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Washington State Department of Transportation

Memorandum

Date: April 23, 1996

From: T. M Allen/D. G. Chadbourne
OSC Geotechnical Branch
47365

Phone: (360) 709-5456
FAX 709-5585

File to Tukwila - Stage 7

Subject: SR-5, CS , OL-1922
~~Port of Tacoma to Tukwila - Stage 4~~
Detention Pond Vic. MP 141.25

To: G. F. Demich/P. D. Slagel
Olympic Region, 47440

As requested, we have completed the geotechnical analysis of the South 360th Regional Retention/Detention Pond. The pond is located to the east of SR-5 in the vicinity of MP 141.3. The detention pond will consist of two cells separated by an embankment located along the existing dike road. Figure 1, in Appendix A, depicts the contours of the proposed detention facility. The maximum height of the Milton Road South embankment will be approximately 3 m (10 ft) on the upstream side. Outlet control structures will be located in the Milton Road South embankment and dike road embankment.

Our analysis included the following project elements:

- overall stability of the detention pond embankments under both normal full pool and rapid draw down conditions
- effect on existing structures in the area, specifically the bridge approach embankment for the SR-5 Overcrossing Bridge No. 161/102 and the embankment along SR-5.
- the detention pond embankments, including recommendations for minimum widths and maximum side slopes
- recommendations for the design of the outlet control structures including seepage control

The analyses, conclusions, and recommendations presented in this memorandum are based on the project description and site conditions that existed at the time of the field exploration. We assume the exploratory borings represent the subsurface conditions throughout the project area. If different subsurface conditions are encountered or appear to be present, we should be contacted so that we can reevaluate our recommendations and assist you.

Regional Geology

The project site is in the southern portion of the Puget Lowland physiographic province of Washington State. The Puget Lowland is a structural and topographic low bounded on the west by the Olympic and Coast Mountains and on the east by the Cascade Range. The north-south trending trough has been subjected to repeated continental glaciation during the Pleistocene Epoch, resulting in extensive modifications to the land forms. Modification was the result of scour during glacial advancement from the north and deposition of glacial sediments during subsequent recessions. Due to repeated glaciation, the majority of the sediments are highly overconsolidated.

Following retreat of the most recent glacial event, the Vashon Stade of the Fraser Glaciation, erosion has been the most active process. The erosion process has primarily been acting in the upland areas with deposition taking place in the lowlands. Consequently, fluvial and estuary deposits of sands, silts, clays and peat are often found overlying the denser glacial deposits.

Seismic Stability

The Puget Lowland is a seismically active area. The seismicity of this area is associated mainly with the interaction of the Juan de Fuca and North American crustal plates. The Juan de Fuca plate is being subducted beneath the North American plate off the coast of Washington. The largest historic earthquakes in the Puget Sound region are the magnitude 7.1 Olympia (1941) and the magnitude 6.5 Seattle-Tacoma (1965) earthquakes.

Because the pond is used as a stormwater detention facility, the likelihood of a seismic failure occurring at the same time as the pond is retaining water to full capacity is remote. Our analysis did not include seismic analysis of the embankments. However, because the detention pond embankments will be founded on the very dense soils, the potential for liquefaction or significant settling of the embankments at the project site is negligible.

Field Exploration

The field exploration for this project consisted of performing seven test borings and five hand holes. In addition one test boring advanced for the foundation exploration of the SR-161 Overcrossing structure was used in design.

The information obtained from the test borings was used to characterize the subsurface conditions throughout the project area. A plan view showing the test boring locations and existing contours of the site is contained in Figure 2, in Appendix A. The edited logs of the test borings are contained in Appendix B. The edited logs of the test borings should be included in the contract documents.

In general, Standard Penetration Tests (SPT) were performed at 1.5 m (5 ft) intervals in the test borings. Disturbed soil samples from the SPT were visually classified in the field then submitted to the Headquarters Materials Laboratory for more detailed classification and testing.

The hand borings were performed along the base of the existing Milton Road South and dike road embankments in the vicinity of the culvert inlets and outlets. WSDOT portable penetrometer tests were performed in the hand borings. The portable penetrometer test consists of driving a 45 mm (1.75 inch) diameter pointed rod into the ground with a 16 kg (35 lb) weight falling 760 mm (30 inches). The results give an approximation of the relative density of the soil being tested. Factors to convert the portable penetrometer blow counts to equivalent SPT values are given on the boring logs. The conversion factors are based on experience and should be considered approximate.

Laboratory Testing

Laboratory testing was performed on selected samples from the field exploration program. The soil samples were visually examined and then grouped together based on particle size distribution, consistency, and color. Once groups of samples were established that had similar characteristics, a minimum of one sample per group was tested. Grain size analyses and water content test were conducted according to the procedures detailed in AASHTO T-27 and T-265 respectively. Determination of Atterberg limits for fine grained samples was done according to AASHTO T-89 and T-90. After testing was complete, the samples were classified using the Unified Soil Classification System (USCS). The results of the laboratory testing are contained in Appendix C.

Existing Conditions

The soils at the project site have been separated into five units based on engineering properties:

Unit 1 - Unit 1 soils make up the fill soils on the project site. Fill is present on the site at the approach embankment for the SR 161 bridge over SR-5, along SR-5, at the Milton Road South embankment and along the dike road. The fill soils generally consist of loose to dense, silty gravel with sand and silty sand with gravel.

Unit 2 - The Unit 2 soils consist of loose to medium dense, silty sand or sandy silt with gravel. Unit 2 soils were encountered in all the test borings and vary in thickness from 0.6 to 2.1 m (2 to 7 ft).

Unit 3 - The Unit 3 soils consist of dense to very dense, silty sand with gravel and silty gravel with sand. These soils generally have a fines content (minus 0.074 mm screen) of from 20 to 40 percent. This unit was encountered below the Unit 2 soils in all the test borings.

Unit 4 - Unit 4 soils consist of very dense, poorly graded sand with gravel. This soil unit was encountered beneath the Unit 3 soils in Test Borings H-4-95 and H-9-95, at depths of 7.5 m (25 ft) and 7 m (23 ft) respectively.

Unit 5 - Unit 5 soil consisting of a very hard, lean clay with sand, was only encountered in one test boring. This soil unit was encountered beneath Unit 3, in Test Boring H-8-95, at a depth of 5.5 m (18 ft).

Embankment Design

Milton Road Embankment

The existing embankment has a maximum height of approximately 5 m (16 ft), with side slopes as steep as 1.5H:1V on the down stream side of the existing culvert. The embankment soils consist of dense, silty gravel with sand and are underlain by 0.3 to 1.5 m (1 to 5 ft) layer of loose to dense, silty sand and sandy silt with gravel. Figure 3, in Appendix A, shows the existing embankment conditions at the site of Test Boring H-4-95.

When the pond is at its normal maximum storage level, the existing embankment will not provide an acceptable factor of safety for overall stability. To provide adequate overall stability, the embankment should be widened approximately 2.5 m (8 ft) on the upstream side. The embankment should have a minimum width of 9 m (30 ft) at the crest. In addition the side slopes on the downstream portion of the embankment should be flattened to 2.5H:1V.

The soil used in the widening should consist of low permeability soils compacted to 95 percent of maximum density. The low permeability soil should have a minimum of 60 percent by weight passing the 6 mm (1/4 inch) screen and a minimum of 20 percent by weight passing the 0.074 mm (No. 200) screen. Based on the test boring explorations and the results of the laboratory testing, common borrow from the detention pond excavations should meet the requirements of low permeability soil.

We understand that the side slopes of the embankment will be protected by gabion baskets or similar slope protection to prevent erosion. If the upstream embankment slopes are protected, side slopes of 2H:1V will provide an acceptable factor of safety for rapid drawdown conditions. If the upstream embankment slopes are not protected, the side slopes should be constructed at 2.5H:1V or flatter. We recommend that a layer of geotextile be placed beneath the gabions to prevent loss of subgrade support. The geotextile should meet the specifications of a construction geotextile for permanent erosion control, moderate survivability, Class B.

Dike Road Embankment

The dike road embankment will separate the two ponds. The embankment will have a maximum height of 3.3 m (11 ft) on the downstream side and 2.8 m (9 ft) on the upstream side. An existing culvert and embankment are located at the east end of the dike road. The existing embankment has a maximum height of approximately 3.3 m (11 ft) and consists of very loose to medium dense, silty sand with gravel. Figure 4, in Appendix A, depicts the subsurface conditions at this site. Our analysis shows that the existing embankment would not be stable under reservoir conditions. We recommend that the embankment be removed and a new embankment constructed. The embankment should be constructed with low permeability soil as described above.

The western portion of the embankment will be formed by excavation of the detention pond on either side. Figure 5, in Appendix A, depicts the subsurface conditions in the vicinity of Test Boring H-2-95. The soils in this section consist of approximately 1.0

m (3 ft) of loose to medium dense silty sand with gravel, underlain by dense to very dense silty sand with gravel. In this section of the proposed embankment, we recommend that the top 1.0 m (3 ft) of loose material be removed and recompacted to the finished height.

For both sections of the embankment, the width across the top should be no less than 8 m (26 ft). The side slopes of the embankment should be 2.5H:1V or flatter. If slope protection such as gabion baskets are placed along the embankment, side slopes of 2H:1V will have adequate stability. A construction geotextile should be placed beneath the gabions to prevent loss of subgrade support. The geotextile should meet the specifications of a construction geotextile for permanent erosion control, moderate survivability, Class B.

Existing SR-5 Overcrossing Bridge Approach Embankment

The approach fill at Pier 1 of Bridge No. 161/102, the SR-5 O'Xing Bridge is being widened under Contract 4789. The top of the cut slope for the detention pond will be approximately 1.5 m (5 ft) from the base of the proposed fill slope. If the 1.5 m minimum distance is maintained, the stability of the approach embankment will not be affected by normal full pool or rapid drawdown conditions in the detention pond.

Embankment along SR-5

Excavation of the detention pond will create an embankment along SR-5. The maximum height difference between the pond water level at normal full pool and the northbound SR-5 ditch line is approximately 2.7 m (9 ft). This condition exists at the south end of the pond in the vicinity of Station 227+445 on SR-5. If the top width of the embankment is a minimum of 9 m (30 ft), the side slopes along SR-5 will have adequate stability under normal full pool conditions. Seepage into the SR-5 ditch line under normal full pool conditions will be negligible.

Outlet Control Structures

Milton Road

We understand that concrete culverts will be installed in both pond embankments at the approximate locations of the existing culverts. An 1.5 m (60 inch) diameter culvert will be installed in the Milton Road South embankment. Portable penetrometer tests were performed on each end of the existing culvert to investigate the subsurface soils. Based on the tests, approximately 0.6 m (2 ft) of loose to medium dense soil should be excavated below the base of the existing culvert to insure that the pipe is founded on the very dense Unit 3 soil. Where loose soil is found at the base of the excavation, the loose soil should be overexcavated and replaced with good quality material compacted to 95 % of maximum density. The culvert excavation should be backfilled with Controlled Density Fill (CDF) to reduce seepage along the pipe.

To intercept any seepage along the pipe, a filter diaphragm should be constructed on the down stream portion of the embankment. The filter diaphragm should be located such that there is a minimum of 1 m (3 ft) cover over the top of the culvert. At the Milton Road Embankment the above criteria will locate the filter approximately 4.5 m

(15 ft) from the down stream shoulder of the embankment. The diaphragm should have a minimum thickness of 0.3 m (1 ft) and extend a minimum of 0.6 m (2 ft) beneath the base of the pipe. The diaphragm should extend out approximately 1.5 m (5 ft) on either side of the culvert. The filter should be constructed of fine aggregate for concrete Class 2, per Section 9-03.1(2)B of the WSDOT Standard Specifications. From the downstream side of the filter diaphragm, a drainage layer of consisting of gravel backfill for drains should be placed below the pipe. The drainage layer should be wrapped with construction geotextile for underground drainage, moderate survivability, Class B. Figure 6 shows a detail for the placement of the CDF and the filter diaphragm. As an alternative, the culvert may be backfilled with CDF for its entire length and the drainage layer constructed beside it downstream from the filter diaphragm.

The outlet control structure located at the toe, on the upstream side of the embankment, should be founded on the very dense Unit 3 soil. At the Milton Road South embankment this will require embedment of approximately 1 m (3 ft) beneath the existing ground surface at the base of the embankment.

Dike Road

Portable penetrometer tests were done at the inlet and outlet of the existing culvert at the dike road embankment. Based on the tests, approximately 0.8 m (2.5 ft) of loose soil should be overexcavated below the elevations of the existing inlet and outlet, to insure that the proposed culvert is founded on the very dense Unit 3 soils. The culvert excavation may be backfilled with CDF as detailed above, or because the embankment height and depth of ponded water will be less than at Milton Road South, the pipe can be backfilled with low permeability soil. For both alternatives a filter diaphragm should be constructed on the downstream slope of the embankment. The diaphragm should be located to insure that there is a minimum of 1 m (3 ft) of cover over the top of the pipe.

The outlet control structure located at the toe, on the upstream side of the embankment, should be founded on the very dense Unit 3 soil. At the dike road embankment this will require embedment of approximately 1 m (3 ft) beneath the existing ground surface at the base of the embankment.

Construction Considerations

Based on the test boring and laboratory testing, the soils excavated at the project site should be suitable for embankment construction where low permeability soils are specified. Soils designated low permeability should have a minimum of 60 percent by weight passing the 6 mm (1/4 inch) screen and a minimum of 20 percent by weight passing the 0.074 mm (No. 200) screen. To facilitate obtaining the necessary fine grained soils from the site excavations, the project engineer should direct the contractor to selectively stockpile the siltier soils from the excavation for use in the low permeability zones of the embankments.

