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SOIL TESTING SERVICES
OF MICHIGAN, INC.
Formerly Northern Michigan Soil & Materials Testing, Inc.
550 EAST OHIO ST. MARQUETTE, MI 49855

June 7, 1982 .

City of Marquette
Engineering Department
300 W. Baraga Ave.
Marquette, Michigan 49855

Attention: Mike Etelamaki

STS Job M-11771

Re: Subsurface exploration and hydrogeologic study at the Cliffs Dow Disposal Site in Marquette, Michigan

Gentlemen:

The subsurface exploration as outlined in our proposal dated March 23, 1982 has been completed. The attached report contains the logs of eleven soil borings, well installation diagrams, a summary of the subsurface conditions and our evaluation of the hydrogeologic conditions at this site. Three copies of this report have been sent to the above address.

We have appreciated this opportunity to be of service to you on this project. If you have any questions concerning this report or the data contained herein, please feel free to contact us at your convenience.

Yours very truly,

SOIL TESTING SERVICES, INC.

James J. Botz, P. E.
Senior Project Engineer

Douglas J. Hermann, P. E.
Environmental Group Manager

JJB/gm

cc: ENCOTEC
3965 Research Park
Ann Arbor, Mi. 48104

SOILS REPORT

CLIFFS DOW DISPOSAL SITE

MARQUETTE, MICHIGAN

INTRODUCTION

The City of Marquette, Michigan owns a disposal site which was previously utilized by the Cliffs Dow Company. The site was used for disposition of waste materials from their charcoal briquet processes. It is suspected that this waste material contains contaminants which may adversely affect the quality of the ground water in the area. The horizontal fill limits can be fairly well defined by visual observation. However, the depth of the waste material at this site is not known at this time.

The purpose of this hydrogeologic study was to determine the depth of the waste material at this site, and determine the geological and hydrogeological conditions. Ground water samples have also been recovered for chemical analysis. The chemical testing or evaluation of the chemical testing was not included in the scope of this work.

FIELD PROCEDURES

Eleven soil borings were performed for this exploration at the locations indicated on the Soil Boring Location Diagram included in the Appendix to this report. These borings were located in the field by Mr. James Botz of Soil Testing Services (STS). Ground surface elevations at the boring locations as well as the horizontal control of the borings were determined by personnel from the City of Marquette Engineering Department. The soil borings were performed with a track-mounted bombardier drill rig and a truck-mounted Joy Model 12-B rotary drill rig. The borings were advanced using a combination of solid stem flight augers and a washed boring technique. The washed boring technique utilizes a tri-cone bit and wash water. Steel casing was utilized in conjunction with the wash boring technique to maintain an open bore hole near the surface. The wash water was not re-circulated in the drilling operation.

Six soil borings were performed on the disposal area. The primary purpose of these borings were to determine the thickness of the fill material and to obtain samples of the underlying natural soils. The fill materials and soils were sampled in general accordance with ASTM Specifications D 1586-67, "Standard Method for Penetration Testing and Split Barrel Sampling of Soils". A 3-inch size split spoon was utilized in this sampling procedure to obtain sufficient sample for chemical analysis. The penetration blow counts should <u>not</u> be considered as standard "N" values having used the oversized spoon. A description of the sampling procedure is included in the Appendix to this report.

Three additional soil borings were performed around the perimeter of fill area primarily for determining the hydrogeologic conditions. Borings 1 and 2 were sampled in general accordance with the split spoon sampling procedure utilizing the standard 2-inch O. D. split spoon sampler. Boring 3 was sampled using a 3-inch split spoon.

Two-inch PVC observation wells were installed in Borings 1 and 2. These observation wells were installed for ground water observation. Two-inch nominal size stainless steel well casing was installed in Borings 3, 3A and 3B. The stainless steel casing was used since these observation wells were to be sampled for chemical analysis. Installation Diagrams of these observation wells are included in the Appendix to this report.

While sampling and drilling the presence of ground water was observed and recorded. Upon completion of the drilling, the presence of ground water was again observed and recorded. Several days after drilling, the observation wells were monitored and bailed. On April 26, 1982, the wells were again monitored and samples were obtained for chemical analysis. Field pH and conductivity were measured on each sample by STS. The samples were placed in containers provided by Environmental Control Technology and delivered to city personnel for transportation to the chemical testing laboratory. The ground water observations are presented on the lower left hand corner of the Boring Logs and on Table I: Water Level Summary included in the Appendix.

LABORATORY PROCEDURES

A representative portion of the soil samples were returned to the laboratory and visually examined by a Geotechnical Engineer. The samples were classified according to type using the Unified Classification System. The capitalized symbol in parenthesis on the Boring Logs is the appropriate group symbol according to this classification system. A chart describing this classification system is included in the Appendix. Most soil samples were placed in quart-sized jars and delivered to city personnel for transportation to the chemical testing laboratory.

Results of the field and laboratory tests were then plotted on boring logs. These logs are contained in the Appendix. Similar soils were grouped into strata on the logs. Please note that the strata contact lines represent approximate boundaries between soil types; the actual transition between soil types in the field may be gradual in both the horizontal and vertical directions.

SITE CONDITIONS

The project site is located on County Road 550 in Marquette, Michigan. More specifically, the project site is located north of County Road 550 and south of the Lake Superior & Ishpeming Railroad tracks. This site is also east of the intersection of the railroad tracks and County Road 550. The area surrounding the site is densely wooded. However, the immediate filled area is sparsely vegetated. Topography in the area surrounding this site is gently rolling to hilly with numerous rock outcrops. No rock outcrops were observed within the immediate vicinity of the fill area.

Soil Profile

Borings 4 to 9 were extended through the existing fill material into the underlying natural soils. The fill material ranged in thickness from 9.5 to 12.5 feet below grade. The fill consisted primarily of a silty fine to medium sand and wood fragments. A petroleum based substance was occasionally observed within the fill material. The fill ranged in relative density from very loose to medium dense. In Boring 4, a trace of wood fragments was encountered to a depth of 13.5 feet.

Below the fill material, the borings encountered a fine to medium sand or silty fine sand which extended to termination depth of the borings. The sand was saturated and was generally in a medium dense to dense condition.

Borings 1, 2 and 3 encountered a thin surface topsoil layer underlain by granular soils which extended to the termination depth of the borings. The granular soils ranged in particle size from fine to coarse with a trace of gravel. These granular soils also ranged in relative density from loose to medium dense.

Boring 3 encountered apparent bedrock at a depth of 27 feet. Greenish gray wash cuttings were observed from drilling into the apparent bedrock indicating a possible schistose bedrock material. This boring was terminated at a 2.5 foot depth into the bedrock surface.

