UNDERGROUND DEVELOPMENT WASTE (784.19)

Introduction

Potential sources of waste rock at Deer Creek Mine are (1) rock slopes and raise construction, (2) entry rehabilitation, and (3) trommel screen reject from the breaker station. Chemical characteristics of waste rock from these sources are similar since rock is taken from roof, floor, or splits of Blind Canyon or Hiawatha Coal Seams during mining. Representative sample analysis of the waste rock is shown in Table 7.

The chemical and physical characteristics of the strata present in the lower Blackhawk Formation which includes rocks immediately above and below the Blind Canyon Seam has been identified by the analyses of over 130 samples (see the original Deer Creek Mine permit application under Overburden - Chemical Composition). These analyses have identified that the floor of the Blind Canyon Seam has a potentially high sodium absorption ratio and the Blind Canyon Seam roof is potentially high in pyrite/marcasite. No other abnormally high readings were identified.

A review of the data concerning the sodium absorption ratio of the Blind Canyon floor reveals that three out of four samples which were taken of that zone, have values less than 5.0 (4.8, 1.5 and 1.3). One sample has a value of 60.4 which raised the sample mean to 17.36 and created a high standard deviation of 25.14. This indicates that in general

TABLE 7

DEER CREEK MINE - WASTE ROCK ANALYSIS

Lithology	Number of Samples: Chemical Tests	Number of Samples: Physical Tests	Chemical Tests: Ca Meq/L	Mg Meq/L	Na Meq/L	SAR[1]	Fe ppm	Zn ppm	SO_4-S ppm	Mo ppm	B ppm	pH (Paste)	E.C.[2] mmhos/cm	Sat. %	Physical Tests: Pyrite FeS_2	Sand %	Silt %	Clay %	Text
Blind Canyon Roof	3	Mean	4.10	1.20	0.87	0.50	5,825	64.42	205.27	<0.1	0.33	7.7	0.83	32.27	8.15	--	--	--	--
		S.D.	1.30	0.56	0.21	0.17	2,528	56.32	61.31	0.00	0.20	0.25	0.25	5.17	10.82	--	--	--	--
Blind Canyon Splits	1	Mean										8.9				--	--	--	--
		S.D.	0.8	0.1	9.2	14.3	5,905	40.69	145.0	<0.1	0.94		1.1	20.9	0.2	--	--	--	--
Blind Canyon Floor	5	Mean	3.90	1.86	18.54	17.36	10,342	55.38	593.58	<0.1	0.55	8.34	2.22	26.46	1.50	--	--	--	--
		S.D.	4.02	1.72	25.43	25.14	4,263	43.90	454.96	0.00	0.60	0.64	2.11	6.57	1.41	--	--	--	--
Hiawatha Roof	3	Mean	4.57	4.30	3.43	1.83	10,925	184.93	198.07	<0.1	0.11	7.80	1.07	32.17	3.3	--	--	--	--
		S.D.	2.54	3.20	3.96	2.14	7,110	203.10	153.48	0.00	0.10	0.17	0.31	7.18	0.00	--	--	--	--
Hiawatha Split	1	Mean	4.9	2.3	1.3	0.7	7,841	69.88	246.1	<0.1	0.26	7.70	0.8	37.5	NA*	--	--	--	--
		S.D.														--	--	--	--
Hiawatha Floor	3	Mean	10.23	16.23	1.27	0.47	3,873	16.32	777.23	<0.1	0.04	5.87	3.03	29.07	NA*	--	--	--	--
		S.D.	1.50	12.53	0.70	0.21	1,394	14.08	313.16	0.00	0.05	2.24	0.90	4.48		--	--	--	--

*NA = Not Available

the Blind Canyon floor rock will not pose a problem from its sodium absorption ratio but from time to time high concentrations will be encountered. These concentrations will be diluted by other rocks with low SAR values. Also the waste rock disposal fill is designed to bury leachable and acid forming substances.

Three samples of the Blind Canyon Seam roof and floor were tested for their pyrite/marcasite content. Two of these core samples are from drill hole B-124 and the other from EM-12C have a pyrite/marcasite content of 0.2% and 0.5% respectively. The third sample from drill hole EM-23C has a pyrite/marcasite value of 15.8%. This core contained vertical fractures which had secondary deposits of FeS_2. This sample is not representative of the Blind Canyon Seam roof pyrite/marcasite content as a whole but does show that localized high concentrations of iron-sulfides do occur. This periodic high content of pyrite should not pose a problem in reclamation of the waste rock disposal site.

Present mine plans could generate as much as 100,000 yd^3 throughout the life of Deer Creek Mine. Waste rock generated during mining will be gobbed until available space is depleted. Rock which cannot be gobbed will be transported outside for disposal in the approved site.

In December 1983, planned construction of the 2,062 foot rock slope tunnel in Main West across the Pleasant Valley Fault in the Deer Creek Mine, will generate an approximate 18,000 yds^3 of waste rock (in-place). The majority of this waste rock will be transported outside for disposal.

Using a swell index of 150%, an approximate area of 27,000 yds^3 will be required for disposal of this waste rock.

Entry rehabilitation will generate an undetermined amount of waste rock during mine life. Waste rock from entry rehabilitation will be gobbed until available space is exhausted. Excess waste rock will be transported from the mine and disposed of accordingly.

Maximum extraction of coal reserves by conventional methods includes unwanted rock in the run-of-mine product. Deer Creek Coal Handling System is designed to extract +6" waste rock from the product stream. A negligible amount of coal is incorporated in the waste rock. Approximately 50 tons of waste rock are taken from the product stream each week and less than 10% of reject is carbonaceous. However, waste rock from the product stream poses no serious threat, as all coal waste along with any potential pyritic material diluted with rock material of a low sulfer value will be buried and compacted with at least a 4-foot coal free cover.

No extemporaneous waste materials such as brattice cloth, wood, or metal trash will be dumped in this site.

All waste rock will be transported and disposed of in a controlled manner as outlined in the plan which follows:

Disposal Location

The waste rock disposal area will be an extension of the existing fill embankment located between the materials storage area and the truck loadout as shown on drawing No. CM-10386-DR. Cross sections of the fill are also shown in the drawing. This waste rock disposal site is designed to contain approximately 90,000 cubic yards of waste rock and will be utilized until mine life ends or the site is filled, in which case applicant will seek approval of an additional site if disposal capacity proves insufficient.

Estimated Waste Rock Volumes

(1) Main West Rock Slope:

(2062' x 18' wide x 10' high) ÷ 27 = 13,746.7 cy

Assume 31% overbreak = 4,253.3

Total 18,000 cy

Use 150% swell factor

Total equals 27,000 cy

(2) Entry Rehabilitation:

100,000 c.y. x 21%

*Assume approximately 21% will require surface disposal. 21,000 cy

(3) Trommel Reject:

35 years x 5 ton/day x 240 day/year = 42,000 tons

42,000 tons x 2,000 lbs/ton ÷ 92 lbs/ft^3 = 913,043 ft^3

913,043 ft^3 ÷ 27 ft^3/c.y. = 33,816 cy

TOTAL VOLUME 81,816 cy

Design

Design of the disposal site and fill was under the direction of a registered professional engineer and is certified. The existing fill is constructed of material taken from the south slope of Deer Creek Canyon and from the sediment pond excavation. A stability analysis has been performed on the existing fill and has shown it to be stable and a factor of safety of 1.5 was obtained. The analysis was performed under the direction of Rollins, Brown and Gunnell, Inc., a professional engineering consultant firm. This study is enclosed.

In August of 1978, Utah Power & Light Company contracted Dames & Moore to perform a geotechnical study in evaluating soils of the area now occupied by the Deer Creek Mine sedimentation pond. Four test holes were drilled.

The pond was constructed in 1979 and is located within 600 feet directly east of the proposed waste rock disposal site.

The applicant states that due to the close proximity of the geotechnical study to the waste rock site, data obtained from this study is applicable.

The sedimentation pond and the waste rock disposal site are separated in elevation by approximately 100 feet.

The sedimentation pond is situated at approximately 7,250 feet above sea level and is stratigraphically located near the base of the Starpoint Sandstone where it interfingers with the Masuk Shale. Bedrock at this location is found to be at or near the sandstone which is comprised of a fine grained sandstone interfingered with small amounts of mudstone.

The waste rock disposal site is situated at approximately 7,350 feet above sea level which places it stratigraphically in the middle of the Starpoint Sandstone. Bedrock in this area is at or near the surface which is also comprised of a fine grained sandstone.

No springs or seeps exist in the area of the waste rock disposal site because of the lack of any recharge in the Starpoint Sandstone formation.

Natural drainages which existed prior to mining activities have been diverted as required. A description of mine site diversions is in the original Deer Creek mine permit application (under the Operation Plan). A summary of hydrologic information concerning the East Mountain area is included in the "UP&L Annual Hydrologic Report" submitted to the Division each year.

Drawing No. CM-10386-DR shows the present slope and the anticipated final slope. Selected cross-sections also show present and anticipated slopes. Finished slopes will be 2h:1v.

Runoff from areas above and adjacent to the fill is collected in open ditches and directed away from the outslope of the fill to the drainage system in the mine yard. Grade of the fill is sloped back from the outslope of the fill.

Runoff from the top surface, therefore, will drain back from the outslope and collect in the "disturbed" drainage system. Runoff from the outslope of the fill drains to a catch basin near the truck loadout where it is collected and conveyed to the sediment pond. This drainage collection system meets the requirements of a 10-year/24-hour storm event. The location of these drainage ditches and catch basins are found on drawing No. CM-10387-DR.

Construction and Operation

Waste rock from slope construction and entry rehabilitation will be transported from the mine to the disposal area and placed in horizontal lifts and in a controlled manner by rubber-tired end-dumping vehicles. Equipment will vary depending on contractor exployed to do the work.

Safety measures prescribed by MSHA will be maintained throughout the life of the disposal site.

Rock from the trommel screen will be hauled by truck from the reject pile and placed with the other waste rock from entry rehabilitation and slope construction sites.

All waste rock will be compacted in 4-foot lifts at the base of the existing fill, providing a working surface and a buttress for stability for the existing fill. A crawler or rubber-tired dozer will be used in the continuous dump-spread compaction fill method.

Maintenance

Maintenance of the disposal site includes inspections and adequate drainage. Inspections for fill stability will be performed quarterly by a registered professional engineer in addition to periodic observations of fill placement compaction, and revegetation. The inspecting engineer will submit a certified report of approved design compliance to the Division within two weeks of each inspection. A copy of each inspection report will be retained at the mine site. Drainage systems will be inspected and cleaned yearly to ensure adequate drainage of the fill.

Reclamation

The fill is deemed to be compatible with the natural surroundings and fulfill the post-mining land use. Drainage will be established to carry runoff from the fill into stabilized channels designed to adequately pass the 100 year/24-hour precipitation event. Vegetation will be established on the fill as outlined in the original Deer Creek Mine permit application (under Reclamation Plan). Details of the final drainage channel locations are also included in the Reclamation Plan. Inactive side slope areas fall under the interim revegetation areas of the mine site and will be revegetated accordingly.

Deer Creek Mine

Waste Rock Hydrologic Drainage Calculations

Given:

Area:		3.0 Acres
Slope:		50%
Slope Length:		300 Feet
Storm Event:		2 Year/24 Hour
Methodology:		Soil Conservation Service
CN	=	85 (see Table 6.4)
Precipitation	=	1.8 (N.O.A.A. 2 Yr/24 Hr)

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} \qquad S = \frac{1000}{CN} - 10 = 1.76$$

$$Q = \frac{(1.8 - 0.2 \times 1.76)^2}{(1.8 + 0.8 \times 1.76)} = \frac{2.10}{3.21}$$

$$Q = .65 \text{ Inches}$$

$$tL = \frac{\ell^{0.8}(S+1)^{0.7}}{1900\ Y^{0.5}} = \frac{300^{0.8}(1.76+1)^{0.7}}{1900\ (50^{0.5})} = \frac{194.5}{13433}$$

$$tL = .0145$$

$$tc = \frac{tL}{\frac{tL}{tc}} = \frac{tL}{0.6} = \frac{.0145}{0.6} \quad \text{(see Exhibit VII)}$$

$$tc = .024$$

$$qp = 1000 \frac{csm}{Inch} \times \frac{3.0 \text{ Acres}}{640 \text{ Acre/Mile}^2} \times .65 \text{ Inches}$$

$$qp = 3.05 \text{ C.F.S.}$$

By inspection, the existing 1.0' ditch is sufficient to handle the peak flow of a 2 Year/24 Hour storm event.

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches

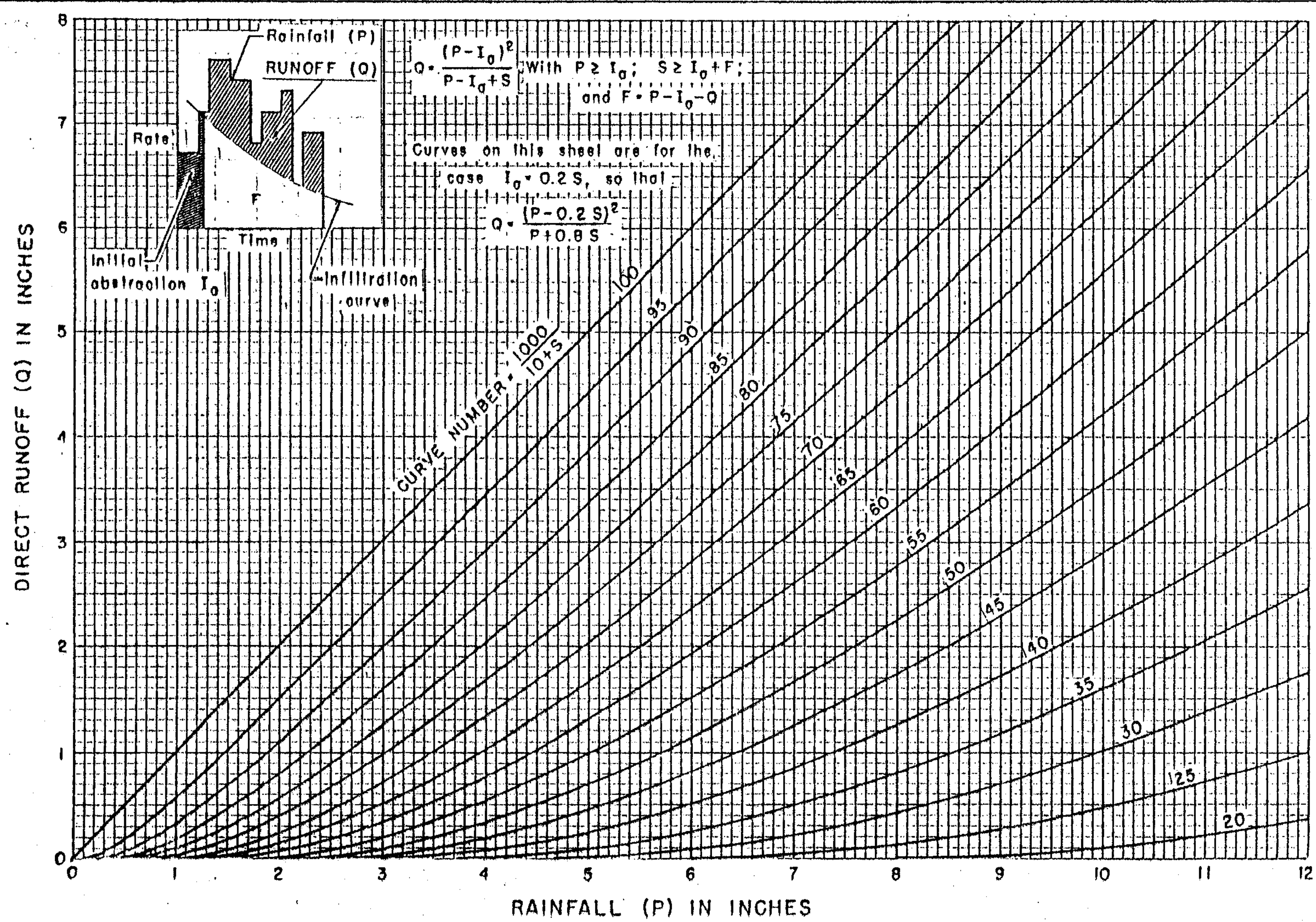

Figure - 10.1 (1 of 2)

