TAILINGS COVER DESIGN

WHITE MESA MILL, OCTOBER 1996

FOR

RECLAMATION

OF

WHITE MESA FACILITIES

BLANDING, UTAH

PREPARED BY

TITAN ENVIRONMENTAL

7939 EAST ARAPAHOE ROAD, SUITE 230

ENGLEWOOD, COLORADO 80112

TITAN Environmental

TAILINGS COVER DESIGN
White Mesa Mill

Prepared For:

Energy Fuels Nuclear, Inc.
1515 Arapahoe, Suite 900
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October 1996

By:

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7939 East Arapahoe Road, Suite 230
Englewood, Colorado 80112

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ENERGY FUELS NUCLEAR

WHITE MESA MILL

TAILINGS COVER DESIGN

1.0 SOIL COVER DESIGN

A six-foot thick soil cover for the uranium tailings Cells 2, 3 and 4A was designed using on-site materials that will contain tailings and radon emissions in compliance with regulations by the United States Nuclear Regulatory Commission (NRC) and by reference, the Environmental Protection Agency (EPA). The cover consists of a one-foot thick layer of clay, available from within the site boundaries (Section 16), below two-feet of random fill, available from stockpiles on-site. The clay is underlain with three feet (minimum) random fill soil, also available on site. The cover layers will be compacted to 95 percent maximum dry density using standard construction techniques. In addition to the soil cover, a minimum 3 inch (on the cover top) to 12-inch (on the cover slopes) layer of riprap material will be placed over the compacted random fill to stabilize slopes and provide long-term erosion resistance.

Uranium tailings soil cover design requirements for agency compliance include:

- Attenuate radon flux to an acceptable level (20 picoCuries-per meter squared-per second [pCi/m^2/sec]) (NRC, 1989);
- Minimize infiltration into the reclaimed tailings cells;
- Maintain a design life of up to 1,000 years or to the extent reasonably achievable and in any case for at least 200 years; and
- Provide long-term slope stability and geomorphic durability to withstand erosional forces of wind, the probable maximum flood event, and a horizontal ground acceleration of 0.1g due to seismic events.

Several models/analyses were utilized in simulating the soil cover effectiveness: radon flux attenuation, hydrologic evaluation of infiltration, freeze/thaw effects, soil cover erosion

protection, and static and pseudostatic slope stability analyses. These analyses and results are discussed in detail in Sections 1.1 through 1.5. The soil cover (from top to the bottom) will consist of: 1) minimum of three inches of riprap material; 2) two feet of compacted random fill; 3) one foot of compacted clay; and 4) minimum three feet of compacted random fill soil.

The soil cover design for the uranium tailings Cells 2, 3, and 4A was developed based on two construction options:

- An integrated soil cover over Disposal Cells 2, 3, and 4A; and
- A cover over Cells 2 and 3, where Cell 4A tailings are excavated and placed into Cell 3.

For modeling/analysis purposes it was assumed that the physical and radiological parameters of the tailings in Cells 2, 3, and 4A are not dependent on the tailing volume in each individual cell. Therefore, each of the two construction options above resulted in the same soil cover configuration. The only variation between the options is in the required volumes of cover materials, which is dependent only on the surface area to be covered (see Section 1.7).

The final grading plans for the two options are presented on Figures 1 and 2, respectively. As indicated on the figures, the top slope of the soil cover will be constructed at 0.2 percent and the side slopes, as well as transitional areas between cells, will be graded to five horizontal to one vertical (5H:1V).

A minimum of three feet random fill is located beneath the compacted fill and clay layers (see cross-sections on Figures 3 and 4). The purpose of the fill is to raise the base of the cover to the desired subgrade elevation. In many areas, the required fill thickness will be much greater. However, the models and analyses were performed conservatively assuming only a three-foot layer. For modeling purposes, this lower, random fill layer was considered as part of the soil cover for performing the radon flux attenuation calculation, as it effectively contributes to the reduction of radon emissions (see Section 1.1). The fill was also evaluated in the slope stability analysis (see Section 1.5). However, it is not defined as part of the soil cover for other design calculations (infiltration, freeze/thaw, and cover erosion).

The following sections describe design considerations, complete with calculations performed and parameters utilized, in developing the tailings impoundment soil cover to meet regulatory requirements.

1.1 Radon Flux Attenuation

The Environmental Protection Agency (EPA) rules in 40 Code of Federal Regulation (CFR) Part 192 require that a "uranium tailings cover be designed to produce reasonable assurance that the radon-222 release rate would not exceed 20 pCi/m^2/sec for a period of 1,000 years to the extent reasonably achievable and in any case for at least 200 years when averaged over the disposal area over at least a one year period" (NRC, 1989). NRC regulations presented in 10 CFR Part 40 also restrict radon flux to less than 20 pCi/m^2/sec. The following sections present the analyses and design for a soil cover which meets this requirement.

1.1.1 Predictive Analysis

The soil cover for the tailings cells at White Mesa Mill was evaluated for attenuation of radon gas using the digital computer program, RADON, presented in the NRC's Regulatory Guide 3.64 (Task WM 503-4) entitled "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers". The RADON model calculates radon-222 flux attenuation by multi-layered earthen uranium mill tailings covers, and determines the minimum cover thickness required to meet NRC and EPA standards. The RADON model uses the following soil properties in the calculation process:

- Soil layer thickness [centimeters (cm)];
- Soil porosity (percent);
- Density [grams-per-cubic centimeter (gm/cm^3)];
- Weight percent moisture (percent);
- Radium activity (piC/g);
- Radon emanation coefficient (unitless); and

- Diffusion coefficient [square centimeters-per-second (cm^2/sec)].

Physical and radiological properties for tailings and random fill were analyzed by Chen and Associates (1987) and Rogers and Associates (1988). Clay physical data from Section 16 was analyzed by Advanced Terra Testing (1996) and Rogers and Associates (1996). See Appendix A for laboratory test data results.

The RADON model was performed for the following cover section (from top to bottom):

- two feet compacted random fill;
- one foot compacted clay; and
- a minimum of three feet random fill occupying the freeboard space between the tailings and clay layer.

The three layers are compacted to 95 percent maximum dry density. The top riprap layer was not included as part of the soil cover for the radon attenuation calculation.

The results of the RADON modeling exercise show that the uranium tailings cover configuration will attenuate radon flux emanating from the tailings to a level of 17.6 pCi/m^2/sec. This number was conservatively calculated as it takes into account the freeze/thaw effect on the uppermost part (6.8 inches) of the cover (Section 1.3). The soil cover and tailing parameters used to run the RADON model, in addition to the RADON input and output data files, are presented in Appendix B as part of the Radon Calculation brief. Based on the model results, the soil cover design of six-foot thickness will meet the requirements of 40 CFR Part 192 and 10 CFR Part 40.

1.1.2 Empirical Data

Radon gas flux measurements have been made at the White Mesa Mill tailings piles over Cells 2 and 3 (see Appendix C). These cells are currently covered with three to four feet of random fill. Radon flux measurements, averaged over the covered areas, were as follows (EFN, 1996):

	1994	1995
Cell 2	7.7 pCi/m^2/sec	6.1 pCi/m^2/sec
Cell 3	7.5 pCi/m^2/sec	11.1 pCi/m^2/sec

Empirical data suggest that the random fill cover, alone, is currently providing an effective barrier to Radon flux. Thus, the proposed tailings cover configuration, which is thicker, moisture adjusted, contains a clay layer and is compacted, is expected to attenuate the Radon flux to a level below that predicted by the RADON model. The field radon flux measurements confirm the conservatism of the cover design. This conservatism is necessary, however, to guarantee compliance with NRC regulations under long term climatic conditions over the required design life of 200 to 1,000 years.

1.2 Infiltration Analysis

The tailings ponds at White Mesa Mill are lined with synthetic geomembrane liners which under certain climatic conditions, could potentially lead to the long-term accumulation of water from infiltration of precipitation. Therefore, the soil cover was evaluated to estimate the potential magnitude of infiltration into the capped tailings ponds. The Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3.0 (EPA, 1994) was used for the analysis. HELP is a quasi two-dimensional hydrologic model of water movement across, into, through, and out of capped and lined impoundments. The model utilizes weather, soil, and engineering design data as input to the model, to account for the effects of surface storage, snowmelt, run-off, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, and unsaturated vertical drainage on the specific design, at the specified location.

The soil cover was evaluated based on a two-foot compacted random fill layer over a one-foot thick, compacted clay layer. The soil cover layers were modeled based on material placement at a minimum of 95 percent of the maximum dry density, and within two percent of the optimum moisture content per American society for Testing and Materials (ASTM) requirements. The top riprap layer and the bottom random fill layer were not included as part of the soil cover for infiltration calculations. These two layers are not playing any role in controlling the infiltration through the cover material.

The random fill will consist of clayey sands and silts with random amounts of gravel and rock-size materials. The average hydraulic conductivity of several samples of random fill was calculated, based on laboratory tests, to be 8.87×10^{-7} cm/sec. The hydraulic conductivity of the clay source from Section 16 was measured in the laboratory to be 3.7×10^{-8} cm/sec. Geotechnical soil properties and laboratory data are presented in Appendix A.

Key HELP model input parameters include:

- Blanding, Utah, monthly temperature and precipitation data, and HELP model default solar radiation, and evapotranspiration data from Grand Junction, Colorado. Grand Junction is located north east of Blanding in similar climate and elevation;
- Soil cover configuration identifying the number of layers, layer types, layer thickness, and the total covered surface area;
- Individual layer material characteristics identifying saturated hydraulic conductivity, porosity, wilting point, field capacity, and percent moisture; and
- Soil Conservation Service runoff curve numbers, evaporative zone depth, maximum leaf area index, and anticipated vegetation quality.

Water balance results, as calculated by the HELP model, indicate that precipitation would either run-off the soil cover or be evaporated. Thus, model simulations predict zero infiltration of surface water through the soil cover, as designed. These model results are conservative and take into account the freeze/thaw effects on the uppermost part (6.8 inches) of the cover (Section 1.3). The HELP model input and output for the tailings soil cover are presented in the HELP Model calculation brief included as Appendix D.

1.3 Freeze/Thaw Evaluation

The tailings soil cover of one foot of compacted clay covered by two feet of random fill was evaluated for freeze/thaw impacts. Repeated freeze/thaw cycles have been shown to increase the bulk soil permeability by breaking down the compacted soil structure.

The soil cover was evaluated for freeze/thaw effects using the modified Berggren equation as presented in Aitken and Berg (1968) and recommended by the NRC (U.S. Department of Energy, 1988). This evaluation was based on the properties of the random fill and clay soil, and meteorological data from both Blanding, Utah and Grand Junction, Colorado.

The results of the freeze/thaw evaluation indicate that the anticipated maximum depth of frost penetration on the soil cover would be less than 6.8 inches. Since the random fill layer is two feet thick, the frost depth would be confined to this layer and would not penetrate into the

underlying clay layer. The performance of the soil cover to attenuate radon gas flux below the prescribed standards, and prevent surface water infiltration, would not be compromised. The input data and results of the freeze/thaw evaluation are presented in the Effects of Freezing on Tailings Covers Calculation brief included as Appendix E.

1.4 Soil Cover Erosion Protection

A riprap layer was designed for erosion protection of the tailings soil cover. According to NRC guidance, the design must be adequate to protect the soil/tailings against exposure and erosion for 200 to 1,000 years (NRC, 1990). Currently, there is no standard industry practice for stabilizing tailings for 1,000 years. However, by treating the embankment slopes as wide channels, the hydraulic design principles and practices associated with channel design were used to design stable slopes that will not erode. Thus, a conservative design based on NRC guidelines was developed. Engineering details and calculations are summarized in the Erosion Protection Calculation brief provided in Appendix F.

Riprap cover specifications for the top and side slopes were determined separately as the side slopes are much steeper than the slope of the top of the cover. The size and thickness of the riprap on the top of the cover was calculated using the Safety Factor Method (NUREG/CR-4651, 1987), while the Stephenson Method (NUREG/CR-4651, 1987) was used for the side slopes. These methodologies were chosen based on NRC recommendations (1990).

By the Safety Factor Method, riprap dimensions for the top slope were calculated in order to achieve a slope "safety factor" of 1.1. For the top of the soil cover, with a slope of 0.2 percent, the Safety Factor Method indicated a median diameter (D_{50}) riprap of 0.28 inches is required to stabilize the top slope. However, this dimension must be modified based on the long-term durability of the specific rock type to be used in construction. The suitability of rock to be used as a protective cover must be assessed by laboratory tests to determine the physical characteristics of the rocks. The sandstones from the confluence of Westwater and Cottonwood Canyons require an oversizing factor of 25 percent. Therefore, riprap created from this sandstone source should have a D_{50} size of at least 0.34 inches and should have an overall layer thickness of at least three inches on the top of the cover.

Riprap dimensions for the side slopes were calculated using Stephenson Method equations. The side slopes of the cover are designed at 5H:1V. At this slope, Stephenson's Method indicated the unmodified riprap D_{50} of 3.24 inches is required. Again assuming that the on-site sandstone will be used, the modified D_{50} size of the riprap should be at least 4.05 inches with an overall layer thickness of at least 12 inches.

The potential of erosion damage due to overland flow, sheetflow, and channel scouring on the top and side slopes of the cover, including the riprap layer, has been evaluated. Overland flow calculations were performed using site meteorological data, cap design specifications, and guidelines set by the NRC (NUREG/CR-4620, 1986). These calculations are included in Appendix F. According to the guidelines, overland flow velocity estimates are to be compared to "permissible velocities", which have been suggested by the NRC, to determine the potential for erosion damage. When calculated, overland flow velocity estimates exceed permissible velocities, additional cover protection should be considered. The permissible velocity for the tailings cover (including the riprap layer) is 5.0 to 6.0 feet-per-second (ft./sec.) (NUREG/CR 4620). The overland flow velocity calculated for the top of the cover is less than 2.0 ft/sec., and the calculated velocity on the side slopes is 4.9 ft/sec. Therefore, the erosion potential of the slopes, due to overland flow/channel scouring, is within acceptable limits and no additional erosion protection is required.

1.5 Slope Stability Analysis

Static and pseudostatic analyses were performed to establish the stability of the side slopes of the tailings soil cover. The side slopes are designed at an angle of 5H:1V. Because the side slope along the southern section of Cell 4A is the longest and the ground elevation drops rapidly at its base, this slope was determined to be critical and is thus the focus of the stability analyses.

The computer software package GSLOPE, developed by MITRE Software Corporation, has been used for these analyses to determine the potential for slope failure. GSLOPE applies Bishop's Method of slices to identify the critical failure surface and calculate a factor of safety (FOS). The slope geometry and properties of the construction materials and bedrock are input into the model. These data and drawings are included in the Stability Analysis of Side Slopes Calculation brief included as Appendix G. For this analysis, competent bedrock is designated at 10 feet below the lowest point of the foundation [i.e., at a 5,540-foot elevation above mean sea

level (msl)]. This is a conservative estimate, based on the borehole logs supplied by Chen and Associates (1979), which indicate bedrock near the surface.

1.5.1 Static Analysis

For the static analysis, a FOS of 1.5 or more was used to indicate an acceptable level of stability. The calculated FOS is 2.91, which indicates that the slope should be stable under static conditions. Results of the computer model simulations are included in Appendix G.

1.5.2 Pseudostatic Analysis (Seismicity)

The slope stability analysis described above was repeated under pseudostatic conditions in order to estimate a FOS for the slope when a horizontal ground acceleration of 0.10g is applied. The slope geometry and material properties used in this analysis are identical to those used in the stability analysis. A FOS of 1.0 or more was used to indicate an acceptable level of stability under pseudostatic conditions. The calculated FOS is 1.903, which indicates that the slope should be stable under dynamic conditions. Details of the analysis and the simulation results are included in Appendix G.

Recently, Lawrence Livermore National Laboratory (LLNL) published a report on seismic activity in southern Utah, in which a horizontal ground acceleration of 0.12g was proposed for the White Mesa site. The evaluations made by LLNL were conservative to account for tectonically active regions that exist, for example, near Moab, Utah. Although, the LLNL report states that "...[Blanding] is located in a region known for its scarcity of recorded seismic events," the stability of the cap design slopes using the LLNL factor was evaluated. The results of a sensitivity analysis reveal that when considering a horizontal ground acceleration of 0.12g, the calculated FOS is 1.778 which is still above the required value of 1.0, indicating adequate safety under pseudostatic conditions. This analysis is also included in Appendix G.

1.6 Cover Material/Cover Material Volumes

Construction materials for reclamation will be obtained from on-site locations. Fill material will be available from the stockpiles that were generated from excavation of the cells for the tailings facility. If required, additional materials are available locally to the west of the site. A clay material source, identified in Section 16 at the southern end of the White Mesa Mill site, will be

used to construct the one-foot compacted clay layer. Riprap material will be taken from on-site sandstone, located at the confluence of Westwater and Cottonwood Canyons.

Material quantities have been calculated for each of the components of the reclamation cover. Volume estimates were made for the two soil cover design options, as follows:

- Option 1: an integrated soil cover which incorporates Disposal Cells 2, 3, and 4A, and
- Option 2: a cover which includes Cells 2 and 3, where Cell 4A tailings have been excavated and placed in Cell 3.

The quantity of random fill required to bring the pond elevation up to the soil cover subgrade and construct the final slope was not calculated. This layer will be a minimum of three feet in depth and is dependent on the final tailings grade, which is not known.

For Design Option 1, construction will require the following approximate quantities of materials:

Material	Volume (cubic yards)
Clay	365,082
Random Fill	737,717
Riprap (top of cover)	82,762
Riprap (side slopes)	41,588

For Design Option 2, construction will require the following approximate quantities of materials:

Material	Volume (cubic yards)
Clay	289,514
Random Fill	585,334
Riprap (top of cover)	64,984
Riprap (side slopes)	35,885

Material quantities calculations are provided in Appendix H as part of the Tailings Cover Material Volume Calculation brief.

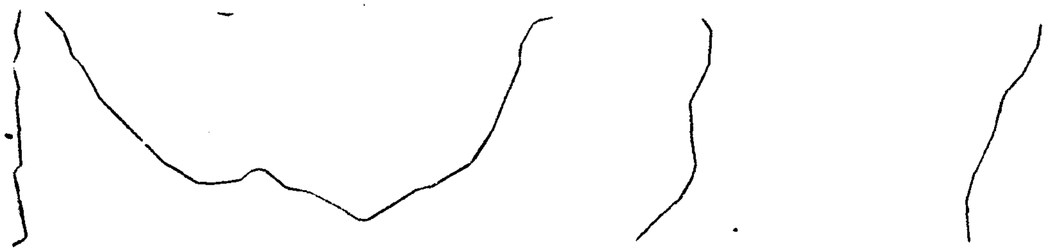
RECLAMATION COVER
GRADING PLAN FOR CELLS 2, 3 & 4A

PREPARED FOR

ENERGY FUELS NUCLEAR
BLANDING, UTAH

TITAN Environmental

DATE:	8-12-96	FIGURE 1	DRAWING NUMBER 6111-E1	1
SCALE:	AS SHOWN			



RECLAMATION COVER
GRADING PLAN FOR CELLS 2 & 3

PREPARED FOR

ENERGY FUELS NUCLEAR
BLANDING, UTAH

TITAN Environmental

ATE:	8–12–96	FIGURE 2	DRAWING NUMBER	1
CALE:	AS SHOWN		6111–E2	

HORIZONTAL SCALE

200 0 200 400 FEET

RECLAMATION COVER
CROSS SECTIONS & DETAILS
PREPARED FOR

ENERGY FUELS NUCLEAR
BLANDING, UTAH

TITAN Environmental

DATE:	8-12-96	FIGURE 3	DRAWING NUMBER	1
SCALE:	AS SHOWN		6111-E3	

HORIZONTAL SCALE

200 0 200 400 FEET

RECLAMATION COVER
CROSS SECTIONS & DETAILS
PREPARED FOR

ENERGY FUELS NUCLEAR
BLANDING, UTAH

TITAN Environmental

DATE:	8-12-96	FIGURE 4	DRAWING NUMBER 6111-E4	1
SCALE:	AS SHOWN			

APPENDIX A

Laboratory Test Data

Table 3.4-1

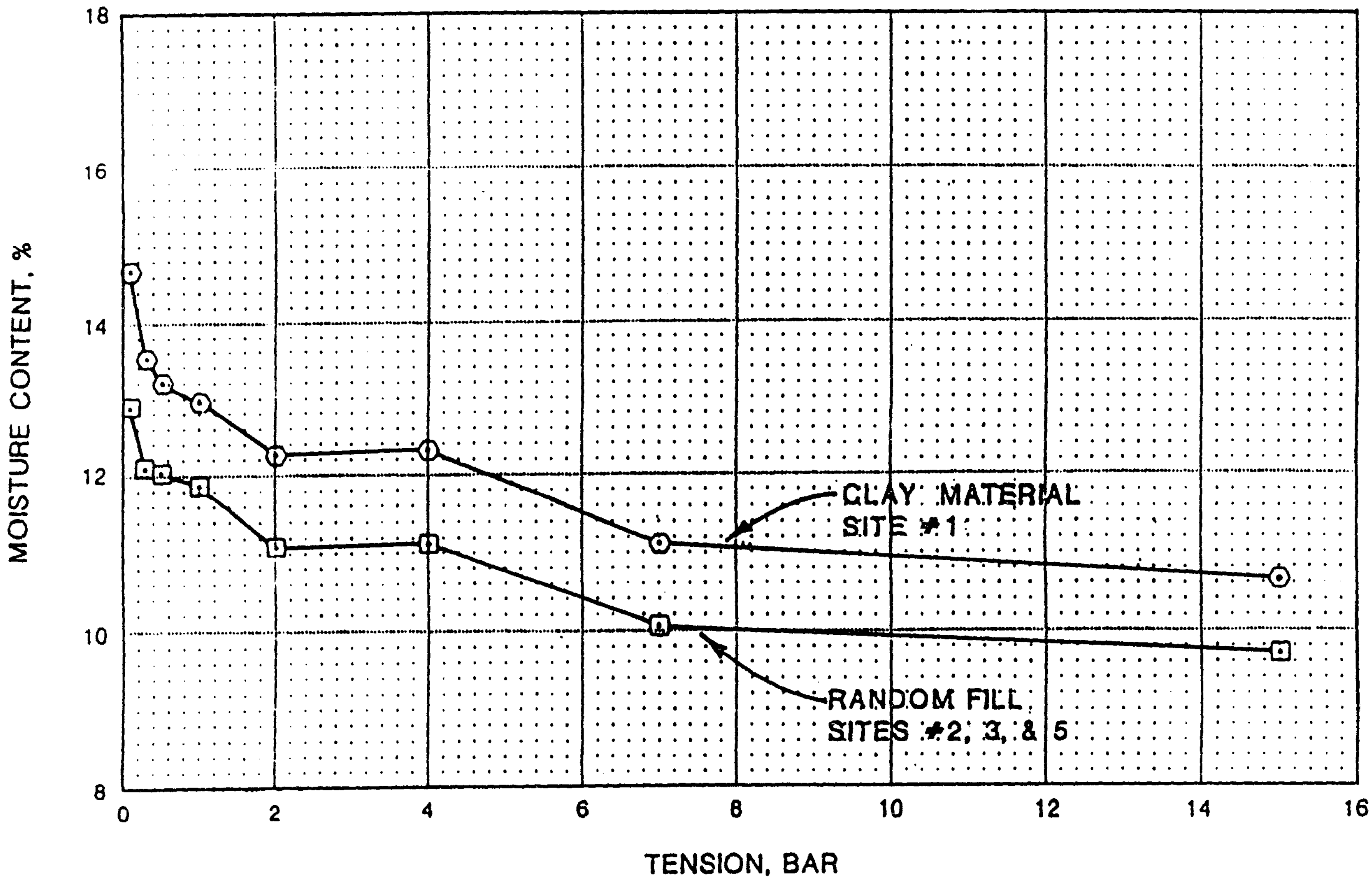
Physical Properties of Tailings

and

Proposed Cover Material

Material Type	Atterberg Limits LL	Atterberg Limits PI	Specific Gravity	% Passing No. 200 Sieve	Maximum Dry Density (pcf)	Optimum Moisture Content
Tailings	28	6	2.85	46	104.0	18.1
Random Fill	22	7	2.67	48	120.2	11.8

Note: Physical Soil Data from Chen and Associates (1987).

