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final

NUREG-0046

environmental statement

related to the operation of

THE HUMECA URANIUM MILL

RIO ALGOM CORPORATION

April 1976

Docket No. 40-8084

U. S. Nuclear Regulatory Commission • Division of Fuel Cycle and Material Safety

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FINAL DETAILED STATEMENT ON THE ENVIRONMENTAL CONSIDERATIONS

BY

DIVISION OF FUEL CYCLE AND MATERIAL SAFETY

U. S. NUCLEAR REGULATORY COMMISSION

RELATED TO THE PROPOSED ISSUANCE OF A LICENSE

TO RIO ALGOM CORPORATION

FOR THE HUMECA URANIUM MILL

DOCKET NO. 40-8084

Effective January 19, 1975, activities under the U. S. Atomic Energy Commission regulatory program were assumed by the U. S. Nuclear Regulatoıy Commission in accordance with the Energy Reorganization Act of 1974. Any reference to the Atomic Energy Commission (AEC) contained herein should be interpreted as Nuclear Regulatory Commission (NRC).

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SUMMARY SHEET FOR ENVIRONMENTAL IMPACT STATEMENT

( ) Draft Environmental Statement
(X) Final Environmental Statement

Responsible Agency Office - Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission

1. Type of Action

   Administrative Action (X)
   Legislative Action ( )

2. Description of Action

   This statement is related to the proposed issuance of an operating license to Rio Algom Corporation for the Humeca Uranium Mill in San Juan County in southeast Utah.

3. Summary of Environmental Impact

   The Humeca Uranium Mill is a carbonate-leach uranium ore refining plant with a capacity of about 500 tons of ore per day. Although the present licensing action does not extend to mining, the statement considers the environmental impact of the combined mining and milling project to be conducted by Rio Algom Corporation.

   The environmental impact, including adverse and beneficial environmental effects of the Rio Algom Uranium Mill, is as follows.

   a. Temporary (about 10 years) reassignment of use of about 120 acres of land out of the total 2,573 acres controlled by Rio Algom Corporation.

   b. The removal of an estimated 8.4 million pounds of uranium concentrates as a natural resource. This material will eventually be used to produce approximately 6.09×10^6 megawatt-days of electricity.

   c. Removal and diversion of approximately 100 gallons per minute of local groundwater.

   d. Stimulation of the local economy through payment of taxes and direct employment of about 200 persons in San Juan County over the next 10 years. Rio Algom estimates they will pay out over $11 million in salaries over this period of time.

e. The creation of stabilized tailings piles covering about 45 acres involving approximately 1,850,000 tons of solids containing solidified waste chemical and radioactive uranium and its daughter products.

f. Discharge of small quantities of chemicals and radioactive materials (that are not expected to produce discernible effects) into the local environs.

4. Alternatives Consid...

The following alternatives to the Humeca uranium project were considered:

A. Processing of the Ore at an Existing Facility.

B. Use of an Alternate Mill Process.

C. Alternate Tailing Storage.

D. Alternate Equipment and Operating Procedures.

E. Substitute Energy Sources.

5. A tabulation of all Federal, State, and local agencies and other sources from which written comments have been received is listed below:

a. Fnvironmental Protection Agency, Washington, D.C.
b. Department of the Army, South Pacific Division, Corps of Engineers
c. Department of Health, Education and Welfare
d. Department of Agriculture
e. Department of Housing & Urban Development
f. John Y. Cole, Attorney at Law, Palo Alto, California
g. University of Utah for Utah Department of Development Services
h. Department of Transporation, United States Coast Guard
i. United States Department of Interior
j. Federal Power Commission

6. In view of the fact that Rio Algom now intends to patent the land, a full term license will be issued subject to the following conditions:

a. Rio Algom will undertake, if necessary, to show by survey its present possessory interest of land on which the tailings dams, tailings piles, fences, and diversion ditches are located.

b. In the event there is a court action which results in a judgment adverse to Rio Algom claim, Rio Algom will purchase the necessary interest in land to perfect its possessory interests, or will move any tailings material involved to an appropriate area, or will arrive at an agreement with Mr. Cole that would preclude Mr. Cole from asserting any interest in any tailings material.

c. Rio Algom will initiate and complete patent procedures and maintain the tailings piles, dams, fences, diversion ditches, and perform periodic environmental monitoring surveys for a period of 50 years after decommissioning.

d. Rio Algom will provide the details of the yearly maintenance program to include the costs associated with the procedures specified in item c. and a guarantee that such an effort will be successfully completed.

Additionally, the license will be subject to the following licensing conditions for the protection of the environment:

a. Any action involving the movement of tailings material as a result of this license condition must be approved by the AEC prior to initiating any such action.

b. Prior to construction of a new tailings basin and dam, plans and procedures for the project must be submitted to the AEC for approval.

c. When the tailings monitor well program reveals concentrations of any radionuclide in excess of the AEC allowable Maximum Permissible Concentration for unrestricted areas, 10 CFR 20, Appendix B, Table II, Column 2, the applicant will take an action that will reduce the concentration of the radionuclide to below allowable Maximum Permissible Concentrations for unrestricted areas. The AEC must be notified as soon as the discovery is made and be provided with the details and objectives of the technique to be used to correct the situation.

d. The applicant will be required to conduct an operational environmental monitoring program delineated in Section II.E.2. of this Final Environmental Statement.

e. The applicant must comply with all of the tailings basin reclamation and restoration procedures and restrictions decribed in all of Chapter II, Section G of this Final Environmental Statement.

f. Mill tailings shall no' transferred from the site at any time without specific pric -oval of the Atomic Energy Commission or the State of Utah.

g. The applicant will control the wastes and effluents as described in Chapter II, Section C of this Final Environmental Statement.

7. The following actions are not license conditions but recommendations which are believed to enhance the applicant's environmental and operational program.

   a. Unless the present construction of the mine shafts provides for a seal between the shaft linings and walls, the annulus should be blocked with grout just below the bottom of the Burro Canyon so as to prevent the possibility of vertical communication of waters between the shaft linings and the rock walls of the shafts.

   b. Because of biological variation expected in sampling only two animals per year, jack rabbits, it is recommended that more than two animals be measured for radionuclides in a year.

   c. The nearest access point to the mine ventilation shaft should be extended and properly posted so that the appropriate MPC value for radon listed in 10 CFR 20, Appendix B, will not be exceeded.

8. In the last stages of preparing the Final Environmental Statement, the applicant submitted a request dated November 12, 1973, to increase the mill tonnage from 500 to 700 tons per day. In support of this request, the applicant has submitted a brief analysis on the effect that the increased milling rate may have on the environmental effects predicted for the lower tonnage operation (see Appendix S). The applicant has concluded that the additional impact will be negligible. It is the opinion of the Commission that the conclusions presented by the applicant generally represent fairly the effects that the increase will have upon the environment and that the proposed increase in mill tonnage will have a minimal effect on the environmental considerations presented in this report. Furthermore, it is the opinion of the AEC that, as a result of the increases, the total effect in the environment will be the same but will occur in a shorter period of time, as it is anticipated that the ore body will be more rapidly depleted from the accelerated mining rate. Furthermore, conditions to be incorporated into the applicant's license and AEC inspections will assure that concentrations of radionuclides released to the environment are maintained as low as practicable. Finally on March 19, 1974, the applicant submitted a request to construct and use a new tailings dam. The AEC notified the applicant that before the proposed dam could be utilized, the applicant would have to submit additional information relating to the request. An evaluation of the proposal is included in Appendix S.

9. This FES was essentially completed in August 1974; however, publication was deferred pending formulation of arrangements for assuring that the tailings would be stabilized, maintained, and monitored as described in Section II, paragraph G, Page II-46 of this document.

By letters dated September 17, 1974, and October 7, 1974, the applicant committed to the Atomic Energy Commission to provide funds for the reclamation and stabilization procedures as well as maintenance costs for the stabilized areas for 50 years. On May 14, 1975, the Utah Division of Oil, Gas, and Mining became the responsible agency for all mine and mill sites within the State under the "Utah Mined Land Reclamation Act of 1975." Under this Act, the Division of Oil, Gas and Mining is responsible for implementing the Act relative to uranium mine and mill reclamation including tailings stabilization and monitoring.

While the details of implementation are being resolved as to whether the Nuclear Regulatory Commission (NRC) or the State of Utah would be the obligee of bonding arrangements, it is the belief of the staff that it is in the public interest to publish the FES at this time. The NRC will continue to work towards resolution of the details of these arrangements which will be implemented prior to issuance of a full term license to Rio Algom. This FES is being made available to the Council on Environmental Quality, to the agencies and persons mentioned in item 5, and to the public in April, 1976.

FOREWORD

The final detailed statement on environmental considerations associated with the proposed issuance of an operating license for the Humeca Uranium Mill (Docket 40-8084) to Rio Algom Corporation (applicant) has been prepared by Fuels and Materials, Directorate of Licensing (the staff) of the U.S. Atomic Energy Commission (AEC) in accordance with the AEC's regulation 10 CFR Part 51, implementing the requirements of the National Environmental Policy Act of 1969.

This statement is based on information contained in correspondence, applications and reports received from Rio Algom. The following documents were mainly used in preparing the report: Application for source material license dated August 26, 1971; Applicant's Environmental Report received by the Commission on August 31, 1971; Applicant's Supplemental Environmental Report dated November 1971; correspondence from applicant dated April 4, 1972, July 7, 1972, August 10, 1972, November 17, 1972, February 20, 1973, May 2, 1973, May 10, 1973, July 6, 1973, August 14, 1973, January 7, 1974, January 30, 1974 and February 26, 1974; Inspection Report of the Rio Algom Humeca Uranium Mill by AEC Regulatory Operations on January 3-4, 1973, dated February 1, 1973; Applicant's response to Agency Comments on Draft Statement, November 1973; and consultants in various disciplines in environmental concerns. Copies of the Applicant's Environmental Reports and correspondence are available for inspection in the AEC Public Document Room, 1717 H Street, N.W., Washington, D.C. 20006; the Utah State Clearinghouse, State Capitol Building, Salt Lake City, Utah 84114; and the San Juan County Library, Monticello, Utah 84535. Copies of the applicant's license application and AEC Inspection Reports are available for public inspection in the AEC Public Document Room, 1717 H Street, N.W., Washington, D.C.

The applicant must comply with all applicable requirements of Section 401 of the Federal Water Pollution Control Act, as amended, under terms of the operating license to be issued by the Commission.

Mr. Richard B. Chitwood is the project manager and Mr. John F. Kendig is the AEC Environmental Analyst for the Final Environmental Statement.

Single copies of this statement may be obtained in either printed form or microfiche by writing the National Technical Information Service, Springfield, Viriginia 22161.

I. INTRODUCTION

Exploratory drilling by the Rio Algom Corporation has led to the discovery of uranium ore body over 1,000,000 tons lying at a depth of 2,500 feet on the down-throw side of the Lisbon Valley fault in San Juan County, Utah. Based on the results of this exploratory drilling, the Rio Algom Corporation decided to develop an underground mine and a surface milling operation to concentrate the uranium. Contracts totaling 8.4 million pounds of uranium oxide (U_3O_8) have been signed. Mining development and operations are being carried out and the 500 ton per day mill is operating under an interim license issued by the Commission on June 7, 1972. This interim license was issued in accordance with the provisions of Paragraph A.14 of Appendix D, 10 CFR Part 50.

Under the Atomic Energy Commission's regulation, 10 CFR Part 40, an AEC license is required in order to mill ores containing 0.05% or more of uranium. Moreover, Appendix D of the Commission's regulation, 10 CFR Part 50, provides for the preparation of a Detailed Environmental Statement pursuant to the National Environmental Policy Act of 1969 prior to the issuance of an AEC license to authorize uranium milling.

The National Environmental Policy Act of 1969 became effective on January 1, 1970. Pursuant to Section 102(2)(C) of the Act, Federal agencies must include, in every major Federal action significantly affecting the quality of the human environment, a detailed statement by the responsible official on:

1. The environmental impact of the proposed action;

2. Any adverse environmental effects which cannot be avoided should the proposal be implemented;

3. Alternatives to the proposed action;

4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity;

5. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

By application dated August 26, 1971, Rio Algom Corporation applied for an AEC source material license authorizing uranium milling activities at the applicant's Humeca Uranium Mill (HUM). In conjunction with this application for a license, the applicant filed an environmental report entitled, "Applicant's Environmental Report Operating License Stage - For Uranium Concentrator", with its application. The applicant later submitted supplemental reports and data. These reports discussed the expected and the possible environmental impacts associated with the proposed mining and milling activities.

AEC regulations do not require mining activities to be licensed by the Commission. However, for the purposes of this detailed statement, the combined environmental impact from both the mining and milling activities is considered since they are interrelated, the relationship being that the main shaft of the mine is located in one corner of the mill area and that ore is delivered by elevator directly to the ore handling conductor system.

Additional applications, approvals and regulatory actions required for the HUM project are listed in Table I below:

Table I

List of Regulatory Approvals and Permits

Goverment Agency	Type of Application	Date of Approval
Utah State Department of Natural Resources	Water Rights	March 1, 1971
U. S. Bureau of Land Management	Right-of-way for Water Pipeline	February 18, 1971
Utah Management Commission	General Safety Regulations	None Required
Utah State Board of Health	Tailings Dam Construction	July 13, 1970
Utah State Board of Health	Air Cleaning Equipment and Heating Plant	October 15, 1971
Utah State Board of Health	Sanitary Sewage System	December 1, 1971
Environmental Protection Agency	Discharge of Water from mine	Pending

I. DESCRIPTION OF THE PROPOSED ACTION

A. SITE LOCATION

The mine-mill complex is located in Lisbon Valley, San Juan County, Utah, as shown in Figures 1 and 2. The site is approximately 4 miles south of the hamlet of La Sal and 30 air miles southeast of Moab. It is about 10 air miles to Colorado on the east and 90 miles to Arizona on the south. The site may be reached by turning onto Highway 46 at La Sal Junction and then south on the Lisbon Valley County road.

The site, as shown in Figure 3, is on property which Rio Algom Corporation states is under their control. The site consists of 130 unpatented mining claims in fraction acquired by Humeca Exploration Company. However, Nuclear Corporation contends that Rio Algom has overstaked their claim and are denying Nuclear Corporation their legal right and obligation to do necessary annual labor on certain of their claims. See Appendix T for complete comments by Nuclear Corporation.

Rio Algom's position with respect to the question of title to the unpatented mining claims by Rio Algom is that this is not a matter directly related to the Environmental Report or the application for the operating license. Rio Algom has stated that the area for which Rio Algom Corporation holds mining claims and leases is held by the Bureau of Land Management except for one parcel covered by a State lease, and that the areas so held were obtained by leases from the original holders of the mineral claims or leases. Rio Algom has indicated that they were completely satisfied with the title opinion of a firm of Utah attorneys and that the lending institution which provided the financing for this project was satisfied with the applicant's title to the mining claims. The United States Department of the Interior in its comments on the draft detailed statement states that there is no record of a Federal lease and that Rio Algom Corporation has leased most of the area they control from mining claimants. However, in a letter from the Bureau of Land Management to Rio Algom dated February 19, 1974 and a memo of a meeting between the Bureau of Land Management and Rio Algom dated October 21, 1971, the Bureau of Land Management has stated that if Rio Algom does not patent the land the long-term problems of the site become the problem of the Bureau of Land Management, and therefore request stipulations and commitments be placed on Rio Algom with respect to the tailing pile. Furthermore, the Bureau of Land Management has indicated by letter from the Bureau of Land Management State Director for Utah to the Director, dated February 1, 1974, that various claims are possibly in conflict with

Figure 1

STATE OF UTAH LOCATION MAP

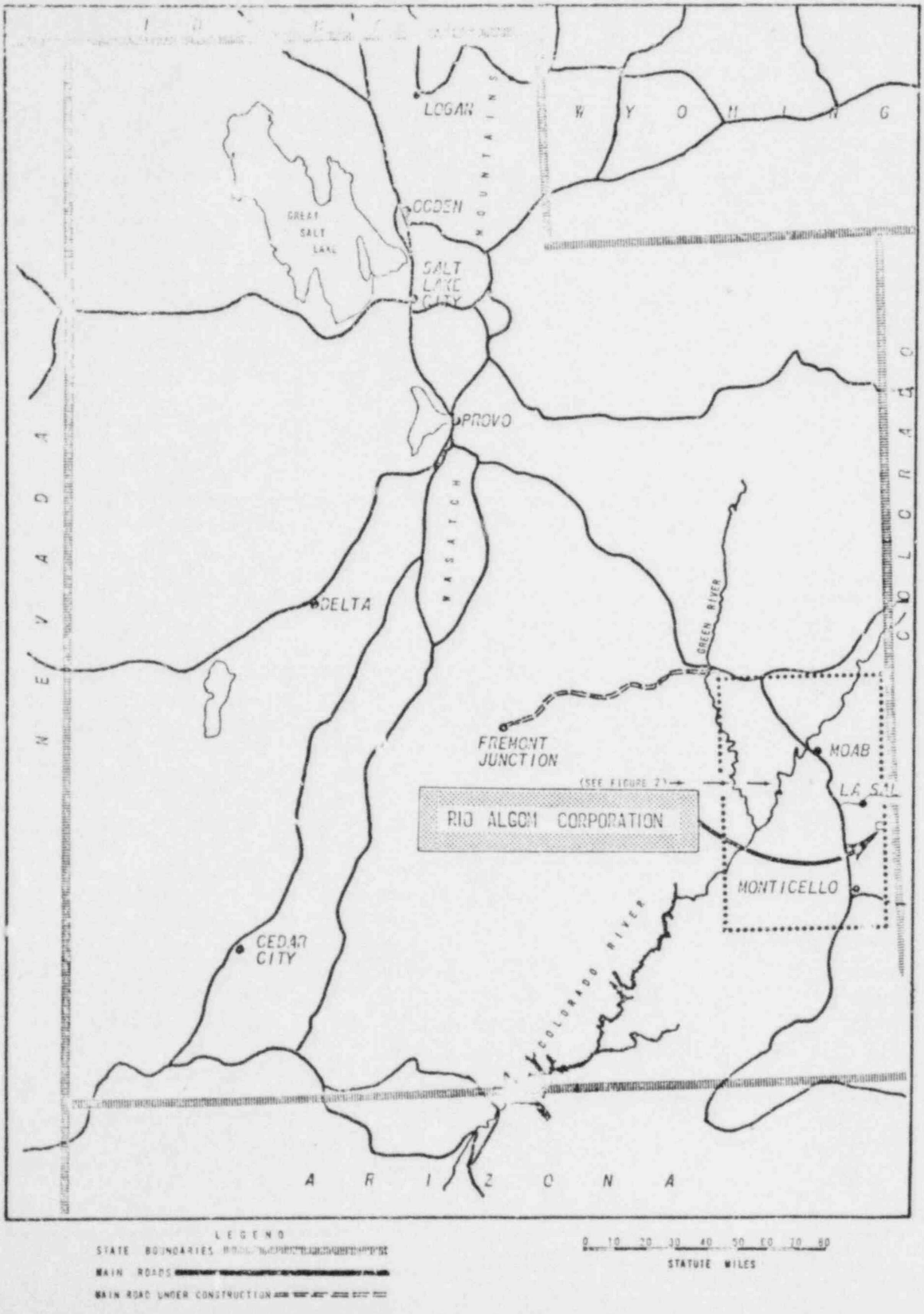


Figure 2

SOUTH EASTERN UTAH

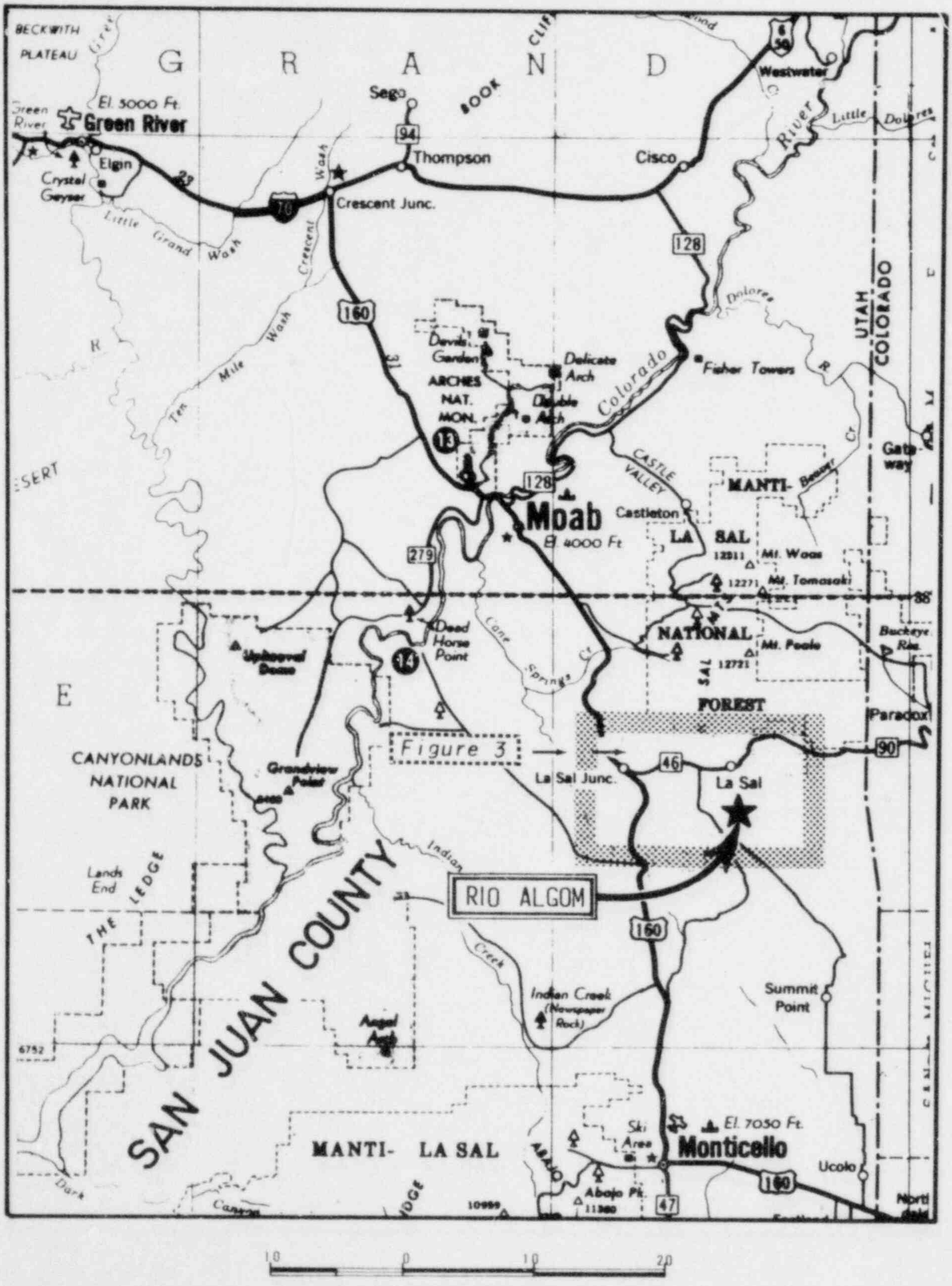
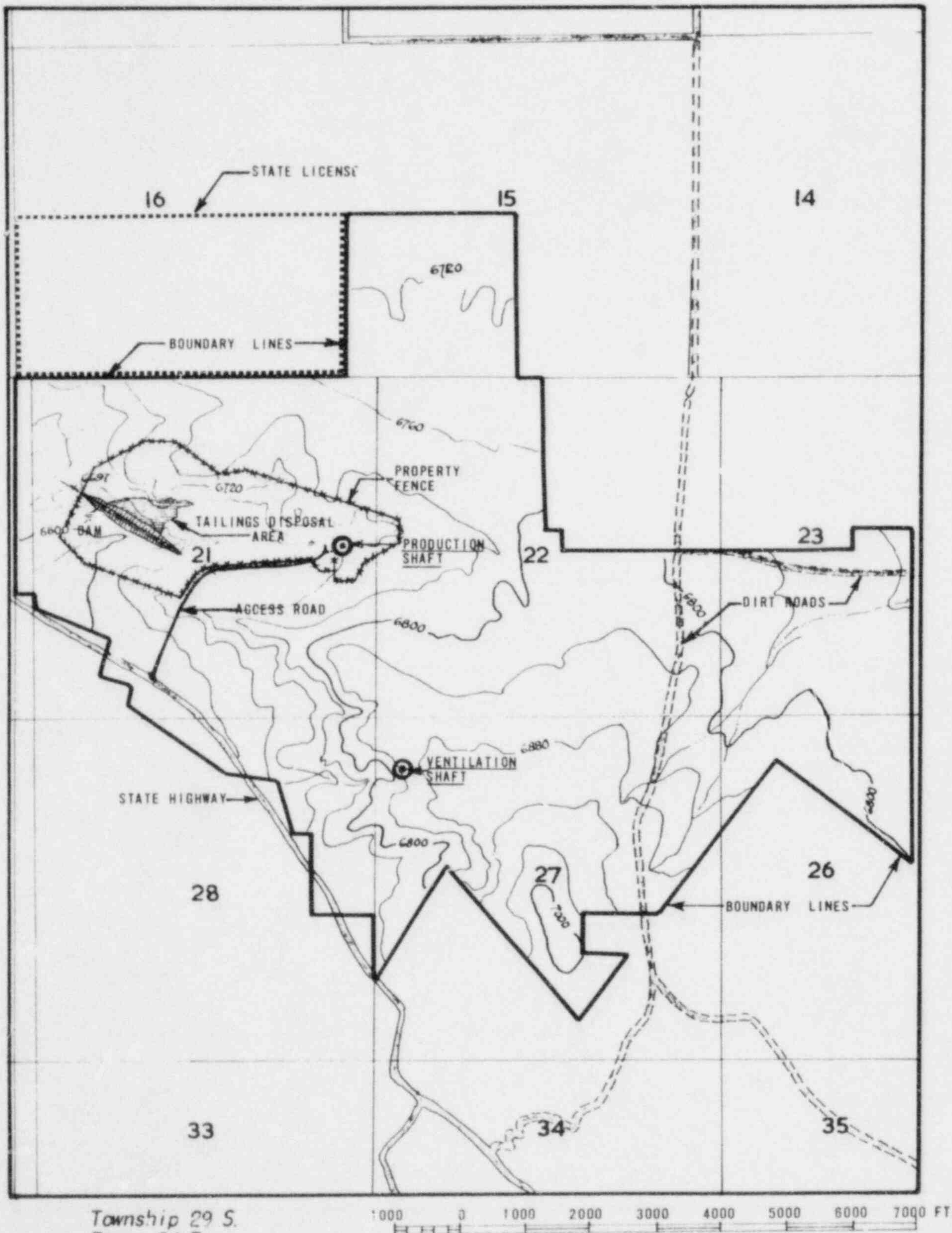


Figure 3

RIO ALGOM PROPERTY



RIO ALGOM CORPORATION - PROPERTY MAP

several of Rio Algom claims (see Appendix A). It is the opinion of the AEC Office of General Counsel that the issue of "Title", raised by Mr. John Y. Cole is not an environmental issue and need only be addressed as a license condition as follows: mill facilities, tail disposal sites, and other fenced areas, if any, shall be located only on land as to which the possessory interest of Rio Algom is undisputed.

The total combined acreage involved is 2,573 acres. The block of ground, as indicated in Figure 3, which contains the mill and the tailings area will be enclosed by a perimeter fence, 3 feet 6 inches high wire fencing with 6 inch by 12 inch openings to prevent access by sheep and cattle, and will be posted to warn unauthorized personnel.

B. REGIONAL DEMOGRAPHY AND LAND USE

1. Population

The populations of Grand and San Juan counties and the towns and villages of interest are given in Table II below:

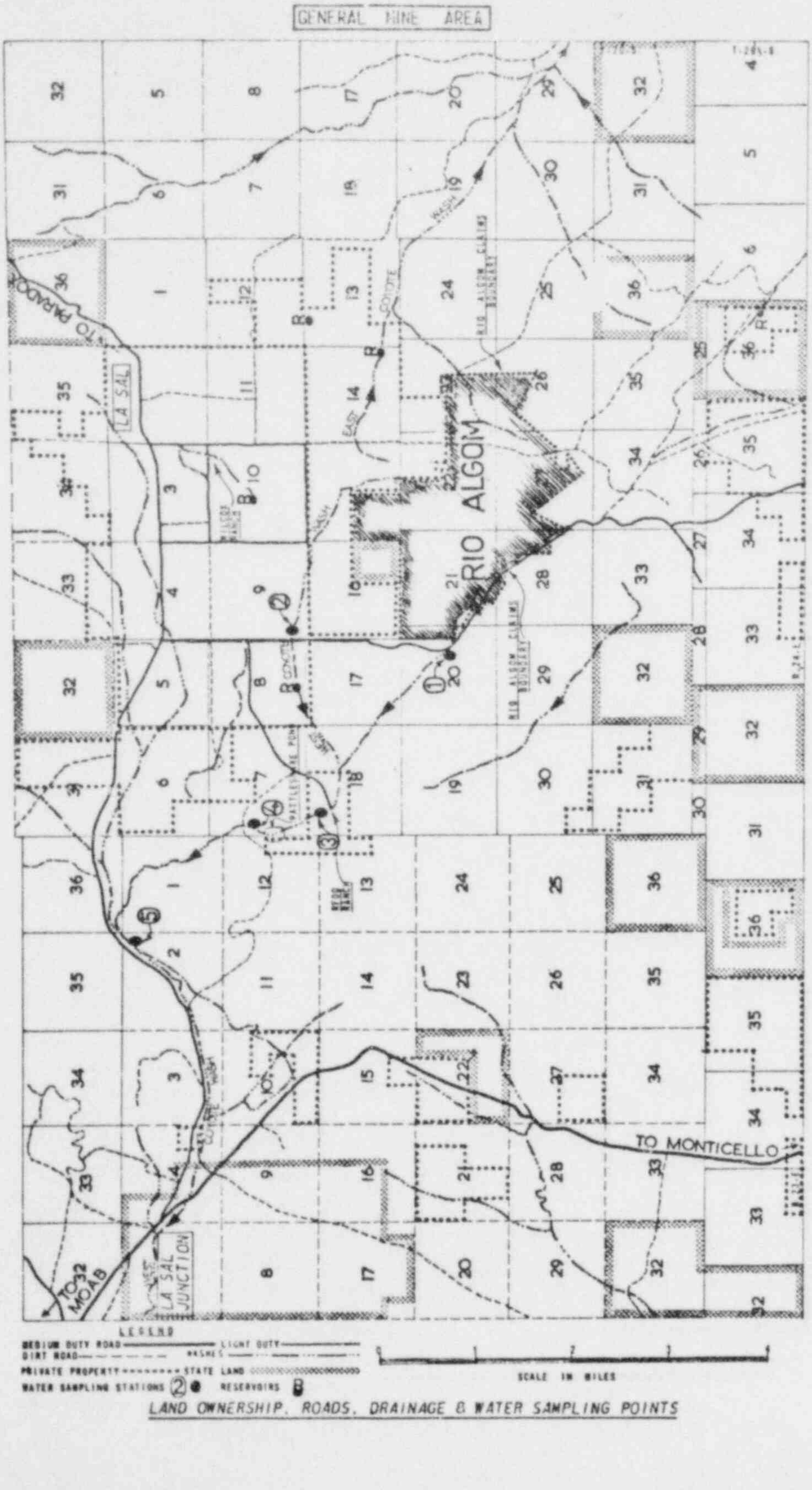
Table II

Population Data

Location	1960	1970	Change
Grand County	6345	6688	+343
Moab	4682	4793	+111
San Juan County	9040	9606	+566
Monticello	1845	1431	-414
La Sal	100	100	0
La Sal Junction	0	2	+ 2

Moab and Monticello are respectively 30 miles northwest and 30 miles south of the site. La Sal and La Sal Junction are respectively 4 miles north and 8 miles northwest of the site. The only other nearby residences are the Redd ranch and the Wilcox ranch as shown in Figure 4. Both ranches are about 2-1/2 miles from the Rio Algom site. At the Redd ranch, the number of residents varies from 1 to 6 depending on the season of the year. At the Wilcox ranch, there are 29 full-time residents

Figure 4



LAND OWNERSHIP, ROADS, DRAINAGE & WATER SAMPLING POINTS living in two houses and seven trailers. The total population within a 7 mile radius of the mine is 351. This gives an average density of about 2.3 persons per square mile for the 7 mile radius and approximately 1.2 persons per square mile for the 2-1/2 mile radius.

2. Land Use

The economy of San Juan County was primarily based on cattle, sheep, and agriculture until after World War II when oil and uranium discoveries in the northern sections of the county developed into major industries. Since 1950 the relative importance of agricultural production has declined in favor of the mineral industry and of tourism. Eight miles south of the Rio Algom mine is the Lisbon Valley oil and gas field. This has been producing since 1959. Uranium production for San Juan County is shown in Table III.

Table III

Uranium Production

	1960	1970	Total 1960-1970
Tons Ore Milled	980,379	380,032	5,551,545
Pounds U_3O_8 Produced	5,654,492	1,164,783	35,140,572

3. Social and Economic

The demographic summary characteristics suggest that no deleterious effects on population structure or composition are likely from the specialized nature of the mine-mill labor force, which will consist of approximately 200 persons. The work force is drawn from the established communities of Moab, Monticello and surrounding areas. Approximately nine percent of the Rio Algom work force is comprised of people of Indian or Mexican decent, as compared to a reported 2 to 3% native population in the general area.

Data for 1971 indicates an unemployment rate increasing from 5.8% in 1960 to 8.1% in 1970 and 10.3% in July 1971[1]. Table IV shows the occupational distribution of the Moab and San Juan Labor Force and the availability of the labor force for the years 1969 through 1971.

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(1) Utah Department of Employment Security

Table IV

OCCUPATIONAL DISTRIBUTION OF MOAB LABOR FORCE 1969

OCCUPATION	TOTAL	MALE	FEMALE
Employed	2,900	2,261	639
Professional, Technical, & Kindred Workers	344	240	104
Engineers, Technical	50	30	20
Teachers, Elementary & Secondary Schools	94	25	69
Other Professional, Etc: Salaried	190	180	10
Self-Employed	10	5	5
Farmers and Farm Managers	63	63	--
Managers, Officials & Propr's, Ex. Farm	381	291	90
Salaried	162	132	30
Self-Employed: Retail Trade	72	46	26
Other than Retail Trade	147	113	34
Clerical and Kindred Workers	231	56	175
Sales Workers	131	72	59
Retail Trade	94	35	59
Other than Retail Trade	36	36	--
Craftsmen, Foremen, & Kindred Workers	382	377	5
Construction Craftsmen	79	79	--
Foremen (nec)	122	122	--
Mechanics and Repairmen	80	100	--
Metal Craftsmen, Except Mechanics	5	5	--
Other Craftsmen	75	70	5
Operatives and Kindred Workers	968	958	10
Drivers and Deliverymen	173	173	--
Other Operatives, Etc: Dur. Goods Mfg.	5	--	5
Non-Dur. Goods Mfg.	5	5	--
Non-Mfg. Industries	785	780	5
Private Household Workers	30	5	25
Service Workers, Ex. Private Household	207	56	151
Protective Service Workers	14	14	--
Waiters, Bartenders, Cooks, & Counter Wrkrs.	79	5	74
Other Service Workers	115	38	77
Farm Laborers, Except Farm and Mine	43	43	--
Construction	5	5	--
Manufacturing	--	--	--
Other Industries	38	38	--
Farm Laborers & Farm Foremen	36	36	--
Occupations not Reported	83	63	20

AVAILABILITY OF LABOR IN MOAB - 1970

	TOTAL	MALE	FEMALE
Total Population	6,200	3,240	2,960
Age Group Distribution			
14-21	720	470	360
22-31	990	470	520
32-41	1,000	540	460
42-51	760	410	350
52-61	550	320	230
Total 14-61 Years	4,020	2,100	1,920
Estimated Employment	2,000	1,600	400
Estimated Not Working	2,020	500	1,520

Source: Utah Department of Employment Security Estimates (July 1970)

Table IV

SAN JUAN LABOUR FORCE

September 1971

1.	MANUFACTURING	90
2.	MINING	370
3.	CONTRACT CONSTRUCTION	100
4.	TRANSP., COMM., & UTILITIES	110
5.	WHOLESALE AND RETAIL TRADE	270
6.	FINANCE, INSURANCE & REAL ESTATE	10
7.	SERVICE & MISC.	190
8.	GOVERNMENT	580
	TOTAL NON-AGRICULTURAL WAGE AND SALARIED JOBS	1,720
9.	AGRICULTURAL JOBS & PERSONS	270
10.	SELF-EMPLOYED PERSONS	460
	TOTAL JOBS & EMPLOYED PERSONS	2,450
11.	UNEMPLOYED PERSONS	360
12.	PERSONS DIRECTLY INVOLVED IN LABOUR DISPUTES	0
	TOTAL JOBS AND UNEMPLOYED PERSONS	2,810

These tables indicate that there were individuals available for work in the area. The Utah Department of Employment Security also indicated to the applicant that 40.1% of the San Juan County residents were receiving welfare assistance as of October 1971. Several events had taken place in the area, e.g., cutback in employment[2] in manufacturing and mining construction and road construction which had added to the unemployment picture.

There were a number of homes available and houses were being built in August of 1971. In addition, there is a large trailer park in Moab that can handle many full-size house trailers.

The school system was down from its highest enrollment in 1971 and was believed to have no problem absorbing additional students.[3]

From the information available in 1971, no significant new public expenditures were indicated because of the applicant's operation. More recent data, April 6, 1973, submitted by the Utah Department of Employment Security, indicates that there has been a reversal in the unemployment trend, with the latest unemployment figures indicating the total number of unemployed in the Moab area has decreased by some 9.1 percent. This decrease in unemployment is attributed to the start up of highway construction, increased construction of houses and trailer sites, start up of small businesses, and an increase in tourism which has created jobs in the trade and service categories.

More detailed and recent information about the Social and Economic aspects of the area is available from the Utah Department of Employment Security.

From the demographic data and the information provided by the Utah Department of Economic Development, it can be concluded that the labor forces, approximately 159 people needed by Rio Algom, will be drawn mainly from the existing labor pool of the area. Consequently the Rio Algom uranium concentrator will not in itself have a significant effect on the population growth curve for the area. In addition, it is the opinion of the Utah Department of Employment Security that the Moab area has a capability of readily supporting a moderate population increase and that existing public facilities in Grand County and the northern part of San Juan County can readily support a population increase of at least 600 persons.

C. HISTORICAL SIGNIFICANCE AND ARCHEOLOGICAL FINDS

The nearest national park to the Rio Algom operation is Canyonlands National Park and is located 25 miles west of the mine. Another national

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(2) Utah Department of Employment Security

(3) Utah Department of Economic Development

park, Arches National Park, is located north of Moab and some 35 miles north of the mine. In addition, Glen Canyon National Recreation area is located approximately 25 miles from the mine. Hovenweep and Natural Bridges are National Monuments which are located over 50 miles from the mine site. Other monuments such as Capitol Reef, Ceder Breaks, and Desolation Canyon are located at even greater distances. Alkali Ridge is a National Historic Landmark and is situated on secondary roads southeast of the town of Blanding. None of the above sites should be affected by the proposed Rio Algom Operations. The applicant requested the State Historical Society to examine the site of the uranium operation for possible impact of the mining and milling activity on any historical or anthropological significance of the site, Appendix B. By letter dated May 7, 1973, the State of Utah Department of Development Services, Division of State History, stated that there are no historic sites that would be adversely affected by the operations of the uranium mine and mill, Appendix B. Additionally, the City of Monticello has stated that, "there appears nothing in their operation at La Sal that in our view would be detrimental to recreational activities or tourism in the county," Appendix B.

D. TOPOGRAPHY

The mine is situated at an elevation of about 6700 feet and the site is dominated by the La Sal mountains which rise some 13,000 feet about 8 miles to the north. The peak is snow-covered for most of the year. The whole area is considered as part of the Colorado Plateau.

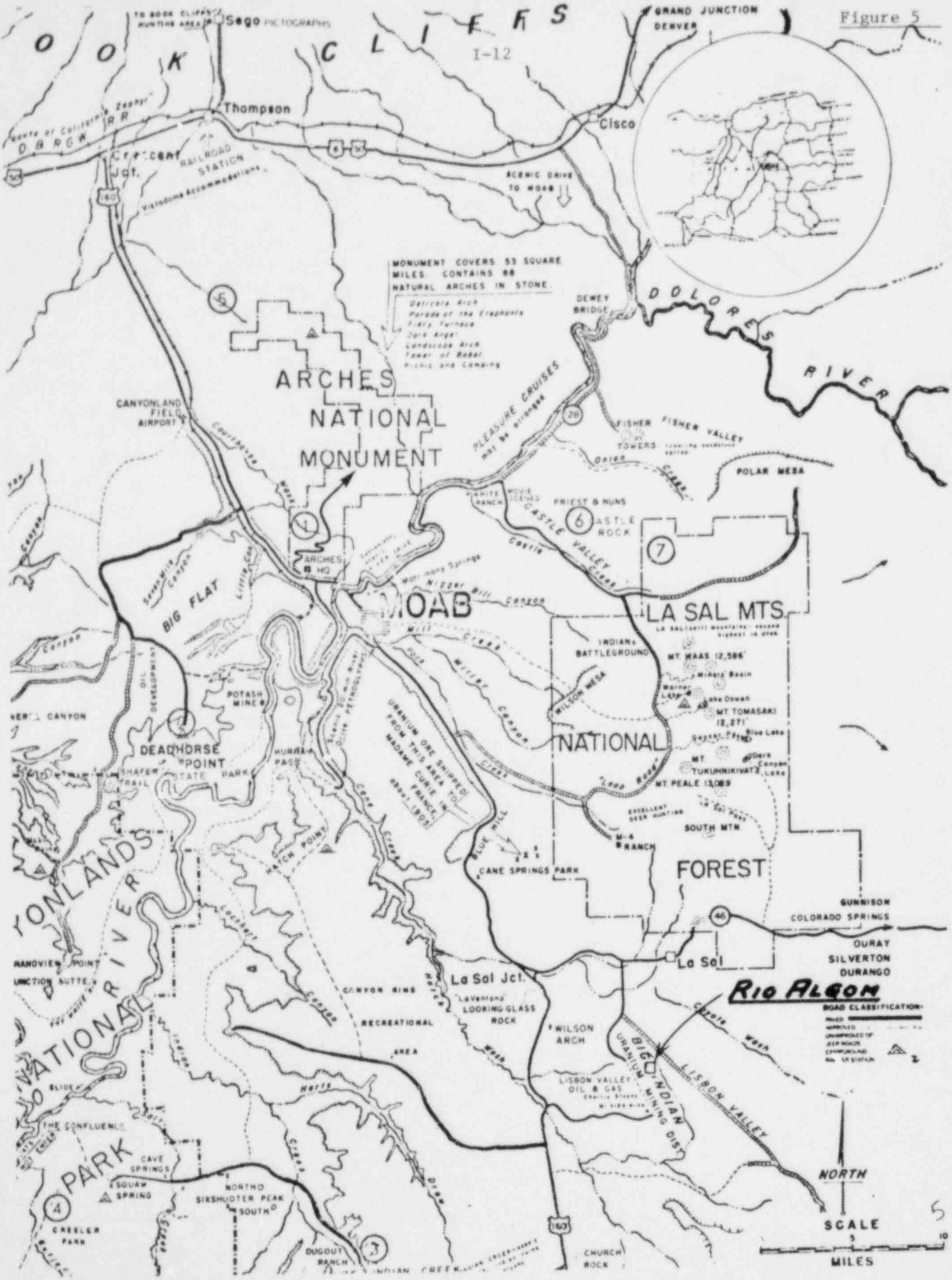
In the vicinity of the mine, the country is rolling with rock outcrops along the valley sides which run in a general NW-SE direction. The hills stand some 50 to 150 feet above the valley floor, and in places are precipitous. Once away from the hills surrounding the mine, the country tends to become more gently rolling upland to the north towards La Sal mountains. To the south the country becomes more broken. Figures 5 and 6 indicate the topography of the area and the drainage pattern around the site.

E. HYDROLOGY

1. Surface Drainage

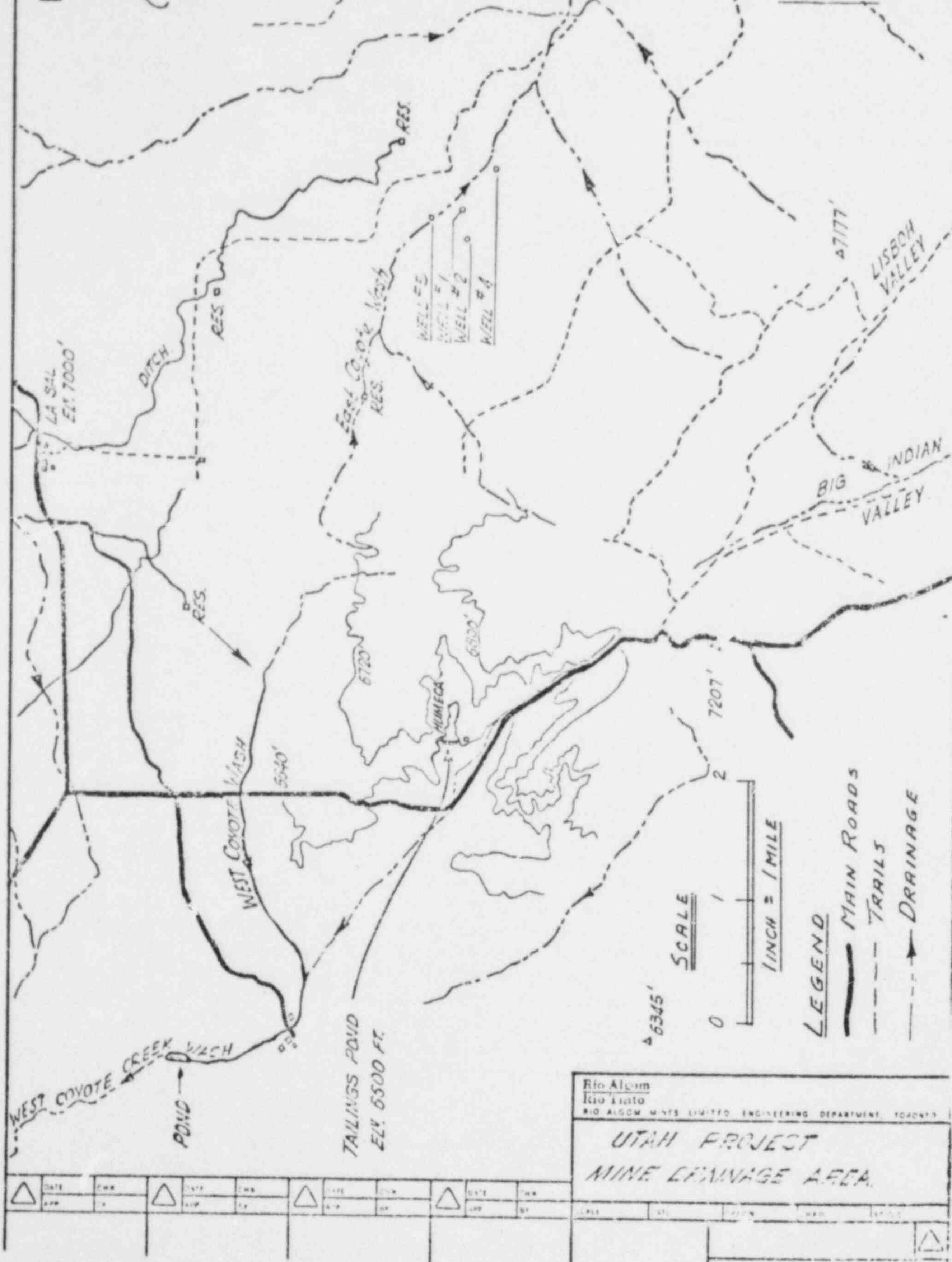
The surface drainage pattern in the immediate area of the mill-mine complex is shown in Figure 5. It comprises the tributaries of the East and West Coyote Wash. The division between the two watersheds is roughly a north-south line passing about a mile east of the mine. Because of the low precipitation in the area, most of the tributaries are dry for a

Figure 5



OOK CLIFFS
TO BOOK CLIFFS HUNTING AREA
Sego PICTOGRAPHS
GRAND JUNCTION
DENVER
Thompson
D&RGW RR
Crescent Jct.
RAILROAD STATION
Cisco
SCENIC DRIVE TO MOAB
MONUMENT COVERS 53 SQUARE MILES. CONTAINS 88 NATURAL ARCHES IN STONE.
Delicate Arch
Parade of the Elephants
Fiery Furnace
Dark Angel
Landscape Arch
Tower of Babel
Picnic and Camping
DEWEY BRIDGE
DOLORES RIVER
ARCHES NATIONAL MONUMENT
CANYONLAND FIELD AIRPORT
PLEASURE CRUISES may be arranged
FISHER TOWERS
FISHER VALLEY
POLAR MESA
PRIEST & NUNS
CASTLE ROCK
CASTLE VALLEY
Castle Creek
ARCHES HQ
BIG FLAT
MOAB
LA SAL MTS
INDIAN BATTLEGROUND
MT WAAS 12,586'
MT TOMASAKI 12,271'
WILSON MESA
NATIONAL
FOREST
MT PEALE 13,089
SOUTH MTN
POTASH MINE
DEADHORSE POINT STATE PARK
SHAFER TRAIL
URANIUM ORE SHIPPED FROM THIS AREA TO MADAME CURIE IN FRANCE ABOUT 1905
HATCH POINT
CANE SPRINGS PARK
BLUE HILL
GUNNISON
COLORADO SPRINGS
OURAY
SILVERTON
DURANGO
La Sal
La Sal Jct.
RIO ALGOM
ROAD CLASSIFICATION
CANYON RIMS RECREATIONAL AREA
LOOKING GLASS ROCK
WILSON ARCH
BIG INDIAN URANIUM MINING DIST
LISBON VALLEY
LISBON VALLEY OIL & GAS
CANYONLANDS NATIONAL PARK
GREEN RIVER
THE CONFLUENCE
CAVE SPRINGS
SQUAW SPRING
SIXSHOOTER PEAK
CREELER PARK
DUGOUT RANCH
INDIAN CREEK
CHURCH ROCK
NORTH
SCALE
MILES

Figure 6



N
LA SAL
ELV. 7000'
DITCH
RES.
RES.
RES.
RES.
RES.
WEST COYOTE CREEK WASH
POND
WEST COYOTE WASH
5640'
TAILINGS POND
ELV. 6500 FT.
6720'
East Coyote Wash
WELL #5
WELL #1
WELL #2
WELL #4
HUMECA
6800'
6345'
7207'
7177'
BIG INDIAN VALLEY
LISBON VALLEY
SCALE
0
1
2
1 INCH = 1 MILE
LEGEND
MAIN ROADS
TRAILS
DRAINAGE
Rio Algom
Rio Tinto
RIO ALGOM MINES LIMITED ENGINEERING DEPARTMENT TORONTO
UTAH PROJECT
MINE DRAINAGE AREA

large portion of the year. In the summer, streams flowing from the La Sal mountains are conducted by means of ditches and old water courses to various reservoirs for stock watering ponds or are used for irrigation. The loss of water by soil absorption and evaporation is considerable. Evaporation is estimated at 55 inches annually. West Coyote Wash, the drainage basin in which the mine is located, leads to Hatch Wash, Cane Creek, and (about 25 miles distant) into the Colorado River some 5 miles below Moab. In the opposite direction, East Coyote Wash drains to the east through open valleys where it eventually disappears due to evaporation and absorption into the soil.

2. Groundwater(4)

There are no permanent streams or adequate surface water sources in the area to provide water for the milling and mining operations. In order to determine the water resources available for the project, the applicant engaged the services of a consultant. The consultant recommended the drilling of test holes on two favorable zones. Zone 1 is located approximately 1-1/4 miles north of the mine on the Humeca block of claims leased by Rio Algom, and described as SW-1/4 Section 15, T.29.S, R24E, Figure 7. Zone 2 is located approximately 4 miles east of the mine on the Maple Leaf block of claims leased by Rio Algom, and described as Section 19, T.29.S., R25E, Figure 8.

Three test wells were drilled and tested during May of 1969 in Zone 1. Groundwater under artesian pressure was encountered in the Dakota formation at 180 feet below surface in each of the wells. The conclusions based on the data collected showed that eight production wells would have been required to produce 200 gpm for a useful life of 10 years. However, the well field could not have been enlarged within the Humeca claims to produce more water than 200 gpm if required at a later date and Zone 2 was explored for possibilities as a source of water.

The drilling and testing of four test wells was carried out in the fall of 1969 at the Maple Leaf claims in Zone 2. The source of water in this area is the Dakota sandstone-Burro Canyon formation. The water bearing formation was generally found from 30 to 100 feet below surface in each of the four wells drilled. The thickness of the aquifer was found to range from 140 to 183 feet thick. The aquifer is artesian in character and the source of recharge is from precipitation and snowmelt in the La Sal Mountains several miles to the north and northeast. The aquifer is fully saturated and excess groundwater is being discharged as spring flow in East Coyote Creek. Analysis of this water for September 1971 is shown in Table V and VI. Concentrations of radionuclides shown in Table V are for the Maple Leaf well field and were taken by the AEC on January 3 and 4, 1973.

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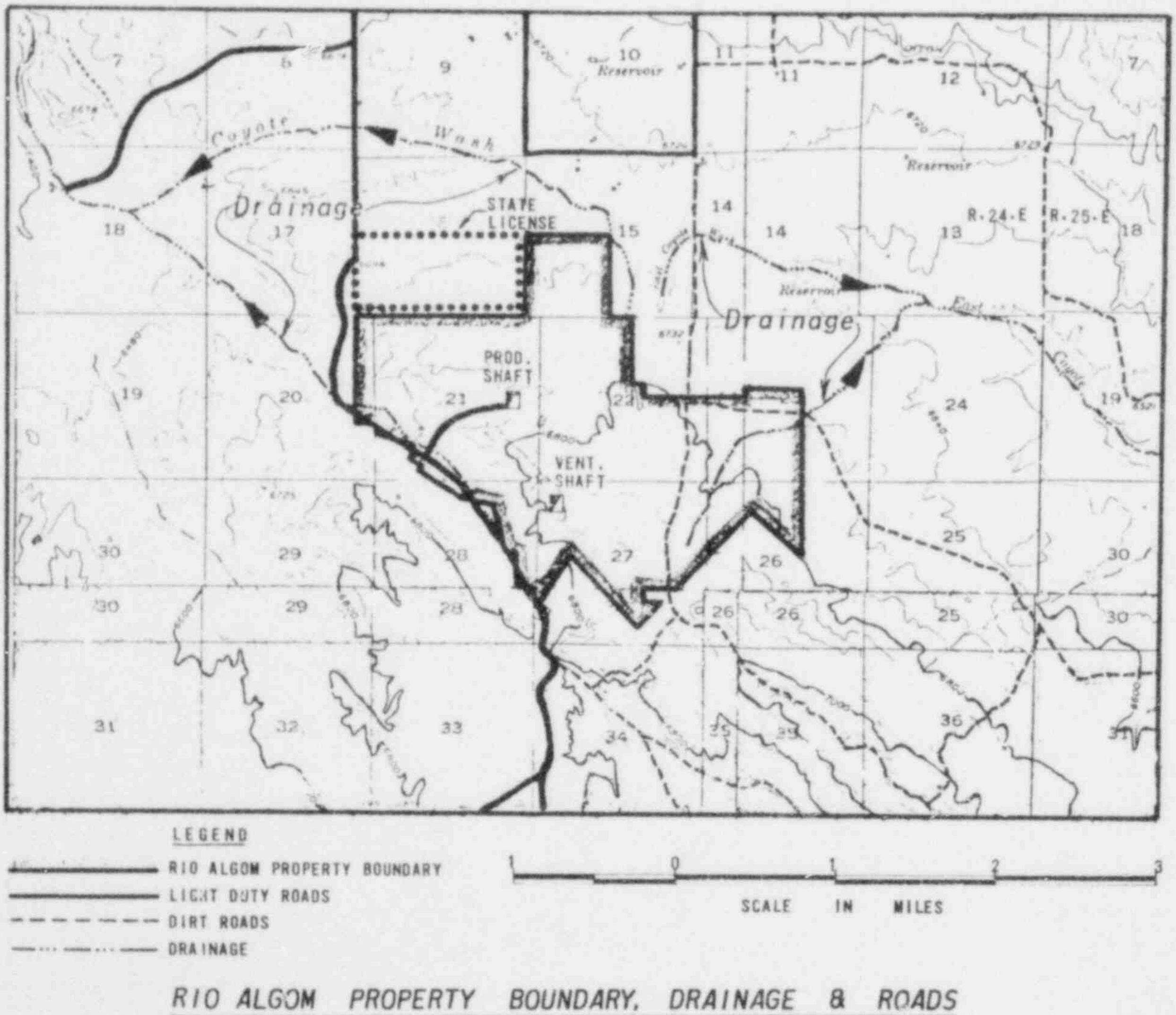
(4) Details pertaining to the groundwater for the project are contained in the consultant's report to the applicant in Appendix C.

Figure 7

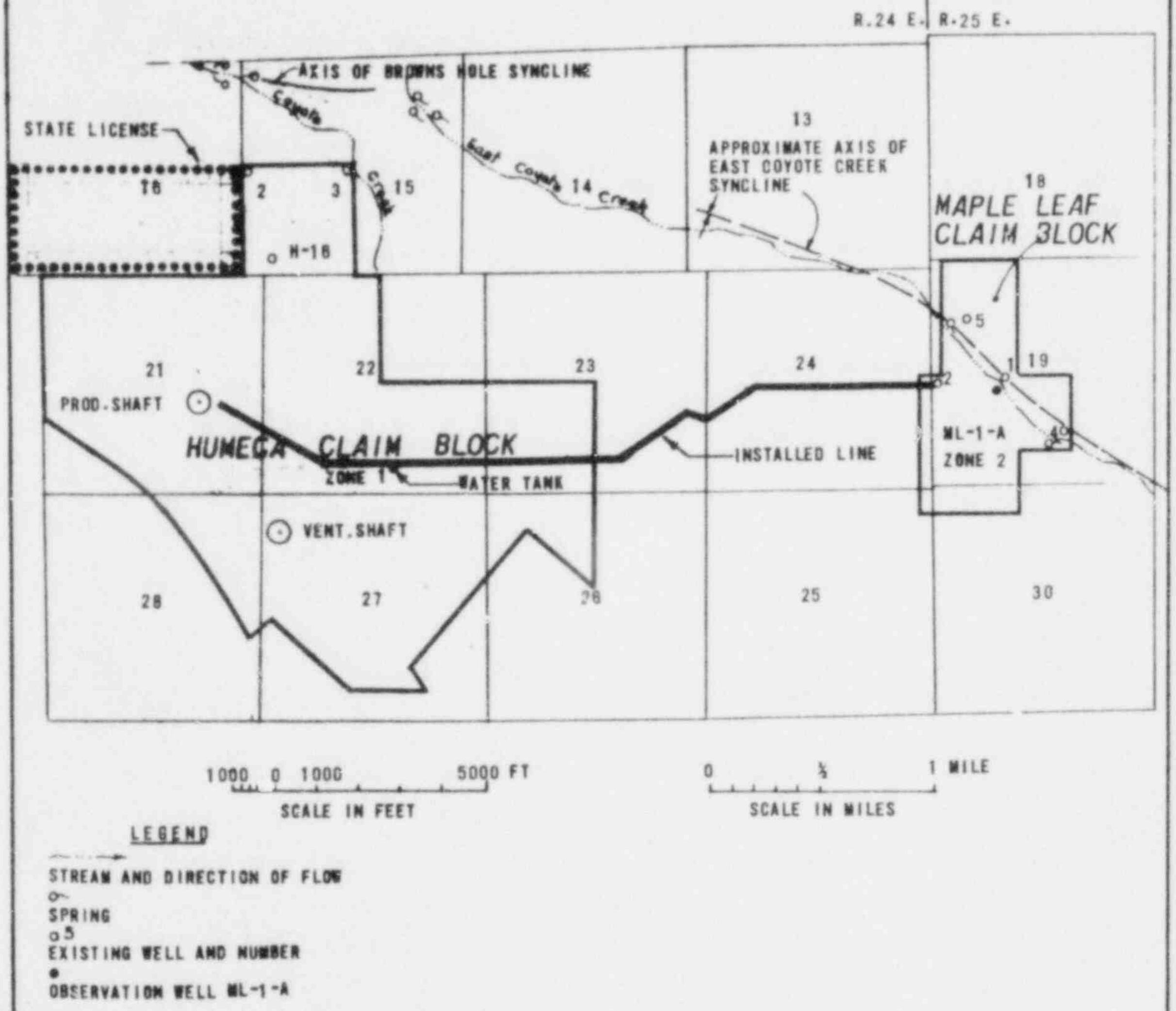
MINE AREA



RIO ALGOM PROPERTY BOUNDARY, DRAINAGE & ROADS

Figure 8

WATER SUPPLY



LOCATION OF TEST WELLS - PORTION OF TOWNSHIP 29 SOUTH

Table V
Water Quality Data (Chemical)
Maple Leaf Well Field

		Parts per Million
Biochemical Oxygen Demand 5 day	=	2.0
Chemical Oxygen Demand	=	19.3
Dissolved Oxygen at 20°	=	5.6
Suspended Solids	=	1.2
Dissolved Solids	=	488
Total Solids	=	489
Hardness	=	378
Chloroform extract	=	1.0
Phenol alkalinity as $CaCO_3$	=	0
Total alkalinity as $CaCO_3$	=	285
pH	=	7.7
Cyanide (CN)	=	none detected
Sulphide (H_2S)	=	none detected
NH_4	=	none detected
NO_3	=	2.04
Phosphate	=	0.01
Na	=	38.0
Ca	=	103
Mg	=	29.5
Cl	=	27.5
SO_4	=	184
Ba	=	none detected
Fe	=	0.35
Zn	=	0.02
Mn	=	none detected
Cr	=	none detected
Cd	=	none detected
As	=	none detected
Ag	=	none detected
Fluoride	=	0.1
Cu	=	none detected
Pb	=	none detected
Se	=	none detected
Silica	=	none detected
Turbidity units	=	20
Colour units	=	30
Odor	=	none

Water Quality Data (Radionuclides)
Samples taken by AEC on January 3 and 4, 1973

U-Natural	=	7.2×10^{-10} µCi/ml
Gross alpha	=	$<2 \times 10^{-9}$ µCi/ml
Gross beta	=	$<1 \times 10^{-8}$ µCi/ml

TABLE VI

ANALYSIS OF WATER DISCHARGED FROM VENTILATION SHAFT
SAMPLED FROM FEBRUARY TO NOVEMBER 1971

	PHS Drinking Water Standards mg/1	10 CFR 20 Appendix B Table II, Col. 2 µCi/ml	Average (ppm)
Dissolved Solids	500		2962
Total Solids			3712
Hardness			181
Phenol Alkalinity	0.001		7.5
Total Alkalinity			420
pH			7.6
Cyanide	0.01		Not Detectable
Sulphide			Not Detectable
Ammonia			Not Detectable
Nitrate	45		9.5
Phosphate			0.20
Sodium			1335
Calcium			37.8
Magnesium			17.2
Chloride	250		1597
Sulphate	250		309
Barium	1.0		Not Detectable
Iron	0.3		0.16
Manganese	0.05		Not Detectable
Zinc	5		0.03
Chromium	0.05		Not Detectable
Arsenic			Not Detectable
Silver	0.05		Not Detectable
Fluoride			1.28
Copper			.10
Lead	0.05		Not Detectable
Cadmium	0.01		Not Detectable
Selenium	0.01		Not Detectable
Silica			14.2
U_3O_8			.035
Mercury			Not Detectable
Results of Samples taken in October 1971			
Radium-226		$3x10^{-8}$	$0.53x10^{-8}$ µCi/ml
Th-230		$2x10^{-6}$	$0.006x10^{-6}$ µCi/ml
Po-210		$7x10^{-7}$	$0.22x10^{-13}$ µCi/ml
U-natural		$2x10^{-5}$	$0.0017x^{-5}$ µCi/ml

Samples by AEC on January 3 and 4, 1973

	10 CFR 20 Appendix B Table II, Col. 2 μCi/ml	
Ra-226	$3x10^{-8}$	$1.4 \pm 0.04x10^{-8}$ μCi/ml
Th-230	$2x10^{-6}$	$<2.0x10^{-8}$ μCi/ml
U-natural	$2x10^{-5}$	$7.2x10^{-10}$ μCi/ml

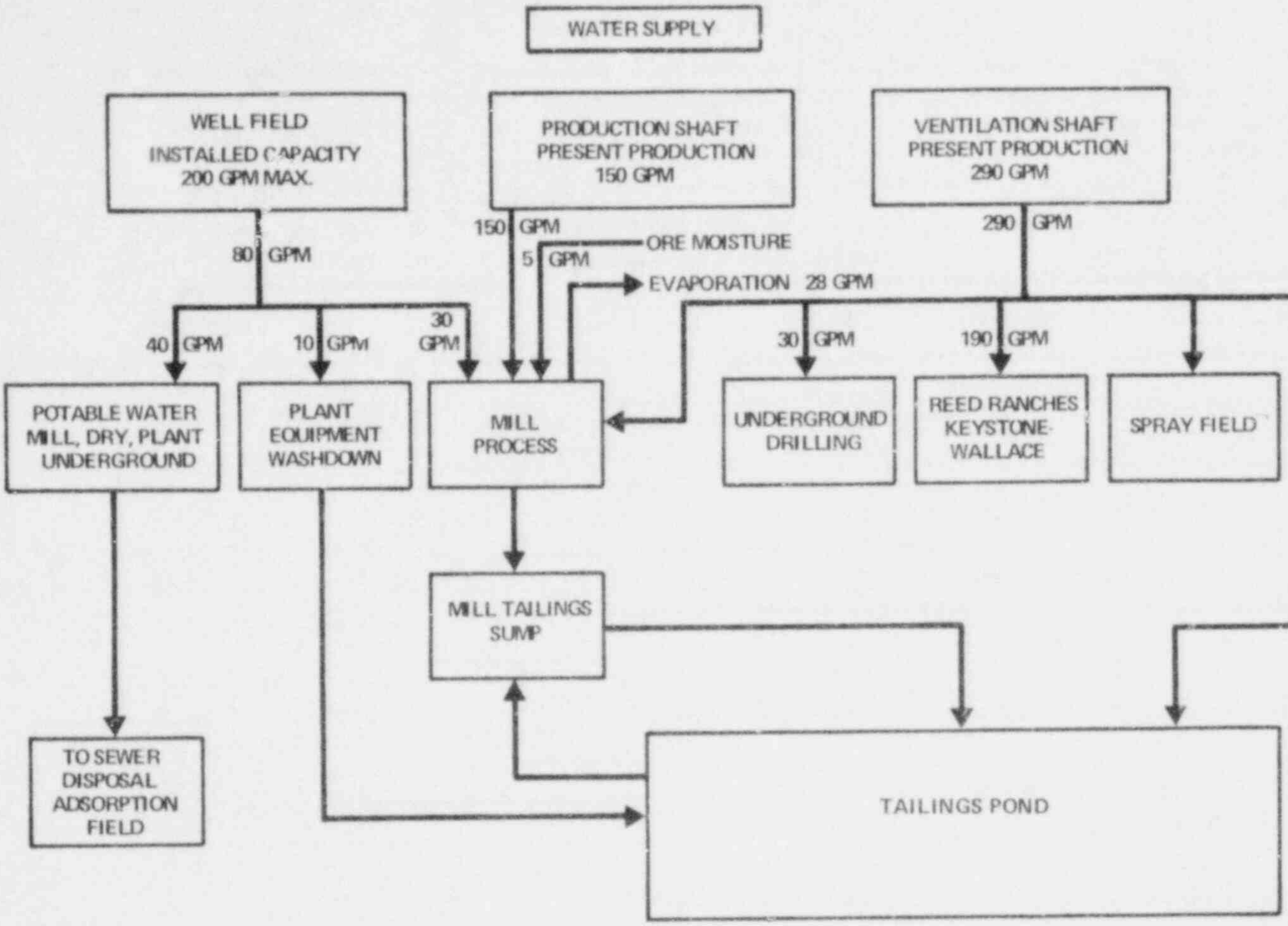
During the shaft sinking and underground devel pment of the mine, water was encountered. The source of this water is om the Navajo, Kayenta and Windgate formations and is located 1500 to 000 feet below ground. The Brushy Basin formation, described as relat ely impervious, lies between the surface aquifers and the Navajo, Kayenta and Windgate formations (see Figure 12). The maximum flow was about 1400 gpm, then decreased to 175 gpm, and then increased to approximately 390 gpm in March of 1973. This increase has been attributed to a more rapid development of new mining areas. As of the applicant's last report dated November 1973, the amount of water discharged through the ventilation shaft averages about 290 gpm, with the balance of the mine water being pumped up the production shaft, and averages about 150 gpm. Analysis of this water is shown in Table VI. The water supply for the mine-mill complex is summarized in Figure 9. This schematic shows that the well field in Zone 2 will be able to supply 200 gpm maximum. However, on the order of 80 gallon per minute is pumped through a buried 6 inch steel line to a 200,000 gallon storage tank located east of the plant. Of this quantity, 80 gpm, approximately 30 gpm will be utilized in the mill process with the remainder, 50 gpm, being used for boiler feed, showers and drinking. The water pumped up the production shaft is used in the mill to replace fresh water from the well field as far as possible. To further reduce fresh water consumption in the mill, the applicant has informed the AEC that a reclaim system is in operation which transports water from the tailing pond back to the mill for re-use. Water from the ventilation shaft (190 gpm) is currently being discharged to a cattle reservoir on the Redd Ranch. In addition, water from the ventilation shaft will be used to maintain a 300,000 gallon plastic-lined storage pond located north and east of the concentrator. This pond is maintained as a secondary source of water for fire protection.

The expected drawdown of the well field aquifer was calculated by the applicant's consultant. The results are tabulated in Table VII and apply only if the four wells pump at 50 gpm each, 200 gpm total, for a period of 10 years.

Table VII
Drawdown of Well Field (200 gpm)

Well No.	Calculated Drawdown (ft)	Thickness of Saturated aquifer remaining at end of 10 years (ft)
1	188	10
2	186	38
3	183	15
4	185	16

Figure 9


WATER SUPPLY
WELL FIELD
INSTALLED CAPACITY
200 GPM MAX.
PRODUCTION SHAFT
PRESENT PRODUCTION
150 GPM
VENTILATION SHAFT
PRESENT PRODUCTION
290 GPM
80 GPM
150 GPM
ORE MOISTURE
5 GPM
EVAPORATION 28 GPM
290 GPM
40 GPM
10 GPM
30 GPM
30 GPM
190 GPM
POTABLE WATER
MILL, DRY, PLANT
UNDERGROUND
PLANT
EQUIPMENT
WASHDOWN
MILL
PROCESS
UNDERGROUND
DRILLING
REED RANCHES
KEYSTONE-
WALLACE
SPRAY FIELD
MILL TAILINGS
SUMP
TO SEWER
DISPOSAL
ADSORPTION
FIELD
TAILINGS POND

Under these conditions, the useful life of the well field is estimated to be a minimum of 10 years, but more probably 20 years or more.

As shown in Figure 9, the well field will only be required to supply on the order of 80 gpm, rather than 200 gpm during the 10-year life of the mill. Consequently, the drawdown at the end of 10 years under these conditions would be less. The applicant's consultant has calculated the drawdown for an 80 gpm requirement, and the data are summarized in Table VIII.

Table VIII
Drawdown of Well Field (80 gpm)

Well No.	Calculated Drawdown (ft)	Thickness of Saturated Aquifer remaining at end of 10 years (ft)
1	87	111
2	86	138
3	85	113
4	86	115

The consultant for the AEC has reviewed the hydrological data and indicates that the drawdown estimates provided to the applicant are reasonable estimates, that the source of water for the springs may, in addition to being recharged by La Sal Mountains, get contributions from ditch seepage and from precipitation absorbed by the sandy textured soils of the area; it is quite unlikely that the springs in the vicinity are supplied by the aquifer; and pumping at 80 gpm from the four wells should not affect the flow of water from surface springs about three miles northwest of the well field. With regard to the drawdown effect caused by the flow from the mine, the applicant's consultant states that there is no feasible method to determine this effect. However, the consultant's latest report dated October 2, 1973 (see Appendix D), estimates that pumping at the rate of 80 gallons per minute would produce 20 feet of drawdown at two miles in 10 years, not considering recharge. It is their opinion that pumpage at the planned rate of 80 gallons per minute may diminish spring flow within 1500 or 2000 feet of the supply wells. Beyond one mile the influence on existing springs should be minor.

If one assumes that the hydrological conditions are the same throughout the Maple Leaf Claim Block; i.e., saturated sandstone 160 feet thick throughout an approximate area of 1.2×10^7 ft^2 and a porosity of 0.3, the volume of water available in the Maple Leaf Claim Block would be on the order of 5.76×10^8 ft^3. If the well field is pumped at 65 gpm for 12 hours a day for 10 years, the volume of water removed over the life of the mine may be 2.1×10^7, or approximately 4%. Additional data relating to this subject is contained in the applicant's consultant's reports submitted November 10, 1971, and a more recent report submitted October 2, 1973. These reports are attached as Appendix D.

F. Geology

Drilling by Rio Algom on the site revealed a flat lying ore body of U_3O_8 at a depth of approximately 2,500 feet, and it lies in a belt some 15 miles long by one-half mile wide on the southwest side of the Lisbon Valley fault, a major structural feature of the area. The Lisbon fault is believed to be located approximately 1500 feet southwest and parallel to the county road, and some 2,500 to 3,000 feet southwest of the tailing dam. The dip is about 55° to the northwest (see Figures 10 and 11).

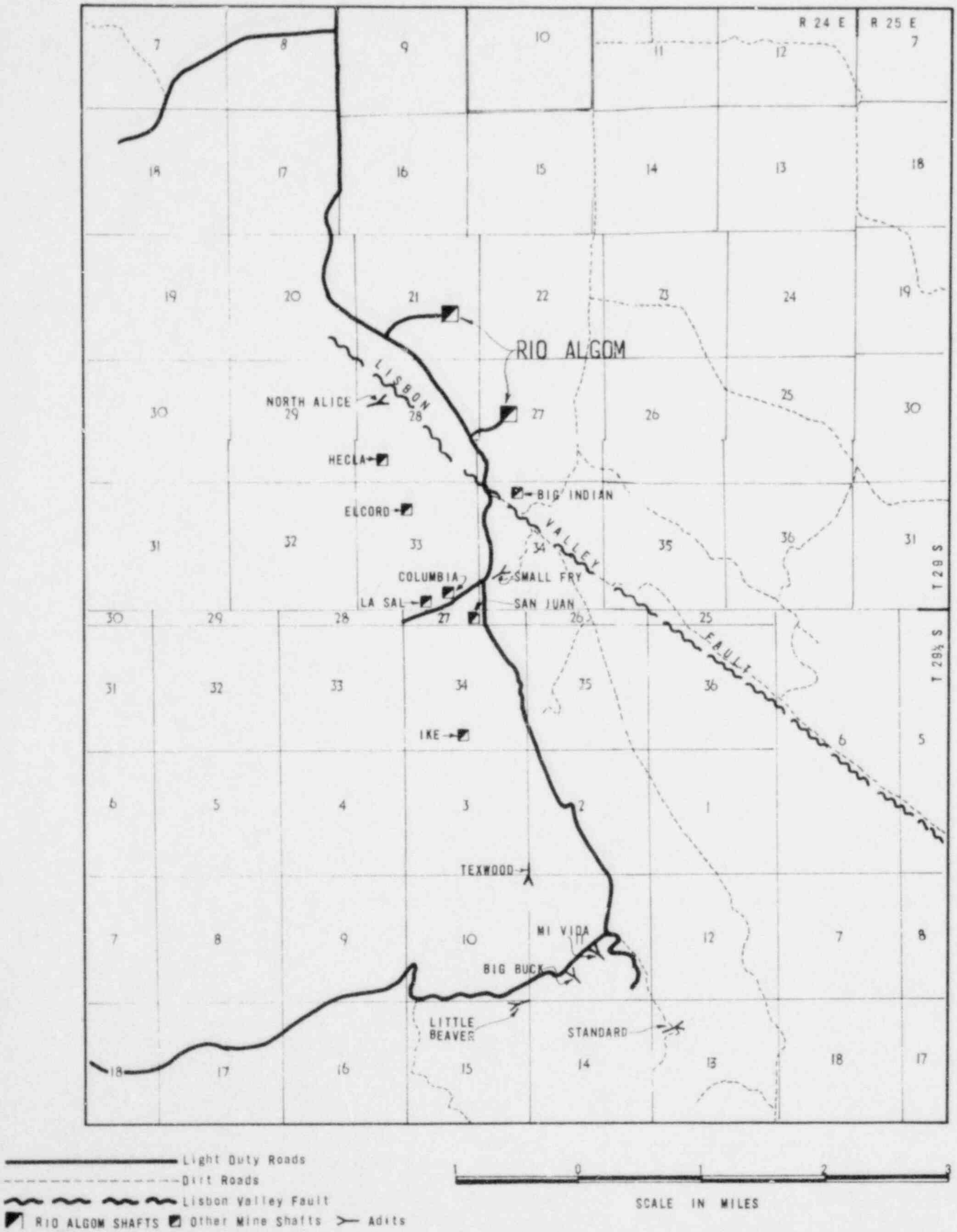
The mineralization occurs in the Mossback member of the Chinle Formation within a few feet of the unconformity between the Chinle and the Cutler Formation. Figures 12 and 13 provide a stratigraphic column which describes the formation. The unconformity referred to occurs at a depth of 500 feet from surface on the west or upthrown side of the fault on an adjoining property and appears in outcrops within a mile or so to the southeast (see Figure 14). Therefore, there is a measurable vertical displacement of approximately 2,000 feet on the fault. The lateral displacement appears to be negligible. The formation on the upthrown side of the fault is tilted 5 to 10 degrees to the southwest, whereas the formations in the Humeca property dip approximately 2 degrees to the northeast.

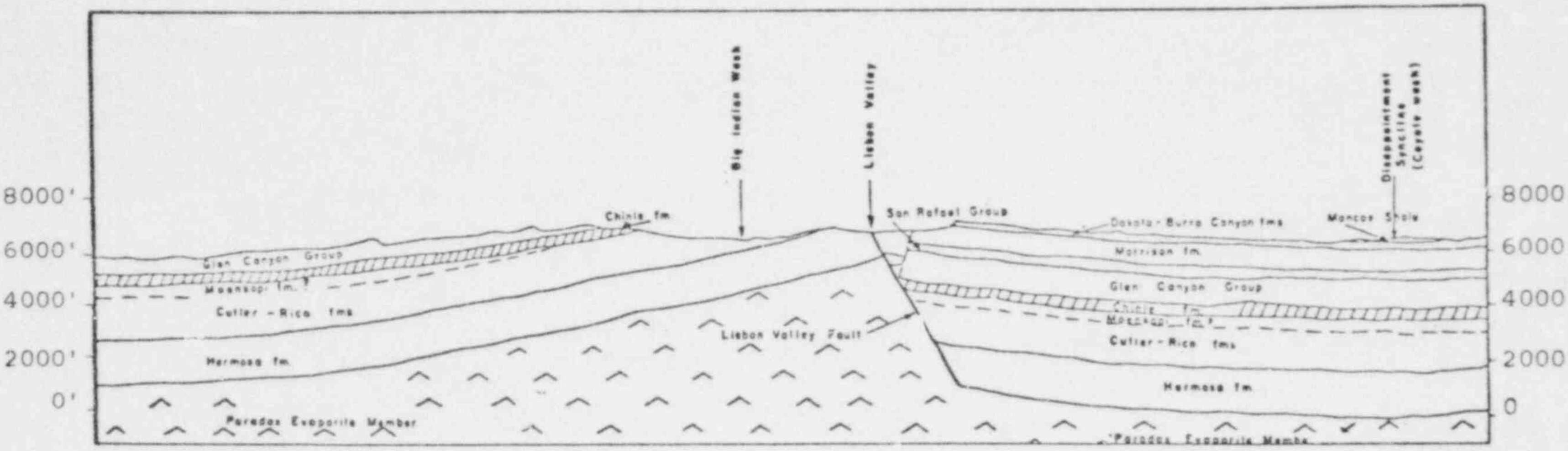
The surface outcrops on the east, or downthrown side of the fault, consist of Dakota Sandstone of upper Cretaceous age. At a depth of some 1,100 feet, the Saltwash member of the Morrison formation of Upper Jurasic Age occurs. The total thickness of some 2500 feet above the mineralized horizon consists of sands with minor shales and siltstone members. Several hundreds of feet below the unconformity a great thickness of evaporite occurs which is reported to consist mainly of salt.

Geological data available from exploration drill holes is shown in Figures 14 and 15 and Table IX, which are longitudinal sections through the tailings area. The surface soils in the tailings and plant areas were described as generally having a low permeability based upon drilling

Figure 10

LISBON VALLEY URANIUM MINES





- NOTE -

Presence of Moenkopi formation, and thickness of Cutler-Rico formations and Hermosa formation on downthrow side of fault are inferred without drilling control.

0 2 4 6
(Scale in 1000 feet)

SECTION ACROSS LISBON VALLEY ANTICLINE

Figure 11

Figure 12

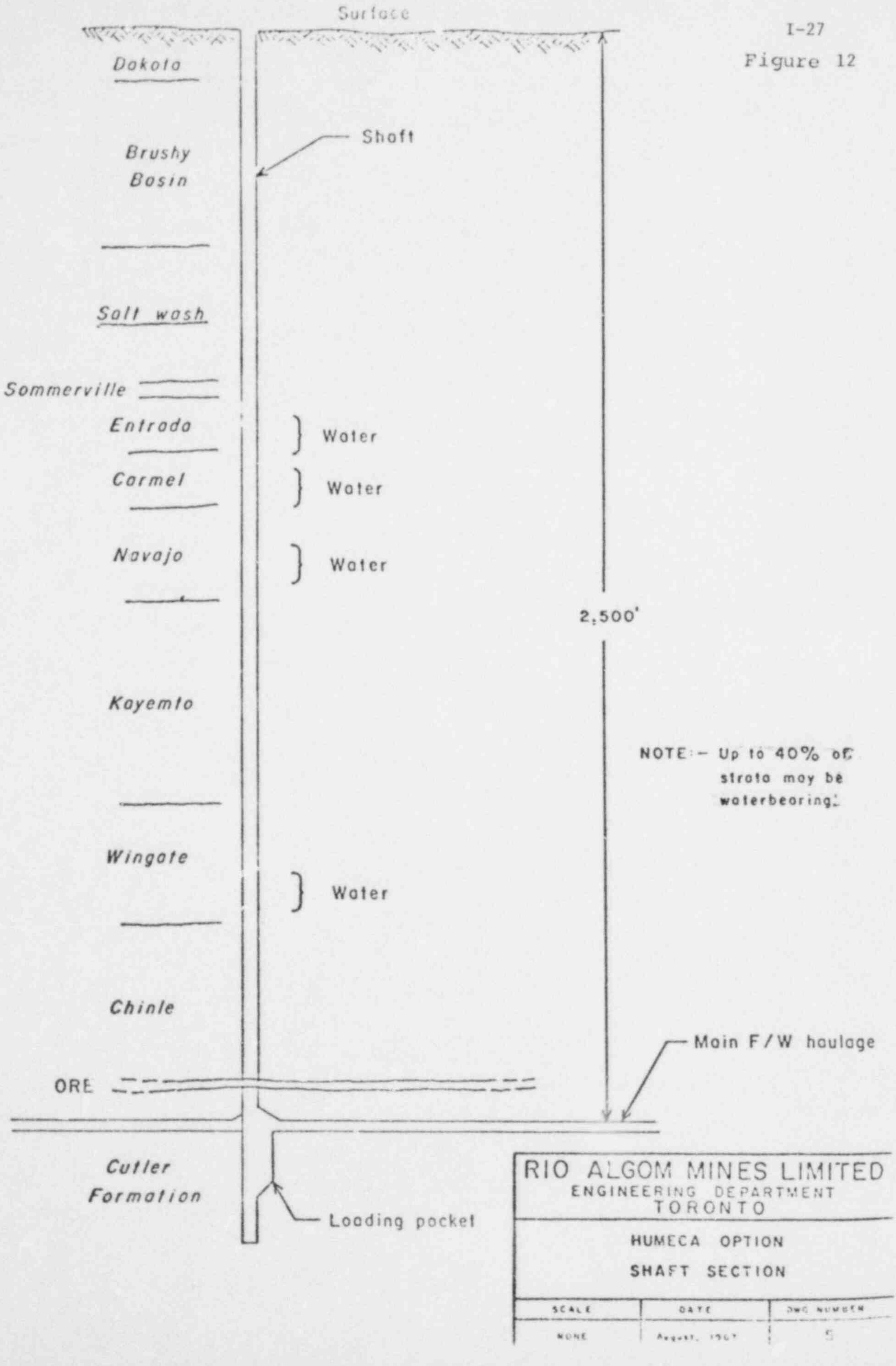
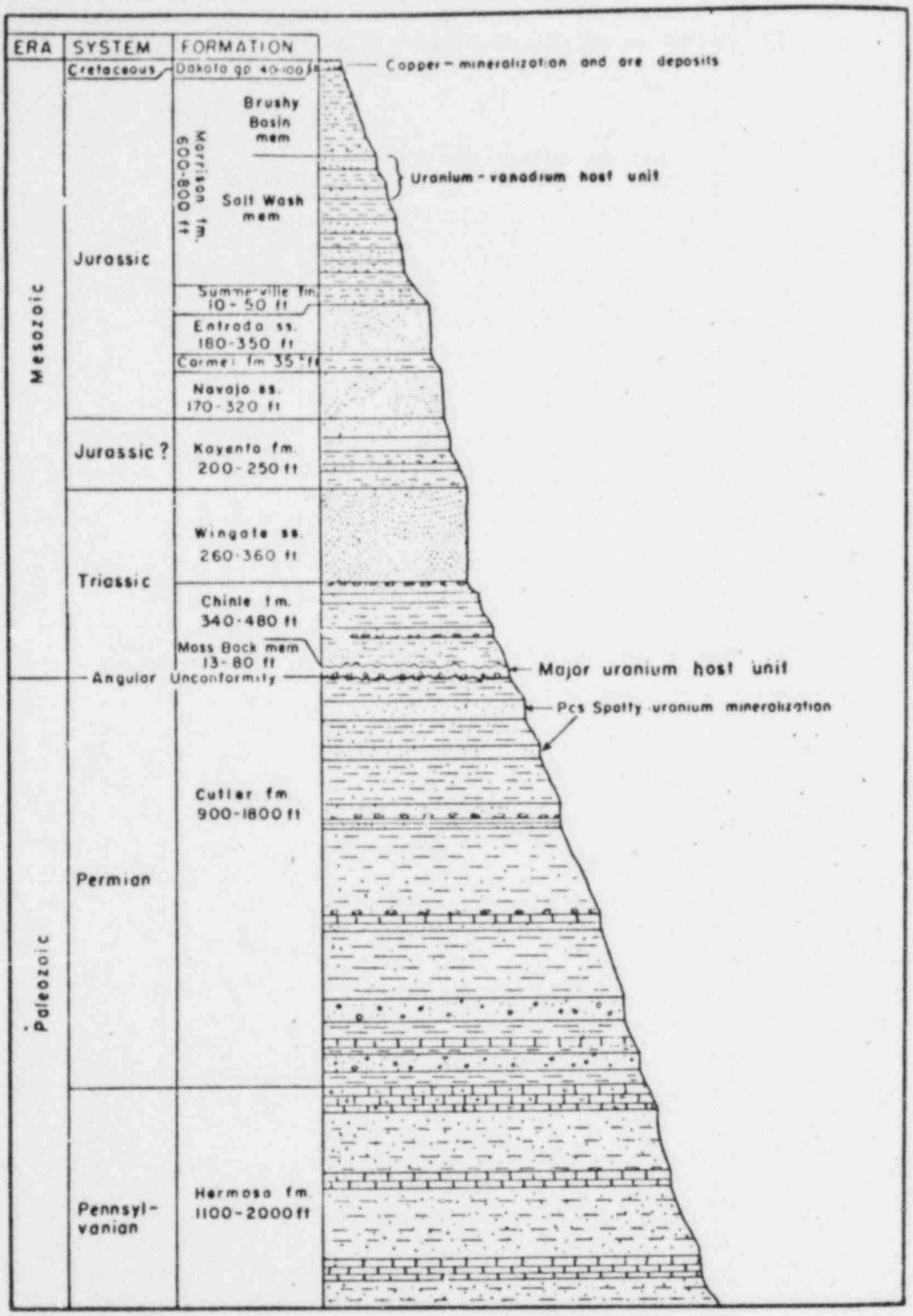
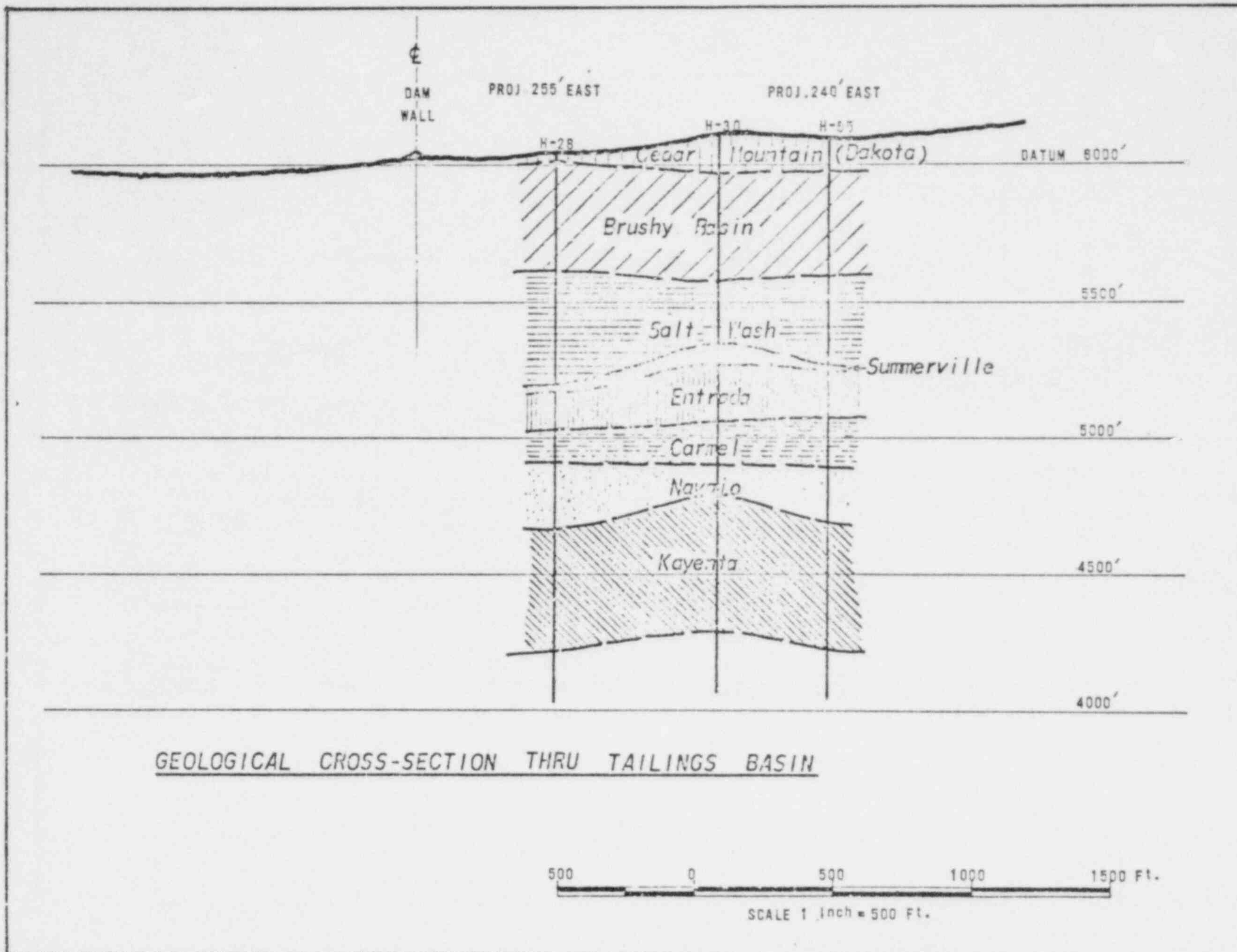

Surface
Dokota
Brushy Basin
Shaft
Salt wash
Sommerville
Entrada
Water
Carmel
Water
Navajo
Water
2,500'
Kayemto
NOTE:- Up to 40% of strata may be waterbearing.
Wingate
Water
Chinle
Main F/W haulage
ORE
Cutler Formation
Loading pocket
RIO ALGOM MINES LIMITED
ENGINEERING DEPARTMENT
TORONTO
HUMECA OPTION
SHAFT SECTION
SCALE
NONE
DATE
DWG NUMBER

Figure 13



Generalized Stratigraphic Section in the Lisbon Valley Area.

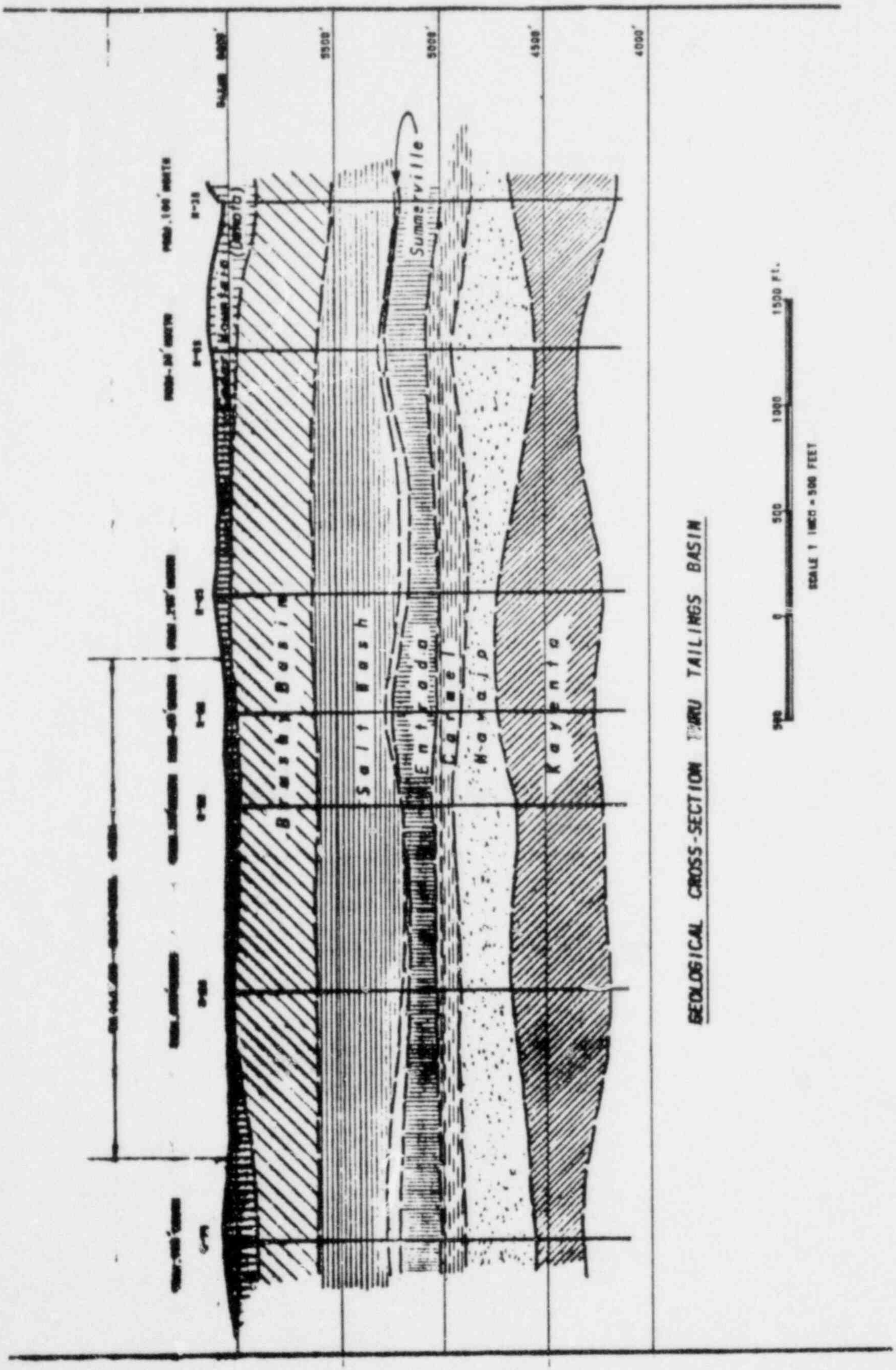
AFTER HIRAM B. WOOD
USAEC, GRAND JUNCTION, CO.



GEOLOGICAL CROSS-SECTION THRU TAILINGS BASIN

Figure 14

Figure 15


5500'
5000'
4500'
4000'
Summerville
Brushy Basin
Salt Wash
Entrada
Carmel
Navajo
Kayenta
GEOLOGICAL CROSS-SECTION THRU TAILINGS BASIN
1500 FT.
SCALE 1 INCH = 500 FEET

results. However, the soil layer logged as, "clay, stiff to very stiff, sandy, red-brown, brown", is not continuous through both the tailings and plant areas. The other soil formation in the area is logged as "sand, loose to medium dense, silty, gravelly, red-brown with occasional layers of sandy silt and clayey sand". This soil formation may be above or below, or both, in relation to the stiff clay formation. No free water was found in soil test holes drilled in the winter of 1968-69 in the tailings dam area. Soil test holes were bottomed from 2 to 5 feet into bed rock. The core samples from drill hole H-69, Table IX, were taken at the production shaft approximately 3,000 feet from the tailings dam location, at which point the Dakota, Cedar Mountain, formation is believed to be only 10 to 30 feet thick. The natural soils in the reservoir area are reported to contain sufficient fines of -200 mesh. Additional information on the geology and sub soils for the area are contained in consultant reports to the applicant, Appendix D and E.

G. Climate

The nearest meteorological station to the mine is at La Sal, some 4 miles distant and 275 feet higher. Table X contains a summary of information for La Sal, together with some comparable data from Moab. Monticello, 30 miles south of the mine, has a precipitation of about 15 inches and a mean temperature of 46°F. Wind records are not available from the above stations, but over the past several years it has been reported that the prevailing wind direction at the mine is N.W. to S.E. Wind speeds are estimated as follows: May through October, 0 to 5 mph; November through February, 2 to 10 mph gusting to 30 mph; March and April, 0 to 20 mph gusting to 50 mph. Table XI shows the recorded wind direction, speed, precipitation and temperature range for a 16 month period at the mine site between the hours of 8 a.m. and 4 p.m. Table XII is a visual display, wind rose, of meteorological data contained in Table XI. Because of the topography of the area, there is a possibility of drainage of air downslope towards Redd Ranch and La Sal Junction during the nighttime hours, therefore, one may expect situations where the prevailing surface wind would be from the southeast as opposed to the wind from the northwest. In addition, atmospheric diffusion conditions would be expected to be poor on occasion during the nighttime hours between 4 p.m. and 8 a.m.

H. Biotic Elements

In the vicinity of the site, a sparse tree cover is confined to the hills north and south of the shallow valley occupied by the mine and tailings basin. The cover consists of pinyon pine and juniper which grow to a height of 12 to 15 feet and are gnarled and twisted. They

TABLE IX
DESCRIPTION OF CORE SAMPLES FROM HOLE NO. H-69

(Based on examination by Frank Klemenchuk.)

0-113.9 feet -- CEDAR MOUNTAIN (DAKOTA)

Predominantly a white, medium-grained sandstone with narrow lens of grit and conglomerate. This formation is locally bedded at 75-80° to C. A.

113.9-500.0 feet -- BRUSHY BASIN

The upper part of this formation (113.9-321.2 feet) is predominantly interbedded red, green and grey mudstone, locally mottled. The lower portion of the Brushy Basin (321.2-500.0') is predominantly interbedded siltstone and sandstone with minor lens of mudstone. From 381.0 to 400.6 feet three beds of sandstone approximately 2.5' in width giving off an sphalitic or oily odour were intersected. From 167.0 to 231.5 feet the mudstone contains a few to locally many hair-like, calcitelined slips at all angles to the core axis, but most often at 45°. Some water was encountered at a depth at 450 feet in this formation.

500.0-796.3 feet -- SALT WASH

Interbedded mudstone, siltstone and sandstone. Sandstone more predominant near lower part of this formation.

796.3-819.3 feet -- SUMMERVILLE

Interbedded mudstone and siltstone with a few narrow (to 6") lenses of sandstone.

819.3-1029.3 feet -- ENTRADA

A medium-grained, gray friable sandstone with locally odd (to 1") mudstone partings. From 867.5-884.6 feet abundant with water grooves to 1-1/2".

1029.3-1153.7 feet -- CARMEL

Predominantly a fine-grained red to brown sandstone with locally a few beds of gray sandstone to widths of four feet. Locally cross-bedded.

TABLE IX (Continued)

1153.7-1539.6 feet -- NAVAJO

Predominantly a fine to medium-grained gray sandstone with locally some light-brown sandstone. Predominantly cross-bedded. Some water was encountered at approximately 1400 feet.

1539.6-1749.0 feet -- KAYENTA

The upper portion of this formation from 1539.6 to 1567.1 is predominantly interbedded red and green mudstone and siltstone. The lower part of this formation is a medium-grained red, brown and white sandstone locally well-banded from 70-85° to core axis and locally some ripple marks (wavey).

1749.0-2050.8 feet -- WINGATE

All a medium-grained white to gray to orange sandstone. From 1749.0-1855.0 massive. From 1855.0-2050.8 feet still predominantly massive with locally minor ripple marks and well-banded at 75° to core axis. An increase in water was noted at these depths: 1820, 1915, and 2020 feet.

2050.8-2468.4 feet -- CHINLE

From 2050.8 to 2219.6 feet red mudstone and siltstone. From 2219.6-2309.4 feet predominantly red and green siltstone with narrow lens of sandstone, grit and conglomerate containing sparse carbon. From 2309.4 to 2377.5 feet predominantly interbedded green-gray, sandstones and conglomerates. Sparse to locally abundant carbon. Locally trace of disseminated pyrite. Locally sandstone well-banded at 80-85° to core axis. From 2377.5 to 2419.4 all red and green siltstone lacking carbon. From 2419.4 to 2443.0 feet predominantly green-gray, fine to medium-grained sandstone with ripple marks. From 2443.0 to 2468.4 feet interbedded siltstone, sandstone, grit and conglomerate, all containing sparse carbon with locally a trace of pyrite. At the base of the Chinle formation is a 0.7 foot bed of gritty, fine-grained, green siltstone.

2468.4-2577.0 feet (bottom of hole) -- CUTLER

This formation is predominantly interbedded medium-grained red and maroon sandstone with locally some bleaching. A few narrow beds of red, fine-grained siltstone also occur. The top 1.3 feet of the Cutler is bleached. Again a 24.3 foot zone from 2485.3 to 2509.6 was sugary in texture and bleached.

TABLE X

CLIMATOLOGY OF MINE AREA

LA SAL, UTAH

	1968 - 1970	1951 - 1960	Record Period Ending in 1960
Mean Annual Precipitation	14.9"	11.8"	12.4" (53 yrs.)
Mean No. of Days Precipitation over 0.5"	-	-	7 (8 yrs.)
Mean Temperature	46.1"	-	46°F. (39 yrs.)
Mean Daily Max. Temperature	-	60°F.	59.1°F (47 yrs.)
Highest Temperature	-	101°F.	101°F. (45 yrs.)
Lowest Temperature	-	-15°F	-27°F. (46 yrs.)
Mean No. of Days with Temp. Above 90 F.			13 (90 yrs.)
Below 32 F.			178 (32 yrs.)

Total evaporation reported to be about 55 inches per year.

Moab, Utah (4 miles NW of town)

	1968 - 1970	1951 - 1960	Record Period Ending in 1960
Mean Annual Precipitation	7.7"	7.1"	8.9" (72 yrs.)
Mean Temperature	54.4°F.	57.1°F	54.8°F. (69 yrs.)
Highest Temperature	-	111°F.	113°F. (66 yrs.)
Lowest Temperature	-	-3°F.	-24°F. (67 yrs.)

Total evaporation April to October inclusive, about 62 inches of water

Information provided to Rio Algom by the Bureau of Land Management dated October 15, 1971, indicated an evaporation rate of 84 inches per year.

TABLE XI

UTAH PROJECT SITE WEATHER RECORDS
8:00 a.m. to 4:00 p.m. only

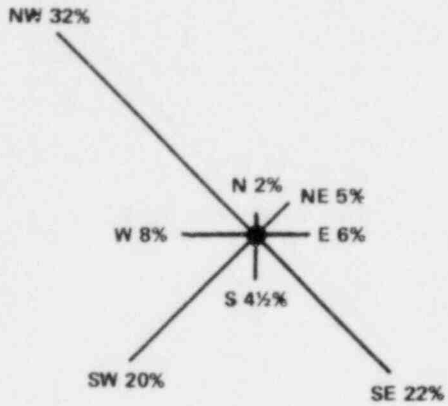
YEAR	WIND DIRECTION DAY								WIND SPEED			RAIN	SNOW	MAX.	MIN.
MONTH	N	NW	W	SW	S	SE	E	NE	-5	5-10	+10	INS.	INS.	F.	F.
1969															
Nov.	-	9	18	3	4	8	10	3	30	16	6	.6	1.0	64	4
Dec.	1	12	13	12	-	13	13	5	45	21	3	.4	8.0	62	1
1970															
Jan.	-	13	16	13	2	10	15	9	53	19	2	-	3.75	57	-5
Feb.	-	15	7	18	3	10	9	7	51	11	5	.1	.75	61	-
Mar.	2	21	22	22	2	6	3	5	45	27	10	.4	15.	57	10
Apr.	-	17	17	30	3	12	5	3	38	34	13	1.2	5.	69	15
May	3	17	11	24	4	16	2	6	61	20	2			84	25
June	-	34	3	15	1	19	-	5	64	13	-	1.2	-	96	20
July	4	22	2	4	1	24	2	4	71	1	-	TR	-	102	40
Aug.	1	12	-	7	1	24	6	1	54	2	1	2.0	-	95	50
Sept.	1	25	3	14	1	14	3	4	50	14	2	1.7	-	91	26
Oct.	4	35	2	5	4	13	3	4	52	21	-	1.1	8.0	78	10
Nov.	7	28	2	13	9	13	3	1	42	29	7	.1	3.25	60	16
Dec.	3	18	-	17	11	24	-	2	39	33	3	-	9.0	69	6
1971															
Jan.	1	39	-	15	3	22	-	1	45	23	6	-	0.5	67	-20
Feb.	-	43	-	11	1	16	-	1	45	18	8	-	4.5	60	-1
100%	2.5%	32%	8%	20%	4.5%	22%	6%	5%	68%	26%	6%				

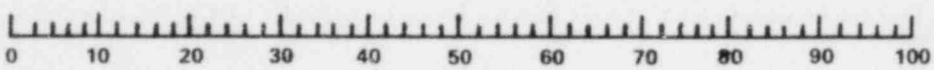
PREVAILING WIND NW TO W

Table XII

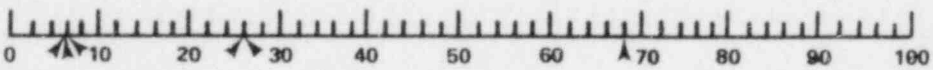
DISPLAY OF METEOROLOGICAL DATA CONTAINED IN TABLE XI

WIND ROSE





SCALE OF WIND DIRECTION PERCENT FOR 16 MONTHS OF DATA



SCALE OF WIND FORCE PERCENT FOR 16 MONTHS OF DATA.
NUMBER OF ARROWS (—►) ON SCALE EQUALS WIND FORCE NUMBER.

WIND FORCE %		FORCE	VELOCITY MILES PER HOUR
		0	< 1
68%	<	1	1 TO 5
26%		2	5 TO 10
6%	>	3	> 10

provide little commercial timber. The soil in the hills in the area has been described as being very rocky and of very fine sandy loam with an estimated understory density of 10 to 15% composed of a mixture of grass and other plants below the scrub trees. The total annual yield may range from 300 down to 150 pounds per acre of air-dried forage per year, depending on soil fertility and moisture availability. The valley of Coyote Wash to the north has a relatively gentle slope and is taken up with range land, dry farming and some irrigation. To the north again the slope gradually increases to the La Sal mountains where, with increased elevation, the vegetation changes to that typical of a temperate climate with spruce, pine, aspen and birch growing to a considerable size. The Coyote Wash area consists of a mixture of Monticello very fine sandy loam and Northdale loam, which produce a yield that ranges from 300 to 1000 pounds per acre of air-dried forage. On the deeper soils in the valley bottoms, a sagebrush/grass combination dominates. Even under the best conditions the understory density seldom exceeds 60%.

The wildlife in the area consists of a resident population of mule deer, sagegrouse, some waterfowl and waterbird, a warmwater fishery in Rattlesnake Pond, mourning dove, a small pheasant population, a generally distributed cottontail rabbit and jack rabbit population, and seasonal habitat for coyote, bobcat, fox and occasionally cougar, a variety of song birds, falcons, hawks, and a significant number of bald and golden eagles near the La Sal area.

The Rio Algom site lies between the range areas of two separate mule deer populations, one to the south and one to the east, which may merge to the southeast in the Lisbon Valley in severe winters. The total population is estimated at several hundred head. The normal range of the mule deer includes higher broken country with pinyon pine and juniper cover. Because of the lack of forage, the valley occupied by the mine-mill complex is not normally included in their range. The sagegrouse population of the La Sal-East Coyote Wash area is estimated to be approximately 300 birds. In summer, the principal diet of the sagegrouse is succulent vegetation and insects; in winter, it is big sagebrush and rabbit brush. The normal range of these birds does not normally include the mine site and is in a drainage basin separate from the proposed mill tailings area. The sagegrouse is preyed upon by the golden eagle, hawks, coyote, bobcat and fox of the area.

Up to 13 bald (Haliaeetus leucocephalus) and 17 golden (chrysaetos) eagles winter in the area between the mine and the La Sal mountains.

They spend 4 to 6 months in the area before migrating north to their nesting areas. These rare birds are drawn to the area by the abundance of small rodents and carrion in the winter.

There are a number of rabbits (cottontcul-sylvilagus nuttali, and blacktail jack-lepus californicus) in the area in addition to the colonies of prairie dogs (cynomys ludovicianus). Waterfowl are limited to two areas; some small reservoirs in East Coyote Wash, and Rattlesnake Pond on the West Coyote Wash, which produce annually some 100 birds. The latter pond, about 1-1/2 acres, has had a bass bluegill fish population for over 25 years. Figure 16 provides a graphic description of the wildlife inventory of the area, and Appendix F a biota inventory of the area prepared by the Bureau of Land Management.

I. Mine and Mill

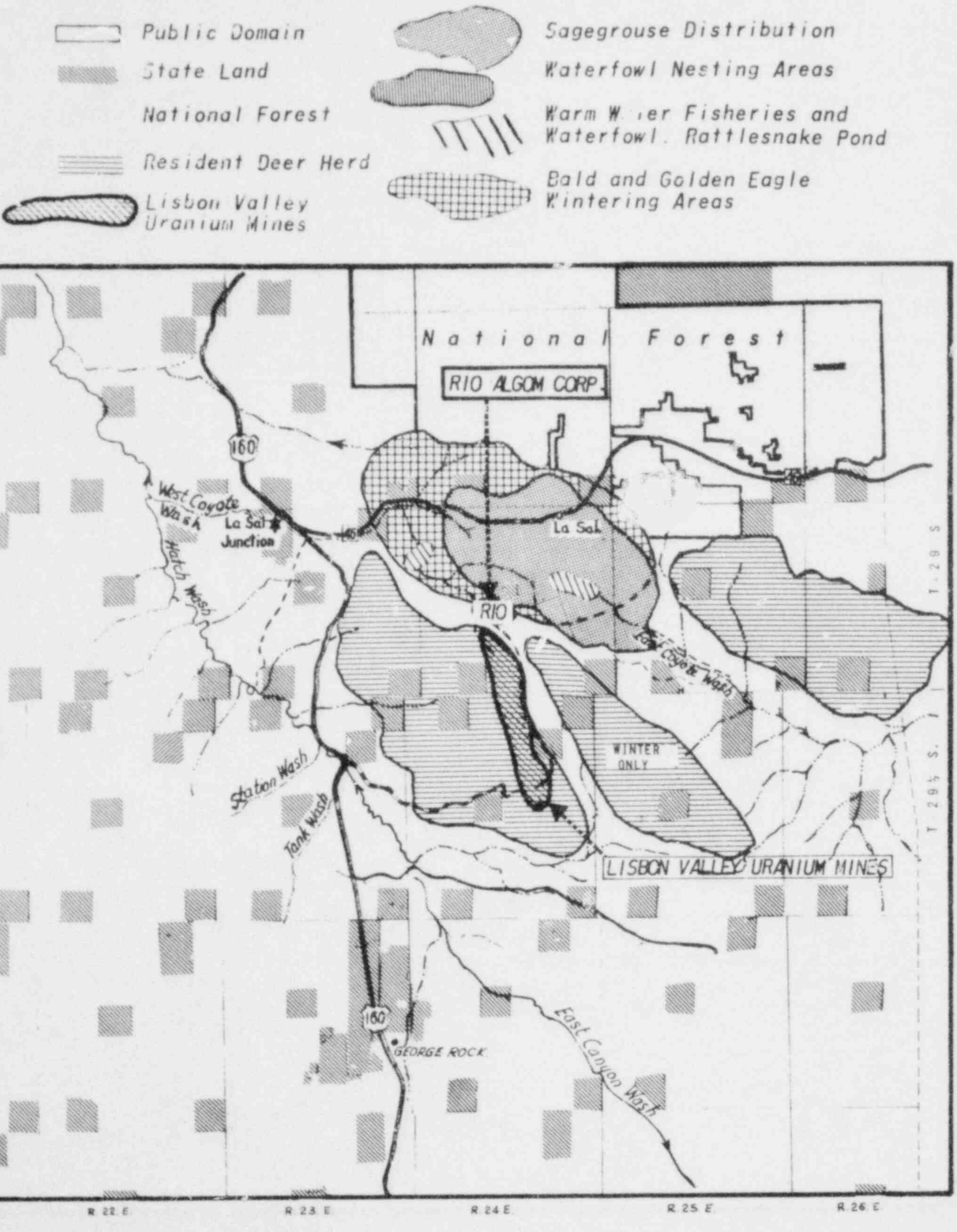
1. The Mine

All uranium bearing ore will be mined using underground mining methods. The ore body averages 6 to 8 feet thick and lies below a thickness of approximately 2,500 feet of shale and sandstone. The initial mine development for rail haulage is carried out in the waste rock below the ore, and the ore body is then developed from mining from these waste headings. Mine waste rock is being disposed of north of the production shaft and on the hillside west of the ventilation shaft. At the plant area, the production shaft area waste is deposited in the low area north of the shaft at the head of the tailings area. This waste is composed of arkose and sandstone from the Cutler formation which will weather gradually to sand and silt. The area estimated to be covered by these waste rock piles is approximately three acres. Waste rock has also been deposited at the ventilation shaft and covers an area of approximately one acre. Mining is planned to be at a rate of 750 tons per day maximum. Mining operations will be carried out on a 5 day-per-week basis.

During the shaft sinking and underground development of the mine, water was encountered. The maximum flow was about 1400 gpm, decreased to approximately 175 gpm, then increased to approximately 390 gpm in March of 1973. Of the 390 gpm, 150 gpm is removed from the production shaft and utilized in the mill process. The other 290 gpm is removed from the ventilation shaft. Of this 290 gpm, 30 gpm is utilized in the underground drilling and 190 gpm is to be discharged to the Redd Ranch located about 2 miles south of the applicant's site.

Figure 16

CURRENT WILDLIFE INVENTORY OF THE COYOTE AREA



The applicant's consultant has studied the geohydrology of the area and their conclusions are presented in Appendix C and D. In summary it is believed that local recharge within a few miles of the site does not penetrate significantly into the impermeable Brushy Basin Shale; deeper aquifers are isolated from the shallower water bearing zones; mixing between aquifers is prevented due to the break in hydraulic continuity at the cone of depression; in flooded workings or open borings, contamination of the shallow aquifers from deeper confined sources is possible (however, at Rio Algom this will be prevented by sealing off the mineralized workings from the shallower formations when operations cease); groundwater will rise in the shafts and if the level reaches the Burro Canyon sandstone, the shaft linings will prevent significant contamination from moving into the formation.

The initial mine development for rail haulage is carried out in the waste rock below the ore, and the ore body is then developed from mining from these waste headings. Rio Algom plans to develop the three mining blocks to the limits of the ore body. The basic mining system now in use is to extract the ore by mining from the exhaust towards the fresh air supply. Bulkheading is currently used to direct the fresh air to the active mining area. A flow of vitiated air is maintained through mined out areas towards the exhaust. It is the slow flow of air towards the exhaust that minimizes the contamination of fresh air. Rio Algom has stated that it has not yet proved practical to isolate a mined out area with permanent bulkheads and maintain it under negative pressure. Total ventilation air volume is about 250,000 cubic feet per minute. To prevent ore dust from being drawn into the fresh air intake to the mine, exhaust systems and associated dust filters are installed at the top and bottom of the production shaft, down which the fresh air is drawn. Monitoring for radiation and determination of air flow is carried out by the Rio Algom staff. Comments pertaining to the mining methods have been relayed to the Bureau of Mines for their information and appropriate action.

2. The Mill

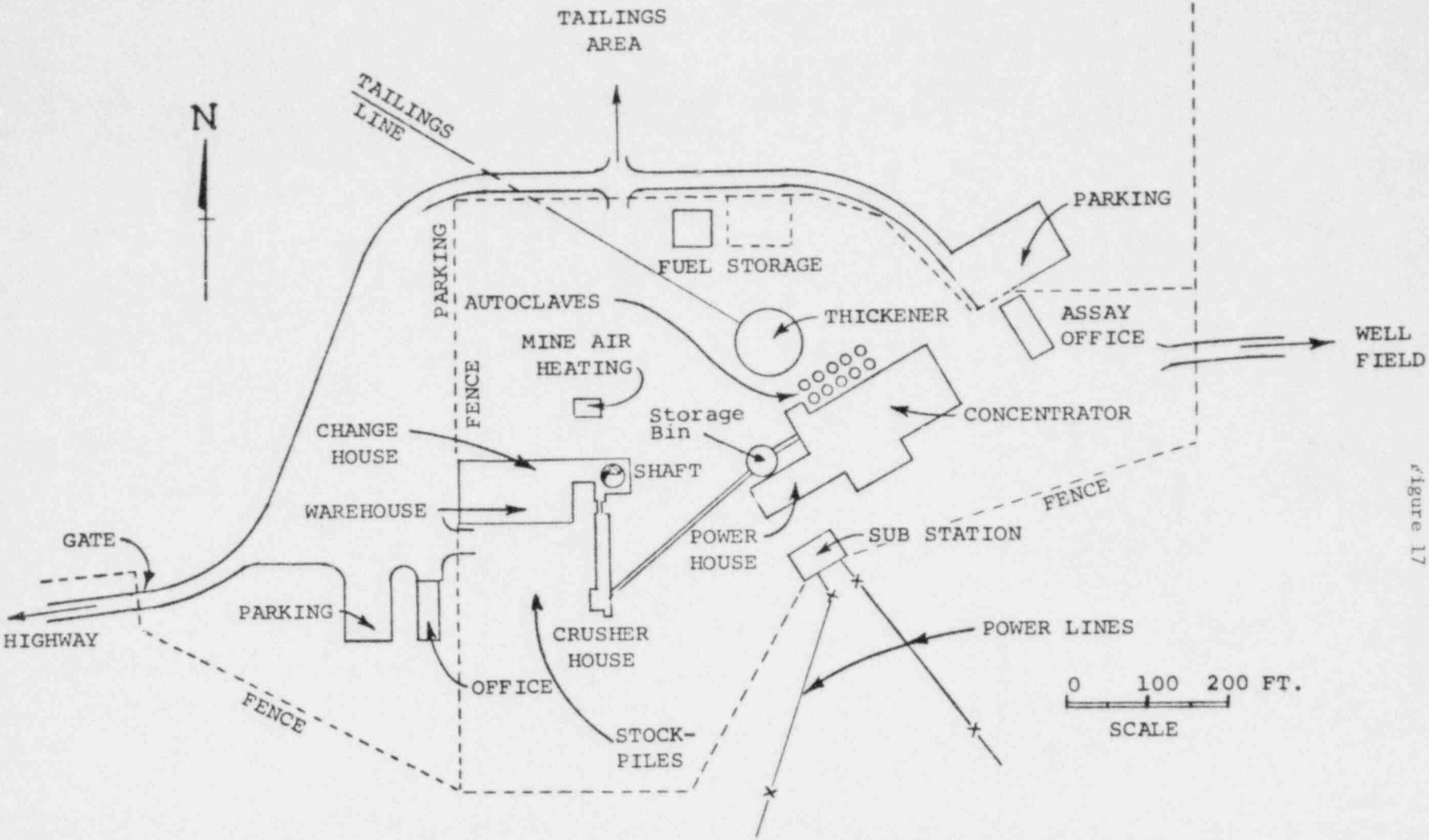
The ore processing plant is composed of the crusher house and the concentrator building. Both buildings are of steel frame construction with concrete footing. Siding is corrugated, galvanized steel with translucent panels. A concrete block structure attached to the mine production shaft head frame will house the warehouse, machine shops, change house and mine offices. This building will be 142 x 73 feet, 25 feet high in the warehouse and shop sections. The main office building is 77 x 30 feet with a full concrete block basement and painted metal siding. The assay office and laboratory situated east of the mill is a single story concrete building 80 x 30 feet. Pressure autoclaves and a thickener will be located outside and adjacent to the concentrator building. A site plan for the plant area is shown in Figure 17.

The ore processing mill is designed to handle 500 tons of ore per day in continuous, 3 shift-per-day operation.

The carbonate process was selected because of ore characteristics. Carbonate leaching, properly buffered, is highly selective for uranium and the chemicals used create no particular environmental problems as discussed below.

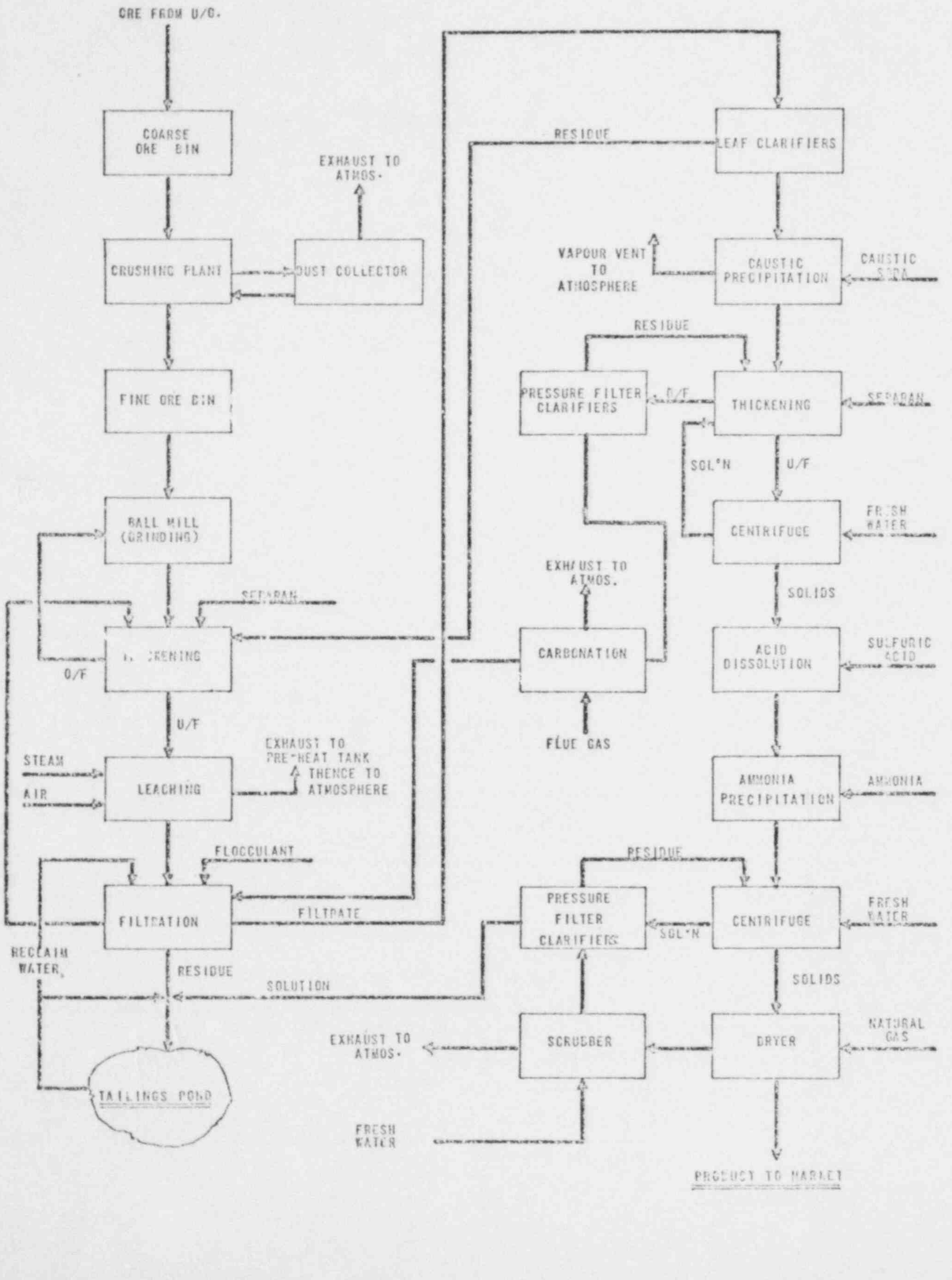
The major plant features include an ore storage and blending area, crushing, wet grinding, thickening, pressure leaching, filtration, liquor clarification, and precipitation of uranium by caustic addition to the pregnant liquor. As shown in the process flow diagram, Figure 18, the extraction of uranium from the ore requires first that the coarse ore be reduced in size to expose the uranium mineral crystals. The crushed and ground ore is then treated with a solution of sodium carbonate and sodium bicarbonate at elevated temperature and pressure (230°F and 50 psig) in leaching autoclaves to solubilize the uranium. The uranium rich solution (pregnant liquor) is now separated from the barren sands (tailings) in a three-stage counter-current vacuum filtration circuit. Concentration of uranium from the clarified pregnant liquor is effected by precipitating sodium diuranate from solution by adding an excess of sodium hydroxide. The precipitate is separated from the essentially uranium free solution by thickening and centrifuging and is redissolved in a sulfuric acid solution at a pH of 1.5. The uranium values in the acid solution are then reprecipitated as ammonium diuranate with anhydrous ammonia at a pH of 7.5. The ammonium diuranate is dewatered by centrifugation with the clarified mother liquor and wash liquor used to convey the leach residue to the tailings pond. The ammonium diuranate (yellow cake) is repuiped with a small amount of water and fed to a natural gas fired furnace where it is dried at 700 to 1100°F to less than 2 percent moisture, passed through a roll crusher, and packaged in 55-gallon drums for shipment. The barren solution from the sodium diuranate dewatering step is treated with flue gas to generate sodium carbonate and bicarbonate and is recycled to the leaching circuit, thus conserving water and reagents.

During the life of the project approximately 120 acres of land will be disturbed by the milling process, i.e., 75 acres for plant and 45 acres



PLANT AREA SITE PLAN

Figure 17


ORE FROM U/G.
COARSE ORE BIN
EXHAUST TO ATMOS.
CRUSHING PLANT
DUST COLLECTOR
FINE ORE BIN
BALL MILL (GRINDING)
SEPARAN
O/F
U/F
STEAM
AIR
LEACHING
EXHAUST TO PRE-HEAT TANK THENCE TO ATMOSPHERE
FLOCCULANT
FILTRATION
FILTRATE
RECLAIM WATER
RESIDUE
SOLUTION
TAILINGS POND
RESIDUE
LEAF CLARIFIERS
VAPOUR VENT TO ATMOSPHERE
CAUSTIC PRECIPITATION
CAUSTIC SODA
RESIDUE
PRESSURE FILTER CLARIFIERS
O/F
THICKENING
SEPARAN
SOL'N
U/F
CENTRIFUGE
FRESH WATER
EXHAUST TO ATMOS.
SOLIDS
CARBONATION
FLUE GAS
ACID DISSOLUTION
SULFURIC ACID
AMMONIA PRECIPITATION
AMMONIA
RESIDUE
PRESSURE FILTER CLARIFIERS
SOL'N
CENTRIFUGE
FRESH WATER
SOLIDS
EXHAUST TO ATMOS.
SCRUBBER
DRYER
NATURAL GAS
FRESH WATER
PRODUCT TO MARKET

for mill tailings impoundment. Even though the mill is located in an isolated area, the structures were designed to be as aesthetically pleasing as possible.

By letter dated 19 July 1973, the Federal Power Commission advised the AEC that 1975-1980 power requirements for the Humeca Uranium Mill were as shown in Table XIII.

TABLE XIII

POWER REQUIREMENTS FOR THE HUMECA URANIUM MILL

	Current Requirements	1975-1980 Estimated Requirements
Maximum Monthly Demand	3,400 kW	4,000 kW
Monthly Energy Requirements	1,949,400 kW hr.	2,500,000 kW hr.

The Federal Power Commission further stated that the Utah Power and Light Company's service line to the applicant's facility is rated at 69 kV. Problems of power supply adequacy are not anticipated in meeting the applicant's capacity and energy requirements, in view of the Utah Power and Light Company's planned system expansion which appears to be keeping pace with the load growth.

The feeder power line has been described as the standard wood pole lines supplying the mine, and that the distribution lines around the mine site are all of a construction similar to that used by the local utility in the area. The conductors are in a triangular formation, using either one horizontal cross-arm or two inclined arms on wooden poles.

The Rio Algom substation located near the concentrator is supplied by a 3,400 foot feeder line from the main distribution line fed from the La Sal 69 kV substation owned by Utah Power and Light. At the substation the voltage is stepped down to 4,160 volts for distribution. One line supplies the ventilation shaft and another installed to supply the tailings water recirculation pump. In the event of a utility power failure a 670 kilowatt diesel powered standby generator has been provided which is capable of operating essential equipment such as the main mine and surface fans, concentrator pumps and thickeners, and the main hoist at reduced speed.

Natural Gas is supplied by the Utah Gas Supply Company. The portion of the line within the mining lease boundary will be the property of Rio Algom Corporation, which will ensure that the right-of-way is properly graded and seeded to prevent erosion. Rio Algom has negotiated a contract with Utah Gas Supply for approximately 157,700 million Btu per year on an interruptible basis for 10 years.

Traffic into the mine-mill complex is roughly estimated at a total of 70 cars and 15 trucks in and out each working day.

II. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

A. GENERAL

The radioactivity associated with uranium mining and milling results from natural uranium and its daughter products present in the ore. During the milling process, the radioisotope that is separated and concentrated is the natural uranium. The bulk of the radioactive uranium daughter products in the ore remain in the uranium depleted pulp (tailings) that is pumped to the tailings retention system.

Since uranium milling deals with very low-level and dilute concentrations of radioactive materials, there are no operations or activities associated with the milling process itself which could result in a serious radiation exposure to either mill employees or members of the general public, even in the case of an accidental release of radioactive materials. Liquid and solid wastes from the milling operation contain only low level concentrations of radioactive materials. These wastes are retained and stored in the earth-dam retention system on the applicant's site. Concentrations of airborne radioactive materials escaping into the surrounding environs from the mill are not expected to be more than a few percent of limits specified in 10 CFR Part 20.

Even though the mine and plant are located in an isolated area, access to the mine, plant and tailings retention system will be controlled by the licensee. The entire mine and mill site is fenced, and there are mill employees on the site at all times.

The Regulatory staff has evaluated the proposed criteria for the accumulation and storage of tailings and the applicant's methods and equipment for minimizing release of radioactive and non-radioactive materials to the surrounding environs of the proposed mine and mill and has concluded that with the conditions that will be placed on the license plus the applicant's proposed criteria, methods, and equipment, then the operation will be consistent with the state of the art in uranium mining and milling technology. The Regulatory staff has also concluded, as outlined below, that the activities planned by the applicant are not expected to produce detectable biological effects on the biota in the vicinity of the proposed mill.

B. SOURCES OF WASTES AND EFFLUENTS

1. Natural Soil

Uranium containing rocks outcrop in Grand and San Juan Counties and are part of the natural geological formation in this part of the country. It is expected that where outcropping has occurred, erosion forces over the centuries have distributed the ore material to other areas and deposited the uranium in the soil. Winds, or passage of vehicles or herds of large animals may raise the dust.