REFERENCE

Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

STANDARD DWG. NO.
ES- 1001
SHEET 1 OF 2
DATE 5-29-56
REVISED 10-1-64

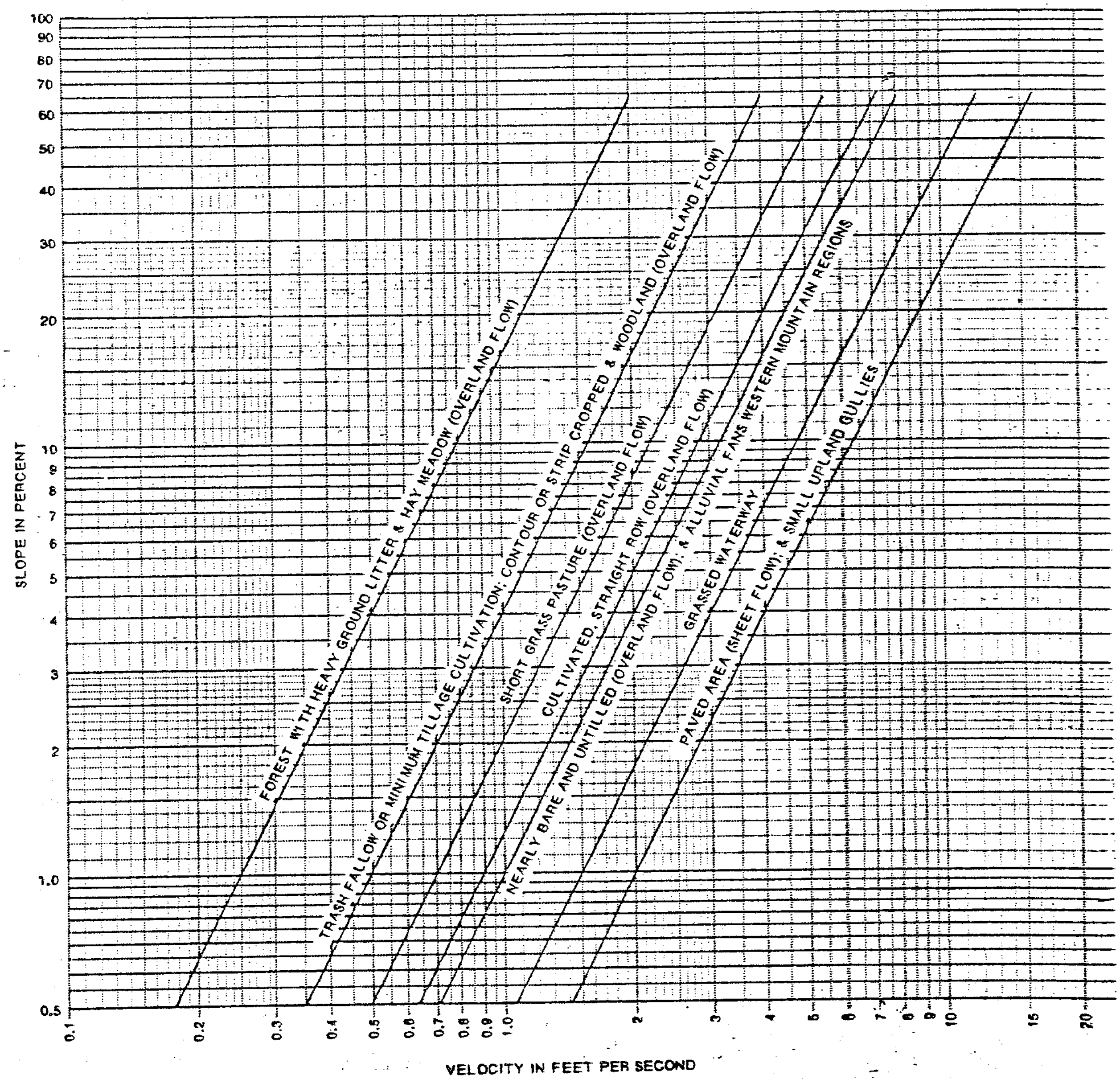

Figure 15.2.—Velocities for upland method of estimating T_c

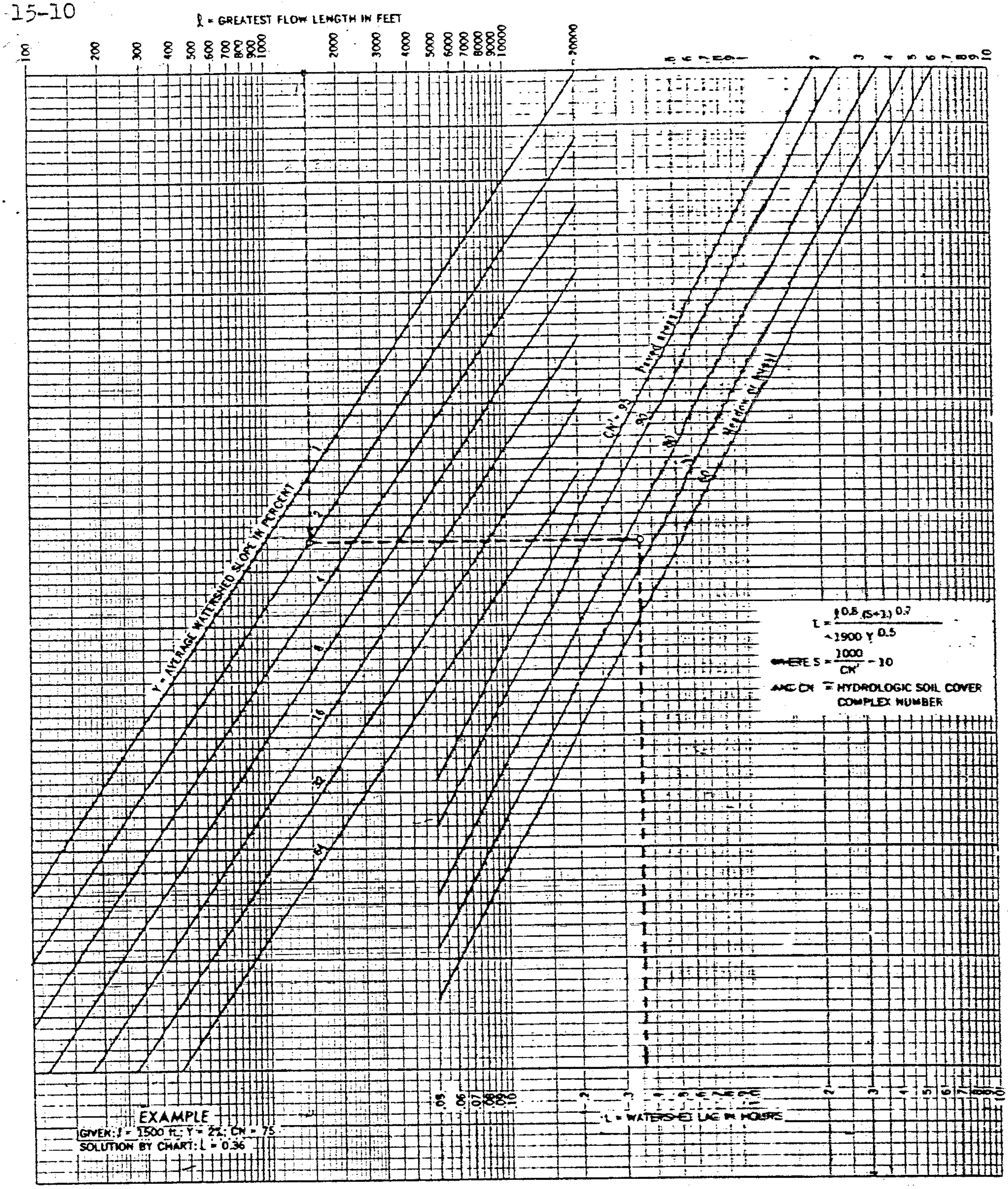

Figure 15.3.--Curve number method for estimating lag (L)

TABLE 6.4

SCS RUNOFF CURVE NUMBERS

Land Cover	Condition	Soil Group A	B	C	D
VIRGIN LANDS					
Forests	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	25	55	70	77
Farmsteads	—	59	74	82	86
Meadow	Good	30	58	71	78
Pasture/Range	Fair	49	69	79	84
REGRADED - REVEGETATED					
Close Seeded Legumes	Poor	63	73	80	83
(Contoured & Terraced)	Good	51	67	76	80
Small Grains	Poor	61	72	79	82
(Contoured & Terraced)	Good	59	70	78	81
Row Crops	Poor	66	74	80	82
(Contoured & Terraced)	Good	62	71	78	81
Fallow	—	77	86	91	94
CLEARED UNVEGETATED					
Dirt Roads	—	72	82	87	89
Hard Surface Roads (or Pit)	—	74	84	90	92
Paved Surfaces	—	98	98	98	98

NOTE: For additional valves see any of a variety of SCS publications, including:

The National Engineering Handbook, Section 4-"Hydrology"

TR-55 "Urban Hydrology for Small Watersheds"

TP-149 "Methods for Estimating Volume and Rate of Runoff From Small Watersheds"

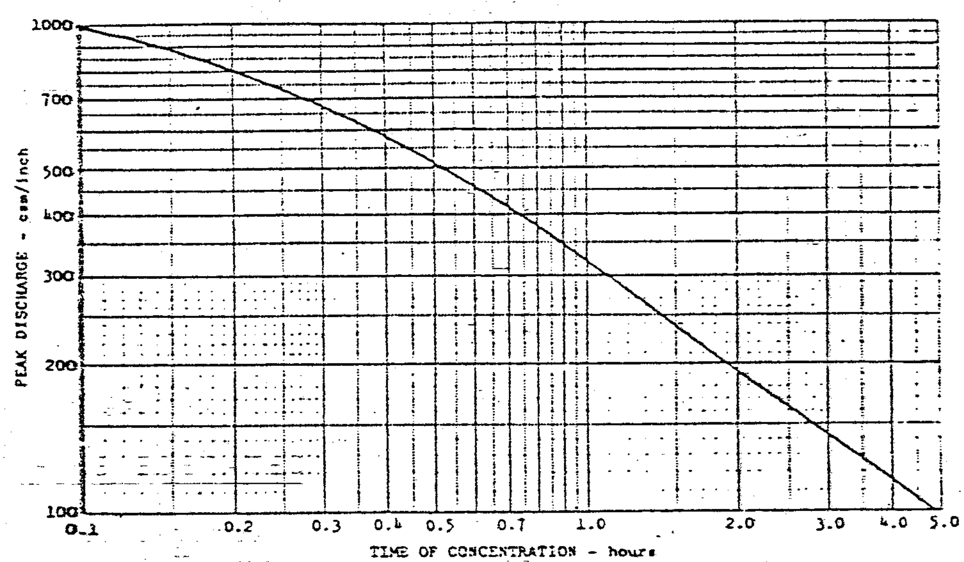

Figure 2.40. Peak discharge in csm per inch of runoff versus time of concentration (t_c) for 24-hour, type II storm distribution.

EXHIBIT VII

Page 115 Barfield

REPORT
OF
SITE INVESTIGATIONS
FOR
DEER CREEK MINE ~~AND CHURCH MINE PROJECTS.~~

FOR

THE MORRISON-KNUDSEN COMPANY, INC.
BOISE, IDAHO

AND

UTAH POWER AND LIGHT COMPANY
SALT LAKE CITY, UTAH

Prepared By

International Engineering Company, Inc.
220 Montgomery Street
San Francisco, California 94104

October 1978

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EXHIBITS

APPENDICES

INTRODUCTION

This report presents the results of field investigations and recommendations resulting from those investigations for the design and construction of sedimentation ponds, dams, embankments, and drainage ditches, for the Deer Creek Mine Project and the Church Mine Project. The locations of both of the projects are shown on Exhibit I.

Field investigations included the exploration of the proposed construction sites to acquire soils and rock data needed to make recommendations for the design of facilities. The areas explored are shown in detail in Exhibits II and III for the Deer Creek and Church Mines, respectively.

All work was performed for the Morrison-Knudsen Company, Inc., of Boise, Idaho. Morrison-Knudsen is the prime contractor to the Utah Power and Light Company, Salt Lake City, Utah.

SCOPE OF WORK

The scope of engineering services provided by International Engineering Company, Inc., is outlined in Intra-Company Work Order No. 8069, dated 16 August 1978. This work order is presented in Appendix A of the report.

Services included drilling, sampling and logging for soils and rock characteristics at each pond site; laboratory testing of selected samples from each mine site; a search for soil materials for embankment construction at each mine site; a visual evaluation of foundation conditions for drainage structures at the Deer Creek Mine; and the preparation of recommendations for the design and construction of embankments, dams, ponds and foundations at both mine sites.

PROPOSED CONSTRUCTION

The proposed construction includes installation of storm water run-off diversion facilities and a sedimentation pond at the Deer Creek Mine and a sedimentation pond at the Church Mine. Diversion facilities are to consist of drainage ditches, diversion pipes, culverts and other items designed to control surface water flow in the mine area. Both ponds are to have low-level dams limited in height to 20 feet as measured vertically from the lowest point on the upstream toe of the dam to the crest of the dam. All facilities constructed are to meet requirements of Office of Surface Mining (OSM) regulations.

FIELD INVESTIGATIONS

Field investigations were performed from August 23 to August 31, 1978 at both the Deer Creek and the Church Mine sites. These included drilling, investigations for surface soil materials and geologic reconnaissance. Drilling was performed by Raymond International, Inc. of Salt Lake City, Utah, using a truck mounted CME 55 (Central Mining Equipment) rotary drilling rig. Surface soil investigations and geologic reconnaissances were performed by International Engineering Company (IECO) engineers.

LABORATORY TESTING

Laboratory tests of samples were made by Pittsburgh Testing Laboratory in Salt Lake City, Utah. The following tests were performed in accordance with the latest ASTM or ASSHTO procedures:

- Sieve analysis
- Standard Proctor Compaction (ASTM 698, ASSHTO T 99)
- Atterberg limits
- Natural moisture content
- Permeability of compacted soil.

SURFACE FEATURES

The Deer Creek Settlement Pond Site is located in Deer Creek Canyon. The canyon is characterized by steep cliffs on each side with talus slopes lying at their bases. The pond is located on the right side of the canyon (looking downstream). The areal dimensions of the pond are limited by the sandstone cliff face on the right side and a conveyor line on the left side.

SITE GEOLOGY

Deer Creek Canyon is one of many stream eroded canyons located in the area. Sandstone and shale beds of Cretaceous Age have been eroded by streamflow into canyons with steep sides and high gradients. At the Deer Creek site the rocks consist of horizontally bedded, yellow to gray, massive sandstone beds intermixed with isolated shale and coal beds, all of the Star Point Sandstone Formation. Jointing in the sandstones is predominantly vertical and the thinner beds are often fairly closely jointed at outcrops. The chief feature of the sandstone layers are their high strength and their ability to form high, near-vertical slopes.