If you have questions or require further information, please contact Don Chadbourne at (360) 705-5456 or Robert Kimmerling at (360) 709-5451.

TMA:dgc

DGC

Attachment

cc: N. Campbell, Olympic Region Materials, 47440
D. Althauser, King Co. DPW, Surface Water Management
J. LaVassar, DOE, Dam Safety Section

APPENDIX - A

Site Plan and Cross Sections

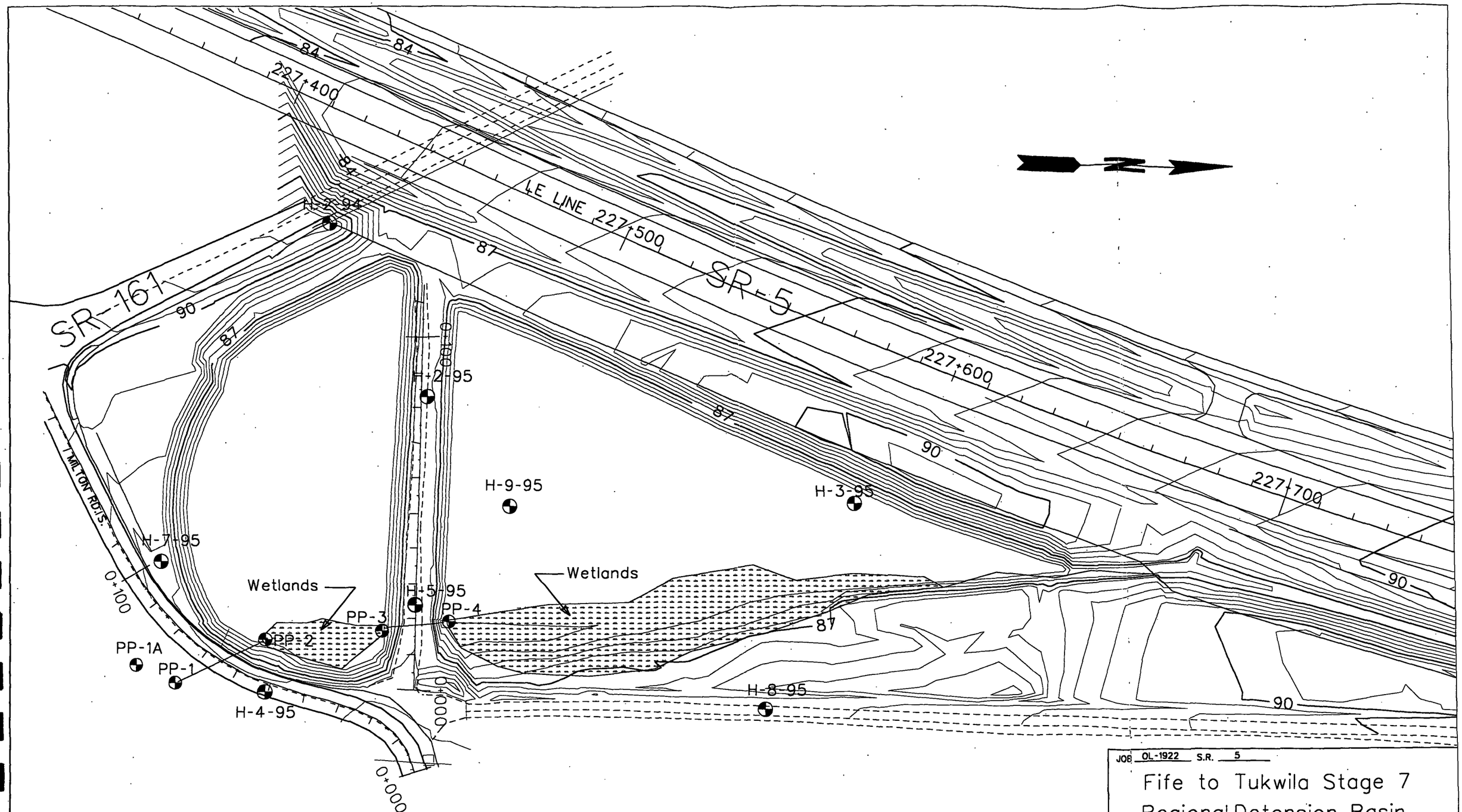

Figure 1: Proposed Detention Basin Contours

Contour interval 0.5 m.

JOB OL-1922 S.R. 5

Fife to Tukwila Stage 7
Regional Detension Basin

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION

MATERIALS BRANCH
D. C. JACKSON MATERIALS ENGINEER

DATE 1/18/96
SCALE 1:100 VERT.
1:100 HORIZ.
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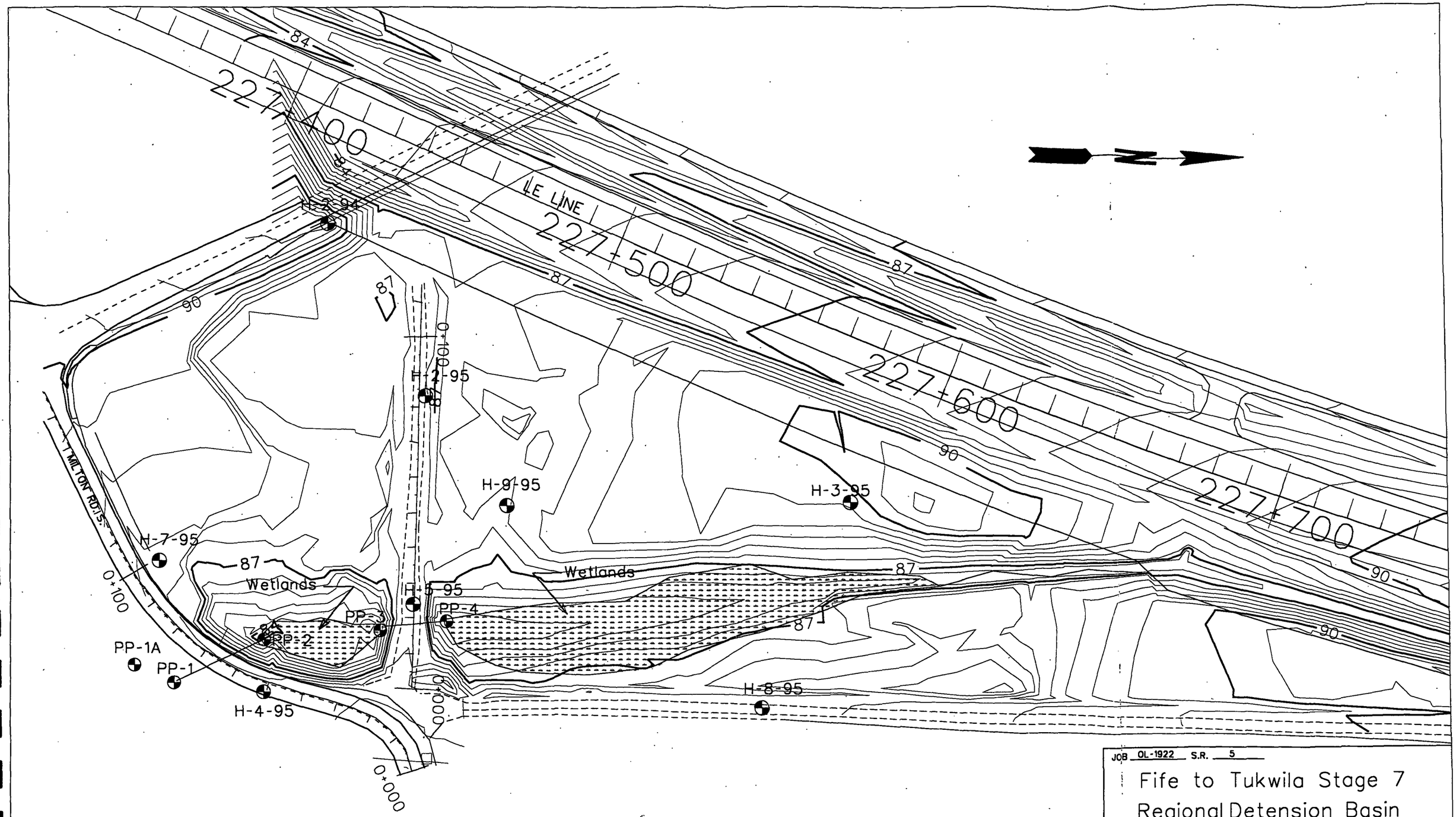

Scale in meters

0 25 50 75 100

Figure 2: Existing Contours at Project Site

Contour interval 0.5 m.

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Fife to Tukwila Stage 7
Regional Detension Basin

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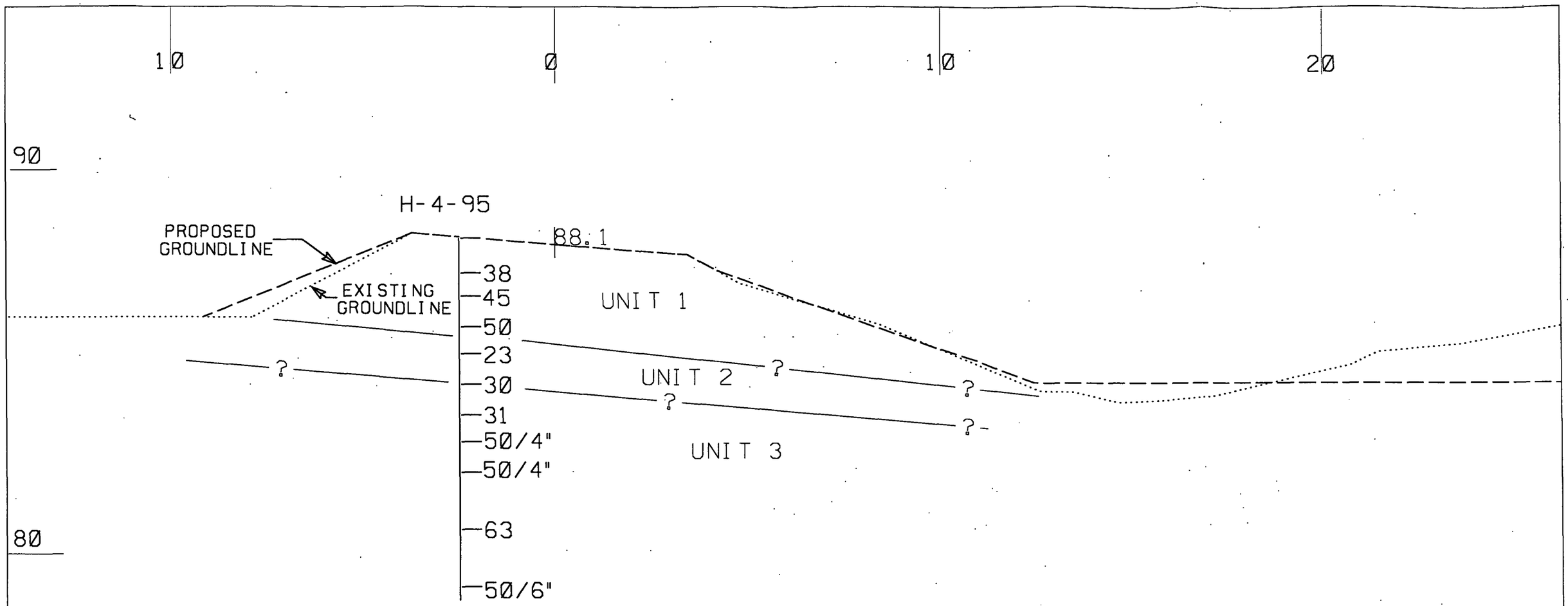

UNIT 1 LOOSE TO DENSE SILTY GRAVEL WITH SAND AND SILTY SAND WITH GRAVEL.

UNIT 2 LOOSE TO MEDIUM DENSE, SILTY SAND WITH GRAVEL AND SANDY SILT WITH GRAVEL.

UNIT 3 DENSE TO VERY DENSE SILTY SAND WITH GRAVEL.