2. Waste Rock

Approximtely 200,000 tons of waste rock were generated in opening the mine at the Rio Algom Site. This includes waste rock from the two shafts and from haulageways and access tunnels to the ore zone.

A portion of this waste was used to level the yards around the shaft areas and for the plant buildings, storage areas, parking lots and roads around the property. This waste rock is expected to only contain uranium value similar to that found in the soils of the area. Consequently, there are no radiation considerations associated with this waste. As pointed out in Section I, Item 1, these wastes are stored principally in two areas. Approximately 200,000 tons of waste rock were generated in opening the mine and it is expected that an additional 200,000 tons of waste will be generated from future development. These "low profile" wastes will also be stored near the shaft areas. It is estimated that 25 truckloads of waste will be dumped a day at peak development rate.

3. Industrial Waste

Solid wastes such as scrap mine timber, scrap cable and shop waste, office waste, and mill reagent containers will be generated. Quantities are not expected to be over one ton per day. Over the life of the project, it is estimated that this waste would require a storage area equivalent to some 0.05 acres. This waste is to be disposed of in the mine waste disposal area north of the production shaft area in the tailings drainage basin.

4. Sanitary Waste

The sanitary sewage systems have been designed on the basis of utilizing a combination of septic tanks and absorption fields. There are two sources of sanitary waste which are located some distance apart. Accordingly, two separate systems will be provided, one to serve the office, shops and mine, and the other to serve the mill office and the assay laboratory.

5. Mine Water

As identified earlier in the report, a portion of the water (190 gpm) from the mine ventilation shaft will be diverted to the Redd Ranch. The remainder is distributed to the mill process, underground mining operations, spray field, and tailing pond. From the standpoint of allowable concentrations, the primary radioactive contaminant of the mine water discharge is radium-226.

6. Dust From Roads

Because the area is arid, the haul roads over the pile of dumped rock are expected to get dry and dusty at times. The access road into the mine is about 3000 feet long and is gravel surfaced. Gravel service roads are provided to the tailings area, well field, and mine ventilation shaft. The principal contaminant from this source would be expected to be dust.

7. Dust from Ore Storage

Ore which is stockpiled directly from the mine will be damp and have less fines than ore after crushing. This ore is reported to contain 5 to 10% moisture. If ore passing through the crushing circuit is not acceptable, it can be stockpiled for blending by use of the conveyor system. Possible radioactive contaminants from this source may be dust, uranium, radon, thorium and radium.

8. Open Burning

No open burning of waste materials will take place. A special permit is required for burning land clearing slash.

9. Products of Combustion

The primary source of fuel for heating for the mine and mill will be natural gas supplied by Utah Gas Supply Company. The contract under negotiation was for 157,700 million Btu per year on an interruptible basis for 10 years. No. 2 fuel oil with a maximum sulphur content of 1.5% will be used for emergencies. Contaminants from the primary fuel is expected to be: Solids, SO_2, NO_2, Hydrocarbons, organic acids, aldehydes, and NH_3.

10. Mine Ventilation Shaft

Effluents discharged from the mine ventilation shaft may be expected to contain contaminants consisting of: diesel exhausts, i.e., carbon monoxide, oxides of nitrogen and aldehydes, dust, and radon resulting from the decay of radium in the ore and radon daughter products. The contaminants will be discharged in an air volume flow rate of approximately 253,000 cubic feet per minute, and the measured value of the dust concentration has been reported to be 2.2 mg/m^3. As mining progresses further from the return airway, the dust discharged may decrease because there will be more time for the dust to settle out prior to being discharged up the shaft.

11. Mill, Air Effluents

From the uranium concentrator radioactive effluents are expected to occur from the production shaft, crusher, headframe, transfer house, and yellow cake dryer. These contaminants are expected to be mainly dust: uranium-natural, thorium-230, radium-226, radon-222 and its daughter products, and will be exhausted through stacks.

12. Mill Liquid Effluents (Tailing Retention System)

Approximately 500 tons per day of solid waste tailings, which is slurried in about 75,000 gallons of waste milling solution, will be generated. The waste milling solutions will have pH value of about 10.2 and will contain sodium, sodium carbonate, sodium bicarbonate and sulfate as the principal dissolved solids. The analysis of solids and liquids discharged to the tailings system is shown in Table XIV. These values are in many cases similar in magnitude to such values reported elsewhere.[5][6] As reported, the concentration of radium-226 in the waste milling solution is expected to be about 2.4×10^{-7} µCi/ml - approximately 8 times the AEC allowable limit for release to unrestricted areas. There will be measurable quantities of thorium-230 and natural uranium in the waste solution, but the concentration of thorium will only be a fraction of the allowable limits for release to unrestricted areas, whereas, the concentration of uranium will be on the order of 10 CFR 20 Appendix B MPC limits for unrestricted areas. The solid waste tailing and milling solutions will be deposited within tailing impoundment areas within a restricted area.

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(5) The Extractive Metallurgy of Uranium, Colorado School of Mines Research Institute, 1971.

(6) Waste Guide for the Uranium Milling Industry, U. S. Department of Health, Education and Welfare, Public Health Service, 1962.

TABLE XIV. ANALYSES OF DISCHARGE TO TAILINGS POND

SOLUTION ANALYSES

Substance	Parts per million
SO_4	6,500
$Na_2\ CO_3$	7,740
$Na\ HCO_3$	3,780
Na	11,700
Mn	0.44
Cu	0.11
Zn	0.09
Fe	0.5
Uranium	46,300 pc/liter
Radium - 226	240 pc/liter
Thorium	110 pc/liter
pH	10.2

SOLIDS ANALYSES

Substance	Parts per million
Mn	0.078
Cu	0.46
Zn	0.60
Fe	10,000
Uranium	7 pc/gram
Radium	21 pc/gram
Thorium	8 pc/gram

C. CONTROLS OF WASTES AND EFFLUENTS

1. Waste Rock

Because the mine waste rock is in a moist condition when it is dumped from the haulage trucks it should not cause a dust problem. Since this rock will contain no uranium values, the radiation hazard from these waste piles should not be any greater than that caused by the natural soil in the area. As the waste rock disposal is completed from the ventilation shaft, winter of 1971-1972, the area will be graded, covered with a layer of topsoil and seeded. There will be approximately 400,000 tons of waste rock generated. The mine waste rock from the production shaft is being deposited in low silhouette piles below the skyline and graded and seeded based on advice received from the Bureau of Land Management. A portion of this waste has been used to build up level yards around the shaft areas and for parking lots around the facility. The applicant states that there are no economically recoverable values in the waste rock.

2. Industrial Waste

Solid wastes generated and identified in Section II.B.3 is disposed of in a sanitary landfill type of operation in an area used to store the mine waste rock from the production shaft.

3. Sanitary Waste

The sanitary sewage systems have been designed on the basis of utilizing a combination of septic tanks and absorption fields. The absorption field for each system is situated north of and down-grade from the plant buildings and within the fence surrounding the plant. The absorption field will be 2 to 5 feet deep. Both systems have been designed in accordance with the Code of Waste Disposal Regulations, Part V, Rev. 9/67 of the State of Utah. The letter of approval from the Utah Division of Health is shown in Appendix G.

4. Mine Water

As indicated in Section II.B.5, a portion of the water from the mine ventilation shaft is being diverted to the Redd Ranch, some is used in the concentrator and the balance disposed of to the tailing pond and to a spray field for evaporation.

Because evaporation will not dispose of sufficient water, a barium chloride treatment system is being installed to reduce the radium levels in the mine water discharge. The design capacity is 500 gpm. The excess mine water is to be discharged to a settling pond where alum will be added to precipitate fine suspended material. The retention time in this pond will be about 24 hours. Barium chloride will be added to the clarified overflow of the first to the second pond to precipitate the radium. The retention time in the second pond will be about 48 hours. A copy of a letter and engineering study relating to the barium treatment process are included in Appendix H. During the period of time that the mine water was receiving the barium treatment, the concentration of radium being discharged was 5 to 9 PCi/l. With the addition of the alum treatment the concentration of radium is expected to be reduced to less than 3 PCi/l. This effluent is to be discharged on surface leases into a ditch which delivers the water to a storage reservoir situated on Section 14 of Township 29S, 24E (see Figure 7). This water will be used for stock water and use by the Redd Ranch. The analysis of this water before treatment is shown in Table VI, page I-19, and shows that the concentration of radium-226 is greater than the Federal Water Quality Criteria (3 PCi/l) and the State of Utah water quality standard (3.3 PCi/l). In addition, data submitted by the applicant dated February 26, 1974 indicates that the concentration of the mine water prior to treatment is now on the order of 65 to 70 PCi/l which is greater than the AEC recommended limits (30 PCi/l). The AEC does not license mining activities. Consequently, the information on the concentration of radium in the mine water was transmitted to the Bureau of Mines.[(7)] Additionally, a copy of the applicant's letter of February 26, 1974 and engineering study relating to the barium treatment process (Appendix H) has been forwarded to the Bureau of Mines, the State of Utah, and the EPA for their information and consideration. In September of 1971 an application to discharge the mine water was submitted to the Corps of Engineers under the requirements of the 1899 Refuse Act (see Appendix I). This application has been transferred to the Environmental Protection Agency as a result of the Federal Water Quality Act Amendments of 1972.

When the mining operation is terminated the applicant will place a concrete seal in the shafts just above the mining horizon. This will isolate the mine water with high radioactivity from the water now seeping into the shafts from the Navajo and Entrada, and limit the radioactive contamination of these formations. The height to which the water will rise in the shafts will depend on the hydrostatic head in these formations. Should the water rise to the elevation of the Burro Canyon formation, transfer of water in or out of the shaft is not anticipated because of the concrete lining. The shaft will also be capped with a concrete slab at ground level. Unless the present construction already provides a seal between the shaft lining and the shaft wall, the annulus should be blocked with grout just below the bottom of the Burro Canyon so as to prevent the possibility of vertical communication of water between the shaft lining and the rock wall of the shaft.

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(7) Letter from AEC to U. S. Department of Interior, Bureau of Mines, dated March 28, 1973.

5. Dust from Roads

Keeping the dust to a minimum at the site is not only important from the standpoint of environmental considerations, but also from the standpoint of preventing dust from entering the mine ventilation intake. When blowing dust becomes a problem on the haul roads over the waste rock, the applicant proposes to control the dust by using water, calcium or surface binders. Other roads into the site, including service roads, will be either graveled, oiled or treated with calcium or some other type of binder for dust control.

6. Dust from Ore Storage

The ore as it comes from the mine will contain 5 to 10% moisture and contain less fines than ore after it is crushed. However, should dust problems occur, water sprays will be used to dampen the ore. When stockpiling of ore by use of the No. 2 conveyor is necessary, water sprays will be used to moisten the ore and suppress the dust. The applicant has stated that experience at another mill in Moab shows that once the surface of a stockpile has become weathered, the clay constituents will form a crust on top of the piles thus reducing the possibility of dust. If this effect is not experienced by the applicant and dusting becomes a problem, a surface coating such as lignosol or similar binder will be used. An inspection of the mill by the AEC was conducted during the month of January 1973. The inspector noted that there was no unusually dusty operations and that the ore was sufficiently moist so that it was not dusty.

7. Products of Combustion

Because natural gas will be the primary fuel, the products of combustion will be less than if other hydrocarbon fuels were used for heating. The secondary fuel, No. 2 fuel oil, will only be used for emergencies. However, No. 2 fuel oil will also produce products of combustion less than that produced by the burning of coal.

Approximately 32% of the flue gas will be directed to the carbonation tower where most of the CO_2 will be absorbed with the balance of the flue gas being discharged out the 60-foot carbonation tower. The other 68% of flue gas is discharged out of a 60-foot stack.

8. Mine Ventilation Shaft

Because wet drilling operations will be performed in the mine, dust production will be less than that encountered by dry drilling. However, there may be a certain amount of dust generated by traffic in the mine tunnels. The high ventilation rates used in the mine, 253,000 ft^3/min, will provide dilution for the dust and radon gas emitted to the atmosphere. However, the concentration of Radon-222 at the point of discharge has been estimated to be about 2.25×10^{-7} μCi/ml. By letter dated March 28, 1973, the AEC indicated to the Bureau of Mines concerns relating to mining procedures.

9. Mill Air Effluents

The release of airborne particulate contaminants to the surrounding environs from the milling operations will be reduced by utilizing various types of air cleaning equipment. The applicant states that the air cleaning equipment has been designed using the principles contained in the 1970 edition, "Industrial Ventilation Manual of Recommended Practices of the American Conference of Governmental Industrial Hygienists." Vapors and dusts from the yellow cake packaging and drying operations are passed through a venturi scrubber and centrifugal eliminator designed to reduce effluent releases to 0.03 grains per cubic foot.(8) Dusts from the ore transfer areas crushing plant and the ore sampling room will be passed through cloth bag filters prior to release through the mill stacks. The concentration of particulates in air discharged from these systems is not expected to exceed 0.03 grains per cubic foot. Rio Algom received permission to install the dust control systems from the State of Utah, October 15, 1971 (see Appendix J). The applicant has informed the AEC that the actual performance of the surface plant stack discharge dust filters has been better than the specified emission rate of 0.03 grains per cubic foot (68.3 mg/m^3) and ranges from a low of 0.585 mg/m^3 for the yellow cake dust filter to a high of 1.27 mg/m^3 for the transfer tower. Visual checks of the dust filter systems and attendant static pressure gauges are performed daily, and maintenance work is carried out on dust control equipment when the process being controlled is shut down. In addition, various units in the process can be shut down for scheduled maintenance. Isokenitic dust samples are taken in the discharge stack from each filter on a monthly basis.

10. Mill Liquid Effluents (Tailings Retention System)

By letter dated July 13, 1970, see Appendix K, Rio Algom received permission to construct a tailings disposal dam and related facilities from the State of Utah. However, Rio Algom's request for deep well disposal of excess water was denied and so stated in the same letter. By application for AEC Source Material License dated August 26, 1971, the applicant stated on page 23 that, "a deep injection well for disposal of tailings water will not be used." This was reaffirmed by letter dated February 16, 1972.

An earth fill clay core dam retention system, see Figure 19, will serve as a collection and storage system for a part of all the liquid and solid wastes generated in the milling circuit. It will permit the evaporation of a portion of the waste liquids and serve as a permanent receptacle for the residual solid tailings. This system was constructed

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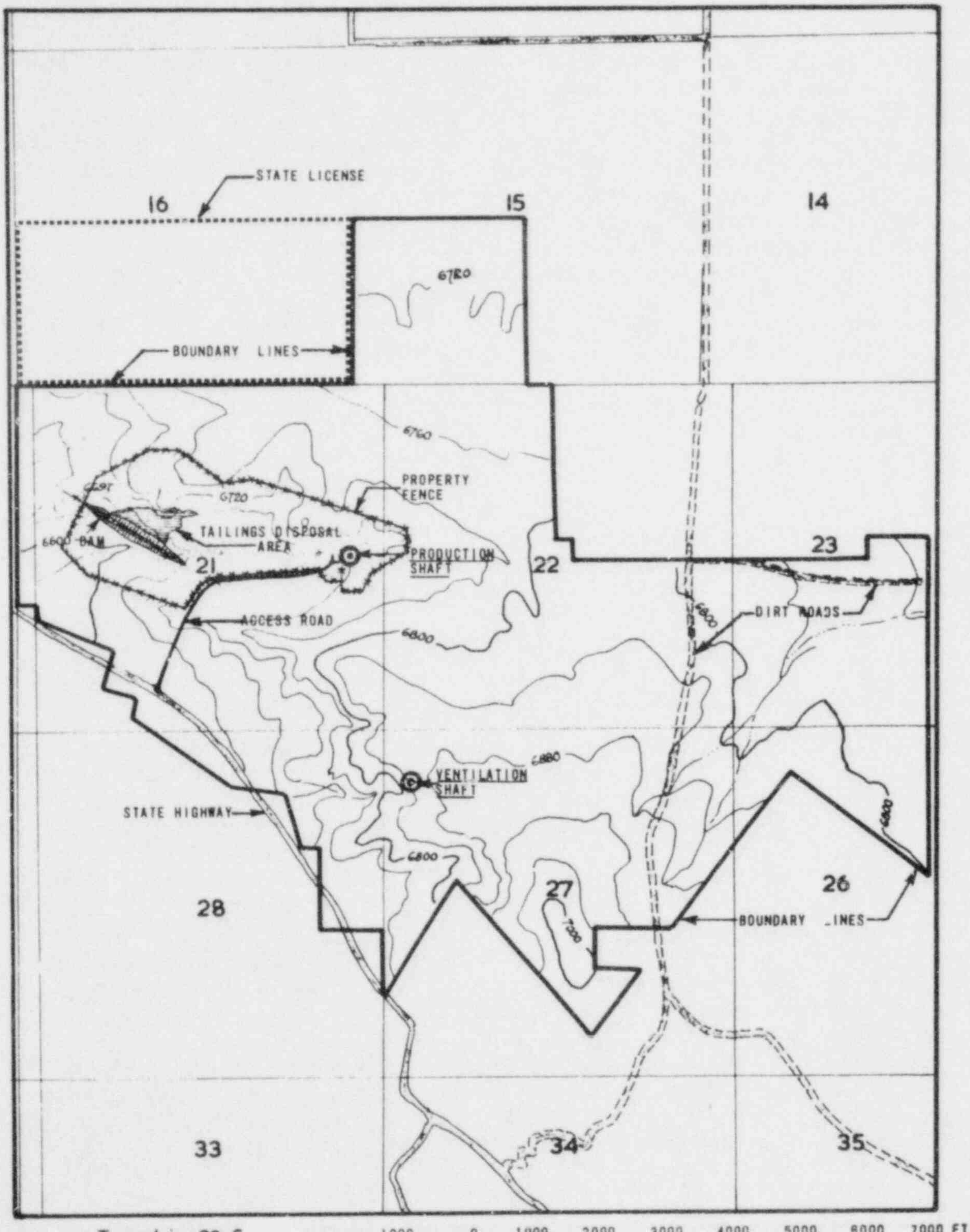
(8) Confirmed by tel-con with Rio Algom, May 10, 1973.

Figure 19

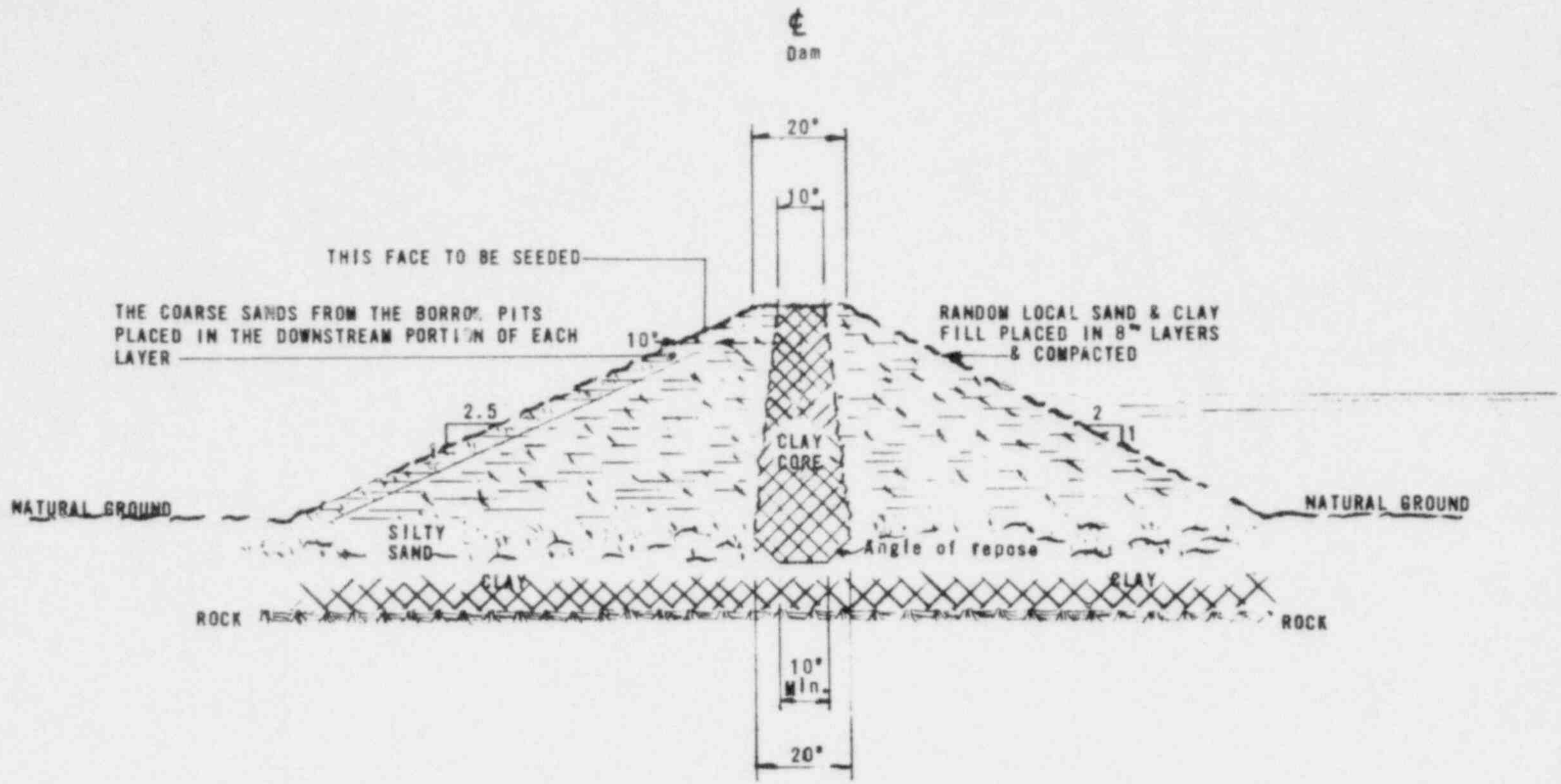


RIO ALGOM CORPORATION - PROPERTY MAP

by erecting an earth fill clay core dam across a natural basin, see Figure 19 for location. The applicant engaged the services of a consultant for assistance in the design of this tailings retention system. The Utah State Department of Highways was contacted and it was their opinion that their would be no appreciable damage to the state highway in the event there was a failure of the dam (see Appendix L).

Basically the system as described by the applicant consists of a starter dam of an outer shell of local sandy clay placed around a core of selected clay material, Figure 20, and all materials compacted in 8-inch layers in accordance with the American Association of State Highway Officials. The top 12 inches of soil and vegetation were removed from the base before fill material was placed. A cut-off trench 6 to 8 feet deep and 10 feet wide at the bottom was excavated for the full length of 1450 feet of the dam. At the abutments, where rock was at or close to the surface, the trench was excavated in rock to remove all fractured material. In the bottom of the valley, for a length of 1100 feet, the cut-off trench was excavated through the silty sand down to the clay formation. The trench was then filled with the selected clay material compacted in 8-inch layers to 95% of maximum density. The dam is described as being built in horizontal layers having a thickness of no more than 8 inches prior to being compacted. The selected clay material from the borrow pits was placed in the middle section of the dam to form the impervious core which is 20 feet wide at the bottom and 10 feet wide at the top. The sandy clays and silty sands were placed on both sides of the core. The coarse sands encountered in the borrow pits were placed in a 10-foot wide horizontal layer on the downstream side of the embankment. Water was added in the borrow pits and on the dam for the purpose of obtaining optimum moisture content. A sheepsfoot roller was used and each layer was compacted to 95% of maximum density as measured by the American Association of State Highway Officials T-90 method of compaction. The dam will be approximately 45 feet high, crest length of 1450 feet with a top width of 20 feet. The side slope ratios are 2-1/2 to 1 for the downstream side of the dam and 2 to 1 for the upstream side. The staff has judged the dam construction to be satisfactory because of the method of depositing the tailings, described on page II-13, and of the method of construction which is further described in Rio Algom's Engineering report[9] (see Appendix M) and consultant's report[9] on the subsoil investigation (see Appendix E). The applicant's consultant has evaluated

(9) All references in the Engineering Report, in Appendix M, relating to raising the dam, deep well disposal and monitoring well are no longer applicable as Rio Algom has submitted changes regarding these subjects. These changes are reflected in this report.



TYPICAL EXISTING DAM CROSS-SECTION

Figure 20

TAILINGS DISPOSAL

the dam based on test boring through the d. n and evaluation of soil parameters and calculated that the minimum safety factor under all conditions (including earthquake loading of 0.05 g) was 1.3. This meets the AEC requirements of the new Regulatory Guide 3.11, "Design Stability of Embankment Retention Systems for Uranium Mills," dated June 1973. In August of 1973, the applicant's consultant drilled three holes, D1, D2 and D3, see Appendix D, on the tailings dam centerline and the applicant has stated that they did not detect water in the dam core. Water in the strata under the dam was detected in 2 of these holes. In addition, piezometers are installed in bore holes D-1 through D-7 to monitor water table levels. When the water level in the present dam reaches a level which is 10 feet below the crest of the dam, a new tailings basin and dam will be utilized. [This tailings retention system was the subject of a separate review and analysis by the licensing authority (see Appendix S).]

Tailings have been deposited at a number of points across the upstream face of the dam to reduce any seepage through the dam. The tailings line is laid on the upstream crest of the dam and the tailings are discharged at a number of points first above the water line. Because the tailings material is so finely ground, very little "beach" of coarser fraction has as yet built up above the pond level of the liquid fraction of the tailings slurry. However, with time the beach is expected to increase. In order to seal the apparently more pervious rock and soil areas on the north and south sides of the dam, the tailings line has been extended along the north side to deposit a blanket of tailings by spigotting. On completion of this, the tailings will then be spigotted along the south side. As the pond level rises, the tailings will be discharged at various points around the perimeter of the pond to keep the liquid fraction of the tailings from direct contact with the bare rock and soil. Because the discharge po it for the tailings is moved fairly frequently and because the tailing are discharged below the dam crest, the formation of slime pockets are not expected to form. Consequently, adverse effects on the dam stability from such an effect are not anticipated. The applicant states that because the operation is a small tonnage operation, the formation of ice during the winter would probably melt before it became buried to any great depth. The freezing and formation of layers of ice in the tailings can be reduced by laying down the tailings with large diameter pipes to a point some distance in back of the dam.

Liquid losses are expected to occur by evaporation and seepage. Because of the method used to deposit the tailings, it is expected that there will be initial seepage through the tailings basin bottom, but that the seepage should decrease with time. At the start of the operation, the high solids to liquids tailings material was deposited around the tailings basin to above the water line that would be reached in the first two years of operation. Low grade ore material or waste was used when the mill started. The perimeter sealing process is to be repeated as necessary as the height of the pond increases. Laboratory seepage tests reported in March of 1972 indicated that the seepage rate may be on the order of

6-8 feet per year for untreated tailings. Of the 52 gallons per minute of tailings being discharged to the tailings pond from the mill processing, approximately 10% was expected to seep through the retention system. Estimates of the amounts of uranium, thorium, and radium expected to seep have been calculated based on a leakage rate of 10%. The results are shown in Table XV.

TABLE XV. ESTIMATES OF RADIONUCLIDES SEEPING FROM TAILING POND

Radionuclide	Quantity Seeped in µCi per day	
	AEC Estimate	Rio Estimate
Uranium Natural	100.0	550
Thorium-230	0.003	0.55
Radium-226	49.0	5.5

The differences between the AEC and Rio Algom estimates in Table XV are primarily due to the concentrations used in the calculations. The AEC estimates are based on earlier values of solution loss of uranium of 0.2%, a thorium concentration of 1×10^{-10} µCi/ml and a radium concentration of 1.8×10^{-6} µCi/ml.

The monitor well drilling conducted by the applicant's consultant indicates that seepage is occurring from the tailing pond and that the seepage probably percolates downward in stages until it reaches the zone of saturation lying on the Burro Canyon-Brushy Basin contact. Here the seepage is believed to be diluted by groundwater and moves down-dip along the contact. It is expected that this seepage will continue until the tailings blanket seals all of the ponded area. Monitoring results (Appendix N) show the concentrations of radionuclides from the monitor well program described in Section II.E.

Additional monitoring well data (Table XVI) was submitted by the applicant for the last two months of 1973.

TABLE XVI MONITORING WELL DATA FOR NOVEMBER AND DECEMBER 1973

Radionuclide	2-Month Average	Range
Uranium-Nat.	16.1×10^{-7} µCi/ml	$0.03 - 121.3 \times 10^{-7}$ µCi/ml
Radium-226	1.6×10^{-9} µCi/ml	$0.7 - 4.0 \times 10^{-9}$ µCi/ml
Thorium-230	All values less than 2.0×10^{-8} µCi/ml	--------

The consultant's report to the applicant (Appendix E) states that the test holes indicate that subsoils beneath the proposed tailing dam consist of loose to medium dense, silty sands and stiff to very stiff, sandy clays over hard sandstone bedrock at depths 2 to 18 feet. No free water was encountered. In addition the natural soils in the reservoir area possess sufficient fines (-200) to be relative impervious. Because of these conditions and the methods used to deposit the tailings, loss of water from the pond by seepage is expected to be abated. If it is assumed that all the water seeped from the bottom and sides of the tailing pond, then all the radioactive constituents dissolved in the water would seep through the pond. The AEC estimate of the amounts of uranium, thorium, and radium which would seep for this maximum condition have been calculated and the results shown in Table XVII.

TABLE XVII. ESTIMATE OF THE QUANTITY OF RADIONUCLIDES SEEPING FROM THE TAILING POND PER DAY, MAXIMUM SEEPAGE

Radionuclide	Quantity Seeped in µCi per day
Uranium-Nat.	1028
Thorium-230	0.03
Radium-226	509

Assuming only a 60 foot thick water bearing Dakota formation of porosity 0.3 exists throughout the 120 acre Rio Algom site, a water volume of 2.66×10^{12} cm^3 would be present. If 509 µCi of radium seeped into the Dakota formation per day for a period of 10 years, the quantity of radium seeped would be 18.54×10^5 µCi. Consequently, the concentration of Ra-226 in the Dakota formation if evenly distributed would be 6.96×10^{-7} $\mu Ci/cm^3$, approximately 23 times the AEC unrestricted area release limit of 3×10^{-8} $\mu Ci/cm^3$. The migration of radioactive particles which may have passed through the tailing pond is expected to be retarded because of the ability of soils to attract ions. The ability of clay to attract ions, especially positive ions, to their surfaces is one of the most important properties which results in the binding of soil elements in ionic form. Because of the type of subsoils beneath the tailing basin, one may expect a cation-exchange capacity on the order of 5 milliequivalents per 100 grams.(10) In one ton of silty sand (20% sand) there would be an adsorptive capacity on the order of 9 equivalent weights. Consequently, one ton of silty sand has the theoretical capability of adsorbing 1000 curies of radium which is greater than the amount of radium which would seep over a period of 10 years at a seepage rate of 49 µCi per day. Another factor which may have an effect on leaching, especially after the tailings pond dries out, is the low precipitation rate for the area, i.e., on the order of 0.27. This factor

(10) The applicant's consultant analyzed soil and rock samples from the borings and found values of cation-exchange capacities ranging from a low of 10.6 to 16.1 milliequivalents per 100 grams.

may tend to reduce the leaching into the soil. Another factor entering into the seepage mechanism is the effect of the seepage effluent on the soil and rock materials below the dam and pond. It is believed that a seepage effluent with a high pH may be capable of causing an increase in the permeability of the soil. A more detailed discussion and analysis of the seepage problem has been investigated by the applicant's consultant in Appendix D. A comparison of the monitoring well data indicates that seepage through the tailing pond is abating. In addition to the monitoring data referred to above, an inspection of the mill by the AEC was conducted during the month of January 1973, in which selective examinations of representative records were performed. It was reported that data generated by two monitor wells located below the tailings dam indicated concentrations below the MPC for uranium-natural, radium and thorium, lead-210 and alpha. Baseline monitor well data for these two wells indicated an average concentration on the order of 1×10^{-9} µCi/ml. During the AEC inspection in January of 1973, the AEC inspector collected a sample from each of these two wells and had them analyzed by an AEC laboratory. The results were reported as being less than 3×10^{-9} µCi/ml for radium-226.

Contrary to the applicant's proposal for action on detection of high levels of seepage contamination,(11) it is the opinion of the AEC that when the applicant's tailing monitor well program reveals concentrations of any radionuclide in excess of the AEC allowable Maximum Permissible Concentration for unrestricted areas,(12) Rio Algom will install pumps in wells drilled on the centerline of the dam to capture the contaminant and return the effluent to the tailings pond. The applicant's consultant has provided the details and objectives of such a system (see Appendix D page II-16). This technique or some other technique acceptable to the Commission will continue until it can be shown that the allowable concentrations will not be exceeded. The license will be conditioned accordingly. The applicant has also stated that the sealing process will be supplemented by using additional sealing agents if experience indicates that further liquid retention is required (see Appendix O). Because of the concentration of Na and SO_4 ions in the tailing pond (see Table XIV) and of the possible seepage through the tailing pond, a potential exists for the contamination of underground water by these chemicals. There will be a dilution factor for those elements that may seep into the underground water. However, it is recognized that the dilution factor may not be as extensive in ground water as an equal volume of surface water. Water heavily saturated with sulfates, carbonates, bicarbonates, chlorides and sodium are capable of causing injurious effects. The injury caused is due to an osmotic effect or a toxic effect depending on the circumstance.(13) The maximum concentration

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(11) When two out of three consecutive analyses from any of the monitor wells indicate that a radioactive contaminant is in excess of the allowable set by the State of Utah, action will be taken to control the contaminant.

(12) Maximum Permissible Concentrations are listed in Title 10 Code of Federal Regulations, Part 20, Appendix B.

(13) Report of the Committee on Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, April 1968.

of salts that can be tolerated safely by domestic animals appears to lie between 15,000 and 17,000 mg/l.[14] However, water that is to be used continually for livestock watering, salt concentrations above 4500 to 7000 mg/l are in some areas of the country described as being unsatisfactory. Drinking water with hardness levels exceeding 250 mg/l are usually considered very hard and undesirable for domestic use. In high concentrations, sodium is toxic to man and plants and is deleterious to soil conditions. Sodium concentrations in drinking water of 200 mg/l may be injurious to man and concentrations on the order of 2000 to 7000 mg/l may cause harmful effects in livestock. Concentrations of sodium on the order of 100 to 200 mg/l in irrigation water can cause deleterious effects to plants. Soils saturated with sodium usually present a problem in irrigation systems due to its effect on soil structure, causing reduced infiltration and permeability rates. In the case of the tailing pond, the high concentration of Na may be an advantage in that high concentrations of sodium may cause the sealing of soil pores and a decrease in soil permeability.[13][14] A situation of this type would be beneficial to the tailing pond in that it would contribute to the sealing of the pond and thereby assist in the abatement of seepage through the tailing pond.

The natural watershed area above the tailings basin is 590 acres. The normal water level within the 16 acre tailings area will be maintained at least 10 feet below the crest of the dam. Data supplied to the applicant by the Bureau of Land Management indicates that once every 100 years there is a risk of a 5-inch rainfall in 10 days.[15] With a holding area of 16 acres[16] and a 10-foot freeboard, the tailing area has a capacity of 160 acre-feet minus the amount of rain that falls in the pond. A five-inch rainfall would lower the freeboard from 10 feet to 9.58 feet. Consequently, the holding capacity of the tailing pond would be 9.58 feet times 16 acres or 153.3 acre-feet. This estimate does not take into consideration water absorption in the soil or soil deposition in the pond due to erosion. Data supplied by the Bureau of Land Management indicates that the amount of run-off water from a 100-year frequency rainstorm of 5 inches in 10 days over the 590-acre watershed would be 58.4 acre-feet.[15] The applicant has stated that records for the town of La Sal, located 4 miles from the mine, indicate that in a 30-year period only twice has the monthly total rainfall approached 6 inches. Figures supplied by Rio Algom Corporation to their consultant have calculated a net storage for the basin to be 167 acre-feet, i.e., capacity of basin above planned water level of 194 acre-feet minus the volume of tailings above the water level of 27 acre-feet or net storage of 167 acre-feet above pond water level. The United States Department of the Interior, Bureau of Land Management, expressed concern about the

(14) Water Quality Criteria, Publication 3-4 Reprint December 1971, California State Water Resources Control Board.

(15) Letter from United States Department of the Interior to Mr. P. F. Pullen, Rio Algom, dated October 15, 1971.

(16) Rio Algom application for Source Material License dated August 26, 1971.

potential run-off accumulation for a 25-day period of a 1,500-year frequency.(17) However, by letter dated February 19, 1974 (see Appendix A), the Bureau of Land Management has indicated that they do not feel it necessary that tailing diversion canals be constructed as long as active mining and milling operations are in progress. A check of the amounts of rainfall which may be experienced in a tropical storm are shown in Table XVIII.(18)

TABLE XVIII

TROPICAL STORMS AND ASSOCIATED RAINFALLS

STORM	AREA OF RAIN	AMOUNT OF RAINFALL
Hurricane Agnes	Cuba	17 in. in 4 days to 9 in. in 6 hours
"	Flordia	12.7 in. in 7 days
"	Eastern Slopes of Blue Ridge Mountains	4 to 10 in. in 48 hours up to 8 in. in 24 hrs.
"	Virginia Maryland Area	13.6 in. in 4 days to 14.7 in. in 24 hours.
"	Pennsylvania	14.5 in. in 24 hours
"	New York	4-day average near 9 in.
Hurricane Carrie	Martha's Vineyard	12.5 in. in 16 hours
Extreme Low Pressure in Texas	Chicago	7 in. in 2 hours
Typhoon Rita	Kyushu	23 in. in 48 hours

The Department of the Army Corps of Engineers has indicated that the reservoir capacity will be reasonably adequate for the 590-acre watershed for the most severe combination of meteorological and hydrological conditions that might reasonably be expected for the area (see Chapter VIII, letter from Department of the Army Corps of Engineers, 6 March 1973). As indicated earlier in this statement, the U.S. Department of Interior has

(17) Letter from U. S. Department of Interior, Bureau of Land Management to Rio Algom dated October 15, 1971.
(18) Mariners Weather Log, Department of Commerce, Vol. 17, No. 1, January 1973.

stated that it is their opinion that it is not necessary to construct a channel to divert flood water around the tailing pond at this time. However, at the end of the mining and milling operations, a channel will be constructed to divert flood waters around the existing tailings area and the proposed tailings area. Maintenance crews are required to inspect the tailings system daily and to repair it if necessary, to ensure proper functioning of the entire retention system.

The tailings retention system has been designed to reduce the probability of dust dispersal by maintaining a portion of the pond under water. Dust generated by high winds acting on the tailings deposits which appear above the surface of the liquid are to be controlled by one or more of the following techniques: (1) installation of an irrigation spray system to keep the tailings wet in the event of a strong wind; (2) installation of snow fencing to slow the wind velocity below the transport velocity; (3) covering the exposed area with a thin layer of mine waste; and (4) use of a chemical stabilizer. The use of an automated irrigation spray system is not a requirement of the AEC. It is the opinion of the AEC that an automated system would not offer any clear-cut advantages over a system based on daily visual observation and inspection.

The release of airborne particulate contaminants to the surrounding environs from the milling operations will be minimized by utilizing various types of air cleaning equipment. The applicant states that the air cleaning equipment has been designed using the principles contained in the 1970 edition of "Industrial Ventilation Manual of Recommended Practices of the American Conference of Governmental Industrial Hygienists." Vapors and dusts from the yellow cake packaging and drying operations are passed through a venturi scrubber and centrifugal eliminator designed to reduce effluent releases to 0.03 grains per cubic foot.[19] Dusts from the ore transfer areas, crushing plant and the ore sampling room will be passed through cloth bag filters prior to release through the mill stacks. The concentration of particulates in air discharged from these systems is not expected to exceed 0.03 grains per cubic foot.

D. ENVIRONMENTAL CONCENTRATIONS AND EFFECT ON LOCAL BIOTA

1. Radiological

The concentrations of airborne radioactive effluents released beyond the boundary from the mill process of Rio Algom (see Table XX) are expected to be below the limits specified in 10 CFR Part 20[20] and at levels consistent with the present state-of-the-art in uranium milling technology. Of the possible sources of airborne contaminants identified in Section B, the mine air ventilation shaft, production shaft, crusher, headframe, transfer house, mill dryer and tailings pond are considered to be the

(19) Value confirmed by letter from Rio Algom, dated May 10, 1973.

(20) The MPC limits listed by Rio Algom on page 59, Part II, of their response to Agency Comments, November 1973, as being applicable to the Lisbon Operation are not applicable. Values listed in 10 CFR 20, Appendix B, are the authorized values.

primary source terms, and the analysis of the effluents from these sources on the environment are based upon these sources. The calculated quantities of each airborne radioactive effluent from these sources are tabulated in Table XIX.

TABLE XIX

RANGES OF QUANTITIES OF RADIOACTIVE EFFLUENTS EMITTED FROM THE MAJOR SOURCES[(21)]

Source	Effluent	µCi/day
Mine Air Vent	Uranium-Natural	15.88
"	Thorium-230	15.88
"	Radium-226	15.88
"	Radon-222	3×10^6
Production Shaft, Crusher, Headframe, and Transfer	Uranium-Natural	41
"	Thorium-230	41
"	Radium-226	41
"	Radon-222	41
Mill Dryer	Uranium-Natural	337
Tailings Pond	Radon-222	8.4×10^5

Meteorological data supplied by the applicant indicate that during the daylight hours the prevailing wind direction at the mine is from the northwest throughout the year. The predominant wind speed for a 16-month period during the daylight hours was 5 miles per hour (see Table XII). During nighttime hours, one may anticipate a circumstance in which a drainage of air downslope towards the northwest would occur. Consequently, to obtain an approximation of the environmental concentrations of radioactive materials resulting from the sources identified in Table XIX, the parameters shown in Appendix P were utilized. In some instances the short-term diffusion formula was utilized while on other occassions the diffusion formula for obtaining annual average concentrations was utilized, or the short-term diffusion formula value corrected to estimate the long-term diffusion formula value. The dust discharge values utilized in these calculations were based on design data. However, by letter dated November 12, 1973, Rio Algom informed the Commission that actual measurements show that the filtration systems are performing considerably better than the spec. value of 68.3 mg/m^3. The measured values range from a low of

(21) Values based on actual measurements have been submitted by the applicant and are shown in Appendix Q. With the exception of the mine ventilation shaft, the measured emission values are less than the design value.

0.097 mg/m^3 for the headframe to a high of 1.27 mg/m^3 for the transfer tower. Rio Algom has computed the concentrations and doses for their operations based on the measured emission values. These results are shown in Appendix Q. Differences that exist between the AEC estimates and Rio Algom estimates are due to the emission rates utilized; as noted above, use of a mix of long-term and short-term techniques for calculating concentrations at a given receptor versus a short-term technique by Rio Algom, consideration of a possible nighttime reversal of the wind flow by the AEC, the differences in the selection of receptor points by each leading to different distances from source to receptor, and solubility considerations of the isotopes under consideration. Because of the many variables which enter into atmospheric dispersion calculations, concentrations and doses derived from these parameters should not be construed to be infallible predictions. They should be viewed as rough approximations and the uncertainties of such a calculation considered when using the data to make a judgement relating to the environmental impact.

The applicant shall be required to conduct an environmental monitoring program to verify the conclusions. See Section E for a description of the air sampling program.

Estimates of concentrations were made for: points at which the maximum concentrations were expected to occur; concentrations from all sources to a point on the border of Rio Algom property for the predominant daytime flow of air; concentrations from all sources to a point on the border of Rio Algom property for the circumstance in which the nighttime flow was to the northwest; and the Redd Ranch located 2-1/2 miles northwest of the site in the direction of nighttime and daytime flow of air. The point where the maximum concentration is expected to occur for effluents from the mine ventilation shaft is approximately 330 feet, and from the stacks from the mill, 820 feet. These distances are within the boundary of the mill and, with the exception of radon-222, the concentrations encountered at these points are all below the allowable restricted area MPC's. The concentration of radon-222 at this distance may be of the order of 4.5×10^{-9} $\mu Ci/cm^3$. The concentration of radon-222 at the point of release has been estimated to be 2.25×10^{-7} $\mu Ci/cm^3$. Unless the Bureau of Mines has provided Rio Algom with other alternatives, the AEC recommends that the nearest access point to the mine ventilation shaft be extended and properly posted so that the appropriate MPC value for radon listed in 10 CFR 20, Appendix B, will not be exceeded. Estimates of airborne concentrations from all sources which may contribute to the pollution at the three locations considered to be of major importance are shown in Table XX.

TABLE XX

ESTIMATES OF CONCENTRATIONS

Location	Concentration U-Natural $\mu Ci/cm^3$	Concentration Th-230 $\mu Ci/cm^3$	Concentration Ra-226 $\mu Ci/cm^3$	Concentration Rn-222 $\mu Ci/cm^3$
Boundary, 1500 feet southeast of mine ventilation shaft. Day Conditions	1.5×10^{-14}	4.1×10^{-15}	5.9×10^{-15}	3.3×10^{-10}
Boundary, 8000 feet northwest of mine ventilation shaft. Day & Night Conditions	1.9×10^{-13}	8.5×10^{-15}	1.8×10^{-13}	1.3×10^{-10}
Redd Ranch Day & Night Conditions	3.1×10^{-14}	1.6×10^{-15}	3.5×10^{-14}	1.017×10^{-10}

For a visual representation of these locations see Figures 3 and 4.

During the AEC Regulatory inspection of the facility on January 3 and 4, 1973, the inspector reported that on several occasions, samples collected from the effluent stream of the discharge stacks indicated concentrations in excess of MPC for unrestricted areas. However, all samples collected at various distances from the mill facility were reported by the inspector as being less than 25% of the unrestricted area MPC or have not approached the MPC for unrestricted areas. Source term data utilized in arriving at the estimates of concentrations in Table XX is presented in tabular form in Appendix P.

Estimates of the potential dose equivalents for an individual if he were located continuously for a year in one of the areas specified in Table XX have been made and are shown in Table XXI.

TABLE XXI

ESTIMATES OF DOSE EQUIVALENTS[22]

Location	Kidney	Bone	Lung
Boundary, 1500 feet southeast of mine ventilation shaft. Day Conditions	0.3 mrem/yr	134 mrem/yr	74 mrem/yr
Boundary, 8000 feet northwest of mine ventilation shaft. Day & Night Conditions	3.1 mrem/yr	246 mrem/yr	33 mrem/yr
Redd Ranch Day & Night Conditions	0.5 mrem/yr	133 mrem/yr	23 mrem/yr

Though one doesn't sum up critical organ doses to determine a whole body dose, a sense of the significance of the estimates of the dose equivalents in Table XXI can be appreciated by noting the background radiation for the State. Whole body exposures from natural background radiation for the State of Utah are estimated to average about 150 millirems per year. The number of residents at the Redd Ranch varies from 1 to 6 depending on the season. At the Wilcox Ranch there are 29 full-time residents living in two houses and seven trailers. The population density per square mile for a 2.5 mile radius around the mill is on the order of 1.8 persons per square mile. The AEC has not established, as yet, a value for "As Low As Practicable" (ALAP) effluent releases from uranium mills, and the presently applicable limits for concentrations and dose are contained in Title 10, Code of Federal Regulations, Part 20. However, the Commission has initiated comprehensive engineering and environmental studies to form the basis for providing specific guidance on as low as practicable effluent releases for fuel cycle facilities including uranium mills. Potential concentrations and dose equivalents were not estimated for the Wilcox Ranch as it is located approximately the same distance from the mill site as the Redd Ranch and in a direction north northeast of the mill, which is not in the direction of the prevailing wind for either day or night. Consequently, the concentrations and dose equivalents would be expected to be less than those calculated for the Redd Ranch.

The estimates of concentrations and dose equivalents agree with the general conclusions reached by the Advisory Committee on the Biological

(22) Doses were estimated using the information presented in TID-4500, "Doses to Various Body Organs from Inhalation or Ingestion of Soluble Radionuclides," and "Control of Radon and Daughters in Uranium Mines and Calculations on Biologic Effects," U.S. Department of Health, Education and Welfare, PHS Publication No. 494. The kidney and bone dose estimates represent the dose to 50 years from breathing the concentrations listed in Table XX for one year. The actual performance of the surface plant stack discharge dust filters has been noted on page II-20 of this report.

Effects of ionizing radiation[23] and U.S. Environmental Protection Agency[24] in that the location of uranium mills in sparsely populated areas can prevent exposures to the population and that no significant radioactive material will reach populated areas and consequently no significant radiation exposure to the public will occur from uranium mills.

The area surrounding the mill is relatively arid, and water and vegetation are scarce. In addition, the surrounding area is uncultivated and used only for occasional grazing by a small number of sheep, cattle and wildlife. With regard to the possible effects of radiation on the environment, "it is felt that if the guidelines and standards are accepted as adequate for man, then it is highly unlikely that populations of other living organisms would be perceptibly harmed."[25]

The tailing reservoir is not an ideal body of water, pH 9.5, for animals or waterfowl to feed or drink from. It is unlikely that such animals would drink water having a pH of 9.5.[26] Experiments on the gustation properties in several species of avian suggest that gustatory stimule probably are present in birds which provide them with a rejection threshold which influence their choice of drinking water. These experiments suggest that migratory birds would not normally drink the tailing pond water, but rather would land there only for resting purposes, then move on to water which is more palatable to their taste. There are four reservoirs of fresh water in Coyote Wash within 2 to 4 miles of the tailings area, plus water in the irrigation ditches. The temperature of the tailing pond is not likely to be a factor in attracting wildlife as the temperature of the tailing pond water would appear to be the same as other bodies of water, except where the tailing line discharges into the tailing pond, based on the observations by Rio Algom personnel of ice on the pond during the winter months.

Exposures from uptake through the food chain are expected to be negligible in view of the small quantities of effluents released and the fact that the surrounding area is uncultivated and used only for occasional grazing by a small number of wild and domestic animals. In the event that game animals should drink the tailing water, it can be shown that an individual would have to eat more than 3 deer kidneys to ingest the

(23) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, Division of Medical Sciences, National Academy of Science, National Research Council, Washington, D.C. 20006, November 1972.

(24) Estimates of Ionizing Radiation Doses in the United States, 1960-2000, U. S. Environmental Protection Agency, ORP/CSD 72-1, August 1972.

(25) Op. cit. (23)

(26) Letter from Colorado State University, Environmental Resources Center to AEC, dated March 13, 1973.

allowable body burden for uranium, or more than 2×10^5 kidneys to ingest the allowable body burden for thorium, or more than 4×10^5 livers to ingest the allowable body burden for thorium. These estimates were arrived at by assuming that the deer took his total intake of water from the tailing pond; deer equals man in the metabolism of uranium and thorium, and that when man eats the contaminated kidney or liver the total quantity ingested goes to man's critical organs. As it is likely that the above assumptions are conservative, greater numbers of kidney or liver would have to be consumed than stated. With respect to vegetation surrounding the area, vegetation sampling results submitted to the AEC inspector on January 3 and 4, 1973 show the quantity of U_3O_8 in several vegetation samples. The highest value reported was 0.20 PPM of U_3O_8. If the sample was dry then the value of uranium would be on the order of 1.3×10^{-7} g of uranium per gram vegetation. This value is less than the recommended limiting concentration of 3×10^{-5} g of uranium per gram of dry matter for food for beef cattle and dairy cows.(27) The applicant's environmental sampling program should provide data which will serve as an indicator of the possible entry of radionuclides into the food chain from soil to man. Additional information on uptake of radionuclides by biological organisms and vegetation have been supplied by the applicant's consultant, by letter dated July 18, 1973, and appears in Appendix R.

2. Non-Radiological

Considering the air cleaning and ventilation equipment installed by the applicant to control effluents, the methods of release and amounts of materials involved, it is not expected that quantities of non-radioactive materials being released to the environment will exceed those values listed in Table XXII. Though the concentrations of dust, SO_2 and NO_2 from the boilers at the point of release exceed(28) the State and Federal ambient air quality standards (Table XXIII), the concentrations, as calculated utilizing methods for estimating annual average concentrations,(29) are not likely to exceed the State or Federal ambient air quality standards at the boundary in the direction of the prevailing wind for meteorological conditions shown in Appendix P and emission rates and air discharge volumes as measured by Rio Algom. Buildup in the environment is not expected in view of the chemical and physical characteristics of the contaminants and the quantities involved. Therefore, such release of non-radioactive materials is not expected to have a significant impact on the environment.

The applicant is required to maintain the concentrations of non-radioactive effluents at levels consistent with the present state-of-the-art in milling technology and may not exceed the ambient air standards established by the State of Utah as listed in Table XXIII.

(27) Health Physics Journal, 1963, Vol. 9, page 597.
(28) As reported by Rio Algom, "Applicant's Response to Agency Comments on Draft Statement," November 1973.
(29) Workbook of Atmospheric Dispersion Estimates, PHS-999-AP-26.

TABLE XXII

ESTIMATES OF ANNUAL EMISSIONS OF PARTICULATE AND NON-RADIOACTIVE EFFLUENTS FROM THE MAJOR SOURCES

Sources	Pollutant	QUANTITY Design Specifications	Measured[(30)] Valves
Mine Ventilation Shaft	Dust	9599 $\frac{lb}{year}$	18286 $\frac{lb}{year}$
Production Shaft, Crusher, Headframe, Transfer House	Dust	40000 $\frac{lb}{year}$	317 $\frac{lb}{year}$
Yellow Cake Operation	Dust	1126 $\frac{lb}{Year}$	45.5 $\frac{lb}{year}$
Boilers	Solids	1577 $\frac{lb}{year}$	--
	SO_2	158 $\frac{lb}{year}$	--
	NO_2	31540 $\frac{lb}{year}$	--
	Hydrocarbons	6308 $\frac{lb}{year}$	--
	Organic Acids	9462 $\frac{lb}{year}$	--
	Aldehydes	1577 $\frac{lb}{year}$	--
	NH_3	3154 $\frac{lb}{year}$	--

(30) Using data from Applicant's Response to Agency Comments on Draft Statement, November 1973.

TABLE XXIII

AMBIENT AIR STANDARDS IN EFFECT IN UTAH

Standard	Pollutant	Concentration	Sample
State	Particulate	90 $\mu g/m^3$	Annual geometric mean
Federal (Primary)	Particulate	75 $\mu g/m^3$	Annual geometric mean
Federal (Primary)	SO_2	0.03 ppm	Annual arithmetic mean
Federal (Primary)	CO	9.0 ppm	8-hour average not to be exceeded once per year, and 35 ppm maximum for a 1-hour average not to be exceeded more than once per year.

Based upon the measured emission values and yearly emission rates for dusts and chemical effluents, concentrations of dust, at the site boundary in the direction of the prevailing wind, are not expected to exceed 2.4 $\mu g/m^3$. The concentrations of SO_2 and NO_2 should not exceed 4.2×10^{-5} ppm and 0.01 ppm, respectively, in the direction of the prevailing wind at the distance, approximately 800 feet, at which the maximum ground level concentration is expected to occur.

3. Effects of Fuel Oil Effluents on Environment

One of the essential functions of stomata is to regulate evaporation. Therefore, it follows that moisture stress in the leaves due to dry climates will cause stomatal closure. Plants in an arid environment may be more resistant to the SO_2 than plants and vegetation common to areas of high humidity and low evaporation rates. Furthermore, the translocation of SO_2 from leaves of vegetation is less effective than uptake through the root system.

Studies have been conducted that show that sulfuric acid aerosol is only toxic to vegetation under special circumstances. It has been postulated that the small droplets do not wet the leaf surfaces or diffuse through the stomata into the interior of the leaf.

Concentrations of NO_2 on the order of 25 ppm have been identified as causing blades of grain plants and needle tips of conifers to assume a bright yellow color.

The concentrations of SO_2 from the milling operation at the site boundary in the direction of the prevailing wind would be below the sensitivity concentration for numerous plants, i.e., 0.1 to 1 ppm. Injury to vegetation caused by emission of SO_2 and NO_2 is not expected because concentrations of these products are expected to be less than that which will cause injury to vegetation. The effect of the above-mentioned effluents on animals grazing or foraging the area should be of no consequence since cattle have been known to graze on vegetation that suffered 25 percent damage to its leaves by exposure to SO_2 without suffering any ill effects.

4. <u>Effect of Mining and Milling on Ecological Primary Energy Capture of the Area</u>

In desert-life areas the annual net primary productivity has been estimated to be 400 k-cal/m^2/yr. During the life of the project, approximately 120 acres or 4.85×10^5 m^2 will be removed from the terrestrial energy productivity ecosystem. This will amount to approximately 1.94×10^{11} calories per year of operation. After reclamation and restoration procedures are put into effect at the end of the mining and milling, the net primary productivity should return to essentially the same levels that existed prior to commencement of the operation.

5. <u>Effects on Animal-Carrying Capacity of the Area</u>

The applicant's report on the inventory of wildlife resources indicates that the Rio Algom site lies on the edge of the ranges of the mule deer (see Appendix F). Consequently, the operations should have little effect on the deer herd or the carrying capacity of the normal range. Other smaller wildlife species were described as occupying the general areas. However, data on population density for the animals are not available. As a result, the impact on these smaller animals is difficult to assess. However, it is believed that the home range for these smaller animals is much less than that of the larger animals; e.g., cottontail rabbits approximately 14 acres, meadow mouse about 1/15 of an acre. Consequently, the impact on these smaller animals and birds is expected to be more than for the larger animals. After reclamation and restoration procedures are completed, the area will be available for use by the wildlife. Depending upon the types of vegetation used in the reclamation effort, some species changes in the wildlife inventory may occur.

E. ENVIRONMENTAL MONITORING

1. Preoperational Monitoring Program

The preoperational environmental monitoring program consisted of a grid of sample points set on an approximate 2000 foot grid (see Figure 24). At each grid point a composite soil sample was obtained in the immediate area. The composite sample consisted of a set of nine one-pound samples taken at a ten foot spacing on a 30 x 30 foot grid adjacent to an identifiable point. Each nine-pound sample was thoroughly mixed and a one-pound sample analyzed for uranium, radium, and thorium. Approximately two pounds were retained for future reference. Sample points were identified and recorded so that additional samples could be obtained. These samples were taken in May and June 1972. At alternate soil sample stations, bulk vegetation samples were obtained, as shown on Figure 21. The succulent portion of these plants were analyzed for uranium, radium, thorium, copper, zinc, and manganese. Samples were also taken of soil in the drainage area below ore and waste dumps from other mining operations located south of the mine and immediately south of the county road. These soil samples were reported to have indicated a greater activity as compared to the samples taken from the grid.

A baseline air sampling program consisted of four sets of air samples taken at the following locations: La Sal Junction, La Sal, Wilcox Ranch, Redd Ranch at Rattlesnake Pond, Rio Algom well field in Section 19, mine service road entrance, and on the county road in Section 27 southwest of the mine (see Figure 22). This sampling was performed in April and May 1972.

Five sampling stations on the West Coyote Wash drainage basin were established for the purpose of obtaining data for watershed contamination. Figure 22 shows this drainage basin located between the mine and La Sal with sample stations marked 1 through 5. Sample Station No. 4 is a fresh water pond with a well-established fish population. Station No. 2 is on the North Branch of West Coyote Wash and clear of any effluents of the Rio Algom operations, and thus serves as a continuous baseline reference point. These samples were analyzed for pH, dissolved solids, sulfate, nitrate, hardness, sodium, chloride, iron, uranium and total radioactivity. Samples were taken twice per month at all stations, with extra samples taken at Station No. 2 from July 1971 for one year.

Two sets of special water samples were obtained at the water sampling stations on West Coyote Wash and two of the water discharged by the production and ventilation shafts. These sets of special samples were analyzed for uranium, radium, thorium, polonium, and lead. Two of the three originally proposed monitor wells were installed below the dam (see Figure 23). The drilling of the third well was held off pending the determination of its most effective location relative to possible seepage from the tailings dam.

LISBON MINE SOIL AND VEGETATION SAMPLING GRID

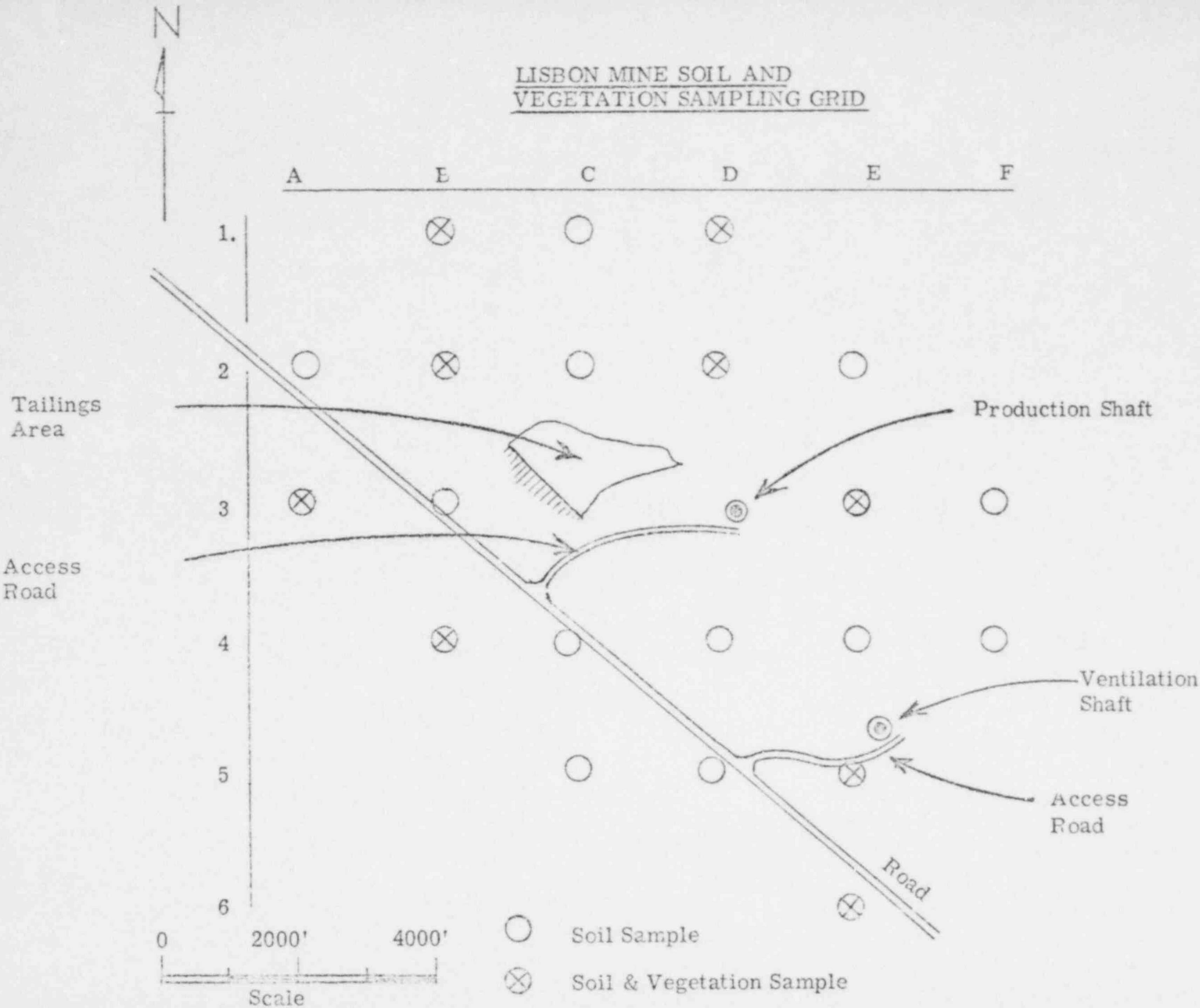
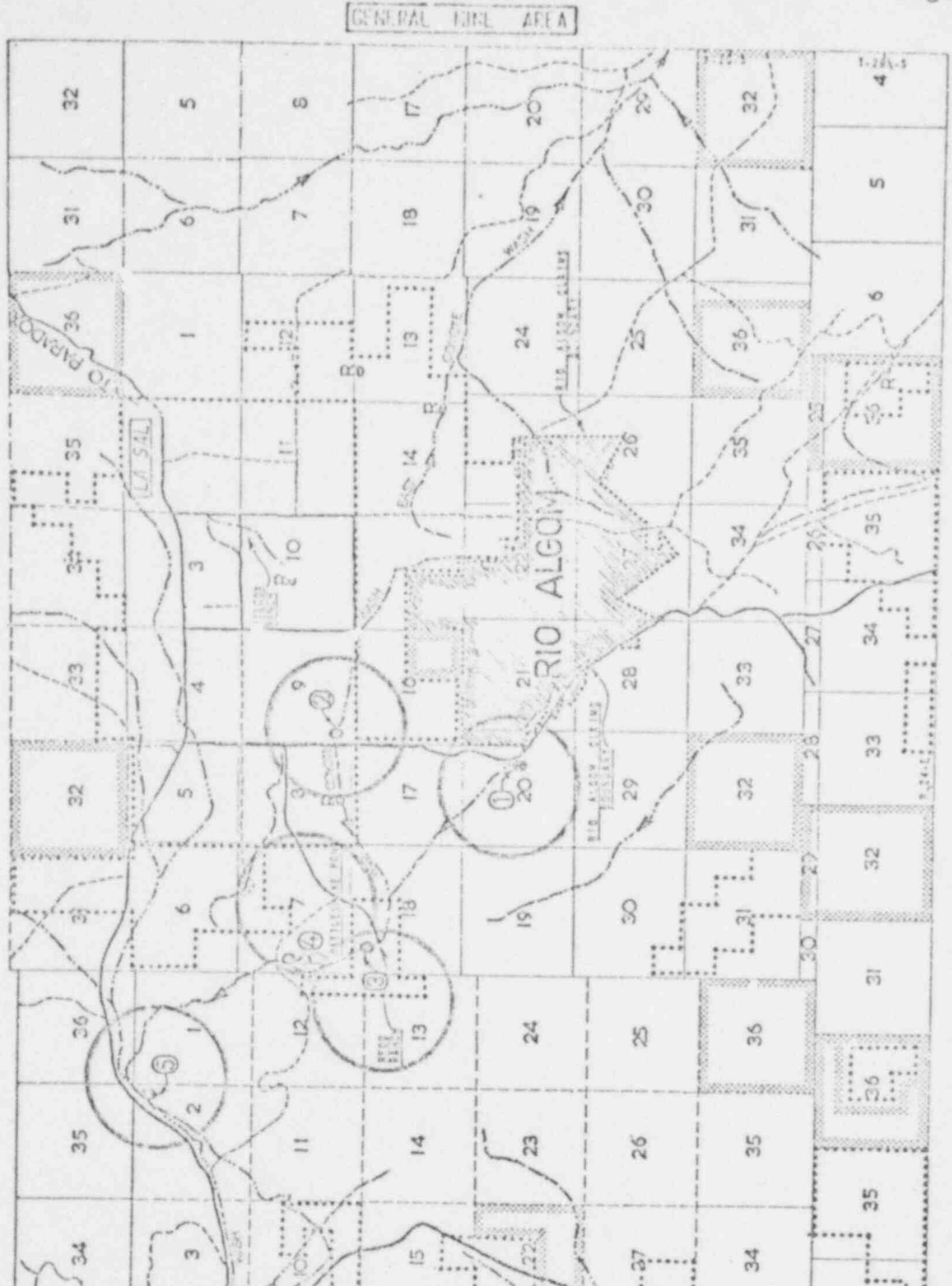
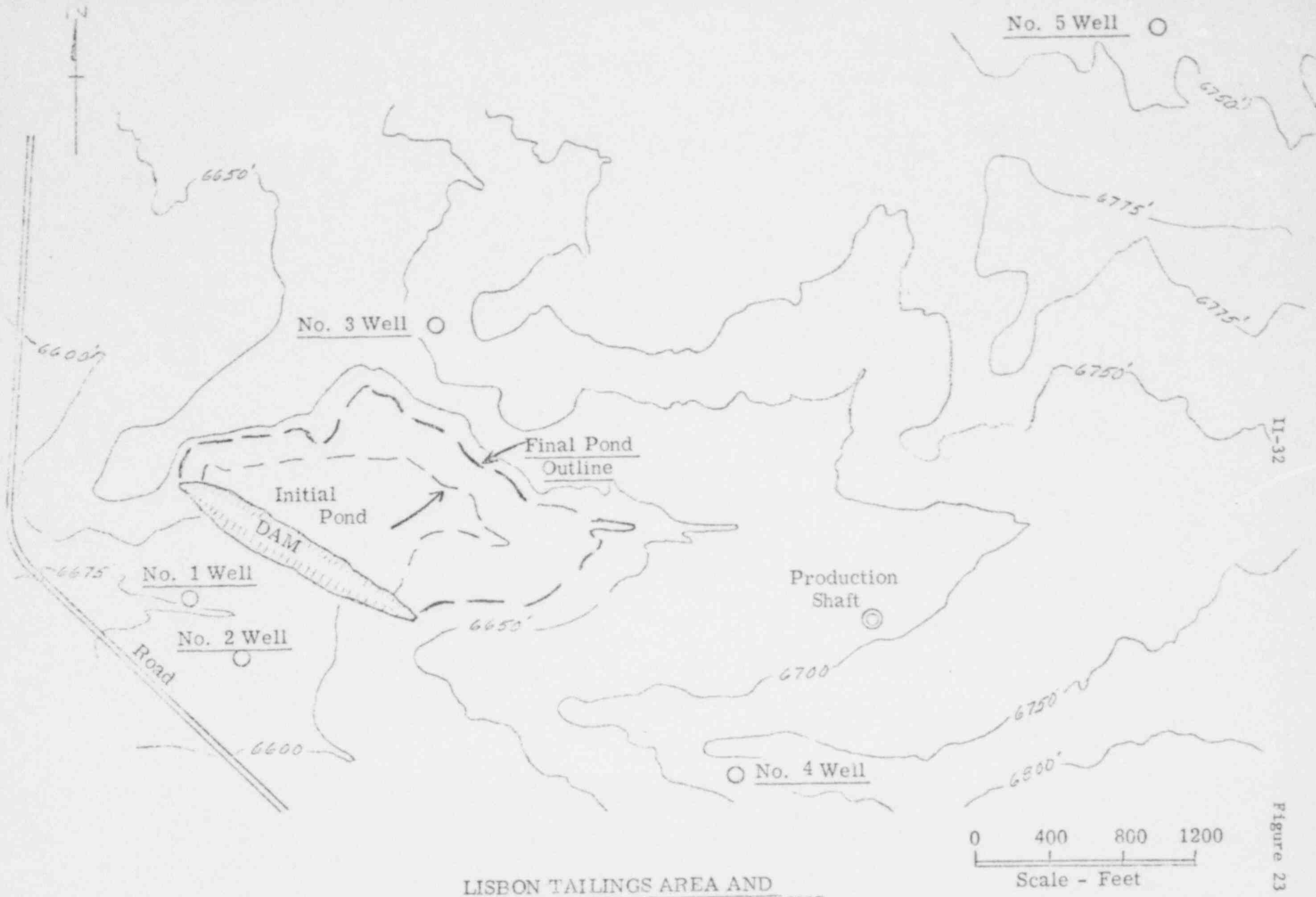


Figure 21



LAND OWNERSHIP, ROADS, DRAINAGE & WATER SAMPLING POINTS

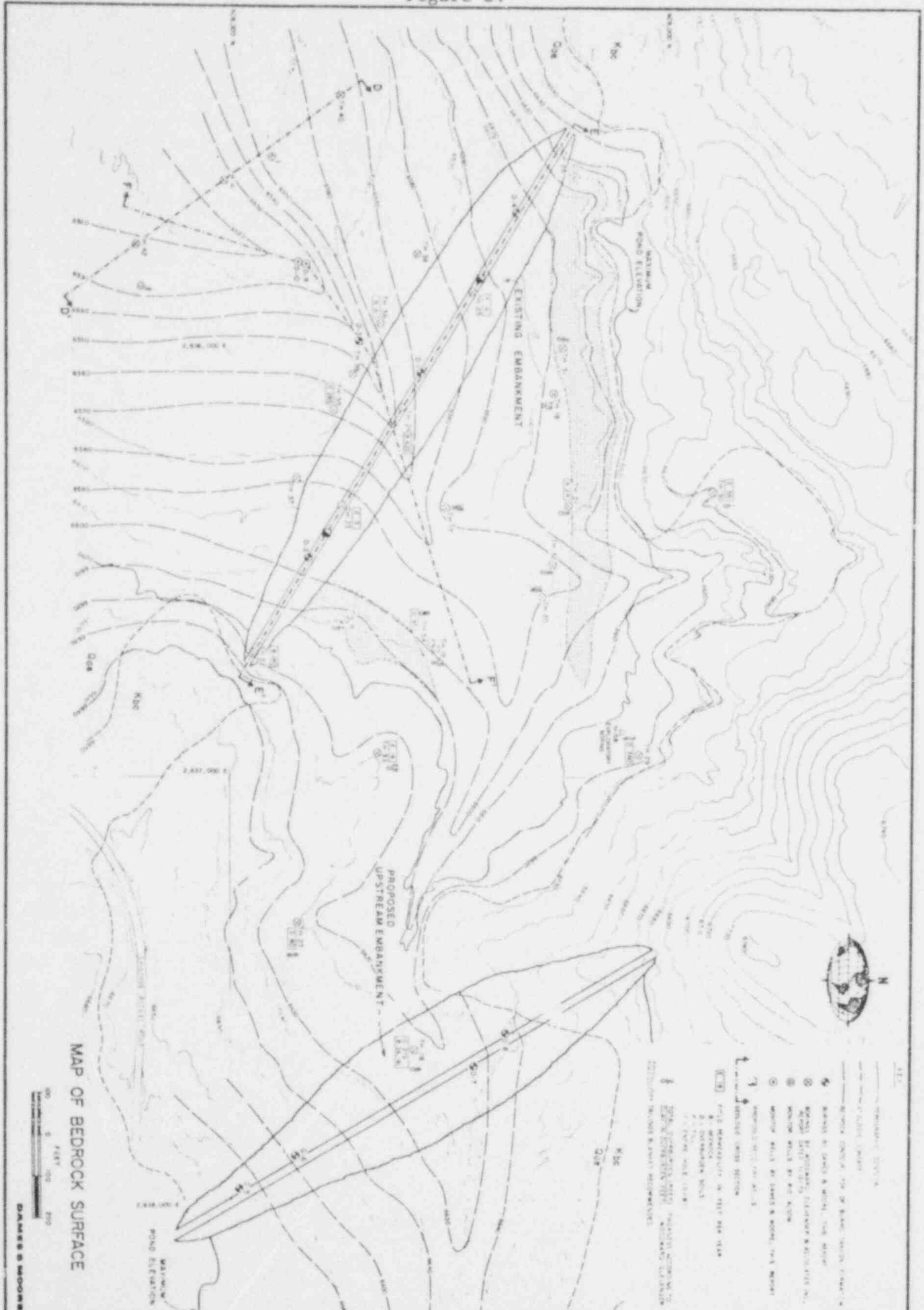


LISBON TAILINGS AREA AND
AND MONITOR WELL LOCATIONS

Figure 23

Figure 24

NEW MONITOR WELLS



Due to delays in getting the contractor on site, only four samples were obtained from each monitor well before plant startup. Two samples were lost in transit from each well about the time of mill startup, but since then four samples per month have been obtained from each well. The original four samples were analyzed for pH, sulphate, chloride and sodium. Because the commercial laboratory to which the samples were sent was not able to do analyses to the required level of detection, all analyses since July 1972 have been carried out in the mill laboratories. Analyses are performed for pH, sulphate, chloride, sodium, uranium, radium, thorium, polonium, lead, and total alpha.

The Bureau of Land Management (BLM) plans to conduct a benthic survey of Rattlesnake pond. However, because of other commitments, the BLM has not yet been able to complete the survey.

2. Operational Monitoring Program

a. Semiannually, soil samples are taken at stations B-3, C-2, C-4, E-2 and E-5, as shown in Figure 21. Two control samples are also taken at points 2 to 2-1/2 miles NW and NE of the mine. In the immediate area of each station a composite soil sample is taken. The composite sample consists of a set of nine one-pound grab samples taken at a ten-foot spacing on a 30 x 30 foot grid adjacent to an easily identifiable point. Each nine-pound sample is thoroughly mixed, and a one-pound sample selected and analyzed for uranium, radium, and thorium. If the samples indicate an upward trend in activity, the points will be re-sampled. If the upward trend is confirmed, the sampling frequency will be increased, the cause determined and corrective action taken to reduce fugitive dust and/or ensure that plant dust control equipment is operating properly.

Vegetation sampling will be conducted quarterly with samples collected adjacent to sampling stations B-2, D-2, D-3 (adjacent to Production Shaft), C-4, E-3, and E-5 (see Figure 21). In addition, two reference samples will be taken at a distance of about two miles from the operation. At each sampling point five-pound samples will be obtained of Sagebrush, Juniper, and Meadow clippings. These samples are analyzed for uranium, radium, and thorium. Analyses for copper, zinc and manganese will be terminated at the end of one year unless high quantities are detected. Should the samples analyzed for radioactivity indicate an upward trend in activity, then the stations will be re-sampled to confirm the trend. Should the upward trend be indicated, adjacent stations will be sampled and the cause of the increase determined and corrected.

On an annual basis two blacktail jack rabbits will be obtained in an area approximately 1000 feet downwind of the plant in relation to the prevailing wind. In order to establish a background level, an additional jack rabbit will be obtained in an area remote from a uranium milling operation. These animals will be analysed for uranium, radium, and thorium in the liver, kidney and femur. Because of biological variation, the data obtained by only sampling two jack rabbits per year should be carefully considered before drawing environmental conclusions.

From the time of start of the mill in June of 1972 until September 1972, 8 to 10 ambient air samples were obtained monthly. For the months of October to December, 4 to 6 samples per month were obtained and since then two samples a month have been taken and will continue to be taken twice per month over the life of the operation. Samples are obtained at distances of approximately 500, 1500 or 3500 feet downwind from the plant, the distance and direction depending on the strength and direction of the wind at the time the sampler is set out. While the samples are being obtained, readings of wind speed and direction are taken at the mine, and the averages recorded. A high-volume air sampler is used to collect a sample on an 8 x 10 inch filter over a period of 8 hours. All samples are weighed to determine the total dust per cubic meters of air and analyzed for the uranium. Quarterly ambient air samples have been obtained over a 24-hour period at the Redd Ranch located 2-1/2 miles northwest of the mine, the Wilcox Ranch located 2-1/2 miles northeast of [illegible], at La Sal and at La Sal Junction (see Figure 22), [illegible] will continue to be taken quarterly for the life of the operation. Wind strength and direction are recorded at the mine while the samples are being taken. In addition, monthly isokinetic dust samples are being collected in the discharge from the filter system of the transfer house, crusher house, headframe, yellowcake scrubber and yellowcake dust filter. These samples are analyzed for dust and uranium. Radon daughter samples are taken monthly of the mine air discharged at the ventilation shaft and semiannually radon daughter samples are taken approximately 2000 feet downwind from the ventilation shaft. Samples are also taken monthly to determine the concentration of dust radon daughters and uranium in the air discharged from the ventilation shaft.

Twice per month sampling of the West Coyote Wash water monitoring stations (see Figure 22) was continued until July 1972. Sampling was then reduced to quarterly. Samples were analyzed for sulphate, uranium, radium, and thorium. Water samples from the ventilation shaft are taken every second month and analyzed for pH, total dissolved solids, hardness, sulphate, nitrate, chloride, iron, uranium, radium, thorium, polonium, and total alpha. Production shaft water is also sampled every two months and analyzed for: pH, total dissolved solids, sulphate, sodium and uranium. Every six months analyses are performed for radium, thorium and polonium. When the treatment facility for radium removal is in operation, samples will be taken weekly from the discharge and analyzed for radium. Every two months complete analyses will be made as for the ventilation shaft samples.

The sampling program for the two monitor wells, Nos. 1 and 2, shown on Figure 23 close to and below the tailings reservoir, is accomplished on a weekly basis. Two exploratory drill holes, Nos. 3 and 4, north and southeast of the tailings area, are being sampled monthly. Monitor well No. 5, also an exploratory drill hole, is some distance northeast of the tailings area and is sampled monthly. The samples taken from wells Nos. 1 and 2 are analyzed weekly for pH, sodium, and uranium, and a composite of these samples analyzed monthly for sulphate, uranium, radium and thorium. Samples from the other three wells are analyzed for pH, sodium, uranium, sulphate, radium and thorium. The monitoring frequency and analysis of the samples from the wells is to be changed in accordance with recommendations by the applicant's consultant. These changes will have to be reported to and approved by the AEC. These changes are shown in Table XXIV. As shown by this table, several new wells are proposed and identified as D-1 through D-10. Their locations are shown in Figure 24.

The applicant's consultant states that monitor wells 1 through 5 were placed inside the Rio Algom property line to detect contamination early enough so that corrective action can be taken before excessive concentrations are able to move off-site. Monitor wells Nos. 1 and 2 are located approximately 500 feet southwest of the tailing dam. Well No. 1 was reported to encounter bedrock at a depth of 15 feet. Well No. 2 penetrated 60 feet of sandy overburden above the Burro Canyon contact in

TABLE XXIV

MONITOR WELL PROGRAM

	Water Level	pH	U(nat)	Ra-226	Th-230	Na	SO_4
MW 1	M	W	W,M_c	M_c	M_c	W	M_c
MW 2	M	W	W,M_c	M_c	M_c	W	M_c
MW 3	M	M	M	M	M	M	M
MW 4	M	M	M	M	M	M	M
MW 5	M	M	M	M	M	M	M
D 1	M		M	M			M
D 2	M		M_c	M_c			M_c
D 3	M	M_c	M_c	M_c			M_c
D 4	M	Now dry; check weekly for water level, then monthly for Ra					
D 5			No sampling				
D 6			No sampling				
D 7	M		M_c	M_c			M_c
D 9	M	Now dry; check weekly for water level, then monthly for Ra					
D 10	M		M_c	M_c			M_c
"Outside Sources" Monitor Wells		initially, two samples one week apart, then monthly composites thereafter, on Uranium, Radium and SO_4					

W = Weekly

M = Monthly

M_c = Monthly composite of weekly samples a bedrock depression. Both wells were drilled 15 feet into the Brushy Basin shale, cased the full length and perforated from the lower 10 feet of overburden to the bottom of the well. The other three monitor wells Nos. 3, 4, and 5 are reported to be former deep exploration borings which have been cased in the upper portion and plugged below the Burro Canyon sandstone. The sites for these wells were chosen north, northeast and southeast of the site on the premise that movement of seepage from the tailings pond would be omni-directional above the main groundwater table. The applicant's consultant states that the movement would be more responsive to bedrock structure in this zone, which slopes generally northeastward into the East Coyote Syncline from the northern sector of the property, with local variations in flow. Additional monitor wells have been installed; two, D-9 and D-10, below the present dam and three, D-5, D-6 and D-7, at the proposed upstream site. In addition, three recent borings, D-1, D-2 and D-4, along the existing dam axis and one boring, D-3, at the toe of the dam, are cased and used to monitor the phreatic line. Monitor well D-9 was drilled 10 feet into the Burro Canyon sandstone and D-10 was drilled within 20 feet of D-9 and taken through the Burro Canyon sandstone approximately 10 feet into the Brushy Basin shale. The overburden and upper bedrock region were sealed off to isolate possible seepage in this zone from groundwater flowing in the lower Burro Canyon foundation. The lower 15 feet of sandstone is described as saturated. Further details are presented in Appendix D, Report of Consulting Services, Dames & Moore Job No. 7144-002-06, pages 1-A through 1-A-7 and Plates A-1A through A-5.

As an alternative to the Bureau of Land Management benthic survey of Rattlesnake Pond, on a quarterly basis samples of water from Rattlesnake pond will be analyzed for selected metals in addition to the current chemical analyses, i.e., Pb, Zn, Ni, Co, Fe, Mn, Cu, Al, Na, K, Ca, U, Mo, Ba, N, NO_3, NH_3 and Ra.

During the AEC Regulatory inspection on January 3 and 4, 1973, the inspector noted that from a selective examination of representative records of environmental monitoring data, all values were found to be less than the AEC unrestricted area Maximum Permissible Concentrations. In the applicant's response to the agency comments on the draft statement dated November 1973, monitor well data indicate that as of September 1973 no sample exceeded the AEC unrestricted area Maximum Permissible Concentration. However, on several sampling periods the concentration of Pa-226 in monitor wells 1, 2, 3, 4, D-1 and D-2 have exceeded the State of Utah Standards for Radium. In all cases, the reported SO_4 or Cl concentrations are less than the 4500 to 7000 mg/l that is considered safe for continual use for watering by livestock.

The applicant's consultant has suggested the possibility of groundwater contamination occurring by surface run-off from other mining operations in the area, and has proposed three other monitor wells situated north of and parallel to the county road which runs in a southeasterly direction. This proposal is being evaluated by the applicant.

The applicant will be required to report any discharges of water or air to the environment which are in excess of State or Federal agency standards, i.e., State of Utah, EPA and AEC - Regulatory Operations. In addition, a uranium mill is designated a priority 2 item and therefore the applicant's environmental monitoring program will be audited annually by the Commission's Directorate of Regulatory Operations during routine inspections of the applicant's milling activities. The results of findings during such audits will form the basis for Regulatory action on a timely basis if corrective action or change should be required.

F. UNPLANNED AND NON-ROUTINE EVENTS

The potential environmental impact associated with three serious types of accidents which are most likely to occur in connection with the proposed activities have been identified. They are a tailings dam failure, a rupture of a process vessel, and a transportation accident involving the shipment of the uranium product.

There are three potential types of accidents which could occur in connection with the tailings dam. Two of these are related to natural phenomena; i.e., failure due to flooding and failure due to an earthquake. Failure to a lesser degree could also result from an equipment malfunction (such as the rupture of a tailings distribution line) or operating error. Failure due to an earthquake is extremely remote since the site is in the Zone One, "minor damage" seismic risk category. Test borings and evaluation of soil parameters by the applicant's consultant indicate that the dam would have adequate stability under a seismic shock of 0.05 times gravity. The minimum factor of safety was found to be 1.3 for the maximum pool elevation. This finding was concurred in by an AEC consultant. Failure by flooding is also considered to be extremely remote in view of the reasons presented in Section II.A.10 of this report, and because of the semiarid climate of the area, and the proposal by the applicant to provide an increase in storage capacity (27 acres) by building a second retention system as mentioned in Section II.A.10 of this report.

An operating error or equipment malfunction could occur but the entire system will be inspected daily by the applicant, thereby minimizing the possibility of the type of occurrence.

The formation of waves in the pond by wind is not believed to be a cause for overtopping the tailing pond because of the required 10-foot freeboard. Three factors influence the size of the waves caused by wind: velocity of the wind, duration of time the wind blows, and the fetch (extent of the open water across which the wind blows). Discounting the statistical chance for the formation of a super wave, a wind of 20 knots must blow along a minimum fetch length of 75 miles for approximately 10 hours to generate a wave height of 10 feet (average of the highest one-tenth of the waves).[(31)]

In protected waters with small fetches, such as rivers, small inland lakes, etc., waves produced by winds are not likely to build to such a magnitude. Wind set up for the tailing ponds is not expected to be a concern for overtopping the dam.[(32)]

Should an accident occur, the stored solids will be transported down the local drainage system for a relatively short distance and be deposited in accordance with the laws of sedimentation. Liquids will also flow down the drainage system an undetermined distance until they are lost by seepage and evaporation. However, because of the area and quantity of liquid involved, it is believed that waste liquids would not reach any flowing stream. Should such an accident occur, the AEC must be notified

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(31) Waves and Beaches, the dynamics of the ocean surface, Willard Bascom, Doubleday & Co., Inc., 1964.

(32) Water-Resources Engineering, Ray K. Linsley and Joseph B. Franzini, McGraw Hill, 1972.

and informed of the approximate time of the accident, estimates of quantities of liquid and solids that have escaped, and the methods being used to contain and clean up the spill. The environmental impact from such an event is believed to be small. The Utah State Department of Highways in a letter to Rio Algom, dated June 14, 1973, stated that they could see no problem that would impact the highway system or the highway user (see Appendix L).

Probably the most significant accident that could occur would be a rupture or fire in the yellowcake drying and packaging system. Investigations, by AEC Regulatory Operations, of fires that have occurred in uranium mills indicate that dispersion of uranium was negligible. It is therefore believed that the environmental effect from such an event would be slight. If such an occurrence were to occur, the surrounding area would be surveyed for uranium and contaminated soils removed and recycled through a mill circuit, thereby minimizing any environmental impact.

If in the course of operations bulk container of toxic chemical were to rupture, the content from inside tanks would be contained within the mill sumps. To contain spillage from tanks located outside the mill a retaining sump has been installed. This sump will contain the volume of the largest tank. In the event the sump cannot contain the total volume, the applicant states that the drainage culvert at the perimeter road can be plugged to create a back-up retaining sump from which any liquid could be transferred into the tailings basin.

The exact method of transporting and routing of the product have not been worked out as of the date of the applicant's submittal of their response to agency comments on the draft statement. However, in September to November of 1973 some 8 cars were to be shipped. In an earlier statement it was estimated than an average of 1 shipment of concentrate per week from the mill would be required. The vehicle transporting uranium concentrates from the mill to a UF_6 refinery could be involved in an accident. In 1969 the accident rate for hazardous materials shipments was 1.69 per million vehicle miles. Based on the rate and the average public highway truck shipment distance of 700 miles, a shipment of non-enriched material might be involved in an accident once in 16 years. The severity of an accident would determine the amount of concentrate (packaged in 55 gallon 18-gauge drums) which might be released. Inasmuch as the only radioactive material that would be involved is natural uranium which has a low radioactive specific activity, no severe radiological safety hazard is possible and the environmental impact from such an accident is expected to be small. The area surrounding the accident would be surveyed and any concentrates or contaminated soils removed and returned to the plant. The possibility of an accident occurring in a watershed has been estimated to be one accident in 2.25×10^3 years. The following rational was used in deriving this value. Approximately 15 bridges with flowing water were counted over a 44-mile stretch of U.S. Route 15 north of Frederick, Maryland. Each bridge was approximately 100 feet in length. Assuming the average distance of a shipment to be 700 miles, there would be 238 bridges crossed for a total of 5 miles of bridges. Utilizing the accident frequency of 1.69 per million vehicle miles, the number of accidents occurring in 5 miles of bridges would be 8.45×10^{-6}. Stating it another way, one accident could occur in 5.92×10^5 miles. Assuming that one shipment per week will be required, then 260 miles of bridges will be traversed in one year. The number of accidents that could occur in one year over the 260 miles of bridges would be 4.39×10^{-4}, or an accident involving a truck shipment with an active watershed will occur once in 2250 years. In Rio Algom's response to agency comments on the Draft Statement, November 1973, Rio Algom states that a shipment during September to November 1973, material will be trucked about 60 miles to a rail siding for transport. During the truck shipment the only water crossed, other than dry drainage ditches, is the Colorado River. Consequently, the accident frequency of one in 2250 years is conservative because of a lesser number of watercourses crossed and a transfer to a less hazardous form of transportation, rail haul, which has an accident frequency of only 0.8 accidents per million rail car miles.(33) Should such an accident occur, the applicant will make every effort to remove the material from the waterway. Monitoring of the waterway will be conducted to ensure that the cleanup has been effective in reducing the concentration to a safe level. In addition, the AEC must be notified of such an accident, and depending upon the circumstances, more stringent measures could be prescribed. For example, the Atomic Energy Commission maintains Regional Coordinating Offices which will receive telephone requests for radiological emergency assistance 24 hours a day and will initiate the support most appropriate for the incident conditions. Many of these requests for assistance are handled directly by the State Radiation Control Officers or one of the interstate nuclear boards.(34) However, should an incident be judged by one of these agencies to be beyond their capability, the AEC would be called upon for assistance. Depending upon the circumstances of the emergency call, the Regional Office can react by dispatching a radiological emergency assistance team to the scene of the incident to: identify and assess the hazards; advise on emergency operations to protect the health and safety of the public;

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(33) Environmental Survey of the Nuclear Fuel Cycle, November 1972, USAEC Fuels and Materials, Directorate of Licensing.

(34) Radiation Emergency Assistance, "A Guide to Available State and Federal Radiation Emergency Response Resources, in the Western States." Western Interstate Nuclear Board, P. O. Box 15038, Lakewood, Colorado 80215.

provide or prescribe procedures which will minimize injury or deleterious effects on the surrounding environment; and to generally provide assistance as may be necessary. In addition, technical, scientific and medical advice will be available on matters pertaining to health and safety problems which may be created as a consequence of the incident.

If the incident were found to be a hazardous situation or have potential for expanding into a highly undesirable situation, signatory agencies to the Interagency Radiological Assistance Plan (IRAP) could be called upon for additional assistance. The Federal IRAP is an agreement entered into voluntarily by Federal agencies of the United States Government. The main purpose of the IRAP is to establish an organization and operating arrangements to be used in the event of a major accidental release or loss of control of radioactive material which would seriously endanger the public health or safety. Through the IRAP, it is expected that Federal agency resources will be able to: mitigate the accidental radiation exposure of the public, minimize the spread of radioactive materials into the environment, and carry out countermeasures appropriate to the control and removal of radiological hazards. In addition to the AEC, there are 10 signatory Federal agencies available for providing every kind of needed manpower, equipment, facility and service capability applicable to the emergency. The total number of personnel, equipment and special services from which assistance can be selected is quite extensive.[35] For example, there are about 700 AEC and AEC contractor personnel on the radiological assistance team rosters. In addition to these, AEC plants and laboratories employ thousands of scientific, engineering, technical and administrative personnel who could be assigned duties in a major emergency. These personnel are located at the various AEC sites over the United States. The Military Services have about 2800 trained radiological emergency team personnel located at over 300 domestic sites and 134 overseas sites. Approximately 3500 additional military personnel are trained in chemical, biological, radiological or medical emergency procedures. Under the Civil Defense program over 132,000 radiological defense radiation monitoring personnel have been trained to operate radiation meters at over 68,000 Civil Defense radiation monitoring stations. Between the U. S. Public Health Service and the Environmental Protection Agency there is an estimated 900 personnel trained for radiological emergencies. Other IRAP signatory agencies have various numbers of specialists and types of equipment and services that could be used in radiological emergency operations. These agencies will respond at the request of AEC Regional Coordinating Offices. They may also respond independently in accordance with their own procedures if they receive the initial request for assistance. State radiation control, civil defense, health and police agencies who receive requests for emergency assistance have, through the Office of the AEC States Agreement Branch of the Directorate of Regulation, been provided plans and procedures for handling radiological emergencies and initiating the requests for Federal assistance.

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(35) USAEC Document, August 1973, Radiological Assistance Program (Origin, Organization, Operation and Objectives).

That the AEC Radiological Assistance Plan is operative and not merely a paper instrument has been demonstrated on several occasions in which the AEC has responded to calls for assistance. An example which exemplifies the degree of involvement of the AEC is an incident involving a transcontinental shipment of 10 curies of radioactive methyl iodide from an East Coast laboratory consigned to a Western State. This incident required the activation of several Regional Radiological Assistance Teams. The details of how the AEC responded to this incident have been reported in the June 1967 issue of the Health Physics Journal.

G. RECLAMATION AND RESTORATION

The State of Utah does not have surface mining or mined land reclamation laws.* However, when the mine operations are terminated, the mine entrance will be sealed with a concrete slab set on the concrete shaft collars. The tailings pile will be graded, covered with earth and topsoil and seeded. Approximately 45 acres will be involved. The downstream face of the present dam has been re-seeded and as of August 1973 it was reported to be covered with grasses (15 to 20%) and annual weeds (65 to 70%) for a total coverage of about 80 to 90%. The seed mixture selected for the tailings area on cessation of operations will be based on the advice of the Bureau of Land Management or the Department of Agriculture as being most suitable for the area and conditions. The applicant has stated that if vegetation has not become sufficiently well established on the face of the dam at time of termination, the slope of the dam will be lowered to a more stable angle before re-seeding. The applicant has stated that in order to reduce radiation from the tailings to acceptable levels approximately 18 inches of soil will be placed over the pile. Depending upon the condition of the tailings pile, i.e., undisturbed and unsaturated soil or wet soil, theoretically a hundredfold decrease of radon concentration could be expected to occur through distances of 9 feet to 1/3 foot. Consequently, the thickness required will be determined by tests at closedown. Radiation levels around the reclaimed tailing basin at Monticello, a former operating mill, have been reported to be near background readings. The tailing basin reclamation will be initiated as soon as an area of the tailing pile surface is in a condition that will permit the use of equipment necessary to accomplish the stabilization and is in a state that will accept the stabilization procedure. The basin will be protected from major amounts of runoff by the diversion system described in an earlier part of this report.

Stabilization procedures described by the applicant have been found to be effective at other sites as reported by Mr. Ludeke of the Pima Mining Company and others at the International Tailing Symposium in Tucson, Arizona, 1972. If the applicant were to encounter difficulties in establishing an adequate ground cover for the area, several techniques are available to help overcome the problem. These methods usually consist of properly preparing the area for seeding by evening out the

*On May 14, 1975, the Utah Division of Oil, Gas, and Mining became the responsible agency for reclamation and stabilization of mine and mill sites within the State under the "Utah Mined Land Reclamation Act of 1975."

slopes, breaking up the soil and applying barley straw and compacting with a sheeps foot roller at the rate of 5 tons per acre. This insulates against heat and cold and breaks up rain drops and prevents erosion. The application of sewage effluent either from a dairy feed lot or municipal sewerage at 1000 to 1500 gallons per acre has been reported used successfully as a fertilizer. During the growth period of the new vegetation animal food stracegically placed around the area will assist in keeping birds and animals from eating seedlings. Other alternative methods are available for stabilization. A few of these techniques and associated costs are identified in Table XXV.[36] The costs shown are for stabilizing a tailing pond of approximately 80% pond area and 20% dike area. Dikes cost approximately 25% more to stabilize.

TABLE XXV. STABILIZATION COSTS

Stabilization Procedure	Cost/Acre
1. Straw harrowing	$ 40
2. Straw harrowing with a 12-inch depth of soil cover	1,700
3. Chemical	250 to 750
4. Vegetative procedures, hydro seeding	200
5. Vegetative procedure, 12-inch soil cover and mechanical seeding	1,750

In those areas where irrigation may be necessary, new techniques are available which would allow the application of water at low rates over a long period of time.

When the applicant submits a request to terminate the license, the stabilization and restoration techniques will be closely reviewed. At that time, and if needed, alternatives similar to those just mentioned would be prescribed prior to terminating the license.

(36) Notes from the First International Tailings Symposium, Tucson, Arizona, October 31, November 1, 2 and 3, 1972.

Rio Algom has estimated the cost of the reclamation to be on the order of \$96,000. Using the large value of \$1,750 per acre from Table XXV as the cost of the stabilization, it is seen that the \$96,000 estimate is realistic for the 45 acres. To ensure a satisfactory performance of the reclamation, a bond of \$201,000 will be posted by Rio Algom Corporation. This amount includes escalation of 5% to 1980. However, the cost of reclamation will be determined to a large degree by the thickness of soil cover required. Depending upon the results of the "as low as practicable" studies for uranium mills (see Section II.G) and the amount of work required to maintain the tailings area for a period of 50 years, the \$201,000 bond would be insufficient.*

Prior to the termination of milling activities, the licensee will be required to apply for an amendment to the license requesting permission to terminate the license. In the request for the amendment, the applicant will be required to describe in detail his decommissioning procedures and perform a radiation survey of the facilities. Prior to the release of the premises or removal of the buildings and foundations, the licensee must show that radiation and contamination levels are within the limits of the AEC guides. Following the review of the report, the AEC will consider visiting the facility to confirm the survey. Depending upon the circumstances, the applicant may be required to submit an environmental statement on the decommissioning operations. This decision will be made by the AEC prior to termination of the license. Depending upon the results of the reclamation and stabilization procedures at shutdown, the construction of a fence around the tailings pond area and permanent warning marker will be evaluated and decided upon.

Upon termination of the license, the land on which the tailings are stored will be subject to the following restrictions.

- The holder of the possessory interest will not permit the exposure and release of the tailings material to the surrounding area.
- The holder of the possessory interest will prohibit erection of any structures for occupancy by man or animals.
- Sub-division of the covered surface will be prohibited.
- No private roads, trails, or rights-of-way may be established across the covered surface.

In order for Rio Algom to obtain a full term license, Rio Algom will be required to initiate and complete patent procedures. Consequently, the encumbrances mentioned above, including annual maintenance and repair of the covering of the tailings piles, diversion ditches, fences and environmental monitoring surveys, will be binding on the applicant while

*By letter dated September 17, 1974, Rio Algom advised the AEC that the cost of the abandonment work had escalated to \$238,000 in 1980, Appendix U.

it holds the land on which the tailings piles rest, and on its successors thereafter, for a period of 50 years or until such time prior to the expiration of the 50-year period as government regulations are instituted to control disposition of uranium mill tailings. The 50-year restriction is an arbitrary figure, but it is believed to be an adequate time period for the tailings problem to be fully studied and resolved.

III. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED

The environmental effects which cannot be avoided are:

- The release of small quantities of radioactive and non-radioactive materials into the environs surrounding the plant.
- The relocation of approximately 400,000 tons of waste rock from the mine will result in a slight permanent change in the local topography.
- The creation of two stabilized tailings retention systems covering about 45 acres total.
- The withdrawal of approximately 120 acres of land from other possible uses for the next 8-10 years.
- The disturbance of the local ground water system due to the mining operation for a period of 8-10 years.
- A temporary removal of terrestrial energy productivity from the ecosystem of approximately 1.94×10^{11} calories per year of operation.
- Temporary shifting of an undetermined number of smaller wildlife species into adjacent surroundings.
- Possible increase in radioactivity in the underlying underground waters until the sealing of the tailing pond progresses with the emplacement of tailings fines.

IV. ALTERNATIVES TO THE PROPOSED ACTION

A. PROCESSING OF THE ORE AT AN EXISTING FACILITY

The ore from the Rio Algom mine could be milled at an existing mill at another location. The nearest available mill that can treat the ore is approximately 34 miles distant. The applicant has advised that there is an economic advantage inherent in the new mill as follows: toll charges to Rio Algom by a custom mill, allowing for 3% escalation, amount to $12.86 per ton treated, compared to an estimate of $4.50 per ton processing for the applicant's mill. The after-tax saving was reported to be $1,200,000 per year. With the capital cost of the mill being $4,600,000, the pay-back period resulting from the above operating savings is nearly 4 years. Using a 10% rate of return on capital, the break-even point in present value terms should be achieved by 1977. See Table XXVI for data supplied by Rio Algom on the economics of constructing the mill.

Other considerations not in favor of electing this alternative are:

- Shipping the ore to another site by truck would create a cost to the State for increased highway maintenance caused by heavy trucks.
- There would be the possibility of increased highway accidents due to the increase in traffic.
- Interference with tourist traffic in a scenic area.
- Annoyance to citizens of Moab due to increased truck traffic through the city.
- Substantial increase in cost to the company for transportation. The unit cost for transporting the ore is on the order of five cents per ton-mile.

B. ALTERNATE MILL PROCESS

The applicant's ore is alkaline in character which makes the carbonate leach process the most desirable from an engineering standpoint. An alternate acid leach process for this ore would result in significantly

TABLE XXVI

ECONOMICS OF CONSTRUCTING MILL

CASH FLOW
$'000

INFLOWS	1972	1973	1974	1975	1976	1977	1978*
Before tax savings	970	1770	1770	1770	1770	1770	1770
Taxes							
State/federal	260	480	480	480	480	480	480
Property	50	90	90	90	90	90	90
Total Tax	310	570	570	570	570	570	570
After tax savings	660	1200	1200	1200	1200	1200	1200
Present value (10%)	629	1040	946	860	782	710	646
OUTFLOWS							
Mill & Surface Plant Equipment	4600						
Present value	4492						
Present value net Cash Flows	(3863)	1040	946	860	782	710	646
Cumulative p.v.	(3863)	(2823)	(1877)	(1017)	(235)	745	1121

* Savings actually extend at $1770 p.a. to 1981 when reserves are depleted.

Assumptions

1. Capital costs for Lisbon Mill and associated facilities $4,600,00.

2. Savings compared to custom milling:

Direct:	$ 8.36/ton milled	
Transport:	1.74/ton milled	
Total	$10.10/ton x 175,000 tpa = $1,770,000/yr.	

3. Taxes

Federal and State income tax:	27%
Property tax (income portion):	5%
Tax applied against savings	32%

4. Tons milled — Tons x 'ooo

1972	1973	1974	1975	1976	1977	1978
96	175	175	175	175	175	175

5. Mine life = 10 years.

higher costs for chemicals. The acid process would require the use of about four times the quantity of water used in the carbonate leach process and would also result in more contaminants in the tailings effluent.

C. ALTERNATE TAILINGS STORAGE

Though underground mining practice may include the return of classified tailing sand to the mine to fill voids and resist the collapse of openings, or to serve as a working floor as mining progresses upwards in an ore body, the disposition of the tailing pile by this technique is not considered at thi time to be an alternative t the proposed surface storage for the following reasons. Classification is a prerequisite to this practice so that the material placed in the mine will drain quickly, otherwise hydrostatic pressure buildup may become a hazard. Rock doubles in volume when crushed and ground, and therefore only about 50% of the total quantity of tailings could be disposed of in this way. Safe mining practices almost always specify that only the course sand fraction be returned to the mine because the coarse fraction promotes the consolidation of the deposits. The fine fraction, which contains the reactive chemical constituents and would remain in the tailing pile, usually remains semi-fluid for extended periods of time. This situation would create more difficult impoundment procedures, add to the difficulties of obtaining a vegetative cover, and increase the length of time needed before restoration procedures could proceed on the remaining pond. Moving of the tailing pile may also create an undesirable radiation source term and cause workers and the environs to be exposed to dust and released radon gas. Finally, the milling process has probably altered the chemical form of the radioactive constituents which may make it more soluble in natural underground waters than the radioactive material in the original ore, thereby creating a potential for contaminating the underground aquafier.

> "The Commission is considering new and alternative methods for disposition of mill tailings and is presently engaged in a project with one of the national laboratories to develop information which can be used by the Directorate of Regulatory Standards for formulating 'As Low As Practicable' guidelines for effluent releases from uranium mills. Included in this project is the development and evaluation of various liquid and solid radwaste treatment systems for uranium mills. The alternatives being studied for disposal of solid waste include among other things, the return of the tailings to the mines."

D. ALTERNATE EQUIPMENT AND OPERATING PROCEDURES

Additional ventilation and air cleaning equipment and modifications in operating procedures (such as the elimination of ore blending) might result in a reduction in the amount of effluents escaping from the mill. However, the applicant states that the dust control equipment for the production shaft loading and dumping points, the conveyor transfer house, and the crushing and screening plant have been designed using the principles contained in the 1970 edition of the "Industrial Ventilation Manual of Recommended Practice, American Conference of Government Industrial Hygientists," and that this equipment will maintain dust emissions to less than that required by emission standards, i.e., 0.03 grains of dust per cubic foot of air. Additionally, the equipment is suitable for use in below freezing climates in unheated environments. The equipment used by the applicant is that which is usually used for medium to heavy dust loads. Based upon these facts, the applicant's dust emission control procedures are considered to be consistent with the present state-of-the-art in uranium milling technology.

E. SUBSTITUTE ENERGY SOURCES

The chairman of the Atomic Energy Commission in an interview with the Associated Press[37] has proposed that the nation undertake a government-industry program to produce substitute fuels. The program would be over and above a five-year energy research and development program recently proposed.

The five major tasks of the program would be to:

- Conserve energy by reducing consumption and conserve energy resources by increasing the technical efficiency of conversion processes.
- Increase domestic production of oil and natural gas as rapidly as possible.
- Increase the use of coal, first to supplement and later to replace oil and natural gas (develop synethetic fuel from coal).

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(37) Washington Star News, Sunday, January 13, 1974, Section A.

- Expand the production of nuclear energy as rapidly as possible, first to supplement and later to replace fossil energy.

- Promote to the maximum extent feasible the use of renewable energy source, hydroelectric, geothermal, solar, fussion and central station solar power.

In addition to the above proposed alternatives, the development of shale oil is reported to be able to produce 600 billion barrels in the shales on government land. There are other alternatives such as gasifying and liquefying coal, produce wood alcohol from vegetable materials as a substitute for gasoline in automobiles, wind driven plants, tidal energy and thermal energy of water.

These alternatives may be expensive and may impose environmental impacts attendant to the alternatives. However, if the price for petroleum continues to escalate, these sources may become economical.

If a major effort is mounted in developing these alternatives, it has been estimated that by the year 1980 a significant supply of energy from these sources could be expected. Until these alternatives can be fully developed to the point where they are marketable for use by the consumer, the uranium output from the Rio Algom facility will help supply the demand for energy. The applicant has stated that virtually all the production from the Lisbon mine is dedicated under long-term contract to the Duke Power Company of Charlotte, North Carolina, and that the Lisbon mine and mill will contribute about four to five percent of the total national supply of uranium concentrates at the current national level of production. Consequently, licensing of the facility will allow a source of energy in the interim period while other sources are being developed.

V. RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The local short-term effects of the proposed activities are those associated with the construction and operation of any large ore milling facility. Releases of radioactive and non-radioactive materials will be maintained at low levels, i.e., below applicable limits. A continuing environmental monitoring program will provide a basis for detecting and assessing any environmental impact that might lead to long-term effects so that timely corrective action can be taken if required.

In the long term, most local areas influenced by the mining and milling activities will be reclaimed. Except for the stabilized tailings pile and the sealed mine entrances, the appearance of the reclaimed site will be little different from the surrounding area.

VI. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

About 8.4 million pounds of natural uranium will be removed from ore for use in nuclear power generators. In addition, about 45 acres of land will be covered with tailings and probably removed from productive use.

VII. BENEFIT-COST ANALYSIS

A. BENEFITS

The benefits expected to be associated with the applicant's project are itemized below. These benefits are quantified insofar as possible.

1. The project will result in the direct employment of about 200 persons in San Juan County over the next 8-10 years. Gross annual wages and salaries of employees resulting from the applicant's activities are expected to be about 1.4 million dollars. Employment opportunities in the area are low and unemployment above the national average existed as late as 1973. Therefore, the project should provide an important economic boost to local communities.

2. The project will generate about 500-600 thousand dollars per year in tax revenues for State and Federal governments. These taxes could be used to provide improved community services such as improved schools, roads, sanitary facilities, and other public benefits.

3. Approximately 8.4 million pounds of uranium (U_3O_8) in concentrate form will be produced during the next 8-10 years for use in generating electricity in the United States. Considering present technology and efficiency of nuclear power plants, and assuming complete utilization of fissionable uranium, this amount of uranium could be converted into sufficient fuel to generate about 6.09×10^6 megawatt days of electricity. This electrical equivalent of 8-10 years uranium production is about 1/16 of the electrical energy annually consumed in the United States at the present time, and will provide a source of energy during the interim period in which other alternative forms of energy are being developed.

4. Other natural resources (gas, oil, coal) will be conserved for use in other applications. The electrical equivalent of the uranium to be produced at Humeca would require nearly 50 million tons of coal, or 0.25 billion barrels of oil, or 1 trillion cubic feet of natural gas based on present technology of generating electricity.

5. The excess water in the amount of about 100 gallons per minute to be generated at the site will provide a fresh water source in a semi-arid region. This water will probably be used as a source of fresh water for livestock in the future.

B. COSTS

The expected social and environmental costs associated with the Rio Algom project are itemized below. For the most part these costs are not quantifiable.

1. The Land - There will be a temporary reassignment of about 120 acres of unused land. This amount of land at Rio Algom's site will sustain approximately 2 head of cattle for a possible 6-month period per year.

   There will also be a small change in the topography of the site involving approximately 3 acres and 400,000 tons of waste rock from mining operations. In view of the restoration and reclamation program (Section IV) to be carried out by the applicant, the 120-acre site (excluding the tailings retention system) is expected to be restored to its former productivity upon completion of the project. Thus the land costs are considered to be essentially those associated with removing 120 acres of land from grazing for approximately 10 years.

   There will be created a stabilized trailings pile covering about 45 acres and involving 1.1 to 1.85 million tons of tailings containing solidified waste chemicals and dilute concentrations of radioactive uranium and its daughter products. This land will be restricted from use for an indeterminable length of time.

2. Cultural and Social Considerations - There will be a slight increase in population and additional traffic generated in connection with the Rio Algom project. Whether any real value can be assigned to resulting changes in the cultural and social factors of the area is debatable. However, the staff's judgement is that the financial benefits to the area will far outweigh the possible social and cultural costs connected with the project.

3. Ecological - The proposed activities by the applicant will result in small releases of chemicals and radioactive materials into the environs surrounding the site. Because of the small quantities of materials involved and the dilution and dispersion that will occur, the potential environmental impact is not considered measurable. Thus, the environmental and ecological costs are expected to be indeterminably small.

4. Depletion of Natural Resources - The project will result in a permanent depletion of 8.4 million pounds of natural uranium as a natural resource. However, at the present time the only known large scale industrial application for use of uranium is in energy production. No other large scale uses appears on the horizon for use of uranium as now exists for fossil fuels.

C. BENEFIT-COST BALANCE

The ultimate costs resulting from the licensing of the Humeca uranium mill are found to be: a temporary reassignment of land use; the creation of a stabilized tailings retention system of approximately 45 acres which may have to be restricted for an indeterminable length of time; depletion of a natural resource; and the discharge of small amounts of chemical and radioactive effluents into the environs of the mine and mill.

The benefits are expected to be: the recovery of 8.4 million pounds of natural uranium (U_3O_8) for use in generating electricity; stimulation of the local economy through taxes and direct employment; the conservation of other natural resources (gas, oil, coal) for use in other applications; and the creation of a water source consisting of 4 wells capable of producing together approximately 200 gallons per minute in a semi-arid region.

While the summing up of the costs and benefits cannot have a purely quantitative basis, the total anticipated social and economic benefits appear to be substantially greater than the environmental costs. Because the applicant must apply the necessary precautionary measures to minimize releases of effluents in accordance with Commission regulations and must restore and reclaim the land affected by its operations, adverse environmental effects are expected to be far outweighed by the benefits to be derived from the project.

VIII. DISPOSITION OF COMMENTS RECEIVED FROM FEDERAL, STATE, LOCAL AGENCIES, PRIVATE ORGANIZATIONS, AND INDIVIDUALS

It is the opinion of the Atomic Energy Commission that the Final Environmental Statement addresses fairly the environmental questions and comments, in the appropriate sections, relating to the contents of the AEC Draft Detailed Statement on the Environmental Considerations for the Humeca Uranium Mill, in conformity with generally accepted principles and guidelines specified in the National Environmental Policy Act and by the Council of Environmental Quality.

Comments received on the Commission's Draft Environmental Statement are attached as Appendix T. A tabulation follows, Table XXVII, which shows the agency providing the comments, the substance of the comments or critique, and the section in the final statement where the response to the comment will be found.

TABLE XXVII - TABULATION OF AGENCY COMMENTS

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
John Y. Cole	1.	Conflict in Claims	Summary, Page ix I, Page 1 II, Page 46 Appendix T
Environmental Protection Agency	1.	More detailed information required for the total tailing retention system to allow a comprehensive evaluation of the environmental impact and the long-term impact of the tailings on the environment.	I, E, Page 11 I, F, Page 24 II, B, 12, Page 4 II, C, 10, Page 9 Appendix C, D, E
	2.	Provide more detailed information about the applicant's total environmental sampling and monitoring program and corrective actions that will be used if monitoring program indicates a need.	II, E, Page 29 II, C, Page 6 II, C, Page 9
	3.	Provide more detailed technical information about the applicant's air pollution control systems.	II, C, Page 6
	4.	Provide more information about the control of the excess mine water which contain radium-226.	II, C, Page 7 Appendix H
	5.	Provide more information on the hydrology of the area so that an estimate can be made on the effect that the operation will have on the drawdown of the underground aquifers, and hence the effect on wildlife, forage and ranchers of the area.	I, E, Page 11 Appendix C & D, I, 1, Page 40
	6.	Provide more information about the methods used to supply fresh air and prevent contamination of fresh air in the mine.	I, 1, Page 40

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Environmental Protection Agency	7.	Describe how non-radioactive industrial wastes will be disposed of.	II, C, 2, 3, Page 2 II, C, 7, Page 3 II, C, 10, Page 4 Appendix G
	8.	Provide all necessary information and data so that concentrations of effluents in the environment can be verified.	II, D, Page 19 Appendix P Appendix Q
	9.	Recommendation that the present tailing dam not be raised as planned by the applicant.	II, C, 10, Page 13
	10.	Correction on Utah State Air Standards	II, D, 2, Page 27
	11.	Provide Operational Monitoring Data for Mill Source Emissions.	II, E, 2, Page 38 II, C, 1, Page 16, 14 II, D, 1, Page 22 Appendix N Appendix Q II, D, Page 25 II, E, Page 38
	12.	Indicate who will receive reports of excessive discharge levels and include this as part of the monitoring program, and indicate the frequency of AEC inspections.	II, E, 2, Page 39
	13.	Recommendation that land occupied by the tailings not be patented or if patented that the covenants be attached to successive transfers of land in question.	II, G, Page 49 Page ix

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Environmental Protection Agency	14.	Provide more detailed information on rehabilitation and restoration plans for the site and include cost estimates. In addition, provide information on how the mill and its associated structures will be disposed of at the end of the operation.	II, G, Page 44 II, C, Page 6
	15.	Provide an analysis relative to the possibility of a transportation accident involving yellowcake in a watershed.	II, F, Page 42
Department of the Army South Pacific Division, Corps of Engineers	1.	Provide an inventory of plant and animal life and the impact of the operation on these elements.	I, H, Page 28 Appendix F
	2.	Provide an archeological inventory.	I, C, Page 10 Appendix B
	3.	Discuss the effects of a "no action" alternative.	IV, A, Page 1
	4.	Applicant has complied with the requirements of Section 13 of the 1899 River and Harbors Act.	Appendix I II, C, 4, Page 7
	5.	Tailings reservoir capacity will be reasonably adequate assuming a safe dam is constructed.	II, C, Page 17
Department of Health, Education & Welfare	1.	Statement relating to a dose in excess of the AEC recommendation for population near nuclear power plants.	II, D, Page 23
	2.	Require the State Highway Department to review and approve the construction of the tailing dam with respect to possible flooding of the roadway.	II, C, Page 11 Appendix L

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Department of Agriculture Soil Conservation Service	1.	The fence used to prevent access of sheep and cattle will not prevent deer and other wildlife gaining access to the tailing pond. What will be the effect on these animals inside the fence, or drink the water or eat flora or fauna associated with the tailing pond.	II, D, Page 24
	2.	Correct the terminology of forage density to understory density.	I, H, Page 37
	3.	Correct the terminology of usable to total annual yield.	I, H, Page 37
	4.	Correct the terminology of rattlesnake area to Rattlesnake Pond and Morning Dove to mourning dove.	I, H, Page 37
	5.	Describe how non-radioactive industrial wastes will be disposed of.	II, C, 2, 3, Page 2 II, C, 7, Page 3 II, C, 10, Page 4 Appendix G
	6.	Contact Ken Ludeke of Pema Mining Company in Tucson, Arizona for information on methods and procedures for vegetating tailings ponds.	II, G, Page 44
	7.	The tailings area would need to have a livestock-deer proof fence and be maintained indefinitely.	I, A, Page 5 II, G, Page 46

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Department of Agriculture, Economic Research Service	1.	Provide information on the supply and demand of the product, yellowcake, and the role of the project in meeting market needs.	IV - 6 VII - 1 VII - 3
	2.	The total benefits of the project (economic, social, environmental) should be compared to the total costs.	IV, Page 1 V, Page 1 VI, Page 1 VII, Page 1
	3.	Clarify the operational status of the mill.	xiii
Department of Agriculture, Forest Service	1.	Expressed concern about the location of the tailing pond and construction of the diversion ditches after the pond is filled.	II, C, Page 17
	2.	Expressed concern about difficulties in stabilizing the tailing pond and inquired as to who will be responsible for maintenance of the tailing pile after the project is terminated.	II, G, Page 44
	3.	Indicated a need for insuring against the possibility of seepage from the tailing pond contaminating underground aquifers.	II, C, Page 9 II, E, Page 6
	4.	Recognize and place a value on relevant factors leading to the choice of the location for the mill.	IV, Page 1

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Department of Housing and Urban Development	1.	Primarily concerned with (1) the effect of a proposed action on the urban environment and, (2) the consistency of such actions with the comprehensive planning for the area. The concerns were satisfactorily answered by the applicant.	I, B, Page 5 Appendix T
Utah Department of Development Services, University of Utah	1.	Provide an analysis of the natural radioactivity present in the ground water.	I, E, Page 17 I, E, Page 18 I, E, Page 19 I, E, Page 20 II, C, Page 7
	2.	Assurance needed for performing surveys of mine water discharge.	II, E, Page 36
	3.	Concern about the permanence of and the technique for raising the tailing dam and desires assurances that this question be resolved.	II, C, 10, Page 11, 13
	4.	Question on the amount of the surety bond, $126,000, for reclaiming the property, i.e., does it take into account expected inflationary effects.	II, G, Page 45, 46
	5.	Assurance requested for no deep well disposal of excess water.	II, C, Page 9
	6.	Recommended a continuation of the proposal for seeding and followup seeding of the tailing pile.	II, G, Page 44

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Department of Transportation, U. S. Coast Guard	1.	Data pertaining to the leaching of materials from the tailing pond should be provided.	II, C, Page 17 Appendix D
Department of Interior	1.	The applicant's methods and equipment for the milling operation have been found to be consistent with the state-of-the-art in uranium ore concentration technology, and that the expected benefits of the project are substantially greater than the anticipated environmental costs.	None
	2.	Provide more information about the interrelationships between social, economic and human values within the project areas of influence.	I, B, Page 3 Appendix T
	3.	Provide data relating to the potential long-range adverse impacts of the proposed action and incorporate in the license binding protective measures. In addition, provide rationale for 50-year restrictions on tailing area.	II, G, Pages 44, 45, 46, and 47 ix
	4.	The fence around the tailing area will not keep small animals out of the area. Depending upon the circumstance, a fence with smaller area may be needed.	II, D, Page 24
	5.	Discuss the use of the tailing pond by waterfowl and the possible effects on the waterfowl.	II, D, Page 24

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Department of Interior	6.	There is no record of a Federal lease to Rio Algam. The tailing pond is located on millsite and unpatented mining claims and that Rio Algom has leased most of the area they control from mining claimants. It is suggested that a program be worked out between AEC and BLM to assure protection of public lands.	I, A, Page 1 II, G, Page 44
	7.	Make appropriate corrections to the name of the blacktailed prairie dog and to names and locations of Historical Sites and Landmarks, and contact the State Liaison Officer of Historic Preservation.	I, H, Page 38 I, C, Page 10
	8.	Have a professional archeological survey performed of the area to establish the presence or absence of archeological resources.	I, C, Page 10 Appendix B
	9.	Provide more information about the geology and hydrology and the effects of mill effluents to underground aquifers, and the effect the operation will have on the drawdown and recharge of the aquifer. In addition, provide more information relating to seepage control of effluents from the tailing pond.	I, E, Page 11 I, 1, Page 40 Appendix C Appendix D II, C, Page 13
	10.	Recommend that the power line design should consider proper protection of wildlife.	I, I, 2, Page 44
	11.	Show the venting of the leaching autoclaves and the precipitation process to the atmosphere on the flowsheet.	I, I, 2, Page 43

TABLE XXVII - TABULATION OF AGENCY COMMENTS (contd.)

Commentator		Substance of Comments or Critiques	Section Where Comment is Covered in Text and Page Indicating the Start of Coverage
Department of Interior	12.	Discuss the measures for preventing the surface ore storage from producing dust, and comment on the value of waste rock.	II, B, Page 3 II, C, 1, Page 6 II, C, 6, Page 8
	13.	Provide information on industrial safety precautions in use and storage of reagents.	Industrial safety precautions relating to inplant activities not considered to be part of EIS. Unplanned and nonroutine events concerning non-Radiological Reagents covered in II F 41.
	14.	Concern about the raising of the tailing dam was expressed as well as the need for a diversion channel.	II, C, Page 13 II, C, Page 17
	15.	Additional information was requested relating to concentrations of effluents and their effect on the biota. In addition, more detailed information was requested for the applicant's total environmental sampling and monitoring program.	II, D, Page 19 Appendix P Appendix Q II, E, Page 28 II, Page 4 II, C, Page 9
Federal Power Commission	1.	Require more data as to load characteristics, peak demand or energy requirements to estimate the effect on the bulk power system supplying the area.	I, I, 2, Page 44

APPENDIX A

1. Letter from Bureau of Land Management to Rio Algom, dated February 19, 1974.
2. Memo of a meeting between the Bureau of Land Management and Rio Algom, dated October 21, 1971.
3. Letter from the Bureau of Land Management State Director for Utah to Director dated February 1, 1974.
4. Letter to U.S. Department of the Interior, Bureau of Land Management Utah State Office to AEC dated March 21, 1972 pertains to location of mining claims.

United States Department of the Interior

3000

BUREAU OF LAND MANAGEMENT
P. O. Box 1327
Monticello, Utah 84535

Appendix A, Reference 1
A-2

February 19, 1974

Mr. Robert Sullivan
Rio Algom Corporation
Moab, Utah 84532

Dear Mr. Sullivan:

In reply to your telephone call of February 12, 1974 concerning the diversion ditches around your tailing ponds I am attaching a staff report.

This staff report of a meeting between BLM and Rio Algom personnel fully explains our position regarding the canals. As mentioned in the report, we do not feel it necessary that the canals be constructed as long as active mining and milling operations are in progress. We are still interested in the tailings and mill area from the standpoint of stabilization and protection at the conclusion of operations. However, specific decisions in the matter should be made at that time.

We would like to take this opportunity to thank you for your past cooperation and we hope we can be of service to you in the future.

Sincerely yours,

Frank C. Shields
District Manager

Attachment
Staff Report
dated 10/21/71

SUBJECT: BLM - Rio Algom Meeting 10/21/71

The meeting actually stemmed from a misunderstanding on the part of Rio Algom (and possibly others) that the proposed solution to the tailings problem submitted by us (which was to construct a diversion canal) was the only solution to the problem and that action was to be taken immediately to construct the ditch.

A clarification of what was meant by our report is that a problem does in fact exist. The hydrology was not computed to check the design of Rio's dam but only to make it statistically clear that a definite amount of water does flow in the watershed in question. The only long term hydrology figures available are for 100 year frequency storms and since the tailings area will be considered a hazard for at least 1600+ years, the intensity of a storm occurring once during this period would be far in excess of that of a 100 year storm and impossible to accurately compute. The intention of the ditch design was only to show that the tailings area could be isolated from the rest of the watershed.. The purpose of both the hydrology and ditch design was only ~~$~~ to offer at least one alternative solution to the problem.

The hydrology and ditch design were submitted as a solution to the problem as though the milling operation had been completed and the active operations were about to conclude. However, in 10 or 15 years, technology may produce a method for more effectively coping with the problem than the diversion canal. The submission of a canal design was done not only to offer one possible solution to the problem but to encourage the other parties involved to submit alternative proposals which would be equally effective; then if technology did not produce more effective methods or solutions all agencies concerned would be aware of what would be required of the company to stabilize the site at the conclusion of operations.

Since the milling operations will probably continue for only 10 to 15 years the size of the tailings pond will <u>most likely</u> be adequate to handle all watershed runoff; therefore, ~~it~~ it will not be absolutely necessary to construct the diversion canal or employ whatever other method is decided upon until operations cease.

The following are some of the items which should be given consideration when we make stipulations regarding the mill site.:

1. Will the site become private land? If not, the problem will be ours for a long time.

2. The stips do not have to specify that a ditch <u>will</u> be constructed; however, they should be specific enough to require Rio's full cooperation at conclusion of operations.

3. If the stipulations are not specific enough we may find ourselves in a position of having to provide continuous extensive maintenance of an industrial waste area virtually forever.

4. Although Rio Algom seems to be a good company to work with now - a promise made now can be easily forgotten in 10 or 15 years unless it is in writing.

5. Put the "monkey on Rio's back" for environmental protection during mill operations.

6. If the tailings area is not covered and revegetated dry tailings will be carried to the surrounding area by the strong winds which prevail in this area.

Stipulations

During Mining and Milling Operations

All necessary precautions shall be taken by Rio Algom to insure that contamination by radioactive materials outside the confines of the mill and tailings area shall not exceed safe limits as prescribed by A.E.C.

In the event of excess contamination outside the mill and tailings area, the Rio Algom corporation shall immediately notify AEC and if the contamination extends onto public doman the Bureau of Land Management shall also be notified; Rio Algom shall then take such corrective action as may be deemed necessary by the agencies involved.

After Mining and Milling Operations have Concluded

Upon conclusion of operations Rio Algom shall "secure" the site in such a manner as to preclude contamination of the surrounding area in any manner. These steps shall be consistent with good engineering practices and shall use the best technology available at the time. All measures taken to stabilize the site shall be approved by the Bureau of Land Management prior to construction and shall also be subject to approval by the BLM upon completion.

Any maintenance requirements necessary to maintain the stabilization of the area in satisfactory condition shall be done by Rio Algom in a manner, and at a frequency suitable to the BLM.

Dalla

10/20/71

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6
UNITED STATES GOVERNMENT

Appendix A, Reference 3
A-5

1791
3800
(U930

Memorandum

380

TO : Director (723)

DATE: FEB 1 1974

FROM : State Director, Utah

SUBJECT: Rio Algom Environmental Impact Statement

Mr. John Y. Cole, President of the Nuclear Corporation residing at 2930 Ramona Street, Palo Alto, California, notified our Monticello District office by letter dated January 10, 1974 of an apparent conflict between claims owned by his company and claims owned by Rio Algom. A copy of this letter was transmitted to your office on January 29, 1973 with our review of the draft environmental statement.

In his letter, Mr. Cole stated that their Sal No's 3,4, and 5 lode mining claims of a 14 claim group, straddled the north-south section line between sections 20 and 21 T29S, R24E SLM and were in conflict with Rio Algom claims. He further stated these claims are recorded in the San Juan County recorders office in Book 456, pages 672-675. Information of record in this office indicates these claims are possibly in conflict with Rio Algom's Audrey No's 15 and 16, Salty Dog No's 2 and 3, Pasco Fractional No. 1 and Lonnie No's 1 and 2, Fraction lode Mining Claims. Copies of the location notices and a sketch map are attached.

No action has been taken by the Bureau of Land Management to resolve this conflict. Matters relating to ownership of mining claims are resolved by civil actions in court between rival claimants.

The question of whether the Rio Algom Corporation should be encouraged to apply for patent on their mining claims and/or the tailings disposal site, or whether the lands should be retained in federal ownership at the conclusion of mining, has not been resolved.

The major problem is, of course, the management of tailings disposal site containing radioactive waste materials at the conclusion of mining and milling activities. Should this area be retained in federal ownership or should it be allowed to go into private ownership? By memorandum dated July 13, 1972 and July 31, 1972, we have requested guidance on this subject from your office.

To date no benthic survey of Rio Algom's fresh water pond has been conducted. (See attached copy of telephone confirmation).

Attachment

[illegible signature]

ACTING

GPO [illegible]

Appendix A, Reference 3
A-6

W-8361

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Audrey #16 mining claim 1500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

Beginning 20 feet Easterly of this location (Discovery) Monument, at the East end Center Monument and running

thence Southerly 300 feet to SE corner No. 1;
thence Westerly 1500 feet to SW corner No. 2;
thence Northerly 600 feet to NW corner No. 3;
thence Easterly 1500 feet to NE corner No. 4;
thence Southerly 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations. Corner #4 of this Claim is S 40°25' E and 1,440 ft. from W¼ Sec. 21, T29S, R24E, SLB&M.

This being the same lode or mining claim originally located on the 16th day of October 1953, and recorded in Book 27, Page 4[illegible], in the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

APR 28 PM 4 01
RECEIVED
UTAH STATE OFFICE
INTERIOR

MAR 4 11 26 AM '68
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

Dated this 23rd day of February, 1968.

Jim L. Anderson
Partner
Jimco Ltd.
821 Kearns Building
Salt Lake City, Utah

Entry No. W-8361
Recorded 3/4/68 At 11:28 A Book 434 Page 77
ARVILLA E. WARREN
Recorder, San Juan County, Utah
FEE PAID
$ 2.00 Arvilla E. Warren Deputy

Appendix A, Reference 3
A-7

Z-4856

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Audrey # 16 mining claim 1,500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

Beginning 20 feet Easterly of this location (Discovery) Monument, at the East end Center Monument and running

thence southerly 300 feet to SE corner No. 1;
thence westerly 1500 feet to SW corner No. 2;
thence northerly 600 feet to NW corner No. 3;
thence easterly 1500 feet to NE corner No. 4;
thence southerly 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations. Corner No. 4 of this claim is S. 70° 25' E and 1,440 ft. from the West quarter corner of Section 21, T. 29 S., R. 24 E., S.L.B. & M.

This being the same lode or mining claim originally located on the 10th day of October 1953, and recorded in Book 27, Page 428 of the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

Amended Notices of Location are recorded in the office of the County Recorder of San Juan County, Utah, in Book 245, Page 224 and Book 434, Page 77.