The floor of Deer Creek Canyon is covered with talus and debris flows consisting of a mix of boulders to diameters of 48 inches, cobbles, gravels, sand, silt and clays. The origin of the talus is the erosion of the cliff faces above the canyon floor. The source of the debris flow materials are stream transport processes including flash flooding. A slow steady process of more rapid erosion of the weaker sandstones is followed by the breaking off of overlying slabs of the more competent sandstones leading, in many cases, to overhangs on the cliff faces.

DRILLING

Exploration drilling at Deer Creek Mine was conducted under the supervision of an IECO geotechnical engineer. Four borings were made at the site; three along the dam axis, and one next to the conveyor belt upstream from the dam axis (see Exhibit II).

Due to the presence of boulders, the following drilling plan was followed. A 6-inch diameter auger was used for drilling from ground surface, until a sandstone boulder was encountered. A 3-3/4-inch tricone bit was then attached to the drill stem in order to pass through the boulder. This drilling was done with water circulating in the hole. In cases where boulders were not encountered augering was taken to bedrock where a change to NX coring equipment was made. Several feet of core were then taken in the bedrock.

Split spoon samples (SPT) were taken at approximately 5-foot intervals in each hole with blow counts being recorded in each case. A free-falling 140-pound hammer dropping apprxomately 30 inches was used to drive the sampler. Also, hand samples were collected from augered material in some of the holes.

Logs of each borehole are presented in Appendix C.

LABORATORY TESTING

Results of laboratory tests are presented in Appendix B. Samples from both the pond site (designated as D-1, D-2, etc.) and the mine storage area located across the paved road from the conveyor tower (designated as N-1, N-2, etc.) are represented.

Laboratory tests indicated a lower plasticity than the field classification of the material. The laboratory tests gave plasticity index values between 0.0 and 11.1, and the estimates made in the field were between 8.0 and 30.0.

Similarly, laboratory test results for natural moisture content also appear somewhat higher than what was estimated during the field classification. Construction personnel should be aware that this material could be more plastic and less wet than laboratory tests indicate.

GROUNDWATER

Groundwater was encountered at 7.5 feet in boring D-2 and at 8.1 feet in boring D-3.

DAM FOUNDATION

Drilling along the dam axis between the present stream channel and the conveyor belt encountered bedrock at 13.0 feet and 19.0 feet. The bedrock in each case was shale. Drilling adjacent to and on the northwest side the conveyor and also along the dam axis, did not encounter bedrock even though drilling was taken to 48.5 feet. Bedrock lies much deeper toward the center of the canyon (see Exhibit IV).

The material under the dam axis is composed of a mix of boulders, cobbles, gravels, sands, silts, and clays (for size classifications see Appendix C). Approximately 20% - 30% of the materials range from boulders to gravels. The remaining smaller sized fractions contain mainly silts mixed with clays to form a silty clay material. There is a lack of the larger sized sand particles. The material is of medium relative density as determined from blow counts. It also has a relatively high permeability as determined by a loss of water during drilling.

POND FOUNDATION

The pond foundation area contains debris and talus materials similar to those described in the section on Dam Foundation. The depth to bedrock should range from approximately 10 to 20 feet. The depth will be greatest under the conveyor line. At the right side of the pond, a talus slope exists with a large volume of loose materials covered over by trees and other vegetation. The rock foundation is composed of a shale bed and/or sandstone beds.

CONCLUSIONS

Earth materials for construction are available from the pond location itself or from nearby areas. These materials can be processed to produce impermeable liner material, embankment material, filter material, gravels and riprap. The recommendations have been made in order to provide a stable structure and to reduce seepage under the dam so that piping of foundation materials will not occur. Excessive seepage can lead to a danger of piping in foundation materials or in the constructed embankment. Specific recommendations for each dam and embankment zone are given below in Recommendations.

RECOMMENDATIONS

A. General Recommendations

1. Type II cement should be specified for all concrete in contact with the ground because of the presence of sulfur compunds in the soil.

2. All buried steel pipes and conduits should be protected with a protective coating because of the presence of sulfur compounds in the soil.

3. Bearing loads for footings on natural soil should be limited to 2000 pounds per square foot.

4. Bearing loads for footings on compacted soil should be limited to 6000 pounds per square foot.

5. Two piezometers should be placed in the side slopes adjacent to the downstream slope of the dam during construction. Sites for the piezometers can be selected during construction.

B. Typical Embankment Section

Recommendations for the Deer Creek Mine Pond dam are shown on Exhibit V. The dam consists of a compacted embankment with a toe drain. An upstream layer is to be placed on the upstream side and along the floor of the pond upstream of the dam as shown on Exhibit V.

C. Embankment Materials

The recommendations for gradations of the materials are based upon laboratory testing and field reconnaissance, and are presented in Table I. Changes in the limits may be required during construction to reflect changed conditions as is normal in embankment construction. Therefore, an engineer with experience in dam design should be on the site during critical periods of construction.

The dam can be constructed from materials located at the site. The present streambed, which can be excavated for the pond, contains sufficient fine material to be used as embankment material and lining material. The talus slope adjacent to the streambed also contains material which can be used for embankment construction. In addition, fill material across the paved road from the conveyor tower (200 feet upstream from the damsite) is also suitable for embankment material and liner material.

TABLE-I

RECOMMENDED GRADATION LIMITS

FOR

DEER CREEK MINE SETTLEMENT POND SITE

Zone	Screen of Sieve Size	Percent Passing
1	2"	100
	No. 4	100-80
	No. 40	100-60
	No. 200	85-30
2	12"	100
	3"	100-30
	No. 4	100-30
	No. 40	80-15
	No. 200	50-10
3	6"	100
	3"	100-70
	No. 4	70-25
	No. 16	40-0
	No. 100	0
4	1-1/2"	100
	No. 4	100-70
	No. 16	95-40
	No. 50	62-5
	No. 100	34-0
	No. 200	5-0

5

- 45% to 75% of the material shall weigh between 10 and 300 pounds.*
- Not more than 25% of the material shall weigh less than 10 pounds.**
- Not more than 10% of the material shall pass the No. 4 sieve.

* Maximum dimension approximately 18".

** Maximum dimension approximately 6".

1. Impervious Liner - The impervious lining can be obtained either from the pond floor or from the mine storage area across the paved road from the conveyor tower. The fill material at the storage area contains a lesser amount of cobbles and gravel and would require less screening than material excavated from the pond floor. All material placed as liner material should be compacted to 95% of maximum Standard Proctor density at not less than -4% below or more than +2% above optimum water content. The moisture limits may be modified as field conditions dictate.

2. Shell - The main embankment can also be constructed from materials located in the pond bottom and in the talus slope. All sizes above 12 inches in diameter should be raked to the outside of the embankment. All materials placed upon the embankment should be compacted to 95% of maximum Standard Proctor density. If design conditions make construction of the shell and liner zones difficult, impervious liner material may be substituted for the shell material, and the entire dam may be constructed of liner material.

3. Rock Toe - The toe drain may be constructed from materials excavated either from the pond bottom area or from the talus area. Boulders, cobbles, gravels and sand can be screened from these materials to meet recommended gradations given.

4. Filter - Filter material should be placed between the toe drain and both the embankment and the foundation as shown on Exhibit V. This material can be processed from the material in the pond floor or from the adjacent talus slope.

5. Slope Protection - The upstream and downstream slopes of the dam should be protected by a blanket of riprap over a blanket of gravel and cobbles. These materials can be processed from talus and debris materials in the pond area.

D. Left Abutment of Dam (Looking Downstream)

The dam should be placed against the left abutment on a smooth cut. Special efforts should be taken to ensure that the embankment material is well compacted against the cut.

E. Stability of Slopes Below Conveyor

An embankment should be constructed against the cut slope below the conveyor upstream from the dam axis in order to prevent slope failures in the soil material under the conveyor (see Exhibit VI). This embankment should parallel the conveyor line and should have a 2-1/2:1 slope below maximum pond level. It should be composed of compacted shell material and should extend down to the floor of the pond or to bedrock. This embankment should be extended upstream at least 140 feet from the dam axis.

F. Lining of Slopes Below Conveyor

Compacted liner material should be placed over the conveyor side embankment for the purpose of sealing the left side of the pond. This liner should be continuous with the liner on the dam, and should extend down to pond bottom. Slope protection should be placed upon the liner. A sectional view of the left side embankment is shown in Exhibit VI.

G. Right Abutment

The embankment should be keyed into the rock on the right abutment in order to reduce seepage through rock. All loose and surface weathered rock should be removed before placing embankment material. If open fissures or joints are encountered, they should be cleaned out and sealed. The dam embankment material should be compacted against the rock abutment.

H. Dam Foundation

The dam may be laid upon the existing site foundation material. All organic material and loose sands, estimated to have depths of 0.5 to 1.0 feet, should be removed and the exposed surface should be compacted prior to placement of embankment material.

I. Pond Lining

Because the pond is founded on permeable materials, a lining is required to prevent piping from occurring in the dam foundation and through the abutments. The left side of the pond should be lined from the dam to a point at least 140 feet upstream from the dam axis as mentioned in Paragraph F. The bottom of the pond should be lined from the dam upstream to where rock is encountered in the pond floor, an estimated distance of 100 feet. The right side of the pond will consist of sandstone. During excavation, special care should be taken to identify possible fractures and other openings where leakage might occur. These fissures and fractures should be sealed at locations below maximum pond water level during construction.

Liner material should consist of silty clay material as specified for zone 1 of the dam. It should be placed with a thickness of not less than 3.0 feet and it should be compacted to 95% of the maximum Standard Proctor density at not less than -4% below or more than +2% above optimum moisture content.

J. Pond Excavation

Material from the floor of the pond area and from the right side of the pond adjacent to the sandstone cliff line can be removed in order to increase pond volume.

Floor material can be excavated down to the bedrock, and, if required, into bedrock. Care should be taken not to create an unstable slope adjacent to the conveyor line. Recommended slopes are listed in Table II.

K. Slope Stability

Excavations of talus materials can be made back to exposed rock on the right side of the pond. A general slope of 1/2 horizontal to 1 vertical (1/2:1) is recommended as a guide for excavation. This approximates the natural slope of rock faces in the pond area as derived from the topography in Exhibit II.

Excavations can be made into rock at slopes greater than 1/2:1 in locations where sound rock exists. Care should be taken during rock excavation not to undermine slopes containing weathered rock and slope wash without removing such material first. During the excavation of all steep slopes in rock, exposed rock faces should be insepcted for stability. If unstable conditions are found, rock bolting or some other form of artificial support should be considered.

Excavations on the left side of the pond should be done carefully in order to prevent slope failures beneath the conveyor. Either an embankment on a 2-1/2:1 slope, or a retaining structure of some type, should be used to ensure the stability of the slope.

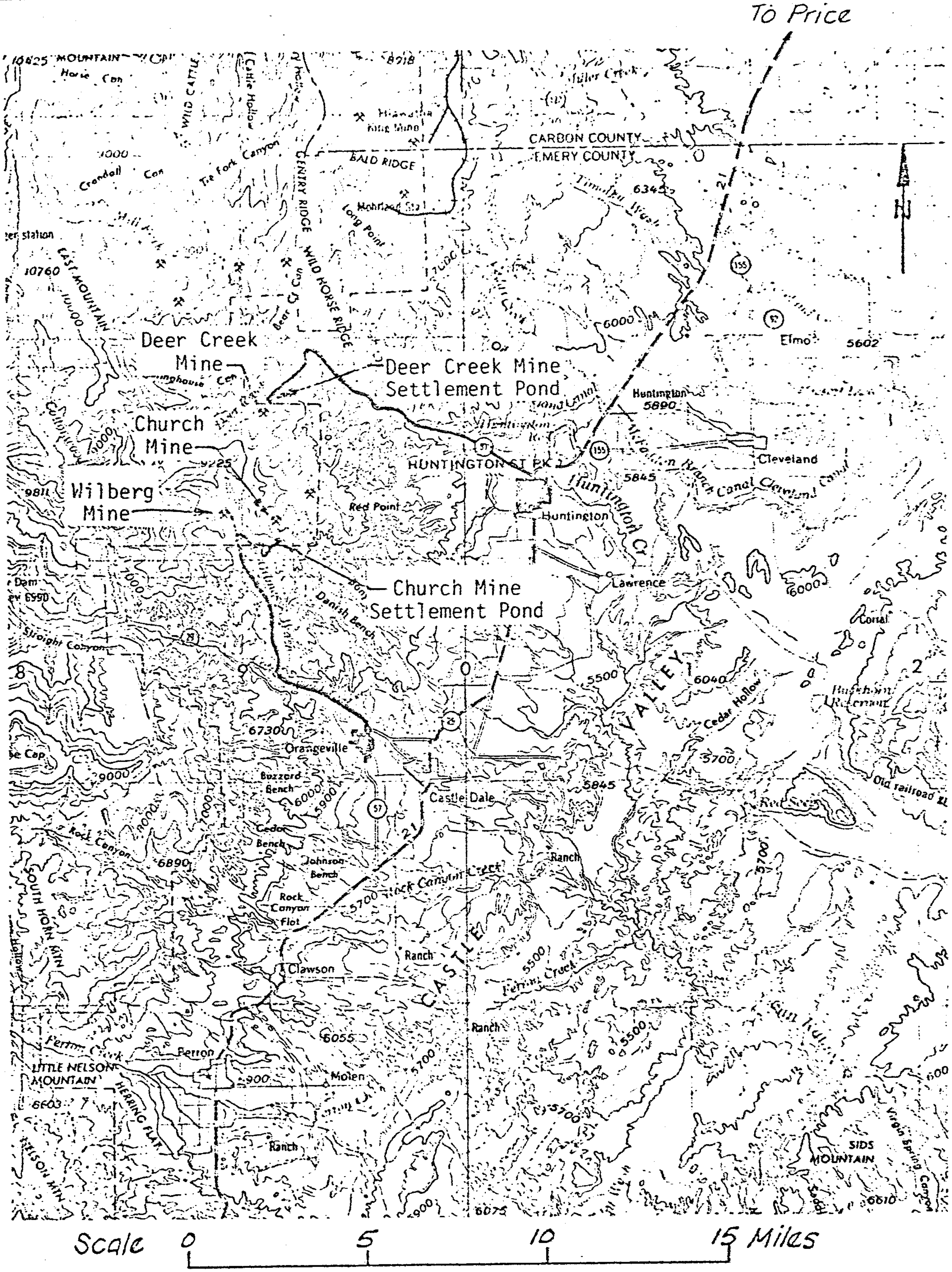
During construction soil slopes should be no steeper than 1:1. Recommended slopes are shown in Table II.

