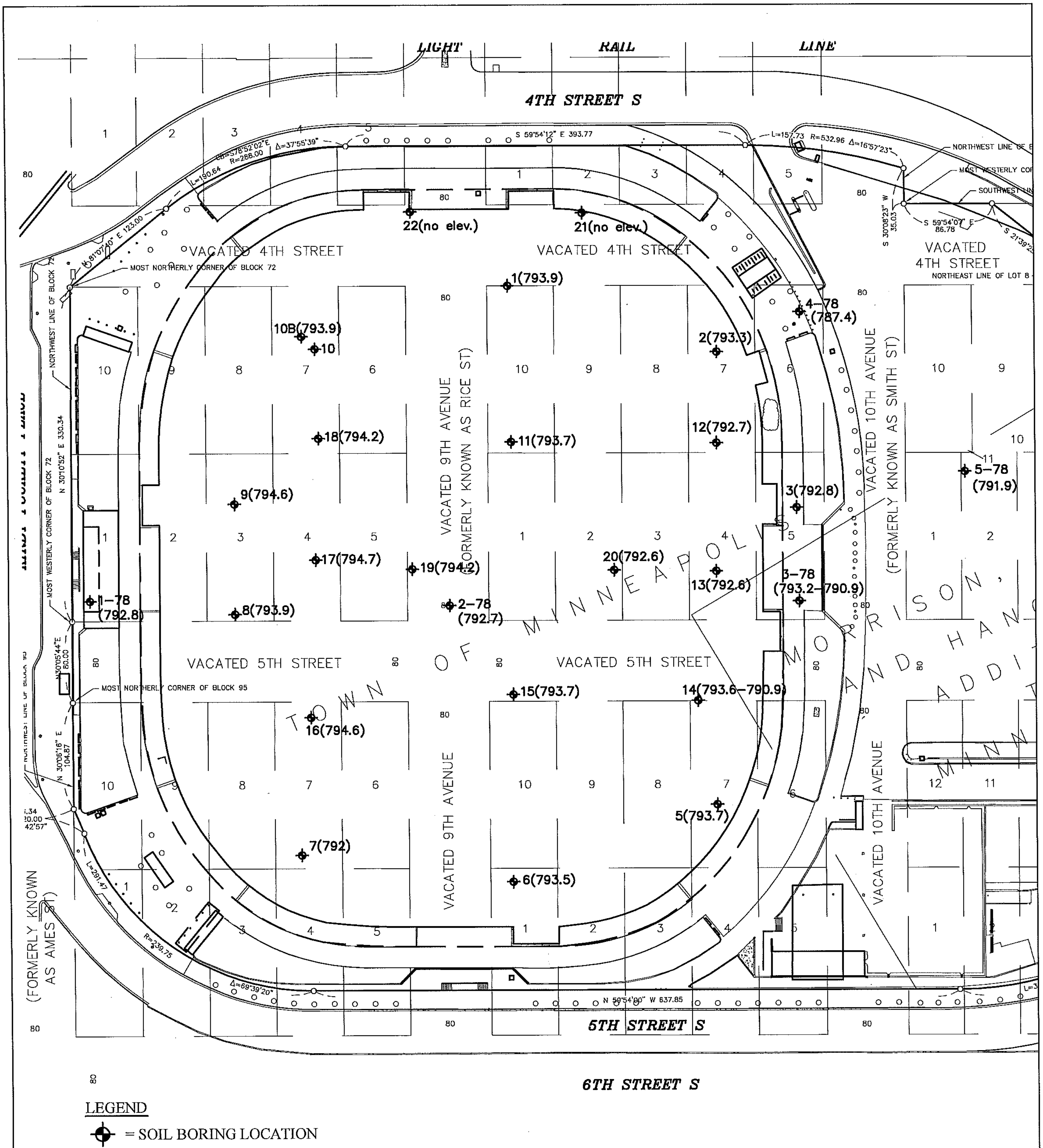
Appendix B

Figure 2 – Past Boring Locations/Top of Bedrock Elevations
1978 – 1979 Soil Exploration Co. Boring Logs
2008 Braun Intertec Boring Logs and Location Figure



AMERICAN ENGINEERING TESTING, INC.	SCALE 0 FEET 130'	**PROJECT** Minnesota Multi-Purpose Stadium Minneapolis, Minnesota	**AET NO.** 01-05723
		SUBJECT Past Boring Locations / Top of Bedrock Elevations	**DATE** February 2013
		DRAWN BY VL / **CHECKED BY** JV	**FIGURE 2**

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 1

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 838.0' (127.7')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	SILTY SAND, a little gravel, black, frozen to 1' then moist (SM) (may be fill)	TOPSOIL or MAY BE FILL			1	HSA				
2	SILTY SAND, fine grained, a trace of gravel, dark brown, moist (SM)	COARSE ALLUVIUM			2	HSA				
4	SAND, medium grained, a little gravel, some pieces of weathered limestone, brown, moist, medium dense, a few lenses of (See#1)		10		3	SS				
6½	SILTY SAND, a little gravel, brown, moist, medium dense to dense (SM)	TILL	11		4	SS				
			17		5	SS				
			22		6	SS				
15	SAND, fine grained, light brown, moist, medium dense (SP-SM)	COARSE ALLUVIUM	14		7	SS				
19	SAND, medium to fine grained, some gravel, a few cobbles, brown, moist, very dense (SP-SM)		48		8	SS				
21½	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense (SM)	TILL	49/0.5		9	SS				
			100/0.0		-	--				
35	Continued on next page									

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 1 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.)		65/0.5		10	SS				
35½	SAND, medium grained, some gravel, brown, moist, very dense (SP)	COARSE ALLUVIUM	98		11	SS				
42	No sample recovered. Appears to be SILTY SAND, a little gravel, brown, moist, very dense based on (See#2)	TILL								
44.1±	LIMESTONE, light brownish gray with some lenses of brown to about 55' then gray to about 60½' then light gray and gray mottled, weathered above about 45½'	PLATTEVILLE FORMATION Magnolia Member	100%		(74%)	BX				
			100%		(52%)	BX				
			100%		(73%)	BX				
		Hidden Falls Member	100%		(58%)	BX				
		Mifflin Member	100%		(0)	BX				
			100%		(55%)	BX				
			100%		(56%)	BX				
70	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 1 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL PL	Qu
70	LIMESTONE (Cont.)	PLATTEVILLE FORMATION (Cont.)								
		Pecatonica Member	100%		(14%)	BX				
74½±	SHALE, gray to about 76½' then greenish gray and brown, shaly sandstone below about 76½'	GLENWOOD FORMATION	100%		(0%)	BX				
			100/0.4		12	SS				
78±	SANDSTONE, light brown to white	ST. PETER FORMATION								
			100/0.15		-	--				
			100/0.15		-	--				
	#1 - silty sand and sandy clay (SP-SM) #2 - action of drilling equipment and on evidence of material returned in drilling fluid.		100/0.15		-	--				
			100/0.15		-	--				
98.65	End of Boring									

R - percent core recovery. ()indicates RQD.

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

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	None
1-19		16'	14½'		to	*
1-20	10:30	98.65'	45.6'		to	*
1-20	11:15	98.65'	None		to	

START 1-19-79 COMPLETE 1-20-79

METHOD 3¼ HSA 0' - 14½' @ 10:30

DM 14½'-45.6', BWC 0'-45.6',

BX diamond bit-cored 45.6'-77.7',

DM 77.7'-98½'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 2

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 836.3' (126.0')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	FILL, mixture of SAND and SILTY SAND, a little gravel, concrete and brick, brown, dark brown and black, frozen to 1½'	FILL			1	HSA				
			17		2	SS				
			30		3	SS				
			12		4	SS				
9	SILTY SAND, some gravel, a few cobbles, brown, moist, very dense, a few lenses of clayey sand (SM)	TILL	47		5	SS				
					6	SS				
12½	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense, a few lenses of sand above 17' (SM)		45							
			37		7	SS				
			100/0.7		8	SS				
			100/0.6		9	SS	12	127		M.A.
			78		10	SS				
35	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 2 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.)		54		11	SS	9	129		M.A.
			40		12	SS				
43±	LIMESTONE, gray to about 44.3' then light brownish gray with a few lenses of brown to about 55' then gray, weathered above about 44'	SEE NOTE 1:								
		Magnolia Member	95%	(59%)		NQ				
			92%	(60%)		NQ				
			92%	(61%)		NQ				
		SEE NOTE 2:								
55.9	End of Boring									

R - percent core recovery, () indicates RQD.

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

**Piezometer installed in boring - see attached illustration/data sheet.

NOTE 1: PLATTEVILLE FORMATION Carimona Member

NOTE 2: Hidden Falls Member

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
1-17	4:15	55.9'	43.8'		to	*
1-17	4:45		**		to	
					to	

START 1-10-79 COMPLETE 1-17-79

METHOD 3¼ HSA 0'-7', @ 4:15

4C 0'-9½', DM 8½'-43.9', NWC 0'-43.8',

NQ wireline-cored 43.9'-55.9'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-4131 | VERTICAL SCALE 1" = 4' | BORING NO 3

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 836.3' (126.0')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	[illegible]	Qu
	FILL, mixture of SAND and SILTY SAND, a little gravel and cinders, dark brown, brown and gray, frozen to ½'	FILL			1	HSA				
			21		2	SS				
					3	SS				
5	SAND, medium grained, a little gravel, light brown, moist, dense to medium dense, a few lenses of silt above 7' (SP)	COARSE ALLUVIUM	16		4	SS				
			9		5	SS				
9½	SILTY SAND, a little gravel, a few cobbles and boulders, brown to grayish brown, moist, very dense to dense (SM)	TILL	30		6	SS				
			34		7	SS				
			31		8	SS				
			47		9	SS				
			23		10	SS				
30										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 3 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	L.L. / P.L.	Qu
30	SILTY SAND (Cont.)		90		11	SS				
			24		12	SS				
			19		-	--				
43½±	LIMESTONE, light brownish gray to about 53' then gray to about 59' then light gray and gray mottled, a 0.1' weathered seam at about 53', weathered above about 45.2'	PLATTEVILLE FORMATION	50/0.0		-	--				
		Magnolia Member								10,240 psi
			94%		(74%)	NQ				
			100%		(0%)	NQ				
			100%		(96%)	NQ				
53		Hidden Falls Member	95%		(82%)	NQ				
			96%		(88%)	NQ				
60										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 3 Cont.

PROJECT PROROSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
60	LIMESTONE (Cont.)	Mifflin Member (Cont.)	100%		(95%)	NQ				
			99%		(95%)	NQ				
		Pecatonica Member	100%		(64%)	NQ				
73.8±	SHALE, gray to about 76' then light gray and gray mottled with a little brown, shaly sandstone below about 76'	GLENWOOD FORMATION	100%		(45%)	NQ				
77½±	SANDSTONE, brown to white	ST. PETER FORMATION	46%		(8%)	NQ				
			0%		(0%)	NQ				
			14%		(0%)	NQ				
90										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 3 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
90	SANDSTONE (Cont.)									
			6%			NQ				
			0%			NQ				
100.8	End of Boring									

R = percent core recovery. () indicates RQD.

*Appears to be drilling/coring fluid.

Note: Samples No. 3 and 8 contain petroleum fuel odor.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-6	10:40	11'	None	10½'	to	None
1-9	9:15	52.9'	47.0'		to	47⅓'*
1-9	3:30	100.8'	47.0'		to	47⅓'*
1-10	8:25	100.8'	None	45'	to	41⅓'*

START 1-6-79 COMPLETE 1-9-79

METHOD 6 FA 0'-9', 4C 0'-9½', @ 3:00

DM 11'-45.2', NC 0'-47.0',

NQ wireline-cored 45.2'-100.8'

CREW CHIEF LeMay & Francis

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 5

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 842.2' (131.9')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	L / P.L	Qu
	FILL, mostly SILTY SAND, a little gravel, brown, frozen	FILL			1	HSA				
2	SAND, fine grained, brown, frozen to 5½' then moist, loose (SP)	COARSE ALLUVIUM			2	HSA				
					3	SS				
			6		4	SS				
9	SAND, medium to fine grained, light brown, moist, loose, a few lenses of silty sand (SP)		6		5	SS				
12	SAND, fine grained, light brown, moist, medium dense (SP)		9		6	SS				
14	SAND, medium grained, a little gravel, brown, moist, loose to dense (SP)		8		7	SS				
			22		8	SS				
23	SANDY CLAY, a little gravel, gray, stiff (CL)	TILL	18		9	SS				
28	SILTY SAND, a little gravel, a few cobbles and boulders, brownish gray, moist, medium dense (SM)									
30										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 5 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
			15		10	SS				
30	SILTY SAND (Cont.)									
34	SAND, medium grained, some gravel, a few cobbles and boulders, brown, moist, dense (SP-SM)	COARSE ALLUVIUM	25		11	SS				
40	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, medium dense to dense (SM)	TILL	9		12	SS				
			100/0.5		-	--				
48½±	LIMESTONE, gray to about 50' then light brownish gray with a few lenses of brown to about 59½' then gray to about 64½' then light gray and gray mottled	PLATTEVILLE FORMATION (See Note:) Magnolia Member	97%		(63%)	BX				
			100%		(93%)	BX				
			96%		(73%)	BX				
60	Continued on next page									

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 5 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
60	LIMESTONE (Cont.)	Hidden Falls Member	96%	(73%)		BX				
		Mifflin Member	100%	(83%)		BX				
			100%	(78%)		BX				
			100%	(87%)		BX				
		Pecatonica Member								
79±	SHALE, gray to about 81' then greenish gray and a little brown, shaly sandstone below about 81'	GLENWOOD FORMATION	86%	(44%)		BX				
83±	SANDSTONE, brown and a little gray mottled to white	ST. PETER FORMATION	100/0.4		13	SS				
			100/0.2		14	SS				
90	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 5 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
90	SANDSTONE (Cont.)									
			100/0.15		-	--				
			100/0.2		-	--				
103.7			100/0.2		-	--				
	End of Boring									
	*No measurement recorded due to presence of drilling/coring fluid.	Note: Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-22		16'	14½'		to	None
1-23	11:00	103.7'	48.9'		to	*
1-23	12:00	103.7'	None		to	*
					to	

START 1-22-79 COMPLETE 1-23-79

METHOD 3¼ HSA 0' - 14½' @ 11:00

DM 14½'-48.9', BWC 0'-48.9',

BX diamond bit-cored 48.9'-82.8',

DM 82.8'-103½'

CREW CHIEF Holan

662 CROMWELL AVENUE SOIL EXPLORATION COMPANY ST PAUL, MN 55114

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 6

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 841.8' (131.5')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	FILL, mixture of SILTY SAND, SANDY CLAY and CONCRETE, a little gravel, a few boulders, brown and black, frozen to 3'	FILL			1	HSA				
					2	HSA				
9	LEAN CLAY, grayish brown, medium (CL)	FINE ALLUVIUM	14		3	SS	28	91	37/14	
10½	SAND, fine grained, light brown, moist, medium dense (SP)	COARSE ALLUVIUM	13		4	SS				
14	SAND, medium grained, light brown to brown, moist, medium dense (SP)		10		5	SS				
17½	SILTY SAND, medium grained, some gravel, a few cobbles and boulders, brown, moist, dense to very dense, a few lenses of sandy clay and sand (SM)		25		-	--				
			32		6	SS				
28	SILTY SAND, fine to medium grained, a little gravel, a few cobbles, grayish brown, moist, dense (SM)		16		7	SS				
33	SAND, medium grained, a little gravel, a few cobbles, grayish brown, moist, dense, some lenses of gray									
35										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 6 Cont

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
35	SAND (Cont.), sandy clay (SP-SM)		24		8	SS				
38	CLAYEY SAND, a little gravel, a few cobbles, gray, rather stiff, lenses of silty sand, a few lenses of sandy clay and sand (SC)	TILL	14		9	SS				
42	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense, a few lenses of sand (SM)		107		10	SS				
48.3±	LIMESTONE, gray to about 49½' then light brownish gray, with a few lenses of brown	SEE NOTE: Magnolia Member	92%		(75%)	BX				
			96%		(85%)	BX				
58.8	End of Boring R = percent core recovery. () indicates RQD. *No measurement recorded due to presence of drilling/coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-12		21'	19½'		to	None
1-12	3:45	58.8'	48.8'		to	*
1-13	9:00	58.8'	None		to	*
					to	

START 1-12-79 COMPLETE 1-12-79

METHOD 3¼ HSA 0' - 19½', @ 3:45

DM 19½'-48.8', BWC 0'-48.8',

BX diamond bit-cored 48.8'-58.8'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 7

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 847.0' (136.7')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL PL	Qu
	FILL, mixture of SILTY SAND (See#1)	FILL			1	FA				
1	CLAYEY SAND, a little gravel, black, frozen (SC) (may be fill)	TOPSOIL or MAY BE FILL			2	FA				
2½	SILTY SAND, fine grained, a trace of gravel, dark brown to brown, (See#2)	COARSE ALLUVIUM			3	FA				
4	CLAYEY SAND, a little gravel, brown, medium, lenses of silty sand (SC-SM)	TILL	8		4	SS				
					5	SS				
7	SILTY SAND, a little gravel, a few cobbles, boulders and slabs of limestone, brown, moist, very dense, a few lenses of sandy clay (SM)		47		6	SS				
			61		-	--				
			50/0.1		7	SS				
13	SILTY SAND, a little gravel, a few cobbles, brown, moist, dense (SM)		43		8	SS				
18	SAND, medium to coarse grained, some gravel, brown, moist, very dense (SP-SM)	COARSE ALLUVIUM	53		9	SS				
24	SAND, fine grained, brown, moist, very dense (SP-SM)		39		10	SS				
28	SAND, medium to fine grained, a little to some gravel, light brown, moist, very dense (SP)									
30										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 7 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	SAND (Cont.)		56		11	SS				
32	SILTY SAND, some gravel, a few cobbles, brown, moist, very dense (SM)	TILL	100/0.65		12	SS				
			100/0.5		13	SS				
43	SAND, fine grained, brown, moist, very dense (SP)	COARSE ALLUVIUM	100/0.55		14	SS				
48	SAND, medium grained, with gravel, cobbles and a few boulders, brown, moist, very dense (SP-SM)		100/0.45		15	SS				
53½	No sample recovered. Appears to be LIMESTONE SLABS or BOULDERS, (See#3)									
55±	LIMESTONE, light brownish gray to about 63½' then gray to about 68½' then light gray and gray mottled, contains a lense of gray shale at about 64.7' and at about 66½'	PLATTEVILLE FORMATION Magnolia Member	99% (85%)	▼		NQ				12,820 psi
60	Continued on next page									

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 7 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
60	LIMESTONE (Cont.)	PLATTEVILLE FORMATION (Cont.)	100%		(100%)	NQ				
		Hidden Falls Member	100%		(100%)	NQ				
			100%		(100%)	NQ				
		Mifflin Member	98%		(94%)	NQ				
			100%		(81%)	NQ				
			100%		(96%)	NQ				
		Pecatonica Member								
83±	SHALE, gray to about 85½' then greenish gray and some light brown	GLENWOOD FORMATION	96%		(81%)	NQ				
87½±	SANDSTONE, tan to white	ST. PETER FORMATION	14%		(14%)	NQ				
90										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 7 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
90	SANDSTONE (Cont.)		100/0.05		16	SS				
			100/0.15		-	--				
			100/0.05		-	--				
			100/0.1		-	--				
110.1			100/0.1		-	--				
	End of Boring									

#1 - and CRUSHED LIMESTONE, black, tan and dark brown, frozen, a layer of blacktop at the surface

#2 - frozen to 3' then moist (SM)

#3 - based on action of drilling equipment.

