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TO
AGRA EARTH & ENVIRONMENTAL

GEOTECHNICAL ENGINEERING REPORT
LOTT CAPITOL LAKE SOUTHERN CONNECTION
OLYMPIA, WASHINGTON

Submitted to:

Parametrix, Inc.
P.O. Box 460
Sumner, Washington 98390

Submitted by:

AGRA Earth & Environmental, Inc.
11335 N.E. 122nd Way, Suite 100
Kirkland, Washington 98034-6918

March 16, 2000

9-91M-11684-B

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Parametrix, Inc.
P.O. Box 460
Sumner, Washington 98390

Attention: Mr. Rick Hermes, P.E.

Subject: **Geotechnical Engineering Report**
LOTT Capitol Lake Southern Connection Project
Olympia, Washington

Dear Mr. Hermes:

AGRA Earth & Environmental, Inc. (AGRA) is pleased to submit this report describing our geotechnical engineering evaluation for the above-referenced project. The purpose of our evaluation was to derive design conclusions and recommendations concerning seismic hazards, dewatering, trench excavations, pipe foundation and bedding, trench backfill, channel crossing, and pavement design. AGRA previously completed a limited geotechnical engineering and seismic hazard study for this project as part of a SEPA Threshold Determination (AGRA Project No. 7-91M-11684, 10 June 1997). We also completed a geotechnical design report for the upgrade of Capitol Lake Pump Station (CLPS) dated November 18, 1998.

As outlined in our proposal dated November 20, 1998, our scope of work consisted of field exploration, laboratory testing, geotechnical research, geotechnical analyses, and report preparation. We received your written authorization for our proposal on April 7, 1999. This report has been prepared for the exclusive use of the LOTT Wastewater Management Partnership, Parametrix, and their consultants, for specific application to this project, in accordance with generally accepted geotechnical engineering practice.

We appreciate the opportunity to be of service to you on this project. Should you have any questions regarding the content of the report, please feel free to contact us.

Sincerely,

James S. Dransfield, P.E.
Principal

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1.0 SUMMARY

The proposed project construction appears feasible with respect to the subsurface conditions encountered along the project alignment. A brief summary of our findings, conclusions, and recommendations is presented below.

- Project Description: The proposed alignment begins at a new control structure to be located near the Capitol Boulevard Bridge in the existing Tumwater Falls Park and extends northward along the Deschutes Parkway to the recently upgraded CLPS, then crossing Capitol Lake via the pedestrian bridge between Marathon Park and Heritage Park, then along Columbia Street and Olympia Avenue, terminating at the existing LOTT wastewater treatment plant by way of a manhole located at the Thurston Avenue and Adams Street intersection in downtown Olympia. The total length of the project is approximately 17,200 feet. The main elements of the project are: the Interceptor Sewer (twin pipes running approximately 10,000 feet from Tumwater Falls Park to CLPS); and the Force Main (a 24-inch High Density Polyethylene (HDPE) pipe) running approximately 7,200 feet between CLPS and the LOTT treatment plant, and associated water supply lines.

- Subsurface Conditions: In the southernmost end of the project, our borings generally encountered roadway fill and a thin veneer of silty sand overlying bedrock. Some interbeds of silt, peat, and clay several feet in thickness were encountered on the east side of Tumwater Falls Park. Soft silt and loose sand deposits were encountered below the gravelly, silty, sandy roadway fill throughout the Deschutes Parkway portion of the alignment. The alignment crosses deltaic deposits at the mouth of Percival Creek and potentially landslide material from the bluffs that are adjacent to Deschutes Parkway. Much of downtown Olympia appears to have been constructed on a substantial thickness of granular, advance glacial outwash, overlain by loose, wet, gravelly, silty sand fill. Some thin interbeds of clay, silt, and peat were encountered near Columbia Street.

- Groundwater Conditions: Groundwater levels were generally encountered at 4 to 7 feet below grades in the borings drilled in downtown Olympia area and along the Deschutes Parkway north of Interstate 5 (I-5) and State Route 101 (SR-101). Groundwater levels were either significantly lower or not encountered in borings located in high ground south of I-5/SR-101. Groundwater levels at the proposed control structure were encountered at approximately 4 feet below grades. Although not encountered in this investigation, our previous exploration indicated that groundwater at depth in the CLPS area occurs in significant quantities at depth and under substantial pressure.

- Seismic Hazards and Mitigations: Due to the high seismicity and vulnerable soil conditions in the project area, potential seismic hazards include temporary ground displacement during wave passage, permanent ground deformations due to lateral spreading, and landslides. Our evaluations indicate that ground strains caused by wave passage would be in the range of 0.3 to 0.6 percent. Depending upon locations, permanent ground deformations due to soil liquefaction and lateral spread could range from 0 to 12 inches and 0 to 28 inches in vertical and lateral directions, respectively. As an alternative to ground modifications to stabilize the overall roadway embankment (such as vibro-replacement stone columns), we recommend using flexible pipe material (such as HDPE) and joint design to accommodate these deformations. On the approaches to the Heritage Park – Marathon Park pedestrian bridge, the pipeline will be located less than 25 feet from the shoreline of Capitol Lake. We present recommendations for improving the stability of these areas by installing a sheet pile bulkhead or by constructing a rock revetment.

- Dewatering: Water level readings taken from our observation wells showed groundwater levels will generally be at or above the excavation depth for the proposed sewer. Dewatering to at least two feet below the base of cut is recommended. We anticipate this will require the installation of a vacuum well point temporary dewatering system for most of the alignment. In the downtown area, we recommend against using a deeper drilled well dewatering system, since it would increase the risk of settlement-related damage to nearby structures. Sump/pump methods may be adequate for perched groundwater conditions on the south end of the project.

- Trench Excavation: The invert depth for much of the proposed sewer pipe is anticipated to be approximately 6 to 8 feet below the existing ground surface. Excavation of soils throughout the project area is likely to be accomplished by conventional trenching with trench box shoring. Some bedrock may be encountered on the south end of the Interceptor Sewer alignment. Sheet pile or soldier pile shoring is recommended where the alignment crosses three former landslide areas. Shoring will be required at each pipe jacking location.

- Pipe Bedding and Foundations: Based on the field explorations and the current anticipated pipe burial depths, it appears that the soils exposed at the sewer and manhole inverts will primarily be loose to medium-dense sand, or medium-stiff to stiff silt. In such areas, excavation to ½ foot below pipe invert is recommended for placement of bedding. In areas where looser sand or soft clay/silt is encountered and trench bottom disturbance occurs, overexcavation of not more than 2 feet (2½ feet below pipe invert) is recommended. To minimize the amount of ground deformation transferred to the pipe during a severe earthquake, a reinforced concrete bedding slab may be considered in areas where permanent ground movements are anticipated to be significant.

- Trench Backfill: The soils which will be excavated for the pipeline trench will generally consist of sands and silty sands. It only appears feasible to reuse the sandy materials as trench backfill if properly moisture conditioned. The clayey silts and sandy silts should not be included in the backfill, due to their high fines contents. Imported fill materials would be required to replace the volume of native soils that are unsuitable for trench backfill. Lightweight backfill (such as coal bottom ash) may be considered for a portion of the trench backfill to reduce the risk of post-construction settlement. Controlled density fill (CDF) may be preferable backfill around manholes, valving, or other areas where mechanical compaction would be difficult.

- Pipe Crossings: Several crossings will be required for the proposed sewer pipe along the alignment, including the railroad crossings located north of the CLPS and possibly the crossing of a few intersections in downtown Olympia. Pipe jacking and boring will likely require shoring and dewatering for each jacking pit and receiving pit.

- Control Structure: An at-grade control structure is planned near the Capitol Lake Boulevard bridge at the south end of the alignment. We anticipate that the concrete structure can be supported by shallow footings, with a slab-on-grade floor founded on a bearing pad of structural fill.

- Environmental Screening: In the downtown Olympia area, a soil sample from boring B-15 contained an identifiable concentration of gasoline and heavy oil-range petroleum hydrocarbons; however, the concentrations were well below MTCA Method A Cleanup Limits. A groundwater sample from MW-5 (B-12), near the Fast Fuel Gas Station encountered elevated concentrations of gasoline-range petroleum hydrocarbons and BTEX. Specifically, concentrations in excess of MTCA Cleanup Criteria include Benzene, Ethylbenzene, and Total Xylenes. Additionally, groundwater samples from MW-5 (B-12), MW-6 (B-15), and MW-7 (B-17) had measured total lead concentrations in excess of cleanup standards.

This summary is presented for introductory purposes only and should be used in conjunction with the full text of this report. The project description, site conditions, and our detailed design and construction recommendations are presented in the text of this report. The exploration procedures and detailed exploration logs are presented in Appendix A. The laboratory soils and analytical testing procedures and results are presented in Appendices B and C, respectively.

2.0 SITE AND PROJECT DESCRIPTION

The project site is located in the Capitol Lake area of Olympia, Washington, and consists of two main elements; the Interceptor Sewer and the Force Main. A general outline of the project site is illustrated in the *Location Map* (Figure 1) and the *Site Vicinity Map* (Figure 2).

The Interceptor Sewer alignment begins at a new control structure to be located near the Capitol Boulevard Bridge in the existing Tumwater Falls Park and extends northward along the Deschutes Parkway, crossing I-5/SR101 and the Burlington Northern Railroad, to the CLPS. The total length of the Interceptor Sewer is approximately 10,000 feet.

The Force Main alignment begins at CLPS, crosses Capitol Lake by way of an existing pedestrian bridge between Marathon Park and Heritage Park, is routed through downtown Olympia along Columbia Street, Olympia Avenue, and Adams Street, terminating at the LOTT Wastewater Treatment Plant. The total length of the Force Main is approximately 7,200 feet.

The Southern Connection is proposed to replace the existing sewer pipeline along the Union Pacific Railroad, south of Capitol Lake. The existing sewer line is considered a temporary repair from the exposure and failure of two Tumwater sewer interceptors in February 1996. The proposed Interceptor Sewer will consist of two HDPE pipes (20-inch and 22-inch diameter) installed in a common trench. Pipe invert depths are typically 6 to 8 feet below grade. Manholes are typically 8 to 10 feet below grade. Where the pipeline crosses beneath utilities or railroad tracks, the pipe will be 10 to 12 feet below grade. In the vicinity of Terrace Falls Restaurant, a cut of up to 20 feet is planned to maintain grade and reduce head loss.

The Force Main alignment includes a 24-inch diameter HDPE pipe, a 16-inch diameter water supply line, and a 12-inch-diameter reclaimed water line, installed in separate trenches or a single wide excavation. Pipe inverts will generally be 6 to 7 feet below grade between the CLPS and downtown, except the pipes will be supported on an existing pedestrian bridge which crosses Capitol Lake. In the downtown area, pipe inverts are typically 6 to 7 feet below grade, but increasing to 10 to 12 feet where pipe jacking may be required beneath major roadway intersections.

The purpose of this study was to establish general subsurface conditions at the site and to subsequently develop conclusions and recommendations for the proposed sewer system design and construction. The scope of work consisted of field explorations, geotechnical engineering analyses, laboratory tests, and report preparation. AGRA previously completed a limited geotechnical engineering and seismic hazard study for this project as part of a SEPA Threshold Determination (AGRA Project 7-91M-11684, June 10, 1997). We also completed a geotechnical design report for the upgrade of CLPS dated November 18, 1998.

3.0 EXPLORATORY METHODS

We explored surface and subsurface conditions at the project site during June and July 1999. In October and November 1999, the proposed alignment for the Force Main sanitary sewer piping was rerouted through Heritage Park across the Capitol Lake pedestrian bridge and through Marathon Park back to Deschutes Parkway, where it then proceeds north to CLPS. A third phase of exploration drilling was advanced in late November and early December 1999, in order to address the realignment of the proposed pipeline. Our exploration and testing programs comprised the following elements:

- A visual surface reconnaissance of the site;
- Thirty-one borings (designated B-1 through B-31) with Standard Penetration Tests, advanced at selected locations along the alignment;
- Seven Cone Penetration Test Probes (designated CPT-1, CPT-4, CPT-4A, CPT-5, and CPT-6) advanced at selected locations along the alignment;
- A review of the logs of 11 borings (herein designated BH-201 through BH-210 and D-7), previously advanced along the alignment by Grover Way, Consulting Soils Engineer (1996);
- A review of the logs of four Cone Penetration Test Probes (designated CPT-01, CPT-02, CPT-06, and CPT-08) previously advanced near the alignment through Heritage Park by Milbor-Pita, Inc. (1996);
- Ten groundwater observation wells (designated MW-1 through MW-10), were installed in strategically located boreholes;
- Twenty-four grain size analyses, performed on selected soil samples obtained from our borings at selected locations beneath the alignment;
- Eleven 200-wash analyses, performed on selected soil samples obtained from strategic locations beneath the alignment;
- Four Atterberg limit determinations, performed on selected samples of cohesive soil obtained from beneath the site;
- Eight analytical tests for hydrocarbons, performed on selected soil samples obtained from borings located in the downtown portion of the project;
- Three analytical tests for hydrocarbons and lead, performed on selected groundwater samples obtained from monitoring wells located in the downtown portion of the project; and
- A review of published geologic and seismologic maps and literature.

Table 1 summarizes the approximate functional locations, surface elevations, and termination depths of all pertinent subsurface explorations, and Figure 2 depicts their approximate relative locations. Appendix A of this report describes our field exploration procedures for auger borings, well installation, and CPT soundings; Appendix B describes our laboratory testing procedures; and Appendix C describes our environmental sampling procedures.

TABLE 1
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Exploration	Functional Location	Surface Elevation (feet)	Termination Depth (feet)
B-1	Deschutes Parkway, IS Station 91+40	97.1	30½
B-2	Deschutes Parkway, IS Station 84+70	83.3	13
B-3	Deschutes Parkway, IS Station 77+05	54.4	24
B-4	Deschutes Parkway, IS Station 88+05	91.1	8
B-5	Deschutes Parkway, IS Station 69+10	25.5	36½
B-6	Deschutes Parkway, IS Station 62+75	21.7	26½
B-7	Deschutes Parkway, IS Station 57+25	19.9	26½
B-8	Deschutes Parkway, IS Station 53+70	21.4	31½
B-9	Tumwater Falls Park, IS Station 100+55	96.8	6
B-10	Exit Driveway of Tumwater Falls Park, IS Station 98+15	98.4	8½
B-11	Tumwater Falls Park, IS Station 102+40	92.7	15½
B-12	Thurston Avenue and Adams Street	9.6	31½
B-13	Thurston Avenue and Capitol Way	10.8**	26½
B-14	Thurston Avenue and Washington Street	10.9	26½
B-15	Olympia Ave. and Columbia Street, FM Station 55+70	10.5	26½
B-16	State Ave. and Columbia Street, FM Station 52+65	11.0	26½
B-17	Olympia Ave. and Capitol Way, FM Station 61+30	10.4	31½
B-18	139 ft. west of Water St. on 5th Avenue	10.8	36½
B-19	94 ft. west of Simmons Rd. on 5th Avenue	11.6	31½
B-20	245 ft. southwest of 5th Avenue Bridge	16.5	31½
B-21	Deschutes Parkway north from Pole 55	16.3	41½
B-22	Deschutes Parkway, IS Station 3+55	14.0	26½
B-23	Deschutes Parkway, IS Station 10+35	11.9	26½
B-24	Deschutes Parkway, IS Station 22+10	14.2	31½
B-25	Deschutes Parkway, IS Station 31+10	13.4	31½
B-26	Deschutes Parkway, IS Station 36+80	15.0	41½
B-27	Deschutes Parkway, IS Station 47+45	21.6	31½
B-28	7th Ave. S.W. and Columbia Street, FM Station 38+95	12.5**	50
B-29	South-central Heritage Park, FM Station 26+10	9.5**	46½
B-30	Exercise area of Marathon Park, FM Station 7+50	10.2**	36½
B-31	East of Capitol Lake Foot Bridge, FM Station 14+40	8.8**	21½

TABLE 1
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Exploration	Functional Location	Surface Elevation (feet)	Termination Depth (feet)
CPT-1	N. of Intersection of 5th Ave. S.W. and Columbia Street, FM Station 47+75	11.3	30
CPT-2	Deschutes Parkway, 45 feet northeast of Pole 60	16.1	35
CPT-3	Deschutes Parkway, IS Station 16+90	14.9	30
CPT-4	Deschutes Parkway, IS Station 26+25	14.6	36
CPT-4a	Deschutes Parkway, across from Pole 35	~14½**	36
CPT-5	Deschutes Parkway, IS Station 42+30	19.3	40
CPT-6	Deschutes Parkway, IS Station 51+00	21.8	36
(B-201)	Deschutes Parkway, IS Station 27+00	14½*	59½
(B-202)	Deschutes Parkway, near IS Station 25+00	15*	49½
(B-203)	Deschutes Parkway, near IS Station 23+00	14½*	54½
(B-204)	Deschutes Parkway, near IS Station 21+90	14½*	49½
(B-205)	Deschutes Parkway, near IS Station 19+90	14*	49½
(B-206)	Deschutes Parkway, near IS Station 17+30	15*	44
(B-207)	Deschutes Parkway, near IS Station 15+30	15½*	49½
(B-208)	Deschutes Parkway, near IS Station 47+25	11½*	44
(B-209)	Deschutes Parkway across from Pole 58	16½*	64½
(B-210)	Deschutes Parkway, near IS Station 10+20	12*	29
(D-7)	Deschutes Parkway, near IS Station 45+25 and 77 feet left	10½*	49
(CPT-01)	Heritage Park, near FM Station 18+35 and 75 feet left	~9**	30½
(CPT-02)	Heritage Park, near FM Station 19+75 and 130 feet left	~8½**	34
(CPT-06)	Heritage Park, near FM Station 28+70 and 70 feet left	~9**	32½
(CPT-08)	Heritage Park, near FM Station 32+40 and 65 feet left	~9**	42½

Elevation datum: Surveyed data provided by Parametrix, Inc.
* Survey data provided by Grover Way (1996).
** Elevation estimated from Parametrix, Inc. Survey data.
(B-201) through (B-210) and (D-7) are borings by Grover Way (1996). (CPT-01), (CPT-02), (CPT-06), and (CPT-08) are cone penetration tests by Milbor-Pita (1996).

The specific number, locations, and depths of our explorations were selected in relation to the existing and proposed site features, under the constraints of surface access, underground utility conflicts, and budget considerations. The relative location and elevation of each of our explorations was determined by survey information and a layout plan provided to us by Parametrix, Inc. We also estimated the relative location of each exploration performed by others by measuring from existing features and scaling these measurements onto a layout plan supplied to us, then we estimated their elevations by interpolating between contour lines or spot elevations shown on this same plan. Consequently, the data listed in Table 1 and the locations depicted on the figures should be considered accurate only to the degree permitted by our data sources and implied by our measuring methods.

