Dec. 7, 1981

T.M.

MUNICIPAL PARKING STRUCTURE

& MTC LAYOVER FACILITY

WASHINGTON AVENUE & 5TH AVENUE S

MINNEAPOLIS, MINNESOTA

SOIL EXPLORATION COMPANY

Gateway

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WATERLOO, IA
MANKATO, MN
ROCHESTER, MN
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EAU CLAIRE, WI

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CASPER, WY
GILLETTE, WY

soil exploration company

662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645-6446

a sister corporation to TWIN CITY TESTING AND ENGINEERING LABORATORY INC.

December 7, 1981

The City of Minneapolis
211 City Hall
Minneapolis, MN 55401

Attn: Greg Finstad

Gentlemen

Subject: Municipal Parking Structure
& MTC Layover Facility
Washington Avenue & 5th Avenue S
Minneapolis, Minnesota
#120-8122

OFFICERS:
CHARLES W. BRITZIUS
chairman of the board
NORMAN E. HENNING
president
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executive vice president
CLINTON R. EUE
secretary/treasurer

HOME OFFICE:
ST. PAUL, MN

OFFICES IN:
MANKATO, MN
ROCHESTER, MN

Attached herewith is one copy of our report covering the subsurface soil exploration for the above referenced project. Additional copies will be sent as noted below. This work was done in accordance with are proposal dated November 11, 1981. And your subsequent authorization.

About 50% of the soil samples and the entire core recovery will be held at this office for one year and will then be discarded unless we are notified to hold them for a longer period of time.

The opinions expressed in this report are based on the conditions observed at the test boring locations. If different conditions are encountered during construction, we request that we be notified so that the new conditions can be reviewed.

Very truly yours

Steven D Koenes

Steven D Koenes, P.E.

SDK/rr

Encs.

cc: 4-Dunhum Associates Inc.
Attn: Mike Ramerth

AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF THE CLIENT

REPORT OF SUBSURFACE SOIL EXPLORATION

MUNICIPAL PARKING STRUCTURE

& MTC LAYOVER FACILITY

WASHINGTON AVENUE & 5TH AVENUE S

MINNEAPOLIS, MINNESOTA

#120-8122

INTRODUCTION

The proposed parking structure and MTC Layover Facility is a five to six story structure with plan dimensions on the order of 312' by 328'. The lower level will be used for bus parking and a turn around facility and the upper stories will be used as automobile parking.

In accordance with our proposal dated November 11, 1981, and your subsequent authorization, a subsurface soil exploration was performed. The preliminary exploration was performed by Soil Exploration Company and the results reported to you in their report #120-4204 dated February 19, 1979. The additional subsurface soil and bedrock exploration included seven test borings numbered A-G. The borings were taken to limestone bedrock and cored approximately 10' into the limestone. The resultant data was then reveiwed with respect to potential foundation types and depths, allowable soil and rock bearing pressures and other design considerations that may be influenced by the subsurface conditions.

The purpose of this report is to present the results of the subsurface soil exploration data and our comments, opinions and recommendations based on review of this data.

SITE, SOIL AND BEDROCK CONDITIONS

Surface Conditions

The site is currently being used as an on-grade parking area. One samll building is located along third Street near the center of the block.

The surface elevations at the boring locations ranged from approximately 826.5' at boring B to 831.5' at boring D, indicating a slight downward slope in a northeasterly direction.

We have no information regarding past usage of the site and particularly any buildings that may have once occupied the site.

Subsurface Conditions

The subsurface conditions encountered at each of the test locations are illustrated on the attached test boring logs. We have included the logs of previous borings 1, 3, 9 and 11 which were put down for the preliminary subsurface exploration.

A review of these logs suggest that a generalized subsurface soil and bedrock profile consist of up to about 12' of fill and/or topsoil underlain by sand to depths on the order of 20' to 33' below existing grade, inturn underlain by clayey sand, sandy clay or silty sand glacial till to the depth of limestone. The limestone was encountered at depths varying from approximately 30'to 35' below existing grade.

The fill consisted of a mixture of soil types including, sand, silty sand, sandy silt, clayey sand and silty clay. A substantial amount of construction debris such as brick, concrete and limestone slabs were also encountered

in the borings along with some wood and ashes. The penetration resistance, (N value) indicated the density of the fill was quite variable.

The sand varied from medium to fine grained and based on N value, had a density varying from loose to very dense. Several of the borings also encountered some relatively thin interbedded layers of clay in the upper portion of the water deposited sand.

The underlying glacial till consisted of sandy clay, clayey sand and silty sand. Generally the cohesive glacial till soils were medium to stiff in consistency and the silty sand glaical till was medium dense. A little gravel was encountered in the glacial till and we anticipate some boulders and cobbles may also be present.

The first bedrock encountered on the site was limestone from the Platteville formation including the Carmonia, Magnolia and Hidden Falls Member. The core recovery in the limestone generally varied from about 86% to 100%. One previous boring (#9) encountered limestone slabs above the limestone and based on the recovery, the limestone in that area may be somewhat more factured and weathered. The RQD (Rock Quality Designation) was also determined on the core samples. The RQD values also were generally in excess of 70%, indicating the limestone bedrock was not badly factured. The lowest RQD values were encountered in the area of boring A.

It should be noted that the area of the borings in relation to the entire area is very small. Conditions between the boring locations or below the depth of our borings may differ from the conditions encountered at the boring location. For these reasons, we do not warrant conditions below the depth of our borings, or that the strata logged in our borings

are necessarily typical of the entire site.

