LANDAU
ASSOCIATES,
INC.
Environmental and Geotechnical Services

TECHNICAL MEMORANDUM

TO: Mr. Dick Malin, Port of Olympia

FROM: Stacy Pischer/Dennis Stettler, Landau Associates

DATE: February 8, 1996

RE: RESULTS OF ADDITIONAL SOIL EXPLORATION PROGRAM TO DETERMINE THE DEPTH TO AQUITARD
CASCADE POLE PROJECT CUTOFF WALL DESIGN
OLYMPIA, WASHINGTON

This memorandum presents the results of the additional soil exploration program that was conducted on November 30 and December 1, 1995 at the Cascade Pole site. The purpose of these additional explorations was to gather supplemental data to better define the top of the Aquitard along the proposed cutoff wall alignment. The purpose and objectives of this exploration program were further outlined in a letter from Landau Associates to the Washington State Department of Ecology (Ecology) and the Port of Olympia dated November 13, 1995.

EXPLORATION PROGRAM

The additional soil boring exploration program was planned to include ten shallow soil borings to better determine the top of the aquitard along the proposed cutoff wall alignment; however, only seven of the planned soil borings (LB-19 through LB-25) were accomplished due to accessibility problems at three locations (identified as E, F, and H on Figure 1). Ponding water and soft surface soil at locations E and F along the southern alignment of the wall did not permit access by the geoprobe rig at these locations and a buried concrete slab(s) at location H along the northern alignment of the proposed cutoff wall did not permit penetration by the geoprobe. As requested by the Port of Olympia, an additional boring (LB-26) was accomplished at the southwestern corner of the proposed cutoff wall alignment to provide additional information regarding the thickness of the aquitard in this area.

All eight borings were accomplished using a truck-mounted geoprobe rig. The geoprobe rig used a push method to drill a hole rather than the typical auger or air rotary methods. A steel drive point (approximately 2 inches O.D.) attached to steel rods was pushed through the formation to the desired depth using a vibrating hammer. Because the drive point is pushed, no soil cuttings are produced. Upon reaching the desired sample depth, the drive point was

removed and a steel sampler lined with an acrylic tube was lowered to the bottom of the borehole and then pushed through the formation material to collect the desired sample interval.

Each boring was drilled to the top of the aquitard and terminated at a depth of approximately 4 ft below the top of the aquitard. The bottom of the aquitard was not encountered in any of the borings. Soil samples were collected from each boring, and lithologic descriptions, as well as field observations, were recorded based on these samples. A description of the soil classification system is presented in Figure 2. Descriptions, observations, and soil sample locations are provided on boring logs LB-19 through LB-26 (Figures 3 through 10). Each geoprobe boring was backfilled from bottom to top at the time of completion using a pressurized bentonite grout and bentonite chips.

The approximate location of the geoprobe boring explorations are shown on Figure 1. Except for boring location LB26, each of the boring locations were surveyed by Southwest Surveying of Olympia, Washington prior to drilling. The survey included position coordinates and ground surface elevation for each boring location. The boring location coordinates were incorporated into the project base map, which also indicates all previous exploration locations. The ground surface elevation at the boring locations are reported on the boring logs.

Field Observations

Strong to moderate, creosote-like odors were noted during drilling at LB-21 at a depth interval beginning at approximately 12.5 ft below ground surface (BGS) and extending to the top of the aquitard which was encountered at 21.0 ft BGS. A soil sample was collected for laboratory analysis at LB-21 from a depth interval of 15.8 to 16.9 ft BGS where strong creosote-like odors were noted.

At soil boring LB-24, strong to moderate, fuel-like odors were noted from approximately 10 ft BGS to the top of the aquitard which was encountered at 21.7 ft BGS. Also, a dark brown, oil-like product was observed at boring LB-24 at a depth interval of 11.7 ft to 12.3 ft BGS and again at 15.3 ft to 16.3 ft BGS. A soil sample was collected from each depth interval where product was observed for potential laboratory analysis.

Laboratory Analyses and Results

The soil sample, CPC-LB21-(15.8-16.9), collected from boring LB-21 was analyzed for PAH using method 8270 SIM and chlorophenols using modified method 8040 at the Analytical Resources Inc. (ARI) laboratory in Seattle, WA. PAH and chlorophenol results for this soil

sample are presented in Table 1. A limited data validation review was conducted by Landau Associates for these results. All data met the appropriate quality control/quality assurance criteria; therefore, no qualifiers were added to the analytical results.

No laboratory analyses were performed on soil samples CPC-LB24-(11.7-12.3) and CPC-LB24-(15.3-16.3); however, these samples are archived at the ARI laboratory.