It should be realized that the explorations performed for this evaluation reveal subsurface conditions only at discrete locations along the project alignment and that actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations would not become evident until additional explorations are performed or until construction activities have begun. If significant variations are observed at that time, we may need to modify our conclusions and recommendations contained in this report to reflect the actual site conditions.

4.0 SITE CONDITIONS

The following sections of text present our observations, measurements, findings, and interpretations regarding surface, subsurface, groundwater, seismic, and environmental conditions at the project site.

4.1 Surface Conditions

The proposed sewer alignment has been divided into two separate alignments consisting of the Force Main sewer line and the Twin Interceptor sewer lines, and will be discussed separately.

Forced Main Sewer Line: Force Main sewer line alignment is approximately 7,200 feet in length, and starts at the intersection of Adams Street and Olympia Avenue. At this point, the sewer alignment proceeds west on Olympia Avenue to the intersection with Columbia Street. At this intersection, the alignment turns south and continues to just south of the intersection of Columbia Street and 7th Avenue. At this juncture, the force main sewer pipeline continues through Heritage Park to the south-southwest along the west side of the power plant access road to the Capitol Lake pedestrian bridge. The sewer alignment will cross over Capitol Lake under the pedestrian bridge, and continue west under the pedestrian path into Marathon Park. The alignment will swing north of the exercise area and facility building to Deschutes Parkway, where it will continue north to the CLPS.

The alignment between Adams Street and 7th Avenue is situated in the northern sector of the City, and the entire alignment is paved, and the property outside the street right-of-way is occupied by sidewalks and commercial and retail buildings. The proposed alignment through Heritage Park from 7th Avenue to the Capitol Lake pedestrian bridge is overlain by newly planted grass from recent park improvements. At the east and west sides of the Capitol Lake pedestrian bridge there are rock abutments, which support the ends of the bridge that is timber pile support and spans a narrow channel across Capitol Lake of approximately 260 feet. After reaching the west bank of the lake, the alignment will underlie a gravel pedestrian path until the east side of the exercise area in Marathon Park. The alignment turns to the northwest at this point for 150 feet before heading west to Deschutes Parkway. The sewer alignment is overlain by grass in this area of Marathon Park. The sewer alignment north on Deschutes Parkway to the CLPS is overlain by concrete pavement.

Topographic relief along the alignment is relatively flat ranging from roughly elevation 11½ feet at the intersection of Adams Street and Olympia Avenue to elevation 12½ feet at the northeast corner of Heritage Park. The elevation ranges from 9 to 10 feet through Heritage and Marathon Parks and increases to 12 to 14 feet north to the CLPS. There are a few deciduous trees which lie along the alignment in Marathon Park which may have to be removed in order to install the sewer line.

Based on our review of literature, field observation, and our explorations, we did not observe any surrounding slope stability issues, in our opinion, that could impact the installation of the Force Main sewer line through this proposal alignment.

Surface water was observed in two locations of the proposed alignment during our site explorations. The first area is where the proposed alignment crosses Capitol Lake between Stations 11+10 and 13+70, and the second area observed in the drainage ditch west of the Burlington Northern & Santa Fe Railway (BN & SF RR) located between Stations 2+65 and ~5+50 on the Interceptor Sewer alignment.

<u>Interceptor Sewer Lines</u>: The Interceptor Sewer alignment is approximately 10,000 feet in length, and starts in Tumwater Falls Park just west of the Capitol Boulevard Bridge. At this point, the sewer alignment goes northwest to the park entrance at Deschutes Parkway, and the proposed sewer alignment continues beneath or beside the Deschutes Parkway, which continues north to where it crosses underneath I-5 and continues north where it parallels the western bank of Capitol Lake up to the CLPS. The sewer alignment in Tumwater Falls Park lies between Stations 96+00 and 103+00, and between Stations 99+00 and 103+00 the sewer alignment lies beneath a partially paved/gravel park trail. Between Stations 96+00 and 99+00 the alignment crosses an asphalt-paved parking entrance driveway and existing paved parking lot. As the sewer alignment continues north, it is beneath or beside asphalt pavement to approximately Station 78+00. Near Station 78+00 north to the CLPS, the sewer alignment is beneath or beside concrete pavement or concrete pavement with an asphalt overlay.

Topographic relief varies significantly along the alignment being at an elevation of 107 feet in Tumwater Falls Park to elevation 12 to 14 feet on Deschutes Parkway across from the CLPS. Elevation at the entrance of Tumwater Falls Park is approximately 107 feet and decreases to an elevation of 92 feet near the Capitol Boulevard Bridge. At the high elevation of 107 feet near the park entrance the sewer alignment elevation drops moderately to an elevation of 23 feet at Station 66+50 approximately 800 feet west of I-5. The elevation then slopes gently to the north, from 23 feet at Station 66+50 to elevation 13 to 14 feet at Station 2+80.. There are a few scattered trees in Tumwater Falls Park which may have to be removed in order to install the sewer lines.

Based on our review of literature, field observation, and our explorations there were several areas determined to have shown signs of past slope instability. A review of the Grover Way Report

(1996) indicated five areas where tension cracks or rotational landslide failures occurred during the 1965 earthquake along the western shoreline of Capitol Lake and extended into the sidewalk and/or into the eastern lane of Deschutes Parkway. The approximate limits of these five failed areas lie between Stations 42+90 to 46+20, 48+10 to 50+40, 55+65 to 59+50, 62+45 to 64+25, and 66+05 to 68+80. Repairs were made to all five areas to restore the damaged areas to their original functional use. The proposed alignment of the Interceptor Sewer lines is beneath or near the western lane of Deschutes Parkway, and is to the west of the first four failed areas. However, the proposed alignment crosses over to the east side of Deschutes Parkway at roughly Station 67+50, and falls within the 1965 failed area between Stations 66+05 to 68+80 for a distance of roughly 130 feet.

During our field observations of the Interceptor Sewer line alignment, steep slopes were observed above the proposed alignment to the west of Deschutes Parkway, from Lakeridge Drive (Station 30+50) south to the ramp for SR-101 (Station 66+00). Multiple areas of slope creep or surficial slumps were observed over this section of the proposed alignment, and did not appear that they would have an impact on the construction phase of the project. However, several areas of concern where landslides were observed are noted below:

1. Station 43+80 to 44+80: There is a definite landslide that has occurred which appears to have been triggered by moderate seepage occurring in the slope throughout this area. It is difficult to determine whether or not the toe of this landslide is above Deschutes Parkway or if it continues beneath it.

2. Station 50+60 to 52+80: There is a definite landslide feature visible above Deschutes Parkway. This slump feature, in our opinion, appears to continue beneath the parkway, but is not visible on the eastern side of the parkway. One of the failed areas noted in the Grover Way Report (1996), between Stations 48+10 to 50+40 lies to the east of this landslide area.

3. Station 53+80 to 56+00: This area appears to either be an old landslide feature or the slope was graded during construction of the embankment for SR-101 that lies upslope to the west. There is a rock buttress (3 to 4 man rock), roughly 140 feet in length, present in this interval from Station 53+80 to 55+30. We were unable to obtain any information on this rock buttress; therefore, we were unable to determine whether or not this rock buttress is for the toe of the slope for SR-101 or at the top of the slope for a rock filled embankment beneath the Deschutes Parkway.

4. Station 57+20 to 58+50: The slope failure in this area appears to be surficial.

Surface water was observed in several areas during our site visits. The most noticeable is the stretch of Deschutes Parkway between Stations 12+00 to 29+00 where Capitol Lake is visible to the east and Percival Cove is visible to the west. Percival Creek connects Percival Cove with Capitol Lake where it crosses under Deschutes Parkway at Station 13+75. Capitol Lake is also present along the western side of the alignment south to Station 68+00. There is a stream drainage that crosses under Deschutes Parkway at Station 40+60 through a 36-inch CMP. It appears that the stream drainage was rocked at one time between Stations 40+45 and 40+75, and this rocked area may cause construction problems along this segment of the alignment. Standing water was also observed in the ditch along the west side of Deschutes Parkway from CLPS south to the driveway entrance (Stations 2+65 and ~5+50) and from Lakeridge Drive south to the stream drainage crossing (Station 30+50 to 40+60). Surface groundwater seepage of significance was observed between Stations 44+00 and 44+50 and is associated with an existing landslide as previously noted. Two other areas of surface water that should be noted are the stormwater drains that discharge from SR-101 to Capitol Lake located at Stations 56+70 and 63+85. It should be noted that these stormwater drains could flood an open utility trench at these stations during moderate to heavy rainfalls.

4.2 Subsurface Conditions

Results and findings of current explorations were used in conjunction with the research completed in our 1997 feasibility study. Regional geology and our interpreted subsurface conditions are summarized in the following sections.

4.2.1 Regional Geology

The Puget Sound Basin is a slightly arcuate, convex-eastward basin lying between the Cascade Range and the Olympic Mountains. The basin is open to the north to the Georgia Depression and the Strait of Juan de Fuca, the latter connecting Puget Sound with the Pacific Ocean. Repeated incursions of Pleistocene continental ice into the basin are characterized by a complex sequence of lacustrine deposits, advance outwash, glaciomarine drift, till, and recessional outwash. The surficial geology of the project site is underlain by undifferentiated sediments of the Quaternary Vashon Drift. The glacial drift is chiefly recessional and proglacial stratified outwash sand and gravel with some silts and clays. Because recessional outwash was not overconsolidated by glacial ice, it is loose to medium dense and can vary markedly in relative density over short distances.

4.2.2 Previous Site Geologic Interpretation

The surficial geology of the project site is evident by the soil borings provided in the soil investigation reports for the renovation of Deschutes Parkway by Grover Way (1996), for improvements to Heritage Park by Milbor-Pita (1996), and in several of AGRA's previous project reports in the Capitol Lake and Tumwater areas. The Deschutes Parkway was apparently constructed of fill material, predominantly bank-run sands and gravels cut from the slope just south of the CLPS. The loose to medium-dense fill material varies in thickness from 10 to 20 feet and the Standard Penetration Test (SPT) N-values range from approximately 2 to 15. The SPT blowcounts of the fill material indicate that the fill was likely end-dumped on the original ground and placed by dozers without significant subgrade preparation or compaction.

The Deschutes Parkway is also within the deltaic deposits of the Deschutes River. The fill is underlain by recent alluvium and recessional outwash deposits that consist of primarily interbedded layers of soft to medium-stiff silts and clays and medium-dense to very dense, gravelly sand and sandy gravel. The majority of the near-surface material prior to the placement of fill consists primarily of accumulated sediments borne by the Deschutes River. Coarse, granular sediments were deposited initially as the river entered the basin due to significant decrease in stream velocity. Lighter, fine-grained sediment and organic material which remain in suspension longer was deposited in the basin further to the north. Toward the mouth of the Deschutes River, the topography has been modified by embankment construction at downtown Olympia into Capitol Lake. Maintenance dredging of the Capitol Lake basin has occurred periodically due to the ongoing sediment accumulation. The offshore sediments carried by the river is derived from alluvial flood plains consisting of peat, silts, sands, and gravels, which originate from the Vashon glacial deposits. In the process of dredging and filling, the hydraulic fill may have intruded into softer natural material and created isolated soil pockets or lenses. The soft to medium-dense sediments and hydraulic fill could be as thick as 20 to 30 feet below mudline, underlain by medium-dense to dense sands and gravels.

Toward the south, the site is flanked by approximately 150-foot-high slopes. These slopes exhibit landslide features, and are mapped in the Slope Stability Map of Thurston County published by Washington Division of Geology and Earth Resources as unstable (Class 3) because of the underlying geologic materials, slopes are generally greater than 15 percent to 30 percent, and older or recent active landslides commonly occur. Downward movements such as occasional landslides of moderate size, slumping, and slicing are common in this area.

4.2.3 Current Interpretation of Subsurface Conditions

Our interpretation of subsurface conditions for this project includes: (1) Force Main Sewer Line and (2) Interceptor Sewer Lines.

Force Main Sewer Line: The north end of the proposed forced main sewer alignment starts at the intersection of Adams Street and Olympia Avenue, continuing through part of the downtown area to the northeast corner of Heritage Park. Much of downtown Olympia in this area appears to have been constructed on a substantial thickness of granular, advance glacial outwash. This glacial material was overlain by approximately 5 to 7 feet of gravelly, silty, sandy fill. The glacial material was encountered to the full depth of our explorations of 40 feet. Some thin interbeds of clay, silt, and peat were encountered at a depth of 10 to 15 feet in boring B-15 near Columbia Street.

The soils underlying Heritage Park from the intersection of 7th Avenue S.W. and Columbia Street to the Capitol Lake pedestrian bridge consists of grass mantling 3 to 10 feet of medium-dense grading to loose, gravelly sand with trace to some silt fill soils. These soils overlie 8 to 16 feet of loose to medium-dense silty sand/sandy silt with traces of organics and wood fibers, and are believed to be dredge fill soils. These fill soils are underlain by 0 to 2 feet of mudline sediments consisting of organic sandy silts before penetrating 2 to 5 feet of soft marine silt with shells ranging from 14 to 30 feet beneath the ground surface. In the south-central area of Heritage Park (in the area of boring B-29), there is a 2- to 6-foot stratum of loose to medium-dense silty sand between the dredge fill and the soft silt with shells. It was difficult to determine if this stratum is a continuation of the dredge fill soils or if stratum is a consists of alluvial detrital deposits. Underlying the soft silt with shells are loose to medium-dense silty sands or medium-stiff to stiff sandy silts, before encountering dense sands to silty sands with trace gravel at depths of 41 to 48 feet below the existing ground surface.

The soils underlying the area of the Capitol Lake pedestrian bridge through the north side of Marathon Park to Deschutes Parkway consist fill soils that are medium-dense grading to loose, gravelly sand/sandy gravel with trace to some silt, increasing from 3 feet at Deschutes Parkway to 15 feet at the pedestrian bridge. These soils are underlain by 2 to 7 feet of loose to medium-dense, gravelly, silty sand to silty sand fill and or dredge fill soils ranging from 10 to 17 feet below the ground surface. These fill soils mantle 2 to 4 feet of a soft marine silt with shells. This marine silt is underlain by interbedded loose to medium-dense silty sand and soft to medium-stiff sandy silts before encountering a very dense, sandy gravel with some silt approximately 27+30 plus feet in depth below the ground surface.

The remaining section of the force main sewer alignment lies under the Deschutes Parkway from Marathon Park north to the CLPS. The parkway pavement section overlies 2 to 7 feet of dense grading to loose, gravelly sand with some silt comprising the roadway fill. The roadway fill soils are underlain by 0 to 2 feet of relic topsoil, which mantles loose, gravelly, silty sand soils to roughly 14 feet below the ground surface. These soils overlie 2 to 4 feet of soft marine silt with shells. The marine sediments are underlain by medium-dense, gravelly, silty sands, which grade into dense to very dense silty sands approximately 20 feet below the ground surface, and continues to the full depth of our explorations (borings B-22 and B-23) of 26½ feet.

The enclosed exploration logs in Appendix A provide a detailed description of the soil strata encountered in the subsurface explorations. The enclosed *Plan and Geologic Profiles* (Figures FM1 through FM14) illustrate our stratigraphic interpretations at select locations along the force main sewer alignment.

<u>Interceptor Sewer Lines</u>: The interceptor sewer alignment will be connected in Tumwater Falls Park near the footpath just west of the Capitol Boulevard Bridge and continue northward along Deschutes Parkway all the way to the CLPS. In the eastern area of Tumwater Falls Park, 0 to 2 feet of grass and topsoil mantle 2 feet of medium-dense sand with some silt. Our boring B-9 also indicates the presence of 0 to 3 feet of peat underlying the topsoil stratum and overlying 2 to 3 feet of soft sandy clay before encountering the medium-dense sand with some silt approximately 6 feet beneath the ground surface. At approximately 4 to 10 feet beneath the ground surface, our explorations encountered a very dense silty sand matrix around dark green black basalt and volcanic breccia rock fragments mapped as bedrock. The bedrock was determined to be the Crescent Formation mapped as lower to middle Eocene of Tertiary age. The western area of the park to Deschutes Parkway has asphalt roadway as parking surface mantling 2 to 4 feet of medium-dense, gravelly sand with some silt of roadway or parking lot fill. These fill soils were underlain by 6 feet of loose, silty, fine sand, which grades to medium-dense with depth. At roughly 4 to 14 feet beneath the ground surface, a very dense, silty, sand gravel was encountered. These

very dense soils are 2 to 4 feet thick and overlie the bedrock or Crescent Formation to the full depth of our explorations.

At Deschutes Parkway, continuing north along the alignment, this same stratigraphic section is present for 1,500 feet (station 80+00) before the Crescent Formation dips below the depth of our explorations. Along this section of the alignment at boring B-1, a medium-stiff silt, 3 feet thick, was encountered at 10 feet in depth between the medium-dense silty sands and dense sandy gravel, and the Crescent Formation was encountered at 16 feet in depth. Further north along this section of the alignment, the stratigraphic section in boring B-2 had 2 to 3 feet of medium-dense roadway fill mantling loose to medium-dense gravelly sands and silty sands to a depth of 8 feet, where the Crescent Formation was encountered.

As the alignment continues north of station 80+00, the contact of the silty sands and the Crescent Formation becomes deeper, and the thickness of the silty sand increased to at least 18 feet thick in our boring B-3 between Ferry Street and the SR-101 ramp and I-5. A substantial thickness of sand and gravel (approximately 18 feet thick) was encountered in this area that we interpret to have been placed during construction of the SR-101 ramps and I-5. This fill became thinner to the north and is gone before reaching Cone Penetrometer Test CPT-6 (station 53+00).

There is a short section of the alignment between station 44+00 and 53+00 where the pavement section mantles 5 to 7 feet of medium-dense grading to loose, gravelly, silty sand roadway fill. The fill soils are underlain by 10 feet of soft sandy silt in the southern area of their segment and by 20 feet of loose to medium-dense silty sands/sandy silts in the northern area of this segment. The central area of this segment has peat interbeds occurring 10 to 30 feet below the ground surface.