Figure 3:

MILTON ROAD EMBANKMENT

JOB OL-1922 S.R. 5

FIFE TO TUKWILA STAGE 7
REGIONAL DETENSION BASIN

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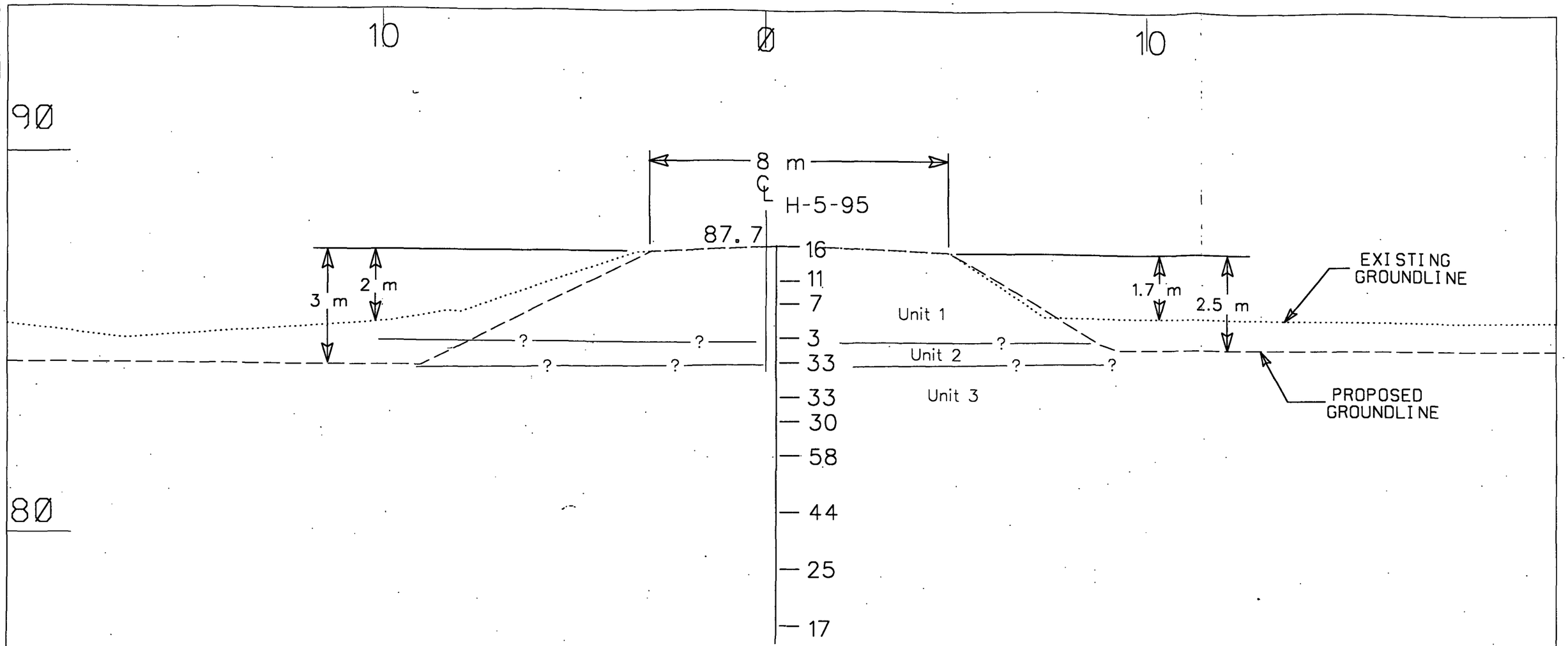

UNIT 1 LOOSE TO DENSE SILTY GRAVEL WITH SAND AND SILTY SAND WITH GRAVEL.

UNIT 2 LOOSE TO MEDIUM DENSE, SILTY SAND WITH GRAVEL AND SANDY SILT WITH GRAVEL.

UNIT 3 DENSE TO VERY DENSE SILTY SAND WITH GRAVEL.

Figure 4:

Existing Dike Road Embankment - East End

JOB OL-1922 S.R. 5

Fife to Tukwila Stage 7 Regional Detension Basin

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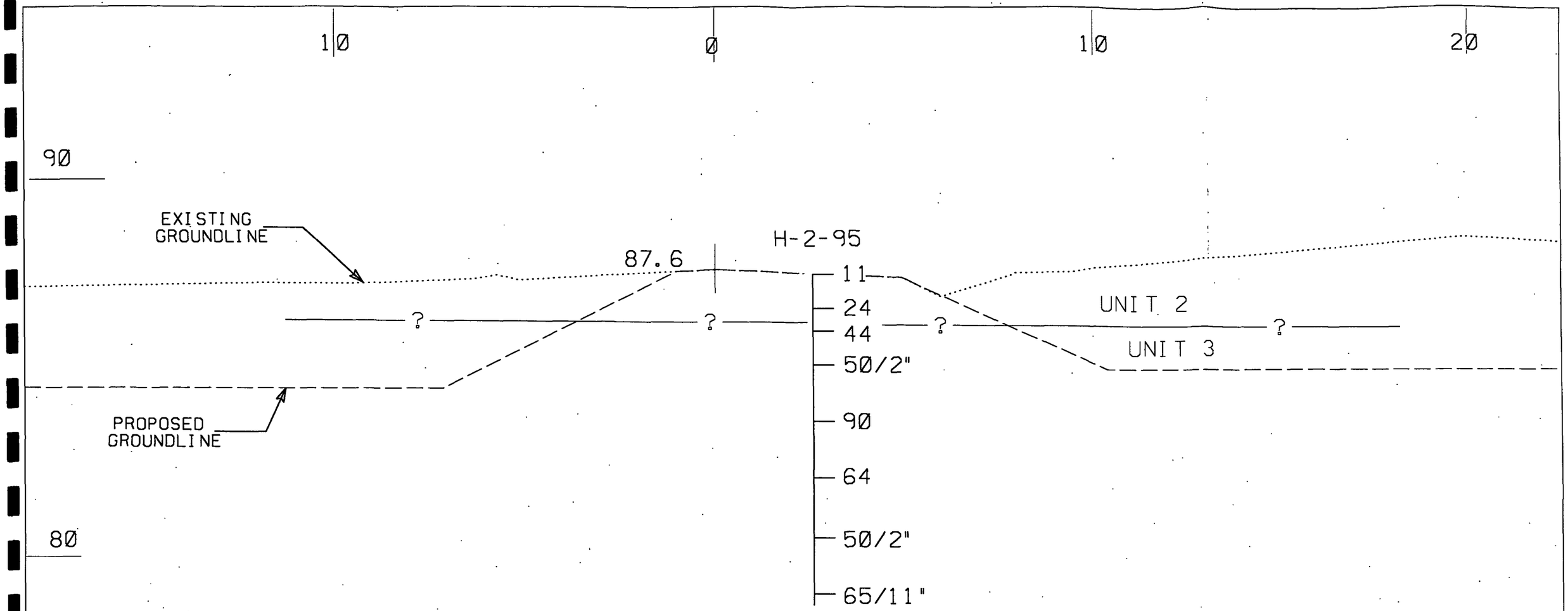

UNIT 2 LOOSE TO MEDIUM DENSE, SILTY SAND WITH GRAVEL AND SANDY SILT WITH GRAVEL.

UNIT 3 DENSE TO VERY DENSE SILTY SAND WITH GRAVEL.

Figure 5:

DIKE ROAD - WEST END OF EMBANKMENT

JOB OL-1922 S.R. 5

Fife to Tukwila Stage 7
Regional Detension Basin

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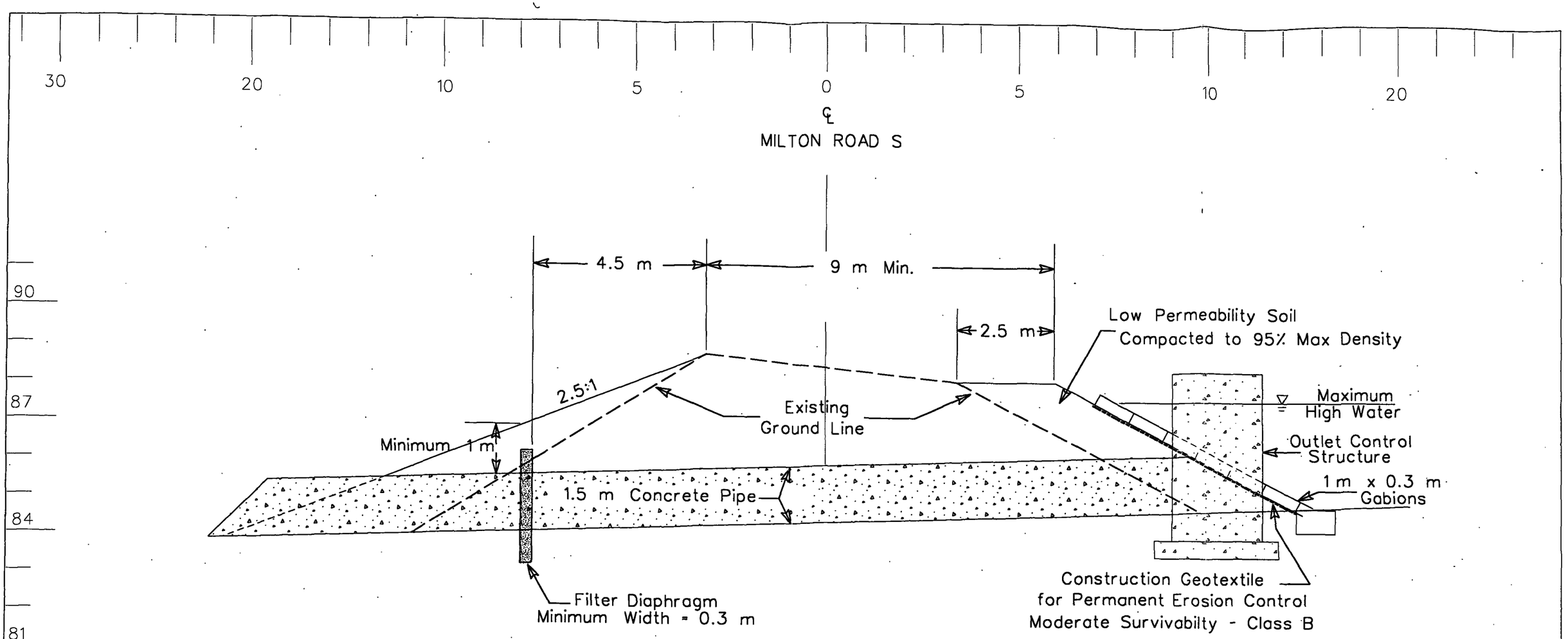

Figure 6:

Milton Road S. Outlet Control Structure

JOB OL-1922 S.R. 5

Fife to Tukwila Stage 7
Regional Detension Basin

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MATERIALS BRANCH
D. C. JACKSON MATERIALS ENGINEER

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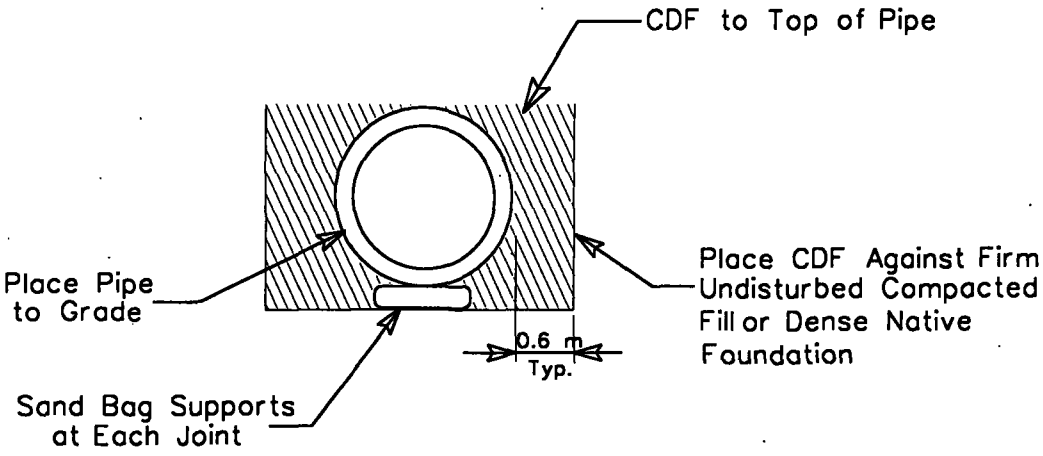
Section Upstream of Filter Diaphragm



Section Downstream of Filter Diaphragm

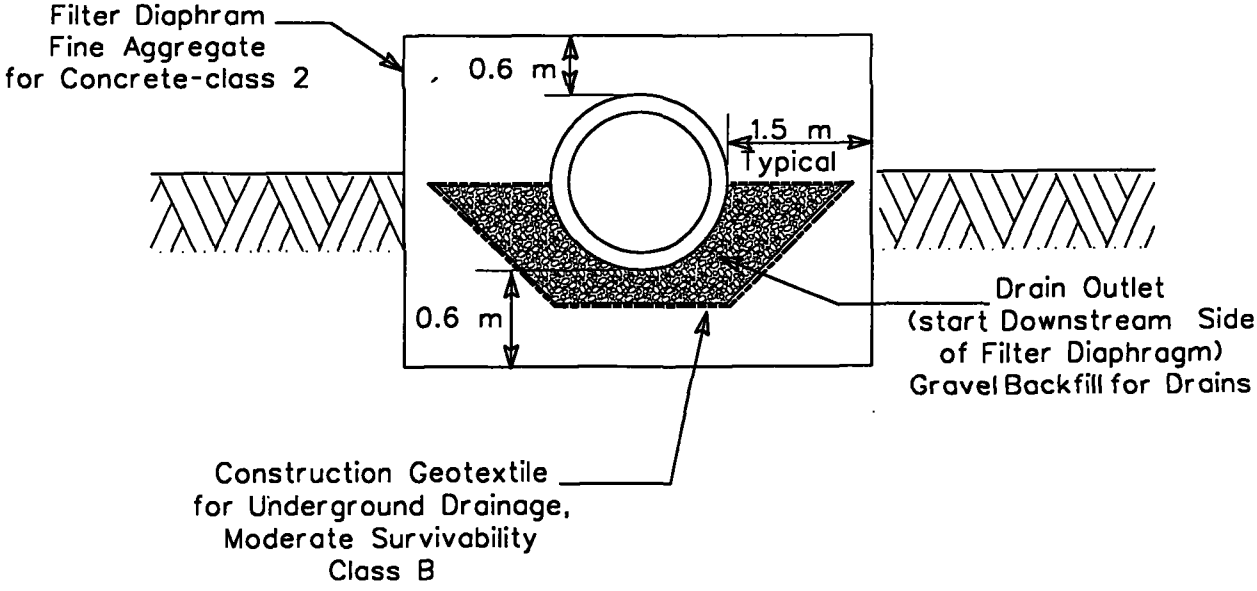


Figure 7: Pipe Bedding Detail

JOB OL-1922 S.R. 5

Fife to Tukwila Stage7
Regional Detension Basin

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D. C. JACKSON MATERIALS ENGINEER

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APPENDIX - B

Logs of Test Borings

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-2-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station **LE 227+467** Offset **64 m. Rt.** C.S. **1701**

Equipment _____ Casing **?** Ground El **287.0 (87.48 m)**

Method of Boring **Augers**

Start Date **October 31, 1995** Completion Date **October 31, 1995** Sheet **1** of **2**