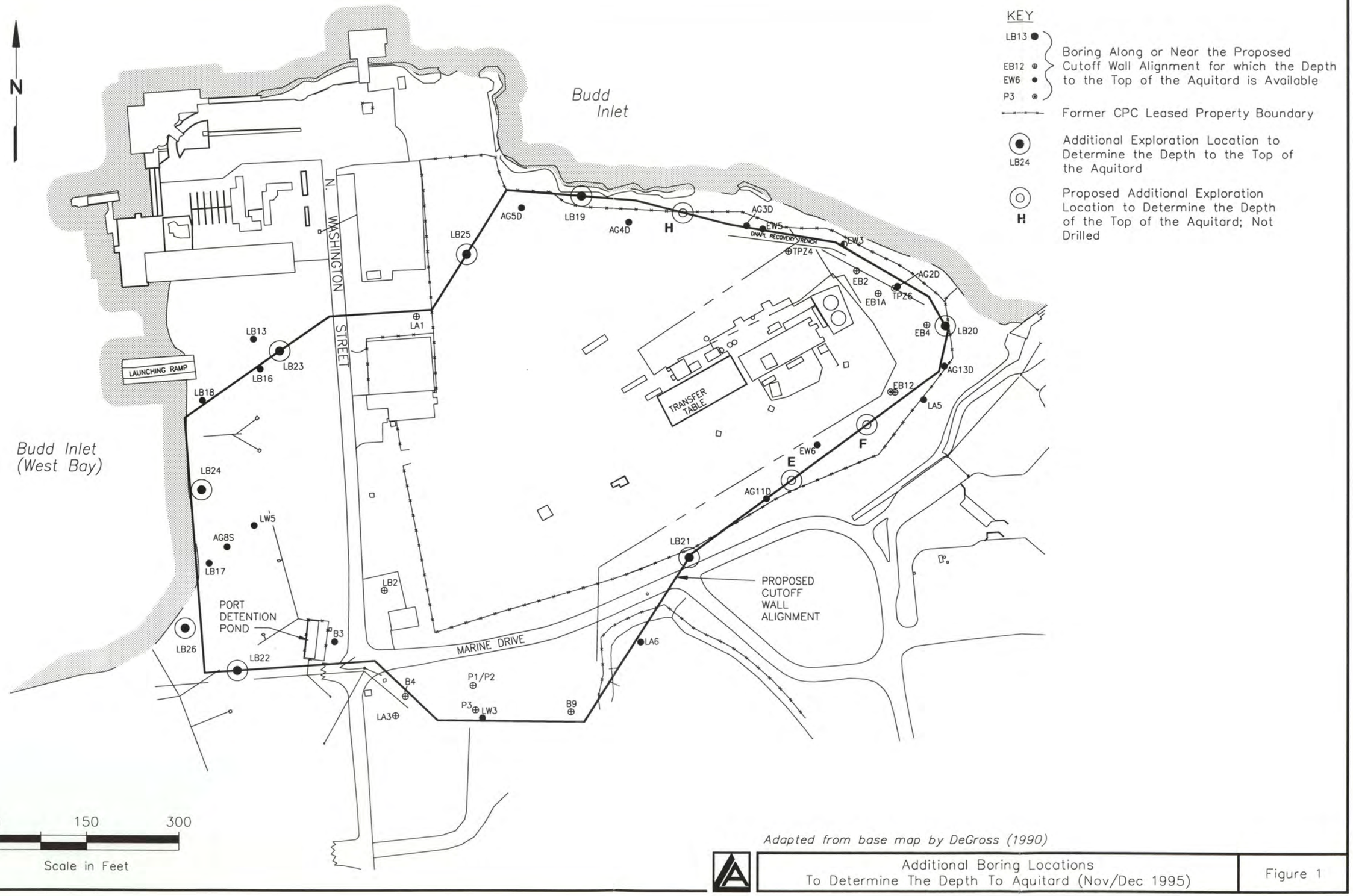
AQUITARD SURFACE ELEVATION AND THICKNESS

The elevation and thickness of the aquitard at each soil boring (LB-19 through LB-26) will be reviewed and compared to existing data. A contour map of the aquitard surface based on these borings and existing information will also be prepared. This data will then be interpreted to form the basis for identifying the planned depth of the cutoff wall construction along the proposed alignment, and as a part of the cutoff wall plans and specifications, incorporated into the cutoff wall plan and profile sheets that will be submitted at a later date to the Port of Olympia and Ecology.

DRS/LLC/sms
No. 021015.91
02/08/96 J:\021\015\091\AQUBORNG.MEM

Attachments: Table 1
Figures 1 through 10

cc: Mr. Don Bache, Port of Olympia



Adapted from base map by DeGross (1990)

Additional Boring Locations
To Determine The Depth To Aquitard (Nov/Dec 1995)

Figure 1

21015.91 Port of Olympia/Cascade Pole Site/Results of Additional Boring Memo (A) 1/96

Soil Classification System

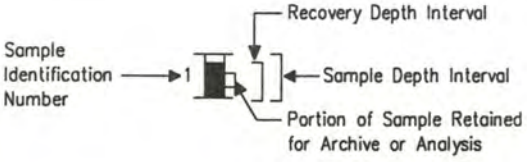
MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL (1)	TYPICAL DESCRIPTIONS (2)(3)
COARSE-GRAINED SOIL (More than 50% of material is larger than No.200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No.4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No.4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No.200 sieve size)	SILT AND CLAY (Liquid Limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid Limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand or silty soil
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
OTHER	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content
	OTHER			AC	Pavement; Asphalt or Concrete
	WOOD			WOOD	Wood, Wood Chips or Bark

Notes:
1. USCS letter symbols correspond to the symbols used by the Unified Soil Classification System and ASTM Classification methods. Dual letter symbols (e.g., SM-SP) for a sand or gravel indicate a soil with an estimated 5-15% fines. Multiple letter symbols (e.g.,ML/CL) indicate borderline or multiple soil classifications.
2. Soil classifications are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	>50%	– "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	>30% and ≤50%	– "very gravelly," "very sandy," "very silty," etc.
	>15% and ≤30%	– "gravelly," "sandy," "silty," etc.
Additional Constituents:	>5% and ≤15%	– "with gravel," "with sand," "with silt," etc.
	≤5%	– "trace gravel," "trace sand," "trace silt," etc., or not noted.