TABLE II

RECOMMENDED SLOPES
FOR
DEER CREEK MINE SETTLEMENT POND SITE

Slope Conditions	Slope	
Cut Slopes		
Talus, Debris, Natural soil	2-1/2:1	below max. water surface
	1-1/2:1	above max. water surface
Temporary Cut Slopes in Soil	1:1	
Rock	1/2:1	to vertical
Fill Slopes		
Silty Clay Material (liner)	2-1/2:1	below max. water surface
	1-1/2:1	above max. water surface
Shell Material	2-1/2:1	below max. water surface
	1-1/2:1	above max. water surface

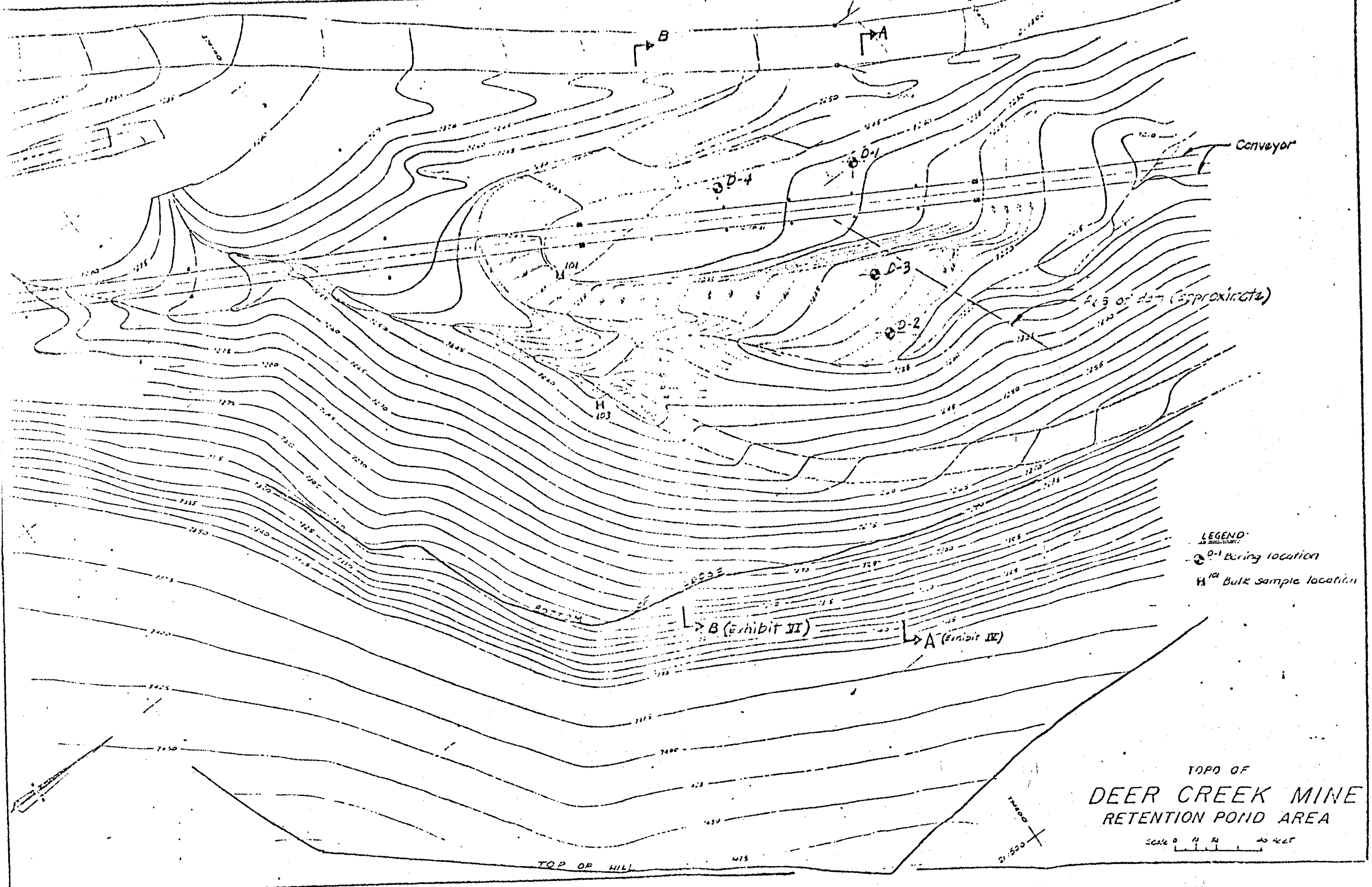
EXHIBITS



DEER CREEK AND CHURCH MINES

LOCATION MAP

10-3-78


B
A
Conveyor
D-1
D-4
D-3
D-2
101
H
103
Axis of dam (approximate)
LEGEND
D-1 Boring location
H 101 Bulk sample location
B (Exhibit II)
A (Exhibit IV)
TOP OF HILL
BOTTOM
TOPO OF
DEER CREEK MINE
RETENTION POND AREA

INTERNATIONAL ENGINEERING COMPANY, INC.

Project: UTAH POWER & LIGHT	Contract No. 8069-01	Sheet	File No.
Feature: DEER CREEK MINE	Designed PRT	Date 9-26-78	
Item: CROSS SECTION A-A	Checked	Date	

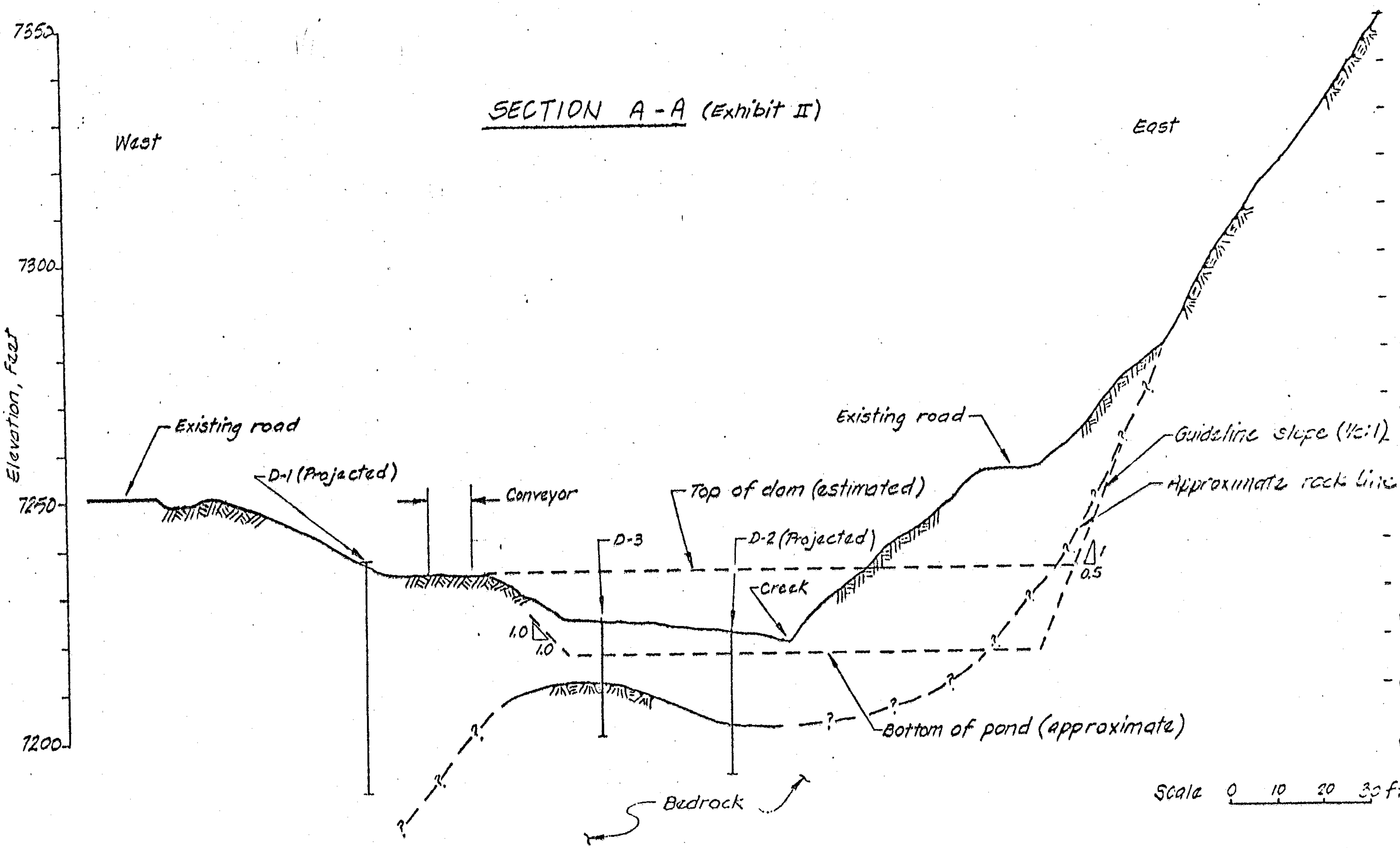
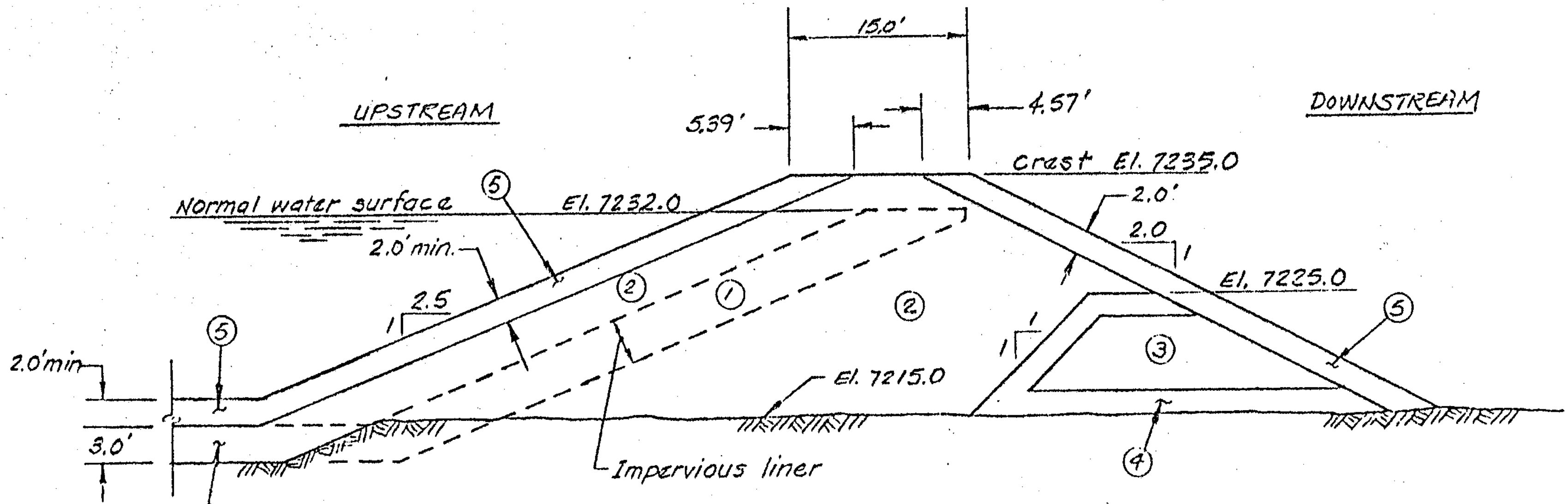


EXHIBIT IV

INTERNATIONAL ENGINEERING COMPANY, INC.

Project: UTAH POWER & LIGHT	Contract No. 8069-01	File No.	Sheet
Feature: DEER CREEK MINE POND	Designed: PKJ	Date: 9-27-78	
Item: TYPICAL EMBANKMENT SECTION	Checked	Date	



TYPICAL EMBANKMENT SECTION

Scale 0 5 10 15 20 Feet

ZONE	MATERIAL	DESCRIPTION
1	Impervious liner	Sandy clayey silt to silty clay
2	Shell	Clay, silt, sand, gravel and cobbles
3	Rock toe	Sand, gravel, cobbles and boulders
4	Filter	Sand and gravel
5	Slope protection	Riprap (gravel, cobbles and boulders)

NOTES:

1. Zone 1 or Zone 2 may be used for the entire shell.
2. Zone 1 or Zone 2 may also be used for pond liner.

EXHIBIT V

INTERNATIONAL ENGINEERING COMPANY, INC.

Project: UTAH POWER & LIGHT — Contract No. 8069-01 — Sheet: — File No.:
Feature: DEER CREEK MINE POND — Designed: PRT — Date: 10-2-78
Item: SECTION B-B — Checked: — Date:

EMBANKMENT BELOW CONVEYOR

SECTION B-B (Exhibit II)

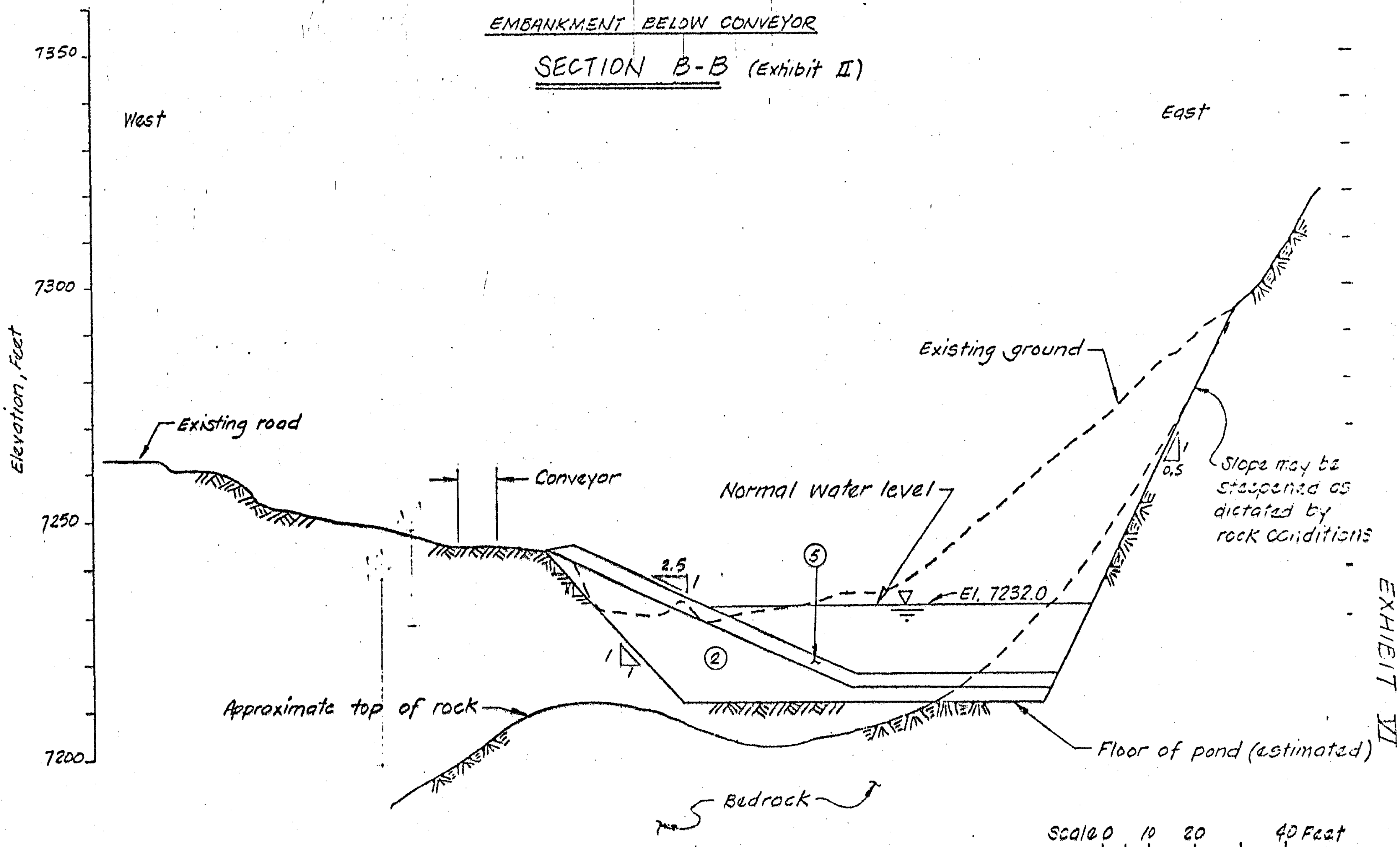


EXHIBIT VI

APPENDIX B

LABORATORY TEST RESULTS

Church Mine (cont'd)

- Field Permeability (Optional) - Performance of a Field Permeability Test using an oil barrel arrangement.