Hydrogeology

The ground water observations made in the observation wells were relatively consistent between readings. Borings 1 and 2 indicate little or no north/south flow vector. The three observation wells indicate that the horizontal flow gradient is predominately east. Additional readings were taken in observation well No. 4 on the abandoned UPPCO flyash site. This reading also indicates primarily a easterly direction of ground water flow. A 0.004 horizontal gradient was calculated across the disposal site. A ground water contour map of data collected on April 26, 1982 is included in the Appendix.

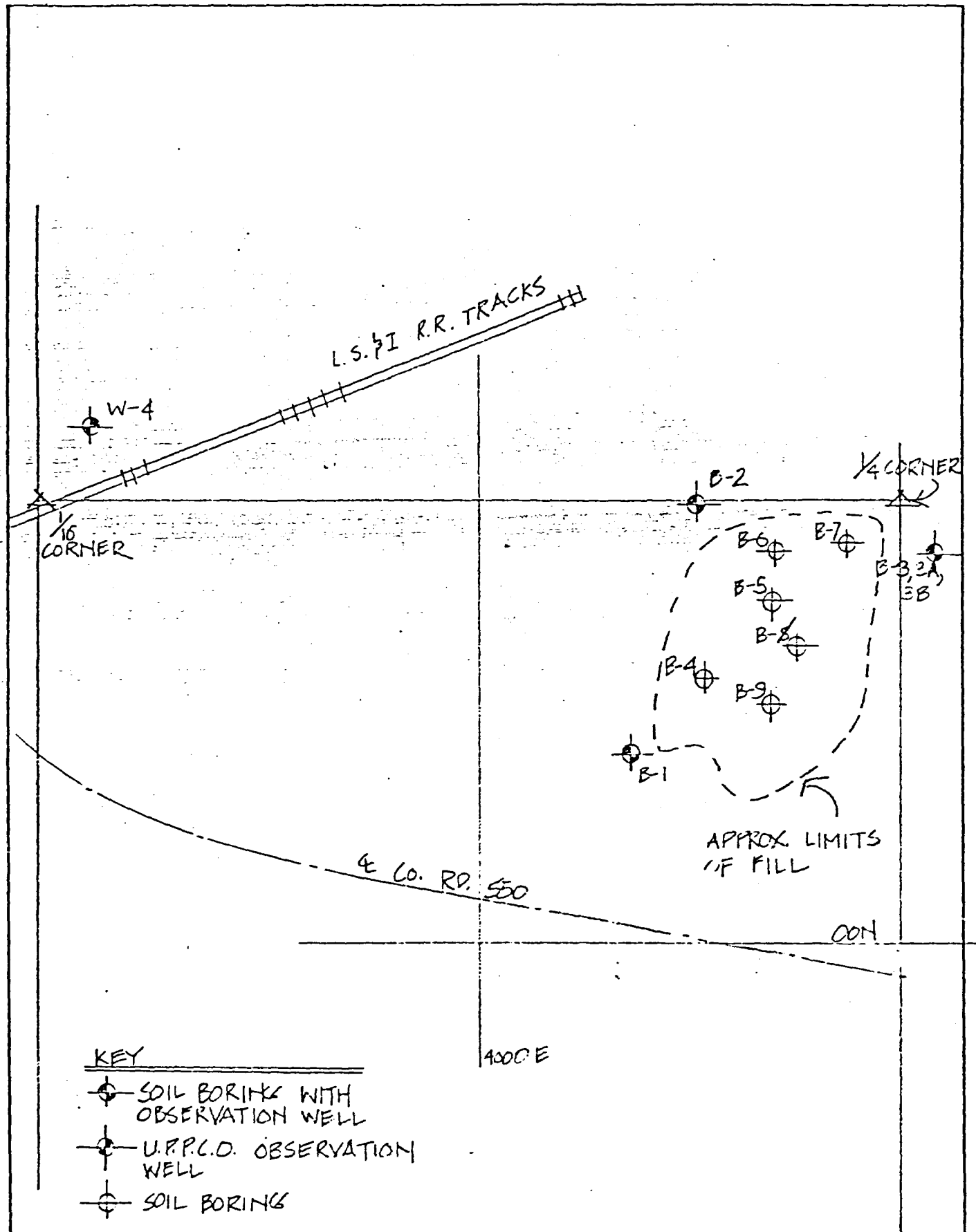
The well cluster at boring location 3 indicated an upward gradient of approximately 0.11 ft/ft. This upward gradient may be present due to the confinement of the relatively impermeable bedrock stratum and the potentially cleaner, more permeable granular soil overlying the bedrock. Samples at 15 and 20 feet could not be obtained in either Boring 3 or 3B. No recovery may indicate a clean, coarse granular material which could have a higher permeability.

GENERAL

The analysis and recommendations submitted in this report are based on data obtained from eleven soil borings. Variations can occur between these borings, the nature and extent of which may not become evident without further exploration. If variations are encountered, it may be necessary to make a re-evaluation of the recommendations of this report after making on-site observations and noting the characteristics of these variations.

Water level readings have been made in the borings at the times and under the conditions stated on the boring logs. This data has been reviewed and an interpretation made in the text of this report. However, it must be noted that the period of observation was relatively short and that seasonal and annual fluctuations in the level of the ground water will likely occur.

APPENDIX



SOIL BORING LOCATION DIAGRAM
CLIFFS DOW DISPOSAL SITE
MARQUETTE, MI

SOIL TESTING SERVICES
550 East Ohio Street
Marquette, Michigan

1"=200	CCS	6-8-82	M11771

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS :	Split Spoon – 1 3/8" I.D., 2" O.D., unless otherwise noted	OS :	Osterberg Sampler – 3" Shelby Tube
ST :	Shelby Tube – 2" O.D., unless otherwise noted	HS :	Hollow Stem Auger
PA :	Power Auger	WS :	Wash Sample
DB :	Diamond Bit – NX: BX: AX	FT :	Fish Trail
AS :	Auger Sample	RB :	Rock Bit
JS :	Jar Sample	BS :	Bulk Sample
VS :	Vane Shear	PM :	Pressuremeter test - in situ

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL :	Water Level
WCI :	Wet Cave In
DCI :	Dry Cave In
WS :	While Sampling
WD :	While Drilling
BCR :	Before Casing Removal
ACR :	After Casing Removal
AB :	After Boring

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several days observation, and additional evidence of ground water elevations must be sought.

GRADATION DESCRIPTION & TERMINOLOGY:

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: clays or clayey silts if they are cohesive, and silts if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their strength or consistency, and their plasticity.

