GeoEngineers

Appendix A
Subsurface Explorations

APPENDIX A
SUBSURFACE EXPLORATIONS

SUBSURFACE EXPLORATIONS

We explored subsurface conditions in the project area by advancing three borings and 10 cone penetration tests (CPTs). The borings were advanced in October and December 2008. The CPTs were advanced in October and November 2008 and January 2009. Our representative located the explorations in the field by hand-taping and pacing from existing site features such as buildings and roadways. Global positioning satellite (GPS) data was also collected on each exploration location. Exploration locations should be considered approximate and are indicated on the Site Plan, Figure 2. A key to the symbols used on the boring logs is included as Figure A-1.

SOIL BORINGS

The borings were advanced using a truck-mounted hollow-stem auger drill rig under subcontract to GeoEngineers. The borings were advanced to depths of 139 to 151.5 feet below existing site grade (bgs). Soil samples were obtained from the borings using a 1.4-inch-inside-diameter split-barrel sampler driven into the soil using a 140-pound hammer free-falling a distance of 30 inches. The number of blows required to drive the sampler the last 12 inches or other indicated distance is recorded on the logs as the blow count. Larger samples in a less disturbed condition were periodically collected using a 2.4-inch-inside-diameter split-barrel ring sampler. Blow counts for the 2.4-inch sampler are reported as the converted blow count approximately equivalent to the SPT blow count. Higher-quality, relatively undisturbed samples were obtained at selected intervals by using a Shelby tube sampler.

Our representative continuously monitored the boring, maintained a log of the subsurface conditions, and made sample attempts at 5-foot-depth intervals. The soils encountered were visually classified in accordance with the system described in Figure A-1, American Society for Testing and Materials (ASTM) D 2488.

CPT SOUNDINGS

The CPT soundings were advanced using equipment and operator under subcontract to GeoEngineers. The CPT soundings were advanced to depths of 12 to 136 feet bgs. CPT 2 met refusal at a depth of 12 feet in the granular fill. The CPT sounding involves pushing an instrumented steel probe into the ground and continuously recording soil friction, tip resistance, dynamic pore pressure and an equivalent SPT "N" value using electronic methods. In addition, CPT 5 was performed as a "seismic cone" to collect information regarding the propagation of sheer waves through the soil encountered. No soil samples are obtained during CPT soundings. Soil types are interpreted based on empirical relationships between measured CPT parameters described above. The CPT method generally provides more detailed information on soil layering than conventional drilling and sampling methods. CPT 1 and CPT 7 were advanced at the same locations as borings 1 and 2, respectively for correlation.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES
				SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	CC	Cement Concrete
	AC	Asphalt Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Measured groundwater level in exploration, well, or piezometer

Groundwater observed at time of exploration

Perched water observed at time of exploration

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE A-1

Date(s) Drilled	10/27/08 - 10/28/08	Logged By	EAW	Checked By	EWH
Drilling Contractor	Boart Longyear	Drilling Method	Mud Rotary	Sampling Methods	SPT, D&M & Shelby
Auger Data	N/A	Hammer Data	140 lb hammer/30 in drop	Drilling Equipment	B-59
Total Depth (ft)	150.5	Surface Elevation (ft)	N/A	Groundwater Level (ft. bgs)	12
Vertical Datum	N/A	Datum/ System	N/A	Easting(x): Northing(y):	

Elevation feet / Depth feet	SAMPLES Interval	Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
0							AC	18 inches asphalt concrete			
							CR	1-1/4-inch crushed rock			
							GP-GM	Gray fine to coarse gravel with sand and silt (medium dense, wet) (granular fill)			
5		0	17								
10		6	47	1				Grades to dense	9		MC
							SP-SM	Gray fine to coarse sand with gravel and silt (dense, wet) (granular fill)			
15		12	32	2					13		%F=11
							MH	Gray silt with sand, trace organics (soft, wet) (silt fill)			
20		8	3	3							Organic odor
							ML	Gray sandy silt (very soft, wet) (silt fill)			
25		18	1	4a					47		%F=61
				4b			MH	Gray elastic silt (very soft, wet) (silt fill)	66		%F=94
							ML	Gray sandy silt (very soft, wet) (silt fill)			
30		18	0	5a					45		%F=62
				5b			MH	Dark gray elastic silt, trace organics (very soft, wet) (silt fill)	70		%F=97; organic odor
35											

Note: See Figure A-1 for explanation of symbols.

LOG OF BORING 1

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-2
Sheet 1 of 4

V6_GTBORING P:\17\17442003\00\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet	Depth feet	SAMPLES Interval	Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	35		18	1	6					72		AL; LL=100; PI=46
	40			3	7					68		%F=94
			20		8					61	58	MC
	45		12	5	9					62		AL; LL=80; PI=33
	50		18	3	10					61		%F=90
	55		18	4	11					68		%F=96
	60		18	7	12					64		AL; LL=81; PI=35
								MH	Gray elastic sandy silt, trace organics (soft, wet) (alluvium)			
	65		18	2	13					51		SA; %F=62
	70		18	1	14					46		%F=60
	75		18	3	15					53		%F=82

V6_GTBORING P:\17\1744200300\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

LOG OF BORING 1 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-2
Sheet 2 of 4

Elevation feet / Depth feet	SAMPLES: Interval	Recovered (in)	Blows/foot	Sub-Sample	Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
80		18	10		16							
									Grades with organics (plant debris)			
85		6	0		17					62		%F=96; vertical grass
									No organics			
90		18	4		18					44		%F=73
		18			19					34	84	MD; AL=non plastic
95		18	5		20					51		%F=52
									Grades with organics (plant debris)			
100		10	4		21					78		%F=91; vertical and horizontal grass
105		18	2		22					51		AL; LL=62; PI=22
		0	4						Trace organics			
110		3	1		23					53		MC
									No organics			
115		18	4		24					69		Vertical and horizontal grass
									With organics (plant debris)			
								OL	Gray organic silt with sand (very soft, wet) (alluvium)			
120		18	0		25					59		%F=75

LOG OF BORING 1 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-2
Sheet 3 of 4

V6_GTBORING P:\17\1744200300\FINALS\174420300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet / Depth feet	SAMPLES: Interval	Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
125		18	8	26					67		AL; LL=87; PI=34; vertical grass
							MH	Gray elastic silt with sand (moist, wet) (alluvium)			
130		18	8	27					40		MC
135		18	0	28					41		%F=81
							SP-SM	Gray fine to coarse sand with silt, occasional gravel (dense, wet) (gravel)			
140		12	39	29					13		SA; %F=11
								Grades to no gravel with silt lenses			
145		12	51	30					22		MC
150		3	60\6"	31							
155											
160											
165											

LOG OF BORING 1 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-2
Sheet 4 of 4

V6 GTBORING P:\17\1744200300\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Date(s) Drilled	10/27/08 - 10/28/08	Logged By	EAW	Checked By	EWH
Drilling Contractor	Boart Longyear	Drilling Method	Mud Rotary	Sampling Methods	SPT, D&M & Shelby
Auger Data	6-inch ID for 15 ft; Mud Rotary @ 15+	Hammer Data	140 lb hammer/30 in drop	Drilling Equipment	B-59
Total Depth (ft)	151.5	Surface Elevation (ft)	N/A	Groundwater Level (ft. bgs)	12.5
Vertical Datum	N/A	Datum/ System	N/A	Easting(x): Northing(y):	

Elevation feet / Depth feet	SAMPLES Interval Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
0						AC	Asphalt concrete			
						CR	1-1/4-inch to 2-inch crushed rock			
						GP	Gray fine to coarse gravel with sand, trace silt (medium dense, moist) (granular fill)			
5	12	8	1					77		MC
						WD	Silt and wood debris (non-dimensional) (wood debris) (medium stiff, moist)			Wood shavings, shredded wood
10	12	7	2					45	53	MD
	3	7	3	▼			Grades to with gravel, wet	37		MC
15	6	8	4							
20	3	6	5							Wood slurry
25	1	16	6				Grades to stiff			Wood slurry
30	1	16	7							Wood slurry
35										

Note: See Figure A-1 for explanation of symbols.

LOG OF BORING 2

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-3
Sheet 1 of 4

V6_GTBORING P:\17\1744200300\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet	Depth feet	Interval	Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	35		6	8	8			MH	Gray elastic silt (soft, wet) (silt fill)			
	40		0	3								
	45		3	3	9							
								SM	Gray silty fine to medium sand with gravel (medium dense, wet) (silt fill)			
	50		12	15	10					36		SA; %F=21
								MH	Gray elastic silt with sand (soft, wet) (silt fill)			
	55		18	2	11					50		%F=79
								MH	Gray elastic sandy silt, trace organics (plant debris) (very soft, wet) (alluvium)			
	60		18	0	12					50		%F=85
	65		18	4	13a					53		MC
					13b			SM	Gray silty fine to medium sand (loose, wet) (alluvium)	41		%F=33
								MH	Gray elastic silt with sand, shell fragments (medium stiff, wet) (alluvium)			
	70		18	4	14					45		%F=71
								SM	Gray silty fine to medium sand interbedded with silt (medium dense, wet)			
	75		18	11	15					45		%F=49

LOG OF BORING 2 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
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Project Number: 17442-003-00

Figure A-3
Sheet 2 of 4

V6 GTBORING P:\17\17442003\00\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet / Depth feet	SAMPLES: Interval Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
80	18	14	16					45		%F=48
						MH	Gray elastic silt, trace organics (medium stiff, wet) (alluvium)			
85	18	4	17					66		AL; LL=80; PI=34
						MH	Gray sandy elastic silt (medium stiff, wet) (alluvium)			
90	18	8	18					40		%F=52
						SM	Gray silty fine to medium sand (medium dense, wet) (alluvium)			
95	18	10	19					49		%F=45
							Grades to with organics			
						MH	Gray elastic silt, trace organics (plant debris) (medium stiff, wet) (alluvium)			
100	18	8	20					74		%F=92; vertical and horizontal grass
105	18	5	21					61		AL; LL=77; PI=31
	12		22					61	60	CS; MD
110	18	5	23					61		MC
						SP-SM	Gray fine to medium sand with silt (medium dense, moist) (gravel)			
115	18	10	24					39		%F=22
120	8	29	25				Grades to with gravel	11		MC

LOG OF BORING 2 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
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Figure A-3
Sheet 3 of 4

V6_GTBORING P:\17\1744200300\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet	Depth feet	SAMPLES Interval	Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
125			12	50	26				Grades to very dense	14		SA; %F=7
								MH	Gray elastic silt (medium stiff, wet) (gravel)			
130			18	5	27					53		AL; LL=69; PI=26
								SP	Gray fine to coarse sand with gravel, trace silt (dense, wet) (gravel)			
135			6	43	28							
140			2	37	29							
								GP	Gray fine gravel with sand, trace silt (dense, wet) (gravel)			
145			8	37	30							
150			10	32	31							
155												
160												
165												

V6_GTBORING P:\17\17442003\00\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

LOG OF BORING 2 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-3
Sheet 4 of 4

Date(s) Drilled	12/29/08 - 12/31/08	Logged By	DCR	Checked By	EWH
Drilling Contractor	Holocene	Drilling Method	HSA/Mud Rotary	Sampling Methods	SPT and D&M
Auger Data	4.25-inch HSA Continuous Flight, Mud Rotary	Hammer Data	140 lb hammer/30 in drop	Drilling Equipment	Mobile Drill B-61 Truck-mounted
Total Depth (ft)	139	Surface Elevation (ft)	N/A	Groundwater Level (ft. bgs)	14.9
Vertical Datum	N/A	Datum/ System	N/A	Easting(x): Northing(y):	

Elevation feet / Depth feet	SAMPLES Interval Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
0						SP-SM	Dark brown fine to coarse sand with silt, occasional gravel (loose, moist) (granular fill)			
	6	4	1					19		%F=13
5						SM	Brown silty fine to coarse sand, occasional gravel (loose, moist)			
	18	4	2					25		%F=23
10										
	18	6	3				Grades to trace wood debris	25		MC
15				▼			Grades to wet			
	6	3	4					16		%F=15
	6	1	5			SP	Grades to very loose Gray sand, trace silt (very loose, wet) (granular fill)			
20						GP	Gray fine gravel with sand, trace silt (loose, wet) (granular fill)			
	2	8	6							
25										
	5	9	7							
30										
	18	4	8			MH	Dark gray elastic silt, trace sand, wood debris (medium stiff, moist) (wood waste)	45		%F=62; gravel fragments
35										

Note: See Figure A-1 for explanation of symbols.

LOG OF BORING 3

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-4
Sheet 1 of 4

V6 GTBORING P:\17\17442003\00\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet / Depth feet	SAMPLES: Interval Recovered (in)	Blows/foot	Sub-Sample	Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
35	18	8		9					37	73	MD
40	6	3		10				Grades to soft			Wood slurry
45	18	3		11			MH	Gray elastic sandy silt (soft, wet) (alluvium)	54		AL; LL=53; PI=13
50	3	2		12							
55	18	8		13			SP-SM	Gray fine to medium sand with silt layers (loose, wet) (alluvium)	23	97	MD; %F=30
60	12	11		14				Grades to medium dense	39		%F=23
65	18	4		15			MH	Gray elastic sandy silt (soft, moist) (alluvium)	47		SA; %F=56
70	18	10		16				Grades stiff, trace shells	42		%F=63
75	18	11		17			SP-SM	Gray fine to medium sand with silt laminations (medium dense, moist) (alluvium)	24	92	MD

LOG OF BORING 3 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-4
Sheet 2 of 4

V6_GTBORING P:\17\1744200300\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

Elevation feet / Depth feet	SAMPLES: Interval Recovered (in)	Blows/foot	Sub-Sample Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
80						MH	Gray elastic silt, occasional organics (medium stiff, moist) (alluvium)			
	18	6	18				Grades to soft	70		AL; LL=76; PI=25
85										
	18	4	19					44		%F=64
90										
	0	1	20				Grades to very soft			
95						MH	Gray elastic silt with decomposing organics (medium stiff, moist) (alluvium)			
	18	7	21					40	71	Vertical and horizontal grass MD; no recovery
100										
	18	7	22					59		%F=96
105							Grades to stiff			
	18	10	23					40		SM; %F=51
110						SM	Gray silty fine to coarse sand, occasional gravel (medium dense, wet) (gravel)			
	18	28	24					23		SA
115						GW	Gray fine to coarse gravel occasional sand and cobbles, trace silt (dense, wet) (gravel)			
	16	35	25					9	115	MD; SA; %F=3
120										

LOG OF BORING 3 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-4
Sheet 3 of 4

V6 GTBORING P:\17\17442003\00\FINALS\1744200300.GPJ GEIV6 1.GDT 1/19/09

Elevation feet / Depth feet	SAMPLES: Interval	Recovered (in)	Blows/foot	Sub-Sample	Sample Number	Water Level	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
		12	24		26				Grades to medium dense			
125												
		18	35		27				Grades to dense			
130												
		18	41		28							
135												
		18	22		29				Grades to medium dense			
140												
145												
150												
155												
160												
165												

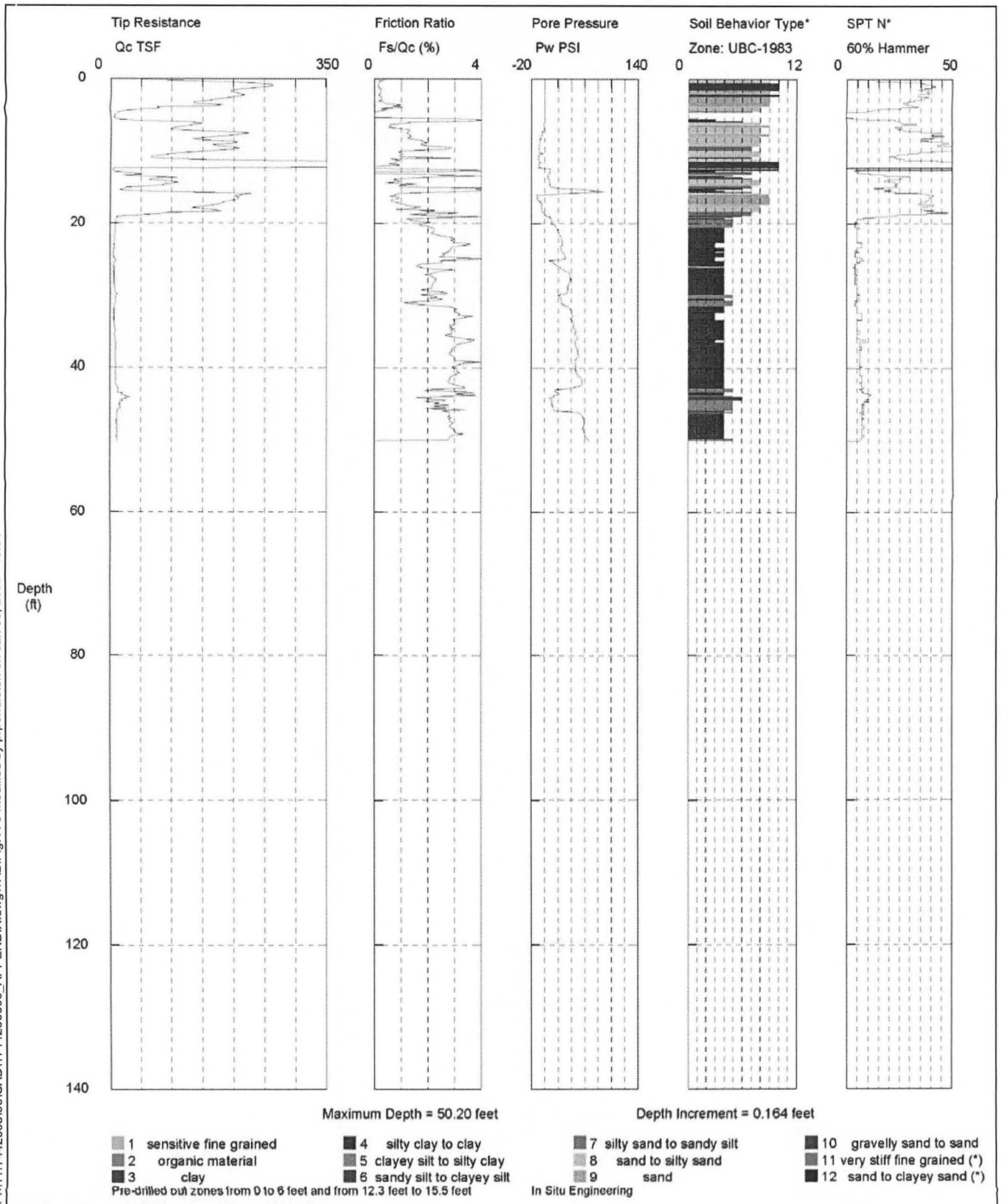
V6 GTBORING P:\17\17442003\00\FINALS\1744200300.GPJ GEIV6_1.GDT 1/19/09

LOG OF BORING 3 (continued)

GEOENGINEERS

Project: Westway Grays Harbor
Project Location: Port of Grays Harbor, Washington
Project Number: 17442-003-00

Figure A-4
Sheet 4 of 4



Not to Scale

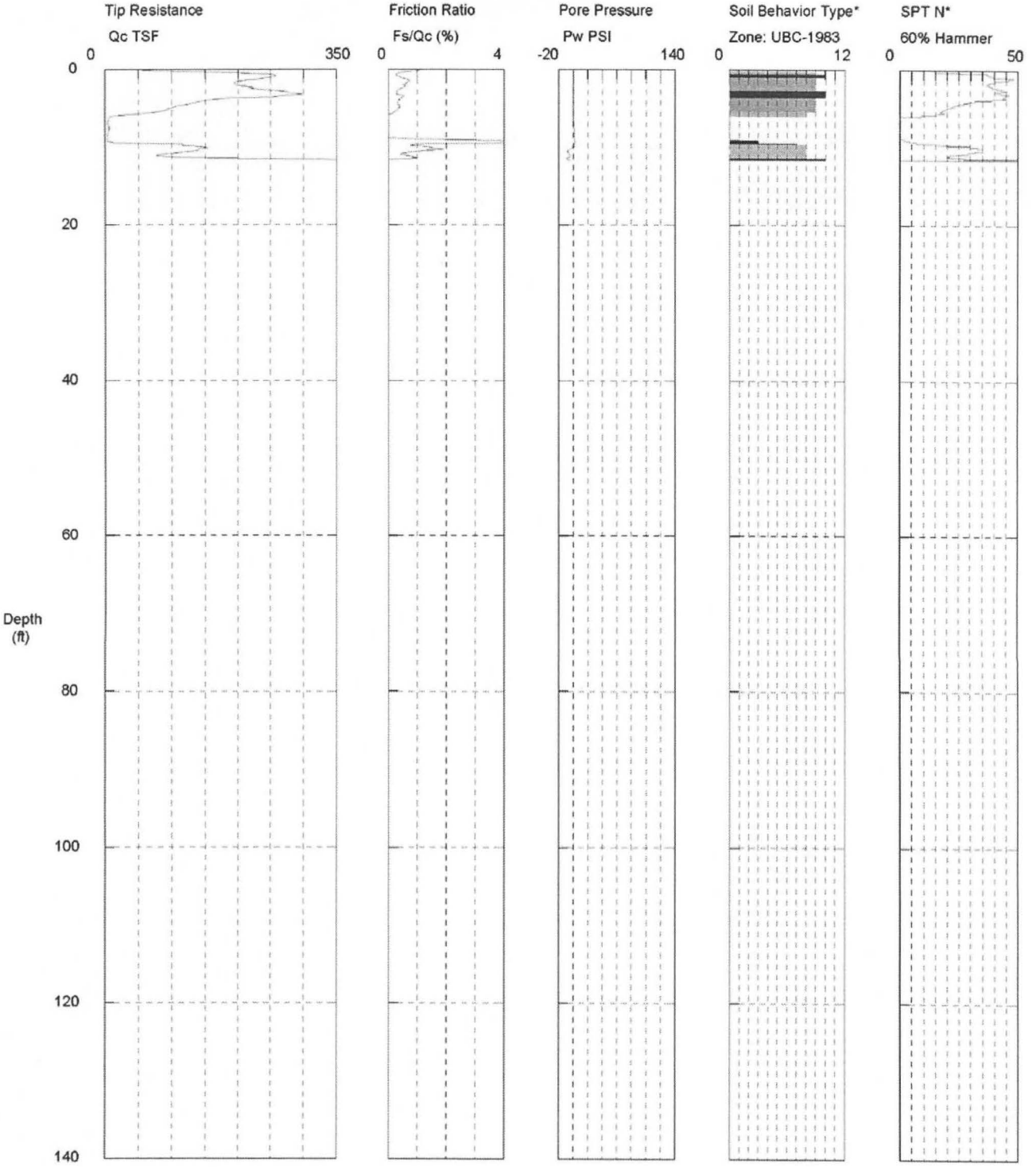
CPT-1

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-5

OFFICE:TACO PM EWH P:\17\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-5 modified by prpendleton on Jan 08, 2009 - 10:54