Laboratory Tests (Salt Lake City, Pittsburgh Testing)

Standard Plasticity Index Tests	(10)
Natural Water Content Determinations	(10)
Sieve Analysis	(2)
Standard Proctor Tests	(2)

Other Work

- Collection of maps and other information on the site.
- Materials search for shell material, sand and gravel, rip-rap and core materials at both sites.
- Preparation of a report.
- Visual evaluation of foundation conditions for drainage structures.

SCOPE OF WORK

GEOTECHNICAL INVESTIGATIONS

UTAH POWER AND LIGHT COAL MINE PONDS

Introduction

Site investigations shall be conducted for settlement pond dams at two locations, one at the Deer Creek Mine and the other for the Church Mine. The detailed scope of work shall include those items listed below and as itemized in the cost estimate. (See Attachment B.)

No costs for work outside of this scope have been included in the estimate, including work associated with hydrology, hydraulics, diversion facility design, dam design or spillway design.

Drilling will be performed by Raymond International, 1526 S 700 W., Salt Lake City, Utah 84104. Testing is to be performed by Pittsburgh Testing, 2955 S.W. Temple, Salt Lake City, Utah.

Scope of Work

Deer Creek Mine

- Drilling - Four (4) auger holes to bedrock at and near damsite with a Field Penetration Test with a split spoon sampler every 5 ft.
- Logging - Preparation of a soils/rock log of each hole drilled.
- Sampling - Collection of 15 samples from the split spoon sampler for laboratory testing, if required.
- Backhoe - If a backhoe is available at the mine, the digging of material for right abutment inspection.
- Falling Head Permeability (Optional) - Performance of a Falling Head Permeability Test in left abutment material at damsite.

Church Mine

- Drilling - Three (3) auger holes to 20 ft depth at the damsite with Field Penetration Tests by a split spoon sampler every 5 ft.
- Logging - Preparation of soils/rock log of each hole drilled.
- Sample - Collection of 15 samples for laboratory tests if required.

APPENDIX A

INTRA-COMPANY WORK ORDER
NO. 8069

SUMMARY OF SOIL TEST RESULTS

Job No 8069-01 Project Name UTAH POWER & LIGHT Feature Coal Mine Ponds Date 9-5-78

Hole or Trench Number	Sample Number	Depth From	Depth To	Laboratory Classification	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Specific Gravity G	Natural w %	Natural γd	Compaction Test	Compaction Optimum w	Compaction Optimum γd	Shear Strength Test	Shear Strength Initial w	Shear Strength Initial γd	C	φ	Permeability γd	Permeability k	Consolidation Cc	Consolidation Cr	Consolidation ē	Notes
er Cr. ne	101			ML	100	30.8	39.2																			From under conveyor
•	102			Shale				28.9	11.1																	From coal shed area
•	103			ML																						From pond area
urch ing	104			Shale									SP	16.3	114.0						90%	*				*Zero seepage after seven says soaking
-1	1	5.0	6.5	ML																						
	2	5.0	10.0	CL-CH							14.7															
	3	10.0	11.5	CL-ML																						
	4	16.0	17.5	CL-ML																						
	5	21.0	22.5	CL-CH																						
-2	1	16.0	17.5	ML																						
-3	1	1.5	2.5	ML/SM																						
	2	5.0	6.5	CL-ML/SP																						
	3	9.0	10.5	ML				Non-plastic																		
-4	1	1.5	3.0	ML/CL																						
	2	0.0	5.0	ML/CL				20.2	5.4		11.2		SP	12.8	118.2											
	3	5.5	7.0	CL																						
	4	5.0	10.0	CL				21.2	5.4																	
i-1	1	5.0	10.0	CL				24.8	8.0		22.6															
		10.2	20.0	CL-CH																						
i-2	1	5.0	10.0	CL-CH				24.0	7.7																	
	2	5.0	10.0	CL-CH							11.4															
-1	1	0.0	5.0	CL-CH																						
	2	5.0	7.0	Shale																						
	3	5.5	5.0	Shale																						

Visual Classification SP ... Proctor MP ... Proctor ... Test
TC = Triaxial Compression UC = Unconfined Compression DS = Direct Shear
UU = Unconsolidated Undrained CU = Consolidated Undrained CD = Consolidated Drained

SUMMARY OF SOIL TEST RESULTS

Job No 8069-01 Project Name UTAH POWER & LIGHT Feature Coal Mine Ponds Date 9/5/78

Hole or Trench Number	Sample Number	Depth From	Depth To	Laboratory Classification	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Specific Gravity G	Natural w	Natural γ_d	Compaction Test	Compaction Optimum w	Compaction Optimum γ_d	Shear Strength Test	Shear Strength Initial w	Shear Strength Initial γ_d	Shear Strength c	Shear Strength ϕ	Permeability γ_d	Permeability k	Consolidation C_c	Consolidation C_r	Consolidation P_c	Notes
C-2	1	0.1	1.0	CL	100	81	17.0																			
	2	5.0	6.5	CL				NP	NP																	
	3																									
	4	16.0	17.5	CL							13.6															
	5	20.0	20.8	CL				25.4	9.2																	
C-3	1	2.0	2.5	CL																						
	2	3.5	5.0	CL				35.8	17.9																	
	3	10.0	11.5	CL							13.3															
	4	14.5	14.8	SW/SP																						
	5	19.5	21.0	SW/SP																						
	6	24.5	26.4	SW/SP																						
	7	27.0	27.2	CL																						
C-4	1	0.0	5.0	CL																						
	2	5.0	5.5	CL																						
	3	10.0	10.5	Shale																						
C-5	1	5.0	6.5	CL				NP	NP																	
	2	10.0	11.5	CL																						
	3	17.0	19.5	GW/GP																						
	4	31.0	31.5	GW/GP																						
	5	37.5	37.6	Shale																						

* Visual Classification

Standard Proctor
MP = Modified Proctor
S = Special - See Text

TC = Triaxial Compression
UC = Unconfined Compression
DS = Direct Shear

UU = Unconsolidated Undrained
CU = Consolidated Undrained
CD = Consolidated Drained

ASTM STANDARD

PARTICLE SIZE IDENTIFICATION

Material	Sieve Size
Boulders	Over 12"
Cobbles	3" - 12"
Gravel	
Coarse	3/4" - 3"
Fine	No. 4 - 3/4"
Sand	
Coarse	No. 4 - No. 10
Medium	No. 10 - No. 40
Fine	No. 40 - No. 200
Fines	Passing #200
Silt*	No. 200 - .005mm
Clay*	Less than .005mm

*Determined by plasticity tests

Job No. 8069-01

Type of Material: Silty sand, gravel and cobbles

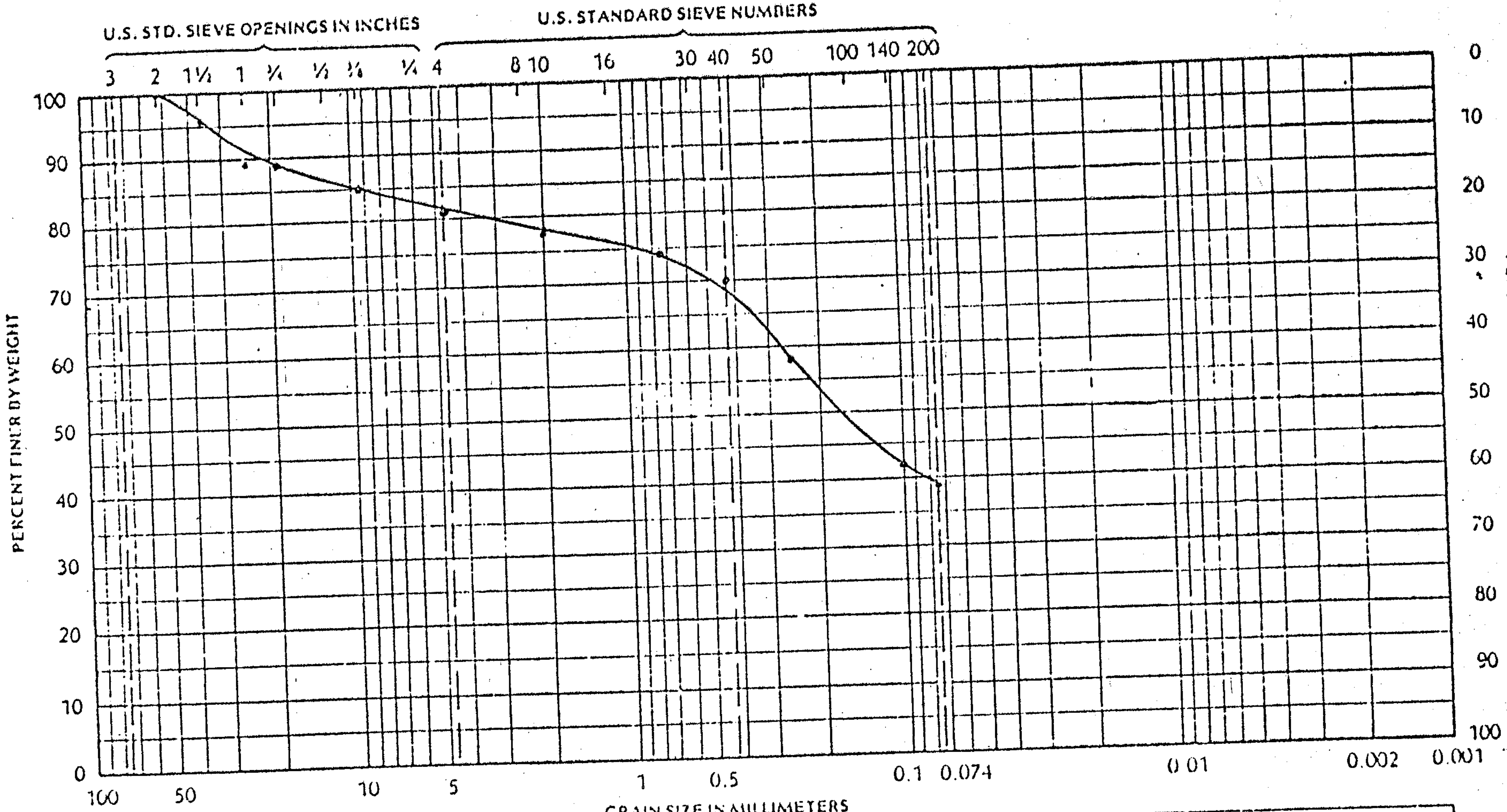
Lab/Inv. No. ______

Source of Material: Sample 101, Deer Creek Mine Pond Area

Test Procedure: ASTM D 422

Tested/Calc. By ______ Date ______

Reviewed By P.R.T. Date 9/5/78



PARTICLE SIZE DISTRIBUTION CHART

Unified	Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt or Clay: Silt / Clay
AASHTO	Gravel		Coarse Sand	Fine Sand	

Particle Size, Percent Passing

2" 100	1" 89.5	½" 87.5	#10 77.4	#30 72.0	#100 49.0	0.05 mm ______
1½" 9[illegible]	¾" 88.9	#4 80.8	#16 77.0	#50 62.0	#200 39.2	0.002 mm ______

Atterberg Limits

Liquid Limit ______ P.I. ______

Plastic Limit ______ Sp[illegible] ______

PITTSBURGH TESTING LABORATORY

2955 SOUTH WEST TEMPLE
SALT LAKE CITY, UTAH 84115

8069-810

SLC-3263
P.O. SF-4549-1

REPORT

September 7, 1978

International Engineering Company, Inc.
220 Montgomery Street
San Francisco, California 94104

Subject: Test of submitted soil samples

Project: Coal Mine Ponds, Utah Power and Light Company

Results:

A. Atterberg Limits

Sample No.	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
102 - surface	28.9	17.8	11.1
D-3 #3, 9'-10.5'	NP	NP	NP
D-4 #2, 1'-5'	20.2	14.8	5.4
D-4 #4, 5'-10'	21.2	15.8	5.4
N-1 #1, 5'-10'	24.8	16.8	8.0
N-2 #1, 5'-10'	24.0	16.3	7.7

B. Moisture-Density Relationship of Soils

see attached results

C. Natural Moisture Content

Sample Number	Percent Moisture
D1 - #2, 5'-10'	14.7
D4 - #2, 1'-5'	11.2
N1 - #1, 5'-10'	22.6
N1 - #2, 10'-20'	11.4

D. <u>Sieve Analysis (Sample 101)</u>

U.S. Stand. Sieve Size	Sample, Percent Passing
2"	100
1-1/2"	96.4
1"	89.5
3/4"	88.9
3/8"	85.0
#4	80.8
#10	77.4
#20	74.5
#40	70.0
#60	58.2
#140	41.6
#200	39.2

Respectfully submitted,

PITTSBURGH TESTING LABORATORY

Robert C. Mathews

Robert C. Mathews, Manager
Salt Lake City District

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PITTSBURGH TESTING LABORATORY
2955 SOUTH WEST TEMPLE
SALT LAKE CITY, UTAH 84115

PITTSBURGH TESTING LABORATORY

2955 SOUTH WEST TEMPLE
SALT LAKE CITY, UTAH 84115

SLC-3263

REPORT OF

MOISTURE-DENSITY RELATIONSHIP TEST

September 7, 1978

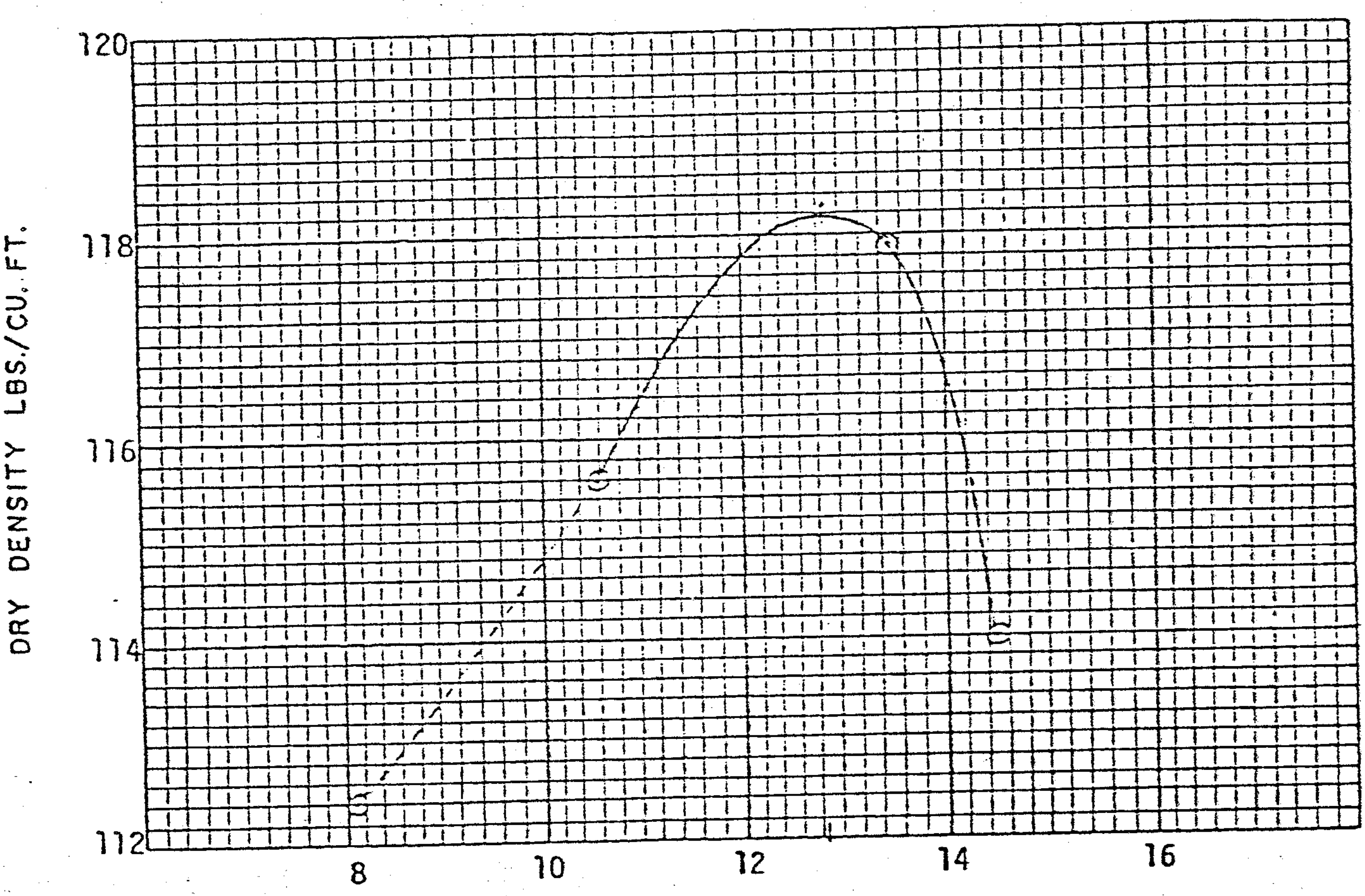
For: International Engineering

Project: Coal Mine Ponds

Location Utah Power and Light

Sample D4 - #2, 1'-5'

METHOD OF TEST ASTM D698



Optimum Moisture 12.8 % Max. Dry Density 118.2 lbs./cu. ft.