Major Component Of Sample	Size Range	Descriptive Term(s) (Of Components Also Present in Sample)	Percent of Dry Weight
Boulders	Over 8 in. (200mm)	Trace	1 – 9
Cobbles	8 in. to 3 in. (200mm to 75mm)	Little	10 – 19
Gravel	3 in. to #4 sieve (75mm to 2mm)	Some	20 – 34
Sand	#4 to #200 sieve (2mm to .074mm)	And	35 – 50
Silt	Passing #200 sieve (0.074mm to 0.005mm)		
Clay	Smaller than 0.005mm		

CONSISTENCY OF COHESIVE SOILS:

Unconfined Comp. Strength, Qu, tsf	Consistency
< 0.25	Very Soft
0.25 – 0.49	Soft
0.50 – 0.99	Medium (Firm)
1.00 – 1.99	Stiff
2.00 – 3.99	Very Stiff
4.00 – 8.00	Hard
>8.00	Very Hard

RELATIVE DENSITY OF GRANULAR SOILS:

N – Blows/ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50 – 80	Very Dense
80+	Extremely Dense

PROCEDURES REGARDING FIELD LOGS, LABORATORY DATA SHEETS AND SAMPLES

In the process of obtaining and testing samples and preparing the report, procedures are followed that represent reasonable and accepted practice in the field of soil and foundation engineering.

Specifically, field logs are prepared during performance of the drilling and sampling operations which are intended to portray essentially field occurrences, sampling locations and other information.

Samples obtained in the field are frequently subjected to additional testing and reclassification in the laboratory by more experienced soils engineers, and differences between the field logs and the final logs exist.

The Engineer preparing the report reviews the field and laboratory logs, classifications and test data, and in his judgement in interpreting this data, may make further changes.

Samples taken in the field, some of which are later subjected to laboratory tests, are retained in our laboratory for sixty (60) days and are then destroyed unless special disposition is requested by our client. Samples retained over a long period of time, even in sealed jars, are subject to moisture loss which changes the apparent strength of cohesive soil, generally increasing the strength from what was originally encountered in the field. Since they are no longer representative of the moisture conditions initially encountered, an inspection of these samples could recognize this factor.

It is common practice in the soil and foundation engineering profession that field logs and laboratory test data sheets not be included in engineering reports, because they do not represent the engineer's final opinion as to the appropriate descriptions for conditions encountered in the exploration and testing work. On the other hand, we are aware that perhaps certain contractors and subcontractors submitting bids or proposals on work might have an interest in studying these documents before submitting a bid or proposal. For this reason, the field logs will be retained in our office for inspection by all contractors submitting a bid or proposal. We would welcome the opportunity to explain any changes that have and typically are made in the preparation of our final reports, to the contractor or sub-contractors, before the firm submits its bid or proposal, and to describe how the information was obtained to the extent the contractor or subcontractor wishes. Results of laboratory tests are generally shown on the boring logs or are described in the text of the report, as appropriate.

LOG OF BORING NO. 1

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

SURFACE ELEVATION 649.1

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3	UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² / PLASTIC LIMIT % / WATER CONTENT % / LIQUID LIMIT % / STANDARD "N" PENETRATION (BLOWS/FT.)
0.0	1	SS		Brown fine to coarse sand (SP)-with trace of silt and fine gravel-moist to wet below 8.5'-medium dense to very loose		11
	2	SS				3
10.0	2A	SS				
				Brown medium to coarse sand (SP)-wet-very loose to medium dense		11
15.0	3	SS				
20.0				End of Boring Boring advanced with solid stem auger to 20 ft. 2" PVC observation well installed to 19 ft.		

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² — 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %

STANDARD "N" PENETRATION (BLOWS/FT.) — 10 20 30 40 50

WATER LEVEL OBSERVATIONS		
W.L.	8.5 - 10' WS	
W.L.	B.C.R.	A.C.R.
W.L.		

SOIL TESTING SERVICES OF MICHIGAN, INC.

550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-8-82
BORING COMPLETED	4-8-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

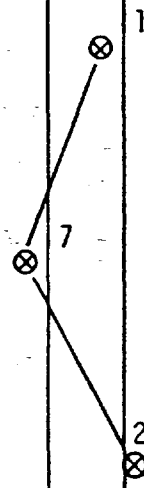
The stratification lines represent the approximate boundary

LOG OF BORING NO. 2

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3
				SURFACE ELEVATION → 646.2	
	1	SS		Brown fine to coarse sand (SP)- with trace of fine to medium gravel-moist	
2.0	2	SS			
2.0	3	SS			
2.0				End of Boring Boring advanced with solid stem auger to 20 ft. 2" PVC observation well installed to 18.5 ft.	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²
1 2 3 4 5
PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
STANDARD "N" PENETRATION (BLOWS/FT.)
10 20 30 40 50



WATER LEVEL OBSERVATIONS	
3.5 - 8.5' WD	
B.C.R.	A.C.R.
6' AB	

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-8-82
BORING COMPLETED	4-8-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

LOG OF BORING NO. 3

OWNER: City of Marquette	ARCHITECT-ENGINEER:
SITE: Co. Rd. 550, Marquette, Mi.	PROJECT NAME: Cliffs Dow Disposal Site

SURFACE ELEVATION 645.6

SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3	STANDARD "N" PENETRATION (BLOWS/FT.)
1	SS		Light brown to reddish brown fine sand (SP)-with trace of fine gravel below 10' - moist to wet at 4.5'		12
1A	SS				
2	SS				26
3	SS				17
4	SS				10
5	SS				12
6	SS				20
7	SS				26
8	SS				100/8"
9	SS				43
			Apparent bedrock or boulder		

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²
1 2 3 4 5
PLASTIC LIMIT % WATER CONTENT % LIQUID LIMIT %
STANDARD "N" PENETRATION (BLOWS/FT.)
10 20 30 40 50

End of Boring
Boring advanced with solid stem auger to 12.5 ft.
Boring advanced from 12.5 to 29 ft. with roller bit and wash water - HW casing set to 26.5 ft.
2" stainless steel observation well installed to 27 ft.

WATER LEVEL OBSERVATIONS
4.5' WS
3.5' B.C.R. | 4' A.C.R.

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-16-82
BORING COMPLETED	4-19-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

LOG OF BORING NO. 3A

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

DEPTH / ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³	UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² (1 2 3 4 5) / PLASTIC LIMIT % / WATER CONTENT % / LIQUID LIMIT % / STANDARD "N" PENETRATION (BLOWS/FT.) (10 20 30 40 50)
					SURFACE ELEVATION → 645.6		
7.0					See log of Boring 3		
638.0							
13.0					End of Boring Boring advanced with solid stem auger to 11 ft. 2" stainless steel observation well installed to 12 ft.		

