tailings dam down into the pond or pumped to evaporating ponds located on a waste dump(s).

2.0
THE SITE

This section includes baseline descriptions of the physical, cultural, biological, and socioeconomic environments that might be affected by the construction and operation of MINERALS' proposed Anderson uranium project.

2.1 SITE LOCATION AND LAYOUT

The proposed uranium mining and milling project is located in Yavapai County, Arizona, approximately 100 air miles northwest of Phoenix (Figure 2.1-1). Access to the site will be by a newly constructed paved country road running westward from U.S. Highway 93.

MINERALS has obtained the mining rights on approximately 4260 acres of land located in T11N, R10W and T12N, R10W (Figure 2.1-2). The U.S. Bureau of Land Management (BLM) owns the surface rights to approximately 2820 acres of this land and the state of Arizona owns the surface rights to the remaining 1440 acres (Figure 2.1-2). A state grazing lease is held by a private individual on 800 acres of the claim area (Figure 2.1-3).

MINERALS intends to mine the uranium deposits located in portions of Sections 9, 10, 11, 14, and 15 of T11N, R10W (Figure 2.1-4). It is estimated that the proposed mine, waste dumps, and haul roads will cover

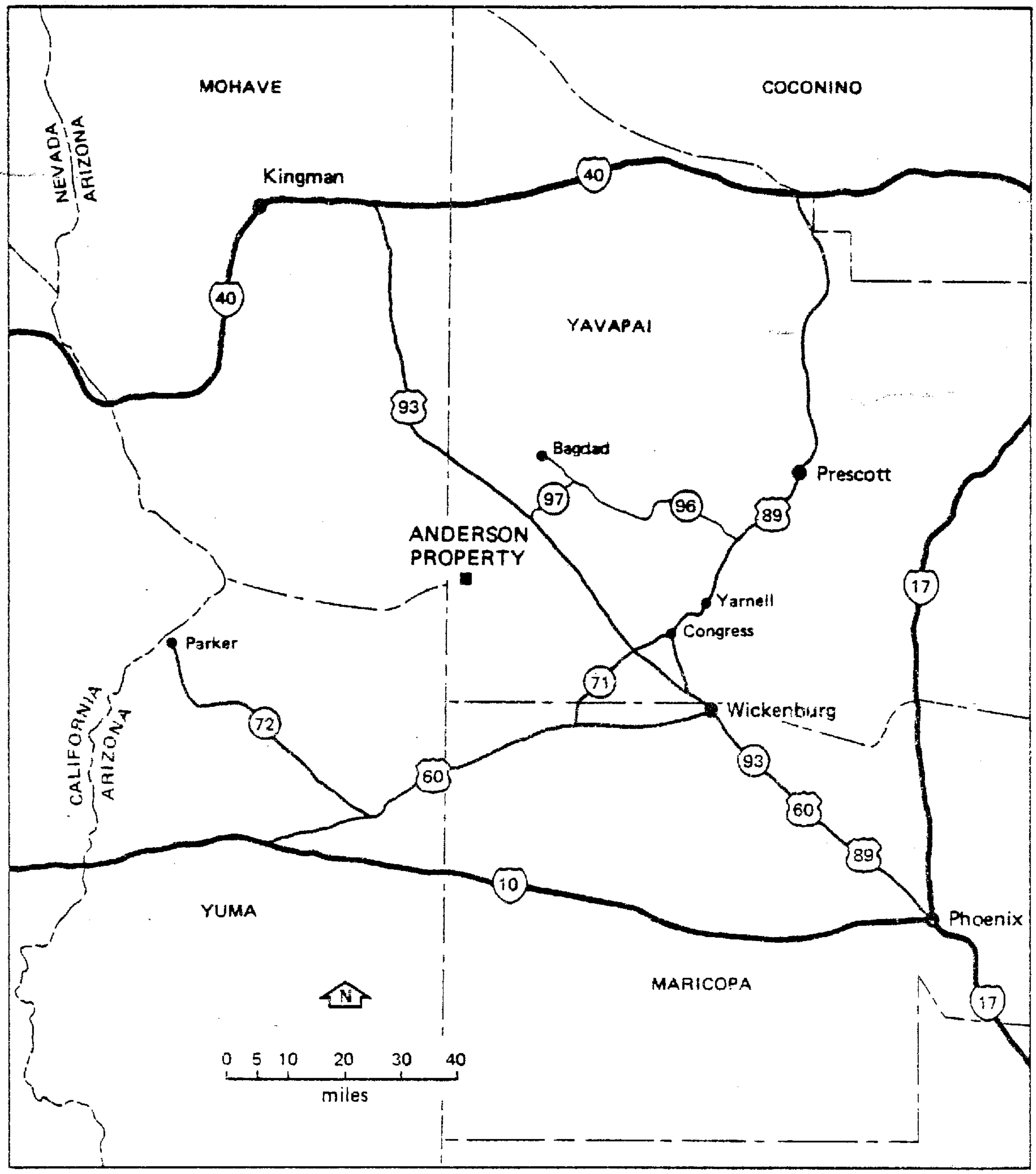


Figure 2.1-1. LOCATION OF ANDERSON PROPERTY

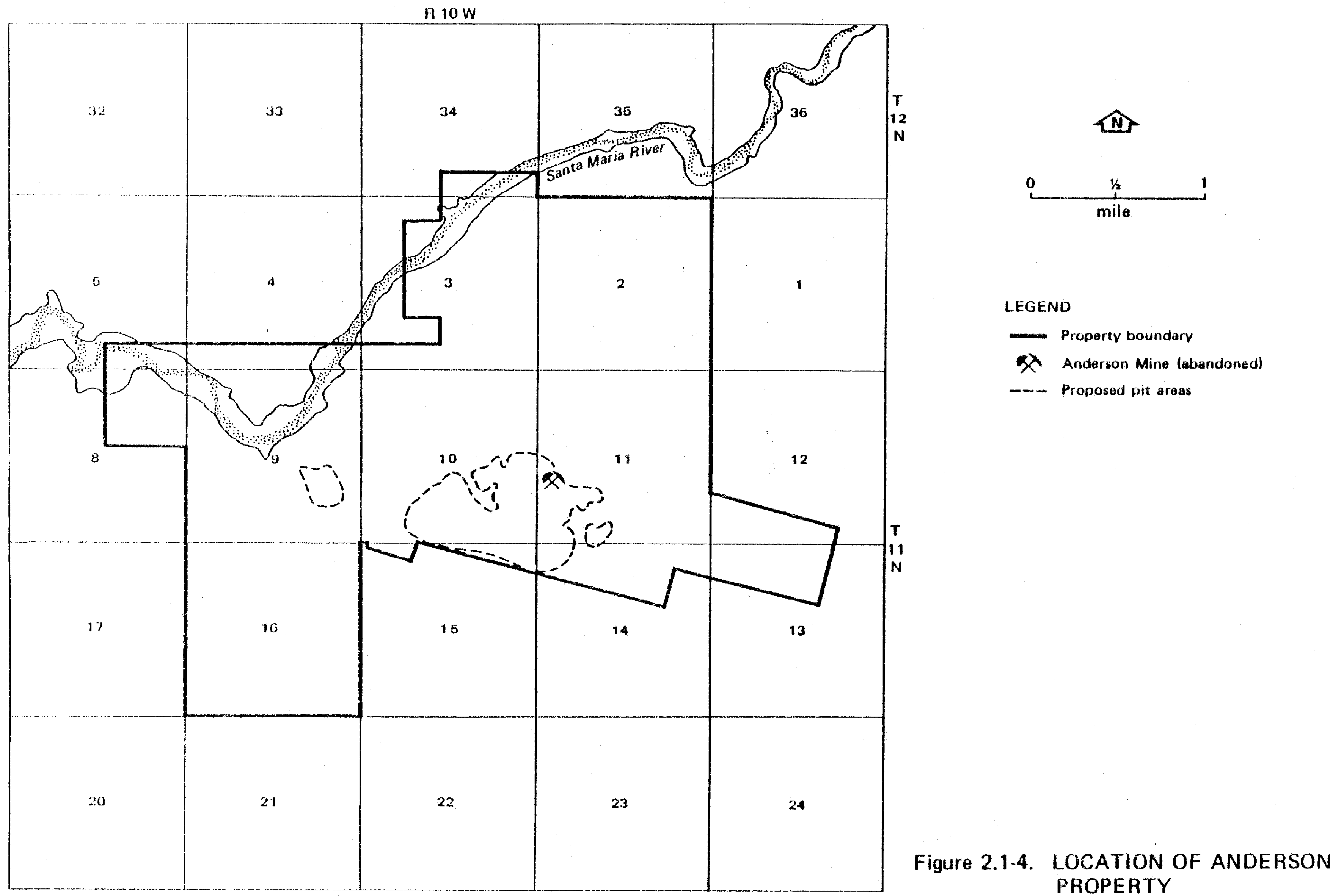


Figure 2.1-4. LOCATION OF ANDERSON PROPERTY

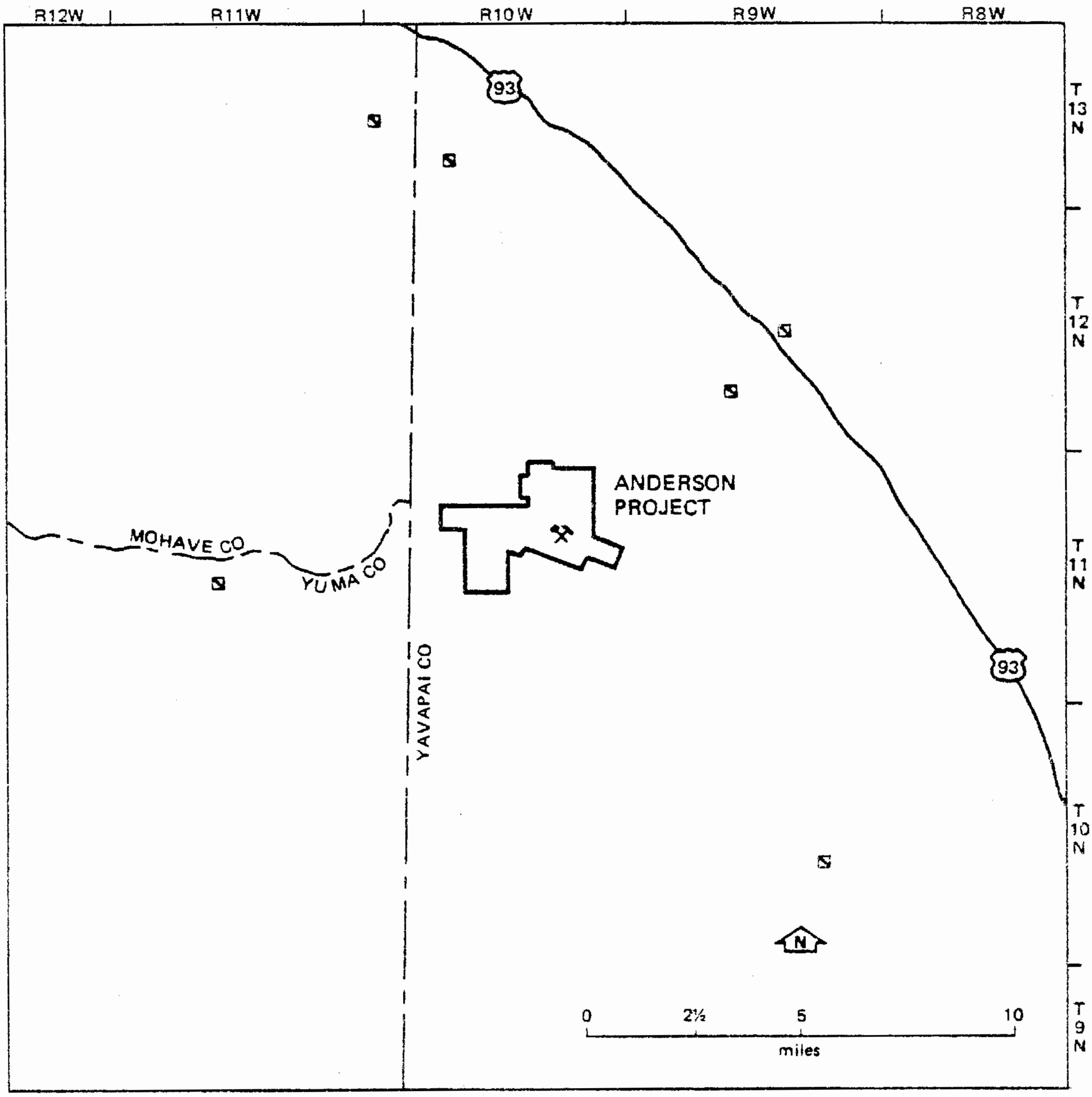
about 770 acres. The mill and related facilities will cover an additional 40 acres. Mining may be extended to other areas within the mining claims described above in the event that economically valuable uranium deposits are discovered on them.

2.2 REGIONAL DEMOGRAPHY AND LAND USES

The following section discusses demography/demographic characteristics, land use and ownership, economic environment, housing and public facilities, and services in the project region. The geographic area to be discussed consists of southwestern Yavapai and northwestern Maricopa counties in west-central Arizona (Figure 2.1-1). Much of the discussion is focused on the town of Wickenburg, located approximately 43 air miles southeast of the Anderson property in Maricopa County. Wickenburg is the largest community and principal trade center in the study region and is expected to experience the greatest socioeconomic impact as a result of project implementation. Attention is also given to the small communities of Congress and Yarnell, located about 28 and 37 air miles east-southeast of the property, respectively.

REGIONAL DEMOGRAPHY

The project region is sparsely populated, rural, and largely undeveloped. Approximately 38 people currently live on ranches or farms within 10 miles of the Anderson property (Figure 2.2-1). The closest community to the property is Bagdad, located approximately 22 air miles to the north-northeast (Figure 2.1-1). Population estimates by annular sector (cardinal points) and distance are given in Table 2.2-1 for a 50-mile radius from the proposed mill site.



LEGEND

◪ Farm or Ranch

Note: Each household represents roughly 6.3 persons
(Source: Urban Decision Systems, Inc., 1978)

Figure 2.2-1. LOCATION OF FARMS OR RANCHES WITHIN TEN MILES OF THE ANDERSON PROPERTY

Table 2.2-1. POPULATION DISTRIBUTION WITHIN 50 MILES OF THE ANDERSON PROPERTY

	Distance (miles)					
Direction	0-5	5-10	10-20	20-30	30-40	40-50
NNE	0	0	89	2966	0	0
NE	0	0	0	0	558	0
ENE	13	0	0	0	0	21125
East	0	0	0	985	0	0
ESE	0	0	0	0	0	907
SE	0	6	0	0	3394	1332
SSE	0	0	0	0	619	0
South	0	0	0	0	0	0
SSW	0	0	0	0	0	875
SW	0	0	0	289	0	0
WSW	0	6	0	0	0	958
West	0	0	0	0	0	0
WNW	0	0	0	0	0	7956
NW	0	0	0	0	312	0
NNW	0	13	0	0	0	317
North	0	0	0	0	0	0

Source: Urban Decision Systems, Inc., 1978.

LAND USE AND OWNERSHIP

Because implementation of the proposed project will alter existing land use patterns within Yavapai County, this section focuses primarily on that county.

Livestock grazing and wildlife habitat are the predominant land uses in Yavapai County and constitute 60 percent of the total county land area (5,178,000 acres) (Table 2.2-2). National forest lands, primarily in the central and eastern portions of the county, represent 38.5 percent of the land area, while urbanized areas (Prescott, Yarnell, Congress) occupy less than one percent. Lands classified as agricultural cropland constitute 0.5 percent (24,000 acres) of the total.

Mineral extraction activities are concentrated at Bagdad, where Cyprus Bagdad Copper Company operates an open pit copper mine, concentrator, and refinery. There is also an underground mine and concentrator operated by Cyprus Bruce Copper & Zinc Company at Bagdad. A limited amount of placer gold mining is done in the Stanton area and around the Vulture Mountains. Generalized existing land uses in Yavapai County are shown in Figure 2.2-2.

Most of the land in the county is under government control (Table 2.2-3). National Forest lands cover about 38.5 percent of the county; while the BLM administers 9.1 percent of the land and other federal agencies control 2.3 percent. The State of Arizona owns almost 1.4

Table 2.2-2. EXISTING LAND USES, YAVAPAI COUNTY

Land Use	Acreage*	Percent
Urbanized Areas	40,000	0.8
National Forest Lands	1,993,000	38.5
Indian Reservations	4,000	0.1
Agricultural Cropland	24,000	0.5
Lake Pleasant Regional Park	6,000	0.1
Desert or Mountainous Areas	3,111,000	60.0
TOTAL	5,178,000	100.0

Source: Ferguson, Morris and Associates, Inc., 1975.

*Numbers rounded to nearest thousand.

Table 2.2-3 LAND OWNERSHIP IN YAVAPAI COUTY

Ownership	Acreage*		Percent	
Federal	2,582,000		50.0	
Indian reservations		4,000		0.1
National forests		1,993,000		38.5
Prescott		1,205,000		23.3
Coconino		428,000		8.2
Tonto		335,000		6.5
Kaibab		25,000		0.5
U.S. BLM		472,000		9.1
Other		120,000		2.3
State	1,399,000		27.0	
Private	1,190,000		23.0	
TOTAL	5,171,000		100.0	

Source: Ferguson, Morris and Associates, Inc., 1975.

*Numbers rounded to nearest thousand.

million acres (27.0 percent) in Yavapai County, while private ownership accounts for almost 1.2 million acres (23.0 percent). Existing land ownership patterns in the county are presented in Figure 2.2-3.

Other than mineral exploration activities associated with this project, the Anderson property and adjacent areas are currently used exclusively for livestock grazing and wildlife habitat. Uranium was surface-mined on the property in the 1950s, and the abandoned pit is still present in the SW 1/4 of Section 11, T11N, R10W. Surface and mineral ownership of the property and adjacent areas is shown in Figures 2.1-2 and 2.1-3.

SOCIOECONOMICS

Wickenburg

Wickenburg is located approximately 54 air miles northwest of Phoenix. It was founded in the 1860s by prospectors attracted to the area by rich gold strikes in the nearby hills. Situated on the main route to California, served by the Santa Fe Railroad, and having a dry, mild climate and productive grazing land, the early boom town became an important freighting and stage junction as well as an attractive place for early settlers.

Today, as in the past, Wickenburg's physiographic location plays an important role in its continued growth. Tourism, cattle ranching, and agriculture still remain the communities' principal economic activities. However, light industry and retirement-oriented facilities have recently assumed preeminence in the economy and further diversification can be expected.

Population. Since 1950, the population of Wickenburg has increased at a slower rate than Maricopa County as a whole (Table 2.2-4). This is due almost entirely to metropolitan growth in the Phoenix area. Between 1950 and 1960, population increased by approximately 41 percent in Wickenburg and roughly doubled in the county. From 1960 to 1970, the community registered a population increase of about 10 percent while Maricopa County again experienced a substantially higher rate of growth (about 46 percent). In recent years, considerable growth has occurred in Wickenburg, although the county has continued to expand at a faster rate.

Wickenburg's population consists of more elderly and fewer minority group members on a percentage basis than Maricopa County or the state. The community has recently become a popular retirement center for Phoenix residents, as evidenced by the high percentage of Wickenburg residents 65 years of age and older (Table 2.2-5). Table 2.2-6 suggests a high degree of racial homogeneity in the community. Minorities comprise only about 10 percent of the residents, compared to 19.7 percent for Maricopa County, and 27.9 percent for the state.

Population projections have been prepared for Wickenburg by the Maricopa Association of Governments and for Maricopa County and the state by the Arizona Department of Economic Security (Table 2.2-7). It is projected that the population of Wickenburg and Maricopa County will increase over the next two decades with the community growing at a substantially faster rate than the county. Population in the community is expected to more than double between 1977 and 1995, compared to 59

Table 2.2-4. POPULATION CHANGE, 1950 - 1977

	Wickenburg	Maricopa County	Arizona
Total Population			
1950	1736	331,770	749,587
1960	2445	663,510	1,302,161
1970	2698	969,425	1,775,400
1977	3015	1,289,059	2,350,950
Percent Change			
1960 - 1970	+10.3	+46.1	+36.3
1970 - 1977	+11.7	+42.0	+32.4

Sources: U.S. Bureau of the Census, 1972
Office of Planning, Arizona Department of Economic Security, 1977

Table 2.2-5. POPULATION BY AGE, 1976 (PERCENT OF TOTAL POPULATION)

Age Group	Wickenburg	Maricopa County	Arizona
Percent under 19 years	21.2	35.9	37.0
Percent 20-64 years	44.5	53.0	52.7
Percent 65 years and over	34.3	11.1	10.3

Source: Arizona Department of Economic Security, 1976

Table 2.2-6. WICKENBURG'S RACIAL COMPOSITION - 1975 (PERCENT OF TOTAL POPULATION)

Ethnic Composition	Wickenburg[a]	Maricopa County	State
White	89.9	80.3	72.1
Black	0.4	3.3	2.9
Indian	-	1.1	5.5
Other	-	0.6	0.7
Spanish Surname	9.7	14.6	18.8

Sources: [a]CETA Grant Demographic Study, 1976
Arizona Department of Economic Security, 1975

Table 2.2-7. POPULATION PROJECTION, 1977 - 1995

Projected Population	Wickenburg[a]	Maricopa County	Arizona
1977	3,015	1,289,059	2,350,950
1980	3,500	1,405,001	2,569,442
1985	4,500	1,611,597	2,934,908
1990	5,600	1,827,021	3,303,716
Percent Change			
1977-1995	+122.0	+58.8	+55.4

Source: [a]Maricopa Association of Governments, 1977
Arizona Department of Economic Security, 1977

percent projected growth rate for the county during the same period. Much of this growth will consist of in-migration as new job opportunities, primarily in tourism- and retirement-oriented facilities, are created in the area.

Employment and Income. Approximately 291 businesses are located in the Wickenburg area (Arizona Office of Economic Planning and Development, 1977). Service and retail trade are the principal employers and income producers in the area, accounting for about 40 percent and 35 percent, respectively, of the total number of businesses identified (Table 2.2-8). The increase in service and retail trade establishments in recent years may be attributed to increased travel- and retirement-oriented activities in the community.

Table 2.2-8. NUMBER OF FIRMS IN THE WICKENBURG AREA BY MAJOR INDUSTRIAL CATEGORY, 1977

Industry	Number	Percent
Agriculture and Mining	5	1.7
Construction	17	5.8
Manufacturing	7	2.4
Transportation and Public Utilities	13	4.5
Wholesale Trade	8	2.7
Retail Trade	100	34.4
Finance, Insurance and Real Estate	20	6.9
Services	117	40.2
Public Administration	4	1.4
TOTAL	291	100

Source: Arizona Office of Economic Planning and Development, 1977

Agriculture continues to be a mainstay of Wickenburg's economy. Five agricultural companies operate in the area with a total of 20,660 acres under cultivation. Thirty-three ranches with an estimated value of approximately nine million dollars are also located near the community. Agriculturally rich Centennial Valley is located to the west of Wickenburg.

Nonagricultural employment in Wickenburg is concentrated in the retail trade and service sectors (Table 2.2-9). Approximately 76 percent of the 1421 workers in the Wickenburg area are employed in these sectors. Approximately 1/5 of service employment is seasonal. As Wickenburg continues to increase in popularity as a retirement and tourist center, additional employment opportunities in the nonagricultural sectors can be expected. Table 2.2-10 further breaks down employment into basic and nonbasic sectors. Services and retail trade dominate basic employment, accounting for 79 percent of all basic employment and 75 percent of total employment.

Table 2.2-11 summarizes general labor force and income characteristics of the Wickenburg area in relation to the county and state for 1975. The unemployment rate in Wickenburg (6.7 percent) was lower than the rate recorded for the county (11 percent) and state (10.1 percent). Families in the community earned considerably less on a percentage basis than the families in the county and state (37 percent less than the county and 28 percent less than the state).

Table 2.2-9. EMPLOYMENT IN THE WICKENBURG AREA, BY MAJOR INDUSTRIAL CATEGORY, 1977[a]

Industry	Full-Time	Part-Time	Seasonal
Agriculture and Mining	15	2	0
Construction	36	9	20
Manufacturing	20	4	4
Transporation and Public Utilities	40	8	7
Wholesale Trade	15	5	1
Retail Trade	369	83	17
Finance, Insurance and Real Estate	54	17	1
Services	377	113	118
Public Administration	66	3	15
Total	992	244	85

Source: Arizona Office of Economic Planning and Development, 1977

[a]The figures on this table represent all workers employed in the Wickenburg area regardless of their place of residence. This would include region residents and in-commuters but exclude out-commuters.

Table 2.2-10. BASIC, NONBASIC, FULL-TIME EMPLOYMENT IN WICKENBURG AREA, BY MAJOR INDUSTRIAL CATEGORY, 1977[a]

Industry	Basic	Nonbasic	Total	Base/Service Ratio
Agriculture and Mining	3.7	11.6	15.3	.32
Construction	11.0	37.3	48.3	.29
Manufacturing	16.4	2.0	18.4	8.2
Transportation and Public Utilities	17.6	26.1	43.7	.67
Wholesale Trade	5.8	5.3	11.1	1.09
Retail Trade	177.4	195.3	372.7	.91
Finance, Insurance and Real Estate	22.1	31.5	53.6	.70
Services	176.6	212.1	388.7	.83
Public Administration	20.0	46.6	66.6	.43
Total	450.6	567.8	1018.4	–

Source: Arizona Office of Economic Planning and Development, 1977

[a]This table includes part-time and seasonal workers (given in Table 2.2-9) arithmetically converted to full-time equivalent employees. Therefore, full-time totals in this table are slightly higher than those shown in Table 2.2-9.

Table 2.2-11. GENERAL LABOR FORCE AND INCOME CHARACTERISTICS, 1975

	Wickenburg	Maricopa County	Arizona
Total Employed (Percent)	93.3[a]	89.0	89.9
Total Unemployed (Percent)	6.7[a]	11.0	10.1
Median Family Income	10,442	14,336	13,362
Per Capita Income	-	5,800	5,383

Source: [a]Arizona Office of Economic Planning and Development, 1977
Arizona Department of Economic Security, 1977

Table 2.2-12. HOUSING UNITS IN WICKENBURG (AUGUST, 1977)

Type of Unit	Number	Percent of Total
Single Family	678	54.2
Multiple Family	129	10.3
Mobile Homes	444	35.5
Total	1251	100.0

Source: Personal communication, Donald W. Hutton, Wickenburg Planning Consultant, November 1977

Housing. A lack of necessary infrastructure and an unresponsive financial market has limited housing construction in Wickenburg. Due to overall inflation and spiraling construction, finance and land costs, average home prices in the area have risen from $20,400 in 1970 to over $35,000 in 1976. Moreover, costs have risen at a faster rate than average household income, reducing the purchasing power of the prospective buyer (Maricopa Association of Governments, 1977). The vacancy rate in Wickenburg for conventional single family units is less than two percent. Vacancies in other types of housing fluctuate widely during the year as a result of the winter and early spring influx of temporary residents. Rents have increased in the community due to demand, inflation, and increased costs of maintenance and utilities.

Table 2.2-12 shows the housing composition in Wickenburg. The single family unit, still favored in the community, dominates the housing market. However, in recent years, the community has witnessed a marked increase in mobile homes and more development is expected. Currently, over half of Wickenburg's residents live in single family units, many of which are located in the Sunnygrove and Palo Verde West subdivisions, approximately 35 percent live in mobile homes concentrated in Westpark and Country Club mobile home parks, and about 10 percent reside in apartments. Several sizeable additions to the housing stock are in various stages of planning, including a proposed major subdivision which will provide between 700 and 800 housing units.*

*Personal communication, Mr. Edward Heller, Wickenburg Town Manager, January, 1978.

Community Attitudes. In Wickenburg, community attitudes are very tangible and apparent and may be used as a barometer of the direction in which the community is moving. Community image, size, and environmental quality are important issues to Wickenburg residents. These issues are directly related to economic changes in the area.

Wickenburg's population is still relatively homogeneous; social and institutional relationships have remained fairly stable through the years. Its residents are fairly cautious towards major growth, especially if it contributes to a decline in environmental quality and hence, in the community's attractiveness as a popular retirement and tourist center. However, as Wickenburg increases its reliance on tourism and seeks further diversification of its economic base through light industry, a gradual change will occur in the community's social and cultural composition. New job opportunities will cause considerable in-migration and provide employment for a large segment of the population in the region. The new population, some of which would be typically young and blue-collar, is expected to have different values and lifestyles than the present population and may influence the existing social, cultural, and institutional structure.

Public Facilities and Social Services. Wickenburg's water supply comes from three wells. Water storage is provided by two elevated tanks with a combined capacity of 900,000 gallons. The water system has a capacity to serve up to 7000 people. Several projects to increase the water system are in various stages of planning, including development of three additional wells, construction of a two million gallon storage reservoir and additional high capacity mains, and development of a new water source and storage/distribution system capable of serving 14,000 people in southeastern Wickenburg and the surrounding area. Estimated costs for these projects are $337,500 for the reservoir, $84,240 for well development, $794,160 for main line construction, and $265,475 for the additional water system (Arizona Office of Economic Planning and Development, 1977).

Wickenburg operates a 600,000 gallon per day (gpd) activated sludge treatment plant that can provide adequate service for 6000 people. However, the sewage plant is subject to flooding from the Hassayampa River. The community has proceeded with the construction of a new treatment facility at a higher site and expansion of the wastewater collection system. The new plant will be capable of initially serving 8000 people, with a final design capacity for 25,000 people. It is currently planned to have the facilities in service by early January 1980 (Arizona Office of Economic Planning and Development, 1977).

Solid waste collection services are provided by the community. Solid waste is hauled to a disposal site near the Wickenburg airport. The site is expected to reach full capacity in about 1981 under projected usage rates. Plans for additional landfill areas are uncertain at this time.

Wickenburg receives electricity from the Arizona Public Service Company (APS). Natural gas is also supplied by APS.

The Community Hospital in Wickenburg has 35 beds and a staff that includes four medical doctors and consulting specialists from Phoenix.

Other health services are provided by the Wickenburg Medical Center, the Health Analysis Center, two chiropractic offices, and the Meadows, an alcoholism treatment center.

The Wickenburg Police Department, Maricopa County Sheriff's Department, and the Arizona Department of Public Service provide police protection to the community. The Wickenburg Police Department has a staff of nine that includes a chief, a sergeant, desk clerk, and six patrolmen. The department has four patrol cars. The Maricopa County Sheriff's Department substation located in Wickenburg is staffed by a sergeant, 11 deputies, and a detective. A 37-member sheriff's posse has also been organized in the Wickenburg area for search and rescue operations. The Department of Public Safety has assigned eight officers to patrol the Wickenburg area.

Fire protection is provided by the Wickenburg Volunteer Fire Department. The community's 23 volunteers operate three pumpers with a combined capacity of 2850 gallons and 1000-gallon tanker with a 750-gallon pump. The community has a National Board Class 6A insurance rating.

Wickenburg School District 9 encompasses approximately 700 square miles of northwestern Maricopa County and serves many neighboring districts. Table 2.2-13 lists districts in the region that send all or part of their students to Wickenburg's school system. Educational facilities within the school system are presently adequate (Table 2.2-14).

Table 2.2-13. OUTSIDE DISTRICTS SERVED BY WICKENBURG SCHOOL DISTRICT 9

District	All High School	All or Part Elementary School
Aguila District 65	X	
Champie District 14	X	X
Congress District 17	X	X
Morristown District 75	X	
Nadaburg District 81	X	
Peeples Valley District 55	X	X
Rincon District 47	X	X
Walnut Grove District	X	
Yarnell District 52	X	X

Source: Personal communication, Mr. Samuel Ambrose, Superintendent of Wickenburg Unified Schools, 1977.

Enrollment projections for the district are provided in Table 2.2-15. The estimates are based on projected population and age distribution in the Wickenburg area, and assume that the population in the unincorporated areas of the region will remain relatively stable. Expansion of all three schools in the district has been proposed as enrollment is expected to increase slightly over the next five years.

Developed recreational facilities within Wickenburg include four parks, a playground, a picnic area, an athletic field, two tennis courts, a shooting range, a swimming pool, and rodeo grounds. School facilities include two gymnasiums, two playgrounds, and an athletic field. In addition, private recreational facilities (e.g., Wickenburg Country Club) help meet the recreational demands of the residents. Prescott National Forest provides a variety of recreational opportunities within a short distance of the community. Finally, Phoenix provides a wide range of recreational facilities within a reasonable distance from Wickenburg.

Table 2.2-14. WICKENBURG SCHOOL SYSTEM ENROLLMENT, September 1978

School	Grades	Enrollment	Student Capacity	Enrollment as Percent of Capacity	Number of Teachers	Student Teacher Ratio
MacLennan Elementary School	K-5	353	400	88	21	16.8:1
Garcia Elementary School	6-8	211	270	78	16	13.2:1
Wickenburg High School	9-12	464	540	86	29	16:1

Source: Personal communication, Mr. Samuel Ambrose, Superintendent of Wickenburg Unified Schools, 1978.

Table 2.2-15. WICKENBURG SCHOOL DISTRICT 9 ENROLLMENT PROJECTIONS, 1979-1995

School	Grades	Projected Enrollment				
		1979	1980	1985	1990	1995
MacLennan Elementary	K-5	368	377	433	495	556
Garcia Elementary	6-8	237	247	303	365	426
Wickenburg High	9-12	455	463	513	566	620
TOTAL		1060	1087	1249	1426	1602

Source: Personal Communication, Mr. Samuel Ambrose, Superintendent of Wickenburg Unified Schools, 1978

Table 2.2-16. TRAFFIC VOLUMES ON WICKENBURG HIGHWAYS

		Average Annual Daily Traffic		
Highway	Length in Miles	1974	1975	1976
U.S. Highway 89 (at Jct. 60)	15.54	1300	1600	1700
U.S. Highway 60 (at Jct. 89)	1.84	5200	5400	6000
U.S. Highway 93 (at Jct. 89)	10.85	1600	1900	1500

Source: Arizona Department of Transportation, 1976

Access to the Wickenburg area is provided by U.S. Highway 60 and 89-93 (Figure 2.1-1). U.S. Highway 60 connects the community with Phoenix to the southeast. Six miles north of Wickenburg, U.S. Highway 89-93 divides and provides direct access to Las Vegas, Nevada (U.S. 93) or Prescott and the Grand Canyon (U.S. 89). Construction of the Black Canyon Highway (Interstate 17 south to Phoenix) and completion of the Brenda Cutoff (Interstate 10 east of Phoenix) have considerably decreased traffic in the Wickenburg area (Table 2.2-16). Rail transportation (freight service only) is provided by the Santa Fe Railroad. Regional bus service is provided by Greyhound Lines and Continental Trailways as well as two local bus lines. Motor freight service is provided by two interstate and two intrastate lines.

The Wickenburg Municipal Airport, located five miles west of town, provides private aircraft service and hangar space. The community has made initial plans to improve the airport for commercial use. However, at present, commercial air service is provided solely by the Phoenix Sky Harbor International Airport.

Financial Resources. The greatest source of revenues for Arizona taxing jurisdictions are from local property taxes and through transfers from taxes collected by the state. Large capital expenditures are generally financed through bonded indebtedness based on assessed valuation and capitalized through the property tax or through intergovernmental transfer payments. Assessed valuation of real and personal property (except mines, railroads, and some utilities) is fixed by county assessment. Real property is assessed at 15 percent of cost.

Arizona levies a four percent sales tax. In addition, incorporated communities levy an additional one percent tax on retail sales. Public finance data for the potentially impacted taxing jurisdictions in the project region are provided in Table 2.2-17.

Yarnell

Yarnell is located in Yavapai County on U.S. 89, approximately 80 air miles northwest of Phoenix and 37 air miles southwest of Prescott. The town is 37 air miles from the Anderson property. Situated high in the Weaver Mountains, Yarnell's 4782-foot elevation provides an excellent year-round climate. The Yarnell area includes the small community of Peeples Valley located immediately northeast of Yarnell.

Yarnell was founded in 1893 after gold was discovered in the area. Today, it is an unincorporated retirement community of approximately 1000 people. The town's growth rate between 1970 and 1977 was appreciably slower than that of Yavapai County. The town's most attractive assets for growth have been its pleasant climate, its natural surroundings, and its low cost of living. In addition to the town's new role as a retirement community, Yarnell serves the many cattle ranches in the surrounding area.

There are 3 motels with a total of 30 units and 3 small trailer parks in Yarnell. Housing values range from approximately $15,000 to $35,000 due to the large number of mobile homes favored by retired people. Housing availability is estimated to average 25 units at any one time.

Table 2.2-17. ASSESSED VALUATION, BONDED INDEBTEDNESS, TAX RATES, AND REVENUE FOR WICKENBURG AND PROJECT REGION, 1977 (DOLLARS)

Government Entity	Assessed Valuation	Total Bonded Indebtedness	Tax Rate (Per $100 Assessed Valuation)	Total Revenues
Town of Wickenburg	5,453,146	-0-	1.61	1,442,214[a]
School District 9, Wickenburg Unified	10,265,000	490,000	5.09	1,761,081
School District 17, Congress	2,382,050	-0-	2.70	103,458
Yavapai County	223,223,582	23,829,352	3.28[b]	10,505,509

Source: Personal communication, Mr. Edward Heller, Wickenburg Town Manager and Mr. Samuel Ambrose, Superintendent of Wickenburg Unified Schools, 1977
Yavapai County Clerk's Report, 1977

[a] does not include interfund transfers

[b] includes Junior College rate (1.3499)

Yarnell's municipal service system is presently adequate to serve a larger population. Rugged terrain in the area has generally prohibited large scale housing development. However, several sizable developments are in the planning stages, including county approval for construction of 100 single family homes, the purchase of two parcels of land totaling about 86 acres for single family housing, and zoning for a 13-acre trailer park development.

Yarnell has a small commercial and service sector that serves the community and the immediate surrounding area. Commercial businesses include three motels, two gas stations, two grocery stores, and a small assortment of clothing stores, cafes, and curio shops. There is no large or small industry in the Yarnell area.

The water system in this community is operated by the Yarnell Water Improvement Association. Expansion of the system was recently completed to allow for community growth. The main water source is wells located in Peeples Valley. The present production and distribution capacity is 936,000 gpd, which is currently limited to 360,000 gpd by the transfer pumps. Summer peak demand is estimated at 120,000 gpd. Water storage is provided by a 500,000-gallon elevated storage tank.

Sewage disposal in Yarnell is provided by septic tanks. APS provides electricity to the town. There is no natural gas supplied to the area.

There is a shortage of medical services in Yarnell. The area normally has only one physician. Major health care is available in Wickenburg and Prescott, both about half an hour's drive from Yarnell.

Three county deputies reside in Yarnell, providing adequate local law protection for the community. Yarnell staffs a 10-member volunteer fire department. The town's National Board insurance rating is 8.

Yarnell School District 52 operates an elementary school for grades K-6. Present enrollment is 64, but new classroom facilites provide capacity for 150 students. Junior and senior high school students are bused to Wickenburg.

Developed recreational opportunities within the community are limited. Recreational activities within close range of Yarnell are offered in Prescott National Forest.

U.S. 89 provides intrastate and interstate truck transportation to Yarnell. Greyhound buses serve the community. The nearest airport is located in Wickenburg.

Congress

Congress is located at the junction of U.S. 89 and 71, approximately 28 air miles south-southeast of the Anderson property in Yavapai County. The unincorporated community began as a bustling mining camp of nearly 2500 people in the late 1880s. Today there is very little activity in the old mines surrounding Congress. The community presently has a population of about 500. More than 36 percent of these people are retired. Local commerce consists of three gas stations, three cafes, one motel, and a post office. Other community services and employment are provided primarily by Wickenburg.

Housing in Congress ranges from older single family units and scattered mobile homes to modern, well designed and constructed homes throughout the main residential area. A lack of demand and available financing has inhibited housing development in the community. However, recent construction has occurred one mile west of Congress in a development know as Paso Del Sol. The major subdivision has on-site provisions (including water) for at least 100 large lots. Home prices start at $35,000. The development is about one quarter complete.

The Congress Water Company recently expanded the town's water system. The company estimates that it has 200 hookups and is capable of supplying an additional 200 hookups. The water system consists of two wells that produce less than 100,000 gpd. Peak usage in 1976 was estimated at 30,000 gpd. Water storage capacity is more than adequate at 450,000 gallons.

Congress relies on Wickenburg and Yarnell for educational facilities. For this service, Congress pays a tuition fee of $1150 plus $100 for capital outlay for each elementary school student and $1550 plus $100 for capital outlay for each high school student.*

Law enforcement and fire protection in Congress are supplied by Yavapai County and Wickenburg.

The community has no sewage treatment system, relying solely on septic tanks. Electric and gas service in Congress is provided by APS.

*Personal communication, Mr. Samuel Ambrose, Superintendent of Wickenburg Unified Schools, 1978.

2.3 CULTURAL RESOURCES

HISTORY AND ARCHAEOLOGY

There are no historical or archaeological sites in the vicinity of the Anderson property that are included in or currently being considered for inclusion in the National Register of Historic Places. This statement is based on a review of the register and correspondence with the Arizona State Historic Preservation Officer (Appendix A).

Few historical or archaeological field studies have been conducted in the vicinity of the property. The earliest known archaeological survey done in the region was conducted by Malcom Rogers in the 1930s (Powers et al., 1978). Rogers is said to have recorded sites along the Bill Williams River to the west of the property. The Arizona State Museum is currently excavating six archaeological sites located during a survey of the Bagdad to Wikieup pipeline corridor that runs to the east of the property. Personnel from Arizona State University are conducting surveys of the cultural resources in the vicinity of Alamo Reservoir, located on the Santa Maria River about eight miles downstream from the Anderson property.

In order to determine the extent of the cultural resources on the property, MINERALS contracted the Museum of Northern Arizona to conduct a historical and archaeological survey of the area. This survey covered approximately 9500 acres in portions of T11N, R10W and T11N, R9W and included all of the land to be disturbed by the proposed mining and milling activities (Figure 2.3-1).

Approximately 15.5 percent of the 9500 acres was surveyed. This survey included 12 randomly located transects generally one mile long by 100-meters (approximately 328 feet) wide and examination of specific areas that could potentially contain cultural sites. Cultural sites were defined according to the following criteria:

- any structural remains
- any artifact scatter of 10 or more items per 10 square meters (108 square feet)
- any historic material pre-dating 1950; the site had to include either structural remains or more than 10 historic artifacts per 10 square meters (Powers et al., 1978).

One historic (NA15,166) and 13 prehistoric sites were identified during the survey. The historic site and eight of the prehistoric sites are located on the property. The remaining five sites are located within two miles of the right-of-way for the proposed access road. Table 2.3-1 is a list of the types of artifacts found at each site. The likely activities that took place at the prehistoric sites are listed in Table 2.3-2.

The single historic site is located on the banks of an intermittent stream in the south half of Section 9, T11N, R10W. This site consists of a 50-gallon drum, a 1000-gallon water tank, a wash tub, some cut logs, and bleached stock bones. It is believed to have been a cattle watering station, possibly dating from the 1920s (Powers et al., 1978).

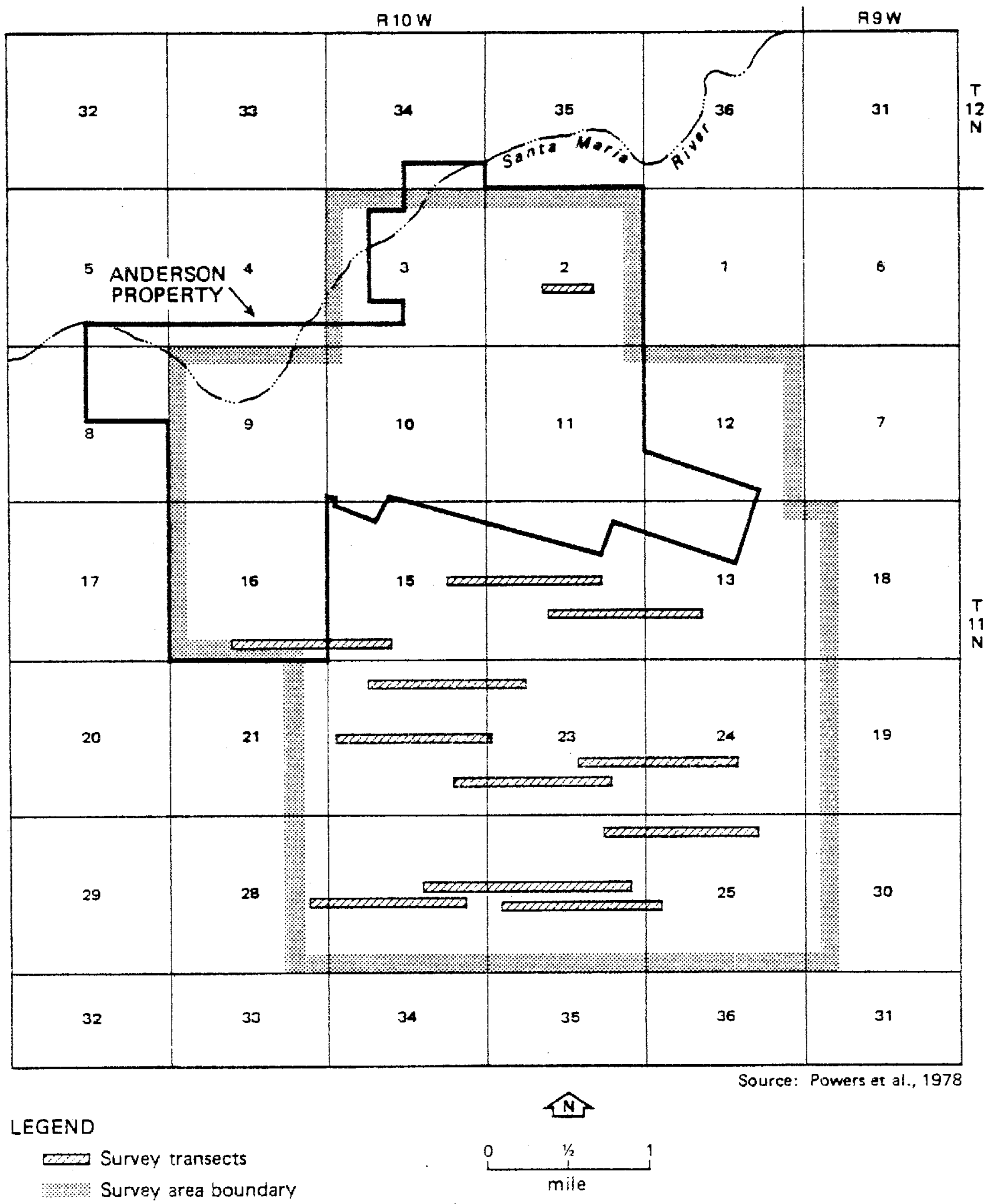


Figure 2.3-1. ARCHAEOLOGICAL SURVEY AREA

Table 2.3-1. TYPES OF ARTIFACTS FOUND ON AND IN THE VICINITY OF THE ANDERSON PROPERTY

	CERAMICS					GROUND STONE		CHIPPED STONE							MISCELLANEOUS					
Site No.	Tizon Brown Ware	Prescott Gray Ware	Lower Colorado Buff Ware	Gila Plain	Pai plainwares	Manos	Metates	Projectile Points	Bifaces	Scrapers	Choppers	Cores	Utilized Flakes	Debitage	Other	Structures	Historic Artifacts	Bone	Charcoal/Ash	Vegetal Remains
NA15,166																	X			
NA15,167												X		X		X				
NA15,168														X	X					
NA15,169	X	X		X		X	X							X					X	
NA15,170						X			X			X		X	X	X				
NA15,171						X	X						X	X						
NA15,172										X			X	X						
NA15,173						X			X			X	X	X						
NA15,174	X					X	X	X	X	X		X	X	X						
NA15,175	X	X			X	X			X	X	X		X	X						
NA15,176	X	X	X		X	X	X	X	X	X	X		X	X		X	X	X	X	X
NA15,177													X	X						
NA15,178										X		X	X	X						
NA15,179													X	X				X	X	X

Source: Powers et al., 1978

Table 2.3-2. PROBABLE ACTIVITIES THAT TOOK PLACE AT ARCHAEOLOGICAL SITES

				STONE WORKING				
	Animal Procurement/ Processing	Plant Processing	Plant Procurement	Final Reduction	Secondary Reduction	Immediate Use	Further Reduction	Initial Reduction
<u>Cluster 1</u>								
NA15,167							X	
NA15,170		X	X			X	X	
NA15,177			X			X		X
NA15,178			X			X		X
<u>Cluster 2</u>								
NA15,168					X		X	X
NA15,171		X	X		X	X	X	
NA15,172		X			X		X	X
NA15,173			X			X	X	
<u>Cluster 3</u>								
NA15,169		X			X			
NA15,174	X	X		X	X		X	
NA15,175		X		X	X		X	
NA15,176	X	X		X	X			
NA15,179*	X							

*No collections were made at this site and only a few artifacts were present at the surface. There is a potential that other activities may have taken place there.

Source: Powers et al., 1978

Except for site NA15,179, the 13 prehistoric sites are geographically clustered into 3 groups. Each group is located on or near a major drainage in the area. Site NA15,179 is set apart from the others approximately six miles southeast of the property. The specific locations of the archaeological sites have been provided to BLM and Arizona state archaeologists. However, for their protection, these locations have not been provided in this report at the request of the Museum of Northern Arizona. Interested parties may obtain this information by contacting Mr. Donald E. Weaver, Jr., Coordinator of Archaeological Research, Museum of Northern Arizona.

One group of prehistoric sites appears to represent a plant procurement area. This hypothesis is based on the presence of many utilized flakes and the absence of other more finished implements. This type of artifact denotes that lithic materials were reduced at the site for immediate use. A lack of charcoal or ash and animal bones excludes the possibility that activities such as animal procurement or food processing regularly took place at these sites.

While some plant procurement and processing was carried out at the second group of sites, this area appears to have been used primarily for the collection and reduction of lithic material into cores, secondary cores, and blanks. These partially-worked stones were then transported to another location for further reduction into finished tools. One of the sites in this group is a prehistoric quarry and many cores were found in the area.

The third group of sites is located to the southeast of the Anderson property. The activities that appear to have taken place at these sites were involved primarily with the secondary processing of materials (both food and lithic material) brought in from other areas. The presence of pottery at some of the sites and a rockshelter (site NA15,176) indicates that this group was used on a more permanent basis than the other two. Site NA15,176 has been extensively vandalized.

Site NA15,179 is a rockshelter. Artifacts found at this site indicate that it was used for animal processing. This rockshelter has been affected by only a few small vandal pits and is in relatively pristine condition.

The archaeological sites on the Anderson property and in adjacent areas are significant because they appear to represent a wide variety of different subsistence and manufacturing activities. These sites constitute evidence of the ways in which prehistoric people adapted to the Mohave-Sonoran Desert ecotone. The two rockshelter sites are particularly important in this respect. They not only offer the opportunity to recover specimens of plant and animal species used by prehistoric inhabitants but also provide a source of radiocarbon samples that can be used to date the period of occupation of the area. Site NA15,176 offers the potential for dating several of the ceramic types found in the area that are poorly understood at the present time.

PALEONTOLOGY

MINERALS contracted the Musuem of Northern Arizona to conduct a paleontological survey of 11,840 acres that included the Anderson property. A total of 11 fossil locations were identified during this survey (Figure 2.3-2 and Table 2.3-3).

The lacustrine and fluvial sediments that outcrop on the property generally contain few fossils; however, some horizons contain numerous palm and water reed fragments (Breed and Billingsley, 1977). Palm root impressions are also common throughout the area. Silicified palm fragments should have been more abundant than what was observed during the survey. The lack of these fossils is due primarily to a thorough examination of the surface area by amateur rock hounds over the past several years.

Very few vertebrate fossils were found during the survey. Isolated specimens may have been removed by rock hounds, but these fossils were probably never abundant on the property. Fossil fish remains were found at sites 3 and 10 (Figure 2.3-2). These specimens are very poorly preserved and fragile. The fish species has been tentatively identified in the Family Cyprinidae (western minnow) by Dr. E. Wiley of the University of Kansas; the genus and species are not known. The age of these fossils ranges from Eocene to Recent, closer dating cannot be made due to their poor condition. One tooth fragment of a rhinoceros (Diceratherium sp.) was found in a talus slope near outcrops of white calcareous sandstone (site 9). The distal end of a left humerus from a

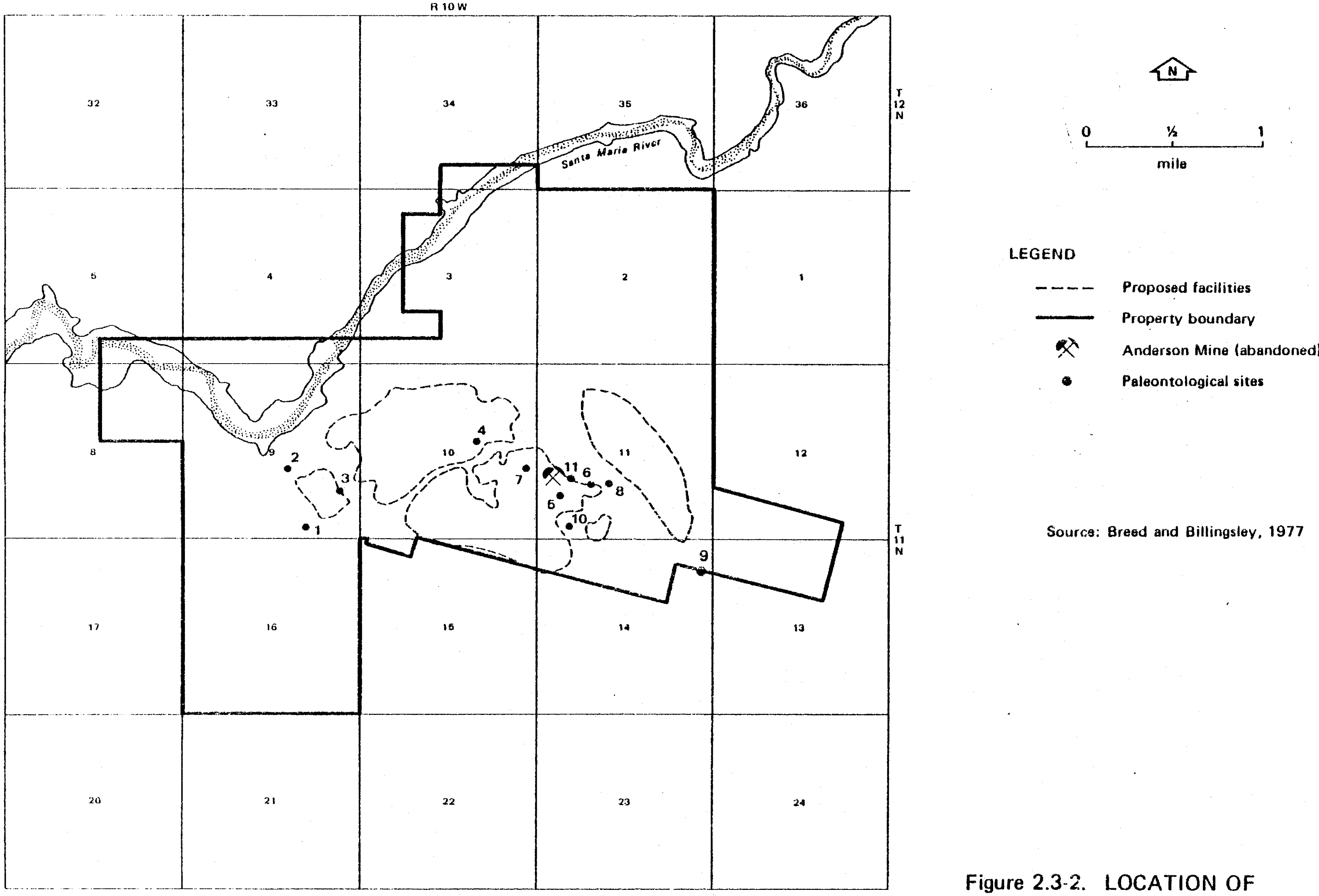


Figure 2.3-2. LOCATION OF PALEONTOLOGICAL SITES

Table 2.3-3. PALEONTOLOGICAL SITES ON THE ANDERSON PROPERTY

Site No.	Site Description	Fossil Description
1	Draw on east side of road in white siliceous and calcareous fine-grained siltstone	Water reeds
2	In silica in abandoned mine	Petrified palm and occasional roots
3	Paper thin beds of calcareous shale, 70-80 yards NE of overhang	Fish and worm burrows
4	Grey marl in wash	Pollen
5	White bed of siliceous and calcareous shale and siltstone between green mudstone layers	Rhinocerous jaw bone found by A. P. Deutsch, camel humerus and gastropods
6	Thin bed of siliceous limestone in steep gully	Silicified gastropods and pelecypods
7	Anderson Mine excavations	Palm bark containing carnotite
8	In silica in eastern section of Anderson mine pit	Weathered palm roots
9	Near top of steep talus slope	Rhinocerous tooth fragments
10	Paper thin beds of calcareous shale	Fish
11	Pink layers of calcareous siltstone	Water reeds

Source: Breed and Billingsley, 1977

camel (Oxydactylus sp.) was found in a cemented fine-grained layer of green calcerous mudstone (site 5). These mammalian fossils are approximately 15 to 20 million years old (Breed and Billingsley, 1977). Other known finds of vertebrate remains in the area are a rhinocerous fossil discovered by A. P. Deutsch in the late 1950s and a few bone fragments found by Mr. Charles Smith in 1972.

Numerous small internal molds of aminocolid gastropod and pelecypod shells, completely replaced with silica, were present in siliceous limestone. These fossils have been tentatively identified as Physa sp., Planorbis sp., and Campeloma sp. by Dr. Dale Nations of Northern Arizona University.

A sample of calcareous siltstone was collected for pollen analysis (site 11). Dr. Hevly of Northern Arizona University found 22 pollen grains and several algal relics (fragments, cysts, and spores) in this sample.

AESTHETICS

Like most of the desert in southwestern Arizona, landforms constitute by far the most dominant visual element in the landscapes on the Anderson property. Since vegetation is quite sparse, the patterns created by erosion are not masked. The details of even minor drainages or rock outcrops can be seen at a distance.

As can be seen in Figure 2.4-2, the Anderson property is located in rugged terrain. Erosion has created a wide variety of strongly angular forms that tend to hold viewer attention. While the maximum relief on the property is only about 700 feet, slopes are generally quite steep, approaching near-vertical walls along many reaches of the Santa Maria River. These slopes are cut by numerous, often relatively straight, erosion channels that visually accentuate their steepness. The channel of the Santa Maria River contrasts strongly with the surrounding mountains. Visually, this channel creates a flat, smooth "ribbon" cutting through areas of highly irregular topography. This visual effect is increased by the contrast between the light-colored alluvial sediments and bordering green vegetation of the channel and the darker grays, browns, and reds of the surrounding land.

Except in foreground views (0 to 0.5 mile), the vegetation in the area adds little color or form to the landscapes. However, much of the vegetation, particularly the saguaro cactus and Joshua trees, are large enough to provide a grainy texture to most middleground (0.5 to three miles) and some background (beyond three miles) views.

2.4 GEOLOGY

REGIONAL CHARACTERISTICS

Physiography and Topography

The Anderson property is located in the Sonoran Desert section of the Basin and Range Province (Fenneman, 1931). Although its boundaries cannot be specifically defined, the Basin and Range Province is generally considered to cover the entire state of Nevada, north- and southeastern California, southeastern Oregon, southern Idaho, western Utah, and northwestern Arizona, as well as parts of northern Mexico. The province is characterized by sets of roughly parallel mountain ranges separated by desert basins that are frequently internally drained. This characteristic structure was formed by horst and graben block faulting.

Mountain ranges in the Sonora Desert region are lower (seldom rising more than 4000 feet above mean sea level [msl]) and perhaps older than the mountains in the central portion of the Basin and Range Province. In addition, many of the basins in this desert are not internally drained. Mountain ranges in the Sonoran Desert trend roughly in a north-northwest to south-southeast direction and are generally quite symmetrical. Individual summits are normally of about equal height and they are laterally equidistant from their valley margins (Dunbier, 1970). The mountains cover approximately one-fifth of the land, while mountain pediments -- broad rock platforms that surround and form the base of these mountains -- cover two-fifths of the area (Fenneman, 1931).

The Anderson property lies along the northeast margin of the Date Creek Basin, a small structural basin bordered to the north and east by the Black Mountains, to the south by the Harcuvar Mountains, and to the west by the Buckskin Mountains (Figure 2.4-1). These mountains rise 3000 to 4000 feet above sea level and are bordered by broad, alluvium-filled valleys. Three drainages cross the basin: the Santa Maria River, Date Creek, and Bullard Wash. The general gradient of these drainages is to the west and northwest.

All of the drainages on the Anderson property grade to the north and northwest into the Santa Maria River (Figure 2.4-2). The erosion of these tributaries southward into the Date Creek Basin surface has resulted in a series of subparallel gullies and ridges trending north and northwest, frequently controlled by northwest-to-southeast oriented faulting. Maximum topographic relief on the property is about 700 feet.

General Geology

Precambrian igneous and metamorphic rocks and thick sections of Tertiary volcanic rocks and interbedded sediments are characteristic of the stratigraphy of the Sonoran Desert. This appears to be due to continued uplift in this portion of the Basin and Range Province, which has resulted in erosion of Paleozoic and Mesozoic rocks (although a few isolated outcrops do occur). Igneous intrusions are more common in the Sonoran Desert than in other portions of the province because

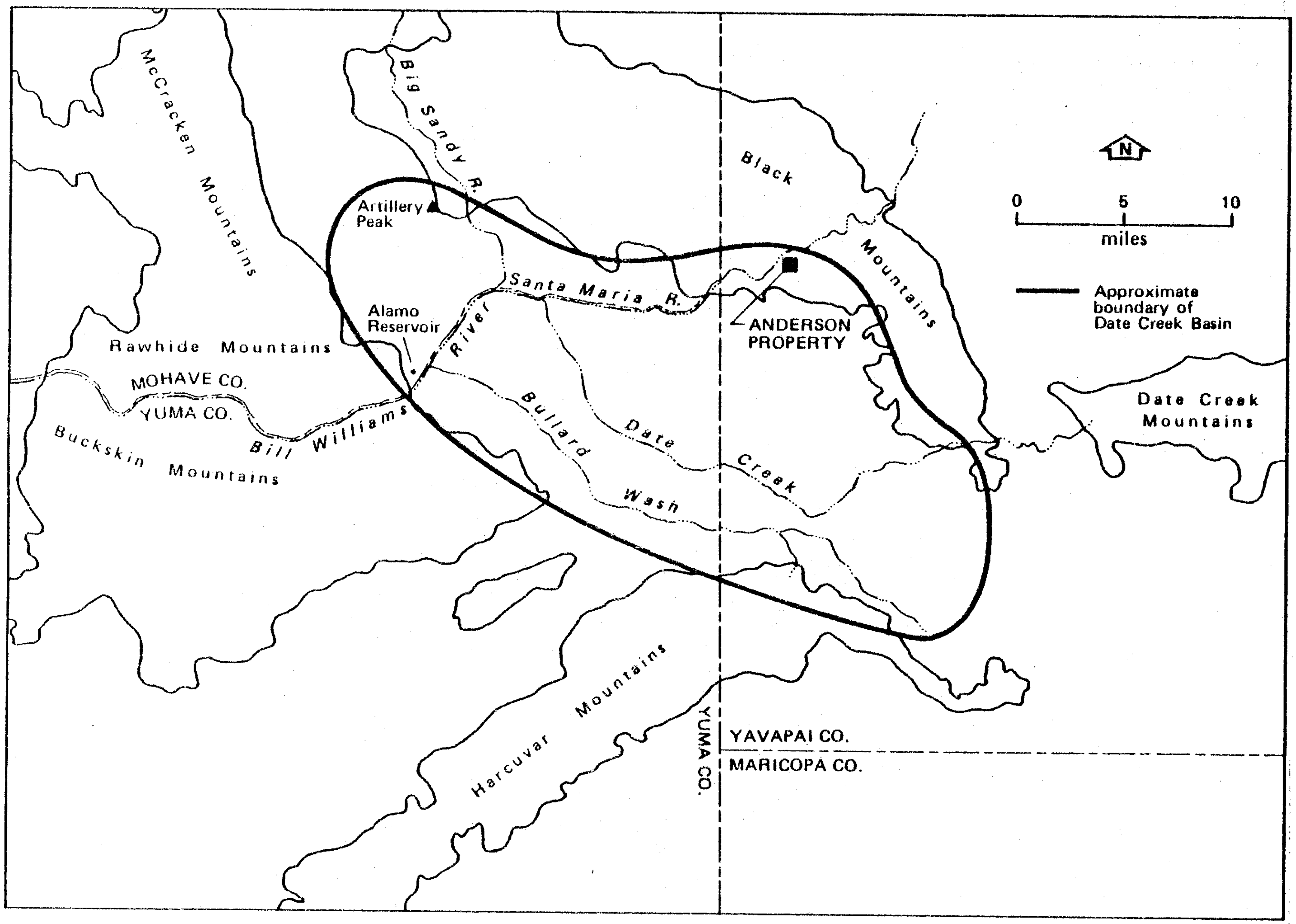


Figure 2.4-1. PHYSIOGRAPHY IN THE VICINITY OF THE ANDERSON PROPERTY

erosion has extended more deeply into the stratigraphic succession and the region is in a more advanced stage of arid-land pedimentation.

Masses of igneous rock were again intruded into the existing rocks during repeated activity in the late Cretaceous. Some volcanic activity also occurred at that time. From the late Cretaceous, and particularly in the Tertiary, deposition was renewed with terrestrial and then lacustrine sediments, as well as the intrusion of volcanic rocks. Since the cessation of volcanic activity in the Quaternary, the region has been undergoing a new cycle of erosion on the mesas and mountains, with deposition of sands and gravels in the valleys.

Tectonic History

In the early Precambrian era, a broad northeast-trending geosyncline extended across much of central Arizona. At the end of this time, compression and uplift during the Mazatzal Orogeny created roughly northeast-trending mountain ranges in this region. Accompanying this orogeny was extensive volcanism and the implacement of many granitic plutonic bodies.

Erosion greatly reduced these mountains during middle Precambrian time. However, central Arizona remained an area of uplift throughout the remainder of the Precambrian and during most of the Paleozoic and Mesozoic eras. At the end of the Precambrian the Grand Canyon Disturbance resulted in deformation and intrusion of diabase to the northwest and southwest of central Arizona.

During the Paleozoic era the area of uplift, called Mazatzal Land, remained relatively stable. At the same time, the Cordilleran Geosyncline to the northwest and the Sonoran Geosyncline to the southeast of Mazatzal Land downwarped and were the sites of the deposition of thousands of feet of Paleozoic sediments. Deposition in these geosynclines continued into the Mesozoic.

From the Mesozoic into the Cenozoic era the relative movement of the North American Plate westward or northwestward increased the compressional forces on the western portion of the continent. A trench or subduction zone formed along the North American Plate margin, and the small plate or plates between it and the Pacific Plate were subducted. This activity initiated a series of orogenies that generally progressed eastward, deforming the Cordilleran Geosyncline and also affecting the Sonoran Geosyncline. Although parts of this general activity have been given separate names, many researchers now apply the name Laramide Orogeny to the entire series of deformations.

In the middle of the Cenozoic (Late Oligocene), the northern portion of the East Pacific Rise was either subducted into the California trench system or passed eastward under the North American Plate. As a result, the trench system ceased and transform movement between the North American and Pacific plates was initiated, releasing compression forces and creating tensional forces. With the transform movement and related tensional forces, western North America is literally being pulled apart. The Basin and Range block faulting is the result of this tension stretching of the earth's crust. Commonly associated with the transform movement is basaltic volcanic occurrences, possibly derived from ocean basin sources subducted beneath the continental plate.

Although it is not proven, it generally appears that the southwest Arizona portion of the Basin and Range Province is a marginal wrench zone between the rest of the Basin and Range Province to the north, the Colorado Plateau to the east and northeast, the Salton Sea Rift to the west, and the Sierra Madre in Mexico to the south. The Sonoran Desert is acting as a pivotal point between the movement of plates to the north, south, and west.

LOCAL GEOLOGY

General

The geology of the area in the vicinity of the Anderson property is relatively complex and further complicated by numerous northwest-to-southeast-trending structural features generally downfaulted to the southwest. No detailed regional geologic map is available for the area; however, the geological units exposed on the property are all Cenozoic in age, resting on Jurassic granites. Precambrian rocks outcrop north of the property.

Sediments dip an average of about 7° to the south on the Anderson property. Since the land surface rises to the south, the depth to a given stratigraphic unit becomes progressively greater in a southerly direction (Figure 2.4-3). Erosion of the overlying conglomerate and basalt has exposed the mineralized units to be mined at the land surface on a portion of the property. Uranium mineralization occurs at depths greater than 1000 feet below the land surface to the south of the Anderson property.

Local Stratigraphy

Nine informal stratigraphic units have been identified by Minerals Exploration Company on the Anderson property. From youngest to oldest, they are: alluvium, upper conglomerate, basaltic volcanic flows and dikes, lower conglomerate, lacustrine sediments, andesitic volcanic flows, felsic to intermediate volcanic clastic sediments, felsic to intermediate (extremely varied composition) intrusions and flows, and crystalline intrusive rocks.

Alluvium (Quaternary) (Qal).* Unconsolidated sands and gravels are present in most of the stream courses on the Anderson property. At least one older alluvial terrace is present in the northeast portion of the area and remnants of several older alluvial deposits are present along some of the deeper drainages. Most of these older deposits have well-developed caliche zones within them. Recent alluvial deposits along the Santa Maria River contain groundwater and are discussed in detail in Section 2.6.

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*The symbols given after each heading refer to the mapping symbols on Figure 2.4-3.

Upper Conglomerate (Quaternary Tertiary) (Qcgl). The upper conglomerate unconformably overlies either the basaltic volcanics or the lower conglomerate. This unit is composed of cobbles and boulders of felsic and mafic volcanics, basalt, granite, and metamorphics in a matrix of medium-to coarse-grained arkosic sandstone. The presence of basaltic boulders differentiates it from the lower conglomerate. The unit is weakly to moderately indurated and is locally well cemented by calcite. In the vicinity of the proposed mine, this formation is generally above the water table.

Basaltic Volcanics (Miocene) (Tmb). Basaltic volcanic flows unconformably overlie the lower conglomerate, forming erosionally resistant caps on many of the mesas and eroding cliffs in the area. Ljung et al. (1976) describe the basalt as "black fine-grained to aphanitic, containing calcite-filled amygdules, and commonly jointed parallel to the flow surface." The basalt attains a maximum thickness of 120 feet southeast of Flat Top Mesa and thins to the east. At least two flows are present in the western portion of the property. To the northeast of Flat Top Mesa (NE 1/4 Sec. 10, T11N, R10W) several dikes, possibly basaltic, have been noted. These dikes cut the felsic to intermediate and andesitic volcanics; however, no direct pipe has been observed to the basaltic flows from these dikes. Pierce* reports that a sample of basalt taken at the Anderson Mine in the southeast 1/4 of Section 10, T11N, R10W, was dated (Potassium Argon Method) at 13 to 14 million years old, or Miocene in age. Basalt to the west of the property at Palmerita Ranch

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*W. Pierce, Arizona Bureau of Mines, personal communication, 1977.

has recently been dated at 11 million years old, and samples from Malpais Mesa, northeast of the property, are 8 to 9 million years old.*

Lower Conglomerate (Miocene) (Tmc). A tan to brown siltstone is usually present immediately above the lacustrine sediments. This siltstone grades upward into arkosic sandstones and then into the conglomerate. The unit is composed primarily of arkosic sands and granitic and metamorphic clasts. Minor amounts of rhyolitic and andesitic volcanic materials are present throughout the unit. The sandstone and conglomerate may be either locally well cemented by calcite or relatively unindurated. To the southwest, where the lake beds interfinger with sandstones, the lower conglomerate is indistinguishable from these sandstones. This conglomerate unit contains groundwater which may be present in sufficient quantities to provide a source of water.

Lacustrine Sediments (Miocene) (Tml). The lacustrine sediments unconformably overlie the andesitic volcanics over most of the Anderson property. However, east of the center of the property they overlie the volcani-clastic sediments and farther to the east they onlap the felsic to intermediate volcanics. The felsic to intermediate volcanics or the tuffaceous part of the volcani-clastic sediments were encountered immediately below the lacustrine sediments in one drill hole in the southeast 1/4 of Section 10, T11N, R10W.

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*W. Pierce, Arizona Bureau of Mines, personal communication, 1977.

Evidence now suggests that deposition of the lacustrine sediments occurred in a restricted basin. These sediments probably represent time-transgressive facies deposited within a narrow, probably shallow, basinal feature. This type of depositional environment exhibits complex rationships between individual facies, such as lensing out, vertical and horizontal gradation, and interfingering. Ljung et al. (1976) simplified these complexities by dividing the lake-bed sequence into four subunits: (1) a basal coarse clastic unit; (2) a mudstone-siltstone unit containing interrelated carbonaceous zones; (3) a succession of interbedded limestones, silicified limestones, cherts, mudstones, and siltstones; and (4) a thin, fissile, fossiliferous marker bed that has been designated the top of the lacustrine unit.

The lake sediments include green siltstones and mudstones, white calcareous siltstones, and silty limestone or calcareous tuffaceous material. Much of this material is silicified to varying extents and was partly derived from volcanic ashes and tuffs common throughout the lake beds. Also present in the lacustrine sequence are zones of carbonaceous siltstone and lignitic material. A basal arkosic sandstone was encountered in drill holes along the southern boundary of the property. To the south and southwest, the "typical" lake beds interfinger with, and eventually are replaced by, a thick, medium- to coarse-grained, arkosic sandstone unit. It is not known whether this unit relates to the basal arkosic sandstone mentioned above.

All of the lake bed facies may exhibit some uranium mineralization. However, the highest grade and most consistent mineralization is located in the carbonaceous siltstones and lignitic materials.

In addition to the organic material in the carbonaceous zones, abundant plant remains (including twigs, reeds, and small roots) are present in the lacustrine sediments. Reyner et al. (1956) identified abundant silicified palm-type wood in these sediments. In addition, many faunal fossil remains are present in the deposits. Freshwater molluscs, up to 1.5 inches long, are locally common. Thin, laminated, calcareous siltstone near the top of the lake beds contains small freshwater fish fossils. The leg bone of a duck found in the unit has been dated as Miocene by the Los Angeles County Museum. A jaw of a rhinoceros reportedly found at the Anderson property is on display at the Wickenburg Museum. Breed and Billingsley (1977), of the Museum of Northern Arizona, collected fossils at the Anderson property in April 1977. Included in their finds were a camel bone, a rhinoceros tooth (Miocene), and freshwater fish fossils (for further discussion of paleontological resources refer to Section 2.3).

Water Development Corporation (1977) refers to a coarse-grained unit (barren sand) which appears to be the equivalent to the basal red arkosic sandstone of the lucustrine sediments. The barren sandstone lies immediately above the volcanic andesite basement. It is absent near outcrop and increases in thickness to the south (see Section 2.6).

Andesitic Volcanics (Tertiary) (Tva). A series of andesitic volcanic flows unconformably overlies the felsic to intermediate volcanics or the volcani-clastic sediments. Reyner et al. (1956) described the unit as a fine-grained, vesicular, augite andesite locally containing calcite-filled amygdules. The flows are generally purple, red-brown, gray-brown, or gray. In several areas of outcrop they are interbedded by volcani-clastic sediments composed of felsic volcanic pebbles and arkosic sands. The andesitic flows have been considered "basement"* on the Anderson property, as no uranium mineralization has been observed in or below them. Before depositon of the lacustrine sediments, erosion and faulting developed a complex paleotopography and locally thick red-brown paleosols on the top of the andesitic volcanics. Agglomerate is also reported as occurring at the top of this formation underlying the lake bed sediments (Water Development Corp., 1977). This agglomerate contains groundwater and is discussed further in Section 2.6.

Volcani-Clastic Sediments (Tertiary) (Tvg). Interbedded with and unconformably overlying the felsic to intermediate volcanics are tuffs, ashes, and volcani-clastic sediments. All of these appear to be of felsic to intermediate composition and are therefore believed to be contemporaneous with the felsic to intermediate volcanics. However, deposition of this unit continued after the felsic to intermediate volcanic activity ceased, as this unit is also interbedded with the overlying andesitic volcanics.

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*"Basement" is used here in reference to the uranium mineralization basement; that is, mineralization lies above it.

The most complete section of this unit is located in the northeast portion of the property. Here the basal part of the section is composed of white felsic to intermediate tuffs, thin ash flows or volcani-clastic sediments, lahar breccias, and volcanic bombs. Volcani-clastic sediments increase upward in the section, and the color changes from white to yellow-tan to tan. These sediments include felsic volcanic material and arkosic sandstone.

Many aspects of these sediments (crossbedding, thin continuous beds, etc.) lead to the conclusion that they were deposited in a lake bed ancestral to that of the overlying lacustrine sediments.

Where exposed on the surface or encountered in drill holes, these volcani-clastic sediments exhibit no anomalous gamma activity.

Felsic to Intermediate Volcanics (Tertiary) (Tuf). Unconformably overlying the crystalline basement, or in fault contact with it, is a series of felsic to intermediate volcanics. This series includes intrusive necks, flows, lahar breccias, and tuffs. These volcanic rocks appear to be rhyolitic to andesitic in composition and are generally white to light gray in color.

Crystalline Intrusive Rock (Jurassic) (J). In the extreme northeast portion of the property, the Santa Maria River and its tributaries have cut into a crystalline basement complex. These rocks are low in quartz content but have been termed granitic (they were termed biotite granite by the analytical lab, despite the apparent low quartz content).

This granitic rock is purplish-gray in color, medium-to-coarse crystalline to pegmatitic, and is intruded by veins of quartz and plagioclase feldspar with large crystals of hornblende and black biotite. A sample of the crystalline basement complex was dated as Jurassic (157.5 million years ago, ±3 million years) by the Geochron Laboratories Division of Kruger Enterprises.

Local Structure

As discussed above, the Anderson property is located in the Sonoran Desert section of the Basin and Range Physiographic Province and the local geology exhibits the general structural pattern common to this region. Parallel to subparallel fault blocks with usually normal bounding faults predominate. These faults are often rotational or hinged and may have experienced some longitudinal movement. While much of the Basin and Range faulting is on the magnitude of thousands of feet of displacement, displacement along faults at the Anderson property are measured in tens and hundreds of feet.

Faulting on the property was active before, during, and after the deposition of the Miocene section (lake beds, lower conglomerate, and basalt). The general dip of the sediments is 5° to 15° to the south, steepening to the north along the granite front. The general dip to the south appears to be the result of the recurrent nature of the faulting, and in these areas dips on the drag folds may surpass 20°. Many of the onlap, pinchout, and lens relationships in the lake beds are probably due to or related to recurrent contemporaneous faulting.

The recurrent and hinging nature of the faulting makes it extremely difficult to predict how a specific fault will affect the individual stratigraphic units along it. At one point along a fault there may be only a few feet of vertical displacement, while 200 feet beyond that point portions of the section may be displaced several tens of feet. Many of the faults that displace the lake beds show diminished or no movement in the basalt, and most of the faults die out before or in the upper conglomerate. The faulting and basalt flows are relatively contemporaneous. Therefore, the basalt is not heavily fractured.

Three major faults - the East Boundary Fault System, Fault 1878 (so named because it intersects a hill of 1878 feet elevation adjacent to the Anderson property), and the West Boundary Fault System - are present in the area. In addition there are many parallel faults that have less displacement (Figure 2.4-4). All of these faults trend between N30°W and N55°W. Another set of faults trending more westerly (N65°W) is present, at least in the south-central portion of the property. A set trending northeast has been conjectured by Urangesellschaft and others, but it has not been observed in the field.

The West Boundary Fault System includes at least two distinct normal faults. Movement on these faults is down to the southwest. Vertical offset of the volcanic basement across the two faults is approximately 100 feet. Another fault is indicated to the southwest that vertically offsets the volcanic basement about 250 feet. Including all three faults of the West Boundary Fault System, total vertical offset of the basement volcanics across the system is more than 700 feet, and vertical offset of the basalt is less than 200 feet.

A large hinge fault, fault 1878, exhibits 200 feet of vertical displacement near the southern boundary of the property. To the northwest along the fault strike, displacement appears to decrease and movements appear to be distributed across a zone of faults. The movement along this normal fault has been down to the southwest. Along the zone of faults, movement, while generally down to the southwest, has produced horst/graben features.

The East Boundary Fault System consists of several large faults along the eastern and northern portions of the property. These faults are beyond the limits of mineralization and have not been thoroughly explored. In general, they are downthrown to the southwest and several of them probably have displacements approaching 1000 feet. The westernmost fault of this system marks the foot of the Black Mountains, and the more eastern faults in the system lie within the Black Mountains.

Geologic History of the Anderson Property

Many of the regional geologic trends are reflected on the Anderson property. The mine is located in an area that has been marginal or is marginal to every regional deformation.

The lack of Paleozoic rocks on the property is the result of the area's position on the margin of Mazatzal Land, a positive, stable area. Rocks of this era were either not deposited or have eroded away.

After a long period of relative quiescence, the Laramide Orogeny began in the Mesozoic. During the later Jurassic, the granite on the northeastern margin of the property was emplaced. This was the result of the Nevadian Orogeny, a local name for part of the Laramide Orogeny.

The felsic volcanics on the Anderson property are possibly associated with the subduction of the Pacific plates into the California trench system. It is expected that dating of these volcanics would provide ages falling in the late Cretaceous to middle Tertiary.

With the termination of the trench system at the end of the Oligocene, Basin and Range block, transform, and normal faulting began. The lacustrine sediments have been dated paleontologically as Miocene, and a geochemical date of Miocene (13 to 14 million years ago) has been obtained for the basalt. These lake beds were probably formed in the early or middle Miocene. During this time, while volcanism was waning, ash and tuff deposits were still common.

Drill hole data lead to the conclusion that deposition of the lacustrine sediments occurred in a very restricted area. To the north of the Anderson property in Section 4, T11N, R10W, the basalt caps Hill 2826 (Figure 2.4-2) and is underlain by the lower conglomerate.

This in turn rests unconformably on the "basement volcanics." Two possibilities arise: (1) the lake beds were never deposited there, or (2) they were deposited and subsequently eroded. The fact that the lake beds thin rapidly northward suggests that the beds were never deposited there. The intertonguing and interfingering of the "typical" lake beds with clastic siltstones and medium- to coarse-grained sandstones to the southwest and south limits the lake boundary in this direction. The relationship of coarse-grained lithologies in this direction and the lack of them to the north in the "typical" lake bed sequence implies that the sediment source was from the west or the south. Drilling has traced the lake beds and mineralization to the southeast. Drilling to the southeast of Urangesellschaft's claims (adjacent to the southern boundary of the Anderson property) has encountered interbedded green siltstones and sandstones and little mineralization. Thus, it appears that the lacustrine sediments were deposited in an area less than three miles wide and only about five or six miles long. The lake trended roughly northwest-southeast and generally paralleled the dominant post-Oligocene faulting trend of the area. One further lithologic implication is of interest. The northern and northeastern margin of the lake was probably the Black Mountains. It is known that the lake sediments thin markedly in this direction and some agglomerates are present within the lake bed sequence north of the proposed mill site.

The lower conglomerate overlying the lake beds attests to the continuation of Basin and Range faulting and development. Erosion from nearby sources, possibly from the north or northeast, is indicated. Near the end of the Miocene the basaltic volcanics flowed across part of the area, possibly marking the passage of the East Pacific Rise beneath the area. Normal faulting continued and the upper conglomerate was deposited. Its very coarse texture implies nearby sediment sources and a high-energy environment of deposition, as it would require a strong current of water to carry such boulders. The inclusion of fresh basaltic boulders suggests the source was to the north and that the transporting agent may have been the Santa Maria River.

Mineralization

Uranium mineralization on the Anderson property is primarily associated with carbon. In fact, it is suspected that mineralization not associated with carbonaceous material may represent the pinchout of this material or very thin carbonaceous laminae. The primary mineralized zones on the property are carbonaceous siltstone and lignitic facies in lake beds. In addition, occasional mineralization has been noted in the basal sandstone of the lacustrine sediments and in the lower conglomerate where uranium was deposited as fracture fillings around and below the main mineralized zones after remobilization. Carbonaceous material is known to occur in these two units.

Carbon tends to immediately fix uranium when soluble forms of the mineral come in contact with it. Much of the mineralization is at the top or bottom of the carbonaceous facies; however, mineralization does occur in the middle of some carbonaceous zones. This latter relationship implies that mineralization occurred contemporaneously with the deposition of the carbonaceous material.

Silicification of various parts of the lake sediments on the property probably occurred soon after deposition. Devitrification of the tuffaceous and ashy lake bed sediments and/or the felsic volcanics were probably the primary sources of silica.

Reyner et al. (1956) suggest three possible origins for the uranium on the Anderson property: hypogene, ash leach, and bog deposition. A fourth possible origin is mobilization across the Date Creek Basin.

Reyner et al. (1956) cite field evidence in favor of a hypogene source and state that "(1) uranium ore has not been observed beyond the boundary faults; (2) intense silicification has altered mudstone and limestone; (3) limonite and hematite staining occurs on bedding and fracture planes; (4) calcite, chalcedony, sepiolite, and manganese are found associated with the west bounding fault." This field evidence can have different interpretations. Drilling data indicate that the carbonaceous sediments also have not been observed beyond the boundary faults. This may explain why the mineral is localized within this area. Further, if uranium-bearing solutions migrated up faults, one would expect mineral and grade to be concentrated along the faults. Subsurface interpretations indicate no such association. Data indicate that faulting offsets mineralization. Intense silification is probably a result of devitrification of silicic volcani-clastic sediments. Bentonite, can also be an alteration product of tuffaceous material. Hematite and limonite stain on bedding and fracture planes was possibly derived from pyrite associated with carbonaceous material. Calcite, sepiolite, chalcedony, and manganese deposited along this zone, but without associated uranium. Such deposits cannot significantly be cited as evidence that uranium-bearing solutions migrated up the fault zone.

Support for this source, over devitrification, is implied by mineralization throughout the carbonaceous materials. If the source had been from overlying sediments containing volcanic fragments, mineralization would be expected only at the top of the carbonaceous zones. Further, if mineralization had been tied with devitrification, uranium should be present in all of the partings and fractures where silica was deposited. This is not the case on the Anderson property.

A fourth possibility for the deposition mechanism is that the uranium was mobilized from the western Date Creek Basin, carried by groundwater across the basin, and deposited in the reducing environment of the lacustrine sediments. It is interesting to note that uranium mineralization in the western Date Creek Basin is limited to the Artillery Peak Formation of Oligocene age. Overlying the Artillery Peak Formation is the Chapin Wash Formation, which is composed of altered (red) arkosic sandstones. Pierce (1976) suggests correlation of the Chapin Wash and the Anderson Lake sediments. Sedimentation at the Anderson property suggests a western or southern source. Groundwater movement during the Miocene therefore may have been easterly across the basin from the west. Uranium, remobilized from the Artillery Peak Formation, or derived from the same source but later, could have been carried in soluble form across the basin to the lacustrine sediments where the reducing environment of the carbonaceous facies precipitated its deposition. Other sources (ashes, tuffs, granites, and hot springs) may have contributed to some extent to the mineralization of the lacustrine sediments.

2.5 SEISMOLOGY

HISTORICAL EARTHQUAKE ACTIVITY

Seismic activity in Arizona or adjacent portions of California that may affect the Anderson property can be assessed in part by examining the earthquake history of the region. The locations and magnitudes of earthquakes that occurred within 100 miles (160 km) of the property between 1930 and July 1976 are shown in Figure 2.5-1. This epicenter map includes events located by their reported effects and events located by modern seismographic instruments. Earthquakes occurring prior to the early 1900s in the Arizona area were not well-recorded instrumentally, and locations were generally assigned on the basis of earthquake effects on people and structures. The Modified Mercalli (MM) intensity scale is used to rate earthquakes by reported effects and observations (Table 2.5-1). Distribution of the reports of effects provides an estimate of both the size and location of an earthquake. Since this analysis depends on recorded reports, its accuracy depends on population density and distribution at the time of the earthquake. After approximately 1902 there was an improvement in seismographic instrument coverage in the region that includes Arizona. Upgrading of instrumental coverage also made possible the more accurate indication of earthquake size as a Richter magnitude determined from seismographic recordings.

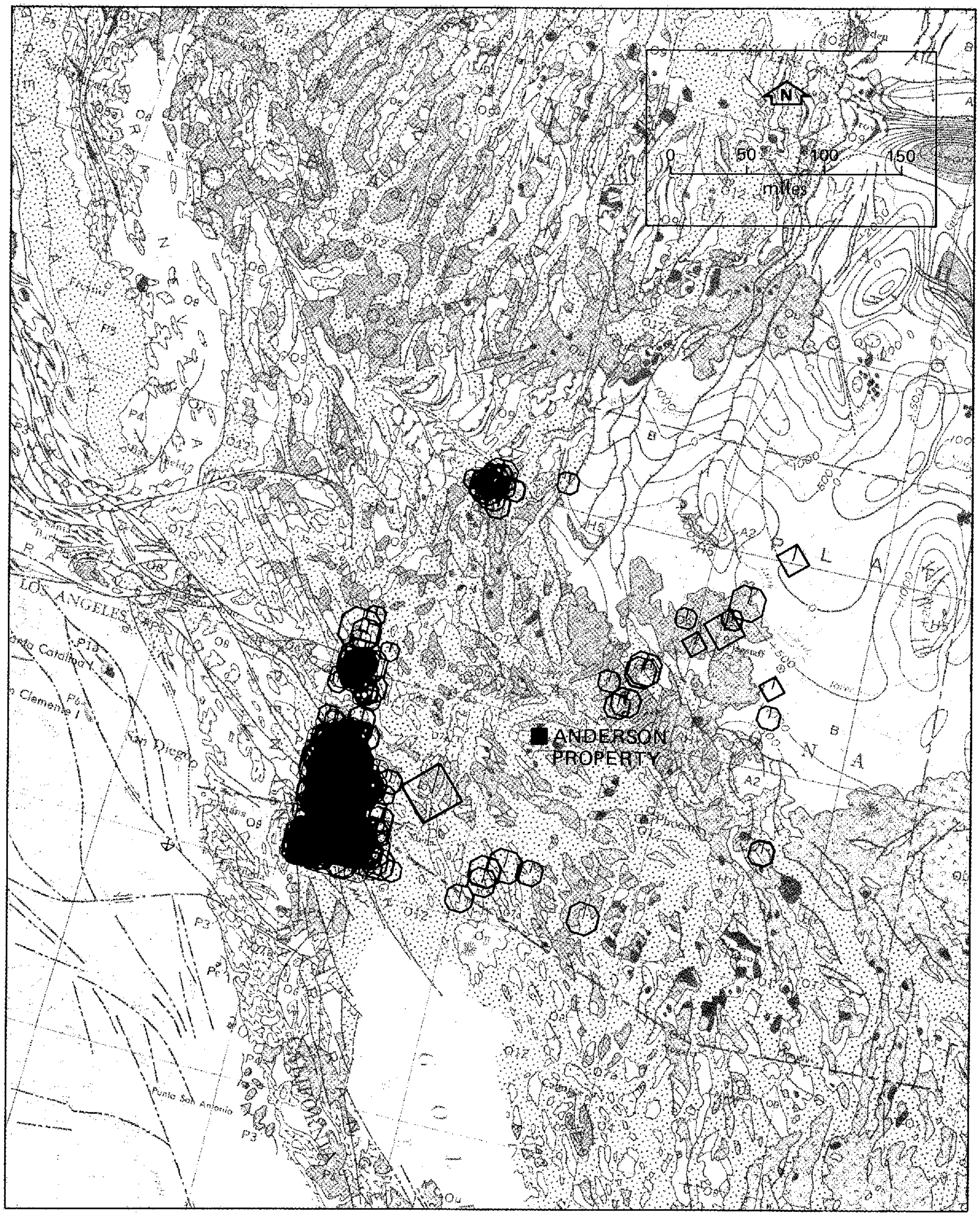
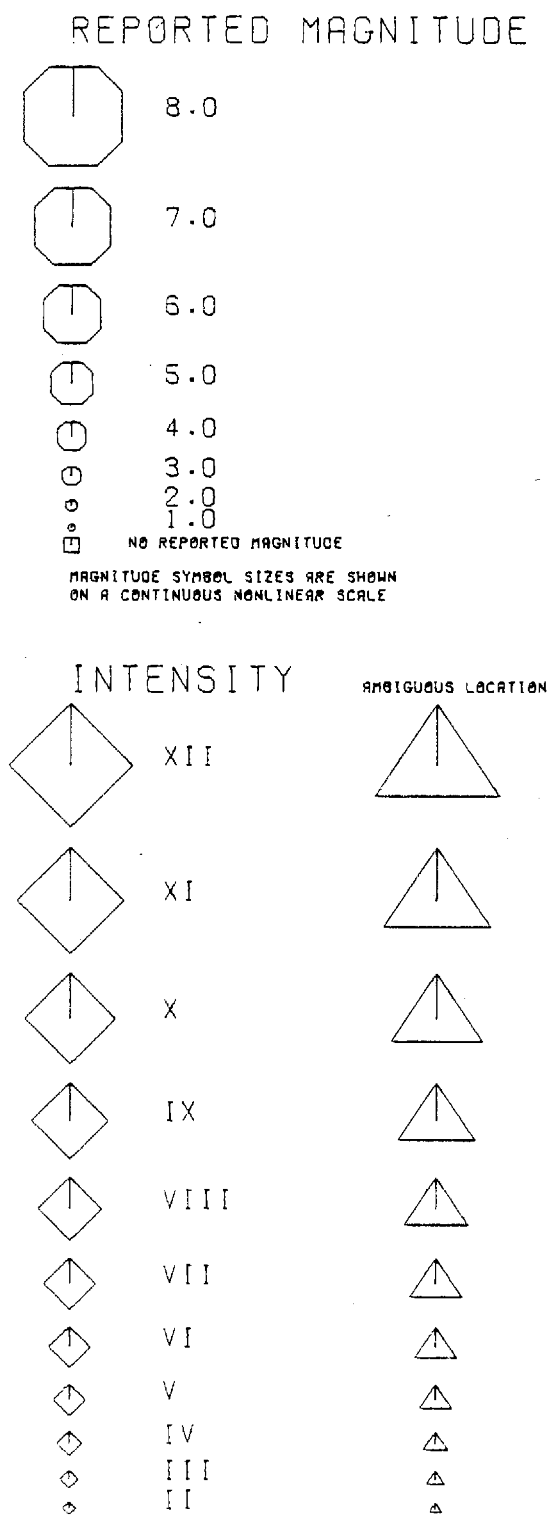


Figure 2.5-1. HISTORICAL SEISMICITY WITHIN A 200-MILE RADIUS OF THE PROPOSED FACILITY

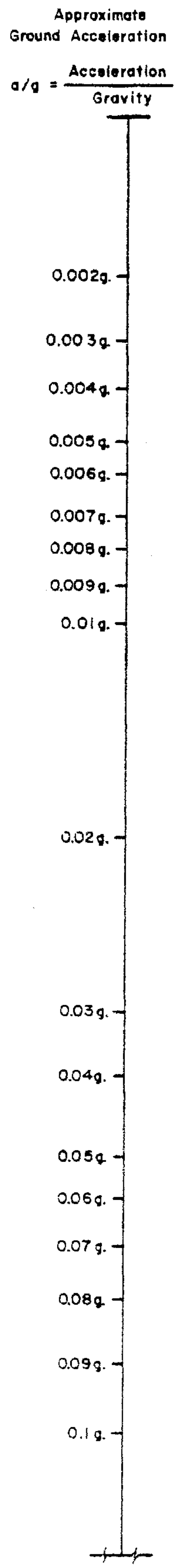
LEGEND for Figure 2.5-1



MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITY

1931

(BASED ON OBSERVER'S REFERENCE TO SCALE OF "EFFECTS")



I Not felt by people, except under especially favorable circumstances. Sometimes birds and animals are uneasy or disturbed. Trees, structures, liquids, bodies of water may sway gently, and doors may swing very slowly.

II Felt indoors by a few people, especially on upper floors of multi-story buildings, and by sensitive or nervous persons. As in Grade I, birds and animals are disturbed, and trees, structures, liquids and bodies of water may sway. Hanging objects swing, especially if they are delicately suspended.

III Felt indoors by several people, usually as a rapid vibration that may not be recognized as an earthquake at first. Vibration is similar to that due to passing of a light, or lightly loaded trucks, or heavy trucks some distance away. Duration may be estimated in some cases. Movements may be appreciable on upper levels of tall structures. Standing motor cars may rock slightly.

IV Felt indoors by many, outdoors by few. Awakens a few individuals, particularly light sleepers, but frightens no one except those apprehensive from previous experience. Vibration like that due to passing of heavy or heavily loaded trucks. Sensation like a heavy body striking building or the falling of heavy objects inside. Dishes, windows and doors rattle; glassware and crockery clink and crash. Walls and house frame creak, especially if intensity is in the upper range of this grade. Hanging objects often swing. Liquids in open vessels are disturbed slightly. Stationary cars rock noticeably.

V Felt indoors by practically everyone, outdoors by most people, with slight excitement. Awakens many or most sleepers. Frightens a few people with slight excitement; some persons may run outdoors. Buildings tremble throughout. Dishes and glassware break to some extent. Windows crack in some cases, but not generally. Vases and small or unstable objects overturn in many instances, and a few fall. Hanging objects and doors swing generally or considerably. Pictures knock against walls, or swing out of place. Doors and shutters open or close abruptly. Pendulum clocks stop or run fast or slow. Small objects move and furnishings may shift to a slight extent. Small amounts of liquids spill from well-filled open containers. Trees and bushes shake slightly.

VI Felt by everyone, indoors and outdoors. Awakens all sleepers, frightens many people; general excitement, and some persons run outdoors. Persons move unsteadily. Trees and bushes shake slightly to moderately. Liquids are set in strong motion. Small bells in churches and schools ring. Poorly built buildings may be damaged. Plaster falls in small amounts. Other plaster cracks somewhat. Many dishes and glasses, and a few windows, break. Knick-knacks, books and pictures fall. Furniture overturns in many instances. heavy furnishings move.

VII Frightens everyone. General alarm, everyone runs outdoors. People find it difficult to stand. Persons driving cars notice shaking. Trees and bushes shake moderately to strongly. Waves form on ponds, lakes and streams. Water is muddied. Gravel or sand stream banks cave in. Large church bells ring. Suspended objects quiver. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Plaster and some stucco fall. Many windows and some furniture break. Loosened brickwork and tiles shake down. Weak chimneys break at the roofline. Cornices fall from towers and high buildings. Bricks and stones are dislodged. Heavy furniture overturns. Concrete irrigation ditches are considerably damaged.

Table 2.5-1

Acceleration	Intensity	Description
0.2g 0.3g	VIII	General fright and alarm approaches panic. Persons driving cars are disturbed. Trees shake strongly and branches and trunks break off (especially palm trees). Sand and mud erupts in small amounts. Flow of springs and wells is temporarily and sometimes permanently changed. Dry wells renew flow. Temperature of spring and well waters varies. Damage slight in brick structures built especially to withstand earthquakes; considerable in ordinary substantial buildings with some partial collapse; heavy in some wooden houses with some tumbling down. Panel walls break away in frame structures. Decayed pilings break off. Walls fall. Solid stone walls crack and break seriously. Wet ground and steep slopes crack to some extent. Chimneys, columns, monuments, and factory stacks and towers twist and fall. Very heavy furniture moves conspicuously or overturns.
0.4g 0.5g	IX	Panic is general. Ground cracks conspicuously. Damage is considerable in masonry structures built especially to withstand earthquakes; great in other masonry buildings, some collapse in large part. Some wood frame houses built especially to withstand earthquakes are thrown out of plumb, others are shifted wholly off foundations. Reservoirs are seriously damaged, and underground pipes sometimes break.
0.6g 0.7g 0.8g 0.9g 1.0g	X	Panic is general. Ground, especially when loose and wet, cracks up to widths of several inches; fissures up to a yard in width run parallel to canal and stream banks. Landsliding is considerable from river banks and steep coasts. Sand and mud shifts horizontally as beaches and flat land. Water level changes in wells. Water is thrown on banks of canals, lakes, rivers, etc. Dams, dikes, embankments are seriously damaged. Well-built wooden structures and bridges are severely damaged and some collapse. Dangerous cracks develop in excellent brick walls. Most masonry and frame structures and their foundations are destroyed. Railroad rails bend slightly. Pipe lines buried in earth, tear apart or are crushed endwise. Open cracks and broad wavy folds open in cement pavements and asphalt road surfaces.
2.0g	XI	Panic is general. Disturbances in ground are many and widespread, varying with the ground material. Broad fissures, earth slumps, and land-slips develop in soft wet ground. Water charged with sand and mud is ejected in large amounts. Sea waves of significant magnitude may develop. Damage is severe to wood frame structures especially near shock centers; great to dams, dikes and embankments, even at long distances. Few if any masonry structures remain standing. Supporting piers or pillars of large well-built bridges are wrecked. Wooden bridges that "give" are less affected. Railroad rails bend greatly and some thrust endwise. Pipe lines buried in earth are put completely out of service.
3.0g 4.0g	XII	Panic is general. Damage is total and practically all works of construction are damaged greatly or destroyed. Disturbances in the ground are great and varied and numerous shearing racks develop. Landslides, rock falls, and slumps in river banks are numerous and extensive. Large rock masses are wrenched loose and torn off. Fault slips develop in firm rock and horizontal and vertical offset displacements are notable. Water channels, both surface and underground, are disturbed and modified greatly. Lakes are dammed, new waterfalls are produced, rivers are deflected, etc. Surface waves are seen on ground surfaces. Lines of sight and level are distorted. Objects are thrown upward into the air.

Table 2.5-1 concluded

The seismic activity data presented in Figure 2.5-1 began in 1930 for the Arizona area. In order to provide an earlier historical record, additional historical seismicity catalogs were examined. Townley and Allen (1939) report earthquakes in Arizona for the period 1850 to 1928. For this period the majority of the reported earthquakes occurred either in northern Arizona, north of Flagstaff or in southwestern Arizona near the Gulf of California and the San Andreas fault zones. None of the larger magnitude events reported by Townley and Allen appear to have occurred closer than about 80 miles (130 km) from the site. In the publication Earthquake History of the United States (Coffman and von Hake, 1973), 14 earthquakes are listed for Arizona. All of these events are included in either the National Oceanic and Atmospheric Administration data presented in Figure 2.5-1 or in Townley and Allen (1939).

Figure 2.5-1 indicates 8 earthquakes within 100 miles (160 km) of the Anderson property. The closest events lie at a distance of 26 to 37 miles (42 to 60 km) northeast of the property. Two of these events (in 1973 and 1974) are suspected explosions. The largest of these 8 earthquakes occurred on February 4, 1976, 50 miles (80 km) northeast of the property and had a magnitude of 4.9.

Published curves relating the decrease of intensity level with increasing distance from the earthquake epicenter (Brazee, 1977) suggest that the maximum intensity that has occurred on the property in the historical period is III to IV MM. This level of intensity is not normally associated with structural damage (Richter, 1958).

EARTHQUAKES AND REGIONAL TECTONICS

The majority of the earthquakes located either by observed effects or by instrumental analysis in Arizona are associated with two zones of seismic activity. The major zone lies along the San Andreas, San Jacinto, and other fault zones in eastern California and encroaching slightly into southwestern Arizona. This zone is clearly identified by the dense concentrations of seismic events in Figure 2.5-1 and is located approximately 150 miles (240 km) or more from the property. The second zone is a region of very diffuse and low-level seismic activity in northern Arizona. This zone is located approximately 100 miles (160 km) or more from the property.

EARTHQUAKE RECURRENCE

Because of the low level of seismic activity within 100 miles (160 km) of the Anderson property, it is difficult to estimate the recurrence of earthquakes and associated ground motions. Algermissen et al. (1976) have published a report and map for the contiguous United States that presents contours representing the probability of exceeding a given level of acceleration (expressed as a percent of gravity) in 50 years at various locations (Figure 2.5-2). Since the Anderson property lies outside of the 0.04g contour, it can be concluded that there is a 10 percent or less chance of exceeding an acceleration of 0.04g on the property over the next 50 years.

Effects from such an acceleration level would depend heavily on the period and duration of the ground shaking and on the site response characteristics. However, this level of acceleration in itself would not be expected to cause other than minor damage, if any, to properly designed and well-built structures.

2.6 HYDROLOGY AND WATER QUALITY

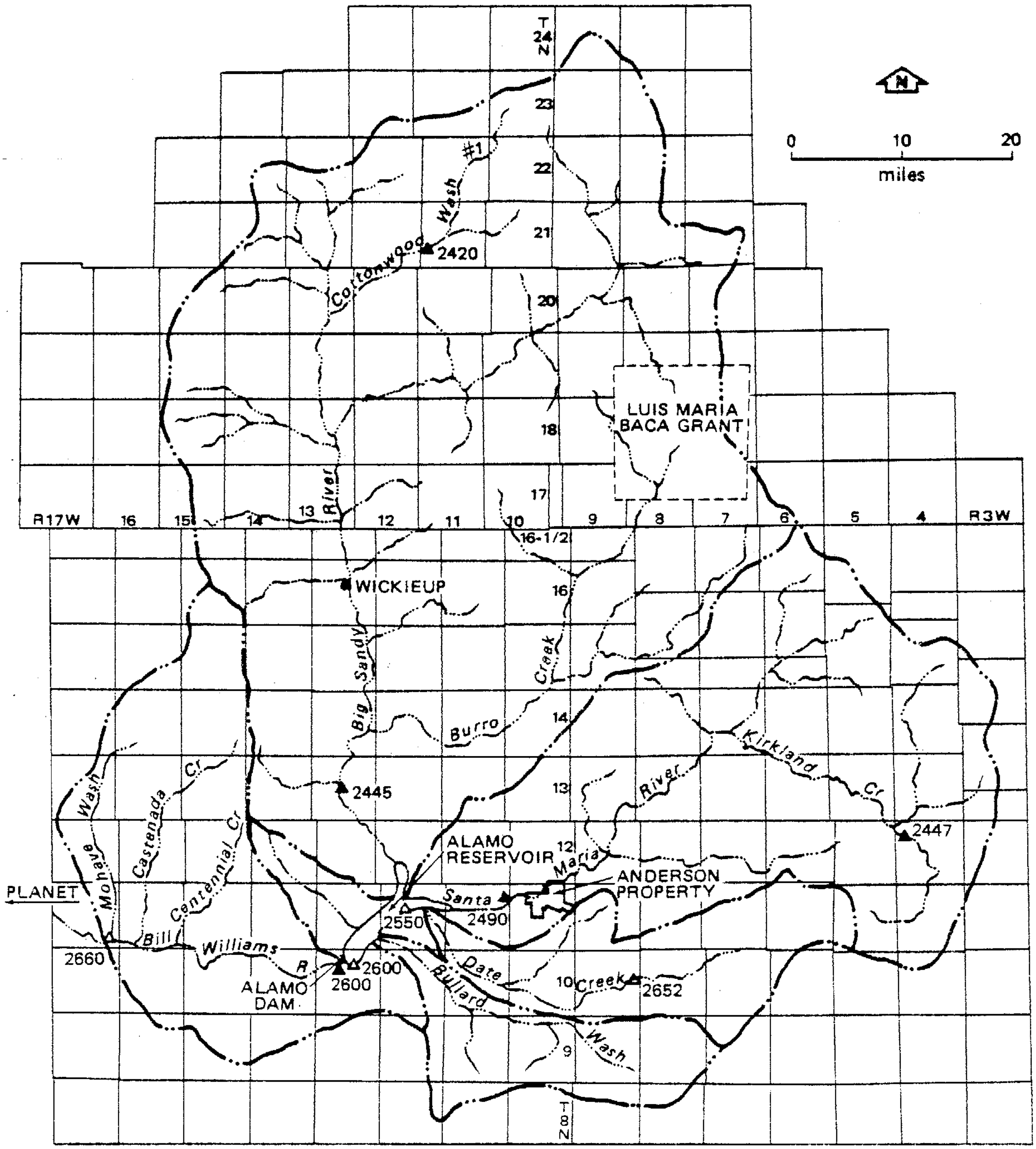
SURFACE WATER HYDROLOGY

Most streams in southwestern Arizona have surface flows for only short periods during the year. This is due largely to the low annual precipitation and high evapotranspiration rate of the region. High infiltration rates also reduce surface flows.

The Anderson property is drained by the Santa Maria River and several of its tributaries. The Santa Maria watershed covers approximately 1520 square miles and constitutes about 30 percent of the Bill Williams River Basin.

Regional Surface Water Hydrology

The Bill Williams River Basin covers approximately 5140 square miles (Figure 2.6-1). The principal subbasins within the basin are listed in Table 2.6-1. The northwest portion of the river basin lies in the Central Highlands water province. Unit runoff for streams in this province ranges from 1 to about 10 inches (Figure 2.6-2). Most of Arizona's perennial streams originate in this mountainous region, and these streams provide approximately 50 percent of the state's total surface runoff (Arizona State Water Plan, 1975). The rest of the Bill Williams River Basin is located within the Basin and Range Province. Surface runoff in the low mountains and alluvial valleys of this province ranges from less than 0.1 inch to 0.5 inch.



Base from U.S. Geological Survey, 1955, state base map, 1: 500,000.

Source: Water Development Corporation, 1977a.

LEGEND

▲ Gaging station active in 1977

△ Former gaging station

Figure 2.6-1. BILL WILLIAMS RIVER DRAINAGE BASIN, ARIZONA

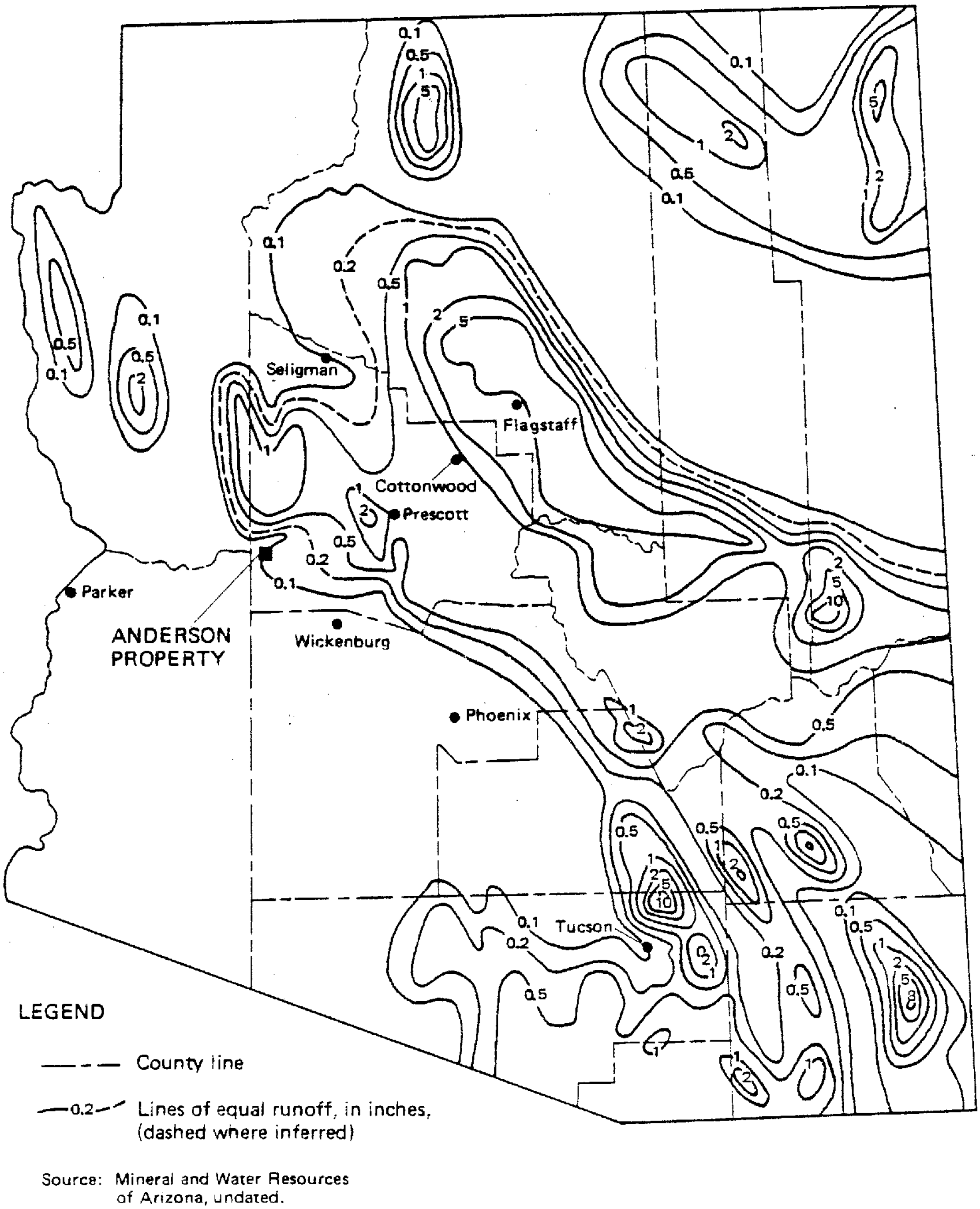


Figure 2.6-2. AVERAGE ANNUAL UNIT RUNOFF

Table 2.6-1. AREAS OF SUBBASINS IN THE BILL WILLIAMS RIVER BASIN

Subbasin	Area (sq mi)	Approximate Percent of Total Area
Big Sandy River		
Above gaging station 2420* on Cottonwood Wash	143	
Above gaging station 2445 on Big Sandy River	2800	
Above mouth of Big Sandy at Alamo Reservoir	2810	
Total	2810	55
Santa Maria River		
Above gaging station 2447 on Kirkland Creek	109	
Above gaging station 2490 on Santa Maria River	1210	
Date Creek and local washes	310	
Total	1520	29
Bullard Wash (runoff into Alamo Reservoir)	400	8
Centennial Wash and Castenada Wash (runoff into Bill Williams River)	410	8
Total drainage area of Bill Williams River Basin at Planet	5140	

*See Table 2.6-2 and Figure 2.6-1 for locations of gaging stations within the drainage basin.

Table 2.6-2. STREAMFLOW GAGING STATIONS IN BILL WILLIAMS RIVER BASIN

Gaging Gaging Station	Location	Drainage Area (sq mi)	Period of Record
2660	Bill Williams River at Planet Ranch (about 6 miles upstream of discharge point into Lake Havasu) SE 1/4 SW 1/4 Sec. 27, T11N, R17W	5140	1913-1915, 1928-1946
2600	Bill Williams River below Alamo Dam, SE 1/4 SE 1/4 Sec. 4, T10N, R13W	4730	1939*
2445	Big Sandy downstream of Wikieup, SE 1/4 Sec. 16, T13N, R13W	2800	1966*
2420	Cottonwood Wash No. 1, NW 1/4 Sec. 29, T21N, R11W	143	1964*
2550	Santa Maria River near Alamo Dam, NE 1/4 SW 1/4 Sec. 9, T11N, R12W	1520	1939-1966
2490	Santa Maria River downstream from Anderson Mine, SE 1/4 Sec. 12, T11N, R11W	1210	1966*
2447	Kirkland Creek, SE 1/4 Sec. 7, T12N, R4W	109	1973*
2652	Date Creek, NW 1/4 SE 1/4 Sec. 13, T10N, R9W	127	1939-1944

Source: Water Development Corp., 1977a.
*To present.

Precipitation within the Bill Williams River Basin is strongly influenced by elevation and ranges from up to about 20 inches per year in the higher mountains to the north and east to less than 10 inches per year in the desert regions to the south. Mean annual precipitation data for selected weather stations in the vicinity of the basin are provided in Table 2.6-3. The data from Prescott, Cottonwood, and Seligman are indicative of the precipitation in the higher portions of the basin, while the records for Parker are typical of the precipitation in the low desert regions of the basin. Throughout the basin, precipitation normally occurs in the late summer and early fall in conjunction with thunderstorm activity and during the winter in the form of snow at higher elevations and rain at lower elevations.

Evaporation rates in the basin are also influenced by elevation. The average annual lake evaporation rate is approximately 50 inches at higher elevations, while it reaches 80 inches in the lower desert regions (Arizona State Water Plan 1975).

As could be expected from these climatic conditions, perennial or near-perennial streams within the Bill Williams River Basin are only found in the mountains to the north and the east. Examples of such streams are Cottonwood Wash No. 1 and the upper reaches of Kirkland Creek (Figure 2.6-1).

Table 2.6-3. CLIMATE OF SELECTED ARIZONA WEATHER STATIONS

Station	County	Elevation (feet)	Mean Annual Temperature Max (°F)	Mean Annual Temperature Min (°F)	Mean Annual Precipitation (inches)
Cottonwood	Yavapai	3320	77.6	48.4	11.12
Prescott	Yavapai	5389	69.4	35.4	18.47
Seligman	Yavapai	5219	71.0	35.2	11.07
Parker	Yuma	425	88.1	51.8	5.04

Source: Arizona State Water Plan, 1975.

The large rivers in the basin -- the Santa Maria, Big Sandy, and Bill Williams rivers -- are located in the hot, dry southern portion of the basin. All of them are intermittent.

Smaller washes in the southern portion of the basin, such as lower Date Creek, Bullard Wash, Centennial Wash, and Castenada Wash are dry during most of the year except for an hour or more after rain storms. Flash floods occur in these washes, during which the runoff is highly erosive. Deposition from flash floods has assisted in creating the broad alluvial channels common to the Santa Maria, Big Sandy, and Bill Williams rivers.

An example of the seasonal distribution of average monthly flow for two of the rivers in the basin, the Bill Williams and the Big Sandy, are given in Figure 2.6-3. As can be seen in this figure and in Table 2.6-4, the maximum monthly discharge for the streams in the basin

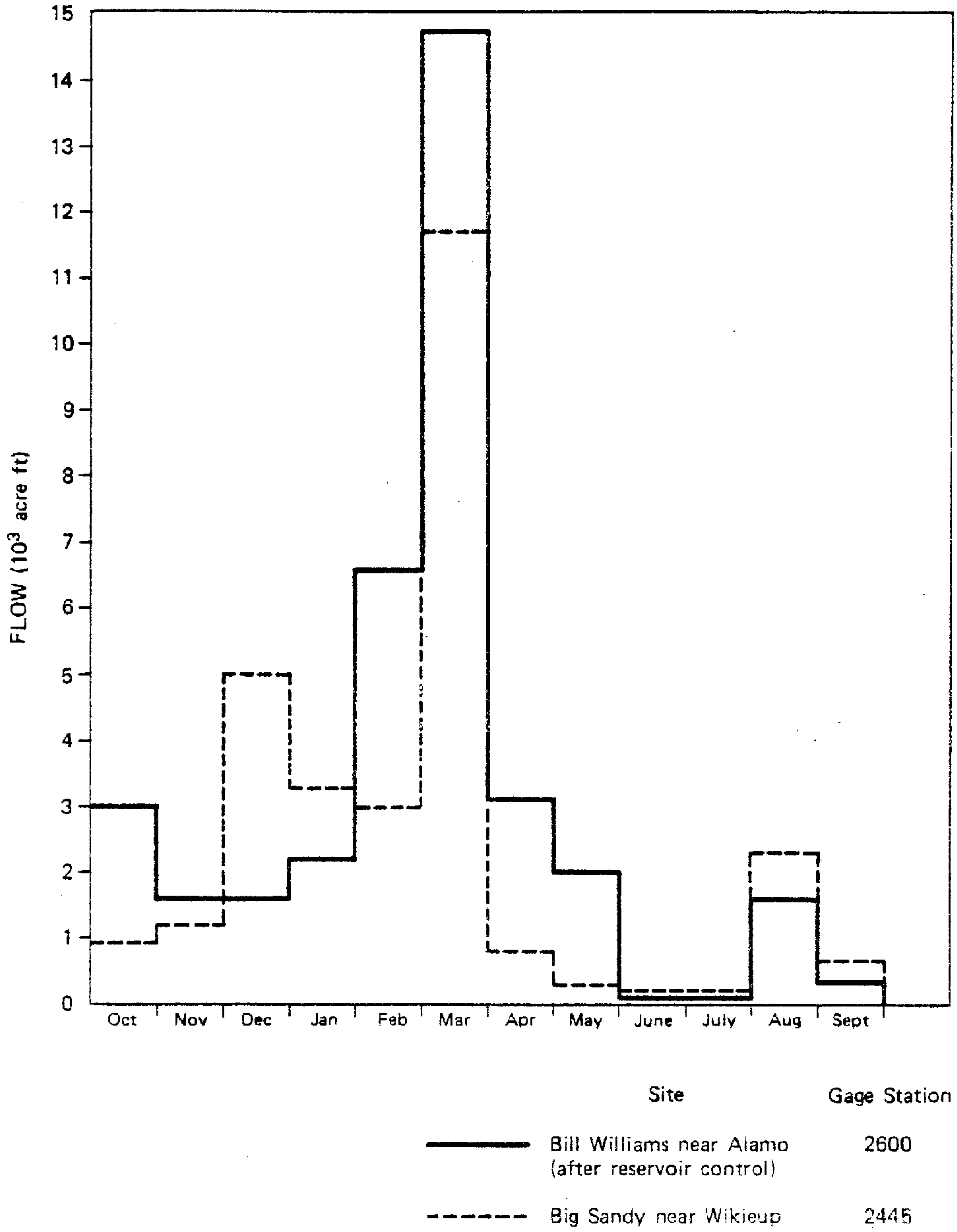


Figure 2.6-3. SEASONAL DISTRIBUTION OF AVERAGE MONTHLY FLOW

Table 2.6-4. FLOW AND DISCHARGE DATA FOR GAGING STATIONS IN BILL WILLIAMS RIVER BASIN

				Annual Flow			Monthly Flow		Daily Flow				Zero Flow		
Location[a]	Gaging Station	Period of Record	Drainage Area (sq mi)	Average Annual Flow (acre-ft)	Maximum Annual Flow (acre-ft)	Water Year of Maximum Annual Flow	Maximum Monthly Discharge (cfs)	Date of Maximum Monthly Discharge	Average Daily Discharge (cfs)	Peak Instantaneous Discharge (cfs)	Water Year or Date of Peak Instantaneous Discharge	Recurrence Interval for Peak Instantaneous Discharge (years)	Average Number of Days of Zero Flow in One Water Year	Maximum Number of Days of Zero Flow[b]	Beginning of Maximum Zero Flow Period[c]
Bill Williams River near Planet	2660	1913-15, 1928-46	5,140	106,800	436,800	1940-41	269,000	Feb. 1932	142	92,500	1936-37		0	0	—
Bill Williams River near Alamo (before Alamo Res.)	2600	1939-68	4,730	66,760	527,600	1940-41	201,500	Mar. 1941	90	65,100[d]	8/29/51	20	0	0	—
Bill Williams River near Alamo (after Alamo Res.)	2600	1968-75	4,730	30,909	162,500	1972-73	75,620	Mar. 1973	49.4	4,950	1968-69		76	163	1974-75
Big Sandy River	2445	1966-75	2,800	30,127	115,600	1972-73	73,380	Mar. 1973	37.7	28,000	12/7/66		19	163	1974-75
Cottonwood Wash No. 1 (tributary to Big Sandy River)	2420	1964-75	143	2,746	4,860	1965-66	2,340	Dec. 1965	3.83	7,000	1963-64		<1	10	1963-64
Santa Maria River near Alamo Res.	2550	1939-66	1,520	22,282	197,800	1940-41	76,400	Mar. 1941	36.1	33,600	8/29/51	30	0	0	—
Santa Maria River	2490	1966-75	1,210	29,816	150,400	1972-73	63,620	Mar. 1973	37.3	13,500	12/7/66	10	282	409	6/20/73
Kirkland Creek (tributary to Santa Maria River)	2447	1973-75	109	1,190	1,990	1973-74	253	Aug. 1973	2.76	785	1972-73		4	11	1972-73
Date Creek (tributary to Santa Maria River)	-	1939-44	127	1,690	7,700	1940-41	3,660	Mar. 1941	2.69	1,400	1940-41		357	365	1939-40

Source: Water Development Corp., 1977a.