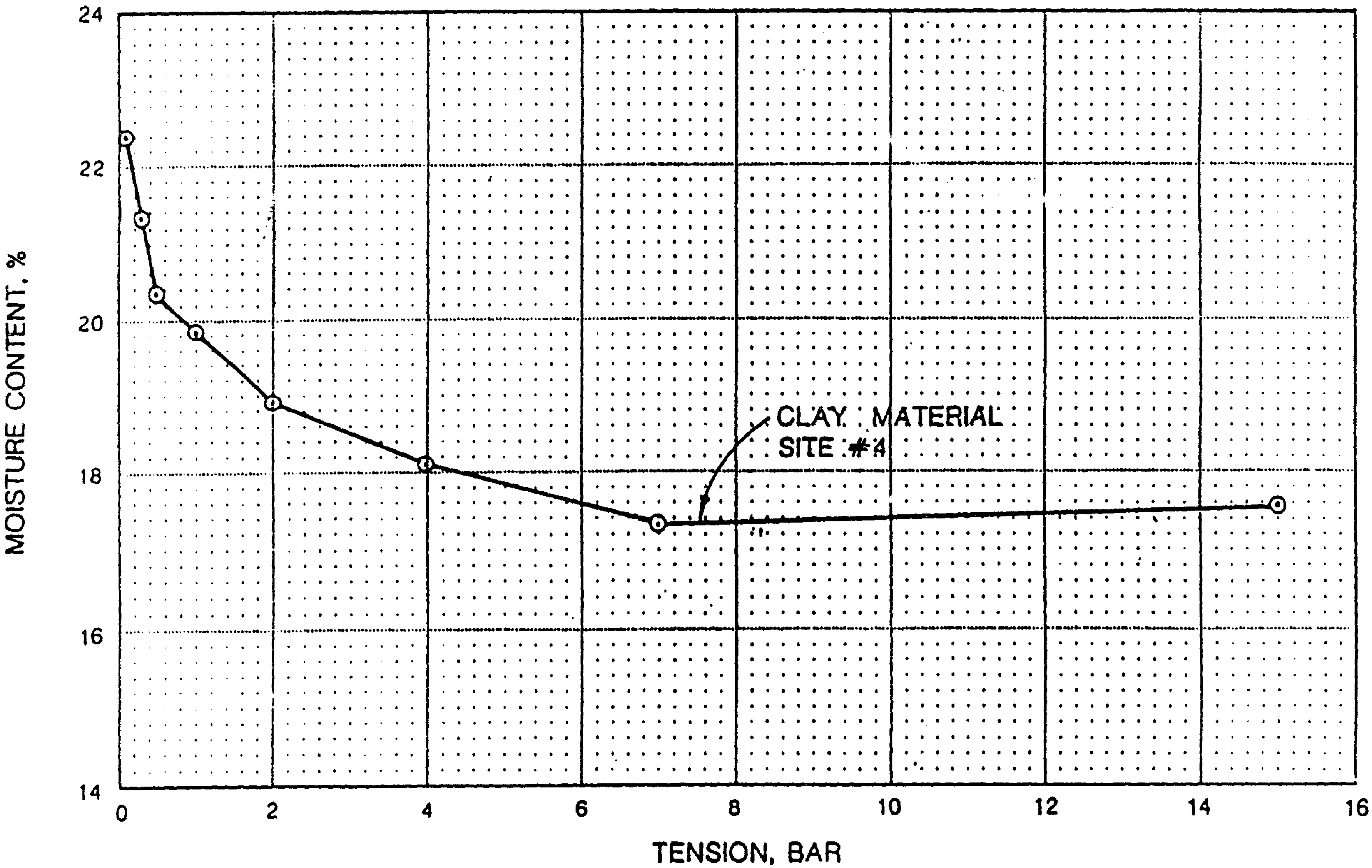


SUMMARY OF CAPILLARY MOISTURE RELATIONSHIP TEST RESULTS

WHITE MESA PROJECT

FIGURE 3.5-1

DATA FROM CHEN & ASSOCIATES



SUMMARY OF CAPILLARY MOISTURE
RELATIONSHIP TEST RESULTS
WHITE MESA PROJECT

DATA FROM CHEN & ASSOCIATES

FIGURE 3.5-2

SECTION 6

ROGERS AND ASSOCIATES ENGINEERING
CORPORATION

Letter Dated March 4, 1988
Letter Dated May 9, 1988

Radiological Properties

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110
(801) 263-1600

March 4, 1988

Mr. C.O.Sealy
Umetco Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

C8700/22

Dear Mr. Sealy:

We have completed the tests ordered on the four samples shipped to us. The results are as follows:

Sample	Radium pCi/gm	Emanation Fraction	Diffusion Coeffic.	(g/cm^3) Density	Moisture	Saturation
Tailings	981±4	0.19±0.01	2.0E-02	1.45	13.2	0.39
			8.4E-03	1.44	19.1	0.56
Composite (2,3,&5)			1.6E-02	1.85	6.5	0.40
			4.5E-04	1.84	12.5	0.75
Site #1			1.6E-02	1.85	8.1	0.48
			1.4E-03	1.84	12.6	0.76
Site #4			1.1E-02	1.65	15.4	0.63
			4.2E-04	1.65	19.3	0.80

The samples will be shipped back to you in the next few weeks. If you have any questions regarding the results on the samples please feel free to call.

Sincerely,

Renee Y. Bowser
Lab Supervisor

RYB/b

515 East 4500 South - Salt Lake City, Utah 84107

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110
(801) 263-1600

MAY 12 1988

May 9, 1988

Mr. C.O. Sealy
UMETCO Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

C8700/22

Dear Mr. Sealy:

The tests for radium content and radon emanation coefficient in the following samples have been completed and the results are as follows:

Sample	Radium (pCi/g)	Radon Emanation Coefficient
Random (2,3 & 5)	1.9 ± 0.1	0.19 ± 0.04
Site 1	2.2 ± 0.1	0.20 ± 0.03
Site 4	2.0 ± 0.1	0.11 ± 0.04

If you have any questions regarding these results please feel free to call Dr. Kirk Nielson or me.

Sincerely,

Renee Y. Bowser
Lab Supervisor

RYB:ms

ADVANCED TERRA TESTING inc

833 Parfet Street
Lakewood, Colorado 80215
(303) 232-8308

ATTERBERG LIMITS TEST

ASTM D 4318

CLIENT Titan Env.

JOB NO. 2234-04

BORING NO.

DEPTH

DATE SAMPLED

DATE TESTED 7-25-96 WEB, RV

SAMPLE NO. UT-1

SOIL DESCR.

TEST TYPE ATTERBERG

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	3.34	4.06	3.42
Wt Dish & Dry Soil	2.96	3.57	3.03
Wt of Moisture	0.38	0.49	0.39
Wt of Dish	1.05	1.11	1.06
Wt of Dry Soil	1.91	2.46	1.97
Moisture Content	19.90	19.92	19.80

Liquid Limit Determination Device Number 0258

	1	2	3	4	5
Number of Blows	39	27	18	14	9
Wt Dish & Wet Soil	12.18	10.42	10.92	12.33	10.06
Wt Dish & Dry Soil	6.64	5.67	5.87	6.53	5.34
Wt of Moisture	5.54	4.75	5.05	5.80	4.72
Wt of Dish	1.10	1.06	1.06	1.10	1.08
Wt of Dry Soil	5.54	4.61	4.81	5.43	4.26
Moisture Content	100.00	103.04	104.99	106.81	110.80

Liquid Limit 103.1

Plastic Limit 19.9

Plasticity Index 83.3

Atterberg Classification CH

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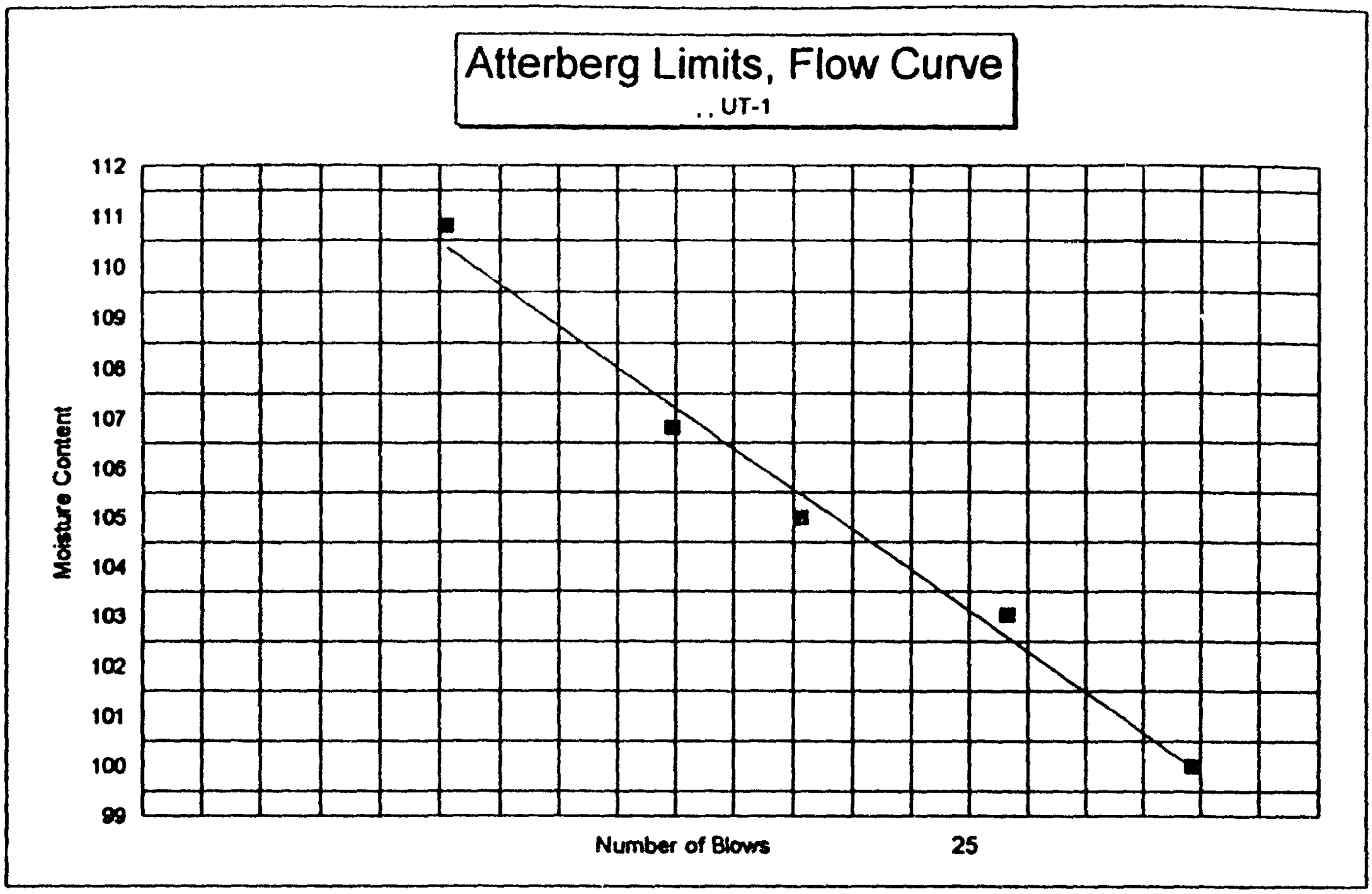
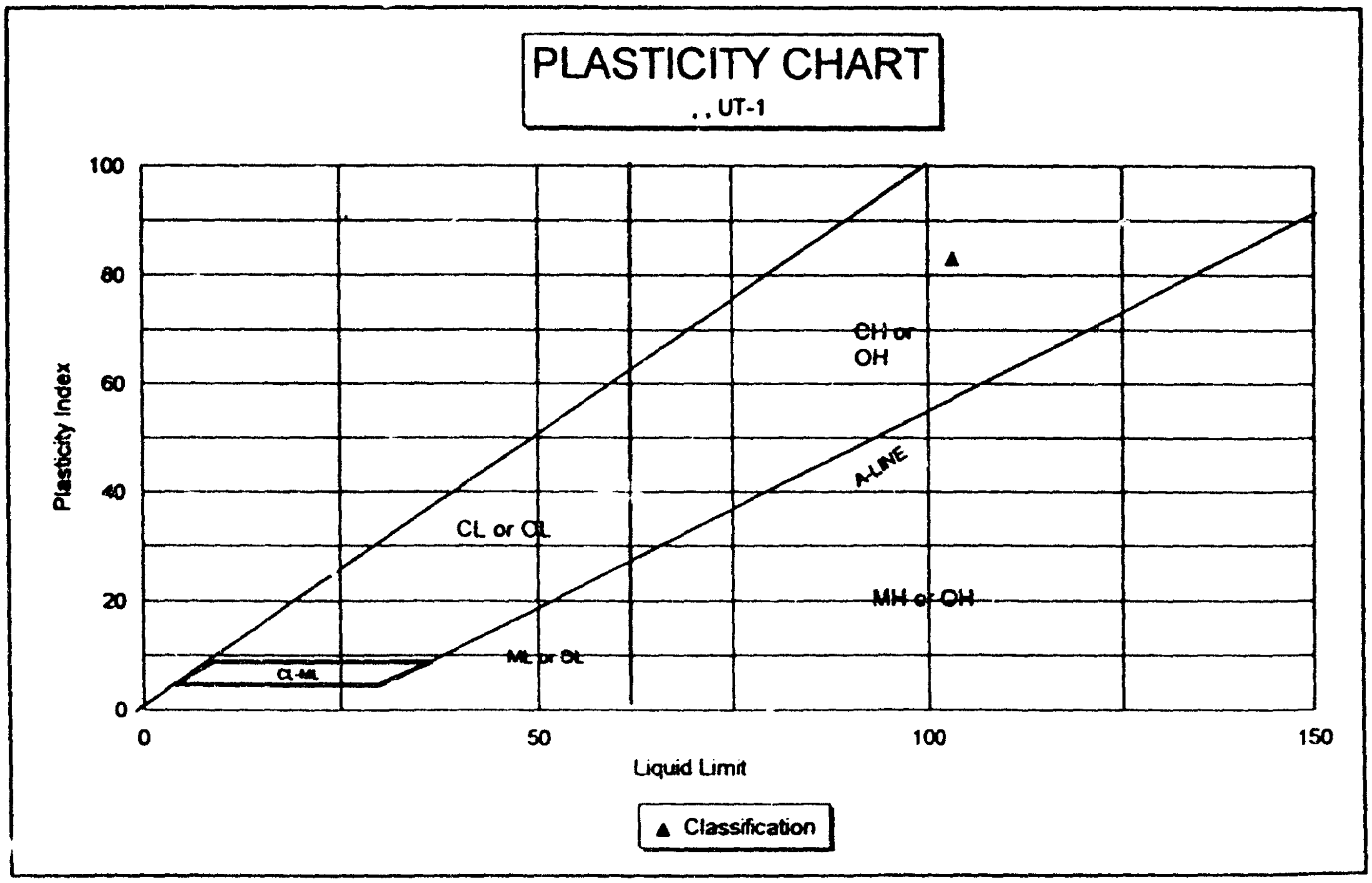
Checked by: [signature] Date: 7-26-96

FileName: TIGOUT1

ADVANCED TERRA TESTING, INC.


Atterberg Limits, Flow Curve
, , UT-1
112
111
110
109
108
107
106
105
104
103
102
101
100
99
Moisture Content
Number of Blows
25


PLASTICITY CHART
, , UT-1
100
80
60
40
20
0
Plasticity Index
0
50
100
150
Liquid Limit
CH or
OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
Classification

COMPACTION TEST
ASTM D 1557 A

CLIENT: Titan Env.

JOB NO. 2234-04

BORING NO.
PTH
SAMPLE NO. UT-1

SOIL DESCR.
DATE SAMPLED
DATE TESTED 7-25-96 RV

Moisture determination

	1	2	3	4	5
Wt of Moisture added (ml)	100.00	150.00	250.00	350.00	450.00
Wt. of soil & dish (g)	384.26	393.92	291.42	244.20	281.17
Dry wt. soil & dish (g)	350.60	355.61	251.40	202.69	225.04
Net loss of moisture (g)	33.66	38.31	40.02	41.51	56.13
Wt. of dish (g)	8.01	8.34	8.31	8.29	8.43
Net wt. of dry soil (g)	342.59	347.27	243.09	194.40	216.61
Moisture Content (%)	9.83	11.03	16.46	21.35	25.91
Corrected Moisture Content					

Density determination

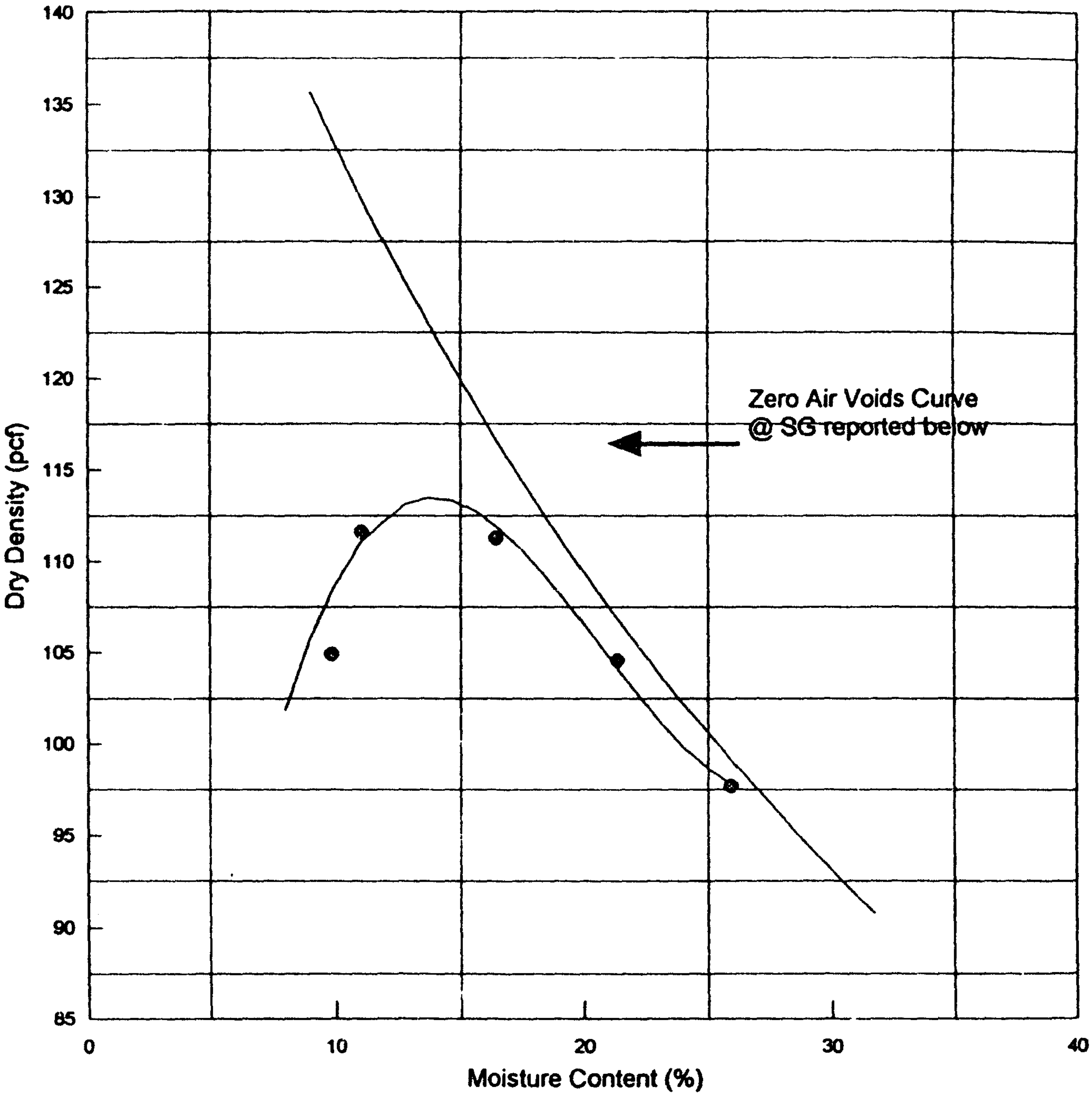
Wt of soil & mold (lb)	14.20	14.49	14.68	14.59	14.46
Wt. of mold (lb)	10.36	10.36	10.36	10.36	10.36
Net wt. of wet soil (lb)	3.84	4.13	4.32	4.23	4.10
Net wt. of dry soil (lb)	3.50	3.72	3.71	3.49	3.26
Dry Density, (pcf)	104.89	111.59	111.28	104.57	97.69
Corrected Dry Density (pcf)					
Volume Factor	30	30	30	30	30

Data entered by: RV Date: 7-26-96
Data checked by: [illegible] Date: 7-26-96
FileName: TIPRUT-1

ADVANCED TERRA TESTING, INC

Proctor Compaction Test

, , UT-1



- Best Fit Curve
- Actual Data
- Zero Air VoidsCurve @ SG = 2.70

OPTIMUM MOISTURE CONTENT = 13.9 MAXIMUM DRY DENSITY = 113.5
ASTM D 1557 A, Rock correction applied? N

ADVANCED TERRA TESTING, INC.