Dated this 20th day of August, 1968.

Jim L. Anderson
Partner

JIMCO, Ltd. for and on behalf of Owners of Claim
821 Kearns Building
Salt Lake City, Utah

Entry No. Z-4856
Recorded 8/26/68 At 2:00 P.M. Book 451 Page 459
ARVILLA E. WARREN
Recorder, San Juan County, Utah
FEE PAID $2.00 By Arvilla E. Warren Deputy

BUREAU OF LAND MGMT. UTAH STATE OFFICE
AUG 26 2 00 PM '68
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

2.00 W-8323

Appendix A, Reference 3
A-8

NOTICE OF LOCATION

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with the requirements of SECTION 2324 of the REVISED STATUTES of the United States, and the Local Laws, Customs and Regulations of the District, has located Fifteen hundred feet in length by ~~600~~ feet in width, on this the Lonnie #2 Fraction Lode, Vein or Deposit, bearing Uranium, Vanadium, Gold, Silver, Copper, Lead and other valuable minerals, situated

Lisbon Valley Area ~~miles~~ of the

Unorganized

Mining District, San Juan County, State of Utah, the location being described and marked on the ground as follows, to-wit:

Beginning 50 feet Northerly of this location (Discovery) Monument, at the North end center monument, and running

thence Easterly ~~300~~ 100 feet to NE corner monument No. 1;
thence Southerly 1500 feet to SE corner monument No. 2;
thence Westerly ~~300~~ 100 feet to South end center monument;
thence Westerly ~~300~~ 100 feet to SW corner monument No. 3;
thence Northerly 1500 feet to NW corner monument No. 4;
thence Easterly ~~300~~ 100 feet to place of beginning; including all Dips, Spurs, Angles and Variations Location monument is 1,090 feet North and 55 feet West of the West Quarter Corner of Section [illegible], T29S, R24E, S L B & M

The above described Mining Claim shall be known as the

Lonnie #2 Fraction

Located this 15 th day of FEB 1968.

NAME OF LOCATOR:

MAR 4 11 21 AM '68
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY

1196 QUAHADA ENGINEERING, GRAND JUNCTION, COLO.

By: Jim L. Hudson
Partner

Jimco Ltd,
821 Kearns Building,
Salt Lake City, Utah.

Entry No. W-8328
Recorded 3/4/68 At 11:21 A.M. Book 434 Page 44
FEE PAID
ARVILLA E. WARREN
Recorder, San Juan County, Utah
$ 2.00 By Arvilla E. Warren Deputy

19

Entry No. T-12962
Recorded 12-18-63 At 10:10 A M. Book 361 Page 115
FEE PAID
$2.00
ARVILLA E. WARREN
Recorder, San Juan County, Utah
By Arvilla E. Warren Deputy

Fee

T-12962

NOTICE OF LOCATION

—x—

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with Section 2324 of the Revised Statutes of the United States, and the Local Laws, Customs and Regulations of this LA SAL Mining District, has located Fifteen Hundred Feet in length by Six Hundred Feet in width on this, the Lode, Vein or Deposit or Sedimentary Deposit bearing gold, silver and other precious metals, situated TWP 27 S RNGE 24 E SECTION 21 in SAN JUAN County, State of Utah, and described and marked on the ground, as follows, to-wit:

Beginning 50 feet WESTERLY of this location (Discovery) Monument, at the WEST end center monument and running thence NORTHERLY 300 feet to NW corner monument No. 1; thence EASTERLY 1500 feet to NE corner monument No. 2; thence SOUTHERLY 600 feet to SE corner monument No. 3; thence WESTERLY 1500 feet to SW corner monument No. 4; thence NORTHERLY 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations

THIS CLAIM JOINS SALTY DOG #2 ON THE WEST AND THE SINDBAD GROUP ON THE NORTH

Dec 18 10 10 AM '63
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

This Mining Claim shall be known as the SALTY DOG #3 Mining Claim.

Located this 17TH day of DECEMBER A. D. 1963

NAMES OF LOCATORS

Mail to-
Danny K. Rexford Sites
P.O. Box 323
Moab, Utah

TIMES-INDEPENDENT PRINTING — MOAB, UTAH

99

Appendix A, Reference 3
A-10

W-8345

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Salty Dog #3 mining claim 1,500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

Beginning 50 feet westerly of this location (Discovery) Monument, at the West end Center Monument or running
thence Northerly 300 feet to NW corner No. 1;
thence Easterly 1500 feet to NE corner No. 2;
thence Southerly 600 feet to SE corner No. 3;
thence Westerly 1500 feet to SW corner No. 4;
thence Northerly 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations. Corner #1 of this Claim is 1,400 ft. South and 70 ft. west of the NE Cor. Sec. 20, T29S, R24E, SLB&M.

This being the same lode or mining claim originally located on the 17th day of December 1963, and recorded in Book 361, Page 115, in the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

DEPT. OF INTERIOR
BUR. OF LAND MGMT
APR 28 PM 3:58
RECEIVED
UTAH STATE OFFICE
SALT LAKE CITY, UTAH

MAR 4 11 25 AM '68
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

Dated this 21st day of February, 1968.

Jim L Hudson
Partner
Jimco Ltd.,
821 Kearns Building
Salt Lake City, Utah

Entry No. W-8345
Recorded 3/4/68 A.M. 11:25 Book 434 Page 61
FEE PAID $2.00
ARVILLA E. WARREN
Recorder, San Juan County, Utah
By Arvilla E. Warren Deputy

NOTICE OF LOCATION

E-9827

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with Section 2324 of the Revised Statutes of the United States, and the Local Laws, Customs and Regulations of this Unorganized Mining District, have located Fifteen Hundred Feet in length by Six Hundred Feet in width on this the Lode, Vein or Deposit or Sedimentary Deposit bearing gold, silver and other precious metals situated About 3/4 Mile North Westerly of The Big Indian Copper Mill

in San Juan County, State of Utah, and described and marked on the ground, as follows, to-wit:

Commencing at this location monument and running ~~30~~ 20 ft Easterly to Center end Stake; thence 300 ft Southerly to Corner No. 1; thence 1500 ft Westerly to Corner No. 2; thence 600 ft Northerly to Corner No. 3; thence 1500 ft Easterly to Corner No. 4; thence 300 ft Southerly to Center end Stake; thence ~~30~~ 20 ft Westerly to place of beginning.

DEPT. OF INTERIOR
BUR. OF LAND MGMT.
'53 ... PM 4:01

ENTRY NO E-9827
RECORDED 10-23-53 AT 9A M BOOK 27 PAGE 427
FEE $1.20
SAN JUAN COUNTY RECORDER
[illegible signature]

This Mining Claim shall be known as Audrey #15 Mining Claim.

Located this 10th day of October A. D. 1953.

NAMES OF LOCATORS

Forest White
Julian Davis
~~[illegible]~~
Otis Dilker

THE TIMES-INDEPENDENT—MOAB, UTAH

AMENDED NOTICE OF LOCATION

STATE OF Utah
County of San Juan } ss.

KNOW ALL MEN BY THESE PRESENTS, That Forrest [illegible], Julian Davis and Otis [illegible]

the undersigned, ha ve this [illegible] day of [illegible], 19[illegible], amended, located and claimed, and by these presents do amend, locate, and claim, by right of discovery and this amended location certificate 1500 linear feet and horizontal measurement on the Audrey 10 lode, vein, ledge or deposit, along the vein thereof, with all its dips, angles and variations, as allowed by law, together with [illegible] feet on the North side and [illegible] feet on the South side of the middle of said vein at the surface, so far as can be determined from present developments, and all veins, lodes, ledges or deposits and surface ground within the lines of said claim [illegible] feet running Easterly from center of discovery Monument and 1[illegible] feet running Westerly from center of discovery Monument said discovery Monument being situate upon said lode, vein, ledge, or deposit, and within the lines of said claim in [illegible] Mining District, County of San Juan and State of Utah, described by metes and bounds as follows, to wit:

Beginning at Corner No. 1 Thence 1500 ft Easterly to Corner No. 2; Thence 6[illegible] ft Northerly to Corner No. 3; Thence 1500 ft Westerly to Corner No. 4; Thence 6[illegible] ft Southerly to the place of beginning.

This being the same lode originally located on the 10 day of October 19[illegible], and recorded on the [illegible] day of October 19[illegible], in Book 27, Page [illegible]27, in the office of the Recorder of San Juan County. this further and amended certificate of location is made without waiver of any previously acquired rights, but for the purpose of correcting any errors in the original location, description or record, or validity. This notice is posted and filed pursuant to the provisions of Public Law 585, 83rd Congress, (Amending the Mineral Leasing Laws To Provide for Multiple Mineral Development of the Same Tracts of Public Lands), and for the purpose of obtaining the benefits thereof.

Said lode was discovered the 10 day of October, A.D. 19[illegible]

[illegible] [SEAL]
Julian Davis [SEAL]
Otis [illegible] [SEAL]
Forrest [illegible] [SEAL]
[SEAL]
[SEAL]

Attest:

Date of Posting Amended Notice of Location, , A.D. 19
Date of Recording Amended Notice of Location, , A.D. 19

[illegible] 40190

RECEIVED
UTAH STATE OFFICE
[illegible] UTAH
APR 28 PM 4:01
DEPT. OF INTERIOR
BUR. OF LAND MGMT

AMENDED NOTICE OF LOCATION

STATE OF Utah
County of San Juan } ss.

KNOW ALL MEN BY THESE PRESENTS, That Forrest [illegible], Julian Davis and Otis [illegible]

the undersigned, ha ve this [illegible] day of [illegible], 19[illegible], amended, located and claimed, and by these presents do amend, locate, and claim, by right of discovery and this amended location certificate 1500 linear feet and horizontal measurement on the Audrey 1[illegible] lode, vein, ledge or deposit, along the vein thereof, with all its dips, angles and variations, as allowed by law, together with [illegible] feet on the North side and [illegible] feet on the South side of the middle of said vein at the surface, so far as can be determined from present developments, and all veins, lodes, ledges or deposits and surface ground within the lines of said claim [illegible] feet running Easterly from center of discovery Monument and 1[illegible] feet running Westerly from center of discovery Monument said discovery Monument being situate upon said lode, vein, ledge, or deposit, and within the lines of said claim in [illegible] Mining District, County of San Juan and State of Utah, described by metes and bounds as follows, to wit:

Beginning at Corner No. 1 Thence 1500 ft Easterly to Corner No. 2; Thence 600 ft Northerly to Corner No. 3; Thence 1500 ft Westerly to Corner No. 4; Thence 600 ft Southerly to the place of beginning.

This being the same lode originally located on the 10 day of October 19[illegible], and recorded on the [illegible] day of October 19[illegible], in Book 27, Page [illegible], in the office of the Recorder of San Juan County. this further and amended certificate of location is made without waiver of any previously acquired rights, but for the purpose of correcting any errors in the original location, description or record, or validity. This notice is posted and filed pursuant to the provisions of Public Law 585, 83rd Congress, (Amending the Mineral Leasing Laws To Provide for Multiple Mineral Development of the Same Tracts of Public Lands), and for the purpose of obtaining the benefits thereof.

Said lode was discovered the 10 day of October, A.D. 19[illegible]

[illegible] [SEAL]
Julian Davis [SEAL]
Otis [illegible] [SEAL]
Forrest [illegible] [SEAL]
[SEAL]

Attest:

Date of Posting Amended Notice of Location, , A.D. 19
Date of Recording Amended Notice of Location, , A.D. 19

[illegible] 40191

Appendix A, Reference 3
A-13

W-8360

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Audrey #15 mining claim 1500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

Beginning 20 feet Easterly of this location (Discovery) Monument, at the East end Center Monument and running

thence Southerly 300 feet to SE corner No. 1;

thence westerly 1500 feet to SW corner No. 2;

thence Northerly 600 feet to NW corner No. 3;

thence Easterly 1500 feet to NE corner No. 4;

thence Southerly 300 feet to place of beginning, including all Dips, Spurs, Angles and Variations. Corner #1 of this claim is S [illegible] 25 E and 1,440 ft. from W¼ Sec. 21, T23S, R24E, SLB&M.

This being the same lode or mining claim originally located on the 10th of October 1953, and recorded in Book 27, Page 127 in the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

RECEIVED DEPT. OF INTERIOR BUR. OF LAND MGMT. STATE OFFICE SALT LAKE CITY PM 4:[illegible]

MAR 4 11 28 AM '68
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

Dated this 23rd day of February, 1968.

Jim L. Hudson
Partner
Jimco Ltd.,
821 Kearns Building
Salt Lake City, Utah

Entry No. W-8360
Recorded 3/4/68 AT 11:28 A.M. Book 434 Page 76
FEE PAID
$ 2.00
ARVILLA E. WARREN
Recorder, San Juan County, Utah
By Arvilla E. Warren, Deputy

K-4855

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Audrey # 15 mining claim 1,500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

Beginning 20 feet Easterly of this location (Discovery) Monument, at the East end Center Monument and running

thence southerly 300 feet to SE corner No. 1;

thence westerly 1500 feet to SW corner No. 2;

thence northerly 600 feet to NW corner No. 3;

thence easterly 1500 feet to NE corner No. 4;

thence southerly 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations. Corner No. 1 of this claim is S. 20° 25' E and 1,440 ft. from the West quarter corner of Section 21, T. 29 S., R. 24 E., S.L.B. & M.

This being the same lode or mining claim originally located on the 10th day of October 1953, and recorded in Book 27, Page 427, in the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

Amended Notices of Location are recorded in the office of the County Recorder of San Juan County, Utah, in Book 245, Page 224 and Book 434, Page 76.

Dated this 20th day of August, 19 68.

Entry No. K-4855
Recorded 5/15/78 At 2:01 P M. Book 451 Page 459
FEE PAID $2.00
ARVILLA E. WARREN
Recorder, San Juan County, Utah
By Arvilla E. Warren Deputy

Jim L. Hudson
Partner

JIMCO, Ltd. for and on behalf of
Owners of Claim
821 Kearns Building
Salt Lake City, Utah

RECEIVED
DEPT. OF THE INTERIOR
BUR. OF LAND MGMT.
UTAH STATE OFFICE

AUG 26 2 00 PM
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

Appendix A, Reference 3
A-15

T-12961

NOTICE OF LOCATION

DEC 16 10 03 AM '63
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

—x—

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with Section 2324 of the Revised Statutes of the United States, and the Local Laws, Customs and Regulations of this LA SAL Mining District, has located Fifteen Hundred Feet in length by Six Hundred Feet in width on this, the Lode, Vein or Deposit or Sedimentary Deposit bearing gold, silver and other precious metals, situated T 29 S RANGE 24 E SECTION 20 in SAN JUAN County, State of Utah, and described and marked on the ground, as follows, to-wit:

Beginning 50 feet NORTHERLY of this location (Discovery) Monument, at the NORTH end center monument, and running
thence EASTERLY 300 feet to NE corner monument No. 1;
thence SOUTHERLY 1500 feet to SE corner monument No. 2;
thence WESTERLY 600 feet to SW corner monument No. 3;
thence NORTHERLY 1500 feet to NW corner monument No. 4;
thence EASTERLY 300 feet to place of beginning; inculding all Dips, Spurs, Angles and Variations

THIS CLAIM JOINS SALTY DOG #1 ON THE NORTH

DEPT. OF INTERIOR
BUR. OF LAND MGMT.
23 PM 3:53

This Mining Claim shall be known as THE SALTY DOG #2 Mining Claim.

Located this 17TH day of DECEMBER A. D. 1963

NAMES OF LOCATORS

Larry L. Perkins Sites

Entry No. T-112961
Recorded 12-18-63 At 10:03 M. Book 361 Page 114
FEE PAID $2.00
ARVILLA E. WARREN
Recorder, San Juan County, Utah
By Arvilla E. Warren Deputy

2.00

W-8344

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Sally Dog #2 mining claim 1,500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

Beginning 50 feet Northerly of this location (Discovery) Monument, at the North end Center Monument and running
thence Easterly 300 feet to NE corner No. 1;
thence Southerly 1500 feet to SE corner No. 2;
thence Westerly 600 feet to SW corner No. 3;
thence Northerly 1500 feet to NW corner No. 4;
thence Easterly 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations. Corner #2 of this claim is 350 ft. South and 180 ft. west of the W¼ Sec. 21, T29S, R24E, SLB&M.

This being the same lode or mining claim originally located on the 17th day of December 1963, and recorded in Book 36T Page 914 of the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

DEPT. OF INTERIOR BUR. OF LAND MGMT.

UTAH ... 3 58

MAR 4 11 25 AM '68
ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY

Dated this 21st day of February, 1968.

Jim L. Nielson
Partner
Jimco Ltd.,
821 Kearns Building
Salt Lake City, Utah

Entry No. W-8344
Recorded 3/4/68 At 11:25 A.M. Book 434 Page 60
FEE PAID
ARVILLA E. WARREN
Recorder, San Juan County, Utah
$ 2.00 By Arvilla E. Warren Deputy

II

60

.00

X-4866

AMENDED NOTICE OF LOCATION

Notice is hereby given that the undersigned claims by right of this amended notice of location the Salty Dog # 2 mining claim 1,500 feet in length by 600 in width on this, the lode, vein or deposit bearing valuable minerals, situated in the Big Indian mining district, County of San Juan State of Utah, and marked on the ground as follows, to-wit:

AUG 26 2 01 PM '68
ARVILLA E. WARREN
RECORDER SAN JUAN COUNTY
BY

Beginning 50 feet Northerly of this location (discovery) Monument, at the North end Center Monument and running

thence easterly 300 feet to NE corner No. 1;

thence southerly 1500 feet to SE corner No. 2;

thence westerly 600 feet to SW corner No. 3;

thence northerly 1500 feet to NW corner No. 4;

thence easterly 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations. Corner No. 2 of this claim is 350 ft. South and 180 ft. west of the West quarter corner of Section 21, T. 29 S., R. 24 E., S.L.B. & M.

This being the same lode or mining claim originally located on the 17th day of December 1963, and recorded in Book 361, Page 114, in the office of the County Recorder of San Juan County, Utah.

This amended notice of location is made without any waiver of any previously acquired rights.

An Amended Notice of Location is recorded in the office of the County Recorder of San Juan County, Utah, in Book 434, Page 60.

Dated this 20th day of August, 1968.

Jim L. Anderson
Partner

JIMCO, Ltd. for and on behalf of Owners of claim
821 Kearns Building
Salt Lake City, Utah

Entry No. X-4866
Recorded 8/26/68 At 2:01 P.M. Book 451 Page 469
FEE PAID $2.00
ARVILLA E. WARREN
Recorder, San Juan County, Utah
By Arvilla E. Warren Deputy

Return: 26 [illegible]

22

A-18

Appendix A, Reference 3

MAR 2 9 14 AM '64

T-13514

NOTICE OF LOCATION

ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
BY ______________________

——×——

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with Section 2324 of the Revised Statutes of the United States, and the Local Laws, Customs and Regulations of this Big Indian Mining District, have located Fifteen Hundred Feet in length by Six Hundred Feet in width on this, the Lode, Vein or Deposit or Sedimentary Deposit bearing gold, silver and other precious metals, situated in the South one-half of the Northwest quarter (S½ NW¼) of Section 15 of Township 29 South, Range 24 East, S.L.M.

in San Juan County, State of Utah, and described and marked on the ground, as follows, to-wit: Beginning at a point 1600 feet South of the surveyed Northwest corner of Section 15 (?), thence –

Beginning 50 feet East of this location (Discovery) Monument, at the West end center monument, and running

thence North 300 feet to Northwest corner monument No. 1;
thence East 1500 feet to Northeast corner monument No. 2;
thence South 600 feet to Southeast corner monument No. 3;
thence West 1500 feet to Southwest corner monument No. 4;
thence North 300 feet to place of beginning; including all Dips, Spurs, Angles and Variations this is a fractional claim overlapping portions of the Salty Dog Group and Rudney Group claims.

Entry No. T-13514
Recorded 3-2-64 At 9:14 M. Book 362 Page 213
FEE PAID
ARVILLA E. WARREN
Recorder, San Juan County, Utah
$2.00 By Arvilla E. Warren Deputy

This Mining Claim shall be known as Pisco Fractional #1 Mining Claim.

Located this 22nd & 23rd day of February A.D. 1964.

NAMES OF LOCATORS

Daniel H. Meyer

Jim L. Hudson

Mail to –
Pacific-Associated Oil & Gas Co.
Suite 224 Atlas Bldg.
Salt Lake City, Utah 84101
Attn: Daniel H. Meyer 213

Appendix A, Reference 3
A-19

AMENDED LOCATION

NOTICE IS HEREBY GIVEN, That Daniel H. Meyer, Jim L. Hudson and Eldon J. Card, of 224 Atlas Building, Salt Lake City, Utah 84101,

citizens of the United States, having complied with all the requirements of the Laws of the United States and the State of Utah, relating to mining claims, and with the local laws, customs, rules and regulations of Big Indian Mining Mining District, hereby make and file this Amended Notice of Location of the Pos[illegible] Fractional #1 Lode, claiming by right of discovery, location, primal appropriation and possession 1500 feet, linear and horizontal measurement on this vein or lode of quartz, or other rock in place bearing uranium, vanadium, base metals and other valuable minerals, along the course of said vein, with all dips, variations and angles, together with 300 feet in width on each side of the middle of said vein at the surface, and all veins, lodes, ledges, mineral deposits, mineral and surface ground within the line of said claim, 1410 feet of said lode running East and 90 feet running West from the Initial Point and Discovery Stake. Said Initial Point and Discovery Stake being situated upon said lode or vein within the line of said claim in the Big Indian Mining District, County of San Juan, State of Utah. Said claim being particularly described by actual field notes of survey this 12th day of July, 1965, as follows, to wit:

Beginning at the Initial Point and Discovery Stake, at which this Notice is posted, with Magnetic Variation at 15 Degrees 0 Minutes East, thence West 90 feet to the end-center stake; thence North 300 feet to the Northwest corner, (corner No. 1); thence East 1500 feet to the Northeast corner (corner No. 2); thence South 600 feet to the Southeast corner (corner No. 3); thence West 1500 feet to the Southwest corner (corner No. 4); thence North 300 feet to the point of beginning. Discovery stake is on the West Section line of Section 21, 240 feet North of the West Quarter Corner of Section 21. The West end line of this claim is common with the east side line of The Salty Dog No. 2 claim. The North side line of this claim is common with the South side line of The Salty Dog No. 3 claim. This claim is in the Northwest ~~xxxxxx~~ quarter of Section 21, Township 29 South, Range 24 East, S.L.M.

THIS AMENDED LOCATION is made in conformity with the Original Location, made February 22 & 23rd, 1964, recorded March 2, 1964, in Book 362, Page 213, of Mining Claims, in the office of the Recorder of said County, and is made for the purpose of appropriating all ground within the boundaries hereinbefore described, and of more definitely describing the locus and boundaries of said Lode, correcting any irregularities, informalities or errors, and supplying any defects which may have existed in the Original Location, or the record thereof, hereby waiving no rights acquired under and by virtue of said Original Location.

Date of Amended Location, July 12, 1965

Mendell M. Bell, Witness

Daniel H. Meyer

Jim L. Hudson

Eldon J. Card

JUL 20 8 41 AM '65

Form 1541-3
(July 1965)
(formerly 4-1539a)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Appendix A, Reference 3
A-20

CONFIRMATION/REPORT OF TELEPHONE CONVERSATION

TO		FROM	
Name	Rulon McRae - Les Sweeney	Name	Don Duff
Office	BLM	Office	USO
Location	Monticello	Location	SLC
Telephone Number	587-2247	Telephone Number	524-5326

Purpose of Call:
re WO memo 1/11/74 on Rio Algom EIS.
Also contacted Josh Warburton SL D.O. re his involvement when on district. Joint studies for aquatic surveys were scheduled with DWR in 1971 & were scheduled for completion within 2 years. BLM relied on DWR to complete biological surveys & this was never done. BLM did not do any work either on biological data.
Monticello confirmed the above statement. DM has sent 2 past letters (dated 4/13/73 & 5/29/73) to a P.F. Pullen, P. Engineer, Chief Environmental Engineer for Rio Algom stating both times that no biological surveys had been completed since none were actually

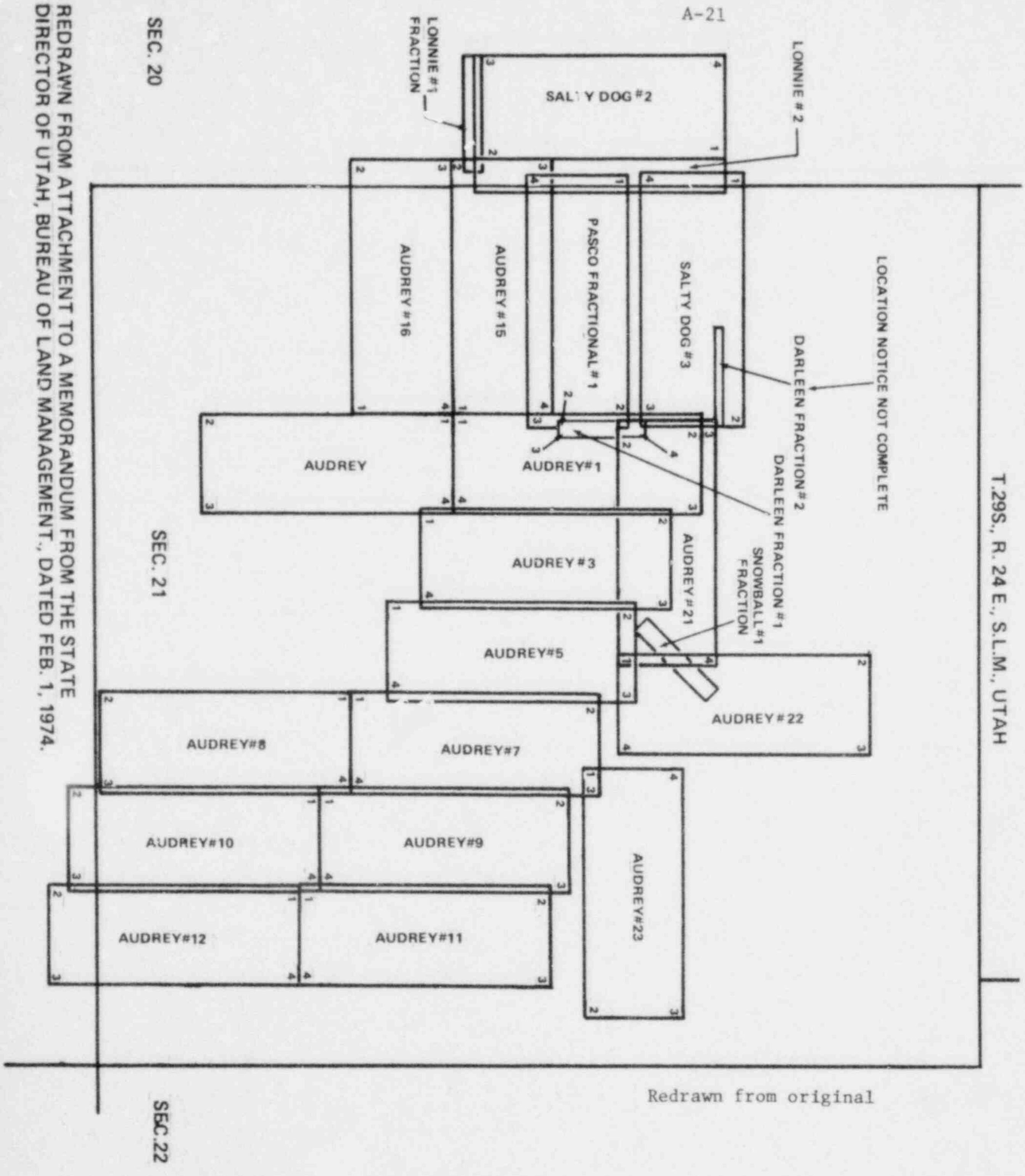
Explanatory Remarks:
undertaken
Therefore we have no further data to advance to W.O. since none is available

1/25/74
(Date)

Donald A. Duff Fisheries Biologist
(Signature)

CONFIRMATION COPY

GPO 851-219 10 780-164



REDRAWN FROM ATTACHMENT TO A MEMORANDUM FROM THE STATE DIRECTOR OF UTAH, BUREAU OF LAND MANAGEMENT, DATED FEB. 1, 1974.

Redrawn from original

W-8327

A-22

Appendix A, Reference 3

NOTICE OF LOCATION

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with the requirements of SECTION 2324 of the REVISED STATUTES of the United States, and the Local Laws, Customs and Regulations of the District, has located ~~fifteen hundred~~ feet in length by ~~600~~ feet in width, on this the Lonnie #1 Fraction Lode, Vein or Deposit, bearing Uranium, Vanadium, Gold, Silver, Copper, Lead and other valuable minerals, situated Lisbon Valley Area ~~miles~~ of the Unorganized Mining District, San Juan County, State of Utah, the location being described and marked on the ground as follows, to-wit:

Beginning 50 feet Westerly of this location (Discovery) Monument, at the West end center monument, and running thence Northerly 50 feet to NW corner monument No. 1; thence Easterly 700 feet to NE corner monument No. 2; thence Southerly 50 feet to East end center monument; thence Southerly 50 feet to SE corner monument No. 3; thence Westerly 700 feet to SW corner monument No. 4; thence Northerly 50 feet to place of beginning; including all Dips, Spurs, Angles and Variations Location monument is 350 feet South and 735 feet East of the West Quarter Corner of Section 21, T., R., SLB&M

The above described Mining Claim shall be known as the Lonnie #1 Fraction

Located this 15th day of Feb 1968.

NAME OF LOCATOR:

By: Jim L. Hudson
Partner
Jimco Ltd.,
821 Kearns Building,
Salt Lake City, Utah

1196 QUAHADA ENGINEERING, GRAND JUNCTION, COLO.

U.S. DEPT. OF INTERIOR
BUREAU OF LAND MGMT.
DEC 23 1980

FILED FOR RECORD AT REQUEST OF ARVILLA E. WARREN
RECORDER, SAN JUAN COUNTY
Mar 4 11 20 AM '68

Entry No. W-8327
Recorded 3/4/68 11:20 A.M. Book 434 Page 43
FEE PAID
ARVILLA E. WARREN
Recorder, San Juan County, Utah
$ 2.00 By Arvilla E. Warren Deputy

A-23

E-9828

NOTICE OF LOCATION

NOTICE IS HEREBY GIVEN, That the undersigned, having complied with Section 2324 of the Revised Statutes of the United States, and the Local Laws, Customs and Regulations of this Unorganized Mining District, have located Fifteen Hundred Feet in length by Six Hundred Feet in width on this, the Lode, Vein or Deposit or Sedimentary Deposit bearing gold, silver and other precious metals, situated About 3/4 mile North Westerly of The Big Indian Copper Mill

in San Juan County, State of Utah, and described and marked on the ground, as follows, to-wit:

Commencing at this location monument and running ~~50~~ 20 ft Easterly to Center end Stake; thence 300 ft Southerly to Corner No. 1; thence 1500 ft Westerly to Corner No. 2; thence 600 ft Northerly to Corner No. 3; thence 1500 ft Easterly to Corner No. 4; thence 300 ft Southerly to Center end Stake; thence ~~50~~ 20 ft Westerly to place of beginning.

APR 28 PM 4:01
DEPT. OF INTERIOR
BUR. OF LAND MGMT.
UTAH STATE OFFICE
SALT LAKE CITY, UTAH

ENTRY NO. E-9828
RECORDED 10-23-53 AT 9 A M. BOOK 27 PAGE 428
FEE PAID
1.20
SAN JUAN COUNTY RECORDER

This Mining Claim shall be known as Audrey No. 16 Mining Claim.

Located this 10th day of October A. D. 1953.

NAMES OF LOCATORS

Forest White
Julian Dean
Otis Dibler

THE TIMES-INDEPENDENT—MOAB UTAH

9

Appendix A, Reference 4
A-24

0783

IN REPLY REFER TO

3800

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
UTAH STATE OFFICE
Post Office Box No. 11505
Salt Lake City, Utah 84111

March 21, 1972

Mr. James C. Malaro
Asst. Chief, Materials Branch
Division of Materials Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Re: AEC Docket 48-80-84 (Rio Algom Corporation)

Dear Mr. Malaro:

Rio Algom Corporation representatives have advised us that they have located some mining claims in Section 21, T. 29 S., R. 24 E., SLM, in San Juan County, Utah.

In response to their request this is to advise you that according to the records of this office Sec. 21, T. 29 S., R. 24 E., SLM, is unreserved public land of the United States open to location, entry and patent under and subject to the provisions of the mining laws of the United States.

Sincerely yours,

R. D. Nielson

R. D. Nielson
State Director

APPENDIX B

1. Letter from Rio Algom to Utah State Historical Society, April 24, 1973, requesting an opinion on the impact of the mining and milling activity on any historical or anthropological significance of the site.

2. Letter from State of Utah, Department of Development Services, to Rio Algom, dated May 7, 1973, regarding effects of Rio Algom operation on historical sites.

3. Letter from City of Monticello to Rio Algom Corporation, dated June 6, 1973, commenting on recreational and tourist activities.

Rio Algom
Rio Tinto

April 24, 1973

Mr. A. Kent Powell
Preservation Historian
Utah State Historical Society
603 - East So. Temple
Salt Lake City, Utah 84102
U. S. A.

Dear Mr. Powell:

Further to my conversation with you on the morning of April 13th, we would be pleased if the Society could examine the site of our uranium operation in San Juan County.

As stated we are operating the uranium mill under an interim permit and are in process of obtaining a licence from the U.S. Atomic Energy Commission in Washington. The AEC wish an expression of opinion of an appropriate authority as to possible impact of the mining and milling activity on any historical or anthropological significance of the site.

Our activities are confined to a small area and we are of course not aware of the site having historical or similar stature. You stated that it would be July before an examination could be made and we would be pleased if you could arrange for such at earliest convenience, and provide us with a letter covering your findings, that we may convey to the AEC.

Time and mileage charges as you indicated should be invoiced to Rio Algom Corporation in care of this address in Toronto.

................/2

April 24, 1973

Attached are location maps and a property description, and the property is readily reached from Moab.

Yours sincerely

RDL

R. D. Lord, Vice-President
Research and Development

RDL/gh
Encls.

b.c.c.

Mr. John F. Kendig
Materials Branch
Directorate of Licensing
United States Atomic Energy Commission
Washington, D.C. 20545.

STATE OF UTAH
Calvin L. Rampton, Governor
DEPARTMENT OF
DEVELOPMENT SERVICES
Division of State History
Melvin T. Smith, Director
603 East South Temple
Salt Lake City, Utah 84102
Telephone: (801) 328-5755

May 7, 1973

Mr. R. D. Lord, Vice President
Research & Development
Rio Algam Mines Limited
120 Adelaide Street West
Toronto 110, Canada

Dear Mr. Lord:

Last Wednesday and Thursday, May 2-3, I traveled to LaSal to see if any historic sites would be affected by the uranium operation of the Rio Algam Corporation. After checking over the site, I found no historic sites that would be adversely affected by the operations of the Rio Algam Uranium Mine and Mill located approximately four miles south of LaSal.

I hope this is sufficient for the Environmental Impact Statement necessary in obtaining a license from the U. S. Atomic Energy Commission.

Sincerely yours,

Kent Powell

Kent Powell
Preservation Historian

KP:hm

CITY OF MONTICELLO

Phone 587-2271
P.O. Box 847 MONTICELLO, UTAH 84535 35 West First North

June 6, 1973

RECEIVED JUN 5 1973 RIO ALGOM MOAB

RECEIVED JUN 7 1973 RIO ALGOM MOAB

Rio Algom Corporation
Box 610
Moab, Utah 84532

Dear Mr. Lawton:

In your application for a license with the AEC, if it may be of assistance, we are pleased to make the following comment. In observing the activities of Rio Algom over the past year or so, there appears nothing in their operation at LaSal that in ourview would be detrimental to recreational activities or tourism in the County. We note that you are employing on your work force, Members of our Hispanic and Indian population which contributes to balanced employment in our District.

Sincerely,

CITY OF MONTICELLO

Gene W. Etherington

Mayor Gene W. Etherington

APPENDIX C

1. Analysis of Data From Maple Leaf Claim Area, San Juan Count , Utah by Water Development Corporation, December 1969.

Appendix C, Reference 1
C-2

Water Development Corporation
CONSULTANTS IN GROUND-WATER HYDROLOGY

ANALYSIS OF DATA FROM MAPLE LEAF CLAIM AREA, SAN JUAN COUNTY, UTAH

By

D. K. Greene and L. C. Halpenny

Tucson, Arizona
December 1969

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ANALYSIS OF DATA FROM MAPLE LEAF CLAIM AREA, SAN JUAN COUNTY, UTAH

By

D. K. Greene and L. C. Halpenny

CONCLUSIONS

The data collected and the evaluation and analysis thereof led to development of the following conclusions:

1. A well field capable of producing 200 gpm (gallons per minute) for 24 hours per day and 365 days per year can be developed within the area presently covered by the Maple Leaf claims.

2. The useful life of the well field is estimated to be a minimum of 10 years and more likely would be 20 years or more.

3. A total of six production water wells is considered necessary, each equipped with a pumping unit capable of producing 40 gpm. Operation of the well field would require five wells on the line and one well in reserve.

4. If more than 200 gpm is required at a later date, it is not considered feasible to develop the additional water in the area presently covered by the Maple Leaf claims.

5. The source of the ground water in the Maple Leaf claim area is the Dakota sandstone-Burro Canyon formation. The aquifer is artesian in character and the source of recharge is from precipitation and snowmelt in the La Sal Mountains several miles to the north and northeast. The aquifer is fully saturated and excess ground water is being discharged as spring flow in East Coyote Creek. The cone of depression caused by operating a well field in the Maple Leaf claim area should eventually intercept part of this spring discharge.

RECOMMENDATIONS

1. In the event a temporary water supply is required during construction and, if feasible, it is recommended that Well No. 1 be equipped with a pump and operated as described in this report. Data obtained from this operation may make it possible to refine the accuracy of the aquifer coefficients developed during the 72-hour pump test.

2. If, at a later date, more than 200 gpm of water is required it is recommended that additional land for two well sites be obtained, if possible, adjacent to the Maple Leaf claim area. One site should be located 2,000 feet southeast of existing Well No. 4 and the other site should be located either 2,000 feet further southeast of this site or 2,000 feet west of proposed Well No. 6.

3. An alternative to recommendation No. 2 above would be to use the existing Humeca Wells Nos. 2 and H-16 if more than 200 gpm of water is required.

INTRODUCTION

This report is the third submitted by Water Development Corporation on the subject of development of a ground-water supply for the Rio Algom Corporation s Humeca project, San Juan County, Utah. The first report, entitled "Water supply for proposed mill at Humeca Orebody, San Juan County, Utah" was submitted in March 1968 and reviewed the possibilities of developing a ground-water supply of 200 gpm within a 5-mile radius of the proposed mill. The report also included recommendations for drilling test production water wells at selected sites in the Humeca and Maple Leaf claim areas (see Fig. 1).

Following receipt and review of the 1968 report, officials of Rio Algom Corporation approved a program which consisted of drilling and testing two water wells in the Humeca claim area and cleaning out and testing mineral hole H-16 also in the Humeca claim area (see Fig. 1). Drilling of a test well in the Maple Leaf claim area was deferred at that time pending analysis of the data obtained from the three Humeca tests. The tests were conducted under the supervision of Water Development Corporation and a report entitled "Analysis of data from test wells at Humeca Orebody, San Juan County, Utah" was submitted in May 1969. The report concluded that it would be possible to develop 200 gpm of ground water in the 160 acres comprising the SW$\frac{1}{4}$ Sec. 15, T.29 S., R. 24 E., and that a total of eight wells, which included one standby well, would be required. The report also concluded that the cone of depression would eventually expand into the Coyote Creek spring area and divert part of the ground water now discharging at these springs. In addition, the report concluded that it would be desirable to spread the distance between wells and recommended exploring the possibility of obtaining well sites from Redd Ranches in the NW$\frac{1}{4}$ Sec. 15, T.29 S., R.24 E. The report also recommended that the deferred well in the Maple Leaf claim area be drilled and tested. This recommendation was followed in July 1969 and the drilling was done by L. R. French Water Wells, the same contractor who did the previous drilling. The Maple Leaf well was tested by L. R. French for approximately 6 hours at a discharge of 110 gpm and a pumping water level of 205 feet.

Negotiations with Redd Ranches for the purpose of obtaining additional well sites in the vicinity of the Humeca claim area were unsuccessful. Due to this fact and the results obtained from the first Maple Leaf well, officials of Rio Algom Corporation decided to drill additional wells in the Maple Leaf claim area to develop the required ground water supply.

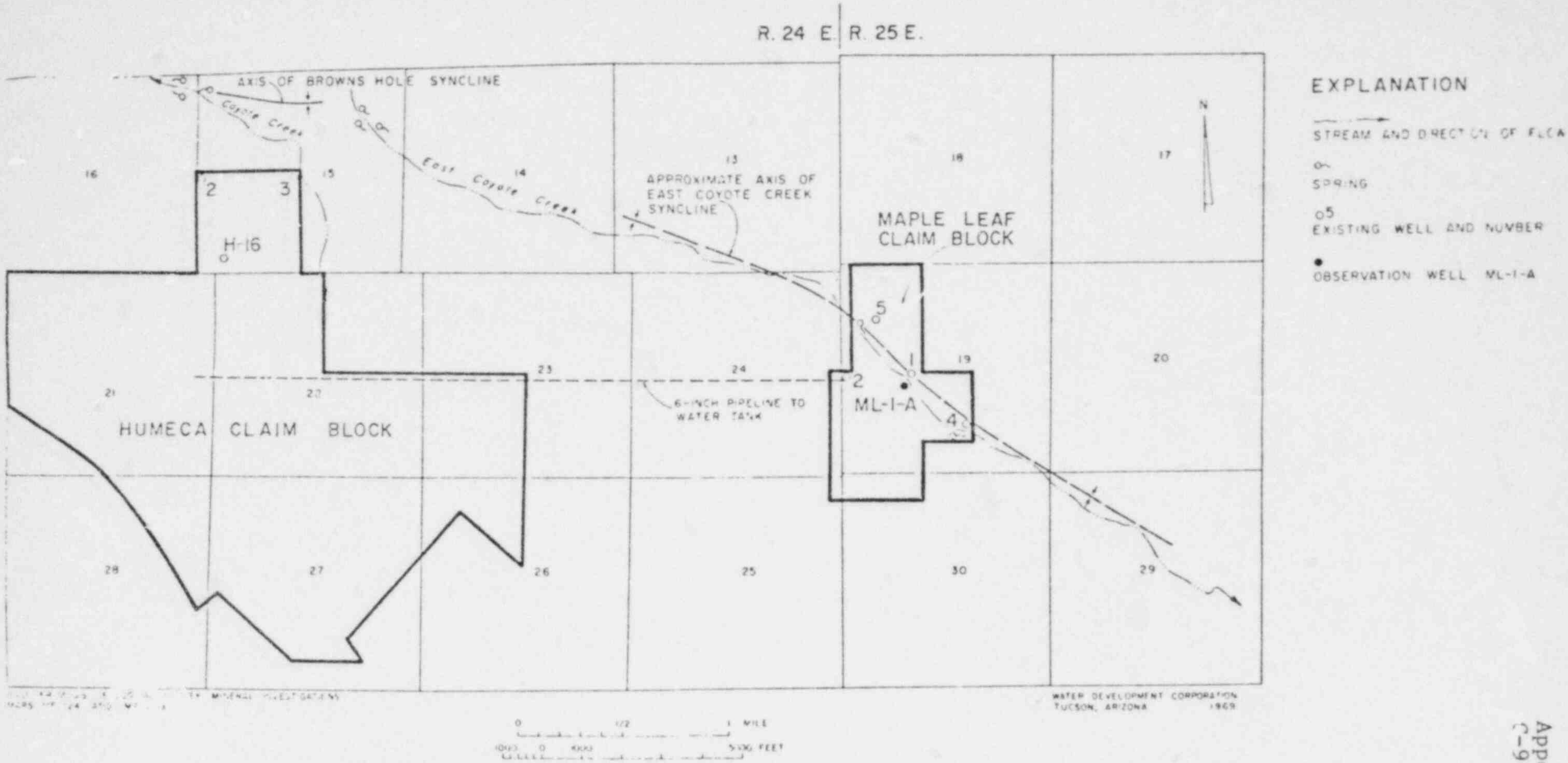


FIGURE 1.--[illegible] PORTION OF TOWNSHIP 29 SOUTH, RANGES 24 AND 25 EAST, SAN JUAN COUNTY, UTAH, SHOWING TEST WELL LOCATIONS.

As of this date a total of four Maple Leaf wells have been drilled and tested. This report contains the data collected during the field work and an analysis of this data with conclusions developed therefrom.

The authors appreciate the assistance and cooperation provided by Messrs. J. E. Moyle, J. D. Guiry, and Andre Belanger of Rio Algom Corporation and the cooperation of Mr. L. R. French and his organization.

c

MAPLE LEAF TEST WELLS

Wells tested for water productivity were Maple Leaf Wells Nos. 1, 2, 4, and 5 (see Fig. 1). Well No. 1, located near the axis of East Coyote Creek syncline was the first well tested. During the 72-hour test on this well, Well No. 2, located further from the synclinal axis, was in the process of being drilled and cased. Following the 72-hour test on Well No. 2 a comparison of the data from these two tests indicated a possibility that wells located closest to the snyclinal axis would have larger yields. As it was planned to drill and test only four wells at this stage of the work it was recommended that site No. 3, located on the flank of the syncline, be passed up at this time and that sites Nos. 4 and 5, which were located nearer the snyclinal axis, be drilled next.

Maple Leaf Well No. 1

Well No. 1 was drilled during July 1969 and, as mentioned previously, a 6-hour pump test was conducted at that time by Mr. L. R. French. The well was drilled to a total depth of 230 feet and the Dakota formation was encountered from land surface to a depth of 200 feet (see Table 1, Appendix A). Ground water was encountered at a depth of 60 feet, giving a saturated thickness of 140 feet of Dakota sandstone. The water was under artesian pressure and rose to within about 2 feet of the land surface.

The well was equipped with a joint of 13-inch surface pipe and cased to total depth with 8-inch casing, perforated from 74 to 230 feet. The perforations were torch-cut slots, approximately 1/8-inch wide by 6 inches long, and spaced so that there were about 12 cuts per foot (9 square inches of opening per foot of casing perforated). The well was cleaned and developed with the drilling rig and a bailer. Elevation of the top of the 8-inch casing is 6,496.65 feet above sea level.

A test pump was installed with the top of the pump bowls set at a depth of 210 feet and operated steadily for 72 hours in October 1969. The discharge ranged from a high of 157 gpm near the beginning of the test to 83 gpm at the end. Average weighted discharge throughout the test was 89.7 gpm and the final pumping water level was 198 feet. Data collected during the test are given in Table 2, Appendix A.

Maple Leaf mineral hole ML-1-A, located 242 feet south and west of Well No. 1 (see Fig. 1) was used as an observation well during the test. Decline in this well as a result of pumping Well No. 1 amounted to about 30 feet at the end of pumping. Measurements made in ML-1-A during the test on Well No. 1 are given in Table 3, Appendix A.

During the test on Well No. 1 and also during subsequent tests, the streamflow in East Coyote Creek was observed to see if pumping had any noticeable effect on the amount of streamflow. No measurable effect could be determined but the weather which prevailed during the period of testing--rain, snow, freezing, and thawing--would make it extremely difficult to determine relatively small effects on streamflow.

Maple Leaf Well No. 2

Well No. 2 was drilled during October 1969 and was completed while Well No. 1 was being tested. The well was drilled to a total depth of 270 feet. The upper 20 feet of material consisted of alluvium and the Brushy Basin member was encountered at a depth of 255 feet, thus, the Dakota thickness at this location was 235 feet (see Table 4, Appendix A). Water was encountered at a depth of 98 feet and eventually rose to about 31 feet. Saturated thickness of Dakota amounted to 157 feet.

The well was equipped with a joint of 13-inch surface pipe and cased to total depth with 8-inch casing, perforated from a depth of 100 to 270 feet. The size and number of perforations per foot were the same as described for Well No. 1. The well was cleaned and developed with the drilling rig and a bailer. Elevation of the top of the 8-inch casing is 6,539.76 feet above sea level.

A 72-hour pump test was made beginning on October 25, 1969, with the top of the pump bowls set at 250 feet. Discharge at the beginning of the test was 73 gpm and at the end was 55 gpm. Final pumping water level was slightly over 246 feet. Data collected during the test are given in Table 5, Appendix A.

Maple Leaf Well No. 1 was used as an observation well during the test on Well No. 2 and the data are given in Table 6, Appendix A. As No. 1 was still recovering from the effect of its own pumping, a precise computation of the true effect of Well No. 2 on Well No. 1 cannot be determined. However, the measured effect during the test amounted to 4.5 feet.

Maple Leaf Well No. 4

Well No. 4 was drilled in November 1969 to a total depth of 235 feet. The Dakota formation was encountered from land surface to a depth of 220 feet (see Table 7, Appendix A). Water was encountered at a depth of 55 feet and rose to a level of about 22 feet. Saturated thickness of Dakota formation at this location is 165 feet.

The well was completed similar to Wells Nos. 1 and 2 with 13-inch surface pipe and 8-inch casing, perforated from a depth of 45 feet to the bottom. Size and number of perforations per foot was the same as for Wells Nos. 1 and 2. The well was cleaned and developed with the drilling rig and bailer before and after casing. Elevation of the top of the 8-inch casing is 6,481.31 feet above sea level.

A 72-hour pump test was conducted on Well No. 4 starting on November 17, 1969 with the top of the pump bowls set at a depth of 210 feet. Discharge at the beginning of the test was 125 gpm and at the end of the test was 77 gpm. Average weighted discharge throughout the test was 78.6 gpm and the final pumping water level was about 178 feet. Data collected during this test are given in Table 8, Appendix A.

Maple Leaf Wells Nos. 1 and 2 were used as observation wells during the test on Well No. 4 and the data are given in Tables 9 and 10 of Appendix A. The cone of depression created by pumping Well No. 4 caused a drawdown of 9.42 feet in Well No. 1 and 2.94 feet in Well No. 2.

Maple Leaf Well No. 5

Drilling and casing of Well No. 5 was completed during the test on Well No. 4. Total depth drilled was 230 feet and the Brushy Basin shale member was encountered at a depth of 215 feet. The Dakota formation occurred at land surface at this location, thus, the thickness of Dakota was 215 feet (see Table 11, Appendix A). The first water was encountered at 32 feet and rose to a level of about 14 feet. Saturated thickness of the Dakota formation at this location was 183 feet.

The well was completed in the same manner as Wells Nos. 1, 2, and 4, with 13-inch surface pipe and 8-inch casing. Perforations were the same as previously described and extended from a depth of 35 feet to total depth of the hole. The well was cleaned and developed with the drilling rig and a bailer before and after casing. Elevation of the top of the 8-inch casing is 6,523.62 feet above sea level.

The test pump was installed with the top of the pump bowls set at 210 feet and a 72-hour pump test was conducted beginning on November 21, 1969. The discharge at the beginning of the test was 165 gpm and at the end was 73 gpm with a final pumping water level of approximately 190 feet. Average weighted discharge during the test was 75.9 gpm. Data collected during the test are given in Table 12, Appendix A.

Wells Nos. 1 and 2 were used as observation wells during the test on Well No. 5 and the data collected are given in Tables 13 and 14 of Appendix A. Both of these wells were still recovering from the effect of pumping Well No. 4. Thus, the true effect of pumping No. 5 on these wells cannot be determined. The measured effect of pumping Well No. 5 was 2.94 feet on Well No. 1 and 4.29 feet on Well No. 2. Well No. 4 was also measured while pumping Well No. 5 but the rate of recovery of Well No. 4 was greater than any drawdown effect caused by Well No. 5. Undoubtedly, the recovery rate of No. 4 was dampened by pumping No. 5 but the amount of dampening is unknown.

ANALYSIS OF DATA

Data collected during the four pump tests, including that collected from wells used as observation wells, were analyzed as thoroughly as possible. This analysis made it possible to determine the relationship between ground-water pumpage and water-level declines and project this relationship into the future. In evaluating the results of the analyses, more weight was given to the results obtained from pumping Wells Nos. 1 and 4. At the beginning of pumping for Wells Nos. 2 and 5, the aquifer had not fully recovered from the effect of testing Wells Nos. 1 and 4. In other words, water levels were still rising and had not yet reached the original static water level, thus the true drawdown could not be determined.

Coefficient of Transmissibility

The coefficient of transmissibility can be determined either from drawdown or recovery measurements in the pumped wells and observation wells. For the pumped wells, generally the recovery measurements provide the best data for the coefficient of transmissibility. During pumping, small variations in engine speed cause fluctuations in the pumping water level which results in an uneven curve when plotted. For observation wells, both drawdown and recovery data provide equally good plots to determine the coefficient of transmissibility.

There were three distinct slopes on recovery data plotted for Well No. 1 after it was pumped. Computations based on these slopes gave coefficients of transmissibility of 760, 950, and 1,700 gpd/ft (gallons per day per foot). Drawdown and recovery data for observation well ML-1-A both gave a coefficient of transmissibility of about 1,200 gpd/ft. Recovery data on Well No. 2 after it was pumped gave a coefficient of transmissibility of 1,080 gpd/ft. The drawdown data on Well No. 1 while pumping Well No. 2 gave a coefficient of transmissibility of 2,640 gpd/ft.

Recovery data for Well No. 4 after it was pumped gave a coefficient of transmissibility of 1,260 gpd/ft and are shown on Figure 2. The drawdown data for Wells Nos. 1 and 2, used as observation wells while pumping Well No. 4, gave coefficients of transmissibility of 1,870 gpd/ft and 4,305 gpd/ft respectively (see Figs. 3 and 4).

The recovery data on Well No. 5 after it was pumped had two distinct slopes from which coefficients of transmissibility of 1,670 and 2,230 gpd/ft were computed. Recovery data from Wells Nos. 1 and 2 after pumping Well No. 5 gave values of 3,300 and 4,600 gpd/ft respectively.

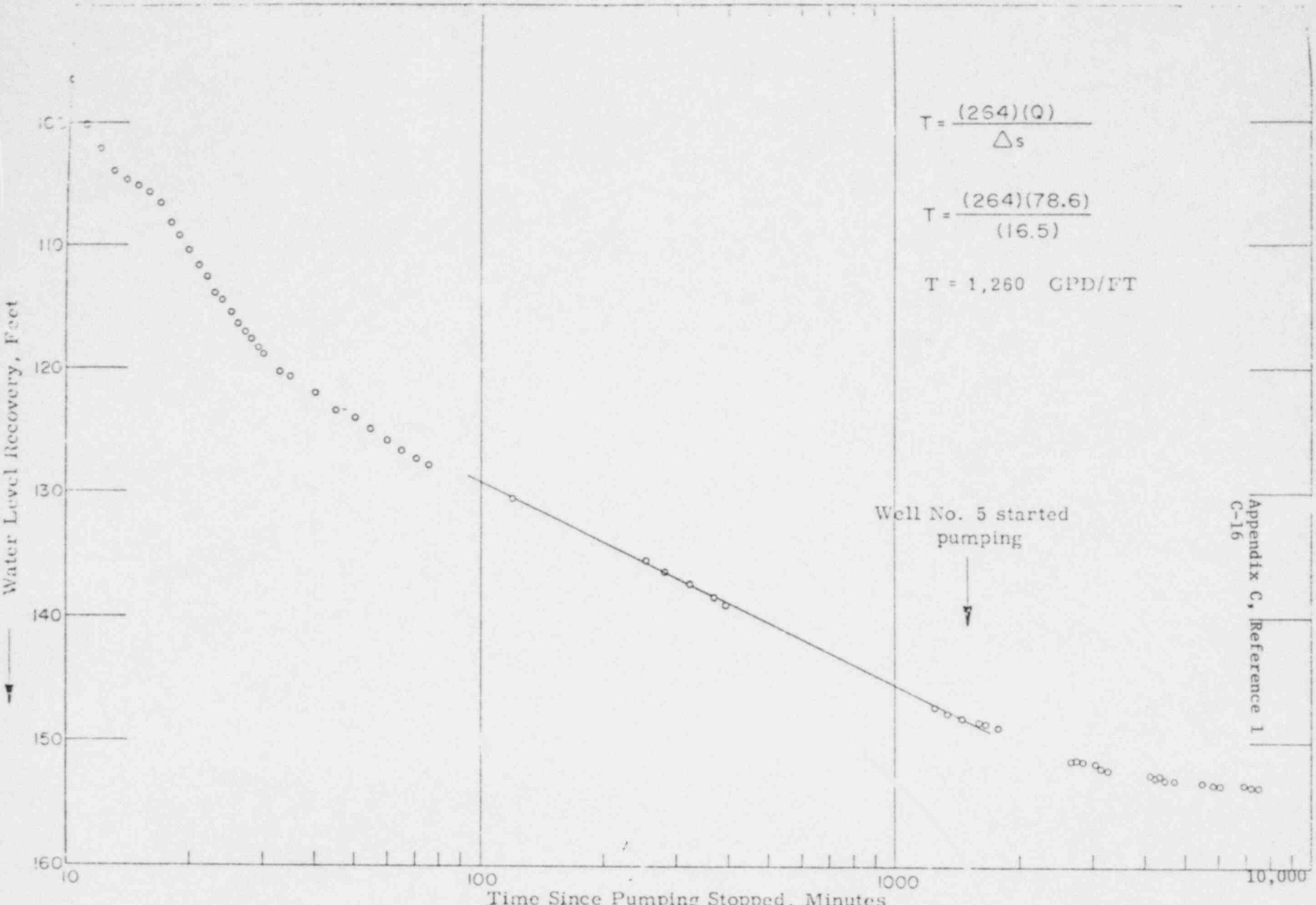


Figure 2. - Recovery Graph, Well No. 4.

$$T = \frac{(264)(Q)}{(\triangle s)}$$

$$T = \frac{(264)(78.6)}{(11.1)}$$

T = 1,870 GPD/FT

$$S = \frac{(0.3)(T)(t_0)}{(r^2)(1440)}$$

$$S = \frac{(0.3)(1870)(640)}{(1811)^2\,(1440)}$$

S = 0.000076

S = 0.0076 %

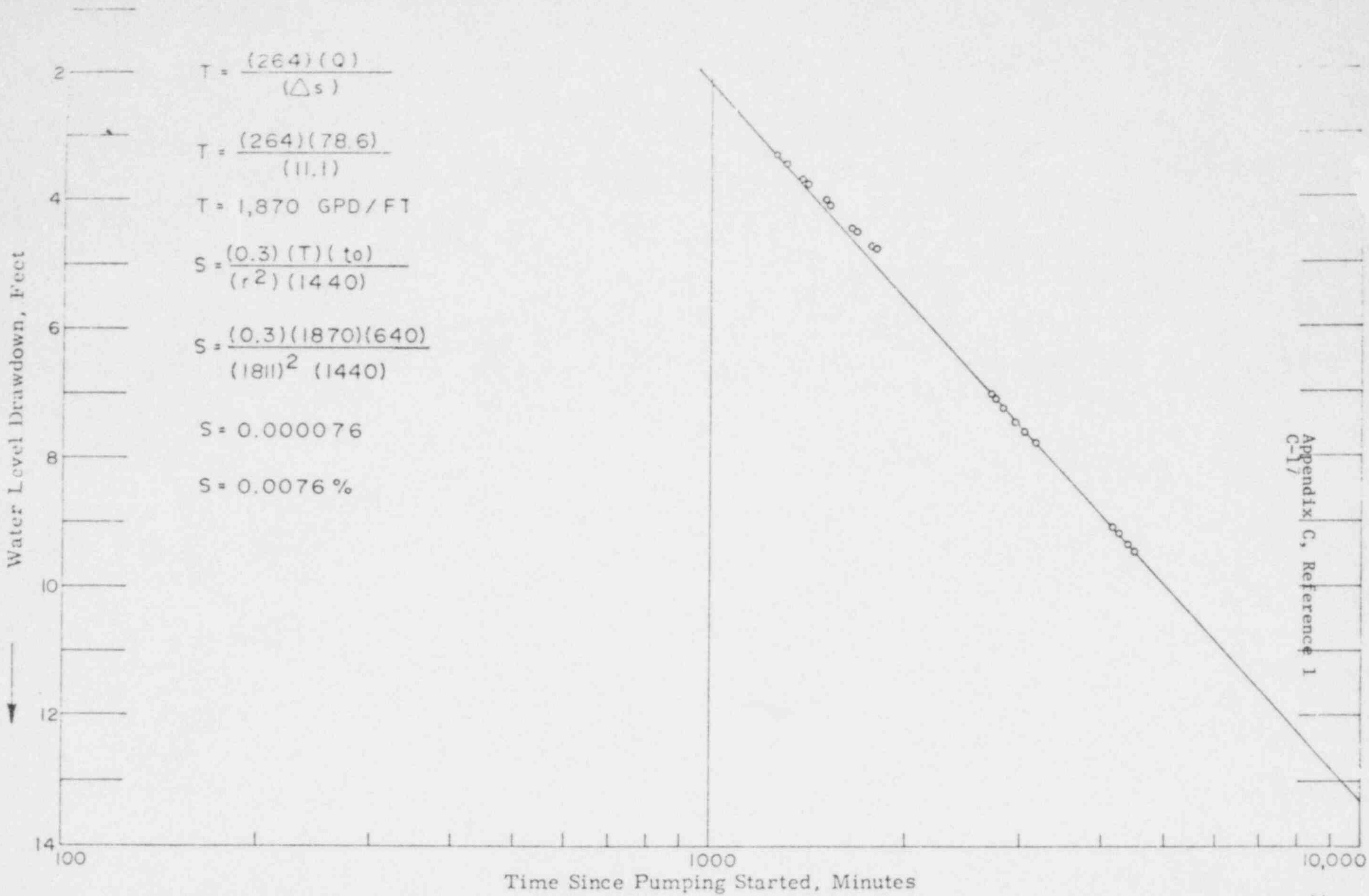


Figure 3. - Drawdown in Well No. 1 While Pumping Well No. 4.

Appendix C, Reference 1
C-17

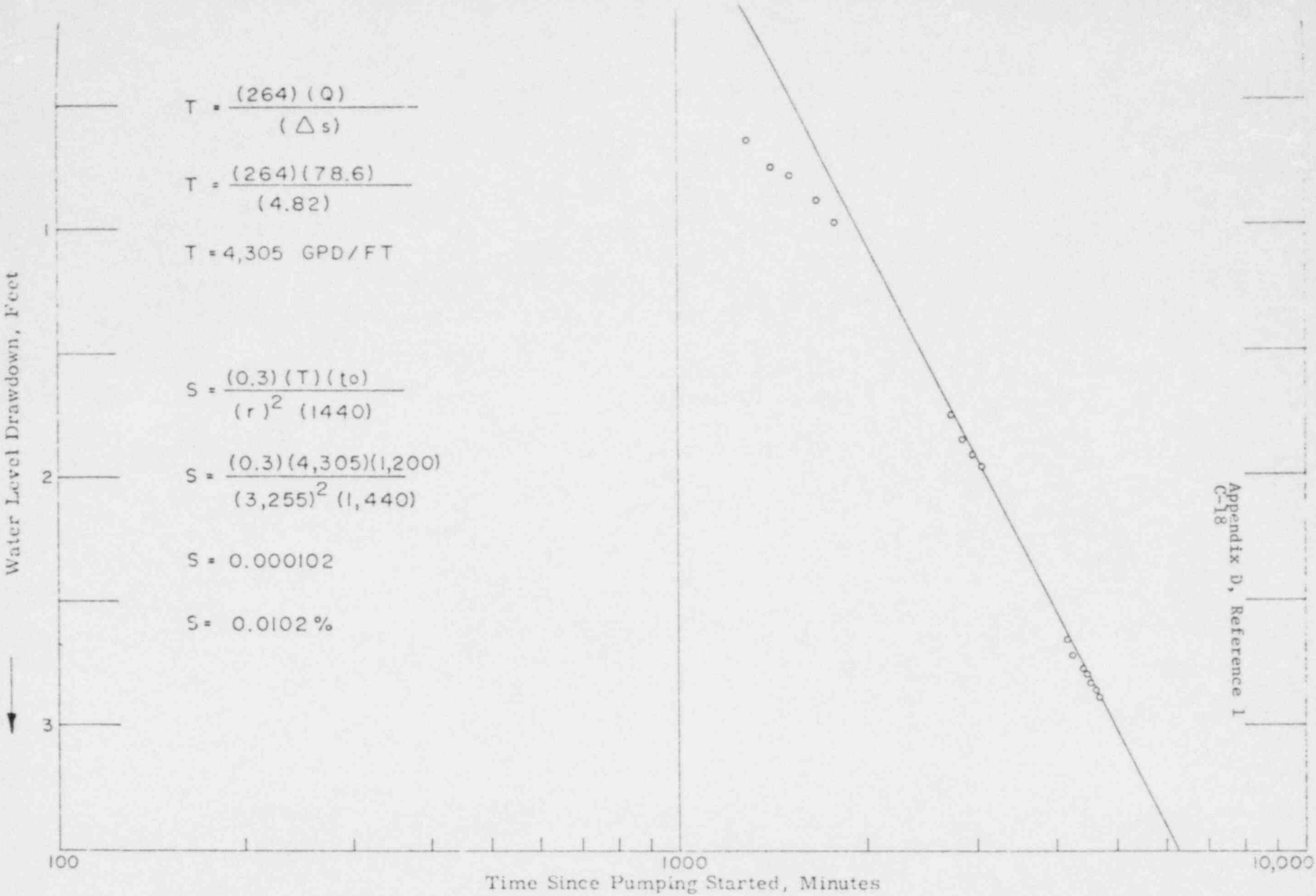


Figure 4. - Drawdown in Well No. 2 While Pumping Well No. 4.

In summary, the coefficients of transmissibility computed at the pumped wells ranged from a low of 760 gpd/ft for Well No. 1 to a high of [illegible] gpd/ft for Well No. 5. The value computed for Well No. 5, however, was affected by an unknown amount due to the fact that the aquifer had not fully recovered from pumping Well No. 4. The coefficient of transmissibility values determined from the observation wells were in general higher and ranged from a low of about 1,200 gpd/ft for well ML-1-A during the test on Well No. 1 to a high of 4,600 gpd/ft at Well No. 2 during the test on Well No. 5. As mentioned previously, the data obtained during the test on Well No. 5 were affected by the just completed test on Well No. 4.

The primary reasons for the lower values of transmissibility occurring at the pumped wells is due to non-laminar flow in the formation near the bore hole and well loss caused by turbulent flow at the well casing. As the distance from the pumped well increases the flow of ground water through the aquifer becomes laminar and the coefficient of transmissibility values are usually higher. In some areas of the Maple Leaf claims where the Dakota sandstone outcropped it was observed to be fractured and in other areas it was massive. The variation in transmissibility coefficients determined from the observation wells was undoubtedly affected by the existence or non-existence of this fracture pattern.

Coefficient of Storage

The coefficient of storage can be determined only by the use of observation wells and is a function of distance from the pumped well, amount of drawdown or recovery during or after pumping and the amount of time it took for the drawdown or recovery to take place.

During the test on Well No. 1 the data from observation well ML-1-A gave values of 0.0615 percent on drawdown and 0.0256 percent on recovery for the coefficient of storage. During the test on Well No. 4 the drawdown data measured in Wells Nos. 1 and 2 gave coefficient of storage values of 0.0076 percent and 0.0102 percent respectively (see Figs. 3 and 4).

Recovery data from Wells Nos. 1 and 2 after pumping Well No. 5 gave values of 0.0124 and 0.0278 respectively for the coefficient of storage.

Summary

The various computed values for the coefficients of transmissibility and storage are tabulated as follows:

Well No.	Type of Data Used	Coefficient of Transmissibility (gpd/ft)	Coefficient of Storage (percent)
Pumped Wells			
1	Recovery	760	--
		950	--
		1,700	--
2	Recovery	1,080	--
4	Recovery	1,260	--
5	Recovery	1,670	--
		2,230	--
Observation Wells			
ML-1-A	Drawdown	1,220	0.0615
	Recovery	1,200	.0256
1	Drawdown	2,640	--
1	Drawdown	1,870	.0076
2	Drawdown	4,305	.0102
1	Recovery	3,300	.0124
2	Recovery	4,600	.0278

Based on the data obtained from the tests and giving consideration to the actual specific capacities (gallons per minute per foot of drawdown) of the pumped wells, it was considered desirable to select two values for the coefficient of transmissibility for use in projecting future pumping water levels. Accordingly, a value of 800 gpd/ft was selected to determine the effect of each pumped well on itself and a value of 3,000 gpd/ft was selected to determine the effect of each pumped well on the remaining wells.

The coefficient of storage determined from the tests falls in the semi-artesian to artesian range. A value of 0.01 percent was considered a reasonable value to use for projecting future pumping water levels.

Quality of Water

Water samples were collected from each of the four wells tested and were analyzed by the Agricultural Engineering Department, University of Arizona. The results of the analyses are tabulated below:

Item (parts per million unless otherwise indicated)	Well No. 1	Well No. 2	Well No. 4	Well No. 5
Date collected	10-18-69	10-28-69	11-20-69	11-24-69
Temperature when collected, ^{o}F	51	51	51	52
Specific Conductance, micromhos	700	560	550	670
pH	7.4	7.7	7.5	7.5
Calcium, Ca	144	114	100	130
Magnesium, Mg	49	26	28	39
Sodium and Potassium, Na+K	26	25	29	27
Carbonate, CO_3	0	0	0	0
Bicarbonate, HCO_3	273	220	249	268
Sulfate, SO_4	285	200	160	246
Chloride, Cl	28	24	32	36
Nitrate, NO_3	0.1	3	0.2	1.6
Fluoride, F	0.3	0.2	< 0.2	< 0.2
Total Soluble Salts	806	612	598	746

The analyses from the Maple Leaf wells were compared with those from the Humeca wells, Coyote Creek, and East Coyote Creek which were included in the May 1969 report. The major deviation in the general character of the water is that the Maple Leaf water is higher in sulfate and calcium content. However, this difference is not significant. It is considered that the basic source of ground water from the Maple Leaf claim area is the same as for the Humeca area, Coyote Creek, and East Coyote Creek.

DEVELOPMENT OF WELL FIELD

Preliminary Calculations

Owing to the higher yields of the Maple Leaf wells in comparison with the Humeca wells, an initial set of calculations was made to determine the effect of operating all four Maple Leaf wells for 10 years at a continuous pumping rate of 50 gpm. The results were as follows:

Well No.	Calculated Drawdown (ft)	Thickness of Saturated Aquifer Remaining at End of 10 Years (ft)
1	188	10
2	186	38
4	183	15
5	185	16

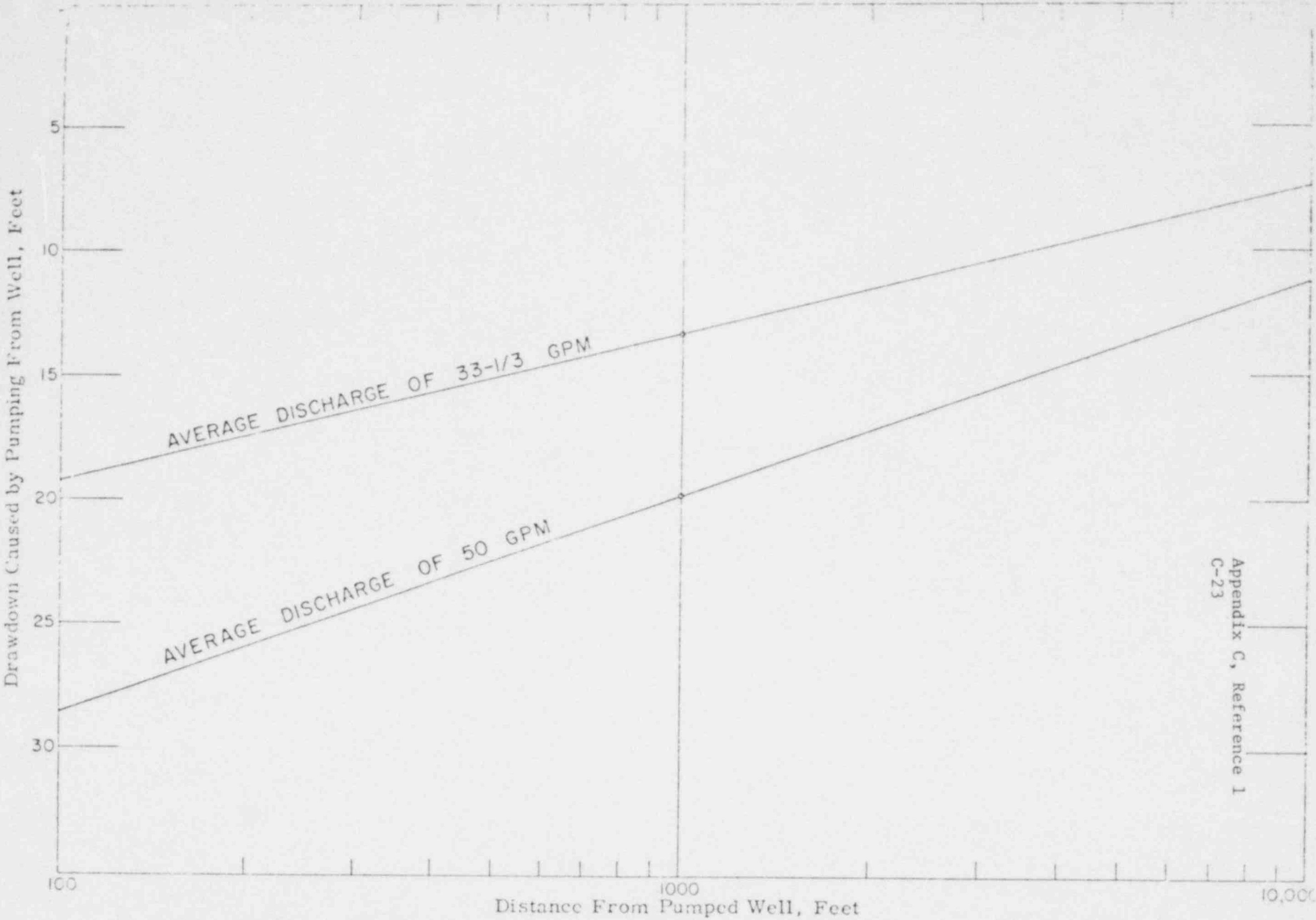
The thickness of saturated aquifer remaining at the end of 10 years is considered inadequate and the authors consider that an attempt to produce 200 gpm from the four wells would be undesirable.

Well Field Capable of Producing 200 Gallons per Minute

Following review of the preliminary calculations a conclusion was reached that a well field in the Maple Leaf claim area that would be capable of producing 200 gpm for 10 to 20 years should consist of six wells. The two additional wells required could be drilled within the existing area of the claim. The recommended site for one of the additional wells is at the location already marked with a stake for Well No. 3. This location is near the site shown on the Rio Algom map designated "Plant Water Supply--Drawing No. 109-80-01," at the south center of Claim No. 21. The site for the other well (No. 6) is recommended at the northwest corner of Claim No. 1, which is the extreme northwest corner of the block of claims.

Of the six wells, all should be equipped with pumps capable of producing 40 gpm. Five wells would be operated at any one time to produce the required 200 gpm; the sixth well would provide standby capacity.

Figure 5 is a graph on semi-logarithmic scale showing the drawdown at the end of 10 years at various distances from a pumped well. Two lines are shown on the graph, one for a continuous pumping rate of



Appendix C, Reference 1
C-23

Figure 5. - Relation Between Drawdown and Distance From Pumped Well at End of 10 Years.

33-1/3 gpm and one for 50 gpm. The drawdown at any distance from the pumped well is, at a pumping rate of 33-1/3 gpm, two-thirds of the drawdown at a pumping rate of 50 gpm.

For a six-well field producing a continuous supply of 200 gpm, the calculations showed the following results for 1 year, 10 years, and 20 years:

Well No.	Calculated Drawdown (ft)	Thickness of Saturated Aquifer Remaining at End of Period (ft)
	At End of 1 Year	
1	141	57
2	140	84
3	139	91
4	136	62
5	140	61
6	136	59
	At End of 10 Years	
1	167	31
2	165	59
3	164	66
4	162	36
5	166	35
6	161	34
	At End of 20 Years	
1	175	23
2	173	51
3	172	58
4	170	28
5	174	27
6	169	26

COMPARISON OF AQUIFER CHARACTERISTICS

Specific Capacity

The results of the well tests on the four new wells drilled in the Maple Leaf claim area indicated that the specific capacity was as follows:

Well No.	Specific Capacity (gpm per ft of drawdown)
1	0.423
2	.257
4	.490
5	.417
Average (four wells)	.40

For comparative purposes the specific capacity of the wells in the Humeca area was as follows:

Well No.	Specific Capacity (gpm per ft of drawdown)
2	0.415
H-16	.517
3	.211
Average (three wells)	.38

The most permeable part of the Dakota sandstone-Burro Canyon formation is at the bottom. The calculations indicate that the well field could be operated at 200 gpm for at least 10 years and possibly for 20 years. By the end of 10 years the capacity of the wells to yield water may have declined to the proposed design yield of 40 gpm per well. By the end of 20 years it may be necessary to operate all six wells all the time and the possibility exists that it might be necessary to drill and utilize a seventh well.

Well Field Capable of Producing 250 Gallons per Minute

The calculations indicate that the present Maple Leaf claim area is not large enough to accommodate a well field capable of yielding a continuous supply of 250 gpm for 10 to 20 years. A total of eight wells would be required. If 250 gpm is needed from the Maple Leaf claim area, it is recommended that additional land should be acquired along the axis of the syncline, which is occupied by East Coyote Creek. The first of the two additional wells could be drilled at a distance of 2,000 feet southeast from Well No. 4, in the SE cor. Sec. 19, T.29 S., R.25 E. The second could be drilled either 2,000 feet farther southeast or it could be drilled at a distance of 2,000 feet west of proposed Well No. 6, on either side of the line between Secs. 13 and 24, T.29 S., R.24 E

Temporary Water Supply During Construction

It is understood that full operation of the water system may not be required for a year or two. This interval of time provides an opportunity to collect additional data which could be used to refine the accuracy of the aquifer coefficients developed during the 72-hour pumping tests on the four wells.

It is suggested that Well No. 1 be equipped with a pump having a capacity of 40 gpm and, if necessary, powered on a temporary basis by means of an internal combustion engine and a gearhead drive. The unit could be converted to electric power at a later date without removal from the well. If this were to be done, the well could be operated to the extent required for construction work until such time as the entire 200 gpm is required.

Collection of data in relation to operation of the well is recommended as follows:

1. Install a Sparling or Badger (or equal) water meter on the discharge line at the well. Record the accumulated meter reading each time the well is turned on. If operation is continuous, record the reading once every 7 days. In recording the data, note the date and hour each time the meter is read and each time the pump is turned on or turned off.

2. Measure the depth to water in Wells Nos. 1, 2, 4, and 5 just before Well No. 1 is turned on and just before it is turned off. Record these data to the nearest one-tenth of a foot and include in the record the date and hour of measurement. If operation is continuous, take water-level readings in all wells once every 7 days. To insure that pumping water levels can be obtained it is recommended that a 3/4-inch measuring tube be installed with the pump.

Summary

Analysis of the data collected during testing of the four wells in the Maple Leaf claim area indicated the following:

1. For producing 200 gpm on a continuous basis for as long as 20 years it is considered necessary to drill two more wells and to equip all six wells with pumping units each capable of yielding 40 gpm;

2. For producing 250 gpm on a continuous basis for as long as 20 years it is considered necessary to extend the claim area southeastward and possibly also westward so that two additional well sites could be acquired, each at a distance of 2,000 feet from the nearest pumping well. The most desirable sites are along the axis of the East Coyote Creek syncline.

ESTIMATED REMAINING COST OF WELL FIELD

Remaining Cost For Well Field Yielding 200 Gallons per Minute

Drilling an additional two wells is estimated to cost $5,000 per well, with a total cost of $10,000.

Purchase and installation of six pumping units, each designed to pump 40 gpm, is estimated to cost $2,000 per unit, with a total cost of $12,000. For selection of pumping units the depth of bowl setting and suggested design pumping lift to the land surface is as follows:

Well No.	Depth to Top of Bowls (ft)	Depth to Pumping Water Level (ft)
1	200	170
2	225	195
3	210	180
4	215	185
5	210	180
6	240	210

Additional Cost For Increasing Capacity of Well Field to 250 Gallons per Minute

Additional costs over and above the cost for a 200 gpm well field would include the cost of two more wells and pumping units and cost of land acquisition. An additional 4,000 to 5,000 feet, depending on the route followed, of pipe line would also be required for the pipe line gathering system.

Estimated Cost of Developing 60 Gallons per Minute From Humeca Wells Nos. 2 and H-16

An alternative method of developing an additional 50 to 60 gallons per minute of well capacity would be to install pumps on Humeca Wells Nos. 2 and H-16, thus eliminating drilling and land acquisition costs.

Two 30 gpm pumping units would be required at an estimated installed cost of $1,500 each. Approximately 5,000 feet of pipe line would be required to connect these two wells to the system.

MANAGEMENT OF WELL FIELD

The calculations described in this report indicated that 200 gpm can be obtained from five wells in the Maple Leaf claim area, each equipped with a 40 gpm pumping unit. One additional well will provide reserve capacity when a well needs to be taken out of service for pump overhaul.

Management of the well field should include rotating the pumped wells on a once-a-week basis so that the reserve well remains in top condition. Under this plan each well would be shut down for one week out of every six weeks. In addition to keeping all wells in top condition, this will distribute the cone of depression more evenly throughout the entire well field.

Recommended data collection on a continuing basis includes the following:

1. Measure and record depth to water level in each well once a month for the first year and once every three months thereafter. Note whether the well was on or off when measured.

2. Record the cycle of operation of the wells--when each was turned on or off.

3. If water meters are not installed at each well, arrange a gated blow-off line at each well and measure the discharge quarterly. If meters are used, record the volume reading of the meter each time the well is turned off.

Diligent collection of the above three items of data on a continuing basis will be invaluable when the time arrives to decide whether or not to overhaul a pump and/or to clean out and redevelop a well. If the yield of a well declines the data will indicate whether the cause is the pump, the well, or the aquifer. Facts are better than opinions, and the authors have seen many unnecessary expenses develop from making guesses about when to overhaul a well.

A P P E N D I X A

TABLE 1

RIO ALGOM MAPLE LEAF WELL NO. 1
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Dakota sandstone--Burro Canyon formation		
0	25	Sandstone
25	60	Green shale
60	108	Gray and white sandstone, water encountered at 60 feet
108	123	Clay ribs and sandstone
123	200	White sandstone
Brushy Basin shale member of Morrison formation		
200	230	Clay and sandstone ribs

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-15-69	16:20	2.14		Measuring point top of surface pipe 0.20 foot above land surface
10-16-69	13:20	2.15		
	15:36	1.80		
10-17-69	09:39	1.65		
	10:20	2.07		Measuring point top of 3/4-inch tube 0.58 foot above land surface
	10:46	2.08		
	11:03	2.08		
	11:30	2.07		
	11:31			Pump on to check equipment
	11:44			Pump off
	12:45	12.95		
	12:49	12.26		
	12:53	11.39		
	13:00			Pump on. Bowls set at 210 feet
	13:01	25.00		
	13:01:30	45.00		
	13:02	55.00		
	13:02:30	65.00		
	13:03	70.00		
	13:04	80.00		
	13:05	90.00		
	13:05:30	95.00		
	13:07	100.00	150	
	13:09	105.00	157	
	13:11	106.29	125	
	13:13	107.67	132	
	13:15	109.27		
	13:16	109.79		
	13:17	110.10		
	13:19	110.40		

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALCOM MAPLE LEAF WELL NO. 1, continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-17-69	13:20	110.57		
	13:22	111.03		
	13:25	111.57		
	13:30	113.33	110	
	13:35	115.86		
	13:38	116.00		
	13:40	116.23	103	
	13:45	117.08		
	13:50	118.13		T = 52° F
	13:55	119.00	97	
	14:02	119.37		
	14:05	120.33	97	
	14:10	120.84		
	14:15	120.45		
	14:24	121.50	99	
	14:34	122.20		
	14:38	123.06		
	14:46	123.18	94	
	14:54	127.33	100	
	15:04	128.49		
	15:19	128.81		
	15:37	129.56		
	15:53	129.42	92	
	16:20	132.58	97	
	16:23		92	
	16:28		100	T = 52° F
	16:29	135.94		
	16:31	136.55		
	16:43		105	
	16:47	142.86		
	16:50		97	
	17:14	144.16	99	
	17:22	144.08	97	
	17:34	144.81		
	18:15	146.21	93	
	18:20		103	

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-17-69	18:26		98	
	18:28	151.26	92	
	18:29	151.56	92	Increased rpm
	19:11	153.20	98	
	20:34		97	
10-18-69	05:56	156.68	87	
	06:05		92	
	06:07		97	
	06:08	163.75		
	06:50	169.49	92	
	07:20	168.52	90	
	07:30	170.33	97	
	08:41	171.20	103	
	09:34	181.20	94	T = 51° F
	10:33	180.29	90	
	11:46	189.64	93	
	12:55	201.80	94	
	13:16	204.91	94	Collected water sample
	13:21		90	
	13:33	205.81	83	
	13:40	196.79	86	
	14:26	180.29	92	
	15:09	182.00	89	
	16:41	181.94	86	
	17:43	181.98	86	
	18:23	182.13	89	
	20:12	184.57	89	
	22:30		89	
10-19-69	00:45		92	
	04:30		89	
	06:55	185.65	89	
	08:46	184.09	87	
	10:27	188.90	87	
	11:50	187.18	87	
	13:16	187.50	85	
	14:44	185.84	85	

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALCOM MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-19-69	16:58	189.61	87	
	18:52	192.92	89	
	20:26	195.00	87	
	22:30		87	
10-20-69	02:00		83	
	04:00		83	
	06:25	199.39	85	
	09:20	196.84	85	
	11:17	197.38	83	
	12:39	197.77	87	
	12:57	197.81	83	
	13:00			Pump off
	13:00:15	185.00		
	13:00:45	155.00		
	13:01	145.00		
	13:01:20	140.00		
	13:01:45	135.00		
	13:02:15	130.00		
	13:02:45	125.00		
	13:03:15	120.00		
	13:04	115.00		
	13:06	110.81		
	13:09	94.29		
	13:15	74.79		
	13:17	73.85		
	13:19	73.00		
	13:21	72.57		
	13:28	70.17		
	13:30	69.46		
	13:32	68.59		
	13:34	67.69		
	13:36	67.19		
	13:38	66.43		
	13:45	64.02		
	13:48	62.70		
	13:58	60.17		

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-20-69	14:00	59.62		
	14:02	59.00		
	14:05	58.31		
	14:12	56.35		
	14:17	55.32		
	14:20	54.76		
	14:23	54.31		
	14:33	52.06		
	14:35	51.85		
	14:39	51.50		
	14:50	49.49		
	14:53	49.04		
	14:57	48.61		
	15:00	48.27		
	15:12	46.97		
	15:14	46.71		
	15:17	46.38		
	15:25	45.45		
	15:29	45.17		
	15:31	44.99		
	15:44	43.84		
	15:48	43.50		
	15:59	42.65		
	16:13	41.59		
	16:32	40.33		
	16:52	38.88		
	17:07	38.04		
	17:25	37.15		
	17:46	35.96		
	18:13	34.88		
	18:37	33.86		
	19:09	32.81		
	19:31	31.95		
	19:59	31.12		
	20:35	30.05		
	21:19	28.80		

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1.
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-21-69	06:52	19.63		
	07:37	19.36		
	07:59	19.05		
	09:03	18.47		
	09:56	17.92		
	11:28	17.17		
	12:20	16.62		
	14:14	15.99		
	14:52	15.82		
	15:45	15.55		Starting to pull pump
10-22-69	15:11	9.99		Measuring point top of 8-inch casing 0.42 foot above land surface
	16:07	9.80		
10-23-69	09:46	7.84		
	11:06	7.74		
10-24-69	15:03	5.85		
	17:59	5.70		
10-25-69	05:52	5.33		
	08:33	5.25		Maple Leaf Well No. 2 pump on 06:00 hrs
	11:23	5.39		

TABLE 3

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF MINERAL HOLE NO. 1-A DURING TEST ON MAPLE LEAF WELL NO. 1

Date	Hour	Depth to Water Level (ft)	Remarks
10-17-69	10:45	0.37 est.	Measuring point top of plate, 1 foot below land surface
	16:15	0.71 ?	Maple Leaf Well No. 1 pump on 1[illegible]00 hrs
	17:29	0.62 ?	
10-18-69	07:37	6.08 ?	
	08:54	19.36	
	09:40	19.76	
	10:44	20.35	
	11:55	21.00	
	13:06	21.62	
	14:36	22.26	
	15:17	22.51	
	16:49	22.96	
	17:44	23.21	
	18:29	23.46	
	20:07	23.92	
10-19-69	08:54	26.71	
	10:18	26.98	
	11:56	27.21	
	13:12	27.37	
	14:54	27.61	
	16:54	27.86	
	19:01	28.26	
	20:24	28.39	
10-20-69	06:19	29.68	
	09:31	30.00	
	11:12	30.15	
	12:46	30.24	
	13:12	30.31	Maple Leaf Well No. 1 pump off 13:00 hrs
	13:25	30.24	
	13:42	29.82	
	13:54	29.52	
	14:09	28.96	
	14:28	28.15	

TABLE 3

DRAWDOWN AND RECOVERY DATA, RIO ALCOM MAPLE LEAF MINERAL HOLE NO. 1-A DURING TEST ON MAPLE LEAF WELL NO. 1, continued.

Date	Hour	Depth to Water Level (ft)	Remarks
10-20-69	14:45	27.25	
	15:04	26.40	
	15:22	25.53	
	15:40	24.76	
	15:56	24.01	
	16:18	22.95	
	16:31	22.13	
	16:54	21.28	
	17:11	20.76	
	17:28	20.08	
	17:50	19.26	
	18:17	18.34	
	18:41	17.61	
	19:05	16.83	
	19:39	15.90	
	19:54	15.49	
	20:41	14.37	
	21:15	13.58	
10-21-69	06:58	5.39	
	07:34	5.25	
	08:06	4.96	
	08:58	4.51	
	10:01	4.04	
	11:52	3.53	
	12:47	2.97	
	14:09	2.49	
	14:57	2.17	
	15:40	1.90	
10-22-69		Flowing	
10-23-69		Flowing	
10-24-69		Flowing	
10-25-69		Flowing	Maple Leaf Well No. 2 pump on 06:00 hrs
10-26-69		Flowing	
10-27-69		Flowing	

TABLE 4

RIO ALGOM MAPLE LEAF WELL NO. 2
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Alluvium		
0	20	Overburden, silt and sand
Dakota sandstone--Burro Canyon formation		
20	40	Medium to coarse grained light tan to white sandstone
40	80	Medium to coarse grained white sandstone and gray mudstone
80	90	Sandstone with gray and reddish mudstone
90	100	Sandy gray mudstone
100	175	Gray and white sandstone, sugary texture
175	185	Gray sandstone and claystone
185	215	White and gray sandstone with stringers of gray mudstone
215	225	Medium to coarse grained white sandstone with some mudstone
225	245	Fine to medium grained gray sandstone with mudstone
245	255	Gray sandstone
Brushy Basin shale member of Morrison formation		
255	270	Green and red clay

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 2

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-15-69	17:30	31.85		Well still being drilled. Measuring point top of platform 0.5 foot above land surface
10-16-69	14:52	31.38		
10-25-69	05:59	35.32		Measuring point top of 3/4-inch tube 2.48 feet above land surface
	06:00			Pump on. Bowls set at 250 feet
	06:00:25	50.00		
	06:01:05	80.00		
	06:01:45	90.00		
	06:02:20	100.00		
	06:03	110.00		
	06:03:45	115.00		
	06:04:45	120.00	73	
	06:05:45	125.00		
	06:07:30	130.00	64	
	06:08	131.18	61	
	06:09	132.39		
	06:10	133.46	58	
	06:11	134.21	56	
	06:12	134.56		
	06:13	135.00	54	
	06:14	135.36		
	06:15	135.56	52	
	06:16	135.95		
	06:17	136.32		
	06:18	136.53	52	
	06:20	137.12		
	06:22	137.58	51	
	06:24	138.06		
	06:26	138.10		
	06:29	138.12		T = 51° F
	06:32	138.63		
	06:35	139.41		

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-25-69	06:39	140.14	49	
	06:43	140.40		
	06:46	140.23		
	06:47	140.58		
	06:50	141.21	48	
	06:53	141.29		
	06:56	140.87		
	06:58	141.01	46	
	07:02	140.91	55	
	07:07	143.70		
	07:10	144.58		
	07:21	145.41		
	07:35	145.45		
	07:50	146.19	47	
	07:59	147.35	55	T = 51° F
	08:08	150.19	48	
	08:17	155.94	52	
	08:23	156.82		
	08:42	156.72	49	
	08:50	165.00	61	
	09:03	164.92	49	
	09:08	175.52	61	
	09:10	177.63		
	09:11	178.38	52	
	09:17	187.53	65	
	09:20	188.46	54	
	09:23	188.87	54	
	09:27	189.41	54	
	09:32	190.00		
	09:35	190.15	53	
	09:45	190.21		
	09:52	190.10		
	10:17	190.92	53	
	10:28	196.11	60	
	10:32	196.52		
	10:47	197.53	55	

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-25-69	11:00	197.36	53	
	11:08	199.47	54	
	11:34	201.24	55	
	11:44	201.10	56	
	11:51	201.62		
	12:06	201.17	56	T = 51° F
	12:45	200.92	55	
	13:06	201.67	54	
	13:23	207.70	53	
	13:45	207.66	55	
	14:07	207.42	55	
	14:48	207.18	53	
	15:16	210.82	56	
	15:43	211.14	56	
	16:34	211.24	55	
	16:53	212.33		
	18:09	210.90	55	
	19:19	211.71	54	
	19:42	216.46	55	
	21:15	218.10	54	
10-26-69	00:30	219.24	55	
	03:30	217.44	55	
	06:00	217.90		
	08:44	216.75	54	
	09:15	218.46	54	
	09:26	219.34		
	10:12	218.61	55	
	10:40	218.88	56	
	11:57	218.94	54	
	12:17	220.37	54	
	13:24	219.92	54	
	13:49	223.39	54	
	14:34	224.01	55	
	15:09	222.45	55	
	16:57	222.44	54	
	17:14	222.97	55	
	18:07	224.61	55	

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-26-69	18:27	227.33	55	
	19:56	226.42	55	
	20:18	228.17	55	
	22:30	230.30	55	
10-27-69	01:30	235.53	55	T = 51° F
	04:30	236.19		
	06:11	235.13	55	
	08:15	235.70	55	
	08:52	234.68	56	
	10:15	236.73	55	
	11:10	236.64		
	11:42	236.56	55	
	12:57	236.68	55	
	13:59	236.57	55	
	15:50	230.68	55	
	17:51	227.67	55	
	22:30	231.10		
10-28-69	02:20	246.90		
	05:00	245.84		
	05:40	246.23	55	Collected water sample
	06:00			Pump off
	06:01	220.00		
	06:01:20	200.00		
	06:02	190.00		
	06:02:20	185.00		
	06:04	175.00		
	06:05	170.78		
	06:05:30	164.36		
	06:06	158.41		
	06:07	149.40		
	06:08	141.71		
	06:09	132.49		
	06:10	127.56		
	06:12	114.40		
	06:13	109.45		
	06:14	104.41		

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-28-69	06:15	99.19		
	06:16	96.50		
	06:17	94.45		
	06:19	90.25		
	06:20	88.75		
	06:21	86.70		
	06:22	84.88		
	06:23	82.82		
	06:26	77.42		
	06:27	75.96		
	06:28	74.97		
	06:30	72.78		
	06:32	71.01		
	06:34	69.61		
	06:38	67.41		
	06:42	65.73		
	06:46	64.95		
	06:51	64.01		
	06:56	63.53		
	07:00	62.91		
	07:05	62.16		
	07:10	61.74		
	07:15	61.24		
	07:21	60.75		
	07:25	60.43		
	07:30	60.09		
	07:40	59.45		
	07:50	58.94		
	08:00	58.51		
	08:15	57.87		
	08:30	57.42		
	08:45	56.94		
	09:00	56.60		
	09:15	56.22		
	09:30	55.62		
	09:45	55.31		

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-28-69	10:01	54.96		
	10:30	54.36		
	11:16	53.43		
	11:43	53.08		
	12:50	52.12		
	13:25	51.66		
	16:00	49.88		
	16:20	49.69		
	16:43	49.47		
	18:30	48.60		
10-29-69	04:30	44.91		
	05:57	44.47		
	06:19	44.33		
	06:45	44.20		
10-30-69	11:00	40.00		
10-31-69	14:30	37.50		

TABLE 6

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 2

Date	Hour	Depth to Water Level (ft)	Remarks
10-25-69	05:52	5.33	Measuring point top of 8-inch casing 0.42 foot above land surface. Well has not fully recovered from being pumped
	08:33		Maple Leaf Well No. 2 pump on 06:00 hrs
	11:23	5.39	
	11:57	5.48	
	14:31	5.63	
	16:43	5.83	
	19:32	6.14	
10-26-69	09:05	7.14	
	10:28	7.52	
	12:09	7.65	
	13:39	7.77	
	14:49	7.83	
	17:08	7.97	
	18:17	8.05	
	20:08	8.17	
10-27-69	06:24	8.80	
	08:32	8.89	
	10:30	9.00	
	13:07	9.13	
	14:10	9.18	
	16:02	9.24	
	18:03	9.33	
10-28-69	06:08	9.92 ?	Maple Leaf Well No. 2 pump off 06:00 hrs
	06:10	9.82	
	06:15	9.82	
	06:30	9.82	
	06:45	9.83	
	07:00	9.82	
	07:15	9.82	
	07:30	9.83	
	07:45	9.82	

TABLE 6

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 2, continued.

Date	Hour	Depth to Water Level (ft)	Remarks
10-28-69	08:50	9.81	
	09:00	9.80	
	09:15	9.19	
	09:30	9.78	
	09:45	9.77	
	10:00	9.75	
	10:20	9.72	
	11:30	9.62	
	14:37	9.24	
	15:30	9.02	
	18:11	8.81	
10-29-69	06:11	7.68	
10-30-69	10:00	5.95	
10-31-69	10:00	4.94	

TABLE 7

RIO ALGOM MAPLE LEAF WELL NO. 4
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Dakota sandstone--Burro Canyon formation		
0	15	Coarse grained brown sandstone
15	25	Brown to gray mudstone and clay
25	30	Medium to coarse grained brown sandstone with some clay
30	45	Gray mudstone and clay with some coarse grained brown sandstone
45	50	Coarse grained brown sandstone with some clay
50	55	Fine to medium grained brown sandstone with gray clay. Water encountered at 55 feet
55	65	Medium to coarse grained light brown sandstone
65	80	Medium to coarse grained light gray sandstone with small amount of clay
80	105	Medium grained light gray sandstone
105	180	Fine to medium grained white sandstone
180	195	Gray mudstone with small amount of sandstone in interval between 190 and 195 feet
195	220	Fine to medium grained white sandstone
Brushy Basin shale member of Morrison formation		
220	235	Green and gray clay with some stringers of sandstone

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-17-69	07:25	22.45		Measuring point top of 3/4-inch tube 0.90 foot above land surface
	08:45	22.45		
	10:20	22.40		
	11:00			Pump on. Bowls set at 210 feet
	11:02	83.00		Water dirty
	11:05	105.95		
	11:07		125	
	11:09	113.45		Still dirty
	11:15	120.66		
	11:17		106	Clearing
	11:18			Surged 4 times. Milky but no sa
	11:23	125.25		
	11:26		110	
	11:30	131.10		
	11:50	134.35	94	
	12:15	136.30	89	
	12:27	137.00		T = 50° F
	12:35	137.20	94	
	12:45	137.92		
	13:00	137.95		
	13:15	138.20	94	
	14:00	139.40	85	
	14:30	139.18	83	
	15:00	139.10	85	
	15:45	139.90	87	
	16:00	139.80		
	16:30	141.25	88	
	17:15	141.10	97	
	17:35	141.80	83	
	18:00	141.95	73	
	19:00	143.00	73	
	20:00	143.50	75	

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-17-69	21:00	143.60	73	
	24:00	145.30		
11-18-69	06:30	148.20	73	
	07:45	149.45	75	
	08:55	149.80		
	09:30	150.33		
	10:00	150.34	75	
	10:55	150.30		
	11:30	150.53		
	12:00	150.27	75	
	12:45	150.35		
	13:30	150.25	73	
	13:35			Increased rpm
	13:37	160.00		
	13:38	165.00		
	13:39	168.40		
	13:40	171.40		
	13:41		87	
	13:42	174.00		
	13:43	174.75		
	13:44	175.00		
	13:45	175.00	85	
	13:50	175.30		
	14:00	175.95		
	14:10	176.10		
	14:30	176.12	83	
	15:20	176.51		
	15:45	177.00		
	16:30	177.25	83	
	17:15	176.55	94	
	17:50	177.40	83	
	19:00	177.20	79	
	20:00	177.10	81	
	21:00	176.90		
11-19-69	07:50	179.00	79	
	09:00	179.90		

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-19-69	09:30	179.55		
	10:00	179.45	80	
	11:00	178.75	81	
	12:00	178.70	81	
	13:00	178.55	80	
	14:00	178.20	79	
	15:00	178.22	77	
	16:00	178.33	77	
	17:00	179.23	77	
	18:00	179.45	78	
	19:00	178.70	77	
11-20-69	07:15	179.23	77	T = 51° F
	08:45	178.80	77	
	09:25	178.12	77	Collected water sample
	10:30	177.90	77	
	10:50	178.35		
	11:00			Pump off
	11:01	131.90		
	11:02	122.50		
	11:03	115.00		
	11:04	108.30		
	11:05	101.75		
	11:06	96.[illegible]8		
	11:09	85.82		
	11:10	82.30		
	11:11	79.00		
	11:12	76.84		
	11:13	74.80		
	11:14	74.25		
	11:15	73.88		
	11:16	73.18		
	11:17	72.37		
	11:18	70.91		
	11:19	69.80		
	11:20	68.63		
	11:21	67.50		
	11:22	66.21		

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-20-69	11:23	65.00		
	11:24	64.35		
	11:25	63.55		
	11:26	62.75		
	11:27	61.97		
	11:28	61.42		
	11:29	60.75		
	11:30	60.23		
	11:33	58.83		
	11:35	58.15		
	11:40	56.95		
	11:45	55.70		
	11:50	55.00		
	11:55	53.98		
	12:00	53.08		
	12:05	52.33		
	12:10	51.68		
	12:15	51.13		
	13:00	48.42		Pulling pump. Measuring point top of 8-inch casing 0.74 foot above land surface
	15:15	43.15		
	15:40	42.39		
	16:22	41.39		
	17:10	40.33		
	17:35	39.80		
11-21-69	07:55	31.53		
	09:20	31.19		
	11:20	30.77		Maple Leaf Well No. 5 pump on 11:45 hrs
	13:40	30.39		
	14:45	30.12		
	16:40	29.88		
11-22-69	07:58	27.43		
	08:25	27.34		
	10:05	27.22		
	11:18	27.11		

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-22-69	13:35	26.89		
	14:45	26.79		
	16:08	26.72		
	17:15	26.65		
11-23-69	08:10	25.98		
	10:00	25.93		
	11:10	25.91		
	13:50	25.83		
	15:00	25.79		
	16:10	25.75		
	17:15	25.76		
11-24-69	07:50	25.56		
	08:58	25.56		
	10:08	25.55		
	13:08	25.51		Maple Leaf Well No. 5 pump off 11:45 hrs
	13:52	25.51		
	14:50	25.50		
	15:50	25.49		
	16:47	25.48		
11-25-69	07:43	25.35		
	08:45	25.32		
	10:45	25.30		
	12:20	25.23		
	13:40	25.21		
	14:48	25.19		
11-26-69		24.70		
11-28-69		24.00		
12- 1-69		23.75		

TABLE 9

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 4

Date	Hour	Depth to Water Level (ft)	Remarks
11-17-69	07:05	3.36	Measuring point top of 8-inch casing 0.42 foot above land surface
	08:15	3.36	
	14:15	3.41	Maple Leaf Well No. 4 pump on 11:00 hrs
	15:10	3.46	
	15:33	3.49	
	16:43	3.64	
	17:05	3.69	
	18:15	3.91	
11-18-69	08:15	6.69	
	08:45	6.80	
	10:18	7.08	
	10:40	7.15	
	12:08	7.38	
	12:37	7.46	
	14:47	7.81	
	15:10	7.88	
	16:40	8.11	
	17:00	8.15	
11-19-69	08:25	10.38	
	08:50	10.42	
	10:20	10.60	
	12:23	10.79	
	14:12	10.96	
	16:12	11.16	
11-20-69	08:10	12.46	
	08:35	12.51	
	09:35	12.57	
	09:55	12.59	
	12:25	12.74	Maple Leaf Well No. 4 pump off 11:00 hrs
	12:45	12.75	
	13:30	12.76	
	14:03	12.78	

TABLE 9

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF
WELL NO. 1 DURING TEST ON
MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Remarks
11-20-69	14:40	12.78	
	15:03	12.78	
	15:50	12.75	
	16:12	12.73	
	16:35	12.71	
	16:55	12.70	
	17:50	12.65	
11-21-69	08:20	10.70	
	08:48	10.68	
	10:02	10.49	
	10:20	10.45	
	10:52	10.40	
	11:12	10.35	Maple Leaf Well No. 5 pump on 11:45 hrs
	13:45	10.00	
	.4:55	9.89	
	15:15	9.86	
	16:50	9.80	

TABLE 10

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 2 DURING TEST ON MAPLE LEAF WELL NO. 4

Date	Hour	Depth to Water Level (ft)	Remarks
11-17-69	08:05	31.73	Measuring point top of 8-inch casing 0.67 foot above land surface
	15:20	31.79	Maple Leaf Well No. 4 pump on 11:00 hrs
	16:52	31.79	
11-18-69	08:30	32.38	
	10:30	32.49	
	12:20	32.52	
	14:53	32.62	
	16:50	32.72	
11-19-69	08:40	33.49	
	10:35	33.60	
	12:35	33.65	
	14:25	33.69	
11-20-69	08:25	34.40	
	09:45	34.46	
	12:35	34.51	Maple Leaf Well No. 4 pump off 11:00 hrs
	13:50	34.53	
	14:52	34.57	
	16:02	34.60	
	16:45	34.62	
11-21-69	08:32	34.67	
	10:12	34.65	
	11:03	34.65	Maple Leaf Well No. 5 pump on 11:45 hrs
	15:05	34.59	
	16:17	34.64	

TABLE 11

RIO ALGOM MAPLE LEAF WELL NO. 5
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Dakota sandstone--Burro Canyon formation		
0	10	Fine to medium grained yellow sandstone
10	20	Medium to coarse grained light yellow sandstone
20	25	Dark gray clay and shale
25	50	Fine to coarse grained brown sandstone. Water encountered at 32 feet
50	55	Medium to coarse grained light gray sandstone
55	60	Similar to interval between 50 and 55 feet. Darker in color with small amount of shale
60	85	Coarse grained gray sandstone
85	95	Gray clay with some sandstone
95	110	Fine to medium grained gray sandstone
110	135	Fine to medium grained light brown sandstone
135	140	Gray clay and shale
140	150	Fine to coarse grained light gray to white sandstone
150	160	Green clay and shale
160	175	Fine to coarse grained light gray to white sandstone
175	185	Clay and shale with some gray sandstone
185	205	Fine to medium grained light gray sandstone with some shale and clay
205	215	Fine grained light gray sandstone with clay and shale
Brushy Basin shale member of Morrison formation		
215	230	Green and gray clay and shale with some fine grained gray sandstone in interval between 225 and 230 feet

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALCOM MAPLE LEAF WELL NO. 5

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
1-17-69	09:10	15.51		Measuring point top of surface pipe 0.19 foot above land surface. Well still being drilled. Present depth 190 feet
1-18-69	08:05	13.93		Still being drilled. Depth 215 ft
1-19-69	08:10	13.82		Drilling completed. Depth 230 ft
1-20-69	08:00	14.15		Casing installed. Measuring point top of 8-inch casing 0.44 foot above land surface
	14:10	17.54		Well was developed, cleaned and bailed with bailer prior to this measurement
1-21-69	07:35	15.42		Installing pump
	08:55	15.40		
	10:30	15.48		Pump installed. Measuring point top of 3/4-inch tube 0.60 foot above land surface
	11:30	15.52		
	11:40	15.67		
	11:45			Pump on. Bowls set at 210 ft
	11:46	84.60		Water dirty
	11:48	135.00		
	11:49		165	Still dirty
	' :50	155.00		
	11:52		122	Still dirty
	11:53	168.40		
	11:55	174.40		Clearing
	11:58		110	
	11:59	179.00		
	12:00	179.50		
	12:02	180.15	106	
	12:06	181.60		Fairly clear
	12:07			Surged 5 times
	12:12	178.50		Very little color or sand
	12:15		132	

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-21-69	12:16	196.00		Decreased rpm
	12:24	175.80		
	12:25		94	Clear
	12:26			Surged 5 times. Very little sand, clear
	12:35		103	
	12:36	175.85		
	12:40	176.65		
	12:45	177.60	89	
	12:50	177.47		
	12:55	177.65	90	
	13:00	177.90		
	13:05	177.72		
	13:10	178.45	92	
	13:15	178.65		
	13:20	179.20		T = 51° F
	13:25	179.25	92	
	13:30	179.58		
	13:50	179.90	89	
	14:00	180.52		
	14:10	180.55		
	14:20	179.60	92	
	14:38	181.21		
	15:20	181.20	89	
	15:30	181.40		
	15:45	180.70	83	
	16:00	181.32		
	16:30	182.65	89	
	16:55	182.90	83	
	17:30	182.85	83	
	18:30	182.60		
	19:30	183.05	79	
	20:30	183.65		
	21:30	183.50		
11-22-69	07:45	184.10	77	
	08:45	184.17		

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-22-69	09:00	183.80		
	09:30	184.40	75	
	10:30	184.12		
	11:00	183.15	75	
	12:00	183.22		
	13:00	183.35	73	
	13:30	183.22		
	13:50	183.73		
	14:30	183.30		
	15:00	183.35	73	
	15:20	183.20		
	16:00	183.30		
	16:20	183.45	73	T = 52° F
	17:00	183.40		
	17:30	183.50	73	
	18:30	184.65	73	
	19:15	184.70		
	20:15	184.64		
	21:15	185.10		
11-23-69	07:40	188.00		
	08:30	187.32	73	
	09:30	189.10		
	10:15	188.95		
	11:00	188.77		
	12:10	187.62		
	13:45	186.83		
	14:30	186.72	75	
	15:15	186.90		
	16:00	186.85	73	
	16:30	186.75		
	17:00	187.72		
	17:30	188.10	73	
	18:30	188.30		
	19:30	189.25		
	20:30	189.10		
	21:30	189.00		

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-24-69	07:10	190.25		
	07:20	190.48	73	
	08:25	190.32		
	09:10	191.02		
	09:35	190.23		T = 52° F
	10:00	191.00	73	Collected water sample
	11:00	190.00		
	11:30	190.32	73	
	11:45			Pump off
	11:46	142.85		
	11:47	135.87		
	11:48	124.80		
	11:49	113.20		
	11:50	104.40		
	11:51	96.50		
	11:52	91.30		
	11:53	86.45		
	11:54	81.10		
	11:55	75.72		
	11:56	72.07		
	11:57	69.04		
	11:58	66.78		
	11:59	64.40		
	12:00	62.07		
	12:01	60.67		
	12:02	59.27		
	12:03	57.86		
	12:04	56.73		
	12:05	55.74		
	12:06	54.85		
	12:07	53.90		
	12:08	53.22		
	12:09	52.42		
	12:10	51.67		
	12:15	48.48		
	12:20	46.48		
	12:25	45.25		

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-24-69	12:30	43.97		
	12:35	42.85		
	12:45	40.91		
	12:55	39.45		
	13:15	37.02		
	13:45	34.65		
	14:04	33.25		
	14:37	31.57		
	15:02	30.57		
	15:05	30.73		
	16:10	29.73		
	16:37	29.06		
	17:10	28.51		
11-25-69	07:30	21.65		
	08:20	21.49		
	08:35	21.44		
	09:00	21.36		
	09:35	21.24		
	10:10	21.12		
	10:35	21.04		
	11:00	20.97		
	11:24	20.90		
	12:10	20.76		
	13:00	20.60		
	13:30	20.53		
	14:10	20.41		
	14:35	20.34		
	15:00	20.29		
11-26-69		17.46		
11-28-69		16.15		
12- 1-69		15.04		

TABLE 13

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 5

Date	Hour	Depth to Water Level (ft)	Remarks
11-21-69	08:20	10.70	Measuring point top of 8-inch casing 0.42 foot above land surface
	08:48	10.68	Well is still recovering from effect of pumping Maple Leaf Well No. 4
	10:02	10.49	
	10:20	10.45	
	10:52	10.40	
	11:12	10.35	
	13:45	10.00	Maple Leaf Well No. 5 pump on 11:45 hrs
	14:55	9.89	
	15:15	9.86	
	16:50	9.80	
11-22-69	08:05	10.81	
	08:27	10.83	
	10:15	10.96	
	11:25	11.04	
	13:45	11.15	
	14:55	11.21	
	16:15	11.27	
	17:20	11.33	
11-23-69	08:20	11.96	
	10:05	12.05	
	12:00	12.10	
	14:00	12.15	
	15:10	12.19	
	16:20	12.21	
	17:25	12.25	
11-24-69	08:00	12.60	
	09:05	12.63	
	10:15	12.68	
	13:10	12.73	Maple Leaf Well No. 5 pump off 11:45 hrs
	14:00	12.74	
	14:55	12.73	

TABLE 15

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 5, continued.

Date	Hour	Depth to Water Level (ft)	Remarks
11-24-69	16:00	12.68	
	17:00	12.60	
11-25-69	07:50	10.66	
	08:50	10.54	
	09:57	10.42	
	10:55	10.33	
	12:30	10.15	
	13:45	9.99	
	14:55	9.88	
11-26-69		8.23	
11-28-69		6.[illegible]	
12- 1-69		5.51	

TABLE 14

DRAWDOWN AND RECOVERY DATA, RIO ALCOM MAPLE LEAF WELL NO. 2 DURING TEST ON MAPLE LEAF WELL NO. 5

Date	Hour	Depth to Water Level (ft)	Remarks
11-21-69	08:32	34.67	Measuring point top of 8-inch casing 0.67 foot above land surface
	10:12	34.65	Well is still recovering from effect of pumping Maple Leaf Well No. 4
	11:03	34.65	Maple Leaf Well No. 5 pump on 11:45 hrs
	15:05	34.59	
	16:17	34.64	
11-22-69	08:17	36.02	
	09:12	36.11	
	10:48	36.28	
	13:10	36.42	
	14:20	36.50	
	15:35	36.58	
11-23-69	09:20	37.70	
	10:25	37.86	
	11:30	37.92	
	14:15	38.02	
	15:35	38.08	
11-24-69	08:08	38.76	
	09:25	38.80	
	10:35	38.84	
	13:27	38.88	Maple Leaf Well No. 5 pump off 11:45 hrs
	14:20	38.88	
11-25-69	08:00	37.73	
	09:20	37.62	
	10:25	37.54	
	11:35	37.43	
	13:15	37.27	
	14:25	37.20	
11-26-69		35.92	
11-28-69		34.24	
12- 1-69		33.35	

APPENDIX D

1. Water Development Corporation, Consultants in Ground-water Hydrology, Analysis of Data from Maple Leaf Claim Area, San Juan County, Utah, December 1969.

2. Letter from Water Development Corporation to Rio Algom, dated November 10, 1971.

3. Report of Consulting Services Tailings Pond Embankment Stability and Ground Water Geohydrology and Seepage Evaluation, Lisbon Valley Mine Tailings Disposal System near La Sal, Utah, For Rio Algom Corporation, dated October 2, 1973.

Appendix D, Reference 1

D-2

Water Development Corporation

CONSULTANTS IN GROUND-WATER HYDROLOGY

ANALYSIS OF DATA FROM MAPLE LEAF CLAIM AREA, SAN JUAN COUNTY, UTAH

By

D. K. Greene and L. C. Halpenny

Tucson, Arizona
December 1969

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ANALYSIS OF DATA FROM MAPLE LEAF CLAIM AREA, SAN JUAN COUNTY, UTAH

By

D. K. Greene and L. C. Halpenny

CONCLUSIONS

The data collected and the evaluation and analysis thereof led to development of the following conclusions:

1. A well field capable of producing 200 gpm (gallons per minute) for 24 hours per day and 365 days per year can be developed within the area presently covered by the Maple Leaf claims.

2. The useful life of the well field is estimated to be a minimum of 10 years and more likely would be 20 years or more.

3. A total of six production water wells is considered necessary, each equipped with a pumping unit capable of producing 40 gpm. Operation of the well field would require five wells on the line and one well in reserve.

4. If more than 200 gpm is required at a later date, it is not considered feasible to develop the additional water in the area presently covered by the Maple Leaf claims.

5. The source of the ground water in the Maple Leaf claim area is the Dakota sandstone-Burro Canyon formation. The aquifer is artesian in character and the source of recharge is from precipitation and snowmelt in the La Sal Mountains several miles to the north and northeast. The aquifer is fully saturated and excess ground water is being discharged as spring flow in East Coyote Creek. The cone of depression caused by operating a well field in the Maple Leaf claim area should eventually intercept part of this spring discharge.

RECOMMENDATIONS

1. In the event a temporary water supply is required during construction and, if feasible, it is recommended that Well No. 1 be equipped with a pump and operated as described in this report. Data obtained from this operation may make it possible to refine the accuracy of the aquifer coefficients developed during the 72-hour pump test.

2. If, at a later date, more than 200 gpm of water is required it is recommended that additional land for two well sites be obtained, if possible, adjacent to the Maple Leaf claim area. One site should be located 2,000 feet southeast of existing Well No. 4 and the other site should be located either 2,000 feet further southeast of this site or 2,000 feet west of proposed Well No. 6.

3. An alternative to recommendation No. 2 above would be to use the existing Humeca Wells Nos. 2 and H-16 if more than 200 gpm of water is required.

INTRODUCTION

This report is the third submitted by Water Development Corporation on the subject of development of a ground-water supply for the Rio Algom Corporation s Humeca project, San Juan County, Utah. The first report, entitled "Water supply for proposed mill at Humeca Orebody, San Juan County, Utah" was submitted in March 1968 and reviewed the possibilities of developing a ground-water supply of 200 gpm within a 5-mile radius of the proposed mill. The report also included recommendations for drilling test production water wells at selected sites in the Humeca and Maple Leaf claim areas (see Fig. 1).

Following receipt and review of the 1968 report, officials of Rio Algom Corporation approved a program which consisted of drilling and testing two water wells in the Humeca claim area and cleaning out and testing mineral hole H-16 also in the Humeca claim area (see Fig. 1). Drilling of a test well in the Maple Leaf claim area was deferred at that time pending analysis of the data obtained from the three Humeca tests. The tests were conducted under the supervision of Water Development Corporation and a report entitled "Analysis of data from test wells at Humeca Orebody, San Juan County, Utah" was submitted in May 1969. The report concluded that it would be possible to develop 200 gpm of ground water in the 160 acres comprising the SW$\frac{1}{4}$ Sec. 15, T.29 S., R. 24 E., and that a total of eight wells, which included one standby well, would be required. The report also concluded that the cone of depression would eventually expand into the Coyote Creek spring area and divert part of the ground water now discharging at these springs. In addition, the report concluded that it would be desirable to spread the distance between wells and recommended exploring the possibility of obtaining well sites from Redd Ranches in the NW$\frac{1}{4}$ Sec. 15, T.29 S., R.24 E. The report also recommended that the deferred well in the Maple Leaf claim area be drilled and tested. This recommendation was followed in July 1969 and the drilling was done by L. R. French Water Wells, the same contractor who did the previous drilling. The Maple Leaf well was tested by L. R. French for approximately 6 hours at a discharge of 110 gpm and a pumping water level of 205 feet.

Negotiations with Redd Ranches for the purpose of obtaining additional well sites in the vicinity of the Humeca claim area were unsuccessful. Due to this fact and the results obtained from the first Maple Leaf well, officials of Rio Algom Corporation decided to drill additional wells in the Maple Leaf claim area to develop the required ground water supply.

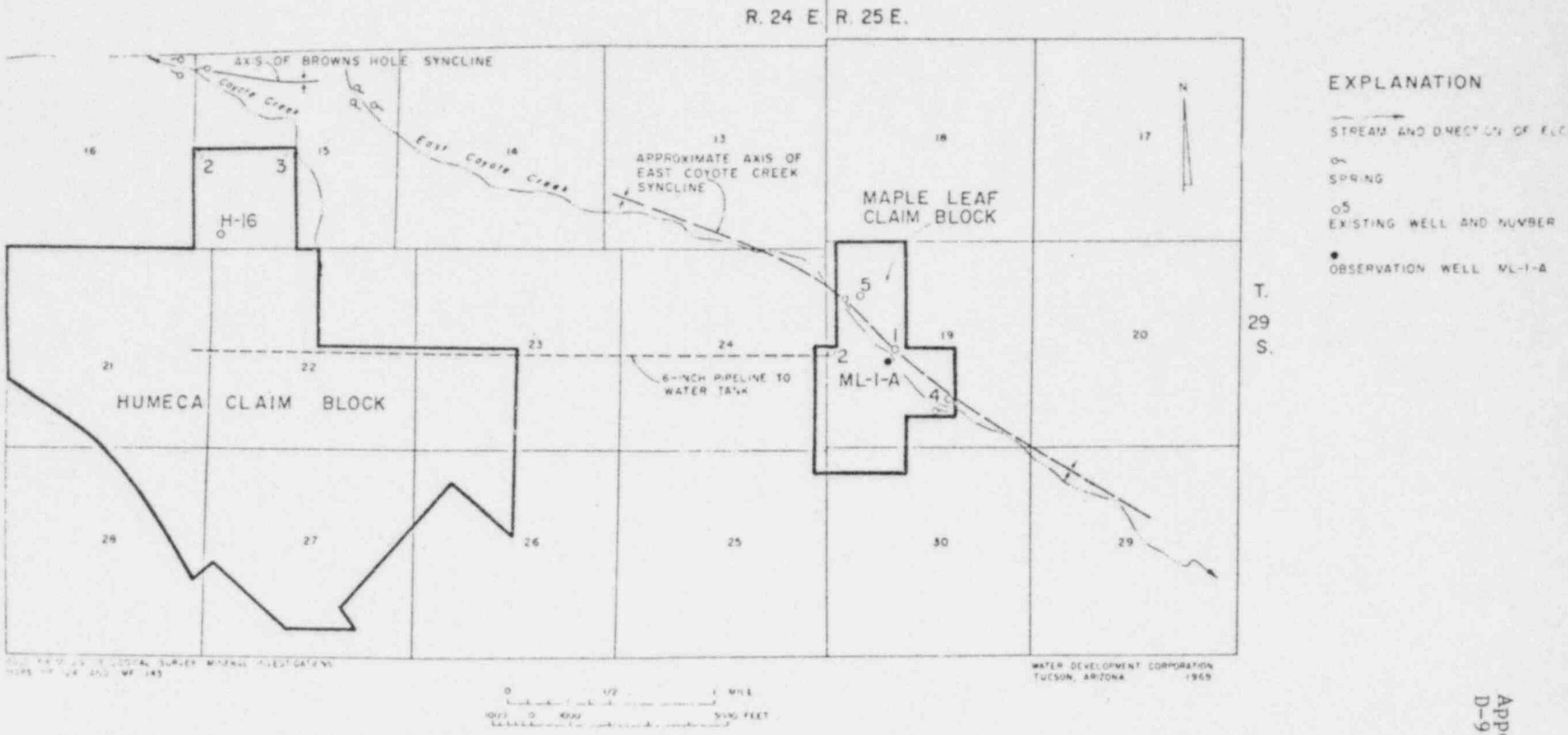


FIGURE 1.--MAP OF A PORTION OF TOWNSHIP 29 SOUTH, RANGES 24 AND 25 EAST, SAN JUAN COUNTY, UTAH, SHOWING TEST WELL LOCATIONS.

As of this date a total of four Maple Leaf wells have been drilled and tested. This report contains the data collected during the field work and an analysis of this data with conclusions developed therefrom.

The authors appreciate th assistance and cooperation provided by Messrs. J E. Moyle, J. D. Guiry, and Andre Belanger of Rio Algom Corporation and the cooperation of Mr. L. R. French and his organization.

MAPLE LEAF TEST WELLS

Wells tested for water productivity were Maple Leaf Wells Nos. 1, 2, 4, and 5 (see Fig. 1). Well No. 1, located near the axis of East Coyote Creek syncline was the first well tested. During the 72-hour test on this well, Well No. 2, located further from the synclinal axis, was in the process of being drilled and cased. Following the 72-hour test on Well No. 2 a comparison of the data from these two tests indicated a possibility that wells located closest to the snyclinal axis would have larger yields. As it was planned to drill and test only four wells at this stage of the work it was recommended that site No. 3, located on the flank of the syncline, be passed up at this time and that sites Nos. 4 and 5, which were located nearer the snyclinal axis, be drilled next.

Maple Leaf Well No. 1

Well No. 1 was drilled during July 1969 and, as mentioned previously, a 6-hour pump test was conducted at that time by Mr. L. R. French. The well was drilled to a total depth of 230 feet and the Dakota formation was encountered from land surface to a depth of 200 feet (see Table 1, Appendix A). Ground water was encountered at a depth of 60 feet, giving a saturated thickness of 140 feet of Dakota sandstone. The water was under artesian pressure and rose to within about 2 feet of the land surface.

The well was equipped with a joint of 13-inch surface pipe and cased to total depth with 8-inch casing, perforated from 74 to 230 feet. The perforations were torch-cut slots, approximately 1/8-inch wide by 6 inches long, and spaced so that there were about 12 cuts per foot (9 square inches of opening per foot of casing perforated). The well was cleaned and developed with the drilling rig and a bailer. Elevation of the top of the 8-inch casing is 6,496.65 feet above sea level

A test pump was installed with the top of the pump bowls set at a depth of 210 feet and operated steadily for 72 hours in October 1969. The discharge ranged from a high of 157 gpm near the beginning of the test to 83 gpm at the end. Average weighted discharge throughout the test was 89.7 gpm and the final pumping water level was 198 feet. Data collected during the test are given in Table 2, Appendix A.

Maple Leaf mineral hole ML-1-A, located 242 feet south and west of Well No. 1 (see Fig. 1) was used as an observation well during the test. Decline in this well as a result of pumping Well No. 1 amounted to about 30 feet at the end of pumping. Measurements made in ML-1-A during the test on Well No. 1 are given in Table 3, Appendix A.

During the test on Well No. 1 and also during subsequent tests, the streamflow in East Coyote Creek was observed to see if pumping had any noticeable effect on the amount of streamflow. No measurable effect could be determined but the weather which prevailed during the period of testing--rain, snow, freezing, and thawing--would make it extremely difficult to determine relatively small effects on streamflow.

Maple Leaf Well No. 2

Well No. 2 was drilled during October 1969 and was completed while Well No. 1 was being tested. The well was drilled to a total depth of 270 feet. The upper 20 feet of material consisted of alluvium and the Brushy Basin member was encountered at a depth of 255 feet, thus, the Dakota thickness at this location was 235 feet (see Table 4, Appendix A). Water was encountered at a depth of 98 feet and eventually rose to about 31 feet. Saturated thickness of Dakota amounted to 157 feet.

The well was equipped with a joint of 13-inch surface pipe and cased to total depth with 8-inch casing, perforated from a depth of 100 to 270 feet. The size and number of perforations per foot were the same as described for Well No. 1. The well was cleaned and developed with the drilling rig and a bailer. Elevation of the top of the 8-inch casing is 6,539.76 feet above sea level.

A 72-hour pump test was made beginning on October 25, 1969, with the top of the pump bowls set at 250 feet. Discharge at the beginning of the test was 73 gpm and at the end was 55 gpm. Final pumping water level was slightly over 246 feet. Data collected during the test are given in Table 5, Appendix A.

Maple Leaf Well No. 1 was used as an observation well during the test on Well No. 2 and the data are given in Table 6, Appendix A. As No. 1 was still recovering from the effect of its own pumping, a precise computation of the true effect of Well No. 2 on Well No. 1 cannot be determined. However, the measured effect during the test amounted to 4.5 feet.

Maple Leaf Well No. 4

Well No. 4 was drilled in November 1969 to a total depth of 235 feet. The Dakota formation was encountered from land surface to a depth of 220 feet (see Table 7, Appendix A). Water was encountered at a depth of 55 feet and rose to a level of about 22 feet. Saturated thickness of Dakota formation at this location is 165 feet.

The well was completed similar to Wells Nos. 1 and 2 with 13-inch surface pipe and 8-inch casing, perforated from a depth of 45 feet to the bottom. Size and number of perforations per foot was the same as for Wells Nos. 1 and 2. The well was cleaned and developed with the drilling rig and bailer before and after casing. Elevation of the top of the 8-inch casing is 6,481.31 feet above sea level.

A 72-hour pump test was conducted on Well No. 4 starting on November 17, 1969 with the top of the pump bowls set at a depth of 210 feet. Discharge at the beginning of the test was 125 gpm and at the end of the test was 77 gpm. Average weighted discharge throughout the test was 78.6 gpm and the final pumping water level was about 178 feet. Data collected during this test are given in Table 8, Appendix A.

Maple Leaf Wells Nos. 1 and 2 were used as observation wells during the test on Well No. 4 and the data are given in Tables 9 and 10 of Appendix A. The cone of depression created by pumping Well No. 4 caused a drawdown of 9.42 feet in Well No. 1 and 2.94 feet in Well No. 2.

Maple Leaf Well No. 5

Drilling and casing of Well No. 5 was completed during the test on Well No. 4. Total depth drilled was 230 feet and the Brushy Basin shale member was encountered at a depth of 215 feet. The Dakota formation occurred at land surface at this location, thus, the thickness of Dakota was 215 feet (see Table 11, Appendix A). The first water was encountered at 32 feet and rose to a level of about 14 feet. Saturated thickness of the Dakota formation at this location was 183 feet.

The well was completed in the same manner as Wells Nos. 1, 2, and 4, with 13-inch surface pipe and 8-inch casing. Perforations were the same as previously described and extended from a depth of 35 feet to total depth of the hole. The well was cleaned and developed with the drilling rig and a bailer before and after casing. Elevation of the top of the 8-inch casing is 6,523.62 feet above sea level.

The test pump was installed with the top of the pump bowls set at 210 feet and a 72-hour pump test was conducted beginning on November 21, 1969. The discharge at the beginning of the test was 165 gpm and at the end was 73 gpm with a final pumping water level of approximately 190 feet. Average weighted discharge during the test was 75.9 gpm. Data collected during the test are given in Table 12, Appendix A.

Wells Nos. 1 and 2 were used as observation wells during the test on Well No. 5 and the data collected are given in Tables 13 and 14 of Appendix A. Both of these wells were still recovering from the effect of pumping Well No. 4. Thus, the true effect of pumping No. 5 on these wells cannot be determined. The measured effect of pumping Well No. 5 was 2.94 feet on Well No. 1 and 4.29 feet on Well No. 2. Well No. 4 was also measured while pumping Well No. 5 but the rate of recovery of Well No. 4 was greater than any drawdown effect caused by Well No. 5. Undoubtedly, the recovery rate of No. 4 was dampened by pumping No. 5 but the amount of dampening is unknown.

ANALYSIS OF DATA

Data collected during the four pump tests, including that collected from wells used as observation wells, were analyzed as thoroughly as possible. This analysis made it possible to determine the relationship between ground-water pumpage and water-level declines and project this relationship into the future. In evaluating the results of the analyses, more weight was given to the results obtained from pumping Wells Nos. 1 and 4. At the beginning of pumping for Wells Nos. 2 and 5, the aquifer had not fully recovered from the effect of testing Wells Nos. 1 and 4. In other words, water levels were still rising and had not yet reached the original static water level, thus the true drawdown could not be determined.

Coefficient of Transmissibility

The coefficient of transmissibility can be determined either from drawdown or recovery measurements in the pumped wells and observation wells. For the pumped wells, generally the recovery measurements provide the best data for the coefficient of transmissibility. During pumping, small variations in engine speed cause fluctuations in the pumping water level which results in an uneven curve when plotted. For observation wells, both drawdown and recovery data provide equally good plots to determine the coefficient of transmissibility.