[a]Locations of gaging stations are described in Table 2.6-2 and are shown in Figure 2.6-1.

[b]Or maximum number of days of zero flow in a water year.

[c]Or water year containing maximum zero flow period.

[d]Peak instantaneous discharge (computed by USGS from high water marks) of 86,000 cfs occurred September 6, 1939.

normally occurs in February or March. This discharge is in response to increased runoff resulting from snowmelt and winter rains. The other major period of flow in these streams occurs in the late summer and early fall in response to precipitation and runoff from thunderstorms.

The average annual flows in the Santa Maria and Big Sandy rivers are comparable even though the Big Sandy has a much larger watershed. This is probably due to higher overall precipitation in the Santa Maria River watershed, since a larger percentage of this watershed is located in mountainous terrain. Table 2.6-5 provides peak discharges for the Santa Maria, Big Sandy, and Bill Williams rivers for selected recurrence intervals.

Infiltration also plays an important role in the surface hydrology of the basin. Long reaches of the Santa Maria, Big Sandy, and Bill Williams rivers, and of the principal washes in the basin, are composed of coarse alluvium. The high permeability of this material, coupled with groundwater levels well below the depth of the stream channel, can drastically reduce surface flows. Substantial groundwater flow, in the form of underflow, also occurs in these channels where the alluvium is underlain by impervious material such as bedrock. Consequently, surface flow in the major streams of the basin may be highly influenced by surface-subsurface water exchange that is regulated by the nature of the underlying sediments and the degree of saturation of these sediments.

Table 2.6-5. PEAK DISCHARGES FOR SELECTED RIVERS IN THE BILL WILLIAMS RIVER BASIN

Recurrence Interval (years)	Santa Maria near Bagdad, Gage 2490 (cfs)	Santa Maria near Alamo, Gage 2550 (cfs)	Bill Williams* near Alamo, Gage 2600 (cfs)
5	8,000	9,800	24,200
10	13,800	16,900	41,800
20	22,400	27,400	68,000
50	33,500	41,100	102,000
100	41,500 (extrapolated)	50,900	126,000

Source: Patterson and Somers, 1966.

*Before construction of Alamo Reservoir and Dam, which now controls flow at Alamo gaging station.

Underflow has been identified as the possible cause of what appears to be contradictory flow data for the Santa Maria and Bill Williams rivers (Water Development Corp. 1977a). The Santa Maria River flows perennially at gaging station 2550 and is quite often dry several miles upstream at station 2490. Apparently, the underlying impermeable layer rises near the downstream station and brings streambed underflow to the surface. The surface flow of the Bill Williams River at Planet is approximately 50 to 90 percent of the upstream flow near Alamo Dam during floods; however, during low-flow periods surface flow at Planet is two to four times greater than that at Alamo Dam. Groundwater recharge during high-flow periods and seepage into the streams during low-flow periods are assumed to be the causes for this phenomenon.

A prominent hydrologic feature within the Bill Williams River Basin is the Alamo Dam and Reservoir, constructed by the U.S. Army Corps of Engineers in the mid-1960s (Figure 2.6-1). The dam was constructed to control flooding in the basin. Both the Big Sandy and Santa Maria rivers flow into the reservoir. The Bill Williams River is fed by the release or overflow from this reservoir.

The Alamo Reservoir contains a recreational pool of 10,000 acre-feet of water with a surface area of 556 acres. A maximum of 1,040,000 acre-feet of water can be stored in the reservoir below the spillway. Annual evaporation loss from the recreational pool is approximately 3290 acre-feet, or about 10 percent of the average annual flow of the Bill Williams River downstream of the dam. Prior to construction of Alamo Dam, the

Bill Williams River was a perennial stream. Since the dam was built, the river has had an average of 76 zero flow days a year (Table 2.6-4). The average annual flow in the Bill Williams River at Alamo was 66,760 acre-feet for the period of record prior to construction of the dam and 30,909 acre-feet for the period of record following completion of the dam. This difference in flow is much larger than the evaporation loss and rate of change in storage and must also be attributed to seepage losses and/or differences in precipitation amounts between the two periods.

Water Rights

The Santa Maria River surface water rights are fully appropriated (Table 2.6-6). Approximately 650 acre-feet per year is appropriated in the vicinity of Palmerita Ranch. Most of this water is used for crop irrigation. An additional 272 acre-feet per year is appropriated from Grapevine Springs for irrigation purposes. Below the Alamo Reservoir, Sevier Mineral annually appropriates 729 acre-feet of water from the Santa Maria River. A total of 724 acre-feet is used for mining. The remaining 5 acre-feet is used for domestic purposes (Water Development Corp. 1977b).

Local Surface Water Hydrology

Surface water hydrology studies were conducted on the Anderson property in 1977. One stage gage was established on the Santa Maria River, and gages were established on seven tributaries of the Santa Maria that drain the property (Figure 2.6-5). The cross sections of the channels were measured and notes were taken on channel

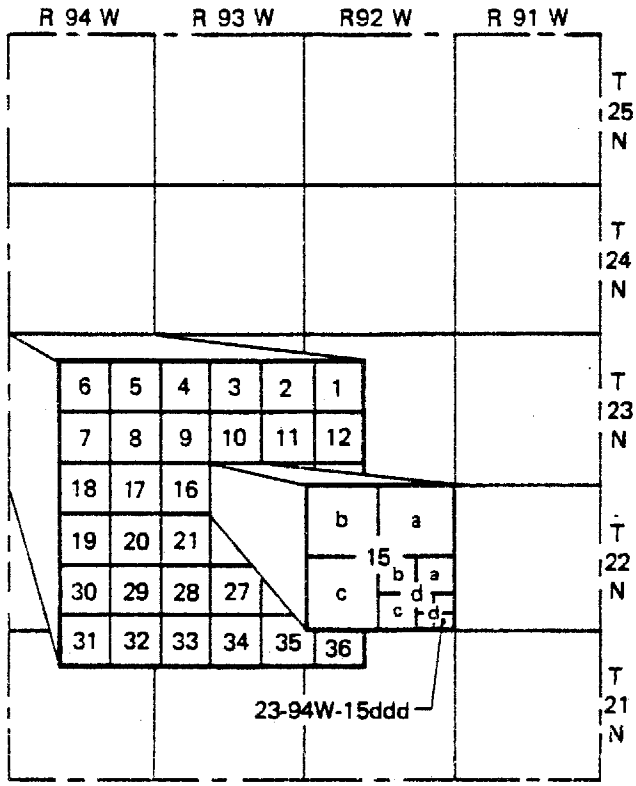
Table 2.6-6. SURFACE WATER RIGHTS NEAR THE ANDERSON PROPERTY

Source	Application No.	Permit No.	Certificate No.	Priority Date	Owner	Diversion Point*	Quantity of Water** (acre-feet/year)	
Santa Maria River	3124	2183	2086	04/17/51	Fuller	11-11W-16 ac	Irr. Stock Dom.	85 1.1 0.9
Santa Maria River	3123	2182	2067	04/17/51	Fuller	11-11W-16 cb	Irr. Stock Dom.	380 1.7 0.9
Santa Maria River	1042	712	410	11/22/29	Whitaker	11-12W-15 aa	Irr.	181
Total Santa Maria River								650.6
Grapevine Springs	255	214	166	12/16/21	Madril	11-11W-22 ab	Irr.	127
Grapevine Springs	256	215	166	12/16/21	Madril	11-11W-22 ab	Irr.	54
Grapevine Springs	257	216	166	12/16/21	Madril	11-11W-22 ab	Irr.	91
Total Grapevine Springs								272.0
Spring	4806	--	--	02/28/65	Van Keuren	11-9W-4 ab	Stock	0.5
Pass	508	--	--	10/07/24	Howard Sheep Co.	11-9W-22 d	Stock	5
Wash	258	--	--	02/02/27	Howard Sheep Co.	11-9W-31 cc	Stock	45
Spring	4683	--	--	09/23/63	Carson	12-9W-6 cc	Stock	0.5
Spring	4681	--	--	09/23/63	Van Keuren	12-10W-3 ab	Stock	0.5
Wash	2409	--	--	12/28/65	Van Keuren	12-10W-8 dd	Stock	127.75
Spring	4682	--	--	09/26/63	Van Keuren	12-10W-20 cb	Stock	146
Ravine	1373	--	--	01/15/57	Knight	10-8W-32 bb	Stock	1.1
Wash	1372	--	--	01/15/57	Knight	10-8W-32 dd	Stock	1.1

Source: Water Development Corp., 1977b and Minerals Exploration Company, 1977.

*Refer to Figure 2.6-4 for explanation of location numbering system.

**Irr. = irrigation; Dom. = domestic.



EXPLANATION: Well and test hole numbers in this report describe the location of wells and test holes according to the Bureau of Land Management's system of land subdivision as follows: first number, township; second number, range; third number, section; first letter, 160-acre tract (quarter section) within that section; second letter, 40-acre tract (quarter-quarter section) within that quarter section; third letter, 10-acre tract (quarter-quarter-quarter section) within that quarter-quarter section. The 160-acre, 40-acre, and 10-acre tracts are designated a, b, c, and d in a counterclockwise direction beginning in the northeast corner. For example, well 23-94W-15ddd is in the SE¼SE¼SE¼ Sec. 15, T23N, R94N. When two or more wells are located in the same 10-acre tract, the wells are numbered serially in the order they were inventoried.

Figure 2.6-4. LOCATION NUMBERING SYSTEM

geometry. Rainfall was monitored at each gaging station, with a single precipitation event (0.51 inches in two hours) that resulted in runoff occurring on August 15. Pertinent hydrologic data for each of the eight tributaries is presented in Table 2.6-7.

The drainages studied during this hydrology program can be divided into the following categories: flat, wide alluvial washes; narrow alluvial washes; and rocky, steep canyons. Alluvial washes (stream stations 1, 3, 4, 6, and 8) are the most common type of drainage channel on the property. The washes normally consist of sand and gravel and are bounded by rocky canyon walls. Sparse vegetation frequently grows in the washes at lower elevations. The channel bottom slopes of these washes generally range from very gradual to moderate. Stream stations 5 and 7 were located in narrow, rocky canyons with moderate channel slopes. While both of these canyons consisted largely of gravel and small boulders, station 7 was established in an area of fine sand. Stream station 2 was located in a steep, narrow canyon. The streambed consists of solid rock and contains numerous large boulders. The channel of this canyon meanders to a considerable extent.

Surface flow seldom occurs in the drainages on the Anderson property except for flash floods immediately following thunderstorms. The dry soil of the washes and canyons tends to seal when wet, inhibiting infiltration and resulting in relatively high runoff. This runoff is normally quite erosive, particularly in the steeper, narrower canyons. Using the U.S. Soil Conservation Service method for estimating

Table 2.6-7. HYDROLOGIC DATA FOR SUBBASINS IN THE VICINITY OF THE ANDERSON PROPERTY

Stream Station	Drainage Area (sq mi)	Drainage Length (mi)	Lag Time (hr)
1	8.0	7.9	2.1
2	0.17	0.66	0.28
3	3.4	3.7	1.1
5	0.50	0.70	0.30
6	0.41	1.3	0.48
7	0.20	2.4	0.79
8	6.0	6.4	1.7

Source: Water Development Corp., 1977a.

Note: The average watershed slope for all subbasins has been assumed to equal 10 percent, as given in Water Development Corp. (1977) for the subbasin contributing to flow at stream station 1. The vegetation cover type for the subbasins is desert shrub and cover density is approximately 40 percent. Soils in all the subbasins are classified in group C. The cover number used for the watersheds is 79.

runoff (Water Development Corp. 1977a), the drainages on the property have a potential maximum water retention (infiltration, interception, and surface storage) of only about 2.7 inches. The lag time between the centroid of rainfall and peak runoff for these drainages ranges from 0.28 to 2.1 hours.

During the single runoff event recorded during the hydrology program, the high-water mark at gaging stations 1, 2, 3, 5, 6, and 8 ranged from 3 to 6 inches (Table 2.6-8). Station 7 in the steep canyon was washed out. No runoff was recorded in the Santa Maria River (station 4), as the water created its own channel at a distance from the stage gage within the broader wash.

Peak discharge was estimated for each tributary over selected recurrence intervals and for the probable maximum precipitation (PMP) event (Table 2.6-9) using the runoff and triangular hydrograph method of the U.S. Soil Conservation Service (1972). Peak discharge was not estimated for the Santa Maria River because of unknown but apparently significant effects of infiltration and underflow. The largest discharges are expected to occur at stations 1, 3, and 8. Peak discharge for these stages ranges from approximately 250 cfs for the 5-year recurrence interval (Station 3) to over 12,000 cfs during the PMP event (Station 1). Peak discharges at stations 2, 6, and 7 are expected to be minimal because of their small drainage areas.

Table 2.6-8. CHANNEL GEOMETRY OF STREAM STATIONS

Stream Station	Stream Location	Approx. Elevation (ft, msl)	Channel Geometry	Channel Bottom Slope (%)	Streambed Material(s)	Manning's Roughness Factor $(ft^{1/6})$	Field Observations of Runoff Event
1	11-10W-3add	1598	Flat, wide, alluvial wash	2.2	Sand, gravel	0.025	3-inch water mark
2	11-10W-3cbd	1580	Steep, rocky, narrow canyon terminating into free overfall	34.0	Rock, large boulders	0.040	5-inch water mark
3	11-10W-10bbb	1544	Flat, wide, alluvial wash	3.5	Sand, fine gravel	0.025	6-inch water mark
4	11-10W-9aab	1710	Flat, very wide, alluvial wash	0.5	Sand, fine gravel	0.025	Flow created channel 8 inches deep and 50 feet wide
5	11-10W-2dab	1735	Moderate slope, narrow rocky canyon	8.1	Gravel, small boulders	0.035	6-inch water mark
6	11-10W-8ada	1576	Flat, narrow wash with wide flood plain containing low vegetation	2.5	Sand, gravel	0.025	6-inch water mark
7	11-10W16-bba	1868	Narrow, highly erodible gully	2.3	Sand	0.020	Flow created channel 8-12 inches deep and 28 feet wide
8	11-10W-11aca	1826	Flat, wide alluvial wash containing low vegetation	2.3	Sand, gravel	0.025	4-inch water mark

See Figure 2.6-4 for description of location numbering system.

Table 2.6-9. ESTIMATED PEAK DISCHARGE AND STAGE FOR SUBBASINS NEAR ANDERSON MINE

Recurrence Interval (years)	Rainfall (inches)	Runoff (inches)	Peak Discharge[c] (cfs) at Stream Stations							Peak Stage[d] (ft) at Stream Stations						
			1	2	3	5	6	7	8	1	2	3	5	6	7	8
5	1.41[a]	0.25	372	26	257	76	51	38	330	1.2	0.19	.63	1.0	1.0	0.32	-0.6
10	1.60[a]	0.30	447	32	309	91	61	46	396	1.3	0.23	.71	1.1	1.0	0.36	-0.4
25	1.88[a]	0.50	745	53	514	151	101	76	660	1.6	0.40	.96	1.3	1.1	0.50	0.0
50	2.20[a]	0.70	1,042	74	720	212	142	107	924	1.8	0.57	1.2	1.5	1.3	0.63	0.2
100	2.48[a]	0.90	1,340	95	926	272	182	138	1,183	1.9	0.76	1.4	1.7	1.4	0.73	0.3
PMP	19[b]	16	12,147	401	6,422	1,173	912	409	9,886	4.8	1.8	4.4	3.7	2.4	1.5	2.5

[a]One-hour-duration rainfall from Water Development Corp., 1977.

[b]Six-hour probable maximum precipitation.

[c]Using runoff and triangular hydrograph method (U.S. Soil Conservation Service, 1972).

[d]Calculated using Manning's Equation with an energy line slope equal to 1.2 times the channel slope; stage given relative to elevation datum.

Peak stages for each of the Santa Maria tributaries were estimated (Table 2.6-9) using Manning's Equation and the channel cross sections shown in Figures 2.6-6 through 2.6-8. It was assumed that the energy line slope during the peak stage was approximately 20 percent greater than the channel bottom slope. Although this assumption is arbitrary, it is felt that the peak stage estimates are correct to the order of magnitude. Because of the effects of cross-sectional area and wetted perimeter on flow, peak stage for each channel is not merely proportional to discharge. For example, the peak stage in narrow canyons may be as high as the peak stage in wide alluvial washes for a correspondingly low discharge. The low stage values estimated for station 2 are probably related to the high channel slope, which would create supercritical flow.

GROUNDWATER HYDROLOGY

As discussed earlier, the Bill Williams River Basin is contained within both the Central Highlands and the Basin and Range provinces, two major physiographic regions in Arizona. In the Basin and Range Province, groundwater generally occurs in unconfined or "water table" aquifers formed in alluvial valleys between mountain blocks. The alluvium, which may be several thousand feet thick, consists of interbedded clays, silts, sands, and gravels. Recharge is small and occurs mainly along mountain fronts and the normally dry stream courses. In the Central Highlands Province, small valleys between volcanic mountain blocks filled with unconsolidated sediments are the main source of

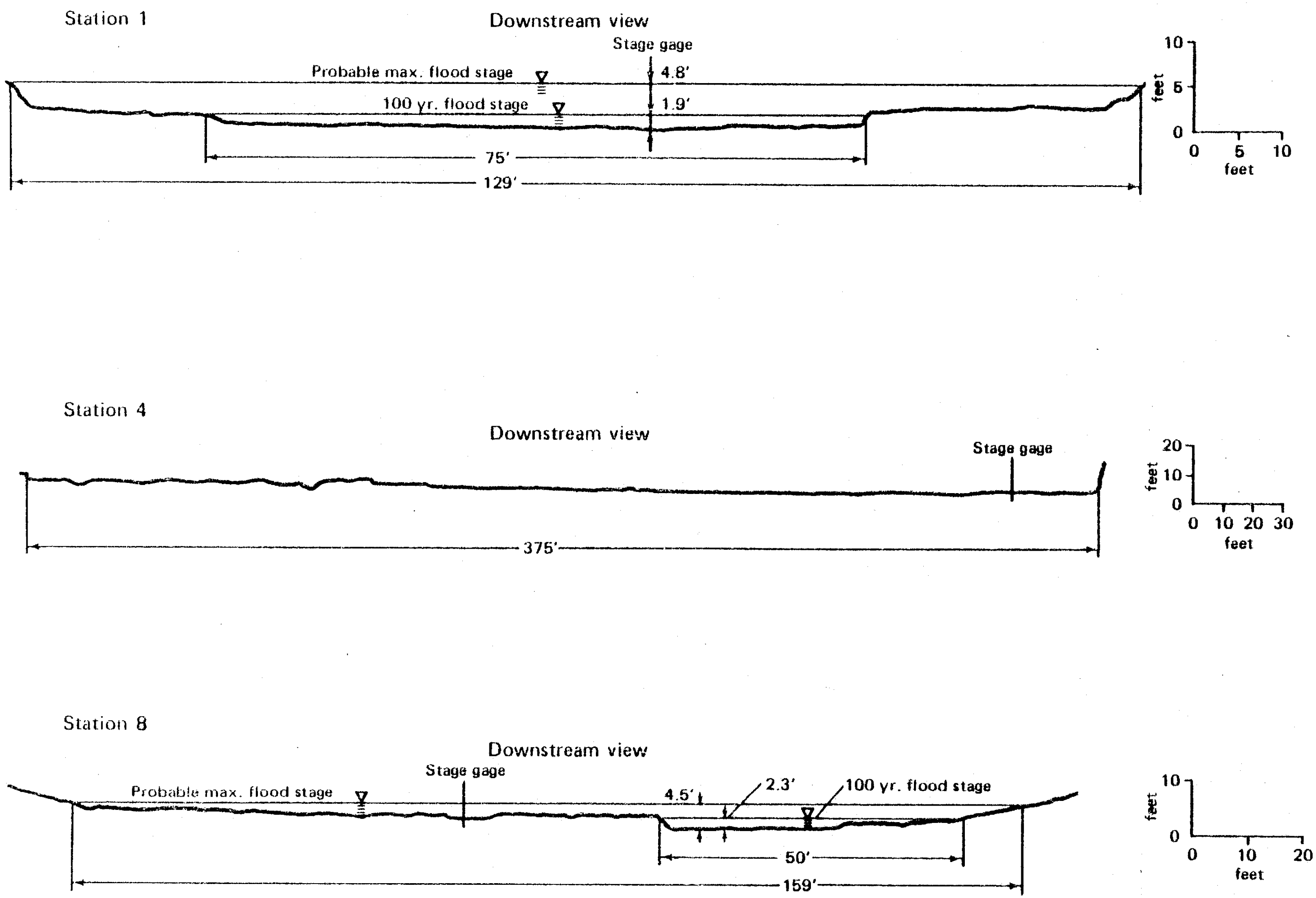
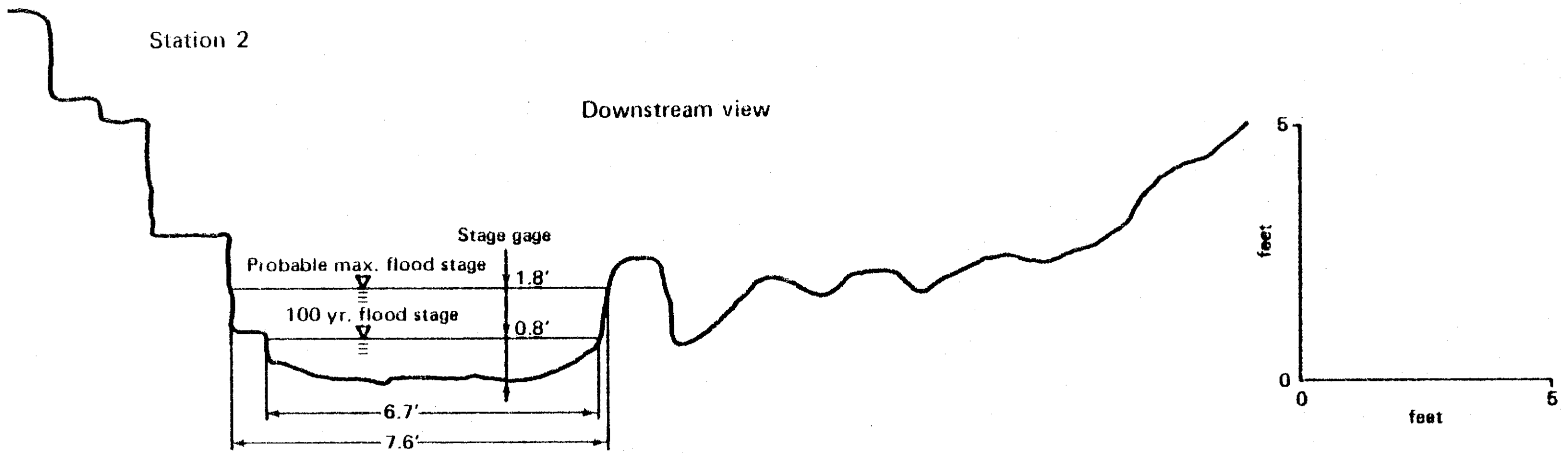


Figure 2.6-6. CHANNEL CROSS SECTIONS AT STATIONS 1, 4, AND 8



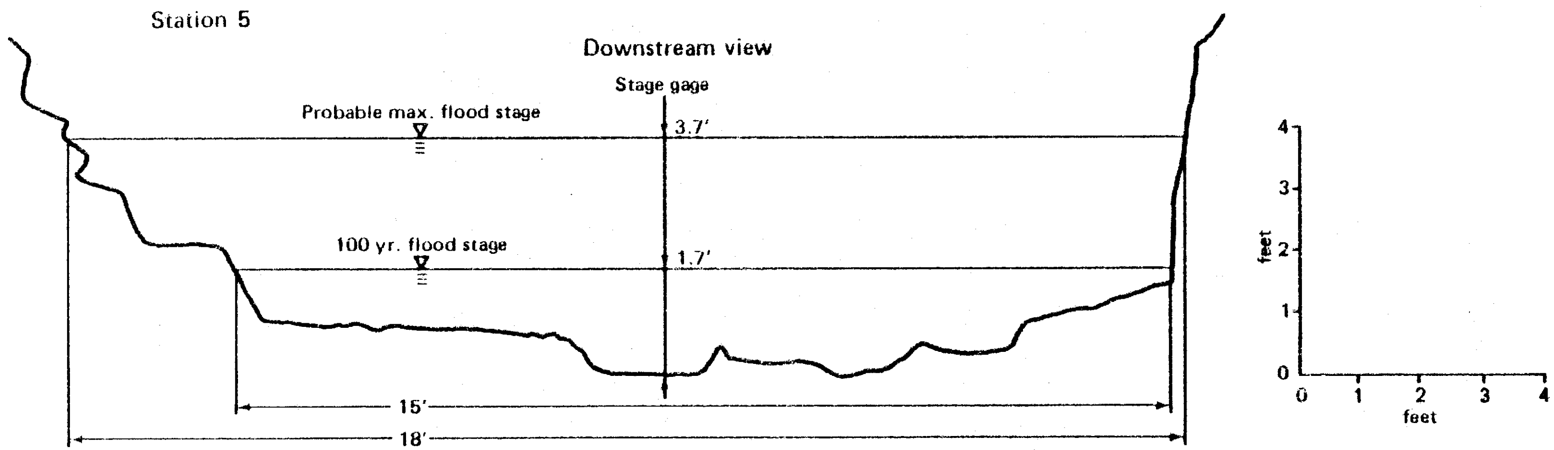


Figure 2.6-7. CHANNEL CROSS SECTIONS AT STATIONS 2 AND 5

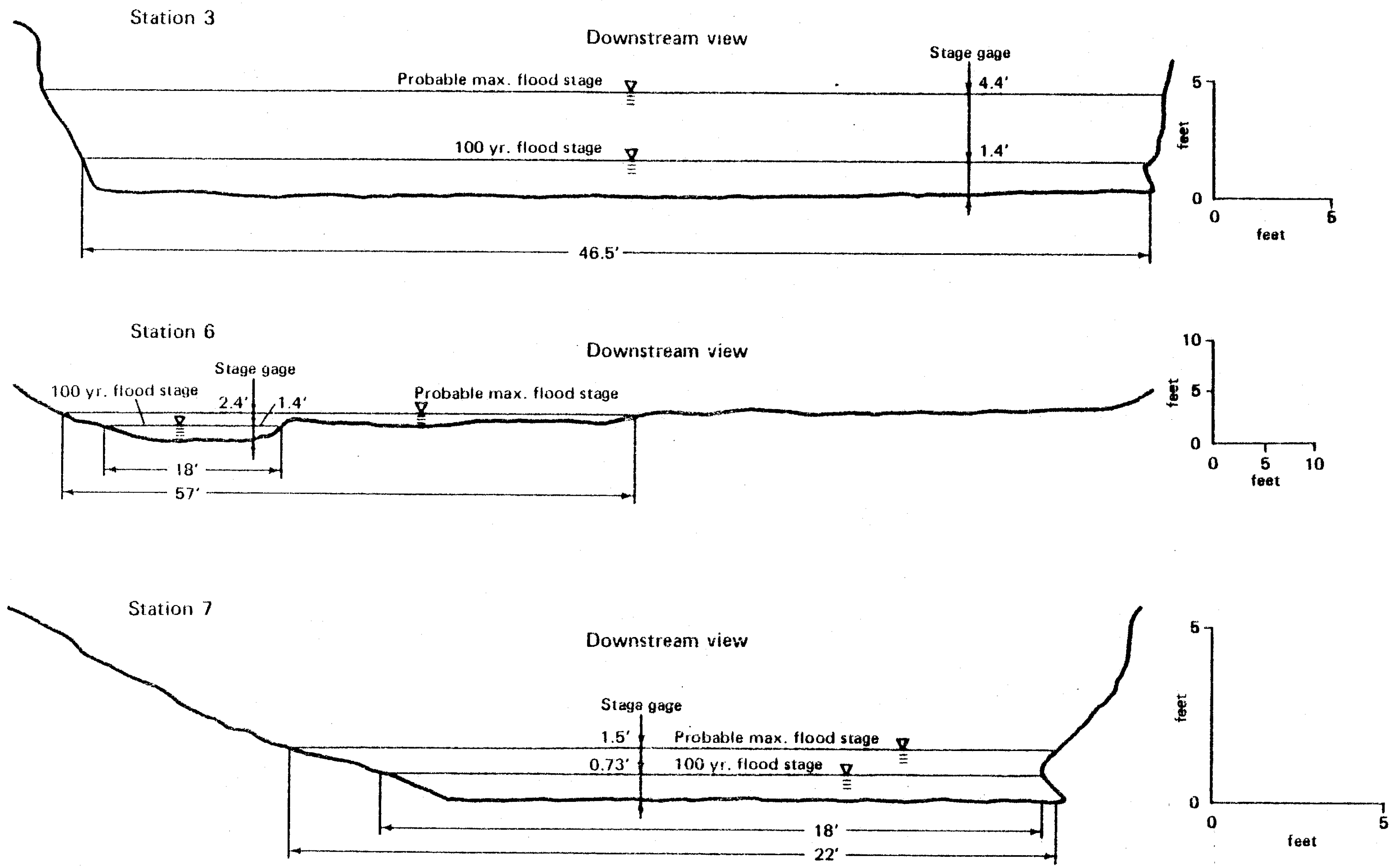


Figure 2.6-8. CHANNEL CROSS SECTIONS AT STATIONS 3, 6, AND 7

groundwater. The mountain blocks offer little potential for the development of groundwater except in places where the rocks are fractured or large solution cavities have formed.

State and Regional Groundwater Uses and Rights

Groundwater provides approximately 60 percent of the annual water requirements of Arizona. Most of this water is used for irrigation. Heavy pumpage for irrigation in many of the basins of the state has caused large changes in the flow pattern of groundwater and substantial drops in the water table. The groundwater reservoir in much of the state has been established over geologic time, and replenishment from recharge areas is much less than pumpage. In this context, groundwater may be considered a nonrenewable resource. Currently, withdrawal from developed aquifers annually exceeds recharge by about 2.2 million acre-feet and the average annual decline in water tables is as high as 14 feet per year for selected basins in central Arizona (Water Development Corp. 1977b).

Approximately 23 million acre-feet of groundwater is stored in the Bill Williams River Basin (Water Development Corp. 1977b). It is estimated that 17 million acre-feet is stored between the water table and 700 feet below the land surface. The remaining 6 million acre-feet lies from 700 to 1200 feet below the land surface. (The depths currently considered practical for irrigation and municipal water withdrawals are 700 and 1200 feet, respectively.) Approximately 5600 acre-feet of this water is used annually for irrigation and 3600 acre-feet per year is used for municipal and industrial purposes. The annual depletion (withdrawal minus recharge) is about 7300 acre-feet. Essentially all of this withdrawal occurs upgradient of the proposed project; consequently, no activities at the mine and mill will impact these existing upgradient uses.

"The Arizona Supreme Court has consistently held that percolating (underground) waters belong to owners of the soil, and has accepted the American Rule of 'reasonable use.' Thus, an overlying owner has a right to withdraw and use percolating water provided the withdrawal is for the purpose of making reasonable use of the land from which the water is taken." For further discussion of water rights in Arizona see 2 Hutchins, Water Rights Laws in the Nineteen Western States, at 635 (1974) and Farmers Investment Co. vs. Bettwy, 558 P.2d 14 (Arizona 1976).

Local Groundwater Hydrology

The following discussion is based primarily on studies conducted by Water Development Corp. (1977b) and Dames & Moore (1977). The purpose of the studies conducted by Water Development Corp. was to determine feasible sources of surface water and/or groundwater in the vicinity of the Anderson property for use in milling operations. The studies included a review of the surface water and groundwater characteristics of the property, compilation of existing well productivity, (Table 2.6-10) and test drilling in selected areas. The purpose of the Dames & Moore study was to determine the stability of the ultimate open

Table 2.6-10. WELLS IN THE VICINITY OF THE ANDERSON PROPERTY

Location*	Well Depth (feet)	Casing Depth (feet)	Case Diameter (inches)	Depth to Water (feet)	Yield (gpm)	Drawdown (feet)	Owner
10-8W-3 dc	180	180	8	110	6	30	Bar D Four Ranch
10-8W-5 dab	265	--	12	120	--	--	USGS
10-8W-5 bbb	216	--	12	120	--	--	USGS
10-8W-5 bbb	130	--	6	120	--	--	USGS
10-8W-5 abd	--	--	12	136	--	--	USGS
10-8W-12 ddb	10	10	22	1	600	1	Evans
10-8W-12 aad	75	Incomplete, File Date 11/76					Matthews
10-8W-13 dca	24	--	--	12	--	1	Anderson
10-8W-14 aaa	40	40	10	28	400	--	Evans
10-8W-14 abd	180	Incomplete, File Date 12/76					Torzec
10-8W-14 adb	200	Incomplete, File Date 12/76					Torzec
10-8W-24 aad	360	30	5	82	3	0	Knight
11-8W-21 bcb	175	175	7	100	--	--	James
12-8W-3 ccc	120	120	7	82	--	--	James
12-8W-27 bbb	100	100	6	28	--	--	James
12-9W-24 dab	50	50	8	--	5	--	Curtis
11-10W-11 ccc	200	200	5	50	125	--	Minerals Exploration Company
11-10W-24 aca	100	22	7	10	--	--	Weaver
12-10W-1 bbb	100	--	--	--	6	5	Curtis
12-10W-12 ddc	50	50	8	25	5	--	Curtis
11-11W-16 abc	61	--	--	--	--	--	--
11-11W-16 dd	64	64	20	19	800	12	Three Rivers Ranch
11-11W-17 dda	60	60	20	10	1800	30	Fuller
11-11W-31 abb	1769	520	16	--	--	--	--
11-11W-31 bbb	888	268	16	60	470	--	Fuller
11-11W-31 bbb	400	400	8	64	10	0	Fuller

Source: Minerals Exploration Company, 1977

*Refer to Figure 2.6-4 for explanation of location numbering system.

pit slopes. A large number of drill holes were measured for static water level.

Alluvium. The alluvial valley of the Santa Maria River varies substantially in width and depth to bedrock. For example, the Santa Maria flows in a narrow canyon from 500 to 1000 feet wide north of the Anderson Mine. Between gaging station 2490 and the Alamo Reservoir (Figure 2.6-1), the valley is one-half to one mile wide. In this reach, the depth to bedrock is approximately 60 feet. As mentioned above, the volume of alluvium, and particularly the depth of the material, influences the proportion of surface flow to underflow in the river valley.

Seven water wells are located in the recent alluvium of the Santa Maria River near the Palmerita Ranch (Figure 2.6-9). These wells range in depth from 60 to 196 feet, with a maximum reported discharge of 2700 gallons per minute (gpm) (Table 2.6-11). The volume, and particularly the thickness of the alluvium, influence the proportion of surface flow to underground flow in the river valley. For example where the alluvium is shallow and confined in a narrow canyon, waters may be forced upward by the underlying bedrock causing some of the water to become surface flow.

As part of a water supply investigation, four hydrologic exploration holes were drilled by Water Development Corp. in the alluvium of the Santa Maria River in Section 3, T11N, R10W (Figure 2.6-9). Well depths ranged from 27 to 61 feet (Table 2.6-12). Well 1 was airlifted

Table 2.6-11. WELL RECORD DATA FOR ALLUVIAL WELLS NEAR PALMERITA RANCH

Well Ident. No.	Well Location*	Date Drilled	Owner	Use	Depth (feet)	Casing Diameter (inches)	Depth to Static Water Level		Discharge (gpm)	Drawdown (feet)
							Feet	Date		
	11-11W-									
	16cba**	Jul. 1951	Fuller	Irrigation	61	–	–	–	–	–
	16dd**	Jun. 1951	Fuller	Irrigation	64	20	19	–	800	12
1	17acaa	Sep. 1963	Fuller	Irrigation	60	20	17.08	11/6/77	1800	30
2	17bdaa	–	Fuller	Irrigation	150	20	14.70	11/6/77	2198	17.49
3	17bcaa	–	Fuller	Irrigation	–	20	14.82	11/6/77	–	–
4	17bcba	–	Fuller	Irrigation	196	18	10.51	11/6/77	–	–
5	17bcbc	Sep. 1973	Fuller	Irrigation	188	18	12.33	11/6/77	–	–
	11-12W-									
	10dda	Aug. 1961	Fuller	Irrigation	143	16	10	Aug. 1961	2700	20
	14dac	Aug. 1961	Fuller	Irrigation	239	16	33	1961	2200	51
	14ddd	Aug. 1961	Fuller	Irrigation	239	16	–	–	2200	50

Source: Water Development Corp., 1977b. Data from Arizona State Land Department and U.S. Geological Survey.

*Refer to Figure 2.6-4 for location numbering system.

**No longer operable.

Table 2.6-12. HYDROLOGIC EXPLORATION HOLES IN THE ALLUVIUM OF THE SANTA MARIA RIVER NORTH OF THE ANDERSON MINE

Well Number	Well Location*	Depth (feet)	Casing Diameter (inches)	Casing Type	Depth to Static Water Level (feet)	Approx. Elevation of Ground Surface Above msl (feet)	Approx. Elevation of Static Water Level Above msl (feet)	Remarks
1	11-10W-3bca	57	6	Pre-perforated	23.6	1600	1576	Airlifted for 3 hr @ 100 gpm, created drawdown of 7 ft
2	11-10W-3aba	27	5	Pre-perforated	19	1520	1501	Encountered bedrock @ 27 ft
3	11-10W-3bcb	30	-	-	-	1500	-	Drilling discontinued @ 30 ft
4	11-10W-3bcc	61	5	Pre-perforated	-	1600	-	Considered to hit bedrock

Source: Water Development Corp., 1977b.

*Refer to Figure 2.6-4 for location numbering system.

for three hours, creating a discharge of about 100 gpm and a drawdown of approximately 7 feet. It would appear that the saturated alluvium in this area, though porous and permeable, is not sufficiently thick (and perhaps not wide enough) to constitute a substantial groundwater reservoir.

A 24-hour pump test on well 2 in the alluvium near the Palmerita Ranch was conducted by Water Development Corp. in 1977. During this test the average flow rate was 2180 gpm. Formation constants (transmissivity and storage coefficients) were estimated on the basis of the rate of drawdown at the pumped well and the surrounding observation wells (wells 1, 3, 4, and 5). For the pumped well, the transmissivity was determined to be approximately 250,000 gallons per day per foot (gpd/ft). Transmissivity was estimated to be from 1×10^5 to 1.5×10^6 gpd/ft in wells 1 and 3. These higher values may be related to the partial penetration of well 1 and the effects of an irrigation channel near well 3. Infiltration from nearby irrigation channels caused a rise in the groundwater level in well 5 and also biased the data for well 4. The short-term storage coefficient ranged from 0.06 to 0.08 for well 1 and was approximately 0.02 for well 3. The long-term storage coefficient for the alluvial aquifer is thought to be in the range of 0.2 (Water Development Corp. 1978).

Lower Sandstone Conglomerate. Table 2.6-13 provides information on wells in the vicinity of the Anderson property that are located in the Lower Sandstone Conglomerate unit. (The upper capping conglomerate

Table 2.6-13. WELLS IN THE LOWER SANDSTONE CONGLOMERATE UNIT IN THE ANDERSON PROPERTY AREA

Well Ident. No.	Well Location*	Owner	Use	Well Depth (feet)	Blank Casing Diameter** (inches)	Depth to Static Water Level (feet)	Approx. Elevation of Ground Surface Above msl (feet)	Elevation of Static Water Level Above msl (feet)	Depth Interval of Blank Casing (feet)	Approximate Depth Interval of Lower Sandstone Conglomerate (feet)	Remarks
AM-28	11-10W-8ccc	Minerals Exploration	Water supply	200***	$5^{9/16}$	52.4	1840	1788	0-60	0-205	Pump test April 14, 15, 1977 @ 57 gpm, drawdown of 22.4 ft
AM-507	11-10W-16cad	Minerals Exploration	Hydrologic test	1495	5	394	2000	1606	0-450	365-1495	Airlift from 800 ft created flow of 123 gpm
DC-6	11-10W-15bab	Urangesell-schaft	Mineral explor.	685	[a]						Encountered no water in over-lying conglomerate
11-10-19-1	11-10W-19bba		Mineral explor.	505	[a]						Reported to produce abundant water between 400 to 505 ft
11-10-19-2	11-10W-19cba		Mineral explor.	1640	[a]					255->1385	
	10-12W-2bbb	Fuller	Irrig.	580	10-6	200				200->580	Discharge 280 gpm, drawdown 50 ft
	10-12W-12aaa	Fuller	Irrig.	1563	$18-12^{3/4}$	246.7				200->1563	Reported unsatisfactory for irrigation
	11-11W-31bba	Fuller	Irrig.	1769	16-8					200-1500	
	11-11W-31bbb	Fuller	Irrig.	888	16	60				200->800	Discharge 470 gpm, drawdown 270 ft
	11-11W-31bbb	Fuller	Stock	400	8	64				200->400	Discharge 10 gpm, drawdown 0 ft

Source: Water Development Corp., 1977b.

*Refer to Figure 2.6-4 for location numbering system.
**Two values indicate a change in diameter with depth.
***Original depth 535 feet.
[a]No casings for exploration boreholes.

is essentially above the water table.) The only existing wells tapping this unit that are located on the property are AM-28 and AM-507. AM-28 was originally drilled to 535 feet for mineral exploration and was later converted to a water supply well. This well has been cased to 200 feet (blank casing down to 60 feet). Well AM-28, located between two major northwesterly trending features (Figure 2.6-9), has a static water level elevation of 1788 feet, the highest elevation of any well in the immediate vicinity of the proposed mine. Well AM-507 was drilled for hydrologic information and is located about 1500 feet southwest of one of the two major structural features on the property (Figure 2.6-9). The hole was air-drilled, and water was encountered at a depth of 485 feet.

A brief pump test was performed on well AM-28. The final flow rate during this test was 57 gpm. The initial and final water depths in the well were 56.2 and 78.6 feet, respectively, yielding a total drawdown of 22.4 feet and a specific capacity of 2.5 gpm/ft of drawdown. During this test, detailed drawdown and recovery rates were not obtained. Therefore, at this time, calculation of formation constants for this unit cannot be made.

Barren Sand. Another groundwater-producing unit at the Anderson Mine is the Barren Sand which pinches out against the andesitic volcanics in the southern portion of the Anderson property (Figure 2.6-10). The water supply well (DC-5, Figure 2.6-9) for Urangesellschaft U.S.A. is the only boring which is presently producing water from this unit. Perforated casing extends from 750 to 950 feet in this well and a submersible

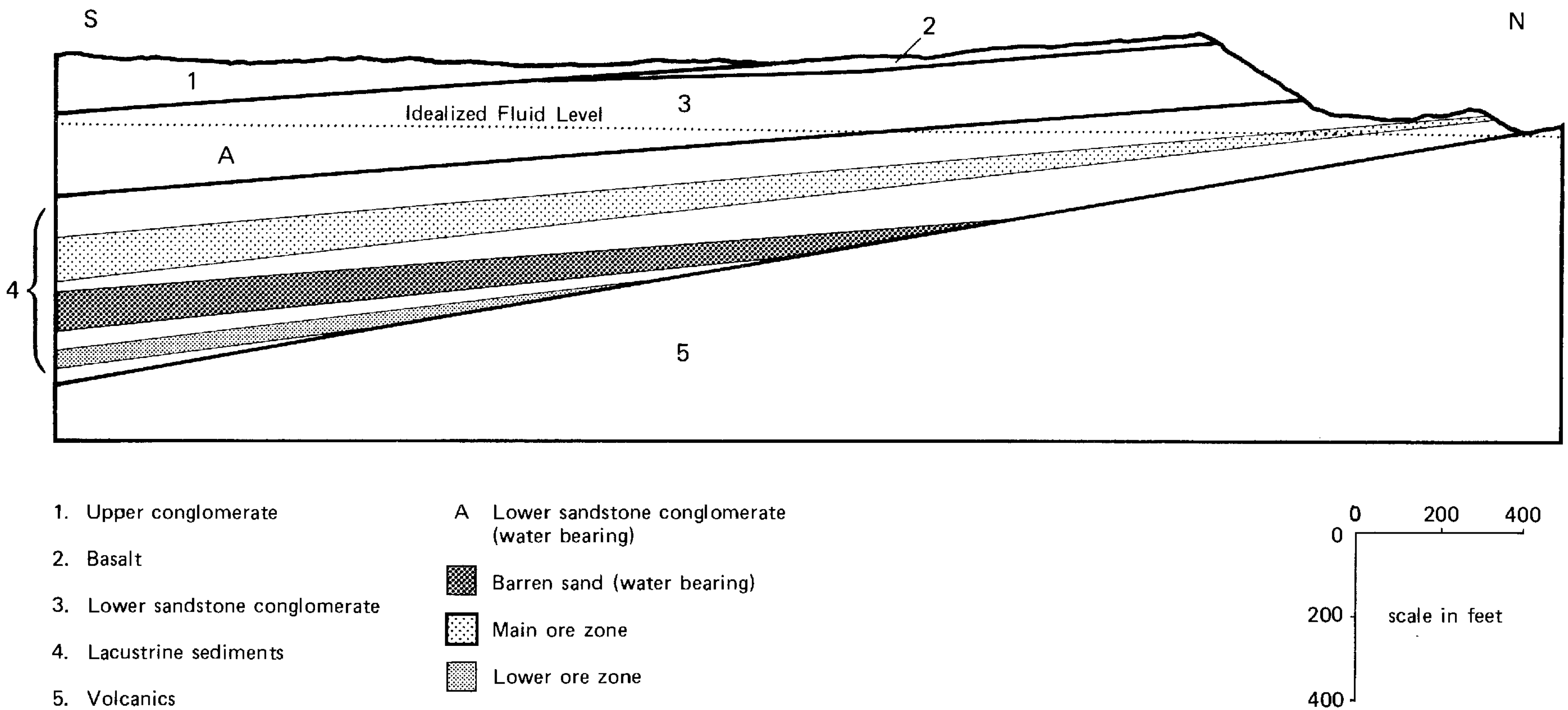


Figure 2.6-10. GENERALIZED CROSS SECTION SHOWING WATER BEARING UNITS AT ANDERSON MINE

pump is located at 815 feet. The top of the Barren Sand unit is at approximately 800 feet (Table 2.6-14). A static water level of 328 feet (elevation 1672 msl) was measured in well DC-5 on December 1, 1976; consequently, it appears that the Barren Sand unit is confined, with an artesian head in the range of 500 feet.

A 10-hour pump test was conducted on well DC-5 by Water Development Corp. in 1977. The average flow rate during this test was 30.7 gpm. The initial and final water depths in the well were 337.1 and 359 feet, respectively, yielding a total drawdown of 21.9 feet and a specific capacity of 1.4 gpm/ft of drawdown. The transmissivity determined from the test was approximately 1000 gpd/ft.

Local Groundwater Movement

The elevation of static water levels in the drill holes penetrating the Lower Conglomerate and Barren Sand units are shown in Figures 2.6-9 and 2.6-11 and presented in Table 2.6-15. The exact source of the water in these drill holes is uncertain. However the data are useful for discussing general trends in groundwater movement. For example, considerable faulting and fracturing in the vicinity of the Anderson mine shows up in marked changes in the water gradient (Figure 2.6-11).

The water elevations in borings through the Barren Sand unit (Section 15, T11N, R10W) generally decrease to the west and north toward the Santa Maria River. This gradient is opposite to the general south to southeast dip of the sediments.

Table 2.6-14. WELLS IN THE BARREN SAND IN THE ANDERSON MINE AREA

Well Ident. No.	Well Location*	Owner	Use	Well Depth (feet)	Blank Casing Diameter (inches)	Depth to Static Water Level (feet)	Date of Static Water Level Measurement	Approx. Elevation of Ground Surface above msl (feet)	Approx. Elevation of Static Water Level above msl (feet)	Depth Interval of Blank Casing (feet)	Approximate Depth Interval of Barren Sand (feet)	Remarks
DC-5	11-10W-15aca	Urangesell-schaft	Water supply	950**	5 9/16	328	12/1/76	2000	1672	0-750	<800->860	Discharge 25 gpm with pump depth of 815 ft
DC-8		Urangesell-schaft	Mineral explora.	1465	60	–	–	–	–	60-1150		No water reported after drilling
DC-13	11-10W-15acb	Urangesell-schaft	Mineral explora.	1153	3	311	[a]	1960	1649	0-650		No water reported after drilling
T-16	11-10W-15ddb	Urangesell-schaft	Mineral explora.	1450	3	452	[a]	2160	1708	0-1150		Little water from 1200 to 1350 ft
T-18		Urangesell-schaft	Mineral explora.	1405	3	–	–	–	–	0-1150		Little water from 1200 to 1300 ft
T-20	11-10W-15adb	Urangesell-schaft	Mineral explora.	1060	3	323	[a]	2000	1677	336-720		No water reported after drilling

Source: Water Development Corp., 1977b.

*Refer to Figure 2.6-4 for location numbering system.
**Original depth 1040 feet.
[a]Measured during Water Development Corp. field program initiated in November 1976.

Table 2.6-15. BORE HOLES IN WHICH STANDING WATER LEVELS WERE MEASURED

Hole No.	Collar Elevation (ft,MSL)	Depth to Fluid Level (ft)	Elevation of Fluid Level (ft,MSL)	Elevation of Base of Sandstone and Conglomerate (ft,MSL)	Elevation of Top of Barren Sand (ft,MSL)	Elevation of Base of Barren Sand (ft,MSL)	Elevation of Top of Basement Volcanics (ft,MSL)
AM-22C	1,954	178	1,776	1,644	1,409	1,364	1,259
AM-23	1,988	250	1,738	1,643	1,478±		1,453
AM-28	1,852	70	1,782	1,627	1,402±	1,377±	1,337
AM-129	1,869	231	1,638	1,654	1,468±	1,454±	1,454
AM-134	2,008	277	1,731	1,643	1,533±	1,518±	1,503
AM-135C	1,994	147	1,847	1,657±	1,509	1,499±	1,500
AM-137	1,924	178	1,746	1,594	NE		1,444
AM-138	1,822	176	1,646	1,577	NE		1,367
AM-139	1,801	35	1,766	1,586	NE		1,421
AM-145	1,767	75	1,892		NE		1,647
AM-155	2,068	337	1,731	1,553	1,478±	1,423±	1,363
AM-167	2,004	308	1,696	1,629	1,404	1,339±	1,314±
AM-170C	1,797	82	1,715		NE		1,677
AM-177	2,014	209	1,805	1,659	1,374±	1,364±	1,364
AM-180	2,060	266	1,794	1,680	1,450	1,410	1,335
AM-182	2,082	278	1,804	1,616	1,452	1,422	1,336
AM-183	2,051	267	1,784	1,651	1,451	1,381	1,281
AM-306C	1,755	35	1,720		NE		1,718
AM-320	1,825	110	1,715		NE		1,575
AM-321	1,786	75	1,711		NE		1,586
AM-325	1,820	100	1,720	1,800	1,605±	1,590±	1,550
AM-326	1,817	100	1,717	1,777	NE		1,602
AM-334	1,844	115	1,729	1,674	NE		1,529
AM-335	1,854	110	1,744	1,639	NE		1,539
AM-336C	1,836	96	1,740	1,746	NE		1,581
AM-350	1,869	65	1,804	1,569±	1,499±	1,449±	1,379±
AM-371	2,008	266	1,742	1,648	NE		1,553
AM-372	1,996	245	1,751	1,641	NE		1,486
AM-378	1,948	212	1,736	1,643	NE		1,443
AM-379	1,974	231	1,743	1,634	NE		1,439
AM-380	1,983	267	1,716	1,678	NE		1,499
AM-384	1,937	238	1,699	1,632	1,467±	1,437±	1,392
AM-385	1,911	168	1,743	1,661	1,471±	1,444±	1,444
AM-402	1,857	140	1,717	1,677	NE		1,587
AM-403	1,893	144	1,749	1,578	1,463±	1,453±	1,453
AM-405	1,906	148	1,758	1,566	NE		1,431
AM-406	1,918	321	1,597	1,578	NE		1,438
AM-417	1,984	361	1,623	1,509	1,364±	1,349±	1,349
AM-419	1,940	318	1,622	1,480	1,350±	1,320±	1,320
AM-422C	1,915	262	1,653	1,570	1,335±	1,315	1,245
AM-423	1,902	256	1,646	1,512	1,347	1,312	1,272
AM-424	1,899	304	1,595	1,519	1,374	1,349	1,324
AM-426	2,035	251	1,784	1,670	1,480	1,405	1,345
AM-427C	2,078	260	1,818	1,643	1,388	1,343	1,343
AM-437	1,894	126	1,768	1,629	1,414	1,364	1,254
AM-439	1,867	104	1,763	1,627	1,407	1,357	1,337
AM-440	1,900	167	1,733	1,630	1,450±	1,430±	1,350
AM-441	1,891	134	1,757	1,626	1,431±	1,420±	1,346
AM-442	1,891	151	1,740	1,596	1,436	1,406	1,341
AM-443	1,807	50	1,757	1,607	1,397	1,357	1,297
AM-444C	1,874	217	1,657	1,635	1,419	1,374	1,306
AM-446	1,984	220	1,764	1,534	1,404	1,324	1,219
AM-448	1,930	159	1,771	1,615	1,405	1,360	1,215
AM-525	1,839	90	1,749	1,709	1,619±	1,579±	1,519
AM-556	1,847	94	1,753	1,780	1,582±	1,547±	1,536
AM-659	1,830			1,570	1,355±	1,325±	1,245
AM-660	1,925	125	1,800	1,660	1,490±	1,470±	1,470
AM-707	2,060-T	414	1,646	1,555	1,380	1,335	
AM-866	1,900	101	1,799	1,600			1,475
AM-874	1,829	73	1,756				
AM-931	2,020	367	1,653	1,480	1,340	1,295	1,230
AM-933	1,998	328	1,670	1,448	1,363	1,318	1,263
AM-945	1,888	242	1,646	1,583	1,288±	1,258±	1,228
AM-960	1,960-T	192	1,768	1,590	1,380±	1,360	

NE: Not encountered
T: Elevation from tops

Groundwater elevations in wells penetrating the Lower Conglomerate (AM-28 and AM-507) decrease in steps to the west-southwest. The series of northwest-trending faults that form these steps in the mine area modify the regional southwest gradient of the water table. Locally, groundwater moves along the fault blacks to the northwest. Within fault blocks, groundwater levels decrease to northwest, substantiating this local movement.

In order to further clarify local groundwater movement and the effects of faulting on the groundwater regime, MINERALS plans to continue hydrologic studies on the Anderson property. This data will be made available to the appropriate review agencies as it is obtained.

WATER QUALITY

Surface Water Quality

Surface flow in the vicinity of the Anderson property normally occurs for only short periods during and immediately after precipitation. A single brief period of runoff was recorded on the property during the study period; however, personnel were not present to obtain water samples. Consequently, surface water quality data are not available for the property.

The water quality monitoring station nearest to the property is located on the Bill Williams River (USGS 09426600) near Planet, Arizona. This station is approximately 43 miles downstream from the Anderson property below the Alamo Reservoir. Data from this station were not included in this report since the hydrologic regime below the reservoir is different from the regime in the vicinity of the property. In addition, the impoundment of the water upstream from the monitoring station can be expected to substantially modify its chemical characteristics.

The results of water quality analyses conducted on a sample taken in the Bill Williams River at the confluence of the Big Sandy and Santa Maria rivers are provided in Table 2.6-16. For comparison, this table also presents pertinent water quality criteria. The drinking water standards presented in the table were compiled from the 1969 U.S. Public Health Service standards, the 1975 U.S. EPA Interim Primary Drinking Water Regulations, and Quality Criteria for Water (EPA, 1976). The water quality criteria for wildlife and livestock use that are given in the table have been extracted from the 1973 proposed water quality standards developed for the EPA by the National Academy of Sciences. These criteria preceded the 1976 standards published by the EPA, which are concerned only with the health of humans and of aquatic and marine organisms.

As can be seen in Table 2.6-16, the water from the Bill Williams River is of fairly good quality. It does, however, exceed the 1975 drinking water standards for total iron and manganese and the 1969 drinking water standard for TDS.

Table 2.6-16. SURFACE WATER QUALITY OF THE BILL WILLIAMS RIVER AT THE CONFLUENCE OF THE BIG SANDY AND THE SANTA MARIA RIVERS

Constituent	Concentration (mg/l)*	1975 U.S. EPA Primary Drinking Water Standard	Water Quality Standards for Wildlife/Livestock
Redox Potential (units)	+245	--	--
Specific Conductance (μmho/cm)	780	--	--
TDS	550	500**	3000
pH (units)	8.5	5-9	6-9
Calcium	0.001	--	--
Magnesium	21	--	--
Potassium	7	--	--
Sodium	100	--	--
Bicarbonate	280	--	--
Chloride	72	250	--
Sulfate	84	250	--
Total Iron	8.2	0.3	
Soluble Iron	<0.1	--	--
Manganese	0.26	0.05	--
Total Phosphorus	0.31	--	--
Nitrate as Nitrogen	0.4	10	22.6
Carbonate	1.8	--	--
Fluoride	1.5	1.4	2.0
Boron	0.21	--	5.0
Aluminum	11	--	5.0
Arsenic	0.03	0.05	0.2

Table 2.6-16 (concluded)

Constituent	Concentration (mg/l)*	1975 U.S. EPA Primary Drinking Water Standard	Water Quality Standards for Wildlife/Livestock
Chromium	0.011	0.05	1.0
Copper	0.04	1.0	0.5
Molybdenum	<0.05	--	--
Nickel	0.034	--	--
Selenium	<0.003	0.01	0.05
Vanadium	<0.05	--	0.1
Zinc	0.007	5.0	25
Total Uranium (pCi/l)	0 ± 3	--	--
Radium-226 (pCi/l)	0.12 ± 0.04	5	5
Radium-228 (pCi/l)	0 ± 1	--	--
Thorium-228 (pCi/l)	0 ± 0.1	--	--
Thorium-230 (pCi/l)	0 ± 0.1	--	--
Thorium-232 (pCi/l)	0 ± 0.2	15	15
Gross Alpha	0 ± 3	--	--
Gross Beta	16 ± 2	--	--

Source: Analyses conducted by LFE Environment Laboratories of Richmond, California. Sample collected on 09/16/77.

*Unless otherwise noted
**1969 U.S. Public Health Service standards.

Flash flooding following storms is typical on the Anderson property. During these flood events the quality of surface water is extremely variable, depending largely on the geologic composition of the streambed. In most cases, however, this water is laden with sediments. The sediment yield from runoff in the vicinity of the Anderson property varies from 0.2 to 1 acre-foot (0.01875 in/yr) of material per square mile per year (Arizona Water Commission 1975).

Groundwater Quality

Groundwater samples were collected from a total of 10 sources (Figure 2.6-12) representing all of the major geohydrologic units in the vicinity of the Anderson property (i.e., alluvium, Barren Sand, Lower Conglomerate, and volcanics). These samples were analyzed for major water quality constituents, minor constituents, trace elements, and radioactive constituents. The results of these analyses are presented in Tables 2.6-17 through 2.6-20. For comparison, these tables also present pertinent water quality criteria in a manner similar to that described for Table 2.6-16.

The data indicate that different types of water are present in the various formations underlying the Anderson property. In the alluvium, water is dominated by calcium bicarbonate (Table 2.6-17). In the Barren Sand unit, the water has a high pH and is dominated by sodium bicarbonate and sodium carbonate. In the Lower Conglomerate unit, the water is again dominated by calcium bicarbonate. Water from both of

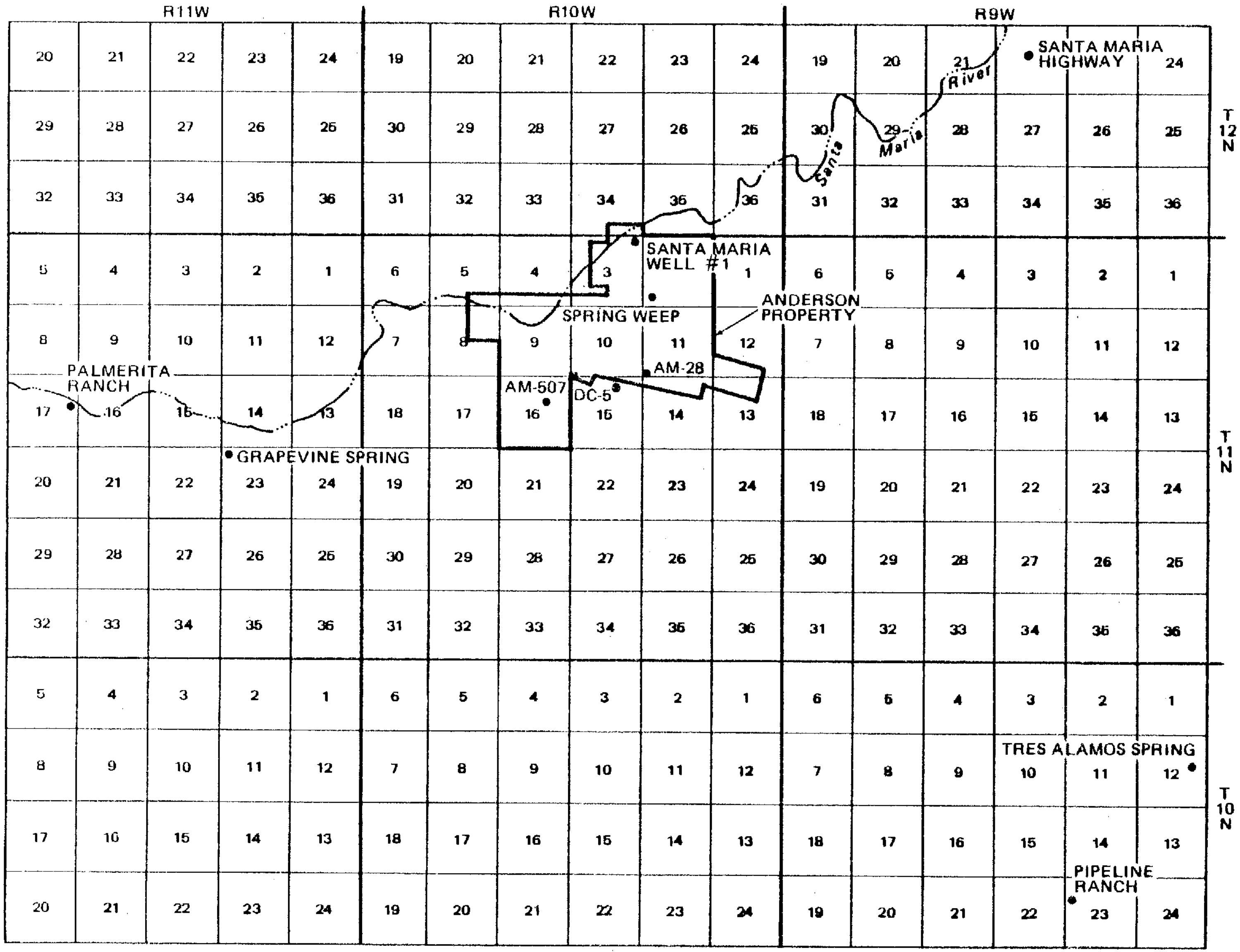


Figure 2.6-12. LOCATION OF GROUNDWATER SAMPLE SITES

Table 2.6-17. MAJOR WATER QUALITY CONSTITUENTS (in mg/l unless otherwise noted)

Identification	Well Location*	Date Sampled	Redox Potential (mV)	Specific Conductance (µmho/cm)	TDS	pH	Ca	Mg	K	Na	HCO_3	Cl	SO_4
Alluvium Wells (Qal)													
Palmerita Ranch	11-11W-17ac	4/12/77	+16.0	460	220	7.6	41	10	4	48	197	23	32
		9/16/77	-	400	260	7.6	42	12	3.2	40	200	28	30
Pipeline Ranch	10-9W-23bc	5/1/77	-70.7	390	239	8.1	30	13	2	22	190	13	24
		9/16/77	+249	400	270	7.4	62	12	2.1	22	220	11	15
Santa Maria Well #1	11-10W-3ab	3/17/77	+14.0	561	470	7.7	105	9	6	57	212	41	57
		9/16/77	+245	550	370	7.4	58	19	5.2	55	240	47	53
Santa Maria Highway	12-9W-22bd	5/1/77	-45.9	1185	785	7.8	64	32	3	92	286	117	110
		9/16/77	+249	960	730	7.6	90	20	5.9	120	360	7.4	110
AM-507	11-10W-16ca	4/20/77	-	390	340	8.0	9	4	5	78	178	18	29
Barren Sand Well (Tmb)													
DC-5	11-10W-15ab	12/19/76	-	850	663	8.9	1	0.2	2	200	366	33	25
		4/15/77	+34.2	714	666	8.8	1	0.3	3	197	322	36	13
Lower Conglomerate (Tmc)													
AM-28	11-10W-11cc	12/1/76	-	290	200	7.3	23	16	3	14	146	10	12
		4/15/77	+125.0	390	221	8.0	22	10	3	15	112	11	14
		9/16/77	+237	260	150	7.6	23	13	3.1	17	120	11	7.6
Grapevine Springs	11-11W-23bb	11/13/76	-	290	227	8.4	24	5	2	40	132	14	20
		5/1/77	-53.7	355	262	7.7	1**	4	2	32	137	15	20
		9/16/77	+238	350	180	8.2	25	4.3	2	45	150	17	13
Volcanics (Tvf)													
Tres Alamos Spring	10-9W-12ad	5/3/77	-60.0	710	591	8.1	30	38	0.5	60	264	53	42
		9/16/77	+238	380	260	7.8	26	22	1.7	35	200	30	<1
Spring Weep	11-10W-11ba	7/18/77	-	675	280	8.7	10	2	9	185	179	60	26
Drinking Water Standards			-	-	500	5-9	-	-	-	-	-	250	250
Water Quality Standard for Wildlife/Livestock			-	-	-	6-9	-	-	-	-	-	-	-

*Refer to Figure 2.6-4 for location numbering system.

**Probable analytical error.

Note: CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

Table 2.6-18. MINOR WATER QUALITY CONSTITUENTS (all analyses in mg/l)

Identification	Date Sampled	Total Fe	Soluble Fe	Mn	PO_4 (as P)	NO_3 (as N)	CO_3	F	B	Laboratory
Alluvium Wells (Qal)										
Palmerita Ranch	4/12/77	0.006	<0.001	0.001	<0.1	0.9	0	0.89	0.2	CEP
	9/16/77	0.31	<0.1	0.019	0.074	0.86	0	1.0	<0.1	LFE
Pipeline Ranch	5/1/77	0.018	0.014	<0.001	0.2	0.6	0	0.05	0.3	CEP
	9/16/77	0.005	<0.1	<0.005	0.026	2.2	0	0.53	<0.1	LFE
Santa Maria Well #1	3/17/77	5.9	0.39	0.076	0.7	<0.1	0	0.89	0.1	CEP
	9/16/77	23	<0.1	0.19	0.29	0.92	0	0.86	0.15	LFE
Santa Maria Highway	5/1/77	0.3	0.05	0.114	1.8	0.4	0	2.03	0.4	CEP
	9/16/77	0.23	<0.1	0.13	0.15	0.4	0	2.5	0.35	LFE
AM-507	4/29/77	-	-	-	-	2.8	0	1.4	-	BC
Barren Sand Well (Tmb)										
DC-5	12/19/76	-	-	-	-	0.4	40	4.2	-	BC
	4/15/77	0.002	<0.001	0.001	<0.1	0.3	27.3	4.2	1.0	CEP
Lower Conglomerate (Tmc)										
AM-28	12/1/76	-	-	-	-	3.8	0	0.7	-	BC
	4/15/77	0.001	<0.001	<0.001	<0.1	5.0	0	0.7	0.1	CEP
	9/16/77	0.012	<0.01	<0.005	<0.02	3.9	0	0.87	<0.1	LFE
Grapevine Springs	11/13/7	-	-	-	-	1.2	11.9	0.6	-	BC
	5/1/77	0.261	0.100	0.043	3.1	1.3	0	0.1	0.3	CEP
	9/16/77	0.24	<0.1	<0.037	0.063	1.2	0	0.58	<0.1	LFE
Volcanics (Tvf)										
Tres Alamos Spring	5/3/77	0.18	0.014	0.014	1.0	2.0	0	0.07	1.2	CEP
	9/16/77	0.06	0.22	0.015	0.013	0.1	0	0.44	<0.1	LFE
Spring Weep	7/18/77	0.046	0.004	0.004	0.1	1.6	15.6	2.4	0.2	CEP
Drinking Water Standards		0.3	-	0.50	-	10	-	1.4	1.0 2.4	
Water Quality Standards for Wildlife/Livestock		-	-	-	-	22.6	-	2.0	5.0	

Note: CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

Table 2.6-19. TRACE WATER QUALITY CONSTITUENTS (all analyses in mg/l)

Identification	Date Sampled	Al	As	Cr	Cu	Mo	Ni	Se	V	Zn	SiO_2	Laboratory
Alluvium Wells (Qal)												
Palmerita Ranch	4/12/77	<0.1	<0.01	<0.001	0.003	0.01	0.001	<0.01	0.01	0.13	2.0	CEP
	9/16/77	0.17	<0.01	<0.005	<0.01	<0.05	0.009	<0.005	<0.05	0.003	25.0	LFE
Pipeline Ranch	5/1/77	<0.1	<0.01	0.002	<0.001	0.004	0.01	<0.01	0.02	<0.01	3.4	CEP
	9/16/77	<0.1	0.005	0.011	0.03	<0.05	0.008	<0.005	<0.05	0.087	14.0	LFE
Santa Maria Well #1	3/17/77	0.01	0.02	<0.001	0.001	0.001	0.001	0.01	<0.01	0.03	30.4	CEP
	9/16/77	1.3	0.0006	0.007	0.03	<0.05	0.045	<0.004	<0.05	0.31	9.4	LFE
Santa Maria Highway	5/1/77	0.9	0.01	0.003	<0.001	0.001	0.01	<0.01	0.01	<0.01	6.28	CEP
	9/16/77	0.15	0.008	0.007	<0.01	<0.05	0.016	<0.003	<0.05	0.003	24.0	LFE
Barren Sand Well (Tmb)												
DC-5	4/15/77	0.01	0.12	0.001	0.029	<0.001	0.001	0.01	0.03	0.01	40.0	CEP
Lower Conglomerate (Tmc)												
AM-28	4/15/77	<0.1	0.011	0.001	0.001	<0.001	0.001	<0.01	0.02	0.02	5.0	CEP
	9/16/77	<0.1	0.008	0.007	<0.01	<0.005	0.005	<0.005	<0.05	0.21	17.0	LFE
Grapevine Springs	5/1/77	0.9	0.01	0.015	<0.001	<0.001	0.01	0.1	0.01	<0.01	3.14	CEP
	9/16/77	1.2	0.012	0.007	<0.001	<0.05	0.007	<0.005	<0.05	0.007	14.0	LFE
Volcanics (Tvf)												
Tres Alamos Spring	5/3/77	0.9	0.01	0.003	<0.001	0.004	<0.01	0.20	0.03	<0.01	7.2	CEP
	9/16/77	<0.01	<0.005	<0.005	<0.01	<0.05	0.005	<0.005	<0.05	0.019	31.0	LFE
Spring Weep	7/18/77	0.5	<0.01	0.001	0.001	0.001	<0.01	<0.01	0.03	<0.01	--	CEP
Drinking Water Standards		-	0.5	0.05	1.0	-	-	0.01	-	5.0	--	
Water Quality Standards for Wildlife/Livestock		5.0	0.2	1.0	0.5	-	-	0.05	0.1	25	--	

Note: CEP is Controls for Environmental Pollution, Inc.
LFE is LFE Environmental Laboratories
BC is BC Laboratories

Table 2.6-20. RADIOACTIVE TRACE CONSTITUENTS (all analyses in pCi/l unless noted)

Identification	Date Sampled	Total U (mg/l)	Rn-222	Ra-226	Ra-228	Th-228	Th-230	Th-232	Gross Alpha	Gross Beta	Laboratory
Alluvium Wells (Qal)											
Palmerita Ranch	4/12/77	0.0050	-	<0.6	7±3	1.9±1.0	2.3±1.1	<0.6	2±2	5±2	CEP
	9/16/77			0.06±0.04	0±1	0±0.2	0±0.1	0±0.1	0±2	6±2	LFE
Pipeline Ranch	5/1/77	0.0072	-	<0.6	<1.0	<0.6	<0.6	<0.6	3±2	3±2	CEP
	9/16/77			0±0.04	0±1	0±0.2	0±0.1	0±0.2	0±3	6±2	LFE
Santa Maria Well #1	3/17/77	0.0115	-	<0.6	<1.0	2.1±1.0	2.9±1.2	1.4±0.9	4±3	4±2	CEP
	9/16/77			0.09±0.04	0±1	0±0.1	0±0.03	0±0.3	0±2	7±2	LFE
Santa Maria Highway	5/1/77	0.0188	-	<0.6	<1.0	<0.6	<0.6	<0.6	8±5	3	CEP
				0.06±0.04	0±1	0±0.2	0±0.2	0±0.2	0±3	13±2	LFE
Barren Sand Well (Tmb)											
DC-5	4/15/77	0.0460	-	<0.6	<1.0	<0.6	<0.6	<0.6	21±5	7±2	CEP
Lower Conglomerate (Tmc)											
AM-28	4/15/77	0.0076	-	<0.6	<1.0	<0.6	<0.6	<0.6	2±1	3	CEP
	9/16/77			0.09±0.04	0±1	0±0.1	0±0.1	0±0.1	0±2	4±2	LFE
Grapevine Springs	5/1/77	0.0111	-	<0.6	<1.0	<0.6	<0.6	<0.6	<2	3	CEP
				0±0.04	0±1	0±0.1	0±0.2	0±0.2	0±2	3±2	LFE
Volcanics (Tvf)											
Tres Alamos Spring	5/3/77	0.0169	-	<0.6	<1.0	<0.6	<0.6	<0.6	7±4	4±2	CEP
	9/16/77			0±0.04	0±1	0±0.2	0±0.1	0±0.2	0±3	5±2	LFE
Spring Weep	7/18/77	0.0152	0±2	0±0.08	0±2	-	0.4±0	0±0.1	0±4	12±1	LFE
Drinking Water Standards			-	5	-	-	-	15	-	-	
Water Quality Standards for Wildlife/Livestock			-	5	-	-	-	15	-	-	

Note: CEP is Controls for Environmental Pollution, Inc.
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BC is BC Laboratories

the springs derived from the volcanics was dominated by sodium bicarbonate.

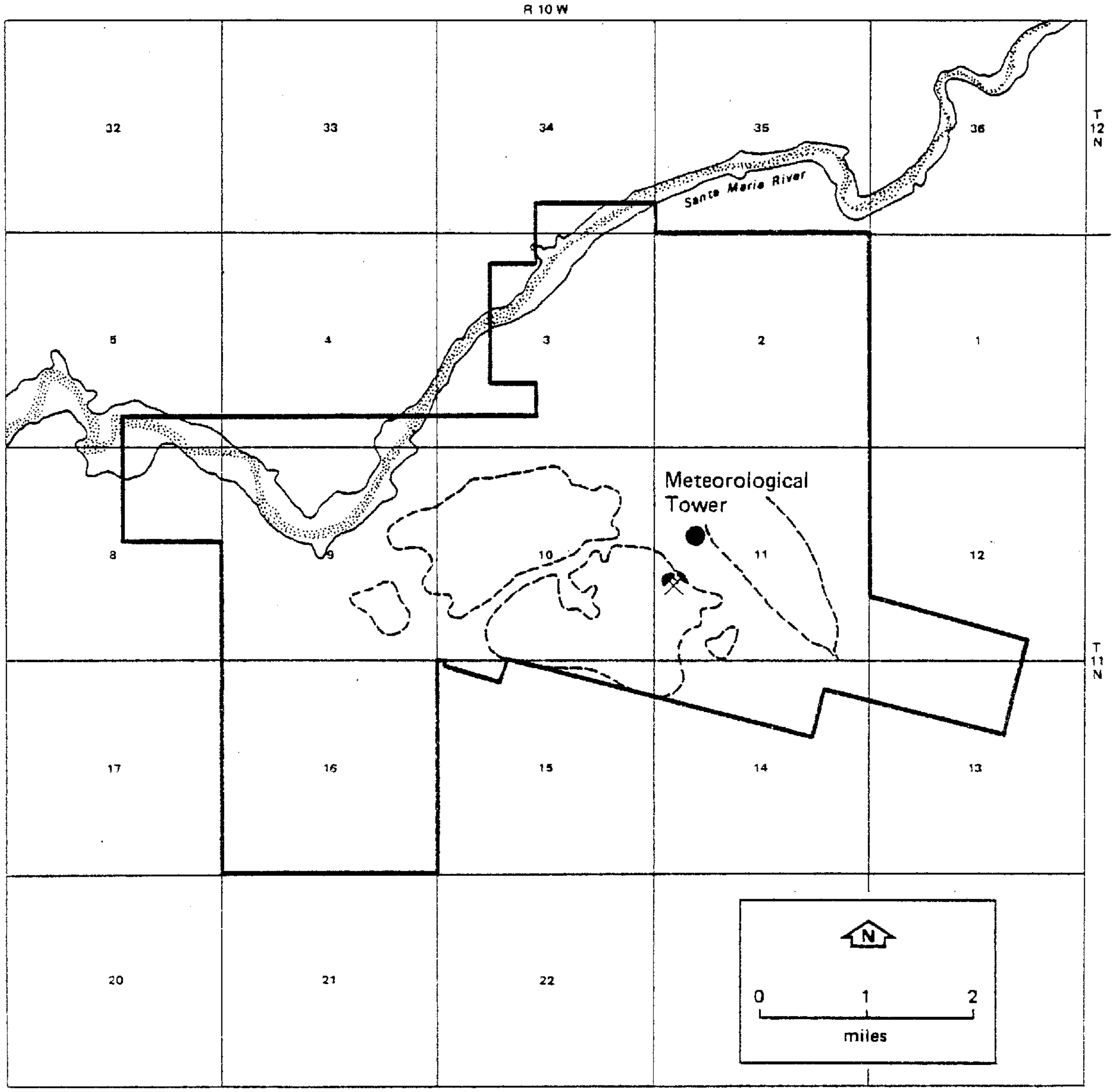
The major potential uses of groundwater in the vicinity of the Anderson property are wildlife and livestock watering and domestic consumption. Based on the recommended criteria provided in Tables 2.6-17 through 2.6-20, groundwater in the area is of fairly good quality for these uses. However, there are several cases where water quality criteria are exceeded. Except for water from the Lower Conglomerate unit, water samples from each of the geologic units underlying the property exceeded the drinking water standard for total dissolved solids (TDS) (Table 2.6-17). Fluoride in the water from the Barren Sand unit exceeded the maximum allowable concentration of 1.4 mg/l for drinking water (Table 2.6-18). Studies have shown that water containing more than 4.0 mg/l of fluoride causes mottled teeth in humans. Untreated water from this unit has the potential of causing this problem. Water from the Barren Sand unit, some of the alluvium, and volcanics also exceeded the fluoride criteria (Table 2.6-18). Water from Santa Maria Well no. 1 exceeded the drinking water standard for iron (Table 2.6-18). Since most of the other samples taken from wells drilled into alluvium contained low concentrations of iron, this fairly high reading may be more indicative of sampling problems, such as an oxidized well casing, than the actual quality of the water. Water from Tres Alamos Spring is of poorer quality than most of the other samples taken in the vicinity of the Anderson property. This water exceeded the drinking water standard for selenium (Tables 2.6-18 and 2.6-19). It also exceeded the wildlife and livestock watering criterion for selenium (Table 2.6-19).

2.7 METEOROLOGY AND AIR QUALITY

A meteorological monitoring program was initiated on the Anderson property in December 1976. A mechanical weather station measuring wind direction, wind speed, and temperature was installed atop a 30-foot meteorological tower (Figure 2.7-1). Early in June 1977, instrumentation was added to measure relative humidity (at 30 feet) and rainfall (at about 10 feet). Estimates of wind direction deviation were used to estimate atmospheric stability for each hour according to methods developed by Slade (1966).

The tower was initially installed on a leveled area approximately 15 to 20 feet below and 200 feet south of the crest of a low hill. Examination of initial meteorological station strip charts indicated that wind turbulence induced by the hill caused exaggerated oscillation of the wind vane (known as a "wake effect") during northerly winds above about 5 mph. The actual wind direction was discernable with reasonable accuracy, but chart interpretation was difficult. To remedy this situation, the tower was relocated to the top of the hill in June 1977 when precipitation and relative humidity sensors were installed. Comparison of wind data before and after relocation of the station indicates that hourly direction measurements were not significantly affected by turbulence.

Air quality was measured during three 5-day continuous monitoring programs near the meteorological tower site. Monitoring was first conducted from 8:00 p.m. on July 13, 1977, to 3:00 p.m. on July 18,



LEGEND

- - - Proposed facilities
— Property boundary
⚒ Anderson Mine (abandoned)

Figure 2.7-1. METEOROLOGICAL AND AIR QUALITY MONITORING LOCATION

1977. The second monitoring period began at 10:00 a.m. on November 10, 1977, and ended at 8:00 a.m. on November 14, 1977. The final monitoring period was conducted from April 23 to 28, 1978.

During each monitoring period, 24-hour suspended particulate concentrations were determined with a standard high-volume air sampler (EPA reference method) fitted with a constant flow controller (± 1 cubic foot per minute), 24-hour sulfur dioxide concentrations were determined by the West-Gaeke bubbler method* (EPA reference method), and ozone concentrations were measured continuously with a Bendix 8002 Chemiluminescence Ozone Monitor (EPA equivalent method). During the final monitoring period, 24-hour nitrogen dioxide concentrations were also determined by the sodium arsenite bubbler method,* continuous carbon monoxide concentrations were determined with a Beckman CO analyzer (EPA equivalent method), and ambient air grab samples were collected for hydrocarbon analysis. In addition, MINERALS began a suspended particulate monitoring program at the site in September 1977. The latter program includes collection of 24-hour particulate samples once each week (usually on the weekend) according to a schedule approved by the Arizona Bureau of Air Quality Control for the project site. Monitoring is scheduled to continue to at least September, 1978. At a minimum of once each quarter, one of the samples collected by MINERALS will be analyzed for sulfate, nitrate, and lead.

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* Bubbler solutions were provided and analyzed by the Arizona Department of Health Services, Bureau of Air Quality Control, under the coordination of Mr. James Guyton, Monitoring Section Manager.

Site data are presented in this section, along with long-term regional data, to describe the existing meteorological and air quality conditions.

METEOROLOGY

The Anderson property is located in a semiarid desert region with the following general characteristics: abundant sunshine, light rainfall, moderate wind speeds, low relative humidity, and large diurnal temperature fluctuations. Summers are hot and winters are relatively mild.

Temperature

July is usually the hottest month, and January and December are usually the coldest months in the region. Based on an analysis of long-term temperature data for various regional weather stations* the normal mean annual temperature on the property is estimated to be about 66° to 67°F. Normal mean temperatures are estimated to be about 48° to 49°F during January and December, and 87°F during July. Normal monthly means and extremes in Phoenix (Figure 2.7-2) are presented in Table 2.7-1 to indicate annual variations. Comparisons of concurrent temperature data at Phoenix and the property during a 9-month period (December 1976 to August 1977) indicate that mean daily minimum and mean daily maximum temperatures are generally about 3°F cooler at the site,

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* Normal mean annual and monthly (January, July, and December) temperatures for the 30-year period from 1941 to 1970 (U.S. Department of Commerce, 1973) were analyzed for 8 regional weather stations at elevations ranging from 323 feet msl to 3773 feet msl and were found to indicate a good correlation between temperature and elevation. Correlation coefficients ranged from -0.94 to -0.99.

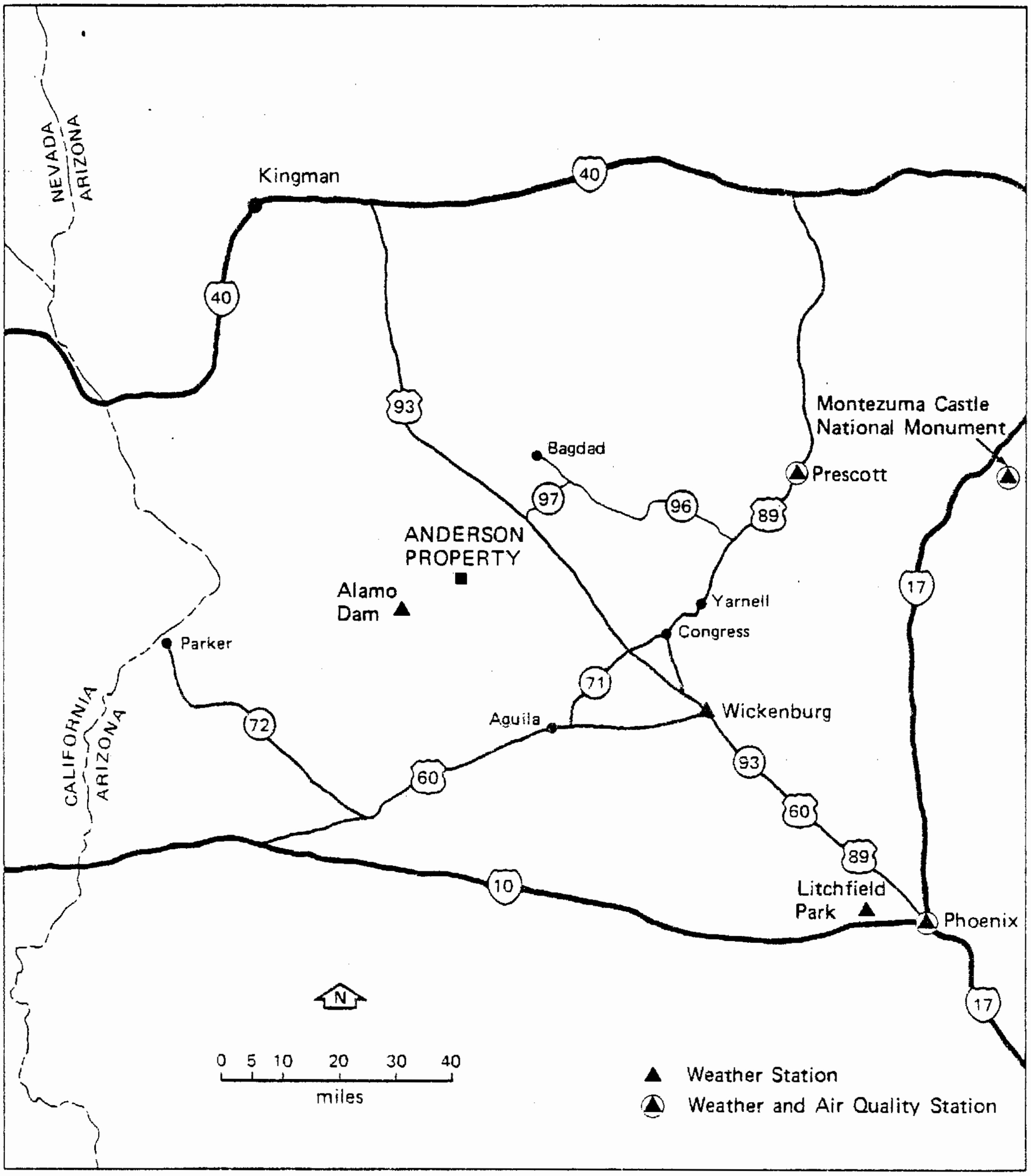

Figure 2.7-2. REGIONAL METOROLOGICAL AND AIR QUALITY MONITORING STATIONS

Table 2.7-1. NORMAL MEAN AND EXTREME TEMPERATURES REPORTED FOR PHOENIX, ARIZONA

	Means[a]			Extremes[b]	
Month	Daily Maximum	Daily Minimum	Monthly	Record Highest	Record Lowest
January	64.8	37.6	51.2	88	19
February	69.3	40.8	55.1	89	26
March	74.5	44.8	59.7	95	25
April	83.6	51.8	67.7	101	37
May	92.9	59.6	76.3	110	40
June	101.5	67.7	84.6	116	51
July	104.8	77.5	91.2	115	67
August	102.2	76.0	89.1	116	61
September	98.4	69.1	83.8	110	47
October	87.6	56.8	72.2	103	34
November	74.7	44.8	59.8	93	31
December	66.4	38.5	52.5	82	24
Annual	85.1	55.4	70.3	116	19

Source: U.S. Department of Commerce, 1976.

[a]Period of record: 30 years, 1941-1970.

[b]Period of record: 15 years, 1962-1976.

while daily minimum and maximum temperatures are generally about 2°F and 5°F cooler, respectively. The minimum temperature reported at the Phoenix Sky Harbor Airport was 19°F in January 1971, and the maximum was 116°F in August 1975. Other stations in the Phoenix vicinity have reported temperatures as high as 118°F and as low as 16°F. On the average, temperatures exceed 90°F about 165 days each year and fall below 32°F only about 13 days a year in Phoenix. Monthly and daily mean, maximum, and minimum temperatures observed at the site during the study period are presented in Appendix B-1.

Relative Humidity

Table 2.7-2 presents mean relative humidity observed on the Anderson property for specific hours of the day for June through August 1977. Table 2.7-3 presents similar data for Phoenix for each month of the year. Comparisons of concurrent Phoenix and Anderson property data indicate that relative humidity on the property is generally higher and does not exhibit as great a diurnal variation as in Phoenix (and other reporting stations in Arizona at similar elevations). This relatively small diurnal range suggests the possibility of a malfunctioning relative humidity sensor. Relative humidity patterns at the property are probably more similar to those observed in Phoenix than the site data would indicate.*

Phoenix data (Table 2.7-3) demonstrate an annual cycle, with maximum relative humidity occurring in winter as a result of cooler temperatures

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* Because of the suspected instrument malfunction, interpretation of site data was discontinued beyond August 1977.

Table 2.7-2. MEAN DIURNAL RELATIVE HUMIDITY ON THE ANDERSON PROPERTY: JUNE-AUGUST 1977

	Relative Humidity (%)			
Month	5 a.m.	11 a.m.	5 p.m.	11 p.m.
June	26	25	24	24
July	39	37	33	29
August	47	44	40	43

Table 2.7-3. NORMAL MEAN DIURNAL RELATIVE HUMIDITY IN PHOENIX, ARIZONA

	Relative Humidity (%)			
Month	5 a.m.	11 a.m.	5 p.m.	11 p.m.
January	66	44	30	55
February	59	37	25	47
March	58	33	23	44
April	44	23	15	29
May	36	17	12	22
June	35	18	12	22
July	46	28	20	33
August	53	34	24	39
September	53	31	23	40
October	53	30	22	42
November	61	38	28	52
December	69	48	35	60
Annual	53	32	22	41

Source: U.S. Department of Commerce, 1976.

Period of record: 15 years, 1962-1976.

and the occasional passage of moisture-laden Pacific air masses, and a secondary maximum (apparent in the 11 a.m. and 5 p.m. data) occurring in August (the month of peak thunderstorm activity and peak precipitation) as a result of moist air masses originating in the Gulf of Mexico and along the western coast of Mexico.

Precipitation

Tropical air masses from the Gulf of Mexico and the western coast of Mexico are the source of peak monthly rainfall in Arizona, occurring as widespread thunderstorm activity in July and August. The other rainfall season occurs during the winter months, from November through March, when the area is subjected to occasional storms from the Pacific Ocean. While this is classed as a rainfall season, there can be periods lasting a month or more in this season (or in any other season) when practically no precipitation occurs. Spring and fall are generally dry, although substantial precipitation has fallen on occasion during every month of the year.

Analysis of regional precipitation data for selected stations at various elevations (Table 2.7-4) indicates that normal annual precipitation on the Anderson property may range from about 7.5 inches at lower elevations (near the Santa Maria River, about 1600 feet msl) to about 11 inches at higher elevations (in southern portions of the property where ground level rises to elevations of 2300 to 2400 feet msl). Normal annual precipitation at the proposed mill site (approximate elevation 1800 feet msl) is probably between 8 and 9 inches. Normal monthly and

Table 2.7-4. NORMAL ANNUAL PRECIPITATION AT SELECTED REGIONAL WEATHER STATIONS

Station[a]	Elevation (feet msl)	Annual Precipitation (inches)
Litchfield Park[b]	1030	7.56
Phoenix Skyharbor Airport[b]	1117	7.05
Alamo Dam[c]	1100, 1480[d]	7.41
Wickenburg[b]	2095	10.76
Montezuma Castle National Monument[b]	3180	11.07

[a]Station locations are shown in Figure 2.7-2.

[b]Period of record: 30 years, 1941-1970.
Source: U.S. Department of Commerce, 1973.

[c]Period of record: 10 years, 1963-1968 and 1970-1973.
Source: U.S. Department of Commerce, 1963-1973.

[d]Alamo Dam station elevation changed in 1970 from 1100 feet to 1480 feet msl.

annual precipitation reported in Phoenix provides an indication of general seasonal fluctuations in precipitation (Table 2.7-5).

Data from the Anderson property are presently available for seven months, June through December 1977 (Table 2.7-6). Drought conditions existed in the region during 1977. During July and August, normally the wettest months of the year, a total of only 1.75 inches of rain was observed at the property. Other stations in the region reported abnormally low precipitation amounts that ranged between 1.5 and 2 inches below normal during the same period (U.S. Department of Commerce, 1977).

Most of the precipitation within the region occurs as rainfall. Usually snow, sleet, and hail account for traces or small percentages of total annual precipitation. However, stations in the region have reported from 1 to 16.5 inches of snowfall on occasion. During a 68-year period of record (1895-1962) at the Phoenix Post Office (elevation 1083 feet msl), a maximum of one inch of snow has fallen (most recently in January 1937). In Wickenburg (elevation 2095 feet msl), a maximum of two inches has fallen (most recently in December 1960) during a 51 year period of record from 1912 to 1962 (Green and Sellers, 1964). At Montezuma Castle National Monument (elevation 3180 feet), more than 1000 feet above the elevation of the proposed mill site, about 2.1 inches of snow normally falls. However, during a 24-year period of record from 1939 to 1962, a maximum of 16.5 inches was recorded

Table 2.7-5. NORMAL MONTHLY AND ANNUAL PRECIPITATION AT PHOENIX SKY HARBOR AIRPORT

Month	Precipitation (inches)
January	0.71
February	0.60
March	0.76
April	0.32
May	0.14
June	0.12
July	0.75
August	1.22
September	0.69
October	0.46
November	0.46
December	0.82
Annual	7.05

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

Period of record: 30 years, 1941-1960.

Table 2.7-6. MONTHLY PRECIPITATION OBSERVED ON THE ANDERSON PROPERTY, JUNE - DECEMBER 1977

Month	Total Monthly Precipitation (inches)
June	0.19
July	0.58
August	0.98
September	1.41
October	0.29
November	0.14
December (1-16)	0.02

in January 1949 (Green and Sellers, 1964). Wickenburg and Montezuma Castle National Monument are both shown in Figure 2.7-2.

Wind Speed, Wind Direction

Winds are generally light to moderate on the Anderson property (Figure 2.7-3). From the latter part of December 1976 through November 1977, hourly average wind speeds were observed to be 4 mph or less about 32 percent of the time, and 7 mph or less about 63 percent of the time. High hourly average wind speeds (25 mph or greater) were observed a total of 15 times (about 2 percent of the total observations). Almost half of these occurrences were observed in August with corresponding average wind directions ranging from northeast to southeast. Two occurrences were observed in June from the southeast, and four occurrences were observed in March and April from the west-northwest and the northwest. The remaining three occurrences were observed in the fall (September through November) from the south-southeast and east-southeast.

During the study period, predominant wind directions were west-southwesterly and westerly. Together those directions occurred almost 20 percent of the time. The next most frequent wind directions were northerly (11.7 percent) and southerly (9.6 percent). As indicated in Figure 2.7-4, general southerly directions dominated northerly winds; winds out of the east-southeast through west-southwest occurred about 1.5 times more often than west-northwest through east-northeast winds. Figure 2.7-5 summarizes the relationship between wind direction and wind speed observed on the property. Comparisons of site data with

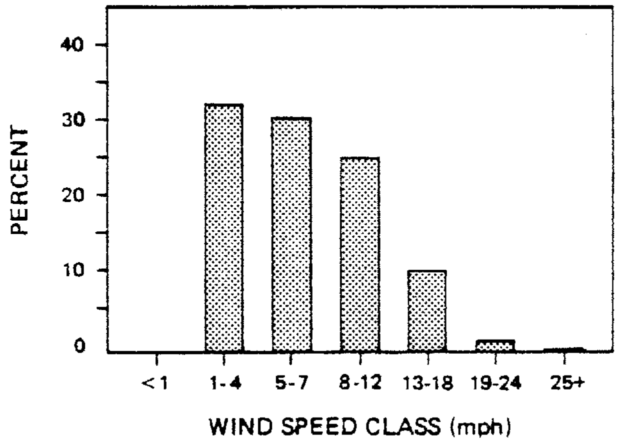

Figure 2.7-3. RELATIVE FREQUENCY DISTRIBUTION OF WIND SPEED CLASSES AT PROJECT SITE: December 22, 1976 - November 30, 1978

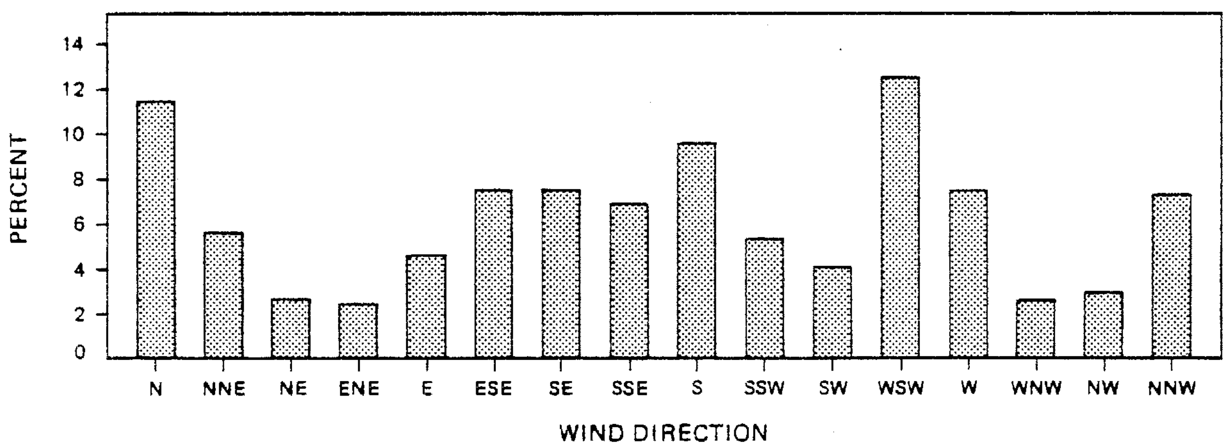

Figure 2.7-4. RELATIVE FREQUENCY DISTRIBUTION OF WIND DIRECTION AT PROJECT SITE: December 22, 1976 - November 30, 1978

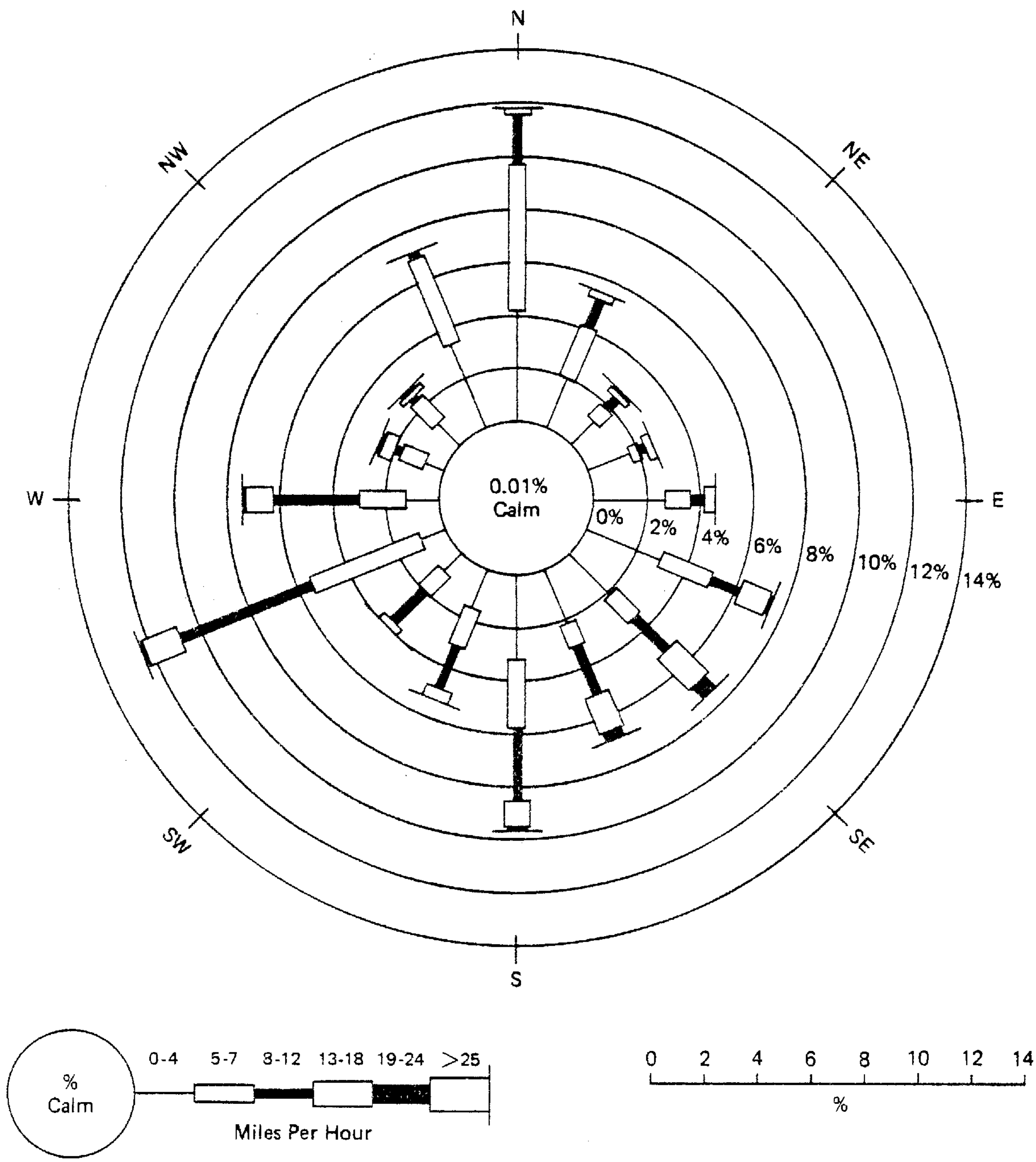

Figure 2.7-5 WIND ROSE FOR THE PROJECT SITE, FOR THE PERIOD DECEMBER 1976 THROUGH NOVEMBER 1977, ANNUAL AVERAGE CONDITIONS

concurrent data from regional weather stations (including Phoenix, Prescott, and Yuma*) indicate that wind direction patterns on the property are significantly different from other areas in the region.

Winds on the Anderson property exhibited a relatively complex diurnal pattern that varied with the seasons. The differences in seasonal patterns (mostly between winter and summer) are probably the combined result of terrain effects and regional circulation that both change with the seasons. During the winter, wind direction was observed to usually follow a full 360-degree, counter-clockwise diurnal shift, with general northerly directions predominating during early morning (after midnight) and continuing almost until noon. Beginning around noon and continuing through about 6:00 p.m., west-southwesterly winds predominated. Subsequently, the wind direction shifted through south and east during evening hours, returning to northerly flow at about midnight. Data taken during the first half of December 1977 also indicate this same general pattern.

During summer, winds exhibited a cyclic southeast-southwest pattern, shifting through south. Directions north of east and west occurred only about 22 percent of the time, and only during morning hours. Topography and its effects on local meteorology are complex in the site area, but it is suspected that daytime southwesterly directions are the result of

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* Wind data for these areas can be obtained from the U.S. Department of Commerce, National Climatic Center, Asheville, North Carolina.

general up-gradient flow along the Santa Maria River. Nighttime southeasterly directions are probably the result of down-gradient flow from higher terrain southeast of the meteorological tower site. Spring and fall both appear to be periods of transition. The diurnal wind direction distributions for these two seasons are similar and appear to represent combinations of the summer and winter patterns. Diurnal frequency distributions for each season and for the entire study period are provided in Appendix B-2.

Dispersion Climatology

In addition to wind speed and wind direction, the ability of the atmosphere to disperse air pollutants depends on several atmospheric variables including stability, mixing depth, and topographic boundaries. Topography is relatively rugged on the property and in some directions, primarily to the south, may tend to inhibit dispersion potential.

Pasquill (1961) and Turner (1964) have developed methods for estimating atmospheric stability based on surface meteorological observations. The input parameters for these calculations are solar altitude, cloud cover, ceiling height, and wind speed. Methods are also available for the estimation of atmospheric stability from the standard deviation of wind direction (sigma-theta, σ_θ). According to the Pasquill system, atmospheric stability is classified as follows:

Pasquill Stability Classification	Degree of Atmospheric Stability	σ_θ *
A	Extremely unstable	25°
B	Unstable	20°
C	Slightly unstable	15°
D	Neutral	10°
E	Slightly stable	5°
F	Stable	2.5°
G	Extremely stable	1.7°

No long-term estimates of atmospheric stability are available in the vicinity of the Anderson property. However, data collected near the property indicate that relatively good atmospheric dispersion conditions exist much of the time. Estimates of atmospheric stability class based on determinations of wind direction deviation, sigma-theta (σ_θ using methods developed by Slade, 1966), indicate a relatively high occurrence of good dispersion conditions. Stability classes A through D occurred about 71 percent of the time during the study period (Table 2.7-7). A relative frequency distribution of wind direction and wind speed by stability class is presented in Appendix B-3 for the study period. This distribution was used for the radiological impact assessment and annual average dispersion modelling for non-radiological air quality impact assessments.

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*Based on Table 2 of NRC Safety Guide 23 (NRC, 1972).

Table 2.7-7. SEASONAL AND ANNUAL RELATIVE FREQUENCY DISTRIBUTIONS OF ATMOSPHERIC STABILITY CLASSES ON THE ANDERSON PROPERTY

Season	Percent Occurrence of Stability Classes					
	A	B	C	D	E	F&G
Winter	2.9	11.0	18.4	35.3	29.8	2.5
Spring	4.7	17.2	14.6	40.7	19.5	3.2
Summer	1.8	22.0	12.9	43.9	16.4	3.0
Fall	2.2	7.9	12.3	36.2	28.2	13.3
Annual	2.9	14.7	14.3	39.3	23.1	5.7

Period of Record: December 22, 1976 - November 30, 1977.

Mixing depth, a measure of the thickness of the atmospheric layer into which air pollutants can be mixed, is an additional useful indicator of dispersion potential. Better dispersion results from greater mixing depth, with a greater volume of air available for dilution of pollutants. Furthermore, the mixing depth typically increases as wind speeds increase.

Low-level nocturnal temperature inversions, which result in low mixing depths, commonly form in the region, particularly in winter. Mixing depth usually increases in the morning and afternoon as daytime solar radiation increases surface temperatures, resulting in convective mixing. During the winter, upper-level inversions can also extend through daylight hours. If these inversions persist, they can create stagnant conditions near ground level for extended periods.

Holzworth (1972) studied mixing depths and wind speeds within the mixing layer for a number of weather stations and generated isopleths for the United States. Table 2.7-8 presents estimated mixing depths and wind speeds for the Anderson property from Holzworth's work. Diurnal variations and seasonal variations in afternoon mixing depths are pronounced, but only small variations in seasonal morning depths were noted. Holzworth's data indicate that low morning mixing depths exist, especially in the winter. However, afternoon mixing depths are among the highest in the country. The average morning wind speeds within the mixing layer are less than afternoon wind speeds, and average wind speeds in winter and autumn are generally less than those in summer and spring, as would be expected.

Based on the above information, atmospheric dispersion conditions on the Anderson property are expected to be reasonably good. As in most areas of the country, the lowest potential for dispersion of atmospheric pollutants usually occurs during the morning, with light wind speeds, high stabilities, and a shallow mixing layer. The highest dispersion potential should occur during spring and summer afternoons. Topography will play a role in dispersion of emissions from proposed project activities. Some topographic effects have been approximated for assessment of project-related impacts through the use of the EPA Valley Model as discussed in Appendix B-6.

Severe Weather

Thunderstorms are frequent during the summer and early fall, when moist air moves into the region from the Gulf of Mexico and the western

Table 2.7-8. ESTIMATED AVERAGE MIXING DEPTHS AND WIND SPEEDS IN MIXING LAYERS FOR THE ANDERSON PROPERTY

	Mixing Depths (meters)	Wind Speeds (meters/sec)
Annual		
Morning	300	4
Afternoon	2400	6
Winter		
Morning	280	3.5
Afternoon	1300	4.5
Spring		
Morning	300	4.5
Afternoon	2600	7
Summer		
Morning	250	4
Afternoon	3200	6
Autumn		
Morning	250	3.5
Afternoon	2100	5

Source: Holzworth, 1972.

coast of Mexico. Related precipitation is usually light, but a heavy local storm can produce over an inch of rain in a single day. The maximum precipitation reported to have fallen within 24 hours over a 38-year period of record at Phoenix was 3.07 inches (U.S. Department of Commerce, 1975). Hailstorms are observed infrequently in this area.

Table 2.7-9 shows the maximum precipitation estimated for any given location on the property (point precipitation) for specific durations and recurrence intervals. The table was compiled using technical procedures outlined by Hershfield (1961) and Miller (1964). Maximum short-term precipitation is usually associated with summer thunderstorms, although winter storms may on occasion deposit comparable amounts of moisture.

Table 2.7-9. ESTIMATED MAXIMUM POINT PRECIPITATION (inches) FOR SELECTED DURATIONS AND RECURRENCE INTERVALS AT THE PROPERTY

	Recurrence Interval				
Duration	2 years	10 years	25 years	50 years	100 years
1 hour	0.7	1.3	1.6	1.8	2.0
12 hours	1.5	2.5	3.0	3.5	4.0
24 hours	1.8	3.0	3.6	4.0	4.6
2 days	2.2	3.3	4.7	5.0	5.3
7 days	2.6	4.5	5.5	6.5	7.0
10 days	3.0	5.0	6.0	7.5	8.0

Sources: Hershfield, 1961; Miller, 1964.

Strong winds can occur in the project area along with thunderstorm activity in the spring and summer. Based on computations by Thom (1968), "extreme-mile" wind speeds 30 feet above the ground are estimated for selected recurrence intervals on the property as follows:

Maximum speed (mph)	62	65	74	80
Recurrence interval (years)	10	25	50	100

The project area is susceptible to duststorms, which vary greatly in intensity, duration, and time of occurrence. The basic conditions for blowing dust are found in the general region: wide areas of exposed, dry topsoil and strong, turbulent winds. Duststorms usually occur during the warmer months following frontal passages and are occasionally associated with thunderstorm activities.

Tornadoes have been observed in the general region, but they occur infrequently. Based on the work of Markee et al. (undated), the probability (P) of a tornado striking a given point on the Anderson property is estimated to be 1.2×10^{-4}. The recurrence interval (1/P) of such an incident is estimated to be about 8300 years.

AIR QUALITY

The Anderson property is located in an isolated rural area of west-central Arizona. Air quality is generally very good and is influenced by natural processes, and occasionally by long-range transport of air pollutants from major urban centers. The nearest town is Bagdad, about 22 miles north-northeast of the property (Figure 2.1-1); the nearest major roadway is U.S. Highway 93 about 13 miles to the northeast; and the nearest major urban center is Phoenix, about 100 miles southeast of the property.

Existing air quality data are sparse for this area of Arizona and are not adequate to describe air quality on the property with statistical significance. Air quality monitoring on the Anderson property, described earlier in this section, has included three five-day monitoring programs conducted in the summer and autumn of 1977 and the spring of 1978. During these programs, suspended particulate matter, sulfur dioxide, and ozone were measured continuously. In addition, nitrogen dioxide, carbon monoxide, and hydrocarbons were measured during the spring 1978 program. A one-year monitoring program to measure suspended particulate concentrations once each week was also begun by MINERALS in September 1977.

The property is located within an area that has recently been designated by the EPA (1978) as an "attainment area" for suspended particulate matter and sulfur dioxide, indicating that National Ambient Air Quality Standards (NAAQS) (Table 2.7-10)* for these major pollutants are not exceeded. However, the EPA has determined that attainment status for photochemical oxidants, nitrogen dioxide, and carbon monoxide to be unclassifiable, on the basis that adequate monitoring data are not presently available for the area to determine attainment.**

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*Arizona has adopted the NAAQS. In the case of suspended particulate matter, the primary annual standard and the secondary 24-hour standard have been adopted.

**Recent attainment designations by Arizona (8/1/78) are the same for Yavapai County as present EPA designations.

Table 2.7-10. NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Description	Pollutant Standard	
		Primary	Secondary
Total suspended particulates	Solid and liquid particles in the atmosphere, including dust, smoke, mists, fumes, and spray	75 $\mu g/m^3$, annual geometric mean; 260 $\mu g/m$, maximum 24-hour average	60 $\mu g/m^3$, annual geometric mean; 150 $\mu g/m^3$, maximum 24-hour average
Sulfur dioxide	Heavy, pungent, colorless gas formed from combustion of coal, oil, and other sources	80 $\mu g/m^3$ (0.03 ppm), annual arithmetic mean; 365 $\mu g/m^3$ (0.14 ppm), maximum 24-hour average	1300 $\mu g/m^3$ (0.5 ppm), maximum 3-hour average
Carbon monoxide	Invisible, odorless gas formed from combustion of gasoline, coal, and other fuels; largest man-made fraction comes from automobiles	10 mg/m^3 (9 ppm), maximum 8-hour average; 40 mg/m^3 (35 ppm), maximum 1-hour average	Same as primary
Photochemical oxidants (such as ozone)	Pungent, colorless toxic gases; ozone is one component of photochemical smog	160 $\mu g/m^3$ (0.08 ppm), maximum 1-hour average	Same as primary
Nitrogen dioxide	Brown, toxic gas formed from fuel combustion. Under certain conditions, it may be associated with ozone production.	100 $\mu g/m^3$ (0.05 ppm), annual arithmetic mean	Same as primary
Hydrocarbons corrected for methane	Known to react with nitrogen oxides to form photochemical oxidants	160 $\mu g/m^3$ (0.24 ppm) 3-hour average from 6 a.m. to 9 p.m.	Same as primary

Source: Hoffman et al., 1975.

According to provisions of the federal Clean Air Act concerning Prevention of Significant Deterioration of Air Quality (and more recent EPA regulations 40 CFR 51 and 40 CFR 52), the Anderson property and surrounding region have been designated Class II. The closest Class I areas are the Sycamore Canyon Wilderness Area to the northeast and the Pine Mountain Wilderness Area to the east. Both of these Class I areas are about 80 miles from the property.

Particulate Matter

Sampling performed on the property to date* indicates generally low concentrations of particulate matter. The state/federal 24-hour standard of 150 $\mu g/m^3$ (micrograms per cubic meter) was not exceeded (Table 2.7-11). The highest value measured on the property was 104 $\mu g/m^3$, when the wind speed averaged 13 mph and ranged as high as 23 mph. Natural blowing dust is expected to have been the cause of this concentration. The geometric mean of the 42 particulate samples taken on the property is 15 $\mu g/m^3$. Data collected by the state from 1971 through 1976 at a background surveillance station located at Montezuma Castle National Monument (Figure 2.7-2) indicate similar air quality conditions (Table 2.7-12).

Significant surface activities (i.e., vehicular and equipment travel and drilling with air drills) began with the resumption of mineral

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*A standard high-volume air sampler fitted with a constant flow controller ($\pm$1 cfm) to increase sampling accuracy and calibrated with a calibrated orifice flow meter has been used to collect samples.

Table 2.7-11. TWENTY-FOUR-HOUR SUSPENDED PARTICULATE CONCENTRATIONS MEASURED ON THE ANDERSON PROPERTY[a]

Date	Concentration ($\mu g/m^3$)	Date	Concentration ($\mu g/m^3$)
7/13/77	38	12/9/77	19
7/14/77	58	12/16/77	23
7/15/77	73	12/23/77	23
7/16/77	39	12/31/77	10
7/17/77	77		
		1/7/78	6
9/16/77	20	1/12/78[c]	3
9/26/77	21	1/12/78	2
		1/4/78	5
10/1/77	13	1/21/78	7
10/8/77	6	1/28/78	5
10/15/77	11		
10/16/77	7	2/4/78	9
10/30/77	9	2/11/78	5
		2/18/78	3
11/5/77	39	2/25/78	15
11/9/77	18	3/4/78	-[d]
11/10/77	17	3/11/78	7
11/11/77	28	3/18/78	10
11/12/77	22	3/25/78	8
11/15/77	18		
11/18/77	104	4/23/78	25
11/25/77	-[b]	4/24/78	27
		4/25/78	21
12/2/77	5	4/26/78	46
		4/27/78	23

[a]Sampling times are generally about 24 hours; however, the timer used to control sampling duration has been observed to occasionally run approximately 1 hour fast in a 24-hour period. This could result in a four percent error in the reported results. Sample periods are also occasionally short due to generator failure. Samples collected for periods less than about 20 hours are not reported.

[b]Sampler power supply ran out of fuel during sample collection.

[c]Two samples were taken simultaneously on January 12, 1978, one 3 feet above ground and the other 10 feet above ground.

[d]Missed due to bad weather and flooding.

exploration prior to the February 25, 1978 sampling period. Exploration activities were initially concentrated in the vicinity of pit sequence 1 (Figure 3.1-2) which is less than 1/2 mile southwest of the sample site. It is meaningful to note in Table 2.7-11 that no significant corresponding increase in measured suspended particulate concentrations was observed during these activities.

Table 2.7-12. SUMMARY OF BASELINE SUSPENDED PARTICULATE CONCENTRATIONS FOR MONTEZUMA CASTLE NATIONAL MONUMENT, ARIZONA

	24-hour Averages		
Year	Maximum ($\mu g/m^3$)	Second Highest ($\mu g/m^3$)	Geometric Mean ($\mu g/m^3$)
1971	49	*	21
1972	111	*	26
1973	54	54	28
1974	72	64	27
1975	164	103	27
1976	64	59	30

Source: Arizona Department of Health Services, 1972-1977.

*Not reported.

Table 2.7-13 presents data for sulfate, nitrate, and lead concentrations in nine particulate samples collected at the site. Measured ambient sulfate concentrations ranged from 1.8 to 4.6 $\mu g/m^3$ and averaged 3.1 $\mu g/m^3$. These concentrations are well below the 25 $\mu g/m^3$ standard adopted by California, one of the few states with a sulfate standard. In 1975, sulfate concentrations reported for Montezuma Castle National

Table 2.7-13. TWENTY-FOUR-HOUR AVERAGE CONCENTRATIONS OF PARTICULATE SULFATE, NITRATE AND LEAD AT THE ANDERSON SITE*

Sample Date	Total Particulate ($\mu g/m^3$)	Sulfate		Nitrate		Lead	
		Ambient ($\mu g/m^3$)	Percentage of Particulate Weight	Ambient ($\mu g/m^3$)	Percentage of Particulate Weight	Ambient ($\mu g/m^3$)	Percentage of Particulate Weight
9/16/77	20	2.4	12	1.0	5	0.02	0.09
9/25/77	21	1.9	9	0.8	4	0.02	0.08
9/30/77	13	2.7	21	1.6	12	0.04	0.3
10/7/77	6	2.7	44	2.3	21	0.03	0.5
10/21/77	7	3.4	46	0.9	12	0.02	0.3
10/29/77	9	4.6	51	1.3	14	0.05	0.6
11/4/77	39	4.6	12	1.9	5	0.07	0.2
11/18/77	104	3.7	4	2.1	2	0.05	0.04
12/2/77	5	1.8	36	1.0	20	0.02	0.5

*Concentrations based on analytical data provided by Union Oil Company, March 1978. Particulates were sampled for approximate 24-hour periods.

Monument averaged 2.5 $\mu g/m^3$ (Arizona Department of Health Services, 1976). Sulfate accounted for as much as 51 percent of the total particulate weight in 1 sample and averaged 26 percent in the 9 samples. It is suspected that native soils in the area are a major contributor to the observed airborne sulfate concentration. However, ambient sulfate levels did not correlate well with ambient suspended particulate levels.

Always lower than sulfate, ambient nitrate concentrations ranged from 0.8 to 2.3 $\mu g/m^3$ in the 9 samples and averaged 1.4 $\mu g/m^3$. This value is very close to the 1.3 $\mu g/m^3$ mean reported for 29 non-urban National Air Surveillance Network stations located throughout the country (Williams et al., 1973). Nitrate accounted for as much as 21 percent of the total particulate weight in 1 sample, but ranged as low as 4 percent of the total. As in the case of sulfate, natural soils in the region are suspected of contributing particulate nitrate to the ambient air.

Sulfate and nitrate combined accounted for 6 to 65 percent of the total particulate weight. The highest percentage occurred in two samples with relatively low total particulate concentration. Conversely, the lowest percentage corresponded to the highest ambient particulate concentration of the nine samples analyzed.