R - percent core recovery. () indicates RQD.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-13		9'	None		to	None
1-17	9:05	110.1'	54.4'		to	58'
					to	
					to	

START 1-13-79 COMPLETE 1-16-79

METHOD 6 FA 0'-7', 4C 0'-8', DM 9'-54.4', NWC 0'-54.4', JW 54.4'-55.8', NQ wireline-cored 55.8'-91.0', DM 91'-110' @ 4:25

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 8

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 841.4' (131.1'))	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mixture of SILTY SAND, SAND and SILTY CLAY, a little gravel, brown, frozen to 1'	FILL			1	HSA				
2	SANDY GRAVEL, a few cobbles and boulders, brown, moist, very dense (GP-GM)	COARSE ALLUVIUM			2	HSA				
5	SAND, medium grained, some gravel, cobbles and boulders, brown, moist, very dense (SP)		31		-	--				
			46		3	SS				
			40/0.5		4	SS				
11	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense (SM)	TILL	50		5	SS				
					6	SS				
			60/0.5		7	SS				
			84		8	SS				
28	SAND, fine to medium grained, a little gravel, brown, moist, very dense (SP-SM)	COARSE ALLUVIUM								
30										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 8 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL / PL	Qu
30	SAND (Cont.)		114		9	SS				
34	SAND, coarse grained, with gravel and cobbles, brown, moist, very dense (SP-SM)		100 / 0.5		10	SS				
			100%							
39½	SILTY SAND, a little gravel, brown, moist, very dense, some lenses of sand (SM)		64 / 0.5		11	SS				
			100 / 0.0		-	--				
47.5±	LIMESTONE, gray to about 48' then light brownish gray	SEE NOTE: Magnolia Member	96%		(58%)	BX				
			100%		(54%)	BX				
57.5	End of Boring R - percent core recovery. () indicates RQD. *No measurement recorded due to presence of drilling/coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-18		16'	14½'		to	None
1-18	3:40	57.5'	47.5'		to	*
1-18	4:05	57.5'	None		to	*
					to	

START 1-18-79 COMPLETE 1-18-79

METHOD 3¼ HSA 0' - 14½' @ 3:40

DM 14½'-47½', BWC 0'-47.5',

BX diamond bit-cored 38.8'-39.1' and 47.5'-57.5'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 9

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 840.1' (129.8')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mostly SILTY SAND, a little gravel, a trace of glass, (See#1)	FILL			1	HSA				
1½	SILTY SAND, a little gravel, a few cobbles, brown, moist, very dense, a few lenses of sand (SM)	TILL	30/0.5		2	SS				
			45		3	SS				
7	SILTY SAND, fine grained, a little gravel, brown, moist, dense (SM-SP)	COARSE ALLUVIUM	21		4	SS				
9	SANDY CLAY, a little gravel, (See#2)	TILL			5	SS				
10	SILTY SAND, a little gravel, (See#3)		22		6	SS				
10½	SAND, fine grained, a trace (See#4)	SEE NOTE:			7	SS				
11½	SILTY SAND, a little gravel, brown, moist, very dense (SM)	TILL	33		8	SS				
14	SANDY CLAY, some gravel, a few cobbles, brown, very stiff (CL-SC)		53		9	SS	10	129	22/12	
17	SAND, fine to medium grained, a little gravel, some layers of gravel, a few cobbles, brown, moist, very dense, a few lenses of silty sand (SP-SM)	COARSE ALLUVIUM	100/0.8		10	SS				
20½	SILTY SAND, some gravel, a few cobbles, brown, moist, very dense (SM)	TILL			11	SS				
			100/0.9		12	SS	7	134		M.A.
30										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 9 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
30	SILTY SAND (Cont.)		100/0.7		13	SS				
			100/0.2		14	SS				
38	SAND, medium grained, some gravel, a few cobbles, brown, moist, very dense (SP-SM)	COARSE ALLUVIUM	100/0.4		15	SS				M.A.
43½	SILTY SAND, some gravel, a few cobbles, grayish brown, moist, very dense (SM)	TILL	112/0.5		16	SS				
45½±	LIMESTONE, light brownish gray to about 56' then gray to about 61.3' then light gray and gray mottled, weathered above about 47.2'	PLATTEVILLE FORMATION Magnolia Member	97%		(64%)	NQ				10,420 psi
			96%	▼	(85%)	NQ				
		Hidden Falls Member	100%		(76%)	NQ				
60										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 9 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL PL	Qu
60	LIMESTONE (Cont.)									
		Mifflin Member	100%		(81%)	NQ				
			100%		(87%)	NQ				
			100%		(89%)	NQ				
		Pecatonica Member								
76±	SHALE, gray to about 77.7' then gray and greenish gray, shaly sandstone below about 77.7'	GLENWOOD FORMATION	91%		(75%)	NQ				
			56%		(0%)	NQ				
80½±	SANDSTONE, light gray to white and tan	ST. PETER FORMATION	16%		(0%)	NQ				
			0%		(0%)	NQ				
90	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 9 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
90	SANDSTONE (Cont.)									
			0%		(0%)	NQ				
			18%		(0%)	NQ				
100.5	End of Boring									

NOTE: COARSE ALLUVIUM

#1 - black and dark brown, frozen

#2 - brown mottled, medium (CL)

#3 - brown, moist, dense, a few lenses of sand (SM)

#4 - of gravel, light brown, moist, dense (SP-SM)

R = percent core recovery. () indicates RQD.

*Influenced by drilling fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-4	1:45	46.5'	46.3'		to	46'*
1-5	4:15	100.5'	47.0'		to	50'*
1-8	8:50	100.5'	None	99½'	to	51½'
1-12	11:15	100.5'	None		to	52'
1-19	12:00	100.5'	None		to	52'
					to	
					to	
					to	

START 1-3-79 COMPLETE 1-5-79

METHOD 3¼ HSA 0' - 12', @ 4:00

4C 0'-10½', DM 13½'-46.2',

NC 0'-47.0', JW 46.2'-47.2',

NQ wireline-cored 47.2'-100.5'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 10

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 839.9' (129.6')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL PL	Qu
	FILL, mixture of SAND and SILTY SAND, a little gravel and lime-stone, brown and dark grayish brown, frozen to 2'	FILL			1	HSA				
			25/0.3		2	SS				
			5		3	SS				
			4		4	SS				
			26		5	SS				
12	FILL, mostly ASHES, gray and black									
			1/4½'		6	SS				
18	FILL, mixture of CLAYEY SAND and SILTY SAND, a trace of gravel, wood and concrete, dark brown and brown									
			39		7	SS				
22	SANDY CLAY, a little gravel, brown, rather stiff (CL)	TILL								
			31*		8	SS				
29½	SAND, medium grained, a little gravel,									
30										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 10 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
30	SAND (Cont.), light brown, moist, dense to very dense (SP)	COARSE ALLUVIUM	17		9	SS				
			36		10	SS				
37½	SILTY SAND, a little gravel, a few cobbles and boulders, grayish brown, wet, medium dense (SM)	TILL	13		11	SS				
43½	Poor sample recovery. Appears to be mostly GRAVEL and COBBLES		33%			BX				
45.5	End of Boring (See Note)									

R = percent core recovery

*High blow count appears to be due to encounter of pieces of coarse gravel.

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

Note: Boring terminated upon unsuccessful attempt in advancing of BW casing through HSA casing due to deflection of HSA casing by boulders. Then moved 3' west for several attempts and advanced boring by spinning down BW casing with drilling mud. This attempt was obstructed and therefore terminated at depth of 43.6' upon encountering boulders below depth of 41½'

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-10		44'	44'		to	None
1-10	11:50	45.5'	44'		to	**
1-10	4:00	45.5'	None		to	**
					to	

START 1-10-79 COMPLETE 1-11-79

METHOD 3¼ HSA 0' - 44' @ 4:40

BX diamond bit-cored 44.0'-45.5'

BWC 0'-43.6'

CREW CHIEF Hagedorn

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 10-A

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 839.9' (129.6'))	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
	No samples taken.									
34½	SILTY SAND, some gravel and cobbles, a few boulders, brownish gray, moist, dense (SM)	TILL	50/0.3		1	SS				
39	End of Boring (See Note)									

Note: Boring terminated upon unsuccessful attempt in retrieval of drilling equipment broken off by cobbles and boulders. Then moved to boring No. 10-B.

Lost drilling equipment consisted of 3 7/8" tricone bit, adaptor, 2' section of "NW" drill rod and "NW casing.

*No measurement recorded due to presence of drilling fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
1-19	9:30	39'	9½'		to	*
1-19	10:00	39'	None		to	*
					to	

START 1-18-79 COMPLETE 1-19-79

METHOD 6 FA 0' - 9½' @ 9:30

4C 0' - 9½'

DM 9½' - 39'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 10-B

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 839.9' (129.6'))	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	No samples taken. Appears to be numerous cobbles, boulders and gravel below 30' and some cobbles and boulders above 30' based on action of drilling equipment									
40½	SAND, fine grained, a trace of gravel, brown, moist, very dense (SP)	COARSE ALLUVIUM	100/0.45		1	SS				
42½	No sample recovered. Appears to be BOULDERS, COBBLES, GRAVEL and (See#1)	MAY BE SEE NOTE:								
44	SANDY CLAY, a little gravel, some cobbles, gray, very stiff (CL)	TILL	100/0.5		2	SS				
46.0±	LIMESTONE, light brownish gray with a few lenses of brown to about 56' then gray, a thin lense of shale at about 52.4'	PLATTEVILLE FORMATION Magnolia Member	98%	(79%)		NQ				
				▼						
			100%	(96%)		NQ				
			93%	(59%)		NQ				
		Hidden Falls Member	85%	(30%)		NQ				
58.0	End of Boring									

#1 - SAND based on action of drilling equipment.

R - percent core recovery. () indicates RQD.

*Piezometer installed in boring - see attached illustration/data sheet.

NOTE: COARSE ALLUVIUM

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
1-22	11:15	58'	46'		to	52½'
1-22	12:45		*		to	
					to	

START 1-19-79 COMPLETE 1-22-79

METHOD 6 FA 0'-9½', 4C 0'-9½' @ 11:00

DM 9½'-46.5', NWC 0'-46.0'

NQ wireline-cored 46.5'-58.0'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 11

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 837.7' (127.4')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mixture of SILTY SAND, CONCRETE and BOULDERS, brown, frozen	FILL			1	HSA				
1½	SILTY SAND, a little gravel, brown, moist, dense (SM)	TILL	25		2	SS				
7	SILTY SAND, medium to fine grained, some gravel, brown, moist, dense to very dense (SM-SP)		22		3	SS				
			52		4	SS				
12	SILTY SAND, a little gravel, brown, moist, dense (SM)		25		5	SS				
15	SAND, fine to medium grained, a little gravel, a few cobbles, brown, moist, very dense (SP-SM)	COARSE ALLUVIUM	51		6	SS				
19	SILTY SAND, some gravel, a few cobbles and boulders, brown, moist, very dense (SM)	TILL	125		7	SS				
			100/0.0		-	--				
			100/0.9		8	SS				
30										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 11 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
30	SILTY SAND (Cont.)									
			100/0.0		-	--				
			100/0.4		-	--				
44.0±	LIMESTONE, light brownish gray to about 53' then gray, weathered above about 45.2'	PLATTEVILLE FORMATION Magnolia Member	100%	(93½%)		BX				
			100%	(66%)		BX				
		Hidden Falls Member								
55.2	End of Boring									

R = percent core recovery. () indicates RQD.

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

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-4		16'	14½'		to	None
1-5	1:00	55.2'	45.2'		to	*
1-5	1:30	55.2'	None		to	*
					to	

START 1-4-79 COMPLETE 1-5-79

METHOD 3¼ HSA 0' - 18' @ 1:00

DM 14½' - 45.2', BWC 0' - 45.2'

BX diamond bit-cored 45.2'-55.2'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 12

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 836.7' (126.4'))	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
1½	FILL, mostly SILTY SAND, a little gravel, black, frozen	FILL			1	HSA				
4	SILTY SAND, fine grained, brown, moist, loose, lenses of silty clay (SM)	COARSE ALLUVIUM			2	HSA				
8½	SAND, medium grained, a trace of gravel, brown, moist, loose, a few lenses of dark brown silty sand (SP)		6		3	SS				
			6		4	SS				
11½	SILTY SAND, medium grained, with gravel, a few cobbles and boulders, brown, moist, very dense (SM)		50		5	SS				
14	SAND, fine grained, light brown, moist, very dense (SP)		38		6	SS				
30	SILTY SAND, some gravel, a few cobbles and boulders, brown, moist, very dense (SM)	TILL	68		7	SS				
			100/0.0		-	--				
			54		8	SS				

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 12 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL / PL	Qu
30	SAND, fine grained, light brown, moist, dense (SP)	COARSE ALLUVIUM	21		9	SS				
33	SAND, medium grained, with gravel, cobbles and boulders, brown, moist, very dense, a few lenses of silty sand (SP-SM)		54		10	SS				
			100/0.5		-	--				
44.0±	LIMESTONE, gray to about 44.7' then light brownish gray, with a few lenses of brown, a few slightly weathered seams above about 50'	SEE NOTE: Magnolia Member	82%		(51%)	BX				
			100%		(43%)	BX				
			100%		(50%)	BX				
54.1	End of Boring R = percent core recovery. () indicates RQD. *No measurement recorded due to presence of drilling/coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-13		11'	9½'		to	None
1-13	1:30	54.1'	44.1'		to	*
1-13	2:10	54.1'	None		to	*
					to	

START 1-13-79 COMPLETE 1-13-79

METHOD 3¼ HSA 0' - 9½' @ 1:30

DM 9½'-44.1', BWC 0'-44.1',

BX diamond bit-cored 44.1'-54.1'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO 13

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 837.4' (127.1')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	L.L. / P.L.	Qu
	FILL, mixture of SILTY SAND, CONCRETE and BOULDERS, grayish brown and black, frozen to 1½'	FILL			1	HSA				
3½	SAND, fine grained, brown to light brown, moist, medium dense to loose, a lense of silty clay at about 4½', a few lenses of silty sand (SP)	COARSE ALLUVIUM	9		2	SS				
			6		3	SS				
9	SAND, medium to fine grained, brown, moist, loose, a few lenses of silty sand (SP)		8		4	SS				
11	SAND, medium grained, with gravel, cobbles and boulders, brown, moist, very dense (SP)		35/0.5		5	SS				
13½	SAND, fine grained, a trace of gravel, brown, moist, dense, a few lenses of silty sand (SP)		21		-	--				
			17		6	SS				
			16		7	SS				
28	SILTY SAND, some gravel, a few cobbles and boulders, brown, moist, dense (SM)	TILL								
30										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 13 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
30	SILTY SAND (Cont.)		21		8	SS				
33	SAND, fine grained, a little gravel, a few cobbles and boulders, brown, moist, very dense, a few lenses of silty sand (SP)	COARSE ALLUVIUM	100/0.0		-	--				
			47		9	SS				
44.8±	LIMESTONE, gray to about 46' then light brownish gray	SEE NOTE: Magnolia Member	80%		(38%)	BX				
			85%		(35%)	BX				
			92%		(63%)	BX				
			92%		(83%)	BX				
54.8	End of Boring R = percent core recovery. () indicates RQD. *No measurement recorded due to presence of drilling/coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-15		13'	12'		to	None
1-16	1:45	54.8'	44.8'		to	*
1-16	2:25	54.8'	None		to	*
					to	