PERMEABILITY DETERMINATION
FALLING HEAD
FIXED WALL

CLIENT Titan Environmental

JOB NO. 2234-04

BORING NO.
DEPTH
SAMPLE NO. UT-1
SOIL DESCR. Remolded 95% Mod Pt. @ OMC
SURCHARGE 200

SAMPLED
TEST STARTED 7-28-96 CAL
TEST FINISHED 8-7-96 CAL
SETUP NO. 1

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil & Ring(s) (g)	386.9	404.5
Wt. Ring(s) (g)	93.0	93.0
Wt. Soil (g)	293.9	311.4
Wet Density PCF	122.3	120.5
Wt. Wet Soil & Pan (g)	302.4	319.9
Wt. Dry Soil & Pan (g)	266.2	266.2
Wt. Lost Moisture (g)	36.2	53.8
Wt. of Pan Only (g)	8.5	8.5
Wt. of Dry Soil (g)	257.7	257.7
Moisture Content %	14.1	20.9
Dry Density PCF	107.2	99.7
Max. Dry Density PCF	113.5	113.5
Percent Compaction	94.4	87.8

ELAPSED TIME (MIN)	BURETTE READING h1 (CC)	BURETTE READING h2 (CC)	PERCOLATION RATE FT/YEAR	PERCOLATION RATE CM/SEC
	0.2			
2599	10.8	10.8	0.14	1.4E-07
1427	14.2	14.2	0.09	8.4E-08
1440	16.8	16.8	0.07	6.5E-08
1440	18.6	18.6	0.05	4.6E-08
1440	20.2	20.2	0.04	4.1E-08
1440	21.6	21.6	0.04	3.7E-08
1469	23.0	23.0	0.04	3.6E-08
1440		24.4	0.04	3.7E-08

Data Entered By: NAA Date: 8-8-96
Date Checked By: JW Date: 8-8-96
Filename:TIFHUT1

ADVANCED TERRA TESTING, INC.

RAE

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110-0330
(801) 263-1600 • FAX (801) 262-1527

September 3, 1996

Pamela Anderson
Titan Environmental Corporation
7939 E. Arapahoe Rd., Suite 230
Englewood, CO 80112

C9600/9

Dear Ms. Anderson:

Enclosed are the results from the radium content, specific gravity, and radon emanation and diffusion coefficient measurements that were performed on the sample sent to our laboratory. We will be returning the sample within the month.

If you have any questions or if we can be of further assistance, please call.

Sincerely,

Bret Rogers

Bret C. Rogers
Scientist

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS
(TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

Report Date: 9/3/96
Contract: C9600/9
By: BCR
Date Received: 8/96

Sample Identification: Titan Environmental

Sample ID	Moisture (Dry Wt. %)	Density (g/cm^3)	Radon Diffusion Coefficient (cm^2/s)	Saturation ($M\rho/P$)	Specific Gravity (g/cm^3)
UT-1	14.5%	1.72	9.1E-03	0.89	2.39

RAE

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Salt Lake City • Utah 84110
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Rogers & Associates Engineering Corporation

REPORT OF RADIUM CONTENT AND EMANATION COEFFICIENT MEASUREMENTS

(LAB PROCEDURE RAE-SQAP-3.1)

Report Date: 9/3/96
Contract: C9600/9
By: BCR
Date Received: 8/96

Sample Identification: Titan Environmental

Sample ID	Moisture (Dry Wt. %)	Radon Emanation Coefficient	Radium-226 (pCi/g)	Comments
UT-1	14.6%	0.22 ± 0.04	1.5 ± 0.3	

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SOIL & FOUNDATION ENGINEERING
96 S. ZUNI • DENVER, COLORADO 80223 • 303/744-7105
1924 EAST FIRST STREET • CASPER, WYOMING 82601 • 307/234-2126

SECTION 2

Extracted Data From

SOIL PROPERTY STUDY
EARTH LINED TAILINGS RETENTION CELLS
WHITE MESA URANIUM PROJECT
BLANDING, UTAH

Prepared for:

ENERGY FUELS NUCLEAR, INC.

PARK CENTRAL
1515 ARAPAHOE STREET
DENVER, COLORADO 80202

Job No. 16,406

July 18, 1978

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Test Hole	Depth (Ft.)	Natural: Moisture Content (%)	Natural: Dry Density (pcf)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plasticity Index (%)	Gradation Analysis: Maximum Size	Gradation Analysis: Passing #200 (%)	Gradation Analysis: Less than 2 μ (%)	Remolded: Dry Density (pcf)	Remolded: Moisture Content (%)	Permeability: ft./yr.	Permeability: cm./sec.	Specific Gravity	Soil Type
2	0-5			117.5	10.8	20	3	#16	58	19	111.6	16.4	0.57	5.5×10^{-7}		Sandy Silt
3	7-8	7.2				21	6	#16	62							Sandy Clayey Silt
5	7½-10			104.1	18.5	33	8	3/4 In.	56	12	102.1	22.0	0.085	8.2×10^{-8}	2.65	Calcareous Silty Clay
6	1-2	10.3				25	7	#16	77							Sandy Clayey Silt
6	8½-9	6.1				27	8	#4	70							Sandy Clay
8	5-5½	13.1					NP	3/4 In.	62							Calcareous Sandy Silt
9	0-1	8.1					NP	#16	53							Sand - Silt
10	4-6½					24	10	#4	73							Sandy Clay
11	5½-6½	14.0				26	6	#16	65							Siltstone-Claystone
12	2-5			101.0	20.6	53	35	#16	8	59	95.0	18.3	0.068	6.6×10^{-8}	2.67	Weathered Claystone
13	7-8	13.1				39	13	#8	84							Calcareous Silt Clay
14	1-2	19.3				40	21	#4	89							Weathered Claystone
15	1½-4½			106.8	19.0	26	8	3/8 In.	65	27	103.4	18.0	0.012	1.2×10^{-8}	2.64	Mod. Calcareous Sandy Clay
17	2-3	11.4				19	4	#8	59							Sandy Silt
19	0-3			117.5	12.8	23	6	#16	70		109.9	12.4	0.035	3.4×10^{-8}		Sandy Clayey Silt
22	1-2	13.2				26	10	#4	73							Sandy Clay
23	1-3					48	24	#30	87							Weathered Claystone
23	6-8					61	30	#30	96							Claystone
25	1-3½	13.3				26	9	#4	57							Sandy Clay
26	4½-5	15.3				41	20	#4	91							Weathered Claystone
28	0-2	12.7				28	10	3/8 In.	72							Sandy Clay
29	2-3	8.5				19	2	#16	59							Sandy Silt
32	8-8½	5.6				23	6	#30	73							Sandy Clayey Silt
37	0-4			118.8	11.5	23	5	#8	72		110.5	11.5	0.63	6.1×10^{-7}		Sandy Clayey Silt
38	5-7			111.0	16.7	29	14	3/8 In.	69		102.4	17.9	0.041	4.0×10^{-8}		Sandy Clay
40	4-5½			110.0	16.2	26	9	#8	64	27	106.4	16.4	0.017	1.6×10^{-8}	2.65	Sandy Clay

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Test Hole	Depth (Ft.)	NATURAL		Maximum Dry Density	Optimum Moisture Content	ATTERBERG LIMITS		GRADATION ANALYSIS			REMOLDED		PERMEABILITY		Specific Gravity	Soil Type
		Moisture Content (%)	Dry Density (pcf)	(pcf)	(%)	Liquid Limit (%)	Plasticity Index (%)	Maximum Size	Passing #200 (%)	Less than 2 μ (%)	Dry Density (pcf)	Moisture Content (%)	ft./yr.	cm./sec.		
40	9-9½	6.8				22	8	3/8 In.	60							Sandy Clay
42	13½-14½	7.6				26	10	3/8 In.	73							Sandy Clay
43	11-12	12.1				41	22	#4	86							Claystone
43	13½-16½			110.0	16.9	40	24	3/8 In.	85	44	104.1	15.8	0.024	2.3×10^{-8}	2.62	Claystone
44	6½-7	7.5				30	11	3/8 In.	79							Calcareous Sandy Clay
46	0-2	12.3				22	6	#16	76							Sandy Clayey Silt
48	5-5½					30	9	3/8 In.	65							Sandy Clay
49	5-7			110.7	15.6	25	9	#16	71		105.2	13.9	0.33	3.2×10^{-8}		Sandy Clay
49	14-15					28	5	#8	55							Calcareous Sandy Silt
54	0-2	12.1				23	9	#8	64							Sandy Clay
55	5-5½	7.8				28	14	#30	71							Sandy Clay
55	9½-10½					28	13	#4	71							Sandy Clay
58	5½-6	12.5				35	11	#4	75							Sandy, Silty Clay
61	0-1	11.5				21	4	#16	75							Sandy Silt
62	11-11½	8.1					NP	1 In.	34							Calcareous Sand & Silt
63	4-5					30	14	#8	68							Sandy Clay
65	1-2	9.0					NP	#16	44							Silty Sand
68	7½-8	8.6				28	13	#8	67							Sandy Clay
70	3½-4½	16.4				27	4	1½ In.	46							Calcareous Sand & Silt
72	0-2	12.2				22	8	#16	59							Sandy Clay
75	10-11	12.4				41	25	#4	75							Weathered Claystone
75	12-14					45	22	#16	93							Claystone

416,406

TABLE II

LABORATORY PERMEABILITY TEST RESULTS

Sample	Soil Type	Compaction Dry Density (pcf)	Compaction Moisture Content (%)	Compaction % of ASTM D698	Surcharge Pressure (psf)	Permeability (Ft/Yr)	Permeability (Cm/
TH 2 @ 0'-5'	Sandy Silt	111.6	16.4	95	500	0.57	5.5x1
TH 5 @ 7½'-10'	Calcareous Silty Clay	102.1	22.0	101	500	0.085	8.2x1
TH 12 @ 2'-5'	Weathered Claystone	95.0	18.3	94	500	0.068	6.6x1
TH 15 @ 1½'-4½'	Calcareous Sandy Clay	103.4	18.0	97	500	0.012	1.2x1
TH 19 @ 0'-3'	Sandy, Clayey Silt	109.9	12.4	94	500	0.035	3.4x1
TH 37 @ 0'-4'	Sandy, Clayey Silt	110.5	11.5	93	500	0.63	6.1x1
TH 38 @ 5'-7'	Sandy Clay	102.4	17.9	92	500	0.041	4.0x1
TH 40 @ 4'-5½'	Sandy Clay	106.4	16.4	97	500	0.017	1.6x1
TH 43 @ 13½-16½'	Claystone	104.1	15.8	95	500	0.024	2.3x1
TH 49 @ 5'-7'	Sandy Clay	105.2	13.9	95	500	0.33	3.2x1

TABLE III

RESULTS OF ATTERBERG LIMITS

SAMPLE	SOIL TYPE	PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS Liquid Limit (%)	Plastic Limit (%)	Shrinkage Limit (%)	SHRINKAGE RATIO
2 @ 0 - 5'	Sandy Silt	58	20	17	17.	1.81
5 @ 7½ - 10'	Calcareous Silty Clay	56	33	25	25	1.62
15 @ 1½-4½'	Calcareous Sandy Clay	65	26	18	17.5	1.76
19 @ 0-3'	Sandy, Clayey Silt	70	23	17	18	1.80
26 @ 4½-5'	Weathered Claystone	91	41	21	12	1.90
38 @ 5 - 7'	Sandy Clay	69	29	15	14	1.89

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SECTION 3

Extracted Data From

SOIL PROPERTY STUDY
PROPOSED TAILINGS RETENTION CELLS
WHITE MESA URANIUM PROJECT
BLANDING, UTAH

Prepared for:

ENERGY FUELS NUCLEAR, INC.
1515 ARAPAHOE STREET
DENVER, COLORADO 80202

Job No. 17,130

January 23, 1979

CHEN AND ASSOCIATES

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	TRIAXIAL SHEAR TESTS		PERCENT PASSING NO. 200 SIEVE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
76	0 - 1	4.5		21	5				78	Sandy silt
	9.5 - 10	4.4			NP				26	Silty, gravelly sand
77	7.5 - 8	8.6		30	15				71	Sandy clay
79	0 - 1	4.1		20	5				83	Sandy silt
	5 - 5.5	5.5			NP				4[illegible]	Calcareous sandy clay
80	4.5 - 7			39	20				78	Calcareous sandy clay
	8 - 8.5	10.1		40	20				86	Weathered claystone
81	3 - 4	6.3		26	8				64	Silty, sandy clay
83	4 - 6			24	7				64	Sandy, clayey silt
84	0 - 2			18	2				65	Sandy silt
	9 - 9.5	2.7			NP				27	Silty sand
86	8 - 8.5	2.6			NP				12	Sandstone
87	0 - 1	3.1		16	1				61	Sandy silt
89	0 - 3			21	5				66	Sandy silt
90	8 - 8.5	12.9		35	15				61	Weathered claystone
92	0 - 1	5.9		21	5				80	Sandy silt
94	5 - 5.5	13.7		27	10				68	Sandy clay
95	6 - 7			23	5				62	Sandy silt
96	0 - 2	5.2		21	4				79	Sandy silt
	8.5 - 9.5			32	6				66	Calcareous sandy clay
98	0 - 1	3.8		20	5				74	Sandy silt
	4 - 4.5	17.8		49	25				76	Weathered claystone
99	8 - 9.5			40	20				89	Weathered claystone

CHEN AND ASSOCIATES

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 PASSING NO. 200 SIEVE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
99	11 - 12	13.5		26	10				73	Claystone
100	0 - 1			17	NP				44	Silty sand
	5.5 - 6	12.0			NP				61	Sandstone-siltstone
102	6.5 - 7	16.7		30	8				79	Calcareous sandy cla
	13.5 - 14	9.5		23	6				87	Claystone-siltstone
103	10 - 10.5	7.0		28	12				57	Sandy clay
104	8 - 8.5	9.2		33	9				70	Calcareous sandy clay
105	0 - 1	5.4		22	6				77	Sandy silt
	6.5 - 7	4.5			NP				86	Sandy silt
106	5 - 5.5	10.4		28	6				59	Claystone-sandstone
107	7.5 - 9				NP				23	Sandstone
108	0 - 1	4.0		18	3				69	Sandy silt
	9.5 - 10	9.9		38	16				93	Claystone
109	4 - 5			25	7				75	Sandy, clayey silt
111	9 - 9.5	5.8		25	10				53	Claystone
113	5 - 8			40	20				84	Weathered claystone
	10.5 - 11			24	10				54	Claystone-sandstone
114	0 - 2			22	6				58	Sandy, clayey silt
115	4.5 - 6				NP				58	Calcareous
116	0 - 3			22	5				72	Sandy silt
	7 - 8			24	10				42	Claystone-sandstone
117	1 - 2	10.6		25	5				77	Sandy silt
118	0 - 2			25	6				77	Sandy silt

CHEN AND ASSOCIATES

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 PASSING NO. 200 SIEVE	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DEVIATOR STRESS (PSF)	CONFINING PRESSURE (PSF)		
118	6.5 - 8.5			40	20				89	Weathered claystone
119	4.5 - 5	10.0		26	12				68	Sandy clay
120	1 - 2			25	8				69	Sandy, clayey silt
	5 - 5.5	15.5		29	10				78	Sandy clay
	11 - 11.5	11.6		42	24				90	Claystone
122	4 - 6			25	8				66	Sandy, silty clay
	14.5 - 15	6.4		26	8				66	Sandy clay
123	1 - 3			23	7				71	Sandy, clayey silt
124	4.5 - 5	6.0		23	7				69	Sandy, clayey silt
125	0 - 1	3.8		22	6				67	Sandy silt
127	5 - 6			54	34				89	Claystone
128	6 - 8			41	24				90	Claystone

.E 11

LABORATORY PERMEABILITY TEST RESULTS

Sample	Classification	Compaction: Dry Density (pcf)	Compaction: Moisture Content (%)	Compaction: % of ASTM D698	Surcharge Pressure (psf)	Permeability Ft./Yr.	Permeability Cm/Sec
TH 80 @ 4½-7'	Calcareous sandy clay -200=78; LL=39; PI=20	100.2	19.4	96	500	0.81	7.8×10^{-7}
TH 84 @ 0-2'	Sandy silt -200=65; LL=18; PI=2	113.8	11.7	96	500	4.45	4.3×10^{-6}
TH 96 @ 8½-9½'	Calcareous sandy clay -200=66; LL=32; PI=6	96.9	20.7	97	500	1.55	1.5×10^{-6}
TH 96 @ 8½-9½'	Calcareous sandy clay	95.7	20.3	96	500	26.90*	2.6×10^{-5}
TH 99 @ 8-9½'	Weathered claystone -200=89; LL=40; PI=20	99.8	18.5	95	500	0.22	2.1×10^{-7}
TH 100 @ 0-1'	Very silty sand -200=44; PI=NP	117.5	9.7	98	500	0.38	3.7×10^{-7}
TH 114 @ 0-2'	Sandy, clayey silt -200=58; LL=22; PI=6	112.4	12.9	95	500	0.60	5.8×10^{-7}
TH 120 @ 1-2'	Sandy, clayey silt -200=69; LL=24; PI=6	108.2	14.7	95	500	0.11	1.1×10^{-7}
TH 122 @ 4-6'	Sandy, silty clay -200=66; LL=25; PI=8	108.8	15.5	96	500	0.43	4.2×10^{-7}
TH 123 @ 1-3'	Sandy, clayey silt -200=71; LL=23; PI=7	110.9	12.6	95	500	0.56	5.4×10^{-7}
TH 128 @ 6-7'	Claystone -200=89; LL=41; PI=24	92.4	23.9	93	500	0.12	1.2×10^{-7}
TH 128 @ 6-7'	Claystone -200=89; LL=41; PI=4	93.1	22.1	94	500	0.52*	5.0×10^{-7}*

* 1.5 pH sulfuric acid liquor used during percolation test interval.