Ambient particulate lead concentrations for the 9 samples ranged from 0.02 to 0.07 $\mu g/m^3$. For comparison, particulate lead concentrations averaged 0.1 $\mu g/m^3$ at Montezuma Castle National Monument in 1975 (Arizona Department of Health Services, 1976). These levels are well below the proposed 1.5 $\mu g/m^3$ National Ambient Air Quality Standard for lead. By weight, lead accounted for only 0.04 to 0.6 percent of total suspended particulate matter. As in the case of sulfate and nitrate, the lowest percentage of lead corresponded to the highest ambient particulate concentration.

Sulfur Dioxide

Consecutive 24-hour-average sulfur dioxide (SO_2) concentrations were measured on the property during the three 5-day monitoring programs, using the Federal Reference Method (West-Gaeke bubblers). Solutions supplied and analyzed by the Arizona Bureau of Air Quality Control were kept in a temperature-controlled shelter during sampling (approximately 200 ml/min air flow rate), and were placed on ice immediately following sampling and kept there until delivery for analysis. These precautionary measures were taken to minimize the possibility of sample degradation.

Sampling results (Table 2.7-14) indicate generally low background SO_2 concentrations that are well below state/federal standards. However, the observed concentrations were higher then would be expected at such a remote site during the first two sampling periods. Potential reasons for the unexpectedly high results could include influence of emissions from the diesel electric power source located downhill and approximately 200 feet from the monitoring station, and possible analytical error or bias. Results from the third period are within the expected range.

Table 2.7-14. TWENTY-FOUR-HOUR SULFUR DIOXIDE CONCENTRATIONS MEASURED ON THE ANDERSON PROPERTY ($\mu g/m^3$)

Date	Concentration	Date	Concentration	Date	Concentration
7/13/77	9	11-9-77	14	4-23-78	6
7/14/77	17	11-10-77	14	4-24-78	6
7/15/77	11	1-11-77	25	4-25-78	3
7/16/77	11	11-12-77	21	4-26-78	<3
7/17/77	16	11-13-77	14	4-27-78	<3

Photochemical Oxidants

Ozone, a major component of photochemical oxidants in rural air, was monitored continuously with a Bendix 8002 Ozone Analyzer (chemiluminescence method) during all three 5-day field studies. The monitor was calibrated against a calibration standard and a calibrated monitor at the Arizona Bureau of Air Quality Control immediately prior to each study. In addition, operational checks were performed daily with an internal ozone generator.

In general, observed ozone concentrations were well below the federal one-hour standard (0.08 ppm). However, levels reached 75 percent of the standard on one day during each the July 1977 and April 1978 studies.

A diurnal cycle was observed in hourly average ozone concentrations during each field study, with higher concentrations occurring during the daytime and lower concentrations during the night. The highest concentrations and greatest daily ranges were observed during the July study as would be expected with greater solar radiation during summer months. Concentrations ranged between 0.025 ppm and 0.062 ppm in July, but were generally below 0.010 ppm during the November study when observed hourly average concentrations ranged between 0.005 ppm and 0.010 ppm. Concentrations during the April study ranged from 0.029 ppm to 0.062 ppm. Observed hourly average ozone concentrations are provided in Appendix B-4.

Synoptic (large-scale) meteorological features in the project region were quite similar during the two 1977 field sampling periods. During both periods, the region was dominated by a quasi-satisfactory anticyclone and southeast winds with surface speeds of five to eight knots. These conditions indicate Phoenix as a possible source of ozone precursers during the 1977 field studies. Long-range transport of photochemical oxidents in urban air pollution plumes to remote rural areas has been observed in other areas of the country.

Due to the passage of the remnants of a cold front, regional air flow was mostly westerly at 5 to 10 knots during the April 1978 field study. However, local winds measured onsite were generally southeasterly to southwesterly, indicating that local conditions dominated the local wind field.

Nitrogen Dioxide

During the April 1978 monitoring period, 24-hour nitrogen dioxide concentrations were determined by the sodium arsenite bubbler method. Solutions were supplied and analyzed by the Arizona Bureau of Air Quality Control. Precautionary measures taken to minimize sample degradation were similar to those used for the sulfur dioxide samples.

Sampling results indicate low background levels of nitrogen dioxide, less than the analysis threshold value of 3 $\mu g/m^3$ on all days. This indicates that concentrations are well below the federal standard of 100 $\mu g/m^3$ (annual arithmetic mean).

Carbon Monoxide

Carbon monoxide was monitored continuously during the April 1978 study using an EPA equivalent method. The first three one-hour averages recorded were 0.50 ppm, 0.60 ppm, and 0.60 ppm (samples taken at 1600, 1700, and 1800 hours, respectively). During the remainder of the 5-day sampling period, values were less than the analysis threshold concentration of 0.42 ppm. Consequently, the first measurements are suspected to be in error. All values are well below federal standards.

Trace Gases and Total Hydrocarbons

Ambient air grab samples were collected for 15 minutes in a stainless steel bottle during the April 1978 field program. These samples were forwarded to the Oregon Graduate Center for analysis under the direction of Dr. R.A. Rasmussen.

Fluorocarbon concentrations (Table 2.7-15) in the samples indicate that the study area was not experiencing any significant influx of urban air during the sampling period. The trace gas levels and ranges also appear to be consistant with a clean air mass. All 10 samples indicated a background carbon monoxide concentration of about 0.2 ppm.

In general, most of the hydrocarbon samples (Table 2.7-16) indicate a rural air quality situation. However, samples 3, 9, and 10 contained hydrocarbon concentrations of 118 $\mu g/m^3$, 70 $\mu g/m^3$, and 157 $\mu g/m^3$, respectively. These higher levels are expected to be the result of interference by local generator exhaust. The 3-hour federal hydrocarbon standard of 160 $\mu g/m^3$ was not exceed in any of the samples.

Table 2.7-15. GRAB SAMPLES - TRACE GAS[a] CONCENTRATIONS (1978)

Sample No.	Date (1977)	Time (Hour)	N_2O (ppbv)	F-12 (pptv)	F-11 (pptv)	CH_3CCl_3 (pptv)	CCl_4 (pptv)	CO (ppbv)	CH_4 (ppmv)
1	4/23	1700	333	281	166	159	142	160	1.67
2	4/24	0900	333	284	168	130	140	167	1.67
3	4/24	1530	333	291	188	130	140	162	1.67
4	4/25	0715	335	293	172	143	142	175	1.68
5	4/25	1530	333	278	162	127	142	135	1.64
6	4/26	0730	335	284	167	161	140	183	1.67
7	4/26	1500	340	282	168	135	142	158	1.68
8	4/27	0730	345	296	179	174	142	210	1.69
9	4/27	1515	333	286	168	146	140	180	1.68
10	4/28	0745	333	287	182	135	142	186	1.68

[a] N_2O = Nitrous Oxide

F-12 = Freon-12

F-11 = Freon-11

CH_3 CCl_3 = 1,1,1-Trichloro Ethane

CCl_4 = Carbon Tetracholride

CO= Carbon Monoxide

CH_4= Methane

Table 2.7-16. GRAB SAMPLES - HYDROCARBON CONCENTRATIONS (1978) ($\mu g/m^3$)

Sample No.	Date	Ethene	C_2 Hydrocarbons Ethane	Acetylene	Lights C_3 to $_{12}$	Heavy's C_6 to $_{12}$	TOTAL
1	4/23	0.41	2.23	0.43	16	15	34
2	4/24	2.47	2.46	0.50	19	11	35
3	4/24	8.29	2.27	0.36	40	67	118
4	4/25	0.75	2.15	0.40	16	19	38
5	4/25	0.39	1.48	0.29	9	17	28
6	4/26	1.95	1.56	0.52	8	24	36
7	4/26	0.44	1.82	0.35	10	22	35
8	4/27	7.27	3.14	0.56	26	17	54
9	4/27	0.94	2.45	0.46	10	56	70
10	4/28	14.32	2.43	0.45	22	118	157

2.8 BIOLOGY

Biological field studies were conducted on the Anderson property and in the vicinity of the proposed access road and Palmerita Ranch water pipeline from February through October, 1977 (Dames & Moore, 1978a and b). Both quantitative and qualitative information on the plant and animal communities in the area was collected during these studies. Sampling procedures used during the field program are discussed in Appendix C-1. Sampling locations were selected randomly in areas undisturbed by previous mining activities. The locations of sampling sites are given in Figure 2.8-1.

The following discussion is based largely on the results of the these field studies. This information was supplemented by data on the mesquite bosque near Palmerita Ranch collected by personnel from the Arizona Academy of Science (Smith and Bender, 1973).

VEGETATION

The Anderson property is located within the Sonoran Desert (Lowe, 1964 and Lowe and Brown, 1973). The plant associations on and in the vicinity of the property can be generally classified into two broad subdivisions of this desert; the Lower Colorado Subdivision, which is dominated by creosotebush/bursage communities, and the Upper Arizona Subdivision, which is characterized by palo verde/saguaro cactus plant communities.

Although most of the species growing in the vicinity of the Anderson property are typical of Sonoran Desert vegetation, there are two, Joshua tree and bladdersage, that are characteristic of the Mohave Desert to the west. The presence of both saguaro cactus and Joshua trees in this area denotes that it is part of a transition zone (or ecotone) between the Sonoran and Mohave deserts (Lowe, 1964).

Four vegetation types were identified in the vicinity of the Anderson property and the proposed access road (Dames & Moore, 1978a and b). These communities are upland desert, Joshua tree woodland, riparian, and pseudoriparian (Figure 2.8-1). The species identified in each of these vegetation types are listed in Table C-2, Appendix C-2.

The four types are recognized primarily by those species that are visibly dominant (over six feet tall). It should be noted that a large number of the plants identified during the field studies are common to most of the types.

Upland Desert

Upland desert constitutes the largest vegetation type on the property, covering more than 2/3 of the area. Species composition and density varies considerably within this vegetation type due to microclimatic and edaphic variability across the property; however, the upland desert type is readily definable.

Vegetation over six feet high in the upland desert community is dominated by palo verde and Joshua trees. These two species have an average dominance value (measured in square feet of basal area per acre) of 2494 and 1298.6, respectively (Table 2.8-1). Although less abundant, saguaro cactus and ocotillo (average dominance values of 602 and 752, respectively) are also common in the upper strata of this type.

Below six feet, the basal area cover of upland desert vegetation is relatively low, varying from 0.6 percent (sample site 7) to 14.8 percent (sample site 8) and averaging 5.3 percent (Table 2.8-2). Shrubs constitute most of this lower strata, accounting for an average of 73 percent of the total basal area cover (Table 2.8-2). The most common shrubs throughout the type are creosotebush, brittlebush, and white bursage.

Except for sample site 13, cacti, lilies, and their allies constitute less than one percent of the cover in the upland desert type. Yucca, a member of the lily family, had a total basal area cover of 57 percent at sample site 13. Grasses and forbs are also relatively sparse, comprising approximately 13 percent of the total basal area cover.

The paucity of desert succulents in the vicinity of the property may be due to soil conditions. Loose gravels or rock crevices where infiltration of precipitation is rapid are necessary for the

TABLE 2.8-1

DENSITY AND DOMINANCE OF UPPER STRATA PLANTS
BASED ON POINT-CENTERED QUARTER DATA

		Palo Verde		Saguaro		Joshua Tree		Ocotillo	
Location	Site	Den.[a]	Dom.	Den.	Dom.	Den.	Dom.	Den.	Dom.
North-facing Slope	1	20	5865	8	202	11	3142	20	1071
	7	16	965	23	296	59	167	57	668
	8	27	652	7	1308	15	587	19	517
MEAN		21.0	2494.0	12.6	602.0	28.3	1298.6	32.0	752.0
Joshua-tree Forest	2	-	-	-	-	10	7162	22	719
	5	12	1539	-	-	20	5669	17	679
	6	-	-	-	-	8	4619	46	283
MEAN		4.0	513.0	0.0	0.0	12.6	5816.8	28.3	560.3

* Density and dominance given as absolute values (Phillips, 1959)

Density given as number per acre.

Dominance given as basal area per acre (in sq.ft.).

Source: Dames & Moore, 1978a.

TABLE 2.8-2.

PERCENT BASAL COVER AND PERCENT RELATIVE COVER OF VEGETATION MEASURED ON LINE INTERCEPTS AT FOURTEEN SAMPLE SITES

SAMPLE SITES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
I. TREES														
% basal cover	ND[a]	ND	0.2[c]	3.0	ND	ND	ND	ND	-[b]	-	ND	ND	ND	ND
Mesquite			100	100										
II SHRUBS, CACTI, LILIES, AND ALLIES														
% basal cover	1.1	0.6	0.2	0.4	10.1	7.6	0.6	12.9	31.7	27.0	5.7	4.8	2.5	22.0
Agave													16	
Brittlebush	21						46							
Burrobrush								9	38					13
Cane Cholla							2		1					
Catclaw				3										7
Creosotebush	60	41			38	19	24	32			69	64	8	5
Englemann Pr. Pear						<1								
Goldenweed					20		13							
Hedgehog Cactus	<1	<1												
Joint-fir						5								
Mesquite			100	89					61	96				75
Paper flower					8	30		18						
Ratany							2							
Saltbush	19	36												
Senecio spp.		23								4			10	
Unidentified spp.							12	9						
White Bursage					34	46		30			31	36		
Wolfeberry				8			1	2						
Yucca													66	
III. GRASSES														
% basal cover	0.2	0.1	0.8	0.3	1.0	0.6	-	1.9	19.0	6.2	0.4	0.4	0.2	-
Bermuda										15				
Big Galleta					51	73		18						
Bush Muhley								24						
Dropseed	48													
Fluffgrass					24	9		40						
Mediterranean Grass	11	18	100	100	6									
Muhley spp.	36													
Red Brome	5										41			
Tobosa Grass		82			19	18		18			59	100	100	
Annual Grasses									100	85				
IV. FORBS														
% basal cover	0.2	0.2	-	-	-	-	-	-	-	0.1	0.3	0.2	0.2	-
Desert Mallow	18													
Filaree	26	33												
Four O'Clock												90		
Owlflower	56	67												
Skeletonweed													100	
Wild Gourd										100				
Wooly Indianwheat											100	10		

a. ND - no data, line intercept (300 ft per line) for the cover used only at sites 3, 4, 9, 10.
b. Dash means no basal cover of the size-class (vertical strata) detected on the intercept
c. % basal cover = $\frac{\text{sum of basal area intercepted}}{\text{300 ft.}} \times 100$

% relative cover = $\frac{\text{sum of species interception}}{\text{total interception for strata}} \times 100$ (rounded to nearest integer greater than one)

* Not identified to species due to absence of specific taxonomic characters.

Source: Dames & Moore, 1978a.

prolific growth of these succulents, particularly cacti. While sandy to gravelly soils are present on and in the vicinity of the property, they may not be sufficiently permeable to support large numbers of these plants.

Precipitation in the Sonoran Desert is seldom high enough to support extensive grasslands. While a variety of annual and perennial grasses such as big galleta, tobosa, dropseed, and fluffgrass are adopted to these arid conditions, they seldom constitute a major portion of any of the desert plant communities. Essentially the same is true for forb species. Grasses and forbs on the property may have been further reduced by the drought conditions that prevailed before and during the field study period and by grazing pressure (refer below to the discussion on Range Condition for further description of the effects of grazing).

As can be expected in desert environments, the response of annuals to sporadic precipitation provides seasonal variation in the species composition of the vegetation on the Anderson property. The first four vegetation sites were sampled in April and the remaining sites were sampled in October. Annual grasses were relatively abundant during the spring sampling period and almost nonexistant in the fall (Table 2.8-2). The composition of the forb component also varied between seasons. Globe mallow, filaree, and owl clover were particularly common in the spring while four o'clock, skeleton weed, wild gourd, and wooly Indianwheat were common in the fall (Dames & Moore, 1978a).

Joshua Tree Woodland

Joshua tree woodland is located on top of the mesa to the south and southwest of the Anderson property (Figure 2.8-1). It generally occurs above the 2000-foot contour. This type is the most prevalent vegetation association along the right-of-way for the proposed access road.

Joshua tree woodland is distinguished from the upland desert type by a lack of saguaro cactus (Table 2.8-1). The paucity of this species may be due to soil conditions. Saguaro cactus is relatively shallow-rooted and top-heavy. In fine soils similar to those on the mesa top, the species is frequently up-rooted by winds and flash flooding. On coarser soils, such as those found on the Anderson property, the species is much more stable.

Species composition of the understory in the Joshua tree woodland is virtually identical to the understory of the upland desert type (Table 2.8-2). However, total basal area cover in the woodland understory is slightly higher than in the understory of the upland desert. Total cover in the Joshua tree woodland averages 6.7 percent compared to 5.3 percent for the upland desert type. If the results from sample site 8 (Table 2.8-2) are deleted, the average basal area cover of the upland desert understory falls to 3.4 percent.

This difference in basal area cover can probably be attributed to soil moisture conditions. Upland desert vegetation is most prevalent on the north facing slopes to the south of the Santa Maria River. Soils on these slopes consist primarily of sands, sandy gravels, and gravels. Soils on the mesa top where the Joshua tree woodland is most prevalent consist largely of silty sands that have a higher moisture retention capacity than the sands and gravels of the north-facing slopes. In addition, the level aspect of the mesa top probably results in a more favorable infiltration to runoff ratio than on the north-facing slopes. Since the mesa top is at a higher elevation than the slopes, it may also receive slightly more precipitation.

Riparian

Riparian vegetation is present along the Santa Maria River in the vicinity of the Anderson property (Figure 2.8-1). This vegetation consists largely of mesquite stands. Where undisturbed, these stands (termed mesquite bosques) are typically quite dense.

Sample sites 3 and 4 are representative of the riparian vegetation on the Anderson property (Figure 2.8-1 and Table 2.8-2). Overstory vegetation consists of essentially 100 percent mesquite. The understory shrub component is also composed largely of young mesquite plants. Other shrub species that may be found in the type in low numbers include white-thorn acacia, wolfberry, creosotebush, and burrobush. Forbs and grasses are often not present in the type. Where sufficient light and surface moisture are available, Mediterranean grass was found to be the most common herbaceous species in the riparian vegetation on the property.

A large, relatively undisturbed mesquite bosque is located along the Santa Maria River near the Palmerita Ranch in Sections 14, 15, and 16 of T11N, R11W (Figure 2.8-1). The bosque covers approximately 960 acres and is located on private land. It is quite dense and contains many old trees, some reaching a height of 25 feet. The only major disturbance to this bosque is an unimproved road running along its southern edge (Smith and Bender, 1973). The bosque has been recommended for designation as a Scientific Natural Area by the Arizona Academy of Science (Smith and Bender, 1973).

Pseudoriparian

Pseudoriparian vegetation is located along the intermittent streams and washes that drain the property and adjacent areas (Figure 2.8-1). Sample site 14 (Figure 2.8-1) is representative of this association (Table 2.8-2).

The pseudoriparian vegetation type is a transition between the riparian vegetation along the Santa Maria River and the upland desert (Dames & Moore, 1978a and b). Mesquite as well as shrub and tree species common to the upland desert are found in the type. Although quantitative data on the overstory component of the pseudoriparian association was not collected, mesquite, Joshua tree, and little-leaf palo verde were observed to be abundant in many of the draws and washes in the area (Dames & Moore, 1978b). The understory vegetation in the type consists largely of mosquite, burrobush, catclaw, and creosotebush (Table 2.8-2) although a variety of other shrubs, cacti, and herbaceous plants are also found in the association (Table C-2, Appendix C). Most of the shrubs observed in the pseudoriparian type were larger and more robust than individuals of the same species growing in adjacent upland areas. This is apparently due to increased soil moisture in the drainages.

Range Condition

Assuming no disturbance, plant communities such as those occurring on the Anderson property and in adjacent areas are described as ephemeral livestock range with the primary forage consisting of annuals such as grasses, filaree, Indianwheat, and mustards (Dames & Moore, 1978a). The growth of these annuals is closely tied to precipitation which is extremely varied from year to year.

Given that the property is not highly productive livestock range, its quality relative to similar habitats can be estimated based on the percentage of regression that has occurred from "climax" vegetation to early successional stages as the result of disturbance. Four range condition classes (excellent, good, fair, and poor) have been recognized (Dames & Moore, 1978a). Each condition class represents a 25 percent reduction in the vegetative potential of a given area of rangeland. The appropriate condition class is generally determined by the abundance of key indicator plant species. These plant indicators are termed decreasers, increasers, and invaders. Decreasers are native plant species such as galleta grass and bush muhley that become less abundant due to grazing pressure. Increasers are native species such as senegio, bursage, and bricklebush that become more abundant due to grazing pressure. Invaders are exotic (nonnative) plant species such as paperflower, buckwheat, and skeleton weed that also become more abundant on disturbed sites.

Point intercepts were taken at three locations in the Joshua tree woodland and one location in the upland desert type (Table 2.8-3). One of the samples (Sample D) was taken in a fenced exclosure constructed by the U.S. Bureau of Land Management (BLM) in the mid-1960's. The vegetation in this exclosure is representative of ungrazed Joshua tree woodland habitat.

As can been seen from the data in Table 2.8-3, the vegetation cover at sample sites A, B, and C was less than half that found in the exclosure. Big galleta grass, which is an important livestock forage plant and a decreaser, was more than five times as abundant in the exclosure than at the other sample sites. Bursage, an increaser, and paperflower, an invader, were found at all of the sample sites except the exclosure. These data, as well as field observations on the low reproduction of palatable forage plants, indicates that the property and adjacent areas are in the "poor" range condition class (Dames & Moore, 1978a).

TABLE 2.8-3

PERCENT RELATIVE COMPOSITION AND PERCENT ABSOLUTE COVER BASED ON POINT INTERCEPT DATA FROM FOUR SAMPLE SITES

SPECIES	SITES A*		B*		C*		D	
	% Com	% Cov	% Com	% Cov	% Com	% Cov	% Com	% Cov
Annual							4	2
Barrel Cactus	2	<1	-	-	-	-	-	-
Beavertail Cactus	-	-	-	-	1	<1	-	-
Blackbrush	2	<1	4	1	1	<1	-	-
Big Galleta	9	1	6	2	1	<1	18	10
Bladderpod	-	-	1	<1	-	-	-	-
Bush muhley	2	<1	1	<1	-	-	2	1
Cane Cholla	15	2	8	2	6	2	15	8
Catclaw	2	<1	5	1	-	-	4	2
Creosotebush	25	4	27	10	23	6	18	12
Desert Holly	-	-	-	-	-	-	2	1
Desert Trumpet	-	-	1	<1	-	-	-	-
Engelmann Pr. Pear	-	-	-	-	-	-	2	1
Eriogonum spp.	4	<1	3	1	4	1	-	-
Flat-top Buckwheat	4	<1	-	-	1	<1	-	-
Fluff Grass	-	-	-	-	1	<1	-	-
Globemallow spp.	-	-	-	-	-	-	2	1
Hedgehog Cactus	-	-	1	<1	-	-	2	1
Joint-fir	-	-	1	<1	1	<1	4	2
Joshua tree	-	-	4	2	-	-	2	8
Little-leaf Palo Verde	4	1	-	-	9	4	-	-

TABLE 2.8-3 concluded

SPECIES	A* % Com	A* % Cov	B* % Com	B* % Cov	C* % Com	C* % Cov	D % Com	D % Cov
Little-leaf Ratany	2	<1	3	1	1	<1	-	-
Mediterianean Grass	2	<1	9	2	4	1	5	3
Nightshade	-	-	-	-	-	-	2	1
Ocotillo	4	<1	4	1	1	<1	-	-
Paperflower	4	<1	8	2	2	<1	-	-
Red Brome	-	-	-	-	2	<1	9	5
Saguaro	-	-	-	-	2	<1	-	-
Squirrel-tail Grass	-	-	1	<1	-	-	-	-
White Brittlebush	-	-	--	-	4	1	-	-
White Bursage	19	3	8	3	19	5	-	-
Wild Gourd	-	-	-	-	-	-	9	5
Wool Indiantwheat	-	-	5	1	17	5	-	-
Total	100	11+	100	24+	100	25+	100	63

* Average of three 100-pt. intercept. A) 3 lines near sample site 6 - Joshua tree forest; B) 3 lines near sample site 5 - Joshua tree forest; C) 3 lines 0.2 miles north of sample site 1 - Sonoran Desert ecotone; and D) one line in an exclosure 4 miles west of Hwy. 93 on Alamo Rd. Joshua tree forest (see Plate 3.1.1-1).

$$\% \text{ Relative Composition} = \frac{\text{No. plants intercepted per species}}{\text{Sum plants intercepted for all species}} \times 100$$

$$\% \text{ Absolute Cover} = \frac{\text{No. Plants intercepted per species}}{\text{Total Plants taken}} \times 100$$

Source: Dames & Moore, 1978a

Drought conditions over the last few years and foraging by feral burros appear to be the primary factors causing a deterioration of the range in the vicinity of the Anderson property. Stocking rates for domestic animals can be easily adjusted to prevent range destruction, but drought and feral burros pose a more perplexing problem. The BLM has recently attempted to bring grazing pressure into balance with range production. They have removed a large number of burros from the general area as one means of reducing further deterioration of the range (Dames & Moore, 1978a).

Grazing pressure on the property is regulated by the BLM. The Anderson property is located in the BLM's Santa Maria Community Allotment which encompasses 62,000 acres. The stocking rate for this allotment is currently 198 animal units (defined as one cow or one cow with unweaned calf) per year (Dames & Moore, 1978a).

Threatened, Endangered or Protected Plant Species

The 1974 listing of protected plant species published by the Arizona Commission of Agriculture and Horticulture includes the following species identified on the Anderson property or in the adjacent area during the biological field program. It should be noted that none of these species are considered to be endangered or threatened.

- Mescal (Agave deserti). 0.1 mile north of the Anderson Mine at about 1800 feet. Approximately 20 plants.
- Saguaro (Cereus giganteus). Throughout upland desert type.

- Hedgehog cactus (Echinocereus fasciculatus). Throughout upland desert on exposed ridges above washes.

- Engelmann hedgehog cactus (E. englemannii). Same location as hedgehog cactus.

- Barrel cactus (Ferocactus acanthodes). On canyon walls and mesa slopes in Sections 3, 10, and 16, T11N, R10W.

- Ocotillo (Fourquieria Splendens). Throughout upland desert on well drained bajada and mesa.

- Crucifixion-thorn (Halocantha emoryi). SW 1/4 of Section 11, T11N, R10W. About 0.3 mile SW of Anderson Mine at base of rocky slope, elevation 1800 feet. Also on mesa slopes to the east and west.

- Fishhook pincushion (Mammallaria microcarpa). Throughout upland desert on slightly modified exposures or at sites where soils have some water retention capacity such as rock crevices, washes, and shaded areas.

- Bigelow nolina (Nolina bigelovii). Six plants immediately south of Anderson Mine road, SW 1/4 of Section 11, T11N, R10W, elevation 1820 feet.

- Buckhorn cholla (Opuntia acanthocarpa). Throughout upland desert on sandy or gravelly soils of benches, mesa slopes, and washes.

- Beavertail cactus (O. basilaris). Upland desert on well-drained sandy and gravelly soils above 1400 feet.

- Teddy bear cholla (O. bigelovii). On well drained, rocky or gravelly south-facing slopes and mesa tops below 2000 feet.

- Pancake prickly pear (O. chlorotica). A few isolated plants on north-facing rocky slopes of higher mesas facing the Santa Maria River in Section 3, T11N, R10W.

- Christmas cactus (O. leptocaulis). Mesas, bajadas, and arroyos throughout upland desert in sandy soils.

- Englemann prickly pear (O. phaecantha). Rocky, gravelly or sandy soils of higher mesas and bajadas in the upland desert to the east and north of the Anderson Mine.

- Banana yucca (*Yucca baccata*). Rocky to sandy soils on higher ridges and protected slopes in the upland desert north and east of the Anderson Mine.

- Joshua tree (*Y. brevifolia*). Throughout upland desert, particularly numerous on arroyo slopes above 1400 feet and in Joshua tree woodland on the mesa south and west of the Anderson property.

- Soaptree yucca (*Y. elata*). Throughout upland desert in arroyo flats and other locations having sandy alluvial soils above the Santa Maria River floodplain.

Agave mckelveyana, which is included in the proposed federal endangered plant list (Federal Register, 6/16/76), has been observed by BLM personnel* in Aso Pass near the proposed access road right-of-way. Larger concentrations of this species are present at higher elevations to the south in the Tres Alamos area and to the north extending well into the Black Mountains. Based on their findings, the Phoenix Office of the BLM intends to notify the U. S. Fish and Wildlife Service (USFWS) that *A. mckelveyana* should be removed from the proposed endangered list.* The U. S. Forest Service has already requested similar action.** The USFWS has recently contracted the Museum of Northern Arizona to conduct research regarding the proposed status of this and other potentially endangered plant species.**

WILDLIFE

A total of 95 species of land vertebrates were identified on the Anderson property and in the vicinity of the proposed water pipeline

*Personal communication, Mr. Dean Durfee, BLM Phoenix Area Manager, 1978.
**Personal communication, Ms. Carol Justice, USFWS Albuquerque Office, 1978.

route and access road (Table C-3, Appendix C-2). Of these species, 2 percent were amphibians, 16 percent were reptiles, 63 percent were birds, and 19 percent were mammals. The low number of amphibian species found in the area is due largely to the general lack of surface water. The large proportion of bird species is charcteristic of temperate terrestrial ecosystems. The mammals observed in the area were primarily rodent species.

Reptiles and Amphibians

Fifteen species of reptiles and two species of amphibians were observed in the vicinity of the Anderson property (Table C-3, Appendix C-3). As would be expected, the amphibian species were found exclusively in the riparian habitat along the Santa Maria River. Of the 15 reptile species, 8 were recorded in the riparian habitat, 6 in pseudoriparian vegetation, 9 in the Joshua tree woodland, and 13 in the upland desert type.

Only five reptile species were collected in the drop-trap grids established in the area (Figure 2.8-1 and Table 2.8-4). The data from this sampling program indicate that the greatest reptile activity took place in June, with the sideblotched lizard being the most commonly caught species followed by the western whip-tail and the banded gecko.

No significant difference in the numbers of captures per species or the total captures per season was found among trap grids (Friedmann Test, S = 16.5 in both cases). These results indicate that captured

TABLE 2.8-4

REPTILIAN COMPOSITION AND ABUNDANCE BASED ON NUMBER OF CAPTURES FROM FOUR 5 X 5 DROP-TRAP GRIDS

	GRID				
I. April 21-23	A*	B	C	C	Total
Side-blotched Lizard	-	-	2	1	3
Desert Horned Lizard	-	-	2	-	2
Western Whiptail	2	2	-	1	5
TOTAL	2	2	4	2	
II. June 8-10					
Banded Gecko	2	-	3	-	5
Side-blotched Lizard	1	-	8	1	10
Desert Horned Lizard	-	-	1	-	1
Western Whiptail	-	3	-	1	4
TOTAL	3	3	12	2	
III. October 21-23					
Zebra-tailed Lizard	1	-	-	-	1
Side-blotched Lizard	2	-	1	1	4
TOTAL	3	-	1	1	

*Grid A - Joshua tree woodland, B- Upland desert, C-Upland desert west of Anderson Mine, and D - Riparian

Source: Dames & Moore, 1978a

reptile species are widely dispersed in the area and show no selective habitat preferences (Dames & Moore, 1978a).

Birds

Based on census transect data (Figure 2.8-1 and Table 2.8-5), there is a significant seasonal change in the number of bird species and the density of birds on the Anderson property and the adjacent areas (Krushal-Wallis Test, $H = 14.20$, $P \leq 0.01$, and $H = 8.92$, $P \leq 0.05$, respectively). Wintering and breeding bird populations are relatively abundant in the riparian vegetation type (transects R-1 and R-2, Table 2.8-5) compared to the Joshua tree woodland (transects M-1 and M-2) and upland desert vegetation type (transects S-1 and S-2). The mesquite bosques along the Santa Maria River are apparently used heavily by resident species during the winter and by a variety of species that breed in the area during the summer. These bosques also appear to be an important habitat for arborescent birds that migrate through the area (Dames & Moore, 1978a).

Transect counts taken during each of four seasons were analyzed for species similarity and density similarity (Table 2.8-6). None of the transect data collected in February were similar in terms of species or mean densities. This indicates a dissimilarity of bird communities among the different vegetation types of the area during the winter. In April, species similarity was greater than 50 percent for all transects except for one case of Joshua tree woodland and mesquite bosque (Transect

TABLE 2.8-5.

AVERAGE BIRD DENSITY
(Per 100 ACRES) BASED ON 3-DAY TRANSECT COUNTS

I. February 25-27

	M-1	M-2	S-1	S-2	R-1	R-2
	$\bar{N}$			$\bar{N}$	$\bar{N}$	
Red-tailed Hawk				<1		
Gambel's Quail	<1				10	
White-throated Swift	<1				6	
Costa's Hummingbird					64	
Gila Woodpecker	2					
Ladder-backed Woodpecker					5	
Verdin	3			3	2	
Cactus Wren	4			2		
Rock Wren				3		
Bendire's Thrasher	1					
Black-tailed Gnatcatcher				3	2	
Phainopepla					8	
Loggerhead Shrike	3					
House Finch					136	
American Goldfinch					5	
Brown Towhee					2	
Black-throated Sparrow	12			7		
White-crowned Sparrow	12				9	
TOTAL AVERAGE DENSITY	~37			~18	249	
TOTAL SPECIES	9			6	11	

*Transect M-1, S-2, and R-1 were run in winter census. All transects were run during other seasons.

II. April 6-8

	$\bar{N}$	$\bar{N}$	$\bar{N}$	$\bar{N}$	$\bar{N}$	$\bar{N}$
Turkey Vulture	<1	<1	<1	<1	<1	<1
Sharp-shinned Hawk			<1	<1	1	2
Red-Tailed Hawk						
Golden Eagle			<1			
American Kestrel	1	<1				
Gambel's Quail	9	3	3	7	9	15
Mourning Dove	2	2			1	
Roadrunner	<1					
White-Throated Swift	<1		1		<1	

TABLE 2.8-5. (continued)

IV. October 21-23

	M-1	M-2	S-1	S-2	R-1	R-2
Red-tailed Hawk	<1					<1
American Kestrel	<1			<1		
Gambel's Quail	3	<1		5	16	
Mourning Dove			3	3		6
Roadrunner		2				
White-throated Swift					5	
Black-ch. Hummingbird						
Costa's Hummingbird					5	
Common Flicker		<1	<1		3	
Gila Woodpecker		2				
Ladder-backed Woodpecker					1	
Violet-green Swallow						1
Cliff Swallow						
White-necked Raven					<1	<1
Verdin			6	1	7	1
Cactus Wren	5	3	3	<1	1	
Canyon Wren					<1	
Rock Wren			2			
Mockingbird		2	<1			2
Curved-billed Thrasher			<1			
Sage Thrasher	2					
Robin						2
Black-tailed Gnatcatcher			5	1	14	6
Phainopepla			7		3	5
Loggerhead Shrike	<1		3	1		
Bell's Vireo					14	16
Yellow Warbler					5	
Yellow-rumped Warbler			2		2	
Brown-headed Cowbird			3			
House Finch		8	2	2	3	12
Lark Bunting		<1		10		
Vesper Sparrow	1					
Black-throated Sparrow	10	2	15	7		
Chippink Sparrow						3
Brewer's Sparrow	7					
White-crowned Sparrow	1					8
TOTAL AVERAGE DENSITY	28	19	51	30	79	63
TOTAL SPECIES	9	10	14	10	15	14

TABLE 2.8-5. (continued)

	M-1	M-2	S-1	S-2	R-1	R-2
Red-tailed Hawk					<1	
American Kestrel	<1					
Gambel's Quail	2	8	2	7	13	13
White-winged Dove	6		1	<1	36	21
Mourning Dove	5	3	4	4	21	4
Great Horned Owl		<1				
Elf Owl			<1			
Lesser Nighthawk	2	2	<1	1		
White-throated Swift						1
Black-ch. Hummingbird					7	9
Costa's Hummingbird	7	3		11	3	
Common Flicker	2		5	2	3	1
Gila Woodpecker			<1			
Ladder-backed Woodpecker					2	5
Western Kingbird	10	3	4	1	7	8
Ash-throated Flycatcher	6	7	10	6	34	19
Say's Phoebe					1	
Violet-green Swallow						
Cliff Swallow					2	
White-necked Raven	<1	<1	<1			<1
Verdin			3	10	21	15
Cactus Wren	17	6	5	8	3	
Canyon Wren						
Rock Wren						
Mockingbird	1		<1		1	
Curve-billed Thrasher	7	3	3	1		
Crissal Thrasher					7	13
Phainopepla					7	
Black-tailed Gnatcatcher	3	8	8	11	34	27
Loggerhead Shrike	3	<1	1	3		
Bell's Vireo					38	14
Lucy's Warbler					48	70
Hooded Oriole						1
Scott's Oriole	5					
House Finch	9	4	6	3	3	7
Lesser Finch					3	4
Brown Towhee					3	4
Black-throated Sparrow	37	30	19	22	2	5
TOTAL AVERAGE DENSITY	~122	~79	~71	~90	~299	~241
TOTAL SPECIES	18	16	18	16	24	20

TABLE 2.8-5. (continued)

	M-1	M-2	S-1	S-2	R-1	R-2
Black-ch. Hummingbird						9
Costa's Hummingbird		2	7			
Common Flicker	7	<1		<1		
Gila Woodpecker		<1				
Ladder-backed Woodpecker						1
Western Kingbird	7	5	4		5	4
Ash-throated Flycatcher	8	5	4			12
Violet-gr. Swallow	<1				2	
White-necked Raven	<1			<1		1
Verdin	4		3	7	5	22
Cactus Wren	7	8	3	10	<1	
Canyon Wren					4	
Rock Wren				7	5	
Mocking Bird		<1	2			
Bendire's Thrasher	5	1		2		
Curved-billed Thrasher	3	<1				
Crissal Thrasher					2	9
Black-tailed Gnatcatcher		1	11	19	2	
Ruby-crowned Kinglet					18	
Phainopepla			2	7	25	32
Loggerhead Shrike	1					
Hutton's Vireo						5
Bell's Vireo						2
Lucy's Warbler					7	40
Yellow-rumped Warbler					5	
Wilson's Warbler					5	8
Scott's Oriole	<1		<1			
House Finch	27	10	2	31	14	37
Brown Towhee			1		3	
Lesser Goldfinch					5	
Black-throated Sparrow	34	12	44	31	5	23
Chipping Sparrow			5			
Brewer's Sparrow	59	19	8	7	28	32
White-crowned Sparrow	5	10			14	31
TOTAL AVERAGE DENSITY	~179	~78	~100	~129	~165	~305
TOTAL SPECIES	21	18	19	14	24	19

III. June 8-10

	M-1	M-2	S-1	S-2	R-1	R-2
Turkey Vulture		<1		1		
Sharp-shinned Hawk		2				

TABLE 2.8-5. (concluded)

IV. October 21-23

	M-1	M-2	S-1	S-2	R-1	R-2
Red-tailed Hawk	<1					<1
American Kestrel	<1			<1		
Gambel's Quail	3	<1		5	16	
Mourning Dove			3	3		6
Roadrunner		2				
White-throated Swift					5	
Black-ch. Hummingbird						
Costa's Hummingbird					5	
Common Flicker		<1	<1		3	
Gila Woodpecker		2				
Ladder-backed Woodpecker					1	
Violet-green Swallow						1
Cliff Swallow						
White-necked Raven					<1	<1
Verdin			6	1	7	1
Cactus Wren	5	3	3	<1	1	
Canyon Wren					<1	
Rock Wren			2			
Mockingbird		2	<1			2
Curved-billed Thrasher			<1			
Sage Thrasher	2					
Robin						2
Black-tailed Gnatcatcher			5	1	14	6
Phainopepla			7		3	5
Loggerhead Shrike	<1		3	1		
Bell's Vireo					14	16
Yellow Warbler					5	
Yellow-rumped Warbler			2		2	
Brown-headed Cowbird			3			
House Finch		8	2	1	3	12
Lark Bunting		<1		10		
Vesper Sparrow	1					
Black-throated Sparrow	10	2	15	7		
Chippink Sparrow						3
Brewer's Sparrow	7					
White-crowned Sparrow	<1					5
TOTAL AVERAGE DENSITY	28	19	51	30	79	[illegible]
TOTAL SPECIES	9	10	14	[illegible]	15	14

Source: Dames & Moore, 1978a.

TABLE 2.8-6

SPECIES AND DENSITY SIMILARITY OF BIRDS BASED ON TRANSECT DATA

I February 25-27

% Density Similarity [a]

Transect		M-1	S-2	R-1	APPROX. TOTAL MEAN DENSITY
	M-1	*	43	8	37
% Species	S-2	40	*	10	18
Similarity [b]	R-1	40	24	*	249
TOTAL SPECIES		9	6	11	

II April 6-8

% Density Similarity

Transect		M-1	M-2	S-1	S-2	R-1	R-2	APPROX. TOTAL MEAN DENSITY
	M-1	*	53	44	55	42	55	178
	M-2	72	*	44	40	44	33	79
% Species	S-1	58	56	*	54	23	24	100
Similarity	S-2	61	53	61	*	36	38	129
	R-1	51	45	56	58	*	51	165
	R-2	53	41	53	56	60	*	305
TOTAL SPECIES		19	20	19	14	24	19	

III June 8-10

% Density Similarity

Transect		M-1	M-2	S-1	S-2	R-1	R-2	APPROX. TOTAL MEAN DENSITY
	M-1	*	65	59	60	20	23	122
	M-2	74	*	73	77	21	24	79
	S-1	83	69	*	74	24	28	69
	S-2	82	73	32	*	27	30	80
	R-1	57	44	55	60	*	63	299
	R-2	53	43	58	56	77	*	241
TOTAL SPECIES		18	17	18	16	24	20	

TABLE 2.8-6. (concluded)

IV October 21-23

% Density Similarity

Transect	M-1	M-2	S-1	S-2	R-1	R-2	APPROX. TOTAL MEAN DENSITY
M-1	*	21	33	35	7	<1	28
M-2	32	*	20	17	8	47	19
S-1	26	42	*	37	29	28	51
S-2	53	50	58	*	16	15	30
R-1	17	32	48	40	*	49	80
R-2	17	17	43	33	41	*	62
TOTAL SPECIES	9	10	14	10	15	14	

a. % Density Similarity = (2 Mw/MA+MB) x 100 where

Mw = smaller density value of a species mutually occuring in two transects.

MA = total mean density of all species for a transect

MB = total mean density of all species for the second transect (Motyka et al., 1950)

b. % Species Similarity = (2c/A+B) x 100 where

c = number of species common to two transects

A = total number of species for a transect

B = total number of species for a second transect (Sorensen, 1948).

c. Total mean density rounded to nearest whole number.

d. Matrix values entered as percent rounded to nearest whole number greater than one. Similarity greater than or equal to 50% enclosed in a polygon.

Source: Dames & Moore, 1978a.

M-2 x R-1 and R-2). Density similarity was also greater in April than in February. The April data indicate that there are three distinct groups or communities of birds in the area during the spring; one group utilizes Joshua tree woodland, upland desert, and mesquite bosque (transects M-1 and M-2 x S-2 and R-2), another inhabits upland desert (transect S-1 x S-2), and the third inhabits riparian vegetation (transect R-1 x R-2). This pattern is the result of resident species dispersing throughout the area and migrant birds utilizing pseudoriparian and riparian habitats (Dames & Moore, 1978a). Similarity patterns in species composition for the June data was identical to that of the April data; however, summer density clustered in two groups, desert (Joshua tree woodland and upland desert) and mesquite bosque. The October transect data indicate dispersal of bird species with mutual species occurrence in deserts (Table 2.8-6). Bird distribution was spotty in the fall, suggesting aggregation, as would be expected preceding and during migration (Dames & Moore, 1978a).

A total of 22 bird species were noted to be breeding in the vicinity of the property (Table C-3, Appendix C-2). Nests of white-winged dove, common flicker, verdin, cactus wren, lesser goldfinch, and black-throated sparrow were found in the area. Juveniles of Gambel's quail, mourning dove, lesser nighthawk, western kingbird, ash-throated flycatcher, black-tailed gnatcatcher, and loggerhead shrike were observed in the area in June and August. Pairs, possibly breeding on or near the property, included redtailed hawk, American kestrel, great horned owl, Costa's hummingbird, canyon wren, rock wren, curvebilled thrasher, crissal thrasher, Bell's vireo, Lucy's warbler, and brown towhee (Dames & Moore, 1978a).

Mammals

A total of 18 species of mammals, primarily rodents, were observed on the Anderson property and in adjacent areas (Table C-3, Appendix C-2). Of these species, 11 were recorded in both the riparian and upland desert vegetation types, 7 were observed in the pseudoriparian type, and 12 were recorded in the Joshua tree woodland.

Small mammals were trapped at seven locations on and near the property during the spring and fall of 1977 (Table 2.8-7). Merriam's kangaroo rat was the most abundant species captured during both sampling periods. The Arizona pocket mouse was also present in relatively large numbers in the spring, but none were captured in the fall (Table 2.8-7). The rock pocket mouse was the third most abundant species captured in the area, being about equally common in both seasons. The other species trapped in the area were not common during either season. As is expected, general breeding activity of these rodents was highest in the spring and sub-adults became increasingly important in the population towards fall (Table 2.8-7).

The similarity for captures among trap lines during the spring was greatest in the Joshua tree woodland (trap line A x G, Table 2.8-8). This was due largely to the abundance of the Arizona rock pocket mouse. Similarity for captures was greater than 50 percent in most of the

TABLE 2.8-7

SMALL MAMMAL DATA OBTAINED FROM
SEVEN SETS OF LIVE-TRAP ASSESSMENT LINES

I. Capture Success

		April 21-23	October 20-22
a.	Number of sample site	7	7
b.	Number of trap lines per sample	2	2
c.	Number of live traps per line	25	25
d.	Number of nights traps were set	3	3
e.	Total trap nights(axbxcxd)	1050	1050
f.	Total captures	98	90
g.	Percent capture success	9.3	8.6

II. Composition, captures, and biomass

	N*	B**	$\bar{B}$	N	B	$\bar{B}$
Yuma Antelope Squirrel	10	1439	143.9	4	393	98.3
Arizona Pocket Mouse	32	390	12.2	-	-	-
Rock Pocket Mouse	14	202	14.4	10	132	13.2
Bailey's Pocket Mouse	-	-	-	4	73	18.3
Merriam's Kangaroo Rat	33	1447	43.8	71	2713	38.2
Deer Mouse	1	13	13.0	-	-	-
Brush Mouse	3	44	14.7	-	-	-
Whitethroated Woodrat	5	708	141.6	1	110	110.0
TOTAL	98	4248		90	3363	

* Number of captures.

** Biomass (B) and average biomass ($\bar{B}$) in grams.

TABLE 2.8-7 concluded

III. Age and Reproductive Status Adults-Reproductively

REPRODUCTIVE STATUS

		ACTIVE		INACTIVE		SUBADULTS	
		MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Yuma Antelope Squirrel	Apr	5	2	-	3	-	-
	Oct	1	-	-	2	1	-
Rock Pocket Mouse	Apr	6	4	-	4	-	-
	Oct	-	-	2	3	2	3
Arizona Pocket Mouse	Apr	11	5	10	4	-	2
	Oct	-	-	-	-	-	-
Bailey's Pocket Mouse	Apr	-	-	-	-	-	-
	Oct	-	-	1	3	-	-
Marriam's Kangaroo Rat	Apr	15	4	2	10	-	2
	Oct	20	1	5	19	4	22
Deer Mouse	Apr	1	-	-	-	-	-
	Oct	-	-	-	-	-	-
Brush Mouse	Apr	-	1	-	1	-	1
	Oct	-	-	-	-	-	-
Whitethroat Woodrat	Apr	-	5	-	-	-	-
	Oct	-	-	-	-	-	-

Source: Dames & Moore, 1978a

TABLE 2.8-8

CAPTURES AND PERCENT SIMILARITY FOR
CAPTURES AMONG ASSESSMENT LINES

I. Captures (April 21-23):

	SITE							
	A	B	C	D	E	F	G	TOTAL
Yuma Antelope Squirrel	2	1	1	1	-	4	1	10
Arizona Pocket Mouse	16	1	-	-	-	5	10	32
Rock Pocket Mouse	1	-	7	1	4	1	-	14
Merriam's Kangroo Rat	15	-	2	1	-	1	15	33
Deer Mouse	-	-	-	1	-	-	-	1
Brush Mouse	-	-	-	1	2	-	-	3
Whitethroated Woodrat	-	1	1	1	-	-	2	5
TOTAL	34	3	11	6	6	10	28	98

II. Captures (October 20-22):

	A	B	C	D	E	F	G	TOTAL
Yuma Antelope Squirrel	-	-	3	-	-	-	-	4
Rock Pocket Mouse	-	-	6	-	1	3	-	10
Bailey's Pocket Mouse	-	-	-	3	1	-	-	4
Merriam's Kangagroo Rat	17	11	5	9	2	11	16	71
Whitethroated Woodrat	-	-	-	-	-	-	1	1
TOTAL	17	11	14	12	4	14	18	90

TABLE 2.8-8 concluded

III. Percent Similarity for Capture Among Assessment Lines For Spring and Fall

SPRING

	Site	A	B	C	D	E	F	G
	A	X	11	18	15	5	36	84
	B	79	X	29	44	0	31	19
	C	32	40	X	47	47	19	21
FALL	D	62	78	62	X	33	25	18
	E	19	27	33	38	X	13	0
	F	71	88	57	92	33	X	32
	G	97	81	40	64	20	73	X

a. % Similarity = (2Mw/MA+MB) x 100 where
Mw = minimum number of mutual captures for a species in two transects
MA = total captures of all species for a transect
MB = total captures of all species for a second transect in the crosswise comparison (Motyka et al., 1947)
% Similarity is rounded to the nearest whole number greater than one.
Similarity greater than, or equal to 50% enclosed in a polygon.

Source: Dames & Moore, 1978a

trap lines run during the fall. This was due primarily to the wide spread occurrence of Merriam's kangaroo rat.

The black-tailed jackrabbit was the only intermediate-sized mammal species commonly observed in the area, although the presence of desert cottontails was also noted. Road census data (approximately 20 mile route) collected over three day periods after sundown in April, June, and October was as follows:

Season	Species	Number and Age Class
Spring	Black-tailed jackrabbit	16 adults
	Desert cottontail	2 adults
Summer	Black-tailed jackrabbit	8 adults, 12 sub-adults
	Desert cottontail	1 adult, 1 sub-adult
Fall	Black-tailed jackrabbit	3 adults

Deer have been occasionally sighted in the vicinity of the Anderson property by MINERALS employees and Dames & Moore biologists. Three sets of deer tracks were noted along bird transect M-1 in February. In October, deep pellet groups were found along bird transect S-2. BLM personnel have observed as many as 35 deer near Tres Alamos Peak southeast of the property. These observations indicate that deer utilize the Anderson property and adjacent areas in small numbers (Dames & Moore, 1978a).

Feral burros appear to utilize the property extensively. Fourteen burros were observed in the wash east of the Anderson Mine in mid-March. Another 21 animals were seen east of the mine in June and 3 burros were observed approximately 1/2 mile south of the driller's camp in

October. Burro tracks were recorded in Section 4, T11N, R10W along the canyons and the Santa Maria River.

Threatened and Endangered Species

None of the species designated by the U.S. Department of the Interior as threatened or endangered were observed on the Anderson property or adjacent areas. There is evidence that two species, the desert tortoise and gila monster (*Heloderma suspectum*), listed by the Arizona Game and Fish Department as "species whose status in Arizona may be in jeopardy in the near future" utilize the area to some extent. Tortoise tracks were observed along the Santa Maria River west of the Anderson property in August and in Section 2, T11N, R10W near the river in October. No gila monsters were observed in the area by Dames & Moore biologists, but unverified sitings of this species have been reported by persons working in the area (Dames & Moore, 1978a).

The Federal Wild Horse and Burro Act of 1971 (Public Law 92-185; 85 Stat. 649) does not recognize the burro as an endangered or threatened species but it does grant the burro protected status. The proliferation of burro populations in the vicinity of Alamo Reservoir has posed a problem for the BLM (Mr. Dean Durfee, Phoenix District Office, BLM, personal communication by Dames & Moore, 1977). As discussed above, feral burros, possibly from the Alamo Reservoir herd, were found to utilize the property, particularly near the Santa Maria River.

ENVIRONMENTAL STRESS

As discussed above, plant productivity in the project region has been reduced during the past several years by drought. Extensive grazing has also resulted in a reduction in productivity. In addition, past human activity on the Anderson property has created some environmental stress.

Disturbance associated with past mining covers a radius of approximately 0.5 mile from the center of the old Anderson Mine. This disturbance is characterized by a scarified surface and the absence of dominant desert plant species. A number of unimproved roads have been constructed recently in the area to accomodate drilling and other mineral exploration activities. These roads have contributed to an increase in the amount of cleared or scarified land on the property and in adjacent areas.

2.9 BACKGROUND RADIOLOGICAL CONSIDERATIONS

Generally speaking, the most significant source of ionizing radiation exposure to the general public is from the natural environment. This exposure is not uniform for all individuals, but varies due to a number of factors, including altitude, geological features, and human habitats. Variations in exposure as a result of these natural factors often exceed exposures from man-made sources (e.g., x-ray equipment and nuclear reactors) that receive considerably more publicity. According to the literature, the dose from natural radiation to an individual in the United States ranges from 80 to 250 mrem/yr. [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 roentgen of x-ray or gamma radiation (400 kilovolts).] The average individual living in the United States in 1964 received an x-ray exposure of 55 mrem/yr for medical purposes. Other sources, such as nuclear reactors account for less than 5 mrem/yr.

In order to determine the significance of the effects of small man-made increments of exposure, it is necessary to determine the larger natural radiation components. Several studies have shown no correlation of background radiation with health effects. However, background radiation exposure is less well defined than exposure to man-made sources, so it may contribute to the deleterious effects that may be associated with low levels of radiation.

Natural background radiation comes from cosmic radiation and from radioactive elements in the earth's crust and in building materials. An additional increment of external exposure, which accounts for less than five percent of the total, is due primarily to the presence of radon isotopes and their radioactive decay products in the atmosphere.

The natural radiation environment is believed to have been relatively constant for at least 10,000 years. However, human living habits have changed in such a way as to increase exposure. Populations have tended to migrate from coastal to inland areas, thus increasing their elevation and exposure to cosmic radiation. Outdoor agrarian society has been largely replaced by indoor work and life in urban centers. Exposure has thus been increased in some instances because of the natural radioactivity of building materials; while in other instances, buildings may attenuate exposure to outdoor terrestrial sources, thereby lowering exposure.

Additional increments of radiation exposure result from ingestion of natural radionuclides. Potassium-40 is the principal contributor of internal doses; other significant internal emitters are carbon-14, radon-222, radium-226 and -228, and their daughter products.

The retention of inhaled radioactive daughter products of radon isotopes is the primary source of lung radiation dose to the general public. 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 250 mrem/yr to occupants of unventilated wood dwellings and about 1800 mrem/yr to occupants of unventilated concrete buildings has been calculated.

Since the proposed mine and mill will release radioactive materials, it is important to establish baseline radiation levels and concentrations of radioactive materials. Periodic monitoring during project operations can then detect any significant increases by comparison with these baseline levels. To obtain the necessary baseline information, the following sampling programs were conducted:

- atmospheric radon-222 concentrations
- radon-222 daughter analysis
- subsoil radon-222 measurements
- integrated gamma radiation
- radionuclide content of sediments, water, vegetation, and soils

RADIOACTIVE MATERIALS IN THE AIR

As a general rule, gaseous radon-222 and radioactive constituents of suspended particulate matter account for most of the background airborne radioactive matter. Surface soils and rock, which are the most significant existing sources of airborne particles in the project 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 that deposit on soil particles and airborne particles that can be ingested by man and animals.

Radon-222

A total of 36 air samples were collected during two periods of two hours each at roughly 24-hour intervals at the meteorological tower located near the center of the ore body and five satellite locations (Figure 2.9-1). The samples were analyzed for radon-222 content within 48 hours of collection by Eberline Instrument Corporation of Albuquerque, New Mexico. The results of these analyses are presented in Table 2.9-1.

Concentrations of radon-222 ranged from undetectable to nearly 2 pCi/l on the property. The average radon concentration for all samples was 0.35 pCi/l.

The highest radon-222 concentration was observed at the meteorological tower which is located on a ridge above the ore body. This reading was taken in the morning during a light, increasing northwest wind following several hours of very light southeast-east to northeast winds. Considering that on the previous day the winds reached a higher peak than on any other day during the sampling period and that flushing was relatively thorough, this reading probably represents a radon-222 buildup of only a few hours.

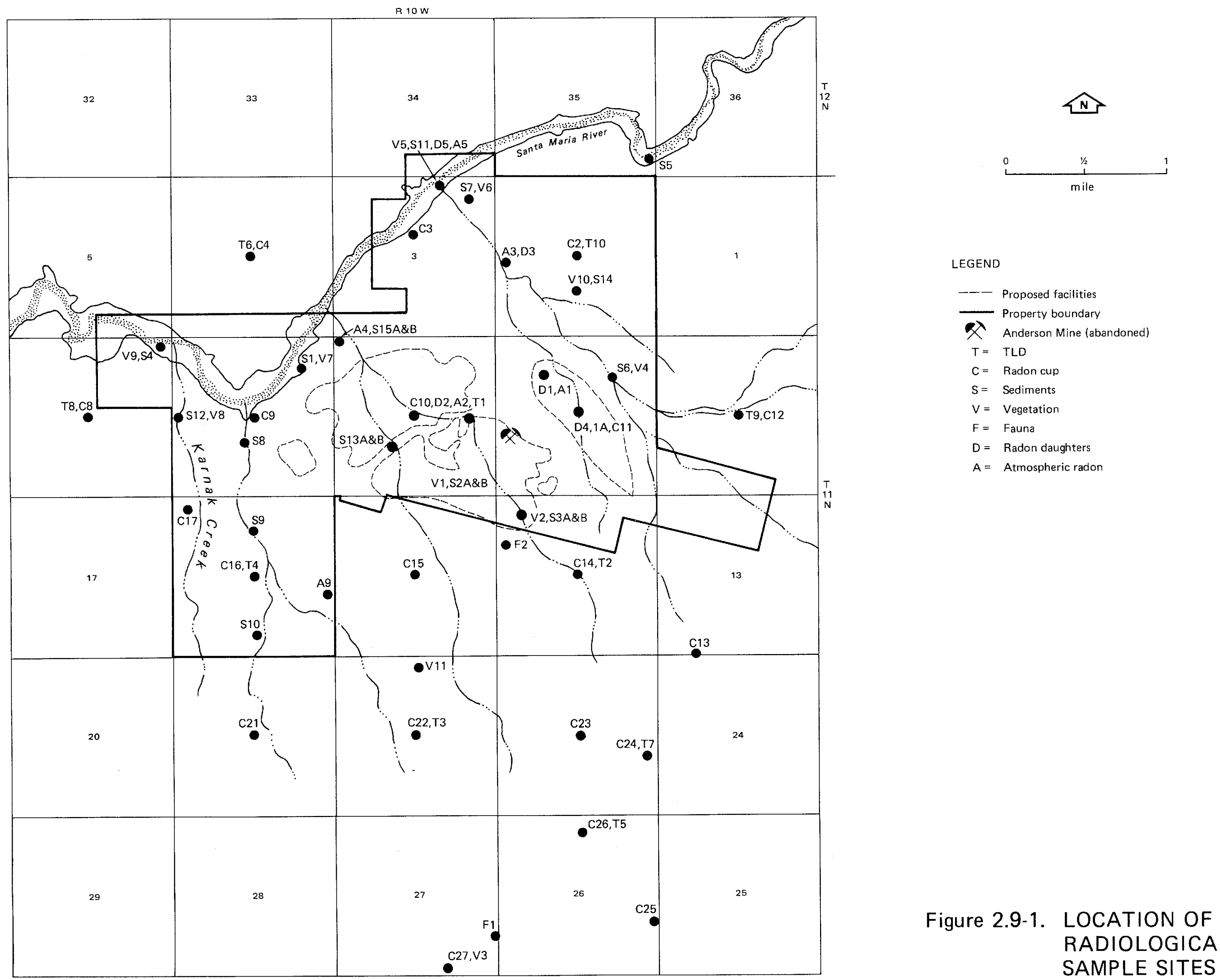

Figure 2.9-1. LOCATION OF RADIOLOGICAL SAMPLE SITES

Radon-222 concentrations at sample sites A3, A4, and A5, located downwind from the ore body (Figure 2.9-1), were not consistantly high during the morning sampling periods (Table 2.9-1). Consequently, overnight drafts from the desert floor did not result in the concentration of radon in canyons and stream channels at lower elevations. Based on these results, there appears to be sufficient winds in the area to disperse radon from the property.

Radon-222 concentrations did not consistantly increase from the morning to the afternoon samples. If such an increase did occur, it would indicate a daytime atmospheric inversion on the property. An inversion would tend to trap the radon-222 emanating from the soil in the lower layers of air where the samples were taken.

Radon Daughters

The presence of radon in the atmosphere is often difficult to detect and/or measure because of its normally low concentration, its character as one of the noble gases, and its transitory presence due to radioactive decay. Radon as a noble gas shows little inclination for concentration on solid surfaces or in liquids because of its inherent resistance to ionization. However, radon gas in the atmosphere breaks down radioactively forming highly ionized polonium, which in turn breaks down forming other ionized isotopes. These highly charged ions are attracted to dust particles in the air and collect on them. In a carefully controlled situation, collection of such dust particles and determination of radon daughter content would provide a measure of radon content in the ambient air. However, in field conditions, drifting air masses dilute or concentrate the daughters. Consequently, the most significant readings reflecting local conditions are those taken during stagnant inversions when air flow is minimal.

Radon-222 has at least 11 daughters (including the final product of stable lead-206), only a few of which are practical to measure. Polonium-218 has a 3.05 minute half-life and its daughter, lead-214, has a 26.8 minute half-life. Both of these radon daughters are commonly measured for direct radon-222 determination where the laboratory apparatus is close at hand or where field conditions support use of a mobile laboratory with this capability. Since the samples collected on the Anderson property for radon daughter analysis were stored for several days, measurement of these isotopes was not meaningful. For the Anderson property samples, the most practical isotopes to measure were lead-210 with a half-life of 21 years and its bismuth and polonium daughters (these daughters should be in equilibrium with lead-210).

Due to its long half-life, lead-210 concentrations reflect only the effective time of dispersion of dust paricles. High winds preceding the sampling may lead to measurements reflecting radon daughter accumulation in regional soils rather than local atmospheric radon or local soil conditions. In any case, it is useful to measure these more stable radon daughters since radioactive material in dust forms a significant portion of atmospheric radioactivity.

Airborne particulate samples were collected at the meteorological tower and four satellite locations (Figure 2.9-1) in 1977. The satellite stations were sampled sequentially and no station was sampled more than once. A total of five samples were collected in July 1977 at the meteorological tower. All samples were analyzed by Eberline Instrument Corporation for total particulates, thorium-230, radium-226, and lead-210. The results of these analyses are presented in Table 2.9-2.

Examination of the data (Table 2.9-2 and Figures 2.9-2 and 2.9-3) indicate that the radioactive composition of the dust is a function of the wind azimuth as well as wind speed. For example, north winds produced the highest dust loads and lowest uranium concentrations, while the highest uranium measurements were taken when the winds were from the east and west. These results may be due to the source of the particulates. Winds from the north cross the Santa Maria River channel and the lower reaches of several tributaries before reaching the sampling sites. Since these drainage channels are covered by loose silts and fine sands, suspended particulates would be relatively high with strong winds. Winds from the east and west cross areas composed of coarser materials; consequently, the dust load of these winds is somewhat lower. North winds cross a minimum of exposed ore deposits in the vicinity of the property so it would be expected that the concentration of radioactive

Table 2.9-2. RADON DAUGHTERS IN THE ATMOSPHERE

Sample	U µg/g	U pg/l	Th^{230} pCi/g	Ra^{226} pCi/g	Pb^{210} pCi/g	Particle Load g	Wind Speed* mph	Azimuth Degrees	Wind Speed: Peak of Period mph	Wind Speed: Azimuth Degrees	Volume Sampled m^3	Temperature* Degrees	Time Hr	Date of Collection
D4	29.5	1.13	5.25	<0.8	328	0.061	6.5	143	17	110	1590	94	9:07 - 9:07	7-13&14-77
D3	93.8	9.80	28.75	<8	<581	0.016	12	122	17	110	153	94	9:05 - 11:30	7-13-77
D4	40.9	2.39	2.25	<0.9	237	0.093	9.9	109	17	100	1590	95	9:15 - 9:15	7-14&15-77
D5	125	8.0	66.25	<6	988	0.008	6.6	140	16	90	125	88	7:10 - 9:00	7-14-77
D5	90.9	14.71	32.73	19.1	1455	0.011	11	110	12	100	68	99	12:00 - 13:00	7-14-77
D3	88.9	6.72	44.44	23.3	<94	0.009	9.0	145	10	120	119	104	14:13 - 16:00	7-14-77
D4	12.8	0.94	<0.7	<0.4	154	0.117	8.5	99	22	40	1590	93	9:18 - 9:22	7-15&16-77
D1	44.7	15.44	<2	7.0	<206	0.047	8.1	77	11	80	136	88	7:30 - 9:30	7-15-77
D1	71.4	7.35	23.57	<4	<643	0.014	9.0	144	10	150	136	102	12:00 - 14:01	7-15-77
D4	33.9	1.32	<2	2.3	258	0.062	3.8	342	12	210	1590	93	9:31 - 9:34	7-16&17-77
D2	90.9	7.35	<10	<5	482	0.011	4.0	76	4	90	136	89	7:30 - 9:03	7-16-77
D2	45.5	7.35	24.55	<2	273	0.022	5.6	300	7	300	136	101	12:07 - 14:07	7-16-77
D4	6.5	0.50	5.45	<0.4	195	0.123	9.4	73	22	30	1590	89	9:37 - 9:37	7-17&18-77

*Geometric mean

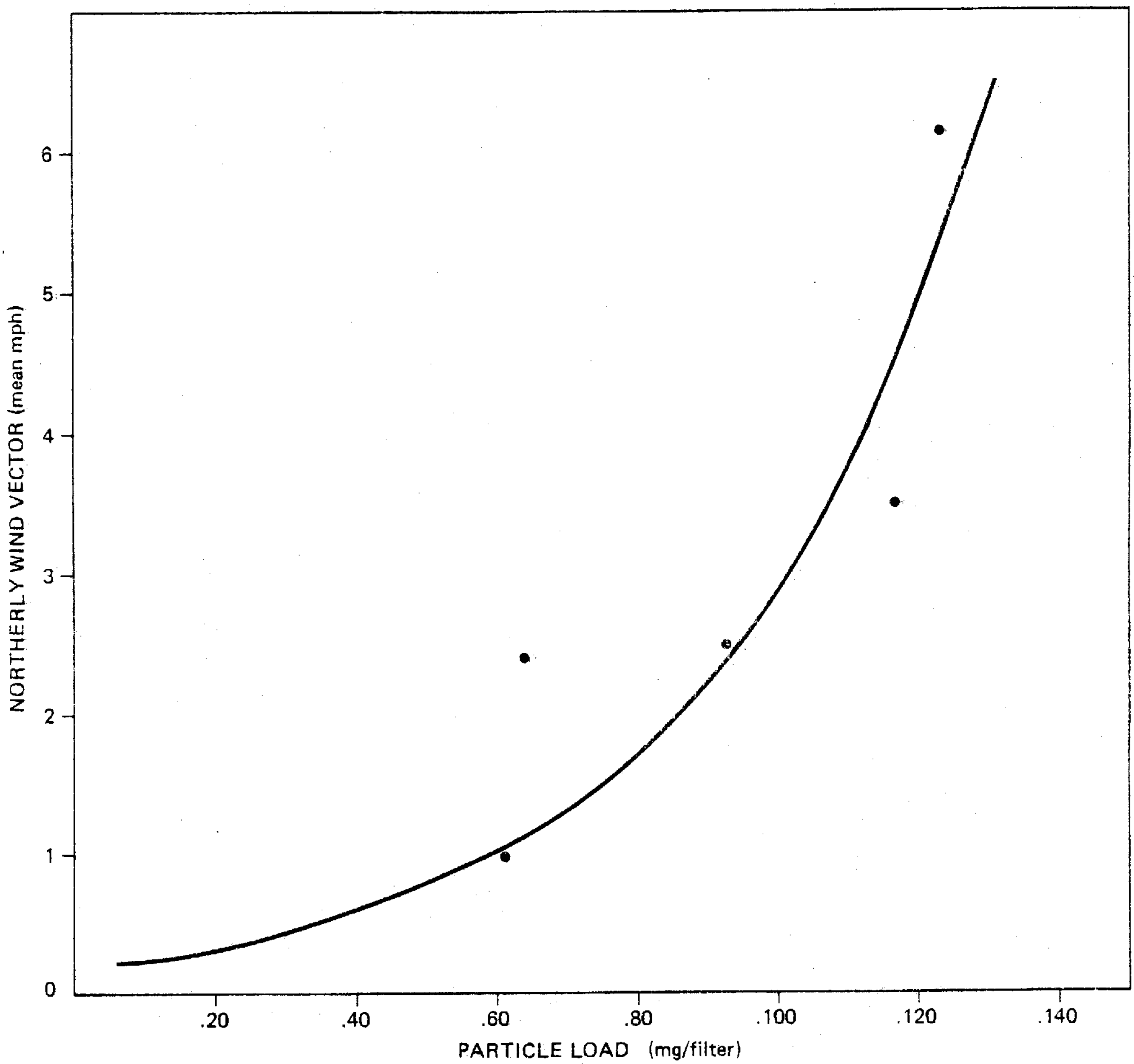

Figure 2.9-2. PARTICULATE LOAD ON THE ANDERSON PROPERTY RELATIVE TO WIND SPEED

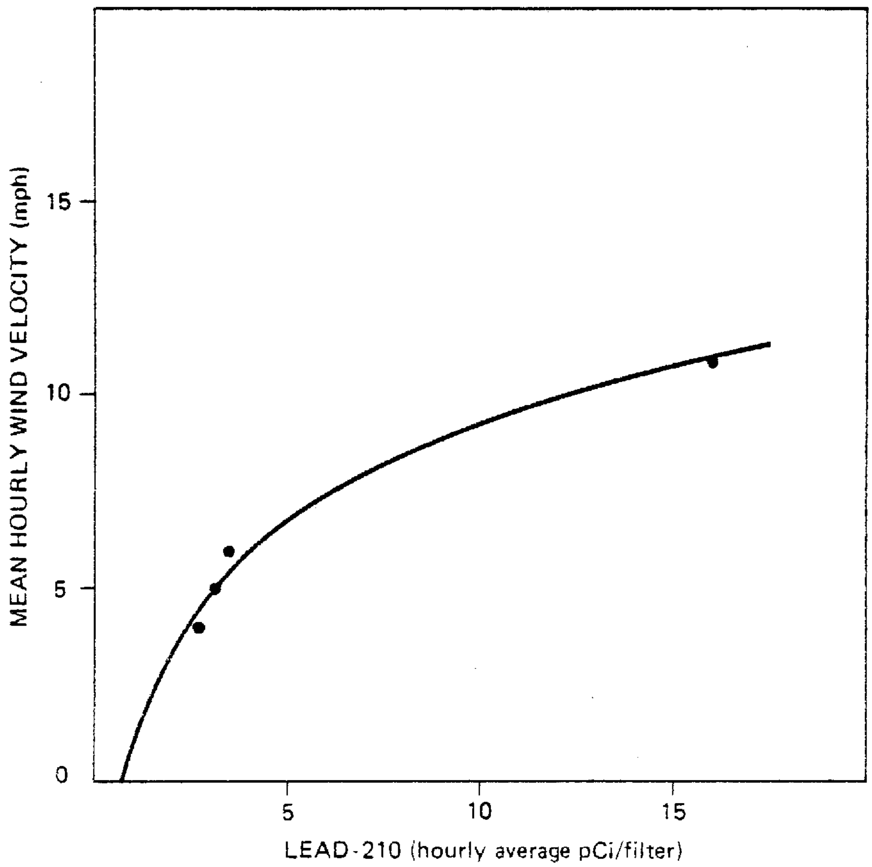

Figure 2.9-3. LEAD-210 CONCENTRATION IN THE ATMOSPHERE RELATIVE TO WIND VELOCITY

materials in the dust would be lower than winds from the east and west which have relatively long sets over exposed ore bodies.

Subsoil Radon Measurements

On a local basis, one of the most significant components of atmospheric radon is provided by radon emanating from the soil. During periods of stable pressure and low winds, radon movement is generally influenced by diffusion coefficients, both in the atmosphere and in the soil. Daily, weekly, and seasonal fluctuations in atmospheric pressure and winds, however, cause migration of radon to and from the surface at accelerated rates; consequently, radon from a considerable depth may find its way to the surface over a period of time. Obviously, with the limited half-life of radon (3.823 days), there is a maximum depth beyond which no significant quantities of radon could be expected to reach the surface. The factors determining this depth include the rate of movement of radon to the surface, the production rate of radon at the source, the flow path, and the features of the soil or rock and atmosphere interface.

The relative emanation of radon from the Anderson property was determined by use of track etching analyses of alpha-sensitive photographic films mounted in inverted styrene cups (radon cups) and buried two to three feet below the surface of the ground at 20 locations (Figure 2.9-1). Because of their physical characteristics, these cup-mounted films sense only radon gas in their immediate environment* and integrate the levels perceived over time. For this determination, two cups were placed in each hole, covered with a plastic bag, and buried. They were not disturbed again except to remove one of the cups after three months and the other after six months. The results of the track etching analyses for the cups are presented in Table 2.9-3. Although an empirical method exists for converting these reading to concentrations on the basis of laboratory testing**, it has yet to be affirmed that this conversion is applicable to field data. Consequently, the relative track numbers obtained are presented in lieu of actual concentrations.

Since the two sets of data provided in Table 2.9-3 represent two different seasons, one relatively dry and the other relatively wet, it is possible to obtain a relative evaluation of the exponential term in the diffusion equation incorporating a decay term (presuming the production of radon-222 in the surface soils is negligible compared to the production at depth).

$$C = C_o \, e^{-\sqrt{\frac{\lambda}{D/S}}\, x}$$

where: C = concentration of radon gas in interstices of soil/rock at distance x from plane source units (pCi/l)

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*These films also may be affected by radon daughters that plate out on the sides of the cup. The influence of the plating out on the radon levels reported is unknown at this time.

**H.W. Alter, President, Terradex Corportion, Walnut Creek, California personal communication, November 21, 1977.

Table 2.9-3. RADION CUP READINGS ON THE ANDERSON PROPERTY

Sample Site	First 3-month Average	Second 3-month Average	6-month Average	k*
	Tracks/mm^2/Month			
C2	28.4	76.0	52.2	1.215
C3	23.2	1.4	12.3	0.3538
C4	17.1	-	-	-
C8	33.6	63.8	48.7	1.135
C9	12.8	-	-	-
C10	113.3	603.3	358.3	1.281
C11	29.9	45.3	37.6	1.090
C12	20.8	67.0	43.9	1.274
C13	28.5	56.3	42.4	1.149
C14	38.1	18.1	28.1	0.847
C15	88.0	-27.8	30.1	-
C16	76.3	70.5	73.4	0.986
C17	44.5	29.5	37.0	0.918
C21	21.9	54.9	38.4	1.213
C22	62.1	72.1	67.1	1.028
C23	12.6	45.2	28.9	1.339
C24	27.6	100.8	64.2	1.285
C25	26.4	46.8	36.6	1.127
C26	51.4	26.4	38.9	0.871
C27	29.4	81.2	55.3	1.220

*Where $u_2 = ku_1$, $k = \frac{\ln C_2}{\ln C_1}$

Co = concentration of radon gas in interstices of source material, presumed homogeneous in distribution (pCi/l)

λ = activity coefficient (2.1×10^{-6} sec^{-1} for radon-222)

D/S = effective diffusion coefficient divided by porosity

x = distance from plane source (cm)

If $u = \sqrt{\frac{\lambda}{D/S}}$ then a ratio of the equation under the two conditions (dry and wet) allows for computation of the relative "u" values where:

$$u_2 = u_1 \frac{\ln C_2}{\ln C_1}$$

These values were calculated for each location and are tabulated in Table 2.9-3. This information shows that while the soils in general were less permeable in the wet season, this was not uniformly the case. Consequently, an areal distribution that bears on geology and geologic structure may be indicated.

Most of the radon cup data from the first three months (dry period) fell within four distinct groups (Figure 2.9-4). Each group could be described by the general equation:

$$y = ax^b$$

where

y = number of tracks

a,b = empirical constants

x = elevation above a datum (ft)

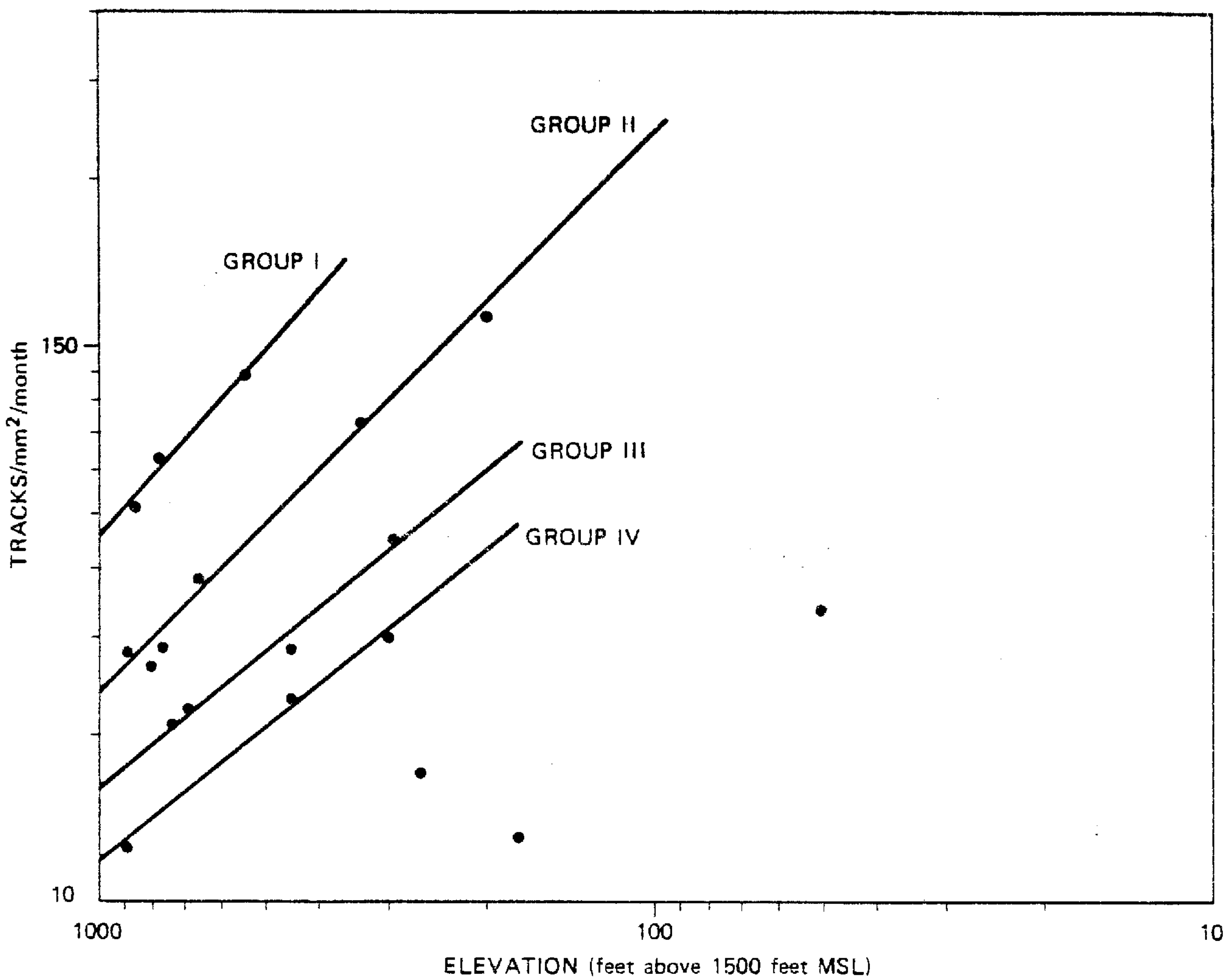


Figure 2.9-4. RADON-222 CONCENTRATIONS RELATIVE TO ELEVATION

The distribution of the data points suggest that the groupings are sensitive to the underlying base rock geology, modified by the relative thickness of the overburden and their proximity to the ore body.

Based on experience, Terradex Corporation has estimated that the overall migration rate of randon-222 through soil and rock on a world wide basis is roughly on the order of 15 to 30 feet per day. Consequently, for the sampling period involved, the radon cups could detect radon emanating from a source at a depth of 100 to 300 feet. This degree of sensitivity allows detection of radioactive materials in the formations beneath the alluvium on the Anderson property.

As Figure 2.9-4 shows, each of the four groups relate to elevation above an arbitrary datum plan (1500 ft msl was used in this analysis). Group I consists of three points on the desert floor south of and stratigraphically above the exposed ore body on the property. Group II consists of seven points that are located progressively further from the central ore body (Figure 2.9-1). Group III consists of four points which appear to be marginally beyond the ore bed. Two of these points lie west-southwest of the deposit and the other two lie east-northeast of the deposit. Group IV consists of three points which are located considerably west of the main ore deposit and are stratigraphically below the Miocene lake beds that constitute the ore bearing zone.

The groupings appear to provide reference points for the relative position of the ore body. They may also identify the relative transmissivity of uranium daughters through the intervening rock and soil. It would not be justified at this point to assume that all of the radon detected by the radon cups was due to radon-222 migration from the ore body. Dissolved radium moving with moisture upward or laterally in rock and soil may, over time, have also contributed to the readings by providing a closer source. However, it is likely that the primary source of the readings is the radon from the ore bed itself.

TOTAL RADIATION LEVELS

Total natural background ionizing radiation from all sources (air, water, and cosmic radiation) was measured on the Anderson property by means of thermoluminescent dosimetry. Special weatherproof thermoluminescent dosimeter (TLD) packets containing three high-sensitivity fluoride chips were placed at some of the same locations as the radon cups to monitor the general ionizing radiation in the area (Figure 2.9-1). Two TLDs were placed at each selected location. One was collected after three months and the other was collected after six months. One TLD was kept at the Eberline laboratory in Santa Fe, New Mexico, for control purposes. The results of this program are presented in Table 2.9-4.

The geometric mean of the TLD readings was 1.97 mrem/week (excluding sample T1, the geometric mean was 1.85 mrem/week), which was slightly higher than the 1.88 mrem/week registered from the control kept at the Eberline laboratory. Except for one high reading from the TLD located above the ore body, the dose data can be separated into two groups, one

Table 2.9-4. TLD READINGS IN THE VICINITY OF THE ANDERSON PROPERTY

Sample Site	TLD Reading mrem/wk
T1	3.40
T2	1.99
T3	1.74
T4	1.76
T5	1.70
T6	1.54
T7	2.06
T8	2.07
T9	2.12
T10	1.76

with a mean of 1.74 mrem/week (sample sites T3, T4, T5, and T10) and one with a mean of 2.06 mrem/week (sample sites T2, T7, T8, and T9).

RADIOACTIVE MATERIALS IN THE WATER

Groundwater samples were collected from a total of 10 sources in the vicinity of the Anderson property (Figure 2.6-12). These samples were analyzed for total uranium, radon-222, radium-226 and -228, thorium-228, -230 and -232, gross alpha, and gross beta (Table 2.6-20). As discussed in Section 2.6, no surface water samples were taken on the property since surface flows did not occur during the field studies.

The following discussion is based on the analyses conducted on samples collected in April and May, 1977. These results are considered to be more accurate than the results from the analyses conducted on the September 1977 samples since they correlate well with nonradiological constituents. It is probable that the analytical procedures used for the September samples were not sensitive enough to detect the small amounts of radioactive materials present in the water.

The assumption that the distribution of uranium isotopes is "normal" in the water on the Anderson property does not appear to be warranted based on the results of the groundwater sampling program. Gross alpha values were too low in all of the samples to account for normal uranium isotope distribution, let alone equilibrium between uranium and its daughters (Table 2.6-20). While gross alpha determinations are often inaccurate for water with a high total dissolved solids content, analytical error does not necessarily account for the mismatch between gross alpha readings and the uranium content of the water on the Anderson property. The results indicate the absence of uranium daughters which suggests a disequilibrium in the uranium parents (uranium-238 and uranium-234).

This disequilibrium may have been brought about by geochemical processes resulting in a differential movement of uranium-234 relative to the other isotopes in the uranium series. The beginning of the uranium decay series is as follows:

Isotope	Half-life
Uranium-238	4.5×10^9 years
↓	
Thorium-234	24.1 days
↓	
Protactinium-234	1.2 minutes
↓	
Uranium-234	2.5×10^5 years
↓	
Thorium-230	8×10^4 years
↓	
Radium-226	1.6×10^3 years

If uranium-238 is in the +4 valence state it does not differ significantly in solubility from the thorium isotopes. Protactinium-234 has too short a half-life to account for any significant change in solubility. Uranium-234, on the other hand, is commonly produced in an oxidized state (+6 valence) which readily forms complexes with bicarbonate ions and is, in essence, solubilized.

Most of the groundwater samples contained few alpha-emitters other than uranium (Table 2.6-20). Consequently, most of the gross alpha readings should be attributed to uranium-238, uranium-235, and uranium-234. By determining the portion of the gross alpha values that can be accounted for by uranium-238 and uranium-235 (uranium-235 does not commonly dissociate from uranium-238 by geochemical processes), it is then possible to estimate the uranium-234 content of the water. Table 2.9-5 provides the expected concentrations of uranium-234 given the gross alpha values for the water samples.

Comparison of the total uranium concentrations to gross alpha readings for the samples suggests a general depletion of uranium-234 in the groundwater of the area (Table 2.6-20). At least two of the samples (AM-28 and Grapevine Springs) had gross alpha readings too low to account for the uranium-238 content alone, indicating analytical problems. Samples from well DC-5, Palmerita Ranch well, Pipeline Ranch well, Santa Maria Highway, and Tres Alamos Spring had gross alpha counts slightly above the level that could be attributed to the presence of uranium-238 and uranium-235. If this difference was due only to uranium-234, approximately 22 percent of the expected concentration of this isotope is present in the samples. Accounting for the thorium and radium isotopes present in two of those samples (Palmerita Ranch well and Santa Maria well #1) would make this fraction even smaller.

Table 2.9-5. EXPECTED CONCENTRATIONS OF URANIUM-234

Total Uranium μg/l Observed	Activity Due to Non-differentiated U^{238} Plus U^{235} @ 0.346 pCi/μg	Alpha (Gross) Observed pCi/l	Difference Assumed to be U^{234} pCi/l	Percentage U^{234} in U Total
7.6	2.63	2 ± 1	<0	-
46.0	15.92	21 ± 5	5.08	1.79E-3
11.1	3.84	<2	<0	-
5.0	1.73	2 ± 2	0.27	0.87E-3
7.2	2.49	3 ± 2	0.51	1.15E-3
11.5	3.98	4 ± 3	0	-
18.8	6.51	8 ± 5	1.495	1.29E-3
16.9	5.85	7 ± 4	1.15	1.10E-3

Except for the sample from the Palmerita Ranch well no significant concentrations of radium-226 or radium-228 were found in the groundwater samples. The water from the Plamerita Ranch well contained a significant quantity of radium-228 (Table 2.6-20). In contrast, this water contained the lowest concentration of total uranium of all the samples. The Palmerita Ranch well water also contained significant quantities of thorium-228 and -230, but no significant concentration of thorium-232 was found. The only other sample with significant thorium levels was taken from Santa Maria Well No. 1. Significant quantities of all three thorium isotopes were found in the water from this well. The total uranium content of the Santa Maria Well No. 1 water was approximately twice that of the Palmerita Ranch well water, but no significant levels of either radium isotope (226 or 228) were found in the water.

In evaluating the relative concentrations of thorium-232 daughters (radium-228 and thorium-228) and the thorium daughter of uranium-234 (thorium-230) in the samples from Santa Maria Well No. 1 and the Palmerita Ranch well, it was noted that these two groundwater sources have several features in common. Water from both sources contain relatively high concentrations of calcium along with low carbonate and were among the lowest in pH (Table 2.6-17). Both wells are also located in the alluvial plain of the Santa Maria River near outcrops or near-surface deposits of basalt, which inherently contains large quantities of calcium. Since calcium and radium are chemically similar, the sampling results imply a coordinated movement of the radium with calcium.

The presence of relatively high levels of radium-228 in the Palmerita Ranch well water with no significant concentration of thorium-232 may be the result of differences in solubility. Thorium is much less soluble in water than radium. Consequently, the results suggest a chemical separation of the two elements, perhaps as a direct result of infiltration of precipitation in a nearby recharge area. If this is the case, then the radium-228 would have moved free of thorium-232 to its present position. The presence of thorium-228 in the water would result from the decay of radium-228.

The water from Santa Maria Well No. 1 contains essentially the same amount of thorium-228 as the water from the Palmerita Ranch well plus the only thorium-232 observed in any of the samples, but no radium-228. In an area lacking significant rainfall for many months and assuming a nominally low rate of groundwater movement, this situation may be due to analytical error.

The apparent lack of radium-226 in any of the groundwater samples may also be due to analytical problems. However, its continuous and conspicuous absence would infer a circulation of the groundwater in the area as opposed to the presence of ancient stagnant waters that have been in place for thousands of years.

Analysis of the uranium content of groundwater in the vicinity of the Anderson property relative to other water quality constituents provides some information on the mobilization mechanisms of the groundwater system in the area. While other radioactive components of the water could also provide this information, only uranium was present in sufficient quantities to provide a reasonably reliable analysis of all the samples.

Uranium appears to be mobilized, i.e., free to enter water, in essentially two forms. One of these forms is a complex of the uranyl ion and the other is when uranium is in the form of or associated with particulates, especially particulates of colloidal size.

Ferruccio (1975) found that dissolution of uranium from carbonate rocks is appreciably influenced by cationic components of the water according to the following series:

$Mg^{++} > Ca^{++} > Na^{+}$

Carbonate rocks are neither characteristic of the country rock nor the ore in the vicinity of the Anderson property, although calcareous chert constitutes a large portion of the upper layer of the Miocene lake beds in which the uranium ore is found.

In the noncarbonate rocks typical of the area, the solubility of uranium appears to be a function of cation concentrations in essentially the inverse of the relationship described by Ferruccio. There is a very high correlation between the uranium content of the groundwater and the concentration of sodium (Figure 2.9-5). The presence of calcium, magnesium, and potassium appears to decrease the solubility of uranium. Consequently, solubilization would not appear to be the mechanism of uranium mobilization on the Anderson property; rather ion exchange or possibly mobilization of colloids containing uranium appears to be the more likely method.

Examination of anion concentrations in the groundwater clarifies this observation to some degree. The presence of sulfate seems to retard the movement of uranium into the water while chloride and bicarbonate appear to encourage it. Although somewhat similar to the effect of sodium at lower concentrations, the data show that at higher bicarbonate levels the movement of uranium into the water accelerates (Figure 2.9-5). This appears to be the result of two reactions. One is the effect of ion exchange, which is relatively linear to bicarbonate concentration, while the other is apparently the result of uranium (probably the uranyl ion) and bicarbonate complexing. A similar, if accelerated, reaction may be seen between uranium and chloride (Figure 2.9-5).

The relationship between uranium content in the groundwater and silica is particularly interesting and reflects the importance of colloidal behavior in uranium mobility. At the pH levels encountered in the sampling program (7.3 to 8.9), colloidal silica must be present to account for the silica concentrations in the groundwater (Table 2.6-19). Therefore, the curve in Figure 2.9-5 relating uranium to silica is essentially Langmuirian and probably relates to the surface area of the silica colloids.

In summary, there appears to be a geochemical situation in the general area of the Anderson property in which certain constituents of the groundwater, namely sodium, chloride, silica, and bicarbonate, encourage the presence of uranium in the water while other constituents are antagonistic to it. The antagonistic constituents include the principal ions calcium, magnesium, sulfate, and potassium.

RADIOACTIVE MATERIALS IN SOILS, PLANTS, AND ANIMALS

Soils

As discussed above, migration of uranium and its daughters occurs in the groundwater on and in the vicinity of the Anderson property. Since uranium mining was conducted on the property in the past and radioactive materials were largely left exposed after termination of these activities, direct particulate displacement due to erosion of the exposed ore beds may have provided another significant source of uranium migration in the area. For this reason, 19 sediment samples were collected along the drainage channels on the property (Figure 2.9-1). These samples were analyzed for uranium-238 and 6 of its 14 daughters (uranium-234, thorium-230, radium-226, lead-214, bismuth-214, and polonium-210). These six daughters were chosen on the basis of their sensitivity to geochemical separation. In addition to these isotopes, the samples were analyzed for thorium-232 and its daughter lead-212, gross alpha, gross beta, cesium-137 (a fallout product), and potassium-40. The results of these analyses are presented in Table 2.9-6.

In order to identify the origin of sediments and erosion mechanisms, an analysis of particle size distribution was also conducted on the samples. Particle sizes ranged in diameter from about 4 to approximately 12,000 microns with distinct peaks at 4 to 40 microns, 111 microns, 220 microns, and 800 to 900 microns. Each peak appears to represent a separate material source. The 4 to 40 micron particles represent wind-blown dust typical of the project region and the other semi-arid and arid regions of the west. On the Anderson property, these particles have been transported to the site by winds largely from the south-southwest. The particles 111 microns in diameter have been generated from the exposed ore deposits on the property. These particles are agglomerative in nature, generally forming aggregates too large to be carried by the wind; consequently, this material is normally transported by surface runoff. Particles in the 220 micron class appear to be derived from the Tertiary volcanic series in the vicinity of the property. These particles are also transported primarily by water. The 800 to 900 micron particles originate from the fluvial material typical of the river alluvium that borders the Anderson property. These particles were moved to the sample sites primarily by strong north-northeast winds.

A good correlation between uranium-238 and uranium-234 concentrations was observed in the sediment samples; however, the uranium-234

Table 2.9-6. RADIOACTIVE MATERIALS IN THE SEDIMENTS ON THE ANDERSON PROPERTY (pCi/g (dry))

Sediment Sample	U^{238}	U^{234}	Th^{230}	Ra^{226}	Pb^{214}	Bi^{214}	Pb^{210}	Th^{232}	Pb^{212}	Gross Alpha	Gross Beta	K^{40}	Cs^{137}
S1					.5 ± .9	.3 ± .5			.5 ± .4	5 ± 3.2	8.5 ± 1.2	22 ± 4	.2 ± .1
S2A	0.82 ± 0.11	.81 ± .11	.45 ± .11	.54 ± .02	1.0 ± .5	.2 ± .5	.5 ± .4	.54 ± .13	.9 ± .5	6.4 ± 3.4	11 ± 2	23 ± 5	.3 ± .2
S2B	0.62 ± 0.11	.60 ± .11	.33 ± .06	.32 ± .01	.6 ± .4	.3 ± .5	.6 ± .4	.48 ± .08	.7 ± .4	8.7 ± 3.8	12 ± 2	29 ± 5	.2 ± .2
S3A	0.90 ± 0.22	.83 ± .21	.48 ± .10	.36 ± .01	.6 ± .5	.3 ± .5	.6 ± .4	1.04 ± .18	.9 ± .5	8.4 ± 3.7	14 ± 3	31 ± 5	<.3
S3B	0.38 ± 0.11	.38 ± .11	.23 ± .06	.23 ± .01	.3 ± .5	.3 ± .4	<0.4	.53 ± .11	.2 ± .5	6.2 ± 3.4	4.7 ± 1.0	31 ± 6	<.2
S4					.9 ± .5	.2 ± .5			.5 ± .4	5.0 ± 3.3	5.8 ± 1.0	33 ± 6	<.2
S5					.3 ± .4	.2 ± .5			.5 ± .4	11 ± 4	10 ± 2	29 ± 6	<.3
S6					1.0 ± .5	.2 ± .5			.9 ± .5	5.9 ± 3.3	8.5 ± 1.2	19 ± 4	<.2
S7					1.2 ± .5	.5 ± .4	.8 ± .4		1.0 ± .4	9.8 ± 3.9	11 ± 2	20 ± 5	<.3
S8					.7 ± .5	.2 ± .4			.8 ± .4	9.2 ± 3.8	8.2 ± 1.1	26 ± 5	<.2
S9					.9 ± .4	.2 ± .4			1.1 ± .4	12 ± 4	8.0 ± 1.1	26 ± 5	<.2
S10					.2 ± .5	.2 ± .5			.6 ± .4	11 ± 4	11 ± 2	28 ± 5	<.2
S11					.2 ± .5	.2 ± .4			.7 ± .4	8.4 ± 3.7	13 ± 2	32 ± 5	.2 ± .1
S12					.8 ± .4	.4 ± .4			1.1 ± .4	7.6 ± 3.6	11 ± 2	24 ± 5	<.2
S13A	0.68 ± .14	.64 ± .13	.35 ± .07	.33 ± .01	.9 ± .1	.7 ± .4	.8 ± .4	.37 ± .07	.9 ± .4	5.0 ± 3.2	11 ± 2	24 ± 4	.2 ±.1
S13B	0.46 ± .10	.45 ± .09	.30 ± .11	.33 ± .01	.9 ± .5	.2 ± .5	.9 ± .4	0.70 ± .17	.6 ± .4	7.6 ± 3.6	5.7 ± 1.0	20 ± 5	.2 ±.2
S14					1.1 ± .5	.9 ± .6	.7 ± .4		.4 ± .4	3.9 ± 3.0	8.8 ± 1.2	22 ± 5	<.2
S15A	0.43 ± .10	.43 ± .10	.26 ± .07	.22 ± .01	.9 ± .4	.2 ± .4	.7 ± .4	.33 ± .08	.8 ± .4	4.5 ± 3.1	8.1 ± 1.1	28 ± 5	<.1
S15B	0.32 ± .08	.30 ± .07	.16 ± .02	.28 ± .01	.9 ± .5	.2 ± .4	.6 ± .4	.26 ± .03	.5 ± .4	8.4 ± 3.7	14 ± 3	25 ± 5	<.2

values were equal to or slightly lower than the uranium-238 values, suggesting that uranium-234 may not yet have reached equilibrium since deposition of the uranium-238. No significant separation of the two uranium isotopes has occurred in the sediments, which indicates that both are oxidized. This is not unexpected in a region with a relatively depressed water table(s).

The thorium-230 concentrations in the samples were approximately half of the value to be expected if this daughter was in equilibrium with its parent, uranium-234. This implies a relatively recent (in geologic time) separation of oxidized uranium and thorium. On the assumption that the transfer of the uranium parent took place without thorium-230 accompanying it, then the separation took place roughly 77,000 years ago.

Comparison of radium-226 data to that of lead-214 showed the latter to be abnormally high relative to the radium content of the sediment samples. Two trends can be seen in the relationship between these isotopes. In samples S2 and S3, the concentration of lead-214 is about twice that of radium-226. In samples S13 and S15, the lead-214 concentration is about three times greater than the concentration of radium-226. This difference in concentrations is possible because of the presence of the highly mobile intervening daughter of radium-226, radon-222. As a gas, radon has the capability of migrating from below the surface of the ground and depositing its daughters, of which lead-214 is one, on or near surface soils.

Lead-214 decays by beta emission to bismuth-214 which has a half-life of less than 30 minutes. Consequently, the concentrations of these two isotopes should be in a 1:1 ratio, but they are not in the sediment samples taken on the Anderson property. Due to the short half-life of lead-214 and bismuth-214 (26.8 minutes and 19.7 minutes, respectively), analysis for these isotopes should be done in the field to obtain accurate results. Because of a high dependence on rapid analysis, ventilation, careful handling, and possibly analytical procedures, the lead-214/bismuth-214 results obtained for the Anderson property may represent procedural bias.

Since lead-210 has a half-life of 22 years, the results of analysis for this isotope should be more pertinent than the lead-214 results for samples transported from the field to a laboratory for analysis. Except for sample S2A which was unaccountably high in lead-214 and sample S3B which had no significant lead-210 concentration, the data verify the lead-214 readings on close to a 1:1 basis.

If uranium-238 is in equilibrium with its daughters and no thorium is present, the gross alpha measured in a sample should be equal to the total activity of the uranium-238 plus its alpha-emitting daughters or roughly eight times the activity of uranium-238 (Faul, 1954). Calculations based on the sediment analyses result in a uranium (plus daughters) to gross alpha ratio of 1:1 to 1:3.3. Allowing for error in the measurement of both variables, these calculations indicate that the alpha levels are slightly higher than can be accounted for by the uranium series.

The only alpha-emitting isotope in the uranium-238 series that would not be expected to be in equilibrium in the sediments is polonium-210. Polonium-210 is a daughter of radon-222. As discussed above, radon migrating to the surface of the soil could deposit its daughters there, resulting in higher than normal concentrations of polonium-210 and other isotopes. This could account for the excess gross alpha readings.

A potential exists for the differential accumulation of polonium-210 in the surface soils compared to its daughter, lead-210. Polonium is relatively insoluble in the alkaline environment typical of the groundwater and soils of the property; consequently, differential migration by groundwater movement seems unlikely. However, polonium-210 is relatively volatile, particularly at the high temperatures experienced in the Arizona desert. Concentrations of polonium-210 relative to lead-210 in the near surface soils could result from "random walk" of polonium atoms.

Thorium-232 concentrations in the sediment samples ranged from 0.26 to 1.04 pCi/g with a geometric mean of 0.48 pCi/g (Table 2.9-6).

Concentrations of lead-212, a thorium-232 daughter, ranged from 0.2 to 1.1 pCi/g with a geometric mean of 0.67 pCi/g. Since the concentrations of these two isotopes should be equal in equilibrium conditions, the results indicate geochemical separation. The highest values for thorium came from samples taken near basalt outcrops. The highest values for lead-212 came from the basalt outcrop areas and the stream course along the western side of the property.

The decay chain for thorium-232 is shown in Figure 2.9-6. The figure includes the primary decay modes (alpha or beta emission) and half-lives of each of the major intermediate products between thorium-232 and stable lead-208. Compared to the uranium series, the time required for thorium-232 to decay to lead-208 is short, taking slightly less than nine years. The most stable nuclides in the series are radium-228 (half-life of 6.7 years) and thorium-228 (half-life of 1.9 years). With the exception of radium-224 (half-life of 3.64 days), all the other intermediate isotopes have half-lives of considerably less than one day. Consequently, after the production of radon-220 (half-life 54.5 seconds), the only nuclides in the series that are reasonable to analyze for in field samples analyzed in a laboratory are lead-212 (half-life of 10.6 hours) and bismuth-212 (half-life of 60.5 minutes).

Due to the short half-life of the intermediate isotopes between thorium-228 and lead-212 and the length of time between sample collection and analysis, thorium-228 and lead-212 should have been in equilibrium at the time laboratory tests were conducted. The only nuclide

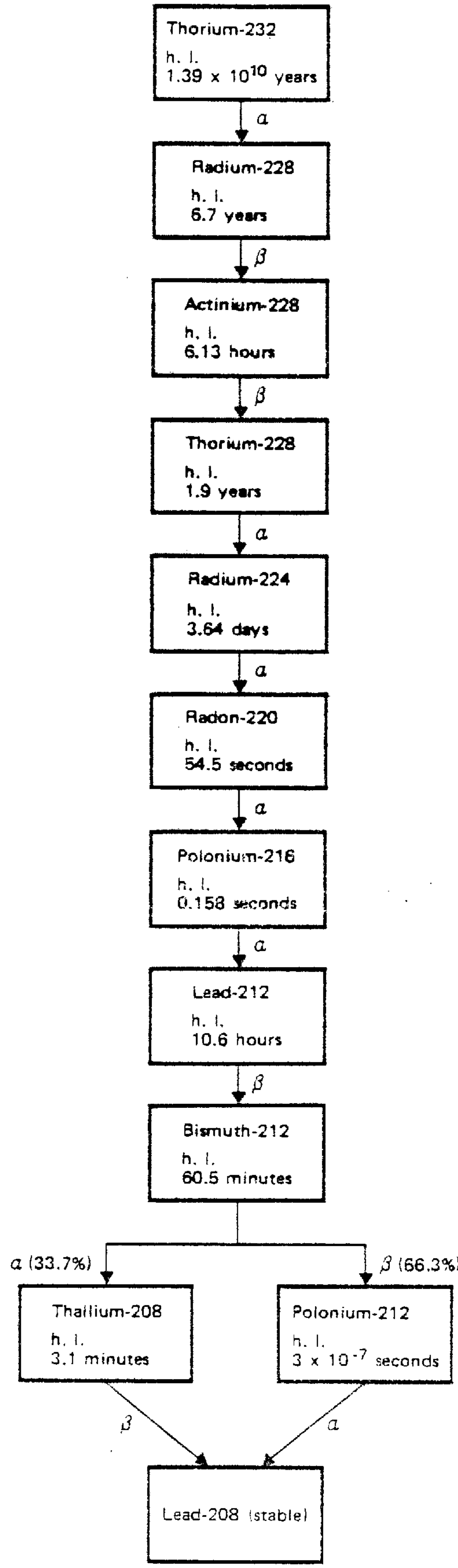


Figure 2.9-6. DECAY CHAIN FOR THORIUM- 232

between thorium-232 and lead-212 that has a sufficiently long half-life, as well as different chemistry, that would permit significant differentiation is radium-228 (half-life of 6.7 years). Therefore, the only plausible explanation for the results is a physical-chemical separation of thorium-232 and radium-228 in the sediments.

An evaluation of the samples for which both thorium-232 and lead-212 concentrations were determined provides some information on the possible mechanisms causing this differentiation. Sample locations S2, S3, and S15 lie along the same stream course (Figure 2.9-1), with sample S3 closest to the basalt that appears to be the primary source of thorium in the area. As may be seen, the average of the thorium-232/lead-212 ratios for the two samples collected at each of the three locations is a continuous function with distance along the stream course (Figure 2.9-7):

$$R = 1.91 - 0.157 \ln D$$

where

R = thorium-232/lead-212 ratio

ln = log to the base e

D = distance in feet from the source along the stream course

Although the number of locations examined is limited, the correlation is good. Since the function is log-linear, the differentiation is probably due to differences in solubility between thorium and radium.

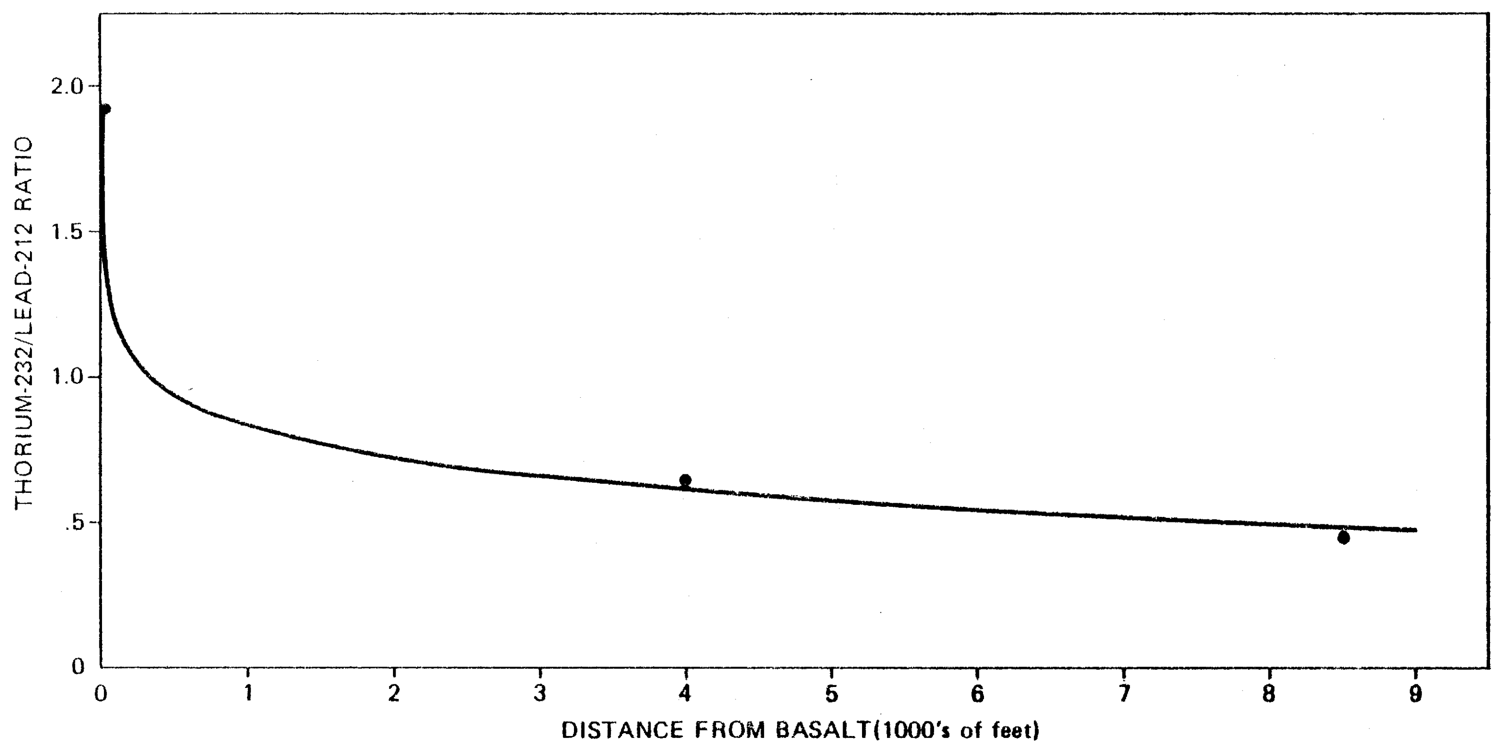


Figure 2.9-7. THORIUM-232/LEAD-212 RATIO AS A FUNCTION OF DISTANCE FROM BASALT DEPOSIT

Evaluation of the uranium-238 and thorium-232 concentrations in the sediments shows two relationships between these isotopes. The upper curve on Figure 2.9-8 represents samples starting at the ore bed and proceeding along the given stream course. The second curve represents samples starting at the basalt outcrop and proceeding downstream; however, all of the samples were not taken from the same stream course. It is interesting to note that both curves have the same zero thorium intercept on the uranium axis, about 0.14 pCi/g.

Cesium-137 levels in the sediment samples were at or below the detection limits of the analysis. Because the values were so low compared to the potential error, it is not possible to determine any distribution relationships for this isotope. However, it should be noted that the locations where cesium-137 may have accumulated correspond with deposition of sediments by southwest winds (Table 2.9-6 and Figure 2.9-1).

Potassium-40 concentrations were generally four to six times the probable analytical error, representing significant levels of this radionuclide in the sediments on the property (Table 2.9-6). Distribution of the potassium appears to be relatively uniform, although higher values were associated with basalt areas and one position in the river bottom roughly at the confluence of Karnak Creek (Figure 2.9-1).

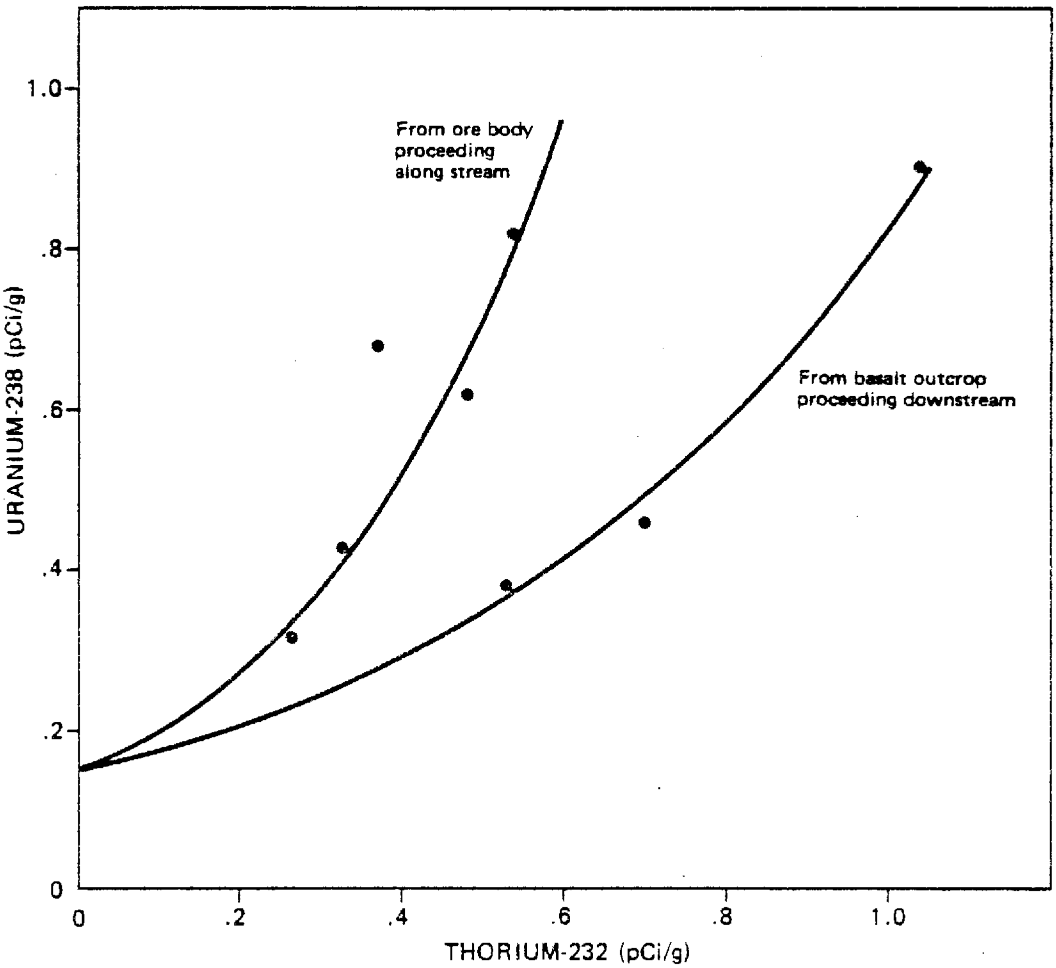


Figure 2.9-8. RELATIONSHIP BETWEEN URANIUM-238 AND THORIUM-232 CONCENTRATIONS IN THE SEDIMENTS ON THE ANDERSON PROPERTY

Comparison of uranium-238 and thorium-232 concentrations with potassium-40 on the property is of interest due to the intense igneous activity that occurred in the area during the Tertiary. Potassium, like uranium and thorium, is commonly rejected to a late crystallizing phase in melted rock. Consequently, associations between the three elements are commonly sought in geochemical analyses. As can be seen in Figure 2.9-9, thorium and uranium are at minimum levels when potassium-40 concentrations are on the order of 26 to 27 pCi/g. Below this concentration, uranium and thorium decrease as potassium increases while above this concentration uranium and thorium increase as potassium increases. The "null" value on the uranium-238/potassium-40 curve in Figure 2.9-9 is close to the value of uranium-238 at the thorium-uranium intercept on Figure 2.9-8. This suggests a baseline concentration of uranium for the area in an earlier geologic time which has subsequently increased due to concentration through altered geochemical conditions.

Vegetation

Vegetation samples were collected at 11 locations encompassing the area exposed to the ore deposits on the Anderson property (Figure 2.9-1 and Table 2.9-7). These samples were composited and analyzed for total uranium, gross alpha, gross beta, potassium-40, beryllium-7 (a natural radioactive isotope found in the atmosphere), the uranium daughters lead-214 and bismuth-214, and five beta-emitting fallout

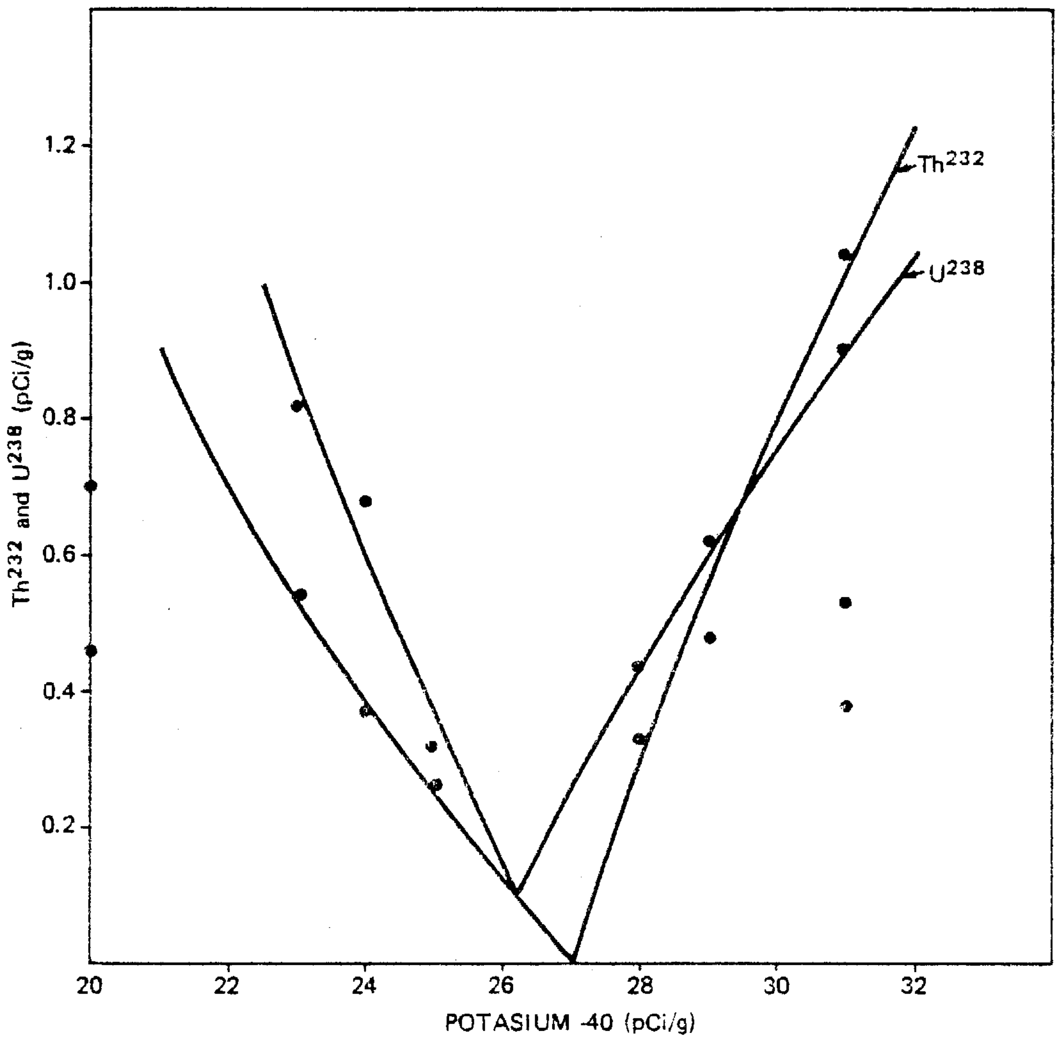


Figure 2.9-9. RELATIONSHIP BETWEEN URANIUM -238/THORIUM -232 AND POTASIUM -40 CONCENTRATIONS IN THE SEDIMENTS ON THE ANDERSON PROPERTY

Table 2.9-7. VEGETATION SAMPLES COLLECTED ON THE ANDERSON PROPERTY FOR RADIOLOGICAL ANALYSIS

Sample	Location	Elevation	Contents (In Descending Order by Weight)
V1	NE 1/4 Sec. 10 Coincides with soil sample #2	1760 ft	Brittlebush (Encelina farinosa) Catclaw (Acacia greggii) Wolfberry (Lycium Spp.)
V2	NW 1/4 Sec. 14 along wash, coincides with soil samples #3 A & B	2120 ft	White Bursage (Franseria dumosa) Globemallow (Sphaeralcea spp.) Joint-fir (Ephedra trifurca) Bladdersage (Salazaria mexicana)
V3	Near tank at South Border Sec. 27	2320 ft	White Ratany (Kamaria Grayi) Beavertail Cactus (Opuntia basilaris) Cane Cholla (O. acanthocarpa) Paperflower (Psilotrophe cooperi) Tabosa Grass (Hilaria mutica)
V4	NE 1/4 Sec. 11, at confluence two washes 1/2 mi. ENE of Anderson Mine. Coincides with soil sample #6	1760 ft	White Bursage Ratany (Kamaria spp.) Catclaw Paperflower Tabosa Grass Globemallow
V5	S. side Santa Maria R. at confluence with wash near north edge Sec. 3, coincides with soil sample #11	1520 ft	Mesquite (Prosopis juliflora) Catclaw Seep-willow (Baceharis glutinosa)
V6	East edge Sec. 3 upslope from confluence of two washes; soil sample #7 taken downstream in wash below this sample	1600 ft	Brittlebush White Bursage Palo Verde (Cercidium microphyllum)
V7	NE 1/4 Sec. 9, south side mesquite bosque at south side Santa Maria River. Coincides with soil sample #1	1580 ft	Mesquite Catclaw Seep-willow Black-bark Rabbitbrush (Chrysothamaus paniculatus)
V8	West edge of Sec. 9 along wash	1600 ft	White Bursage False Palo Verde (Holocantha emoryi) Bladder-stem
V9	South side Santa Maria River at north border Sec. 8, about 0.2 mi. west of NE Sec. corner	1480 ft	Catclaw Mesquite Cane Cholla
V10	Southwest facing slope of Black Mtn., SE 1/4 Sec. 2, about 0.1 mi northwest soil sample #14	1750 ft	Brittlebush White Bursage
V11	Near road junction at north edge Sec. 22.	2268 ft	Brittlebush Beavertail Cactus

isotopes (ruthenium-103, niobium-95, zirconium-95, cesium-137 and cerium-144) (Table 2.9-8).

Total uranium content was low in all the samples with less than half having concentrations greater than the limit of detection (approximately 0.05 μg/g). The highest concentration of uranium (0.3 μg/g) was detected in the vegetation growing on the ore deposits. Of the four other vegetation samples that contained detectable levels of uranium, two were taken downstream of the ore deposits, one was taken in the vicinity of the basalt outcrops on the property, and one (the lowest detectable concentration) was taken on the desert floor approximately one mile south of the exposed ore deposits (Table 2.9-8 and Figure 2.9-1).

The highest uranium concentration in vegetation was only about 10 percent of the uranium concentration found in the sediments at the sample sites. The other vegetation samples also contained far less uranium than the soils where they were growing. This may be due to rejection of the heavy uranium isotopes by the plants and/or the uranium may not be in a chemical form available for plant uptake.