Maximum Depth = 11.81 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

Predrilled to 9 feet, refused CPT at 12 feet

*Soil behavior type and SPT based on data from UBC-1983

In Situ Engineering

Not to Scale

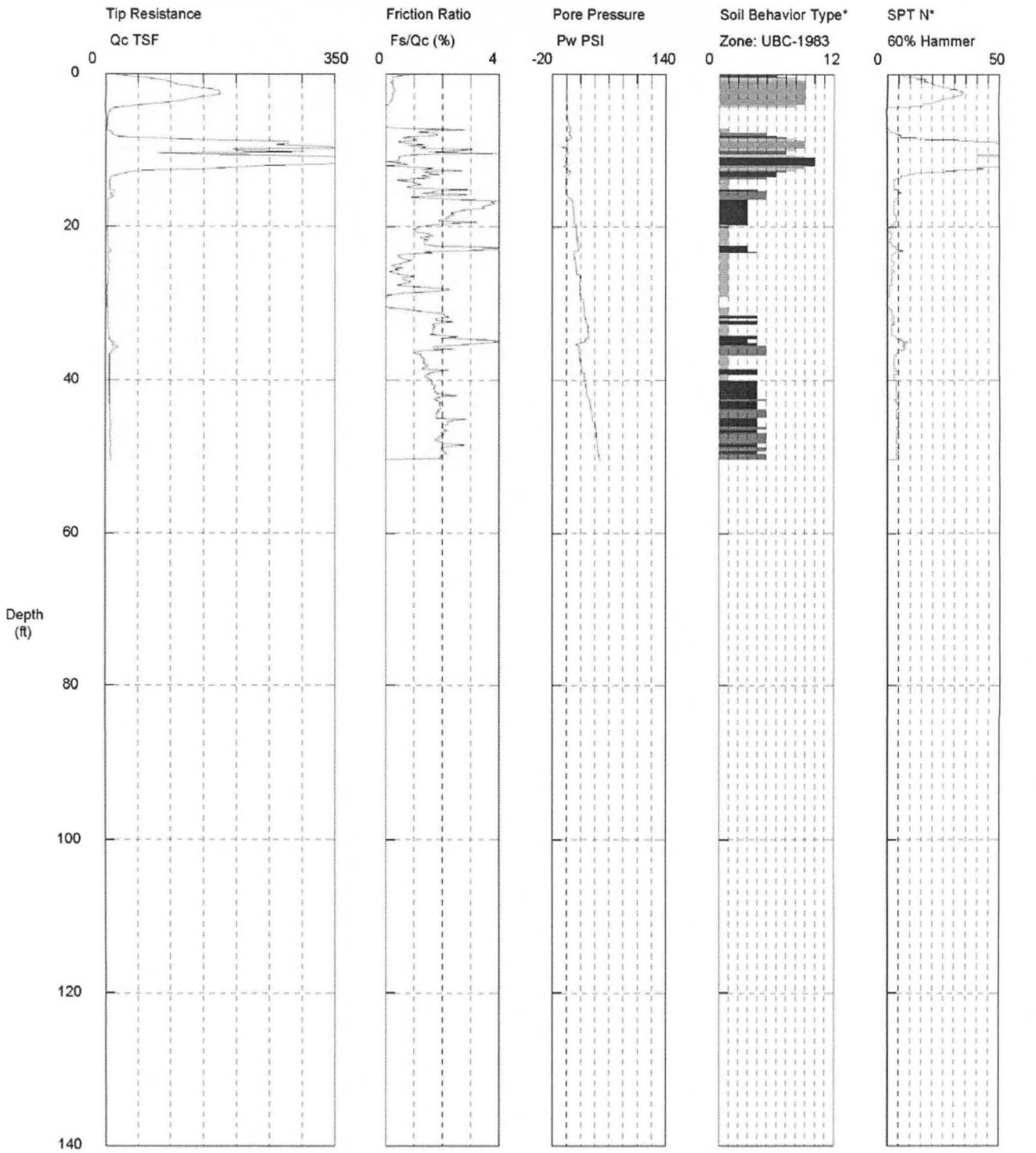
CPT-2

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-6

OFFICE:TACO PM:EWH P:\1\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-6 modified by prpendleton on Jan 08, 2009 - 10:55



*Soil behavior type and SPT based on data from UBC-1983

In Situ Engineering

Not to Scale

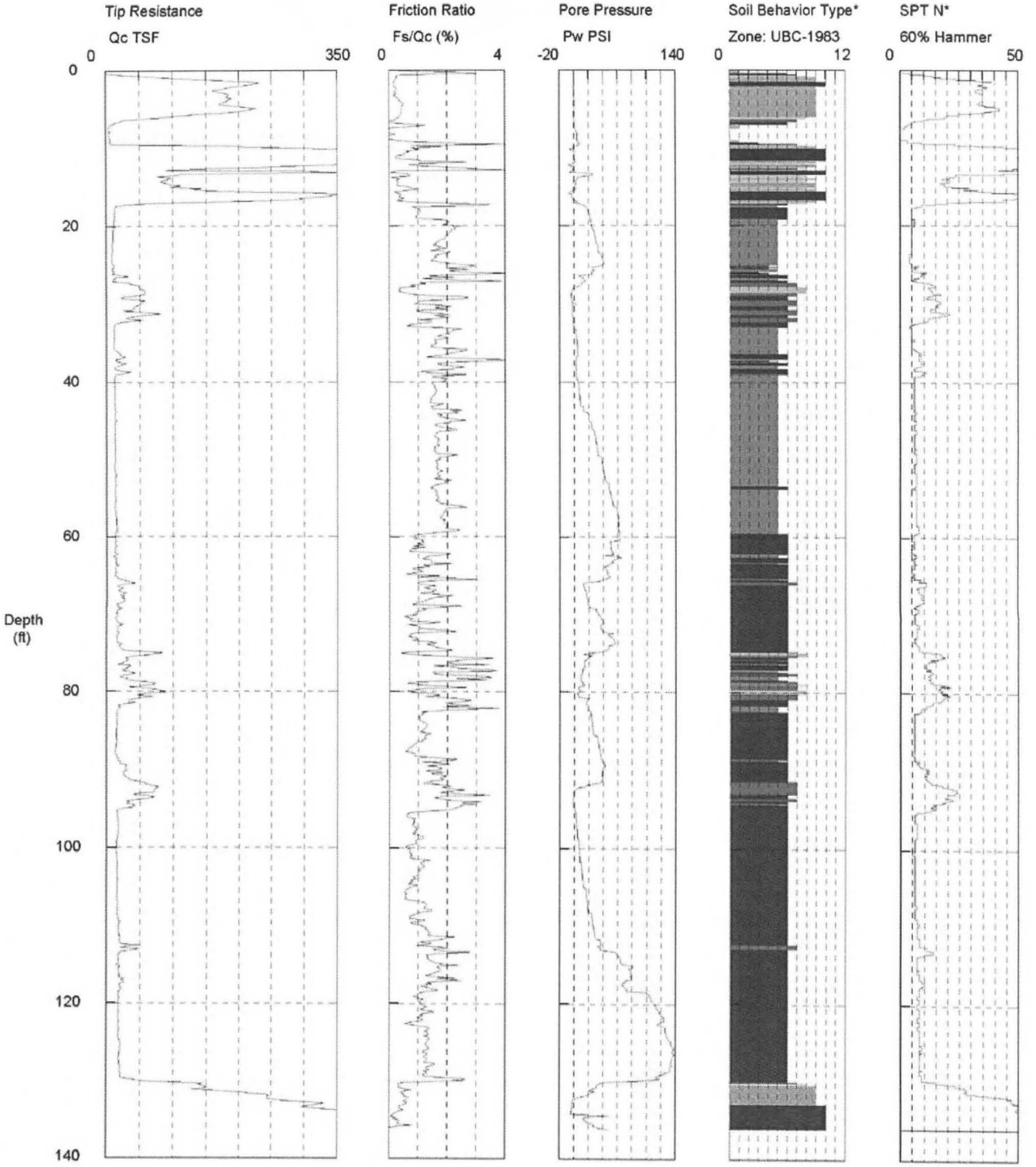
CPT-3

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-7

P:\17\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-7 modified by prpendleton on Jan 08, 2009 - 10:56
PM EWH
OFFICE:TACO



Maximum Depth = 136.32 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

Predrilled out zones from 0 to 9.8 feet and 13.2 feet to 15.5 feet

In Situ Engineering

*Soil behavior type and SPT based on data from UBC-1983

Not to Scale

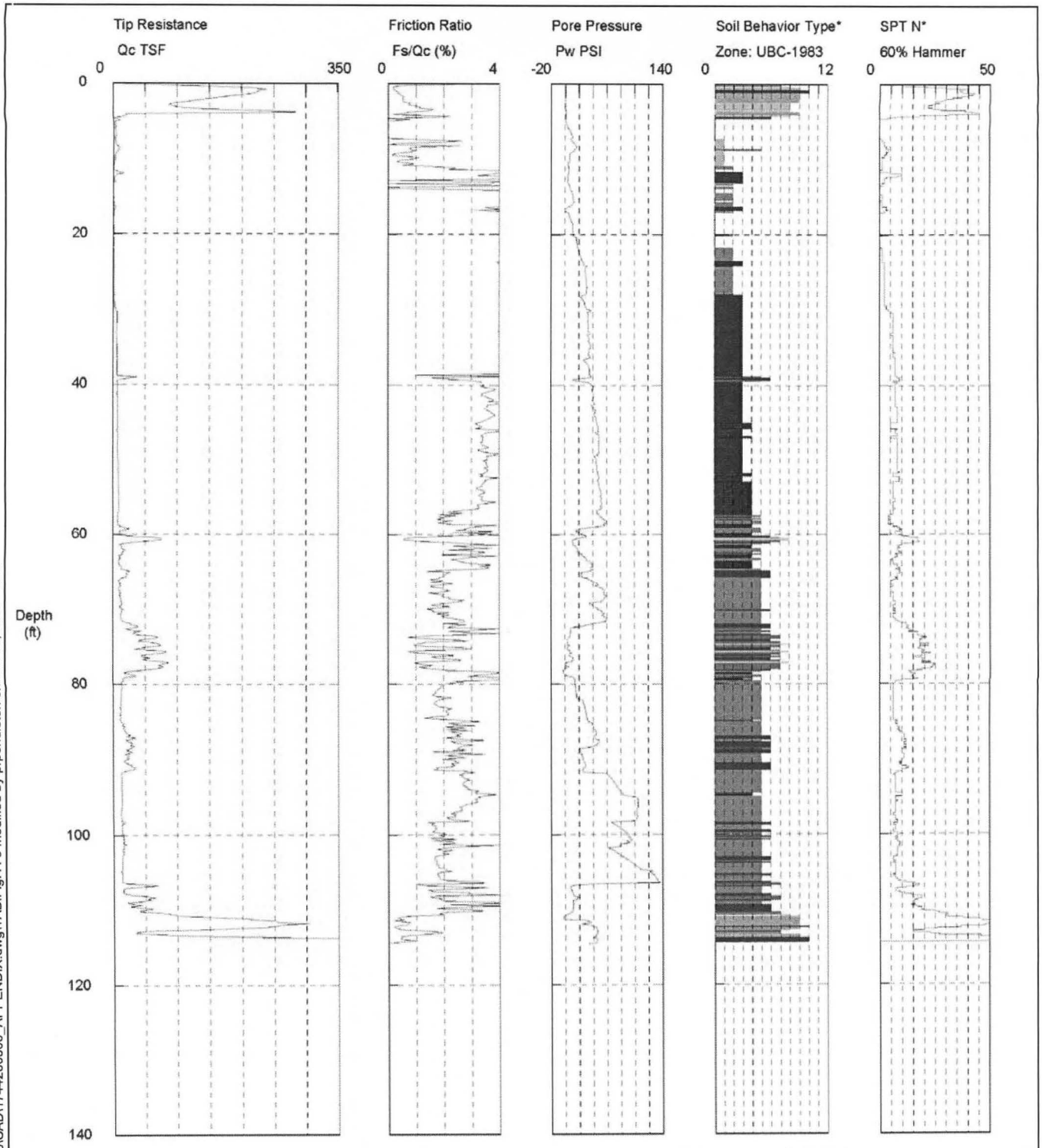
CPT-4

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-8

P:\1711744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-8 modified by prpendleton on Jan 08, 2009 - 10:57
PM EWH
OFFICE:TACO



*Soil behavior type and SPT based on data from UBC-1983

Not to Scale

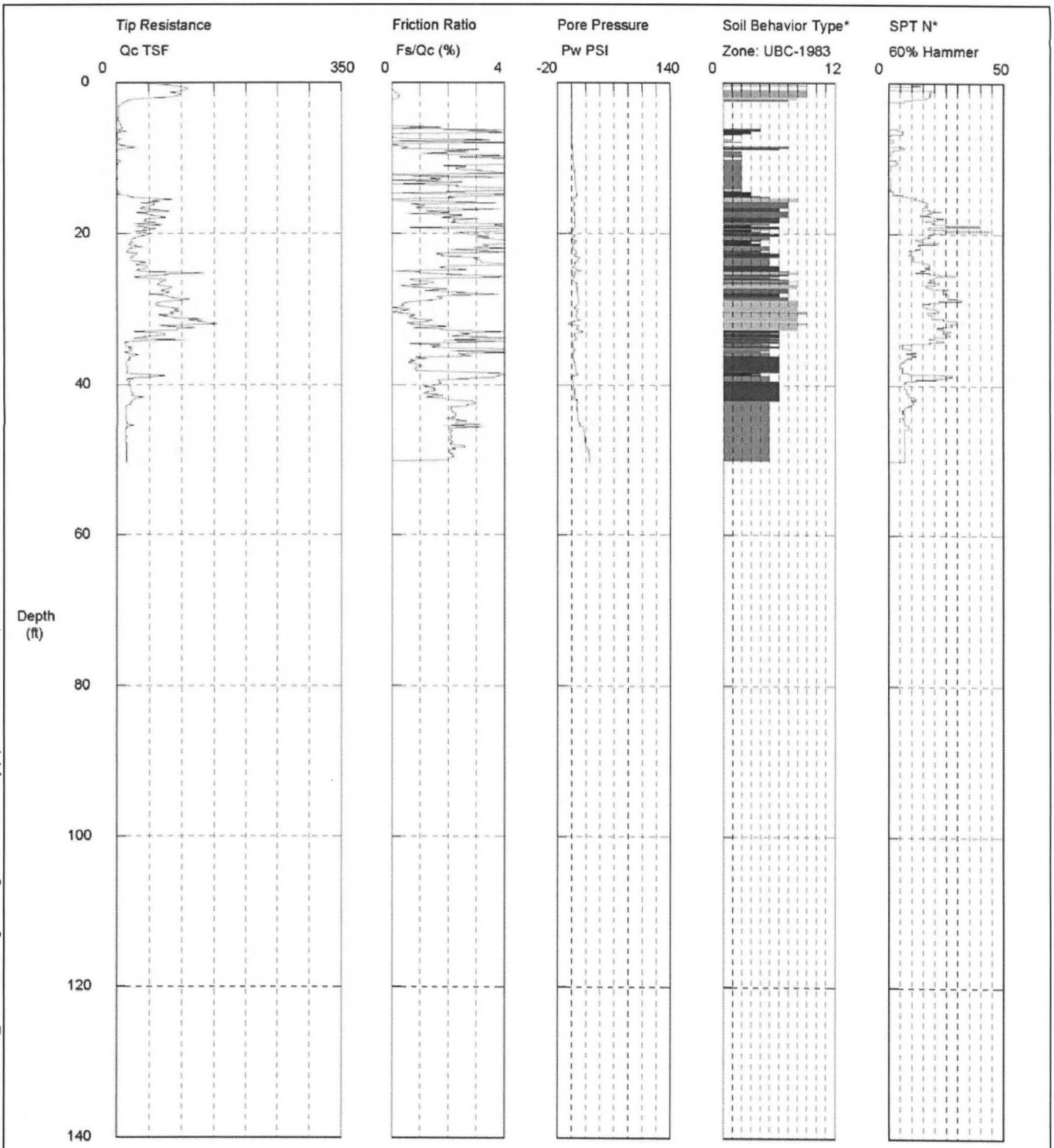
CPT-5

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-9

OFFICE:TACO PM EWH P:\1\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-9 modified by prpendleton on Jan 13, 2009 - 9:22



1 sensitive fine grained
2 organic material
3 clay
Predrilled to 15 feet.

4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt

7 silty sand to sandy silt
8 sand to silty sand
9 sand

10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

In Situ Engineering

Not to Scale

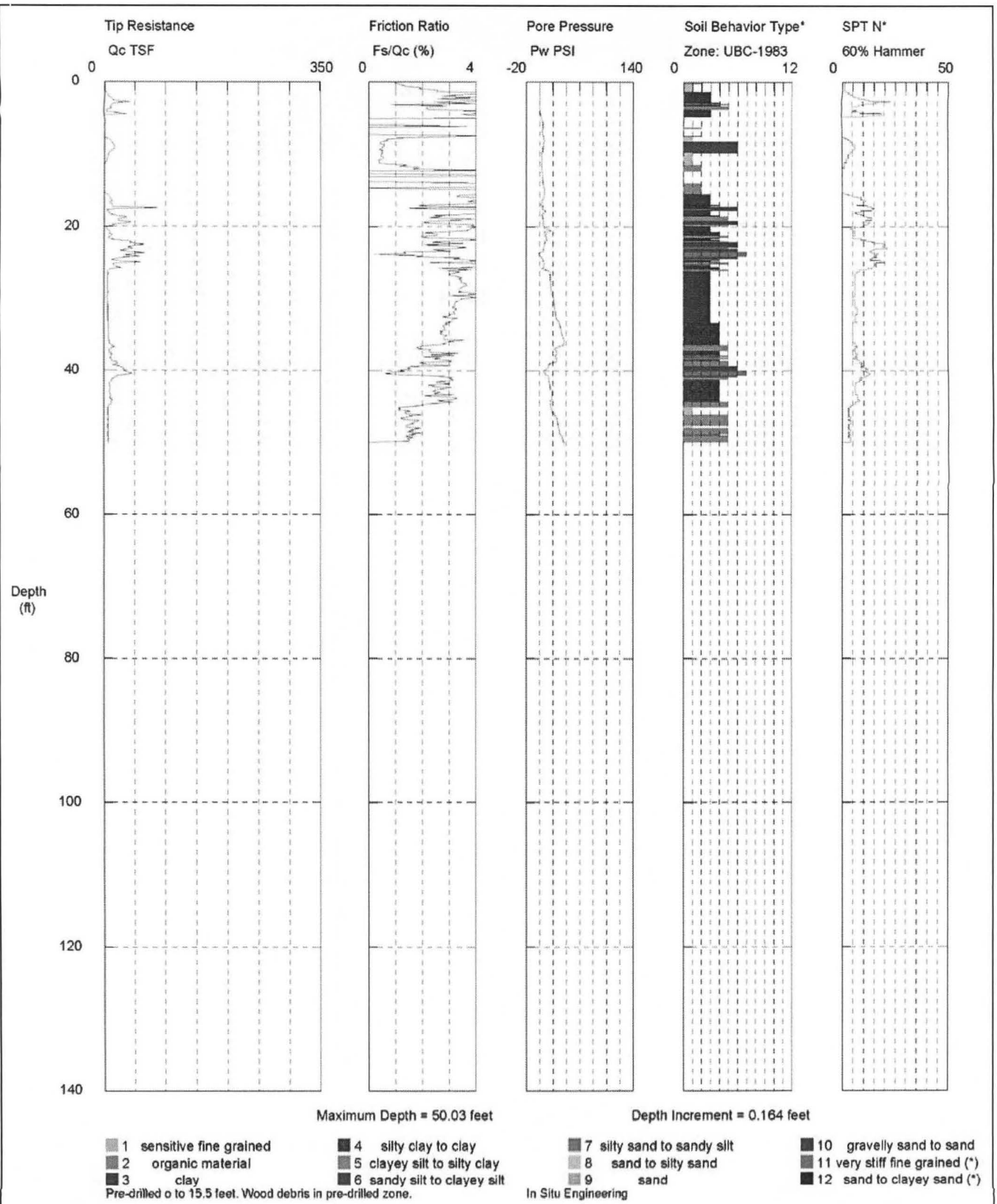
CPT-6

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-10

P:\17\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-10 modified by prpendleton on Jan 08, 2009 - 11:00
PM EWH
OFFICE:TACO



*Soil behavior type and SPT based on data from UBC-1983

Not to Scale

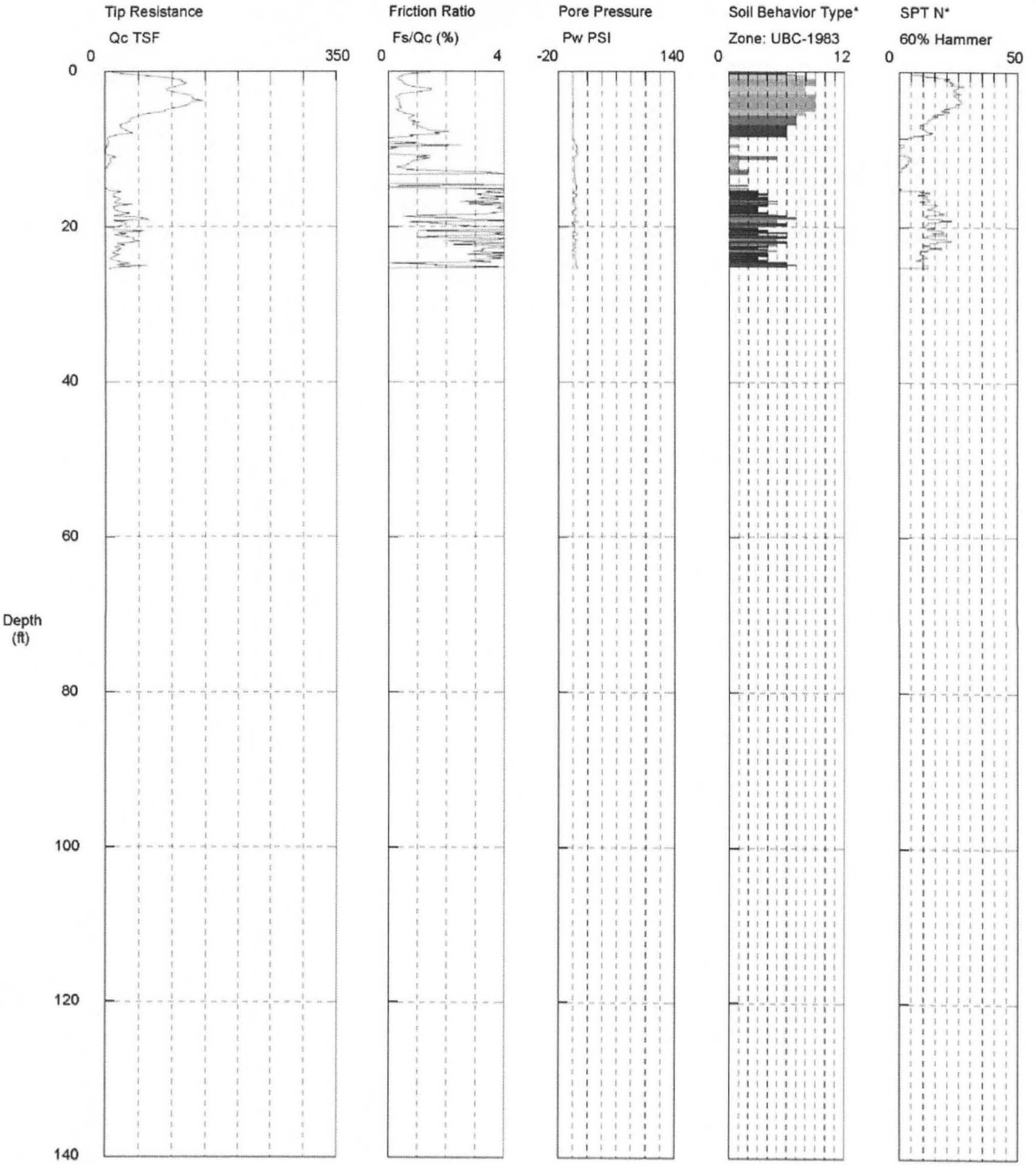
CPT-7

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-11

P:\17\1744200300\00\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-11 modified by prpendleton on Jan 08, 2009 - 11:00
OFFICE:TACO PM EWH



Maximum Depth = 25.43 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
Predrilled to 15 feet.

4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt

7 silty sand to sandy silt
8 sand to silty sand
9 sand

10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*Soil behavior type and SPT based on data from UBC-1983

In Situ Engineering

Not to Scale

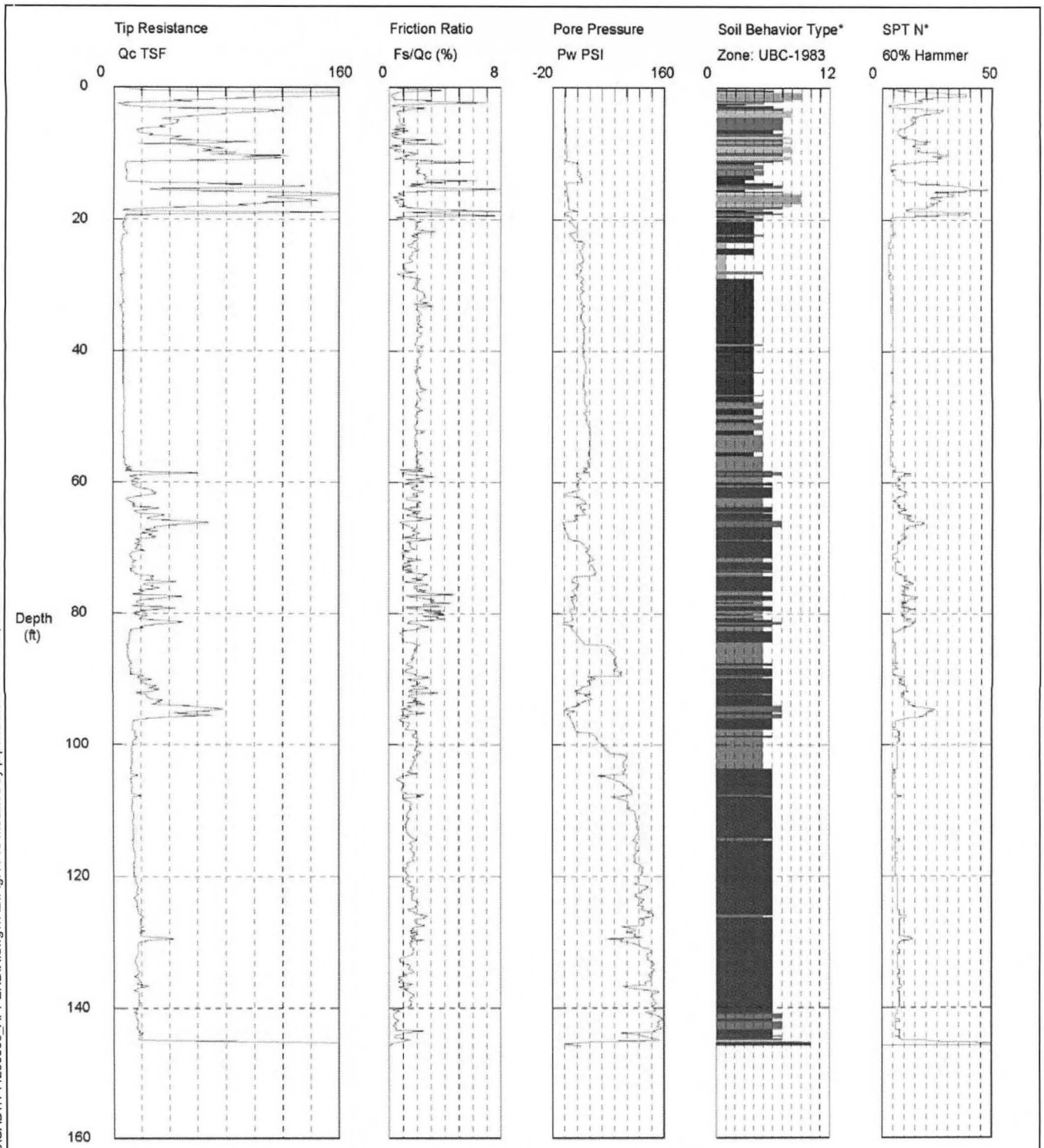
CPT-8

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-12

OFFICE:TACO PM EWH P:\17\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-12 modified by prpendleton on Jan 08, 2009 - 11:02



1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

Pre-drilled top 4 feet through gravel and sand.