T/B 10/6/94

1/2

MRAP - [illegible] - GEOTECHNICAL DATA BASE FOR MONTICELLO MILLSITE CHARACTERIZATION - [illegible]; CREATED [illegible]; LAST UPDATED [illegible]

AREA	DATA SOURC	BORING OR TEST PIT NUMBER	SAMPLE NUMBER & TYPE	TOP OF SAMPLE (FEET)	BASE OF SAMPLE (FEET)	SAMPLE MIDPOINT (FEET)	USCS SYMBOL	MATERIAL TYPE	IN-PLACE DRY DENSITY (PCF)	NATURAL MOISTURE CONTENT (PERCENT)	SPECIFIC GRAVITY	FRACTION PASSING #4 SIEVE (PERCENT)	FRACTION PASSING #200 SIEVE (PERCENT)	LIQUID LIMIT	PLASTICITY INDEX	ASTM D 698 MAXIMUM DRY DENSITY (PCF)	ASTM D 698 OPTIMUM MOISTURE CONTENT (PERCENT)	OTHER TESTS
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL-ML(?)	Tailings(?)	69.8	4.6	2.67	100.0	97.0	NP	NP	NA	NA	Consolidation, CoH @15 bar
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	107.0	4.9	2.62	100.0	40.0	NP	NP	NA	NA	Consolidation, CoH @16 bar
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ML	Clay	NA	NA	NA	100.0	67.0	NA	NA	114.7	14.0	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP	Tailings	NA	NA	NA	NA	NA	NA	NA	102.0	13.0	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SC(?)	Tailings	NA	NA	2.70	NA	NA	NA	NA	94.0	20.3	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL-ML	Tailings/Alluvium	38.1	27.4	2.67	100.0	84.0	38.0	4.0	NA	NA	Consolidation, CoH @16 bar
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Tailings	NA	30.4	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP-SM	Tailings	NA	2.3	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP-SM	Tailings	NA	5.4	2.80	100.0	11.4	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP-SM	Tailings	NA	4.5	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	5.8	NA	100.0	16.1	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	14.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL-ML/SM	Tailings/Alluvium	NA	27.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	3.7	2.60	100.0	15.6	NP	NP	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	6.3	NA	100.0	22.5	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	8.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	8.6	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ML/SM	Tailings/Alluvium	NA	30.9	NA	NA	NA	NP	NP	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL-ML/SM	Tailings/Alluvium	NA	21.5	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL-ML/SC	Tailings/Alluvium	NA	22.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP-SM	Tailings	NA	24.2	2.70	100.0	9.7	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings/Alluvium	NA	22.3	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings/Alluvium	NA	25.2	NA	100.0	14.0	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	26.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	26.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	23.0	NA	NA	NA	30.5	16.2	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	22.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	20.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	[illegible]	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SC-GC(?)	Gravel(?)	NA	10.3	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	12.4	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	20.1	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings/Alluvium(?)	NA	20.7	NA	98.2	12.6	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tailings	80.8	20.4	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP-SM	Tailings	NA	21.3	NA	100.0	7.0	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP-SM	Tailings	92.6	7.2	NA	100.0	10.2	NA	NA	NA	NA	Triax-CU/PP
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	82.0	6.8	NA	100.0	21.0	NA	NA	NA	NA	Triax-CU/PP, Perm
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	97.1	7.1	NA	100.0	10.3	NA	NA	NA	NA	Triax-CU/PP
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	11.0	2.70	100.0	14.6	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SP	Tailings	NA	20.4	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	20.5	NA	NA	NA	32.1	12.1	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	24.8	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM/CL(?)	Tailings/Alluvium	NA	7.7	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Tailings	NA	21.1	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	6.2	NA	100.0	14.9	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	8.6	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	27.0	[illegible]	NA	NA	49.0	23.0	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	9.2	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	22.2	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	20.8	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	12.4	2.60	100.0	30.7	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	16.5	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	16.5	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	Alluvium	NA	19.0	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Shale(?)	NA	2.5	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	TP-4	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	88.1	4.7	NA	NA	NA	NA	NA	NA	NA	
CARBONATE FILL	[illegible]	TP-4	[illegible]	[illegible]	[illegible]	[illegible]	SM	Tailings	NA	6.1	NA	NA	NA	NP	NP	104.0	17.2	Consol., Perm
CARBONATE FILL	[illegible]	TP-4	[illegible]	[illegible]	[illegible]	[illegible]	ML	Tailings(?)	82.3	27.2	NA	NA	NA	21.5	[illegible]	NA	NA	
CARBONATE FILL	[illegible]	TP-4	[illegible]	[illegible]	[illegible]	[illegible]	ML	Tailings(?)	71.0	28.4	NA	NA	NA	NA	NA	NA	NA	

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MRAP - 71[illegible] - GEOTECHNICAL DATA BASE FOR MONTICELLO MILLSITE CHARACTERIZATION - R.N. MORRIS: CREATED [illegible]/91; LAST UPDATED 11/[illegible]/91

AREA	DATA SOURC	BORING OR TEST PIT NUMBER	SAMPLE NUMBER & TYPE	TOP OF SAMPLE (FEET)	BASE OF SAMPLE (FEET)	SAMPLE MIDPOINT (FEET)	USCS SYMBOL	MATERIAL TYPE	IN-PLACE DRY DENSITY (PCF)	NATURAL MOISTURE CONTENT (PERCENT)	SPECIFIC GRAVITY	FRACTION PASSING #4 SIEVE (PERCENT)	FRACTION PASSING #200 SIEVE (PERCENT)	LIQUID LIMIT	PLASTICITY INDEX	ASTM D 698 MAXIMUM DRY DENSITY (PCF)	ASTM D 698 OPTIMUM MOISTURE CONTENT (PERCENT)	OTHER TESTS
CARBONATE PILE	DAM	TP-6	4/ST	10.5	11.0	10.75	CL	Tails-slm	73.6	48.3	NA	NA	NA	NA	NA	NA	NA	
CARBONATE PILE	DAM	TP-6	5/ST	17.0	17.5	17.25	SM	Tails-snd	72.3	10.8	NA	NA	NA	NA	NA	NA	NA	
CARBONATE PILE	DAM	TP-6	4/BULK	16.0	16.0	16.00	SM	Tails-snd(?)	NA	16.3	NA	100.0	48.4	NA	NA	93.1	18.8	
CARBONATE PILE	DAM	TP-11	4/BULK	6.0	6.0	6.00	SM	Tails-snd(?)	NA	18.7	2.76	100.0	47.8	NA	NA	108.7	16.0	Dir Shear, Perm, Mat Prop
CARBONATE PILE	DAM	TP-11	4/BULK	16.0	16.0	16.00	CL	Tails-slm	NA	22.1	NA	100.0	91.3	NA	NA	98.4	24.0	
VANADIUM PILE	BENDIX	MRAP-88-04	MKB-[illegible]/ST	4.0	6.0	5.00	SC	Tails-snd&slm	88.7	[illegible]	2.62	100.0	44.5	27.8	10.0	NA	NA	Consol w/perm, CMR @16 bar
VANADIUM PILE	BENDIX	MRAP-88-07	MKB-[illegible]/BULK	1.0	1.0	1.00	ML	Cover	NA	NA	NA	NA	71.6	NA	NA	114.3	12.7	
VANADIUM PILE	BENDIX	MRAP-88-07	MKB-[illegible]/BULK	3.0	3.0	3.00	SP	Tails-snd	NA	NA	2.67	NA	NA	NA	NA	107.5	13.2	
VANADIUM PILE	BENDIX	MRAP-88-07	MKB-[illegible]/BULK	7.0	7.0	7.00	ML	Tails-slm	NA	NA	2.60	NA	NA	NA	NA	112.0	13.3	
VANADIUM PILE	BENDIX	MRAP-88-[illegible]	MKB-[illegible]/ST	6.0	[illegible]	[illegible]	CL-ML	Tails-slm	75.1	41.7	2.63	100.0	94.0	21.0	3.0	NA	NA	Consol w/perm, CMR @16 bar
VANADIUM PILE	DAM	31SW01-[illegible]	2/ST	5.5	7.5	6.50	SM	Tails-snd	NA	8.4	2.69	100.0	31.6	28.1	17.1	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	1/SS	2.0	3.0	2.75	SM/GC	Cover	NA	10.8	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	3/SS	3.5	5.0	4.25	SM/CL	Tails-snd/slm	NA	10.9	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	3/SS	5.0	6.5	5.75	SM	Tails-snd(?)	NA	15.6	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	5/SS	8.5	10.0	9.25	ML	Tails-slm	NA	34.1	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	6/SS	10.5	11.5	10.75	SM	Tails-snd&slm	NA	11.5	2.69	100.0	31.5	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	7/SS	11.5	13.0	12.25	ML	Tails-slm	NA	28.0	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	8/SS	16.0	16.5	15.75	SM/CL	Tails-snd/slm	NA	20.0	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	10/SS	16.5	18.0	17.25	SM/CL	Tails-snd/slm	NA	10.3	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	11/SS	18.5	19.5	19.25	CL	Alluvium	NA	20.9	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	12/SS	19.5	21.5	20.50	CL	Alluvium	NA	19.7	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	13/SS	21.5	23.5	22.50	CL	Alluvium	NA	23.1	NA	NA	NA	44.3	24.0	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	14/SS	24.5	26.0	24.50	CL	Alluvium	NA	18.6	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	15/SS	26.5	27.5	26.50	CL	Alluvium	NA	23.6	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	16/SS	27.5	28.5	28.00	CL	Alluvium	NA	17.8	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	17/SS	29.5	31.5	30.50	CL	Alluvium	NA	17.9	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	18/SS	31.5	33.5	32.00	CL	Alluvium	NA	18.5	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	19/SS	33.5	34.5	34.10	CL	Alluvium	NA	17.8	NA	NA	NA	37.9	19.1	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	20/SS	36.5	37.5	37.00	CL	Alluvium	NA	23.7	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	21/SS	37.0	38.5	38.30	CL	Alluvium	NA	22.1	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	22/SS	39.5	41.0	40.25	CL	Alluvium	NA	22.1	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	23/SS	41.5	42.5	42.10	SC/CL	Alluvium	NA	23.2	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	24/SS	43.5	44.5	44.20	GC	Alluvium	NA	19.9	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	25/SS	45.5	46.0	45.70	[illegible]	Shale	NA	10.6	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	3/ST	6.0	7.5	6.75	CL	Tails-slm	93.1	28.3	NA	NA	NA	46.7	24.9	NA	NA	Perm, CMR
VANADIUM PILE	DAM	31SW01-[illegible]	8/SS	13.5	14.5	14.12	CL	Tails-slm	NA	20.3	2.90	NA	NA	46.7	22.8	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	9/SS	18.1	20.5	19.00	CL	Tails-slm	NA	12.4	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-[illegible]	11/SS	23.5	25.3	24.40	CL	Tails-slm	NA	22.4	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	1/SS	5.5	6.0	5.80	CL	Tails(?)-slm(?)	NA	23.5	NA	NA	NA	31.7	14.9	NA	NA	
VANADIUM PILE	DAM	31SW01-011	2/SS	10.0	11.0	10.50	CL	Alluvium	NA	21.3	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	3/SS	14.0	15.5	15.50	CL	Alluvium	NA	10.5	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	4/SS	20.0	20.0	20.00	CL	Alluvium	NA	14.9	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	5/SS	28.0	31.5	28.00	CL	Alluvium	NA	10.2	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	6/SS	34.5	35.5	35.25	CL	Alluvium	NA	27.7	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	9/SS	38.0	40.0	38.50	SC	Alluvium	NA	13.2	NA	100.0	48.1	NA	NA	NA	NA	
VANADIUM PILE	DAM	31SW01-011	10/SS	44.0	44.5	44.25	[illegible]	Sandstone	NA	3.3	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	TP-4	1/ST	4.5	5.0	4.75	SM	Tails-snd	98.1	7.4	NA	NA	NA	NP	NP	NA	NA	
VANADIUM PILE	DAM	TP-6	2/ST	5.5	6.0	5.75	CL	Tails-slm	70.7	51.5	NA	NA	NA	NA	NA	NA	NA	Unsat Cons
VANADIUM PILE	DAM	TP-6	4/ST	9.0	9.5	9.25	CL	Tails-slm	71.9	40.7	NA	NA	NA	NA	NA	NA	NA	Unsat Cons
VANADIUM PILE	DAM	TP-6	6/ST	11.0	11.5	11.25	CL	Tails-slm	84.5	16.5	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	TP-6	7/ST	14.0	14.5	14.25	CL	Tails(?)-slm(?)	68.5	51.0	NA	NA	NA	NA	NA	NA	NA	
VANADIUM PILE	DAM	TP-12	4/BULK	6.0	6.0	6.00	CL	Tails-slm	NA	24.3	2.75	NA	NA	29.2	12.3	115.0	14.0	Perm, Mat Prop
VANADIUM PILE	DAM	TP-12	4/BULK	12.0	12.0	12.00	CL	Tails-slm	NA	23.0	2.84	NA	NA	44.7	20.5	108.7	21.2	TAm-CUPP, Perm, Mat Prop, CMR
EAST PILE	BENDIX	MRAP-88-[illegible]	MKB-[illegible]/ST	2.0	4.0	3.00	SM	Tails-snd	96.4	5.2	2.67	100.0	47.0	NP	NP	NA	NA	Consol w/perm, CMR @15 bar
EAST PILE	BENDIX	MRAP-88-67	MKB-77[illegible]/BULK	1.0	1.0	1.00	ML	Cover	NA	NA	NA	100.0	53.0	NA	NA	111.2	14.1	
EAST PILE	BENDIX	MRAP-88-67	MKB-[illegible]/BULK	3.0	3.0	3.00	SM(?)	Tails-snd	NA	NA	NA	NA	NA	NA	NA	107.1	16.3	
EAST PILE	BENDIX	MRAP-88-67	MKB-[illegible]/BULK	15.0	15.0	15.00	SP(?)	Tails-snd(?)	NA	NA	2.70	NA	NA	NA	NA	103.6	15.5	
EAST PILE	BENDIX	MRAP-88-67	MKB-61[illegible]/ST	2.0	4.0	3.00	SM	Tails-snd	94.9	9.9	2.61	100.0	19.6	NP	NP	NA	NA	Consol w/perm, CMR @15 bar
EAST PILE	BENDIX	MRAP-88-69	MKB-71[illegible]/ST	12.0	14.0	13.00	CL	Tails-slm	102.8	34.4	2.70	100.0	81.0	41.0	22.0	NA	NA	Consol w/perm, CMR @15 bar
EAST PILE	BENDIX	MRAP-88-69	MKB-70[illegible]/ST	4.0	6.0	5.00	ML	Tails-slm	102.7	21.4	2.63	100.0	86.0	42.0	13.0	NA	NA	Consol w/perm, CMR @15 bar
EAST PILE	DAM	31SW01-[illegible]	1/SS	3.5	5.5	4.50	SP	Tails-snd	NA	12.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	31SW01-[illegible]	2/SS	8.5	10.5	9.50	SM/ML	Tails-snd/slm	NA	10.0	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	31SW01-[illegible]	3/SS	13.5	15.3	14.50	SM/ML	Tails-snd/slm	NA	15.3	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	31SW01-[illegible]	NA	24.0	25.0	24.50	CL	Alluvium	NA	10.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	31SW01-[illegible]	10/SS	28.0	30.0	29.00	CL	Alluvium	NA	10.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	31SW01-[illegible]	2/SS	7.0	8.3	7.50	ML	MRP sand	NA	7.2	NA	NA	NA	NA	NA	NA	NA	

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MMAP - 71[illegible] - GEOTECHNICAL DATA BASE FOR MONTICELLO MILLSITE CHARACTERIZATION - R.N. MORRIS; CREATED [illegible]/91; LAST UPDATED [illegible]/91

AREA	DATA SOURC	BORING OR TEST PIT NUMBER	SAMPLE NUMBER & TYPE	TOP OF SAMPLE (FEET)	BASE OF SAMPLE (FEET)	SAMPLE MIDPOINT (FEET)	USCS SYMBOL	MATERIAL TYPE	IN-PLACE DRY DENSITY (PCF)	NATURAL MOISTURE CONTENT (PERCENT)	SPECIFIC GRAVITY	FRACTION PASSING #4 SIEVE (PERCENT)	FRACTION PASSING #200 SIEVE (PERCENT)	LIQUID LIMIT	PLASTICITY INDEX	ASTM D 698 MAXIMUM DRY DENSITY (PCF)	ASTM D 698 OPTIMUM MOISTURE CONTENT (PERCENT)	OTHER TESTS
EAST PILE	DAM	[illegible]	9/SS	20.5	22.0	21.38	CL	Tailings-ore	NA	28.2	NA	NA	NA	48.4	22.3	NA	NA	
EAST PILE	DAM	[illegible]	11/SS	24.5	26.0	25.25	CL/ML	Tailings-andesite	NA	34.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	13/SS	28.1	30.0	27.25	CL/ML/ML	Tailings-andesite	NA	30.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	13/SS	30.3	30.6	30.25	ML	Tailings-andesite	NA	20.7	NA	100.0	72.3	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	16/SS	40.0	40.2	40.25	ML	Alluvium	NA	24.6	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	20/SS	40.0	40.7	40.25	ML	Alluvium	NA	22.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	21/SS	40.5	40.2	40.75	ML	Alluvium	NA	22.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	22/SS	40.0	40.7	40.25	ML	Alluvium	NA	24.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	1/SS	3.5	5.0	4.25	CL	MVP spoil	NA	18.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	3/SS	8.5	10.0	9.75	SM	Tailings-sand	NA	20.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	3U	14.5	15.0	14.75	CL	Tailings-clay	88.1	23.1	NA	NA	NA	38.8	12.7	NA	NA	
EAST PILE	DAM	[illegible]	4U	18.5	20.0	18.75	CL	Alluvium	91.0	22.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	5SS	22.5	24.0	24.25	CL	Alluvium	NA	19.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6SS	27.0	28.4	27.70	CL	Alluvium	NA	19.3	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	7SS	28.5	30.0	29.25	CL	Alluvium	NA	18.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	8SS	33.5	35.0	34.25	CL	Alluvium	NA	22.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	9U	38.5	40.0	38.75	CL	Alluvium	100.2	22.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	1U	4.0	5.0	4.38	SM	Tailings-sand	99.2	7.9	NA	100.0	21.0	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	4U	15.0	16.0	16.25	CL	Tailings-clay	84.1	88.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6U	19.5	20.0	19.75	ML	Tailings-clay	84.3	30.1	NA	NA	NA	22.2	2.8	NA	NA	Triax-CUPP
EAST PILE	DAM	[illegible]	7U	23.5	25.0	24.25	CH	Alluvium	87.3	87.4	NA	NA	NA	81.4	33.6	NA	NA	
EAST PILE	DAM	[illegible]	8U	28.5	30.0	29.25	CL	Alluvium	91.1	34.2	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6ST	16.5	17.5	16.75	CL	Tailings-andesite	93.1	26.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	7ST	20.5	22.0	21.00	CL	Tailings-clay	90.0	63.5	NA	NA	NA	NA	NA	NA	NA	Unconf Comp, Consol, Perm, Chem
EAST PILE	DAM	[illegible]	1SS	8.4	10.0	8.75	CL	Alluvium	NA	10.0	NA	NA	NA	30.2	10.8	NA	NA	
EAST PILE	DAM	[illegible]	3SS	15.5	20.0	18.25	CL	Alluvium	NA	19.2	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	4SS	24.0	25.5	24.75	CL	Alluvium	NA	14.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	5SS	28.0	30.5	28.75	CL	Alluvium	NA	16.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	3SS	34.0	35.5	34.75	CL	Alluvium	NA	17.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	4SS	38.5	40.0	38.75	CL	Alluvium	NA	17.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	5SS	44.5	45.0	44.75	CL/SC	Alluvium	NA	21.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6SS	48.0	49.5	48.25	SC	Alluvium	NA	13.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	2ST	10.5	12.0	11.00	CL	Tailings-clay	90.0	87.2	NA	NA	NA	NA	NA	NA	NA	Unconf Comp
EAST PILE	DAM	[illegible]	6ST	26.5	27.3	26.90	CL/ML	Tailings-andesite	88.7	88.6	NA	NA	NA	NA	NA	NA	NA	Triax-CUPP, Consol
EAST PILE	DAM	[illegible]	10SS	28.5	28.5	28.30	CL/SM	Tailings-andesite	NA	28.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	1U	4.5	5.0	4.75	CL	MVP spoil	100.6	8.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	2U	8.5	10.0	8.75	SM	Tailings-sand	98.7	7.8	NA	100.0	23.0	NA	NA	NA	NA	Dir Shear
EAST PILE	DAM	[illegible]	3U	14.5	15.0	14.75	CL	Alluvium(?)	93.4	25.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	7U	19.5	20.0	19.75	CL	Alluvium(?)	90.0	70.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	8U	24.0	24.5	24.25	CL	Alluvium(?)	62.0	62.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	10SS	40.0	45.5	44.45	Sm	Shale	NA	13.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	1U	2.5	3.0	3.12	SM	Tailings-sand	88.3	7.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	2U	7.5	8.?	8.15	SM	Alluvium	85.6	25.4	2.81	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	3U	12.5	13.7	13.10	CL/SC	Alluvium	NA	16.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	1SS	5.5	6.5	6.00	ML	Tailings-andesite(?)	NA	18.3	NA	100.0	86.4	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	2SS	6.0	8.5	8.75	SM	Tailings-sand	NA	12.4	NA	99.2	45.1	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	4SS	11.0	12.5	11.75	SM	Tailings-sand	NA	6.2	NA	99.5	30.0	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	8SS	12.5	14.0	13.25	SM	Tailings-sand	NA	1.9	NA	100.0	23.2	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	7SS	14.0	15.5	14.75	SM	Tailings-sand	NA	17.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6SS	18.0	17.5	16.25	SM	Tailings-sand	NA	17.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	8SS	17.0	18.5	17.75	CL	Tailings-clay	NA	42.7	NA	NA	NA	38.0	13.9	NA	NA	
EAST PILE	DAM	[illegible]	10SS	18.5	20.0	19.25	CL	Tailings-clay	NA	34.4	NA	NA	NA	44.7	16.3	NA	NA	
EAST PILE	DAM	[illegible]	11SS	20.0	21.5	20.75	CL	Alluvium(?)	NA	22.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	12SS	21.5	23.0	22.25	CL	Alluvium(?)	NA	24.7	NA	NA	NA	29.0	10.9	NA	NA	
EAST PILE	DAM	[illegible]	13SS	30.0	32.5	32.25	SC	Alluvium	NA	8.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	1SS	4.0	5.5	4.75	CL	Alluvium	NA	14.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	2SS	8.0	10.0	8.75	CL	Alluvium	NA	12.2	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	3SS	14.0	15.5	14.75	CL	Alluvium	NA	15.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	4SS	19.0	20.0	19.75	CL	Alluvium	NA	13.6	NA	NA	NA	45.0	23.5	NA	NA	
EAST PILE	DAM	[illegible]	5SS	24.0	25.5	24.75	CL	Alluvium	NA	16.8	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6SS	28.0	30.5	29.75	SC	Alluvium	NA	21.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	7SS	34.0	35.0	34.80	SC	Alluvium	NA	18.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	3U	13.0	13.7	13.38	CL	Alluvium	101.6	22.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	4U	18.0	19.5	18.75	CL	Alluvium	96.5	25.3	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	5SS	23.0	24.5	24.75	SC(?)	Alluvium	97.0	23.2	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	[illegible]	6U	28.3	29.4	28.85	Sm	Shale	113.4	18.1	NA	NA	NA	NA	NA	NA	NA	

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MRAP - [illegible] - GEOTECHNICAL DATA BASE FOR MONTICELLO MILLSITE CHARACTERIZATION - R.H. MORRIS; CREATED [illegible]; LAST UPDATED [illegible]