Gross alpha counts for the vegetation averaged about 1.2 pCi/g. Three samples had a zero reading for gross alpha and the count for the remaining 8 samples ranged from 1.1 to 2.5 pCi/g with analytical error ranging from 0.9 to 1.5 pCi/g, respectively (Table 2.9-8).

In the vegetation sample with the highest gross alpha reading, approximately 80 percent of the count can be attributed to uranium, thorium, and their daughters. In the other samples with significant alpha readings, the uranium and thorium series accounts for only about 25 percent of the gross alpha activity. This suggests that the lower error limit (i.e., 1.6 - 1.3 = 0.3 pCi/g for sample V2) may be the actual gross alpha reading in these samples.

Gross beta counts for the vegetation averaged 16.6 pCi/g and ranged from 10 to 25 pCi/g. In most cases, these readings can be attributed primarily to potassium-40. In fact, in samples V1, V2, V3, V5, V8, and V11, potassium-40 levels were higher than the gross beta counts, indicating self-absorption during the laboratory tests.

Of the fallout isotopes, only niobium-95 and zirconium-95 were measured at reasonably detectable levels in most of the vegetation samples (Table 2.9-8). Concentrations of the other fallout nuclides (rubium-103, cesium-137, cerium-144, and beryllium-7) were relatively low (Table 2.9-8). For most of these nuclides, the higher concentrations were measured in samples taken in the vicinity of the ore deposits. This is apparently due to the drop off from the desert platform at this location, providing a deposition point for winds from the southwest.

No significant concentrations of lead-214 and bismuth-214 were found in the vegetation samples (Table 2.9-8).

Fauna

Two jackrabbits were collected on the Anderson property for radionuclide analyses (Figure 2.9-1). Both total biomass and skeletal tissue was analyzed for total uranium, gross alpha, gross beta, potassium-40, lead-212, lead-214, lead-210, radium-226, cesium-137, thorium-230, and thorium-232 (Table 2.9-8).

None of the radionuclides were found in significant concentrations except for potassium-40. Both jackrabbits contained higher levels of potassium-40 in their skeletal tissue than in all the tissue as a whole. The potassium-40 levels observed in the skeletal tissue were approximately the same as the concentrations measured in the sediment samples taken on the desert floor in the general vicinity of the fauna collection sites (Table 2.9-6) and close to the "null" value of uranium in the uranium/potassium curve shown in Figure 2.9-9.

Assuming that the relationship of uranium and thorium to potassium observed in the sediment samples is correct, then a concentration of 26 to 27 pCi/g of potassium in the jackrabbit tissue should be accompanied by 0.2 to 0.4 pCi/g of uranium-238 and 0 to 0.3 pCi/g of thorium-232. Neither uranium-238 nor thorium-232 were found above the limits of detection in the animal tissue. One skeletal sample did contain 0.02 ($\pm$0.01) pCi/g of thorium-230. If it is assumed that the thorium-230 was in equilibrium with uranium-238, then biochemical rejection of uranium relative to potassium has occurred in the jack-rabbits by at least a factor of 10.

The gross alpha counts for the total biomass of the jackrabbits, while subject to many variables, are on the same order as the radon-222 levels measured in the general area of collection for roughly a comparable volume of material. Since no heavy isotopes were reported for the jackrabbit biomass, equilibration of radon-222 content between the atmosphere and the tissue (assumed to be mostly water) may be a factor attributing to the gross alpha readings.

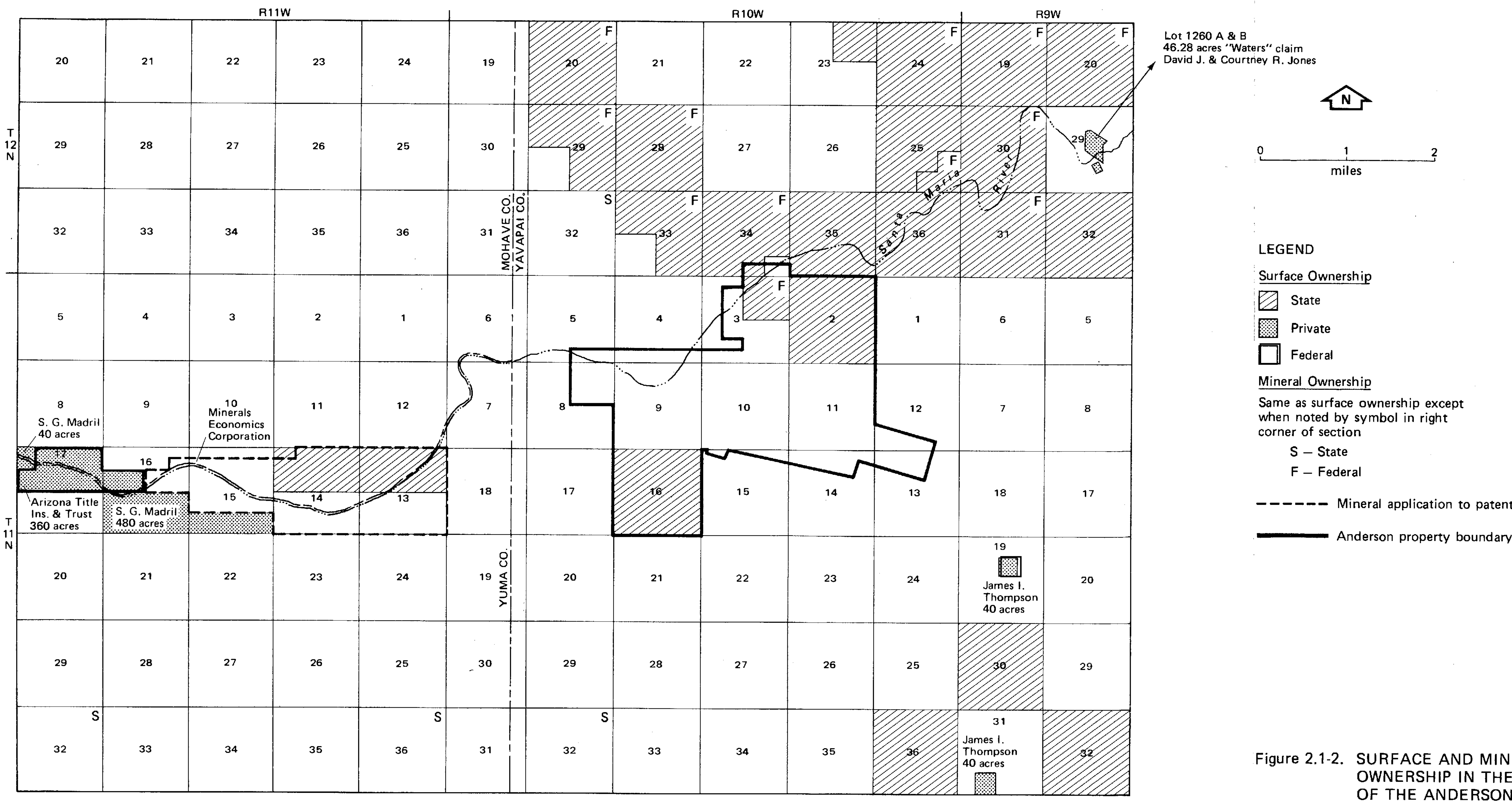


Figure 2.1-2. SURFACE AND MINERAL OWNERSHIP IN THE VICINITY OF THE ANDERSON PROPERTY

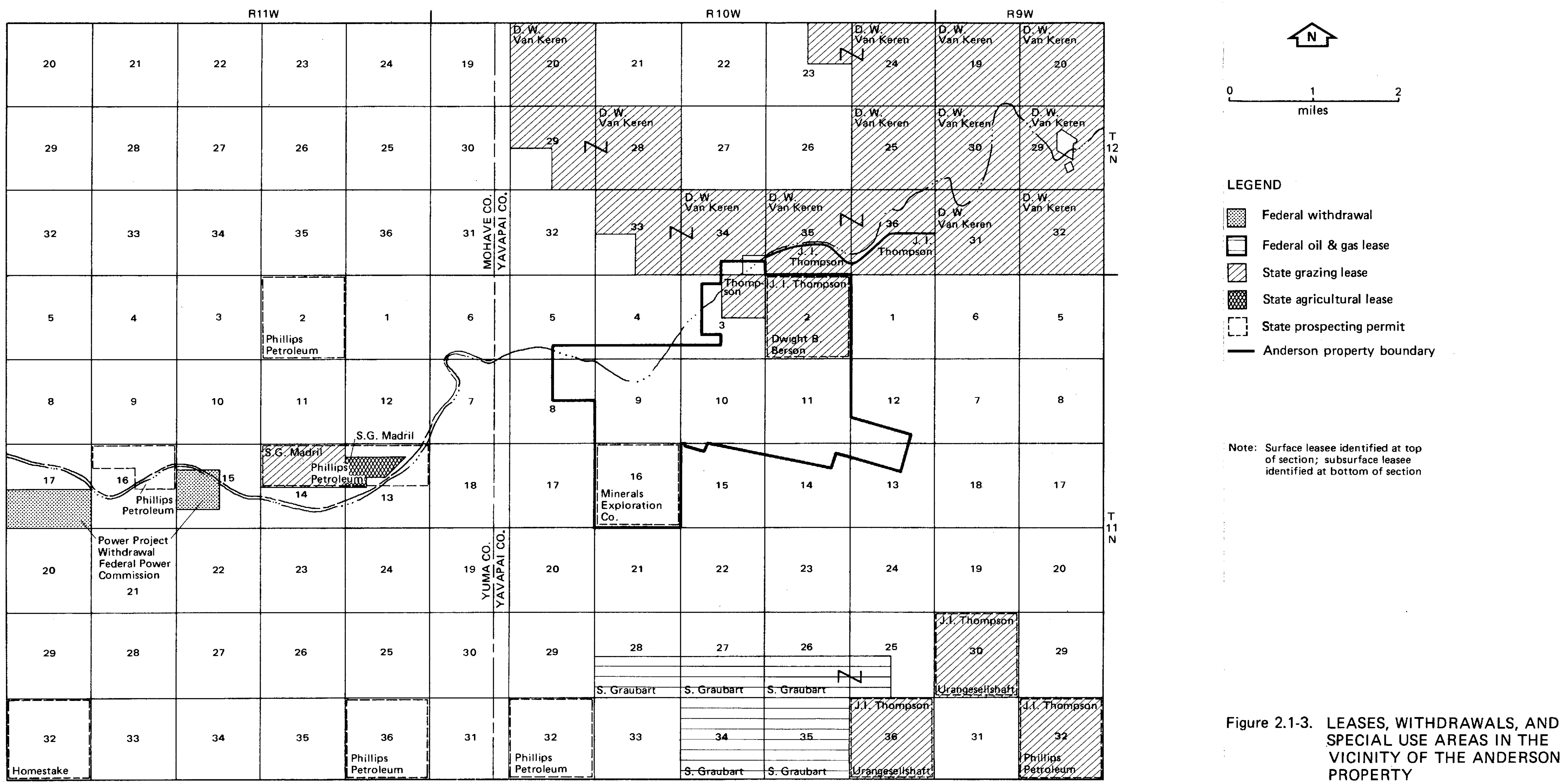


Figure 2.1-3. LEASES, WITHDRAWALS, AND SPECIAL USE AREAS IN THE VICINITY OF THE ANDERSON PROPERTY

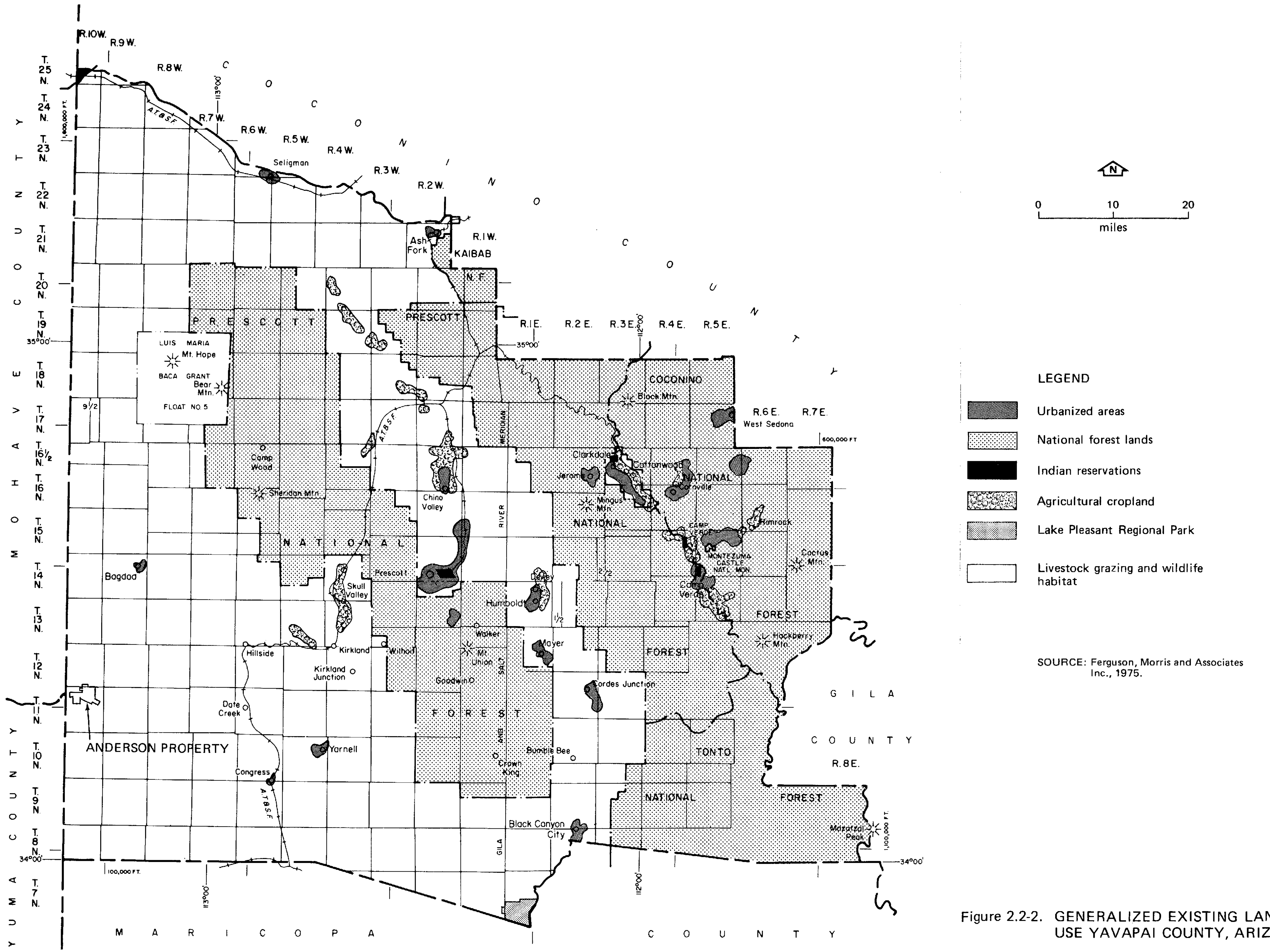
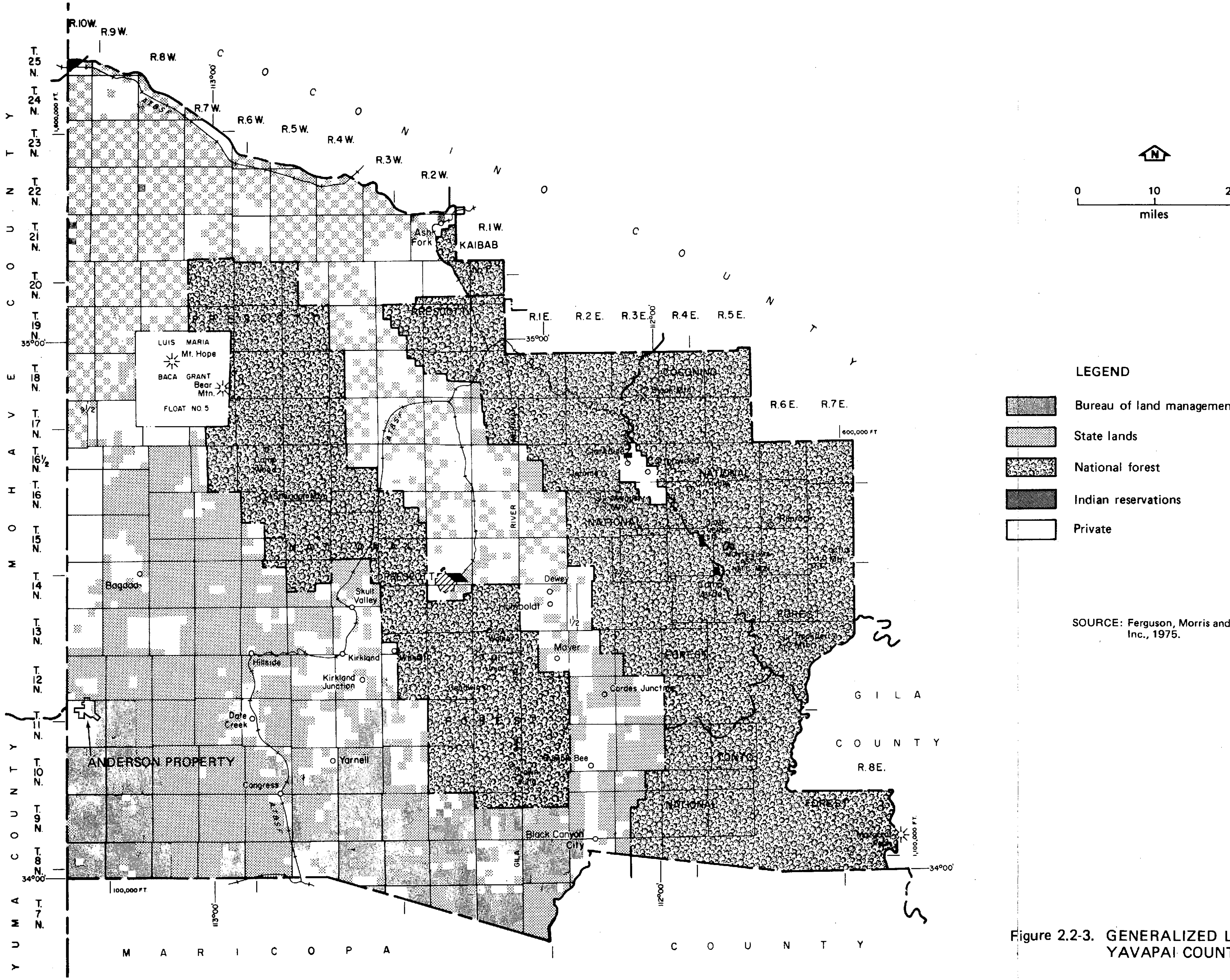


Figure 2.2-2. GENERALIZED EXISTING LAND USE YAVAPAI COUNTY, ARIZONA



SOURCE: Ferguson, Morris and Associates Inc., 1975.

Figure 2.2-3. GENERALIZED LAND OWNERSHIP YAVAPAI COUNTY, ARIZONA

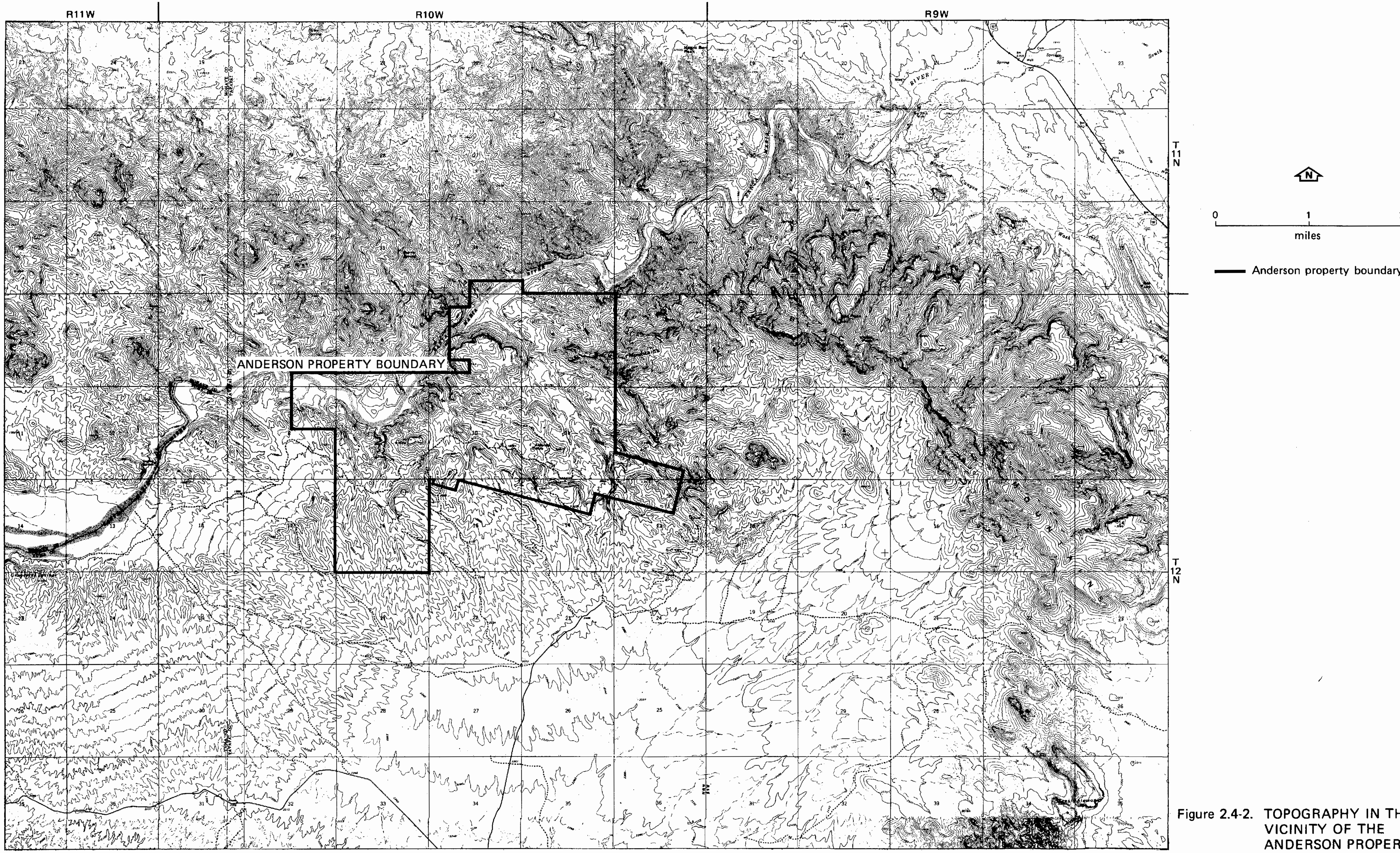
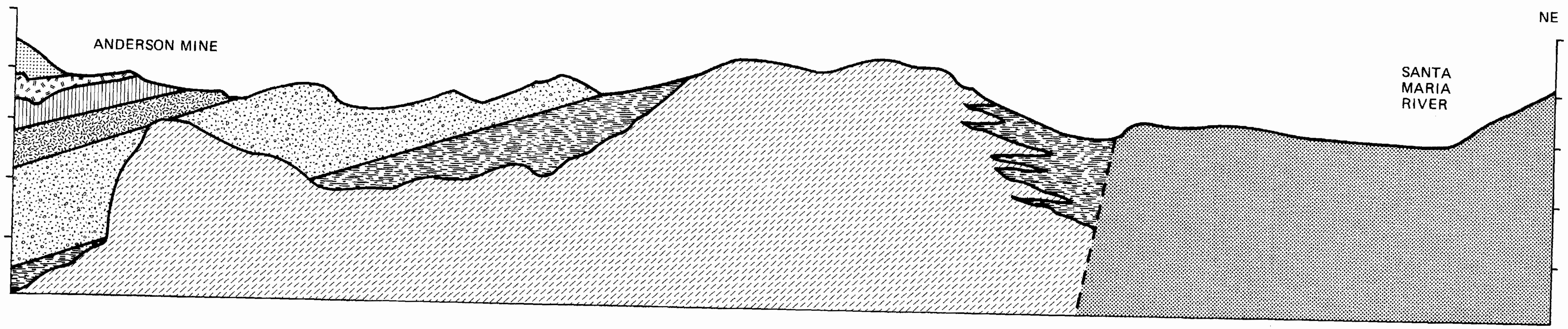


Figure 2.4-2. TOPOGRAPHY IN THE VICINITY OF THE ANDERSON PROPERTY



LEGEND

- Quaternery-Tertiary conglomerate, 0-400', tan to white, sandy to very coarse, locally calcite cemented, granitic metamorphic felsic and basalitic clasts
- Tertiary Miocene basalt, black, fine-grained to aphanitic, calcite-filled amygdules, commonly parallel to flow surface, 0-120'
- Tertiary miocene conglomerate, tan to brown siltstone grades upward into arkosic sandstone and then into conglomerate with granitic and felsic clasts, 200-450'
- Tertiary Miocene lacustrine sediments, basal arkosic sandstone, carbonaceous siltstone and lignite, silty limestone, limy siltstone, green siltstones and mudstones, tuffaceous material throughout, 0-400'
- Tertiary volcanic andesite, gray, gray-brown, red-brown, fine-grained, vesicular augite andesite, locally containing calcite-filled amygdules
- Tertiary volcaniclastic sediments, gray to white, felsic to intermediate tuffs, ash flows, lahar breccias, upper section yellow-tan to tan, sandy
- Tertiary felsic to intermediate volcanics, white to gray, pink-gray, necks, flows and tuffs
- Jurassic granite, brown, purple-gray, biotite granite

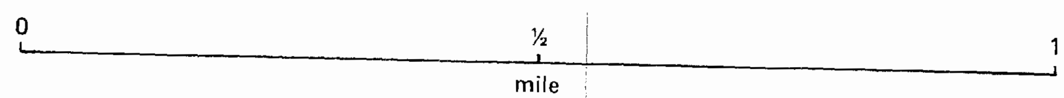


Figure 2.4-3. GENERALIZED CROSS SECTION OF THE ANDERSON PROPERTY (refer to Figure 2.4-4 for location of cross section)

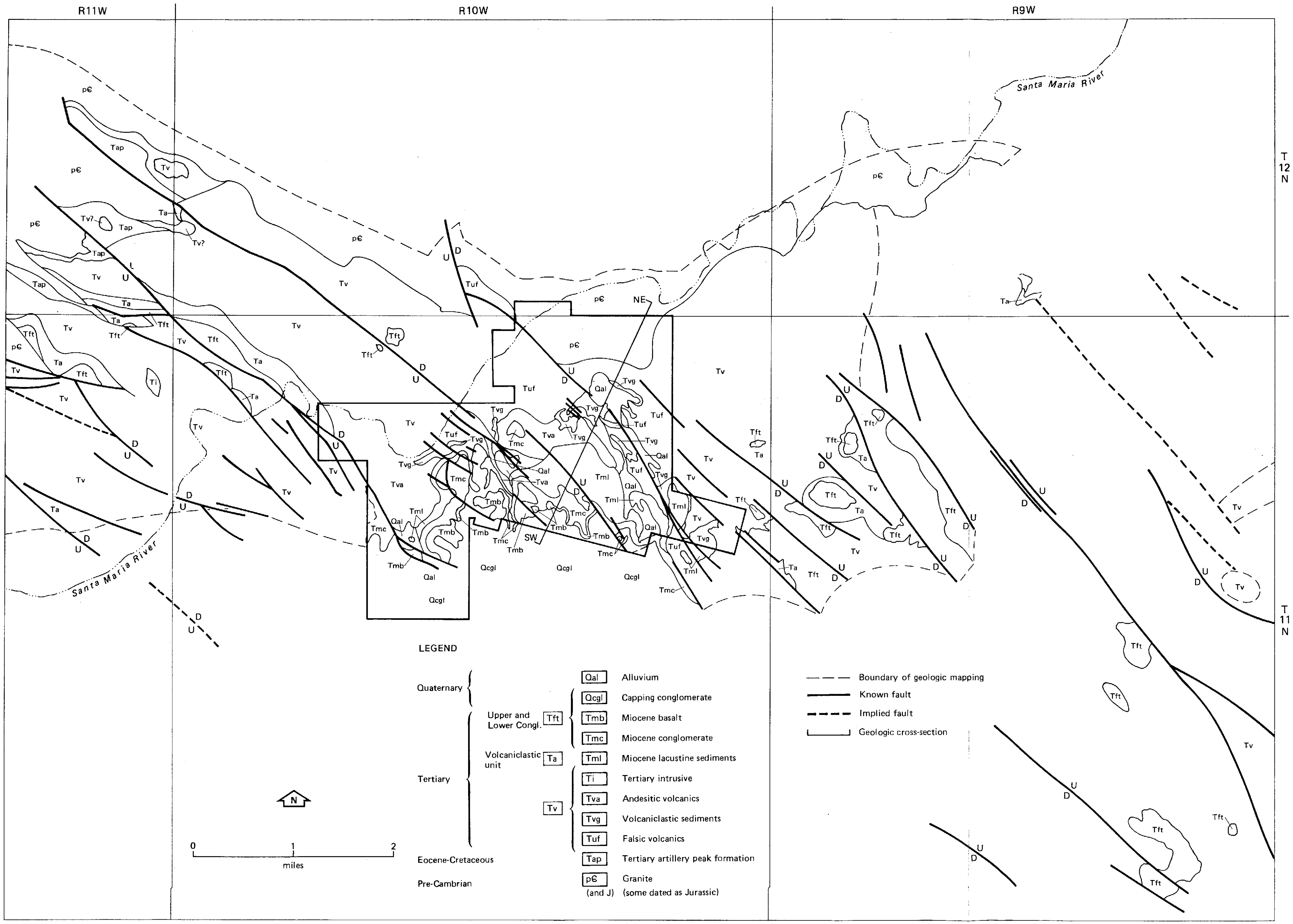


Figure 2.4-4. GEOLOGY OF THE ANDERSON PROPERTY

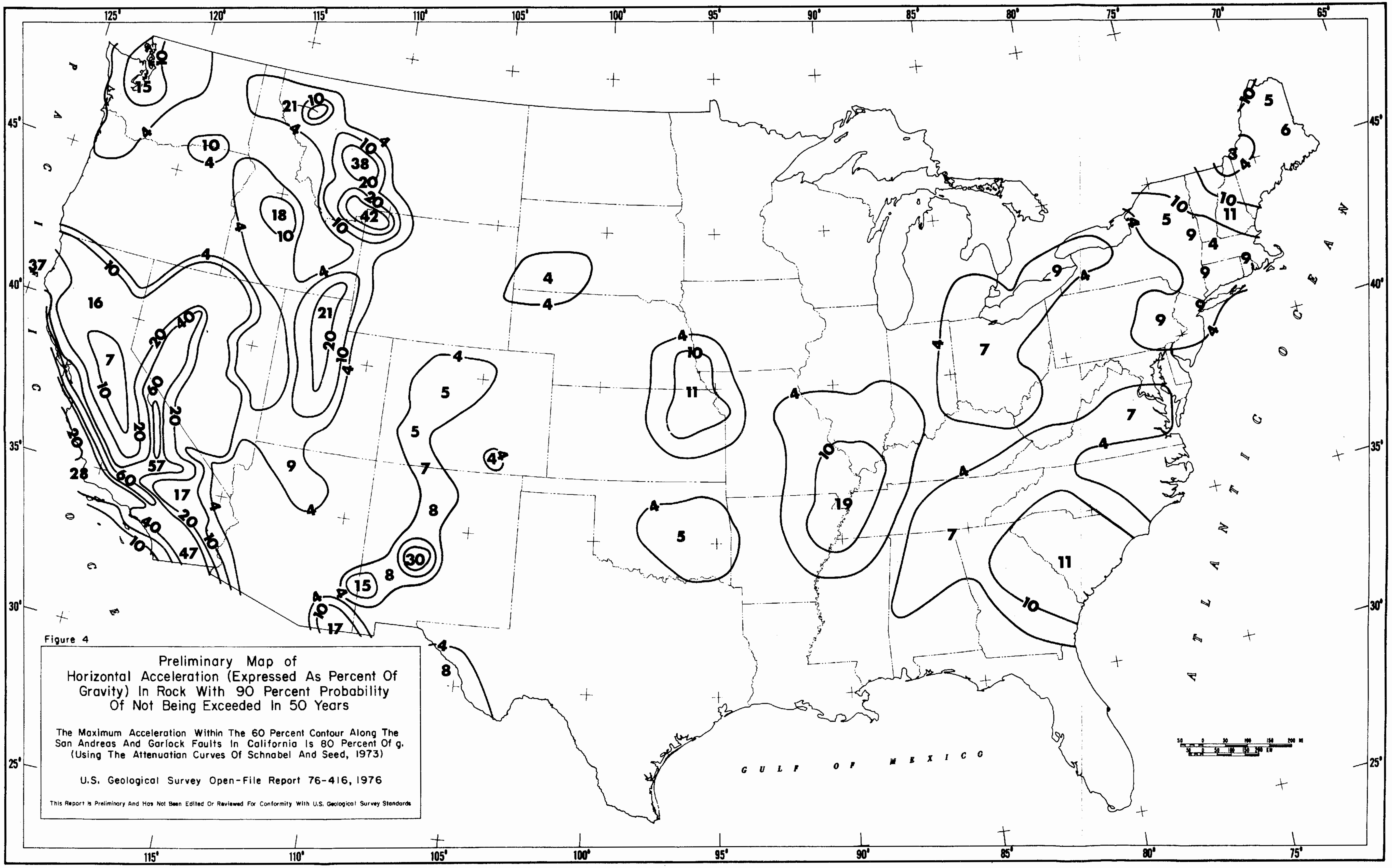


Figure 4
Preliminary Map of Horizontal Acceleration (Expressed As Percent Of Gravity) In Rock With 90 Percent Probability Of Not Being Exceeded In 50 Years
The Maximum Acceleration Within The 60 Percent Contour Along The San Andreas And Garlock Faults In California Is 80 Percent Of g. (Using The Attenuation Curves Of Schnabel And Seed, 1973)
U.S. Geological Survey Open-File Report 76-416, 1976
This Report Is Preliminary And Has Not Been Edited Or Reviewed For Conformity With U.S. Geological Survey Standards
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO

Figure 2.5-2

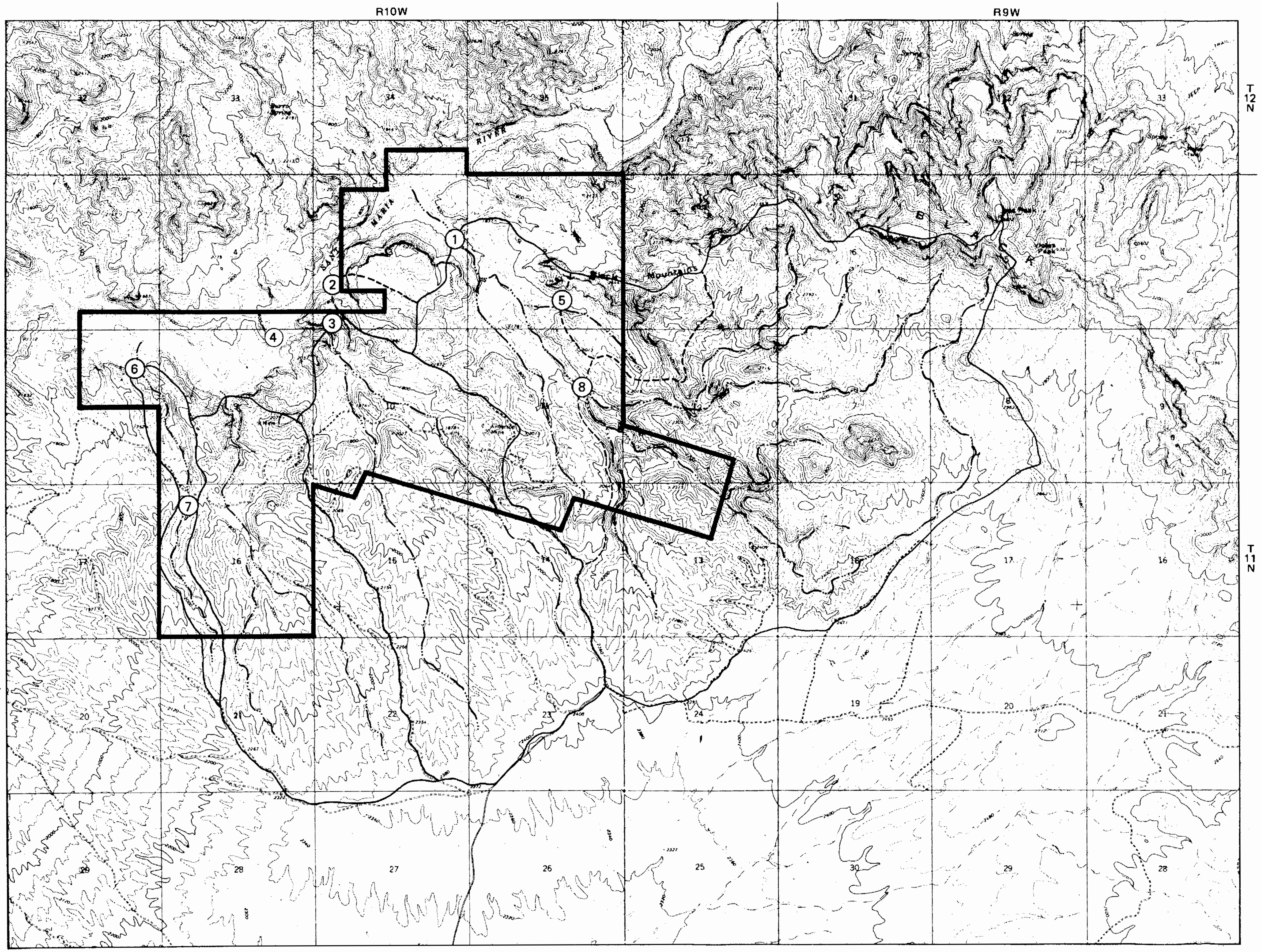
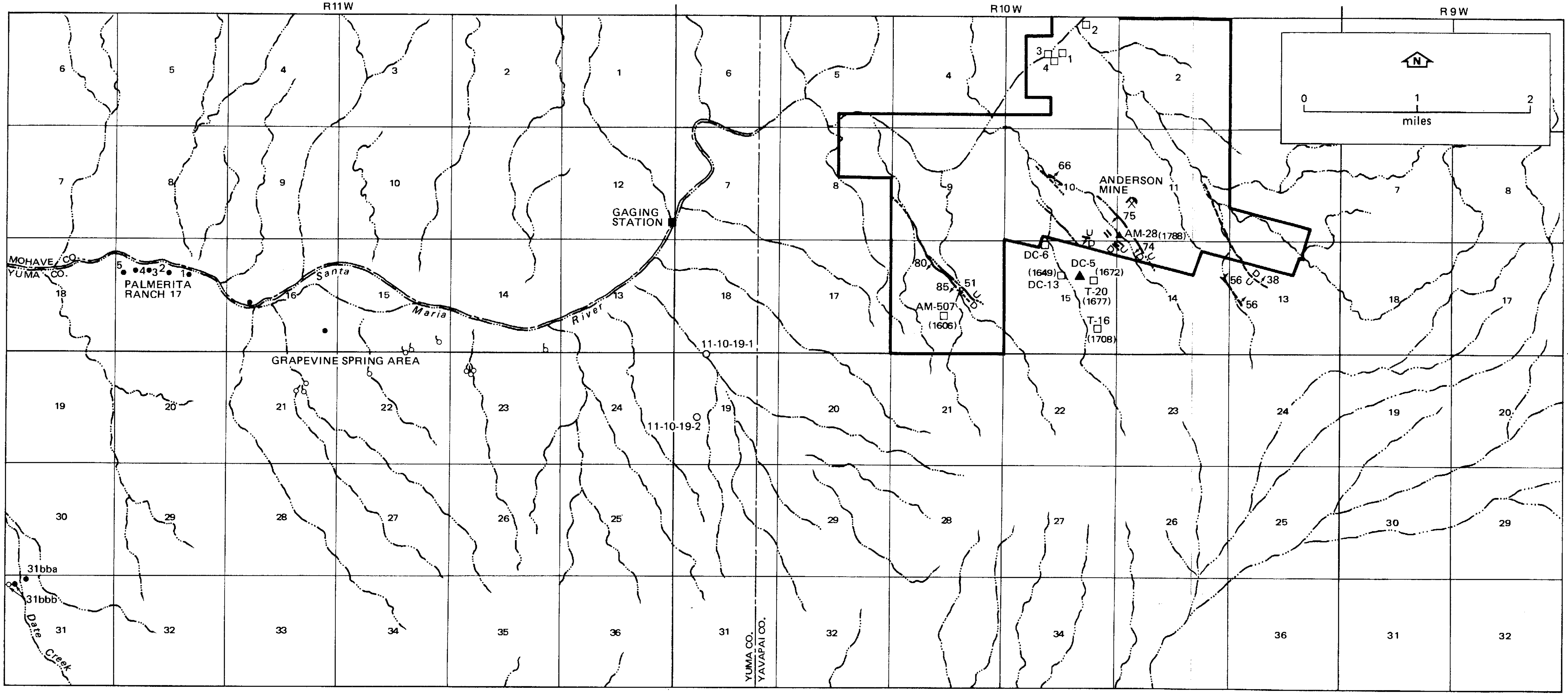


Figure 2.6-5. STAGE GAGE STATION LOCATIONS ON THE ANDERSON PROPERTY



Base from U.S. Geological survey maps.
Source: Water Development Corp., 1977.

LEGEND

- ● Irrigation well
- ○ Stock well
- ▲ Drilling water supply well
- Spring
- Intermittent stream
- □ Hydrologic exploration hole
- Fault showing dip (dashed where approximate)
- Anderson property boundary

Figure 2.6-9. PRINCIPAL WELLS IN THE VICINITY OF THE THE ANDERSON PROPERTY

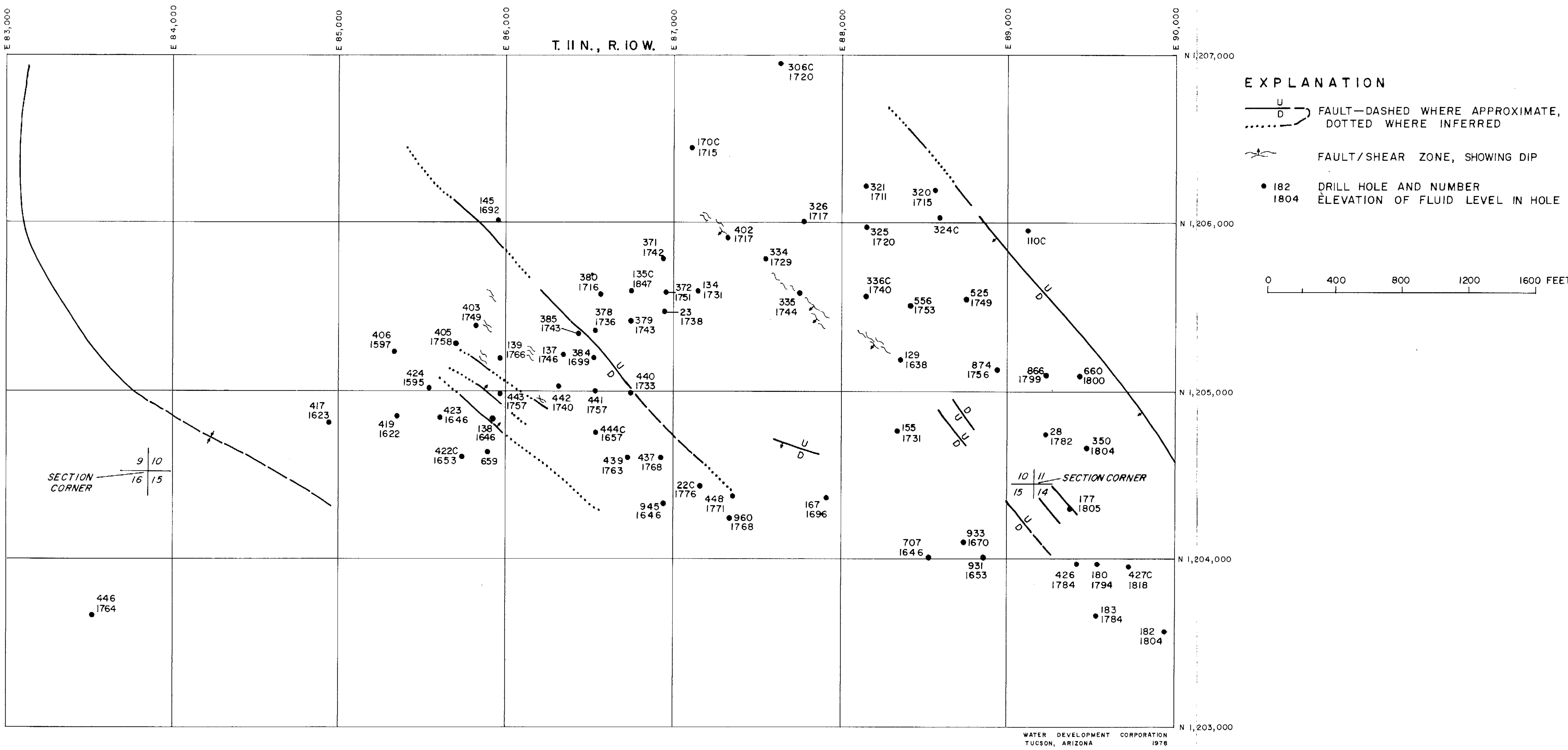
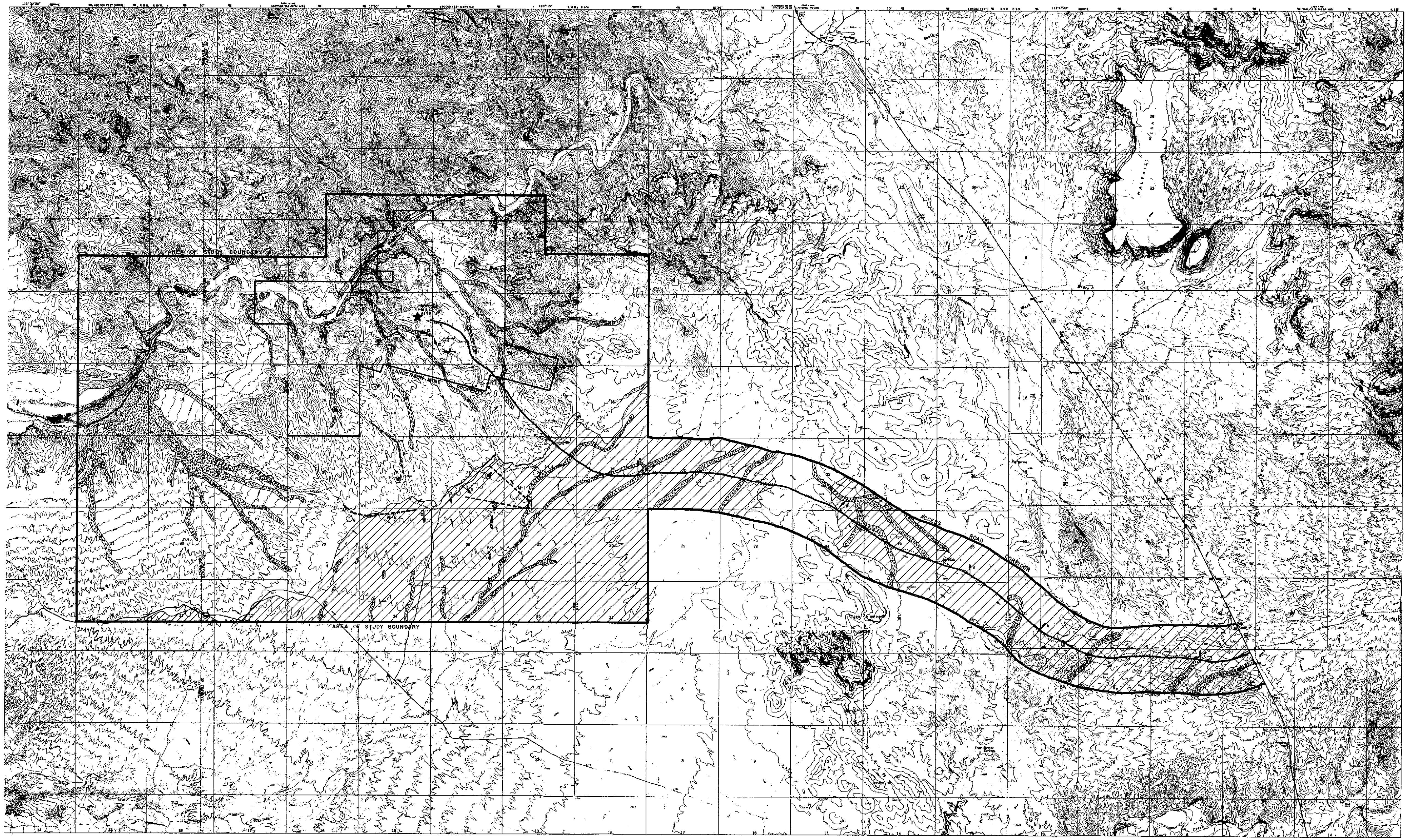


Figure 2.6-11. DRILL-HOLE FLUID-LEVEL ELEVATIONS, ANDERSON MINE AREA



LEGEND

- Riparian
- Upland desert
- Joshua tree woodland
- Pseudoriparian
- Vegetation sample site
- 5 x 5 drop-trap grid
- Proposed mill site
- Small mammal assessment line
- Bird transect

N

0 1 2
miles

Figure 2.8-1. BIOLOGICAL SAMPLE SITES AND VEGETATION TYPES

Source: Domes and Moore, 1978 a

Table 2.9-1. ATMOSPHERIC RADON CONTENT IN THE VICINITY OF THE ANDERSON PROPERTY

Date of Collection	Time of Collection	Sample A1 (pCi/l)	Time of Collection	Sample A2 (pCi/l)	Time of Collection	Sample A3 (pCi/l)	Time of Collection	Sample A4 (pCi/l)	Time of Collection	Sample A5 (pCi/l)	Time of Collection	Sample 1A (pCi/l)	Time of Collection	Sample A9 (pCi/l)
7-13-77	09:12 - 11:15	0.00* ± 0.10			09:06 - 11:06	0.00 ± 0.20								
	13:04 - 15:04	0.00 ± 0:20			14:15 - 16:15	0.00 ± 0.20								
7-14-77	07:15 - 09:00	0.35 ± 0.23							07:10 - 08:55	0.10 ± 0.08*				
	12:00 - 14:00	0.14 ± 0.10							11:55 - 13:15	0.00 ± 0.20				
7-15-77	07:40 - 09:40	0.00 ± 0.20									07:30 - 09:30	0.00 ± 0.20		
	12:21 - 14:21	0.29 ± 0.22									12:00 - 14:01	0.37 ± 0.19		
7-16-77	07:17 - 09:17	0.44* ± 0.13	07:05 - 09:05	1.4 ± 0.3										
	12:15 - 14:15	1.6 ± 0.3	12:07 - 14:07	1.0 ± 0.3										
11-9-77					08:55 - 10:55	1.0 ± 0.4								
11-9-77	12:00 - 14:00	0.3 ± 0.1			12:00 - 14:00	0.3 ± 0.1								
11-9-77 to 11-10-77	07:30 to 09:30	0.00 ± 0.2												
11-10-77	07:30 - 09:30	0.3 ± 0.2							07:30 - 09:30	0.0 ± 0.2				
	12:00 - 14:00	0.3 ± 0.1							12:00 - 14:00	0.0 ± 0.2				
11-11-77	07:30 - 09:30	0.0 ± 0.2					07:40 - 09:40	0.0 ± 0.2						
	12:00 - 14:00	0.8 ± 0.2					12:00 - 14:00	0.4 ± 0.1						
11-12-77	07:30 - 09:30	0.8 ± 0.1	07:30 - 09:30	0.8 ± 0.2										
	12:00 - 14:00	0.0 ± 0.2	11:50 - 13:50	0.5 ± 0.1										
11-13-77	07:30 - 09:30	0.7 ± 0.2											08:10 - 10:10	0.6 ± 0.3
	12:00 - 14:00	0.0 ± 0.2											12:00 - 14:00	0.7 ± 0.3

*Sample bag leaked, reading is for total sample received.

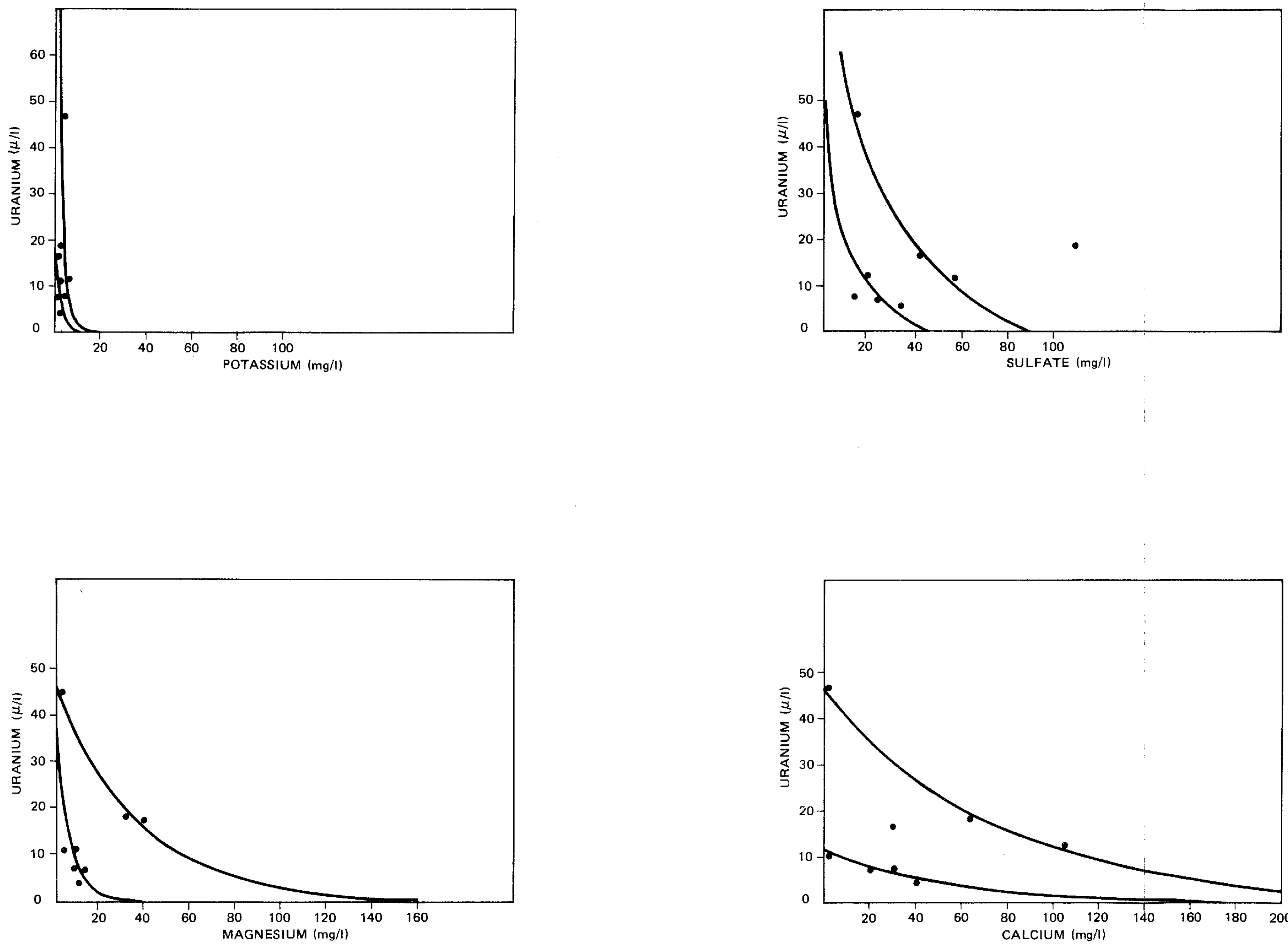


Figure 2.9-5. URANIUM CONCENTRATIONS IN GROUNDWATER RELATIVE TO OTHER MAJOR WATER QUALITY CONSTITUENTS

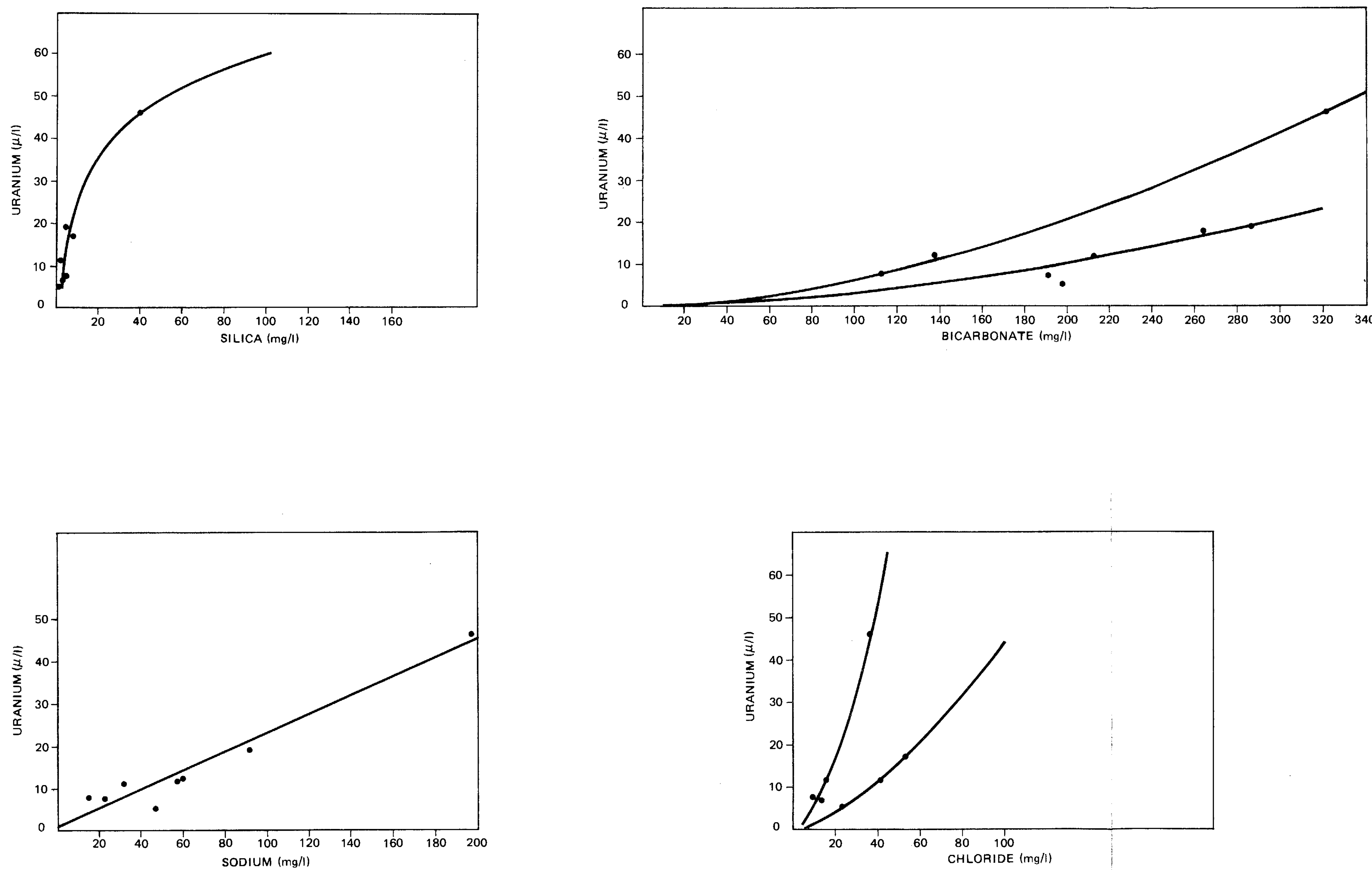


Figure 2.9-5-1. URANIUM CONCENTRATIONS IN GROUNDWATER RELATIVE TO OTHER MAJOR WATER QUALITY CONSTITUENTS

Table 2.9-8. RADIOACTIVE MATERIALS IN PLANTS AND ANIMALS ON THE ANDERSON PROPERTY (pCi/g (dry) unless otherwise noted)

Vegetation Sample	U Tot µg/g	Gross Alpha	Gross Beta	K^{40}	Zr^{95}	Nb^{95}	Ru^{103}	Pb^{214}	Bi^{214}	Cs^{137}	Ce^{144}	Be^{7}	Weight (Grams) Wet	Weight (Grams) Dry	Pb^{212}	Ra^{226}	Th^{230}	Th^{232}	Pb^{210}
V1	0.3	2.5 ± 1.5	25 ± 2	43 ± 13	3.6 ± 0.8	2.0 ± 0.7	1.0 ± 0.5	-	<2.1	<0.6	6.3 ± 5.4	5.7 ± 4.7	500	154					
V2	0.07	1.6 ± 1.3	10 ± 1	11 ± 5	1.4 ± 0.5	1.0 ± 0.4	<0.6	1.4 ± 1.2	-	0.3 ± 0.2	-	4.3 ± 2.4	500	362					
V3	<0.05	1.4 ± 1.3	14 ± 1	16 ± 4	0.9 ± 0.3	0.7 ± 0.3	-	-	<0.8	<0.2	2.2 ± 1.9	-	500	293					
V4	<0.05	0.0 ± 1.0	12 ± 1	10 ± 5	0.9 ± 0.4	0.5 ± 0.3	-	<1.6	<0.5	<0.4	<4.6	3.1 ± 2.2	400	376					
V5	<0.05	0.0 ± 1.0	16 ± 1	21 ± 10	1.2 ± 0.6	1.2 ± 0.6	-	-	-	<0.6	-	-	400	204					
V6	<0.05	1.4 ± 1.3	20 ± 2	<6.3	-	-	0.6 ± 0.5	-	-	<1.4	-	-	400	330					
V7	<0.05	1.4 ± 1.3	13 ± 1	10 ± 5	0.7 ± 0.3	0.5 ± 0.3	0.3 ± 0.2	<1.3	<1.3	<0.2	2.6 ± 2.3	<2.8	300	244					
V8	0.08	1.8 ± 1.3	16 ± 1	17 ± 6	1.2 ± 0.4	0.5 ± 0.3	0.5 ± 0.3	<1.5	-	<0.4	2.9 ± 2.8	-	400	222					
V9	<0.05	0.0 ± 1.0	11 ± 1	8.1 ± 4.2	0.9 ± 0.4	0.5 ± 0.3	-	<1.5	<1.2	<0.3	0	3.7 ± 2.0	500	343					
V10	0.08	1.4 ± 1.3	25 ± 2	15 ± 4	0.7 ± 0.3	0.6 ± 0.3	0.3 ± 0.2	-	<1.5	0.3 ± 0.1	2.1 ± 1.9	< 2.1	500	276					
V11	0.06	1.1 ± 0.9	21 ± 2	25 ± 10	0.9 ± 0.5	<1.0	0.4 ± 0.3	-	-	<0.4	-	-	500	189					
	avg.	1.15	16.6	16.6	1.13	0.75													
Fauna Sample																			
Biomass 1	<0.05	0.6 ± 0.2	8.9 ± 0.3	14 ± 7						<0.5					<1.5	0.00 ± 0.05	<0.02	<0.02	<0.1
Skeleton 1	<0.05	0.0 ± 0.1	1.7 ± 0.2	27 ± 8				<0.2		<0.1					<0.2	0.00 ± 0.05	0.02 ± 0.01	<0.02	<0.1
Biomass 2	<0.05	0.6 ± 0.2	8.6 ± 0.2	9.2 ± 4						<0.2					<0.7	0.00 ± 0.05	<0.02	<0.02	<0.1
Skeleton 2	<0.05	0.0 ± 0.1	2.1 ± 0.1	28 ± 6				<0.1		<0.1					<0.1	0.00 ± 0.05	<0.02	<0.02	<0.1

3.0

PROPOSED ACTION

3.1 MINING ACTIVITIES

MINERALS proposes to mine uranium ore located primarily in Sections 9, 10, 11, 14, and 15 of T11N, R10W (Figure 2.1-4). It is estimated that these deposits consist of 7.2 million tons of ore containing 10.3 million pounds of uranium oxide. The principal mineral in the ore is tyuyamunite ($Ca(UO_2)_2(VO_4)_2 \cdot 5\text{-}8\ H_2O$) which generally occurs in carbonaceous material. The ore ranges in grade from 0.03 to more than 0.15 percent uranium oxide and has an average grade of 0.072 percent. This ore will be used to supply a uranium mill to be constructed on the property (see sections 3.2 and 3.3).

Surface mining is the most appropriate method of recovering the ore on the Anderson property because of the relatively shallow depth of the deposits. Current plans call for surface mining operations to begin in the fourth quarter of 1979 (Figure 3.1-1). Within approximately 3 months, overburden removal will reach 2.43 million tons/month. After 5.75 years, overburden removal will decrease to 1.73 million tons/month and remain at this level for the life of the project. By March 1980, ore production will begin. Material removed from the

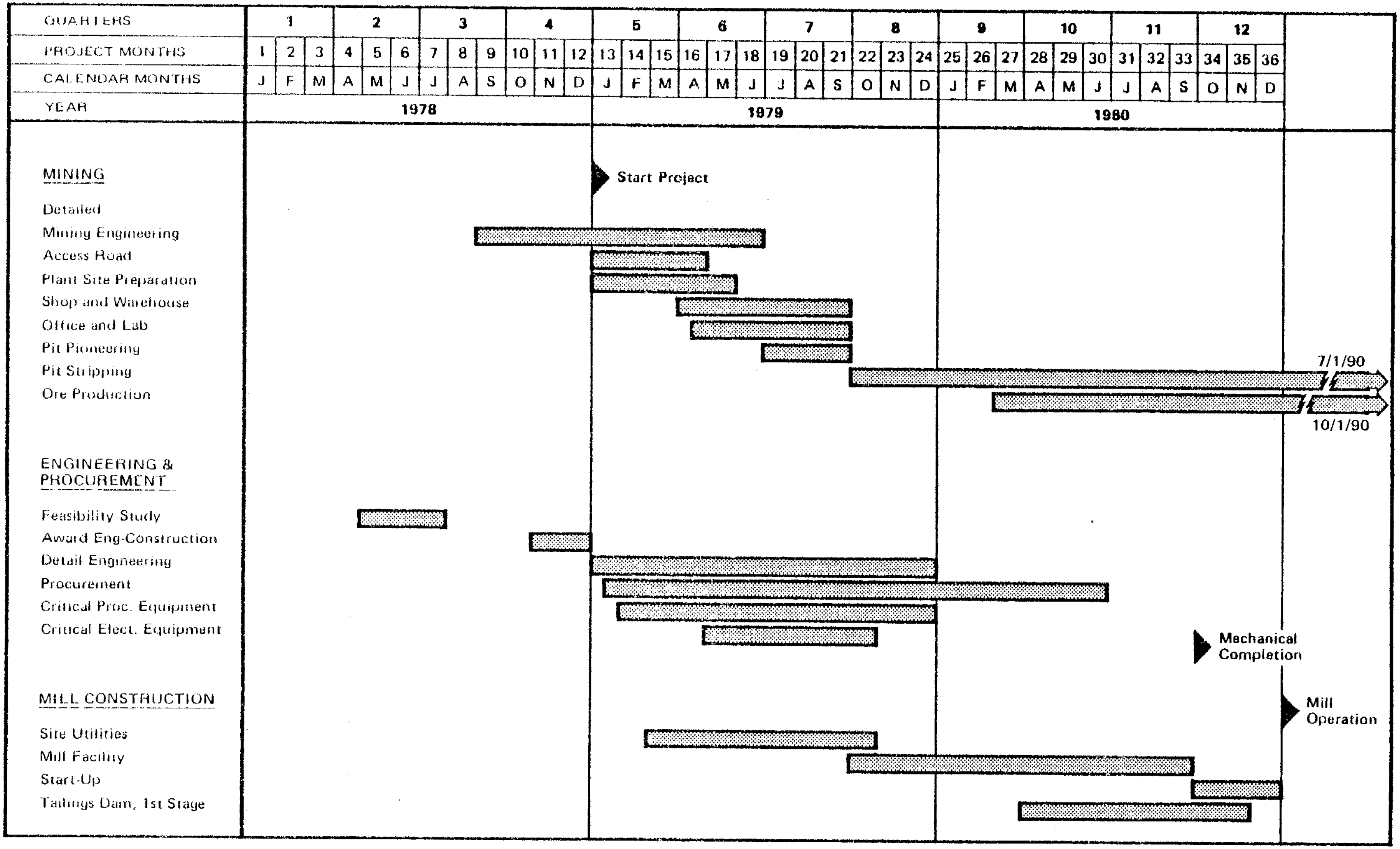


Figure 3.1-1. ANDERSON PROJECT SCHEDULE

mining zone will consist of 730,000 tons per year of ore and 2.71 million tons of associated "internal" waste for 10 years, when presently known ore reserves are exhausted.

The mine will operate primary stripping crews for 18 eight-hour shifts per week, 52 weeks per year. Mining crews will operate 15 eight-hour shifts per week, 52 weeks per year.

MINING PROCEDURES

Surface mining will consist of excavating one large pit and two isolated, smaller ore bodies (Figure 3.1-2). Overburden will be stripped from the pit areas with electric shovels (Table 3.1-1). Where necessary, the overburden will be drilled, charged, and blasted to facilitate removal. The overburden will be loaded into dump trucks and hauled either to the waste dump areas located east and west of the ore body (Figure 3.1-2) or to an exhausted pit area where it will be used as backfill.

Stripping will be done on 50-foot benches (Figure 3.1-3). The approximate slope between each bench will be 0.5:1, with an overall pit slope varying between 0.4:1 and 1.0:1, depending on the height of the slope (this includes safety benches with a minimum width of 10 feet). These slopes will have a factor of safety of at least 1.1 (Dames & Moore, 1978).

Table 3.1-1. TYPE OF EQUIPMENT TO BE USED FOR THE ANDERSON MINING OPERATION (including dam construction)

Item	Diesel	Gas	Fleet Operating Hrs Per Year	Horsepower
120-ton Haul Truck	X		59,063	1200
Rotary Drill	X		10,500	375
AN Truck	X		1,750	150
Tractor Dozer	X		13,125	310
5-yd Hydraulic Face Shovel	X		10,500	375
35-ton Haul Truck	X		45,000	302
Air Track Drill and Compressor	X		1,000	85
Motor Patrol	X		13,125	250
Rubber-tired Dozer	X		7,500	300
Water Truck	X		11,250	576
Lube Truck	X		3,900	290
2-ton Flat Bed Truck	X		3,900	150
1 1/2-ton Flat Bed Truck		X	3,900	280
Low Boy Transport	X		520	290
3-ton Stake Bed Truck	X		2,912	209
75-ton Truck Crane	X		520	318 150
15 Ton RT Crane	X		520	137
10 Ton Forklift	X		1,500	137
Pickup Trucks		X	18,750	150
Light Plant (4)	X		12,012	6

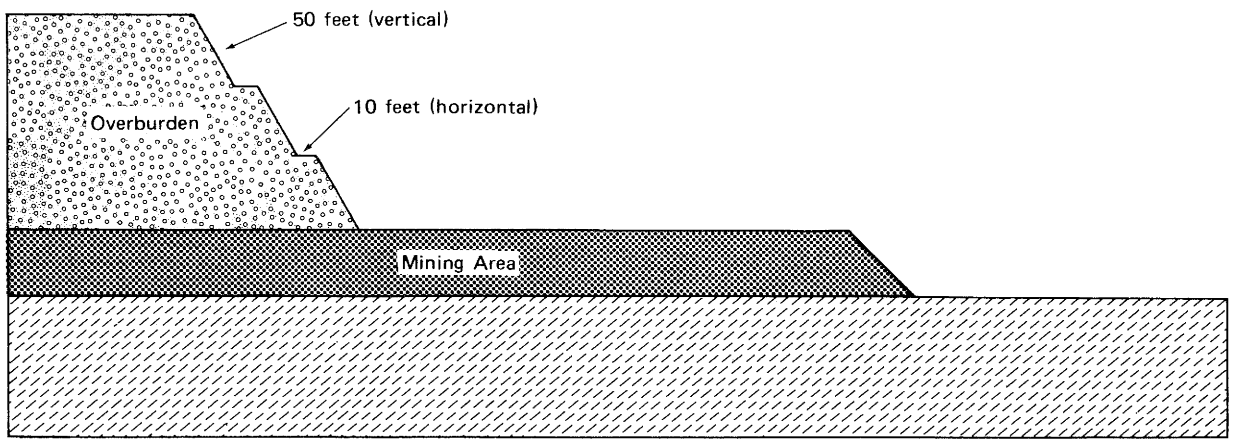


Figure 3.1-3. SCHEMATIC CROSS SECTION OF A SURFACE MINE

Before the final overburden bench is excavated, additional holes will be drilled to determine the exact location of the ore body. This information will be used to control the actual bottom elevation of the final bench and to determine the final mining plan.

The ore body to be mined consists of lenses of uranium mineralization surrounded and separated by barren rock, called internal waste. In order to accurately locate material containing uranium, an ore control map will be prepared from the information collected during the drilling program.

A tractor dozer equipped with a ripper bar will be used to loosen the ore. Once the ore in a given area has been loosened, the area will be checked for uranium content with either gamma probes or portable x-ray analyzers. The ore will then be staked out by grade and a map will be prepared for the loader operators.

A hydraulic shovel will segregate the ore and internal waste and load the material into dump trucks. The waste material will be hauled to one of the waste dumps or an exhausted pit area. The ore will be transported from the mine to a probe tower where a sample will be analyzed to determine uranium content. Material containing less than 0.028 percent uranium oxide will be hauled to either a low grade stockpile or an exhausted pit area. Material with a higher uranium oxide content will be deposited in one of three mill stockpiles (refer to Section 3.2 for further discussion of ore storage at the mill).

MINING SEQUENCE

The planned mining sequence is shown in Figure 3.1-2. Mining will begin in sequence 1 and proceed through the sequences shown in the figure in numerical order. Overburden and internal waste from these areas will be hauled to one of the waste dumps or an exhausted pit area. The year in which the west and east pits are to be mined will be determined after mining commences. The amount of land to be disturbed by mining operations is provided in Table 3.1-2.

Tailings from the proposed mill will be discharged into exhausted pit areas. Since mining will progress downslope on the natural grade, it will be necessary to construct a dam to contain the tailings. In order to provide sufficient storage capacity without interrupting milling operations, the construction of this dam will be phased in conjunction with mining activities. A detailed discussion of dam construction is provided in Section 3.4.

The mining sequence has been designed to average out the ore grade as much as possible and to minimize reworking of the haul roads from the pits. In almost all cases, the ramps from the pits have been located either in areas where removal of overburden accounts for much of the excavation required for their construction or in areas where backfill can be utilized for ramps.

Table 3.1-2. ACREAGE TO BE DISTURBED BY THE PROPOSED ANDERSON PROJECT

Facility	Area (acres)
Mill	
Mill Site	42
Tailings Impoundment*	81
Mine**	
Pit Area	257
Backslope Area	135
Waste Dumps	
East Dump	196
West Dump A	93
West Dump B	89
Access Road	200

*Tailings impoundment will be located in the pit area. Tailings area shown in Figure 3.1-2 does not include evaporation ponds.
**Includes haul roads.

DEWATERING AND SURFACE WATER CONTROL

Mining will expose essentially four stratigraphic units. From youngest to oldest, these are: upper conglomerate, basaltic volcanics, lower conglomerate, and lacustrine sediments (see Section 2.4). Andesitic volcanic flows underlie the lacustrine sediments. The upper conglomerate and basalt are above the water table. In some areas, the lower conglomerate, lacustrine sediments, and basement andesite are below the water table due to the dip of the beds. The lacustrine sediments and basement andesite have extremely low permeabilities; consequently, little water is expected from these units. The lower conglomerate is relatively permeable and does contain sufficient groundwater to result in seepage into the pit during mining operations (Water Development Corp., 1978).

It is estimated that about 200 vertical feet of the lower conglomerate aquifer will be exposed during mining. Based on a coefficient of transmissibility of about 340 gallons per day per foot*, a coefficient of storage of 0.05, and a maximum drainage area length of 4500 feet (total width of ore body), a maximum of 200 gpm of groundwater is estimated to drain into the pit area (Water Development Corp., 1978). Since the entire width of the ore body will not be exposed at any one time, the actual seepage is estimated to be far less than this maximum. To control

*Horizontal and vertical permeabilities for the aquifer are estimated to be 40 and 80 feet per year, respectively. This results in a permeability in meinzer units of 1.64 gallons per day per square foot. Transmissibility is the product of permeability and saturated thickness (1.64 x 200) (Water Development Corp., 1978).

seepage, sumps in the bottom of the pit will be used to collect the water. Water from these sumps will be used for dust supression.

A drainage system will be built and maintained to control runoff into the open pit area. The system will include dikes and ditches to direct surface runoff away from the open pits.

ROADS

Haul roads will be constructed from the mining area to the waste dumps and mill (Figure 3.1-2). These roads will consist of compacted overburden surfaced with coarse sand from the overburden. The haul roads will have a travel width of approximately 100 feet and will be elevated 1 to 3 feet above the existing grade for good drainage. Drainage ditches will be constructed alongside the roads. A water truck and a chemical stabilizer will be used to control dust on all active roads.

3.2 EXTERNAL APPEARANCE OF THE MILL

The general layout and perimeter (exclusion boundary) of the mill are shown in Figure 3.2-1. Plot plans and elevations of mill facilities are presented in Figures 3.3-3, 3.3-4, 3.3-5, 3.3-6, 3.3-8, 3.3-10, and 3.3-11. Figure 3.2-2 is an artist's conception of how the facilities may look when completed.

The physical layout of the mill was designed for efficient materials handling; however, consideration has also been given to the aesthetics of the complex. Compatible process equipment and support facilities have been grouped to achieve a visually simple, compact arrangement. Buildings will be colored in earth-tone shades to blend with the surrounding landscape.

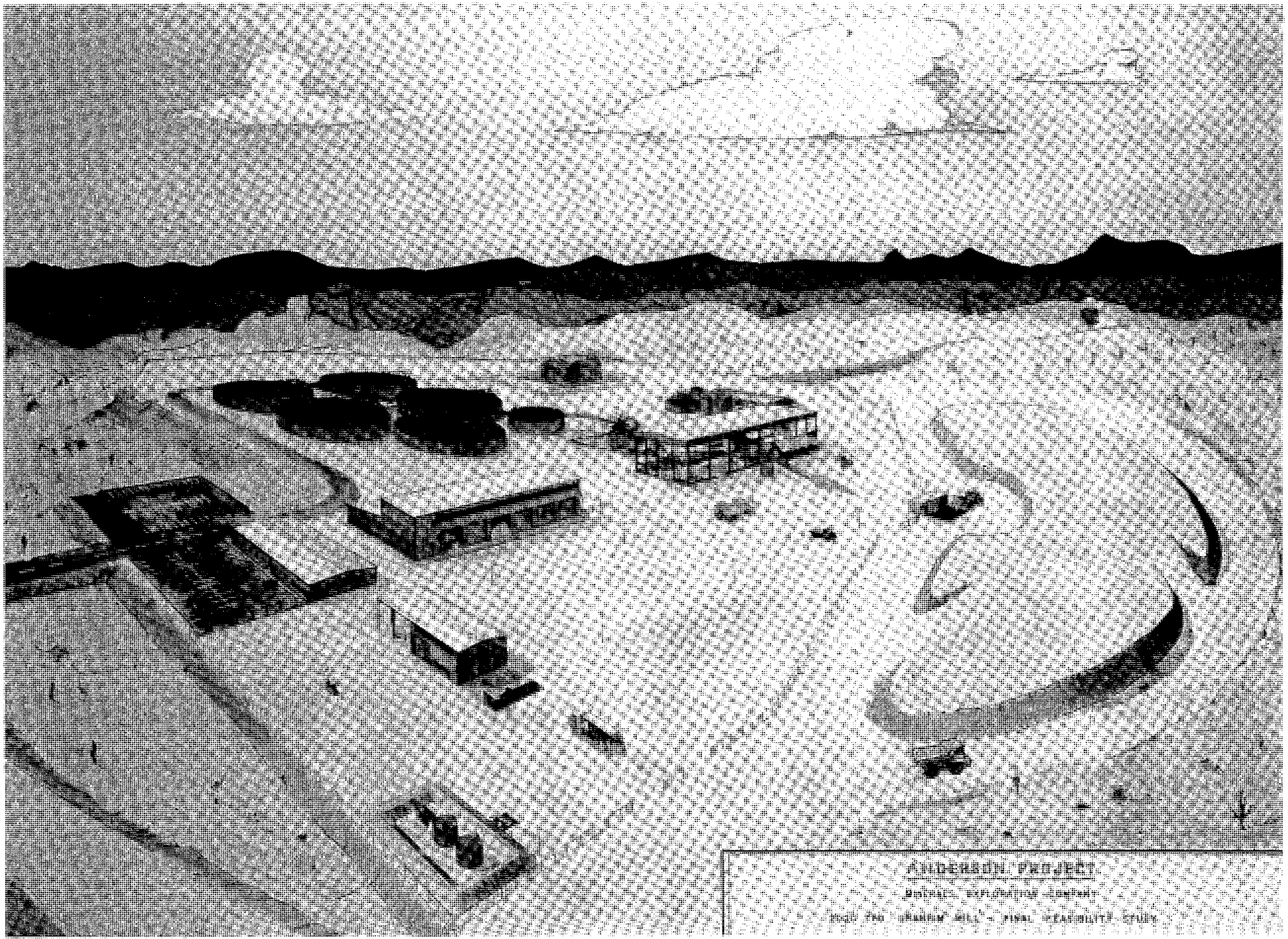


Figure 3.2-2. CONCEPTUAL DRAWING OF MILL FACILITIES

3.3 MILL CIRCUIT

Construction of the proposed uranium mill will begin in the third quarter of 1979 (Figure 3.1-1). Milling operations will begin in the first quarter of 1981. The proposed mill will process an average of 2000 tons of ore per day (dry weight basis), 365 days per year. A process design rate of 2200 tons per day (TPD) has been used for the mill to allow for planned and nonscheduled shutdowns.*

It has been determined that the ore to be mined for this mill contains an average of 0.072 percent uranium oxide (U_3O_8). However, a grade of 0.10 percent was used as the design criterion in order to attain flexibility in milling operations.

It is expected that the mill will have an overall uranium oxide recovery rate of 88.6 percent. Based on this anticipated recovery, the average processing rate of 2000 TPD of ore, and the average ore grade of 0.072 percent, the mill will produce about 2550 pounds per day (lb/d) of uranium oxide, or approximately 930,000 pounds per year (lb/yr).

It will be necessary to employ a series of grinding and processing circuits in the mill to extract the uranium oxide from the ore. The ore will first be processed through a semiautogenous grinding (SAG)

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*It should be noted that only a preliminary design of the mill has been completed at this time. This design will be subject to some alterations in the future. While specific pieces of equipment may change, the expected average throughputs and discharges discussed in this section will remain unchanged.

mill and a rod mill to reduce its size. The fine ore will then be mixed with an acid solution and agitated in tanks to dissolve the uranium minerals. The discharge from the leaching circuit will be pumped to a counter-current decantation system to separate the uranium-rich (pregnant) acid solution from the barren tailings. The tailings will be discharged to an impoundment in an exhausted pit area. The pregnant solution will be clarified and then pumped to a solvent extraction system. In this system, the pregnant liquor passes through a series of stages in which the dissolved uranium is transferred from the aqueous phase to an organic or solvent phase and then stripped, purified, and concentrated. Ammonia will be added to the uranium-rich (loaded) strip solution to precipitate the uranium oxide as ammonium diuranate. Finally, precipitated uranium oxide will be dried, packaged, and shipped to a conversion facility. Figure 3.3-1 provides a generalized flow diagram of this milling operation.

ORE STOCKPILES

Ore from the mine will be hauled by truck to a probe tower where its uranium oxide content will be determined. The trucks will then haul the ore to one of three stockpiles (Figure 3.1-2). In order to control mill feed grade, each stockpile will contain a different average grade of ore. One stockpile will be maintained at an average mill grade, another smaller stockpile will contain high grade ore, and a third stockpile will contain low grade ore. The grade distribution, in respect to total ore production, will be approximately 40 to 50 percent

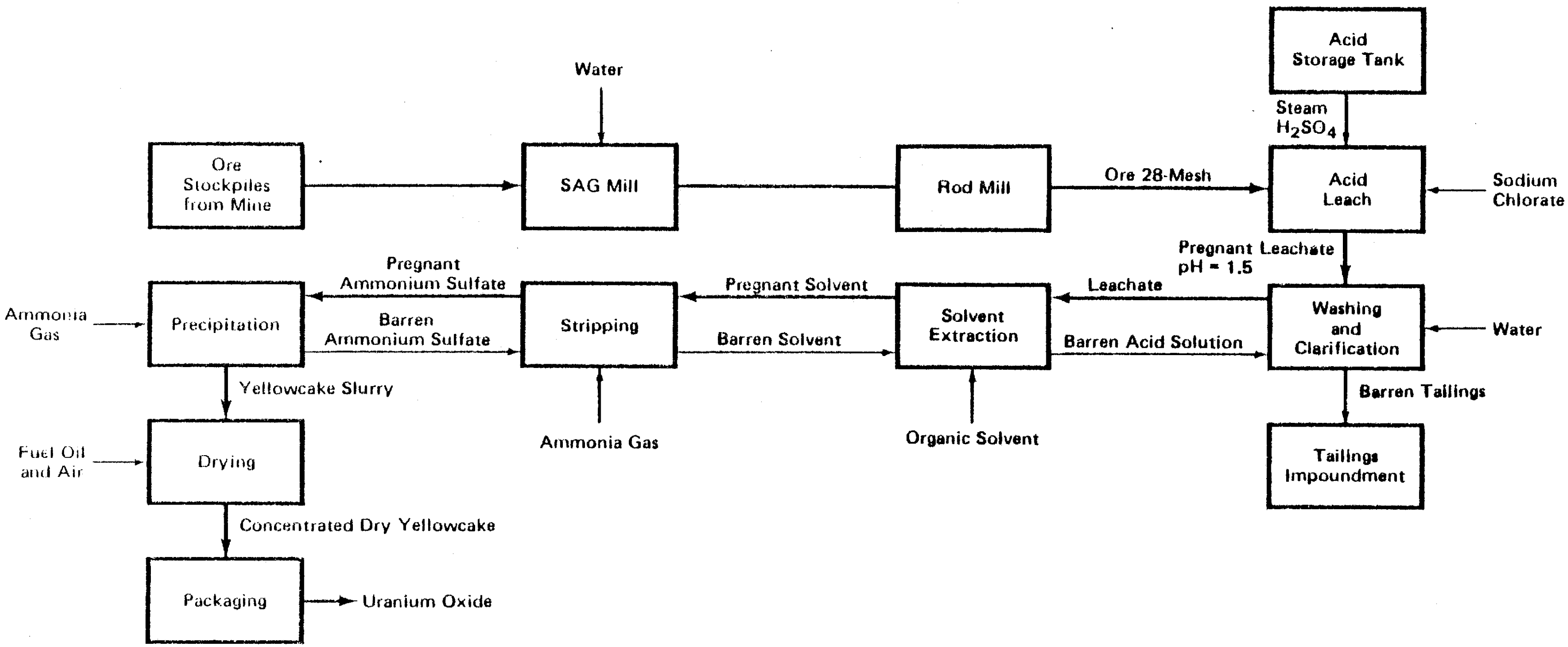

Figure 3.3-1. GENERALIZED FLOW SHEET OF MILL

low grade, 30 to 40 percent mill run, and 10 to 15 percent high grade. During mill operation, ore will be withdrawn from all three stockpiles and blended to produce the required feed grade.

Preproduction mining will create a total stockpile inventory of approximately 550,000 tons of ore. This inventory will be roughly maintained throughout the life of the project until the last years of production when it will be gradually reduced to zero.

Effluents

Solid. The stockpiled ore will be wet, with a moisture content as high as 10 percent. Consequently, fugitive dust from dumping, loadout, and wind erosion of the stockpiles is expected to be minimized. Haul roads leading to and traversing the stockpiles will be watered to reduce dust emissions due to haul truck travel. In addition, areas of loadout and blending activities will be watered to control dust generation. Dust emission estimates for stockpiling activities are presented in Appendix B.

Liquid. Some of the water contained in the ore, as well as rain, will drain through the ore stockpile or run off the surface. This water will be collected in the general mill drainage system and sent to the tailings impoundment.

Gaseous. Radium-226 contained in the uranium ore will continuously decay, generating radon-222, a radioactive gas. The half-life of radon-222 is 3.8 days; therefore, 99 percent of the escaping gas will decay within 4 weeks to solid radionuclides. If ore piles were left undisturbed, only about 0.65 Ci/day* of radon generated near the surface of the piles would reach the atmosphere because the gas would not have time to diffuse through the ore before decaying to a solid radionuclide. However, disturbance of the ore by transporting it from the stockpiles to the mill receiving hopper will release a portion of the entrapped radon gas to the atmosphere. This release is discussed under grinding.

GRINDING

The uranium ore on the Anderson property is a carbonaceous siltstone with varying degrees of silicification. The uranium minerals occur as thin coatings and pore fillings on and between the grains of the siltstone. To assure that these minerals are effectively removed from the grains, mined ore must first be reduced in size to fine particles so that a large surface area is exposed to the acid leach solution.

Blended ore from the mill stockpiles will be loaded into a receiving hopper. This hopper will contain a stationary grizzly with 18-inch-square openings (Figure 3.3-2). Material that does not pass through the grizzly will be set aside for further size reduction before it is again loaded into the receiving hopper. Material that does pass

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*Assumes an average ore grade of 0.072 percent uranium oxide, a stockpile surface area of about 23,000 sq. meters, and a radon emanation rate of 1.6 pCi/m^2-sec per pCi of radium-226 per gram of ore.

through the grizzly will be transported by an apron feeder to the grinding circuit.

In the grinding circuit, the ore will be reduced to minus 28 mesh in a two-stage process consisting of a semiautogenous mill followed by a rod mill operating in closed circuit with a static screen. Ore that passes through the final screen will be transported to the leaching circuit (Figure 3.3-2). Oversize ore will be fed back into the grinding circuit.

Effluents

Solids. All conveyor belts in the grinding circuit will be enclosed and a wet scrubber will be used to control dust emissions. (Figures 3.3-3 and 3.3-4.)

Liquid. The grinding mills and screens will contain a thick slurry of uranium ore and water. Any spillage from the mills, screens, pumps or piping system will collect in floor sumps. The spilled materials will be pumped back into the feed to the mill.

Gaseous. Modest amounts of radon-222 will be released into the environment by the total milling operation. A hypothetical "worst case" condition has been assumed in which all the radon emissions from the plant are released through the SAG mill stack. The emissions were estimated on the basis of an ore grade of 0.072 percent uranium oxide and a throughput of 2000 tons/day. Using the method taken from the Draft Environmental Statement for the Sweetwater Project (NRC, 1977), the release is estimated to be about 0.074 Ci/day.

LEACHING

The leach circuit dissolves the uranium minerals from the siltstone. Leaching will be done with a solution of sulfuric acid and small amounts of sodium chlorate at a temperature of 175°F and a pH of 1.5. The process will take place in two acid mix tanks and a series of four leach tanks (Figure 3.3-2). Each tank will have slow-moving agitators to keep the ore in suspension.

Discharge from the leach circuit will be a thick slurry consisting of barren silt and fine sand grains and a dilute sulfuric acid solution rich in uranium. This slurry will be pumped to the countercurrent decantation circuit.

Effluents

Solid. There will be no solid effluents released from the leach circuit.

Liquid. The leach tanks will contain a slurry of about 45 percent solids. These tanks will be placed on an inclined floor which drains to a sump (Figure 3.3-5). Any spillage from the tanks will drain into the sump and be pumped back into the process system. The recessed impoundment area of the floor will be large enough to contain the entire volume of any of the leach tanks.

Gaseous. The leach tanks will be covered. Air from the tanks will be vented through a wet scrubber (Figures 3.3-5 and 3.3-6 and Table 3.3-1). Exhaust from the scrubber will contain traces of radon-222. The acid mist and vapors removed by the scrubber will be returned to the leach tanks.

COUNTERCURRENT DECANTATION THICKENING

The leach circuit discharge slurry will be pumped into the top of the first of a series of five countercurrent decantation tanks (known as "thickeners") (Figures 3.3-7 and 3.3-8). This material will then be pumped into the top of the second thickener and so on until it is discharged from the fifth thickener as a slurry consisting of approximately 38 percent solids (by weight). This slurry will be pumped to a tailings box and ultimately discharged to the tailings impoundment. Wash water will be added to the fifth thickener. The clear solution that overflows this thickener will advance to the fourth thickener and so on to the first thickener. This countercurrent flow will wash the dissolved uranium from the ore.

As it leaves the first thickener, the pregnant acid solution will contain 150 to 200 ppm of solids. In order to reduce the solids content, the solution will be pumped to a clarifier. A glue solution will be added to the clarifier to flocculate the suspended solids. Overflow

Table 3.3-1. MILL STACK EMISSIONS AND DESIGN SPECIFICATIONS

Stack Location	Emission Control Equipment	Collection Efficiency %	Exit Flow Rate[a] (cfm)	Exit Temperature (°F)	Exit Diameter (inches)	Release Height (ft)	Pollutant	Stack Concentration[a] or Emission Rate
1. Ore Receiving Facility	Wet Scrubber	99+	2000	ambient	12	70	Ore dust	<0.008 g/m^3; <0.016[b] lb/hr (<0.002 g/sec)[b]
2. Leach Tank Area	Wet scrubber	99+	5000	70	18	70	H_2SO_4 mist	0.04 g/m^3; <0.74 lb/hr (<0.09 g/sec)
3. Uranium Concentrate Area								
a. Precipitation & Dewatering Area	Wet Scrubber	99+	1200				Ammonia	<50 ppm; <0.31 lb/hr (<0.04 g/sec)
b. Drying Area[c]	Wet scrubber	99+	800	120	12	70	Yellowcake	<0.003 g/m^3; <0.03 lb/hr[d] (<0.004 g/sec)
c. Packaging Area	Wet scrubber	99+	550					
4. Laboratory Hood Manifold	None	-	2000	70	12	40	Acid vapors	0.03 g/m^3; <0.10 lb/hr (<0.01 g/sec)
5. Emergency Power	None	-	-	-	8	35	Misc.	Intermittent
6. Boiler	None	-	7500	450	22	70	See Table 3.1-5	

[a]Exit flow rates and stack concentrations are at specified stack temperatures.

[b]Based on an emission factor for mine material dumping - 0.02 lb dust/ton ore dumped (PEDCo 1978). The high moisture content of the ore is expected to yield actual total emissions less that those presented.

[c]See Table 3.3-3 for emissions from Herrschoff multiple hearth type furnace.

[d]Yellowcake emission rates given above are annual-average values. The maximum 24-hour emission rate assumed for modeling was 0.04 lb/hr (0.005 g/sec) from the uranium concentrate area.

from the clarifier will then be pumped through sand filters. The filtered solution will contain less than 10 ppm of suspended solids. This solution will be pumped to a storage tank to provide feed to the solvent extraction circuit (Figure 3.3-7).

Effluents

Solid. The barren tailings will be pumped to a holding tank and then discharged to the tailings impoundment by gravity flow through a pipeline. The chemical components of the water in the slurry are provided in Table 3.3-2. The solid tailings will contain approximately 0.17 lb of uranium oxide/ton of ore not recovered in the milling process, as well as the following radionuclides:

Radionuclide	Concentration (μCi/gm)
Ra-226	2.1 (±0.2) x 10^{-4}
Th-230	7.9 (±0.8) x 10^{-5}
Pb-210	1.45 (±0.02) x 10^{-4}

The tailings in the impoundment will be kept wet over the life of the project. Consequently, dust emissions are not expected to be significant. At the conclusion of milling operations, the impoundment will be reclaimed.

Liquid. The thickeners will be located outdoors, (Figure 3.3-6). A berm will be constructed around the area to contain spills. The berm will be high enough to hold the contents from any one of the thickeners.

Table 3.3-2. CHEMICAL COMPOSITION OF THE WATER IN THE TAILINGS SLURRY

Constituent	Composition (g/l unless otherwise stated)
Total dissolved solids	45.8
Total suspended solids	<0.01
Fe (total)	1.93
Fe (dissolved)	1.93
Cl	0.33
Cr	0.003
Ni	0.005
Mn	0.065
Zn	0.017
SiO_2	0.18
Pb	0.0007
U (total)	0.0004
Th (total)	<0.001
As	0.013
P	0.11
F	0.21
Al	1.31
Mo	<0.005
Hg	<0.0001
K	0.31
Cu	0.003
Cd	0.0003
V	0.078
Na	0.72
Mg	2.1
Ca	0.32
Total organic carbon	0.02
Ra-226	$0(\pm 9) \times 10^{-8}$ μCi/ml
Th-230	$3.32(\pm 0.05) \times 10^{-5}$ μCi/ml
Ra-228	$2(\pm 0.05) \times 10^{-8}$ μCi/ml
Hardness as $CaCO_3$	12.8
Nitrate as N	1.4 mg/l
B	16 mg/l
Se	0.01 mg/l

Source: Hazen Research, Inc., 1978.

In the event of a spill or tank rupture, the liquid will be pumped back for reuse by a portable slurry pump.

The floors inside the thickener pump house will be sloped to a sump for reclamation of internal spillage and easy equipment washdown.

Some seepage of liquid effluent will occur through the tailings dam and through the bottom of the tailings impoundment. The maximum seepage rate through the dam and the bottom is estimated to be 5 gpm and 2 gpm, respectively, for a total of 0.14 acre-feet/year (Dames & Moore, 1978). This rate will occur when the final stage of the dam has been constructed and the reservoir is at full capacity. Further discussion of seepage from the tailings disposal system is provided in Section 3.4.

The potential maximum seepage rate from the impoundment is considered to be very low. For comparison, recent New Mexico water quality regulations limit the rate of seepage from tailings ponds to no more than 0.5 acre-feet/year. New Mexico is one of the few states that regulates seepage from this type of impoundment and their limitations are considered to be quite stringent (Dames & Moore, 1978).

<u>Gaseous.</u> Some water vapor, acid mist, and minor amounts of radon-222 will escape into the atmosphere from the open thickeners. Natural air currents should provide sufficient dispersion and dilution to prevent any hazardous concentrations even at the surface of the tanks.

A small amount of radon-222 will be released from the tailings impoundment. Assuming an average ore grade of 0.072 percent and a total surface area of 83 acres for the impoundment, the release of radon-222 is estimated to be 8.5 x 10^{-3} Ci/day using the method given in the Draft Environmental Statement for the Sweetwater Uranium Project (NRC, 1977).

SOLVENT EXTRACTION

The primary purpose of the solvent extraction circuit is to upgrade the uranium-bearing solutions. This circuit consists of two unit operations (Figure 3.3-9). First, uranium minerals are transferred from the aqueous acid solution to an organic liquid by ion exchange. Second, the uranium is stripped from the organic solvent with ammonium sulfate.

To accomplish the first operation, the clarified acid solution will be pumped to an extraction mixer/settling tank where it will be mixed with an organic solvent consisting of 2.5 percent alamine 336, 2.5 percent isodecanol, and 95 percent kerosene. The two solutions (aqueous and organic) will then be allowed to separate in the tank. After going through a series of four mixing/settling tanks, almost all of the uranium will have been removed from the acid solution. The raffinate will be returned for use as wash water in the countercurrent decantation tanks or for dilution in the tailings slurry. The uranium-rich organic solvent will be advanced to a holding tank and then to the stripping operation.

In this second operation, the pregnant organic solvent will be passed through a heat exchanger to raise its temperature to 86°F and then mixed with an ammonium sulfate solution. Gaseous ammonia will be added to the solution to keep the pH between 4.0 and 4.3. The ammonium sulfate will strip the uranium from the organic solvent. After being processed through four mixing/settling tanks, the uranium-rich ammonium sulfate solution will advance to the precipitation circuit. Most of the barren organic solvent will be recycled to the beginning of the solvent extraction operation. A small portion of the barren solvent will be bled off to a sludge holding tank. Ammonia, sulfuric acid, and water will be added to the solvent in this tank to remove impurities such as molybdenum that otherwise might build up in the circuit and prevent an efficient uranium extraction. The sludge from this tank will be discharged to the tailings impoundment. The clean solvent will be pumped to the barren organic holding tank for reuse in the stripping operation.

Effluents

Solid. There will be no solid effluents released from the solvent extraction circuit.

Liquid. The solvent extraction and stripping tanks and their mixers, pumps, piping, storage tanks, and other appurtenances will be located in a building (Figure 3.3-10). The concrete floor of this building will be sloped toward a sump. Any spill will drain into the sump and be pumped back into the process system.

It is estimated that approximately 470 gallons of kerosene will be lost each day from the solvent extraction circuit. Based on the experience of operating mills, it is known that about 90 percent of the kerosene losses result from adsorption onto particles in the barren acid that is returned to the leach circuit. This kerosene will eventually be discharged from the mill in the tailings, and for all practical purposes, it will remain adsorbed on tailings particles.

Gaseous. Approximately 10 percent of the kerosene losses from the solvent extraction circuit will result from evaporation. Assuming a specific gravity of 0.82 (Chemical Rubber Company, 1970), roughly 150 kilograms/day, or 2 g/sec, of kerosene will evaporate from settling tanks. Air in the solvent extraction building will be released into the atmosphere through roof ventilators.

PRECIPITATION

The pregnant ammonium sulfate solution will be passed through a heat exchanger to raise its temperature to between 140°F and 160°F and then it will be pumped into two agitated precipitation tanks (Figure 3.3-9). Gaseous ammonia will be injected into the tanks at a rate of approximately 0.2 lb for each pound of uranium oxide to precipitate the uranium as ammonium diuranate (uranium concentrate).

The uranium concentrate slurry from the precipitation tanks will be pumped to a washing thickener. The barren ammonium sulfate solution that overflows this thickener will be passed through a continuous sand-type filter and recycled to the stripping stage of the solvent extraction circuit. The uranium concentrate underflow from the thickener will be mixed with water for washing and passed through a centrifuge. The concentrate from the centrifuge will be recycled to the washing thickener. The centrifuged uranium concentrate will be discharged to a dryer at about 60 percent solids.

Effluents

Solid. There will be no solid effluents released from the precipitation circuit.

Liquid. The precipitation tanks and the uranium concentrate thickener, as well as all associated piping and appurtenances, will be contained in the main mill building. Any spillage will be collected and returned to the system.

Gaseous. Air from the precipitators, thickener, and centrifuge area will be passed through a wet scrubber and vented to the atmosphere from a stack (Figures 3.3-11 and 3.3-6 and Table 3.3-1). The exhaust gases will contain less than 100 ppm of ammonia and traces of radon-222.

DRYING AND PACKAGING

The washed uranium concentrate from the centrifuge will be dried in an oil-fired, multiple-hearth, Herrshoff-type furnace (Figure 3.3-9). The dried product will then be passed through a roll crusher for reduction to minus 0.25 inch. The finished product will contain less than two percent moisture.

Dried uranium concentrate will be stored in a 275-cubic foot bin for packaging during the day shift. The product will be discharged from the bin into 55-gallon steel drums (approximately 900 pounds per drum). It will then be hand sampled and stored in shipping lots of approximately 40,000 pounds.

Effluents

Solid. Exhaust from the furnace and packaging equipment will be vented to the atmosphere through a wet scrubber (Figures 3.3-11 and 3.3-6 and Table 3.3-1). Uranium concentrate dust will be emitted with this exhaust at an average rate of 0.032 lb/hr. Assuming a quality of 85 percent, the uranium concentrate will contain approximately 0.24 μCi/g of uranium-234, 0.011 μCi/g of uranium-235, and 0.24 μCi/g of uranium-238.

Finished product will be discharged into steel drums through a sealed collar equipped with a wet scrubber (Figures 3.3-11 and 3.3-6 and Table 3.3-1).

All sludge from the wet scrubbers in the drying and packaging circuit will be recycled to the uranium concentrate thickener.

Liquid. No liquid effluent will be released from the drying and packaging circuits.

Gaseous. Table 3.3-3 summarizes the gaseous emissions from the Herrschoff furnace.

Table 3.3-3. ESTIMATED HERRSCHOFF MULTIPLE HEARTH TYPE FURNACE EMISSIONS[e]

	Emission Rate[a] (lb/hr (g/sec))	
Pollutant	Maximum[b]	Annual Average[c]
Particulates	<0.00016(<0.00002)	<0.00009(<0.00001)
Sulfur dioxide[d]	<0.568(<0.072)	<0.319(<0.040)
Carbon monoxide	<0.040(<0.005)	<0.023(<0.003)
Hydrocarbons	<0.008(<0.001)	<0.005(0.0006)
Nitrogen oxides (as NO_2)	<0.176(<0.002)	<0.099(<0.013)

[a]Emission estimates based on EPA (1975) emission factors.

[b]Maximum emissions based on a distillate fuel oil consumption rate of 8.0 gal/hr.

[c]Annual average emissions based on a distillate fuel oil consumption rate of 4.5 gal/hr.

[d]Sulfur content of fuel assumed to be 0.5 percent.

[e]Emissions vented through wet scrubber. Calculations assume 99+% scrubbing efficiency on particulate emissions only.

3.4 TAILINGS DISPOSAL SYSTEM

As mentioned in Section 3.1, tailings from the milling operation will be discharged to an impoundment located in exhausted pit areas (Figure 3.1-2). Mining will progress from north to south through the initial pits; consequently, it will be necessary to construct this impoundment in the northern portion of the mine area. In order to contain the tailings it will be necessary to construct a dam.

The tailings dam will be built in stages to prevent interference with mining operations and still provide adequate tailings storage capacity.* The first stage of the dam will be constructed in portions of sequence 1 and 3 (Figure 3.4-1). This stage will provide storage for the first 33 months of tailings discharge from the mill. The impoundment created by the dam will cover a maximum of approximately 28 acres and have a capacity of about 50 million cubic feet (Figure 3.4-2). The second stage of construction will extend the dam further into sequence 1 (Figure 3.4-3). This extension will be completed by the end of the second year of milling (Table 3.4-1) and will provide an additional nine months of storage capacity to the impoundment.

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*The proposed tailings impoundment was designed for a mill with a 14 year life. Further development drilling by MINERALS now indicates that reserves will be available for only 10 years of milling. However, the quantity of tailings to be discharged over the 10 years will be essentially the same as that used for the original design. Consequently, the figures given in this discussion are accurate. Several of the graphs in the text showing impoundment capacity and the water budget for the system use a time scale of 14 years. While this time scale will be reduced, the quantities given will remain approximately the same.

The second stage impoundment will cover a maximum of approximately 47 acres and have a capacity of about 65 million cubic feet. The final dam will be constructed in several stages (Table 3.4-1) as increased tailings storage capacity is required. This dam will incorporate the southern and western segments of the first stage dam and all of the second stage dam (Figure 3.4-4). The north-south segment of the first stage dam will be abandoned and covered with tailings as the impoundment level rises. The final tailings impoundment will cover approximately 81 acres and have a storage capacity of 190 million cubic feet.

DAM DESIGN

The lacustrine sediments that will be exposed at the bottom of exhausted pit areas consist primarily of highly impervious claystone and siltstone. The material will significantly reduce seepage from the impoundment. Stripping to remove permeable material such as topsoil and highly weathered rock will only be required on the western side of the impoundment where the tailings dam will be constructed on the crest of the pit. Claystone and siltstone crop out in most of this area; therefore, the need for stripping is expected to be minimal.

During construction of the tailings dam, the impoundment bottom will be carefully examined to insure that the claystone and siltstone are continuous. In the event that more pervious materials are found, they will be covered with a five-foot layer of compacted mudstone.

Table 3.4-1. PROPOSED TAILINGS DAM CONSTRUCTION SCHEDULE

Stage	Crest Elevation In Feet	Required Time For Construction
First	1750	Prior to start of milling
Second	1750	2nd year of milling
Third	1750	3rd year of milling
Fourth	1780	4th year of milling
Fifth	1795	6th year of milling
Final	1820	8th year of milling

The tailings dam will consist of four general sections: the upstream shell, core, transition zone, and downstream shell. The relative location of these sections is shown in Figure 3.4-5.

The dam core will function as the primary barrier to the seepage of liquids through the dam. This core will consist of compacted claystone obtained from the non-mineralized lacustrine sediments. The core will be tied to bedrock with a key trench that will be at least 5 feet deep and 15 feet wide.

The downstream shell of the tailings dam will provide structural support for the clay core and overall embankment stability. This shell will be constructed with sand and gravel obtained from the lower conglomerate material in the overburden. The use of these granular materials will provide a high ratio of permeability between the downstream shell and the core; reducing seepage gradients and maintaining a very low phreatic surface in the dam.

Twenty-foot wide benches will be constructed at 75-foot intervals in the downstream shell to provide access and control erosion. The shell will have a 2:1 slope between benches.

A ten-foot transition zone between the impervious core and the downstream shell will be provided to prevent the migration of clay particles from the core. This zone will also be constructed from lower conglomerate sand and gravel; however, the material used will be less than three inches in size and it will be well graded.

The principal purpose of the upstream shell is to protect the dam core from erosion. This shell will consist of sand and gravel obtained from upper and lower conglomerate overburden. An 18-inch layer of cobble to boulder-sized rock will be placed on the outside of the upstream shell to provide protection against wave action. This rock will be obtained from the basalt and/or strongly cemented sedimentary material in the overburden.

Tailings Dam Stability

Slope Stability. Stability analyses of the dam have been conducted by Dames & Moore (1978). The results of these analyses indicate that adequate factors of safety against the failure of the upstream slopes have been provided for the most critical loading conditions anticipated. The most critical mode of failure for the upstream and downstream slopes consists of very shallow-seated failures tangential to the slopes. This type of failure would result in local sloughing of the slopes which could be readily repaired during normal maintenance. Factors of safety computed for infinite slope failure of the dam are 1.6 for static conditions and 1.25 for earthquake loading conditions. Factors of safety computed for deep-seated failures of the upstream slope at the end of dam construction* are 1.5 for static conditions and 1.25 for seismic conditions. The factors of safety for deep-seated failures of the downstream slope are 1.5 for static conditions and 1.0 for earthquake loading conditions.

Settlement. The dam is expected to settle a maximum of about 12 inches at its highest point. This settlement is expected to take place during construction and should have no effect on dam stability (Dames & Moore, 1978).

Liquefaction. Soil liquefaction is a phenomenon normally associated with very loose to loose, saturated granular material subjected to cyclic shear stress caused by events such as earthquakes. Since the dam foundation will consist of moderately indurated, fine-grained materials and all materials in the dam embankment will be compacted to a relatively dense condition, the dam should not be subject to liquefaction (Dames & Moore, 1978).

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*Since the disposal of tailings against the upstream slope should increase its overall stability, the most critical stability condition for this slope is at the end of dam construction prior to tailings discharge.

Freeboard Requirements

Total minimum freeboard that will be provided for each stage of the tailings dam is presented in Table 3.4-2. This freeboard provides sufficient storage capacity for all storm waters that would runoff into the impoundment area as well as three additional feet to protect against erosion caused by waves generated during the design storm conditions.

Table 3.4-2. MINIMUM FREEBOARD REQUIREMENTS FOR THE TAILINGS DAM

Stage of Construction	Crest Elevation In Feet	Minimum Freeboard In Feet
First	1750	6.0
Second	1750	9.0
Third	1765	7.0
Fourth	1780	6.5
Fifth	1795	6.5
Final	1820	5.5

The impoundment has been designed at every stage of development to contain a probable maximum flood series preceded or followed by a 100-year flood. The probable maximum flood series is defined as the probable maximum flood (PMF) and a flood equivalent to about 40 percent of the PMF occurring within about 3 to 5 days of the main flood.

A probable maximum precipitation value of approximately 11 inches was used in computing the required storm water storage requirements. Precipitation of 3.3 inches is anticipated to result from a 100-year storm of 6 hours duration. The drainage area of the impoundment during the first, second, and final stages of the dam is approximately 50, 61, and 129 acres, respectively (Figure 3.4-6).

TAILING DISPOSAL

As discussed in Section 3.3, the tailings will be discharged from the mill in a slurry consisting of approximately 38 percent solids by weight. The slurry will be transported to the tailings impoundment through a pipeline. Since the mill is located about 150 feet higher in elevation than the impoundment it will not be necessary to pump the slurry. Instead, approximately 10 drop boxes will be installed along the line to break the hydrostatic pressure generated by the discharge.

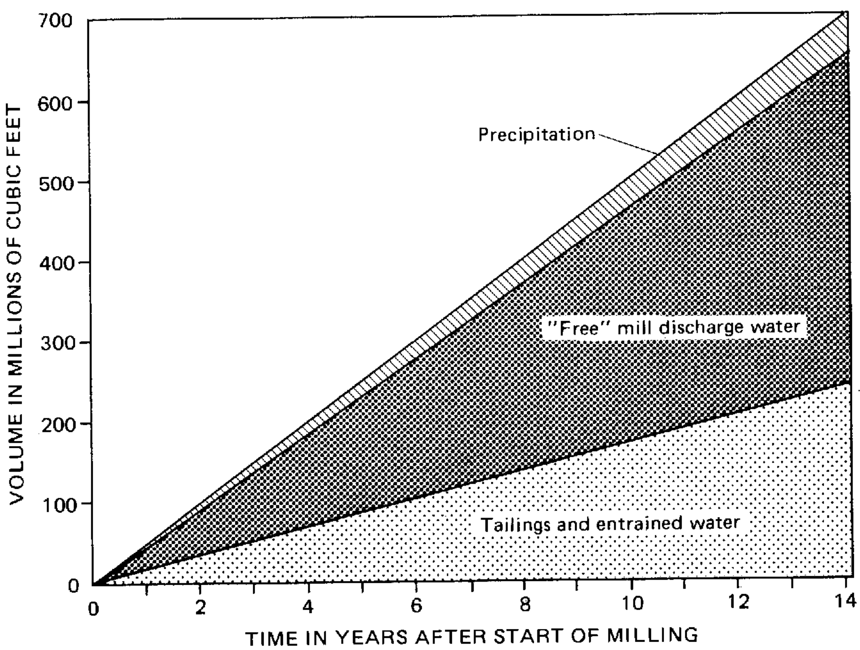
The tailings slurry will be discharged into the impoundment at a rate of about 695 gpm through spigots located on the crest of the dam. Spigot valves will be placed on approximately 100-foot centers. To control erosion, discharge from the spigot points will occur through feeder lines laid on the inside slope of the dam embankment. As the tailings are discharged, the coarser sand fractions will settle out at the base of the dam, and the finer solids and most of the water in the slurry will move toward the center of the impoundment.

Water Balance

Inputs to the tailings impoundment will consists of tailings and waste water from the mill and precipitation. Tailings production is expected to average about 2000 TPD. This will be discharged along with approximately 564 gpm of water. Approximately 20 percent of the waste water will become entrained in the tailings, and the remainder will form a pond. The mean yearly precipitation in the vicinity of the property is 7.47 inches. For the purpose of this analysis, it is assumed that 100 percent of the precipitation falling on the drainage area of the impoundment will collect in the pond (Dames & Moore, 1978).

It is estimated that the average wet density of the tailings will be on the order of 112 pounds per cubic foot (Dames & Moore, 1978). Consequently, about 17.2 million cubic feet per year of tailings and entrained water will be deposited in the impoundment. The rate of "free" mill water discharged to the impoundment is estimated to be about 31.7 million cubic feet per year. The amount of precipitation entering the impoundment will be dependent on the drainage area which is in turn related to the construction schedule for the impoundment. The relationship between time and volume of the various inputs is shown graphically in Figure 3.4-7.

Outputs from the tailings impoundment will consist of surface evaporation from the pond and seepage (seepage is discussed in detail below). The long-term average evaporation rate for the property is reported to be within the range of 76 to 80 inches per year; an evaporation



Source: Dames & Moore 1978

Figure 3.4-7. VOLUME OF POND INPUTS VS TIME rate of 78 inches per year was assumed for the purpose of this analysis (Dames & Moore, 1978). Since evaporation and seepage are dependent on the area of the impoundment, they are in turn dependent on the construction schedule of the impoundment. The relationship between time and volume of evaporation and seepage outputs is shown in Figure 3.4-8.

Figure 3.4-9 is a composite of Figures 3.4-7 and 3.4-8 and the storage capacity of the tailings impoundment at various stages of development. As can be seen in this figure, the impoundment is large enough to store the tailings and entrained water produced by the mill, but not large enough to also store all of the "free" water. It is estimated that a minimum of about 231 million cubic feet of excess water must be removed from the impoundment over the life of the project to prevent overtopping of the tailings dam.

Excess water will be removed from the impoundment by evaporation. This will be accomplished by spraying water from the impoundment pond into the air and/or by evaporation ponds. If spraying proves to be feasible, the water will be sprayed from the top of the tailings dam down into the pond to minimize drift into surrounding areas.

SEEPAGE

Seepage will occur through the tailings dam and the bottom of the impoundment. In determining the amount of seepage, the following permeability values were used:

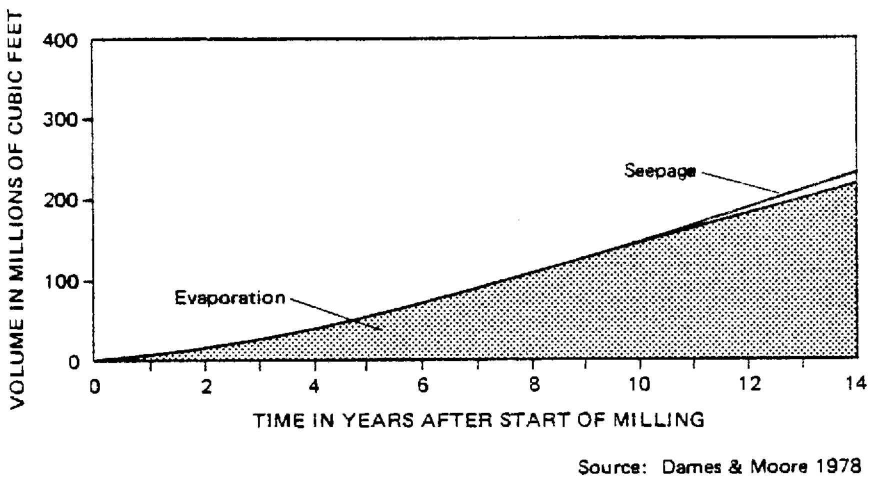


Figure 3.4-8. VOLUME OF POND OUTPUTS VS TIME

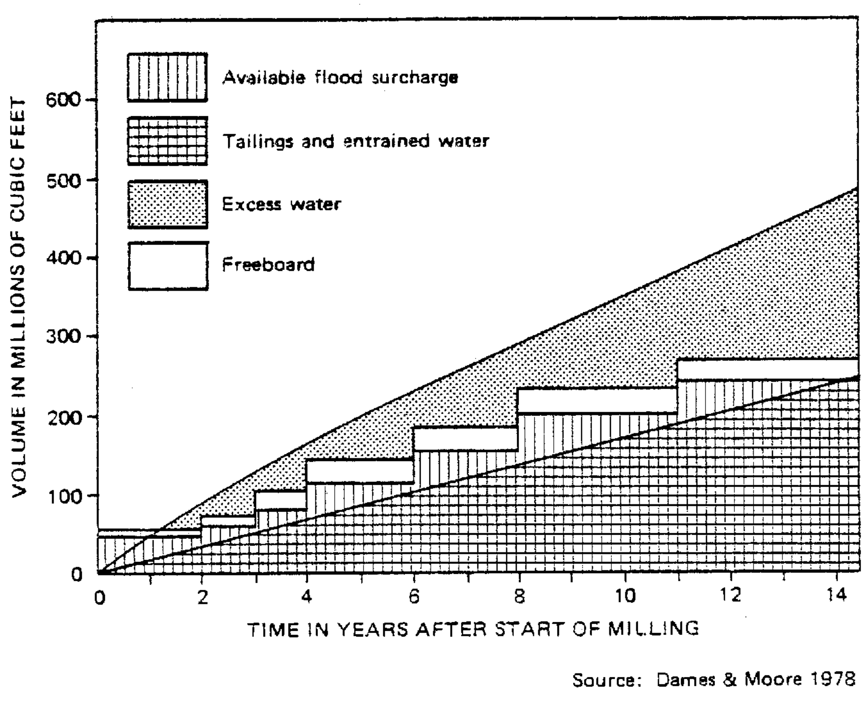


Figure 3.4-9. VOLUME OF EXCESS WATER VS TIME

Material	Coefficient of Permeability (ft/min)
Dam Core	2×10^{-7}
Dam Shell	2×10^{-4}
Impoundment Floor	2×10^{-7} (vertical)
	2×10^{-6} (horizontal)

These values are typical for the materials to be used in constructing the dam and for the impoundment bottom. They have been confirmed by field and laboratory studies (Dames & Moore, 1978).

Seepage Through Dam

In this analysis, it was assumed that slimes accumulating on the upstream surface of the dam and the upstream shell would not resist the flow of water to the dam core. This provides a degree of conservatism to the seepage estimate.

Flow through the core will be dependent on the dam perimeter and the height of water in the impoundment. Predicted seepage varies to a maximum of about 0.6 cubic feet per minute, which will occur during the final dam stage when the tailings impoundment is filled to elevation 1812.

The permeability of the downstream shell is high enough relative to the core so that water passing through the core will drip vertically through the shell and accumulate on the foundation. This water will discharge into the mine pit area on the south side of the dam. The small seepage quantities and gradients make it unnecessary to design drainage facilities to control this flow.

Seepage Through Impoundment Bottom

Seepage through the bottom of the tailings impoundment can be expected to exit in the pit area to the south of the impoundment (Figure 3.4-10). This is due primarily to the effects of mine dewatering on groundwater flow. Dewatering will lower the groundwater table to the bottom of the pit and a flow gradient will be created toward the pit.

Seepage quantities will be dependent on dam geometry, topography, pond size and configuration, and pond surface elevation. Assuming that the permeabilities for the bottom material given above are correct, the maximum quantity of seepage through the bottom of the impoundment is estimated to be about 0.3 cubic feet per minute. This maximum would occur during the final stage of the impoundment.