RESPECTFULLY SUBMITTED,
PITTSBURGH TESTING LABORATORY

Robert C. Mathews
DISTRICT MANAGER

PITTSBURGH TESTING LABORATORY

2955 SOUTH WEST TEMPLE
SALT LAKE CITY, UTAH 84115

SLC-3263
P.O. SF-4549-1

REPORT

September 20, 1978

International Engineering Company, Inc.
220 Montgomery Street
San Francisco, California 94104

Subject: Tests of submitted soil samples

Project: Coal Mine Ponds, ~~Utah Power And Light Company~~

Results:

A. Moisture Content

Sample Number	Moisture Content (%)
C-2(16.0'-17.5')	13.6
C-3(10.0'-11.5')	13.3

B. Atterberg Limits

Sample Number	Liquid Limit	Plastic Limit	Plastic Index
C-2(5.0'-6.5')	NP	NP	NP
C-2(20.0'-20.8')	25.4	16.2	9.2
C-3(3.5'-4.0')	35.8	17.9	17.9
C-5(5.0'-6.5')	NP	NP	NP

C. Gradation - Sample C-3 (19.5'-21.0')

U. S. Sandard Sieve Size	Percent Passing by Weight
3/4"	99
3/8"	90
#4	81
#10	68
#20	54
#40	50
#60	44
#140	22
#200	17.6

D. Maximum Density-Optimum Moisture Relationship

Sample No. - C-3 (Grab sample-Shale)
Method of Test - AASHTO T99
See attached curve

E. Permeability - Sample C-3 (Grab Sample-Shale)

Procedure -- 36" head falling head permeameter
Compaction -- 92.5%*
Sample impermeable after seven day soaking period

*Percent compaction based on maximum dry density of 114.0 pcf as determined by AASHTO T99.

Respectfully submitted,

PITTSBURGH TESTING LABORATORY

Robert C. Mathews

Robert C. Mathews, Manager
Salt Lake City District

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atch: (1)

2955 SOUTH WEST TEMPLE
SALT LAKE CITY, UTAH 84115

SLC-3263
P.O. SF-4549-1

REPORT OF

MOISTURE-DENSITY RELATIONSHIP TEST

September 20, 1978

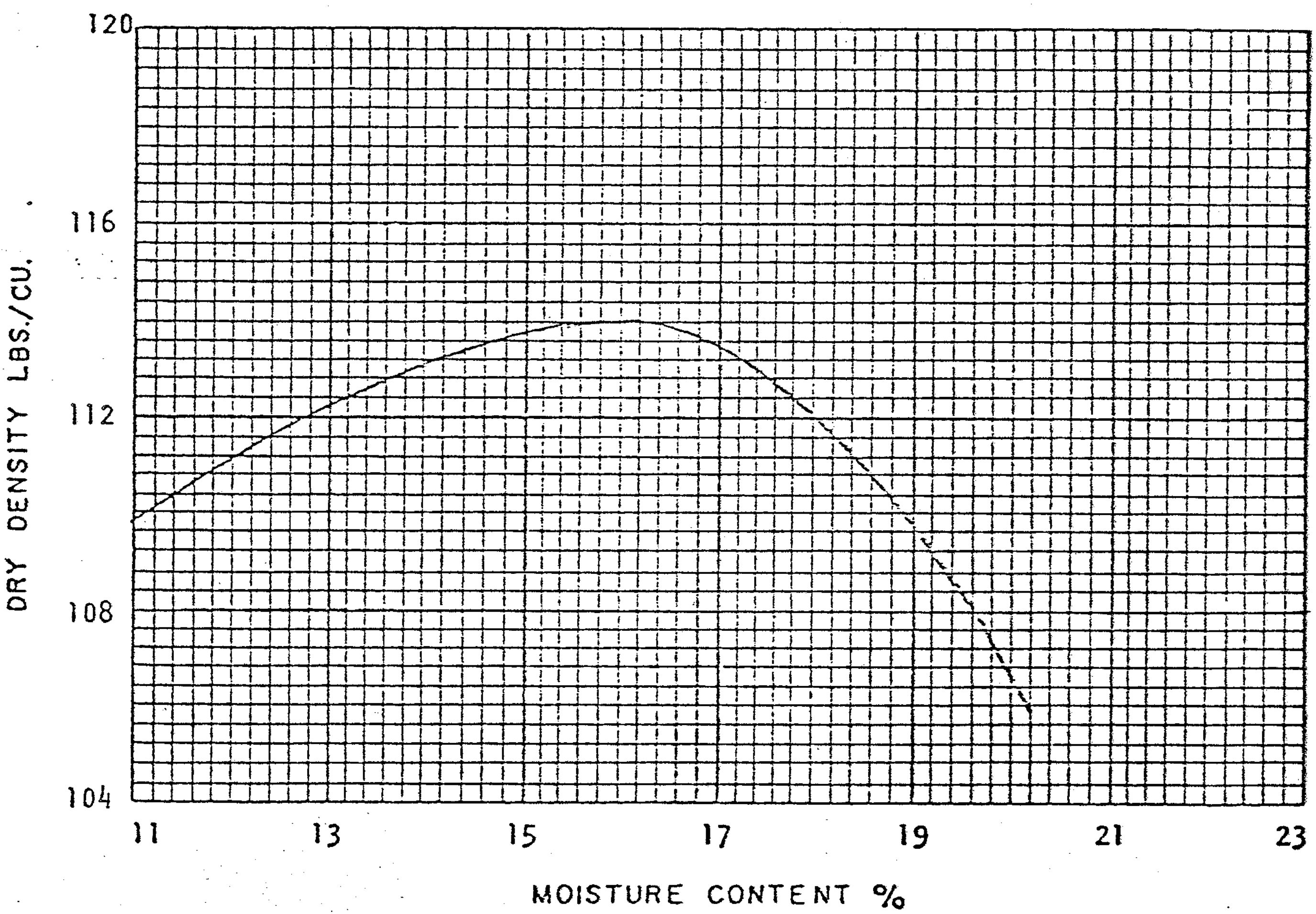
For: International Engineering Company, Inc.

Project: Coal Mine Ponds, Utah Power and Light Company

Location Sample No. C 3 (Grab sample-Shale)

Sample Gray Clayey Silt

METHOD OF TEST AASHTO T99



Optimum Moisture 16.3 % Max. Dry Density 114.0 lbs./cu. ft.

RESPECTFULLY SUBMITTED,
PITTSBURGH TESTING LABORATORY

DISTRICT MANAGER

APPENDIX C

BOREHOLE LOGS FOR DEER CREEK AND CHURCH MINES

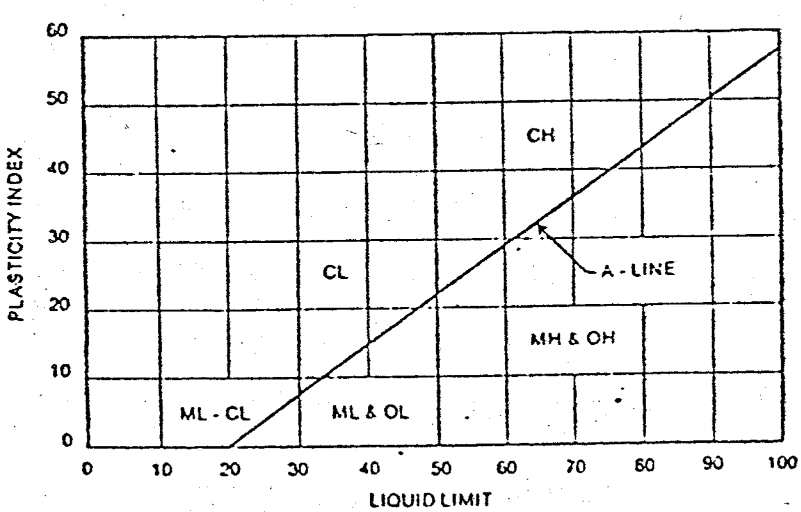
SOIL CLASSIFICATION CHART and KEY to TEST DATA

SYMBOL	LETTER	DESCRIPTION	MAJOR DIVISIONS			
	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	CLEAN GRAVELS (little or no fines)	GRAVELS	MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	GP	POORLY-GRADED GRAVELS OR GRAVEL SAND MIXTURES, LITTLE OR NO FINES	CLEAN GRAVELS (little or no fines)	GRAVELS	MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	GRAVELS WITH FINES (appreciable amount of fines)	GRAVELS	MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	GRAVELS WITH FINES (appreciable amount of fines)	GRAVELS	MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES	CLEAN SANDS (little or no fines)	SANDS	MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	SP	POORLY-GRADED SANDS OR GRAVELLY SANDS LITTLE OR NO FINES	CLEAN SANDS (little or no fines)	SANDS	MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	SM	SILTY SANDS, SAND-SILT MIXTURES	SANDS WITH FINES (appreciable amount of fines)	SANDS	MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES	SANDS WITH FINES (appreciable amount of fines)	SANDS	MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE
	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50			MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50			MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50			MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50			MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50			MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50			MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	HIGHLY ORGANIC SOILS			

For visual classification, the ¼" size may be used as equivalent to the no. 4 sieve size

The no. 200 sieve size is about the smallest particle visible to the naked eye

SOIL CLASSIFICATION CHART
UNIFIED SOIL CLASSIFICATION SYSTEM



PLASTICITY CHART

KEY TO SAMPLES

☐ -Indicates location of sample

⊠ -Indicates location of sample attempt with no recovery

SPT -Indicates location of standard penetration test

INTERNATIONAL ENGINEERING CO., INC. SHEET 1 OF 3

DRILL LOG	PROJECT UTAH POWER & LIGHT	JOB NO. 5069-01	HOLE NO. D-1

SITE	BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING
DEER CREEK MINE POND	8-23-78	8-24-78		90°

COORDINATES	DEPTH/EL GROUND WATER	GROUND EL.	DEPTH/EL. TOP OF ROCK
	NOT ENCOUNTERED	7233.0'	NOT ENCOUNTERED

DRILLING CONTRACTOR	CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
RAYMOND INTERNATIONAL	—	5	—	48.5'/7184.5

DRILL MAKE AND MODEL	LOGGED BY:
CME 55	P.R. THUENER

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
6" Auger				Grinding at 1.0'		0–1			Silty SAND, GRAVEL & COBBLES, brown, trace clay, loose, dry [working pad]
						1–5			Sandy Clayey SILT/Silty CLAY (ML/CL), brown, angular sand, low to medium plasticity, slight moisture. Grading to silty CLAY (CL-CH) medium stiff, medium to high plasticity, moist at 3.5' — ? — ? — ? — ? —
SPT	2, 3, 3	18"	12"			5–7		#1	SILT (ML), mottled light and medium browns, slightly moist. Sandy at 6.0' — ? — ? — ? — ? —
				Grinding 8'-9'		7–10	#2		Silty CLAY (CL-CH), brown, medium to high plasticity, moist. Boulder
						10			Sandy SILT (ML) lense, Yell. brown/brown
SPT	3, 5, 3	18"	8"	Grinding 11'-15.5' Very slow drilling. Cased to 13.5' (4" I.D.) 8-23-78		10.5–11.5		#3	Silty CLAY/Clayey SILT (CL/ML), brown, medium plastic, moist
						11.5–16			SANDSTONE, Yellow-brown, weak, severely weathered, moist. 12.5: Moderately weathered
3¾" Tricone Bit				Using water to drill. Easy drilling, dirty returns, good circulation. Losing water 15.0-16.0'. No returns at 16.0'		13.5–16			
SPT	4, 7, 8	18"	6"	Easy drilling 16.0'-20.0'		16–17.5		#4	Sand Silty CLAY to Clayey SILT (CL to ML), Yellow-brown, brown, mottled, fine to coarse sand, angular, stiff, moist (SANDSTONE, severely weathered)

HOLE NO. D-1

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG

PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE

JOB NO: 8069-01

HOLE NO.: D-1

Type Tool and Dia.	Method N. Blow Count	Advance	Recovery	Remarks (Water Levels, Water Return, Drilling Fluid, Casing Depth)	Elevation	Depth	Graphic Log	Box/Sample No	Material Classification – Physical Description
3¾" Tri-cone bit	—			No returns, easy drilling		18, 19			As above
						20			Cobble
						21			Dense
SPT	12 / 23 / 25	18"	14"			22		5	Sandy CLAY (CL-CH), grey, fine sand, medium to high plasticity, moist
						23, 24			23.5' to 23.5' Boulder
						25, 26, 27			
						28			Silty SAND (SP), brown, medium angular sand, dense to very dense moist.
SPT	23 / 49	6" / 3"	18"	Sandstone gravel size (3") plugging SPT sampler		29, 30			Sandy silty CLAY / Clayey SILT (CL/ML) Yellow-brown to brown, mottled, fine sand and coarse gravel, moist [SANDSTONE & SHALE, severely weathered]
				Harder drilling		31, 32			
SPT	11 / 16 / 14	4" / 6" / 6"	4"	Slough in sampler - attempted sample at 35.0' but could only reach 32.5'		33, 34			As above with fresh to slightly weathered SANDSTONE fragments, fine grained
				Rocky drilling		35, 36			

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE	JOB NO. 8069-01	HOLE NO. D-1

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
3⅞" Tri-cone bit				No circulation					As above
						37			
				Greater drilling pressure required.		38			
				Rate: 1 ft/min.		39			
				Attempted sample - slough clogging hole		40			
						41			
						42			
						43			
						44			
						45			
				Hard surface 46.5'-47.0'		46			
				" " 47.5' - 48.0					
						47			
						48			
				Hole left open 8-24-78		49			Bottom of hole at 48.5'
						50			

