FILE

Washington State Department of Transportation

MEMORANDUM

3/18/03

TONY M. ALLEN
STATE OF WASHINGTON
25339
REGISTERED PROFESSIONAL ENGINEER

EXPIRES 07-01-03

March 18, 2003

TO: Mark Russell
Northwest Region NB82-55

FROM: Tony Allen/William Hegge
EEP Geotechnical Branch, 47365

SUBJECT: SR 543, OL-3500
Geotechnical Report Addendum No. 1
SR 5 to International Boundary Modifications

INTRODUCTION

Our office prepared a geotechnical report entitled "Geotechnical Report, SR 543, SR5 to International Boundary Modifications" dated August 8, 2002. The location of the project site is shown on the Vicinity Map (Figure 1 in Appendix A). The report contained geotechnical recommendations for various structures along the proposed project, including retaining walls, signal standards, and a new bridge at D Street. Specifically, ten new retaining walls are planned as part of the project to support the soils on each side of the alignment throughout the depressed roadway section, and to support the soils forming the new off-ramp structures rising to the elevation of the two bridges over SR 543 at the original grade of the intersection with D Street. These retaining walls, designated Retaining Walls 1 through 10, are shown on the Wall Layout (Figure 2 in Appendix A) and on the Site and Exploration Plans (Figures 3A through 3C in Appendix A).

Larry Scholten of the Bellingham Project Office informed us that the project scope has changed since August 2002. Based upon these conversations, we understand that it is desirable from a cost standpoint to replace proposed Retaining Walls No. 10, No. 9 and most of Retaining Wall No. 8 with cut slopes. In addition, the truck parking area adjacent to these retaining walls will be regraded. Currently, the truck parking area is sloped to grade to the west. In the new design the truck parking lot will be sloped to grade to the east, by lowering the existing grade approximately 1.6 meters (5 feet) along the toe of the proposed slope that would replace the northern half of Retaining Wall No. 9.

Due to the complexity of the proposed alignment, ten separate centerlines were used for the project. The centerline used for the truck lanes (adjacent to the toe of the proposed slope that will replace the proposed retaining walls) was designated the T Line.

SITE EXPLORATIONS

No additional explorations were performed at the site as part of this new evaluation. Instead, borings from our August 2002 report were used in the analyses. Four borings were drilled in the vicinity of the slopes proposed to replace proposed Retaining Walls No. 10, No. 9 and most of Retaining Wall No. 8. These borings are designated TH-1-99, TH-10-99, TH-7-01 and TH-9-01. Two of these borings were drilled in 1999 and two were drilled in 2001 at the approximate locations shown on Figures 3A through 3C in Appendix A. Soil samples were obtained during drilling using a SPT (Standard Penetration Test) sampler. The number of blows required to achieve the final 12 inches of penetration was recorded as the soil's SPT resistance, or N-value to assist in determining soil strength properties. Boring logs are included in Appendix B.

At the time of our previous explorations, collected soil samples were returned to our laboratory for further testing and evaluation. The laboratory tests performed at that time included moisture content determinations, grain size analyses and plasticity characteristics (Atterberg Limits). These laboratory test results are presented in Appendix C.

SUBSURFACE CONDITIONS

Geology

The site is located within an area that has been occupied by glaciers several times in the last million years. The glaciers carved relatively deep north-south trending channels within the Puget Sound Basin that have been infilled with glacial outwash materials and subsequently eroded and/or infilled by alluvial/fluvial deposits.

The geologic map for the area (USGS map entitled "Western Whatcom County" by Don J. Easterbrook, 1976) shows that the surficial soils in the site vicinity are mapped as Outwash Sand and Gravel of the Sumas Stade. Underlying the outwash material is a geological unit known as Bellingham Glaciomarine Drift (GMD).

Soil Conditions

Based on our test borings, the portion of the site where cut slopes will be used to replace proposed Retaining Walls No. 10, No. 9 and most of Retaining Wall No. 8 appears to be mantled by Outwash Sand and Gravel overlying Bellingham Glaciomarine Drift (GMD), consistent with the geologic map. For the purposes of this report, the soils are grouped into five units. These units vary in thickness and all units are not present everywhere on the project site. These soil units are shown on the subsurface profiles presented in Figures 4A, 4B, 5A and 5B in Appendix A.

Groundwater

Groundwater was observed in each of the test holes except TH-7-01 that were made in the portion of the site where cut slopes will be used to replace proposed Retaining Walls No. 10, No. 9 and most of Retaining Wall No. 8. The data show that there is a perched groundwater level in the near surface sands and gravels that is not connected to the groundwater level in the underlying silts and clays. This was clearly demonstrated in the nested piezometers installed in TH-12-99 on another portion of the site. The near surface piezometer measured a groundwater elevation that was consistently between 6.6 to 7.0 meters (21.8 to 23.1 feet) above the groundwater elevation in the piezometer installed in the deeper clays. Therefore our opinion is that it is not conservative to use the lower groundwater levels observed in some of the borings for design. After a review of the groundwater data, a groundwater depth of 1.5 meters (5 feet) below the surface was selected for the design of the project. The complete groundwater level data is shown on Table B-2 in Appendix B.

GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

Cut Slopes

Using soil strength parameters developed during the previous site investigations, we assessed the stability of the proposed cut slopes in the portion of the project where they will replace proposed Retaining Walls No. 10, No. 9 and most of Retaining Wall No. 8 under static conditions. In accordance with WSDOT policy for slopes that do not support a structure, we did not include the effects of seismic forces or potential soil liquefaction in the analyses.

To accomplish this, analytical models of slope stability were created using the computer program XSTABL Version 5.2, with various cut slope angles. XSTABL analyses of the existing slopes for static conditions using these strength values were performed. Our analyses indicated cut slopes of 3H:1V (Horizontal:Vertical) do not have an adequate factor of safety against slope failure. However, further analyses indicated that proposed cut slopes of 4H:1V do have an adequate factor of safety against slope failure. Based upon these analyses, we recommend cut slopes no steeper than 4H:1V.

Retaining Walls

The proposed site grading will leave a portion of Retaining Wall No. 8 in place with a 4H:1V cut slope behind it. The presence of deep soft soils at this location limits the proposed wall type to a tangent pile wall, consisting of rows of adjacent drilled-in-place concrete shafts as described in our August 2002 report.

Lateral earth pressure diagrams to be used in the design of the tangent pile and soldier pile walls are presented in Appendix D. Lateral support is presented in accordance with the design methodology presented in the *Bridge Design Manual*. For this situation, we have assumed that the tangent pile wall will be allowed to deform up to 1 percent of its unsupported height. By allowing this wall to deflect, it may be designed to resist active earth

pressures. These active lateral earth pressures should be taken to act across two pile diameters both above and below the base of the excavation for the tangent pile wall.

As shown on the lateral earth pressure diagram, we recommend disregarding passive resistance contribution from soils less than 1.2 meters (4 feet) below the base of the excavation. The purpose of this is to account for future utility trenching in front of the walls. For the tangent pile wall the resistance contribution from lean concrete piles should not be used in the design and passive resistance should be taken to act over two tangent pile diameters (structural concrete piles only). A factor of safety of 1.5 should be applied to the passive earth pressure.

The lateral capacities of the tangent piles should be computed using the LPILE computer program and the P-Y curve input parameters presented in Appendix E.

CONSTRUCTION CONSIDERATIONS

The proposed excavations for the roadway and cut slopes in this portion of the project are expected to extend down into the soft to very soft soils observed in the borings. These soils are wet and difficult to excavate. Significant excavation and equipment mobility issues will be encountered during earthwork operations. Soft wet subgrade conditions may prevent the use of wheeled equipment as well as tracked equipment with standard tracks. Low ground pressure equipment may be necessary to move and work on the exposed subgrade. Groundwater flow from sandy zones in the excavations may be initially heavy. However, experience has shown that these sandy zones are generally isolated from each other so the initial groundwater flow generally decreases rapidly as the sandy zone drains. Long term flows from these sandy zones are expected to be small. Much of the exposed subgrade will be located below the existing groundwater table and the subgrade materials are expected to be highly moisture sensitive. To minimize the potential for subgrade disturbance and constructability problems, we recommend the final cut slope excavation and subgrade preparation be conducted during the drier summer months.

On site soils encountered during excavating are anticipated to have very high moisture contents and will be difficult to reuse without sufficient reconditioning/aeration. Consequently, we recommend against using on site soils as structural embankment fill or wall backfill. On site soils should be disposed of off-site or used only in non-settlement sensitive areas, such as for landscaping.

Drilled shafts at the project site will require the use of temporary casing at all of the drilled shaft locations because of the presence of very soft to soft/loose silts, clays and sands that are susceptible to severe caving and displacement. We suggest that temporary casing extend at least 3 meters (9.8 feet) into the dense sand layer (unit 4) underlying the soft/loose silts, clays and sands observed in the subsurface explorations. The minimum depth of temporary casing below the proposed roadway along the project alignment is shown in Table 2 below:

Table 2 - Minimum Depth of Temporary Casing Below the Proposed Roadway

Retaining Wall	Starting Station (m)	Ending Station (m)	Minimum Depth of Temporary Casing Below the Proposed Roadway m (ft)	Reference Boring
8	1+723 (L Line)	1+785 (LR Line)	14.0 (46.0)	TH-1-99
8	1+785 (LR Line)	1+831 (T Line	121.3 (70.1)	TH-10-99

Because of the potential for seepage, soil disturbance, bottom heave, and caving, all shaft excavations will need to be constructed using slurry, even those shafts with full depth temporary casing. Water slurry may be used for those shafts with full depth temporary casing. Mineral or polymer slurries should be used for those shaft excavations that extend below the temporary casings. Caving is possible even in the dense to very dense soils (units 4 and 5) underlying the soft silts and clays. Therefore, the contractor may need to take steps to prevent caving in the dense to very dense soils (units 4 and 5).

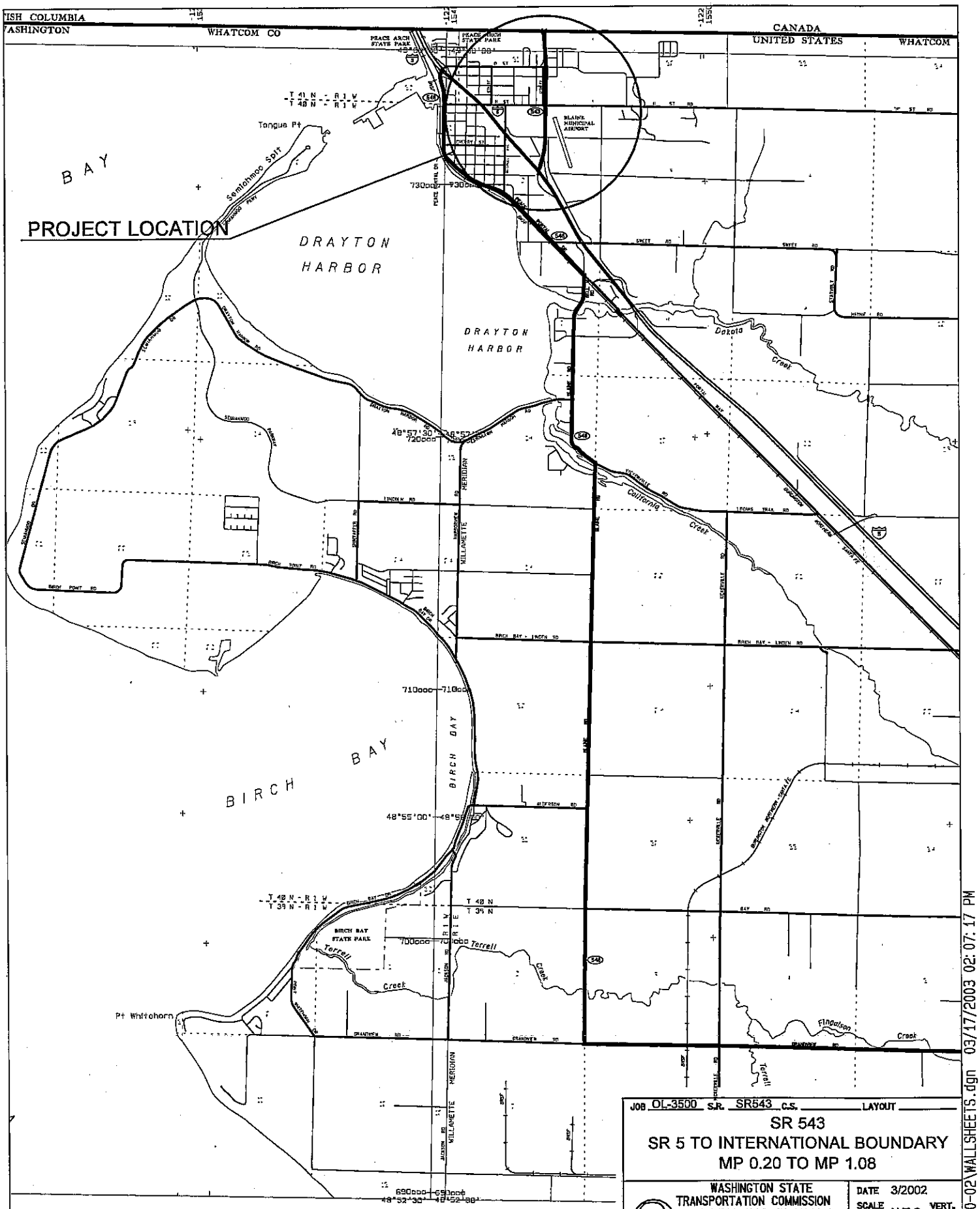
The stability of temporary excavations is the responsibility of the contractor. We do not anticipate shoring will be necessary at this site because of the location of the proposed bridge and retaining walls in relation to the existing structures.

While cobbles and boulders were not encountered in the borings, based on the geologic nature of the soil units, cobbles and boulders may still be encountered in all soil units at this site.

If you have questions or require further information, please contact William Hegge at (360) 709-5415.

TMA:wh

APPENDIX A - FIGURES



JOB OL-3500 S.R. SR543 C.S. _____ LAYOUT _____

SR 543
SR 5 TO INTERNATIONAL BOUNDARY
MP 0.20 TO MP 1.08

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2002
SCALE N.T.S. VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY W.M.

FIGURE 1: VICINITY MAP

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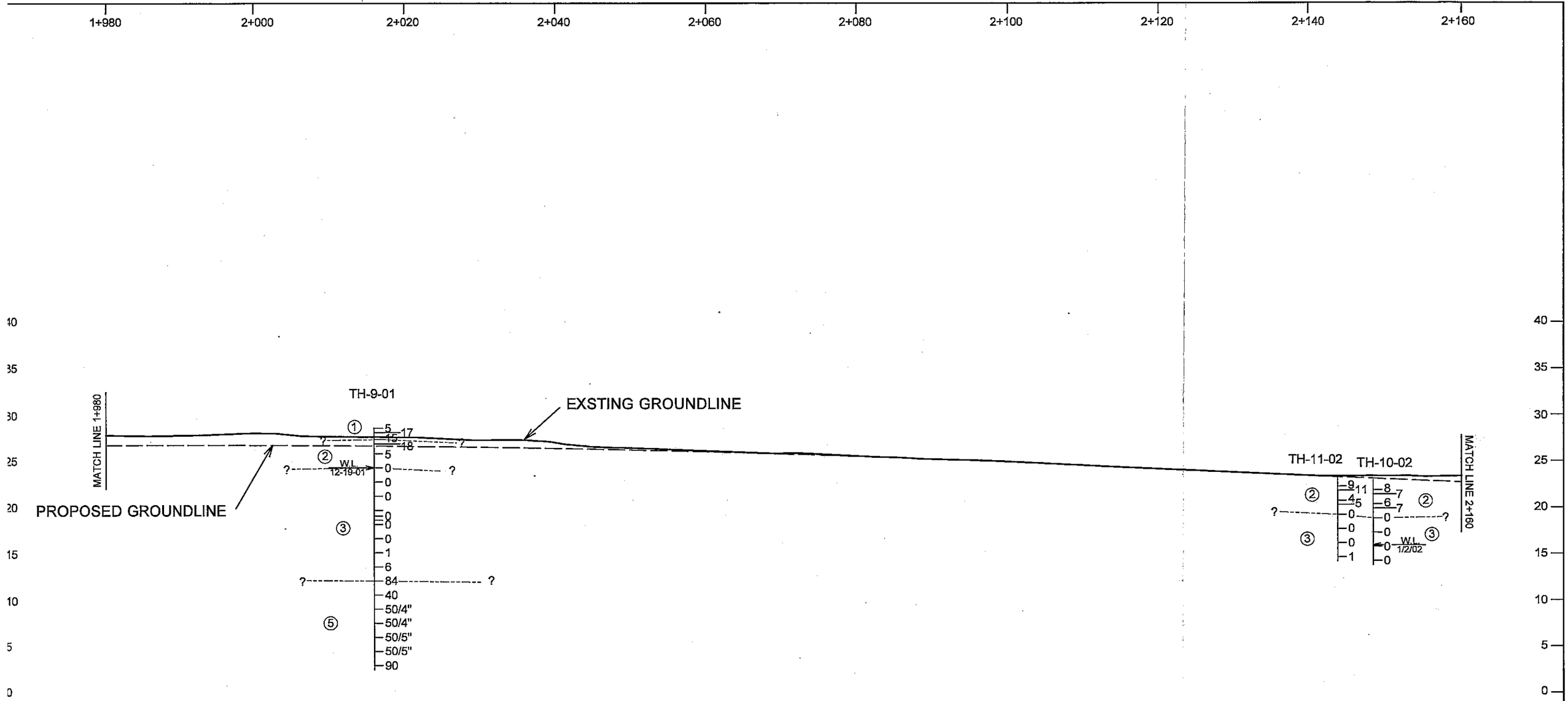

SOIL UNITS

① Moist, medium dense to very dense silty sand and gravel.
② Wet, medium stiff to very stiff clay and/or medium dense silt with varying amounts of sand.
③ Wet, very soft to soft clay and/or loose silt with varying amounts of sand and layers of loose sand.
⑤ Wet, very dense sand with gravel and varying amounts of silt and clay and layers of hard sandy silt.

