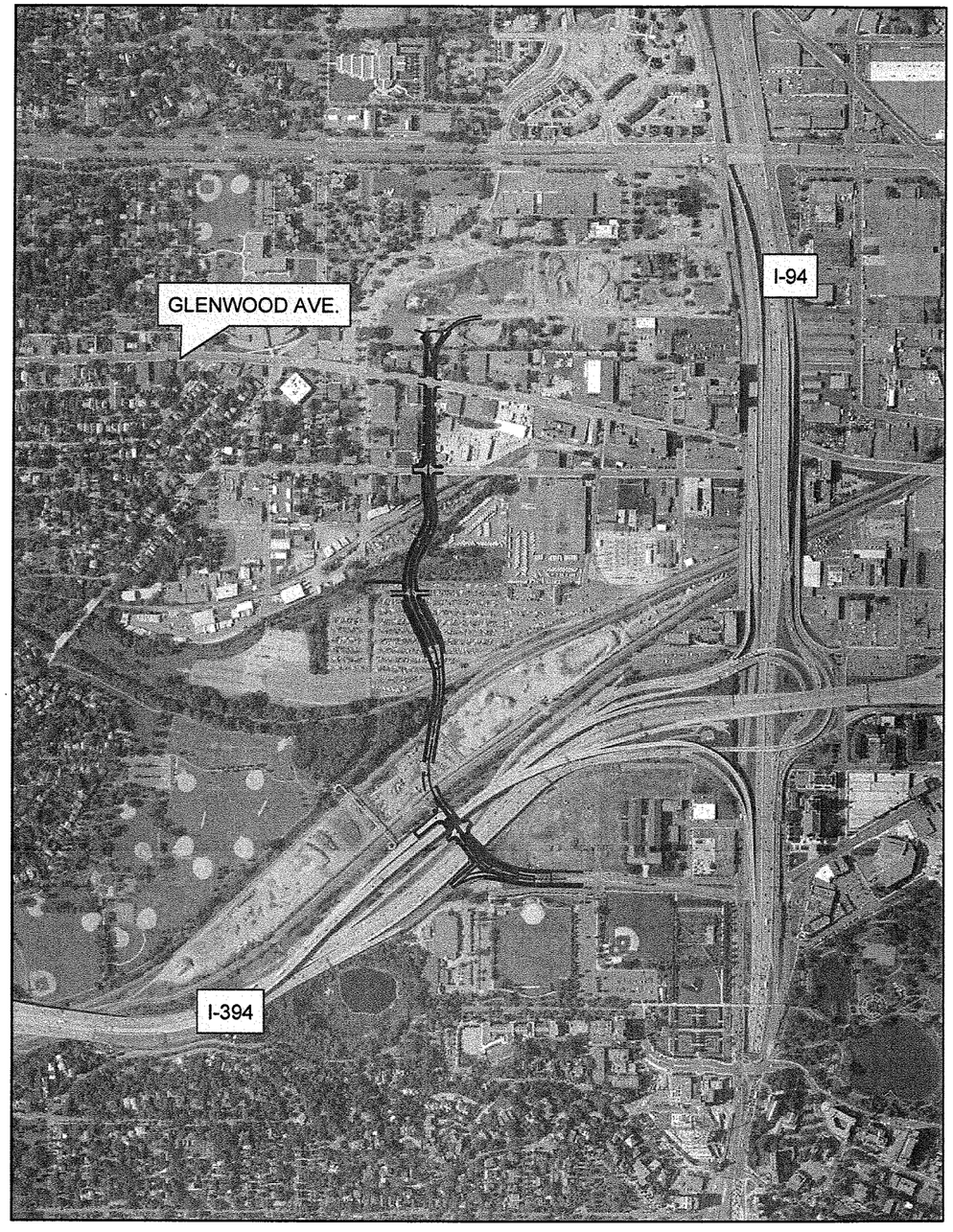
Plates



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers®

GENERAL PROJECT LOCATION - VAN WHITE MEMORIAL BOULEVARD

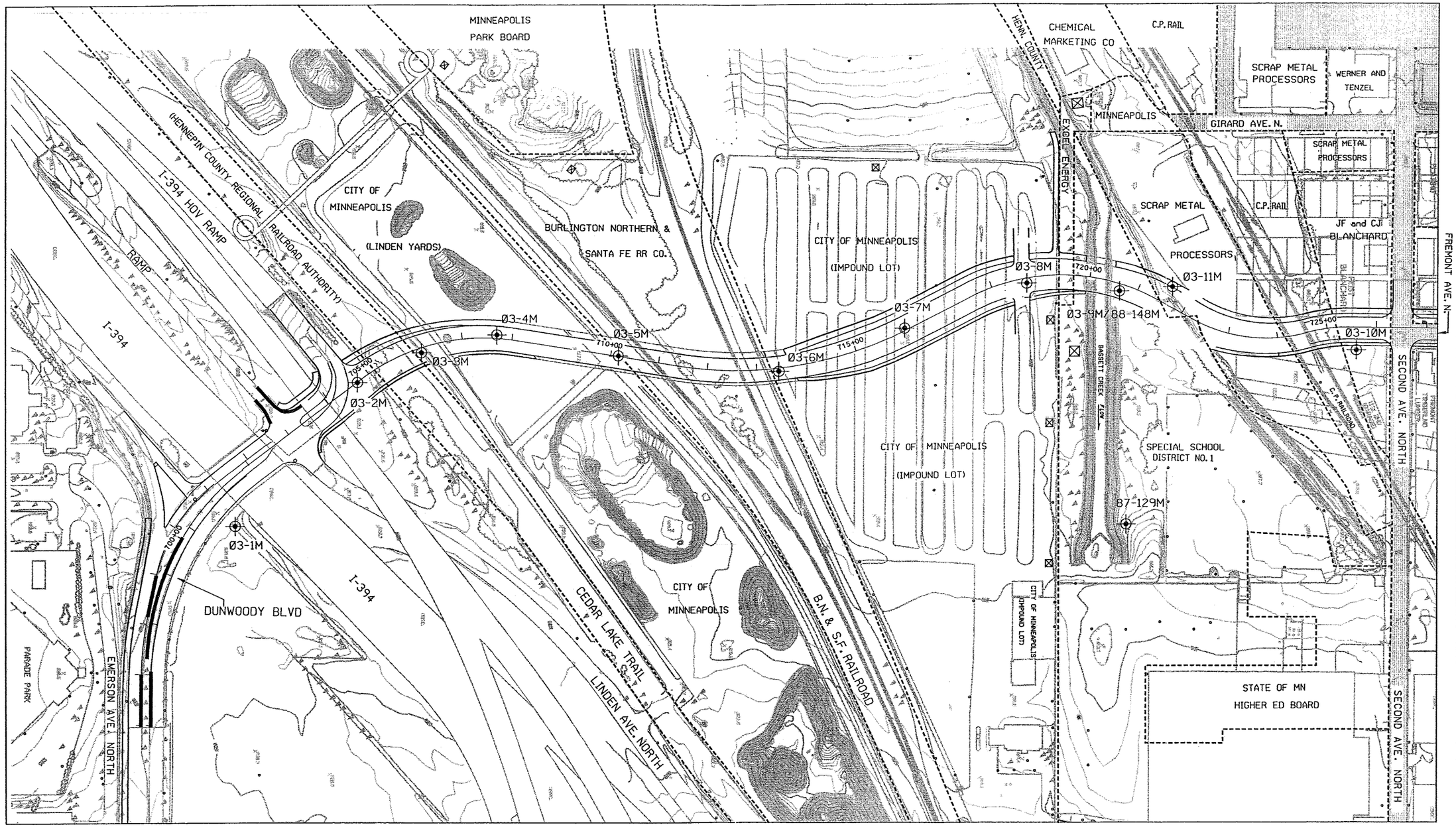
600 0 600 1,200 1,800 2,400
Feet

N

Plate 1

= PROPERTY BOUNDARIES

NOTE: PROPERTY BOUNDARIES AS SHOWN ARE APPROXIMATE.



= SOIL BORING LOCATION

03-1M YEAR OF BORING, BORING NUMBER, BORING TYPE (M = MACHINE)

DRAFTED BORING STAFF 87-129M NOT SHOWN ON PLATES, BUT TEST DATA WAS USED FOR ANALYSIS. TO VIEW BORING LOG CALL (651) 290-5599.

100 0 100 200
SCALE IN FEET

US Army Corps of Engineers
St. Paul District

Symbol	Description	Date	Appr.

DESIGNED: GAR
DRAWN:
CHECKED:
SCALE: AS SHOWN
CADD FILE NAME:
SOL. NO: 0-03
DESIGNED:
CHECKED:
DATE: JAN. 2004
AE APPROVING OFFICIAL:

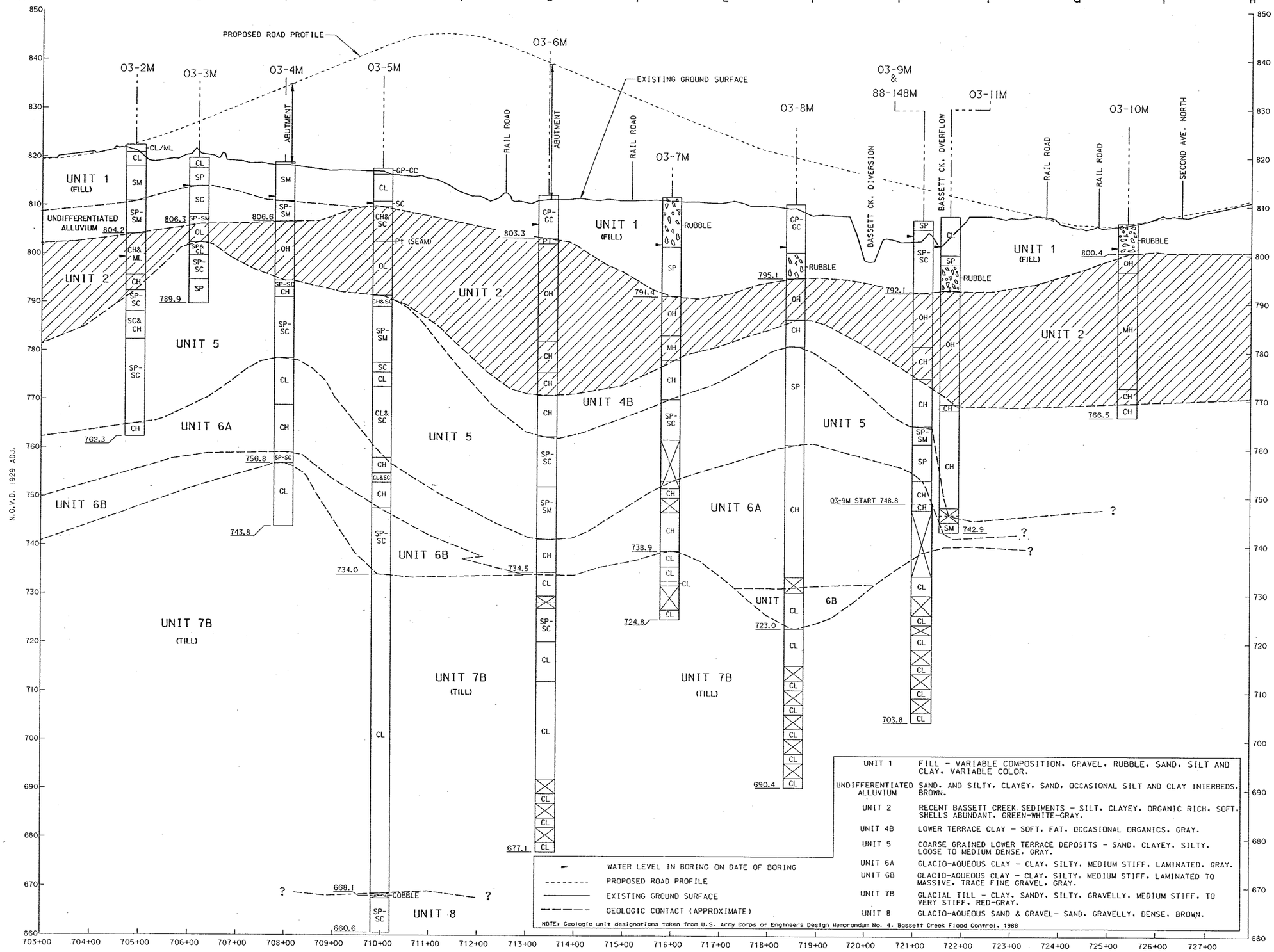
DEPARTMENT OF THE ARMY
ST. PAUL, MINNESOTA
CORPS OF ENGINEERS
ST. PAUL DISTRICT

VAN WHITE MEMORIAL BOULELVARD
MINNEAPOLIS, MINNESOTA

GEOTECHNICAL SOIL BORING LOCATIONS

DRAWING NUMBER:
Plate 2

SHT OF



GEOLOGIC PROFILE ALONG PROPOSED ALIGNMENT - VAN WHITE MEMORIAL BOULEVARD

US Army Corps of Engineers
St. Paul District

Symbol	Description	Date	Appr.

DESIGNED: CWB/KSN
CHECKED: GAR
DRAWN: KSN/GAR
XXX/XXX
CHECKED: XXX/XXX
SCALE: AS SHOWN
DATE: APRIL 2004
CADD FILE NAME: CROSS_SECTION.DGN
SOL. NO.:
AE APPROVING OFFICIAL:

DEPARTMENT OF THE ARMY
ST. PAUL, MINNESOTA
CORPS OF ENGINEERS
ST. PAUL DISTRICT

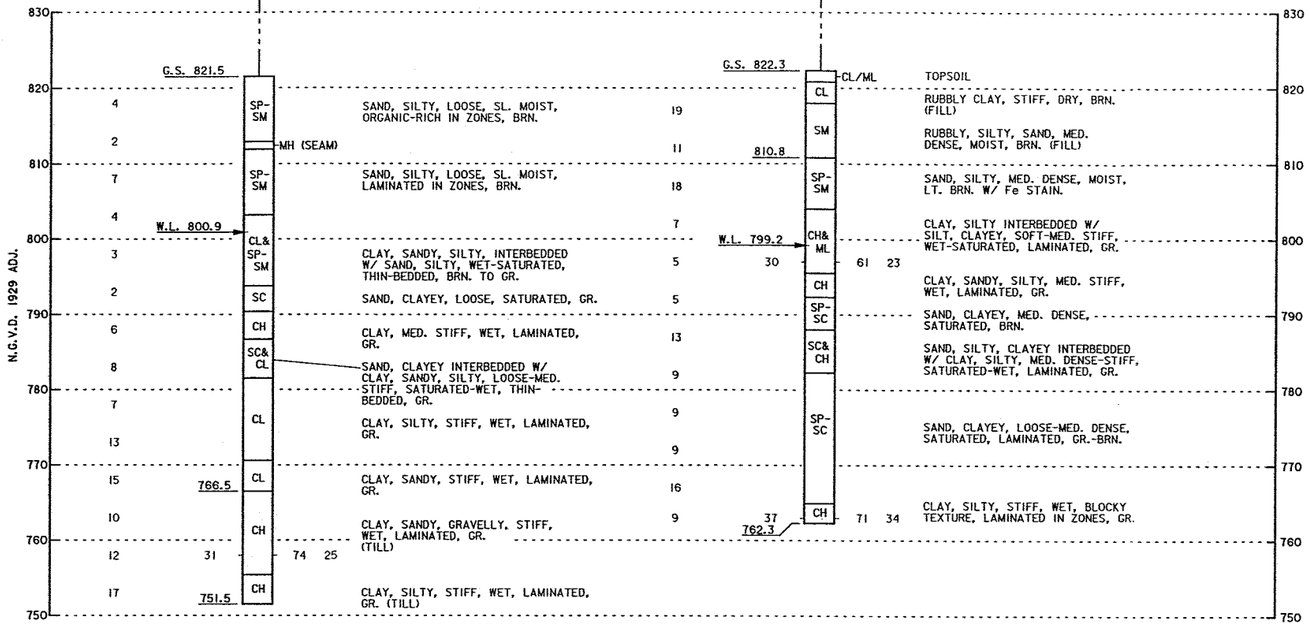
VAN WHITE MEMORIAL BOULEVARD
MINNEAPOLIS, MINNESOTA

GEOLOGIC DATA

GEOLOGIC PROFILE
CENTER LINE OF
PROPOSED ROAD ALIGNMENT

DRAWING NUMBER:
PLATE 3
SHT OF

03-1M
13 NOVEMBER 2003



NOTES

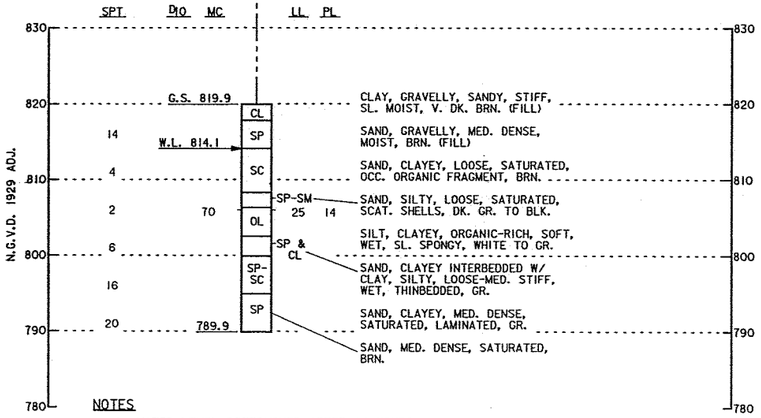
1. WATER LEVEL DETERMINED AFTER 30 MINUTES..
   HOLLOW STEM AUGER SET TO EL. 801.5'.
   HOLE OPEN TO EL. 800.2'.
2. HOLLOW STEM AUGER SET TO EL. 756.5'.
3. SAMPLES BETWEEN EL. 821.5'- 801.5' FIELD SCREENED W/ P.I.D.
3. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

03-2M
14 NOVEMBER 2003

NOTES

1. WATER LEVEL DETERMINED AFTER 60 MINUTES.
   HOLLOW STEM AUGER SET TO EL. 797.3'.
   HOLE OPEN TO EL. 793.2'.
2. HOLLOW STEM AUGER SET TO EL. 767.3'.
3. SAMPLES BETWEEN EL. 822.3'- 802.3' FIELD SCREENED W/ P.I.D.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

03-3M
14 NOVEMBER 2003



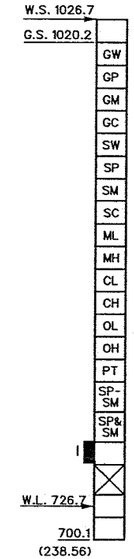
NOTES

1. WATER LEVEL DETERMINED AFTER 14 HOURS.
   HOLLOW STEM AUGER SET TO EL. 791.9'.
   THEN WITHDRAWN.
   HOLE OPEN TO EL. 793.2'.
2. HOLLOW STEM AUGER SET TO EL. 791.9'.
3. SAND HEAVING INTO HOLE BELOW EL. 791.9'.
4. SAMPLES BETWEEN EL. 819.9'- 809.9' FIELD SCREENED W/ P.I.D.
3. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

GENERAL BORING LEGEND

84-1M — YEAR OF BORING-BORING NUMBER, BORING TYPE (EG: M-MACHINE, A-AUGER, TP-TEST PIT, P-PIEZOMETER).

1 MAY 1984 — DATE OF BORING



WATER SURFACE ELEVATION ON DAY OF BORING
GROUND SURFACE ELEVATION AT BORING
WELL GRADED GRAVELS, GRAVEL - SAND MIXTURE, LITTLE OR NO FINES
POORLY GRADED GRAVELS, LITTLE OR NO FINES
SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SILTY SANDS, SAND - SILT MIXTURES
CLAYEY SANDS, SAND - CLAY MIXTURES
INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50
INORGANIC CLAYS, LOW TO MEDIUM PLASTICITY, LIQUID LIMIT LESS THAN 50
INORGANIC CLAYS, HIGH TO PLASTICITY, LIQUID LIMIT GREATER THAN 50
ORGANIC SILTS OR CLAYS, LOW PLASTICITY, LIQUID LIMIT LESS THAN 50
ORGANIC SILTS OR CLAYS, MEDIUM TO HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
PEAT
BORDERLINE MATERIAL
STRATIFIED MATERIAL
LOCATION AND SAMPLE NUMBER FOR UNDISTURBED SAMPLE
NO RECOVERY
WATER LEVEL ON DATE OF BORING
ELEVATION AT BOTTOM OF BORING
ELEVATION IN METERS

GENERAL BORING NOTES

1. GENERAL: THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. THE LEGEND REPRESENTS ONLY THE BASIC SOILS. TO COMPLETE THE CLASSIFICATION, PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING STAFF, NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

2. MOISTURE CONTENT: THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (MC) IS SHOWN TO THE LEFT OF THE BORING STAFF.

3. BLOW COUNT (SPT): BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTED, ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12". STANDARD BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST (SPT) USING A 1⅜" X 2" SAMPLER, 140 LB. HAMMER AND A 30" DROP. FOR NON-STANDARD BLOW COUNTS, SAMPLER SIZE, HAMMER WEIGHT AND HEIGHT OF DROP ARE AS SHOWN.

4. ATTERBERG LIMITS: LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO THE RIGHT OF THE BORING STAFF.

5. D_{10} SIZE: THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO THE LEFT OF THE BORING STAFF.

6. RQD: ROCK QUALITY DESIGNATION (RQD) IS SHOWN TO THE LEFT OF THE PERCENT RECOVERY COLUMN. ROD IS THE PERCENT RECOVERY CONSISTING OF UNBROKEN PIECES LONGER THAN 4".

7. % RECOVERY: PERCENT CORE RECOVERY IS SHOWN TO THE LEFT OF THE BORING STAFF. PERCENT RECOVERY IS LENGTH OF CORE RECOVERED/LENGTH OF CORE CUT X 100. UNLESS SPECIFIED OTHERWISE, ALL CORE IS 4" DIAMETER.

8. ELEVATIONS REFERENCED TO N.G.V.D. 1929 ADJ.

9 THE BORINGS SHOW SUMMARIES OF INFORMATION RECORDED ON THE ORIGINAL FIELD LOGS. THESE LOGS ARE AVAILABLE FOR INSPECTION AT THE ST. PAUL DISTRICT OFFICE. ARRANGEMENTS TO INSPECT LOGS CAN BE MADE BY CALLING (651) 290-5599.