WATER LEVEL OBSERVATIONS		
WL	4.5' WD	
WL	B.C.R.	A.C.R.
WL		

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-19-82
BORING COMPLETED	4-19-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB #M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

LOG OF BORING NO. 3B

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

SURFACE ELEVATION 645.6

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² (1, 2, 3, 4, 5)

PLASTIC LIMIT % | WATER CONTENT % | LIQUID LIMIT %

STANDARD "N" PENETRATION (BLOWS/FT.) (10, 20, 30, 40, 50)

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³
5.0				See log of Boring 3	
10.0					
15.0					
20.0	1	SS			
25.0				End of Boring Boring advanced with solid stem auger to 20 ft. Boring advanced from 20 to 23.5 ft. with roller bit and wash water HW casing set to 21 ft. 2" stainless steel observation well installed to 21 ft.	

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WATER LEVEL OBSERVATIONS		
W.L.		
W.L.	B.C.R.	A.C.R.
W.L.		

SOIL TESTING SERVICES OF MICHIGAN, INC.

550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-19-82
BORING COMPLETED	4-19-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB #M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary

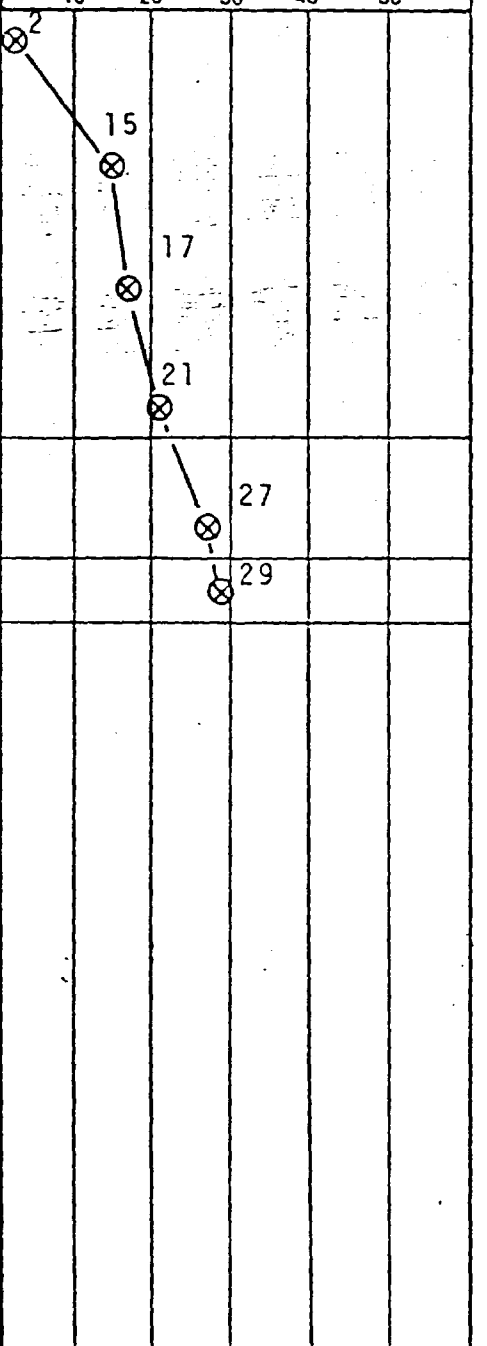
LOG OF BORING NO. 4

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

SURFACE ELEVATION 647.7

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3
0.0	1	SS		Fill-Black silty fine to medium sand (SM)-and wood fragments-with a little black tar-wet	
	2	SS			
	3	SS			
	4	SS			
4.0	5	SS		Black to brown silty fine sand (SM) with trace of wood fragments-wet-medium dense	
5.0	6	SS		Brown fine to coarse sand (SP)-wet-medium dense	
				End of Boring Boring advanced with solid stem auger to 12 ft. Boring advanced from 12 to 15 ft. with roller bit and wash water HW casing set to 15 ft. Borehole backfilled with on-site soils	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²
1 2 3 4 5
PLASTIC LIMIT % WATER CONTENT % LIQUID LIMIT %
STANDARD "N" PENETRATION (BLOWS/FT.)
10 20 30 40 50



WATER LEVEL OBSERVATIONS		
3 - 6' WD		
4' B.C.R.	4.5' A.C.R.	

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

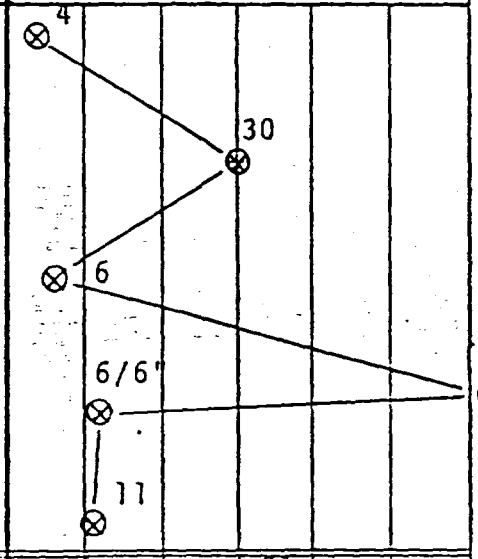
BORING STARTED	4-8-82
BORING COMPLETED	4-8-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

LOG OF BORING NO. 5

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3
					SURFACE ELEVATION 647.5	
	1	SS			Fill-Black silty fine sand (SM) with a little wood fragments- with trace of gravel-moist to wet below 3' - loose to dense	
5.0	2	SS				
	3	SS				
10.0	4	SS				
5.4	5	SS			Black Peat (Pt)-wet-medium	
15.0	6	SS			Brown silty fine sand (SM)- wet-dense	
					End of Boring Boring advanced with solid stem auger to 12 ft. Boring advanced from 12 to 15 ft. with roller bit and wash water HW casing set to 15 ft. Borehole backfilled with on-site soils	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²
1 2 3 4 5
PLASTIC LIMIT % WATER CONTENT % LIQUID LIMIT %
STANDARD "N" PENETRATION (BLOWS/FT.)
10 20 30 40 50



WATER LEVEL OBSERVATIONS		
W.L.	3 - 4.5' WS	
W.L.	2' B.C.R.	6.7' A.C.R.
W.L.		