TEST HOLE LEGEND

H-I-98 TEST HOLE NUMBER
0+265 TEST HOLE STATION
3.5 m Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)
UNDISTURBED SAMPLE
W.L. 8-6-86 WATER LEVEL & DATE
? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS
INDICATES INTACT ROCK
86% INDICATES CORE SAMPLE TAKEN
ROCK QUALITY DESIGNATION

FIGURE 5B: PROFILE-T LINE

JOB OL-3500 S.R. 543 C.S.

SR 543
SR 5 TO INTERNATIONAL BOUNDARY
MP 0.20 TO MP 1.08

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2002
SCALE 1=400 VERT.
1=500 HORIZ.
SHEET ___ OF ___
DRAWN BY W.M.

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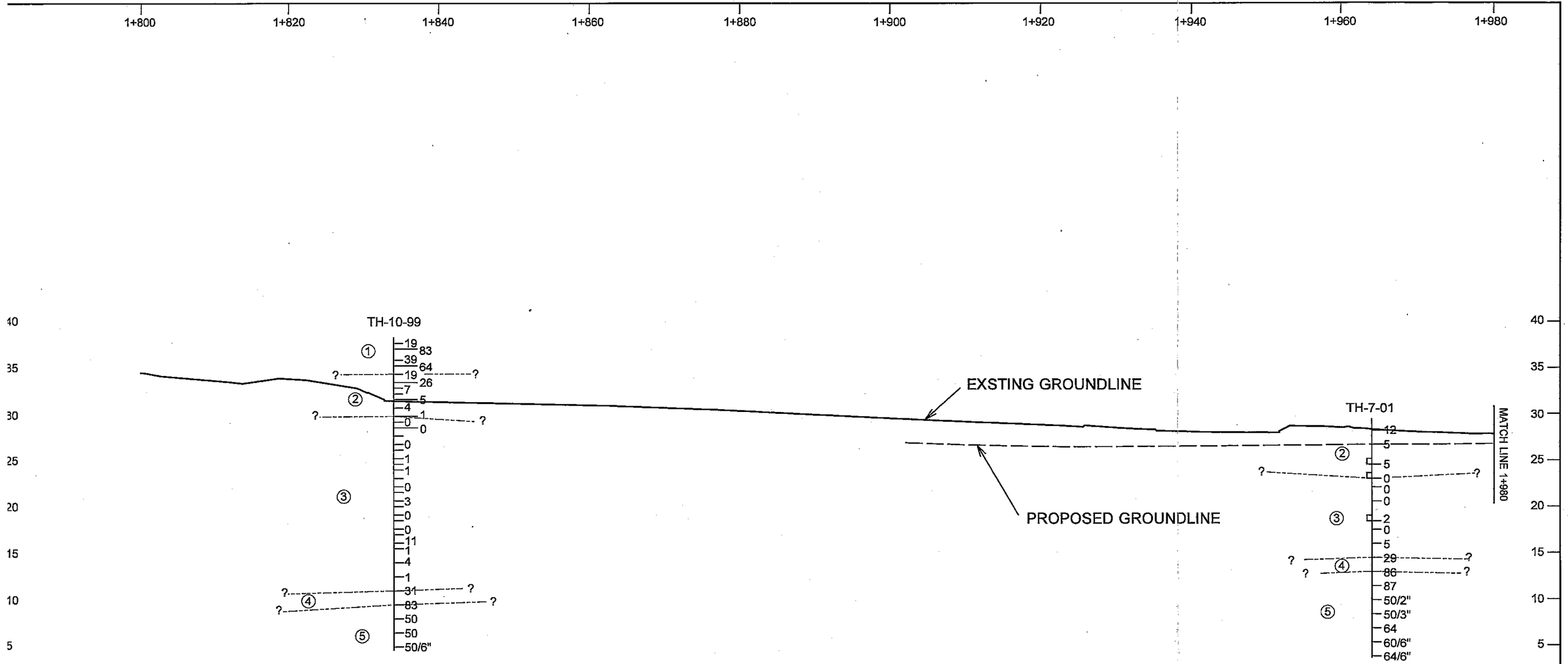

TEST HOLE LEGEND

H-1-98 TEST HOLE NUMBER
0+265 TEST HOLE STATION
3.5 m Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)
UNDISTURBED SAMPLE
W.L. 8-6-86 WATER LEVEL & DATE
? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS
INDICATES INTACT ROCK
86% INDICATES CORE SAMPLE TAKEN
ROCK QUALITY DESIGNATION

SOIL UNITS

1. Moist, medium dense to very dense silty sand and gravel.
2. Wet, medium stiff to very stiff clay and/or medium dense silt with varying amounts of sand.
3. Wet, very soft to soft clay and/or loose silt with varying amounts of sand and layers of loose sand.
4. Wet, loose to dense sand with varying amounts of silt and clay and layers of medium stiff to hard sandy silt.
5. Wet, very dense sand with gravel and varying amounts of silt and clay and layers of hard sandy silt.

FIGURE 5A: PROFILE-T LINE

JOB OL-3500 S.R. 543 C.S.

SR 543

SR 5 TO INTERNATIONAL BOUNDARY

MP 0.20 TO MP 1.08

WASHINGTON STATE TRANSPORTATION COMMISSION
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MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2002
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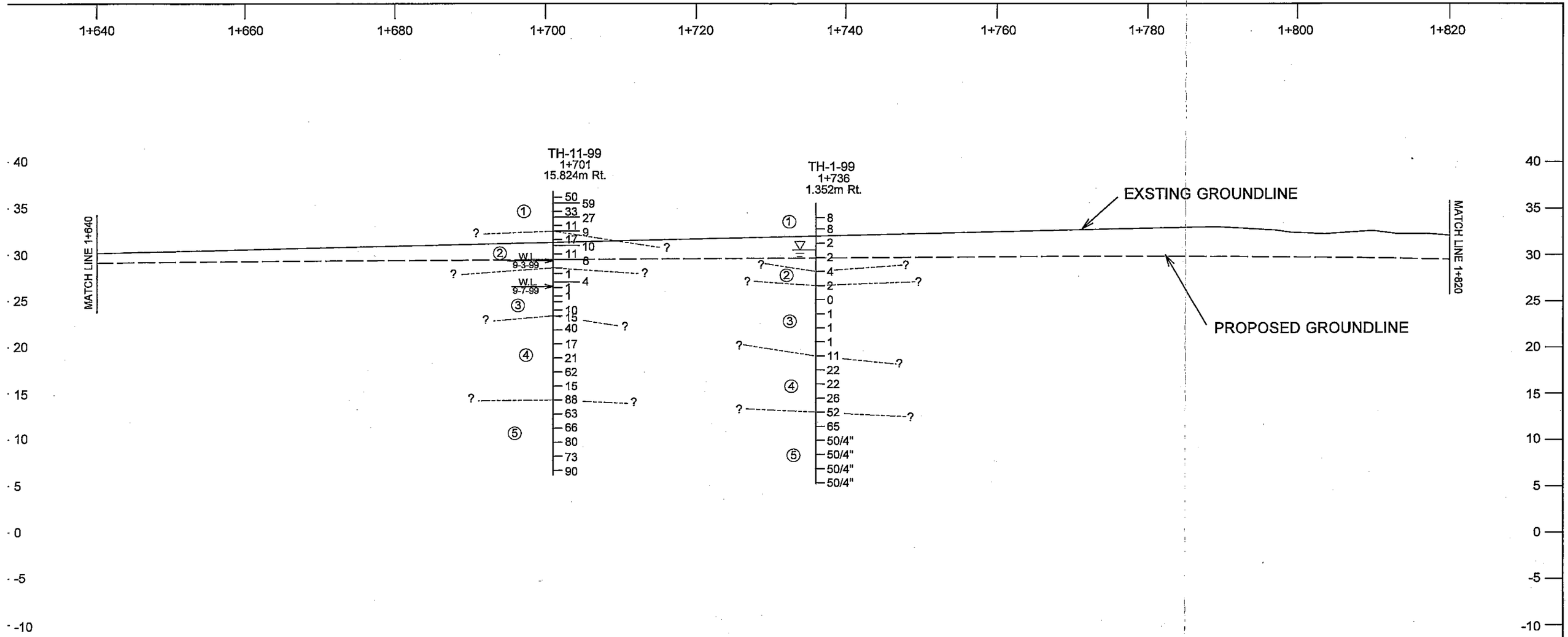

TEST HOLE LEGEND

H-1-98 TEST HOLE NUMBER
0+265 TEST HOLE STATION
3.5 m Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)

UNDISTURBED SAMPLE

W.L. 8-6-86 WATER LEVEL & DATE

? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS

INDICATES INTACT ROCK

86% INDICATES CORE SAMPLE TAKEN

ROCK QUALITY DESIGNATION

SOIL UNITS

1. Moist, medium dense to very dense silty sand and gravel.
2. Wet, medium stiff to very stiff clay and/or medium dense silt with varying amounts of sand.
3. Wet, very soft to soft clay and/or loose silt with varying amounts of sand and layers of loose sand.
4. Wet, loose to dense sand with varying amounts of silt and clay and layers of medium stiff to hard sandy silt.
5. Wet, very dense sand with gravel and varying amounts of silt and clay and layers of hard sandy silt.

FIGURE 4A: PROFILE-LR LINE

JOB OL-3500 S.R. 543 C.S. _____

SR 543

SR 5 TO INTERNATIONAL BOUNDARY

MP 0.20 TO MP 1.08

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION

MATERIALS BRANCH

T. E. BAKER MATERIALS ENGINEER

DATE 3/2002
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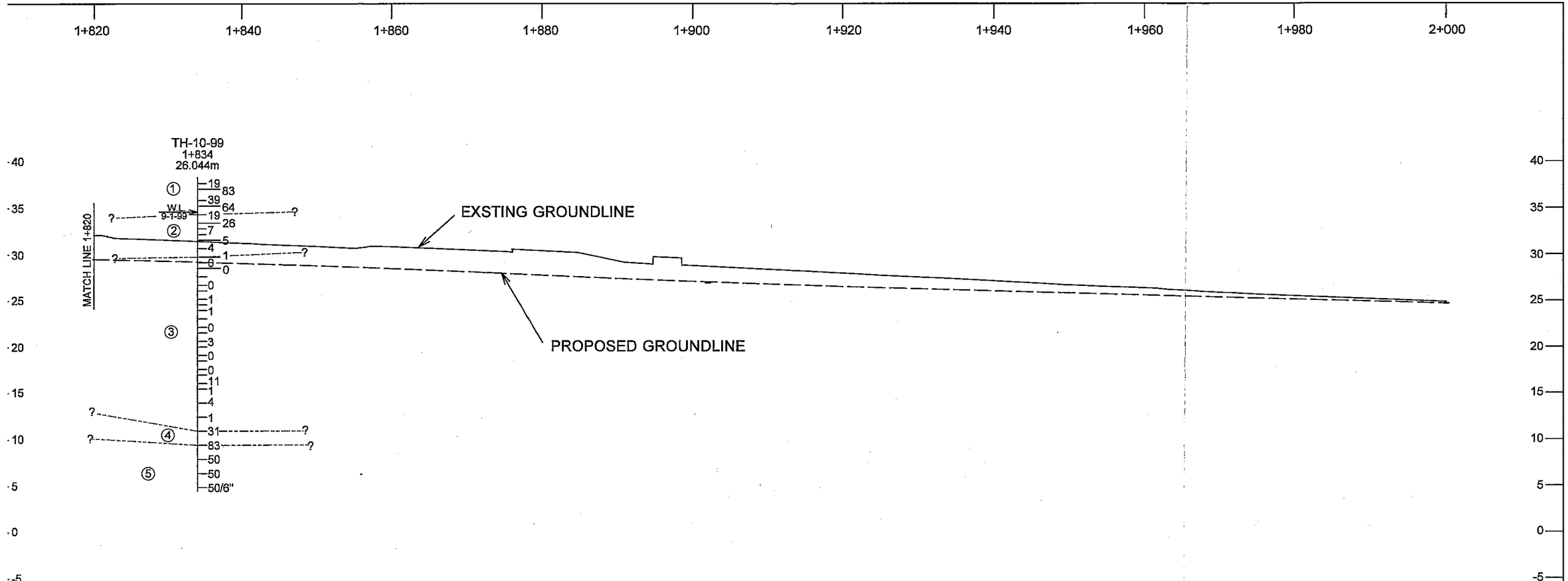

TEST HOLE LEGEND

H-I-98 TEST HOLE NUMBER
0+265 TEST HOLE STATION
3.5 m Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)

UNDISTURBED SAMPLE

W.L. 8-6-86 WATER LEVEL & DATE

? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS

INDICATES INTACT ROCK

86% INDICATES CORE SAMPLE TAKEN

ROCK QUALITY DESIGNATION

SOIL UNITS

1. Moist, medium dense to very dense silty sand and gravel.
2. Wet, medium stiff to very stiff clay and/or medium dense silt with varying amounts of sand.
3. Wet, very soft to soft clay and/or loose silt with varying amounts of sand and layers of loose sand.
4. Wet, loose to dense sand with varying amounts of silt and clay and layers of medium stiff to hard sandy silt.
5. Wet, very dense sand with gravel and varying amounts of silt and clay and layers of hard sandy silt.

FIGURE 4B: PROFILE-LR LINE

JOB OL-3500 S.R. 543 C.S. _____

SR 543

SR 5 TO INTERNATIONAL BOUNDARY

MP 0.20 TO MP 1.08

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2002
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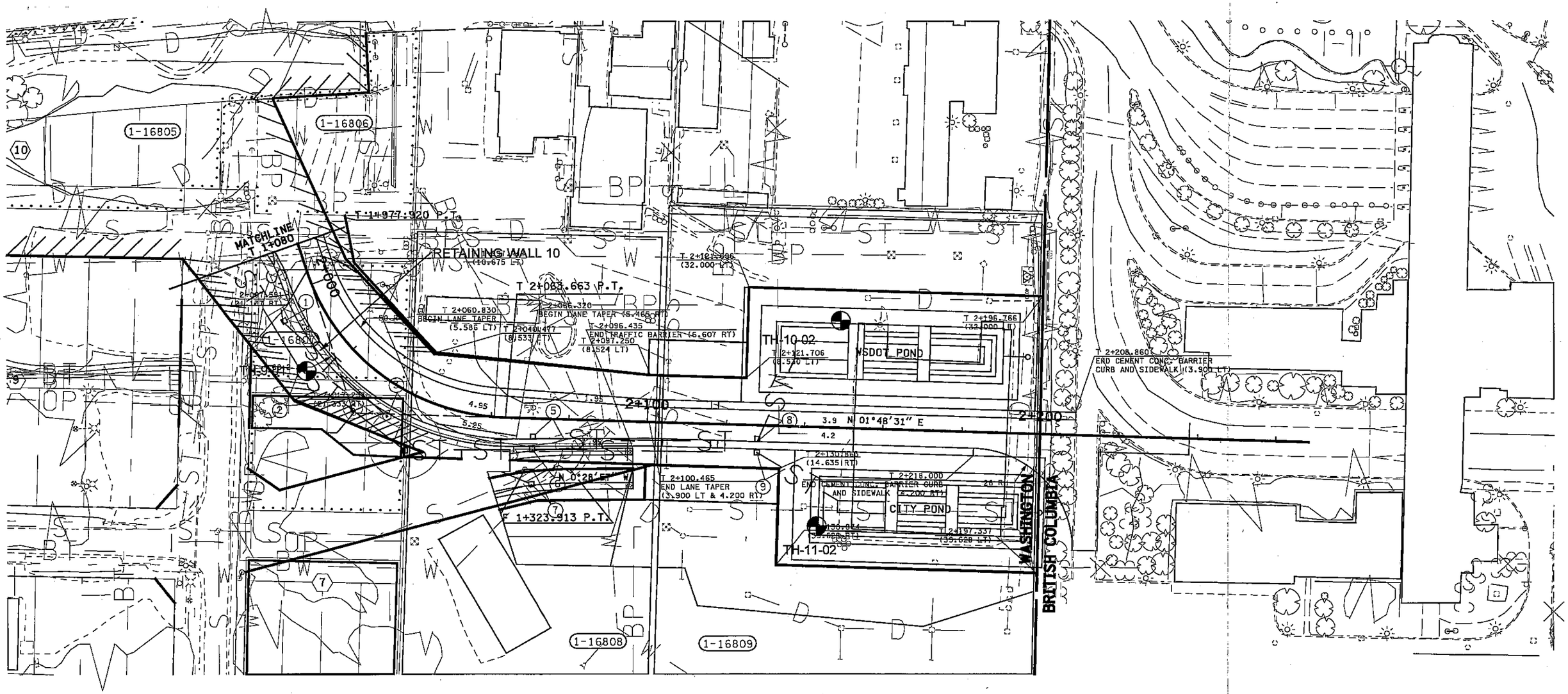