WATER LEVEL OBSERVATIONS

Water was encountered in several of the borings at the time of the exploration. The water level data is shown on the attached boring logs, including both the water level and times of determination. The borings generally indicated water levels at approximately elevation 804' a few feet above the elevation of the underlying glacial till. It is our judgment, that this water level may indicate a perched water condition. During the coring of the limestone a substantial amount of drilling fluid was not recovered during the coring operation. This often indicates that the upper portion of the limestone strata is not water bearing and the actual ground water level on the site may be several feet into the limestone bedrock strata.

The ground water level should be expected to fluctuate both seasonally and yearly.

LABORATORY TESTS

Several samples were selected for additional laboratory testing. The test included determination of moisture, density and grain size distribution. The results of the laboratory test were used to aid in classifying these soils and also in determining engineering properties of the soils. The results of the laboratory tests are shown on the boring logs opposite the samples on which the test were performed or on attached sheets.

ENGINEERING REVIEW

Project Information

The following data represents our understanding of the project. It comprises an important part of our engineering review. If, as the project develops, there are changes from the stated values, we request that you contact us for additional review.

We understand the proposed parking ramp and MTC layover facility will be a five to six story structure approximately 312' by 323' in plan dimensions.

Since the time of the preliminary subsurface exploration report a drilled pier foundation has been designed for the structure based on an allowable bearing capacity of up to 50 tsf (tons per square foot) on the underlying limestone.

The plans furnished to us indicates pier end bearing diameter varying form 48" to 54".

The lower floor level will be constructed at approximately existing grade and will be used primarily for bus parking. We understand the lower floor slab will be a 8" structural slab with both top and bottom steel.

Foundation Recommendations

Based on the results of the additional subsurface soil exploration, it is our judgment that the proposed structure can be supported on a drilled pier foundation. As indicated in our previous report the drilled piers can be designed for an allowable end bearing pressure of up to 50 tsf (tons per square foot).

Water was encountered in the borings at the depth of approximately 804'. As previously mentioned it is our judgment the water level indicates a perched water condition and the actual water level on the site may be several feet into the limestone. Because of the presence of the upper water level and some relatively clean sands within a few feet of the top elevation of the limestone, it is our judgment belling the piers my not be feasible. Because of this, we recommend the piers be constructed as straight shaft and casing should be installed to full depth in an effort to seal off the water and prevent caving. The drilled piers should have a minimum diameter of 36" to allow for proper observation of the bottom.

Our previous report recommended extending the drilled piers through any loose slabs and weathered material to a minimum of 1' into the limestone. In reviewing the additional boring logs, it is our judgment relatively hard unweathered limestone may be encountered directly at the surface of the limestone and therefore, in our opinion the minimum 1' penetration into the limestone would not be required. In any event, the drilled piers should extend through any loose slabs and weathered material to the elevation of the sound limestone. The bottom of each individual drilled pier should be observed and a pneumatic drill should be used to drill a hole to a minimum of two pier diameters below the bottom of the pier. The purpose of the probe hole would be to further observe the condition of the bedrock immediately below each individual pier.

The casings should be removed during concrete placement always maintaining a postive head of concrete above the bottom of casing.

Floor Slab

The existing fill, topsoil and some of the upper clays are somewhat compressible and may consolidate due to the anticipated floor loads. We understand the lower floor slab will be an 8" reinforced concrete slab.

Elimination of lower floor slabs settlement would require excavating the existing fill, topsoil and soft clays to the elevation of the underlying sand. This procedure would be relatively expensive. If some settlement of the lower floor slab can be tolerated, supporting the lower floor slab on some of the existing compressible soils may be feasible. It is our judgment, that subcutting the existing soils to a depth of at least 3' below bottom of floor slab elevation and replacement with a clean compacted granular soil should reduce potential floor slab settlement to about 1". Because of the possibility of localized poorer areas of existing soils some very localized areas of greater settlement may occur, however, in our opinion these areas should be very localized and the probability of this additional settlement could further be reduced by close observation of the existing fills during the earthwork.

If settlements of the above magnitudes can be tolerated we recommend subcutting the existing soils to a depth of at least 3' below bottom of slab elevation, surface compaction of the exposed fill soils with a large vibratory compactor, and placement of a clean granular soil to plan bottom of floor slab elevation. Some borings encountered clays in the bottom of the 3' subcut. We caution that compaction of these layers may cause disturbance of the clays and a subsequent loss of strength therefore, surface compaction should not be performed in areas where clay is exposed.

All fill placed below the floor slab should be compacted to a minimum of 98% of ASTM: D 698-78 (standard proctor).

We have also considered the possiblity of frost heave of the subgrade soils beneath the floor slab. The soil type with the highest probability of frost heave would be the cohesive soils such as the clays and finer grained fill soils. Based on our review, it is our judgment that any frost heave below the floor slab will be quite minimal and should not be the significant factor in the floor slab design.

OBSERVATION AND TESTING

As previously mentioned, the bottom of each drill pier should be observed by a geotechnical engineer, including checking the condition of the bedrock in each probe hole extended to a depth of 2 diameters below each pier. Generally, the observation can best be performed on a full-time basis. The exposed soils in the bottom of the floor slab subcut should also be observed and subcut to an additional depth if very poor quality soils are observed.

FIELD EXPLORATION PROCEDURES

Test Borings

Seven additional soil test borings (A-G) were put down between the dates of November 11 and November 19, 1981. The borings were put down approximately at the locations indicated on the site plan furnished to us or as discussed with you. The boring locations are shown on the attached sketch. The surface elevations were referenced to the top of hydrant located at the southeast corner of the intersection of Washington Ave and 4th Ave. This elevation was taken as 829.54'.