START 1-15-79 COMPLETE 1-16-79

METHOD 3¼ HSA 0' - 13½' @ 1:45

DM 12'-44.8', BWC 0' - 44.8',

BX diamond bit-cored 44.8'-54.8'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 14

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 842.1' (131.8')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	SILTY SAND, fine grained, dark brown, frozen to 1' then moist (SM) (may be fill)	WEATHERED ALLUVIUM OR FILL			1	FA				
2½	SILTY SAND, fine grained, dark brown to brown, moist, medium dense to dense, a few lenses of silty clay (SM)	COARSE ALLUVIUM	14		2	SS				
					3	SS				
			18		4	SS				
					5	SS				
8	SAND, fine grained, brown, moist, dense to medium dense (SP-SM)		16		6	SS				
			27		7	SS				
			14		8	SS				
			13		9	SS				
18½	SAND, medium grained, a little gravel, a few cobbles, brown, moist, medium dense (SP)		12		10	SS				
			13		-	--				
28	SAND, medium to coarse grained, with gravel, a few cobbles and boulders, brown, moist, very dense (SP-SM)		63		11	SS				
33	SILTY SAND, a little gravel, a few cobbles and boulders, gray to brownish gray, moist, dense to very dense	TILL								
35										

Continued on next page

LOG OF TEST BORING

JOB NO 102-4131 VERTICAL SCALE 1" = 4' BORING NO 14 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.), to medium dense, a few lenses of clayey sand and sand below 44' (SM)		16		12	SS				
			32		13	SS				
			9		14 15 16 17	SS SS SS SS				
48½	No sample recovered. Appears to be LIMESTONE SLABS OR COBBLES, with a weathered or soft zone from 50'-50½' based on action of drilling equipment	TILL OR WEATHERED ROCK	50/0.05		-	--				
51.2±	LIMESTONE, light brownish gray to about 59' then gray, a lense of shale at about 59.3'	PLATTEVILLE FORMATION Magnolia Member	100% (59%)	▼		NQ				
			100%		(79%)	NQ				
		Hidden Falls Member	100%		(52%)	NQ				
62.6	End of Boring R - percent core recovery. () indicates RQD *Piezometer installed in boring-see attached illustration/data sheet									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
1-24	11:15	62.6'	51.0'		to	53½'
1-24	11:45		*		to	
					to	

START 1-22-79 COMPLETE 1-24-79

METHOD 6 FA 0'-7', 4C 0'-9½' @ 11:00

DM 9½'-51', NWC 0'-51.0', JW 51'-51.2'

NQ wireline - cored 51.2'-62.6'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 15

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 845.2' (134.9')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	[illegible]	Qu
	FILL, mixture of SILTY SAND (See#1)	FILL			1	HSA				
1	SAND, fine grained, brown, moist, loose, a few lenses of silt (SP-SM)	COARSE ALLUVIUM	6		2	SS				
4	SAND, fine grained, light brown, moist, loose to medium dense, a few lenses of medium grained sand below about 7' (SP)		8		3	SS				
			11		4	SS				
			12		5	SS				
11½	SAND, medium grained, a trace of gravel, brown, moist, medium dense (SP)		10		6	SS				
15	SAND, medium grained, with gravel, a few cobbles, brown, moist, very dense (SP-SM)		45		7	SS				
18	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense to dense (SM)	TILL	100/0.0		-	--				
			13/0.5		8	SS				
			38		9	SS				
35	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 15 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
35	SILTY SAND (Cont.)		31		10	SS				
			26		-	--				
41	SAND, fine grained, a few cobbles and boulders, light brown, moist, dense (SP)	COARSE ALLUVIUM	21		11	SS				
			100/0.0		-	--				
51.5±	LIMESTONE, gray to about 52½' then light brownish gray, somewhat fractured at about 52'-52½'	SEE NOTE: Magnolia Member	90%		(60%)	BX				
			98%		(88%)	BX				
61.5	End of Boring	NOTE: PLATTEVILLE FORMATION Carimona Member								

#1 - and SANDY CLAY, black and brown, frozen

R = percent core recovery. () indicates RQD.

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

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-11		16'	14½'		to	None
1-11	4:15	61.5'	51.5'		to	*
1-12	10:00	61.5'	None		to	*
					to	

START 1-11-79 COMPLETE 1-11-79

METHOD 3¼ HSA 0' - 14½', @ 4:15

DM 14½' - 51.5', BWC 0' - 51.5'

BX diamond bit-cored 51.5'-61.5'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131   VERTICAL SCALE 1" = 4'   BORING NO 16

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 847.3' (137.0')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL	Qu
	FILL, mixture of SILTY SAND, SAND and CLAYEY SAND, a little gravel, black, dark brown and brown, frozen	FILL			1	FA				
2	SAND, fine grained, brown, frozen to 3½' then moist (SP-SM) (may be fill)	COARSE ALLUVIUM OR MAY BE FILL			2	FA				
4½	SILTY SAND, a little gravel, a few cobbles, brown, moist, dense, some lenses of sand (SM) (may be fill)		17		3	SS				
			28		4	SS				
8	SAND, medium grained, a little gravel, brown, moist, dense (SP)	COARSE ALLUVIUM	26		5	SS				
11	SAND, medium to coarse grained, some gravel, a few cobbles, brown, moist, very dense (SP)		82/0.7		6	SS				
13½	SILTY SAND, some gravel, a few cobbles, brown, moist, very dense, a few lenses of sand (SM)	TILL	75		7	SS				
			100/0.9		8	SS	9	130		M.A.
			100/0.7		9	SS				
			50/0.1		-	--				
35										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 16 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.)		100/0.4		10	SS				
38	SAND, medium grained, some gravel, a few cobbles, brown, moist, very dense (SP)	COARSE ALLUVIUM	100/0.4		11	SS				
44	SAND, medium to coarse grained, some gravel and cobbles, brown, moist, very dense (SP)		100/0.4		12	SS				
49½	SILTY SAND, GRAVEL, COBBLES and BOULDERS, brown, moist, very dense (GM)		100/0.2		-	--				
52.7±	LIMESTONE, gray to about 54' then light brownish gray with a few lenses of brown, a very weathered seam at about 56½', a lense of gray shale at about 62'	SEE NOTE: Magnolia Member	97%		(61%)	NQ				
			100% (95%)	▼		NQ				
			100%		(88%)	NQ				
64.0	End of Boring R = percent core recovery. () indicates RQD *Piezometer installed in boring-see attached illustration data sheet	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
1-13	10:45	64.0'	51.5'		to	58½'
1-13	12:30		*		to	
					to	

START 1-11-79 COMPLETE 1-13-79 @ 10:40

METHOD 6 FA 0'-7, 4C 0'-8', DM 8½'-52', NWC 0'-51.5', NQ wireline-cored 52.0'-64.0'

CREW CHIEF LeMay

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 17

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 840.7' (130.4')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mixture of SILTY SAND, with boulders and concrete, black and brown, frozen to 1½'	FILL			1	HSA				
3½	SILTY SAND, a little gravel, brown, moist, dense (SM)	TILL	20		2	SS				
7½	SAND, fine to medium grained, a little gravel, light brown, moist, dense to medium dense (SP)	COARSE ALLUVIUM	16		3	SS				
			14		4	SS				
10½	SILTY SAND, a little gravel, brown, moist, medium dense to dense, a few lenses of sand (SM)	TILL	27		5	SS				
14½	SILTY SAND, fine grained, a little gravel, brown, moist, dense (SM)	COARSE ALLUVIUM	20		6	SS				
16	SAND, medium grained, some gravel, a few cobbles and boulders, brown, moist, very dense to dense, a few lenses of silty sand (SP-SM)		100/0.0		-	--				
			26		7	SS				
			18		8	SS				
			100/0.0		-	--				
35										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 17 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SAND (Cont.)									
38½	SAND, medium to fine grained, a little gravel, a few cobbles and boulders, brown, moist, very dense (SP-SM)		100/0.6		9	SS				
43	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense (SM)	TILL	100/0.7		10	SS				
46.0±	LIMESTONE, gray to about 47' then light brownish gray with a few lenses of brown	SEE NOTE: Magnolia Member	93%		(53%)	BX				
			100%		(90%)	BX				
			100%		(75%)	BX				
56.1	End of Boring R - percent core recovery. () indicates RQD. *No measurement recorded due to presence of drilling/coring fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-16		16'	14½'		to	None
1-17	3:45	56.1'	46.0'		to	*
1-17	4:05	56.1'	None		to	*
					to	

START 1-16-79 COMPLETE 1-17-79

METHOD 3¼ HSA 0' - 14½' @ 3:45

DM 14½'-46.0', BWC 0'-46.0'

BX diamond bit-cored 46.0'-56.1'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 18

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 839.1' (128.8')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	SILTY SAND, fine grained, brown, frozen to 1' then moist (SM-SP)	COARSE ALLUVIUM			1	HSA				
2	SAND, fine grained, light brown, moist, medium dense (SP)		13		2	SS				
5½	SAND, medium grained, some gravel, a few cobbles and boulders, brown, moist, dense to very dense (SP-SM)		18		3	SS				
			100/0.8		4	SS				
			34/0.5		5	SS				
10	SILTY SAND, some gravel, cobbles and boulders, brown, moist, very dense (SM)	TILL								
			41		6	SS				
			38		7	SS				
			34		8	SS				
25	SILTY SAND, coarse grained, with gravel, some cobbles and boulders, brown, moist, dense (SM-GM)	COARSE ALLUVIUM	30		9	SS				
30										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 18 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
30	SILTY SAND (Cont.)		30		10	SS				
33	No samples recovered. Appears to be SAND, medium grained, a little gravel, brown, moist, dense (SP) based on action of drilling equipment and on evidence of material returned in drilling fluid		17		-	--				
			17		-	--				
44.9±	LIMESTONE, gray to about 46' then light brownish gray, a thin weathered zone at about 48.2'	SEE NOTE: Magnolia Member	94%		(74%)	BX				
			96%		(66%)	BX				
54.9	End of Boring R=percent core recovery. () indicates RQD. *No measurement recorded due to presence of drilling fluid. NOTE: Initial attempt obstructed by boulder at depth of 10'; Then moved 5' east (location as shown) and continued with sampling below this depth.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-9		10'	9½'		to	None
1-10	2:45	54.9'	44.9'		to	*
1-10	3:15	54.9'	None		to	*
					to	

START 1-9-79 COMPLETE 1-10-79

METHOD 3¼ HSA 0' - 9½', @ 2:45

DM 9½'-44.9', BWC 0'-44.9',

BX diamond bit-cored 44.9'-54.9'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 19

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 840.2' (129.9')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mostly SILTY SAND, some sand and gravel, a few cobbles, brown and a little black, frozen to 1'	FILL			1	HSA				
			19		2	SS				
			18		3	SS				
6	SILTY SAND, medium grained, some gravel, a few cobbles, brown, moist, very dense to dense, a few lenses of sand (SM)	COARSE ALLUVIUM	31		4	SS				
			20		5	SS				
12	SAND, medium grained, some gravel, a few cobbles and boulders, dark brown to brown, moist, very dense (SP)		53		6	SS				
			32		7	SS				
19	SILTY SAND, a little gravel, a few cobbles, brown to grayish brown, moist, very dense, a few lenses of sand above 22' (SM)	TILL	58		8	SS				
			78		9	SS				
			59/0.5		10	SS				
			33/0.5		11	SS				
35										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 | VERTICAL SCALE 1" = 4' | BORING NO. 19 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.)									
			85/0.5		-	--				
			57		12	SS				
46.0	LIMESTONE, gray to about 47' then light brownish gray	SEE NOTE:								
		Magnolia Member	90%		(67%)	BX				
			98%		(85%)	BX				
56.1	End of Boring									
	R = percent core recovery. () indicates RQD.	NOTE: PLATTEVILLE FORMATION								
	**No measurement recorded due to presence of drilling/coring fluid.	Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-8		21'	19½'		to	None
1-8	2:35	56.1'	46.0'		to	*
1-9	10:25	56.1'	None		to	*
					to	

START 1-8-79 COMPLETE 1-9-79

METHOD 3¼ HSA 0' - 19½', @ 9:45

DM 19½'-46.1', BWC 0'-46.0'

BX diamond bit-cored 46.1'-56.1'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 20

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 838.4' (128.1')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	L.L./P.L.	Qu
	FILL, mostly SILTY SAND, black (See# 1)	FILL			1	HSA				
1	SAND, fine grained, light brown, moist, medium dense (SP)	COARSE ALLUVIUM	11		2	SS				
			10		3	SS				
					4	*				M.A.
			12		5	SS				
9	SAND, medium grained, a trace of gravel, light brown, moist, medium dense to loose (SP)		15		6	SS				
					7	*				
			6		8	SS				M.A.
					9	*				
			6		10	SS				
16	SANDY CLAY, some gravel, a few cobbles, brown and gray mottled, stiff, some lenses of silty sand (CL)	TILL	23		11	SS	13		24/12	2800
22	SAND, fine grained, a trace of gravel, light brown, moist, dense (SP)	COARSE ALLUVIUM			12	*				
			17		13	SS				
27	SILTY SAND, a little gravel, grayish brown to gray, moist to wet, dense to very dense to loose to very dense, a lense of brown sand at about 40½' (SM)	TILL	18		14	SS				
35	Continued on next page									

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 20 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.)		59		-	--				
			7		15	SS	13	123		M.A.
			100/0.0		-	--				
45.8	LIMESTONE, gray to about 46½' then light brownish gray	SEE NOTE Magnolia Member	90%		(71%)	BX				
			100%		(96%)	BX				
			92%		(53%)	BX				
56.0	End of Boring	NOTE: PLATTEVILLE FORMATION Carimona Member								

#1 *- and brown, frozen

*Collective bag sample

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

R = percent core recovery. () indicates RQD.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-5		21'	19½'		to	None
1-8	9:25	56.0'	46.0'		to	**
1-8	10:10	56.0'	None		to	**
					to	

START 1-5-79 COMPLETE 1-8-79

METHOD 3¼ HSA 0' - 19½', @ 9:25

DM 19½'-46.0', BWC 0'-46.0'

BX diamond bit-cored 46.0'-56.0'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 21

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D		Qu
	FILL, mostly SILTY SAND, black, frozen, a concrete sidewalk at the surface				1	HSA				
2	SILTY SAND, fine grained, dark brown, frozen to 4' then moist (SM) (may be fill)				2	HSA				
5	CLAYEY SAND, dark brown to (See#1)		9		3	SS				
6	SAND, fine grained, light brown, moist, medium dense, a few lenses of silty sand (SP)		13		4	SS				
			8		5	SS				
10½	SAND, medium grained, a little gravel, brown, moist, loose to very dense (SP-SM)		25/0.6		6	SS				
13	SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist, very dense (SM)		25		7	SS				
			82		8	SS				
30										

Continued on next page

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 21 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
			94		9	SS				
30	SILTY SAND (Cont.)		112		10	SS				
38	SAND, medium grained, a little gravel, a few cobbles, brown, moist, very dense (SP-SM)		43/0.5		11	SS				
41½	No sample recovered. Appears to be SILTY SAND, a little gravel, a few cobbles and boulders, brown, moist (SM) based on action of (See#2)									
44.5	LIMESTONE, gray to about 45.6' then light brownish gray with a few lenses of brown, weathered lenses at about 54', quite badly fractured above about 47½'	SEE NOTE: Magnolia Member	100%		(19%)	BX				
			91%		(74%)	BX				
			100%		(79%)	BX				
			89%		(44%)	BX				
55.0	End of Boring R=percent core recovery. () indicates RQD. #1 - brown, rather stiff (SC) (may be fill) #2 - drilling equipment and on evidence of material returned in drilling fluid.	NOTE: PLATTEVILLE FORMATION Carimona Member								

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
2-1	2:30	55.0'	9½'		to	*
2-1	9:30	55.0'	None		to	*
					to	

START 2-1-79 COMPLETE 2-1-79

METHOD 3¼ HSA 0' - 9½' @ 4:00

DM 9½' - 45.3'

BX diamond bit-cored 45.3'-55.0'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-4131 VERTICAL SCALE 1" = 4' BORING NO 22

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION ____)	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mostly SILTY SAND, a little gravel, black, frozen, a concrete sidewalk at the surface				1	HSA				
2	SILTY SAND, fine grained, brown, moist, loose to dense (SM-SP)		7		2	SS				
			16		3	SS				
9	SAND, fine grained, brown, moist, medium dense, a few lenses of silty sand (SP)		9		4	SS				
11½	SAND, medium grained, a little gravel, brown, moist, very loose, a few lenses of silty sand (SP)		4		5	SS				
14	SAND, medium grained, some gravel, brown, moist, medium dense (SP)		11		6	SS				
20	SAND, fine grained, light brown, moist, dense (SM)		21		7	SS				
22½	SILTY SAND, a little gravel, a few cobbles, brown, moist, very dense, a few lenses of sand (SM)		86		8	SS				
			23/0.5		-	--				
			100/0.4		9	SS				
35										

Continued on next page

LOG OF TEST BORING

JOB NO. 120-4131 VERTICAL SCALE 1" = 4' BORING NO. 22 Cont.