TH-1-01 TEST HOLE DESIGNATION AND APPROXIMATE LOCATION

RETAINING WALL

FIGURE 3C: SITE AND EXPLORATION PLAN

JOB 01-3500 S.R. SR 543 C.S. _____

SR 543

SR 5 TO INTERNATIONAL BOUNDARY

MP 0.20 TO MP 1.08

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION

MATERIALS BRANCH

T. E. BAKER MATERIALS ENGINEER

DATE 3/2002

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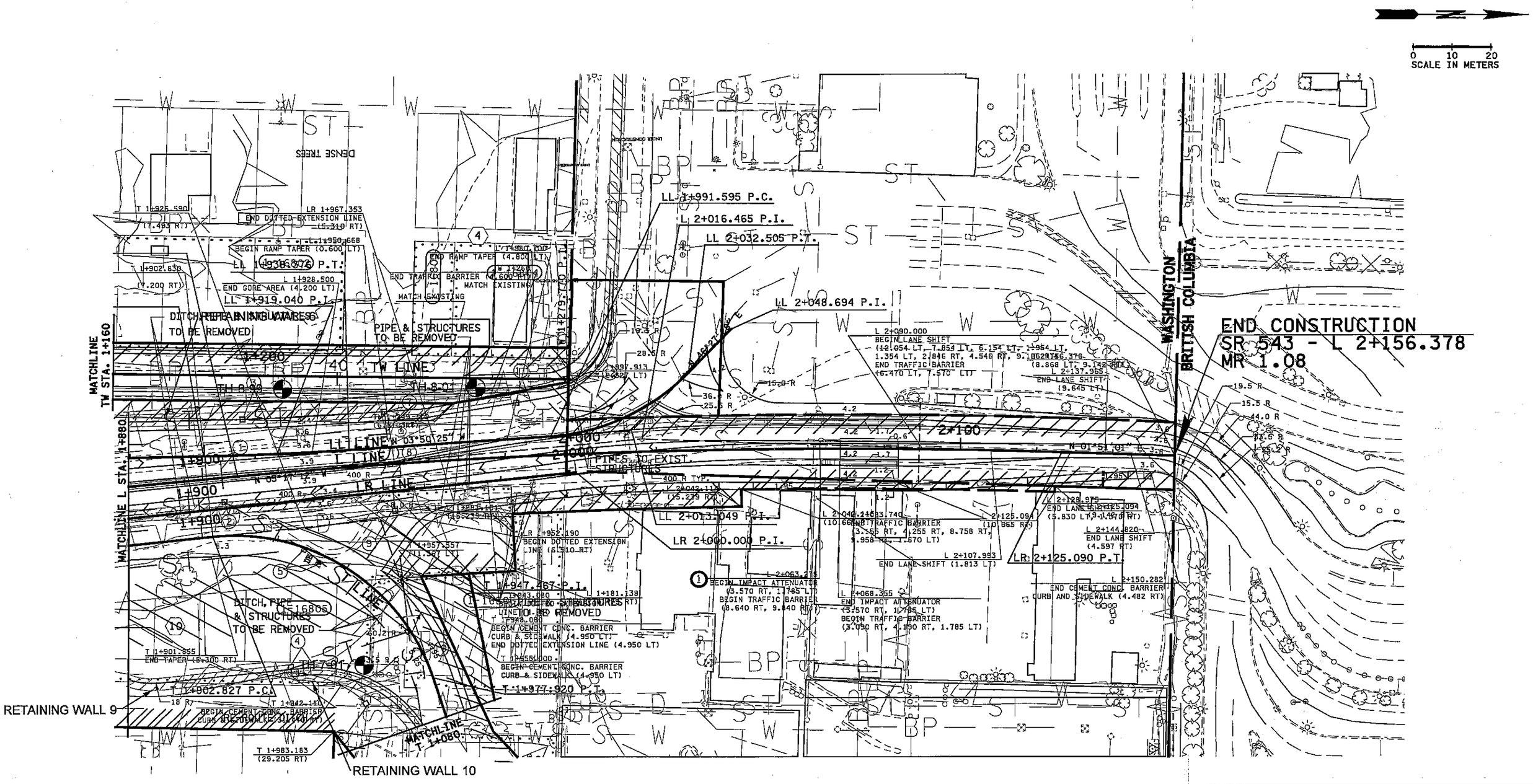

TH-1-01 TEST HOLE DESIGNATION AND APPROXIMATE LOCATION

RETAINING WALL

FIGURE 3B: SITE AND EXPLORATION PLAN

JOB OL-3500 S.R. SR 543 C.S. _____

SR 543

SR 5 TO INTERNATIONAL BOUNDARY

MP 0.20 TO MP 1.08

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MATERIALS BRANCH

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DATE 3/2002

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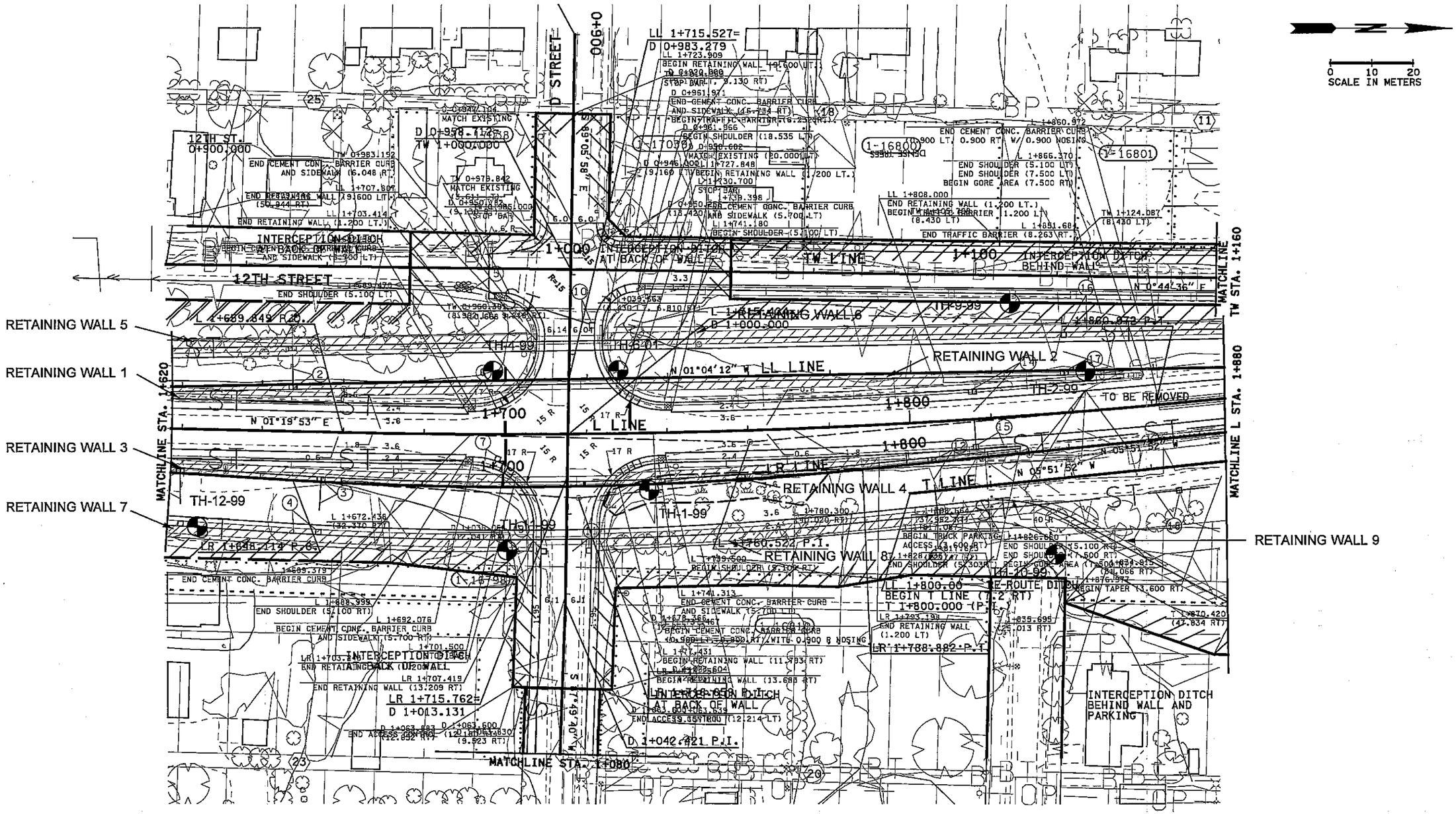

TH-1-01 TEST HOLE DESIGNATION AND APPROXIMATE LOCATION

RETAINING WALL

FIGURE 3A: SITE AND EXPLORATION PLAN

JOB OL-3500 S.R. SR 543 C.S.

SR 543

SR 5 TO INTERNATIONAL BOUNDARY

MP 0.20 TO MP 1.08

WASHINGTON STATE TRANSPORTATION COMMISSION
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DATE 3/2002
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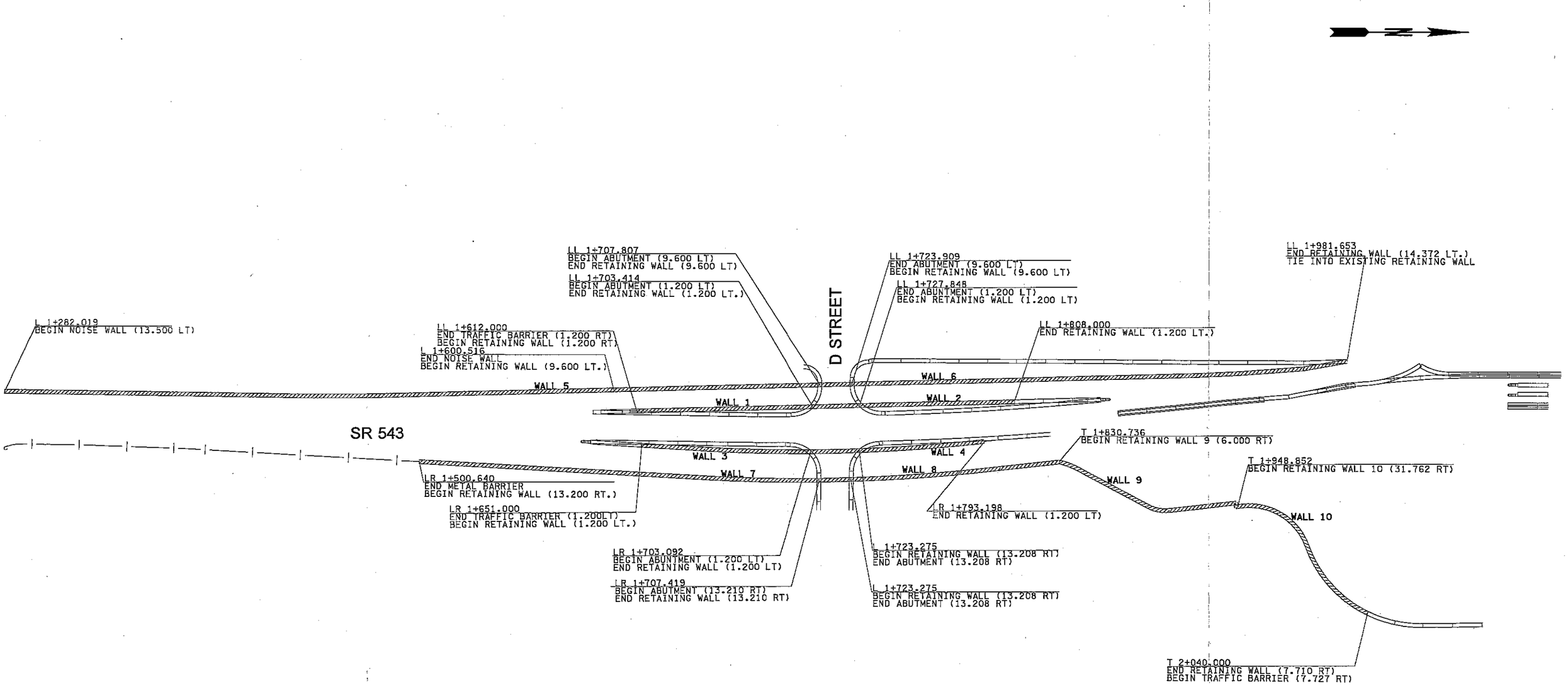

FIGURE 2: WALL LAYOUT

JOB OL-3500 S.R. SR543 C.S. _____

SR 543
SR 5 TO INTERNATIONAL BOUNDARY
MP 0.20 TO MP 1.08

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION

MATERIALS BRANCH

T. E. BAKER MATERIALS ENGINEER

DATE 3/2002
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APPENDIX B - FIELD EXPLORATIONS

FIELD EXPLORATIONS

The field exploration program for this portion of the project the project consisted of 4 exploratory borings. The first phase of the site explorations (consisting of borings TH-1-99 and TH-10-99) was conducted between February 26, 1999 and September 9, 1999. The second phase of the site explorations (consisting of TH-7-01 and TH-9-01) was conducted between November 6, 2001 and January 2, 2002. The approximate exploration locations are shown on the Site and Exploration Plans, Figures 3A through 3C in Appendix A. Logs of the test borings are attached. These logs should be included in the contract documents.

The borings in this portion of the project were completed using three types of drill rigs. Two of the borings were complete using a CME-850 track-mounted drill rig, one using a CME 45 skid-mounted drill rig, and one using a CME-55 truck-mounted drill rig. The borings were advanced to depths between 25.9 and 33.8 meters (85 and 111.0) feet below the ground surface using mud rotary drilling methods.

At each location, soil samples were obtained using a SPT (Standard Penetration Test) sampler, in general accordance with ASTM T 206-87. SPTs are obtained by driving a 50 mm (2-inch) outside diameter split-spoon sampler 450 mm (18-inches) into the soil with a 63-kg (140-pound) hammer. The number of blows required to achieve each 150 mm (6 inches) of penetration is recorded and the soil's SPT resistance, or N-value, is calculated as the number of blows required to achieve the final 300 mm (12 inches) of penetration. Each drill rig is equipped with an automatic trip hammer to drive the split-spoon sampler. The automatic hammers on these two rigs are rated at approximately 70 percent efficiency, as compared to approximately 60 percent for manual hammers.

In addition to the SPT sampler, thin walled Shelby tubes were used to obtain soil samples at selected depths in some of the borings in general accordance with ASTM T-207-96. The samples are pushed into the soil using the hydraulics of the drill rig. Because they are pushed and not driven, and are obtained using a thin walled sampler, they are relatively undisturbed and suitable for strength and consolidation testing.

Following completion of the drilling program, select soil samples were then submitted to the OSC Materials Laboratory for laboratory testing.

The in-situ characteristics of the soils in one of the borings in this portion of the project site (TH-10-99) was evaluated at selected depths using a vane shear test, in general accordance with ASTM T 223-96. This test consists of placing a four bladed vane in the undisturbed soil and rotating it from the surface to determine the torsional shear resistance required to cause a cylindrical surface to be sheared by the vane. This force is then converted to a unit shearing resistance of the cylindrical surface. The results of these tests are shown on the boring log in this appendix and on Table B1 below:

Table B1 – Vane Shear Tests

Boring No.	Sample No.	Soil Type	Soil Stiff.	Dept h (m)	Depth (ft)	Undist. Shear Strength (kPa)	Undist. Shear Strength (psf)
TH-10-99	VS-20	Fat CLAY with Sand	Very Soft	15.2	50	47.4	990
TH-10-99	VS-28	Lean CLAY with Sand	Very Soft	21.3	70	100.5	2100

The groundwater levels in the borings in this portion of the project were measured at various times following completion of the borings. A complete record of these measurements is shown in Table B2 below:

Table B2 - Groundwater Level Measurements

Bor. No.	Bor. Elev. (m)	Bor. Elev. (ft)	Date	Depth to Ground Water (m)	Depth to Ground Water (feet)	Ground Water Elev. (m)	Ground Water Elev. (feet)
TH-1-99	35.5	116.6	2/26/99	1.5*	5.0*	34.0*	111.6*
"	"	"	10/6/99	11.3	37.0	24.2	79.6
"	"	"	12/29/99	10.4	34.2	25.1	82.4
"	"	"	2/3/00	10.1	33.2	25.4	83.4
"	"	"	1/11/02	9.8	32.2	25.7	84.4
"	"	"	3/15/02	9.6	31.6	25.9	85.0
TH-10-99	38.3	125.7	9/1/99	3.7*	12.1*	34.6*	113.6*
"	"	"	9/9/99	6.6	21.5	31.8	104.2

Table B2 - Groundwater Level Measurements (Continued)

Bor. No.	Bor. Elev. (m)	Bor. Elev. (ft)	Date	Depth to Ground Water (m)	Depth to Ground Water (feet)	Ground Water Elev. (m)	Ground Water Elev. (feet)
TH-10-99	38.3	125.7	10/6/99	7.9	25.8	30.4	99.9
"	"	"	12/29/99	9.4	30.7	29.0	95.0
"	"	"	2/3/00	9.0	29.6	29.3	96.1
"	"	"	1/17/02	9.5	31.2	28.8	94.5
TH-7-01	29.4	96.4	N/A	No Data	No Data	No Data	No Data
TH-9-01	28.6	93.8	12/19/01	4.3*	14.0*	24.3*	79.8*
"	"	"	1/11/02	2.2	7.3	26.4	86.5

* Groundwater level data obtained at time of drilling.

In addition to the borings, three cone penetration tests, designated CPT-5, CPT-6 and CPT-7 were made at the project site. However, when the data from these tests were analyzed, it was discovered that the data was inaccurate due to an electronic fault in the cone penetration test equipment. Since the data is not usable, it is not reported in this technical memorandum.