Key

SAMPLE NUMBER & INTERVAL



TEST DATA

Code	*Description*

SAMPLER TYPE

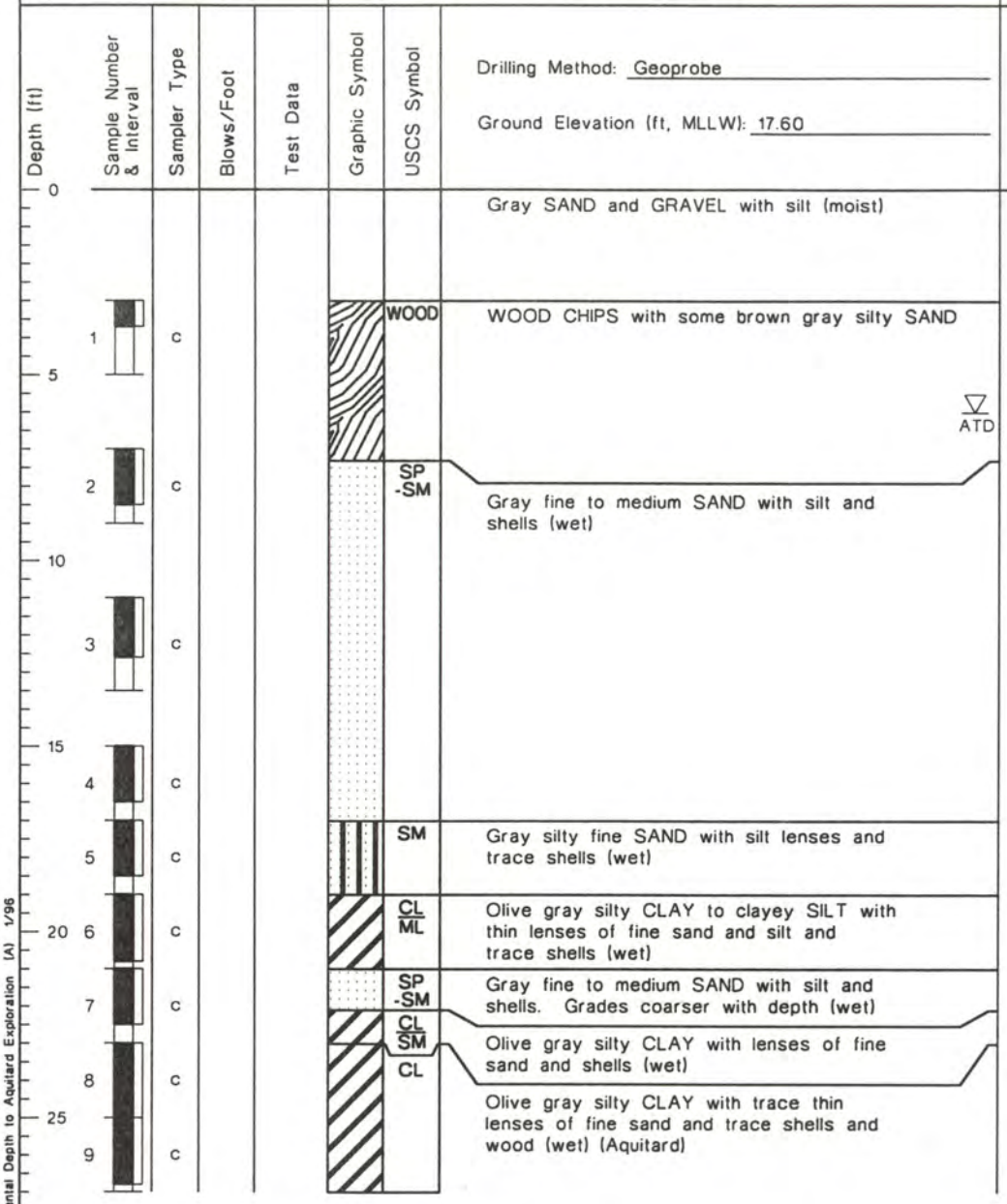
Code	*Description*
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon Sampler
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon Sampler
c	1.50-inch O.D., 1.00-inch I.D. Sample Tube
d	Grab Sample
e	3.00-inch I.D. Core Barrel Sampler
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	350-lb. Hammer, 30-inch Drop

OTHER

▽ ATD	Approximate Water Elevation At Time of Drilling (ATD) or On Date Noted

Soil Classification System and Key | Figure 2

LB-19



Boring Completed 11/30/95
Total Depth = 27.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