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
				16 6 5 6 (11)		D-1		Silty SAND with gravel and root hairs, rounded, brown, moist. Retained: 1.5 ft.		
	1			5 10 14 16 (24)		D-2	GS MC AL	SM, M.C. = 13% Silty SAND with gravel rounded, medium dense, grayish brown, moist. Retained 1.6 ft.		
5	2			16 21 23 33 (44)		D-3		SM, M.C. = 8% Silty SAND with gravel, dense, gray, moist. Retained: 0.25 ft.		
				50 (50/2")		D-4		Silty GRAVEL, rounded, very dense, gray, moist,(sample is mostly silt but drill behavoir indicates gravel). Retained : 0.15 ft.		
10	3									
	4		> >	25 40 50 (90)		D-5	GS MC	SM, M.C. = 9% Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 1.25 ft.		
15	5									
			> >	20 32 32 26 (64)		D-6		Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 1.3 ft.		
20	6									

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. H-2-95

Sheet 2 of 2

PROJECT FIFE TO TUKWILA-STAGE 7

Job No. OL-1922

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
	7			50 (50/2")		D-7		Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 0.2 ft.		
25	8									
			> >	15 50/5 (65/11")		D-8		Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 0.9 ft.		
	9							End of test hole boring at 28.9 ft. below ground elevation.		
30								Water table elevation not determined.		
	10							This is a summary Log of Test Hole Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
35	11									
	12									
40										
	13									
45										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-3-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station **LE 227+587** Offset **44 m.Rt.** C.S. **1701**

Equipment _____ Casing **?** Ground El **294.0 (89.61 m)**

Method of Boring **Augers**

Start Date **October 24, 1995** Completion Date **October 24, 1995** Sheet **1** of **2**

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
				2 2 3 2 (5)		D-1		Silty SAND with gravel and root hairs, rounded, loose, brown, moist. Retained: 1.5 ft.		
	1			10 28 32 34 (60)		D-2	GS MC	SM, M.C. = 4% Silty SAND with gravel, rounded, very dense, brown, moist. Retained: 1.5 ft.		
5				24 47 27 30 (74)		D-3		Silty SAND with gravel, rounded, very dense, brown, moist. Retained: 1.8 ft.		
	2			21 50/2" (50/2")		D-4	GS MC	SM, M.C. = 8% Silty SAND, subrounded, very dense, gray, moist. Retained: 0.7 ft.		
10	3									
	4			22 52 (52/6")		D-5		Silty SAND, subrounded, very dense, gray, dry. Retained: 0.8 ft.		
15	5									
				14 30 50 (80/10)		D-6		Silty SAND, rounded, very dense, gray, moist. Retained: 1.3 ft.		
20	6							Test Hole Boring stopped at 19.3 ft below ground		

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. H-3-95

Sheet 2 of 2

PROJECT FIFE TO TUKWILA-STAGE 7

Job No. OL-1922

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
								elevation. Water table elevation not determined. This is a Summary Log of Test Hole Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	7									
25										
	8									
	9									
30										
	10									
35										
	11									
	12									
40										
	13									
45										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-4-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

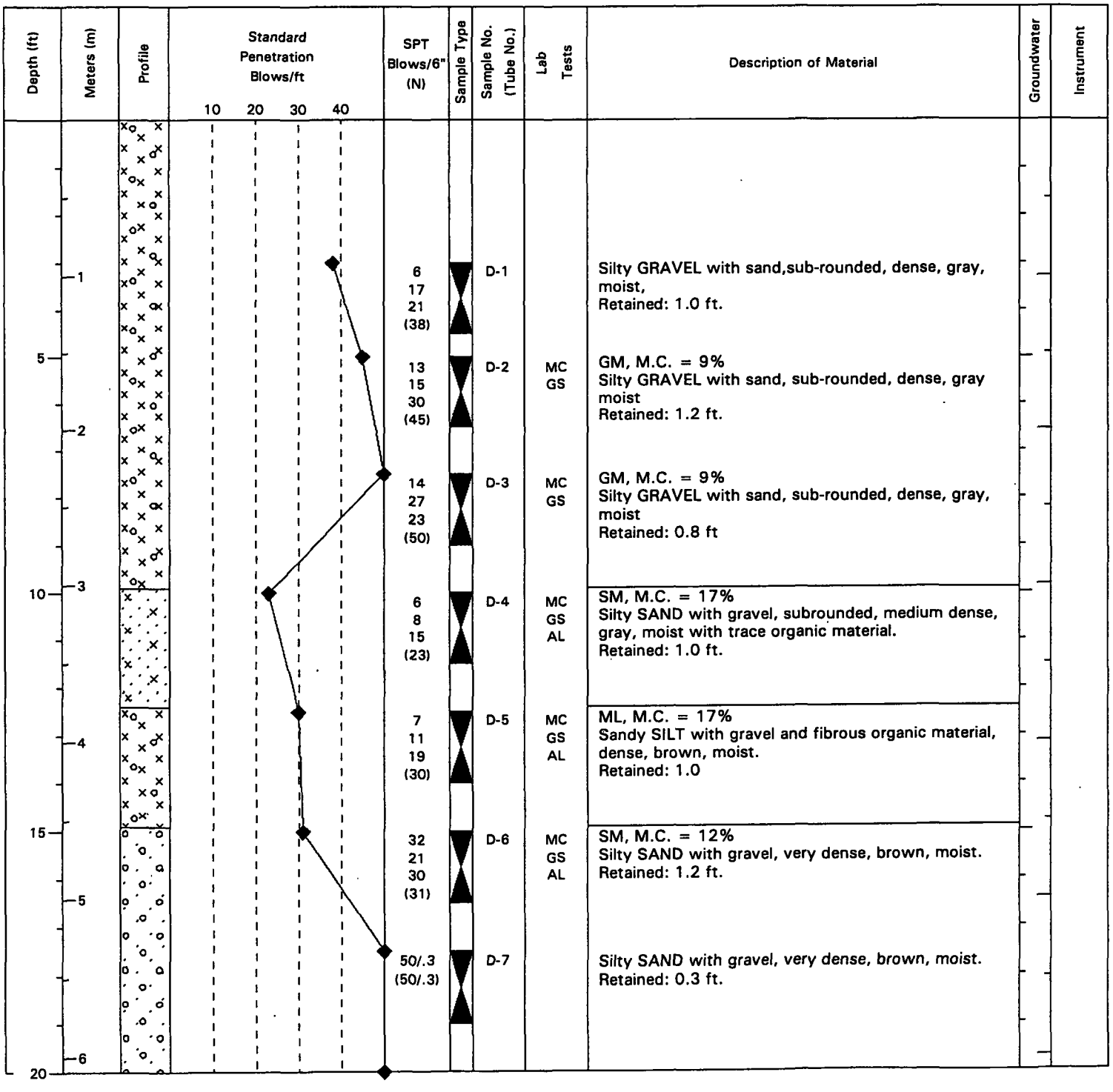
S.R. **5**

Station **LE 227+458** Offset **158 m. Rt.** C.S. **1701**

Equipment **Mobile B-61** Casing Ground El **289.0 (88.09 m)**

Method of Boring

Start Date **December 26, 1995** Completion Date **December 26, 1995** Sheet **1** of **2**



LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-4-95**

Sheet 2 of 2

PROJECT **FIFE TO TUKWILA-STAGE 7**

Job No. **OL-1922**

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
				28 50 (50/.3)		D-8		Silty SAND with gravel, very dense, brown, moist. Retained: 0.2 ft.		
25	7			18 33 30 (63)		D-9		Poorly graded SAND with gravel, very dense, brown, moist. Retained: 0.8 ft.		
30	9			21 50 (50/.5)		D-10	MC GS	SP, M.C. = 17% Poorly graded SAND with gravel, very dense, brown, moist to wet . Retained: 0.7 ft.		
								End of Test Hole Boring at 31.0 ft. below ground elevation.		
	10							Water table elevation at 28.9 ft. below ground elevation.		
35	11							This is a summary Log of Test Hole Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
40	12									
	13									
45										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-5-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station **LE 227+487** Offset **118 m. Rt.** C.S. **1701**

Equipment _____ Casing _____ Ground El **288.0 (87.78 m)**

Method of Boring **Augers**

Start Date **October 25, 1995** Completion Date **October 25, 1995** Sheet **1** of **2**

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
				22 9 7 6 (16)		D-1		Silty SAND with gravel, medium dense, brown, dry. Recovered: 1.0 ft. Retained: 0.5 ft.		
	1			3 4 7 5 (11)		D-2		Silty SAND with gravel, rounded, medium dense, brown, dry. Retained: 0.5 ft.		
5				3 4 3 3 (7)		D-3	GS MC	SM, M.C. = 9% Silty SAND with gravel,rounded, loose, brown, dry, disrupted. Retained: 0.7 ft.		
	2			1 2 1 9 (3)		D-4		SM, M.C. = 11% Silty SAND with gravel, rounded, very loose, brown, moist. Retained: 0.8 ft.		
10	3			10 18 15 8 (33)		D-5		Silty SAND with gravel, rounded, dense, gray, wet. Retained: 1.5 ft.	▽	
	4			14 15 18 22 (33		D-6	GS MC AL	SM, M.C. = 5% Silty SAND with gravel, rounded, dense, gray, wet. Retained: 1.25 ft.		
15	5			15 12 18 50 (30)		D-7	GS MC	SM, M.C. =11% Silty SAND with gravel, rounded, dense, gray, wet to moist. Retained: 1.7 ft.		
			>>	15 29 29 37 (58)		D-8		Silty SAND with gravel, rounded, very dense, gray, wet to moist. Retained: 2.0 ft.		
20	6									

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-5-95**

Sheet **2** of **2**

PROJECT **FIFE TO TUKWILA-STAGE 7**

Job No. **OL-1922**

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
				15 20 24 (44)		D-9		Silty SAND with gravel,subrounded, dense, gray, moist. Retained: 1.1 ft.		
25	7									
	8									
				12 13 12 18 (25)		D-10	GS MC	SM, M.C. = 10% Silty SAND, dense, gray, moist. Retained: 1.7 ft		
30	9									
	10			11 7 10 (17)		D-11		Silty SAND, dense, gray, moist. Retained: 1.3 ft.		
35	11							End of Test Hole Boring at 34.5 ft. below ground elevation. Water table Elevation at 12.5 ft below ground elevation. This is a summary Log of Test Hole Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	12									
40	13									
45										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-7-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station **LE 227+95** Offset **136 m. Rt.** C.S. **1701**

Equipment _____ Casing _____ Ground El **290.0 (88.39 m)**

Method of Boring **Augers**

Start Date **October 30, 1995** Completion Date **October 30, 1995** Sheet **1** of **2**

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
				4 5 2 1 (7)		D-1		Silty SAND with gravel and root hairs, rounded, loose, brownish gray, moist. Retained: 0.25 ft.		
	1			2 1 6 7 (7)		D-2	GS MC	SM, M.C. = 14% Silty SAND with gravel and root hairs, rounded, loose, brownish gray, moist. Retained: 0.5 ft.		
5				5 6 9 13 (15)		D-3	GS MC AL	ML, M.C. = 15% Sandy SILT, very stiff, gray, brown, moist to dry. Retained: 1.2 ft.		
	2		> >	18 33 31 29 (64		D-4	GS MC	SM, M.C. = 9% Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 1.3 ft.		
10	3			19 24 23 22 (47)		D-5		SM, M.C. = 8% Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 1.5 ft.		
	4		> >	33 47 45 50 (92)		D-6		Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 1.4 ft.		
15	5		> >	29 50/5 (50/5")		D-7		Silty SAND with gravel, rounded, very dense, gray, moist. Retained: 0.9 ft.		
								End of Test Hole Boring at 16.9 ft. below ground elevation. Water table elevation not determined. This is a summary Log of Test Hole boring.		
20	6									

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. H-7-95

Sheet 2 of 2

PROJECT FIFE TO TUKWILA-STAGE 7

Job No. OL-1922

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
								Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	7									
25										
	8									
	9									
30										
	10									
35										
	11									
	12									
40										
	13									
45										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-8-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