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-1-99

PROJECT I-5 to International Boundary Sheet 1 of 5

Inspector Williams

Station 1+736 (LR LINE) Offset 1.4 m Rt. Equipment CME 45 w/ autohammer

Latitude Longitude Method Wet Rotary

Northing 323898.297 Easting 460847.909 Casing HW/HQ

Ground Elevation 116.6 (35.5 m) Start Date February 24, 1999 Completion Date February 26, 1999

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
5	1			5 3 5 (8)		D-1		02/26/1999 Clayey SAND, loose, gray, wet, homogenous, no HCL reaction Length Recovered 1.5 ft, Length Retained 1.5 ft	▽	
10	2			1 4 4 (8)		D-2	GS MC PI	SC, MC=18%, PI=13 Clayey SAND, loose, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
15	3			1 1 1 (2)		D-3		Clayey SAND, very loose, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
20	4			1 1		D-4	GS MC	SC, MC=20%, PI=13 Clayey SAND, very loose, gray, wet, Homogeneous, no		

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-1-99

PROJECT I-5 to International Boundary Sheet 2 of 5

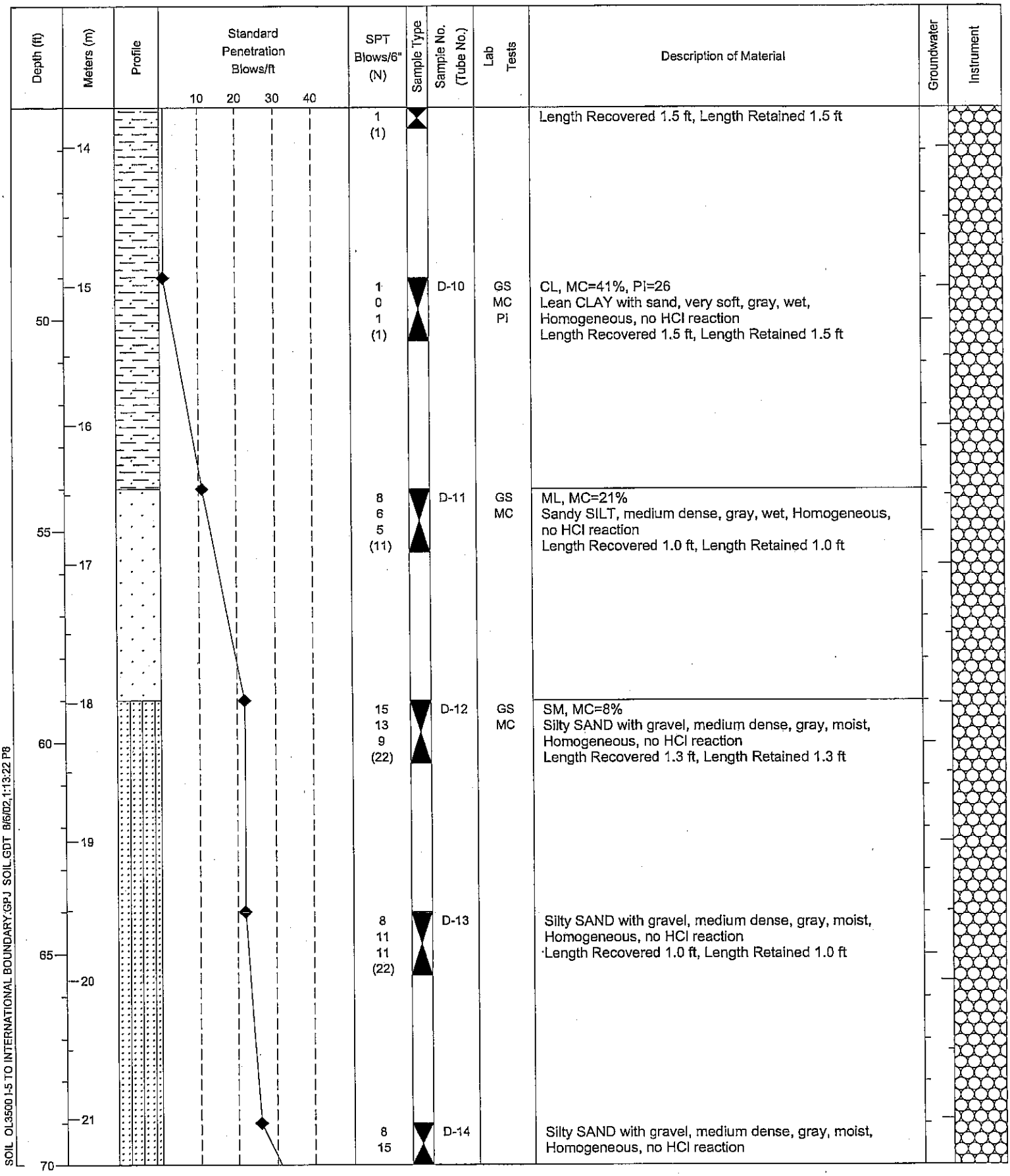
Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				1 (2)			PI	HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	7									
25				0 2 2 (4)		D-5	GS MC PI	CL, MC=19%, PI=10 Sandy Lean CLAY, soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	8									
30	9			0 1 1 (2)		D-6		No Recovery	1/11/02	
	10									
35				0 (0)		D-7		Lean CLAY with sand, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	11									
40	12			0 0 1 (1)		D-8	GS MC PI	CL, MC=21%, PI=22 Lean CLAY with sand, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	13									
45				1 0		D-9		Lean CLAY with sand, very soft, gray, wet, Homogeneous, no HCl reaction		

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-1-99

PROJECT I-5 to International Boundary Sheet 3 of 5



SOIL OL3500 I-5 TO INTERNATIONAL BOUNDARY.GPJ SOIL.GDT 8/6/02 1:13:22 P8

Washington State Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-1-99

PROJECT I-5 to International Boundary Sheet 4 of 5

Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			11 (26)				Length Recovered 1.0 ft, Length Retained 1.0 ft		
	22								
		>>	23 28 24 (52)		D-15	GS MC	SM, MC=9% Silty SAND, dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
75	23								
	24	>>	16 37 28 (65)		D-16		Silty SAND, very dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 0.8 ft, Length Retained 0.8 ft		
80									
	25								
			50/4" (50/4")		D-17		Silty SAND, very dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 0.1 ft, Length Retained 0.1 ft		
85	26								
	27		50/4" (50/4")		D-18		Silty SAND, very dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 0.2 ft, Length Retained 0.2 ft		
90	28								
			50/4" (50/4")		D-19		Silty SAND, very dense, gray, moist, Homogeneous, no HCl reaction		
95									

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-1-99

PROJECT I-5 to International Boundary Sheet 5 of 5

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	29							Length Recovered 0.2 ft, Length Retained 0.2 ft		
	30			50/4" (50/4")		D-20		Silty SAND, very dense, gray, wet, Homogeneous, no HCl reaction Length Recovered 0.1 ft, Length Retained 0.1 ft		
100								End of test hole boring at 99.3 ft below ground elevation.		
	31							This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
105	32									
	33									
110										
	34									
115	35									
	36									
120										

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-10-99

PROJECT I-5 to International Boundary Sheet 1 of 5

Inspector Brian M. Breck

Station 1+834 (T LINE) Offset 18.8 m Rt. Equipment CME 850 w/ autohammer

Latitude Longitude Method Wet Rotary

Northing 323998.567 Easting 460864.102 Casing HW

Ground Elevation 125.7 (38.3 m) Start Date August 30, 1999 Completion Date September 1, 1999

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				10 9 10 (19)		D - 1		Silty SAND with gravel, medium dense, brown, moist, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
5	1		>>	25 45 38 (83)		D - 2		Silty SAND with gravel, very dense, brownish gray, moist, Homogeneous, no HCl reaction Length Recovered 0.2 ft, Length Retained 0.2 ft		
	2			8 16 23 (39)		D - 3	GS MC	SM, MC=12% Silty SAND, dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
10	3		>>	9 32 32 (64)		D - 4	MC	MC=12% Silty SAND, very dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft	▽ 09/01/1999	
	4			7 8 11 (19)		D - 5	GS MC	ML, MC=19% Sandy SILT, medium dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
15	5			6 12 14 (26)		D - 6		Sandy SILT, medium, dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 0.5 ft, Length Retained 0.5 ft		
20	6			2 3 4 (7)		D - 7	MC	MC=23% Lean CLAY with sand, medium stiff, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-10-99

PROJECT I-5 to International Boundary Sheet 2 of 5

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
						S - 8		Sandy Lean CLAY, gray, moist, Homogeneous, no HCl reaction Length Recovered 2.0 ft, Length Retained 2.0 ft		
	7			2 2 3 (5)		D - 9	GS MC PI	CL, MC=21%, PI=20 Lean CLAY with sand, medium stiff, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
25	8			1 2 2 (4)		D - 10	MC	MC=30% Sandy Lean CLAY, soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	9			0 0 1 (1)		D - 11	GS MC PI	SC, MC=24%, PI=10 Clayey SAND, very loose, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft	2/3/00	
30				0 0 0 (0)		D - 12		Clayey SAND, very loose, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	10			0 0 0 (0)		D - 13	GS MC PI	CL-ML, MC=24%, PI=7 Sandy silty CLAY, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
35	11					S - 14		No Recovery		
	12			0 0 0 (0)		D - 15	GS MC PI	CL, MC=27%, PI=24 Lean CLAY with sand, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
40						S - 16		No Recovery		
	13			0 0 1 (1)		D - 17	GS MC PI	CH, MC=45%, PI=45 Fat CLAY with sand, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
45										

Washington State Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-10-99

PROJECT I-5 to International Boundary Sheet 3 of 5

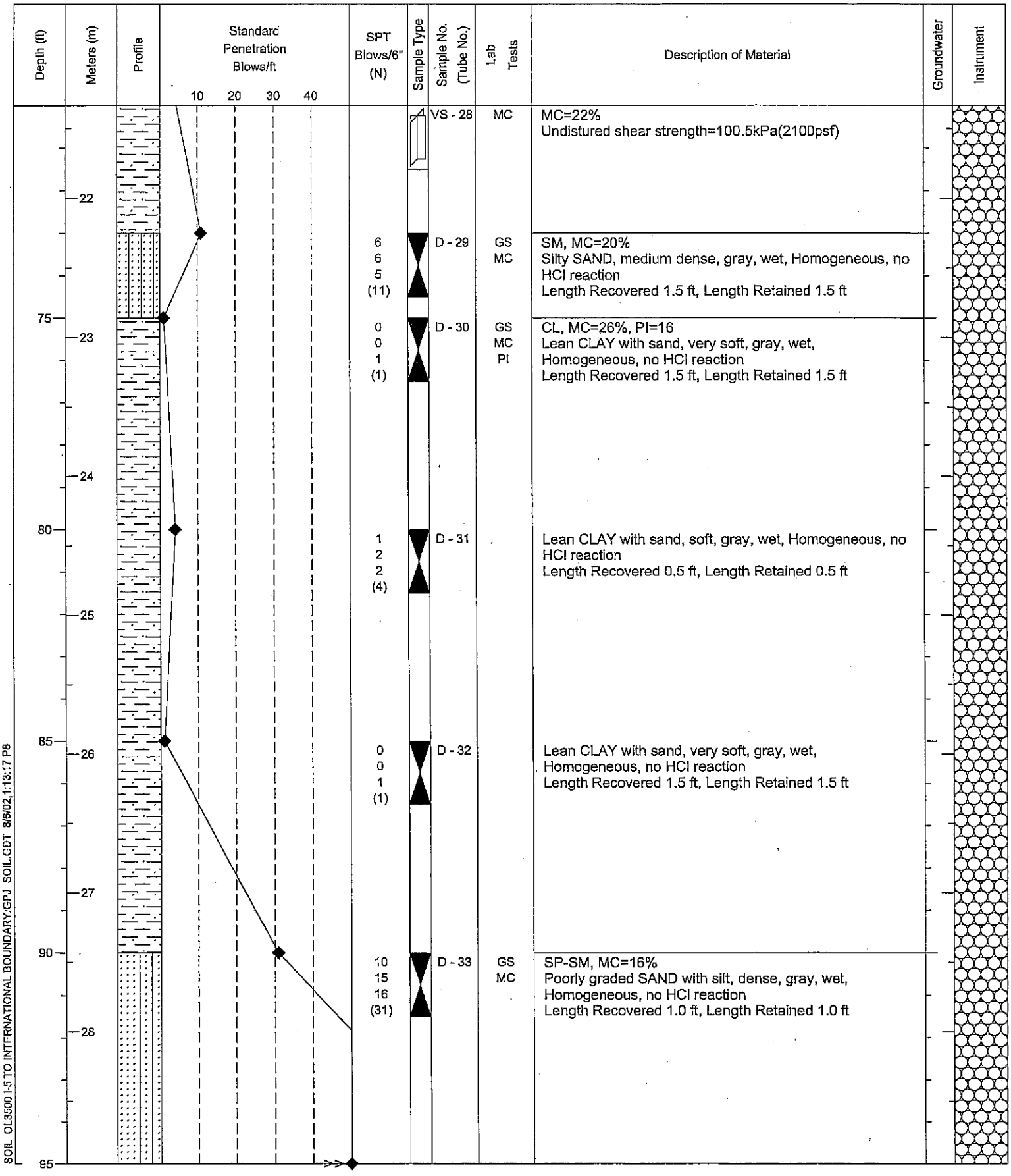
Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
					S - 18	GS MC PI CU	CH, MC=39%, PI=38 (S-18B)Fat CLAY, gray, wet, Homogeneous, no HCl reaction CH, MC=41%, PI=38 (S-18C)Fat CLAY		
	14		0 0 1 (1)		D - 19	MC	CH, MC=41%, PI=44 (S-18D)Fat CLAY Length Recovered 2.0 ft, Length Retained 2.0 ft MC=47% Fat CLAY, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	15								
50					VS-20	GS MC PI	CH, MC=52%, PI=44 Fat CLAY with sand Undistured shear strength=47.4kPa(990psf)		
	16		0 0 0 (0)		D - 21	GS MC PI	CL, MC=30%, PI=17 Lean CLAY, very soft, gray, wet, Homogeneous, no HCl reaction. Length Recovered 1.5 ft, Length Retained 1.5 ft		
55					S - 22		No Recovery		
	17								
	18		1 1 2 (3)		D - 23	GS MC	SM, MC=13% Silty SAND with sand lenses, very loose, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
60					S - 24		No Recovery		
	19		0 0 0 (0)		D - 25	GS MC	ML, MC=36% SILT with sand lenses, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
65					S - 26		No Recovery		
	20								
	21		0 0 0 (0)		D - 27	GS MC PI	CL, MC=30%, PI=13 Lean CLAY with sand, very soft, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
70									

Washington State Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-10-99

PROJECT I-5 to International Boundary Sheet 4 of 5



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Washington State Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-10-99

PROJECT I-5 to International Boundary Sheet 5 of 5

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	29			27 33 50 (83)		D - 34		Poorly graded SAND with silt, very dense, gray, wet, Homogeneous, no HCl reaction Length Recovered 0.2 ft, Length Retained 0.2 ft		
	30									
100				37 50/6" (50/6")		D - 35		Poorly graded SAND with silt, very dense, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
	31									
105	32			41 50/6" (50/6")		D - 36		Poorly graded SAND with silt, very dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
	33									
110				50/6" (50/6")		D - 37		Poorly graded SAND with silt and gravel, very dense, gray, wet, Homogeneous, no HCl reaction Length Recovered 0.5 ft, Length Retained 0.5 ft		
	34							End of test hole boring at 111 ft below ground elevation.		
								This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
115	35									
	36									
120										

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-7-01

PROJECT I-5 to International Boundary Sheet 1 of 4

Inspector Brian Hilts

Station 1+965 (T LINE) Offset 15.5 m Rt. Equipment CME 55 w/ autohammer

Latitude Longitude Method Wet Rotary

Northing 324105 Easting 460872.8 Casing HQx87

Ground Elevation 96.4 (29.4 m) Start Date November 8, 2001 Completion Date November 14, 2001

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
5	1			4 5 7 (12)		D-1	GS MC PI	CL, MC=23%, PI=19 Lean CLAY with sand, stiff, olive brown, moist, Laminated, no HCl reaction, with FeO stains, trace of gravel, with sand lenses. Length Recovered 1.3 ft, Length Retained 1.3 ft		
	2							NOTE: At approximately 8' to 9' we encountered very hard drilling.		
10	3			2 2 3 (5)		D-2		Lean CLAY with sand, medium stiff, olive brown, moist, Laminated, no HCl reaction, with FeO stains and traces of hair roots and sand lenses. Length Recovered 1.5 ft, Length Retained 1.5 ft		
	4					U-3		No Recovery		
15	5			1 2 3 (5)		D-4	GS MC PI	CL, MC=30%, PI=20 Lean CLAY with sand, medium stiff, gray, wet, Homogeneous, no HCl reaction Length Recovered 1.1 ft, Length Retained 1.1 ft		
20	6					U-5 A	GS MC	CL, MC=25%, PI=10 Sandy lean CLAY, gray, wet, Homogeneous, no HCl		

Washington State Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-7-01

PROJECT I-5 to International Boundary Sheet 2 of 4

Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
						PI	reaction		
					B	UU	Length Recovered 1.0 ft, Length Retained 1.0 ft		
					C				
			0		D-6	GS	CH, MC=25%, PI=36%		
			0			MC	Sandy fat CLAY, very soft, gray, wet, Homogeneous, no		
			0			PI	HCl reaction, with trace of gravel.		
			(0)				Length Recovered 0.8 ft, Length Retained 0.8 ft		
	7								
			0		D-7		No Recovery		
			0						
25			0						
			(0)						
	8								
			0		D-8	GS	CH, MC=41%, PI=36%		
	9		0			MC	Fat CLAY, very soft, gray, wet, Homogeneous, no HCl		
30			0			PI	reaction		
			(0)				Length Recovered 1.5 ft, Length Retained 1.5 ft		
	10								
					U-9	GS	CL, MC=39%, PI=24		
					A	MC	Lean CLAY, gray, wet, Homogeneous, no HCl reaction,		
35					B	PI	with occasional gravel		
					C	UU	Length Recovered 1.7 ft, Length Retained 1.7 ft		
					D				
	11		0		D-10	GS	CH, MC=55%, PI=37%		
			1			MC	Fat CLAY with sand, soft, gray, wet, Homogeneous, no		
			1			PI	HCl reaction		
			(2)				Length Recovered 1.1 ft, Length Retained 1.1 ft		
	12		0		D-11		Lean CLAY, very soft, gray, wet, Homogeneous, no HCl		
			0				reaction		
40			0				Length Recovered 1.5 ft, Length Retained 1.5 ft		
			(0)						
	13								
			1		D-12	GS	ML, MC=19%, PI=18		
			2			MC	Sandy SILT, medium stiff, gray, wet, Stratified,		
45									

Washington State Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-7-01

PROJECT I-5 to International Boundary Sheet 3 of 4

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				3 (5)			PI	Laminated, no HCl reaction, with sand lenses. Length Recovered 1.5 ft, Length Retained 1.5 ft		
	14									
								NOTE: At approximately 48.5' denser soil was encountered.		
	15			4 5 24 (29)		D-13	GS MC	SM, MC=11% Silty SAND, medium dense, gray, wet, Stratified, no HCl reaction, with some gravel Length Recovered 1.3 ft, Length Retained 1.3 ft		
50										
	16									
			>>	25 47 39 (86)		D-14	GS MC	SM, MC=10% Silty SAND, very dense, gray, wet, Stratified, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
55	17									
	18		>>	27 37 50/5" (87)		D-15	GS MC	SM, MC=9% Silty SAND, very dense, gray, moist, Homogeneous, no HCl reaction Length Recovered 1.4 ft, Length Retained 1.4 ft		
60	19									
				32 50/2" (50/2")		D-16		Silty SAND with gravel, very dense, gray, wet, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft NOTE: Encountered a 4 to 6" cobble at approx. 65'. On 11/14/01 at 7:30 a.m. the water table inside the casing was at 17'.		
65	20									
	21			36 50/3"		D-17		Silty SAND with gravel, very dense, gray, moist, Homogeneous, no HCl reaction		
70										