*Soil behavior type and SPT based on data from UBC-1983

In Situ Engineering

Not to Scale

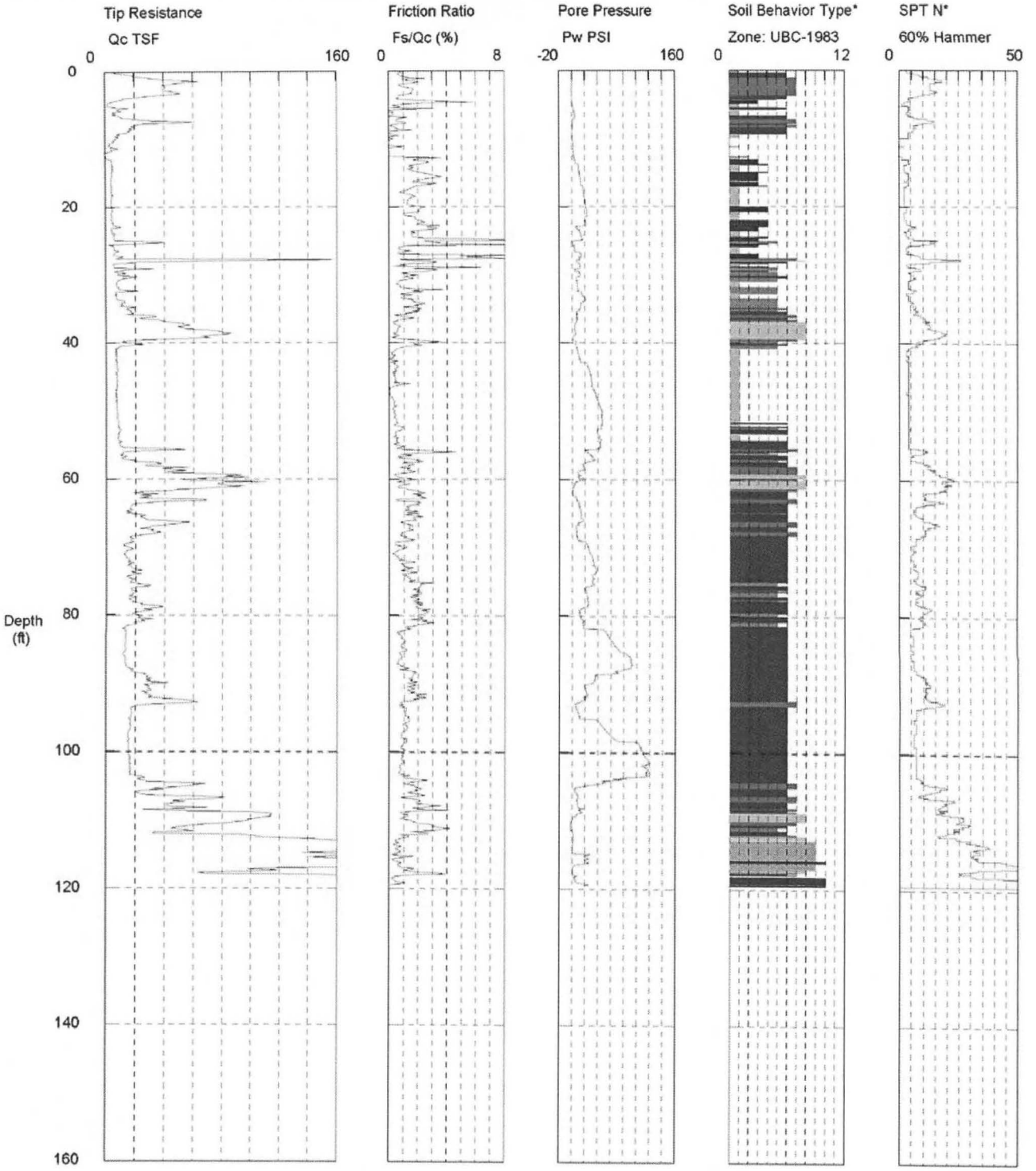
CPT-9

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-13

P:\17\1744200300\00\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-13 modified by prpendleton on Jan 12, 2009 - 16:08
PM EWH
OFFICE:TACO



Maximum Depth = 119.59 feet

Depth Increment = 0.164 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

Pre-drilled top 14 feet through gravel and sand.

*Soil behavior type and SPT based on data from UBC-1983

In Situ Engineering

Not to Scale

CPT-10

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure A-14

P:\17\1744200300\CAD\1744200300_APPENDIX.dwg\TAB:Fig. A-14 modified by prpendleton on Jan 12, 2009 - 16:09
PM EWH
OFFICE:TACO

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Appendix B
Laboratory Testing

APPENDIX B
LABORATORY TESTING

LABORATORY TEST RESULTS

Soil samples obtained from the borings were transported to GeoEngineers laboratory. Representative soil samples were selected for laboratory tests to evaluate the pertinent geotechnical engineering characteristics of the site soils and to confirm our field classification. The following paragraphs provide a description of the tests performed.

Moisture Content and Density

The moisture content and/or density of selected samples were determined in general accordance with ASTM Test Methods D 2216 and D 2937, respectively. The test results are used to aid in soil classification and correlation with other pertinent engineering soil properties. The test results are presented on the boring logs in Appendix A.

Particle-Size Analysis

Particle-size analyses were performed on selected samples in general accordance with ASTM Test Method D 422. This test method covers the quantitative determination of the distribution of particle sizes in soils. Typically, the distribution of particle sizes larger than 75 micrometers (μm) is determined by sieving. The results of the tests were used to verify field soil classifications. Figures B-1 and B-2 present the results of the sieve analyses.

Atterberg Limit Testing

Atterberg Limit Tests were performed on selected samples in general accordance with ASTM Test Method D 4318. This test method determines the liquid limit, plastic limit and plasticity index of soil particles passing the No. 40 sieve. The results of the tests are used to assist in soil classification as well as engineering design. Figures B-3 through B-6 present the results of the Atterberg Limits Tests.

Consolidation

Consolidation testing was performed to determine the settlement potential of selected samples in accordance with ASTM D 2435. The consolidation test determines the magnitude and rate of consolidation of soil restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. Test results are shown on Figures B-7 and B-8.

Direct Shear

Direct shear testing was performed in accordance with ASTM D 3080. The direct shear test determines strength properties of the soil including the angle of internal friction and apparent cohesion. An axial confining pressure is applied to a sample then the sample is sheared on a horizontal plane. This is typically performed at three confining pressures, forming a failure envelope. Test results are shown on Figures B-9 and B-10.

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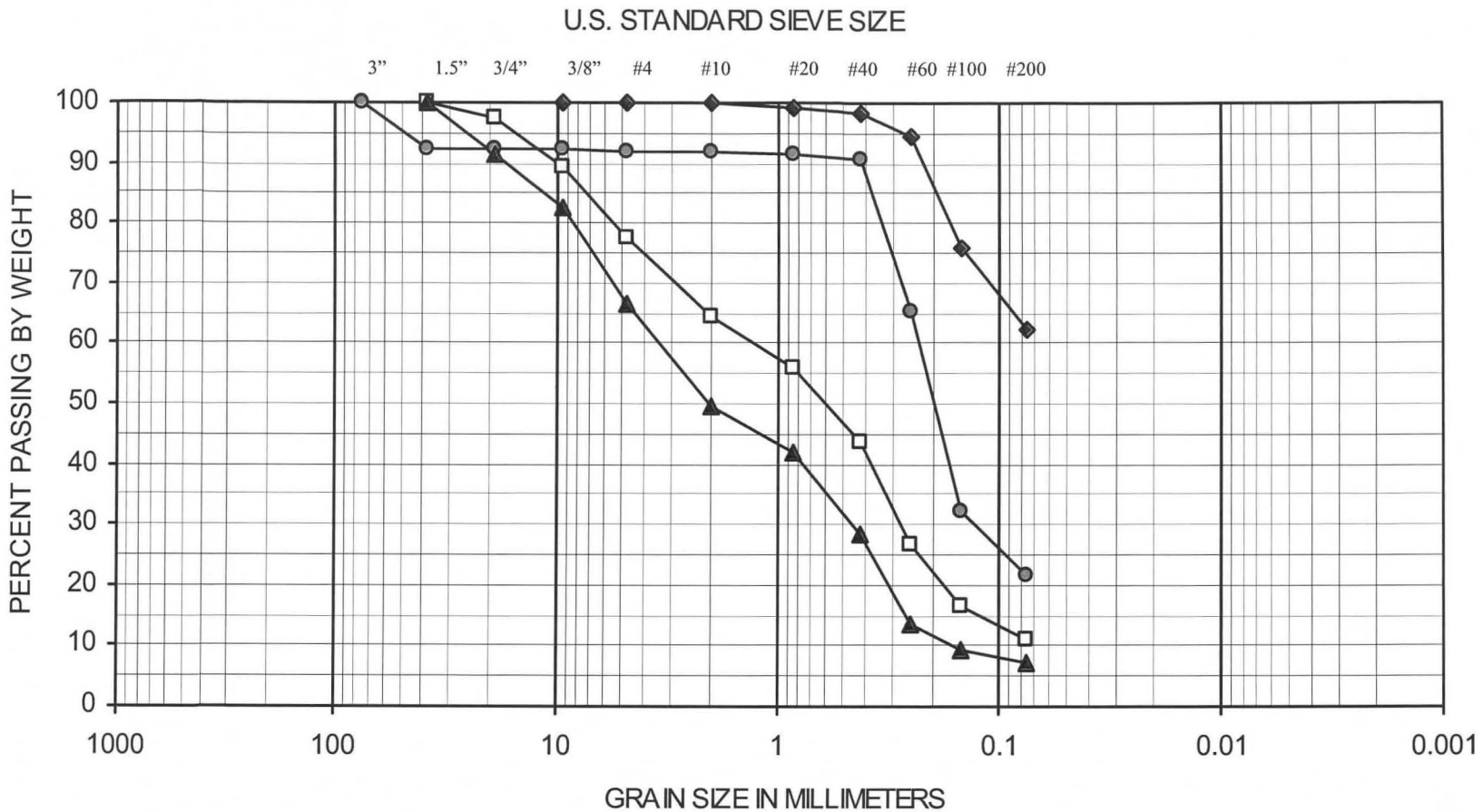


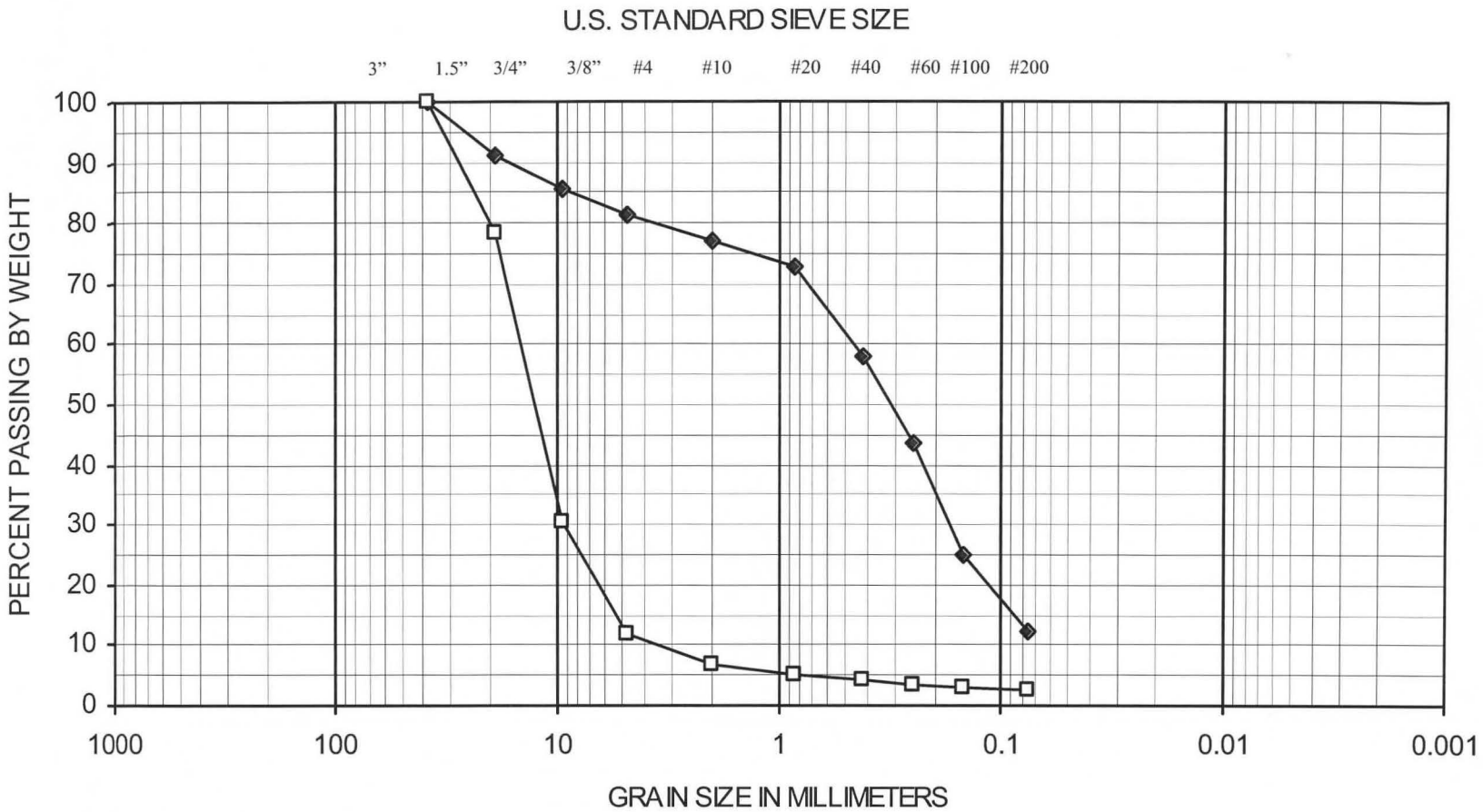
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	MOISTURE (%)	SOIL CLASSIFICATION
◆	B-1	66.5	51	Sandy silt (ML)
□	B-1	141.5	13	Fine to coarse sand with silt and gravel (SP-SM)
●	B-2	51.5	36	Silty fine sand (SM)
▲	B-2	126.5	14	Fine to coarse sand with silt and gravel (SP-SM)

SIEVE ANALYSIS RESULTS

FIGURE B-1

GEOENGINEERS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	MOISTURE (%)	SOIL CLASSIFICATION
◆	B-3	112.5	23	Fine to coarse silty sand with gravel (SM)
□	B-3	117.5	13	Fine to coarse gravel (GW)

SIEVE ANALYSIS RESULTS

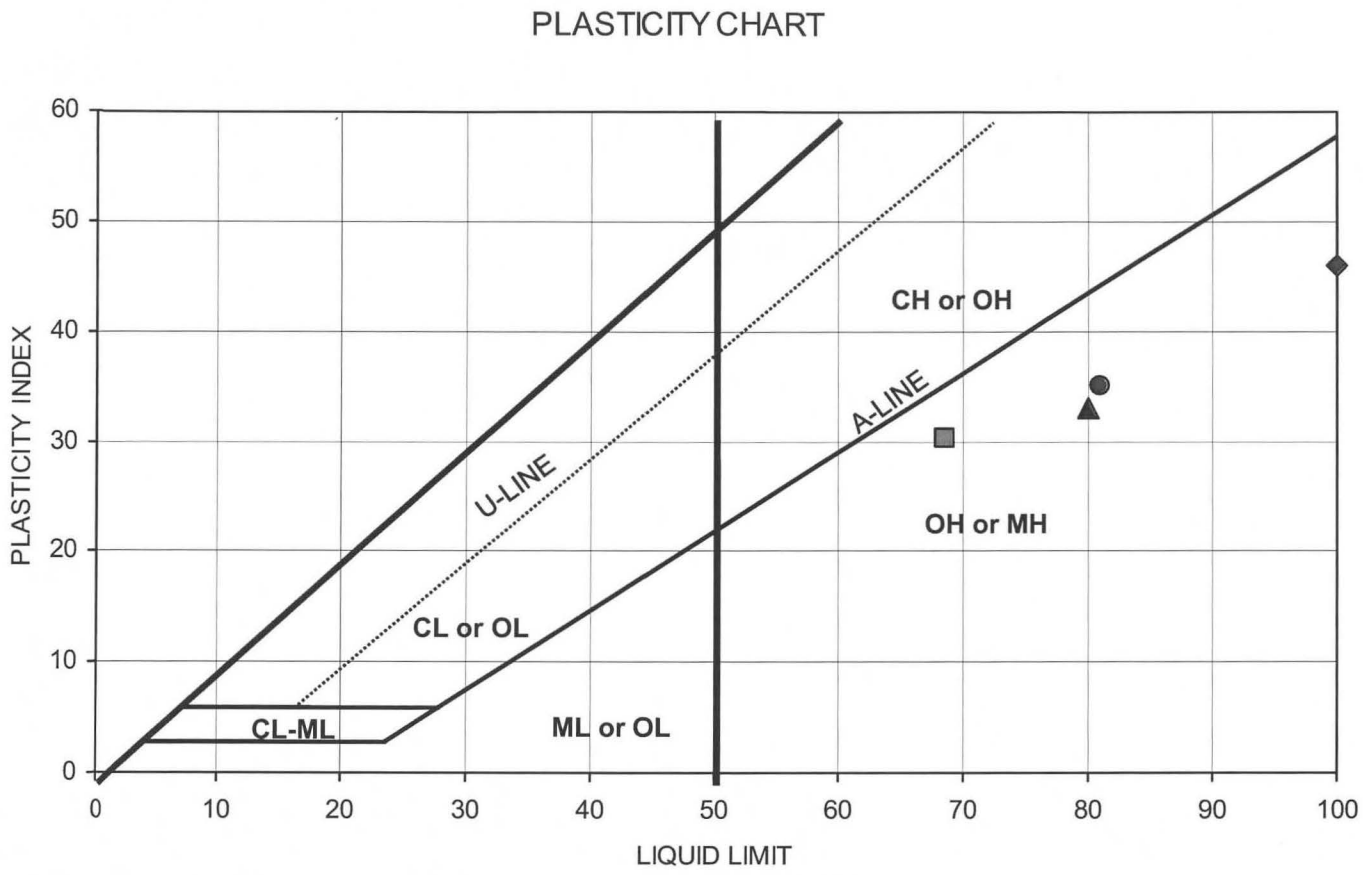
FIGURE B-2

TACO:\17\17442003\00\Finals\1744200300_FigureB3.ppt EWH:BAR:tt 011909

GEOENGINEERS

ATTERBERG LIMITS TEST RESULTS

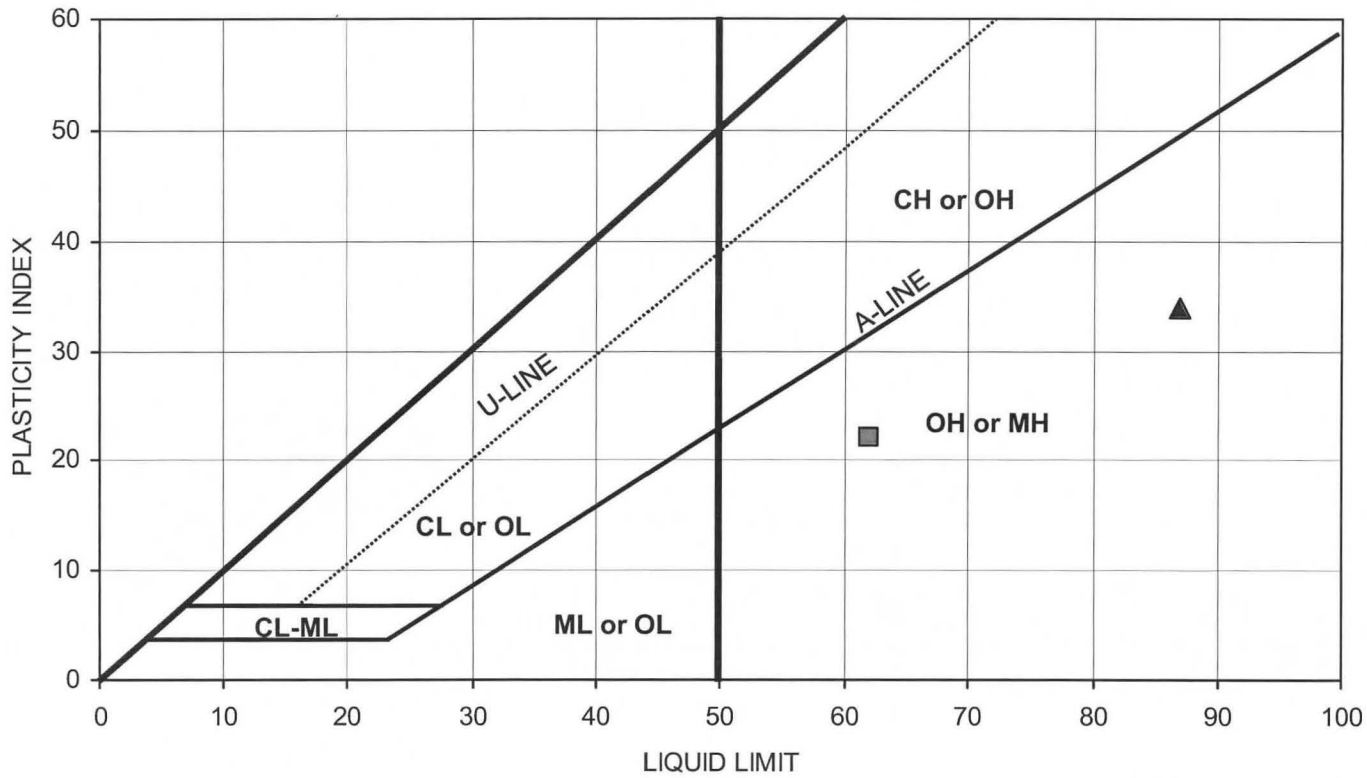
FIGURE B-3



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-1	36.5	72	100	46	Elastic silt (MH)
■	B-1	43.5	64	68	30	Elastic silt (MH)
▲	B-1	46.5	62	80	33	Elastic silt (MH)
●	B-1	61.5	64	81	35	Elastic silt (MH)