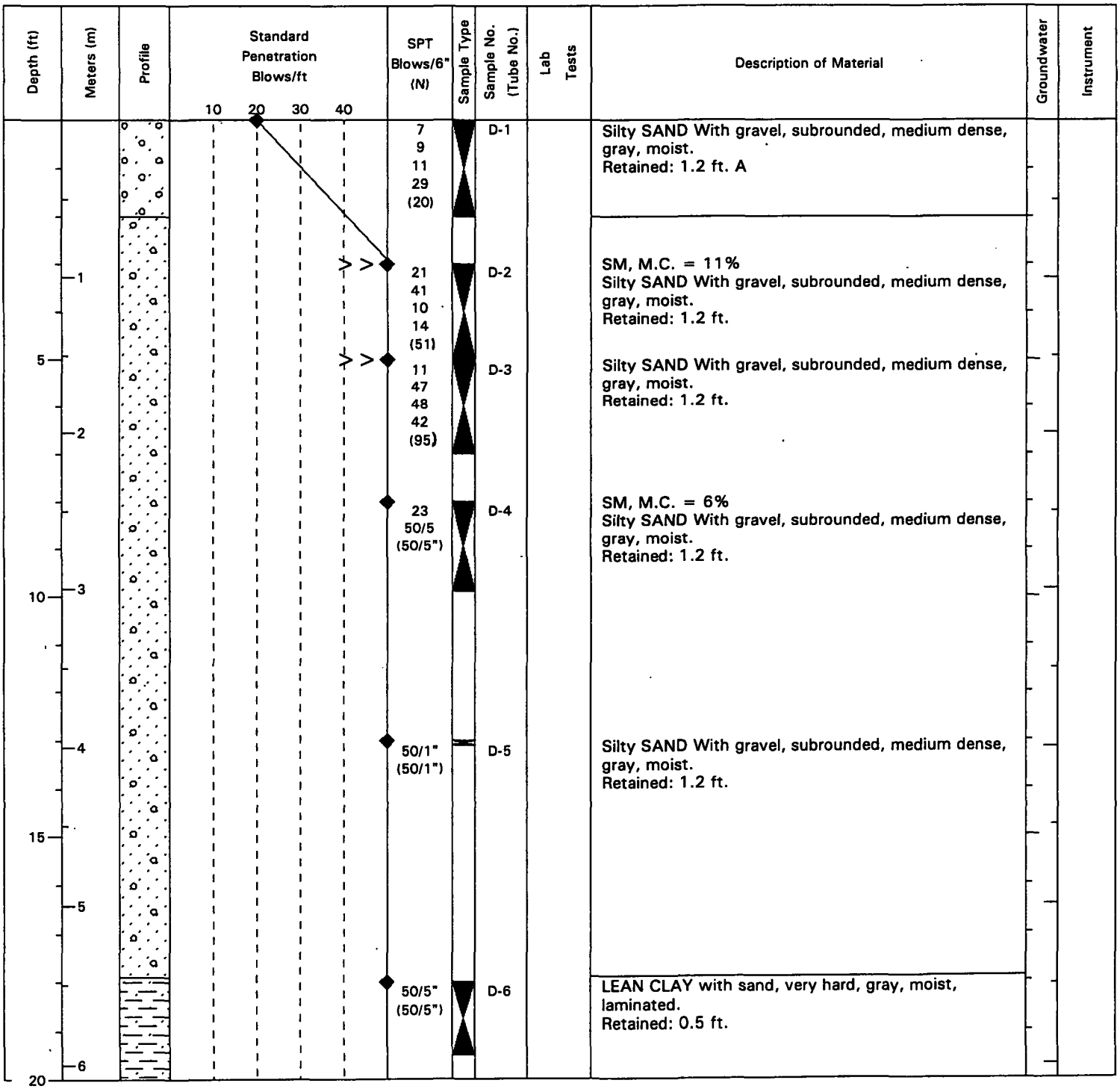
S.R. **5**

Station **LE 227+584** Offset **113 m. Rt.** C.S. **1701**

Equipment _____ Casing _____ Ground El **290.0 (88.39 m)**

Method of Boring **Augers**

Start Date **October 26, 1995** Completion Date **October 26, 1995** Sheet **1** of **2**



LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. H-8-95

Sheet 2 of 2

PROJECT FIFE TO TUKWILA-STAGE 7

Job No. OL-1922

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
	7			14 22 33 50 (55)	D-7			CL, M.C. = 21% LEAN CLAY with sand, hard, gray, moist, laminated. Retained: 2.0 ft.		
25	8							Test Hole Boring stopped at 24.9 ft below ground elevation. Water table elevation not determined. This is a summary Log of Test Hole Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
30	9									
	10									
35	11									
	12									
40	13									
45										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **H-9-95**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station **LE 227+500** Offset **83 m. Rt.** C.S. **1701**

Equipment _____ Casing _____ Ground El **289.0 (88.09 m)**

Method of Boring **Augers**

Start Date **December 11, 1995** Completion Date **December 11, 1995** Sheet **1** of **2**

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
				6 6 4 (10)		D-1		SILT with Sand, stiff, brown, moist. Retained: 1.6 ft.		
	1			3 15 25 (40)		D-2	GS AL MC	SM, M.C. = 11% Silty SAND with Gravel, rounded, dense, gray, moist. Retained: 0.5 ft		
5	2			8 22 33 (55)		D-3	GS AL MC	SM, M.C. = 9% Silty SAND with Gravel, rounded, very dense, gray, moist. Retained: 1.0 ft.		
10	3									
	4			11 22 22 (44)		D-4		Silty SAND with Gravel, rounded, dense, gray, moist. Retained: 1.3 ft.		
15	5									
				10 12 9 (21)		D-5	GS AL MC	SM, M.C. = 12% Silty SAND with Gravel, rounded, medium dense, gray, moist to wet. Retained: 1.5 ft.		
20	6									

LOG OF TEST BORING

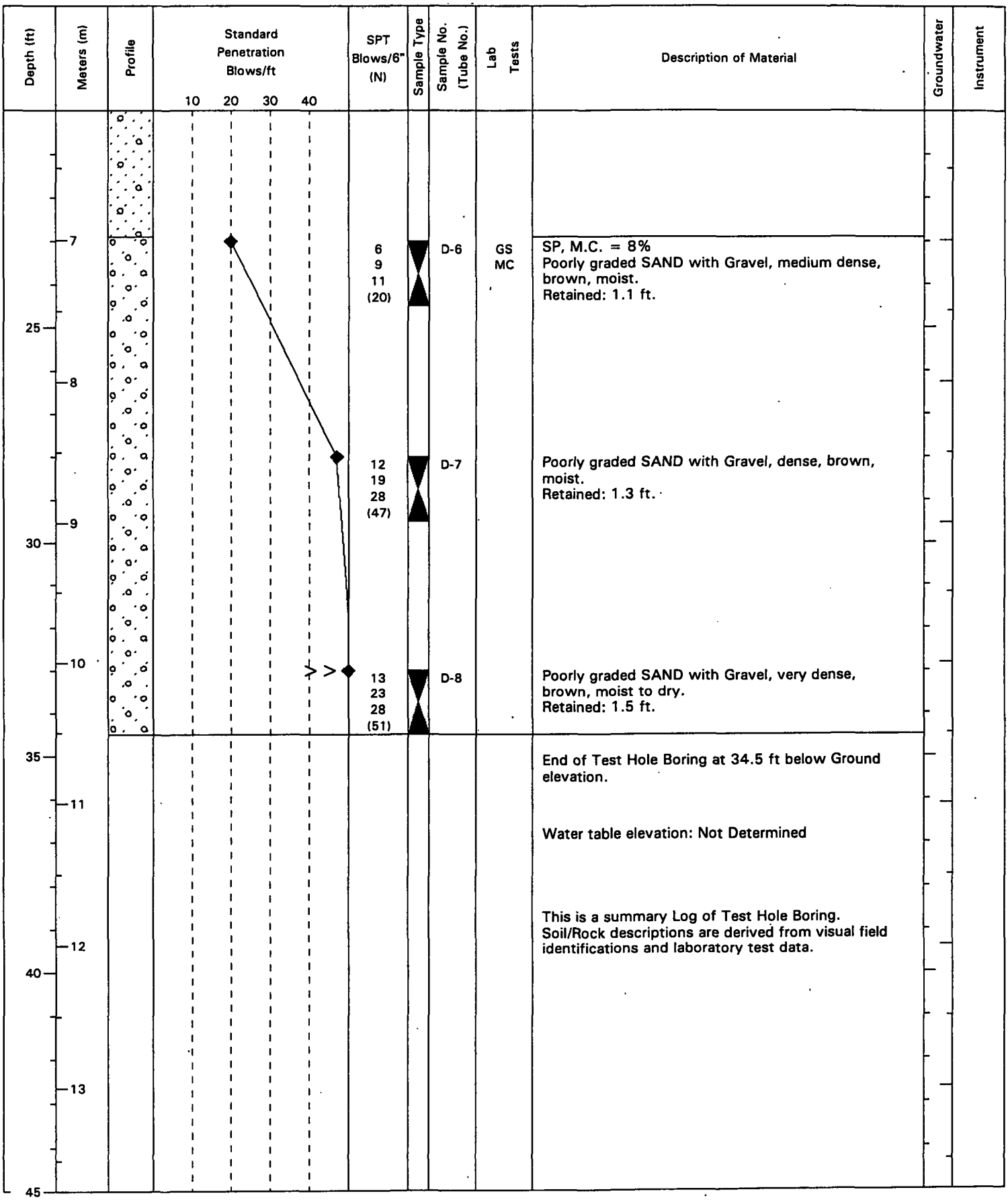
Washington State Department of Transportation

HOLE No. H-9-95

Sheet 2 of 2

PROJECT FIFE TO TUKWILA-STAGE 7

Job No. OL-1922



LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **PP-1-96**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

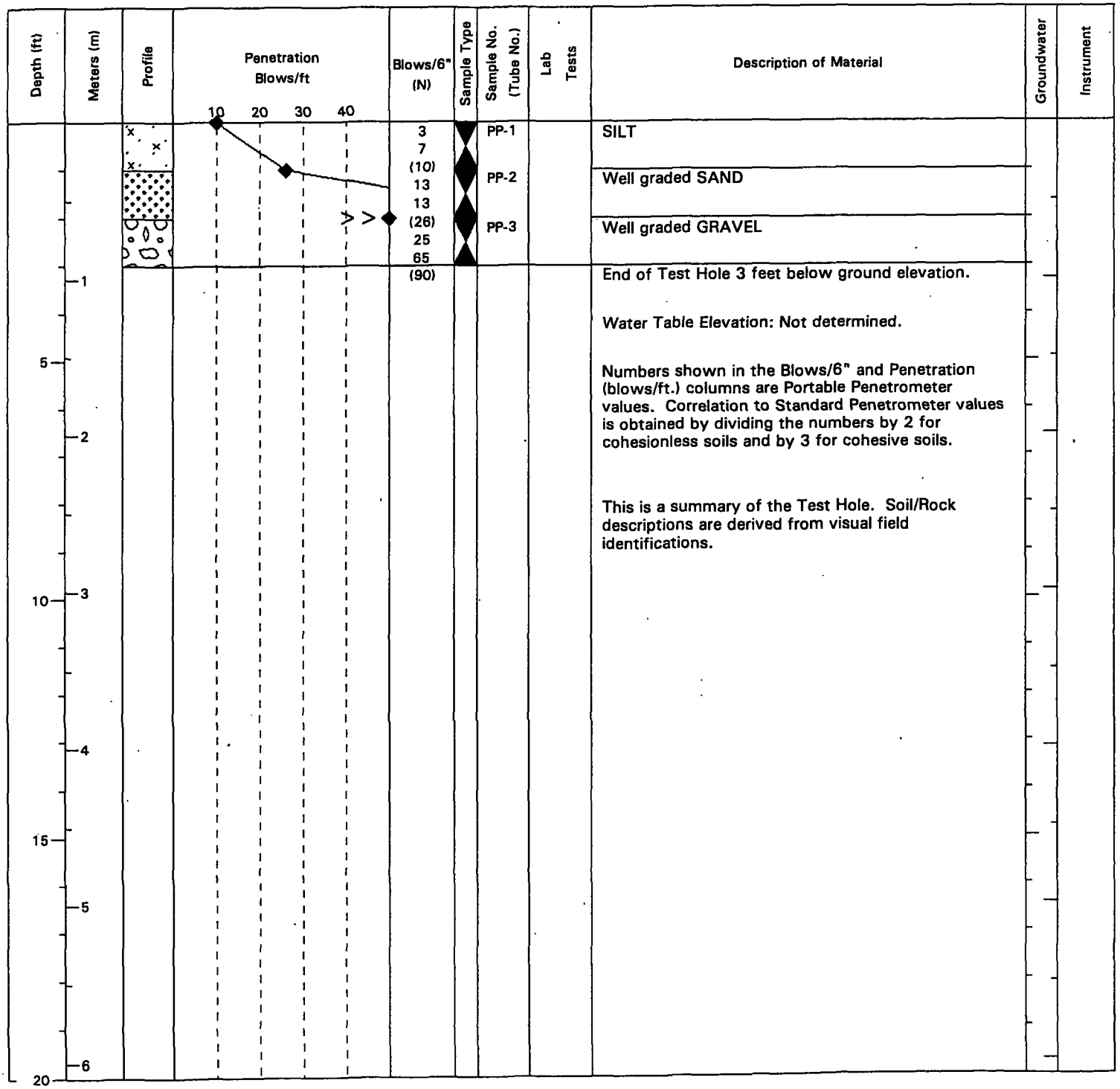
S.R. **5**

Station _____ Offset _____ C.S. **1701**

Equipment **Port. Penetrometer** Casing _____ Ground El **(m)**

Method of Boring **Port. Penetrometer**

Start Date **January 31, 1996** Completion Date **January 31, 1996** Sheet **1** of **1**



LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **PP-1A-96**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station _____ Offset _____ C.S. **1701**

Equipment _____ Casing _____ Ground El **(m)**

Method of Boring **Portable Pen.**

Start Date **January 31, 1996** Completion Date **January 31, 1996** Sheet **1** of **1**

Depth (ft)	Meters (m)	Profile	Penetration Blows/ft (10 20 30 40)	Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				6 11 (17) 26		PP-1		Well graded SAND		
				20 (46) 11		PP-2				
				9 (20) 15 60		PP-3		SILT		
				(75)		PP-4		Well graded GRAVEL		
5	1							End of Test Hole at 4 feet below ground elevation.		
	2							Water Table Elevation: Not determined.		
10	3							Numbers shown in the Blows/6" and Penetration (blows/ft) columns are Portable Penetrometer values. Correlation to Standard Penetrometer values is obtained by dividing the numbers by 2 for cohesionless soils and by 3 for cohesive soils.		
	4							This is a summary of the Test Hole. Soil/Rock descriptions are derived from visual field identifications.		
15	5									
20	6									

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **PP-2-96**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