PROJECT PROPOSED SPORTS STADIUM - MINNEAPOLIS, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	SILTY SAND (Cont.)		32		10	SS				
42½	SANDY CLAY, a little gravel, gray, stiff (CL)		26		11	SS				
46.2	LIMESTONE, gray to about 47' then light brownish gray with a few lenses of brown, very thin weathered lenses at about 49.3' and at about 55'	SEE NOTE: Magnolia Member	98%		(66%)	BX				
			100%		(76%)	BX				
56.3	End of Boring	NOTE: PLATTEVILLE FORMATION Carimona Member								

R - percent core recovery. () indicates RQD.

*No measurement recorded due to presence of drilling fluid.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
1-31	3:30	56.3'	14½'		to	*
2-1	9:50	56.3'	None		to	*
					to	

START 1-31-79 COMPLETE 2-1-79

METHOD 3¼ HSA 0' - 14½' @ 9:15

DM 14½' - 46.3'

BX diamond bit-cored 46.3'-56.3'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 1-78

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 842.1' (131.8')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mixture of SILTY SAND, GRAVEL and CONCRETE, brown, frozen to 2½', (may be old concrete floor at about 4½'-5½')	FILL			1	HSA				
5½	SAND, fine grained, light brown, moist, dense, a few lenses of silt (SP)	COARSE ALLUVIUM	26		2	SS				
9½	SILTY SAND, a trace of gravel, brown, moist, dense, a few lenses of sand (SM)	TILL	19		3	SS				
			18		4	SS				
			26		5	SS				
16	SAND, medium grained, some gravel, a few cobbles, brown, moist, very dense (SP)	COARSE ALLUVIUM	31		6	SS				
23	SILTY SAND, some gravel and cobbles, brown, moist, very dense (SP)	TILL	79		-	--				
			100/0.7		7	SS				
35										

Continued on next page

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 1-78 Cont.

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL PL	Qu
35			100/0.8		8	SS				
			100/0.6		9	SS				
			100/0.0		-	--				
49.3	LIMESTONE, gray, fossiliferous	PLATTEVILLE FORMATION Magnolia Member	90%			BX				
			100%			BX				
54.5	End of Boring									

R = percent core recovery

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

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-20		16'	14½'	16'	to	None
1-21	10:00	54.5'	49.3'		to	*
1-21	10:20	54.5'	None		to	*
					to	

START 1-20-78 COMPLETE 1-21-78

METHOD 3¼ HSA 0' - 24½' @ 10:00

DM 14½'-49', BWC 0' - 49.3'

BX diamondbit - cored 49.3'-54.5'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 2-78 & 2A

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 839.9' (129.6')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL	QU
	SAND, medium to fine grained, a trace of gravel, light brown, moist, dense (SP)	COARSE ALLUVIUM			1	HSA				
			18		2	SS				
			24		3	SS				
			50/0.1		-	--				
9½	SILTY SAND, some gravel and cobbles, brown, moist, very dense, a few lenses of sand and sandy clay (SM)	TILL								
			34		4	SS				
			37		5	SS				
			60		6	SS				
24	SAND, medium to coarse grained, some gravel, a few cobbles, brown, moist, very dense (SP-SM)	COARSE ALLUVIUM	135		7	SS				
28	SILTY SAND, a little gravel, a few cobbles, brown, moist, very dense (SM)	TILL	100/0.3		8	SS				
			100/0.6		9	SS				
35	Continued on next page									

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 2-78 & 2A Cont.

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N / R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35										
			108		10	SS				
43½	LEAN CLAY, a little gravel, a few limestone slabs, gray, stiff (CL)		82		11	SS				
47.2	LIMESTONE, gray, fossiliferous	PLATTEVILLE FORMATION Magnolia Member	100%			BX				
			81%			BX				
53.0	End of Boring									

R = percent core recovery

*Appears to be coring fluid.

Note: Boring #2 terminated at depth of 28' due to obstruction. Then moved to Boring #2A and continued with sampling and coring.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-23		26'	24½'	26'	to	None
1-24	10:00	53.0'	48.0'		to	38½'*
1-24	10:50	53.0'	None	13'	to	None
					to	

START 1-23-78 COMPLETE 1-24-78

METHOD 3¼ HSA 0' - 24½' @ 10:00

DM 24½'-47.2', BWC 0'-48.0'

BX diamond bit-cored 48.0'-53.0'

CREW CHIEF Kulhanek

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 3-78

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 837.4' (127.1')	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 gravel and brick, black and brown, frozen to 2'	FILL			1	HSA				
					2	HSA				
4	FILL, mostly CONCRETE and BRICK, brown and grayish brown		4		3	SS				
			12		4	SS				
9½	SAND, medium grained, a trace of gravel, light brown, moist, loose (SP)	COARSE ALLUVIUM	6		5	SS				
12½	SAND, fine grained, light brown, moist, medium dense (SP)		11		6	SS				
14½	SAND, medium grained, with boulders, brown, moist, dense (SP)		14*/0.5		7	SS				
16	SILTY SAND, a little gravel, a few cobbles, brown, moist, dense to very dense, a few lenses of clayey sand and sand above 25' (SM)	TILL	19		8	SS				
			16		9	SS				
			100/0.0		-	--				
35	Continued on next page									

LOG OF TEST BORING

JOB NO. 120-2642   VERTICAL SCALE 1" = 4'   BORING NO. 3-78 Cont.

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL PL	Qu
35			64		10	SS				
			100/0.0		-	--				
39½	GRAVEL, COBBLES AND BOULDERS		100%			BX				
44.2±	LIMESTONE SLABS or CARIMONA MEMBER of PLATTEVILLE FORMATION, gray	LIMESTONE OR COLLUVIUM	69%			BX				
			43%			BX				
46½	LIMESTONE, light brownish gray and a little brown, fossiliferous	PLATTEVILLE FORMATION Magnolia Member	90%			BX				
51.5	End of Boring									

R = percent core recovery

*Blow count recorded for initial 6" set then obstructed by boulder.

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

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-19	9:15	29½'	29½'	29½'	to	None
1-19	2:45	51.5'	46.5'		to	**
1-19	3:25	51.5'	None		to	**
					to	

START 1-18-78   COMPLETE 1-19-78 @ 2:45

METHOD 3¼ HSA 0' - 29½'

DM 29½'-46½', BWC 0' - 46.5'

BX diamond bit-cored 42.3'-46.2' and 46.5'-51.5'

CREW CHIEF Holan

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 4-78, 4A & 4B

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 835.4' (125.1')	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D		Qu
	FILL, mostly SILTY SAND, a little gravel, brown, frozen	FILL			1	HSA				
4	FILL, mostly CONCRETE, grayish brown		81		2	SS				
			50/0.2		-	--				
			50/0.05		-	--				
			50/0.1		3	SS				
			75/0.0		-	--				
15	SILTY SAND, a little gravel, brown, moist, very dense (SM)	TILL								
			121		4	SS				
			100/0.6		5	SS				
					6	SS				
30½	SAND, medium grained, a little gravel, brown, moist, very (See#1)	COARSE ALLUVIUM	65		7	SS				
32	SILTY SAND, medium grained, with gravel, brown, moist, very dense (SM)									
35			75/0.5		8	SS				

Continued on next page

LOG OF TEST BORING

BORING NO 4-78, 4A & 4B Cont.

JOB NO 120-2642 VERTICAL SCALE 1" = 4'

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	LL / PL	Qu
35										
38	LEAN CLAY, some gravel, cobbles and slabs of limestone, gray, very stiff (CL)	TILL	100/0.2		9	SS				
			100/0.1		-	--				
48±	LIMESTONE, gray, with some light gray from about 51' to 52', a few laminations of shale from about 51' to 52', weathered above about 49', fossiliferous above 51.5'	PLATTEVILLE FORMATION	*			BX				
			100/0.0		10	SS				
		Hidden Falls Member	93%			BX				
53.9	End of Boring		*83%							

R = percent core recovery

#1 - dense (SP-SM)

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

Note: Boring #4 terminated at depth of 12' due to obstruction. Then moved to Boring #4A and continued with sampling to depth of 49½' where obstruction was encountered. Then proceeded to spin B casing down boring. When down to depth of about 44', bottom 5' section of B casing (including casing bit) broke off. Being unable to retrieve the 5' section of casing, the boring was terminated. Then moved to Boring #4B and continued with coring below depth of 48.9' upon advancing to this depth with combination of 3¼" hollow stem auger, drilling mud and B casing.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-19		25.6'	24½'	25.6'	to	None
1-21	1:25	53.9'	48.9'		to	*
1-21	2:00	53.9'	None		to	*
					to	

START 1-19-78 COMPLETE 1-21-78

METHOD 3¼ HSA 0' - 24½' @ 1:25

DM 24½'-48.9', BWC 0'-48.9',

BX diamond bit-cored 48.9'-53.9'

CREW CHIEF Kulhanek

LOG OF TEST BORING

JOB NO 120-2642 VERTICAL SCALE 1" = 4' BORING NO 5-78

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION 833.7' (123.4')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LABORATORY TESTS W	D	—	Qu
2	FILL, mostly SILTY SAND, a little gravel, black and brown	FILL			1	HSA				
4	SAND, medium grained, a little gravel, brown, moist (SP-SM)	COARSE ALLUVIUM			2	HSA				
	SILTY SAND, a little gravel, a few cobbles, brown, moist, medium dense to dense (SM)	TILL	13		3	SS				
			24		4	SS				
			28		5	SS				
			31		6	SS				
			20		7	SS				
24½			18		8	SS				
	SAND, medium to coarse grained, some gravel, a few cobbles and slabs of limestone, brown, moist, loose to very dense (SP)	COARSE ALLUVIUM	7		-	--				
35			32		9	SS				

Continued on next page

LOG OF TEST BORING

JOB NO. 120-2642 VERTICAL SCALE 1" = 4' BORING NO. 5-78 Cont.

PROJECT PROPOSED STADIUM SITE - MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or R	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35			109		10	SS				
			0%			BX				
			100/0.9		11	SS				
			42%			BX				
41.8		SEE NOTE:	100%			BX				
	LIMESTONE, gray to about 42.2' then light brownish gray, fossiliferous below 42.2'	Magnolia Member	94%			BX				
			100%			BX				
			100%			BX				
46.8	End of Boring									

R = percent core recovery

*No measurement recorded due to presence of coring fluid.

**Note: Unable to retrieve 25' of 3¼" I.D. Hollow Stem Auger and auger bit broken off in boring.

NOTE: PLATTEVILLE FORMATION

Carimona Member

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
1-16	3:15	26'	24½'	26'	to	None
1-16	4:00	36'	34½'	35'	to	None
1-18	10:30	46.8'	41.8'		to	*
1-19	9:00	46.8'	**		to	*

START 1-16-78 COMPLETE 1-18-78

METHOD 3¼ HSA 0' - 41.8' @ 10:30

BX diamond bit-cored 36.4'-37.9', 39.6'-41.5' and 41.8'-46.8'

CREW CHIEF Kulhanek

BRAUN℠
INTERTEC

LOG OF BORING

Braun Project BL-08-05061 **GROUNDWATER EVALUATION** **Metrodome** **4th Street South and 11th Ave. South** **Minneapolis, Minnesota**	BORING: **ST-1** LOCATION: See attached sketch.

DRILLER: J. Chermak	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/18/08**	SCALE: **1" = 4'**

Elev. feet 839.7	Depth feet 0.0	ASTM Symbol	Description of Materials (ASTM D2488 or D2487)	BPF	WL	Tests or Notes
838.4	1.3	PAV	5 1/2 inches of bituminous over 10 inches of aggregate base.			Benchmark: Elevations were obtained using GPS and the State of Minnesota's permanent base station network.
819.7	20.0	FILL	FILL: Silty Sand, fine- to medium-grained, with a trace of Gravel and concrete, black, brown and dark brown, moist.	17		
815.5	24.2	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel and Cobbles, light brown, dry, medium dense to very dense. (Glacial Outwash)	12 50/2"		
			END OF BORING. Auger met refusal at 24-foot depth. Water not observed while drilling. Boring immediately backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING 05061.GPJ BRAUN_08.GDT 12/2/08 07:43

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-08-05061 **GROUNDWATER EVALUATION** **Metrodome** **4th Street South and 11th Ave. South** **Minneapolis, Minnesota**	BORING: **ST-2** LOCATION: See attached sketch.

DRILLER: J. Chermak	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/18/08	SCALE: 1" = 4'

Elev. feet 842.6	Depth feet 0.0	ASTM Symbol	Description of Materials (ASTM D2488 or D2487)	BPF	WL	Tests or Notes
841.3	1.3	PAV	5 inches of bituminous over 10 inches of aggregate base.			
838.6	4.0	FILL	FILL: Silty Sand, fine- to medium-grained, dark brown and black, moist.			
836.6	6.0	FILL	FILL: Poorly Graded Sand, fine- to medium-grained, brown, moist.			
823.6	19.0	FILL	FILL: Silty Sand, fine- to medium-grained, with Gravel and brick, black, brown and dark brown, moist.	14		
817.6	25.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, brown, moist, dense. (Glacial Till)	52		
		SP	POORLY GRADED SAND, fine- to medium-grained, light brown, dry, medium dense. (Glacial Outwash)	27		

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING 05061.GPJ BRAUN_08.GDT 12/2/08 07:43

BRAUN℠
INTERTEC

LOG OF BORING

Braun Project BL-08-05061 **GROUNDWATER EVALUATION** **Metrodome** **4th Street South and 11th Ave. South** **Minneapolis, Minnesota**	BORING: **ST-2 (cont.)** LOCATION: See attached sketch.
DRILLER: J. Chermak — METHOD: 3 1/4" HSA, Autohammer	DATE: **11/18/08** — SCALE: **1" = 4'**

Elev. feet 810.6	Depth feet 32.0	ASTM Symbol	Description of Materials (ASTM D2488 or D2487)	BPF	WL	Tests or Notes
			POORLY GRADED SAND, fine- to medium-grained, light brown, dry, medium dense. (Glacial Outwash) *(continued)*			
805.6	37.0	SM	SILTY SAND, fine- to coarse-grained, with Gravel and Cobbles, brown, moist to waterbearing, very dense. (Glacial Till)	50/2" 80/2" 44 55/3"	▽	An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling. Groundwater levels fluctuate.
793.6	49.0	LS	WEATHERED LIMESTONE, gray.	50/3"		
792.3	50.3		END OF BORING. Auger met refusal at 43-foot depth. Rotary drilling used below 43-foot depth. Temporary piezometer installed on 11/19/08 but damaged by outside source. Temporary piezometer re-installed on 11/26/08. Water observed at 46.3 feet 2 days after installation of piezometer. Boring then backfilled and piezometer removed.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING 05061.GPJ BRAUN_08.GDT 12/2/08 07:43

BRAUN℠
INTERTEC

LOG OF BORING

Braun Project BL-08-05061 GROUNDWATER EVALUATION Metrodome 4th Street South and 11th Ave. South Minneapolis, Minnesota		BORING: ST-3 LOCATION: See attached sketch.	
DRILLER: J. Chermak	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/18/08	SCALE: 1" = 4'

Elev. feet 842.9	Depth feet 0.0	ASTM Symbol	Description of Materials (ASTM D2488 or D2487)	BPF	WL	Tests or Notes
841.7	1.2	PAV	5 inches of bituminous over 9 inches of aggregate base.			
832.8	10.1	FILL	FILL: Silty Sand, fine- to medium-grained, with Gravel, brown, dark brown and black, moist. With concrete from 8 to 10 feet.	50/1"		
			END OF BORING. Auger met refusal at 10-foot depth. Water not observed while drilling. Boring immediately backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING 05061.GPJ BRAUN_08.GDT 12/2/08 07:43

BRAUN[SM]
INTERTEC

LOG OF BORING

Braun Project BL-08-05061 **GROUNDWATER EVALUATION** **Metrodome** **4th Street South and 11th Ave. South** **Minneapolis, Minnesota**	BORING: **ST-4** LOCATION: See attached sketch.
DRILLER: J. Chermak — METHOD: 3 1/4" HSA, Autohammer	DATE: **11/18/08** — SCALE: **1" = 4'**

Elev. feet 842.8	Depth feet 0.0	ASTM Symbol	Description of Materials (ASTM D2488 or D2487)	BPF	WL	Tests or Notes
841.6	1.2	PAV	5 inches of bituminous over 9 inches of aggregate base.			
838.8	4.0	FILL	FILL: Silty Sand, fine- to medium-grained, with a trace of Gravel, brown, moist.			
837.8	5.0	FILL	FILL: Sandy Lean Clay, with a trace of Gravel, black, wet.			
834.8	8.0	FILL	FILL: Silty Sand, fine- to medium-grained, dark brown, moist.			
823.8	19.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, brown, moist, very dense. (Glacial Till)	78		
		SP	POORLY GRADED SAND, fine- to medium-grained, light brown, dry, medium dense. (Glacial Outwash)	19 32		

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING 05061.GPJ BRAUN_08.GDT 12/2/08 07:43