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Boring LB-19 | Figure 3

LB-20

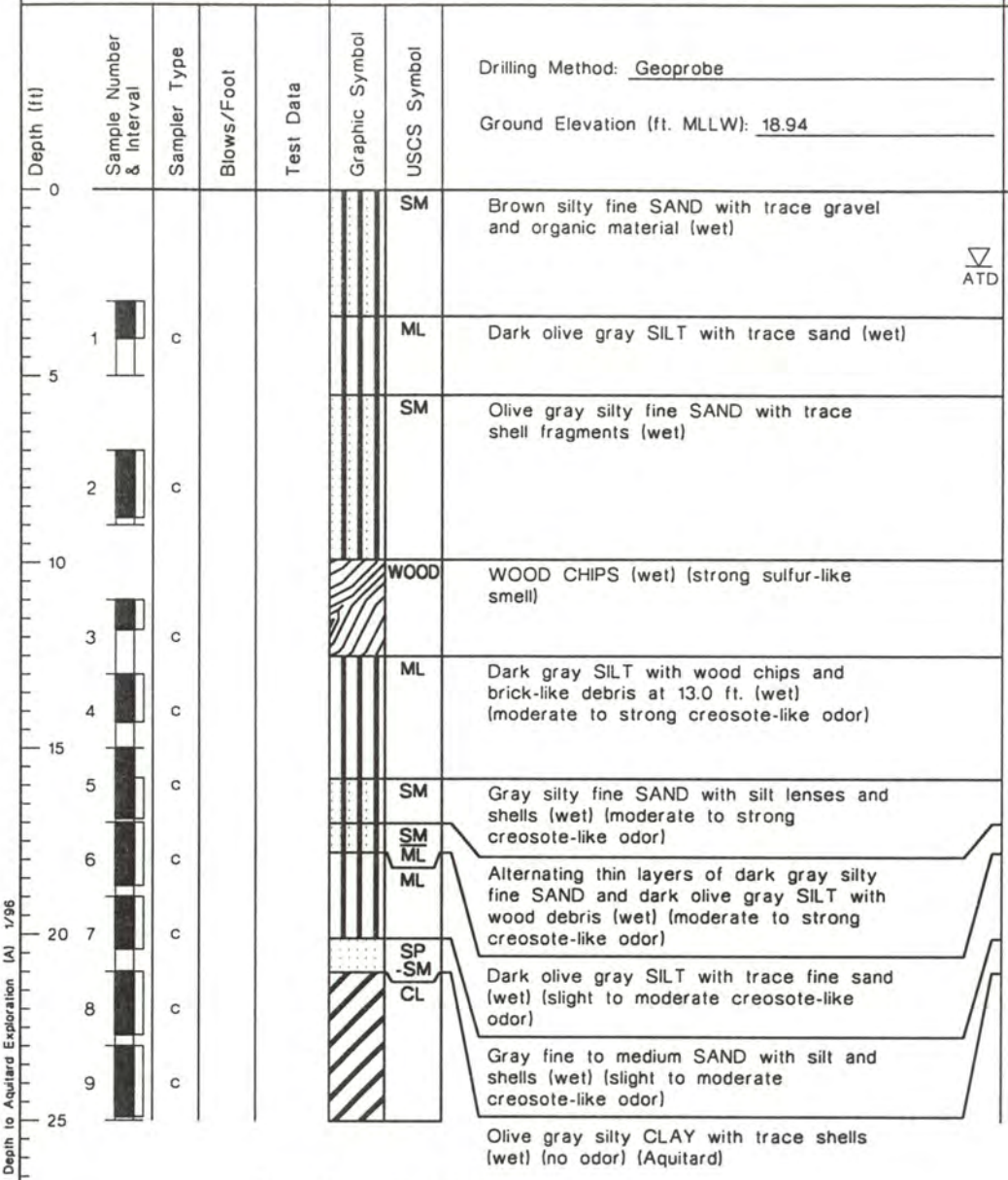
SAMPLE DATA				SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe Ground Elevation (ft. MLLW): 16.16
0						SP	Gray fine to medium SAND with coarse sand and shells (wet)
5	1	C					
	2	C					
10	3	C				CL	Dark olive gray silty CLAY with trace wood and shells (wet) (Aquitard)
	4	C					
15	5	C					
	6	C					
20	7	C					
	8	C					
25							
30							

Boring Completed 11/30/95
Total Depth = 23.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