Plate 4

US Army Corps of Engineers
St. Paul District

Symbol	Description	Date	Appr

DESIGNED: GAR
DRAWN: G.R.S.
CHECKED: GAR
DESIGNED:
CHECKED:
SCALE: AS SHOWN
DATE: MAR. 2004
CADD FILE NAME: wfo01b00001.DGN
SOL. NO.: DACW37-99-B-0000
AE APPROVING OFFICIAL:

DEPARTMENT OF THE ARMY
ST. PAUL, MINNESOTA
CORPS OF ENGINEERS
ST. PAUL DISTRICT

VAN WHITE MEMORIAL BOULEVARD
MINNEAPOLIS, MINNESOTA
GEOLOGIC DATA
LEGEND, GENERAL NOTES & BORING LOGS: 03-1M, 2M & 3M

DRAWING NUMBER:
M34.3-S-10/122
SHT 1 OF 4

03-4M
15 NOVEMBER 2003

SPT	D_{10}	MC	LL	PL		
		G.S. 818.8				
7		W.L. 811.7			SM	SAND, SILTY, GRAVELLY, W/ RUBBLE, LOOSE-MED. DENSE, SL. MOIST TO WET, MULTI-COLORED. (FILL)
3		810.8			SP-SM	SAND, SILTY, LOOSE, SATURATED, GR.
6						
	126		147	65	OH	SILT, SANDY, ORGANIC-RICH, SOFT, SATURATED, ABUNDANT SHELLS, GRN. TO GR.
1	101		155	69		
10					SP-SC	SAND, CLAYEY, MED. DENSE, SATURATED, GR.
					CH	Pt (SEAM)
9						CLAY, SILTY, MED. STIFF, WET, MEALY TEXTURE, GR.
12					SP-SC	SAND, CLAYEY, MED. DENSE, SATURATED, GR.
14	32		44	23		
10					CL	CLAY, SILTY, MED. STIFF-STIFF, WET, LAMINATED IN ZONES, GR.
6	43		84	32		
5					CH	CLAY, SILTY, MED. STIFF, WET, LAMINATED TO MASSIVE, GR.
14		756.8			SP-SC	SAND, CLAYEY, MED. DENSE, SAT., BRN.
16	16		27	14		
23					CL	CLAY, GRAVELLY, SANDY, STIFF, WET, GR. (TILL)
14	22		36	15		
		743.8				

NOTES
1. WATER LEVEL DETERMINED AFTER 60 MINUTES. HOLLOW STEM AUGER SET TO EL. 808.8'. HOLE OPEN TO EL. 807.0'.
2. HOLLOW STEM AUGER SET TO EL. 748.8'. AUGER KEPT FULL WITH CLEAN H_2O BELOW EL. 790.8'.
3. SAND HEAVING INTO HOLE BELOW EL. 790.8'.
4. SAMPLES BETWEEN EL. 818.8'– 798.8' FIELD SCREENED W/ P.I.D.
5. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

03-5M
19-21 NOVEMBER 2003

SPT	D_{10}	MC	LL	PL		
		G.S. 817.6				
9		810.8			GP-GC	GRAVEL, RUBBLY, CLAYEY, LOOSE-MED. STIFF, MOIST, BRN. (FILL)
		APPROX. W.L. 810.4			CL	CLAY, RUBBLY, GRAVELLY, MED. STIFF, MOIST-WET, BRN. TO BLUE GR. (FILL)
3					SC	
2					CH& SC	SAND, CLAYEY, LOOSE, WET-SATURATED, BRN. TO GR.
					Pt (SEAM)	CLAY, SILTY INTERBEDDED W/ SAND, CLAYEY, SOFT-LOOSE, WET-SATURATED, MED. BEDDED, BLUE-GR. TO BRN.
2					OL	SILT, CLAYEY, ORGANIC-RICH, SOFT, WET, SPONGY, ABUNDANT SHELLS, GRN.-GR.
2					CH & SC	CLAY, SILTY, INTERBEDDED W/ SAND, CLAYEY, MED. STIFF-LOOSE, WET, STICKY IN ZONES, MED. BEDDED, GR.
7						
9					SP-SM	SAND, SILTY, LOOSE-MED. DENSE, SATURATED, GR.
6					SC	SAND, CLAYEY, LOOSE, SATURATED, GR.
5					CL	CLAY, SANDY, MED. STIFF, WET, CRUMBLY TEXTURE, GR.
6					CL& SC	CLAY, SANDY INTERBEDDED W/ SAND, CLAYEY, MED. STIFF-LOOSE, WET, MED. BEDDED, GR.
14						
16					CH	CLAY, SILTY, MED. STIFF, WET, GR.
7					CL&SC	CLAY, SANDY INTERBEDDED W/ SAND, CLAYEY, MED. STIFF-LOOSE, WET, MED. BEDDED, GR.
36			68	24	CH	CLAY, SILTY, STIFF, WET, LAMINATED, GR.
13						
22					SP-SC	SAND, GRAVELLY, CLAYEY, MED. DENSE, SATURATED, BRN.
12						
		734.0				
20						
15			26	13		
16						
20						
14			28	14		
23						
19						
24			28	15		
16						
22						
13			28	14	CL	CLAY, SANDY, GRAVELLY, STIFF-V. STIFF, WET, GR. (TILL)
22						
11			25	12		
19						
23						
13			25	13		
38						
32						
56			25	14		
13						
		668.1			ROCK	
33						
43					SP-SC	SAND, GRAVELLY, CLAYEY, DENSE, WET-SATURATED, BRN.
		660.6				

NOTES
1. WATER LEVEL LOGGED AS A DRILLING ENCOUNTER.
2. HOLLOW STEM AUGER SET TO EL. 803.6'. HOLE STABILIZED W/ DRILLING MUD BELOW EL. 803.6'.
3. SAMPLES BETWEEN EL. 817.6'– 797.6' FIELD SCREENED W/ P.I.D.
5. HOLE BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.

03-6M
22-25 NOVEMBER 2003

SPT	D_{10}	MC	LL	PL		
		G.S. 812.1				ASPHALT PARKING LOT
10		W.L. 806.1			GP-GC	GRAVEL, SILTY, SANDY, CLAYEY, MED. DENSE, MOIST TO SATURATED, ASPHALT STAINED, BRN. TO BLK. (FILL)
2		803.3			Pt	PEAT, SANDY, SOFT, WET, SPONGY, SL. PETROLEUM ODOR, BRN.-BLK.
2	161		97	70		
2	113		146	73	OH	SILT, CLAYEY, ORGANIC-RICH, SOFT-LOOSE, WET-SATURATED, SPONGY, ABUNDANT SHELLS, GRN.
4						
3	119		89	60		
4	103		165	55	CH	CLAY, SILTY, SOFT, WET, SPONGY, GRN.
1	87		182	43	CH	CLAY, SILTY, SOFT, WET, SPONGY, LAMINATED, GR. W/ GRN. MOTTLE.
0	62	2	70	24	CH	CLAY, SILTY, SOFT, WET, STICKY, GR.
6						
18					SP-SC	SAND, CLAYEY, MED. DENSE-LOOSE, SATURATED, GR.
6						
23					SP-SM	SAND, SILTY, GRAVELLY, MED. DENSE-DENSE, SATURATED, GR.
30						
8	40		83	25	CH	CLAY, SILTY, MED. STIFF, WET, LAMINATED, GR.
		734.5				
13					CL	CLAY, GRAVELLY, SANDY, STIFF, WET, RED-GR. (TILL)
22	17		22	12		
16					SP-SC	SAND, GRAVELLY, CLAYEY, MED. DENSE, WET, BRN.
16						
12	18	3	32	14	CL	CLAY, GRAVELLY, SANDY, MED. STIFF-STIFF, WET, RED-GR. (TILL)
14						
15	18		28	14		
12	16		18	13	CL	CLAY, GRAVELLY, SANDY, MED. STIFF-STIFF, WET, GR. (TILL)
16						
11						
19	14		24	14		
25	677.1					

NOTES
1. WATER LEVEL DETERMINED AFTER 30 MINUTES. HOLLOW STEM AUGER SET TO EL. 802.1' HOLE OPEN TO EL. 801.5'.
2. HOLLOW STEM AUGER SET TO EL. 782.1'. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 782.1'.
3. ROUGH DRILLING ACTION BETWEEN EL. 727.1'– EL. 717.1' DUE TO LARGE COBBLES.
4. FIVE-INCH UNDISTURBED SAMPLES TAKEN IN OFFSET BOREHOLE.
3. HOLE BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.

N.G.V.D. 1929 ADJ.

Plate 5

US Army Corps of Engineers
St. Paul District

Symbol	Description	Date	Appr.

DESIGNED: CAD	SCALE: AS SHOWN	DATE: MAR. 2004	
CHECKED: CAR	CADD FILE NAME: wf01015002.dgn		
DRAWN: G.R.S.	SOL. NO: DACW37-02-B-0000	AE APPROVING OFFICIAL:	
DESIGNED	CHECKED		

E0-D E0-H

DEPARTMENT OF THE ARMY
ST. PAUL, MINNESOTA
CORPS OF ENGINEERS
ST. PAUL DISTRICT

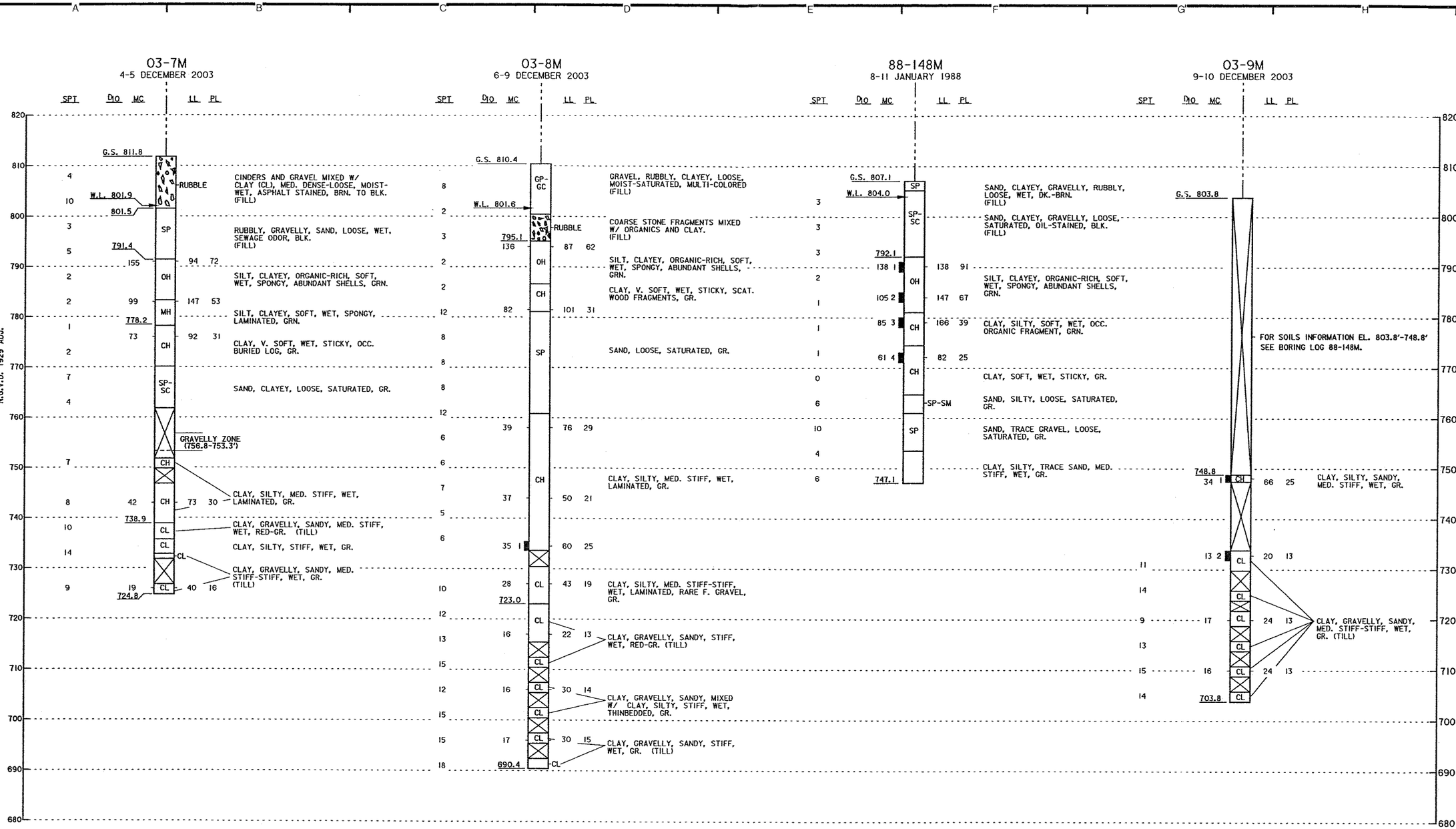
VAN WHITE MEMORIAL BOULELVARD
MINNEAPOLIS, MINNESOTA

GEOLOGICAL DATA

BORING LOGS: 03-4M, 03-5M & 03-6M

DRAWING NUMBER:
M34.3-S-10/123

SHT 2 OF 4



NOTES

1. WATER LEVEL DETERMINED AFTER 20 MINUTES. HOLLOW STEM AUGER SET TO EL. 796.8'. HOLE OPEN TO EL. 796.0'.
2. HOLLOW STEM AUGER SET TO EL. 772.8'. HOLE STABILIZED W/ DRILLING MUD BETWEEN EL. 772.8'-751.8'. HOLLOW STEM AUGER RESET TO EL. 751.8'. HOLE STABILIZED W/ DRILLING MUD BELOW EL. 751.8'.
4. SAMPLES BETWEEN EL. 811.8'- 791.8' FIELD SCREENED W/ P.I.D.
3. HOLE BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE.

NOTES

1. WATER LEVEL DETERMINED AFTER 30 MINUTES. HOLLOW STEM AUGER SET TO EL. 795.4'. HOLE OPEN TO EL. 795.4'.
2. HOLLOW STEM AUGER SET TO EL. 782.4'. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 782.4'.
3. THREE-INCH SHELBY PUSH-TYPE UNDISTURBED SAMPLES TAKEN IN PILOT BORING.
4. SAMPLES BETWEEN EL. 810.4'- 800.4' FIELD SCREENED W/ P.I.D.
5. HOLE BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.

NOTES

1. BORING 88-148M ORIGINALLY COMPLETED FOR BASSETT CREEK STORM TUNNEL PROJECT. NEAR SURFACE GROUND CONDITIONS MAY BE ALTERED BY CONSTRUCTION ACTIVITIES.
2. WATER LEVEL DETERMINED AFTER 10 MINUTES. HOLLOW STEM AUGER SET TO EL. 802.1' HOLE OPEN TO EL. 799.7'.
3. HOLLOW STEM AUGER SET TO EL. 798.6'. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 798.6'.
4. FIVE-INCH UNDISTURBED SAMPLES TAKEN IN OFFSET BORING.

NOTES

1. BORING 03-9M IS AN OFF-SET CONTINUATION OF BORING LOG 88-148M.
2. WATER LEVEL NOT DETERMINED.
3. HOLLOW STEM AUGER SET TO EL. 733.8'. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 733.8'.
4. HOLE BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.

US Army Corps of Engineers
St. Paul District

Symbol	Description	Date	Appr.

DESIGNED: SAR
DRAWN: CAR
CHECKED: CAR
E0-03

DESIGNED: G.R.S.
DRAWN: G.R.S.
CHECKED:
H-03

DATE: MAR. 2004
SCALE: AS SHOWN
CADD FILE NAME: wfo10\b003.dgn
SOL. NO: DACW37-02-B-0000
AE APPROVING OFFICIAL:

DEPARTMENT OF THE ARMY
ST. PAUL MINNESOTA
CORPS OF ENGINEERS
ST. PAUL DISTRICT

VAN WHITE MEMORIAL BOULEVARD
MINNEAPOLIS, MINNESOTA

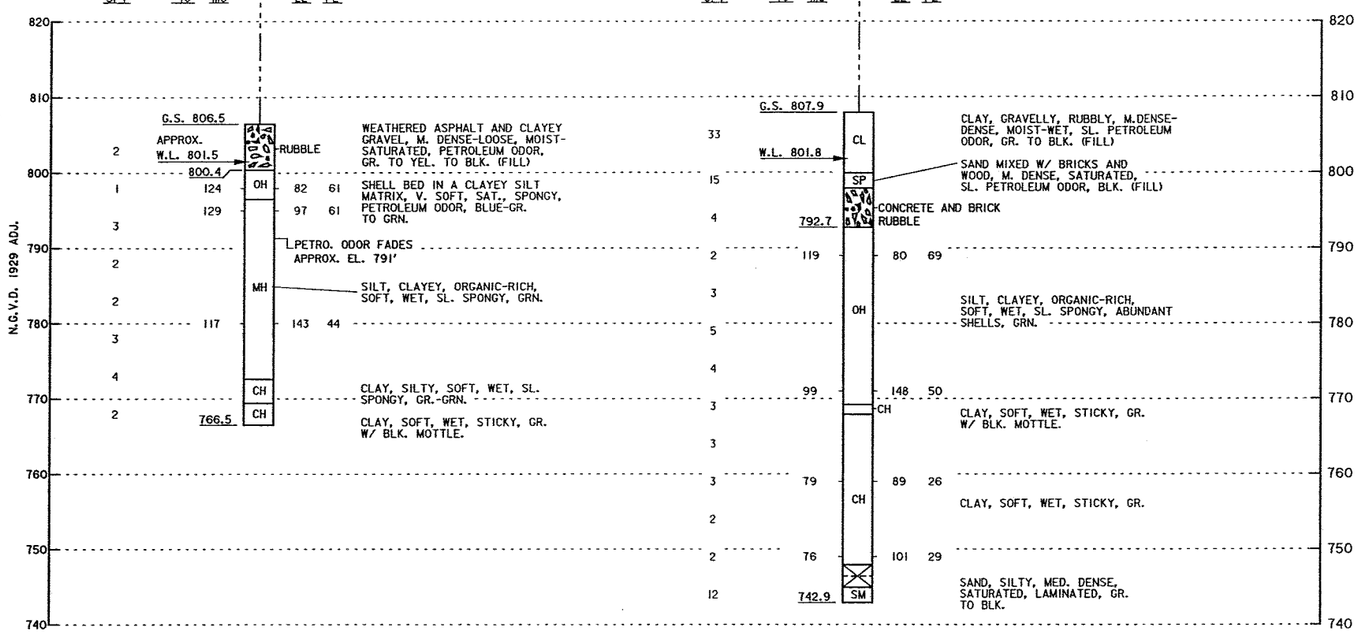
GEOLOGICAL DATA

BORING LOGS: 03-7M, 03-8M, 03-9M & 88-148M

DRAWING NUMBER:
M34.3-S-10/124
SHT 3 OF 4

Plate 6

03-10M
11 DECEMBER 2003



NOTES

1. WATER LEVEL LOGGED AS A DRILLING ENCOUNTER.
2. HOLLOW STEM AUGER SET TO EL. 771.5'.
3. SAMPLES BETWEEN EL. 806.5 - 781.5' FIELD SCREENED W/ P.I.D.
4. HOLE DRY UPON COMPLETION. HOLE BACKFILLED BY POURING 3/8-INCH BENTONITE CHIPS THROUGH THE AUGER FROM GROUND SURFACE.

03-11M
12 DECEMBER 2003

NOTES

1. WATER LEVEL DETERMINED AFTER 30 MINUTES. HOLLOW STEM AUGER SET TO EL. 797.9', HOLE OPEN TO EL. 796.6'. W.S. EL. IN ADJACENT BASSETT CREEK = 802.97'
2. HOLLOW STEM AUGER SET TO EL. 744.9'.
3. SAMPLES BETWEEN EL. 807.9 - 787.9' FIELD SCREENED W/ P.I.D.
4. HOLE BACKFILLED WITH TREMIED HIGH SOLIDS BENTONITE GROUT.

Plate 7

US Army Corps of Engineers
St. Paul District

Symbol	Description	Date	Appr.

DESIGNED: | SCALE: AS SHOWN | DATE: MAR. 2004
CHECKED: GAR | CADD FILE NAME: wf01b004.dgn
DRAWN: G.R.S. | SOL. NO: DACW37-02-B-0000
DESIGNED: | CHECKED: | AE APPROVING OFFICIAL:
G-03 | H-03

DEPARTMENT OF THE ARMY
ST. PAUL, MINNESOTA
CORPS OF ENGINEERS
ST. PAUL DISTRICT

VAN WHITE MEMORIAL BOULEVARD
MINNEAPOLIS, MINNESOTA
GEOLOGICAL DATA
BORING LOGS: 03-10M & 03-11M

DRAWING NUMBER:
M34.3-S-10/125
SHT 4 OF 4

Soils Information Worksheet
Project: Van White Memorial Boulevard
Unit: 2

TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_S	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)
					1		109.0			0.50		2.88	41.1	85.9	87.3
1	87-129MU	13.0	796.8	1	2	167	108.0	51	116	0.49	2.55	2.74	42.5	88.4	88.3
					3		107.0			0.48		2.75	42.4	87.8	88.2
					1		108.0			0.49		2.69	43.1	89.6	88.6
2	87-129MU	13.0	796.8	1	2	167	109.0	51	116	0.50	2.55	2.72	42.8	89.5	88.4
					3		109.0			0.50		2.72	42.8	89.5	88.4
					1		164.0			1.55		4.36	29.5	77.9	80.2
3	88-148MU	17.0	790.1	1	2	138	148.0	91	47	1.21	2.53	3.89	32.3	80.1	81.9
					3		142.0			1.09		2.85	32.6	78.9	87.2
					1		143.3			1.11		3.72	33.4	81.3	82.6
4	88-148MU	17.0	790.1	1	2	138	142.3	91	47	1.09	2.53	3.67	33.8	81.9	82.8
					3		143.0			1.11		3.67	33.8	82.1	82.8
5	88-148MU	17.0	790.1	1	1	138	137.5	91	47	0.99	2.53	3.61	34.2	81.2	83.1
					1		101.0			0.43		2.80	43.1	86.6	89.0
6	88-148MU	23.0	784.1	2	2	147	105.0	67	80	0.48	2.62	2.88	42.2	86.5	88.5
					3		107.0			0.50		2.94	41.5	85.9	88.1
7	88-148MU	23.0	784.1	2	1	147	101.8	67	80	0.44	2.62	2.69	44.3	89.4	89.8
					1		102.0			0.50		2.69	43.7	88.3	89.1
8	88-148MU	28.0	779.1	3	2	166	105.0	39	127	0.52	2.58	2.78	42.5	87.1	88.5
					3		107.0			0.54		2.87	41.6	86.1	87.9
9	88-148MU	28.0	779.1	3	1	166	106.7	39	127	0.53	2.58	2.80	42.4	87.6	88.3
10	88-148MU	28.0	779.1	3	1	166	85.3	39	127	0.36	2.58	2.29	49.0	90.8	92.4
					1		108.7			0.49		2.98	40.9	85.4	87.6
11	03-6MU	20.7	791.4	1	2	146	108.1	73	73	0.48	2.61	2.98	41.0	85.3	87.6
					3		112.7			0.54		3.13	39.5	84.0	86.7
					1		114.5			0.57		3.20	38.8	83.2	86.3
12	03-6MU	20.7	791.4	1	2	146	115.4	73	73	0.58	2.61	3.22	38.6	83.1	86.2
					3		115.8			0.59		3.23	38.5	83.1	86.2
13	03-6MU	20.7	791.4	1	1	146	113.4	73	73	0.55	2.61	3.10	39.8	84.9	86.9
	AVERAGE	19.8	789.1			152	116.5	66	86	0.66	2.57	3.06	39.7	85.2	86.9
	MAXIMUM	28.0	796.8			167	164.0	91	127	1.55	2.62	4.36	49.0	90.8	92.4
	MINIMUM	13.0	779.1			138	85.3	39	47	0.36	2.53	2.29	29.5	77.9	80.2

Plate 8

PLATE NO.