Radiochemical Contaminant Migration

Seepage of radioactive materials that are in solution with the tailings water will not occur outside of the immediate boundaries of the tailings impoundment during the life of the proposed project or over the long-term. Based on analyses conducted by Dames & Moore (1978), the maximum distance of migration of thorium-230, uranium-238, and radium-226 into the relatively impervious boundaries of the tailings impoundment over a period of 100 years is expected to be on the order of 2, 4, and

80 centimeters, respectively. The actual migration distances should be much less since the design life of the project is only about 10 years. At this time discharge into the impoundment will cease and the hydraulic gradient within the impoundment will gradually decrease, resulting in insignificant seepage from the impoundment.

3.5 ANCILLARY FACILITIES

OFFICES, WAREHOUSE, AND SHOPS

The office, warehouse, and shops for the Anderson project will be located at the mill. A one-story, insulated, prefabricated building will contain analytical and metallurgical laboratories, emergency medical facilities, and offices for the mine and mill staffs. An insulated prefabricated building will contain a warehouse, a machine shop, several large bays for mine vehicle maintenance, and change rooms. The main office building will cover approximately 12,800 square feet. The building containing the other project-support facilities will cover approximately 26,000 square feet.

FIRE PROTECTION

All vehicles used in the Anderson project, including mining equipment, will carry 2.5- to 10-lb fire extinquishers. The shop and mill buildings will also have 30-lb portable foam fire extinquishers spaced at 50-foot intervals (spacing may be closer in areas separated by partitions).

Water for fire protection will be supplied from a 500,000-gallon storage tank (Figure 3.5-1). A pipeline will be constructed from the tank around the mill facilities. Sufficient hydrants and hose boxes will be located along this pipeline to provide adequate fire protection for the mill facilities (Figure 3.2-1).

MEDICAL FACILITIES

The office building will contain a first-aid treatment room. An ambulance will also be maintained on the property at all times.

A safety and environmental administrator will be included in the mining staff. He will organize ongoing safety programs, regularly inspect all mine and mill facilities for compliance with safety regulations, and organize and train a first-aid crew. At least one person trained in first aid will be present during each work shift.

WATER SUPPLY

Water will be supplied to the project from wells at the Palmerita Ranch and/or Section 16, T11N, R10W. The water will be pumped at a rate of 1000 gpm to the mill site through a 10-inch diameter pipeline. This water will be stored in a 500,000-gallon tank located to the north of the mill area (Figure 3.5-1). A pump house located adjacent to the storage tank will contain the pumps for fire protection, process makeup, and potable water. Chlorination and filtering equipment for potable water will also be located in this pump house.

Approximately 564 gpm of water will be required in the milling process to make up for losses to the tailings impoundment. This water will be pumped from the storage tank to the appropriate process circuits.

Water from the storage tank will be pumped through treatment facilities to a 40,000-gallon potable water holding tank located adjacent to the pump house. This tank will contain sufficient water to supply the mill for three days at normal usage rates.

Water for boiler feed will be obtained from the potable water tank at a rate of approximately 48 gpm. Prior to use in the boiler, this water will be purified by passing it through a package sodium zeolite ion exchanger equipped with brine tank automatic backwash and regeneration controls.

SANITARY AND OTHER WASTE WATER SYSTEMS

A sewage treatment plant consisting of below-grade concrete tanks will be installed at the mill. This plant will be equipped with facilities for screening, aeration, and clarification with chlorine treatment. The plant is designed to serve 336 people with an estimated flow of 16,800 gallons per day. The effluent from the plant will be discharged to a leach field.

Testing procedures in the laboratories will produce some liquid wastes such as water diluted acids, bases, and solvents. These wastes will be collected and pumped to the mill circuit at an estimated average rate of three gpm.

Regular maintenance of the boiler and bleed lines will generate liquid waste at a rate of approximately five gpm. This water will be returned to the mill circuit.

STEAM GENERATION

A 22,000 pounds per hour, 125 psig, oil-fired boiler will supply the process steam for the leaching, solvent extraction, precipitation, and sodium chlorate facilities. An additional boiler will also be installed as a backup unit. The boiler is expected to burn about 278.25 gal/hr of distillate fuel oil at maximum firing rate and burn an average of 207.4 gal/hr. Boiler stack emissions are provided in Table 3.5-1.

FUEL STORAGE

Two 100,000-gallon fuel tanks and a fuel island will be located to the east of the main mill building. It is estimated that fuel consumption during the project will be approximately 14,082 gallons per day. The storage tanks will provide a two week supply.

ELECTRICITY

Electrical power will be required at the mine site for lighting and for use of the electric shovel. It will be needed at the mill site for pumps and other electrical equipment used in the various mill circuits, laboratories, offices, warehouse, and shops. Power will be supplied by Arizona Public Service (APS) via a 115 kilovolt (kv) transmission line running from the Willow Lake substation located approximately 60

Table 3.5-1. ESTIMATED BOILER STACK EMISSIONS[e]

Pollutant	Emission Rate[a] (lb/hr (g/sec))	
	Maximum[b]	Annual Average[c]
Particulates	0.5 (0.08)	0.37 (0.06)
Sulfur dioxide[d]	19.8 (2.50)	14.7 (1.85)
Carbon monoxide	1.24 (0.18)	0.99 (0.14)
Hydrocarbons	0.25 (0.04)	0.25 (0.03)
Nitrogen oxides (as NO_2)	6.08 (0.77)	4.57 (0.58)

[a]Emission estimates based on EPA (1975) emission factors.

[b]Maximum emissions based on a distillate fuel oil consumption rate of 278.25 gal/hr (159 bbl/day) @ 41°F (avg. 24-hour temperature).

[c]Annual average emissions based on a distillate fuel oil consumption rate of 207.4 gal/hr (118.5 bbl/day) @ 60°F corrected to average annual ambient temperature of 67°F.

[d]Sulfur content of fuel assumed to be 0.5 percent.

[e]Boiler capacities equal 22,000 lb. steam/hr each (equivalent 25.4 MMBTU/hr). One boiler operating - one standby.

miles away. Approximately 22 miles of new line will be constructed. This line will come into a substation at the northeastern corner of the property. Two 12.47 kv lines will be constructed from this substation. One line will be looped around the mine area. The other line will run to the mill facilities. Adequate grounding to ensure safe operation will be built into the system at circuit breakers, transformer banks, and switching points.

ACCESS ROAD

Access to the Anderson property from U.S. Highway 93 will be provided by a paved road about 12 miles long to be constructed by MINERALS and dedicated to Yavapai County (Figure 3.5-2). This road will have a 26-foot wide paved traveled way. Culverts will be installed where the road crosses major drainage channels, and drainage ditches will be constructed along side the road.

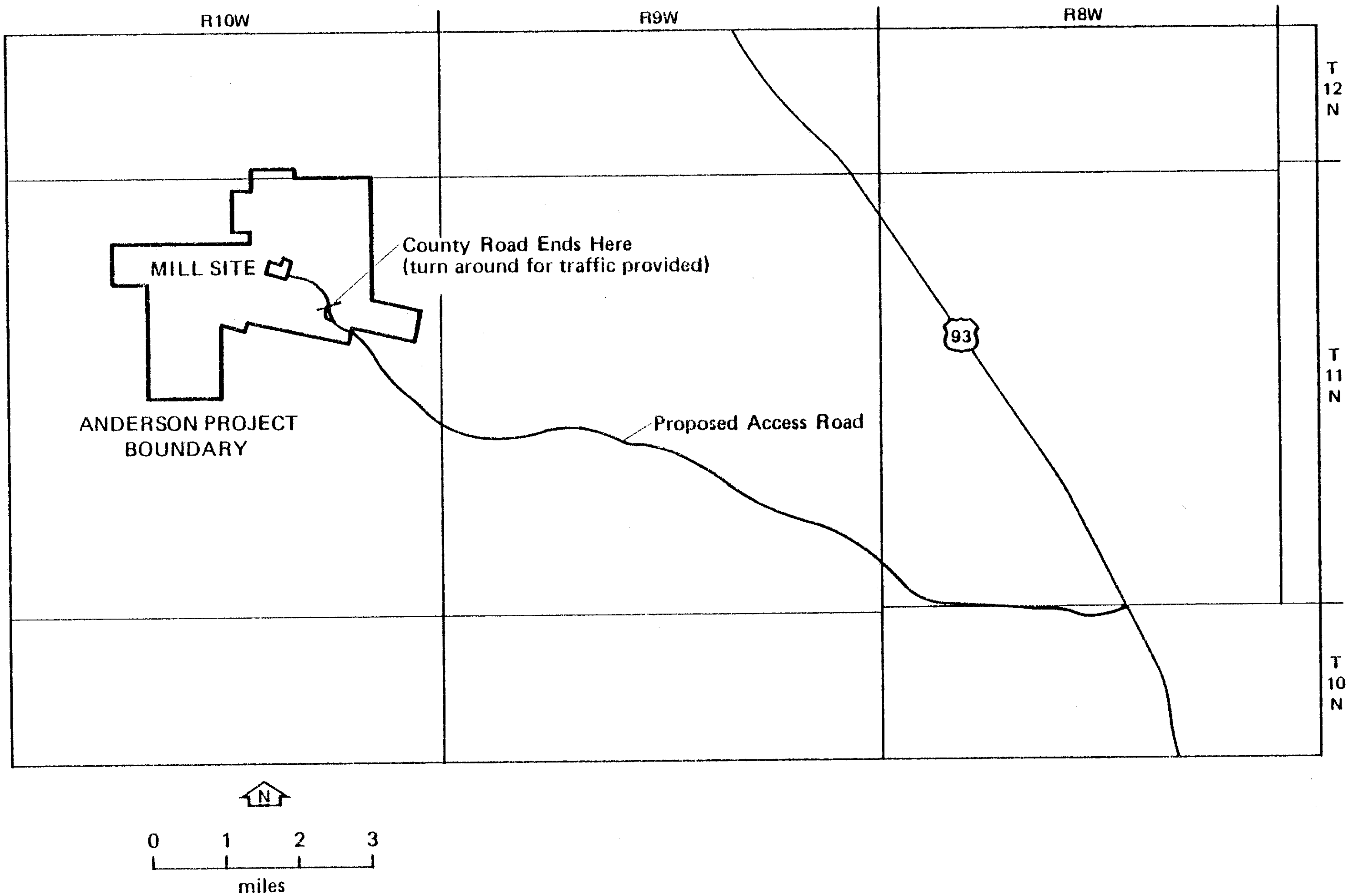
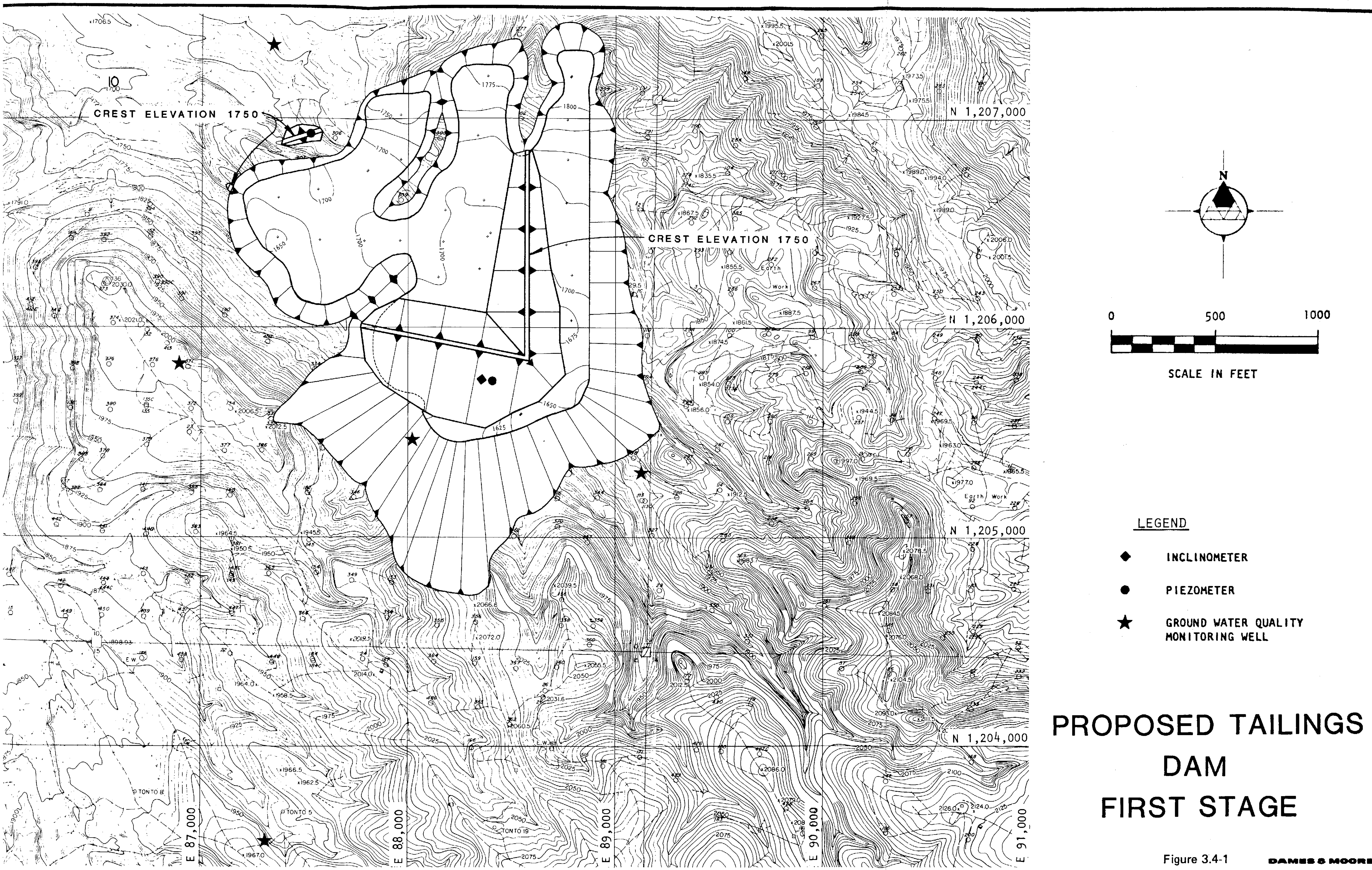


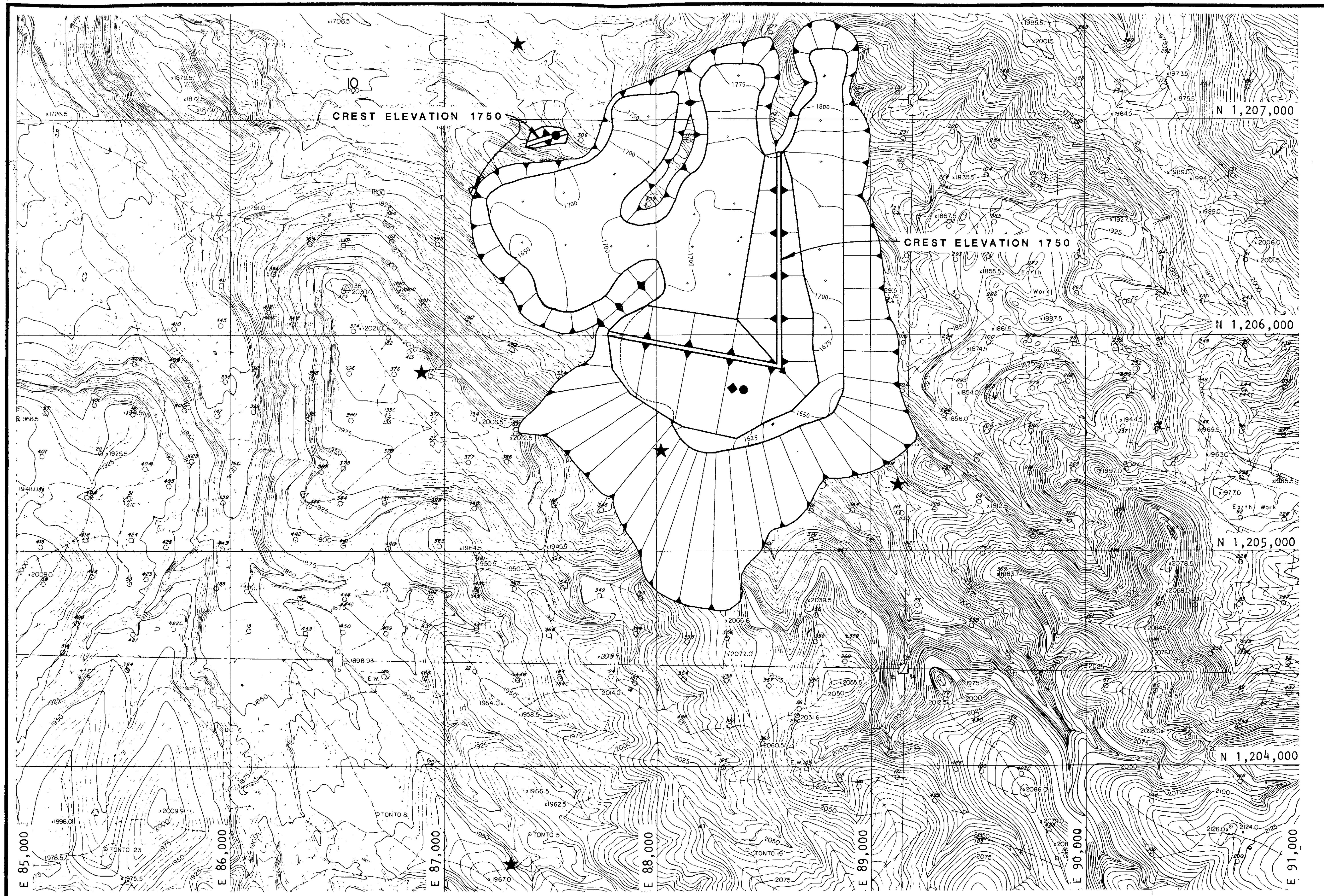
Figure 3.5-2. PROPOSED ACCESS ROAD



PROPOSED TAILINGS DAM FIRST STAGE

Figure 3.4-1

DAMES & MOORE


CREST ELEVATION 1750
CREST ELEVATION 1750
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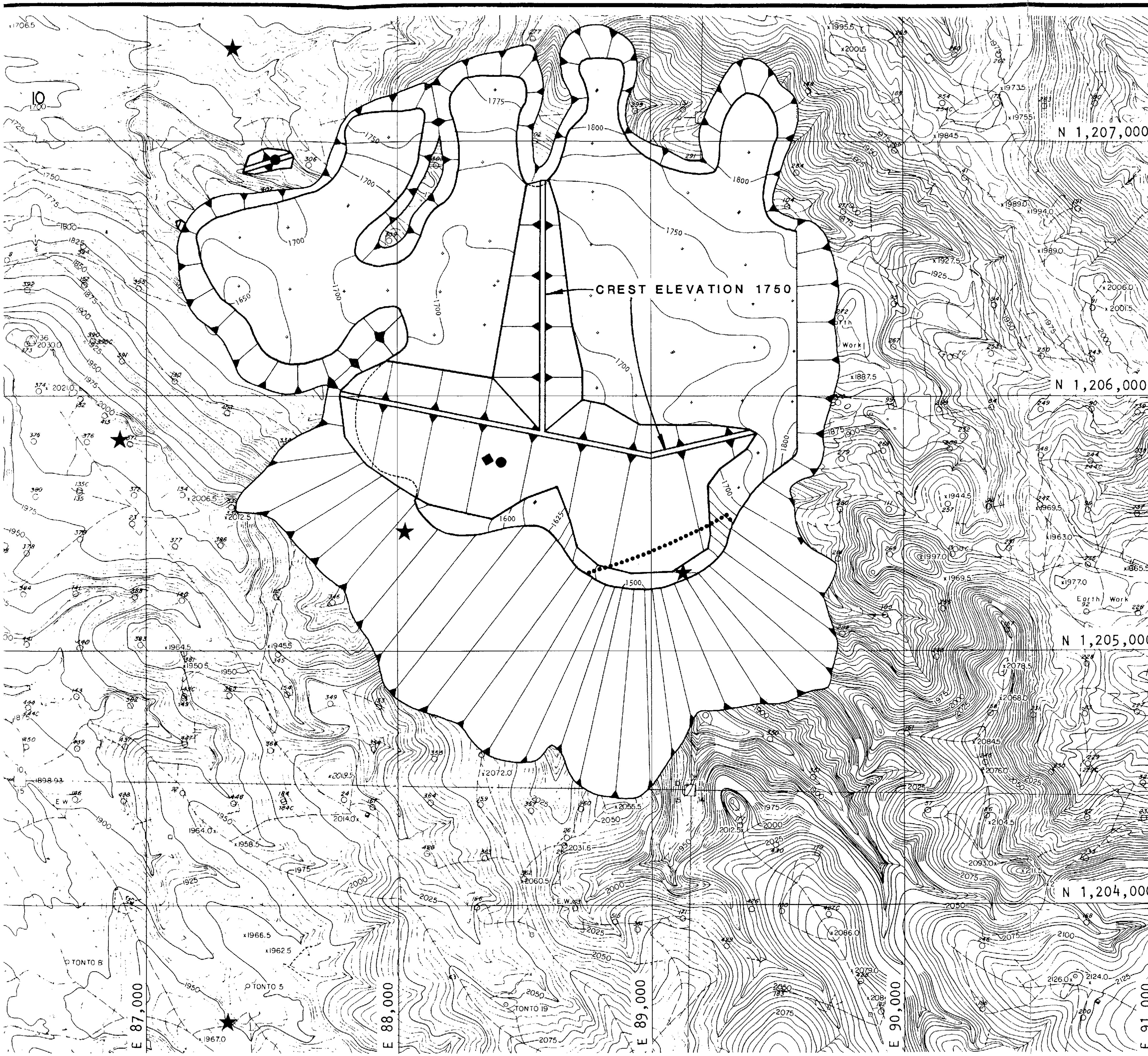
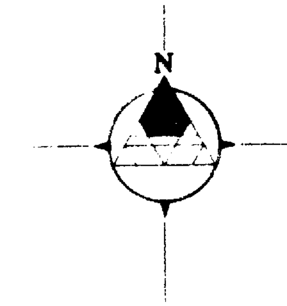
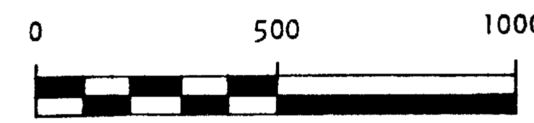
E 91,000

F







SCALE IN FEET

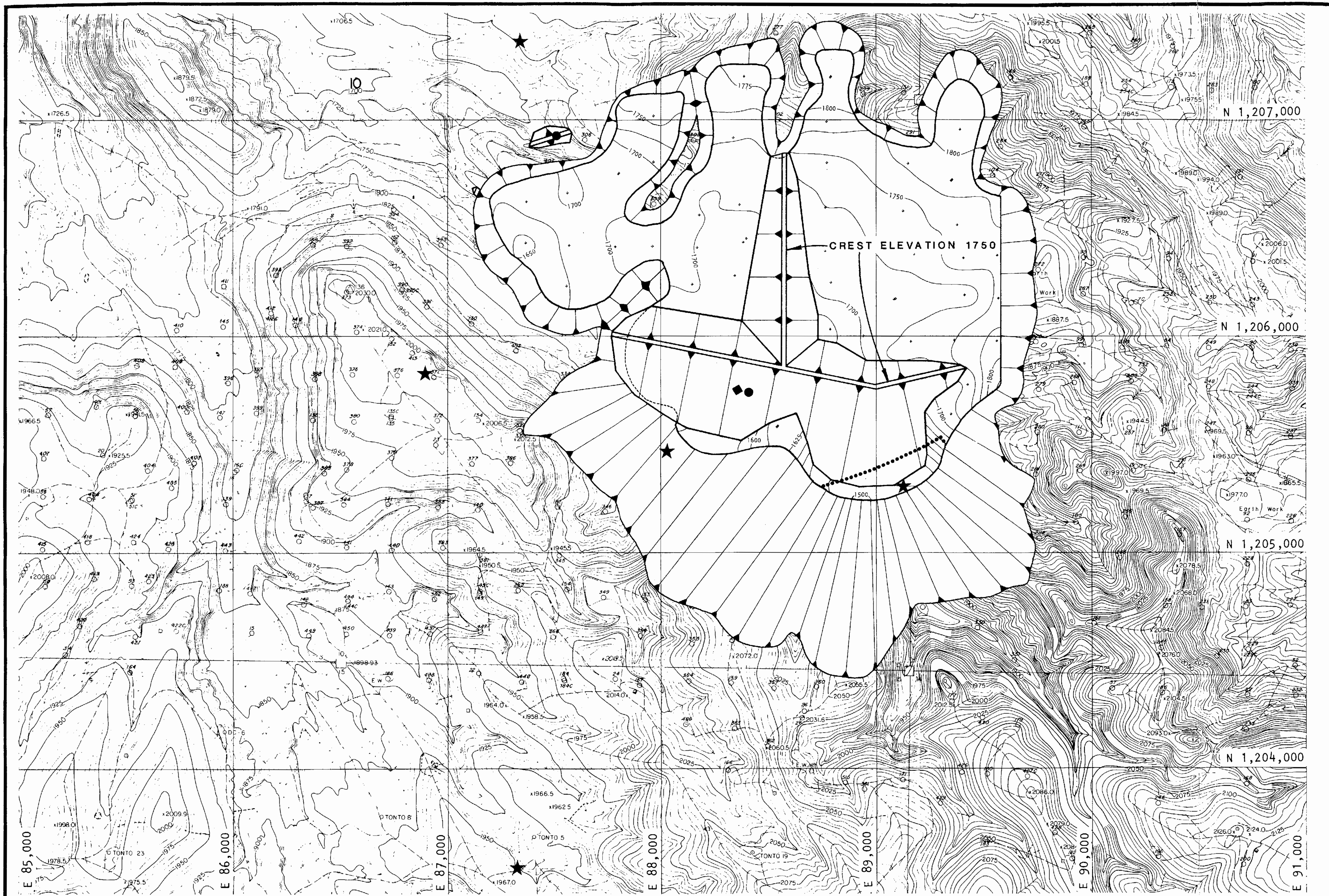
LEGEND

- .... APPROXIMATE BOUNDARIES OF PLANNED MINING SEQUENCES. EXACT BOUNDARIES AND ORDER IN WHICH SEQUENCES ARE MINED WILL BE DESIGNED TO COMPLEMENT STAGED DAM CONSTRUCTION
- ◆ INCLINOMETER
- ● PIEZOMETER
- ★ GROUND WATER QUALITY MONITORING WELL

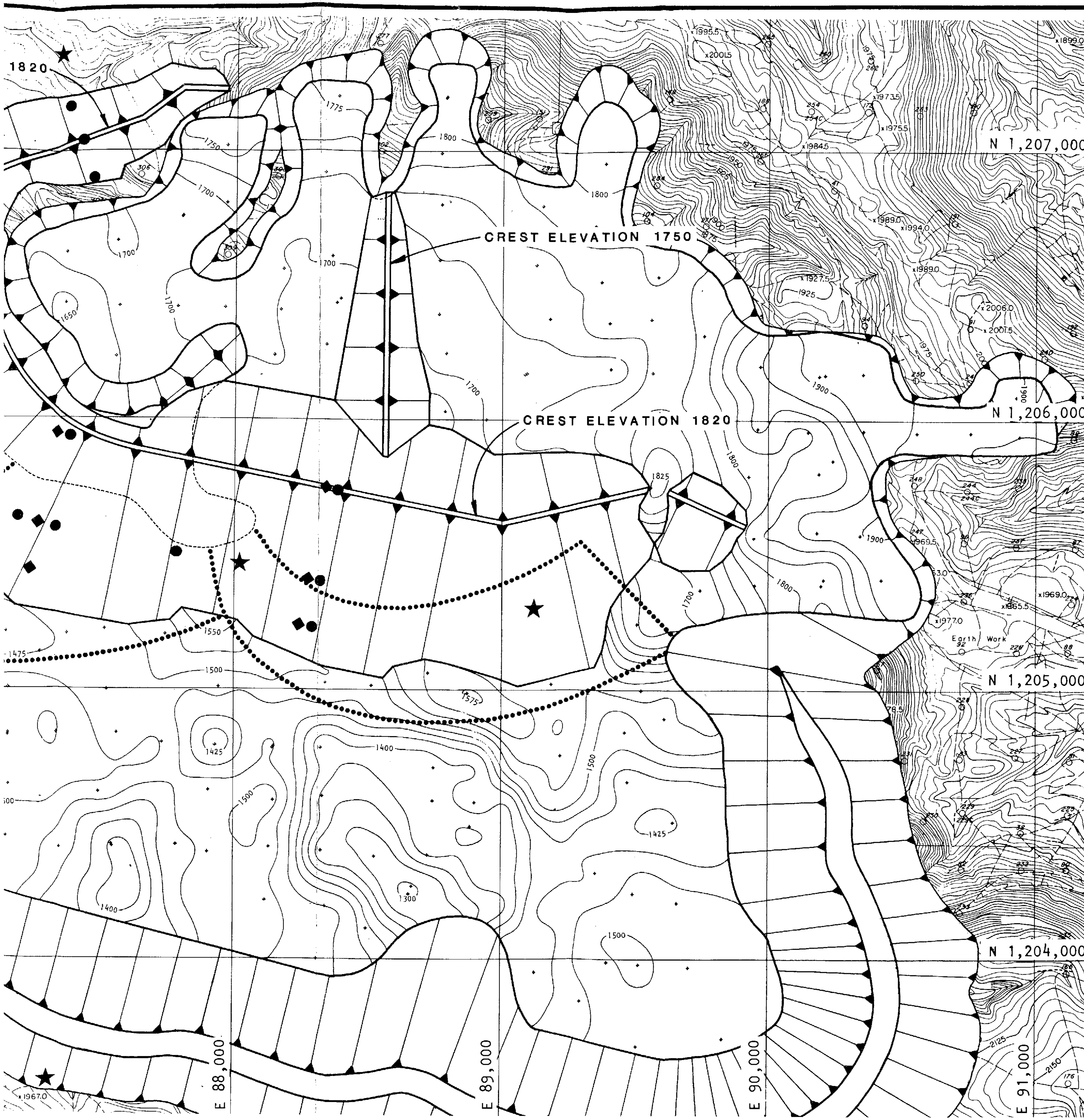
PROPOSED TAILINGS DAM SECOND STAGE

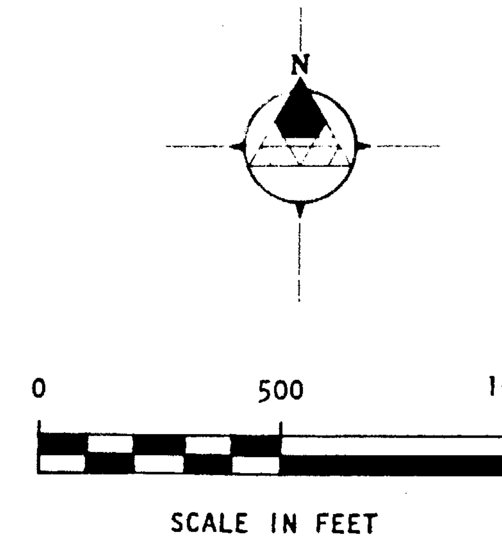
Figure 3.4-3

DAMES & MOORE



CREST ELEVATION 1750
N 1,207,000
N 1,206,000
N 1,205,000
N 1,204,000
E 85,000
E 86,000
E 87,000
E 88,000
E 89,000
E 90,000
E 91,000





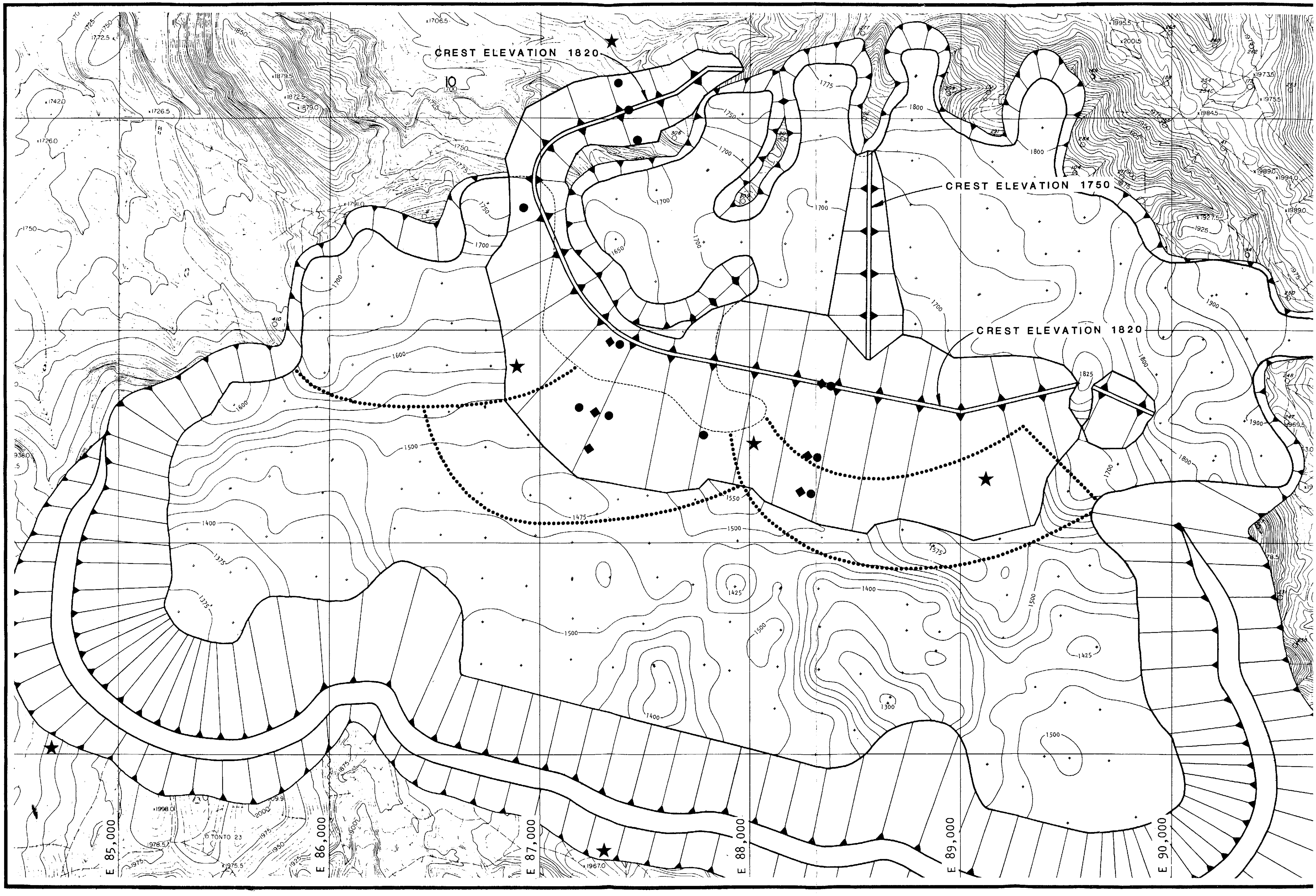
LEGEND

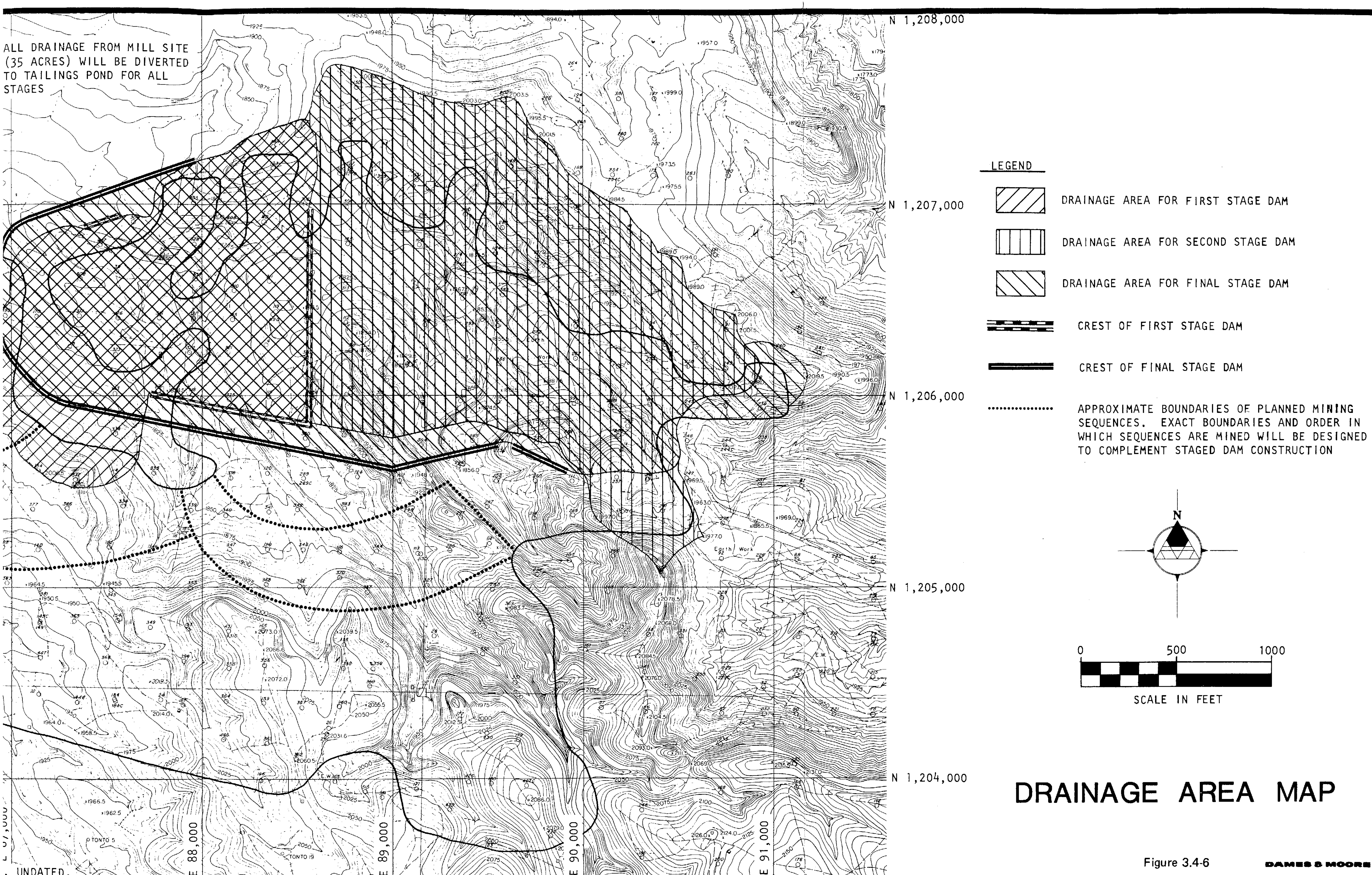
- ·········· APPROXIMATE BOUNDARIES OF PLANNED MINING SEQUENCES. EXACT BOUNDARIES AND ORDER IN WHICH SEQUENCES ARE MINED WILL BE DESIGNED TO COMPLEMENT STAGED DAM CONSTRUCTION
- ⬢ INCLINOMETER
- ● PIEZOMETER
- ★ GROUND WATER QUALITY MONITORING WELL

PROPOSED TAILINGS DAM FINAL STAGE

Figure 3.4-4

DAMES & MOORE


CREST ELEVATION 1820
CREST ELEVATION 1750
CREST ELEVATION 1820
E 85,000
E 86,000
E 87,000
E 88,000
E 89,000
E 90,000

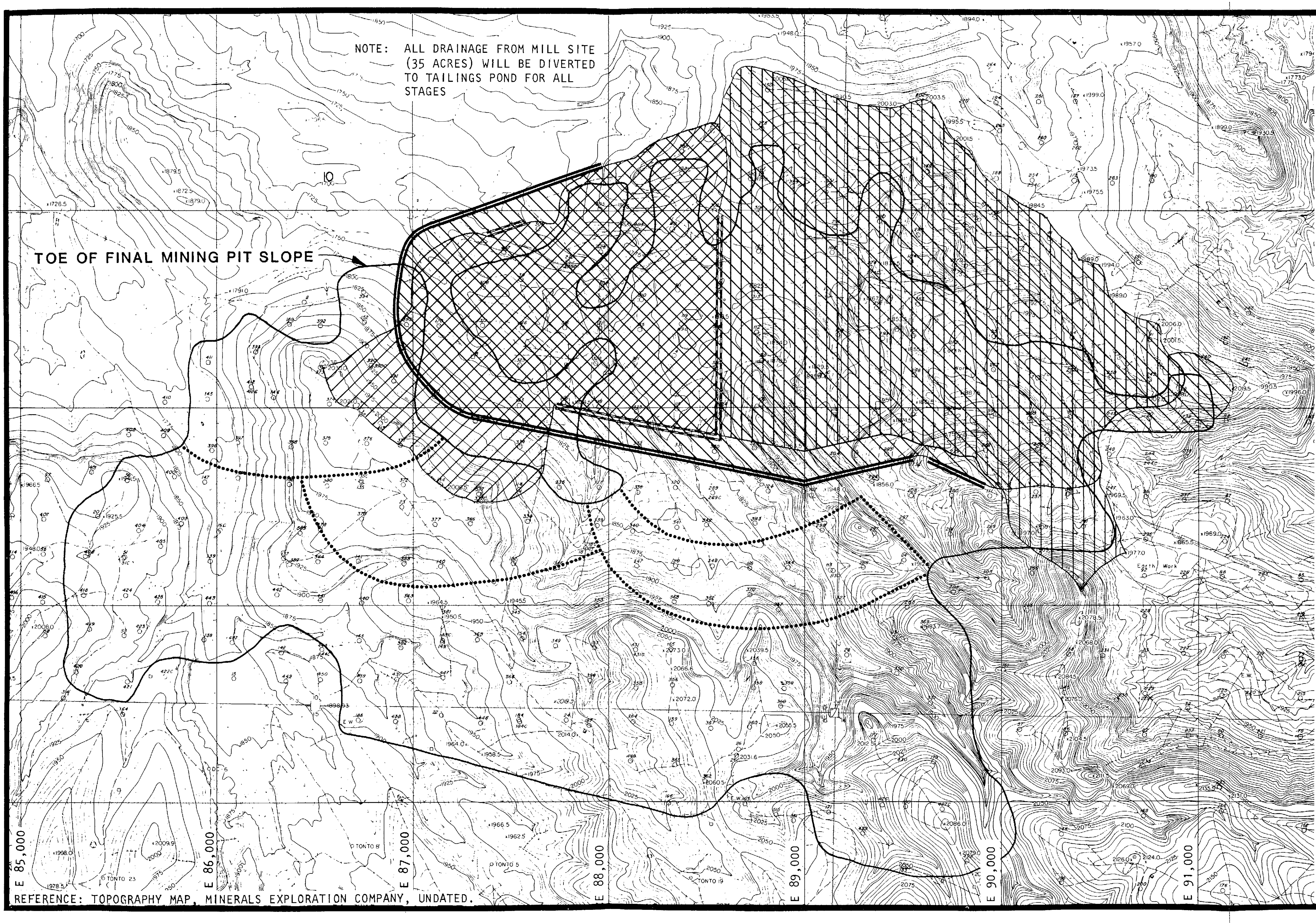


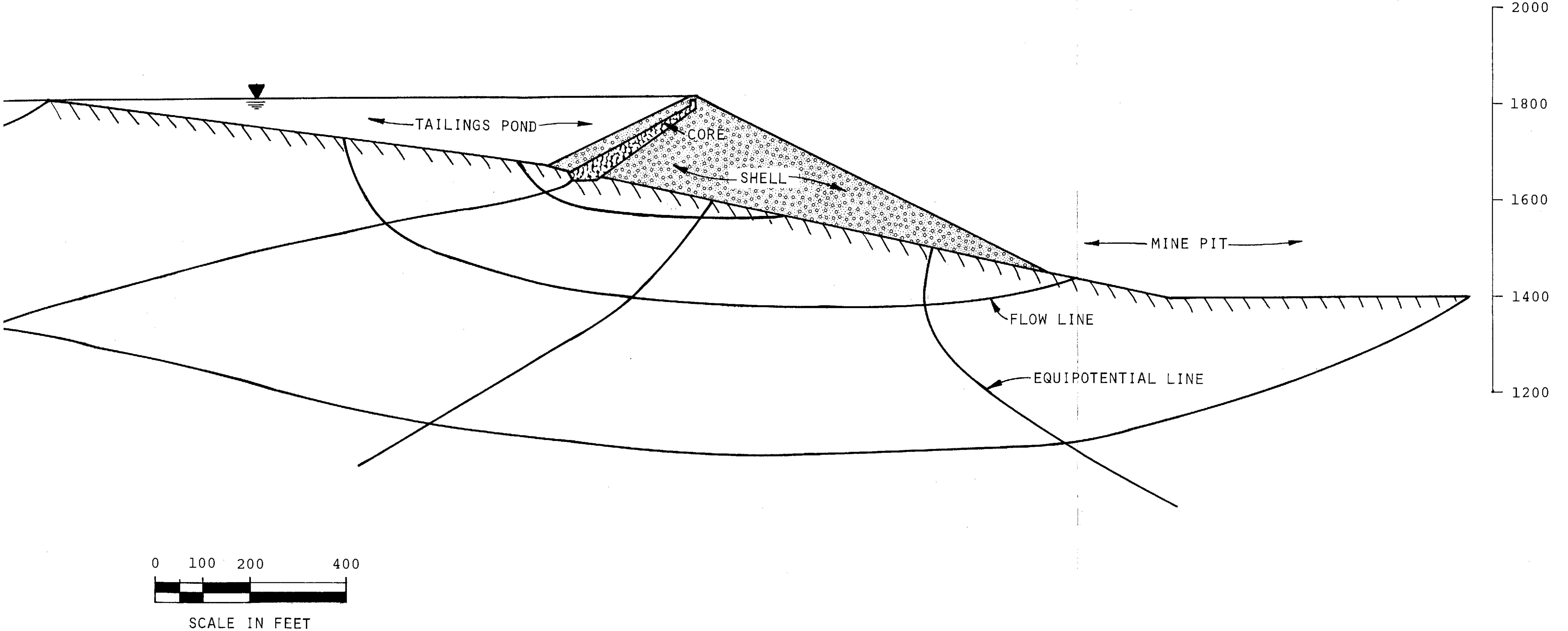
DRAINAGE AREA MAP

Figure 3.4-6

DAMES & MOORE

PLATE 11


NOTE: ALL DRAINAGE FROM MILL SITE (35 ACRES) WILL BE DIVERTED TO TAILINGS POND FOR ALL STAGES
TOE OF FINAL MINING PIT SLOPE
E 85,000
E 86,000
E 87,000
E 88,000
E 89,000
E 90,000
E 91,000
REFERENCE: TOPOGRAPHY MAP, MINERALS EXPLORATION COMPANY, UNDATED.

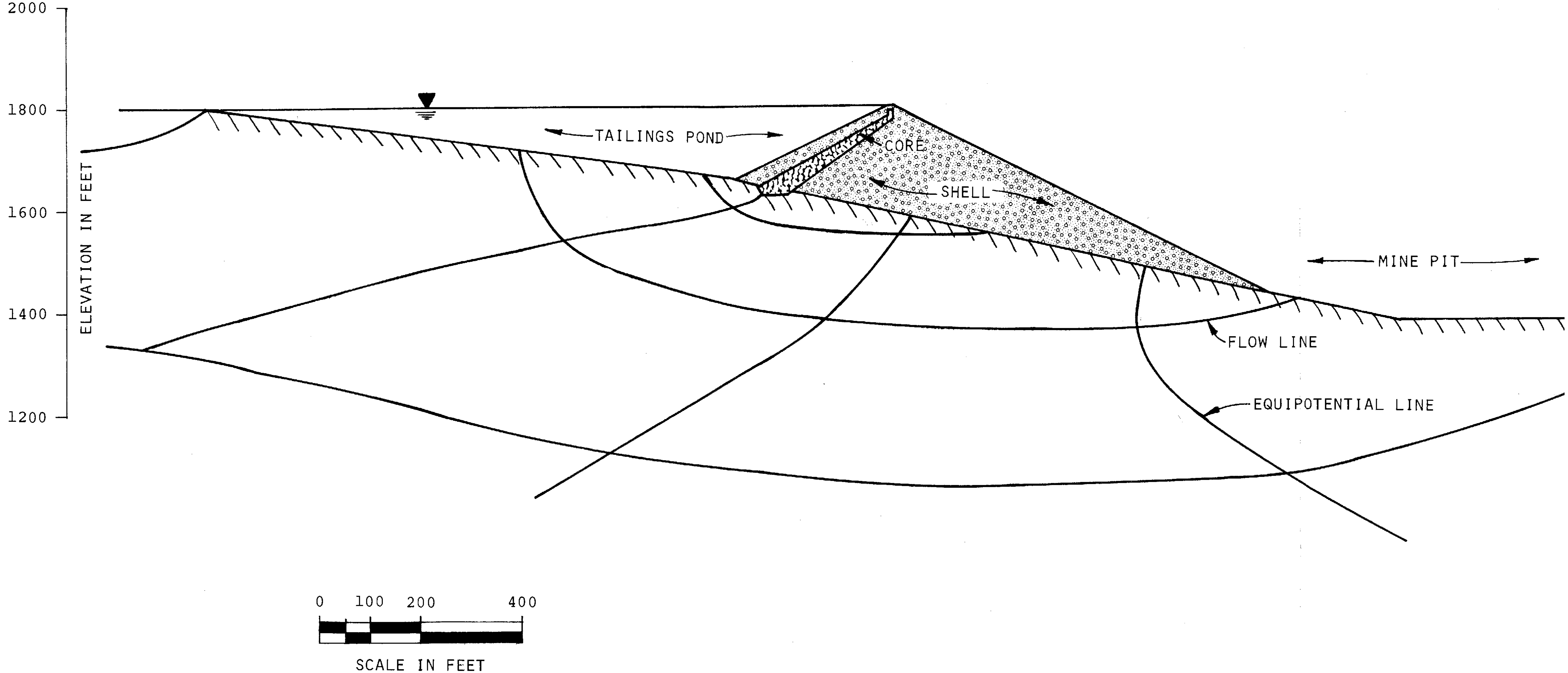


TYPICAL SECTION SEEPAGE ANALYSIS

Figure 3.4-10

DAMES & MOORE

PLATE C-1



TYPICA
SEEPAG

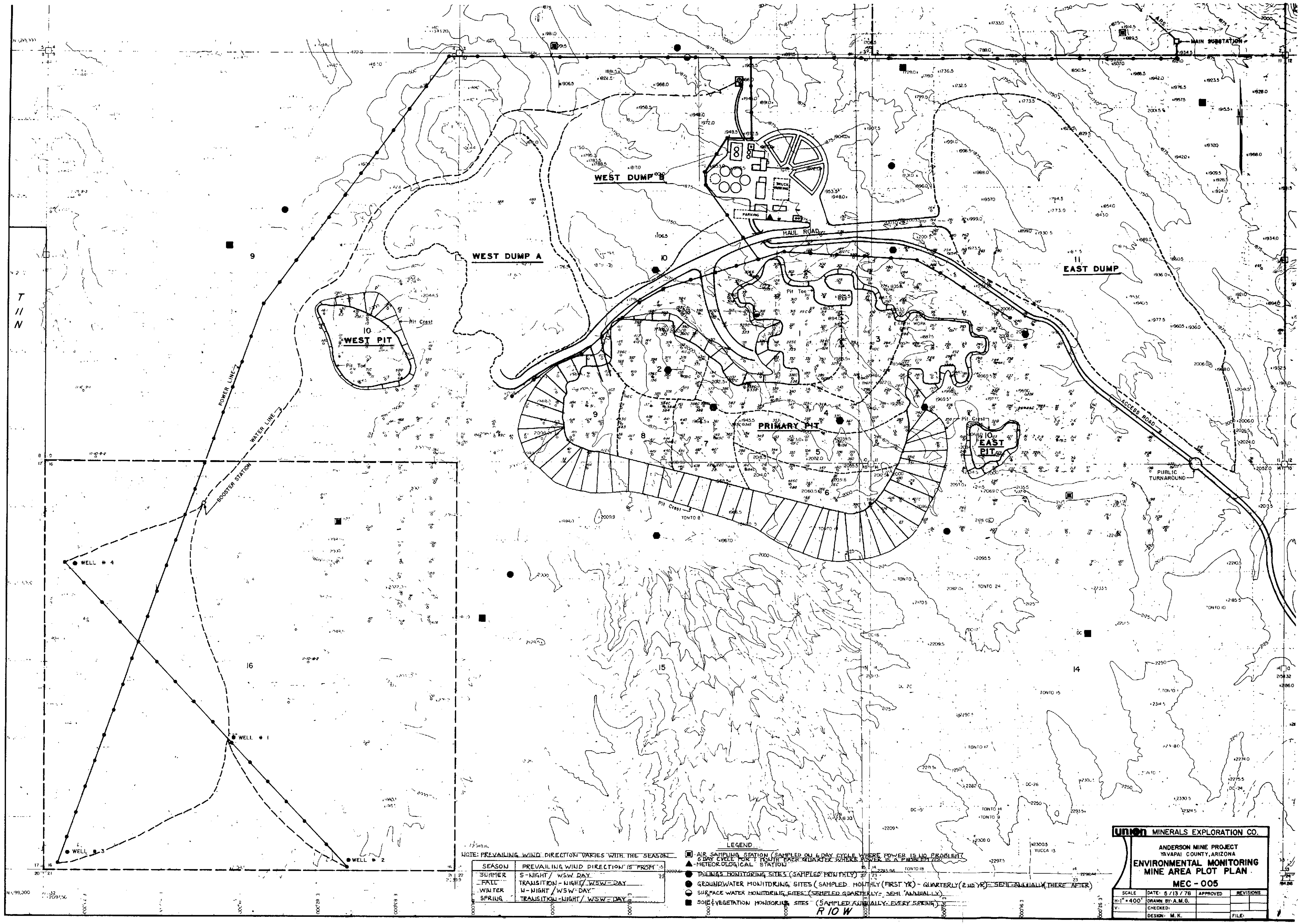
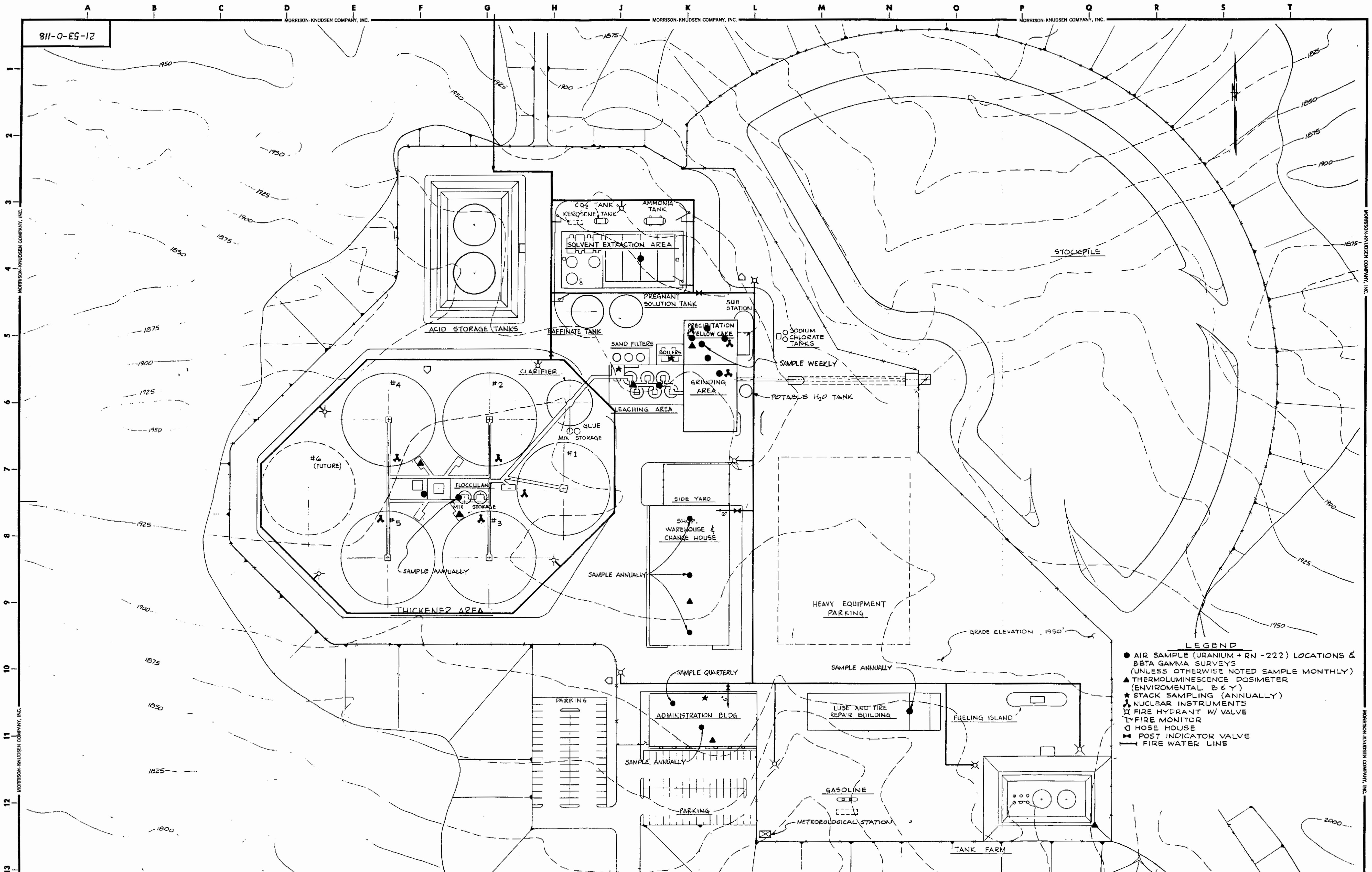

WEST DUMP B
WEST DUMP A
HAUL ROAD
EAST DUMP
WEST PIT
Pit Crest
Pit Toe
PRIMARY PIT
EAST PIT
ACCESS ROAD
PUBLIC TURNAROUND
MAIN SUBSTATION
PARKING
POWER LINE
WATER LINE
BOOSTER STATION
WELL # 4
WELL # 1
WELL # 3
WELL # 2
T 11 N
R 10 W
NOTE: PREVAILING WIND DIRECTION VARIES WITH THE SEASON
SEASON | PREVAILING WIND DIRECTION IS FROM
SUMMER | S-NIGHT / WSW DAY
FALL | TRANSITION - NIGHT / WSW - DAY
WINTER | N-NIGHT / WSW-DAY
SPRING | TRANSITION - NIGHT / WSW - DAY
LEGEND
AIR SAMPLING STATION (SAMPLED ON 6 DAY CYCLE WHERE POWER IS NO PROBLEM; 6 DAY CYCLE FOR 1 MONTH EACH QUARTER WHERE POWER IS A PROBLEM)
METEOROLOGICAL STATION
TAILINGS MONITORING SITES (SAMPLED MONTHLY)
GROUNDWATER MONITORING SITES (SAMPLED MONTHLY (FIRST YR) - QUARTERLY (2ND YR) - SEMI-ANNUALLY THERE AFTER)
SURFACE WATER MONITORING SITES (SAMPLED QUARTERLY - SEMI ANNUALLY)
SOIL & VEGETATION MONITORING SITES (SAMPLED ANNUALLY - EVERY SPRING)
UNION MINERALS EXPLORATION CO.
ANDERSON MINE PROJECT
YAVAPAI COUNTY, ARIZONA
ENVIRONMENTAL MONITORING
MINE AREA PLOT PLAN
MEC - 005
SCALE H: 1" = 400'
DATE: 5/13/78
DRAWN BY: A.M.G.
CHECKED:
DESIGN: M.K.
APPROVED
REVISIONS
FILE:

Figure 3.1-2



BUILDING FIRE PROTECTION —

- ADMINISTRATION BLDG. / SHOP, WAREHOUSE, CHANGE HOUSE BLDG. } AUTOMATIC SPRINKLER & HAND EXTINGUISHERS
- MILL BUILDING — HOSE REELS & HAND EXTINGUISHERS
- LUBE & TIRE BLDG. / FUELING ISLAND / LEACHING AREA / THICKENER CONTROL RM. & FLOC. AREA } HAND EXTINGUISHERS
- SOLVENT EXTRACTION AREA — AUTOMATIC CO2 & HAND EXTINGUISHERS

NO.	DATE	REVISION	BY	APPR.	APPR.	REFERENCE DRAWING	NUMBER	NOTES

DESCRIPTION | COST ACCOUNT
WORK COVERED BY THIS DRAWING CHARGED TO COST ACCOUNT ABOVE

MINERALS EXPLORATION COMPANY
ANDERSON PROJECT

2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA

PROPRIETARY STATEMENT

	APPROVALS	DATE
CLIENT		
PROJECT MANAGER	[signature]	7-19-78

		DATE
SCALE	1" = 50'	
DRAWN BY	S. BUTTERBRODT	6/22/78
DESIGNED BY		
CHECKED BY	J. KUZILIK	7/11/78
APPROVED	[signature]	7/18/78
APPROVED	[signature]	7/18/78

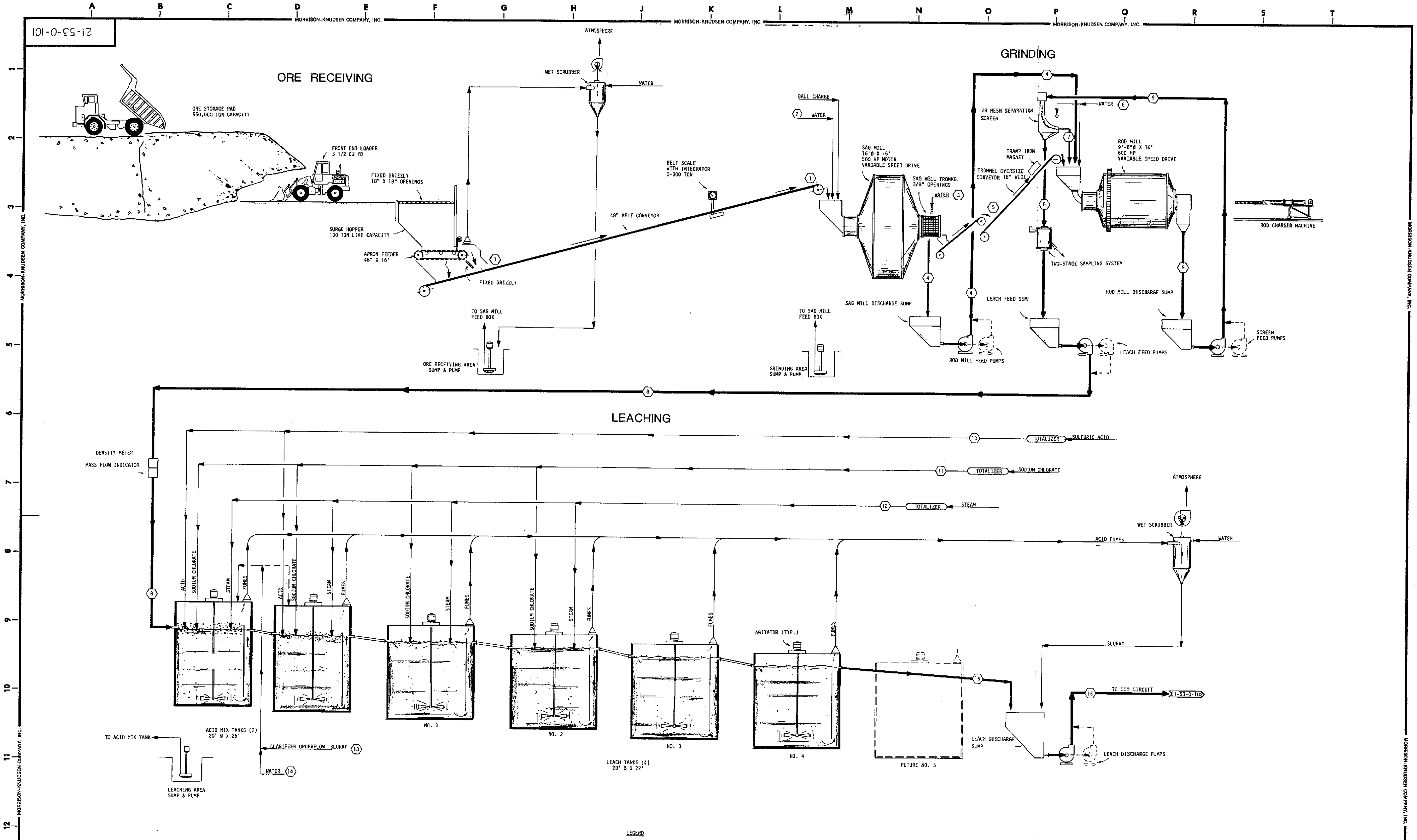
DEPT.	ARCH.	STRUCT.	MECH.	ELECT.	P.&I.	PIPING	SAF. DEPT.	P.E.
INITIAL								
DATE								

MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729

MILL & MINE FACILITY
EMISSION CONTROL
& FIRE PROTECTION

JOB NO. 1114 | DRAWING NO. 21-53-0-118 | REVISION 0

Figure 3.2-1



STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SOLIDS TPH	91.7	---	---	82.5	9.2	---	18.3	91.7	110.0	---	---	---	---	---	95.1
LIQUID TPH	10.1	64.9	3.0	77.0	1.0	8.8	3.2	91.7	90.0	20.4	0.7	9.8	2.0	6.4	116.2
TOTAL FLOW GPM		259.6	12.0	446.9		35.2		521.2	545.3	*44.7	2.0	39.2	8.0	25.6	609.6

*27.7 GPM ARE USED UP BY $CaCO_3$

#1

REFERENCE DRAWING	NUMBER
ORE RECEIVING & CONVEYING PLAN & EL.	21-53-0-105
CCD CLARIFYING & TAILING FLOW SHEET	21-53-0-102
MILL BUILDING PLAN & EL.	21-53-0-107
LEACH & FILTER AREA PLAN & EL.	21-53-0-108

NO. | DATE | REVISION | BY | APPR. | APPR.

NOTES
1. LEACH TANKS LOCATED OUTDOORS
2. LEACHING CIRCUIT BYPASS LINES OMITTED FOR CLARITY

DESCRIPTION | COST ACCOUNT
WORK COVERED BY THIS DRAWING CHARGED TO COST ACCOUNT ABOVE

MINERALS EXPLORATION COMPANY
ANDERSON PROJECT

2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA

PROPRIETARY STATEMENT

APPROVALS		DATE
CLIENT		
PROJECT MANAGER	[signature]	7-18-78

		DATE
SCALE	NONE	
DRAWN BY	[signature]	30 MAY 78
DESIGNED BY		
CHECKED BY	J.KUZILIK	7/11/78
APPROVED	[signature]	7/18/78
APPROVED	[signature]	7/18/78

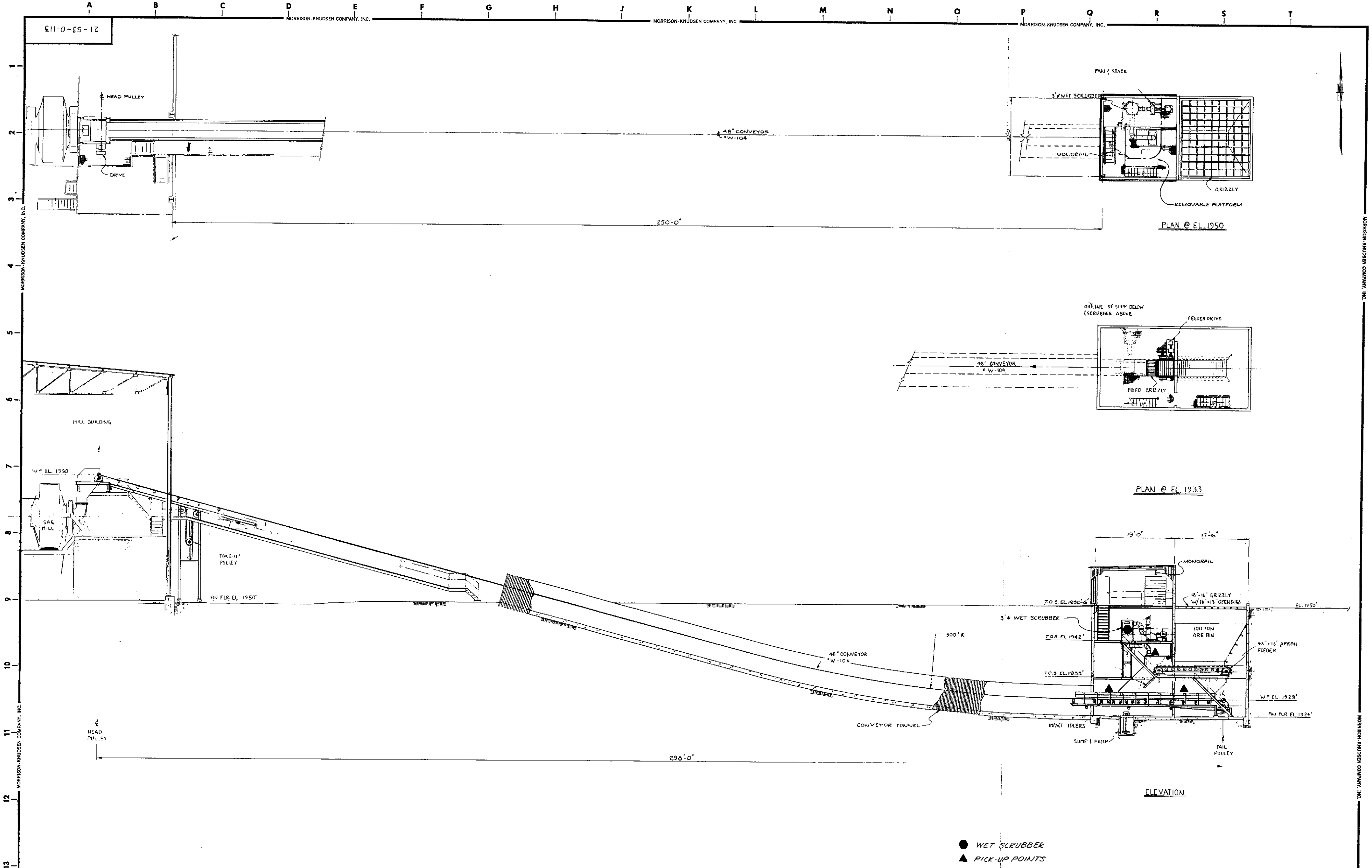
DEPT.	ARCH.	STRUCT.	MECH.	ELECT.	P.&I.	PIPING	SAF. DEPT.	P.E.
INITIAL								
DATE								

MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729

ORE RECEIVING, GRINDING & LEACHING FLOW SHEET

JOB NO. 1114 | DRAWING NO. 21-53-0-101 | REVISION 0

Figure 3.3-2



REFERENCE DRAWING	NUMBER
MILL BUILDING PLAN & ELEVATION	21-53-0-106
MILL SITE PLAN	21-53-0-104
RECEIVING, GRINDING & LEACHING FLOW SHEET	21-53-0-101

NO. | DATE | REVISION | BY | APPR. | APPR.

NOTES

DESCRIPTION | COST ACCOUNT

WORK COVERED BY THIS DRAWING CHARGED TO COST ACCOUNT ABOVE

PROPRIETARY STATEMENT

MINERALS EXPLORATION COMPANY
ANDERSON PROJECT

2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA

APPROVALS	DATE
CLIENT	
PROJECT MANAGER [signature]	7-17-78

		DATE
SCALE	1/8" = 1'-0"	
DRAWN BY	D.B.	6/28/78
DESIGNED BY		
CHECKED BY	J. KUZIUK	7/11/78
APPROVED	[signature]	7/18/78
APPROVED	[signature]	7/18/78

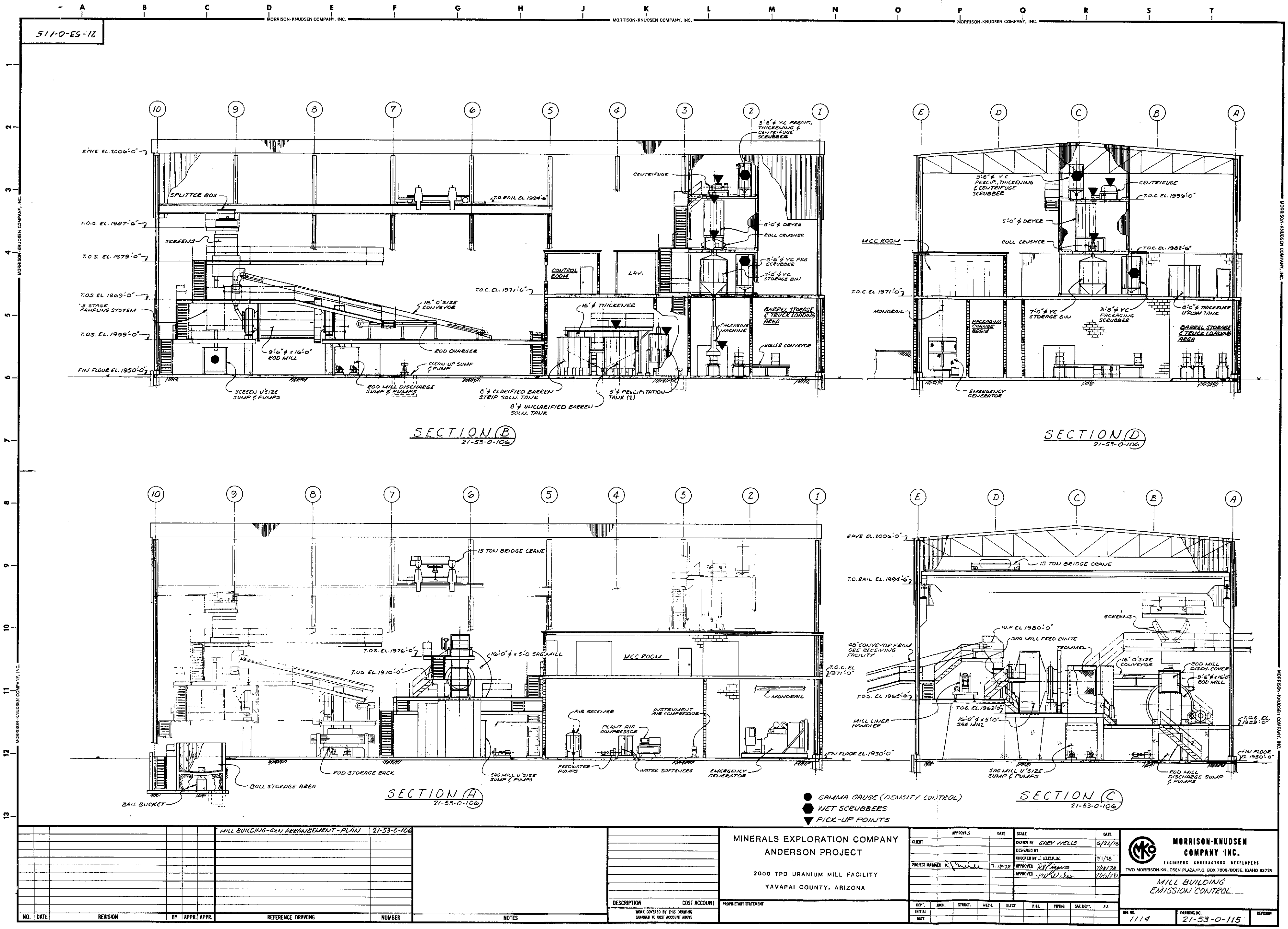
DEPT.	ARCH.	STRUCT.	MECH.	ELECT.	P.&I.	PIPING	SAF. DEPT.	P.E.
INITIAL								
DATE								

MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729

ORE RECEIVING & CONVEYING EMISSION CONTROL

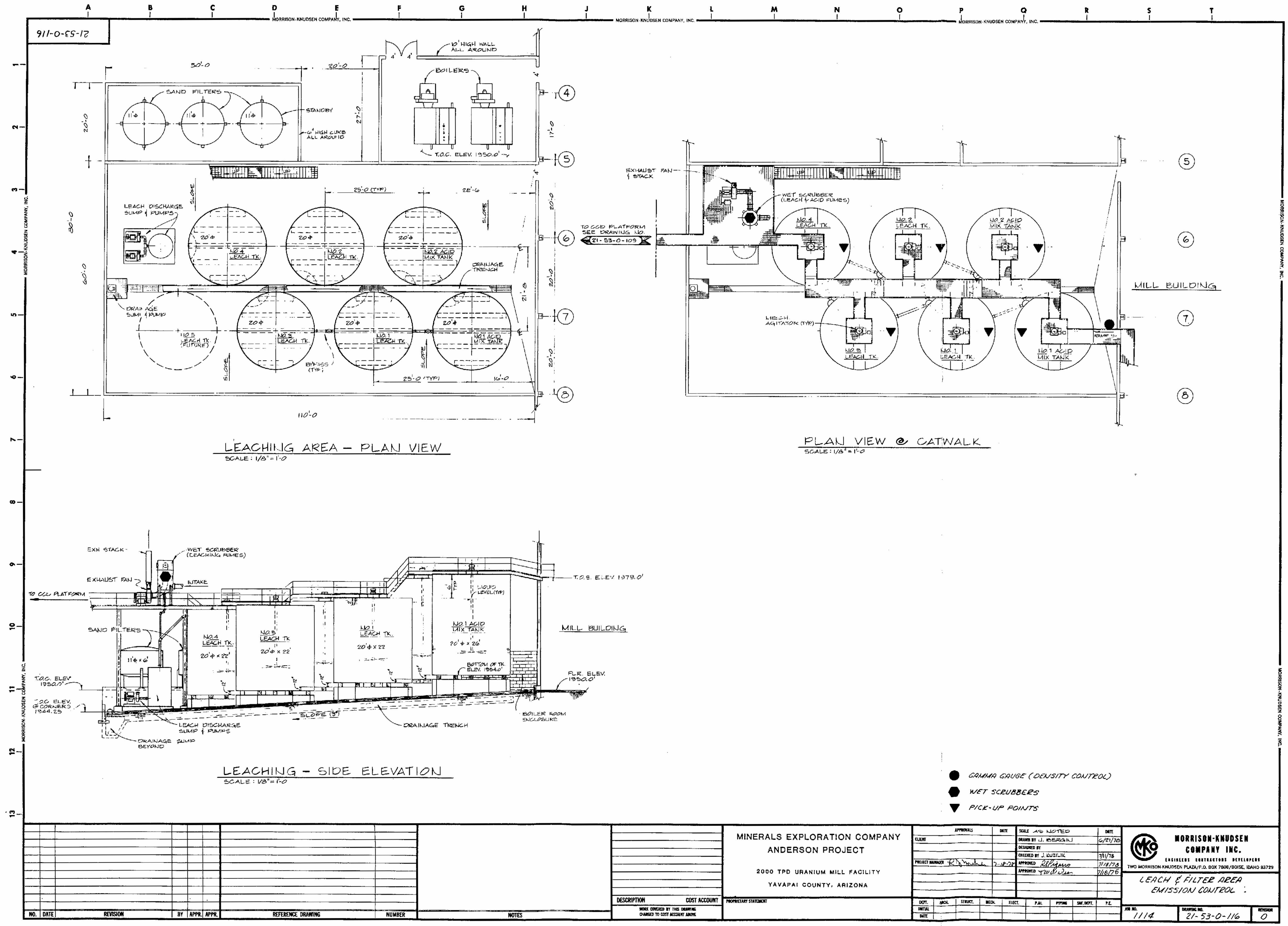
JOB NO. 1114 | DRAWING NO. 21-53-0-113 | REVISION 0

Figure 3.3-3



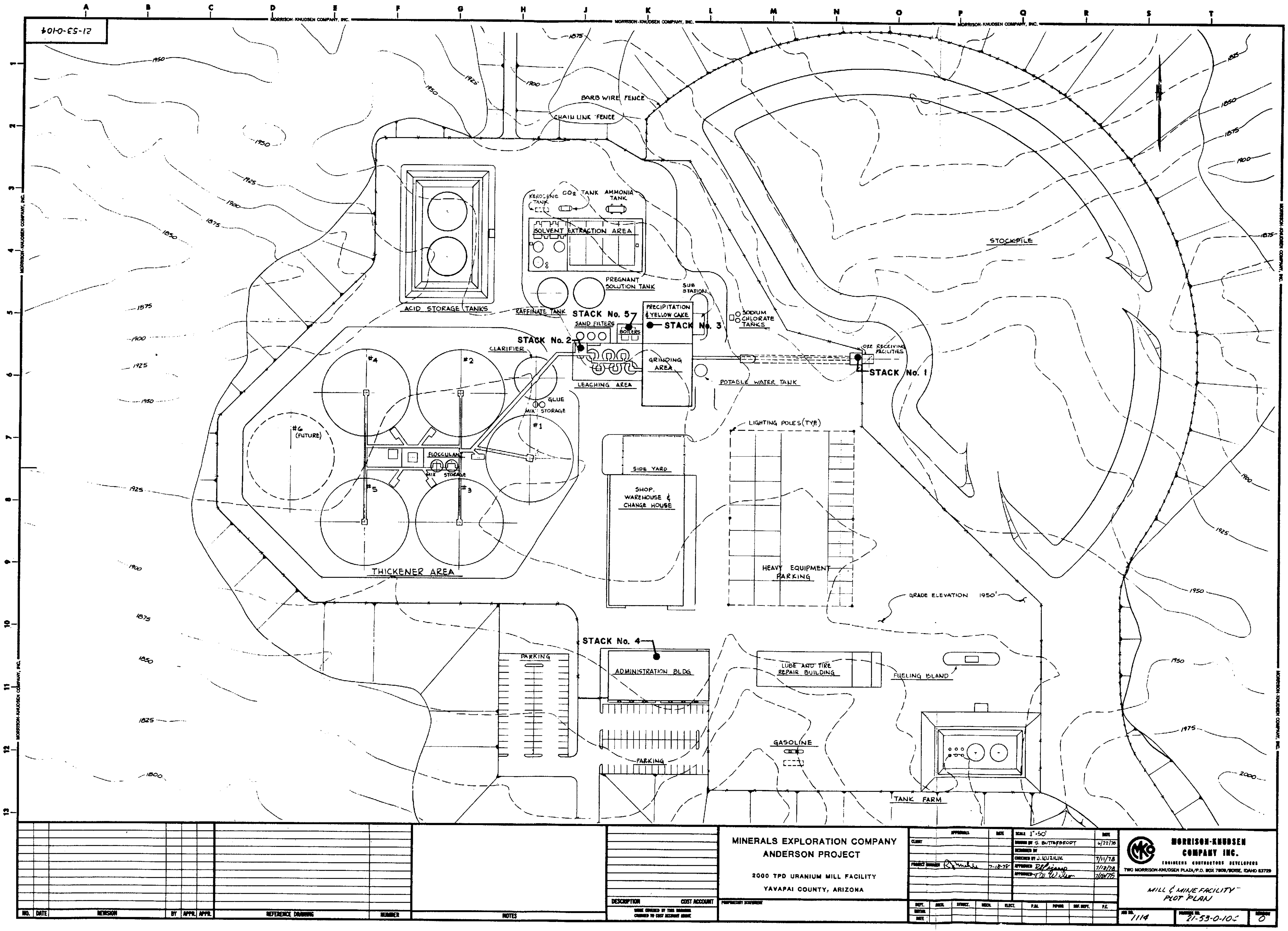
511-0-ES-12
MORRISON-KNUDSEN COMPANY, INC.
SECTION (B) 21-53-0-106
SECTION (D) 21-53-0-106
SECTION (A) 21-53-0-106
SECTION (C) 21-53-0-106
EAVE EL. 2006'-0"
T.O.S. EL. 1987'-6"
T.O.S. EL. 1979'-0"
T.O.S. EL. 1969'-0"
3 STAGE SAMPLING SYSTEM
T.O.S. EL. 1959'-0"
FIN. FLOOR EL. 1950'-0"
SPLITTER BOX
SCREENS
T.O. RAIL EL. 1994'-6"
18" O'SIZE CONVEYOR
9'-6" ϕ x 16'-0" ROD MILL
ROD CHARGER
CLEAN-UP SUMP & PUMP
SCREEN U'SIZE SUMP & PUMPS
ROD MILL DISCHARGE SUMP & PUMPS
T.O.C. EL. 1971'-0"
CONTROL ROOM
LAV.
18' ϕ THICKENER
8' ϕ CLARIFIED BARREN STRIP SOLN. TANK
8' ϕ UNCLARIFIED BARREN SOLN. TANK
5' ϕ PRECIPITATION TANK (2)
CENTRIFUGE
3'-8" ϕ YC PRECIP., THICKENING & CENTRIFUGE SCRUBBER
5'-0" ϕ DRYER
ROLL CRUSHER
3'-6" ϕ YC PKG SCRUBBER
7'-0" ϕ YC STORAGE BIN
PACKAGING MACHINE
BARREL STORAGE & TRUCK LOADING AREA
ROLLER CONVEYOR
MCC ROOM
T.O.C. EL. 1996'-0"
T.O.C. EL. 1982'-6"
MONORAIL
PACKAGING CHANGE ROOM
7'-0" ϕ YC STORAGE BIN
3'-8" ϕ YC PACKAGING SCRUBBER
8'-0" ϕ THICKENER U'FLOW TANK
EMERGENCY GENERATOR
15 TON BRIDGE CRANE
T.O.S. EL. 1976'-0"
T.O.S. EL. 1970'-0"
16'-0" ϕ x 5'-0 SAG MILL
MCC ROOM
T.O.C. EL 1971'-0"
AIR RECEIVER
PLANT AIR COMPRESSOR
INSTRUMENT AIR COMPRESSOR
FIN. FLOOR EL. 1950'-0"
ROD STORAGE RACK
BALL STORAGE AREA
BALL BUCKET
SAG MILL U'SIZE SUMP & PUMPS
FEEDWATER PUMPS
WATER SOFTENERS
EMERGENCY GENERATOR
T.O. RAIL EL. 1994'-6"
W.P. EL 1980'-0"
SAG MILL FEED CHUTE
SCREENS
48" CONVEYOR FROM ORE RECEIVING FACILITY
TROMMEL
18" O'SIZE CONVEYOR
ROD MILL DISCH. COVER
9'-6" ϕ x 16'-0" ROD MILL
T.O.S. EL 1965'-6"
T.O.S. EL. 1962'-0"
MILL LINER HANDLER
16'-0" ϕ x 5'-0" SAG MILL
T.O.S. EL. 1959'-0"
FIN. FLOOR EL. 1950'-0"
ROD MILL DISCHARGE SUMP & PUMPS
GAMMA GAUGE (DENSITY CONTROL)
WET SCRUBBERS
PICK-UP POINTS
MILL BUILDING-GEN. ARRANGEMENT-PLAN 21-53-0-106
NO. DATE REVISION BY APPR. APPR. REFERENCE DRAWING NUMBER NOTES
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
DESCRIPTION COST ACCOUNT
PROPRIETARY STATEMENT
DRAWN BY GARY WELLS 6/22/78
MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729
MILL BUILDING EMISSION CONTROL
JOB NO. 1114
DRAWING NO. 21-53-0-115

Figure 3.3-4



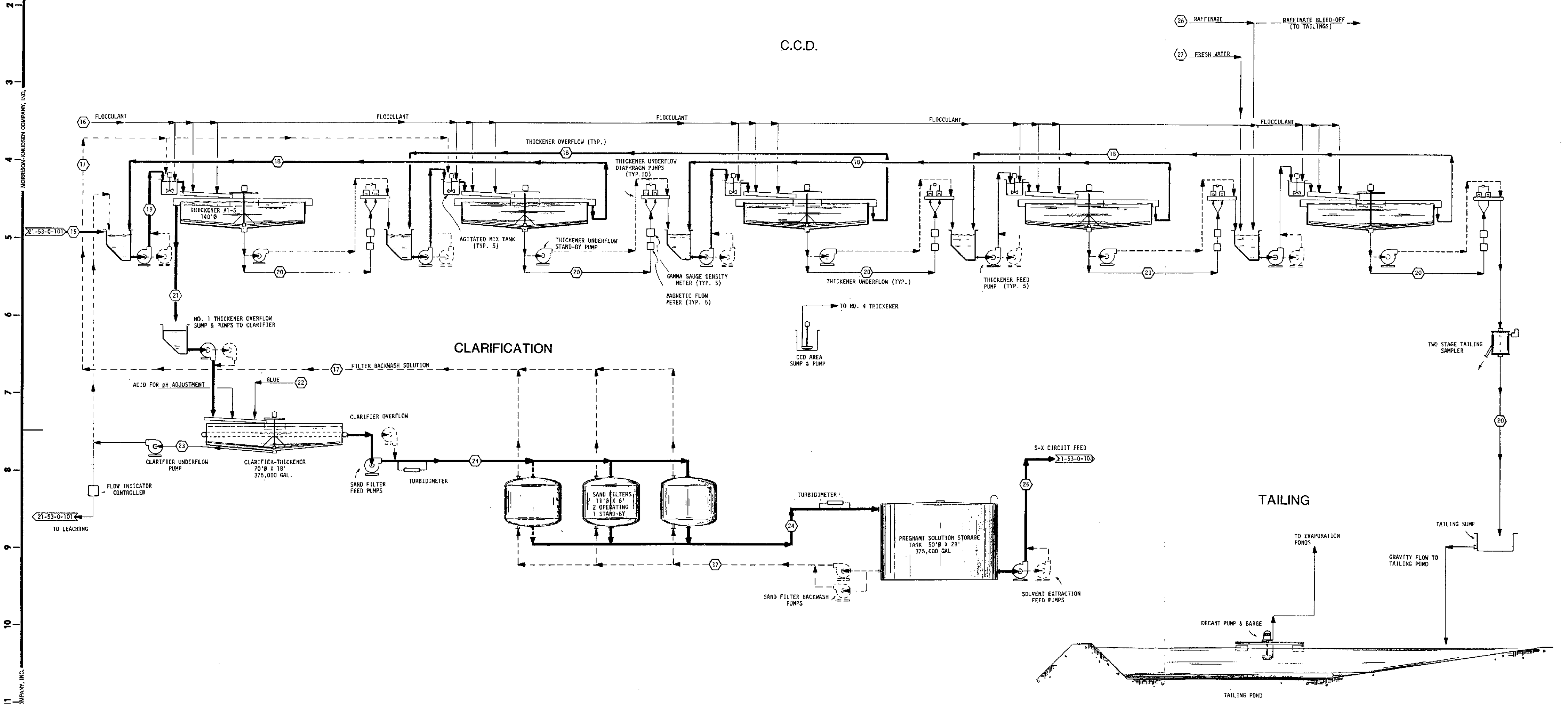
21-53-0-116
10' HIGH WALL ALL AROUND
BOILERS
SAND FILTERS
STANDBY
6" HIGH CURB ALL AROUND
T.O.C. ELEV. 1950.0'
LEACH DISCHARGE SUMP & PUMPS
NO. 4 LEACH TK
NO. 2 LEACH TK
NO. 2 ACID MIX TANK
DRAINAGE TRENCH
DRAINAGE SUMP & PUMP
NO. 5 LEACH TK (FUTURE)
NO. 3 LEACH TK.
NO. 1 LEACH TK
NO. 1 ACID MIX TANK
BYPASS (TYP)
SLOPE
110'-0
LEACHING AREA – PLAN VIEW
SCALE: 1/8" = 1'-0
EXHAUST FAN & STACK
WET SCRUBBER (LEACH & ACID FUMES)
TO CCD PLATFORM SEE DRAWING NO. 21-53-0-109
MESH AGITATOR (TYP)
MILL BUILDING
PLAN VIEW @ CATWALK
SCALE: 1/8" = 1'-0
EXH STACK
WET SCRUBBER (LEACHING FUMES)
EXHAUST FAN
INTAKE
TO CCD PLATFORM
T.O.S. ELEV 1979.0'
LIQUID LEVEL (TYP)
SAND FILTERS
11'φ x 6'
NO. 4 LEACH TK. 20'φ x 22'
NO. 3 LEACH TK 20'φ x 22'
NO. 1 LEACH TK. 20'φ x 22'
NO. 1 ACID MIX TANK 20'φ x 26'
BOTTOM OF TK ELEV. 1954.0'
MILL BUILDING
T.O.C. ELEV 1950.0'
FLR. ELEV. 1950.0'
SLOPE
DRAINAGE TRENCH
LEACH DISCHARGE SUMP & PUMPS
DRAINAGE SUMP BEYOND
BOILER ROOM ENCLOSURE
LEACHING – SIDE ELEVATION
SCALE: 1/8" = 1'-0
GAMMA GAUGE (DENSITY CONTROL)
WET SCRUBBERS
PICK-UP POINTS
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
MORRISON-KNUDSEN COMPANY INC.
LEACH & FILTER AREA EMISSION CONTROL
1114
21-53-0-116
0

Figure 3.3-5



21-53-0-104
BARB WIRE FENCE
CHAIN LINK FENCE
KEROSENE TANK
CO2 TANK
AMMONIA TANK
SOLVENT EXTRACTION AREA
ACID STORAGE TANKS
PREGNANT SOLUTION TANK
RAFFINATE TANK
SUB STATION
STACK No. 5
SAND FILTERS
BOILERS
PRECIPITATION & YELLOW CAKE
STACK No. 3
SODIUM CHLORATE TANKS
STACK No. 2
CLARIFIER
GRINDING AREA
LEACHING AREA
POTABLE WATER TANK
ORE RECEIVING FACILITIES
STACK No. 1
STOCKPILE
GLUE MIX STORAGE
#6 (FUTURE)
FLOCCULANT MIX STORAGE
THICKENER AREA
LIGHTING POLES (TYP)
SIDE YARD
SHOP, WAREHOUSE & CHANGE HOUSE
HEAVY EQUIPMENT PARKING
GRADE ELEVATION 1950'
STACK No. 4
PARKING
ADMINISTRATION BLDG
LUBE AND TIRE REPAIR BUILDING
FUELING ISLAND
GASOLINE
TANK FARM
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
MORRISON-KNUDSEN COMPANY INC.
MILL & MINE FACILITY PLOT PLAN
21-53-0-105

Figure 3.3-6



STREAM NO.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SOLIDS TPH	---	---	---	95.1	95.1	---	---	---	---	---	---	---			
LIQUID TPH	5.6	12.5	424.7	559.0	155.1	403.9	0.6	2.0	402.5	390	390	34.7			
TOTAL FLOW GPM	22.6	50.0	1698.8	2381.0	765.5	1615.5	2.5	8.0	1610.0	1560	1560	138.8			

LEGEND

- INDICATES MAIN PRODUCT FLOW
- INDICATES STAND-BY OR INTERMITTENT FLOW
- INDICATES DRAWING NO. OF LINE CONTINUATION
- INDICATES STREAM NUMBER

#2

REFERENCE DRAWING	NUMBER
RECEIVING, GRINDING, & LEACHING FLOWSHEET	21-53-0-101
CCD AREA PLAN & ELEVATION	21-53-0-109
LEACH & FILTER AREA PLAN & ELEVATION	21-53-0-108
MILL SITE PLAN	21-53-0-104
S-X, STRIPPING PRECIPITATION DRYING & PACKAGING FLOWSHEET	21-53-0-103

NO. | DATE | REVISION | BY | APPR. | APPR.

NOTES

1. THICKENER BYPASS AND RECIRCULATION LINES OMITTED FOR CLARITY

DESCRIPTION | COST ACCOUNT

WORK COVERED BY THIS DRAWING CHARGED TO COST ACCOUNT ABOVE

PROPRIETARY STATEMENT

MINERALS EXPLORATION COMPANY
ANDERSON PROJECT

2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA

APPROVALS | DATE
CLIENT
PROJECT MANAGER 7-18-78

SCALE NONE
DRAWN BY — 31 MAY 78
DESIGNED BY
CHECKED BY J. KUZILIK 7/11/78
APPROVED 7/18/78
APPROVED 7/18/78

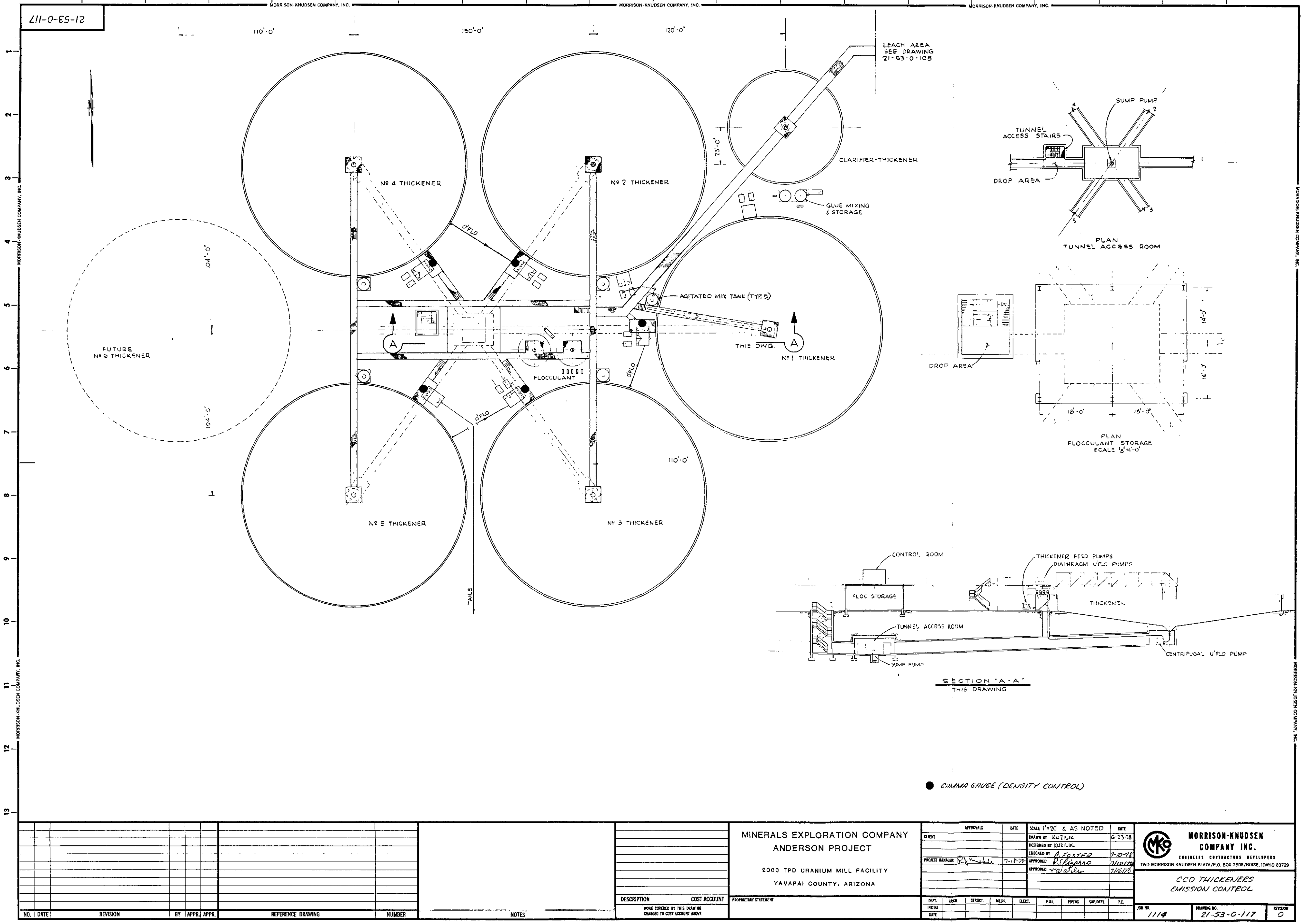
DEPT. | ARCH. | STRUCT. | MECH. | ELECT. | P.&I. | PIPING | SAF. DEPT. | P.E.
INITIAL
DATE

MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729

C.C.D. CLARIFICATION & TAILING FLOW SHEET

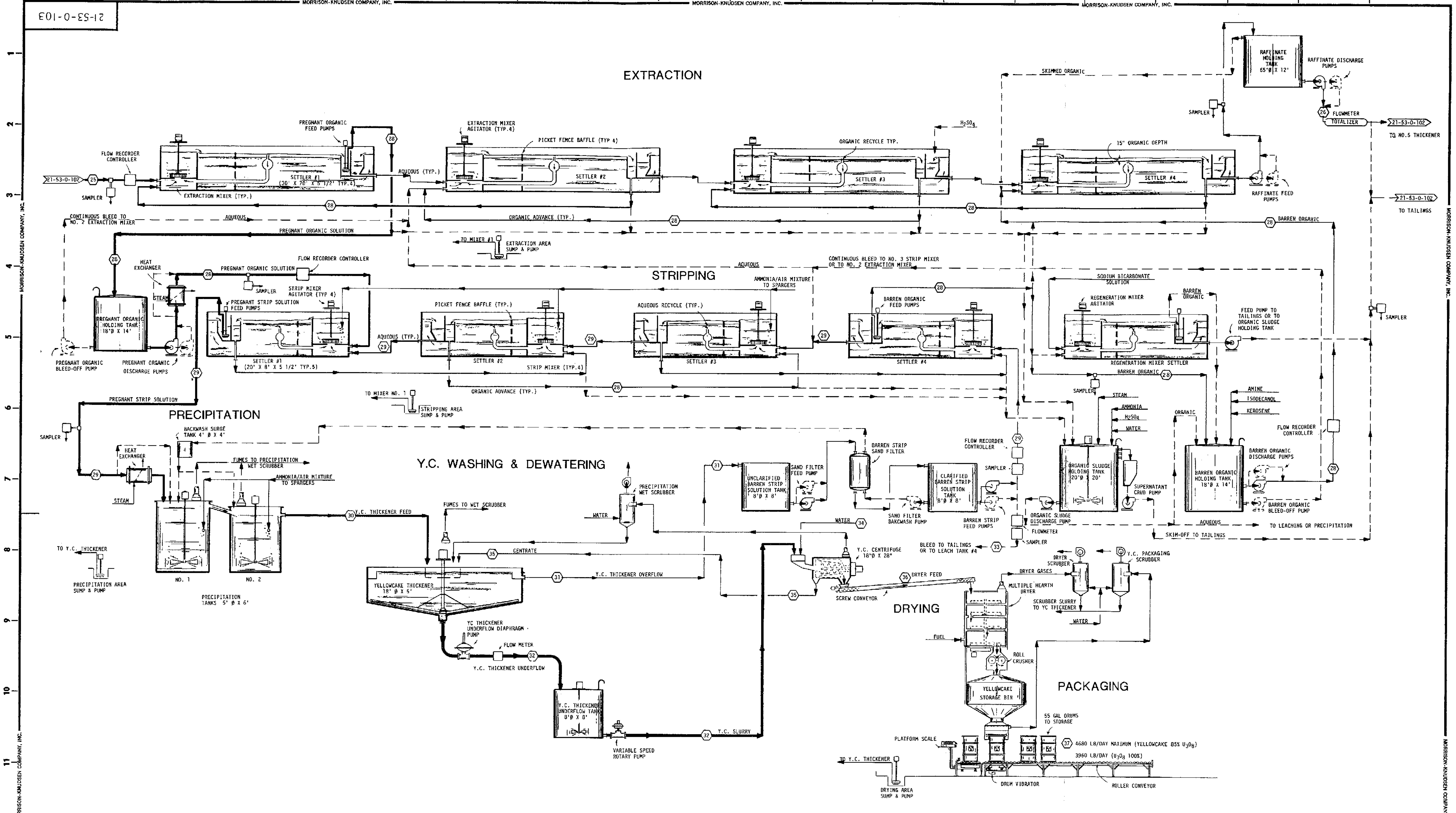
JOB NO. 1114 | DRAWING NO. 21-53-0-102 | REVISION 0

Figure 3.3-7



21-53-0-117
LEACH AREA SEE DRAWING 21-53-0-108
CLARIFIER-THICKENER
GLUE MIXING & STORAGE
№ 4 THICKENER
№ 2 THICKENER
№ 1 THICKENER
№ 3 THICKENER
№ 5 THICKENER
FUTURE № 6 THICKENER
AGITATED MIX TANK (TYP. 5)
THIS DWG.
FLOCCULANT
O'FLO
TAILS
110'-0'
150'-0'
120'-0'
104'-0'
23'-0'
SUMP PUMP
TUNNEL ACCESS STAIRS
DROP AREA
PLAN
TUNNEL ACCESS ROOM
PLAN
FLOCCULANT STORAGE
SCALE 1/8"=1'-0"
14'-0"
18'-0"
CONTROL ROOM
FLOC. STORAGE
THICKENER FEED PUMPS
DIAPHRAGM U'FLO PUMPS
THICKENER
TUNNEL ACCESS ROOM
SUMP PUMP
CENTRIFUGAL U'FLO PUMP
SECTION 'A-A'
THIS DRAWING
● GAMMA GAUGE (DENSITY CONTROL)
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
SCALE 1"=20' & AS NOTED
DRAWN BY KUZILIK 6-23-78
DESIGNED BY KUZILIK
CHECKED BY A. FOSTER
MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729
CCD THICKENERS
EMISSION CONTROL
JOB NO. 1114
DRAWING NO. 21-53-0-117
REVISION 0

Figure 3.3-8



STREAM NO.	25	26		28	29	30	31	32	33	34	35	36	37				
SOLIDS TPH	---	---		---	---	.083	---	.083	---	---	---	.083	.083				
LIQUID TPH	390.0	390		33.0	3.7	4.79	4.62	.17	.92	1.04	1.09	.124	.002				
TOTAL FLOW GPM	1560	1560		165	13.2	17.9	17.25	.65	3.4	4.16	4.16	.5	*				

* 3960 LB/DAY U_3O_8 (100%) EQUIVALENT TO 4659 LB/DAY U_3O_8 (85%)

LEGEND

- INDICATES MAIN PRODUCT FLOW
- INDICATES STAND-BY OR INTERMITTENT FLOW
- INDICATES DRAWING NO. OF LINE CONTINUATION
- INDICATES STREAM NUMBER

#3

REFERENCE DRAWING	NUMBER
SOLVENT EXTRACTION & STRIPPING PLAN & ELEVATION	21-53-0-110
MILL BUILDING PLAN & ELEVATIONS	21-53-0-107
MILL BUILDING PLAN & ELEVATIONS	21-53-0-106
MILL SITE PLAN	21-53-0-104
CCD, CLARIFYING & TAILINGS FLOWSHEET	21-53-0-102

NO. | DATE | REVISION | BY | APPR. | APPR. | NOTES

DESCRIPTION | COST ACCOUNT

MINERALS EXPLORATION COMPANY
ANDERSON PROJECT

2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA

SCALE NONE — DATE 6 JUNE 78

MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729

SOLVENT EXTRACTION, STRIPPING Y.C. PRECIPITATION & PACKAGING FLOW SHEET

JOB NO. 1114 — DRAWING NO. 21-53-0-103 — REVISION 0

Figure 3.3-9

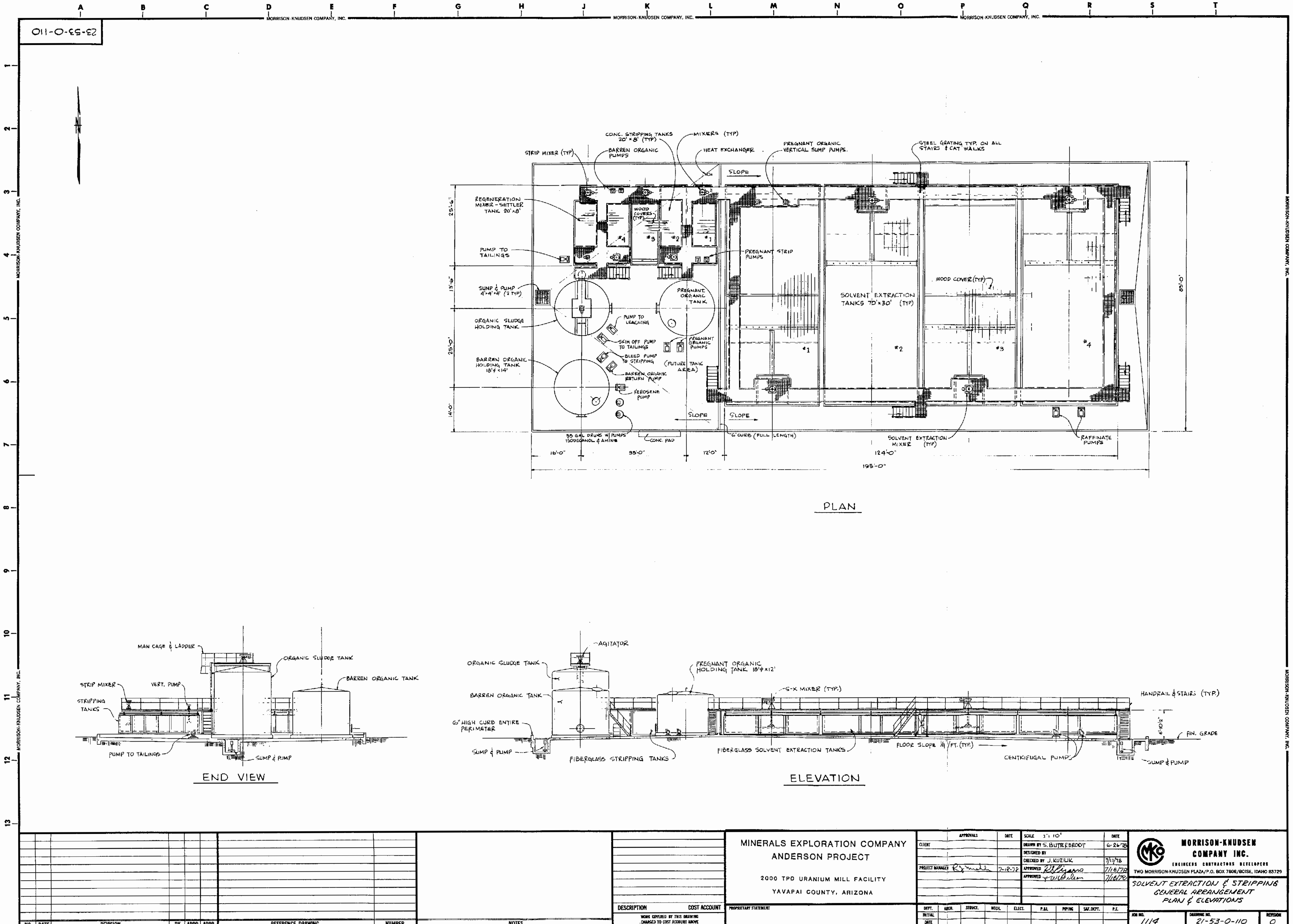

23-53-0-110
MORRISON-KNUDSEN COMPANY, INC.
CONC. STRIPPING TANKS 20' x 8' (TYP)
MIXERS (TYP)
STRIP MIXER (TYP)
BARREN ORGANIC PUMPS
HEAT EXCHANGER
PREGNANT ORGANIC VERTICAL SUMP PUMPS.
STEEL GRATING TYP. ON ALL STAIRS & CAT WALKS
REGENERATION MIXER-SETTLER TANK 20' x 8'
WOOD COVERS (TYP)
PUMP TO TAILINGS
PREGNANT STRIP PUMPS
SUMP & PUMP 4' x 4' x 4' (2 TYP)
PREGNANT ORGANIC TANK
ORGANIC SLUDGE HOLDING TANK
PUMP TO LEACHING
SKIM OFF PUMP TO TAILINGS
PREGNANT ORGANIC PUMPS
BLEED PUMP TO STRIPPING
BARREN ORGANIC HOLDING TANK 18' ϕ x 14'
(FUTURE TANK AREA)
BARREN ORGANIC RETURN PUMP
KEROSENE PUMP
SOLVENT EXTRACTION TANKS 70' x 30' (TYP)
WOOD COVER (TYP)
SLOPE
55 GAL DRUMS W/ PUMPS ISODECANOL & AMINE
CONC. PAD
6" CURB (FULL LENGTH)
SOLVENT EXTRACTION MIXER (TYP)
RAFFINATE PUMPS
16'-0"
35'-0"
12'-0"
124'-0"
195'-0"
85'-0"
PLAN
MAN CAGE & LADDER
ORGANIC SLUDGE TANK
BARREN ORGANIC TANK
STRIP MIXER
VERT. PUMP
STRIPPING TANKS
PUMP TO TAILINGS
SUMP & PUMP
END VIEW
AGITATOR
ORGANIC SLUDGE TANK
PREGNANT ORGANIC HOLDING TANK 18' ϕ x 12'
BARREN ORGANIC TANK
S-X MIXER (TYP.)
HANDRAIL & STAIRS (TYP.)
6" HIGH CURB ENTIRE PERIMETER
FIN. GRADE
SUMP & PUMP
FIBERGLASS STRIPPING TANKS
FIBERGLASS SOLVENT EXTRACTION TANKS
FLOOR SLOPE 1/8"/FT. (TYP.)
CENTRIFUGAL PUMPS
SUMP & PUMP
ELEVATION
NO. | DATE | REVISION | BY | APPR. | APPR.
REFERENCE DRAWING | NUMBER
NOTES
DESCRIPTION | COST ACCOUNT
WORK COVERED BY THIS DRAWING CHARGED TO COST ACCOUNT ABOVE
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
PROPRIETARY STATEMENT
APPROVALS | DATE
CLIENT
PROJECT MANAGER | 7-18-78
SCALE 1" = 10' | DATE
DRAWN BY S. BUTTERBRODT | 6-26-78
DESIGNED BY
CHECKED BY J. KUZILIK | 7/11/78
APPROVED | 7/18/78
APPROVED | 7/18/78
DEPT. | ARCH. | STRUCT. | MECH. | ELECT. | P.&I. | PIPING | SAF.DEPT. | P.E.
INITIAL
DATE
MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729
SOLVENT EXTRACTION & STRIPPING
GENERAL ARRANGEMENT
PLAN & ELEVATIONS
JOB NO. 1114
DRAWING NO. 21-53-0-110
REVISION 0

Figure 3.3-10

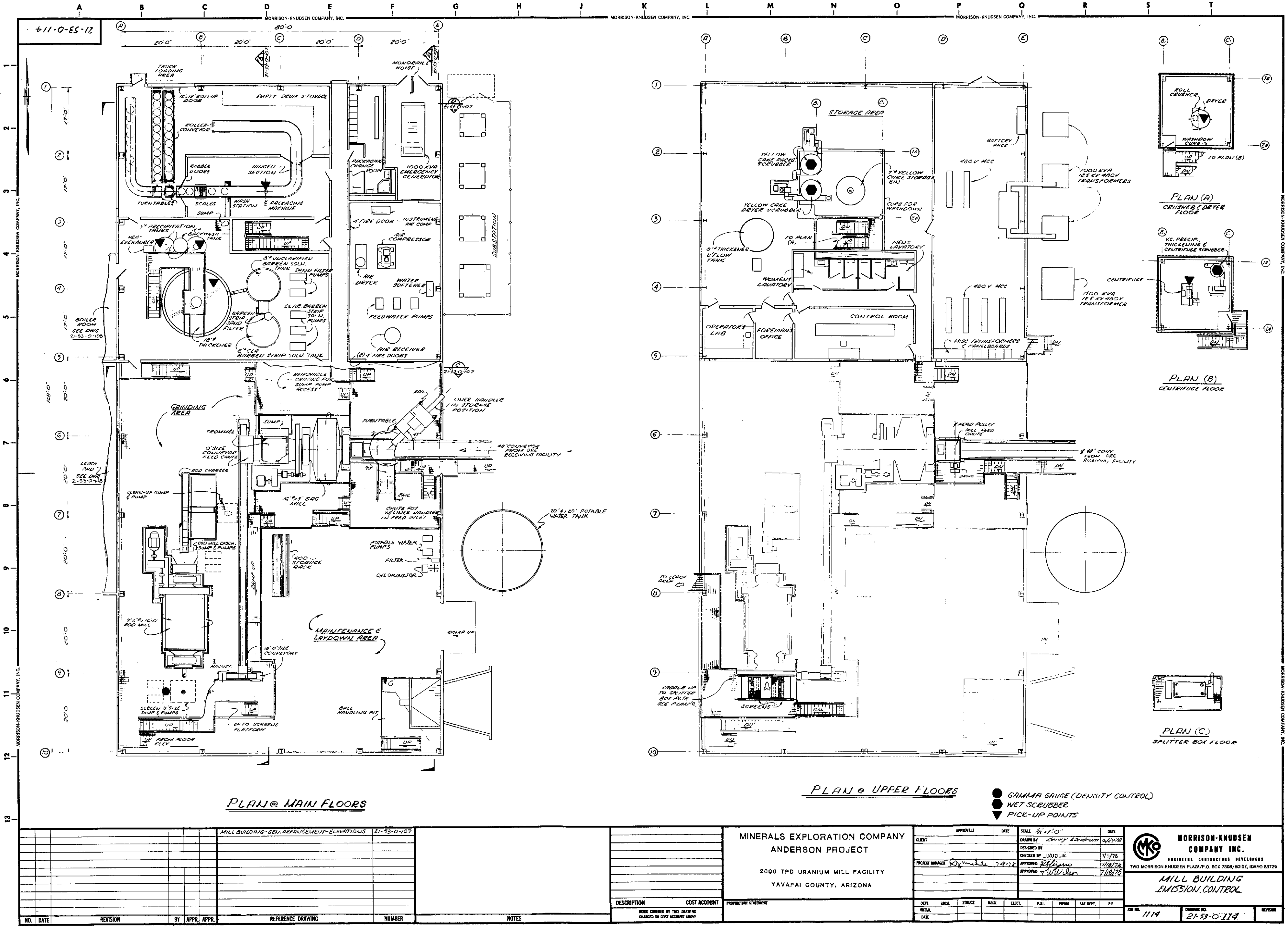
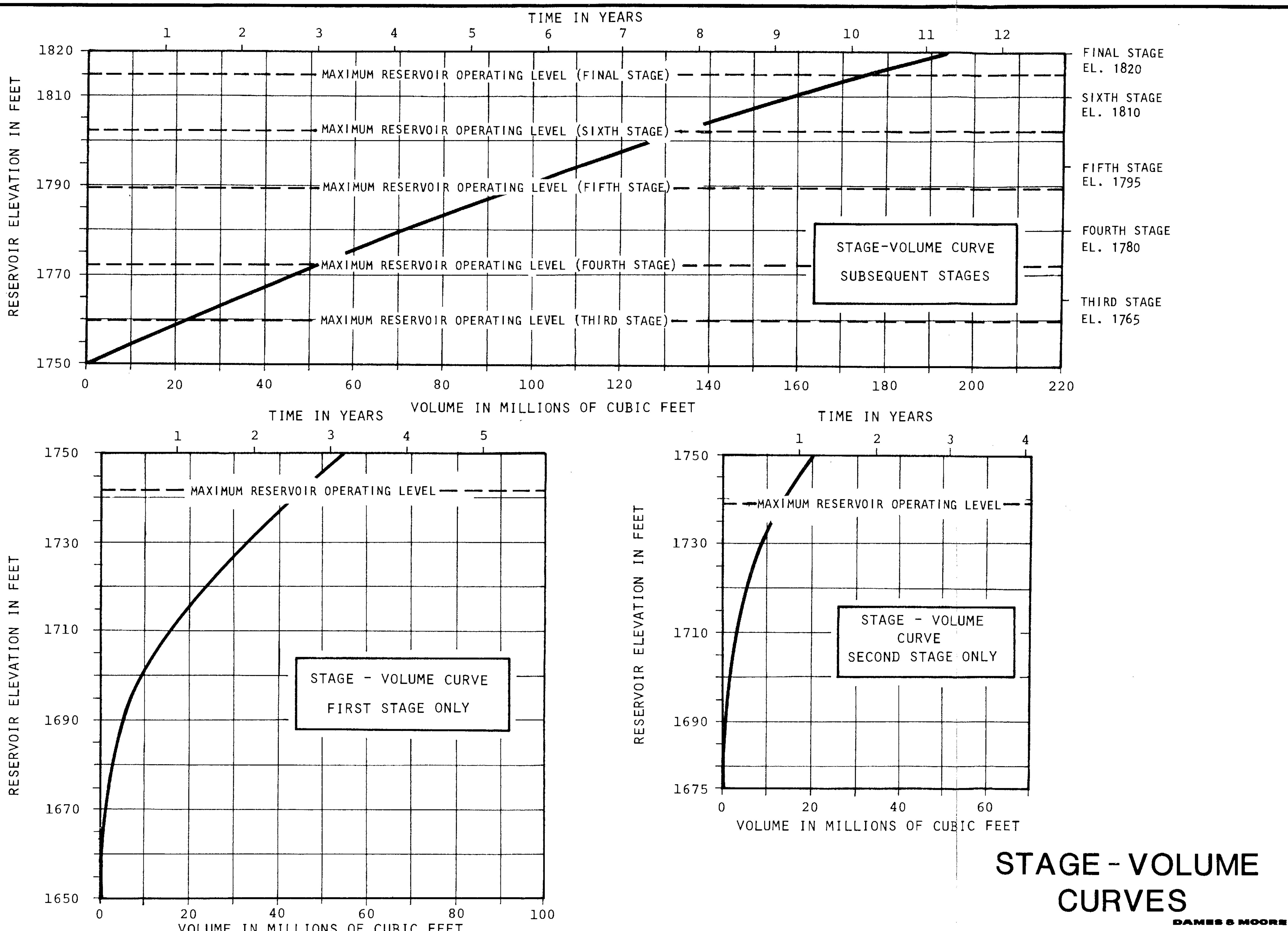

21-53-0-114
PLAN @ MAIN FLOORS
PLAN @ UPPER FLOORS
PLAN (A)
CRUSHER & DRYER FLOOR
PLAN (B)
CENTRIFUGE FLOOR
PLAN (C)
SPLITTER BOX FLOOR
GAMMA GAUGE (DENSITY CONTROL)
WET SCRUBBER
PICK-UP POINTS
TRUCK LOADING AREA
EMPTY DRUM STORAGE
ROLLER CONVEYOR
RUBBER DOORS
HINGED SECTION
TURNTABLES
SCALES
SUMP
WASH STATION
PACKAGING MACHINE
PACKAGING CHANGE ROOM
1000 KVA EMERGENCY GENERATOR
MONORAIL HOIST
SUBSTATION
HEAT EXCHANGER
BACKWASH TANK
CLAR. BARREN STRIP SOLN. PUMPS
SAND FILTER PUMPS
THICKENER
INSTRUMENT AIR COMP
AIR COMPRESSOR
AIR DRYER
WATER SOFTENER
FEEDWATER PUMPS
AIR RECEIVER
BOILER ROOM
GRINDING AREA
TROMMEL
SUMP
ROD CHARGER
CLEAN-UP SUMP & PUMP
TURNTABLE
LINER HANDLER IN STORAGE POSITION
CONVEYOR FROM ORE RECEIVING FACILITY
CHUTE FOR RE/LINER HANDLER IN FEED INLET
POTABLE WATER TANK
POTABLE WATER PUMPS
FILTER
CHLORINATOR
ROD STORAGE RACK
MAINTENANCE & LAYDOWN AREA
RAMP UP
ROD MILL
MAGNET
SCREENS
BALL HANDLING PIT
UP TO SCREENS PLATFORM
STORAGE AREA
YELLOW CAKE PACKER SCRUBBER
YELLOW CAKE DRYER SCRUBBER
YELLOW CAKE STORAGE BIN
CURB FOR WASHDOWN
BATTERY RACK
480 V MCC
1000 KVA 12.5 KV 480 V TRANSFORMERS
MENS LAVATORY
WOMENS LAVATORY
CONTROL ROOM
OPERATORS LAB
FOREMANS OFFICE
MISC TRANSFORMERS & PANELBOARDS
1500 KVA 12.5 KV 480 V TRANSFORMER
HEAD PULLEY
MILL FEED CHUTE
TO LEACH AREA
LADDER UP TO SPLITTER BOX PLTF.
ROLL CRUSHER
DRYER
WASHDOWN CURB
CENTRIFUGE
MILL BUILDING-GEN. ARRANGEMENT-ELEVATIONS 21-53-0-107
NO. DATE REVISION BY APPR. APPR.
REFERENCE DRAWING
NUMBER
NOTES
DESCRIPTION
COST ACCOUNT
PROPRIETARY STATEMENT
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, IDAHO 83729
MILL BUILDING
EMISSION CONTROL
1114
21-53-0-114

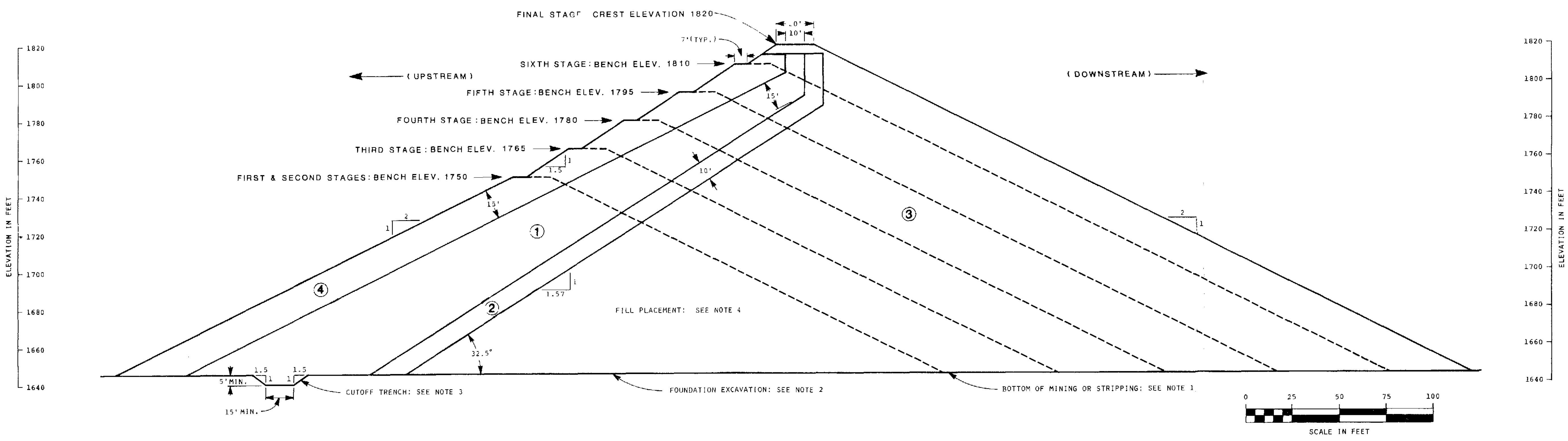
Figure 3.3-11



STAGE - VOLUME CURVES

DAMES & MOORE

Figure 3.4-2



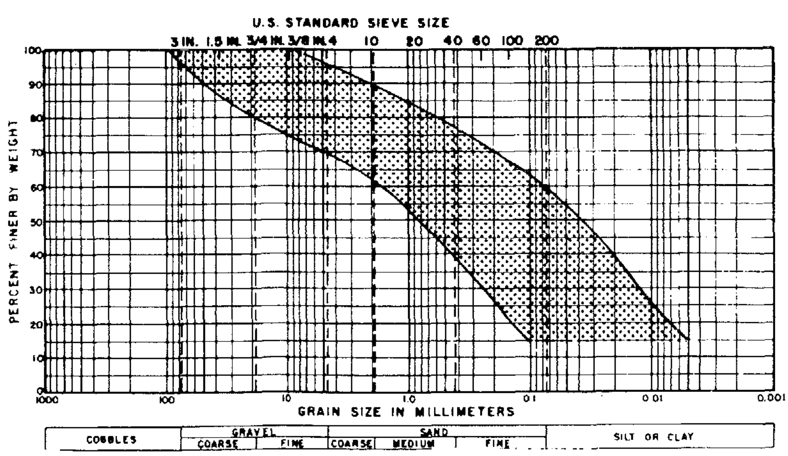
KEY:

① ZONE 1. (CORE) FILL. SHALL CONSIST OF CLAY AND/OR SILTY CLAY MIXTURE CONFORMING TO THE GRADATION SHOWN, AND COMPACTED TO A MINIMUM OF 90 PERCENT OF THE ASTM (D 1557-70) MAXIMUM DRY DENSITY.