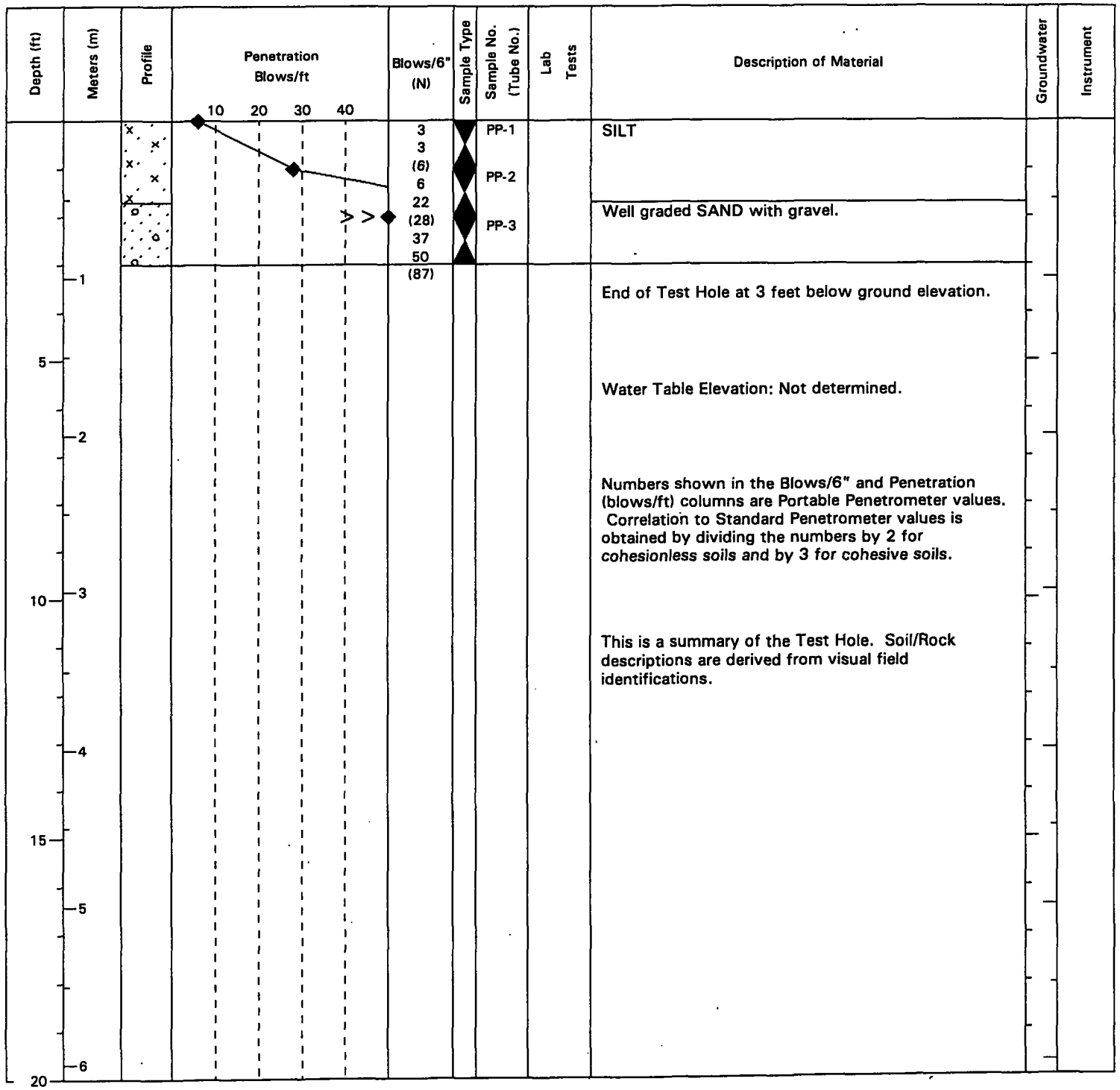
S.R. **5**

Station _____ Offset _____ C.S. **1701**

Equipment _____ Casing _____ Ground El **(m)**

Method of Boring **Portable Pen.**

Start Date **January 31, 1996** Completion Date **January 31, 1996** Sheet **1** of **1**



LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **PP-3-96**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

S.R. **5**

Station _____ Offset _____ C.S. **1701**

Equipment _____ Casing _____ Ground El **(m)**

Method of Boring **Portable Pen.**

Start Date **January 31, 1996** Completion Date **January 31, 1996** Sheet **1** of **1**

Depth (ft)	Meters (m)	Profile	Penetration Blows/ft (10 20 30 40)	Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				7		PP-1		SILT		
				7 (14)						
				8		PP-2				
				16 (24)						
				20		PP-3		Well graded SAND with gravel		
	1			27 (47)						
				40		PP-4				
				60 (100)				End of Test Hole at 4 feet below ground elevation.		
5	2							Water Table Elevation: Not determined.		
								Numbers shown in the Blows/6" and Penetration (blows/ft) columns are Portable Penetrometer values. Correlation to Standard Penetrometer values is obtained by dividing the numbers by 2 for cohesionless soils and by 3 for cohesive soils.		
10	3							This is a summary of the Test Hole. Soil/Rock descriptions are derived from visual field identifications.		
	4									
15	5									
20	6									

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **PP-4-96**

PROJECT **FIFE TO TUKWILA-STAGE 7** Job No. **OL-1922**

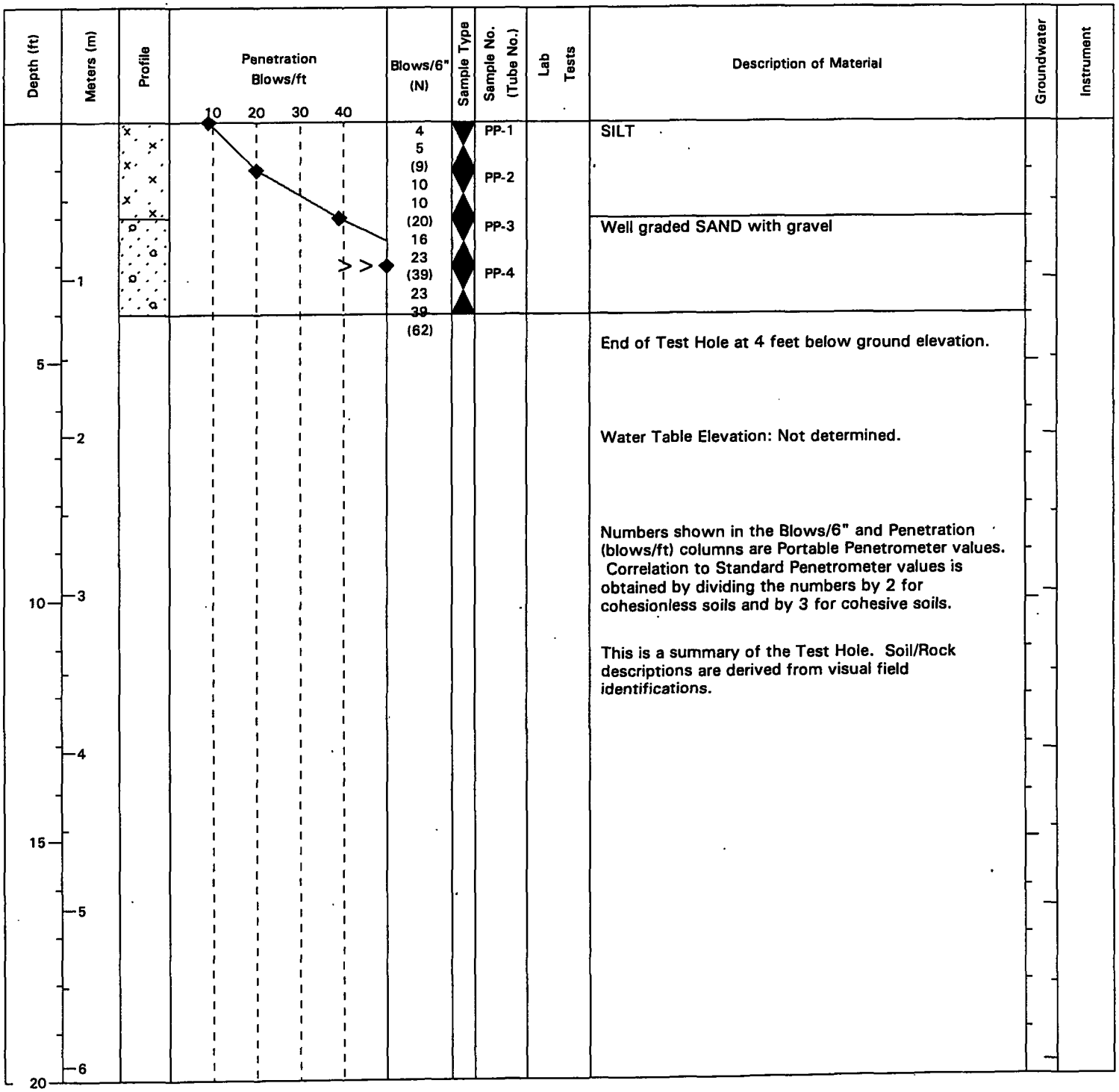
S.R. **5**

Station _____ Offset _____ C.S. **1701**

Equipment _____ Casing _____ Ground El **(m)**

Method of Boring **Portable Pen.**

Start Date **January 31, 1996** Completion Date **January 31, 1996** Sheet **1** of **1**



APPENDIX - C

Laboratory Test Data

Job No. OL-1922 Date January 23, 1996

Hole No. H-2-95 Sheet 1 of 1

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

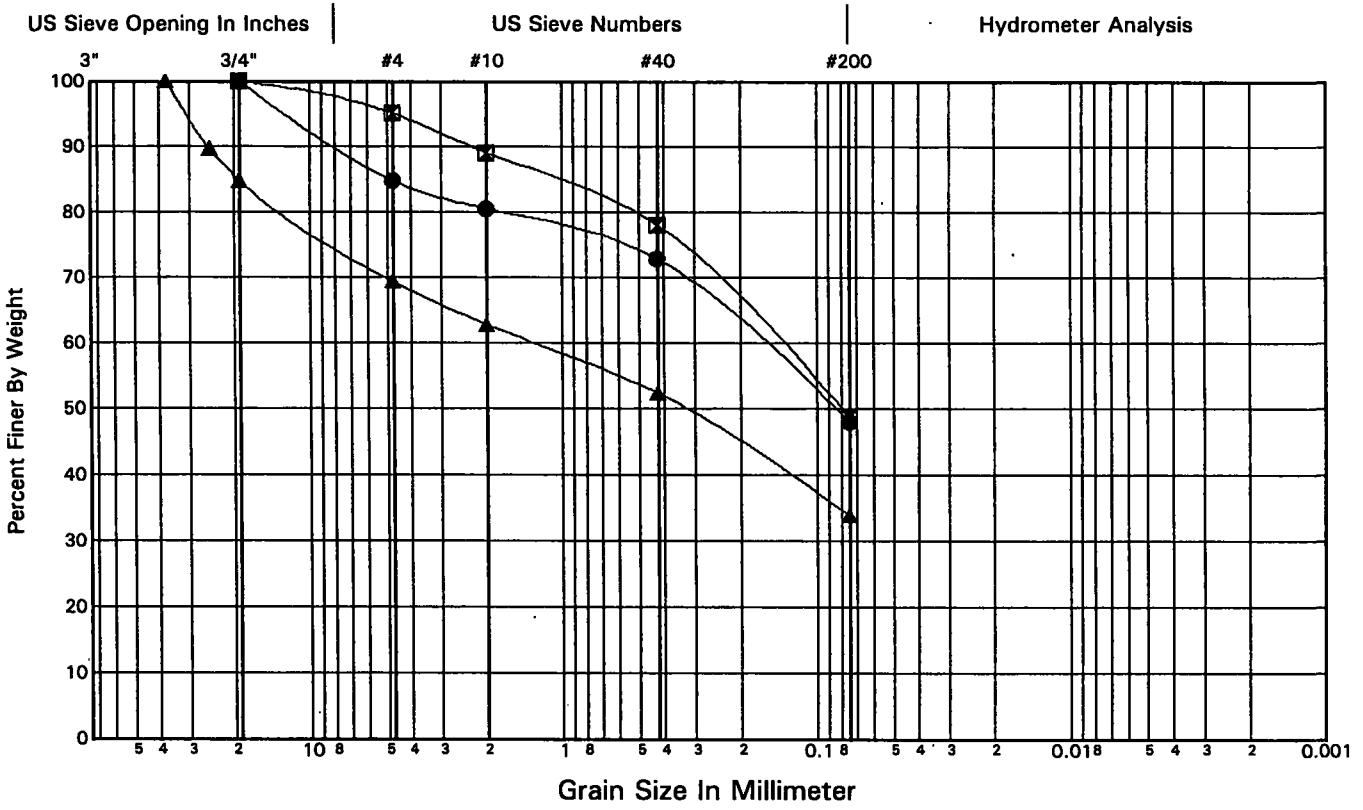
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	3.0	0.91	D-2	SM	GRAYISH BROWN	SILTY SAND with GRAVEL	13	NP	NP	NP
⊠	5.0	1.52	D-3	SM	OLIVE GRAY	SILTY SAND	8	NP	NP	NP
▲	13.0	3.96	D-5	SM	OLIVE GRAY	SILTY SAND with GRAVEL	9	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	15.2	36.8	48.0		
⊠	4.9	46.4	48.7		
▲	30.6	35.5	33.9		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.17	0.09			
⊠	0.15	0.08			
▲	1.32	0.34			