There were three distinct slopes on recovery data plotted for Well No. 1 after it was pumped. Computations based on these slopes gave coefficients of transmissibility of 760, 950, and 1,700 gpd/ft (gallons per day per foot). Drawdown and recovery data for observation well ML-1-A both gave a coefficient of transmissibility of about 1,200 gpd/ft. Recovery data on Well No. 2 after it was pumped gave a coefficient of transmissibility of 1,080 gpd/ft. The drawdown data on Well No. 1 while pumping Well No. 2 gave a coefficient of transmissibility of 2,640 gpd/ft.

Recovery data for Well No. 4 after it was pumped gave a coefficient of transmissibility of 1,260 gpd/ft and are shown on Figure 2. The drawdown data for Wells Nos. 1 and 2, used as observation wells while pumping Well No. 4, gave coefficients of transmissibility of 1,870 gpd/ft and 4,305 gpd/ft respectively (see Figs. 3 and 4).

The recovery data on Well No. 5 after it was pumped had two distinct slopes from which coefficients of transmissibility of 1,670 and 2,230 gpd/ft were computed. Recovery data from Wells Nos. 1 and 2 after pumping Well No. 5 gave values of 3,300 and 4,600 gpd/ft respectively.

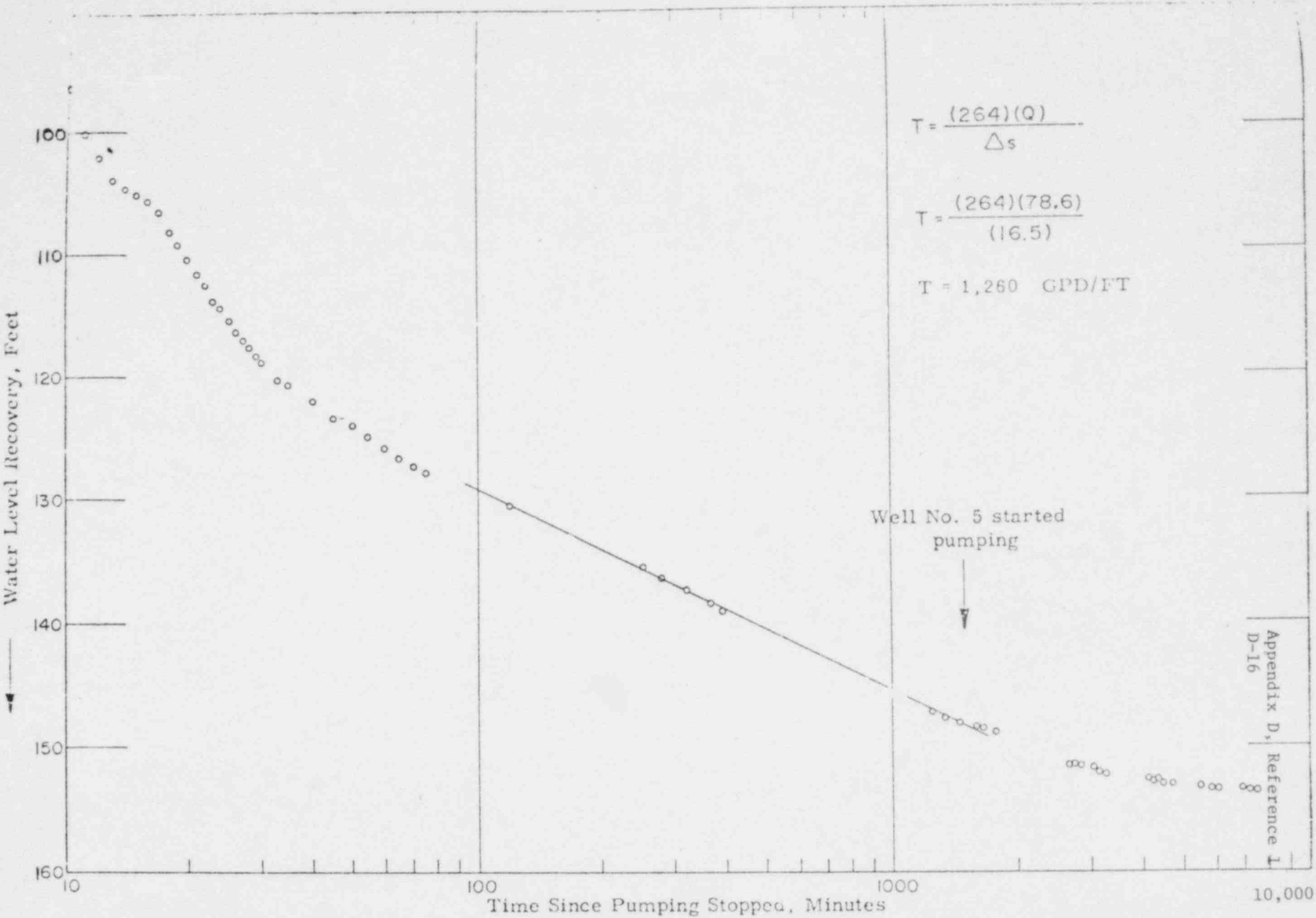


Figure 2. - Recovery Graph, Well No. 4.

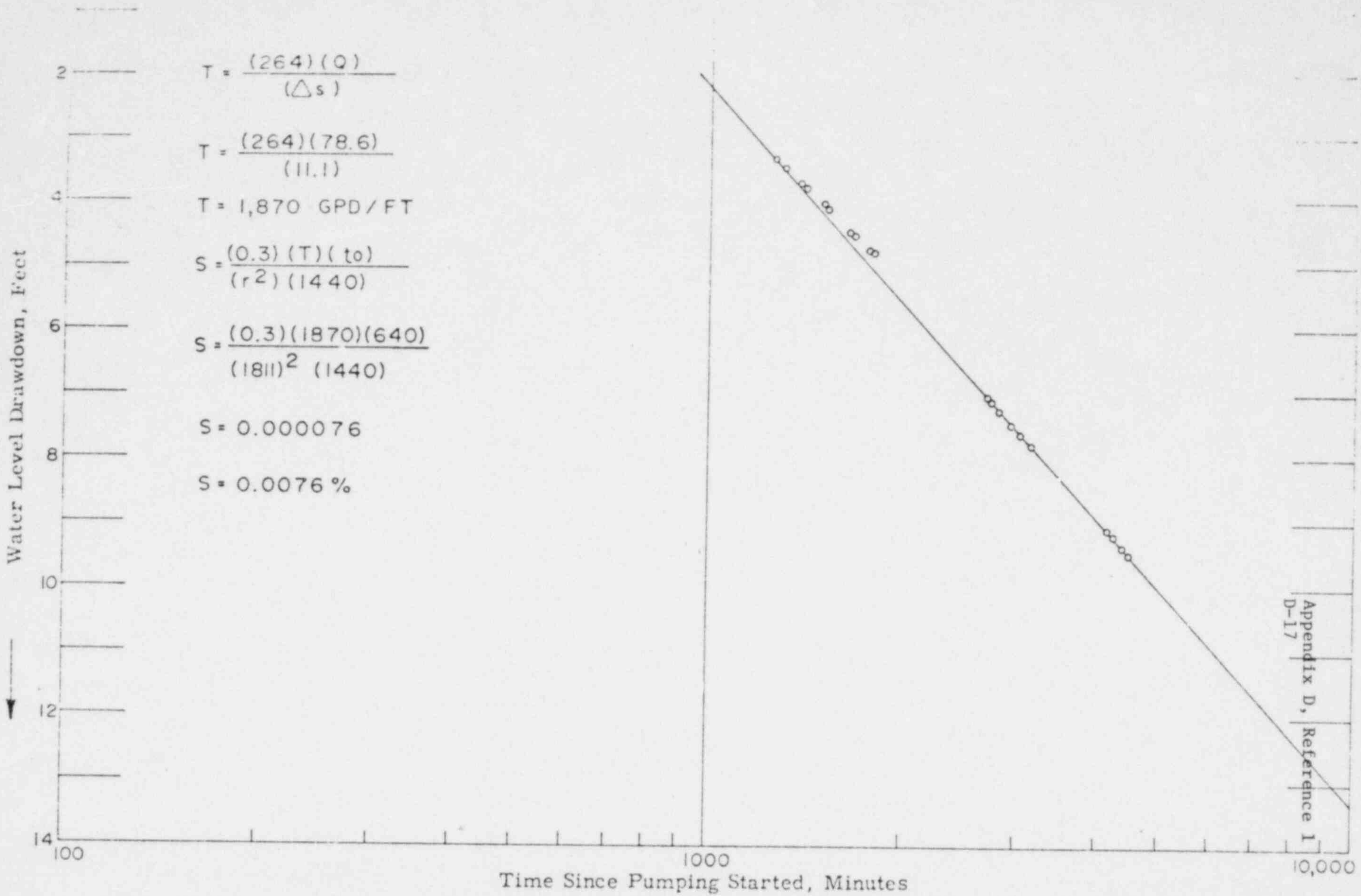
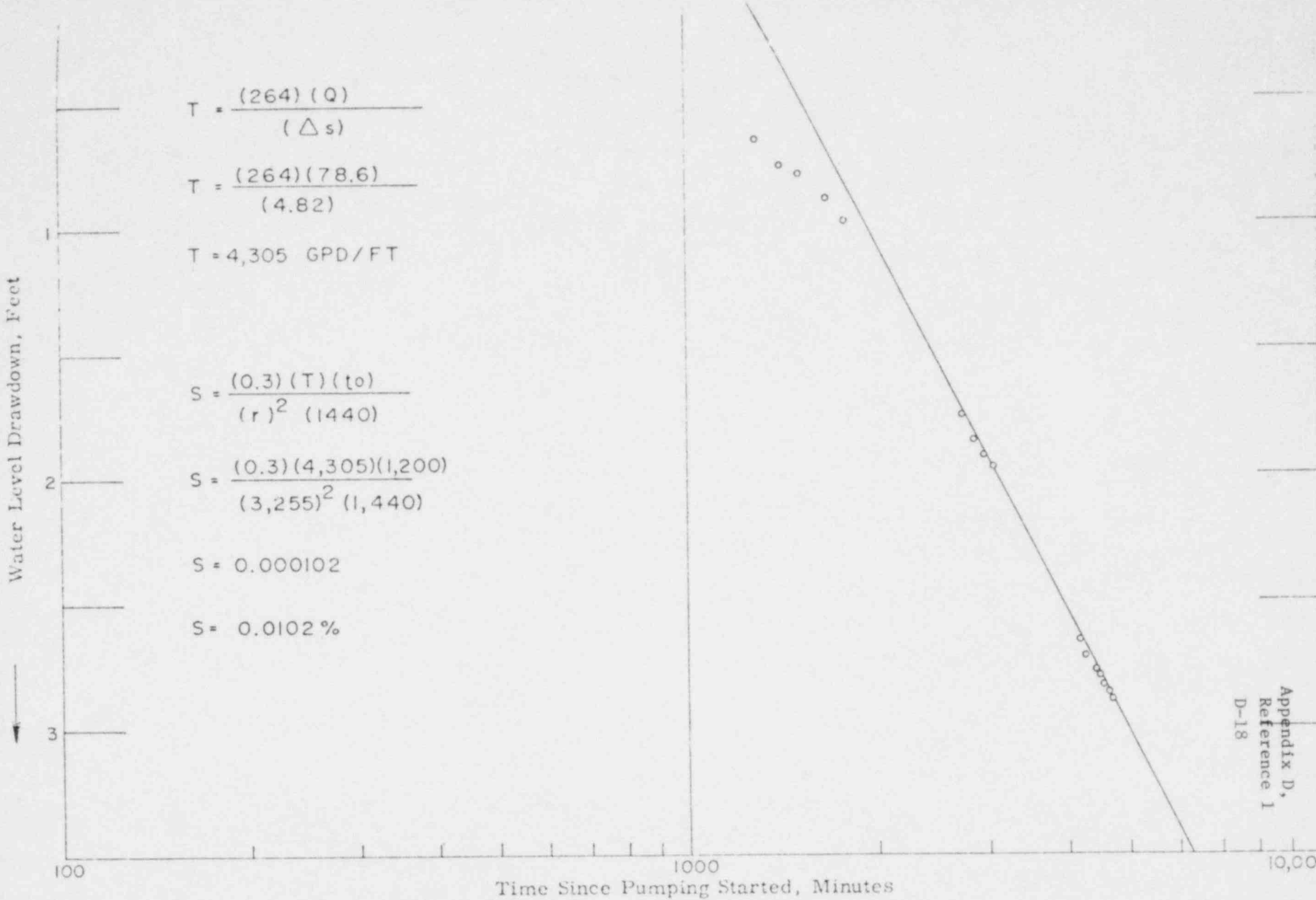


Figure 3. - Drawdown in Well No. 1 While Pumping Well No. 4.



$$T = \frac{(264)(Q)}{(\Delta s)}$$

$$T = \frac{(264)(78.6)}{(4.82)}$$

$$T = 4{,}305 \text{ GPD/FT}$$

$$S = \frac{(0.3)(T)(t_o)}{(r)^2\ (1440)}$$

$$S = \frac{(0.3)(4{,}305)(1{,}200)}{(3{,}255)^2\ (1{,}440)}$$

$$S = 0.000102$$

$$S = 0.0102\,\%$$

Figure 4. - Drawdown in Well No. 2 While Pumping Well No. 4.

In summary, the coefficients of transmissibility computed at the pumped wells ranged from a low of 730 gpd/ft for Well No. 1 to a high of [illegible] gpd/ft for Well No. 5. The value computed for Well No. 5, however, was affected by an unknown amount due to the fact that the aquifer was not fully recovered from pumping Well No. 4. The coefficient of transmissibility values determined from the observation wells were in general higher and ranged from a low of about 1,200 gpd/ft for well ML-1-A during the test on Well No. 1 to a high of 4,600 gpd/ft at Well No. 2 during the test on Well No. 5. As mentioned previously, the data obtained during the test on Well No. 5 were affected by the just completed test on Well No. 4.

The primary reasons for the lower values of transmissibility occurring at the pumped wells is due to non-laminar flow in the formation near the bore hole and well loss caused by turbulent flow at the well casing. As the distance from the pumped well increases the flow of ground water through the aquifer becomes laminar and the coefficient of transmissibility values are usually higher. In some areas of the Maple Leaf claim where the Dakota sandstone outcropped it was observed to be fractured and in other areas it was massive. The variation in transmissibility coefficients determined from the observation wells was undoubtedly affected by the existence or non-existence of this fracture pattern.

Coefficient of Storage

The coefficient of storage can be determined only by the use of observation wells and is a function of distance from the pumped well, amount of drawdown or recovery during or after pumping and the amount of time it took for the drawdown or recovery to take place.

During the test on Well No. 1 the data from observation well ML-1-A gave values of 0.0615 percent on drawdown and 0.0256 percent on recovery for the coefficient of storage. During the test on Well No. 4 the drawdown data measured in Wells Nos. 1 and 2 gave coefficient of storage values of 0.0076 percent and 0.0102 percent respectively (see Figs. 3 and 4).

Recovery data from Wells Nos. 1 and 2 after pumping Well No. 5 gave values of 0.0124 and 0.0278 respectively for the coefficient of storage.

Summary

The various computed values for the coefficients of transmissibility and storage are tabulated as follows:

Well No.	Type of Data Used	Coefficient of Transmissibility (gpd/ft)	Coefficient of Storage (percent)
Pumped Wells			
1	Recovery	760	--
		950	--
		1,700	--
2	Recovery	1,080	--
4	Recovery	1,260	--
5	Recovery	1,670	--
		2,230	--
Observation Wells			
ML-1-A	Drawdown	1,220	0.0615
	Recovery	1,200	.0256
1	Drawdown	2,640	--
1	Drawdown	1,870	.0076
2	Drawdown	4,305	.0102
1	Recovery	3,300	.0124
2	Recovery	4,600	.0278

Based on the data obtained from the tests and giving consideration to the actual specific capacities (gallons per minute per foot of drawdown) of the pumped wells, it was considered desirable to select two values for the coefficient of transmissibility for use in projecting future pumping water levels. Accordingly, a value of 800 gpd/ft was selected to determine the effect of each pumped well on itself and a value of 3,000 gpd/ft was selected to determine the effect of each pumped well on the remaining wells.

The coefficient of storage determined from the tests falls in the semi-artesian to artesian range. A value of 0.01 percent was considered a reasonable value to use for projecting future pumping water levels.

Quality of Water

Water samples were collected from each of the four wells tested and were analyzed by the Agricultural Engineering Department, University of Arizona. The results of the analyses are tabulated below:

Item (parts per million unless otherwise indicated)	Well No. 1	Well No. 2	Well No. 4	Well No. 5
Date collected	10-18-69	10-28-69	11-20-69	11-24-69
Temperature when collected, °F	51	51	51	52
Specific Conductance, micromhos	700	560	550	670
pH	7.4	7.7	7.5	7.5
Calcium, Ca	144	114	100	130
Magnesium, Mg	49	26	28	39
Sodium and Potassium, Na+K	26	25	29	27
Carbonate, CO_3	0	0	0	0
Bicarbonate, HCO_3	273	220	249	268
Sulfate, SO_4	286	200	160	246
Chloride, Cl	28	24	32	36
Nitrate, NO_3	0.1	3	0.2	1.6
Fluoride, F	0.3	0.2	< 0.2	< 0.2
Total Soluble Salts	806	612	598	746

The analyses from the Maple Leaf wells were compared with those from the Humeca wells, Coyote Creek, and East Coyote Creek which were included in the May 1969 report. The major deviation in the general character of the water is that the Maple Leaf water is higher in sulfate and calcium content. However, this difference is not significant. It is considered that the basic source of ground water from the Maple Leaf claim area is the same as for the Humeca area, Coyote Creek, and East Coyote Creek.

DEVELOPMENT OF WELL FIELD

Preliminary Calculations

Owing to the higher yields of the Maple Leaf wells in comparison with the Humeca wells, an initial set of calculations was made to determine the effect of operating all four Maple Leaf wells for 10 years at a continuous pumping rate of 50 gpm. The results were as follows:

Well No.	Calculated Drawdown (ft)	Thickness of Saturated Aquifer Remaining at End of 10 Years (ft)
1	188	10
2	186	38
4	183	15
5	185	16

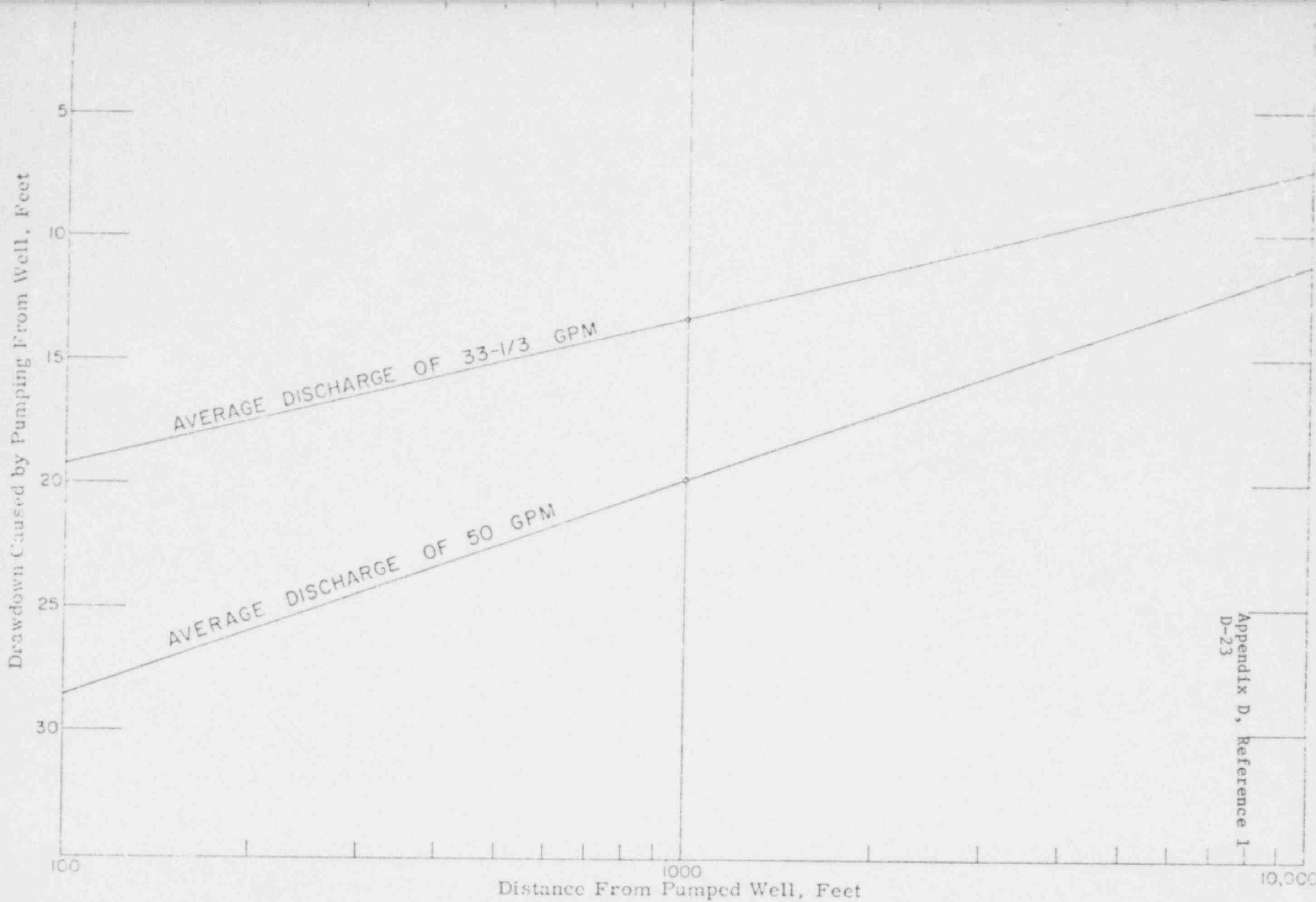
The thickness of saturated aquifer remaining at the end of 10 years is considered inadequate and the authors consider that an attempt to produce 200 gpm from the four wells would be undesirable.

Well Field Capable of Producing 200 Gallons per Minute

Following review of the preliminary calculations a conclusion was reached that a well field in the Maple Leaf claim area that would be capable of producing 200 gpm for 10 to 20 years should consist of six wells. The two additional wells required could be drilled within the existing area of the claim. The recommended site for one of the additional wells is at the location already marked with a stake for Well No. 3. This location is near the site shown on the Rio Algom map designated "Plant Water Supply--Drawing No. .09-80-01," at the south center of Claim No. 21. The site for the other well (No. 6) is recommended at the northwest corner of Claim No. 1, which is the extreme northwest corner of the block of claims.

Of the six wells, all should be equipped with pumps capable of producing 40 gpm. Five wells would be operated at any one time to produce the required 200 gpm; the sixth well would provide standby capacity.

Figure 5 is a graph on semi-logarithmic scale showing the drawdown at the end of 10 years at various distances from a pumped well. Two lines are shown on the graph, one for a continuous pumping rate of



Appendix D, Reference 1
D-23

Figure 5. - Relation Between Drawdown and Distance From Pumped Well at End of 10 Years.

33-1/3 gpm and one for 50 gpm. The drawdown at any distance from the pumped well is, at a pumping rate of 33-1/3 gpm, two-thirds of the drawdown at a pumping rate of 50 gpm.

For a six-well field producing a continuous supply of 200 gpm, the calculations showed the following results for 1 year, 10 years, and 20 years:

Well No.	Calculated Drawdown (ft)	Thickness of Saturated Aquifer Remaining at End of Period (ft)
	At End of 1 Year	
1	141	57
2	140	84
3	139	91
4	136	62
5	140	61
6	136	59
	At End of 10 Years	
1	167	31
2	165	59
3	164	66
4	162	36
5	166	35
6	161	34
	At End of 20 Years	
1	175	23
2	173	51
3	172	58
4	170	28
5	174	27
6	169	26

COMPARISON OF AQUIFER CHARACTERISTICS

Specific Capacity

The results of the well tests on the four new wells drilled in the Maple Leaf claim area indicated that the specific capacity was as follows:

Well No.	Specific Capacity (gpm per ft of drawdown)
1	0.423
2	.257
4	.490
5	.417
Average (four wells)	.40

For comparative purposes the specific capacity of the wells in the Humeca area was as follows:

Well No.	Specific Capacity (gpm per ft of drawdown)
2	0.415
H-16	.517
3	.211
Average (three wells)	.38

The most permeable part of the Dakota sandstone-Burro Canyon formation is at the bottom. The calculations indicate that the well field could be operated at 200 gpm for at least 10 years and possibly for 20 years. By the end of 10 years the capacity of the wells to yield water may have declined to the proposed design yield of 40 gpm per well. By the end of 20 years it may be necessary to operate all six wells all the time and the possibility exists that it might be necessary to drill and utilize a seventh well.

Well Field Capable of Producing 250 Gallons per Minute

The calculations indicate that the present Maple Leaf claim area is not large enough to accommodate a well field capable of yielding a continuous supply of 250 gpm for 10 to 20 years. A total of eight wells would be required. If 250 gpm is needed from the Maple Leaf claim area, it is recommended that additional land should be acquired along the axis of the syncline, which is occupied by East Coyote Creek. The first of the two additional wells could be drilled at a distance of 2,000 feet southeast from Well No. 4, in the SE cor. Sec. 19, T.29 S., R.25 E. The second could be drilled either 2,000 feet farther southeast or it could be drilled at a distance of 2,000 feet west of proposed Well No. 6, on either side of the line between Secs. 13 and 24, T.29 S., R.24 E

Temporary Water Supply During Construction

It is understood that full operation of the water system may not be required for a year or two. This interval of time provides an opportunity to collect additional data which could be used to refine the accuracy of the aquifer coefficients developed during the 72-hour pumping tests on the four wells.

It is suggested that Well No. 1 be equipped with a pump having a capacity of 40 gpm and, if necessary, powered on a temporary basis by means of an internal combustion engine and a gearhead drive. The unit could be converted to electric power at a later date without removal from the well. If this were to be done, the well could be operated to the extent required for construction work until such time as the entire 200 gpm is required.

Collection of data in relation to operation of the well is recommended as follows:

1. Install a Sparling or Badger (or equal) water meter on the discharge line at the well. Record the accumulated meter reading each time the well is turned on. If operation is continuous, record the reading once every 7 days. In recording the data, note the date and hour each time the meter is read and each time the pump is turned on or turned off.

2. Measure the depth to water in Wells Nos. 1, 2, 4, and 5 just before Well No. 1 is turned on and just before it is turned off. Record these data to the nearest one-tenth of a foot and include in the record the date and hour of measurement. If operation is continuous, take water-level readings in all wells once every 7 days. To insure that pumping water levels can be obtained it is recommended that a 3/4-inch measuring tube be installed with the pump.

Summary

Analysis of the data collected during testing of the four wells in the Maple Leaf claim area indicated the following:

1. For producing 200 gpm on a continuous basis for as long as 20 years it is considered necessary to drill two more wells and to equip all six wells with pumping units each capable of yielding 40 gpm;

2. For producing 250 gpm on a continuous basis for as long as 20 years it is considered necessary to extend the claim area southeastward and possibly also westward so that two additional well sites could be acquired, each at a distance of 2,000 feet from the nearest pumping well. The most desirable sites are along the axis of the East Coyote Creek syncline.

ESTIMATED REMAINING COST OF WELL FIELD

Remaining Cost For Well Field Yielding 200 Gallons per Minute

Drilling an additional two wells is estimated to cost $5,000 per well, with a total cost of $10,000.

Purchase and installation of six pumping units, each designed to pump 40 gpm, is estimated to cost $2,000 per unit, with a total cost of $12,000. For selection of pumping units the depth of bowl setting and suggested design pumping lift to the land surface is as follows:

Well No.	Depth to Top of Bowls (ft)	Depth to Pumping Water Level (ft)
1	200	170
2	225	195
3	210	180
4	215	185
5	210	180
6	240	210

Additional Cost For Increasing Capacity of Well Field to 250 Gallons per Minute

Additional costs over and above the cost for a 200 gpm well field would include the cost of two more wells and pumping units and cost of land acquisition. An additional 4,000 to 5,000 feet, depending on the route followed, of pipe line would also be required for the pipe line gathering system.

Estimated Cost of Developing 60 Gallons per Minute From Humeca Wells Nos. 2 and H-16

An alternative method of developing an additional 50 to 60 gallons per minute of well capacity would be to install pumps on Humeca Wells Nos. 2 and H-16, thus eliminating drilling and land acquisition costs.

Two 30 gpm pumping units would be required at an estimated installed cost of $1,500 each. Approximately 5,000 feet of pipe line would be required to connect these two wells to the system.

MANAGEMENT OF WELL FIELD

The calculations described in this report indicated that 200 gpm can be obtained from five wells in the Maple Leaf claim area, each equipped with a 40 gpm pumping unit. One additional well will provide reserve capacity when a well needs to be taken out of service for pump overhaul.

Management of the well field should include rotating the pumped wells on a once-a-week basis so that the reserve well remains in top condition. Under this plan each well would be shut down for one week out of every six weeks. In addition to keeping all wells in top condition, this will distribute the cone of depression more evenly throughout the entire well field.

Recommended data collection on a continuing basis includes the following:

1. Measure and record depth to water level in each well once a month for the first year and once every three months thereafter. Note whether the well was on or off when measured.

2. Record the cycle of operation of the wells--when each was turned on or off.

3. If water meters are not installed at each well, arrange a gated blow-off line at each well and measure the discharge quarterly. If meters are used, record the volume reading of the meter each time the well is turned off.

Diligent collection of the above three items of data on a continuing basis will be invaluable when the time arrives to decide whether or not to overhaul a pump and/or to clean out and redevelop a well. If the yield of a well declines the data will indicate whether the cause is the pump, the well, or the aquifer. Facts are better than opinions, and the authors have seen many unnecessary expenses develop from making guesses about when to overhaul a well.

A P P E N D I X   A

TABLE 1

RIO ALGOM MAPLE LEAF WELL NO. 1
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Dakota sandstone--Burro Canyon formation		
0	25	Sandstone
25	60	Green shale
60	108	Gray and white sandstone, water encountered at 60 feet
108	123	Clay ribs and sandstone
123	200	White sandstone
Brushy Basin shale member of Morrison formation		
200	230	Clay and sandstone ribs

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-15-69	16:20	2.14		Measuring point top of surface pipe 0.20 foot above land surface
10-16-69	13:20	2.15		
	15:36	1.80		
10-17-69	09:39	1.65		
	10:20	2.07		Measuring point top of 3/4-inch tube 0.58 foot above land surface
	10:46	2.08		
	11:03	2.08		
	11:30	2.07		
	11:31			Pump on to check equipment
	11:44			Pump off
	12:45	12.95		
	12:49	12.26		
	12:53	11.39		
	13:00			Pump on. Bowls set at 210 feet
	13:01	25.00		
	13:01:30	45.00		
	13:02	55.00		
	13:02:30	65.00		
	13:03	70.00		
	13:04	80.00		
	13:05	90.00		
	13:05:30	95.00		
	13:07	100.00	150	
	13:09	105.00	157	
	13:11	106.29	125	
	13:13	107.67	132	
	13:15	109.27		
	13:16	109.79		
	13:17	110.10		
	13:19	110.40		

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALCOM MAPLE LEAF WELL NO. 1, continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-17-69	13:20	110.57		
	13:22	111.03		
	13:25	111.57		
	13:30	113.33	110	
	13:35	115.86		
	13:38	116.00		
	13:40	116.23	103	
	13:45	117.08		
	13:50	118.13		T = 52° F
	13:55	119.00	97	
	14:02	119.37		
	14:05	120.33	97	
	14:10	120.84		
	14:15	120.45		
	14:24	121.50	99	
	14:34	122.20		
	14:38	123.06		
	14:46	123.18	94	
	14:54	127.38	100	
	15:04	128.49		
	15:19	128.81		
	15:37	129.56		
	15:53	129.42	92	
	16:20	132.58	97	
	16:23		92	
	16:28		100	T - 52° F
	16:29	135.04		
	16:31	136.55		
	16:43		105	
	16:47	142.86		
	16:50		97	
	17:14	144.16	99	
	17:22	144.08	97	
	17:34	144.81		
	18:15	146.21	93	
	18:20		103	

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-17-69	18:26		98	
	18:28	151.26	92	
	18:29	151.56	92	Increased rpm
	19:11	153.20	98	
	20:34		97	
10-18-69	05:56	156.68	87	
	06:05		92	
	06:07		97	
	06:08	163.75		
	06:50	169.49	92	
	07:20	168.52	90	
	07:30	170.33	97	
	08:41	171.20	103	
	09:34	181.20	94	T = 51° F
	10:33	180.29	90	
	11:46	189.64	93	
	12:55	201.80	94	
	13:16	204.91	94	Collected water sample
	13:21		90	
	13:33	205.81	83	
	13:40	196.79	86	
	14:26	180.29	92	
	15:09	182.00	89	
	16:41	181.94	86	
	17:43	181.98	86	
	18:23	182.13	89	
	20:12	184.57	89	
	22:30		89	
10-19-69	00:45		92	
	04:30		89	
	06:55	185.65	89	
	08:46	184.09	87	
	10:27	188.90	87	
	11:50	187.18	87	
	13:16	187.50	85	
	14:44	185.84	85	

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1, continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-19-69	16:58	189.61	87	
	18:52	192.92	89	
	20:26	195.00	87	
	22:30		87	
10-20-69	02:00		83	
	04:00		83	
	06:25	199.39	85	
	09:20	196.84	85	
	11:17	197.38	83	
	12:39	197.77	87	
	12:57	197.81	83	
	13:00			Pump off
	13:00:15	185.00		
	13:00:45	155.00		
	13:01	145.00		
	13:01:20	140.00		
	13:01:45	135.00		
	13:02:15	130.00		
	13:02:45	125.00		
	13:03:15	120.00		
	13:04	115.00		
	13:06	110.81		
	13:09	94.29		
	13:15	74.79		
	13:17	73.85		
	13:19	73.00		
	13:21	72.57		
	13:28	70.17		
	13:30	69.46		
	13:32	68.59		
	13:34	67.69		
	13:36	67.19		
	13:38	66.43		
	13:45	64.02		
	13:48	62.70		
	13:58	60.17		

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-20-69	14:00	59.62		
	14:02	59.00		
	14:05	58.31		
	14:12	56.35		
	14:17	55.32		
	14:20	54.76		
	14:23	54.31		
	14:33	52.06		
	14:35	51.85		
	14:39	51.50		
	14:50	49.49		
	14:53	49.04		
	14:57	48.61		
	15:00	48.27		
	15:12	46.97		
	15:14	46.71		
	15:17	46.38		
	15:25	45.45		
	15:29	45.17		
	15:31	44.99		
	15:44	43.84		
	15:48	43.50		
	15:59	42.65		
	16:13	41.59		
	16:32	40.33		
	16:52	38.88		
	17:07	38.04		
	17:25	37.15		
	17:46	35.96		
	18:13	34.88		
	18:37	33.86		
	19:09	32.81		
	19:31	31.95		
	19:59	31.12		
	20:35	30.05		
	21:19	28.80		

TABLE 2

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-21-69	06:52	19.63		
	07:37	19.36		
	07:59	19.05		
	09:03	18.47		
	09:56	17.92		
	11:28	17.17		
	12:20	16.62		
	14:14	15.99		
	14:52	15.82		
	15:45	15.55		Starting to pull pump
10-22-69	15:11	9.99		Measuring point top of 8-inch casing 0.42 foot above land surface
	16:07	9.80		
10-23-69	09:46	7.84		
	11:06	7.74		
10-24-69	15:03	5.85		
	17:59	5.70		
10-25-69	05:52	5.33		
	08:33	5.25		Maple Leaf Well No. 2 pump on 06:00 hrs
	11:23	5.39		

TABLE 3

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF MINERAL HOLE NO. 1-A DURING TEST ON MAPLE LEAF WELL NO. 1

Date	Hour	Depth to Water Level (ft)	Remarks
10-17-69	10:45	0.37 est.	Measuring point top of plate, 1 foot below land surface
	16:15	0.71 ?	Maple Leaf Well No. 1 pump on 13:00 hrs
	17:29	0.62 ?	
10-18-69	07:37	6.08 ?	
	08:54	19.36	
	09:40	19.76	
	10:44	20.35	
	11:55	21.00	
	13:06	21.62	
	14:36	22.26	
	15:17	22.51	
	16:49	22.96	
	17:44	23.21	
	18:29	23.46	
	20:07	23.92	
10-19-69	08:54	26.71	
	10:18	26.98	
	11:56	27.21	
	13:12	27.37	
	14:54	27.61	
	16:54	27.86	
	19:01	28.26	
	20:24	28.39	
10-20-69	06:19	29.68	
	09:31	30.00	
	11:12	30.15	
	12:46	30.24	
	13:12	30.31	Maple Leaf Well No. 1 pump off 13:00 hrs
	13:25	30.24	
	13:42	29.82	
	13:54	29.52	
	14:09	28.96	
	14:28	28.15	

TABLE 3

DRAWDOWN AND RECOVERY DATA, RIO ALCOM MAPLE LEAF
MINERAL HOLE NO. 1-A DURING TEST ON
MAPLE LEAF WELL NO. 1,
continued.

Date	Hour	Depth to Water Level (ft)	Remarks
10-20-69	14:45	27.25	
	15:04	26.40	
	15:22	25.53	
	15:40	24.76	
	15:56	24.01	
	16:18	22.95	
	16:31	22.13	
	16:54	21.28	
	17:11	20.76	
	17:28	20.08	
	17:50	19.26	
	18:17	18.34	
	18:41	17.61	
	19:05	16.83	
	19:39	15.90	
	19:54	15.49	
	20:41	14.37	
	21:15	13.58	
10-21-69	06:58	5.39	
	07:34	5.25	
	08:06	4.96	
	08:58	4.51	
	10:01	4.04	
	11:52	3.53	
	12:47	2.97	
	14:09	2.49	
	14:57	2.17	
	15:40	1.90	
10-22-69		Flowing	
10-23-69		Flowing	
10-24-69		Flowing	
10-25-69		Flowing	Maple Leaf Well No. 2 pump on 06:00 hrs
10-26-69		Flowing	
10-27-69		Flowing	

TABLE 4

RIO ALGOM MAPLE LEAF WELL NO. 2
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Alluvium		
0	20	Overburden, silt and sand
Dakota sandstone--Burro Canyon formation		
20	40	Medium to coarse grained light tan to white sandstone
40	80	Medium to coarse grained white sandstone and gray mudstone
30	90	Sandstone with gray and reddish mudstone
90	100	Sandy gray mudstone
100	175	Gray and white sandstone, sugary texture
175	185	Gray sandstone and claystone
185	215	White and gray sandstone with stringers of gray mudstone
215	225	Medium to coarse grained white sandstone with some mudstone
225	245	Fine to medium grained gray sandstone with mudstone
245	255	Gray sandstone
Brushy Basin shale member of Morrison formation		
255	270	Green and red clay

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 2

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-15-69	17:30	31.85		Well still being drilled. Measuring point top of platform 0.5 foot above land surface
10-16-69	14:52	31.38		
10-25-69	05:59	35.32		Measuring point top of 3/4-inch tube 2.48 feet above land surface
	06:00			Pump on. Bowls set at 250 feet
	06:00:25	50.00		
	06:01:05	80.00		
	06:01:45	90.00		
	06:02:20	100.00		
	06:03	110.00		
	06:03:45	115.00		
	06:04:45	120.00	73	
	06:05:45	125.00		
	06:07:30	130.00	64	
	06:08	131.18	61	
	06:09	132.39		
	06:10	133.46	58	
	06:11	134.21	56	
	06:12	134.56		
	06:13	135.00	54	
	06:14	135.36		
	06:15	135.56	52	
	06:16	135.95		
	06:17	136.32		
	06:18	136.53	52	
	06:20	137.12		
	06:22	137.58	51	
	06:24	138.06		
	06:26	138.10		
	06:29	138.12		T = 51° F
	06:32	138.63		
	06:35	139.41		

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-25-69	06:39	140.14	49	
	06:43	140.40		
	06:46	140.23		
	06:47	140.58		
	06:50	141.21	48	
	06:53	141.29		
	06:56	140.87		
	06:58	141.01	46	
	07:02	140.91	55	
	07:07	143.70		
	07:10	144.58		
	07:21	145.41		
	07:35	145.45		
	07:50	146.19	47	
	07:59	147.35	55	T = 51° F
	08:08	150.19	48	
	08:17	155.94	52	
	08:23	156.82		
	08:42	156.72	49	
	08:50	165.00	61	
	09:03	164.02	49	
	09:08	175.52	61	
	09:10	177.63		
	09:11	178.38	52	
	09:17	187.53	65	
	09:20	188.46	54	
	09:23	188.87	54	
	09:27	189.41	54	
	09:32	190.00		
	09:35	190.15	53	
	09:45	190.21		
	09:52	190.10		
	10:17	190.92	53	
	10:28	196.11	60	
	10:32	196.52		
	10:47	197.53	55	

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-25-69	11:00	197.36	53	
	11:08	199.47	54	
	11:34	201.24	55	
	11:44	201.10	56	
	11:51	201.62		
	12:06	201.17	56	T = 51° F
	12:45	200.92	55	
	13:06	201.67	54	
	13:23	207.70	53	
	13:45	207.66	55	
	14:07	207.42	55	
	14:48	207.18	53	
	15:16	210.82	56	
	15:43	211.14	56	
	16:34	211.24	55	
	16:53	212.33		
	18:09	210.90	55	
	19:19	211.71	54	
	19:42	216.46	55	
	21:15	218.10	54	
10-26-69	00:30	219.24	55	
	03:30	217.44	55	
	06:00	217.90		
	08:44	216.75	54	
	09:15	218.46	54	
	09:26	219.34		
	10:12	218.61	55	
	10:40	218.88	56	
	11:57	218.94	54	
	12:17	220.37	54	
	13:24	219.92	54	
	13:49	223.39	54	
	14:34	224.01	55	
	15:09	222.45	55	
	16:57	222.44	54	
	17:14	222.97	55	
	18:07	224.61	55	

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-26-69	18:27	227.33	55	
	19:56	226.42	55	
	20:18	228.17	55	
	22:30	230.30	55	
10-27-69	01:30	235.53	55	T = 51° F
	04:30	236.19		
	06:11	235.13	55	
	08:15	235.70	55	
	08:52	234.68	56	
	10:15	236.73	55	
	11:10	236.64		
	11:42	236.56	55	
	12:57	236.68	55	
	13:59	236.57	55	
	15:50	230.68	55	
	17:51	227.67	55	
	22:30	231.10		
10-28-69	02:20	246.90		
	05:00	245.84		
	05:40	246.23	55	Collected water sample
	06:00			Pump off
	06:01	220.00		
	06:01:20	200.00		
	06:02	190.00		
	06:02:20	185.00		
	06:04	175.00		
	06.05	170.78		
	06:05:30	164.36		
	06:06	158.41		
	06:07	149.40		
	06:08	141.71		
	06:09	132.49		
	06:10	127.56		
	06:12	114.40		
	06:13	109.45		
	06:14	104.41		

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-28-69	06:15	99.19		
	06:16	96.50		
	06:17	94.45		
	06:19	90.25		
	06:20	88.75		
	06:21	86.70		
	06:22	84.88		
	06:23	82.82		
	06:26	77.42		
	06:27	75.96		
	06:28	74.97		
	06:30	72.78		
	06:32	71.01		
	06:34	69.61		
	06:38	67.41		
	06:42	65.73		
	06:46	64.95		
	06:51	64.01		
	06:56	63.53		
	07:00	62.91		
	07:05	62.16		
	07:10	61.74		
	07:15	61.24		
	07:21	60.75		
	07:25	60.43		
	07:30	60.09		
	07:40	59.45		
	07:50	58.94		
	08:00	58.51		
	08:15	57.87		
	08:30	57.42		
	08:45	56.94		
	09:00	56.60		
	09:15	56.22		
	09:30	55.62		
	09:45	55.31		

TABLE 5

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 2, continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
10-28-69	10:01	54.96		
	10:30	54.36		
	11:16	53.43		
	11:43	53.06		
	12:50	52.12		
	13:25	51.66		
	16:00	49.88		
	16:20	49.69		
	16:43	49.47		
	18:30	48.60		
10-29-69	04:30	44.91		
	05:57	44.47		
	06:19	44.33		
	06:45	44.20		
10-30-69	11:00	40.00		
10-31-69	14:30	37.50		

TABLE 6

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 2

Date	Hour	Depth to Water Level (ft)	Remarks
10-25-69	05:52	5.33	Measuring point top of 8-inch casing 0.42 foot above land surface. Well has not fully recovered from being pumped
	08:33		Maple Leaf Well No. 2 pump on 06:00 hrs
	11:23	5.39	
	11:57	5.48	
	14:31	5.63	
	16:43	5.83	
	19:32	6.14	
10-26-69	09:05	7.14	
	10:28	7.52	
	12:09	7.65	
	13:39	7.77	
	14:49	7.83	
	17:08	7.97	
	18:17	8.05	
	20:08	8.17	
10-27-69	06:24	8.80	
	08:32	8.89	
	10:30	9.00	
	13:07	9.13	
	14:10	9.18	
	16:02	9.24	
	18:03	9.33	
10-28-69	06:08	9.92 ?	Maple Leaf Well No. 2 pump off 06:00 hrs
	06:10	9.82	
	06:15	9.82	
	06:30	9.82	
	06:45	9.83	
	07:00	9.82	
	07:15	9.82	
	07:30	9.83	
	07:45	9.82	

TABLE 6

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF
WELL NO. 1 DURING TEST ON
MAPLE LEAF WELL NO. 2,
continued.

Date	Hour	Depth to Water Level (ft)	Remarks
10-28-69	08:50	9.81	
	09:00	9.80	
	09:15	9.19	
	09:30	9.78	
	09:45	9.77	
	10:00	9.75	
	10:20	9.72	
	11:30	9.62	
	14:37	9.24	
	15:30	9.02	
	18:11	8.81	
10-29-69	06:11	7.68	
10-30-69	10:00	5.95	
10-31-69	10:00	4.94	

TABLE 7

RIO ALGOM MAPLE LEAF WELL NO. 4
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Dakota sandstone--Burro Canyon formation		
0	15	Coarse grained brown sandstone
15	25	Brown to gray mudstone and clay
25	30	Medium to coarse grained brown sandstone with some clay
30	45	Gray mudstone and clay with some coarse grained brown sandstone
45	50	Coarse grained brown sandstone with some clay
50	55	Fine to medium grained brown sandstone with gray clay. Water encountered at 55 feet
55	65	Medium to coarse grained light brown sandstone
65	80	Medium to coarse grained light gray sandstone with small amount of clay
80	105	Medium grained light gray sandstone
105	180	Fine to medium grained white sandstone
180	195	Gray mudstone with small amount of sandstone in interval between 190 and 195 feet
195	220	Fine to medium grained white sandstone
Brushy Basin shale member of Morrison formation		
220	235	Green and gray clay with some stringers of sandstone

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-17-69	07:25	22.45		Measuring point top of 3/4-inch tube 0.90 foot above land surface
	08:45	22.45		
	10:20	22.40		
	11:00			Pump on. Bowls set at 210 feet
	11:02	83.00		Water dirty
	11:05	105.95		
	11:07		125	
	11:09	113.45		Still dirty
	11:15	120.66		
	11:17		106	Clearing
	11:18			Surged 4 times. Milky but no san
	11:23	125.25		
	11:26		110	
	11:30	131.10		
	11:50	134.35	94	
	12:15	136.30	89	
	12:27	137.00		T = 50^{o} F
	12:35	137.20	94	
	12:45	137.92		
	13:00	137.95		
	13:15	138.20	94	
	14:00	139.40	85	
	14:30	139.18	83	
	15:00	139.10	85	
	15:45	139.90	87	
	16:00	139.80		
	16:30	141.25	88	
	17:15	141.10	97	
	17:35	141.80	83	
	18:00	141.95	73	
	19:00	143.00	73	
	20:00	143.50	75	

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-17-69	21:00	143.60	73	
	24:00	145.30		
11-18-69	06:30	148.20	73	
	07:45	149.45	75	
	08:55	149.80		
	09:30	150.33		
	10:00	150.34	75	
	10:55	150.30		
	11:30	150.53		
	12:00	150.27	75	
	12:45	150.35		
	13:30	150.25	73	
	13:35			Increased rpm
	13:37	160.00		
	13:38	165.00		
	13:39	168.40		
	13:40	171.40		
	13:41		87	
	13:42	174.00		
	13:43	174.75		
	13:44	175.00		
	13:45	175.00	85	
	13:50	175.30		
	14:00	175.95		
	14:10	176.10		
	14:30	176.12	83	
	15:20	176.51		
	15:45	177.00		
	16:30	177.25	83	
	17:15	176.55	94	
	17:50	177.40	83	
	19:00	177.20	79	
	20:00	177.10	81	
	21:00	176.90		
11-19-69	07:50	179.00	79	
	09:00	179.90		

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-19-69	09:30	179.55		
	10:00	179.45	80	
	11:00	178.75	81	
	12:00	178.70	81	
	13:00	178.55	80	
	14:00	178.20	79	
	15:00	178.22	77	
	16:00	178.33	77	
	17:00	179.23	77	
	18:00	179.45	78	
	19:00	178.70	77	
11-20-69	07:15	179.23	77	T = 51° F
	08:45	178.80	77	
	09:25	178.12	77	Collected water sample
	10:30	177.90	77	
	10:50	178.35		
	11:00			Pump off
	11:01	131.90		
	11:02	122.50		
	11:03	115.00		
	11:04	108.30		
	11:05	101.75		
	11:06	96.18		
	11:09	85.82		
	11:10	82.30		
	11:11	79.00		
	11:12	76.84		
	11:13	74.80		
	11:14	74.25		
	11:15	73.88		
	11:16	73.18		
	11:17	72.37		
	11:18	70.91		
	11:19	69.80		
	11:20	68.63		
	11:21	67.50		
	11:22	66.21		

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 4,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-20-69	11:23	65.00		
	11:24	64.35		
	11:25	63.55		
	11:26	62.75		
	11:27	61.97		
	11:28	61.42		
	11:29	60.75		
	11:30	60.23		
	11:33	58.83		
	11:35	58.15		
	11:40	56.95		
	11:45	55.70		
	11:50	55.00		
	11:55	53.98		
	12:00	53.08		
	12:05	52.33		
	12:10	51.68		
	12:15	51.13		
	13:00	48.42		Pulling pump. Measuring point top of 8-inch casing 0.74 foot above land surface
	15:15	43.15		
	15:40	42.39		
	16:22	41.39		
	17:10	40.33		
	17:35	39.80		
11-21-69	07:55	31.53		
	09:20	31.19		
	11:20	30.77		Maple Leaf Well No. 5 pump on 11:45 hrs
	13:40	30.39		
	14:45	30.12		
	16:40	29.88		
11-22-69	07:58	27.43		
	08:25	27.34		
	10:05	27.22		
	11:18	27.11		

TABLE 8

DRAWDOWN, DISCHARGE, AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 4, continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-22-69	13:35	26.89		
	14:45	26.79		
	16:08	26.72		
	17:15	26.65		
11-23-69	08:10	25.98		
	10:00	25.93		
	11:10	25.91		
	13:50	25.83		
	15:00	25.79		
	16:10	25.75		
	17:15	25.76		
11-24-69	07:50	25.56		
	08:58	25.56		
	10:08	25.55		
	13:08	25.51		Maple Leaf Well No. 5 pump off 11:45 hrs
	13:52	25.51		
	14:50	25.50		
	15:50	25.49		
	16:47	25.48		
11-25-69	07:43	25.35		
	08:45	25.32		
	10:45	25.30		
	12:20	25.23		
	13:40	25.21		
	14:48	25.19		
11-26-69		24.70		
11-28-69		24.00		
12- 1-69		23.75		

TABLE 9

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 4

Date	Hour	Depth to Water Level (ft)	Remarks
11-17-69	07:05	3.36	Measuring point top of 8-inch casing 0.42 foot above land surface
	`8:15	3.36	
	14:15	3.41	Maple Leaf Well No. 4 pump on 11:00 hrs
	15:10	3.46	
	15:33	3.49	
	16:43	3.64	
	17:05	3.69	
	18:15	3.91	
11-18-69	08:15	6.69	
	08:45	6.80	
	10:18	7.08	
	10:40	7.15	
	12:08	7.38	
	12:37	7.46	
	14:47	7.81	
	15:10	7.88	
	16:40	8.11	
	17:00	8.15	
11-19-69	08:25	10.38	
	08:50	10.42	
	10:20	10.60	
	12:23	10.79	
	14:12	10.96	
	16:12	11.16	
11-20-69	08:10	12.46	
	08:35	12.51	
	09:35	12.57	
	09:55	12.59	
	12:25	12.74	Maple Leaf Well No. 4 pump off 11:00 hrs
	12.45	12.75	
	13:30	12.76	
	14:03	12.78	

TABLE 9

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 4, continued.

Date	Hour	Depth to Water Level (ft)	Remarks
11-20-69	14:40	12.78	
	15:03	12.78	
	15:50	12.75	
	16:12	12.73	
	16:35	12.71	
	16:55	12.70	
	17:50	12.65	
11-21-69	08:20	10.70	
	08:48	10.68	
	10:02	10.49	
	10:20	10.45	
	10:52	10.40	
	11:12	10.35	Maple Leaf Well No. 5 pump on 11:45 hrs
	13:45	10.00	
	14:55	9.89	
	15:15	9.86	
	16:50	9.80	

TABLE 10

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF
WELL NO. 2 DURING TEST ON
MAPLE LEAF WELL NO. 4

Date	Hour	Depth to Water Level (ft)	Remarks
11-17-69	08:05	31.73	Measuring point top of 8-inch casing 0.67 foot above land surface
	15:20	31.79	Maple Leaf Well No. 4 pump on 11:00 hrs
	16:52	31.79	
11-18-69	08:30	32.38	
	10:30	32.49	
	12:20	32.52	
	14:58	32.62	
	16:50	32.72	
11-19-69	08:40	33.49	
	10:35	33.60	
	12:35	33.65	
	14:25	33.69	
11-20-69	08:25	34.40	
	09:45	34.46	
	12:35	34.51	Maple Leaf Well No. 4 pump off 11:00 hrs
	13:50	34.53	
	14:52	34.57	
	16:02	34.60	
	16:45	34.62	
11-21-69	08:32	34.67	
	10:12	34.65	
	11:03	34.65	Maple Leaf Well No. 5 pump on 11:45 hrs
	15:05	34.59	
	16:17	34.64	

TABLE 11

RIO ALGOM MAPLE LEAF WELL NO. 5
GENERALIZED DESCRIPTION OF DRILL CUTTINGS

From (ft)	To (ft)	Material
Dakota sandstone--Burro Canyon formation		
0	10	Fine to medium grained yellow sandstone
10	20	Medium to coarse grained light yellow sandstone
20	25	Dark gray clay and shale
25	50	Fine to coarse grained brown sandstone. Water encountered at 32 feet
50	55	Medium to coarse grained light gray sandstone
55	60	Similar to interval between 50 and 55 feet. Darker in color with small amount of shale
60	85	Coarse grained gray sandstone
85	95	Gray clay with some sandstone
95	110	Fine to medium grained gray sandstone
110	135	Fine to medium grained light brown sandstone
135	140	Gray clay and shale
140	150	Fine to coarse grained light gray to white sandstone
150	160	Green clay and shale
160	175	Fine to coarse grained light gray to white sandstone
175	185	Clay and shale with some gray sandstone
185	205	Fine to medium grained light gray sandstone with some shale and clay
205	215	Fine grained light gray sandstone with clay and shale
Brushy Basin shale member of Morrison formation		
215	230	Green and gray clay and shale with some fine grained gray sandstone in interval between 225 and 230 feet

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5

(Discharge measured with 55 gallon drum and stop watch)

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-17-69	09:10	15.51		Measuring point top of surface pipe 0.19 foot above land surface. Well still being drilled. Present depth 190 feet
11-18-69	08:05	13.93		Still being drilled. Depth 215 ft
11-19-69	08:10	13.82		Drilling completed. Depth 230 ft
11-20-69	08:00	14.15		Casing installed. Measuring point top of 8-inch casing 0.44 foot above land surface
	14:10	17.54		Well was developed, cleaned and bailed with bailer prior to this measurement
11-21-69	07:35	15.42		Installing pump
	08:55	15.40		
	10:30	15.48		Pump installed. Measuring point top of 3/4-inch tube 0.60 foot above land surface
	11:30	15.52		
	11:40	15.67		
	11:45			Pump on. Bowls set at 210 ft
	11:46	84.60		Water dirty
	11:48	135.00		
	11:49		165	Still dirty
	11:50	155.00		
	11:52		122	Still dirty
	11:53	168.40		
	11:55	174.40		Clearing
	11:58		110	
	11:59	179.00		
	12:00	179.50		
	12:02	180.15	106	
	12:06	181.60		Fairly clear
	12:07			Surged 5 times
	12:12	178.50		Very little color or sand
	12:15		132	

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-21-69	12:16	196.00		Decreased rpm
	12:24	175.80		
	12:25		94	Clear
	12:26			Surged 5 times. Very little sand, clear
	12:35		103	
	12:36	175.85		
	12:40	176.65		
	12:45	177.60	89	
	12:50	177.47		
	12:55	177.65	90	
	13:00	177.90		
	13:05	177.72		
	13:10	178.45	92	
	13:15	178.65		
	13:20	179.20		T = 51° F
	13:25	179.25	92	
	13:30	179.58		
	13:50	179.90	89	
	14:00	180.52		
	14:10	180.55		
	14:20	179.60	92	
	14:38	181.21		
	15:20	181.20	89	
	15:30	181.40		
	15:45	180.70	83	
	16:00	181.32		
	16:30	182.65	89	
	16:55	182.90	83	
	17:30	182.85	83	
	18:30	182.60		
	19:30	183.05	79	
	20:30	183.65		
	21:30	183.50		
11-22-69	07:45	184.10	77	
	08:45	184.17		

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-22-69	09:00	183.80		
	09:30	184.40	75	
	10:30	184.12		
	11:00	183.15	75	
	12:00	183.22		
	13:00	183.35	73	
	13:30	183.22		
	13:50	183.73		
	14:30	183.30		
	15:00	183.35	73	
	15:20	183.20		
	16:00	183.30		
	16:20	183.45	73	$T = 52^{\circ}$ F
	17:00	183.40		
	17:30	183.50	73	
	18:30	184.65	73	
	19:15	184.70		
	20:15	184.64		
	21:15	185.10		
11-23-69	07:40	188.00		
	08:30	187.32	73	
	09:30	189.10		
	10:15	188.95		
	11:00	188.77		
	12:10	187.62		
	13:45	186.83		
	14:30	186.72	75	
	15:15	186.90		
	16:00	186.85	73	
	16:30	186.75		
	17:00	187.72		
	17:30	188.10	73	
	18:30	188.30		
	19:30	189.25		
	20:30	189.10		
	21:30	189.00		

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-24-69	07:10	190.25		
	07:20	190.48	73	
	08:25	190.32		
	09:10	191.02		
	09:35	190.23		T = 52° F
	10:00	191.00	73	Collected water sample
	11:00	190.00		
	11:30	190.32	73	
	11:45			Pump off
	11:46	142.85		
	11:47	135.87		
	11:48	124.80		
	11:49	113.20		
	11:50	104.40		
	11:51	96.50		
	11:52	91.30		
	11:53	86.45		
	11:54	81.10		
	11:55	75.72		
	11:56	72.07		
	11:57	69.04		
	11:58	66.78		
	11:59	64.40		
	12:00	62.07		
	12:01	60.67		
	12:02	59.27		
	12:03	57.86		
	12:04	56.73		
	12:05	55.74		
	12:06	54.85		
	12:07	53.90		
	12:08	53.22		
	12:09	52.42		
	12:10	51.67		
	12:15	48.48		
	12:20	46.48		
	12:25	45.25		

TABLE 12

DRAWDOWN, DISCHARGE, AND RECOVERY DATA,
RIO ALGOM MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Discharge (gpm)	Remarks
11-24-69	12:30	43.97		
	12:35	42.85		
	12:45	40.91		
	12:55	39.45		
	13:15	37.02		
	13:45	34.65		
	14:04	33.25		
	14:37	31.57		
	15:02	30.57		
	15:05	30.73		
	16:10	29.73		
	16:37	29.06		
	17:10	28.51		
11-25-69	07:30	21.65		
	08:20	21.49		
	08:35	21.44		
	09:00	21.36		
	09:35	21.24		
	10:10	21.12		
	10:35	21.04		
	11:00	20.97		
	11:24	20.90		
	12:10	20.76		
	13:00	20.60		
	13:30	20.53		
	14:10	20.41		
	14:35	20.34		
	15:00	20.29		
11-26-69		17.46		
11-28-69		16.15		
12- 1-69		15.04		

TABLE 13

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF WELL NO. 1 DURING TEST ON MAPLE LEAF WELL NO. 5

Date	Hour	Depth to Water Level (ft)	Remarks
11-21-69	08:20	10.70	Measuring point top of 8-inch casing 0.42 foot above land surface
	08:48	10.68	Well is still recovering from effect of pumping Maple Leaf Well No. 4
	10:02	10.49	
	10:20	10.45	
	10:52	10.40	
	11:12	10.35	
	13:45	10.00	Maple Leaf Well No. 5 pump on 11:45 hrs
	14:55	9.89	
	15:15	9.86	
	16:50	9.80	
11-22-69	08:05	10.81	
	08:27	10.83	
	10:15	10.96	
	11:25	11.04	
	13:45	11.15	
	14:55	11.21	
	16:15	11.27	
	17:20	11.33	
11-23-69	08:20	11.96	
	10:05	12.05	
	12:00	12.10	
	14:00	12.15	
	15:10	12.19	
	16:20	12.21	
	17:25	12.25	
11-24-69	08:00	12.60	
	09:05	12.63	
	10:15	12.68	
	13:10	12.73	Maple Leaf Well No. 5 pump off 11:45 hrs
	14:00	12.74	
	14:55	12.73	

TABLE 13

DRAWDOWN AND RECOVERY DATA, RIO ALGOM MAPLE LEAF
WELL NO. 1 DURING TEST ON
MAPLE LEAF WELL NO. 5,
continued.

Date	Hour	Depth to Water Level (ft)	Remarks
11-24-69	16:00	12.68	
	17:00	12.60	
11-25-69	07:50	10.66	
	08:50	10.54	
	09:57	10.42	
	10:55	10.33	
	12:30	10.15	
	13:45	9.99	
	14:55	9.88	
11-26-69		8.23	
11-28-69		6.40	
12- 1-69		5.51	

TABLE 14

DRAWDOWN AND RECOVERY DATA, RIO ALCOM MAPLE LEAF
WELL NO. 2 DURING TEST ON
MAPLE LEAF WELL NO. 5

Date	Hour	Depth to Water Level (ft)	Remarks
11-21-69	08:32	34.67	Measuring point top of 8-inch casing 0.67 foot above land surface
	10:12	34.65	Well is still recovering from effect of pumping Maple Leaf Well No. 4
	11:03	34.65	Maple Leaf Well No. 5 pump on 11:45 hrs
	15:05	34.59	
	16:17	34.64	
11-22-69	08:17	36.02	
	09:12	36.11	
	10:48	36.28	
	13:10	36.42	
	14:20	36.50	
	15:35	36.58	
11-23-69	09:20	37.79	
	10:25	37.86	
	11:30	37.92	
	14:15	38.02	
	15:35	38.08	
11-24-69	08:08	38.76	
	09:25	38.80	
	10:35	38.84	
	13:27	38.88	Maple Leaf Well No. 5 pump off 11:45 hrs
	14:20	38.88	
11-25-69	08:00	37.73	
	09:20	37.62	
	10:25	37.54	
	11:35	37.43	
	13:15	37.27	
	14:25	37.20	
11-26-69		35.92	
11-28-69		34.24	
12- 1-69		33.35	

Water Development Corporation
CONSULTANTS IN WATER RESOURCES

3930 Santa Barbara Avenue
Tucson, Arizona 85711

Phone: 602-326-1132
Cable: WADEVCO, Tucson

November 10, 1971

Mr. Andre Belanger
Rio Algom Mines Limited
120 Adelaide Street, West
Toronto, Ontario
CANADA

Dear Mr. Belanger:

In response to your phone call of November 3, 1971 we offer the following comments related to 1) the effect on springflow of pumping 80 gpm (gallons per minute) from the Maple Leaf well field, and 2) the drawdown effect caused by the 80 gpm presently issuing from the fault encountered in the haulage drift:

1. Theoretical computations based on operating the well field at 80 gpm indicate that the piezometric decline in the vicinity of the major spring area, approximately three miles northwest of the Maple Leaf well field, would be 8.4 feet in one year, 15.2 feet in 10 years and 17.4 feet in 20 years. It must be emphasized however, that these computations assume absolutely no recharge is occuring within the system and that all water is removed from storage which is not the case in this area. The Dakota sandstone is saturated to the overflow point and the base flow from the springs is a measure of the recharge the Dakota sandstone is able to accept in the area of recharge to the north. By virtue of being full to the overflow point there is additional potential recharge to the system which cannot enter and is presently being lost in the form of runoff or evapotranspiration. Operation of the well field would eventually spread the cone of depression to the point at which it would induce recharge to the aquifer which is now being rejected. While we cannot put precise values on this induced recharge, it is our opinion that operation of the well field will not have a significant effect on the major spring area to the northwest.

2. With respect to the drawdown effect caused by the 80 gpm flow presently issuing from the haulage drift we see no feasible method to determine this. Although the quality-of-water data and initial piezometric level during inflow indicate a definite likelihood that the source of water could be the Wingate formation, this has not been proven. Assuming that it could be determined conclusively that the source of this water is the Wingate, there still remains the problem of the path of movement of the

ground water. The water could be feeding into the structural feature from a substantial distance away and then moving along the fault to the haulage drift or it could be feeding into the structural feature locally. If there were positive evidence that the latter were the case, it would then be necessary to drill several deep observation wells into the Wingate formation, cemented off from the overlying formations. Water-level measurements in these observation wells taken over a period of several months could then be used to predict the long-term drawdown effect.

In the event the source of water to the haulage drift is being derived locally from the Wingate formation it is possible that at some future date the amount of water being contributed by the Wingate formation in the ventilation shaft will decrease in volume.

If you have any comments or questions concerning the above, please feel free to call or write.

Very truly yours,

Donald K. Greene

Donald K. Greene

DKG/cm

REPORT OF CONSULTING SERVICES
TAILINGS POND EMBANKMENT STABILITY
AND
GROUND WATER GEOHYDROLOGY AND SEEPAGE EVALUATION
LISBON VALLEY MINE TAILINGS DISPOSAL SYSTEM
NEAR LA SAL, UTAH
FOR RIO ALGOM CORPORATION

Dames & Moore Job No. 7144-002-06

October 2, 1973

Rio Algom Corporation
120 Adelaide Street West
Toronto 1, Canada

Attention: Dr. R. D. Lord, Vice President
Research and Development

Gentlemen:

Six copies of our report "Consulting Services, Tailings Pond Embankment Stability and Ground Water Geohydrology and Seepage Evaluation, Lisbon Valley Mine Tailings Disposal System, Near La Sal, Utah, For Rio Algom Corporation," are herewith submitted.

The purpose and scope of our consulting services were described in our letter of May 17, 1973. This scope was altered to meet existing conditions and requirements during numerous discussions between Dr. R. D. Lord, Messrs. J. E. Moyle, P. F. Pullen and M. D. Lawton of Rio Algom Corporation and Messrs. George Toland, William Mead and George Lamb of Dames & Moore. A draft of our report was reviewed by your engineering staff prior to this final submittal.

The results of our evaluations indicate that adequate safety factors for embankment stability and flood control exist in the present tailings pond system and that by following the recommendations provided in this report, a satisfactory continuing disposal system can be developed. Off-site ground water contamination from the tailings system can be avoided by implementation of the control measures proposed herein.

oOo

Rio Algom Corporation
October 2, 1973
Page -2-

We appreciate the opportunity of performing this service for you. If you have any questions concerning this report, or if you desire additional information, please contact us.

Yours very truly,

DAMES & MOORE

George C. Toland

George C. Toland
Consulting Partner
Professional Engineer No. 2311
State of Utah

William E. Mead

William E. Mead
Consulting Partner
Professional Geologist No. 939
State of California

GCT/WEM:ab

Enclosures

REPORT OF CONSULTING SERVICES
TAILINGS POND EMBANKMENT STABILITY
AND
GROUND WATER GEOHYDROLOGY AND SEEPAGE EVALUATION
LISBON VALLEY MINE TAILINGS DISPOSAL SYSTEM
NEAR LA SAL, UTAH
FOR RIO ALGOM CORPORATION

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INTRODUCTION

GENERAL

This report presents the results of our consulting services for Rio Algom's tailings disposal system at the Lisbon Valley Mine near La Sal, Utah. The location of the mine with respect to major roadways and towns in southeastern Utah is presented on Plate 1, Location Map. Detailed maps of the system and the surrounding area are presented in Part I and Part II sections of this report.

PURPOSE AND SCOPE

The extent of our services was planned and subsequently altered during numerous discussions between Dr. R. D. Lord, Messrs. J. E. Moyle, P. F. Pullen and M. D. Lawton of Rio Algom Corporation and Messrs. George Toland, William Mead and George Lamb of Dames & Moore. The purposes and scope of our services as developed are presented as introductory sections in the Part I and Part II sections of this report.

SITE CONDITIONS

SURFACE:

The plant site is located approximately four miles south of La Sal, Utah and seven miles southeast of La Sal Junction. The Rio Algom mine tailings disposal area is located in a small west-trending drainage area, approximately one-half mile west of the main mine shaft.

Overburden soils cover the flatter slopes of the site. Weathered sandstone bedrock outcrops on the valley flank. A sparse growth of grass, weeds and sagebrush is found on the flatter slopes. Pinon pine and juniper trees are the predominant vegetation in the steeper areas adjacent to bedrock outcrops.

SEISMICITY:

The seismicity of the Lisbon Valley Mine was provided in our report of February 24, 1972 to Rio Algom. The site was placed in a Zone 2 seismic area with a horizontal force of 0.05 times gravity recommended for design.

SITE GEOLOGY:

The surficial geologic materials in the site vicinity consist of overburden soils and outcrops of Burro Canyon (Dakota) sandstone.

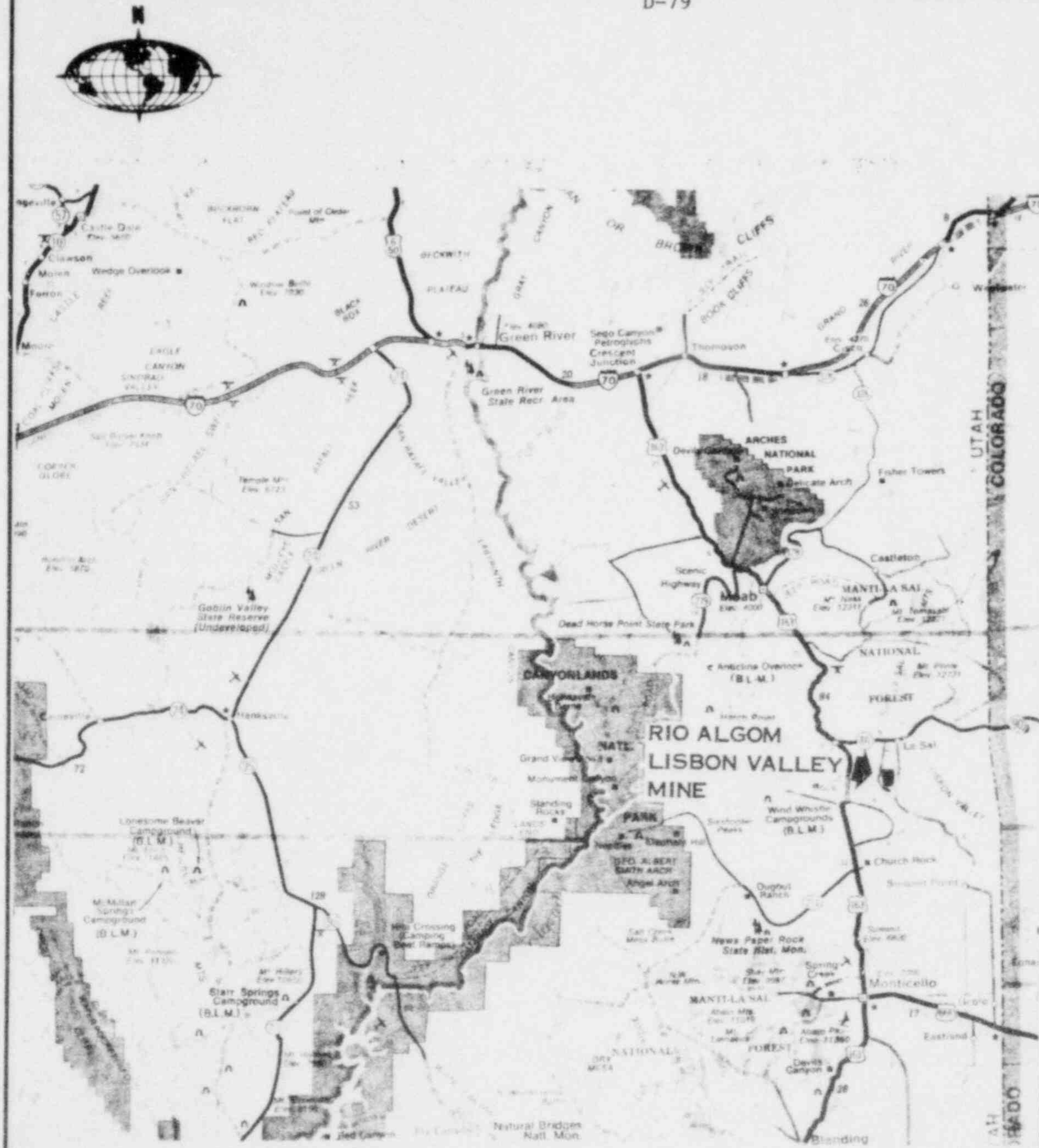
Residual soils, slope wash and alluvium comprise the overburden. The residual soils and slope wash occupy the flanks of valleys and rarely exceed 10 feet in thickness. They consist of sandy clays and clayey to silty sands. The alluvium varies from 5 to 60 feet thick and is composed of sandy silts containing abundant gravel.

The Burro Canyon sandstone is on the order of 280 feet thick where not eroded, as on the Norma claims in the north extremity of the property. In the vicinity of the tailings dam, this formation is over 100 feet thick, except in the buried channel beneath the dam, where erosion has reduced its thickness to 35 or 40 feet. In outcrops the Burro Canyon sandstone is highly weathered and fractured.

Beneath the Burro Canyon beds is a thick series of impervious shales and mudstones comprising the Brushy Basin Member of the Morrison Formation.

Local bedrock folding is extensive and conforms to the regional pattern. The East Coyote Syncline, a major structure, lies less than a mile northeast of the site. The Lisbon Valley Anticline enters the property from the southeast and merges with an unnamed syncline along the same structural trend. All of these folds have a northwesterly axial orientation. One-quarter mile southwest of the site boundary lies the Lisbon Valley Fault, which also strikes northwest, parallel to the folding.

Formations as deep as the Permian Cutler beds have been penetrated at the site. Detailed maps in Part II of this report relating to ground water and seepage show the general structural relationships of the area.



REFERENCE
STATE OF UTAH ROAD MAP

Scale: One inch: approximately 17.4 miles

LOCATION MAP

DAMES & MOORE

PLATE I

BY H.B.T. DATE 9-26-73 FILE 7144-06 RIO ALGOM - MOAB REVISIONS BY ____ DATE ____

CHECKED BY ____ BY ____

PART I
TAILINGS POND EMBANKMENT STABILITY

PURPOSE AND SCOPE

As described previously, the purpose and scope of our studies were developed progressively as the needs and design options became evident.

The purpose of our Tailings Pond Embankment Stability Studies (Part I), as developed and presented in this section of our report, was to:

1. Determine the stability of the existing tailings pond embankment.
2. Define requirements for a continuing tailings storage system.
3. Provide answers to questions of stability and tailings pond development posed by the agencies which reviewed Rio Algom's "Supplemental Environmental Report."

In accomplishing the above purposes we performed the following scope:

1. A field investigation under the direction of an experienced geological engineer from our staff consisting of:
   a. A general site reconnaissance.
   b. The drilling of 8 test borings.
   c. The excavation of 6 test pits.
   d. The drilling and installing of two monitor wells.
   e. The installation of 7 piezometers in Borings 1 to 7.
   f. A field survey.

2. A laboratory testing program to determine the engineering properties of the soils encountered.
3. Technical and analytical evaluations of the existing and future tailings system. The analytical approach used in determining the overall stability analysis was the ordinary method of slices (Fellenius Method). The analysis was performed on a Univac 1108 electronic computer utilizing a program developed by Dames & Moore.
4. Presenting our data, analyses, conclusions and recommendations in the Part I Report.

EVALUATION OF EXISTING TAILINGS POND EMBANKMENT

BASIS OF DESIGN:

The embankment location and maximum pool elevation are shown on Plate 1, Plot Plan. The configuration and physical characteristics of the existing tailings pond embankment presented herein is based on a general site reconnaissance of the area, verbal discussion with personnel familiar with the construction of the embankment, a review of reports by others, and the results of our field exploration program.

Field exploration data and laboratory test results pertinent to the embankment and foundation soils are presented in the appendix of this Part I Report. The soils encountered in Boring D1, D2 and D4 overlying the sandstone bedrock were found to be medium-stiff to very stiff, reddish-brown to brown, fine, sandy silty clay to fine, sandy clayey silt. These materials are considered typical of the natural soils and compacted embankment fills. The geometry of the embankment is shown on Plate 2, Typical Section Existing Embankment.

EMBANKMENT SECTION:

The existing embankment was constructed during 1970 to elevation 6630* with a crest length of 1,450 feet.

The construction plans specified that the embankment be constructed utilizing engineered fill, consisting of the natural surface soils located in the proposed pond area, compacted in 8-inch layers to 95 percent maximum density, in accordance with the A.A.S.H.O.** T90, Method of Compaction. The embankment was to have a 20-foot-wide crest with the upstream slope at two horizontal to one vertical, the downstream slope at two and one-half horizontal to one vertical. The geometry of the embankment is shown on Plate 2.

DISCHARGE SYSTEM:

The tailings from the mill are pumped in a slurry to the tailings pond and discharged into the pond from a spigot line established on the upstream face of the embankment approximately two feet above the pond water level. The amount of discharge at the present time is approximately 200-250 gallons per minute. The average total output of tailings from the mill is presently 600-700 tons per day. The tailings slurry contains approximately 40 percent of tailings by weight. The grind is approximately 97 percent

*Elevations furnished by Rio Algom Corporation.

**American Association of State Highway Officials.

passing the No. 80 mesh and 70 percent passing the No. 325 mesh, as shown on Plate A-2A, Gradation Curve, in the appendix.

STABILITY ANALYSES:

In determining the factor of safety of the embankment, procedures defined by the ordinary method of slices (Fellenius Method) were utilized. The ordinary method of slices technique, which assumes a circular failure surface, was analyzed on an electronic computer utilizing a program developed by Dames & Moore. The soil parameters utilized in our analyses were based on the results of laboratory tests performed on undisturbed samples obtained from the embankment and underlying foundation soils.

Three different time-related storage pond configurations were analyzed. The different conditions are shown on Plate 2. The first condition analyzed was the end of the construction prior to tailings storage. Both the upstream and downstream slopes were analyzed. The factors of safety were found to be 1.7 and 1.9, respectively. The second and third conditions were selected as an intermediate and maximum storage pond pool elevation. Although no seepage was evident on the downstream face, the maximum theoretical top flow line for long-term seepage was assumed. The downstream slope was analyzed in conjunction with the maximum pool elevation and the upstream slope was analyzed in conjunction with the intermediate pool elevation, as recommended by the Atomic Energy Commission. The factors of safety were found to be 1.5 and 2.0, respectively.

The three conditions also analyzed were with a maximum anticipated earthquake loading of 0.05g*. For this condition, the factors of safety

*This value was recommended in our February, 1972 seismicity study for Rio Algom Corporation.

were found to be 1.5 and 1.7 for the end of construction cases, 1.3 for the maximum pool elevation and 1.7 for the intermediate pool elevation. These factors of safety meet the limits of the A.E.C. requirements published in June 1973.

FLOOD CONTROL:

As previously reported by Rio Algom Corporation, the natural watershed area above the tailings basin is 590 acres, including the plant area. The runoff water from a 100-year frequency rainstorm on this watershed was predicted by the Monticello office of the Bureau of Land Management as follows:

100-year, 2-day	4.0 inches	47 acre-feet
100-year, 4-day	4.2 inches	49 acre-feet
100-year, 7-day	4.5 inches	52 acre-feet
100-year, 10-day	5.0 inches	58 acre-feet

In the tailings pond, the normal water level will be maintained at least 10 feet below the crest of the dam (6620 maximum storage pond pool elevation), and therefore the upper portion of the storage may be assumed to be available for surge or flood capacity. From this capacity must be deducted the volume of tailings that are calculated to be above the pond elevation to obtain the net storage capacity.

The following figures have been reported by Rio Algom Corporation as the capacity available for flood control:

Capacity of basin above planned water level	194 acre-feet
Estimated volume of tailings above water level	27 acre-feet
Net storage of basin	167 acre-feet (above pond water level)

For the maximum calculated runoff of 58 acre-feet, the factor of safety against overtopping of the dam is $\frac{167}{58}$ or 2.9.

CONCLUSIONS:

Stability. Our stability studies indicate that the existing embankment under static loading and long-term seepage has factors of safety for the end of construction, prior to tailings storage, of 1.7 and 1.9 against deep-seated failure of the upstream and downstream slopes, respectively. Factors of safety against deep-seated failure of the downstream slope with a maximum pool elevation and the upstream slope with an intermediate pool elevation were found to be at least 1.5 and 2.0, respectively. Therefore, adequate stability safety exists for normal operation of this pond.

Flood Control. Based on the computed overtopping safety factor of the pond and from discussions by Rio Algom Corporation with the Bureau of Land Management, it is our opinion that a channel to divert possible flood water around the tailings pond is not necessary at this time. At the end of the mining and milling operation, the tailings pond area and the waste rock piles will be covered with a layer of soil. A diversion channel around the south side of the tailings pond should then be constructed to bypass drainage around the tailings pond area.

CONTINUING TAILINGS POND SYSTEM

EVALUATION OF ORIGINAL DESIGN:

The design storage capacity of the existing tailings pond at its present crest elevation, as provided by Rio Algom Corporation, is 605,000 tons. The estimated 1,550,000 total tons of ore would then require an additional storage area for the remaining 945,000 tons.

The original proposed design for capacity increases, as furnished by Rio Algom Corporation, indicated that the existing dam was to be raised in 5-foot increments as the pond surface raised, to a final crest elevation of 6655 feet. A beach, created by the coarse fraction of the tailings as they were discharged from the line, was to provide the base for this construction.

A basic assumption in the initial analysis that the tailings would have only 50 percent of the material finer than the No. 200 sieve and 95 percent finer than the No. 50 sieve was incorrect. Actually, the tailings are now averaging as much as 70 percent finer than the No. 325 sieve. With such fine material, the "upstream" method of construction described above would be impractical.

SUGGESTED ALTERNATE DESIGNS:

As an alternate, we suggested raising the existing embankment 25 feet to the maximum elevation of 6555 feet by maintaining the 20-foot crest width and two and one-half horizontal to one vertical downstream slope angle, with all new fill being placed downstream of the existing embankment. We suggested that a second alternate would be to construct a new embankment and create a second pond upstream from the existing embankment. With the second alternate, the existing embankment would act as a secondary dam in case of spillage or leakage from the upstream dam, and provide additional safety and flexibility to the operation.

After examination of the two alternatives, Rio Algom Corporation determined that the new embankment would provide the best method for increasing storage volume. Therefore, only the proposed upstream pond has been analyzed in detail.

EVALUATION OF UPSTREAM TAILINGS POND:

Basis of Design. Evaluation of the upper pond embankment has been based on design requirements provided by Rio Algom Corporation. These requirements were as follows:

1. A crest level at elevation 6680.
2. A maximum pool elevation of 6675.
3. Flood control for a drainage area similar to the existing dam.
4. A continually operated decant system.

Use of Material. The location of the proposed upper tailings pond area is shown on Plate 1, Plot Plan. The natural soil, reddish-brown to brown, fine, sandy silty-clay mixture encountered in the test pits located within the future proposed ponded area, may be used for embankment fill (see attached appendix). The fill material should be placed in layers not to exceed eight inches in loose thickness and compacted to 90 percent of the maximum density determined in accordance with the A.A.S.H.O. T180, Method of Compaction. No segregation or zoning of materials during construction will be required.

The loose foundation soils below the embankment within the area shown on Plate 3, Typical Section Proposed Upstream Embankment, should be removed and conditioned and replaced to the density standard specified.

Stability Analyses. To meet topographic and design requirements the proposed pond embankment will be a maximum of 45 feet high and have a 20-foot-wide crest. The soil parameters utilized in our analyses were based on the results of laboratory tests on remolded samples compacted to the previously mentioned specifications, and the results of laboratory tests performed on undisturbed samples obtained from Borings D5, D6 and D7 (see appendix). A series of slopes were analyzed to select the recommended slopes shown on Plate 3. These recommended slopes are two and one-half horizontal to one vertical upstream and three horizontal to one vertical downstream. As for the existing embankment, factors of safety of the embankments were defined by utilizing the ordinary method of slices (Fellenius Method) computer program.

Three different time-related storage pond configurations were analyzed. The different conditions are shown on Plate 3. The first condition analyzed was the end of construction prior to tailings storage for both the upstream and downstream slopes. The factors of safety were found to be 1.4 and 1.8, respectively. The second and third conditions were selected as an intermediate and maximum storage pond pool elevation. Although a decant system should be installed to remove the majority of the water from the pond, the maximum theoretical top flowline for long-term seepage was assumed. The downstream slope was analyzed in conjunction with the maximum pool elevation and the upstream slope was analyzed in conjunction with the intermediate pool elevation, as recommended by the Atomic Energy Commission. The factors of safety were found to be 1.6 and 1.7, respectively. The three conditions were also analyzed with a maximum anticipated earthquake loading of 0.05g. For this condition, the factors of safety were found to be 1.2 and 1.6 for the end of construction cases, 1.3 for the maximum pool elevation, and 1.4 for the intermediate pool elevation.

Flood Control. Although the maximum theoretical top flowline was assumed for the stability analysis, we recommend a continuous operating decant system be installed in the proposed upstream storage pond. This decant system will remove the water by gravity to the downstream existing pond for recycling to the mill and/or for evaporation. This will permit a greater storage capacity behind the upstream embankment.

Since the downstream pond embankment will be maintained at the designed 10-foot freeboard level and as the upstream embankment with a 5-foot minimum tailings surface freeboard will have more storage volume than the downstream pond, the flood control factor of safety previously determined by Rio Algom Corporation (2.9) will remain the minimum factor against overtopping of the system. Therefore, as discussed for the downstream embankment, a diversion channel would not be required until the end of the mining operations.

ANSWERS TO REVIEW QUESTIONS

A list of review questions, and where in the text of the Part II Report the answers to seepage questions may be found, is presented in Appendix II-D of the Part II Report. Answers to the Tailings Pond Embankment Stability questions are not indexed in Appendix II-D; however, we feel that these questions are answered in this report as follows:

1. Our field exploration program, soil test data and stability analyses confirm the existing dam to have an adequate safety factor for embankment stability.
2. Surface hydrology and runoff evaluations confirm that the proposed freeboard requirements for the existing and proposed upper tailings pond will provide an adequate safety factor against overtopping without a spillway or bypass canal.
3. Construction of the proposed upstream tailings pond to the design requirements presented in this report will resolve the questions regarding future tailings disposal.

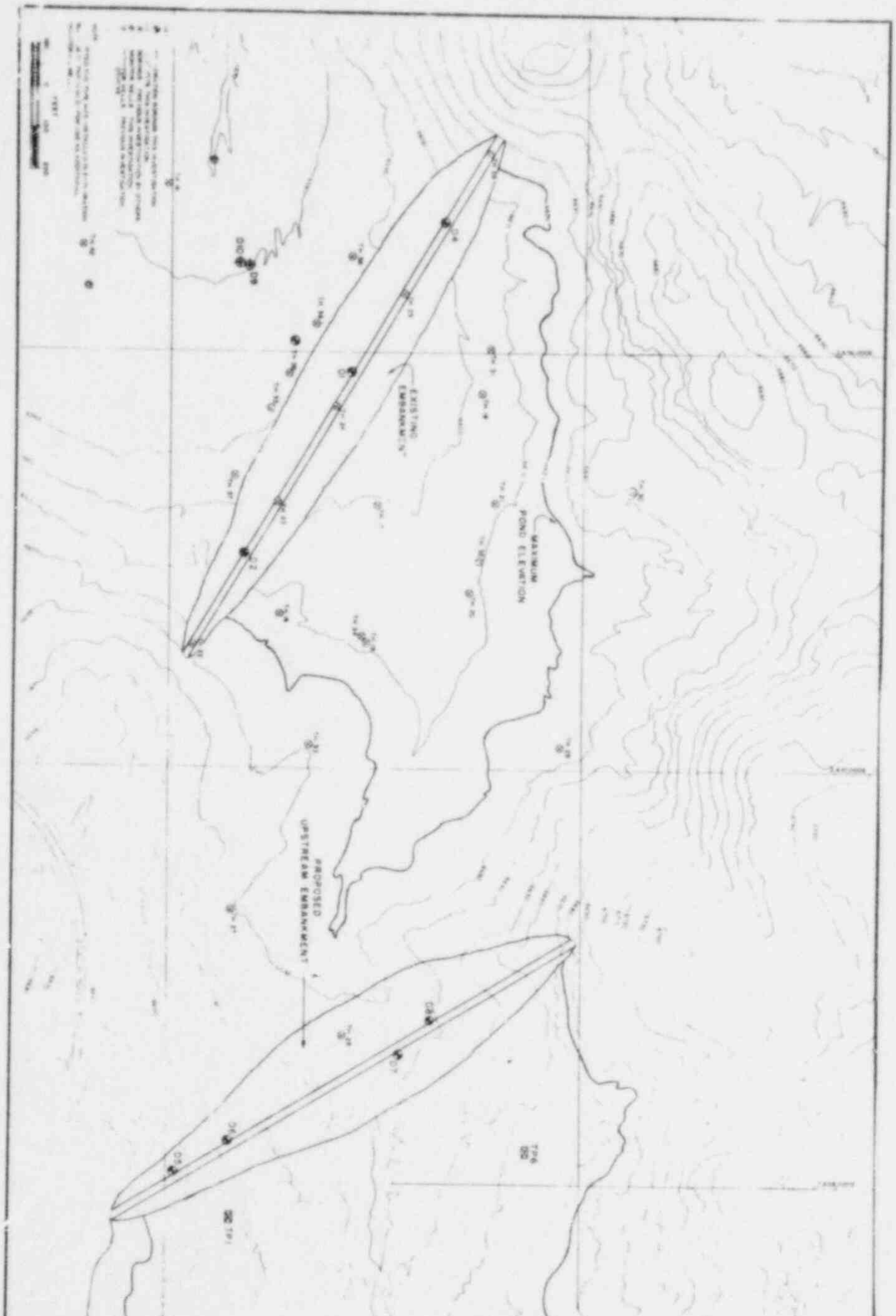
Respectfully submitted,

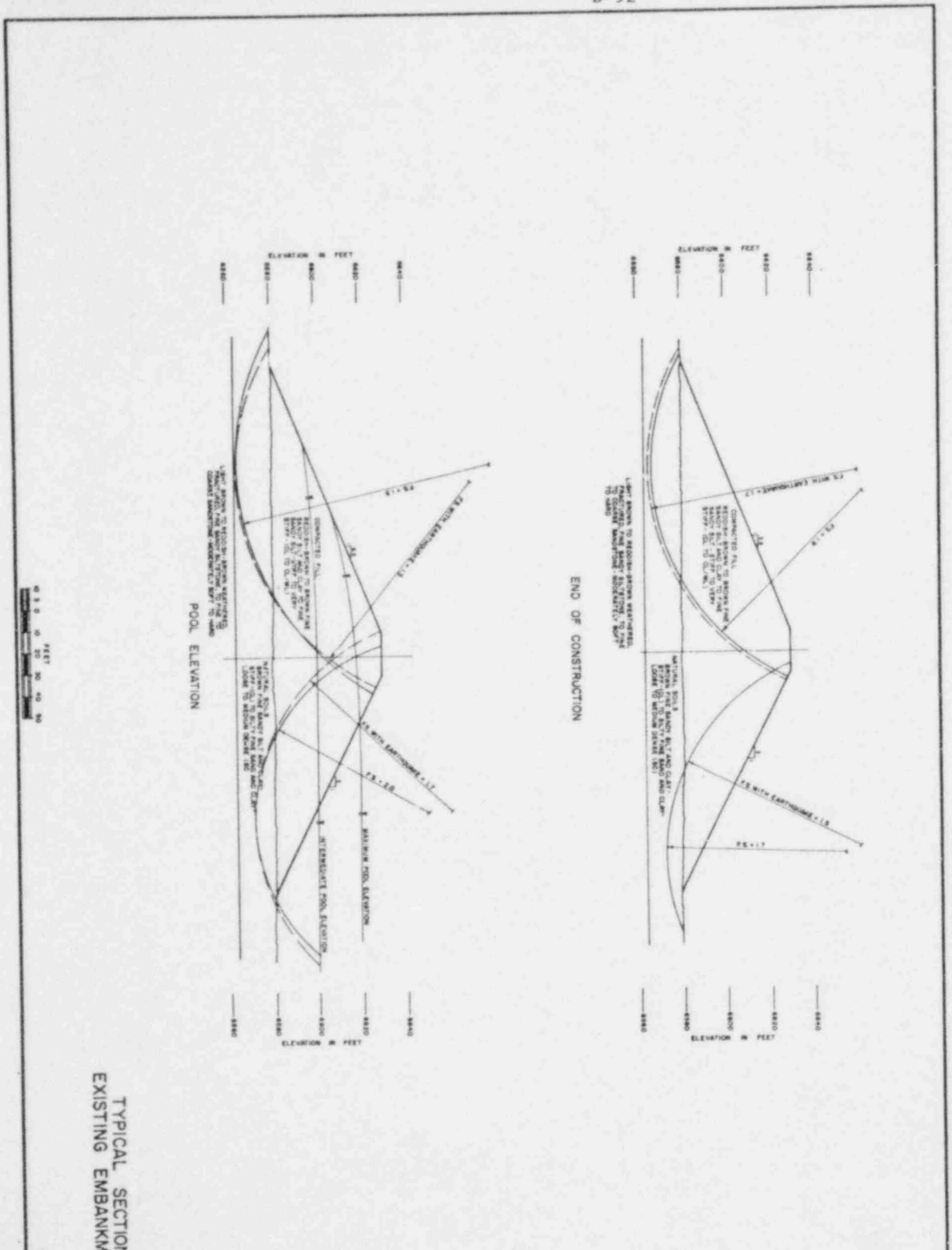
DAMES & MOORE

George C. Toland

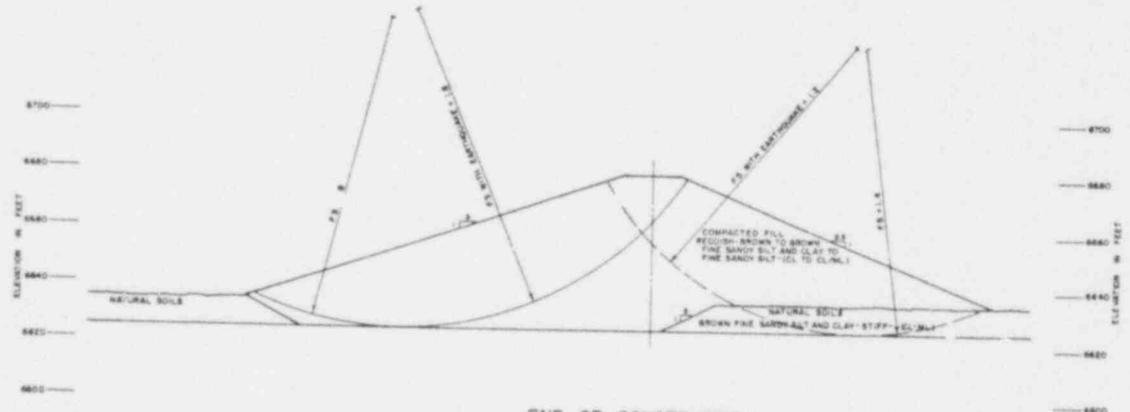
George C. Toland
Consulting Partner
Professional Engineer No. 2311
State of Utah

GCT:ab

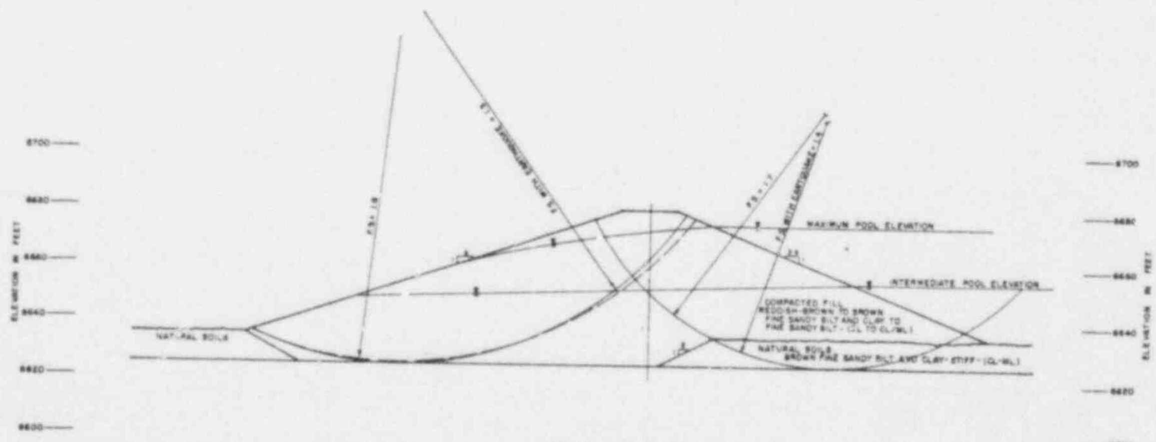

EXISTING EMBANKMENT
MAXIMUM POND ELEVATION
PROPOSED UPSTREAM EMBANKMENT
MAXIMUM POND ELEVATION
TP1
TP2
TP4
TP5
TP6
PLOT PLAN
PLATE 1


END OF CONSTRUCTION
POOL ELEVATION
ELEVATION IN FEET
TYPICAL SECTION
EXISTING EMBANKMENT
DAMES & MOORE
PLATE 2

Appendix D, Reference 3
D-93



END OF CONSTRUCTION



POOL ELEVATION

TYPICAL SECTION
PROPOSED UPSTREAM
EMBANKMENT

FEET
10 5 0 10 20 30 40 50

DAMES & MOORE

PLATE 3

APPENDIX I-A

FIELD STUDIES AND LABORATORY TESTING

FIELD STUDIES:

General. The field portion of our investigation included a reconnaissance of the site area, drilling of test borings, excavation of test pits, and the installation of monitor wells. The field studies were directed by engineers from our staff.

Site Reconnaissance. Prior to and during our field exploration program a general reconnaissance of the site was performed. The reconnaissance study was performed to aid in evaluating the geology of the site and the performance of the existing tailings pond system. In addition, the reconnaissance information was utilized in selecting the number, locations and depths of the test pits and borings.

Field Exploration. Subsurface soil and ground water conditions at the site were investigated by drilling eight exploration borings, excavating six test pits and installing nine monitor wells. The locations of the borings, test pits and monitor wells are presented on Plate 1, Plot Plan, in the text of this section of the report.

The borings were drilled with a truck-mounted rotary rig and extended to depths ranging from 24.0 to 71.3 feet. The backhoe pits extended to depths ranging from 6.0 to 13.0 feet. The test pits were excavated to determine the extent of the natural surface soils suitable for construction of the proposed upstream dam.

The following table gives details of the six test pits excavated:

TABLE A-1

Test Pit Number	Depth To Bedrock (Feet)	Total Depth Excavated (Feet)
1	Not encountered	12
2	4.5	6
3*	Not encountered	13
4	Not encountered	12
5	Not encountered	9
6	5.0	6

*Located in main shaft waste pile.

The soils encountered in all test pits can be classified as CL-ML material, reddish-brown to brown, fine, sandy silty clay to clayey silts.

Undisturbed soil samples were obtained from exploration borings by utilizing a Type U Dames & Moore sampler, as illustrated on Plate A-3. The soils were classified by visual and textural examination in the field and a complete log was maintained of each boring. These classifications were supplemented by inspection and testing in our laboratory. The nomenclature utilized in describing the soil types appears on Plate A-4, Unified Soil Classification System. Graphical representation of the soils encountered in the exploration borings is shown on Plates A-1A through A-1C, Log of Borings.

In order to monitor the ground water gradient and provide a means of sampling the ground water, a series of nine monitor wells were installed. Seven of the wells, which consist of slotted three-inch-diameter PVC pipe, were installed in borings D1 to D7. Two monitor wells, denoted as D9 and

D10 were drilled and installed downstream of the existing embankment. The following table gives details of these monitoring wells:

TABLE A-2

	Monitor Well No. D9	Monitor Well No. D10
Soil Overburden	0-55 feet	0- 55 feet
Burro Canyon Sandstone	57-67 feet	57- 93 feet
Brushy Basin Shale	-	93-103 feet
Monitor Well Casing	0-67 feet	0-103 feet
Casing Perforations	57-67 feet	93-103 feet

Monitoring of the ground water levels and water sampling and analyses is being performed by representatives of Rio Algom Corporation. This data is transmitted on a periodic basis to our office for our review.

Surveying. The location and elevations of all borings and test pits was done by Rio Algom Corporation. The locations are shown on Plate 2, Plot Plan. The following Table A-3 provides numerical data based on Rio Algom Plant datum:

TABLE A-3

Station (Boring Number)	Rio Algom Plant Coordinates North	East	Rio Algom Plant Elevations
D1	608441	636048	6629.4
D2	608182	636483	6630.0
D3	608299	635975	6588.0
D4	608661	635687	6628.0
D5	608018	637972	6675.0
D6	608150	637898	6657.0

TABLE A-3 (Cont.)

Station (Boring Number)	Rio Algom Plant Coordinates North	East	Rio Algom Plant Elevations
D7	608565	637683	6639.0
D8	608638	637606	6639.0
D9	608180	635798	6579.0
D10	608161	635792	6580.0
(Test Pit Number)			
TP1	608125	638081	6663.0
TP2	608140	638622	6664.0
TP3	608608	639644	6701.0
TP4	608760	638787	6675.0
TP6	608865	637922	6661.0

LABORATORY TESTING:

General. Our laboratory testing program included moisture and density tests, gradation tests, Atterberg Limits and direct shear tests. A description plus the results of the tests are presented in subsequent sections.

Moisture and Density. To aid in classifying and correlating the soils, moisture and density determinations were conducted on selected samples. The moisture and density test data obtained are presented to the left of the boring logs on Plates A-1A through A-1C.

Gradation Tests. Additional classification data was obtained by performing partial gradation tests on selected soil samples. The results of the gradation tests are shown on Plates A-2A through A-2C.

Atterberg Limits. Additional classification data was obtained on selected soil samples. The results of the Atterberg Limits tests are presented in tabular form below:

Boring No.	Depth In Feet	Soil Classification	Liquid Limit In Percent	Plasticity Index In Percent
D1	6.5	CL	19.8	2.6
D1	12.5	CL-ML	19.5	5.4
D1	30.5	CL	23.6	7.3
D1	39.5	CL	17.2	0.8
D2	6.5	CL-ML	14.3	3.5
D2	15.5	CL-ML	24.8	6.8
D4	6.0	SM	Non-Plastic	
D4	14.5	CL-ML	21.5	5.6
Tailings Pond	Bulk	CL-ML	21.1	4.6

Direct Shear Tests. To provide additional strength data, a series of direct and double direct shear tests were performed on selected undisturbed samples. The tests were performed in accordance with the method described on Plate A-5, Method of Performing Direct Shear and Friction Tests.

The tests were run at a strain rate of 0.005 inches per minute. At this rate, the samples were assumed to be able to drain without building up excess pore pressures. Therefore, the tests have been classified as "drained."

The results of the tests are tabulated on the following page.

I-A-6

Boring No.	Depth In Feet	Soil Type	Normal Pressure In PSF	Peak Shearing Strength In PSF	Yield Shearing Strength In PSF
D1	10.0	CL-ML	500	1,500	700
D1	12.5	CL-ML	1,000	1,760	600
D1	18.5	CL	500	1,650	950
D1	24.5	CL	1,000	2,380	1,400
D1	30.5	CL	1,500	3,340	1,250
D1	39.5	CL	1,000	2,030	1,150
D1	45.5	CL-ML	2,000	2,000	800
D1	48.5	CL	2,500	2,380	1,550
D1	51.5	CL	3,000	2,460	900
D1	54.5	CL	3,500	2,875	1,175
D2	6.5	CL-ML	500	2,240	1,820
D2	9.5	CL-ML	1,000	2,500	1,050
D2	15.5	CL-ML	1,500	2,780	1,300
D2	21.5	CL-ML	2,000	2,220	1,100
D2	24.5	CL-ML	2,500	3,390	1,100
D4	6.0	SM	3,500	3,880	2,050
D4	6.0	SM	4,000	4,150	1,950
D4	14.5	CL-ML	4,500	4,800	1,700
D4	24.5	CL-ML	3,000	3,200	1,520
D4	24.5	CL-ML	4,500	4,720	1,430
D4	29.5	CL-ML	3,500	4,000	1,030
D4	29.5	CL-ML	4,000	2,550	1,250
D5	5.5	CL-ML	2,000	2,950	1,720
D6	2.5	CL-ML	1,000	2,800	2,050

I-A-7

Boring No.	Depth In Feet	Soil Type	Normal Pressure In PSF	Peak Shearing Strength In PSF	Yield Shearing Strength In PSF
D6	5.5	CL-ML	500	1,050	675
D6	8.5	SM	1,500	1,975	925
D7	2.5	CL-ML	3,000	2,300	1,080
D7	2.5	CL-ML	4,000	2,890	1,1[illegible]
D7	8.5	ML	3,500	2,140	770
D7	8.5	ML	3,500	2,590	930

The following plates are attached and complete this appendix:

Plates A-1A through A-1C - Log of Borings (Borings 1 through 8)

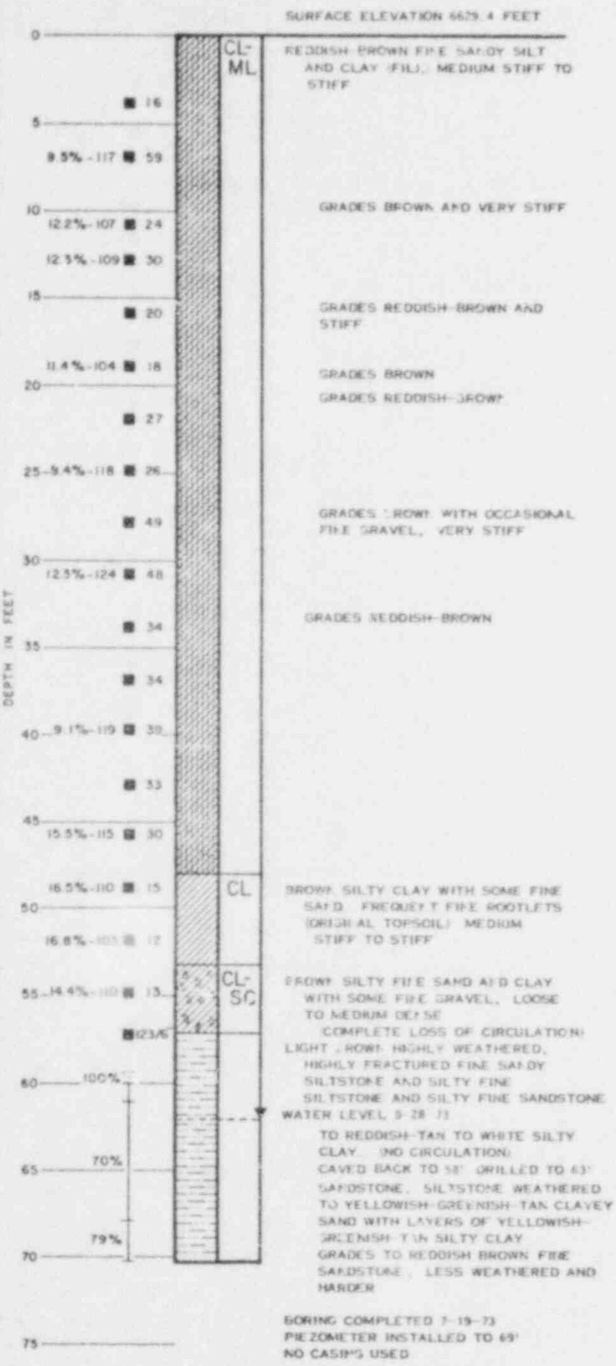
Plates A-2A through A-2C - Gradation Curves

Plate A-3 - Soil Sampler Type U

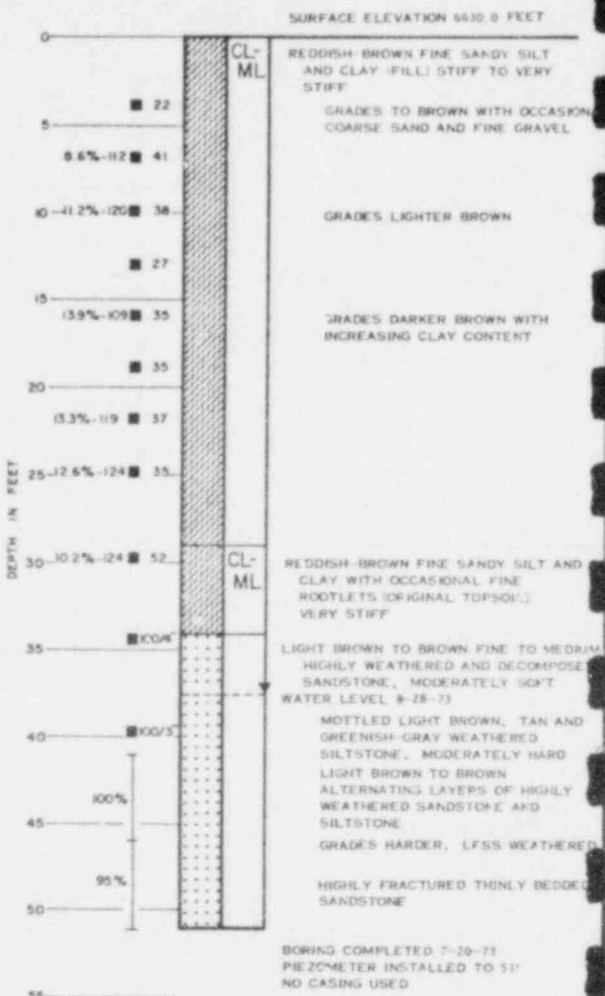
Plate A-4 - Unified Soil Classification System

Plate A-5 - Method of Performing Direct Shear and Friction Tests

BORING D-1



BORING D-2



NOTES

GROUND WATER WAS NOT ENCOUNTERED, TO THE DEPTHS EXPLORED, IN ANY OF THE TEST PITS AT THIS SITE.

THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED, "SITE CONDITIONS, SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

KEY

A - B ■

A FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL

B DRY DENSITY EXPRESSED IN LBS. PER CUBIC FOOT

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

☒ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

☐ SAMPLING ATTEMPT WITH NO RECOVERY

☒ BULK SAMPLE

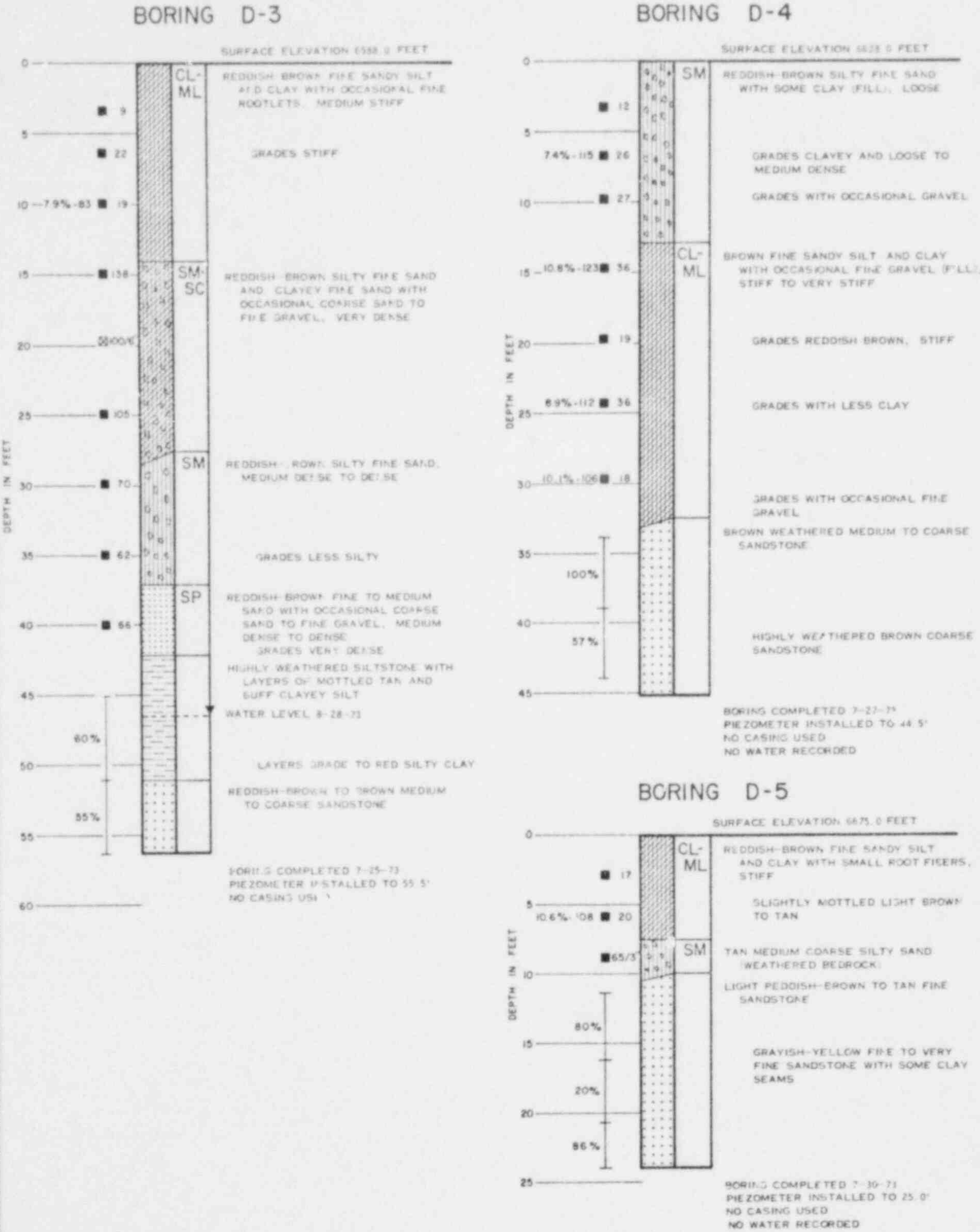
ELEVATIONS FURNISHED BY RIO ALGOM CORPORATION

A INDICATES DEPTH AND LENGTH OF CORE RUN

PERCENT OF CORE RUN RECOVERED

LOG OF BORINGS

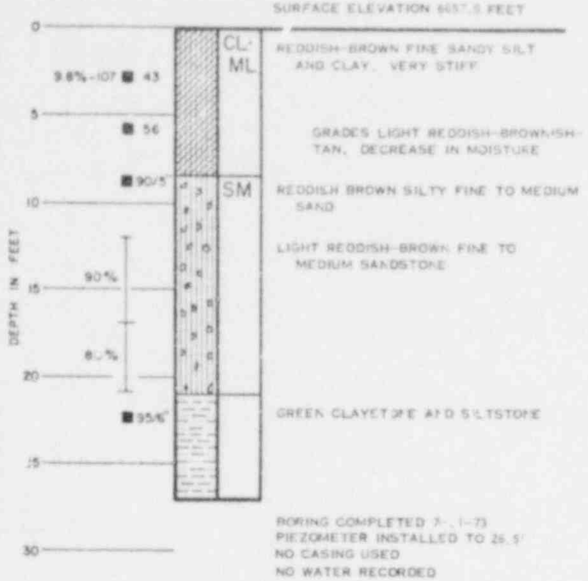
DAMES & MOORE



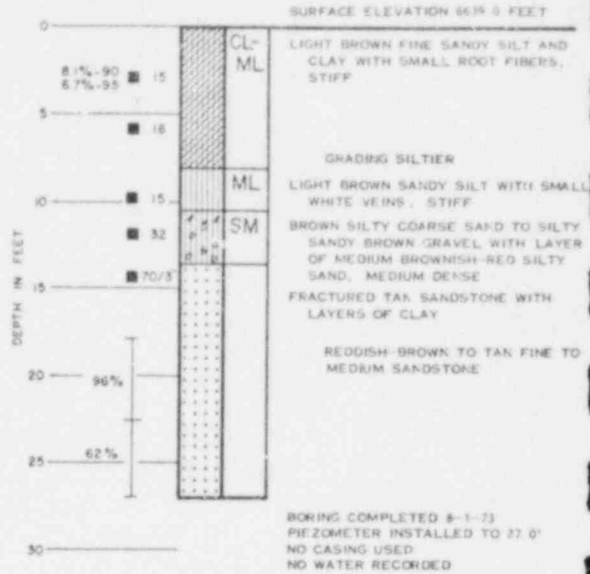
LOG OF BORINGS

DAMES & MOORE

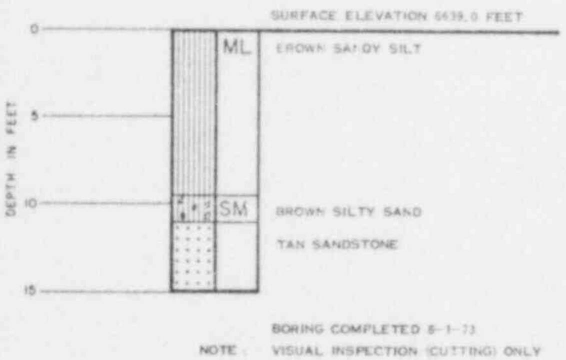
BORING D-6



BORING D-7



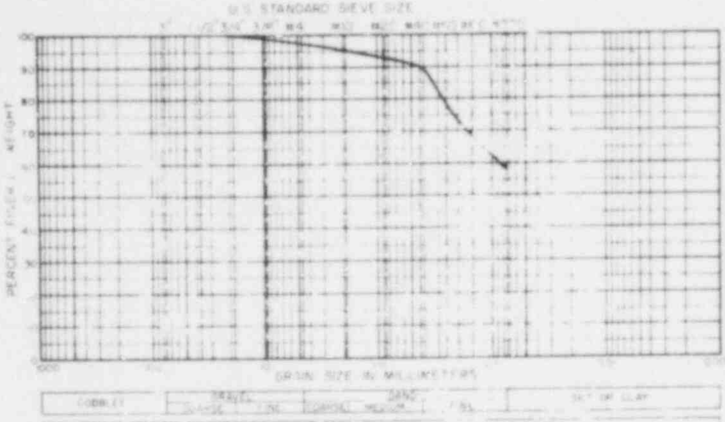
BORING D-8



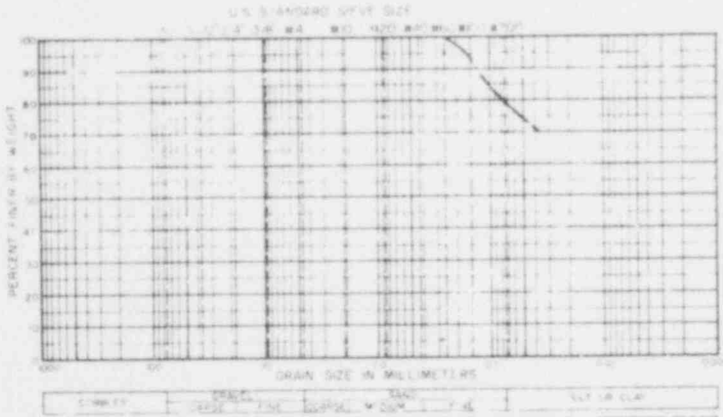
LOG OF BORINGS

DAMES & MOORE

PLATE A-1C



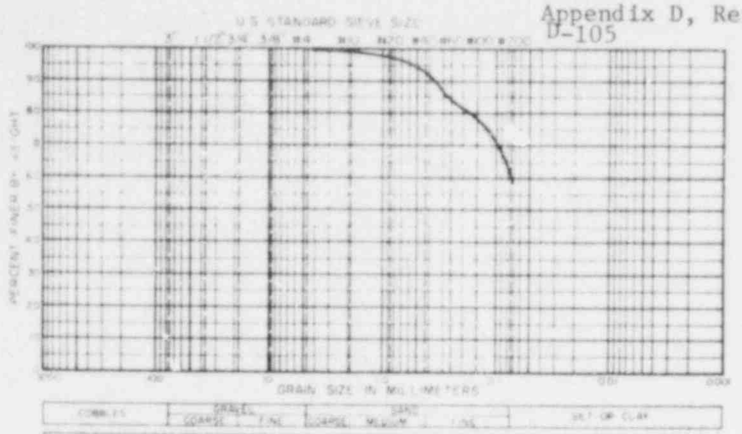
LOCATION	DEPTH	CLASSIFICATION
EXISTING EMBANKMENT	BULK	CL-ML [illegible] SANDY SILT AND CLAY



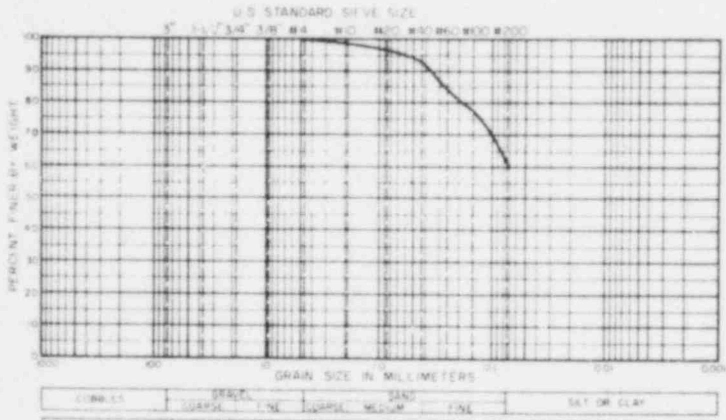
LOCATION	DEPTH	CLASSIFICATION
EXISTING POND	BULK	TAILINGS

GRADATION CURVES

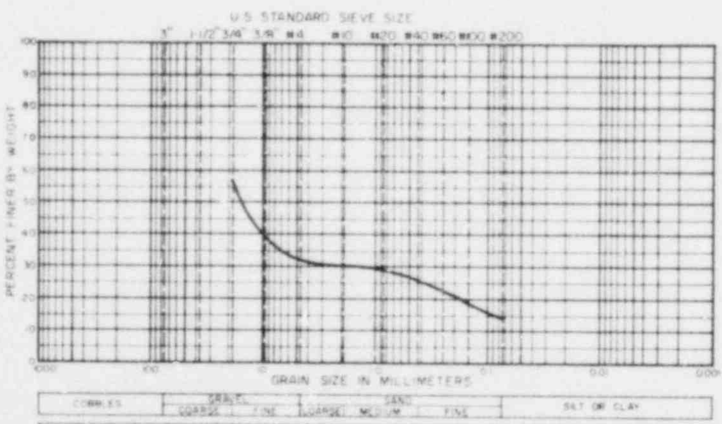
DAMES & MOORE



LOCATION	DEPTH	CLASSIFICATION
TEST PIT 1	BULK	CL-ML ..DDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS



LOCATION	DEPTH	CLASSIFICATION
TEST PIT 2	BULK	CL-ML REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS

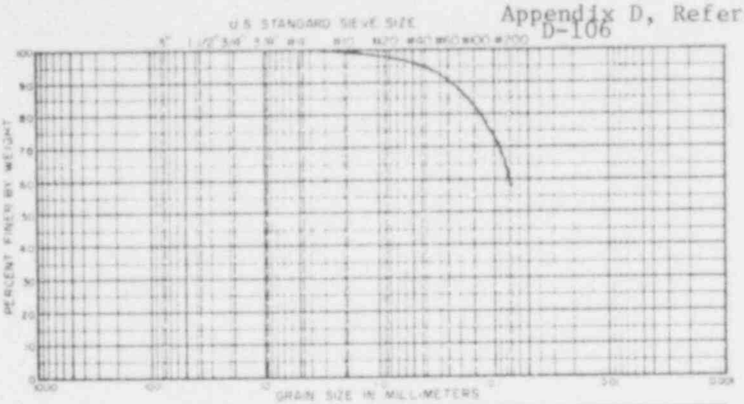


LOCATION	DEPTH	CLASSIFICATION
TEST PIT 3	BULK-WASTE PILE	MIXTURE OF SANDS, SILTS AND CLAYS FROM MAIN SHAFT UNDERGROUND MINE WASTE

GRADATION CURVES

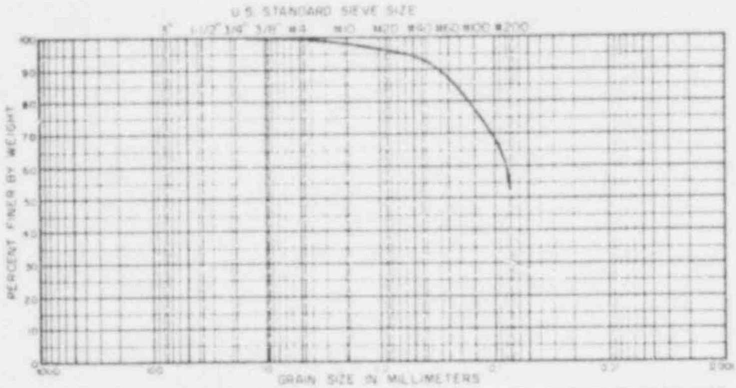
DAMES & MOORE

PLATE A-28



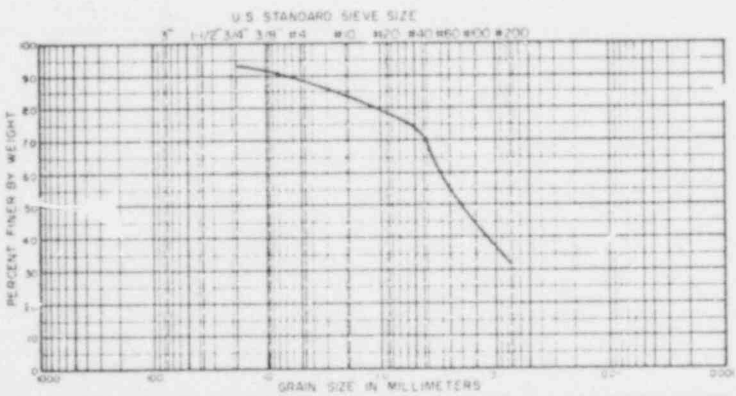
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 4	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 5	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS

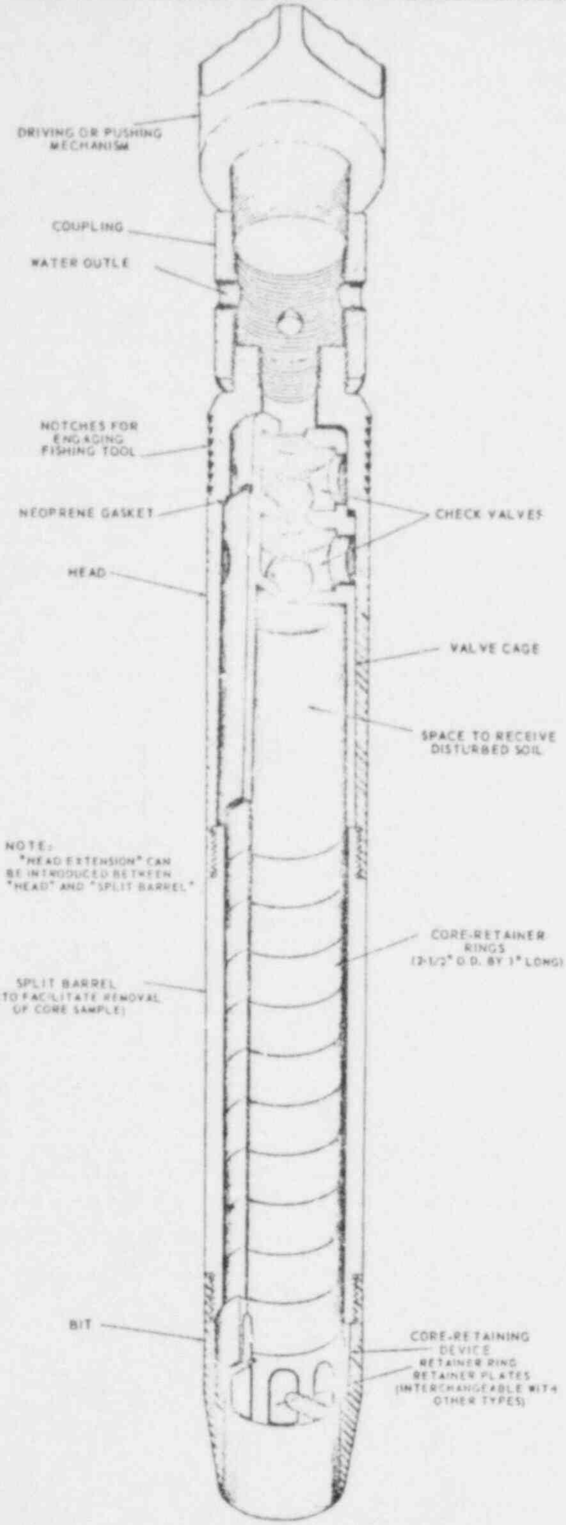


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

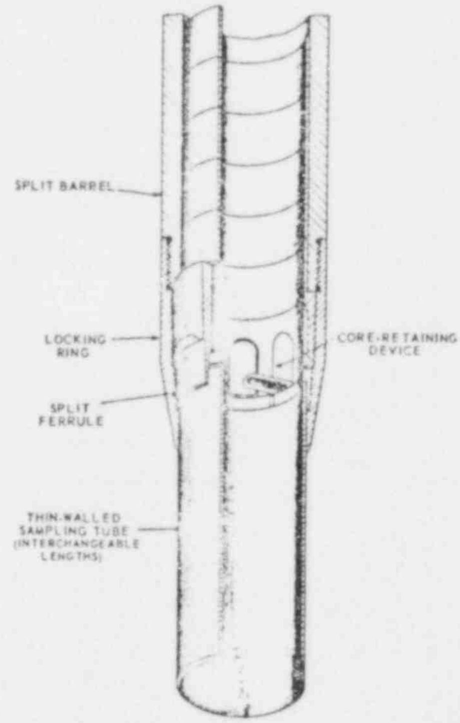
LOCATION	DEPTH	CLASSIFICATION
TEST PIT 6	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS WITH OCCASIONAL THIN LAYERS OF LIGHT TAN TO WHITE FINE SAND

GRADATION CURVES

DAMES & MOORE



ALTERNATE ATTACHMENTS



SOIL SAMPLER TYPE U

U. S. PATENT NO. 2,318,062

DAMES & MOORE

PLATE A-3

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

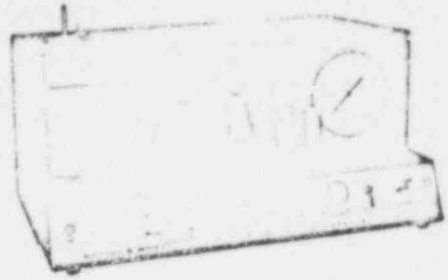
NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE

DIRECT SHEAR TESTS ARE PERFORMED TO DETERMINE THE SHEARING STRENGTHS OF SOILS. FRICTION TESTS ARE PERFORMED TO DETERMINE THE FRICTIONAL RESISTANCES BETWEEN SOILS AND VARIOUS OTHER MATERIALS SUCH AS WOOD, STEEL, OR CONCRETE. THE TESTS ARE PERFORMED IN THE LABORATORY TO SIMULATE ANTICIPATED FIELD CONDITIONS.



DIRECT SHEAR TESTING & RECORDING APPARATUS

EACH SAMPLE IS TESTED WITHIN THREE BRASS RINGS, TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

Direct Shear Tests

A THREE-INCH LENGTH OF THE SAMPLE IS TESTED IN DIRECT DOUBLE SHEAR. A CONSTANT PRESSURE, APPROPRIATE TO THE CONDITIONS OF THE PROBLEM FOR WHICH THE TEST IS BEING PERFORMED, IS APPLIED NORMAL TO THE ENDS OF THE SAMPLE THROUGH POROUS STONES. A SHEARING FAILURE OF THE SAMPLE IS CAUSED BY MOVING THE CENTER RING IN A DIRECTION PERPENDICULAR TO THE AXIS OF THE SAMPLE. TRANSVERSE MOVEMENT OF THE OUTER RINGS IS PREVENTED.