BRAUN INTERTEC

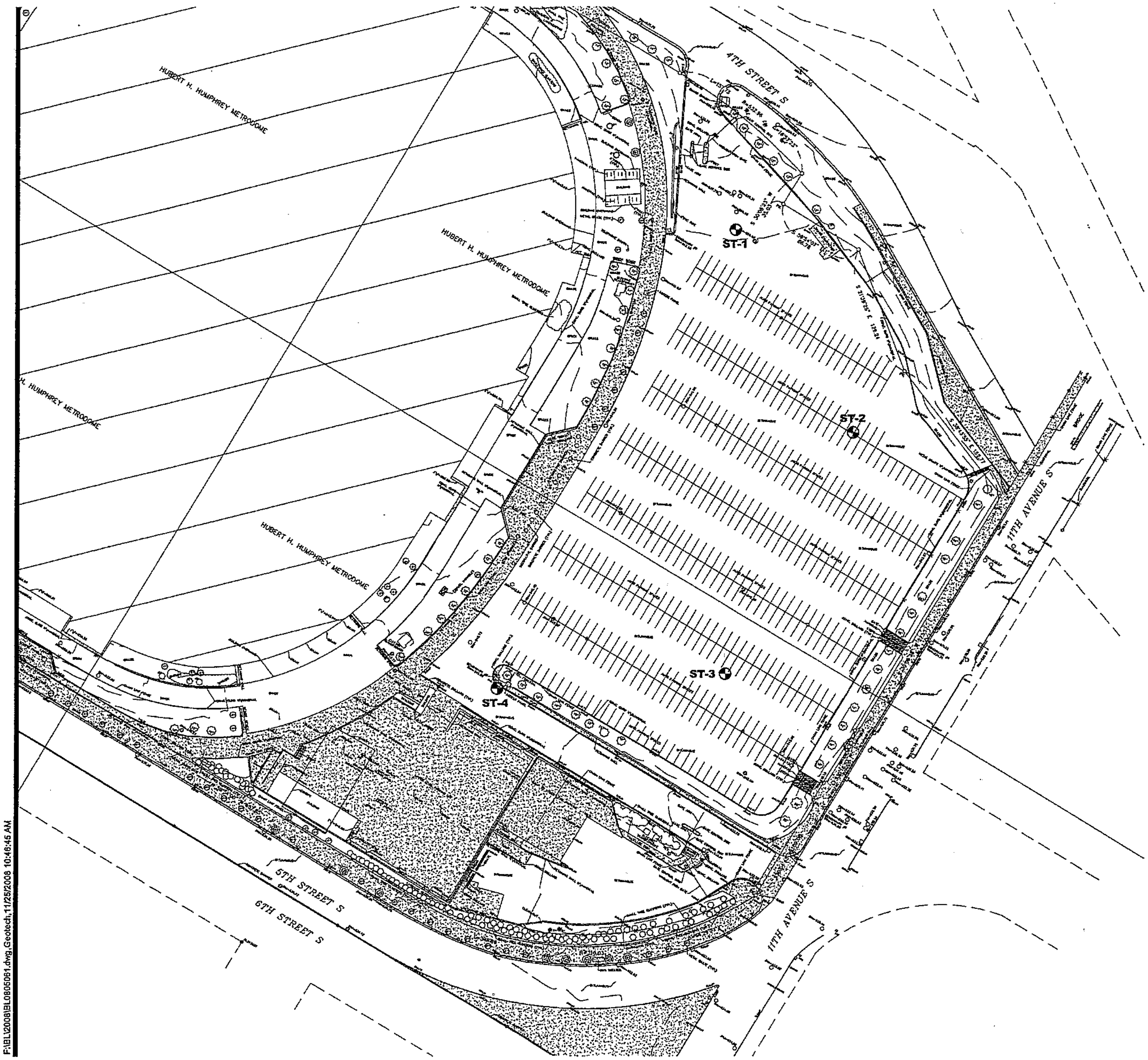
LOG OF BORING

Braun Project BL-08-05061 GROUNDWATER EVALUATION Metrodome 4th Street South and 11th Ave. South Minneapolis, Minnesota	BORING: ST-4 (cont.) LOCATION: See attached sketch.
DRILLER: J. Chermak / METHOD: 3 1/4" HSA, Autohammer	DATE: 11/18/08 / SCALE: 1" = 4'

Elev. feet 810.8	Depth feet 32.0	ASTM Symbol	Description of Materials (ASTM D2488 or D2487)	BPF	WL	Tests or Notes
			POORLY GRADED SAND, fine- to medium-grained, light brown, dry, medium dense. (Glacial Outwash) *(continued)*			
805.8	37.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, Cobbles and Boulders, brown, moist to waterbearing, very dense. (Glacial Till)	40/2" 50/3"	∇	
798.8	44.0	SM	SILTY SAND, fine- to coarse-grained, with Gravel, brown, waterbearing, very dense. (Glacial Till)	100/6"		
794.8	48.0	LS	WEATHERED LIMESTONE, gray.			
792.8	50.0		END OF BORING. Auger met refusal at 43-foot depth. Rotary drilling used below 43-foot depth. Temporary piezometer installed on 11/20/08. Water observed at 42.6 feet 8 days after installation of piezometer. Boring then backfilled and piezometer removed.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING 05061.GPJ BRAUN_08.GDT 12/2/08 07:43



DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING

50' 0 100'

SCALE: 1"= 100'

BRAUN INTERTEC
11001 Hampshire Avenue So.
Minneapolis, MN 55438
PH. (952) 995-2000
FAX (952) 995-2020

Base Dwg Provided By:
METROPOLITAN SPORTS FACILITIES COMMISSION

SOIL BORING LOCATION SKETCH
GEOTECHNICAL EVALUATION
METRODOME GROUNDWATER EVALUATION
4TH STREET SOUTH AND 11TH AVENUE SOUTH
MINNEAPOLIS, MINNESOTA

Project No:	BL0805061
Drawing No:	BL0805061
Scale:	1"= 100'
Drawn By:	JAG
Date Drawn:	11/13/08
Checked By:	NLM
Last Modified:	11/25/08
Sheet: of	Fig:

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Appendix C

Geotechnical Report Limitations and Guidelines for Use

Appendix C
Geotechnical Report Limitations and Guidelines for Use
Report No. 01-05723.2

B.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by ASFE[1], of which, we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. And no one, not even you, should apply the report for any purpose or project except the one originally contemplated.

B.2.2 Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

B.2.3 A Geotechnical Engineering Report is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typically factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes, even minor ones, and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

B.2.4 Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical engineering report whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

1 ASFE, 8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 : www.asfe.org

B.2.5 Most Geotechnical Findings Are Professional Opinions
Site exploration identified subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

B.2.6 A Report's Recommendations Are Not Final
Do not overrely on the construction recommendations included in your report. Those recommendations are not final, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.

B.2.7 A Geotechnical Engineering Report Is Subject to Misinterpretation
Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

B.2.8 Do Not Redraw the Engineer's Logs
Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

B.2.9 Give Contractors a Complete Report and Guidance
Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In the letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need to prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

B.2.10 Read Responsibility Provisions Closely
Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their report. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

B.2.11 Geoenvironmental Concerns Are Not Covered
The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated environmental problems have led to numerous project failures. If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. Do not rely on an environmental report prepared for someone else.

AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
- ENVIRONMENTAL
- GEOTECHNICAL
- MATERIALS
- FORENSICS

REPORT OF PRELIMINARY GEOTECHNICAL EXPLORATION AND REVIEW

Minnesota Multi-Purpose Stadium

900 South 5th Street
Minneapolis, Minnesota

Report No. 01-05723.2

Date:

October 2, 2013
(Supersedes Report of May 3, 2013)

Prepared for:

Minnesota Sports Facilities Authority
900 South 5th Street
Minneapolis, MN 55415

www.amengtest.com

AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
- ENVIRONMENTAL
- GEOTECHNICAL
- MATERIALS
- FORENSICS

October 2, 2013

Minnesota Sports Facilities Authority
900 South 5th Street
Minneapolis, MN 55415

Attn: Steve Maki, PE

RE: Preliminary Geotechnical Exploration and Review
Minnesota Multi-Purpose Stadium
Minneapolis, Minnesota
Report No. 01-05723.2

Dear Mr. Maki:

American Engineering Testing, Inc. (AET) is pleased to present this update to the past subsurface exploration programs and associated geotechnical engineering review conducted for the new Minnesota Multi-Purpose Stadium to be constructed at the existing Metrodome site in Minneapolis, Minnesota. The work is being completed per our proposal dated February 5, 2013 and our subsequent service agreement.

In addition to the electronic copy, we are submitting two hard copies of the report to you. Additional copies are being sent on your behalf, as shown below.

Sincerely,
American Engineering Testing, Inc.

Jeffery K. Voyen, PE
Vice President/Principal Engineer
Phone: (651) 659-1305
Cell: (612) 961-9186
jvoyen@amengtest.com

Cc: (2) HKS, Attn: Kevin Taylor, AIA
(2) Thornton Tomasetti, Attn: Robert Treece, PE
(1) EVS, Inc., Attn: Richard Koppy, PE

SIGNATURE PAGE

Prepared for:

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Jeffery K. Voyen, PE
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Reviewed By:

Gregory R. Reuter, PE, PG, D.GE
Principal Engineer

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under Minnesota Statute Section 326.02 to 326.15

Name: Jeffery K. Voyen

Date: 10/2/13 **License #: 15928**

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1.0 INTRODUCTION

A new Multi-Purpose Stadium is planned to be constructed at the existing Metrodome site in Minneapolis, Minnesota. To assist planning and design of the project, you have authorized American Engineering Testing, Inc. (AET) to conduct several phases of subsurface exploration/testing at the site, to conduct soil/rock laboratory testing, and to perform a geotechnical engineering review for the project. This report presents the results of the geotechnical exploration, testing, and review services conducted to date, and it provides our associated engineering recommendations.

2.0 SCOPE OF SERVICES

The service scope was presented in the "Geotechnical Investigation Scope of Work" prepared by Thornton Tomasetti, dated January 16, 2013, and acknowledged by our February 5, 2013 proposal. Authorization to proceed with the stadium component of the services was formally received through the Project Services Agreement, dated February 11, 2013. The scope performed to date consists of the following:

- Drill and sample sixteen standard penetration test (SPT) borings to the bedrock, followed by rock coring into the underlying limestone bedrock.
- Perform geotechnical laboratory testing to evaluate soil and rock properties (water content, sieve analysis, rock core compressive strength, and rock core triaxial compression testing).
- Conduct geotechnical engineering analysis based on the gained data, and prepare geotechnical engineering reports (past reports have been submitted on February 25, 2013 and May 3, 2013).
- Provide this updated report, which includes additional geotechnical opinions and recommendations generated as the project design has developed.

These services were intended for geotechnical purposes. The scope was not intended to explore for the presence or extent of environmental contamination. During drilling, we did detect contamination at Boring A8 by means of smell. Notes regarding this odor detection appear on the boring logs.

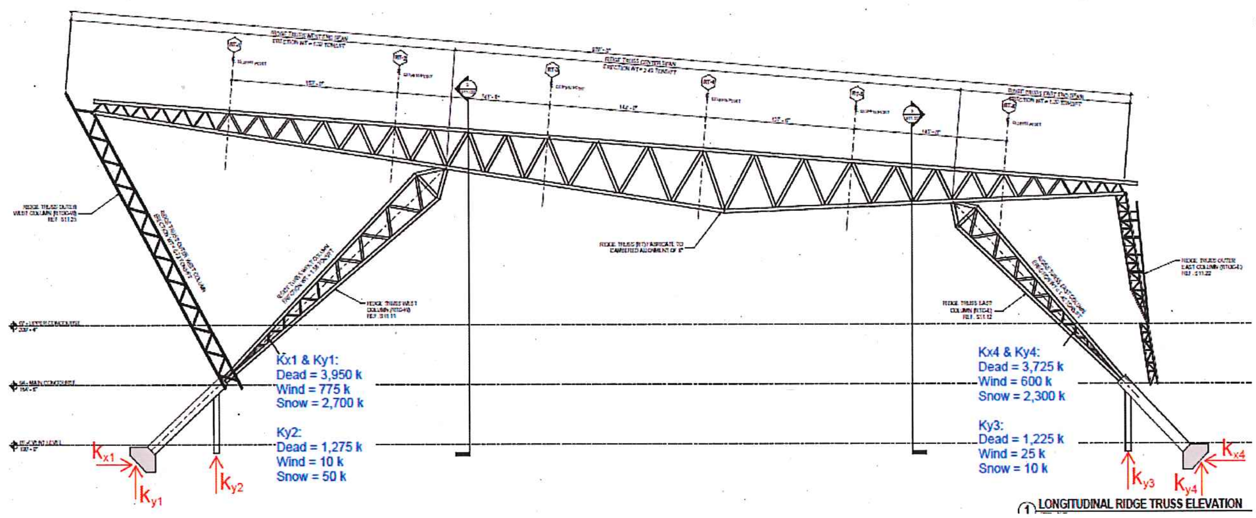
Also available for this review are the boring logs and tests from the pre-construction geotechnical report for the original Metrodome construction (conducted in 1978 and 1979) and from borings/temporary piezometers conducted by Braun Intertec in 2008. The logs from those reports have been included with this report in Appendix B.

3.0 PROJECT INFORMATION

The site is located on and adjacent to the existing Metrodome site in downtown Minneapolis, as shown on Figure 1. The new stadium will have an approximate footprint of 750 feet by 950 feet, located over the existing Metrodome footprint and in the current parking lot area to the east/southeast. Most of the new structure will be founded below the Event Level elevation of 797'-4½". This is slightly above the current Metrodome event level elevation of 795'-11", although much of the new Event Level will be cut into current grades outside of the Metrodome event level footprint. This new level will be roughly 35 feet to 50 feet below surrounding street grades, requiring a permanent retention system around the seating bowl area and temporary retention systems for service tunnel/below grade loading dock areas.

The structural frame will consist of a cast-in-place concrete seating bowl frame and a steel roof structure, with lateral loads resisted by concrete and/or structural steel framing. The roof will have significant bearing on a longitudinal ridge truss system, supported on each end by a buttress foundation and buttress column. Anticipated loads are as shown of Figure 3.0.

Figure 3.0 – Anticipated Buttress Foundation Loads



Other than the roof truss system, we understand service level (allowable) loads are on the order of 3000 kips per column (Grid C) to 9500 kips per column at Grid F (at roof support), with the self-weight of the structure being about 60% of the total load. Lateral loads are anticipated to reach a maximum of 175 kips (not accounting for the soil load component).

We understand acceptable column/wall settlement to be ½ inch or less and acceptable stadium floor settlement of less than ¾ inch. We understand buttress deformation should be maintained within 3/8 inch. We are assuming a minimum factor of safety of 3.0 with respect to localized shear or base failure of the foundation (whether spread footing or end bearing on a drilled pier).

New pavements are planned to be constructed, likely in the form of access drives. We assume access drives will need to accommodate heavier truck traffic. We are also providing pavement designs for light-duty traffic if "auto-only" parking areas will be constructed.

The stated information represents our current understanding of the proposed construction. This information is an integral part of our engineering review. It is important that you contact us if there are changes from that described so that we can evaluate whether modifications to our recommendations are appropriate.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted to date has consisted of sixteen standard penetration test borings drilled to bedrock, followed by rock coring. The boring/core logs appear in Appendix A. The logs contain information concerning soil/rock layering, classification and material description, geologic description, and moisture condition. Relative density or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

The boring locations appear graphically on Figure 1. The test locations were measured by AET using GPS (submeter accuracy, but not surveyor accuracy). The Hennepin County coordinates are shown on the boring logs. The boring surface elevations were measured by AET using an engineer's level and rod. The benchmarks used were the top rim of manholes which appear on the provided survey plans.

4.2 Laboratory Testing

During laboratory classification logging, water content tests were conducted on cohesive/organic soil samples. In addition, the test program included:

- two sieve analysis tests
- eleven rock compressive strength tests
- eight triaxial rock compression tests

The test results appear on the individual boring logs and/or on the data sheets following the boring logs.

4.3 Historical Soil Boring Data

The original geotechnical report prepared in 1979 for the Metrodome project was available for our review. The report included numerous boring/rock coring logs, which we have included in Appendix B. It is important to note that site conditions have significantly changed (considerable excavation in the Metrodome area and some filling in the east parking lot area) since those borings. Still, the logs offer good data on the elevation and condition of the deeper bedrock, which for the most part, should be relatively unchanged.

Borings were also drilled in the east parking lot area in 2008 by Braun Intertec. Two of the borings extended to the bedrock and temporary piezometers were installed. This data also appears in Appendix B.

5.0 SITE CONDITIONS

5.1 Subsurface Soils/Geology

The recent borings encountered 14 feet to 41½ feet of fill at the top of the profile. The fill is a typically silty sand, clayey sand, or sand with silt, with lesser amounts of sand and sandy lean clay. The fill includes gravel and appear to include cobbles and possibly boulders. Debris is sometimes present, such as pieces of concrete and, to a lesser degree, brick, glass, and wood. Based on N-values, the fill has variable compaction ranging from relatively high to moderately low.

The natural overburden geology includes both glacially-deposited till and water-deposited alluvium. The till includes silty sand, clayey sand, and sandy lean clay. The alluvium includes sand, sand with silt, and silty sand which often include significant gravel content. A significant portion of both the till and alluvium appears to include cobbles and likely boulders. Relatively large boulders were encountered during excavation for the original Metrodome.