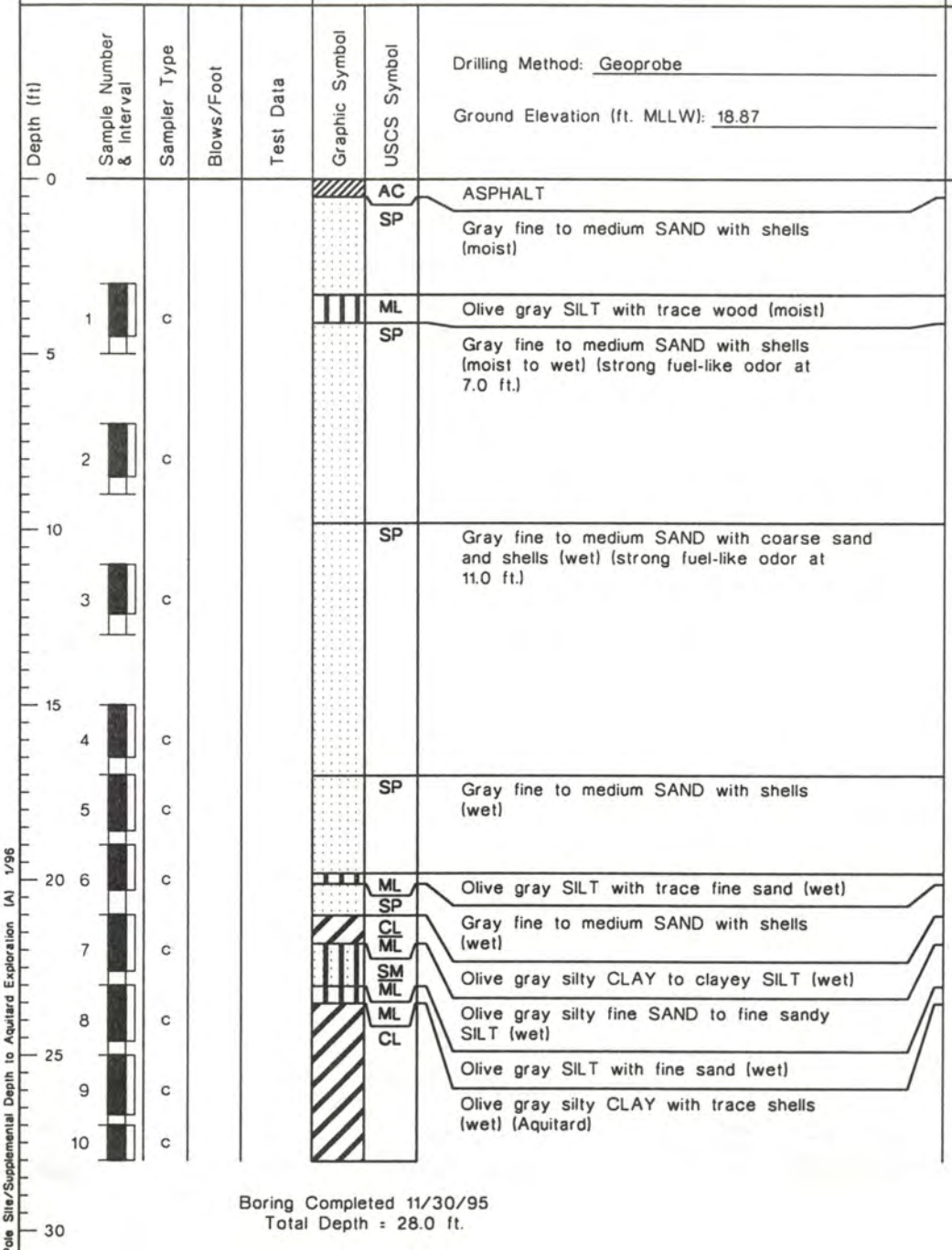
Boring LB-20 | Figure 4

LB-21



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

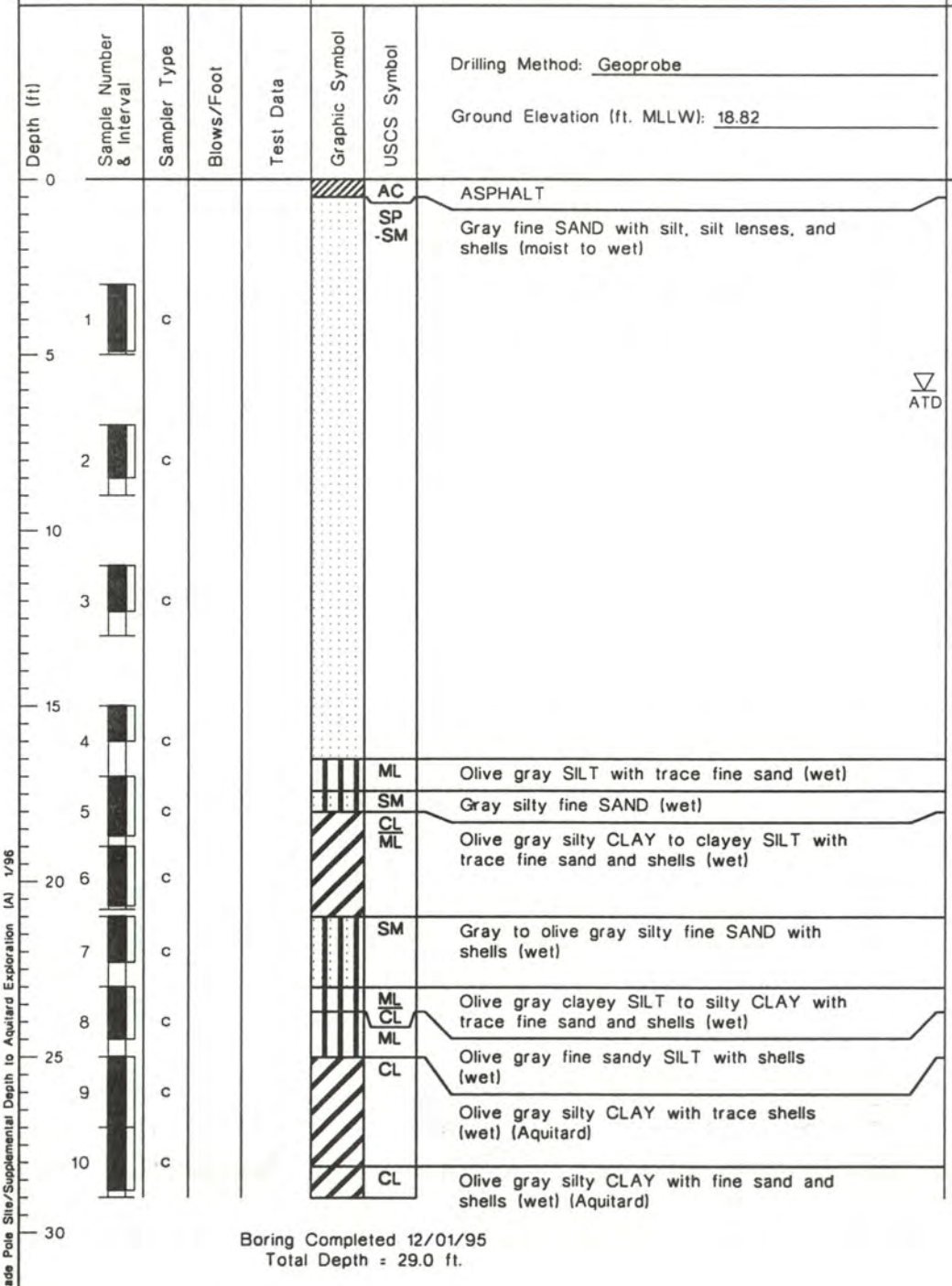
LB-22



Boring Completed 11/30/95
Total Depth = 28.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