THE SHEARING FAILURE MAY BE ACCOMPLISHED BY APPLYING TO THE CENTER RING EITHER A CONSTANT RATE OF LOAD, A CONSTANT RATE OF DEFLECTION, OR INCREMENTS OF LOAD OR DEFLECTION. IN EACH CASE, THE SHEARING LOAD AND THE DEFLECTIONS IN BOTH THE AXIAL AND TRANSVERSE DIRECTIONS ARE RECORDED AND PLOTTED. THE SHEARING STRENGTH OF THE SOIL IS DETERMINED FROM THE RESULTING LOAD-DEFLECTION CURVES.

Friction Tests

IN ORDER TO DETERMINE THE FRICTIONAL RESISTANCE BETWEEN SOIL AND THE SURFACES OF VARIOUS MATERIALS, THE CENTER RING OF SOIL IN THE DIRECT SHEAR TEST IS REPLACED BY A DISK OF THE MATERIAL TO BE TESTED. THE TEST IS THEN PERFORMED IN THE SAME MANNER AS THE DIRECT SHEAR TEST BY FORCING THE DISK OF MATERIAL FROM THE SOIL SURFACES.

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DAMES & MOORE

946.7 (REV. 6-61)

REVISIONS BY ____ DATE ____
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BY ____ DATE ____
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PART II
GROUND WATER GEOHYDROLOGY AND SEEPAGE EVALUATION

PURPOSE AND SCOPE

The purpose of Part II of this investigation was to provide:

1. A full discussion of the regional and local geologic conditions, particularly as they relate to ground water flow.
2. An evaluation of the mode of seepage loss from the tailings pond and the means for its control.
3. A report which is sufficiently comprehensive to answer questions relating to geology, ground water and reservoir seepage raised by the agencies which reviewed Rio Algom's "Supplemental Environmental Report."

With these objectives in mind, the following scope of work was undertaken:

1. All published data of relevance was reviewed, and earlier studies performed by others for Rio Algom were evaluated.
2. A simple bailer test was performed in one of the monitor wells.
3. The borings drilled by Dames & Moore in conjunction with the Part I studies relating to dam stability and siting of a new pond were utilized to obtain further information on seepage characteristics below the reservoir. Several of these borings were established as new monitoring points.
4. Representative samples of soil and rock core were analyzed for petrographic information, solubility and cation exchange capacity.

REGIONAL GEOHYDROLOGY

REGIONAL GEOLOGY:

The site is located in the Colorado Plateau physiographic province approximately 12 miles south of the La Sal Mountains and some 40 miles southwest of the Uncompahgre structural uplift. The region surrounding the site is underlain by sedimentary strata of Cretaceous, Jurassic, Triassic, and older ages which are folded into a series of broad, northwest-trending anticlines and synclines. Tertiary intrusives outcrop as domes 8 to 20 miles north of the site.

The undulating bedrock folds are expressed topographically as low hill ranges and intervening valleys trending generally northwest. The principal surface drainages parallel the valleys.

Faults are common in the region and the more important structures trend northwest, similar to the folding and topography. Both normal and reverse faults have been identified.

The sedimentary deposits consist of continental and shallow marine beds, including sandstone, conglomerate, shale, mudstone, and lesser amounts of limestone and evaporites (gypsum, salt and anhydrite). Uranium deposits occur widely throughout the region and are most commonly associated with the sandstone and conglomerate formations.

Plate 1, Regional Geology, shows the principal geologic features. Plate 2, Regional Stratigraphic Description, provides general information as to bedrock lithologies, formational sequence and water bearing characteristics. Plate 3, Regional Geologic Structure Profile, shows a typical cross section.

GROUND WATER MOVEMENT:

Surface runoff and ground water movement in the site region are influenced strongly by the La Sal Mountains, which rise to an elevation of 12,700 feet. These highlands act as a ground water recharge area to permeable formations. Infiltration from rain and snowmelt in the La Sal Mountains enters Quaternary alluvium or permeable bedrock strata (generally sandstone or conglomerate) and moves to lower topographic or structural elevations. Some of this recharge flows toward the site, and thence to the west and northwest in the direction of the Colorado River. Plates 1 and 3 show the general paths of ground water flow toward the site and beyond. The interpretation is based upon topography and geologic structure in the absence of good water table data from well records.

Faults in the region trending across the path of ground water movement may or may not serve as barriers, depending on the inherent permeability of the fault material and the character of the formations opposite the fault.

Artesian pressures exist in some wells of the region where ground water moves through aquifers to lower elevations beneath confining layers (aquicludes) such as the Morrison shale or mudstone tongues in the Dakota sandstone. No flowing wells are known to occur.

The rate of ground water movement through the bedrock aquifers is believed to be on the order of several hundred feet per year. Where the flow gradient has been steepened near wells due to high drawdown, the rate of movement is greater.

Ground water in the alluvium or in shallow bedrock aquifers such as the Burro Canyon sandstone discharges as springs or directly into streams.

A few springs having this origin occur northeast and east of the site. Direct ground water recharge to the surface waterways is believed to occur mostly downstream several miles from the property, where the drainage channels have eroded through the aquifers.

GROUND WATER USE:

Good information on well characteristics in the region is lacking. Table 1 gives a summary of wells within a radius of several miles, but the specific aquifer in most cases can only be inferred. Many of the wells appear to be developed in the Dakota or Burro Canyon sandstone. Wells less than 80 or 90 feet in depth probably produce from the Quaternary alluvium. Wells deeper than 300 feet are believed to withdraw ground water from the Entrada, Navajo, or Wingate sandstones. Plate 1 and Plate 4, Vicinity Map, show the recorded wells in the region referred to in Table 1.

GROUND WATER QUALITY:

Data on the quality of ground water in the region is limited. Values for selected constituents in typical wells are provided on Table 1. In the Burro Canyon (Dakota) sandstone, the ground water is generally of potable quality. Many of the listed wells are suspected or known to be in the Burro Canyon formation and indicate fair to good potability. Analyses of the ground water from the production shaft show much higher mineralization in the Wingate and Navajo sandstones. The dissolved constituents in these two aquifers range, as follows:

Wingate Sandstone:	2500-4500	ppm total dissolved solids
	475- 500	ppm sulfates
	760-1876	ppm chlorides
Navajo Sandstone:	1200-1700	ppm total dissolved solids
	22- 62	ppm sulfates
	465- 690	ppm chlorides

TABLE 1

GROUND WATER USE

Well[1] (Serial Number)	Yield Reported[2] (Sec-Feet)	Depth[3] Of Well (Feet)	Aquifer[4]	Rad.[5]	TDS	SO_4	Cl	U_3O_8
05-213	0.015	90						
05-360	1.5	600-1,000		IAB[8]	618	235	27	0.001
05-623	0.045	150						
05-204	0.014	109						
05-784	0.010	50-150						
05-105	3.0	100-300						
05-376	1.5	80-300						
05- 79	0.0506	60						
05-779	0.1	100-150						
05-306	0.5	3 wells: 70, 78, 86	Alluvium					
05-203	0.015	78-80						
05-780	0.1	2 wells: 100, 200						
05-321	0.1	140		IAB	788	275	43	0.002
05-320	0.017	?		IAB	682	221	28	0.001
05-800	0.5	200-300						
05-791	0.5	300-500						
05-154	0.556	3 wells: Depths?						
05-426	0.02	828		IAB	246	33	23	0.002
Rio Algom 2	0.10	275	B.C.[7]	?	277	118	16	
Rio Algom 3	0.075	322	B.C.	?	345	135	22	No U_3O_8
Rio Alg'm M-1	0.20	230	B.C.	?	598	160	24	assays
Rio Algom M-2	0.12	270	B.C.	?	to	to	to	in ppm
Rio Algom M-4	0.18	235	B.C.	?	806	286	36	
Rio Algom M-5	0.16	230	B.C.	?				

1. Serial Number, Utah Division of Water Rights
2. At time of completion
3. Where given as range, depth applied for
4. Where data omitted, none available
5. Rad. = radioactivity in gross alpha pico-Curies per ml
6. All constituents except radioactivity given in ppm
7. B.C. = Burro Canyon sandstone
8. IAB = Insignificant above background

in geographic or stratigraphic proximity to uranium deposits, some contamination by radionuclides may occur, particularly if shafts or open borings permit the mingling of ground water from various formations.

SITE GEOHYDROLOGY

SITE GEOLOGY:

The surficial geologic materials in the site vicinity consist of overburden soils and outcrops of Dakota or Burro Canyon sandstone. These materials are further described in the introductory section of this report. Plate 5, Vicinity Geology, and Plate 6, Vicinity Ground Water Flow, show the general structural relationships of the area.

A contour map drawn on the top of the Brushy Basin shale in the vicinity of the early exploration borings shows considerably more complexity in local bedrock structure than would be inferred from published data. Among these small local features are several shallow domes and troughs. Because the top of the shale acts as a bottoming layer for shallow percolation, these irregularities exert some localized influence upon ground water flow, as discussed in the next section of the report.

GROUND WATER MOVEMENT:

Deep Ground Water. Ground water is present in several formations beneath the site; namely, the Burro Canyon, the Navajo, and the Wingate sandstones. Some ground water was also reported in the Kayenta formation during the shaft sinking. In all cases, ground water movement into the area is believed to occur principally from the northeast, although increments of this flow are probably diverted to the northwest or southeast along synclinal depressions. A smaller component of flow may enter the site from the southeast, following the north side of the Lisbon Valley fault and the nose of the Lisbon Valley Anticline.

Local recharge within a few miles of the site does not penetrate significantly into the impermeable Brushy Basin shale. Deeper aquifers are isolated from the shallower water bearing zones by these shale beds and by the lower aquicludes, unless interconnection is provided by faults, borings, shafts, or underground workings. In pumped workings, mixing between aquifers is largely prevented due to the break in hydraulic continuity at the cone of depression. In flooded workings or open borings, contamination of the shallow aquifers from deeper confined sources is possible. At Rio Algom, however, this will be prevented when the operations are abandoned by sealing off the mineralized workings from the shallower formations.

Based upon present information, the ultimate flooding level in the shafts subsequent to mine closure cannot be anticipated with certainty. Ground water will rise in the shafts to a level which is in hydrostatic equilibrium with the formation having the highest piezometric head. This head has not been measured for the deeper aquifers. If it were sufficient to reach the Burro Canyon sandstone, we believe that no significant contamination could move either into this formation, or from it into the shaft, because of the shaft linings.

Shallow Ground Water. Infiltration of surface waters occurs through the soils in the drainage depressions and through fractured and weathered Burro Canyon sandstone, both where it outcrops and where covered by overburden.

Percolation rates have been measured in the soils and the Burro Canyon sandstone by field permeability tests conducted by others. These test results are shown on Plate 7, Map of Bedrock Surface, and are summarized in Appendix II-A.

Shallow ground water probably moves off the site through the lower Burro Canyon formation, remaining perched on the Brushy Basin shale, and enters the shallow synclinal trough southwest of the property. Flow which reaches the Lisbon Valley fault either penetrates through it into the upthrown Wingate sandstone on the opposite fault block, or is diverted northwestward along the fault, perhaps eventually to discharge into the south branch of West Coyote Wash.

The low anticlinal divide northeast of the mine, as shown in Plate 6, may affect slightly the directions of ground water movement. Because of this structural feature, any ground water entering the Burro Canyon sandstone or deeper aquifers at the production shaft would probably flow southwest, which is the apparent slope of the hydraulic gradient. The divide, aided by shaft pumpage, may help to prevent pond seepage from flowing northeast or east toward wells.

In the immediate vicinity of the operations, local irregularities in the Brushy Basin surface as discussed in the previous section would be expected to impose a variety of directional components in the flow by ground water. For example, the axis of the proposed upstream tailings dam coincides with a local ground water divide. Seepage from the proposed reservoir could enter a northwesterly ground water flow pattern, whereas any seepage beneath the proposed dam might join the southwesterly flow system that passes beneath the existing tailings pond. Infiltration from the spray field, which also straddles this divide, could similarly move either northeast or southwest.

Any seepage entering the Burro Canyon sandstone from the production shaft, which appears to occupy a saddle in the Brushy Basin shale, would tend to flow southwest after encountering the main ground water zone, although movement into troughs extending eastward and northwestward from the shaft is also possible.

The proposed site for construction of barium treatment ponds is also situated on a saddle between troughs in the Brushy Basin shale. These troughs extend roughly eastward and northwestward from the contemplated pond site and will influence the movement of any seepage from the ponds.

Plate 8, Geologic Cross-Sections-Tailings Pond, shows the interpreted paths of seepage and ground water movement in the vicinity of the existing impoundment.

SEEPAGE FROM TAILINGS POND

MOVEMENT OF SEEPAGE:

It has been anticipated that seepage from the tailings pond will reduce to negligible amounts as sealing of the bottom progresses with the emplacement of tailings fines. Rio Algom has determined from field tests that the permeability of the tailings is about 6 feet per year.

Until this tailings blanket effectively seals all of the ponded area, effluent will percolate through the more permeable natural soils and into the underlying fractured Burro Canyon sandstone or it will infiltrate directly into the sandstone where this rock is in contact with the effluent.

Some seepage, though probably negligible, can be expected even after the tailings blanket is essentially complete.

Seepage from the pond percolates to the natural ground water zone in the lower Burro Canyon formation, either directly or by stages via perching layers in the soil or rock and then moves downgradient beneath the dam, past the monitor wells and eventually off-site. Dilution, dispersion, and cation exchange occur along this seepage path with attendant reduction in the concentration levels of radionuclides and other constituents.

At its present elevation, the outer portions of the pond on the north side are in direct contact with fractured Burro Canyon sandstone, or separated from it by only two or three feet of overburden. Percolation through the bedrock fractures can be many times the rate estimated from field permeability tests of the soils or unfractured sandstone. This is borne out by the range of permeabilities determined for the in-place sandstone as shown on Plate 7.

RADIONUCLIDE LEVELS:

Plates 9A, 9B, and 9C show the variations in concentration of the principal radionuclides in the monitor wells and shafts at the site. These curves show the effects of dilution by the natural ground water beneath the site and indicate a time lag between fluctuations of radionuclide levels in the pond and response in the monitor wells.

The Utah standards pertaining to radioactive effluent limitations which are shown on these plates are based on one-thirtieth of the maximum permissible concentrations for the critical body organ as defined in the National Bureau of Standards Handbook No. 69. These standards are much stricter than the limits stipulated by the Atomic Energy Commission.

In general, the uranium levels have diminished in the monitor wells since mill startup and are currently well below the Utah standard. Radium, on the other hand, has increased somewhat over this same period with a few of the analyses exceeding the standard. The trend suggests that ground water contamination from pond seepage may reach objectionable levels unless control measures are undertaken.

The radium concentration in monitor wells MW-1 and MW-2 probably results from their close proximity to the tailings pond, coupled with their downstream and "downdip" position relative to the pond. The radium increase in monitor well MW-4, located about 2000 feet southeast of the tailings dam, is more difficult to interpret. The latest recorded water level, in July, 1973, was at elevation 6577 feet, or about 20 feet below the lowest pond bottom elevation. The site for MW-4 is slightly "up-dip" from the pond along the Brushy Basin contact but otherwise does not lie along a feasible flow path from this body of water. Any contaminants infiltrating from the production shaft might move in this direction, however. MW-4 is situated in the drainage area downstream from other uranium mines southeast of Rio Algom, which opens the possibility of contaminants reaching MW-4 from that direction. Contradicting this assumption, however, is the fact that the increase in radium content in MW-4 appears to coincide roughly with the radium increase in the Rio Algom tailings pond and in monitor wells MW-1 and MW-2.

CATION EXCHANGE:

The soil and rock materials beneath the reservoir and along seepage flow paths have the capacity of adsorbing effluent constituents such as radium by the process of cation exchange. An adequate evaluation of this process requires detailed knowledge as to the chemical content of each radionuclide and principal non-radioactive constituent in the effluent. The greatest difficulty, however, lies in conceptualizing quantitatively the physical environment in which cation exchange takes place. With time, the adsorptive capacity of the soil and rock materials at a given location is fully consumed by prolonged contact with the effluent so that the constituents are required to migrate further downgradient where unused exchange capacity is still available. This advancing front of contaminant is affected by radioactive decay and normal dilution as well as by cation exchange. The net result is observable in monitor wells, but differentiating each process and its relative influence is exceedingly complex.

It is probable that cation exchange has already proceeded to completion in the vicinity of the tailings pond though it may still be an active process at some distance from the pond. Cation exchange by itself, however, would not be capable of fixing a sufficient amount of radionuclide, such as radium, to reduce its concentration below permissible limits.

Present techniques of cation exchange analysis utilize a diffusion model computer program and require several months to complete. A detailed evaluation of this phenomenon lies outside the scope of the present study.

However, seven samples of soil and four rock core samples from the site were analyzed for cation exchange capacity (CEC) by the calcium carbonate exchange method. The results are given in Table 2, in milliequivalents per 100 grams of soil or rock.

TABLE 2

CATION EXCHANGE CAPACITY

Boring	Depth (ft)	Description	% Cations Available	CEC (Mev/100 gms)
D-1	51.5-54.5	SM	28.6	15.6
D-3	24.5	SP-GP	24.7	13.5
D-3	39.5	SP	29.1	16.0
D-4	19.5	CL-ML	28.3	15.5
D-4	29.5	CL-ML	29.4	16.1
D-3	9.5	CL-ML	25.4	13.9
D-3	34.5	SM	27.3	15.0
D-1	60.5	Sandstone	26.1	14.3
D-2	42.5	Sandstone	19.3	10.6
D-3	46.5	Sandstone	19.8	10.9
D-4	34.5	Sandstone	21.3	11.7

SOLVENT EFFECTS OF EFFLUENT:

Some attempt was made to determine the susceptibility of the soil and rock materials beneath the dam to solution when exposed to the seepage effluent. Appendix II-B describes the results of petrographic analysis to identify soluble minerals, and solubility testing in solutions of various compositions. The generalized conclusions which can be drawn from these analyses is that one percent or less of the typical soils would be subject to solution in a pH 9.0 environment. The rock would be still less soluble.

Quartz is abundant in most of the samples. When the effluent becomes more alkaline than pH 10.0, as occasionally shown by the records, silica in the earth materials may be affected. Although tests were not run under these conditions, the possibility exists that high pH seepage below the tailings pond and above the zone of saturation may be capable of dissolving some of the quartz in the soils and rock, with a resultant increase in permeability.

OTHER DILUTING EFFECTS:

Seepage which reaches the zone of ground water saturation undergoes rapid dilution. A measure of this dilution rate is indicated by monitor well MW-1 in which the radium concentration during July, 1973 was only two to five percent of that recorded in the pond over the previous two months. Monitor well MW-1 is 725 feet from the nearest approach of the pond.

Recently completed monitor well D-10 is located about midway between the pond and monitor well MW-1. Radium in this well from the one assay thus far obtained (in August, 1973) was 3.0×10^{-9} uC/ml lower than MW-1, suggesting an even higher rate of dilution.

CONTROL OF OFF-SITE CONTAMINATION

GENERAL:

The Burro Canyon formation supplies numerous wells in the region with potable water, including those maintained by Rio Algom. This aquifer is also the uppermost bedrock unit near the tailings pond. Monitor wells in the vicinity of the pond have shown that seepage is occurring. Among the radioactive constituents, radium has most closely approached acceptable state limits, indicating that seepage control measures may be necessary to insure that off-site contamination does not occur. Such measures will be undertaken in the near future.

An "action level" of radioactivity in the monitor wells should be established and it is proposed that wells MW-1 and MW-2 below the tailings dam be used to identify this level. These wells are 320 feet and 170 feet, respectively, from the nearest property boundary and are downgradient from the pond. In view of the probable dilution rate versus distance, an action level in the monitor wells should be selected which is sufficiently below the Utah standard to allow time for implementation of effective control measures before concentrations exceed acceptable limits at the property boundary.

Based upon the present concentrations of radioactive constituents in the monitor wells, it is proposed that radium serve as the index constituent governing the action level. A reasonable action level, in our opinion, would be indicated when two out of three consecutive monthly composite radium analyses exceed the Utah standard in either of these wells.

Two general methods for achieving control are seepage recovery by pumping wells and total containment by reservoir sealing. Effective sealing of the reservoir may take several months to accomplish, and it therefore seems advisable that a well recovery system be activated in the near future. These wells will then serve as a backup system after the reservoir has been sealed.

RESERVOIR SEALING:

Sealing of the reservoir is clearly the most positive way of controlling the seepage of contaminants. Though such a method is not likely to eliminate seepage entirely, it should be capable of reducing these losses to an acceptable maximum.

It is the intent of the tailings placement plan to accomplish sealing of the reservoir. Identification and treatment of the areas having the highest seepage potential should be of first priority. However, sealing of the entire reservoir should be the ultimate goal and will require that a tailings blanket at least six inches thick be placed under all areas occupied by water, so that at no point does this effluent come in direct contact with the natural ground surface. As the pond level rises, additional layers of tailings must be deposited on the newly inundated banks around the periphery of the reservoir. This [illegible] applies both to the existing pond and the proposed second tail[illegible]ment area. Sealing of these basins is essential regardless of any recovery well system contemplated.

The north side of the reservoir is believed to be one of the principal areas of high seepage loss. In this locality, a tailings seal should be emplaced which blankets all zones having less than three feet of natural soils and which extends to the maximum pool elevation. The area within the reservoir basin from which embankment material was excavated may require similar treatment. The areas recommended for placement of tailings are shown on Plate 7.

RECOVERY WELLS:

Recovery of contaminant seepage will be necessary until the reservoir sealing process has become effective. Seepage percolates downward some 40 to 50 feet below the reservoir before reaching the zone of saturation at the ground water table. Some portion of the seepage is intercepted by discontinuous mudstone layers in the sandstone. In the zone of saturation, the seepage moves laterally downgradient. Recovery is possible only after the seepage enters this zone. Wells pumped to extract the contaminants will also withdraw some ground water which is not contaminated.

The primary objectives of the well recovery system would be to remove contaminants and to create a cone of depression which induces flow toward the wells by reversing the natural gradient. This has proven to be an effective technique in other instances for lowering the ground water table and restricting the movement of contaminants.

A pumping test should be conducted in the proposed recovery area to determine the local hydraulic characteristics of the sandstone. From these data, the number, arrangement and discharge capacity of the recovery wells can be prescribed which will provide an appropriate drawdown configuration. Although supply wells of 30 to 40 gallons per minute capacity have been developed elsewhere in the Burro Canyon formation, as at the Maple Leaf claims, seepage recovery wells at the tailings pond probably will not require pumping at these rates to form an effective seepage barrier.

A crude bailer-type pumping test was conducted in monitor well MW-1 to gain some impression as to the feasibility of pumping as a seepage recovery measure. Approximately five gallons per minute were bailed over a 30-minute period without producing a significant drawdown. The results suggest that there is sufficient transmissivity in the sandstone to warrant the use of submersible or vertical turbine pumps.

As an alternative to test pumping prior to designing a recovery well system, wells could be installed on a trial and error basis according to our present limited knowledge of the aquifer hydraulics at the site. These wells should be located so as to intercept seepage as close as possible to its confluence with the ground water system, in order to recover the highest concentrations. The crest of the tailings dam would be an effective and convenient area for the recovery wells. It is proposed that two wells be installed initially, one near each zone of suspected maximum seepage in the pond, as indicated on Plate 5. Each well should extend at least 15 feet into the Brushy Basin shale, to provide a sump for the pump intake. We estimate that these wells should be fitted with a pump capable of lifting 10 to 20 gallons per minute against a head of 120 to 130 feet. This would require a 1 to 1-1/2 horsepower pump and a minimum well diameter of four inches.

Existing monitor wells MW-1 and MW-2 would continue to be monitored and could also be pumped, if necessary, as backup to the proposed recovery system.

Discharge from the recovery wells would be returned to the reservoir and pumpage should be kept to the minimum required for an effective barrier. Depression of the water table as a consequence of recovery well operation will have no adverse affect upon dam stability. The permeability of neither the soils nor bedrock beneath the tailings pond will be increased, although the velocity of present ground water flow from the northeast (upgradient) will be greater.

TREATMENT:

The radium concentration in the ventilation shaft currently exceeds Utah standards for effluent discharge, due principally to the fact that some contaminated mine water is pumped through this shaft. Plans for exporting water from the vent shaft to off-site users therefore cannot be implemented until the radium content is reduced. This will be accomplished by pumping mine water only through the production shaft in the future and treating the unused excess volume with barium chloride to remove the radium. The treated water will then be combined with the improved vent shaft water for discharge to the Redd Ranch Reservoir.

MONITORING

EXISTING MONITOR WELLS:

Five monitor wells are currently used to maintain surveillance of the ground water quality in the site vicinity. Their locations are shown on Plate 5. The well sites were placed a sufficient distance inside the Rio Algom property line to insure early detection of undesirable contaminant levels and trends and to permit corrective action to be taken before excessive concentrations are able to move off-site. Two of these wells, MW-1 and MW-2, are approximately 500 feet southwest of the tailings dam. MW-1 reportedly encountered bedrock at a depth of 15 feet rather than at 70 feet in a bedrock depression as predicted by the seismic refraction survey. MW-2 penetrated 60 feet of sandy overburden above the Burro Canyon contact in a bedrock depression. Both wells were drilled 15 feet into the Brushy Basin shale, cased the full length, and perforated from the lower 10 feet of overburden to the bottom of the well.

The other three monitor wells are former deep exploration borings which have been cased in the upper portion and plugged below the Burro Canyon sandstone. The sites for these wells were chosen north, northeast and southeast of the site on the premise that movement of seepage from the tailings pond would be omnidirectional above the main ground water table. Movement would also be more responsive to bedrock structure in this zone, which slopes generally northeastward into the East Coyote Syncline from the northern sector of the property, with local variations in flow as described on page 8. The radionuclide levels in these wells were discussed earlier.

During the cou. of the prevent investigation, additional monitor wells were installed, two below the present dam (D-9, D-10) and three (D-5, D-6 and D-7) at the proposed upstream site. In addition, three of the recent borings (D-1, D-2 and D-4) along the existing dam axis and one boring (D-3) at the toe of the dam were cased and will be used to monitor the phreatic line.

Monitor well D-9 was drilled 10 feet into the Burro Canyon sandstone to observe whether seepage was flowing in the overburden or upper fractured bedrock, possibly perched on a mudstone layer in the sandstone. No water has been recorded in D-4 or D-9, indicating that seepage is penetrating deeper into the Burro Canyon beds before reaching monitor wells MW-1 and MW-2.

Monitor well D-10 was drilled within 20 feet of D-9 and taken through the Burro Canyon sandstone approximately 10 feet into the Brushy Basin shale. The overburden and upper bedrock region were sealed off to isolate possible seepage in this zone from ground water flowing in the lower Burro Canyon formation. The lower 15 feet of sandstone is saturated.

PROPOSED MONITOR WELLS:

The possibility of ground water contamination originating from sources other than Rio Algom has been considered. Mining operations southeast of the property and northeast of the Lisbon Valley fault are suspect. This area is up-dip from Rio Algom, on the nose of the Lisbon Valley anticline, and ground water movement toward Rio Algom within the Burro Canyon sandstone is conceivable. In order to confirm possible contamination of the Rio Algom monitor wells from this region, two additional monitor wells are proposed, one in the northwest corner of Audrey 19 claim and one in the northwest portion of Audrey 2 claim.

A third site might be considered on the Susan Jean 20 claim, to monitor possible sources from the upper portion of the watershed. Each of the proposed monitor wells should extend five feet into the Brushy Basin shale, and be sealed above 10 feet of depth in the Burro Canyon formation.

MONITORING SCHEDULE:

A rather large number of existing and proposed new monitor wells at the site makes it practical to limit the frequency of sampling and the extent of analysis. Table 3 presents our recommendations as to a future schedule for sampling in these wells. The program should be reviewed every two or three months and modified as appropriate.

AFFECT OF GROUND WATER WITHDRAWALS

SUPPLY WELLS:

The water supply well system on the Maple Leaf claims has been designed for a capacity of 200 gallons per minute. Subsequent reassessment of the operational needs has reduced the foreseeable requirement to approximately 80 gpm. Review of the pump test analyses performed by others indicates a probable drawdown per well of 10 feet in 10 years at a distance of two miles, assuming a pumping rate of 40 gallons per minute and no recharge. Accepting these calculations, 80 gallons per minute of pumpage for plant use would produce 20 feet of drawdown at two miles in 10 years, without making allowance for recharge. Recharge of the Burro Canyon aquifer is an actuality, however, as proven by the existence of several springs emanating from this formation in the region. These overflows indicate an excess of recharge over storage capacity. Pumpage at the planned rate may possibly diminish springflow within 1500 or 2000 feet of the supply wells and affect forage near any local springs. Beyond one mile, the influence on existing springs should be minor. The nearest known well to the Maple Leaf well field is ov r one mile distant to the northwest.

MINE SHAFTS:

Combined pumpage from the two shafts on the property has increased from about 250 gallons per minute in July, 1972, to nearly 400 gallons per minute in September, 1973. Approximately equal amounts are discharged currently from each shaft. Most of this water originates from the Navajo and Wingate sandstones, which range in depth, respectively, from 1150 to 1540 feet and from 1749 to 2051 feet in the region northeast of the Lisbon Valley fault. These aquifers are deeper than any well of record within five miles of the mine. The other principal aquifer, the Burro Canyon sandstone, is lined with concrete in the shafts and hence sealed against leakage into them.

Due to the foregoing circumstances, mine pumpage will have no adverse affect upon present aquifer use in the region.

Among the aquifers penetrated by the shafts, only the Burro Canyon sandstone outcrops in the vicinity or is the source of springs. There are no springs known to be present within one mile of the shafts and those which

TABLE 3

MONITOR WELL PROGRAM

	Water Level	pH	U(nat)	RA226	Th230	Na	SO_4
MW 1	M	W	W,M_c	M_c	M_c	W	M_c
MW 2	M	W	W,M_c	M_c	M_c	W	M_c
MW 3	M	M	M	M	M	M	M
MW 4	M	M	M	M	M	M	M
MW 5	M	M	M	M	M	M	M
D 1	M		M	M			M
D 2	M		M_c	M_c			M_c
D 3	M	M_c	M_c	M_c			M_c
D 4	M	Now dry; check weekly for water level, then monthly for Ra.					
D 5		No sampling					
D 6		No sampling					
D 7	M		M_c	M_c			M_c
D 9	M	Now dry; check weekly for water level, then monthly for Ra.					
D 10	M		M_c	M_c			M_c
"Outside Sources" Monitor Wells	initially, two samples one week apart, then monthly composites thereafter, on Uranium, Radium and SO_4						

W = Weekly

M = Monthly

M_c= Monthly composite of weekly samples are nearest have shown no change in flow which might be attributed to mine drainage operations.

Imported high quality water from the Maple Leaf well field is now being used primarily for culinary purposes, while most other needs are met by pumpage from the shafts.

The ventilation shaft water is relatively low in radionuclide contamination, whereas water from the production shaft is highly contaminated. It is planned that the production shaft water in excess of on-site requirements will be treated to acceptable standards and exported from the site.

In our view, present or planned schemes for water use of the Rio Algom operations reflect due regard for the need of conserving this resource.

Respectfully submitted,

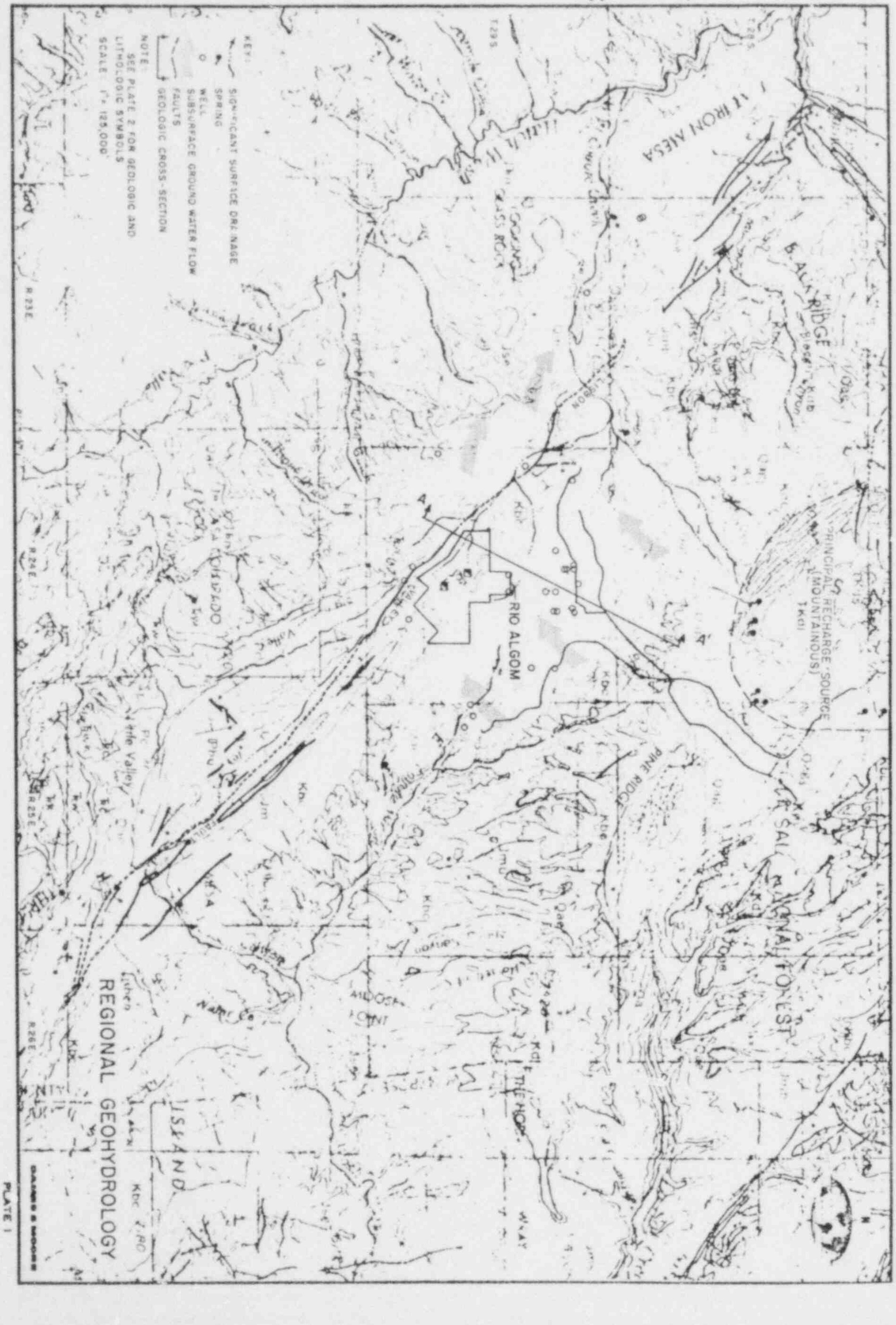
DAMES & MOORE

William E. Mead

William E. Mead
Consulting Partner

WEM:ab

Attachments


KEY:
SIGNIFICANT SURFACE DRAINAGE
SPRING
WELL
SUBSURFACE GROUND WATER FLOW
FAULTS
GEOLOGIC CROSS-SECTION
NOTE:
SEE PLATE 2 FOR GEOLOGIC AND LITHOLOGIC SYMBOLS
IRON MESA
BLACK RIDGE
PRINCIPAL RECHARGE SOURCE (MOUNTAINOUS)
RIO ALGOM
PINE RIDGE
REGIONAL GEOHYDROLOGY
PLATE 1

		GENERAL DESCRIPTION	THICKNESS IN FT.	GENERAL WATER-BEARING CHARACTERISTICS
QUATERNARY	Qaf	ALLUVIAL FAN GRAVELS		AQUIFER
	Qag	ALLUVIAL GRAVELS, MOSTLY GLACIAL OUTWASH		AQUIFER
	Qae Qa Qap	ALLUVIUM AND WIND BLOWN DEPOSITS, UNDIFFERENTIATED		AQUIFER (SEVERAL OFF-SITE WELLS ARE IN THIS FORMATION)
	Qc	COLLUVIAL DEPOSITS		MINIMAL
TERTIARY	TKds TKdl	DIORITE PORPHRY (IGNEOUS INTRUSIVE)		MINIMAL
CRETACEOUS	Kd	DAKOTA (CEDAR MOUNTAIN) SANDSTONE, INTERBEDDED CONGLOMERATE SANDSTONE, CARBONACEOUS SHALE	5 TO 200	AQUIFER
	Kbc	BURRO CANYON FORMATION: SANDSTONE AND CONGLOMERATE INTERBEDDED WITH SILTSTONE, SHALE, MUDSTONE, THIN BEDDED LIMESTONE (OUTCROPS AT SITE)	0 TO 200	*AQUIFER SUPPLIES WELLS FOR SITE. FEEDS SPRINGS NEAR SITE. SEVERAL OFF-SITE WELLS APPEAR TO BE IN THIS FORMATION
JURASSIC	Jm (Jmb, Jms)	MORRISON FORMATION: SHALE, MUDSTONE, AND SANDSTONE. SOME THIN LIMESTONE		AQUICLUDE
	Jmb	BRUSHY BASIN SHALE MEMBER: CHIEFLY MUDSTONE, LESSER SANDSTONE AND CONGLOMERATE	250 TO 500	AQUICLUDE
	Jms	SALTWASH SANDSTONE MEMBER: SANDSTONE, LESSER MUDSTONE, THIN LIMESTONE	190 TO 490	MINIMAL
	Js	SUMMERVILLE FORMATION: SANDY SHALE AND MUDSTONE	60 TO 150	AQUICLUDE
	Je	ENTRADA SANDSTONE	180 TO 350	MODERATE (1 OR 2 OFF-SITE WELLS MAY BE IN THIS FORMATION)
	Jc	CARMEL FORMATION: SILTSTONE, LESSER SANDSTONE	35	AQUICLUDE
	JTRn	NAVAJO SANDSTONE	400	*MODERATE PRODUCES SOME WATER IN RIO ALGOM SHAFTS
TRIASSIC	TRk	KAYENTA FORMATION: SHALE, SILTSTONE AND SANDSTONE	0 TO 240	AQUICLUDE (CONTAINS SOME WATER AT SITE)
	TRw	WINGATE SANDSTONE	0 TO 350	*MODERATE PRODUCES WATER IN RIO ALGOM SHAFTS
	TRc (TRcu, TRcb)	CHINLE FORMATION: SILTSTONE, SANDSTONE, SHALE, CONGLOMERATE	0 TO 600	AQUICLUDE (ORE BEARING AT SITE)
	TRcu	UPPER CHINLE		
	TRcb	MOSS BACK MEMBER: SANDSTONE, LESSER MUDSTONE		
	TRm	MOENKOPI FORMATION: CHIEFLY SHALE AND MUDSTONE, LESSER SANDSTONE AND CONGLOMERATE	0 TO 1000	AQUICLUDE MISSING AT SITE
PERMIAN	Pc	CUTLER FORMATION: ARKOSIC CONGLOMERATE	0 TO 8000	UNKNOWN
PENNSYLVANIAN	Ph (Phu, Php)	HERMOSA FORMATION		
	Phu	UPPER HERMOSA: LIMESTONE, LESSER SANDSTONE, SILTSTONE, SHALE	0 TO 1800	UNKNOWN
	Php	PARADOX MEMBER: SALT, GYPSUM, ANHYDRITE, SHALE, SANDSTONE, LIMESTONE	0 TO 11,000	UNKNOWN

* WATER BEARING AT SITE

CONTACT

FAULT

6
STRIKE AND DIP OF BEDS

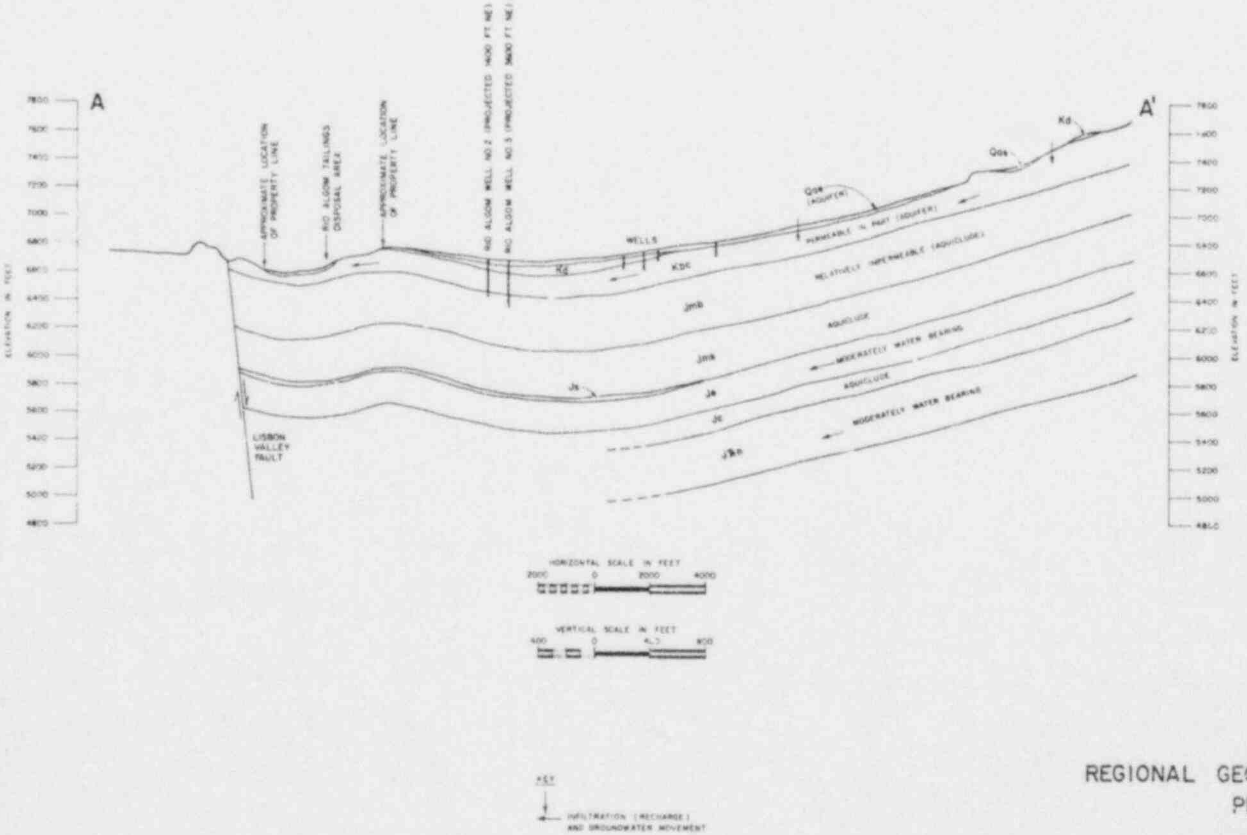
HORIZONTAL BEDS

REFERENCE:
MODIFIED FROM WILLIAMS (1964)

REGIONAL STRATIGRAPHIC DESCRIPTION

DAMES & MOORE

PLATE 2



REGIONAL GEOLOGIC STRUCTURE PROFILE

CROSS SECTION A - A'

DAMES & MOORE

PLATE 3

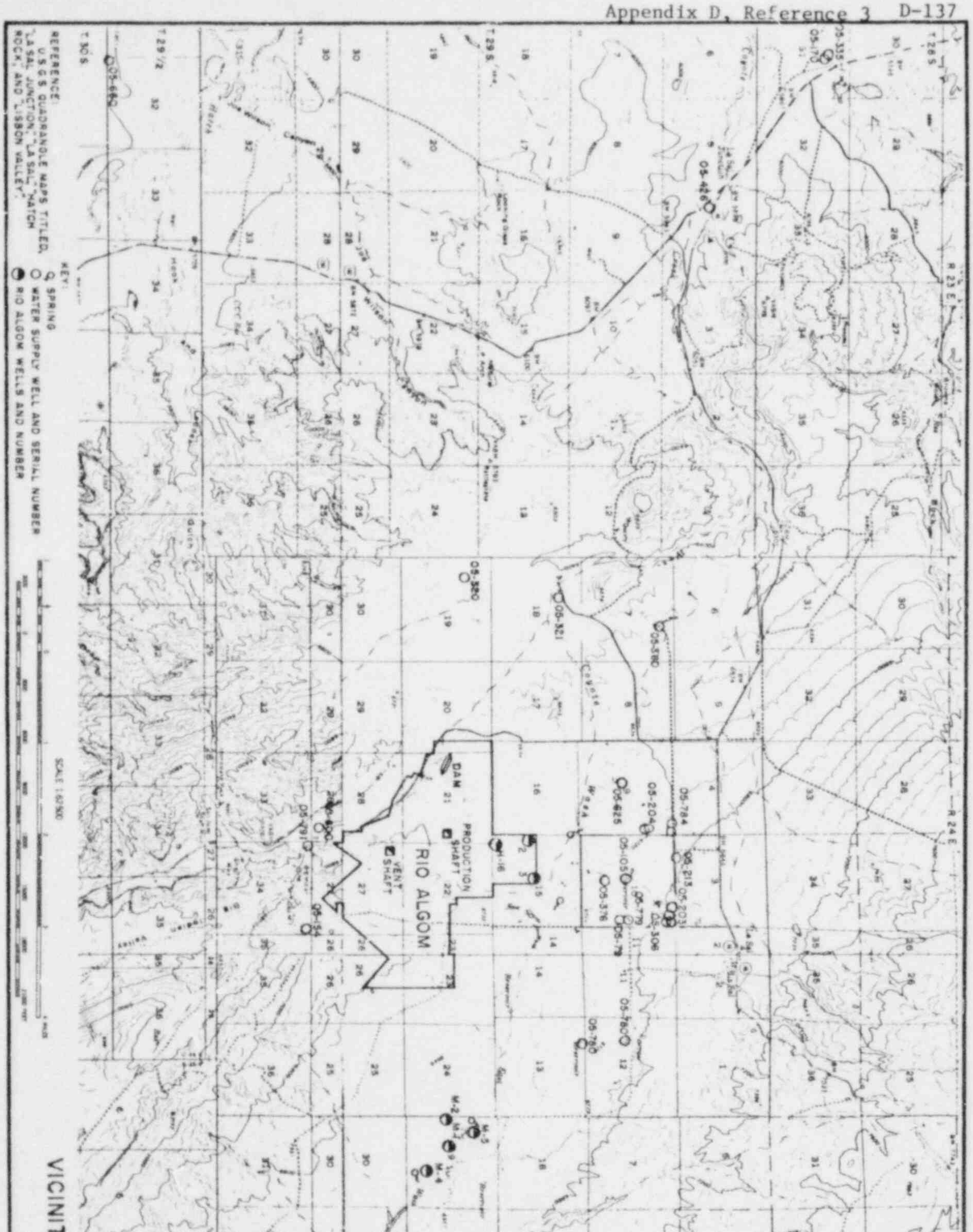

VICINITY MAP
RIO ALGOM
PRODUCTION SHAFT
VENT SHAFT
DAM
T 26 S
T 29 S
T 30 S
R 23 E
R 24 E
R 25 E
KEY:
SPRING
WATER SUPPLY WELL AND SERIAL NUMBER
RIO ALGOM WELLS AND NUMBER
REFERENCE:
U.S.G.S. QUADRANGLE MAPS TITLED,
"LA SAL JUNCTION," "LA SAL," "HATCH
ROCK," AND "LISBON VALLEY".
SCALE 1:62500

PLATE 4

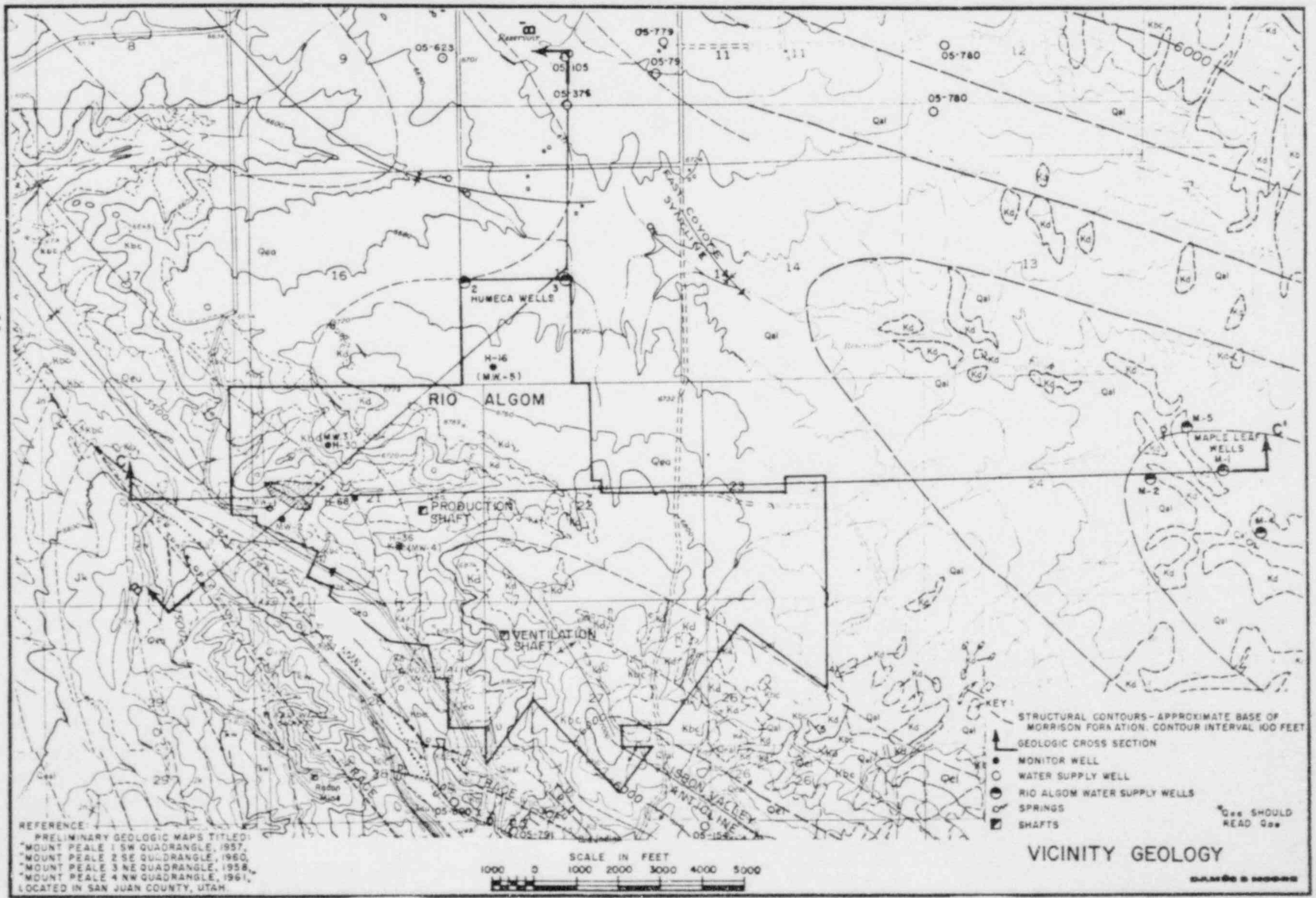
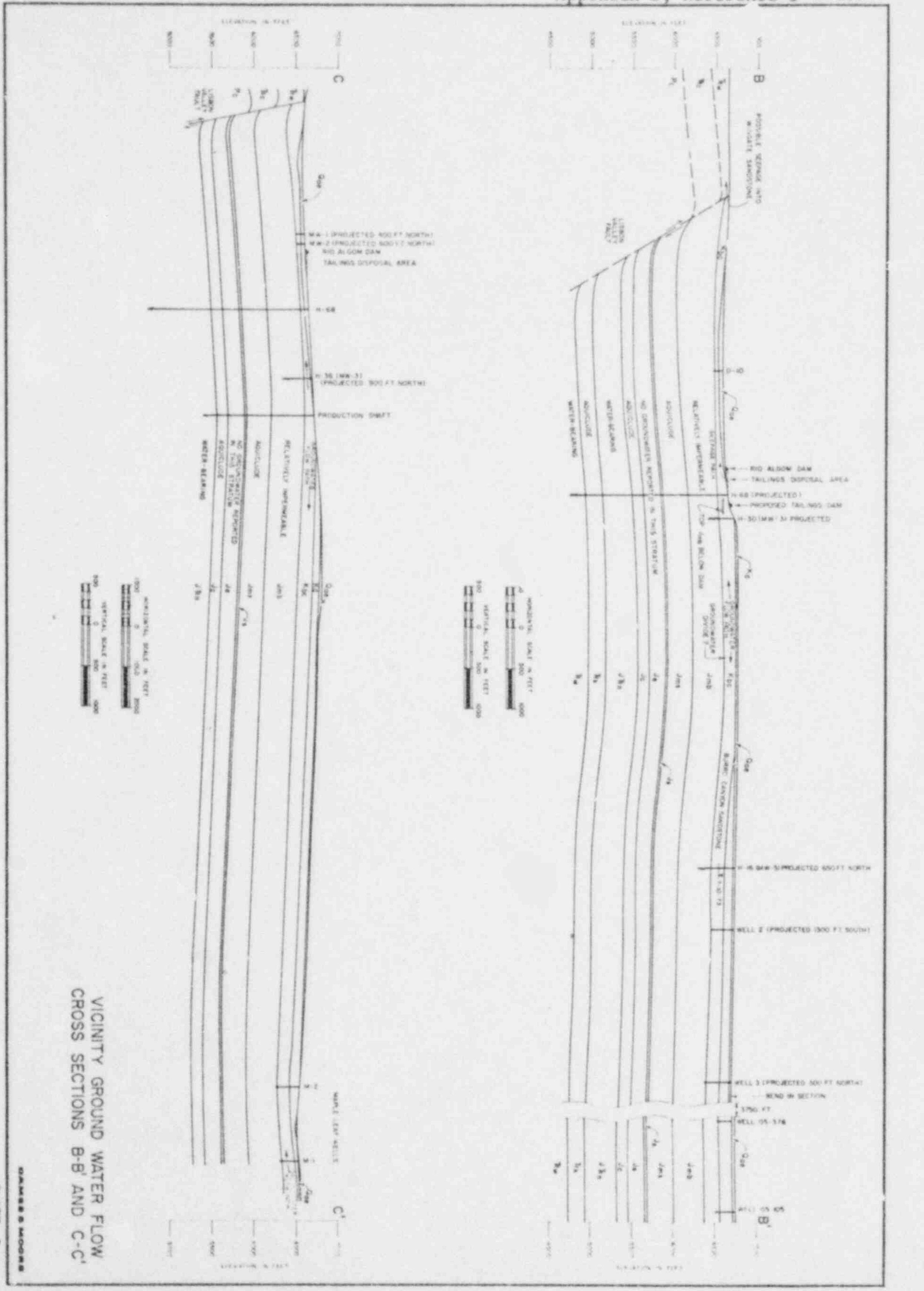
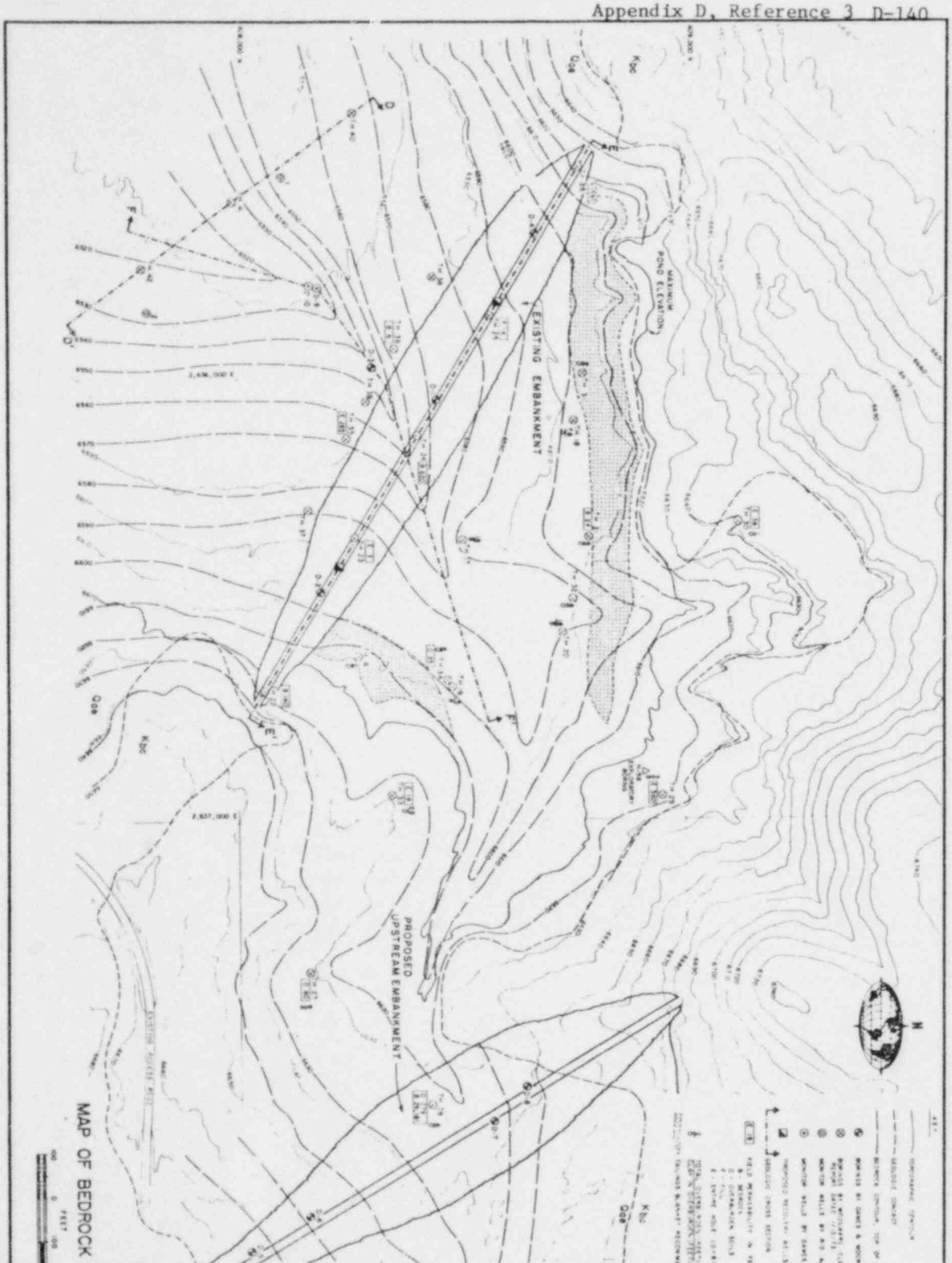

RIO ALGOM
HUMECA WELLS
H-16
(MW-5)
PRODUCTION SHAFT
VENTILATION SHAFT
H-36
(MW-4)
H-68
H-30
MAPLE LEAF WELLS
M-1
M-2
M-5
EAST COYOTE SYNCLINE
LISBON VALLEY ANTICLINE
05-623
05-105
05-376
05-779
05-79
05-780
KEY:
STRUCTURAL CONTOURS-APPROXIMATE BASE OF MORRISON FORMATION. CONTOUR INTERVAL 100 FEET
GEOLOGIC CROSS SECTION
MONITOR WELL
WATER SUPPLY WELL
RIO ALGOM WATER SUPPLY WELLS
SPRINGS
SHAFTS
*Qea SHOULD READ Qeo
REFERENCE:
PRELIMINARY GEOLOGIC MAPS TITLED:
"MOUNT PEALE 1 SW QUADRANGLE, 1957,"
"MOUNT PEALE 2 SE QUADRANGLE, 1960,"
"MOUNT PEALE 3 NE QUADRANGLE, 1958,"
"MOUNT PEALE 4 NW QUADRANGLE, 1961,"
LOCATED IN SAN JUAN COUNTY, UTAH.
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000
VICINITY GEOLOGY

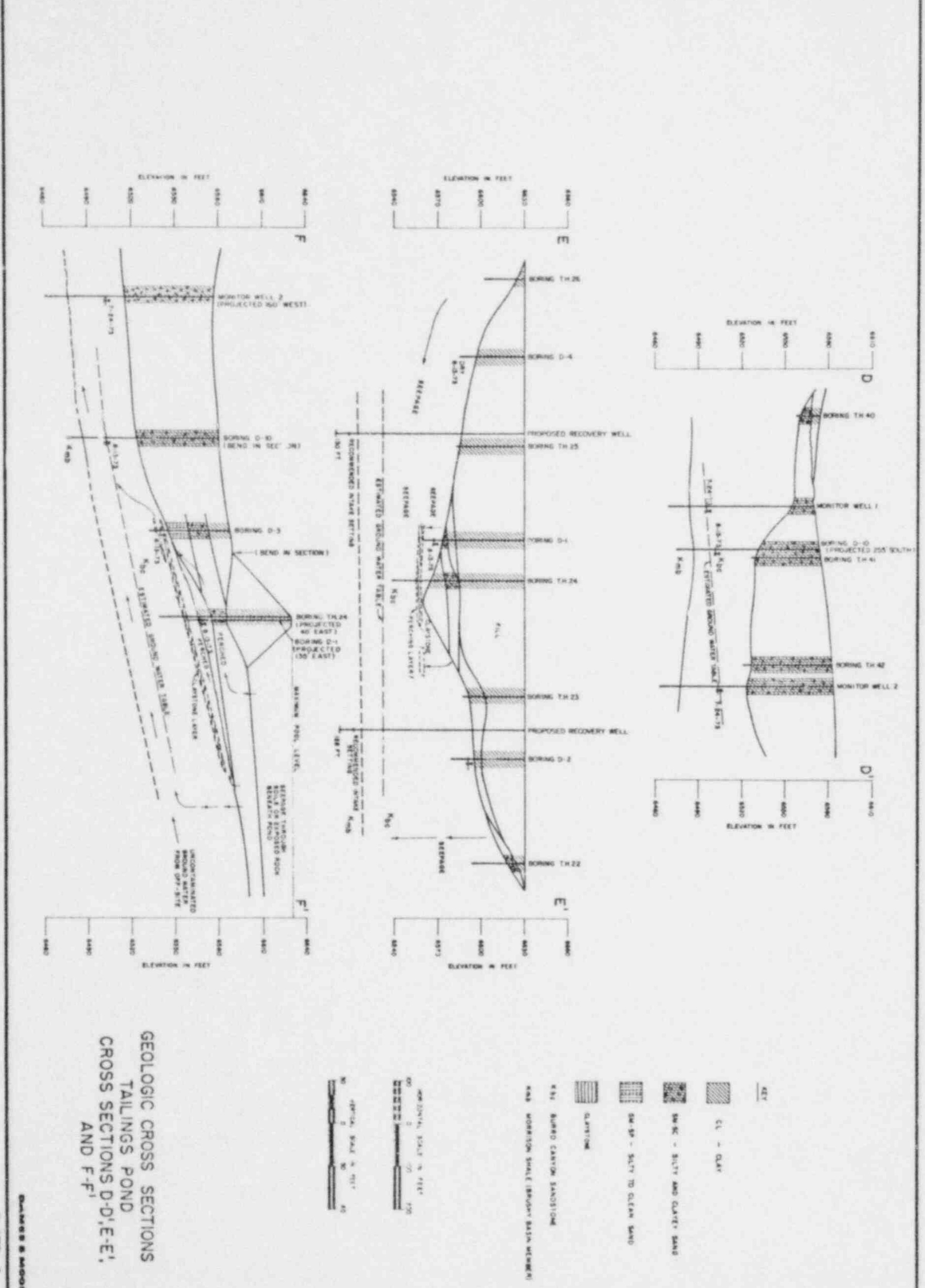
PLATE 5

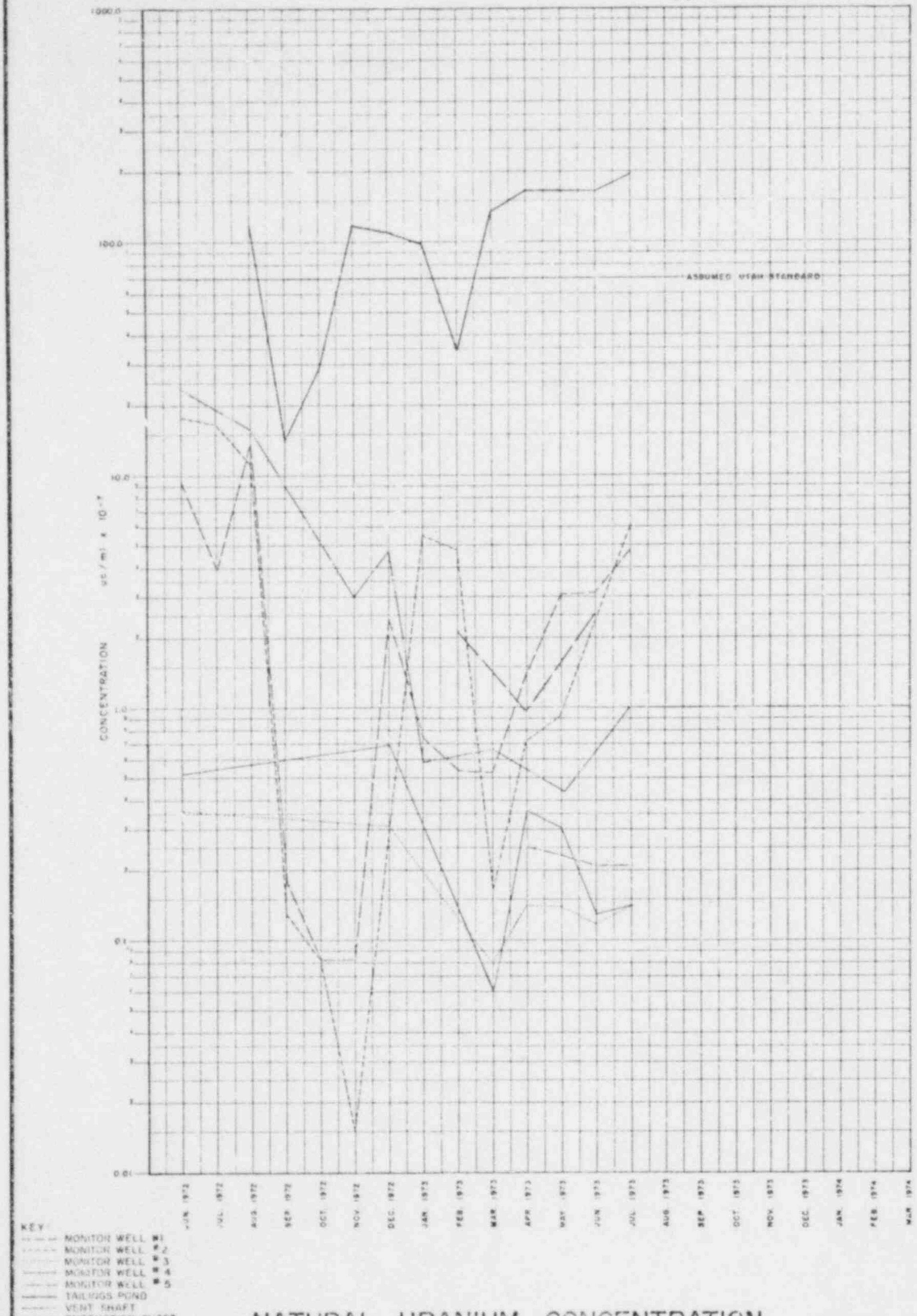

VICINITY GROUND WATER FLOW
CROSS SECTIONS B-B' AND C-C'
DAMES & MOORE
PLATE 6
ELEVATION IN FEET
B
B'
C
C'
POSSIBLE SEEPAGE INTO
WINGATE SANDSTONE
LISBON VALLEY FAULT
RIO ALGOM DAM
TAILINGS DISPOSAL AREA
H-68 (PROJECTED)
PROPOSED TAILINGS DAM
H-30 (MW-3) PROJECTED
D-10
RELATIVELY IMPERMEABLE
AQUICLUDE
NO GROUNDWATER REPORTED IN THIS STRATUM
WATER-BEARING
BURRO CANYON SANDSTONE
WELL 2 (PROJECTED 500 FT SOUTH)
WELL 3 (PROJECTED 500 FT NORTH)
BEND IN SECTION
MW-1 (PROJECTED 400 FT NORTH)
MW-2 (PROJECTED 500 FT NORTH)
H-68
H-30 (MW-3)
(PROJECTED 500 FT NORTH)
PRODUCTION SHAFT
HORIZONTAL SCALE IN FEET
VERTICAL SCALE IN FEET



MAP OF BEDROCK SURFACE

PLATE 7

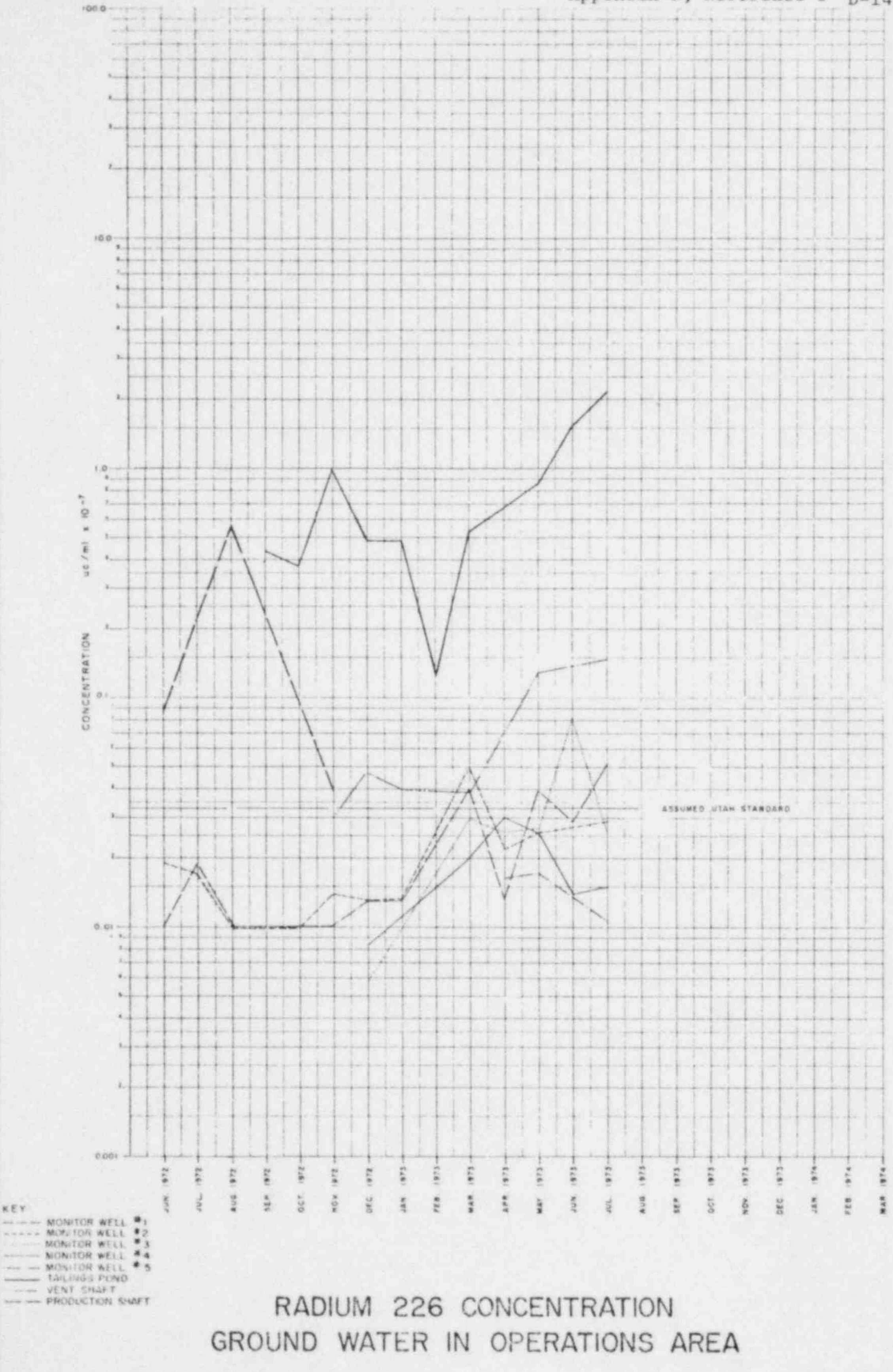

GEOLOGIC CROSS SECTIONS
TAILINGS POND
CROSS SECTIONS D-D', E-E',
AND F-F'
DAMES & MOORE
PLATE 8
KEY
CL - CLAY
SM-SC - SILTY AND CLAYEY SAND
SM-SP - SILTY TO CLEAN SAND
CLAYSTONE
Kbc BURRO CANYON SANDSTONE
Jmb MORRISON SHALE (BRUSHY BASIN MEMBER)
HORIZONTAL SCALE IN FEET
VERTICAL SCALE IN FEET
ELEVATION IN FEET
BORING T.H.40
MONITOR WELL 1
BORING D-10
(PROJECTED 255' SOUTH)
BORING T.H.41
BORING T.H.42
MONITOR WELL 2
ESTIMATED GROUND WATER TABLE
BORING T.H.26
BORING D-4
PROPOSED RECOVERY WELL
BORING T.H.25
BORING D-1
BORING T.H.24
FILL
BORING T.H.23
BORING D-2
BORING T.H.22
SEEPAGE
RECOMMENDED INTAKE SETTING
MONITOR WELL 2
(PROJECTED 150' WEST)
BORING D-10
(BEND IN SECTION)
BORING D-3
(BEND IN SECTION)
BORING T.H.24
(PROJECTED 40' EAST)
BORING D-1
(PROJECTED 30' EAST)
PERCHED
MAXIMUM POOL LEVEL
SEEPAGE THROUGH SOILS OR EXPOSED ROCK BENEATH POND
UNCONTAMINATED GROUND WATER FROM OFF-SITE



NATURAL URANIUM CONCENTRATION
GROUND WATER IN OPERATIONS AREA

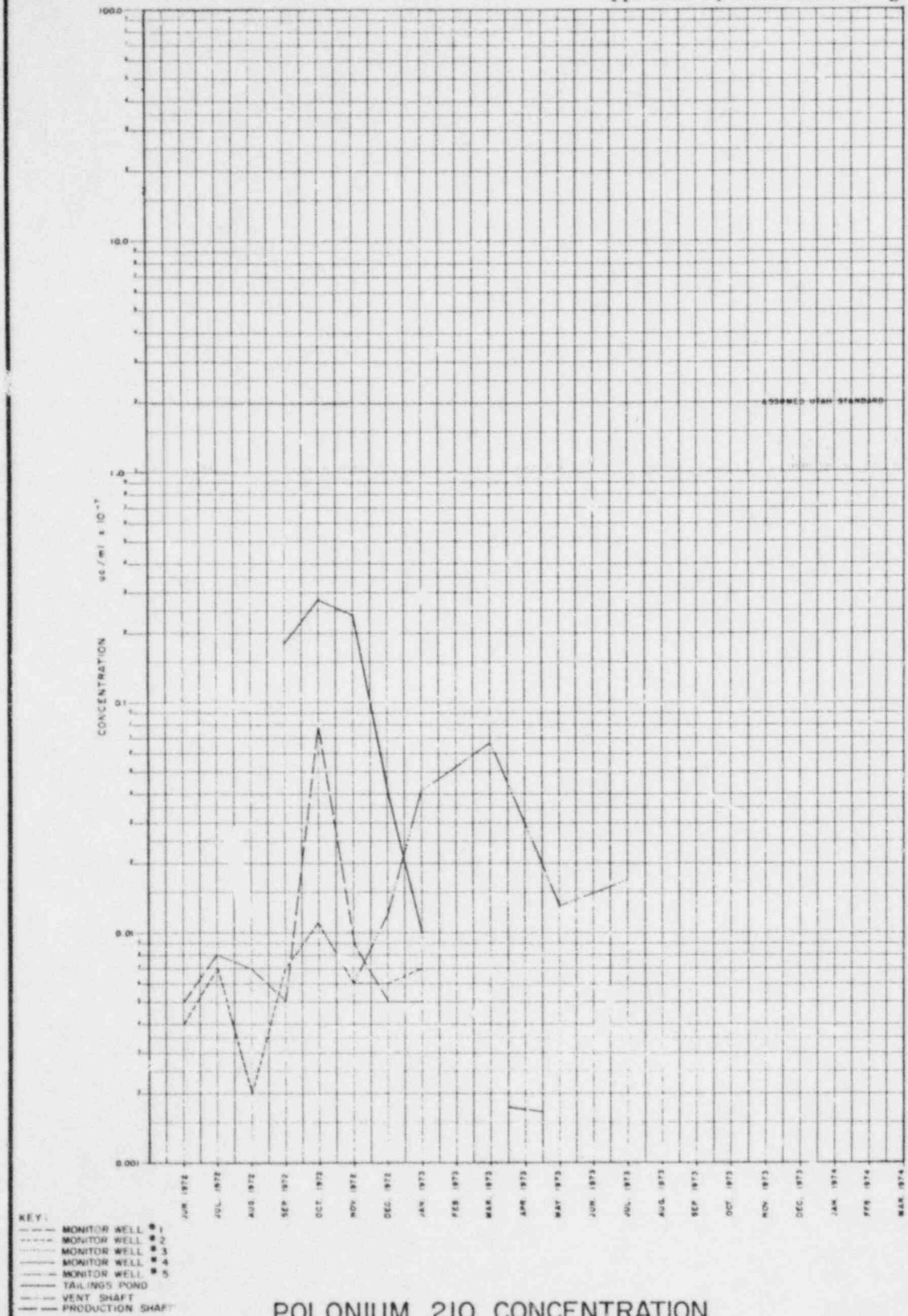
DAMES & MOORE

PLATE 9A



RADIUM 226 CONCENTRATION
GROUND WATER IN OPERATIONS AREA

DAMES & MOORE



POLONIUM 210 CONCENTRATION
GROUND WATER IN OPERATIONS AREA

DAMES & MOORE

PLATE 9C

APPENDIX II-A

PERMEABILITY TESTING

Field tests were conducted in January, 1972 by others to determine the permeability of the soils and bedrock in the vicinity of the tailings pond and along the axis of the starter dam. These tests were made at 14 separate locations by falling head or constant head permeameter techniques in an open, uncased boring or by single packer method. The procedures used are standard methods established by the U. S. Bureau of Reclamation. Under adequately controlled conditions, these tests indicate approximate ranges and orders of magnitude for permeability.

The results of the field testing are presented in Table II-A1. Based on these results, the following average permeabilities were assumed for the natural soil and rock materials:

	Permeability Range (Ft/yr)	Average Permeability (Ft/yr)
Overburden soils and shallow, weathered bedrock	19 to 340	150
Burro Canyon sandstone	0 to 1595	400

A general qualitative guide to degree of permeability, expressed in feet per year, is as follows:

Relatively Impermeable	-	Less than 10 feet per year
Slightly Permeable	-	10 to 100 feet per year
Moderately Permeable	-	100 to 1000 feet per year
Highly Permeable	-	Over 1000 feet per year

TABLE II-A1

FIELD PERMEABILITY TESTS

Boring	Depth (Ft)	Test Type	Material	Permeability (Ft/yr)
22	11.3	1	B	14
	9.3	1	B	33
	7.4	1	B	71
23	43.3	1	E	2.6
	43.3	1	E	3.4
	43.3	1	E	2.4
25	35.3	1	C	1.4
27	11.0	1	D	98
	9.5	1	D	83
	9.9	1	D	58
28	14.0	2	B	380
	14.5	1	B	350
	11.5	1	B	108
29	8.0	2	E	360
30	4.1	1	A	63
	3.0	1	A	66
	3.0	1	A	46

1. Open Hole - Falling Head, Uncased
2. Open Hole - Constant Head, Uncased
3. Packer - Constant Head
   - A. Sandstone
   - B. Sand: dense, clayey or silty
   - C. Clay Fill
   - D. Clay: stiff
   - E. Combined overburden and sandstone

TABLE II-A1 (Cont.)

FIELD PERMEABILITY TESTS

Boring	Depth (Ft)	Test Type	Material	Permeability (Ft/yr)
33	5.7	1	E	11
	5.0	1	E	26
	2.3	1	E	20
34	9.2	1	E	53
	9.4	1	E	16
35	24.0	2	E	420
	24.0	2	E	147
36	49.0	2	D	180
22	16-37	3	A	139
	16-37	3	A	141
24	69-92	3	A	620
26	12-28	3	A	1780
	12-28	3	A	1410
28	18-35	3	A	26.5
	18-35	3	A	181
32	14-34	3	A	24
36	33-49	3	A	6

1. Open Hole - Falling Head, Uncased
2. Open Hole - Constant Head, Uncased
3. Packer - Constant Head
   A. Sandstone
   B. Sand: dense, clayey or silty
   C. Clay Fill
   D. Clay: stiff
   E. Combined overburden and sandstone

APPENDIX II-B

PETROGRAPHIC AND SOLUBILITY ANALYSES

Several soil and rock samples were analyzed petrographically, primarily to ascertain the presence of soluble constituents such as gypsum or calcite. Removal of soluble minerals by the tailings pond effluent, which frequent[illegible] a pH exceeding 10, would increase the permeability of the soil or rock so affected and would promote seepage loss.

The results of petrographic analysis are as follows:

Boring D-1; Sample depth 54.5 feet; Soil-SM

Percent moisture: 15 (as percentage of oven-dried weight)

Percent clay size fraction: 7

Composition of clay size fraction: quartz, 4 percent; kaolin, 2 percent; illite, 1 percent

Overall description: A soil. Coarse fraction consists of euhedral quartz crystals less than 0.5 mm in size, in a matrix of silt and clay. The matrix is predominantly quartz.

Boring D-2; Sample depth 29.5 feet; Soil-SM

Percent moisture: 10

Percent clay size fraction: 11

Composition of clay size fraction: quartz, 5 percent; calcite, 4 percent; kaolin, 1 percent; other, 1 percent

Overall description: Mostly quartz cemented by calcite. The quartz is euhedral to subhedral, with one half percent quartz rounded.

Boring D-3; Sample depth 39.5 feet; Soil-SP

Percent moisture: 9

Percent clay size fraction: 12

Composition of clay size fraction: quartz, 8 percent; calcite, 2 percent; kaolin, 2 percent

Overall description: Poorly sorted with pebbles up to one-inch (left out in moisture determination). Euhedral quartz and rounded calcite fragments occur in the silt and clay fraction.

Boring D-3; Sample depth 47.0 feet; Rock core-sandy mudstone

Percent moisture: 3

Percent clay size fraction: 16

Composition of clay size fraction: kaolin, 12 percent; halloysite, 4 percent

Overall description: Rounded quartz and calcite grains in a matrix of silt and clay. Occasional gypsum grains. Friable, breaks in the hand.

Boring D-4; Sample depth 34.0 feet; Rock core-sandstone

Percent moisture: 2

Percent clay size fraction: Less than one percent

Composition of clay size fraction:

Major: An unidentified mineral with a strong 3.3 Å line - very possibly an iron mica - glauconite, celedonite, or biotite and quarts.

Minor: Kaolin. Trace of montmorillonite.

Overall description: Many of the quartz grains are sharp and doubly terminated. A few are rounded. Cement is calcite. Visual estimate of porosity is 20 percent. The clay sized fraction occurs as inclusions up to 1/4-inch across.

In addition to the foregoing petrographic studies, the samples were evaluated for solubility in distilled water at 88° C, in water of pH = 9 and in weak acid solution. In each case, the sample was agitated in the solution and allowed to stand for 24 hours before determining the percentage of dissolved solids. The results are on the following page.

IV-B-3

Sample No.	Solubility Neutral Water	Solubility pH 9.0 (%)	Solubility Acid (%)
D-1, 54.5 feet	Nil	1.0	2.0
D-2, 29.5 feet	Nil	0.9	0.9
D-3, 39.5 feet	Nil	Nil	5.7
D-3, 47.0 feet	Nil	Nil	3.1
D-4, 34.0 feet	Nil	0.2	.0.7

APPENDIX E

1. Subsoil Investigation and Consultation on Foundation for Proposed Headframe, Preliminary Subsoil Investigations and Consultation on Foundations Proposed Uranium Processing Plant Site and Tailings Dam, Rio Algom Uranium Plant South of La Salle, San Juan County, Utah, by Woodward-Clyde and Associates, Consulting Soil Engineers and Geologists; February 28, 1969.

WOODWARD-CLYDE & ASSOCIATES
CONSULTING SOIL ENGINEERS AND GEOLOGISTS
2[illegible]00 WEST SEVENTH AVENUE
DENVER, COLORADO 80204
TELEPHONE 222 943[illegible]

SUBSOIL INVESTIGATION AND CONSULTATION ON FOUNDATIONS FOR PROPOSED HEADFRAME, PRELIMINARY SUBSOIL INVESTIGATIONS AND CONSULTATION ON FOUNDATIONS PROPOSED URANIUM PROCESSING PLANT SITE & TAILING DAM RIO ALGOM URANIUM PLANT SOUTH OF LA SALLE, SAN JUAN COUNTY, UTAH

Prepared for

Stearns-Roger Corporation
Attn: Mr. Gordon Swanby
P. O. Box 5888
Denver, Colorado

Job No. 11809

February 28, 1969

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PLANT SITE	3
Proposed Construction	3
Subsoils	3
Structure Foundations	4
Excavation Difficulties and Slopes	4
TAILING DAM	5
Proposed Construction	5
Subsoils	5
Foundation	5
Borrow	6
Underseepage	6
LIMITATIONS	6

FIGURE 1 - LOCATION OF TEST HOLES, PROPOSED TAILING DAM AND PLANT SITE

FIGURE 2 - LOCATION OF TEST HOLES, PROPOSED PLANT SITE

FIGURE 3 - SUMMARY LOGS OF TEST HOLES, PROPOSED PLANT SITE

FIGURE 4 - SUMMARY LOGS OF TEST HOLES, PROPOSED TAILING DAM

FIGURE 5 - CORE LOG

FIGURES 6 & 7 - SWELL-CONSOLIDATION TEST RESULTS

FIGURES 8, 9 & 10 - GRADATION ANALYSIS

TABLE I - SUMMARY OF LABORATORY TEST RESULTS

SCOPE

This report presents results of a subsoil investigation and consultation on foundations for the proposed headframe, as well as preliminary subsoil investigations and consultation on the foundations for the proposed uranium processing plant site and tailing dam for the Rio Algom Uranium Plant, three miles south of La Salle, San Juan County, Utah. The study was made to assist in determination of the best types and depths of foundations for the headframe and to enable us to provide our opinions concerning the suitability of the proposed plant and tailing dam sites for the proposed construction from the soils, engineering geologic and foundation viewpoint. Factual data gathered during the field and laboratory work are summarized on Figures 1 through 10 and Table I attached. Our opinions, based on the results of our investigation and our experience in the area, are summarized below.

SUMMARY OF CONCLUSIONS

(1) We believe the main shaft headframe should be founded with spread footings on the hard sandstone bedrock, found at depth 6' feet.

(2) In our opinion, the proposed plant site will be suitable, from a soils and foundation standpoint, for construction of the proposed mill building and related structures.

(3) The natural soils and bedrock at the tailing dam site will, in our opinion, provide adequate support for a properly designed tailing starter dam and tailing dam of the proposed heights.

(4) We believe sufficient borrow soils are available in the reservoir area for construction of the proposed tailing starter dam.

(5) A cutoff trench should be constructed beneath the tailing starter dam to minimize underseepage losses beneath the dam and blanketing of the sandstone bedrock on the right abutment may be necessary.

SITE CONDITIONS

The proposed plant site sloped down gently to the north toward a small intermittent drainage 200± feet away. The g und in the vicinity of the headframe had been graded level to accommodate a large drilling rig. Vegetation consisted of grass, sage and a few pine trees in the vicinity of the headframe and plant site. About 6 inches of snow covered the ground at the time of our investigations. There were no bedrock outcrops on the plant site, but sandstone was exposed on the hill located approximately 300 feet north of the plant site.

As currently planned, the proposed tailing dam will be constructed across an intermittent stream, approximately 1/2 mile west of the proposed plant site. The abutments of the tailing dam site were heavily forested with pine and cedar trees. Sandstone bedrock was exposed on the right abutment.

HEADFRAME

Proposed Construction

The headframe for the main shaft will, as currently planned, be 28 x 40 feet in plan dimension, of steel frame construction and 130 feet high. We understand that the total dead load will be of the order of 1,400 kips, with a dead plus live load of the order of 1,500 kips, and that there will be no uplift loads. The structure will be supported by columns.

Foundations

Our test holes indicate that man-made fill and loose to medium dense, silty sands are underlain by hard sandstone bedrock at depth 6± feet. No free water was found in our test holes, but we understand that free water level beneath the site was found at depth 150± feet in the test hole at the center of the shaft.

The sandstone core from the hole drilled by others at the center of the shaft and stored on the site was examined and logged by our field engineer. No attempt was made to obtain core in the upper 40 feet of the hole. Our log of the core is shown on Figure 5. Examination of sandstone exposures in the area, as well as data obtained in drilling our test holes here and in the proposed plant area, indicates that the upper portion of the sandstone is hard and moderately fractured.

The headframe should, in our opinion, be founded with spread footings on the hard sandstone bedrock, found at depth 6± feet. The footings should be designed for a maximum soil pressure of 15,000 psf.

PLANT SITE

Proposed Construction

As currently planned, structures at the plant site will include a two story high mill building, housing crushers, mills, tanks and other equipment; 6, 90± foot diameter thickener tanks; conveyors; and one sotry high, office, warehouse, shaft house and gate house buildings. Steel frame buildings are contemplated, with slab-on-grade floors.

Subsoils

Our test holes indicate that loose to medium dense sands and very stiff to hard, sandy clays overlie hard sandstone bedrock at depth 4.0 to 15.0 feet. No free water was found. The clays will swell slightly and the sands will settle slightly upon wetting.

Structure Foundations

There are two subsurface strata having engineering properties of significance in founding structures at this site: (a) the overburden soils; and (b) the sandstone bedrock. We believe final investigations will confirm that the near-surface sands will support spread footings designed for pressures of the order of 2,000 to 4,000 psf and that the clays will support footings designed for maximum soil pressures of 3,500 to 7,000 psf, depending upon the final siting and grade established for the structures.

Site grading may make the use of controlled, compacted fill beneath foundations desirable. In our opinion, a controlled, compacted fill, constructed of the overburden soils, would support footings designed for pressures of 4,000 to 6,000 psf.

Excavation Difficulties and Slopes

Excavation of the overburden soils in the plant area can, in our opinion, be accomplished with conventional construction equipment, but the shallow, weathered and fractured surface (1 to 4 feet) of the bedrock will require ripping. We believe both overburden soils and the shallow, weathered bedrock will stand on temporary construction slopes of 1:1.

We believe blasting will be necessary in the deeper, hard sandstone bedrock and that it will stand on temporary, near-vertical slopes. We suggest permanent slopes of 1-1/2:1 in the natural soils and 1:1 in the sandstone.

TAILING DAM

Proposed Construction

As currently planned, the proposed tailing dam will be located approximately 1/2 mile west of the plant site, across a small drainage. Ultimate crest length will be 2000± feet, with a maximum height of 75± feet, crest elevation 6670. A compacted earth tailing starter dam, 20± feet high, with a crest length of 750 feet, and constructed of local materials is planned for initial storage. After completion of initial storage, the disposal area will be raised in increments by depositing tailing at the top of small dikes, resting on previously placed tailing materials. We understand that it is desirable to minimize seepage losses.

Subsoils

Our test holes indicate that subsoils beneath the proposed tailing dam consist of loose to medium dense, silty sands and stiff to very stiff, sandy clays over hard sandstone bedrock at depth 2.0 to 18.0 feet. No free water was encountered. Sandstone bedrock is exposed on the right abutment and is mantled by a thin layer of soil on the left abutment. No free water was found.

Foundation

We believe the foundation soils and the sandstone will provide adequate support for a tailing starter dam of the proposed height with slopes of about 2-1/2:1 (horizontal to vertical), and the ultimate tailing dam with an outer slope of the order of 3:1.

Borrow

In our opinion, there is ample, suitable borrow soil within the tailing pond area to construct the proposed starter dam.

Underseepage

The natural soils in the reservoir area possess sufficient fines (-#200) to be relatively impervious. However, in view of the desire to minimize underseepage losses, we believe a cutoff trench of compacted earth will be appropriate beneath the tailing starter dam extending into the clay soils, and for the abutments, 5 feet into the sandstone bedrock. Final investigations may indicate the desirability of blanketing the sandstone outcrop on the right abutment for some distance upstream of the starter dam with compacted, impervious fill.

LIMITATIONS

Test holes for the headframe were closely spaced to give a reasonably accurate subsoil picture, and widely spaced in the plant site and tailing dam areas, typical of preliminary investigations. Variations in subsoils not indicated by the borings are always possible, particularly with widely spaced preliminary borings. We recommend that the excavations for the headframe be inspected by a competent soil specialist to assure that subsurface conditions are as indicated by the test holes. Final investigations should be performed in the plant and tailing dam areas prior to design to enable confirmation of our preliminary opinions and determination of design criteria. We will be happy to accomplish these inspections and investigations for you, if desired.

Field investigations and analyses for this report have been made under the supervision of Mr. Bradley E. Vote, who also prepared the draft of this report. Information on the structures was provided by Mr. Gordon Swanby of the Stearns-Roger Corporation. This report has been reviewed and approved by the undersigned principal of this firm.

It has been a pleasure to partici ate with you on this project. If we may be of further service in discussing the contents of this report, in analysis of structural features from the soil and foundation viewpoint, or in accomplishing final investigations in the plant and tailing dam areas, please call on us.

By S. T. Thorfinnson

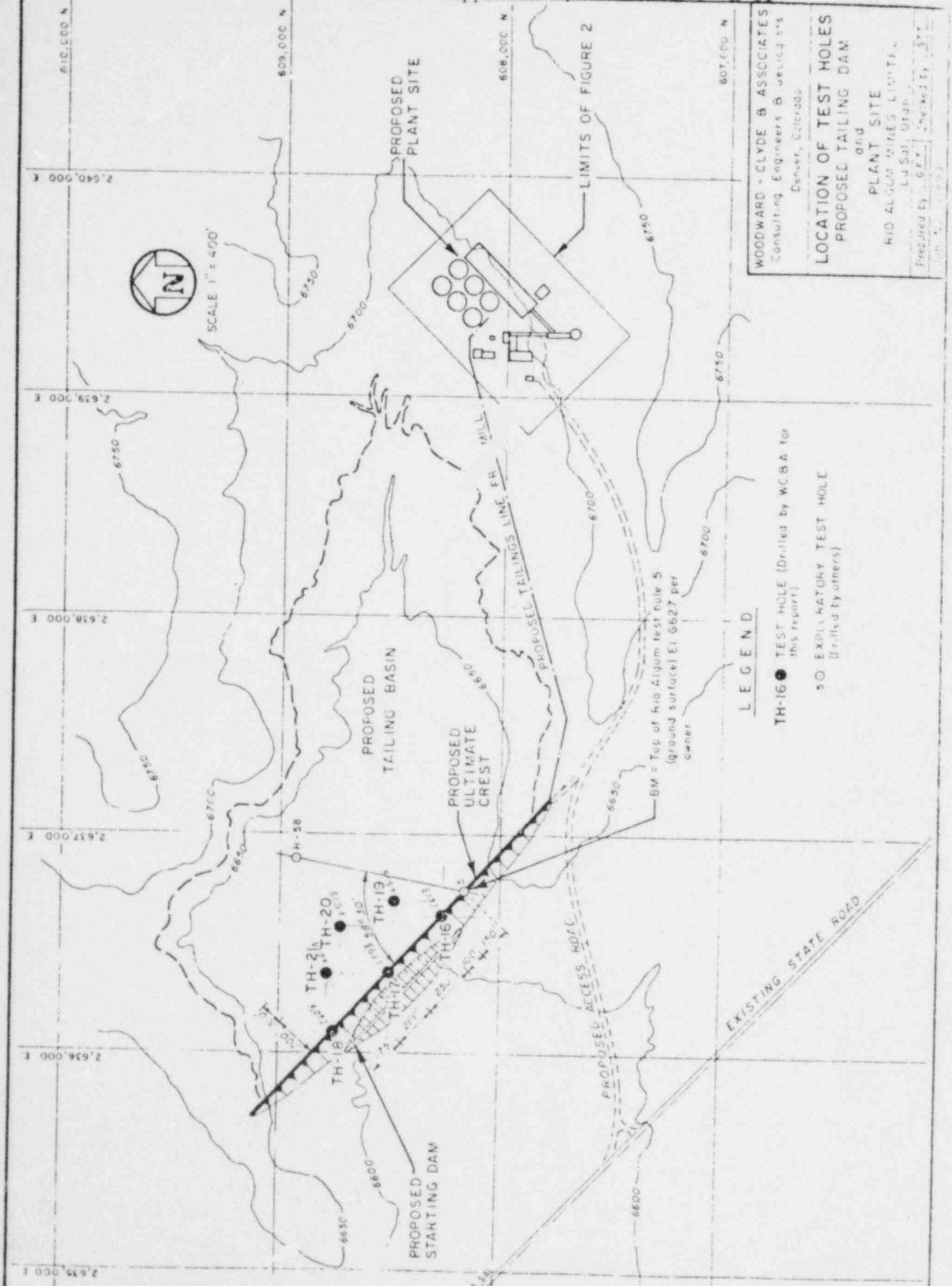
S. T. Thorfinnson
Senior Vice President

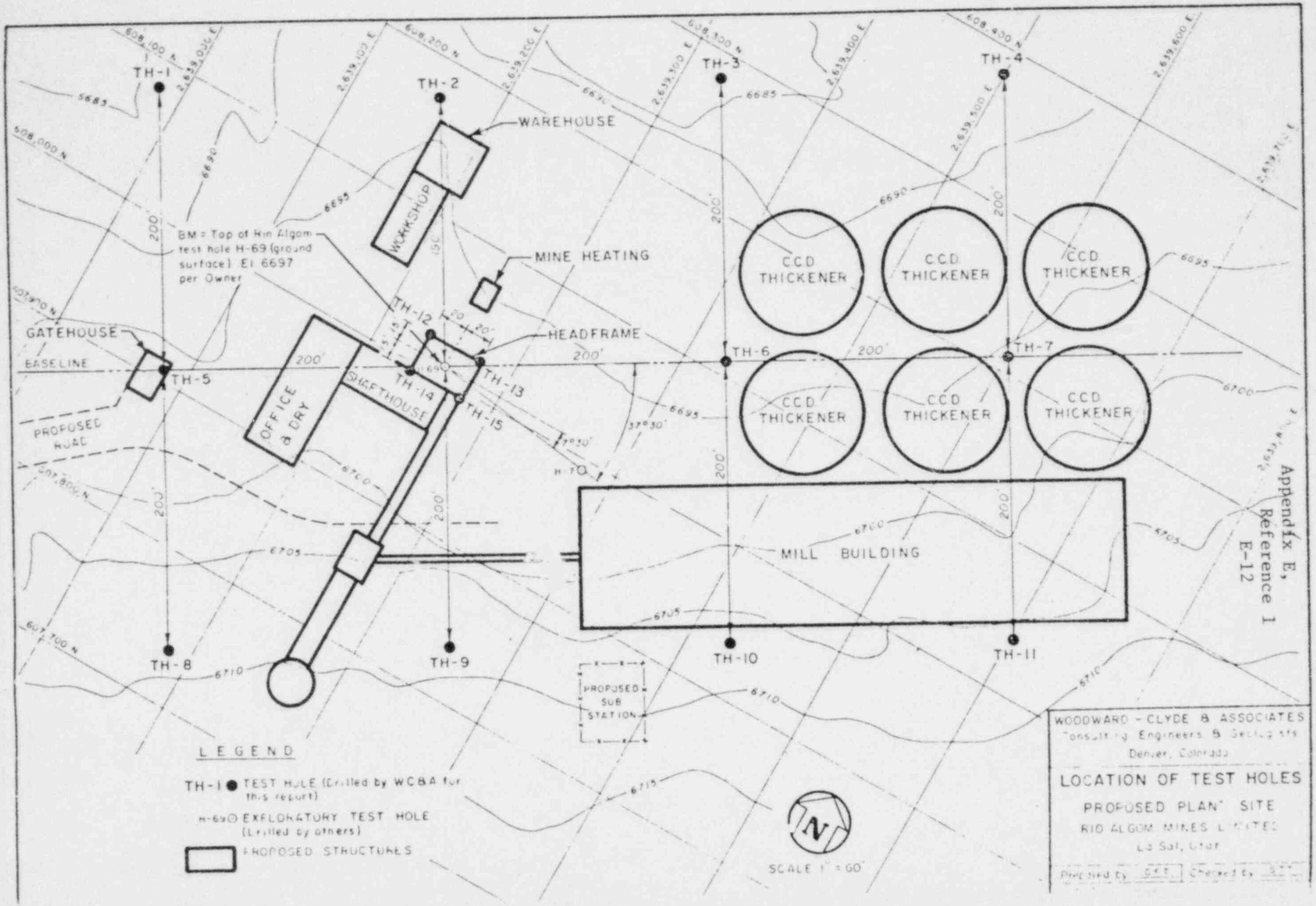
S(3 copies sent)

CC: Mr. Sven Ronlov

CC: Mr. James D. Guiry, Project Engineer
Rio Algom Mines, Ltd.
120 Adelaide Street West
Toronto 1, Ontario,
Canada

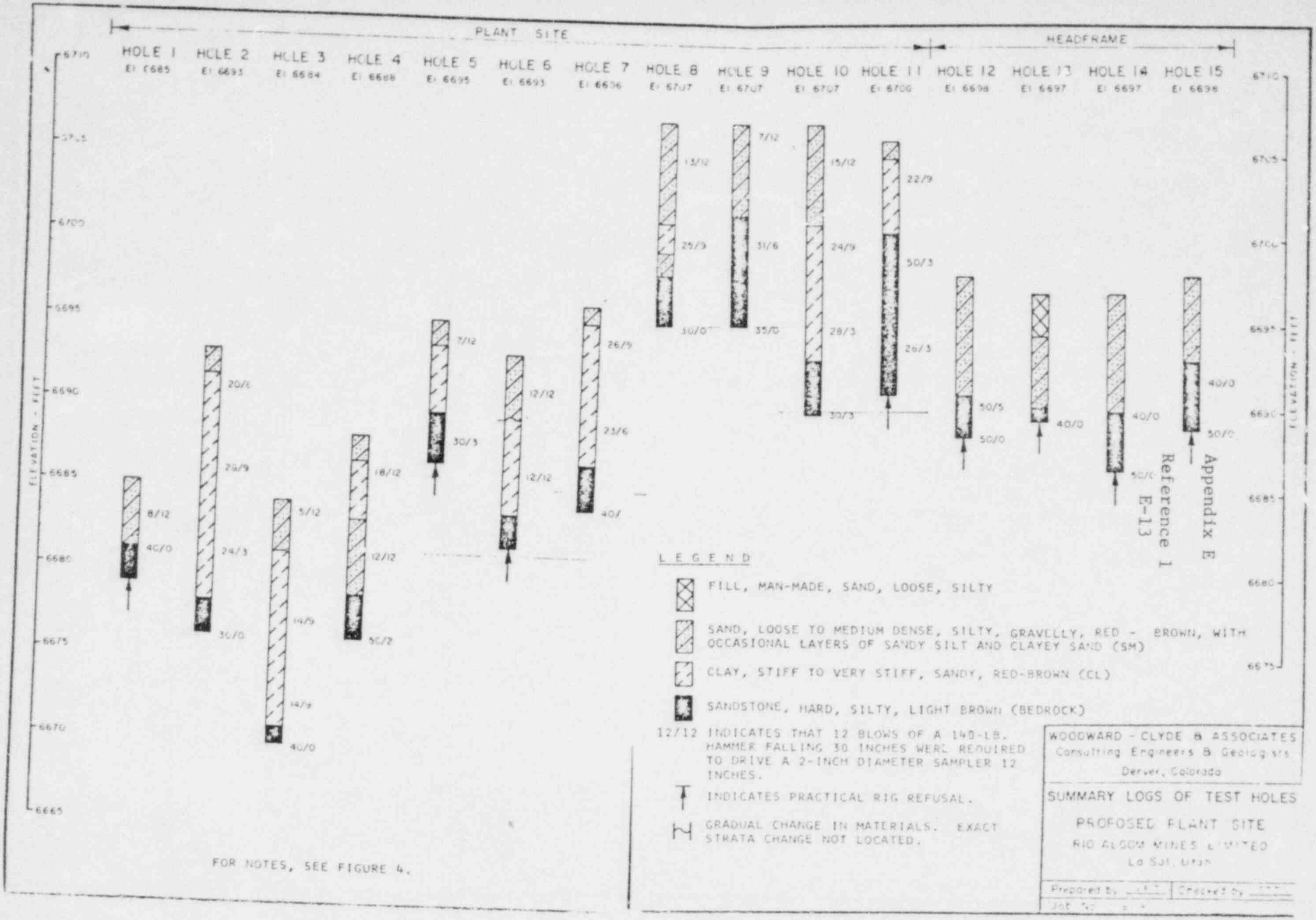
STANLEY T. THORFINNSON
REGISTERED
4285
PROFESSIONAL ENGINEER
STATE OF COLORADO


WOODWARD - CLYDE & ASSOCIATES
Consulting Engineers & Geologists
Denver, Colorado
LOCATION OF TEST HOLES
PROPOSED TAILING DAM
and
PLANT SITE
RIO ALGOM MINES LIMITED
PROPOSED PLANT SITE
LIMITS OF FIGURE 2
SCALE 1" = 400'
N
PROPOSED TAILING BASIN
PROPOSED ULTIMATE CREST
PROPOSED STARTING DAM
PROPOSED TAILINGS LINE FR. MILL
PROPOSED ACCESS ROAD
EXISTING STATE ROAD
TO LA SAL
LEGEND
TH-16 TEST HOLE (Drilled by W.C.B.A. for this report)
5 EXPLORATORY TEST HOLE (Drilled by others)
BM = Top of Rio Algom test hole 5 (ground surface) El 6627 per owner
TH-13
TH-16
TH-17
TH-18
TH-20
TH-21
H-58
610,000 N
609,000 N
608,000 N
607,000 N
2,635,000 E
2,636,000 E
2,637,000 E
2,638,000 E
2,639,000 E
2,640,000 E
6600
6650
6700
6750

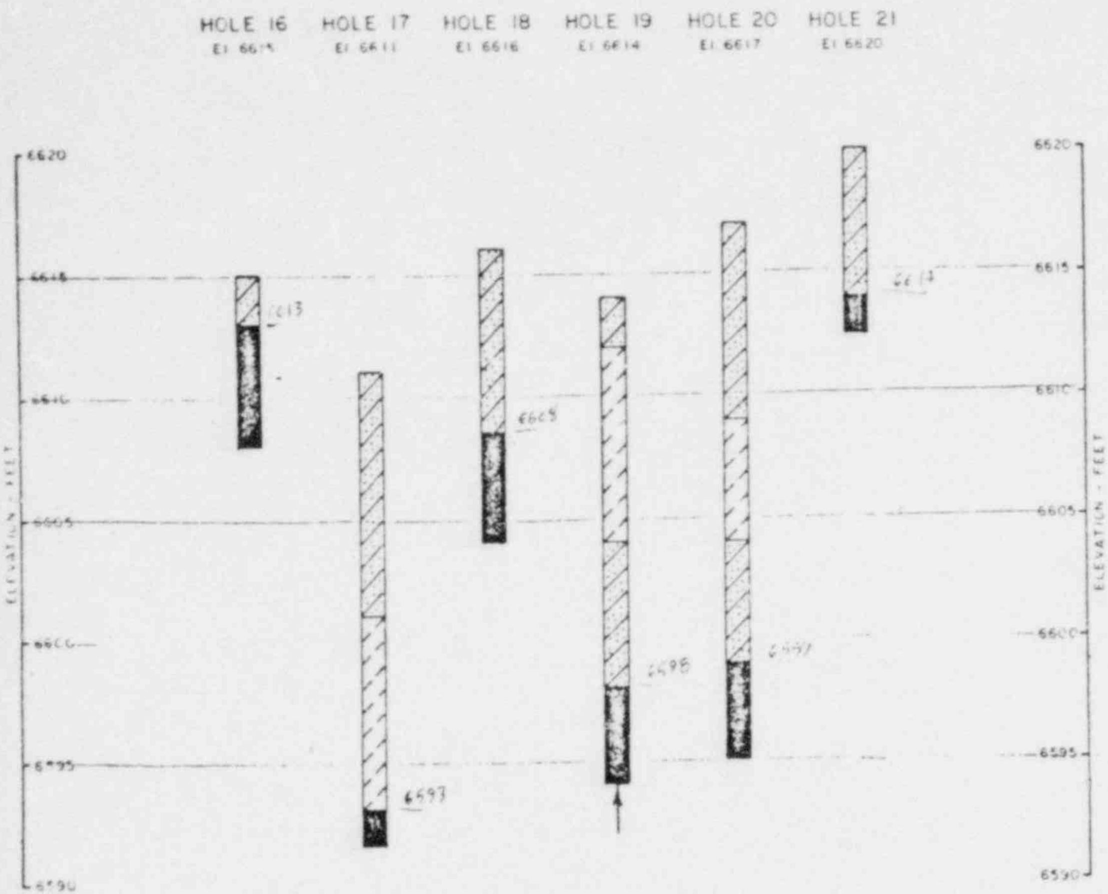


Appendix E, Reference 1

E-12



Appendix E
Reference 1
E-13



LEGEND

- SAND, LOOSE TO MEDIUM DENSE, SILTY, GRAVELLY, RED-BROWN, WITH OCCASIONAL LAYERS OF SANDY SILT AND CLAYEY SAND (SM)
- CLAY, STIFF TO VERY STIFF, SANDY, RED-BROWN, BROWN (CL)
- SANDSTONE, HARD, SILTY, LIGHT BROWN (BEDROCK)
- INDICATES PRACTICAL RIG REFUSAL.

NOTES:

1. TEST HOLES WERE DRILLED ON FEBRUARY 19, 1969 WITH A 4-INCH DIAMETER HELICAL POWER AUGER.
2. ELEVATIONS ARE APPROXIMATE AND REFER TO BENCHMARKS ON FIGURES 1 AND 2. B.M. ON FIGURE 1 WAS USED FOR HOLE 16 THROUGH 21 AND B.M. ON FIGURE 2 WAS USED FOR HOLES 1 THROUGH 15.
3. NO FREE WATER WAS FOUND IN TEST HOLES AT TIME OF DRILLING.
4. DRILL LOGS IN THIS REPORT ARE SUBJECT TO LIMITATIONS, EXPLANATIONS AND CONCLUSIONS OF THIS REPORT.

WOODWARD - CLYDE & ASSOCIATES
Consulting Engineers & Geologists
Denver, Colorado

SUMMARY LOGS OF TEST HOLES

PROPOSED TAILING DAM
RIO ALGOM MINES LIMITED
La Sal, Utah

Prepared: | Checked By:

WOODWARD - CLYDE & ASSOCIATES
CORE LOG

Project No. 11809
Project Name Rio Algom Uranium Plant
enter of Main Shaft
Drilled by Others

H-69

X

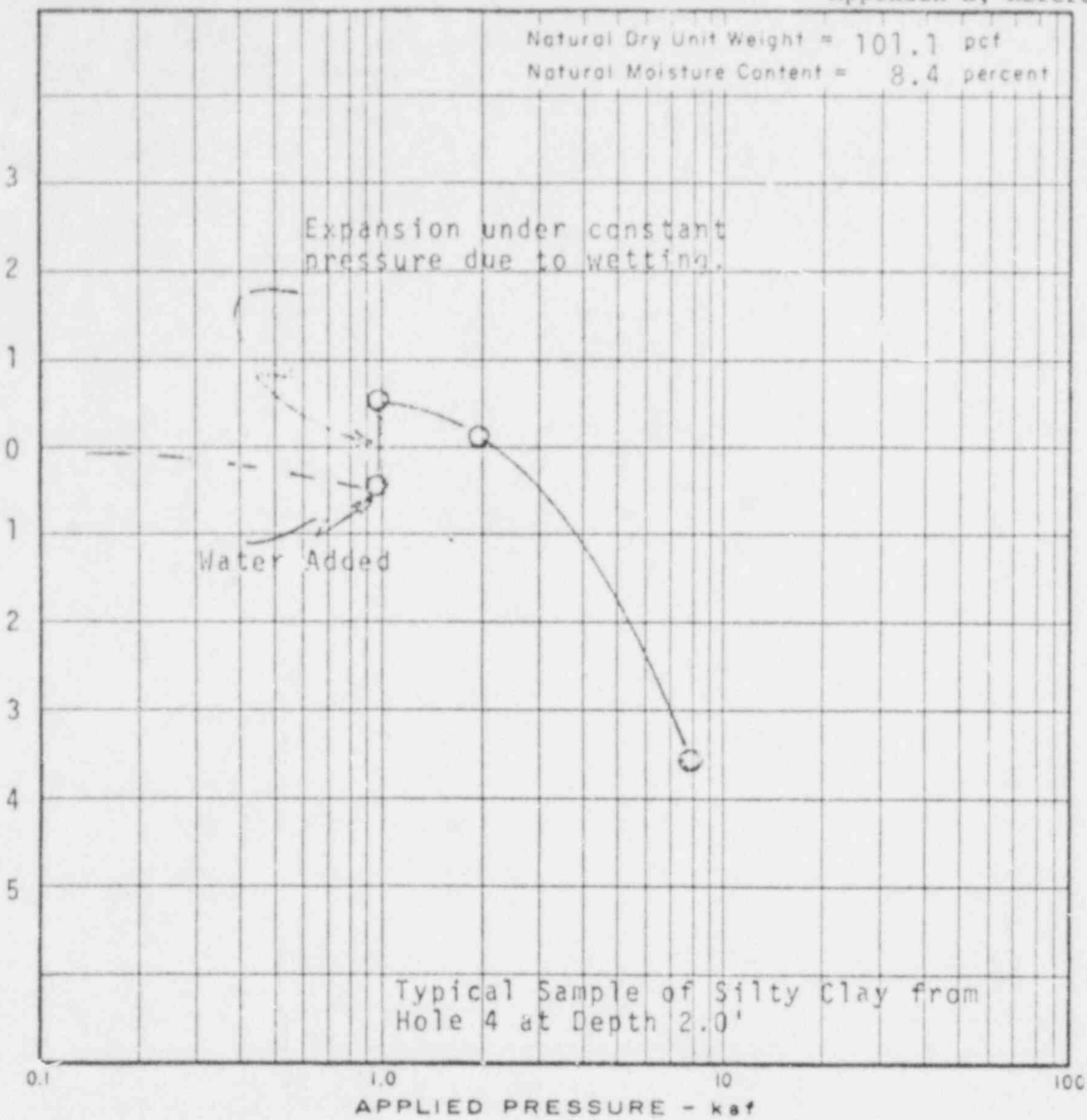
Depth	Description	Remarks
50	SANDSTONE, very hard, fairly horizontally bedded, Dakota formation, yellow-brown sandstone, fine and medium grained, friable at times, fractures widely spaced (est. 5± feet)	Hole drilled with rock bit to depth 30 feet below ground. Cored with 60 foot core barrel. Set surface pipe to 40 feet and commence coring-no core first 10 feet. *RQD 51 to 57=85% Thin 2" mudseam at 51.4 Vertical Joint 51-51.7 Vertical Joint 60-60.7 RQD 57.0-60.7=40% RQD 64.0-78.5=83% Diagonal fracture 75.5-76.5 Friable 64-64.8 and 71.5-72.0 78.5-82.2 is slightly friable Lost core 82.2 to 107 (got 4 ft. of core)-friable sandstone this interval.
60		
70		
80		
90		
100		
110		
120		
130		
140		
150		

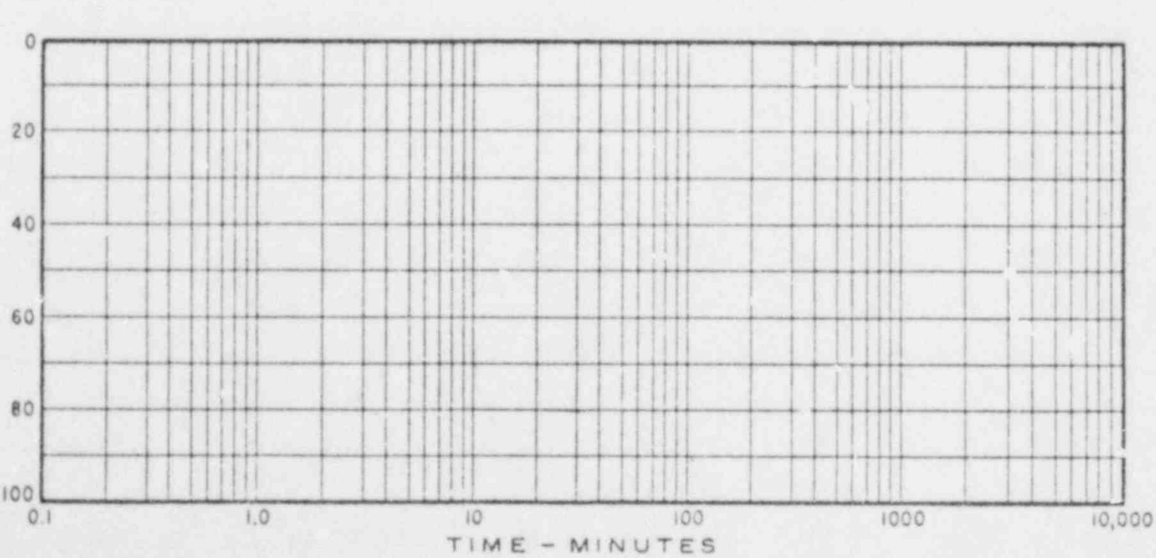
*RQD refers to the Rock Quality Designation, a classification system for very hard rock, which is correlatable to seismic response. The percentage shown indicates the percent of core fragments in excess of 4" long for the stated core run. 0-25% is very poor; 25-50% is poor; 50-75% is fair; 75-90% is good; and 90-100% is excellent.

Logged by our field engineer, Mr. Bradley E. Vote, from examination of the core in boxes stored in shack on the site.

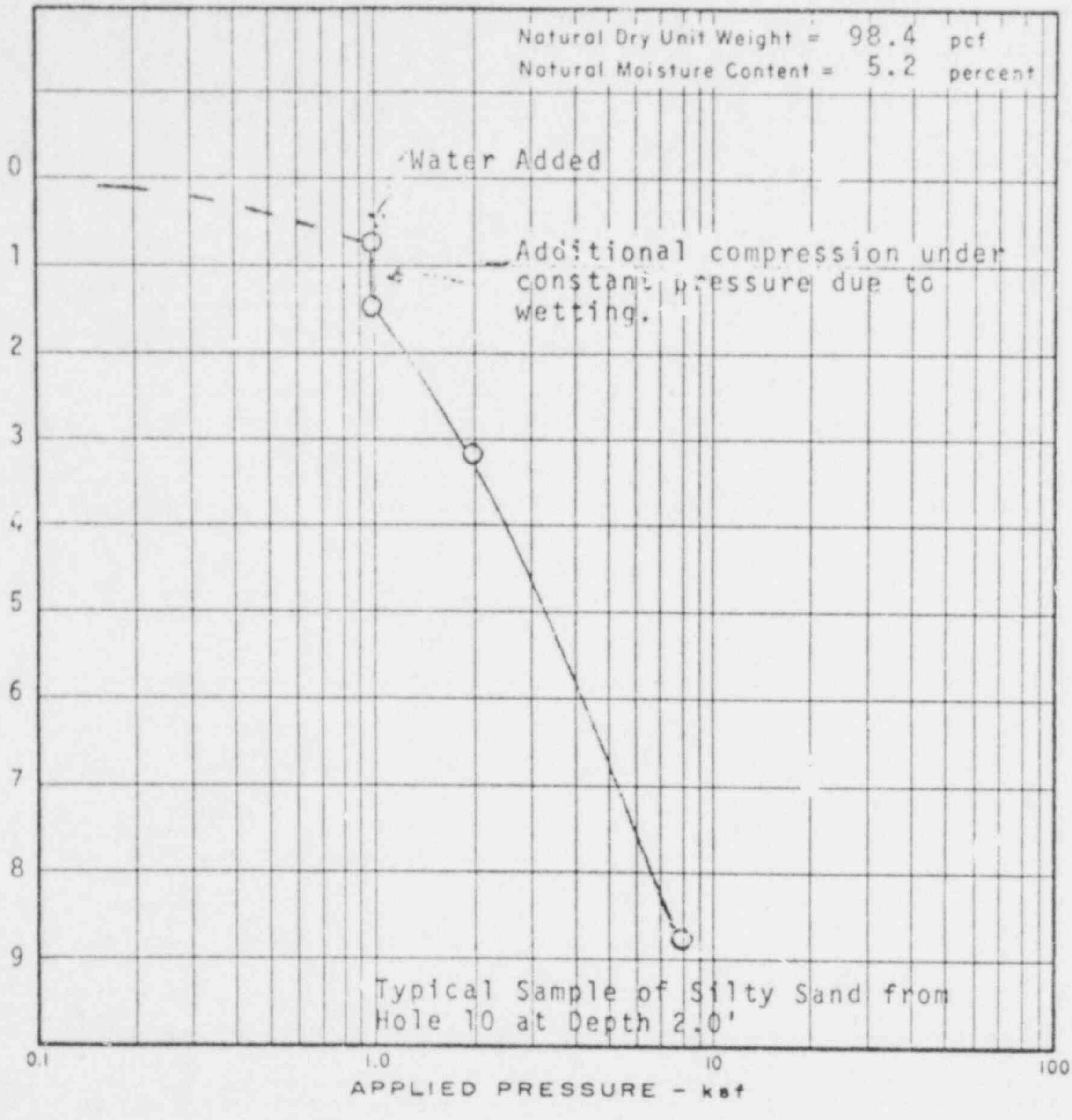
Note: All depths refer to Kelley bushing, which is 10 feet above ground level.

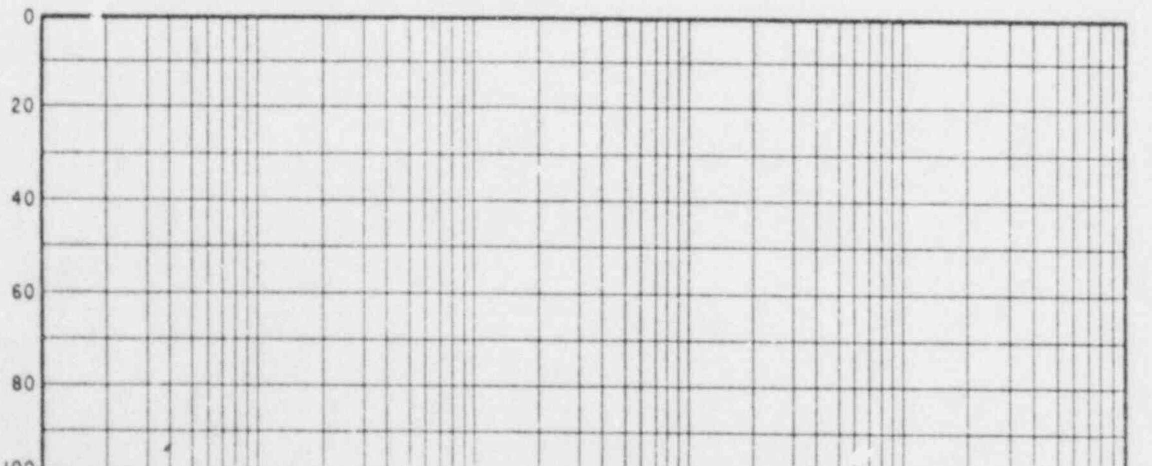
FIGURE 5





SWELL-CONSOLIDATION TEST RESULTS

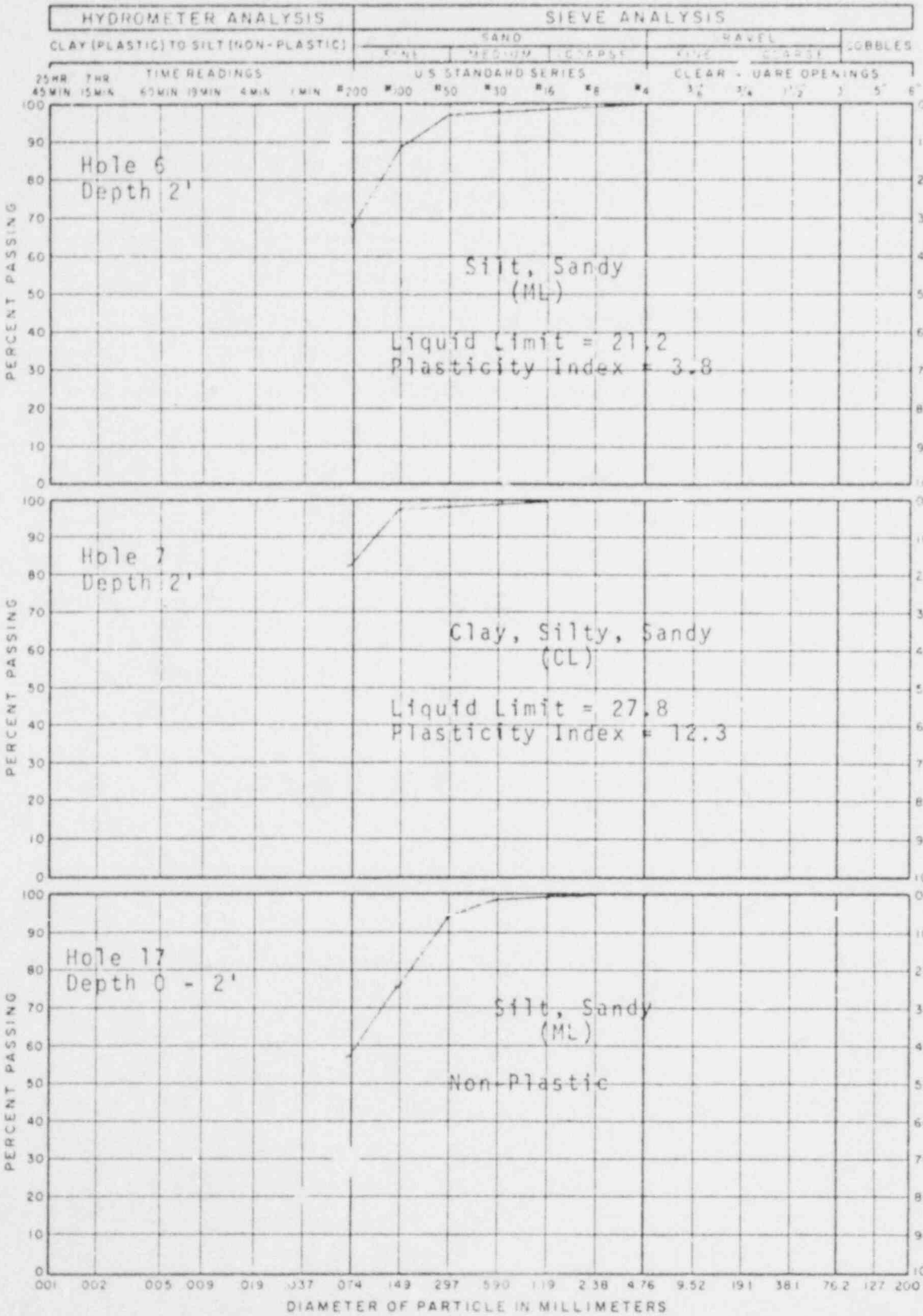




SWELL-CONSOLIDATION TEST RESULTS

WOODWARD - CLYDE & ASSOCIATES

GRADATION ANALYSIS



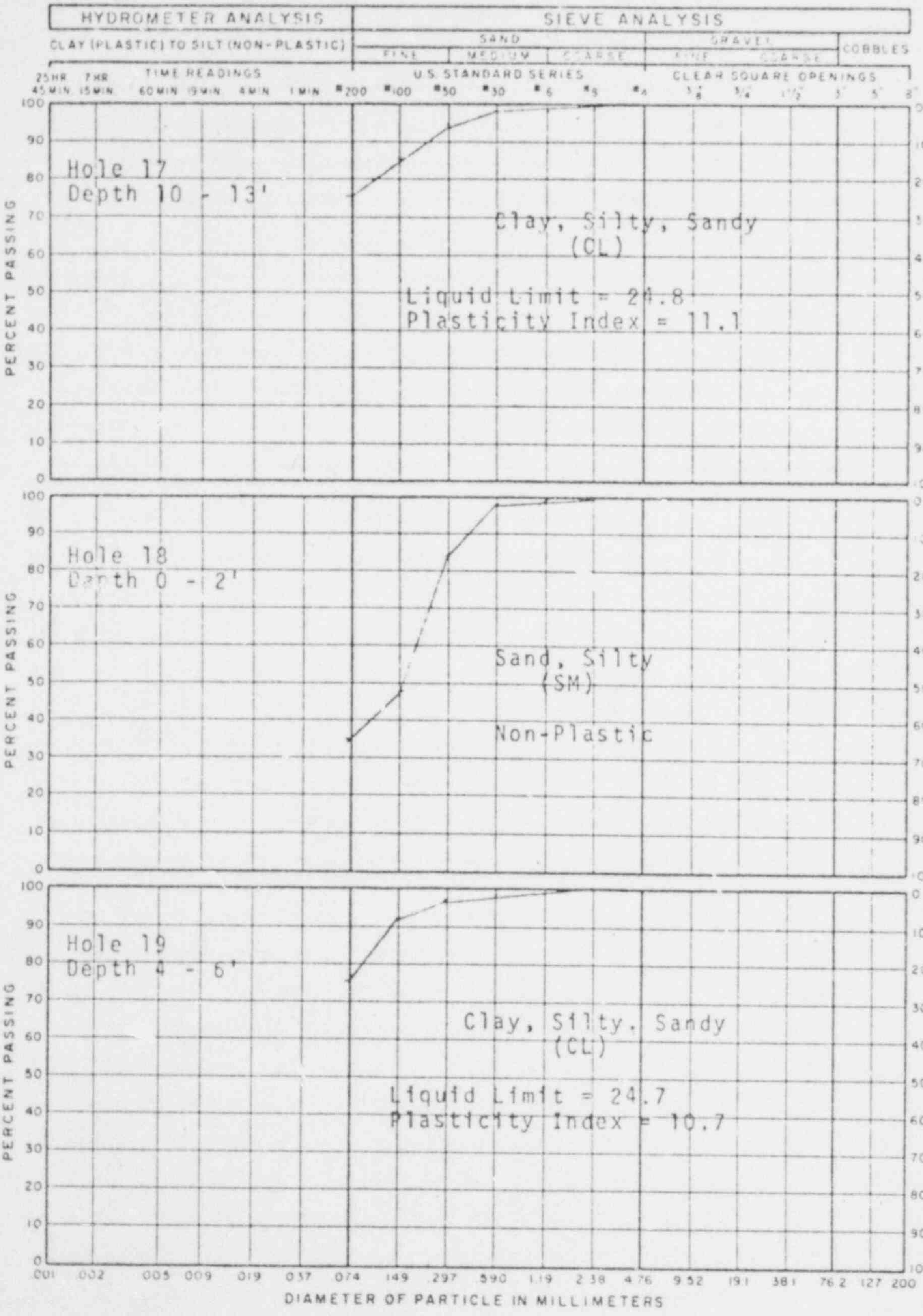
Job No. 11809

FIG. 8

WOODWARD - CLYDE & ASSOCIATES

Appendix E, Reference 1
E-19

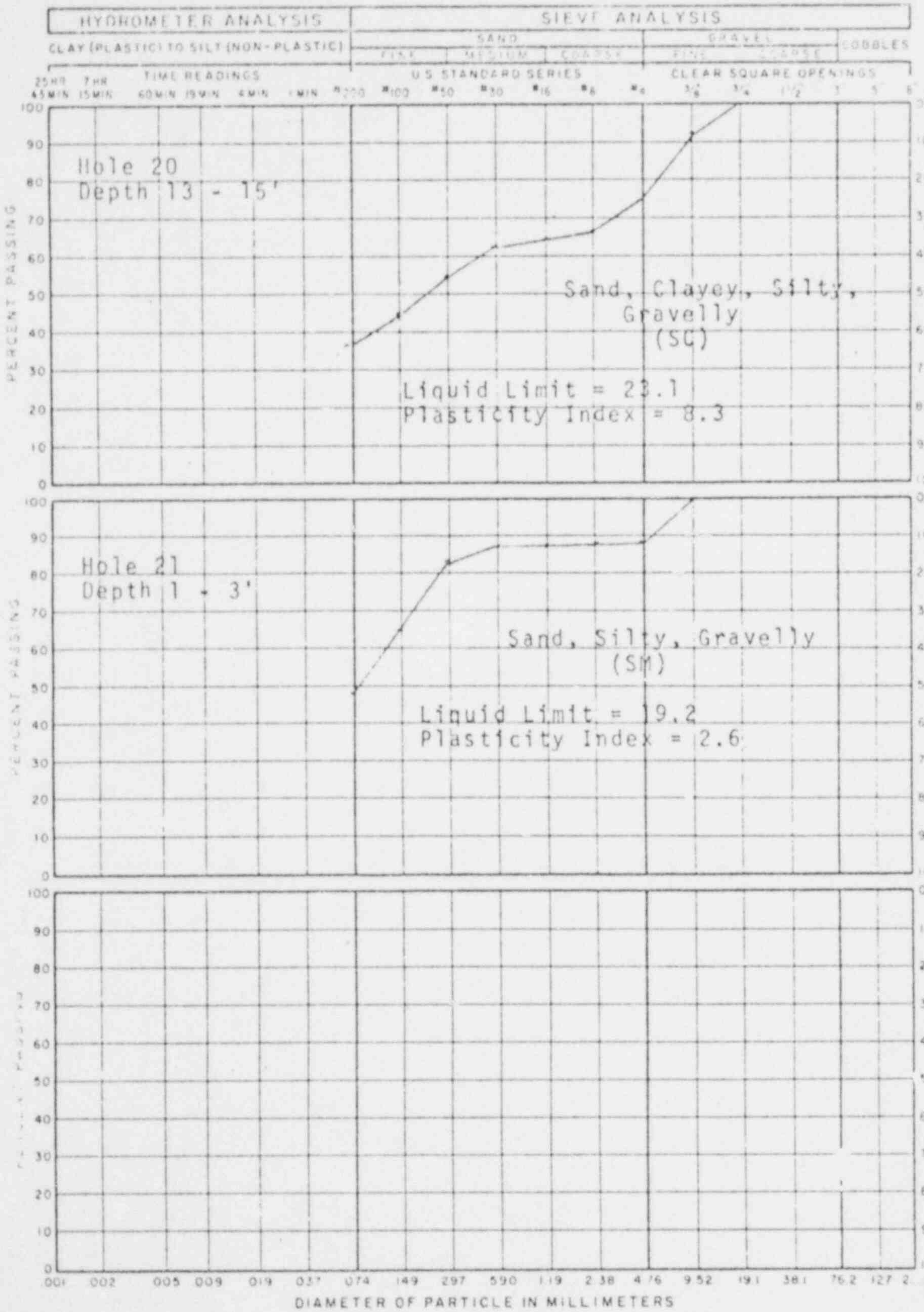
GRADATION ANALYSIS



Job No. 11809

FIG. 9

GRADATION ANALYSIS



ob No. 11809

FIG. 10

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	TRIAXIAL SHEAR TESTS		PERCENT WATER SOLUBLE SULFATE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
2	2.0	8.2	105.1			5400				SILT, slightly clayey, sandy, porous, reddish-brown
3	7.0	6.7	111.0			20600			<.001	CLAY, very silty, reddish-brown
4	2.0	8.4	101.1							CLAY, very silty, slightly porous, reddish-brown
6	2.0	5.3		21.2	3.8					SILT, sandy, roots, reddish-brown
7	2.0	4.5		27.8	12.3					CLAY, sandy, silty, porous, reddish-brown
10	2.0	5.2	98.4							SAND, silty, slightly clayey, porous, roots, reddish-brown
12	7.5	5.3							.009	SAND, silty, tan

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	TRIAXIAL SHEAR TESTS		PERCENT WATER SOLUBLE SULFATE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
17	0-2.0	12.6		Non-Plastic						SILT, very sandy, reddish-brown
17	10-13.0	11.7		24.8	11.1					CLAY, sandy, silty, reddish-brown
18	0-2.0	8.7		Non-Plastic						SAND, silty, reddish-brown
19	4-6.0	6.2		24.7	10.7					CLAY, sandy, silty, reddish-brown
20	13-15.0	5.3		23.1	8.3					SAND, clayey, silty, gravelly, brown
21	1-3.0	11.4		19.2	2.6					SAND, very silty, gravelly, reddish-brown

APPENDIX F

1. A Brief Inventory of the Wildlife Resources In the Coyote Wash Area, by the Bureau of Land Management, March 25, 1971.