② ZONE 2. (TRANSITION ZONE) FILL. SHALL CONSIST OF A WELL GRADED SILTY SAND CONFORMING TO THE GRADATION SHOWN, AND COMPACTED TO A MINIMUM OF 90 PERCENT OF THE ASTM (D 1557-70 MAXIMUM DRY DENSITY. OVER COMPACTION SHOULD BE AVOIDED.

③ ZONE 3. (DOWNSTREAM SHELL) RANDOM FILL. SHALL CONSIST OF A SILTY SAND AND/OR SAND. ROCK FRAGMENTS UP TO SIX INCHES MAY BE INCLUDED PROVIDED THEY ARE DISTRIBUTED IN A SOIL MATRIX SUCH THAT NO OPEN WORK VOIDS EXIST. ZONE 3 SHALL BE COMPACTED TO A MINIMUM OF 90 PERCENT OF ASTM (D 1557-70) MAXIMUM DRY DENSITY.

④ ZONE 4. (UPSTREAM SHELL) RANDOM FILL. SAME MATERIAL CRITERIA AS FOR ZONE 3. ZONE 4 SHALL BE COMPACTED TO A MINIMUM OF 90 PERCENT OF THE ASTM (D 1557-70) MAXIMUM DRY DENSITY.



GRADATION SPECIFICATIONS

FOR ZONE 2 FILL

NOTES:

1 STRIPPING. WHERE THE DAM IS CONSTRUCTED OUTSIDE OF THE OPEN PIT ALL TOPSOIL AND VEGETATION WILL BE REMOVED.

2 FOUNDATION EXCAVATION. FOLLOWING STRIPPING, ALL MATERIALS IN THE DAM FOUNDATION MEETING REQUIREMENTS FOR ZONE 1 FILL SHALL BE EXCAVATED AND STOCKPILED FOR SUBSEQUENT USE AS CORE MATERIAL. ANY REMAINING FOUNDATION MATERIALS WHICH ARE EXCESSIVELY LOOSE, SOFT, OR DISTURBED SHOULD BE REMOVED PRIOR TO PLACEMENT OF FILL.

3 CUTOFF TRENCH. THE CUTOFF TRENCH SHALL BE EXCAVATED DOWN TO A MINIMUM OF FIVE FEET. SIDESLOPES OF 1.5:1 SHOULD BE MAINTAINED. MATERIALS SHOULD BE SEGREGATED DURING EXCAVATION ACCORDING TO THEIR SUITABILITY FOR USE IN THE VARIOUS FILL ZONES.

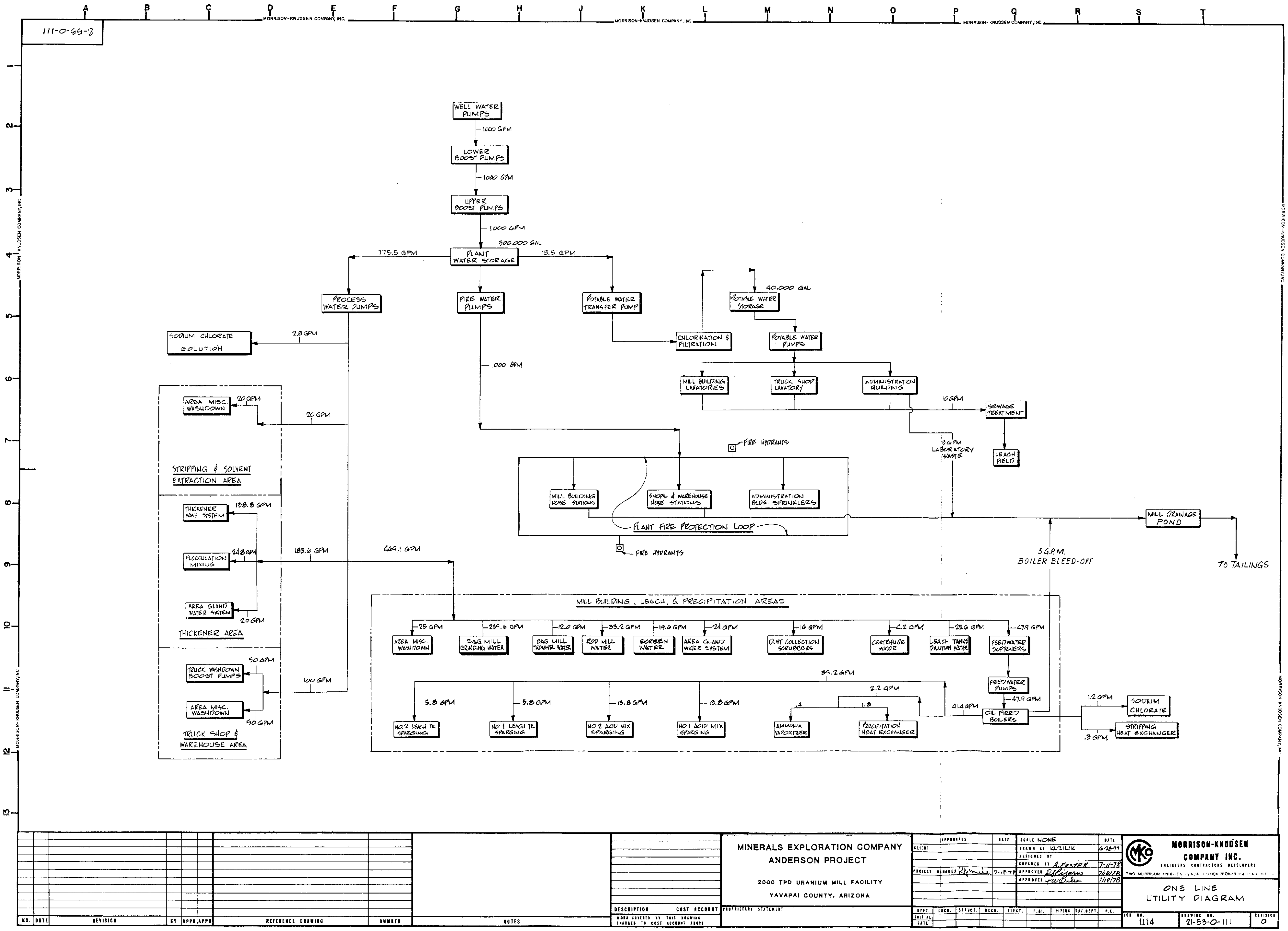
4 FILL PLACEMENT. IF SURFACE OF FILL BECOMES DRY OR HARD, SCARIFY PRIOR TO PLACING NEXT LIFT OF FILL.

5 THE FINAL STAGE WILL BE CONSTRUCTED AT THE SAME TIME AS STAGE 6.

TYPICAL DAM SECTION

DAMES & MOORE

Figure 3.4-5



111-0-65-12
WELL WATER PUMPS
1000 GPM
LOWER BOOST PUMPS
1000 GPM
UPPER BOOST PUMPS
1000 GPM
500,000 GAL
PLANT WATER STORAGE
775.5 GPM
18.5 GPM
PROCESS WATER PUMPS
FIRE WATER PUMPS
POTABLE WATER TRANSFER PUMP
40,000 GAL
POTABLE WATER STORAGE
CHLORINATION & FILTRATION
POTABLE WATER PUMPS
MILL BUILDING LAVATORIES
TRUCK SHOP LAVATORY
ADMINISTRATION BUILDING
10 GPM
SEWAGE TREATMENT
LEACH FIELD
3 GPM LABORATORY WASTE
SODIUM CHLORATE SOLUTION
2.8 GPM
1000 GPM
AREA MISC. WASHDOWN
20 GPM
20 GPM
STRIPPING & SOLVENT EXTRACTION AREA
FIRE HYDRANTS
MILL BUILDING HOSE STATIONS
SHOPS & WAREHOUSE HOSE STATIONS
ADMINISTRATION BLDG SPRINKLERS
PLANT FIRE PROTECTION LOOP
FIRE HYDRANTS
MILL DRAINAGE POND
TO TAILINGS
5 G.P.M. BOILER BLEED-OFF
THICKENER WASH SYSTEM
138.8 GPM
FLOCCULATION MIXING
24.8 GPM
183.6 GPM
469.1 GPM
AREA GLAND WATER SYSTEM
20 GPM
THICKENER AREA
MILL BUILDING, LEACH, & PRECIPITATION AREAS
23 GPM
259.6 GPM
12.0 GPM
35.2 GPM
19.6 GPM
24 GPM
16 GPM
4.2 GPM
25.6 GPM
47.9 GPM
AREA MISC. WASHDOWN
SAG MILL GRINDING WATER
SAG MILL TROMMEL WATER
ROD MILL WATER
SCREEN WATER
AREA GLAND WATER SYSTEM
DUST COLLECTION SCRUBBERS
CENTRIFUGE WATER
LEACH TANKS DILUTION WATER
FEEDWATER SOFTENERS
FEEDWATER PUMPS
47.9 GPM
OIL FIRED BOILERS
41.4 GPM
1.2 GPM
SODIUM CHLORATE
.3 GPM
STRIPPING HEAT EXCHANGER
34.2 GPM
2.2 GPM
.4
1.8
5.8 GPM
5.8 GPM
13.8 GPM
13.8 GPM
NO. 2 LEACH TK. SPARGING
NO. 1 LEACH TK. SPARGING
NO. 2 ACID MIX SPARGING
NO. 1 ACID MIX SPARGING
AMMONIA VAPORIZER
PRECIPITATION HEAT EXCHANGER
TRUCK WASHDOWN BOOST PUMPS
50 GPM
100 GPM
AREA MISC. WASHDOWN
50 GPM
TRUCK SHOP & WAREHOUSE AREA
MORRISON-KNUDSEN COMPANY, INC.
NO. | DATE | REVISION | BY | APPR | APPR | REFERENCE DRAWING | NUMBER | NOTES
DESCRIPTION | COST ACCOUNT
WORK COVERED BY THIS DRAWING CHARGED TO COST ACCOUNT ABOVE
PROPRIETARY STATEMENT
MINERALS EXPLORATION COMPANY
ANDERSON PROJECT
2000 TPD URANIUM MILL FACILITY
YAVAPAI COUNTY, ARIZONA
APPROVALS | DATE
CLIENT
PROJECT MANAGER 7-18-78
SCALE NONE
DRAWN BY KUZILIK 6-28-77
DESIGNED BY
CHECKED BY A. FOSTER 7-11-78
APPROVED 7/18/78
APPROVED 7/18/78
DEPT. | ARCH. | STRUCT. | MECH. | ELECT. | P.&I. | PIPING | SAF.DEPT. | P.E.
INITIAL
DATE
MORRISON-KNUDSEN COMPANY INC.
ENGINEERS CONTRACTORS DEVELOPERS
ONE LINE UTILITY DIAGRAM
JOB NO. 1114
DRAWING NO. 21-53-O-111
REVISION 0

Figure 3.5-1

4.0

ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

4.1 LAND USE

Implementation of the proposed project will convert a total of approximately 1000 acres of ephemeral grazing land to industrial uses. Since construction and operation of the project are closely phased (Figure 3.1-1) and the types of land use impacts resulting from both are essentially the same, construction and operational impacts will not be differentiated in this subsection.

The mill complex (mill buildings, ore stockpiles, administrative building, parking lots, etc.) will cover approximately 42 acres (Table 4.1-1). This complex will remain as a permanent feature of the landscape during the life of the project. After project termination, the mill complex will be decontaminated, removed, and the land will be revegetated so that it is returned to its present multiple uses.

As discussed in Section 3.0, tailings from the proposed mill will be discharged to an impoundment located in exhausted pit areas. At its maximum size, toward the end of the project, the impoundment will cover approximately 81 acres (Table 4.1-1). After project termination the impoundment will be reclaimed.

TABLE 4.1-1. ANDERSON PROJECT LAND REQUIREMENTS[a]

Facility	Acreage Required
Mill Complex and Ancillary Facililties Sites	42
Total Tailings Area[b]	81
Mine Area[c]	392
Dump Area	378
Access Road[d]	200

[a]Does not include the 160 acres required for housing and commerce in Wickenburg (based upon an estimated 13.44 acres/100 project-related persons residing in single family homes, 8.6 acres/100 persons in multi-family residences, 3.34 acres/100 persons in mobile homes, plus an additional 15 percent for public purposes, 15 percent for new streets and public rights-of-way, and 10 percent for new commercial and industrial use).

[b]Located in exhausted mine area.

[c]Includes haul roads.

[d]Includes entire right-of-way. Actual roadbed will have a paved surface 26 feet wide. This will cover a total of approximately 45 acres.

Mining will be performed in a sequential manner and will directly disturb a total of 392 acres of land over the life of the proposed project. An additional 378 acres will be disturbed by the creation of overburden waste dumps to the east and west of the mine area. Since mining will be progressive, it is expected that about 65 acres will be disturbed in any given year. Areas disturbed by mining activities will be reclaimed to support their present multiple uses.

The duration of the land use impacts resulting from project construction and operation are dependent on the length of time required for vegetation in the region to become reestablished on disturbed areas. This process of reestablishment is discussed in Section 4.5.

Access to the Anderson property will be by a newly constructed, 26-foot wide, asphalt-surfaced county road beginning at U.S. Highway 93 (Figure 3.5-2). This road will permanently preempt other uses on approximately 45 acres.

The proposed project will result in secondary land use impacts related to project-induced residential development. The extent of these secondary impacts will depend on housing mix, intensity of develoment, and ability of the communities involved to manage growth. Based on general land requirements for housing and commerce that have been recently developed by Hutton (1977) for Wickenburg, it is estimated that the amount of land required for project-related urbanization should not exceed 160 acres. This amounts to approximately 13 percent of all unoccupied vacant land in Wickenburg.

4.2 DEMOGRAPHIC AND SOCIOECONOMIC CONSIDERATIONS

Socioeconomic and demographic impacts resulting from the proposed project will center primarily in Wickenburg, although the smaller communities of Congress and Yarnell (Figure 2.1-1) are also likely to be affected by the project. The methodologies used to determine the potential effects of project implementation are based largely on the Economic-Demographic Projection Model and the Wickenburg Arizona Economic Base Analysis constructed by the Arizona Office of Economic Planning and Development (OEPAD) (1977). The OEPAD studies examine basic employment and trace through the resulting changes in secondary and/or service related employment. Multipliers developed for the following discussion were estimated from analysis of the OEPAD studies and from analogies with other communities in the west experiencing energy-related growth.

Construction and operation of the Anderson uranium project will create basic employment which, in turn, can be expected to generate some secondary local service employment. The combination of basic and service employees plus their families leads to a population forecast which is a key variable in the evaluation of project-related socioeconomic and demographic impacts. For this evaluation, project-related population growth was subjectively allocated to the communities in the study area on the basis of distance between the Anderson property and the communities in the area, current population, physical barriers, community attitudes toward growth, quality of local services, cost of living, and availability of housing. The proportions allocated to each community were reviewed by Ms. Anna L. Hernandez of OEPAD (Community Affairs), Professor Leigh Gibson of the University of Arizona, local public officials, and industry representatives. There was general concurrence that the estimates correspond to those used for local planning and that they are reasonable.

EMPLOYMENT

Project construction will begin in the first quarter of 1979 and continue through the third quarter of 1980. The construction labor force will reach a peak of 130 workers in the first quarter of 1980 and remain at that level for about 6 months (Table 4.2-1). Beginning in the second quarter of 1980, construction-related employment will gradually decrease; terminating in the fourth quarter of 1980 when mill operations begin. Average employment over the 21-month construction period is expected to be approximately 98 people.

Approximately 204 permanent employees will be hired for project operations during 1979, primarily in the second half of the year. Operational employment will increase to about 340 during the first half of 1980 and reach a peak of 347 in the fourth quarter of that year. Employment will remain at this level until late 1985 when it will decrease to 315. Employment will again decrease in 1989 to 307. It will remain at this level until project termination (currently planned for 1990).

The amount of secondary employment generated by project construction and operation will depend on the communities' expectations of permanent

Table 4.2-1. ANDERSON PROJECT EMPLOYMENT PROFILE, 1979-1990

Time Period	Employment			
	Construction	Operation	Local Service	Total
First Quarter 1979	55	0	0[a]	55
Second Quarter 1979	85	0	42	127
Third Quarter 1979	90	0	45	135
Fourth Quarter 1979	115	204	159	478
First Quarter 1980	130	339	422	891
Second Quarter 1980	130	339	422	891
Third Quarter 1980	80	339	377	796
Fourth Quarter 1980	0	339	305	644
1981	0	347	437	784
1982	0	347	437	784
1983	0	347	437	784
1984	0	347	437	784
1985	0	347	437	784
1986	0	315	396	711
1987	0	315	396	711
1988	0	315	396	711
1989	0	307	387	694
1990	0	307	387	694

[a]Assumes time lag in build up of local service employment.

growth, competition between local communities and Phoenix, aggressiveness of local businessmen to expand present services, and the attractiveness of Wickenburg, Congress, and Yarnell to outside developers. It is assumed that the basic employment created by the proposed project will have a secondary employment multiplier of 0.5 in 1979, increasing to 0.9 during most of 1980, and reaching a peak of 1.26 in late 1980 when mill operations begin. These multipliers acknowledge the time lag between basic employment and the development of local service industries common in communities experiencing energy-related growth and should more closely reflect actual secondary employment growth patterns. Consequently, the creation of 347 new jobs in basic industry as the result of project implementation is estimated to induce 437 secondary jobs in local service industries.

POPULATION

Total estimated population growth resulting from construction and operation of the proposed project is provided in Table 4.2-2. It was assumed that 90 percent of the construction and operations work force would relocate to the project region and the remaining 10 percent of the work force would be hired locally. This assumption was based on the availability of local labor, distance to Phoenix, transportation facilities, and the skills required for employment. It is expected that a portion of the locally-hired employees will come from that segment of the community currently considered unemployed. The remainder of the locally-hired employees will consist of people not presently in the job market, people who are upgrading their jobs, or marginally employed

Table 4.2-2. ANDERSON PROJECT POPULATION PROJECTIONS, 1979-1990

Population Source	Time Period: First Quarter 1979	Second Quarter 1979	Third Quarter 1979	Fourth Quarter 1979	First Quarter 1980	Second Quarter 1980	Third Quarter 1980	Fourth Quarter 1980[a]	1981-1985	1986-1988	1989 1990
Family Population											
Construction	92	142	151	193	218	218	134	0	0	0	0
Operations	0	0	0	484	804	804	804	804	823	747	728
Local Service	0	52	56	197	523	523	468	378	542	491	480
Subtotal	92	194	207	874	1545	1545	1406	1182	1365	1238	1208
Single Population											
Construction	20	31	33	41	47	47	29	0	0	0	0
Operations	0	0	0	28	46	46	46	46	47	43	42
Local Service	0	4	5	16	42	42	38	31	44	40	39
Subtotal	20	35	38	85	135	135	113	77	91	83	81
Total Population	112	229	245	959	1680	1680	1519	1259	1456	1321	1289

people. It should be noted that the estimated percentages are not based in any way on the hiring practices of MINERALS.

Based on local household characteristics and previous studies of communities experiencing growth due to energy-related development (Denver Research Insitute, 1976 and U.S. Department of Housing and Urban Development, 1976), it is anticipated that 60 percent of the in-migrant construction workers hired for the Anderson project will be the heads of household. These households are estimated to consist of an average of 3.1 people with 0.8 school age children. The remaining 40 percent of the in-migrant construction employees will be single or will not bring their families to the region. Approximately 85 percent of the operational employees relocating to the area will be the heads of household; 15 percent will be single. Forty percent of the local service employees hired as a result of the project are expected to be the heads of household, while 10 percent will be single. The remaining jobs in project-induced services will be filled by local people (those currently unemployed or marginally employed, people not presently in the labor force, etc.) and members of the permanent households of project employees (primarily spouses). The households of operations employees and secondary service-related employees are estimated to consist of 3.1 people with 0.8 school age children.

Because Wickenburg is the largest community and principal trade center in the project region, it is assumed that approximately 75 percent of the project-related population growth will occur there (Table 4.2-3).

Table 4.2-3. ANDERSON PROJECT POPULATION DISTRIBUTION, 1979-1990

	Wickenburg Area				Outside Wickenburg Area[b]
Time Period	Without[a] Project	With Project	Project Induced Population Growth	Percent of Total Population	Project Induced Population Growth
First Quarter 1979	3340	3424	+84	2.5	+28
Second Quarter 1979	3380	3352	+172	5.1	+57
Third Quarter 1979	3420	3604	+184	5.4	+61
Fourth Quarter 1979	3460	4179	+719	20.8	+240
First Quarter 1980	3500	4760	+1260	36.0	+420
Second Quarter 1980	3550	4810	+1260	35.5	+420
Third Quarter 1980	3600	4739	+1139	31.6	+380
Fourth Quarter 1980	3650	4594	+944	25.9	+315
1981	3700	4792	+1092	29.5	+364
1982	3900	4992	+1092	28.0	+364
1983	4100	5192	+1092	26.6	+364
1984	4300	5392	+1092	25.4	+364
1985	4500	5592	+1092	24.3	+364
1986	4720	5711	+991	21.0	+330
1987	4940	5931	+991	20.1	+330
1988	5160	6151	+991	19.2	+330
1989	5380	6347	+967	18.0	+322
1990	5600	6567	+967	17.3	+322

[a]Source: Maricopa Association of Governments, 1978.
[b]Includes rural portion of southwestern Yavapai County and northwestern Maricopa County. Population projections for Congress and Yarnell are not available; however, it is expected that a large portion of these people will settle in the two communities.

The remaining 25 percent of this population growth is expected to occur in the small communities, principally Yarnell and Congress, and rural areas of southwestern Yavapai and northwestern Maricopa counties. By the first quarter of 1980, project-induced growth may increase the population of Wickenburg by 1260 people which represents 75 percent of the total project-induced growth. This represents a 36 percent increase over the projected population growth for that community without the project. Project implementation may increase the populations of Congress, Yarnell, and rural portions of Yavapai and Maricopa counties by a maximum of about 420 people.

Construction of the proposed mine and mill is expected to encourage an influx of relatively young families (Table 4.2-4) with either very few or no children (Mountain West Research, 1976). This will alter the age composition of the Wickenburg area. The 20 to 64 year-old age group (currently 44.5 percent of the Wickenburg population) may increase by about 2 percent during the construction period, while the 62 and over age group (currently 34 percent of the population) may decrease by almost 6 percent.

Families of operations employees are expected to be somewhat older than those of construction workers. The influx of these employees may also alter the age composition in the Wickenburg area in a manner similar to that described above.

Table 4.2-4. COMPARISON OF AGE PROFILES, WICKENBURG AND PROJECT CONSTRUCTION RELATED MIGRANTS (percent of total)

Age Group	Wickenburg	Project Construction Related Migrants
Percent under 19 years	21.2	41.2
Percent 20-64 years	44.5	58.2
Percent 65 years and over	34.3	0.6

Source: Arizona Department of Economic Security, 1976 and Mountain West Research, 1976.

SCHOOL ENROLLMENT

As discussed above, families relocating to the study region as a result of project implementation are assumed to have an average of 0.8 school-age children. It is expected that most of these children will be enrolled in Wickenburg School District 9. For this assessment, the distribution of students between elementary and secondary enrollment was based on state-wide averages held constant over time.

Project-related school enrollment is expected to begin in early 1979 with roughly 24 students. By the first quarter of 1980, enrollment will reach a peak of 398 pupils. Enrollment will gradually decline as construction employment decreases, reaching a constant level of about 352 students in 1981 (Table 4.2-5). Enrollment will again decline in 1986 and reach a low of about 312 students in 1989. Project related enrollment will remain at this level until project termination. The total enrollment for the

Table 4.2-5. ESTIMATES OF ANDERSON PROJECT-RELATED ENROLLMENT, WICKENBURG SCHOOL DISTRICT 9[a]

School	Grades	Students										
		1979 (quarters)				1980 (quarters)				1981–1985	1986–1988	1989–1990
		1	2	3	4	1	2	3	4			
Maclennan Elementary School	K–5	11	23	24	102	179	179	163	137	158	144	140
Garcia Elementary School	6–8	6	12	13	54	96	96	87	73	85	77	75
Wickenburg High School	9–12	7	15	16	70	123	123	113	95	109	100	97
Change		+24	+26	+3	+173	+172	0	−35	−58	+47	−31	−9

[a]Assumes 45 percent of total students will be enrolled in grades K-5, 24 percent in grades 6-8, and 31 percent in grades 9-12.

Wickenburg School District is estimated to increase 37 percent by 1980. Approximately 93 percent of this growth will be related to the Anderson project (Table 4.2-6).

Since the proposed mine and mill are located outside of the boundaries of School District 9, the district will not receive property tax revenues directly from the project. It is probable that the district will have less new assessed valuation per student after project implementation than it has now. School District 17 (Congress) will receive all of the tax revenues generated by the project while it is not expected to receive a large portion of the project-related educational costs. It should be noted that the costs incurred by School District 9 as a result of an increase in students from Congress, Yarnell, and rural areas of Yavapai County will be offset by the tuition payed by School District 17 (refer to Section 2.2).

HOUSING

Table 4.2-7 provides an estimate of the housing requirements that may result from project-induced population growth. These estimates are based on employment projections, work force characteristics, housing preferences, housing availability, and research conducted by Mountain West Research (1976). It is estimated that 53 percent of the in-migrant construction workers will reside in mobile homes, 17 percent will live in single family units, and 30 percent will live in motels, apartments, and town houses. It is estimated that 54 percent of the in-migrant operations employees

Table 4.2-6. ENROLLMENT PROJECTIONS FOR WICKENBURG SCHOOL DISTRICT 9 WITH AND WITHOUT THE ANDERSON PROJECT, 1979-1990

	School					
	Maclennan Elementary (K-5)		Garcia Elementary (6-8)		Wickenburg High (9-12)	
Time Period (Fall)	Without Project	With Project	Without Project	With Project	Without Project	With Project
1979	368	392	237	250	455	471
1980	377	540	247	334	463	576
1985	433	591	303	388	513	622
1990	495	635	365	440	566	663
Student Capacity	400		270		540	

Table 4.2-7. ESTIMATE OF PROJECT-RELATED HOUSING REQUIREMENTS

Type of Unit	Number of Units										
	1979				1980				1981–1985	1986–1988	198 1990
	Quarters										
	1	2	3	4	1	2	3	4			
Wickenburg Area											
Single Family	5	14	16	106	194	194	183	164	186	168	165
Multiple Family	10	20	21	51	96	96	78	56	71	65	63
Mobile Homes	17	30	32	98	155	155	137	105	119	107	104
Subtotal	32	64	69	255	455	455	398	325	376	340	332
Remainder of Study Region											
Single Family	2	5	5	35	65	65	61	55	62	56	55
Multiple Family	3	6	6	17	32	32	26	19	24	21	21
Mobile Homes	6	10	10	32	52	52	45	35	39	36	35
Subtotal	11	21	21	84	149	149	132	109	125	113	111
Total	43	85	90	339	594	594	530	434	501	453	443
Change	+43	+42	+5	+249	+255	0	−63	−96	+67	−48	−10

and their families will live in single family units, 36 percent will reside in mobile homes, and the remaining 10 percent will live in apartments or townhouses. It is estimated that 43 percent of the people moving into the region to fill project-induced secondary jobs will live in single family units and 25 percent will live in apartments or townhouses. The remaining 32 percent will live in mobile homes. It was assumed that an average of 1.5 single employees would live in a single housing unit.

Demand for housing by project-related employees will begin in early 1979. By the first quarter of 1980, approximately 594 units, including about 259 single family houses, will be needed to meet demands of project-induced population growth. As discussed in Section 2.2, housing in the project area is essentially at capacity. While sizeable additions to the housing stock are currently in various stages of planning, there may be a shortage of units during the construction phase of the project and at the beginning of operations.

INCOME AND RETAIL SALES

Total project-related gross personal income is expected to increase from approximately 2.79 million dollars in 1979 to about 9.64 million dollars in 1980, and approach 95 million dollars over the life of the project (Table 4.2-8).*

*Personal income estimates are based on 1976 state average wage levels scaled upward annually.

Table 4.2-8. ESTIMATES OF PROJECT-RELATED NET PERSONAL INCOME (MILLIONS), 1976 DOLLARS

	Year-end				
Net Personal Income[a]	1979	1980	1981	1986	1989
Construction[b]	1.54	1.52	-	-	-
Operation[c]	0.71	4.75	4.86	4.41	4.30
Local Service[d]	0.54	3.37	3.86	3.50	3.42
Total	2.79	9.64	8.72	7.91	7.72

[a]Estimated to be 65 percent of gross income for construction workers and 70 percent of gross income for operational and local service workers.

[b]Based on the 1976 Arizona average weekly construction worker's earnings of $420, escalated 8 percent annually to 1979 ($529).

[c]Based on an average 1979 annual wage of $20,000.

[d]Based on the 1975 Arizona average annual wage of $9,270, escalated 8 percent annually to 1979 ($12,612).

Growth of retail facilities is generally a function of potential retail sales, which in turn, is dependent on personal income. The supply of retail facilities in the study region will most likely lag behind demand, particularly during the 21-month construction period when demand would probably be viewed as temporary.

Table 4.2-9 provides an estimate of total retail sales resulting from project-induced population growth. It is assumed that the retail establishments in the Wickenburg area will receive only about half of the total expenditures during the construction period. Due to its size and proximity, Phoenix is assumed to receive the rest of the retail sales business

Table 4.2-9. ESTIMATES OF PROJECT-RELATED RETAIL TRADE DEMAND (MILLIONS)[a]

Year end	Wickenburg	Outside Wickenburg[b]
1979	$0.49	$0.49
1980	1.77	1.63
1981	1.80	1.25
1986	1.63	1.13
1989	1.59	1.11

[a]Estimated to be 35 percent of net personal income.

[b]Primarily Phoenix.

during this period. When project operations begin and the supply of retail facilities begins to reach demand, a larger percent of retail trade expenditures will go to the Wickenburg area.

TAXES

The proposed project will generate considerable tax revenues to the state and local governments. State income tax will amount to approximately 10.5 percent of the corporate profit on the proposed project. MINERALS will pay a state ad valorem property tax of $6.797/$100 assessed valuation. A large portion of the ad valorem tax revenues will be redistributed to Yavapai County, the Yavapai County Junior College, and Congress School District 17. Part of the funds collected by the Congress School District will be distributed to the Wickenburg schools in the form of tuition payments. MINERALS will also pay a state sales tax of 2.5 percent on the gross income derived from the mined product and a state sales tax of 4 percent on such items as fuel and maintenance and office supplies purchased in Arizona. If these supplies are purchased in Wickenburg, Phoenix, or most other incorporated cities in the state, MINERALS will pay one percent city sales tax as well as the state tax.

In addition to direct taxes on facilities and goods produced, the project will generate employee-related tax revenues. An unemployment security tax equaling 27 percent of the gross wages of the first $6000/worker will be payed to the state each year for the first two years of operation. After this time, the unemployment security tax will be dependent on the employment turnover ratio of the project. MINERALS will also contribute to the state workman's compensation fund. Project employees, as well as project-induced secondary employees, will pay state ad valorem property tax, state income tax, a state sales tax of four percent on most goods other than food, and a sales tax of one percent on purchases in incorporated cities.

In total, it is estimated that the proposed project, including direct employees, could result in $4.5 million in state and local taxes each year. This estimate does not include tax revenues generated by the secondary employment the project will create.

PUBLIC FACILITIES AND SERVICES

Projected public facility requirements for the Wickenburg area with and without the proposed project are provided in Table 4.2-10. These projections are based on engineering standards developed for each facility applied to population projections, project-related employment patterns, and expected project-induced population growth. For the most part, state and national standards were used to more adequately reflect the long range needs for community services. However, local standards were used when they were more stringent than the state or national averages.

Many of the public facilities in the Wickenburg area are either presently adequate or are now being expanded to sufficient capacity to serve a much larger population than is projected for the area. Nominal increases in health care, law enforcement, and fire protection will be needed at the start of project construction. Wickenburg School District 9 will also need additional teachers at this time (Table 4.2-10).

Table 4.2-10. ESTIMATE OF WICKENBURG AREA PUBLIC FACILITY AND SERVICE REQUIREMENTS, 1979-1990

Public Services Facilities	Year											
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1889	1990
Water supply (Total mgd)[a]												
Without Project	.8	.9	.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.4
With Project	.9	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.6	1.6
Water Treatment (Total mgd)[b]												
Without Project	2.0	2.3	2.3	2.5	2.5	2.8	2.8	3.0	3.0	3.3	3.5	3.5
With Project	2.0	3.0	3.0	3.3	3.3	3.5	3.5	3.5	3.8	3.8	4.0	4.0
Sewer Treatment (total mgd)[c]												
Without Project	.3	.4	.4	.4	.4	.4	.5	.5	.5	.5	.5	.6
With Project	.3	.5	.5	.5	.5	.5	.6	.6	.6	.6	.6	.7
Fire protection (total no. of vehicles)[d]												
Without Project	3.4	3.6	3.7	3.9	4.1	4.3	4.5	4.7	4.9	5.2	5.4	5.6
With Project	3.6	4.7	4.8	5.0	5.2	5.4	5.6	5.7	5.9	6.2	6.3	6.6
Law Enforcement (total no. of officers)[e]												
Without Project	8.3	8.8	9.3	9.8	10.3	10.8	11.3	11.8	12.3	12.9	13.5	14.0
With Project	8.5	12.0	11.8	12.5	13.0	13.5	14.0	14.3	14.8	15.4	15.9	16.4
Law Enforcement (total no. of vehicles)[f]												
Without Project	4.5	4.7	4.9	5.2	5.5	5.7	6.0	6.3	6.6	6.9	7.2	7.5
With Project	4.6	6.4	6.4	6.7	6.9	7.2	7.5	7.6	7.9	8.2	8.5	8.8
Health Care (total no. of doctors)[g]												
Without Project	5.3	5.4	5.6	5.8	6.0	6.1	6.3	6.4	6.6	6.8	7.0	7.2
With Project	5.4	6.8	7.0	7.1	7.2	7.3	7.5	7.6	7.7	7.9	8.1	8.3
Health Care (total no. of beds)[h]												
Without Project	36.7	37.7	38.9	40.0	41.2	42.3	43.5	44.8	46.1	47.3	48.6	49.9
With Project	37.0	41.7	43.6	44.7	45.9	47.0	48.2	49.0	50.3	51.5	51.7	52.9
Education-Wickenburg School District 9 (total no. of teachers)[i]												
Without Project	69.7	71.5	73.6	75.8	77.9	80.1	82.2	84.5	86.8	89.1	91.5	93.8
With Project	73.3	97.4	96.8	99.0	101.1	110.8	105.4	105.5	102.0	104.3	112.0	114.3

[a] Based on 250 gallons per day/per capital (average daily per capita consumption in Wickenburg).

[b] Based on 2.5 (x) average mgd per year.

[c] Based on 100 gallons per day/per capital (average daily sewage use in Wickenburg).

[d] Based on 1 vehicle/1000 population.

[e] Based on 2.5 officers/1000 population,

[f] Based on 1 patrol car/750 population (Arizona Justice Planning Agency and Wickenburg averages).

[g] Based on region wide ratio of 1 doctor/1200 population, 3.2 hospital beds/1000 population (Arizona Department of Health).

[h] Based on region wide ratio of 1 doctor/1200 population, 3.2 hospital beds/1000 population (Arizona Department of Health).

[i] Based on school district wide student/teacher ratio of 15.2/1 (Wickenburg School District 9 percent ratio).

4.3 HYDROLOGY AND WATER QUALITY

Potential hydrologic and water quality impacts resulting from the proposed Anderson project will be associated primarily with groundwater. Dewatering of the mine plus the consumption of additional water in the mill process will cause some drawdown of local aquifers. Since all of the liquid wastes from the mill (with the exception of sanitary wastes) will be discharged to the tailings impoundment and evaporation, no surface waters will be contaminated directly by project activities. However, there is some potential for indirect impacts on surface water quality. Over the long-term, these may include the effects of leachates from the tailings impoundment and mine waste dumps and the action of heavy rainfall on mine waste dumps.

As discussed in Section 3.5, sanitary wastes will first be treated in a plant equipped with facilities for screening, aeration, and clarification with chlorine. The treated wastes will then be discharged to a leach field. This disposal method is not expected to result in any significant environmental impacts.

HYDROLOGY

During operations, the mine will be excavated to an average of about 200 feet below the present grundwater level in the area. Calculations by Water Development Corporation (1978) indicate that a geometric mean of about 70 gpm of groundwater would drain into the mine over the first five stages of development.* Faults and fractures encountered during mining may yield several hundred gpm for up to a few weeks; however, these flows should decrease to the mean mentioned above within a relatively short time.

The development of the mine is not anticipated to seriously impact other users in the area. Effectively all use of Santa Maria River water takes place up gradient to the east of the property. For those users down dip on the aquifers, the low transmissivities of the formations encountered during mining and the southerly dip of the beds involved should preclude any impact on water users in the Date Creek drainage; the nearest of which is the Pipeline Ranch.

Mine drainage will not meet all of the water demands of the proposed project, since the mill process and other project activities (e.g., sewage treatment, washdown, scrubbers) will require approximately 1000 gpm at peak consumption. For this reason, MINERALS will obtain additional water from wells located in either the alluvium of the Santa Maria River at the Palmerita Ranch or bedded horizons in Section 16, T11N, R10W.

<u>Palmerita Ranch Wells</u>

As discussed in Section 2.6, much of the flow in the principal rivers in the vicinity of the Anderson property consists of subflow in the alluvium of the stream channels. Examination of groundwater

*Groundwater drainage was calculated using a formula developed by Ferris et al. Permeability of the aquifer was assumed to be 1.64 gal/day/ft^2. A figure of 340 gal/day/ft was used for the coefficient of transmissibility and the coefficient of storage was assumed to be 0.05 (Water Development Corporation, 1978).

levels, alluvium permeability, gradients, and historic surface flows supports the contention that groundwater in the alluvium of the Santa Maria River is underlain by igneous rock in the general vicinity of the proposed mine and that the groundwater is impounded by a natural barrier of basement rock in the general area of the Alamo Reservoir Dam. Based on flows prior to the construction of the dam, approximately 15 cfs of the average annual surface flow of the Bill Williams River could not be accounted for in the surface flows of its two major tributaries - the Big Sandy and Santa Maria rivers. If this 15 cfs is assumed to be underflow forced to the surface by the basement rock barrier, and if it is proportioned to the two tributaries on the basis of their individual contribution to the total drainage area, the underflow attributable to the Santa Maria river is 4.44 cfs.

Based on the cross-sectional area and slope of the alluvium in the river immediately north of the proposed project and an under-flow of 4.44 cfs, the transmissivity of the alluvial aquifer is 1.4×10^6 gpd/ft^2. This value approximates the larger values of transmissivity observed in wells in the alluvium at the Palmerita Ranch (Water Development Corporation, 1978). The geometric mean of all the transmissivity values determined at the ranch was 733,000 gpd/ft^2 or about half that calculated on the basis of probable underflow. Based on this geometric mean, permeability of the alluvium in the Santa Maria River and associated channels would be about 0.0134 ft/sec.

If all of the water supply wells for the proposed project are located in the vicinity of Palmerita Ranch Well No. 1 (NE1/4NE1/4SW1/4NE1/4, Section 17, T11N, R11W), drawdown at the main channel of the Santa Maria River near the well field would be:

$$s = \frac{264Q}{T} \log \frac{0.3Tt}{r^2 S}$$

where: T = transmissivity (gpd/ft^2)

t = number of days of zero flow in one year for an average year (days)

Q = pumping rate (gpm)

r = radial distance from well to observation point (ft)

S = storage coefficient (unitless)

Therefore,

$$s = \frac{264 \times 600}{733000} \log \left(\frac{0.3 \times 733000 \times 262}{(100)^2 \times 0.2} \right) = 0.964 \text{ feet of drawdown}$$

The maximum length of time of no surface flow recorded on the Santa Maria River is 409 days. Over such a period, the drawdown induced by pumping would be 1.005 feet. Under the worst-case condition of 1000 gpm continuous pumping during 409 days of no surface flow, the drawdown in the main channel of the Santa Maria River would only be about 1.68 feet in that portion of the stream nearest to the source well (i.e., approximately 100 feet).

Based on these calculations, the withdrawal of water from the alluvium of the Santa Maria River in the vicinity of the Palmerita

Ranch will result in relatively minor drawdown of the aquifer. Even under conditions of more limited transmissivity (250,000 gdp/ft^2), water table declines in the area marginal to the Alamo Reservoir would be at the most less than 0.5 foot (Water Development Corp., 1978). The water withdrawn from this aquifer, even if pumping is maintained at a rate of 1000 gpm, would constitute about 6 percent of the annual average daily discharge of the Santa Maria River. Consequently, groundwater recharge following termination of the proposed project should be essentially complete within a short time following the next notable flow in the river.

Section 16 Wells

Due to the relatively low transmissivity of the sandstone and conglomeratic sections tested in Section 16, and because of very slow recharge, pumping at a rate of 350 gpm for 10 years would result in a pumping water level at the pumped well of nearly 1040 feet. Three wells placed in a triangular pattern 0.5 mile apart, and each pumping at a rate of 350 gpm, would result in a pumping water level of approximately 1250 feet (Water Development Corporation, 1978). It is expected that recharge of the affected aquifer would be insignificant; consequently, water withdrawn from this location would be essentially mined.

The radius of influence from wells located in Section 16 would not be greater than 1.5 miles. Assuming that all three wells were located at the same point, a drawdown of 0.1 foot at a distance of 7500 feet from the pumped well was calculated using the Theis nonequilibrium equation. Consequently, the withdrawal of water from Section 16 should have no significant effect on springs or other users in the area.

WATER QUALITY

As discussed in Section 3.4, seepage from the tailings impoundment will reach a maximum of 7 gpm (5 gpm through the dam and 2 gpm through the bottom of the reservoir) when the impoundment is filled to capacity. In the event that any of this seepage appears at the surface below the dam, a portion will evaporate and the rest will infiltrate to the mine pit.

Excess water from the tailings impoundment will be evaporated by spraying and/or discharge into shallow evaporation ponds. If spraying is used, some drift outside of the impoundment is expected. This drift will contain compounds of iron, aluminum, and magnesium, as well as calcium sulfate and sulfuric acid. Trace elements, particularly boron, and some radioactive materials will also be present in the drift (refer to Section 4.7 for a discussion of the potential effects of the radioactive components in the spray drift). Since the spray will be directed down into the impoundment, most of the drift should be contained in the mine area; consequently, impacts on surrounding vegetation are expected to be minor. Some of the constituents of the spray drift can be expected to settle in minor drainages on the Anderson property. These constituents may eventually be washed into the Santa Maria River and ultimately be deposited in the Alamo Reservoir. Due to the low concentrations involved and the high dilution rate, this is not expected to significantly effect the quality of the water in the reservoir. If evaporation ponds are used, wind drift of aerosols would spread insignificant amounts of trace elements and some radioactive materials outside of the ponds. Some seepage through the pond liners is also likely; however, it is expected to be minor.

4.4 AIR QUALITY

Both particulate and gaseous air pollutants will be emitted during construction, development, and operation of the project. By far, the dominant particulate emission will be fugitive dust from haul roads, stockpiles, and working surfaces. Vehicle and equipment engine exhaust and mill stack effluents will contribute relatively minor additional amounts of particulate matter. From an evaluation of the proposed project schedule, it is predicted that maximum annual particulate emissions will occur from 1981 through 1984 when combined stockpiling and overburden stripping activities will be greatest. Gaseous air pollutant emissions will reach a maximum after 1980 when the mill and mine are in operation and remain at that level for the life of the project.

EMISSIONS

Uncontrolled, fugitive dust emissions from the project would be about 1300 tons/year from 1981 through 1984. However, control measures will be used to minimize dust generation, including frequent watering of active haul roads and working surfaces. Heavily used haul roads will also be treated with chemical binders, as necessary, and mine walls and working areas will be sprinkled during primary stripping, secondary stripping, and mining, as appropriate. Dusty, inactive working surfaces will be sprayed with chemical binders to reduce wind erosion. As a result of these control measures, total annual particulate emissions during peak years are estimated to be about 820 tons. This represents a 40 percent control of the potential emissions. Detailed calculations of fugitive dust emissions resulting from the proposed project are provided in Appendix B-5.

Fugitive dust, as defined in EPA regulations (40 CFR 51 and 40 CFR 52), is currently exempt from consideration in air quality impact assessments, specifically with regard to consumption of Prevention of Significant Deterioration (PSD) increments. Particulate emission sources that must be considered in the impact assessment include the ore recieving area stack (Stack No. 1), the yellowcake concentrate area stack (Stack No. 3), and the mill boiler stack (Stack No. 5). The yellowcake concentrate area stack combines releases from the yellowcake dryer and packaging operations. The location of each stack is shown in Figure 3.3-6 and appropriate design parameters and emission rates are provided in Tables 3.3-1 and 3.3-3. An indicated in these tables, gaseous pollutants will also be emitted from Stacks 3 and 5.

AMBIENT CONCENTRATIONS

The EPA (1977) Valley Model (with Briggs plume rise for bouyant stack plumes) was used with annual site meteorological data to calculate annual average offsite pollutant concentrations above background resulting from project activities. Short-term estimates (also using the Valley Model) were based on the worst-case meteorological assumption of up to six hours of persistent wind direction with F stability and a wind speed of one m/sec. For averaging periods of less than six hours, continuous worst-case conditions were assumed. The Valley Model and input data are described further in Appendix B-6. Concentrations were calculated for 13 distances out to 10 kilometers relative to a reference point located near the ore recieving stack in each of the 16 cardinal compass directions. Table 4.4-1 presents computed maximum offsite concentrations above background for each pollutant. Modeling results are presented in greater detail in Appendix B-6.

All computed concentrations are well below respective PSD increments for particulates and sulfur dioxide (Table 4.4-2). In addition, onsite emissions are not expected to exceed National Ambient Air Quality Standards (Table 2.7-10).

Table 4.4-1. MAXIMUM OFFSITE AIR POLLUTANT CONCENTRATIONS ABOVE BACKGROUND RESULTING FROM MILL BOILER, ORE RECIEVING, AND URANIUM CONCENTRATE AREA STACK EMISSIONS

Pollutant	Averaging Time	Concentration ($\mu g/m^3$)	Location Distance(m)	Location Direction
Particulate matter	Annual	0.1	1500	South
	24-hour	1.0	1800	South-Southwest
Sulfur dioxide	Annual	1.2	1500	South
	24-hour	20.4	2100	East-Northeast
	3-hour	81.6	2100	East-Northeast
Nitrogen dioxide	Annual	0.4	1500	South
Carbon monoxide	8-hour	4.4	2100	East-Northeast
	1-hour	5.8	2100	East-Northeast
Hydrocarbons	3-hour	1.3	2100	East-Northeast

Table 4.4-2. PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS FOR CLASS II AREAS

Pollutant	Averaging Time	Allowable Increment ($\mu g/m^3$)
Particulate matter	Annual	19
	24-hour	37
Sulfur dioxide	Annual	20
	24-hour	91
	3-hour	512

Source: 40 CFR 51 and 40 CFR 52

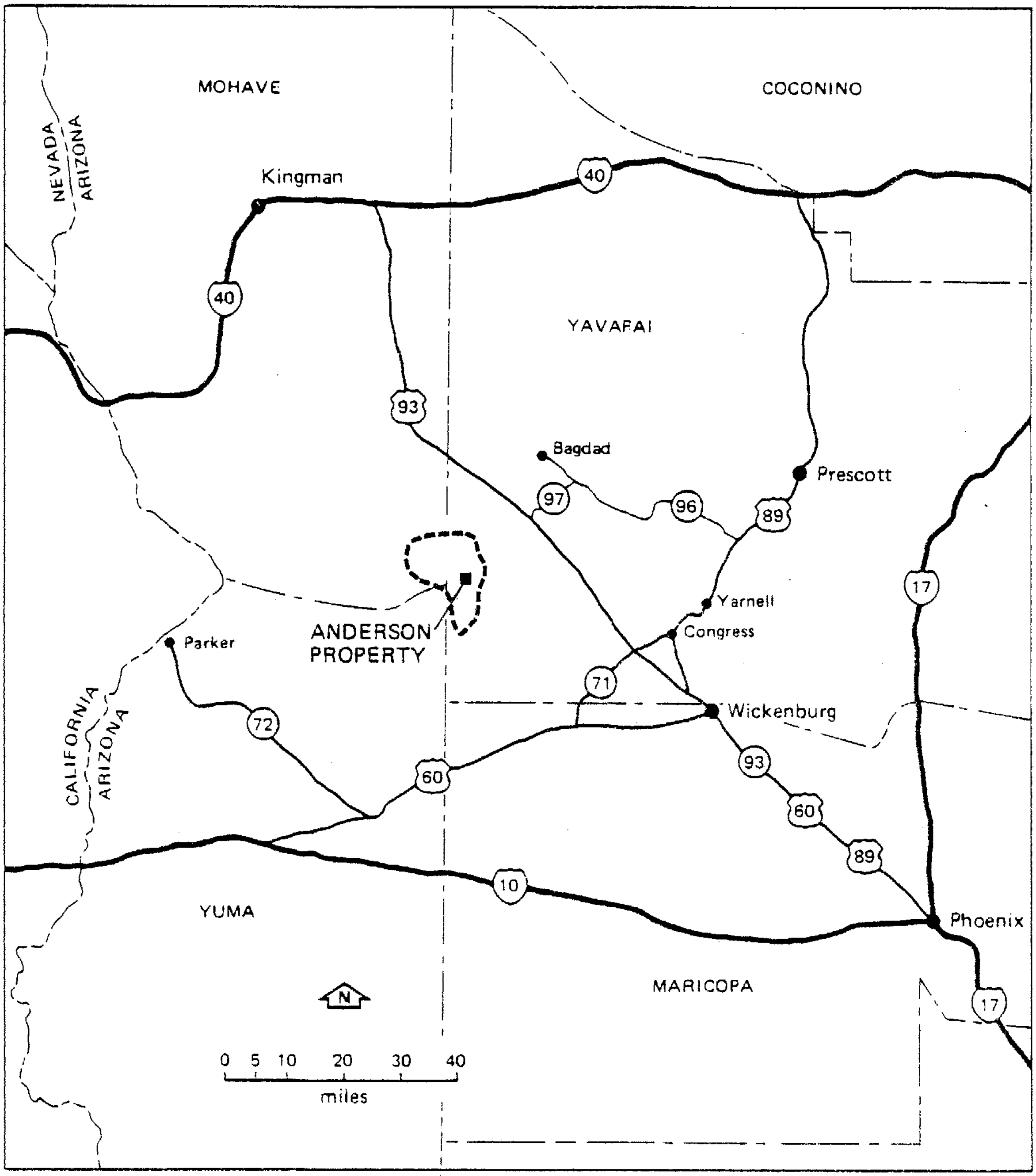


Figure 4.7-4. ZONE OF INCREASED RADIATION EXPOSURE

4.5 BIOLOGY

VEGETATION

Approximately 1000 acres of vegetation will be removed over the life of the proposed project. This vegetation will consist largely of creosotebush, brittlebush, white bursage, palo verde, Joshua tree, saguaro cactus, and ocotillo.

Approximately 400 acres of vegetation will be removed during the 21-month construction period when the mill facilities, haul roads, and access road are constructed and the initial pit sequences are opened. During the 10-year operating life of the project, development of the mine will result in the removal of an average of slightly more than 65 acres of vegetation a year.

After completion of the proposed project, the 81 acre tailings impoundment will be reclaimed with grasses. Reclamation will also be conducted on the rest of the land disturbed by project activities; however, the extent of revegetation efforts has not yet been determined. Revegetation methods to be used for reclamation are currently under study.

Reclamation of lands disturbed by project activities is likely to establish a plant cover at least equal to that now present in the area within a few years. However, it will take longer for mature or "climax"*

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*A mature plant community is defined as a relatively stable association of plants. Baring any major disturbance, the species composition of a mature plant community should not change significantly over time.

plant communities to develop. Native species most likely to initially reinvade disturbed lands are creosotebush, brittlebush, and white bursage. Due to their poor germination rate, several species such as saguaro cactus, may take several decades to become re-established on the site. Based on the life histories of the species most commonly found on the Anderson property, it is likely that mature plant communities will not become established on lands disturbed by project activities for 100 to 150 years.

WILDLIFE

The species observed on the Anderson property are common throughout many regions of the Southwest. For this reason, any loss of individuals that might result from project activities is not expected to affect the overall maintenance of any species. It is also unlikely that project activities will result in a long-term decrease of species populations in adjacent undisturbed habitats.

Some individuals of the small animal species such as the small burrowing mammals, snakes, lizards, and arthropods that now live in areas that will be disturbed by construction and operation of the proposed project will be destroyed when the vegetation is removed. Many individuals of these species of smaller animals will not be able to escape to adjacent undisturbed habitats.

Highly mobile species, such as the larger mammals (burros, coyotes, and rabbits) and most birds, will be able to escape the disturbed areas. The movement of these animals into adjacent undisturbed habitat may bring increased competition for food, shelter, breeding habitat, and other necessities. Consequently, some of these animals can be expected to be lost as the result of project activities.

The increased number of people in the project area could have an additional impact on wildlife populations, since some wildlife are likely to be killed by increased vehicular traffic. However, the numbers of any species lost in this manner should be minimal and not have a significant effect on the overall maintenance of the population.

Wildlife species will begin to reinvade areas disturbed by the proposed project within a relatively short period of time after vegetation has become reestablished. The permanent movement of animal species into disturbed areas occurs gradually and is not accomplished by distinct groups at specific times. Each species has its own range of ecological requirements that must be satisfied before it can successfully live and reproduce in a particular habitat. Some animals can survive only within a narrow range. It is difficult, therefore, to predict the precise succession of species accurately, since many of their requirements are unknown or are difficult to measure.

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4.6 CULTURAL RESOURCES

HISTORY AND ARCHAEOLOGY

There are no historical or archaeological sites on the land to be disturbed by project activities that are included in the National Register of Historic Places. Some archaeological sites will be disturbed by construction of the proposed access road. Measures to mitigate this impact are being discussed with appropriate BLM personnel. Archaeological clearance will be obtained prior to construction of the road.

Since a relatively high density of archaeological sites were found on portions of the Anderson property that will not be disturbed by the proposed project, a potential does exist for the presence of unidentified sites in the mine and mill area. In the event that an unknown site is discovered and studied as a result of project implementation, it will result in positive scientific benefits. On the other hand, if an unknown site is destroyed or damaged during project construction or operation, it will result in an irretrievable adverse impact.

PALEONTOLOGY

Fossils are generally not abundant on the Anderson property. Those that do exist are often poorly preserved and fragile. Project implementation is therefore not expected to result in significant impacts on this resource. As is the case with archaeological resources, if paleontological sites are discovered and studied due to implementation of the proposed project, it will result in positive scientific benefits.

AESTHETICS

The main mill building containing the grinding circuit (Figure 3.3-4) will be the tallest (56 feet) and most visible structure in the mill complex. Due to the topography of the area, the mill will not be visible from distances greater than about one mile. When the proposed mill facilities can be seen, the lines and forms that they create will tend to contrast with the natural lines and forms of the landscape. To keep this contrast at a minimum, earthtone paints will be used for the facilities when feasible. It should be emphasized that the proposed project is located in a relatively isolated area, roughly 15 miles from the nearest highway. Very few people who are not employed at the facility will ever approach close enough to view it.

When in full operation, mining will create a large open pit that will continually change in size and shape over the life of the proposed project. The pit will have relatively straight lines and angular forms and will be somewhat lighter in color than the surrounding landscape. Since the pit will be at surrounding topographic relief, it will not be readily visible. However, it should dominate the natural landscape in views that include it.

4.7 RADIOLOGICAL CONSIDERATIONS

RADIOLOGICAL IMPACTS ON BIOTA OTHER THAN MAN

Exposure Pathways

The mine, tailings impoundment, ore piles, and the mill are expected to be the principal sources from which nonhuman biota can be exposed to radionuclides. The significant means of exposure include particulate emissions (i.e., dust) from the ore piles and from the milling operations, plus radon gas escaping from the tailings area, the mill, and the mines. Aerosols from the tailings impoundment may also provide a source of exposure to radionuclides.

The tailings impoundment will contain thorium-230, radium-226, and lead-210. Small amounts of these radionuclides could enter natural food chains if they were distributed as windblown dust into the surrounding area and assimilated by plants or ingested by animals. However, such dispersal will be held to insignificant levels by keeping the tailings wet.

Normal access routes to the impoundment will be fenced. While this will prevent large animals from entering the area, arthropods, reptiles, and small mammals will be able to gain access to the tailings impoundment. It will also be possible for birds, including migratory waterfowl, to land on and adjacent to the impoundment. In addition, raptors may seek prey around the impoundment. Since the tailings water will be acidic (pH about 1.5 to 2.0), it will be distinctly unpalatable and will discourage the approach of animals and waterfowl. It is therefore unlikely that appreciable quantities of radionuclides will enter the food chain through ingestion of tailings water by mammals and waterfowl.

As discussed in Section 3.0, it will be necessary to dispose of approximately 231 million cubic feet (about 1.73×10^9 gallons) of excess water from the tailings impoundment over the life of the project. It is planned to accomplish this by accelerating evaporation. This may be done by either spraying water from the impoundment into the air or by decanting the excess water and pumping it to sealed evaporation ponds located on the waste dumps.

In the event that a spray system is used, water from the tailings pond will be pumped from barges to the top of the tailings dam at a rate of 2000 to 2500 gpm and sprayed back into the impoundment through nozzles spaced at 10- to 15-foot intervals along the perimeter of the dam. It is expected that this operation will increase evaporation by approximately 400 gpm.

In order to minimize the drift of spray droplets and resultant residual aerosols, the spray nozzles will be aimed down into the tailings impoundment. This will substantially increase the humidity of air within the impoundment basin. During daylight hours when the sun heats the air in the basin it will rise even in the absence of wind. It is expected that this column of buoyant air will normally be intercepted by surface winds and by winds aloft, creating a rapid dispersion of the aerosols and gases left in the atmosphere by the evaporating water.

These gases and aerosols may include traces of radioactive elements and their daughters.

Since models are not readily available for the type of spray system planned, it is difficult to determine the composition or magnitude of emissions resulting from this operation. Less than 9×10^{-8} μCi/ml of radium-226 would be dispersed in the tailings liquid, thereby creating equilibrium concentrations of radon-222 to the atmosphere. These emissions are expected to be minor compared with other radon sources created by project operations. The radium in the solid tailings could be kept toward the bottom of the pool below the wave base by restricting wind fetch across the pond and controlling the configuration of the bottom of the impoundment. Radon-222 would then have to reach the atmosphere by diffusion and/or currents, which would considerably reduce the potential for exposing the area's biota to radiation.

The tailings liquor will have a pH of about 1.3 as it is discharged to the impoundment. Based on the mean annual humidity of the area, absorption of water from the atmosphere by the acid in the liquor is likely to raise the pH to slightly below 2. The pH should remain roughly at this level since ionization of the second acid radical of the sulfuric acid molecule (as well as other components) will act as a buffer for the liquor.

This buffering effect could potentially act as a control on radioactive emissions from the spray system. The tailings will contain some iron, approximately 60 percent in ferric form and 40 percent in ferrous form. With a pH of about 2, the iron may act as a flocculant which would be effective in sweeping many molecules out of the tailings liquor and incorporating them into bottom sediments. It is conceivable that at a pH of about 2, and certainly under more alkaline conditions, iron floc could remove radionuclides from the tailings water.

Small quantities of some radionuclides, such as thorium-230, may be dispersed into the atmosphere as the result of the spray program. The prevailing winds and the barriers created by the tailings dam, waste dumps, and surrounding mountains, should force mixing to the degree that background concentrations in the atmosphere would be approached within a few miles of the impoundment. The immediate area around the impoundment possibly would be subject to fluctuations in radionuclide concentrations. If deposited on the soil surface, these materials may ultimately be washed into the Santa Maria River by precipitation runoff and eventually reach the Alamo Reservoir. This dispersal of radionuclides could result in exposure to nonhuman biota.

The use of evaporation ponds would virtually eliminate the potential emission of radionuclides as aerosols. Since the bottom of the ponds would be sealed, radioactive materials would not enter the natural environment through seepage into the soil. Some radon-222 would escape from the tailings water; however, it would probably be in lesser quantities than that emitted as the result of the spray program.

Because of their smaller size, the ore storage piles have a lower potential for exposing the area's biota to radiation than the tailings impoundment. The ore piles will contain about 0.072 percent uranium oxide and approximately equilibrium amounts of lead-210, radium-226, and thorium-230. Some potential exists for radionuclides to enter the food chain from windblown dust originating from the ore piles. However, dust from the ore piles will be held to low levels by the moisture in the ore (about 10 percent).

Radon-222 will emanate from the tailings impoundment, the mine, the ore piles, and the mill. The radon and daughters will, in large part, be dispersed in the atmosphere. The air dispersion and inhalation pathways will contribute only small doses to biota.

The possible paths of radionuclides through the various trophic levels are illustrated in Figure 4.7-1. Plant and animal species in the area have been analyzed for present levels of radionuclides (Section 2.9). Any significant increases can be noted by reanalysis of these species. The reanalyses can provide an indication of incipient contamination of the surrounding areas.

Radioactivity in the Environment

The proposed mill will generate some effluents that could distribute modest amounts of natural radioactivity (uranium and daughters) to the project area. Solid and liquid effluents from the mill will be closely controlled and contained. The airborne radioactive effluents

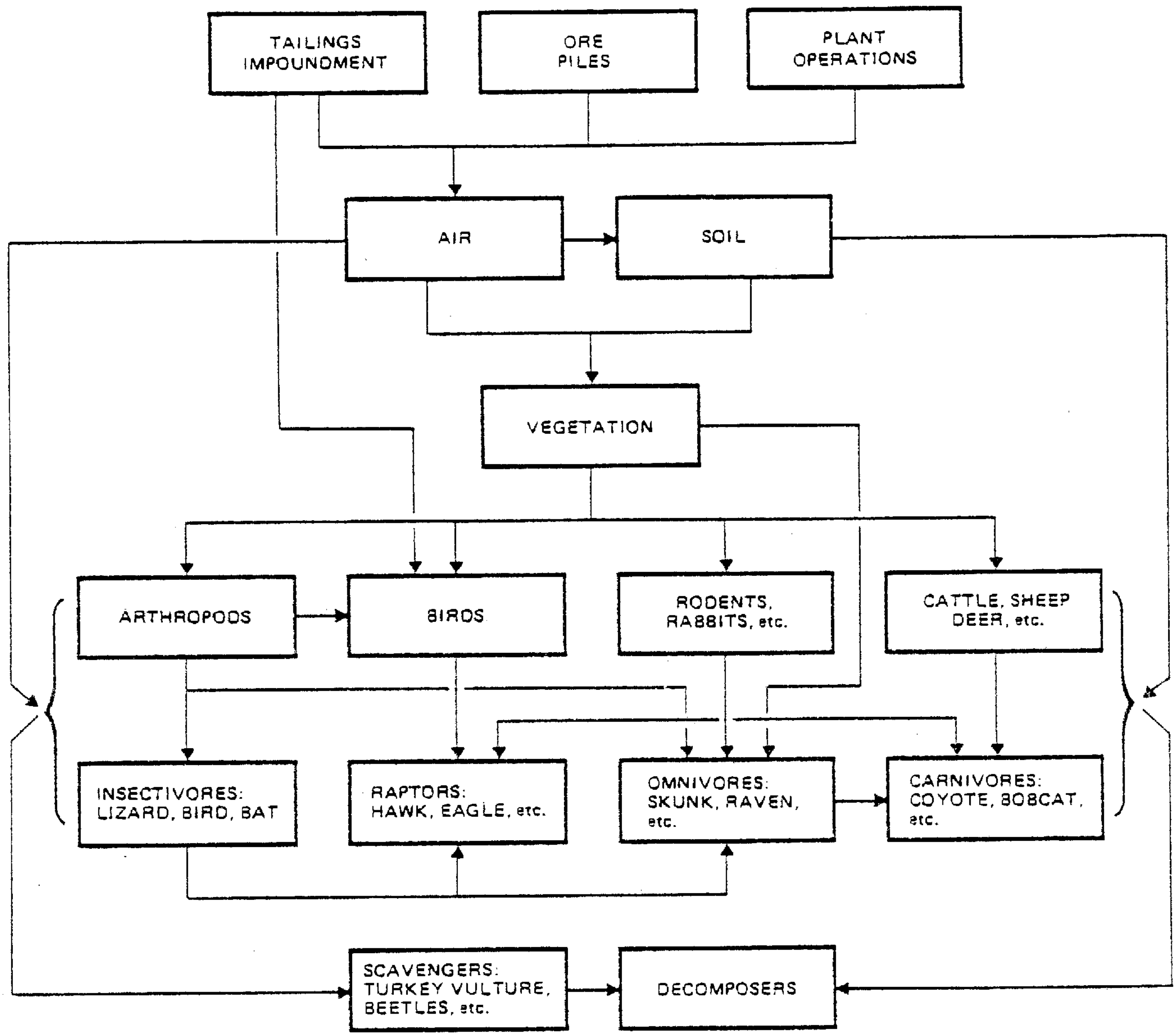


Figure 4.7-1. POSSIBLE EXPOSURE PATHWAYS TO NONHUMAN BIOTA

will be emitted at low concentrations and will be diluted to even lower concentrations by natural diffusion and dispersion processes within a short distance from the points of emission. At the site boundaries, the radioactivity will be only slightly above the natural background level. Table 4.7-1 gives concentrations at selected points for radon-222 released from the project. Table 4.7-2 gives similar information for uranium-238. The atmospheric dispersion factors for all sources considered in the analysis are given in Appendix D-2.

Radioactivity released from the mine is expected to consist principally of radon-222 emanating from exposed ore. The high moisture content of the ore (10 percent) and groundwater seepage into the pits are expected to hold ore dust emissions from the mine to insignificant levels. A monitoring program is proposed to measure changes in ambient radioactivity (Section 5.0).

The liquid and solid process wastes that contain most of the radioactivity will be retained in the tailings impoundment. There is presently no surface water on or near the site, and there will be no surface discharge of fluids from the tailings impoundment system. Consequently, there will be no buildup of radionuclides in freestanding surface water bodies. For the continuing measurement of groundwater quality, wells around the tailings area will be sampled and water will be analyzed periodically for the parameters described in Section 5.0.

Table 4.7-1. ANNUAL RADON-222 CONCENTRATIONS AT THE ANDERSON URANIUM MINE AND MILL (μCi/ml)

DISTANCE METERS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
600.	1.9-10	1.7-10	1.2-10	1.4-10	1.6-10	1.4-10	1.9-10	4.8-10	6.0-10	4.9-10	3.3-10	2.9-10	2.7-10	2.3-10	2.0-10	2.0-10
900.	1.3-10	1.0-10	9.0-11	8.7-11	1.0-10	1.1-10	1.3-10	5.2-10	7.0-10	5.5-10	2.6-10	2.6-10	2.2-10	1.7-10	1.6-10	1.3-10
1200.	9.7-11	7.6-11	6.3-11	7.2-11	7.1-11	8.8-11	1.0-10	1.8-10	5.6-10	3.1-10	2.4-10	2.2-10	1.7-10	1.5-10	1.2-10	1.0-10
1500.	8.1-11	6.2-11	5.2-11	5.3-11	5.6-11	6.5-11	9.6-11	1.7-10	2.5-10	2.0-10	1.9-10	1.7-10	1.4-10	1.3-10	1.0-10	8.8-11
1800.	7.1-11	5.4-11	4.4-11	4.2-11	4.8-11	5.3-11	7.4-11	1.5-10	2.1-10	1.7-10	1.4-10	1.4-10	1.3-10	1.1-10	9.1-11	7.9-11
2000.	6.8-11	5.1-11	3.3-11	3.6-11	4.3-11	4.2-11	5.6-11	1.4-10	2.0-10	1.6-10	9.9-11	1.0-10	1.2-10	9.5-11	7.4-11	7.8-11
2100.	6.0-11	4.4-11	3.6-11	3.5-11	4.2-11	4.3-11	6.0-11	1.2-10	1.7-10	1.3-10	1.1-10	1.1-10	1.1-10	9.3-11	7.9-11	6.7-11
3000.	4.4-11	2.8-11	1.7-11	2.0-11	2.6-11	2.4-11	3.1-11	7.6-11	1.2-10	6.9-11	5.0-11	5.8-11	7.1-11	5.7-11	4.5-11	4.3-11
4000.	3.0-11	1.8-11	1.1-11	1.5-11	1.6-11	1.5-11	1.7-11	4.5-11	7.5-11	3.8-11	2.5-11	3.8-11	4.4-11	4.3-11	3.2-11	3.0-11
5000.	2.3-11	1.4-11	8.7-12	1.1-11	1.1-11	9.2-12	1.2-11	3.5-11	5.2-11	2.9-11	1.7-11	2.3-11	3.1-11	3.2-11	2.5-11	2.3-11
6000.	1.8-11	1.1-11	7.0-12	8.7-12	8.8-12	7.0-12	8.9-12	2.6-11	3.8-11	2.1-11	1.3-11	1.7-11	2.5-11	2.6-11	2.0-11	1.9-11
7000.	1.5-11	9.0-12	5.7-12	6.8-12	7.0-12	5.3-12	7.0-12	2.1-11	2.9-11	1.6-11	1.1-11	1.3-11	2.0-11	2.1-11	1.7-11	1.5-11
10000.	9.3-12	5.4-12	3.9-12	4.2-12	4.1-12	2.9-12	4.4-12	1.2-11	1.7-11	1.8-11	4.1-12	7.1-12	1.2-11	1.3-11	7.7-12	1.5-11
20000.	3.9-12	1.8-12	1.1-12	1.6-12	1.4-12	9.5-13	1.2-12	4.3-12	6.5-12	3.1-12	1.8-12	2.2-12	4.5-12	5.3-12	3.9-12	4.0-12
30000.	2.2-12	9.7-13	6.8-13	9.5-13	8.1-13	5.6-13	7.1-13	2.4-12	3.5-12	1.6-12	1.1-12	1.3-12	2.6-12	3.1-12	2.5-12	2.0-12
40000.	1.4-12	5.7-13	4.5-13	7.2-13	5.3-13	4.3-13	4.7-13	1.5-12	2.2-12	9.9-13	7.4-13	9.6-13	1.7-12	2.4-12	1.7-12	1.3-12
50000.	1.0-12	4.3-13	3.4-13	5.1-13	3.9-13	3.1-13	3.6-13	1.2-12	1.6-12	7.6-13	5.6-13	7.0-13	1.3-12	1.7-12	1.3-12	9.9-13
60000.	8.3-13	3.6-13	2.7-13	4.0-13	3.0-13	2.4-13	2.9-13	9.4-13	1.2-12	6.1-13	4.5-13	5.4-13	9.9-13	1.4-12	1.1-12	8.0-13
70000.	6.7-13	3.0-13	2.3-13	3.1-13	2.5-13	1.9-13	2.4-13	7.7-13	9.9-13	5.0-13	3.7-13	4.1-13	8.0-13	1.1-12	8.9-13	6.7-13

Table 4.7-2. ANNUAL URANIUM-238 CONCENTRATIONS (UNDEPLETED) AT THE ANDERSON URANIUM MINE AND MILL (μCi/ml)

DISTANCE METERS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
600.	2.0-14	1.8-14	9.0-15	1.2-14	1.1-14	6.6-15	1.2-14	2.6-14	2.0-14	1.4-14	8.3-15	9.3-15	1.6-14	1.7-14	1.7-14	2.2-14
900.	1.1-14	7.7-15	4.8-15	5.9-15	5.6-15	3.6-15	6.3-15	1.2-14	1.2-14	6.9-15	4.8-15	5.3-15	8.9-15	1.0-14	1.0-14	1.2-14
1200.	6.8-15	3.9-15	2.7-15	4.3-15	3.3-15	2.5-15	3.6-15	6.9-15	7.3-15	3.9-15	2.9-15	3.8-15	5.5-15	7.5-15	6.0-15	5.2-15
1500.	4.1-15	2.6-15	1.9-15	2.8-15	2.2-15	1.5-15	2.5-15	5.7-15	6.0-15	3.6-15	2.1-15	2.5-15	3.9-15	5.0-15	4.3-15	3.8-15
1800.	3.1-15	2.0-15	1.4-15	2.1-15	1.5-15	1.1-15	1.8-15	4.4-15	4.5-15	2.4-15	1.5-15	1.9-15	2.9-15	3.8-15	3.3-15	3.8-15
2000.	2.9-15	1.9-15	9.6-16	1.6-15	1.4-15	7.4-16	1.3-15	4.2-15	4.2-15	2.6-15	1.1-15	1.3-15	2.4-15	2.7-15	2.4-15	3.4-15
2100.	2.4-15	1.5-15	1.1-15	1.6-15	1.2-15	8.1-16	1.5-15	3.5-15	3.6-15	2.2-15	1.3-15	1.4-15	2.3-15	2.9-15	2.6-15	2.8-15
3000.	1.8-15	8.1-16	5.2-16	8.2-16	6.8-16	4.5-16	7.1-16	1.9-15	2.5-15	1.2-15	6.8-16	7.0-16	1.3-15	2.3-15	1.9-15	1.4-15
4000.	1.1-15	4.8-16	3.0-16	5.8-16	4.2-16	3.2-16	4.2-16	1.1-15	1.5-15	7.2-16	5.0-16	5.2-16	8.3-16	1.2-15	1.2-15	9.5-16
5000.	7.2-16	3.5-16	2.2-16	4.1-16	2.8-16	2.1-16	2.9-16	8.4-16	1.1-15	5.5-16	3.5-16	3.6-16	6.0-16	8.3-16	8.6-16	6.4-16
6000.	5.3-16	2.7-16	1.9-16	3.1-16	2.1-16	1.6-16	2.2-16	6.6-16	8.4-16	4.3-16	2.6-16	2.7-16	4.6-16	6.6-16	6.8-16	4.7-16
7000.	4.1-16	2.2-16	1.5-16	2.3-16	1.6-16	1.2-16	1.8-16	5.2-16	6.6-16	3.4-16	2.2-16	2.0-16	3.8-16	5.5-16	5.1-16	3.8-16
10000.	2.5-16	1.2-16	9.8-17	1.2-16	9.8-17	6.0-17	9.8-17	3.2-16	4.1-16	3.6-16	1.0-16	1.3-16	2.3-16	3.2-16	1.8-16	3.4-16
20000.	9.5-17	4.6-17	3.1-17	4.0-17	3.2-17	2.1-17	2.9-17	1.2-16	1.7-16	8.6-17	4.4-17	4.3-17	8.9-17	1.4-16	8.3-17	9.5-17
30000.	5.5-17	2.2-17	1.8-17	2.4-17	1.8-17	1.2-17	1.9-17	6.4-17	9.2-17	3.5-17	3.0-17	3.1-17	5.8-17	8.3-17	5.4-17	5.6-17
40000.	3.4-17	1.4-17	1.2-17	1.8-17	1.2-17	9.7-18	1.2-17	4.2-17	6.2-17	2.7-17	2.1-17	2.0-17	4.6-17	6.7-17	4.3-17	2.8-17
50000.	2.5-17	1.0-17	7.8-18	1.3-17	9.1-18	7.4-18	9.8-18	3.2-17	4.0-17	2.1-17	1.5-17	1.6-17	2.9-17	4.4-17	2.8-17	2.3-17
60000.	2.0-17	8.7-18	6.3-18	1.0-17	7.2-18	5.8-18	7.7-18	2.7-17	3.6-17	1.7-17	1.2-17	1.3-17	2.1-17	3.9-17	2.2-17	1.8-17
70000.	1.6-17	7.1-18	5.2-18	7.8-18	5.8-18	4.1-18	6.7-18	2.2-17	2.6-17	1.4-17	9.3-18	9.3-18	1.7-17	3.2-17	1.9-17	1.5-17

When project operations are terminated, the tailings impoundment will be reclaimed (see Section 5.2 for the reclamation plan).

DOSE RATE ESTIMATES

Of the various pathways that could expose the local vegetation and fauna to radioactivity, physical deposition of dust particles on plants is the most significant. Herbivores may ingest the particles along with plant material. Since radon-222 is gaseous, it does not deposit on vegetation, but radon daughter products can become affixed to vegetation after attachment to dust particles. Very small amounts of lead-210 and its daughters may be ingested from this source.

Sheep, beef cattle, and feral burros are the principal animals of concern in the area. These are all medium-sized to large mammals, and radiation doses received by them should be comparable to the values for man presented below. These animals are likely to receive some additional radioactive exposure by inhalation of radon-222. Radiation doses to the digestive tract, or to specific tissues, through ingestion of deposited dust on vegetation will be small.

RADIOLOGICAL IMPACT ON MAN

Exposure Pathways

The main pathways of man's exposure to radiation from the proposed project will be inhalation, ingestion of meat, and ingestion of vegetables. Less significant pathways include immersion in the effluent plume (the collective gaseous and airborne particulate emissions from the project) and ground shine from deposited particulates. In the general case, the consumption of locally raised animals (cattle and sheep) and of vegetables grown locally which have been exposed to particulate radionuclides presents some potential for the contamination of man's food chain. Elevated doses from locally produced foodstuffs are unlikely because of the limited forage available for grazing and the absence of substantial agricultural production. For the purposes of this discussion, however, it has been assumed in the analysis that 10 percent of the annual vegetable consumption and 20 percent of the annual beef consumption by area residents is supplied by local production. Doses resulting from each of these pathways have been determined using the models given in Appendix D-1.

An increase in concentrations of radionuclides in or on various plant species, indicating the possibility for exposure to man through the food chain (trophic transfer), can be detected because present levels of radionuclides for representative plant species in the area are known.

Figure 4.7-2 presents a flow chart of the possible pathways of exposure to man.

Liquid Effluents

The mine and mill will not release radioactivity directly into surface waters. As discussed in Section 3.0, the maximum potential seepage from the tailings impoundment will be 0.6 cubic feet per minute. Assuming that seepage occurs at this rate throughout the life of the project, then

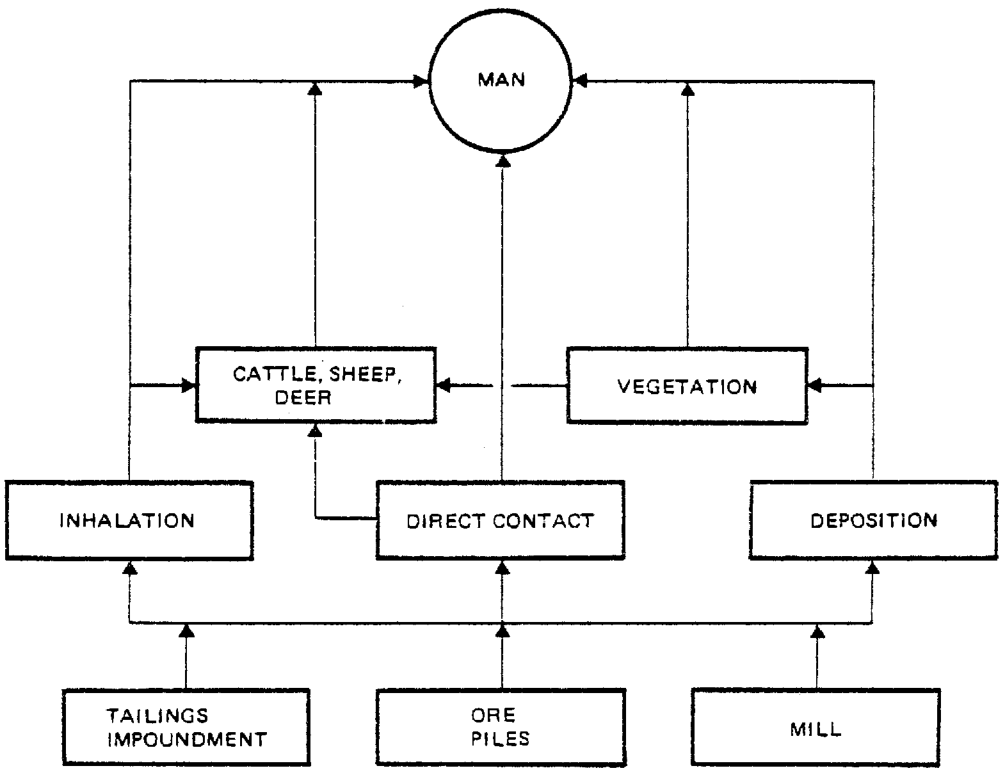


Figure 4.7-2. POSSIBLE EXPOSURE PATHWAYS TO MAN

a total of about 3.15×10^6 cubic feet of effluent will escape from the impoundment. Using an average impoundment area of 65 acres and assuming that the underlying rock consists of 20 percent voids by volume, then this seepage would penetrate approximately 5.6 feet below the impoundment. Much of this effluent would remain in place due to the high absorptive capacity of the mudstone and siltstone that underlies the area. The remaining effluent would be drawn toward active mining areas due to the drawdown of the groundwater table caused by mine dewatering. Consequently, receiving water-related pathways are not considered to contribute significantly to the dose to the population in the area.

Airborne Effluents

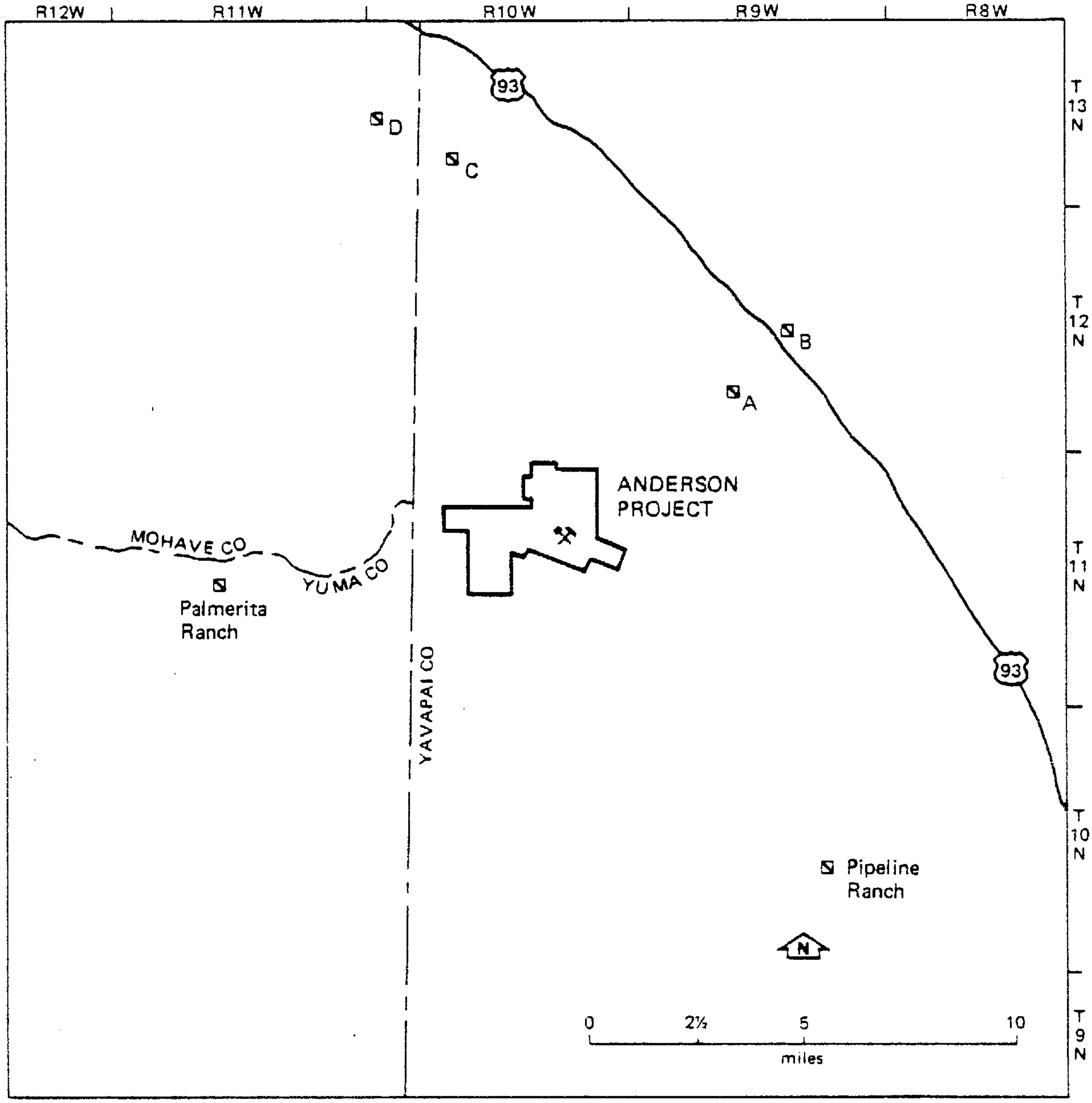
The primary source of airborne radioactivity from the project will be uranium-bearing dust (i.e., dust from ore, product, and tailings) and radon-222 emitted from the mill, tailing, and mine. Small amounts of radionuclides, such as thorium-230 and radium-226, will be released in the dusts. The possible dose from such releases is small and will be controlled by such measures as keeping materials and surfaces wetted and by the use of pollution control equipment. Based on the concentrations presented in Tables 4.7-1 and 4.7-2, it is estimated that less than 10 percent of the maximum permissible concentration of these radionuclides will be released to the unrestricted area on an annual average (10 CFR 20).

For purposes of calculating diffusion and dispersion of uranium-bearing dust and radon-222, the models given in NRC Regulatory Guide

1.111 were applied, utilizing meteorological data from the site, as discussed in Appendix D-1. A ground-level release was assumed for the ore pile. The ore crushing system and yellowcake drying and packaging system are vented through stacks equipped with controls. The tailings impoundment was treated as an area source. No decay of radon-222 was assumed in the dispersion process; however, complete secular equilibrium of the radon daughters was also assumed. The net effect of these assumptions is to add a degree of conservatism to the calculations.

The mine is expected to produce ore at about the same rate as the mill will process ore. Both mining and processing will result in the release of radon from the exposed ore. No significant radioactive particulate emissions are expected from the mine since the ore will be wet when it is removed. It will also be kept wet in the mill ore stockpiles. Therefore, the only pathway of concern from this source is the lung dose due to radon-222. In that pathway the residents at a ranch approximately 4.7 miles ENE are the nearest receptors (Figure 4.7-3). Natural dispersion and diffusion will reduce the radon-222 concentrations significantly over that distance.

Total-body and specific organ doses resulting from immersion in and inhalation of airborne radionuclides, as well as from ingestion of meat and vegetables raised in the vicinity of the mill, were calculated for a 50-mile radius using the models and methods described in Appendix D-1. The most significant exposures to man due to particulates from the mill at locations of interest are given in Table 4.7-3 for all pathways.



LEGEND

Farm or Ranch

Figure 4.7-3. LOCATION OF FARMS OR RANCHES WITHIN TEN MILES OF THE PROPOSED ANDERSON PROJECT

Table 4.7-3. PARTICULATE RADIATION DOSES TO THE NEAREST RECEPTORS FROM ALL EXPOSURE PATHWAYS (mrem/yr)

Location and Direction	Distance from Plant Center (kilometers)	Bone	Total Body	Kidney	Lung	Skin
Ranch A - NE	6.7	3.4	1.8	0.35	0.36	0.015
Ranch B - NE	9.6	2.2	1.1	0.22	0.23	0.009
Ranch C - N	12.7	4.0	2.1	0.42	0.44	0.018
Ranch D - NNW	14.4	4.3	2.2	0.45	0.46	0.019
Palmerita Ranch - W	9.6	6.3	3.3	0.64	0.70	0.028
Pipeline Ranch - SE	15.6	1.1	0.50	0.11	0.11	0.005
S.G.* - N	2.4	1.5	0.11	0.40	0.51	0.021
S.G.* - E	1.9	10.3	0.78	2.8	3.6	0.15
S.B.* - S	1.4	3.8	0.29	1.0	1.4	0.055
S.B.* - W	3.7	0.77	0.06	0.21	0.28	0.011
S.B.* - NNW	1.0	5.9	0.44	1.6	2.0	0.08

S.B.* Plant site boundary. All site boundary doses include an occupancy factor as described in Appendix D. These locations are not expected to yield significant exposures via ingestion.

Doses due to radon releases are given in Table 4.7-4. Residents of nearby ranches (Figure 4.7-3) will be the nearest receptors and are assumed to be exposed by ingestion. Exposure at the site boundary occurs via the immersion, inhalation, and ground shine pathways only.

Food crops grown in the project vicinity, on which airborne radioactive material could be deposited, are expected to be confined to small areas of production. Forage may collect low levels of uranium-bearing dust but no large doses are expected through that pathway.

Summary of Annual Radiation Doses

The only pathways that appear capable of imparting any significant exposure to man are inhalation of airborne effluents, immersion in airborne effluents, and deposition of radioactive dust on the ground or vegetation. Particulate deposition gives rise to irradiation of man by ground shine and by the consumption of wildlife or livestock that inhabit the area. The pathway through wild animals is relatively insignificant because of their small populations in the area and the small fractions of those animals consumed by man.

The total radiation doses from these pathways are shown in Table 4.7-3 for individuals spending all their time at locations given where a residence exists and for individuals spending five percent of their time at the site boundary. The occupancy factor for the site boundary is based on an individual spending approximately 4 hours a day, 2 days a week, 52 weeks a year at the site boundary. Table 4.7-5 compares

Table 4.7-4. TOTAL RADON RADIATION DOSES TO NEAREST RECEPTORS

Location and Direction	Distance From Plant Center (miles)	Lung Dose (mrem/yr)				
		Ore Storage Piles	Grinding	Tailings	Mine	Total
Ranch A - NE	6.7	0.58	0.047	0.0087	8.4	9.1
Ranch B - NE	9.6	0.37	0.030	0.0055	5.5	5.9
Ranch C - N	12.7	0.40	0.032	0.0099	9.3	9.7
Ranch D - NNW	14.4	0.25	0.020	0.0023	10.1	10.4
Palmerita Ranch - W	9.6	0.45	0.037	0.018	17.3	17.8
Pipeline Ranch - SE	15.6	0.12	0.009	0.0018	2.6	2.6
S.B.* - N	2.4	0.46	0.037	0.0042	3.4	3.9
S.B.* - E	1.9	3.26	0.26	0.0031	3.0	6.5
S.B.* - S	1.4	1.26	0.10	0.0043	17.3	18.7
S.B.* - W	3.7	0.24	0.020	0.0033	3.4	3.7
S.B.* - NNW	1.0	1.9	0.15	0.0114	7.0	9.1

S.B.* Plant site boundary. All site boundary doses include an occupancy factor as described in Appendix D.

Table 4.7-5. COMPARISION OF ANNUAL DOSE TO INDIVIDUALS AT PALMERITA RANCH WITH RADIATION PROTECTION STANDARDS

Receptor Organ	Estimated Annual Dose At Palmerita Ranch (mrem/year)	Present NRC Regulation (10 CFR 20) (mrem/year)	Future EPA Standards (40 CFR 190) (mrem/year)
Whole body	3.3	500	25
Lung	0.64	1500	25
Bone	6.3	3000	25
Bronchial epithelium[a]	17.8[b]	500	NA[c]

[a]Lung dose due to radon-222 daughters.

[b]Radiation standards for exposures to radon-222 and daughter products are expressed in Working Level (WL). WL means the amount of any combination of short-lived radioactive decay products of radon-222 in one liter of air that will release 1.3×10^5 mega electron volts of alpha particle energy during their radioactive decay to lead-210 (radium D). For this comparison, WL was converted to dose assuming complete equilibrium between radon-222 and its short-lived daughter products.

[c]Not applicable since 40 CFR 190 does not include doses from radon-222 daughters.

annual radiation doses at the nearest residence (Palmerita Ranch) with present and future radiation protection standards.

Because there are no receiving-water related pathways for exposure to radioactivity, there is no population dose from such pathways. The total doses (whole-body and specific organ doses) from the project to the population within 50 miles are given in Table 4.7-6. The sparse population of this portion of Arizona is reflected in the small population doses.

Figure 4.7-4 shows the area in which background radiation levels may be raised by one percent as a result of project implementation.

Table 4.7-6. ANNUAL POPULATION DOSES (man-rems)

PARTICULATE DOSES					RADON DOSES
Bone	Total Body	Kidney	Lung	Skin	Lung
13	6.5	1.3	1.5	0.57	33

5.0

MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE IMPACTS

5.1 ENGINEERING, CONSTRUCTION, AND OPERATION

Measures to mitigate many of the adverse impacts that would result from construction and operation of the proposed project will be incorporated into the design and operating plans for the mine and mill. These measures include the following:

- Water trucks will wet down all heavily traveled unpaved roads on the property to control dust.
- Berms and ditches will be constructed to channel surface runoff away from the pit area to preclude contamination from disturbed areas.
- The overall pit slope will vary between 0.4:1 and 1.0:1, depending on the height of the slope (this includes safety benches with a minimum width of 10 feet). These slopes will have a factor of safety of at least 1.1. Pit slopes will be continuously monitored during operation of the mine.
- Tailings will be discharged to an exhausted pit area. This will reduce the amount of land disturbed by the proposed project. In addition, if tailings are accidentally spilled or the dam is breeched, the tailings will be contained in the pit area.
- The bottom of the tailings impoundment and the dam core will consist of highly impermeable lacustrine sediments which will reduce seepage to seven gpm.

- The mining sequence has been designed to average out the ore grade as much as possible and to minimize reworking of the haul roads from the pit area. In almost all cases, the ramps from the pit have been located either in areas where removal of overburden accounts for much of the excavation required for their construction or in areas where backfill can be utilized for ramps.

- Volatile fuels and reagents will be stored in closed tanks to minimize the escape of vapors to the atmosphere.

- Many unit operations will be carried out within buildings or closed vessels. The air in the buildings and gases from the vessels will be passed through scrubbers to remove mists, gaseous pollutants, and dust.

- Due to the relatively large quantity of water used in the SAG mill, no dust will be emitted from the grinding circuit.

- Buildings housing various mill operations will have concrete floors. These floors will normally be sloped down to a sump that will collect any spillage. Spilled materials will be pumped back into the appropriate mill circuit.

- The floors of the mill buildings will be curbed off or recessed so that they can contain the entire volume of any of the process tanks in the event of a tank rupture.

- Mill process equipment located outdoors will be contained in an impoundment capable of holding the entire volume of any of the tanks.

- Instrumentation will be installed in all mill circuits to monitor and control the milling process. This instrumentation will significantly reduce the probability of an accidental release of effluents to the environment.

5.2 RECLAMATION

MINERALS will reclaim the proposed tailings impoundment after project termination. The intent of the reclamation plan is to reduce gamma and radon-222 emissions from the impoundment to safe levels (background for gamma radiation and twice background for radon), promote long-term stability of the tailings, and return native vegetation to the site.

After project termination, discharge of tailings and water to the impoundment will cease and standing water will be allowed to evaporate. When sufficient water has evaporated to provide a competent surface, the tailings will be covered with 14 feet of overburden material (Figure 5.2-1) (Dames & Moore, 1978). This material will be obtained from either mined out pit areas or the waste dumps.

It is estimated that gamma radiation and radon-222 emissions from the tailings after project termination will be 4640 mrem/year and 325.9 pCi/m^2-sec, respectively. This is considerably higher than background (average background radon flux is estimated to be 0.96 Ci/m^2-sec; average background gamma dose is 107 mrem/year). A 14-foot cover of overburden material will reduce gamma radiation to approximately 0.05 mrem/year and radon-222 emanation to less than 1.92 pCi/m^2-sec (Dames & Moore, 1978).

In addition to covering the surface of the tailings, overburden material will be placed against the downstream slope of the tailings dam and benches will be graded to control rill erosion (Figure 5.2-1)

(Dames & Moore, 1978). To further control erosion, a small retention dike will be constructed at the crest of the impoundment to minimize runoff over the slopes.

After the overburden cap and erosion controls are in place, the impoundment will be revegetated with grasses. If evaporation ponds are used to remove excess water from the tailings impoundment, these ponds will be reclaimed and revegetated at project termination. Reclamation will also be conducted on the rest of the land disturbed by project activities; however, the extent of revegetation efforts has not yet been determined. Revegetation methods to be used for reclamation are currently under study.

5.3 PREOPERATIONAL MONITORING

It was necessary to collect baseline information on the Anderson property in order to adequately assess the potential impacts of the proposed project. This baseline data will also provide an environmental "benchmark" for future operational monitoring in order to detect potential problems at an early stage.

METEOROLOGY AND AIR QUALITY

A meteorological monitoring program was initiated on the Anderson property in December 1976. A mechanical weather station measuring wind direction, wind speed, and temperature was installed atop a 30-foot meteorological tower (Figure 2.7-1). Early in June 1977, instrumentation was added to measure relative humidity and rainfall. Estimates of wind direction deviation were used to estimate atmospheric stability for each hour according to methods developed by Slade (1966).

Air quality was measured during three five-day continuous monitoring programs near the meteorological tower site. Monitoring was first conducted from July 13 to 18, 1977. The second monitoring period began on November 10, 1977. The final monitoring program was conducted from April 23 to 28, 1978.

During each monitoring period, 24-hour suspended particulate concentrations were determined with a standard high-volume air sampler (EPA reference method) fitted with a constant flow controller (+1 cubic foot per minute); 24-hour sulfur dioxide concentrations were determined by the West-Gaeke bubbler method* (EPA reference method), and ozone concentrations were measured continuously with a Bendix 8002 Chemiluminescence Ozone Monitor (EPA equivalent method). During the final monitoring period, 24-hour nitrogen dioxide concentrations were determined by the sodium arsenite bubbler method*, continuous carbon monoxide concentrations were determined with a Beckman CO analyzer (EPA equivalent method), and ambient air grab samples were collected for hydrocarbon analysis. In addition, MINERALS began a suspended particulate monitoring program at the site in September 1977. This program includes collection of 24-hour particulate samples once each week (usually on the weekend) according to a schedule approved by the Arizona Bureau of Air Quality Control for the project site. Monitoring is scheduled to continue to at least September 1978. At a minimum of once each quarter, one of the samples collected by MINERALS will be analyzed for sulfate, nitrate, and lead.

HYDROLOGY

Surface Water

In 1977, one stage gage was established on the Santa Maria River, and gages were established on seven tributaries of the Santa Maria that drain the Anderson property (Figure 2.6-5). The cross sections of the channels were measured (Figures 2.6-6 through 2.6-8) and notes were taken on channel geometry. Rainfall was monitored at each gaging station during the summer and fall of 1977.

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*Bubbler solutions were provided and analyzed by the Arizona Department of Health Services, Bureau of Air Quality Control, under the coordination of Mr. James Guyton, Monitoring Section Manager.

Groundwater

Groundwater hydrology studies were conducted on the Anderson property by Water Development Corporation and Dames & Moore in 1977. The purpose of the studies conducted by Water Development Corporation were to determine feasible sources of surface water and/or groundwater in the vicinity of the property for use in milling operations. During the studies conducted by Water Development Corporation, 4 test holes were drilled and another 24 wells or test holes were examined. Pump tests were conducted on Palmerita Ranch Well No. 2, DC-71, AM-507, AM-516, and AM-28 (Figure 2.6-9). The purpose of the Dames & Moore study was to determine the stability of the ultimate open pit slope. A large number of drill holes were measured for static water level (Table 2.6-15) during this study.

WATER QUALITY

Surface Water

Surface flow in the vicinity of the Anderson property normally occurs for only short periods during and immediately after precipitation. A single brief period of runoff was recorded on the property during the study period; however, personnel were not present to obtain water samples.

Groundwater

Groundwater samples were collected from a total of 10 sources (Figure 2.6-12) representing all of the major geohydrologic units in the vicinity of the Anderson property. These samples were analyzed for redox potential, specific conductance, TDS, pH, Ca, Mg, K, Na, HCO_3, Cl, SO_4, total Fe, soluble Fe, Mn, PO_4, NO_3, CO_3, F, B, Al, As, Cr, Cu, Mo, Ni, Se, V, Zn, SiO_2, and several radioactive trace constituents.

BIOLOGY

Biological field studies were conducted on the Anderson property and in the vicinity of the proposed access road and Palmerita Ranch water pipeline in 1977. The line intercept method was used to measure vegetation cover and composition of shrubs, forbs, and grasses. The density of forbs and grasses was measured by the use of square meter quadrats placed along each line intercept. The point-center quarters method was used to measure absolute density and dominance of large shrubs, trees, and cacti at six sample sites. Ten 100-point intercepts were read in upland areas to measure percent relative composition and cover.

Four rectilinear drop-trap grids were used to sample reptiles. Birds were surveyed seasonally along six transects. Small mammals were sampled in the fall and spring using the modified Calhoun method. Seven sample sites were established in the area (Figure 2.8-1). Four of these sites coincided with the drop-trap grids. Two parallel traplines were established at each site. The relative abundance and population trend data for rabbits and other intermediate-sized mammals was obtained by using the roadside spotlight method (Lord, 1959). This census was conducted for three consecutive nights during April, June, and October, 1977. Deer were sampled by noting evidence of tracks and pellet groups along bird transects. Other mammals such as predators and bats were noted by sightings and evidence of sign (burrows, scat, tracks, etc.) during general reconnaissance of the Anderson property.

RADIOLOGICAL CONSIDERATIONS

The following radiological sampling programs were conducted on the Anderson property:

- atmospheric radon-222 concentrations
- radon-222 daughter analysis
- subsurface radon measurements
- integrated gamma radiation
- radionuclide content of sediments, water, vegetation and soils

Air samples were collected for two periods of two hours each at roughly 24-hour intervals at the meteorological tower located near the center of the ore body and five satellite locations (Figure 2.9-1). The samples were analyzed for radon-222 content within 48 hours of collection.

Airborne particulate samples were collected at the meteorological tower and four satellite locations (Figure 2.9-1) in 1977. The satellite stations were sampled sequentially and no station was sampled more than once. A total of five samples were collected in July 1977 at the meteorological tower. All samples were analyzed for total particulates, thorium-230, radium-226, and lead-210.

The relative emanation of radon from the Anderson property was determined by use of track etching analyses of alpha-sensitive photographic films mounted in inverted styrene cups (radon cups) and buried two to three feet below the surface of the ground at 20 locations (Figure 2.9-1). Two cups were buried at each location. These cups were not disturbed again except to remove one of the cups after three months and the other after six months.

Total natural background ionizing radiation from all sources (air, water, and cosmic radiation) was measured on the property by means of thermoluminescent dosimetry. Special weatherproof TLD packets containing three high-sensitivity fluoride chips were placed at some of the same locations as the radon cups to monitor the general ionizing radiation in the area (Figure 2.9-1). Two TLDs were placed at each selected location. One was collected after three months and the other was collected after six months.

The groundwater samples described above were sampled for the following radioactive constituents: total uranium, radon-222, radium-226 and -228, thorium-228, -230, and -232, gross alpha, and gross beta.

A total of 19 sediment samples were collected along the drainage channels on the Anderson property (Figure 2.9-1). These samples were analyzed for uranium-238 and six of its 14 daughters (uranium-234, thorium-230, radium-226, lead-214, bismuth-214, and polonium-210). In addition to these isotopes, the samples were analyzed for thorium-232 and its daughter, lead-212, gross alpha, gross beta, cesium-137 (a fallout product), and potassium-40.

Vegetation samples were collected at 11 locations encompassing the area exposed to the ore deposits on the property (Figure 2.9-1 and Table 2.9-7). These samples were composited and analyzed for total uranium, gross alpha, gross beta, potassium-40, beryllium-7, lead-214, bismuth-214, ruthenium-103, niobium-95, zirconium-95, cesium-137, and cerium-144.

Two jackrabbits were collected for radionuclide analyses. Both total biomass and skeletal tissue was analyzed for total uranium, gross alpha, gross beta, potassium-40, lead-212, lead-214, lead-210, radium-226, cesium-137, thorium-230, and thorium-232.

CULTURAL RESOURCES

MINERALS contracted the Museum of Northern Arizona to conduct a historical and archaeological survey of approximately 9500 acres in portions of T11N, R10W and T11N, R9W. This survey included all of the land to be disturbed by the proposed mining and milling activities (Figures 2.3-1). Approximately 15.5 percent of the 9500 acres was surveyed. This survey included 12 randomly located transects generally one mile long by 1000-meters wide and examination of specific areas that could potentially contain cultural sites.

MINERALS also contracted the museum to conduct a paleontological survey of 11,840 acres that included the Anderson property.

The University of Arizona was contracted to conduct an archaeological survey of the proposed access road.

5.4 OPERATIONAL MONITORING

Figures 3.1-2 and 3.2-1 and Tables 5.4-1 through 5.4-5 show type, frequency, and location of all in-plant and environmental monitoring. All areas where radiation, dust, or other hazards may exist have been included in the in-plant monitoring program. The number of samples, locations of monitoring points, and type of sampling have been derived from experience and planned metallurgical activity in the area. If any problems develop during operations, the monitoring program will be intensified as needed and modifications will be made as necessary to adhere to the ALARA philosophy.

Environmental monitoring locations, types, and sample frequencies have been designed to determine incremental changes in ambient background concentrations. Stack monitoring programs were designed to comply with state and federal regulations and where potential radionuclide emissions may occur.

SAMPLING METHODS

Water

Samples will be taken at a site which is representative of the water being sampled. Care will be taken to avoid sample contamination. The samples will be stored in a manner that ensures that the constituents to be analyzed for are not altered during storage.

Table 5.4-1. IN PLANT AMBIENT AIR MONITORING PROGRAM

Sample Location [(a)]	Sample Description	Frequency	Sample Type	Total-U	Rn-222 [(b)]
Ore Pad	Traversing Pad	Monthly	(1)	X	X
Ore Receiving	Traversing Area	Monthly	(1)	X	X
Leach Area	Traversing Area Around Leach Tanks	Monthly	(1)	X	X
Leach Operator	Personnel Sampler	Quarterly	(2)	X	
C.C.D.	Traversing Upper Level	Monthly	(1)	X	X
C.C.D. Operator	Personnel Sampler	Quarterly	(2)	X	
Solvent Extraction	Traversing SX Area	Monthly	(1)	X	X
Solvent Extraction	Personnel Sample	Quarterly	(2)	X	
Precipitation	Traversing Precipitation Area	Monthly	(1)	X	X
Uranium Concentrate Dryer	Traversing Upper Level	Monthly	(1)	X	X
Uranium Concentrate Dryer	Traversing Middle Level	Monthly	(1)	X	X
Uranium Concentrate Packaging	Traversing Lower Level	Weekly	(1)	X	X
Uranium Concentrate Operator	Personnel Sample	Quarterly	(2)	X	
Maintenance Operator	Personnel Sample	Quarterly	(2)	X	
Laboratory	Traversing Laboratory	Quarterly	(1)	X	X
Wash & Tire Pad	Traversing Area	Annually	(1)	X	X
Administration Building	Traversing Area	Quarterly[(c)]	(1)	X	X
Garage & Shop	Traversing Area	Quarterly[(c)]	(1)	X	X
Warehouse	Traversing Area	Quarterly[(c)]	(1)	X	X
Change Room	Traversing Area	Quarterly[(c)]	(1)	X	X

Sample Types
(1) High volume (1-5 minutes)
(2) Personnel Breathing Zone Samples (2-8 hours)

(a) See Figure 3.1-2 for locations.
(b) Radon will be sampled using the standard method.
(c) Ref. - Bureau of Mines
Annually after 1st year's quarterly data.

Table 5.4-2. OTHER INPLANT MONITORING

Sample Location	Environmental Parameter	Sample Frequency	Measurement
Mill & Mainten-ance Employees	Beta Gama (TLD)	Monthly	Beta Gamma
Air Sample Locations (See Table 5.4-1	Beta Gama (Survey Meter)	Semi-annually after 1st year's quarterly data	Beta Gamma
Ore Area Composite Leach and CCD Composite Uranium Concentrate Composite	Air	Semi-annually	Uranium Ra-226 Th-230

Table 5.4-3. ENVIRONMENTAL MONITORING PROGRAM

Environmental Parameter	Sample Location	Sample Frequency	Measurement
Surface water (Santa Maria River)	2 locations - See (Fig. 3.2-1)	Semi-annually	Ra-226, Th-230, Pb-210, Po-210, U. Chemical, Water Level
Tailings Impound-ment	1 location (Fig. 3.2-1)	Quarterly Semi-annually	Ra-226, Th-230 Pb-210, Po-210, U. Chemical, Water level
Groundwater	6 locations (Fig. 3.2-1)	Semi-annually following 1st year's monthly data and 2nd year's quarterly data	Ra-225, U, pH Pb-210, Po-210
		Annually	Th-230 Chemical
Groundwater (Tailings Impoundment)	6 locations (Fig. 3.2-1)	Quarterly following 1st year's monthly data	Ra-226, U, pH Pb-210, Po-210
		Annually following 1st year's quarterly data	Th-230 Chemical*
Air	4 locations (Fig. 3.2-1)	Sampled on 6 day cycle where power is no prob-lem, 6 day cycle for 1 month each quarter where power is a problem	Particulates, Ra-226, U, Th-230, Pb-210, Po-210
Air	4 locations (Fig. 3.2-1)	Annually after 1st year's quar-terly data, 48-hour integrated sample/quarterly	Rn-222
Meteorological	(Fig. 3.2-1)	Continuous	Wind Speed, Wind Direc-tion, Tem-perature, Pressure, Humidity, Precipitation
Beta Gamma	4 Air Monitor locations - See (Fig. 3.2-1)	Continuous (Read quarterly)	Gamma Beta
Soils	5 locations (Fig. 3.2-1)	Annually	U, Ra-226, Th-230, Pb-210, Po-210
Vegetation	5 Soil Sample locations, See (Fig. 3.2-1)	Annually	U, Ra-226 Th-230, Pb-210, Po-210
Mammals	Composite Re-stricted Area, Composite Unre-stricted Area	Annually	U, Ra-226 Th-230, Pb-210, Po-210

*Parameters included in Chemical Analysis are listed below:

pH	Alkalinity	Silica	Chromium
Temperature	Hardness	Zinc	Chloride
Total Dissolved Solids	Sulfate	Manganese	CCD
Total Suspended Solids	Lead	Nickel	Nitrate (as N)

Arsenic	Aluminum	Potassium
Boron	Redox Potential	Copper
Phosphorus	Mercury	Cadmium
Fluoride	Selenium	Vanadium
		Sodium

Table 5.4-4. STACK MONITORING PROGRAM

STACK DESCRIPTION	FREQUENCY	PARAMETERS							
		PARTICULATES	U	Ra-226	Rn-222	Th-230	H_2SO_4 MIST	NH_3	HYDROCARBONS (TOTAL)
Ore Receiving (Stack No. 1)	1	X	X	X	X	X			
Leach Area (Stack No. 2)	1	X	X	X	X	X			
Uranium Concentrate Precipitator Centrifuge, Dryer, Packaging Room (Stack No. 3)	1	X	X	X	X	X	X		
Laboratory (Stack No. 4)	1	X	X	X	X	X	X		
Boiler (Stack No. 5)	1	X							X*

(1) FREQUENCIES: Periodically after first year's semi-annual sampling.

*Includes SO_2

Table 5.4-5. ANALYTICAL SENSITIVITY OF RADIOLOGICAL PARAMETERS

Medium	Parameter	Sensitivity	Approximate Sample Size	
			Inplant	Environmental
Water	Ra-226	0.05 pCi/l	4 liters	4 liters
	Th-230	0.01 pCi/l	4 liters	4 liters
	U	5 μg/l	4 liters	4 liters
Air	Ra-226	9×10^{-5} pCi/m^3	300 m^3	300 m^3
	Th-230	5×10^{-5} pCi/m^3	300 m^3	300 m^3
	U	6×10^{-5} pCi/m^3	1 m	300 m^3
	Rn-222	0.02 pCi/l*	10 liters	50 liters
Soils	Ra-226	0.05 pCi/g (dry)	--	200 g
Vegetation and Mammals**	Th-230	0.01 pCi/g (dry)	--	200 g
	U	0.05 μg/g (dry)	--	200 g

*Kusnetz Method 0.5 pCi/l
**Mammals sample size = 200 g

Air

High volume air samples (500 to 2000 liters/minute) will be used to collect airborne particulates. The sampling time will be two or three minutes for in-plant samples used for exposure analysis and two to six hours for environmental samples. The filter paper will be preweighed and then weighed again after sampling is completed. The particulate concentration will be calculated from the weight gain (after 24 to 48 hours in a desiccator) divided by the sample volume. The filter will be dissolved and analyzed using an approved method.

A light-weight, battery-operated low volume sampler (1 to 20 liters/minute) that can be attached to an employees' clothing and operated for 4 to 8 hours will be used to monitor personnel breathing zones. The filter will be dissolved and analyzed using an approved method. Good industrial hygiene methodology will be employed throughout the sampling period.

Radon samples taken in the mill will be collected and analyzed using the standard Kusnetz method. This method is described in Volume 2, Appendix 3, page 137 of Controlling Employee Exposure to Alpha Radiation in Underground Uranium Mines. Environmental radon samples will be collected in a plastic or nylon bag with a pump using a sampling rate of 0.5 to 2 liters/minute. The sample duration will be approximately 48 hours. Radon will be analyzed using a scintillation cell, as described in Standard Methods (1975).

Soil

A composite soil sample will be collected on 10-foot centers from a 900-square foot area at each of the locations shown in Figure 3.2-1. The surface sample will be cleaned of roots and rocks, dried, pulverized, blended, and analyzed using an accepted method.

Vegetation

Vegetation samples will be collected in the same areas as soil samples. Species that are relatively abundant and/or play an important role in the food chain will be sampled.

Animals

Approximately 200 grams of small mammals will be collected within the restricted area and a similar amount in the unrestricted area. The mammals will be washed, frozen, and stored until a sufficient number have been collected for analysis. They will then be dissolved and analyzed using an accepted method.

RECORDING PROCEDURES

Each sample collected for environmental monitoring will be labeled with the following information:

- Designation or location
- Date and time of collection
- Sample type

In addition to this information, a sample data sheet containing the following information will be filled out.

- Sample designation or location
- Sample date and time of collection
- Sampled by
- Analysis required
- Date sent to laboratory
- Weather data (wind speed, direction, temp., etc.) (this information will be included when applicable)
- Comments

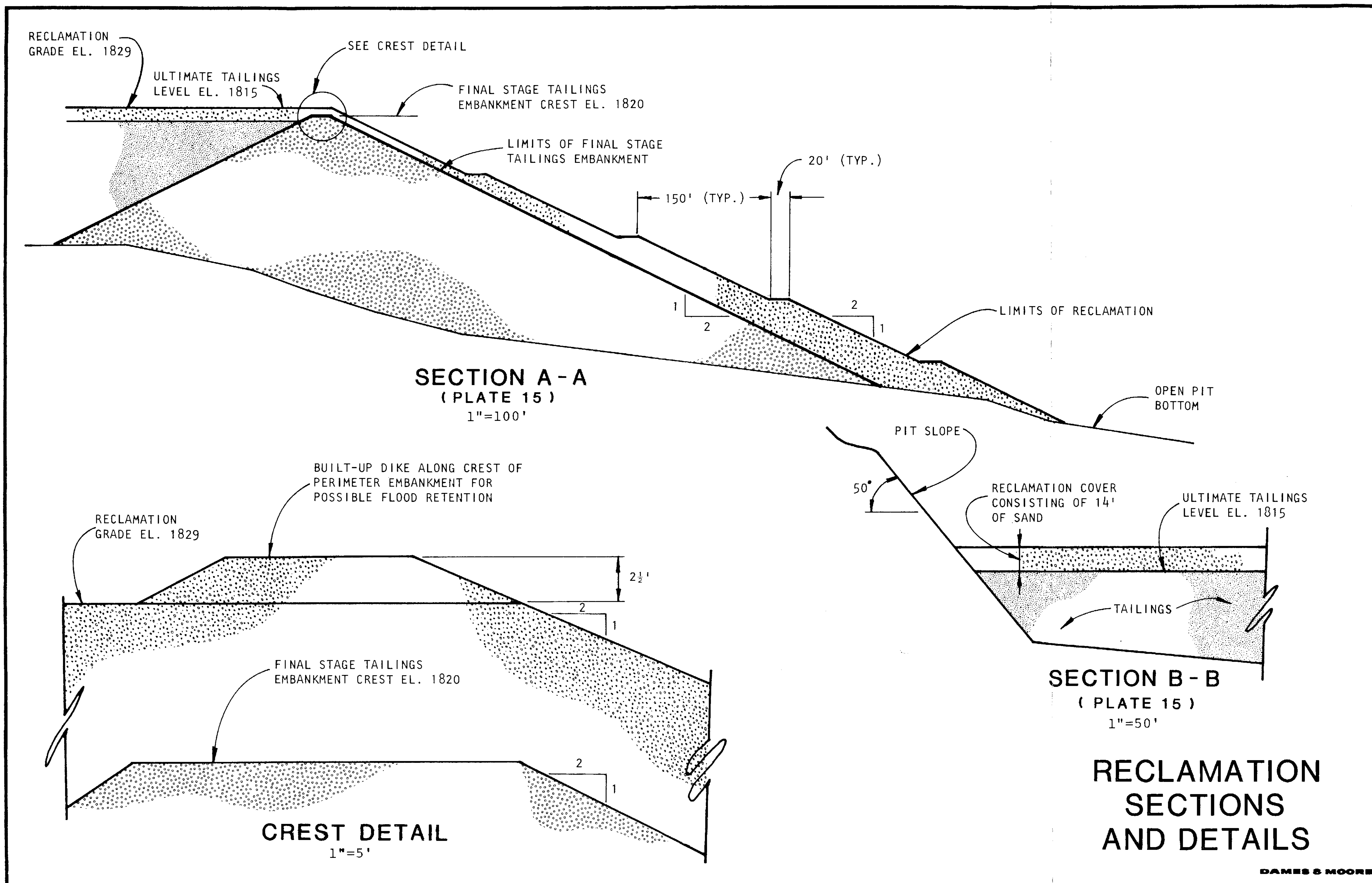
RECLAMATION GRADE EL. 1829
SEE CREST DETAIL
ULTIMATE TAILINGS LEVEL EL. 1815
FINAL STAGE TAILINGS EMBANKMENT CREST EL. 1820
LIMITS OF FINAL STAGE TAILINGS EMBANKMENT
20' (TYP.)
150' (TYP.)
1
2
2
1
LIMITS OF RECLAMATION
SECTION A-A
(PLATE 15)
1"=100'
OPEN PIT BOTTOM
PIT SLOPE
50°
BUILT-UP DIKE ALONG CREST OF PERIMETER EMBANKMENT FOR POSSIBLE FLOOD RETENTION
RECLAMATION GRADE EL. 1829
2½'
2
1
RECLAMATION COVER CONSISTING OF 14' OF SAND
ULTIMATE TAILINGS LEVEL EL. 1815
TAILINGS
FINAL STAGE TAILINGS EMBANKMENT CREST EL. 1820
2
1
SECTION B-B
(PLATE 15)
1"=50'
CREST DETAIL
1"=5'
RECLAMATION SECTIONS AND DETAILS
DAMES & MOORE

Figure 5.2-1.