Continuing north along the sewer alignment from station 44+00 to Lakeridge Drive (station 30+00), the roadway fill ranges from 2 to 6 feet thick and grades to a dense gravelly sand with some silt. These roadway fill mantles another 8 to 12 feet of loose to medium-dense gravelly sand with some silt. These soils are underlain by interbedded, loose, silty sand/sandy silt with some gravel that is more than 30 feet thick. These loose, silty, sandy soils thin to 11 feet in boring B-25, where a soft silt was encountered from 21 to 28 feet. The soft silt soils overlie a dense silty sand present of the full depth of our exploration of 31½ feet.

Between Lakeridge Drive (station 30+00) and Percival Creek (station 13+00), soil conditions vary dramatically from the rest of the alignment. The roadway embankment through this segment of the alignment separates Capitol Lake from Percival Cove. Through this interval, the roadway fill averages 5 to 6 feet of medium-dense, gravelly sand with some silt. The roadway fill is underlain by additional fill soils of loose, silty, gravelly sand or loose to medium-dense silty sand 15 to 23 feet thick. This thick section of loose to medium-dense gravelly and sandy soils could be attributed to deltic deposits at the mouth of Percival Creek or possibly landslide material from the bluffs that are adjacent to Deschutes Parkway. These soils underlie a soft silt 5 to 20 feet thick, and in borehole B-204 (station 21+80), the soft silt has been logged as present to near the surface, suggesting a thickness of 28 to 33 feet for the soft silt. The soft silt is underlain by loose to medium-dense, gravelly sand with some silt to depths of 27 to 45 feet beneath the ground surface, where a dense, silty, fine sand was encountered to the full depth of the explorations.

The remaining section of the sewer alignment lies between Percival Creek and CLPS. The parkway pavement here is underlain by 2 to 7 feet of dense grading to lose gravelly sand with some silt. In the southern portion of this section of the sewer alignment, the roadway fill overlies a loose, gravelly, silty sand. In the northern section, the roadway fill overlies 0 to 2 feet of relic topsoil before encountering the loose sandy soils. The loose, gravelly, silty sand soils continue in depth to roughly 14 feet below the ground surface. These soils overlie 2 to 4 feet of soft marine silt with shells. The marine sediments are underlain by medium-dense, gravelly, silty sands, which grade into dense to very dense silty sands approximately 20 feet below the ground surface, and continue to the full depth of our explorations (borings B-22 and B-23) of 26½ feet.

The enclosed exploration logs in Appendix A provide a detailed description of the soil strata encountered in the subsurface explorations. The enclosed *Plan and Geologic Profiles* (Figures IS1 through IS9) illustrate our stratigraphic interpretations at select locations along the interceptor sewer alignment.

Our geotechnical laboratory tests for both sewer alignments are summarized in Table 2. We interpret the majority of the soils encountered to be currently above their optimum moisture contents, and highly sensitive to moisture content variations. The enclosed laboratory testing sheets graphically present our test results.

TABLE 2
LABORATORY TEST RESULTS FOR NON-ORGANIC ON-SITE SOILS

Soil Type (Soil Source)	Sample Depth (feet)	Moisture Content (percent)	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)
B-1/S-3	10 – 11½	33.1	—	—	68.2
B-5/S-5	12½ – 14	15.1	23.3	72.6	4.1
B-5/S-8	25 – 26½	21.7	—	—	21.5
B-6/S-2	5 – 6½	31.7	12.0	71.8	16.2
B-6/S-5	12½ – 14	24.8	0.2	88.9	10.9
B-7/S-4	10 – 11½	13.9	—	—	22.6
B-7/S-6	15 – 16½	29.5	2.0	63.6	34.4
B-8/S-3	7½ – 9	27.3	—	—	35.6
B-8/S-5	12½ – 14	23.6	0.6	78.3	21.1
B-15/S-5	12½ – 14	80.7	—	—	64.3
B-18/S-5	12½ – 14	50.0	—	—	38.0
B-19/S-8	25 – 26½	34.0	—	—	19.6

TABLE 2
LABORATORY TEST RESULTS FOR NON-ORGANIC ON-SITE SOILS

Soil Type (Soil Source)	Sample Depth (feet)	Moisture Content (percent)	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)
B-20/S-3	7½ – 9	9.2	—	—	8.5
B-20/S-6	15 – 16½	21.4	7.2	90.1	2.7
B-21/S-4	10 – 11½	16.3	13.8	78.7	7.5
B-21/S-8	25 – 26½	22.9	5.0	78.5	16.5
B-22/S-3	7½ – 9	30.7	35.7	53.9	10.4
B-22/S-6	15 – 16½	21.2	16.1	54.4	29.5
B-23/S-3	7½ – 9	16.7	1.5	89.3	9.2
B-23/S-5	12½ – 14	38.8	8.8	55.3	35.9
B-24/ S-3	7½ – 9	22.6	2.6	84.8	12.6
B-24/S-7	25 – 26½	11.7	34.7	61.8	3.5
B-25/S-3	7½ – 9	16.2	29.4	66.9	3.7
B-25/S-5	12½ – 14	45.8	12.1	70.8	17.1
B-25/S-8	25 – 26½	27.0	—	—	59.2
B-26/S-5	12½ – 14	27.7	12.2	47.6	40.2
B-26/S-9	30 – 31½	29.0	0.6	85.4	14.0
B-27/S-2	5 – 6½	17.3	10.4	57.2	32.4
B-27/S-6	15 – 16½	14.5	11.9	54.8	33.3
B-28/S-3 & S-4	10 – 14	27.6 avg.	1.3	86.1	12.6
B-28/S-7	25 – 26½	34.3	—	—	17.8
B-29/S-1, S-2 & S-3	5 – 11½	32.4 avg.	0	53.8	46.2
B-29/S-7	25 – 26½	41.5	—	—	54.4
B-30/S-1 through S-4	2½ – 12½	17.9 avg.	26.7	63.3	10
B-30/S-9 & S-10	30 – 36½	10.8 avg.	54.0	39.2	6.8
B-31/S-1 through S-5	2½ – 14	17.9 avg.	26.7	63.3	10
N/T = not tested					

4.3 Groundwater Conditions

At the time of drilling (July, November, and December 1999), most of our explorations encountered groundwater, at depths ranging from approximately 4 to 12 feet below existing grades. Table 3 summarizes the approximate groundwater depths and elevations that were observed at the time of drilling. Also at the time of drilling, groundwater monitoring wells with a 2-inch-diameter slotted PVC casing were installed in 10 of our exploration borings (B-3, B-5, B-8, B-11, B-12, B-15, B-17, B-20, B-24, and B-25). We took readings in September 1999 (presumably near the low levels for the year) and again in February 2000 (near the annual high). Table 3a summarizes the approximate groundwater depths and elevations that we measured in our observation wells. Throughout the year, groundwater levels would likely fluctuate in response to changing precipitation patterns, off-site construction activities, and site utilization.

TABLE 3
APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN EXPLORATIONS

Exploration	Depth of Groundwater (feet)	Elevation of Groundwater (feet)	Date of Measurement
B-1	12	85	July 7, 1999
B-2	N/E	—	July 7, 1999
B-3	8½	46	July 7, 1999
B-4	N/E	—	July 8, 1999
B-5	7	18½	July 8, 1999
B-6	7½	14	July 9, 1999
B-7	7½	12½	July 9, 1999
B-8	4½	17	July 9, 1999
B-9	N/E	—	July 12, 1999
B-10	N/E	—	July 12, 1999
B-11	5	87½	July 12, 1999
B-12	5	4½	July 19, 1999
B-13	5½	5¼	July 19, 1999
B-14	6	5	July 20, 1999
B-15	4½	6	July 20, 1999
B-16	4½	6½	July 20, 1999
B-17	5	5½	July 26, 1999
B-18	5½	5¼	July 26, 1999
B-19	6½	5	July 26, 1999
B-20	8	8½	July 27, 1999
B-21	7	9¼	July 27, 1999
B-22	10	4	July 27, 1999
B-23	6½	5½	July 28, 1999
B-24	7½	6¾	July 28, 1999
B-25	5	8½	July 28, 1999
B-26	7½	7½	July 28, 1999

TABLE 3
APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN EXPLORATIONS

Exploration	Depth of Groundwater (feet)	Elevation of Groundwater (feet)	Date of Measurement
B-27	8	13½	July 28, 1999
B-28	9½	3	November 30, 1999
B-29	Mud Rotary ~8	1½	November 30, 1999
B-30	Mud Rotary ~5½	4¾	December 1, 1999
B-31	Mud Rotary ~3½	5¼	December 1, 1999
CPT-1	8*	5.3	July 21, 1999
CPT-2	7*	9.1	July 21,1999
CPT-3	7*	7.9	July 21, 1999
CPT-4	7*	9.6	July 21, 1999
CPT-4a	7*	9.6	July 23, 1999
CPT-5	9*	10.3	July 23, 1999
CPT-6	11*	10.8	July 23, 1999

* At time of cone penetration testing.

TABLE 3a
APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN MONITORING WELLS

Exploration	Observation Well	Depth of Groundwater (feet)	Elevation of Groundwater (feet)	Date of Measurement
B-3	MW-1 MW-1	9.13 4.03	45.24 50.34	Sept. 1, 1999 Feb. 21, 2000
B-5	MW-2 MW-2	4.58 5.80	20.94 19.72	Sept. 1, 1999 Feb. 21, 2000
B-8	MW-3 MW-3	3.92 3.56	17.44 17.80	Sept. 1, 1999 Feb. 21, 2000
B-11	MW-4 MW-4	4.04 2.41	88.67 90.30	Sept. 1, 1999 Feb. 21, 2000
B-12	MW-5 MW-5	4.03 3.55	5.54 6.02	Sept. 1, 1999 Feb. 21, 2000
B-15	MW-6 MW-6	5.14 4.86	5.36 5.64	Sept. 1, 1999 Feb. 21, 2000

TABLE 3a
APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN MONITORING WELLS

Exploration	Observation Well	Depth of Groundwater (feet)	Elevation of Groundwater (feet)	Date of Measurement
B-17	MW-7 MW-7	5.31 5.00	5.06 5.37	Sept. 1, 1999 Feb. 21, 2000
B-20	MW-8 MW-8	7.67 6.35	8.78 10.10	Sept. 1, 1999 Feb. 21, 2000
B-24	MW-9 MW-9	7.65 7.55	6.50 6.60	Sept. 1, 1999 Feb. 21, 2000
B-25	MW-10 MW-10	1.21 1.35	12.23 12.09	Sept. 1, 1999 Feb 21, 2000

4.4 Environmental Conditions

A summary of environmental testing completed by our Portland, Oregon analytical laboratory is provided as follows. The analytical laboratory's testing certificates are included in Appendix C of this report.

Soil Conditions: Soil samples were submitted from borings within the downtown portion of the alignment due to potential for environmental impairment from on and off-site sources. Samples were tested for gasoline, diesel, and heavy oil-range petroleum hydrocarbons by Washington State Method WTPH-G/BTEX and WTPH-Diesel Extended. Test results are summarized in Appendix C. Generally, no concentrations in excess of method detection limits were identified from any of the borings. Boring B-15 did contained identifiable concentration of gasoline and heavy oil-range petroleum hydrocarbons, however the concentrations were well below MTCA Method A Cleanup Limits.

Groundwater Conditions: Groundwater samples were submitted from monitoring wells within the downtown portion of the alignment due to potential for environmental impairment from on and off-site sources. Sample were tested for gasoline, diesel, and heavy oil-range petroleum hydrocarbons by the methods listed above and Total Lead by EPA Method 6010/7000. Groundwater result from MW-5 (B-12), near the Fast Fuel Gas Station, indicate that groundwater has been impacted by gasoline-range petroleum hydrocarbons and BTEX. Concentrations in excess of MTCA Cleanup Criteria include Benzene, Ethylbenzene, and Total Xylenes. No concentrations of gasoline-range or BTEX hydrocarbons were observed from MW-6 (B-15) and MW-7 (B-17) or diesel- and heavy oil-range petroleum hydrocarbons from MW-5 (B-12), MW-6 (B-15), or MW-7 (B-17). However, total lead concentrations were detected in all three monitor wells in excess of cleanup standards.

4.5 Seismic Conditions

The Puget Sound area is located in a moderately active tectonic province that has been subjected to earthquakes of low to moderate strength and occasionally to strong shocks during the 160-year historical record of the Pacific Northwest. The largest historical earthquakes in the region are believed to be associated with deep-seated plate-tectonic activities, such as the subduction thrust between the Juan de Fuca plate and the North American plate and intraplate movements.

The strongest earthquakes to have shaken the Puget Sound region this century occurred in 1949 and 1965. The 1949 Olympia earthquake occurred at a depth of 54 kilometers (km) and at an epicentral distance of about 5 km from a recording station at the Highway Test Laboratory in Olympia. The 1965 Seattle-Tacoma earthquake occurred at a depth of 60 km and at an epicentral distance of 21 km and 61 km from record stations at the Seattle Federal Office Building and the Olympia Highway Research Laboratory. Both the 1949 and 1965 earthquakes were "intraplate" type earthquakes. They generated seismic events that were rated VII to VIII on the Modified Mercalli intensity (MMI) scale in the Olympia area. The 1949 Olympia earthquake was a magnitude 7.1 event with an observed maximum peak ground acceleration of 0.28g and the 1965 Seattle-Tacoma earthquake was a magnitude 6.5 event with an observed maximum peak ground acceleration of 0.20g.

In addition to the historical earthquakes, it is increasingly believed that a megathrust Cascadia subduction-zone earthquake is likely to occur in the Puget Sound region. Silva et al. (1998) proposed a magnitude 8.5 earthquake model with the rupture plane defined as east-west dipping, 280 km long, and 120 km wide. The proposed rupture plane is about 25 km deep and has a source-to-site distance of about 100 km to downtown Olympia. The attenuation effect results in a predicted, horizontal peak ground acceleration of about 0.15g in Olympia.

A probabilistic study completed by National Earthquake Hazard Reduction Program (NEHRP) in 1997 indicated that the bedrock peak ground acceleration at the project site would be 0.26g and 0.49g for 10 percent and 2 percent probability exceedance in 50 years, respectively. For design purposes, we selected the 1949 Olympia earthquake as the near field event and a hypothetical Cascadia subduction earthquake (Silva et al. 1998) as the far field event. Using an attenuation equation commonly used for the western U.S. (Campbell, 1997), the peak horizontal acceleration (PHA) for the near field event is estimated to be about 0.05g to 0.15g with an average value of about 0.10g. For deep/subduction type earthquakes, an attenuation equation (Youngs et al. 1997) indicates that the PHA for the far field event would be about 0.1g to 0.3g with an average value of 0.2g. The results are similar to the findings by Silva et al. (1998) which indicated that the predicted peak horizontal accelerations in Olympia are 0.15g, 0.10g, and 0.15g for the 1949 Olympia, 1965 Seattle-Tacoma, and the hypothetical Cascadia subdduction earthquakes, respectively. We would conservatively select 0.26g and 0.20g for the bedrock peak acceleration of near field and far field events, respectively.

Local site effects can influence the characteristics of ground surface motions. Case histories of ground response in Mexico City, the San Francisco Bay area, and many other locations have clearly shown that local site conditions strongly influence peak acceleration amplitudes and the amplitudes and shapes of response spectra. Based on comparisons of peak acceleration attenuation relationships for sites underlain by different types of soil profiles, Seed et al. (1976) suggested an overall trend that peak acceleration at the surfaces of stiff soil deposits are slightly greater than on rock when peak accelerations are small and somewhat smaller at higher acceleration levels. Idriss (1990) related peak acceleration on soft soil sites to those on rock sites. The results showed that peak accelerations at soft sites are likely to be greater than on rock sites, however, the low stiffness and nonlinearity of soft soils often prevent the surface from developing peak acceleration as large as those observed on rock.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This section of the report addresses the design and construction aspects of the proposed sewer pipe improvement including: seismic hazards, dewatering, trench excavations, pipe foundation and bedding, trench backfill, channel crossing, and pavement design. Subsurface conditions inferred from the explorations, and soil properties inferred from the field observations and subsequent visual evaluation and laboratory testing of the samples secured, have formed the basis for developing the geotechnical engineering recommendations in this report. If subsurface conditions significantly different from those described in this report are observed or appear to be present at locations between our test borings during construction, AGRA should be advised so that we can review the conditions and make recommendations to reflect the differing conditions, where necessary.

5.1 Seismic Hazards and Mitigation Measures

The following discussion of seismic mitigation measures is intended to protect the pipeline from earthquake-related damage. More extensive mitigation measures would be required to stabilize the Deschutes Parkway embankment from damage. We could provide a discussion of these more comprehensive measures at your request. The site seismicity was discussed in Section 4.5.

For the proposed project site, a bedrock peak acceleration of 0.26g and 0.20g would correspond to a surface peak acceleration of approximately 0.32g and 0.30g for soft soil sites. For design purposes, the attenuation relationship suggested by Barlett and Youd (1995) can be used for the selected near field and far field events. The near field earthquake would be a magnitude 7.5 intraplate earthquake with a surface peak acceleration of 0.32g and a distance of about 20 km. The far field earthquake would be a magnitude 8.5 subduction earthquake with a surface peak acceleration of about 0.30g and a distance of about 100km. These design values are used for estimating ground strains due to seismic wave propagation and permanent ground deformations due to soil liquefaction and lateral spread.

Significant and widespread damage to buildings, bridges, and roadways were reported during the 1949 and 1965 earthquakes (Noson et. al. 1988). Sand boils, lateral spreading, and ground subsidence caused by soil liquefaction were observed along Capitol Lake at the Deschutes Parkway and the Union Pacific Railway branch line (Thorsen 1986). Landslides triggered by earthquakes were also reported at steep slope locations in the same general area.

Due to the presence of surficial loose sands, silty sands, and gravelly sands along the Deschutes Parkway and downtown Olympia areas, soil liquefaction is very likely to occur again during the next major seismic event. Soil liquefaction could cause ground subsidence and loss of pipe support. Soil liquefaction along with sloping ground or free face in the lakeshore could result in lateral spread and horizontal movements of the roadway embankment toward the depression lake. The ground shaking could also trigger a large-scale landslide at locations where a steep slope is present. Where slopes are near the roadway, such major landslides may directly impact upon the Deschutes Parkway embankment, causing displacement or washout of the roadway and sewer pipeline. Such a landslide event might also impose a lateral loading to the soft sediments below or adjacent to the roadway embankment, producing more gradual creep of the embankment toward Capitol Lake over a period of time.

The following paragraphs intend to provide evaluations of various seismic hazards, including wave propagation and permanent ground deformations, and their impacts to the proposed sewer project. Mitigation options will also be discussed.