Soils Information Worksheet
Project: Van White Memorial Boulevard
Unit: 4B

TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_S	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)
					1		64.1			0.96		1.65	63.0	103.4	101.7
1	87-129MU	16.0	793.8	2	2	66	66.1	21	45	1.00	2.67	1.70	61.7	102.5	101.0
2	87-129MU	16.0	793.8	2	1	66	53.4	21	45	0.72	2.67	1.41	69.3	106.3	105.6
					1		74.6			0.87		2.05	54.6	95.3	96.6
3	88-148MU	35.0	772.1	4	2	82	65.0	25	57	0.70	2.67	1.75	60.5	99.8	100.3
					3		61.0			0.63		1.61	63.7	102.6	102.3
4	88-148MU	35.0	772.1	4	1	82	61.1	25	57	0.63	2.67	1.65	63.0	101.5	101.7
					1		62.3			0.83		1.73	61.9	100.5	101.5
5	03-6MU	43.8	768.3	2	2	70	62.4	24	46	0.83	2.71	1.76	61.3	99.6	101.1
					3		62.7			0.84		1.78	60.8	98.9	100.8
					1		61.2			0.81		1.66	63.5	102.4	102.5
6	03-6MU	43.8	768.3	2	2	70	61.1	24	46	0.81	2.71	1.69	63.0	101.5	102.1
					3		61.3			0.81		1.68	63.2	101.9	102.2
7	03-6MU	43.8	768.3	2	1	70	64.1	24	46	0.87	2.71	1.82	60.1	98.6	100.2
	AVERAGE	35.3	774.9			73	62.9	24	49	0.81	2.69	1.71	62.1	101.1	101.4
	MAXIMUM	43.8	793.8			82	74.6	25	57	1.00	2.71	2.05	69.3	106.3	105.6
	MINIMUM	16.0	768.3			66	53.4	21	45	0.63	2.67	1.41	54.6	95.3	96.6

Plate 9

PLATE NO.

Soils Information Worksheet
Project: Van White Memorial Boulevard
Unit: 6A

TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_S	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)
					1		35.6			0.30		0.97	86.0	116.6	116.6
1	03-8M	75.9	734.5	1	2	60	36.0	25	35	0.31	2.71	0.97	85.8	116.7	116.6
					3		34.3			0.27		0.96	86.4	116.0	116.8
					1		32.5			0.21		0.91	88.5	117.3	118.3
2	03-8M	75.9	734.5	1	2	60	32.7	25	35	0.22	2.71	0.92	88.3	117.2	118.0
3	03-8M	75.9	734.5	1	1	60	39.1	25	35	0.40	2.71	1.05	82.4	114.6	114.5
					1		26.7			0.04		0.75	96.1	121.8	123.0
4	03-9M	55.7	748.1	1	2	66	28.4	25	41	0.08	2.70	0.81	93.3	119.8	121.0
					3		31.9			0.17		0.88	89.5	118.1	118.8
					1		40.0			0.37		1.11	80.0	112.0	112.7
5	03-9M	55.7	748.1	1	2	66	39.3	25	41	0.35	2.70	1.10	80.4	112.0	112.9
6	03-9M	55.7	748.1	1	1	66	37.9	25	41	0.31	2.70	1.02	83.6	115.3	114.9
AVERAGE		65.8	741.3			63	34.5	25	38	0.25	2.71	0.95	86.7	116.4	117.0
MAXIMUM		75.9	748.1			66	40.0	25	41	0.40	2.71	1.11	96.1	121.8	123.0
MINIMUM		55.7	734.5			60	26.7	25	35	0.04	2.70	0.75	80.0	112.0	112.7

Plate 10

PLATE NO.

Soils Information Worksheet

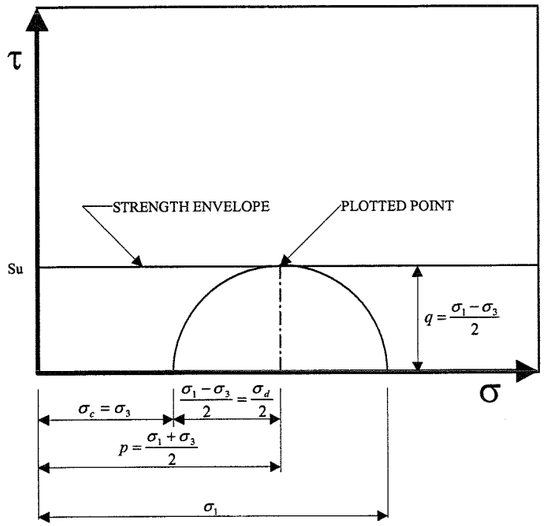
Project: Van White Memorial Boulevard

Unit: 7B

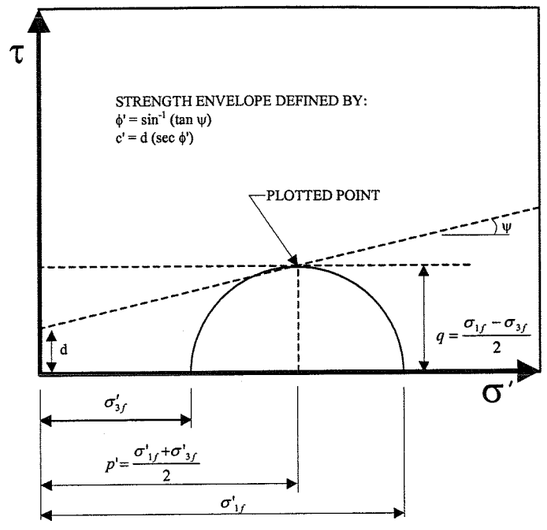
TEST NO.	BORING NO.	MID-DEPTH (feet)	ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_S	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)
					1		18.9			0.27		0.50	110.7	131.6	131.9
1	03-6MU	98.0	714.1	3	2	32	18.6	14	18	0.26	2.67	0.49	112.0	132.8	132.3
					3		18.0			0.22		0.48	112.2	132.4	132.8
					1		16.8			-0.90		0.44	115.8	135.3	136.5
2	03-6MU	98.0	714.1	3	2	32	17.2	14	18	0.18	2.67	0.46	113.9	133.5	133.8
3	03-6MU	98.0	714.1	3	1	32	19.8	14	18	0.32	2.67	0.52	109.7	131.4	131.0
					1		15.1			0.30		0.37	121.6	140.0	138.5
4	03-9M	71.0	732.8	2	2	20	14.0	13	7	0.14	2.67	0.32	126.0	143.6	141.3
					3		11.2			-0.26		0.26	132.7	147.6	145.1
					1		9.9			-0.44		0.25	132.8	145.9	145.8
5	03-9M	71.0	732.8	2	2	20	14.3	13	7	0.19	2.67	0.37	121.7	139.1	138.5
6	03-9M	71.0	732.8	2	1	20	16.3	13	7	0.47	2.67	0.44	115.5	134.3	134.8
	AVERAGE	84.5	723.5			26	15.8	14	12	0.06	2.67	0.41	118.7	137.3	136.8
	MAXIMUM	98.0	732.8			32	19.8	24	18	0.47	2.71	0.52	132.8	147.6	145.8
	MINIMUM	71.0	714.1			20	9.9	13	7	-0.90	2.67	0.25	109.7	131.4	131.0

Plate 11

PLATE NO.

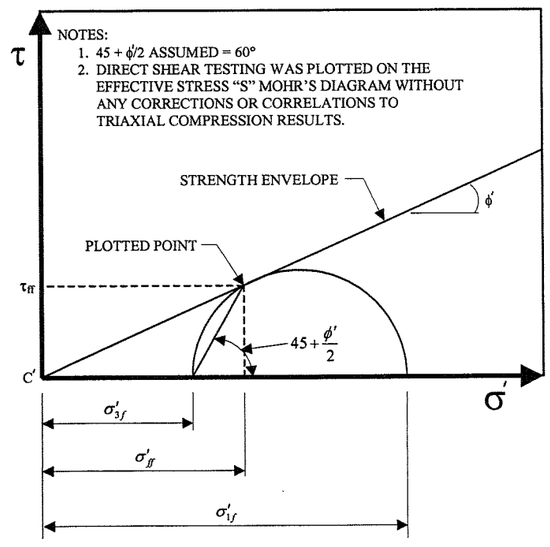


UU MOHR'S DIAGRAM



CD MOHR'S DIAGRAM

(Stresses on the plane of maximum shear stress)



CD MOHR'S DIAGRAM

(Stresses on the failure plane)

NOTATION

σ	NORMAL STRESS
σ_c	CONFINING STRESS
σ_d	DEVIATOR STRESS
σ_1	MAJOR PRINCIPAL STRESS
σ_3	MINOR PRINCIPAL STRESS
σ_{fc}, σ_{ff}	NORMAL STRESS ON THE FAILURE PLANE AT CONSOLIDATION, FAILURE
τ	SHEAR STRESS
τ_{fc}, τ_{ff}	SHEAR STRESS ON THE FAILURE PLANE AT CONSOLIDATION, FAILURE

UNIT WEIGHT EQUATIONS

$$\gamma_m = (1+w)\gamma_d$$

$$\gamma_{sat} = \frac{(G_s + e)}{(1+e)}\gamma_w$$

Unit 2 - Effective Shear Strength Envelope

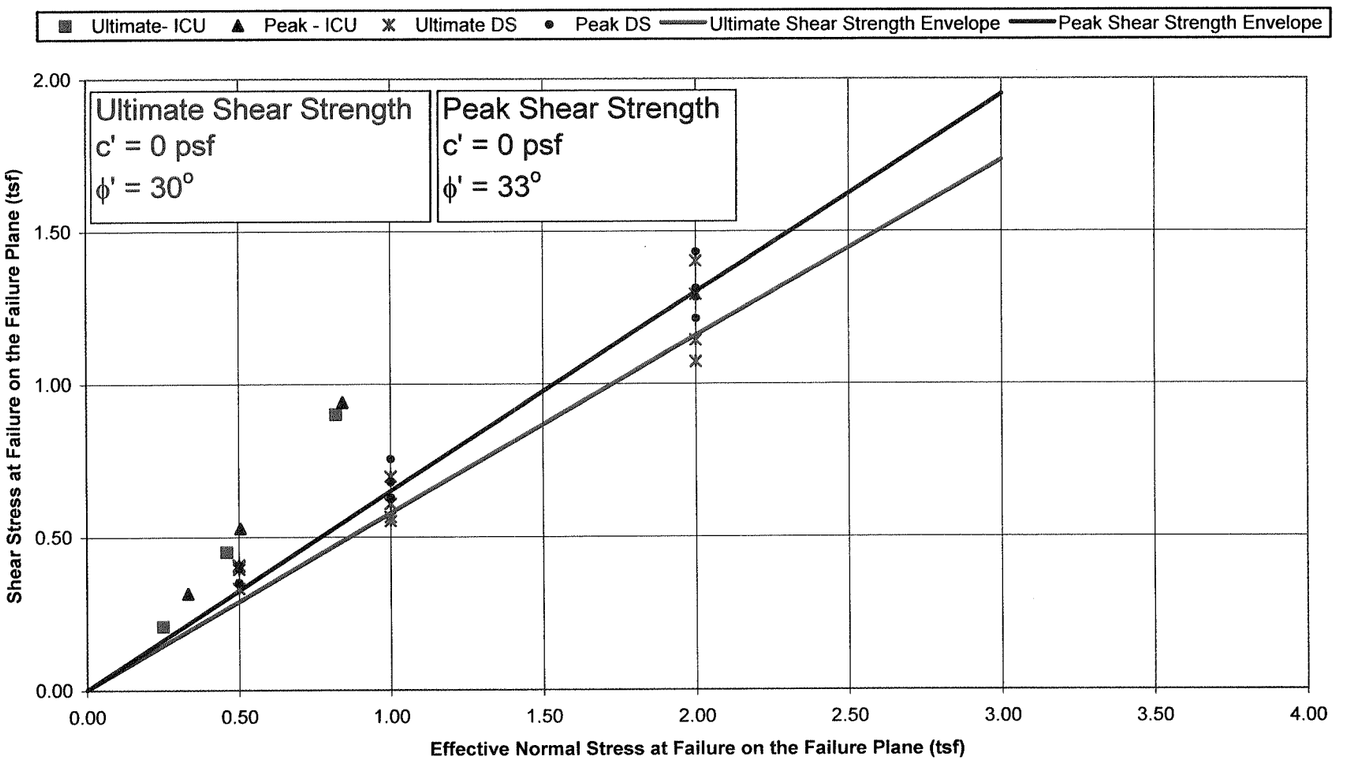


Plate 13

Unit 4B - Effective Shear Strength Envelope

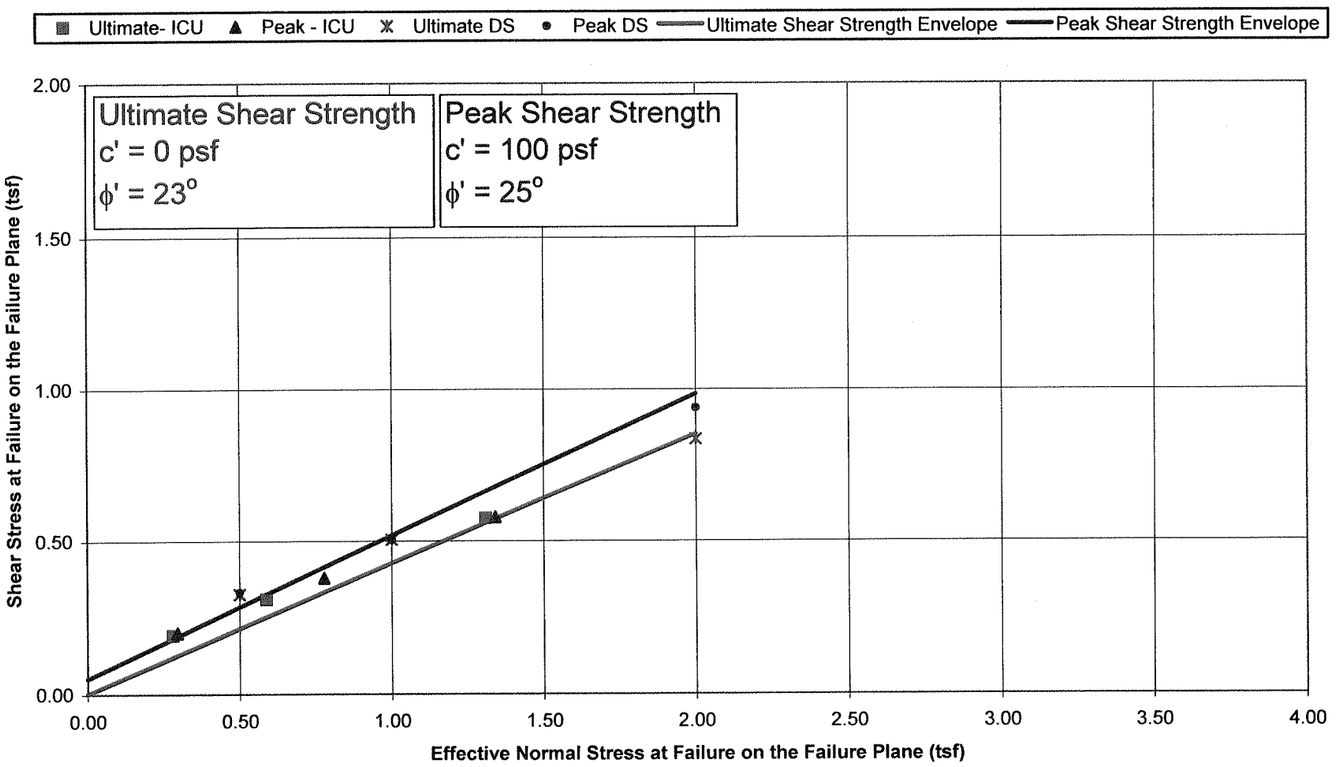


Plate 14

Unit 6A - Effective Shear Strength Envelope

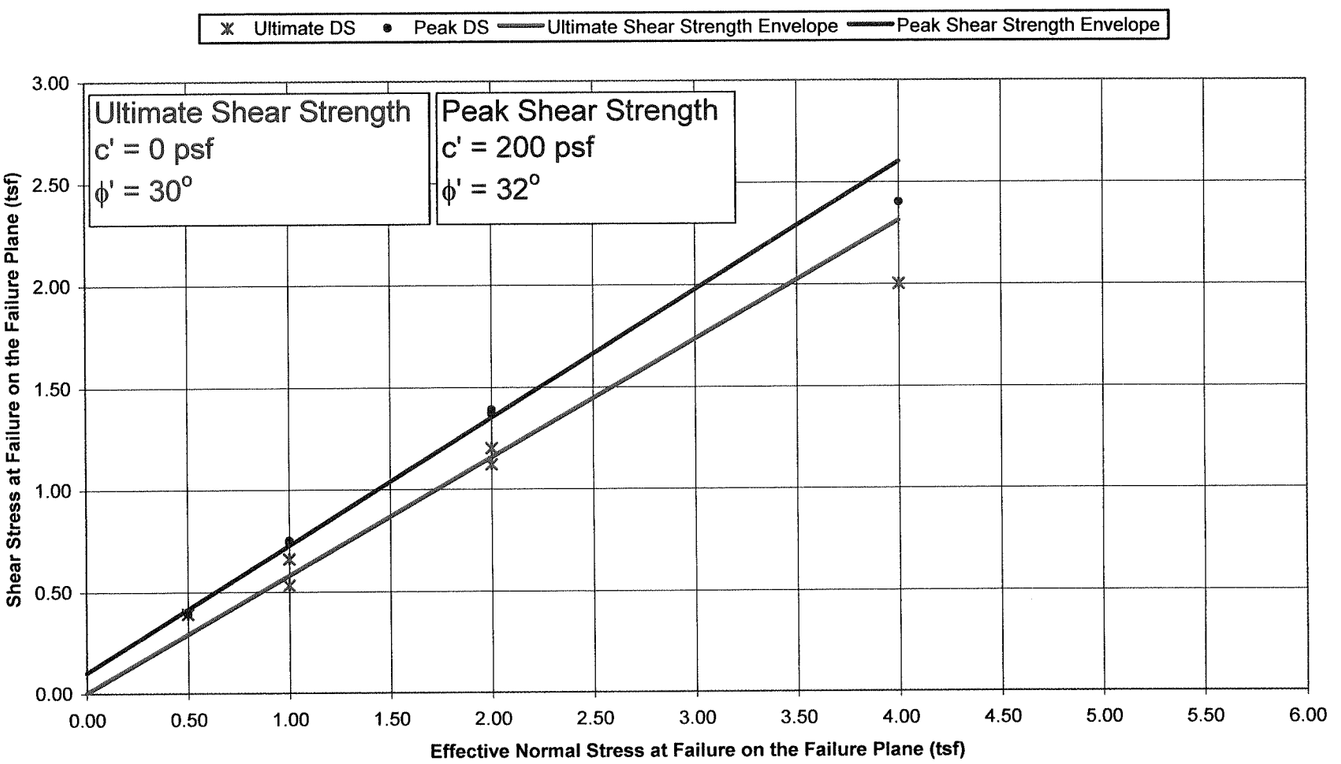


Plate 15

Unit 7B - Effective Shear Strength Envelope

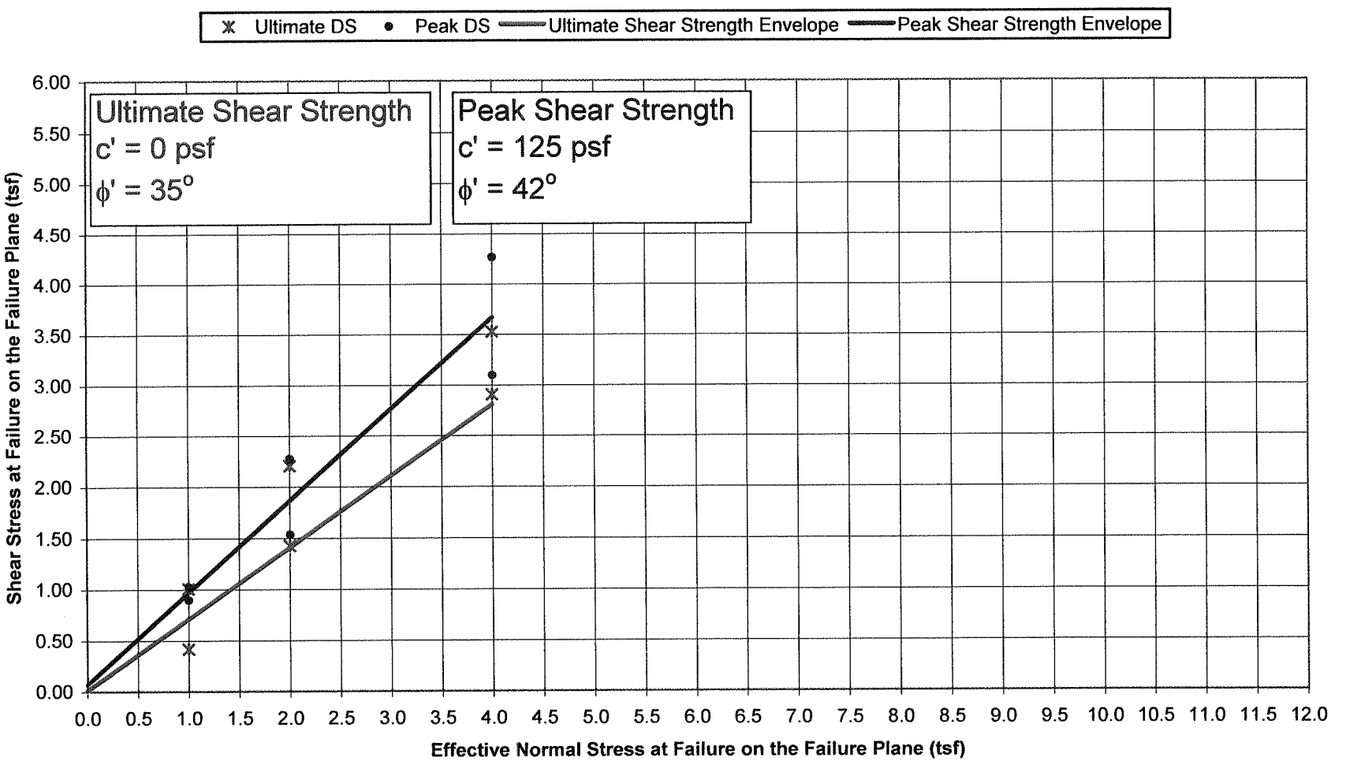


Plate 16

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 2

Direct Shear Test Data

Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH (feet)	Sample ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_S	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)	Ultimate τ_{ff} (tsf)	Ultimate σ_{ff}' (tsf)	Peak τ_{ff} (tsf)	Peak σ_{ff}' (tsf)	USCS SOIL TYPE	Notes
88-148-1	1	88-148	17.0	790.1	1	1	138	164.0	91	47	1.55	2.53	4.36	29.5	77.9	80.2	0.40	0.50	0.41	0.50	MH	
						2		148.0			1.21		3.89	32.3	80.1	81.9	0.61	1.00	0.68	1.00		
						3		142.0			1.09		3.85	32.6	78.9	82.1	1.29	2.00	1.31	2.00		
88-148-2	2	88-148	23.0	784.1	2	1	147	101.0	67	80	0.43	2.62	2.80	43.1	86.6	89.0	0.40	0.50	0.40	0.50	MH	
						2		105.0			0.48		2.88	42.2	86.5	88.5	0.57	1.00	0.63	1.00		
						3		107.0			0.50		2.94	41.5	85.9	88.1	1.07	2.00	1.28	2.00		
88-148-3	3	88-148	28.0	779.1	3	1	166	102.0	39	127	0.50	2.58	2.69	43.7	88.3	89.1	0.33	0.50	0.35	0.50	CH	
						2		105.0			0.52		2.78	42.5	87.1	88.5	0.55	1.00	0.62	1.00		
						3		107.0			0.54		2.87	41.6	86.1	87.9	1.14	2.00	1.21	2.00		
87-129-1	4	87-129	13.0	796.8	1	1	167	109.0	51	116	0.50	2.55	2.88	41.1	85.9	87.3	0.41	0.50	0.41	0.50	CH	
						2		108.0			0.49		2.74	42.5	88.4	88.3	0.70	1.00	0.75	1.00		
						3		107.0			0.48		2.75	42.4	87.8	88.2	1.40	2.00	1.43	2.00		
Maximum Values			28.0	796.8			167	164.0	91	127	1.55	2.62	4.36	43.7	88.4	89.1	1.40	2.00	1.43	2.00		
Minimum Values			13.0	779.1			138	101.0	39	47	0.43	2.53	2.69	29.5	77.9	80.2	0.33	0.50	0.35	0.50		
Average Values			20.3	787.5			155	117.1	62	93	0.69	2.57	3.12	39.6	85.0	86.6	0.74	1.17	0.79	1.17		