SAMPLING

Soil sampling was done in accordance with ASTM: D 1586-67. Using this procedure, a 2" O.D. split barrel sampler is driven into the soil by a 140 lb weight falling 30". After an initial set of 6", the number of blows required to drive the sampler an additional 12" is known as the penetration resistance or N value. The N value is an index of the relative density of cohesionless soils and the consitency of cohesive soils. Rock core samples were obtained by rotary drilling in accordance with ASTM: D 2113-70.

Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM: D 2488-79. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification. In addition, selected samples were submitted to a program of laboratory tests. Logs of the borings indicating the depth and identification of the various strata, the N value, the laboratory test depth, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are attached. Charts illustrating the soil classification procedure, the descriptive terminology and symbols used on the boring logs are also attached.

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Steven D. Koenes

STEVEN D. KOENES

Date 12-7-81 Registration No. 13180

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. A

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 830.3')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SILTY SAND, SANDY SILT, GRAVEL and CRUSHED LIMESTONE, brown and black, a layer of (See #1)	FILL		***	1	HSA				
2	MEDIUM FAT CLAY, brown and light gray mottled, soft to rather stiff, some laminations of silt (CH-CL)	FINE ALLUVIUM	3		2	SB	33	88		
					3	SB				
6	SAND, fine to medium (See #2)(SP)	COARSE*	16							
7	FAT CLAY, brown, medium (CH)	FINE*			4	SB				
7½	SAND, fine to medium grained, a trace of gravel, (See #3) (SP)	COARSE ALLUVIUM	15		5	SB				
9	SAND, medium grained, some to a trace of gravel, light brown, moist, dense (SP)		19		6	SB				
			19		7	SB				
14	SAND, fine grained, light brown, moist, medium dense (SP)		12		8	SB				
18	SAND, fine to medium grained, light brown, moist, dense to medium dense (SP)		16		9	SB				
25	Continued on next page	*ALLUVIUM								

#1 - blacktop at the surface

#2 - grained, light brown, moist, dense (SP)

#3 - light brown, moist, medium dense (SP)

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO A Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	RQD
25	SAND, (continued) (SP)	COARSE ALLUVIUM (cont.)	9		10	SB				
28½	SILTY SAND, a little to some gravel, gray, rather stiff, a few layers of silty sand (SM)	TILL	11		11	SB	18	111		MA
32½	LIMESTONE, light brownish gray, with some layers of brown above about 37', somewhat fractured, some vertical fractures, weathered above 33'	PLATTEVILLE FORMATION** MAGNOLIA MEMBER	100%			NQ				71%
			100%			NQ				55%
			100%			NQ				60%
			90%			NQ				20%
43.0	End of Boring	**CARIMONA MEMBER	0% Note#1			NQ				0%

***Water level is estimated to be at depth in vicinity of 26½'

****Influenced by coring

Note #1 - No void core dropped out of core barrel

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-16	11:30	27'	25'	25½'	to	None
11-16	3:00	43.0'	33'		to	17½'****
11-16	3:20	43.0'	None	14'	to	None
					to	

START 11-16-81 COMPLETE 11-16-81

METHOD HSA 0 - 33' @ 2:40

NQ Cored 33.0-43.0'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. B

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 826.5')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SAND and SILTY SAND, a little gravel, brick and concrete, brown	FILL			1	HSA				
			25		2	SB				
			21		3	SB				
			21		4	SB				
11	SAND, fine grained, brown, moist, medium dense (SP)	COARSE ALLUVIUM	10		5	SB				
14	SAND, medium grained, a little gravel, brown, moist, medium dense (SP)		10		6	SB				
18	SAND, fine grained, brown, moist, medium dense (SP)									
20½	SILTY SAND, a little gravel, gray, wet, medium dense (SM)	TILL	10		7	SB				
25	Continued on next page									

LOG OF TEST BORING

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO B Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	RQD
25	SILTY SAND, (continued) (SM)	TILL (cont.)	14		8	SB				MA
29.7	LIMESTONE, brownish gray to 30.2' then light brownish gray with a few layers of brown	* MAGNOLIA MEMBER	86%			NQ				84%
			100%			NQ				90%
40.3	End of Boring *Coring fluid	*PLATTEVILLE FORMATION CARIMONA MEMBER								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
11-16	9:15	40.3'	29.7'		to	7' *
11-16	9:25	40.3'	19½'		to	17' *
11-16	9:35	40.3'	None	10'	to	None

START 11-13-81 COMPLETE 11-16-81

METHOD HSA 0 - 29.7' @ 9:15

NQ cored 29.7'-40.3'

CREW CHIEF Hegland & LeMay

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. C

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 829.3')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SILTY SAND, SANDY SILT, BRICK and CONCRETE, a little gravel, black and dark grayish brown, (See #1)	FILL			1	HSA				
3	CLAYEY SAND, black, medium (SC)	TOPSOIL			2	HSA				
5½					3	SB				
	FAT CLAY, brownish gray and brown mottled, (See #2) (CH)	FINE ALLUVIUM	5		4	SB	34	86		
7	SAND, fine to medium grained, a trace of gravel, (See #3) (SP)	COARSE ALLUVIUM	11		5	SB				
8½	FAT CLAY, gray, soft to rather stiff (CH)	FINE ALLUVIUM								
11			11		6	SB				
	SAND, fine to medium grained, light brown and brown, moist, dense to medium dense (SP-SM)	COARSE ALLUVIUM			7	SB				
			16		8	SB				
			14		9	SB				
18	SAND, medium grained, a little gravel, light brown, moist, dense (SP)									
			23		10	SB				
23	SAND, fine to medium grained, brown, moist to 24½' then waterbearing, dense to (SP)			▼						
26			16		11	SB				
	CLAYEY SAND, a little gravel, gray, rather stiff (SC)	TILL			12	SB				
30					13	SB				