5.1.1 Seismic Wave Propagation

Propagating earthquake waves move the soil as they pass. If the movement is small and within the elastic range of the soil, the soil moves back to its original position once the wave has moved on. If the movement is sufficiently large such that the deformation of the soil is beyond elastic range and in the plastic range, permanent ground deformations would occur. Earthquake waves can be in the form of body waves (compression and shear waves) or surface waves (Love and Rayleigh waves). Both body and surface waves are of interest since most pipelines are buried within 3 to 10 feet in depth. From the perspective of pipeline design, these waves can be either sine waves or compression waves depending upon the direction of wave propagation relative to the pipe alignment. In general, traveling waves induce out-of-phase motion along pipe axis leading to both axial and flexural strains. Sine waves move the pipe laterally. Most pipe can readily accommodate some lateral movement. Compression waves cause differential longitudinal movement along the pipe axis. Since pipes are typically stiff for axial loads and are more flexible for bending, axial deformation usually governs for straight pipe. Some pipe systems can accommodate some differential movement from wave passage by either accommodating it in the joint, or in pipe strain and ductility. Some damage from wave passage may occur, but it can usually be widely distributed throughout the system unless a brittle pipe with rigid joints is used.

Seismic wave propagation induces ground strains. The maximum ground strain is usually defined as the ratio of maximum horizontal ground velocity in the direction of wave propagation to the wave propagation velocity of the soil (Newmark, 1973). Similar to the peak horizontal acceleration, the maximum horizontal ground velocity can also be determined from published attenuation equations. As previously discussed, we selected a magnitude 7.5 near field event and a hypothetical, magnitude 8.5 far field event for design earthquakes. The maximum horizontal ground velocity is estimated to be about 1.5 to 2 feet per second (ft/sec) for both far and near field events (Kamiyama et al. 1992). Our seismic cone penetration tests along the alignment indicated that the shear (S) wave velocity of the surficial soils (upper 30 to 40 feet) is in the range of 400 to 600 ft/sec. The compression (P) wave velocity is typically about 2 to 3 times faster than the S wave and the Rayleigh wave velocity is about 90 percent of the S wave. Love waves generate bending strains which are generally less significant than axial strains.

For wave propagation where both the direction of propagation and the particle motion are parallel to the ground surface (R-waves), the maximum ground strain is calculated to be 0.3 to 0.6 percent. For wave propagation in the vertical plane at an angle to the ground surface (body waves), the ground strain will be significantly lower than the estimated values. The estimated ground strain should be readily accommodated if flexible pipe and joints (such as HDPE) can be used for this project.

5.1.2 Permanent Ground Deformations

Permanent ground deformations can be caused by soil liquefaction, lateral spread, and landslides. Underground pipes could experience tension, compression, bending, and shear forces as a result of permanent ground deformation.

Liquefaction-Induced Settlement: Liquefaction is the sudden loss of soil shear strength and sudden increase in pore water pressure caused by shear strains, as could result from an earthquake. Research has shown that saturated, loose to medium-dense sands with a silt content less than about 35 percent are most susceptible to liquefaction. In certain cases, non-plastic silts and plastic, fine-grained soils are also susceptible to liquefaction. Our borings and in-situ testing encountered loose to medium dense sands and silty sands below the groundwater table at the site. Considering these conditions of density, saturation, and grain size distribution, we performed an empirical analysis to evaluate the soil liquefaction potential during a seismic event. It should be noted that a recent study by Washington State Department of Natural Resources (WSDNR), Division of Geology and Earth Sciences (Palmer et al. 1999) concluded that the majority of the proposed sewer alignment is located in the area designated as having high liquefaction susceptibility.

For purposes of evaluating liquefaction potential, we selected a design earthquake with a Magnitude of 7.5 and a peak ground acceleration of 0.32g. This design criteria is similar to the one used in the recent WSDNR study (Palmer et al. 1999) that assumed a magnitude 7.3 and a peak ground acceleration of 0.30g. Three methods were used to evaluate the site liquefaction potential: (1) an empirical SPT-N (blowcount) procedure (Seed et al., 1983) for the upper soils explored with auger borings, (2) a cone penetration tip resistance procedure (Robertson and Fear, 1996), and (3) a shear wave velocity procedure (Andrus and Stokoe, 1996) for the deeper soils explored with seismic CPT soundings.

The SPT-N method calculates the factor of safety as the ratio of the cyclic stress ratio that the soil can resist under a certain magnitude of earthquake, to the cyclic stress ratio that is expected to be induced by the equivalent ground motion. The method was originally developed for clean sands and was later modified to incorporate fines content (percent passing No. 200 sieve) up to 35 percent. For the same SPT penetration resistance, the liquefaction resistance generally increases with increasing fines content. The cone tip resistance procedure evaluates liquefaction potential of the soils based on a relationship between the cyclic stress ratio and the corrected cone tip resistance. Similarly, the shear wave velocity approach evaluates liquefaction potential of the soils based on a relationship between the cyclic stress ratio and the corrected shear wave velocity of the soil. The cone tip resistance and shear wave velocity measured for the site soils as a part of the CPT testing are presented in Appendix A.

Based on our analysis, we conclude that there is a moderate to high risk that soil liquefaction will occur in layers within the upper 10 to 30 feet below ground surface across the site during the design earthquake. Surficial disturbance, such as sand boils or differential settlement, are likely to occur following soil liquefaction. Using an empirical procedure developed by Tokimatsu and Seed (1987), we summarize the estimated liquefaction-induced (vertical) ground movements for each segment of the alignment in Table 4.

TABLE 4
SUMMARY OF PERMANENT GROUND DEFORMATIONS

Segment		**Assumed Distance to Lake (ft)**	**Estimated Vertical Movement (in.)**	**Estimated Horizontal Movement (in.)**
From	**To**			
LOTT Plant	Columbia St./7th Ave.	200+	3 to 5	0 to 2
Columbia St./7th Ave.	Heritage Park	75 to 100	5 to 12	4 to 18
Heritage Park	Lakeridge Drive	25 to 50	6 to 10	14 to 28
Lakeridge Drive	I-5/SR-101	75 to 100	5 to 10	5 to 12
I-5/SR-101	Capitol Blvd. Bridge	200+	0	0

Lateral Spread: As a result of soil liquefaction during an earthquake, horizontal displacements due to lateral spread tend to occur in the gently sloping ground or where a free face is present in the ground. Prediction for the magnitude of lateral displacement has recently been developed (Barlett and Youd, 1995) based on a large database of field observations and measurements after several major earthquakes. The method requires input parameters such as soil properties, ground geometry, and earthquake data. In specific, design parameters for estimating lateral spread include: (1) grain size, fines content, and thickness of liquefiable soils; (2) ground slope, height of free face, and distance to free face; and (3) earthquake magnitude and distance to seismic energy source.

Due to the high soil liquefaction potential and its close proximity to the Capitol Lake, the proposed sewer project presents a high risk for lateral spread. We performed a lateral spread analysis using both near field and far field events. Table 4 summarizes our estimate of horizontal ground movement by segments along the proposed sewer alignment. In downtown Olympia, the lateral ground movement is expected to be insignificant due to its greater distance to the lake. Along the Deschutes Parkway south of I-5/SR-101, the soil is not susceptible to liquefaction and no lateral spread is anticipated during ground shaking. For the remaining alignment, we estimated that horizontal ground movement due to lateral spread could range from 4 to 12 inches and could be up to 18 inches in some locations. In general, lateral displacement increases as the distance to the lake decreases. We would recommend that the proposed sewer pipe be installed as for away from the lake (free face) as possible. In narrow embankment areas where water is present on both sides, such as the section of Deschutes Parkway between the railroad tracks and the Lakeridge Drive, the estimated horizontal ground movement due to lateral spread could be from 14 to 28 inches. Retaining structures such as sheetpile walls or pipe anchors may be necessary if the estimated ground movement exceeds the design deformation capacity of the pipe and joints.

Earthquake-Induced Landslides

For the Force Main alignment at each end of the pedestrian bridge, it appears the pipe will be closer than 25 feet away from the shoreline. Specifically, this appears to occur between Station 9+15 to 11+10, and from Station 13+65 to 14+10. For these areas, there is a risk of earthquake-induced sliding, where lateral movements could be significantly greater than those predicted in Table 4.

Using the method developed by Bartlett and Youd (1995), for a condition of a free face of 8 to 10 feet high, at 8 to 10 feet away, we compute a displacement due to lateral spreading of 45 feet. The Bartlett and Youd method is based on linear regression of data from several case histories. Photographs of lateral movement observed on the embankment shoulders of Deschutes Parkway during the 1965 earthquake appear to be on the order of 25 feet.

If the pipeline cannot be relocated further away from the shoreline, we would recommend consideration be given to one of the following for this interval:

- Pile support of the pipeline, similar to the bridge;
- Construction of a sheet pile bulkhead on the waterward side of the trench; and
- Reconstruction of the waterfront edge as a rock revetment, with a prism of free-draining crushed rock fill.

5.2 Dewatering Considerations

Water level readings taken from our observation wells showed groundwater levels will be either slightly above or below the excavation depth for the proposed sewer lines. We anticipate that most excavations will extend down into the gravelly sand and silty sands which are expected to be relatively pervious. Some amount of gravel-sized material was also encountered in some of our test borings. Groundwater levels should also be expected to fluctuate, and may be either higher or lower than currently measured depending on the time of year construction is performed. Dewatering requirements will likely be reduced if construction is performed during the summer and early fall months when groundwater levels are typically at seasonal lows. In any event, at locations where groundwater level is above the excavation depth, we recommend that groundwater level be maintained by dewatering at a depth of at least 2 feet below the pipeline invert elevation. Such dewatering would reduce the risk of unstable conditions and disturbance of the trench bottom, thereby reducing post construction pipe settlements and providing a more stable pipe foundation.

The actual design of the dewatering system depth and spacing should be the responsibility of the contractor. Typical dewatering systems which would be appropriate for this site consist of a vacuum wellpoint system or a series of deeper wells with submersible pumps, or the use of pumps and sumps inside the excavation. With the exception of the south end of the project (south of I-5/SR-101), in our opinion, the vacuum well point dewatering system would be appropriate for most of this project as a means of lowering groundwater levels to roughly 10 to 15 feet below grade. In our opinion, sump/pump methods will be inadequate to prevent boiling or destabilization of the trench bottom and post-construction settlement. Deep dewatering systems are undesirable due to the risk for inducing subjacent settlement, the greater length of time to accomplish dewatering, and the greater volume of water to be handled.

It should be realized that dewatering, particularly within areas underlain by loose sands or soft clays, can cause ground settlement due to an increase in the effective weight of the dewatered soils. Dewatering-induced ground settlements are highly dependent upon drawdown and soil conditions, and are very difficult to predict. Possible effects on adjacent settlement sensitive elements should be taken into consideration, and the use of a sheetpile cutoff as a barrier to lateral seepage, recharging the groundwater outside the excavation, or alternative installation methods such as pipe boring should be considered, where appropriate. We, therefore recommend that the condition of the adjacent structures, roads, and other settlement-sensitive facilities be documented prior to the start of construction. In addition, settlement benchmarks should be established and monitored on a regular basis during dewatering and excavation.

Downtown Olympia Dewatering Considerations: In the downtown area, there is a higher risk of dewatering inducing settlement of roadways and adjacent structures. Furthermore, we understand there will be limitations on the duration of street closure. Because of these conditions, dewatering using deep drilled wells should not be allowed in the downtown area due to the greater risk of inducing settlement, and the greater length of time required for dewatering. We recommend use of a vacuum wellpoint dewatering system, unless the contractor is dewatering within a fully enclosed sheet pile-shored excavation. Based on our experience with LOTT projects to the north of downtown, we would expect that dewatering will need to begin 2 to 4 weeks in advance of excavation. Typical discharge from a 10-foot deep trench, dewatered to 12 feet, would be expected to be on the order of ¼ gallon per minute per foot of trench. The contractor should submit a dewatering plan prior to beginning work, and should be required to install observation wells at least one per every 100 feet of trench to confirm adequate dewatering has been accomplished.

Well construction and water withdrawn from dewatering wells, sumps, and collected runoff will need to be handled in accordance with Washington State Department of Ecology guidelines. Based on our testing, groundwater in the vicinity of borings B-12 (MW-5), B-15 (MW-6), and B-17 (MW-7) will be impacted by elevated concentrations of petroleum and/or lead compounds. Permitted discharge to holding tanks or sanitary sewers should be expected. It may be feasible to discharge water into infiltration basins, ponds, or portable tanks where other drainage devices are not available. In order to minimize the amount of silt or other fine particles in the water, it may be appropriate to discharge the water into a series of sedimentation ponds or tanks prior to final release.

5.3 Trench Excavations

The invert depth for the proposed sewer pipe is anticipated to be approximately 4 to 5 feet below the existing ground surface. Excavation of soils throughout the project area is likely to be accomplished by backhoe and trench box methods, possibly supplemented by shoring in some areas.

At locations where trench excavation is possible, excavation of on-site soils could be accomplished by open cut methods provided the soils are sloped back or shored sufficiently to maintain sidewall stability and protect workers. At locations where safe slope angles cannot be accommodated, or other areas of high groundwater, and where sloughing of the excavation sides could endanger either adjacent utilities, workers, pavement traffic lanes, or other features, we recommend that adequate shoring be utilized. We anticipate that a steel strutted trench box, braced sheeting, or braced sheetpiling could be utilized in any areas where sloughing and/or caving of the trench sidewalls would endanger workers or features adjacent to the trench. Design of trench shoring should be the responsibility of the contractor and should be capable of retaining lateral pressures described in Section 5.4. We should be contacted to review any areas where deeper excavations might be required for utility crossings; it may be necessary to provide continuous sheetpiling for control of seepage or subjacent settlement.

Even if shoring is used, some sloughing should still be anticipated within the soils under the surrounding pavement. Given the current condition of existing roadway pavements, saw-cutting and repairing the roadway pavement by conventional means appear feasible, in our opinion. Other alternatives include removing concrete panels and grinding the asphalt in-place prior to trench excavation and subsequent replacement of the pavement section would provide feasible re-establishment of the roadway. For cases where lateral constraints and pavement conditions permit sawcutting and asphalt patching, we recommend that sawcut asphalt patches extend a minimum of 12 inches beyond either side of the stable trench width.

Landslides Hazards During construction, Interceptor Sewer Alignment

Based on our review of literature, field observation, and our explorations there were several areas determined to have shown signs of past slope instability. A review of the Grover Way Report (1996) indicated five areas where tension cracks or rotational landslide failures occurred during the 1965 earthquake along the western shoreline of Capitol Lake and extended into the sidewalk and/or into the eastern lane of Deschutes Parkway. The approximate limits of these five failed areas lie between Stations 42+90 to 46+20, 48+10 to 50+40, 55+65 to 59+50, 62+45 to 64+25, and 66+05 to 68+80. Repairs were made to all five areas to restore the damaged areas to their original functional use. The proposed alignment of the Interceptor Sewer lines is beneath or near the western lane of Deschutes Parkway, and is to the west of the first four failed areas. However, the proposed alignment crosses over to the east side of Deschutes Parkway at roughly Station 67+50, and falls within the 1965 failed area between Stations 66+05 to 68+80 for a distance of roughly 130 feet.

During our field observations of the Interceptor Sewer line alignment, steep slopes were observed above the proposed alignment to the west of Deschutes Parkway, from Lakeridge Drive (Station 30+50) south to the ramp for SR-101 (Station 66+00). Multiple areas of slope creep or surficial slumps were observed over this section of the proposed alignment, and did not appear that they would have an impact on the construction phase of the project. However, several areas of concern where landslides were observed are noted below:

1. Station 43+80 to 44+80: There is a definite landslide that has occurred which appears to have been triggered by moderate seepage occurring in the slope throughout this area. It is difficult to determine whether or not the toe of this landslide is above Deschutes Parkway or if it continues beneath it.

2. Station 50+60 to 52+80: There is a definite landslide feature visible above Deschutes Parkway. This slump feature, in our opinion, appears to continue beneath the parkway, but is not visible on the eastern side of the parkway. One of the failed areas noted in the Grover Way Report (1996), between Stations 48+10 to 50+40 lies to the east of this landslide area.

3. Station 53+80 to 56+00: This area appears to either be an old landslide feature or the slope was graded during construction of the embankment for SR-101 that lies upslope to the west. There is a rock buttress (3 to 4 man rock), roughly 140 feet in length, present in this interval from Station 53+80 to 55+30. We were unable to obtain any information on this rock buttress; therefore, we were unable to determine whether or not this rock buttress is for the toe of the slope for SR-101 or at the top of the slope for a rock filled embankment beneath the Deschutes Parkway.

4. Station 57+20 to 58+50: The slope failure in this area appears to be surficial.

All of these areas should be identified in the bid documents as potential slide zones, where the contractor should be required to submit a specific plan for shoring and for slope monitoring. For Station 43+80 to 44+80, and Station 50+60 to 52+80, there is a relatively high risk that excavation may initiate further earth movement, in our opinion. For these areas, we recommend that the contractor be required to provide shoring.

5.4 Shoring and Temporary Slopes

Temporary excavation slope stability is a function of many factors, including soil type, density, slope, inclination, depth, the presence of groundwater, adjacent surcharges, and the length of time the cut remains open. Temporary slope safety should remain the responsibility of the contractor who is present at the site, able to observe changes in site soil and groundwater conditions, and monitor the performance of the excavation. In all cases, cut slope angles and shoring should conform to applicable Federal, State, and/or local guidelines. For planning purposes, we anticipate that temporary open-cut, sloping excavations within <u>dewatered</u> soils could be made at inclinations of 1½H:1V or flatter. If these temporary slopes cannot be accommodated then a trench box should be used.

If necessary, sheetpiling shoring could be used to act as a cut-off to reduce lateral seepage into the excavations and also reduce the radius of influence of the groundwater drawdown, thereby reducing potential dewatering-induced ground settlements. As previously discussed, sheetpiling could also be installed along either side of the narrow embankment to limit horizontal ground movement due to lateral spread during ground shaking. Such a system would consist of driving a row of interlocking steel sheets below the planned excavation base for trench sidewall support. The embedment of the sheets should satisfy structural and lateral stability design requirements. The sheetpile must be extended to sufficient depths to prevent "blowout" (heave) or "boiling" (piping) of the excavation base, particularly where the soils outside the sheets cannot be effectively dewatered.