Plate 17

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 2

CD Test Data from CU With Pore Water Pressure Measurement (R-bar)

																	Ultimate Stress Values										Peak Stress Values											
Test-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_s	e	γ_d	γ_m	γ_{sat}	σ_c'	σ_d	u	q	q	p	p'	τ_{ff}	σ_n	σ_{ff}'	σ_d	u	q	q	p	p'	τ_{ff}	σ_n	σ_{ff}'	USCS SOIL TYPE	Notes
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)		
03-6-1	1	03-6	20.7	791.4	1	1	146	114.5	73	73	0.57	2.61	3.20	38.8	83.2	86.3	0.5	0.48	0.37	0.24	480	0.74	0.37	0.21	0.62	0.25	0.73	0.35	0.37	730	0.87	0.52	0.32	0.68	0.33	OH	
						2		115.4			0.58		3.22	38.6	83.1	86.2	1.0	1.04	0.80	0.52	1040	1.52	0.72	0.45	1.26	0.46	1.22	0.80	0.61	1220	1.61	0.81	0.53	1.31	0.51		
						3		115.8			0.59		3.23	38.5	83.1	86.2	2.0	2.08	1.70	1.04	2080	3.04	1.34	0.90	2.52	0.82	2.17	1.70	1.09	2170	3.09	1.39	0.94	2.54	0.84		
Maximum Values			20.7	791.4			146	115.8	73	73	0.59	2.61	3.23	38.8	83.2	86.3	2.00	2.08	1.70	1.04	2080	3.04	1.34	0.90	2.52	0.82	2.17	1.70	1.09	2170	3.09	1.39	0.94	2.54	0.84		
Minimum Values			20.7	791.4			146	114.5	73	73	0.57	2.61	3.20	38.5	83.1	86.2	0.50	0.48	0.37	0.24	480	0.74	0.37	0.21	0.62	0.25	0.73	0.35	0.37	730	0.87	0.52	0.32	0.68	0.33		
Average Values			20.7	791.4			146	115.2	73	73	0.58	2.61	3.22	38.6	83.2	86.2	1.17	1.20	0.96	0.60	1200	1.77	0.81	0.52	1.47	0.51	1.37	0.95	0.69	1373	1.85	0.90	0.59	1.51	0.56		

Plate 18

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 4B

Direct Shear Test Data

																Ultimate		Peak			
Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_S	e	γ_d	γ_m	γ_{sat}	τ_{ff}	σ_{ff}'	τ_{ff}	σ_{ff}'	USCS SOIL TYPE	Notes
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(tsf)		
88-148-4	1	88-148	35.0	772.1	4	1	82	74.6	25	57	0.87	2.67	2.05	54.6	95.3	96.6	0.32	0.50	0.33	0.50	CH	
						2		65.0			0.70		1.75	60.5	99.8	100.3	0.50	1.00	0.50	1.00		
						3		61.0			0.63		1.61	63.7	102.6	102.3	0.83	2.00	0.94	2.00		
Maximum Values			35.0	772.1			82	74.6	25	57	0.87	2.67	2.05	63.7	102.6	102.3	0.83	2.00	0.94	2.00		
Minimum Values			35.0	772.1			82	61.0	25	57	0.63	2.67	1.61	54.6	95.3	96.6	0.32	0.50	0.33	0.50		
Average Values			35.0	772.1			82	66.9	25	57	0.73	2.67	1.80	59.6	99.2	99.7	0.55	1.17	0.59	1.17		

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 4B

CD Test Data from CU With Pore Water Pressure Measurement (R-bar)

																Ultimate Stress Values									Peak Stress Values										
Type Hole Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. No.	LL	MC	PL	PI	LI	G_s	e	γ_d	γ_m	γ_{sat}	σ_c'	σ_d	u	q	q	p	p'	τ_{ff}	σ_{ff}	σ_{ff}'	σ_c	u	q	q	p	p'	τ_{ff}	σ_{ff}	σ_{ff}'	USCS SOIL TYPE	Notes
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(tsf)	(tsf)	
03-6-2	1	03-6	43.8	768.3	2	1	70	61.2	24	46	0.81	2.71	1.66	63.5	102.4	102.5	0.5	0.44	0.33	0.22	440	0.72	0.39	0.19	0.61	0.28	0.46	0.32	0.23	460	0.73	0.41	0.20	0.62	0.30	CH	
						2		61.1			0.81		1.69	63.0	101.5	102.1	1.0	0.71	0.59	0.36	710	1.36	0.77	0.31	1.18	0.59	0.87	0.44	0.44	870	1.44	1.00	0.38	1.22	0.78		
						3		61.3			0.81		1.68	63.2	101.9	102.2	2.0	1.32	1.02	0.66	1320	2.66	1.64	0.57	2.33	1.31	1.33	0.99	0.67	1330	2.67	1.68	0.58	2.33	1.34		
Maximum Values			43.8	768.3			70	61.3	24	46	0.81	2.71	1.69	63.5	102.4	102.5	2.00	1.32	1.02	0.66	1320	2.66	1.64	0.57	2.33	1.31	1.33	0.99	0.67	1330	2.67	1.68	0.58	2.33	1.34		
Minimum Values			43.8	768.3			70	61.1	24	46	0.81	2.71	1.66	63.0	101.5	102.1	0.50	0.44	0.33	0.22	440	0.72	0.39	0.19	0.61	0.28	0.46	0.32	0.23	460	0.73	0.41	0.20	0.62	0.30		
Average Values			43.8	768.3			70	61.2	24	46	0.81	2.71	1.68	63.2	101.9	102.3	1.17	0.82	0.65	0.41	823	1.58	0.93	0.36	1.37	0.73	0.89	0.58	0.44	887	1.61	1.03	0.38	1.39	0.81		

Plate 20

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 6A

Direct Shear Test Data

Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH (feet)	Sample ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_s	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)	Ultimate τ_{ff} (tsf)	Ultimate σ_{ff}' (tsf)	Peak τ_{ff} (tsf)	Peak σ_{ff}' (tsf)	USCS SOIL TYPE	Notes
03-8-1	1	03-8	75.9	734.5	1	1	60	35.6	25	35	0.30	2.71	0.97	86.0	116.6	116.6	0.53	1.00	0.75	1.00	CH	
						2		36.0			0.31		0.97	85.8	116.7	116.6	1.12	2.00	1.37	2.00		
						3		34.3			0.27		0.96	86.4	116.0	116.8	2.00	4.00	2.40	4.00		
03-9-1	2	03-9	55.7	748.1	1	1	66	26.7	25	41	0.04	2.70	0.75	96.1	121.8	123.0	0.39	0.50	0.39	0.50	CH	
						2		28.4			0.08		0.81	93.3	119.8	121.0	0.66	1.00	0.74	1.00		
						3		31.9			0.17		0.88	89.5	118.1	118.8	1.20	2.00	1.39	2.00		
Maximum Values			75.9	748.1			66	36.0	25	41	0.31	2.71	0.97	96.1	121.8	123.0	2.00	4.00	2.40	4.00		
Minimum Values			55.7	734.5			60	26.7	25	35	0.04	2.70	0.75	85.8	116.0	116.6	0.39	0.50	0.39	0.50		
Average Values			65.8	741.3			63	32.2	25	38	0.20	2.71	0.89	89.5	118.2	118.8	0.98	1.75	1.17	1.75		

Plate 21

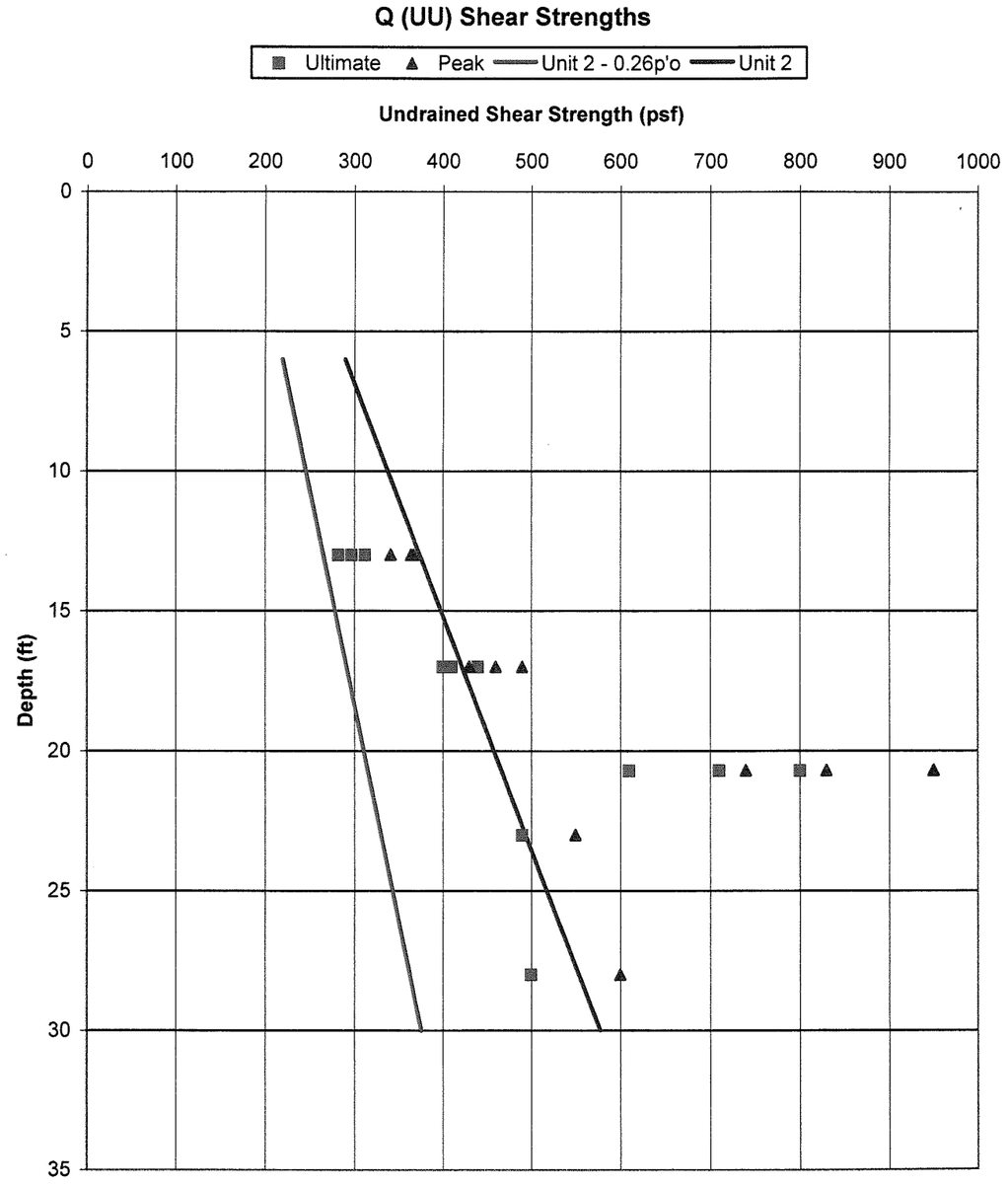
Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 7B

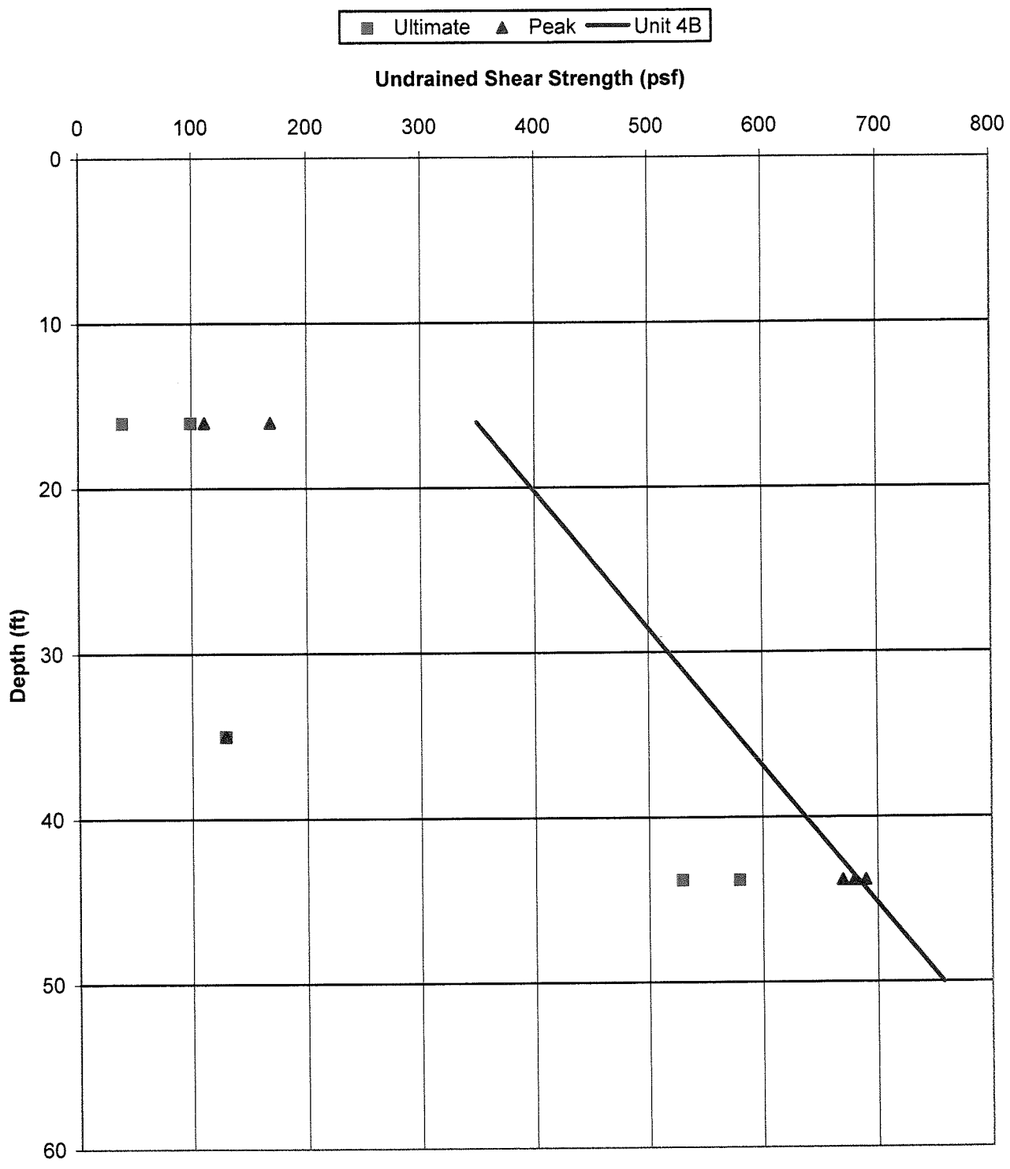
Direct Shear Test Data

Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH (feet)	Sample ELEV. (feet)	SAMPLE NO.	SPEC. NO.	LL (%)	MC (%)	PL (%)	PI (%)	LI	G_S	e	γ_d (pcf)	γ_m (pcf)	γ_{sat} (pcf)	Ultimate τ_{ff} (tsf)	Ultimate σ_{ff}' (tsf)	Peak τ_{ff} (tsf)	Peak σ_{ff}' (tsf)	USCS SOIL TYPE	Notes
03-6-3	1	03-6	98.0	714.1	3	1	32	18.9	14	18	0.27	2.67	0.50	110.7	131.6	131.9	0.41	1.00	0.89	1.00	CL	
						2		18.6			0.26		0.49	112.0	132.8	132.3	1.42	2.00	1.53	2.00		
						3		18.0			0.22		0.48	112.2	132.4	132.8	2.90	4.00	3.09	4.00		
03-9-2	2	03-9	71.0	732.8	2	1	20	15.1	13	7	0.30	2.67	0.37	121.6	140.0	138.5	1.00	1.00	1.02	1.00	CL	
						2		14.0			0.14		0.32	126.0	143.6	141.3	2.20	2.00	2.27	2.00		
						3		11.2			-0.26		0.26	132.7	147.6	145.1	3.52	4.00	4.26	4.00		
Maximum Values			98.0	732.8			32	18.9	14	18	0.30	2.67	0.50	132.7	147.6	145.1	3.52	4.00	4.26	4.00		
Minimum Values			71.0	714.1			20	11.2	13	7	-0.26	2.67	0.26	110.7	131.6	131.9	0.41	1.00	0.89	1.00		
Average Values			84.5	723.5			26	16.0	14	13	0.16	2.67	0.40	119.2	138.0	137.0	1.91	2.33	2.18	2.33		

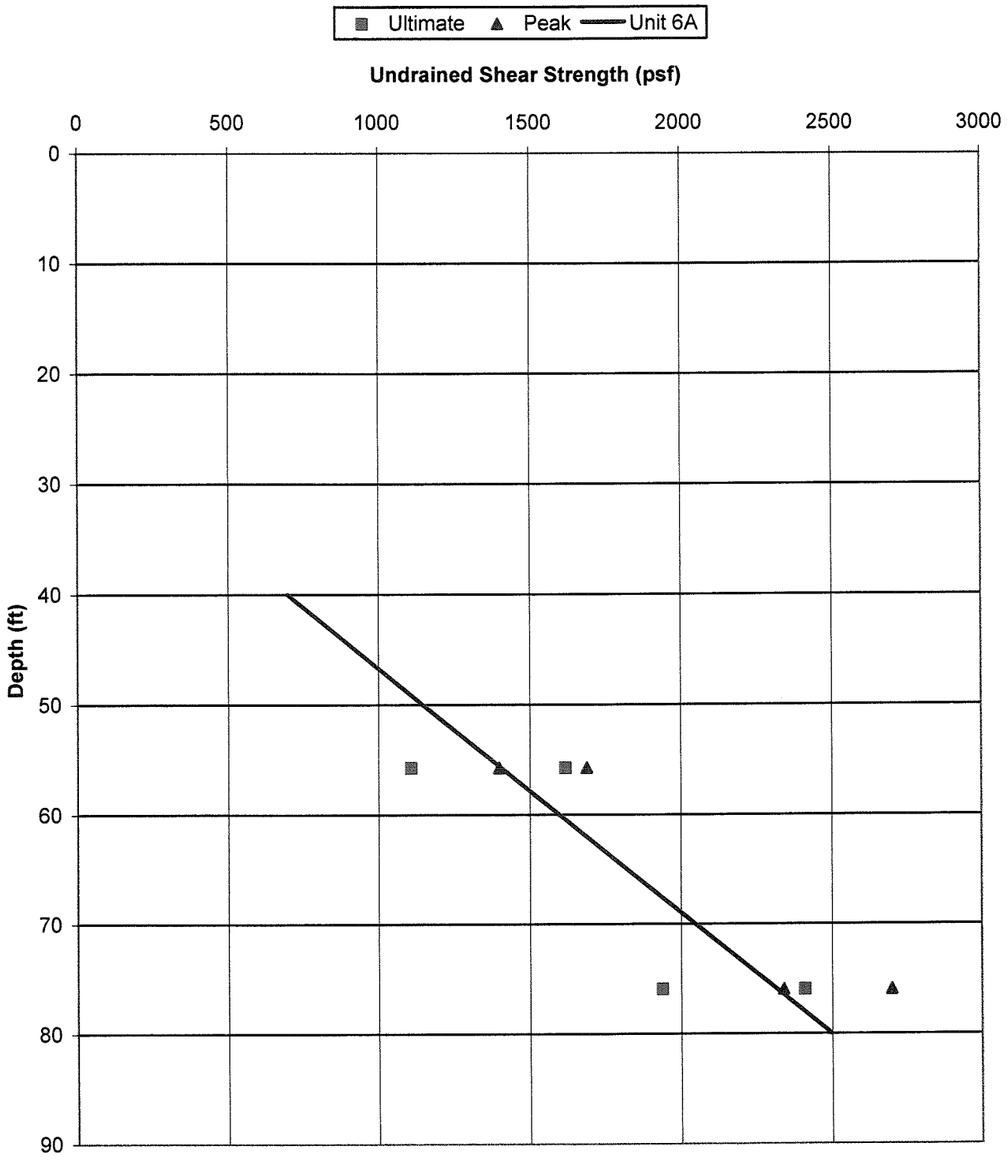
Q (UU) Shear Strengths



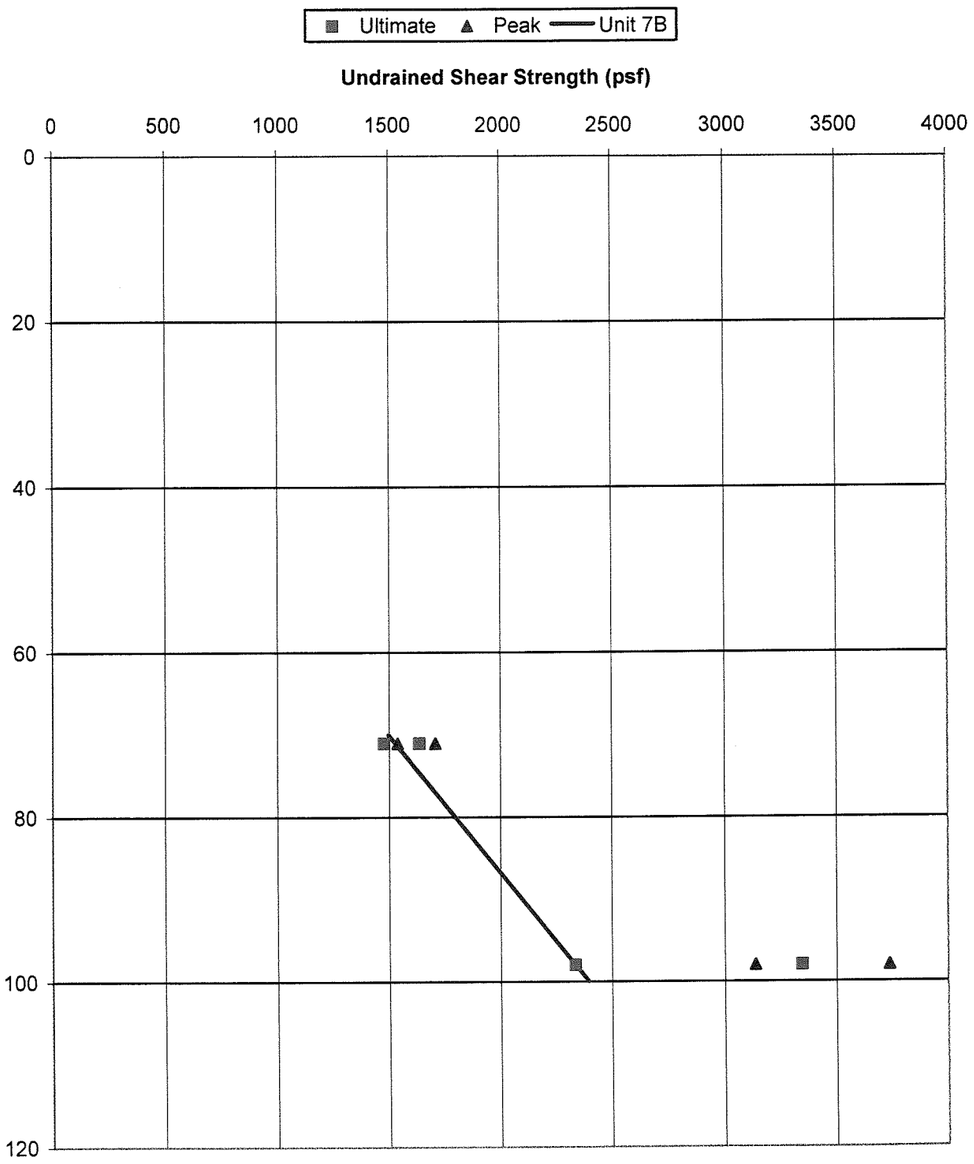
Q (UU) Shear Strengths



Q (UU) Shear Strengths



Q (UU) Shear Strengths



Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 2

UU and Unconfined Test Compression Data (Q)

Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_S	e	γ_d	γ_m	γ_{sat}	σ_c	Ultimate Stress Values				Peak Stress Values				USCS SOIL TYPE	Notes
																		σ_d	q	q	p	σ_d	q	q	p		
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)		
03-6-1	1	03-6	20.7	791.4	1	1	146	108.7	73	73	0.49	2.61	2.98	40.9	85.4	87.6	0.5	0.61	0.31	610	0.81	0.74	0.37	740	0.87	OH	
						2		108.1			0.48		2.98	41.0	85.3	87.6	1.0	0.71	0.36	710	1.36	0.83	0.42	830	1.42		
						3		112.7			0.54		3.13	39.5	84.0	86.7	2.0	0.80	0.40	800	2.40	0.95	0.48	950	2.48		
88-148-1	2	88-148	17.0	790.1	1	1	138	143.3	91	47	1.11	2.53	3.72	33.4	81.3	82.6	0.5	0.40	0.20	400	0.70	0.46	0.23	460	0.73	MH	
						2		142.3			1.09		3.67	33.8	81.9	82.8	1.0	0.41	0.21	410	1.21	0.43	0.22	430	1.22		
						3		143.0			1.11		3.67	33.8	82.1	82.8	2.0	0.44	0.22	440	2.22	0.49	0.25	490	2.25		
88-148-2	3	88-148	23.0	784.1	1	1	147	101.8	67	80	0.44	2.62	2.69	44.3	89.4	89.8	0.0	0.49	0.25	490	0.25	0.55	0.28	550	0.28	MH	
88-148-3	4	88-148	28.0	779.1	3	1	166	106.7	39	127	0.53	2.58	2.80	42.4	87.6	88.3	0.0	0.50	0.25	500	0.25	0.60	0.30	600	0.30	CH	
87-129-1	5	87-129	13.0	796.8	1	1	167	108.0	51	116	0.49	2.55	2.69	43.1	89.6	88.6	0.5	0.28	0.14	282	0.64	0.34	0.17	341	0.67	CH	
						2		109.0			0.50		2.72	42.8	89.5	88.4	1.0	0.31	0.16	312	1.16	0.37	0.18	367	1.18		
						3		109.0			0.50		2.72	42.8	89.5	88.4	2.0	0.30	0.15	297	2.15	0.36	0.18	364	2.18		
Maximum Values			28.0	796.8			167	143.3	91	127	1.11	2.62	3.72	44.3	89.6	89.8	2.00	0.50	0.25	500	2.22	0.60	0.30	600	2.25		
Minimum Values			13.0	779.1			138	101.8	39	47	0.44	2.53	2.69	33.4	81.3	82.6	0.00	0.28	0.14	282	0.25	0.34	0.17	341	0.28		
Average Values			17.6	790.5			154	120.4	67	87	0.72	2.56	3.09	39.6	86.4	86.5	0.88	0.39	0.20	391	1.07	0.45	0.23	450	1.10		

Plate 27

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 4B

UU and Unconfined Test Compression Data (Q)

																	Ultimate Stress Values				Peak Stress Values					
Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample EL.EV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_S	e	γ_d	γ_m	γ_{sat}	σ_c	σ_d	q	q	p	σ_d	q	q	p	USCS SOIL TYPE	Notes
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)		
03-6-2	1	03-6	43.8	768.3	2	1	70	62.3	24	46	0.83	2.71	1.73	61.9	100.5	101.5	0.5	0.58	0.29	590	0.79	0.68	0.34	680	0.84		
						2		62.4			0.83		1.76	61.3	99.6	101.1	1.0	0.58	0.29	590	1.29	0.67	0.34	670	1.34	CH	
						3		62.7			0.84		1.78	60.8	98.9	100.8	2.0	0.53	0.27	530	2.27	0.69	0.35	690	2.35		
88-148-4	2	88-148	35.0	772.1	4	1	82	61.1	25	57	0.63	2.67	1.65	63.0	101.5	101.7	0.0	0.13	0.07	130	0.07	0.13	0.07	130	0.07	CH	Disturbed
87-129-2	3	87-129	16.0	793.8	2	1	66	64.1	21	45	0.96	2.67	1.65	63.0	103.4	101.7	0.5	0.04	0.02	40	0.52	0.11	0.06	112	0.56		
						2		66.1			1.00		1.70	61.7	102.5	101.0	1.0	0.10	0.05	100	1.05	0.17	0.08	169	1.08	CH	

Plate 28

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 6A

UU and Unconfined Test Compression Data (Q)

Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_S	e	γ_d	γ_m	γ_{sat}	σ_c	Ultimate Stress Values				Peak Stress Values				USCS SOIL TYPE	Notes
																		σ_d	q	q	p	σ_d	q	q	p		
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)		
03-8-1	1	03-8	75.9	734.5	1	1	60	32.5	25	35	0.21	2.71	0.91	88.5	117.3	118.3	1.0	2.41	1.21	2410	2.21	2.70	1.35	2700	2.35		
						2		32.7			0.22		0.92	88.3	117.2	118.0	2.0	1.94	0.97	1940	2.97	2.34	1.17	2340	3.17	CH	
03-9-1	2	03-9	55.7	748.1	1	1	66	40.0	25	41	0.37	2.70	1.11	80.0	112.0	112.7	0.5	1.11	0.56	1110	1.06	1.40	0.70	1400	1.20		
						2		39.3			0.35		1.10	80.4	112.0	112.9	1.0	1.62	0.81	1620	1.81	1.69	0.85	1690	1.85	CH	
Maximum Values			55.7	748.1			66	40.0	25	41	0.37	2.70	1.11	80.4	112.0	112.9	1.00	1.62	0.81	1620	1.81	1.69	0.85	1690	1.85		
Minimum Values			55.7	748.1			66	39.3	25	41	0.35	2.70	1.10	80.0	112.0	112.7	0.50	1.11	0.56	1110	1.06	1.40	0.70	1400	1.20		
Average Values			55.7	748.1			66	39.7	25	41	0.36	2.70	1.11	80.2	112.0	112.8	0.75	1.37	0.68	1365	1.43	1.55	0.77	1545	1.52		

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004
Soil Formation: Unit 7B

UU and Unconfined Test Compression Data (Q)

																	Ultimate Stress Values				Peak Stress Values					
Year-Hole-Sample	TEST NO.	BORING NO.	MID. DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_s	e	γ_d	γ_m	γ_{sat}	σ_c	σ_d	q	q	p	σ_d	q	q	p	USCS SOIL TYPE	Notes
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)	(tsf)	(tsf)	(psf)	(tsf)		
03-6-3	1	03-6	98.0	714.1	3	1		16.8			0.16		0.44	115.8	135.3	134.8	1.0	2.34	1.17	2340	2.17	3.14	1.57	3140	2.57		
						2	32	17.2	14	18	0.18	2.67	0.46	113.9	133.5	133.8	2.0	3.35	1.68	3350	3.68	3.74	1.87	3740	3.87	CL	
03-9-2	2	03-9	71.0	732.8	2	1		9.9			-0.44		0.25	132.8	145.9	145.8	1.0	1.48	0.74	1480	1.74	1.54	0.77	1540	1.77		
						2	20	14.3	13	7	0.19	2.67	0.37	121.7	139.1	138.5	2.0	1.64	0.82	1640	2.82	1.71	0.86	1710	2.86	CL	
Maximum Values			71.0	732.8			20	14.3	13	7	0.19	2.67	0.37	132.8	145.9	145.8	2.00	1.64	0.82	1640	2.82	1.71	0.86	1710	2.86		
Minimum Values			71.0	732.8			20	9.9	13	7	-0.44	2.67	0.25	121.7	139.1	138.5	1.00	1.48	0.74	1480	1.74	1.54	0.77	1540	1.77		
Average Values			71.0	732.8			20	12.1	13	7	-0.13	2.67	0.31	127.3	142.5	142.1	1.50	1.56	0.78	1560	2.28	1.63	0.81	1625	2.31		

Plate 30

Soils Information Worksheet

Project: Van White Memorial Boulevard
Date: March 2004

Consolidation Test Data

Year-Hole-Sample	TEST NO.	BORING NO.	MID-DEPTH	Sample ELEV.	SAMPLE NO.	SPEC. NO.	LL	MC	PL	PI	LI	G_s	e	γ_d	γ_m	γ_{sat}	p_o'	p_c'	OCR	Cc	Cr	C_v (ft^2/yr)			USCS SOIL TYPE	SOIL UNIT
			(feet)	(feet)			(%)	(%)	(%)	(%)				(pcf)	(pcf)	(pcf)	(tsf)	(tsf)				LI=1 tsf	LI=2 tsf	LI=4 tsf		
03-6-1	1	03-6	20.7	791.4	1	1	146	113.4	73	73	0.55	2.61	3.10	39.8	84.9	86.9	0.6	0.6	1.1	1.24	0.10	292	13	8	OH	Unit 2
03-6-2	2	03-6	43.8	768.3	2	1	70	64.1	24	46	0.87	2.71	1.82	60.1	98.6	100.2	0.9	0.9	1.1	0.72	0.13	4	3	4	CH	Unit 4B
03-6-3	3	03-6	98.0	714.1	3	1	32	19.8	14	18	0.32	2.67	0.52	109.7	131.4	131.0	2.6	2.9	1.1	0.12	0.02	44	75	34	CL	Unit 7B
03-8-1	4	03-8	75.9	734.5	1	1	60	39.1	25	35	0.40	2.71	1.05	82.4	114.6	114.5	2.2	2.2	1.0	0.32	0.06	9	12	6	CH	Unit 6A
03-9-1	5	03-9	55.7	748.1	1	1	66	37.9	25	41	0.31	2.70	1.02	83.6	115.3	114.9	1.3	2.6	2.0	0.31	0.07	20	19	19	CH	Unit 6A
03-9-2	6	03-9	71.0	732.8	2	1	20	16.3	13	7	0.47	2.67	0.44	115.5	134.3	134.8	1.9	1.9	1.0	0.08	0.01	32	44	64	CL	Unit 7B
88-148-1	7	88-148	17.0	790.1	1	1	138	137.5	91	47	0.99	2.53	3.61	34.2	81.2	83.1	0.5	0.7	1.4	1.40	0.11	--	--	--	MH	Unit 2
88-148-3	8	88-148	28.0	779.1	3	1	166	85.3	39	127	0.36	2.58	2.29	49.0	90.8	92.4	0.7	0.8	1.2	1.00	0.16	--	--	--	CH	Unit 2
87-129-2	9	87-129	16.0	793.8	2	1	66	53.4	21	45	0.72	2.67	1.41	69.3	106.3	105.6	0.5	0.8	1.6	0.56	0.10	--	17	19	CH	Unit 4B

Estimate of Effective Vertical Overburden Pressure in Undisturbed Samples

Boring Number	Sample Number	Elevation (feet)	Depth (feet)	Effective Unit Weight (pcf)	Effective Vertical Overburden Pressure (psf)	Effective Vertical Overburden Pressure (tsf)	Geologic Unit
03-6M		812.1	0	0	0	0.00	1
		806.1	6	115	690	0.35	1
		803.3	8.8	57.6	851	0.43	1
	1	791.5	20.6	23.6	1130	0.56	2
		770.9	41.2	23.6	1616	0.81	2
	2	768.4	43.7	38.6	1712	0.86	4B
		762.4	49.7	38.6	1944	0.97	4B
		741.3	70.8	67.6	3370	1.69	5
		734.5	77.6	54.6	3742	1.87	6A
	3	714.1	98	72.6	5223	2.61	7B

Boring Number	Sample Number	Elevation (feet)	Depth (feet)	Effective Unit Weight (pcf)	Effective Vertical Overburden Pressure (psf)	Effective Vertical Overburden Pressure (tsf)	Geologic Unit
03-8M		810.4	0	0	0	0.00	1
		801.6	8.8	115	1012	0.51	1
		795.1	15.3	57.6	1386	0.69	1
		781.1	29.3	23.6	1717	0.86	2
		760.8	49.6	60.6	2947	1.47	5
	1	734.5	75.9	54.6	4383	2.19	6A

Boring Number	Sample Number	Elevation (feet)	Depth (feet)	Effective Unit Weight (pcf)	Effective Vertical Overburden Pressure (psf)	Effective Vertical Overburden Pressure (tsf)	Geologic Unit
03-9M		803.8	0	0	0	0.00	1
/88-148M		800.8	3	115	345	0.17	1
		792.1	11.7	57.6	846	0.42	1
		774.5	29.3	23.6	1261	0.63	2
		764.7	39.1	38.6	1640	0.82	4B
		753.5	50.3	60.6	2318	1.16	5
	1	748.1	55.7	54.6	2613	1.31	6A
		733.8	70	72.6	3652	1.83	7B
	2	732.8	71	72.6	3724	1.86	7B

Boring Number	Sample Number	Elevation (feet)	Depth (feet)	Effective Unit Weight (pcf)	Effective Vertical Overburden Pressure (psf)	Effective Vertical Overburden Pressure (tsf)	Geologic Unit
88-148M		807.1	0	0	0	0.00	1
		804	3.1	115	357	0.18	1
		792.1	15	57.6	1042	0.52	1
	1	790.1	17	23.6	1089	0.54	2
	3	779.1	28	23.6	1349	0.67	2

Boring Number	Sample Number	Elevation (feet)	Depth (feet)	Effective Unit Weight (pcf)	Effective Vertical Overburden Pressure (psf)	Effective Vertical Overburden Pressure (tsf)	Geologic Unit
87-129M		809.8	0	0	0	0.00	1
		804	5.8	115	667	0.33	1
		802.2	7.6	57.6	771	0.39	1
		795.3	14.5	23.6	934	0.47	2
	2	793.8	16	38.6	991	0.50	4B

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Van White Memorial Blvd. SFO	COMPUTED BY: CWB.	DATE: 3-04	SHEET: 11 / 1
	SUBJECT TITLE: Settlement	CHECKED BY:	DATE:	CONTRACT NO.:

Cross-Section: North Abutment of South Bridge

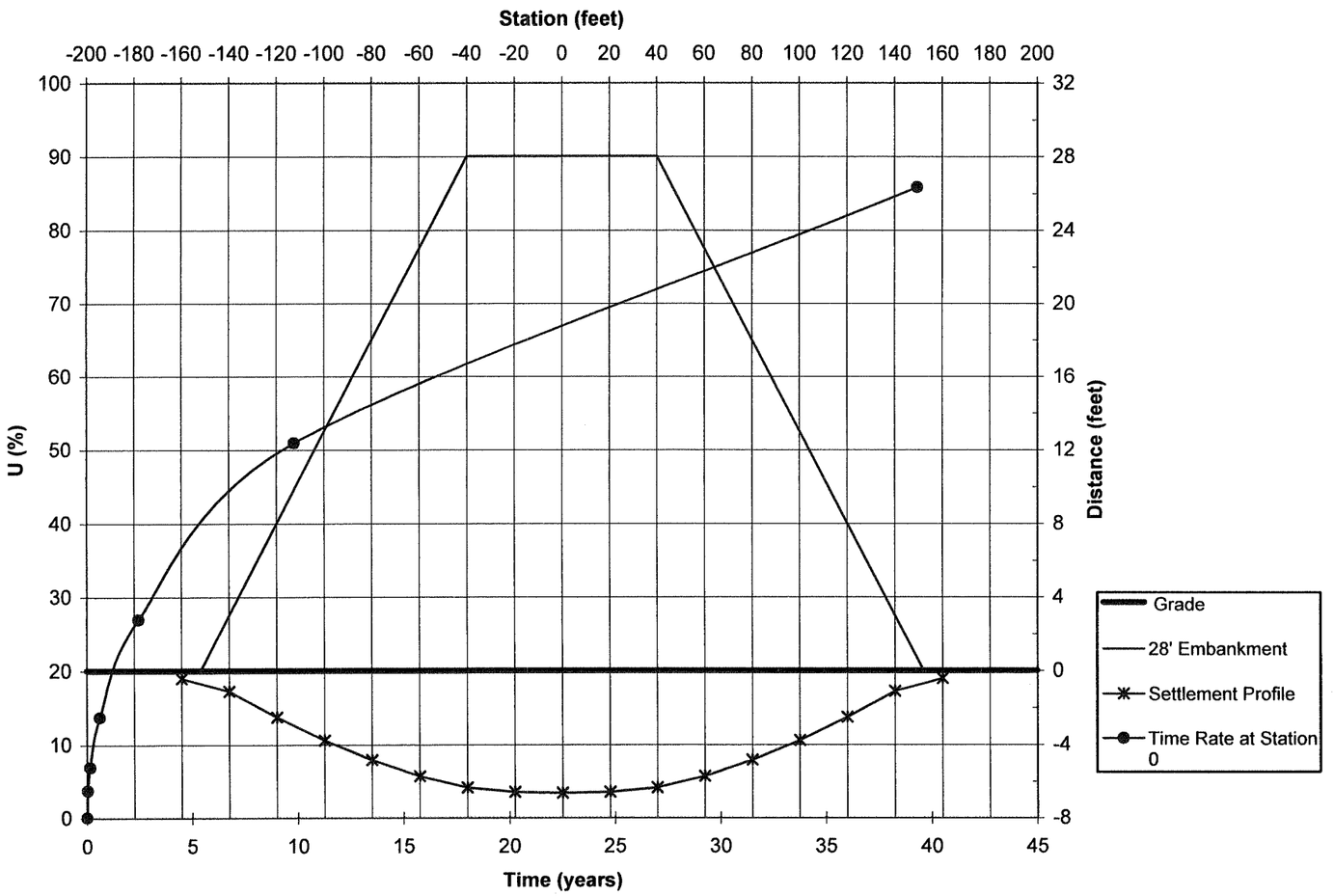

Station (feet)
-200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200
U (%)
Distance (feet)
Time (years)
0 5 10 15 20 25 30 35 40 45
Grade
28' Embankment
Settlement Profile
Time Rate at Station 0

Plate 35

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Van White Memorial Blvd. SFO	COMPUTED BY: CWB	DATE: 3-04	SHEET: 11 / 1
	SUBJECT TITLE: Settlement	CHECKED BY:	DATE:	CONTRACT NO.:

Cross-Section: ~ Sta. 716+00

CENCS14 23JAN92

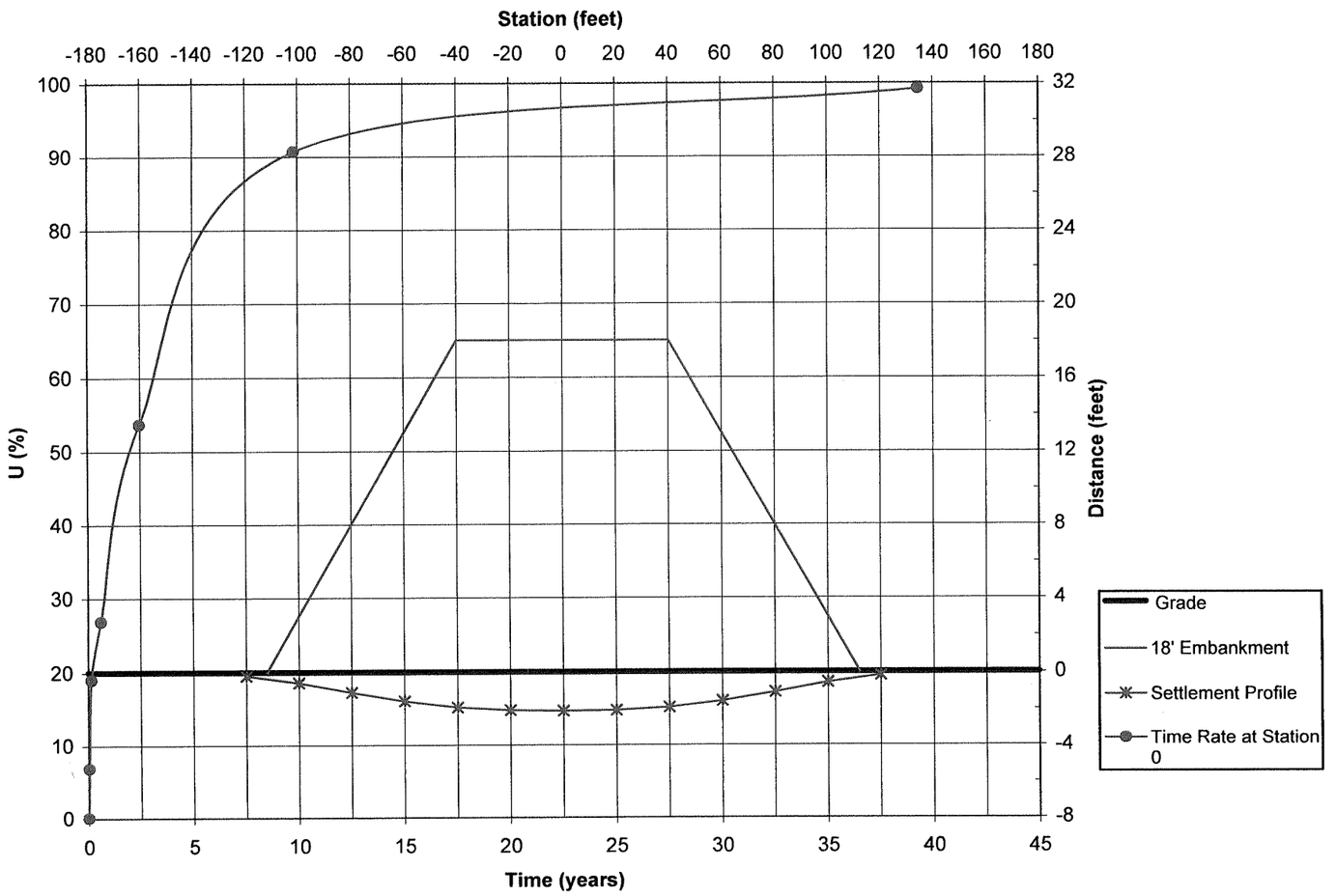

Station (feet)
-180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180
U (%)
100 90 80 70 60 50 40 30 20 10 0
Distance (feet)
32 28 24 20 16 12 8 4 0 -4 -8
0 5 10 15 20 25 30 35 40 45
Time (years)
Grade
18' Embankment
Settlement Profile
Time Rate at Station 0

Plate 37

Typical Embankment Section (Sta. 716+00)