Continued on next page

#1 - a layer of blacktop at the surface

#2 - medium, a few laminations of silt and sand (CH)

#3 - light brown, moist, medium dense, a few layers of fat clay (SP)

LOG OF TEST BORING

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO C Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	RQD
30	CLAYEY SAND, (continued) (SC)	TILL (cont.)	15		14	SB				
32.9	LIMESTONE, light brownish gray, with a few layers of brown to about 41½' then gray, weathered and fractured zone between about 41.3 - 41.6'	* MAGNOLIA MEMBER	100%			NQ				81%
			100%			NQ				100%
		HIDDEN FALLS MEMBER	100%			NQ				80%
43.0	End of Boring **Influenced by coring fluid	*PLATTEVILLE FORMATION CARIMONA MEMBER								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-17	10:30	27'	25'		to	24½'
11-17	12:20	43.0'	32.9'		to	18½'**
11-17	1:25	43.0'	None	12'	to	None
					to	

START 11-17-81 COMPLETE 11-17-81

METHOD HSA 0 - 32.9' @ 12:10

NQ cored 32.9-43.0'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. D

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 831.5')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	FILL, mixture of BRICK, SAND, SILTY SAND, GRAVEL and SLABS of CONCRETE, brown	FILL								
					1	HSA				
			8		2	SB				
			15		3	SB				
9	SAND, fine grained, a trace of gravel, light brown, moist, medium dense to very dense (SP)	COARSE ALLUVIUM	12		4	SB				
13	SAND, medium grained, some to a trace of gravel, light brown, moist, dense (SP)		38		5	SB				
			18		6	SB				
			18		-	--				
22	SAND, medium to fine grained, a trace of gravel, brown, moist to 27½' then water-bearing, dense to medium dense (SP-SM)		24	▼	7	SB				
30	Continued on next page									

LOG OF TEST BORING

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO D Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	RQD
30	SAND, (continued) (SP-SM)	COARSE ALLUVIUM (cont.)	9		8	SB				MA
33	CLAYEY SAND, a little gravel, gray, rather stiff (NSR) (SC-SM)	TILL	4* / 0.5							
35½	LIMESTONE, light brownish gray, with a few layers of brown to about 39' then gray, very weathered seam at about 43', somewhat weathered and fractured between about 43 - 44½'	PLATTEVILLE FORMATION MAGNOLIA MEMBER	100%			NQ				96%
			100%			NQ				62%
		HIDDEN FALLS MEMBER	100%			NQ				88%
45.5	End of Boring *Blow count recorded for initial 6" set then obstructed. **Influenced by coring fluid									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-18	12:15	32'	32'		to	27½'
11-18	1:30	35½'	35½'		to	27½'
11-18	2:55	45.5'	35½'		to	25½'**
11-18	3:20	45.5'	None	10'	to	None

START 11-18-81 COMPLETE 11-18-81

METHOD HSA 0 - 35½' @ 2:45

NQ cored 35.5-45.5'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. E

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 827.7')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SILTY SAND, SANDY CLAY and SILTY CLAY, some gravel and brick, black and dark brown, (See #1)	FILL			1	HSA				
3	CLAYEY SAND, black, medium (SC)	TOPSOIL			2	HSA				
4	SILTY SAND, a trace of (See #2) (SM)				3	SB				
4½	SAND, fine to medium grained, a trace of gravel, brown, moist, dense, a few layers of silty sand (SP-SM)	COARSE ALLUVIUM	18		4	SB				
7	SAND, medium to fine grained, a trace of gravel, brown, moist, loose (SP)		8		5	SB				
			6		6	SB				
12	SAND, fine grained, brown, moist, loose, a few lenses of silt (SP)		8		7	SB				
15	SAND, medium grained, a little gravel, light brown, moist, medium dense (SP)		11		8	SB				
20	SAND, fine to medium grained, a trace of gravel, brown, moist to 23½' then waterbearing, medium dense (SP)		11	▼	9	SB				
			10		10	SB				
26	CLAYEY SAND, a little gravel, brownish gray to gray, rather stiff to stiff (SC-SM)	TILL								
30			18		11	SB				

Continued on next page

#1 - a layer of blacktop at the surface

#2 - gravel, brownish gray, moist (SM)

LOG OF TEST BORING

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO E Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	RQD
30	CLAYEY SAND, (continued) (SC-SM)	TILL (cont.)			12	SB				MA
32.3	LIMESTONE, light brownish gray to about 40½' then gray, of brown at about 40'	PLATTEVILLE FORMATION MAGNOLIA MEMBER	95%			NQ				83%
			100%			NQ				95%
			100%			NQ				93%
		HIDDEN FALLS MEMBER								
42.3	End of Boring *Influenced by coring fluid									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-17	2:45	26'	24'		to	23½'
11-18	10:05	42.3'	32.3'		to	38½'
11-18	10:15	42.3'	24'		to	23' *
11-18	10:35	42.3'	None	13'	to	12½' *