In some areas, the zone just above the bedrock appears to have colluvial deposition (gravity-deposited pieces of bedrock and residual soils). Some of the colluvium appears to include limestone slabs.

The approximate top of bedrock elevation at the recent boring locations ranges from elevation 790 feet to 795 feet. This is relatively consistent with the elevation range portrayed by the historical boring data. Figure 2 in Appendix B shows apparent top of bedrock elevation at the 1978/1979 boring locations.

The upper bedrock is limestone of the Platteville Formation. The Platteville can be subdivided into five members, although it appears the upper Carimona member is absent, leaving the fossiliferous Magnolia member as the upper zone of bedrock. The blocky and hard Magnolia member is underlain by the Hidden Falls member, which includes shaley/bentonitic beds and is more prone to weathering than the Magnolia. However, since the Hidden Falls member appears below elevation 783 feet, the Magnolia cap appears to have reasonably protected the Hidden Falls zone, as clay seams and shale weathering appears sufficiently low. The Hidden Falls is then underlain by competent Mifflin and Pecatonica members. The top of the Mifflin member lowers slightly to the east, ranging from approximate elevation 778½ feet at previous Boring 9-79 to approximate elevation 777 feet at Boring A3. The Platteville Formation is underlain by Glenwood shale (about 4½ feet thick) and then St. Peter sandstone.

Six rock compressive strength tests have been conducted on limestone samples from the Magnolia member (three as a part of this program and three in 1979). The test results range from 10,240 psi to 19,550 psi, with an average of 12,600 psi. The average RQD of the upper zone is about 40%, although it was as low as 20%.

5.2 Ground Water

Ground-water levels have risen in the area since the original Metrodome construction. Piezometers installed during the 1978/1979 geotechnical program found hydrostatic water levels in the bedrock, below elevation 790 feet. The rise in the levels since then has necessitated considerable pumping efforts to control water levels below the current event level.

Review of the water levels measured in the recent soil borings suggests a hydrostatic ground-water level in the vicinity of elevation 796 feet to 798½ feet at the time of our exploration. The lower levels are nearer to the Metrodome, and it is quite possible that water levels are being drawn down by the on-going pumping within the Metrodome. One of the temporary piezometers installed by Braun Intertec in 2008 indicates a water level as high as elevation 800.2 feet.

Ground-water levels should be expected to fluctuate with time due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors. Ground-water levels measured at the time of our exploration may be low due to the fact that the borings were drilled in the winter during the time of reduced surface infiltration, and also the fact that the area is currently experiencing drought conditions. Ground-water levels could rise once precipitation patterns return to normal.

6.0 DEFINITIONS

The ensuing sections use italicized words, which have specific definitions, as presented below.

Coarse Filter Material is No. 8 Coarse Aggregate material as defined in ASTM:C33 (Standard Specification For Concrete Aggregates), having the following gradational requirements.

Sieve Size or Number	Percentage Finer Than (by weight)
1/2"	100%
3/8"	85% - 100%
No. 4	10% - 30%
No. 8	0% - 10%
No. 16	0% - 5%

Fine Filter Material is Fine Aggregate material as defined in ASTM:C33 (Standard Specification For Concrete Aggregates), having the following gradational requirements.

Sieve Size or Number	Percentage Finer Than (by weight)
3/8"	100%
No. 4	95% - 100%
No. 8	80% - 100%
No. 16	50% - 85%
No. 30	25% - 60%
No. 50	5% - 30%
No. 100	0% -10%
No. 200	0% - 3%

Type I geotextile fabric should meet the requirements of a Type I geotextile as defined in Mn/DOT Specification 3733.

Type V geotextile fabric should meet the requirements of a Type V geotextile as defined in Mn/DOT Specification 3733.

Collector pipe is a perforated pipe which can take in water. Perforations should be limited to sizes not exceeding ¼ inch. PVC pipes are acceptable.

Header pipe is a non-perforated pipe intended to transport water from collector pipes to sump pump locations.

Top of grading grade is defined as the grade which contacts the bottom of the aggregate base layer (for pavement subgrades).

Sand subbase is a uniform thickness sand layer placed as the top of an exterior pavement or slab subgrade (directly below top of grading grade) which is intended to improve the frost and drainage characteristics of the pavement system by better draining excess water in the aggregate base and subbase, by reducing and "bridging" frost heaving, and by reducing spring thaw weakening effects.

Critical subgrade zone is the pavement subgrade portion beneath and within three vertical feet of the *top of grading grade* (which can be reduced to 2½ feet for light-duty pavements). A *sand subbase*, if placed, would be considered the upper portion of the critical subgrade zone.

Select Granular Material shall meet the requirements of Mn/DOT Specification 3149.2B2.

Test roll is a means of evaluating the near-surface stability of subgrade soils (usually non-granular). Suitability is determined by the depth of rutting or deflection caused by passage of heavy rubber-tired construction equipment, such as a loaded dump truck, over the test area. Yielding of less than 1-inch is normally considered acceptable, although engineering judgment may be applied depending on equipment used, soil conditions present, and/or pavement performance expectations.

Unstable soils are those soils which do not pass a *test roll.* Unstable soils typically have water content exceeding the *standard optimum water content* defined in ASTM:D698 (Standard Proctor test).

Organic soils are those soils which have sufficient organic content such that engineering properties/stability are affected (assumed to be 3% or more organic content in this report). These soils are usually black to dark brown in color.

7.0 RECOMMENDATIONS

7.1 Spread Foundation Support

With foundations being placed below the Event Level elevation, they will be very near or into the Magnolia member of the limestone bedrock, pending location and foundation thickness. Foundations placed on the intact Magnolia member can be proportioned to exert an allowable bearing capacity of 25 tsf, but with additional penetration where needed, it should be feasible to increase this allowable bearing capacity to 75 tsf. The recent borings do indicate zones of the bedrock have reduced Rock Quality Designation (RQD) as compared to the borings associated with the original Metrodome program. The recent rock coring includes zone of rock with RQD values in the 20% to 40% range, which limits capacity. To attain the 75 tsf allowable capacity, the bedrock should have an RQD of at least 40% within a vertical distance of 0.25B (B = footing width) of footing grade and an <u>average</u> RQD of 40% over a 1.0B distance of footing grade. Based on our review of the cores, which also considers RQD of partial runs, the excavation elevations shown on Table 7.1 are estimated for each boring/core location. Note that the actual depths will vary, as the rock excavation will break in blocks and along seams which may well differ from that shown at the test locations.

Table 7.1 – Estimated Depths/Elevations

Boring No.	For Allowable Bearing Capacity = 75 tsf	
	Depth (ft)	Elevation (ft)
A1	52.3	792.3
A2	46.4	786.8
A3	53.2	789.8
A4	54.6	787.8
A5	52.4	787.4
A6	48.8	793.8
A7	52.0	790.6
A8	51.2	790.9
B9	52.0	791.0
B10	54.0	788.9
B11	59.7	788.1
B13	49.1	787.1
B15	52.5	790.3
B16	52.8	790.2
B17	54.6	786.8
B27	65.6	787.2

The quality of the bedrock at each foundation should be evaluated in a probe hole drilled to a depth equal to one footing width below foundation grade (1.0B). The number of probe holes should be increased to two where foundations widths are greater than 5-feet. Where rock quality criterion is not met, the area should be excavated further as needed to meet the criteria. This should include evaluating the intent of the above described RQD criteria. In addition, the bedrock beneath the bearing surface should not contain voids or soil filled fissures greater than ½-inch within one foundation width (1.0B).

As an option to deeper rock excavation, it may be possible to improve the modulus properties of the bedrock which does not meet the desired criterion by means of pressure grouting the rock zone through the probe holes. In this case, it may be recommended that additional probe holes be drilled and grouted, pending rock condition and footing size. The risk of this approach is that, pending horizontal movement of grout, a significant grout volume could result.

7.2 Buttress Foundation Support

The buttress foundations supporting the primary roof truss are located in the vicinity of Borings B9 and B10 (east), and B11 (west). Potential deformations of these foundations under the projected loads with a base elevation of 774.5 feet were analyzed as follows:

7.2.1 Analysis Methods

Displacement calculations for the planned buttress foundations were analyzed using the Fast Lagrangian Analysis of Continua (FLAC) 7.0 computer program. The program is a two-dimensional explicit finite difference program for engineering mechanics computations. FLAC models structures and soils as elements which form grids that behave according to a prescribed linear or nonlinear stress/strain law in response to applied forces or boundary restraints. For this project, Mohr-Coulomb material parameters were used for all materials included in the model. Joints in the bearing material were also modeled using ubiquitous joints at varying angles and with no cohesion.

7.2.2 Analysis Results

The vertical and horizontal displacement contour results are shown in Figures 7.2.2a and 7.2.2b. The resultant of the two indicates a deformation of 0.15 inches, which is within the 3/8 inch criteria desired. We recommend maintaining the foundation base elevation of 774.5 feet.

Figure 7.2.2a – FLAC Results, Vertical Displacement Contour

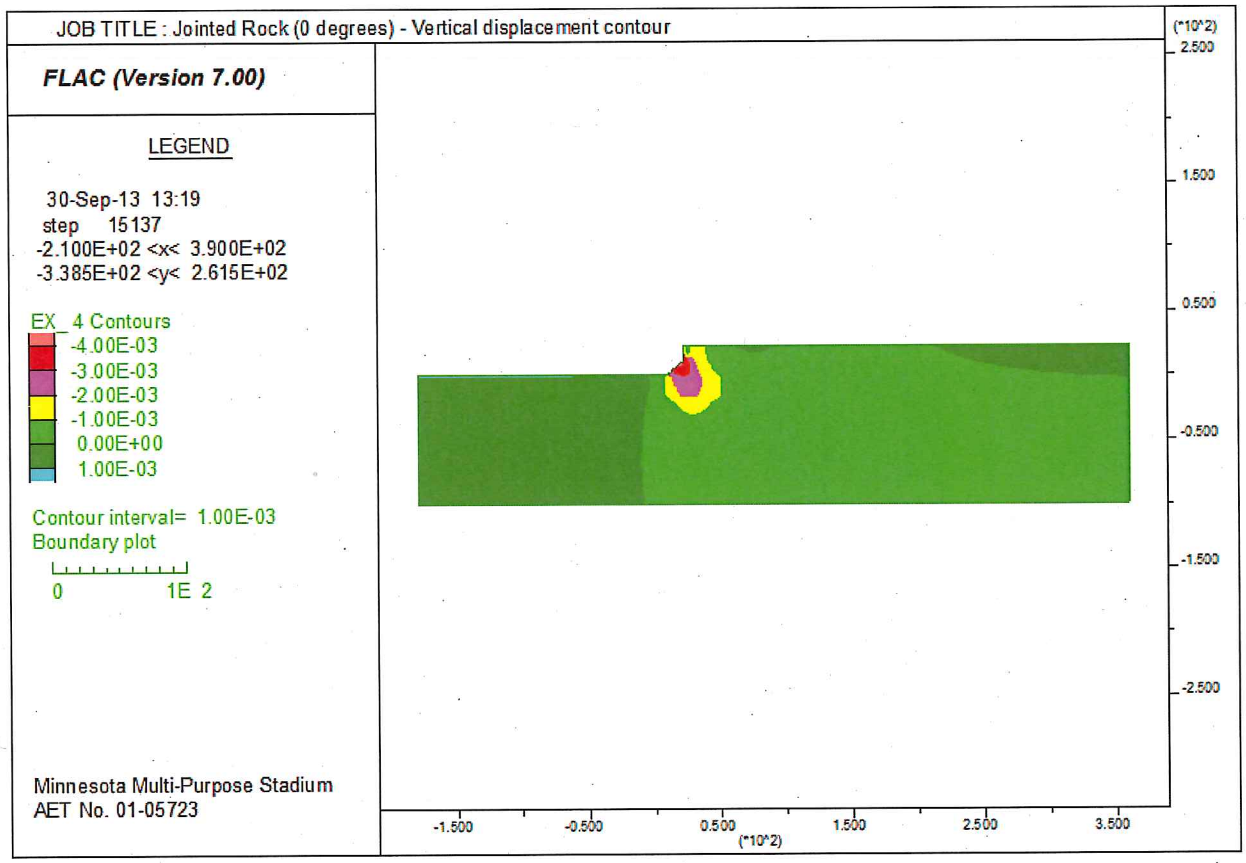
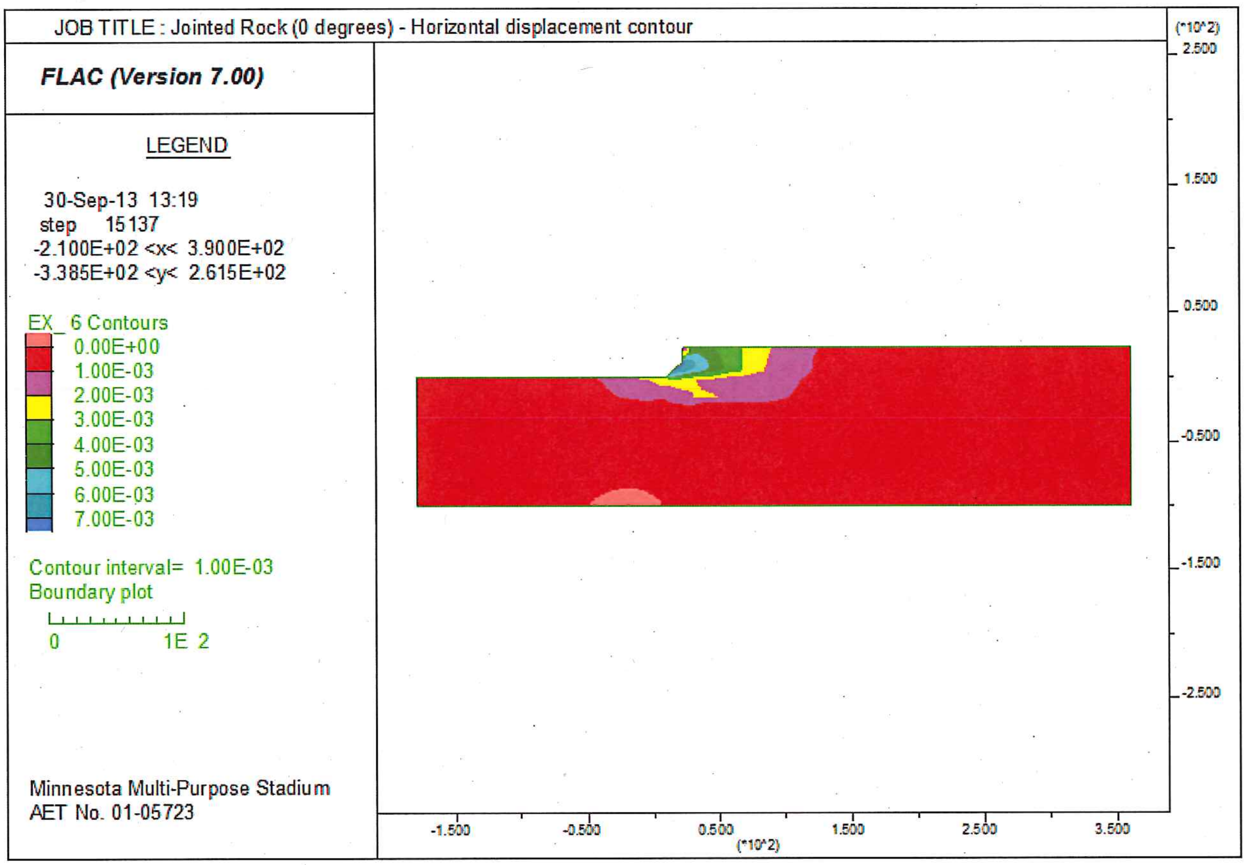


Figure 7.2.2b – FLAC Results, Horizontal Displacement Contour



7.2.3 Excavation Issues

A sloped face may be difficult to excavate. The rock will more likely break up in blocks, resulting in a stepped face. To avoid dislodged rock blocks, it may be necessary to line drill the rock for better excavation face control. Vertical excavation faces may provide better control of rock intactness. Over-excavated rock can then be filled with additional foundation concrete.

7.3 Drilled Pier Foundation Support

The use of drilled piers for foundation support below the Event Level will likely not be feasible as compared to spread footings, as drilled shaft coring in fractured hard rock can be quite difficult, and the excavation approaches for spread footings will likely be preferred over drilled pier coring by the contractor. However, we understand drilled piers may be used for superstructure support outside of the Event Level perimeter, which penetrate through overburden soils.

We have reviewed drilled pier capacities with respect to adding side resistance of a rock socket to the base resistance. Conventional practice in this area is to neglect side resistance in the design of rock-socketed piers. Although some literature on the topic suggests limiting capacity to one or the other (side or base) due to the non-ductile (brittle) nature of the rock, FHWA-NHI-10-016 (2010) indicates that brittle behavior along the sidewall is not commonly observed in load tests on rock sockets. Using evaluation methods found in FHWA (2010) and Wyllie, D.C., *Foundations on Rock* (1999), it is our judgment that adding a side resistance value of 7 ksf over the drilled pier perimeter area in contact with the bedrock below a depth of 2-feet below top of bedrock could be added to the base resistance.