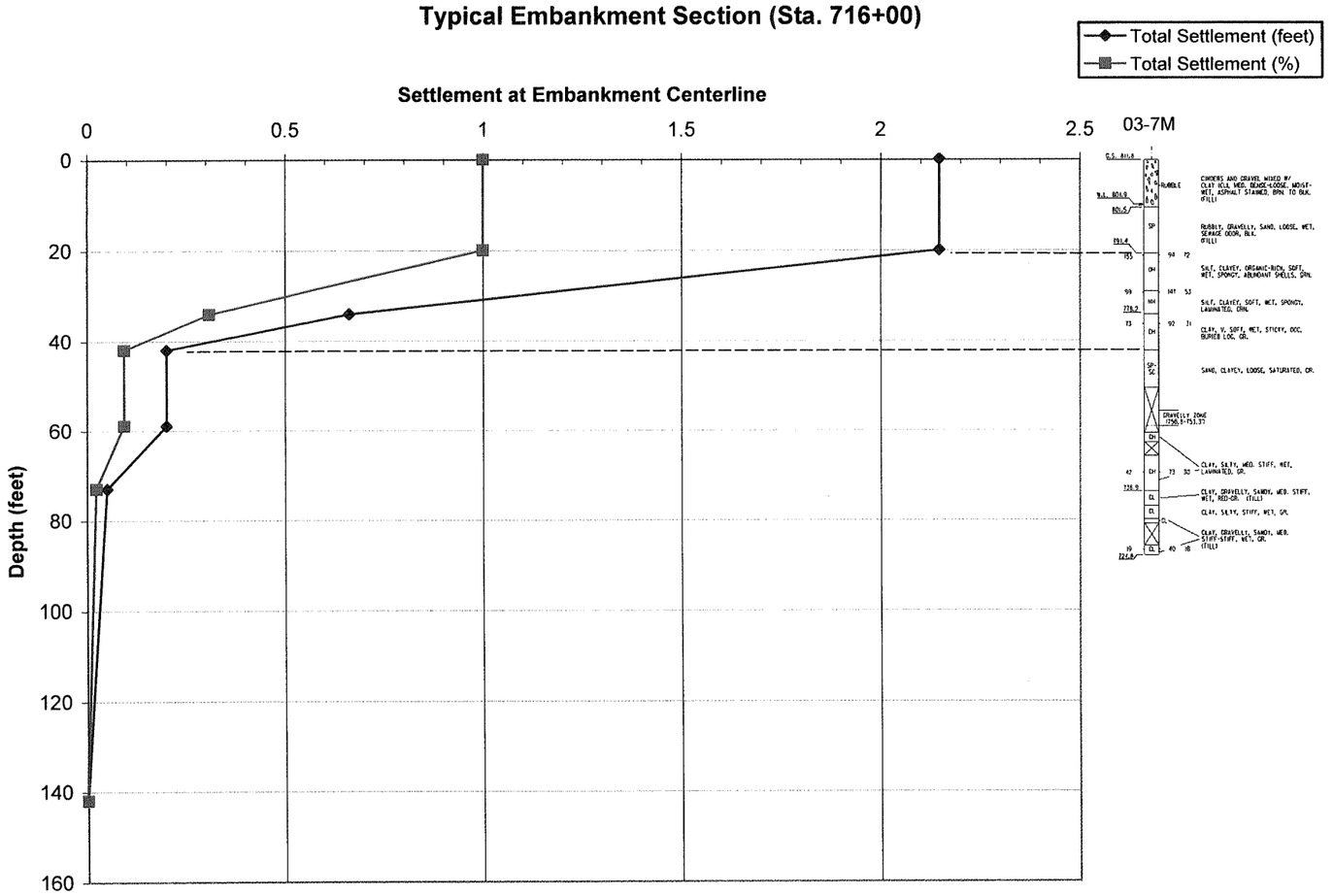


Plate 38

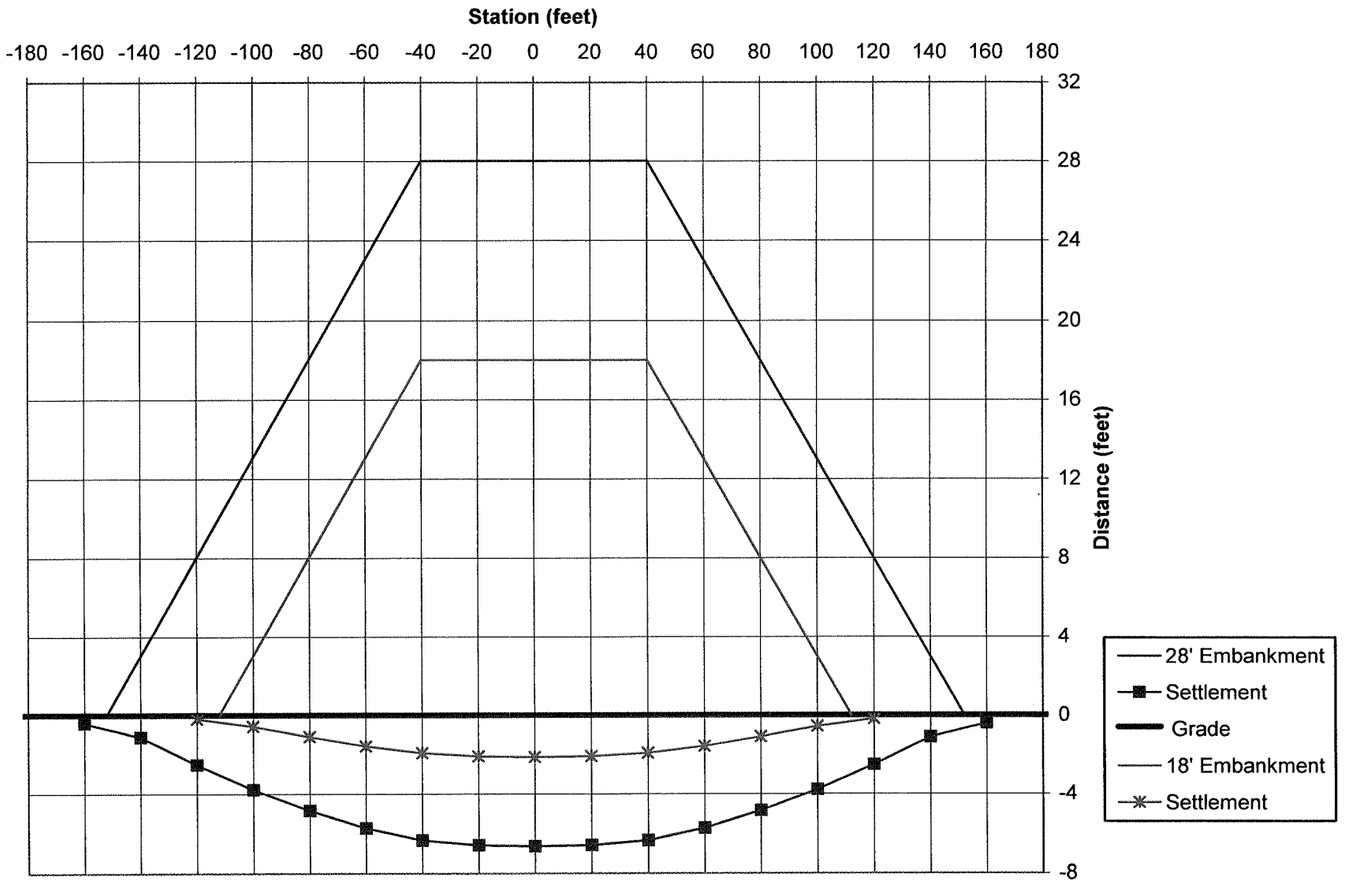
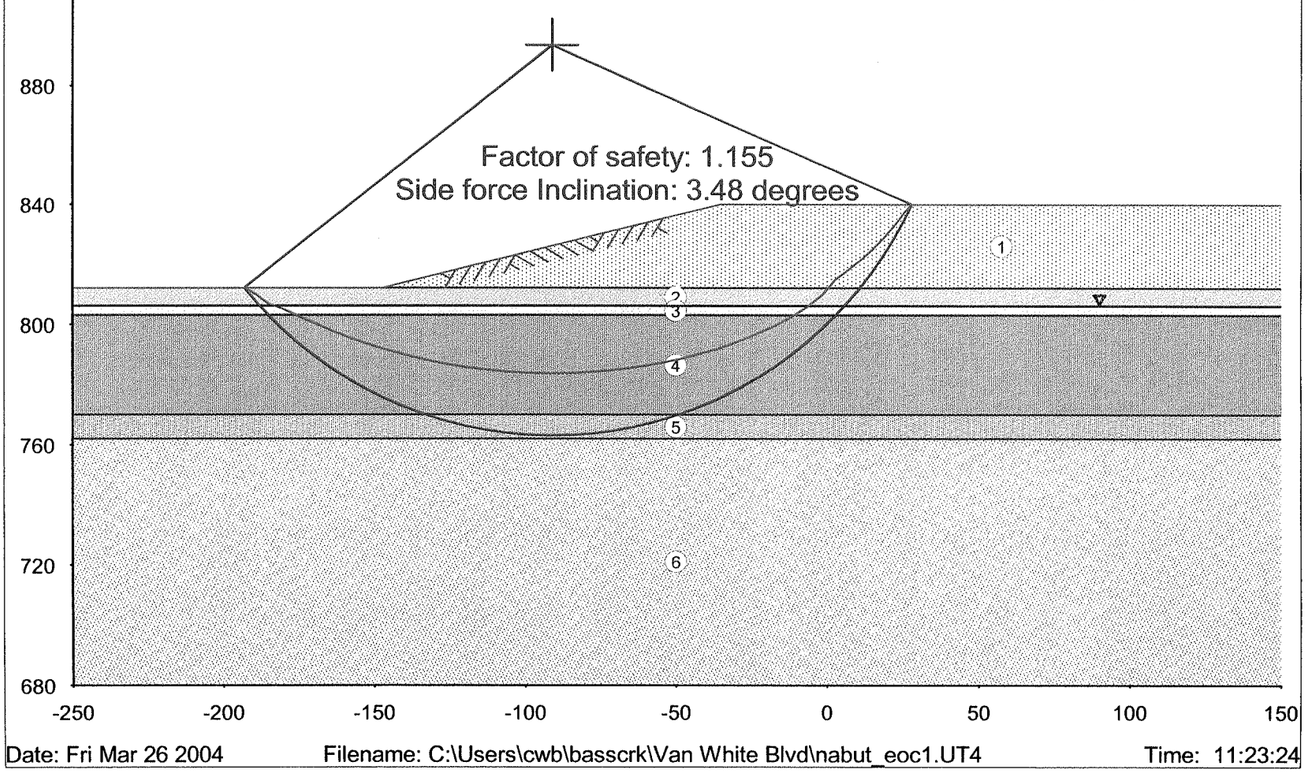

Station (feet)
-180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180
32
28
24
20
16
12
8
4
0
-4
-8
Distance (feet)
28' Embankment
Settlement
Grade
18' Embankment
Settlement

Plate 39

Bassett Creek- Van White Memorial Boulevard

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE	NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Embankment Fill	122	Cohesion: 0 Friction angle: 30	None	4	Unit 2 (Organic, Soft Silt/Clay)	87	S @ Profile: 330.00 dS/dz: 12.00	Piezometric Line no. 1
2	Unit 1 (Fill)	115	Cohesion: 0 Friction angle: 30	None	5	Unit 4B (Soft, Fat Clay)	101	Cohesion: 675 Friction angle: 0	Piezometric Line no. 1
3	Unit 1 (Fill, saturated)	120	Cohesion: 0 Friction angle: 30	Piezometric Line no. 1	6	Unit 5 (Clayey Sand)	123	Cohesion: 0 Friction angle: 33	Piezometric Line no. 1

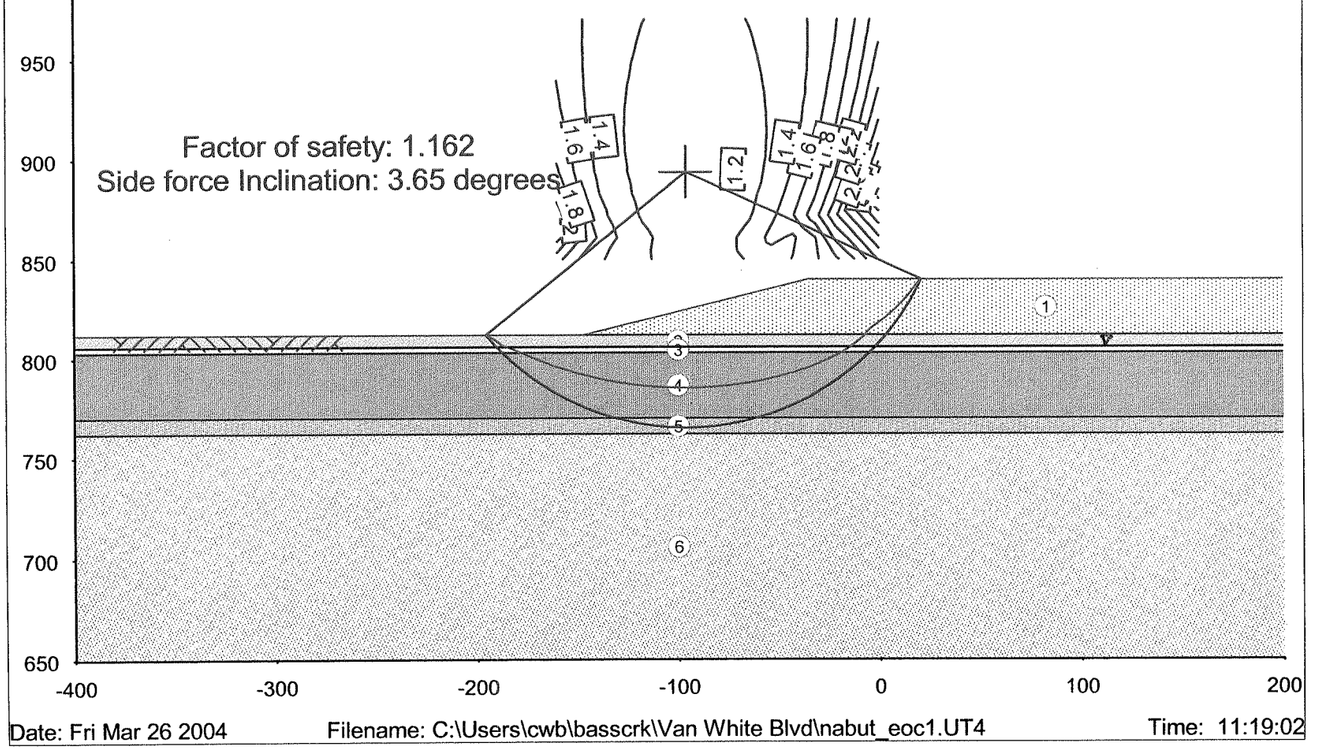


Date: Fri Mar 26 2004 Filename: C:\Users\cwb\basscrk\Van White Blvd\nabut_eoc1.UT4 Time: 11:23:24

Plate 40

Bassett Creek- Van White Memorial Boulevard

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE	NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Embankment Fill	122	Cohesion: 0 Friction angle: 30	None	4	Unit 2 (Organic, Soft Silt/Clay)	87	S @ Profile: 330.00 dS/dz: 12.00	Piezometric Line no. 1
2	Unit 1 (Fill)	115	Cohesion: 0 Friction angle: 30	None	5	Unit 4B (Soft, Fat Clay)	101	Cohesion: 675 Friction angle: 0	Piezometric Line no. 1
3	Unit 1 (Fill, saturated)	120	Cohesion: 0 Friction angle: 30	Piezometric Line no. 1	6	Unit 5 (Clayey Sand)	123	Cohesion: 0 Friction angle: 33	Piezometric Line no. 1

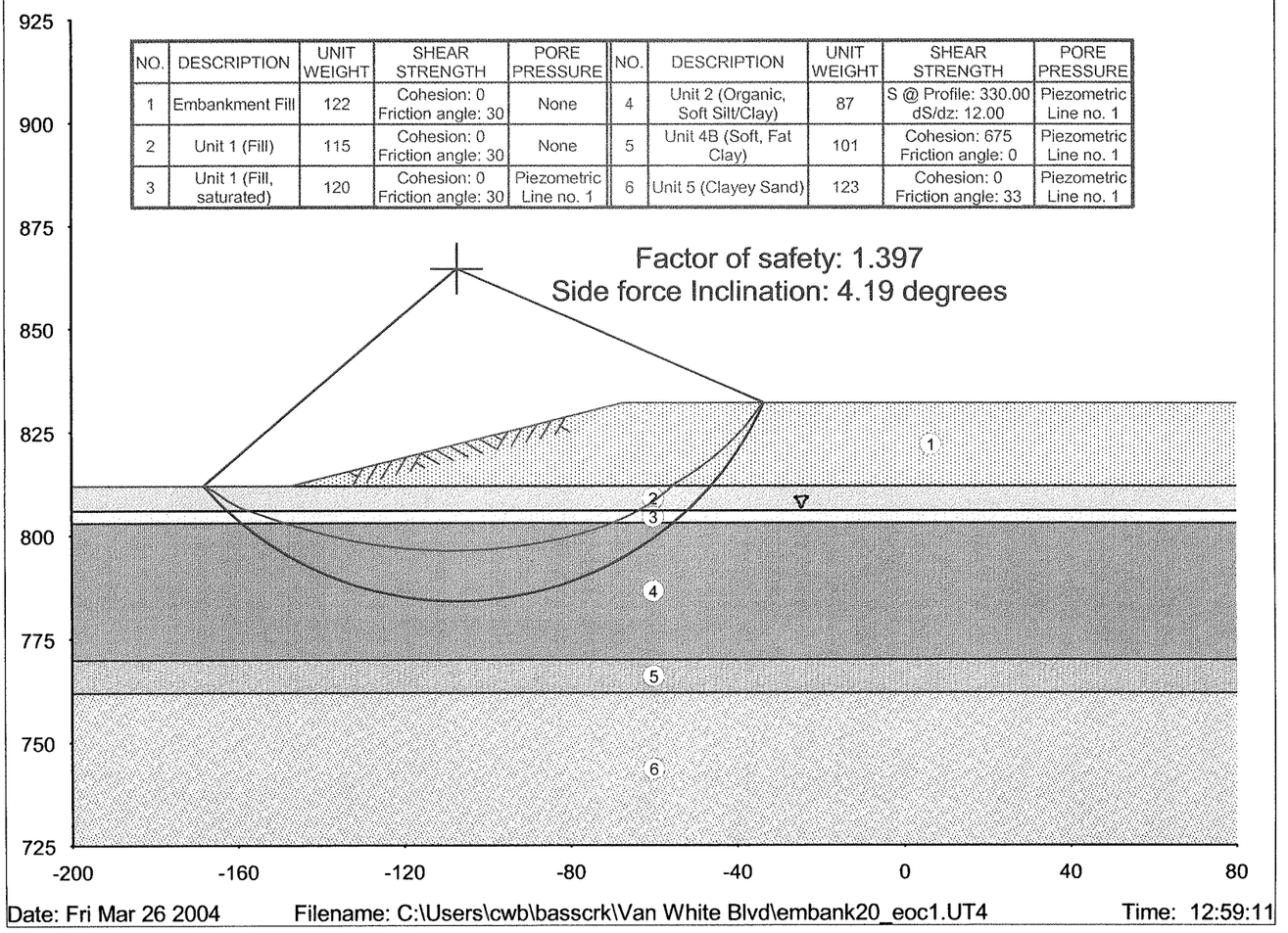


Date: Fri Mar 26 2004 Filename: C:\Users\cwb\basscrk\Van White Blvd\nabut_eoc1.UT4 Time: 11:19:02

Plate 41

Bassett Creek- Van White Memorial Boulevard

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE	NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Embankment Fill	122	Cohesion: 0 Friction angle: 30	None	4	Unit 2 (Organic, Soft Silt/Clay)	87	S @ Profile: 330.00 dS/dz: 12.00	Piezometric Line no. 1
2	Unit 1 (Fill)	115	Cohesion: 0 Friction angle: 30	None	5	Unit 4B (Soft, Fat Clay)	101	Cohesion: 675 Friction angle: 0	Piezometric Line no. 1
3	Unit 1 (Fill, saturated)	120	Cohesion: 0 Friction angle: 30	Piezometric Line no. 1	6	Unit 5 (Clayey Sand)	123	Cohesion: 0 Friction angle: 33	Piezometric Line no. 1

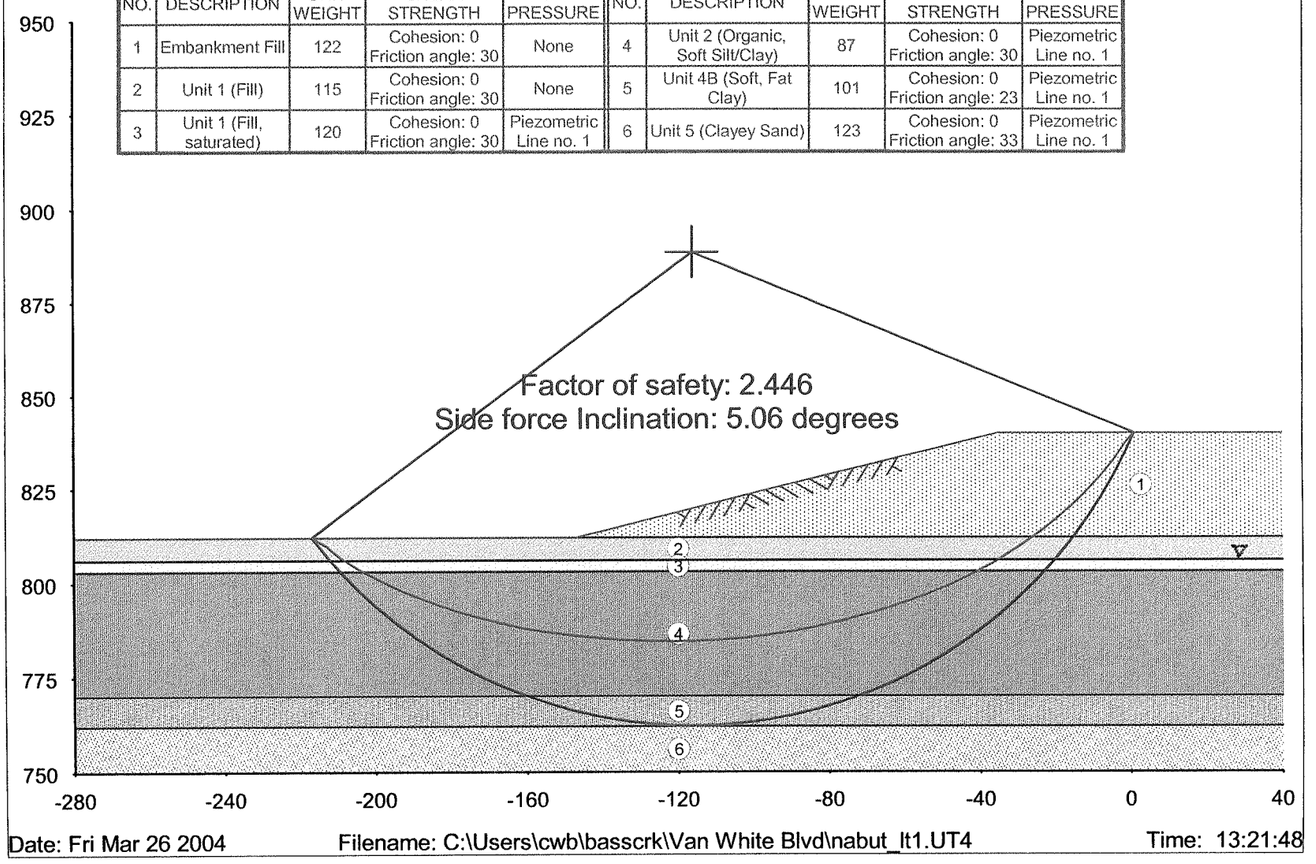


Date: Fri Mar 26 2004 Filename: C:\Users\cwb\basscrk\Van White Blvd\embank20_eoc1.UT4 Time: 12:59:11