Informational Report:

A BRIEF INVENTORY OF THE WILDLIFE RESOURCES IN THE COYOTE WASH AREA

Submitted to: Rio Algom Corporation as per request of Edward Jacobson, Mine Superintendent

Prepared by: Joshua L. Warburton, Wildlife Management Biologist, Monticello District, Bureau of Land Management

Date Submitted: March 25, 1971

A BRIEF INVENTORY OF THE W DLIFE RESOURCES IN THE COYOTE WAS AREA

Introduction: During the past few years considerable attention has been directed to the area south of the La Sal Mountain by the Bureau of Land Management. During this period an extensive inventory and analysis of the natural resources has been conducted, and in some instances long range objectives have been recommended. By no means has the inventory effort been complete, for this is a dynamic environment and natural resource values are constantly changing. No effort has been made in this report to discuss the array of problems facing the BLM in managing these resources; however, several specifics may be cited at various times.

I have included material on the current status of the wildlife resources as well as potentials that have been identified. By no means should material discussed in this brief analysis be construed as bureau commitments, or pertaining to decisions which have been finalized by this office.

Current Situation: There are several wildlife values of noted importance in the Coyote Wash area. Among them are a resident population of mule deer, sagegrouse, some waterfowl and waterbird production, a warmwater fisheries in the Rattlesnake area, morning dove nesting areas, a small pheasant population, a generally distributed cottontail population, and seasonal habitat for coyote, bobcats, fox, an occasional cougar, a variety of song birds, falcons, hawks, and a significant number of bald and golden eagles near the La Sal area. Each major species will be briefly discussed as well as the opportunities for management and development. These should be viewed only as potentials.

Mule Deer: The Coyote area lies between two major herd units of Utah. These units are La Sal 30, to the north; and Blue Mountain, 31-A, to the south. During exceptionally severe winters portions of the winter ranges of these herds merge near the Lisbon area, but generally deer activity is restricted to a resident population of several hundred head which spend the entire year in the Lisbon, Big Indian area. There has been only slight pressure applied to this herd during the regular hunting season, but the habitat appears to be adequate in supporting the existing population. No recommendations have been made to expand the herd at this time, but increased human demands may require agencies involved to enhance this resource.

Sagegrouse: Historically the sagegrouse population of San Juan County numbered in the thousands with activity from the La Sal Mountain to Blanding. Today populations are restricted to East Coyote, and the plateau east of Monticello. These populations have not been assessed, but it is expected that the county currently supports no more than 2000 birds. The sage-grouse is a diminishing species throughout the United States, and is of national concern.

A remnant population still inhabits the East Coyote/La Sal area, but the population probably does not exceed 300 birds. The limiting factors appear to be summer range which consists of moist grassland meadows with free water. This species is also tied directly with big sagebrush (Artemesia tridentata) during the fall, winter and spring seasons, and as this type decreases so will follow the sagegrouse. However, the abundance of sage-brush in the Coyote Wash and adjacent areas is more than adequate in providing for the existing population of grouse, but meadow types are restricted to private lands around La Sal and upper Coyote Wash. The life requirements of this habitat specific species could be discussed at great length, but suffice it to say that the success of the species lies in the abundance of moist meadows and big sagebrush vegetation types.

The Coyote Wash area, particularly East Coyote, offers considerable opportunities to enhance the sagegrouse population of the area. Earlier in history this area offered fairly extensive meadow bottoms throughout the drainages adjacent to sagebrush knolls and valleys, making it ideal habitat for sagegrouse. Today the sagebrush parks are available, but as previously mentioned, meadows are diminishing. Gullying, due to over-grazing, has cut through what was once essential meadows, and consequently lowered the water table to the point which has eliminated meadowland species. Some water is currently available in East and West Coyote which could be used to produce essential summer habitat for sagegrouse. However, the majority of the water is used for irrigation of private lands, and what surplus that is available fluctuates and is not reliable. Studies are being conducted to determine the feasibility of impounding surplus waters during available periods and applying them during the critical spring and summer seasons. As of yet no recommendations have been made on a program to enhance this diminishing species.

Waterfowl and waterbirds: Another resource which is losing essiential habitat annually is waterfowl and associated species. Wet lands are critical for the required production in sustaining this resource. Although southeastern Utah is considered a semi-arid region, a few areas produce birds during most years. East Coyote and the Rattlesnake ponds offer suitable habitat for nesting waterfowl; however, these areas are very limited. From past surveys, some 20 broods of ducks, including mallards, gadwall, teal, redhead, and pintail, have been produced annually. This would only amount to possibly 100 to 125 birds per year produced in this area, but the potential is much greater. In addition to the production of ducks, a variety of shorebirds utilize these same areas for nesting and brood rearing activities.

In conjunction with the opportunities discussed for sagegrouse, increased marshland habitat could be offered in the East Coyote and West Coyote areas, provided water is available. No project plans have been developed at this time; however, the feasibility of habitat development for waterfowl and other waterbirds has been incorporated in the analysis of the Coyote Wash areas. It is expected that the study will be completed within the next two years, and recommendations shall be submitted at that time.

Fisheries: The only existing fisheries within the area of this report occur in the small empoundments [illegible] as the Rattlesnake Pond in West Coyote. The pond supports a bass/bluegill association which has been established for 25 plus years. The pond is small, approximately 1½ surface acres, but is quite productive. The current status of the fisheries is overpopulation of bluegill, and consequently, stunted bass and bluegill have resulted.

The pond lies on public domain, but the water rights belong to an adjacent rancher who has indicated that the water may be utilized for irrigation in the near future. Plans were being made to treat the population of bluegill and restock with bass to allow better growth of fish, but no work will be conducted if the water is to be pulled for irrigation.

This portion of the state has very limited water oriented recreation opportunities. Fishing, duck hunting, swimming and boating are not available to the people of San Juan County without traveling long distances which usually result in high expenses.

Wherever water is available the opportunities for offering such facilities to the public of this region should be thoroughly evaluated. Such opportunities are being studied in the East Coyote Valley. The feasibility of maintaining a warmwater fisheries in this area is also under study. Water quality in East Coyote and the Rattlesnake empoundment has not been analyzed, but both areas are of such quality necessary in maintaining fisheries. A complete analysis of all water sources and their availability will be part of the study. Hopefully, added recreation and wildlife resources can be added to the area.

Other Wildlife: Several species occupy the general area with no specific sites of significant importance. Among them are mourning doves, cottontail rabbit, several species of songbirds and small predators including grey fox, bobcat, coyote, ringtail cat, prairie dogs and possibly the rare and endangered black-footed ferret. Also avian predators, including marshhawk, red tail, ferruginous hawk, prairie falcon, an occasional peregrine falcon, and sparrow hawks can be found throughout the area. Little is known of their abundance or the reasons for their occupancy in the area.

There is also a small population of ringneck pheasant associated with the agricultural lands near LaSal and East Coyote. This population is limited by croplands and no recommendations are being made to enhance the species.

Of additional significance is the use made of the area by 10 to 30 eagles during the winter months. As many as 13 bald eagles and 17 golden eagles have been observed from La Sal Junction south to Big Indian. These rare birds spend from four to six months in the area and migrate further north to nesting sites.

The reason for the occupancy in the Coyote Wash area is due mainly to the abundance of prey species and availability of carion. No nesting activity has been observed; however, a few birds have been seen during spring and summer seasons. Little is known of what is required to maintain these populations, but the responsibility is there. As questions are answered, management programs will be developed and implemented.

Land Classification: The bureau has classified the Dry Valley Planning Unit for retention under the Multiple Use Act of 1964. Included within this planning unit is the area of discussion, Coyote Wash and Lisbon areas. The objectives will be to manage for the many resources the area offers. Among the major values are: watershed, wildlife, livestock forage, recreation, minerals and woodland products. However, some potential for agriculture has also been identified in East Coyote, Lisbon Valley and East Canyon, and these areas will be further studied as to their suitability for farming, but decisions will be made in the best interest of the public.

Attached is a map* depicting generally the distribution of some of the wildlife species discussed in this report. Although we have not gone into much detail, I hope this information is of the nature you requested. If additional information is needed, we will assist you with what is available.

Julius G. Wlaschin

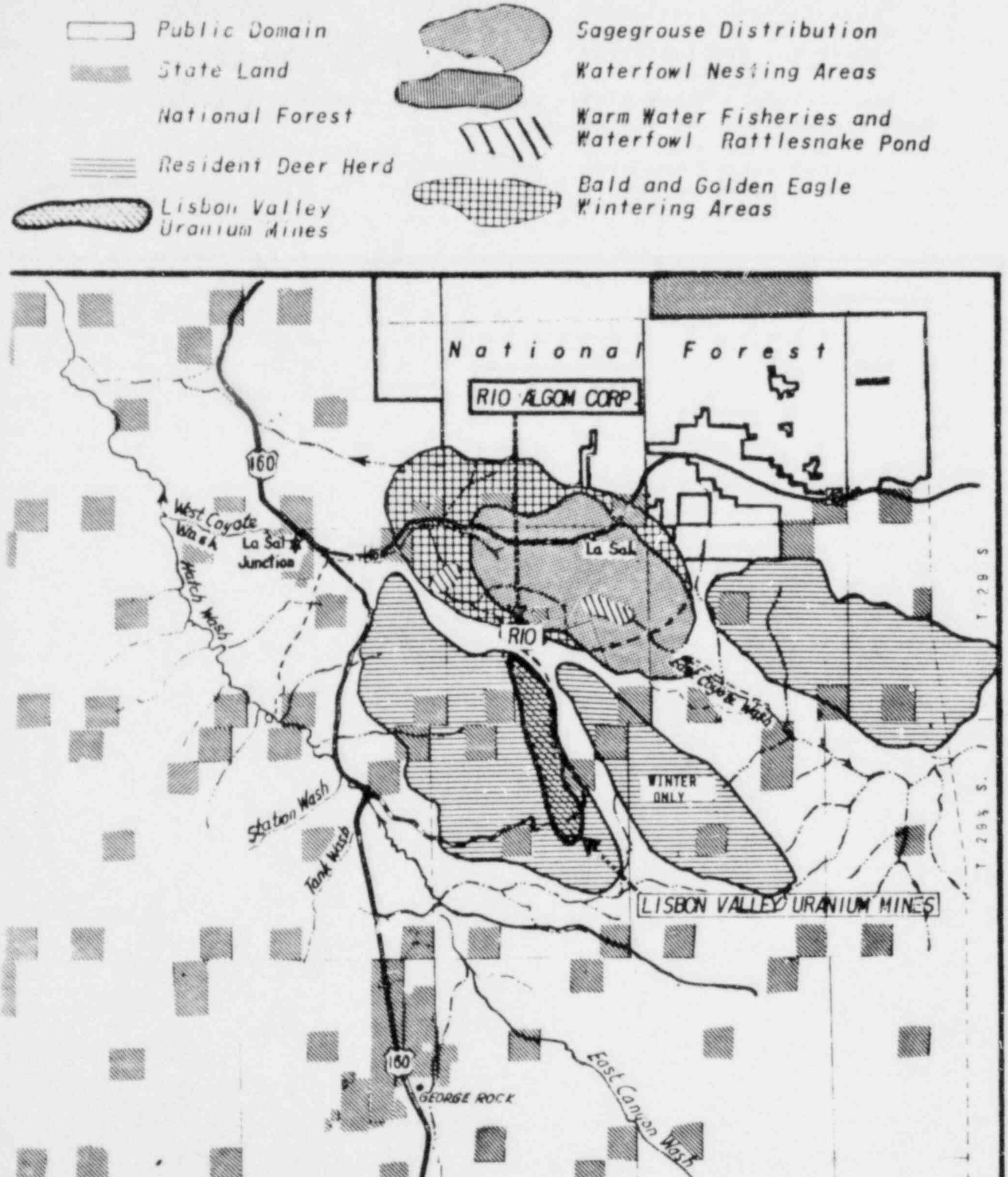
* See Fig.6, Section 4.1.5.

Vegetal Species List - Rio Algom Mill Site

Shrubs & Trees	Binamial
Pinon Pine	Pinus edulis
One Seed Juniper	Juniperus monosperma
Rocky Mountain Juniper	Juniperus scopulorum
Big Sagebrush	Airtemesia tridemtata
Rabbitbrush	Chryso thamnus nauseosus
Gambel Oak	Quercus gambelli
4 Wing Saltbush	Atriplex camescens
Little leaf Mahogany	Cercocarpus intricatus
Brown Snakeweed	Gutierrezia sarothrea
Greasewood	Sarcobatus uermiculatus
Yucca	Yucca spp.
Grasses	
Indian Rice Grass	Oryzopsis hymenoides
Needle & Thread	Stipa comata
Squirrel tail	Sitanian hystrix
Crested Wheat grass	Ogropyron crestalum
Cheatgrass	Bromus tectorum
Sand Dropseed	Sporobalus cryptandrus
Forbs	
Russian Thistle	
Thistle	Cirsuim rothrockii
Blue Flax	Linum lewisii
Rocky Mountain Bee plant	Cleome lutea
Groundsel	Senecio spp.
Prarie Sunflower	Helianthus petiolaris
Golden Rod	Solidago petradoria
Bladderpod	Physaria didymocarpa
Eriogonum - Buckwheat	Eriogonum spp.
Red Gilia	Gilia aggregata
Cacti	
Prickly pear	Opuntia spp.
Hedgehog	Echinocerus spp.
Beehive Cacti	Mammillaria spp.

Figure 6

CURRENT WILDLIFE INVENTORY OF THE COYOTE AREA



APPENDIX G

1. Letter from State of Utah, Division of Health to Rio Algom Corporation, dated December 1, 1971 regarding Sanitary Waste Disposal System.

STATE OF UTAH—DEPARTMENT OF SOCIAL SERVICES

DIVISION OF HEALTH
44 MEDICAL DRIVE
SALT LAKE CITY, UTAH 84113
AREA CODE 801
328-6121

[illegible] OLSEN, M.D., M.P.H.
Director of Health

December 1, 1971

J.E. Moyle
Manager Engineering
Rio Algom Corporation
120 Adelaide Street West
Toronto 1, Ontario
Canada

Re: Rio Algom Corp., Utah Project
Sanitary Waste Disposal System

Dear Mr. Moyle:

On November 22, 1971, additional information and revised plans for the above referenced project were received in this office. We have now completed our review of these plans and find them to be in conformance with State standards. On the basis of our review these plans are hereby approved and a construction permit, as constituted by this letter, is issued subject to the following conditions.

1. The revised drawing indicates that tarred roofing felt is to be used to cover the gravel backfill in the absorption trenches. The Code of Waste Disposal Regulations, Part V, requires an untreated type of material to be used for this purpose. It is requested that this change be made.

2. It is recommended that all tile lines be laid level and the ends be interconnected to form closed loops.

The wastewater disposal facility as described in the above mentioned plans consists of two separate septic tank and drainfield systems. The system serving the main office and the "mine dry" is comprised of a 6900 gallon septic tank and a drainfield with a trench area of 4800 square feet. The design flow for this system is 4250 gallons per day. The system serving the mill office and the assay lab is comprised of a 1900 gallon septic tank and an absorption field with a trench area of 1710 square feet. This second system has a design flow of 1000 gallons per day.

Since we have only one set of drawings we are retaining them for our files. We thank you for your cooperation. If we can be of any further assistance please let us know.

Sincerely yours,

UTAH WATER POLLUTION COMMITTEE

Calvin K. Sudweeks

Calvin K. Sudweeks
Executive Secretary

DMW:ss
cc: Peter W. Harvey
San Juan County Health Department
State Division of Health, Price

APPENDIX H

1. Letter from Rio Algom Corporation to AEC dated February 26, 1974, regarding Barium Treatment Facility.
2. Letter from Dames and Moore to Rio Algom Corporation dated February 22, 1974, regarding seepage from proposed Barium Treatment Facility.
3. Report of Engineering Study, Pond Seepage and Embankment Stability, Proposed Barium Chloride Treatment Facility, Lisbon Mine, La Sal, Utah for Rio Algom Corporation, by Dames and Moore dated November 8, 1973.

Rio Algom
Rio Tinto

February 26th, 1974.

Mr. John F. Kendig,
Materials Branch,
Directorate of Licensing,
United States Atomic Energy Commission,
Washington, D.C. 20545.

RECEIVED MAR 1 1974

Dear Mr. Kendig:

Further to my letter of 30th January 1974, we are attaching copies of the following letters:

1. Letter from Dames & Moore of 22nd February re Seepage, Proposed Barium Chloride Treatment Facility, Lisbon Mine. The expected seepage rate of some 7½ feet per year based on soil tests should be further reduced by the alum floc used in the initial treatment pond for the clarification of the mine water, and by the fine barium precipitate in the radium removal pond. There appears to be no necessity for additional monitor wells at this time.

   Barium treatment started 23rd January on mine water analyzing 65 to 70 pCi/l radium and the treated water is currently discharged at 5 to 9 pCi/l. Alum addition will be instituted on receipt of equipment on order to clarify the mine water and improve the efficiency of the operation. Analyses of the effluent are expected to be below 3 pCi/l when alum is used.

2. A letter from the Bureau of Land Management Monticello of 19th February with attached Staff Report of 21st October 1971, stating that there is no need for a diversion ditch at this time, and that a specific decision on the necessity of a ditch may be made at the conclusion of operations.

   We trust that this information is satisfactory.

Yours truly,

R. D. Lord

RDL/mm

R. D. Lord.

C416

P. S. - Also attached is a copy of the Dames & Moore Engineering Study on Pond Seepage & Embankment Stability for Barium Chloride Treatment Facility.

February 22, 1974

Rio Algom Corporation
120 Adelaide Street West
Toronto 1, Ontario
Canada

Attention: Mr. Jack Calwell

Gentlemen:

Seepage
Proposed Barium Chloride Treatment Facility
Lisbon Mine
La Sal, Utah
For Rio Algom Corporation

This letter relates to your questions regarding the movement of seepage from your proposed barium chloride treatment facility at the Lisbon Mine, and the possible need for monitor wells.

Both treatment ponds will be situated on the northwestward sloping surface of the drainage depression extending westward toward your tailings ponds. The soils are believed to be residual from the weathering of the Burro Canyon formation. Whether the soils are residual or transported, however, any layering in them will slope to the west.

The bedrock surface, which is developed on Burro Canyon sandstone, also slopes westward. The base of the Burro Canyon sandstone at this location forms a ridge with flanking troughs that slope to the northwest and southeast away from the ridge, accord[illegible] to the structure contour map prepared by Rio Algom Corporation.

Seepage will move to the northwest and west, conforming to the topography, soil layering and bedrock surface, unless it reaches the top of the Brushy Basin shale. It then could move either northwest or southeast following the troughs, unless restricted to one of these directions by an existing water table.

In our "Report of Engineering Study, Pond Seepage and Embankment Stability, Proposed Barium Chloride Treatment Facility, Lisbon Mine, LaSal, Utah, For Rio Algom Corporation", dated November 8, 1973, we indicated that a seepage rate not exceeding 0.25 inches per day would be experienced at the ponds

DAMES & MOORE

Rio Algom Corporation
February 22, 1974
Page -2-

if constructed according to the recommended procedure. This is equivalent to 7.58 feet per year. The absence of distinct soil layering in our test borings indicates that the horizontal and vertical soil permeabilities are essentially similar at this location. Hence, any seepage from the ponds would not be detected for many years by monitor wells unless they were placed very close to the ponds. Seepage following a westerly path would coalesce with the ground water mound beneath the tailings pond, and would become a part of that seepage system which is already being monitored.

Although it is not expected that any seepage would move southeastward unless it reached the surface of the Brushy Basin shale, adaptation of an existing exploration boring to serve as a monitor well in the area a few hundred feet southeast of the ponds is being considered.

If you have any questions, please contact us.

Yours very truly,

DAMES & MOORE

William E. Mead

William E. Mead
Consulting Partner

WEM/pc

SUITE 200, 250 EAST BROADWAY · SALT LAKE CITY, UTAH 84111 · (801) [illegible]
CABLE: DAMEMORE TWX: 910-925-[illegible]

November 8, 1973

Rio Algom Corporation
120 Adelaide Street West
Toronto 1, Ontario

Attention: Mr. J. Calwell

Gentlemen:

Six copies of our report entitled "Report of Engineering Study, Pond Seepage and Embankment Stability, Proposed Barium Chloride Treatment Facility, Lisbon Mine, La Sal, Utah, For Rio Algom Corporation," are herewith submitted.

The purpose and scope of our study were planned in discussions between Mr. J. Calwell of Rio Algom Corporation and Mr. George Toland of Dames & Moore. Authorization to proceed was provided by Mr. Calwell in his letter of September 26, 1973.

The results of our study indicate that appropriate materials are available in the immediate site area with which to construct a pond with minimal leakage. By utilizing the recommended embankment slopes, slope stability will be assured under all normal design conditions.

oOo

We appreciate being able to provide this service for you. If you have any questions, please contact us.

Yours very truly,

DAMES & MOORE

George C. Toland

George C. Toland
Consulting Partner
Professional Engineer No. 2311
State of Utah

GCT/JCK:ab

Enclosures

REPORT OF ENGINEERING STUDY
POND SEEPAGE AND EMBANKMENT STABILITY
PROPOSED BARIUM CHLORIDE TREATMENT FACILITY
LISBON MINE
LA SAL, UTAH
FOR RIO ALGOM CORPORATION

Dames & Moore Job No. 7144-003-06

REPORT OF ENGINEERING STUDY

POND SEEPAGE AND EMBANKMENT STABILITY

PROPOSED BARIUM CHLORIDE TREATMENT FACILITY

LISBON MINE

LA SAL, UTAH

FOR RIO ALGOM CORPORATION

INTRODUCTION

This letter presents the results of our studies performed to evaluate the seepage potential and embankment stability for the proposed barium chloride treatment facility to be constructed at the Lisbon Mine. The location of the mine with respect to La Sal, Utah and the surrounding area is shown on Plate 1, Vicinity Map. The configuration proposed for the barium chloride and alum treatment ponds is shown on Plate 2, Plot Plan.

PURPOSE AND SCOPE

The purpose and scope of this study were determined in telephone conversations between Mr. J. Calwell of Rio Algom Corporation and Mr. George Toland of Dames & Moore. A summary of these conversations and authorization to proceed with the study was provided in a letter of September 26, 1973 by Mr. Calwell. The purpose of our study was to evaluate the pond design as proposed by Rio Algom Corporation personnel and provide recommendations regarding the stability of the proposed embankments and to estimate the anticipated seepage losses for a soil lined pond if native materials are utilized for construction. To accomplish the above purpose, the following scope was undertaken:

1. A field program which consisted of a site reconnaissance and the drilling of six borings, including two shallow supplemental borings. In addition, disturbed bulk samples were obtained of prospective borrow materials.
2. The laboratory testing program to determine the strength, compressibility and permeability of natural and remolded specimens.
3. A program of engineering analyses to conclude with the preparation of this written report.

PROPOSED CONSTRUCTION

The proposed barium chloride and alum treatment ponds will be constructed in an unused area located to the east of the plant site. The proposed ponds will be contiguous with an existing vacuum cooling and fire protection pond; the easternmost dike of the fire protection pond will be included in the dike system for the proposed treatment ponds.

The proposed ponds will be of rectangular shape, with the 136 feet by 236 feet alum treatment pond being located adjacent to the fire protection pond. The barium chloride treatment pond will be 242 feet by 236 feet in plan and will be contiguous with the north side of the alum treatment pond. To accommodate the sloping ground surface at the site, the crest of the alum treatment pond will be at elevation 6731 feet, while the crest of the barium chloride treatment pond will be at elevation 6715 feet. The bottom of the alum treatment pond will be at elevation 6719 with the sloping bottom of the barium chloride treatment pond at 6693 feet at its lowest point.

The proposed pond embankments will have a crest width of 10 feet and interior sideslopes of 3 horizontal to 1 vertical. As originally proposed, the exterior sideslopes would be 1.5 horizontal to 1 vertical. At the highest point the embankment would be approximately 22 feet high.

SITE CONDITIONS

SURFACE:

The proposed site is an open field presently covered with grass and sagebrush. The site area is bounded directly to the southwest by the Rio Algom Corporation mill and on the other sides by open fields. A moderate growth of pinon and cedar trees are located on the southwest and northwest sides of the site. The ground surface at the site is moderately irregular and slopes gradually to the northwest.

A dirt road from the plant area bisects the site in an east-west direction approximately midway through the site area. The site is similarly bisected in a north-south direction by a fence. In the south portion of the area, the ground surface was cleared and graded during construction of the existing cooling pond. A dump area consisting of debris and metal materials is located to the north of the dirt road extending through the site.

SUBSURFACE:

Topsoil in the pond area is of negligible thickness. The near-surface soils at the site are either reddish-brown sandy silt with clay or clayey silt with sand. These soils were encountered extending to depths ranging from 6.5 to 11.5 feet below adjacent grade, generally grading firmer with depth. Bedrock, encountered immediately underlying the surface soils, consists generally of weathered gray or greenish-gray clayey siltstone.

Within the upper few feet the siltstone bedrock is highly weathered and is relatively impervious. With depth, the bedrock becomes more fractured and broken and is therefore more permeable.

Ground water was not encountered to the depths explored in any of the borings at the site. Surface moist areas were uncovered in the area of boring 3, however. The surface moisture is thought to be resulting from runoff and not related to a ground water table.

DISCUSSIONS AND RECOMMENDATIONS

GENERAL:

The results of our study indicate that the proposed ponds may be feasibly constructed at the site selected, using native materials. We understand, following discussions with Rio Algom Corporation personnel, that the pond design will likely be modified from the originally proposed configuration. These modifications will include a sloping instead of flat pond bottom and other related changes to avoid excavating in the bedrock at the site. Our laboratory testing indicates relatively low permeability in the upper bedrock strata, and therefore excavating the pond bottom to or near the bedrock would be acceptable. More detailed discussions regarding seepage, embankment stability and earthwork placement recommendations are presented in subsequent sections of this report. Supporting data is presented in the appendix. Data was also derived from our previous report for the existing tailings dam dated October 2, 1973.

SEEPAGE CONTROL:

It is our understanding that requirements for construction of treatment ponds of this type indicate that minimal seepage will be tolerated.

Allowable rates or quantity of seepage are not specified, however. In our opinion, a rate of seepage not exceeding 0.25 inches per day would be an acceptable maximum. This rate, projected over the entire pond area, would result in a seepage loss of 10 gpm. We feel that a loss rate of approximately 10 gpm will be experienced with the proposed ponds.

Due to the sloping ground surface at the site, considerable fill will be required at the north end of the ponds, while cuts on the order of 8 feet are necessary at the south end. The permeability of properly placed fill material, derived from either the borrow area or the south end of the site, will be sufficiently low. In cut, however, the natural soils at the site exhibit layering and root holes and will require improvement procedures. We recommend that all cut areas be overexcavated by a minimum of one-half foot, and that the exposed cut surface be scarified and compacted and then be covered by a one-half-foot thickness of compacted fill imported from the borrow area.

EMBANKMENT STABILITY:

As presently proposed, the embankments will have interior slopes of three horizontal to one vertical and a crest width of ten feet. Exterior sideslopes as steep as one and one-half horizontal to one vertical would be desired to reduce earthwork quantities. We have reviewed the proposed section and checked the stability for a steady seepage case by the computer method. Our analyses, by the ordinary method of slices procedure, indicate that the proposed section would theoretically be stable, with a computed safety factor in excess of 2.0 under both static and moderate earthquake conditions. However, in consideration of the desired long-term use of the facility, the necessity for safe containment of material within the pond and practical factors such as ease of maintenance and protection from erosion, we recommend the maximum exterior slopes be no steeper than two horizontal to one vertical. Settlements of the embankments due to consolidation of fill and natural soils should be well within tolerable limits.

EARTHWORK:

Site Preparation. The proposed site should be stripped of all vegetation, debris and other existing materials unsuitable for support of the proposed ponds. We estimate that a depth of stripping of one to two inches would be required to remove vegetation and major roots.

Fill Materials. Materials utilized as fill will generally be those materials excavated in cut sections within the pond area, supplemented by borrow from the existing area to the south. Fill material should be limited to the sandy silt with clay to clayey silt soils at the site, or the weathered bedrock. Soils which are predominantly sand or bedrock materials and are not sufficiently weathered to remold into soil when compacted should be avoided near the interior of the pond. These materials can be incorporated into exterior slopes, however, if desired.

Fill Installation. All fill materials should be placed in layers not exceeding eight inches in loose thickness and be compacted to a minimum dry density of 90 percent of the maximum dry density as determined by the A.A.S.H.O.* T180, Method of Compaction. Sheepsfoot or tamping foot-type equipment is recommended. Cut areas should be overexcavated by one-half foot

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*American Association of State Highway Officials.

and the underlying surfaces scarified and compacted to the standards for fill. Additional compacted fill should then be added to bring areas to final grade.

OTHER CONSTRUCTION:

The preliminary plot plan received from Rio Algom Corporation indicates other facilities in the pond area which should be specifically designed for a soil-lined pond. This equipment includes the pond discharge launder between the alum treatment pond and the barium chloride treatment pond, the emergency overflow from the barium chloride treatment pond and the pipeline through the dike and leading to the pump house. We recommend that the overflow and launder be constructed sufficiently long to avoid undue turbulence and subsequent erosion of the pond interior. The overflow exit should be extended to discharge beyond the toe of the exterior slope. Seepage along the pipeline should be prevented by constructing a large seepage flange within the dike and at right angles to the pipe. We recommend that the flange be a minimum of five feet in diameter. It is our understanding that these recommendations have been incorporated into the final designs.

INSPECTION:

All earthwork operations should be monitored closely by qualified engineering personnel to insure compliance with the intent of the job specifications. Testing should be performed to substantiate the degree of compaction achieved. Particular attention should be directed toward the placement of the upper one foot of fill in the pond interiors.

oOo

The following plates and appendix are attached and complete this report:

Plate 1 - Vicinity Map

Plate 2 - Plot Plan

Plate 3 - Recommended Embankment Section

Appendix - Field Exploration and Laboratory Tests.

Respectfully submitted,

DAMES & MOORE

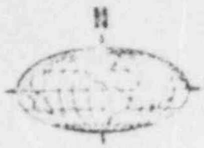
George C. Toland

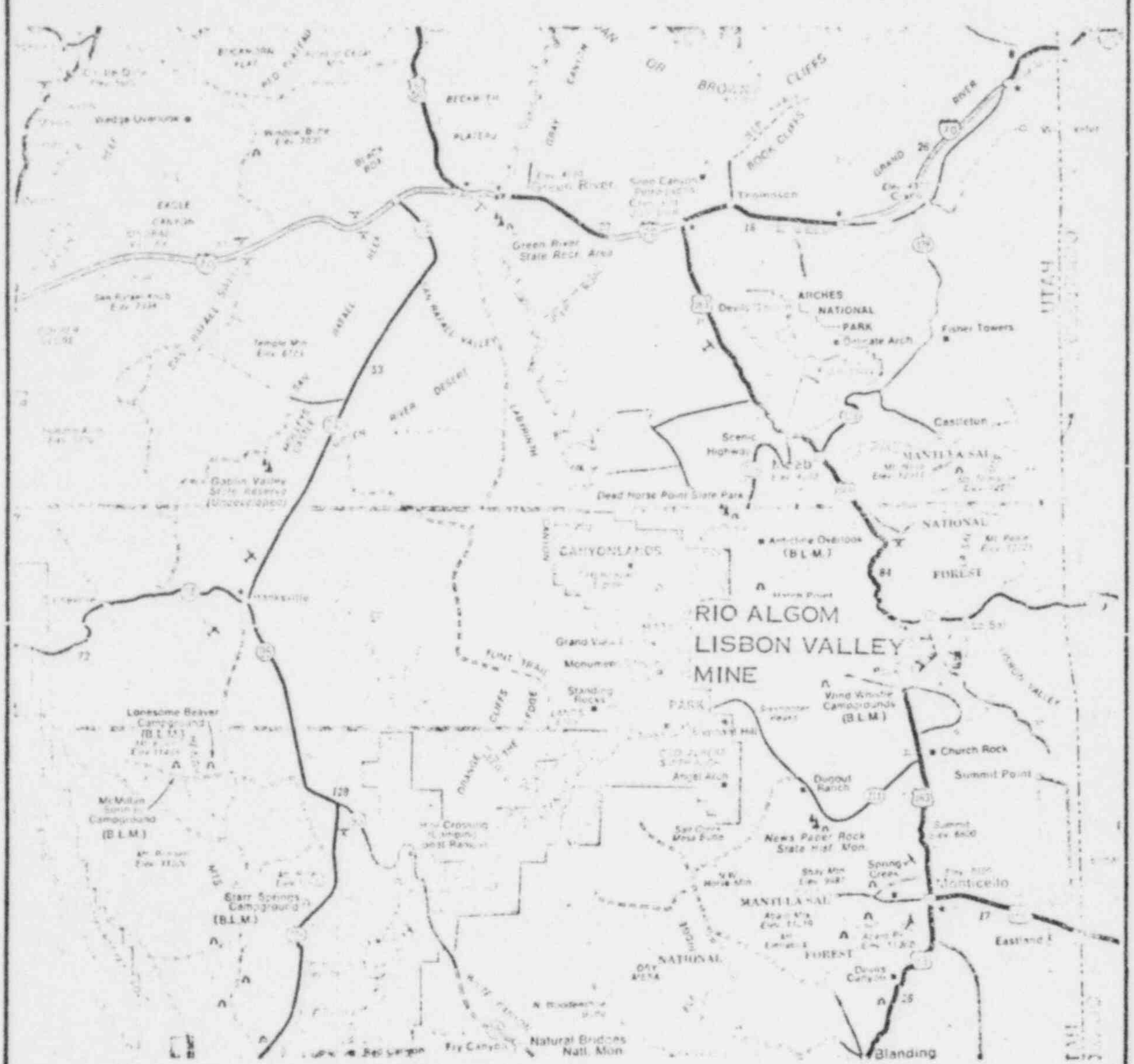
George C. Toland
Consulting Partner
Professional Engineer No. 2311
State of Utah

GCT/JCK:ab

Attachments

BY H.B.T. DATE 9-26-73 FILE 7144-002 RIO ALGOM- MOAB REVISIONS BY ____ DATE ____
CHECKED BY ____





REFERENCE
STATE OF UTAH ROAD MAP

Scale: One inch approximately 17.4 miles

VICINITY MAP

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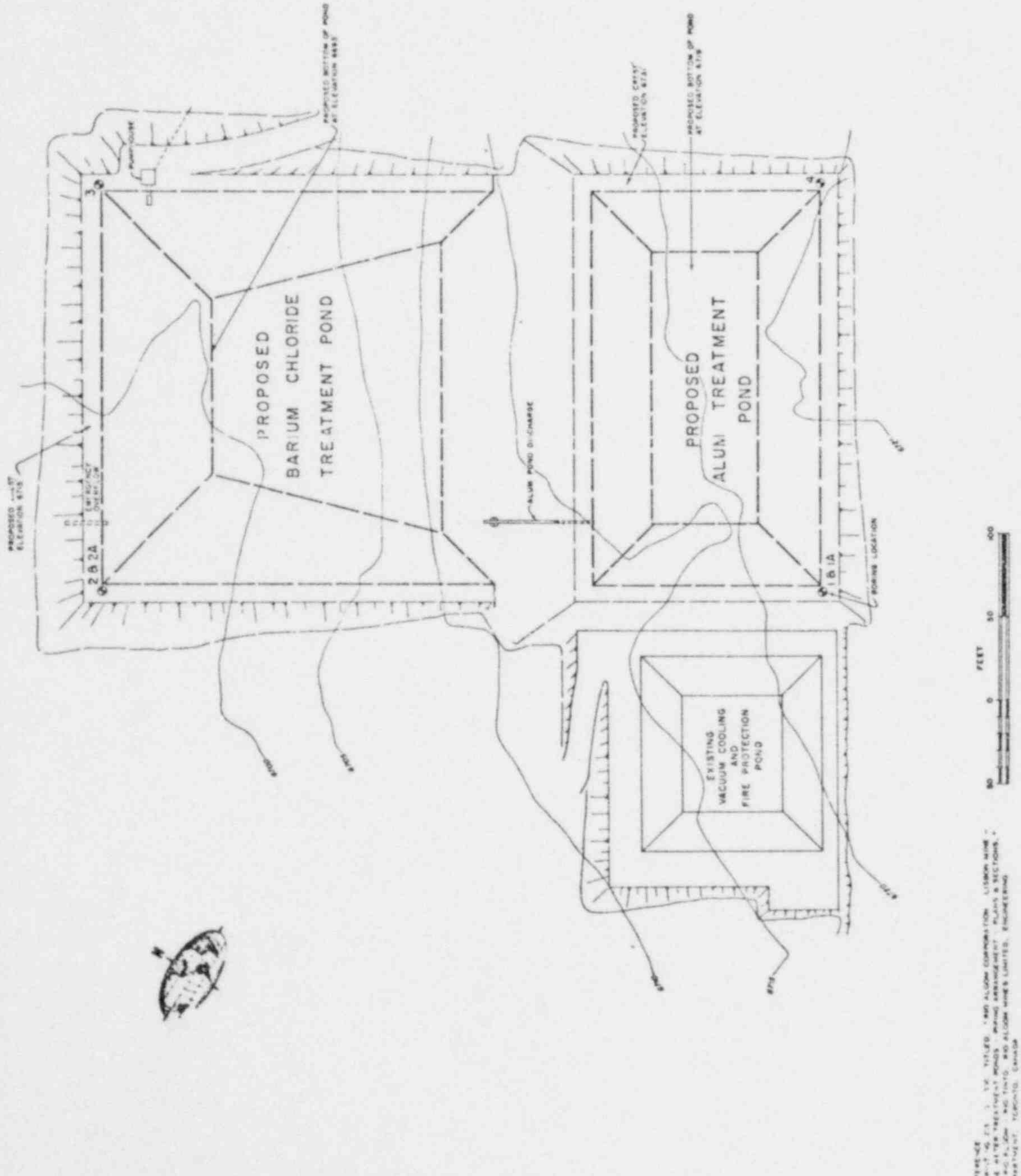
PLATE I

Appendix H, Reference 3

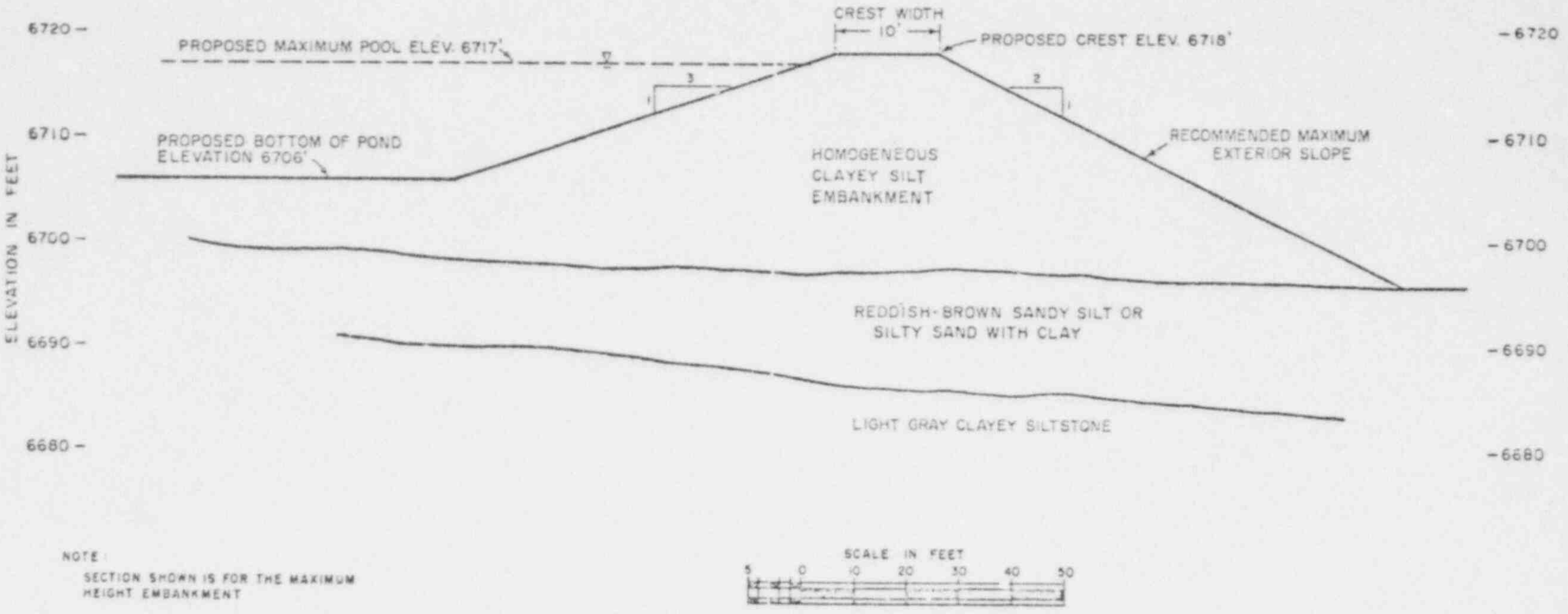
H-17

PLOT PLAN



DAMES & MOORE

PLATE 2



NOTE:
SECTION SHOWN IS FOR THE MAXIMUM HEIGHT EMBANKMENT

Appendix H, Reference 3
H-18

RECOMMENDED EMBANKMENT
SECTION

DAMES & MOORE

PLATE 3

APPENDIX

FIELD EXPLORATION AND LABORATORY TESTS

FIELD EXPLORATION:

The subsurface conditions at the site of the proposed pond were investigated by drilling a total of four exploration borings and two supplemental borings. The main exploration borings extended to depths ranging from 21.0 to 29.5 feet below existing grade. The two supplemental borings drilled adjacent to borings 1 and 2 and labeled 1A and 2A, respectively, were drilled to shallower depths to obtain samples of the near-surface materials. The exploration borings were drilled with truck mounted rotary-type drilling equipment using water as a drilling medium. The locations of the borings are shown on Plate 2, Plot Plan, in the text of this report.

The field exploration program was conducted and supervised by an experienced soils engineer from our office. Disturbed soil samples were obtained from the borings using a standard two-inch outside diameter split-spoon sampler. Undisturbed samples were obtained using the Dames & Moore soil sampler as shown on Plate A-3, Soil Sampler Type U. As can be noted on the boring logs, borings 1 and 2 were sampled using the split-spoon sampler while borings 1A, 2A, 3 and 4 were sampled using the Dames & Moore Type U Sampler. Bulk disturbed samples were obtained from prospective borrow areas located to the south of the proposed pond area to provide additional material for laboratory testing. The soils encountered were classified by visual and textural examination in the field and a complete log was maintained of each boring. The field classifications were reviewed and revised, if necessary, following supplemental inspection and testing in our laboratory. Graphical representation of the soils encountered in the exploration borings is presented on Plates A-1A through A-1C, Log of Borings. The nomenclature used to describe the soil types encountered appears on Plate A-2, Unified Soil Classification System.

LABORATORY TESTS:

General. To determine the engineering characteristics of the various soils encountered in the borings and prospective borrow area, several types of soil tests were performed. The testing program included a series of moisture and density tests, gradation analyses, consolidation tests, compaction tests, permeability determinations, strength tests and sulfate analyses. Discussions of the individual tests are presented below.

Moisture and Density Tests. Moisture and density tests were performed on selected undisturbed samples to determine the in-situ moisture content and dry density of the soils. This is used to aid in classifying the soils and to help correlate other test data. The results of the moisture and density tests are presented to the left of the boring logs on Plates A-1A through A-1C.

Gradation Tests. Partial gradation tests were performed by washing representative materials on the No. 200 sieve. This test indicates the percentage of coarse grained and fine grained components in the soil and assists in classifying the various soils. The results of the partial gradation tests are presented on the following page.

Sample Location	Depth In Feet	Soil Type	Percentage Passing No. 200 Sieve
1A	8.0	Siltstone	52.2
2A	0.5	ML/SM	50.1
3	4.5	ML/SM	79.8
4	1.0	ML	78.9
Bulk Sample #2	Surface	ML/SM	60.0
Bulk Sample #5	Surface	ML/CL	70.4

Consolidation Tests. A consolidation test was performed on a representative undisturbed sample of near-surface soil from the lower elevation portions of the site. The results of the tests are utilized in estimating the amount of settlement which would occur under the embankment. The test method is described on Plate A-4, Method of Performing Consolidation Tests. The test results are presented on Plate A-5, Consolidation Test Data.

Compaction Tests. A compaction test was performed on a representative bulk sample of the soils found in the proposed borrow area and was conducted in accordance with the method described on Plate A-6, Method of Performing Compaction Tests. The results of the tests are utilized in the preparation of recompacted specimens and are shown on Plate A-7, Compaction Test Data.

Percolation Tests. Laboratory percolation tests were performed to aid in estimating the amount of seepage which would occur from a soil lined pond. Tests were performed on undisturbed samples of the soils and bedrock at the site and on recompacted specimens prepared from material obtained in the proposed borrow area. The method utilized in performing the tests is presented on Plate A-8, Method of Performing Percolation Tests. The test results are presented in tabular form below:

Sample	Depth In Feet	Soil Type	Permeability Rate (K) In Feet Per Year
Boring 1A	8.0	Siltstone	0.5
Boring 2A	4.5	ML/SM	145.
Boring 3	0.5	ML/SM	0.4
Boring 3	11.5	Siltstone	0.4
Bulk Sample No.5	Surface	ML/CL	2.0
Bulk Sample No.5	Surface	ML/CL	3.5

Direct Shear Tests. Several direct shear tests were performed on recompacted samples of prospective embankment material. The strength characteristics obtained were utilized in determining the stability of the proposed embankment. The tests were performed in accordance with the method described on Plate A-9, Method of Performing Direct Shear and Friction Tests. The test results are presented in tabular form below:

Sample	Soil Type	Normal Pressure In PSF	Yield Shear Strength In PSF
Bulk Sample No. 5	ML/CL	1,000	1,100
Bulk Sample No. 5	ML/CL	2,000	1,200
Bulk Sample No. 5	ML/CL	3,000	1,200
Bulk Sample No. 5	ML/CL	[illegible],000	1,600

Soluble Sulfates Determination. To determine the amount of soluble materials in the on-site soils, two tests were performed on representative samples, one from the pond area and one from the borrow area. The test results are tabulated on the following page.

Sample Location	Depth In Feet	Calcium Sulfate $CaSO_4$	Magnesium Sulfate $MgSO_4$	Sodium Sulfate $NaSO_4$	Total Soluble Solids
Bulk Sample No.4	4.0	0.069	0.028	0.019	0.118
Boring 1A	4.5	0.085	0.015	0.012	0.114

oOo

The following plates are attached and complete this appendix:

Plates A-1A through A-1C - Log of Borings

Plate A-2 - Unified Soil Classification System

Plate A-3 - Soil Sampler Type U

Plate A-4 - Method of Performing Consolidation Tests

Plate A-5 - Consolidation Test Data

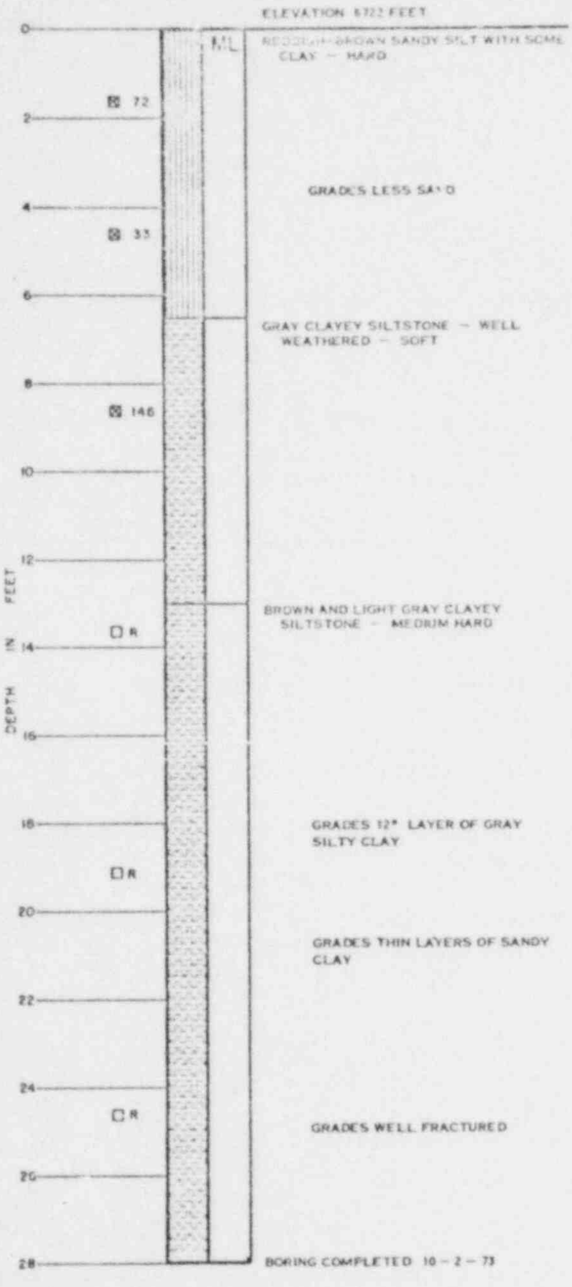
Plate A-6 - Method of Performing Compaction Tests

Plate A-7 - Compaction Test Data

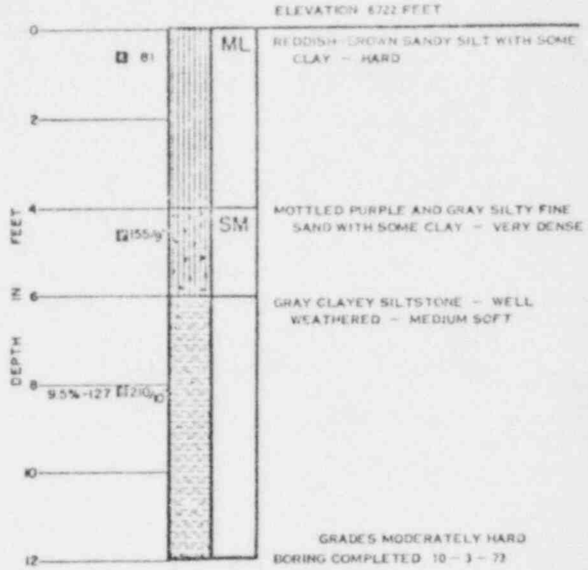
Plate A-8 - Method of Performing Percolation Tests

Plate A-9 - Method of Performing Direct Shear and Friction Tests.

BORING 1



BORING 1A



KEY

A — B ■ C

A FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL

B DRY DENSITY EXPRESSED IN LBS. PER CUBIC FOOT

C BLOWS PER FOOT OF PENETRATION USING A 140 LB. HAMMER DROPPING 30 INCHES

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

⊠ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

□ SAMPLING ATTEMPT WITH NO RECOVERY

R DESIGNATES REFUSAL

NOTES

GROUND WATER WAS NOT ENCOUNTERED TO THE DEPTHS EXPLORED, IN ANY OF THE BORINGS AT THIS SITE.

THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED, "SITE CONDITIONS, SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

BORINGS 1 AND 2 WERE SAMPLED USING A STANDARD 2" SPLIT SPOON SAMPLER. SAMPLES WERE OBTAINED IN BORINGS 1A, 2A, 3 AND 4 USING A DAMES & MOORE TYPE U SAMPLER.

ELEVATION DATA WAS INTERPOLATED FROM PRINT NO. 205 - 0 - 01, TITLED, "RIO ALGOM CORPORATION — LISBON MINE — MINE WATER TREATMENT — PONDS GENERAL ARRANGEMENT — PLANS & SECTIONS", BY RIO ALGOM - RIO TINTO, RIO ALGOM MINES LTD., ENGINEERING DEPARTMENT, TORONTO, CANADA.

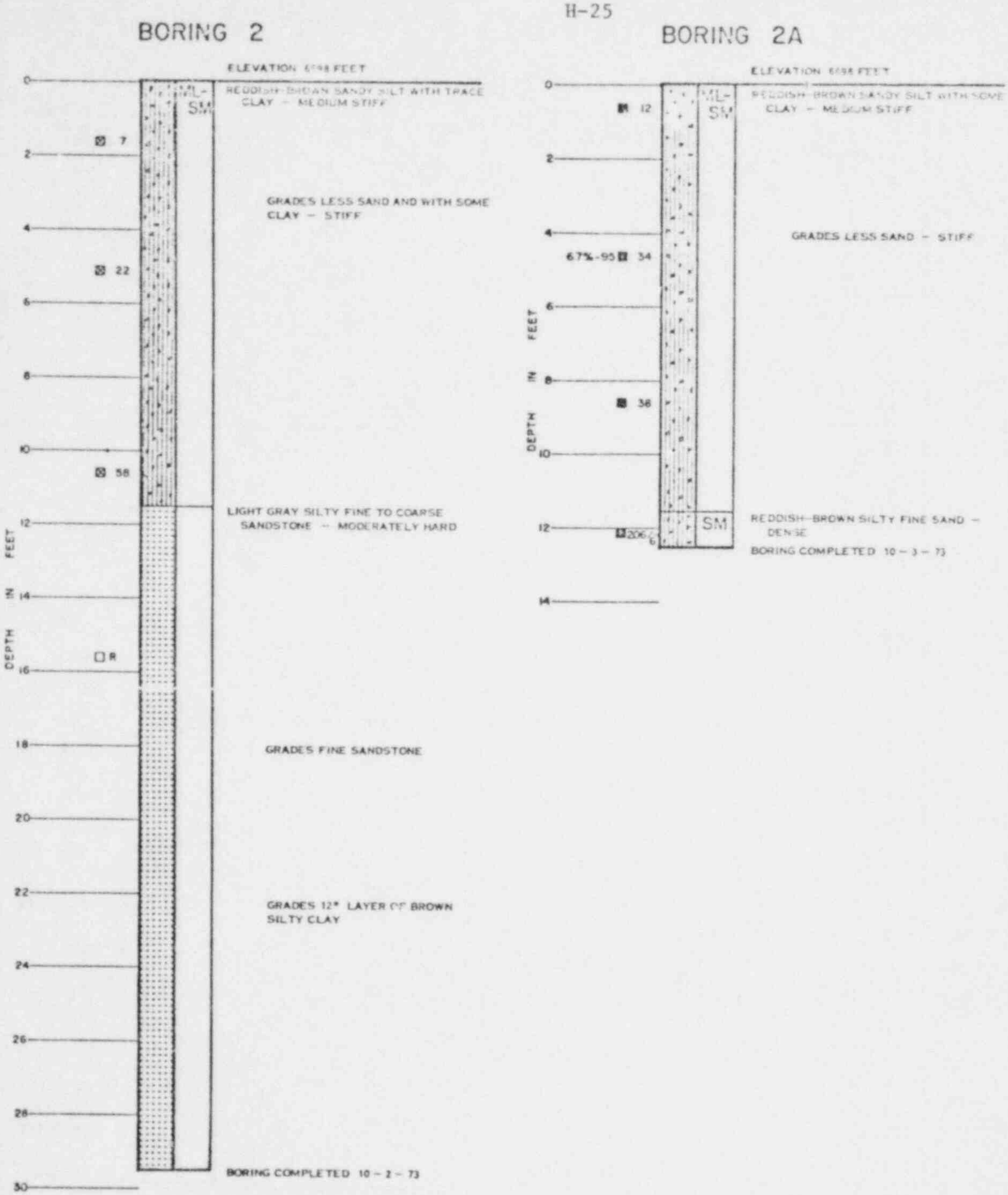
LOG OF BORINGS

DAMES & MOORE

PLATE A-1A

Appendix H, Reference 3

H-25

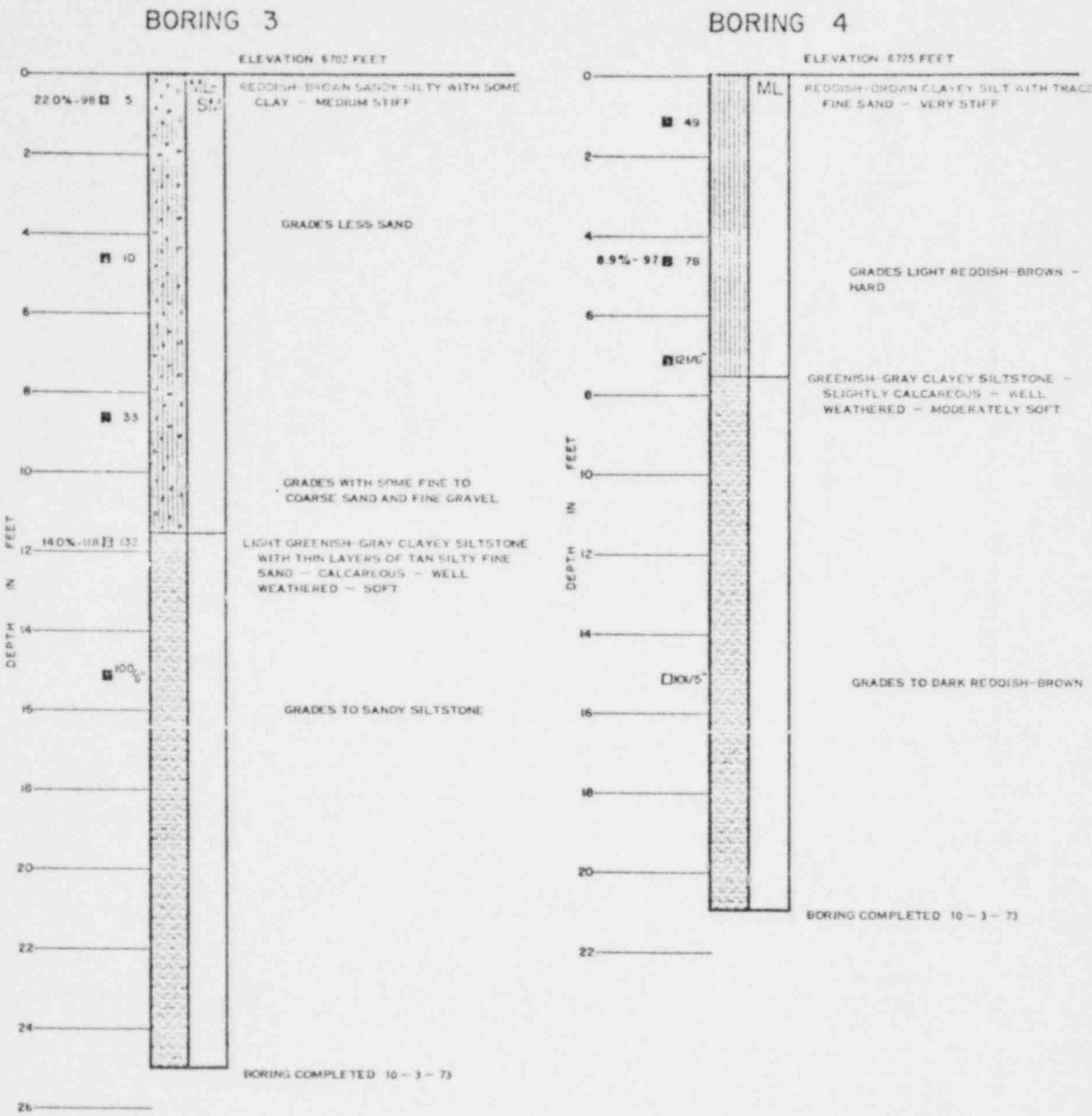


LOG OF BORINGS

DAMES & MOORE

PLATE A-1B

Appendix H, Reference 3
H-26



LOG OF BORINGS

DAMES & MOORE

PLATE A-1C

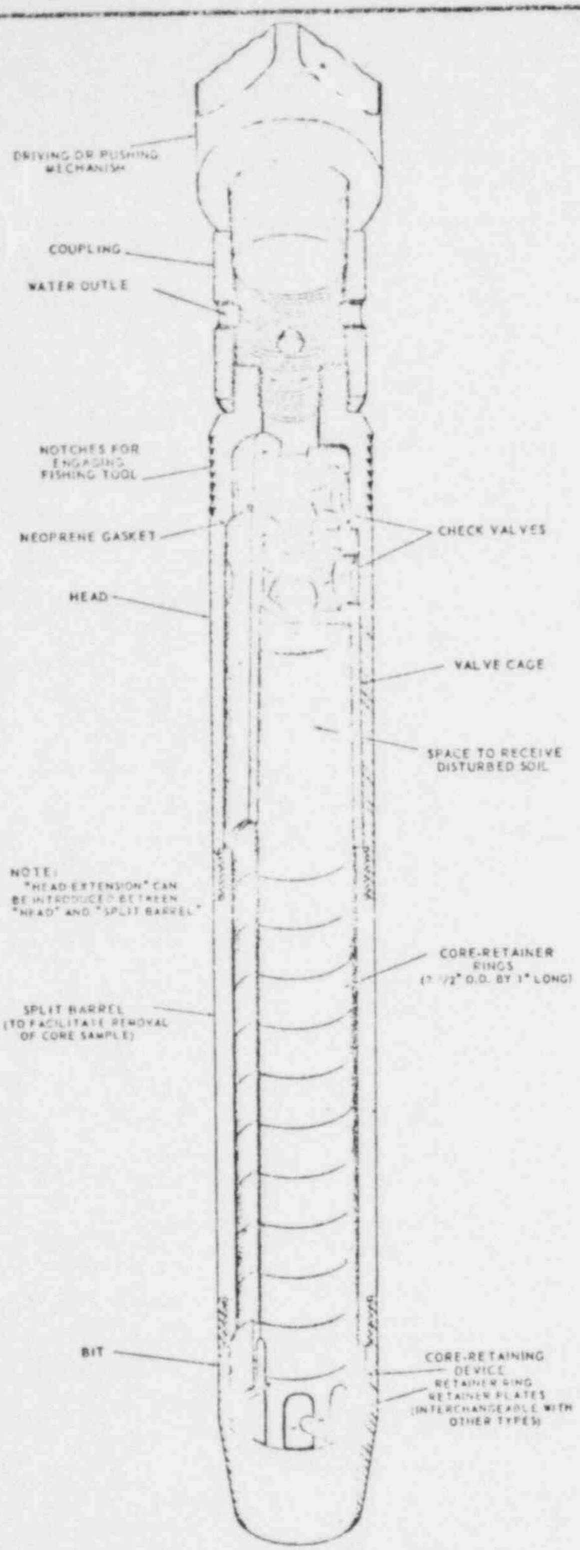
MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

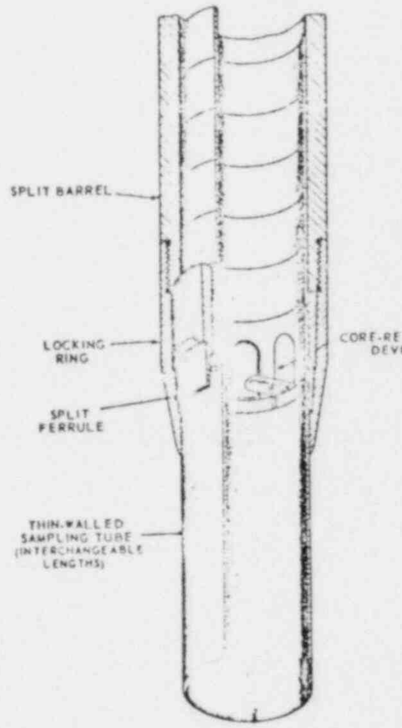
SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE



ALTERNATE ATTACHMENTS



SOIL SAMPLER TYPE U

U. S. PATENT NO. 2,318,062

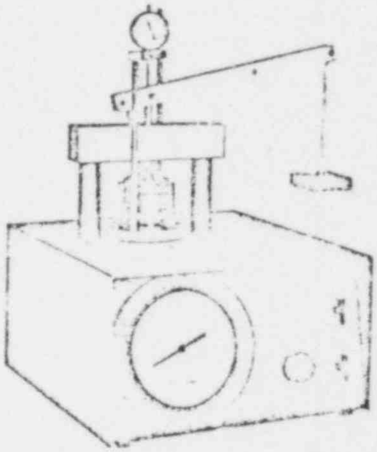
DAMES & MOORE

PLATE A-3

BY ______ DATE ______
CHECKED BY ______ FILE ______
REVISIONS
BY ______ DATE ______

CONSOLIDATION TESTS ARE PERFORMED TO EVALUATE THE VOLUME CHANGES OF SOILS SUBJECTED TO INCREASED LOADS. TIME-CONSOLIDATION AND PRESSURE-CONSOLIDATION CURVES MAY BE PLOTTED FROM THE DATA OBTAINED IN THE TESTS. ENGINEERING ANALYSES BASED ON THESE CURVES PERMIT ESTIMATES TO BE MADE OF THE PROBABLE MAGNITUDE AND RATE OF SETTLEMENT OF THE TESTED SOILS UNDER APPLIED LOADS.

EACH SAMPLE IS TESTED WITHIN BRASS RINGS TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

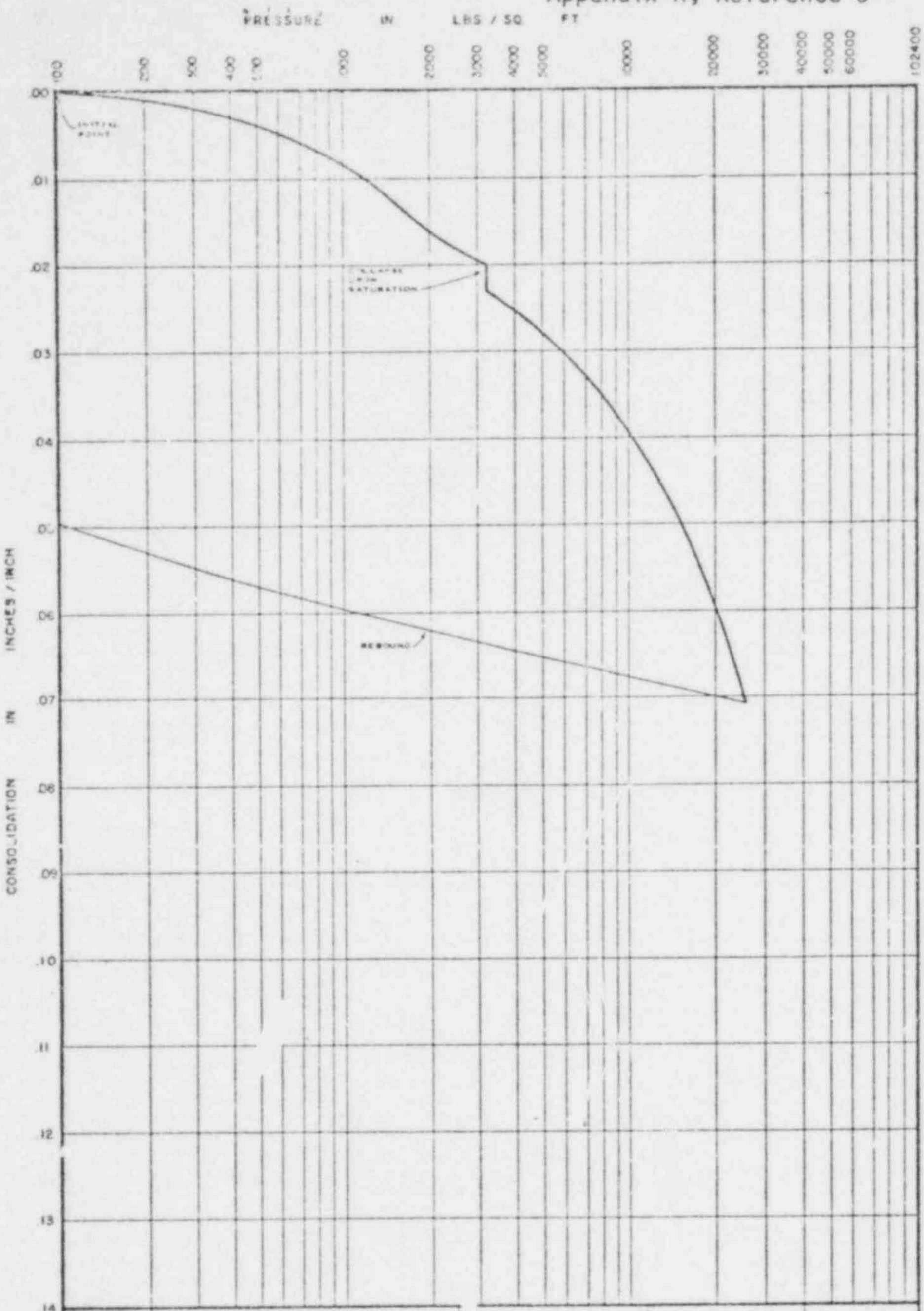


DEAD LOAD-PNEUMATIC CONSOLIDOMETER

IN TESTING, THE SAMPLE IS RIGIDLY CONFINED LATERALLY BY THE BRASS RING. AXIAL LOADS ARE TRANSMITTED TO THE ENDS OF THE SAMPLE BY POROUS DISKS. THE DISKS ALLOW DRAINAGE OF THE LOADED SAMPLE. THE AXIAL COMPRESSION OR EXPANSION OF THE SAMPLE IS MEASURED BY A MICROMETER DIAL INDICATOR AT APPROPRIATE TIME INTERVALS AFTER EACH LOAD INCREMENT IS APPLIED. EACH LOAD IS ORDINARILY TWICE THE PRECEDING LOAD. THE INCREMENTS ARE SELECTED TO OBTAIN CONSOLIDATION DATA REPRESENTING THE FIELD LOADING CONDITIONS FOR WHICH THE TEST IS BEING PERFORMED. EACH LOAD INCREMENT IS ALLOWED TO ACT OVER AN INTERVAL OF TIME DEPENDENT ON THE TYPE AND EXTENT OF THE SOIL IN THE FIELD.

METHOD OF PERFORMING CONSOLIDATION TESTS

REVISIONS BY ______ DATE ______
FILE ______
BY ______ DATE ______
CHECKED BY ______



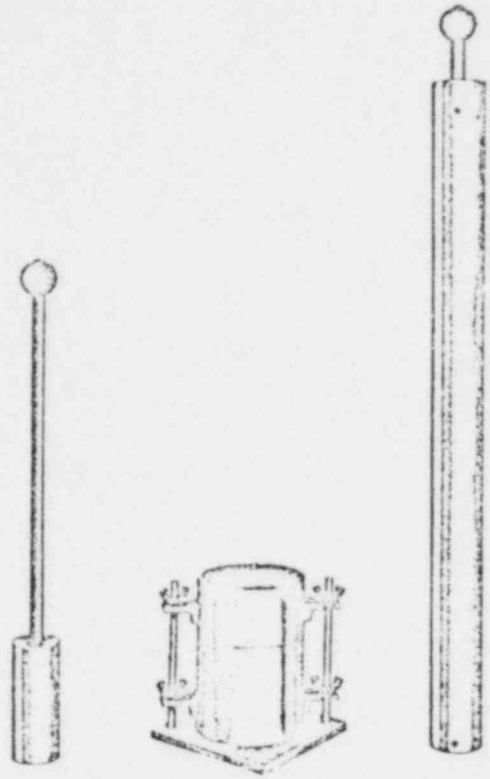
BORING		SOIL TYPE	MOISTURE CONTENT IN PERCENT		DRY DENSITY IN LBS. / CU. FT	SYMBOL
NO	DEPTH		BEFORE	AFTER		
4	4 1'	REDDISH-BROWN CLAYEY SILT WITH TRACE FINE SAND (ML)	8.9	23.2	97	———

CONSOLIDATION TEST DATA

DAMES & MOORE

It has been established that when compacting effort is held constant, the density of a rolled earth fill increases with added moisture until a maximum dry density is obtained at a moisture content termed the "optimum moisture content," after which the dry density decreases. The compaction curve showing the relationship between density and moisture content for a specific compacting effort is determined by experimental methods. Two commonly used methods are described in the following paragraphs.

For the "standard A.A.S.H.O." (A.S.T.M. D698-58T & A.A.S.H.O. T99-57) method of compaction a portion of the soil sample passing the No. 4 sieve is compacted at a specific moisture content in three equal layers in a standard compaction cylinder having a volume of 1/30 cubic foot, using twenty-five 12-inch blows of a standard 5-1/2 pound rammer to compact each layer.



SOME APPARATUS FOR PERFORMING COMPACTION TESTS
Shows, from left to right, 5-1/2 pound rammer (sleeve controlling 12" height of drop removed), 1/30 cubic-foot cylinder with removable collar and base plate, and 10 pound rammer within sleeve.

In the "modified A.A.S.H.O." (A.S.T.M. D-1557-58T & A.A.S.H.O. T 180-57) method of compaction a portion of the soil sample passing the No. 4 sieve is compacted at a specific moisture content in five equal layers in a standard compaction cylinder having a volume of 1/30 cubic foot, using twenty-five 18-inch blows of a 10-pound rammer to compact each layer. Several variations of these compaction testing methods are often used and these are described in A.A.S.H.O. & A.S.T.M. specifications.

For both methods, the wet density of the compacted sample is determined by weighing the known volume of soil; the moisture content, by measuring the loss of weight of a portion of the sample when oven dried; and the dry density, by computing it from the wet density and moisture content. A series of such compactions is performed at increasing moisture contents until a sufficient number of points defining the moisture-density relationship have been obtained to permit the plotting of the compaction curve. The maximum dry density and optimum moisture content for the particular compacting effort are determined from the compaction curve.

METHOD OF PERFORMING COMPACTION TESTS
(STANDARD AND MODIFIED A.A.S.H.O. METHODS)

DAMES & MOORE

PLATE A-6

BY ____ DATE ____ CHECKED BY ____ FILE ____ REVISIONS BY ____ DATE ____

Appendix H, Reference 3

SAMPLE NO. BULK SAMPLE NO. 5 H-32

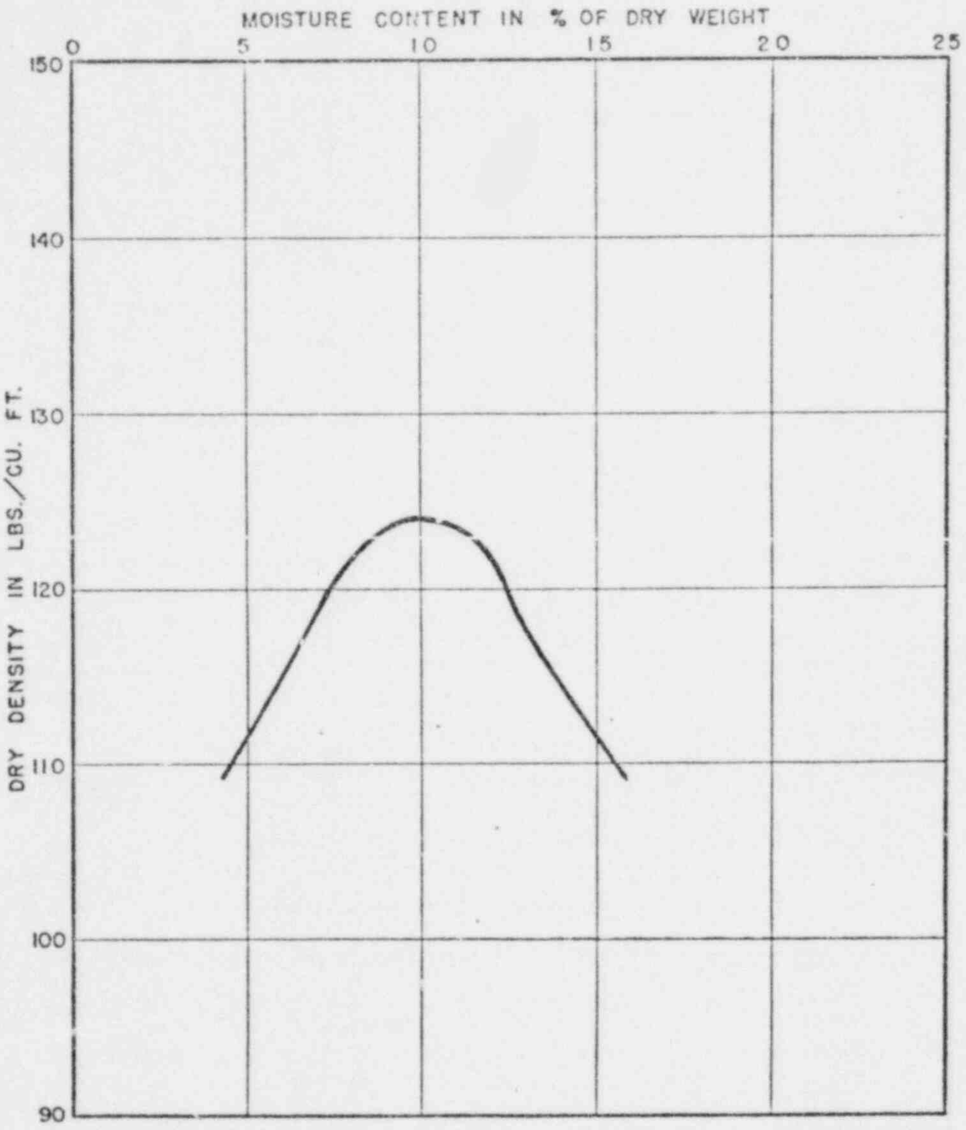
SOIL REDDISH-BROWN CLAYEY SILT WITH FINE SAND (ML-CL)

LOCATION BORROW AREA SOUTH OF POND SITE

OPTIMUM MOISTURE CONTENT 10.0 PERCENT

MAXIMUM DRY DENSITY 124 LBS. PER CUBIC FOOT

METHOD OF COMPACTION A.A.S.H.O. T180



COMPACTION TEST DATA

DRAWN BY ___ DATE ___
CHECKED BY JCK DATE 10/26/73

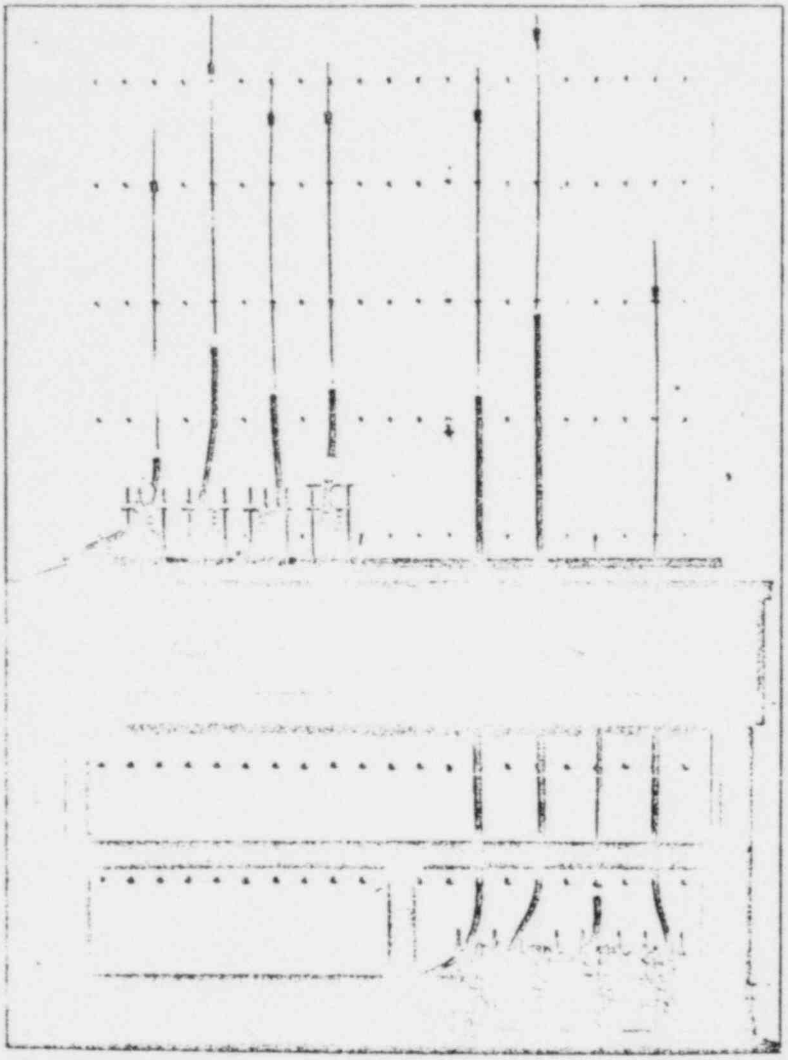
REVISION 2
BY ___
DATE ___

REVISION 1
BY ___
DATE ___

FILE 7144-003
RIO ALGOM

DAMES & MOORE

The quantity and the velocity of flow of water which will escape through an earth structure or percolate through soil are dependent upon the permeability of the earth structure or soil. The permeability of soil has often been calculated by empirical formulas but is best determined by laboratory tests, especially in the case of compacted soils.



APPARATUS FOR PERFORMING PERCOLATIONS TESTS
Shows tests in progress on eight samples simultaneously.

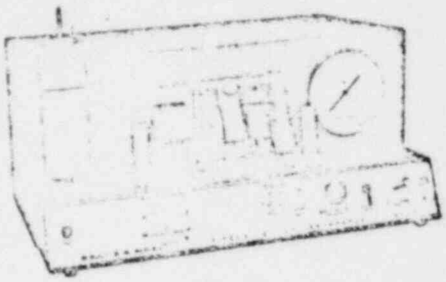
A one-inch length of the core sample is sealed in the percolation apparatus, placed under a confining load, or surcharge pressure, and subjected to the pressure of a known head of water. The percolation rate is computed from the measurements of the volume of water which flows through the sample in a series of time intervals. These rates are usually expressed as the velocity of flow in feet per year under a hydraulic gradient of one and at a temperature of 20 degrees Centigrade. The rate so expressed may be adjusted for any set of conditions involving the same soil by employing established physical laws. Generally, the percolation rate varies over a wide range at the beginning of the test and gradually approaches equilibrium as the test progresses.

During the performance of the test, continuous readings of the deflection of the sample are taken by means of micrometer dial gauges. The amount of compression or expansion, expressed as a percentage of the original length of the sample, is a valuable indication of the compression of the soil which will occur under the action of load or the expansion of the soil as saturation takes place.

METHOD OF PERFORMING PERCOLATION TESTS

CHECKED BY ______ FILE ______ BY ______ DATE ______

Direct shear tests are performed to determine the shearing strengths of soils. Friction tests are performed to determine the frictional resistances between soils and various other materials such as wood, steel, or concrete. The tests are performed in the laboratory to simulate anticipated field conditions.



DIRECT SHEAR TESTING & RECORDING APPARATUS

Each sample is tested within three brass rings, two and one-half inches in diameter and one inch in length. Undisturbed samples of in-place soils are tested in rings taken from the sampling device in which the samples were obtained. Loose samples of soils to be used in constructing earth fills are compacted in rings to predetermined conditions and tested.

Direct Shear Tests

A three-inch length of the sample is tested in direct double shear. A constant pressure, appropriate to the conditions of the problem for which the test is being performed, is applied normal to the ends of the sample through porous stones. A shearing failure of the sample is caused by moving the center ring in a direction perpendicular to the axis of the sample. Transverse movement of the outer rings is prevented.

The shearing failure may be accomplished by applying to the center ring either a constant rate of load, a constant rate of deflection, or increments of load or deflection. In each case, the shearing load and the deflections in both the axial and transverse directions are recorded and plotted. The shearing strength of the soil is determined from the resulting load-deflection curves.

Friction Tests

In order to determine the frictional resistance between soil and the surfaces of various materials, the center ring of soil in the direct shear test is replaced by a disk of the material to be tested. The test is then performed in the same manner as the direct shear test by forcing the disk of material from the soil surfaces.

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DAMES & MOORE

REVISIONS BY ____ DATE ____

FILE ____

BY ____ DATE ____ CHECKED BY ____

940.7 (REV. 6-61)

APPENDIX I

1. Application For Permit to Discharge or Work in Navigable Waters and Their Tributaries.

FORM APPROVED
OMB NO. 49-R 0408

DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

APPLICATION FOR PERMIT TO DISCHARGE OR WORK IN NAVIGABLE WATERS AND THEIR TRIBUTARIES

SECTION I. GENERAL INFORMATION

1. State: Utah

Application Number (to be assigned by Corps of Engineers)
Div. ___ Dist. ___ Type ___ Sequence No. ___

2. Name of applicant and title of signing official: RIO ALGOM CORPORATION
G. R. Albino, Vice-President

3. Mailing address of applicant:
Head Office: 120 Adelaide Street West,
Toronto 110,
Ontario, Canada.
Area Office: P.O. Box 610,
Moab, Utah, 84532.

4. Name, address, telephone number and title of applicant's authorized agent for permit application coordination and correspondance.
P.F. Pullen, Chief Environmental Engineer,
Rio Algom Mines Limited,
120 Adelaide Street West,
Toronto 110, Ontario, Canada.

NOTE TO APPLICANT: Refer to the pamphlet entitled "Permits for Work and Structures in and for Discharges or Deposits into Navigable Waters" before attempting to complete this form.

Required Information

a. All information contained in this application will, upon request, be made available to the public for inspection and copying. A separate sheet entitled "Confidential Answers" must be used to set out information which is considered by the applicant to constitute trade secrets or commercial or financial information of a confidential nature. The information must clearly indicate the item number to which it applies. Confidential treatment can be considered only for that information for which a specific written request of confidentiality has been made on the attached sheet. However, in no event will identification of the contents and frequency of a discharge be recognized as confidential or privileged information.

b. The applicant shall furnish such supplementary information as is required by the District Engineer in order to evaluate fully an application.

c. If additional space is needed for a complete response to any item on this form, attach a sheet entitled "Additional Information." Indicate on that sheet the item numbers to which answers apply.

d. Drawings required by items 20 and 21 should be attached to this application. Other papers which must be attached to this application include, if applicable, copies of a water quality certification or a written communication which describes water quality impact (see Item 22 and Item 10 of Section II below), the additional information sheet(s) in "c" above, and the confidential information sheet described in "a" above.

Fees

If any discharge or deposit is involved, an application fee of $100 must be submitted with this application. An additional $50 is required for each additional point of discharge or deposit.

Signature

a. If a discharge is involved, an application submitted by a corporation must be signed by the principal executive officer of that corporation or by an official of the rank of corporate vice president or above who reports directly to such principal executive officer and who has been designated by the principal executive officer to make such applications on behalf of the corporation. In the case of a partnership or a sole proprietorship, the application must be signed by a general partner or the proprietor. Other signature requirements are discussed in the pamphlet.

b. If no discharge is involved, an application may be signed by the applicant or his authorized agent.

Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate.

G R Albino
Signature of Applicant

18 U.S.C. Section 1001 provides that:

Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and wilfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

FOR CORPS OF ENGINEERS USE ONLY

Acronym name of applicant ______

Date received, form not complete __ __ / __ __ / __ __
Date received, form complete but without certificate __ __ / __ __ / __ __
Date received, form complete __ __ / __ __ / __ __
Date of Cert./Ltr. __ __ / __ __ / __ __
day mo yr

Are discharge structures
Major? ☐ Minor? ☐ N/A? ☐

Date sent to EPA, form not complete __ __ / __ __ / __ __
Date sent to EPA, NOAA, D/I, AEC, FFC in complete form __ __ / __ __ / __ __
day mo yr

5. Date August 10 1971 mo day yr	(Office use only)
6. Check type of application: a. Original [X] b. Revision [ ]	7. Number of original application 001

8. Name of facility where discharge or construction will occur.

Utah Project

9. Full mailing address of facility named in item 8 above.

Rio Algom Corporation,
P.O. Box 610,
Moab, Utah 84532.

10. Names and mailing addresses of all adjoining property owners whose property also adjoins the waterway.

See attached Figure 4.

11. Check to indicate the nature of the proposed activity:

a. Dredging [ ] b. Construction [ ] c. Construction with Discharge [ ] b. Discharge only [X]

12. If activity is temporary in nature, estimate its duration in months.

Possibly continuing for expected 8 year life of the mine.

If application is for a discharge:

13. List intake sources

Source	Estimated Volume in Million Gallons Per day or Fraction Thereof	
Municipal or private water supply system		
Surface water body		(.21 well field
Ground water	0.38	(.17 mine water
Other		

14. Describe water usage within the plant

Type	Estimated Volume in Million Gallons Per day or Fraction Thereof
Cooling water	
Boiler Feed water	.02
Process water	.04
Sanitary system*	.03
Other	

15. List volume of discharges or losses other than into navigable waters.

Type	Estimated Volume in Million Gallons Per day or Fraction Thereof
Municipal waste treatment system	
Surface containment	
Underground disposal	
Waste Acceptance firms	
Evaporation	0.12
Consumption	

* Indicate number employees served per day 160

Note: All above volumes are estimates only of future volumes.

If structures exist, or dredging, filling or other construction will occur, the precise location of the activity must be described.

(Office use only)

a. Name the corporate boundaries within which the structures exist or the activity will occur.

16. State: Utah   17. County: San Juan   18. City or Town: Tsp 29S Range 24E

b. Name of waterway at the location of the activity

19. West Coyote Wash

20. Maps and sketches which show the location and character of each structure or activity, including any and all outfall devices, dispersive devices, and non-structural points of discharge, must be attached to this application. Figures 1, 2, 3 & 4

21. For construction or work in navigable waters for which a separate permit is sought under 33 U.S.C. 403, the character of each structure must be fully shown on detailed plans to be submitted with this application. Note on the drawings those structures for which separate discharge information (Section II of this form) has been submitted.

22. List all approvals or denials granted by Federal, interstate, State or local agencies for any structures, construction, discharges or deposits described in this application.

Type of document	Id. No.	Date	Issuing Agency
Letter attached	Appendix A	13 July 1970	C. K. Sudweeks, Utah Water Pollution Committee, Bureau of Environmental Health, Salt Lake City

23. Check if facility existed or was lawfully under construction prior to April 3, 1970. [X]

24. If dredging or filling will occur:

State the type of materials involved, their volume in cubic yards, and the proposed method of measurement.

N/A

25. Describe the proposed method of instrumentation which will be used to measure the volume of any solids which may be deposited and to determine its effect upon the waterway.

N/A

26. State rates and periods of deposition described in Item 25.

N/A

SECTION II. PLANT PROCESS AND DISCHARGE DESCRIPTION

1. Discharge described below is
   a. Present [X]
   b. Proposed new or changed [ ]

2. Implementation schedule [ ]

(Office use only)

Name of corporate boundaries within which the point of discharge is located.

3. State: Utah
4. County: San Juan
5. City or Town: Tsp 29S Range 24E

6. Discharge Serial No. 001

State the precise location of the point of discharge.

7. Latitude 38 Degrees; 15 Min; 20 Sec.
8. Longitude 109 Degrees; 15 Min; 50 Sec.

9. Name of waterway at the point of discharge.
West Coyote Wash
(La Sal Junction Quadrangle, USGS
N3815 - W10915/15)

10. Has application for water quality certification or description of impact been made? If so, give date:

Date: __ __ __ (mo day yr)

Check if certificate is attached to form [ ]

Name Issuing Agency: Not made

11. Narrative description of activity (include terms of general 4-digit Standard Industrial Classification, and specific manufacturing process).

Disposal of mine and shaft seepage water pumped to surface.

12. Standard industrial classification number.
SIC 10-14

13. Principal product.
Uranium ore

14. Amount of principal product produced per day.
500 tons/day milled

15. Principal raw material.

16. Amount of principal raw material consumed per day.

17. Number of batch discharges per day.
Pump discharge as required.

18. Average gallons per batch discharge.
Mine seepage variable.

19. Date discharge began.
March 3 71 (mo day yr)

20. Date discharge will begin.
__ __ __ (mo day yr)

21. Describe waste abatement practices.

See attached, Appendix B.

22. PHYSICAL DESCRIPTION OF INTAKE WATER AND DISCHARGE

Intake / Discharge (Office use only)

Discharge Serial No. 001

Parameter and (Code)	UNTREATED INTAKE WATER (1)	TREATED INTAKE WATER (2)	AVERAGE (DAILY) (3)	MINIMUM (OPERATING YEAR) (4)	MAXIMUM (OPERATING YEAR) (5)	SAMPLE FREQUENCY (6)	CONTINUOUS MONITORING (7)
Flow (Gallons per ~~day~~ min.) 00058	up to 200		150	120	1200	Monthly	ABS
pH 00400	7.4 to 7.7		7.8	?	?	Occasional	ABS
Temperature (Winter) (°F) 74028	51° to 57° F.		Approx. 75°	?	?	Occasional	ABS
Temperature (Summer) (°F) 74027	?		Approx. 75°	?	?	Occasional	ABS

23. DISCHARGE CONTENTS

PARAMETER	PRESENT	ABSENT	PARAMETER	PRESENT	ABSENT	PARAMETER	PRESENT	ABSENT
Color 00080			Aluminum 01105		X	Nickel 01067	?	
Turbidity 00070	X		Antimony 01097		X	Selenium 01147		X
Radioactivity 74050	X		Arsenic 01002		X	Silver 01077		X
Hardness 00900	X		Beryllium 01012		X	Potassium 00937	X	
Solids 00500	X		Barium 01007		X	Sodium 00929	X	
Ammonia 00610		X	Boron 01022	?		Titanium 01152	?	
Organic Nitrogen 00605		X	Cadmium 01027		X	Tin 01102	?	
Nitrate 00620	X		Calcium 00916	X		Zinc 01092	X	
Nitrite 00615 No analysis yet			Cobalt 01037	?		Algicides 74051		X
Phosphorus 00665	X		Chromium 01034		X	Oil and Grease 00550	?	
Sulfate 00945	X		Copper 01042		X	Phenols 32730		X
Sulfide 00745		X	Iron 01045	X		Surfactants 38260		X
Sulfite 00740	?		Lead 01051		X	Chlorinated Hydrocarbons 74052		X
Bromide 71870	?		Magnesium 00927	X		Pesticides 74053		X
Chloride 00940	X		Manganese 01055		X	Fecal Streptococci Bacteria 74054	?	
Cyanide 00720		X	Mercury 71900	?		Coliform Bacteria 74056	?	
Fluoride 00951	X		Molybdenum 01062	?				

H

24a. Have all known hazardous or potentially hazardous substances in your plant been inventoried?

☐ Yes ☒ No

24b. If yes, have steps been taken to insure that there exists no possibility of any such known hazardous or potentially hazardous substance entering this discharge?

☐ Yes ☐ No

25. Remarks.

See attached, Appendix B.

The information above completes the basic reporting requirements which are required of all applicants. Those applicants whose discharge results from an activity included within any of the Standard Industrial Classification Code (SIC Code) categories listed below must complete Part A of this form as well.

CRITICAL INDUSTRIAL GROUPS

SIC	098	FISH HATCHERIES, FARMS, AND PRESERVES
SIC	10-14	DIVISION B – MINING
SIC	201	MEAT PRODUCTS
SIC	202	DAIRY PRODUCTS
SIC	203	CANNED PRESERVED FRUITS, VEGETABLES (EXCEPT SEAFOODS, SIC 2031 AND 2036)
SIC	2031, 2036	CANNED AND CURED FISH AND SEAFOODS; FRESH OR FROZEN PACKAGED FISH AND SEAFOODS
SIC	204	GRAIN MILL PRODUCTS
SIC	206	SUGAR
SIC	207	CONFECTIONARY AND RELATED PRODUCTS
SIC	208	BEVERAGES
SIC	209	MISCELLANEOUS FOOD PREPARATIONS AND KINDRED PRODUCTS
SIC	22	TEXTILE MILL PRODUCTS
SIC	23	APPAREL AND OTHER FINISHED PRODUCTS MADE FROM FABRICS AND SIMILAR MATERIALS
SIC	242	SAWMILLS AND PLANING MILLS
SIC	2432	VENEER AND PLYWOOD
SIC	2491	WOOD PRESERVING
SIC	26	PAPER AND ALLIED PRODUCTS
SIC	281	INDUSTRIAL INORGANIC AND ORGANIC CHEMICALS (EXCEPT SIC 2818)
SIC	2818	INDUSTRIAL ORGANIC CHEMICALS
SIC	282	PLASTICS MATERIALS AND SYNTHETIC RESINS, SYNTHETIC RUBBER, SYNTHETIC AND OTHER MAN-MADE FIBERS, EXCEPT GLASS
SIC	283	DRUGS
SIC	284	SOAP, DETERGENTS AND CLEANING PREPARATIONS, PERFUMES, COSMETICS, AND OTHER TOILET PREPARATIONS
SIC	285	PAINTS, VARNISHES, LACQUERS, ENAMELS, AND ALLIED PRODUCTS
SIC	2871	FERTILIZERS
SIC	2879	AGRICULTURAL PESTICIDES, AND OTHER AGRICULTURAL CHEMICALS, NOT ELSEWHERE CLASSIFIED
SIC	2891	ADHESIVES AND GELATIN
SIC	2892	EXPLOSIVES
SIC	29	PETROLEUM REFINING AND RELATED INDUSTRIES
SIC	3011, 3069	TIRES AND INNER TUBES; FABRICATED RUBBER PRODUCTS, NOT ELSEWHERE CLASSIFIED
SIC	3079	MISCELLANEOUS PLASTICS PRODUCTS
SIC	311	LEATHER TANNING AND FINISHING
SIC	32	STONE, CLAY, GLASS, AND CONCRETE PRODUCTS
SIC	331	BLAST FURNACES, STEEL WORKS, AND ROLLING AND FINISHING MILLS
SIC	332	IRON AND STEEL FOUNDRIES
SIC	333, 334	PRIMARY SMELTING AND REFINING OF NONFERROUS METALS; SECONDARY SMELTING AND REFINING OF NONFERROUS METALS
SIC	336	NONFERROUS FOUNDRIES
SIC	347	COATING, ENGRAVING, AND ALLIED SERVICES
SIC	35	MACHINERY, EXCEPT ELECTRICAL
SIC	36	ELECTRICAL MACHINERY, EQUIPMENT, AND SUPPLIES
SIC	37	TRANSPORTATION EQUIPMENT (EXCEPT SHIP BUILDING AND REPAIRING, SIC 3731)
SIC	3731	SHIP BUILDING AND REPAIRING
SIC	491	ELECTRIC COMPANIES AND SYSTEMS
SIC	493	COMBINATION COMPANIES AND SYSTEMS

PART A

(Note: Submission of Part A is required of all applicants whose processes are listed on page 3 above.)

(Office use only)

Discharge Serial No. 001

INFORMATION REQUIRED OF SPECIFIED INDUSTRIES

PARAMETER AND CODE	Intake: (DAILY AVG. CONCENTRATION) UNTREATED INTAKE WATER (1)	Intake: (DAILY AVG. CONCENTRATION) TREATED INTAKE WATER (2)	Discharge: MAXIMUM CONCENTRATION (3)	MAXIMUM POUNDS PER DAY PER PROCESS UNIT (4)	MAXIMUM POUNDS PER DAY (5)	DAILY AVG CONCENTRATION Mg/l (6)	AVERAGE POUNDS PER DAY (7)	SAMPLE TYPE (8)	SAMPLE FREQUENCY (9)	METHOD OF ANALYSIS (10)	CONTINUOUS MONITORING (11)
ALKALINITY (as $CaCO_3$) 00410	-	-	390	Production rate will vary from 0 at present to 750 tpd in one year.		(3) 368		AVR	OTHR		ABS
B.O.D. 5-DAY 00310	-	-	?					-			
CHEMICAL OXYGEN DEMAND (C.O.D.) 00340	-	-	?					-			
TOTAL SOLIDS 00500	-	-	3706			(4) 3049		AVR	OTHR		ABS
TOTAL DISSOLVED SOLIDS 70300	-	-	?			(1) 2927		AVR	OTHR		ABS
TOTAL SUSPENDED SOLIDS 00530	-	-	?			122		AVR	OTHR		ABS
TOTAL VOLATILE SOLIDS 00505	-	-	-			-		-			
AMMONIA (as N) 00610	-	-	-1.0			(2) -1.0		AVR	OTHR		ABS
KJELDAHL NITROGEN 00625	-	-	-			-		-			
NITRATE (as N) ~~00630~~ (NO_3)	-	-	39.6			(2) 21.3		AVR	OTHR		ABS
PHOSPHORUS TOTAL (as P) ~~00665~~ (PO_4)	-	-	.15			(2) .08		AVR	OTHR		ABS

APPENDIX J

1. Letter from State of Utah - Department of Social Services, Division of Health to Rio Algom dated October 15, 1971 granting authorization to proceed with installation of dust control systems.

STATE OF UTAH—DEPARTMENT OF SOCIAL SERVICES

DIVISION OF HEALTH
44 MEDICAL DRIVE
SALT LAKE CITY, UTAH 84113
AREA CODE 801
328-6121

LYMAN J. OLSEN, M.D., M.P.H.
Director of Health

October 15, 1971

Mr. P. F. Pullen
Chief Environmental Engineer
Rio Algom Mines Limited
120 Adelaide Street
West Toronto 110 CANADA

Dear Mr. Pullen:

Receipt of the following reports, plans, and specifications relative to dust control systems for Rio Algom's Moab operation is acknowledged.

Submitted in person on July 15, 1971 were:

1. Draft copy of Applicants Environmental Report -- Operating License Stage, Rio Algom Corporation, Moab, Utah, July 9, 1971.

2. Drawing No. 109-90-08, General Arrangement Skip Loading Dust Collection System.

3. Drawing No. 109-12-0', General Arrangement Hoist Tower Dust Collection System.

4. Drawing No. 109-16-03, General Arrangement Transfer House Dust Collection System.

5. Drawing No. 109-16-04, Crusher House Dust Collection System.

6. Drawing No. 109-71-403, Power House Arrangement and Details Boiler Flues and Stack.

Received August 9, 1971 with your covering letter of August 4, 1971:

1. Drawing No. 109-16-02, General Arrangement Crusher House.

2. Specifications for four fabric filter dust collectors. One for each system: Skip Dump, Skip Loading Pocket, Transfer House, Crushing Plant.

Authorization to proceed with installation of the dust control systems and the heating plant in accordance with the plans and specifications submitted to and reviewed by this office is hereby granted.

We commend Rio Algom Corporation for its cooperation with this office and for the thought and effort extended to date to make certain its Utah operation will be in full compliance with governmental rules and regulations.

Sincerely yours,

Casper A. Nelson

Casper A. Nelson
Industrial Hygienist

Approved:

Grant S. Winn

Grant S. Winn, Ph.D., Chief
Air Quality Section

APPENDIX K

1. Letter from State of Utah, Department of Social Services, Division of Health, to Rio Algom Corporation dated July 13, 1970, granting a construction permit for Tailings Disposal Dam and Related Facilities.

K-2

STATE OF UTAH — DEPARTMENT OF SOCIAL SERVICES

DIVISION OF HEALTH

328-6121
July 13, 1970

Rio Algom Corporation
P. O. Box 610
Moab, Utah 84532

Re: Construction Permit, Tailings Disposal Dam & Related Facilities-Lisbon Valley Uranium Mill

Gentlemen:

We are in receipt and have reviewed the following itemized drawings and supporting information which you submitted relating to proposed tailings disposal facilities for your proposed uranium mill to be located in the Lisbon Valley approximately 3 miles south of LaSal, Utah.

1. One copy of Drawing 109-52-02, Tailings Disposal Site Plan.
2. One copy of Drawing 109-52-03, Tailings Disposal Dams and Test Holes Sections.
3. An Engineering Report prepared by your Toronto Engineer Department.
4. A Report on Subsoil Investigations by Woodward, Clyde and Associates.
5. A Drill Core Report of the shaft hole H-69.
6. A Report of "Analysis of Data from Test Holes at Humeca Ore Body", by the Water Development Corporation.

On the basis of our review of the above itemized information, a construction permit is hereby issued for the tailings disposal dam and related facilities, subject to the following condition:

Your proposal for disposal of possible excess water in a deep well is not acceptable. Therefore, should you find it necessary to dispose of excess water, further negotiations with the Utah Water Pollution Committee will be required to arrive at an acceptable solution.

We appreciate your cooperation in this matter and the thorough and efficient manner in which you are working out the critical details of this proposed operation.

Sincerely yours,

UTAH WATER POLLUTION COMMITTEE

Calvin K. Sudweeks
Executive Secretary

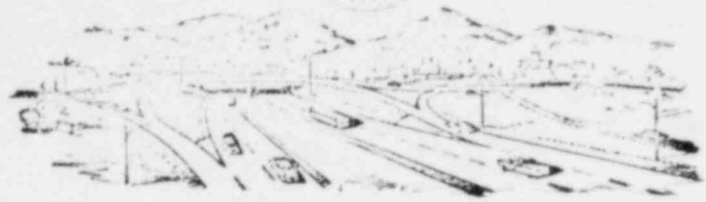
APPENDIX L

1. Letter from Utah State Department of Highways, dated June 14, 1973 commenting on the tailings dam and highway system.

Appendix L, Reference 1

L-2

DIRECTOR
HENRY C. HELLAND



STATE HIGHWAY ENGINEER
BLAINE J. KAY

ADDRESS REPLY TO
DISTRICT ENGINEER

Utah State Department of Highways
Price, Utah

JAMES L. DEATON
DISTRICT ENGINEER

June 14, 1973

Mr. P. E. Pullen, P.E.
Chief Environmental Engineer
Rio Algom
Rio Tinto
120 Adelaide Street
West Toronto, Canada

Dear Mr. Pullen:

I am in the receipt of your May 30, 1973, letter pertinent to the proposed mining operations in San Juan County. I can see no problem that would impact the Highway system or the highway user.

The safety feature designed into the dam seem adequate in the event of leekage or a break, the present land contour would fan or spread the water over a wide area resulting in little or no damage to the State Highway system.

Yours truly,

James L. Deaton

James L. Deaton
District Engineer

JLD/ajs

cc: C. V. Anderson, P. E. State Highway Engineer
Sam Taylor, Commissioner
LaVar Hamilton, Design Engineer

"safe today – alive tomorrow"

APPENDIX M

1. Utah Project, Tailings Disposal, Engineering Report, dated June 25, 1970

UTAH PROJECT
TAILINGS DISPOSAL
Engineering Report

PREPARED FOR PRESENTATION TO

THE UTAH STATE DIVISION OF HEALTH

SALT LAKE CITY

Engineering Department
Rio Algom Mines Limited
TORONTO, Ontario

June 25, 1970

Utah Project

TAILING DISPOSAL REPORT

Table of Contents

		Page
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2.0	Design Considerations and Construction Program	2
	2.1 Dam.	3
	2.2 Recirculation of pond water.	5
	2.3 Excess water and evaporation.	6
	2.4 Deep well decant system.	6
	2.5 Monitoring well	7
	2.6 Stabilization and rehabi[illegible]tion.	8
3.0	Estimate	9
4.0	Drawing List	10
5.0	Appendices	11

Utah Project

TAILINGS DISPOSAL

1.0 Summary

The uranium mill of [illegible] Algom Corporation, located in the Lisbon Valley approximately 3 miles south of La Sal, Utah, is scheduled to commence operation in March 1972. The projected annual milling rate will be 175,000 tons.

Tailings will be placed in a natural basin adjacent to the mill. At the west end of the disposal area, a dam having an ultimate length of 1,600 feet will be constructed to impound the tailings. It is intended to build the dam to elevation 6,630 feet, a maximum height of 40 feet during 1970 and to raise it approximatel 3 feet per year after 1974. Present ore reserves would take the tailings pond elevation to 6,645 feet after ten years.

Construction of the dam is scheduled to commence during 1970 since it will take one year for the water to rise to elevation 6,620 in the pond During operation up to 70% of the process water will be recirculated between the tailings pond and the mill.

It is expected that all or most of the water accumulating in the pond will be evaporated. However, provision has been made in the estimate for the drilling of a deep well down to the porous

Navajo formation to dispose of excess water.

At the end of mining operations, the tailings dam wall will be stabilized and the tailings disposal area will be rehabilitated. This will be done by seeding and fertilizing.

2.0 Design Considerations and Construction Program.

2.1 Dam

The dam will reach elevation 6,655 feet at the end of the mining operation. During 1970 it is intended to build the dam up to elevation 6,630 feet, a maximum height of 40 feet and a crest length of 1,450 feet.

Woodward, Clyde and Associates, Consulting Soils Engineers, carried out a subsoil investigation at the site of the proposed dam during 1969 and submitted a report on the foundation and on the method of constructing the dam. A copy of their report is enclosed.

The Woodward, Clyde and Associates report concludes the following:-

a) The subsoils beneath the proposed tailings dam consist of loose to medium dense; silty sands and stiff to very stiff sandy clays over hard sandstone bedrock at depth 2.0 to 18.0 feet No free water was encountered.
b) The foundation soils and the sandstone will provide adequate support for the dam.
c) There is ample, suitable borrow material within the tailings pond area to construct the proposed dam.
d) The natural soils in the reservoir area possess sufficient fines to be relatively impervious.

Since a layer of silty sand covers clay and rock, a cut off trench of ten feet wide will be excavated down to the clay formation or to rock whichever is encountered first. The trench will be filled with compacted clay soil. At each abutment, the rock will be exposed and cleaned for a length of 150 feet by 10 feet wide minimum and filled with selected clay soil. If the exposed rock at the abutment is fractured, it will be excavated down to firm rock.

The dam will be constructed from the natural soils from the reservoir area. The selected clay materials from the borrow pits will be placed in the middle of the dam to form an impervious core of 10-20 feet wide. The sands and silty sands will be placed on each side. The coarse sands formation encountered in borrow pits will be placed on the downstream side of the embankment to act as a toe drain. The downstream slope of the embankment will be 2.5:1 and the upstream slope 2:1.

The embankment will be built in horizontal layers having a thickness of not more than 8 inches prior to being compacted. The material will be compacted at optimum moisture content. Moistening of the material will be performed at the site of the excavation and will be supplemented if required by sprinkling on the embankment. Each layer will be compacted to 95% of maximum density.

The seepage through the dam and foundation was calculated to be in the order of 1 - 5 gallons per minute. This is assuming a coefficient of permeability of 10^{-4}cm/sec for the silty sand and

10^{-6}cm/sec for the clay core. Since tailings will be spigotted into the pond from the upstream face of the dam and since a large portion of the tailings sand is finer than 200 mesh, seepage will be reduced by the placing of the tailings all along the upstream face of the dam.

It is expected that no appreciable pollution will be created from seepage through and under the dam. Should a high concentration of radioactive material be recorded in the monitoring well and/or a larger seepage than expected occur, then a trench will be excavated down to bedrock to intercept the seepage downstream fro the dam. The seepage water will be pumped back into the tailings pond from a sump excavated into rock at the low point of the ditch.

2.2 Recirculation of pond water

Used water will be pumped from the tailings pond to the mill at approximately 80 gallons per minute. A floating pumphouse will be provided for this purpose.

The dam construction is scheduled for 1970 because it will take approximately one year to fill the pond up to elevation 6,620 feet at a constant inflow of 150 gallons per minute.

2.3 Excess water.

The surface area of the pond will be 16 acres at elevation 6,620 feet. Using an evaporation rate of 55 inches per year, the average evaporation will be 35 gallons per minute over the year.

Therefore we can assume that 35 gallons per minute of excess water will be disposed of by evaporation. The amount of excess water which will be generated by the plant is not known at the present time. Therefore provision has been made in the estimate for the drilling of a deep well to dispose of excess water in the case that it exceeds 35 gpm.

2.4 Deep well decant system

If required, a well will be drilled down to the porous Navajo formation to dispose of excess water. The total depth of the well would be 1,400 feet to provide a section of 200 feet into the Navajo formation. The top 1,200 feet would be cased with 6" solid casing and the bottom 200 feet with 6" perforated casing. It is expected that a quantity of 100 gpm could be absorbed easily by the well since the pressure created by the high column of water would be as high as 500 lbs. if necessary. During the sinking of the production shaft, approximately 2,000 feet from the proposed well, free water was encountered in the Navajo formation at 1,200 feet below surface. The water was sealed in the shaft walls by cement grouting in holes at a pressure of less than 200 lbs.

The water discharged into this well will not contaminate the sources of water in Lisbon Valley because the irrigation and potable water wells of the area are less than 300 feet deep into a different rock formation.

2.5 Monitoring well.

A monitoring well will be provided approximately 400 feet downstream from the dam for the purpose of obtaining water samples of ground water. The well will extend 30 feet into bedrock. The drilled hole will be cased with an 18" casing. After the soil is washed out inside the casing, a 6" well pipe consisting of a screen and riser will be lowered in the casing and properly aligned. The sand filter will be placed between the screen and casing in 8" layers and the casing withdrawn a like amount. This process will be repeated until 6 feet below the collar. The casing will be completely withdrawn and impervious backfill or concrete will be placed around the riser pipe for the top six feet.

2.6 Slope Stabilization and rehabilitation

The dam will have a downstream slope of 2.5:1. The slope will be protected against erosion by planting grasses suitable for the locality.

At the end of the mining operation the tailings disposal area will be rehabilitated. The tailings sand will be planted with appropriate vegetation. It will not be neccessary to provide a spillway over the dam since the evaporation will exceed the inflow from the 590 acres watershed.

3.0 Estimate

Item	Description	Estimated Cost
1	Dam Construction	86,500
2	Deep Well Decant System	16,400
3	Monitoring Well	4,000
4	Downstream Trench and Piping	9,000
5	Floating Pumphouse, reclaim pumps, tailings pumps	22,750
6	Piping, Tailings line and reclaim water lines	70,400
7	Electrics, pump motors and controls	21,100
8	Transmission line	20,750
	Sub Total	250,900
	Contingencies	~~24,100~~
	Grand Total	$275,000

4.0 Drawings List

109-52-02	TAILINGS DISPOSAL SITE PLAN
109-52-03	TAILINGS DISPOSAL DAM AND TEST HOLES SECTIONS

5.0 Appendices.

A - Graph showing the tailings basin area vs the ground contour elevation.

B - Graph showing the capacity of the basin vs the average elevation of the tailings.

C - Graph showing the average elevation of the tailings vs calendar years

D - Graph showing excess water evaporation vs water surface area.

APPENDIX A

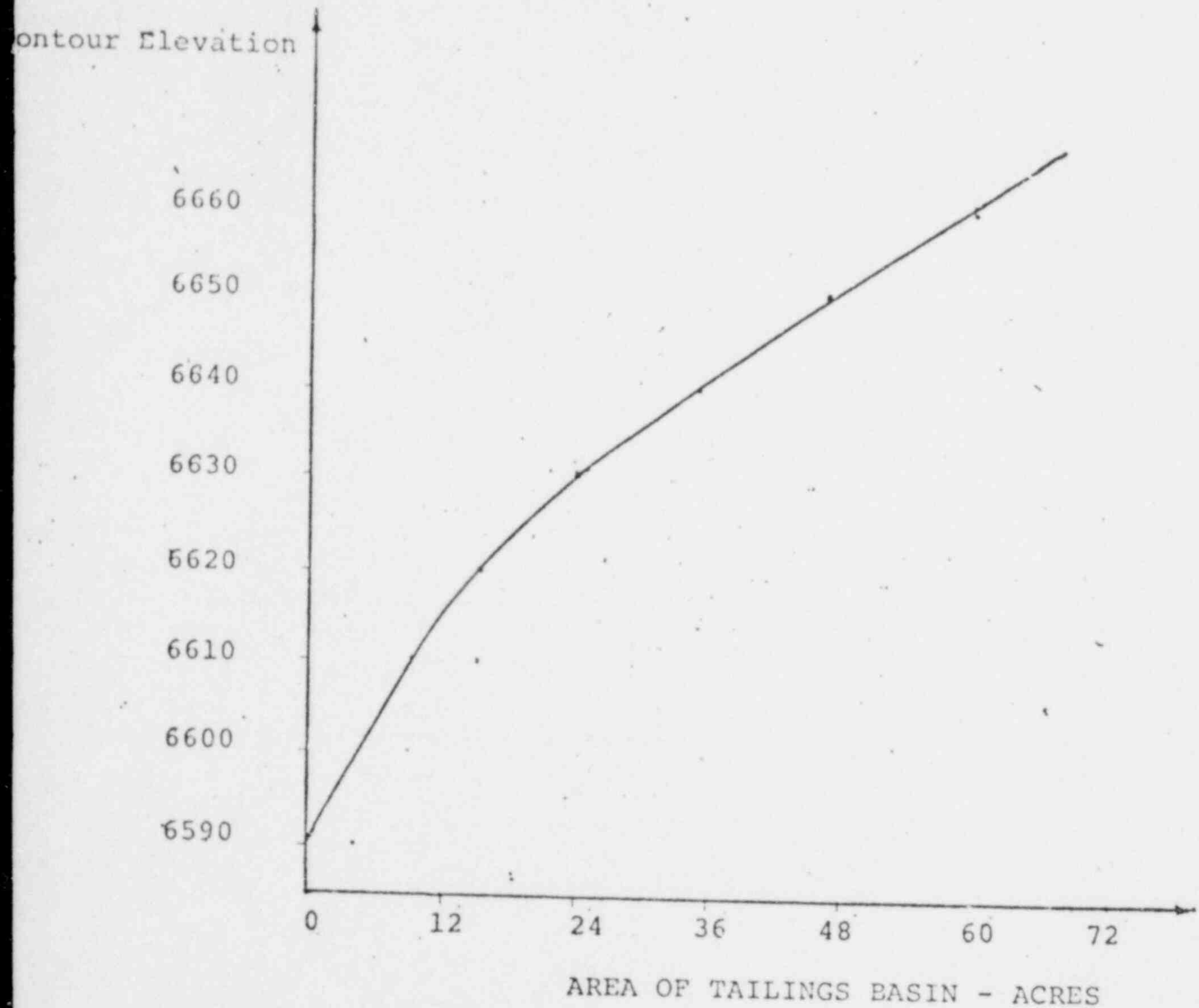
DATE: June 1970

UTAH PROJECT

Appendix M, Reference 1
M-15

TAILINGS DISPOSAL

AREA OF DISPOSAL BASIN VS. GROUND CONTOUR ELEVATION

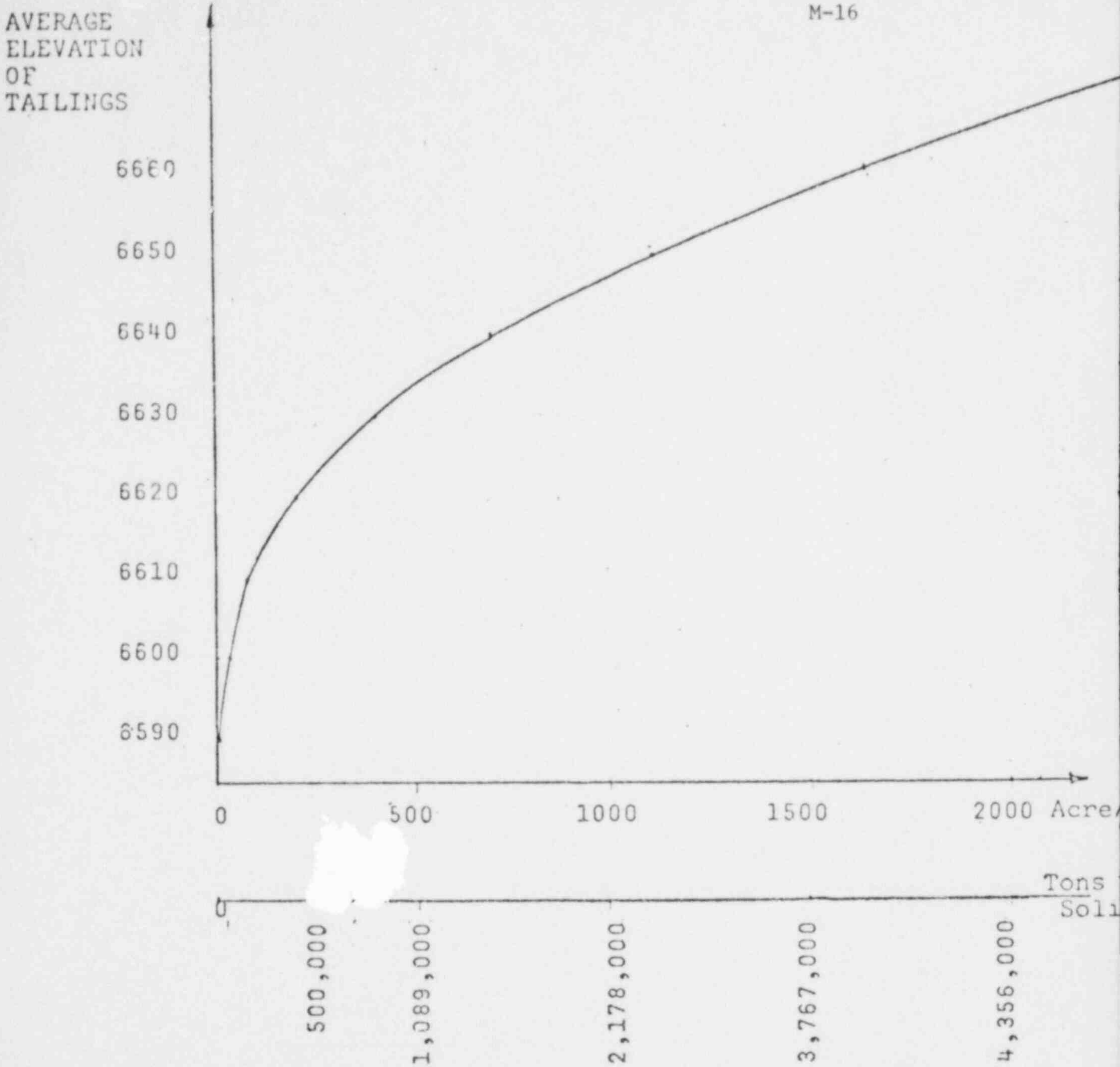


APPENDIX B

CAPACITY OF TAILINGS BASIN VERSUS AVERAGE ELEVATION OF TAILINGS

Appendix M, Reference 1

M-16

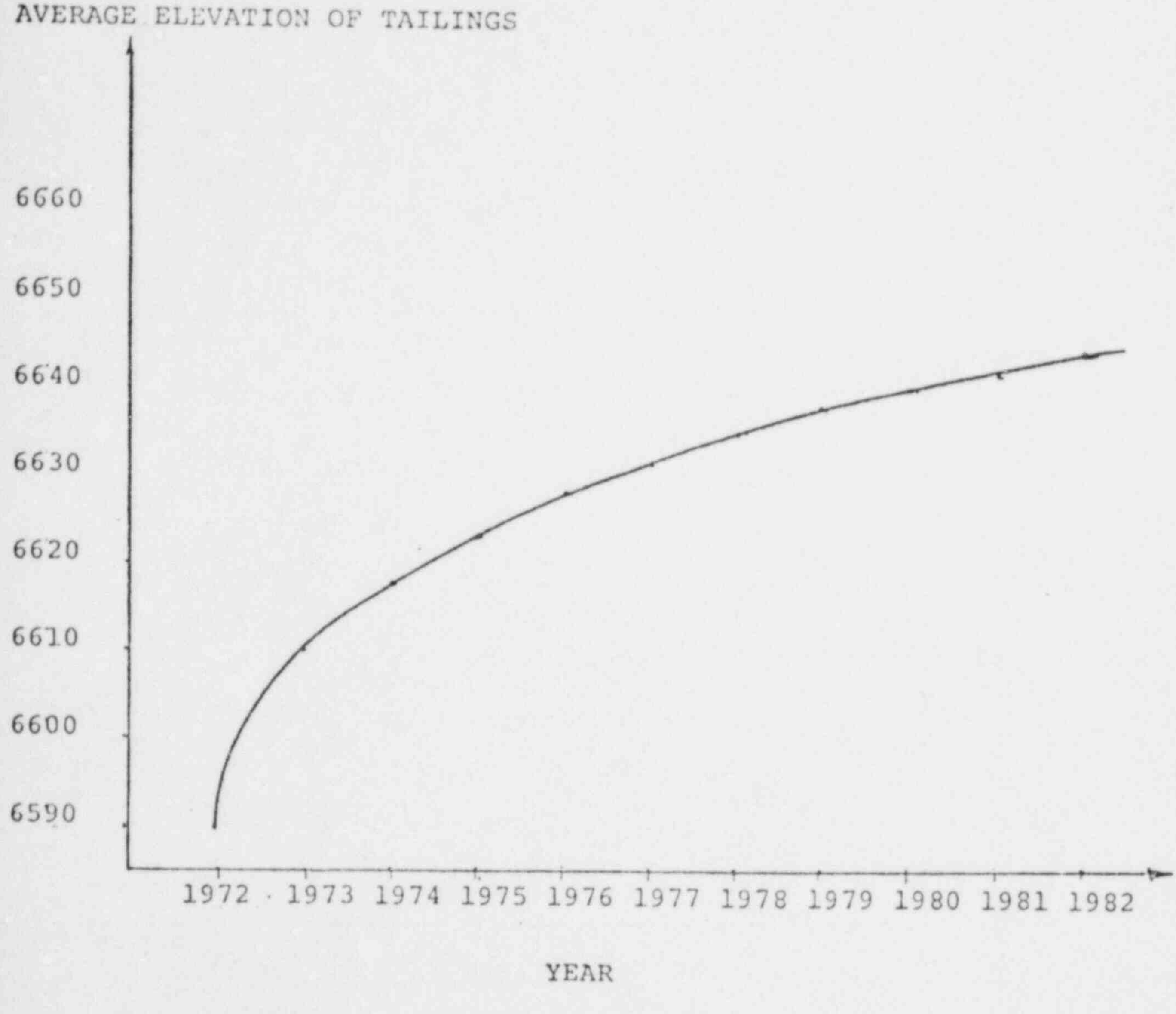


CAPACITY OF BASIN - Acre/Ft and Tons of Solid

NOTE: Dam top elevation to be 10 Ft. higher than average elevation of tailings

CONTOUR LEVEL	CUMULATIVE CAPACITY OF BASIN - ACRE
6600	24
6610	87
6620	204
6630	398
6640	693
6650	1097
6660	1619

TAILINGS POND ELEVATION VS. YEAR



ABOVE GRAPH FOR 500 T.P.D. SOLIDS - 175,000 TONS/YEAR

NOTE - DAM TOP 10 FT. HIGHER THAN AVERAGE ELEVATION OF TAILINGS

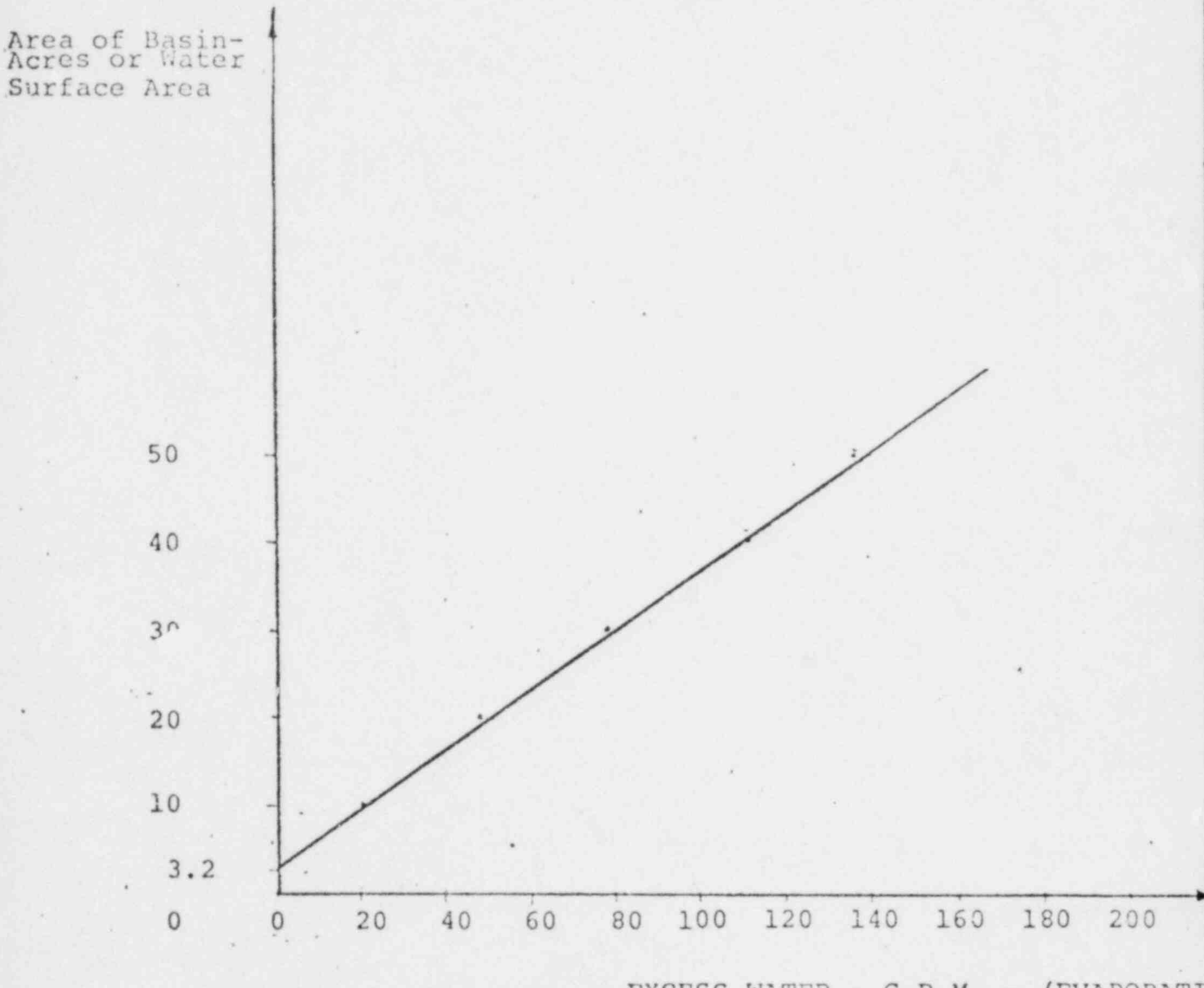
APPENDIX D

M-18
Appendix M, Reference 1

DATE: March 1970

UTAH PROJECT

TAILINGS DISPOSAL



EXCESS WATER = LIQUIDS DISCHARGED FROM PLANT AND MILL - RECIRCULATED WATER

- THE ABOVE GRAPH SHOWS THE POND WATER SURFACE AREA REQUIRED TO EVAPORATE ANY GIVEN VALUES OF EXCESS WATER -

ABOVE GRAPH FOR: MEAN ANNUAL RAINFALL = 12 INCHES
COEFFICIENT OF RUNOFF OF 0.01 FOR 3" FLOOD
EVAPORATION = 55 INCHES PER YEAR
PERCOLATION OR INFILTRATION = 0

APPENDIX N

1. Monitor Well Results and Corrections From Rio Algom, dated January 7, 1974.

40-8084

Rio Algom
Rio Tinto

January 7th, 1974.