Along the project alignment, sheetpiles should be designed to support active pressure distributions with an equivalent fluid pressure of 40 pounds per cubic foot (pcf) above the groundwater table and 80 pcf below the groundwater table. These values would be applicable for a cantilever sheetpile system or with up to one row of internal or external lateral bracing. Surcharges should be added as appropriate for construction equipment, soil stockpiles, traffic, or other surface loading. Forty percent of the applied vertical surcharge should generally be used for lateral surcharge pressure within a 1½H:1V plane subtended up from the bottom of the sheetpiling. A minimum surcharge equivalent to 2 feet of soil should be used in all areas, with higher surcharges if necessary for areas accessible to construction equipment and activities. Passive earth pressures can be assumed to act below the base of the excavation. The uppermost 2 feet of passive earth pressure should be ignored. An allowable passive earth pressure equivalent to 220 pcf fluid pressure is recommended for lateral support.

<u>Landslide-Prone Areas</u>: Assuming an average backslope of 2H:1V where shoring may be required above the roadway and below the roadway, cantilevered shoring should be designed to resist an active earth pressure of 88 pounds per cubic foot, expressed as an equivalent fluid unit weight. This value assumes a hydrostatic pressure will act against the shoring. Passive pressure acts over the embedded front of the wall (neglecting the upper 1 foot). Assuming a level foreslope at the wall location, we recommend a passive pressure acting over the portion of the wall below the base of the excavation of 260 pounds per cubic foot. This value incorporates a safety factor of at least 1.5.

If an internally braced cut is to be installed (such as a double row of sheet piles with internal struts), we recommend it be designed to resist a lateral earth pressure (full hydrostatic condition) of 57H in psf, where H is the height of the cut in feet.

Shoring Plan: All excavations involve a risk of soil movement, potential delays, and damage to nearby structures. However, in our opinion, based on the soil conditions encountered in our borings, this risk could be considered minimal if the design considerations in this report are implemented. Nonetheless, the actual level of risk will depend on the particular shoring techniques and design criteria selected by the design team and/or contractor. Consequently, we recommend that the contractor submit a shoring plan in advance of construction, for review by the owner, the structural engineer, and the geotechnical engineer.

5.5 Pipe Foundation and Bedding

Based on the field explorations and the current anticipated pipe burial depths, it appears that the soils exposed at the sewer and manhole inverts will primarily be loose to medium-dense gravelly or silty sand. On the south end of the alignment, bedrock may be encountered.

We understand that the material for pipes will likely consist of butt fusion welded, continuous smooth bore, HDPE type pipe. We recommend using one of the following pipe bedding materials:

> *Gravel Backfill for Drains* meeting the requirement of 1998 WSDOT Standard Specification, Section 9-03.12(4); or
>
> *Crushed Surfacing Top Course* meeting the requirements of 1998 WSDOT Standard Specification, Section 9-03.9(3).

We recommend crushed surfacing top course (⅝-inch crushed rock) be utilized for pipe bedding only if a water-free trench conditions can be maintained. The ⅝-inch crushed rock bedding becomes difficult to compact and may provide degraded pipe support when moisture contents are greater than 3 percent above optimum moisture due to a fines content of 7 to 10 percent. If the water within the trench cannot be controlled, the ⅝-inch crushed rock may be utilized with the modification that the fines content be specified at 3 percent maximum. Otherwise, we recommend gravel backfill for drains as presented above.

At a minimum, we recommend excavation to 6 inches below all pipe for pipe bedding. In all cases, the pipe bedding material should be placed to fully envelope the pipe, with minimum thickness of 6 inches both under and over the pipe to ensure proper pipe support and protection during backfilling activities. Where the pipe bedding material is placed over coarse foundation material, it may be necessary to increase the thickness of bedding material under the pipe in order to fill the interstices of the foundation material with a portion of the bedding material and to ensure adequate pipe protection. In this instance, the pipe bedding material should be worked into the void spaces of the underlying foundation material by mechanical methods prior to installing the pipe.

We recommend that pipe bedding material be placed and consolidated in lift thicknesses not to exceed one-half the diameter of the pipe or 12 inches, whichever is smaller. Following compaction of the initial bedding and installation of the pipe, bedding materials should be placed to spring-line of the pipe and consolidated by means of mechanical compaction methods. Subsequently, pipe bedding material should be placed to cover the pipe and consolidated by means of mechanical compaction methods.

In addition to the pipe bedding material recommended above, a reinforced concrete slab could be installed directly beneath the pipe to support against permanent ground deformations and potential buoyancy due to soil liquefaction during a severe earthquake. We anticipate that this reinforced concrete slab will be installed for the proposed sewer alignment where soil liquefaction potential is high. As discussed in Section 5.1.2, significant permanent ground deformations are expected along the proposed sewer alignment beginning from the LOTT treatment plant in downtown Olympia and ending at an approximate location near I-5/SR-101.

At locations where trench excavation extends below groundwater level, porous pipe bedding material may tend to transmit groundwater along the pipe alignment. We recommend installation of low permeability seepage cutoffs along the trench at regular intervals. Contractors may choose to use low permeability pipe collars, such as CDF, clay or concrete collars, to serve as a construction expedient to control groundwater flow along the trench. The location of the pipe collars could also be situated at locations where groundwater migration through the pipe bedding may adversely impact future planned excavations, dewatering, or construction activities. The pipe collars should be situated such that future planned excavations or construction activities will not damage the integrity of the pipe collars. Regardless of which material is selected, the pipe collar should fully envelope the pipe and extend a minimum of 1 foot below the base of the trench and 1 foot above the top of the pipe bedding. We anticipate that pipe collars on the order of 3 to 4 feet in length should be adequate. In our opinion, embedment of the pipe collars into the sides of the excavation does not appear necessary.

5.5.1 Foundation Overexcavation

In addition to the standard pipe bedding practices described above, we recommend that the contract provisions provide for an additional (maximum) 2 feet overexcavation (2½ feet below pipe invert) and foundation material placement beneath the pipe and manholes within the areas encountering disturbed loose sands or soft silts. The depth of overexcavation (of properly dewatered trench lines) will vary, and should be authorized in advance by the geotechnical engineer or his representative. Depending on the subgrade condition, it may be necessary to place a layer of geotextile fabric to separate the foundation material from the subsoil.

5.5.2 Foundation Material and Geotextiles

For foundation material, we recommend using one of the following materials:

- *Quarry Spalls* meeting the requirements of the 1998 WSDOT Standard Specification, Section 9-13.6; or
- *Shoulder Ballast* meeting the requirements of the 1998 WSDOT Standard Specification, Section 9-03.9(2).

For geotextile fabric, we recommend using a woven or nonwoven geotextile, conforming to the requirements of WSDOT 9-33.2, Table 3, Geotextile for Separation.

5.6 Trench Backfill

Based on the field explorations and proposed pipe burial depths, it appears that the soils excavated for the pipeline will consist of gravelly silty sands, clean fine to medium sand, and silty sands. In our opinion, the gravelly silty sand, as well as clean sand may be feasible for reuse as structural trench backfill. However, this would depend on the ability of the contractor to separate out the suitable drier soils, protect them from additional moisture, and subsequently place and recompact them. Additionally, re-use of the on-site soils would depend on separation of these soils from organic contents or wood fragments.

Given this information, we recommend that the contract provisions include reuse of the gravelly silty sand/sand soils as a bid alternate to aid in quantifying the potential cost savings should this option be selected. The reuse of on-site soils should be pursued only during periods of extended dry, warm weather conditions which regionally occur during the months of mid-July through mid-October.

5.6.1 Fill Material and Settlement

The suitability of soils for compacted backfill use depends primarily on the gradation and moisture content of the soil when it is placed. As the amount of fines (that portion passing the U.S. No. 200 Sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. Generally, soils containing more than about 5 percent fines by weight cannot be compacted to a firm, non-yielding condition when the moisture content is more than 3 percent above or below optimum moisture.

As previously discussed, the bulk of native soils excavated from the trench will consist of gravelly sands and silty sands. These native soils generally have similar in-place densities as the conventional "bank-run" sand and gravel backfill. Therefore, we do not anticipate excessive pipeline settlements if "bank-run" sand and gravel backfill is used. However, if the pipeline is underlain by soft clayey/sandy silts or loose sands, we would recommend using soils consisting of clean to silty, fine to medium sand, with less than 30 percent gravel for use as trench backfill to minimize pipeline settlements. The compacted unit weight of the backfilled soils should be maintained below 125 pounds per cubic foot (pcf). By limiting the maximum unit weight to 125 pcf, we estimate that total, static pipe settlement at any location along alignment would not exceed 1 inch. Higher gravel contents may be used if larger settlements are allowed. It should be noted that the use of silty sand backfill soils or soils with more than 5 percent fines may be difficult to properly moisture condition and compact, and should be limited to use in extended dry weather conditions.

Lightweight Fill: A lighter weight bottom ash (available locally as a byproduct of coal-fired power plants in Centralia) has been used successfully on other projects in the vicinity, and would be appropriate on this project, as a means to further reduce the risk of post-construction settlement.

A controlled density fill (CDF) may be appropriate for backfill around manholes, valving or other restricted spaces. Although more costly than other fill, CDF can provide high strength at a low density. Furthermore, CDF is also a "flowable fill", which can reduce the occurrence of voids in the backfill of restricted spaces.

5.6.2 Placement and Compaction

Prior to placement of compacted backfill, the pipe bedding should be placed to a minimum of 6 inches over the top of the pipe. Pipe bedding material should be uniformly compacted along the haunches of the pipe, so that variable density bedding does not exist along the pipe. An initial lift not exceeding 18 inches in depth should be placed over a minimum of 6 inches of pipe bedding immediately above the pipe. Backfill above this initial lift should be placed in lifts not exceeding 12 inches in loose thickness. Within the top 2 feet below pavements and structures, backfill should be placed in lifts not exceeding 8 inches in loose thickness. Individual lifts should be mechanically compacted to product a firm and non-yielding condition prior to placement of additional backfill. All backfill material should be compacted to a uniform density of at least 90 percent of the modified Proctor maximum dry density (ASTM:D-1557). Within the top 2 feet below pavements and structures, all backfill should be compacted to a uniform density of at least 95 percent of the same maximum density. A summary of recommended minimum compaction requirements is presented below in Table 5.

TABLE 5
MINIMUM COMPACTION REQUIREMENTS

Fill Application	Minimum Compaction*
Non-Structural	90%
ACP/PCC[1] Pavement Subgrade (top 2 feet)	95%
ACP/PCC Pavement Subgrade (below 2 feet)	90%
Concrete Walkway Subgrade	90%
Pavement Base Course	95%
Pavement Subbase Course	95%

[1] ACP — Asphaltic Concrete Pavement; PCC — Portland Cement Concrete Pavement
* ASTM:D-1557

5.7 Pipe Crossings

The proposed sewer alignment will have two channel crossings: one on the Deschutes Parkway at the mouth of Percival Creek, and the other one across Capitol Lake between Marathon Park and Heritage Park. For the Percival Creek crossing, the pipes are to pass through a steel casing pipe which will span the channel. For the Capitol Lake crossing, the pipes are to be supported on the existing pedestrian bridge.

Pipe Jacking: Pipe boring and jacking is required at as many as six locations. The alignment will cross beneath railroad tracks at three locations on Deschutes Parkway. In downtown Olympia, pipe boring and jacking is required at crossings beneath 5th Avenue S.W., 4th Avenue S.W, and State Avenue. We understand the Deschutes Parkway casings are to be 54-inch diameter, being jacked about 60 to 105 feet. The three downtown casings are to be 36-inch diameter, each being jacked about 70 feet. The depth of the jacked casings are about 10 to 12 feet below grade. The soils at the Deschutes Parkway jacking sites appear to consist of very loose silty sand or soft sand silt. Groundwater levels were at 6½ feet at the time of drilling. The soils we encountered near the downtown jacking sites were loose to medium dense, gravelly, silty sand fill over generally loose, silty sand or soft to medium stiff, sandy silt. The downtown Olympia groundwater levels were 4 to 5 feet below ground surface.

Based on these conditions, dewatering will be required for jacking pits and pipe boring. Unless groundwater pressures are maintained below the bottom of the casing, the soil materials in and below the bottom of the casing will pipe, heave, boil, and lead to instability of the excavation. Groundwater elevations should be confirmed by means of observation wells prior to and during pipe jacking activities. For baseline purposes, three boulders or logs, between one foot and two feet in maximum dimension are expected to be encountered in the course of pipe boring and jacking. The jacking pipe should be large enough for removal of obstructions (such as buried logs which are typical in alluvial sediments) and to allow flexibility in alignment control. At a minimum, the auger or excavating system should be recessed back from a hooded shield to create a soil plug and control face stability to inhibit soil loss and reduce the risk of settlement of the ground surface above. Adjustments to the distance the auger is recessed may be necessary as soil conditions vary.

In order to temporarily fill any voids around the pipe, and to reduce frictional drag on the pipe, bentonite grout should be injected immediately behind the overcutting ring at the crown and sides of the pipe. The injected amount of bentonite should just make up for the void left outside the pipe as a result of the slightly larger diameter overcutting ring. Injection pressures should be controlled so that voids are properly filled, but otherwise limited so as not to cause ground heave or pipe deformation. Additional injection ports along the sides of the carrier pipe may be necessary depending on conditions encountered during installation.

The contractor should provide a pipe jacking plan, with detailed information regarding qualifications, methods of alignment and grade control, face stability control and ground loss control.

Selection of the pipe material should be sufficient to accommodate the following conditions:

- Minimum wall thickness and compressive strengths capable of sustaining jacking stresses;

- Hoop and crushing strengths capable of supporting vertical earth pressures assuming a 1-inch void along the sides of the pipe; and

- Sealed or welded joints capable of sustaining watertightness through jacking installation until curing of the annular ("free-space") fill.

For purposes of design and construction, the following average soil loading characteristics are recommended for the jacked pipe:

Frictional Resistance	300 psf (pipe surface area)
Lateral Earth Pressure	500 psf
External Water Pressure	375 psf
Vertical Earth Pressure	700 psf

These values are based on 7 feet of overburden and 6 feet of groundwater depth and do not include a safety factor; and are assumed to be utilized for temporary loading on the carrier pipe until the interior "free space" is backfilled. As such, an appropriate factor of safety should be incorporated for design. We recommend that pipe deflection and ground loss be closely monitored during carrier pipe installation.

Following installation of the carrier pipe, any voids outside the pipe created during installation should be pressure grouted to reduce potential surface settlement. As we understand, the "free-space" within the carrier pipe may be sealed only at the ends to accommodate space for future utilities. If this is the case, the installed carrier pipes should be strapped to skids anchored to the carrier pipe (for buoyancy control) and the ends of the carrier pipe should be filled with flowable fill such as grout or a mixture of sand, cement and flyash (CDF) to create a watertight seal.

Surface settlements as a result of pipe-jacking or tunnel excavation are typically distributed in a settlement trough aligned parallel with the pipe. Maximum settlement typically occurs over the centerline of the jacked pipe and decreasing laterally away from the centerline. The zone of influence of the settlement trough is generally defined in terms of a draw angle subtended from the jacked pipe spring line to the ground surface. We estimate that a draw angle of 30 degrees from a vertical plane tangent to the jacked pipe spring line appears appropriate for local soil conditions. We recommend that surface settlements be monitored by surveying monitoring points stationed over the centerline and laterally outward of the pipe jack alignment.

Additionally, we recommend that the contract provisions include a requirement to perform compaction grouting above the crown of the pipe and within the settlement trough if observed surface settlements exceed a maximum tolerable amount. We anticipated that a maximum tolerable settlement of ½ to 1 inch would be acceptable for railroad embankment. However, we recommend that maximum tolerable amounts of settlement be confirmed by the right-of-way owner. Additionally, we recommend that the contract provisions include a maximum tolerable settlement which defines the threshold at which costs for compaction grouting will be borne by the contractor.

Jacking pit dimensions vary depending upon the diameter and length of pipe sections and nature of the muck removal and handling systems. The pit must accommodate at least one pipe section, the jacking frame and jacks, and the reaction block. We anticipate that jacking pits will be limited in size due to the shallow pipe depth. For the purposes of design and construction, we tentatively expect that jacking forces may be resisted by means of a concrete or steel thrust block against the side of the pipe jacking pit. We expect that an ultimate passive earth pressure of 400 pcf (expressed as an equivalent fluid unit weight) may be assumed for thrust block reaction pressures against an excavation wall in a sheet pile shored excavation. If the ground appears to be unstable during pit excavation, reaction may be provided by a ground slab with tie-down anchors or key-ways, or even heavily reinforced cantilever piles anchored in better soil at depth.

5.8 Control Structure

We understand that an at-grade control structure will be constructed near the Capitol Lake Boulevard Bridge in the Tumwater Falls Park. Based on the soil conditions disclosed in our explorations, we provide our recommendations on the foundations, slab-on-grade floor, drainage system, and structural fill in this section of the report.

5.8.1 Foundations

We anticipate that the control structure will be a relatively lightweight, one-story structure. Shallow footings should be adequate to support these structures provided that design recommendations provided herein are followed. The subgrades shall be prepared as described in the following sections for the use of conventional shallow footings.

The subsurface condition (inferred by our boring B-11) near the Capitol Lake Boulevard Bridge consists of soft organic peat and soft sandy silt underlain by a very loose fine sand. The very dense silty sand and rock fragments (inferred as the Crescent Formation) was encountered at approximately 9 feet below grade. Local groundwater depth was observed to be approximately 4 to 5 feet below grade. In order to reduce post-construction settlements, the organic peat and soft sandy clay should be overexcavated and all footings should be underlain by a minimum 2 feet of compacted granular structural fill founded on undisturbed native silty sand.

The overexcavations should be wide enough to contain a 1H:1V slope extending from each edge of the footing down to the native soils. For deep overexcavations, the structural fill prism can be truncated at a width of 4 footing widths or 10 feet, whichever is less. The footing overexcavations should be backfilled with granular structural fill compacted to 90 percent density.

Our boring (B-11) indicated that overexcavation of organic peat and soft sandy silt may extend near or slightly below the groundwater level at approximately 4 to 5 feet. Local dewatering using sump and pump should be adequate for overexcavation. Alternatively, quarry spalls or crushed rock can be used for backfilling below the groundwater level.

No footings may be cast atop loose, soft, or frozen soil, slough, debris, uncontrolled fill or surfaces covered by standing water. The condition of all subgrades will be verified by the geotechnical engineer of record before any fill or concrete is placed.

Footings that bear on properly prepared structural fill prisms placed over suitable subgrades can be designed for a maximum allowable soil bearing pressure of 2,000 psf. This value may be increased by one-third to resist transient dynamic loads such as wind or seismic forces. The soil surrounding the foundation elements will provide lateral resistance for wind or seismic forces. We recommend using an allowable base friction value of 0.35 and an allowable passive earth pressure of 250 pcf (equivalent fluid pressure) for those portions of footings embedded at least 1 foot below finish grade.