Plate 42

Bassett Creek- Van White Memorial Boulevard

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE	NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Embankment Fill	122	Cohesion: 0 Friction angle: 30	None	4	Unit 2 (Organic, Soft Silt/Clay)	87	Cohesion: 0 Friction angle: 30	Piezometric Line no. 1
2	Unit 1 (Fill)	115	Cohesion: 0 Friction angle: 30	None	5	Unit 4B (Soft, Fat Clay)	101	Cohesion: 0 Friction angle: 23	Piezometric Line no. 1
3	Unit 1 (Fill, saturated)	120	Cohesion: 0 Friction angle: 30	Piezometric Line no. 1	6	Unit 5 (Clayey Sand)	123	Cohesion: 0 Friction angle: 33	Piezometric Line no. 1



Date: Fri Mar 26 2004 Filename: C:\Users\cwb\basscrk\Van White Blvd\nabut_lt1.UT4 Time: 13:21:48

Plate 43

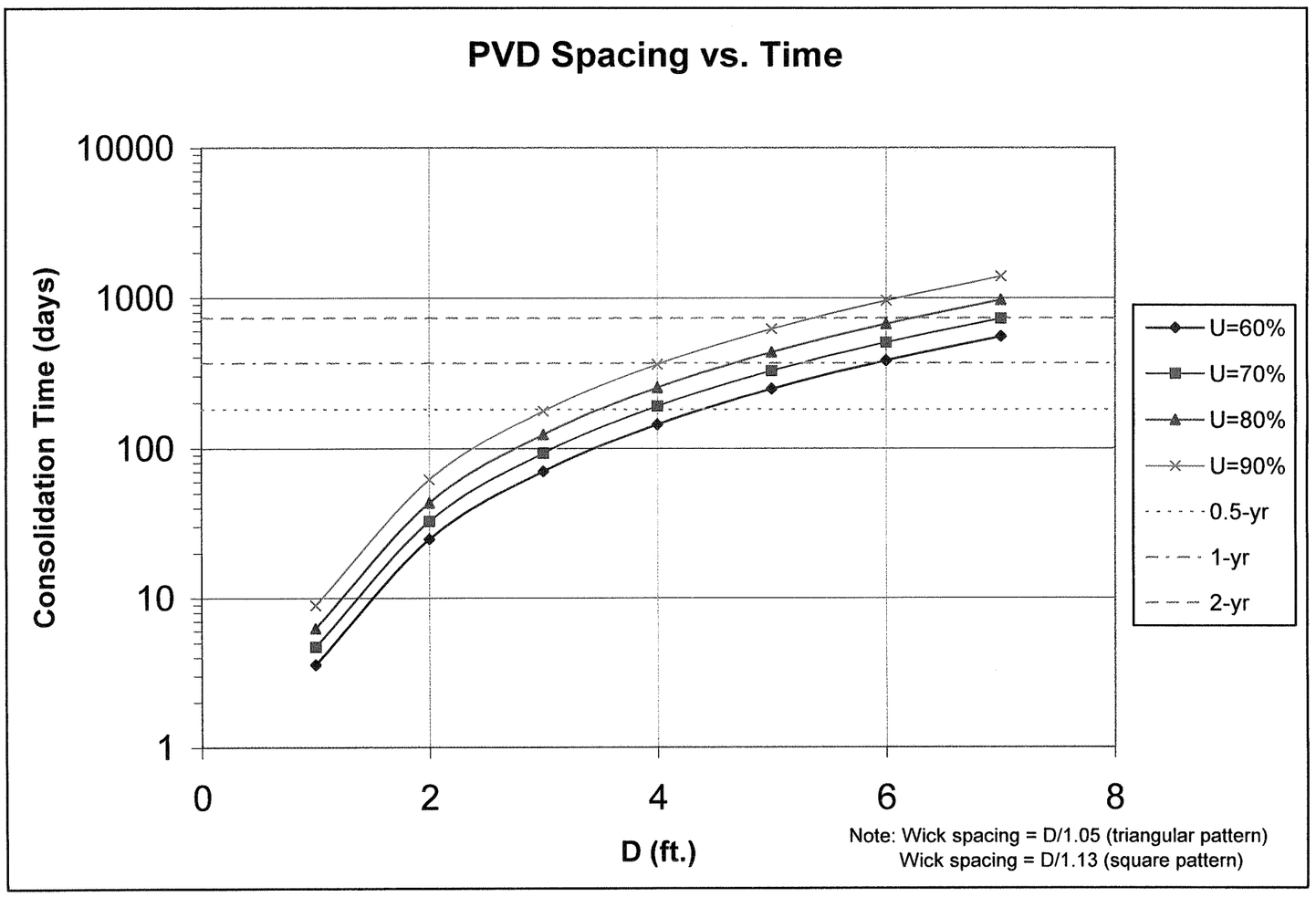

PVD Spacing vs. Time
Consolidation Time (days)
10000
1000
100
10
1
0
2
4
6
8
D (ft.)
U=60%
U=70%
U=80%
U=90%
0.5-yr
1-yr
2-yr
Note: Wick spacing = D/1.05 (triangular pattern)
Wick spacing = D/1.13 (square pattern)

Plate 44

Preliminary Design of Prefabricated Vertical Drains
Drain Spacing versus Time

		Source:	Mebra drain		Typical Values, Ref.: Hansbo (1979)
c_v =	0.028 ($ft.^2$/day)	wick width, a =	0.0131	feet	3.2 - 4 mm
c_h/c_v =	1	wick thickness, b =	0.3281	feet	93 - 100 mm
c_h =	0.028 ($ft.^2$/day)	equivalent diameter, d =	0.2172	feet	62 - 66 mm

$t = D^2/8c_h [\ln (D/d) / 1 - (d/D)^2 - (3 - (d/D)^2)/4] \ln [1-/(1-U)]$ Source: Hansbo (1979) Ideal Case - ignores the effects of soil disturbance and drain resistance

t = the time for consolidation (days)
c_h = the coefficient of consolidation of soil for horizontal flow ($ft.^2$/day)
d = the equivalent diameter of a strip drain ($\simeq 2(a+b)/\pi$ in ft.)
D = the sphere of influence of the vertical strip drain (for triangular pattern use 1.05 * direct spacing; for square pattern use 1.13 * direct spacing)
U = the average degree of consolidation

t (days)	2.67441296	3.535382	4.645363	6.209795	8.884208
D (ft.)	1	1	1	1	1
c_h ($ft.^2$/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9
t (days)	18.55980949	24.53473	32.23775	43.09454	61.65435
D (ft.)	2	2	2	2	2
c_h ($ft.^2$/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9
t (days)	52.65337072	69.60397	91.45709	122.2573	174.9107
D (ft.)	3	3	3	3	3
c_h ($ft.^2$/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9
t (days)	107.5624187	142.1898	186.8322	249.7522	357.3146
D (ft.)	4	4	4	4	4

c_h (ft.^{2}/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9
t (days)	185.1004067	244.6894	321.513	429.7898	614.8902
D (ft.)	5	5	5	5	5
c_h (ft.^{2}/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9
t (days)	286.663432	378.9484	497.9245	665.6119	952.2753
D (ft.)	6	6	6	6	6
c_h (ft.^{2}/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9
t (days)	413.3880072	546.4692	718.0407	959.8572	1373.245
D (ft.)	7	7	7	7	7
c_h (ft.^{2}/day)	0.028	0.028	0.028	0.028	0.028
d (ft.)	0.217214666	0.217215	0.217215	0.217215	0.217215
U	0.5	0.6	0.7	0.8	0.9

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Surcharge Design w/ Vertical Drains	COMPUTED BY: CWB	DATE: 4-04	SHEET: 1/	
	SUBJECT TITLE: Typical Embankment X-Section (Sta. 716)	CHECKED BY:	DATE:	CONTRACT NO.:	

Problem: Determine a surcharge that would minimize secondary compression

Given/Assumptions: Prefabricated vertical drains will be installed through the shallow, compressible soils (units 2+4B), since the majority of settlement will take place in these deposits.
- Initially, assume 5-ft. pvd spacing in a triangular pattern and that for practical purposes $t_{90} = t_{pr}$ (time to U_H = 90% = time to complete primary consolidation)

Start: For the "typical" embankment cross-section at Sta. 716+00, the finished height is about 18-ft. Based on stability completed for varying embankment heights, 23-ft. is the practical limit without flattening slope, constructing stability berms, or staging embankment construction.

So try 5-ft. surcharge (23'-18') left in place until primary consolidation is completed (t_{pr} = 2-yrs. for assumed pvd spacing)

Reference: (A) Terzaghi, Peck, + Mesri. (1996). pp 110, 111

① Determine the effective surcharge ratio, R_s'

$$R_s' = \frac{\sigma_{vf}' + \Delta\sigma_{vs}'}{\sigma_{vf}'} - 1 = \frac{\sigma_{vs}'}{\sigma_{vf}'} - 1$$

σ_{vs}' = max. effective vertical stress reached before surcharge removal

σ_{vf}' = final eff. vert. stress after surcharge removal

$R_s' = 0.15$ (See results from attached spreadsheet)

② From Fig. 16.12, Ref. (A)

$$\frac{t_\ell}{t_{pr}} = 100 R_s'^{1.7}$$ where t_ℓ = time from surcharge removal to start of secondary compression

$t_\ell = (2\text{yrs})100(0.15)^{1.7} \cong 8\text{yrs}$

Effective Surcharge Ratio, R'_s

$R'_s = (\sigma'_{vs}/\sigma'_{vf}) - 1$

CSETT Results

Emankment H = 23 ft.

X = 0

Stratum	Depth (feet)	po' (psf)	Δ p (psf)	σ'_{vs} po' + Δ p (psf)	Sc (feet)
	0	0	3050	3050	0
1	5	575	2805.13	3380.13	0
2	15	1438	2793.68	4231.68	0
3	27	1898.2	2748.04	4646.24	1.758
4	38	2224.8	2677.23	4902.03	0.571
5	50.5	2894.3	2568.05	5462.35	0
6	66	3791.6	2414.32	6205.92	0.246
7	107.5	6747.5	2006.7	8754.2	0.078
					2.653

X = -40

Stratum	Depth (feet)	po' (psf)	Δ p (psf)	po' + Δ p (psf)	Sc (feet)
1	5	575	2757.45	3332.45	0
2	15	1438	2660.35	4098.35	0
3	27	1898.2	2543.86	4442.06	1.671
4	38	2224.8	2437.5	4662.3	0.529
5	50.5	2894.3	2318.3	5212.6	0
6	66	3791.6	2174.32	5965.92	0.208
7	107.5	6747.5	1833.22	8580.72	0.07
					2.478

Emankment H = 18 ft.

X = 0

Stratum	Depth (feet)	po' (psf)	Δ p (psf)	σ'_{vf} po' + Δ p (psf)	Sc (feet)	R'_s
	0	0	2440	2440	0	0.25
1	5	575	2195.18	2770.18	0	0.220184
2	15	1438	2184.2	3622.2	0	0.168262
3	27	1898.2	2140.88	4039.08	1.484	0.150321
4	38	2224.8	2074.4	4299.2	0.461	0.140219
5	50.5	2894.3	1973.65	4867.95	0	0.122105
6	66	3791.6	1834.74	5626.34	0.15	0.103012
7	107.5	6747.5	1485.77	8233.27	0.051	0.063271
					2.146	

X = -40

Stratum	Depth (feet)	po' (psf)	Δ p (psf)	po' + Δ p (psf)	Sc (feet)	R'_s
1	5	575	2147.53	2722.53	0	0.224027
2	15	1438	2051.3	3489.3	0	0.174548
3	27	1898.2	1938.88	3837.08	1.383	0.157667
4	38	2224.8	1839.57	4064.37	0.415	0.147115
5	50.5	2894.3	1732.9	4627.2	0	0.126513
6	66	3791.6	1608.92	5400.52	0.108	0.104694
7	107.5	6747.5	1332.61	8080.11	0.044	0.061956
					1.95	

Plate 48

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Surcharge Design w/ Vertical Drains	COMPUTED BY: CWB	DATE: 4-04	SHEET: 21	
	SUBJECT TITLE: Typical Embankment X-Section (Sta. 716)	CHECKED BY:	DATE:	CONTRACT NO.:	

③ Assume $t = 50$-yrs, where t = time from t_ℓ over which secondary compression will be evaluated

From Fig. 16.11, Ref Ⓐ

for $t/t_\ell = 50\text{yrs}/8\text{yrs} = 6.25$

$\Rightarrow C''_\alpha/C_\alpha \cong 0.08$

④ From Table 16.1, Ref. Ⓐ

Assume $C_\alpha/C_c = 0.05$ (for organic clays + silts, unit 2)

$C_\alpha/C_c = 0.04$ (for inorganic clays, unit 4B)

⑤ Secondary Compression, $S_{sc} = \left[\dfrac{\frac{C''_\alpha}{C_c} \times \frac{C_\alpha}{C_c} \times C_c}{1+e_o}\right] L_o \log \dfrac{t}{t_\ell}$ Ref. Ⓐ, Equ. 16.14

$$S_{SC\text{-}2} = \frac{(0.08)(0.05)(1.25)}{1+3.06}(14')\log\left(\frac{50\text{yr}}{8\text{yr}}\right) = 0.014'$$

$$S_{SC\text{-}4B} = \frac{(0.08)(0.04)(0.65)}{1+1.71}(8')\log\left(\frac{50\text{yr}}{8\text{yr}}\right) = 0.005'$$

Total S_{sc} = 0.019-ft. or ~0.25 in.

⑥ Evaluate remaining primary consolidation settlement in the deep, fine-grained deposits (units 6A + 7B). Assume negligible secondary compr. in these soils, since t_{pr} is large.

$S_{PC\ Remaining} = S_{PC\ f} - S_{PC\ surch-2yrs}$

Soil Type	Ult. Primary Consol. under Finished Embankment (feet)		Primary Consol. under Surcharge Embankment after 2 years (feet)	S_{PC} Rem. (ft.)
6A	0.150	-	0.126	= 0.024
7B	0.051	-	0.009	= 0.041
				0.065'
				or ~0.75"

⑦ Approximate Total Settlement after Surcharge Removal (surcharge in place for 2-yrs)

$S_{TOT} = 0.019' + 0.065' = 0.084$-ft. or about 1-inch.

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Surcharge Design with Vertical Drains	COMPUTED BY: CWB	DATE: 4-04	SHEET: 31	
	SUBJECT TITLE: Typical Embankment X-Section (Sta. 716+00)	CHECKED BY:	DATE:	CONTRACT NO.:	

(8) For the typical embankment section, a 5-ft. surcharge left in place for 2-yrs produces a reasonable post surcharge settlement of an inch. The final design would require establishing an acceptable length of time to surcharge the soils and an acceptable level of post surcharge settlement. These items require the owner's input/consent and are beyond the scope of a preliminary design.

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Surcharge Design with Vertical Drains	COMPUTED BY: CWB	DATE: 4-04	SHEET: 41	
	SUBJECT TITLE: Max. Ht. Embank. N. Abut., S. Bridge	CHECKED BY:	DATE:	CONTRACT NO.:	

Problem: Determine a surcharge that would minimize secondary compression for the max. embankment height at the north abutment, south bridge

Given/Assumptions: Same as for typical embankment cross-section.

Start: Try a 10' surcharge (38'-28') left in place until the end of primary consolidation.

Note: If this option was selected to "remove settlement" from site, the embankment construction would require staging or flatter slopes or a benched slope. For settlement purposes only, the surcharge embankment was assumed 38-ft. high with 1V-4H side slopes.

① $R_s' = 0.25$ (see results from enclosed spdsht.)

② From Fig. 16.12, Ref. (A) (for $t_{pr} \cong 2$-yrs), $\frac{t_2}{t_{pr}} = 100(0.25)^{1.7} \cong 19$-yrs

③ From Fig. 16.11, Ref. (A) for $t/t_2 = 50\text{yrs}/19\text{yrs} = 2.63$

$\Rightarrow C_\alpha''/C_\alpha \cong 0.02$

④ Same as previous analysis

⑤ $S_{sc-2} = \frac{(0.02)(0.05)(1.25)}{1+3.06}(34')\log(2.63) = 0.0044'$

$S_{sc-4B} = \frac{(0.02)(0.04)(0.65)}{1+7.71}(8')\log(2.63) = 0.0006'$

Total $S_{sc} = 0.0051'$ or $0.06''$

⑥ S_{PC} remaining in soil types 6A + 7B

	$S_{PC\,final}$ (ft.)		$S_{PC\,surch-2yrs}$ (ft.)		$S_{PC\,Rem.}$ (ft.)
6A	0.142	-	0.204	=	-0.062
7B	0.428	-	0.113	=	0.315
					0.253'

⑦ Approximate total settlement after surcharge removal = 0.258' or about 3-inches for $t_s = 2$yrs

Effective Surcharge Ratio, R'_s

$R'_s = (\sigma'_{vs}/\sigma'_{vf}) - 1$

CSETT Results at North Abutment of South Bridge

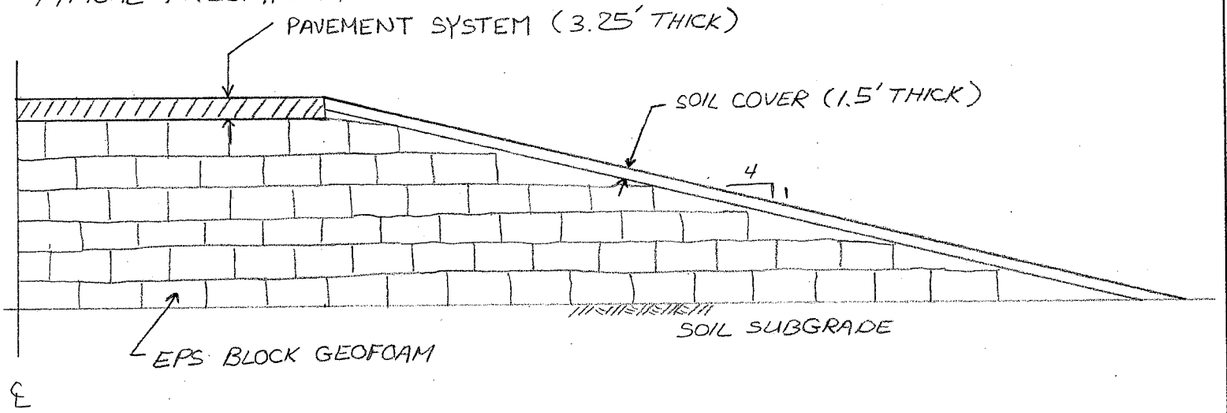
Emankment H = 38 ft.
X = 0

Stratum	Depth (feet)	po' (psf)	Δ p (psf)	σ'_{vs} po' + Δ p (psf)	Sc (feet)
	0	0	4636	4636	0
1	3	345	4635.85	4980.85	0
2	7	747.6	4634.7	5382.3	0
3	25	1223.4	4573.87	5797.27	6.548
4	46	1796	4423.03	6219.03	0.794
5	60.5	2586.7	4262.79	6849.49	0
6	74.5	3414.1	4093.37	7507.47	0.228
7	110	5992.4	3650.23	9642.63	0.678
					8.248

Emankment H = 28 ft.
X = 0

Stratum	Depth (feet)	po' (psf)	Δ p (psf)	σ'_{vf} po' + Δ p (psf)	Sc (feet)	R'_s
	0	0	3416	3416	0	0.357143
1	3	345	3415.85	3760.85	0	0.324395
2	7	747.6	3414.7	4162.3	0	0.293107
3	25	1223.4	3356.15	4579.55	5.47	0.265904
4	46	1796	3212.47	5008.47	0.615	0.241703
5	60.5	2586.7	3063.21	5649.91	0	0.212318
6	74.5	3414.1	2908.3	6322.4	0.142	0.18744
7	110	5992.4	2523.31	8515.71	0.428	0.132334
					6.655	

TYPICAL PRELIMINARY DESIGN CROSS-SECTION



℄

DESIGN ASSUMPTIONS: (Source: Horvath, J.S. (2001))

- PAVEMENT IS 3.25-FT. THICK, $\gamma_{PAVEMENT}$ = 125 PCF
- γ_{EPS} = 1.25 PCF
- SOIL COVER ON THE SIDE SLOPES IS 1.5-FT THICK, $\gamma_{SOIL\ COVER}$ = 125 PCF.