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-8-82
BORING COMPLETED	4-8-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

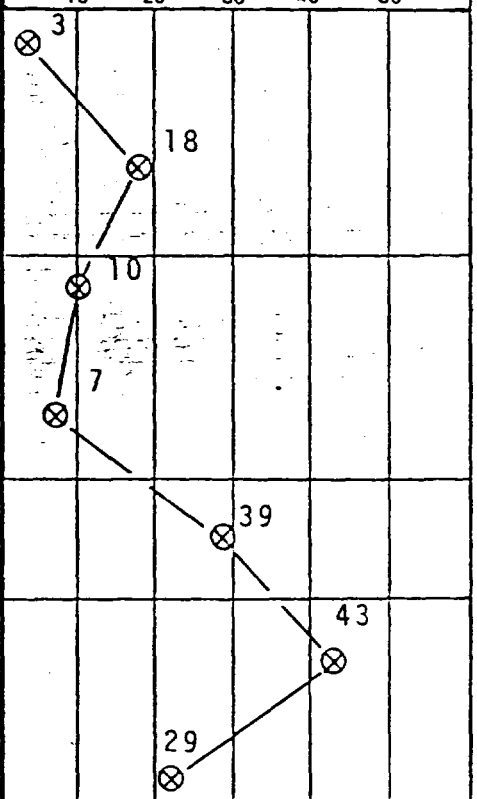
The stratification lines represent the approximate boundary

LOG OF BORING NO. 6

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT. 3
				SURFACE ELEVATION 648.7	
0	1	SS		Fill-Wood fragments-moist-very loose	
	2	SS			
	3	SS		Fill-Black silty fine sand (SM) with some wood fragments and gravel-moist to wet below 9'	
10.0	4	SS			
	5	SS		Brown silty fine sand (SM)-wet-medium dense	
15.0	6	SS		Brown fine sand (SP)-wet-dense	
	7	SS			
20.0				End of Boring Boring advanced with solid stem auger to 12 ft. Boring advanced from 12 to 19.5 ft. with roller bit and wash water HW casing set to 18 ft. Borehole backfilled with on-site soils	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²
1 2 3 4 5
PLASTIC LIMIT % WATER CONTENT % LIQUID LIMIT %
STANDARD "N" PENETRATION (BLOWS/FT.)
10 20 30 40 50



WATER LEVEL OBSERVATIONS		
W.L.	6 - 9' WD	
W.L.	6' B.C.R.	7' A.C.R.
W.L.		

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-9-82
BORING COMPLETED	4-9-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary

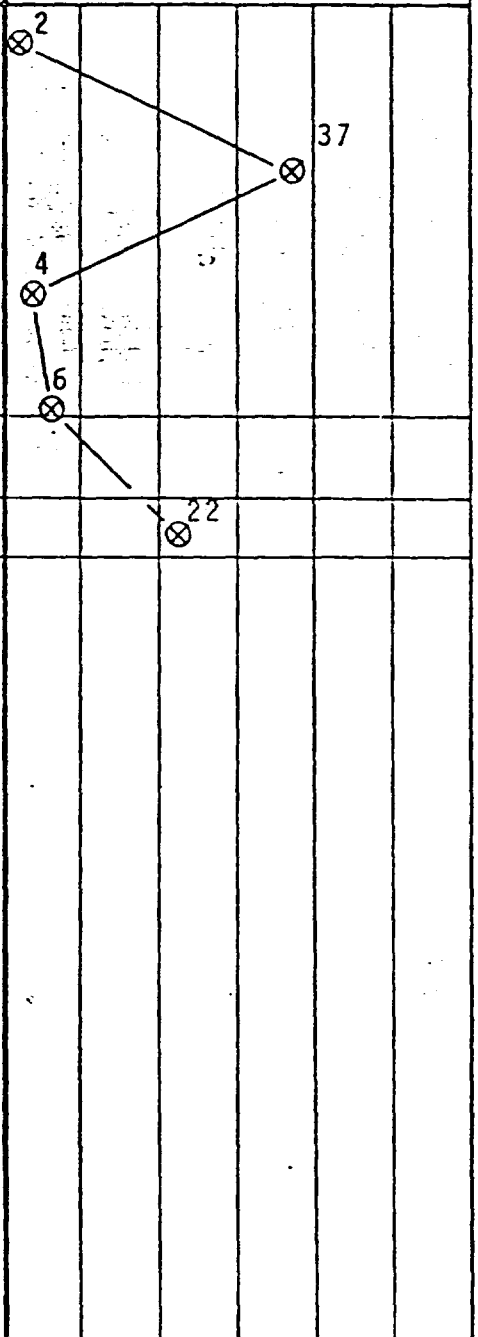
LOG OF BORING NO. 7

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

SURFACE ELEVATION 647.7

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3
	1	SS			Fill - Black peat and wood fragments (PE)-moist-very loose	
	2	SS				
5.0					Fill - Black silty sand (SM)-with trace of gravel and wood fragments-wet-dense to loose	
	3	SS				
10.0	4	SS				
	4A	SS			Brown silty fine sand (SP-SM)-with trace of silt-wet-loose	
	5	SS			Grayish brown fine to coarse sand (SP)-wet-medium dense	
15.0					End of Boring Boring advanced with solid stem auger to 9 ft. Boring advanced from 9 ft to 13.5 ft. with roller bit and wash water HW casing set to 12 ft. Borehole backfilled with on-site soils	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²
1 2 3 4 5
PLASTIC LIMIT % | WATER CONTENT % | LIQUID LIMIT %
STANDARD "N" PENETRATION (BLOWS/FT.)
10 20 30 40 50



WATER LEVEL OBSERVATIONS		
W.L.	3 - 6' WS	
W.L.	2' B.C.R.	5.4' A.C.R.
W.L.		

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

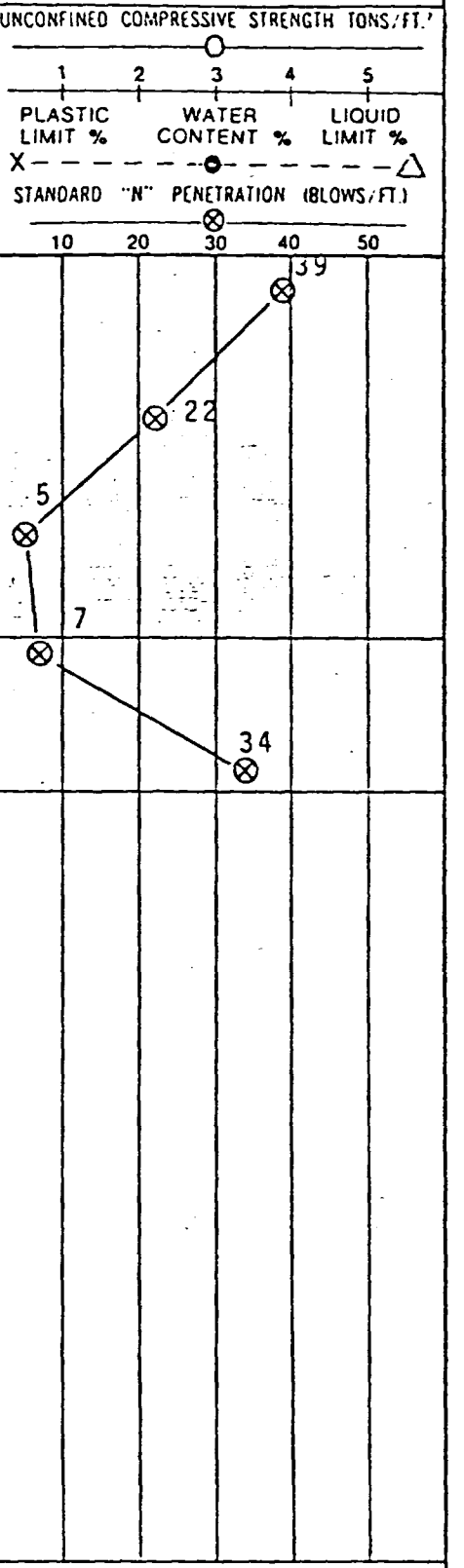
BORING STARTED	4-9-82
BORING COMPLETED	4-9-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary between soil types and the transition