START 11-17-81 COMPLETE 11-18-81

METHOD HSA 0 - 32.3' @ 10:00

NQ cored 32.3-42.3'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. F

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 828.7')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	FILL, mixture of CLAYEY SAND, SILTY SAND, SILTY CLAY and SAND, a little gravel, a few bricks, a few slabs of concrete, black, brown and dark brown	FILL			1	HSA				
					2	SB				
6	FAT CLAY, gray and brownish gray mottled, medium (CH)	FINE ALLUVIUM	5		3	SB				
7½	SAND, fine grained, light brown, moist, medium dense, a few layers of silty clay (SP)	COARSE ALLUVIUM	12		4	SB				
			12		5	SB				
12	SAND, medium grained, a trace of gravel, light brown to brown, moist to 24½' then waterbearing, dense to medium dense (SP)		16		6	SB				
			12		7	SB				
			13		8	SB				
				▼						
25	Continued on next page									

LOG OF TEST BORING

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO. F Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	RQD
25	SAND, (continued) (SP)	COARSE*			9	SB				
26			10							
	LEAN CLAY, a little gravel, gray, medium (CL)	TILL			10	SB				
28½	CLAYEY SAND, some gravel, gray, stiff (SC-SM)		23		11	SB				
31.8	LIMESTONE, light brownish gray, with a few layers of brown to about 41' then gray, a 0.3' weathered zone at about 41'	PLATTEVILLE FORMATION MAGNOLIA MEMBER	86%			NQ				84%
			100%			NQ				80%
			100%			NQ				86%
41.8	End of Boring	HIDDEN**								
		*ALLUVIUM (cont.)								
		**FALLS MEMBER								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-12	2:15	26½'	25'		to	24½'
11-12	2:40	13.8'	31.8'		to	26'
11-13	11:30	41.8'	31.8'	41½'	to	28'
					to	

START 11-12-81 COMPLETE 11-13-81

METHOD HSA 0 - 31.8' @ 11:30

NQ cored 31.8-41.8'

CREW CHIEF LeMay Hegland

LOG OF TEST BORING

JOB NO. 120-8122 VERTICAL SCALE 1" = 4' BORING NO. G

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 826.9')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of BRICK, CONCRETE, ASHES, WOOD, SILTY SAND and SAND, a little gravel, black, dark brown and brown, a layer of blacktop at the surface	FILL			1	HSA				
			11		2	SB				
			4		3	SB				
			22		4	SB				
11	SAND, medium grained, a little gravel, brown, moist, dense (SP)	COARSE ALLUVIUM	22		5	SB				
			30		6	SB				
20	SAND, fine to medium grained, a trace of gravel, brown, moist, medium dense (SP)		15		7	SB				
24	CLAYEY SAND, a little gravel, gray, soft to medium (SC)	TILL			8	SB				
25½	SILTY SAND, a little gravel, a few slabs of limestone, gray, wet, medium dense to loose (SM)		41	▼	9	SB				
30	Continued on next page									

LOG OF TEST BORING

JOB NO 120-8122 VERTICAL SCALE 1" = 4' BORING NO G Cont.

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	RQD
30½	SILTY SAND, (continued) (SM)	TILL (cont.)	**		-	--				
	LIMESTONE, brownish gray to about 31.3' then light brownish gray with a few layers of brown	* MAGNOLIA MEMBER	98%			NQ				80%
			100%			NQ				72%
40.6	End of Boring	*PLATTEVILLE FORMATION CARIMONA MEMBER								
	** 50/0.0									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-12	9:50	27'	25'	27'	to	None
11-12	10:10	30.6'	30.6'		to	27'
11-12	11:45	40.6'	30.6'		to	28'
11-12	12:05	40.6'	None	14'	to	None

START 11-12-81 COMPLETE 11-12-81

METHOD HSA 0 - 30.6' @ 11:45

NQ cored 30.6-40.7'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 1

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 826.7')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL	Qu
	FILL, mostly SILTY SAND, dark grayish brown, frozen to 3½', a layer of concrete at the surface	FILL			1	HSA				
5	SANDY CLAY, black, soft (CL) (may be fill)	FILL OR TOPSOIL			2	HSA				
7½	SAND, medium grained, a little gravel, light brown to brown, moist to 22' then waterbearing, loose to dense (SP)	COARSE ALLUVIUM	5		3	SS				
			11		4	SS				
			16		5	SS				
			14	▼	6	SS				
			21		7	SS				
26	SANDY CLAY, a little gravel, gray, stiff (CL-SC)	TILL								
30			13 / 0.5		8	SS				
	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 1 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	% or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	LIMESTONE, light brownish gray with a few lenses of brown	PLATTEVILLE FORMATION								
		Magnolia Member	100%			BX				
			100%			BX				
		Hidden Falls Member								
39.7	End of Boring									

R = percent core recovery

*No measurement recorded due to presence of coring fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-9		27'	24½'	24½'	10	22'
2-9	11:00	39.7'	30.0'		10	*
2-9	11:15	39.7'	None		10	*
					10	

START 2-8-79 COMPLETE 2-9-79

METHOD 3¼ HSA 0' - 29' @ 11:00

BWC 0' - 30.0'

BX diamond bit-cored 30.0'-39.7'