For frost and erosion protection, exterior footings should penetrate at least 18 inches below adjacent outside grades, whereas interior footings need extend only 12 inches below the surrounding slab surface level. To minimize post-construction settlements, continuous (wall) and isolated (column) footings should be at least 18 and 24 inches wide, respectively.

We estimate that total post-construction settlement of properly sized footings bearing on properly prepared subgrades would be less than 1 inch with differential settlement on the order of ½ inch or less.

5.8.2 Slab-on-Grade Floors

A soil supported slab-on-grade floor can be used for the proposed control structure provided that the subgrades are prepared as described in the previous section. The organic peat and soft sandy clay should be overexcavated and the floor slab should be underlain by a minimum 2 feet of compacted granular structural fill founded on undisturbed native silty sand. We provide the following additional comments and recommendations concerning slab-on-grade floors.

To minimize moisture infiltration into the building, the upper 10 inches of soil directly beneath all slab-on-grade floors shall be composed of the following layers (top to bottom):

- Vapor Barrier: A layer of plastic sheeting (such as puncture resistant, minimum 8-mil thick, Visqueen or Moistop) to prevent the upward migration of ground moisture.
- Capillary Break: A 4-inch layer of clean gravel, such as pea gravel, to retard the upward wicking of groundwater. The material shall conform to the WSDOT 9-03.12(4) specification.
- Subbase: A minimum 6-inch layer of gravel backfill in order to protect the subgrade and provide a working surface. The gravel backfill shall conform with WSDOT 9-03.12(2).

Slab-on-grade floors can deflect downward when vertical loads are applied, due to elastic compression of the subgrade. A subgrade reaction modulus of 150 pounds per cubic inch (pci) can be used to estimate such deflections.

Slab-on-grade floors constructed in the recommended manner may incur differential settlement on the order of 1inch or less.

5.8.3 Drainage Systems

The new building must be provided with permanent drainage systems to reduce the risk of groundwater infiltration. We offer the following recommendations and comments for drainage design and construction purposes.

The building should be provided with a perimeter footing drain system consisting of a 6-inch-diameter perforated PVC pipe, within an envelope of pea gravel or washed rock, extending at least 6 inches on all sides of the pipe. The gravel envelope should be wrapped with filter fabric to reduce the migration of fines from the surrounding soils. This pipe should be placed at the footing subgrade elevation or below the lowest subfloor utilities which might be affected if seepage comes in contact with them. The perimeter drain should drain by gravity to a storm drain or other suitable discharge location.

Roof runoff and surface run-off water may <u>not</u> discharge into the perimeter drain. Instead, they should discharge into separate tightline pipes and be routed away from the building to a suitable discharge point.

We recommend that finished grades around the site route surface drainage away from the buildings. Ideally, the area surrounding the building would be capped with concrete or asphalt to prohibit surface-water infiltration.

5.8.4 Structural Fill

"Structural fill" refers to all materials placed under foundations, retaining walls, slab-on-grade floors, sidewalks, pavements, and other structures. Our comments, conclusions, and recommendations concerning structural fill are presented in the following paragraphs.

Typical structural fill materials include sand, pea gravel, washed rock, crushed rock, quarry spalls, controlled-density fill (CDF), and lean-mix concrete, as well as well-graded mixtures of sand and gravel (commonly called "gravel borrow" or "pit-run"). Recycled asphalt and concrete, which are derived from pulverizing the parent materials, are also potentially useful as structural fill in certain applications. Soils used for structural fill shall not contain any organic matter, debris, or individual particles greater than about 6 inches in diameter. For planning and bidding purposes, soils used for structural fill shall meet the requirements of WSDOT 9-03.12(2).

For planning purposes, the on-site soils may not be used for structural fill due to their moisture sensitivity. We offer the following evaluation of these on-site soils in the event that careful control of moisture contents is practical during construction.

- <u>Topsoil and Organic Peat</u>: The sod, topsoil, and organic-rich soils mantling most of the site are <u>not</u> suitable for use as structural fill under any circumstances, due to their high organic content. Consequently, these materials can be used only for non-structural purposes, such as in landscaping areas.

- Clayey Silt/Silty Clay: The silt underlying the topsoil do not appear suitable for reuse as structural fill, due to their cohesive characteristics and high moisture sensitivity.

- Silty fine Sand: The deeper silty fine sands underlying the subject site are not suitable for reuse as structural fill at their present moisture contents due to their moderately high silt contents. However, these soils may be used during dry weather at optimum moisture, and only upon approval by the geotechnical engineer of record.

Generally, pea gravel, washed rock, quarry spalls, CDF, and lean-mix concrete do not require special placement and compaction procedures. In contrast, pit-run, clean sand, crushed rock, soil mixtures, and recycled materials shall be placed in horizontal lifts not exceeding 8 inches in loose thickness, and each lift shall be thoroughly compacted with a mechanical compactor.

Using the Modified Proctor test (ASTM:D-1557) as the standard, the structural fill used for various applications shall be compacted to the following minimum densities:

Fill Application	**Minimum Compaction**
Footing subgrade	95 percent
Slab-on-grade floor subgrade	95 percent
Foundation Backfill	90 percent
Concrete sidewalk subgrade	90 percent
Asphaltic pavement base and subbase	95 percent
Asphaltic pavement subgrade (upper 2 feet)	95 percent
Asphaltic pavement subgrade (below 2 feet)	90 percent

Regardless of material or location, all structural fill shall be placed over firm, unyielding subgrades prepared in accordance with the *Site Preparation* section of this report. The condition of all subgrades shall be verified by the geotechnical engineer of record before filling or construction begins. Also, fill soil compaction shall be verified by means of in-place density tests performed during fill placement so that adequacy of soil compaction efforts may be evaluated as earthwork progresses.

5.9 Pavement Design

We understand that pavement will be restored to its current condition following the sewer construction. The existing pavement system includes asphalt and Portland cement concrete pavement sections. The following comments and recommendations are given for pavement design and construction purposes.

Based on our subsurface explorations, an average CBR value of 12 was selected for the native subgrade soils. It is our experience that the effective subgrade support for soils is primarily dependent on compaction and moisture content of the subgrade. Based on the recommended subgrade compaction, our pavement design is based on the following:

Imported crushed rock, such as "crushed surfacing" per WSDOT Standard Specification 9-03.9(3), should be used for the base course. Imported, clean, well-graded sand and gravel, such as "ballast" per WSDOT 9-03.9(1) may be used for the granular subbase or as structural fill beneath the pavement sections.

All base course material, and any fill placed below the base course, should be placed and compacted according to our recommendations given in the *Structural Fill* section of this report; specifically, the upper 2 feet of soils shall be compacted to at least 95 percent of the modified Proctor maximum dry density (ASTM:D-1557), and all soils below this 2-foot depth should be compacted to at least 90 percent. The geotechnical engineer of record should verify the condition of the subgrade, subbase, and base course before each successive layer is placed.

6.0 CLOSURE

The conclusions and recommendations presented in this report are based on the explorations accomplished for this study. The number, location, and depth of the explorations were completed within the site and proposal constraints so as to yield the information necessary to formulate these recommendations.

The integrity of the utility system will depend on proper earthwork and construction procedures. Due to the nature of the site conditions encountered at the exploration locations, geotechnical engineering decisions may be required during construction in the event that localized variations in the subsurface conditions become apparent. It is recommended that AGRA be retained to provide geotechnical engineering services during the dewatering, excavation, backfill, and pipe jacking/boring phases of the project.

We appreciate this opportunity to provide these services. Please feel free to call if you have any questions, or need additional information.

Sincerely,

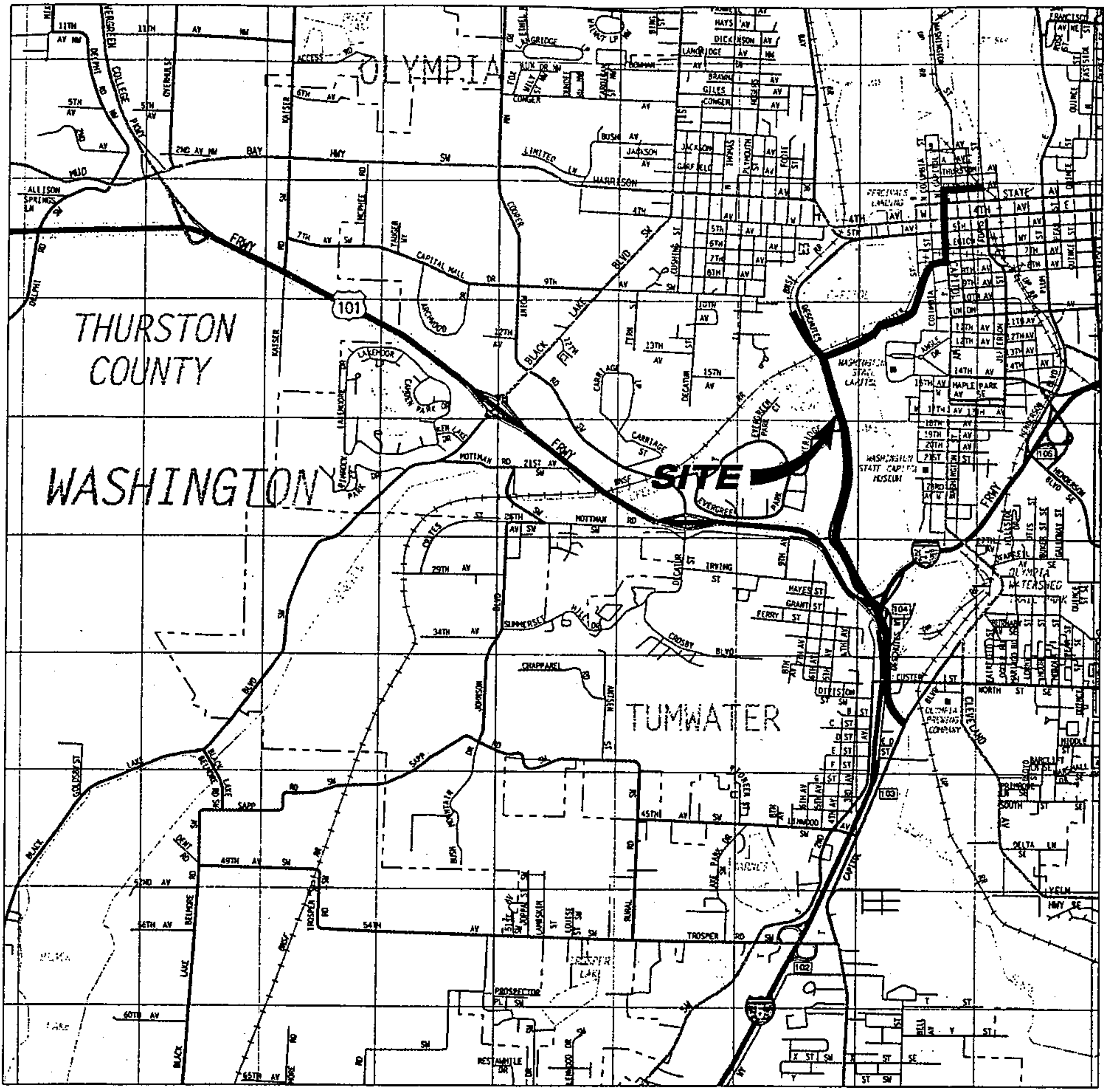
DRAFT COPY
PLEASE REVIEW AND
RETURN WITH COMMENTS
TO
AGRA EARTH & ENVIRONMENTAL

Storr L. Nelson, P.G.
Senior Project Geologist

Henry W. Brenniman, P.G.
Senior Project Geologist

James S. Dransfield, P.E.
Principal

SLN/HWB/JSD/jdp



N.T.S.

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JOB NO.: 0-91M-11684-B | DWG DATE: 03-07-2000 | SCALE: N.T.S. | DESIGN BY: HWB | FILE NAME: LOCATION.DWG

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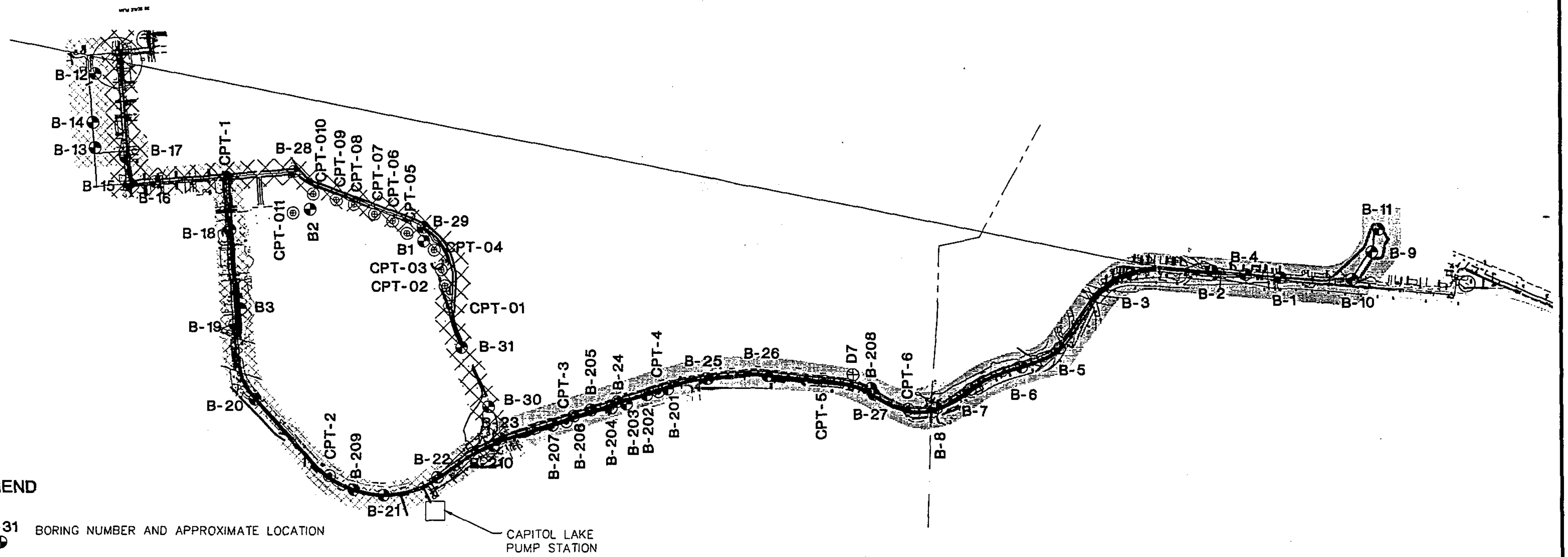
LOCATION MAP

LOTT - CAPITOL LAKE SOUTHERN CONNECTION

OLYMPIA, WASHINGTON

FIGURE

1



LEGEND

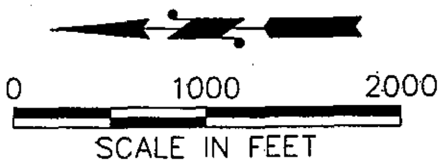
B-31 ●	BORING NUMBER AND APPROXIMATE LOCATION
B-210 ●	BORING NUMBER AND APPROXIMATE LOCATION (GROVER WAY, 1996)
D7 ⊕	BORING NUMBER AND APPROXIMATE LOCATION (GROVER WAY, 1996)
CPT-6 ◉	CONE PENETROMETER TEST NUMBER AND APPROXIMATE LOCATION
B3 ●	BORING NUMBER AND APPROXIMATE (MILBOR-PITA 1996)
CPT-011 ⊕	CONE PENETROMETER TEST NUMBER AND APPROXIMATE LOCATION, (MILBOR-PITA, 1996)
B-31	BORING NUMBER AND APPROXIMATE LOCATION
5	STANDARD PENETRATION RESISTANCE IN BLOWS PER FOOT
P ▼	PERCHED GROUNDWATER LEVEL AT TIME OF DRILLING
▼	GROUNDWATER LEVEL AT TIME OF DRILLING
TD 51.5'	TOTAL DEPTH OF BORING

▨	INITIAL ROUTE OF FORCE MAIN SEWER LINE
⊠	REVISED ROUTE OF FORCE MAIN SEWER LINE SEE FIGURES FM-1 THROUGH FM-14
▩	ROUTE OF INTERCEPTOR SEWER TWIN PIPELINE SEE FIGURES IS-1 THROUGH IS-9

NOTES:

THE STRATA ARE BASED UPON INTERPOLATION BETWEEN EXPLORATIONS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS.

SIMPLIFIED NAMES ARE SHOWN FOR SOIL DEPOSITS, BASED ON GENERALIZATIONS OF SOIL DESCRIPTIONS. SEE EXPLORATION LOGS AND REPORT TEXT FOR COMPLETE SOIL DESCRIPTIONS.