GEOENGINEERS

PLASTICITY CHART



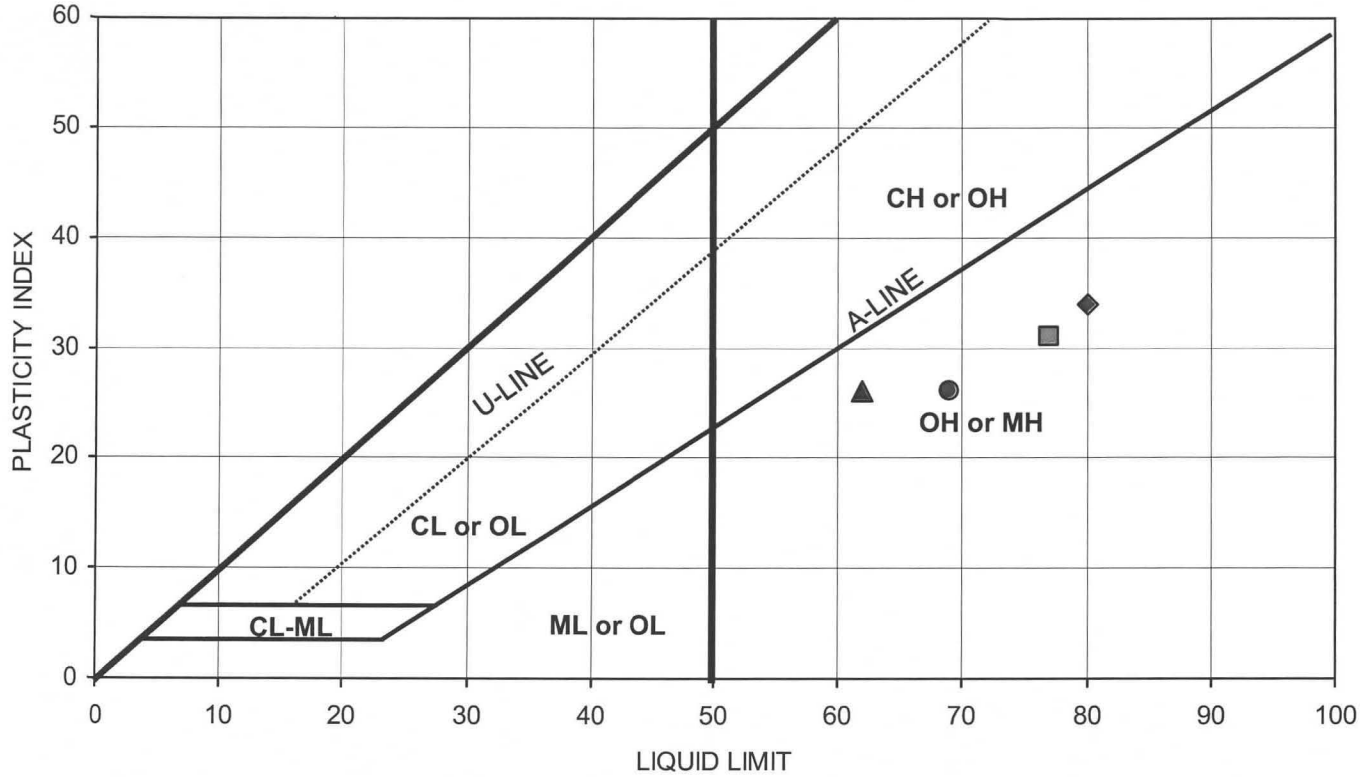
SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-1	93.5	34	Non	Plastic	Non plastic silt (ML)
■	B-1	106.5	51	62	22	Elastic silt (MH)
▲	B-1	126.5	67	87	34	Elastic silt (MH)

ATTERBERG LIMITS TEST RESULTS

FIGURE B-4

GEOENGINEERS

PLASTICITY CHART



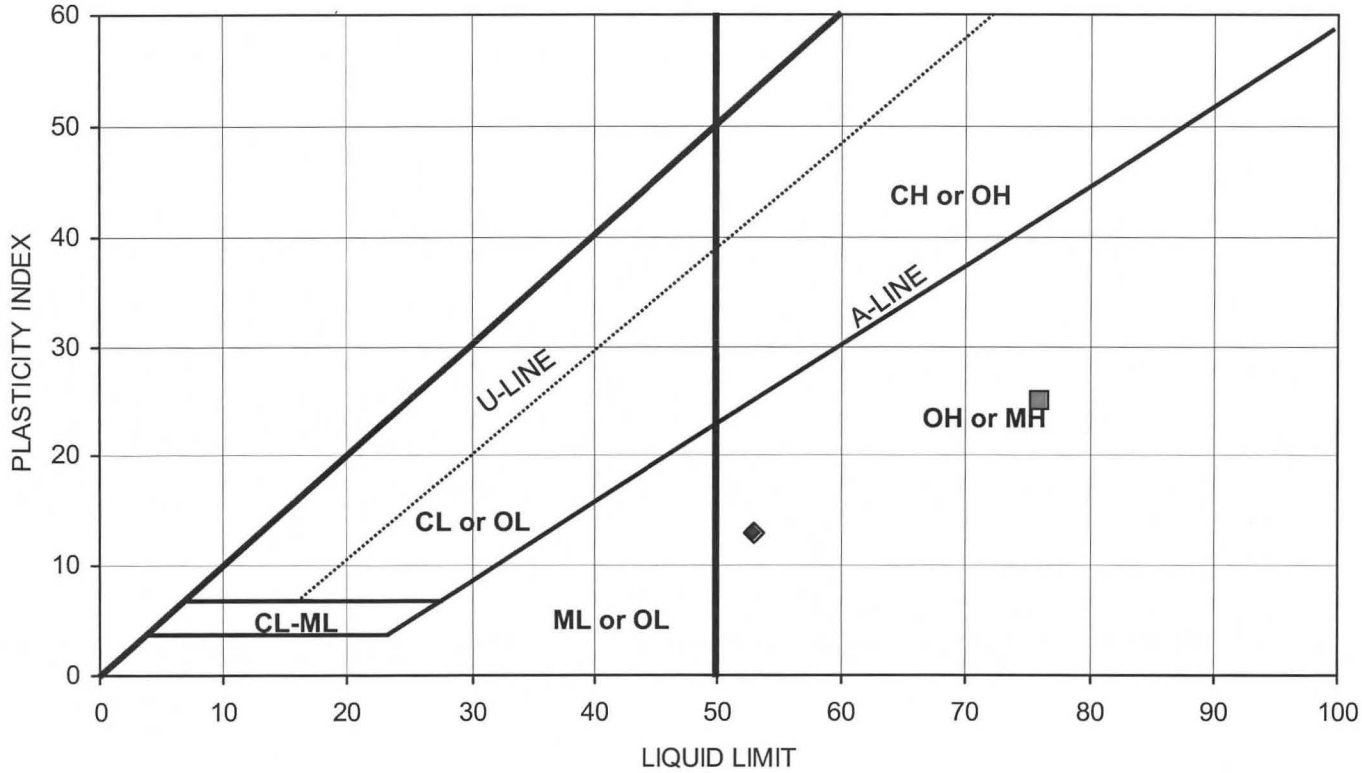
SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-2	86.5	66	80	34	Elastic silt (MH)
■	B-2	106.5	34	77	31	Elastic silt (MH)
▲	B-2	108	61	62	26	Elastic silt (MH)
●	B-2	131.5	53	69	26	Elastic silt (MH)

ATTERBERG LIMITS TEST RESULTS

FIGURE B-5

GEOENGINEERS

PLASTICITY CHART

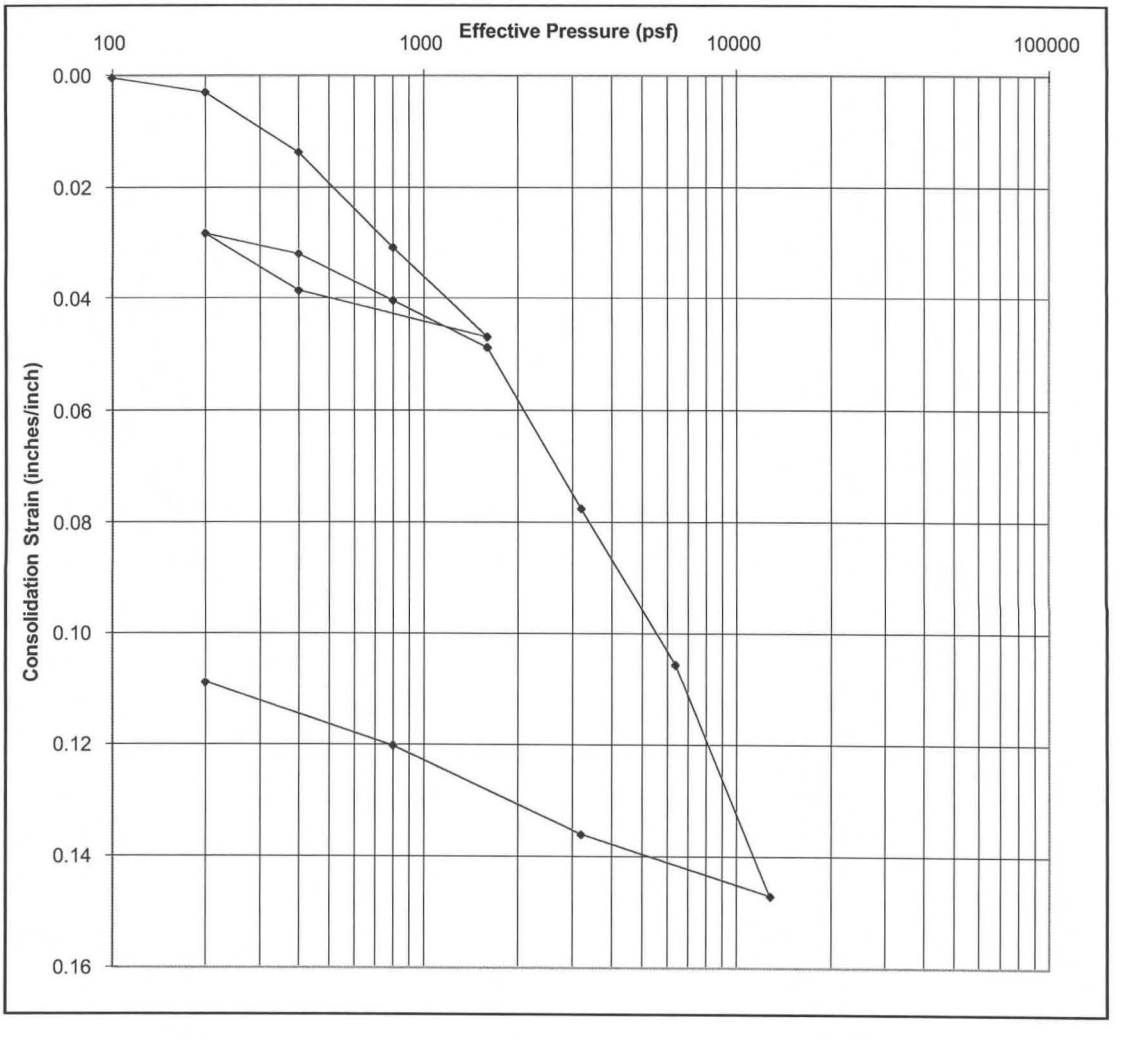


SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (FT)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-3	47.5	54	53	13	Elastic silt (MH)
■	B-3	82.5	70	76	25	Elastic silt (MH)

ATTERBERG LIMITS TEST RESULTS

FIGURE B-6

Project:	Westway	**Lab No.**	08-0057
Project No.	17442-003-00	**Date:**	11/06/08
Boring/TP No.	B-1	**Tested By:**	KAR
Sample No./Depth:	S-8/43.5'	**Checked By:**	
Description:	MH	**PA/PM:**	EWH



	Initial	Final
Moisture Content	**61%**	**47%**
Dry Density (pcf)	**63.5**	**69.5**

Sample Height (in)	**1.0**
Sample Diameter (in)	**2.42**
Area (in^2)	**4.58**

NOTES: **Primary Consolidation Only**

NOTE: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of samples obtained at other times or locations, or generated by other operations or processes.

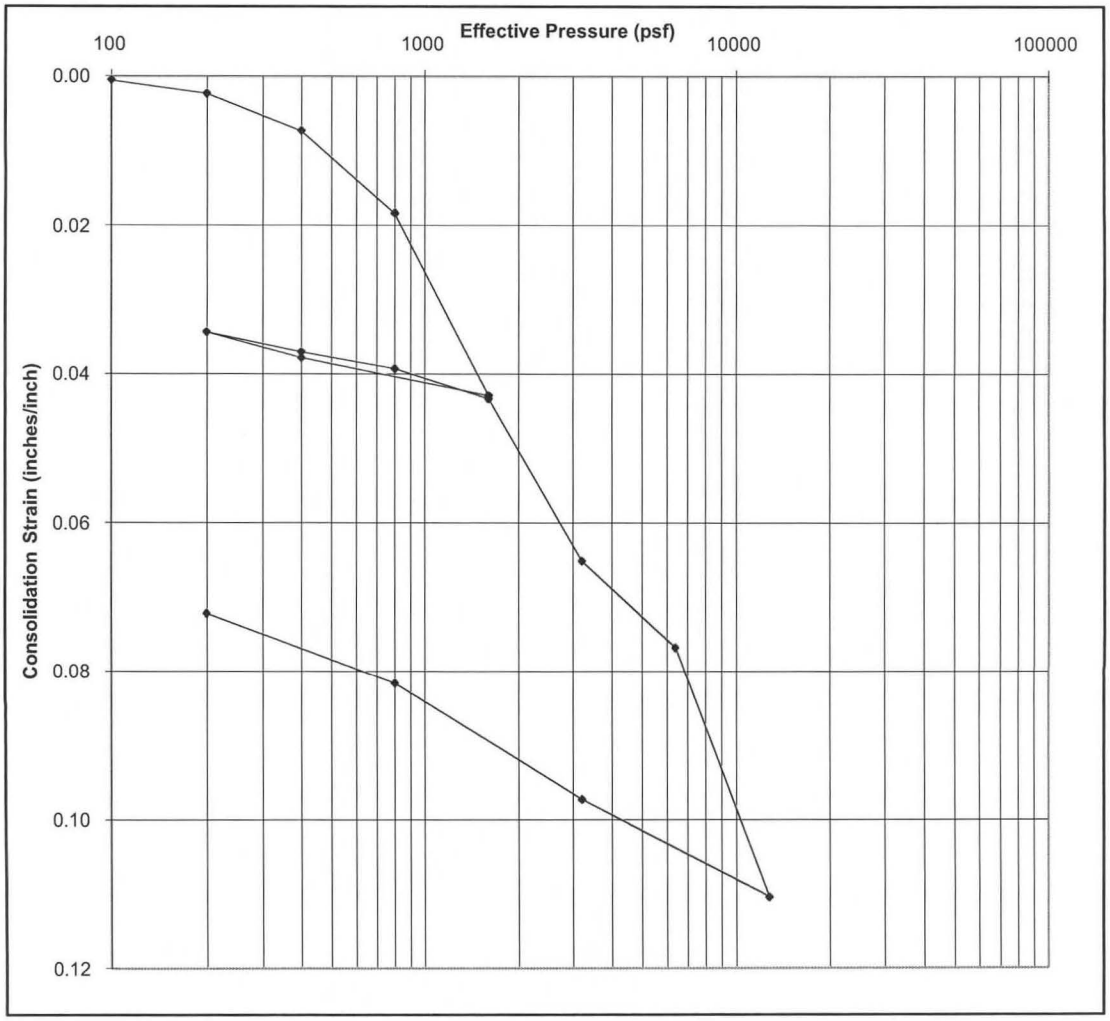
GEOENGINEERS

CONSOLIDATION TEST ASTM D 2435

FIGURE B-7

TACO:\17\1744200300\Finals\1744200300FigureB7.xls

Project:	Westway	**Lab No.**	08-0057
Project No.	17442-003-00	**Date:**	11/06/08
Boring/TP No.	B-2	**Tested By:**	KAR
Sample No./Depth:	S-22/108'	**Checked By:**	
Description:	MH	**PA/PM:**	EWH



	Initial	Final
Moisture Content	**61%**	**54%**
Dry Density (pcf)	**62.6**	**65.0**

Sample Height (in)	**1.0**
Sample Diameter (in)	**2.42**
Area (in^2)	**4.58**

NOTES: **Primary Consolidation Only**

NOTE: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of samples obtained at other times or locations, or generated by other operations or processes.

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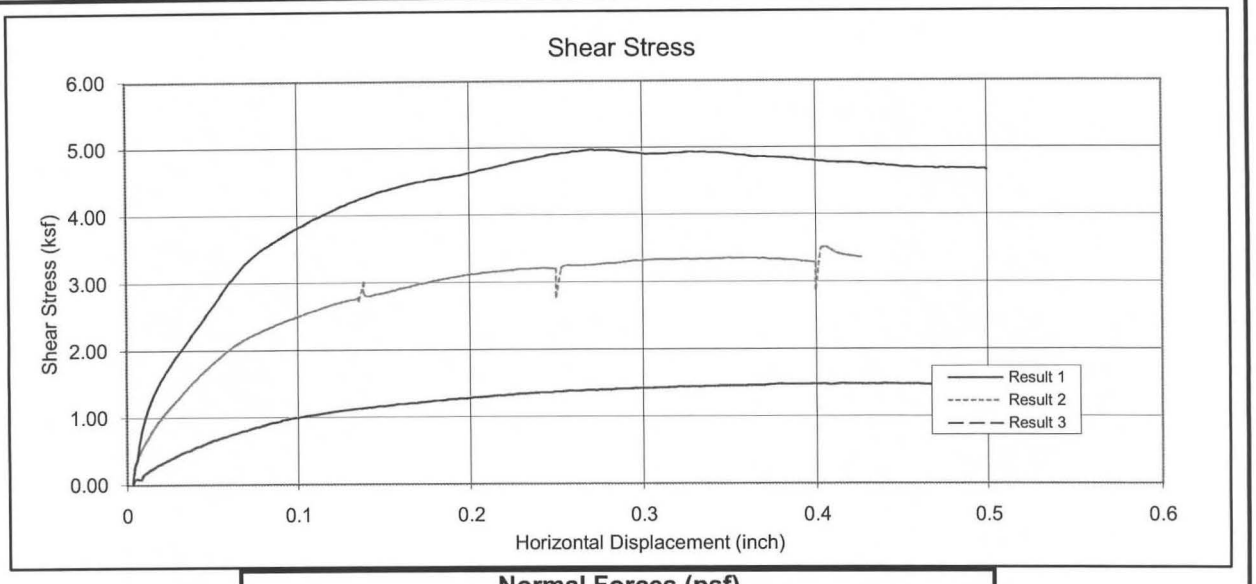
CONSOLIDATION TEST ASTM D 2435

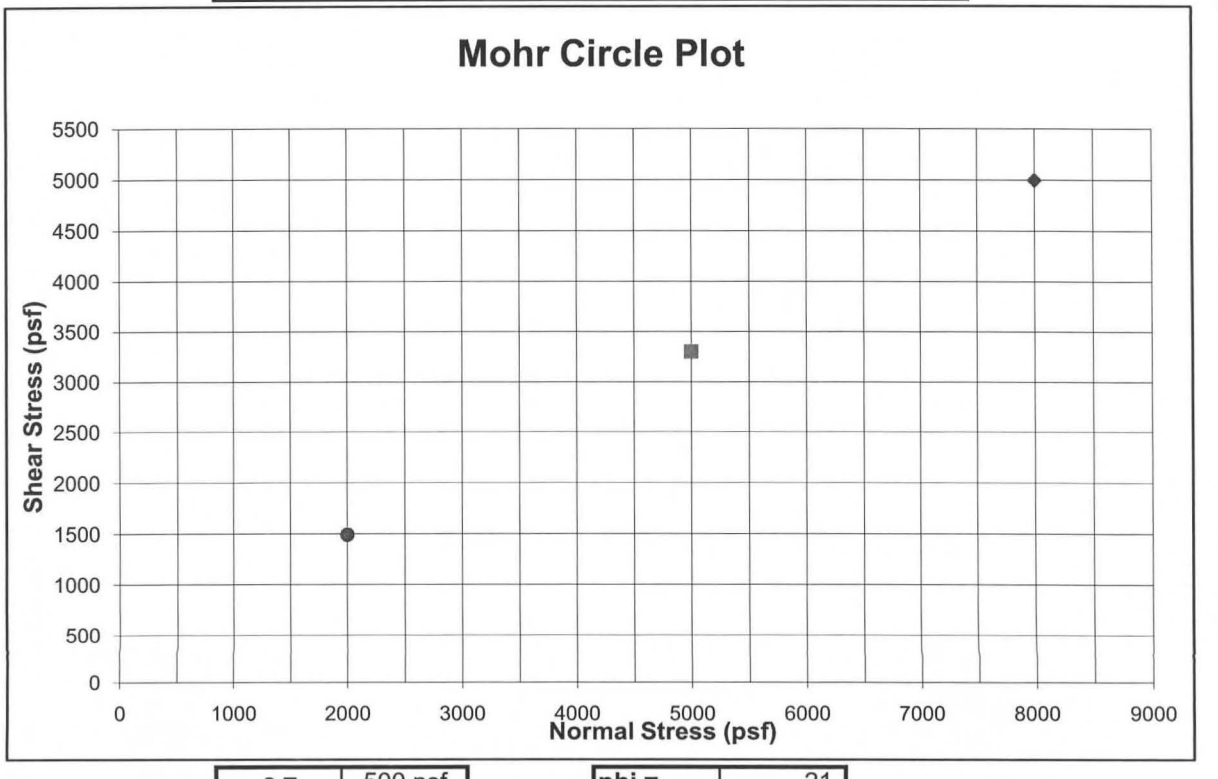
FIGURE B-8

TACO\17\17442003\00\Finals\17442003\00FigureB8.xls

Project:	Westway	**Lab No.**	08-0057
Project No.	17442-003-00	**Date:**	11/05/08
Boring/TP No.	B-1	**Tested By:**	KAR
Sample No./Depth:	S-8	**Checked By:**	
Description:	MH	**PA/PM:**	EWH



Normal Forces (psf)		
Low	**Intermediate**	**High**
2,000	5,000	8,000



c =	500 psf	**phi =**	21

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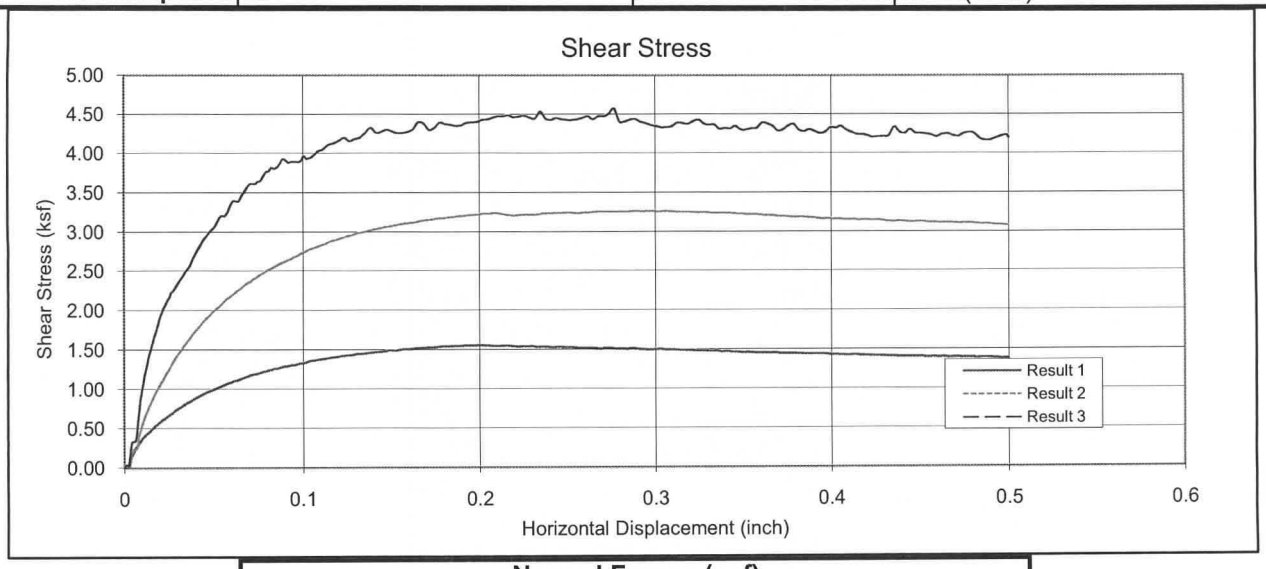
GEOENGINEERS

DIRECT SHEAR ASTM D 3080

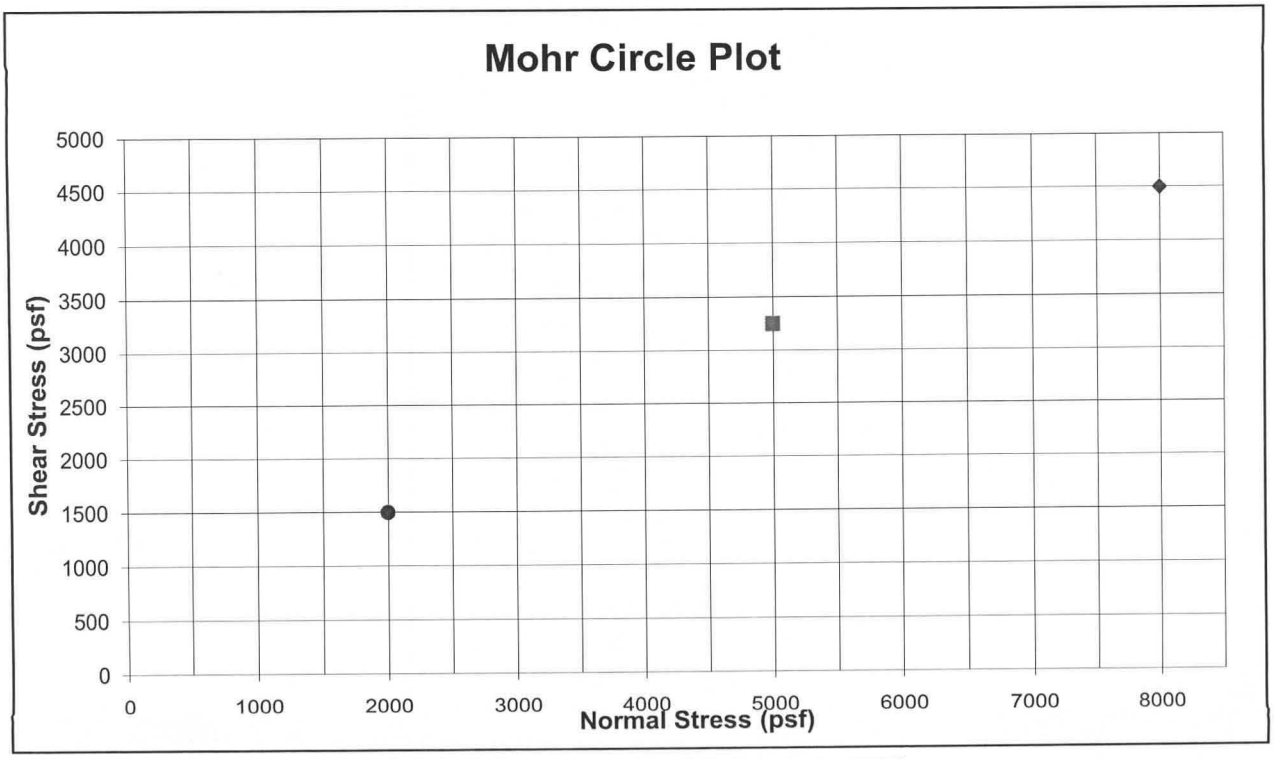
FIGURE B-9

TACO:\17\1744200300\Finals\1744200300FigureB9.xls

Project:	Westway	**Lab No.**	08-0057
Project No.	17442-003-00	**Date:**	11/05/08
Boring/TP No.	B-2	**Tested By:**	KAR
Sample No./Depth:	S-22/108'	**Checked By:**	
Description:	ML	**PA/PM:**	EWH(TAC)



Normal Forces (psf)		
Low	**Intermediate**	**High**
2,000	5,000	8,000



c =	600 psf

phi=	240

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DIRECT SHEAR ASTM D 3080

FIGURE B-10

TACO:\17\1744200300\Finals\1744200300FigureB10.xls

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Appendix C

Site-specific Seismic Response Analysis

APPENDIX C
SITE-SPECIFIC SEISMIC RESPONSE ANALYSIS

GENERAL

A site specific seismic response analysis was completed for this project to evaluate the site effect and to develop the ground surface design response spectra for use in the design of the tanks and the associated structures planned at the project site. The analysis was completed and the design response spectra were developed in general accordance with the procedures outlined in Chapter 21 of the American Society of Civil Engineers (ASCE) 7-05 code. The following presents the general approach in completing the analysis and development of the ground surface design spectra:

- Developing a target rock outcrop response spectrum using the probabilistic ground motion parameters determined from the 2002 United States Geological Survey (USGS) Probabilistic Seismic Hazard Model.
- Selecting representative earthquake time histories with source zones, magnitudes and site to source distance that are consistent with the site regional tectonic setting and seismicity.
- Scaling the selected time histories so that the average of their response spectra is a good match to the target rock outcrop response spectrum.
- Developing a soil model using subsurface soil information obtained from the explorations completed at the project site.
- Propagating the scaled time histories through the soil model developed to assess the amplification and damping effect of the site soils and developing response spectra at the ground surface (top of the soil profile).
- Establishing site specific design spectra using the results of the seismic response analysis per ASCE 7-05 code.