CREW CHIEF Holan

662 CROMWELL AVENUE SOIL EXPLORATION COMPANY ST PAUL, MN 55114

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 3

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 825.8')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL	Qu
	FILL, mostly SILTY SAND, a little brick, gravel and concrete, dark brown, brown and dark grayish brown, frozen to 3', a concrete sidewalk at the surface	FILL		*	1	HSA				
			8		2	SS				
			19		3	SS				
			12		4	SS				
11½	SAND, medium to fine grained, a little gravel, light brown, moist, medium dense (SP)	COARSE ALLUVIUM	9		5	SS				
14½	SAND, medium to coarse grained, some gravel, brown, moist, dense (SP-SM)		22		6	SS				
20	SANDY CLAY, a little gravel, gray, stiff to rather stiff (CL)	TILL	19		7	SS	15	117		3800
			15		8	SS				
26	SILTY SAND, a little gravel, grayish brown, wet, dense (SM)				9	SS				
29.4										
30	LIMESTONE, light brownish gray with									

Continued on next page

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 3 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	QU
30	LIMESTONE (Cont.), a few lenses of brown to about 38½' then gray, weathered and fractured at about 37½' - 38½'	PLATTEVILLE FORMATION Magnolia Member	100%			BX				
			100%			BX				
		Hidden Falls Member								
39.8	End of Boring									

R = percent core recovery

*A little water may exist below depth of about 26' based on observation while sampling.

**No measurement recorded due to presence of coring fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-7	11:00	29½'	29½'	29½'	to	None*
2-8	12:20	39.8'	29.8'		to	**
2-8	1:20	39.8'	None		to	**
					to	

START 2-7-79 COMPLETE 2-8-79

METHOD 3¼ HSA 0' - 29½' @ 12:20

BWC 0' - 29.8'

BX diamond bit-cored 29.8'-39.8'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 9

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 831.3')	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	SILTY SAND, a little gravel, brown, a layer of concrete at the surface (SM) (may be fill)	FILL OR COARSE ALLUVIUM			1	HSA				
4	SAND, medium grained, a little gravel, light brown, moist to 27' then waterbearing, medium dense to dense to medium dense (SP)	COARSE ALLUVIUM			2	HSA				
			13		3	SS				MA
			14		4	SS				
			12		5	SS				
			21		6	SS				
			12	▼	7	SS				
28	SANDY CLAY, a little gravel, gray, medium (CL)	TILL								
30	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 9 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	SANDY CLAY (Cont.)		7		8	SS	24	102		1700
32	LIMESTONE SLABS, gray, with a few pieces of gravel	COLLUVIUM								
33.6±	LIMESTONE, light brownish gray with a few lenses of brown	SEE NOTE: Magnolia Member	77%			BX				
			80%			BX				
			100%			BX				
			95%			BX				
42.8	End of Boring									
	R = percent core recovery *No measurement recorded due to presence of coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
2-9		27'	24½'	27'	to	27'
2-9	4:00	42.8'	32.0'		to	*
2-10	9:15	42.8'	None		to	*

START 2-9-79 COMPLETE 2-9-79

METHOD 3¼ HSA 0'-29½' @ 4:00

BWC 0' - 32.0'

BX diamond bit-cored 32.0'-42.8'

CREW CHIEF Holan

SOIL EXPLORATION COMPANY
662 CROMWELL AVENUE ST PAUL, MN 55114

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 11

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 828.9')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mixture of SILTY SAND and CLAYEY SAND, a little fat clay and gravel, brown, dark brown and gray, frozen to 6', a layer of concrete at the surface	FILL			1	HSA				
					2	HSA				
			3		3	SS				
12	SAND, medium grained, a little gravel, light brown, moist, medium dense to dense (SP)	COARSE ALLUVIUM	9		4	SS				
15½	SAND, fine grained, light brown, moist, dense (SP)		17		5	SS				MA
21	SAND, medium grained, a little gravel, brown, moist to about 24' then waterbearing, medium dense (SP)		20	*	6	SS				
26			13		7	SS				
	CLAYEY SAND, a little gravel, gray, medium, a layer of gravel below 32' (SC)	TILL								
30	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4204 VERTICAL SCALE 1" = 4' BORING NO 11 Cont.

PROJECT MUNICIPAL PARKING STRUCTURE AND MTC FACILITY, CITY OF MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	or N R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	CLAYEY SAND (Cont.)		8		8	SS				
33.2	LIMESTONE, light brownish gray with a few lenses of brown to about 41½' then gray	PLATTEVILLE FORMATION Magnolia Member	95%			BX				
			98%			BX				
		Hidden Falls Member								
43.0	End of Boring									

R = percent core recovery

*Water level shown (24') is an estimate based on observation while sampling.

**No measurement recorded due to presence of coring fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
2-6	1:30	43.0'	33.3'		to	**
2-6	2:00	43.0'	None		to	**

START 2-6-79 COMPLETE 2-6-79

METHOD @ 1:30

3¼ HSA 0'-14½', BWC 0'-33.3'
BX diamond bit-cored 33.3'-43.0'

CREW CHIEF Holan

SOIL EXPLORATION company

662 CROMWELL AVENUE SOIL EXPLORATION company ST PAUL, MN 55114

SE-2 (77-B-4)