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VICINITY MAP

LOTT – CAPITOL LAKE SOUTHERN CONNECTION

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FIGURE
2

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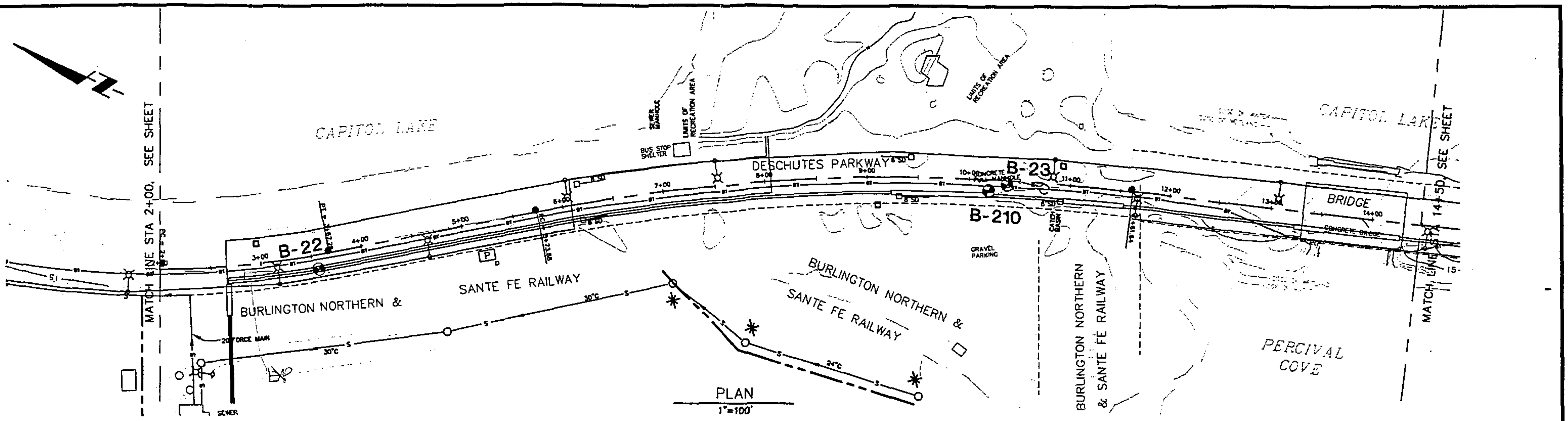

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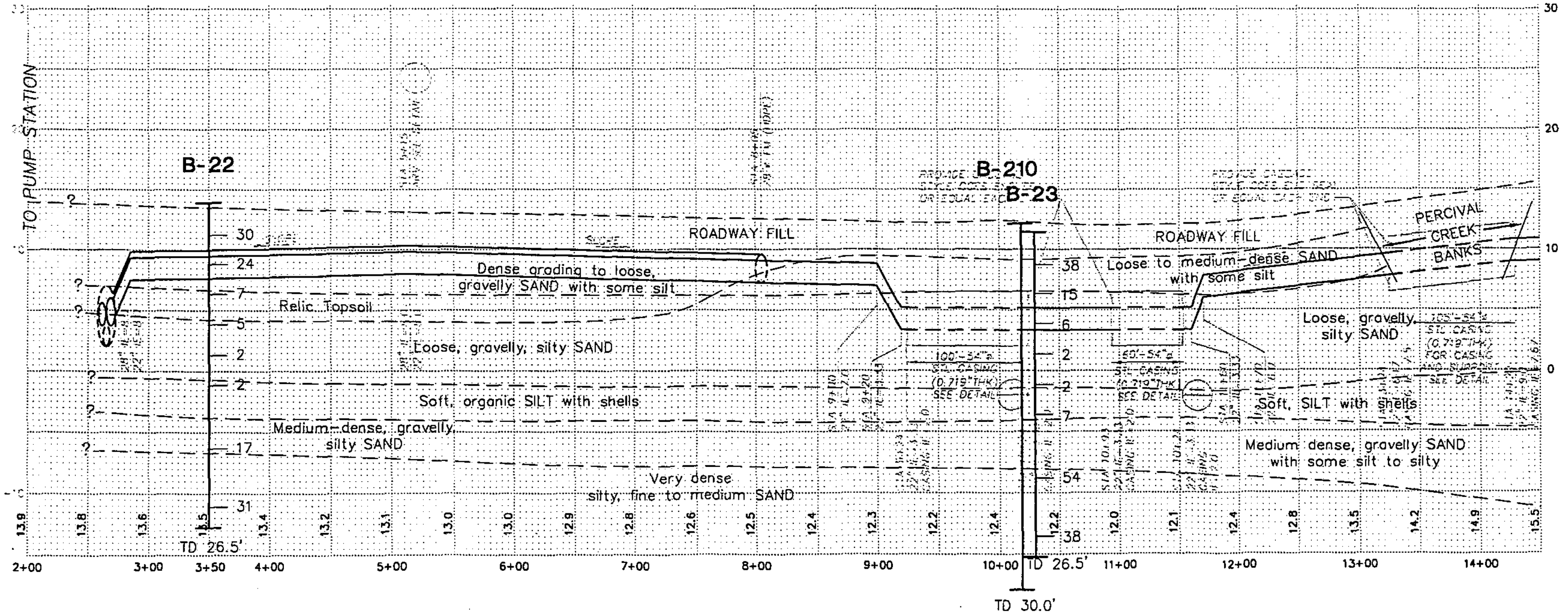

PROFILE
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SITE AND EXPLORATION PLAN

LOTT - CAPITOL LAKE SOUTHERN CONNECTION
INTERCEPTOR SEWER

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FIGURE

IS1

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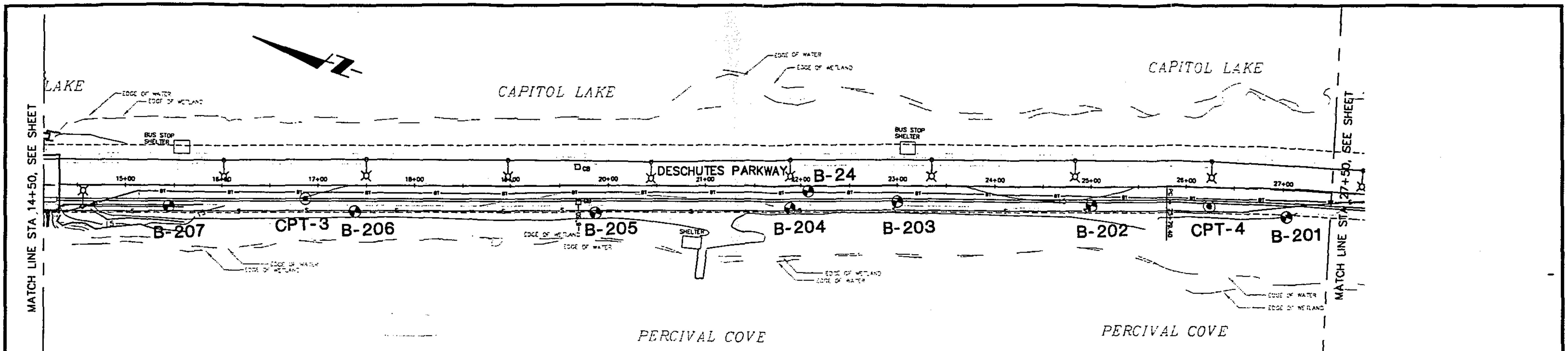

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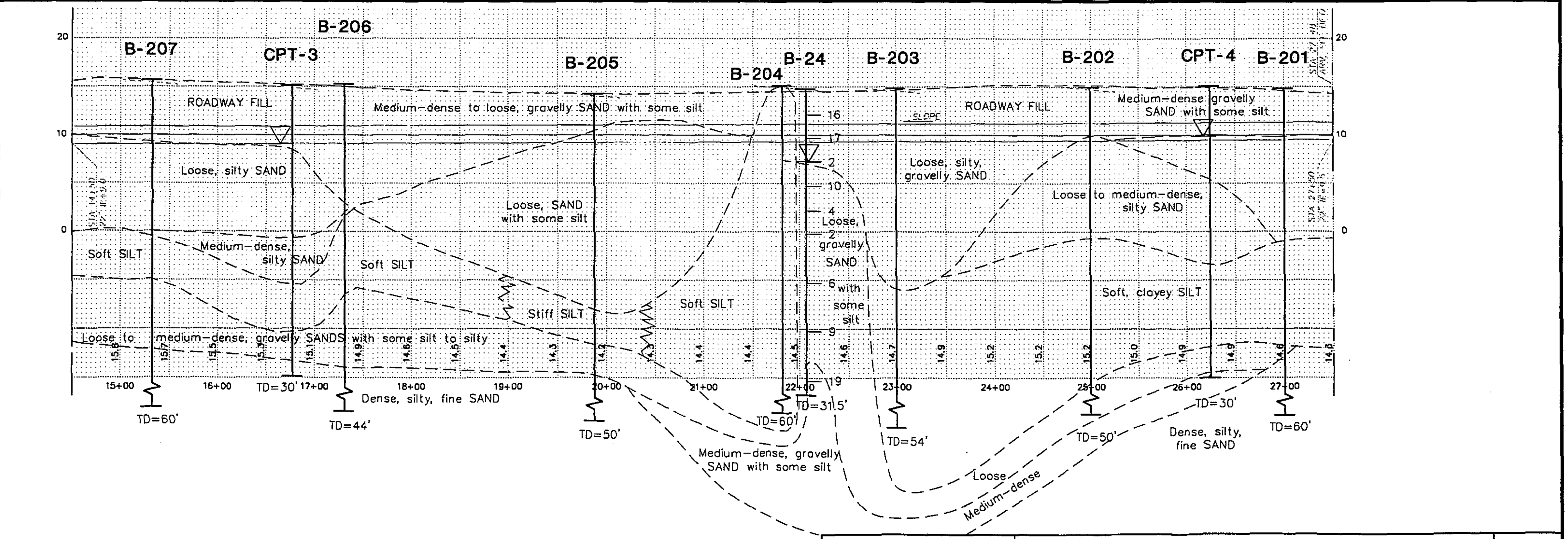

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SITE AND EXPLORATION PLAN

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OLYMPIA, WASHINGTON

FIGURE

IS2

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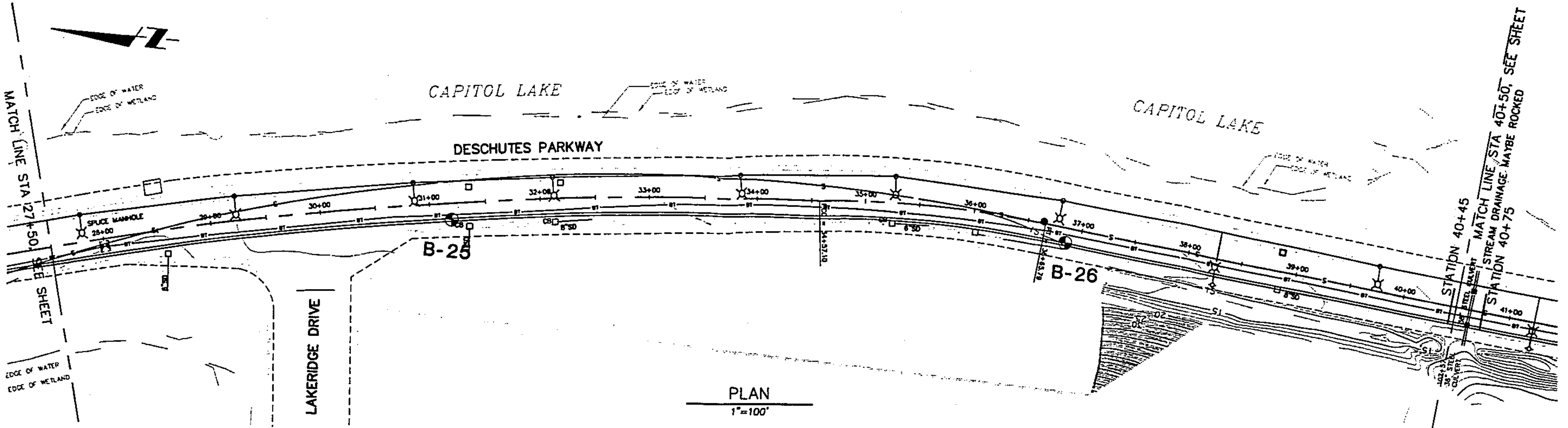

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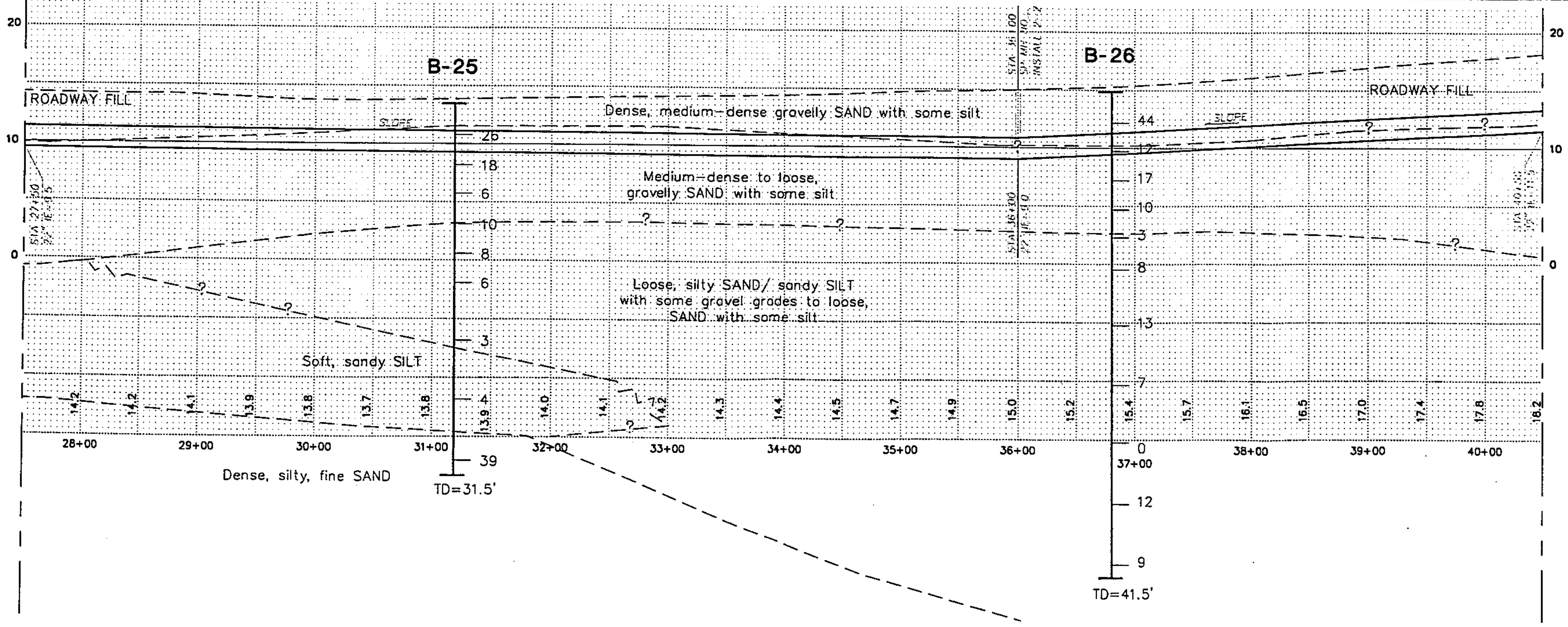

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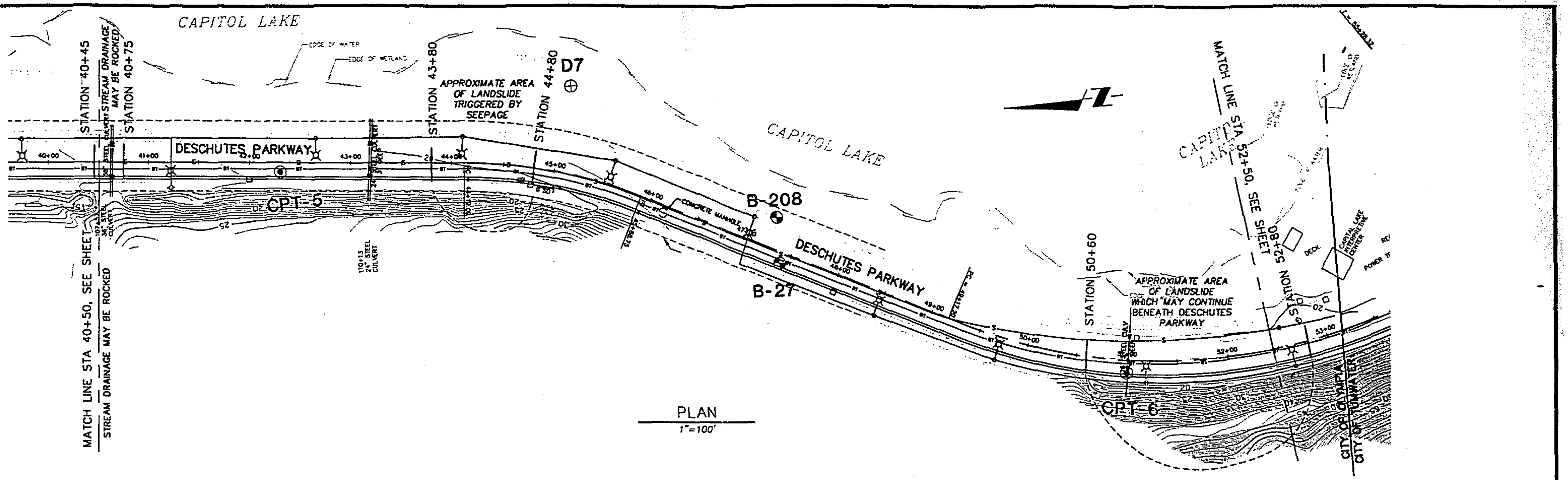
SITE AND EXPLORATION PLAN

LOTT – CAPITOL LAKE SOUTHERN CONNECTION
INTERCEPTOR SEWER

OLYMPIA, WASHINGTON

FIGURE

IS3



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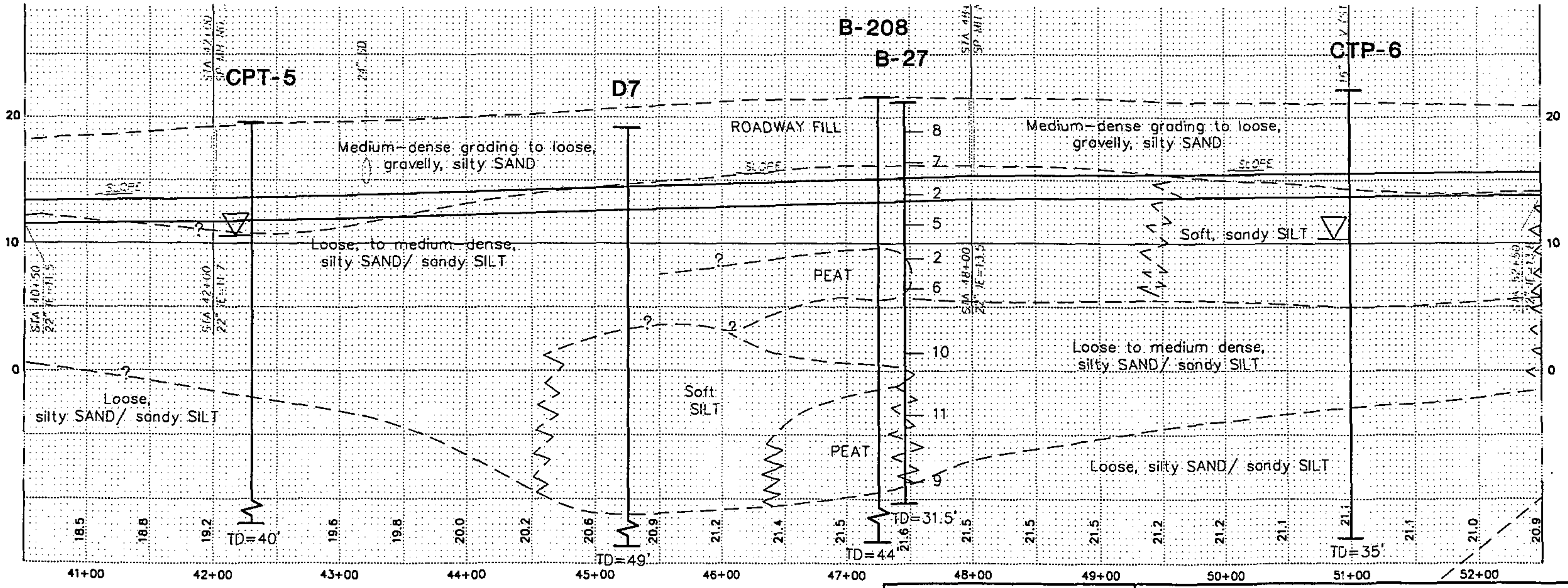