LB-23



Boring Completed 12/01/95
Total Depth = 29.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

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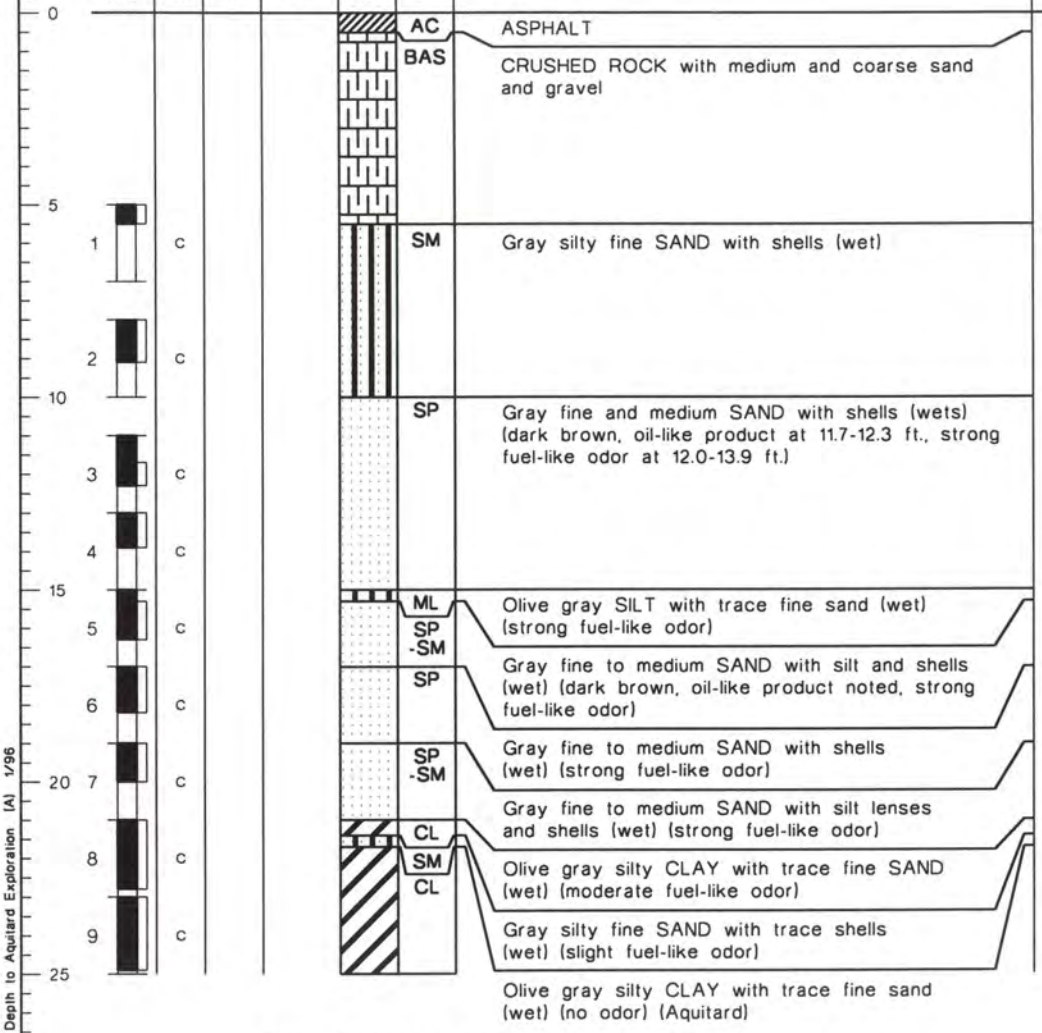
Boring LB-23