SIEVE ANALYSIS TESTS

PROJECT MUNICIPAL PARKING RAMP AND MTC LAYOVER FACILITY-MINNEAPOLIS, MINNESOTA

DATE 12-3-81

REPORTED TO City of Minneapolis

JOB NO. 120-8122

BORING NO.	A	B	D	E
SAMPLE NO.	11	8	8	11
DEPTH (ft)	30-32	25-26	30-32	29½-31
TYPE OF SAMPLE	SB	SB	SB	SB
CLASSIFICATION (ASTM: D 2487)				
Symbol	SM	SM	SP-SM	SC-SM
Description	SILTY SAND, some gravel, gray	SILTY SAND, some gravel, gray	SAND, meidum to fine grained trace of gravel brown	CLAYEY SAND, a little gravel gray
MECHANICAL ANALYSIS:				
Dry Weight of Total Sample (grams)	143	326	266	245
Based on Total Sample				
% Finer Than 3"				
2"				
1"	100	100	100	100
3/4"				
3/8"	87	92	100	98
# 4	82	84	99	95
# 10	77	76	98	91
# 40	63	54	35	79
# 100	37	30	8	54
# 200	28	28	6	50

GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	3 1/4" I.D. Hollow Stem Auger
_FA	4", 6" or 10" Diameter Flight Auger
_HA	2", 4" or 6" Hand Auger
_DC	2 1/2", 4", 5" or 6" Steel Drive Casing
_RC	Size A, B or N Rotary Casing
PD	Pipe Drill or Cleanout Tube
CS	Continuous Split Barrel Sampling
DM	Drilling Mud
JW	Jet Water
SB	2" O.D. Split Barrel Sample
_L	2 1/2" or 3 1/2" O.D. SB Liner Sample
_T	2" or 3" Thin Walled Tube Sample
3TP	3" TWT (Pitcher Sampler)
_TO	2" or 3" TWT (Osterberg Sampler)
W	Wash Sample
B	Bag Sample
P	Test Pit Sample
_Q	BQ, NQ or PQ Wireline System
_X	AX, BX or NX Double Tube Barrel
CR	Core Recovery – Percent
NSR	No Sample Recovered, classification based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit.
NMR	No Measurement Recorded, primarily due to presence of drilling or coring fluid.
▼	Water Level Symbol

LABORATORY TEST SYMBOLS

SYMBOL	DEFINITION
W	Water Content - % of Dry Wt. - ASTM D 2216
D	Dry Density - Pounds Per Cubic Foot
LL, PL	Liquid and Plastic Limit - ASTM D423 and 424
Qu	Unconfined Compressive Strength - in Pounds/ Square Foot - ASTM D 2166

Additional Insertions in Qu Column

Pq	Penetrometer Reading - Tons/Square Foot
Ts	Torvane Reading -Tons/Square Foot
G	Specific Gravity - ASTM D 854
SL	Shrinkage Limit - ASTM D 427
pH	Hydrogen ion Content - Meter Method
OC	Organic Content - Combustion Method
SP	Swell Pressure - Tons/Square Foot
PS	Percent Swell
FS	Free Swell - Percent
SC	Sulfate Content - Parts/Million, same as mg/L
CC	Chloride Content - Parts/Million, same as mg/L
C *	One Dimensional Consolidation - ASTM D 2435
Qc *	Triaxial Compression
D.S. *	Direct Shear - ASTM D3080
K *	Coefficient of Permeability - cm/sec
D *	Dispersion Test
MA *	Particle Size Analysis - ASTM D 422
R	Laboratory Resistivity, in ohm - cm
E *	Pressuremeter Deformation Modulus - TSF
Vs *	Field Vane Shear - ASTM D 2573
RQD	Rock Quality Designation - Percent

* See attached data sheet or graph

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels may be considered reliable ground water levels. In clay soil, it may not be possible to determine the ground water level within the normal time required for test borings, except where lenses or layers of more pervious waterbearing soil are present and even then an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	"N" VALUE	CONSISTENCY TERM
Very Loose	0-4	Soft
Loose	5-8	Medium
Medium Dense	9-15	Rather Stiff
Dense	16-30	Stiff
Very Dense	Over 30	Very Stiff

Standard "N" Penetration: Blows Per Foot of a 140 Pound Hammer Falling 30 inches on a 2 inch OD Split Barrel Sampler.

Lamination	Up to 1/2" thick stratum
Layer	1/2" to 6" thick stratum
Lens	1/2" to 6" discontinuous stratum, pocket
Varved	Alternating laminations of clay, silt and/or fine grained sand, or colors thereof
Dry	Powdery, no noticeable water
Moist	Below saturation
Wet	Saturated, above liquid limit
Waterbearing	Pervious soil below water

RELATIVE PROPORTIONS AND SIZES

Term	Range
Trace	0-5%
A Little	5-15%
Some	15-30%
With	30-50%

Boulder	Over 12"
Cobble	3" - 12"
Gravel	
Coarse	3/4" - 3"
Fine	#4 - 3/4"
Sand	
Coarse	#4 - #10
Medium	#10 - #40
Fine	#40 - #200
Silt & Clay	– #200, Based on Plasticity

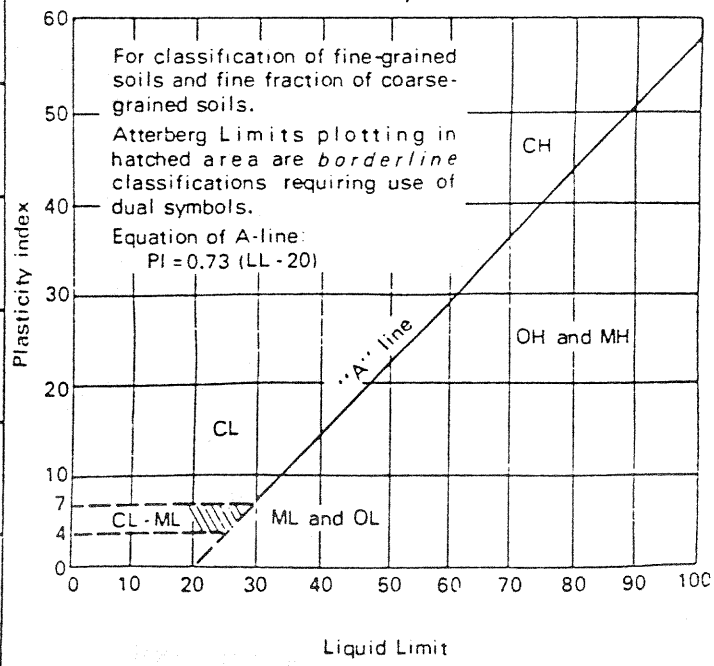
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 69 AND D 2488 – 69