Job No. **OL-1922** Date **March 29, 1996**

Hole No. **H-3-95** Sheet **1** of **1**

Project **FIFE TO TUKWILA-STAGE 7**

Laboratory Summary

Washington State Department of Transportation

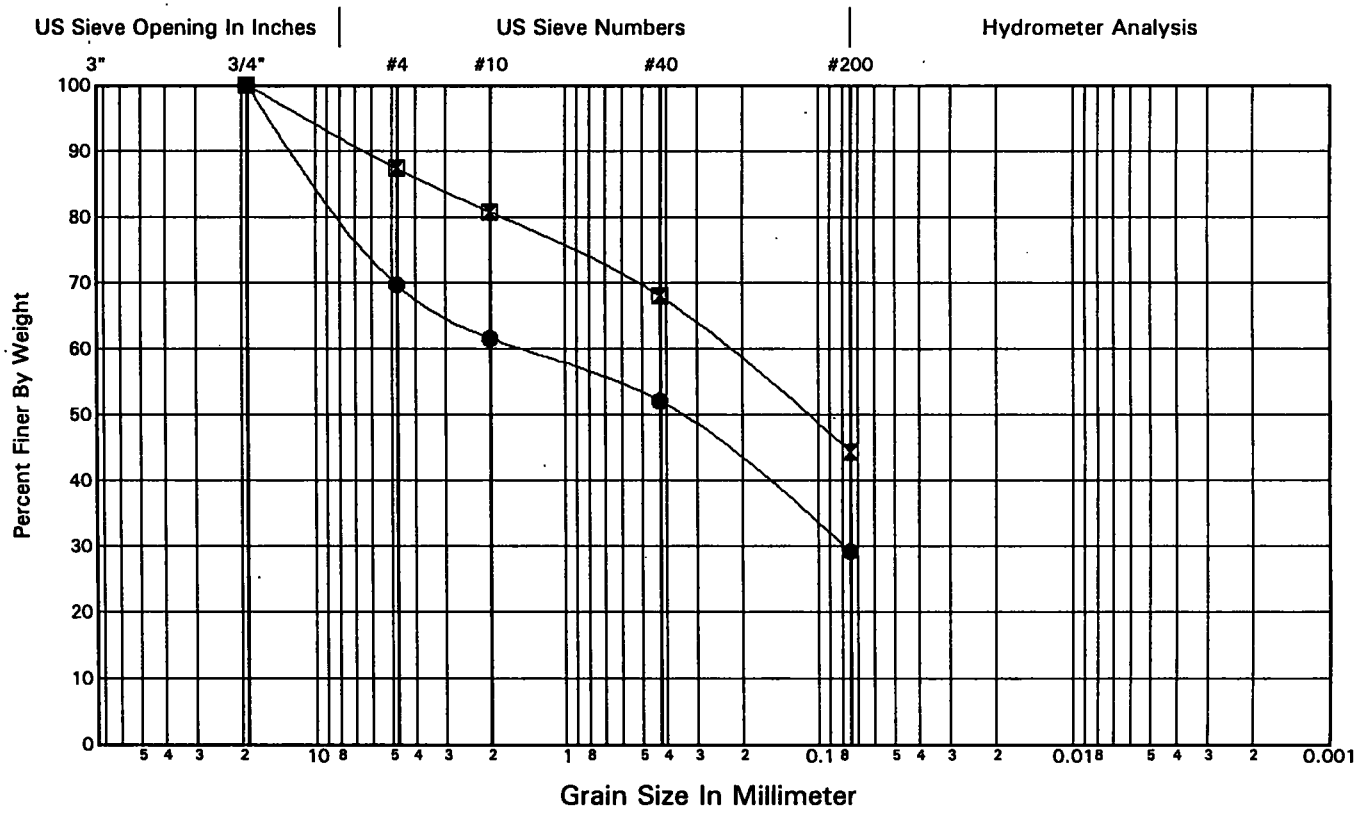
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	3.0	0.91	D-2	SM	LT. OLIVE GRAY	SILTY SAND with GRAVEL	4	NP	NP	NP
⊠	8.0	2.44	D-4	SM	OLIVE GRAY	SILTY SAND	8	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	30.3	40.5	29.2		
⊠	12.6	43.0	44.4		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	1.54	0.36	0.08		
⊠	0.24	0.11			



Job No. OL-1922 Date January 19, 1996

Hole No. H-4-95 Sheet 1 of 2

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

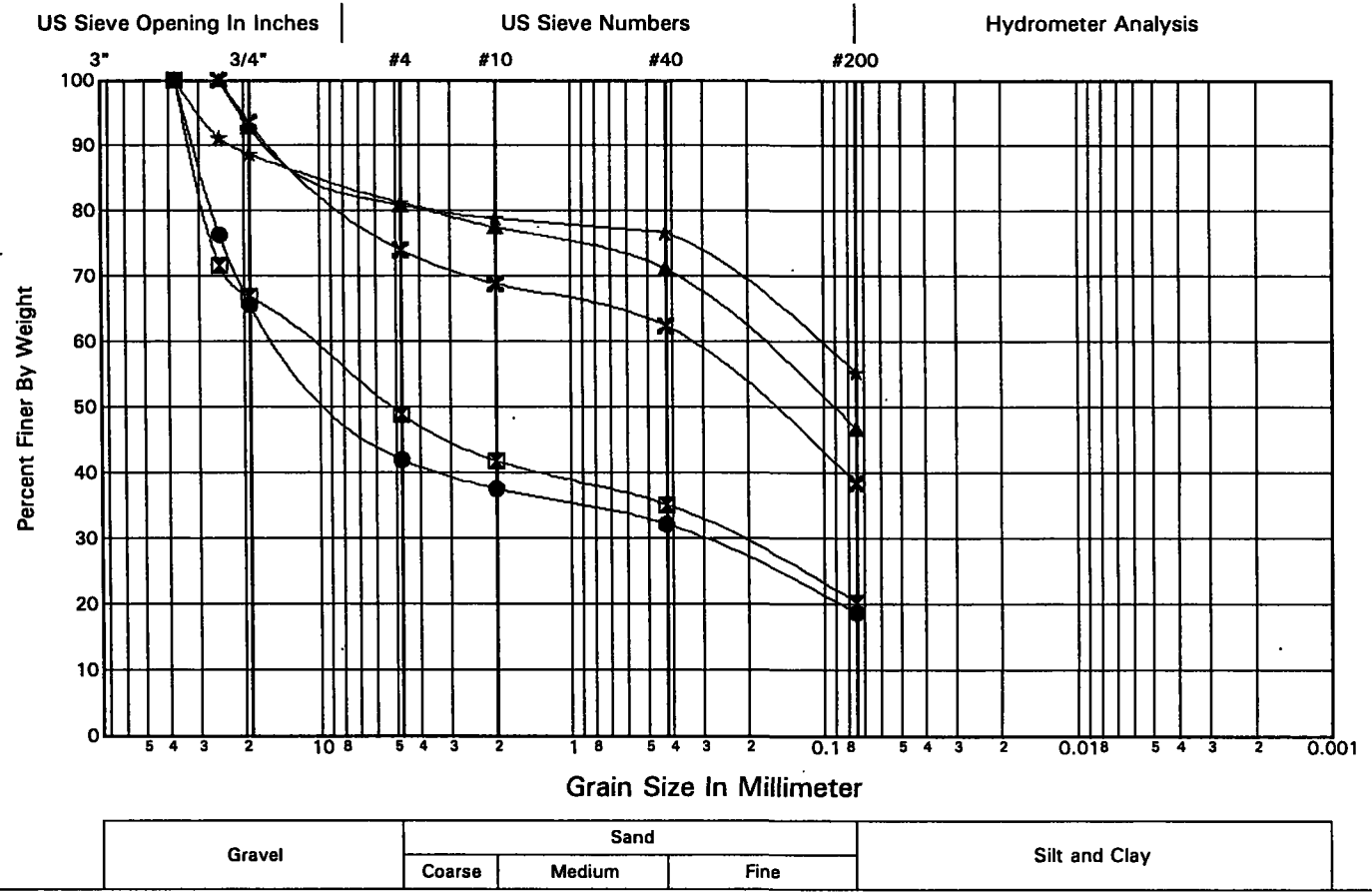
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	5.0	1.52	D-2	GM	OLIVE GRAY	SILTY GRAVEL with SAND	9	NP	NP	NP
⊠	7.5	2.29	D-3	GM	DARK YELLOWISH BROWN	SILTY GRAVEL with SAND	9	NP	NP	NP
▲	10.0	3.05	D-4	SM	DARK GRAYISH BROWN	SILTY SAND with GRAVEL	17	NP	NP	NP
★	12.5	3.81	D-5	ML	LT. YELLOWISH BROWN	SANDY SILT with GRAVEL with fibrous organic material	17	23	19	4
✕	15.0	4.57	D-6	SM	LT. YELLOWISH BROWN	SILTY SAND with GRAVEL	12	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	58.0	23.3	18.7		
⊠	51.1	28.6	20.3		
▲	19.1	34.2	46.7		
★	18.8	25.9	55.3		
✕	26.0	35.6	38.4		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	13.67	7.60	0.32	0.09	
⊠	11.22	5.17	0.23		
▲	0.19	0.09			
★	0.11				
✕	0.36	0.17			



Job No. OL-1922 Date January 19, 1996

Hole No. H-4-95 Sheet 2 of 2

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

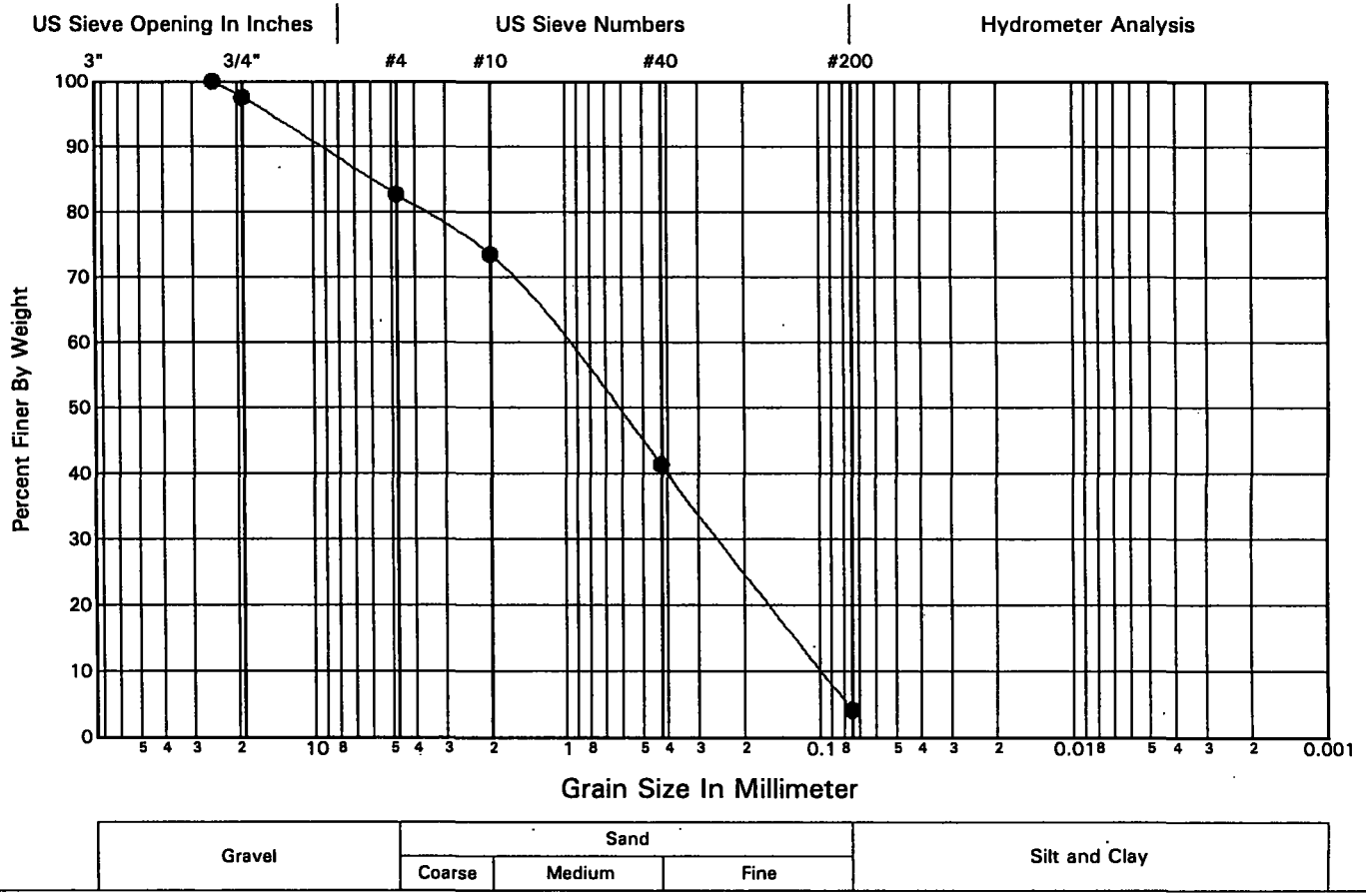
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	30.0	9.14	D-10	SP	OLIVE BROWN	POORLY GRADED SAND with GRAVEL	17	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	17.3	78.5	4.2	0.6	10.6