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-7-01

PROJECT I-5 to International Boundary Sheet 4 of 4

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				(50/3")				Length Recovered 0.8 ft, Length Retained 0.8 ft		
	22									
75	23		>>	22 33 31 (64)		D-18	GS MC	SM, MC=20% Silty SAND, very dense, gray, wet, Stratified, no HCl reaction, with silty sand lenses and occasional gravel. Length Recovered 1.5 ft, Length Retained 1.5 ft		
80	24		>>	24 60/6" (60/6")		D-19	GS MC	SM, MC=17% Silty SAND with gravel, very dense, gray, wet, Stratified, no HCl reaction Length Recovered 0.9 ft, Length Retained 0.9 ft		
	25									
85	26		>>	64/6" (64/6")		D-20	GS MC	SP-SM, MC=9% Poorly graded SAND with silt and gravel, very dense, gray, wet, Homogeneous, no HCl reaction Length Recovered 0.5 ft, Length Retained 0.5 ft End of test hole boring at 84.5 ft below ground elevation.		
	27							This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
90	28									
95										

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-9-01

PROJECT I-5 to International Boundary Sheet 1 of 4

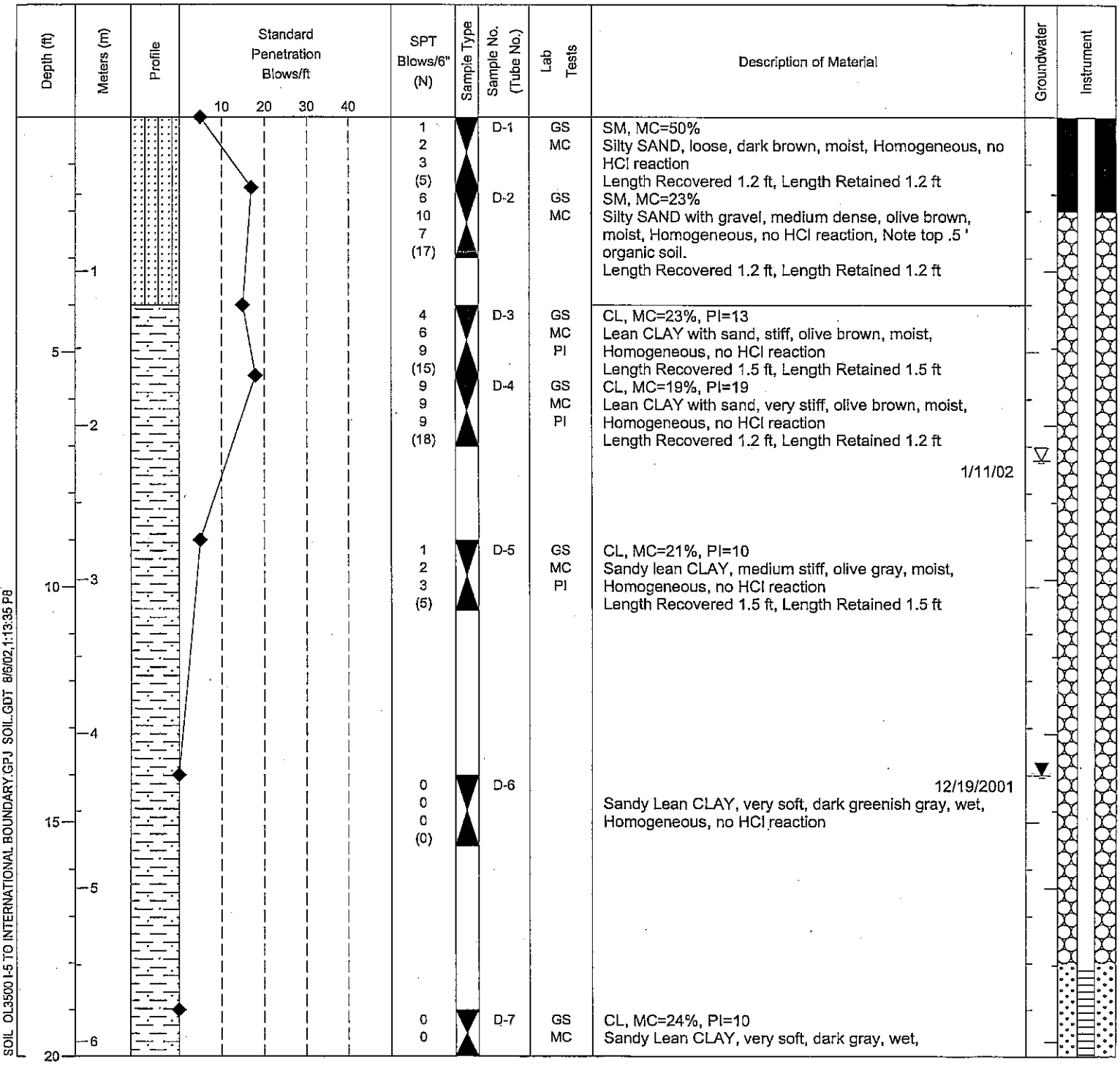
Inspector Hanning

Station 2+017 (T LINE) Offset 12.7 m Rt. Equipment CME 850 w/ autohammer

Latitude Longitude Method Wet Rotary

Northing 324129.1 Easting 460919.6 Casing HQ

Ground Elevation 93.8 (28.6 m) Start Date December 19, 2001 Completion Date December 19, 2001



SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
1 2 3 (5)		D-1	GS MC	SM, MC=50% Silty SAND, loose, dark brown, moist, Homogeneous, no HCl reaction Length Recovered 1.2 ft, Length Retained 1.2 ft
6 10 7 (17)		D-2	GS MC	SM, MC=23% Silty SAND with gravel, medium dense, olive brown, moist, Homogeneous, no HCl reaction, Note top .5 ' organic soil. Length Recovered 1.2 ft, Length Retained 1.2 ft
4 6 9 (15)		D-3	GS MC PI	CL, MC=23%, PI=13 Lean CLAY with sand, stiff, olive brown, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft
9 9 9 (18)		D-4	GS MC PI	CL, MC=19%, PI=19 Lean CLAY with sand, very stiff, olive brown, moist, Homogeneous, no HCl reaction Length Recovered 1.2 ft, Length Retained 1.2 ft 1/11/02
1 2 3 (5)		D-5	GS MC PI	CL, MC=21%, PI=10 Sandy lean CLAY, medium stiff, olive gray, moist, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft
0 0 0 (0)		D-6		12/19/2001 Sandy Lean CLAY, very soft, dark greenish gray, wet, Homogeneous, no HCl reaction
0 0		D-7	GS MC	CL, MC=24%, PI=10 Sandy Lean CLAY, very soft, dark gray, wet,

SOIL OL3500 I-5 TO INTERNATIONAL BOUNDARY.GPJ SOIL.GDT 8/6/02,1:13:35 P8

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-9-01

PROJECT I-5 to International Boundary Sheet 2 of 4

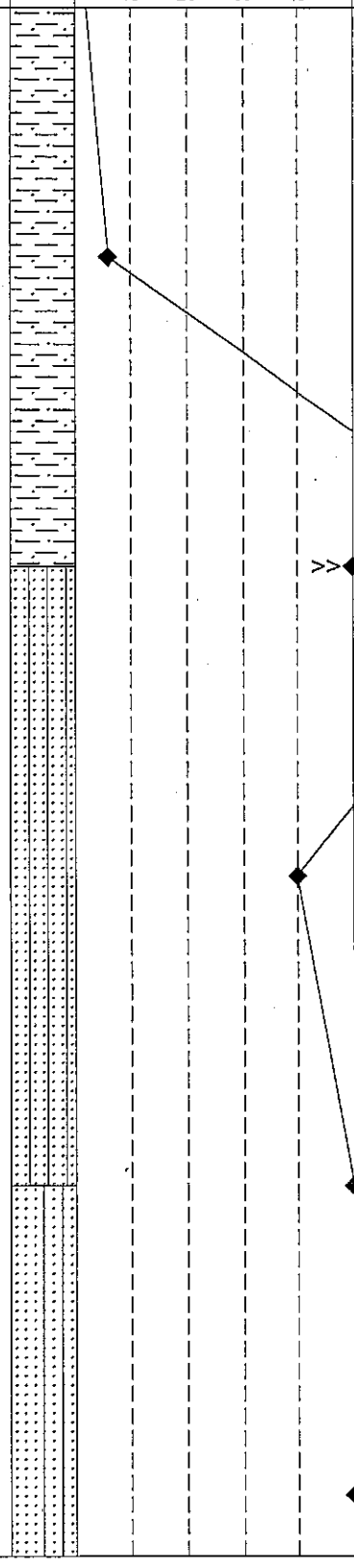
Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				0 (0)			PI	Homogeneous, no HCl reaction Length Recovered 1.2 ft, Length Retained 1.2 ft		
	7									
				0 0 0 (0)		D-8	GS MC PI	CL, MC=31%, PI=19 Lean CLAY, very soft, dark gray, wet, Homogeneous, no HCl reaction Length Recovered 1.3 ft, Length Retained 1.3 ft		
25										
	8									
						S-9		No Recovery		
	9									
30										
				0 0 0 (0)		D-10	GS MC PI	CL, MC=24%, PI=9 Sandy Lean CLAY, very soft, dark gray, wet, Homogeneous, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft		
	10					S-11		No Recovery		
				0 0 0 (0)		D-12		Sandy Lean CLAY, very soft, dark gray, wet, Homogeneous, no HCl reaction Length Recovered 1.3 ft, Length Retained 1.3 ft		
35										
	11									
	12			0 0 0 (0)		D-13	GS MC PI	CL-ML, MC=29%, PI=6 Sandy silty CLAY, very soft, dark gray, wet, Stratified, no HCl reaction, Note top .3' sandy silt. Length Recovered 1.5 ft, Length Retained 1.5 ft		
40										
	13									
				1 0		D-14		Sandy Lean CLAY with gravel, very soft, dark gray, wet, Stratified, no HCl reaction, Note used 2" sampler to		
45										

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-9-01

PROJECT I-5 to International Boundary Sheet 3 of 4



Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14	1 (1)				recover material. Length Recovered 1.5 ft, Length Retained 1.5 ft		
50	15	1 1 5 (6)		D-15		Sandy Lean CLAY with gravel, medium stiff, dark gray, wet, Stratified, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft NOTE: Drilling behavior indicates material change at 51'.		
	16							
55	17	10 34 50 (84)		D-16	GS MC PI	SM, MC=9%, PI=14 Silty SAND with gravel, very dense, dark gray, moist, Stratified, no HCl reaction Length Recovered 1.2 ft, Length Retained 1.2 ft		
60	18 19	14 18 22 (40)		D-17		Silty SAND with gravel, dense, dark gray, wet, Stratified, no HCl reaction. NOTE: Drilling indicates increasing gravel. Length Recovered 1.5 ft, Length Retained 1.5 ft		
65	20	42 50/4" (50/4")		D-18	GS MC PI	SP-SM, MC=11% Poorly graded SAND with silt and gravel, very dense, dark gray, wet, Stratified, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
70	21	44 50/4"		D-19		Poorly graded SAND with silt and gravel, very dense, dark gray, wet, Stratified, no HCl reaction		

Washington State
Department of Transportation

LOG OF TEST BORING

Job No. 0L-3500 SR 543 HOLE No. TH-9-01

PROJECT I-5 to International Boundary Sheet 4 of 4

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				(50/4")				Length Recovered 0.8 ft, Length Retained 0.8 ft		
	22									
75	23			42 50/5" (50/5")		D-20		Poorly graded SAND with silt and gravel, very dense, dark gray, wet, Stratified, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft		
	24									
80				40 50/5" (50/5")		D-21	GS MC PI	SM, MC=12% Silty SAND with gravel, very dense, dark gray, wet, Stratified, no HCl reaction Length Recovered 0.9 ft, Length Retained 0.9 ft		
	25									
85	26			>> 18 40 50 (90)		D-22		Silty SAND with gravel, very dense, dark gray, wet, Stratified, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft		
	27							NOTE: Bailed water to a depth of 40' prior to installing piezometer. End of test hole boring at 85.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
90	28									
95										

APPENDIX C - LABORATORY TESTING

LABORATORY TESTING

Laboratory testing was performed on selected samples from the field exploration program. All disturbed samples were visually examined and then grouped together based upon particle size distribution, consistency and color. Once a group of samples was established that had similar characteristic, a minimum of one sample per group was tested. The testing consisted of performing moisture content, grain size analyses, and Atterberg Limits tests. The tests were done in general accordance with AASHTO T-88, T-89 and T-90 guide specifications, respectively. After testing was complete, the samples were classified in general accordance with the Unified Soil Classification System (USCS).

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-1-99** Sheet **1** of **2**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

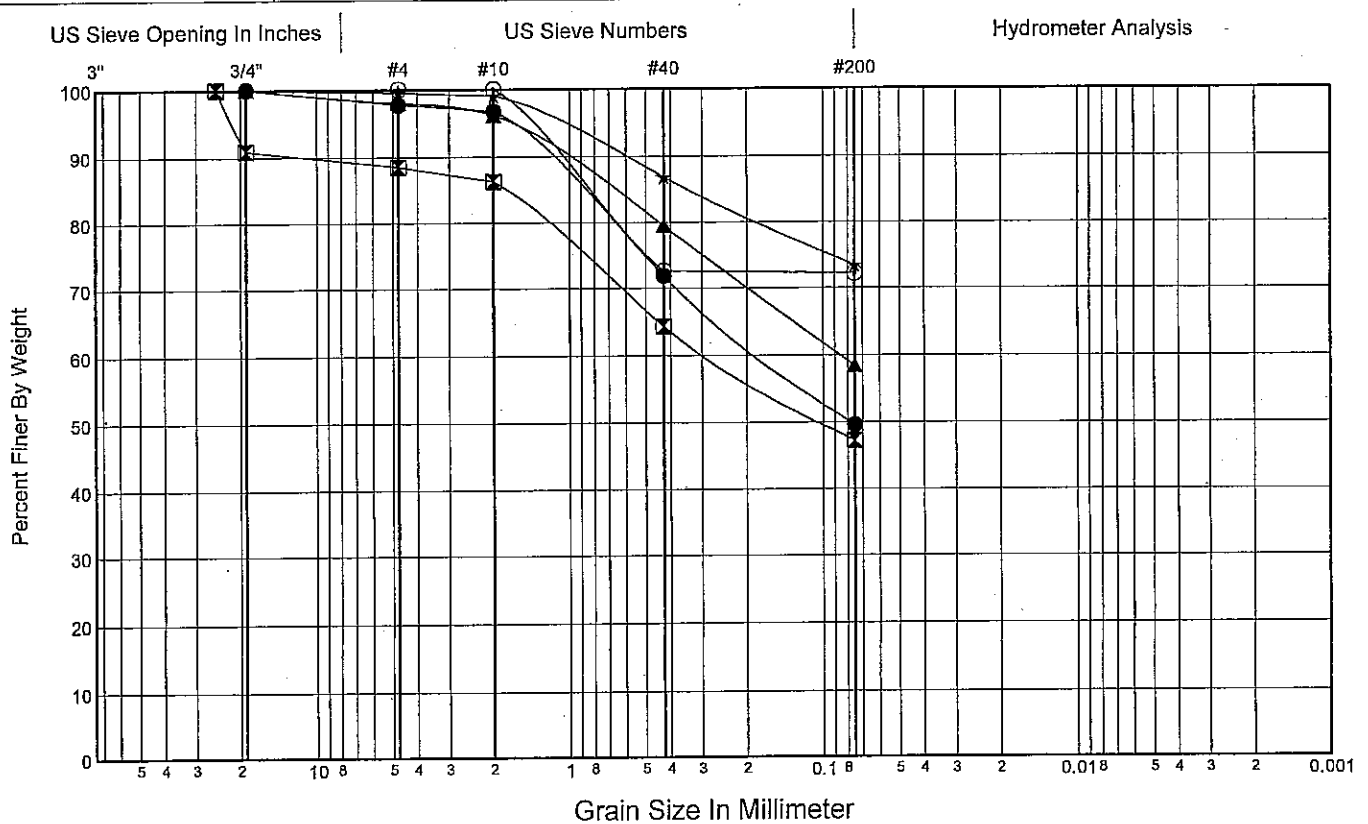
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	9.0	2.74	D-2	SC	See Boring Log	CLAYEY SAND	18	28	15	13
⊠	19.0	5.79	D-4	SC	See Boring Log	CLAYEY SAND	20	28	15	13
▲	24.0	7.32	D-5	CL	See Boring Log	SANDY LEAN CLAY	19	24	14	10
★	39.0	11.89	D-8	CL	See Boring Log	LEAN CLAY with SAND	21	37	15	22
⊙	49.0	14.94	D-10	CL	See Boring Log	LEAN CLAY with SAND	41	44	18	26

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	2.3	48.1	49.6		
⊠	11.6	41.2	47.2		
▲	2.0	39.6	58.4		
★	0.5	26.1	73.4		
⊙	0.0	27.8	72.2		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.169	0.08			
⊠	0.274	0.10			
▲	0.085				
★					
⊙					



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-1-99** Sheet **2** of **2**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