DEVELOPMENT OF TARGET ROCK OUTCROP RESPONSE SPECTRUM

The USGS 2002 probabilistic seismic hazard deaggregation was completed and used to evaluate the seismic hazard at the project area (123.855 W, 46.967 N). Using the spectral acceleration values estimated by the USGS for periods between 0 and 2 seconds, a maximum considered earthquake (MCE) response spectrum for rock site condition was constructed and was used as the target spectrum in scaling our selected input motions used in our site response analysis, as described below.

SITE-RESPONSE ANALYSIS

Selection of Input Ground Motions

In order to provide representative earthquake acceleration time histories for the site-response analysis, we reviewed the percent contribution of the regional source zones to the estimated seismic hazard at the project area using the USGS 2002 probabilistic seismic hazard deaggregation for ground motions with a 2 percent PE in 50 years. From the USGS deaggregation, we observed that the earthquakes associated with the interface between the subducting plate and overriding plate (interface subduction zone event, IF) off the coast of Washington contributed approximately 80 percent of the seismic hazard at the project area. Deep gridded Pacific Northwest earthquakes contributed the remaining 20 percent of the seismic hazard at the project area. Based on this evaluation, we selected one intraplate subduction zone (IP) event

and six interplate subduction zone events to be used as input ground motions for the site response analysis. The ground motions selected using the criteria described above are presented in Table C-1.

Scaling of Input Ground Motions

The selected input motion time histories were scaled prior to completing site response analysis. Each selected time history was scaled so that its response spectrum is, on average, approximately at the level of the target rock site response spectrum as defined above over the period range of 0 to 2 seconds. The scaling factors applied to each earthquake are shown in Table C-2. Figure C-1 shows the response spectra for each orthogonal pair of scaled input motion time histories, their average and the target response spectrum used as a guide for scaling the input motions.

Table C-1. Ground Motions

Earthquake, Year	Recording Station	Magnitude	Distance (km)	Unscaled PGA (orientation of orthogonal component)	Scale Factor for 475-YR Event	Fault Mechanism
Japan, Tokachi-Oki, 2003	HKD122	8.3	246	0.05 (NS)	9	Subduction Zone, Interface
				0.07 (EW)		
Japan, Tokachi-Oki, 2003	HKD094	8.3	157	0.12 (NS)	4	Subduction Zone, Interface
				0.13 (EW)		
Japan, Tokachi-Oki, 1968	S252	8.2	187	0.30 (NS)	1.85	Subduction Zone, Interface
				0.23 (EW)		
Mexico, 1985	Michoacan La Villita	8.1	48	0.10 (NS)	6	Subduction Zone, Interface
				0.11 (EW)		
Mexico, 1985	Michoacan La Union	8.1	80	0.17 (180)	4	Subduction Zone, Interface
				0.15 (090)		
El Salvador, 2001	Santiago de Maria	7.6	52.2	0.72 (090)	0.9	Subduction Zone, Intraplate
				0.88 (360)		
Synthetic	Cascadia Subduction Zone	9.0	n/a	0.44 (FP)	2.1	Subduction Zone, Interface
				0.09 (FN)		

Soil Profile

A site-response model based on low-strain shear wave velocities was developed for this project. The explorations completed at the project area extend to an approximate maximum depth of 150 feet and were terminated in medium dense to very dense sand and gravel. Based on our review of the regional geology at the site, the bedrock was modeled at depth of 250 feet.

Based on the field data from our subsurface explorations and previous experience in the area, the project area was split into two areas: the west profile and east profile. Because the east profile was determined to be the softest site condition, site-specific seismic response analysis was only performed on the east half of the project area. The results of the seismic analysis using the east profile were then adjusted to develop the design spectrum for the west profile.

The shear wave velocities of the soil for the east profile were determined using correlations based on boring B-2 and CPT-5, CPT-6, CPT-7 and CPT-8. The design shear wave velocity profile and the shear wave velocity profile used in D-MOD2000 for the east profile are shown in Figure C-2. Shear wave velocity below the exploration depth is assumed to increase linearly in accordance with measured values until bedrock is reached at a depth of 250 feet. Table C-2 summarizes the soil type, unit weights, shear wave velocity and shear modulus and damping reduction curves used in the D-MOD2000 model for the soil profile used in our analysis.

Table C-2. Soil Profile Model for East Profile

Depth (ft)			γ	Vs	
Start	End	Material Type	(pcf)	(ft/s)	Shear Modulus Reduction and Damping Curves
0	5	Gravelly Sand Fill	130	575	EPRI: Deep, Cohesionless soils: 0 – 20 ft
5	35	Wood Waste	90	175	Fibrous Organic Soil, Sherman Island (Wehling 2003)
35	55	Elastic Silt Fill	100	400	Darendeli et al (2001): PI = 35, OCR = 1, □'m = 0.74 atm
55	120	Native Elastic Silt	105	445	Darendeli et al (2001): PI = 30, OCR = 1, □'m = 1.29 atm
120	130	Gravelly Sand	130	509	EPRI: Deep, Cohesionless soils: 121 – 250 ft
130	140	Gravelly Sand	130	533	EPRI: Deep, Cohesionless soils: 121 – 250 ft
140	150	Gravelly Sand	130	557	EPRI: Deep, Cohesionless soils: 121 – 250 ft
150	250	Gravelly Sand	130	690	EPRI: Deep, Cohesionless soils: 121 – 250 ft
> 250		Bedrock	135	2,500	Elastic Half Space

Site-Response Analysis and Computed Results

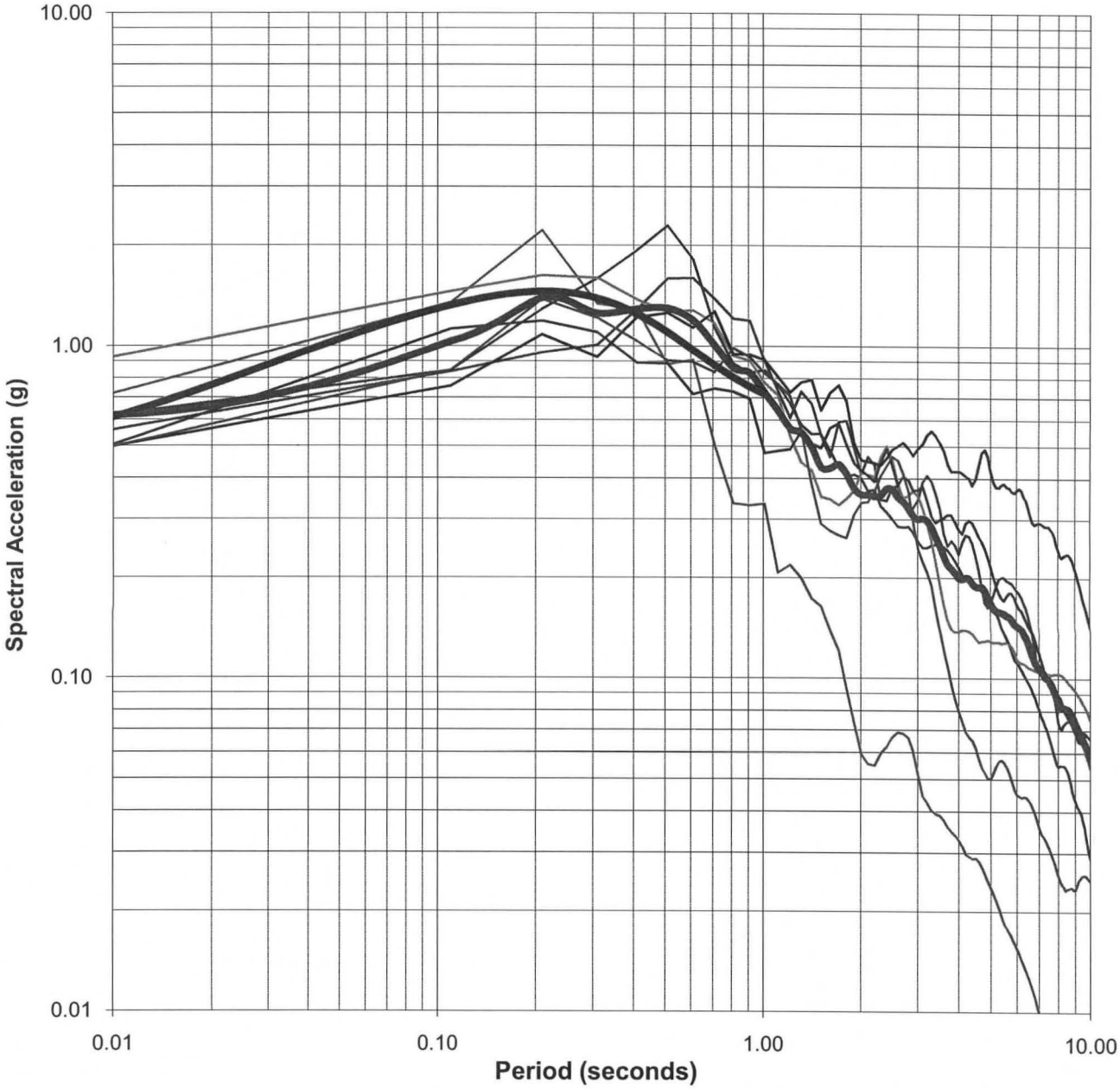
The site-response analysis was completed using the computer program D-MOD2000 (GeoMotions, LLC. 2007). D-MOD2000 is a computer program for nonlinear, one-dimensional seismic-response analysis.

Response spectra for 5 percent structural damping were developed for the site by propagating the scaled input motions through the soil profile using D-MOD2000. Figure C-3 shows the MCE response spectra at the ground surface calculated for the east profile. The amplification factor (AF), which is the ratio of the surface spectral acceleration to the scaled input rock spectral acceleration, was then calculated for each profile and shown in Figure C-4. The average AF at the ground surface was then used to construct the site-specific design spectra for the project, as described below.

Site-Specific Design Spectrum

The site-specific design spectrum for the project area was determined by applying the average AF for each profile to the target rock spectrum in accordance with the procedures outlined in the ASCE 7-05 code, Sections 21.1.3 and 21.4. Figure C-5 shows the computed average design response spectrum (2/3 MCE response spectra) for the east profile alongside the recommended design response for the east profile. Also shown in Figure C-5 is the site class E generalized design response spectrum per the ASCE 7-05, which is recommended for use as the design spectrum for the west profile. The recommended site-specific response spectrum for both the east profile and west profiles are also shown in Figure 5 in the report.

Westway Grays Harbor, Port of Grays Harbor, Washington
(Response Spectra of Scaled Rock Outcrop Ground Motions, 2475-yr Earthquake)



El Salvador Santiago de Maria AVG [IP]	1985 Michoacan Mexico La Villita AVG [IF]
Synthetic Cascadia AVG [IF]	Michoacan La Union AVG [IF]
2003 Tokachi-Oki 122 AVG [IF]	2003 Tokachi-Oki 094 AVG [IF]
1968 Tokachi-Oki 252 AVG [IF]	Avg RS of 7 Input EQs
Rock Outcrop (2475 yrs)	

[IP] = Subduction Zone, Intraplate [IF] = Subduction Zone, Interface

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2475-YR, SCALED ROCK OUTCROP RESPONSE SPECTRA

FIGURE C-1

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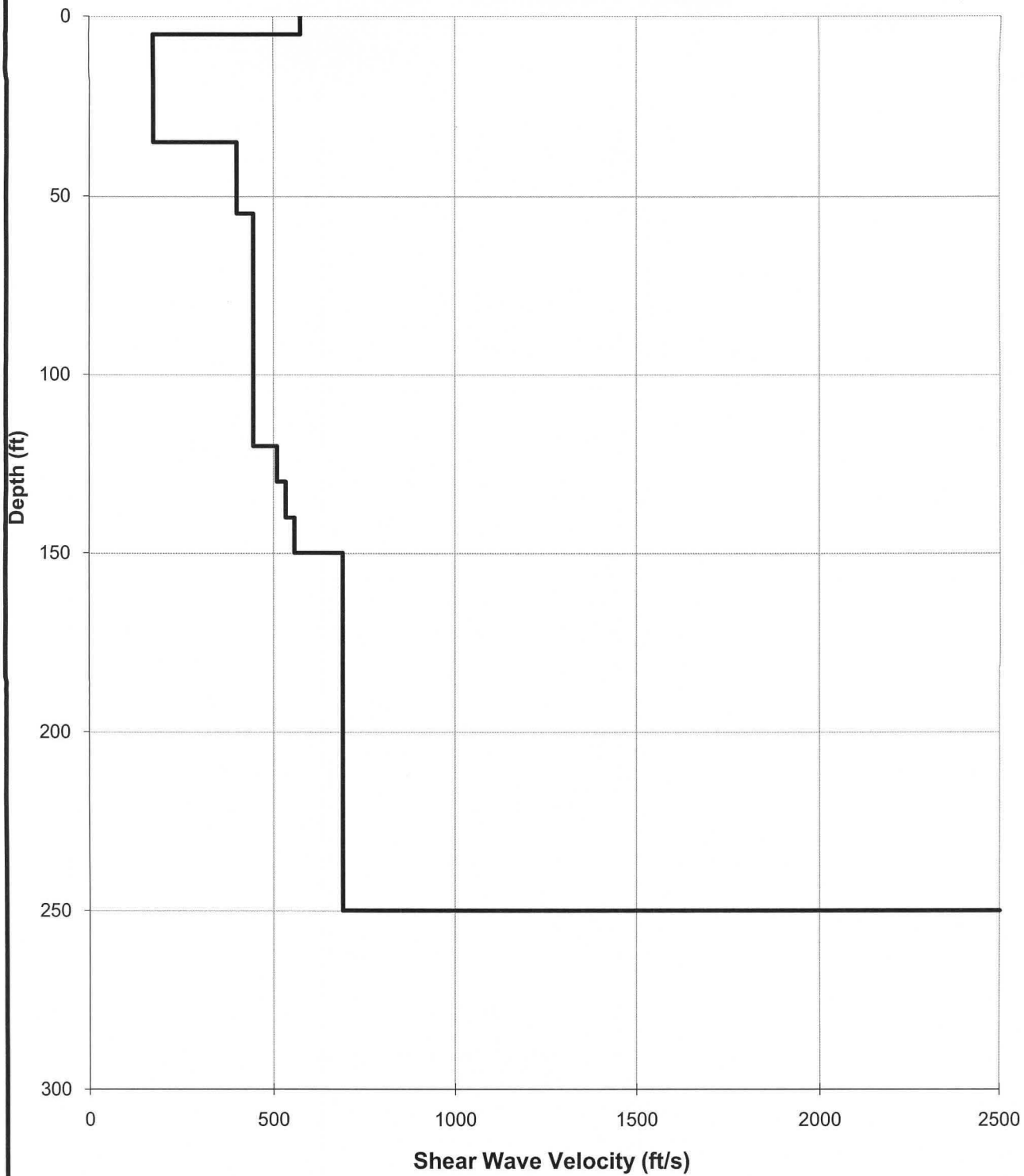
Westway Grays Harbor, Port of Grays Harbor, Washington
(Shear Wave Velocity Profile, East Profile)



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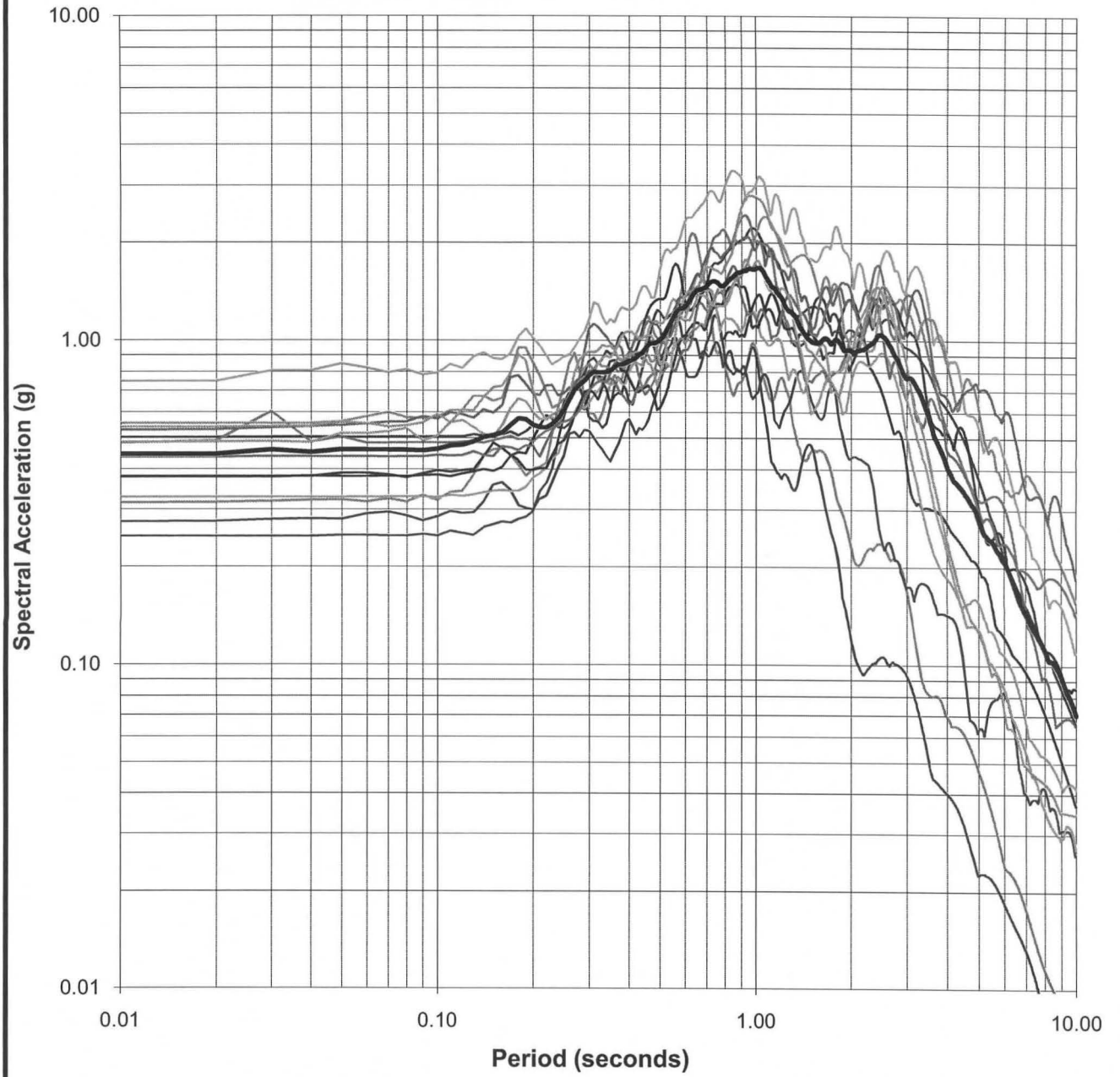
SHEAR WAVE VELOCITY PROFILE

FIGURE C-2

Westway Grays Harbor, Port of Grays Harbor, Washington
(MCE Response Spectra at Ground Surface, East Profile)



El Salvador Santiago de Maria 090 [IP]	El Salvador Santiago de Maria 360 [IP]
1985 Michoacan Mexico La Villita NS [IF]	1986 Michoacan Mexico La Villita EW [IF]
Synthetic Cascadia FN [IF]	Synthetic Cascadia FP [IF]
Michoacan La Union 180 [IF]	Michoacan La Union 090 [IF]
Tokachi-Oki 122 EW [IF]	Tokachi-Oki 122 NS [IF]
2003 Tokachi-Oki 094 NS [IF]	2004 Tokachi-Oki 094 EW [IF]
1968 Tokachi-Oki 252 NS [IF]	1969 Tokachi-Oki 252 EW [IF]
Average MCE Spectrum	