One item of concern is that penetration into the Magnolia member will place the base closer to the Hidden Falls member, which may have lower end bearing resistance (and cannot be field evaluated). We would recommend that the pier bottom be maintained 5 feet above the Hidden Falls. Because this penetration into the bedrock for side resistance contribution will be limited by this, it may be prudent to extend the pier to the Mifflin member, which would result in a somewhat smaller diameter pier, where there will be higher end resistance in addition to the increased side resistance. We recommend continuing to use 75 tsf for end bearing on the

Magnolia (with the 5-foot Hidden Falls separation requirement) and 100 tsf for end bearing on the Mifflin. Higher end bearing on the Mifflin may be possible; however, human entry into the shaft to evaluate probe holes at the bottom may not be possible due to safety policies, so it will not be feasible to substantiate actual rock bearing conditions.

7.4 Soil/Rock Parameters for Lateral Resistance and Uplift Review

Table 7.3 provides our estimation of soil/rock parameters which can be used for your lateral resistance analysis using LPILE software.

Table 7.4 – LPILE Soil/Rock Parameters

Soil Type from Boring	LPILE Soil Type	Depth below grade at Boring A3	Effective Unit Weight* (pcf)	Undrained Cohesion, (psf)	ε_{50}	Friction Angle (degrees)	K p-y (pci)
Medium Dense Sand	Sand	27'-31.5'	120	0	--	32	90
Dense Sand	Sand	31.5'-34'	124	0	--	35	225
Very Dense Silty Sand	Sand	34'-38.5'	138	0	--	38	225
Very Dense Sand	Sand	38.5'-46.5'	128	0	--	38	225
Gravel	Sand	46.5'-53'	72.5	0	--	38	125
Limestone Bedrock	Weak Rock	53'-81'	95	**	**	**	**

*Water table set at depth of 46.5 feet.
** "Weak Rock" parameters: Young's Modulus, E_m = 7.5E5 psi (based on E_i = 5E6 psi x 0.15 RQD reduction), Uniaxial Compressive Strength = 12,000 psi, k_{rm} = 0.0005

For frictional resistance between mass foundation concrete on the limestone bedrock, we recommend using a Friction Factor (tan δ) of 0.70. An appropriate factor of safety should be applied to this value.

For passive resistance of rock against the sides of spread footings, we recommend not exceeding a value of 300 pcf. Even if penetrated into rock, uncontrolled excavation techniques could result in the rock being broken up and acting like gravel. As the "gravel" may also be submerged, the effective unit weight would be reduced (vs. a non-submerged condition).

We understand certain grade beams/shear walls will require resistance of a horizontal force of 26 kips/foot. This resistance can be provided with penetration into the limestone bedrock if the excavation face is controlled and evaluated, and the concrete is in direct contact with the rock face. The structural element should extend a minimum of 18 inches into competent bedrock. The resisting rock face shall be cut vertically in a manner which maintains the intactness of the rock without creating a rubble condition. The exposed face must have at least one sound, unfractured rock zone with a minimum vertical thickness of 6 inches, or two unfractured rock zones of at least 4 inches. If this is not met, the wall shall penetrate deeper per the direction of the Geotechnical engineer. If line penetrations into the rock occur parallel to the wall (such as an interior collector pipe), then the grade beam/shearwall excavation should extend a minimum of 6 inches deeper than the interior line excavation, and the exposed face lower than the exterior line excavation shall have at least one unfractured rock zone of 4 inches.

We understand uplift may be resisted by anchors which are drilled and grouted into the limestone. An ultimate bond stress of 0.25 ksi can be assumed along the limestone/grout interface. Center-to-center anchor spacing should be at least 4 feet.

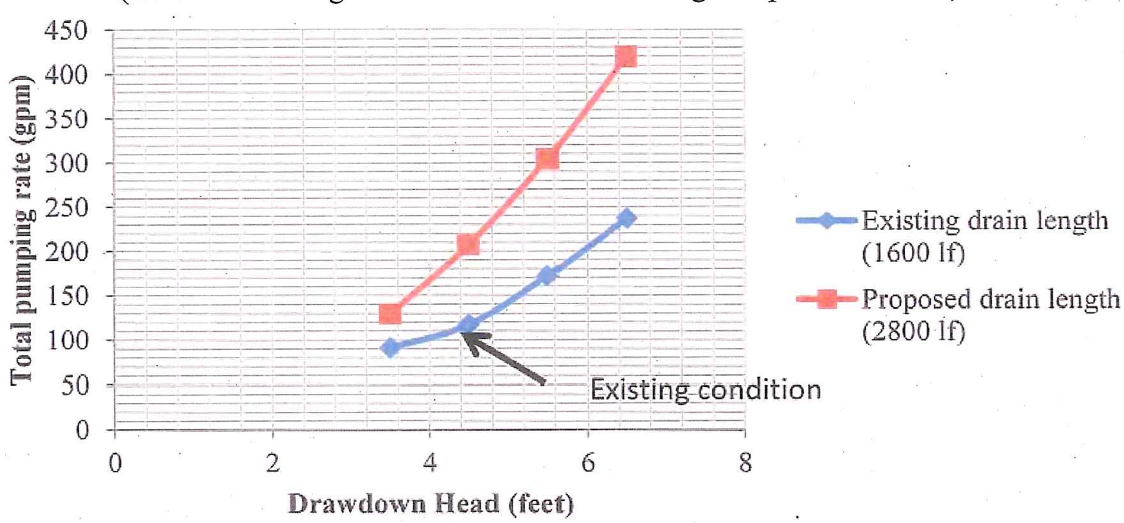
7.5 Floor Slab/Ground Water Protection

Ground-water level measurements indicate water levels very near or above the planned Event Level slab elevation. These measured levels may not even represent high ground-water level conditions. Accordingly, we recommend the installation of exterior and interior/underfloor drainage systems which can adequately collect and dispose of water through pumping.

7.5.1 Estimated Pumping Rates

The existing Metrodome is currently disposing of below-floor water with several pumps, each rated at 500 gpm. Based on discussions about the system and pumping durations with maintenance personnel, we are estimating that the current pumping rate may be on the order of 100 gpm. However, with the new Event Level perimeter being about 75% larger than the existing playing field level, greater volumes of water may need to be pumped. Figure 7.5.1 demonstrates estimated gpm vs. drawdown head for both existing and future cases.

Figure 7.5.1 – Estimated GPM vs. Drawdown Head
(assumes existing WT at 797 feet and existing sump at 792.5 feet)



As the above evaluation is based on assumed parameters which are highly approximated (low confidence), we recommend a significant factor of safety be applied. We understand four pumps are planned, with each pump handling an Event Level quadrant. We recommend these pumps (combined) be capable of handling a total of 700 gpm. The system should consider the effects of a mechanical or electrical failure and the use of backup pumps and electrical systems.

7.5.2 Perimeter Collection System

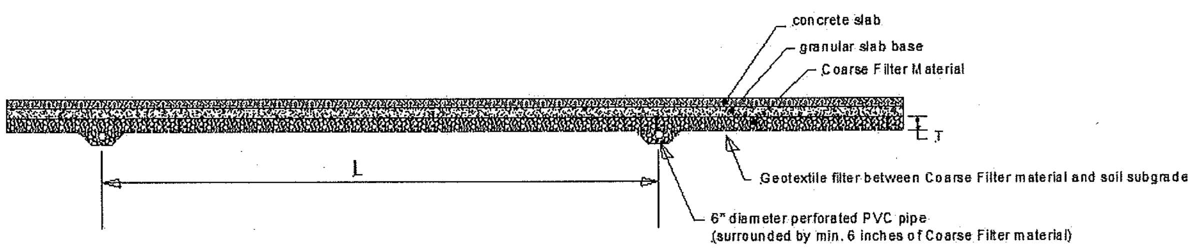
It is our recommendation that water be collected on the exterior side of the Event Level perimeter wall. If not done, water build-up upon the wall and intrusion through the wall would be expected. This would require that the retention system and permanent wall be separated to allow a drainage system, or a means of exterior drainage be incorporated into the wall/retainage system used. The preferred system outside of the wall would include 6-inch diameter *collector pipes* surrounded by *Coarse Filter Material*, which is then completely enveloped in *Type 1 geotextile fabric*. The exterior water collected should preferably be transported through sloped *header pipes* directly to the sump area for direct removal without impedance from the interior system. Sloping of pipes should be no flatter than 4 inches of vertical drop over a 100-foot length.

As the ground water migrates through relatively free-draining sands above the bedrock, it should be recognized that significant flow will enter from the perimeter. It is possible to create a cut-off barrier around the perimeter of the Event Level to significantly reduce water inflow which may migrate into the drainage layer zone. This could be in the form of below grade "clay dams", slurry walls, or structural walls extending to the bedrock. With this inflow control, an interior underfloor system will still be required to collect potential seepage, because seepage would still be expected through fractures and joints in the bedrock. However, with this perimeter control approach, we anticipate that pumping could be significantly reduced.

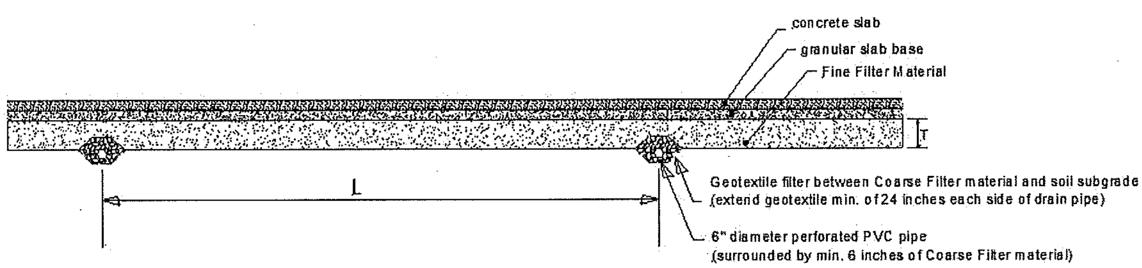
7.5.3 Interior Underfloor Drainage System

The underfloor drainage system should consist of a series of parallel *collector pipes* placed in a drainage media blanket. Refer to Figure 7.5.3 for an illustration of our recommendations.

Figure 7.5.3 – Underfloor Drainage Options



Option A: Coarse Filter Blanket Drain



Option B: Fine Filter Blanket Drain

The blanket can consist of either *Coarse Filter Material* or *Fine Filter Material*, although the zone which surrounds the *collector pipes* must be *Coarse Filter Material* if the blanket is made up of *Fine Filter Aggregate.* All *Coarse Filter Material* should be separated from the native soils with a *Type I or Type V geotextile fabric*. There may also be a need to separate the *Coarse Filter Material* from the "granular slab base" layer shown (this layer discussed further in Section

7.5.4). Geotextile fabric separation between *Coarse Filter Material* and *Fine Filter Material* is not required. The spacing of collector pipes would be dependent on the blanket thickness. The pipe spacing and blanket thickness options can be evaluated based on the data presented in Table 7.5.3. This table is based on a total seepage collection of 400 gpm, and estimated permeability coefficients of 12.5 ft/hr and 125 ft/hr for *Fine Filter Material* and *Coarse Filter Material*, respectively. *Collector pipe* and *header pipe* sloping should again be no flatter than 4 inches of vertical drop over a 100-foot length. The top of any pipe should be placed a minimum of 6 inches below the bottom of the floor slab. The pipes should also be surrounded on all sides and bottom by a 6-inch minimum zone of *Coarse Filter Material*. The sloping and cover requirements may then dictate blanket thickness (pending geometry and pump locations).

Table 7.5.3 – Collector Pipe vs. Blanket Thickness Options

Drain Spacing L (ft)	Option A- Coarse Filter Material *T (ft)	Option B- Fine Filter Material *T (ft)
200	0.7	2.3
150	0.5	1.7
100	0.5	1.1
50 or less	0.5	0.6
*minimum blanket thickness		

7.5.4 Floor Slab Base Material/Vapor Protection

Our recommendations pertaining to the "granular slab base" material and moisture/vapor protection of floor slabs appears on the attached sheet entitled "Floor Slab Moisture/Vapor Protection." We refer you to the American Concrete Institute *Guide for Concrete Floor and Slab*

Construction (ACI, 302.1R-04) Sections 4.1.4 and 4.1.5 for additional details. If the base material used does not have the gradational properties to act as a "choker" course over *Coarse Filter Material*, a *Type I or Type V geotextile fabric* should be added between the base and the *Coarse Filter Material.*

7.5.5 Bituminous Floor Alternative

We understand that the Event Space and Entry may incorporate a bituminous pavement system rather than a concrete slab. As trucks may be driven on the floor, we recommend a heavy-duty design as follows.

Table 7.5.5 – Bituminous Floor Thickness Design

Material	Thickness
Bituminous (SPWEA440E)	2"
Bituminous (SPWEB440E)	2.5"
Class 5, 6 or 7 Aggregate Base	6"

The aggregate base would be placed over the *Coarse Filter Material.* It will be important to separate the aggregate base and *Coarse Filter Material* with a geotextile fabric. In this case, we recommend a *Type V geotextile fabric*.

7.6 Retention Systems

Soldier pile/lagging and soil anchor tie-back earth retention systems are commonly used in the downtown Minneapolis area. This system can be used, but can be prone to sloughing and poor settlement control, and may be complicated by the cobbles and boulders which may be encountered. An alternate system having better settlement control may be a soil nail shotcrete earth retention system, wherein the wall is incrementally built from top down using shotcrete, steel reinforcement, and soil nails/tiebacks which can be in the form of helical pile anchors or grouted tiebacks. Where soils are prone to sloughing, shotcrete can be applied as an initial step to control the ground movement.

Diaphragm/slurry walls or a grouting procedure (such as jet grouting) may be a consideration, although construction may be complicated by cobbles/boulders and in-place utilities. The benefit of the reinforced shotcrete approach is that the areas worked are visible and obstacles can be openly dealt with or worked around.

The base of the wall construction will be complicated by the presence of the ground-water level. An option may be to use grouting or slurry wall construction procedures at the base of the wall once the excavation reaches an elevation just above the ground-water level. This method can then be designed and constructed to assist in "cutting off" the perimeter for ground-water reduction control as discussed in the prior section.

Retention systems are typically designed by engineers of the specialty contractors (based on performance-based specifications).

Assuming the retention system will be designed and constructed to maintain its integrity on a permanent basis, and the interior wall is built separately from this system, a narrow backfill zone would exist. Presuming water control will be needed, a gravel bed/drainage pipe system can be placed at the base, with free draining sand fill or a geosynthetic drainage board placed above this. All open-graded gravel materials should be separated from finer materials with a geotextile separation fabric to prevent internal erosion of fines into the gravel void space. It may be difficult to compact backfill due to space limitations, and alternate materials or methods may be needed to prevent surface subsidence (or a structural bridge could be created at the surface such that subsidence is not an issue).

7.7 Retaining Wall Backfill

For general recommendations on backfilling of retaining walls having imbalanced fill loads, we refer you to the attached sheet entitled "Basement/Retaining Wall Backfill and Water Control." This sheet also presents recommended lateral pressure estimates for design.

During the design process, we had been requested to review methods for further reducing lateral loads on walls to reduce structural retaining wall lateral resistance needs. The result was to incorporate a cleaner sand backfill material intended to impart equivalent fluid pressures of 30 pcf in the "active" case and 48 pcf in the "at-rest" case. To achieve this, we recommend importing sand which meets the following specification:

> A washed, poorly-graded medium to coarse grained sand to fine gravel which has 100 percent passing the 3/8-inch sieve and less than 3 percent by weight passing the #200 sieve. The material shall have the appropriate combination of unit weight and internal friction angle such that a calculated active pressure of 30 pcf is not exceeded. The following table provides a guide for meeting this criterion:

Soil Case	Internal Friction Angle	Unit Weight (pcf)
1	37°	120.6 or less
2	36°	115.5 or less
3	35°	110.7 or less
4	34°	106.0 or less
5	33°	101.7 or less

The unit weight would be considered the "wet" density. For material evaluation, we recommend the unit weight be taken as the *standard maximum dry unit weight* defined in ASTM: D698 (Standard Proctor test), at a water content which is half of the *standard optimum water content.*

(the clean sand fill is not expected to become saturated with the subsurface drainage systems provided). For example, assuming a Standard Proctor density of 110 pcf and an optimum water content of 10%, the unit weight would be 115.5 pcf (110 pcf x 1.05). The internal friction angle should be determined by the Direct Shear test (ASTM:D3080).

We have been asked about the amount of wall movement needed to mobilize the "active" case with respect to the north foundation wall. That particular wall will be up to 46 feet tall, and it will be restrained at its top by the club-level structural slab. Within medium dense sands, horizontal movements at the top of the wall of about 0.001 to 0.002 times the wall height are typically necessary to fully mobilize the "active" case. For the north foundation wall, that would equate to movement of about ½ to 1 inch at the top of the wall. We understand that the computed maximum magnitude of wall deflection under the "at-rest" case is about 4 inches (at or near the mid-height of the wall), and that deflection under the "at-rest" case would be even greater when the long-term creep behavior of concrete is taken into account.

Therefore, we were asked to comment on the possibility of using Geofoam to reduce lateral pressures, as well as how the lateral pressures would change due to creep of the concrete wall. Because the wall will be restrained at its top, as well as given the uncertainty in the exact distribution of lateral earth pressure that will result from compaction of the sand backfill, we still recommend the wall be designed for the "at-rest" case, but that long-term creep deflections of the concrete may be evaluated using the "active" case (because as post-construction creep deflections occur, lateral earth pressures should trend toward the "active" case). Regarding the use of Geofoam, we evaluated this possibility using both analytic models and computer finite element modeling and determined that the Geofoam would need to extend back beyond the theoretical "active" wedge behind the wall (even for the "at-rest" case). This would be on the order of 20 to 25 feet behind the wall, meaning that an extensive volume of Geofoam would be needed in order to have any significant reduction on lateral earth pressures.