RECEIVED JAN 10 1974 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

Ref. (40-8084)

John F. Kendig, Esq.,
Materials Branch,
Directorate of Licensing,
United States Atomic Energy Commission,
WASHINGTON, D.C. 20545.

Dear Mr. Kendig:

My apologies for the discrepancies on Pages 48, 49 and Appendix C of our Response to the Agency Comments on the Draft Statement on the Lisbon Uranium Mill.

Page 48 last line of Sec. 2A should read:

2.25×10^{-7} uC/ml = 2.32×10^{6} uC/day

Page 49 fifth line from the bottom should read:

Surface plant stacks 1.03 uC/day.

Appendix C - Monitor well analyses for wells 1, 2, 3, 4, 5, D-1, D-2, D-3 and D-10 should have the same units for Unat, radium 226 and thorium 230 as the analyses tables previous to July 1973. Attached are corrected tables.

Yours truly,

P. F. Pullen

PFP/mm

P. F. Pullen, P. Eng.,
Chief Environmental Engineer.

cc: R. D. Lord

RIO ALGOM MINES LIMITED 120 ADELAIDE STREET WEST TORONTO 110 CANADA 416 367-4000 TELEX 02-2204 CABLE RIOTINTO

LIBSON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMAR'
		pH	Na	So4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
7-3-73	80'		385		5.1				
7-10-73	75'		385		3.9				
7-17-73	75'		385		4.8				
7-24-73	75'		385		4.6				
COMPOSITE				698	4.8	5.22	< 2.0		
8-7-73	75'	7.2	295		2.9				
8-14-73	75'	7.6	333		3.3				
8-21-73	75'	7.4	335		3.6				
COMPOSITE				489		4.78	<2.0		
8-28-73	74'	7.4	386		2.4				
9-4-73	73'	7.5	330		1.6				
9-11-73	73'	7.6	340		1.4				
9-18-73	73'	7.3	315		1.4				
COMPOSITE				473	1.7	1.84	< 2.0		
9-25-73	73'	7.4	330		2.4				
10-2-73	73'	7.5	325		1.5				
10-9-73	73'	7.6	328		1.4				
					x 10^{-7}	x 10^{-9}	x 10^{-8}		

M = monthly
Mc = monthly composite
W = weekly

9600

Appendix N, Reference 1

N-3

LIBSON MINE

TAILINGS MONITOR WELL #2

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARK
		pH	Na	So4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
7-3-73	85'		394		5.8				
7-10-73	80'		393		6.4				
7-17-73	80'		394		5.6				
7-24-73	80'		393		6.6				
COMPOSITE				715	6.2	2.96	< 2.0		
8-7-73	80'	7.3	395		6.5				
8-13-73	80'	7.6	300		2.0				
8-20-73	80'	7.5	392		4.7				
COMPOSITE				481	4.4	4.14	<2.0		
8-28-73	80'		410		4.2				
9-4-73	80'		360		3.9				
9-11-73	81'		370		4.2				
9-18-73	81'		365		2.8				
COMPOSITE				420	3.9	2.40	<2.0		
9-25-73	82'	7.6	446		3.9				
10-2-73	82'	7.6	345		3.4				
10-9-73	82'	7.6	360		4.2				
					x 10^{-7}	x 10^{-9}	x 10^{-8}		

M = monthly
Mc = monthly composite
W = weekly

0096

Appendix N, Reference 1

LIBSON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN 73	SNOWBOUND								
FEB 73	SNOWBOUND								
3-13 73	155'	8.2	160	260	.08	3.0	<2.0		
4-13-73	150'	8.1	72	254	.16	2.6	<2.0		
4-25-73	150'	8.0	72	253	.12	2.6	<2.0		
5-1-73	150'	8.4	150	135	.15	2.6	<2.0		
5-8-73	145'	8.3	150	130	.15	2.8	<2.0		
5-15-73	145'	8.2	153	137	.14	2.8	<2.0		
5-22-73	145'	8.3	150	142	.14	2.5	<2.0		
6-12-73	145'	8.1	51	210	.12	8.3	<2.0		
7-10-73	145'	8.2	83	278	.14	2.6	<2.0		
8-14-73	145'	7.4	48	160	2.50	5.7	<2.0		
9-4-73	145'	7.6	40	167	2.30	3.75	<2.0		
10-2-73	145'	7.3	38	168	.20	1.56	<2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

0096

M = monthly
Mc = monthly composite
W = weekly

Appendix N, Reference 1
N-5

LIBSON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARK
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc.		
JAN. 73	SNOWBOUND								
FEB. 73	SNOWBOUND								
3-13-73	155'	8.3	187	277	.06	2.0	2.0		
4-13-73	150'	8.1	158	253	.42	1.2	2.0		
4-25-73	150'	8.1	154	254	.31	4.9	2.0		
5- 1-73	150'	8.4	114	155	.30	2.6	2.0		
5- 8-73	145'	8.4	107	150	.30	2.7	2.0		
5-15-73	145'	8.4	114	153	.31	2.5	2.0		
5-22-73	145'	8.4	121	148	.29	2.6	2.0		
6-12-73	145'	8.4	100	301	.13	1.4	2.0		
7-10-73	145'	8.4	173	349	.14	1.5	2.0		
8-14-73		7.7	140	250	1.90	5.3	2.0		
9- 4-73	145'	7.9	130	310	1.60	3.25	2.0		
10-2-73	152'	7.6	130	213	.20	3.22	2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

9600

LIBSON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	DEPTH TO WATER	pH (ppm)	Na (ppm)	So^4 (ppm)	Unat (uc/ml)	Ra 226 (uc/ml)	Th 230 (uc/ml)		REMARK
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc.		
JAN. 73	SNOWBOUND								
FEB. 73	SNOWBOUND								
3-13-73	155'	8.3	187	277	.06	2.0	2.0		
4-13-73	150'	8.1	158	253	.42	1.2	2.0		
4-25-73	150'	8.1	154	254	.31	4.9	2.0		
5- 1-73	150'	8.4	114	155	.30	2.6	2.0		
5- 8-73	145'	8.4	107	150	.30	2.7	2.0		
5-15-73	145'	8.4	114	153	.31	2.5	2.0		
5-22-73	145'	8.4	121	148	.29	2.6	2.0		
6-12-73	145'	8.4	100	301	.13	1.4	2.0		
7-10-73	145'	8.4	173	349	.14	1.5	2.0		
8-14-73		7.7	140	250	1.90	5.3	2.0		
9- 4-73	145'	7.9	130	310	1.60	3.25	2.0		
10-2-73	152'	7.6	130	213	.20	3.22	2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

9600

Appendix N, Reference 1
B-7

LIBSON MINE

TAILINGS MONITOR WELL #5

SAMPLE DATE	DEPTH TO WATER	ppm pH	ppm Na	ppm So^4	uc/ml Unat	uc/ml Ra 226	uc/ml Th 230		REMARKS
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN. 73	SNOWBOUND								
FEB. 73	SNOWBOUND								
MAR. 73	SNOWBOUND & MUD								
4-13-73	205'	7.9	42	324	.28	1.81	2.0		
4-25-73	200'	7.8	42	264	.23	1.45	2.0		
5- 1-73	195'	8.4	29	215	.23	1.63	2.0		
5- 8-73	195'	8.4	29	210	.24	1.75	2.0		
5-15-73	195	8.3	29	219	.23	1.78	2.0		
5-22-73	195'	8.4	29	223	.23	1.78	2.0		
6-12-73	195	8.2	31	338	.21	1.39	2.0		
7-10-73	195'	8.2	50	424	.21	1.07	2.0		
8-14-73	195'	7.4	26	250	1.20	1.85	2.0		
9- 4-73	195'	7.5	20	301	1.40	1.65	2.0		
10-5-73	195'	7.2	19	182	.30	1.94	2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

Appendix N, Reference 1
N-8

0096

LIBSON MINE

TAILINGS MONITOR WELLS D-1, D-2, D-3 & D-10

AMPLE ATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
REQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
D-1									
8-13-73		7.6		261	.20	6.99			
9-26-73		7.4		381	.10				
D-2									
8-13-73		7.7		2688	84.1	3.40			
BEFORE BAILING									
D-2A 9-26-73		7.7		3135	121.3				
AFTER BAILING									
D-2B 9-26-73		7.8		3376	126.9				
10-8-73		7.8		3376	126.9				
D-3									
8-13-73		7.4		1705	50.4	2.35			
9-26-73		7.6		1915	5.3				
D-10									
8-13-73		7.5		350	.70	1.71			
9-26-73		10.5		923	.03				
					$x\ 10^{-7}$	$x\ 10^{-9}$	$x\ 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

Appendix N, Reference 1

LISBON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE		H2O LEVEL	DISSOLVED SOLIDS (PPM)	HARDNESS (PPM)	SO4 (PPM)	NO3 (PPM)	Na (PPM)	Cl (PPM)	Fe (PPM)	10-7 URANIUM (uc/ml)	10-9 RADIUM 226 (uc/ml)	10-8 THORIUM 230 (uc/ml)	10-9 POLONIUM 210 (uc/ml)	10-9 LEAD 210 (uc/ml)	10-9 TOTAL ALPHA (uc/ml)
1973															
1- 4-73	7.9					ND	293	525		.84					
1-24-73	8.0					2	286	536		.67					
1-31-73	8.0					4	289	543		.67					
COMPOSITE					383						1.3	< 2.0	0.5		
2- 5-73	8.0	85'					290			.46					
2-12-73	7.8	85'					290			.51					
2-19-73	7.8	85'					280			.48					
2-26-73	7.6	85'					280			.55					
COMPOSITE					458					.53		< 2.0			
3- 5-73	7.6	80'					300			.17					
3-13-73	8.0	80'					294			.75					
3-19-73	8.1	80'					298			.75					
3-26-73	8.1	80'					298			.42					
COMPOSITE					475					.52	4.0	< 2.0			
4- 3-73	7.3	80'					261			.71					
4-10-73	7.6	80'					261			1.06					
4-17-73	7.7	75'					261			2.26					
4-24-73	7.7	75'					261			1.78					
COMPOSITE					284.8					1.38	1.3	< 2.0			
5- 1-73	8.2	75'					300			4.29					
5- 8-73	8.2	75'					300			2.10					
5-15-73	8.3	75'					300			2.10					
5-22-73	8.2	75'					314			4.40					
COMPOSITE					251					3.24	4.02	< 2.0			
6-5-73	7.9	75					289			3.44					
6-12-73	7.9	75					322			3.69					
6-19-73	8.0	75					300			3.19					
6-26-73	8.0	75					311			3.05					
COMPOSITE					604					3.38	2.91	< 2.0			
MPC										$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL															
AVERAGE															

LISBON MINE

TAILINGS MONITOR WELL #2

SAMPLE DATE	PH	PPM WATER LEVEL	HARDNESS	SO4	NO3	Na	Cl	Fe	uc/ml 10^{-7} URANIUM	10^{-9} RADIUM 226	10^{-8} THORIUM 230	10^{-9} POLONIUM 210	10^{-9} LEAD 210	10^{-9} TOTAL ALPHA
1972														
1- 4-73	7.5				4	300	582		1.79					
1-24-73	7.4				2	293	571		1.51					
1-31-73	7.5				2	295	564		1.34					
COMPOSITE				343						1.3	< 2.0	.7		
2- 5-73	7.6	90'				356			3.02					
2-12-73	7.6	90'				367			6.09					
2-10-73	7.7	90'				344			5.33					
2-26-73	7.6	90'				333			4.12					
COMPOSITE				557					4.72		< 2.0			
3- 5-73	7.8	85'				396			.35					
3-12-73	8.2	85'				396			.10					
3-19-73	8.2	85'				394			.75					
3-26-73	8.3	85'				396			.10					
COMPOSITE				330					.16	5.0	< 2.0			
4- 3-73	7.9	85'				340			.26					
4-10-73	7.9	85'				340			.82					
4-17-73	7.9	80'				360			.98					
4-24-73	7.9	80'				360			1.14					
COMPOSITE				296					.72	2.2	< 2.0			
5- 1-73	8.3	80'				460			.96					
5- 8-73	8.3	80'				440			.96					
5-15-73	8.3	80'				420			.96					
5-22-73	8.3	80'				460			.79					
COMPOSITE				324					.92	2.6	< 2.0			
6-5-73	8.1	75'				389			.45					
6-12-73	8.0	75				378			.45					
6-19-73	8.0	75				378			.70					
6-26-73	8.0	75				367			.42					
COMPOSITE				695					.50	3.3	< 2.0			
MPC									2×10^{-5}	3×10^{-8}	2×10^{-6}	7×10^{-7}	1×10^{-7}	
TOTAL														
AVERAGE														

LISBON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	PH	PPM							uc/ml					
		WATER LEVEL	HARDNESS	SO4	NO3	Na	Cl	Fe	10-7 URANIUM	10-9 RADIUM 226	10-8 THORIUM 230	10-9 POLONIUM 210	10-9 LEAD 210	10-9 TOTAL ALPHA
1972														
JAN 73----SNOWBOUND--------														
FEB 73----SNOWBOUND--------														
3-13-73	8.2	155'		260		160			.08	3.0	< 2.0			
4-13-73	8.1	150'		254		72			.16	2.6	< 2.0			
4-25-73	8.0	150'		253		72			.12	2.6	< 2.0			
5- 1-73	8.4	150'		135		150			.15	2.6	< 2.0			
5- 8-73	8.3	145'		130		150			.15	2.8	< 2.0			
5-15-73	8.2	145'		137		153			.14	2.8	< 2.0			
5-22-73	8.3	145'		142		150			.14	2.5	< 2.0			
6-12-73	8.1	145'		210		51			.12	8.3	< 2.0			
7-10-73	8.2	145'		278		83			.14	2.6	< 2.0			
8-14-73	7.4	145'		160		48			2.50	5.7	< 2.0			
MPC									$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL														
AVERAGE														

LISBON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	PH	PPM							uc/ml					
		WATER LEVEL	HARDNESS	SO4	NO3	Na	Cl	Fe	10^{-7} URANIUM	10^{-9} RADIUM 226	10^{-8} THORIUM 230	10^{-9} POLONIUM 210	10^{-9} LEAD 210	10^{-9} TOTAL ALPHA
1972														
JAN 73------	-SNOWBOUND-------													
FEB 73------	-SNOWBOUND-------													
3-13-73	8.3	155'		277		187			.06	2.0	< 2.0			
4-13-73	8.1	150'		253		158			.42	1.2	< 2.0			
4-25-73	8.1	150'		254		154			.31	4.9	< 2.0			
5- 1-73	8.4	150'		155		114			.30	2.6	< 2.0			
5- 8-73	8.4	145'		150		107			.30	2.7	< 2.0			
5-15-73	8.4	145'		153		114			.31	2.5	< 2.0			
5-22-73	8.4	145'		148		121			.29	2.6	< 2.0			
6-12-73	8.4	145'		381		100			.13	1.4	< 2.0			
7-10-73	8.4	145'		349		173			.14	1.5	< 2.0			
8-14-73	7.7			250		140			1.90	5.3	< 2.0			
MPC									$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL														
AVERAGE														

LISBON MINE

TAILINGS MONITOR WELL #5

SAMPLE DATE 1973	PH	H2O DEPTH	PPM DISSOLVED SOLIDS	HARDNESS	SO4	NO3	Na	Cl	Fe	uc/ml 10^{-7} URANIUM	10^{-9} RADIUM 226	10^{-8} THORIUM 230	10^{-9} POLONIUM 210	10^{-9} LEAD 210	10^{-9} TOTAL ALPHA
JAN 73-----	-SNOWBOUND--------														
FEB 73-----	-SNOWBOUND---------														
MAR 73-----	-SNOWBOUND & MUDBOUND------														
4-13-73	7.9	205'			324		42			.28	1.81	< 2.0			
4-25-73	7.8	200'			264		42			.23	1.45	< 2.0			
5- 1-73	8.4	195			215		29			.23	1.63	< 2.0			
5- 8-73	8.4	195			210		29			.24	1.75	< 2.0			
5-15-73	8.3	195			219		29			.23	1.78	<2.0			
5-22-73	8.4	195			223		29			.23	1.78	<2.0			
6-12-73	8.2	195			338		31			.21	1.39	<2.0			
7-10-73	8.2	195'			424		50			.21	1.07	<2.0			
8-14-73	7.4	195			250		26			1.20	1.85	<2.0			
MPC										$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL															
AVERAGE															

Appendix N, Reference 1

LISBON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE	PH	PPM SO4	PPM NO3	PPM Na	PPM Cl	10-7 uc/ml URANIUM	10-9 uc/ml RADIUM	10-8 uc/ml THORIUM	10-9 uc/ml POLONIUM	10-9 TOTAL ALPHA uc/ml	10-9 uc/ml LEAD-210
4-6-72	7.7	310		230	430						
4-13-72	7.7	295		220	470						
4-19-72	7.65	340		220	480						
4-26-72	7.4	345		280	428						
--------MILL STARTUP-------											
6-13-72	7.5	279	22	270	511	6.63	< 1.0	< 2.0	0.6	0±2.5	5.0±.20
6-19-72	7.6	291	25	270	539	14.1	1.14	2.99	0.5	0±2.5	3.03±.04
6-26-72	7.3	291	20	264	546	7.97	< 1.0	1.76	0.5	0±2.5	.43±.01
7-3-72	7.6	340	25	271	550	.811	2.96	3.16	0.7	0±2.5	1.73±.06
7-10-72	7.3	350	25	292	518	1.84	< 1.0	3.45	0.8	0±2.5	.00±.11
7-17-72	7.3	361	25	364	546		2.73	4.92	1.0	0±2.5	.43±.01
7-23-72	7.3	319	25	336	681	8.96	< 1.0	< 2.0	0.7	14±7	0±.01
8-8-72	7.4	153	22	289	737	5.26	< 1.0	< 2.0	0.1	0±2.5	.58±.01
8-14-72	7.8	256	22	298	737	5.39	< 1.0	< 2.0	0.2	40±17	2.31±.07
8-21-72	7.4	283	24	292	567	38.35	< 1.0	< 2.0	0.2	27±15	.86±.02
8-28-72	7.6	251	27	202	629	7.67	< 1.0	< 2.0	2.2	41±17	1.29±.03
9-6-72	7.8	288	52	265	600	N.D.					
9-11-72	8.2	171	47	257	603	.342					
9-18-72	8.0	156	30	283	333	.013					
9-25-72	8.1	198	34	374	363	N.D.					
COMPOSITE							< 1.0	< 2.0	0.5	44±2	1.15±.02
10-2-72	7.6	254	11	273	464	N.D.					
10-9-72	7.8	246	10	273	464	.005					
10-24-72	7.7	328	9	250	446	.157					
COMPOSITE							< 1.0	< 2.0	9.0		28.8±.7
11-7-72	7.6	165	10	258	582	.013					
11-13-72	7.7	184	14	258	593	.009					
11-20-72	7.9	209	15	258	582	.295					
11-27-72	7.8	228	10	235	593	.014					
COMPOSITE							< 1.0	< 2.0	0.9		3.31±.10
12-5-72	8.0	399	3	293	602	4.10					
12-15-72	7.9	383	3	280	588	1.37					
12-19-72	8.0	377	3	287	594	2.05					
12-26-72	8.1	394	3	293	594	2.05					
COMPOSITE							1.3	< 2.0	0.5		4.42±.16
TOTAL	229.75	8444	516	8235	16370	107.399					
AVERAGE	7.66	281.5	19.8	274.5	545.7	4.88					

LISBON MINE

TAILINGS MONITOR WELL NO. 2

SAMPLE DATE	PH	PPM SO4	NO3	Na	Cl	10-7 uc/ml URANIUM	10-9 uc/ml RADIUM	10-8 uc/ml THORIUM	10-9 uc/ml POLONIUM	10-9 TOTAL ALPHA	10-9 uc/ml LEAD-210
4-6-72	7.6	200		210	580						
4-13-72	6.65	200		210	630						
4-19-72	7.7	225		220	600						
4-26-72	7.5	175		260	575						
--------MILL STARTUP----------											
6-13-72	7.5	178	98	240	610	10.6	<1.0	8.26	0.5	0±2.5	3.30±.20
6-19-72	7.5	198	92	270	638	25.6	3.63	4.04	0.1	0±2.5	8.36±.30
6-26-72	7.5	167	78	258	628	11.5	<1.0	1.05	0.5	0±2.5	1.58±.04
7-3-72	7.8	141	92	264	628	3.61	<1.0	3.16	0.7	0±2.5	.58±.01
7-10-72	7.5	354	92	271	599	1.38	3.17	3.16	0.8	0±2.5	4.76±.17
7-17-72	7.5	504	92	327	631	5.38	1.63	<2.0	0.8	17±14	.00±.01
7-23-72	7.5	198	73	309	738	55.6	<1.0	<2.0	0.5	27±15	.14±.01
8-8-72	7.1	289	96	298	751	20.64	<1.0	<2.0	0.2	17±14	1.58±.04
8-14-72	7.7	360	96	313	751	8.79	<1.0	<2.0	0.2	0±2.5	2.31±.06
8-21-72	7.3	369	95	298	524	4.26	<1.0	<2.0	0.2	15±13	.00±.01
8-28-72	7.8	362	75	326	562	6.82	<1.0	<2.0	0.3	32±16	1.30±.05
9-6-72	8.1	390	14	309	559	N.D.					
9-11-72	8.1	313	13	307	560	.383					
9-18-72	7.8	275	8	325	255	.013					
9-25-72	8.2	299	4	333	277	.005					
COMPOSITE							<1.0	<2.0	0.7	25±15	3.30±13
10-2-72	8.1	382	9	327	396	N.D.					
10-9-72	8.2	387	7	314	390	.006					
10-24-72	8.2	423	6	314	372	.157	<1.0	<2.0	1.1	OCT. COMPOSITE	14.4±.4
11-7-72	7.8	322	43	304	582	.009					
11-13-72	7.9	335	43	304	582	.007					
11-20-72	7.9	304	40	281	557	.028					
11-27-72	7.9	631	40	327	571	.014					
COMPOSITE							1.418	<2.0	0.6		2.45±.07
12-5-72	7.8	435	42	318	587	.21					
12-15-72	7.5	351	34	287	590	.41					
12-19-72	7.8	361	19	260	588	.24					
12-26-72	7.8	372	12	293	588	.29					
COMPOSITE							1.3	<2.0	0.6		4.48±.18
TOTAL	231.25	9500	1313	8677	16899	155.952					
AVERAGE	7.71	316.7	50.5	289.2	563.3	6.50					

LISBON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	PH	PPM				10^{-7} uc/ml URANIUM	10^{-9} uc/ml RADIUM 226	10^{-8} uc/ml THORIUM 230	10^{-9} uc/ml POLONIUM 210	10^{-9} uc/ml TOTAL ALPHA	10^{-9} uc/ml LEAD-210
		SO4	NO3	Na	Cl						
6-1-72	7.9	1600	5	71	98	.36					
12-15-72	8.0	1520	3	68	115	.32	5.7	<2.0	.5		.32 ± .07
TOTAL	15.9	3120	8	139	213	.68					.32
AVERAGE	7.95	1560	4	69.5	106.5	.34					.32

LISBON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	PH	PPM				10^{-7} uc/ml URANIUM	10^{-9} uc/ml RADIUM 226	10^{-8} uc/ml THORIUM 230	10^{-9} uc/ml POLONIUM 210	TOTAL ALPHA	10^{-9} uc/ml LEAD-210
		SO4	NO3	Na	Cl						
6-1-72	8.1	410	5	100	132	.52					
12-12-72	8.2	315	3	160	123	.68	.81	<2.0	.5		14.6±.07
TOTAL	16.3	725	8	260	255	1.20					
AVERAGE	8.15	362.5	4	130	127.5	.60					

APPENDIX O

1. Rio Algom Inter-Office Memo from J. T. Mather to M. E. Grimes, dated March 2, 1972, Seepage Tests on Utah Tailings.
2. Rio Algom Inter-Office Memo from J. T. Mather to E. Barnes, dated October 16, 1973, Seepage through Utah Tailings Test on fresh tailings from Lisbon, Utah.

Inter-Office Memorandum File No. ....

To: M. E. Grimes Date March 2, 1972

From: J. T. Mather c.c. J. W. Fisher

Subject: Seepage Tests on Utah Tailings

The current series of lab seepage tests are giving steady seepage rates of 6-8 ft./yr. (Fig. 1) for untreated tailings after one week under simulated field conditions. These rates are similar to the figures used by Clevenger & Ass. in their estimate of loss by seepage from the base of the tailings area (10 ft./yr for whole tailings).

If the seepage loss estimated by Clevenger & Ass. is considered to be excessive, we would recommend the use of sealing agents added to or sprayed on the tailings, with the qualification that outside advice be sought on the stability of the tailings embankment after the sealing treatment. The proposed tailings retaining structure consists of a starter dam backed up by coarser tailings deposited by conventional spigotting. Placing of an impermeable layer of sealant or treated tails immediately behind the starter dam might affect the stability of the retaining embankment by keeping the whole of the tailings behind the dam semi-fluid, rather than letting a layer of coarse material drain and consolidate and add to the strength of the starter dyke.

We are presently evaluating the effectiveness of two Dow sealing agents that may be sprayed on a prepared base, using methods supplied by Mr. E. K. Anderson of Dowell of Canada, Calgary. The costs range from $200 to $900 per acre for sealant only. We are also evaluating the use of one of these reagents mixed in with tailings before deposition, and the use of $FeSO_4 \cdot 7H_2O$ (Copperas) in like manner. The latter technique could save on sealant costs, but is not specifically recommended by Dowell.

All these techniques for sealing require that the sealant or treated material be placed on a prepared base in order to minimise reagent cost. Since it is not intended to grade the tailings area to obtain a clean, uniform base, it will be necessary to lay down an initial layer of untreated tailings

..../2

over the area to be sealed, preferably to a minimum of 6" depth. This job might be simplified by some bulldozing of very rough areas and by brushing the entire area, depending on the topography.

Preliminary figures on the effectiveness of various sealing agents should be available in one week.

J. T. Mather

J. T. Mather

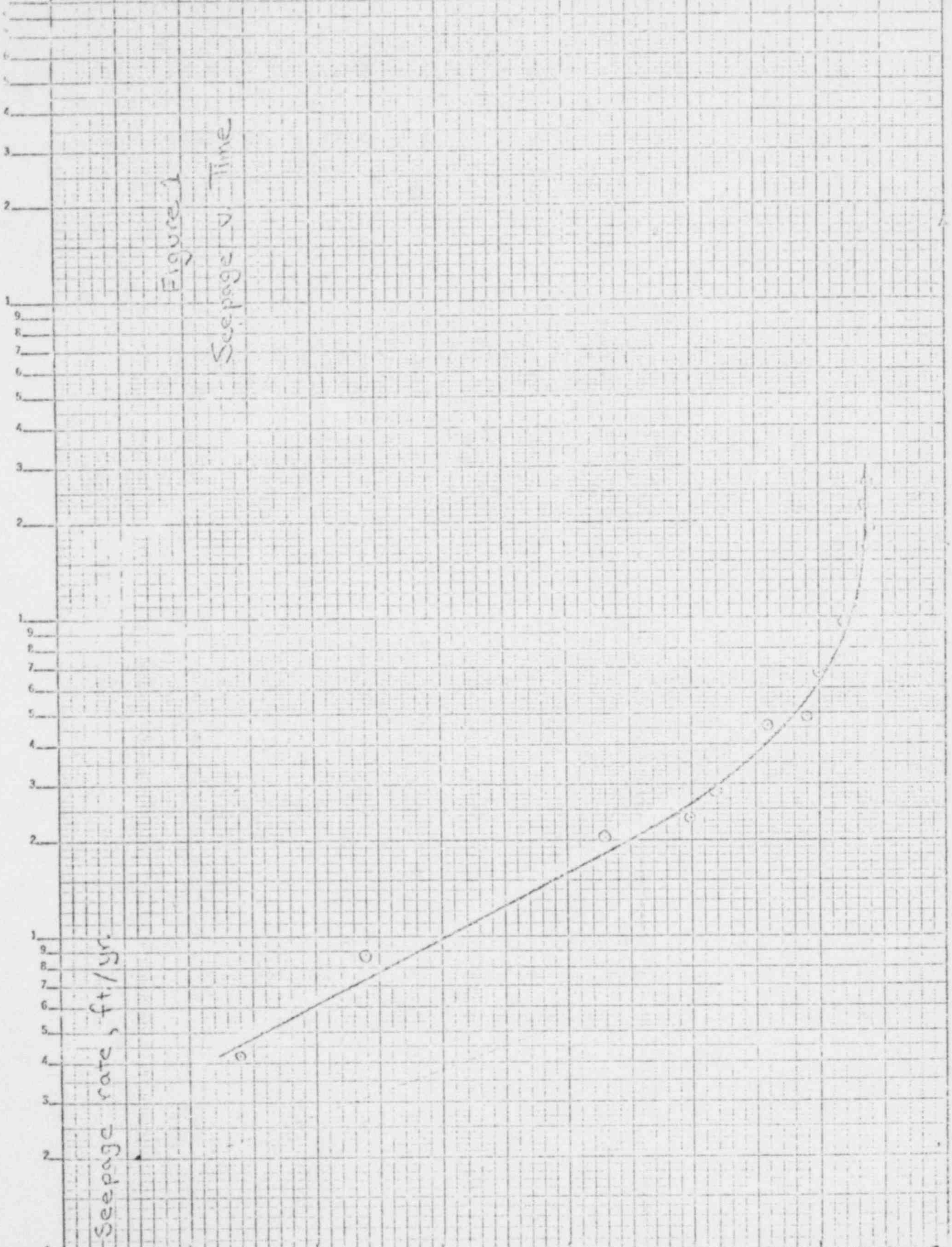


Figure 1
Seepage v. Time
Seepage rate, ft/yr
80
40
30
20
10

Inter-Office Memorandum

File No. ....

To: E. Barnes

Date October 16, 1973

From: J. T. Mather

Subject: Seepage through Utah Tailings Test on fresh tailings from Lisbon, Utah

A fresh sample of whole tailings from the Lisbon treatment plant was received on August 3, 1973 and labelled 73BD7. The tailings slurry, of Sg 1.342, was mixed thoroughly and poured onto a base of washed clarifier sand in a 1½" i.d. glass column.

The Percolation rate was monitored over a period of 38 days, keeping the surface of the tailings just covered with water i.e. equivalent to a hydraulic gradient of 1 ft. water per ft. tailings. Results are shown graphically on Figure 1. The percolation dropped from an initial value around 100 ft/yr to a steady 6 ft/yr after 7 days. These results are virtually identical to those for the tailings prepared by leaching North Alice material in our laboratory autoclave, see memo J.T. Mather to M.E. Grimes dated March 2, 1972.

J Mather.

JTM:kbc

J. T. Mather

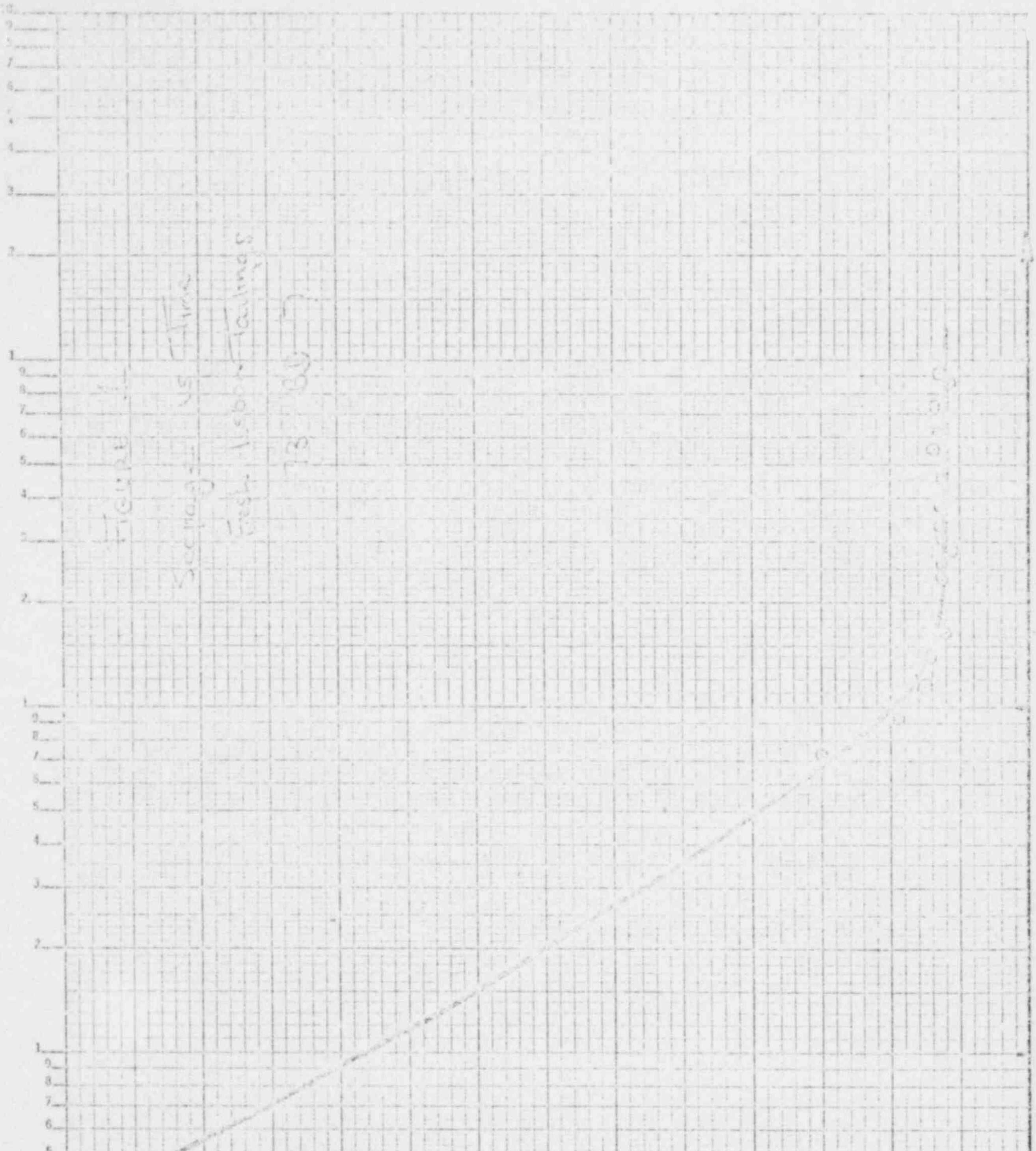


Figure 1
Seepage vs Time
Test Lisbon Tailings
73-80
1000
100
10
60
50
40
30
20
10

APPENDIX P

1. Parameters used to estimate environmental Concentrations.

DATA USED FOR CALCULATING CONCENTRATIONS AND DOSE FOR RECEPTORS LOCATED 1500 FEET SOUTHEAST OF THE REFERENCE POINT, I.E. MINE VENTILATION SHAFT

Source Term	Volume of Air Discharged	Concentration of Dust in Discharge	% of U_3O_8 in Dust	Stack Height in Meters	Solids Content of Tailings by Weight	Density of Tailings	Diffusion Coefficient of Radon in Water	Size of Tailing Pond	Operating Time for Quantities Emitted per Day	No. of Days Per Year for Dose Calculations
Mine Vent. Shaft	195,000 ft^3/min	1.5 mg/m^3	0.4	3.0	–	–	–	–	24 h/day	365
Yellow Cake Dryer	1000 ft^3/min	68.6 mg/m^3	85.0	15.0	–	–	–	–	12 h/day	365
Production Shaft, Head Frame Transfer House	26,700 ft^3/min all sources	68.6 mg/m^3	0.4	18 avg	–	–	–	–	16 h/day	365
Tailing** Pond	–	–	0.4	–	75%	1.856 g/ml	2.4×10^{-5} cm^2/sec	45 acres	24 h/day	365

DATA USED FOR CALCULATING CONCENTRATIONS AND DOSE FOR RECEPTORS LOCATED 8000 FEET NORTHWEST OF THE REFERENCE POINT, I.E. MINE VENTILATION SHAFT

Source Term										
Mine Vent. Shaft	195,000 ft^3/min	1.5 mg/m^3	0.4	3.0	–	–	–	–	24 h/day	365
Yellow Cake Dryer	1000 ft^3/min	68.6 mg/m^3	85	15.0	–	–	–	–	12 h/day	365
Production Shaft, Head Frame Transfer House	26,700 ft^3/min all sources	68.6 mg/m^3	0.4	18 avg	–	–	–	–	16 h/day	365
Tailing** Pond	–	–	0.4	–	75%	1.856 g/ml	2.4×10^{-5} cm^2/sec	45 acres	24 h/day	365

Source Term	U - NAT.					THORIUM - 230				
	Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second	Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second
Mine Vent. Shaft	1500 ft S.E. of mine vent. shaft	D	100%	short term diffusion and correction factor to estimate long term diff.	4.5 m/sec	1500 ft S.E. of mine vent. shaft	D	32%	long term diffusion	4.5 m/sec
Yellow Cake Dryer	do	D	100%	do	4.5 m/sec	N/A	N/A	N/A	N/A	N/A
Production Shaft, Head Frame Transfer House	do	D	100%	do	4.5 m/sec	do	D	32%	long term diffusion	4.5 m/sec
Tailing** Pond	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source Term										
Mine Vent. Shaft	8000 ft N.W. of mine vent. shaft	F day+night	100%	short term diffusion and correction factor to estimate long term diff.	2 m/sec	8000 ft N.W. of mine vent. shaft	F	44%	long term diffusion	2 m/sec
Yellow Cake Dryer	do	F	100%	do	2 m/sec	N/A	N/A	N/A	N/A	N/A
Production Shaft, Head Frame Transfer House	do	F	100%	short term diffusion and correction factor to estimate long term diff.	2 m/sec	8000 ft N.W. of mine vent. shaft	F	44%	long term diffusion	2 m/sec
Tailing** Pond	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source Term	Ra - 226 Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second	Rh - 222 Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second
Mine Vent. Shaft	1500 ft S.E. of mine vent. shaft	D	100%	short term diffusion and correction factors to estimate long term diff.	4.5 m/sec	1500 ft S.E. of mine vent. shaft	D	32%	long term* diffusion	4.5 m/sec
Yellow Cake Dryer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Production Shaft, Head Frame Transfer House	1500 ft S.E. of mine vent. shaft	D	100%	short term diffusion and correction factors to estimate long term diff.	4.5 m/sec	1500 ft S.E. of mine vent. shaft	D	100%	short term diffusion	4.5 m/sec
Tailing** Pond	N/A	N/A	N/A	N/A	N/A	do	D	32%	long term diff. plus area source modification	4.5 m/sec

Mine Vent. Shaft	8000 ft N.W. of mine vent. shaft	F	100%	short term diffusion	2 m/sec	8000 ft N.W. of mine vent. shaft	F	44%	long term* diffusion	2 m/sec
Yellow Cake Dryer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Production Shaft, Head Frame Transfer House	8000 ft N.W. of mine vent. shaft	F	100%	short term diffusion	2 m/sec	8000 ft N.W. of mine vent. shaft	F	100%	short term diffusion	2 m/sec
Tailing** Pond	N/A	N/A	N/A	N/A	N/A	do	F	44%	long term diff. plus area source modification	2 m/sec

*Down Wind Concentration Arrived at by Assuming a Concentration at the Source of 3.9×10^{-7} mg/ml

DATA USED FOR CALCULATING CONCENTRATIONS
AND DOSE FOR REDD RANCH

Source Term	Volume of Air Discharged	Concentration of Dust in Discharge	% of U_3O_8 in Dust	Stuck Height in Meters	Solids Content of Tailings by Weight	Density of Tailings	Diffusion Coefficient of Radon in Water	Size of Tailing Pond	Operating Time for Quantities Emitted per Day	No. of Days Per Year for Dose Calculations
Mine Vent Shaft	195,000 ft^3/min	1.5 mg/m^3	0.4	3	—	—	—	—	24 h/day	365
Yellow Cake Dryer	1000 ft^3/min	68.6 mg/m^3	85	15	—	—	—	—	12 h/day	365
Production Shaft, Head Frame Transfer House	26,700 ft^3/min	68.6 mg/m^3	0.4	18 avg	—	—	—	—	16 h/day	365
Tailing** Pond	—	—	0.4	—	75%	1.856 g/ml	2.4×10^{-5} cm^2/sec	45 acres	24 h/day	365

	U - NAT.					THORIUM - 230				
	Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second	Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second
Mine Vent Shaft	Redd Ranch	F	88%	long term diffusion	2 m/sec	Redd Ranch	F	44%	long term diffusion	2 m/sec
Yellow Cake Dryer	do	F	100%	short term diffusion and correction factor to estimate long term diff.	2 m/sec	N/A	N/A	N/A	N/A	N/A
Production Shaft, Head Frame Transfer House	do	F	100%	do	2 m/sec	do	F	44%	long term diffusion	2 m/sec
Tailing** Pond	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Ra - 226					Rn - 222				
	Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second	Receptor	Stability Class	Frequency of Wind Direction	Method for Calculating Concentration	Wind Speed Meters per Second
Mine Vent Shaft	Redd Ranch	F	44%	long term diffusion	2 m/sec	Redd Ranch	F	100%	short term* diffusion and correction factor to estimate long term diff.	2 m/sec
Yellow Cake Dryer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Production Shaft, Head Frame Transfer House	Redd Ranch	F	100%	short term diffusion and correction factor to convert from 100% wind frequency to 44%	2 m/sec	Redd Ranch	F	100%	short term diffusion	2 m/sec
Tailing Pond**	N/A	N/A	N/A	N/A	N/A	Redd Ranch	F	50%	long term diffusion	2 m/sec

**In estimating the Quantity of Radon - 222 Generated over the Tailing Pond the Following Assumptions were Utilized:

1. All Radon Diffusing is Liberated to Air
2. All Tailing Material is Submerged in Water
3. Radon Content Assumes Secular Equilibrium
4. Because of the Distance Between the Tailing Pond and Receptors, the Tailing Pond is Considered to be a Point Source
5. The Size of the Pond is that Size that will Exist at the End of the Operation

*Downwind Concentration Arrived at by Assuming a Concentration at the Source of 3.9×10^{-7} μCi/ml

APPENDIX Q

1. Rio Algom computations for concentrations and doses based on measured emission rates.

Dust emissions from the various sources have been calculated as follows:

1. VENTILATION SHAFT DISCHARGE

Volume of air discharged		253,000 CFM
	=	7,160 M^3/min.
Average measured dust content		2.2 mg/M^3
Emission rate		15,750 mg per minute
Total dust emitted in 24 hours		22,700 grams
	=	50.1 pounds

2. SURFACE PLANT AIR DISCHARGES

The actual performance of the surface plant stack discharge dust filters has been considerably better than the specified emission rate of 0.03 grains per cubic foot or 68.3 mg/M^3, as shown below.

	Specification Airflow CFM	Actual Airflow CFM	Actual Dust mg/M^3	Dust Emitted in 24 hours grams
Crusher house	13,000	13,000	1.19	315
Headframe	11,000	11,000	.097	21.7
Transfer Tower	2,500	2,200	1.27	57.0
Yellowcake scrubber	1,000	960	.941	30.7
Yellowcake dust filter	2,400	1,300	.585	25.9

Total emission 450.3 grams in 24 hours - under 1 lb.

Detailed calculations are shown in Table I, Appendix J.

ENVIRONMENTAL EFFECTS OF DUST EMITTED

The State of Utah's Ambient Air Standards limit particulate matter to an annual geometric mean of 90 ug/M^3 or 0.09 mg/M^3. All actual discharge concentrations from the operating stacks are higher than this during the period each particular unit is in operation, but diminish rapidly downwind from the stacks due to dispersion.

The ventilation shaft is located outside the plant fence, and it is improbable that there will be many people entering the area between this shaft and a minor road, on which travel is highly occasional, mainly by ranchers. The point on this road nearest the ventilation shaft is approximately 325 feet from it. Calculations of the dust content of the air at this point have been made according to Equation 3.3 (p. 6) in D. Bruce Turner's "Workbook of Atmospheric Dispersion Estimates" (published by the U.S. Department of Health, Education, and Welfare.)

The nearest point outside the property fence from any of the plant dust emitters is located about 250 feet from these sources. The concentration of dust at this distance from each of these emitters has also been calculated as well as the total emission from all the plant stacks.

Calculations of downwind concentrations from all these emitters at the points mentioned are reported in Tables 2a through 2c. Some anomalous results are apparent, and the results at these short distances must be treated with reserve

The calculation used is: -

$$C = \frac{Q}{\pi u \sigma_y \sigma_z} \exp -\frac{1}{2} \left(\frac{H}{\sigma_z} \right)^2$$

where C is the ground-level centre-line concentration (in g/M^3) of dust in the plume,

Q is the emission rate (g/sec) at the stack,

u is the wind velocity (M/sec),

σ_y, σ_z are the horizontal and vertical dispersion coefficients, in meters, as a function of the downwind distance from source to point of measurement. These are obtainable from curves (Figures 3-2 and 3-3) in the Workbook.

H is the effective stack height, in meters.

The dispersion coefficients are naturally affected by the wind strength and by its directional stability. For the calculations, (Tables 2a through 2c, Appendix J) an average velocity of 5 mph (= 2.24 M/sec) has been taken, together with the most, least, and average stable conditions (Stability Classes F, A, and D respectively in the Workbook).

The effective height H of the stacks has been taken as the actual height in making these calculations. In the case of the ventilation shaft the discharge is horizontal; in the other cases discharge velocities are low, so that the plume would not rise very much above the actual stack. It is considered that no serious error is introduced by making this assumption.

Actual stack heights are:-

	Feet	=Meters
Ventilation shaft	6	2
Crusher	45	14
Headframe	75	23
Transfer	55	17
Scrubber	50	15
Filter	32	10

In making these calculations, average emission rates over 24 hours have been used for the individual surface plant stacks. Figures are also given for the total concentrations when all units are in operation simultaneously and for the totals over the 24 hour average emission rate.

To compare with the Utah ambient air standard of 0.09 (= 9×10^{-2}) mg/M^3, these concentrations, at the plume centre-line and at the nearest access points are summarized as follows:-

	mg/M^3		
	Stability A	Stability F	Stability D
Ventilation Shaft	9.4×10^{-2}	2.8	9.1×10^{-1}
Crusher	1.9×10^{-3}	1.3×10^{-14}	6.6×10^{-5}
Headframe	2.8×10^{-5}	9.9×10^{-38}	4.4×10^{-11}
Transfer House	2.2×10^{-4}	1.5×10^{-21}	4.7×10^{-7}
Scrubber	9.4×10^{-5}	9.0×10^{-18}	1.4×10^{-6}
Filter	1.4×10^{-4}	1.7×10^{-9}	8.9×10^{-5}
Total surface plant - not including ventilation shaft			
1. all units in operation simultaneously	1.9×10^{-3}	1.7×10^{-18}	1.1×10^{-5}
2. 24-hour average	1.0×10^{-3}	8.9×10^{-19}	5.8×10^{-6}

With the exception of the ventilation shaft discharge when it reaches the road, all these discharges would meet Utah ambient air standards at any point of public access. Normally, with increasing stability however, that is from Class A towards Class F, concentrations would be expected to increase, but only in the case of the ventilation shaft do they do so The method of calculation is generally considered to lose accuracy at the shorter distances, and this appears to be the case here.

RADIOACTIVE EMISSIONS FROM DUST

The figures for radionuclide release in Appendix G of the Supplemental Environmental Report were based on the assumption that the dust discharged from the plant stacks would have the same uranium content as the ore, which had been assessed at 8 lb/ton of $U_3 O_8$, and that the radioactive disintegration products of the uranium would be in equilibrium with it.

Figures measured during actual operations (Figure 5, Section IV C, Part 2) are used in the following calculations.

a. Uranium (natural) emissions

	Volume of Air Discharged in 24 hours (M^3 x 1000) (From Table 1, Section IV E)	Radioactive Release		
		µCi/ml x 10^{-11}	µCi/day	Average µCi/Sec.
Ventilation Shaft	10316	.07	7.22	8.36×10^{-5}
Crusher	265	.299	.792	9.17×10^{-6}
Headframe	224	.0527	.118	1.37×10^{-6}
Transfer House	44.9	.267	.120	1.39×10^{-6}
Scrubber	32.6	6.68	2.18	2.52×10^{-5}
Filter	44.2	.652	.288	3.33×10^{-6}

Total emission from the surface plant stacks is thus 3.5 µCi/day.

b. <u>Thorium - 230, Radium - 226, and Radon - 222 from the surface Plant</u>

At secular equilibrium in the ore, the radioactivity of natural uranium is equal to that of the associated Th-230, Ra-226, and Rn-222. These elements are not carried through to the yellowcake final product.

<u>Thorium - 230</u>

From the crusher, transfer house and headframe dust collectors only, Th-230 released

= .792 + .118 + .120 = 1.03 μCi/day

<u>Radium - 226</u>

From the crusher, transfer house and headframe dust collectors only, Ra-226 released

= 1.03 μCi/day from Ra-226 also.

<u>Radon - 222</u>

The radon emitted from the plant stacks will be that emitted while the ore is being handled on the surface. Once more therefore, radioactivity due to Rn-222, from the crusher, transfer house, and headframe collectors,

= 1.03 μCi/day from Rn-222.

RADON - 222 EMISSIONS FROM THE VENTILATION SHAFT

The original calculations of radon and radon daughters in the mine air discharged at surface gave an estimated radon daughter figure of 1.0 WL from 3.9×10^{-7} μCi/ml of radon. Frequent tests of the air as discharged at surface indicate an average of about 0.58 WL of radon daughters. No radon readings have been taken, but on the assumption that the radon is reduced in the same ratio as the radon daughters, a value of about 2.25×10^{-7} μCi/ml of radon is derived.

$$2.25 \times 10^{-7} \text{ uCi/ml} = 2.32 \times 10^{-6} \text{ uCi/day}^{*}$$

V B 2B RADIATION DOSAGE FROM RADON - 222 RELEASED AT THE TAILINGS POND

The calculations in Appendix M of the Supplemental Environmental Report are valid up to the point where the diffussion of radon at the surface of tailings is calculated at 3.58×10^{-5} μCi/M^2/second. Further calculations are based on the fact that it is now proposed to build a second tailings pond upstream from the original one, which has not been filled, but will be used as a settling pond for decant liquid from the new pond before such liquid is recycled to the plant.

It has been calculated that 15 acres of the old pond will be covered with tailings before additions cease, and that the new pond will be covered to an area of 27 acres before the termination of operations.

* Note correction statement submitted by Rio Algom at end of this section.

The two ponds must be considered separately.

1. Original Tailings Pond - 15 acres

$$15 \text{ acres} = \frac{15 \times 4840 \times 36^2}{39.37^2} \text{ M}^2$$

$$= 60700 \text{ M}^2$$

$$\text{Total Rn emission} = 6.07 \times 10^4 \times 3.58 \times 10^{-5}$$

$$= 2.17 \ \mu\text{Ci/sec or } 1.87 \times 10^5 \ \mu\text{Ci/day}$$

2. New Tailings Pond - 27 acres (when completely filled)

$$27 \text{ acres} = \frac{27 \times 4840 \times 36^2}{39.37^2} \text{ M}^2$$

$$= 109,000 \text{ M}^2$$

$$\text{Total Rn emission} = 1.09 \times 10^5 \times 3.58 \times 10^{-5}$$

$$= 3.90 \ \mu\text{Ci/sec or } 3.37 \times 10^5 \ \mu\text{Ci/day.}$$

Final total emissions from both ponds will thus be $(1.87 + 3.37) \times 10^5$

$= 5.24 \times 10^5 \ \mu$Ci/day.

Rn-222 emissions from all sources will be:-

Ventilation Shaft	2.3×10^6 μCi/day or
*Surface plant stacks	1.03×10^6 " " "
Tailings ponds	5.24×10^5 " " "
Total	2.82×10^6 " " "

The ventilation shaft discharge is thus in excess of 80% of the total.

* Note correction statement submitted by Rio Algom at end of this section.

3 DOWNWIND RADIOACTIVE CONCENTRATIONS

Downwind calculations of radioactivity have been made, using the method also described for dust (Section IV E). In addition to concentrations at the nearest property boundary for each stability (A, F, and D), (Tables 1a through 1c, Appendix K), concentrations at 8,000 feet from the ventilation shaft and at $2\frac{1}{2}$ miles, the distance of the Redd Ranch from the mine, have been made, and are reported in Tables 2a through 2c and 3a through 3c, Appendix K, respectively.

Because information is not available from which a wind rose may be derived, calculations have been made on the basis that in each case the wind will blow steadily for 100% of the time towards the point of measurement, which is taken as lying on the centre-line of the discharge plume.

Where a number of stacks are emitting simultaneously, only if they were all in line could the receptor be on the centre-line of every plume. At the nearest property boundary, emissions from each source are considered separately, except the plant stacks, which are close together and have been taken as a single source. At the greater receptor distances, all emissions from the distant emitter are considered additive.

Calculation:-

In all cases, wind velocity u is taken at 5 mph, = 2.24 m/sec, and wind direction directly towards the receptor.

The calculation in this instance is (Compare p.40, Section IV E)

$$C = \frac{Q}{\pi \, u \, \sigma_y \, \sigma_z} \exp -\frac{1}{2} \left(\frac{H}{\sigma_z}\right)^2$$

C = curies/M^3 or µCi/ml - downwind centre-line ground-level concentration.

Q = curies emitted per second

Type A stability has been assumed in Tables 1a, 2a, and 3a, Appendix K, as giving the lowest plume centre-line ground-level concentrations, Type F stability for Tables 1b, 2b, and 3b, as giving the opposite effect, while Type D, average stability, has been used in calculating Tables 1c, 2c, and 3c. The results for Type D only were used for derivation of radiation exposure calculations, pages 61&62. As in the case of the dust calculations, Section IV E, anomalous results (very low concentrations) were obtained for Stability F at the nearest distances.

Emission Rates:-

a. Stack Discharges. For these the emission rates shown on page 32 have been taken; total average emissions when all surface units are in operation at the same time, and total 24-hour average emissions have been calculated.

b. Tailings Ponds. The emission rates from two tailings ponds are shown on page 49.

Tailings Ponds Calculations:-

For the purposes of calculation, downwind concentrations from an area source such as a pond, are assumed to originate in a virtual point source.

The distance of such a virtual source from the downwind edge of the pond, is found by dividing the side of the pond, taken as square, by 2 x the standard deviation of 2.15 for the downwind dispersion of an area source, taking the result as the horizontal dispersion coefficient from the virtual source, and deriving the distance from this. The downwind distance to the receptor is then the sum of the virtual source distance and the distance from the pond edge to the receptor.

The concentration downwind from an area source is given (Workbook) by

$$C = \frac{Q}{\Pi \; \sigma_y \; \sigma_z \; u}$$

Where C = Concentration at downwind point in µCi/ml

Q = Quantity discharged by area source in µCi/sec

u = Wind speed in meters/sec

σ_y, σ_z are the horizontal and vertical dispersion coefficients in meters.

Virtual Source Calculations

1. Original Pond

Area = 60, 700 M^2; if square, side would be 245 M.

245 ÷ (2 x 2. 15) = 57 M;

a. At the nearest property boundary, 1000 feet = 305 M from pond edge: -

	Stability A	Stability F	Stability D
Virtual source distance giving horizontal dispersion coefficient of 57 M (From Fig. 3-2 in the Workbook)	260 M	2000 M	820 M
Distance from pond edge to boundary	305 M	305 M	305 M
Total Distance	565 M	2305 M	1125 M

For the total distances:-

σ_y	130	72	78
σ_z	180	23	34

b. At a boundary point, 8000 feet = 2500 M from mine operations:-

	Stability A	Stability F	Stability D
Virtual source distance	260 M	2000 M	820 M
Distance, mine to receptor point	2500 M	2500 M	2500 M
Total	2760 M	4500 M	3320 M

	Stability A	Stability F	Stability D
For the total distances:-			
σ_y	500 M	140	210
σ_z	3700	33	78

c. At the Redd Ranch, $2\frac{1}{2}$ miles = 4000 M from the mine:-

	Stability A	Stability F	Stability D
Virtual source distance	260 M	2000 M	820 M
Distance, mine to receptor point	4000 M	4000 M	4000 M
Total	4260 M	6000 M	4820 M
For the total distances:-			
σ_y	750	175	290
σ_z	8000	37	86

2. New Pond (when completed)

Area = 109,000 M^2, if square would have sides of 330 M.

The virtual distance of the source is found by dividing the pond side by 2 x 2.15 = 4.30 as before

$$330 \div 4.30 = 77 \text{ M}$$

a. The new pond is nearer the property boundary than the original pond. The nearest boundary is assumed to be at 500 feet or say 150 M.

	Stability A	Stability F	Stability D
Virtual source distance giving horizontal dispersion coefficient of 77 M (From Fig. 3-2 in Workbook)	330 M	2400 M	1090 M
Distance from pond edge to boundary	150 M	150 M	150 M
Total	480 M	2550 M	1240 M
For the total distances:-			
σ_y	115	80	85
σ_z	102	24.5	37

b. At a boundary point 8000 feet = 2500 M from operations:-

	Stability A	Stability F	Stability D
Virtual source distance	330 M	2400 M	1090 M
Pond edge to receptor point	2500 M	2500 M	2500 M
Total	2830 M	4900 M	3590 M
For the total distance:-			
σ_y	520	145	220
σ_z	4200	34	73

c. At the Redd Ranch, $2\frac{1}{2}$ miles = 4000 M from the mine:-

	Stability A	Stability F	Stability D
Virtual source distance	330 M	2400 M	1090 M
Distance, mine to receptor point	4000 M	4000 M	4000 M
Total	4330 M	6400 M	5090 M

For the total distances:-

σ_y	760	185	205
σ_z	9000	38	90

Calculations of downwind concentrations from both ponds are shown on Tables 1a through 1c, 2a through 2c, and 3a through 3c, Appendix K.

4 RADIATION EXPOSURES

Additive Downwind Concentrations of Radioactivity

When a number of emitters are discharging simultaneously, only if they were all in line could the receptor ever be located on the centre line of every plume. Additive figures for other cases can be obtained in a number of ways, but if it is assumed that all plumes are in a straight line, regardless of the wind direction at any moment, and that the downwind concentrations are additive, this would be the worst possible case. Such an assumption is not unreasonable for distances greater than 1 mile when the emitters are within a relatively short distance of one another, and this assumption has therefore been made in respect of the total emissions reported in Tables 2a through 3c. Additive figures for stability Class D emissions are given on p. 60.

For the short distances, -- from the emitter to the nearest access point - concentrations are considered individually, except in the cases of the surface plant stacks, these are sufficiently close together that they may by considered a single source; the total uranium emission from all five is only 1.36 times that of the highest single source, that of the crusher.

Radiation Exposures

The A.E.C. has laid down maximum permissible concentrations in air for radionuclides to limit the exposure of the whole body and certain critical organs to 1500 mrem per annum, in both restricted areas, which in general are those where people are exposed to radioactivity in the course of their employment, when exposure time is limited to a maximum of 40 hours weekly, as well as in unrestricted areas, where the general public moves freely for 168 hours per week.

MPC limits applicable to the Lisbon operation are as follows ($\mu Ci/ml$).

Isotope	Restricted Areas (Exposure Limited to 40 hours/week)		Unrestricted Area 168 Hours/week	Critical Organ
Uranium (natural)	8×10^{-10}		3×10^{-10}	Whole body
	6×10^{-11}		3×10^{-12}	Kidney
Thorium - 230	2×10^{-11}	Soluble	5×10^{-12}	Whole body
	2×10^{-12}	Insoluble	3×10^{-13}	Lung
	2×10^{-11}	Soluble	8×10^{-14}	Bone
Radium - 226	5×10^{-11}		2×10^{-11}	Whole body
	3×10^{-11}		3×10^{-12}	Bone
Radon - 222	1×10^{-7}		3×10^{-9}	Lung

Unrestricted Areas

Additive Radioactivity, µCi/ml, at Stability D
at the Longer Distances
(From Tables 2c and 3c)

Emitter	At 2500 M	At 4000 M
URANIUM		
Ventilation Shaft	1.30×10^{-15}	8.57×10^{-16}
Surface Plant, at max. emission rate	8.71×10^{-16}	5.83×10^{-16}
Tailings Ponds	NIL	NIL
Total	2.17×10^{-15}	1.44×10^{-15}
RADON - 222		
Ventilation Shaft	4.14×10^{-10}	2.73×10^{-10}
Surface Plant, at max. emission rate	3.53×10^{-16}	2.37×10^{-16}
Tailings Pond, Old	1.89×10^{-11}	1.23×10^{-11}
Tailings Pond, New	3.45×10^{-11}	2.02×10^{-11}
Total	4.67×10^{-10}	3.06×10^{-10}
THORIUM - 230 and RADIUM - 226		
Ventilation Shaft	1.30×10^{-15}	8.57×10^{-10}
Surface Plant, at max. emission rate	3.53×10^{-16}	2.37×10^{-10}
Tailings Ponds	NIL	NIL
Total	1.65×10^{-15}	1.09×10^{-15}

Only the average stability (Class D) has been considered, since the extreme Classes A and F will not often occur.

In the further calculations it is assumed that 50% of the Thorium - 230 is in the soluble and 50% in the insoluble form.

EXPOSURE RATES AT NEAREST ACCESS POINTS (from Table 1 C)

1. Ventilation Shaft Discharge

Radionuclide	Uranium	Thorium-230	Radium-226	Radon-222	Total
μCi/ml	2.88×10^{-13}	2.88×10^{-13}	2.88×10^{-13}	9.14×10^{-8}	
Exposure, mrem/year for 100% occupancy					
Kidney - U	145	--	--	--	145
Lung - Th	--	2160	--	--	--
- Rn	--	--	--	4.59×10^{7}	--
Total Lung					4.59×10^{7}
Bone - Th	--	2700	--	--	--
- Ra	--	--	144	--	--
Total Bone					2840
Whole Body	1.44	432	21.6	--	455

2. Plant Discharge

	Uranium	Thorium-230	Radium-226	Radon-222	Total
μCi/ml	6.45×10^{-17}	6.45×10^{-17}	2.45×10^{-17}	2.45×10^{-17}	
Exposure, mrem/year for 100% occupancy					
Kidney - U	3.23×10^{-2}	--	--	--	3.23×10^{-2}
Lung - Th	--	6.16×10^{-3}	--	--	--
- Rn	--	--	--	1.23×10^{-6}	--
Total Lung					6.16×10^{-3}
Bone - Th	--	2.30×10^{-2}	--	--	--
- Ra	--	--	1.23×10^{-3}	--	--
Total Bone					2.42×10^{-3}
Whole Body	3.23×10^{-4}	3.68×10^{-3}	1.84×10^{-3}	--	5.84×10^{-3}

3. Tailings Ponds

	Old Pond	New Pond	Total
Radionuclide, Radon-μCi/ml	1.16×10^{-10}	1.76×10^{-10}	
Exposure mrem/year for 100% occupancy			
Lung	5800	8800	14,600

TOTAL EXPOSURE RATES AT THE FURTHER POINTS (See Table p60)

Distance		2500 M		4000 M	
		Total Concentration uCi/ml	Exposure mrem/year	Total Concentration uCi/ml	Exposure mrem/year
Organ	Radionuclide				
Kidney	- Uranium	2.17×10^{-15}	1.09	1.44×10^{-15}	7.2×10^{-1}
Lung	- Thorium	8.25×10^{-16}	4.13	5.45×10^{-16}	2.73
	- Radon	4.67×10^{-10}	233.	3.06×10^{-10}	153.
	- Total		2.37×10^{2}		1.56×10^{2}
Bone	- Thorium	8.25×10^{-16}	15.5	5.45×10^{-16}	10.2
	- Radium	1.65×10^{-15}	.825	1.09×10^{-15}	.545
	- Total		16.3		10.7
Whole Body	- Uranium	2.17×10^{-15}	.010	1.44×10^{-15}	.0072
	- Thorium	8.25×10^{-16}	.25	5.45×10^{-16}	.164
	- Radium	1.65×10^{-15}	.12	1.09×10^{-15}	.082
	- Total		0.38		0.253

Actual Exposure Rates To The General Public

The calculated concentrations and exposures have been based on a constant wind speed and a constant wind direction, directly towards the acceptor, and as these are improbable conditions actual exposures at a given point will not be the same as those calculated.

The assumption that all emissions at the mine are additive in the case of the more distant acceptor points, has been made to present the least favourable case, so even at constant conditions actual exposures would be lower than those reported.

In the case of wind speed, other factors being constant, exposures will vary inversely as the speed, taken as 5 mph for the calculations. Varying speeds will of course have some effect on the plume stability also, but the combined effect of small variations is not easy to determine.

Wind direction is a more important variable. The reported figures are based on a constant wind direction, day and night, and give the concentrations at the plume centre-line. Concentrations to either side of the centre-line fall off quite rapidly.

Wind records from the minesite show the following percentages for each direction under daytime conditions.-

Wind Direction From	%
North	2-1/2
Northwest	32
West	8
Southwest	20
South	4-1/2
Southeast	22
East	6
Northeast	5

The Redd Ranch at 2-1/2 miles distance, is the point of greatest interest, as being the nearest po' it inhabited by members of the general public. Located roughly to the northwest of the mine, it would be exposed to downwind concentrations a maximum of perhaps 25% of the time, reducing lung exposures to a maximum of 39 mrem per year and bone exposure to 2.7 mrem/year.

The 8000 feet (= 2500 M) point at the nearest boundary, and also in the direction of the wind of second highest daytime frequency, would also not be exposed to downwind concentrations more than 25% of the time.

The prevailing wind, from the northwest, blows in the direction of uninhabited areas; it can however be assumed that at the distances stated human exposures would be limited to one third of the calculated amounts.

TABLE I

CALCULATION OF DUST EMISSIONS (SURFACE PLANT)

	Crusher	Headframe	Transfer	Yellowcake Scrubber	Yellowcake Filter
Average actual operating time (hours/day)	12	12	12	20	20
CFM	13,000	11,000	2,200	960	1,300
= CF in 24 hours (x 1,000)	9,360	7,920	1,584	1,152	1,560
= M^3 in 24 hours (x 1,000)	265	224	44.9	32.6	[illegible].2
Dust content (mg/M^3)	1.19	.097	1.27	.941	.585
Dust emitted in 24 hrs. (grams)	315.	21.7	57.0	30.7	25.9
Total dust emission	450.3 grams in 24 hours - under 1 lb.				

TABLE 2A

CALCULATION OF DOWNWIND CENTRE-LINE DUST CONCENTRATIONS AT NEAREST ACCESS POINT

(Minimum Stability - Class A)

Emitter	Receptor Distance (meters)	σ_y	H (meters)	σ_z	$\frac{H}{\sigma_z}$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	Dust Emitted g/day	Q g/sec	$\Pi u \sigma_y \sigma_z$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	Concentrations C (g/M^3)
Ventilation Shaft	99	28	2	14	.143	9.90×10^{-1}	22,000	.263	2760	9.53×10^{-5}	9.43×10^{-5}
Crusher (12 hours)	76	22	14	10.5	1.33	4.13×10^{-1}	315	7.29×10^{-3}	1625	4.49×10^{-6}	1.85×10^{-6}
Headframe (12 hours)	76	22	23	10.5	2.19	9.09×10^{-2}	21.7	5.02×10^{-4}	1625	3.09×10^{-7}	2.81×10^{-8}
Transfer (12 hours)	76	22	17	10.5	1.62	2.69×10^{-1}	57.0	1.32×10^{-3}	1625	8.12×10^{-7}	2.18×10^{-7}
Scrubber (20 hours)	76	22	15	10.5	1.43	3.60×10^{-1}	30.7	4.26×10^{-4}	1625	2.62×10^{-7}	9.43×10^{-8}
Filter (20 hours)	76	22	10	10.5	.953	6.35×10^{-1}	25.9	3.60×10^{-4}	1625	2.22×10^{-7}	1.41×10^{-7}
*Total Surface Plant Emissions	76	22	16 (Average)	10.5	1.52	3.15×10^{-1}		*9.90×10^{-3}	1625	6.09×10^{-6}	1.92×10^{-6}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	76	22	16 (Average)	10.5	1.52	3.15×10^{-1}	450.3	5.21×10^{-3}	1625	3.21×10^{-6}	1.01×10^{-6}

*When all surface plant units are in operation simultaneously.

Wind Speed u = 5 mph = 2.24 M/sec.

TABLE 2B

CALCULATION OF DOWNWIND CENTRE-LINE DUST CONCENTRATIONS AT NEAREST ACCESS POINT

(Maximum Stability - Class F)

Emitter	Receptor Distance (meters)	σ_y	H (meters)	σ_z	H/σ_z	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	Dust emitted g/day	$\frac{Q}{g/sec}$	$\Pi u \sigma_y \sigma_z$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	Concentrations C (g/M^3)
Ventilation Shaft	99	4.0	2	2.3	.870	6.85×10^{-1}	22,700	.263	64.7	4.06×10^{-3}	2.78×10^{-3}
Crusher (12 hours)	76	3.2	14	1.8	7.78	7.19×10^{-14}	315	7.29×10^{-3}	40.5	1.80×10^{-4}	1.29×10^{-17}
Headframe (12 hours)	76	3.2	23	1.8	12.8	8×10^{-36}	21.7	5.02×10^{-4}	40.5	1.24×10^{-5}	9.92×10^{-41}
Transfer (12 hours)	76	3.2	17	1.8	9.44	4.46×10^{-20}	57.0	1.32×10^{-3}	40.5	3.26×10^{-5}	1.45×10^{-24}
Scrubber (20 hours)	76	3.2	15	1.8	8.33	8.56×10^{-16}	30.7	4.26×10^{-4}	40.5	1.05×10^{-5}	8.98×10^{-21}
Filter (20 hours)	76	3.2	10	1.8	5.56	1.94×10^{-7}	25.9	3.60×10^{-4}	40.5	8.89×10^{-6}	1.72×10^{-12}
*Total surface plant Emissions	76	3.2	16 (Average)	1.8	8.89	6.89×10^{-18}		*9.90×10^{-3}	40.5	2.44×10^{-4}	1.68×10^{-21}
24-hour average total surface ore treatment plant emissions	76	3.2	16 (Average)	1.8	8.89	6.89×10^{-18}	450.3	5.21×10^{-3}	40.5	1.29×10^{-4}	8.86×10^{-22}

Wind Speed u = 5 m.p.h. = 2.24 M/sec

*When all surface plant units are operating simultaneously.

TABLE 2C

CALCULATION OF DOWNWIND CENTRE-LINE DUST CONCENTRATIONS AT NEAREST ACCESS POINT

(Average Stability - Class D)

Emitter	Receptor Distance (meters)	σ_y	H (meters)	σ_z	H/σ_z	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	Dust emitted g/day	Q g/sec	$\Pi u \sigma_y \sigma_z$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	Concentrations C (g/M³)
Ventilation Shaft	99	8.0	2	4.7	.425	9.14×10^{-1}	22,700	.263	265	9.92×10^{-4}	9.06×10^{-4}
Crusher (12 hours)	76	4.8	14	3.8	3.68	1.15×10^{-3}	315	7.29×10^{-3}	128	5.70×10^{-5}	6.56×10^{-8}
Headframe (12 hours)	76	4.8	23	3.8	6.05	1.13×10^{-8}	21.7	5.02×10^{-4}	128	3.92×10^{-6}	4.43×10^{-14}
Transfer (12 hours)	76	4.8	17	3.8	4.47	4.58×10^{-5}	57.0	1.32×10^{-3}	128	1.03×10^{-5}	4.71×10^{-10}
Scrubber (20 hours)	76	4.8	15	3.8	3.95	4.09×10^{-4}	30.7	4.26×10^{-4}	128	3.33×10^{-6}	1.36×10^{-9}
Filter (20 hours)	76	4.8	10	3.8	2.63	3.15×10^{-2}	25.9	3.60×10^{-4}	128	2.81×10^{-6}	8.85×10^{-8}
*Total surface plant emissions	76	4.8	16 (Average)	3.8	4.21	1.42×10^{-4}		*9.90×10^{-3}	128	7.73×10^{-5}	1.10×10^{-8}
24-hour average total surface ore treatment plant emissions	76	4.8	16 (Average)	3.8	4.21	1.42×10^{-4}	450.3	5.21×10^{-3}	128	4.07×10^{-5}	5.78×10^{-9}

Wind Speed u = 5 m.p.h. = 2.24 M/sec

*When all surface plant units are operating simultaneously.

TABLE 1A

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT NEAREST ACCESS POINT

(Minimum Stability - Class A)

$u = 2.24$ M/sec

A. URANIUM

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	100	2	8.36×10^{-11}	28	14	.143	2760	9.90×10^{-1}	3.03×10^{-14}	3.00×10^{-14}
Plant Stacks: -										
Crusher	76	14	9.17×10^{-12}	22	10.5	1.33	1625	4.13×10^{-1}	5.64×10^{-15}	2.33×10^{-15}
Headframe	76	23	1.37×10^{-12}	22	10.5	2.19	1625	9.09×10^{-2}	8.43×10^{-16}	7.66×10^{-17}
Transfer	76	17	1.39×10^{-12}	22	10.5	1.62	1625	2.69×10^{-1}	8.55×10^{-16}	2.30×10^{-16}
Scrubber	76	15	2.52×10^{-11}	22	10.5	1.43	1625	3.60×10^{-1}	1.55×10^{-14}	5.58×10^{-15}
Filter	76	10	3.33×10^{-12}	22	10.5	.953	1625	6.35×10^{-1}	2.04×10^{-15}	1.30×10^{-15}
Total Surface Plant Emissions*	76	16 Ave.	5.81×10^{-11}*	22	10.5	1.52	1625	3.15×10^{-1}	3.58×10^{-14}	1.13×10^{-14}
24-Hour Ave., total surface plant emissions	76	16 Ave.	4.05×10^{-11}	22	10.5	1.52	1625	3.15×10^{-1}	2.49×10^{-14}	7.84×10^{-15}
Tailings Ponds: -										
Original			Nil							
New			Nil							

B. RADON - 222 (No allowance made for radon decay)

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	100	2	2.66×10^{-5}	28	14	.143	2760	9.90×10^{-1}	9.64×10^{-9}	9.54×10^{-9}
Plant Stacks: -										
Crusher	76	14	9.17×10^{-12}	22	10.5	1.33	1625	4.13×10^{-1}	5.64×10^{-15}	2.33×10^{-15}
Headframe	76	23	1.37×10^{-12}	22	10.5	2.19	1625	9.09×10^{-1}	8.43×10^{-16}	7.66×10^{-17}
Transfer	76	17	1.39×10^{-12}	22	10.5	1.62	1625	2.69×10^{-1}	8.55×10^{-16}	2.30×10^{-16}
Total Emissions from ore Treatment Plant*	76	18 Ave.	2.38×10^{-11}*	22	10.5	1.71	1625	2.32×10^{-1}	1.46×10^{-14}	3.38×10^{-15}
24-Hour Ave., total surface ore treatment plant emissions	76	18 Ave.	1.19×10^{-11}	22	10.5	1.71	1625	2.32×10^{-1}	7.32×10^{-15}	1.69×10^{-15}
Tailings Ponds: -										
Original	305 Actual	-	2.17×10^{-6}	130	180	-	165,000	-	1.32×10^{-11}	1.32×10^{-11}
New	150 Actual	-	3.90×10^{-6}	115	102	-	82,500	-	4.72×10^{-11}	4.72×10^{-11}

C. THORIUM - 230 and RADIUM -226

At secular equilibrium in the ore the radioactivity of the natural uranium and the thorium, radium, and radon associated with it are equal to one another. Thorium, radium, and radon are not carried through to the yellowcake product and the individual as well as the total and average concentrations of the thorium and radium in the plant stacks are therefore equal to those reported for the radon in this instance.

*When all surface plant units are in operation simultaneously.

TABLE 1B

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT NEAREST ACCESS POINT

(Maximum Stability - Class F)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C µCi/ml
A. URANIUM										
Ventilation Shaft	100	2	8.36×10^{-11}	4.0	2.3	.870	64.7	6.85×10^{-1}	1.29×10^{-12}	8.86×10^{-13}
Plant Stacks:-										
Crusher	76	14	9.17×10^{-12}	3.2	1.8	7.78	40.5	7.19×10^{-14}	2.26×10^{-13}	1.62×10^{-26}
Headframe	76	23	1.37×10^{-12}	3.2	1.8	12.8	40.5	8.00×10^{-36}	3.38×10^{-14}	2.70×10^{-49}
Transfer	76	17	1.39×10^{-12}	3.2	1.8	9.44	40.5	4.46×10^{-20}	3.43×10^{-14}	1.52×10^{-33}
Scrubber	76	15	2.52×10^{-11}	3.2	1.8	8.33	40.5	8.56×10^{-16}	6.22×10^{-13}	5.32×10^{-28}
Filter	76	10	3.33×10^{-12}	3.2	1.8	5.56	40.5	1.94×10^{-7}	8.22×10^{-14}	1.59×10^{-20}
Total Surface Plant Emissions*	76 (Ave.)	16	5.81×10^{-11}*	3.2	1.8	8.89	40.5	6.89×10^{-18}	1.43×10^{-12}	9.88×10^{-30}
24 Hr. Ave. total surface plant emissions	76 (Ave.)	16	4.05×10^{-11}	3.2	1.8	8.89	40.5	6.89×10^{-18}	1.00×10^{-12}	6.89×10^{-30}
Tailings Ponds:-										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	100	2	2.66×10^{-5}	4.0	2.3	.870	64.7	6.85×10^{-1}	4.11×10^{-7}	2.82×10^{-7}
Plant Stacks:-										
Crusher	76	14	9.17×10^{-12}	3.2	1.8	7.78	40.5	7.19×10^{-14}	2.26×10^{-13}	1.62×10^{-26}
Headframe	76	23	1.37×10^{-12}	3.2	1.8	12.8	40.5	8.00×10^{-36}	3.38×10^{-14}	2.70×10^{-49}
Transfer	76	17	1.39×10^{-12}	3.2	1.8	9.44	40.5	4.46×10^{-20}	3.43×10^{-14}	1.52×10^{-33}
Total Emissions from ore Treatment Plant	76	18 (Average)	2.38×10^{-11}*	3.2	1.8	10.0	40.5	1.90×10^{-22}	5.88×10^{-13}	1.12×10^{-34}
24 Hour Average Total Surface Ore Treatment Plant Emissions	76	18 (Average)	1.19×10^{-11}	3.2	1.8	10.0	40.5	1.90×10^{-22}	2.94×10^{-13}	5.59×10^{-35}
Tailings Ponds:-										
Original	305(Actual)	-	2.17×10^{-6}	72	23	-	11700	-	1.85×10^{-10}	1.85×10^{-10}
New	150	-	3.90×10^{-6}	80	24.5	-	13800	-	2.83×10^{-10}	2.83×10^{-10}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A

*When all surface plant units are in operation simultaneously.

TABLE 1C

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT NEAREST ACCESS POINT

(Average Stability - Class D)

$u = 2.24$ M/sec

A. URANIUM

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C μCi/ml
Ventilation Shaft	100	2	8.36×10^{-11}	8	4.7	.425	265	9.14×10^{-1}	3.15×10^{-13}	2.88×10^{-13}
Plant Stacks:-										
Crusher	76	14	9.17×10^{-12}	4.8	3.8	3.68	128	1.15×10^{-3}	7.16×10^{-14}	8.23×10^{-17}
Headframe	76	23	1.37×10^{-12}	4.8	3.8	6.05	128	1.13×10^{-8}	1.07×10^{-14}	1.21×10^{-22}
Transfer	76	17	1.39×10^{-12}	4.8	3.8	4.47	128	4.58×10^{-5}	1.09×10^{-14}	4.99×10^{-19}
Scrubber	76	15	2.52×10^{-11}	4.8	3.8	3.95	128	4.09×10^{-4}	1.97×10^{-13}	8.05×10^{-17}
Filter	76	10	3.33×10^{-12}	4.8	3.8	2.63	128	3.15×10^{-2}	2.60×10^{-14}	8.19×10^{-16}
Total Surface Plant Emissions*	76	(Ave.) 16	5.81×10^{-11}*	4.8	3.8	4.21	128	1.42×10^{-4}	4.54×10^{-13}	6.45×10^{-17}
24-Hour Average, total Surface Plant Emissions	76	(Ave.) 16	4.05×10^{-11}	4.8	3.8	4.21	128	1.42×10^{-4}	3.16×10^{-13}	4.49×10^{-17}
Tailings Ponds:-										
Original			Nil							
New			Nil							

B. RADON - 222 (No allowance made for radon decay)

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C μCi/ml
Ventilation Shaft	100	2	2.66×10^{-5}	8	4.7	.425	265	9.14×10^{-1}	1.00×10^{-7}	9.14×10^{-8}
Plant Stacks:-										
Crusher	76	14	9.17×10^{-12}	4.8	3.8	3.68	128	1.15×10^{-3}	7.16×10^{-14}	8.23×10^{-17}
Headframe	76	23	1.37×10^{-12}	4.8	3.8	6.05	128	1.13×10^{-8}	1.07×10^{-14}	1.21×10^{-22}
Transfer	76	17	1.39×10^{-12}	4.8	3.8	4.47	128	4.58×10^{-5}	1.09×10^{-14}	4.99×10^{-19}
Total Emissions from ore Treatment Plant*	76	18 (Average)	2.38×10^{-11}*	4.8	3.8	4.74	128	1.32×10^{-5}	1.86×10^{-13}	2.45×10^{-18}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	76	18 (Average)	1.19×10^{-11}	4.8	3.8	4.74	128	1.32×10^{-5}	9.30×10^{-14}	1.23×10^{-18}
Tailings Ponds:-										
Original	305 Actual	-	2.17×10^{-6}	78	34	-	18,700	-	1.16×10^{-10}	1.16×10^{-10}
New	150 Actual	-	3.90×10^{-6}	85	37	-	22,100	-	1.76×10^{-10}	1.76×10^{-10}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A

*When all surface plant units are in operation simultaneously.

TABLE 2A

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT 8000 FEET (2500 M) FROM MINE OPERATIONS

(Minimum Stability - Class A)

$u = 2.24$ M/sec

A. URANIUM

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	2,500	2	8.36×10^{-11}	430	3300	.0006	9.98×10^{6}	1.0	8.38×10^{-16}	8.38×10^{-16}
Plant Stacks: -										
Crusher	2,500	14	9.17×10^{-12}	430	3300	.0042	9.98×10^{6}	1.0	9.18×10^{-17}	9.18×10^{-17}
Headframe	2,500	23	1.37×10^{-12}	430	3300	.0070	9.98×10^{6}	1.0	1.37×10^{-17}	1.37×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	430	3300	.0052	9.98×10^{6}	1.0	1.39×10^{-17}	1.39×10^{-17}
Scrubber	2,500	15	2.52×10^{-11}	430	3300	.0055	9.98×10^{6}	1.0	2.52×10^{-17}	2.52×10^{-17}
Filter	2,500	10	3.33×10^{-12}	430	3300	.0030	9.98×10^{6}	1.0	3.34×10^{-17}	3.34×10^{-17}
Total Surface Plant Emissions*	2,500	16(Ave.)	5.81×10^{-11}*	430	3300	.0048	9.98×10^{6}	1.0	5.82×10^{-16}	5.82×10^{-16}
24-Hour Average, Total Surface Plant Emissions	2,500	16(Ave.)	4.05×10^{-11}	430	3300	.0048	9.98×10^{6}	1.0	4.06×10^{-16}	4.06×10^{-16}
Tailings Ponds: -										
Original			Nil							
New			Nil							

B. RADON - 222 (No allowance made for radon decay)

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	2,500	2	2.66×10^{-5}	430	3300	.0006	9.98×10^{6}	1.0	2.67×10^{-10}	2.67×10^{-10}
Plant Stacks: -										
Crusher	2,500	14	9.17×10^{-12}	430	3300	.0042	9.98×10^{6}	1.0	9.19×10^{-17}	9.19×10^{-17}
Headframe	2,500	23	1.37×10^{-12}	430	3300	.0070	9.98×10^{6}	1.0	1.37×10^{-17}	1.37×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	430	3300	.0052	9.98×10^{6}	1.0	1.39×10^{-17}	1.39×10^{-17}
Total Emissions from Ore Treatment Plant*	2,500	18 (Average)	2.38×10^{-11}*	430	3300	.0055	9.98×10^{6}	1.0	2.38×10^{-16}	2.38×10^{-16}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	2,500	18 (Average)	1.19×10^{-11}	430	3300	.0055	9.98×10^{6}	1.0	1.19×10^{-16}	1.19×10^{-16}
Tailings Ponds: -										
Original	2,500 (Actual)	-	2.17×10^{-6}	500	3700	-	1.30×10^{7}	-	1.67×10^{-13}	1.67×10^{-13}
New	2,500 (Actual)	-	3.90×10^{-6}	520	4200	-	1.54×10^{7}	-	2.53×10^{-13}	2.53×10^{-13}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A

*When all surface plant units are in operation simultaneously.

TABLE 2B

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT 8,000 FEET FROM MINE OPERATIONS

(Maximum Stability - Class F)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C μCi/ml
A. URANIUM										
Ventilation Shaft	2,500	2	8.36×10^{-11}	77	24	.083	13,000	9.97×10^{-1}	6.43×10^{-15}	6.41×10^{-15}
Plant Stacks:-										
Crusher	2,500	14	9.17×10^{-12}	77	24	.583	13,000	8.44×10^{-1}	7.05×10^{-16}	5.95×10^{-16}
Headframe	2,500	23	1.37×10^{-12}	77	24	.958	13,000	6.31×10^{-1}	1.05×10^{-16}	6.62×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	77	24	.708	13,000	7.79×10^{-1}	1.07×10^{-16}	8.33×10^{-17}
Scrubber	2,500	15	2.52×10^{-11}	77	24	.625	13,000	8.23×10^{-1}	1.94×10^{-15}	1.60×10^{-15}
Filter	2,500	10	3.33×10^{-12}	77	24	.417	13,000	9.17×10^{-1}	2.56×10^{-16}	2.34×10^{-16}
Total Surface Plant Emissions*	2,500	16 (Average)	5.81×10^{-11}*	77	24	.667	13,000	8.01×10^{-1}	4.46×10^{-15}	3.75×10^{-15}
24-Hour Average, Total Surface Plant Emissions	2,500	16 (Average)	4.05×10^{-11}	77	24	.667	13,000	8.01×10^{-1}	3.12×10^{-15}	2.49×10^{-15}
Tailings Ponds:-										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	2,500	2	2.66×10^{-5}	77	24	.083	13,000	9.97×10^{-1}	2.05×10^{-9}	2.04×10^{-9}
Plant Stacks:-										
Crusher	2,500	14	[illegible]17 x 10^{-12}	77	24	.583	13,000	8.44×10^{-1}	7.05×10^{-16}	5.95×10^{-16}
Headframe	2,500	23	1.[illegible] 10^{-12}	77	24	.958	13,000	6.31×10^{-1}	1.05×10^{-16}	6.62×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	77	24	.708	13,000	7.79×10^{-1}	1.07×10^{-16}	8.33×10^{-17}
Total Emissions From Ore Treatment Plant*	2,500	18 (Average)	2.38×10^{-11}*	77	24	.750	13,000	7.75×10^{-1}	1.83×10^{-15}	1.40×10^{-15}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	2,500	18 (Average)	1.19×10^{-11}	77	24	.750	13,000	7.75×10^{-1}	9.15×10^{-16}	7.09×10^{-16}
Tailings Ponds:-										
Original	2,500(actual)	-	2.17×10^{-6}	140	33	-	32,500	-	6.67×10^{-11}	6.67×10^{-11}
New	2,500(actual)	-	3.90×10^{-6}	145	34	-	34,700	-	1.12×10^{-10}	1.12×10^{-10}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 2C

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT 8000 FEET FROM MINE OPERATIONS

(Average Stability - Class D)
$u = 2.24$ M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -1/2 \left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C μCi/ml
A. URANIUM										
Ventilation Shaft	2500	2	8.36×10^{-11}	160	57	.0351	64200	9.99×10^{-1}	1.30×10^{-15}	1.30×10^{-15}
Plant Stacks:-										
Crusher	2500	14	9.17×10^{-12}	160	57	.246	64200	9.70×10^{-1}	1.43×10^{-16}	1.39×10^{-16}
Headframe	2500	23	1.37×10^{-12}	160	57	.404	64200	9.21×10^{-1}	2.13×10^{-17}	1.96×10^{-17}
Transfer	2500	17	1.39×10^{-12}	160	57	.298	64200	9.56×10^{-1}	2.17×10^{-17}	2.07×10^{-17}
Scrubber	2500	15	2.52×10^{-11}	160	57	.263	64200	9.66×10^{-1}	3.93×10^{-16}	3.80×10^{-16}
Filter	2500	10	3.33×10^{-12}	160	57	.175	64200	9.85×10^{-1}	5.19×10^{-17}	5.11×10^{-17}
Total Surface Plant Emissions*	2500	16 (Average)	5.81×10^{-11}*	160	57	.281	64200	9.62×10^{-1}	9.05×10^{-16}	8.71×10^{-16}
24 Hr. Ave. total surface emissions	2500	16 (Average)	4.05×10^{-11}	160	57	.281	64200	9.62×10^{-1}	6.31×10^{-16}	6.07×10^{-16}
Tailings Ponds:-										
Original			NIL							
New			NIL							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	2500	2	2.66×10^{-5}	160	57	.0351	64200	9.99×10^{-1}	4.14×10^{-10}	4.14×10^{-10}
Plant Stacks:										
Crusher	2500	14	9.17×10^{-12}	160	57	.246	64200	9.70×10^{-1}	1.43×10^{-16}	1.39×10^{-16}
Headframe	2500	23	1.37×10^{-12}	160	57	.404	64200	9.21×10^{-1}	2.13×10^{-17}	1.96×10^{-17}
Transfer	2500	17	1.39×10^{-12}	160	57	.298	64200	9.56×10^{-1}	2.17×10^{-17}	2.07×10^{-17}
Total Emissions from ore Treatment Plant*	2500	18 (Average)	2.38×10^{-11}*	160	57	.316	64200	9.51×10^{-1}	3.71×10^{-16}	3.53×10^{-16}
24 Hour Average Total Surface Ore Treatment Plant Emissions	2500	18 (Average)	1.19×10^{-11}	160	57	.316	64200	9.51×10^{-1}	1.85×10^{-16}	1.76×10^{-16}
Tailings Ponds:-										
Original	2500 (Actual)	-	2.17×10^{-6}	210	78	-	115000	-	1.89×10^{-11}	1.89×10^{-11}
New	2500 (Actual)	-	3.90×10^{-6}	220	73	-	113000	-	3.45×10^{-11}	3.45×10^{-11}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 3A

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT THE REDD RANCH
2 1/2 MILES (=4,000 meters) FROM THE PROPERTY (MINIMUM STABILITY - CLASS A)

$u = 2.24$ M/sec.

A. URANIUM Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C μCi/ml
Ventilation Shaft	4,000	2	8.36×10^{-11}	710	7,000	.0003	3.5×10^{7}	1.0	2.39×10^{-18}	2.39×10^{-18}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	710	7,000	.0020	3.5×10^{7}	1.0	2.62×10^{-19}	2.62×10^{-19}
Headframe	4,000	23	1.37×10^{-12}	710	7,000	.0033	3.5×10^{7}	1.0	3.91×10^{-20}	3.91×10^{-20}
Transfer	4,000	17	1.39×10^{-12}	710	7,000	.0024	3.5×10^{7}	1.0	3.97×10^{-20}	3.97×10^{-20}
Scrubber	4,000	15	2.52×10^{-11}	710	7,000	.0021	3.5×10^{7}	1.0	7.20×10^{-19}	7.20×10^{-19}
Filter	4,000	10	3.33×10^{-12}	710	7,000	.0014	3.5×10^{7}	1.0	9.51×10^{-20}	9.51×10^{-20}
Total Surface Plant Emissions*	4,[illegible]	16 (Average)	5.81×10^{-11}*	710	7,000	.0023	3.5×10^{7}	1.0	1.66×10^{-18}	1.66×10^{-18}
24-Hour Avg. Total Surface Plant Emissions		16 (Average)	4.05×10^{-11}	710	7,000	.0023	3.5×10^{7}	1.0	1.16×10^{-18}	1.16×10^{-18}
Tailings Ponds: -										
Original			nil							
New			nil							
B. RADON -222 (No allowance made for radon decay)										
Ventilation Shaft	4,000	2	2.66×10^{-5}	710	7,000	.0003	3.5×10^{7}	1.0	7.60×10^{-13}	7.60×10^{-13}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	710	7,000	.0020	3.5×10^{7}	1.0	2.62×10^{-19}	2.62×10^{-19}
Headframe	4,000	23	1.37×10^{-12}	710	7,000	.0033	3.5×10^{7}	1.0	3.91×10^{-20}	3.91×10^{-20}
Transfer	4,000	17	1.39×10^{-12}	710	7,000	.0024	3.5×10^{7}	1.0	3.97×10^{-20}	3.97×10^{-20}
Total Emissions from Ore Treatment Plant*	4,000	18 (Average)	2.38×10^{-11}*	710	7,000	.0026	3.5×10^{7}	1.0	6.80×10^{-19}	6.80×10^{-19}
24-Hour Avg., Total surface ore treatment plant emissions	4,000	18 (Average)	1.19×10^{-11}	710	7,000	.0026	3.5×10^{7}	1.0	3.40×10^{-19}	3.40×10^{-19}
Tailings Ponds: -										
Original	4,000(actual)	-	2.17×10^{-6}	750	8,000	-	4.22×10^{7}	-	5.14×10^{-14}	5.14×10^{-14}
New	4,000(actual)	-	3.90×10^{-6}	760	9,000	-	4.81×10^{7}	-	8.11×10^{-14}	8.11×10^{-14}

C. THORIUM -230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 3B

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT THE REDD RANCH, 2½ MILES (≈4,000 meters) FROM THE PROPERTY

(Maximum Stability - Class F)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	$\frac{C}{\mu Ci/ml}$
A. URANIUM										
Ventilation Shaft	4,000	2	8.36×10^{-11}	120	31	.0645	26,200	9.98×10^{-1}	3.19×10^{-15}	3.18×10^{-15}
Plant Stacks:-										
Crusher	4,000	14	9.17×10^{-12}	120	31	.452	26,200	9.03×10^{-1}	3.50×10^{-16}	3.16×10^{-16}
Headframe	4,000	23	1.37×10^{-12}	120	31	.742	26,200	7.60×10^{-1}	5.23×10^{-17}	3.97×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	120	31	.548	26,200	8.60×10^{-1}	5.31×10^{-17}	4.56×10^{-17}
Scrubber	4,000	15	2.52×10^{-11}	120	31	.483	26,200	8.90×10^{-1}	9.62×10^{-16}	8.56×10^{-16}
Filter	4,000	10	3.33×10^{-12}	120	31	.323	26,200	9.49×10^{-1}	1.27×10^{-16}	1.21×10^{-16}
Total Surface Plant Emissions*	4,000	16 (Average)	5.81×10^{-11}*	120	31	.516	26,200	8.76×10^{-1}	2.22×10^{-15}	1.94×10^{-15}
24-Hour Average, Total Surface Plant Emissions		16 (Average)	4.05×10^{-11}	120	31	.516	26,200	8.76×10^{-1}	1.55×10^{-15}	1.35×10^{-15}
Tailings Ponds:-										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	4,000	2	2.66×10^{-5}	120	31	.0645	26,200	9.98×10^{-1}	1.02×10^{-9}	1.02×10^{-9}
Plant Stacks:-										
Crusher	4,000	14	9.17×10^{-12}	120	31	.452	26,200	9.03×10^{-1}	3.50×10^{-16}	3.16×10^{-16}
Headframe	4,000	23	1.37×10^{-12}	120	31	.742	26,200	7.60×10^{-1}	5.23×10^{-17}	3.97×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	120	31	.548	26,200	8.60×10^{-1}	5.31×10^{-17}	4.56×10^{-17}
Total Emissions from Ore Treatment Plant*	4,000	18 (Average)	2.38×10^{-11}*	120	31	.581	26,200	8.45×10^{-1}	9.08×10^{-16}	7.67×10^{-16}
24-Hour Average Total Surface Ore Treatment plant emissions	4,000	18 (Average)	1.19×10^{-11}	120	31	.581	26,200	8.45×10^{-1}	4.54×10^{-16}	3.84×10^{-16}
Tailings Ponds:-										
Original	4,000 (actual)	-	2.17×10^{-6}	175	37	-	45,500	-	4.76×10^{-11}	4.76×10^{-11}
New	4,000 (actual)	-	3.90×10^{-6}	185	38	-	49,500	-	7.87×10^{-11}	7.87×10^{-11}

C. THORIUM -230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 3C

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT THE REDD RANCH (≈ 4000 METERS) FROM THE PROPERTY

(Average Stability - Class D)

u = 2.24 M/sec

A. URANIUM

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C μCi/ml
Ventilation Shaft	4,000	2	8.36×10^{-11}	180	77	.0260	97,500	1.0	8.57×10^{-16}	8.57×10^{-16}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	180	77	.182	97,500	9.84×10^{-1}	9.41×10^{-17}	9.26×10^{-17}
Headframe	4,000	23	1.37×10^{-12}	180	77	.299	97,500	9.56×10^{-1}	1.41×10^{-17}	1.35×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	180	77	.221	97,500	9.76×10^{-1}	1.43×10^{-17}	1.40×10^{-17}
Scrubber	4,000	15	2.52×10^{-11}	180	77	.195	97,500	9.81×10^{-1}	2.58×10^{-16}	2.53×10^{-16}
Filter	4,000	10	3.33×10^{-12}	180	77	.130	97,500	9.92×10^{-1}	3.42×10^{-17}	3.39×10^{-17}
Total Surface Plant Emissions*	4,000	16 (Average)	5.81×10^{-11}*	180	77	.208	97,500	9.78×10^{-1}	5.96×10^{-16}	5.83×10^{-16}
24-Hour Avg. Total Surface Plant Emissions	4,000	16 (Average)	4.05×10^{-11}	180	77	.208	97,500	9.78×10^{-1}	4.15×10^{-16}	4.06×10^{-16}
Tailings Ponds: -										
Original			nil							
New			nil							

B. RADON - 222 (No allowance made for radon decay)

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C μCi/ml
Ventilation Shaft	4,000	2	2.66×10^{-5}	180	77	.0260	97,500	1.0	2.73×10^{-10}	2.73×10^{-10}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	180	77	.182	97,500	9.84×10^{-1}	9.41×10^{-17}	9.26×10^{-17}
Headframe	4,000	23	1.37×10^{-12}	180	77	.299	97,500	9.56×10^{-1}	1.41×10^{-17}	1.35×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	180	77	.221	97,500	9.76×10^{-1}	1.43×10^{-17}	1.40×10^{-17}
Total Emissions from Ore Treatment Plant*	4,000	18 (Average)	2.38×10^{-11}*	180	77	.234	97,500	9.73×10^{-1}	2.44×10^{-16}	2.37×10^{-16}
24-Hour Avg. Total Surface Ore Treatment Plant Emissions	4,000	18 (Average)	1.19×10^{-11}	180	77	.234	97,50C	9.73×10^{-1}	1.22×10^{-16}	1.19×10^{-16}
Tailings Ponds: -										
Original	4,000(actual)		2.17×10^{-6}	290	86	-	176,000	-	1.23×10^{-11}	1.23×10^{-11}
New	4,000(actual)		3.90×10^{-6}	305	90	-	193,000	-	2.02×10^{-11}	2.02×10^{-11}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

40-8084

Rio Algom
Rio Tinto

January 7th, 1974.

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Regulatory
Mail Section

Ref. (40-8084)

John F. Kendig, Esq.,
Materials Branch,
Directorate of Licensing,
United States Atomic Energy Commission,
WASHINGTON, D.C. 20545.

Dear Mr. Kendig:

My apologies for the discrepancies on Pages 48, 49 and Appendix C of our Response to the Agency Comments on the Draft Statement on the Lisbon Uranium Mill.

Page 48 last line of Sec. 2A should read:

2.25×10^{-7} uC/ml = 2.32×10^{6} uC/day

Page 49 fifth line from the bottom should read:

Surface plant stacks 1.03 uC/day.

Appendix C - Monitor well analyses for wells 1, 2, 3, 4, 5, D-1, D-2, D-3 and D-10 should have the same units for Unat, radium 226 and thorium 230 as the analyses tables previous to July 1973. Attached are corrected tables.

Yours truly,

P F Pullen

PFP/mm

P. F. Pullen, P. Eng.,
Chief Environmental Engineer.

cc: R. D. Lord

0096

LIBSON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMAR
		pH	Na	So4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
7-3-73	80'		385		5.1				
7-10-73	75'		385		3.9				
7-17-73	75'		385		4.8				
7-24-73	75'		385		4.6				
COMPOSITE				698	4.8	5.22	< 2.0		
8-7-73	75'	7.2	295		2.9				
8-14-73	75'	7.6	333		3.3				
8-21-73	75'	7.4	335		3.6				
COMPOSITE				489		4.78	<2.0		
8-28-73	74'	7.4	386		2.4				
9-4-73	73'	7.5	330		1.6				
9-11-73	73'	7.6	340		1.4				
9-18-73	73'	7.3	315		1.4				
COMPOSITE				473	1.7	1.84	< 2.0		
9-25-73	73'	7.4	330		2.4				
10-2-73	73'	7.5	325		1.5				
10-9-73	73'	7.6	328		1.4				
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

9600

Appendix O, Reference 1
Q-42

LIBSON MINE

TAILINGS MONITOR WELL #2

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARK
		pH	Na	So4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
7-3-73	85'		394		5.8				
7-10-73	80'		393		6.4				
7-17-73	80'		394		5.6				
7-24-73	80'		393		6.6				
COMPOSITE				715	6.2	2.96	< 2.0		
8-7-73	80'	7.3	395		6.5				
8-13-73	80'	7.6	300		2.0				
8-20-73	80'	7.5	392		4.7				
COMPOSITE				481	4.4	4.14	< 2.0		
8-28-73	80'		410		4.2				
9-4-73	80'		360		3.9				
9-11-73	81'		370		4.2				
9-18-73	81'		365		2.8				
COMPOSITE				420	3.9	2.40	< 2.0		
9-25-73	82'	7.6	446		3.9				
10-2-73	82'	7.6	345		3.4				
10-9-73	82'	7.6	360		4.2				
					$x 10^{-7}$	$x 10^{-9}$	$x 10^{-8}$		

= monthly
= monthlily composite
= weekly

0096

Appendix Q, Reference 1
Q-43

LIBSON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	DEPTH TO WATER	ppm pH	Na	SO_4	uc/ml Unat	Ra 226	Th 230		REMARKS
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN 73	SNOWBOUND								
FEB 73	SNOWBOUND								
3-13-73	155'	8.2	160	260	.08	3.0	<2.0		
4-13-73	150'	8.1	72	254	.16	2.6	<2.0		
4-25-73	150'	8.0	72	253	.12	2.6	<2.0		
5-1-73	150'	8.4	150	135	.15	2.6	<2.0		
5-8-73	145'	8.3	150	130	.15	2.8	<2.0		
5-15-73	145'	8.2	153	137	.14	2.8	<2.0		
5-22-73	145'	8.3	150	142	.14	2.5	<2.0		
6-12-73	145'	8.1	51	210	.12	8.3	<2.0		
7-10-73	145'	8.2	83	278	.14	2.6	<2.0		
8-14-73	145'	7.4	48	160	2.50	5.7	<2.0		
9-4-73	145'	7.6	40	167	2.30	3.75	<2.0		
10-2-73	145'	7.3	38	168	.20	1.56	<2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

9600

M = monthly
Mc = monthly composite
W = weekly

Appendix Q, Reference 1
Q-44

LIBSON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	DEPTH TO WATER	ppm pH	ppm Na	ppm So^4	uc/ml Unat	uc/ml Ra 226	uc/ml Th 230		REMARK
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN. 73	SNOWBOUND								
FEB. 73	SNOWBOUND								
3-13-73	155'	8.3	187	277	.06	2.0	2.0		
4-13-73	150'	8.1	158	253	.42	1.2	2.0		
4-25-73	150'	8.1	154	254	.31	4.9	2.0		
5- 1-73	150'	8.4	114	155	.30	2.6	2.0		
5- 8-73	145'	8.4	107	150	.30	2.7	2.0		
5-15-73	145'	8.4	114	153	.31	2.5	2.0		
5-22-73	145'	8.4	121	148	.29	2.6	2.0		
6-12-73	145'	8.4	100	301	.13	1.4	2.0		
7-10-73	145'	8.4	173	349	.14	1.5	2.0		
8-14-73		7.7	140	250	1.90	5.3	2.0		
9- 4-73	145'	7.9	130	310	1.60	3.25	2.0		
10-2-73	152'	7.6	130	213	.20	3.22	2.0		
					$x 10^{-7}$	$x 10^{-9}$	$x 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

9600

LIBSON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc.		
JAN. 73	SNOWBOUND								
FEB. 73	SNOWBOUND								
3-13-73	155'	8.3	187	277	.06	2.0	2.0		
4-13-73	150'	8.1	158	253	.42	1.2	2.0		
4-25-73	150'	8.1	154	254	.31	4.9	2.0		
5- 1-73	150'	8.4	114	155	.30	2.6	2.0		
5- 8-73	145'	8.4	107	150	.30	2.7	2.0		
5-15-73	145'	8.4	114	153	.31	2.5	2.0		
5-22-73	145'	8.4	121	148	.29	2.6	2.0		
6-12-73	145'	8.4	100	301	.13	1.4	2.0		
7-10-73	145'	8.4	173	349	.14	1.5	2.0		
8-14-73		7.7	140	250	1.90	5.3	2.0		
9- 4-73	145'	7.9	130	310	1.60	3.25	2.0		
10-2-73	152'	7.6	130	213	.20	3.22	2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

9600

M = monthly
Mc = monthly composite
W = weekly

LIBSON MINE

TAILINGS MONITOR WELL #5

SAMPLE DATE	DEPTH TO WATER	ppm pH	ppm Na	ppm So^4	uc/ml Unat	uc/ml Ra 226	uc/ml Th 230		REMARKS
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN. 73-----	SNOWBOUND---------								
FEB. 73-----	SNOWBOUND---------								
MAR. 73-----	SNOWBOUND & MUD--								
4-13-73	205'	7.9	42	324	.28	1.81	2.0		
4-25-73	200'	7.8	42	264	.23	1.45	2.0		
5- 1-73	195'	8.4	29	215	.23	1.63	2.0		
5- 8-73	195'	8.4	29	210	.24	1.75	2.0		
5-15-73	195	8.3	29	219	.23	1.78	2.0		
5-22-73	195'	8.4	29	223	.23	1.78	2.0		
6-12-73	195	8.2	31	338	.21	1.39	2.0		
7-10-73	195'	8.2	50	424	.21	1.07	2.0		
8-14-73	195'	7.4	26	250	1.20	1.85	2.0		
9- 4-73	195'	7.5	20	301	1.40	1.65	2.0		
10-5-73	195'	7.2	19	182	.30	1.94	2.0		
					$\times 10^{-7}$	$\times 10^{-9}$	$\times 10^{-8}$		

M = monthly
Mc = monthly composite
W = weekly

0096

Appendix Q, Reference 1

LIBSON MINE

TAILINGS MONITOR WELLS D-1, D-2, D-3 & D-10

AMPLE ATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So4	Unat	Ra 226	Th 230		
REQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
D-1									
8-13-73		7.6		261	.20	6.99			
9-26-73		7.4		381	.10				
D-2									
8-13-73		7.7		2688	84.1	3.40			
BEFORE BAILING									
D-2A 9-26-73		7.7		3135	121.3				
AFTER BAILING									
D-2B 9-26-73		7.8		3376	126.9				
10-8-73		7.8		3376	126.9				
D-3									
8-13-73		7.4		1705	50.4	2.35			
9-26-73		7.6		1915	5.3				
D-10									
8-13-73		7.5		350	.70	1.71			
9-26-73		10.5		923	.03				
					x 10^{-7}	x 10^{-9}	x 10^{-8}		

M = monthly
Mc = monthly composite
W = weekly

Appendix Q, Reference 1

Q-48

APPENDIX R

L. Letter from the University of Utah, Radiological Health Department, to Rio Algom, dated July 18, 1973.

Appendix R, Reference 1

R-2

THE UNIVERSITY OF UTAH

SALT LAKE CITY 84112

RADIOLOGICAL HEALTH DEPARTMENT
100 Orson Spencer Hall

July 18, 1973

Mr. P. F. Pullen
Chief Environmental Engineer
Rio Algom Mines, Limited
120 Adelaide Street West
Toronto, Canada

Dear Mr. Pullen:

Per your request I have re-done my replies to your questions.

I have also found uptake of radium in organisms grow on soils heavily contaminated with tailings from a uranium extraction plant. However, such uptake by plants from any materials in your plant site could only be expected to occur after the tailings pile has been established and covered. If the cover is insufficient there should be some plant uptake over a protracted time. This could be especially serious if there were breaks in the soil mantle as a result of erosion.

Plants grown in such a situation would give a characteristic spectrum of radionuclides associated with the makeup of the tailings materials below. However, the quantity of radium in the plants would be a direct giveaway since this would be higher than the levels in the parent soils and would be presumptive evidence that the plant roots had reached the zone of relatively high concentration and were transferring the radium from that source. However, the uptake of radium by plants growing over the very small area of your tailings plant would not make a significant contribution to game animals or livestock grazing through the area when compared with the general level of radioactivity in the soils of San Juan County, and particularly the area surrounding your plant.

I regret that it has taken so long for me to reply to your original request.

Sincerely yours,

Robert C. Pendleton, Director
Radiological Health Department

ts

Enclosure

RIO ALGOM

1. How will a determination be made as to whether any radioactivity found in plants is the result of dry deposition or uptake from the soil?

Results of sampling of many thousands of plants in the intermountain area show very low or nonexistent levels of natural radioactive materials of the kinds that would be associated with your operation. However, the soils surrounding the Rio Algom Mine all contain appreciable quantities of uranium, radium, thorium, and the associated daughter products. Accordingly, low levels of all these materials could be expected to be present in plants but would be represented in direct proportion to the amount of rad: active materials in the soils. With this situation, it would be very difficult to separate radioactivity found in or on the plants from that taken up from the soil, since all the elements named have been observed to be transportable as wind-borne dust and a considerable amount of contamination of low-growing plants results from splash-up of surface soil during the intense rainfall associated with thundershowers, ~~which is~~ the predominant source of summer precipitation. Sampling performed in this laboratory indicated that whenever a significant quantity of radioactivity from the natural emitters (other than potassium) is found, it has originated from direct deposition of soil or dust. More important than attempting to determine whether the radioactivity has its origin in plant uptake or dust is the determination of a base level which can then be used to determine whether or not an increase in the vicinity of the mine can be demonstrated. This can be done by sampling representative species of plants adjacent to and distant from the operation and in sufficient numbers to act as a statistically valid level from which all future sampling can be compared. Following this, sampling on a specified schedule can be used to determine what build up, if any, has occurred.

Determination of changes can be made as follows:

Sample three plant types on a schedule of at least once each calendar quarter: sagebrush (Artemesia tridentata), juniper (Juniperus Utahensis), and meadow clippings (mixed grasses from the improved grazing areas).

Sample sagebrush by plucking off the new growth-leaves and new, succulent stems.

Sample juniper by pulling off the leaves.

Sample grasses by cutting the stems with grass clippers. Take great care to cut above any evidence of rain splash-up. This will show as dry mud on the lower stems and leaves.

Each sample should be at least two kilograms (2.2. lbs/kg) and one sample of each type should be taken from each of your sampling sites, and from many different shrubs and trees within the area of the sampling site.

Analyses should be made for U_3O_8 by methods developed in your laboratory. In addition, analyses using gamma spectrometry should be performed on an aliquot of each sample. The gamma-ray spectrometry analyses will show the presence of fallout nuclides, but will demonstrate the presence of very low levels of Th and Rn daughters (Bi-214 and Pb-214).

So long as the materials found in the plants show essentially the same ratio of radioactive materials as found in the soils one can assume that the accumulation stems from soil splash-up or wind transported dust.

2. If radionuclides are found in plants, what will be the equilibrium concentrations of the radionuclides in plants?

Except for plants growing at the edges of the tailings ponds that might have root access to seepage, no long-term buildup of radionuclides in plants is possible. The toxic properties of the tailings water precludes growth that might accumulate nuclides.

All plants growing in the area, excepting juniper and pinyon (Pinus edulis), are deciduous. Sagebrush retains leaves over winter, but drops all old leaves when the new crop appears in the spring.

Juniper and pinyon replace needles and leaves progressively, but a complete replacement is usually accomplished in two to five years. These species are only minor foods for deer in winter and are not cropped by cattle. The juniper has been proved to be efficient in retaining fallout radionuclides, however, and should prove to be a valuable species for analysis of any buildup of airborne effluents.

Because the only significant route of accumulation in plants is via airborne dusts, the dropping of edible leaves and die-back of grasses and annuals each year precludes accumulations greater than could be deposited in a single growing season. The sampling methods outlined above will show any increases during the growing season, and annual mean values can be compared for determining changes in subsequent years.

3. How long will radionuclides, if found on plants, persist after operations have ceased?

Annual die-back of grasses, loss of deciduous foliage, and gradual loss of leaves from evergreen species precludes persistence beyond five years. Because the soils in this area are uraniferous, some transfer from surface soil (not via roots) may always be expected on some plants in the same amounts as were found before the mine was built.

Because the quantity of U_3O_8 released by your plant is so small, it is doubtful that a demonstrable build-up of this material can be expected, but the sequential sampling-analysis procedure I have described will show any changes associated with time.

The soils of this region are high in uranium, radium, thorium and associated daughter products. Wind-borne dust and rain splash-up are the principle ways that vegetation in this area could become contaminated with isotopes that might be construed as having origins in your plant. Surface contamination of plants as a result of soil transfers (splash-up or dust - secondary aerosols) can be easily identified by simple mechanical separation of the dust by shaking dried material in a plastic bag and sampling the dust separated from plant fragments. (Microscopic examination of the dust would provide conclusive identification of the material.) Only if an increase in Po-210 or U_3O_8 above the recorded quantity in soil is found on the plants would corrective action be indicated.

4. At what concentration in soil, vegetation, water or animal, will actions be taken to prevent a further increase in contamination?

Action to reduce release of uranium oxide will be taken if any demonstrable increase of this nature is detected. Since the quantity of U_3O_8 required to make a demonstrable contamination exceeds the quantity normally released by the plant by many thousand-fold, it is inconceivable that such a serious loss of product could occur. However, levels applicable to this problem will be those given in Paragraph B, Title 10, Part 20, Code of Federal Regulations, for air pertaining to uranium and daughter products in unknown mix.

Action involved in stopping the contamination would involve tightening procedures for limiting loss of U_3O_8 in the production system and limiting of releases of dust.

5. What biological organism will be used to set the limit?

Determination of accumulation of uranium, thorium, or daughter products should be made using the liver, kidneys and femur of the blacktail jackrabbit (Lepus californicus). This animal is sufficiently abundant in the vicinity of the plant to be obtained in sufficient numbers for sampling throughout the year and has the advantage over all other species in the area of having broad food selection habits, thus acting as an integrator of any contamination levels that might be encountered on plants.

Other rodent forms are too seasonal and too few for use in this operation, there are no deer present in sufficient numbers to be used for samples, and cattle spend so little time in this area as to be useless from the standpoint of sampling specimens.

During a thorough ecological surveillance of the area surrounding your plant, I noted a very rich fauna of songbirds, cottontail rabbits, and jackrabbits. I observed tracks of a resident herd of deer comprised of two does, one fawn, and one yearling buck. There were no game birds nor were there sites for their breeding. The resident organisms do not obtain and cannot obtain enough uranium, thorium or uranium daughters from any source to have a demonstrable effect on the health of the organisms nor their reproductive potential. The only effect on wildlife will be the reduction of available juniper pygmy forest as the tailings pond deepens. Although winter populations of deer may be larger than the resident herd, it is highly doubtful that any significant numbers will remain in the vicinity of the plant, and the total ingestion under the conditions that are being maintained could not have a demonstrable effect on these animals. This is also true of the occasional livestock grazing the area.

APPENDIX S

1. Rio Algom Corporation Application For Mill Increase and Changes in Draft Detailed Statement, dated November 12, 1973.
2. Letter from U. S. Atomic Energy Commission to Rio Algom, dated August 6, 1974.
3. Supplemental Evaluation

AN AFFILIATE OF

Rio Algom

Rio Tinto

November 12, 1973

PLEASE REPLY TO ______________ OFFICE

RECEIVED
NOV 15 1973
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

RIO ALGOM CORPORATION

APPLICATION FOR MILL INCREASE

REF. USAEC DOCKET 40.8084

8275

Rio Algom Corporation
P.O. BOX 610 MOAB UTAH 84532 TORONTO OFFICE 120 ADELAIDE STREET WEST TORONTO 1 ONTARIO

CHANGES IN EQUIPMENT AND PROCESS REQUIRED TO INCREASE LISBON MILL TONNAGE FROM 500 TO 700 TONS PER DAY

ALSO

CHANGES IN DRAFT DETAILED STATEMENT

NECESSITY FOR INCREASE

As the orebody has been explored underground it has become clear that the disposition is sucn that more than the expected amount of barren rock must be mined along with the pay material. The result is a lower grade feed to the mill (7.1 rather than 7.6 lbs per ton U_3O_8) and the operation is not quite breaking even.

An improvement in economics can only be achieved by a modest scale-up in mining rate. The extra waste can be handled and some increase in production obtained by limited plant adjustments as follows:

SUMMARY OF EQUIPMENT CHANGES

The increase in Lisbon mill capacity from 500 to 700 tons per day requires additional equipment at only two points in the mill circuit. There are no changes in the basic flow sheet due to tonnage increase.

Three drum filters have been added to the nine units originally in service, and three pachucas will be inserted in series between the thickener and the ten autoclaves now in use.

CHANGES REQUIRED IN A.E.C. DRAFT DETAILED STATEMENT

As requested by the A.E.C., the following sections of the A.E.C. Draft Detailed Statement of December 1972 are effected by the proposed milling rate increase.

III B 2. POWER AND NATURAL GAS SUPPLY

Power consumption is expected to increase somewhat less than the ratio of the increased tonnage to about 3.5 million Kw Hr. maximum per month. This should have a negligable impact on the local utilities system.

The total amount of natural gas, propane and oil anticipated to be used in the 1972-73 season is 133,000 million Btu. The tonnage increase is estimated to require an increase in fuel consumption of about 10%.

III B 3. WATER SUPPLY

The water supplied from the well field is not expected to be appreciably changed by the increase in tonnage. Present consumption is:

Mill process water	30 gpm
Boiler feed, showers, drinking	50 gpm
Total	80 gpm

III B 4. ACCESS AND SERVICE ROADS

For the increased tonnage, no new roads will be required, nor will there be an appreciable increase in truck traffic. Personnel travelling in private cars may increase somewhat.

III B 5. MILLING PROCESS

No major change in equipment or flow sheet is required in the mill to increase from 500 to 700 tons per day. Testing to date has indicated that the ball mill will require a speed increase from 20.1 to 22 rpm for increased through-put and satisfactory grind.

To provide efficient leaching at the new tonnage three pach[illegible] 15-1/2 feet in diameter and 50 feet high will be installed outside the mill. These tanks will be insulated and operate in series on pulp received from the thickener, discharging to the original autoclave circuit. Steam coils are installed inside the pachucas to maintain a temperature of 170°F. The exhaust air from the autoclaves, which formerly discharged to the atmosphere via the re-heat tank, will feed the pachucas, where the process heat will be recovered as it passes up through the slurry in the tank.

The pachuca discharge to atmosphere will contain low temperature steam, some small quantity of leaching chemicals ($Na_2\ CO_3$ and $Na\ H\ CO_3$) and a small quantity of entrained dust. The environmental impact of this is considered to be negligable.

In the filtration stage an identical 11.5 feet diameter by 16 feet long unit has been added to each of the three filter stages, to increase the filters from 9 to 12.

In the precipitate re-treatment stage there has been a change in the flow sheet because of product specification requirements. Hydrogen peroxide is now used in addition to the originally proposed reagents, sulphuric acid and anhydrous ammonia. This change has no bearing on the tonnage increase.

The mill operating staff now totals some 45 employees. The increased tonnage will not require additional personnel.

IV B SOURCES OF WASTE AND EFFLUENTS

A tailings pond recycling system is now in operation, bringing tailings solution back to the mill for process water. Thus at the increased milling rate 700 tons per day of finely ground tailings solids will go to the tailings area slurried in 252,000 gallons of re-cycled tailings solution. Losses by evaporation and tailings pond seepage will be made up from mine water. The pH of the tailings slurry is about 10, and the current analyses has been given. Neither are expected to change appreciably.

Increased tonnage will change slightly the major sources of effluents that have been identified as follows:

1. Contamination from the mine ventilation shaft

The total volume of air as measured underground varies between 230,000 to 250,000 cfm. This is anticipated to be adequate for the increased tonnage now but will have to be increased at some time in the future as the mine workings increase. The installed fans are capable of the expected increase.

Radiation and dust discharged from the shaft are functions of tonnage mined, area of mining horizon open for ventilation, total distance of travel of air, distance of discharge from active mining, etc. With an increase in tonnage the discharge in radiation and dust concentrations should increase somewhate, but less than in direct proportion to the tonnage increase.

2. Crusher and Transfer House

No change in equipment size or speed of operation will be made for the increased tonnage. The hours of operation will however increase by a factor of 1.4. Contaminants will thus be released at the same rate but for a longer period.

3. Yellowcake Drier and Yellowcake Dust Filter

There is no change in equipment in this area, but the equipment will operate for an increased time each day.

4. Tailings Area

Two tailings ponds are now planned in place of the original one. The total final surface area of the two is practically the same as the original area. Because radon emanation from the tailings area is a function of surface area an increased tonnage rate should have little effect on the total emanation. Because the tonnage increase may involve mining of some lower grade material, the total tons of tailings may increase somewhat. Seepage should also be little changed.

IV C CONTROL OF WASTE EFFLUENTS

The increase in milling rate is not expected to increase the seepage from the tailings area to any detectable extent. In fact the diversion of excess mine water from the tailings pond should decrease seepage to a major extent by allowing a smaller pond to be maintained.

Air-borne contaminants from the concentrator should remain at the same concentration level as at present, but will be discharged for more hours per day.

IV D ENVIRONMENTAL CONCENTRATIONS AND EFFECT ON LOCAL BIOTA

For an increase in tonnage from 500 to 700 tons per day the range in radioactive effluents emitted per day from the major sources will be changed in Table X approximately as follows:

Mine Ventilation	increase variable up to 15%
Production shaft, crusher and Transfer House Dust Control	increase about 40%
Yellowcake Drier and Dust Control	increase about 40%
Tailings Pond	negligable increase

Likewise the estimates of concentrations given in Table X at various points from the ventilation shaft should be increased up to about 15% for an increase in tonnage milled. The estimates of dose equivalents given in Table XI will likewise be increased.

The tonnage increase should have no detectable impact on the groundwater of interest to the local ranchers or to the inhabitants.

IV E ENVIRONMENTAL MONITORING

The estimated 40% increase in the total quantity of particulates discharged from the concentrator is not expected to have a detectable effect on the soils or vegetation contamination.

IV F ACCIDENTS

The proposed increase in tonnage milled should have no detectable adverse effect on the three types of accidents considered.

IV G MISCELLANEOUS

The tonnage increase of 40% may require an increase of manpower in the mine and services of some 15 men, bringing the total labour force to an estimated 210. This increase in manpower should have little adverse effect on the social-economic pattern of the area, rather the reverse.

The above manpower increase will be handled with the presently installed sanitary facilities at Lisbon with no problems.

V ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

The increased milling rate should have a negligable increase in the adverse effect of the operation. The increased tons of lower grade ore that may be mined has an insignificant incremental effect.

VII IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

There may be a slight increase in the total quantity of uranium that will be removed from the ground by mining at a higher rate and mining some marginal grade ore.

IX BENEFIT - COST ANALYSIS

A. Benefits

1. The increased mining rate is expected to result in a payroll increase of about 15 persons with attendant economic benefit to the area.

2. Total tax revenue should be increased markedly above that now estimated because the operation becomes economically viable.
3. Because of the increased milling rate, some additional marginal ore will be mined which will increase the power production potential corresponding to the additional uranium recovered. This additional uranium is a positive benefit because if not mined now will be lost for all time as economics rule against recovering small quantities of marginal ore after the original mine has been abandoned.
4. Other natural resources in the form of fuel will be conserved for other use in direct proportion to any slight increase in the amount of uranium recovered from the body.
5. The increased milling rate will have no appreciable impact on the amount of water available.

B. Costs

1. The Land

There is no appreciable change in the social and environmental costs associated in the proposed tonnage increase.

2. Cultural and Social Considerations

In balance an increase in employment in the area due to a tonnage increase has greater benefits than social and cultural costs.

3. Ecological

An increase in milling rate will result in a small increase in contaminants to the environment in some areas, but the increased impact is not considered of significance.

4. Depletion of Natural Resources

The recovery of uranium in addition to the expected 8.4 million pounds does not deplete what are now classified as recoverable ore reserves. In effect it realizes now a resource that it would be unlikely to be recoverable in the future.

SUMMARY OF ENVIRONMENTAL IMPACT

The increased milling rate will have a minimal adverse effect on the environment in a limited number of areas. The main impact will be the increased total pounds of total materials discharged to the atmosphere by the plant. However it is anticipated that the additional inpact will be negligable.

To alleviate an economic problem we wish to amend our original licence application for 500 T.P.D. to 700 T.P.D., and ask for the consideration of the Commission of this enclosure.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

August 6, 1974

40-8084

Rio Algom Mines Limited
ATTN: Mr. R. D. Lord
Vice President
Research & Development
120 Adelaide Street, West
Toronto, Canada

Gentlemen:

This refers to your application of March 19, 1974, as supplemented May 22, 1974, June 13, 1974 and July 23, 1974 for amendment to Source Material License No. SUA-1119 to construct and use a new tailings disposal area at your La Sal, Utah, uranium mill.

We have reviewed your proposed design and plans for construction of the tailings pond embankment and have found them adequate. Accordingly, we have no objection to your proceeding with the construction of the embankment system. However, we are not in a position to issue an amendment to your license for use of this system for retention of mill tailings until we have obtained the following additional information:

1. A description of a program for monitoring nearby deep wells to determine base ground water flows and background quality and to detect any unexpected radioactive intrusion by seepage from the retention ponds into deep confined aquifers.

2. An analytical demonstration that credible runoff (at least a 50 year flood) will not breach the confinement of the new embankment, or

3. A description of diversion ditches which will be constructed prior to use of the pond and a demonstration of their capability to handle the expected maximum runoff, or

4. A demonstration that breach of both dams by overflow caused by the flooding will have no significant environmental impact downstream.

Sincerely,

Original Signed by
Leland C. Rouse

L. C. Rouse, Chief
Fuel Fabrication and Reprocessing
Branch
Directorate of Licensing

cc: Harold P. Green, Esq.
Fried, Frank, Harris, Shriver
& Kampelman
Suite 1000, The Watergate 600
600 New Hampshire Avenue, N. W.
Washington, D. C. 20037

SUPPLEMENTAL EVALUATION

Docket 40-8084

By letter dated March 19, 1974, the applicant submitted a request to construct and use a new tailings disposal area. The new dam and its basin is located within the same locale as the original tailings basin, and the total area of the retention system is to be essentially the same as the original area -- that is, 45 acres versus an area of 15 acres and a new area of 26 acres.

The main environmental concern relating to the construction of the new dam pertained to the seepage aspects of the tailings retention system and the placement of monitor wells to detect seepage if it occurred. Based upon an analysis of the regional stratigraphy and hydrogeology of the plant area, the staff has concluded that the applicant's placement of monitor wells is acceptable (Site Safety Analysis, October 11, 1974, Enclosure 1). Seepage velocities conservatively estimated by the staff at approximately 5 feet per day, are small enough such that sufficient time is available to detect and remove any dangerous contaminants in the shallow unconfined aquifers from the groundwater system. Also, the presence of several aquicludes restricts vertical movement of the groundwater so that the risk of contaminant penetration into deeper aquifers is essentially negligible.

Regarding flood control for the tailings basin due to area runoff into the retention area, the applicant (letter dated December 12, 1974, Enclosure 2) provided an assessment of the flood potential for a 100-year, 5 inch precipitation in 10 hours or 2.5 inch precipitation in 6-hour event and a 6-hour, 8.7 inch PMP storm. These calculations were verified (Site Safety Analysis, December 17, 1975. Enclosure 3), and the staff concludes that the second dam will contain the 100-year event. The Environmental Protection Agency has recommended in their "Development Document for Interim Final and Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Ore Mining and Dressing Industry," that where tailings impoundments are used, the design should be sufficient to contain the precipitation from a 10-year, 24-hour rainfall so as to meet effluent limitations of July 1977 or for 1983 standards, designed to contain the precipitation from a 25-year, 24-hour rainfall. Although the EPA document recommends a design for 1983 for a 25-year, 24-hour event, the NRC staff generally believes that the 100-year design is more conservative than the Environmental Protection Agency suggested design criteria,but not as conservative as the PMP event.(1) (2)

In order to gain an insight to the consequences of a dam failure at the time of a PMP event, the applicant postulated that the lower dam would fail, 50 acre feet of water would be released from the lower retention area and that 10% of the 600,000 tons of tailings in the lower retention area would be released (letter dated April 4, 1975, Enclosure 4). Table 1 shows the measured contents and concentrations of the liquid in the pond during the early part of 1975. The applicant did not report a thorium result so a thorium value from the FES was included so that the data is available for a contamination analysis later on in the report

TABLE 1

(see next page)

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(1) Elements of Hydraulic Engineering, McGraw Hill Civil Engineering Series, Linsley and Franzini, Page 113. The consequences of project failure must be very serious to justify design against the maximum possible flood. Such a condition exists where the failure of a dam would result in heavy loss of life downstream.

(2) Site Planning (second edition), Kevin Lynch, page 174. A low year of storm may be chosen as the basis for calculation where an occasional overload of the system is not critical. A high year of storm would be used for a dense high value area where even infrequent flooding might be serious. Thus, 10-year or 5-year storm frequencies may be used for residential development, and 25-year or even 50-year frequencies for shopping centers.

TABLE 1

Element	Concentration	Unrestricted Area MPC* or PHS Limiting Concentration**
Sulphate	8103 ppm	250 mg/ℓ**
Sodium	10320 ppm	2000 mg/ℓ**
Carbonate	8210 ppm	-
Natural Uranium	4.79×10^{-5} μCi/mℓ	3×10^{-5} μCi/mℓ*
Radium-226	6.60×10^{-8} μCi/mℓ	3×10^{-8} μCi/mℓ*
Polonium-210	2.30×10^{-8} μCi/mℓ	7×10^{-7} μCi/mℓ*
Thorium-230	1.1×10^{-7} μCi/mℓ	2×10^{-6} μCi/mℓ*

The applicant has indicated that the runoff from a PMP event would amount to 267 acre feet. Therefore, when the event occurred, the liquid in the pond (50 acre feet) would be diluted to $\frac{267}{50}$. The staff is of the opinion that should such an event occur, the upper dam would also fail, (Site Safety Analysis, December 17, 1975, Enclosure 3), and although there would be dilution, the applicant's estimate of $\frac{267}{50}$ is on the high side. However, it is expected that the concentrations of the elements shown in Table 1 will be diluted and that additional dilution by runoff farther down stream would be expected to reduce the concentrations to even lesser values.

The closest inhabited area to the dam is the Redd Ranch with one to six persons, depending upon the time of the year. The applicant has estimated that the flow of water is expected to move in a north westerly direction towards the Redd Ranch located some 2 miles distance and then on towards LaSal Junction, some 8 miles from the mine. The applicant has stated (letter dated April 4, 1974, Enclosure 4), that the Redd Ranch buildings are on a rise in the middle of a large flat area of some 200 acres of which 180 acres are cultivated. Of this 180 acres, the applicant estimated that perhaps one-half of the cultivated area might become flooded. At LaSal Junction, a village of less than 10 permanent residents, the buildings are described as situated approximately 1,000 feet from and 40 feet above the stream bed. It is believed that there are no inhabitants on the watercourse between LaSal and the Colorado River some 25 miles away. Rattle Snake pond, located a short distance downstream from the Reed Ranch, most likely would be in the path of the flood water from the mill site, as well as the flood water from a much larger drainage area than that around the mill site.