[IP] = Subduction Zone, Intraplate [IF] = Subduction Zone, Interface

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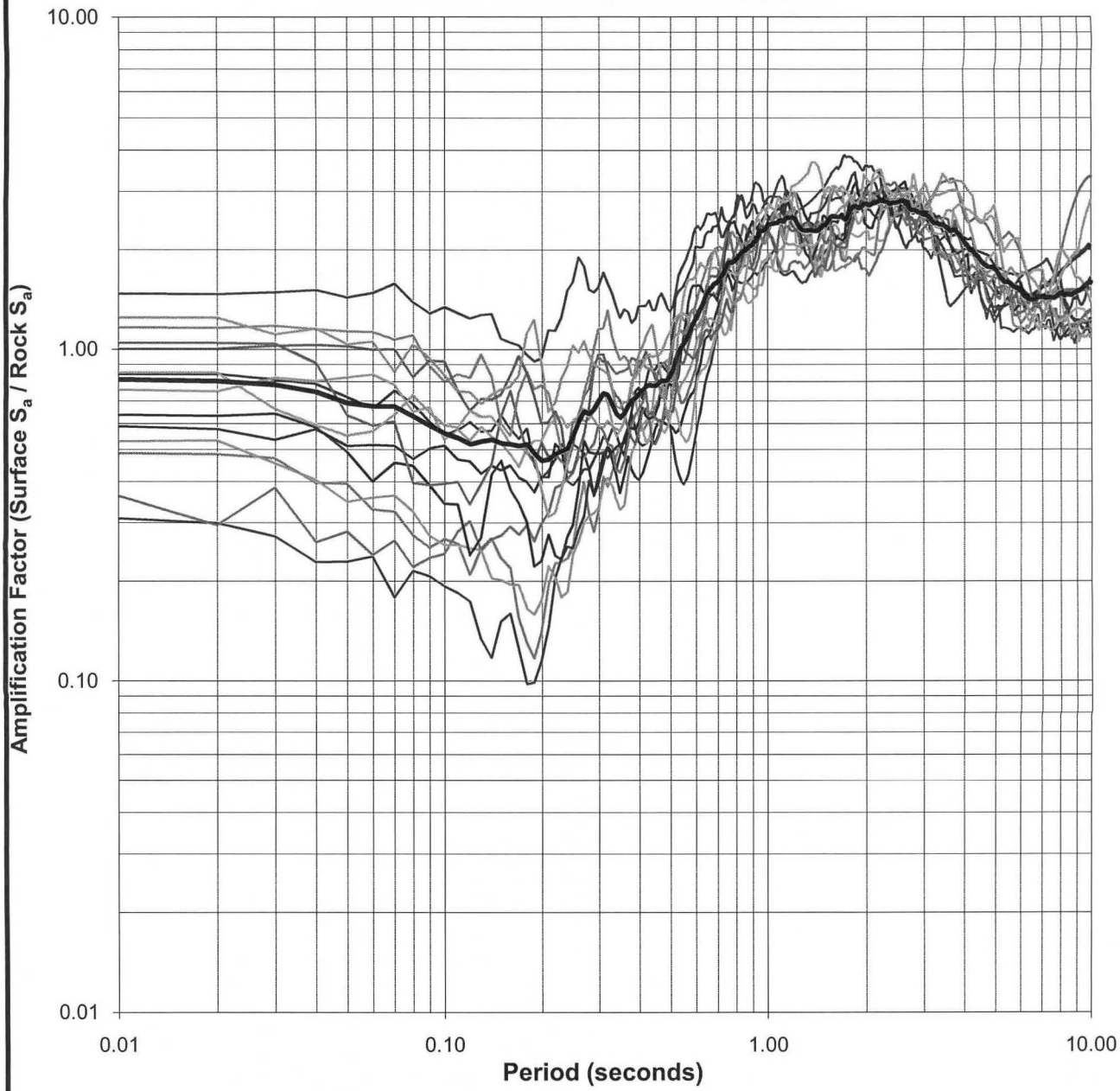
5% DAMPED MCE SPECTRA

FIGURE C-3

Westway Grays Harbor, Port of Grays Harbor, Washington
(MCE Amplification Factor at Ground Surface, East Profile)



El Salvador Santiago de Maria 090 [IP]	El Salvador Santiago de Maria 360 [IP]
1985 Michoacan Mexico La Villita NS [IF]	1986 Michoacan Mexico La Villita EW [IF]
Synthetic Cascadia FN [IF]	Synthetic Cascadia FP [IF]
Michoacan La Union 180 [IF]	Michoacan La Union 090 [IF]
Tokachi-Oki 122 EW [IF]	Tokachi-Oki 122 NS [IF]
2003 Tokachi-Oki 094 NS [IF]	2004 Tokachi-Oki 094 EW [IF]
1968 Tokachi-Oki 252 NS [IF]	1969 Tokachi-Oki 252 EW [IF]
Average MCE AF 2475	

[IP] = Subduction Zone, Intraplate [IF] = Subduction Zone, Interface

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5% DAMPED MCE AF

FIGURE C-4

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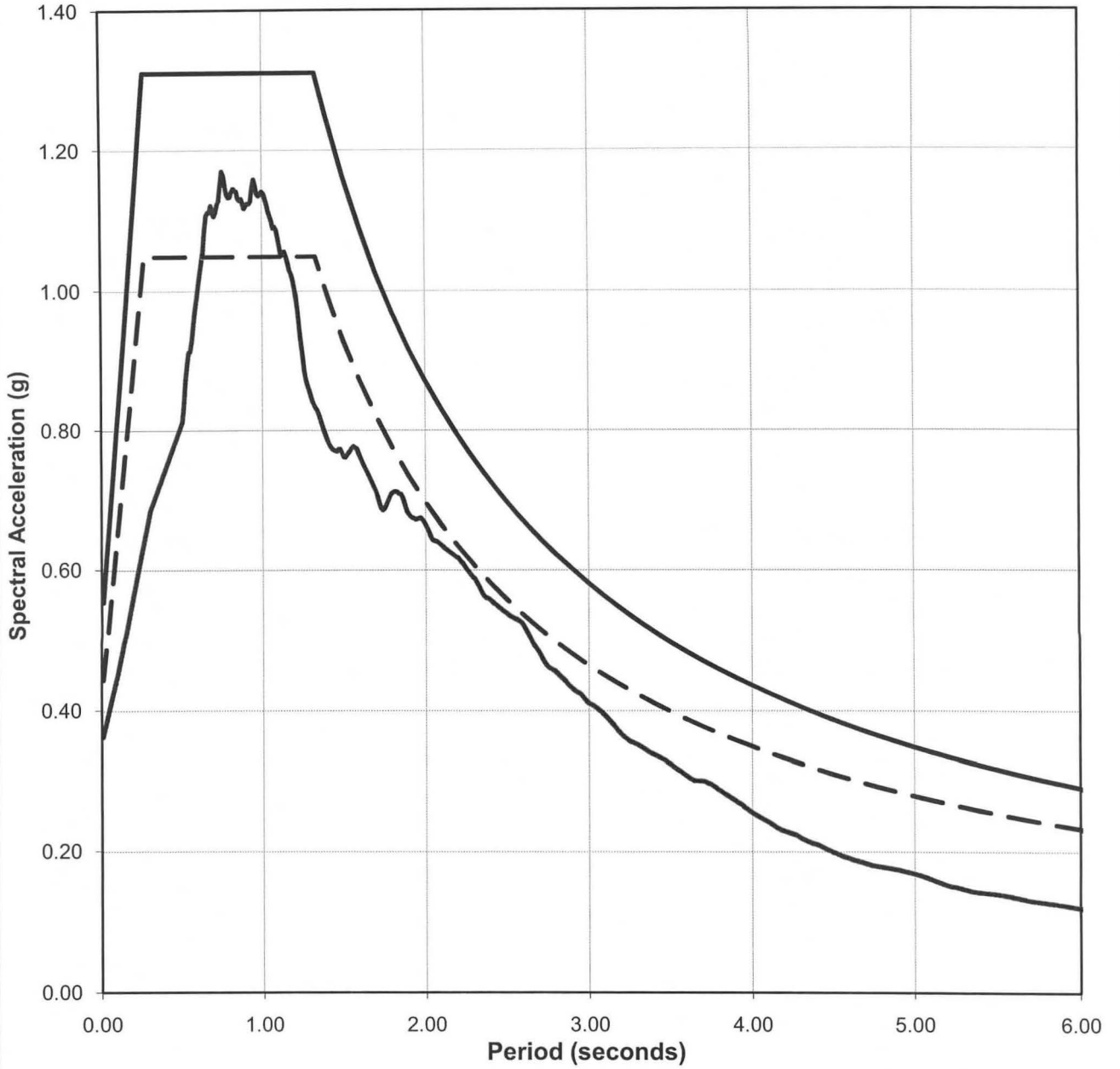
Westway Grays Harbor, Port of Grays Harbor, Washington
(Response Spectra of Ground Motions, 2475-yr Earthquake, East Profile)



(2/3) East Profile Average 2475YR AF X Site Class B General Response Spectrum (ASCE 7 Approach)

Site Class E General Response Spectrum (ASCE 7 Approach)

0.8 x Site Class E General Response Spectrum (ASCE 7 Approach)

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2475-YR EQ RESPONSE SPECTRA (ASCE 7 APP)

FIGURE C-5

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Appendix D
L-PILE Analysis

APPENDIX D
L-PILE ANALYSIS

We evaluated lateral load behavior using the L-PILE computer program. Tables D-1 and D-2 provide the input data for the soil profile; Table D-3 provides the input data for the pile properties. For this project, we have analyzed a closed-end 12-inch-steel pile filled with concrete as per our conversations with Harris Group.

Table D-1. L-PILE Soil Properties West Portion of Site

Depth (in.)	USCS Soil Classification	Effective Unit Weight (pci)	Friction Angle ϕ (degrees)	Soil Modulus (k, psi)	Cohesion (psi)	Strain Modulus, ε_{50}
0 – 144	GP-GM	0.075	32	90		
144 – 204	GP-GM	0.039	32	60		
204 – 720	MH/SM	0.023			3.47	0.02
720 – 1,680	MH	0.024			4.86	0.02
720 – 1,440	MH	0.025			4.86	0.02
1,440 – 2,400	SP-SM	0.041	38	125		

Table D-2. L-PILE Soil Properties East Portion of Site

Depth (in.)	USCS Soil Classification	Effective Unit Weight (pci)	Friction Angle ϕ (degrees)	Soil Modulus (k, psi)	Cohesion (psi)	Strain Modulus, ε_{50}
0 – 72	GP-GM	0.075	32	90		
72 – 144	Wood Waste	0.044	15	25		
144 – 420	Wood	0.008	15	20		
420 – 720	MH	0.022			3.47	0.02
720 – 1,344	MH / SM	0.028			3.47	0.02
1,344 – 2,400	SP -SM	0.041	38	125		

Table D-3. L-PILE Pile Properties

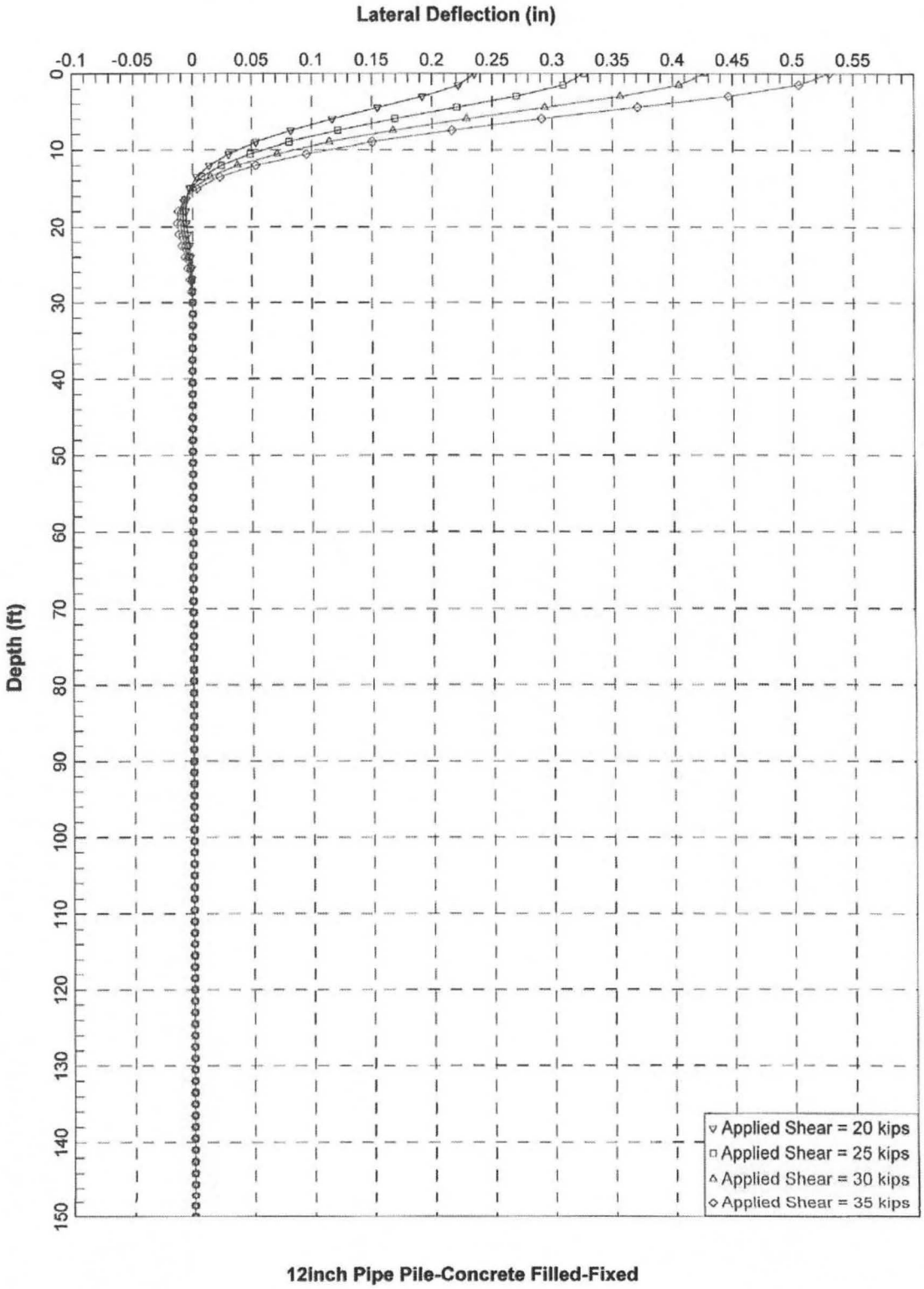
Pile Type	Head Free to Rotate[1]	Length (in.)	Diameter (in.)	Moment of Inertia (in.^{4})	Area[2] (in.^{2})	Modulus of Elasticity (psi x 10^6)
12-inch steel pipe[3], concrete filled	No	1,800	12.75	405	28.9	29
12-inch steel pipe[3], concrete filled	Yes	1,800	12.75	405	28.9	29

Notes:
[1] L-PILE considered either perfectly fixed or perfectly free to rotate.
[2] Transformed area for composite piles provided by structural engineer, Harris Group.
[3] Wall thickness of 12-inch-steel pile is 0.375 in., outer diameter of 12.75 in.

The applied loads used in our analysis were provided by the structural engineer, Harris Group. The axial load used for all conditions is 247 kips. Four lateral (shear) loads conditions are analyzed *20, 25, 30* and 35 kips. A total of four cases were analyzed as indicated in Table D-4.

Table D-4. L-PILE Analyses

Analysis	Profile	Pile Head Fixity	Shear Load (kips)	Deflection Diagram	Moment Diagram	Shear Diagram
1	East	Fixed	20, 25, 30, 35	Figure D-1	Figure D-2	Figure D-3
2	East	Free	20, 25, 30, 35	Figure D-4	Figure D-5	Figure D-6
3	West	Fixed	20, 25, 30, 35	Figure D-7	Figure D-8	Figure D-9
4	West	Free	20, 25, 30, 35	Figure D-10	Figure D-11	Figure D-12



12inch Pipe Pile-Concrete Filled-Fixed

Not to Scale

Case 1 - Lateral Deflection	
Westway Grays Harbor Port of Grays Harbor, Washington	
GEOENGINEERS	Figure D-1

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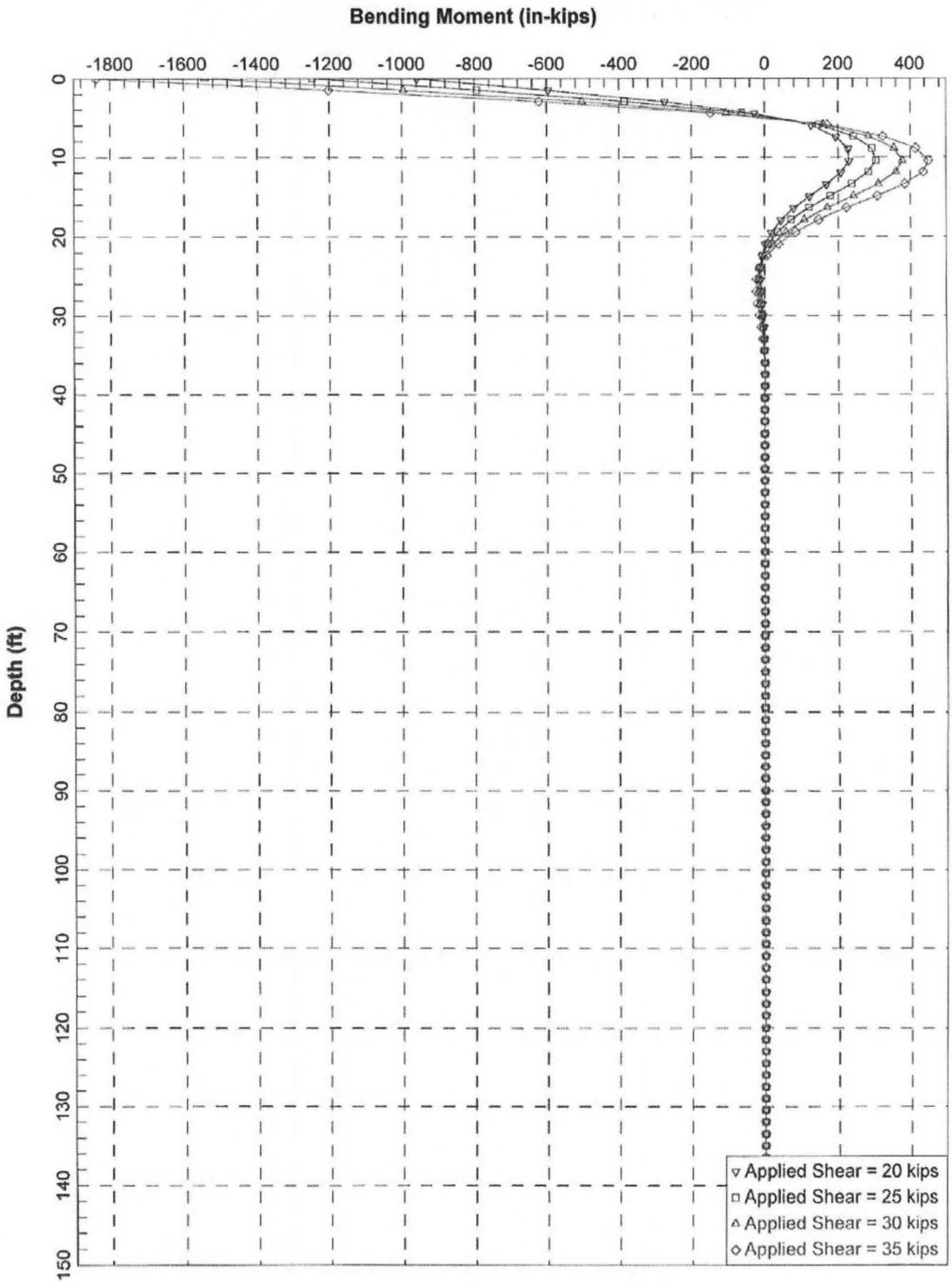

12inch Pipe Pile-Concrete Filled-Fixed

Not to Scale

Case 1 - Bending Moment

Westway Grays Harbor
Port of Grays Harbor, Washington

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Figure D-2

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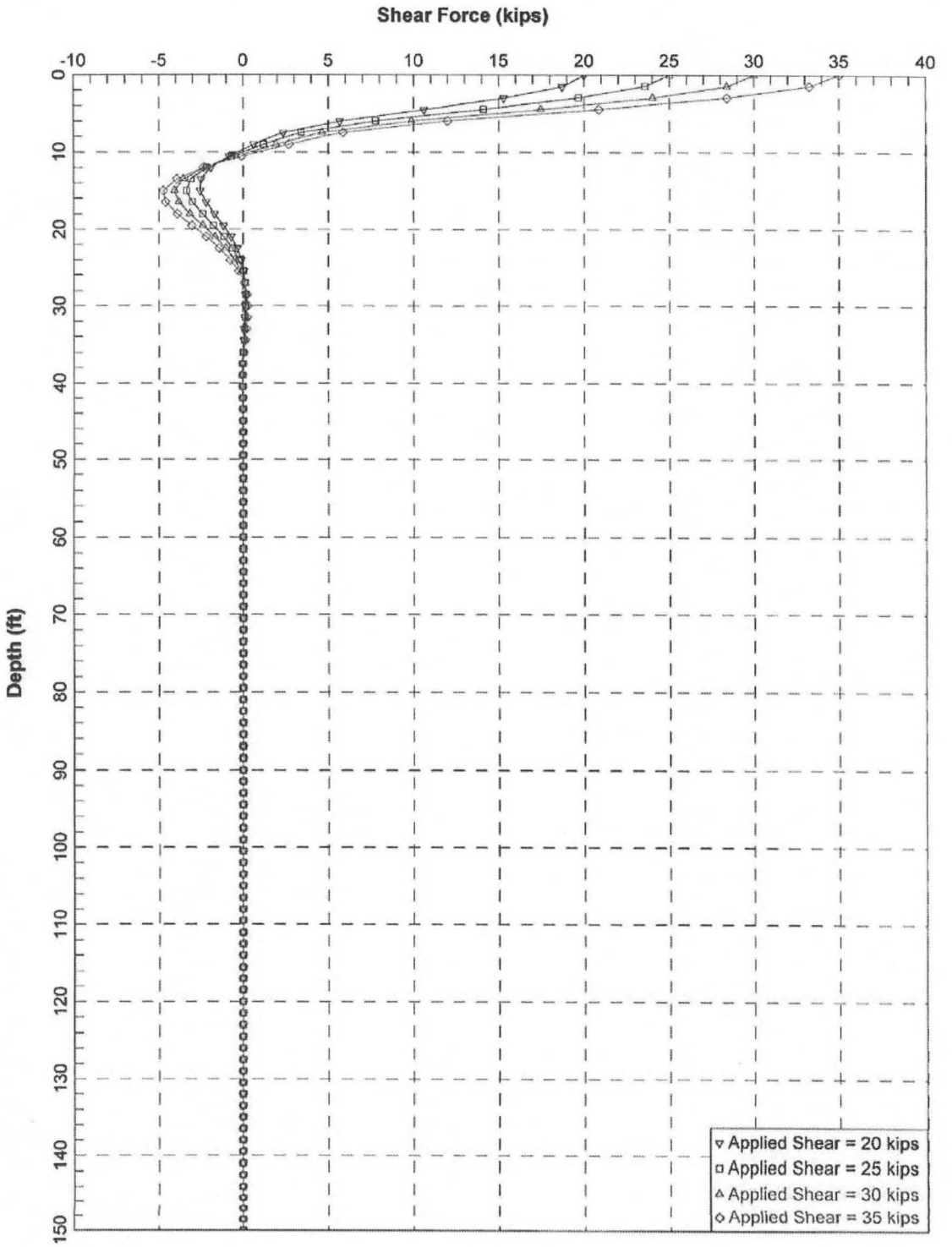

12inch Pipe Pile-Concrete Filled-Fixed

Not to Scale

Case 1 - Shear Force	
Westway Grays Harbor Port of Grays Harbor, Washington	
GEOENGINEERS	**Figure D-3**

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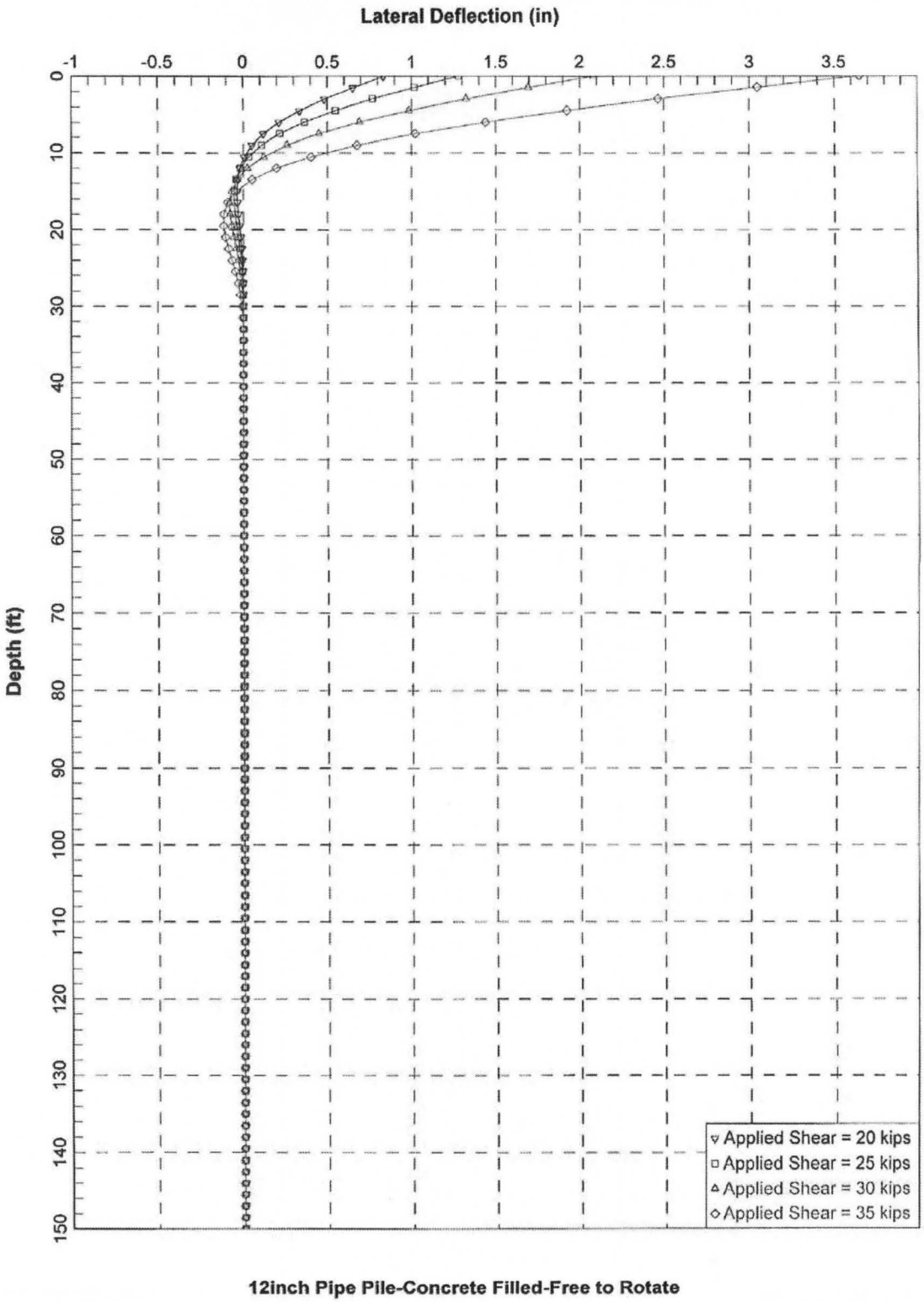