LOG OF BORING NO. 8

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT. 3
					SURFACE ELEVATION → 645.3	
	1	SS			Fill-Black silty fine sand (SM) with some brick fragments-with trace of wood-moist to wet below 3'-dense to loose	
	2	SS				
5.0						
	3	SS				
	4	SS				
10.0	4A	SS			Brown silty fine to medium sand (SM)-wet	
	5	SS				
15.0					End of Boring Boring advanced with solid stem auger to 9 ft. Boring advanced from 9 to 13.5 ft. with roller bit and wash water HW casing set to 12 ft. Borehole backfilled with on-site soils	



WATER LEVEL OBSERVATIONS			
W.L.	3 - 6' WD		
W.L.	2' B.C.R.	1' A.C.R.	
W.L.			

SOIL TESTING SERVICES OF MICHIGAN, INC.
550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-9-82
BORING COMPLETED	4-9-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB #1-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

LOG OF BORING NO. 9

OWNER	ARCHITECT-ENGINEER
City of Marquette	
SITE	**PROJECT NAME**
Co. Rd. 550, Marquette, Mi.	Cliffs Dow Disposal Site

SURFACE ELEVATION 647.3

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST. RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.3	UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² / STANDARD "N" PENETRATION (BLOWS/FT.)
	1	SS		Fill - Brown wood fragments - moist		3
5.0	2	SS		Fill - Black silty fine sand (SM) and wood fragments - wet		17
	3	SS				11
10.0	4	SS				32
	4A	SS		Brown silty fine sand (SM) - wet - dense		
	5	SS		Brown fine sand (SP) - wet - dense		132
15.0	6	SS		Brown clayey silt (ML) - moist - medium dense		
	6A	SS		Brown fine to medium sand (SP) - wet - medium dense		25
20.0				End of Boring Boring advanced with solid stem auger to 9 ft. Boring advanced from 9 ft. to 16.5 ft. with roller bit and wash water HW casing set to 15 ft. Borehole backfilled with on-site soils		

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²: 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %

STANDARD "N" PENETRATION (BLOWS/FT.): 10 20 30 40 50

WATER LEVEL OBSERVATIONS			
W.L.	3 - 9' WD		
W.L.	2' B.C.R.	4' A.C.R.	
W.L.			

SOIL TESTING SERVICES OF MICHIGAN, INC.

550 EAST OHIO STREET
MARQUETTE, MICHIGAN 49855

BORING STARTED	4-9-82
BORING COMPLETED	4-9-82
RIG Bomb	FOREMAN JW
DRAWN JHI	APPROVED JJB
JOB # M-11771	SHEET 1 of 1

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

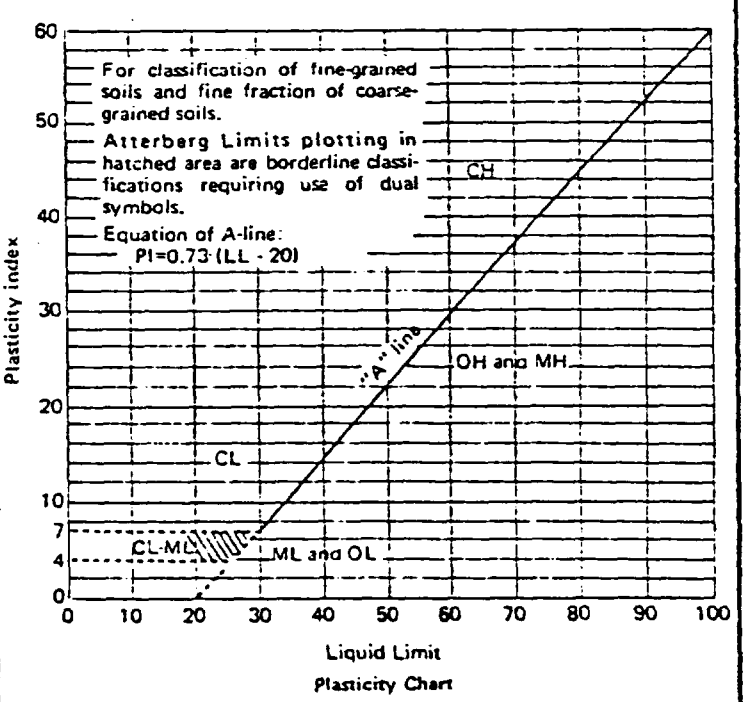
UNIFIED SOIL CLASSIFICATION SYSTEM

Major divisions			Group symbols	Typical names	Laboratory classification criteria
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW
		Gravels with fines (Appreciable amount of fines)	GM d / u	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM d / u	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7
Fine-grained soils (More than half of material is *smaller* than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity, organic silts	
Highly organic soils			Pt	Peat and other highly organic soils	