AREA	DATA SOURC	BORING OR TEST PIT NUMBER	SAMPLE NUMBER & TYPE	TOP OF SAMPLE (FEET)	BASE OF SAMPLE (FEET)	SAMPLE MIDPOINT (FEET)	USCS SYMBOL	MATERIAL TYPE	IN-PLACE DRY DENSITY (PCF)	NATURAL MOISTURE CONTENT (PERCENT)	SPECIFIC GRAVITY	FRACTION PASSING #4 SIEVE (PERCENT)	FRACTION PASSING #200 SIEVE (PERCENT)	LIQUID LIMIT	PLASTICITY INDEX	ASTM D 698 MAXIMUM DRY DENSITY (PCF)	ASTM D 698 OPTIMUM MOISTURE CONTENT (PERCENT)	OTHER TESTS
EAST PILE	DAM	TP-1	1/ST	6.6	7.0	6.75	CL	MVP sand	103.3	11.1	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-1	-/BULK	7.0	7.0	7.00	CL	MVP sand	NA	10.2	NA	NA	NA	NA	NA	102.1	10.1	Perm, Mod Proc
EAST PILE	DAM	TP-1	2/ST	9.0	9.5	9.25	CL	MVP sand	99.8	20.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-1	3/ST	14.0	14.5	14.25	SM	Tails-sand	101.5	7.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-1	-/BULK	15.0	15.0	15.00	SM	Tails-sand	NA	16.0	NA	99.0	31.0	NA	NA	109.4	14.2	
EAST PILE	DAM	TP-2	1/ST	6.0	6.5	6.25	SM	Tails-sand	91.5	27.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-2	-/BULK	10.0	10.0	10.00	ML	Tails-slm	NA	23.0	NA	NA	NA	NA	NA	109.0	20.0	Consol, CMR
EAST PILE	DAM	TP-2	2/ST	10.5	11.0	10.75	SM	Tails-sand	97.3	1.7	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-2	3/ST	13.5	14.0	13.75	ML	Tails-sand/slm(?)	88.0	18.5	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-3	-/BULK	14.0	14.0	14.00	ML	Tails-sand/slm(?)	NA	7.8	NA	100.0	84.4	NA	NA	102.6	17.1	CMR
EAST PILE	DAM	TP-3	4/ST	14.5	15.0	14.75	ML	Tails-sand/slm(?)	74.0	23.4	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-4	-/BULK	9.0	9.0	9.00	ML	Tails-sand/slm	NA	22.4	NA	100.0	91.0	NA	NA	88.0	21.8	Dir Shear, Perm, CMR
EAST PILE	DAM	TP-4	2/ST	8.5	14.0	8.75	ML	Tails-sand/slm	81.8	7.9	NA	NA	NA	NA	NA	NA	NA	
EAST PILE	DAM	TP-4	-/BULK	14.0	14.0	14.00	ML	Tails-sand/slm	NA	14.7	2.71	100.0	95.0	NA	NA	101.5	17.3	Perm, CMR
EAST PILE	DAM	TP-4	3/ST	14.5	15.0	14.75	ML	Tails-sand/slm	91.0	27.1	NA	100.0	94.1	NA	NA	NA	NA	
ACID PILE	BENDIX	MRAP-86-10	MKB-[illegible]/ST	4.0	6.0	5.00	CL	Tails-slm	86.1	41.1	2.63	100.0	79.0	29.0	11.0	NA	NA	
ACID PILE	BENDIX	MRAP-86-10*	MKB-[illegible]/BULK	1.0	1.0	1.00	SM	Cover	NA	NA	NA	100.0	40.0	NA	NA	111.5	16.9	
ACID PILE	BENDIX	MRAP-86-10*	MKB-[illegible]/BULK	3.0	3.0	3.00	SP	Tails-sand	NA	NA	NA	NA	NA	NA	NA	119.4	12.4	
ACID PILE	BENDIX	MRAP-86-10*	MKB-[illegible]/BULK	6.0	6.0	6.00	CL	Tails-slm	NA	NA	2.78	NA	NA	NA	NA	94.5	20.3	
ACID PILE	BENDIX	MRAP-86-11	MKB-[illegible]/ST	4.0	6.0	5.00	CL	Tails-slm	74.8	30.0	2.00	100.0	72.0	44.0	20.0	NA	NA	Consol-[illegible], CMR @15 bar
ACID PILE	BENDIX	MRAP-86-12	MKB-[illegible]/ST	4.0	6.0	5.00	ML	Tails-slm	78.4	40.0	2.00	100.0	87.0	47.0	16.0	NA	NA	Consol-[illegible], CMR @15 bar
ACID PILE	DAM	310N01-[illegible]	1/SS	4.5	5.0	4.75	CL	Tails-sand/slm	NA	20.0	NA	NA	NA	33.0	13.1	NA	NA	
ACID PILE	DAM	310N01-[illegible]	2/SS	6.5	9.0	6.75	CL	Alluvium	NA	12.0	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	3/SS	12.5	14.5	14.00	CL	Alluvium	NA	17.1	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-407	2/ST	6.0	8.0	7.00	CH	Alluvium	71.5	40.0	NA	NA	NA	66.0	23.7	NA	NA	Triax-CUPP, Unsat'd Comp, Perm, CMR
ACID PILE	DAM	310N01-407	4/ST	9.0	11.5	10.25	CH	Alluvium	86.0	71.3	NA	NA	NA	68.0	31.4	NA	NA	Triax-CUPP, Unsat'd Comp, Consol
ACID PILE	DAM	310N01-407	6/ST	19.0	20.5	19.75	CL/SC	Alluvium	103.3	16.3	NA	NA	NA	37.4	21.0	NA	NA	Triax-CUPP, Unsat'd Comp, Perm, CMR
ACID PILE	DAM	310N01-[illegible]	2/SS	4.0	6.0	5.00	SM	Tails-sand(?)	NA	17.2	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	3/SS	6.0	6.9	6.44	SM	Tails-sand	NA	17.2	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	4/SS	9.0	10.0	9.50	CL-ML	Tails-slm	NA	27.0	2.70	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	5/SS	10.5	12.0	11.25	ML	Tails-slm	NA	20.0	NA	NA	NA	34.0	9.6	NA	NA	
ACID PILE	DAM	310N01-[illegible]	6/SS	13.5	15.0	14.25	ML	Tails-sand/slm	NA	27.0	NA	100.0	51.7	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	7/SS	15.0	17.4	16.50	SM	Tails-sand/slm	NA	10.0	NA	100.0	34.7	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	8/SS	18.0	19.0	18.50	ML	Tails-slm	NA	40.3	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	9/SS	19.0	21.0	20.00	ML	Tails-slm	NA	20.0	NA	100.0	65.0	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	10/SS	22.1	22.5	22.75	SM	Tails-sand	NA	62.0	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	11/SS	24.4	25.0	24.5[illegible]	ML/CL	Tails-sand/slm	NA	53.1	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	12/SS	25.0	27.0	26.00	ML/CL	Tails-sand/slm	NA	51.3	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	13/SS	27.0	29.0	28.00	CL	Tails-sand/slm	NA	55.0	NA	100.0	92.0	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	14/SS	29.0	30.5	29.75	ML/CL	Tails-sand/slm	NA	61.4	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	15/SS	31.0	33.0	32.00	CL	Tails-sand/slm	NA	64.7	NA	NA	NA	40.0	21.2	NA	NA	
ACID PILE	DAM	310N01-[illegible]	16/SS	33.0	34.0	33.75	ML	Tails-sand/slm	NA	41.3	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	17/SS	35.0	37.0	36.00	ML/SC	Alluvium(?)	NA	19.1	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	18/SS	37.5	39.0	38.25	SC/CL	Alluvium	NA	20.9	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	19/SS	39.0	41.0	40.00	CL	Alluvium	NA	24.5	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-40A	1/SS	5.0	6.0	5.50	ML/CL	Tails-slm	NA	17.2	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-40A	2/SS	14.5	16.0	15.00	CL-ML	Tails-slm	NA	17.3	2.00	NA	NA	47.4	17.8	NA	NA	
ACID PILE	DAM	310N01-[illegible]	7/SS	29.0	31.5	30.25	Rx	Shale	NA	10.1	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	3/SS	6.0	6.5	6.25	SM	Tails-sand	NA	6.0	NA	100.0	20.7	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	4/SS	10.0	10.5	10.25	SM	Tails-sand	NA	5.1	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	6/SS	12.0	12.5	12.25	SM	Tails-sand	NA	16.3	NA	100.0	20.9	NA	NA	NA	NA	
ACID PILE	DAM	310N01-[illegible]	8/ST	18.0	20.0	19.00	SM	Tails-sand	102.8	12.4	NA	100.0	17.2	NA	NA	NA	NA	Dir Shear, Perm, CMR
ACID PILE	DAM	310N01-[illegible]	12/SS	24.5	25.0	24.75	CL-ML	Tails-slm	NA	19.4	NA	NA	NA	40.0	16.3	NA	NA	
ACID PILE	DAM	TP-7	-/BULK	2.0	2.0	2.00	SM	Tails-sand	NA	8.4	2.71	100.0	42.3	NP	NP	100.0	14.8	Triax-CUPP, Consol, Perm, Mod Proc, CMR
ACID PILE	DAM	TP-7	2/ST	5.0	5.5	5.25	CL	Tails-slm	62.5	62.0	NA	NA	NA	NA	NA	NA	NA	Unsat'd Shear
ACID PILE	DAM	TP-7	3/ST	6.5	7.0	6.75	CL	Tails-slm	66.1	64.4	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	TP-7	4/ST	8.5	10.0	8.75	CL	Tails-slm	61.3	60.0	NA	NA	NA	NA	NA	NA	NA	Unsat'd Shear
ACID PILE	DAM	TP-7	5/ST	12.5	13.0	12.75	CL	Tails-slm	53.1	53.1	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	TP-7	6/ST	16.5	17.0	16.75	CL	Tails-slm	51.4	56.1	NA	NA	NA	NA	NA	NA	NA	Unsat'd Shear
ACID PILE	DAM	TP-8	1/ST	2.5	3.0	2.75	SM/ML	Tails-sand/slm	78.0	11.0	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	TP-8	2/ST	4.5	5.0	4.75	SM	Tails-sand	90.0	6.5	2.62	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	TP-8	-/BULK	4.5	4.5	4.50	SM	Tails-sand	NA	7.5	NA	100.0	26.9	NA	NA	103.0	15.0	Dir Shear, Perm, Mod Proc, CMR
ACID PILE	DAM	TP-8	3/ST	6.0	6.5	6.25	SM	Tails-sand(?)	82.5	14.3	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	TP-8	4/ST	10.0	10.5	10.25	ML	Tails-slm	86.7	30.6	2.70	100.0	62.0	NA	NA	NA	NA	
ACID PILE	DAM	TP-8	5/ST	12.0	12.5	12.25	CL	Tails-slm	80.2	70.9	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	DAM	TP-8	-/BULK	13.0	13.0	13.00	CL	Tails-slm	NA	NA	NA	NA	NA	NA	NA	NA	NA	Perm

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MAAP - [illegible] - GEOTECHNICAL DATA BASE FOR MONTICELLO MILLSITE CHARACTERIZATION -- R.K. MORRIS: CREATED [illegible]: LAST UPDATED [illegible]

AREA	DATA SOURC	BORING OR TEST PIT NUMBER	SAMPLE NUMBER & TYPE	TOP OF SAMPLE (FEET)	BASE OF SAMPLE (FEET)	SAMPLE MIDPOINT (FEET)	USCS SYMBOL	MATERIAL TYPE	INPLACE DRY DENSITY (PCF)	NATURAL MOISTURE CONTENT (PERCENT)	SPECIFIC GRAVITY	FRACTION PASSING #4 SIEVE (PERCENT)	FRACTION PASSING #200 SIEVE (PERCENT)	LIQUID LIMIT	PLASTICITY INDEX	ASTM D 698 MAXIMUM DRY DENSITY (PCF)	ASTM D 698 OPTIMUM MOISTURE CONTENT (PERCENT)	OTHER TESTS
ACID PILE	D&M	TP-6	[illegible]	1.5	2.0	1.75	SM	Tailsand	88.4?	4.6	NA	NA	NA	NA	NA	NA	NA	
ACID PILE	D&M	TP-6	[illegible]	2.6	3.5	3.25?	SM	Tailsand	90.6?	8.0	NA	100.0	10.5?	NA	NA	NA	NA	
ACID PILE	D&M	TP-6	4/BULK	10.0	10.0	10.00	ML	Alluvium	NA	23.4	NA	93.5	61.0	24.2	10.1	114.0	14.5	Perm, Mod Proct, CMR
SOMERVILLE TRACT	BENDIX	MAAP-88-17	[illegible]	0.0	2.0	1.00	SC	Alluvium	NA	40.2	2.57	100.0	31.0	33.0	18.0	NA	NA	Perm, CMR @15 bar
SOMERVILLE TRACT	BENDIX	MAAP-88-17	[illegible]BULK	0.0	5.0	2.50	ML	Alluvium(Shale?)	NA	NA	NA	97.0	81.0	NA	NA	105.3	17.0	
SOMERVILLE TRACT	BENDIX	MAAP-88-16	[illegible]	0.0	2.0	1.00	CL	Alluvium	NA	14.3	2.58	100.0	85.0	22.0	14.0	NA	NA	Perm, Consol w/perm, CMR @15 bar
SOMERVILLE TRACT	BENDIX	MAAP-88-16	[illegible]BULK	0.0	5.0	2.50	ML	Alluvium	NA	NA	NA	100.0	85.0	NA	NA	105.3	18.0	
BLM COMPOUND	BENDIX	MAAP-88-20	[illegible]	0.0	2.0	1.00	CL	Alluvium	NA	16.6	2.62	100.0	85.5	44.0	7.0	NA	NA	Perm, CMR @15 bar
BLM COMPOUND	BENDIX	MAAP-88-20	[illegible]BULK	0.0	3.0	1.50	CL	Alluvium	NA	NA	NA	100.0	71.0	NA	NA	101.9	11.0	
BLM COMPOUND	D&M	[illegible]	[illegible]	3.5	4.5	4.00	CL	Alluvium	NA	25.4	NA	NA	NA	40.7	20.0	NA	NA	
BLM COMPOUND	D&M	[illegible]	[illegible]	4.5	5.5	5.00	CL	Alluvium	NA	21.0	NA	NA	NA	35.0	16.0	NA	NA	
BLM COMPOUND	D&M	[illegible]	[illegible]	8.0	10.5	9.75	ML	Alluvium	NA	17.1	NA	100.0	71.2	NA	NA	NA	NA	
VALLEY BOTTOM	BENDIX	MAAP-88-21	[illegible]	0.0	2.0	1.00	CL	Alluvium	NA	7.8	2.68	NA	NA	30.0	13.0	NA	NA	Perm, CMR @15 bar
VALLEY BOTTOM	BENDIX	MAAP-88-21	[illegible]BULK	0.0	3.5	1.80	SM	Tailsand	NA	NA	NA	100.0	43.0	NA	NA	113.2	12.0	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	3.5	4.8	4.15	CL	Alluvium	NA	12.8	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	8.5	10.0	9.25	CL	Alluvium	NA	16.2	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	12.5	14.3	13.50	CL	Alluvium	NA	16.3	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	11/BULK	24.0	25.0	24.50	GC	Alluvium	NA	16.5	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	8.5	8.9	8.75	SC	Alluvium	NA	9.9	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	13.5	13.0	13.00	SW	Alluvium	NA	6.4	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	4.0	6.0	5.00	CL	Alluvium	NA	16.0	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	9.5	11.0	10.25	SC	Alluvium	NA	12.5	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	14.3	14.7	14.50	[illegible]	Shale	NA	12.3	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	3.5	4.0	3.75	SM	Alluvium	NA	10.2	NA	83.1	46.7	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	8.5	10.0	9.25	SP	Alluvium	NA	8.1	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	14.0	14.5	14.25	SM	Alluvium	NA	13.0	NA	88.4	15.5	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	4.5	5.0	4.75	ML	Alluvium	NA	10.7	NA	97.3	71.3	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	8.0	8.5	8.25	ML	Alluvium(?)	NA	9.8	NA	100.0	91.6	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	10.0	10.5	10.25	ML	Alluvium(?)	NA	9.9	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	[illegible]	[illegible]	13.5	14.5	14.00	CL	Alluvium(?)	NA	12.2	NA	NA	NA	NA	NA	NA	NA	
VALLEY BOTTOM	D&M	TP-10	4/BULK	2.0	8.0	5.00	GC	Alluvium	NA	20.3	NA	66.1	41.0	25.4	17.0	116.1	12.2	
MAIN MILLSITE	D&M	[illegible]	[illegible]	6.0	6.5	6.25	CL	Alluvium	NA	27.7	NA	NA	NA	NA	NA	NA	NA	
MAIN MILLSITE	D&M	[illegible]	[illegible]	8.3	9.5	8.88	CL	Alluvium	NA	20.5	NA	NA	NA	NA	NA	NA	NA	
MAIN MILLSITE	D&M	[illegible]	[illegible]	13.5	15.0	14.25	CL	Alluvium	NA	21.5	NA	NA	NA	NA	NA	NA	NA	
MAIN MILLSITE	D&M	[illegible]	[illegible]	3.5	4.5	4.13	CL	Alluvium(Shale?)	NA	22.9	NA	NA	NA	NA	NA	NA	NA	
MAIN MILLSITE	D&M	[illegible]	[illegible]	0.5	2.0	1.25	CL	Fill	NA	11.8	NA	NA	NA	40.3	22.0	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	10.0	10.5	10.25	CL	Alluvium(Shale?)	NA	22.6	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	8.5	9.0	8.75	CL	Alluvium	NA	7.3	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	10.0	10.5	10.25	CL	Alluvium	NA	10.0	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	2.0	2.5	2.25	CL	Alluvium	NA	8.8	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	9.0	10.3	9.65	CL	Alluvium	NA	14.2	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	10.3	11.8	10.95	SC	Alluvium	NA	14.0	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	14.0	14.2	14.10	CL	Alluvium	NA	12.2	NA	NA	NA	NA	NA	NA	NA	
SOUTH VALLEY WALL	D&M	[illegible]	[illegible]	4.5	5.0	4.75	CL	Alluvium	NA	11.4	NA	100.0	85.4	43.3	23.4	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	3.5	5.5	4.50	CL	Alluvium(?)	NA	12.9	NA	NA	NA	28.3	17.1	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	8.5	10.5	9.50	CL	Alluvium(?)	NA	20.1	NA	100.0	97.8	NA	NA	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	2.0	4.0	3.00	CL	Alluvium	NA	14.2	NA	NA	NA	NA	NA	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	8.0	11.0	10.00	CL	Alluvium	NA	10.5	NA	NA	NA	33.4	13.0	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	8.5	9.0	8.75	CL	Alluvium(?)	NA	21.3	NA	NA	NA	NA	NA	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	14.5	15.0	14.75	CL	Alluvium(?)	NA	23.3	2.70	NA	NA	40.2	25.0	NA	NA	
NORTH VALLEY WALL	D&M	[illegible]	[illegible]	16.5	17.0	16.75	CL	Alluvium(?)	NA	23.5	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	3.5	4.0	3.75	CL	Alluvium	NA	11.9	NA	NA	NA	30.3	13.8	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	12.5	14.3	13.50	CL	Alluvium	NA	18.8	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	20.0	20.5	20.25	CL	Alluvium	NA	20.1	NA	NA	NA	44.3	22.8	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	8.0	8.5	8.25	CL	Alluvium	NA	23.9	NA	NA	NA	41.3	20.7	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	9.5	10.0	9.75	CL	Alluvium	NA	17.5	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	11.0	11.5	11.25	CL	Alluvium	NA	14.5	NA	NA	NA	27.3	9.4	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	20.0	20.5	20.25	CL	Alluvium	NA	18.1	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	3.5	4.5	3.90	CL	Alluvium(Loess?)	NA	17.4	NA	NA	NA	49.9	22.7	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	8.5	9.5	9.00	CL	Alluvium(Loess?)	NA	15.5	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	8.5	9.0	8.80	CL	Alluvium	NA	10.0	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	12.5	14.5	13.50	CL	Alluvium	NA	10.0	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	8.0	9.0	8.50	CL	Alluvium	NA	15.9	NA	NA	NA	44.7	23.4	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	10.0	10.5	10.40	SW	Alluvium	NA	8.9	NA	NA	NA	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	3.5	4.0	3.75	SM	Alluvium	NA	6.1	NA	80.9	38.4	NA	NA	NA	NA	
BLM PROPERTY-NORT	D&M	[illegible]	[illegible]	9.5	10.5	9.98	CL	Alluvium(?)	NA	23.5	NA	NA	NA	NA	NA	NA	NA	

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7/20

MAAP - [illegible] - GEOTECHNICAL DATA ...ES FOR MONTICELLO MILLSITE CHARACTE... ..TION - R.H. MORRIS; CREATED 09/20/91; LAST UPDATED 11/22/91

AREA	DATA SOURC	BORING OR TEST PIT NUMBER	SAMPLE NUMBER & TYPE	TOP OF SAMPLE (FEET)	BASE OF SAMPLE (FEET)	SAMPLE MIDPOINT (FEET)	USCS SYMBOL	MATERIAL TYPE	IN-PLACE DRY DENSITY (PCF)	NATURAL MOISTURE CONTENT (PERCENT)	SPECIFIC GRAVITY	FRACTION PASSING #4 SIEVE (PERCENT)	FRACTION PASSING #200 SIEVE (PERCENT)	LIQUID LIMIT	PLASTICITY INDEX	ASTM D 698 MAXIMUM DRY DENSITY (PCF)	ASTM D 698 OPTIMUM MOISTURE CONTENT (PERCENT)	OTHER TESTS
BLM PROPERTY-NORTH	D&M	TP-10	*BULK	5.0	5.0	5.00	CL	Loess(?)	NA	18.8	NA	100.0	88.5	23.5	11.1	107.7	14.3	Mod Proct
BLM PROPERTY-NORTH	D&M	TP-10	3ST	6.0	6.5	6.25	CL	Loess(?)	91.7	3.2	NA	NA	NA	27.3	9.6	NA	NA	Unconf Comp
BLM PROPERTY-NORTH	D&M	TP-10	4ST	11.0	11.5	11.25	CL	Loess(?)	100.3	18.7	NA	NA	NA	48.5	21.8	NA	NA	Perm

KEY:

USCS Unified Soil Classification System group symbol, ASTM D 2487 or D2488 (For dual, symbol indicates [illegible])
ASTM Test designation of the American Society for Testing and Materials
SFPEC "Data Collection for Engineering for the Uranium Mill Tailings Site and Adjacent Peripheral Properties, Monticello, Utah," Sergent Field Engineering Corporation, September 1986
D&M "Final Report, Monticello Remedial Action Project, 1991 Millsite Characterization Study," Dames & Moore, September 17, 1991
* Sample taken from a test pit [illegible] next to the designated borehole.
(?) Questionable value or identification

MATERIAL TYPE:

Tails-sand	Tailings sands
Tails-slm	Tailings slimes
Tails-interlayered	Tailings sands and slimes, interbedded
Tails-sand/slm	Tailings sands and slimes, mixed
Cover	Cover material in place on tailings piles
MVP spoils	Material removed from Monticello Vicinity Properties
Alluvium	Miscellaneous surficial deposits, mostly stream-laid
Loess	Windblown fine-grained deposits
Shale	Mancos Shale, mostly weathered
Sandstone	Dakota Sandstone
Fill	Miscellaneous man-made fill

OTHER TESTS:

Mod Proct	Modified Proctor compaction
Unconf Comp	Unconfined compressive strength
Dir Shear	Direct shear, consolidated-drained
Triax-CU/PP	Triaxial shear, consolidated-undrained with pore pressure measurements
Consol	One-dimensional consolidation
Perm	Permeability, falling-head or flexible-membrane
CMR	Capillary moisture [illegible]

SAMPLE TYPES:

BULK	Disturbed bag sample of loose cuttings or materials from test pit
SS	Disturbed sample from 2.0" O.D. standard split-spoon drive sampler
ST	Relatively undisturbed sample from 3.0" O.D. thin-walled (Shelby) tube sampler
U	Relatively undisturbed sample from Dames & Moore Type "U" ring-lined drive sampler

All data in this table compiled or interpreted from consultant's reports by R.H. Morris, Chem-Nuclear Geotech, Inc., October 1991. Checked by L.H. [illegible] & corrected by R.H. Morris, November 1991.