6.0

UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

HYDROLOGY

Dewatering of the mine and the use of groundwater for the mill process will result in the drawdown of local aquifers. If water is obtained from wells in the alluvium of the Santa Maria River at Palmerita Ranch, drawdown in the main channel of the river would be less than two feet in that portion of the stream nearest to the source well. After project termination, recharge of this aquifer should return to normal within a short period of time. If water is obtained from wells in the sandstone and conglomerate of Section 16, T11N, R10W, a pumping water level of approximately 1250 feet would result. It is expected that recharge of the affected aquifer would be insignificant; consequently, water withdrawn from this location would be essentially mined. The radius of influence from wells located in Section 16 would not be greater than about 1.5 miles. Consequently, withdrawal of water from this location should have no significant effect on springs or other users in the area.

BIOLOGY

Implementation of the proposed project will result in the removal of approximately 1000 acres of vegetation with a concomitant loss of wildlife. While revegetation will establish biotic communities on some distrubed land within a few years, it is likely that mature native plant communities will not become established for 100 to 150 years.

AESTHETICS

When in full operation, mining will create a large open pit that will continually change in size and shape over the life of the proposed project. The pit will have relatively straight lines and angular forms and will be somewhat lighter in color than the surrounding landscape. Since the pit will be at surrounding topographic relief, it will not be readily visible. However, it should dominate the natural landscape in views that include it.

7.0

ENVIRONMENTAL EFFECTS OF ACCIDENTS

The potential for accidents at the proposed mine and mill will be minimized through proper design, manufacture, and operation. A quality control program will also be designed to establish and maintain safe operations. Notwithstanding these safeguards, some potential does exist for accidents that may result in environmental impacts. These accidents may include fires, spills, failure of air pollution control equipment, loss of utilities, boiler explosion, and natural disasters. The probability and severity of each type of accident has been subjectively determined through an objective review of available industry data and information, and experience (Table 7.0-1).

MILL

Fires

Solvent Extraction Circuit. Approximately 125,000 gallons of kerosene are contained in the solvent extraction circuit. This kerosene represents the greatest potential for a serious fire at the project site.

It is possible for the kerosene to catch fire, releasing a heavy black smoke containing carbon soot and some natural uranium. The solvent

Table 7.0-1. POTENTIAL FOR ACCIDENTS AT THE ANDERSON PROJECT SITE

Type of Accident	Probability*	Severity**
FIRES		
Solvent Extraction Circuit	2	4-5
Storage Areas	3	4
PROCESS LEAKS		
Piping	5	1
Tanks	3	3
Impoundments	2	5
TAILINGS RELEASE		
Dam Failure	1	5
Line Failure	3	5
UTILITY LOSS		
Equipment Shutdown	5	2
Process Overflows	5	1-2
SCRUBBER FAILURE		
Partial	4	2
Complete	3	3
BOILER EXPLOSION	1	5
NATURAL DISASTERS		
Winds	3	3-4
Floods	1	4-5
Seismic	1	4-5
OTHER ACCIDENTS		
Chemical Releases	4	2
Ammonia Releases	4	3
Operator Error	5	2-3
Industrial Accidents	5	1-5

Table 7.0-1. (Concluded)

*Probability Scale

1. Improbable - recognized, but not reasonably expected to occur.
2. Possible - not expected to occur, but planned for.
3. Rare - may occur once or more during the operating life of the facility, but under extreme or unusual conditions.
4. Infrequent - expected to occur more than once during the operating life of the facility.
5. Frequent - expected to occur during normal operations.

**Severity Scale

1. Trivial - requires operator/supervisory review and/or minor adjustment - no impact.
2. Minor - requires supervisory review and instructions to correct - no impact.
3. Significant - requires management notice and reporting, supervisory instructions to correct - may have plant area impact.
4. Serious - requires management notice and instructions to correct - potential limited impact to local environment.
5. Major - requires management and regulatory agency notice. Explicit instructions to correct impacts, if any.

extraction building will be equipped with an automatic sprinkler system capable of containing a fire in one of the process tanks before other tanks are compromised. The smoke generated by the fire would be released to the atmosphere through the air vents in the top of the building.

Since the project is located in a remote area, such a fire is not expected to cause significant environmental impacts. The short-term release of smoke, soot, and unburned hydrocarbons would decrease air quality within the immediate vicinity of the plant, but these effects would be short-term in nature. The uranium carried in the soot could be dispersed over the same area as the smoke but it would contain very low levels of radioactivity.

In a documented case of an actual fire in a uranium solvent extraction unit, the area around the burned building was sampled at distances of 100 feet and 1/4 mile. No detectable uranium was found.*

Any fire in the solvent extraction system would most likely be caused by human carelessness rather than by spontaneous or process-related incidents. To avoid these kinds of accidental fire, the following precautions will be taken:

- Smoking by personnel will not be permitted.
- Welding will be allowed only by special authorization.
- No open fires will be permitted.

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*Mill Superintendent, Petrotomics, personal communication to Humble Oil and Refining Co., 1971.

- Hazard warnings will be posted.
- Maintenance will be performed only after the responsible supervisor certifies that it can be done safely.
- Tanks will be instrumented to prevent overflows.

The estimated maximum probability of such an occurrence is one fire per 200 years of operation. The probability that a fire would produce a significant environmental impact is negligible. There have been two fires of this type in other mills, both of which were caused by maintenance errors that could have been prevented with proper planning.

Storage Areas. Fires originating in reagent storage areas are unlikely to cause significant radiological hazards unless allowed to propagate and spread. Reagents will be segregated from other mill facilities and enclosed in diked areas where spills and subsequent flame propagation can be contained and controlled. Flammable materials stored outside will also be segregated from other mill facilities; consequently, they pose no abnormal hazards. Fires in any of the storage areas would have a negligible environmental impact.

Process Leaks

Piping. Minor leaks may occur in the mill circuit piping. Since the mill is completely self contained, the possibility of liquid loss from the plant is highly unlikely. An entrapment basin will be provided to preclude loss of liquid spills from restricted areas. A leak in exposed piping would be quickly detected and corrected. Any spilled process liquids would be promptly cleaned up.

Tanks. All tanks, pump boxes, and sump wells in the plant will be contained within diked or enclosed areas to preclude discharge to unrestricted areas. Leaks from these facilities would be quickly detected during the normal course of operations and repairs would be made as needed.

Massive rupture of any tankage would cause local plant damage and/or contamination which would have to be cleaned up and decontaminated in accordance with Annex A, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for Byproduct, Source, or Special Nuclear Material (NRC, 1976).

As discussed above, outside storage facilities will be enclosed in diked areas which will minimize the impact of accidental discharge of fluids.

Tailings Release

Dam Failure. The probable accidents relating to a tailings dam failure are discussed in detail in the Design Report: Proposed Tailings Impoundment - Anderson Uranium Project (Dames & Moore, 1978). Dam failure would most probably be caused by the overflow of tailings and/or wastewater, breaching by flood water, a destructive earthquake, or structural failure. Dam design and the geologic nature of the dam site are considered to have reduced the probability of dam failure due to any one or a combination of these events to a very low level. In the event that the dam does fail, the discharge would be channeled into open pit areas where it would be contained. At any given time during the life of the project, these areas will have the capacity to contain the maximum volume of the tailings impoundment.

Environmental impacts resulting from a dam failure are considered negligible primarily due to the containment of any discharge. Some seepage into permeable strata in the pit walls could occur. However, the only aquifer in the area is used solely for drilling water. In addition, radionuclide migration due to absorption is not expected to occur beyond an area within tens of feet of the open pit.

Pipeline Failure. The tailings discharge line will be pressurized and located above a trench designed to accept the maximum capacity of the line. This trench will direct any leakage or loss to drainages that lead to the tailings impoundment. The tailings dam and pipeline will be periodically checked during each operating shift.

Utility Loss

Equipment Shutdown. Temporary loss of water or power to the mill could cause a scrubber or ventilation equipment to fail. The drying and packaging room scrubber system will have water and power interlock systems that will shut down the dryer and minimize the amount of emissions in the event of water or power loss.

A prolonged loss of electrical power is considered unlikely since diesel generators will supply emergency power to the mill. Failure of the standby generators during a prolonged power outage would leave the mill without power but is considered extremely unlikely. A prolonged water loss is also considered unlikely as water is available from a number of sources on the property. Loss of ventilation for prolonged periods of time would require evacuation and/or special work procedures to be implemented in the affected areas.

Process Overflows. Loss of power would cause some pump boxes, and under worst-case conditons, portions of the leach, countercurrent decantation, and solvent extraction circuits to overflow. Since all of these areas are contained within dikes, cleanup and/or decontamination would proceed on a routine basis when power returned.

Scrubber Failure

Partial Failure. The failure of various mechanical components of the scrubber assembly could result in less than maximum operating efficiency of the equipment. Failures would be detected through process instrumentation, direct observation, ammonia fumes, and heat buildup. Corrective action would be partly automatic through the instrumentation interlock system which shuts down the dryer. Additional monitoring surveys would be taken to assess the extent of the impact on the plant and the environment. The measurable effects of a scrubber failure are expected to be limited and well below permissible emission standards.

Complete Failure. The same analysis holds true for complete failure. However, failure of the interlock devices would extend the period of emissions until the operator took corrective action. Extensive monitoring and cleanup might be required depending on conditions prevalent at the time of failure.

Boiler Explosion

The principal hazards connected with a boiler explosion would be fires and rupture of piping or tanks. The consequences of these accidents are described in the above discussions on fires and process leaks.

Natural Disasters

Winds. Strong winds and localized storms occur periodically in the project area. Severe winds could cause wave action in the tailings pond and release fugitive dust from inactive areas. The tailings dam face will be protected from erosion due to wave action by a method such as riprap. Fugitive dust could spread some radioactive material, but it would be minor in nature and probably not detectable at the air quality monitoring stations that will be established around the project area (refer to Section 5.0).

Floods. Major precipitation which could cause flooding is not expected to cause dispersal of radionuclides off the Anderson property due to design of the facilities and local topographic conditions. However, low level radionuclide discharge from fugitive sources could occur along drainages entering the Santa Maria River.

All drainage from active mining and milling areas which could tend to accumulate surface deposits of radionuclides will be directed to the tailings impoundment. The impoundment freeboard has been designed to contain the runoff from a 100-year storm plus 1.4 times the maximum expected annual precipitation. It should be noted that if a flood should cause a tailings dam failure, the entire discharge would be contained in the open pit areas.

Seismological. The mill and ancillary facilities have been designed to withstand the maximum seismic disturbance probable for the region. Failure of the tailings dam due to seismic activity is discussed in the tailings dam design report (Dames & Moore, 1978).

TRANSPORTATION

The mill product, consisting primarily of uranium oxide, is the only radioactive material expected to be transported from the project site. Based on published accident statistics (NRC, 1977), the probability of an accident involving a truck transporting product from the mill is 1.6×10^{-6} to 2.6×10^{-6}/mile. As discussed in Section 3.0, approximately 930,000 pounds of uranium oxide will be produced from the mill each year. Assuming that the trucks used to transport the product carry an average of about 40,000 pounds (44 drums) per load, then about 23 trips will be made from the mill each year. Assuming that each truck travels an average of 1100 miles (approximate distance between the mill and Oklahoma City, Oklahoma), the potential for accidents involving trucks transporting product ranges from 0.04 to 0.066 accident per year.

Tests conducted by the NRC (NRC, 1977) indicate that an average of only three percent of a truck load of uranium oxide would be spilled in an accident. However, in an actual accident on September 27, 1977, a tractor trailer containing 40,329 pounds of uranium concentrate overturned after a collision, spilling about 30 percent of the load (12,000 pounds) (Mattson, undated). Using the accident probabilities given above, and assuming that 30 percent of the load would be released, approximately 4800 to 8000 pounds of product would be spilled as a result of transportation accidents in 10 years of operation. However, it should be noted that shipping precautions and cleanup contingency plans (refer to following discussion) will be instituted to reduce this potential hazard.

Because most of the radioactive daughters of uranium will have been removed in the extraction process, and because of the very slow regrowth of gamma radiation, the uranium oxide will have a very low level of radioactivity. Under the regulations of the U.S. Department of Transportation, uranium oxide is classified as low specific activity material (49 CFR Part 173, Sections 173.389C and 173.392). In addition, the material has a very high density (approximately 7 g/cm^3) and is not easily dispersed. Because of these physical characteristics and cleanup contingency plans, any uranium oxide spilled as the result of a transportation accident is not likely to result in a significant impact on the environment.

Shipping Precautions

The product will be packed in steel drums to a net weight of approximately 900 pounds prior to shipment. The drums will be sealed and marked with the standard symbol for radioactive material. The vehicles transporting the product will also be properly marked.

MINERALS will prepare written procedures for shipping the product. These procedures will require product shipments to be in compliance with applicable state and federal regulations.

Product Recovery

In response to the September, 1977 uranium concentrate shipping accident, several proposed cleanup contingency plans have been developed. The American National Standards Institute, Inc. issued a proposed American National Standard titled Agency Responsibilities & Emergency Procedures for Highway Transportation Accidents Involving Radioactive Materials in May, 1978. The Atomic Industrial Forum submitted a draft transportation accident response guide for uranium ore concentrate shippers and transporters to the uranium industry for review in July, 1978. While the U.S. Department of Transportation has not developed specific requirements for such contingency plans, it is expected that they will do so shortly. MINERALS intends to comply with all industry standards and federal regulations concerning uranium concentrate cleanup in the event of a transportation accident.

OTHER ACCIDENTS

Other mishaps such as overflows from process tanks, chemical explosions, fires, or large spills of reagents such as sulfuric acid or kerosene are credible accidents that may occur in uranium mill operations, as in any chemical process industry. All reagents are stored within diked areas. Spillage in the mill will be washed down and pumped back into the mill circuit.

The environmental effects of these types of accidents will be confined to the plant site, and the probability of the accidents' having any significant effect on the off-site environment is negligible.

Explosives used in mining operations will be stored in a special, isolated powder magazine. If the magazine were accidentally detonated, the resulting explosion would be extremely violent. This explosion would create a crater at the magazine site and considerable dust, as well as destroy vegetation and wildlife in the immediate vicinity. Because of the isolated location of the magazine, injury to project personnel or damage to the pits, equipment, and mill facilities is unlikely.

8.0

ECONOMIC AND SOCIAL EFFECTS OF MILL CONSTRUCTION AND OPERATION

8.1 BENEFITS

The Anderson uranium mill is expected to have an annual average production rate of about 930,000 lbs./year of uranium oxide for its 10-year economic life. Based on an assumed selling price of $43/lb., a 10-year mill life, and a discount rate of 12 percent, the present worth of uranium oxide production from the Anderson project is about $226,000,000.

Uranium production in Arizona is currently quite small compared to the traditional uranium-producing states of Wyoming and New Mexico. The U.S. Energy Research and Development Administration (ERDA) frequently combines Arizona, Colorado, Florida, South Dakota, Texas, Utah, and Washington together in their statistical reports on the uranium industry in the United States. In 1976, these 7 states produced a total of 2642 tons of uranium concentrate (ERDA, 1977). Annual production from the Anderson project (465 tons) would represent about 18 percent of this total and approximately 4 percent of the total United States uranium concentrate production (12,747 tons) for 1976.

The annual average uranium oxide production from the project would also represent approximately 1.63×10^{10} kilowatt-hours of electricity when it is used to make nuclear fuel rods.*

Implementation of the Anderson project will create an average of 98 direct jobs during construction. The total gross wages accruing to construction-related personnel are estimated at $4.35 million over the 21-month construction period. It is anticipated that the majority of the workers will reside in the Wickenburg area.

Operational activities will employ an average of 320 persons directly. These jobs will extend for the 10-year life of the facility and generate annual average wages reaching about $6.94 million.

Both construction and operations will induce secondary service employment. Jobs in this sector will gradually increase between the construction and operational phases of the project, reaching a maximum of 437 when the mine and mill are in full operation. Secondary employment will generate annual average wages reaching about $5.5 million.

The proposed project will generate numerous tax revenues, both directly and indirectly, during its operational life. State income tax will amount to approximately 10.5 percent of the corporate profit on the Anderson project. MINERALS will pay a state ad valorem property tax of $6.797/$100 assessed valuation. A large portion of the ad

*Based on 1.75×10^4 kwh/lb of U_3O_8 (AEC, 1972).

valorem tax revenues will be redistributed to Yavapai County, the Yavapai County Junior College, and Congress School District 17. Part of the funds collected by the Congress School District will be distributed to the Wickenburg schools in the form of tuition payments. MINERALS will also pay a state tax of 2.5 percent on the gross income derived from the mined product and a state sales tax of 4 percent on such items as fuel and maintenance and office supplies purchased in Arizona. If these supplies are purchased in Wickenburg, Phoenix, or most other incorporated cities in the state, MINERALS will pay 1 percent city sales tax as well as the state tax.

In addition to direct taxes on facilities and goods produced, the projects will generate employee-related tax revenues. MINERALS will contribute to the state workman's compensation fund and pay unemployment security tax. Those people moving into the region as a result of the project will pay state ad valorem property tax, state income tax, a state sales tax of 4 percent on most goods other than food, and a sales tax of 1 percent on purchases in incorporated cities.

In total, it is estimated that the proposed project, including direct employees, could result in $4.5 million in state and local taxes each year.

8.2 COSTS

INTERNAL COSTS

Those costs which must be borne internally by the applicant include capital costs incurred during construction, equipment replacement, and operations and maintenance costs which occur throughout the economic life of the project. A summary of estimated capital costs is presented in Table 8.2-1. Total fixed project capital costs are estimated at approximately $64,519,491. Annual operating costs are estimated at $23,331,673 for the 10-year economic life of the project (Table 8.2-2).

EXTERNAL COSTS

Any new demands on public services and facilities in Yavapai County created by the proposed project will be more than offset by property taxes. However, Maricopa County, particularly Wickenburg, is expected to receive the bulk of the project-induced population growth without an equal increase in the tax base.

Capital outlays by the taxing jurisdictions in Maricopa County, particularly Wickenburg and Wickenburg School District 9, would be limited to the expansion of existing buildings and minor additions of equipment. Operating expenditures by Wickenburg will increase as the demand for additional public services increases. Expenditures by School District 9 will increase almost directly in proportion to increased enrollments (much of this increase will be for new teacher

Table 8.2-1. SUMMARY OF ESTIMATED CAPITAL COSTS OF ANDERSON PROJECT*

Mill		
Mill building and systems	$22,485,830	
First stage dam construction	2,118,013	
Dam construction equipment	544,852	
Total mill costs		$25,148,695
Mine		
Preproduction	$14,092,643	
Mine equipment	14,549,596	
Maintenance	3,803,882	
Administration	721,418	
Total mine costs		$33,167,539
Ancillary		
Access road	$2,353,368	
Water supply	1,471,230	
Power supply	2,024,659	
Environmental	150,000	
Communications	204,000	
Total Ancillary costs		$ 6,203,257
Total Fixed Capital Costs		$64,519,491

Source: Morrison-Knudsen, 1978.

*June 1, 1978 costs.

Table 8.2-2. ANNUAL OPERATING COSTS OF ANDERSON PROJECT*

Mill		
Operating	$1,173,955	
Supplies	8,633,152	
Maintenance	1,384,248	
Tailings dam	138,773	
Annual mill operating costs		$11,330,128
Mine		
Preproduction (21 months)		
Operating	$7,366,757	
Support	1,366,031	
Maintenance	667,005	
Production I (4.5 years)		
Operating	$10,192,077	
Support	1,727,865	
Maintenance	657,674	
Production II (4.75 years)		
Operating	$ 8,578,376	
Support	1,364,760	
Maintenance	637,734	
Average annual mine operating costs		$11,251,260
Administration		$ 750,285
Total Project Operating Costs		$23,331,673

Source: Morrison-Knudsen, 1978.

*June 1, 1978 costs.

salaries). These demands for public services will be primarily offset by additional state and local revenues generated by sales taxes, property taxes on housing, utility service charges, and tuition payed by Congress School District 17. Since Wickenburg and School District 9 are not planning any major capital improvements and these jurisdictions are expected to receive project-induced growth in good financial positions, no serious shortage of capital financing should occur.

Although sales tax revenues and user fees should keep pace with population growth and substantial economies of scale will be realized in the operation of Wickenburg's new sewer and water systems, the timing and geographic distribution of tax revenues may lead to some minor front-end financing problems in Wickenburg and School District 9. Past studies have estimated a lag time of three to eight years between public expenditures and future realized uses (Colorado Geological Survey, 1974). In relation to the Anderson project, the critical period will be from early 1979 when the construction work force arrives, to the early 1980's when project-related employment stabilizes and residential and commercial property taxes begin to be collected. Operating costs of Wickenburg and School District 9 are expected to peak in early 1980. Any deficits that may accumulate during construction and early operation of the proposed project should be eliminated in early 1982, assuming a minimum 3 year lag between the arrival of construction workers and the time property taxes are collected. A surplus of revenues will be available to Wickenburg and School District 9 in the following years as a result of property tax revenues from expanded housing. However, Wickenburg and School District 9 may be required to adjust their existing financial structures without external assistance during the critical period to maintain present public service levels.

9.0

THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENCHANCEMENT OF LONG-TERM PRODUCTIVITY

SHORT-TERM USES

The Anderson uranium mill is expected to have an annual production rate of about 930,000 lbs of uranium oxide for its 10-year economic life. Based on an assumed selling price of $43/lb and a discount rate of 12 percent, the present worth of uranium oxide produced from the mill over the life of the project is $226,000,000.

The proposed project will create an estimated maximum of 891 new jobs in Yavapai and Maricopa counties. It would also result in an additional $4.5 million of tax revenues annually to the state, counties, and local governments.

Uranium is the primary fuel used for the generation of nuclear power. It is estimated that the United States will consume 476,300 tons of uranium oxide between 1978 and 1990 (ERDA, 1977). Uranium mills in the country produced a total of only 12,747 tons of uranium oxide in 1976, with a total delivery commitment of 168,000 tons between 1978 and 1990. Based on the projected demand of uranium and the supply produced by existing mills, it is quite possible that a long-term shortage of uranium oxide could develop within the United States in the coming years. The production of uranium oxide from the proposed Anderson project would provide one percent of the country's total estimated requirements for uranium between 1980 and 1990.

LONG-TERM PRODUCTIVITY

Implementation of the proposed project will result in the removal of approximately 1000 acres of vegetation with a concomitant loss of some wildlife. However, lands disturbed by project activities will be reclaimed.

10.0

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Site preparation and mill construction will require the commitment of a variety of building materials and process equipment, as well as commitments of labor, energy, and capital. The dollars invested will be recovered through the sale of uranium oxide produced in the mill. At the end of the project, most of the process equipment and some of the building materials will be salvaged. However, the other resources should be considered irretrievable commitments.

Estimated recoverable reserves now dedicated to the project are approximately 10.3 million pounds of uranium oxide. Exploration on MINERALS' mining claims is continuing, and the possibility exists for the discovery of further reserves.

Approximately 1000 acres of land will be preempted from ephemeral livestock grazing and wildlife habitat over the life of the proposed project. Since mining will be done progressively over a 10-year period, the amount of land preempted each year would be much smaller than this total; more on the order of about 50 to 100 acres annually. Approximately 45 acres of this land will be committed permanently to a new county road. The remainder will be reclaimed.

Milling operations will consume the following amounts of process chemicals per day:

Acid	520 tons	Amine	200 lbs
Chlorate	6 tons	Ammonium nitrate	13 tons
Flocculant	600 lbs	Lubricant (oil and grease)	319 lbs
Glue	200 lbs	Diesel #2 fuel	17,850 gal
Kerosene	470 gallons	Gasoline	218 gal
Ammonia	2380 lbs		
Isodecanol	410 lbs		

In addition, mining and milling will expend energy in the form of electricity.

Implementation of the proposed project will create a maximum of 891 new jobs. Many of the people filling these jobs will relocate from other regions and settle in the Wickenburg area. This influx of people will require the construction of a maximum of approximately 594 new housing units. Besides the commitment of building materials, capital, labor, and energy, the construction of these units will preempt other uses on approximately 160 acres of land.

Community resources in the form of services and public facilities (i.e., police and fire protection, public transportation, education, etc.) will also be committed as a result of this population influx.

11.0

ALTERNATIVES TO THE PROPOSED ACTION

The objectives of the proposed project are to mine uranium ore on the Anderson property and extract the uranium oxide from this ore. This section will present the alternatives considered to meet the stated objectives. The "no action" alternative will also be discussed.

MINING METHODS

Three possible mining methods were considered for this project: underground, in-situ leach, and open pit. The following factors were considered when evaluating each method:

- characteristics of the ore deposit (size, shape, attitude, and depth)
- physical properties and geology of the ore and surrounding rock
- surface water and groundwater hydrology
- economics (grade of ore, mining costs, and desired production rates)
- water and air quality.

The truck and shovel open pit method was selected for this project for a variety of reasons. The open pit method is most effective when an ore deposit is near the surface and there is suitable area for disposal of overburden within economic haul distances. In this case, the ore deposit begins as an outcrop with a variable 7° to 10° dip to the south-southwest with the surface topography rising quite steeply just south of the outcrop. However, approximately 90 percent of the mineable ore within the project boundary can be removed before depth to the ore bed would make open pit methods uneconomical. Also, permanent waste dump areas are available within suitable haulage distances. The degree of inactive faulting in the area has created a number of different ore bed elevations with varying dips. Open pit mining flexibility will allow excellent ore control in this situation. Surface water diversions will be constructed during the course of normal mining operations. Water trucks and sprays will be used to control dust. Groundwater seepage into the pit will be collected and used in the mill.

Underground mining was not selected as the principal mining method because of the poor economics associated with decreased ore recovery.

The in-situ leaching technique was not selected because the lacustrine lake bed ore deposit is nearly impermeable due to clay-size particles in the deposit. This impermeability will not allow effective passage of the leach solutions.

PROCESSING METHODS

There are no existing uranium mills in the vicinity of the Anderson property. Consequently, it is necessary for MINERALS to construct their own mill.

Ore Grinding

In order to effectively leach the uranium ore, particle size must be reduced. This can be done either by impact crushing and then grinding in a rod or ball mill or by grinding in a semiautogenous mill. A semiautogenous mill offers an initial savings in capital cost over the impact crusher/ball or rod mill system. The crusher/mill system is a dry process while the semiautogenous mill is a wet process; consequently, the semiautogenous mill offers a higher degree of dust control. Some uranium ores are not amenable to semiautogenous grinding. However, tests conducted by MINERALS has shown that ore from the Anderson property is suitable for this type of mill. Consequently, a semiautogenous mill was chosen for this project.

Extraction

Uranium can be recovered from ores with either an acid or alkaline leaching system. The leaching system used is largely dependent on the chemical characteristics of the host rock. Tests (A.H. Ross & Associates, 1977) conducted on the ore from the Anderson property have shown that acid leaching results in higher uranium extraction than alkaline leaching, but the use of alkaline leaching results in a significant reduction in reagent costs. Further tests showed the presence of substantial unmanageable quantities of soluble organic material in the liquor from the alkaline leaching system. Consequently, the acid leach process was chosen for the proposed project.

Separation

The uranium bearing leach liquor can be separated from barren tailings by either countercurrent decantation or filtration. Filtration is a difficult process with most ores and can be very expensive. For these reasons, countercurrent decantation was selected for the Anderson project.

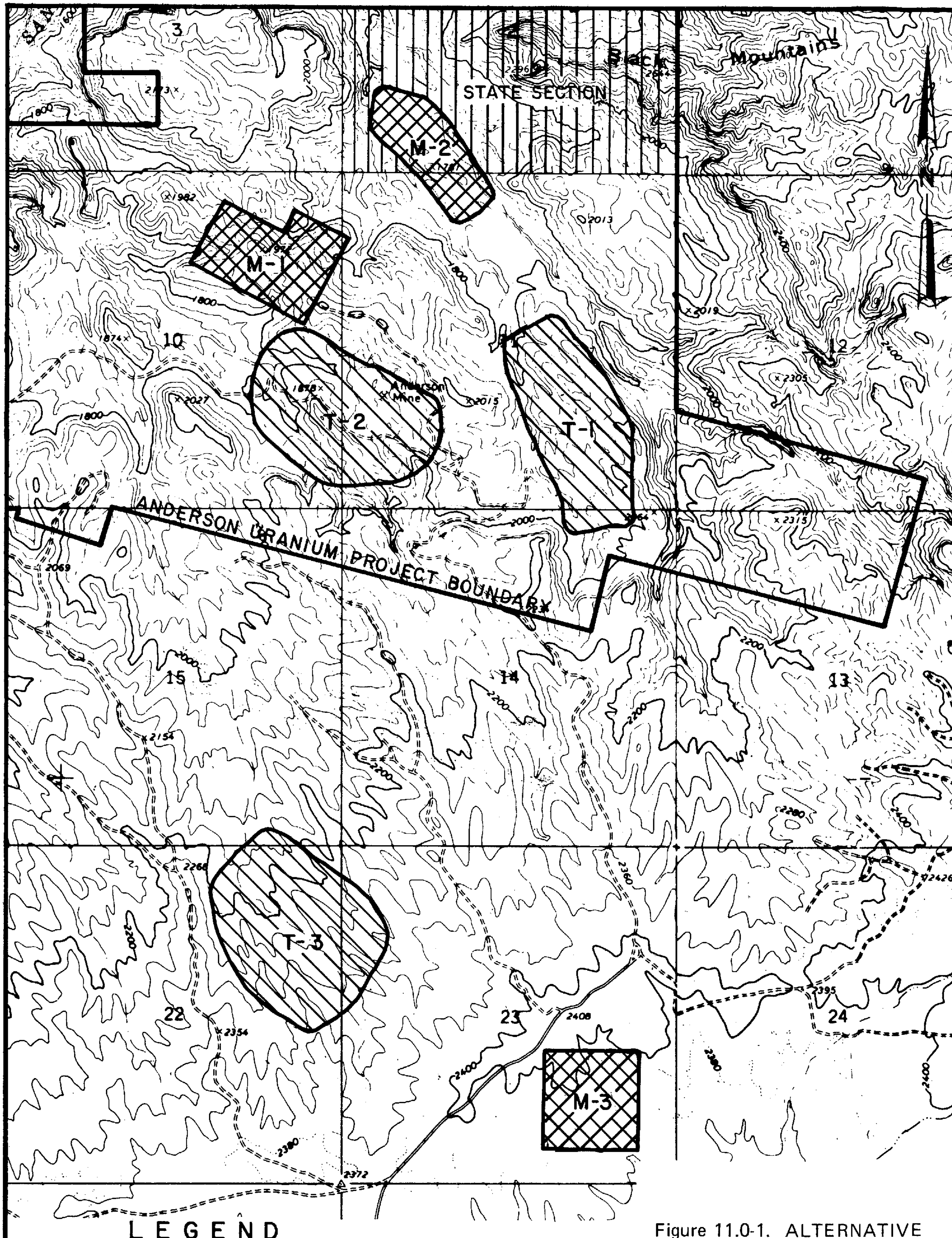
Concentration

The uranium oxide extracted during acid leaching can be concentrated by using either solvent extraction or ion-exchange. Since the solvent extraction system allows continuous automated handling and control, it is simpler than ion-exchange. In addition, due to limited recycling of the solution in the system, ion-exchange uses more water than solvent extraction. Consequently, solvent extraction will be used in the Anderson mill.

LOCATION OF MILL

Three locations were evaluated as possible mill sites (Figure 11.0-1). This evaluation was based on proximity to the proposed mine, topography and access, hydrological features, air quality, biological features, geological characteristics, archaeological and paleontological resources, land ownership, decommissioning, and final reclamation including future monitoring and maintenance, and future mineable ore deposits.

Mill Site No. 1 is located directly adjacent to the mine on a relatively steep, south-sloping andesite flow below the ore zone. The site



L E G E N D

Mill Site

Tailings Disposal Site

Unless otherwise noted all land ownership is BLM

Figure 11.0-1. ALTERNATIVE MILL AND TAILINGS DISPOSAL SITES would require cut and fill modifications to existing topography to accommodate the mill and associated facilities. The andesite and structural fill at this site would have relatively low permeability.

Mill Site No. 2 is located adjacent to a major drainage of the Santa Maria River on granular alluvium below any possible ore zone. The site is approximately one mile from the proposed mine and is relatively flat, allowing for easy construction of the proposed facilities. Soils at Mill Site No. 2 are relatively permeable and the site is located near a drainage. However, proper design of the mill would preclude accidental releases of effluents from reaching the soils.

Mill Site No. 3 is approximately three miles from the mine on a plateau of upper conglomerate. The site is relatively flat, facilitating easy construction of the mill. The upper conglomerate on this site is relatively permeable; however, due to the depth of the groundwater, recharge is relatively minor. Mining claims on this site are not owned by MINERALS; consequently, the extent of mineralization is unknown.

Mill Sites Nos. 1 and 2 are located within the Anderson property boundary. MINERALS has the unpatented mineral claims on federal land and exploration permits on the state land in this area. The mineral claims on Mill Site No. 3 are held by Urangesellschaft, USA.

Two archaeological sites, which appear to be restricted to the surface, were discovered on Mill Site No. 2. No archaeological finds were made at the other two sites. No paleontological finds were made at any of the sites.

Differentiation between the three proposed mill sites on the basis of biological, geological, air quality, decommissioning, and reclamation considerations was not sufficient to facilitate site selection. The composition and productivity of the plant and animal communities at each site were relatively similar. None of the communities are particularly unique in southwestern Arizona and there are no habitats on any of the sites that are more likely to support protected, threatened, or endangered species than other habitats in the region. The area encompassing all three sites is characterized by a relatively large number of small-scale faults which appear to be at least 10,000 to 15,000 years old. These faults were not detrimental in the site selection process since they are considered inactive. Winds at all three sites are sufficient to create relatively thorough mixing; consequently, potential air quality impacts between the sites were expected to be similar. All sites are equally acceptable when considering decommissioning and reclamation with no future maintenance after project termination.

Based on this evaluation, Site No. 1 was selected for the Anderson mill. Mill Site No. 2 was rejected because of the presence of archaeological resources and its proximity to a major drainage of the Santa Maria River. Mill Site No. 3 was rejected because of the excessive haul distance from the mine and because MINERALS does not hold the mineral claims to this land.

TAILINGS IMPOUNDMENT LOCATION

Three locations were also evaluated as possible tailings disposal sites (Figure 11.0-1). These sites were chosen on the basis of their proximity to potential mill sites. The same criteria used for selecting the mill location were used in the tailings disposal area evaluation. Operating safety was also considered in the selection of the impoundment site.

Tailings Disposal Area No. 3 was rejected because MINERALS does not hold the mineral claims to the site.

As was the case with the mill location, differentiation between Tailings Disposal Area Nos. 1 and 2 on the basis of biological, geological, air quality, and reclamation considerations was not sufficient to facilitate site selection. In addition, the two sites could not be differentiated on the basis of seepage. Lacustrine sediments cover most of both potential disposal areas. These sediments contain a high percentage of clay and will therefore act as a natural barrier to seepage from the impoundment.

No archaeological sites were found at Disposal Area No. 2; however, a tool procurement site was found on the west side of Disposal Area No. 1 which would require investigation if that site was selected. Two paleontological sites were discovered at Disposal Area No. 2 and one site was found at Disposal Area No. 1. The paleontological sites were not considered significant enough to salvage and clearance was given for construction in the area (Breed and Billingsley, 1977).

Tailings Disposal Area No. 1 is located near the head of a tributary to the Santa Maria River while Disposal Area No. 2 will be located in a mined-out portion of the pit area. The surface runoff catchment area for both disposal sites is relatively small and a minimum of drainage diversion would be required at either site. However, if the tailings dam were to fail at Disposal Area No. 1, tailings could reach the Santa Maria River and ultimately the Alamo Reservoir. If the tailings dam were to fail at Disposal Area No. 2, the tailings would be contained within the pit area.

During operations, overburden will be backfilled against the downstream face of the dam at Tailings Disposal Area No. 2. This will increase the factor of safety for the dam. In addition, the backfill will eliminate the need for recontouring or placement of more overburden to prevent erosion of the downstream face after project termination. Consequently, the use of Disposal Area No. 2 will facilitate decommissioning.

Tailings Disposal Area No. 2 was selected over Disposal Area No. 1 for the following reasons:

- no archaeological resources are present in the area
- the site facilitates construction of a tailings dam with a high factor of safety
- accidental releases of effluents from the impoundment would not reach the natural environment
- the site facilitates decommissioning.

TAILINGS MANAGEMENT

Tailings management consists of disposing of the tailings or solid waste and waste leach solutions. The following management plans were considered for the proposed project:

- Tailings impoundment with natural foundation
- Tailings impoundment with clay liner
- Tailings impoundment with synthetic liner
- Slurry pipeline to mine pit
- Tailings impoundment in specially excavated pit
- Settling pond, evaporation pond, and dry transport to mine pit
- Liquids/solids separation, evaporation, and solids disposal

Tailings Impoundment with Natural Foundation

As discussed in Section 3.0 and above, the tailings impoundment will be located in a mined-out portion of the pit area. The bottom of the impoundment will consist of lacustrine sediments at least five feet thick. Laboratory tests indicate that approximately five feet of these sediments in-place will have a permeability no greater than 2×10^{-6} ft/min (Dames & Moore, 1978).

A seepage analysis was conductd by Dames & Moore (1978) on an impoundment design using in-place lacustrine sediments for the impoundment liner and the same sediments for the dam core. Results of this analysis show that seepage through the bottom of the impoundment would be about 2 gpm. Seepage through the dam would be approximately 3 gpm.

The uranium oxide to be mined is also contained in lacustrine sediments. The tailings produced from this ore will be fine, with 41 percent by weight passing the #200 sieve and 35 percent passing the #400 sieve. These fine tailings will also help seal the bottom of the impoundment against seepage.

Tailings Impoundment with Clay Liner

Since the natural foundation of the proposed tailings impoundment consists primarily of clay with a very low permeability, this management method was rejected.

Tailings Impoundment with Synthetic Liner

This management alternative would consist of installing a 20 mil PVC liner on top of the natural clay bottom of the tailings impoundment. This liner would reduce seepage to zero unless it was punctured by rock or torn by differential settlement. Extreme care must be taken in placing the liner to avoid tears or punctures. No information exists as to the long-term durability (e.g., 100 years plus) of synthetic liners. The use of a synthetic liner was rejected due to the difficulty of installing it and its high cost relative to the minor reduction in seepage achieved by its use.

Slurry Pipeline to Mine Pit

In this alternative, the ore body would be mined so that a depression is created that is large enough to contain the tailings from the mill. Due to a combination of the dip of the ore bed and the topography of the area, a large portion of the ore would have to be left in place as a tailings dam. This alternative was rejected because it would require leaving a large amount of ore in the mine, making the proposed project economically unfeasible.

Tailings Impoundment in Specially Excavated Pit

In this management alternative, the tailings would be discharged to a pit excavated in a nonmineralized area. The pit would cover approximately 175 acres and it would be about 40 feet deep. Due to topography, mineralization, and land ownership, the only location identified for such a pit that was close enough to the mill to facilitate tailings transport on a cost-effective basis was in a major drainage channel to the Santa Maria River (Mill Site No. 2). This alternative was rejected due to the high cost of excavating the pit. In addition, a liner would be required to prevent seepage from the pit entering the adjacent drainage.

Settling Pond, Evaporation Pond, and Dry Transport

In this alternative, the tailings slurry from the mill would be discharged to a partitioned settling pond. The tailings in each cell of the pond would be allowed to settle and "free" water in the slurry would be decanted into an evaporation pond. After the tailings dried, they would be dumped in a mined out portion of the pit that had been backfilled to above the water table. Since the tailings would be dry, there would be no need to line the impoundment in the mine pit. This management alternative would require approximately 225 acres in addition to the pit area used to impound the dry tailings.

The proposed project is located on a relatively small area of land due to rugged terrain and land ownership. It would be extremely difficult to find a large enough area within the Anderson property to construct the settling and evaporation ponds needed for this tailings management plan.

This alternative method would also create an additional exposure pathway to workers since it would potentially require handling dry tailings during windy conditions. For these reasons, the alternative was rejected.

Liquids/Solids Separation, Evaporation, and Solids Disposal

This management method consists of separating solids from liquids in the tailings slurry by filtration or similar means, evaporating the liquids, and transporting the filter cake to a disposal area. The alternative was rejected due to its high cost and the low amenability of the Anderson ore to filtration.

TAILINGS IMPOUNDMENT DECOMMISSIONING

Two methods of covering the tailings impoundment surface to reduce gamma radiation to background and radon emanation to twice background were evaluated. One method requires the placement of five feet of compacted clay and five feet of overburden material over the tailings. The other method requires the placement of 14 feet of overburden material on the tailings. Material calculations show that there is not enough clay left on the site after dam construction to complete the clay cap to the desired thickness. Therefore, only the overburden cap was considered.

Calculations show the exposure rate from gamma radiation at the surface of the uncovered tailings to be 4640 mrem/year. This is 44 times the background value of 107 mrem/year determined from site studies. Five feet of packed overburden material will reduce the exposure rate to 0.05 mrem/year, which is less than background.

The radon flux at the surface of the exposed tailings is estimated to be 325.9 pCi/m^2-sec compared to an adjusted background radon flux of 0.96 pCi/m^2-sec. The proposed cover of 14 feet of overburden will effectively reduce radon emanation from the reclaimed impoundment to about twice background.

NO ACTION

If the proposed mine and mill are not built, the potential environmental impacts discussed in Sections 4.0 and 6.0 would be avoided. On the other hand, the "no action" alternative would prevent the creation of a maximum of 891 new jobs in Yavapai and Maricopa counties. It would also result in a loss of more than $4.5 million per year in tax revenues.

Although objections to its continued development have been raised, it is likely that nuclear power will remain an important source of energy in the United States for at least one or two decades. This is particularly true in light of the dwindling world supply of fossil fuels and our present lack of technology for the large-scale use of such alternative energy sources as solar radiation, tidal power, and wind.

Uranium is the primary fuel used for the generation of nuclear power. It is estimated that the United States will consume 476,300 tons of uranium oxide between 1978 and 1990 (ERDA, 1977). Demand is expected to be 19,800 tons in 1978 and average slightly over 42,000 tons per year between 1984 and 1990 (ERDA, 1977). Uranium mills in the country produced a total of only 12,747 tons of uranium oxide in 1976, with a total delivery commitment of 168,000 tons between 1978 and 1990. Based on the projected demand for uranium and the supply produced by existing mills, it is quite possible that a long-term shortage of uranium oxide could develop within the United States in the coming years. Annual production from the Anderson project (465 tons) would represent approximately 2 percent of the expected 1978 demand.

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Appendix A
CULTURAL RESOURCES

(Letter has not yet been received from the Arizona Historic Preservation Officer.)

APPENDIX B

METEOROLOGY

APPENDIX B-1

DAILY AND MONTHLY TEMPERATURE DATA

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
12	21	52.9	64.0	44.0
12	22	48.8	63.0	39.0
12	23	50.2	64.0	39.0
12	24	46.5	57.0	36.0
12	25	43.4	62.0	38.0
12	26	52.3	64.0	42.0
12	27	49.6	62.0	40.0
12	28	51.9	68.0	39.0
12	29	50.7	59.0	43.0
12	30	44.6	52.0	37.0
12	31	41.9	43.0	41.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
12	49.0	59.8	39.8	68.0	36.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77 -

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
1	1	43.4	50.0	40.0
1	2	45.7	52.0	38.0
1	3	45.4	52.0	40.0
1	4	44.5	54.0	36.0
1	5	42.3	50.0	37.0
1	6	46.3	55.0	40.0
1	7	44.0	49.0	40.0
1	8	41.2	46.0	36.0
1	9	39.1	48.0	33.0
1	10	38.8	51.0	28.0
1	11	41.0	57.0	28.0
1	12	47.4	60.0	40.0
1	13	45.4	60.0	34.0
1	14	46.1	59.0	35.0
1	15	47.0	62.0	33.0
1	16	50.9	66.0	38.0
1	17	55.7	68.0	43.0
1	18	60.5	73.0	51.0
1	19	61.9	77.0	50.0
1	20	61.9	72.0	53.0
1	21	55.3	61.0	51.0
1	22	55.1	64.0	50.0
1	23	54.9	67.0	46.0
1	24	53.5	67.0	43.0
1	25	51.3	60.0	45.0
1	26	49.7	58.0	43.0
1	27	49.9	62.0	39.0
1	28	54.0	68.0	43.0
1	29	55.1	63.0	49.0
1	30	55.5	70.0	45.0
1	31	55.3	73.0	43.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
1	49.6	60.4	41.0	77.0	28.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
2	1	51.8	63.0	43.0
2	2	49.9	63.0	38.0
2	3	54.4	67.0	45.0
2	4	54.1	68.0	43.0
2	5	56.8	72.0	47.0
2	6	54.6	70.0	42.0
2	7	59.5	73.0	51.0
2	8	61.2	73.0	53.0
2	9	58.4	72.0	47.0
2	10	57.9	73.0	45.0
2	11	61.0	77.0	43.0
2	12	63.4	77.0	53.0
2	13	60.3	77.0	44.0
2	14	51.8	53.0	50.0
2	15	999.9	999.9	999.9
2	16	71.7	82.0	58.0
2	17	66.6	83.0	48.0
2	18	66.0	83.0	51.0
2	19	70.3	85.0	59.0
2	20	68.0	83.0	56.0
2	21	69.2	83.0	52.0
2	22	50.8	67.0	49.0
2	23	53.7	66.0	41.0
2	24	48.1	57.0	38.0
2	25	43.5	52.0	31.0
2	26	48.9	60.0	36.0
2	27	52.1	69.0	37.0
2	28	59.0	74.0	49.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
2	58.3	71.2	46.3	85.0	31.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
3	1	51.0	58.0	43.0
3	2	46.8	56.0	37.0
3	3	45.8	57.0	32.0
3	4	51.0	64.0	40.0
3	5	53.8	67.0	44.0
3	6	56.3	69.0	47.0
3	7	63.4	85.0	48.0
3	8	67.8	84.0	57.0
3	9	64.8	78.0	53.0
3	10	50.3	57.0	45.0
3	11	55.3	66.0	44.0
3	12	59.9	73.0	50.0
3	13	55.3	66.0	45.0
3	14	48.6	58.0	38.0
3	15	53.1	70.0	39.0
3	16	56.5	70.0	46.0
3	17	50.4	60.0	41.0
3	18	53.0	66.0	40.0
3	19	56.5	70.0	40.0
3	20	59.5	72.0	42.0
3	21	64.0	77.0	50.0
3	22	71.1	86.0	59.0
3	23	67.8	80.0	55.0
3	24	60.5	71.0	52.0
3	25	43.8	57.0	35.0
3	26	46.1	58.0	34.0
3	27	54.3	69.0	42.0
3	28	55.5	63.0	46.0
3	29	50.7	61.0	42.0
3	30	54.8	67.0	44.0
3	31	53.4	66.0	44.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
3	55.6	67.8	44.3	86.0	32.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
4	1	51.8	60.0	39.0
4	2	41.0	47.0	38.0
4	3	49.0	63.0	32.0
4	4	59.1	73.0	42.0
4	5	68.8	87.0	53.0
4	6	77.5	94.0	66.0
4	7	79.6	97.0	66.0
4	8	76.5	90.0	64.0
4	9	74.4	89.0	63.0
4	10	67.0	76.0	57.0
4	11	65.6	77.0	53.0
4	12	72.2	84.0	57.0
4	13	76.1	88.0	63.0
4	14	72.3	87.0	63.0
4	15	68.4	77.0	55.0
4	16	72.7	85.0	63.0
4	17	77.2	93.0	62.0
4	18	76.6	89.0	63.0
4	19	71.5	82.0	62.0
4	20	70.8	82.0	59.0
4	21	74.5	91.0	59.0
4	22	78.0	93.0	65.0
4	23	85.4	98.0	72.0
4	24	79.5	88.0	70.0
4	25	82.0	95.0	71.0
4	26	82.6	95.0	71.0
4	27	79.5	89.0	72.0
4	28	76.1	89.0	60.0
4	29	77.2	91.0	63.0
4	30	78.5	90.0	66.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
4	72.0	84.6	59.6	98.0	32.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
5	1	77.3	88.0	67.0
5	2	77.1	90.0	63.0
5	3	76.5	87.0	66.0
5	4	72.8	86.0	58.0
5	5	70.8	80.0	62.0
5	6	64.5	73.0	57.0
5	7	62.4	69.0	55.0
5	8	69.5	81.0	60.0
5	9	55.4	64.0	49.0
5	10	60.3	73.0	45.0
5	11	67.4	78.0	53.0
5	12	67.0	77.0	59.0
5	13	58.3	68.0	51.0
5	14	62.0	74.0	50.0
5	15	69.4	81.0	55.0
5	16	67.6	77.0	60.0
5	17	62.8	71.0	50.0
5	18	66.2	77.0	55.0
5	19	70.8	85.0	57.0
5	20	77.1	89.0	63.0
5	21	79.3	92.0	63.0
5	22	81.3	93.0	59.0
5	23	76.4	89.0	69.0
5	24	59.5	68.0	54.0
5	25	67.4	80.0	56.0
5	26	72.0	84.0	57.0
5	27	76.5	89.0	61.0
5	28	83.6	96.0	65.0
5	29	999.9	999.9	999.9
5	30	999.9	999.9	999.9
5	31	999.9	999.9	999.9

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY
5	69.7	80.7	57.8	96.0	45.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
6	1	999.9	999.9	999.9
6	2	92.8	102.0	79.0
6	3	93.5	105.0	83.0
6	4	89.4	100.0	82.0
6	5	89.8	102.0	79.0
6	6	90.7	101.0	82.0
6	7	89.3	100.0	81.0
6	8	84.4	95.0	76.0
6	9	85.0	95.0	75.0
6	10	82.5	93.0	71.0
6	11	82.5	93.0	70.0
6	12	84.7	98.0	71.0
6	13	85.9	99.0	70.0
6	14	88.2	101.0	74.0
6	15	90.1	104.0	74.0
6	16	90.5	103.0	75.0
6	17	90.8	104.0	78.0
6	18	88.9	102.0	75.0
6	19	85.0	97.0	70.0
6	20	85.7	98.0	72.0
6	21	85.8	97.0	72.0
6	22	89.8	101.0	77.0
6	23	91.5	102.0	76.0
6	24	93.6	105.0	82.0
6	25	94.6	105.0	82.0
6	26	95.5	107.0	82.0
6	27	97.4	110.0	82.0
6	28	99.0	110.0	84.0
6	29	99.4	110.0	86.0
6	30	99.5	110.0	87.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
6	90.2	101.7	77.5	110.0	70.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
7	1	95.0	105.0	84.0
7	2	94.8	103.0	83.0
7	3	88.4	93.0	80.0
7	4	88.9	98.0	80.0
7	5	90.0	100.0	78.0
7	6	93.8	105.0	80.0
7	7	96.1	107.0	82.0
7	8	96.4	107.0	82.0
7	9	97.0	107.0	82.0
7	10	94.4	103.0	82.0
7	11	94.0	103.0	84.0
7	12	94.9	105.0	82.0
7	13	95.2	105.0	85.0
7	14	94.6	106.0	81.0
7	15	92.7	107.0	85.0
7	16	93.4	108.0	85.0
7	17	92.0	106.0	85.0
7	18	83.1	86.0	77.0
7	19	89.3	100.0	79.0
7	20	92.1	107.0	80.0
7	21	92.2	101.0	83.0
7	22	91.8	98.0	83.0
7	23	79.3	88.0	73.0
7	24	85.7	100.0	70.0
7	25	95.6	108.0	80.0
7	26	94.9	108.0	82.0
7	27	96.6	108.0	83.0
7	28	100.3	112.0	87.0
7	29	97.8	107.0	91.0
7	30	95.1	102.0	86.0
7	31	98.9	111.0	85.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
7	93.0	103.4	82.1	112.0	70.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
8	1	97.6	108.0	87.0
8	2	96.9	108.0	85.0
8	3	97.9	109.0	87.0
8	4	97.2	108.0	85.0
8	5	98.8	110.0	85.0
8	6	96.8	108.0	85.0
8	7	96.3	106.0	87.0
8	8	95.5	103.0	85.0
8	9	92.4	103.0	84.0
8	10	89.0	103.0	82.0
8	11	93.4	108.0	80.0
8	12	90.4	104.0	83.0
8	13	92.8	104.0	82.0
8	14	89.6	104.0	82.0
8	15	80.1	91.0	72.0
8	16	76.0	85.0	72.0
8	17	81.0	91.0	72.0
8	18	87.0	98.0	73.0
8	19	90.6	102.0	79.0
8	20	93.9	106.0	80.0
8	21	91.8	102.0	82.0
8	22	88.2	98.0	80.0
8	23	84.7	95.0	72.0
8	24	86.8	98.0	76.0
8	25	89.1	102.0	78.0
8	26	87.0	98.0	78.0
8	27	84.4	97.0	72.0
8	28	89.0	103.0	76.0
8	29	91.1	103.0	75.0
8	30	91.9	103.0	80.0
8	31	90.1	102.0	78.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY M
8	90.5	101.9	79.8	110.0	72.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
9	1	91.1	102.0	79.0
9	2	92.5	102.0	83.0
9	3	94.1	104.0	83.0
9	4	95.4	106.0	63.0
9	5	94.3	106.0	81.0
9	6	94.8	108.0	82.0
9	7	97.4	110.0	86.0
9	8	96.8	110.0	84.0
9	9	92.9	103.0	83.0
9	10	83.6	94.0	73.0
9	11	73.8	79.0	63.0
9	12	78.1	90.0	69.0
9	13	82.8	97.0	72.0
9	14	84.5	95.0	75.0
9	15	81.9	93.0	70.0
9	16	77.7	87.0	70.0
9	17	73.8	84.0	62.0
9	18	78.8	93.0	66.0
9	19	80.3	93.0	68.0
9	20	76.7	89.0	64.0
9	21	77.8	90.0	66.0
9	22	77.9	89.0	70.0
9	23	79.3	89.0	70.0
9	24	80.3	93.0	69.0
9	25	84.3	97.0	72.0
9	26	86.0	95.0	77.0
9	27	71.1	80.0	65.0
9	28	76.6	90.0	65.0
9	29	80.8	93.0	70.0
9	30	78.0	89.0	67.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY MIN
9	83.8	95.0	72.9	110.0	62.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE

AT: MINERALS - ANDERSON

PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
10	1	79.3	94.0	68.0
10	2	81.1	95.0	68.0
10	3	83.1	96.0	72.0
10	4	83.3	97.0	70.0
10	5	80.6	94.0	73.0
10	6	67.1	70.0	63.0
10	7	72.9	84.0	65.0
10	8	74.3	89.0	66.0
10	9	75.7	86.0	64.0
10	10	76.3	88.0	66.0
10	11	79.0	92.0	72.0
10	12	79.0	90.0	71.0
10	13	77.4	92.0	68.0
10	14	78.6	93.0	65.0
10	15	83.1	95.0	74.0
10	16	83.1	93.0	76.0
10	17	83.2	97.0	73.0
10	18	80.7	94.0	72.0
10	19	75.3	86.0	67.0
10	20	69.3	77.0	62.0
10	21	67.6	78.0	60.0
10	22	70.7	83.0	59.0
10	23	73.1	84.0	64.0
10	24	72.4	86.0	64.0
10	25	74.7	88.0	62.0
10	26	77.0	89.0	68.0
10	27	74.2	84.0	65.0
10	28	73.7	83.0	63.0
10	29	68.7	73.0	63.0
10	30	63.9	75.0	53.0
10	31	63.5	75.0	53.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY MIN
10	75.5	87.1	66.1	97.0	53.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
11	1	64.2	77.0	53.0
11	2	68.6	81.0	57.0
11	3	71.4	84.0	60.0
11	4	69.8	82.0	59.0
11	5	65.8	76.0	57.0
11	6	51.7	59.0	46.0
11	7	51.1	59.0	44.0
11	8	55.2	69.0	43.0
11	9	55.2	65.0	49.0
11	10	62.0	75.0	50.0
11	11	68.7	80.0	61.0
11	12	68.8	84.0	60.0
11	13	69.2	82.0	59.0
11	14	65.5	78.0	54.0
11	15	64.3	77.0	52.0
11	16	65.0	78.0	52.0
11	17	65.0	82.0	54.0
11	18	64.4	73.0	56.0
11	19	59.9	65.0	52.0
11	20	49.3	57.0	43.0
11	21	51.4	65.0	39.0
11	22	57.8	70.0	49.0
11	23	58.6	71.0	50.0
11	24	60.5	73.0	49.0
11	25	62.8	81.0	50.0
11	26	66.1	81.0	53.0
11	27	63.6	76.0	53.0
11	28	62.0	73.0	49.0
11	29	60.4	68.0	54.0
11	30	59.8	73.0	46.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY MI
11	61.9	73.8	51.8	84.0	39.0

AVERAGE AND EXTREME DAILY AND MONTHLY VALUES FOR TEMPERATURE
AT: MINERALS - ANDERSON
PERIOD: 12/21/76 - 12/16/77

MONTH	DAY	DAILY AVERAGE	DAILY MAX	DAILY MIN
12	1	57.0	69.0	47.0
12	2	57.1	70.0	45.0
12	3	59.0	73.0	46.0
12	4	59.0	73.0	48.0
12	5	59.1	72.0	47.0
12	6	62.1	77.0	47.0
12	7	61.5	76.0	50.0
12	8	60.4	74.0	50.0
12	9	61.9	76.0	50.0
12	10	63.3	73.0	56.0
12	11	60.7	73.0	52.0
12	12	56.9	68.0	48.0
12	13	57.4	69.0	49.0
12	14	57.1	73.0	44.0
12	15	60.4	72.0	50.0
12	16	48.7	55.0	44.0

MONTH	MONTHLY AVE	MONTHLY AVE MAX	MONTHLY AVE MIN	MONTHLY MAX	MONTHLY MI
12	58.8	71.4	48.3	77.0	44.0

APPENDIX B-2

DIURNAL WIND DIRECTION FREQUENCY TABULATIONS SEASONAL AND ANNUAL

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS

MINERALS - ANDERSON

12/21/76 - 2/28/77

SPEED CLASS ALL MPH

WINTER

	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	TOTL
N	12	20	20	13	23	18	17	14	14	16	10	13	3	2	4	2	0	1	1	0	0	3	3	9	218
NNE	7	4	8	11	9	8	8	9	9	12	11	5	1	3	1	0	0	0	0	2	0	1	2	8	119
NE	4	10	3	5	1	3	1	3	2	3	6	0	2	1	0	0	0	0	0	0	3	3	4	6	60
ENE	4	3	3	1	0	2	0	2	2	3	0	2	2	0	0	0	0	0	1	1	0	3	4	7	40
E	4	3	1	2	1	1	0	2	2	0	2	1	0	2	0	1	2	2	1	1	3	2	10	13	56
ESE	5	6	2	0	2	1	3	2	2	3	3	0	0	0	1	1	2	0	2	10	18	16	20	11	110
SE	1	2	2	1	1	1	1	1	3	3	0	2	2	3	3	5	4	6	4	8	9	17	7	1	87
SSE	0	0	0	0	3	1	0	0	0	0	0	1	2	1	2	3	3	0	5	5	15	11	4	2	58
S	3	1	2	1	0	0	1	0	0	1	4	1	0	1	0	0	1	6	4	14	9	5	2	1	57
SSW	2	1	1	0	0	1	2	1	0	0	4	2	1	0	0	1	2	5	4	5	3	1	0	1	37
SW	3	1	0	0	1	1	0	1	0	1	0	2	3	6	3	6	7	4	7	5	2	0	1	1	55
WSW	0	0	4	3	1	1	2	3	2	0	6	13	24	19	34	38	38	35	29	11	0	1	0	2	266
W	3	0	2	2	2	2	5	4	5	1	7	9	5	16	13	8	3	5	6	3	2	1	0	0	104
WNW	1	3	6	7	6	6	7	5	4	7	1	4	4	4	2	1	1	2	2	2	4	3	4	1	87
NW	8	5	5	7	6	6	7	3	5	5	5	9	11	5	3	1	2	2	1	1	0	0	3	3	103
NNW	11	9	8	14	11	15	12	16	16	11	7	2	7	3	1	0	3	0	1	0	0	1	4	2	154
CALM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTL	68	68	67	67	67	67	66	66	66	66	66	66	67	66	67	67	68	68	68	68	68	68	68	68	1611

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS SPRING

MINERALS - ANDERSON

3/ 1/77 - 5/31/77

SPEED CLASS ALL MPH

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	TOTL
N	7	13	20	21	22	30	28	31	35	21	10	3	4	2	1	1	2	2	6	2	2	2	4	5	274
NNE	10	9	8	19	16	9	16	16	15	6	3	2	2	0	0	1	1	1	0	2	1	2	4	4	147
NE	6	6	3	5	10	6	3	4	4	1	1	2	0	0	0	0	1	1	1	0	0	0	2	3	59
ENE	1	6	6	4	1	3	3	3	1	2	1	0	0	0	0	0	0	2	0	1	0	1	1	3	39
E	4	8	8	7	3	4	4	3	5	2	0	2	0	1	1	1	1	1	1	0	0	0	2	6	64
ESE	20	14	12	5	5	9	11	10	8	6	5	5	6	2	0	0	0	0	0	2	0	8	10	24	162
SE	11	7	4	4	5	4	1	3	3	8	10	9	7	5	4	3	0	2	1	1	8	10	14	9	133
SSE	4	6	5	1	3	2	2	3	3	1	6	10	15	13	9	8	12	8	8	11	11	10	7	7	165
S	5	3	5	6	4	6	1	1	0	4	3	5	10	15	23	20	15	12	11	12	13	12	15	7	208
SSW	4	2	3	1	1	3	1	0	0	2	1	5	9	11	11	11	10	14	12	4	9	10	4	4	132
SW	4	2	2	3	0	1	0	0	0	1	3	3	2	9	8	10	12	8	3	9	7	5	7	4	103
WSW	3	3	2	4	2	0	1	1	3	6	15	16	13	13	14	17	19	19	26	23	18	12	7	6	243
W	2	2	1	0	1	2	3	0	0	4	4	10	11	9	12	10	8	11	14	12	8	6	3	1	134
WNW	2	1	1	1	2	2	3	4	2	2	5	2	2	2	3	4	3	3	3	4	6	5	1	2	65
NW	0	1	2	1	5	0	1	2	0	4	8	5	2	2	0	1	1	2	0	3	2	2	3	1	48
NNW	3	6	7	7	9	8	11	8	10	19	13	8	3	3	1	0	2	1	1	1	2	2	3	1	129
CALM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTL	87	89	89	89	89	89	89	89	89	89	88	87	86	87	87	87	87	87	87	87	87	87	87	87	2106

SUMMER

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS
MINERALS - ANDERSON
6/ 1/77 - 8/31/77
SPEED CLASS ALL MPH

	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	TOTL
N	0	2	4	2	8	7	9	17	17	11	2	2	0	1	0	2	3	2	2	2	1	2	0	1	97
NNE	5	2	1	2	5	5	4	5	5	1	3	1	3	0	2	2	1	1	2	0	4	2	3	2	61
NE	0	2	1	5	2	1	1	4	1	0	0	0	0	0	1	0	0	1	2	4	2	0	1	2	30
ENE	2	1	8	10	6	7	8	7	9	1	2	0	0	1	1	0	0	1	1	2	3	4	4	2	80
E	8	11	16	18	13	18	19	12	12	9	6	4	1	1	0	2	1	1	0	0	1	5	0	3	161
ESE	20	21	23	15	17	10	12	7	8	11	11	10	9	3	1	2	3	1	0	1	1	3	6	6	201
SE	19	21	15	10	12	10	9	3	2	4	13	16	9	6	3	0	1	1	2	0	1	3	2	14	176
SSE	8	5	4	5	5	7	1	3	2	0	2	13	20	11	10	10	9	7	4	4	2	2	9	14	157
S	18	13	12	13	8	11	12	11	14	23	12	14	11	27	20	17	17	19	15	11	9	9	18	28	362
SSW	5	5	4	3	4	1	3	3	1	4	5	7	4	8	13	14	9	11	13	10	8	10	20	7	172
SW	1	0	1	0	1	0	1	0	0	0	2	1	0	4	5	2	6	5	8	8	14	10	14	2	85
WSW	3	2	1	3	0	0	0	0	0	2	7	8	22	12	14	21	15	16	16	22	15	18	6	2	205
W	2	4	0	2	2	0	0	0	2	3	9	10	10	14	18	16	24	22	22	24	29	22	5	4	244
WNW	0	0	0	0	0	0	0	2	1	5	2	2	1	1	1	1	0	1	1	0	1	0	1	1	21
NW	0	0	0	0	2	1	1	4	5	4	7	1	0	0	0	0	0	1	0	0	0	1	0	1	28
NNW	0	1	0	2	5	12	10	12	11	12	7	1	0	0	0	1	1	0	1	1	0	0	2	2	81
CALM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTL	91	90	90	90	90	90	90	90	90	90	90	90	90	89	89	90	90	90	89	89	91	91	91	91	2161

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS
MINERALS - ANDERSON
9/ 1/77 - 11/30/77
SPEED CLASS ALL MPH

FALL

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	TOTL
N	12	16	19	22	33	35	38	34	34	34	19	13	6	4	2	2	2	2	1	2	4	2	5	12	353
NNE	6	7	13	8	5	11	12	7	11	7	6	3	1	0	1	0	0	1	2	3	1	2	3	5	115
NE	3	6	3	7	8	9	7	8	4	4	3	2	0	1	0	0	1	0	1	0	0	1	0	1	69
ENE	6	3	7	2	6	1	3	0	4	2	1	0	1	0	0	2	0	0	0	0	0	1	3	7	49
E	12	12	11	6	4	7	1	2	4	1	1	0	2	1	1	1	0	2	1	0	1	2	6	12	90
ESE	12	9	7	4	6	5	5	8	6	3	3	6	2	1	2	0	1	0	1	0	4	10	17	14	126
SE	15	11	10	8	2	3	3	4	2	2	4	2	6	5	5	4	3	3	9	13	21	25	25	16	201
SSE	3	2	2	1	2	3	4	1	1	2	4	12	10	13	11	11	10	10	8	15	11	17	12	10	175
S	6	3	2	0	1	1	2	2	1	1	6	6	9	7	7	9	9	7	10	13	18	14	6	5	145
SSW	0	2	0	1	2	0	0	1	1	3	2	4	5	9	13	7	8	8	4	4	9	1	6	0	90
SW	3	1	1	2	2	1	0	0	0	2	2	2	4	4	6	5	5	6	9	7	5	7	1	2	77
WSW	1	0	0	3	0	0	0	0	0	5	4	14	15	21	29	39	34	34	33	23	14	7	3	2	281
W	1	3	2	4	2	0	1	0	1	0	3	5	17	17	9	7	14	13	9	8	0	0	1	0	117
WNW	1	0	1	1	1	0	2	2	1	1	2	1	1	2	2	1	1	2	2	1	2	0	0	2	29
NW	0	0	1	3	1	1	2	2	1	5	3	8	5	3	1	1	2	2	1	1	1	1	1	0	46
NNW	10	16	12	19	16	14	11	20	20	19	28	13	7	3	2	2	1	1	0	1	0	1	2	3	221
CALM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTL	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	2184

B-20

DIURNAL WIND DIRECTION FREQUENCY BY SPEED CLASS

MINERALS - ANDERSON

12/21/76 - 11/30/77

SPEED CLASS ALL MPH

ANNUAL

	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	TOTL
N	31	50	63	58	86	90	92	96	100	82	41	31	13	9	7	7	7	7	10	6	7	9	12	27	941
NNE	28	22	30	40	35	33	40	37	40	26	23	11	7	3	4	3	2	3	4	7	6	7	12	19	442
NE	13	24	10	22	21	19	12	19	11	8	10	4	2	2	1	0	2	2	4	4	5	4	7	12	218
ENE	13	13	24	17	13	13	14	12	16	8	4	2	3	1	1	2	0	3	2	4	3	9	12	19	208
E	28	34	36	33	21	30	24	19	23	12	9	7	3	5	2	5	4	6	3	1	5	9	18	34	371
ESE	57	50	44	24	30	25	31	27	24	23	22	21	17	6	4	3	6	1	3	13	23	37	53	55	599
SE	46	41	31	23	20	18	14	11	10	17	27	29	24	19	15	12	8	12	16	22	39	55	48	40	597
SSE	15	13	11	7	13	13	7	7	6	3	12	36	47	38	32	32	34	25	25	35	39	40	32	33	555
S	32	20	21	20	13	18	16	14	15	29	25	26	30	50	50	46	42	44	40	50	49	40	41	41	772
SSW	11	10	8	5	7	5	6	5	2	9	12	18	19	28	37	33	29	38	33	23	29	22	30	12	431
SW	11	4	4	5	4	3	1	1	0	4	7	8	9	23	22	23	30	23	27	29	28	22	23	9	320
WSW	7	5	7	13	3	1	3	4	5	13	32	51	74	65	91	115	106	104	104	79	47	38	16	12	995
W	8	9	5	8	7	4	9	4	9	8	23	34	43	56	52	41	49	51	51	47	39	29	9	5	599
WNW	4	4	8	9	9	8	12	13	8	15	10	9	8	9	8	7	5	8	8	7	13	8	6	6	202
NW	8	6	8	11	14	8	11	11	11	18	23	23	18	10	4	3	5	7	2	5	3	4	7	5	225
NNW	24	32	27	42	41	49	44	56	57	61	55	24	17	9	4	3	7	2	3	3	2	4	11	8	585
CALM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTL	337	337	337	337	337	337	336	336	334	336	335	334	334	333	334	335	336	336	335	335	337	337	337	337	8061

Appendix B-3

ANNUAL RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION AND SPEED BY STABILITY CLASS 12/21/76 -11/30/77

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS A

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.000372	0.002109	0.000868	0.000124	0.0	0.0	0.003474
NNE	0.000124	0.000620	0.000496	0.0	0.0	0.0	0.001241
NE	0.0	0.0	0.000124	0.0	0.0	0.0	0.000124
ENE	0.0	0.000124	0.0	0.0	0.0	0.0	0.000124
E	0.0	0.000248	0.0	0.0	0.0	0.0	0.000248
ESE	0.0	0.000124	0.0	0.0	0.0	0.0	0.000124
SE	0.0	0.000124	0.000496	0.000124	0.0	0.0	0.000744
SSE	0.0	0.000124	0.001613	0.000496	0.000372	0.000248	0.002853
S	0.0	0.000620	0.002233	0.000372	0.0	0.0	0.003225
SSW	0.000372	0.001116	0.001613	0.000620	0.0	0.0	0.003722
SW	0.000124	0.000868	0.000992	0.000372	0.0	0.0	0.002357
WSW	0.0	0.000496	0.002357	0.000248	0.0	0.0	0.003101
W	0.000372	0.000744	0.001116	0.000248	0.0	0.0	0.002481
WNW	0.000248	0.000496	0.000496	0.0	0.0	0.0	0.001241
NW	0.000248	0.000992	0.000124	0.0	0.0	0.0	0.001365
NNW	0.000372	0.001737	0.000124	0.0	0.0	0.0	0.002233
TOTL	0.002233	0.010545	0.012654	0.002605	0.000372	0.000248	0.028656

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS A

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	3	17	7	1	0	0	28	6.7
NNE	1	5	4	0	0	0	10	7.2
NE	0	0	1	0	0	0	1	9.0
ENE	0	1	0	0	0	0	1	7.0
E	0	2	0	0	0	0	2	6.0
ESE	0	1	0	0	0	0	1	6.0
SE	0	1	4	1	0	0	6	9.8
SSE	0	1	13	4	3	2	23	13.7
S	0	5	18	3	0	0	26	9.6
SSW	3	9	13	5	0	0	30	9.1
SW	1	7	8	3	0	0	19	8.6
WSW	0	4	19	2	0	0	25	9.2
W	3	6	9	2	0	0	20	8.2
WNW	2	4	4	0	0	0	10	6.6
NW	2	8	1	0	0	0	11	5.6
NNW	3	14	1	0	0	0	18	5.6
TOTL	18	85	102	21	3	2	231	8.6

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS B

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.001985	0.005210	0.003598	0.0	0.0	0.0	0.010793
NNE	0.000868	0.001985	0.001861	0.000248	0.000124	0.0	0.005086
NE	0.000372	0.000496	0.000992	0.0	0.000124	0.0	0.001985
ENE	0.000496	0.000496	0.000620	0.000124	0.000124	0.0	0.001861
E	0.000248	0.000620	0.000496	0.000496	0.000124	0.0	0.001985
ESE	0.0	0.000868	0.001116	0.0	0.0	0.0	0.001985
SE	0.000248	0.000372	0.001365	0.000620	0.0	0.0	0.002605
SSE	0.000248	0.001985	0.005831	0.002233	0.0	0.0	0.010296
S	0.002357	0.007939	0.010296	0.003225	0.000248	0.0	0.024066
SSW	0.002853	0.004838	0.006823	0.001116	0.0	0.0	0.015631
SW	0.000992	0.003101	0.004838	0.000868	0.0	0.0	0.009800
WSW	0.001985	0.007691	0.011785	0.002977	0.000248	0.0	0.024687
W	0.003349	0.005582	0.009676	0.001116	0.000124	0.0	0.019849
WNW	0.000868	0.001116	0.000992	0.000248	0.0	0.0	0.003225
NW	0.001613	0.001985	0.000496	0.0	0.0	0.0	0.004094
NNW	0.002481	0.006203	0.000744	0.0	0.0	0.0	0.009428
TOTL	0.020965	0.050490	0.061531	0.013274	0.001116	0.0	0.147376

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS B

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	16	42	29	0	0	0	87	6.4
NNE	7	16	15	2	1	0	41	7.7
NE	3	4	8	0	1	0	16	8.3
ENE	4	4	5	1	1	0	15	8.1
E	2	5	4	4	1	0	16	9.6
ESE	0	7	9	0	0	0	16	8.1
SE	2	3	11	5	0	0	21	9.8
SSE	2	16	47	18	0	0	83	10.2
S	19	64	83	26	2	0	194	8.4
SSW	23	39	55	9	0	0	126	7.7
SW	8	25	39	7	0	0	79	8.3
WSW	16	62	95	24	2	0	199	8.6
W	27	45	78	9	1	0	160	7.9
WNW	7	9	8	2	0	0	26	6.8
NW	13	16	4	0	0	0	33	5.4
NNW	20	50	6	0	0	0	76	5.4
TOTL	169	407	496	107	9	0	1188	8.0

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS C

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.002605	0.006327	0.002853	0.000248	0.000124	0.0	0.012157
NNE	0.000496	0.002481	0.000992	0.000372	0.0	0.0	0.004342
NE	0.000372	0.000496	0.000992	0.000372	0.000124	0.0	0.002357
ENE	0.000620	0.000496	0.0	0.0	0.000124	0.0	0.001241
E	0.000372	0.000620	0.000868	0.000124	0.0	0.0	0.001985
ESE	0.000372	0.000248	0.000992	0.000992	0.0	0.0	0.002605
SE	0.000372	0.000372	0.002729	0.002109	0.000620	0.0	0.006203
SSE	0.000372	0.001241	0.004218	0.003722	0.000868	0.0	0.010421
S	0.003722	0.003349	0.004218	0.002605	0.000372	0.0	0.014266
SSW	0.001116	0.001985	0.003846	0.001116	0.0	0.0	0.008064
SW	0.000868	0.001985	0.002977	0.000992	0.000248	0.0	0.007071
WSW	0.002481	0.012529	0.016375	0.005582	0.000868	0.0	0.037836
W	0.001489	0.004714	0.007691	0.003846	0.000248	0.0	0.017988
WNW	0.001241	0.001116	0.000496	0.000620	0.000124	0.0	0.003598
NW	0.001365	0.002729	0.000248	0.000248	0.000496	0.0	0.005086
NNW	0.002233	0.004466	0.000992	0.000124	0.0	0.0	0.007815
TOTL	0.020097	0.045156	0.050490	0.023074	0.004218	0.0	0.143034

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS C

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	21	51	23	2	1	0	98	6.5
NNE	4	20	8	3	0	0	35	7.1
NE	3	4	8	3	1	0	19	9.4
ENE	5	4	0	0	1	0	10	5.7
E	3	5	7	1	0	0	16	7.7
ESE	3	2	8	8	0	0	21	10.7
SE	3	3	22	17	5	0	50	11.7
SSE	3	10	34	30	7	0	84	12.1
S	30	27	34	21	3	0	115	8.6
SSW	9	16	31	9	0	0	65	8.7
SW	7	16	24	8	2	0	57	8.9
WSW	20	101	132	45	7	0	305	9.1
W	12	38	62	31	2	0	145	9.6
WNW	10	9	4	5	1	0	29	7.6
NW	11	22	2	2	4	0	41	7.5
NNW	18	36	8	1	0	0	63	5.7
TOTL	162	364	407	186	34	0	1153	8.8

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
STABILITY CLASS D

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.018112	0.038333	0.011041	0.001116	0.0	0.0	0.068602
NNE	0.008188	0.015135	0.008436	0.001613	0.000248	0.0	0.033619
NE	0.002729	0.004714	0.003474	0.000992	0.000372	0.000372	0.012654
ENE	0.004466	0.002853	0.002233	0.000868	0.000248	0.000248	0.010917
E	0.005582	0.004962	0.003598	0.001116	0.000124	0.000124	0.015507
ESE	0.005831	0.005334	0.003846	0.004342	0.000124	0.0	0.019476
SE	0.003970	0.003101	0.002853	0.004466	0.001489	0.0	0.015879
SSE	0.007319	0.002605	0.005210	0.003846	0.000620	0.0	0.019601
S	0.012778	0.012033	0.008808	0.002853	0.0	0.0	0.036472
SSW	0.005706	0.006451	0.004714	0.001737	0.0	0.0	0.018608
SW	0.002357	0.003722	0.007071	0.001613	0.0	0.0	0.014762
WSW	0.002729	0.017368	0.020469	0.004590	0.000744	0.0	0.045900
W	0.002481	0.004466	0.011785	0.006203	0.000744	0.0	0.025679
WNW	0.001737	0.004218	0.000744	0.002481	0.000992	0.000372	0.010545
NW	0.004838	0.003598	0.001116	0.001116	0.000372	0.000124	0.011165
NNW	0.013770	0.017864	0.001737	0.0	0.0	0.0	0.033371
TOTL	0.102593	0.146756	0.097134	0.038953	0.006079	0.001241	0.392755

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS D

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	146	309	89	9	0	0	553	5.9
NNE	66	122	68	13	2	0	271	6.8
NE	22	38	28	8	3	3	102	8.0
ENE	36	23	18	7	2	2	88	7.2
E	45	40	29	9	1	1	125	6.9
ESE	47	43	31	35	1	0	157	8.1
SE	32	25	23	36	12	0	128	9.8
SSE	59	21	42	31	5	0	158	8.2
S	103	97	71	23	0	0	294	6.5
SSW	46	52	38	14	0	0	150	6.9
SW	19	30	57	13	0	0	119	8.2
WSW	22	140	165	37	6	0	370	8.5
W	20	36	95	50	6	0	207	9.8
WNW	14	34	6	20	8	3	85	10.0
NW	39	29	9	9	3	1	90	7.0
NNW	111	144	14	0	0	0	269	5.0
TOTL	827	1183	783	314	49	10	3166	7.3

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS E

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.017258	0.002109	0.000124	0.0	0.0	0.0	0.019491
NNE	0.009312	0.000620	0.0	0.0	0.0	0.0	0.009932
NE	0.009436	0.000124	0.0	0.0	0.0	0.0	0.009560
ENE	0.009684	0.0	0.000372	0.000372	0.0	0.0	0.010429
E	0.016637	0.001737	0.001241	0.001737	0.0	0.0	0.021351
ESE	0.017258	0.008064	0.003970	0.004962	0.000992	0.000124	0.035370
SE	0.011547	0.005086	0.004590	0.005458	0.002233	0.000248	0.029162
SSE	0.010553	0.001985	0.003101	0.003474	0.000868	0.0	0.019981
S	0.011547	0.001365	0.001985	0.000620	0.0	0.0	0.015516
SSW	0.005090	0.000744	0.000868	0.000248	0.000124	0.0	0.007075
SW	0.003849	0.001116	0.000124	0.0	0.0	0.0	0.005089
WSW	0.002731	0.004466	0.003225	0.000124	0.0	0.0	0.010547
W	0.003352	0.001985	0.001985	0.000124	0.0	0.0	0.007446
WNW	0.004221	0.001241	0.000372	0.000372	0.0	0.0	0.006206
NW	0.004221	0.001241	0.000124	0.000248	0.000248	0.0	0.006082
NNW	0.012912	0.004342	0.000248	0.0	0.0	0.0	0.017502
TOTL	0.149609	0.036224	0.022330	0.017740	0.004466	0.000372	0.230741

RELATIVE FREQUENCY OF CALMS 0.000124

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS E

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	139	17	1	0	0	0	157	3.3
NNE	75	5	0	0	0	0	80	2.9
NE	76	1	0	0	0	0	77	2.6
ENE	78	0	3	3	0	0	84	3.2
E	134	14	10	14	0	0	172	4.5
ESE	139	65	32	40	8	1	285	6.7
SE	93	41	37	44	18	2	235	8.4
SSE	85	16	25	28	7	0	161	7.1
S	93	11	16	5	0	0	125	4.5
SSW	41	6	7	2	1	0	57	4.8
SW	31	9	1	0	0	0	41	3.9
WSW	22	36	26	1	0	0	85	6.2
W	27	16	16	1	0	0	60	5.5
WNW	34	10	3	3	0	0	50	4.6
NW	34	10	1	2	2	0	49	4.9
NNW	104	35	2	0	0	0	141	3.7
TOTL	1205	292	180	143	36	3	1859	5.3

NUMBER OF CALMS 1

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS F

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.001365	0.000248	0.0	0.0	0.0	0.0	0.001613
NNE	0.000248	0.0	0.0	0.0	0.0	0.0	0.000248
NE	0.000124	0.0	0.0	0.0	0.0	0.0	0.000124
ENE	0.000744	0.0	0.0	0.0	0.0	0.0	0.000744
E	0.002605	0.000620	0.0	0.000124	0.0	0.0	0.003349
ESE	0.004218	0.003474	0.001737	0.000744	0.0	0.0	0.010172
SE	0.003349	0.003225	0.003225	0.002605	0.001489	0.0	0.013894
SSE	0.001737	0.000372	0.000372	0.000868	0.000248	0.0	0.003598
S	0.001241	0.000372	0.0	0.0	0.0	0.0	0.001613
SSW	0.0	0.000124	0.0	0.0	0.0	0.0	0.000124
SW	0.000372	0.0	0.0	0.0	0.0	0.0	0.000372
WSW	0.000372	0.000868	0.0	0.0	0.0	0.0	0.001241
W	0.000496	0.000248	0.000124	0.0	0.0	0.0	0.000868
WNW	0.0	0.0	0.000124	0.0	0.0	0.0	0.000124
NW	0.000124	0.0	0.0	0.0	0.0	0.0	0.000124
NNW	0.000992	0.000620	0.0	0.0	0.0	0.0	0.001613
TOTL	0.017968	0.010172	0.005582	0.004342	0.001737	0.0	0.039821

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS F

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	11	2	0	0	0	0	13	3.5
NNE	2	0	0	0	0	0	2	3.0
NE	1	0	0	0	0	0	1	2.0
ENE	6	0	0	0	0	0	6	3.0
E	21	5	0	1	0	0	27	3.9
ESE	34	28	14	6	0	0	82	6.2
SE	27	26	26	21	12	0	112	9.5
SSE	14	3	3	7	2	0	29	8.4
S	10	3	0	0	0	0	13	3.5
SSW	0	1	0	0	0	0	1	6.0
SW	3	0	0	0	0	0	3	3.3
WSW	3	7	0	0	0	0	10	5.2
W	4	2	1	0	0	0	7	4.3
WNW	0	0	1	0	0	0	1	10.0
NW	1	0	0	0	0	0	1	2.0
NNW	8	5	0	0	0	0	13	3.9
TOTL	145	82	45	35	14	0	321	6.9

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS G

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.000496	0.000124	0.0	0.0	0.0	0.0	0.000620
NNE	0.000372	0.0	0.0	0.0	0.0	0.0	0.000372
NE	0.000248	0.0	0.0	0.0	0.0	0.0	0.000248
ENE	0.000496	0.0	0.0	0.0	0.0	0.0	0.000496
E	0.001365	0.000124	0.000124	0.0	0.0	0.0	0.001613
ESE	0.002233	0.001489	0.000620	0.000248	0.0	0.0	0.004590
SE	0.001613	0.001241	0.002357	0.000372	0.0	0.0	0.005582
SSE	0.001489	0.000496	0.000124	0.0	0.0	0.0	0.002109
S	0.000620	0.0	0.0	0.0	0.0	0.0	0.000620
SSW	0.000248	0.0	0.0	0.0	0.0	0.0	0.000248
SW	0.000248	0.0	0.0	0.0	0.0	0.0	0.000248
WSW	0.0	0.000124	0.0	0.0	0.0	0.0	0.000124
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WNW	0.000124	0.0	0.0	0.0	0.0	0.0	0.000124
NW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NNW	0.000496	0.000124	0.0	0.0	0.0	0.0	0.000620
TOTL	0.010048	0.003722	0.003225	0.000620	0.0	0.0	0.017616

RELATIVE FREQUENCY OF CALMS 0.0

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS G

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	4	1	0	0	0	0	5	3.0
NNE	3	0	0	0	0	0	3	2.3
NE	2	0	0	0	0	0	2	1.5
ENE	4	0	0	0	0	0	4	3.3
E	11	1	1	0	0	0	13	3.4
ESE	18	12	5	2	0	0	37	5.7
SE	13	10	19	3	0	0	45	7.5
SSE	12	4	1	0	0	0	17	4.1
S	5	0	0	0	0	0	5	3.2
SSW	2	0	0	0	0	0	2	2.0
SW	2	0	0	0	0	0	2	3.5
WSW	0	1	0	0	0	0	1	5.0
W	0	0	0	0	0	0	0	0.0
WNW	1	0	0	0	0	0	1	1.0
NW	0	0	0	0	0	0	0	0.0
NNW	4	1	0	0	0	0	5	3.6
TOTL	81	30	26	5	0	0	142	5.3

NUMBER OF CALMS 0

RELATIVE FREQUENCY DISTRIBUTION FOR WIND DIRECTION
AND SPEED BY NRC STABILITY CLASS (WDD) FOR ONE YEAR
MINERALS - ANDERSON
PERIOD 12/21/76 - 11/30/77 FOR ALL MO.S
STABILITY CLASS ALL

WIND SPEED (MPH)

DIRECTION	0 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL
N	0.042195	0.054460	0.015464	0.001489	0.000124	0.0	0.116751
NNE	0.019608	0.020841	0.011785	0.002233	0.000372	0.0	0.054839
NE	0.013279	0.005831	0.005582	0.001365	0.000620	0.000372	0.027049
ENE	0.016506	0.003970	0.003225	0.001365	0.000496	0.000248	0.025810
E	0.026806	0.008932	0.006327	0.003598	0.000248	0.000124	0.046034
ESE	0.029909	0.019601	0.012281	0.011289	0.001116	0.000124	0.074320
SE	0.021097	0.013522	0.017616	0.015755	0.005831	0.000248	0.074068
SSE	0.021718	0.008808	0.020469	0.014638	0.002977	0.000248	0.068858
S	0.032266	0.025679	0.027540	0.009676	0.000620	0.0	0.095782
SSW	0.015389	0.015259	0.017864	0.004838	0.000124	0.0	0.053473
SW	0.008811	0.010793	0.016003	0.003846	0.000248	0.0	0.039701
WSW	0.010300	0.043543	0.054212	0.013522	0.001861	0.0	0.123438
W	0.011541	0.017740	0.032378	0.011537	0.001116	0.0	0.074313
WNW	0.008439	0.008188	0.003225	0.003722	0.001116	0.000372	0.025062
NW	0.012410	0.010545	0.002109	0.001613	0.001116	0.000124	0.027917
NNW	0.033259	0.035355	0.003846	0.000124	0.0	0.0	0.072584
TOTL	0.323533	0.303064	0.252946	0.100608	0.017988	0.001861	1.000000

RELATIVE FREQUENCY OF CALMS 0.000124

NUMBER OF CASES AND AVERAGE SPEED
(AVERAGE SPEEDS INCLUDE CALMS)
STABILITY CLASS ALL

WIND SPEED (MPH)

DIRECTION	1 - 4	5 - 7	8 - 12	13 - 18	19 - 24	25 +	TOTAL	AVG WS
N	340	439	149	12	1	0	941	5.5
NNE	158	168	95	18	3	0	442	6.1
NE	107	47	45	11	5	3	218	6.2
ENE	133	32	26	11	4	2	208	5.4
E	216	72	51	29	2	1	371	5.6
ESE	241	158	99	91	9	1	599	7.1
SE	170	109	142	127	47	2	597	9.2
SSE	175	71	165	118	24	2	555	8.9
S	260	207	222	78	5	0	772	7.0
SSW	124	123	144	39	1	0	431	7.3
SW	71	87	129	31	2	0	320	7.8
WSW	83	351	437	109	15	0	995	8.5
W	93	143	261	93	9	0	599	8.7
WNW	68	66	26	30	9	3	202	7.7
NW	100	85	17	13	9	1	225	6.3
NNW	268	285	31	1	0	0	585	4.8
TOTL	2607	2443	2039	811	145	15	8060	7.2

NUMBER OF CALMS 1
TOTAL CASES 8061

APPENDIX B-4

HOURLY AVERAGE OZONE CONCENTRATIONS

Table B-4-1. MEASURED HOURLY-AVERAGE OZONE CONCENTRATIONS (ppm).

Time (MST)	4/23/78	4/24/78	4/25/78	4/26/78	4/27/78	4/28/78
0000		.042	.043	.030	.047	.043
0100		.036	.038	.029	.047	.041
0200		.037	.035	.029	.046	.037
0300		.034	.035	.029	.046	.032
0400		.034	.035	.027	.043	.030
0500		.035	.036	.027	.041	.031
0600		.036	.036	.028	.039	.030
0700		.036	.041	.027	.037	.031
0800		.036	.043	.029	.034	.034
0900		.039	.047	.030	.043	.037
1000		.042	.055	.033	.045	.043
1100		.046	.062	.038	.050	.047
1200		.047	.060	.042	.053	.049
1300		.049	.059	.045	.057	.050
1400		.051	.053	.047	.055	.050
1500		.052	.043	.048	.054	.051
1600	.051	.055	.044	.050	.051	
1700	.050	.055	.039	.050	.050	
1800	.053	.053	.038	.053	.049	
1900	.051	.052	.037	.057	.048	
2000	.045	.048	.037	.057	.046	
2100	.044	.046	.033	.052	.044	
2200	.045	.045	.032	.053	.044	
2300	.046	.041	.030	.050	.043	

Appendix B-5

FUGITIVE DUST EMISSION ESTIMATES

As discussed in Section 4.4, annual fugitive dust emissions resulting from the proposed project are expected to reach maximum levels from 1981 through 1984. Emissions have been estimated for each of the following source types individually:

- mine stripping and ore production
- haul road traffic
- wind erosion from mine area
- mine waste dump development
- ore stockpiling

Calculations for each source type are described in this appendix and are based on information provided by Minerals Exploration Company on the proposed action. Emissions from each of the sources are considered to be "fugitive dust" as defined in EPA regulations for the Prevention of Significant Deterioration of Air Quality (40 CFR 51.24 and 40 CFR 52.21) and are therefore exempt from analysis to determine PSD increment consumption (Union Oil Company, 1978).

MINE STRIPPING AND ORE PRODUCTION

Stripping

Primary overburden stripping will begin in the fourth quarter of 1979. After 3 months, stripping will reach a rate of about 2.43×10^6 tons/month (2.92×10^7 tons/year). This rate will be maintained through the second quarter of 1985 after which overburden removal will decrease to 1.73×10^6 tons/month (2.08×10^7 tons/year) for the remaining life of the project. Approximately one half of the overburden material will be below the water table and will have a moisture content of about 10 percent. With this high moisture content and frequent sprinkling of active working areas and mine walls, fugitive dust from areas below the water table is expected to be negligible. Stripping above the water table is estimated to produce 0.05 pound of dust/ton of overburden (Cowherd, 1974). Based on studies for dirt road emissions (EPA, 1975), it is expected that 60 percent of the dust will remain suspended in the air and 40 percent will rapidly settle. With frequent wetting of working surfaces and sprinkling of mine walls, about 60 percent control of emissions could be expected; therefore, actual suspended emissions are predicted to be 0.012 lb/ton. From 1980 through 1984, annual dust emissions from overburden stripping are estimated to be:

$$2.92 \times 10^7 \text{ tons/yr} \times 1/2 \times 0.012 \text{ lb/ton} \times 1 \text{ ton/2000 lb} = 87 \text{ tons/year}$$

After 1985, annual emissions will drop to about 62 tons.

Ore Production

Ore producing zones and areas of secondary stripping will be below the table and materials will have a moisture content of about 10 percent. With supplemental watering of dry, active working areas, fugitive dust emissions will be negligible relative to other sources.

Haul Road Traffic

The average speed of ore and stripping haul trucks will be about 12 mph. Figure 11.2-1 of the EPA's Compilation of Air Pollutant Emission Factors (EPA, 1975), also known as AP-42, indicates that the project area has about 60 days with 0.01 inch or more of rain per year. With an assumed silt content of 5 percent in the road surface, the equation in Section 11.2 of AP-42 indicates that haul road dust emissions will be about:

$$(0.81 \times 5) \left(\frac{12}{30}\right)^{2*} \left(\frac{365 - 60}{365}\right) \times 2.5^{**} = 1.35 \text{ lb/vehicle mile}$$

Since only 60 percent of these emissions can be considered suspended particulate matter (EPA, 1975) and frequent watering and use of chemical binders on permanent road surfaces will result in about 50 percent control (EPA, 1975), actual emissions will be about 0.41 lb/vehicle mile.

*AP-12 indicates that below 30 mph, emissions become a square function of vehicle speed.

**Emissions were multiplied by 2.5 to correct for the size of the haul trucks.

Overburden Haulage. Overburden will be hauled to waste dumps and backfill areas in 120-ton trucks. Assuming an average haul distance of 1 mile, annual fugitive dust emissions will be:

2.92×10^7 tons/yr x 2 trips/120 tons x 1 mile/trip x 0.41 lb/mile x 1 ton/2000 lb = 99 tons/year

Ore Haulage. About 730,000 tons of ore per year will be hauled approximately 1 mile to the ore stockpile area in 35-ton trucks. Annual fugitive dust emissions are predicted to be:

730,000 tons/yr x 2 trips/35 tons x 1 mile/trip x 0.41 lb/mile x 1 ton/2000 lb = 8.6 tons/year

Internal Waste Haulage. An estimated 2.7×10^6 tons of internal waste per year will be hauled approximately 1 mile to waste dumps and backfill areas in 35-ton trucks. Annual fugitive dust emissions will be:

2.7×10^6 tons/yr x 2 trips/35 tons x 1 mile/trip x 0.41 lb/mile x 1 ton/2000 lb = 32 tons/year

Total Annual Haul Road Emissions (1980-1984). Total annual haul road emissions from 1980 through 1984 will be:

Overburden	99 tons
Ore	9 tons
Internal waste	32 tons
Total	140 tons

Wind Erosion From Mine Area

An emission factor of 0.9 tons/acre-year developed for agricultural fields (Cowherd et al., 1976) was used to estimate wind erosion emissions from exposed soil and rock surfaces in the mine area. This emission factor is expected to be conservatively high since the farm fields used to develop the emission factor are located in the Saint Louis area where the erodability factor (Chepil et al., 1962) is higher than in the project area, and loose farm soils should be less resistant to erosion than exposed ore and overburden rock. During each year of mining, approximately 92 acres will be exposed, half of which will be under the water table or will be wetted or treated with chemical binders. The remaining 46 acres should produce, at most, 41 tons of dust per year as a result of wind erosion.

Waste Dump Development

Overburden and internal waste will be deposited in waste dumps and backfill areas. The internal mine waste emissions are expected to be insignificant since this material will be extracted from below the water table. Half of the overburden will also have been removed from below the water table, and the other half will have been watered or sprinkled prior to removal. It is expected that the moisture content and sprinkling will reduce potential truck dumping emissions of 0.02/ton (PEDCo, 1978) by half. With about 40 percent of the resultant emissions settling out near the source, the emission factor for waste dump development is 0.006 lb/ton. Annual fugitive dust emissions from this source for the period 1981 through 1984 are calculated to be:

2.92×10^7 tons/yr x 0.006 lb/ton x 1 ton/2000 lb =

88 tons/yr

ORE STOCKPILING

The EPA (1975) emission factor for aggregate stockpiling in the project region is 3.2 lb/ton of ore stored (P-E factor = 32). Stockpiling emissions can generally be divided into the following source activities:

- on-loading (12 percent or 0.39 lb/ton)
- off-loading (15 percent or 0.48 lb/ton)
- vehicle activity (40 percent or 1.29 lb/ton)
- wind erosion (33 percent or 1.06 lb/ton)

These emission factors represent uncontrolled potential emissions (i.e., without application of dust inhibitors). Each source of activity is described below.

On-loading. Ore from the mines will be removed from below the water table and is expected to contain at least 10 percent moisture. For this reason, loading of the ore onto stockpiles is expected to result in minimal fugitive dust emissions. To provide conservatism to the emission estimates, it is assumed that the high moisture content of the ore will reduce emissions by 50 percent to 0.20 lb/ton of ore.

Off-loading. The ore is expected to retain a high percentage of its moisture in the stockpiles. In addition, these piles will be sprinkled to control wind erosion losses. This high moisture content was assumed to reduce potential emissions by 50 percent to approximately 0.24 lb/ton of ore.

Vehicular Traffic. Active working surfaces will be watered frequently to control dust. This is expected to reduce emissions by 50 percent to approximately 0.65 lb/ton. Of this amount, about 50 percent (0.33 lb/ton) is assumed to be ore dust and the remainder will be dust from natural soil surfaces.

Wind erosion. The wind erosion component of stockpile emissions has been modified to reflect the lower surface area/volume ratio of the uranium stockpiles than the aggregate stockpiles studied by Midwest Research Institute (1974 and reported in AP-42). The proposed 550,000-ton stockpile for the Anderson project is estimated to have a surface area* of approximately 250,000 square feet, or about 0.63 ft^2/ton of ore. The aggregate stockpiles studied by MRI had an overall surface area/volume ratio of 1.9 ft^2/ton of aggregate. To correct for this significant difference, the erosion factor (1.06 lb/ton) was multiplied by the ratio of 0.63 to 1.9. In addition, sprinkling of the stockpile surfaces and application of chemical stablizers as necessary is expected to reduce emissions by an additional 50 percent. Therefore, wind erosion emissions are expected to be 0.17 lb/ton of ore.

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*Surface area calculations for the project stockpile were based on the assumption that the exposed surface of the three stockpiles will be between that of three cubes and three cones with 1/2 height-to-radius ratio.

Total stockpile emissions. Component emission factors for the ore stockpiles at the Anderson project are summarized below.

Source	Emissions (lb/ton) Total Dust	Ore Dust
On-Loading	0.20	0.20
Off-Loading	0.24	0.24
Vehicular traffic	0.65	0.33
Wind erosion	0.17	0.17
Total	1.26	0.94

Assuming that 2000 tons of ore will pass through the stockpile per day, 365 days/year, annual stockpile dust emissions will be 460 tons. About 340 tons will consist of ore dust.

Summary of Fugitive Dust

Annual fugitive dust emissions resulting from the proposed project for years 1981 through 1984 are summarized below.

Activity	Annual Emissions (tons)
Overburden stripping	87
Haul road travel	147
Wind erosion	41
Waste dump development	88
Ore stockpiling	460
Total	816

ATMOSPHERIC DISPERSION MODELING
A DESCRIPTION OF THE MODEL WITH INPUT AND OUTPUT DATA

THE VALLEY MODEL

The U.S. Environmental Protection Agency's Valley Model (EPA, 1977) was chosen to predict dispersion of gaseous and particulate pollutants resulting from the proposed Anderson project. Briefly, the Valley Model simulates the effect of complex terrain on dispersion of air pollutants released from elevated sources. No terrain corrections are made for ground-level sources with minimal effective stack heights. The Valley Model equation (or algorithm) is a modified form of the Pasquill-Gifford equation for annual-average and short-term estimates. Briggs' plume rise equation is used to calculate effective stack heights for buoyant plumes. A more detailed description of the Valley Model, including input and output parameters, is available in the "Valley Model User's Guide" (EPA, 1977). The version of this model used for impact assessment has been modified to provide tabular output and is capable of handling more than seven receptor rings (a limitation of the basic Valley Model computer code).

MODEL INPUT AND OUTPUT

Annual Average Calculations

Following this discussion are the results of individual Valley Model runs for particulate matter, sulfur dioxide, and nitrogen dioxide. Each run consists of individual source contributions (i.e., mill boiler stack and yellowcake concentrate stack for sulfur dioxide and nitrogen dioxide, and the ore receiving stack in addition to the above two stacks for particulate matter) and a table of total concentrations. All concentrations are reported in units of micrograms per cubic meter ($\mu g/m^3$). Concentrations are reported for each of the 16 cardinal compass directions at 10 distances from a reference point near the ore receiving stack. Elevation data were input for each source and receptor location. Elevation differences (relative to the reference point) are summarized in the final table of each set. Annual average meteorological data described earlier in this appendix were used in the computations.

Short-Term Calculations

Short-term (24-hour) concentrations were calculated individually for each source, as well as in combination, for each of five pollutants. In order to avoid improper overlapping of source plumes that can occur as a result of the sources being separated from the receptor grid center point, four separate runs were performed for each pollutant with four opposing directions per run (i.e., first run - N/E/S/W, second run - NNE/ESE/SSW/WNW, etc.). The point of maximum concentration beyond site boundaries was determined from each set of four runs. Maximum particulate concentrations were found to occur south-southwest of the reference point, but due to a difference in source distribution, maximum concentrations for sulfur dioxide, nitrogen dioxide, carbon monoxide, and hydrocarbons were found to occur east-northeast of the reference point. Therefore, only model output for the NNE/ESE/SSW/WNW directions is presented for particulate matter (TSP), while output for the ENE/SSE/WSW/NNW directions is presented for the other pollutants in this appendix.

Concentrations for 8-hour averaging times and less were calculated from the 24-hour values presented in the following pages. The Valley Model code assumes 6 hours of continuous wind speed, wind direction and stability class for 24-hour computations, and multiplies all short-term values by 6/24 prior to output. Therefore, values presented in Table 4.4-1 for other averaging periods were obtained by multiplying Valley Model results by the following factors:

Averaging Time (hours)	Conversion Factor
8	8/6
3	24/6
1	24/6

MINERALS ANDERSON-60245A-ANNUAL CO

NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER-TSP	6.0000-02	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	21.5	17.9

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	4.638-02	3.948-02	7.331-02	8.193-02	1.593-02	1.334-02	1.146-02	2.430-02	1.609-02	9.216-03
NNE	3.695-02	2.574-02	2.537-02	1.180-02	9.216-03	7.510-03	6.303-03	4.552-03	6.372-03	4.627-03
NE	6.861-02	2.957-02	1.694-02	1.115-02	7.993-03	6.566-03	4.968-03	3.239-03	1.982-03	1.542-03
ENE	.102	6.012-02	4.050-02	2.940-02	2.257-02	1.837-02	2.385-02	1.308-02	7.530-03	6.480-03
E	6.659-02	3.597-02	2.330-02	1.643-02	1.246-02	9.967-03	9.862-03	9.275-03	6.011-03	4.041-03
ESE	3.749-02	1.663-02	1.103-02	8.207-03	5.234-03	4.240-03	4.569-03	5.026-03	4.647-03	3.067-03
SE	1.724-02	1.127-02	8.370-03	6.631-03	6.549-03	5.580-03	1.166-02	8.031-03	5.416-03	3.692-03
SSE	1.922-02	2.203-02	1.844-02	1.557-02	3.169-02	3.764-02	3.690-02	2.477-02	1.606-02	1.223-02
S	5.333-02	4.797-02	3.799-02	3.071-02	3.783-02	2.879-02	2.928-02	3.776-02	2.433-02	1.765-02
SSW	.123	5.121-02	2.986-02	2.081-02	2.130-02	1.374-02	2.900-02	1.132-02	1.320-02	9.279-03
SW	6.820-02	2.031-02	1.116-02	7.507-03	5.593-03	4.386-03	4.577-03	3.231-03	5.823-03	3.346-03
WSW	2.422-02	8.735-03	5.777-03	4.452-03	3.777-03	3.212-03	2.856-03	2.181-03	1.697-03	1.376-03
W	3.579-02	1.328-02	8.396-03	6.259-03	5.076-03	4.364-03	3.856-03	2.866-03	2.210-03	1.778-03
WNW	3.745-02	1.603-02	9.991-03	7.323-03	5.868-03	4.959-03	4.346-03	4.018-02	2.720-03	2.203-03
NW	5.839-02	2.011-02	1.114-02	7.529-03	5.680-03	4.592-03	3.845-03	3.339-02	2.100-02	1.482-02
NNW	8.264-02	3.580-02	4.689-02	1.310-02	9.554-03	3.852-02	3.673-02	8.084-03	1.642-02	8.938-03

MINERALS ANDERSON-60245A-ANNUAL CO

NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	6.093-03	4.996-03	2.901-03
NNE	3.302-03	3.282-03	1.785-03
NE	2.308-03	1.504-03	1.003-03
ENE	4.561-03	3.505-03	1.882-03
E	2.851-03	2.328-03	1.607-03
ESE	2.340-03	1.813-03	7.210-04
SE	2.907-03	2.399-03	6.632-04
SSE	9.953-03	8.239-03	5.192-03
S	1.412-02	1.172-02	7.619-03
SSW	7.054-03	5.763-03	3.673-03
SW	2.170-03	2.005-03	2.412-03
WSW	1.099-03	9.125-04	8.827-04
W	1.551-03	1.829-03	1.148-03
WNW	2.272-03	3.497-03	4.755-03
NW	1.173-02	7.109-03	1.818-03
NNW	4.835-03	4.116-03	1.190-03

MAXIMUM (SSW SECTOR, 300. METERS) = .1229 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
ORE RECIEVING-TSP	3.2000-02	-12.	-40.	1950.	0.	21.	292.	.30	12.9	.91	0.	.0	.0	.0

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - ORE RECIEVING-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	.199	.194	.110	6.653-02	2.423-02	1.847-02	1.485-02	1.657-02	1.042-02	5.909-03
NNE	.128	8.995-02	5.067-02	1.920-02	1.227-02	9.345-03	7.349-03	5.601-03	4.274-03	3.659-03
NE	7.577-02	2.671-02	1.599-02	9.557-03	6.934-03	8.359-03	5.259-03	3.656-03	1.832-03	1.387-03
ENE	.168	6.905-02	3.987-02	2.629-02	1.864-02	1.602-02	1.647-02	8.137-03	4.546-03	3.751-03
E	.159	5.356-02	2.785-02	1.737-02	1.211-02	9.522-03	1.095-02	5.690-03	3.542-03	2.320-03
ESE	9.434-02	3.786-02	3.377-02	1.906-02	7.369-03	6.017-03	6.996-03	4.820-03	2.705-03	1.731-03
SE	7.938-02	3.444-02	1.927-02	1.549-02	1.592-02	1.149-02	1.023-02	5.641-03	3.617-03	2.398-03
SSE	.207	9.067-02	5.268-02	4.578-02	5.671-02	4.192-02	3.259-02	1.757-02	1.074-02	7.775-03
S	.718	.237	.113	6.908-02	8.175-02	5.732-02	4.727-02	2.570-02	1.586-02	1.110-02
SSW	.153	6.392-02	3.843-02	3.992-02	3.916-02	2.311-02	2.202-02	1.280-02	7.952-03	5.569-03
SW	5.624-02	2.231-02	1.250-02	1.564-02	1.002-02	6.219-03	9.852-03	5.465-03	5.722-03	3.623-03
WSW	6.748-02	2.687-02	1.515-02	1.093-02	1.210-02	5.417-03	4.253-03	2.988-03	1.966-03	1.450-03
W	7.550-02	3.220-02	1.870-02	1.237-02	8.901-03	6.775-03	5.369-03	3.258-03	2.261-03	1.699-03
WNW	6.874-02	3.184-02	1.903-02	1.284-02	9.354-03	7.640-03	6.651-03	2.354-02	3.698-03	2.647-03
NW	7.001-02	2.685-02	1.518-02	9.888-03	7.491-03	6.154-03	4.665-03	1.679-02	1.060-02	7.479-03
NNW	.111	.110	9.371-02	1.721-02	1.125-02	3.156-02	2.045-02	1.259-02	9.063-03	4.919-03

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - ORE RECIEVING-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	3.834-03	3.038-03	1.642-03
NNE	2.083-03	1.973-03	1.020-03
NE	1.963-03	1.353-03	8.224-04
ENE	2.598-03	1.967-03	1.263-03
E	1.605-03	1.285-03	8.561-04
ESE	1.287-03	9.775-04	3.635-04
SE	1.826-03	1.459-03	4.674-04
SSE	6.088-03	4.904-03	2.921-03
S	8.614-03	6.982-03	4.295-03
SSW	4.192-03	3.340-03	2.071-03
SW	2.403-03	2.028-03	1.475-03
WSW	9.919-04	7.498-04	8.676-04
W	1.571-03	2.134-03	1.162-03
WNW	2.810-03	4.208-03	2.192-03
NW	5.928-03	3.478-03	7.273-04
NNW	2.629-03	2.204-03	6.570-04

MAXIMUM (S SECTOR, 300. METERS) = .7182 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA-TSP	4.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	9.0	7.5

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-TSP
OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	1.140-02	1.549-02	1.160-02	7.348-03	2.577-03	2.008-03	1.621-03	1.977-03	1.261-03	7.242-04
NNE	7.101-03	7.900-03	5.507-03	1.779-03	1.284-03	9.942-04	7.961-04	5.544-04	5.101-04	4.226-04
NE	9.422-03	3.656-03	1.975-03	1.233-03	8.559-04	7.946-04	5.423-04	3.529-04	1.930-04	1.461-04
ENE	1.403-02	6.932-03	4.200-03	2.864-03	2.092-03	1.714-03	1.959-03	9.876-04	5.594-04	4.648-04
E	9.925-03	4.477-03	2.586-03	1.702-03	1.237-03	9.778-04	1.068-03	6.918-04	4.372-04	2.895-04
ESE	6.378-03	2.623-03	2.176-03	1.440-03	6.818-04	5.496-04	6.300-04	5.247-04	3.296-04	2.145-04
SE	4.716-03	2.721-03	1.745-03	1.303-03	1.316-03	1.006-03	1.195-03	6.682-04	4.324-04	2.887-04
SSE	7.692-03	6.366-03	4.424-03	3.470-03	5.660-03	4.571-03	3.631-03	2.036-03	1.275-03	9.358-04
S	2.067-02	1.287-02	8.370-03	5.910-03	7.541-03	5.116-03	4.557-03	3.074-03	1.913-03	1.346-03
SSW	3.724-02	1.130-02	5.738-03	4.054-03	4.293-03	2.372-03	3.034-03	1.413-03	1.001-03	6.863-04
SW	1.644-02	4.236-03	2.057-03	1.366-03	9.399-04	6.562-04	8.248-04	4.777-04	6.198-04	3.700-04
WSW	8.316-03	3.070-03	1.768-03	1.185-03	9.917-04	6.644-04	5.296-04	3.304-04	2.184-04	1.601-04
W	1.103-02	3.945-03	2.264-03	1.511-03	1.094-03	8.444-04	6.766-04	4.028-04	2.683-04	1.969-04
WNW	8.407-03	3.848-03	2.313-03	1.576-03	1.155-03	8.966-04	7.340-04	3.170-03	3.561-04	2.616-04
NW	1.155-02	4.018-03	2.160-03	1.379-03	9.731-04	7.413-04	5.761-04	2.236-03	1.390-03	9.712-04
NNW	2.229-02	8.034-03	1.390-02	2.444-03	1.672-03	4.376-03	2.816-03	1.196-03	1.169-03	6.336-04

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	4.750-04	3.794-04	2.094-04
NNE	2.535-04	2.414-04	1.273-04
NE	2.140-04	1.416-04	8.869-05
ENE	3.240-04	2.464-04	1.459-04
E	2.019-04	1.625-04	1.088-04
ESE	1.612-04	1.235-04	4.770-05
SE	2.217-04	1.788-04	5.594-05
SSE	7.393-04	6.003-04	3.639-04
S	1.048-03	8.545-04	5.340-04
SSW	5.178-04	4.155-04	2.605-04
SW	2.385-04	2.073-04	1.861-04
WSW	1.153-04	8.932-05	8.934-05
W	1.685-04	2.080-04	1.171-04
WNW	2.659-04	3.961-04	2.986-04
NW	7.669-04	4.579-04	1.071-04
NNW	3.421-04	2.866-04	8.045-05

MAXIMUM (SSW SECTOR, 300. METERS) = 3.7242-02 MICROGRAMS PER CUBIC METER

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER-TSP	6.0000-02	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	21.5	17.9
ORE RECIEVING-TSP	3.2000-02	-12.	-40.	1950.	0.	21.	292.	.30	12.9	.91	0.	.0	.0	.0
URANIUM CONC AREA-TSP	4.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	9.0	7.5

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

DISTANCE - IN METERS

SECTOR	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	.256	.249	.195	.156	4.274-02	3.382-02	2.793-02	4.284-02	2.777-02	1.585-02
NNE	.172	.124	8.154-02	3.277-02	2.277-02	1.785-02	1.445-02	1.071-02	1.116-02	8.708-03
NE	.154	5.993-02	3.491-02	2.194-02	1.578-02	1.572-02	1.077-02	7.248-03	4.007-03	3.076-03
ENE	.284	.136	8.457-02	5.856-02	4.330-02	3.610-02	4.228-02	2.220-02	1.264-02	1.070-02
E	.236	9.401-02	5.374-02	3.550-02	2.581-02	2.047-02	2.187-02	1.566-02	9.990-03	6.651-03
ESE	.138	5.711-02	4.697-02	2.871-02	1.328-02	1.081-02	1.220-02	1.037-02	7.682-03	5.013-03
SE	.101	4.842-02	2.939-02	2.343-02	2.378-02	1.807-02	2.308-02	1.434-02	9.466-03	6.380-03
SSE	.234	.119	7.555-02	6.482-02	9.405-02	8.413-02	7.312-02	4.438-02	2.807-02	2.095-02
S	.792	.298	.159	.106	.127	9.122-02	8.110-02	6.653-02	4.210-02	3.009-02
SSW	.314	.126	7.403-02	6.478-02	6.476-02	3.921-02	5.405-02	2.554-02	2.215-02	1.553-02
SW	.141	4.685-02	2.572-02	2.451-02	1.655-02	1.126-02	1.525-02	9.174-03	1.216-02	7.339-03
WSW	.100	3.868-02	2.269-02	1.657-02	1.687-02	9.293-03	7.639-03	5.500-03	3.882-03	2.986-03
W	.122	4.943-02	2.936-02	2.014-02	1.507-02	1.198-02	9.901-03	6.527-03	4.740-03	3.674-03
WNW	.115	5.172-02	3.133-02	2.174-02	1.638-02	1.350-02	1.173-02	6.689-02	6.774-03	5.112-03
NW	.140	5.097-02	2.848-02	1.880-02	1.414-02	1.149-02	9.085-03	5.241-02	3.299-02	2.327-02
NNW	.215	.154	.154	3.275-02	2.247-02	7.446-02	5.999-02	2.187-02	2.665-02	1.449-02

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	1.040-02	8.414-03	4.753-03
NNE	5.639-03	5.497-03	2.932-03
NE	4.484-03	2.998-03	1.914-03
ENE	7.482-03	5.718-03	3.291-03
E	4.657-03	3.776-03	2.572-03
ESE	3.788-03	2.914-03	1.132-03
SE	4.955-03	4.037-03	1.187-03
SSE	1.678-02	1.374-02	8.478-03
S	2.378-02	1.955-02	1.245-02
SSW	1.176-02	9.519-03	6.005-03
SW	4.811-03	4.240-03	4.073-03
WSW	2.207-03	1.752-03	1.840-03
W	3.291-03	4.171-03	2.427-03
WNW	5.348-03	8.101-03	7.245-03
NW	1.843-02	1.104-02	2.652-03
NNW	7.806-03	6.607-03	1.928-03

MAXIMUM (S SECTOR, 300. METERS) = .7922 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CO
NCENTRATIONS

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

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MINERALS ANDERSON-60245A-ANNUAL CO

NCENTRATIONS

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

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MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-SO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER-SO2	1.850	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	21.5	17.9

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-SO2

(OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	1.43	1.22	2.26	2.53	.491	.411	.353	.749	.496	.284
NNE	1.14	.794	.782	.364	.284	.232	.194	.140	.196	.143
NE	2.12	.912	.522	.344	.246	.202	.153	9.986-02	6.110-02	4.755-02
ENE	3.15	1.85	1.25	.906	.696	.566	.735	.403	.232	.200
E	2.05	1.11	.718	.507	.384	.307	.304	.286	.185	.125
ESE	1.16	.513	.340	.253	.161	.131	.141	.155	.143	9.458-02
SE	.532	.347	.258	.204	.202	.172	.360	.248	.167	.114
SSE	.593	.679	.569	.480	.977	1.16	1.14	.764	.495	.377
S	1.64	1.48	1.17	.947	1.17	.888	.903	1.16	.750	.544
SSW	3.79	1.58	.921	.642	.657	.424	.894	.349	.407	.286
SW	2.10	.626	.344	.231	.172	.135	.141	9.964-02	.180	.103
WSW	.747	.269	.178	.137	.116	9.902-02	8.806-02	6.726-02	5.232-02	4.241-02
W	1.10	.409	.259	.193	.157	.135	.119	8.836-02	6.815-02	5.483-02
WNW	1.15	.494	.308	.226	.181	.153	.134	1.24	8.386-02	6.792-02
NW	1.80	.620	.344	.232	.175	.142	.119	1.03	.647	.457
NNW	2.55	1.10	1.45	.404	.295	1.19	1.13	.249	.506	.276

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-SO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	.188	.154	8.945-02
NNE	.102	.101	5.504-02
NE	7.115-02	4.636-02	3.093-02
ENE	.141	.108	5.803-02
E	8.791-02	7.178-02	4.954-02
ESE	7.214-02	5.590-02	2.223-02
SE	8.963-02	7.398-02	2.045-02
SSE	.307	.254	.160
S	.435	.361	.235
SSW	.217	.178	.113
SW	6.690-02	6.182-02	7.436-02
WSW	3.390-02	2.814-02	2.722-02
W	4.783-02	5.639-02	3.539-02
WNW	7.006-02	.108	.147
NW	.362	.219	5.606-02
NNW	.149	.127	3.670-02

MAXIMUM (SSW SECTOR, 300. METERS) = 3.790 MICROGRAMS PER CUBIC METER

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-SO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA-SO2	4.0000-02	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	9.0	7.5

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-SO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	.114	.155	.116	7.348-02	2.577-02	2.008-02	1.621-02	1.977-02	1.261-02	7.242-03
NNE	7.101-02	7.900-02	5.507-02	1.779-02	1.284-02	9.942-03	7.961-03	5.544-03	5.101-03	4.226-03
NE	9.422-02	3.656-02	1.975-02	1.233-02	8.559-03	7.946-03	5.423-03	3.529-03	1.930-03	1.461-03
ENE	.140	6.932-02	4.200-02	2.864-02	2.092-02	1.714-02	1.959-02	9.876-03	5.594-03	4.648-03
E	9.925-02	4.477-02	2.586-02	1.702-02	1.237-02	9.778-03	1.068-02	6.918-03	4.372-03	2.895-03
ESE	6.378-02	2.623-02	2.176-02	1.440-02	6.818-03	5.496-03	6.300-03	5.247-03	3.296-03	2.145-03
SE	4.716-02	2.721-02	1.745-02	1.303-02	1.316-02	1.006-02	1.195-02	6.682-03	4.324-03	2.887-03
SSE	7.692-02	6.366-02	4.424-02	3.470-02	5.660-02	4.571-02	3.631-02	2.036-02	1.275-02	9.358-03
S	.207	.129	8.370-02	5.910-02	7.541-02	5.116-02	4.557-02	3.074-02	1.913-02	1.346-02
SSW	.372	.113	5.738-02	4.054-02	4.293-02	2.372-02	3.034-02	1.413-02	1.001-02	6.863-03
SW	.164	4.236-02	2.057-02	1.366-02	9.399-03	6.562-03	8.248-03	4.777-03	6.198-03	3.700-03
WSW	8.316-02	3.070-02	1.768-02	1.185-02	9.917-03	6.644-03	5.296-03	3.304-03	2.184-03	1.601-03
W	.110	3.945-02	2.264-02	1.511-02	1.094-02	8.444-03	6.766-03	4.028-03	2.683-03	1.969-03
WNW	8.407-02	3.848-02	2.313-02	1.576-02	1.155-02	8.966-03	7.340-03	3.170-02	3.561-03	2.616-03
NW	.116	4.018-02	2.160-02	1.379-02	9.731-03	7.413-03	5.761-03	2.236-02	1.390-02	9.712-03
NNW	.223	8.034-02	.139	2.444-02	1.672-02	4.376-02	2.816-02	1.196-02	1.169-02	6.336-03