(Unified Soil Classification System)

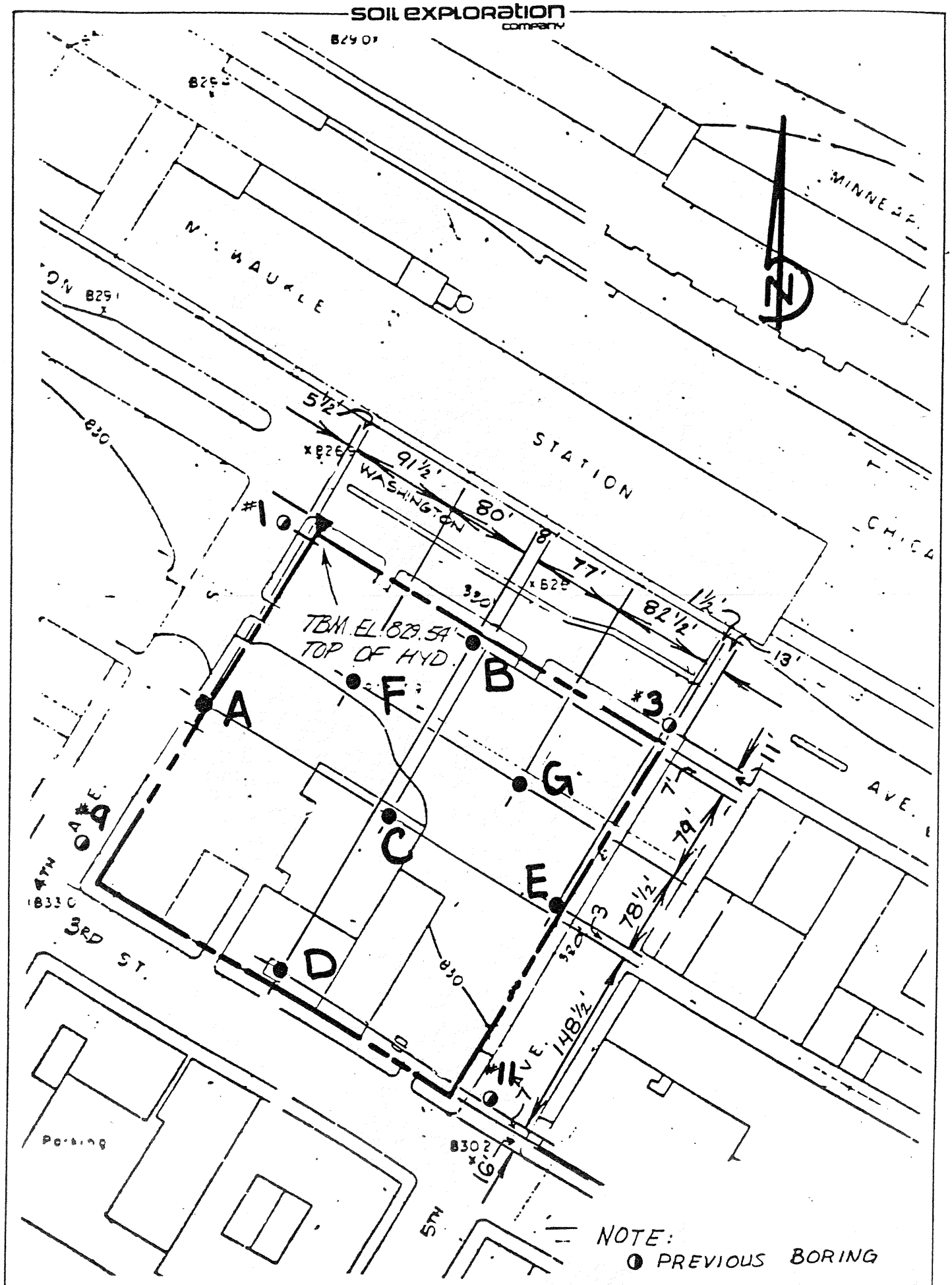
Major divisions			Group symbols	Typical names	Classification criteria		
Coarse-grained soils More than 50% retained on No. 200 sieve*	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve . . . . . GW, GP, SW, SP More than 12% pass No. 200 sieve . . . . . GM, GC, SM, SC 5 to 12% pass No. 200 sieve . . . . . *Borderline* classifications requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		Sands with fines	SM	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils 50% or more passes No. 200 sieve*	Silts and clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands			
			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 sands or silts, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity			
	Highly organic soils		Pt	Peat, muck and other highly organic soils			

Plasticity Chart



*Based on the material passing the 3 in. (76 mm) sieve.

SOIL EXPLORATION COMPANY



SOIL TEST BORINGS	JOB NO. 120-8122	SCALE: 1" = 100'	DRAWN BY PR	CHECKED BY SK