GRADATION VALUES

	D60	D50	D30	D20	D10
●	1.04	0.64	0.25	0.16	0.10



Job No. OL-1922 Date January 23, 1996

Hole No. H-5-95 Sheet 1 of 1

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

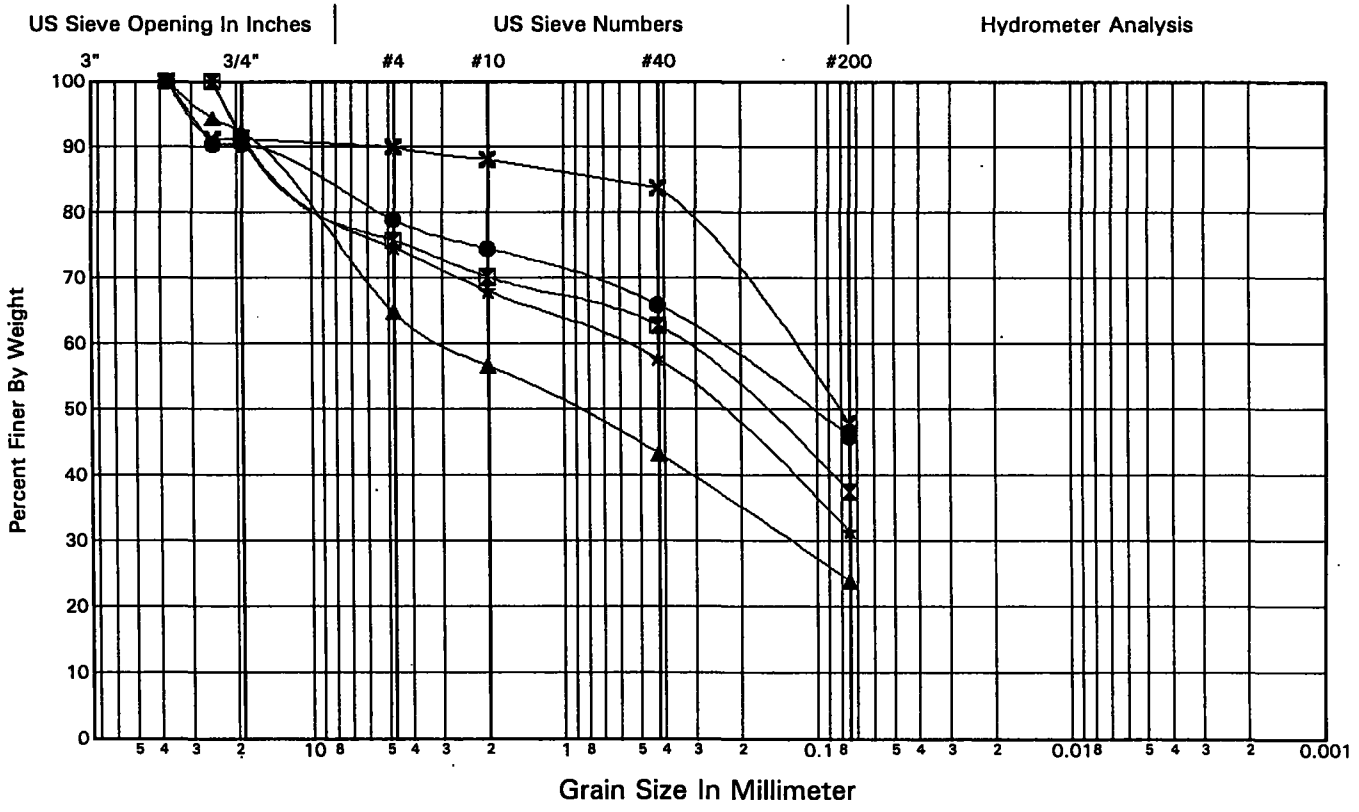
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	5.0	1.52	D-3	SM	OLIVE	SILTY SAND with GRAVEL	9	NP	NP	NP
⊠	8.0	2.44	D-4	SM	OLIVE	SILTY SAND with GRAVEL	11	NP	NP	NP
▲	13.0	3.96	D-6	SM	LIGHT BROWN	SILTY SAND with GRAVEL	5	NP	NP	NP
★	15.0	4.57	D-7	SM	OLIVE GRAY	SILTY SAND with GRAVEL	11	NP	NP	NP
✕	28.0	8.53	D-10	SM	OLIVE	SILTY SAND	10	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	21.1	33.0	45.9		
⊠	24.3	38.2	37.5		
▲	35.2	40.9	23.9		
★	25.4	43.2	31.4		
✕	10.1	42.0	47.9		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.25	0.11			
⊠	0.35	0.18			
▲	2.86	0.93	0.13		
★	0.60	0.26			
✕	0.13	0.08			



Job No. OL-1922 Date January 23, 1996

Hole No. H-7-95 Sheet 1 of 1

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

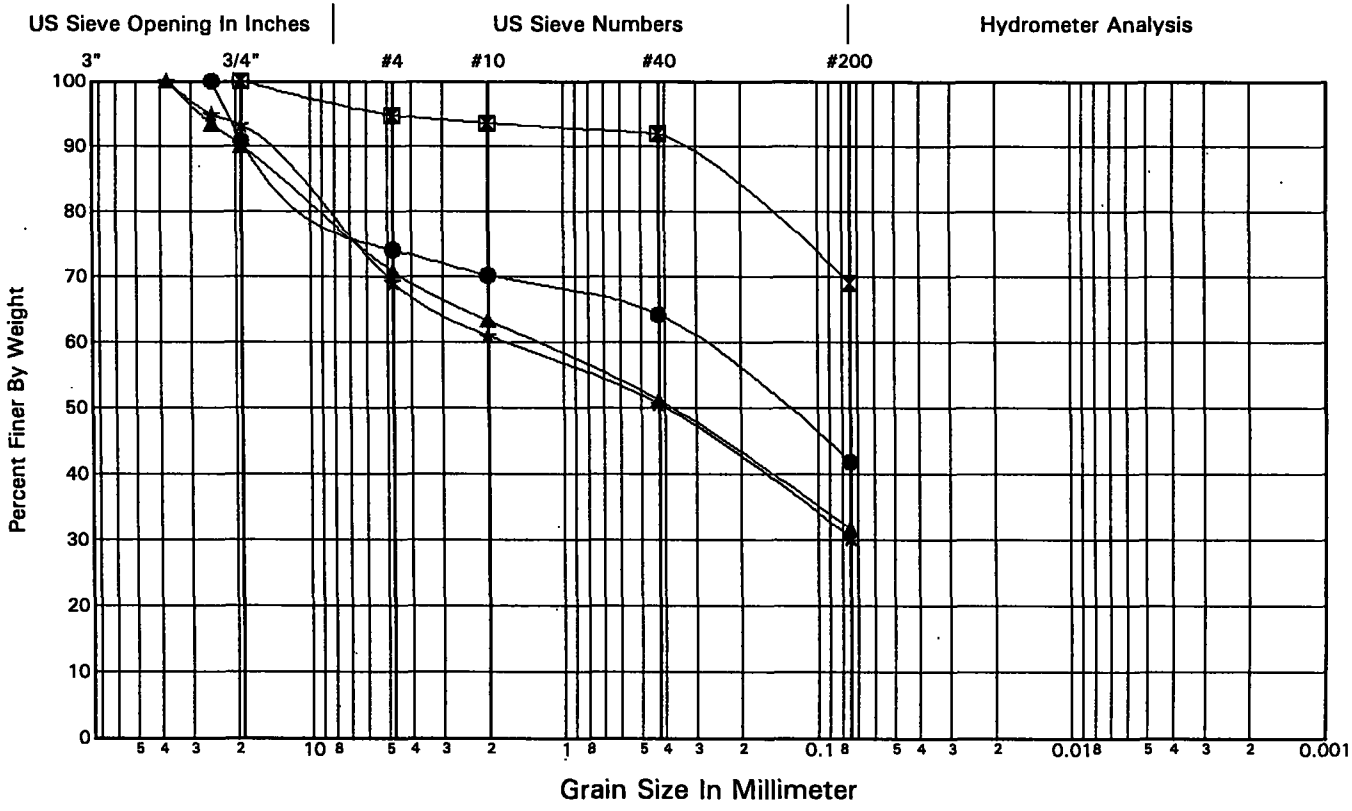
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	3.0	0.91	D-2	SM	GRAYISH BROWN	SILTY SAND with GRAVEL with root hairs	14	NP	NP	NP
⊠	5.0	1.52	D-3	ML	LIGHT OLIVE BROWN	SANDY SILT	15	NP	NP	NP
▲	8.0	2.44	D-4	SM	OLIVE GRAY	SILTY SAND with GRAVEL	9	NP	NP	NP
★	10.0	3.05	D-5	SM	OLIVE GRAY	SILTY SAND with GRAVEL	8	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	25.9	32.2	41.9		
⊠	5.3	25.7	69.0		
▲	29.2	39.1	31.7		
★	30.8	38.8	30.4		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.31	0.14			
⊠					
▲	1.31	0.38			
★	1.72	0.40			



Job No. OL-1922 Date December 22, 1995

Hole No. H-8-95 Sheet 1 of 1

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

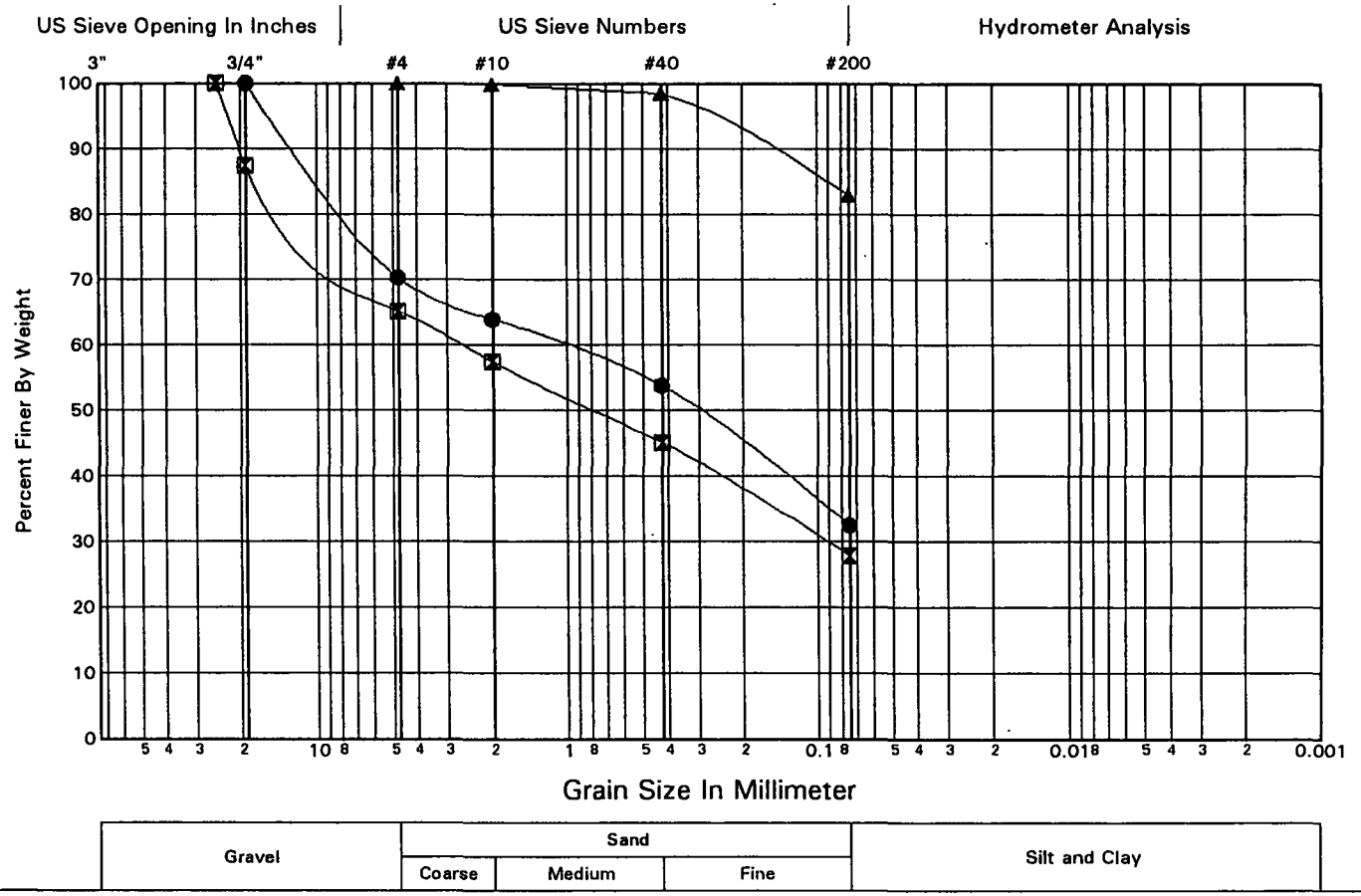
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	3.0	0.91	D-2	SM	OLIVE GRAY	SILTY SAND with GRAVEL	11	NP	NP	NP
⊠	8.0	2.44	D-4	SM	OLIVE GRAY	SILTY SAND with GRAVEL	6	NP	NP	NP
▲	23.0	7.01	D-7	CL	GRAYISH BROWN	LEAN CLAY with SAND	21	25	18	7

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	29.7	37.8	32.5		
⊠	34.8	37.3	27.9		
▲	0.0	17.1	82.9		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	1.10	0.31			
⊠	2.67	0.79	0.09		
▲					



Job No. OL-1922 Date January 23, 1996

Hole No. H-9-95 Sheet 1 of 1

Project FIFE TO TUKWILA-STAGE 7

Laboratory Summary

Washington State Department of Transportation

	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	3.0	0.91	D-2	SM	OLIVE GRAY	SILTY SAND with GRAVEL	11	NP	NP	NP
⊠	8.0	2.44	D-3	SM	OLIVE GRAY	SILTY SAND with GRAVEL	9	NP	NP	NP
▲	18.0	5.49	D-5	SM	OLIVE GRAY	SILTY SAND with GRAVEL	12	NP	NP	NP
★	23.0	7.01	D-6	SP	OLIVE GRAY	POORLY GRADED SAND with GRAVEL	8	NP	NP	NP

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cu	Cc
●	25.5	40.7	33.8		
⊠	24.9	33.1	42.0		
▲	30.4	35.6	34.0		
★	14.6	82.9	2.5	0.8	10.6

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.50	0.23			
⊠	0.38	0.15			
▲	1.09	0.29			
★	1.18	0.77	0.32	0.19	0.11