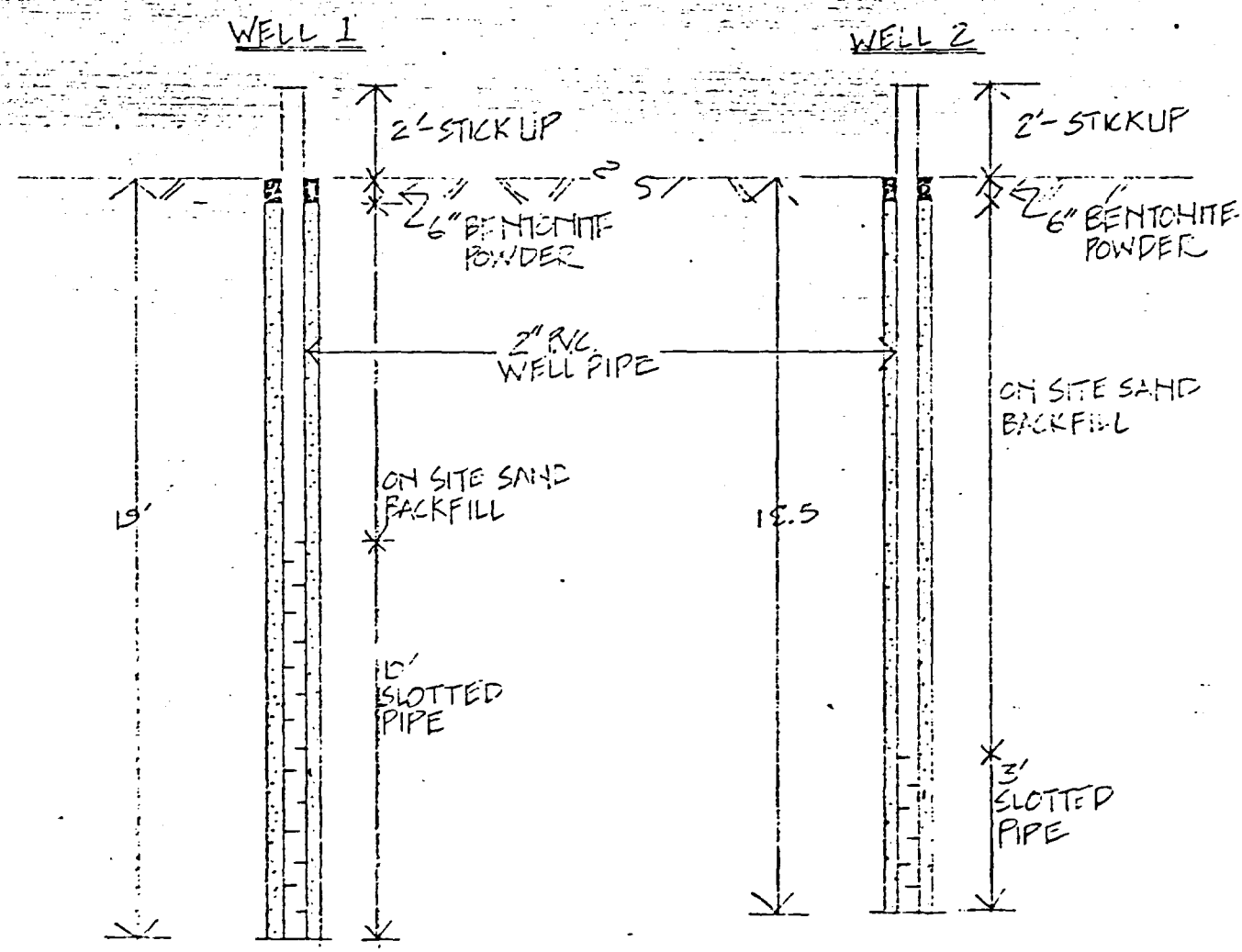
Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:
Less than 5 per cent . . . . . GW, GP, SW, SP
More than 12 per cent . . . . . GM, GC, SM, SC
5 to 12 per cent . . . . . *Borderline* cases requiring dual symbols

Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols

Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols.