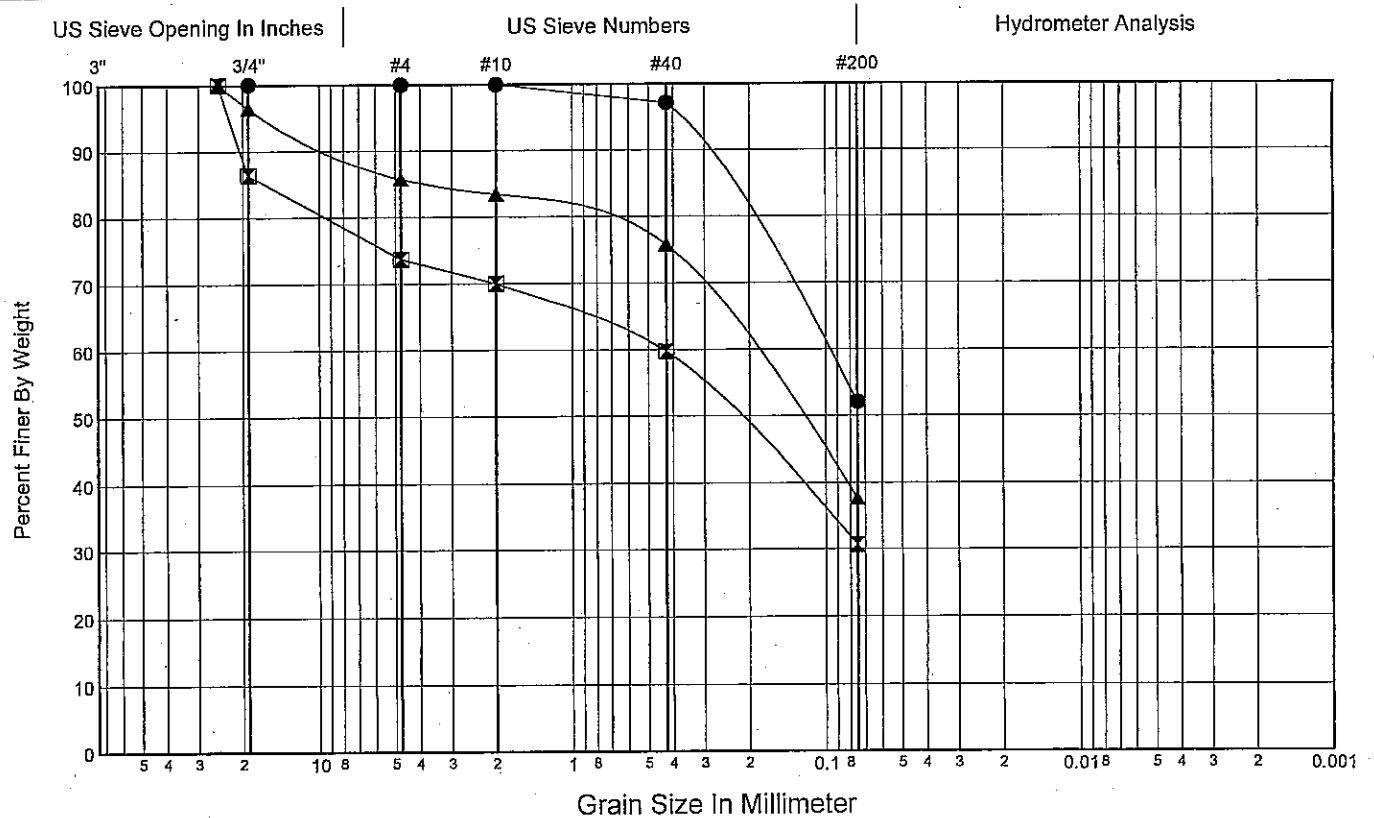
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	54.0	16.46	D-11	ML	See Boring Log	SANDY SILT	21			
⊠	59.0	17.98	D-12	SM	See Boring Log	SILTY SAND with GRAVEL	8			
▲	74.0	22.56	D-15	SM	See Boring Log	SILTY SAND	9			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	0.1	47.9	52.1		
⊠	26.3	43.0	30.7		
▲	14.3	48.1	37.6		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.102				
⊠	0.444	0.24			
▲	0.207	0.13			



Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-10-99** Sheet **1** of **4**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

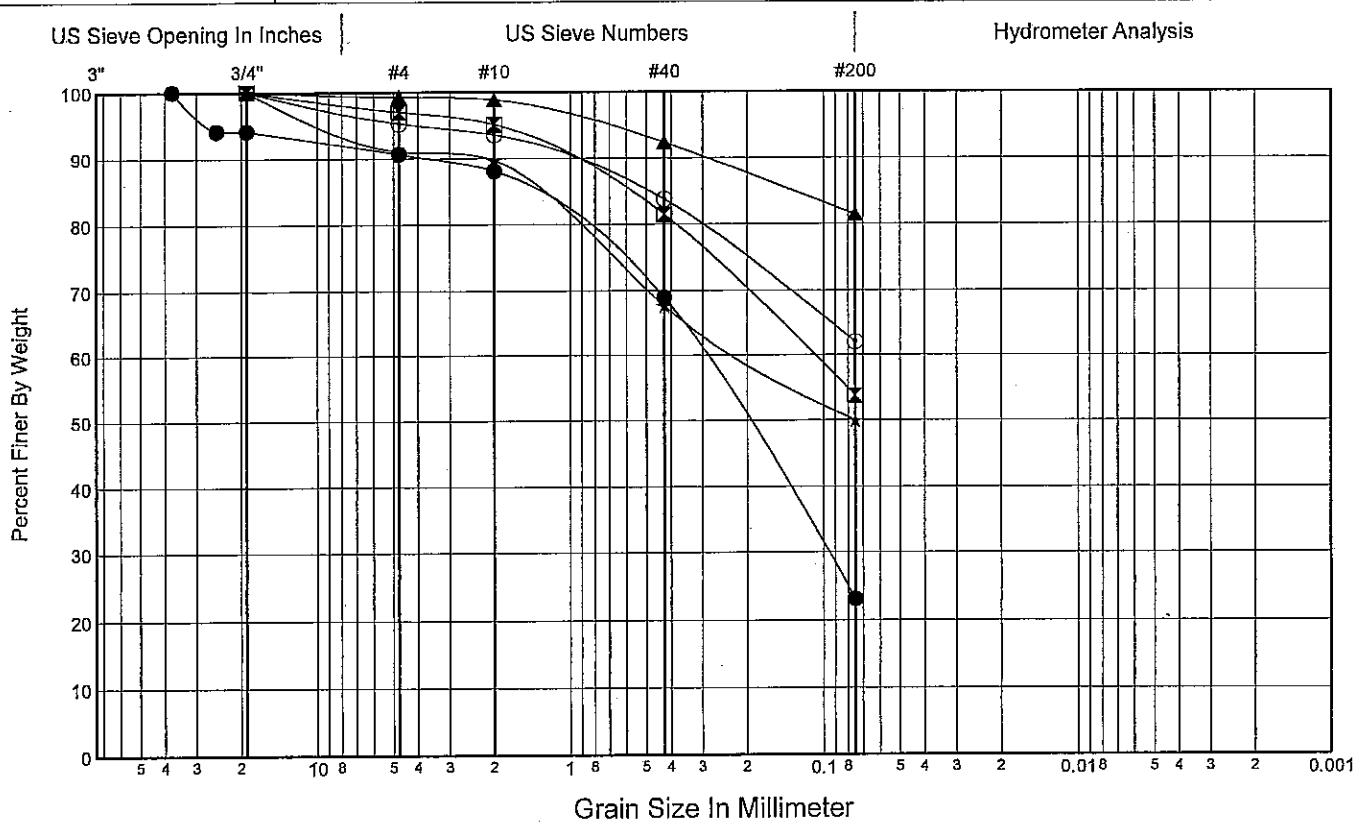
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	8.0	2.44	D-3	SM	See Boring Log	SILTY SAND	12			
⊠	13.0	3.96	D-5	ML	See Boring Log	SANDY SILT	19			
▲	22.0	6.71	D-9	CL	See Boring Log	LEAN CLAY with SAND	21	39	19	20
★	28.0	8.53	D-11	SC	See Boring Log	CLAYEY SAND	24	24	14	10
⊙	33.0	10.06	D-13	CL-ML	See Boring Log	SANDY SILTY CLAY	24	21	14	7

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	9.4	67.5	23.1		
⊠	3.0	43.2	53.8		
▲	0.8	17.8	81.4		
★	9.0	41.0	50.0		
⊙	4.8	33.2	62.0		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.303	0.21	0.10		
⊠	0.111				
▲					
★	0.201	0.08			
⊙					



Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-10-99** Sheet **2** of **4**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

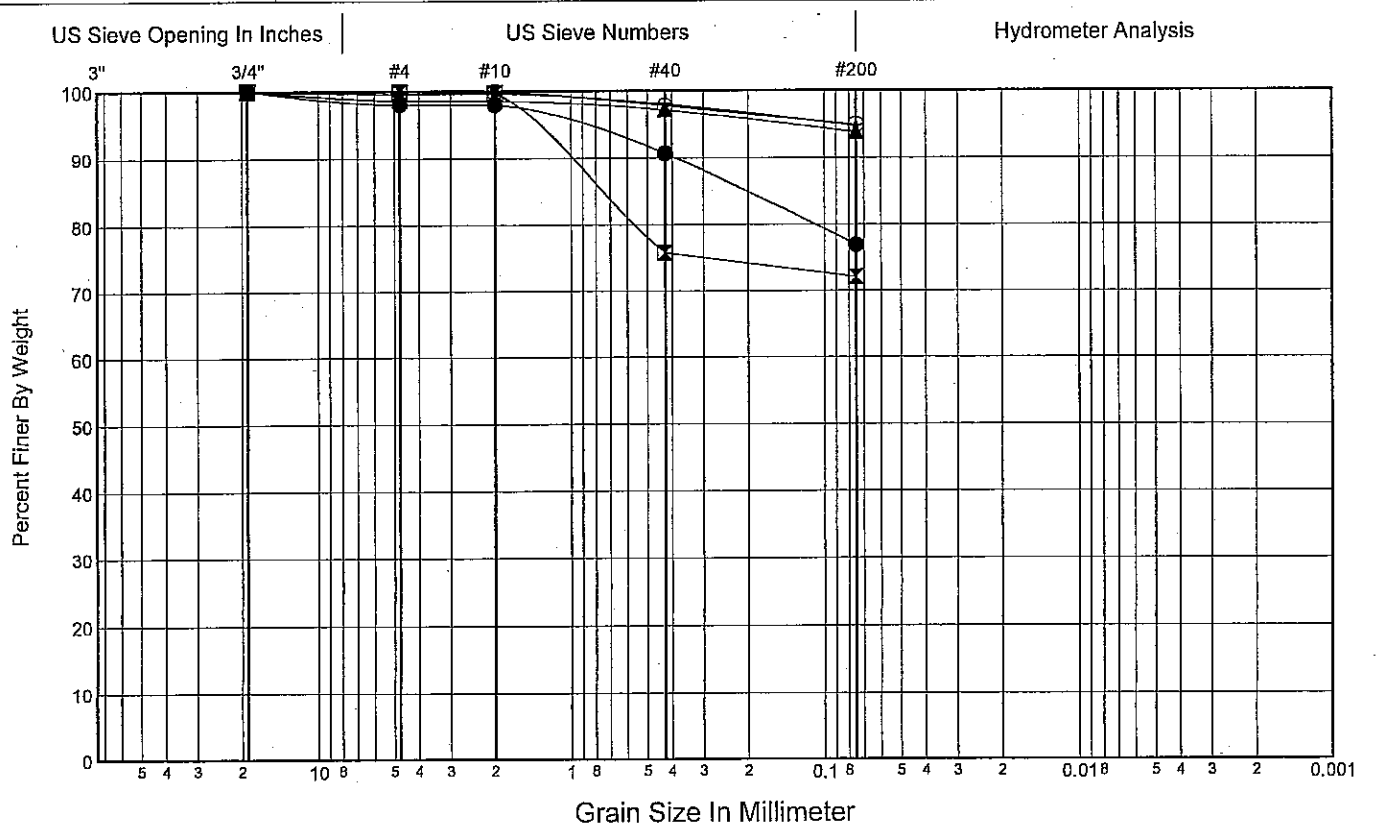
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	38.0	11.58	D-15	CL	See Boring Log	LEAN CLAY with SAND	27	41	17	24
⊠	43.0	13.11	D-17	CH	See Boring Log	FAT CLAY with SAND	45	67	22	45
▲	45.3	13.81	S-18B	CH	See Boring Log	FAT CLAY	39	59	21	38
★	45.8	13.96	S-18C	CH	See Boring Log	FAT CLAY	41	60	22	38
⊙	46.3	14.11	S-18D	CH	See Boring Log	FAT CLAY	41	66	22	44

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	2.0	21.1	76.9		
⊠	0.1	27.8	72.1		
▲	1.4	4.9	93.7		
★	0.5	4.9	94.7		
⊙	0.1	5.1	94.9		

GRADATION VALUES

	D60	D50	D30	D20	D10
●					
⊠					
▲					
★					
⊙					



Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-10-99** Sheet **3** of **4**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

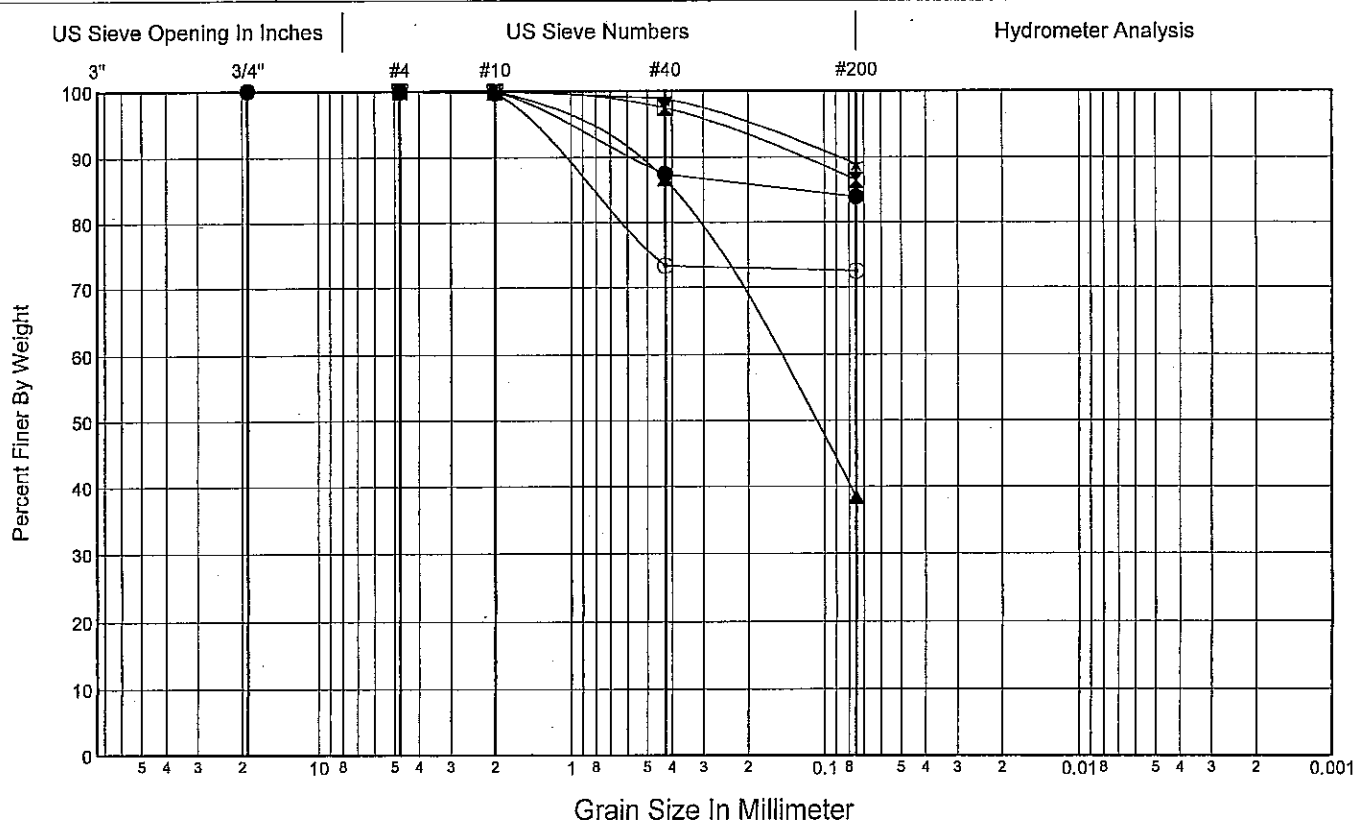
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	50.0	15.24	VS-20	CH	See Boring Log	FAT CLAY with SAND	52	63	19	44
⊠	53.0	16.15	D-21	CL	See Boring Log	LEAN CLAY	30	33	16	17
▲	58.0	17.68	D-23	SM	See Boring Log	SILTY SAND	13			
★	63.0	19.20	D-25	ML	See Boring Log	SILT	36			
⊙	68.0	20.73	D-27	CL	See Boring Log	LEAN CLAY with SAND	30	31	18	13

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	0.1	16.1	83.8		
⊠	0.0	13.6	86.4		
▲	0.0	61.7	38.3		
★	0.0	11.1	88.9		
⊙	0.1	27.4	72.5		

GRADATION VALUES

	D60	D50	D30	D20	D10
●					
⊠					
▲	0.164	0.11			
★					
⊙					



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-10-99** Sheet **4** of **4**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