Not to Scale

Case 2 - Lateral Deflection

Westway Grays Harbor
Port of Grays Harbor, Washington

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Figure D-4

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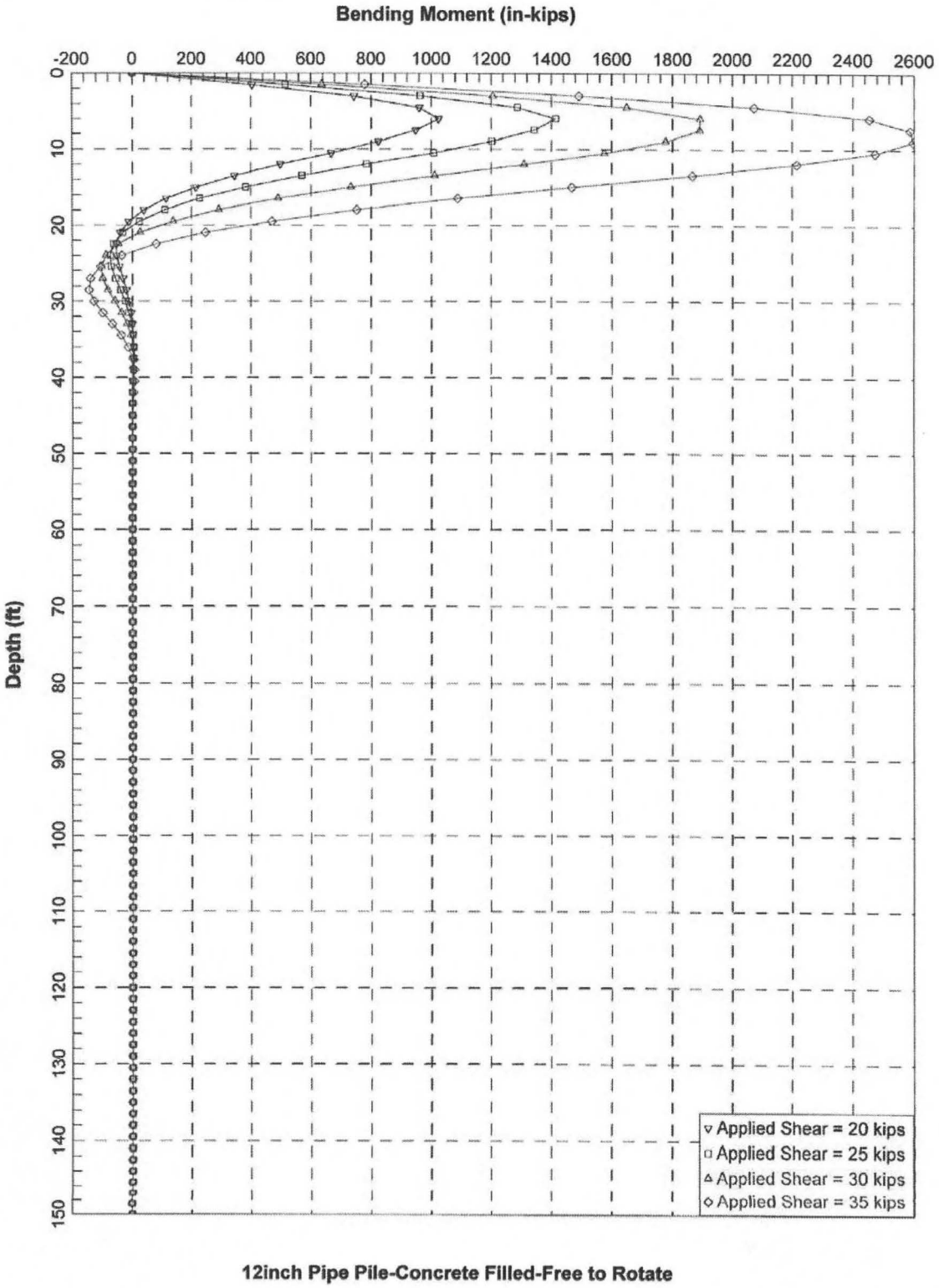

12inch Pipe Pile-Concrete Filled-Free to Rotate

Not to Scale

Case 2 - Bending Movement

Westway Grays Harbor
Port of Grays Harbor, Washington

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Figure D-5

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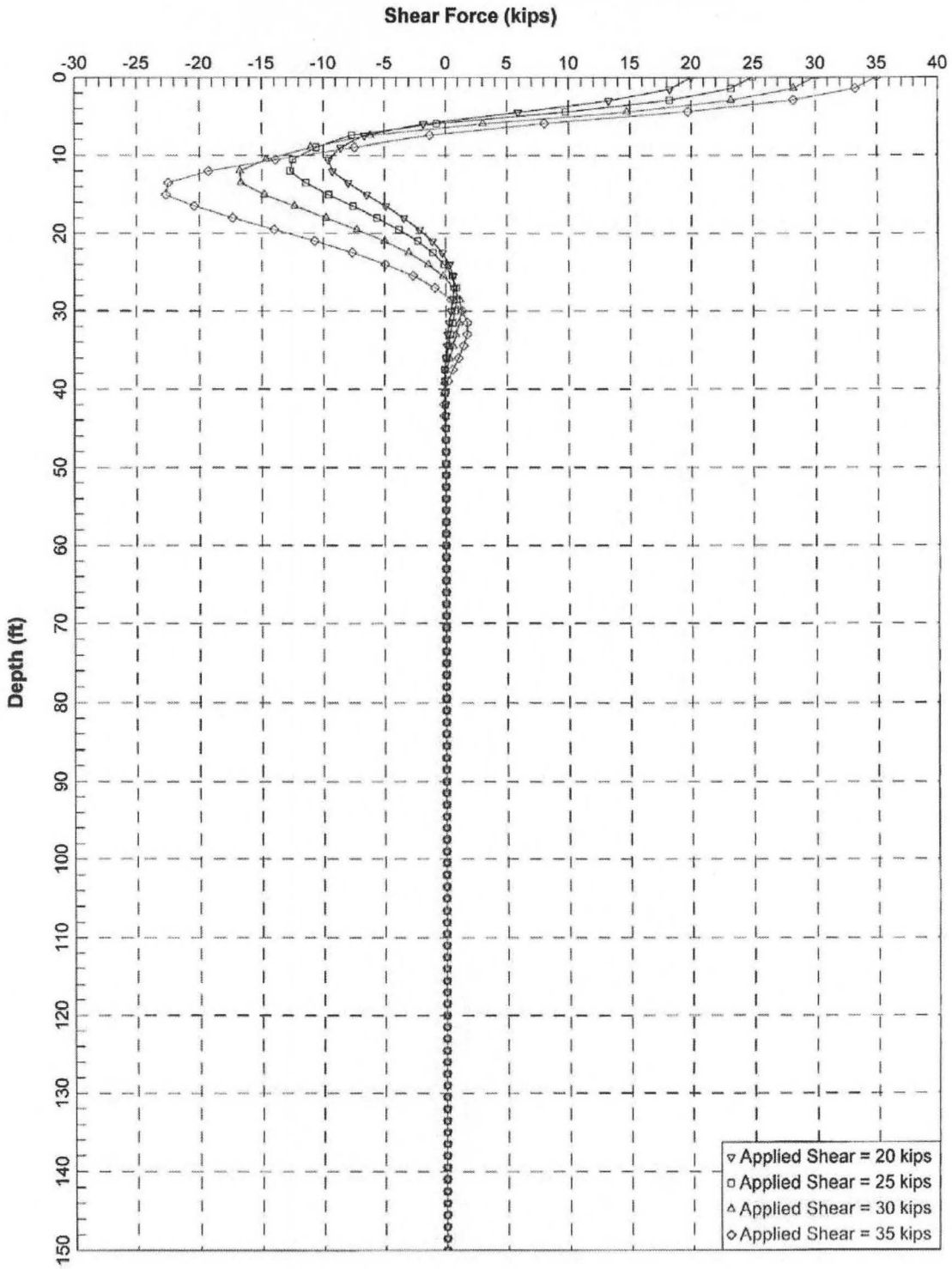

12inch Pipe Pile-Concrete Filled-Free to Rotate

Not to Scale

Case 2 - Shear Force

Westway Grays Harbor
Port of Grays Harbor, Washington

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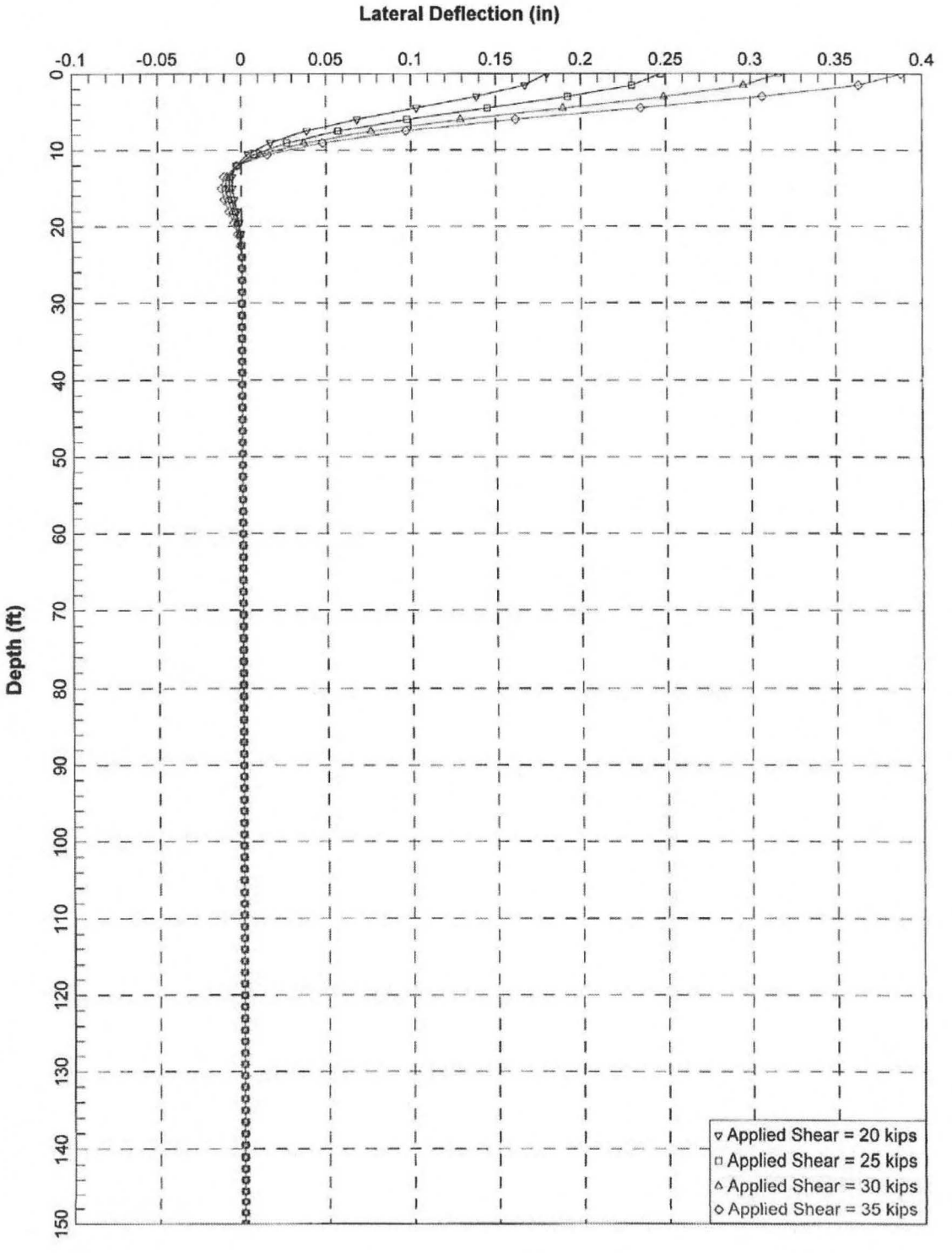
Figure D-6

OFFICE:TACO PM EWH P:\17\1744200300\CAD\1744200300_D1-D12.dwg\TAB:Fig. D-6 modified by prpendleton on Jan 15, 2009 - 11:53



12inch Pipe Pile-Concrete Filled-Fixed

Not to Scale

Case 3 - Lateral Deflection

Westway Grays Harbor
Port of Grays Harbor, Washington

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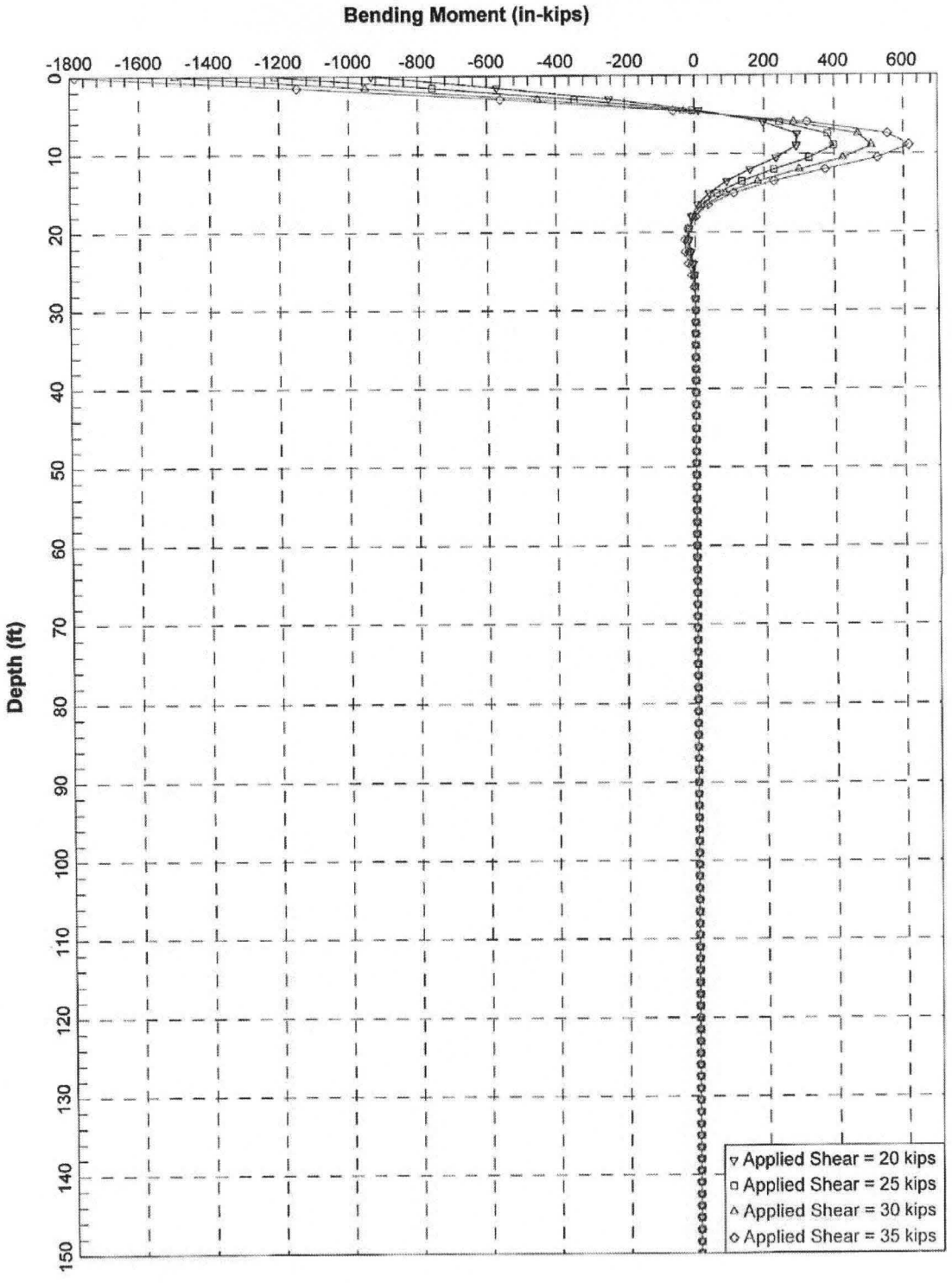
Figure D-7

OFFICE:TACO PM EWH P:\17\1744200300\CAD\1744200300_D1-D12.dwg\TAB:Fig. D-7 modified by prpendleton on Jan 15, 2009 - 11:55



12inch Pipe Pile-Concrete Filled-Fixed

Not to Scale

Case 3 - Bending Movement

Westway Grays Harbor
Port of Grays Harbor, Washington

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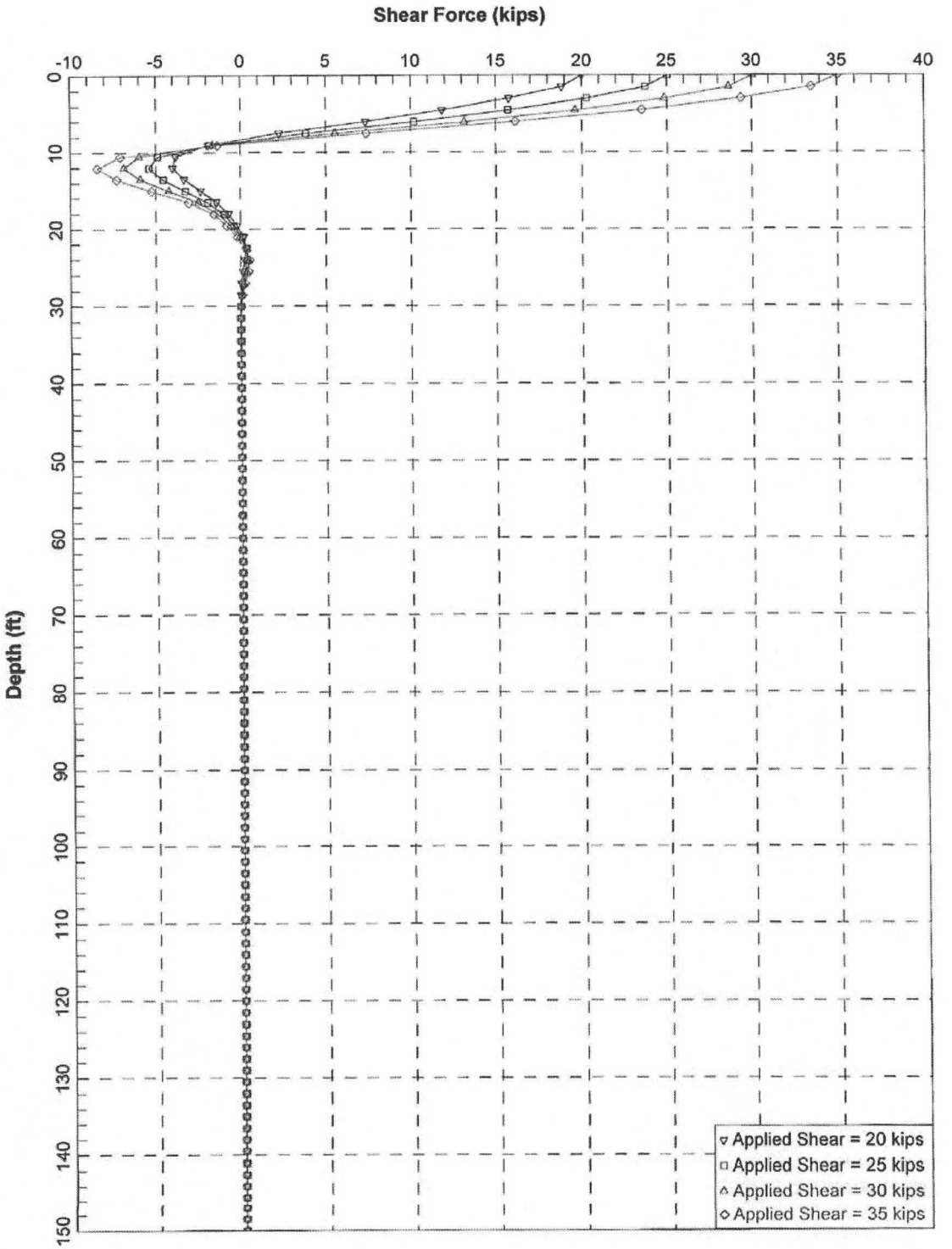
Figure D-8

OFFICE:TACO PM EWH P:\17\1744200300\CAD\1744200300_D1-D12.dwg\TAB:Fig. D-8 modified by prpendleton on Jan 15, 2009 - 11:56



12inch Pipe Pile-Concrete Filled-Fixed

Not to Scale

Case 3 - Shear Force

Westway Grays Harbor
Port of Grays Harbor, Washington

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Figure D-9

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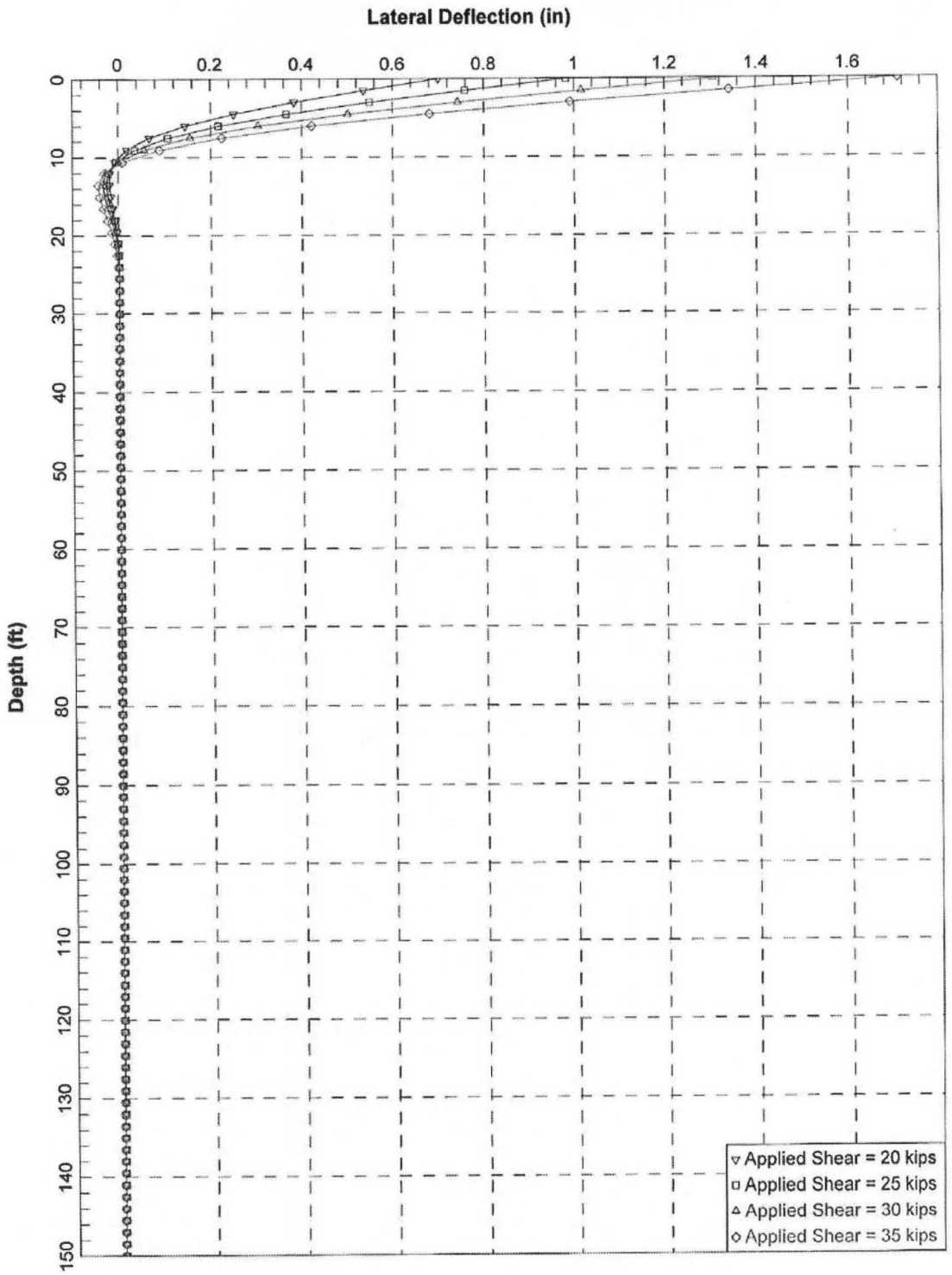