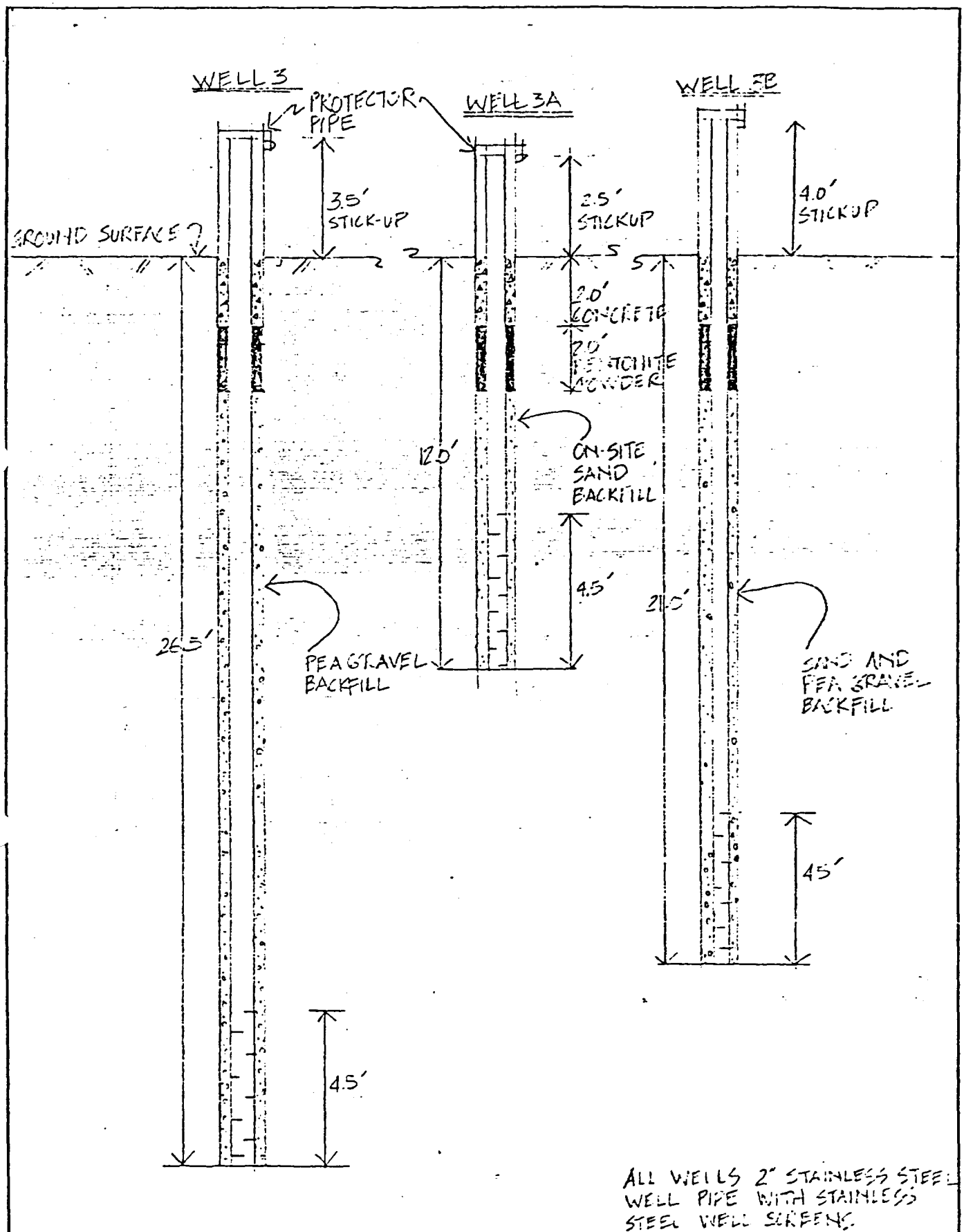
Plasticity Chart



FIELD WELL INSTALLATION DIAGRAM
CLIFFS POW DISPOSAL SITE
MARQUETTE, MI

SOIL TESTING SERVICES OF WISCONSIN, INC.
540 LAMBEAU ST. GREEN BAY, WISCONSIN 54303

NOSCALE	116	6-8-82	M11771



FIELD WELL INSTALLATION DIAGRAM
CLIFFS FOW DISPOSAL SITE
MARQUETTE, MI

SOIL TESTING SERVICES OF WISCONSIN, INC.
540 LAMBEAU ST. GREEN BAY, WISCONSIN 54303

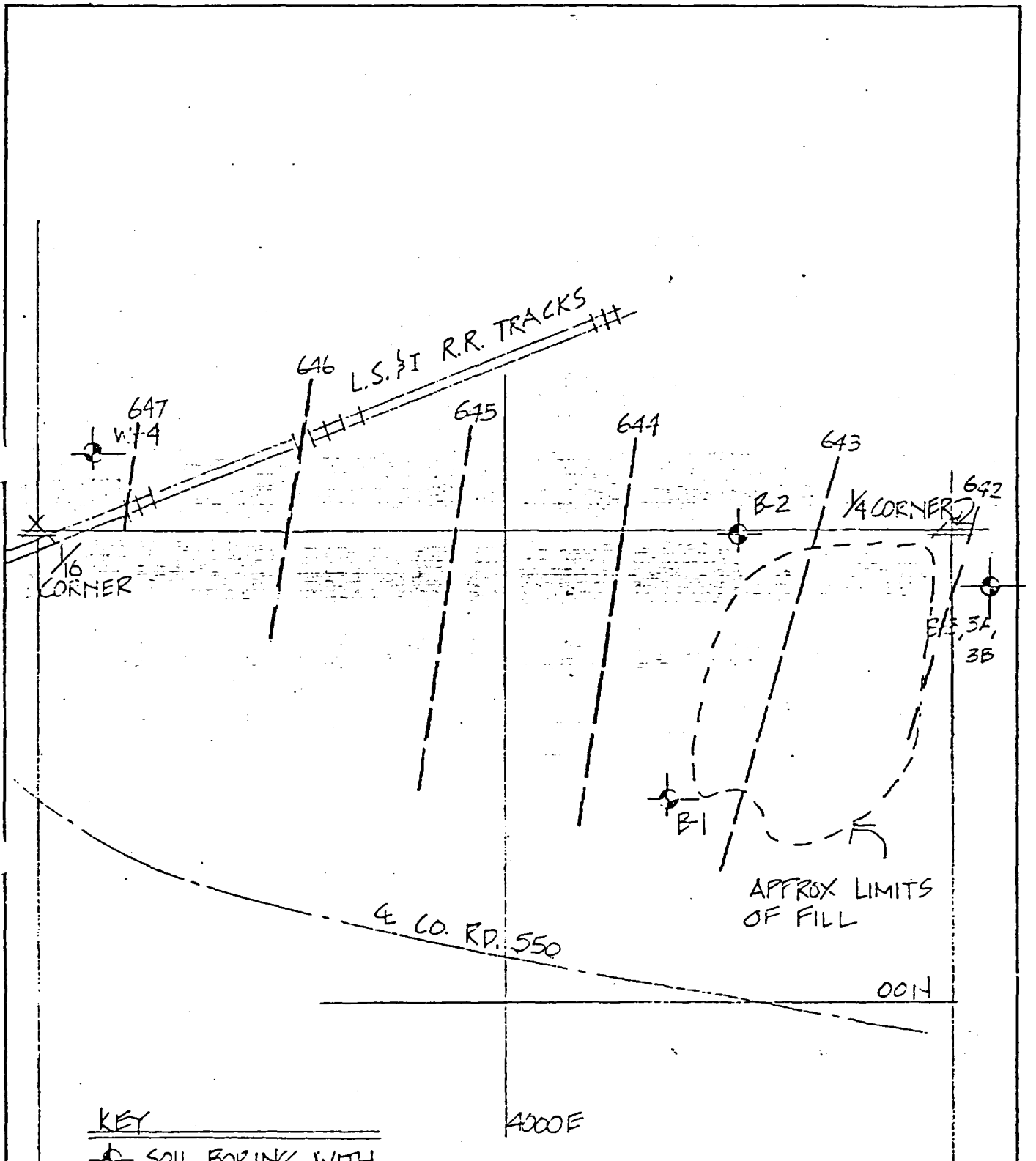
NO SCALE	CLS	5-3-12	M11771

TABLE I: Water Level Summary

Marquette, Michigan
STS No. M-11771

Well No.	Ground Surface Elevation	Top of Well Pipe Elevation	April 21, 1982		April 26, 1982			
			Depth, ft.	Elevation	Depth, ft	Elevation	Field pH	Field Conductivity µohm/cm
1	649.1	651.0	8.7	642.3	7.5	643.5	-	-
2	646.2	648.5	6.0	642.5	5.0	643.5	-	-
3	645.6	648.7	7.0	641.7	6.0	642.7	5.5	167
3A	645.6	647.9	6.7	641.2	6.2	641.7	6.0	1350
3B	645.6	649.2	7.5	641.7	6.5	642.7	5.5	550
UPPCO #4	649.5	-	-	-	4.1	647.3	-	-

Notes:
Wells bailed after 4-21-82 readings
Depths measured from top of well pipe



GROUNDWATER CONTOUR MAP
CLIFFS POW DISPOSAL SITE
MARQUETTE, MI

SOIL TESTING SERVICES
550 East Ohio Street
Marquette, Michigan

1"=200'	CLS	6-8-82	M11771

PENETRATION TESTING PROCEDURE

Representative soil samples were obtained by means of the split-barrel sampling procedure in general accordance with ASTM Specification D 1586-67. In this procedure, a 2-inch OD split-barrel sampler is driven into the soil a distance of 18 inches by means of a 140-pound hammer falling 30 inches. The standard penetration resistance value is the number of blows per foot of penetration for the final 12 inches of driving. This value can be used to provide a qualitative indication of the in-place relative density of cohesionless soils. This indication is qualitative since many factors can significantly affect the standard penetration resistance value and prevent direct correlation between drill crews, drill rigs, drilling procedures, and hammer-rod-spoon assemblies.

After driving, the sampler was returned to the surface and opened. The length of sample (recovery) was measured and the soil was preliminarily classified according to type by a Soils Technician. A representative portion of each sample was then sealed in a glass jar, labeled, and returned to our laboratory for further examination and testing.