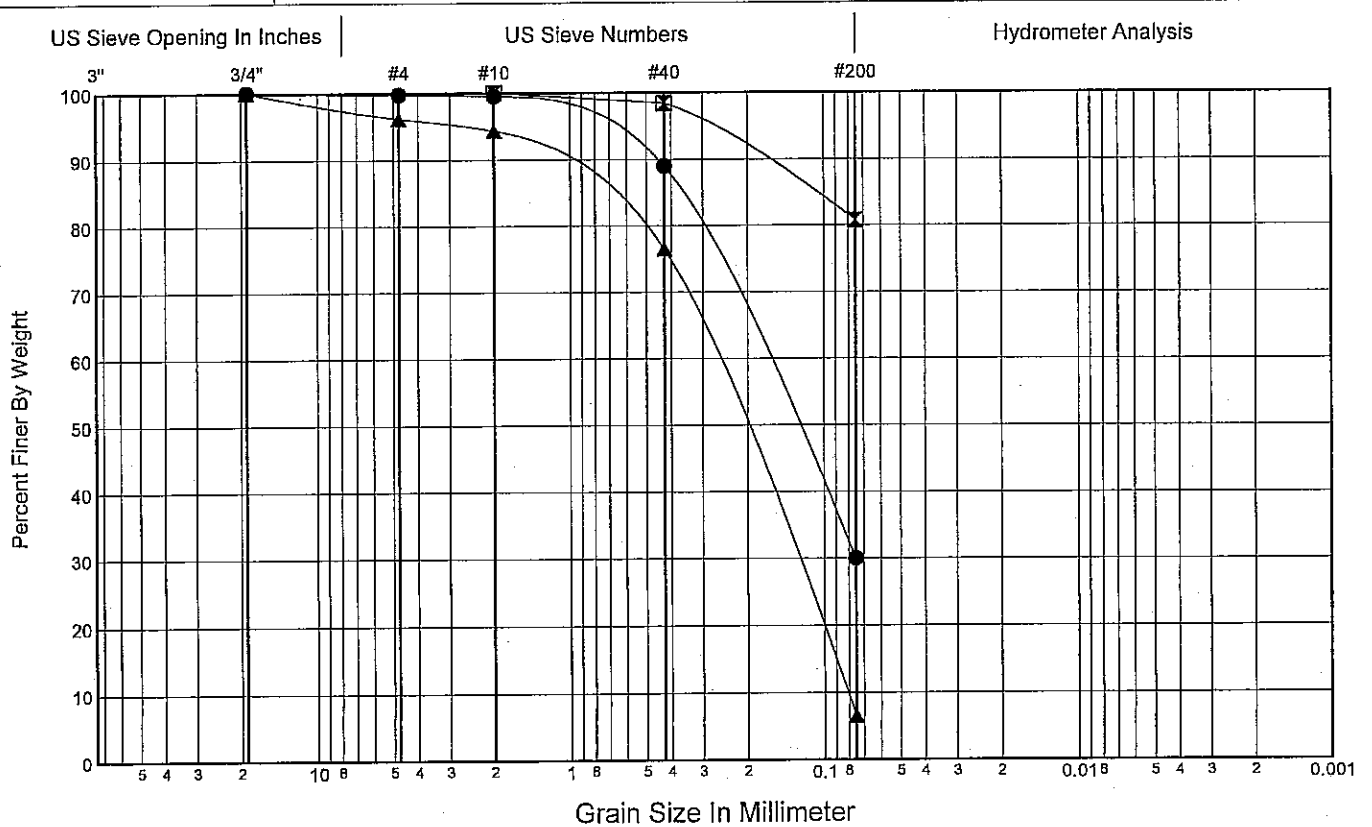
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	73.0	22.25	D-29	SM	See Boring Log	SILTY SAND	20			
⊠	75.0	22.86	D-30	CL	See Boring Log	LEAN CLAY with SAND	26	33	17	16
▲	90.0	27.43	D-33	SP-SM	See Boring Log	POORLY GRADED SAND with SILT	16			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	0.3	69.8	30.0		
⊠	0.0	19.2	80.8		
▲	3.9	89.6	6.5	0.8	3.5

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.181	0.14	0.08		
⊠					
▲	0.283	0.22	0.13	0.10	0.082



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-7-01** Sheet **1** of **3**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

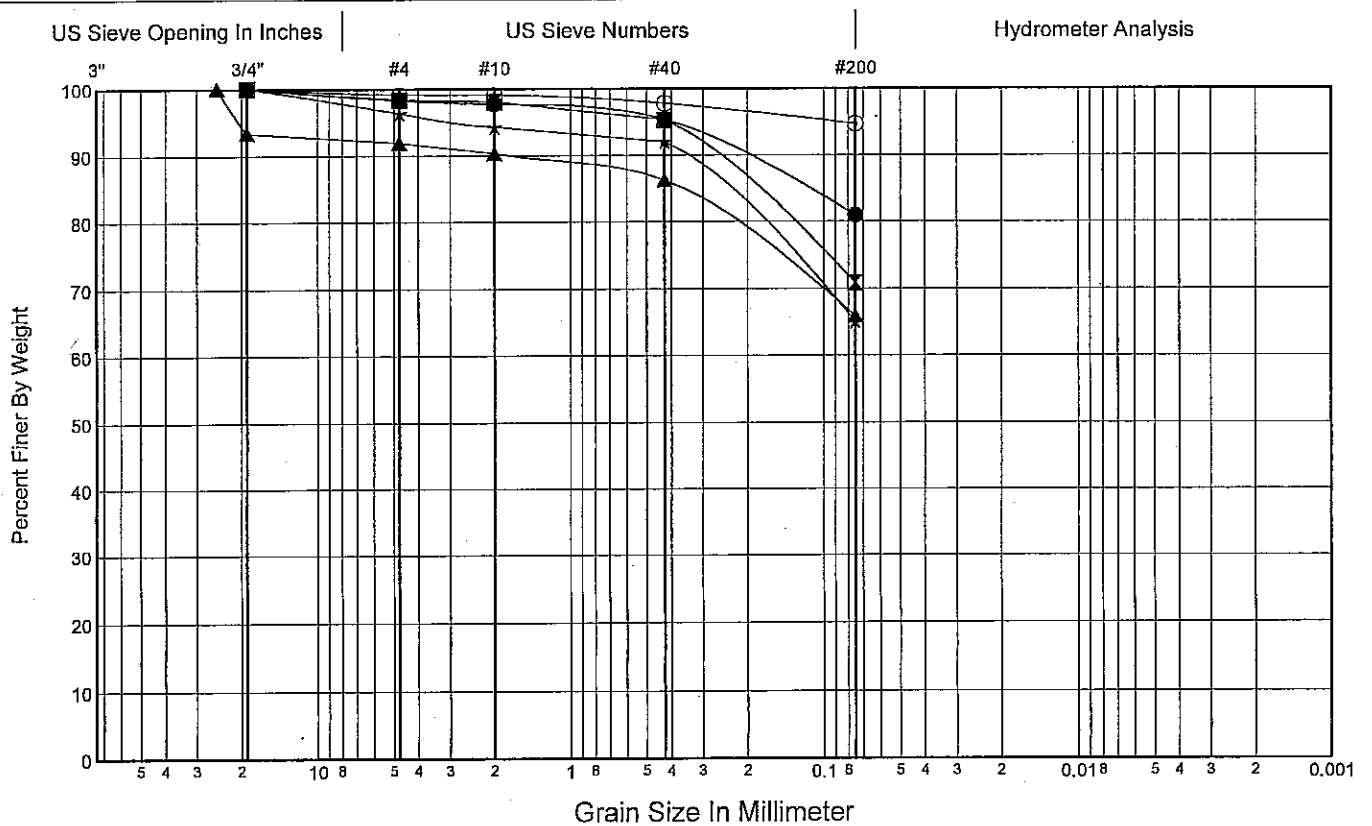
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	4.0	1.22	D-1	CL	See Boring Log	LEAN CLAY with SAND	23	41	22	19
⊠	16.0	4.88	D-4	CL	See Boring Log	LEAN CLAY with SAND	30	37	17	20
▲	19.0	5.79	U-5	CL	See Boring Log	SANDY LEAN CLAY	25	24	14	10
★	21.0	6.40	D-6	CH	See Boring Log	SANDY FAT CLAY	25	62	26	36
⊙	29.0	8.84	D-8	CH	See Boring Log	FAT CLAY	41	58	22	36

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	1.8	17.3	80.9		
⊠	1.7	27.5	70.8		
▲	8.1	26.0	65.9		
★	3.7	31.2	65.1		
⊙	0.9	4.5	94.6		

GRADATION VALUES

	D60	D50	D30	D20	D10
●					
⊠					
▲					
★					
⊙					



Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-7-01** Sheet **2** of **3**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

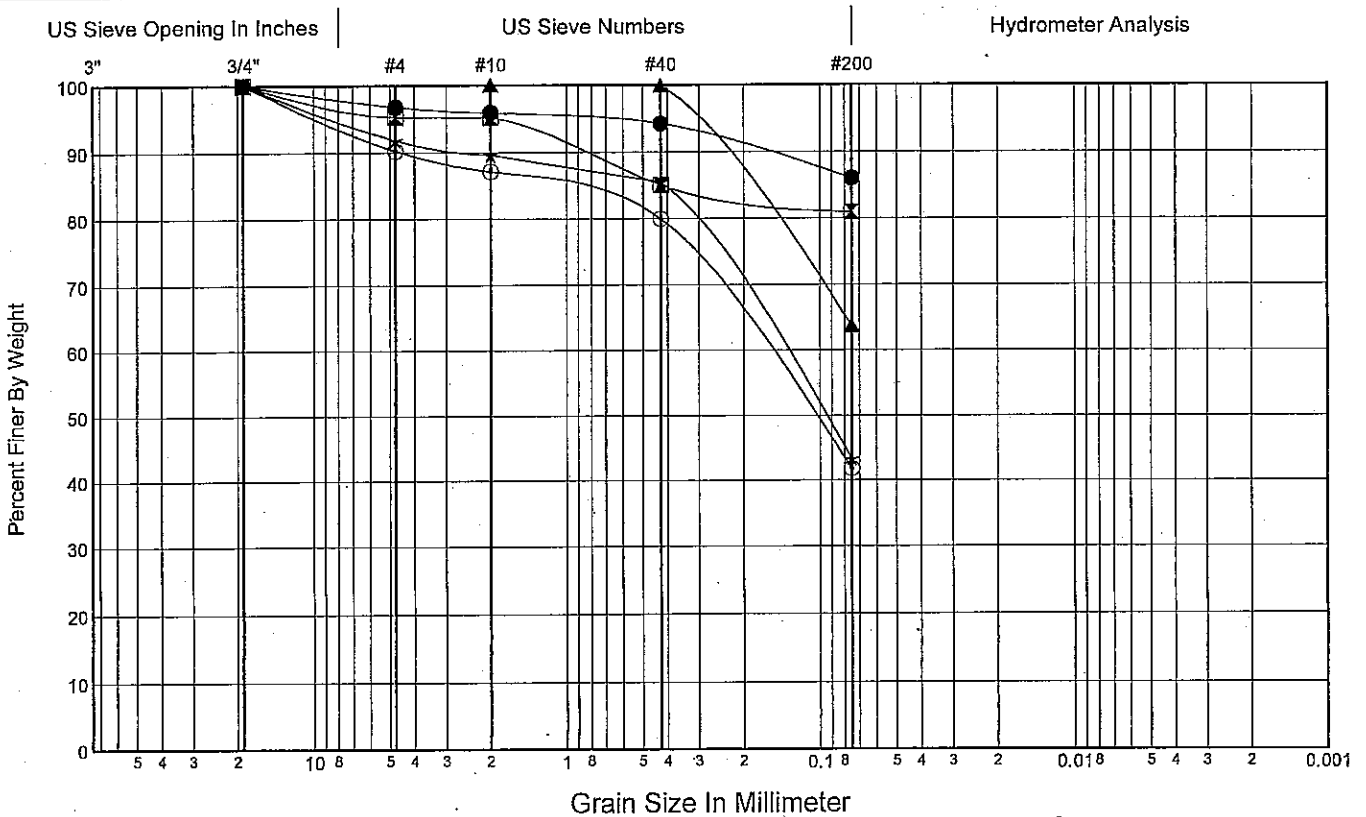
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	34.2	10.42	U-9A	CL	See Boring Log	LEAN CLAY	39	42	18	24
⊠	36.0	10.97	D-10	CH	See Boring Log	FAT CLAY with SAND	55	56	19	37
▲	44.0	13.41	D-12	ML	See Boring Log	SANDY SILT	19	18	NP	18
★	49.0	14.94	D-13	SM	See Boring Log	SILTY SAND	11			
⊙	54.0	16.46	D-14	SM	See Boring Log	SILTY SAND	10			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	3.3	10.7	86.0		
⊠	4.7	14.3	81.0		
▲	0.0	36.3	63.7		
★	8.2	48.5	43.3		
⊙	9.8	48.4	41.8		

GRADATION VALUES

	D60	D50	D30	D20	D10
●					
⊠					
▲					
★	0.149	0.10			
⊙	0.172	0.11			



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-7-01** Sheet **3** of **3**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

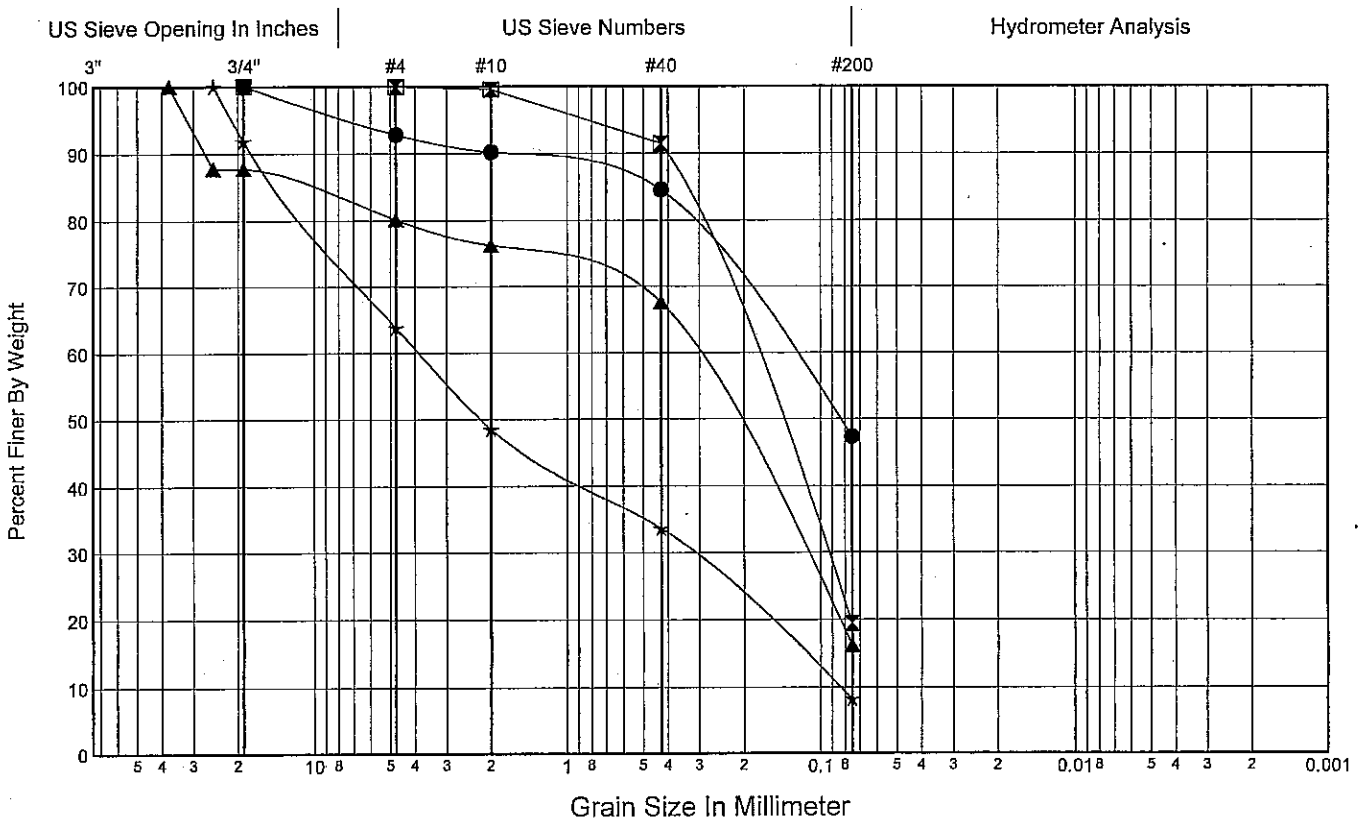
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	59.0	17.98	D-15	SM	See Boring Log	SILTY SAND	9			
⊠	74.0	22.56	D-18	SM	See Boring Log	SILTY SAND	20			
▲	79.0	24.08	D-19	SM	See Boring Log	SILTY SAND with GRAVEL	17			
★	84.0	25.60	D-20	SP-SM	See Boring Log	POORLY GRADED SAND with SILT and GRAVEL	9			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	7.3	45.5	47.3		
⊠	0.1	80.4	19.4		
▲	19.9	64.0	16.1		
★	36.2	55.6	8.2	0.3	45.3

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.136	0.09			
⊠	0.199	0.16	0.10	0.08	
▲	0.329	0.24	0.12	0.09	
★	3.833	2.18	0.33	0.17	0.085



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-9-01** Sheet **1** of **3**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