The solid tailings material released from the impoundment area is expected to settle out below the dam and be retained in the sage brush covering the drainage area. The extent of the area covered is difficult to assess. The amount of material and dispersion of material would depend upon the topography, the elapsed time, the way in which the breach occurred, dispersion pattern, and the amount of solution in the impoundment area. To gain an insight into the possible magnitude and consequences of a tailings dam failure, one can look to the past history of such events. During the years 1959 to 1971, there were 12 incidents involving tailings releases from impoundment areas.[(3)] Of these 12 incidents, 7 were reported as not causing concentrations in surface water to exceed 10 CFR 20 limits or as not constituting a hazard; 1 was reported as having a small amount reaching the river; 1 as having the spill frozen in place; 1 where the licensee extended the fence around the spill to make the area a restricted area; 1 as loosing liquid which contained a Radium concentration slightly in excess (5.5×10^{-8} μCi/mℓ) of 10 CFR 20 unrestricted area limits (3×10^{-8} μCi/mℓ); and one where no conclusions were drawn. However, further investigation into the "Reported Releases of Uranium Milling Waste" reveals that the radium concentrations were below 10 CFR 20 limits. Of the incidents reported, it appears that the tailings dam washout which occurred on August 19, 1959, and which released 15,000 tons of sand, and the incident on November 23, 1968, which released 1-10-acre feet of waste liquid, were the most significant. A 15,000 ton release would be the equivalent to a 30 day plant waste [illegible] ilings area from a 500 ton a day operation or a 15 day plant [illegible] to tailings area from a 1,000 ton a day mill.

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(3) "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, US AEC, April, 1974

The applicant has stated that they expect on the order of 10% of the tailings contained in the pond to escape. Furthermore, they estimate that by the end of the year 1977, they expect the lower pond to contain 600,000 tons of tailings. This would amount to 60,000 tons of tailings ($1.3 \times 10^6 ft^3$) released in a PMP events or four times greater than the largest release to date. In the applicant's submittal of April 4, 1974 (Enclosure 4), it is stated that the above volume of tailings could cover a 2 mile length of the shallow valley to a width up to one-eighth of a mile and to a depth of slightly over one inch. However, a staff evaluation indicates that the applicant's evaluation of the principle area of impact is conservative (Site Safety Analysis, December 17, 1975, Enclosure 3).

The radioactive material within the tailings waste is the same radioactive material which was formerly under the earth's surface. The main radiological concern with the release of the mill tailings lies in the possible increase in background radiation levels over the affected and adjacent areas in which the tailings may be spread, and eventual transport of these wastes by wind and rain.

Past experiences in the uranium milling industry indicates that on the order of 515 μCi(4) of each member of the uranium decay chain is present in one ton of ore. In the alkaline process, approximately 7%(5) of the uranium goes to the tailings. Therefore, in the 60,000 tons of ore, there would be 2 Ci of uranium, 30.9 Ci of Ra-226, and 30.9 Ci of Thorium-230 present in the released tailings. These quantities may be a conservative estimate in that the applicant reported the solids content in an earlier submittal to be: Uranium, 7 pCi/gram; Radium, 21 pCi/gram; and Thorium, 8 pCi/gram.

Accepting the applicant's estimate that the solids will spread out over an area 2 miles long by one-eighth mile wide, the depth of the 60,000 tons of tailings, if evenly deposited in depth, would be 1.72 inches. The quantities of Uranium, Radium-226 and Thorium-230 calculated above would be contained within the dimensions of this volume, i.e., 2 Ci of Uranium; 30.9 Ci of Radium-226; and 30.9 Ci of Thorium-230. It is expected that the actual geometrical configuration of the disbursed tailings would not have the shape of a uniform rectangular shaped box but would more nearly represent

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(4) ORNL - TM - 4903, Vol. 1, Page 22

(5) ORNL - TM - 4903, Vol. 1, Page 174

a triangular wedge shaped mass; that is, the distribution of the solids would be deeper in the area around the toe of the dam and then slope downstream to a lesser depth. The applicant estimates this depth at 2 miles to be one inch. Regardless of the geometrical shape, only the top surface of the dry tailings material will be available for resuspension and dispersion by the wind at any one time. Assuming that only the top half centimeter will be affected by the wind at any one time, the amount of Uranium, Radium-226 and Thorium-230 available for dispersion by the wind at that moment from the volume of dimension 2 miles by 1/8 mile by 0.5 cm would be 0.22 Ci of Uranium; 3.45 Ci of Radium-226; and 3.45 Curies of Thorium-230. The levels of contamination of the land over which the tailings are assumed to lie would be: Uranium, 3.46×10^{-5} $\mu Ci/cm^2$; Radium-226, 5.34×10^{-4} $\mu Ci/cm^2$; and Thorium-230, 5.34×10^{-4} $\mu Ci/cm^2$. A sense of the significance of having these radionuclides distributed over such an area may be revealed by comparing these contamination levels with other criteria and events. Seven such examples are: (1) These values are factors of 3.5 to 50 times greater than acceptable contamination values for working places in inactive areas[6], i.e., 1×10^{-5} $\mu Ci/cm^2$; (2) The State of Colorado takes the position that 1×10^{-6} $\mu Ci/cm^2$ of plutonium presents a sufficient hazard to public health. Since the MPC of Plutonium-239 in air for unrestricted areas is 1×10^{-12} $\mu Ci/m\ell$ and the MPC of Uranium-natural in air for unrestricted areas is 5×10^{-12} $\mu Ci/m\ell$, one may rationalize that Plutonium is about 5 times more hazardous than Uranium. Consequently, a ground level contamination of 10^{-5} $\mu Ci/cm^2$ of Uranium may be considered to be the limit for Uranium contamination. The value of 10^{-5} $\mu Ci/cm^2$ may also be considered as the limit for Radium-226 because of the similar radiotoxicities of Plutonium and Radium[7][8]; (3) The State of New York allows a contamination level of 9×10^{-7} $\mu Ci/g$ for Plutonium which translates into a value of approximately 1×10^{-6} $\mu Ci/cm^2$; (4) The permissible surface contamination level for plutonium for a dirty rural area is thought, in some cases, to be 100 ug/m^2 or 6.17×10^{-4} $\mu Ci/cm^2$[9]. Assuming that Radium is nearly as hazardous

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(6) Handbook of Radioactive Nuclides, Chemical Rubber Co., page 644

(7) Beir Report, page 127, states that monomeric Pu-239 is about 9 times more effective on the basis of average skeletal dose than Ra-226, with the polymeric Pu-239 somewhat less effective than the monomeric form.

(8) UCRL-50639, page 7, states that Pu is 5 to 10 times more effective than Radium.

(9) Handbook for Nuclear Emergency Teams, October 1, 1961, DASA.

as Plutonium, the contamination level of 6.17 X 10^{-4} $\mu Ci/cm^2$ could conceivably be the same for Radium, or about the same level of contamination estimated for the assumed event; (5) As the result of the Plutonium incident in Spain [10], all crops were stripped from the fields and destroyed where readings above 5 ug/m^2 (3.1 X 10^{-5} $\mu Ci/cm^2$) of Plutonium were observed near a village of 300 people; (6) Decontamination limits for Uranium mills are 1000 d/m/100 cm^2 or 4.55 X 10^{-6} $\mu Ci/cm^2$ for removable contamination; and (7) EPA, in correspondence to ERDA dated January 8, 1975, regarding the phase II studies, recommended a decontamination level for Radium in the soil to less than two times the Radium background specific for the area.

Airborne concentrations which may be anticipated above the dispersed tailings sands may run on the order of 3.46 X 10^{-16} $\mu Ci/cm^3$ of Uranium; 5.34 X 10^{-15} $\mu Ci/cm^3$ for Radium-226; and 5.34 X 10^{-15} $\mu Ci/cm^3$ for Thorium. These concentrations were derived by assuming a resuspension factor of 1 X 10^{-9} [illegible] [11] for a desert-like area associated with a wind speed of 10 miles per hour.[12] These concentrations are all less than the allowable 10 CFR 20 limits for unrestricted areas.

In order to estimate the order of magnitude of the possible consequence should these airborne concentrations occur, the inhalation dose to an individual for 50 years, breathing the concentration of resuspended Uranium, Radium-226 and Thorium-230, prior to any cleanup for a year, have been estimated and are shown in Table 2.

TABLE 2

Radionuclide	Concentration $\mu Ci/cm^3$	Dose Kidney	Dose Bone (delivered over 50 years)
Uranium	3.46 X 10^{-16}	0.01 mrem	-
Radium-226	5.34 X 10^{-15}	-	26.0 mrem
Thorium-230	5.34 X 10^{-15}	-	372.0 mrem

(10) The Problem of Large-Area Plutonium Contamination, USPHS, BRH, Seminar Paper No. 002.

(11) ORNL - TM - 4903, Vol. 1, page 93

(12) Winds of Velocity 5 to 10 mph only occur at the site 26% of the time, whereas velocities under 5 mph are reported to occur 68% of the time.

The dose value for uranium was calculated, using the information presented in TID-4500, "Doses to Various Body Organs from Inhalation or Ingestion of Soluble Radionuclides." Dose values for Radium and Thorium were calculated according to the information presented in "Meteorology and Atomic Energy," 1968, Chapter 7, page 369.

It is the opinion of the Advisory Committee on the Biological Effects of Ionizing Radiation(13), that if the exposure is kept well below the natural background radiation (on the order of 15 to 50 mrem per year), as is believed to be the case for the circumstance, that the additional consequences will neither differ in kind from those which have been experienced throughout human history, nor exceed them in quantity.

Attachments:
1. Site Safety Analysis Rpt dtd 10/11/74
2. Ltr from Rio Algom dtd 12/12/74
3. Site Safety Analysis Rpt dtd 12/17/75.
4. Ltr from Rio Algom dtd 4/4/75

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(13) Biological Effects of Ionizing Radiation (BEIR REPORT), Nov. 1972

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Appendix S, Reference 3
S-23
Attachment 1

OCT 11 1974

Richard E. Cunningham, Assistant Director for Fuel Cycle, L

EVALUATION OF MONITORING PROGRAM AND FLOOD POTENTIAL - TAR 1117

PLANT NAME: Lisbon Uranium Mill, Rio Algom Corporation
LICENSING STAGE: OL
DOCKET NUMBER: 40-8084
RESPONSIBLE BRANCH: Technical Support Branch
REQUESTED COMPLETION DATE: October 11, 1974
REVIEW STATUS: SAB (Hydrologic Engineering Section) - Complete

Enclosed is a hydrologic engineering summary, prepared by T. L. Johnson and L. G. Hulman, regarding the proposed tailings retention system at the subject plant in response to TAR 1117. It is our conclusion that the proposed embankment should be designed to contain the runoff resulting from an occurrence of the local probable maximum precipitation, unless it can be demonstrated that failure of the tailings dam will cause no severe flooding and/or radiological consequences downstream.

JG Bentley
for Harold R. Denton, Assistant Director
for Site Safety
Directorate of Licensing

Enclosure:
As stated

cc: w/o enclosure
S. Smiley
W. McDonald
H. Lowenberg

cc: w/enclosure
R. Chitwood
A. Kenneke
J. Kendig
T. Johnson
SS Branch Chiefs

HYDROLOGIC ENGINEERING SUMMARY
EVALUATION OF MONITORING PROGRAM AND FLOOD POTENTIAL
LISBON URANIUM MILL, RIO ALGOM CORP.
DOCKET NO. 40-8084

Based upon further analysis of the regional stratigraphy and hydrogeology of the plant area, the staff has concluded that the applicant's placement of monitor wells is acceptable. Seepage velocities, conservatively estimated by the staff at approximately 5-ft/day, are small enough such that sufficient time is available to detect and remove any dangerous contaminants in the shallow unconfined aquifers from the groundwater system. Also, the presence of several aquicludes restricts vertical movement of the groundwater, so that the risk of contaminant penetration into deeper aquifers is essentially negligible.

The applicant did not respond to our previous request to evaluate the potential for dam failure due to local intense precipitation and subsequent runoff. We suggested that a PMF on the drainage area should be evaluated and resulting consequences determined. The applicant chose, instead, to state that the proposed embankment was adequate to withstand a 10-day 100-year flood. The staff has independently concluded that a local PMF would overtop the proposed embankment and very likely cause erosion failure of the embankment. Failure of the proposed upstream embankment would also cause failure of the existing embankment. The tailings materials would be eroded and carried downstream by the flood, possibly causing severe radiological consequences.

The staff concludes that the applicant should design the embankments to contain the runoff resulting from a local PMP, without overtopping, unless it can be demonstrated and adequately substantiated that no severe flooding or radiological consequences will occur downstream. At the present time, we have no bases for concluding that failure of the tailings pond embankment will not present a downstream safety hazard.

Rio Algom
Rio Tinto

December 12, 1974.

DEC 18 1974

Mr. L C. Rouse, Chief,
Fuel Fabrication & Reprocessing Branch,
Directorate of Licensing,
U.S. Atomic Energy Commission,
Washington, D.C. 20545.

Dear Mr. Rouse:

Docket 40.8084

Further to our meeting with you on November 1st, 1974 we have made what we believe is a thorough examination of the flood control aspects of our Lisbon tailings deposit. Our calculations and proposals set out in the attached may be summarized as follows:-

1. The probability of a possible maximum precipitation impacting the site appears too remote to warrant the cost of providing for same.

2. While safeguards considered adequate will be maintained to insure against an overspill of the tailings area, such an event would have a limited environmental impact.

3. During operation the minimum flood capacity of the upper pond is 118 acre-feet, compared to run-off of 25 acre feet for a 100-year storm. This gives a safety factor of 4.72. It would seem the cost of a spillway is not supportable for the limited period (5 years) that it would apply.

4. While provision for a PMP is in our view not warranted we propose to excavate, at the termination of the operation, a diversion ditch that would handle four times the one hundred year flood figure of the Bureau of Land Management.

I trust you may find the above proposals acceptable.

2443

Yours truly,

R. D. Lord

R. D Lord,
Vice President,
Research & Developm...

RDL/aa
Encl.

PROPOSAL REGARDING

FLOOD CONTROL FOR LISBON TAILINGS BASIN

A. Tailings Drainage Area Runoff Calculations

The watershead which includes the Lisbon tailings deposit totals some 590 acres, of which about 515 acres drains to the upper and 75 acres to the lower tailings basin. The ground cover is a mixture of sagebrush on Monticello sands and silts (65%) and pinon-juniper on rock and shallow with gentle slopes (3 - 4%) except towards the bottom of the basin near the two dams.

Original calculations for runoff were done by the Bureau of Land Management (BLM) based on a 100-year storm with 5.0" precipitation over 10 days , with a concentration of 2.5 inches in a 6-hour period (Appendix I). This calculation gave a runoff of 0.63 inches, 29 acre-feet or 148 cu. ft/sec for the whole basin.

At the request of the AEC and based on the methods given in the report "Probable Maximum Thunderstorm Precipitation Estimates", Appendix II gives the calculations for the precipitation of 8.7 inches in a 6-hour period for a possible maximum precipitation (PMP) storm for the Lisbon area. Using the BLM methods of calculation the following runoff figures (Appendix III) are also derived:

Area	Acres	6-Hr PMP Storm Runoff	6-Hr PMP Storm Acre-Ft	6-Hr PMP Storm CFS	6-Hr 100-Yr Storm Runoff	6-Hr 100-Yr Storm Acre-Ft	6-Hr 100-Yr Storm CFS
To Lower Pond	75	6.5	40	390			
To Upper Pond	515	5.3	227	1780	0.58	25	108
Total Area	590		267	2170	0.63	29	148

B. Probability of a PMP Storm at Lisbon

The Report "Probable Maximum Thunderstorm Precipitation Estimates" states on page 22 that "intense summer thunderstorm rainfalls in the Southwest --- are, without exception, very local in extent ---", and examples are given. Based on these factors it is assumed that a PMP storm in the Lisbon area would cover at the maximum about 50 square miles (7 x 7 miles).

Assuming that there may have been 10 PMP storms in Utah in the past 85 years (only 1 has been recorded, at Morgan) and that the state has an area of 85,000 square miles, then the probability of a PMP storm including the 1 square mile drainage basin in question is:

$$\frac{50}{85,000} \times \frac{10}{85} \text{ or about 1 in 15,000 years.}$$

Further the probability of one impacting the site, during its remaining six years of expected activity is $\frac{6}{15,000}$ or one chance in 2500.

Monthly rainfall records for La Sal (about 4 miles north of the tailings basin) for 1939 to 1960 and partial records for Lisbon mine for 1969 to 1972 are given in Appendix IV. Records for 1960-74 have not yet been received from the weather bureau. For the periods covered, the monthly maximum rainfall is $5\frac{1}{2}$ inches at La Sal in October 1957 and at the mine the daily maximum was 1.7 inches in the short period given. From these records it would appear that the 100-year storm basis would be a more practical criteria to use for the next comparatively short period of 6 years.

Should a dam be breached by a major storm during the 6-year operating life of the tailings area the impounded liquid would be released, but only a portion of the contained tailings. Much of these released solids would settle out in the 2 mile distance to the nearest habitation (Redd Ranch) where the average grade is about $1\frac{1}{2}$%. Remaining solids would settle in a pond about another mile further down West Coyote Wash.

At Redd Ranch there are normally 1 to 6 inhabitants depending on the time of the year, and at the distance of 2 miles from the tailings area these people are believed to be in relatively little physical danger from a possible failure of a tailings dam. Some 8 miles from the mine the village of La Sal (less than 10 permanent residents is situated some height above Coyote Wash and would be in no physical danger. Five miles further on West Coyote Wash enters Hatch Wash which flows into Cane Creek Canyon and then into the Colorado River some 25 miles distant. It is believed that there are no habitations on the watercourse between La Sal and the Colorado River. Between the mine and Hatch Wash practically all the land is sparse range land.

Based on the above information, should the impounded water and some tailings be released from a tailings pond due to a heavy storm, there would be a very limited impact.

On the cessation of milling operations it is proposed to stabilize the tailings deposits in such a manner that water cannot collect on the material, and that any runoff will not erode the dams and so expose tailings to water transport. Runoff from the drainage basin above the tailings areas will by-pass the area through the diversion ditch to be installed. On this basis there should be no impact on the country below the tailings due to any storm.

Based on the above it appears that any possible hazard due to a PMP is limited to the remaining active 6-year life of the tailings area, and the improbability of such an occurrence is too extreme to justify significant expense at this time. On this basis it is proposed that for the active life of the tailings area, that the design of control measures be based on the 100-year storm criteria.

Proposed Storm Control Design

For a 100-year storm with a 6-hour precipitation of 2.5 inches the runoff has been calculated to be 25 acre-ft or 108 cu. ft/sec to the upper pond (Appendix III).

With the upper tailings pond at a maximum elevation of 6675', the storage capacity has been determined, based on a survey of the basin to elevation 6675' after the construction of the dam. (Appendix IV).

Surveyed acre-ft to dam crest, elevation 6680'	625
Surveyed acre-ft at elevation 6675'	470
Difference, acre-ft	155
Deduct Estimated Volume of Tailings to be Deposited above water	10
Available Storage Capacity	145

Average Storage/Vertical Ft. of Surge Capacity = 145/5 = 27 acre-ft

Maximum surge pond elevation for storage at 6679' (allowing a freeboard of 1 foot below the dam crest) is 145 - 27 = 118 acre feet.

For a 25 acre-foot runoff to the upper tailings basin for a 100-year storm, the basin has a safety factor of 118/25 = 4.72

The 118 acre-foot surge capacity of the upper tailings basin will contain 52% of the runoff of 227 acre-feet to the basin from a PMP storm should it ever occur. The lower basin has ample capacity to hold the calculated 40 acre-foot runoff to it from a PMP storm.

With the pond in the lower tailings basin maintained at the design elevation of 6620', or 10' below the dam crest, the estimated storage capacity may be derived from the design data (Appendix V).

Total acre-feet at dam crest, elevation 6630'		398
Capacity at pond elevation, 6620'		204
Difference		194
Less estimated tailings above water		27
Storage capacity available, acre-feet		167
Average storage capacity/ft of freeboard = 167/10	=	17
Estimated storage capacity to elevation 6629'		
or 1 ft. below dam crest = 167-17 or		150 acre-ft.

D. Control of Runoff from a Storm after Mine Close Down

In June 1969 the State of Utah issued a draft proposal regarding the treatment of abandoned uranium tailings areas (Appendix VI). This proposal included levelling the tailings and covering with soil to prevent the ponding of any water on the deposit.

In conjunction with the covering of the tailings at Lisbon, a diversion ditch is required to carry water from the drainage basin above the upper pond past both ponds to prevent any erosion of tailings.

As soon as the ponds in both tailings basins have dried up after cessation of operations soil will be placed over the tailings to the required depth. The source of this material could be the portion of the dams above the tailings elevation and the diversion ditch around the two basins and adjacent soil areas.

Provision of a ditch around the tailings areas to handle up to 2200 cu. ft./sec. in the unlikely event of there being a PMP storm in this small drainage basis does not appear justifiable on the basis of high cost and minimum impact in the event of erosion of tailings. No body of contaminated water will be released.

On this basis it is proposed to provide a diversion ditch at close-down to handle up to 4 times the calculated runoff from a 100-year storm of 2.5 inches precipitation in 6 hours, or for 600 cu. ft./sec.

The following are three configurations for such a ditch depending on actual soil conditions, slope and estimated friction factor. To minimize erosion and silting care will have to be taken in the selection of appropriate velocities.

Volume, cu. ft./sec.	600	600	600
Velocity, ft./sec.	3.01	5.05	5.11
Area of cross-section, sq.ft.	199	119	117
Ditch side slopes	2:1	2:1	2:1
Friction factor, n	0.025	0.035	0.035
Ditch slope, 5, ft./ft.	0.00035 (.035%)	0.003 (0.3%)	0.004 (0.4%)
Hydraulic radius, n	4.4	3.2	2.4
Bottom width, ft.	12	16	32
Top width of water, ft.	41.6	34.4	47
Depth of water, ft.	7.4	4.6	3.0
Depth of ditch, ft.	9.4	6.6	5.0
Excavated cross-section, sq.ft.	289	193	210

F. <u>Projected Upper Tailings Basin Elevations</u>

Based on the surveyed capacity of the upper tailings basin and the projected 700 tons per day mill capacity, Appendix VII gives the estimated elevations of the pond and settled solids for the first

12 months of operation. In 6 months the liquid level will be at 6650' and at 12 months at 6656.6' with the solids about one foot lower. Excess water is decanted to the lower pond. Most of this liquid is recycled to the concentrator. After one year of operation the liquid level in the upper pond should be about 19 feet below the design maximum of 6675 feet.

G. Proposal re Lisbon Tailings Area Operating Procedure

1. Criteria to be met are:

a) The liquid in the lower pond should be at about elevation 6620 by the end of August 1975, and the upper pond liquid should not go above 6675 feet.

b) When the operation is closed, it is anticipated that the tailings areas when covered by about 1½ feet of waste material, will have a surface contour such that water will not be able to lie on the surface of the former pond with subsequent leaching of the tailings by percolation. To this end it will be advantageous to fill each pond with tailings to as uniform an elevation as possible to minimize the final stabilization work required.

2. It is understood that tailings are now being deposited against the upstream face of the lower dam and this will continue at least until permission has been received to use the upper pond. A beach is being built to protect the dam from wave action and to move the fluid back from the dam. During this time the maximum quantity of water will be recycled to the mill to minimize any increase in pond levels.

3. The reclaim pump in the lower pond should be positioned to permit the lowering of the liquid level in this pond when tailings are being discharged to the upper pond. Provision should be made for maintaining open water around the pump during cold weather periods.

4. Weather permitting, tailings should be discharged into the upper pond as soon as possible after permission is received. This will permit the gradual lowering of the liquid level in the lower pond. After the liquid level has been appreciably lowered tailings can again be discharged into the lower pond with the objective of gradually filling it with tailings towards the 6620'. Tailings would thus be alternately discharged into the two ponds.

At all times the storm surge capacity required by the A. E. C. must be maintained between the two ponds.

5. It will be possible to increase the tailings storage capacity of both ponds by discharging tailings high on the banks away from each dam. However, at close down, all tailings will require covering to bring radiation to acceptable levels. Therefore tailings deposits should be confined as far as practical and not discharged appreciably above pond levels to minimize the area that must be covered with inert material.

Form 7120-2
(November 1966)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Appendix S, Reference 3

Attachment 2 S-38

HYDROLOGIC DATA SHEET

ESTIMATED PEAK RATE OF RUNOFF

1. Drainage basin

2. LOCATION

SECTION	TOWNSHIP	RANGE	MERIDIAN
21	29 S.	24 E.	SLB&M

3. Drainage area 556 acres = .869 sq. mi.

4. Watershed length (L) 12,932 ft.

5. Elevation change (Δh) 274 ft.

6. Watershed slope (S) = $\frac{\Delta h}{L} \times 100$ = 2.7 percent

7. Design frequency 100 yrs.

8. HYDROLOGIC SOIL COVER COMPLEXES (Illustrations 7-8)

HYDROLOGIC SOIL GROUP	LAND COVER	CLASS CONDITION	TREATMENT OR PRACTICE	CURVE NO.	ACRES	PER-CENT OF AREA	CURVE NO. × PERCENT
D (Rock)	P.J.	Fair	None	89	193	35	3115
B	S.B.	Fair	None	66	363	65	4290
				TOTAL	556	100	7405

Weighted Curve Number = $\frac{7405}{100}$ = 74.05 use 74

9. Rainfall (P) 2.5 inches (illus. 1-6)

10. Runoff (Q) .63 inches (illus. 10)

11. Watershed runoff = Q × ac ÷ 12 = 29.2 ac. ft.
.63 x 556/12

12. Time of concentration (T_c) .72 hrs. (illus. 11)

13. Hydrograph Family No. 3.75 (illus. 12)

14. Unit peak discharge 270 csm (illus. 13)

15. Watershed peak discharge rate (q) = csm × sq. mi. × Q = 147.8 cfs

270 x 0.869 x 0.63 = 147.8

ESTIMATION OF THUNDERSTORM POSSIBLE MAXIMUM PRECIPITATION FOR THE LISBON TAILINGS DRAINAGE BASIN

Total drainage basin to tailings area = 590 acres or about 0.92 sq. miles.

Thunderstorm PMP for 1-hour and 6-hour duration are based on a minimum of 1 sq. mile.

Lisbon tailings drainage basin is situated about 80 miles north of the Arizona border and 10 miles west of Colorado.

Method of Precipitation Calculation

1. On Figure 23 this locates the basin in an area subject to possible 8.4 inches of rainfall in a 1-hour PMP thunderstorm over a 1 sq. mile area.

2. The elevation of the area is between 6600 and 7025 feet, or say 6800 feet average. For every 1000 feet in elevation above 5000 feet the precipitation is decreased by 5 percent. This precipitation decrease for 1800 feet above the datum is 1.8 x 5 = 9.0%.
   Estimated PMP on a 1-hour basis is then 8.4 x 0.91 or 7.6 inches.

3. From Figure 24 the 6-hour to 1-hour precipitation ratio is determined to be 115%. Thus the 6-hour PMP for the 1 sq. mile basin is 1.15.

4. For the 6-hour to 1-hour ratio of 1.15 for the basin, Table 10 gives the following:

6-/1-hr. ratio	1-hr. duration	6-hr. duration
1.1	100%	110
1.15	100%	115 (by interpolat
1.2	100%	120

Thus the 6-hour PMP is 7.6 x 1.15 = 8.7 inches.

5. Using the 6-hour to 1-hour ratio of 115% determined from Figure 24, from Figure 21 determine the variable depth - duration values for 1 to 6 hours for a 1 sq. mile area (page 54a) :

Duration	Amount	%	Corrected Amount	Hourly Increment
1 hour	7.6 ins	100	7.6 ins	7.6
2 " "		108	8.2	0.6
3 " "		112	8.5	0.3
4 " "		114	8.6	0.1
5 " "		114.5	8.7	0.1
6 " "		115	8.7	0.0

6. Time sequence of increments arranged according to HMR No.5 in Table 11

HOUR	1	2	3	4	5	6	
Ppt. ins	0.1	0.3	7.6	0.6	0.1	0.0	= 8.7 ins.

Thus 87% of the PMP of 8.7 inches will fall in the third hour of a 6-hour event.

Calculations follow method given in preliminary report:

"Probable Maximum Thunderstorm Precipitation Estimates, Southwest States".

National Weather Service, Silon Springs, Maryland, August 1972.

Appendix S, Reference 3

Attachment 2 S-41

HYDROLOGICAL DATA SHEET

ESTIMATED PEAK RATE OF RUNOFF

6-HOUR 8·7" PMP STORM

1. DRAINAGE BASIN Area Draining to Upper Tailings Pond only

2. LOCATION

SECTION	TOWNSHIP	RANGE	MERIDIAN
21	29S	24E	SLB&M

3. DRAINAGE AREA 590-75=515 ACRES 0·805 SQ. MILES

4. WATERSHED LENGTH (L) 8600 FT. 5. ELEVATION CHANGE (Δh) 310 FT

6. WATERSHED SLOPE $(\bar{S}) = \frac{\Delta h}{L} \times 100$ = 3·6% 7. DESIGN FREQUENCY PMP YRS.

8. HYDROLOGICAL SOIL COVER COMPLEXES (ILLUSTRATIONS 7-8)

HYDROLOGICAL SOIL GROUP	LAND COVER	CLASS CONDITION	TREATMENT OR PRACTICE	CURVE NO	ACRES	% OF AREA	CURVE NO. X %
B	Sage Brush	Fair	Nil	66	363	71	4690
D	Pinon-Juniper	Fair	Nil	89	152	29	2580
			TOTALS		515	100	7270

WEIGHTED RUNOFF CURVE NO. $\frac{7270}{100}$ = 72·7 . USE 73

9. RAINFALL (R) 8·7 INS. (6 hours) (ILLUS. 1-6) 10. RUNOFF (Q) 5·3 INS. (ILLUS. 10)

11. WATERSHED RUNOFF $\frac{Q \times Acres}{12} = \frac{5.3 \times 515}{12}$ = 227 ACRE FT.

12. TIME OF CONCENTRATION (T_C) = 0·66 HRS (ILLUS. 11)

13. HYDROGRAPH FAMILY NO. 2·25 (ILLUS. 12)

14. UNIT PEAK DISCHARGE 420 CSM (ILLUS. 13)

15. WATERSHED PEAK DISCHARGE RATE (q) = CSM x SQ. MI. x Q =

= 420 x 0·8 x 5·3 = 1780 CFS

6985'
6675'
310

$\frac{310 \times 100}{8600}$ = 3·6%

HYDROLOGICAL DATA SHEET

ESTIMATED PEAK RATE OF RUNOFF

6-HOUR 8.7" PMP STORM

1. DRAINAGE BASIN Area Drainage to Lower Tailings Pond only

2. LOCATION

SECTION	TOWNSHIP	RANGE	MERIDIAN
21	29S	24E	SLB&M

3. DRAINAGE AREA 75 ACRES 0.117 SQ. MILES

4. WATERSHED LENGTH (L) 1200 FT. 5. ELEVATION CHANGE (Δh) 110 FT.

6. WATERSHED SLOPE (S)= $\frac{\Delta h}{L} x^{100}$ = 9.2% 7. DESIGN FREQUENCY PMP YRS.

8. HYDROLOGICAL SOIL COVER COMPLEXES (ILLUSTRATIONS 7-8)

HYDROLOGICAL SOIL GROUP	LAND COVER	CLASS CONDITION	TREATMENT OR PRACTICE	CURVE NO.	ACRES	% OF AREA	CURVE NO. X
B	Sage Brush	Fair	Nil	66	21	29	1920
	Pinion Juniper	Fair	Nil	89	54	71	6320
			TOTAL		75	100	8240

WEIGHTED RUNOFF CURVE NO. $\frac{8240}{100}$ = 82.4 USE 82

9. RAINFALL (R) 8.7 (6 HOUR) INS. (ILLUS. 1-6 | 10. RUNOFF (Q) 6.45 INS. (ILLUS. 10)

11. WATERSHED RUNOFF $\frac{Q \times Acres}{12}$ = $\frac{6.45 \times 75}{12}$ = 40.2 ACRE-FT. ✓

12. TIME OF CONCENTRATION ($^T/C$) = 0.28 HRS. (ILLUS. 11)

13. HYDROGRAPH FAMILY NO. = 1.7 (ILLUS. 12)

14. UNIT PEAK DISCHARGE 630 CSM (ILLUS. 13)

15. WATERSHED PEAK DISCHARGE RATE (q) = CSM x SQ. MI. x Q = 390 CFS

= 630 × 0.117 × 5.3 = 390

El 6735 Av
6625
Diff 110'

$\frac{110}{1200}$ = 9.2%

HYDROLOGICAL DATA SHEET

ESTIMATED PEAK RATE OF RUNOFF

100-YEAR. 5.0" DPT IN 10 DAYS (BLM) OR 2.5" IN 6 HOURS

1. DRAINAGE BASIN Area draining to Upper Tailings Pond only

2. LOCATION

SECTION	TOWNSHIP	RANGE	MERIDIAN
21	29S	24E	SLB&M

3. DRAINAGE AREA 590-75 = 515 ACRES = 0.805 SQ. MILES

4. WATERSHED LENGTH (L) 8600 FT. 5. ELEVATION CHANGE (Δ h) 310 FT.

6. WATERSHED SLOPE (S) = $\frac{\Delta h}{L} \times 100$ = 3.6% 7. DESIGN FREQUENCY 100 YRS.

8. HYDROLOGICAL SOIL COVER COMPLEXES (ILLUSTRATIONS 7-8)

HYDROLOGICAL SOIL GROUP	LAND COVER	CLASS CONDITION	TREATMENT OR PRACTICE	CURVE NO.	ACRES	% OF AREA	CURVE NO. X %
B	Sage Brush	Fair	Nil	66	363	71	4690
D	Pinon-Juniper	Fair	Nil	89	152	29	2580
			TOTALS		515	100	7270

WEIGHTED RUNOFF CURVE NO. $\frac{7270}{100}$ = 72.7. USE 73.

9. RAINFALL (R) 2.5 INS. (6 HOURS) (ILLUS. 1-6) 10. RUNOFF (Q) 0.58 INS. (ILLUS. 10)

11. WATERSHED RUNOFF $\frac{Q \times Acres}{12} = \frac{0.58 \times 515}{12}$ = 24.9 ACRE FT.

12. TIME OF CONCENTRATION (^{T}C) = 0.68 HRS. (ILLUS. 11)

13. HYDROGRAPH FAMILY NO. 3.75 (ILLUS. 12)

14. UNIT PEAK DISCHARGE 270 CSM (ILLUS. 13)

15. WATERSHED PEAK DISCHARGE RATE (q) = CSM x SQ. MI. x Q = 108

= 270 x 0.8 x 0.5 = 108 CFS

6985
6615

$\frac{310 \times 100}{8600}$ = 3.6%

UPPER TAILINGS BASIN CAPACITY AT LISBON

ELEVATIONS	CAPACITY, CUBIC FEET
Below 6,635'	21,350
6,635 - 6,640	215,600
6,640 - 6,645	722,750
6,645 - 6,650	1,381,750
6,650 - 6,655	2,004,250
6,655 - 6,660	2,680,500
6,660 - 6,665	3,479,250
6,665 - 6,670	4,377,000
6,670 - 6,675	5,553,000

TOTAL = 20,435,450 = 470 acre-ft.

Capacity based on survey of November 1974.

Capacity between elevations 6670' & 6675' = 127 acre-ft or 127/5 = 25 acre-ft. per foot of elevation.

MAXIMUM PRECIPITATION RECORDS

LA SAL, UTAH

Month	1939 - 1952 Highest Monthly Fall	Year	Average	1951 - 1960 Highest Monthly Fall	Year	Average
January	2.02	1939	.95	2.04	1957	1.09
February	1.44	1940	.92	2.41	1958	.96
March	1.75	1948	.96	1.45	1952	.89
April	2.86	1941	1.17	2.89	1957	1.07
May	1.53	1947	.76	2.64	1957	.80
June	2.20	1941	.75	1.79	1957	.71
July	2.12	1945	1.54	2.47	1953	1.35
August	3.23	1946	1.83	3.15	1957	1.62
September	3.66	1939	1.28	3.20	1954	1.16
October	5.34	1941	1.40	5.49	1957	1.47
November	2.08	1944	.78	2.10	1957	.78
December	1.88	1940	.93	2.11	1959	.90
Total Yearly Fall						
Highest	24.77	1941	13.27	24.16	1957	
Lowest				6.50	1956	
Average				12.80		

PRECIPITATION AT LISBON MINE

Month	1969 Rain	1969 Snow	1970 Rain	1970 Snow	1971 Rain	1971 Snow	1972 Rain	1972 Snow
January				8.7		0.5		1.0
February			0.01	0.7		4.2		?
March			0.41	14.5		3.2		?
April			0.8	5.0	0.4	8.7		?
May			?		0.6			?
June			1.2			?		?
July			0.001		0.2		0.68	
August			2.0		2.45		0.50	
September			1.7		0.8		1.45	
October	1.42		1.1	8.5	4.0	3.0	5.7	0.7
November	0.6	1.0	0.7	3.2		7.5	0.11	4.3
December	0.4	8.0	-	9.0		25.7		16.0
Total Rain	2.42		7.921		8.45		8.44	
Total Snow		9.0		49.6		52.8		22.0

NOTE: October 1971, daily maximum 1.7" rain.

October 1972, daily maximum 1.3" rain.

(SUPPLEMENTARY ENVIRONMENTAL REPORT)

Dam Crest Elevation	Max. water level in pond from operations	Capacity of basin above water level acre-ft.	Estimated volume of tailings above water level acre-ft.	Net Storage Capacity of basin; acre-ft. above pond water level	Safety Factor
6630	6620	194	27	167	2.85
6640	6630	295	31	261	4.52
6650	6640	404	36	368	6.30

The tailings pond could therefore contain a minimum of 167 acre-ft. of flood water at elevation 6620 and a minimum of 368 acre-ft. of water at elevation 6640. For the maximum calculated run-off of 58 acre-ft., the safety factor against overtopping the dam is 2.85 at a pond water elevation of 6620 and 6.30 at elevation 6640. Therefore, a long duration flood of more than 100 year frequency will easily be contained in the pond.

Based on discussions with the Bureau of Land Management, it is not believed necessary to construct a channel to divert possible flood water around the tailings pond at this time. At the end of the mining and milling operation, the plant area and the waste rock piles will be covered with a layer of soil. A diversion channel around the south side of the tailings pond will then be constructed to bypass drainage from the tailings area. The cost of the proposed 2,500 foot long channel to be constructed at the end of Rio Algom operations is estimated at $30,000. This future diversion channel is shown on Figure 7.

REGULATIONS REQUIRING STABILIZATION OF URANIUM AND THORIUM MILL TAILINGS PILES

1. These regulations are for the purpose of controlling environmental radioactivity and shall apply to mining, milling or manufacturing operations where wastes, tailings piles or stockpiled ore which contain radioactive materials are accumulated. Since these materials are of an essentially permanent nature in relation to methods for their containment, requirements specified by these regulations must be regarded as interim measures, subject to renewal or modification as found necessary.

2. Planning, management, stabilization and containment of tailings piles are the responsibility of the individual mill or tailings pile owners. Each owner shall submit to the Utah State Division of Health specific plans for accomplishing such management, stabilization and containment.

3. The following requirements shall apply to both active and inactive tailings piles:

   a. Side slopes shall be stabilized by riprap, dikes, reduction of grades, vegetation or any other method or combination of methods that will insure stabilization.

   b. If pile edges are adjacent to a river, creek, gulch or other watercourse that might reasonably be expected to erode the edges during periods of high water, the exposed slopes shall be stabilized and the edges shall be diked and riprapped sufficiently to prevent erosion of the pile.

   c. Drainage ditches shall be provided around pile edges to prevent surface run-off water from neighboring land from reaching and eroding the pile.

d. Access to the stabilized pile area shall be controlled by the operator or owner and properly posted.

e. The pile shall be maintained in such a manner that excessive erosion or hazard from radioactive materials does not occur.

f. With the exception of use or reprocessing at the mill site itself, prior approval of the Utah State Division of Health must be obtained before any material is removed from a tailings pile.

g. The State Board of Health may waive individual requirements in regard to stabilization or utilization of tailings materials if it can be shown that they are unnecessary or impractical in specific cases.

4. The following additional requirements shall apply to inactive tailings piles:

a. Ponds shall be drained and covered with materials that prevent blowing of dust. Water drained from the ponds shall be disposed of in a manner approved by the Utah Water Pollution Committee.

b. Tailings piles shall be leveled and graded so that there is, insofar as possible, a gradual slope to eliminate low spots on the pile which could collect water.

c. The pile shall be structurally stabilized and contained to prevent wind and water erosion. The method of stabilization may consist of vegetation, or a cover of soil, soil containing rock or stone, cement or concrete products, petroleum products, or any other soil stabilization material presently recognized or which may be recognized in the future or any combination of these.

d. The owner of th tailings pile site shall give e Utah State Division of Health written notice at least ten days in advance of any contemplated transfer of right, title or interest in the site by deed, lease or other conveyance. The written notice shall contain the name and address of the proposed purchaser or transferee. Prior written approval of the State Division of Health shall be obtained before the surface area of the land is put to any use, and no use shall be permitted which could result in dosage to the public exceeding 0.5 rem per year.

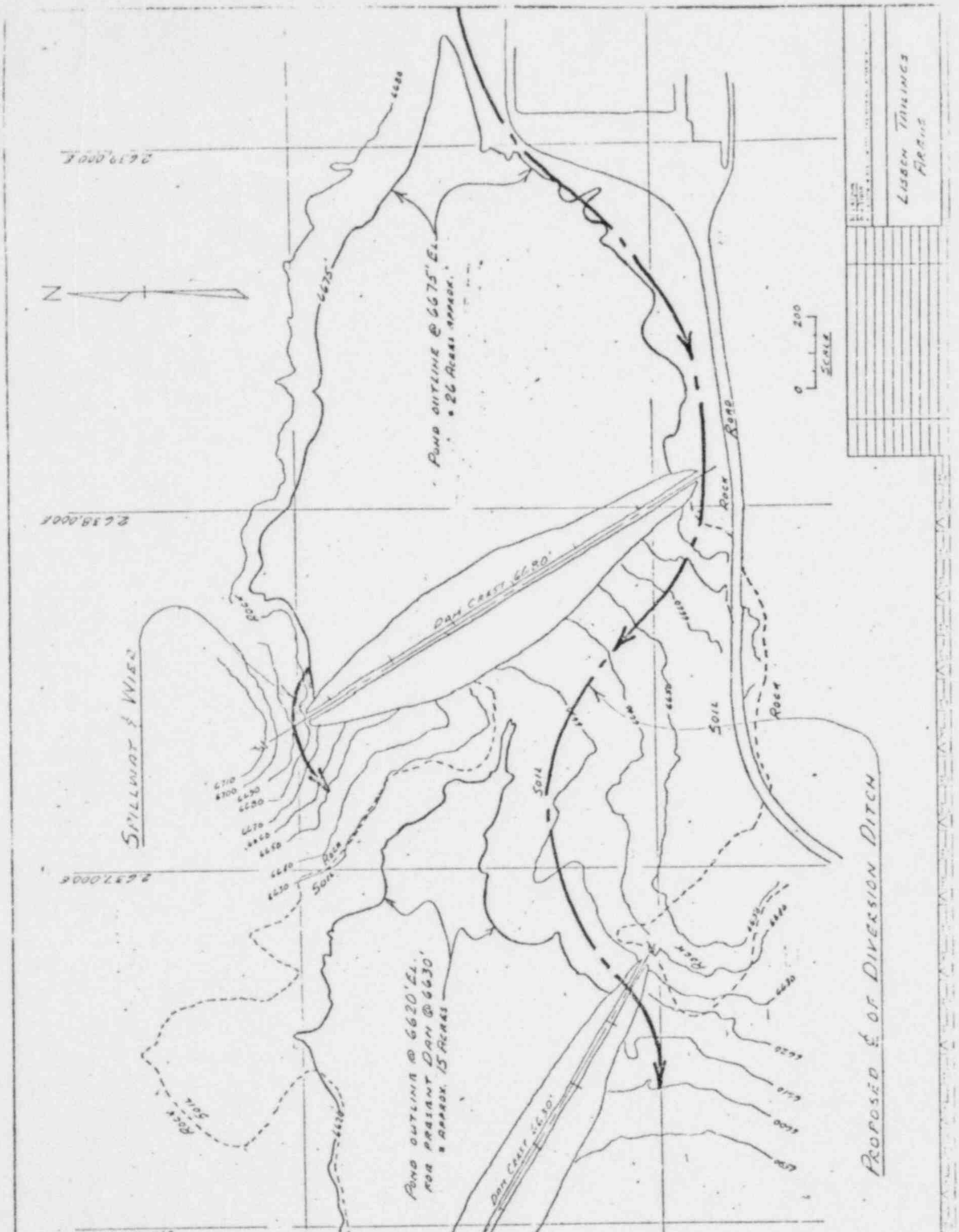
ESTIMATED TAILINGS ELEVATION IN THE LISBON UPPER TAILINGS BASICS BY MONTHS OF OPERATION BASED ON A MILLING RATE OF 700 TONS PER DAY

MONTH	LIQUID ELEVATION	SETTLED SOLIDS ELEVATION
1	6,642.1'	6,641.0'
2	6,645.4	6,643.5
3	6,647.4	6,645.6
4	6,648.5	6,647.0
5	6,648.5	6,648.4
6	6,650.3	6,649.7
7	6,651.6	6,650.7
8	6,652 5	6,651.7
9	6,653.1	6,652.7
10	6,654.5	6,653.6
11	6,655.6	6,654.6
12	6,656.6	6,655.4

Note: Tailings slurry as discharged 26 cu. ft./ton
Settled Tailings 18.2 ct. ft./ton

Decant Elevations: No. 1-6,648.5'
No. 2-6,652.5'

The settled solids are assumed to have been deposited at a uniform elevation.


Lisbon Tailings Areas
Proposed ℄ of Diversion Ditch
Spillway & Weir
Pond outline @ 6675' El.
• 26 Acres approx.
Pond outline @ 6620' El.
for present dam @ 6630'
• approx. 15 acres
Dam Crest 6690'
Dam Crest 6630'
Road
Rock
Soil
Scale
0
200
2,639,000 E
2,638,000 E
2,637,000 E
2,636,000 E
602,000 N
603,000 N
N

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 17 1975

R. E. Cunningham, Assistant Director
for Fuel Cycle, RL

EVALUATION OF TAILINGS RETENTION SYSTEM - TAR 1117

PLANT NAME: Lisbon Uranium Mill
LICENSING STAGE: CP
DOCKET NUMBER: 40-8084
RESPONSIBLE BRANCH: Fuel Cycle Environmental Projects Branch
REVIEW STATUS: Hydrologic Engineering Section (SAB) - Complete

Enclosed is a hydrologic engineering summary, addressing your questions outlined in TAR - 1117, dated November 24, 1975. This summary was prepared by T. L. Johnson and L. G. Hulman.

HR Denton

Harold R. Denton, Assistant Director
for Site Safety
Division of Technical Review
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc: w/o enclosure
S. Smiley
W. McDonald
H. Lowenberg

cc: w/enclosure
R. Chitwood
L. Rouse
SS Branch Chiefs
D. Crutchfield
T. Johnson
J. Kendig

HYDROLOGIC ENGINEERING SUMMARY
LISBON URANIUM - RIO ALGOM CORPORATION
DOCKET NO.: 40-8084

We have independently evaluated the applicant's flood analyses and dam failure analyses. Based on these evaluations, we conclude that the upper tailings retention area will contain the runoff from both the 100-year, 6-hour and 100-year, 10-day precipitation events. We conclude that the applicant has not correctly or conservatively computed the peak rate of runoff from these events; however, this is a minor point, since the upper tailings retention area will contain the entire runoff from these storms.

In the event of a failure of the lower tailings and embankment, the applicant estimated the tailings would be deposited for a distance of two miles downstream. Based on our evaluations, we conclude that this estimate is conservative. However, the applicant has made some assumptions for which there appears to be no basis. The applicant assumed a failure of the lower tailings pond embankment (which is acceptable), and no failure of the upper embankment. The applicant states that the upper pond will not contain the PMP runoff and will therefore be overtopped; we conclude that the upper pond would likely fail if overtopped. The applicant did not consider that some tailings could be eroded from the upper area and move into the lower tailings area. This could be important in determining the concentrations of material that would be eroded when the lower embankment susbsequently fails. However, we conclude that the applicants estimate of 1.3 million cubic feet of released (eroded) tailings from the lower area is conservative.

In response to your question regarding rainfall comparisons for the site area, the 10-year, 24-hour rainfall is approximately 2.2 inches; the 25-year, 24-hour rainfall is approximately 2.5 inches.

Rio Algom
Rio Tinto

April 4th, 1975.

Mr. L. C. Rouse, Chief,
Fuel Fabrication & Reprocessing Branch,
Directorate of Licensing,
U.S. Atomic Energy Commission,
Washington, D.C. 20545.

Dear Mr. Rouse:

D)cket 40-8084

Further to our recent conversation we have made an assessment of the possible environmental impact from a PMP storm in the event of a breach in the tailings dam. As an immedi.te dilution of an out flow of water would immediately occur, we have taken this into account and it is shown that radium levels would be below limits for public exposure before reaching the nearest habitation.

In considering the possibility of release of solid material, we have considered that a breach coincidence with a PMP storm might allow 10% of the total solids to escape. Ground cover would arrest most of this within a short distance and we have computed the average depth to be about 1".

Please advise if we should pursue this further.

Yours truly,

R. D. Lord,
Vice President,
Research & Development.

RDL/mm

IMPACT OF A BREACH IN THE LISBON TAILINGS DAM

As requested an evaluation is made of the impact should a tailings dam at Lisbon be breached due to a PMP storm.

When the upper tailings pond is placed in operation it should be possible to maintain the liquid level below an elevation of 6670' for a period of $2\frac{1}{2}$ to 3 years, or until towards the end of 1977. Tailings deposited until then should be below this elevation.

Between elevation 6670' and 6679' (1' below the dam crest) the surge capacity is in excess of the calculated volume of 227 acre-feet that would go to the upper pond in the event of a PMP storm. As pointed out in our submission of 12 December 1974 the probability of a PMP storm including the 1 square mile of the drainage basin is about 1 in 15,000 years. Alternatively the probability of one impacting the site in the remaining six years of operation is $^{6}/5,000$ or 1 in 2,500 years. For about half of this period surge capacity is provided to contain the required run-off should such a storm occur.

If a PMP storm should occur after 1977 when the upper pond could not contain the run-off, it has been assumed for the purpose of this estimate, that the failure would occur only in the lower dam.

It is estimated that the lower tailings pond contain in the order of 50 acre-feet of liquid by the end of 1977, due to evaporation and the addition of further tailings to minimize the remaining pond volume.

The analyses of the liquid in the lower pond averaged over the past three months are:-

Sulphate	8103 ppm
Sodium	10, 320 ppm
Carbonate	8, 210 ppm
Natural Uranium	4.79×10^{-5} uc/ml
Radium	6.60×10^{-8} uc/ml
Polonium	2.3×10^{-8} uc/ml

Attached is a topographical map showing the West Coyote drainage basin as far as Hatch Wash. At the head of the drainage basin is shown the area draining to the Lisbon tailings areas. (Area 1, in red).

Area 1 is taken as one square mile in area (590 acres) and calculations in our submission of 12 December 1974 give a run-off of 267 acre-feet in a theoretical PMP storm.

The dilution of the liquid now in the lower pond would then be 267 to 50 or 5.3 to 1. The uranium concentration will then be reduced to about 0.9×10^{-5} and the radium to 1.2×10^{-8} uc/ml. These concentrations are about half the A. E. C. limits for the general public, should the liquids escape from the tailings area in the unlikely event of a PMP storm.

The attached Table I lists the drainage areas 1 to 5 shown on the map giving the incremental area in square miles, the expected dilution factor of the tailings pond liquid and the contaminant concentrations down to the discharge to Hatch Wash.

The dilution factors are based on soil and run-off characteristics for each drainage area being approximately similar to the tailings drainage basin. General knowledge of the area indicates that this assumption is approximately correct.

Area 2 (in green) goes as far as the junction with the continuous fresh water flow of Coyote Wash, and Area 3 (in blue) goes as far as Rattlesnake Pond.

Redd Ranch buildings are on a rise in the middle of a large flat area some 200 acres in extent, about 180 acres of which are cultivated as shown in the attached panoramic view. It is estimated that possibly one-half of the cultivated area might become flooded in the event of a dam failure. However because of the dilution (between 20:1 and 75:1) the liquids will pose no problem at this point. Fresh water is always available to this area for irrigation from the reservoir on West Coyote Wash.

The inhabitants living at Redd Ranch vary from 1 to 6 according to the time of the year, and they should be in no physical danger from a flood.

Because of the dilution factor of 75:1 there should be no impact on the ecology of Rattlesnake Pond. At La Sal Junction (Area 4, Orange) the buildings are some 1,000 feet from and 40 feet above the stream bed. Thus the inhabitants should be in no physical danger should the tailings escape in a PMP flood.

Attached is a print of a soil survey map of the area from the mine site to within a few miles of La Sal Junction. On this are marked in red the tailings ponds and Redd Ranch, the drainange courses in blue and the field in view of two photographs and a panorama covering the Redd Ranch area.

Photo 1 is taken from the lower tailings dam, while Photo 2 is from the road, both looking down the drainage course. It will be noted that the drainage is through a flat wide valley with considerable sage brush and sparse grass. Above Redd Ranch the valley narrows for a short distance before entering a wide flat area that is cultivated.

Should the dam be breached, it is estimated that some 10% of the solid tailings might escape. By the end of 1977 the lower pond should hold about 600,000 tons. Thus the released tailings could amount to some 1.3 million cubic feet.

Most of the solids in the released slurry would settle out and be retained in the sage brush covering the drainage area. The above volume of tailings could cover the 2 mile length of the shallow valley down to the junction with West Coyote Wash and up to one-eighth of a mile wide to a depth of slightly over one inch.

Area 5 (black), goes as far as Hatch Wash, where the dilution factor 265:1 will again be much increased. This Wash has its source some 20 miles to the south, and flows some 20 miles northward before joining the Colorado River. There are no known inhabitants between the junction with West Coyote Wash and the Colorado.

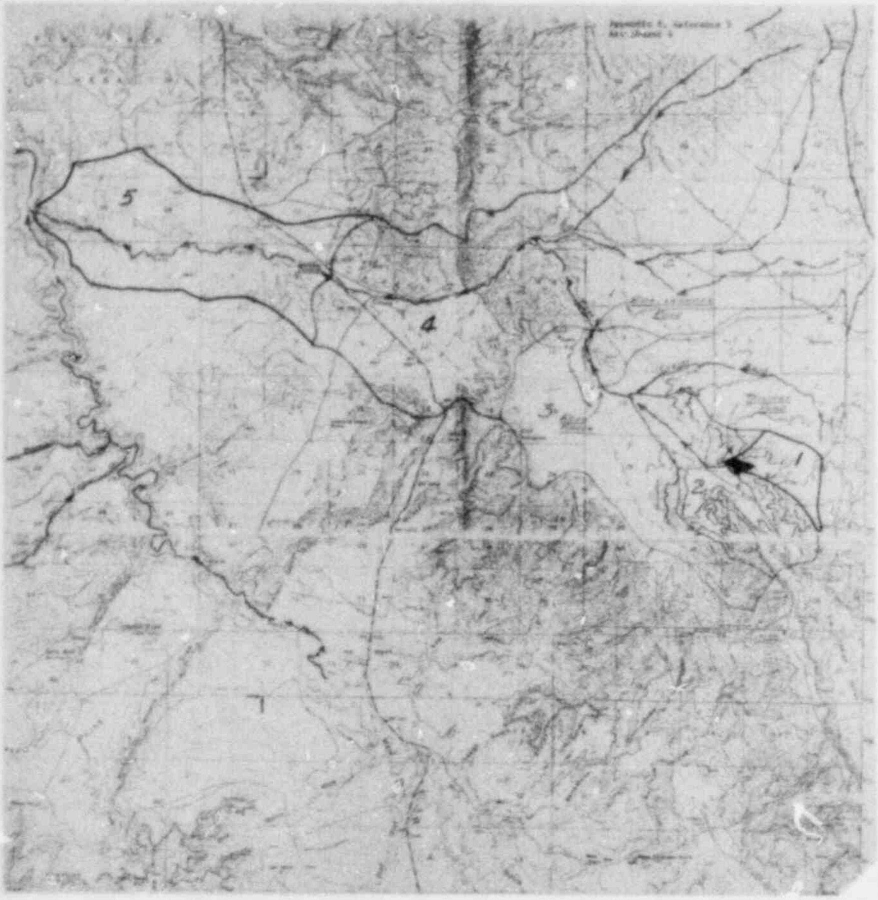
It is submitted that if it is accepted that chances of there being a PMP storm in the next 6 years is 1 in 2,500, then the chances of there being a storm in the period 1978 and 1980 are about 1 in 5,000 years. It is only in those years that the run-off from an improbable PMP storm may not be under control.

PFPullen
4th April 1975

TABLE I

TABLE OF DRAINAGE AREAS, ESTIMATED DILUTION FACTORS & CONCENTRATIONS ON RELEASE OF LIQUID FROM THE LOWER POND TAILINGS BY A PMP STORM

		Lower Tailings Pond	Drainage Areas					
			Area 1 (Red)	Area 2 (Green)	Area 3 (Blue)	Area 4 (Orange)	Area 5 (Black)	Total
Area, Square Miles (incremental)		(12 acres + At El. 6620')	1	4	10	31	5	51
Dilution Factor			5.3:1	20:1	75:1	240:1	265:1	265:1
Contaminant:			Concentrations of Mixture Leaving Above Areas					
Sulphate	PPM	8,103	1530	405	108	34	31	
Sodium	PPM	10,320	1950	516	137	43	39	
Carbonate	PPM	8,210	1550	410	109	34	31	
Natural U,	uc/ml	4.8×10^{-5}	0.9×10^{-5}	0.2×10^{-5}	6.4×10^{-7}	2.0×10^{-7}	1.8×10^{-7}	
Radium	uc/ml	6.6×10^{-8}	1.2×10^{-8}	0.3×10^{-8}	8.8×10^{-10}	2.7×10^{-10}	2.5×10^{-10}	
Polonium	μc/ml	$<2.3 \times 10^{-8}$	$<0.4 \times 10^{-8}$	$<0.1 \times 10^{-8}$	$<3.1 \times 10^{-10}$	$<0.9 \times 10^{-10}$	$<0.8 \times 10^{-10}$	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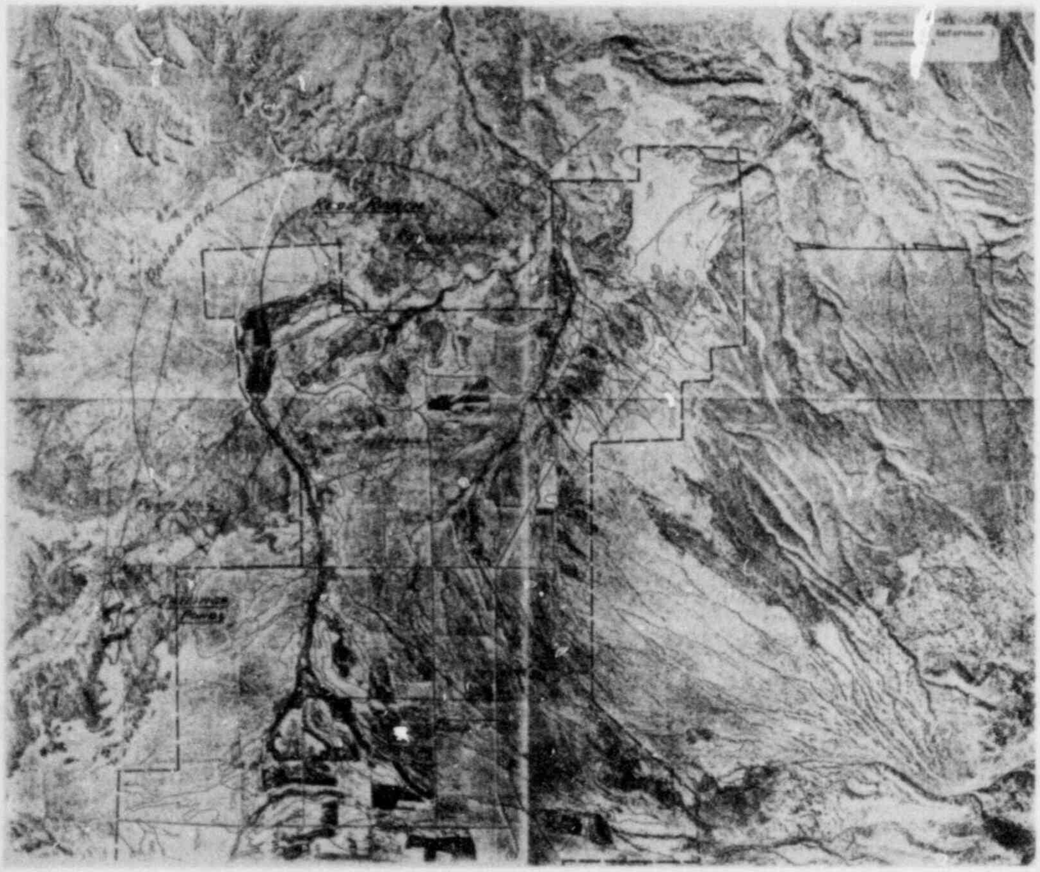
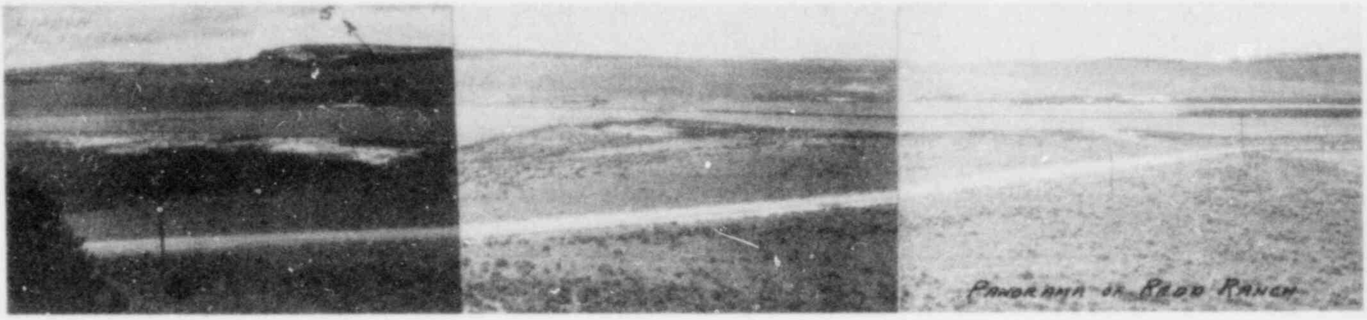
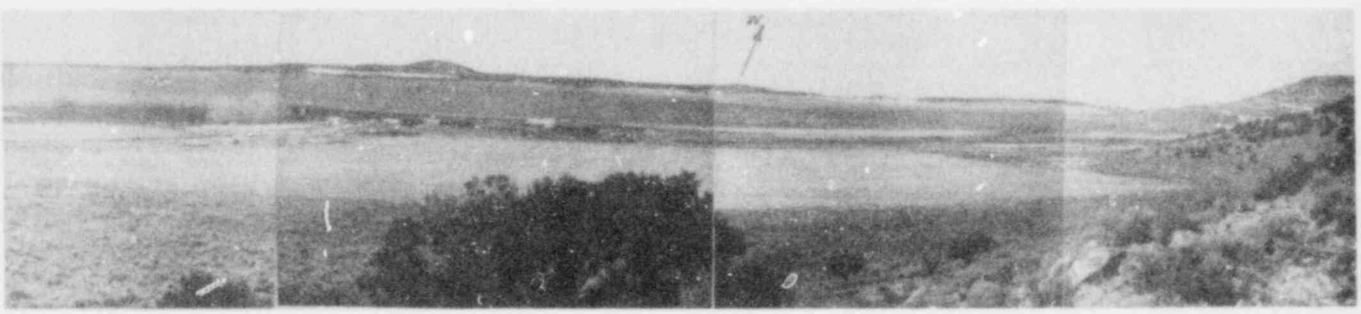


REPRODUCTION OF PHOTOS





APPENDIX T

1. Comments recived from Federal, State, local agencies, private organizations, and individuals.

DOCKET NO. 40-8084

JOHN Y. COLE

ATTORNEY AT LAW
CALIFORNIA AND NEW YORK

Appendix T, Reference 1
T-2

2930 RAMONA STREET
PALO ALTO, CALIFORNIA 94306

TEL: (415) 323-3682

January 10, 1973

RECEIVED
JAN 15 1973

Deputy Director
Fuel and Materials
Director of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Also att: Mr. John F. Kendig-Analyst

Dear Sirs:

We are today in receipt of a copy of a "Draft Detailed Statement of Environment Conditions", for the Humeca Mill, near Moab, Utah; Docket No. 40-8084. This has been referred to in the News as requiring replies, complaints etc., by January 29, 1973. This reply is posted and registered by air mail prior to that date.

I, John Y. Cole, represent the Nuclear Corporation as President, which owns mining claims known as the "Sal" group and of which Sal claims 3-4-5 extend to the East of the Lisbon Valley County Road in Sections 20 and 21; as shown on the map of "Sal" claims enclosed. These, though they should be, are not shown on the alleged map filed in your Draft published as of December 1972. This map of Rio page 12, figure 4, nor in the Draft, makes no mention of these Sal claims, or others, in the Draft Report of the facts. Rio knowing all these facts have filed a map and information which is not inclusive. This they well knew, because of papers filed by Rio in the Record Office in Monticello: namely in Book 456, pages 672-675 (P.23 chapter xiii), of a back dated lease recognizing the prior locations of the Sal Claims of the Nuclear Corporation and John Y. Cole, as being overstaked by their alleged claims known as "Salty Dog" etc.; and a copy thereof is enclosed. Their map and notes, so far as the Brief states, makes no reference to this Sal ground over which they and/or their predecessors overstaked. This is a major factoral omission making their map and the Draft Report not correct. Our position therefore must be considered.

Also, they represent that Rio Algom Corporation is the interested party as owner. This Company is a United States owned subsidiary of the Rio Algom, an Ontario, Canada company, which in turn is owned by Rio Tinto of England. The President of Rio Tinto is so also of Rio Algom. Their signs posted at the Mine area also state it to be owned by Rio Tinto, Rio Algom and in small letters Rio Algom Corporation. This is not a United States citizenship ownership on its face and the latter is not so necessarily.

Any damage to the area of Sal 3-4-5, so far as ecology is concerned was done by Rio without our consent or knowledge. Since but ten years is the estimate of the life of this mine, it seems reasonable that ore could be treated in nearby

Deputy Director
Fuel and Materials
U.S. Atomic Energy Commission
Page 2 - January 10, 1973

mills as all others have done; rather than contaminate this lovely area for a long time to come.

On or about May 16, 1972 I was told by a reliable source that Rio proposed to use the method of ecology to enable them to build a fence along the East side of the Lisbon Valley road to cut off our entry to our Sal claims 3-4-5. Done to stop us doing our annual labor thereon and to establish support for their assuming possessory rights, etc. This you can not permit, as it is unnecessary for ecology, nor legal.

On or about May 16, 1972 the East line of Sal 3-4-5 and this the old line to the NE and SW for all locations prior to that by Rio, was shown to an engineer of the staff of Rio, or anyone else who wished to do so. This is the true East line of Sal 3-4-5 as of 1954 and now and in accord with the ties set out in the filings of the locations in 1954, all of which they well knew and admitted.

Further on June 22, 1972 this matter was explained to Mr. Frank Shields, Chief the Bureau of Land Management in Monticello and others there. A sketch was left and a report by them filed, and also this line was viewed by Mr. Wilson of that office. They affirmed no fence would be built which would prevent our entrance to Sal 3-4-5 claims.

In this Draft, Rio alleges they will exclude others from is so-called area. It is one thing to protect their immediate mine buil s, but it is another thing to set up an army post of an area. They do not own all the area and this is Federal surface land, thus they are limited to the use in the mine building area. It would be a travesty of authority and law to permit the restriction in a y way on our legal right and obligation to do the necessary annual labor thereon in the guise of their ecology or anything else.

The Sal claims were located in 1954 by me and the laws have en complied with since then at considerable expense to me. No legal dispute has ever been filed against them in these twenty-four years. They were transferred by me to the Nuclear Corporation which I had incorporated in August 5, 1955 and in September 30, 1955 the Prospectus was issued in compliance with the S.E.C. Registration in Denver. This included a map and report as well as title verification. This, too, has been ignored by Rio.

About the middle of the 1960's predecessors of Rio alleged to overlocate Sal 3-4-5, but it stands admitted that these "Salty Dog" etc. claims were not located according to law. The required monuments and markings were never put up until done by Rio by a survey and then only new posts and markings done about 1968 and then these so-called locations were moved from time to time. The so-called projections for the corners were merely projected by survey as true north and south as they saw fit without any prior markings as required by law, nor with any regard for the old 1954 monuments then and still there and photographed of the Sal claims.

Deputy Director
Fuel and Materials
U.S. Atomic Energy Commission
Page 3 - January 10, 1973

On or about June 21, 1972 I saw Mr. M. Hanson at the A.E.C. in Grand Junction. I left with him a sketch of the Sal claims. I was told there that the map filed by Rio as to their drilling in no way referred to the "Salty Dog" etc. claims. They had no knowledge of this ground which is now on the map of Rio in the Draft and alleged overlocating the Sal claims.

About May 16, 1972 Rio put up a wire fence, over a larger area than called for, around their settling pond, which they named as a "cattle fence". They intruded onto the east side of Sal 3 and cut off the NE monument of Sal NE3. An old sign of "Smitty" claims was obliterated and some of Sal's posts there since 1954 were then taken. A new post was put up, but that too was disregarded for no good reason.

We must insist and request that the Federal and State authorities forbid and prevent any fence, road, obstruction, tailings, patents or the like be placed to in any way affect the rights of entry and movement on the Sal claims or their borders by Rio or their agents in this matter under the guise of ecology or the like; for we have the legal right to freely enter in to these Sal claims and do our annual labor required by law on these claims. Such environmental considerations on this ground is irrelevant and now unnecessary. We may be a small unit, but we are entitled to the protection of the law as citizens.

Please acknowledge receipt of this by the Official of your Agency in charge of this above-headed subject, and oblige.

Sincerely,

The Nuclear Corporation
and John Y. Cole (President)

JYC:vgh

11.2 In the event of the termination of this Lease for any reason, irrespective of any provisions contained above, if any taxes as specified above have accrued but are not then payable, Lessees shall remain responsible for the payment of their portion thereof, calculated in the manner as set forth above.

11.3 Nothing herein shall be construed as an obligation or undertaking by one party to indemnify the other in respect of or to pay the other's income taxes, in whole or in part.

XII

ANNUAL ASSESSMENT WORK

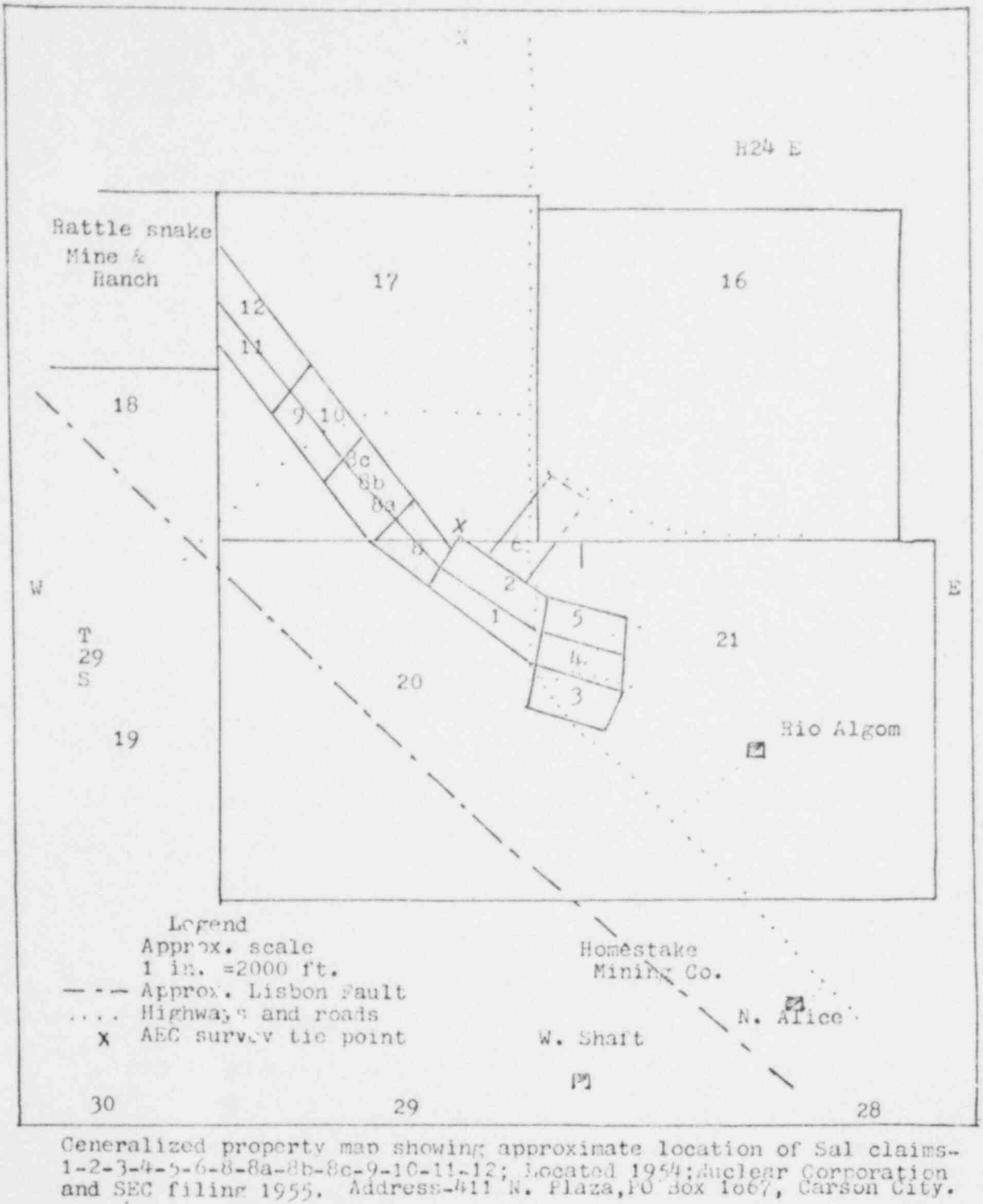
12. During each assessment year during the term of this Lease, Lessees will perform upon or for the benefit of each of the unpatented mining claims forming a part of the Sindbad-Salty Dog Group, assessment work of a value and character reasonably expected to satisfy the requirements of the mining laws of the United States and the State of Utah and will file necessary affidavits and proof thereof.

XIII

TITLE

13.1 Lessors' title to the Sindbad-Salty Dog Group is based upon the entry and location of unpatented lode mining claims by Lessors, or their predecessors in interest, in good faith and in attempted compliance with the mining laws of the State of Utah and the United States of America. Lessors have no notice or knowledge of adverse claimants to their said title except as to certain claims asserted by John Y. Cole and The Nuclear Corporation with respect to mining claims known as the Sal Group. Lessors warrant the title to said Sindbad-Salty Dog Group as against, but only as against, any persons claiming the whole or any part thereof by, through or under Lessors.

Sal claims, Lisbon Valley, Utah



Generalized property map showing approximate location of Sal claims-1-2-3-4-5-6-8-8a-8b-8c-9-10-11-12; Located 1954; Nuclear Corporation and SEC filing 1955. Address-411 N. Plaza, PO Box 1667, Carson City.

DOCKET NO. 40-8084

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

1 MAR 1973

RECEIVED MAR 12 1973

OFFICE OF THE ADMINISTRATOR

rbc

Mr. Leland C. Rouse, Chief
Technical Support Branch
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rouse:

The Environmental Protection Agency has reviewed the draft environmental statement for Rio Algom Corporation's Humeca Uranium Mill and our detailed comments are enclosed.

Our primary radiological concern with the operation of the Humeca Mill concerns the tailings retention system. We urge the AEC to work with the applicant to assure that the uranium tailings are isolated from the biosphere to the maximum extent possible. This assurance could be achieved by encouraging the adoption, by the State of Utah, of regulations for the control and stabilization of radioactive mill tailings. An alternative to the adoption of state regulations would be to allow the land to remain under the jurisdiction of the Bureau of Land Management following license termination.

In light of our review of the Humeca facility and in accordance with EPA procedures, we have classified the project as ER (Environmental Reservations) and rated the draft statement as "Category 2" (Insufficient Information). Enclosed is a detailed explanation of our classification system for your information. We will be pleased to discuss our comments or the classification with you or members of your staff.

Sincerely,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities

Enclosure

Appendix T, Reference 1

DOCKET NO. 40-8084

T-8

RECEIVED MAR 12 1973

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

JANUARY 1973

EVIRONMENTAL IMPACT STATEMENT COMMENTS

Rio Algom Corporation-Humeca Uranium Mill

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INTRODUCTION AND CONCLUSIONS

This report summarizes an evaluation of the Humeca Uranium Mill submitted by the Atomic Energy Commission (AEC) for formal review on December 14, 1972. This facility has been constructed and is presently in operation under a temporary license. The purpose of the Humeca facility is the mining of uranium ore found in the Lisbon Valley - San Juan County, Utah.

Our major conclusions are as follows:

1. Additional information is necessary and is requested in the final statement concerning the tailings retention system to allow a comprehensive evaluation of the anticipated environmental impact. The proposed termination of Rio Algom's responsibility following 50 years is important in light of the fact that the impact of the tailings upon the environment and public health may extend beyond 10,000 years. The AEC and the Rio Algom-Rio Tinto Corporation should make every effort to assure that the uranium tailings are isolated from the biosphere to the extent that current technology will allow. This asssurance could be achieved by encouraging the adoption, by the State of Utah, of regulations for the control and stabilization of radioactive mill tailings. An alternative to state regulations would be to allow the tailings area to remain unpatented and therefore under the Bureau of Land Management's (BLM) jurisdication following license termination.

2. The final statement should further address the adequateness of the applicant's environmental sampling program. An enlarged soil

and biota sampling program with a specified sampling frequency should be implemented.

3. The draft statement does not provide sufficient technical information to comprehensively evaluate the environmental impact on ambient air in the area of this mining operation; however, assuming the best control technology will be used and the emission of gaseous and particulates can be maintained at or below the concentration shown on page 34, we believe that an acceptable degree of control can be obtained and ambient air standards can be met.

MINING

The proposal to discharge approximately 100 gpm of excess mine water containing 5.3 pCi of radium-226 per liter, without treatment, to the Redd Ranch and the Keystone-Wallace cooper leaching operation is not acceptable. Utah water quality standards require that radioactive substances shall not exceed 1/30th of the MPC values given for continuous occupational exposure in the National Bureau of Standards (NBS) Handbook #69. Application of this criteria leads to a maximum allowable radium-226 concentration of 3.3 pCi per liter. This water will drain essentially undiluted and freely across land not controlled by the applicant, and in drainages considered to be waters of the state. It appears therefore that the water quality standards of the State of Utah will be violated by this action. The final statement should indicate how compliance will be attained.

The draft statement indicates two water sources in the area. One is used by neighboring ranchers and the mill as the primary source for potable water. The other is the water pumped from the mine. Since the average rainfall is less than 15 inches/year and the evaporation rate is 55 inches/year, all excess water used must come from precipitation in the La Sal mountains. This would indicate an overall shortage of water and a need for conservation. To assess the impact of the mining and mill operation upon the ground water, further information is required. The relative depths of the two sources should be shown on the Stratigraphic Section (Figure 6). The expected drawdown in the potable water aquifer should be shown and the effect of such drawdown upon the ranchers, wildlife and forage should be discussed.

The draft statement indicates that the volume of mine water is decreasing, but fails to given any reason or rate of the decrease. There is no indication whether a direct connection exists between the mine water source and the potable water aquifer. This should be clarified in the final statement. The most efficient use of water should be required in all cases. It is assumed that the mine water comes from aquifers below those economically available for use by the ranchers in the area. Therefore, it would appear that the mine water should be used for industrial processes exclusively, leaving the well water for use by the ranchers who depend on these wells as their only source. Although the draft statement says that the volume does not appear adequate for the process requirements, the alternative of using waste mine water supplemented by well water when necessary should be discussed. The draft statement does not show how the Redd Ranch plans to use the mine water. This should be discussed. No alternatives involving possible reuse of any portion of the water have been shown. These items should be discussed in the final statement.

The draft statement indicates that when mining has been completed in a block "it will be isolated by permanent bulkheads and maintained under negative pressure to prevent contamination of the fresh air supply." Further information on the procedures for this are required. The final statement should show the length of time the negative pressure will be required, monitoring procedures, and measures for purifying the air removed from the block in order to maintain the negative pressure.

MILLING

The draft statement indicates that solid waste in the form of chemical containers and other associated trash will result from the milling operation. It should be clearly stated in the final statement that the disposal of such solid waste will be in a manner which conforms to all applicable state, local, and Federal requlations.

The draft statement indicates that dust from the yellowcake packaging and drying operation, as released to the atmosphere, will be reduced to 0.03 grains per cubic foot. However, the applicant's environmental report states, in Table I and II of Appendix H, that the maximum concentration discharge from the yellowcake scrubber exhaust stack is designed to be 0.05 grains per cubic foot. The final statement should indicate which value is correct. If the 0.05 grains per cubic foot is the true concentration from the stack in question, a determination should be made as to the validity of the values for "Concentration U-Natural" given in Table X of the draft statement and the associated Table XI exposure values. Furthermore, insufficient information is included in the draft statement to evaluate the ambient air concentrations from these emissions. The final statement should include all needed meteorological and engineering data and show calculations to substantiate the conclusions that non-radioactive gaseous and particulate emissions will meet ambient air standards.

The Utah state air standards listed in Table VIII of the draft statement are not effluent standards. Rather, the values listed are ambient air standards, except for the visible emission item which should be listed as a new source emission standard. Also, there is an error in the value for carbon monoxide (CO). The proper allowable concentration should read 9 ppm maximum for an 8-hour average, not to be exceeded more than once per year, and 35 ppm maximum for a 1-hour average, not to be exceeded more than once per year. The above information was extracted from the Utah State Division of Health Code of Air Conservation Regulations. It is believed that the author has utilized the 1967 regulations rather than the updated code adopted November 29, 1969. Due to the above stated discrepancies, it is recommended that all conclusions with respect to compliance with the air standards be reviewed.

Since the mill has been operating under an interim license since June 7, 1972, actual data should have been available and utilized in Table IX, rather than the design parameters for airborne particulate emissions. The means of controlling gaseous particulate emissions during maintenance of control equipment should also be discussed in the final statement.

ENVIRONMENTAL MONITORING

No mention is made in the draft statement of the sampling of mine water discharge. It is recommended that this discharge be monitored until determinations have been made by cognizant agencies or authorities that all standards are being met.

Page 38 of the draft statement indicates that a set of sampling wells for the tailings retention system has been established. However, page 56 (Section 6.6.3) of the applicant's environmental report mentions only "a monitoring well." The final statement should clarify how many wells will be used. The draft statement also indicates that samples from these wells around the tailings retention system will initially be taken weekly and later monthly, if results indicate the need. Since the mill has been operating since June, the final statement should contain actual sampling information relating to the occurrence of seepage prior to sealing, as is predicted for the bottom and side walls of the system. In addition to the above data, the location of the monitoring wells should be indicated as well as depth and strata sampled. This information is necessary to insure that the sampling points are representative.

At least during the first year of operation, process stacks should be sampled at a frequency greater than quarterly; weekly sampling to coincide with the ambient air measurements would seem appropriate. Information should also be presented on the proposed sampling procedures for stack and ambient air monitoring; for example, the numbers, location, and type of samplers that will be used and the lengths of compositing periods. The final statement should include a discussion of what additional control measures will be used if non-radioactive gaseous and particulates are not maintained at acceptable levels, as determined by the monitoring network.

The draft statement does not describe an adequate environmental sampling program. The applicant's supplemental environmental report, pages 42 and 130, indicates that a base-line survey of soil and biota will be conducted within 6,000 feet of the plant. The sampling grid in the report appears to be well laid out, however some samples should have been taken within the restricted area. Biota samples should also be taken from a specified grid rather than as stated, "plant samples will also be taken throughout the area." Post operational environmental sampling should be conducted on a regular basis instead of when contamination is suspected. The final statement should develop these points and specify the frequency of collection of these environmental samples.

Occurrences of excessive discharge levels should be reported to the appropriate cognizant authorities such as the AEC, the EPA, and the State of Utah. This action is recommended to be included as a part of the monitoring program. In addition, sample results should be maintained in records that are available for viewing by those same authorities.

TAILINGS RETENTION

It is stated on page 7 of the draft statement that the Rio Algom Corporation intends to patent the land upon which the tailings are to be located. Further, it is stated on page 42 of the draft statement, that the Rio Algom Corporation, or future owners of the land in question, will be responsible for the tailings area for 50 years or until the State of Utah gets radioactive tailings control regulation. Considering that the Federal government at the present time has control of this land and that the half life of radium-226, i.e., the major radioactive contaminant of the tailings, is 1620 years, EPA recommends that the land occupied by the tailings retention system not be patented and therefore be allowed to remain under BLM management following termination of the Rio Algom Corporation lease.

Should the tailings area be patented by the Rio Algom Corporation, the covenants proposed to be attached to successive transfers of the land in question, as listed on page 42 of the draft statement, are recommended to be attached with the initial patent to Rio Algom.

As has been the case with other uranium mills, it is optimistically predicted that seepage from the tailings pond will be minimal with the seal provided by deposited sand tailings. However, experience indicates that this mechanism may be far less effective than anticipated and liquid loss by seepage will most likely be significant and require additional control procedures.

It is stated that the pumping of seepage back to the system will be initiated, when and if necessary, but the method of collection and return is unspecified. This should be outlined in greater detail. It is also recommended that necessary equipment and facilities (e.g., collection basin at foot of dam), for such events should be available.

The EPA has considerable concerns relating to the proposed method for lifting the tailings retention dam. As a result of a meeting with the Bureau of Reclamation, Earth Dams Division, it was verified that the method of raising the tailings dam is not acceptable. Generally the Corps of Engineers review and subsequent license stipulations should prove adequate, but the proposed stipulations should be explicitly incorporated in the final statement to prevent omission of them in future licenses. In addition, the Bureau of Reclamation-Earth Dams Division, and the Bureau of Mines should also be directly consulted prior to additional lifting of the present retention dam.

The reference on page 31 of the draft statement to the spigotting technique is misleading with respect to the term "surface water." The final statement should refer to the liquid tailings solution, rather than surface water.

Other questions concerning tailings retention which are not resolved in the draft statement and which should be addressed in the final statement are:

1) Is the underlying silty sand and clay, into which the dam is keyed, impermeable to the tailings seepage?
2) What provisions have been made to prevent formation of ice lenses or slime pockets near the crest of the dam and near other critical structural points in the dam?
3) Does the applicant intend to monitor the position of the phraetic line during deposition of tailings?

The stated intention of constructing a flood control channel around the tailings pond should be accelerated in schedule and not delayed until cessation of the milling activity. This would provide protection from failure. Comments on this recommendation should be made in the final statement, along with an implementation schedule, if adopted.

The importance of the radon emission from the tailings, as presented in Table IX of the draft statement, seems to have been understated when the draft statement notes that "a major portion of the radon activity is emitted from the mine ventilation shaft." The radon from tailings is estimated at 8.4×10^5 μCi/day and from the ventilation shaft at 3×10^6 μCi/day, which are of comparable magnitude. Since mill operation is underway, a discussion of the availability and use of dust control equipment in the retention system should be included in the final statement. We are aware that spray irrigation equipment is now installed. Has the spray equipment proved adequate? If not, what additional equipment is available?

REHABILITATION AND RESTORATION

The applicant's environmental reports indicate that a mixture of native grasses is to be used in revegetating the dam and the tailings area. Considering the problems encountered with establishing permanent growth on the dam face, test plots should be begun early in the life of the mill to ensure stabilization success. It is unclear as to whether the applicant's plan for revegetation of the tailings area includes a commitment to provide spray irrigation, if such a practice is necessary, to establish and perpetuate an adequate vegetative cover. If not, the applicant's cost estimates for rehabilitation should reflect this possible need.

The draft statement does not indicate how the mill and other structures will ultimately be disposed of. Clarification of this point should be presented in the final statement.

ADDITIONAL COMMENTS

During the review we noted in certain instances that the draft statement did not present sufficient information to substantiate the conclusions presented. We recognize that much of this information is not of major importance in evaluating the environmental impact of the Rio Algom Corporation-Humeca Uranium Mill. The cumulative effects, however, could be significant. It would, therefore, be helpful in determining the impact of the plant if the following topics were addressed in the final statement.

1. When estimating downwind concentrations of particulates, the calculations should be made using the same assumptions applied to the estimation of radioactive contaminants. This is recommended in order to demonstrate compliance or non-compliance with Utah Ambient Air Standards. Incorporated in the particulate calculation should be estimates for fugitive dust from tailings and the other point sources.

2. The first reference in the last paragraph on page 35 to Table X is thought to be in error and should refer to Table IX. The final statement should present the equations used and assumptions made in determining source emission rates and concentrations of the various contaminants at their respective sources (i.e., exhaust stacks, tailings pile, etc.).

3. In the event of a product transport accident, it is stated that no severe radiological safety hazard is possible. The possibility of such an accident occurring in a water-shed has been neglected. In such an event, both a chemical and radiological

safety hazard exists to aquatic life and other beneficial uses of the waters.

4. Safety measures should be stressed throughout the final statement. Efforts to detect operating errors and equipment malfunction should not rely entirely upon visual inspection by the applicant but should be continuously monitored by automatic detection and alarm systems. The frequency of routine inspections by the AEC should be indicated.

U.S. Environmental Protection Agency Procedures for Classifying Federal Projects and Associated Draft Environmental Impact Statements

Environmental Impact of the Project

LO--Lack of Objections

EPA has no objections to the proposed project as described in the draft impact statement; or suggests only minor changes in the proposed project.

ER--Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed project. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to reassess these aspects.

EU--Environmentally Unsatisfactory

EPA believes that the proposed project is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this project. The Agency recommends that alternatives to the project be analyzed further (including the possibility of no action at all).

Adequacy of the Impact Statement

Category 1--Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project as well as alternatives reasonably available to the project.

Category 2--Insufficient Information

EPA believes that the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3--Inadequate

EPA believes that the draft impact statements does not adequately assess the environmental impact of the proposed project, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement.

If a draft impact statement is assigned a Category 3, no rating will be made of the project, since a basis does not generally exist on which to make such a determination.

DOCKET NO. 40-8084

Appendix T, Reference 1

T-24

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
630 Sansome Street, Room 1216
San Francisco, California 94111

REPLY TO ATTENTION OF:

SPDPD

6 March 1973

MAR 13 1973

Mr. Leland C. Rouse, Chief
Technical Support Branch
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rouse:

This is in response to your request for Corps of Engineers review and comments on the draft environmental statement related to Rio Algom Corporation's Humeca Uranium Mill. In accordance with our review procedures, this letter shall serve as the consolidated response of the District Engineer, Sacramento, and the Division Engineer, South Pacific.

Our comments are as follows:

a. Rio Algom Corporation has complied with the requirements of Section 13 of the 1899 River and Harbors Act by filing an application for permit to discharge into a navigable waterway during construction and in event of accidental spills or discharges. All applications to the Corps of Engineers for such permits have been transferred to the Environmental Protection Agency as a result of the Federal Water Quality Act Amendments of 1972.

b. The facilities proposed for construction near Moab, Utah are for mining and milling uranium ore for a period of about 10 years. The facilities include a dam and reservoir for disposal of tailings and contaminated liquid wastes from the milling operations. Since it is intended that none of the contaminated liquid or other material in the reservoir escape, except by evaporation, the capacity of the reservoir must be sufficient to contain at all times the tailings, liquid waste discharge, and runoff from the 590-acre drainage area from the most severe combination of meteorological and hydrological conditions that might reasonably be expected for that area. Examination of the plans indicates that the reservoir capacity will be reasonably adequate, assuming a safe dam is constructed.

SPDPD
Mr. Leland C. Rouse, Chief

6 March 1973

c. There are no Corps of Engineers projects at this time in the area of the subject project. We have no investigations underway which would be affected.

d. In other environmental statements of this type, it has been found desirable to include:

(1) Inventory of plant and animal life and project impact thereon.

(2) Archeological inventory.

(3) Effects of "no action" alternative.

Sincerely yours,

Everett E Love
for DAVID N. HUTCHISON Col CE
Colonel, CE
Deputy Division Engineer

DOCKET NO. 40-8084

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

MAR 12 1973

MAR 9 1973

Mr. Leland C. Rouse
Chief, Technical Support Branch
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rouse:

This is in response to your letter of December 14, 1972, wherein you requested comments on the draft environmental impact statement related to Rio Algom Corporation's Humeca Uranium Mill.

This Department has reviewed the health aspects of the above project as presented in the documents submitted. The following comments are offered:

1. The estimated dose equivalent for bone to occupants of the Redd Ranch is 42 mrem per year. While the number of occupants is very low, the dose is certainly in excess of the Atomic Energy Commission's recommendation for population near nuclear power plants; i.e., 1% of natural background. Natural background in Utah is given as 150 mrem per year.

2. The possibility of flooding due to the failure of the dam from the 45 acre tailings pond is considered remote. However, there is a State road within 1200 feet of the dam. The list of State agencies that Rio Algom Corporation has contacted does not include the State Highway Department. This group should review and approve the construction of the dam with respect to possible flooding of the roadway.

The opportunity to review the draft environmental impact statement is appreciated.

Sincerely yours,

Richard L. Seggel

Richard L. Seggel
Acting Assistant Secretary
for Health

DOCKET NO. 40-8084

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

RECEIVED
FEB 15 1973
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Appendix T, Reference 1
T-27

FEB 14 1973

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

We have had the draft environmental statement for the Rio Algom Corporation's Humeca Uranium Mill - Issuance of License, reviewed in the relevant agencies of the Department of Agriculture, and comments from Soil Conservation Service and Economic Research Service, both agencies of the Department, are enclosed.

Forest Service, also an agency of the Department, has not yet finished its review and will communicate with you directly if it has any comments.

Sincerely,

T C Byerly

T. C. BYERLY
Coordinator, Environmental
Quality Activities

Enclosures

DOCKET NO. 40-8084

UNITED STATES DEPARTMENT OF AGRICULTURE Appendix T, Reference 1
Soil Conservation Service

T-28

COMMENTS ON THE

U. S. ATOMIC ENERGY COMMISSION

DRAFT DETAILED STATEMENT ON THE ENVIRONMENTAL CONSIDERATIONS

RELATED TO THE

PROPOSED ISSUANCE OF A LICENSE

TO THE RIO ALGOM CORPORATION

FOR THE HUMECA URANIUM MILL

DOCKET NO. 40-8084

January 18, 1973

1. Page 7, third paragraph, states, in part, "The block of ground as indicated in Figure 3 which contains the mill and the tailings area will be enclosed by a perimeter fence, 3'6" high wire fencing with 6" x 12" openings to prevent access by sheep and cattle..." This fence will not prevent access by deer and other wildlife. The 45 acre lake will be an attractant to waterfowl, waterbirds and other wildlife. What will be the effect on wildlife species once they get inside the fence, land on the lake, or drink the water or eat flora or fauna associated with the lake?

2. Page 19, line 7--"understory" density would be preferable to "forage density. Not all understory plants are forage plants.

3. Page 19, lines 8 and 12--"usable forage" has little meaning unless related to the kind of animal and season of use. In order to interpret forage yield, the kind of animal and season of use must be related to species composition of the plant community. A better term is total annual yield which gives total production related to precipitation, growth period and soils.

4. Page 19, lines 17 and 18--"a warmwater fishery in the rattlesnake area" probably should read "a warmwater fishery in Rattlesnake Pond." As stated, it infers a warmwater fishery located in an area inhabited by rattlesnakes. "Morning dove" should be "mourning dove."

5. Page 28, third paragraph, last sentence--there is no indication of a method for disposal of solid trash waste, such as a sanitary landfill.

6. Page 33, third paragraph--suggest that for information on methods and procedure for vegetating tailings ponds, that you contact:

Ken Ludeke
Pima Mining Company
P. O. Box 7187
Tucson, Arizona 85713

He has had remarkable success in vegetating the tailings ponds near Tucson.

7. Page 37, third paragraph, first sentence--our comment #1 applies here also.

8. Page 43--are we to assume that after 8-10 years this area will be reopened for public use? It appears that there is a conflict between pages 43 and 45, and that the 120 acres should be shown under section VII, "Irreversible and Irretrievable Commitment of Resources," because of radioactive contamination.

9. Page 45--if the 45 acres is removed from productive use because of contamination, the area would need to have a livestock-deer-proof fence. The fence would need to be maintained indefinitely.

DOCKET NO. 40-8084

ECONOMIC RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

1. The draft statement considers the environmental impact from the entire mining and milling operation (p. 1). In Section VIII, Alternatives to the Proposed Action, the statement considers alternatives to the mill site and milling process only. It would seem that consistent treatment should be accorded to mining. For example, the Applicant should address itself to the question of "How important is the development of this mining site to the supply (national, regional) of uranium concentrates?" If crucial, the alternative of "no mining" may not be worthy of consideration. If excess capacity exists due to production at other sites, postponement of further investment might be desirable. In brief, the statement should include information on the supply and demand of the product in question and the role of the project in meeting market needs.

2. The economic and social justification of any public investment project requires that total benefits exceed total costs. The statement that "anticipated benefits appear to be...greater than environmental costs (p. 50, paragraph 3) seems to rank total benefits against only one type of cost. The statement should be rephrased such that total benefits (economic, social, environmental) be compared to total costs.

3. Paragraph 1, p. 4 and paragraph 2, p. 5 appear to be inconsistent. In the former, it is stated that "the...mill is operating," while in the latter it is stated that the mill "is presently under construction."

DOCKET NO 40-8084

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Washington, D. C. 20250

Appendix T, Reference 1
T-31

RECEIVED MAR 5 1973

MAR 2 1973
1940

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

The Forest Service has completed its review of the draft environmental statement for the Proposed Issuance of a License to the RIO ALGOM CORPORATION for the HUMECA URANIUM MILL. Our comments follow:

The Rio Algom mine and proposed mill site are located approximately eight miles due south of the Moab Ranger District, Manti-LaSal National Forest. There are no apparent adverse impacts on National Forest lands.

The draft environmental statement adequately documents the existing ecological and physical characteristics of the land and has recognized the major environmental impacts that may be created for one alternative. The major weaknesses of this statement are the superficial evaluation of the alternatives to the proposed action and the short time span (8-10 years) considered in evaluating the adverse impacts.

We raise the following questions concerning the evaluation of impacts:

1. The tailing pond is being constructed in a drainage channel to take advantage of the storage capacity without excavation. This is hazardous even in this

arid climate. Heavy intensity, local "cloud bursts" are common in this area. If the proposed site is developed, the channel diversion should be constructed before the pond is filled.

2. It will be difficult to stabilize the tailings pond against wind action in this dry climate. An aggregate "mulch" or other physical treatment may be needed for effective stabilization. The security bond will insure that money is available for initial stabilization work, but who will be responsible for maintenance after the mill work is completed and the plant dismantled? If the tailings material is washed from the site into the adjacent dry washes, the proposed company solution is to gather up or bury the deposited material. This may create a substantial environmental impact.

3. No impervious lining is planned for the tailings pond. Only a small amount of seepage is anticipated, and the soil beneath should tie up the alkaline ions before they contaminate the ground water. There should be adequate insurance against the possibility of this seepage contaminating underground aquifers that supply water wells to the south.

4. How can the most effective decision be made on the proper place for milling the ore without recognizing and placing a value on relevant factors involved, including environmental, economic, and others?

We appreciate the opportunity to review this draft environmental statement.

Sincerely,

Philip L. Thornton

PHILIP L. THORNTON
Deputy Chief

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
FEDERAL BUILDING, 19th AND STOUT STREETS
DENVER, COLORADO 80202

January 9, 1973

REGION VIII

RECEIVED JAN 15 1973 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

IN REPLY REFER TO:
8M

Mr. Leland C. Rouse
Chief, Technical Support Branch
Directorate of Licensing
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rouse:

Subject: Comments on Draft Environmental Statement; Rio Algom Corporation's Humeca Uranium Mill, Moab, Utah; Docket No. 40-8084

We have reviewed the subject draft Environmental Statement transmitted to us by your December 14, 1972, letter.

As you know, HUD is primarily concerned with (1) the effect of a proposed action on the urban environment and, (2) the consistency of such actions with the comprehensive planning for the area.

This office raised some questions on the proposed project in a letter to the Rio Algom Corporation, dated July 19, 1971. The questions were satisfactorily answered in letters received which were dated August 4 and August 23, 1971. We are attaching copies of these letters for your information.

We have no further comments to make on the proposed project. If you have any questions on the above comments, please do not hesitate to contact us.

For future reviews only one (1) copy of the documents are required by this office.

Sincerely,

for Michael T. Kastanek
Assistant Regional Administrator
Community Planning and Management

July 19, 1971

8SDA

Mr. H. D. Lawton
Manager
Rio Algom Corporation
P. O. Box 610
Moab, Utah 84532

Dear Mr. Lawton:

I certainly appreciated the courtesies extended to me during my recent environmental review of the proposed Rio Algom uranium mine in San Juan County.

As I mentioned during our meeting, the following matters should be considered in greater detail:

1. What is the impact of the proposed mine on the human environment? Consideration should be given to the impact, if any, the mine operation will have on the people living and working in the area.

   Consideration should also be given to the impact which this proposal will have on the urban environment. What is the approximate number of employees that will have to be hired from outside the immediate area? A rapid increase in the population of communities such as Moab and Monticello may tax the capacity of facilities such as schools, water and sewer, housing, police and fire protection, etc. A study of the capacity of such facilities in the communities to be affected, in conjunction with a study of the proposed location of families moving into the area, should be done before the effects on the urban environment can be evaluated.

2. What restrictive measures will be taken to prevent the use of uranium mill tailings for land fill by individuals or companies in the area? Will the gate(s) to the tailing area be locked? Will signs be posted to warn the public against trespassing and against the use of uranium mill tailings?

If you have any questions on these comments, please contact me.

Sincerely,

Eldon J. Halingstad
Environmental Clearance Officer

8SDA:HALINGSTAD:ct 7/19/71

AN AFFILIATE OF

Rio Algom

Rio Tinto

Appendix T, Reference 1

T-36

PLEASE REPLY TO Moab OFFICE

August 4, 1971

Mr. Eldon J. Halingstad
Environmental Clearance Officer
Department of Housing and Urban Development
Federal Building, 19th and Stout Streets
Denver, Colorado 80202

Dear Mr. Halingstad:

Thank you for your points for consideration with respect to our mine.

Point 1. In discussions with local people, ie Chamber of Commerce and the Mayor, I find we can be a great help for the area.

Homestake is, I am told, in the process of closing and we can supply continuity of work to many of their staff.

Moab has seen a boom in the past and housing and school facilities were catered to this boom. Housing and school services are now well beyond the present requirements. The new families and children will be catered for by existing services.

When Rio Algom Corporation attains full strength more accomodations will be required than is currently available.

There are, however, some houses available, houses are being built and there is a large trailer park that can handle many more full-size house trailers.

Yours very truly,

RIO ALGOM CORPORATION

M. D. Lawton
Mine Manager

MDL/glc
cc: P. Fullen

Rio Algom
Rio Tinto

Appendix T, Reference 1
T-37
August 23rd, 1971.

Mr. Eldon J. Halingstad,
Environmental Clearance Officer,
Department of Housing and Urban Development,
Federal Building, 19th and Stout Streets,
DENVER, Colorado, 80202.

Dear Mr. Halingstad:

Further to your letter of 19th July to Mr. M.D. Lawton and his reply of 4th August, the attached letter from the Director of the Grand County Department of Economic Development will further answer some of your questions.

Further to your second item, there probably will be only 2 gates into the tailings area, one from the enclosed plant area, and one from the road to the mine at the dam. The latter should be kept locked at all times to unauthorized personnel, and the former as soon as active operations cease at the mill. While the tailings area is active, it is unlikely that anyone would want to pick up the saturated tailings. When the area is inactive, the tailings area will be revegetated and hence will be less attractive for land-fill due to the mixture of vegetation and top soil.

Rio Algom Corporation or its successors will maintain control of the enclosed tailings areas either by purchase or leasing until such time as the area is declared safe from harmful radiation. The integrity of the perimeter fence will have to be maintained.

It is suggested that some form of caution or restraint be registered against the title of any land on which radioactive tailings are deposited in order that such tailings may not inadvertently come into the hands of someone who is not aware of the potential hazards from such tailings.

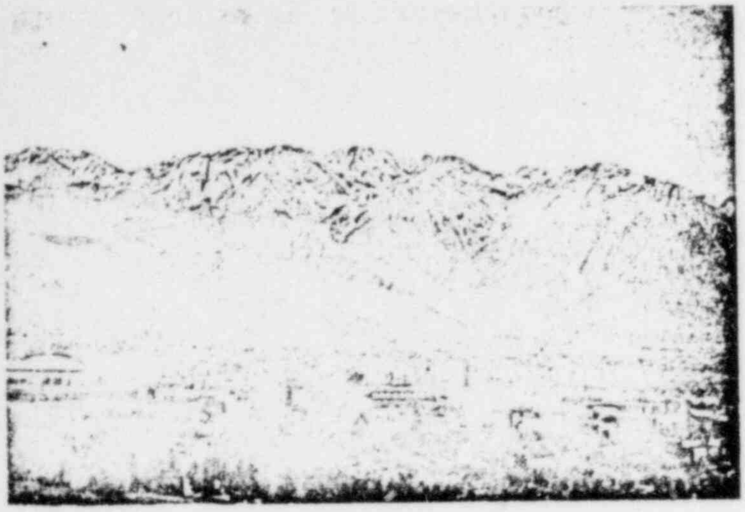
I hope that the above answers your comments on our Environmental Report.

Yours very truly,

P.F. Pullen,
Chief Environmental Engineer.

PFP:nd

cc: M.D. Lawton



Appendix T, Reference 1
T-38

THE UNIVERSITY OF UTAH

SALT LAKE CITY 84112

DEPARTMENT OF MECHANICAL ENGINEERING

3008 MEB
(801) 581-6441

January 26, 1973

RECEIVED JAN 29 1973

Mr. Leland C. Rouse, Chief
Technical Support Branch
Directorate of Licensing
United States Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rouse: Re: Docket No. 40-8084

Your letter of December 14, 1972, a copy of which was sent to Utah's Department of Development Services, has been given to me for review along with a copy of the draft-detailed environmental statement related to Rio Algom Corporation's Humeca Uranium Mill and copies of Rio Algom's Environmental Report and supplements. I have taken the opportunity to review these documents and have asked for comments by members of the Utah Nuclear Energy Commission.

It appears as though Rio Algom has done a good job in preparing their environmental statement. There are a few items, however, upon which we would like to comment:

1. In Rio Algom's analysis of their potable ground water supply, they failed to provide an analysis of the natural radioactivity present in the water. They have agreed to provide this data to the AEC. We would like to be assured that this is done.

2. According to the report, about one hundred gallons per minute of excess process or waste water pumped from the mine will be diverted for use at the Redd Ranch in the Keystone-Wallace heap leaching operations located about two miles south of the applicant's site. Initial testing of the mine water for radioactivity showed the radium content of some samples to be about one-sixth of the limit for release to an unrestricted area as set forth in the AEC's 10 CFR Part 20. The AEC is requiring the applicant to perform surveys to assure that the radioactivity in the water diverted to the Redd Ranch is within acceptable limits. We would like to be assured that this is done.

3. According to the report, approximately five hundred tons per day of solid waste tailings (slurried in about seventy-five thousand gallons of waste milling solutions) will be generated. The waste milling solutions will

Mr. Rouse
January 26, 1973
Page 2

have a pH value of about 9.5 and will contain solium carbonate, bicarbonate, and sulfate as the principle dissolved solids. The probable analysis of solids and liquids discharged to the tailings systems (based on laboratory study and process design) is included in Rio Algom's report. The anticipated concentration of Radium 226 in the waste milling solution will be about 180×10^{-8} microcuries per millileter--approximately sixty times the allowable limit for release to unrestricted areas. There will be measurable quantities of Thorium 230 and natural uranium in the waste solution, but their concentration will only be a fraction of the allowable limits for release to unrestricted areas. The solid waste tailings and milling solutions will be permanently retained within a restricted area at the site.

An earth-fill, clay-core dam retention system serves as a collection and storage system for all of the liquid and solid waste generated in the milling circuit. The Department of the Army, South Pacific Division Corps of Engineers has raised a question concerning the methods used to raise the dam. The AEC proposes to resolve the question with the Corps of Engineers before authorizing the applicant to raise the dam. We would like to be assured that this question is resolved satisfactorily.

The violence of local thunderstorms and floods is well known for the area in which this project is proposed, and a very careful study of the permanence of this type of fill and tailings pile is needed. This should be a structure that will withstand erosion for a greater period than fifty years, since the radioactive materials contained within the pile will take many more than fifty years to decay to innocuous levels.

4. The report states that when the mine operations are terminated, the mine entrances will be sealed with a concrete slab set on the concrete shaft collars. The tailings pile will be graded, covered with earth and topsoil, and seeded. Approximately forty-five acres will be involved; the cost of the reclamation and channel construction has been estimated to be \$126,000. In order to guarantee that funds will be available for reclamation of the tailings area and channel construction when milling activities are terminated, the applicant has agreed to post a surety bond of \$126,000 to be payable to the Bureau of Land Management (BLM) in the event the AEC (or any successor agency with licensing and regulatory responsibilities over the activities involved) determines that Rio Algom has defaulted on these commitments, the proceeds of the bond to be used by the BLM as the AEC (or successor agency) may advise. "Alternatively, Rio Algom will create an irrevocable trust with a Salt Lake City bank as trustee, the terms of which trust will provide that its assets, in the amount of \$126,000, will be disbursed by the trustee as the AEC (or successor agency) may direct in the event of default by Rio Algom on the above commitments." (Letter, April 4, 1972, from R.D. Lord, Vice President, Research and Development, Rio Algom Corporation, to James Malaro, Division of Materials and Licensing, AEC Washington, D.C.).

As noted on the attached benefit-cost analysis, page 49, paragraph four, this stabilized tailings pile covering about forty-five acres will be restricted from use for an indeterminable length of time. Restrictions, including maintenance of the covering, will be binding on the applicant while it owns

Mr. Rouse
January 26, 1973
Page 3

the land, and on successive owners thereafter for a period of fifty years or until such time prior to the exploration of the fifty-year period as government regulations are instituted to control disposition of uranium mill tailings.

Concerning the estimated cost of reclaiming the property, we question whether or not the estimate of $126,000 accounts for expected inflationary effects.

5. In a letter dated July 13, 1970, from Calvin K. Sudweeks, Executive Secretary, Division of Health, Rio Algom, was issued a state construction permit for the tailings disposal dam and related faciliti[illegible] subject to the following condition: "Your proposal for disposal of possi[illegible] excess water in a deep well is not acceptable; therefore, should you find it necessary to dispose of excess water, further negotiations with the Utah Water Pollution Committee will be required to arrive at an acceptable solution." (Rio Algom's Supplemental Environmental Report, Appendix F). There was no evidence in the report showing that this had been resolved.

6. With regard to the necessary control procedures to prevent exposure of employees to dust and Radon gas, our Division of Health issued a letter to Rio Algom on October 15, 1971, indicating that Rio Algom's procedures appeared to be adequate. Rio Algom has proposed to determine that there is no appreciable internal or external radiation hazard by raking Radon daughter samples every two months. (Rio Algom's Environmental Report, Section 6.1). Our Division of Health has recommended that initially Radon daughter samples' should be taken at least bi-weekly rather than bi-monthly, and that sample frequency can be reduced following verification of low concentrations. They have also agreed that stabilization of the tailings pile by use of topsoil and seeding appears to be the best solution at the present time. However, the proposed "seeding" is rather vague and therefore, we would recommend a continuation of this proposal to include seeding and follow-up seeding to assure that permanent vegetation cover [illegible]as been achieved. The term "seeding" should also carry the connotation that the choice of seeded plants will be of such a nature that the surface will be well fixed. Many of the choice range grasses such as crested wheat grass would need to be supplemented by other species having a better capability to hold the soil, both in winter and summer.

If you have any questions related to those comments, please let me know.

Sincerely,

Richard E. Turley

Richard E. Turley
Executive Director
Utah Nuclear Energy Commission

RET/dh

DOCKET NO. 40-8084

DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

Appendix T, Reference 1

T-41

MAILING ADDRESS:
U.S. COAST GUARD (GWS/83)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: 202- 426-2262

Mr. Leland C. Rouse
Chief, Technical Support Branch
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr Rouse:

This is in response to your letter of 14 December 1972 addressed to Mr. John E. Hirten, Assistant Secertary for Environment and Urban Systems, concerning the draft environmental impact statement, environmental report and other material on the Humeca Uranium Mill in Lisbon Valley, San Juan County, Utah.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted. Noted in the review by the Coast Guard is the following:

"The statement that there will be no leeching from the tailings pond appears to be unsubstantiated. It is recommended that the data for the tests be included in the final statement."

The Department of Transportation has no further comments to offer on the draft statement. We have no objection to the project, nor to its implementation. The final statement, however, should include the data requested by the Coast Guard.

The opportunity for the Department of Transportation to review the proposed impact statement for the Humeca Uranium Mill is appreciated.

Sincerely,

J D Mcllo

[illegible]

Appendix T, Reference 1

T-42

DOCKET NO. 40-8084

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

RECEIVED MAR 23 1973

ER-72/1445

MAR 19 1973

Dear Mr. Rouse:

This is in response to your letter of December 14, 1972, requesting our comments on the Atomic Energy Commission's draft statement, dated December 1972, on environmental considerations for the Rio Algom Corporation's proposed Humeca Uranium Mill, San Juan County, Utah.

General

The applicant's methods and equipment for the milling operation described in the subject impact statement have been carefully reviewed by this Department and found to be consistent with the state-of-the-art in uranium ore concentration technology. Our conclusion drawn from the review is in agreement with the Atomic Energy Commission's staff conclusion which is presented as item 5 on page 2. However, the draft does not depict the environmental setting, impacts or project alternatives in sufficient detail to permit a complete independent environmental evaluation.

The statement should discuss the interrelationships between social, economic, and human values within the project area of influence. Quantification and further identification of probable impacts is needed.

The potential long-range adverse impacts of the proposed action has not been addressed by AEC. Since many of these impacts are essentially unknown, we suggest that AEC incorporate in the license binding protective measures that would insure its adequate protection over the life of the hazards.

Our detailed comments are presented according to the format of the statement or according to specific subjects.

Location

The tailing disposal area fence described on page 7 will not keep small animals out of the area. A fence with smaller openings may be needed if operational experience indicates that a significant number of animals visit the disposal area. The statement should recognize that future hazards to wildlife could develop regarding radiations. For example, eagles and other raptors could be damaged by eating rodents contaminated with radionuclides from the mill effluents.

Effects on waterfowl should also be discussed and possibilities of discouraging waterfowl use on the tailings pond explored. Steep sloped banks will discourage emergent vegetation and lessen the attractiveness to waterfowl. Eliminating vegetation around the pond will also help. The probable temperature of the water is not discussed. If the pond remained ice free when other water in the area was frozen it would be attractive to waterfowl. We suggest that the Atomic Energy Commission work with the Bureau of Sport Fisheries and Wildlife to develop protective measures for waterfowl and include the measures in the final statement if time permits. If time does not permit this coordination, the statement should reflect a working agreement to finalize the drafting of these protective measures.

The third paragraph on page 7 states that "the area so enclosed is owned by the Bureau of Land Management (BLM), a department of the United States Government, and leased to Rio Algom Corporation." There is no record of a Federal lease. The tailings pond is located on millsites and unpatented mining claims. Rio Algom Corporation has leased most of the area they control from mining claimants.

The area is situated adjacent to a large block of public land administered by the Bureau of Land Management of this Department. Therefore, we suggest that a program be worked out between AEC and BLM to assure protection of public lands which would be consistent with hazards and risks involved.

Historical Sites and Landmarks

"Arches Memorial Monument" on page 11 should be changed to "Arches National Park." It should also be stated that Canyonlands National Park is the nearest national site and is located 25 miles west of the mine. Natural Bridges and Hovenweep should be identified as National Monuments and Alkali Ridge as a National Historic Landmark. Glen Canyon National Recreation Area should be mentioned here since it is located a little over 25 miles away.

It is recommended that the State Liaison Officer for Historic Preservation be consulted in reference to the proposed action. This officer for Utah is the Director, Department of Development Services, 312 State Capitol Building, Salt Lake City, Utah 84102.

A professional archeological survey should have been made to establish the presence or absence of archeological resources within the affected area. Findings from such a survey are essential to a comprehensive evaluation of impacts on cultural resources.

Hydrology

The effect of discharging a significant fraction of the 100gpm excess mine water was not covered. As this water has relatively high dissolved solids (2,962 ppm), sodium (1,335 ppm), and chloride (1,597 ppm), the effect on the aquifer underlying the Coyote Wash area may be detrimental to the water quality.

The impacts of eventually allowing the industrial wastes in the pond to seep into the ground water should be identified. In the milling process, approximately 60% of the milling solution is sent to the tailings pond. Based on the concentrations stated, concentrations in the tailing pond will be nearly 4,500 ppm of sulfate and 4,300 ppm of sodium. Although the 2 feet per year of milling solution could all evaporate, there will be periods of surface-water runoff into the tailings pond which will result in significant percolation of water to the ground water.

Geology

The sections on geology and hydrology are exceedingly brief and are inadequate to provide the background necessary for independently judging the AEC's assessment of the environmental impact of the proposed mill and its operations. These sections should be expanded to include a detailed description of the geology of the site and a general description of the geology of the region around the site. The expanded section should include discussions of the lithologic and hydrogeologic properties and the geographic distribution of stratigraphic units, and should be illustrated by geologic and hydrologic maps at scales appropriate to document the basis for various conclusions stated in other sections in the report. In particular, it will be necessary to define and discuss all aquifers potentially affected by the plant during and after its operational lifetime. Areas of recharge and discharge of aquifers, directions and rates of ground water movements, and present and potential use of water from these aquifers should be specified.

Ecology

The scientific name of the blacktailed prairie dog should be spelled *Cynomys ludovicianus*.

Power and Natural Gas Supply

According to page 24 standard wooden poles will be used for the 3,400 foot feeder power line. We suggest that the power line design should consider proper protection of wildlife. Significant electrocution of eagles and other raptors in Utah have been caused by power lines.

Milling Process

We are pleased that the applicant has chosen the carbonate leaching process for the reasons indicated on page 25 and also since it would result in fewer environmental problems than would result from the more commonly used acid leaching process. The alkaline leaching process uses roughly one-fourth as much fresh water, contributes smaller quantities of contaminants in the tailings and the recarbonation cycle, and has low reagent consumption.

The pressure of leaching autoclaves is controlled by bleed-off valves. Since these valves will periodically vent to the atmosphere, they should be shown on the flowsheet given on page 26. Also, the precipitation process which utilizes the caustic soda addition will be done in a series of 7 tanks, each of which will vent reaction vapors directly to the atmosphere. This venting should be included on the flowsheet.

Another area of concern is the outside, surface-storage of ore. The necessity for keeping this material either moist or covered under moderate-to-heavy wind conditions should be specifically commented on.

The statement should contain data on the industrial safety precautions to be observed in the use and storage of large quantities of sulfuric acid (3,500 gallons), caustic soda (16,000 gallons) and anhydrous ammonia (40 tons).

The statement should indicate whether there are any values retrievable from the 400,000 tons of waste rock resulting from the mining operations. The 4,000 tons mentioned on page 49 appears to be in error.

Sources of Wastes and Effluents

The fourth paragraph on page 28 refers to the "probable analysis" of the tailings based on laboratory studies and process design could be backed up with sample analyses of tailings from similar milling operations elsewhere, with adjustment to take into account differences in location parameters.

It is indicated on pages 28 and 31 that the dam and pond will serve as a permanent retainer for the mill tailings. It is also indicated in the section covering accidents beginning on page 29 that floods and earthquakes are not considered as likely to cause dam failure, but that in the event of failure the drainage system would be surveyed and all waste solids and contaminated soils would be reburied or returned to the tailings system. However, according to page 42, such remedial actions, restoration, maintenance and restrictions on land use apparently apply to only a period of 50 years unless government regulations for disposition of uranium mill tailings are instituted prior to that time.

The statement indicates on page 42 that under certain conditions, the AEC intends to further discuss certain restrictions on land use in order to assure control over the tailings beyond 50 years, if required. The basis for the specification of 50 years in the above cases should be explained. Without perpetual maintenance, an earthfill structure, such as the proposed tailings pond and dam, that is built in a natural water course is certain to be subject to severe erosion and consequent offsite transport of its constituents, as shown by experience with earthfill dams and other structures in many places in the southwestern United States. For this reason it appears prudent that the decisions concerning the disposition and the responsibility and regulations for mine tailings should be made prior to AEC licensing of their disposal, rather than allowing a period of up to 50 years to elapse before the decisions are made.

Control of Waste Effluents

The liquid and solid chemical wastes discharged into the tailings pond area is a major potential source of adverse environmental impacts. Therefore, we think that the statement should describe the prevention techniques more fully. For example, would the proposed irrigation spray system be automated to activate when the wind velocities exceeded a particular magnitude; and what precautions with respect to the flow rate of the spray system are taken to avoid creating additional seepage problems due to leaching of the tailings pile. The use of a chemical stabilizer is probably more applicable to long-term problems; however, the type of stabilization should be discussed in more detail, particularly since this is one of the major environmental problems associated with the operation. For example, it is mentioned on page 42 that when the mine operations are terminated the tailings pile will be graded, covered with earth and topsoil and seeded. The type of seeds to be used, the depth of topsoil and source of topsoil should be indicated.

An adequate basis has not been provided in the draft statement for assessing the potential effects on ground water from seepage of radioactive or chemical wastes from the tailings pond. The statement briefly specified that tailings will be deposited around the pond as a "perimeter sealing process" and specifies th[illegible]ld seepage appear in monitor wells around the dam [illegible]e collected and pumped back. However, without furthe[illegible]scription of the physical features, and without any description, discussion or documentation of the geology and hydrology of the site of the pond and its vicinity, it is not possible to judge (1) whether the "perimeter sealing process" or other (unspecified) sealing agents will be useful, (2) whether the monitoring wells will be properly located, sufficiently deep, and properly designed to detect the seepage, or (3) whether the seepage can be collected efficaciously and returned to the pond.

It is stated on page 33 that liquid losses will occur principally by evaporation is misleading. The soluble salts introduced will be available for leaching and downward percolation until depleted. Artificial lining of the floor of the pond was rejected because laboratory tests conducted by the applicant on tailings from a mine adjacent to Rio Algom indicated that tailings of a high solid to liquid ratio have a very slow percolation rate. However, it should be recognized that if the rock underlying the floor of the tailings pond is highly fractured or jointed and has a thin natural lining of silt and clay, the rate of percolation might be greatly enhanced -- especially as the hydraulic head is increased by filling of the pond, or in the event the solid to liquid ratio of the tailings is reduced by storm runoff into the pond. Regardless of the evaporation potential, there will be downward percolation of water unless the bed is absolutely impermeable. With present conditions there is enough permeability so that a more concentrated solution will flow to the ground water. Losses by both mechanisms will occur and there is little basis to assume that evaporation will be the principal mechanism.

The initial dam which will be approximately 40 feet high, will be raised to a final height of 65 feet and have a minimum freeboard of 10 feet. The freeboard for dam heights of less than 65 feet is not given. The size of the drainage area above the dam is not given in the statement, but according to figure 3 on page 10 the drainage area seems large enough to produce cloudburst-flood runoff that might endanger a 40 foot high dam with only a 10 foot freeboard. The minimum freeboard of 10 feet at the maximum dam height of 65 feet seems adequate for storm runoff. It is stated on page 33 that a channel will be constructed to divert floodwaters around the tailing pond. It appears to us that if this channel is constructed prior to the milling operations as an added safety precaution, many of our concerns expressed in these comments would be satisfied.

The Corps of Engineers has raised a question concerning the proposed method to raise the dam. The method proposed would tend to increase the permeability of the upper layers of the dam. Permeability rates for clays range from one to ten feet per year with pure clay being near the bottom of the range. According to page 31 the AEC intends to resolve this question with the Corps prior to granting authorization to raise the dam. We suggest that this question be resolved prior to construction rather than wait until raising the pond level is necessary for continued operation. Also, it may be found necessary to modify the initial 40 foot dam to accommodate desirable changes in the design for the top 25 feet.

Environmental Concentrations and Effect on Local Biota

The discussion on page 37 related to Table XI should state the "whole body" exposure for persons residing in the area for comparison to the "whole body" exposure from natural background conditions.

Environmental Monitoring

This section of the statement should be expanded to document the validity of the assumption that these processes will limit migration of contaminants. The documentation should include discussions of (1) the chemical and radioactive substances that might be expected to seep from the pond, (2) the lithology, sorptive and exchange capacities, and the thickness and distribution of the earth materials through which the seepage fluids might move, and (3) the natural ground water chemistry and paths and rates of movement of water in these materials.

The Environmental Monitoring section also specifies that the applicant will perform periodic sampling from wells to confirm that migration by seepage is not occurring, and that the AEC will periodically audit the applicant's monitoring program. Therefore, it would be appropriate to describe the AEC criteria for determining when corrective action or changes would be required and explain how the specified regulatory action would be taken.

It is recognized on page 38 that the principal ionic form of radioactive wastes will be complex anions. We think that due to the anions and salt concentrations expected in the tailing pond the result of the retention mechanisms will be much less than the maximum implied. It can be expected that a volume of ground water will be contaminated with sulfate-rich wastes and some radiochemical constituents.

Normally regulatory action is after the fact and therefore is noncorrective since little corrective action is possible except to recycle pumped water. This section should not consider migration to be negligible. It will occur, although it is unlikely to be hazardous.

There is a remote possibility that the mine drainage operations would result in a detectable decrease in natural ground water discharge, such as spring flow. If there are nearby springs discharging from the rocks dewatered by mine drainage operation, periodic discharge measurements of those springs are recommended as part of the monitoring program.

We think that initially stack exhaust should be monitored more frequently than quarterly to establish a range of radioactive particulate release since dust conditions would vary to some extent.

Reclamation and Restoration

The draft statement should indicate who would be responsible for surveillance and management of the abandoned millsite and mining claim areas, particularly since certain uses such as human occupancy would be prohibited and other types of uses, including grazing, would be safe.

We hope these comments will be helpful to you in the preparation of the final environmental statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Mr. Leland C. Rouse, Chief
Technical Support Branch
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

DOCKET NO. 40-8084

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

MAR 22 1973

Mr. Leland C. Rouse
Chief, Technical Support Branch
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rouse:

This is in response to your letter of December 14, 1972, requesting comment on the AEC Draft Environmental Statement related to the proposed issuance of a license to the Rio Algom Corporation for the operation of the Humeca Uranium Mill in San Juan County, Utah. The Statement discusses the environmental impact of the entire mining and milling project, but does not supply any data with respect to the expected power and energy requirements or the load characteristics.

Comments by the Federal Power Commission's Bureau of Power staff on projects of this nature, made in accordance with the National Environmental Policy Act of 1969, and the April 23, 1971, Guidelines of the Council on Environmental Quality, are intended to relate primarily to the project's effect on the adequacy and reliability of the bulk electric power system affected.

Since no data as to the load characteristics, peak demand, or energy requirements of the proposed Humeca Mill are supplied in the draft environmental statement, we are unable to estimate the effect on the bulk power system supplying the area. If we are to provide useful comments on the adequacy of power supply for the project, we must be furnished a schedule of demand and energy requirements related to the expected time span during which electric power will be needed. It is recommended that the same schedule of electric needs be furnished to and discussed with the utility system serving the area. It is particularly advisable to discuss the project with the utility in view of the temporary nature of the facilities.

We are aware of the need for a continuing supply of uranium fuel to supply the estimated 475,000 megawatts of generating capacity expected to be in operation by 1990. However, we have no comments on the need for, advisability or economic viability of any specific uranium processing plant.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

DOCKET NO. 40-8084

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

Appendix T, Reference 1
T-52

19 JUL 1973

Mr. Leland C. Rouse
Chief, Technical Support Branch
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rouse:

This letter is supplementary to my letter of March 22, 1973, commenting on the AEC Draft Environmental Statement relating to Rio Algom Corporation's Humeca Uranium Mill in San Juan County, Utah.

The Applicant's letter of June 28, 1973, to the Utah Power and Light Company, advised that the estimated 1975-1980 power requirements for the Humeca Uranium Mill were as follows:

	Current Requirements	1975-1980 Estimated Requirements
Maximum Monthly Demand	3,400 kW	4,000 kW
Energy Requirements, Monthly	1,949,400 kWhr.	2,500,000 kWhr.

The Utah Power and Light Company's service line to the Applicant's facility is rated at 69 kilovolts. Problems of power supply adequacy are not anticipated in meeting the Applicant's capacity and energy requirements, in view of the Utah Power and Light Company's planned system expansion which appears to be keeping pace with the load growth.

Very truly yours,

T. A. Phillips
T. A. Phillips
Chief, Bureau of Power

5658

APPENDIX U

1. Letter from Rio Algom to Atomic Energy Commission dated September 17, 1974

Rio Algom
Rio Tinto

Received W/Ltr. Dated ____

Appendix U, Reference 1
U-2

September 17, 1974

Mr. John F. Kendig
Materials Branch
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Re: Docket No. 40-8084

Dear Mr. Kendig:

In response to your queries by telephone September 9th, we submit the following.

1. We have authorized our attorneys in Salt Lake to commission John C. Shephard, a cadastral surveyor, registered with the Bureau of Land Management, to carry out a metes and bounds survey of relavent area. Mr. Shephard had advised he can start the work in April '75 and it may require three months for completion.

   Patent proceedings have been initiated, and are expected to require three years as a likely minimum.

   Should any of the mining claims required to encompass the relevant area not qualify for patent "Mill site patents" will be applied for under the authority of U.S. Code Title 30, Section 42, as an effective alternative.

2. Our estimate of the cost of the abandonment work has escalated to $175,000 in current terms, and is further moved up to $238,000 in 1980 dollars (the estimated time of closure of operations).

3. We have conferred with the A.E.C. office in Grand Junction, Col., as to their cost experience for remedial work with tailings at Monticello, Utah. There the catchment area, which drains between the two tailings piles, is 26.6 square miles. They estimate $1,000 to $5,000 per annum for maintenance.

... 2

RIO ALGOM MINES LIMITED 120 ADELAIDE STREET WEST TORONTO CANADA M5H 1W5 416/367-4000 TELEX/02-2204 CABLE RIO

Received W/Ltr. Dated

Appendix U, Reference 1
U-2

September 17, 1974

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Materials Branch
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

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... 2

APPENDIX U

1. Letter from Rio Algom to Atomic Energy Commission dated September 17, 1974

We are undertaking to provide a by-pass trench through undisturbed ground from a catchment area of less than one square mile, in a lower rainfall area.

From the above reference we propose to provide, following abandonment in 1980, for $17,500 for each of the first two 5-year periods, and $12,500 for each successive 5-year period to cover the 50-year span.

4. It is proposed to provide funds for items 2 and 3 above in an undertaking by Rio Algom Corp., - with a guarantee by Rio Algom Mines Limited, to take effect in 1980. The latter is a parent company of substantial assets, as indicated by the 1973 annual report attached. The undertaking will provide for the abandonment work, $238,000 in or about 1980, when this can be carried out. Rio Algom Corp., further undertakes, to place in escrow in 1980 a sum of $37,294, deemed sufficient to cover the maintenance costs given above. It is proposed that this latter sum, in the form of a self-liquidating annuity, be deposited with the A.E.C. or such agency as it may approve.

It is estimated that the re-survey and patenting of the ground will cost approximately $75,000 (in addition to the above). We deplore this heavy charge against a small operation, as it contributes nothing to environmental security. If the A.E.C. could suggest a less onerous alternative the company would be most appreciative.

Yours very truly,

R. D. Lord

R. D. Lord
Vice-President
Research & Development

RDL:k
Att.