Figure 7

LB-24



Boring Completed 12/01/95
Total Depth = 25.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

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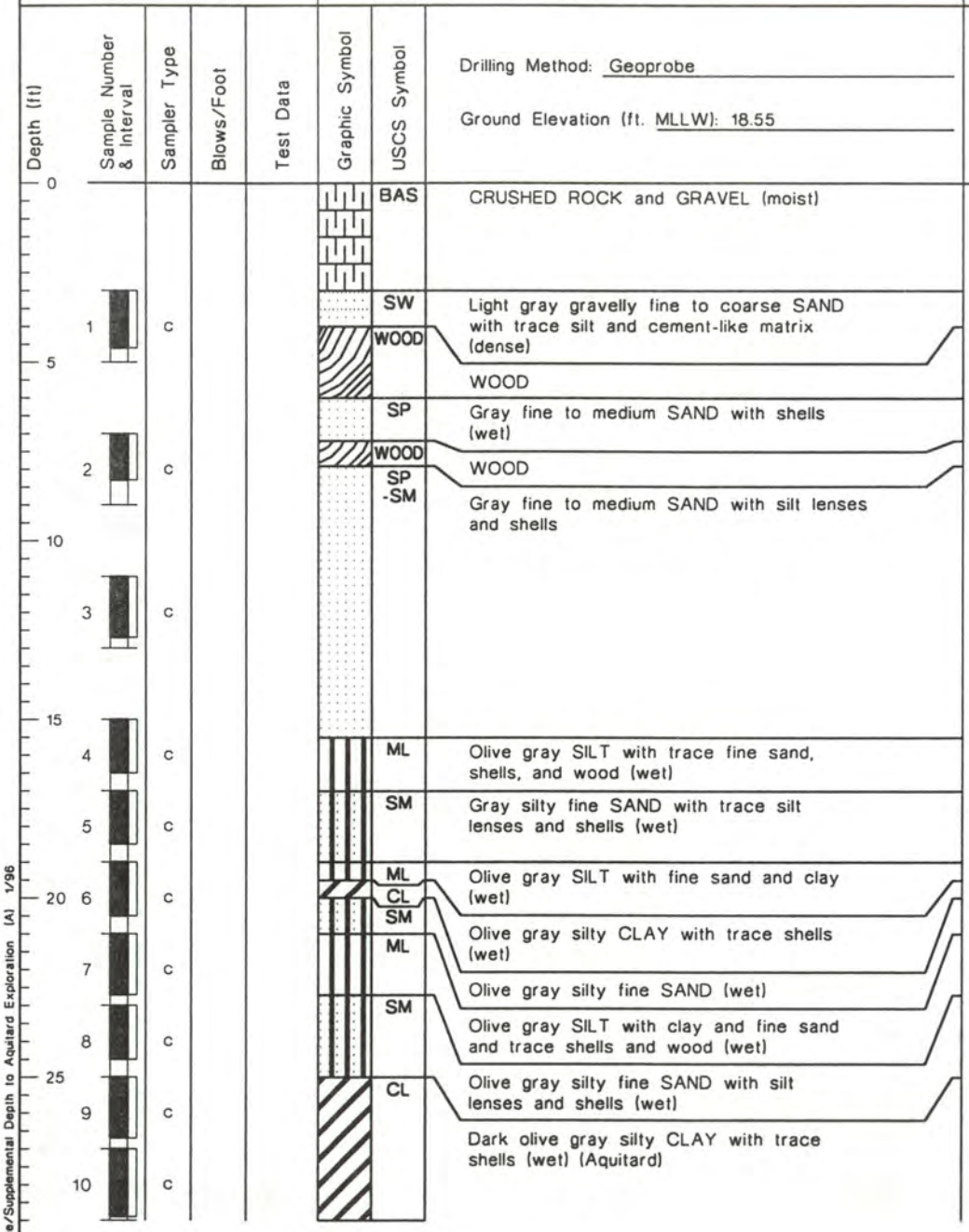
Boring LB-24 | Figure 8

LB-25



Boring Completed 12/01/95
Total Depth = 29.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