7.8 Fill Placement – West Side

The west side of the existing Metrodome will be below design grades following demolition and removals. An on-grade plaza will be constructed on the west exterior of the new structure, which will necessitate the placement of a substantial thickness of engineered fill. To control settlement of the plaza area, we recommend *Select Granular Material* be used as the fill beneath this slab. We also recommend that the fill be uniformly compacted in thin lifts to a minimum of 98% of the *standard maximum dry unit weight* defined in ASTM: D698 (Standard Proctor test).

The exterior plaza slab and the interior will be separated by a grade beam between the columns for the perimeter wall. The fill system will then slope downward into the interior of the structure. We recommend the slopes be no steeper than 2H:1V. To maintain a slope factor of safety of 1.3, we recommend the use of *Select Granular Material* uniformly compacted in thin lifts to a minimum of 95% of the *standard maximum dry unit weight* defined in ASTM: D698 (Standard Proctor test).

7.9 Pavements/Exterior Slabs

7.9.1 Recycling of On-site Materials

The on-site concrete and bituminous materials can be recycled if they are crushed to an aggregate base-like gradation specification. Crushed bituminous, to be reused as aggregate base, should be blended with mineral soils/gravel or crushed concrete to meet Mn/DOT Class 7 Specification 3138.2A2.

7.9.2 Subgrade Preparation

Many of the on-site soils present in potential subgrade areas are silty sands and clayey sands, with occasional inclusions of clays. These soils are frost susceptible and can have limited drainage characteristics. In these soil types, it is desired to place a *sand subbase* layer of *Select Granular Material* directly below the aggregate base layer to better reduce periods of aggregate and upper subgrade saturation and the associated frost movements and thaw weakening effects. In areas where these more silty and clayey soils are present, we recommend a 1-foot thick *sand subbase* layer of *Select Granular Material* be placed.

There may be areas where the subgrade soils already meet a *Select Granular Material* specification (soils classified as sand or sand with silt). In this case, the incorporation of a *sand subbase* would not be necessary.

Where a *sand subbase* is placed and there is a need to vary the thickness of the subbase, we recommend the thickness have a taper of no steeper than 10:1 (H:V). To the outside of paved or slab areas, the subcut and *sand subbase* placement should extend slightly beyond the outer edge of the curb/slab edge to maintain frost uniformity.

Sand subbase layers should be provided with a positive means of subsurface drainage. Where the pavement or slab slopes, subsurface water will migrate upon the underlying slow draining soils through the *sand subbase* layer to the lower elevation points. If sufficient granular soils underlie the *sand subbase*, infiltration will occur. However, where the subbase is underlain by soils with poor infiltration properties, the design should include a means of drainage at the low elevation points, such as placing an engineered perforated drain pipe which daylights to storm sewers. In more level areas, periodically spaced drainage lines should be created.

The final subgrade should have proper stability within the *critical subgrade zone*. Granular soils should be surface compacted. In more clayey/silty areas, the stability of the soils exposed prior to *sand subbase* placement should be evaluated using the *test roll* procedure. Instability will likely be a result of wetter clayey soils. More widespread instability can be anticipated during wetter seasons. *Unstable soils* should either be subcut and replaced, or reworked in-place. If soils are reworked in-place, they may need to undergo considerable scarification and drying to reach a proper level of stability (ability to pass a *test roll*). Reworked soils should be prepared similar to new fill materials, and should meet the water content and compaction requirements outlined later for new fill placement. We caution that instability of soils present beneath the soils being reworked and compacted may limit the ability to compact the upper soils. In this case, greater depths of subcutting and stability improvement may be needed.

If *organic soils* or debris-laden soils (to the point of creating void space) are found to be present, we recommend removing these materials where present within the *critical subgrade zone*.

Following the above recommended excavations and preparation of existing soils, fill can be placed as needed to attain subgrade elevation. Fill should be placed and compacted per the requirements of Mn/DOT Specification 2105.3F1 (Specified Density Method). Using ASTM terminology, this specification requires soils placed within the *critical subgrade zone* be compacted to a minimum of 100% of the *standard maximum dry unit weight* defined in ASTM: D698 (Standard Proctor test), at a water content from 65% to 102% of the *standard optimum water content*. A reduced minimum compaction level of 95% of the standard maximum dry unit weight can be used below the *critical subgrade zone*. A *sand subbase* can be considered part of a composite subgrade; and the top of the subbase can be figured as the top of the 3-foot subgrade zone needing the 100% compaction level. However, the lower (dry) end of the water content range requirement does not need to apply to the sands.

Placement of uniform *sand subbase* layers will also provide improved performance for exterior concrete sidewalks and slabs. To eliminate differential frost heave at doorway areas, a *sand subbase* thickness of 5 feet should be provided on the exterior side, which includes thickness tapers away from the local door area.

7.9.3 Pavement Designs

We are presenting pavement designs based on two potential traffic situations (light-duty and heavy-duty). The light-duty design refers to pavements which are intended for automobiles and passenger truck/vans. The heavy-duty design is intended for pavements which will experience truck traffic.

Based on the clayey soils encountered and the recommended subgrade preparation (with a 1-foot *sand subbase* if *Select Granular Material* is not already in-place), we estimate an R-value of 30 or a k-value of 200 pci is appropriate for the pavement design. Based on these parameters and the assumed traffic, our recommended minimum design sections appear in the following tables.

Table 7.9.3a – Bituminous Pavement Thickness Designs

Material	**Section Thicknesses (R=30)**	
	Light Duty	**Heavy Duty**
Bituminous (SPWEA440F)	1.5"	2"
Bituminous (SPWEB440E)	1.5"	2.5"
Class 5, 6 or 7 Aggregate Base	5"	6"

Table 7.9.3b – Concrete Pavement Thickness Designs

Material	Section Thicknesses (k=200 pci)	
	Light Duty	Heavy Duty
Concrete	3.5"	5.5"
Class 5, 6 or 7 Aggregate Base	4"	4"

The concrete design assumes that no dowels are needed for load transfer. Although the aggregate base layer is not necessarily needed for strength reasons, it was added to the concrete design to assist in controlling "mud pumping" at the joints. The design assumes a minimum concrete compressive strength (f'_c) of 4000 psi at 28 days.

The presented designs have been based on "20-year" pavement life design charts. However, the concrete design is expected to have a longer pavement life; or at least, does not require the on-going maintenance of a bituminous system. The benefit of a bituminous system is that rehabilitation techniques, such as mill and overlay procedures, can be more easily performed.

8.0 CONSTRUCTION CONSIDERATIONS

8.1 Excavation Backsloping

Where excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce side-slope erosion or running which could require slope maintenance. The responsibility for excavation face maintenance in accordance with OSHA requirements should lie with the contractor, and we recommend the construction documents be prepared as such.

8.2 Shoring Tower Foundations

We understand various temporary shoring tower types are being considered during construction, located in the general area of Grids A and B (lower seating area outside of the playing field area). Pending the type used, maximum axial loads could range from 200 kips to 1050 kips. We assume the towers are designed to resist overturning and lateral loads, and include minimum foundation size requirements as a part of this. We have been requested to recommend maximum allowable bearing pressures for two potential cases; footings placed on the overburden soils below the Event Level and footings placed on the top of bedrock without penetrate into the rock for low RQD reasons. We understand there are no settlement requirements for this temporary case, as short-term settlement can be accounted for by additional jacking of the structure.

For the case of temporary footings placed on the overburden soil, we judge that an allowable bearing pressure of up to 12.5 tsf could be used. This allowable bearing pressure could be increased to 50 tsf for temporary foundations placed on the bedrock, qualified that the bedrock is intact (i.e., not rubble, residual soil, or colluvium).

8.3 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring/core locations. Since the conditions are expected to vary away from the test locations, we recommend on-site observation by a representative of the geotechnical engineer-of-record during construction to evaluate these potential changes.

At each rock-bearing foundation, a 1½ inch minimum diameter probe hole should be drilled by the contractor in the presence of the geotechnical representative which extends to a depth of at pier). A second probe hole should be added (center of diagonal quadrants) for spread footings exceeding a width of 5 feet. The probe hole should be evaluated for the presence of open seams or clay-filled seams using a feeler rod. Where the bedrock is found deficient, additional penetration into the rock should be performed as directed by the geotechnical representative (or pressure grouting could be performed as discussed).

Soil density and Proctor testing should be performed on new fill placed in order to document that project specifications for compaction have been satisfied. Sieve analysis, Proctor, and direct shear tests should be conducted on soil and gravel/aggregate materials as needed to evaluate compliance with the project material specifications.

8.4 Construction Impacts on Surrounding Property

Protection of surrounding property will be an important consideration. Where construction is expected to generate vibrations, we recommend conducting pre-construction and post-construction condition surveys of the nearby structures. Vibration monitoring is also recommended during construction, depending on structure proximity and sensitivity, and on the construction methods used.

8.5 Other Potential Construction Difficulties

8.5.1 Rock Excavation

Excavations will be needed into the limestone bedrock. Excavation into the harder intact limestone will likely require hard rock excavation techniques such as rock chipping, possibly requiring line drilling in advance of the chipping. The limestone will break into blocks, which can be large. Accordingly, rock excavation volumes due to rock overbreakage can then be somewhat greater than "plan" excavation volumes. Also, if concrete foundations are not formed in the rock excavations, concrete volumes can also be increased due to this overexcavation.

8.5.2 Cobbles, Boulders, and Debris

The soils at this site are expected to include a significant amount of cobbles and boulders. Debris and buried slabs may also be encountered. These larger particles will make construction procedures somewhat more difficult than normal where they are encountered. They may also require the need for tieback or anchor design revisions to retention systems if they obstruct penetration during construction.

8.5.3 Water in Excavations

The ground-water level is higher than most of the planned excavation and will have a significant impact on constructability. To allow observation of excavation bottoms and to facilitate construction operations, we recommend water be removed from within the excavations during construction. With the excavations required into overburden soils having a wide range of permeability and into waterbearing jointed rock, control of this ground water will be difficult.

8.5.4 Disturbance of Soils

The on-site soils can become disturbed under construction traffic, especially if finer grained soils are wet. If soils become disturbed, they should be subcut to the underlying undisturbed soils. The subcut soils can then be dried and recompacted back into place, or they should be removed and replaced with drier imported fill.

8.5.5 Wet or Dry Soils

Some of the site soils available for re-use may be wet or could become wet of the "optimum water content" condition; or they may be too dry. Such soils may then need to be moisture conditioned in order to achieve specified compaction levels.

9.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, either express or implied, is intended.

Important information regarding risk management and proper use of this report is given in Appendix C entitled "Geotechnical Report Limitations and Guidelines for Use."

FLOOR SLAB MOISTURE/VAPOR PROTECTION

Floor slab design relative to moisture/vapor protection should consider the type and location of two elements, a granular layer and a vapor membrane (vapor retarder, water resistant barrier or vapor barrier). In the following sections, the pros and cons of the possible options regarding these elements will be presented, such that you and your specifier can make an engineering decision based on the benefits and costs of the choices.

GRANULAR LAYER

In American Concrete Institute (ACI) 302.1R-04, a "base material" is recommended over the vapor membrane, rather than the conventional clean "sand cushion" material. The base layer should be a minimum of 4 inches (100 mm) thick, trimmable, compactible, granular fill (not sand), a so-called crusher-run material. Usually graded from 1½ inches to 2 inches (38 to 50 mm) down to rock dust is suitable. Following compaction, the surface can be choked off with a fine-grade material. We refer you to ACI 302.1R-04 for additional details regarding the requirements for the base material.

In cases where potential static water levels or significant perched water sources appear near or above the floor slab, an under floor drainage system may be needed wherein a draintile system is placed within a thicker clean sand or gravel layer. Such a system should be properly engineered depending on subgrade soil types and rate/head of water inflow.

VAPOR MEMBRANE

The need for a vapor membrane depends on whether the floor slab will have a vapor sensitive covering, will have vapor sensitive items stored on the slab, or if the space above the slab will be a humidity controlled area. If the project does not have this vapor sensitivity or moisture control need, placement of a vapor membrane may not be necessary. Your decision will then relate to whether to use the ACI base material or a conventional sand cushion layer. However, if any of the above sensitivity issues apply, placement of a vapor membrane is recommended. Some floor covering systems (adhesives and flooring materials) require installation of a vapor membrane to limit the slab moisture content as a condition of their warranty.

VAPOR MEMBRANE/GRANULAR LAYER PLACEMENT

A number of issues should be considered when deciding whether to place the vapor membrane above or below the granular layer. The benefits of placing the slab on a granular layer, with the vapor membrane placed **below** the granular layer, include **reduction** of the following:

- Slab curling during the curing and drying process.
- Time of bleeding, which allows for quicker finishing.
- Vapor membrane puncturing.
- Surface blistering or delamination caused by an extended bleeding period.
- Cracking caused by plastic or drying shrinkage.

The benefits of placing the vapor membrane **over** the granular layer include the following:

- A lower moisture emission rate is achieved faster.
- Eliminates a potential water reservoir within the granular layer above the membrane.
- Provides a "slip surface", thereby reducing slab restraint and the associated random cracking.

If a membrane is to be used in conjunction with a granular layer, the approach recommended depends on slab usage and the construction schedule. The vapor membrane should be placed above the granular layer when:

- Vapor sensitive floor covering systems are used or vapor sensitive items will be directly placed on the slab.
- The area will be humidity controlled, but the slab will be placed before the building is enclosed and sealed from rain.
- Required by a floor covering manufacturer's system warranty.

The vapor membrane should be placed below the granular layer when:

- Used in humidity controlled areas (without vapor sensitive coverings/stored items), with the roof membrane in place, and the building enclosed to the point where precipitation will not intrude into the slab area. Consideration should be given to slight sloping of the membrane to edges where draintile or other disposal methods can alleviate potential water sources, such as pipe or roof leaks, foundation wall damp proofing failure, fire sprinkler system activation, etc.

There may be cases where membrane placement may have a detrimental effect on the subgrade support system (e.g., expansive soils). In these cases, your decision will need to weigh the cost of subgrade options and the performance risks.

BASEMENT/RETAINING WALL BACKFILL AND WATER CONTROL

DRAINAGE

Below grade basements should include a perimeter backfill drainage system on the exterior side of the wall. The exception may be where basements lie within free draining sands where water will not perch in the backfill. Drainage systems should consist of perforated or slotted PVC drainage pipes located at the bottom of the backfill trench, lower than the interior floor grade. The drain pipe should be surrounded by properly graded filter rock. A filter fabric should then envelope the filter rock. The drain pipe should be connected to a suitable means of disposal, such as a sump basket or a gravity outfall. A storm sewer gravity outfall would be preferred over exterior daylighting, as the latter may freeze during winter. For non-building, exterior retaining walls, weep holes at the base of the wall can be substituted for a drain pipe.

BACKFILLING

Prior to backfilling, damp/water proofing should be applied on perimeter basement walls. The backfill materials placed against basement walls will exert lateral loadings. To reduce this loading by allowing for drainage, we recommend using free draining sands for backfill. The zone of sand backfill should extend outward from the wall at least 2', and then upward and outward from the wall at a 30° or greater angle from vertical. As a minimum, the sands should contain no greater than 12% by weight passing the #200 sieve, which would include (SP) and (SP-SM) soils. The sand backfill should be placed in lifts and compacted with portable compaction equipment. This compaction should be to the specified levels if slabs or pavements are placed above. Where slab/pavements are not above, we recommend capping the sand backfill with a layer of clayey soil to minimize surface water infiltration. Positive surface drainage away from the building should also be maintained. If surface capping or positive surface drainage cannot be maintained, then the trench should be filled with more permeable soils, such as the Fine Filter or Coarse Filter Aggregates defined in Mn/DOT Specification 3149. You should recognize that if the backfill soils are not properly compacted, settlements may occur which may affect surface drainage away from the building.

Backfilling with silty or clayey soil is possible but not preferred. These soils can build-up water which increases lateral pressures and results in wet wall conditions and possible water infiltration into the basement. If you elect to place silty or clayey soils as backfill, we recommend you place a prefabricated drainage composite against the wall which is hydraulically connected to a drainage pipe at the base of the backfill trench. High plasticity clays should be avoided as backfill due to their swelling potential.

LATERAL PRESSURES

Lateral earth pressures on below grade walls vary, depending on backfill soil classification, backfill compaction and slope of the backfill surface. Static or dynamic surcharge loads near the wall will also increase lateral wall pressure. For design, we recommend the following ultimate lateral earth pressure values (given in equivalent fluid pressure values) for a drained soil compacted to 95% of the Standard Proctor density and a level ground surface.

	Equivalent Fluid Density	
Soil Type	**Active (pcf)**	**At-Rest (pcf)**
Sands (SP or SP-SM)	35	50
Silty Sands (SM)	45	65
Fine Grained Soils (SC, CL or ML)	70	90

Basement walls are normally restrained at the top which restricts movement. In this case, the design lateral pressures should be the "at-rest" pressure situation. Retaining walls which are free to rotate or deflect should be designed using the active case. Lateral earth pressures will be significantly higher than that shown if the backfill soils are not drained and become saturated.