APPENDIX B

Radon Calculation

TITANEnvironmental

Purpose: To determine the required soil cover thicknesses to limit radon emissions from the White Mesa tailings impoundments to 20 pCi/m^2/sec using United States Nuclear Regulatory Commission (NRC) approved methods and inputs. The White Mesa Mill site is located in Blanding, Utah.

Method: Determine the geotechnical and radiological properties of the tailings and cover materials based on NRC-accepted methods and existing database values previously collected. Input parameters into the computer modeling program "RADON" to determine the radon flux values through the cover materials. A variety of scenarios adjusting cover thicknesses were run to determine the optimum thickness of cover materials to meet NRC specifications. It was assumed that the tailings located in the three cells at the White Mesa Mill site (Cells 2, 3, and 4A) have similar properties (Figure 1). Therefore, cover layer configurations as determined by the RADON model are applicable to the three tailings cells.

Results: A 2-layer uranium mill tailings cover composed of (from top to bottom) a 2-foot layer of random fill and a 1-foot compacted clay layer will meet NRC specifications. In addition to the tailings cover materials, a minimum of 3 feet of random fill will be placed between the tailings and soil cover to fill the currently existing freeboard. This 3 foot layer was included for modeling purposes since it will assist in reducing the radon flux from the tailings impoundments. This layer, however, is not considered a part of the actual soil cover. The resulting radon flux exiting the top cover layer of the tailings impoundment will be 13.6 pCi/m^2/sec (see Appendix A1 for RADON output).

As indicated in the "Effects of Freezing on Uranium Mill Tailings Covers Calculation Brief" (6/17/96), 6.8 inches of the top random fill cover layer will be effected by freeze/thaw conditions at Blanding Utah. This suggests that 6.8 inches of the top layer may not contribute to reductions of radon emanation from the tailings covers. To conservatively compensate for effects from freezing and thawing, 6.8 inches were subtracted from the top random fill cover layer. Executing the RADON model based on this cover configuration resulted in a radon flux emanation of 17.6 pCi/m^2/sec (see Appendix A2 for RADON output).

NRC specifications (Regulatory Guide 3.64) requires that a uranium tailings cover "..produce resonable assurance that the radon-222 release rate would not exceed 20 pCi/m^2/sec for a period of 1,000 years to the extent reasonably achievable and in any case for at least 200 years when averaged over the disposal area over at

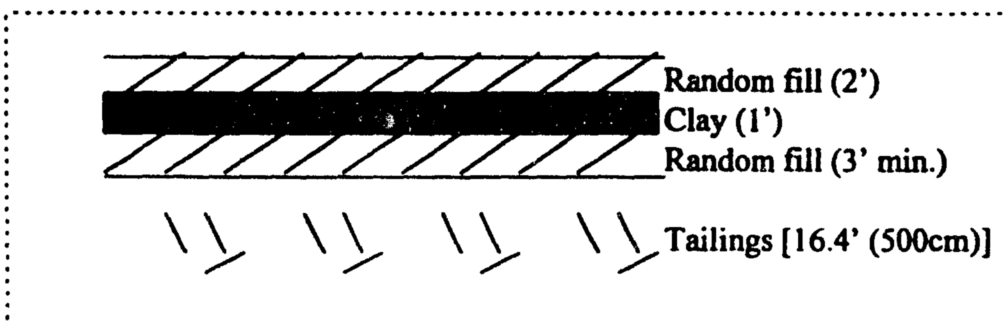
least a one-year period" (NRC, 1989). Therefore, the above design with accounting for freezing and thawing conditions is adequate.

Parameters: The RADON model requires input of the following parameters for all tailings and soil cover layers:

- layer thickness (centimeter (cm));
- porosity;
- mass density (g/cm^3);
- radium activity (pCi/gr), source term, or ore grade percentage;
- emanation coefficient;
- weight percent moisture (long-term) (percent), and;
- diffusion coefficient (cm^2/sec).

Physical and radiological properties for Tailings and Random Fill were analyzed by Chen and Associates (1987) and Rogers and Associates (1988) respectively. See Appendix B1 for analysis results. Clay physical data input for RADON modeling are included in Appendix B2 and were analyzed by Advanced Terra Testing (1996) and Rogers and Associates (1996).

The following cover profile was modeled.



This cover configuration represents the actual cover layer thicknesses which would be constructed on site. The cover profile above was adjusting for modeling purposes to account for freezing and thawing conditions. The modeled profile is identical to the one above with the exception of the top random fill layer which was reduced to 1.4 feet (2 feet minus 6.8 inches). It is assumed that 6.8 inches of the top cover layer effected by freeze/thaw conditions will not contribute to reductions in radon emanation from the tailings covers.

Layer thicknesses

The thickness of the tailings was assumed to be effectively an infinitely thick radon source. In accordance with NRC criteria (Reg. Guide 3.64, p. 3.64-5) a tailings thickness greater than about 100-200 cm is considered to be effectively, infinitely thick. A value of 500 cm represents an equivalent infinitely thick tailings source. The actual tailings thickness of Cell 3 at White Mesa is approximately 28 feet (850 cm), therefore, a value of 500 cm was used for the RADON model.

A minimum of 3-feet (91.5 cm) of random fill will cover the tailings to fill the existing freeboard and bring the tailings piles up to the subgrade elevation of the soil cover. A 1-foot (30.5 cm) layer of compacted clay covers the random fill with an additional 2 feet (61 cm) of random fill overlying the clay layer. Adjusting for freeze/thaw conditions results in a (43 cm) random fill layer overlaying the clay layer.

Porosity

Porosity is calculated from the specific gravity and dry bulk density according to the following equations;

1. Dry bulk density = [(specific gravity)(density of water)]/[1 + e] (Ref.: Principles & Practice of Civil Engineering, 1996, equation 14.5.6). See Appendix C.
2. Porosity = [e / (1+e)] x 100 (Ref.: Principles & Practice of Civil Engineering, 1996, equation 14.5.4). See Appendix C.

	Max. Dry Density (lb/ft^3)	Bulk Dry Density (lb/ft^3) (1)	Specific Gravity	Density of Water (lb/ft^3)	"e" (2)	porosity (3)
Tailings (4)	104.0	98.8	2.85	62.4	0.80	44%
Clay (5)	113.5	107.8	2.39	62.4	0.38	28%
Random fill (4)	120.2	114.2	2.67	62.4	0.46	31.5%

Notes:
1. Bulk dry density is 95% of the ASTM Proctor maximum dry density for all materials.
2. Calculated using Equation 1 above where "e" is the volume of voids per volume of solids.
3. Calculated using Equation 2 above.
4. Physical tailings and random fill data from Chen and Associates (1987) included in Appendix B1.
5. Clay physical data from Advanced Terra Testing (1996) and Rogers and Associates (1996) included in Appendix B2.

Mass Density

Mass densities were measured by Rogers and Associates (1988 and 1996) to be (see Appendix B1 and B2):

Tailings	= 1.45 g/cm^3
Clay	= 1.72 g/cm^3
Random Fill	= 1.85 g/cm^3

Radium Activity, Source Term, or Ore Grade %

Radium activity values from Rogers & Associates (1988 and 1996), were input for White Mesa tailings and cover materials (Appendix B1 and B2). The radium activity values are:

Tailings	= 981 pCi/gm
Clay	= 1.5 pCi/gm
Random Fill	= 1.9 pCi/gm.

Emanation Coefficient

Emanation coefficient input for the tailings and cover materials are measured values from Rogers & Associates (1988 and 1996), included in Appendix B1 and B2. The coefficients are:

Tailings	= 0.19
Clay	= 0.22
Random Fill	= 0.19

Note: Use of NRC's default value of E=0.35 is not considered appropriate since laboratory analyses of emanation coefficients are available.

Weight Percent Moisture

Long-term moisture content (weight percent moisture) was assumed to be 6% for the tailings. NRC Regulatory Guide 3.64 states, "if acceptable documented alternative information is not furnished by the applicant, the staff will use a reference value of 6% for the tailings moisture content because 6% is a lower bound for moisture in western soils" (NRC, 1989). Laboratory data does not exist to determine the actual weight percent moisture of tailings therefore, this is a conservative assumption.

The weight percent moisture of the new clay source (UT-1) is also unknown therefore, it was assumed that the average weight percent moisture from clay (site #1 and site #4) would be equivalent to the new clay source (UT-1). This is also a conservative assumption as the new clay

source is believed to be of better quality. Weight percent moisture values for clay and random fill were derived from the "Summary of Capillary Moisture Relationship Test Results" figures included in Appendix B1. Weight percent moisture values used for modeling purposes are:

Tailings	= 6%
Clay	= 14.1%
Random Fill	= 9.8%

Diffusion Coefficient

Diffusion coefficient input for the tailings and cover materials are measured values from Rogers & Associates (1988 and 1996), included in Appendix B1 and B2. The coefficients used for tailings and random fill were an average of the two values presented. The coefficients for each material are as follows:

Tailings	= 0.0142 cm^2/sec
Clay	= 0.0091 cm^2/sec
Random Fill	= 0.0082 cm^2/sec

References:

Advanced Terra Testing, 1996, Physical soil data, White Mesa Project, Blanding Utah, July 25, 1996.

Chen and Associates, 1987. Physical soil data, White Mesa Project Blanding Utah.

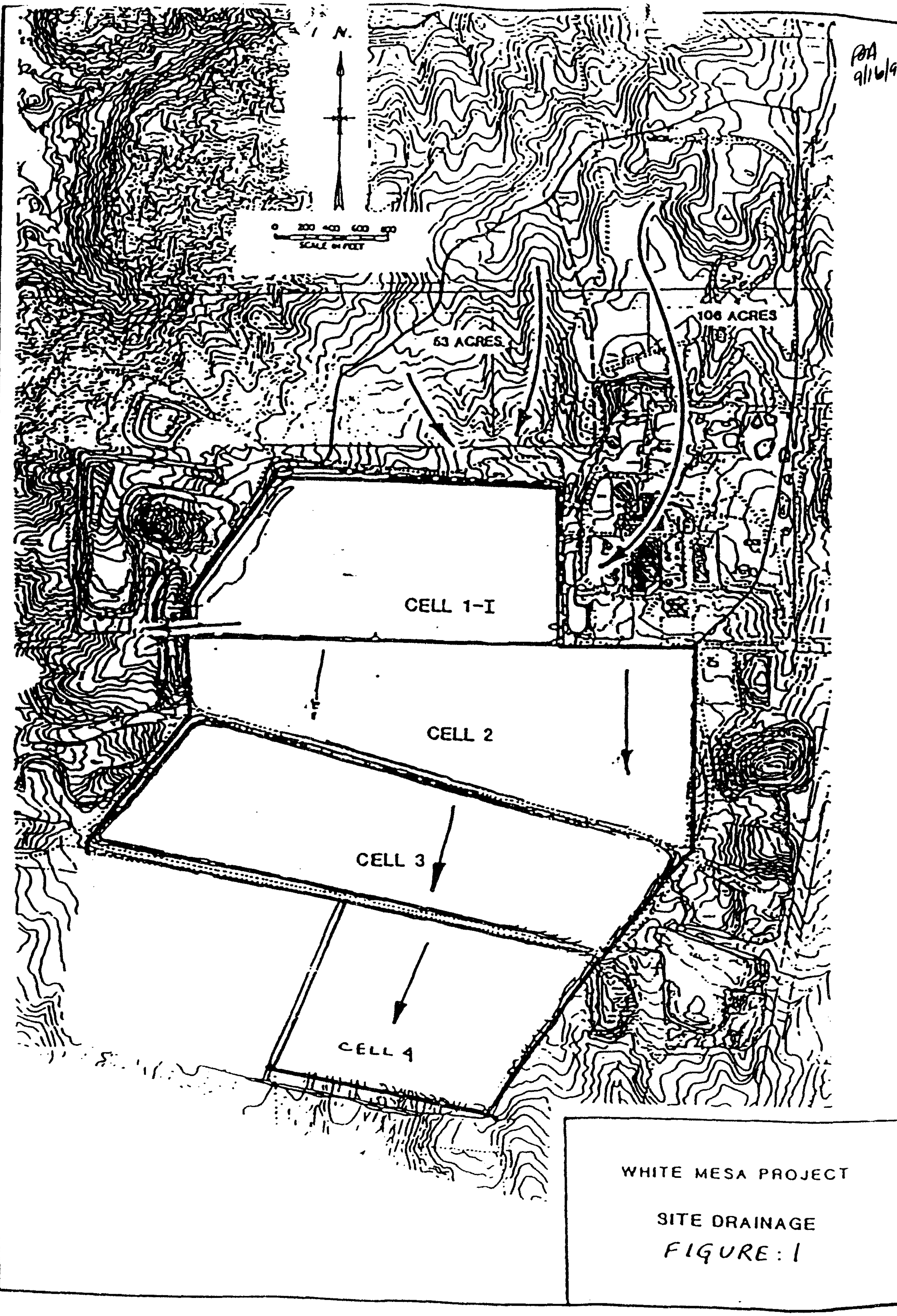
Freeze R. Allan and Cherry, John A., 1979, "Groundwater".

Principles & Practice of Civil Engineering, 2nd Edition, 1996.

Rogers and Associates Engineering Company, 1988. Radiological Properties Letters to C.O. Sealy from R.Y. Bowser dated March 4 and May 9, 1988.

Rogers and Associates Engineering Company, 1996. Report of Radon Diffusion Coefficient Measurements, Radium Content, and Emanation Coefficient Measurements, September 3, 1996.

U.S. Nuclear Regulatory Commission (NRC), 1989. "Regulatory Guide 3.64 (Task WM 503-4) Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers", March 1989.



WHITE MESA PROJECT

SITE DRAINAGE

FIGURE: 1

6/32

Appendix A1

-----*****! RADON !*****-----

8/32

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS

DATE/TIME OF THIS RUN
09-10-1996/18:06:33

EFN - WHITE MESA

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	4	
DESIRED RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
RADON FLUX INTO LAYER 1	0	pCi m^-2 s^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 TAILINGS

THICKNESS	500	cm
POROSITY	.44	
MEASURED MASS DENSITY	1.45	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	1.290D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.198	
MEASURED DIFFUSION COEFFICIENT	.0142	cm^2 s^-1

LAYER 2 RANDOM FILL (FILL FREEBOARD)

THICKNESS	91.5	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.85	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.452D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.800000000000001	%
MOISTURE SATURATION FRACTION	.576	
MEASURED DIFFUSION COEFFICIENT	8.200000000000001D-03	cm^2 s^-1

9/32

LAYER 3 CLAY (UT-1)

THICKNESS	30.5	cm
ROSITY	.28	
MEASURED MASS DENSITY	1.72	g cm^-3
MEASURED RADIUM ACTIVITY	1.5	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.22	
CALCULATED SOURCE TERM CONCENTRATION	4.257D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	14.1	%
MOISTURE SATURATION FRACTION	.866	
MEASURED DIFFUSION COEFFICIENT	.0091	cm^2 s^-1

LAYER 4 RANDOM FILL

THICKNESS	61	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.85	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.452D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.800000000000001	%
MOISTURE SATURATION FRACTION	.576	
MEASURED DIFFUSION COEFFICIENT	8.200000000000001D-03	cm^2 s^-1

DATA SENT TO THE FILE 'RNDATA' ON DEFAULT DRIVE

N	F01	CN1	ICOST	CRITJ	ACC
4	0.000D+00	0.000D+00	0	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	1.420D-02	4.400D-01	1.290D-03	1.977D-01	1.450
2	9.150D+01	8.200D-03	3.150D-01	4.452D-06	5.756D-01	1.850
3	3.050D+01	9.100D-03	2.800D-01	4.257D-06	8.661D-01	1.720
4	6.100D+01	8.200D-03	3.150D-01	4.452D-06	5.756D-01	1.850

BARE SOURCE FLUX FROM LAYER 1: 4.667D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	1.233D+02	4.519D+05
2	9.150D+01	2.562D+01	7.892D+04
3	3.050D+01	1.962D+01	2.276D+04
4	6.100D+01	1.361D+01	0.000D+00

Appendix A2

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

12/32

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS

DATE/TIME OF THIS RUN
09-10-1996/14:46:46

EFN - WHITE MESA (ACCOUNTING FOR FREEZE/THAW CONDITIONS)

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	4	
DESIRED RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
RADON FLUX INTO LAYER 1	0	pCi m^-2 s^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 TAILINGS

THICKNESS	500	cm
POROSITY	.44	
MEASURED MASS DENSITY	1.45	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	1.290D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.198	
MEASURED DIFFUSION COEFFICIENT	.0142	cm^2 s^-1

LAYER 2 RANDOM FILL

THICKNESS	91.5	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.85	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.452D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.800000000000001	%
STURE SATURATION FRACTION	.576	
MEASURED DIFFUSION COEFFICIENT	8.200000000000001D-03	cm^2 s^-1

13/32

LAYER 3 CLAY

THICKNESS	30.5	cm
POROSITY	.28	
MEASURED MASS DENSITY	1.72	g cm^-3
MEASURED RADIUM ACTIVITY	1.5	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.22	
CALCULATED SOURCE TERM CONCENTRATION	4.257D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	14.1	%
MOISTURE SATURATION FRACTION	.866	
MEASURED DIFFUSION COEFFICIENT	.0091	cm^2 s^-1

LAYER 4 RANDOM FILL

THICKNESS	43	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.85	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.452D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.800000000000001	%
MOISTURE SATURATION FRACTION	.576	
MEASURED DIFFUSION COEFFICIENT	8.200000000000001D-03	cm^2 s^-1

DATA SENT TO THE FILE 'RNDATA' ON DEFAULT DRIVE

N	F01	CN1	ICOST	CRITJ	ACC
4	0.000D+00	0.000D+00	0	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	1.420D-02	4.400D-01	1.290D-03	1.977D-01	1.450
2	9.150D+01	8.200D-03	3.150D-01	4.452D-06	5.756D-01	1.850
3	3.050D+01	9.100D-03	2.800D-01	4.257D-06	8.661D-01	1.720
4	4.300D+01	8.200D-03	3.150D-01	4.452D-06	5.756D-01	1.850

BARE SOURCE FLUX FROM LAYER 1: 4.667D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	1.237D+02	4.514D+05
2	9.150D+01	2.679D+01	7.622D+04
3	3.050D+01	2.123D+01	1.944D+04
4	4.300D+01	1.756D+01	0.000D+00

Appendix B1

TAILINGS AND RANDOM FILL PROPERTIES

Table 3.4-1

Physical Properties of Tailings

and

Proposed Cover Materials

Material Type	Atterberg Limits LL	Atterberg Limits PI	Specific Gravity	% Passing No. 200 Sieve	Maximum Dry Density (pcf)	Optimum Moisture Content
Tailings	28	6	2.85	46	104.0	18.1
Random Fill	22	7	2.67	48	120.2	11.8
Clay	29	14	2.69	56	121.3	12.1
Clay	36	19	2.75	68	108.7	18.5

Note: Physical Soil Data from Chen and Associates (1987).

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110
(801) 263-1600

17/32

March 4, 1988

Mr. C.O.S aly
Umetco Min rals Corporation
P.O. Box 10
Grand Junc n, CO 81502

C8700/22

Dear Mr. Sealy:

We have completed the tests ordered on the four samples shipped to us. The results are as follows:

Sample	Radium pCi/gm	Emanation Fraction	Diffusion Coeffic.	(g/cm^3) Density	Moisture	Saturation
Tailings	981±4	0.19±0.01	2.0E-02	1.45	13.2	0.39
Composite (2,3,&5)			8.4E-03	1.44	19.1	0.56
			1.6E-02	1.85	6.5	0.40
Site #1			4.5E-04	1.84	12.5	0.75
			1.6E-02	1.85	8.1	0.48
Site #4			1.4E-03	1.84	12.6	0.76
			1.1E-02	1.65	15.4	0.63
			4.2E-04	1.65	19.3	0.80

The samples will be shipped back to you in the next few weeks. If you have any questions regarding the results on the samples please feel free to call.

Sincerely,

Renee Y. Bowser
Lab Supervisor

RYB/b

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110
(801) 263-1600

18/32

MAY 12 1988

May 9, 1988

Mr. C.O. Sealy
UMETCO Minerals Corporation
P.O. Box 1029
Grand Junction, CO 81502

C8700/22

Dear Mr. Sealy:

The tests for radium content and radon emanation coefficient in the following samples have been completed and the results are as follows:

Sample	Radium (pCi/g)	Radon Emanation Coefficient
Random (2,3 & 5)	1.9 ± 0.1	0.19 ± 0.04
Site 1	2.2 ± 0.1	0.20 ± 0.03
Site 4	2.0 ± 0.1	0.11 ± 0.04

If you have any questions regarding these results please feel free to call Dr. Kirk Nielson or me.