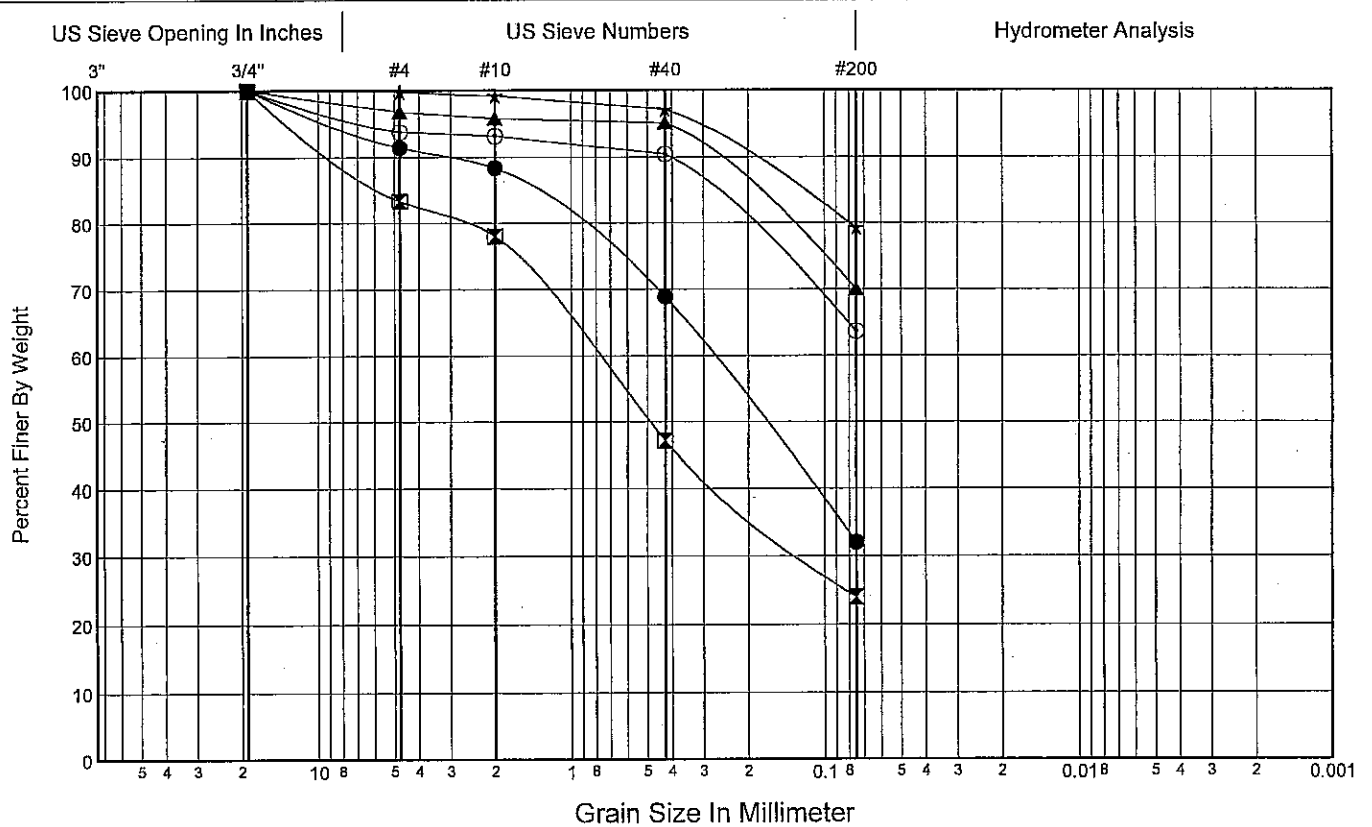
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	0.0	0.00	D-1	SM	See Boring Log	SILTY SAND	50			
⊠	1.5	0.46	D-2	SM	See Boring Log	SILTY SAND with GRAVEL	23			
▲	4.0	1.22	D-3	CL	See Boring Log	LEAN CLAY with SAND	23	31	18	13
★	5.5	1.68	D-4	CL	See Boring Log	LEAN CLAY with SAND	19	37	18	19
⊙	9.0	2.74	D-5	CL	See Boring Log	SANDY LEAN CLAY	21	26	16	10

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	8.6	59.4	32.0		
⊠	16.7	59.3	24.0		
▲	3.2	26.8	70.0		
★	0.3	20.5	79.2		
⊙	6.2	30.2	63.6		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.280	0.17			
⊠	0.810	0.49	0.12		
▲					
★					
⊙					



Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-9-01** Sheet **2** of **3**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

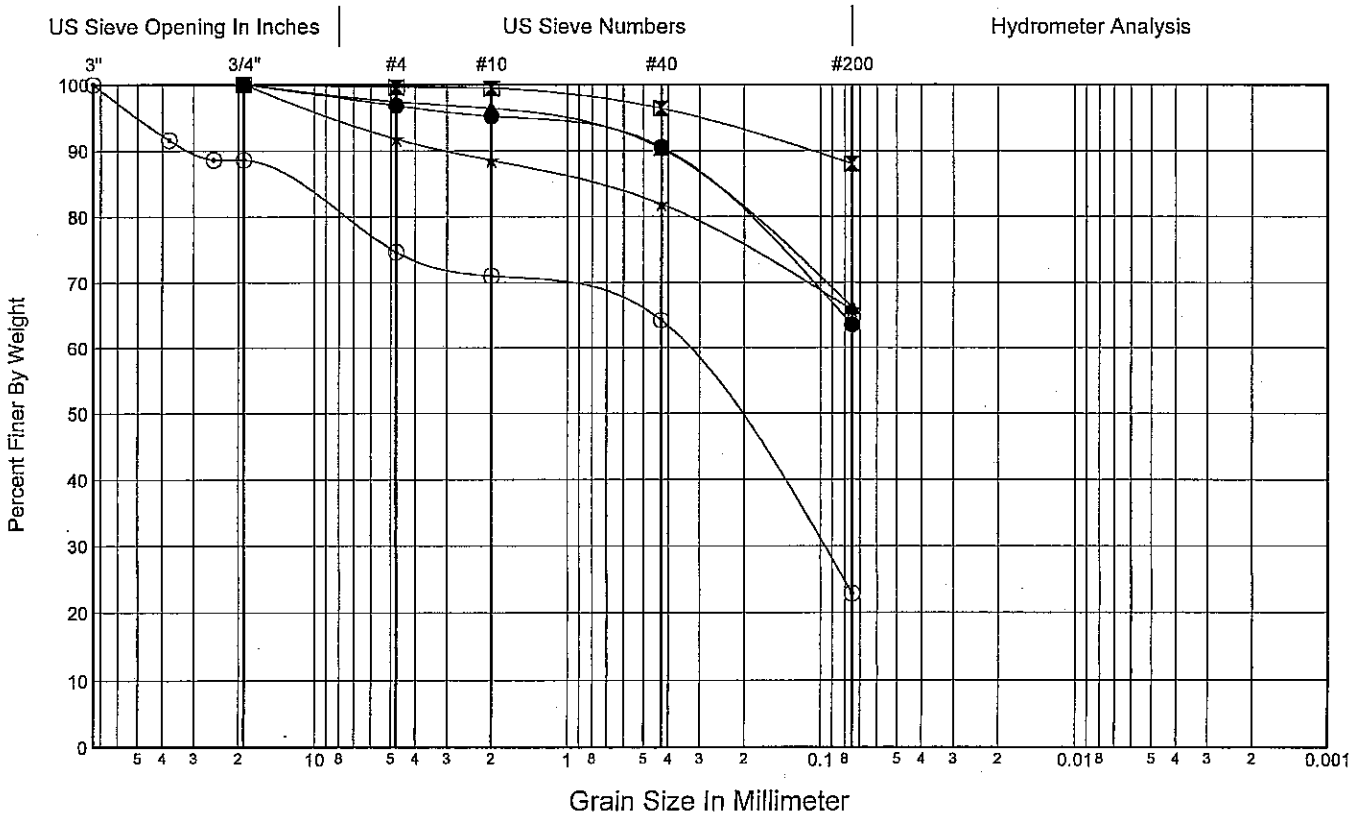
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	19.0	5.79	D-7	CL	See Boring Log	SANDY LEAN CLAY	24	24	14	10
⊠	24.0	7.32	D-8	CL	See Boring Log	LEAN CLAY	31	37	18	19
▲	31.0	9.45	D-10	CL	See Boring Log	SANDY LEAN CLAY	24	23	14	9
★	39.0	11.89	D-13	CL-ML	See Boring Log	SANDY SILTY CLAY	29	21	15	6
⊙	54.0	16.46	D-16	SM	See Boring Log	SILTY SAND with GRAVEL	9	14	NP	14

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	3.2	33.4	63.4		
⊠	0.4	11.6	88.0		
▲	2.6	31.2	66.2		
★	8.3	26.0	65.7		
⊙	25.4	51.8	22.8		

GRADATION VALUES

	D60	D50	D30	D20	D10
●					
⊠					
▲					
★					
⊙	0.357	0.23	0.10		



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

Job No. **0L-3500** Date **June 11, 2002**

Hole No. **TH-9-01** Sheet **3** of **3**

Project **I-5 to International Boundary**

Laboratory Summary

Washington State Department of Transportation

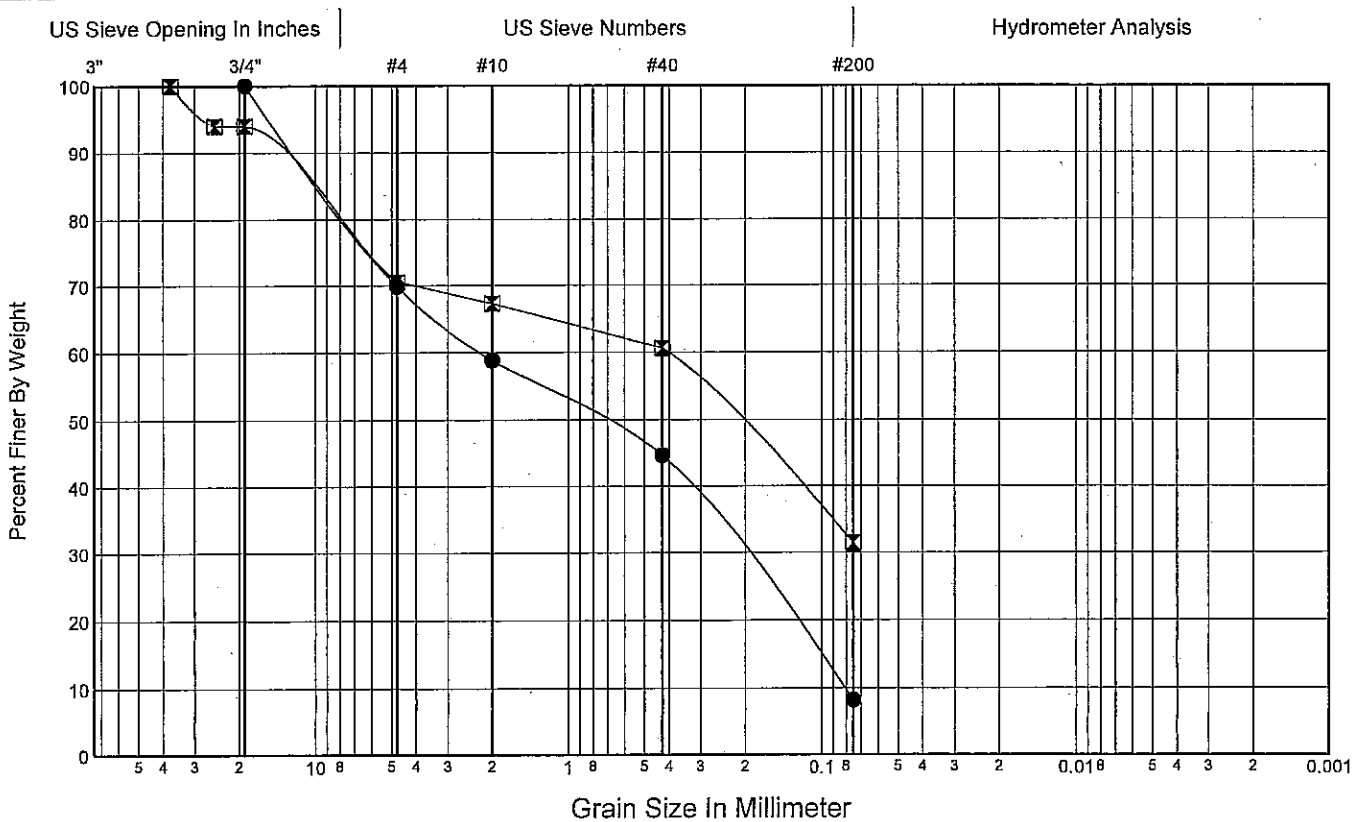
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	64.0	19.51	D-18	SP-SM	See Boring Log	POORLY GRADED SAND with SILT and GRAVEL	11			
⊠	79.0	24.08	D-21	SM	See Boring Log	SILTY SAND with GRAVEL	12			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	30.1	61.7	8.2	0.3	26.9
⊠	29.4	39.2	31.4		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	2.196	0.76	0.21	0.13	0.082
⊠	0.410	0.23			



Gravel	Sand			Silt and Clay
	Coarse	Medium	Fine	

APPENDIX E - P-Y CURVE INPUT PARAMETERS

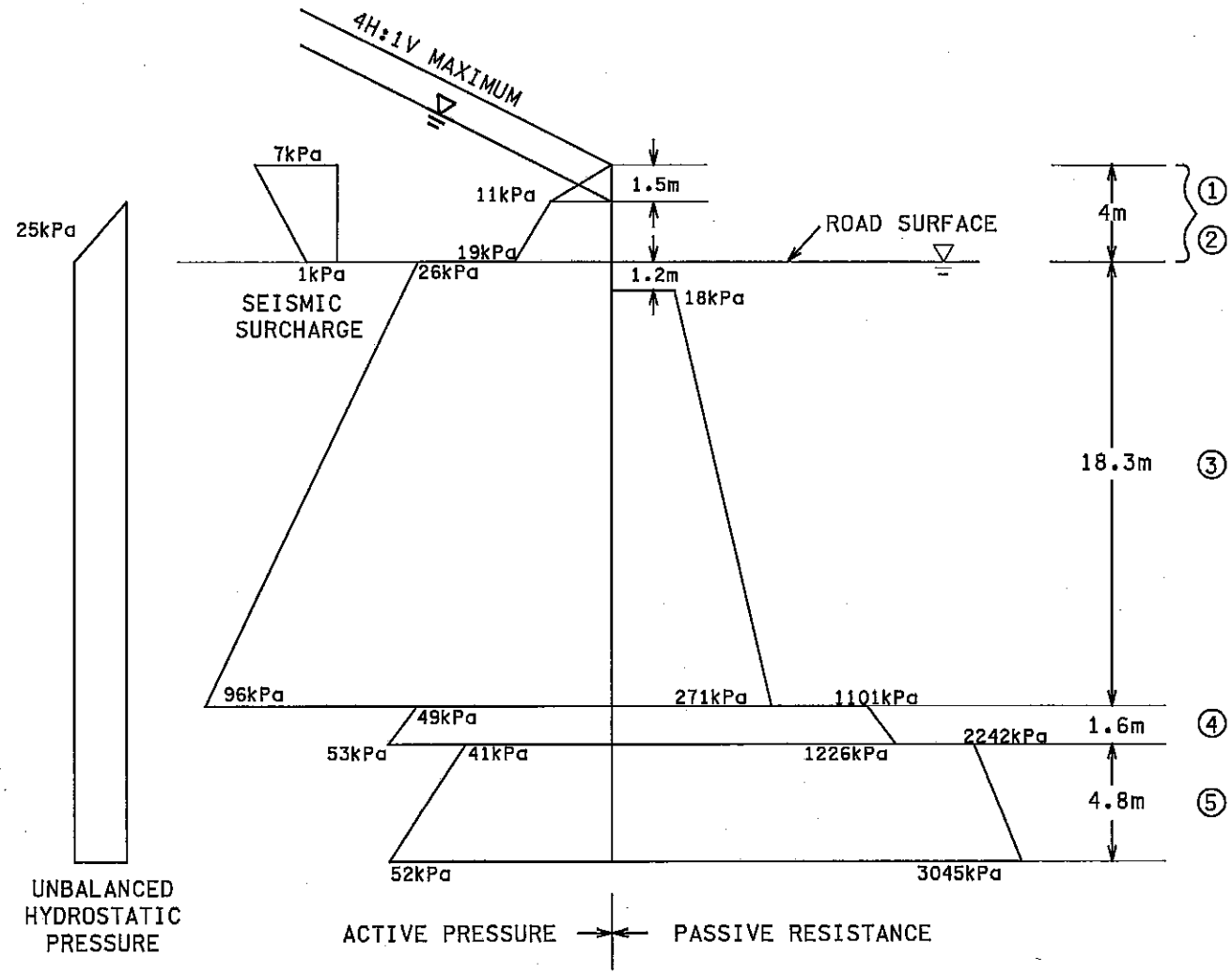
SR-5 to International Boundary Modifications
P-Y Curve Parameters for LPILE Input

Retaining Wall 8, Sta 1+723 - 1+831 - Static Analyses

Boring Elevation = 38.3 m

Soil Unit	Depth (Above) Below Road Surface		Soil Type	Soil Profile Type (KSOIL)	STATIC ANALYSES: Effective Unit Weight of Soil			Saturated Undrained Strength, Su			Axial Strain ε_{50}	Friction Angle ϕ	Modulus of Subgrade Reaction	
	m	ft			kN/m3	pci	pcf	kPa	psi	psf	(%)	(deg)	MN/m3	pci
1A	(9.1) - (7.6)	29.9)-(24.9	SAND	4	19.6	0.07	125	0.0	0.0	0	-	36	26	95
1B	(7.6) - (5.1)	(24.9)-16.7	SAND	4	11.4	0.04	73	0.0	0.0	0	-	38	31	115
2	(5.1) - (0.6)	(16.7)-(2.0)	CLAY	2	8.3	0.03	53	71.9	10.4	1500	0.007	0	80	300
3	(0.6) - 18.3	(2.0) - 60.0	CLAY	1	7.5	0.03	48	6.2	0.9	130	0.02	0		
5	>18.3	>60.0	SAND	4	9.8	0.04	63	0.0	0.0	0	-	42	46	170

APPENDIX D – LATERAL PRESSURE DIAGRAM



① & ② $\varnothing = 31°$, $\gamma_m = 18.9\ kN/m^3$, $\gamma_{sub} = 9.1\ kN/m^3$, $K_a = 0.38$, $\Delta K_{ae} = 0.12$

③ $\varnothing = 19°$, $\gamma_{sub} = 7.5\ kN/m^3$, $K_a = 0.51$, $K_p = 1.97$

④ $\varnothing = 36°$, $\gamma_{sub} = 9.8\ kN/m^3$, $K_a = 0.26$, $K_p = 8.02$

⑤ $\varnothing = 42°$, $\gamma_{sub} = 11.4\ kN/m^3$, $K_a = 0.20$, $K_p = 14.66$

RETAINING WALL 8 STATION 1+723-1+831 (4H:1V) BACKSLOPE

FIGURE D-1: EARTH PRESSURE DIAGRAM

JOB OL-3500 S.R. 543 C.S. _____ LAYOUT _____

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