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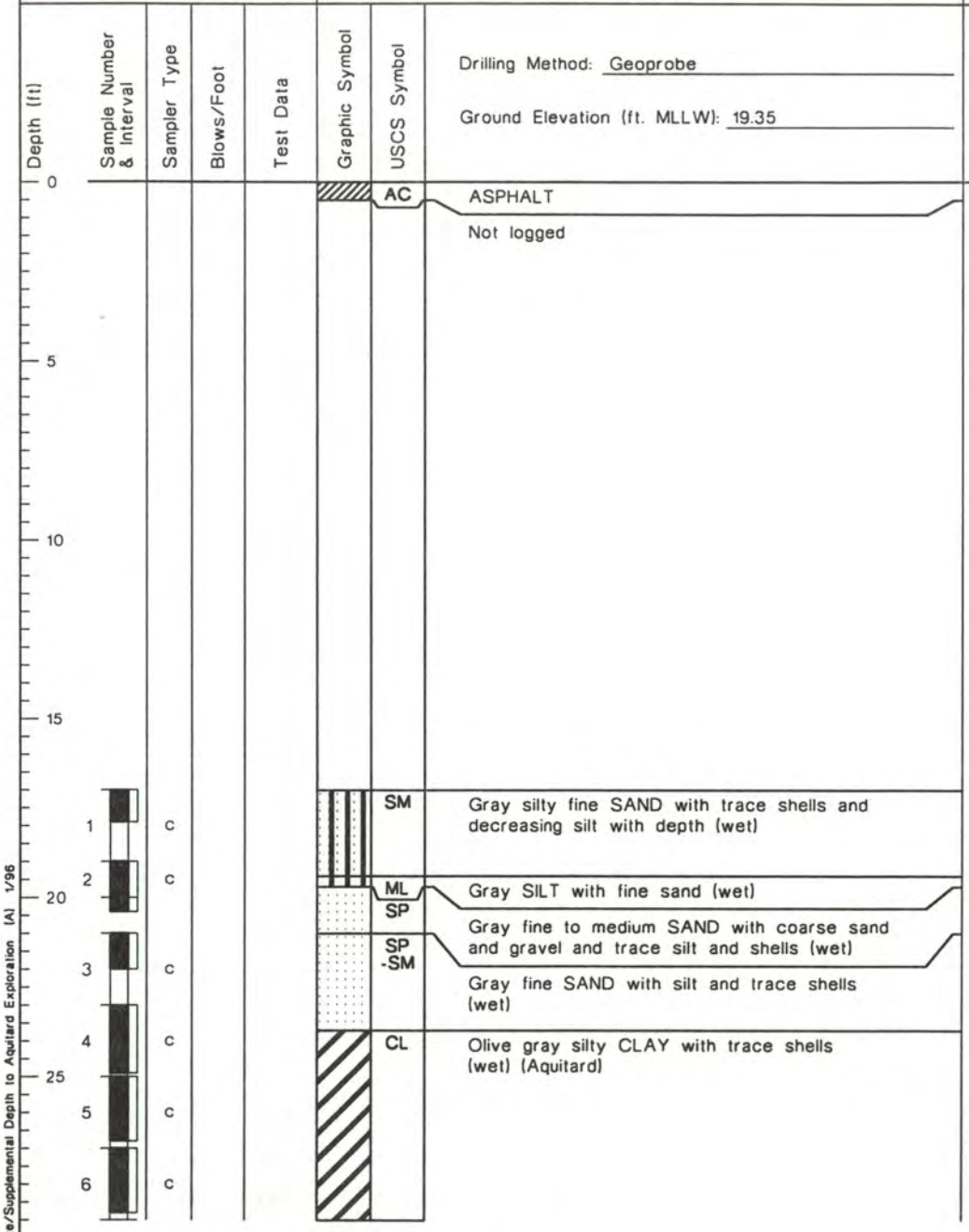
Boring LB-25

Figure 9

LB-26



Boring Completed 12/01/95
Total Depth = 29.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate. Refer to the text for an explanation of subsurface conditions.
2. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
3. All borings were accomplished with a GEOPROBE rig. Hammer weight and drop not applicable. Blow counts not obtained.
4. All borings were backfilled from bottom to top with pressurized bentonite grout and bentonite chips.

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Boring LB-26

Figure 10

TABLE 1

SOIL SAMPLING ANALYTICAL RESULTS
ADDITIONAL SOIL EXPLORATION PROGRAM (NOVEMBER/DECEMBER 1995)
PORT OF OLYMPIA
CASCADE POLE SITE

Sample ID:	CPC-LB21-(15.8-16.9)	
Date Collected:	11/30/95	
PAH (mg/kg)		
(Method 8270 SIM)		
Naphthalene	22	D
2-Methylnaphthalene	4.4	D
Acenaphthylene	0.010	
Acenaphthene	2.1	D
Fluorene	0.780	
Phenanthrene	0.490	
Anthracene	0.042	
Fluoranthene	0.044	
Pyrene	0.034	
Benzo(a)anthracene	0.0096	U
Chrysene	0.0096	U
Benzo(b)fluoranthene	0.0096	U
Benzo(k)fluoranthene	0.0096	U
Benzo(a)pyrene	0.0096	U
Indeno(1,2,3-cd)pyrene	0.0096	U
Dibenz(a,h)anthracene	0.0096	U
Benzo(g,h,i)perylene	0.0096	U
Dibenzofuran	1.2	D
Chlorophenols (mg/kg)		
(Method 8040 modified)		
Pentachlorophenol	0.009	U
2,4,6-Trichlorophenol	0.009	U
2,3,6-Trichlorophenol	0.009	U
2,4,5-Trichlorophenol	0.009	U
2,3,4-Trichlorophenol	0.009	U
2,3,5,6-Tetrachlorophenol	0.009	U
2,3,4,5-Tetrachlorophenol	0.009	U

D = sample diluted.
U = compound not detected at the given detection limit.