12inch Pipe Pile-Concrete Filled-Free to Rotate

Not to Scale

Case 4 - Lateral Deflection

Westway Grays Harbor
Port of Grays Harbor, Washington

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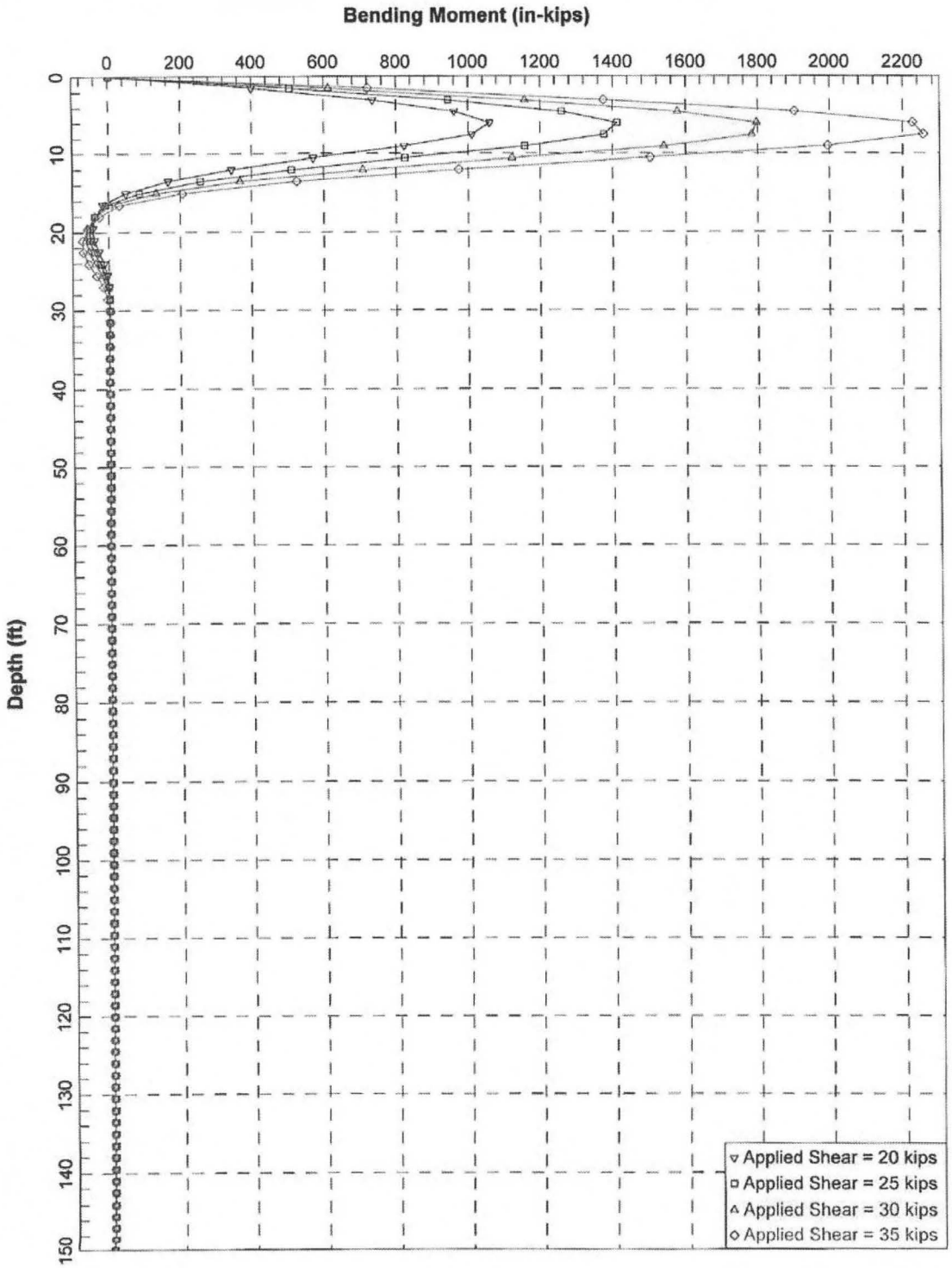
Figure D-10

OFFICE:TACO PM EWH P:\17\1744200300\CAD\1744200300_D1-D12.dwg\TAB:Fig. D-10 modified by prpendleton on Jan 15, 2009 - 11:58



12inch Pipe Pile-Concrete Filled-Free to Rotate

Not to Scale

Case 4 -Bending Movement

Westway Grays Harbor
Port of Grays Harbor, Washington

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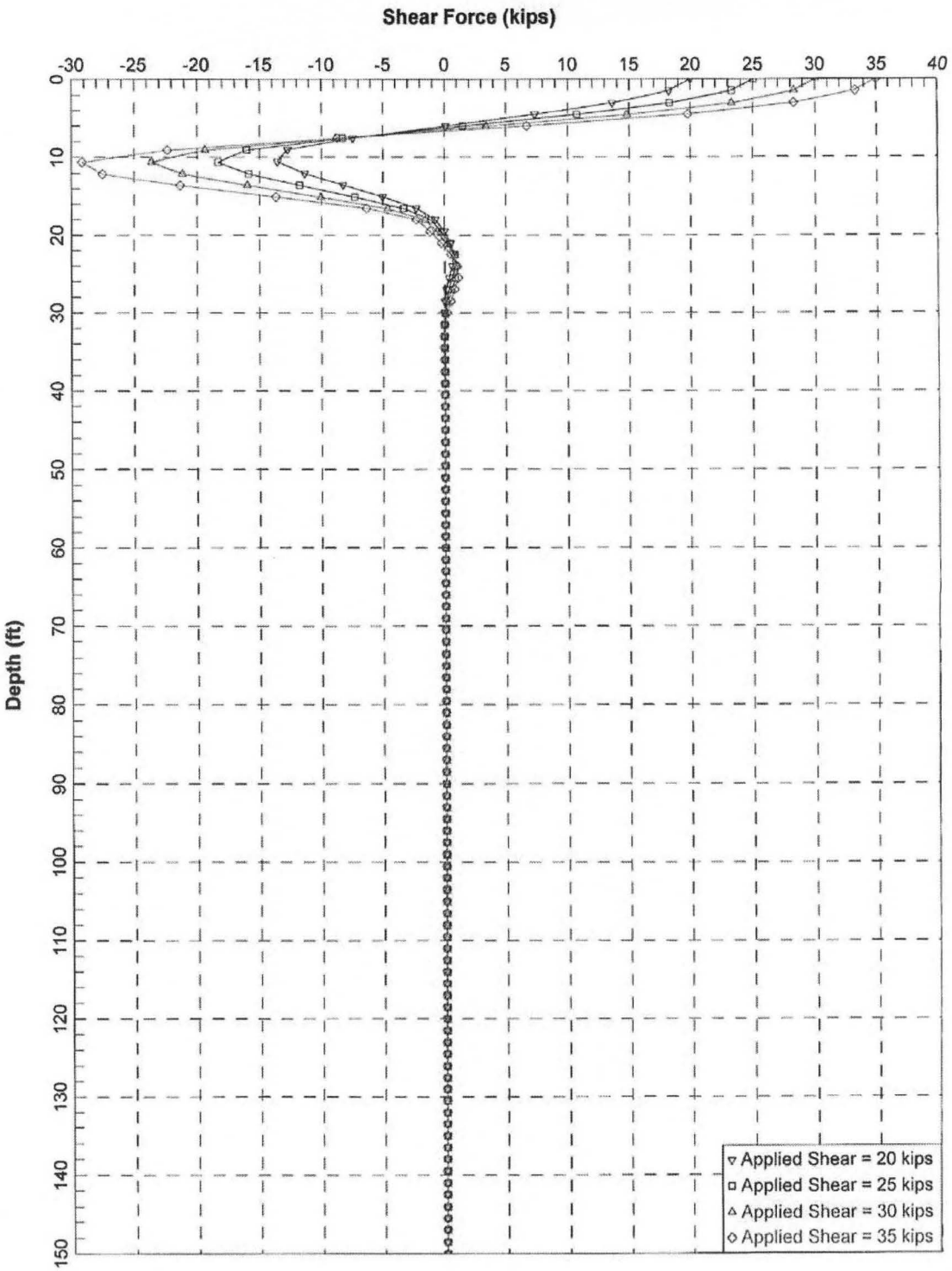
Figure D-11

OFFICE:TACO PM:EWH P:\17\1744200300\CAD\1744200300_D1-D12.dwg\TAB:Fig. D-11 modified by prpendleton on Jan 15, 2009 - 12:00



12inch Pipe Pile-Concrete Filled-Free to Rotate

Not to Scale

Case 4 -Shear Force

Westway Grays Harbor
Port of Grays Harbor, Washington

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Figure D-12

OFFICE:TACO PM EWH P:\17\1744200300\00\CAD\1744200300_D1-D12.dwg\TAB:Fig. D-12 modified by prpendleton on Jan 15, 2009 - 12:02

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Appendix E

Report Limitations and Guidelines for Use

APPENDIX E
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES, PERSONS AND PROJECTS

This report has been prepared for the exclusive use of Westway Terminals, Inc., and their authorized agents including Harris Group, Inc. This report is not intended for use by others, and the information contained herein is not applicable to any area outside the described project area.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A GEOTECHNICAL ENGINEERING OR GEOLOGIC REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

This report has been prepared for the proposed Westway Grays Harbor proposed storage tanks located at the Port of Grays Harbor, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it 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.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Topsoil

For the purposes of this report, we consider topsoil to consist of generally fine-grained soil with an appreciable amount of organic matter based on visual examination, and to be unsuitable for direct support of the proposed improvements. However, the organic content and other mineralogical and gradational characteristics used to evaluate the suitability of soil for use in landscaping and agricultural purposes was not determined, nor considered in our analyses. Therefore, the information and recommendations in this report, and our logs and descriptions should not be used as a basis for estimating the volume of topsoil available for such purposes.

Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists 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 or geologic 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.

Give Contractors a Complete Report and Guidance

Some owners and design professionals 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 or geologic report, but preface it with a clearly written letter of transmittal. In that 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 GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

Contractors are Responsible for Site Safety on their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

GEOTECHNICAL, GEOLOGIC AND ENVIRONMENTAL REPORTS SHOULD NOT BE INTERCHANGED

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.

BIOLOGICAL POLLUTANTS

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention, or assessment of the presence of Biological Pollutants in or around any structure. Accordingly, this report includes no interpretations, recommendations, findings, or conclusions for the purpose of detecting, preventing, assessing, or abating Biological Pollutants. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

REPORT
GEOTECHNICAL ENGINEERING SERVICES
WESTWAY GRAYS HARBOR
PROPOSED STORAGE TANKS
PORT OF GRAYS HARBOR, WASHINGTON

JANUARY 22, 2009

FOR
WESTWAY TERMINALS, INC.

GEOENGINEERS

File No. 17442-003-00

Geotechnical Engineering Services
File No. 17442-003-00

January 22, 2009

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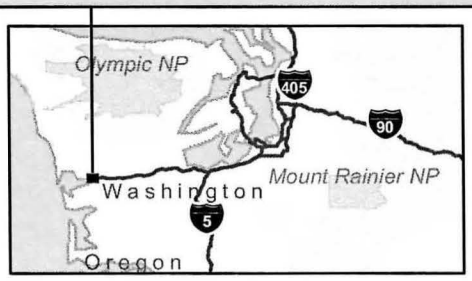

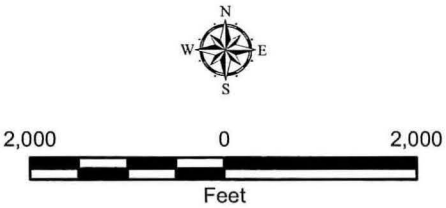

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
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Data Sources: ESRI Data & Maps, Street Maps 2005
Transverse Mercator, Zone 10 N North, North American Datum 1983
North arrow oriented to grid north

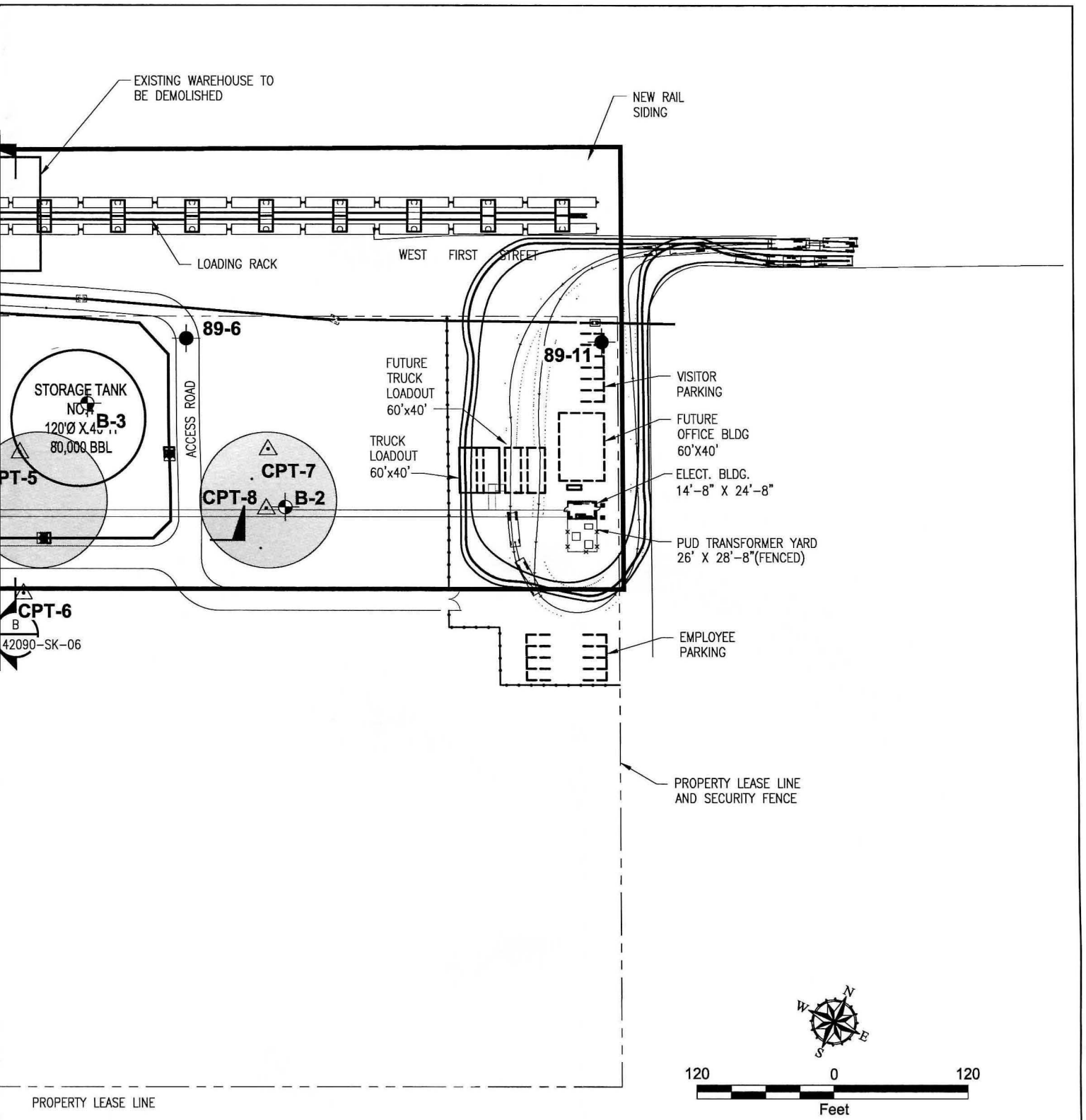
Vicinity Map

Westway Grays Harbor
Port of Grays Harbor, Washington

GEOENGINEERS

Figure 1

Office: TACO Path: P:\17\1744200300\GIS\17442003 Figure1 .mxd PRP Map Revised: December 29, 2008



, 2009

t by GeoEngineers, 2009

, 1989

Proposed tank locations

Previous proposed tank locations

Project Area Boundary

Site Boundary

Site Plan

Westway Grays Harbor
Port of Grays Harbor, Washington

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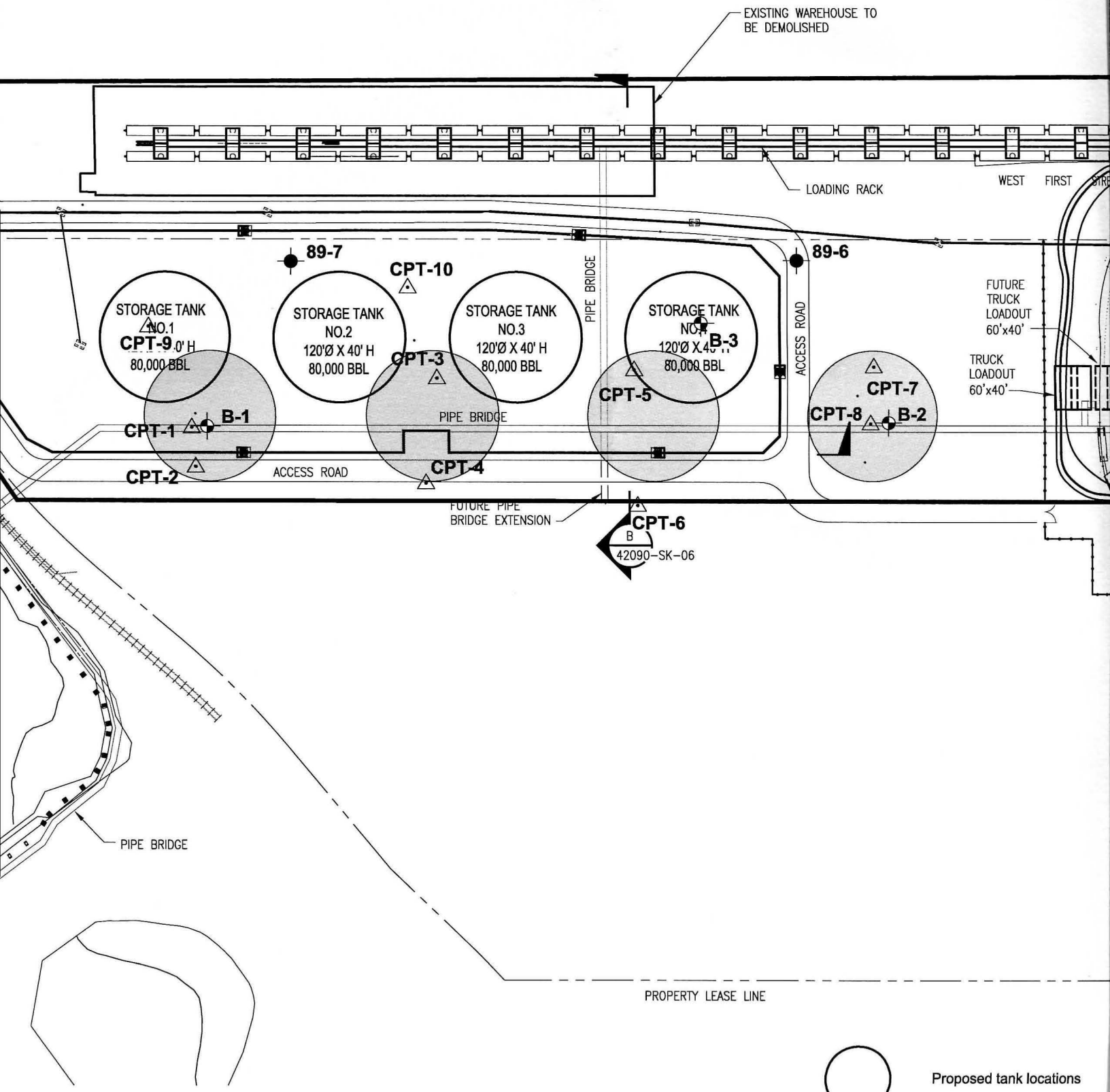
Figure 2



LEGEND:

B-1 Approximate location of boring by GeoEngineers, 2009

CPT-1 Approximate location of Cone Penetrometer Test by GeoEngineers, 2009

89-6 Approximate location of boring by GeoEngineers, 1989

Proposed tank locations

Previous proposed tank locat

Project Area Boundary

Site Boundary

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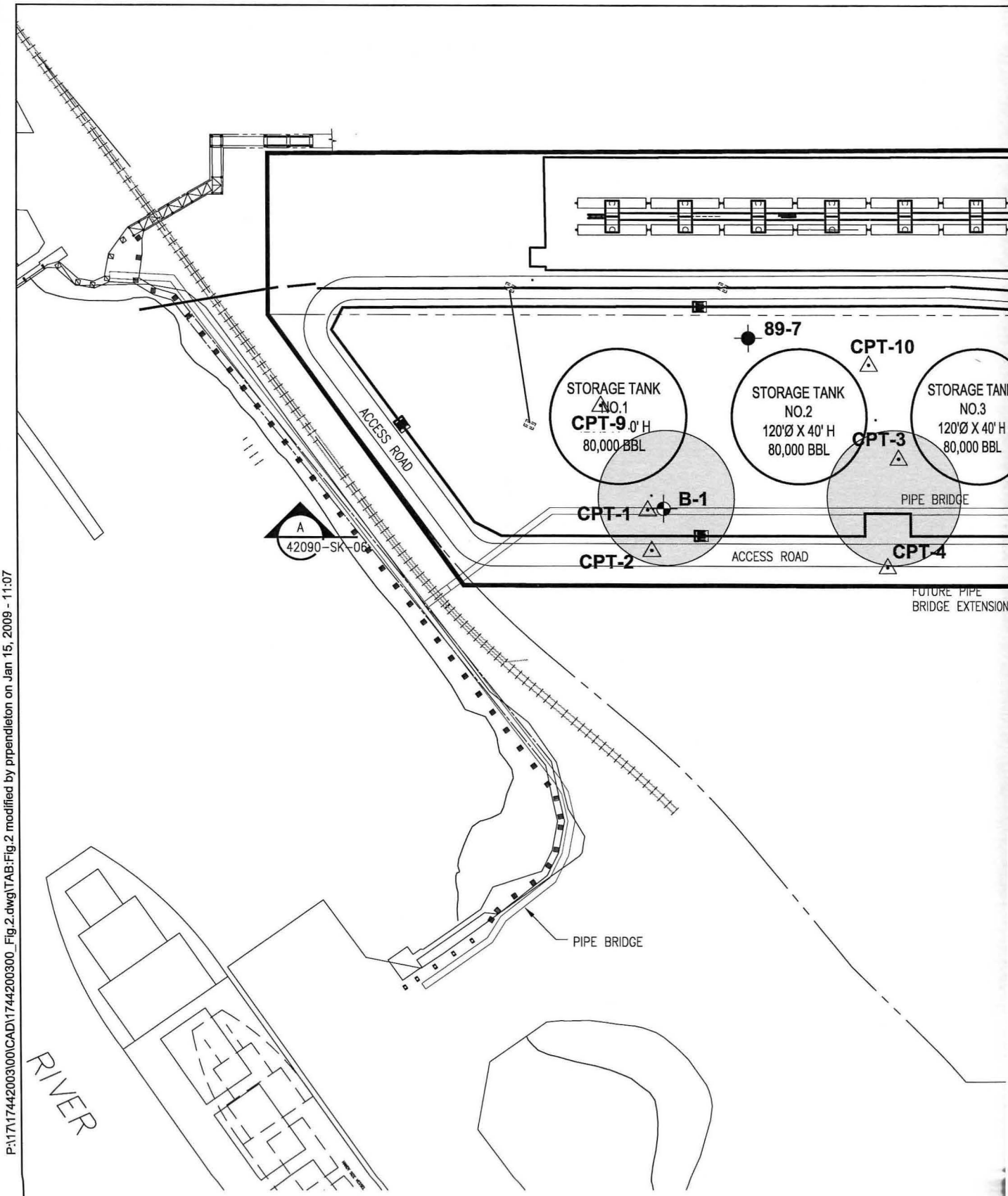

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1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The *master file is stored by GeoEngineers, Inc. and will serve as the official* record of this communication.
Reference: Drawing provided by Harris Group Inc.

LEGEND:

B-1 Approximate location of boring by Geo

CPT-1 Approximate location of Cone Penetro

89-6 Approximate location of boring by Geo

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