US Army Corps of Engineers
Saint Paul District

PROJECT TITLE: Van White Memorial Blvd.
SUBJECT TITLE: Typical EPS Block Geofoam Embankment Cross-Section
COMPUTED BY: CWB
CHECKED BY:
DATE: 4-04
DATE:
SHEET: 11 / 1
CONTRACT NO.:

CEMVP Form 14 (Jun 97)

Plate 53

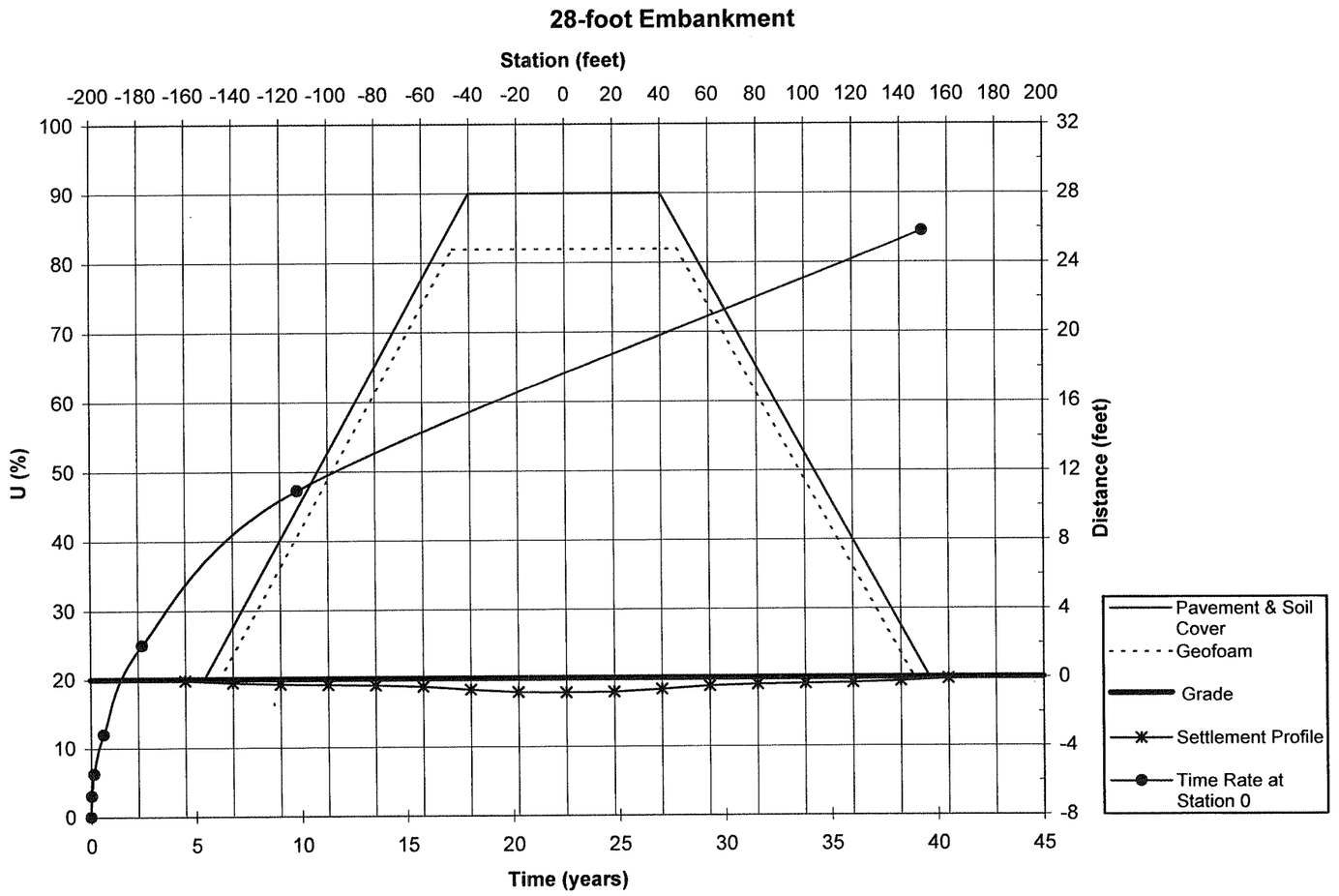

28-foot Embankment
Station (feet)
-200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200
U (%)
100 90 80 70 60 50 40 30 20 10 0
Distance (feet)
32 28 24 20 16 12 8 4 0 -4 -8
0 5 10 15 20 25 30 35 40 45
Time (years)
Pavement & Soil Cover
Geofoam
Grade
Settlement Profile
Time Rate at Station 0

Plate 54

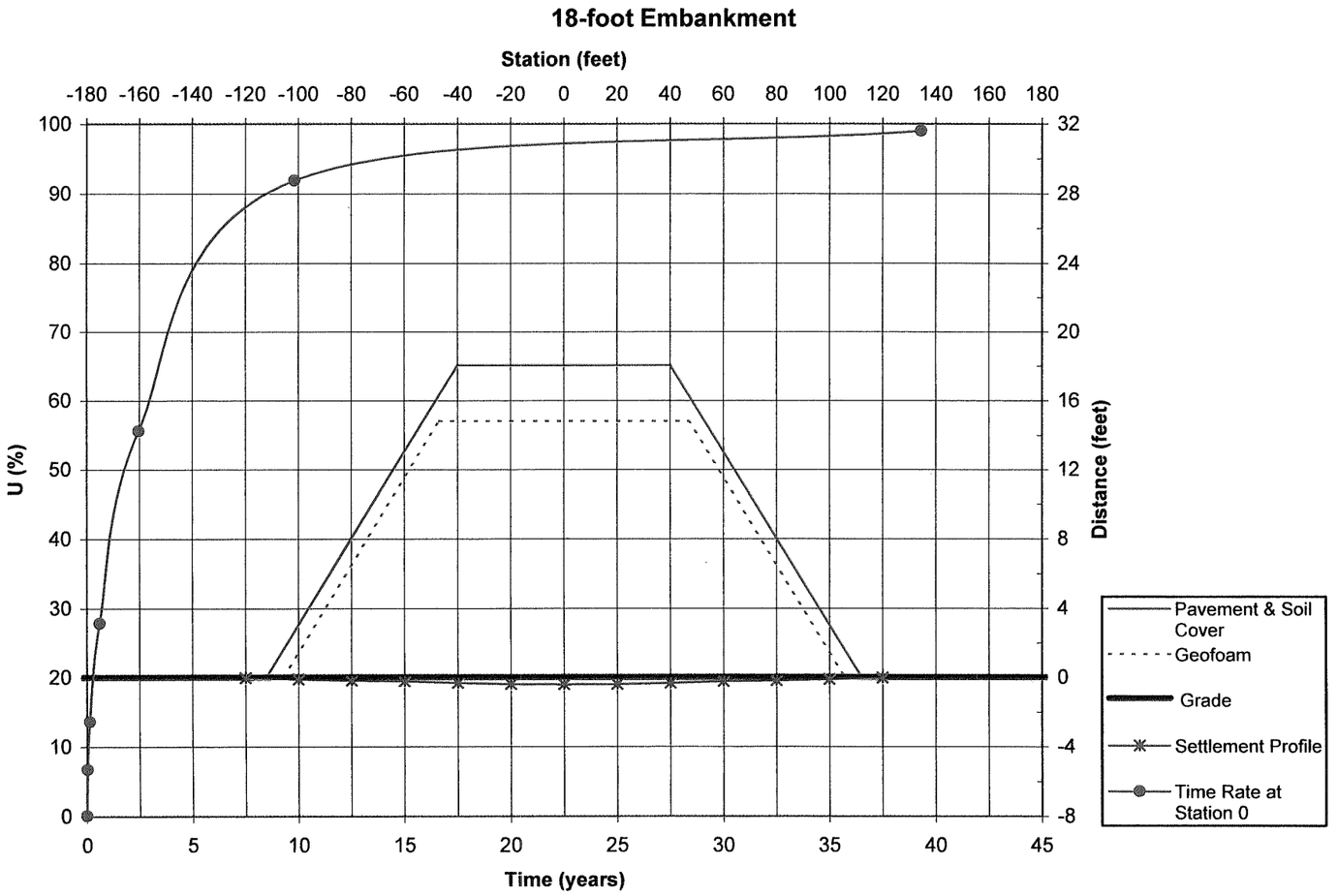
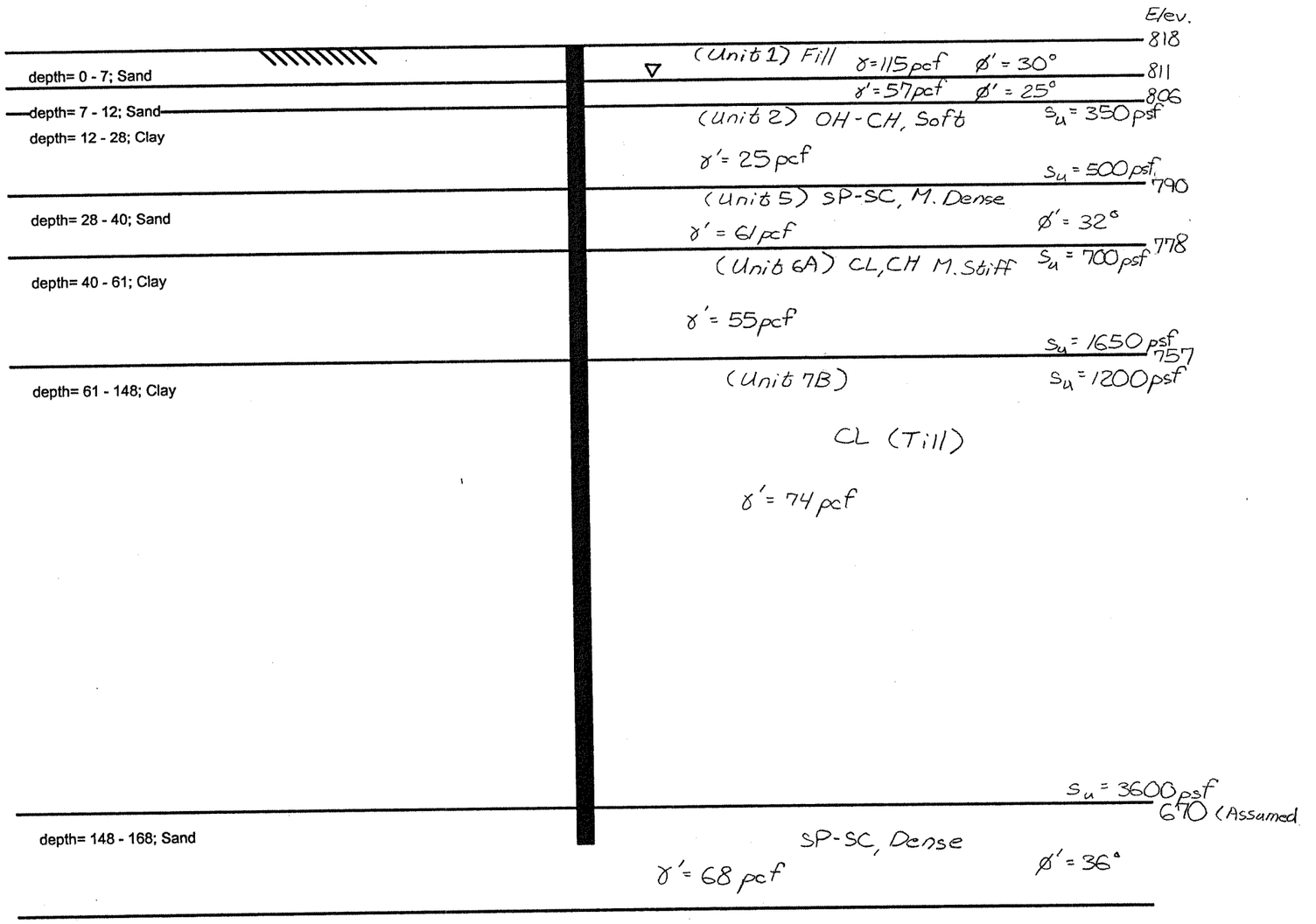
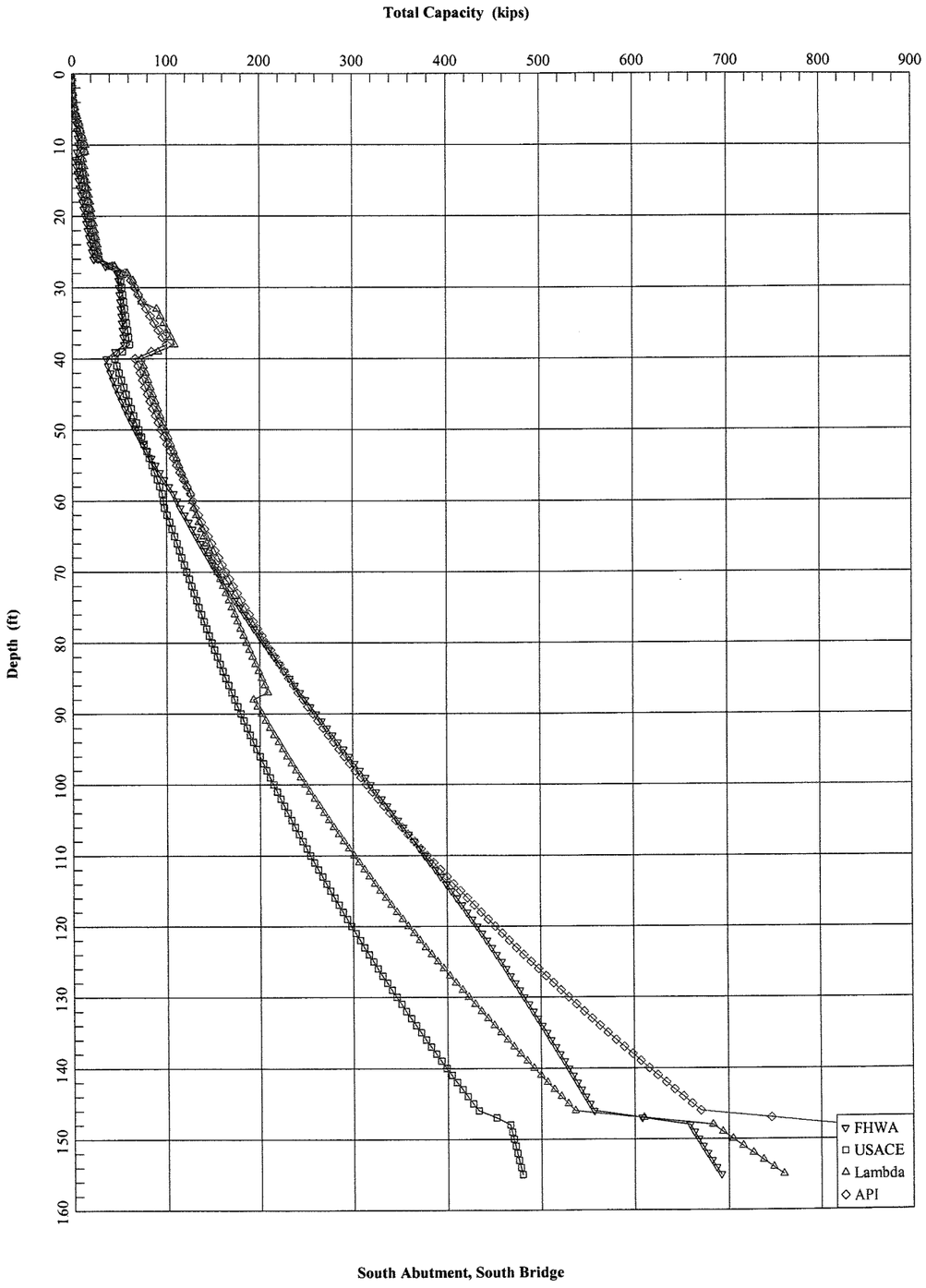

18-foot Embankment
Station (feet)
-180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180
U (%)
100 90 80 70 60 50 40 30 20 10 0
Distance (feet)
32 28 24 20 16 12 8 4 0 -4 -8
Time (years)
0 5 10 15 20 25 30 35 40 45
Pavement & Soil Cover
Geofoam
Grade
Settlement Profile
Time Rate at Station 0

Plate 55



South Abutment, South Bridge
Geologic Stratigraphy

Plate 56


Total Capacity (kips)
0
100
200
300
400
500
600
700
800
900
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FHWA
USACE
Lambda
API
South Abutment, South Bridge

Axial Loaded Pile Capacities from APILEplus, Version 3.0
South Bridge, South Abutment

Pile Head Elevation = 818 feet
Pile Tip Elevation = 728 feet
Pile Length = 90 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	261
USACE	180
Lambda 2	203
API	257
Average	225

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	87
USACE	60
Lambda 2	68
API	86
Average	75

Pile Head Elevation = 818 feet
Pile Tip Elevation = 708 feet
Pile Length = 110 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	377
USACE	255
Lambda 2	302
API	380
Average	329

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	126
USACE	85
Lambda 2	101
API	127
Average	110

Pile Head Elevation = 818 feet
Pile Tip Elevation = 688 feet
Pile Length = 130 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	482
USACE	347
Lambda 2	424
API	530
Average	446

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	161
USACE	116
Lambda 2	141
API	177
Average	149

Pile Head Elevation = 818 feet
Pile Tip Elevation = 668 feet
Pile Length = 150 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	668
USACE	471
Lambda 2	705
API	834
Average	670

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	223
USACE	157
Lambda 2	235
API	278
Average	223

North Abutment South Bridge
Geologic Stratigraphy

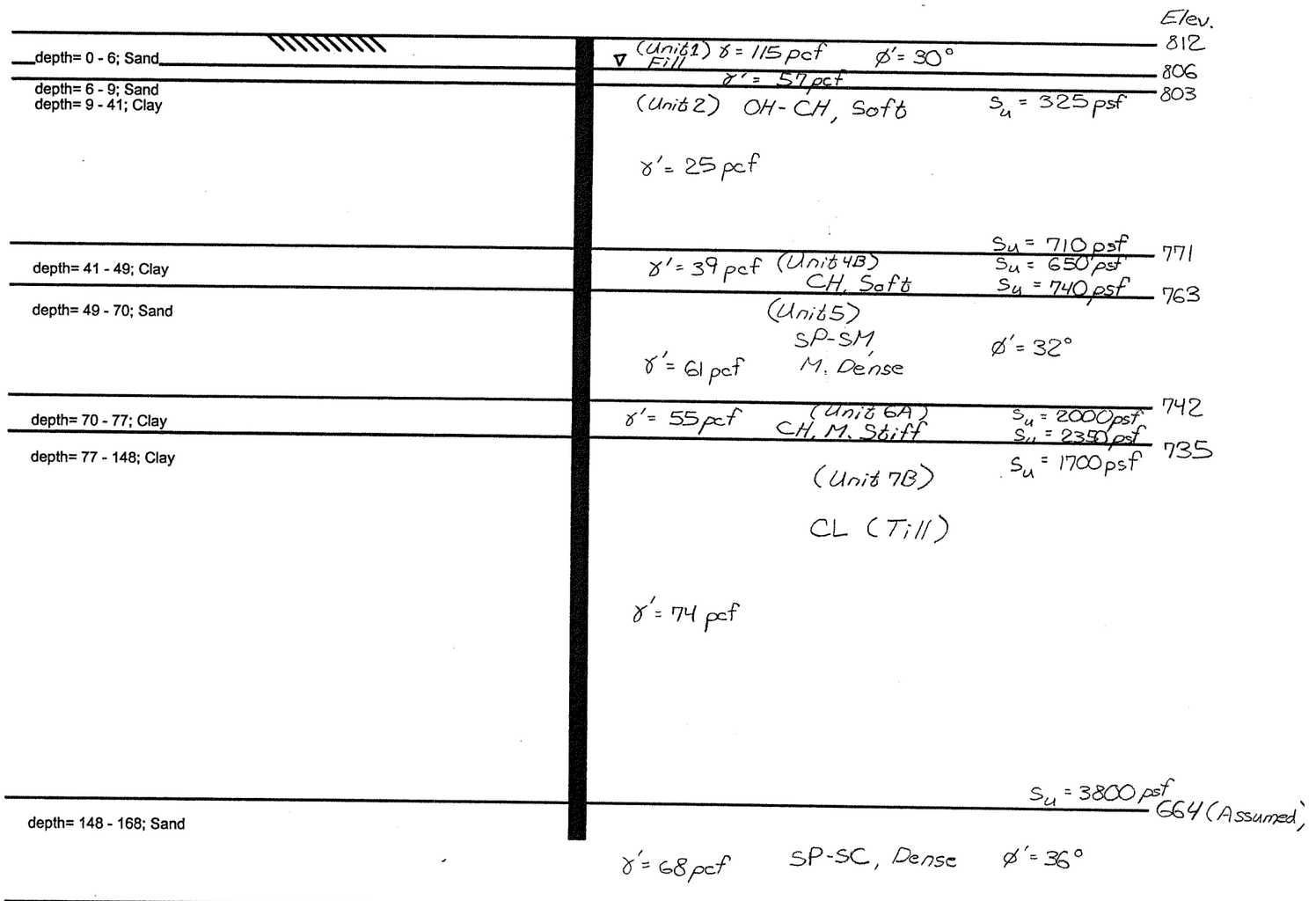
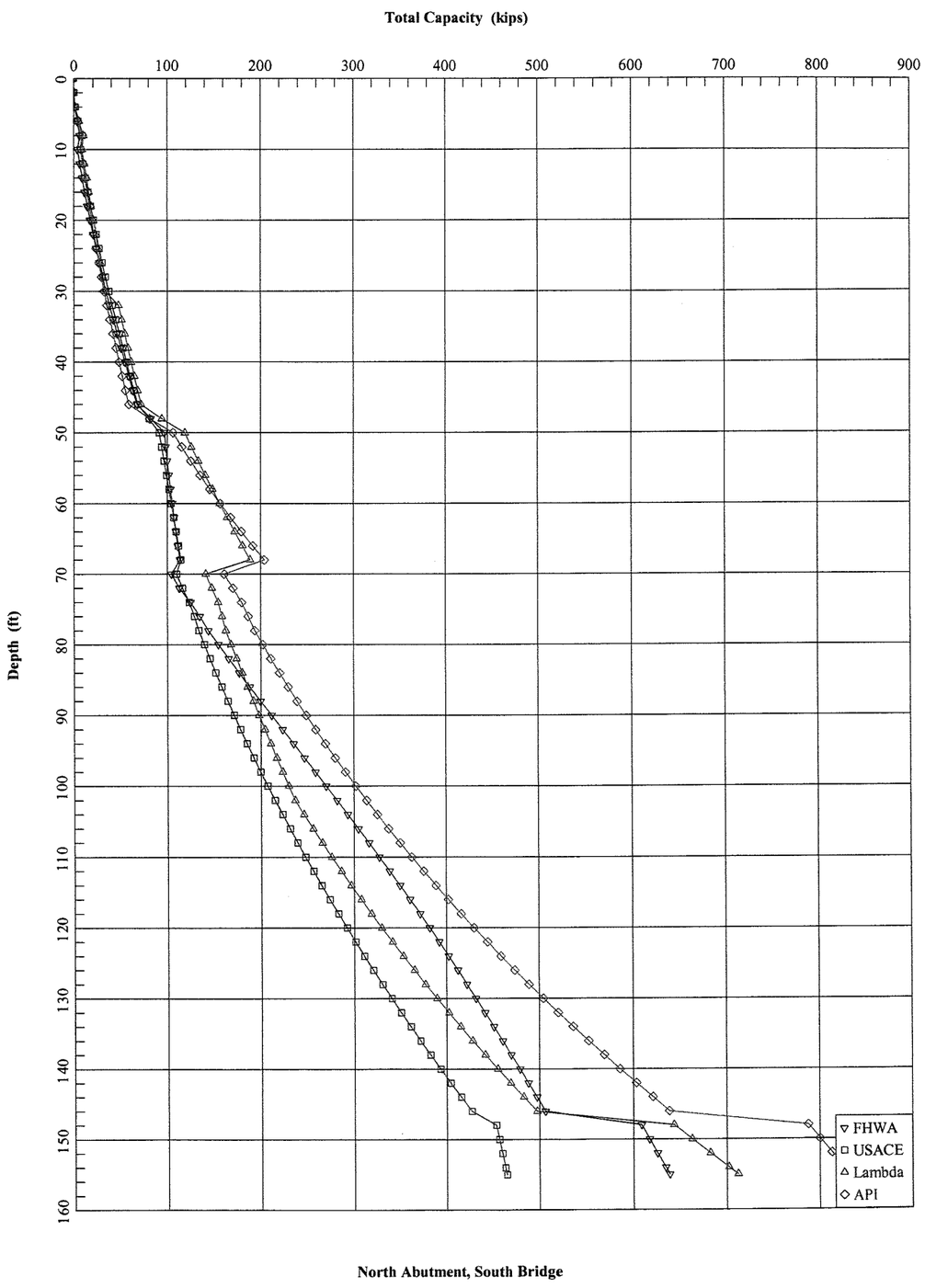


Plate 59


Total Capacity (kips)
0
100
200
300
400
500
600
700
800
900
Depth (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FHWA
USACE
Lambda
API
North Abutment, South Bridge

Axial Loaded Pile Capacities from APILEplus, Version 3.0
South Bridge, North Abutment

Pile Head Elevation = 812 feet
Pile Tip Elevation = 722 feet
Pile Length = 90 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	211
USACE	172
Lambda 2	199
API	249
Average	208

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	70
USACE	57
Lambda 2	66
API	83
Average	69

Pile Head Elevation = 812 feet
Pile Tip Elevation = 702 feet
Pile Length = 110 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	327
USACE	248
Lambda 2	277
API	363
Average	304

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	109
USACE	83
Lambda 2	92
API	121
Average	101

Pile Head Elevation = 812 feet
Pile Tip Elevation = 682 feet
Pile Length = 130 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	432
USACE	341
Lambda 2	391
API	505
Average	417

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	144
USACE	114
Lambda 2	130
API	168
Average	139

Pile Head Elevation = 812 feet
Pile Tip Elevation = 662 feet
Pile Length = 150 feet

Ultimate Compressive Capacity (kips)

Analysis Method	
FHA	617
USACE	457
Lambda 2	663
API	800
Average	634

Allowable Compressive Capacity (kips)
FS = 3

Analysis Method	
FHA	206
USACE	152
Lambda 2	221
API	267
Average	211