Sincerely,

Renee Y. Bowser
Lab Supervisor

RYB:ms

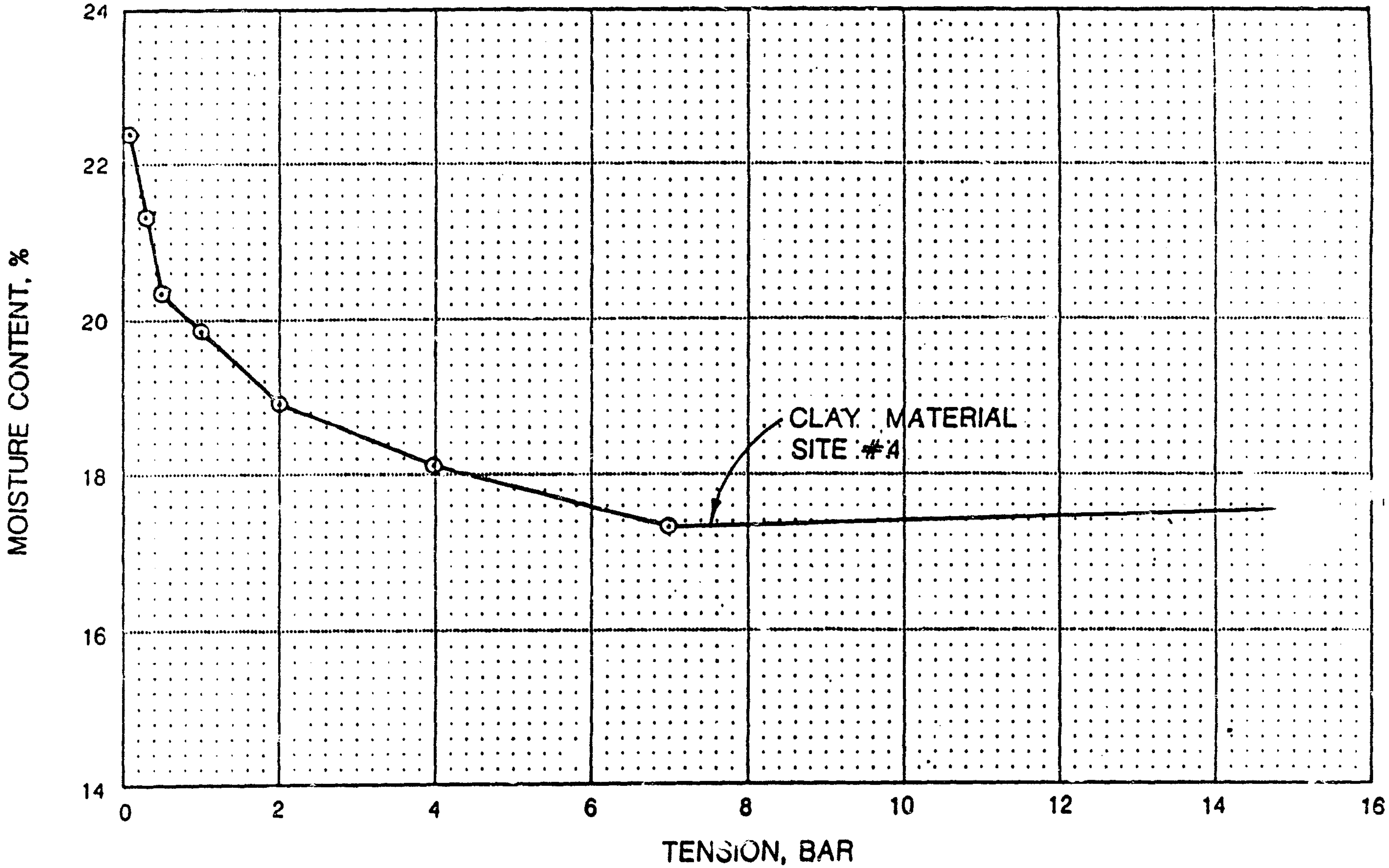


FIGURE 4.4-2
SUMMARY OF CAPILLARY MOISTURE
RELATIONSHIP TEST RESULTS
WHITE MESA PROJECT

DATA FROM CHEN & ASSOCIATES.

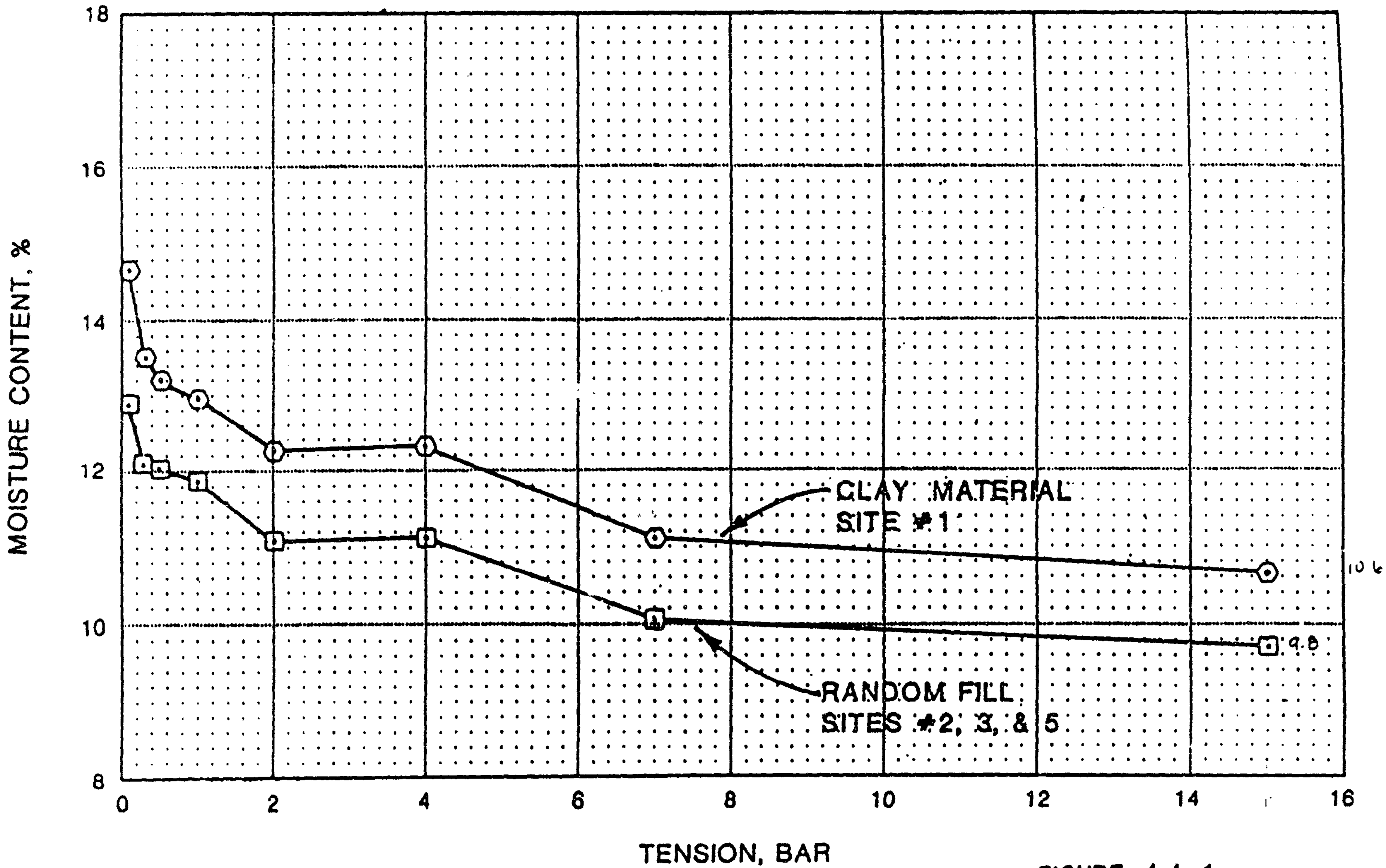


FIGURE 4.4-1
SUMMARY OF CAPILLARY MOISTURE
RELATIONSHIP TEST RESULTS
WHITE MESA PROJECT

DATA FROM CHEN & ASSOCIATES

Appendix B2

22/32

833 Parfet Street
Lakewood, Colorado 80215
(303) 232-8308

23/32

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Titan Env.	JOB NO.	2234-04
BORING NO.			
DEPTH		DATE SAMPLED	
SAMPLE NO.	UT-1	DATE TESTED	7-25-96 WEB, RV
SOIL DESCR.			
TEST TYPE	ATTERBERG		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	3.34	4.06	3.42
Wt Dish & Dry Soil	2.96	3.57	3.03
Wt of Moisture	0.38	0.49	0.39
Wt of Dish	1.05	1.11	1.06
Wt of Dry Soil	1.91	2.46	1.97
Moisture Content	19.90	19.92	19.80

Liquid Limit Determination   Device Number 0258

	1	2	3	4	5
Number of Blows	39	27	18	14	9
Wt Dish & Wet Soil	12.18	10.42	10.92	12.33	10.06
Wt Dish & Dry Soil	6.64	5.67	5.87	6.53	5.34
Wt of Moisture	5.54	4.75	5.05	5.80	4.72
Wt of Dish	1.10	1.06	1.06	1.10	1.08
Wt of Dry Soil	5.54	4.61	4.81	5.43	4.26
Moisture Content	100.00	103.04	104.99	106.81	110.80

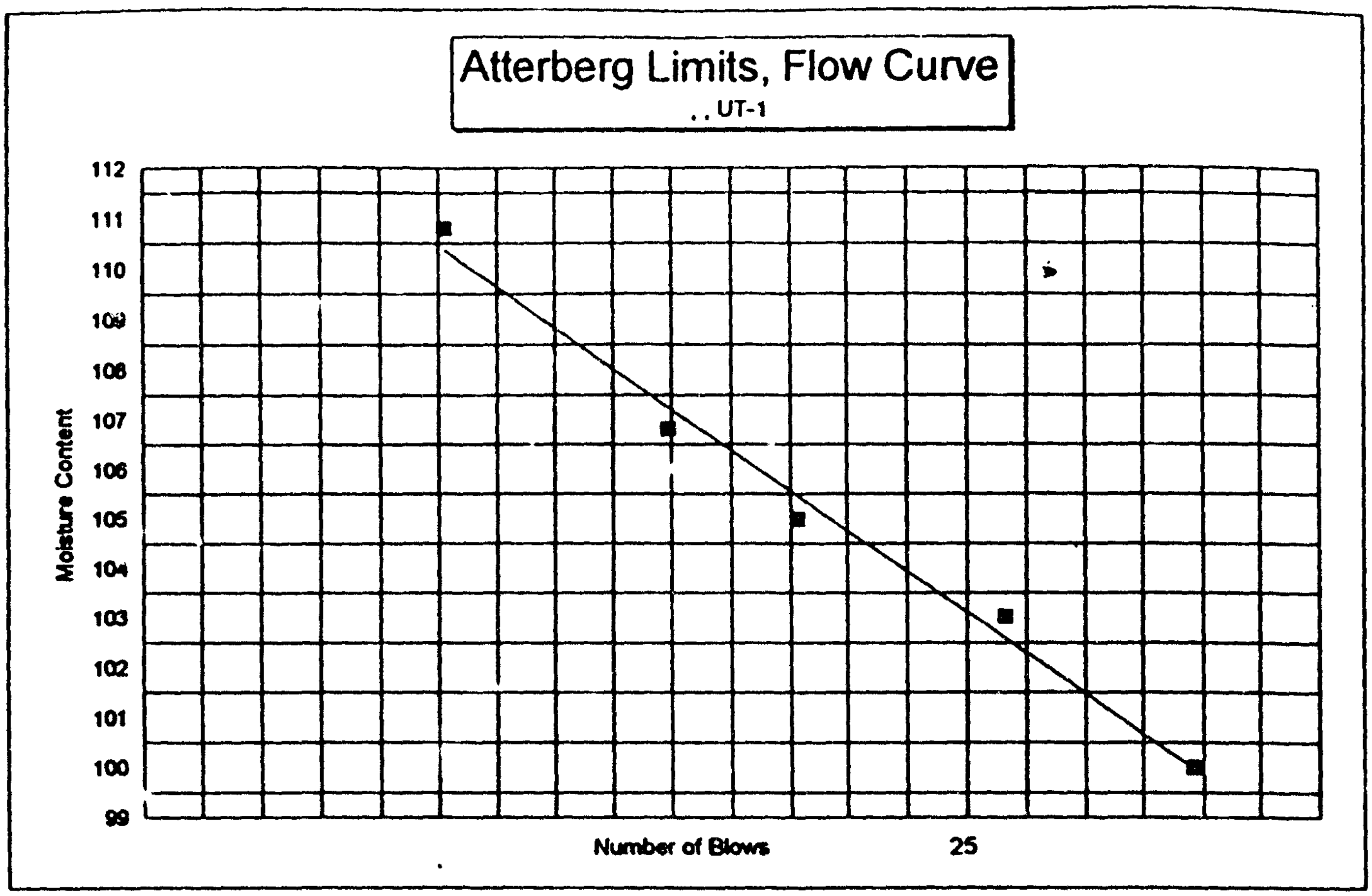
Liquid Limit	103.1
Plastic Limit	19.9
Plasticity Index	83.3

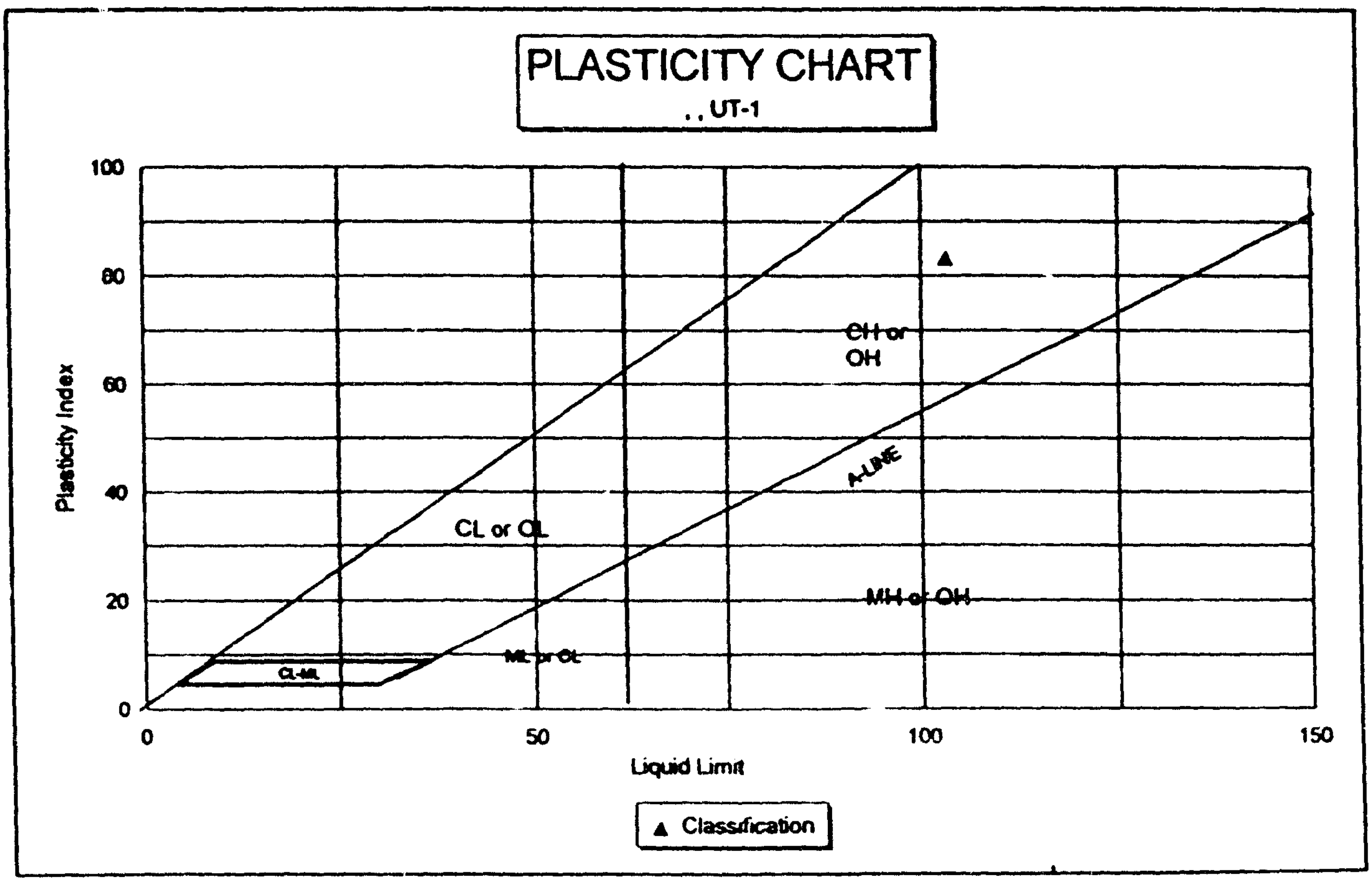
Atterberg Classification CH

Data entry by: NAA   Date: 7-26-96
Checked by: [signature]   Date: 7-26-96
FileName: TIGOUT1

ADVANCED TERRA TESTING, INC.

24/32


Atterberg Limits, Flow Curve
, , UT-1
Moisture Content
112
111
110
109
108
107
106
105
104
103
102
101
100
99
Number of Blows
25


PLASTICITY CHART
, , UT-1
Plasticity Index
100
80
60
40
20
0
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
0
50
100
150
Liquid Limit
Classification

C .PACTION TEST
ASTM D 1557 A

CLIENT: Titan Env. JOB NO. 2234-04

25/32

BORING NO.
:PTH
.AMPLE NO. UT-1

SOIL DESCR.
DATE SAMPLED
DATE TESTED 7-25-96 RV

Moisture determination

	1	2	3	4	5
Wt of Moisture added (ml)	100.00	150.00	250.00	350.00	450.00
Wt. of soil & dish (g)	384.26	393.92	291.42	244.20	281.17
Dry wt. soil & dish (g)	350.60	355.61	251.40	202.69	225.04
Net loss of moisture (g)	33.66	38.31	40.02	41.51	56.13
Wt. of dish (g)	8.01	8.34	8.31	8.29	8.43
Net wt. of dry soil (g)	342.59	347.27	243.09	194.40	216.61
Moisture Content (%)	9.83	11.03	16.46	21.35	25.91
Corrected Moisture Content					

Density determination

	1	2	3	4	5
Wt of soil & mold (lb)	14.20	14.49	14.68	14.59	14.46
Wt. of mold (lb)	10.36	10.36	10.36	10.36	10.36
Net wt. of wet soil (lb)	3.84	4.13	4.32	4.23	4.10
''t wt of dry soil (lb)	3.50	3.72	3.71	3.49	3.26
, Density, (pcf)	104.89	111.59	111.28	104.57	97.69
Corrected Dry Density (pcf)					
Volume Factor	30	30	30	30	30

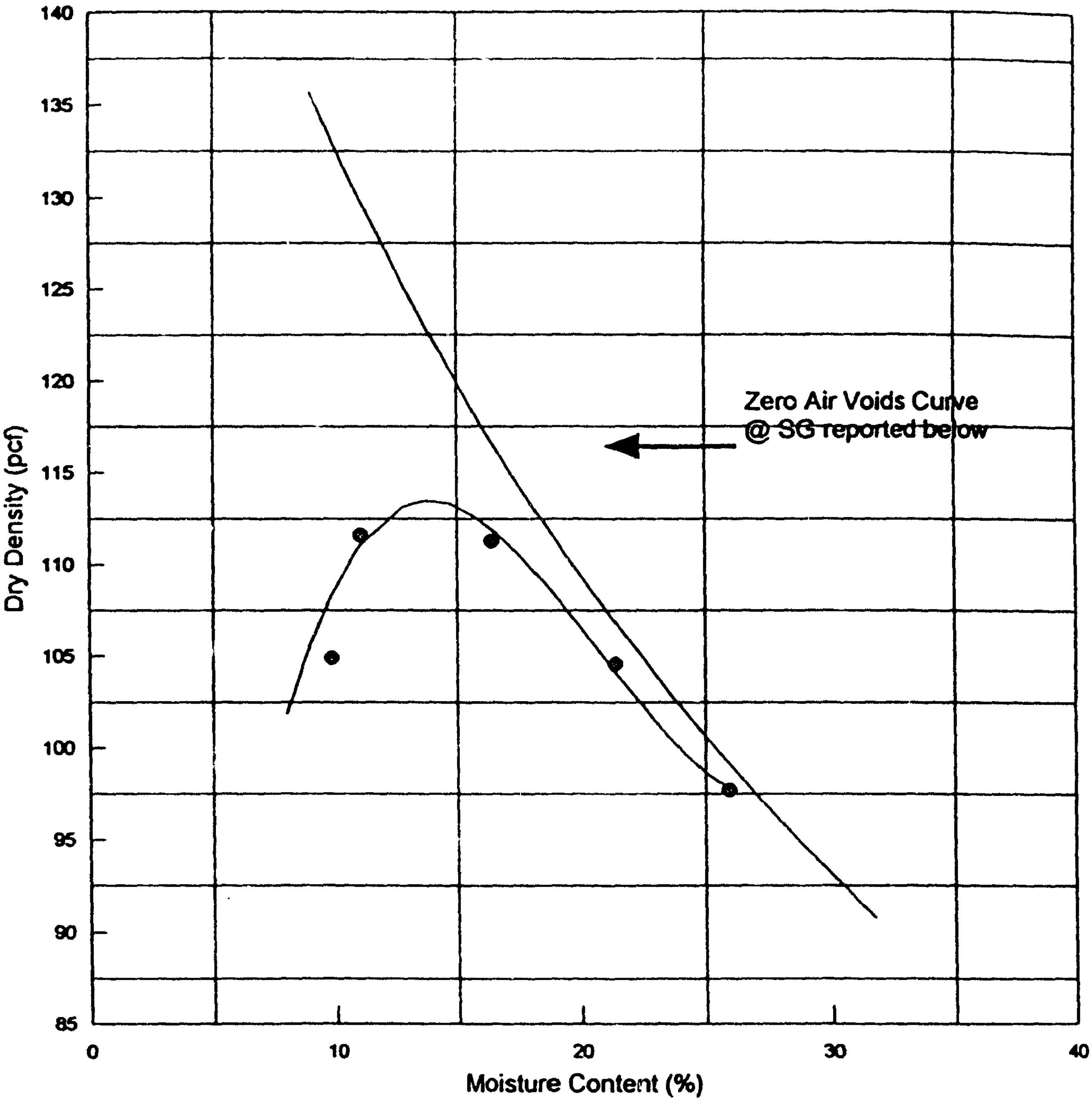
Data entered by: RV Date: 7-26-96
a checked by: [signature] Date: 7-26-96
FileName: TIPRUT-1

ADVANCED TERRA TESTING, INC

Proctor Compaction Test

, , UT-1

26/32



- Best Fit Curve
- Actual Data
- Zero Air VoidsCurve @ SG = 2.70

OPTIMUM MOISTURE CONTENT = 13.9 MAXIMUM DRY DE[illegible]SITY = 113.5
ASTM D 1557 A, Rock correction applied? N

ADVANCED TERRA TESTING, INC.