HOLE NO. D-1

INTERNATIONAL ENGINEERING CO., INC. SHEET 1 OF 2

DRILL LOG	PROJECT: UTAH POWER & LIGHT		JOB NO.: 8069-01	HOLE NO.: D-2
SITE: DEER CREEK MINE POND	BEGUN: 8-25-78	COMPLETED: 8-25-78	HOLE SIZE:	ANGLE FROM HORIZ. & BEARING: 90°
COORDINATES:	DEPTH/EL GROUND WATER: 7.5' / 7214.3		GROUND EL.: 7221.8	DEPTH/EL. TOP OF ROCK: 19.0' / 7202.8
DRILLING CONTRACTOR: RAYMOND INTERNATIONAL	CORE RECOV LENGTH/%: 81" / 84%	SAMPLES: 1	CORE BOXES: 1	DEPTH/EL. BOTTOM OF HOLE: 29.0' / 7192.8
DRILL MAKE AND MODEL: CME 55	LOGGED BY: P.R. THUENER			

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
6" Auger				Hard starting hole - lots of boulders		0–1			clayey sandy SILT (ML) and gravel, cobbles and boulders, brown, angular coarse fraction, trace clay, slight plasticity, boulders to 5', dry.
						2–3			2.5': Sandy SILT with angular coal fragments, fine to coarse sand, non-plastic, dry
				Grinding 4.0'-4.7'		4			3.5' Dark brown
				" 5.5'-6.0'		5–6			Cobble
						7			Cobble
				Ground water level ▽ 8-28-78		8			Cobble
				Attempted SPT at 8.5' - refusal on boulder		9			Boulder
				Slow drilling		10–12			(Returns: sandy clayey SILT (ML), dark brown, fine sand, low plasticity, moist to saturated)
				Attempted SPT at 13.0' - Refusal on boulder		13			Boulder
3 3/4" Tricone bit				Set 4" ID casing to 13.5' Using water		14			
				Light brown returns, losing some water		15			
				Lost circulation at 16.0'		16			SANDSTONE, SHALE & COAL in sandy clayey SILT matrix (ML) low plasticity
SPT	18 / 16 / 13	18"	3"	15" Slough - Sandstone fragments; Easy drilling at 16.0'		17		#1	

HOLE NO. D-2

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG

PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE | JOB NO. 8069-01 | HOLE NO. D-2

Type Tool and Dia.	Method N- Blow Count	Advance	Recovery	Remarks (Water Levels, Water Return, Drilling Fluid, Casing Depth)	Elevation	Depth	Graphic Log	Box/Sample No	Material Classification – Physical Description
3¾" Tricone bit				Easy drilling to 19.0' Hard drilling at 19.0' Circulation returned at 18.5' but losing water		18–21			As above Soft to 19.0' / SHALE, light to dark grey, fresh, massive, moderately hard, horizontal laminations
NX Core bit	RQD = 100 %	36"	36"	losing water, brown returns Drilling rate: 3"/min.		21–24			
	RQD = 42"/60" = 70 %	60"	45"	No returns		24–29			
				Hole left open 8-25-78		29–30			Bottom of hole 19.0'

HOLE NO. D-2

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG	PROJECT: UTAH POWER & LIGHT	JOB NO.: 8069-01	HOLE NO.: D-3

SITE	BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING
DEER CREEK MINE POND	8-28-78	8-28-78		90° ±0°

COORDINATES	DEPTH/EL GROUND WATER	GROUND EL.	DEPTH/EL. TOP OF ROCK
	8.1' / 7216.2	7224.3	13.0' / 7211.3

DRILLING CONTRACTOR	CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
RAYMOND INTERNATIONAL	24" / 100%	3	1	24.0' / 7200.3

DRILL MAKE AND MODEL	LOGGED BY
CME 55	P.R. THUENER

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
6" Auger						0–1			Sandy SILT/Silty SAND (ML/SM) dark brown, with trace clay & angular gravel, cobbles and boulders, medium dense, 5% clay, dry
SPT	12, 40	12"	4"	Grinding 2.4'-4.0'		2		#1	coal fragments
						3			Boulder, SANDSTONE 2.2'-4.0'
				Slow, smooth drilling to 5.0'. Rough drilling at 5.0		4–5			SAND, SILT and CLAY (CL-ML/SP), mottled browns, angular sandstone fragment to 3/4", low plasticity, very dense, dry [Severely weathered SANDSTONE]
SPT	15, 21, 39	18"	8"	Grinding 6.0'-7.8'		6		#2	Coal fragments
						7			Boulder 6.2'-7.6'
						8–9			Sandy silty CLAY (CL), angular, medium to coarse sand size sandstone fragments, low plasticity, dry
SPT	7, 2, 2	18"	8"	Squealing 9.5'-10.8'	▽	10		#3	Grading to more silt, less clay
				Easy drilling 10.8'-13.0'		11–12			Sandy SILT (ML) with trace clay, dark brown, fine to coarse sand, angular, loose, moist at 10.5' [Severely weathered SANDSTONE in silty matrix]
				Grinding at 13.0'. Set 4" casing to 13.5'		13			
3 3/4" Tricone bit				Hole not plumb. Rocky drilling - losing all water. Add 50 lb. bentonite at 15.2', add lime. Still no circulation. Drilling with only water. Hole clean - cuttings going into formation.		14–17			SHALE, light to dark grey, fresh massive, moderately hard, horizontally laminated.

HOLE NO. D-3

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE	JOB NO. 8069-01	HOLE NO. D-3

Type Tool and Dia.	Method N-Blow Count	Advance	Recovery	Remarks (Water Levels, Water Return, Drilling Fluid, Casing Depth)	Elevation	Depth	Graphic Log	Box/Sample No	Material Classification – Physical Description
3¾" Tricone				No circulation. Cuttings from bit are dark grey, fine sand sizes - Shale		18, 19, 20, 21, 22			As above
Nx Core barrel	RQD=100%	24"	24"	Bit clogging at 24.0'. Made 3 attempts to core.		23, 24			
				Placed cobble over hole 8-24-78		25			Bottom of hole at 24.0'

HOLE NO. D-3

DRILL LOG

PROJECT	UTAH POWER & LIGHT
JOB NO.	8069-01
HOLE NO.	D-4
SITE	DEER CREEK MINE POND
BEGUN	8-28-78
COMPLETED	8-29-78
HOLE SIZE	
ANGLE FROM HORIZ. & BEARING	90°
COORDINATES	
DEPTH/EL GROUND WATER	NOT ENCOUNTERED
GROUND EL.	7243.0'
DEPTH/EL. TOP OF ROCK	NOT ENCOUNTERED
DRILLING CONTRACTOR	RAYMOND INTERNATIONAL
CORE RECOV LENGTH/%	—
SAMPLES	5
CORE BOXES	—
DEPTH/EL. BOTTOM OF HOLE	20.0'/7223.0
DRILL MAKE AND MODEL	CME 55
LOGGED BY:	

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
6" Auger						0–1			Clayey SILT (ML) with sand, gravel, cobbles, and boulders, angular, low plasticity, 5-10% clay, 60% silt, dry
SPT	17 / 11 / 8	18"	8"			2	#2	#1	More clay (ML/CL)
						4			Sandy silty CLAY (CL), dark brown, medium plastic, medium to coarse sand, moist at 4.0' Wet at 5.0', stiff
				Grinding 5.0'-5.5		5			
SPT	– / 6 / 7	18"	4"	SPT mostly slough		6		#3	
						7–9			
SPT	– / –			Grinding at 10.5'		10		5	SANDSTONE, yellow brown in silty to clayey matrix, fine grained sandstone, moderately to severely weathered, low plasticity fines, dry
				Set 4" casing to 12.0'		12			
3¾" Tricone bit				using water, no returns		13			
				Easy drilling		14			
SPT	0 / 9 / 11 / 15			80% SPT is slough — discarded sample		15			Dense, moist
				Smooth drilling		16–17			

HOLE NO. D-4

INTERNATIONAL ENGINEERING CO., INC. SHEET 2 OF 2

DRILL LOG	PROJECT UTAH POWER & LIGHT - DEER CREEK MINE	JOB NO 6067-01	HOLE NO. D-4

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
3⅞" Tri-cone bit									As above
						18			
				Attempted SPT at 20.0' - Refusal		19			
				8-29-78		20			Bottom of hole at 20.0'
						21			

HOLE NO. D-4

DRILL LOG	PROJECT: UTAH POWER & LIGHT	JOB NO.: 8059-01	HOLE NO.: N-1

SITE	BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ & BEARING
DEER CREEK MINE - SEEPAGE FIELD	8-25-78	8-25-78	6"	90°

COORDINATES	DEPTH/EL GROUND WATER	GROUND EL.	DEPTH/EL. TOP OF ROCK
	NOT ENCOUNTERED	7571	NOT ENCOUNTERED

DRILLING CONTRACTOR	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
RAYMOND INTERNATIONAL	—	2	—	20.0 / 7551

DRILL MAKE AND MODEL	LOGGED BY:
CME 55 (Central Mining Equipment)	P. R. THUENER

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
6" Auger				~~Grinding at 1.5'~~		0–4			Sandy clayey SILT / Silty CLAY (ML/CL) Dark brown with fine to coarse angular gravel, medium to coarse angular sand, slight plasticity, high to very high dry strength, dry. 2.2' to 3.0' Cobble. Grading to silt clay
						4–6			Sandy silty Clay (CL), dark brown with angular gravel (1½") angular medium sand, medium plasticity, very high dry strength, dry
				Grinding 6'-8' " 9'-10'		6–8		#1	Boulder
						8–9			Becoming more plastic (CL-CH)
						9–10			Cobble
				Easy drilling 10' to 20'		10–14		#2	Medium to high plasticity (CL/CH)
						14–15			Cobble
						15–17			

HOLE NO. N-1

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE	JOB NO: 8069-01	HOLE NO.: N-1

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
6" Auger									As above
						18			
						19			
				Hole left open per J. Neymeyer 8-23-78		20			Bottom of hole at 20.0'

HOLE NO. N-1

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG

PROJECT: UTAH POWER & LIGHT		JOB NO.: 8069-01	HOLE NO.: N-2
SITE: DEER CREEK MINE - SEEPAGE FIELD	BEGUN: 8-23-78	COMPLETED: 8-23-78	HOLE SIZE: 6" / ANGLE FROM HORIZ. & BEARING: 90°
COORDINATES:	DEPTH/EL GROUND WATER: NOT ENCOUNTERED	GROUND EL.: 7354	DEPTH/EL. TOP OF ROCK: NOT ENCOUNTERED
DRILLING CONTRACTOR: RAYMOND INTERNATIONAL	CORE RECOV LENGTH/%: -	SAMPLES: 2 / CORE BOXES: -	DEPTH/EL. BOTTOM OF HOLE: 20.0/7334
DRILL MAKE AND MODEL: CME 55	LOGGED BY: P.R. THUENER		

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
6" Auger				Grinding 1.0'-1.5'		1			Silty SAND and GRAVEL (SM/GM) Brown/Black, fine sand to fine gravel, angular fragments, loose, 20% silt, dry
				" 2.5'-2.7'		2			
						3			Sandy gravelly CLAY (CL/CH), dark brown, angular sand and gravel fragments to 1/2", medium to high plasticity, high to very high dry strength, ~80% clay, moist
				Smooth, easy drilling		4			
						5			
						6			
						7			Finer gravel fragments at 7.0'
						8			
						9			
						10			
						11			
						12			
						13			
						14			Gravel fragments to 1½"
						15			
						16			More sand (fine) with trace coal, dry
						17			

HOLE NO. N-2

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE	JOB NO. 8069-01	HOLE NO. N-2

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
6" Auger						18			As above
						19			
				Backfilled hole 8-23-78		20			Bottom of hole at 20.0'

HOLE NO: N-2

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT UTAH POWER & LIGHT		JOB NO. 8069-01	HOLE NO. N-3
SITE DEER CREEK MINE- SEEPAGE FIELD	BEGUN 8-23-78	COMPLETED 8-23-78	HOLE SIZE 6"	ANGLE FROM HORIZ & BEARING 90°
COORDINATES	DEPTH/EL GROUND WATER NOT ENCOUNTERED	GROUND EL. 7330	DEPTH/EL. TOP OF ROCK NOT ENCOUNTERED	
DRILLING CONTRACTOR RAYMOND INTERNATIONAL	CORE RECOV LENGTH/% –	SAMPLES –	CORE BOXES –	DEPTH/EL. BOTTOM OF HOLE 20.0/7310
DRILL MAKE AND MODEL CME 55	LOGGED BY: P.R. THUENER			

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
6" Auger				(New bit teeth)		0–2			Silty sandy CLAY / Silty clayey SAND (CL-CH/SC), brown, medium sand to 3/4" gravel, angular, soft/loose, medium to high plasticity, dry
				Grinding 3.5'-4.6'		2–9			Sandy CLAY (CL), brown, medium sand, angular fragments, medium plasticity, high dry strength, approx. 80% clay, dry. Dark brown at 4.5'
				Smooth, slow drilling		6			
						9–11			Boulder
						13			Medium to high plasticity (CL-CH) Approx. 90% clay
						17			

HOLE NO. N-3

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: UTAH POWER & LIGHT - DEER CREEK MINE	JOB NO. 3069-01	HOLE NO. N-3

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
6" Auger									As above
						18			
						19			
				Hole left open per J. Neymeyer 8-23-78		20			Bottom of hole at 20.0'

HOLE NO. N-3

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

March 10, 1981

Utah Power and Light Company
Engineering Division
P.O. Box 899
Salt Lake City, UT 84110

ATTENTION: Bill Whitney

Gentlemen:

In accordance with your request, a slope stability analysis has been completed for certain slopes in the vicinity of the Deer Creek Mine in Carbon County, Utah. The investigation has been performed to determine the factor of safety of the existing slopes and to determine, where required, what remedial measures would be necessary to obtain a desired factor of safety. The method used during the stability analysis follows the general procedure outlined by Spencer, which is valid for both force and moment equilibrium. The computer program used in the analysis was developed by Stephen Wright of the University of Texas and is capable of performing both a total stress and an effective stress analysis.

The results of the investigation, along with the factors of safety for the existing and modified slope conditions, are outlined in the following sections of this report.

1. Existing Conditions

The general layout of the existing conditions in the vicinity of the Deer Creek Mine is presented in Figure 1. The slope stability analysis has been performed for the existing slope on the right-hand side of the highway leading to the parking area. The refuse material existing within the slope consists of fine-grained soils intermixed with some cobble- and boulder-size materials. The amount of the fine-grained material existing in the refuse pile will most likely control the performance of the slope. The section where the stability analysis was performed is presented as AA in Figure 1.

1435 WEST 820 NORTH, P.O. BOX 711, PROVO, UTAH 84601 TELEPHONE 374-5771

There was no indication of any groundwater throughout the area, and it is not anticipated that any portion of the slope will be saturated throughout the life of the structure.

2. Results of Field and Laboratory Tests

In order to obtain an indication of the characteristics of the subsurface material within the dumps, three in-place density tests were performed in pits excavated along the surface of the slope. The in-place densities of the -3/4 material at the test locations were 61.8, 87.5 and 98.1 pounds per cubic foot respectively.

No subsurface exploration was performed at the site, since it was the opinion of the personnel from Utah Power and Light that the material displayed along the surface of the slope was characteristic of the dump material. It is our opinion that the in-place density obtained along the surface of the slope will generally represent the limiting density of the material within the dump.

Atterberg limits were performed on the fine-grained portion of the dump material, and the results of these tests indicated a liquid limit of 19.3 percent, a plastic limit of 16.5 percent, and a plastic index of 2.8 percent.