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MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-SO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	4.750-03	3.794-03	2.094-03
NNE	2.535-03	2.414-03	1.273-03
NE	2.140-03	1.416-03	8.869-04
ENE	3.240-03	2.464-03	1.459-03
E	2.019-03	1.625-03	1.088-03
ESE	1.612-03	1.235-03	4.770-04
SE	2.217-03	1.788-03	5.594-04
SSE	7.393-03	6.003-03	3.639-03
S	1.048-02	8.545-03	5.340-03
SSW	5.178-03	4.155-03	2.605-03
SW	2.385-03	2.073-03	1.861-03
WSW	1.153-03	8.932-04	8.934-04
W	1.685-03	2.080-03	1.171-03
WNW	2.659-03	3.961-03	2.986-03
NW	7.669-03	4.579-03	1.071-03
NNW	3.421-03	2.866-03	8.045-04

MAXIMUM (SSW SECTOR, 300. METERS) = .3724 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER-SO2	1.850	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	21.5	17.9
URANIUM CONC AREA-SO2	4.0000-02	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	9.0	7.5

MINERALS ANDFRSON-60245A-ANNUAL CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VFRSION OF EPA VALLEY MODEL)

CONCFNTRATION - IN MICROGRAMS PER CUBIC METFR

SFCTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.	WORST-CASE OUTSIDE BOUNDARY	
N	1.54	1.37	2.38	2.60	.517	.431	.370	.769	.509	.291	.769	
NNF	1.21	.873	.837	.382	.297	.241	.202	.146	.202	.147	.241	
NF	2.21	.948	.542	.356	.255	.210	.159	.103	6.303-02	4.901-02	.159	
FNF	3.30	1.92	1.29	.935	.717	.583	.755	.413	.238	.204	.755	
F	2.15	1.15	.744	.524	.397	.317	.315	.293	.190	.127	.316	
FSF	1.22	.539	.362	.267	.168	.136	.147	.160	.147	9.672-02	.147	
SF	.579	.375	.276	.217	.215	.182	.372	.254	.171	.117	.254	
SSF	.669	.743	.613	.515	1.03	1.21	1.17	.784	.508	.387	1.21	
S	1.85	1.61	1.26	1.01	1.24	.939	.948	1.19	.769	.558	1.24	1500
SSW	4.16	1.69	.978	.682	.700	.447	.924	.363	.417	.293	.700	
SW	2.27	.669	.365	.245	.182	.142	.149	.104	.186	.107	.149	
WSW	.830	.300	.196	.149	.126	.106	9.336-02	7.057-02	5.451-02	4.402-02	.05	
W	1.21	.449	.282	.208	.167	.143	.126	9.239-02	7.083-02	5.680-02	.07	
WNW	1.24	.533	.331	.242	.192	.162	.141	1.27	8.742-02	7.053-02	.242	
NW	1.92	.660	.365	.246	.185	.149	.124	1.05	.661	.467	.365	
NNW	2.77	1.18	1.58	.428	.311	1.23	1.16	.261	.518	.282	1.23	

MINERALS ANDERSON-60245A-ANNUAL CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	.193	.158	9.155-02
NNE	.104	.104	5.631-02
NE	7.329-02	4.778-02	3.182-02
ENE	.144	.111	5.949-02
E	8.993-02	7.340-02	5.063-02
ESE	7.375-02	5.713-02	2.271-02
SE	9.185-02	7.576-02	2.101-02
SSE	.314	.260	.164
S	.446	.370	.240
SSW	.223	.182	.116
SW	6.928-02	6.389-02	7.622-02
WSW	3.505-02	2.903-02	2.811-02
W	4.952-02	5.847-02	3.656-02
WNW	7.272-02	.112	.150
NW	.369	.224	5.713-02
NNW	.152	.130	3.750-02

MAXIMUM (SSW SECTOR, 300. METERS) = 4.162 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

MINERALS ANDERSON-60245A-ANNUAL CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

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MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER NO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER NO2	.5800	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	21.5	17.9

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER NO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	.448	.382	.709	.792	.154	.129	.111	.235	.156	8.909-02
NNE	.357	.249	.245	.114	8.909-02	7.259-02	6.093-02	4.400-02	6.159-02	4.472-02
NE	.663	.286	.164	.108	7.727-02	6.347-02	4.803-02	3.131-02	1.916-02	1.491-02
ENE	.989	.581	.392	.284	.218	.178	.231	.126	7.279-02	6.264-02
E	.644	.348	.225	.159	.120	9.635-02	9.533-02	8.966-02	5.811-02	3.906-02
ESE	.362	.161	.107	7.934-02	5.059-02	4.099-02	4.417-02	4.858-02	4.492-02	2.965-02
SE	.167	.109	8.091-02	6.410-02	6.330-02	5.394-02	.113	7.763-02	5.236-02	3.569-02
SSE	.186	.213	.178	.151	.306	.364	.357	.239	.155	.118
S	.516	.464	.367	.297	.366	.278	.283	.365	.235	.171
SSW	1.19	.495	.289	.201	.206	.133	.280	.109	.128	8.970-02
SW	.659	.196	.108	7.257-02	5.406-02	4.240-02	4.424-02	3.124-02	5.629-02	3.234-02
WSW	.234	8.444-02	5.584-02	4.304-02	3.652-02	3.105-02	2.761-02	2.109-02	1.640-02	1.330-02
W	.346	.128	8.116-02	6.051-02	4.907-02	4.219-02	3.727-02	2.770-02	2.137-02	1.719-02
WNW	.362	.155	9.658-02	7.079-02	5.672-02	4.793-02	4.202-02	.388	2.629-02	2.129-02
NW	.564	.194	.108	7.278-02	5.491-02	4.439-02	3.716-02	.323	.203	.143
NNW	.799	.346	.453	.127	9.235-02	.372	.355	7.815-02	.159	8.640-02

.365 S 3000

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER NO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	5.890-02	4.830-02	2.804-02
NNE	3.192-02	3.173-02	1.726-02
NE	2.231-02	1.454-02	9.697-03
ENE	4.409-02	3.388-02	1.819-02
E	2.756-02	2.250-02	1.553-02
ESE	2.262-02	1.753-02	6.970-03
SE	2.810-02	2.319-02	6.411-03
SSE	9.621-02	7.964-02	5.019-02
S	.137	.113	7.365-02
SSW	6.818-02	5.571-02	3.551-02
SW	2.097-02	1.938-02	2.331-02
WSW	1.063-02	8.821-03	8.533-03
W	1.500-02	1.768-02	1.109-02
WNW	2.197-02	3.380-02	4.596-02
NW	.113	6.872-02	1.757-02
NNW	4.674-02	3.979-02	1.150-02

MAXIMUM (SSW SECTOR, 300. METERS) = 1.188 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA NO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA NO2	1.3000-02	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	9.0	7.5

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA NO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	3.705-02	5.034-02	3.770-02	2.388-02	8.374-03	6.526-03	5.269-03	6.425-03	4.098-03	2.354-03
NNE	2.308-02	2.568-02	1.790-02	5.780-03	4.172-03	3.231-03	2.587-03	1.802-03	1.658-03	1.373-03
NE	3.062-02	1.188-02	6.417-03	4.006-03	2.782-03	2.582-03	1.762-03	1.147-03	6.272-04	4.748-04
ENE	4.561-02	2.253-02	1.365-02	9.307-03	6.799-03	5.571-03	6.365-03	3.210-03	1.818-03	1.510-03
E	3.225-02	1.455-02	8.404-03	5.533-03	4.020-03	3.178-03	3.471-03	2.248-03	1.421-03	9.408-04
ESE	2.073-02	8.525-03	7.072-03	4.680-03	2.216-03	1.786-03	2.047-03	1.705-03	1.071-03	6.972-04
SE	1.533-02	8.844-03	5.670-03	4.234-03	4.276-03	3.268-03	3.882-03	2.172-03	1.405-03	9.382-04
SSE	2.500-02	2.069-02	1.438-02	1.128-02	1.840-02	1.485-02	1.180-02	6.618-03	4.143-03	3.041-03
S	6.719-02	4.183-02	2.720-02	1.921-02	2.451-02	1.663-02	1.481-02	9.989-03	6.217-03	4.374-03
SSW	.121	3.671-02	1.865-02	1.318-02	1.395-02	7.708-03	9.861-03	4.593-03	3.252-03	2.230-03
SW	5.344-02	1.377-02	6.685-03	4.439-03	3.055-03	2.133-03	2.681-03	1.553-03	2.014-03	1.203-03
WSW	2.703-02	9.979-03	5.746-03	3.852-03	3.223-03	2.159-03	1.721-03	1.074-03	7.097-04	5.204-04
W	3.585-02	1.282-02	7.357-03	4.912-03	3.555-03	2.744-03	2.199-03	1.309-03	8.721-04	6.399-04
WNW	2.732-02	1.251-02	7.516-03	5.123-03	3.754-03	2.914-03	2.386-03	1.030-02	1.157-03	8.503-04
NW	3.755-02	1.306-02	7.019-03	4.481-03	3.162-03	2.409-03	1.872-03	7.266-03	4.516-03	3.157-03
NNW	7.246-02	2.611-02	4.517-02	7.944-03	5.435-03	1.422-02	9.151-03	3.888-03	3.798-03	2.059-03

MINERALS ANDERSON-60245A-ANNUAL CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA NO2

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	1.544-03	1.233-03	6.805-04
NNE	8.238-04	7.846-04	4.136-04
NE	6.955-04	4.601-04	2.882-04
ENE	1.053-03	8.009-04	4.742-04
E	6.562-04	5.280-04	3.538-04
ESE	5.239-04	4.013-04	1.550-04
SE	7.207-04	5.811-04	1.818-04
SSE	2.403-03	1.951-03	1.183-03
S	3.405-03	2.777-03	1.736-03
SSW	1.683-03	1.350-03	8.466-04
SW	7.751-04	6.739-04	6.048-04
WSW	3.746-04	2.903-04	2.903-04
W	5.476-04	6.761-04	3.807-04
WNW	8.643-04	1.287-03	9.704-04
NW	2.492-03	1.488-03	3.480-04
NNW	1.112-03	9.313-04	2.615-04

MAXIMUM (SSW SECTOR, 300. METERS) = .1210 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

LONG-TERM (ANNUAL) CONCENTRATIONS COMPUTED (ISHORT=0)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = .67 2.45 4.77 6.93 9.61 12.52
SUM OF WIND FREQUENCY MATRIX = 1.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHI) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER NO2	.5800	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	21.5	17.9
URANIUM CONC AREA NO2	1.3000-02	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	9.0	7.5

MINERALS ANDERSON-60245A-ANNUAL CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	.485	.432	.746	.816	.162	.136	.116	.241	.160	9.145-02
NNE	.380	.274	.263	.120	9.326-02	7.582-02	6.351-02	4.580-02	6.325-02	4.610-02
NE	.694	.298	.170	.112	8.005-02	6.606-02	4.979-02	3.245-02	1.978-02	1.538-02
ENE	1.03	.604	.405	.293	.225	.183	.237	.130	7.461-02	6.415-02
E	.676	.362	.234	.164	.124	9.953-02	9.880-02	9.191-02	5.953-02	4.000-02
ESE	.383	.169	.114	8.402-02	5.281-02	4.277-02	4.622-02	5.029-02	4.599-02	3.035-02
SE	.182	.118	8.658-02	6.833-02	6.758-02	5.721-02	.117	7.981-02	5.376-02	3.663-02
SSE	.211	.234	.193	.162	.325	.379	.368	.246	.159	.121
S	.583	.506	.394	.316	.390	.295	.298	.375	.241	.175
SSW	1.31	.532	.307	.214	.220	.140	.290	.114	.131	9.193-02
SW	.713	.210	.115	7.700-02	5.712-02	4.453-02	4.692-02	3.279-02	5.830-02	3.355-02
WSW	.261	9.441-02	6.159-02	4.689-02	3.974-02	3.321-02	2.933-02	2.216-02	1.711-02	1.382-02
W	.382	.141	8.852-02	6.542-02	5.263-02	4.493-02	3.947-02	2.901-02	2.224-02	1.783-02
WNW	.389	.167	.104	7.591-02	6.048-02	5.085-02	4.440-02	.399	2.745-02	2.214-02
NW	.602	.207	.115	7.726-02	5.807-02	4.680-02	3.904-02	.330	.207	.146
NNW	.871	.372	.498	.135	9.779-02	.387	.364	8.204-02	.162	8.846-02

MINERALS ANDERSON-60245A-ANNUAL CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	6.044-02	4.953-02	2.873-02
NNE	3.275-02	3.251-02	1.767-02
NE	2.300-02	1.500-02	9.985-03
ENE	4.514-02	3.468-02	1.867-02
E	2.822-02	2.303-02	1.588-02
ESE	2.314-02	1.793-02	7.125-03
SE	2.882-02	2.377-02	6.592-03
SSE	9.862-02	8.160-02	5.138-02
S	.140	.116	7.539-02
SSW	6.987-02	5.706-02	3.636-02
SW	2.175-02	2.005-02	2.392-02
WSW	1.100-02	9.111-03	8.823-03
W	1.554-02	1.835-02	1.147-02
WNW	2.283-02	3.509-02	4.693-02
NW	.116	7.021-02	1.792-02
NNW	4.785-02	4.072-02	1.177-02

MAXIMUM (SSW SECTOR, 300. METERS) = 1.309 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-ANNUAL CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

MINERALS ANDERSON-60245A-ANNUAL CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

@FIN

Short-Term Calculations

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-24TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (TSHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA-24TSP	5.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA-24TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	2.913-11	.134	.106	7.040-02	1.245-14	9.787-17	4.639-09	2.187-02	1.399-02	6.109-03
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENE	4.909-07	7.209-17	1.123-18	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	1.167-05	4.953-07	2.171-07	5.909-07	2.355-06	4.246-05	1.119-02	1.773-02	1.115-02	6.646-03
ESE	2.421-06	3.888-05	2.890-03	1.289-03	4.488-06	1.077-05	2.500-04	2.587-04	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S	0.000	2.489-04	1.336-04	7.652-05	3.681-02	1.492-02	2.170-02	2.337-02	1.437-02	1.014-02
SSW	0.000	0.000	3.627-09	1.722-04	5.328-03	3.653-04	4.537-03	7.374-04	3.473-04	4.162-05
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
W	0.000	0.000	2.836-16	0.000	0.000	0.000	1.062-17	2.366-10	1.794-08	7.610-08
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNW	0.000	2.755-04	5.590-02	7.286-09	0.000	8.862-03	4.276-03	4.627-04	5.865-04	1.286-04

MINERALS ANDERSON-60245A-24HR CONC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	2.961-03	2.414-03	1.119-03
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	0.000	0.000	0.000
E	3.950-03	3.401-03	3.099-03
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	0.000	0.000	0.000
S	8.251-03	6.966-03	4.653-03
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	0.000	0.000	0.000
W	1.969-06	1.227-04	4.839-05
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	1.043-05	0.000	0.000

MAXIMUM (N SECTOR, 600. METERS) = .1344 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - ORE RECIEVING-24TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
ORE RECIEVING-24TSP	3.2000-02	-12.	-40.	1950.	0.	21.	292.	.30	12.9	.91	0.	.0	*****	.0

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - ORE RECIEVING-241SP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	3.393-03	1.45	.903	.542	5.819-11	3.465-13	1.407-06	.145	9.071-02	3.770-02
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	4.416-02	5.022-04	1.073-04	9.501-05	2.457-04	2.525-03	.182	.111	6.870-02	4.005-02
ESE	1.345-02	1.320-02	7.777-02	2.170-02	1.416-04	1.541-04	5.722-04	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S	1.54	.397	6.586-02	1.781-02	.524	.297	.296	.158	9.422-02	6.534-02
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	1.599-18	6.467-07	8.214-05	0.000	0.000	0.000	0.000	0.000
W	0.000	0.000	2.091-09	1.578-13	0.000	3.693-16	1.238-13	7.062-08	1.764-06	4.647-06
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNW	1.433-13	3.024-02	3.037-02	4.286-07	0.000	0.000	0.000	0.000	0.000	0.000

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - ORE RECIEVING-24TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	1.710-02	1.386-02	6.012-03
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	0.000	0.000	0.000
E	2.309-02	1.995-02	1.871-02
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	0.000	0.000	0.000
S	5.272-02	4.428-02	2.930-02
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	0.000	0.000	0.000
W	6.944-05	2.302-03	8.374-04
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	0.000	0.000	0.000

MAXIMUM (S SECTOR, 300. METERS) = 1.537 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-24TSP

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	Y (SVFT) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER-24TSP	8.0000-02	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER-24TSP

(OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	1.623-02	1.27	1.16	1.139-17	0.000	2.076-10	.368	.237	.108
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENE	4.024-14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	3.370-12	3.813-11	2.839-10	7.681-09	1.281-07	9.136-06	2.434-02	.305	.193	.118
ESE	1.595-13	2.015-08	3.206-04	4.603-04	4.571-07	3.122-06	3.999-04	2.353-03	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S	0.000	2.729-08	4.668-07	1.762-06	6.499-02	2.297-02	6.537-02	.393	.244	.173
SSW	0.000	0.000	1.750-13	6.626-06	6.712-03	2.147-04	7.158-02	4.001-03	8.444-03	2.136-03
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.818-11	5.507-09	4.432-08
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNW	0.000	4.423-08	.144	1.176-11	0.000	.112	8.314-02	1.526-03	1.235-02	3.205-03

MINERALS ANDERSON-60245A-24HR CONC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	5.598-02	4.567-02	2.236-02
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	0.000	0.000	0.000
E	7.208-02	6.165-02	5.408-02
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	0.000	0.000	0.000
S	.140	.118	7.877-02
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	0.000	0.000	0.000
W	2.367-06	3.433-04	1.610-04
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	5.555-04	0.000	0.000

MAXIMUM (N SECTOR, 900. METERS) = 1.275 MICROGRAMS PER CUBIC METER

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA-24TSP	5.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9
ORE RECIEVING-24TSP	3.2000-02	-12.	-40.	1950.	0.	21.	292.	.30	12.9	.91	0.	.0	*****	.0
MILL BOILER-24TSP	8.0000-02	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	3.393-03	1.60	2.28	1.77	5.820-11	3.466-13	1.412-06	.536	.342	.152
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENE	4.909-07	7.209-17	1.123-18	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	4.417-02	5.026-04	1.075-04	9.561-05	2.481-04	2.576-03	.217	.434	.273	.164
ESE	1.345-02	1.324-02	8.098-02	2.345-02	1.465-04	1.680-04	1.222-03	2.612-03	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S	1.54	.397	6.599-02	1.788-02	.626	.335	.383	.574	.352	.248
SSW	0.000	0.000	3.627-09	1.789-04	1.204-02	5.800-04	7.612-02	4.738-03	8.792-03	2.178-03
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	1.599-18	6.467-07	8.214-05	0.000	0.000	0.000	0.000	0.000
W	0.000	0.000	2.091-09	1.578-13	0.000	3.693-16	1.238-13	7.088-08	1.788-06	4.767-06
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNW	1.433-13	3.052-02	.231	4.359-07	0.000	.121	8.741-02	1.989-03	1.294-02	3.334-03

1C

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	7.604-02	6.194-02	2.949-02
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	0.000	0.000	0.000
E	9.911-02	8.501-02	7.589-02
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	0.000	0.000	0.000
S	.201	.170	.113
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	0.000	0.000	0.000
W	7.377-05	2.768-03	1.047-03
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	5.659-04	0.000	0.000

MAXIMUM (N SECTOR, 900. METERS) = 2.283 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

DISTANCE - IN METERS

SECTOR	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24S02

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA 24S02	7.2000-02	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24S02

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	3.588-06	5.806-11	1.660-06	0.000	6.318-10	8.218-04	3.123-05	5.648-05	0.000	0.000
ENE	1.837-04	5.744-13	7.087-14	1.920-07	8.338-09	4.447-03	.608	.222	7.550-02	.119
E	1.108-05	1.345-07	2.431-08	1.106-08	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	1.396-09	1.608-03	.920	.709	.567	.310	.188	.143
S	1.031-03	3.655-03	7.466-04	2.189-04	.117	3.422-02	4.067-02	2.435-02	7.696-03	2.453-03
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	1.371-07	8.228-04	1.268-09	2.528-12	1.352-05	1.682-05	2.598-05
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	8.790-16	0.000	5.432-15	0.000	1.062-09	4.920-08	1.122-08	1.914-02	5.415-03	1.048-03
NNW	0.000	3.908-03	1.63	8.507-07	0.000	.731	.450	.100	.227	.112

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24S02

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	6.602-02	4.453-02	8.776-03
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	.117	9.751-02	6.091-02
S	4.130-04	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	2.396-06	4.318-07	1.800-03
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	4.751-02	4.229-02	0.000

MAXIMUM (SECTOR, 1200. METERS) = 1.627 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER 24S02	2.500	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24S02

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	1.549-13	1.855-16	4.409-09	0.000	1.133-11	1.070-03	2.740-05	3.353-04	0.000	0.000
ENE	1.113-10	0.000	0.000	2.180-09	1.805-10	3.580-03	19.8	8.36	3.09	4.47
E	1.455-12	6.976-12	2.530-11	1.224-10	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	1.554-13	1.281-04	8.25	17.5	19.7	11.3	6.96	5.27
S	5.998-13	1.280-06	5.376-06	8.803-06	.444	.113	.275	1.06	.358	.132
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	1.314-10	8.319-05	1.622-11	3.111-14	8.165-06	2.062-05	5.091-05
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	5.790-12	2.132-09	8.349-10	.830	.258	7.095-02
NNW	0.000	9.292-07	8.37	4.123-09	0.000	18.0	16.6	.679	8.33	4.22

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24S02

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	2.57	1.77	.103
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	4.33	3.60	2.25
S	4.288-02	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	4.505-06	8.312-07	1.516-02
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	1.92	1.69	.118

MAXIMUM (ENE SECTOR, 2100. METERS) = 19.75 MICROGRAMS PER CUBIC METER

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA 24S02	7.2000-02	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9
MILL BOILER 24S02	2.500	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	3.588-06	5.806-11	1.665-06	0.000	6.432-10	1.892-03	5.863-05	3.918-04	0.000	0.000
ENE	1.837-04	5.744-13	7.087-14	1.942-07	8.518-09	8.026-03	20.4	8.58	3.17	4.59
E	1.108-05	1.345-07	2.433-08	1.118-08	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	1.396-09	1.736-03	9.17	18.3	20.2	11.6	7.14	5.41
S	1.031-03	3.656-03	7.520-04	2.277-04	.561	.147	.315	1.08	.366	.135
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	1.372-07	9.060-04	1.285-09	2.559-12	2.169-05	3.744-05	7.689-05
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	8.790-16	0.000	5.432-15	0.000	1.067-09	5.133-08	1.206-08	.849	.263	7.200-02
NNW	0.000	3.909-03	10.00	8.548-07	0.000	18.7	17.0	.780	8.56	4.33

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	2.63	1.81	.112
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	4.45	3.69	2.31
S	4.329-02	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	6.902-06	1.263-06	1.696-02
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	1.97	1.73	.118

MAXIMUM (ENE SECTOR, 2100. METERS) = 20.36 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

@FIN

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24CO

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00

SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME TEMP (TS) DEG-K	PLUME RISE PARAMETERS DIA (D) M	PLUME RISE PARAMETERS VEL (VS) M/SEC	PLUME RISE PARAMETERS FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA 24CO	5.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24CO

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	2.492-07	4.032-12	1.153-07	0.000	4.388-11	5.707-05	2.169-06	3.922-06	0.000	0.000
ENE	1.275-05	3.989-14	4.921-15	1.334-08	5.790-10	3.088-04	4.224-02	1.540-02	5.243-03	8.264-03
E	7.693-07	9.340-09	1.688-09	7.682-10	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	9.694-11	1.117-04	6.390-02	4.922-02	3.937-02	2.149-02	1.307-02	9.905-03
S	7.162-05	2.538-04	5.185-05	1.520-05	8.115-03	2.377-03	2.824-03	1.691-03	5.344-04	1.703-04
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	9.521-09	5.714-05	8.809-11	1.756-13	9.390-07	1.168-06	1.804-06
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	6.104-17	0.000	3.772-16	0.000	7.372-11	3.417-09	7.792-10	1.329-03	3.760-04	7.277-05
NNW	0.000	2.714-04	.113	5.907-08	0.000	5.074-02	3.125-02	6.973-03	1.580-02	7.760-03

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24CO

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	4.585-03	3.092-03	6.094-04
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	8.154-03	6.771-03	4.230-03
S	2.868-05	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	1.664-07	2.999-08	1.250-04
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	3.299-03	2.937-03	0.000

MAXIMUM (SECTOR, 1200. METERS) = .1130 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24CO

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
MILL BOILER 24CO	.1800	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24C0

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	1.116-14	1.336-17	3.175-10	0.000	8.160-13	7.705-05	1.973-06	2.414-05	0.000	0.000
ENE	8.012-12	0.000	0.000	1.570-10	1.299-11	2.577-04	1.42	.602	.223	.322
E	1.047-13	5.022-13	1.822-12	8.809-12	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	1.119-14	9.221-06	.594	1.26	1.42	.815	.501	.380
S	4.319-14	9.215-08	3.871-07	6.338-07	3.200-02	8.107-03	1.978-02	7.601-02	2.578-02	9.513-03
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	9.458-12	5.990-06	1.168-12	2.240-15	5.878-07	1.485-06	3.665-06
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	4.169-13	1.535-10	6.011-11	5.974-02	1.856-02	5.109-03
NNW	0.000	6.690-08	.603	2.968-10	0.000	1.30	1.19	4.890-02	.600	.304

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24CO

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	.185	.127	7.406-03
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	.312	.259	.162
S	3.087-03	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	3.244-07	5.985-08	1.092-03
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	.138	.122	8.468-03

MAXIMUM (ENE SECTOR, 2100. METERS) = 1.422 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000.
6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA 24CO	5.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9
MILL BOILER 24CO	.1800	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	2.492-07	4.032-12	1.156-07	0.000	4.469-11	1.341-04	4.142-06	2.807-05	0.000	0.000
ENE	1.275-05	3.989-14	4.921-15	1.349-08	5.920-10	5.665-04	1.46	.618	.228	.330
E	7.693-07	9.341-09	1.690-09	7.770-10	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	9.695-11	1.209-04	.658	1.31	1.46	.836	.514	.389
S	7.162-05	2.539-04	5.224-05	1.584-05	4.011-02	1.048-02	2.260-02	7.770-02	2.631-02	9.684-03
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	9.530-09	6.313-05	8.925-11	1.778-13	1.527-06	2.653-06	5.469-06
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	6.104-17	0.000	3.772-16	0.000	7.414-11	3.570-09	8.393-10	6.107-02	1.893-02	5.181-03
NNW	0.000	2.715-04	.716	5.937-08	0.000	1.35	1.22	5.588-02	.616	.312

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	.189	.131	8.016-03
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	.320	.266	.166
S	3.116-03	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	4.908-07	8.983-08	1.217-03
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	.142	.125	8.468-03

MAXIMUM (ENE SECTOR, 2100. METERS) = 1.465 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

@FIN

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24HC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

```
RECEPTOR RING RADII (R) IN METERS =     300.    600.    900.   1200.   1500.   1800.   2100.   3000.   4000.   5000.
                                       6000.   7000.  10000.
RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS =   0.     0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC =    1.00     .00     .00     .00     .00     .00
     SUM OF WIND FREQUENCY MATRIX =   4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN =  292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS =   945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.
```

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA 24HC	1.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24HC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	4.984-08	8.064-13	2.306-08	0.000	8.775-12	1.141-05	4.338-07	7.844-07	0.000	0.000
ENE	2.551-06	7.978-15	9.843-16	2.667-09	1.158-10	6.176-05	8.449-03	3.081-03	1.049-03	1.653-03
E	1.539-07	1.868-09	3.376-10	1.536-10	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	1.939-11	2.233-05	1.278-02	9.844-03	7.874-03	4.299-03	2.615-03	1.981-03
S	1.432-05	5.076-05	1.037-05	3.040-06	1.623-03	4.753-04	5.648-04	3.382-04	1.069-04	3.406-05
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	1.904-09	1.143-05	1.762-11	3.512-14	1.878-07	2.336-07	3.608-07
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	1.221-17	0.000	7.544-17	0.000	1.474-11	6.834-10	1.558-10	2.659-04	7.521-05	1.455-05
NNW	0.000	5.428-05	2.260-02	1.181-08	0.000	1.015-02	6.251-03	1.395-03	3.159-03	1.552-03

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - URANIUM CONC AREA 24HC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	9.170-04	6.184-04	1.219-04
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	1.631-03	1.354-03	8.460-04
S	5.736-06	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	3.328-08	5.998-09	2.500-05
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	6.599-04	5.874-04	0.000

MAXIMUM (SECTOR, 1200. METERS) = 2.2604-02 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24HC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00

SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.

AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.

AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME TEMP (TS) DEG-K	RISE PARAMETERS DIA (D) M	RISE PARAMETERS VEL (VS) M/SEC	RISE PARAMETERS FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS BRIGUN	BRIGE	BRIGF
MILL BOILER 24HC	4.0000-02	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24HC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS									
	300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	2.479-15	2.969-18	7.055-11	0.000	1.813-13	1.712-05	4.384-07	5.366-06	0.000	0.000
ENE	1.780-12	0.000	0.000	3.488-11	2.888-12	5.727-05	.316	.134	4.951-02	7.157-02
E	2.327-14	1.116-13	4.048-13	1.958-12	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	2.487-15	2.049-06	.132	.281	.315	.181	.111	8.434-02
S	9.597-15	2.048-08	8.601-08	1.408-07	7.111-03	1.801-03	4.395-03	1.689-02	5.728-03	2.114-03
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	2.102-12	1.331-06	2.595-13	4.978-16	1.306-07	3.300-07	8.145-07
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	0.000	0.000	0.000	0.000	9.265-14	3.410-11	1.336-11	1.328-02	4.124-03	1.135-03
NNW	0.000	1.487-08	.134	6.596-11	0.000	.288	.265	1.087-02	.133	6.751-02

MINERALS ANDERSON-60245A-24HR CONC

INDIVIDUAL SOURCE CONTRIBUTION - MILL BOILER 24HC

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS		
	6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	4.105-02	2.833-02	1.646-03
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	6.930-02	5.752-02	3.598-02
S	6.861-04	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	7.209-08	1.330-08	2.426-04
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	3.077-02	2.707-02	1.882-03

MAXIMUM (ENE SECTOR, 2100. METERS) = .3161 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

VALLEY MODEL OPTION SELECTION

SHORT-TERM (24-HR) CONCENTRATIONS COMPUTED (ISHORT=1)

SLOPING TERRAIN CORRECTION ALGORITHM OF VALLEY MODEL UTILIZED

RURAL DISPERSION PARAMETERS UTILIZED (IUR=2)

CONCENTRATIONS COMPUTED AS UG/M**3 AT AMBIENT CONDITIONS

MODIFICATIONS TO VALLEY MODEL ALGORITHM:

RECEPTORS ARE LOCATED ON CONCENTRIC RINGS OF VARIABLE RADII

INPUT PARAMETER LIST:

RECEPTOR RING RADII (R) IN METERS = 300. 600. 900. 1200. 1500. 1800. 2100. 3000. 4000. 5000. 6000. 7000. 10000.

RINGS CENTERED AT X,Y (CNTRX,CNTRY) IN METERS = 0. 0.

WIND SPEED CLASS MEANS (WSA) IN M/SEC = 1.00 .00 .00 .00 .00 .00
SUM OF WIND FREQUENCY MATRIX = 4.00

AMBIENT AIR TEMPERATURE (TEMP) IN KELVIN = 292.
AMBIENT AIR PRESSURE (P) IN MILLIBARS = 945.
AFTERNOON MIXING HEIGHT (DMIX) IN METERS = 2400.

SOURCE PARAMETERS	EMISSION RATE (QSOT) G/SEC	COORDINATES X (SHOT) M	COORDINATES Y (SVET) M	GROUND ELEV (SORHT) FT	AREA WIDTH (WT) M	STACK HGT (HST) M	PLUME RISE PARAMETERS TEMP (TS) DEG-K	DIA (D) M	VEL (VS) M/SEC	FLOW (VF) M3/SEC	FIXED RISE (GT) M	CALCULATED BRIGGS PLUME RISE FACTORS (BRIGUN	BRIGE	BRIGF)
URANIUM CONC AREA 24HC	1.0000-03	-115.	-26.	1950.	0.	21.	322.	.30	16.5	1.17	0.	9.5	*****	15.9
MILL BOILER 24HC	4.0000-02	-126.	-26.	1950.	0.	21.	505.	.56	14.4	3.55	0.	68.1	*****	38.0

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NNE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NE	4.984-08	8.064-13	2.313-08	0.000	8.957-12	2.854-05	8.722-07	6.150-06	0.000	0.000
ENE	2.551-06	7.976-15	9.843-16	2.702-09	1.187-10	1.190-04	.325	.137	5.056-02	7.322-02
E	1.539-07	1.868-09	3.380-10	1.556-10	0.000	0.000	0.000	0.000	0.000	0.000
ESE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SSE	0.000	0.000	1.939-11	2.438-05	.145	.291	.323	.185	.114	8.632-02
S	1.432-05	5.078-05	1.046-05	3.181-06	8.734-03	2.277-03	4.960-03	1.723-02	5.835-03	2.148-03
SSW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WSW	0.000	0.000	0.000	1.906-09	1.276-05	1.788-11	3.561-14	3.184-07	5.636-07	1.175-06
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WNW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NW	1.221-17	0.000	7.544-17	0.000	1.484-11	7.175-10	1.692-10	1.354-02	4.199-03	1.150-03
NNW	0.000	5.430-05	.157	1.188-08	0.000	.298	.272	1.226-02	.137	6.906-02

MINERALS ANDERSON-60245A-24HR CONC

SUM OF ALL SOURCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

CONCENTRATION - IN MICROGRAMS PER CUBIC METER

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	0.000	0.000	0.000
NNE	0.000	0.000	0.000
NE	0.000	0.000	0.000
ENE	4.197-02	2.895-02	1.768-03
E	0.000	0.000	0.000
ESE	0.000	0.000	0.000
SE	0.000	0.000	0.000
SSE	7.093-02	5.888-02	3.683-02
S	6.918-04	0.000	0.000
SSW	0.000	0.000	0.000
SW	0.000	0.000	0.000
WSW	1.054-07	1.930-08	2.676-04
W	0.000	0.000	0.000
WNW	0.000	0.000	0.000
NW	0.000	0.000	0.000
NNW	3.143-02	2.765-02	1.882-03

MAXIMUM (ENE SECTOR, 2100. METERS) = .3245 MICROGRAMS PER CUBIC METER

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 300.	600.	900.	1200.	1500.	1800.	2100.	3000.	4000.	5000.
N	-3.	27.	46.	91.	-107.	-137.	-94.	91.	113.	247.
NNE	3.	27.	34.	-34.	-119.	-91.	-107.	-46.	162.	24.
NE	0.	-34.	-27.	-107.	-76.	-21.	-46.	-40.	-82.	-82.
ENE	3.	-46.	-70.	-58.	-82.	-34.	46.	204.	320.	186.
E	3.	-18.	-34.	-46.	-52.	-46.	-3.	168.	186.	235.
ESE	3.	-3.	9.	3.	-34.	-34.	-9.	18.	104.	162.
SE	-12.	-21.	-46.	-24.	-3.	-9.	46.	82.	88.	140.
SSE	-34.	-61.	-46.	-21.	27.	40.	49.	98.	134.	128.
S	12.	3.	-9.	-21.	15.	3.	9.	76.	110.	125.
SSW	-52.	-46.	-30.	-9.	12.	-12.	43.	6.	64.	79.
SW	-61.	-30.	-70.	-21.	-34.	-52.	-21.	-34.	12.	-12.
WSW	-46.	-82.	-82.	-46.	-30.	-91.	-125.	-88.	-104.	-113.
W	-70.	-82.	-58.	-98.	-152.	-152.	-152.	-131.	-131.	-137.
WNW	-18.	-40.	-119.	-143.	-131.	-82.	-79.	46.	-85.	-98.
NW	-6.	-58.	-58.	-119.	-70.	-70.	-85.	76.	94.	107.
NNW	-24.	3.	34.	-46.	-143.	40.	137.	-9.	76.	198.

MINERALS ANDERSON-60245A-24HR CONC

RECEPTOR TERRAIN,GRID HEIGHT DIFFERENCES

OUTPUT FROM PROGRAM VALMOD (A MODIFIED VERSION OF EPA VALLEY MODEL)

TERRAIN HEIGHT - IN METERS ABOVE SOURCE NO. 1

SECTOR	DISTANCE - IN METERS 6000.	7000.	10000.
N	320.	320.	351.
NNE	229.	113.	198.
NE	3.	-27.	-30.
ENE	259.	290.	-61.
E	283.	274.	198.
ESE	174.	195.	351.
SE	140.	137.	564.
SSE	113.	107.	107.
S	113.	101.	76.
SSW	88.	88.	61.
SW	-34.	-30.	30.
WSW	-143.	-168.	-91.
W	-122.	-82.	-107.
WNW	-82.	-46.	259.
NW	98.	201.	381.
NNW	308.	296.	442.

@FIN

APPENDIX C

BIOLOGY

APPENDIX C-1

BIOLOGICAL SAMPLING PROCEDURES

Sample site locations were stratified to obtain a representative sample of each of the major vegetation types identified on the Anderson property and in adjacent areas. Three major strata were recognized during a reconnaissance of the area: Joshua tree woodland, upland desert, and riverine (riparian and pseudoriparian). All sample grids, lines, and point transects were selected randomly within each strata. The objective of each sample method was to obtain maximum coverage and provide replication within strata. When a random sampling point fell in an area that had been obviously disturbed, such as areas disturbed by past mining activities, new random sites were selected. The field sampling schedule is provided in Table C-1.

VEGETATION

Vegetation sampling procedures used in the field program are described by Mueller-Dombois and Ellenberg (1974) and Phillips (1959). The line intercept method was used to measure vegetation cover and composition of shrubs, forbs, and grasses. Size-class criterion was used in the sampling; measurement of basal area of any intercepted plant

TABLE C-1

VEGETATION AND WILDLIFE FIELD SCHEDULE FOR THE ANDERSON URANIUM PROJECT

OBJECTIVE/TECHNIQUE	SAMPLE PERIOD	COMMENTS
1. Floristics	All Field Visits	General Reconnaissance
2. Vegetation Sampling		
a. Line intercept,	11-15 Apr., 1977	Sites 1-4
and quadrats	31 Oct.-06 Nov, 1977	Sites 5-14
b. Point-centered	13-15 Apr., 1977	Sites 1 and 2
quadrats	31 Oct.-06 Nov., 1977	Sites 5,6,7, and 8
c. 100 pt.-line	17 Aug. 1977	Near Sites 1,5, and 6
intercept		and at Almo Rd Enclosure.
3. Faunistics	All Field Visits	General Reconnaissance
4. Faunal Sampling		
a. Herptiles		
1) 5x5 drop-trap	21-23 Apr., 1977	All grids (A,B,C, and D)
grids	08-10 June, 1977	All grids
	21-23 Oct., 1977	All grids
b. Birds		
1) Transect Counts	25-27 Feb., 1977	Transects M-1, S-2, and R-1
	06-08 Apr., 1977	Tr. M-1, M-2, S-1, S-2, R-1, and R-2
	07-10 June, 1977	Same as April
	20-23 Oct., 1977	Same as April
2) Breeding Data	Mar.-Aug., 1977	General Reconnaissance
5. Small Mammals		
a. Live trap assess-	20-23 Apr., 1977	Sites A-G
ment lines	19-23 Oct., 1977	Sites A-G
6. Rabbits		
a. Spring count	06-08 Apr., 1977	20 mi. in and near project site
b. Summer count	07-09 June, 1977	Same as April
c. Fall count	20-22 Oct., 1977	Same as April
7. Deer		
a. Track and Pellet	Same as birds	Transects M-1 through R-2
8. Other Mammals	All Field Visits	General Reconnaissance

Source: Dames & Moore, 1978a

less than six feet in height was included in the sample. Line intercepts were run at 14 locations (Figure 2.8-1). Twenty square meter quadrats were placed along each line intercept at 15-foot intervals. The density of forbs and grasses was measured in each quadrat.

The point-center quarters method was used to measure absolute density and dominance of large shrubs, trees, and cacti on sample sites 1, 2, 5, 6, 7, and 8 (Figure 2.8-1). At each of the selected sample sites, 20 points were read along a compass transect. Points along the transect were placed at 100-foot intervals to insure that plants were not resampled. At each point a 90° arc was read from true north dividing the full circle into four quadrants. In each quadrant the distance from the point to the nearest plant exceeding six feet in height was measured as well as the plant diameter at ground level.

Ten 100-point intercepts were read in upland areas to measure percent relative composition and cover. The points were read at three foot intervals along the intercepts. All plants intercepting the vertical plane to the point were tallied and the sum of sample plants per species was recorded. Three intercepts were run at each of the following locations: 0.2 mile north of sample site 1, in the vicinity of sample site 5, and in the vicinity of sample site 6. These locations were selected as representative of Joshua tree woodland and upland desert vegetation. One 100-point intercept was read in an established exclosure in Joshua tree woodland vegetation approximately four miles west of Highway 93 on Alamo Road. This site is about 16 miles southeast of the Anderson property. The exclosure has been fenced from livestock since the mid-1960s.

In addition to these samples, six 300-foot line intercepts were run parallel to the proposed access road right-of-way at intervals of approximately 2.2 miles. Plant occurrence was noted along the lines. Plants less than six feet in height that intercepted the vertical plane of the lines were counted. All plants greater than six feet in height within 50 feet of the road were counted. These data are in general agreement with the data presented in this report.

During the field program, floral composition was studied through the use of standard keys and field guides. Kearney and Peebles (1960) was referenced as the authority for scientific nomenclature.

WILDLIFE

Four rectilinear drop-trap grids were used to sample herptiles (reptiles and amphibians) (Figure 2.8-1). Traps consisted of open top, one gallon cans set in the ground so that the rims were level with the surface. The cans were placed at 12 meter intervals along coordinates in a 5 x 5 can grid. Samples were taken on a seasonal basis (Table C-1). During each sample period a one-square-foot masonite board was placed over each can and supported on stones to insure about two inches of clearance between the can rim and the lid. After three days, all traps were inspected for captures.

Birds were surveyed seasonally (Table C-1) by transect counts and general reconnaissance. Six transects were established in the area (Figure 2.8-1). In each season, counts were taken on three consecutive days along each transect. The number of all birds and the distance between the transect and the sighting were recorded. These data were converted to density based on methods described by Emlen (1971). Signs of breeding activity were recorded during all censuses and general reconnaissance. Data on breeding included evidence of breeding pairs, courtship behavior and presence of nests, juveniles, and broods.

Small mammals were sampled in the fall and spring (Table C-1) using the modified Calhoun method (1956). Seven sample sites were established in the area (Figure 2.8-1). Four of these sites (A, B, C and D) coincided with the drop-trap grids. Two traplines were established at each site. These lines were placed 250 feet apart and parallel to each other. Twenty-five Sherman live traps were places at 12-meter intervals along each line. The traps were baited and checked for three consecutive nights. Captured animals were marked, identifed, sexed, aged, and released at the point of capture. These data were used to determine composition, abundance, and reproductive status.

The relative abundance and population trend data for rabbits and other intermediate-sized mammals was obtained by using the roadsite-spotlight method (Lord, 1959). This census was conducted for three consecutive nights during April, June, and October (Table C-1) and involved counting all sightings within the headlight beams of a vehicle driven at less than 10 mph. The routes randomly traversed approximately 20 miles of unimproved road in the area (Figure 2.8-1).

Deer were sampled by noting evidence of tracks and pellet groups along bird transects. Sampling was conducted simultaneously with bird counts.

Other mammals such as predators and bats were noted by sightings and evidence of sign during general reconnaissance.

During the field program, wildlife was identified using standard keys and field guides. Scientific nomenclature follows Stebbins (1966), Blair et al. (1968), American Orithologist Union (1957), Phillips et al. (1964), Robbins et al. (1966), Burt and Gossenheider (1964), and Cockrum (1960).

APPENDIX C-2

PLANTS AND ANIMALS OBSERVED IN THE VICINITY OF THE ANDERSON PROPERTY

TABLE C-2

PLANTS OBSERVED AT THE ANDERSON URANIUM PROJECT AREA

TREES		COMMUNITY/VEGETATION TYPE[a] 1	2	3	4
Canotia holocantha	Crucifixion Thorn		X	X	X
Cercidium floridum	Blue Palo Verde	X	X		
C. microphyllum	Little-leaf Palo Verde	X	X	X	X
Chilopsis linearis	Desert Willow	X	X		
Populus Fremontii	Fremont Cottonwood	X			
Salix spp.	Willow	X			
SHRUBS, CACTI, AND LILLIES					
Acacia constricta	White-thorn	X	X	X	
A. Greggi	Catclaw	X	X	X	
Agave parryi	Agave				X
Agave spp.	Mescal				X
Aplopappus gracilis	Slender Goldenbush		X		
Aplopappus spp.	Goldenbush	X	X	X	

a. Community/Vegetation Type:

1. Riparian
2. Pseudoriparian
3. Joshua Tree Woodland
4. Upland desert

TABLE C-2 (CONTINUED)

Atriplex polycarpa	Desert Saltbush	X	X		
Atriplex spp.	Saltbush	X	X		
Baccharis glutinosa	Seep-willow	X			
B. sarothroides	Desert-broom	X	X	X	
Brickellia californica	Brickelbush		X		

SHRUBS, CACTI, AND LILLIES		COMMUNITY/VEGETATION TYPE 1	2	3	4
Cereus giganteus	Saguaro				X
Chrysothamnus paniculatus	Black-bark Rabbitbush	X			
Condalia spp.	Graythorn		X		
Cowania Stansburiana	Cliff-rose		X		
Crossosoma Bigelovii	Bigelow Ragged Rock-flower		X		
Echinocereus fasciculatus	Hedgehog Cactus			X	X
E. Engelmanii	Englemann Hedgehog Cactus				X
Encelia farinosa	Brittlebush		X		X
Ephedra trifurca	Joint-fir		X	X	X
Ephedra spp.	Joint-fir			X	
Eriogonum fasciculatum	Flat-top Buckwheat-brush	X	X	X	X
Ferocactus acanthodes	Barrel Cactus			X	X
Fouquieria splendens	Ocotillo			X	X
Franseria deltoidea	Triangle Bursage		X		X
F. dumosa	White Bursage		X	X	X
Holocantha Emoryi	Crucifixion-thorn		X		X

TABLE C-2 (CONTINUED)

		COMMUNITY/VEGETATION TYPE 1	2	3	4
menoclea monogyra	Burrobush				X
H. salsola	Burrobush		X		
Hyptis Emoryi	Desert Lavender		X		
Krameria Grayi	White Ratany			X	X
K. parvifolia	Range Ratany			X	X
Larrea divaricata	Creosotebush		X	X	X
Lycium Andersonii	Anderson Thornbush		X		X
SHRUBS, CACTI, AND LILLIES					
L. pallidum	Rabbit-thorn		X		
Lycium spp.	Wolfberry	X	X	X	
Mammallaria microcarpa	Fishhook Pincushion		X	X	X
Nolina Bigelovii	Bigelow Nolina				X
Opuntia acanthocarpa	Buckhorn Cholla	X	X	X	X
O. basilaris	Beavertail Cactus			X	X
O. bigelovii	Teddy Bear Cholla				X
O. chlorotica	Pancake Prickly Pear				X
O. englemannii	Englemann Prickly Pear				X
O. leptocaulis	Christmas Cactus			X	X
O. phaecantha	Engelmann Prickly Pear				X
Psilostrophe cooperi	Paper Flower			X	X
Prosopis juliflora	Mesquite	X	X		
P. pubescens	Screwbean	X	X		
Salazaria mexicana	Baldder-sage			X	X

TABLE C-2 (CONTINUED)

Senecio spp.	Goldenbush			X	X
Tamarix pentandra	Salt Cedar	X			
Yucca baccata	Banana Yucca			X	X
Y. brevifolia	Joshua Tree		X	X	X
Y. elata	Soaptree Yucca				X
Yucca spp.	Yucca			X	X
GRASSES					
Aristida spp.	Threeawn	X	X		
Bouteloua aristidoides	Six Weeks Grama		X		X

GRASSES		COMMUNITY/VEGETATION TYPE 1	2	3	4
Bouteloua spp.	Grama Grass		X		X
Bromus arizonicus	Arizona Brome			X	X
Bromus rubens	Red Brome			X	X
Cynodon Dactylon	Bermuda Grass	X			
Hilaria mutica	Tobosa		X	X	X
H. rigida	Big Galleta		X	X	X
Muhlenbergia porteri	Bush Muhley		X	X	X
Muhlenbergia spp.	Muhley			X	
Schismus barbatus	Schismus	X	X	X	X
Setaria spp.	Bristlegrass		X		
Sporobolus cryptandrus	Sand Dropseed		X		
Sporobolus spp.	Dropseed		X		X
Tridens pulchellus	Desert Fluffgrass				X

TABLE C-2 (CONTINUED)

		COMMUNITY/VEGETATION TYPE 1	2	3	4
FORBS					
Allionia incarnata	Trailing Four O'Clock	X	X		
Allionia spp.	Four O'Clock	X	X		
Ambrosia spp.	Ragweed	X	X		
Amsinckia spp.	Fiddle-neck	X	X	X	X
Aster abatus	Mohave Aster				X
Aster spp.	Aster	X	X	X	X
Baileya multiradiata	Desert Marigold			X	X
Boerhaavia spp.	Spiderling	X	X	X	X
Chaenactis stevioides	Chaenactis			X	X
Calochortus Kennedyi	Mariposa Lily	X	X	X	X
Cassia spp.	Senna	X	X	X	X
Cucurbita digitata	Wild Gourd			X	X
Datura meteloides	Western-jimson	X	X		
Erigeron spp.	Fleabane	X	X	X	X
Eriogonum deflexum	Skeletonweed			X	X
Eriogonum inflatum	Desert Trumpet		X		X
Eriogonum spp.	Buckwheat	X	X	X	X
Erodium circutarium	Filaree	X	X		X
Euphorbia prostrata	Spurge		X	X	X

TABLE C-2 Concluded

FORBS		COMMUNITY/VEGETATION TYPE 1	2	3	4
Hymenoxys spp.	Rubberweed			X	X
Lepidium spp.	Peppergrass	X	X	X	X
Lesquerella gordoni	Bladderpod			X	X
L. palmeri	Bladderpod		X		X
Lupinus sparsiflorus	Arizona Bluebonnet		X		
Lupinus spp.	Lupine			X	X
Mimulus spp.	Monkey Flower	X			
Monoptilon belloides	Mohave Desert-star		X	X	X
Nicotiana spp.	Tobacco	X	X		
Oenothera brevipes	Desert Sundrop		X		
Oenothera spp.	Primrose	X	X		
Orobanche ludoviciana	Broomrape	X	X		
Orobanche multiflora	Broomrape	X	X		
Orthocarpus purpurascens	Owl Clover		X	X	X
Phacelia Fremontii	Scorpionweed		X	X	X
Phacelia spp.	Scorpionweed			X	X
Plantago Purshii	Wooly Indianwheat			X	X
Rafinesquia neomexicana	Desert Chickory	X	X	X	X
Rafinesquia spp.	Desert Dandelion		X		X
Rumex spp.	Sorrel	X	X		
Senecio spp.	Senecio	X	X		
Sisymbrium irio	London Rocket	X	X		
Sphaeralcea ambigua	Desert Mallow				X
Sphaeralcea spp.	Globemallow	X	X	X	X
Verbena spp.	Verbena		X		X

Source: Dames & Moore, 1978a

TABLE C-3

WILDLIFE OBSERVED AT THE ANDERSON URANIUM PROJECT AREA

		VEGETATION TYPE			
		1	2	3	4
AMPHIBIANS					
Scaphiopus spp.	Spadefoot	X			
Bufo punctatus	Red-spotted Toad	X			
REPTILES					
Gopherus agassizi	Desert Tortoise	X			
Coleonyx variegatus	Banded Gecko		X	X	X
Sauromalus obesus	Chuckwalla			X	X
Dipsosaurus dorsalis	Desert Iguana		X	X	X
Callisaurus draconoides	Zebra-tailed Lizard	X	X	X	
Sceloporus magister	Desert Spiny Lizard				X
Uta stansburiana	Side-blotched Lizard	X	X	X	X

a. Vegetation Type:

1. Riparian
2. Pseudoriparian
3. Joshua Tree Woodland
4. Upland desert

TABLE C-3 (CONTINUED)

REPTILES		VEGETATION TYPE 1	2	3	4
Phrynosoma platyrhinos	Desert Horned Lizard				X
Cnemidophorus tigris	Western Whiptail	X	X	X	X
Salvadora hexalepis	Western Patch-nosed Snake				X
Pituophis melanoleucus	Gopher Snake	X	X	X	X
Arizona elegans	Glossy Snake			X	X
Crotalus atrox	Western Diamondback	X	X	X	X
C. cerastes	Sidewinder	X	X	X	X
C. scutulatus	Mohave Rattlesnake			X	X
BIRDS					
Cathartes aura	Turkey Vulture	X	X	X	X
* *Buteo jamaicensis*	Red-tailed Hawk	X	X	X	X
Accipiter cooperii	Cooper's Hawk			X	X
Aquila chrysaetos	Golden Eagle	X	X	X	X
Falco mexicana	Prairie Falcon				X
F. sparverius	American Kestrel	X	X	X	X

* Bird species of which evidence of breeding was noted on the project area.

TABLE C-3 (CONTINUED)

BIRDS		VEGETATION TYPE 1	2	3	4
* Lophortyx gambelii	Gambel's Quail	X	X	X	X
* Zenaida asiatica	White-winged Dove	X	X		X
* Z. macroura	Mourning Dove	X	X	X	X
Geococcyx californianus	Roadrunner	X	X	X	X
Otus asio	Screech Owl				X
* Bubo virginianus	Great Horned Owl	X	X	X	X
Micrathene whitneyi	Elf Owl				X
Phalaenoptilus nuttalli	Poorwill			X	X
* Chordeiles acutipennis	Lesser Nighthawk			X	X
Aeronautes saxatalis	White-throated swift	X		X	X
Archilochus alexandri	Black-chinned Hummingbird	X			
* Calypte costae	Costa's Hummingbird	X		X	X
* Colaptes auratus	Common Flicker	X	X	X	X
Centurus uropygialis	Gila Woodpecker				X
Dendrocopos scalaris	Ladder-backed Woodpecker	X			
* Tyrannus verticalis	Western Kingbird	X	X	X	X

TABLE C-3 (CONTINUED)

BIRDS		VEGETATION TYPE 1	2	3	4
* Myiarchus cinerascens	Ash-throated Flycatcher	X	X	X	X
Sayornis saya	Say's Phoebe	X			
Tachycineta thalassina	Violet-green Swallow	X		X	
Petrochelidon pyrrhonata	Cliff Swallow	X			
Corvus cryptoleucus	White-necked Raven	X	X	X	X
* Auriparus flaviceps	Verdin	X	X	X	X
* Campylorhynchus brunneicapillus	Cactus Wren		X	X	X
Catherpes mexicanus	Canyon Wren		X		
Salpinctes obsoletus	Rock Wren		X		
Mimus polyglottos	Mockingbird	X	X	X	X
Toxostoma bendirei	Bendire's Thrasher		X	X	X
* T. curvirostre	Curve-billed Thrasher	X	X	X	
* T. dorsale	Crissal Thrasher	X	X		
Oreoscoptes montanus	Sage Thrasher			X	
Turdus migratorious	Robin	X			
* Polioptila melanura	Black-tailed Gnatcatcher	X	X	X	X
Regulus calendula	Ruby-crowned Kinglet	X			

TABLE C-3 (CONTINUED)

BIRDS		VEGETATION TYPE 1	2	3	4
Phainopepla nitens	Phainopepla	X	X	X	X
* Lanius ludoviciana	Loggerhead Shrike	X	X	X	X
* Vireo bellii	Bell's Vireo	X			
V. vicinior	Gray Vireo	X			
* Vermivora luciae	Lucy's Warbler	X			
Dendroica petechia	Yellow Warbler	X			
D. coronata	Yellow-rumped Warbler	X			
Wilsonia pusilla	Wilson's Warbler	X			
Icterus cucullatus	Hooded Oriole	X			
* I. parisorum	Scott's Oriole			X	X
* Molothous ater	Brown-headed Cowbird			X	X
Carpodacus mexicanus	House Finch	X	X	X	X
Spinus tristis	American Goldfinch	X			
* S. psaltria	Lesser Goldfinch	X			
Pipilo fuscus	Brown Towhee	X		X	
Calamospiza melanocorys	Lark Bunting			X	X
Pooecetes gramineus	Vesper Sparrow			X	

TABLE C-3 (CONTINUED)

BIRDS		VEGETATION TYPE 1	2	3	4
* Amphispiza bilineata	Black-throated Sparrow		X	X	X
Spizella passerina	Chipping Sparrow		X		X
S. breweri	Brewer's Sparrow		X	X	X
Zonotrichia leucophrys	White-crowned Sparrow	X	X	X	
MAMMALS					
Myotis spp.	Myotine Bat	X			
Bassariscus astutus	Ringtail			X	X
Taxidea taxus	Badger			X	X
Canis latrans	Coyote	X	X	X	X
Lynx rufus	Bobcat	X	X	X	X
Citellus tereticaudus	Mohave Ground Squirrel			X	
Ammospermophilus harrisi	Yuma Antelope Squirrel			X	X
Perognathus amplus	Arizona Pocket Mouse			X	
P. intermedius	Rock Pocket Mouse		X		X
P. baileyi	Bailey's Pocket Mouse	X	X		

TABLE C-3 Concluded

MAMMALS		VEGETATION TYPE 1	2	3	4
Dipodomys merriami	Merriam's Kangaroo Rat	X		X	X
Peromyscus maniculatus	Deer Mouse	X			
P. boylei	Brush Mouse	X			
Neotoma albigula	Whitethroat Woodrat			X	X
Lepus californicus	Blacktail Jackrabbit	X	X	X	X
Sylvilagus auduboni	Desert Cottontail	X	X		
Odocoileus hemionus	Mule Deer	X		X	X
Equus asinus	Feral Burro	X	X	X	X

Source: Dames & Moore, 1978a

Appendix D

RADIOLOGICAL CONSIDERATIONS

RADIOLOGICAL CONSIDERATIONS

ACTIVITY RELEASES

The estimated radioactivity releases from the Anderson project are given in Table D-1. These estimates are based on an average ore grade of 0.072 percent uranium oxide. The estimates for the releases of radon-222 from all sources are based on the methods used in the Sweetwater Project Draft Environmental Statement (NRC, 1977). The ore dust releases from the ore stockpiles were estimated from information about aggregate piles (EPA, 1975). The methods and assumptions used are discussed in Appendix B. The estimates of yellowcake emissions and of ore dust from the grinding operation are based on information provided by the architect-engineer for the project.

DOSE MODELS FOR AIRBORNE EFFLUENTS

Individual and population doses are calculated at various locations around the site as a function of pathway and organ (including the whole body). Individual doses are summed over all pathways at a given location so that the maximum individual dose can be determined. Population doses are summed over all pathways to obtain the total population dose at a given location. Population doses are then summed over all locations to obtain the total population dose for each organ.

Table D-1. ACTIVITY RELEASES

Isotope	Releases (Ci/yr) Ore Storage Piles	Grinding	Yellowcake Concentrating & Packaging	Tailings	Mines	Total
Lead-210	6.4E-2	1.3E-5	6.4E-5	-	-	6.4E-2
Radon-222	2.38E+2	2.7E+1	-	3.1E0	3.03E+3	3.3E+3
Radium-226	6.4E-2	1.3E-5	6.4E-5	-	-	6.4E-2
Thorium-230	6.4E-2	1.3E-5	1.6E-3	-	-	6.6E-2
Uranium-234	6.4E-2	1.3E-5	3.2E-2	-	-	9.6E-2
Uranium-235	3.0E-3	6.1E-7	1.5E-3	-	-	4.5E-3
Uranium-238	6.4E-2	1.3E-5	3.2E-2	-	-	9.6E-2

Inhalation and ingestion dose conversion factors are based on NRC Regulatory Guide 1.109.

The dose model for exposure from contaminated ground is based on the assumption that the receptor is 1 meter above a uniformly contaminated plane that extends in all directions. Dose conversion factors used in the analyses are discussed by Soldat (1971) and others.

The external exposure dose model assumes that the contaminated medium is large compared with the range of emitted radiation. Under this assumption, the energy absorbed is equal to the energy emitted.

The following calculational models based on NRC Regulatory Guide 1.109, Rev. 0, were used to evaluate the individual and population exposures resulting from releases of airborne radioactive material. The pathways by which an individual may be significantly exposed are immersion, ground shine, inhalation, and ingestion.

IMMERSION DOSES

The model for gamma whole-body dose is based on the assumption that the contaminated medium is an "infinite volume." An "infinite volume" is one such that the extent of the medium in all directions from the point of interest is greater than the range of the emitted particles in the medium. The resulting whole-body dose is then given by:

$$D_{WB_I} = 7.88 \times 10^9 \sum_i^N R_i \, \chi/Q \, \overline{E}_{\gamma_i} \qquad \text{(D-1)}$$

where:

D_{WB_I} = whole-body gamma dose due to immersion in the cloud, mrem/yr

R_i = release rate of isotope i, Ci/sec

χ/Q = atmospheric dispersion factor, sec/m^3

$\overline{E}_{\gamma_i}$ = average gamma decay energy for isotope i, MeV/dis

7.88×10^9 = conversion factor:

$$0.25 \frac{\text{rem/sec}}{(\text{Ci/m}^3)(\text{MeV/dis})} \times 3.15 \times 10^7 \text{ sec/yr} \times 10^3 \text{ mrem/rem}$$

Activity release rates for each source are given in Table D-1. Values for the average decay energy are presented in Table D-2.

Table D-2. ISOTOPE DATA

Isotope	E_γ (MeV/dis)	λ (sec^{-1})
Lead-210	1.88E-3	1.08E-9
Radon-222	3.57E-4	2.10E-6
Radium-226	7.46E-3	1.37E-11
Thorium-230	6.00E-4	2.75E-13
Uranium-234	1.20E-1	8.90E-14
Uranium-235	1.26E-6	3.10E-17
Uranium-238	-	4.87E-18

GROUND SHINE DOSES

As it travels downwind from the project, particulate activity will deposit on the ground and be removed by decay. The ground-surface concentration of isotope i is given by:

$$C_{i_g} = R_i \, \chi/Q \, V_d \, \frac{1 - \exp(-\lambda_i t_g)}{\lambda_i} \qquad \text{(D-2)}$$

where:

C_{i_g} = ground-surface concentration of isotope i, Ci/m^2

V_d = deposition velocity = 0.003 m/sec

λ_i = radiological decay constant for isotope i, sec^{-1} (values are presented in Table D-2)

t_g = ground deposition accumulation time, sec (value used: 10 yr = 3.15×10^8 sec)

The resulting doses are determined from:

$$D_m^{(g)} = 8.76 \times 10^6 \sum_{i=1}^{N} C_i^{(g)} \, DF_{mi}^{(g)} \qquad \text{(D-3)}$$

where: $D_m^{(g)}$ = dose to organ m for ground shine, mrem/yr

8.76×10^6 = conversion factor: $\frac{8760\ hr}{yr} \times \frac{10^3\ mrem}{rem}$

$DF_{mi}^{(g)}$ = dose conversion factor (rem-meters^2/Ci-hr) for organ m due to ground shine from isotope i

The dose conversion factors for shine from the soil are based on a dose receptor standing on a plane source of uniform concentration. Values of these factors are given in Table D-3.

Table D-3. DOSE CONVERSION FACTORS FOR GROUND SHINE

Isotope	Dose Conversion Factor $\frac{rem/hr}{Ci/m^2}$	
	Whole Body	Skin
Lead-210	1.30E-2	1.70E-2
Radium-226	6.40E+0	7.40E+0
Thorium-230	6.50E+0	7.50E+0
Uranium-234	6.30E-4	1.59E-1
Uranium-235	3.20E+0	4.00E+0
Uranium-238	1.10E-1	1.50E-1

INHALATION DOSES

Inhalation of radioactive gases and particulates results in radiation exposure to the body and to specific organs. The amount of radioactive material inhaled depends on the plume concentration and the breathing rate. The resulting inhalation dose is given by:

$$D_{Inh}^{m} = 3.15 \times 10^{16} \sum_{i=1}^{N} R_i \ \chi/Q \ B_R \ DF_i^{Inh} \qquad (D\text{-}4)$$

where:

D^{m}_{Inh} = inhalation dose to organ m, mrem/yr

B_R = breathing rate = 2.32×10^{-4} m^3/sec

DF^{Inh}_{i} = inhalation dose conversion factor for organ m and isotope i, rem/μCi

3.15×10^{16} = conversion factor: $3.15 \times 10^{7} \frac{sec}{yr} \times \frac{10^{6}\mu Ci}{Ci} \times \frac{10^{3} mrem}{rem}$

Values for the inhalation dose conversion factor are presented in Table D-4.

Table D-4. DOSE CONVERSION FACTORS FOR INHALATION*

Isotope	Dose Conversion Factor (rem/μCi)			
	Bone	Whole Body	Kidney	Lung
Lead-210	2.64E+1	8.37E-1	2.12E+1	2.63E+1
Radon-222	-	-	-	2.05E-1
Radium-226	1.25E+2	9.13E+1	6.77E-2	1.17E+2
Thorium-230	2.29E+3	6.36E+1	6.40E+2	6.22E+2
Uranium-234	1.04E+1	6.46E-1	2.49E+0	5.22E+1
Uranium-235	1.00E+1	6.07E-1	2.34E+0	4.90E+1
Uranium-238	9.58E+0	5.67E-1	2.18E+0	4.58E+1

*All values are based on NRC Regulatory Guide 1.109 except for radon-222, which is based on ICRP Publication 2.

INGESTION DOSES

Activity can enter humans who ingest food containing radioactive materials. Activity enters the food ingestion pathway by deposition on grass eaten by cattle and by deposition on vegetables. The isotope concentration is a function of the concentration in air, the deposition rate, the buildup rate on the ground, the pathway, and the type of vegetation. Radioactive material will enter plants by direct deposition of activity on the shoots and by uptake from the soil. The concentration of radioactive materials in vegetation is given by:

$$C_i^v = 1.0 \times 10^6 \; R_i \; \chi/Q \; V_d \; \frac{F_R[1-\exp(-\lambda_{wi} t_e)]A_d}{Y\lambda_{wi}} + \frac{SC_i \; [1-\exp(-\lambda_i t_s)]}{P_s \lambda_i} \qquad \text{(D-5)}$$

where:

C_i^v = concentration of isotope i in vegetation, μCi/kg

F_R = fraction of deposited activity that is retained by vegetation = 0.2 for particulates

A_d = fraction of the ground surface area that is covered by vegetation
pasture grass = 0.27
vegetables = 1.0

λ_{wi} = $\lambda_w + \lambda_i$ = effective removal rate due to radioactive decay and weathering ($\lambda_w = 5.83 \times 10^{-7}$ sec^{-1} for a weathering half-life of 14 days)

Y = vegetation yield (kg/m^2 wet weight) = 0.04 kg/m^2 for pasture grass and 2.0 kg/m^2 for vegetables

t_e = time that crops are exposed to contamination
= 90 days (7.78×10^6 sec) for pasture grass
= 60 days (5.18×10^6 sec) for vegetables

SC_i = soil uptake concentration factor for isotope i (pCi/kg, wet weight, per pCi/kg, dry soil weight) (values for the soil uptake factor are presented in Table D-5)

t_s = soil exposure time (use expected plant life: 10 years = 3.15×10^8 sec)

P_s = soil surface density (productive soil layer) = 240 kg/m^2

1.0×10^6 = conversion factor from Ci to μCi

The quantity contributed by the grass is given by the first term in brackets in Equation D-5, while the quantity contributed by the soil is given by the second term.

Table D-5. SOIL AND BEEF CONCENTRATION FACTORS

Isotope	SC_i	G_b (day/kg)
Lead-210	6.50E-1	2.90E-4
Radon-222	-	-
Radium-226	3.10E-4	3.40E-2
Thorium-230	4.20E-3	2.00E-4
Uranium-234	2.50E-3	3.40E-4
Uranium-235	2.50E-3	3.40E-4
Uranium-238	2.50E-3	3.40E-4

The activity concentration in beef depends on the animal feed concentrations, feed consumption rates, and the amount of the activity consumed by the animal which is transferred to the food product of interest. For a given location and animal feed consumption pattern, the concentration of isotope i in an animal's feed is given by the following equation:

$$C_i^f = f_f\, f_g\, C_i^v \exp(-\lambda_i t_d) + (1 - f_f\, f_g) C_i^S \exp(-\lambda_i t_s) \quad \text{(D-6)}$$

where:

C_i^f = concentration of isotope i in the animal feed, μCi/kg

f_f = fraction of daily feed that is pasture grass when animal grazes on pasture = 1.0

f_g = fraction of the year that animals graze on pasture = 1.0

C_i^v = concentration of isotope i in pasture grass, μCi/kg

C_i^s = Concentration in feed at time of storage, µCi/kg (it is assumed that stored feed is grown beyond the 50-mile radius; therefore, $C_i^s = 0$)

t_d = delay between deposition on pasture grass and consumption by animals, sec = 0.0

t_s = delay time between harvest of stored food and consumption by animals, sec = 0.0

The concentrations in beef are then given by:

$$C_i^b = G_b \, Q_F \, C_i^f \, e^{-\lambda_i t_t} \qquad \text{(D-7)}$$

where:

C_i^b = concentration of isotope i in meat, µCi/kg

G_b = feed to food product transfer factor (Ci/kg)/(Ci/day) for beef (values for the transfer factor are presented in Table D-5)

Q_F = animal's rate of feed consumption for beef pathway = 50 kg/day for beef cattle

t_t = transport time from food production to consumption by man, sec = 0.0

The doses to man resulting from the consumption of meat and vegetables that contains radioactive materials are given by:

$$D_b^m = 1.0 \times 10^3 \sum_{i=1}^{N} C_i^b \, U_b \, DF_i^{ing} \text{ (for beef)} \qquad \text{(D-8)}$$

$$D_b^m = 1.0 \times 10^3 \sum_{i=1}^{N} C_i^v \, U_v \, DF_i^{ing} \text{ (for vegetables)}$$

where:

D_b^m = ingestion dose to organ m, mrem/yr

U = annual consumption rate of beef or vegetables, kg/yr

U_b = 210 kg/yr for beef

U_v = 60 kg/yr for vegetables

DF_i^{ing} = ingestion dose conversion factor for organ m and isotope i, rem/μCi (values for the dose conversion factor are presented in Table D-6)

1.0×10^3 = conversion factor from rem to mrem

Doses from vegetable consumption are based on the assumption that 10 percent of the annual individual consumption is supplied by local sources. For the beef pathway, the assumption is that 20 percent of the consumption is from local sources. The remainder of an individual's food consumption is assumed to be supplied by sources outside the 50-mile radius. These consumption rates are also used for the calculation of population doses.

Table D-6. DOSE CONVERSION FACTORS FOR INGESTION

	Dose Conversion Factor (rem/μCi)*			
Isotope	Bone	Whole Body	Kidney	Gastrointestinal Tract
Lead-210	1.53E+1	5.44E-1	1.23E+1	5.42E-2
Radon-222	-	-	-	-
Radium-226	3.05E+2	2.21E+2	1.63E-1	3.32E-1
Thorium-230	2.08E+0	5.76E-2	5.69E-1	6.02E-2
Uranium-234	8.37E-1	5.18E-2	1.99E-1	6.14E-2
Uranium-235	8.02E-1	4.86E-2	1.87E-1	7.81E-2
Uranium-238	7.67E-1	4.55E-2	1.75E-1	1.66E-1

*All values are based on NRC Regulatory Guide 1.109.

POPULATION DOSES

In order to obtain population doses it is necessary to combine individual doses with population distributions. The population dose is the summation, over all sector-distance intervals, of the product of the individual dose and the number of individuals.

$$P^m = 10^{-3} \sum_{\ell} P_{\ell} D_{\ell}^m \qquad \text{(D-9)}$$

where:

P^m = population dose to organ m obtained by summing over all locations ℓ, man-rem/yr

P_{ℓ} = human population at location ℓ

D_{ℓ}^m = individual dose to organ m at location ℓ, mrem/yr

10^{-3} = conversion factor from mrem to rem

Appendix D-2

ATMOSPHERIC DISPERSION FACTORS

This appendix gives a list of the atmospheric dispersion factors (X/Q) used in the radiological assessment.

60.7 /== 53.3 39.5
RELOCATE 2/3 INCH UP=/ 62.4

70.4 48.3

69.0

71.0 33.5

77.3 54.3

81.5 40.3

EAST MINE PIT

78.3

87.4 63.8

90.9 47.0

MINERALS ANDERSON PR

OJECT == 60245A == ANNUAL CONCS

103.3 97.3 55.5

85.3 102.0 78.6 30.9

HLIFE= ***** HRS. CONCIR CORRCID TO STD COND VIA FACTOR 1.000. MAX TOWARD 180. DEG. NORTH TOWARD TOP. PLOT 676.920

97.5 35.9

126.3 76.0

111.7 119.9 45.0

127.5 105.6

128.8 144.7 95.7 58.9

140.1 68.9

145.9

172.4 170.4 144.1 98.2

160.5 147.5

199.8 **********144.9 MULTIPLY PRINTED VALUES BY

* COORD * 1.0-02 TO GET CONC. IN UG/M3

105.7 118.7 134.3 158.4 195.9 221.9 216.5 * =.= *141.3 117.9 85.0 61.1 50.1 43.8 38.7

* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH

237.1 **********151.1 1840.FT -490. -1351. 0.M 1.0000+00 1.

192.5 144.1

265.9 200.6 152.9 120.9 BRIG.E BRIG.F OMIX DMNI STAR F WIDTH

221.2 ************** 2400. 100. 1.00 945.

248.3 103.3

213.8 314.8 146.2 80.7 BRIGUN

462.4 391.7 ********

163.5 539.1 61.4

248.8 VV MEAN WIND SPDS(MPS) VV 107.3

132.4 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 50.6

105.4 545.7 487.6 41.3

232.0 676.9 91.1

AIR T GAS T DIAM GAS V FLOW

292.****************************

191.6 89.8

304.5 155.7

547.2

135.6 69.6

195.7 158.1

107.3 56.9

237.7

163.7 138.6

0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM

I....+....I....+....I....+....I....+....I....+....I....+....I

205.4 ==RELOCATE 2/3 INCH DOWN

RURL. LONG-TERM MODE. 126.1 166.5==/ 114.4 SLOPING TERRAIN CONCEPT.

4.1 /-- 1.9 1.7
RELOCATE 2/3 INCH UP-/ 2.1

4.5 2.0

2.4
7.8 1.7
3.9 2.3

7.4 1.9
2.6 WEST MINE PIT
3.5 2.6
7.7 2.2
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
7.0 3.9 2.5
13.5 4.2 3.0 2.0
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 247. DEG. NORTH TOWARD TOP. PLOT 292.801
18.0 2.4
5.1 3.0
14.1 4.2 2.7
5.3 3.8
11.7 6.6 3.6 3.1
8.1 3.5
4.7
8.6 5.8 4.7 4.3
5.5 5.1
6.5 ********* 5.3 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-01 TO GET CONC. IN UG/M3
45.0 45.2 34.8 22.1 14.4 9.8 7.7 * -.- * 5.6 4.3 3.4 2.8 2.4 2.1 1.8
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
9.0 ********* 5.4 1750.FT -1832. -937. 0.M 1.0000+00 1.
7.7 5.8
13.5 9.4 6.1 4.0 BRIG.F BRIG.F OMIX OMNI STAR F WIDTH
6.8 ************** 2400. 100. 1.00 365.
19.4 3.4
25.9 11.4 4.4 3.0 BRIGUN
8.3 5.3 ********
54.6 6.7 2.5
15.3 VV MEAN WIND SPDS(MPS) VV 4.0
292.8 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 2.3

94.2 9.5 4.8 1.8
18.5 6.3 3.2
AIR T GAS T DIAM GAS V FLOW
292.***************************
24.5 2.3
8.6 3.1
4.6
41.0 2.0

7.5 2.8
52.8 1.7
4.5

11.1 2.6
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
3.2 --RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 11.9 3.8--/ 2.3 SLOPING TERRAIN CONCEPT.

9.6 /== 9.8 6.5
RELOCATE 2/3 INCH UP=/ 12.9

12.2 8.6

17.2
11.9 4.3
16.1 11.3

15.0 5.6
24.8 ORE STOCK PILE
22.0 17.0
19.7 7.7
MINERALS ANDERSON PR
OJECT == 60245A == ANNUAL CONCS
27.5 42.2 11.4
13.1 39.0 31.2 5.9
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 337. DEG. NORTH TOWARD TOP. PLOT 342.004
17.5 8.3
46.0 20.4
23.0 86.2 11.4
90.2 81.5
34.6 77.3 38.3 17.6
47.8 24.6
225.1
77.3 174.2 239.1 51.5
342.0 232.2
189.0 *********136.8 MULTIPLY PRINTED VALUES BY
* COORD * 1.0=01 TO GET CONC. IN UG/M3
10.2 13.1 17.5 25.2 40.7 73.5 168.0 * =.= *161.6 52.2 24.8 14.3 9.2 6.5 4.8
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
114.5 *********163.5 1950.FT 37. -67. 0.M 1.0000+00 1.
178.9 288.9
42.5 77.5 257.6 30.6 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
168.7 ************** 2400. 100. 1.00 157.
24.2 15.6
17.2 33.5 56.6 10.8 BRIGUN
47.8 121.0 ********
11.3 85.4 6.7
19.9 VV MEAN WIND SPDS(MPS) VV 29.3
8.3 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 4.7

6.0 25.5 52.6 3.3
11.9 47.8 16.1
AIR T GAS T DIAM GAS V FLOW
292.****************************
8.5 10.8
13.7 30.6
29.5
6.5 7.8

11.2 21.6
5.1 5.9
21.1

8.3 16.5
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
16.2 ==RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 6.5 12.6==/ 12.8 SLOPING TERRAIN CONCEPT.

7.1 /== 4.7 2.5
RELOCATE 2/3 INCH UP=/ 6.1

11.0 3.2
8.0
1.6 1.8
3.8 4.0

2.1 2.8
22.5 CRUSHER STACKS AS ONE
5.6 6.1
2.5 2.4
MINERALS ANDERSON PR
OJECT == 60245A == ANNUAL CONCS
3.1 40.3 3.2
2.2 32.4 17.4 5.4
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 180. DEG, NORTH TOWARD TOP, PLOT 214.137
2.6 5.6
4.8 5.4
3.2 75.5 6.6
38.5 36.7
4.5 7.6 8.4 9.7
5.9 13.1
74.4
9.8 17.4 47.2 23.1
49.7 27.3
22.0 ********* 63.2 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-01 TO GET CONC. IN UG/M3
1.7 2.2 2.9 3.9 5.9 9.9 22.2 * =.= * 44.9 16.1 8.7 5.5 3.9 3.1 3.6
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
16.7 ********* 20.6 1950.FT 0. 0. 21.M 1.0000+00 ******
65.4 30.6
7.1 11.7 71.3 10.0 BRIG.E BRIG.F DMIX OMNI STAR F WIDTH
214.1 0. 0. 2400. 100. 1.00 0.
4.4 9.7
3.6 6.2 10.4 6.4 BRIGUN
21.4 33.3 ********
4.0 77.5 2.4
3.8 VV MEAN WIND SPDS(MPS) VV 6.2
1.8 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 2.0

1.3 11.7 16.9 2.3
5.0 36.4 4.9
AIR T GAS T DIAM GAS V FLOW
292. 292. 1.2 8.9 10.4
3.2 5.2
11.8 14.4
21.4
2.0 3.9

11.8 18.0
3.2 3.5
25.0

7.3 13.9
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
17.6 ==RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 7.1 14.2==/ 10.8 SLOPING TERRAIN CONCEPT.

80.2 /-- 41.9 21.5
RELOCATE 2/3 INCH UP-/ 53.5

125.9 26.8

69.1
17.6 18.8
54.2 32.4

22.7 27.9
185.7 LEACH AREA STACK
75.3 45.4
29.6 28.9
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
41.8 297.7 41.0
20.8 419.6 141.2 46.1
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 202. DEG. NORTH TOWARD TOP. PLOT 758.651
27.1 44.1
71.8 71.3
35.7 412.4 51.7
381.2 229.3
52.5 135.3 124.4 73.3
70.9 94.6
282.1
130.2 381.1 256.4 142.6
533.1 424.6
428.2 *********282.0 MULTIPLY PRINTED VALUES BY
* COORD * 1.0=02 TO GET CONC. IN UG/M3
18.7 23.8 31.9 45.5 71.5 134.8 446.1 * -.- *204.1 99.5 60.8 41.4 30.5 24.7 28.3
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
296.9 *********124.8 1950.FT -175. 32. 21.M 1.0000+00 ******
758.7 126.5
83.6 524.6 166.1 55.8 BRIG.E BRIG.F OMIX OMNI STAB F WIDTH
549.3 10. 8. 2400. 100. 1.00 0.
49.8 57.1
37.3 157.6 64.5 40.8 BRIGUN
423.9 144.4 2.
31.6 371.2 17.5
80.2 VV MEAN WIND SPDS(MPS) VV 43.3
19.1 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 14.8

14.0 190.0 108.2 17.2
53.5 234.4 34.8
AIR T GAS T DIAM GAS V FLOW
292. 294. .5 14.2 2.4
35.7 37.3
135.2 88.8
157.5
24.1 28.7

148.0 139.2
30.6 30.3
205.8

81.3 109.3
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
141.3 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 88.6 119.6--/ 87.9 SLOPING TERRAIN CONCEPT.

81.4 /-- 39.3 20.2
RELOCATE 2/3 INCH UP-/ 49.7

127.5 25.0

63.2
16.7 17.8
51.9 30.0

21.3 25.4
175.7 URANIUM CONC. STACK
70.8 40.0
27.9 28.4
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
39.0 273.1 40.2
19.3 417.9 133.9 45.3
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 202. DEG. NORTH TOWARD TOP. PLOT 517.361
25.3 41.0
65.6 68.0
33.0 279.6 40.1
319.8 170.4
47.5 121.0 118.5 68.8
62.9 88.0
215.3
111.7 412.6 247.1 129.1
364.9 365.0
370.1 *********232.0 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-02 TO GET CONC. IN UG/M3
17.6 22.3 29.4 41.1 62.7 113.7 356.1 * -.- *165.5 88.2 55.4 38.3 29.5 22.7 25.1
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
347.0 ********* 97.0 1950.FT -194. 36. 21.M 1.0000+00 ******
517.4 99.1
70.9 509.6 130.3 42.0 BRIG.E BRIG.F DMIX OMNT STAR F WIDTH
322.2 19. 16. 2400. 100. 1.00 0.
43.9 42.8
33.4 145.2 54.0 31.8 BRIGUN
378.1 113.2 10.
25.8 256.4 15.1
75.7 VV MEAN WIND SPDS(MPS) VV 37.9
17.8 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 12.5

13.3 175.0 92.0 14.6
46.0 184.5 29.2
AIR T GAS T DIAM GAS V FLOW
292. 322. .3 4.0 1.2
31.7 30.8
113.7 72.4
131.9
22.5 24.2

127.1 125.4
25.4 29.5
173.0

70.7 105.1
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
119.5 --RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 90.2 105.1--/ 85.1 SLOPING TERRAIN CONCEPT.

```
7.2 /== 6.7 4.8
RELOCATE 2/3 INCH UP=/ 8.2
8.7 5.8
10.0
7.2 3.0
10.3 7.0
8.4 3.5
12.6 TAILINGS IMPOUNDMENT
13.1 8.9
9.9 5.1
MINERALS ANDERSON PR
OJECT == 60245A == ANNUAL CONCS
12.1 17.1 7.8
9.2 17.8 14.0 3.5
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 180. DEG, NORTH TOWARD TOP, PLOT 267.995
11.4 4.9
18.1 12.9
14.8 24.1 6.5
28.5 24.4
20.6 26.6 18.6 8.6
25.8 10.3
35.5
35.1 37.7 34.9 19.1
42.0 35.0
47.6 ********* 33.0 MULTIPLY PRINTED VALUES BY
* COORD * 1.0=01 TO GET CONC, IN UG/M3
10.8 14.4 19.7 26.1 34.4 45.9 56.3 * *.* * 39.4 22.8 15.7 11.1 9.1 6.8 5.1
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
69.5 ********* 47.3 1820.FT -90. -791. 0.M 1.0000+00 1.
89.6 69.6
58.9 93.6 84.0 27.9 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
110.0 ************** 2400. 100. 1.00 386.
42.7 20.4
31.1 77.4 41.5 16.3 BRIGUN
118.4 189.0 ********
21.3 268.0 11.0
50.2 VV MEAN WIND SPDS(MPS) VV 28.9
15.1 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 7.5
9.3 61.9 69.0 4.5
28.2 95.7 16.0
AIR T GAS T DIAM GAS V FLOW
292.***************************
17.9 10.9
28.0 41.3
58.7
12.2 7.2
20.3 32.6
8.3 4.9
42.2
13.3 24.1
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
29.9 ==RELOCATE 2/3 INCH DOWN
RURL, LONG=TERM MODE. 8.9 21.0==/ 17.1 SLOPING TERRAIN CONCEPT.
```

-13.7 /-- 9.4 10.7
RELOCATE 2/3 INCH UP-/ 13.7

-4.0 9.1

10.7
8.5 4.6
14.3 11.9

7.0 2.1
GROUND ELEV DIFFERENCES.
-9.1
4.6 3.4
7.0 7.6
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
11.9 -4.6 10.7
7.9 -3.4 -3.4 -4.6
NORTH TOWARD TOP. (1/10)((SOURCE HT(1))-(RECPTR HT(N))). HTS IN METERS.
8.2 3.4
5.8 2.7
13.1 -2.7 8.2
-.3 -2.7
14.3 5.8 3.4 5.8
11.9 7.0
.3
4.0 .6 -.3 4.6
2.4 .0
1.8 ********* -.3 MULTIPLY PRINTED VALUES BY
* COORD * 1.0+01 TO GET GROUND ELEV DIFF IN M
15.2 15.2 15.2 9.8 5.8 8.2 7.0 * -.- * -.3 1.8 3.4 4.6 5.2 4.6 .3
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
4.6 ********* -.3 1950.FT************************M 0.0000 ******
5.2 1.2
8.2 6.1 3.4 .3 BRIG.E BRIG.F DMIX OMNI STAR F WIDTH
-1.2 **
8.2 -.9
4.6 3.0 2.1 -.3 BRIGUN
4.6 6.1 ********
3.0 -.3 3.4
7.0 VV MEAN WIND SPDS(MPS) VV 4.6
9.1 *** 3.4
12.5 3.0 4.6 .9
2.1 .9 2.4
AIR T GAS T DIAM GAS V FLOW
****
3.4 .3
.9 2.1
2.1
5.2 .9
-1.2 -2.7
2.1 -4.6
-1.5
1.2 -4.0
0 KM .375KM .750KM 1.125KM 1.500KM 1.875KM 2.250KM
I....+....I....+....I....+....I....+....I....+....I....+....I
-.3 --RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. -4.3 -.9--/ -4.9 SLOPING TERRAIN CONCEPT.

14.5 /-- 13.6 8.5
RELOCATE 2/3 INCH UP-/ 16.9

17.7 10.6

21.1
15.9 5.4
21.3 12.9

19.0 6.6
27.5 EAST MINE PIT
28.1 17.2
23.2 8.2
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
29.2 39.6 10.7
19.3 39.9 25.7 6.3
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 180. DEG. NORTH TOWARD TOP. PLOT 636.914
24.2 8.0
41.1 15.6
29.8 60.1 9.9
69.8 45.6
39.4 66.8 31.0 13.1
52.2 18.0
88.9
87.1 102.3 75.4 31.5
115.6 77.3
138.9 ********* 63.8 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-02 TO GET CONC. IN UG/M3
19.0 23.5 30.1 41.7 68.5 109.6 183.0 * -.- * 76.9 40.0 24.8 15.2 10.8 8.3 6.6
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
222.1 ********* 80.4 1840.FT -490. -1351. 0.M 1.0000+00 1.
544.6 108.2
101.5 230.0 468.5 40.2 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
636.9 ************** 2400. 100. 1.00 945.
57.1 22.9
36.7 97.1 52.4 14.7 BRIGUN
154.9 128.3 ********
21.9 195.8 8.8
49.4 VV MEAN WIND SPDS(MPS) VV 29.5
16.7 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 6.7

12.4 67.4 72.3 5.0
24.1 112.6 15.9
AIR T GAS T DIAM GAS V FLOW
292.****************************

16.6 11.0
37.2 42.8
72.2
12.8 8.4

28.1 33.4
10.2 6.6
49.7

20.7 25.0
0 KM 1.250KM 2.500KM 3.750KM 5.000KM 6.250KM 7.500KM
I....+....I....+....I....+....I....+....I....+....I....+....I
36.8 --RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 15.9 27.9--/ 19.6 SLOPING TERRAIN CONCEPT.

15.7 /-- 9.6 5.0
RELOCATE 2/3 INCH UP-/ 11.2

19.2 5.9

13.0
18.4 4.5
23.5 6.8

22.0 5.4
15.2 WEST MINE PIT
31.7 8.4
29.4 6.6
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
36.3 18.0 8.3
26.1 34.6 11.3 5.6
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 247. DEG. NORTH TOWARD TOP. PLOT 904.607
34.8 7.1
56.6 11.6
47.2 20.8 8.8
46.4 20.1
59.8 80.8 16.3 11.4
78.5 13.8
34.7
152.4 71.9 28.8 20.8
51.3 30.5
108.2 ********* 33.8 MULTIPLY PRINTED VALUES BY
COORD * 1.0-02 TO GET CONC. IN UG/M3
29.0 39.5 58.1 102.5 212.7 456.4 154.1 * -.- * 31.5 19.3 13.1 9.6 7.4 5.9 4.8
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
225.7 ********* 30.9 1750.FT -1832. -937. 0.M 1.0000+00 1.
89.5 40.7
904.6 186.8 44.4 17.1 BRIG.E BRIG.F DMIX OMNI STAR F WIDTH
51.0 ************** 2400. 100. 1.00 365.
161.0 10.5
80.8 316.8 16.3 8.4 BRIGUN
130.5 25.0 ********
39.6 31.7 6.3
176.6 VV MEAN WIND SPDS(MPS) VV 11.4
25.3 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 5.0

16.3 123.3 14.4 3.9
46.0 42.2 7.6
AIR T GAS T DIAM GAS V FLOW
292.**************************
28.7 6.1
85.2 11.2
36.2
19.8 5.1

50.4 12.2
14.7 4.4
35.4

35.4 11.0
0 KM 1.250KM 2.500KM 3.750KM 5.000KM 6.250KM 7.500KM
I....+....I....+....I....+....I....+....I....+....I....+....I....+....I
27.8 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 25.8 22.3--/ 9.9 SLOPING TERRAIN CONCEPT.

14.9 /-- 15.6 7.7
RELOCATE 2/3 INCH UP-/ 20.2

18.7 9.9
26.5
18.9 5.5
23.3 12.3
23.2 6.8
37.2 ORE STOCK PILE
32.4 17.7
29.6 8.8
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
39.7 61.8 12.2
22.3 51.9 32.9 8.2
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 337. DEG, NORTH TOWARD TOP, PLOT 607.051
29.0 11.0
62.9 20.7
37.4 120.5 14.7
119.5 80.2
55.0 109.8 39.1 21.4
74.1 29.2
336.7
120.7 268.0 276.5 59.3
607.1 211.5
357.0 **********215.2 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-02 TO GET CONC. IN UG/M3
16.3 20.5 26.8 37.6 58.4 110.5 341.8 * -.- *203.3 53.1 25.3 15.3 10.4 7.7 6.0
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
193.1 **********134.0 1950.FT 37. -67. 0.M 1.0000+00 1.
393.9 304.0
56.2 115.8 474.7 29.8 BRIG.E BRIG.F OMIX OMNI STAR F WIDTH
388.1 ************** 2400. 100. 1.00 157.
30.5 15.9
22.6 47.2 53.2 11.5 BRIGUN
77.3 158.0 ********
15.5 152.5 7.6
26.8 VV MEAN WIND SPDS(MPS) VV 27.1
11.7 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 5.8
8.6 37.7 68.7 4.3
16.6 82.2 15.5
AIR T GAS T DIAM GAS V FLOW
292.****************************
12.4 10.9
23.4 40.1
51.0
9.7 8.1
17.7 30.1
7.9 6.4
37.0
14.1 23.2
0 KM 1.250KM 2.500KM 3.750KM 5.000KM 6.250KM 7.500KM
I....+....I....+....I....+....I....+....I....+....I....+....I
28.5 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 11.3 22.3--/ 18.3 SLOPING TERRAIN CONCEPT.

```
                      7.3          /--   9.4                6.5
              RELOCATE 2/3 INCH UP-/     12.2
                         8.7                       6.9
                                         18.8
          11.7                                                        4.5
                          15.8                        11.5
             19.7                                               6.5
                                         33.3                             CRUSHER STACKS AS ONE
                            28.2                   13.2
                 24.3                                         4.5
                                                                          MINERALS ANDERSON PR
                                              OJECT -- 60245A -- ANNUAL CONCS
                     33.4                57.0               5.7
    13.3                          41.3              18.1                                     6.2
     HLIFE= ***** HRS.  CONCTR CORRCTD TO STD COND VIA  FACTOR 1.000.  MAX TOWARD 337. DEG.  NORTH TOWARD TOP.  PLOT 470.581
         9.2                                                                 8.7
                         54.5                           11.8
            8.6                          57.0                                   12.5
                                  86.6         30.6
                 12.4       17.5                        17.0        15.9
                     71.6                                         24.7
                                        319.1
                          26.0     30.9    161.0        54.7
                                      470.6   52.7
                                  50.0  **********108.1                      MULTIPLY PRINTED VALUES BY
                                        * COORD *                               1.0-02 TO GET CONC. IN UG/M3
   6.8      5.0      5.4      7.2     10.5     18.8    338.0  *  -.-  *105.9    39.9    18.5    11.4     7.4     5.1     4.1
                                        *  0.0  *       SOR ELEV  COORDX  COORDY  STK HT  Q(GM/SEC)  FIXD DH
                                  36.7  ********** 82.8    1950.FT     0.      0.     21.M  1.0000+00     ******
                                      161.7    64.3
                          13.0     25.1    157.0        20.9   BRIG.E  BRIG.F  DMIX    DMNI  STAR F WIDTH
                                         455.8                   0.      0.  2400.    100.    1.00      0.
                      9.1                                 14.6
                 6.6        17.4                   33.7        9.3               BRIGUN
                                  87.9     131.5                                ********
            4.7                         157.2                             5.7
                         17.1  VV MEAN WIND SPDS(MPS) VV    18.0
        3.2             .67000  2.45000  4.77000  6.93000  9.61000 12.52000             4.3
    2.3                           39.9              56.1                                     3.1
                     17.4                84.8               11.2
                                                                       ATR T  GAS T   DIAM  GAS V  FLOW
                                                                        292.   292.    1.2    8.9  10.4
                 11.5                                            7.7
                            23.8                   32.7
                                         49.2
              7.8                                                  6.0
                         17.3                        24.5
           6.7                                                            4.9
                                         34.5
                       13.6                         20.0
                                    0 KM     1.250KM   2.500KM   3.750KM   5.000KM   6.250KM   7.500KM
                                    I....+....I....+....I....+....I....+....I....+....I....+....I
                                        26.8  --RELOCATE 2/3 INCH DOWN
  RURL. LONG-TERM MODE.      10.9            21.2--/              16.1              SLOPING TERRAIN CONCEPT.
```

7.4 /-- 9.1 6.2
RELOCATE 2/3 INCH UP-/ 11.8

9.0 6.6

18.1
12.0 4.0
16.4 10.8

19.9 5.9
31.6 LEACH AREA STACK
28.5 12.3
24.8 4.1
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
34.4 52.9 5.4
11.3 37.7 15.3 6.0
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 337. DEG, NORTH TOWARD TOP, PLOT 642.450
7.9 8.2
57.3 11.0
7.7 50.4 11.5
95.8 24.9
10.7 17.3 17.4 14.6
75.9 22.4
250.2
22.9 40.7 113.6 44.5
642.4 72.4
61.4 ********* 77.2 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-02 TO GET CONC. IN UG/M3
5.9 4.6 5.3 7.2 10.8 20.2 364.8 * -.- * 68.8 30.9 16.7 10.6 7.0 4.9 4.0
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
41.7 ********* 57.4 1950.FT -175. 32. 21.M 1.0000+00 ******
307.6 44.5
13.4 43.2 99.0 16.3 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
305.5 10. 8. 2400. 100. 1.00 0.
8.4 13.0
6.1 18.4 27.7 8.8 BRIGUN
102.7 97.3 2.
4.3 125.1 5.5
15.7 VV MEAN WIND SPDS(MPS) VV 16.1
3.0 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 4.2

2.2 43.5 49.5 3.0
16.9 79.3 10.2
AIR T GAS T DIAM GAS V FLOW
292. 294. .5 14.2 2.4
10.6 7.1
24.2 28.9
46.6
6.9 5.6

18.7 22.9
5.9 4.6
32.9

13.7 18.5
0 KM 1.250KM 2.500KM 3.750KM 5.000KM 6.250KM 7.500KM
I....+....I....+....I....+....I....+....I....+....I....+....I
25.6 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 10.7 20.3--/ 15.1 SLOPING TERRAIN CONCEPT.

```
7.6          /--   9.2          6.3
RELOCATE 2/3 INCH UP-/   11.9

9.3          6.6

18.1
12.3          3.7
16.8          10.4

20.4          5.6
31.4          URANIUM CONC, STACK
29.1          12.3
25.4          3.9
MINERALS ANDERSON PR
OJECT  -- 60245A -- ANNUAL CONCS
35.2          52.3          5.2
9.8          32.4          13.9          5.9
HLIFE= ***** HRS,  CONCTR CORRCTD TO STD COND VIA  FACTOR 1,000,  MAX TOWARD 337. DEG,  NORTH TOWARD TOP,  PLOT 628.562
6.9          8.1
58.7          10.2
6.9          47.0          11.4
97.7          23.2
9.5          15.9          16.4          14.4
77.7          22.0
233.5
20.3     38.1     84.6          41.5
628.6   69.8
54.6  ********* 72.1          MULTIPLY PRINTED VALUES BY
* COORD *          1.0-02 TO GET CONC, IN UG/M3
5.2   4.2   5.0   6.8   10.4   19.0   213.3  *  -.-  * 57.7   27.4   16.5   10.5   7.0   4.9   4.0
*  0.0  *          SOR ELEV  COORDX  COORDY  STK HT  Q(GM/SEC)  FIXD OH
37.2  ********* 45.5   1950.FT   -194.   36.   21.M  1.0000+00   ******
277.8   38.7
12.7   41.7   84.3   13.9   BRIG.E  BRIG.F  DMIX   DHNI  STAR F WIDTH
223.6          19.   16.   2400.   100.   1.00   0.
7.7          12.1
5.7          16.7          24.9          8.9          BRIGUN
99.7          93.5          10.
4.0          106.0          5.5
13.5  VV MEAN WIND SPDS(MPS) VV   15.9
2.9     .67000  2.45000  4.77000  6.93000  9.61000 12.52000     4.2

2.1          40.5          48.6          3.1
15.9          78.5          10.2
AIR T  GAS T   DIAM  GAS V  FLOW
292.   322.   .3   4.0   1.2
9.6          7.1
24.7          28.6
46.4
6.2          5.6

19.1          22.8
5.4          4.6
32.9

14.0          18.5
0 KM     1.250KM   2.500KM   3.750KM   5.000KM   6.250KM   7.500KM
|....+....|....+....|....+....|....+....|....+....|....+....|
25.7   --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE,     11.0     20.4--/     15.1     SLOPING TERRAIN CONCEPT,
```

1,4 /-- 1,4 ,8
RELOCATE 2/3 INCH UP-/ 1,8

1,7 1,0

2,3
1,7 ,5
2,1 1,3

2,0 ,7
3,1 TAILINGS IMPOUNDMENT
2,9 1,7
2,5 ,9
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
3,1 4,7 1,1
2,1 4,4 2,9 ,7
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1,000, MAX TOWARD 202, DEG, NORTH TOWARD TOP, PLOT 102,579
2,7 ,9
4,5 1,7
3,3 7,8 1,2
8,8 5,7
4,5 6,8 2,8 1,6
5,7 2,1
15,0
9,3 11,9 12,6 3,5
22,9 13,3
22,5 ********* 9,7 MULTIPLY PRINTED VALUES BY
* COORD * 1,0-01 TO GET CONC, IN UG/M3
1,9 2,3 3,1 4,2 6,4 11,8 30,5 * -,- * 14,2 5,6 2,7 1,7 1,2 ,9 ,7
* 0,0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
34,8 ********* 17,3 1820,FT -90, -791, 0,M 1,0000+00 1,
102,6 29,9
8,3 27,1 62,8 4,0 BRIG,E BRIG,F DMIX DMNI STAR F WIDTH
82,6 ************** 2400, 100, 1,00 386,
4,3 2,0
3,2 7,1 4,2 1,4 BRIGUN
12,4 20,3 ********
2,1 27,4 ,9
3,4 VV MEAN WIND SPDS(MPS) VV 2,2
1,6 ,67000 2,45000 4,77000 6,93000 9,61000 12,52000 ,7

1,1 4,5 8,4 ,5
2,1 11,9 1,4
AIR T GAS T DIAM GAS V FLOW
292,****************************
1,5 1,0
2,7 4,3
6,6
1,2 ,8

2,0 3,4
,9 ,6
4,5

1,6 2,5
0 KM 1,250KM 2,500KM 3,750KM 5,000KM 6,250KM 7,500KM
I....+....I....+....I....+....I....+....I....+....I....+....I
3,4 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE, 1,2 2,5--/ 1,9 SLOPING TERRAIN CONCEPT,

```
                    -29.6           /-- -32.0              -11.3
           RELOCATE 2/3 INCH UP-/       -32.0

                        -30.8                          -22.9
                                        -24.7
        -20.1                                                              2.7
                               -19.8                  -2.4
               -9.8                                                   -.3
                                        -11.3                                  GROUND ELEV DIFFERENCES.
                                  -7.6                -16.2
                   -10.7                                           8.2
                                                                         MINERALS ANDERSON PR
                                             OJECT  -- 60245A -- ANNUAL CONCS
                        -9.4                -9.1                8.2
    4.6                                .9                4.6                           -29.0
          NORTH TOWARD TOP.  (1/10)((SOURCE HT(1))-(RECPTR HT(N))). HTS IN METERS.
         8.2                                                                 -25.9
                              -7.6                          4.0
           9.8                                  13.1                        -18.6
                                      -13.7          9.8
                   8.5                    7.0              4.6        -32.0
                         -4.6                                    -20.4
                                            -5.2
                              6.4      7.6       -1.5          -1.5
                                          -4.6    4.0
                                     10.7  *********  5.5                 MULTIPLY PRINTED VALUES BY
                                           * COORD *                  1.0+01 TO GET GROUND ELEV DIFF IN M
 8.2    12.2    13.7    13.1    13.1    12.5   -1.8  *  -.-  *   .3     .0  -16.8  -18.6  -23.5  -28.3  -27.4
                                           *  0.0  *     SOR ELEV  COORDX  COORDY  STK HT  Q(GM/SEC)  FIXD DH
                                      6.4  ********* -1.2   1950.FT***********************M  0.0000      ******
                                             3.4    4.0
                              10.7     6.4       4.0         1.2   BRIG.E  BRIG.F  DMIX     DMNT  STAR F WIDTH
                                             -.9                   ******************************************
                          8.8                                      -1.8
                  10.4              5.2                -1.5         -10.4          BRIGUN
                                       -2.7        -5.2                           ********
           11.3                                .3                        -16.2
                              3.4  VV MEAN WIND SPDS(MPS) VV  -8.2
      14.3         ***************************************************                -17.4
  16.8                                 -.6                -9.8                          -19.5
                        -1.2                 -7.6                   -8.8
                                                                    AIR T  GAS T   DIAM  GAS V  FLOW
                                                                    ***********************************
                   1.2                                           -14.0
                                   -6.4                 -13.4
                                             -11.0
               3.4                                                -14.0
                                  -7.9                   -12.8
          3.0                                                        -13.7
                                             -12.5
                             -8.8                        -11.3
                                        0 KM     1.250KM  2.500KM   3.750KM   5.000KM   6.250KM   7.500KM
                                        I....+....I....+....I....+....I....+....I....+....I....+....I
                                             -11.3    --RELOCATE 2/3 INCH DOWN
   RURL. LONG-TERM MODE.         -8.8        -10.1--/            -10.7              SLOPING TERRAIN CONCEPT.
```

6.3 /-- 6.3 2.8
RELOCATE 2/3 INCH UP-/ 7.8

7.6 3.4

9.9

8.4 2.1
9.3 4.1

10.0 2.6
13.3 EAST MINE PIT
12.1 5.4
12.4 3.2
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
15.9 20.9 4.2
10.3 18.5 9.2 3.0
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 202. DEG, NORTH TOWARD TOP, PLOT 171,172
13.1 3.8
23.4 6.4
16.5 37.2 4.8
38.0 16.8
22.6 36.6 10.3 6.8
29.0 8.8
87.3
49.8 72.6 51.3 15.5
142.5 36.4
121.3 ********* 39.6 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-03 TO GET CONC. IN UG/M3
7.6 9.3 12.0 16.2 24.2 42.8 115.0 * -.- * 38.9 13.6 7.6 5.1 3.7 2.9 2.3
* 0.0 * SOR ELEV COORDX COORDY STK HT G(GM/SEC) FIXD OH
68.6 ********* 27.4 1840.FT -490. -1351. 0.M 1.0000+00 1.
171.2 42.0
21.0 38.8 110.9 9.1 BRIG.E BRIG.F CMIX OHNI STAR F WIDTH
162.6 ************** 2400. 100. 1.00 945.
12.1 5.4
9.1 17.4 10.9 4.1 BRIGUN
29.3 40.6 ********
6.6 61.9 2.9
10.6 VV MEAN WIND SPDS(MPS) VV 6.7
5.1 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 2.3

3.9 15.1 22.4 1.8
6.9 33.0 4.4
AIR T GAS T DIAM GAS V FLOW
292.***************************
5.3 3.4
9.3 13.9
20.5
4.2 2.7

7.2 11.0
3.5 2.2
15.0

5.8 8.9
0 KM 12.500KM 25.000KM 37.500KM 50.000KM 62.500KM 75.000KM
I....+....I....+....I....+....I....+....I....+....I....+....I
11.7 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 4.7 9.4--/ 7.2 SLOPING TERRAIN CONCEPT.

6.4 /-- 6.1 2.7
RELOCATE 2/3 INCH UP-/ 7.6

7.8 3.3

9.6
8.6 2.1
9.7 4.0

10.3 2.5 WEST MINE PIT
12.8
12.5 5.3
12.8 3.1
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
16.5 19.5 4.0
10.6 19.6 8.1 2.9
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 202. DEG, NORTH TOWARD TOP, PLOT 266.813
13.6 3.8
24.7 6.0
17.2 32.8 4.8
39.0 15.1
23.9 39.3 9.6 6.5
31.0 8.5
68.1
53.4 81.7 33.7 13.8
157.6 31.4
145.8 ********* 33.9 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-03 TO GET CONC, IN UG/M3
7.8 9.5 12.2 16.8 25.4 47.0 149.0 * -.- * 30.6 11.8 6.9 4.7 3.5 2.7 2.3
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
75.6 ********* 23.1 1750.FT -1632. -937. 0.M 1.0000+00 1.
266.8 31.6
20.5 46.1 72.6 8.2 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
140.6 ************** 2400. 100. 1.00 365.
12.1 5.0
9.2 18.9 10.1 3.8 BRIGUN
36.2 34.3 ********
6.7 58.1 2.8
11.1 VV MEAN WIND SPDS(MPS) VV 6.4
5.3 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 2.2

4.0 17.6 20.2 1.7
7.1 32.0 4.2
AIR T GAS T DIAM GAS V FLOW
292.*****************************

5.4 3.3
9.8 13.0
20.2
4.3 2.6

7.9 10.5 2.2
3.6
14.9

6.0 8.5
0 KM 12.500KM 25.000KM 37.500KM 50.000KM 62.500KM 75.000KM
I....+....I....+....I....+....I....+....I....+....I....+....I
11.6 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 4.8 9.2--/ 7.0 SLOPING TERRAIN CONCEPT.

6.5 /-- 6.5 2.9
RELOCATE 2/3 INCH UP-/ 8.2

7.9 3.6
10.4
8.8 2.2
9.7 4.2
10.6 2.7
14.1 ONE STOCK PILE
12.4 5.6
13.0 3.3
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
16.8 22.0 4.3
10.6 19.4 8.7 3.1
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 337. DEG, NORTH TOWARD TOP, PLOT 147.532
13.6 4.0
24.8 6.5
17.2 39.1 5.1
39.2 17.3
23.1 39.0 10.3 7.0
29.6 9.2
95.2
48.9 79.3 43.6 15.6
147.5 35.8
124.4 ********* 43.6 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-03 TO GET CONC. IN UG/M3
7.8 9.5 12.0 16.1 23.4 39.8 100.2 * -.- * 35.0 12.9 7.5 5.1 3.7 2.9 2.4
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
53.4 ********* 24.1 1950.FT 37. -67. 0.M 1.0000+00 1.
115.0 40.0
18.1 33.2 109.3 8.5 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
137.6 ************** 2400. 100. 1.00 157.
11.2 5.2
8.7 16.1 10.8 4.0 BRIGUN
28.2 42.6 ********
6.4 57.2 2.9
10.2 VV MEAN WIND SPDS(MPS) VV 6.8
5.1 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 2.3
3.9 14.6 22.2 1.8
6.9 32.0 4.5
AIR T GAS T DIAM GAS V FLOW
292.****************************
5.3 3.4
9.1 14.2
20.4
4.3 2.8
7.2 11.0
3.6 2.3
15.1
5.8 9.1
0 KM 12.500KM 25.000KM 37.500KM 50.000KM 62.500KM 75.000KM
I....+....I....+....I....+....I....+....I....+....I....+....I
11.8 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE. 4.7 9.4--/ 7.4 SLOPING TERRAIN CONCEPT.

1.4 /-- 2.3 1.2
RELOCATE 2/3 INCH UP-/ 2.9

1.5 1.5

3.8
.8 .7
2.7 1.8

.9 .8
5.2 CRUSHER STACKS AS ONE
2.5 2.5
1.2 1.0
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
10.8 10.0 3.5
9.8 15.7 4.0 1.6
HLIFE= ***** HRS. CONCTR CORRCTD TO STD COND VIA FACTOR 1.000. MAX TOWARD 180. DEG. NORTH TOWARD TOP. PLOT 134.044
11.2 2.1
2.5 4.6
8.1 16.0 2.7
14.0 11.5
19.4 4.1 10.1 3.9
26.8 5.2
52.1
34.9 16.9 34.7 9.0
38.1 30.7
63.3 ********* 36.8 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-03 TO GET CONC. IN UG/M3
1.9 2.1 5.3 12.2 12.5 9.8 36.7 * -.- * 27.4 5.7 3.2 2.1 1.5 1.2 1.0
* 0.0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
25.5 ********* 10.5 1950.FT 0. 0. 21.M 1.0000+00 ******
114.4 17.8
7.4 34.3 98.5 4.1 BRIG.E BRIG.F DMIX DMNI STAR F WIDTH
134.0 0. 0. 2400. 100. 1.00 0.
10.0 1.5
2.6 13.0 7.0 1.5 BRIGGN
28.9 36.8 ********
3.6 50.8 1.3
9.3 VV MEAN WIND SPDS(MPS) VV 4.9
3.2 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 1.0

1.6 5.9 17.6 .5
6.9 26.6 2.9
AIR T GAS T DIAM GAS V FLOW
292. 292. 1.2 8.9 10.4
4.6 2.8
7.9 13.5
20.5
3.8 2.0

6.9 9.2
2.3 2.0
8.4

5.7 8.4
0 KM 12.500KM 25.000KM 37.500KM 50.000KM 62.500KM 75.000KM
I....+....I....+....I....+....I....+....I....+....I....+....I
11.3 --RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 4.5 7.8--/ 7.6 SLOPING TERRAIN CONCEPT.

```
1.5          /--   2.3                  1.2
RELOCATE 2/3 INCH UP-/     2.9

1.5                                     1.5

                                   3.7
.8                                                          .7
2.8                                     1.7

.9                                                          .8
                                   5.2                           LEACH AREA STACK
2.5                              2.4
1.2                                                    1.0
                                                                 MINERALS ANDERSON PR
                                    OJECT -- 602454 -- ANNUAL CONCS
10.0                               10.2               3.5
9.9                     15.8                3.9                                   1.6
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 180. DEG. NORTH TOWARD TOP. PLOT 129.369
11.4                                                                  2.1
                        2.8                      4.7
8.5                                15.6                           2.6
                              14.3       11.0
19.4              4.1                           10.0        3.8
24.3                                                  5.0
                                   51.4
34.6              18.6         33.3        8.3
                           39.6   27.1
                        64.4 ********* 32.8               MULTIPLY PRINTED VALUES BY
                             * COORD *                     1.0-03 TO GET CONC. IN UG/M3
1.7   2.0   4.9   12.6   11.5   9.0   32.8 * -.- * 26.9   5.7   3.2   2.1   1.5   1.2   .9
                             * 0.0 *      SOR ELEV  COORDX  COORDY  STK HT  Q(GM/SEC)  FIXD DH
                        22.6 ********* 10.7   1950.FT   -175.   32.   21.M  1.0000+00   ******
                           121.5   16.8
                  6.6   34.4       92.7     4.0  BRIG.E  BRIG.F  OMIX   OMNI  STAR F WIDTH
                           129.4                  10.     8.   2400.   100.   1.00    0.
            9.1                                   1.4
2.4               12.0                  7.0            1.6            BRIGUN
                        28.0      33.8                                  2.
3.3                               50.4                          1.4
                  9.4  VV MEAN WIND SPDS(MPS) VV    5.0
3.0        .67000  2.45000  4.77000  6.93000  9.61000 12.52000           1.1

1.4                      5.8              17.9                                      .4
            6.7                    26.6               3.0
                                                          AIR T  GAS T   DIAM  GAS V  FLOW
                                                          292.   294.     .5   14.2   2.4
4.4                                                    2.8
                  7.8                      13.1
                                   20.6
3.6                                                        2.1

                  6.8                       9.2
2.1                                                          2.0
                                   8.6

                  5.5                        8.4
                        0 KM    12.500KM  25.000KM  37.500KM  50.000KM  62.500KM  75.000KM
                        |....+....|....+....|....+....|....+....|....+....|....+....|....+....|
                                   11.4   --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE.        4.4      7.5--/             7.3           SLOPING TERRAIN CONCEPT.
```

1.6 /-- 2.2 1.2
RELOCATE 2/3 INCH UP-/ 2.9

1.5 1.5

3.7
.8 .7
3.0 1.7

.9 .8
5.2 URANIUM CONC. STACK
2.5 2.4
1.2 1.0
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
9.2 10.5 3.6
10.1 16.1 3.9 1.6
HLIFE= ***** HRS, CONCTR CORRCTD TO STD COND VIA FACTOR 1.000, MAX TOWARD 180. DEG, NORTH TOWARD TOP, PLOT 130,154
11.7 2.1
3.2 4.8
8.8 15.6 2.6
15.0 11.2
19.9 4.1 10.2 3.8
23.0 5.0
52.1
35.6 20.1 33.6 8.3
39.7 25.1
67.0 ********* 31.6 MULTIPLY PRINTED VALUES BY
* COORD * 1.0-03 TO GET CONC. IN UG/M3
1.6 1.9 4.5 12.9 10.6 8.4 29.4 * -.- * 27.1 5.8 3.2 2.1 1.5 1.2 .9
* 0.0 * SUR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
20.4 ********* 11.0 1950.FT -194. 36. 21.M 1.0000+00 ******
123.8 16.5
6.1 33.9 93.2 4.2 BRIG.E BRIG.F DMIX DENI STAR F WIDTH
130.2 19. 16. 2400. 100. 1.00 0.
8.6 1.4
2.3 11.2 7.1 1.6 BRIGUN
28.4 34.2 10.
3.1 50.9 1.4
9.6 VV MEAN WIND SPDS(MPS) VV 5.0
2.8 .67000 2.45000 4.77000 6.93000 9.61000 12.52000 1.1

1.4 5.7 18.2 .4
6.6 27.0 3.0
AIR T GAS T DIAM GAS V FLOW
292. 322. .3 4.0 1.2
4.2 2.8
8.0 13.3
20.5
3.4 2.1

6.9 9.4
2.0 2.1
8.8

5.4 8.5
0 KM 12.500KM 25.000KM 37.500KM 50.000KM 62.500KM 75.000KM
I....+....I....+....I....+....I....+....I....+....I....+....I
11.5 --RELOCATE 2/3 INCH DOWN
RURL. LONG-TERM MODE. 4.3 7.2--/ 7.3 SLOPING TERRAIN CONCEPT.

-41,1 /-- ***** *****
RELOCATE 2/3 INCH UP-/ -89,4

-56,4 *****
-50,3
-80,8 -91,4
-38,1 *****
-47,2 -74,7
-47,2 GROUND ELEV DIFFERENCES,
-48,8 -86,9
-50,3 -48,8
MINERALS ANDERSON PR
OJECT -- 60245A -- ANNUAL CONCS
7,6 -38,1 -13,7
-6,1 -12,2 -54,9 *****
NORTH TOWARD TOP, (1/10)((SOURCE HT(I))-(RECPTR HT(N))), HTS IN METERS,
-10,7 -77,7
-42,7 -19,8
-25,9 -44,2 -76,2
-35,1 -29,0
-10,7 -56,4 -4,6 -48,8
3,0 -74,7
-35,1
-16,8 -38,1 -19,8 -64,0
-44,2 3,0
-25,9 ********* 6,1 MULTIPLY PRINTED VALUES BY
* COORD * 1,0+01 TO GET GROUND ELEV DIFF IN M
25,9 25,9 15,2 -13,7 10,7 18,3 10,7 * -,- A-19,8 -42,7 -44,2 -83,8 -80,8 -79,2 -68,6
* 0,0 * SOR ELEV COORDX COORDY STK HT Q(GM/SEC) FIXD DH
9,1 *********-35,1 1950,FT*********************M 0,0000 ******
-6,1 -56,4
15,2 -3,0 -10,7 -32,0 BRIG,E BRIG,F OMIX OMNI STAR F WIDTH
-7,6 **
4,6 -50,3
22,9 6,1 -27,4 -36,6 BRIGUN
-4,6 -15,2 ********
13,7 -12,2 -32,0
-7,6 VV MEAN WIND SPDS(MPS) VV -21,3
12,2 ** -32,0
21,3 -61,0 -16,8 -50,3
,0 -15,2 -25,9
AIR T GAS T DIAM GAS V FLOW
****
6,1 -15,2
-13,7 -7,6
-3,0
6,1 -19,8
-6,1 -13,7
13,7 -10,7
-32,0
3,0 -7,6
0 KM 12,500KM 25,000KM 37,500KM 50,000KM 62,500KM 75,000KM
I....+....I....+....I....+....I....+....I....+....I....+....I
-6,1 --RELOCATE 2/3 INCH DOWN
RURL, LONG-TERM MODE, 4,6 9,1--/ -1,5 SLOPING TERRAIN CONCEPT,

```
                     6.4        /--  6.4                 2.9
              RELOCATE 2/3 INCH UP-/  8.0

                          7.8                        3.5
                                     10.2
             8.6                                                     2.2
                          9.3                       4.1
               10.2                                          2.6
                                     13.6                            TAILINGS IMPOUNDMENT
                              12.1              5.5
                 12.6                                       3.2
                                                                     MINERALS ANDERSON PR
                                        OJECT  -- 60245A -- ANNUAL CONCS
                       16.1          21.0              4.1
       10.3                      18.3          8.8                               3.0
        HLIFE= ***** HRS.  CONCTR CORRCTD TO STD COND VIA  FACTOR 1.000.  MAX TOWARD 180. DEG.  NORTH TOWARD TOP.  PLOT 149.542
           13.1                                                        3.8
                         23.7                       6.3
             16.5                    37.0                              4.9
                               37.3        16.6
                22.7         37.2               10.2        6.9
                   29.2                               9.0
                                     88.0
                         48.4    75.2    46.4       15.4
                                  136.5   36.4
                              121.3  ********* 41.4                   MULTIPLY PRINTED VALUES BY
                                     * COORD *                          1.0-03 TO GET CONC. IN UG/M3
  7.6    9.2    11.6    15.7    23.2    40.8    110.5  *  -.-  * 38.7    13.2    7.4    4.9    3.6    2.8    2.3
                                     *  0.0  *      SOR ELEV  COORDX  COORDY  STK HT  Q(GM/SEC)  FIXD DH
                               64.1  ********* 27.0   1820.FT    -90.   -791.    0.M  1.0000+00      1.
                                     126.1   39.9
                          18.7    36.6    109.8       8.5  BRIG.E  BRIG.F  DMIX    DMNI  STAR F WIDTH
                                     149.5                 **************  2400.    100.   1.00   386.
                    11.4                                5.3
                  8.8         16.7              10.9       4.1           BRIGUN
                                29.2     42.6                            ********
             6.3                     58.8                         2.9
                         10.3  VV MEAN WIND SPDS(MPS) VV      6.7
          5.0            .67000  2.45000  4.77000  6.93000  9.61000 12.52000      2.3

      4.0                        14.5          22.8                              1.8
                    6.8                 32.3                 4.4
                                                                AIR T  GAS T   DIAM  GAS V  FLOW
                                                                292.****************************
                 5.2                                        3.4
                              9.3                 14.2
                                     20.6
              4.2                                              2.7

                              7.3                   11.2
           3.5                                                        2.3
                                     15.2

                         5.8                          9.0
                                  0 KM    12.500KM  25.000KM  37.500KM  50.000KM  62.500KM  75.000KM
                                  I....+....I....+....I....+....I....+....I....+....I....+....I
                                     11.9    --RELOCATE 2/3 INCH DOWN
    RURL. LONG-TERM MODE.       4.7          9.5--/              7.4          SLOPING TERRAIN CONCEPT.
```