PERMEABILITY DETERMINATION
FALLING HEAD
FIXED WALL

27/32

CLIENT	Titan Environmental	JOB NO.	2234-04
BORING NO.		SAMPLED	
DEPTH		TEST STARTED	7-28-96 CAL
SAMPLE NO.	UT-1	TEST FINISHED	8-7-96 CAL
SOIL DESCR.	Remolded 95% Mod Pt. @ OMC	SETUP NO.	1
SURCHARGE	200		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil & Ring(s) (g)	386.9	404.5
Wt. Ring(s) (g)	93.0	93.0
Wt. Soil (g)	293.9	311.4
Wet Density PCF	122.3	120.5
Wt. Wet Soil & Pan (g)	302.4	319.9
Wt. Dry Soil & Pan (g)	266.2	266.2
Wt. Lost Moisture (g)	36.2	53.8
Wt. of Pan Only (g)	8.5	8.5
Wt. of Dry Soil (g)	257.7	257.7
Moisture Content %	14.1	20.9
Dry Density PCF	107.2	99.7
Max. Dry Density PCF	113.5	113.5
Percent Compaction	94.4	87.8

ELAPSED TIME (MIN)	BURETTE READING h1 (CC)	BURETTE READING h2 (CC)	PERCOLATION RATE FT/YEAR	PERCOLATION RATE CM/SEC
	0.2			
2599	10.8	10.8	0.14	1.4E-07
1427	14.2	14.2	0.09	8.4E-08
1440	16.8	16.8	0.07	6.5E-08
1440	18.6	18.6	0.05	4.6E-08
1440	20.2	20.2	0.04	4.1E-08
1440	21.6	21.6	0.04	3.7E-08
1469	23.0	23.0	0.04	3.6E-08
1440		24.4	0.04	3.7E-08

Data Entered By: NAA Date: 8-8-96
Date Checked By: [signature] Date: 8-8-96
Filename:TIFHUT1

ADVANCED TERRA TESTING, INC.

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REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS
(TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

Report Date: 9/3/96
Contract: C96009
By: BCR
Date Received: 8/96

Sample Identification: Titan Environmental

Sample ID	Moisture (Dry Wt. %)	Density (g/cm^3)	Radon Diffusion Coefficient (cm^2/s)	Saturation (Mp/P)	Specific Gravity (g/cm^3)
UT-1	14.6%	1.72	9.1E-03	0.89	2.39

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Rogers & Associates Engineering Corporation

29/32

REPORT OF RADIUM CONTENT AND EMANATION COEFFICIENT MEASUREMENTS

(LAB PROCEDURE RAE-SQAP-3.1)

Report Date: 9/3/96
Contract: C96009
By: BCR
Date Received: 8/96

Sample Identification: Titan Environmental

Sample ID	Moisture (Dry Wt. %)	Radon Emanation Coefficient	Radium-226 (pCi/g)	Comments
UT-1	14.6%	0.22 ± 0.04	1.5 ± 0.3	

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Appendix C

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...from the Professors who know it best...

PRINCIPLES & PRACTICE OF CIVIL ENGINEERING

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14.5 Other Useful Equations for Weight-Volume Problems

It is strongly recommended that weight-volume problems be solved using phase diagrams rather than only formulas, as completing a phase diagram clearly indicates whether sufficient information is known to complete the problem, whether information is insufficient and assumptions must be made, or whether too much information is present and the problem is overconstrained. For example, it may not be immediately apparent from the information given whether a soil is saturated until all quantities are calculated. Nevertheless, following are given additional useful equations that may be used to solve certain classes of weight-volume problems.

A very useful equation relating four different quantities is

$$Se = wG_s \tag{14.5.1}$$

For saturated soils (S = 100%) there results

$$e = wG_s \tag{14.5.2}$$

The relationships between the void ratio and porosity are

$$e = \frac{n}{1-n} \tag{14.5.3}$$

and

$$* \quad n = \frac{e}{1+e} \tag{14.5.4}$$

n = porosity
e = Volume of Voids / Volume of Solids

The total unit weight can be obtained as

$$\gamma = \frac{(G_s + Se)\gamma_w}{1+e} = \frac{(1+w)\gamma_w}{w/S + 1/G_s} \tag{14.5.5}$$

The dry unit weight can be obtained as

$$* \quad \gamma_d = \frac{G_s\gamma_w}{1+e} = \frac{G_s\gamma_w}{1+(wG_s/S)} \tag{14.5.6}$$

γ_d: Dry Bulk Density
G_s: Specific Gravity
γ_w: Density of Water

EXAMPLE 14.8

Rework example 14.6 using equations introduced in this section.

Solution.

$$Se = wG_s$$

$$S = wG_s/e = (.20)(2.65)/(0.800) = 0.6625 \text{ or } 66.3\%$$

$$n = \frac{e}{1+e} = \frac{0.800}{1+0.800} = 0.444$$

$$\gamma = \frac{(1+w)\gamma_w}{w/S + 1/G_s} = \frac{(1.20)(62.4)}{0.2/0.6625 + 1/2.65} = 110.2 \text{ lb/ft}^3$$

$$\gamma_d = \frac{G_s\gamma_w}{1+e} = \frac{(2.65)(62.4)}{1+0.800} = 91.9 \text{ lb/ft}^3$$

APPENDIX C

Radon Flux Measurments

1994 Results

Site Specific Sample Results (reference Figure 6-1)

(a) The mean radon flux for each region within each cell is as follows:

Cell 2 - Cover Area = 7.7 pCi/m^2-s (based on 225,882 m^2 area)
- Beach Areas = 23.3 pCi/m^2-s (based on 41,761 m^2 area)
- Standing Liquid Areas = 0 pCi/m^2-s (based on 2,982 m^2 area)

Cell 3 - Cover Area = 7.5 pCi/m^2-s (based on 82,762 m^2 area)
- Beach Areas = 39.7 pCi/m^2-s (based on 62,761 m^2 area)
- Standing Liquid Areas = 0 pCi/m^2-s (based on 143,335 m^2 area)

Note: Reference Appendix B of this report for entire summary for individual measurement results and specific sample region maps.

(b) Using the data presented above, we have calculated the total mean radon flux for each pile (cell) as follows:

Cell 2 = 10.0 pCi/m^2-s

$$\frac{(7.7)(225,882) + (23.3)(41,761) + (0)(2,982)}{270,625}$$

Cell 3 = 10.8 pCi/m^2-s

$$\frac{(7.5)(82,762) + (39.7)(62,761) + (0)(143,335)}{288,858}$$

1995 Results

6.0 SAMPLE RESULTS/CALCULATIONS

Referencing 40 CFR, Part 61, Subpart W, Appendix B, Method 115 - Monitoring for Radon-222 Emissions, Subsection 2.1.7 - Calculations, "the mean radon flux for each region of the pile and for the total pile shall be calculated and reported as follows:

(a) The individual radon flux calculations shall be made as provided in Appendix A EPA 86(1). The mean radon flux for each region of the pile shall be calculated by summing all individual flux measurements for the region and dividing by the total number of flux measurements for the region.

(b) The mean radon flux for the total uranium mill tailings pile shall be calculated as follows:

$$J_s = \frac{J_1A_1 + \ldots J_2A_2 [+] \ldots J_iA_i}{A_t}$$

Where: J_s = Mean flux for the total pile (pCi/m²-s)
J_i = Mean flux measured in region i (pCi/m²-s)
A_i = Area of region i (m²)
A_t = Total area of the pile (m²)

2.1.8 Reporting. The results of individual flux measurements, the approximate locations on the pile, and the mean radon flux for each region and the mean radon flux for the total stack [pile] shall be included in the emission test report. Any condition or unusual event that occurred during the measurements that could significantly affect the results should be reported."

Site Specific Sample Results (reference Figure 6-1)

(a) The mean radon flux for each region within each cell is as follows:

Cell 2	Cover Area	= 6.1 pCi/m²-s (based on 225,882 m² area)
	Beach Areas	= 28.4 pCi/m²-s (based on 41,761 m² area)
	Standing Liquid Areas	= 0 pCi/m²-s (based on 2,982 m² area)
Cell 3	Cover Area	= 11.1 pCi/m²-s (based on 82,762 m² area)
	Beach Areas	= 44.8 pCi/m²-s (based on 62,761 m² area)
	Standing Liquid Areas	= 0 pCi/m²-s (based on 143,335 m² area)

Note: Reference Appendix B of this report for entire summary for individual measurement results and specific sample region maps.

(b) Using the data presented above, we have calculated the total mean radon flux for each pile (cell) as follows:

Cell 2 = 9.5 pCi/m^2-s

$$\frac{(6.1)(225,882) + (28.4)(41,761) + (0)(2,982)}{270,625}$$

Cell 3 = 12.9 pCi/m^2-s

$$\frac{(11.1)(82,762) + (44.8)(62,761) + (0)(143,335)}{288,858}$$

APPENDIX D

HELP Model

Purpose: To determine the required soil cover thicknesses to minimize surface water infiltration through the White Mesa tailings impoundments so that precipitation will not fully penetrate the soil cover. The White Mesa Mill site is located in Blanding, Utah. The performance of the tailings cover was evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) Model. The HELP model was developed to facilitate rapid, economical estimation of the amounts of surface runoff, subsurface drainage, and leachate that may be expected to result from the operation of a wide variety of possible cover designs.

Method: Determine the soil properties of the cover materials and climatic properties of Blanding, Utah based on existing database values previously collected, and acceptable default parameters. Input parameters into the computer modeling program "HELP" to determine the percolation through the cover materials. A variety of scenarios adjusting cover thicknesses were run to determine the optimum thicknesses of cover materials to eliminate percolation through the bottom cover layer. The modeled tailings cover consists of a compacted clay layer over the tailings, with a random fill soil layer covering the clay.

The model was developed for Cell 3 at the White Mesa Mill since it is the largest of the three cells to be covered (Cells 2, 3, and 4A). Figure 1 shows the location of the cells. The cover requirements determined for Cell 3 will be applied to the remaining cells as well. This is a conservative approach since the remaining cells are smaller in size and require less time and distance for precipitation runoff.

Results: A two-layer uranium mill tailings cover composed of a 2-foot layer of random fill over a 1-foot compacted clay layer will reduce percolation into the tailings material to a negligible quantity (see Appendix A for HELP results). As indicated by the model results, precipitation will either runoff the soil cover or be evaporated.

The cover thicknesses recommended above were also determined to be the minimum thickness requirements for White Mesa tailings covers based on results from radon flux calculations (see "Calculation of Radon Flux from the White Mesa Tailings Cover", 9/11/96). As indicated in the Radon Flux calculation, to restrict radon flux to 20 pCi/m2/sec, (Regulatory Guide 3.64), a cover consisting of 2-feet random fill and 1-foot compacted clay is required.

Parameters: The HELP model requires input of the following parameters for the cover materials:

- Weather Data:
  - Evapotranspiration
  - Precipitation
  - Temperature
  - Solar Radiation

- Soil and Design Data:
  - Landfill area (area of Cell 3)
  - Percent of area where runoff is possible
  - Moisture content initialization

- Cover Layer Data:
  - Layer type
  - Default soil/material texture number
  - Runoff curve number

Weather Data

Evapotranspiration and *solar radiation* data was input using the default parameters from Grand Junction, Colorado. Grand Junction is located north east of Blanding Utah in a similar climate and elevation. The elevation at Grand Junction is 4,600 feet and the elevation at Blanding Utah is 5,600 feet. Figure 1 in Appendix B shows the locations of Blanding and Grand Junction in relation to one another.

Precipitation data from 1988 to 1993 (skipping 1989) was obtained from Utah State University (see Appendix C). Daily precipitation values for the five years were input manually into the HELP model. *Temperature* data was obtained from the Dames & Moore (1978) and is also included in Appendix C. Daily temperature data was not available for manual entry therefore, the computer calculated mean monthly temperatures based on the default location (Grand Junction, Colorado). These values were then edited to match the actual mean monthly temperatures for Blanding, Utah.

Soil and Design Data

The surface area of Cell 3 at the White Mesa Mill, Blanding, Utah was used for the landfill area value. The surface area, as indicated on Figure 1, is 78.7 acres. It was assumed that runoff was possible over 100% of this area and that no rain would sit on the tailings cover.

Cover Layer Data

Layer Thickness:
A two-layer cover over approximately 28 feet of uranium mill tailings was used to run the HELP model. Actual cover thicknesses which would be constructed on site consist of 2-feet of random fill over a 1-foot compacted clay layer. This cover profile was adjusted for modeling purposes to account for freezing and thawing conditions. As indicated in the "Effects of Freezing on Uranium Mill Tailings Covers Calculation Brief" (6/17/96), 6.8 inches of the top random fill cover layer will be effected by freeze/thaw conditions at Blanding, Utah. This suggests that 6.8 inches of the top layer may not contribute to reductions of infiltration into the tailings piles. To conservatively compensate for effects from freezing and thawing, 6.8 inches were subtracted from the top random fill cover layer. Therefore, modeled layer thicknesses consisted of 17.2 inches of random fill over 12 inches of clay.

Layer Type:
The random fill soil layer was classified as a vertical percolation layer. Vertical percolation layers are composed of moderate to high permeability material that drains vertically, primarily as unsaturated flow. The clay layer was classified as a barrier soil liner. This material consists of low permeability soil designed to limit percolation/leakage and drains only vertically as a saturated flow.

Moisture Storage Parameters:
Required moisture storage parameters such as; porosity, field capacity, wilting point, initial soil water content, and permeability, are interrelated with the exception of permeability. The porosity must be greater than zero but less than 1. The field capacity must be between zero and 1 but must be smaller than the porosity. The wilting point must be greater than zero but less than the field capacity, and the initial moisture content must be greater than or equal to the wilting point and less than or equal to the porosity (U.S. EPA, 1994).

Based on these relations, actual measured porosity and permeability values were input for random fill (Chen and Associates, 1987) and clay (Advanced Terra Testing, 1996, sample UT-1). See Appendix D for physical property data. In addition, wilting point data for the layers was se'

equal to the long-term moisture content of the materials and the soil water content was adjusted to equal the optimum moisture content. Field capacity values just less than the porosity's were assumed to maintain the interrelationship of the parameters.

Runoff Curve Number
The runoff curve number was calculated by the HELP model based on a minimum surface slope of 0.2%, slope length of 1,200 feet, soil texture of the top layer, and vegetation. A slope length of 1,200 feet was assumed to be the maximum distance which precipitation would travel over the soil cover. The top layer on the tailings cover will be minimum 3" of rock riprap (sandstone) therefore, no vegetation will exist. This top layer, however, was not included in the model to determine percolation quantities.

References:

Advanced Terra Testing, 1996, Physical soil data, White Mesa Project, Blanding Utah, July 25, 1996.

Chen and Associates, 1987. Physical soil data, White Mesa Project, Blanding, Utah.

Dames & Moore, 1978. "Environmental Report, White Mesa Uranium Project, San Juan County Utah", January 20, 1978, revised May 15, 1978.

Principles & Practice of Civil Engineering, 2nd Edition, 1996.

U.S. Environmental Protection Agency (EPA), 1994. "The Hydrologic Evaluation of Landfill Performance (HELP) Model", September, 1994.

Utah Climate Center, Utah State University, Daily Precipitation Values, Station #42073807, Blanding, Utah, January 1988 through December 1993.

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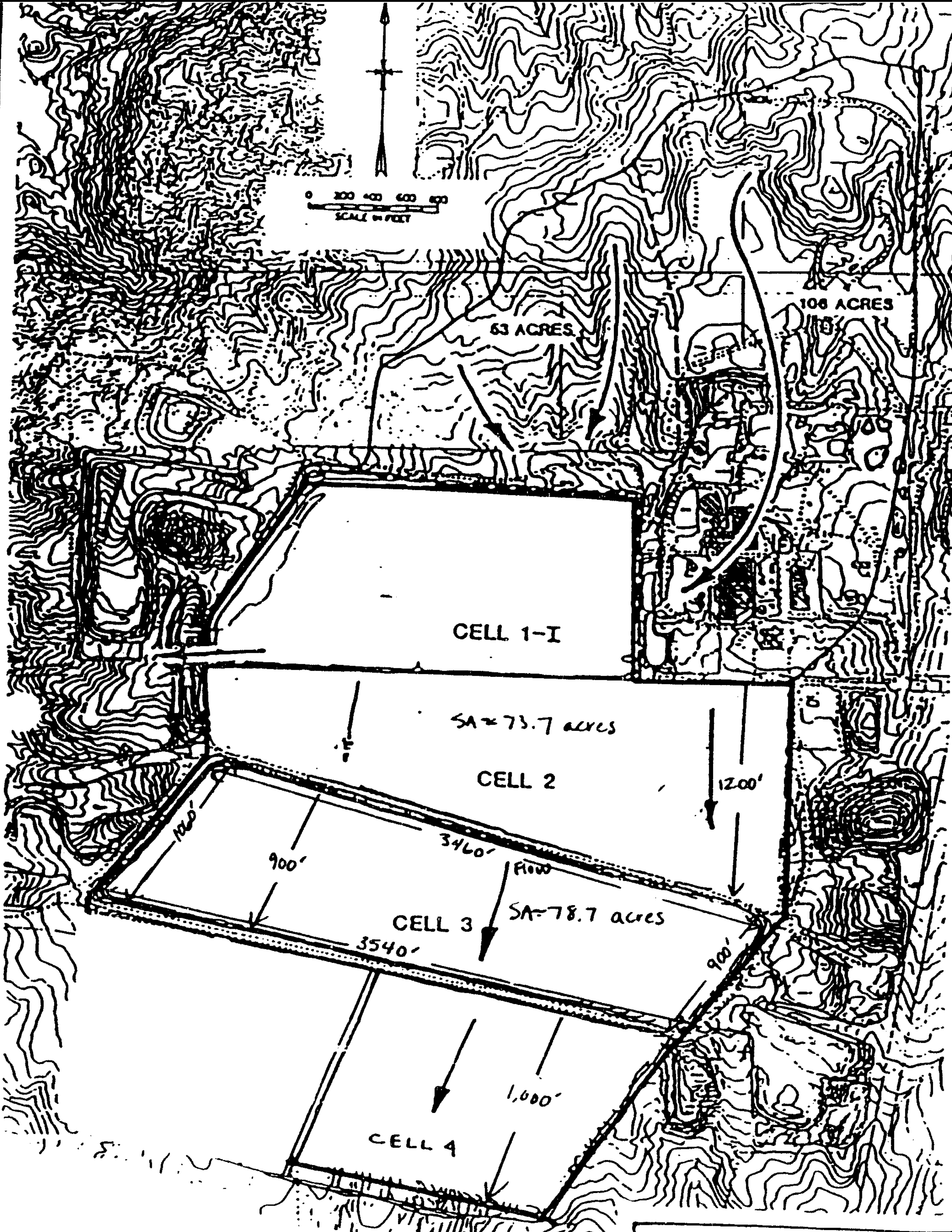

Max distance water will travel over Cells: 1,200' + 900' + 1,000' = 3,100'

WHITE MESA PROJECT

SITE DRAINAGE

FIGURE: 1

Appendix A

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
 *           HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                  **
**             HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                  **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                 USAE WATERWAYS EXPERIMENT STATION                        **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************
```

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```
PRECIPITATION DATA FILE:      C:\HELP3\PRECIP.D4
TEMPERATURE DATA FILE:        C:\HELP3\TEMP2.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\SOLAR.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\EVAP.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\efn-fin2.D10
OUTPUT DATA FILE:             C:\HELP3\efn-fin2.OUT


TIME:  14: 9     DATE:   9/11/1996


  ****************************************************************************

     TITLE:  EFN - White Mesa

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                      LAYER  1
                                      --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER  88
              THICKNESS                     =     17.20    INCHES
              POROSITY                      =      0.3150 VOL/VOL
              FIELD CAPACITY                =      0.3140 VOL/VOL
              WILTING POINT                 =      0.0980 VOL/VOL
              INITIAL SOIL WATER CONTENT    =      0.1180 VOL/VOL
              EFFECTIVE SAT. HYD. COND.     =  0.886999999000E-06 CM/SEC


                                      LAYER  2
```

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 89

THICKNESS	=	12.00	INCHES
POROSITY	=	0.2800	VOL/VOL
FIELD CAPACITY	=	0.2799	VOL/VOL
WILTING POINT	=	0.1410	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2800	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999995000E-07	CM/SEC

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GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #27 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 0.% AND A SLOPE LENGTH OF 1200. FEET.

SCS RUNOFF CURVE NUMBER	=	96.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	78.700	ACRES
EVAPORATIVE ZONE DEPTH	=	17.2	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.030	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	5.418	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.686	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.390	INCHES
TOTAL INITIAL WATER	=	5.390	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM GRAND JUNCTION COLORADO

MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	109	
END OF GROWING SEASON (JULIAN DATE)	=	293	
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	36.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	57.00	%

NOTE: PRECIPITATION DATA FOR BLANDING UTAH WAS ENTERED BY THE USER.