In order to obtain an indication of the strength characteristics of the dump material, three triaxial shear tests were performed on representative samples of the -No. 10 material. Each triaxial specimen was densified to an in-place unit weight of 94 pounds per cubic foot at the natural moisture content. No attempt was made to saturate the triaxial specimens, since there is no indication at the site that the dumps would be saturated by groundwater. Confining pressures of 30 psi, 60 psi, and 120 psi were used in performing the triaxial shear tests.

The Mohr envelopes for the three triaxial shear tests are presented in Figure 2, and it will be observed that a friction angle of 31 degrees and a cohesion of 1500 pounds per square foot were obtained for the test. The relatively high cohesion obtained for this test is attributed to the relatively dry characteristics of the dump material.

3. Stability Analysis

A stability analysis was performed for the cross section shown in Figure 3. It will be observed that the existing slope has a height of 106 feet and a slope of 1.20

horizontal to 1 vertical. In performing the stability analysis, the friction angle was held constant at a value of 31 degrees and the cohesion was permitted to vary. Factors of safety obtained for various values of the cohesion are presented in Table 1 below:

Table 1

Factors of Safety for the
Deer Creek Mine Slope

Friction Angle	Cohesion	Factor of Safety
31°	400	1.28
31°	500	1.37
31°	600	1.46
31°	700	1.54
31°	800	1.62

It is apparent from Table 1 that the factor of safety is a rather sensitive function of the cohesion and that if a cohesion of 700 pounds per square foot exists within the dump material, a factor of safety of 1.54 will be obtained.

The results of the triaxial shear tests indicated a cohesion value of 1500 pounds per square foot. The cohesion is a function of the in-place density of the dump material, and it is possible that the overall density of the dump material is less than the density of the samples used to determine the shear strength parameters. If the slope at the Deer Creek Mine is benched back as shown in Figure 1, and if a cohesion value of 400 pounds per square foot is used in the stability analysis, an factor of safety of 1.5 is obtained.

It is our opinion that the overall cohesion value within the dump at this site is equal to 700 pounds per square foot, and it will not be necessary to modify the slope as indicated above.

4. Summary and Conclusions

A stability analysis has been completed for certain slopes located in the vicinity of the Deer Creek Mine. The characteristics of the dump material within the slope were defined by visual observation along with several field and laboratory tests including in-place density determinations on the slope surface, Atterberg limits, and triaxial shear tests.

The results of the triaxial shear tests indicate a friction angle of 31 degrees and a cohesion of 1500 pounds per square foot.

The results of a computer stability analysis indicate that a factor of safety of 1.54 can be obtained for the Deer Creek Mine dump if a cohesion value of 700 pounds per square foot develops within the dump material. A stability analysis was also performed for a modified slope at the Deer Creek Mine which indicated a factor of safety of 1.5 using a cohesion of 400 pounds per square foot and a friction angle of 31 degrees. It is our opinion that a cohesion value of 700 pounds per square foot is realistic and that modifying the slope as indicated above is not necessary.

The conclusions and recommendations presented in this report are based upon the results of the field and laboratory tests which, in our opinion, define the characteristics of the subsurface material throughout the site in a satisfactory manner. If during construction conditions are encountered which appear to be different than those presented herein, please advise us in order that appropriate action may be taken.

Yours truly,

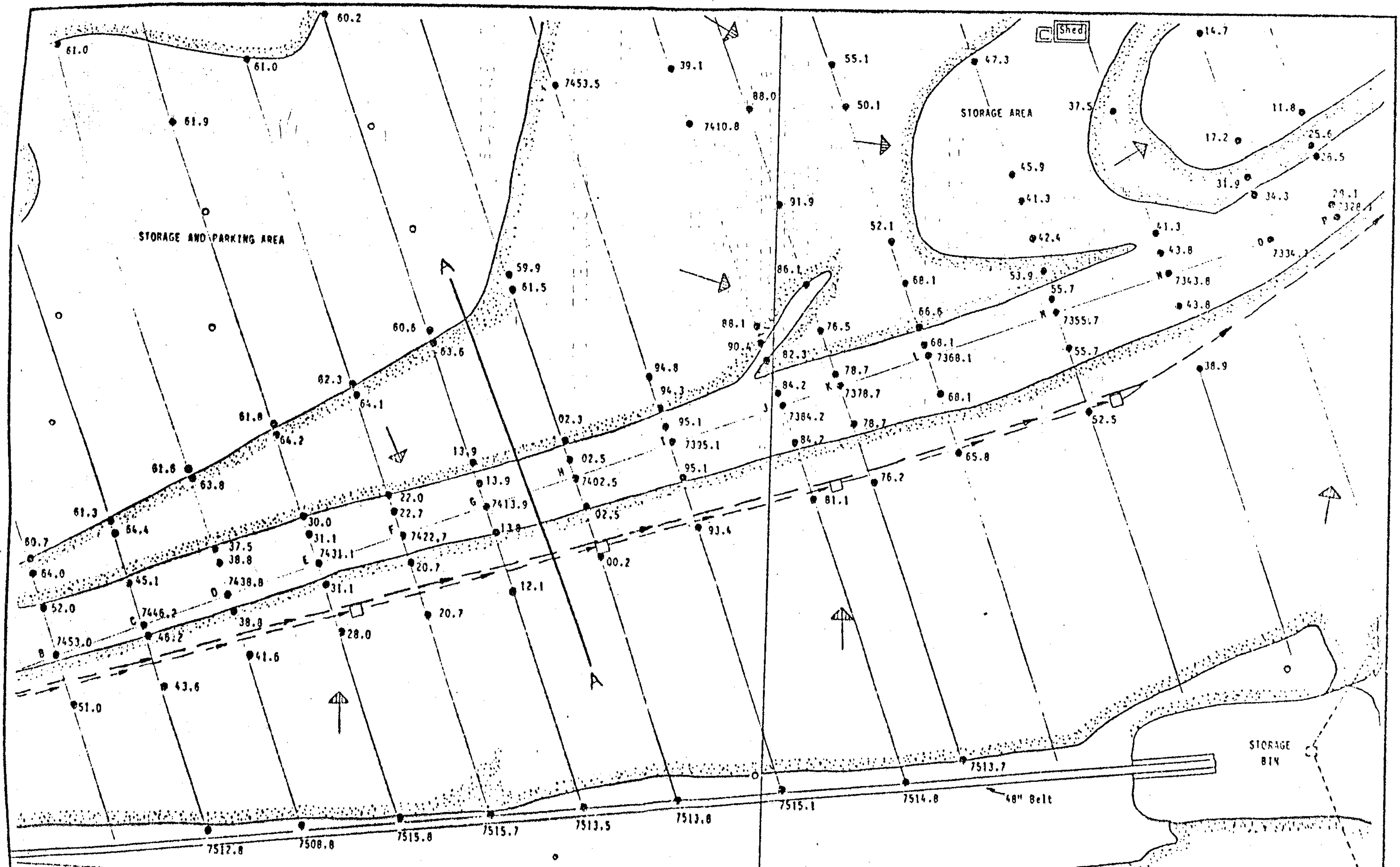
ROLLINS, BROWN AND GUNNELL, INC.

Ralph L Rollins

Ralph L. Rollins

lgw

RBG



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DRAWN ______ DATE ______
APPROVED ______ LICENSE NO. ______

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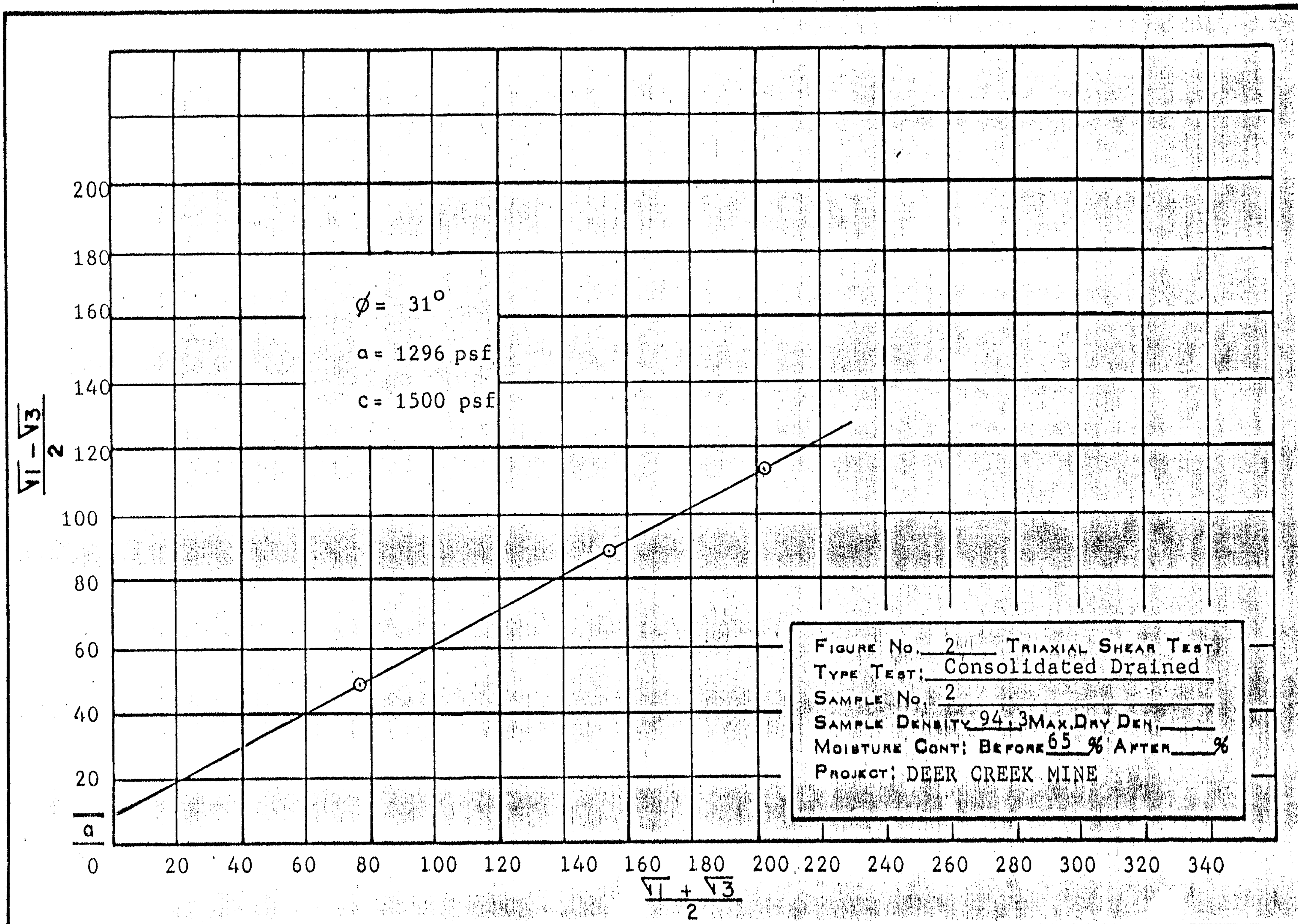
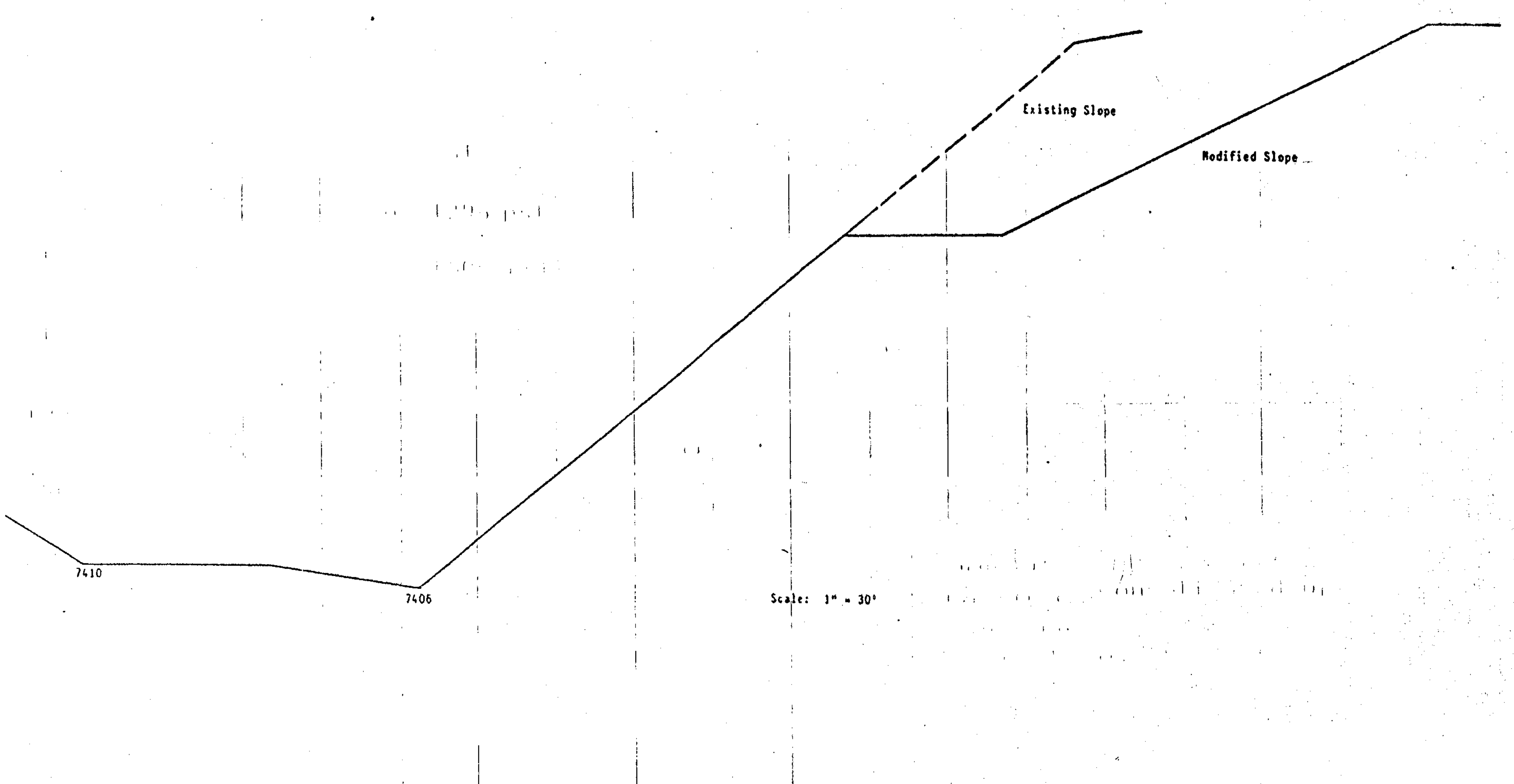
CONSULTING ENGINEERS

CROSS SECTION OF THE DEER CREEK MINE SLOPE

Figure No. 1



Ø = 31°
a = 1296 psf
c = 1500 psf
200
180
160
140
120
100
80
60
40
20
a
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
(σ1 − σ3)/2
(σ1 + σ3)/2
FIGURE No. 2 TRIAXIAL SHEAR TEST
TYPE TEST: Consolidated Drained
SAMPLE No. 2
SAMPLE DENSITY 94.3 MAX. DRY DEN.
MOISTURE CONT: BEFORE 6.5 % AFTER %
PROJECT: DEER CREEK MINE



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CROSS SECTION USED IN THE STABILITY ANALYSIS FOR THE DEER CREEK MINE

Figure No. 3