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SITE AND EXPLORATION PLAN

LOTT – CAPITOL LAKE SOUTHERN CONNECTION
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FIGURE

IS4

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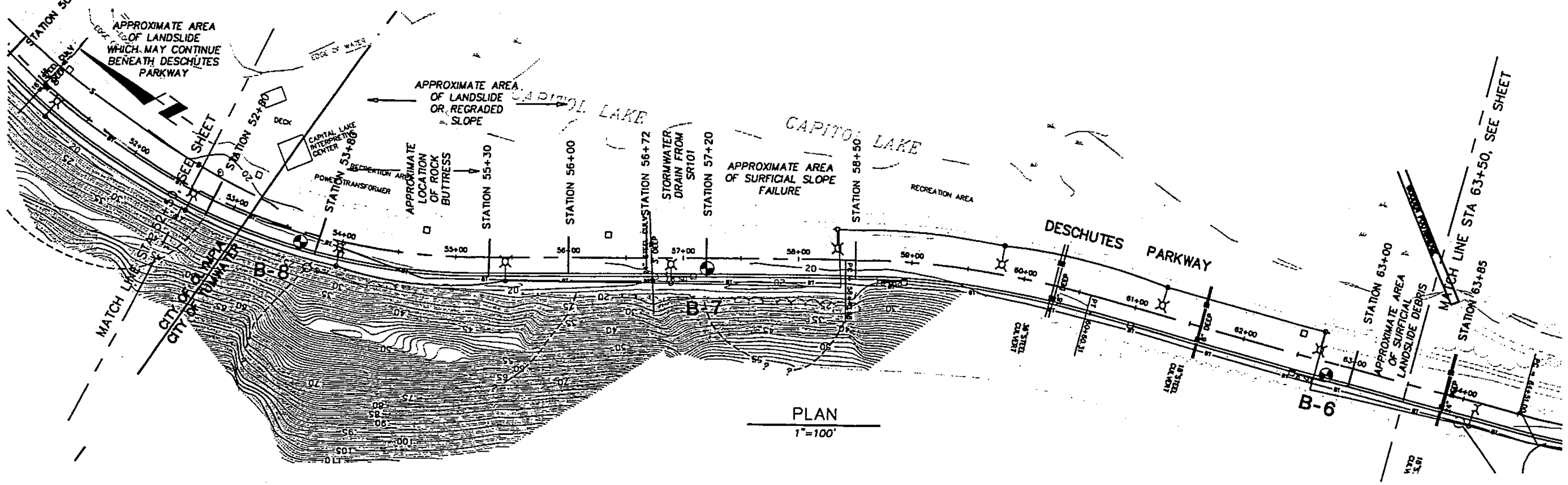

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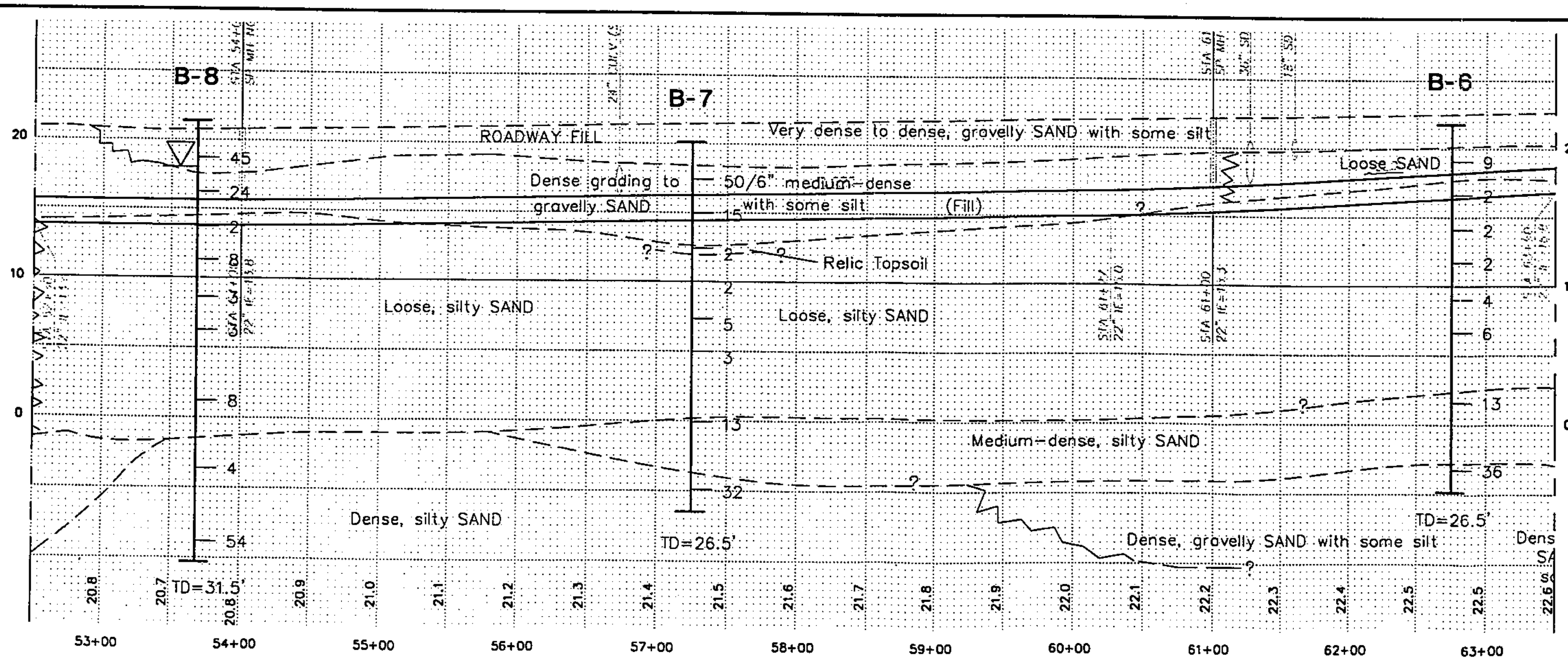

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SITE AND EXPLORATION PLAN

LOTT – CAPITOL LAKE SOUTHERN CONNECTION
INTERCEPTOR SEWER

OLYMPIA, WASHINGTON

FIGURE
IS5

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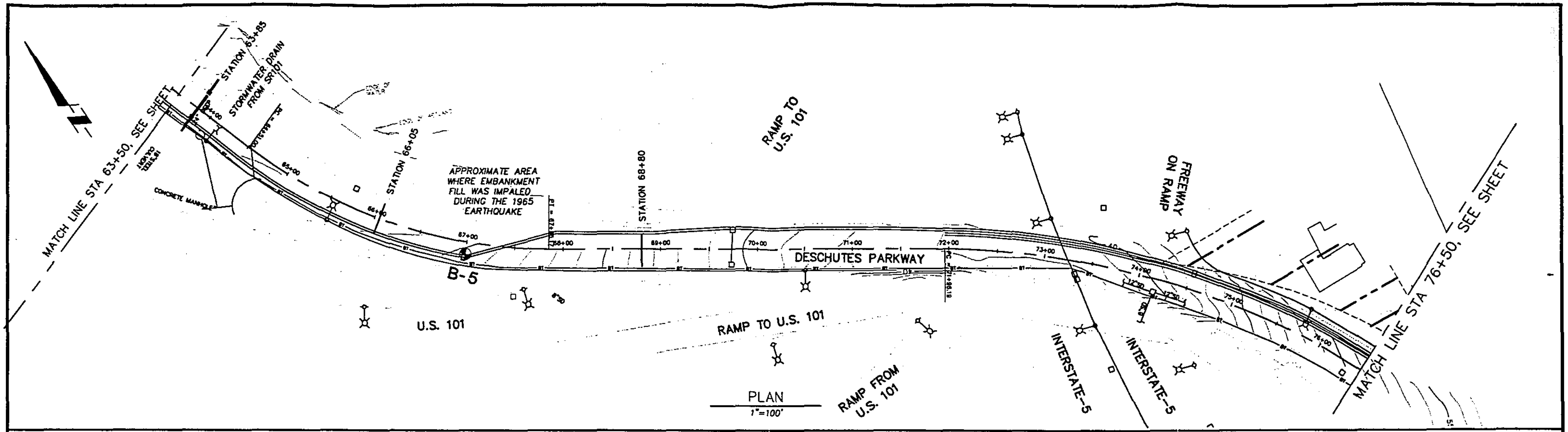

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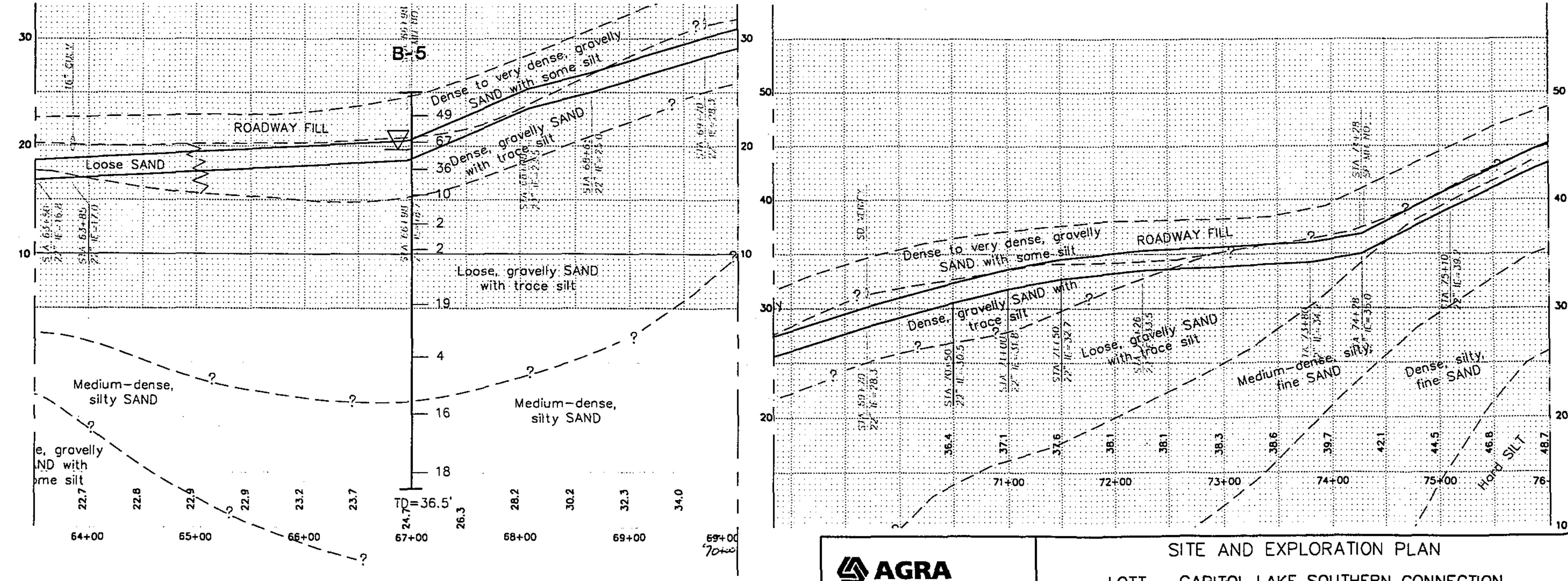

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SITE AND EXPLORATION PLAN

LOTT – CAPITOL LAKE SOUTHERN CONNECTION
INTERCEPTOR SEWER

OLYMPIA, WASHINGTON

FIGURE

IS6

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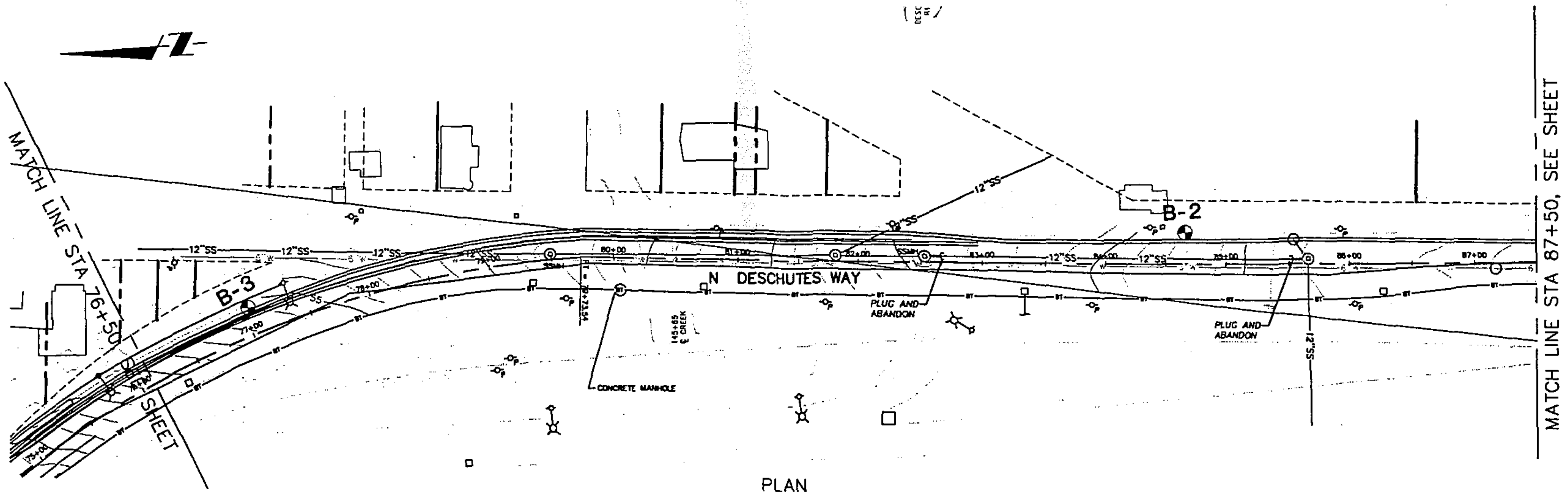

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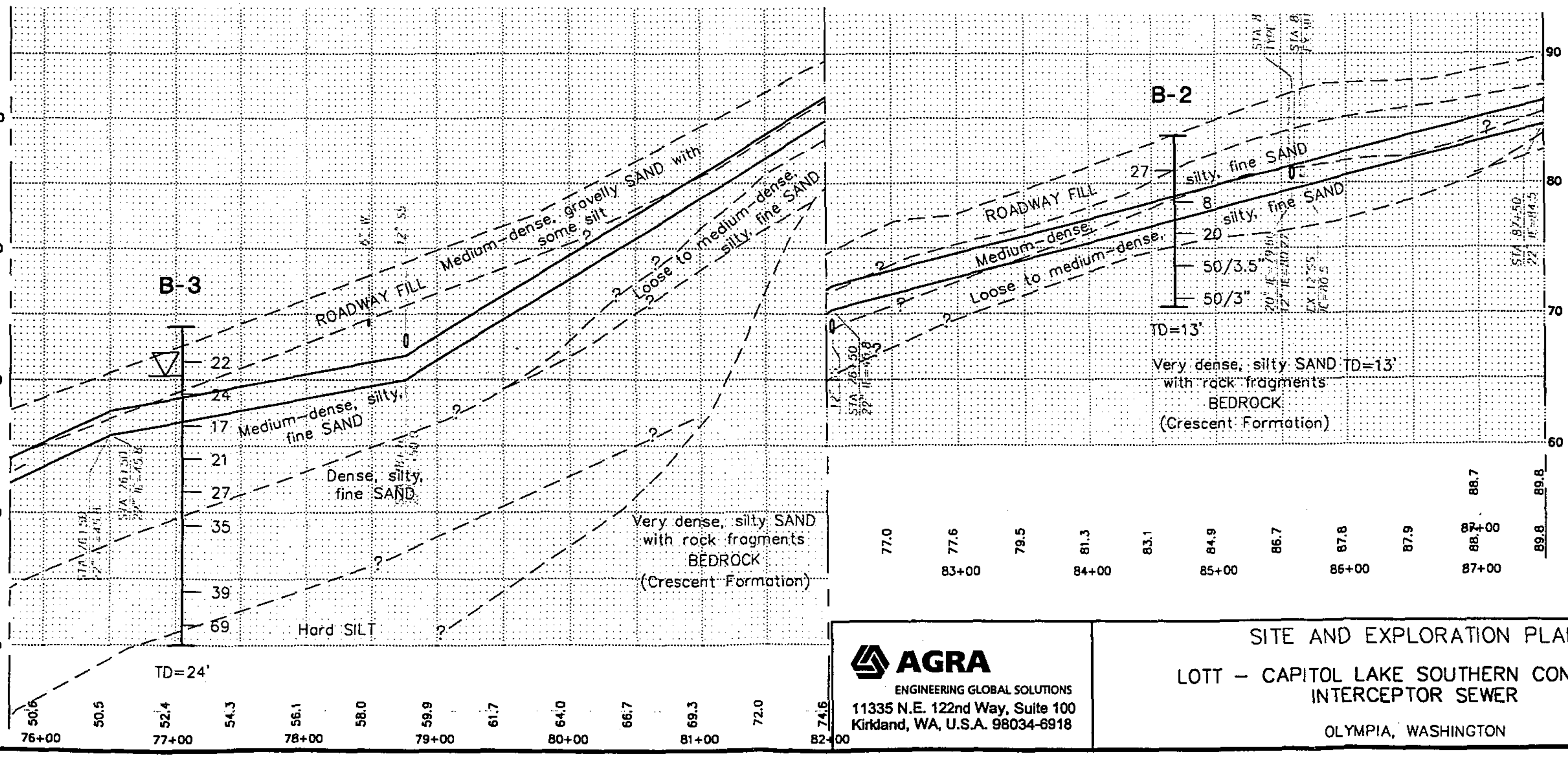

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SITE AND EXPLORATION PLAN

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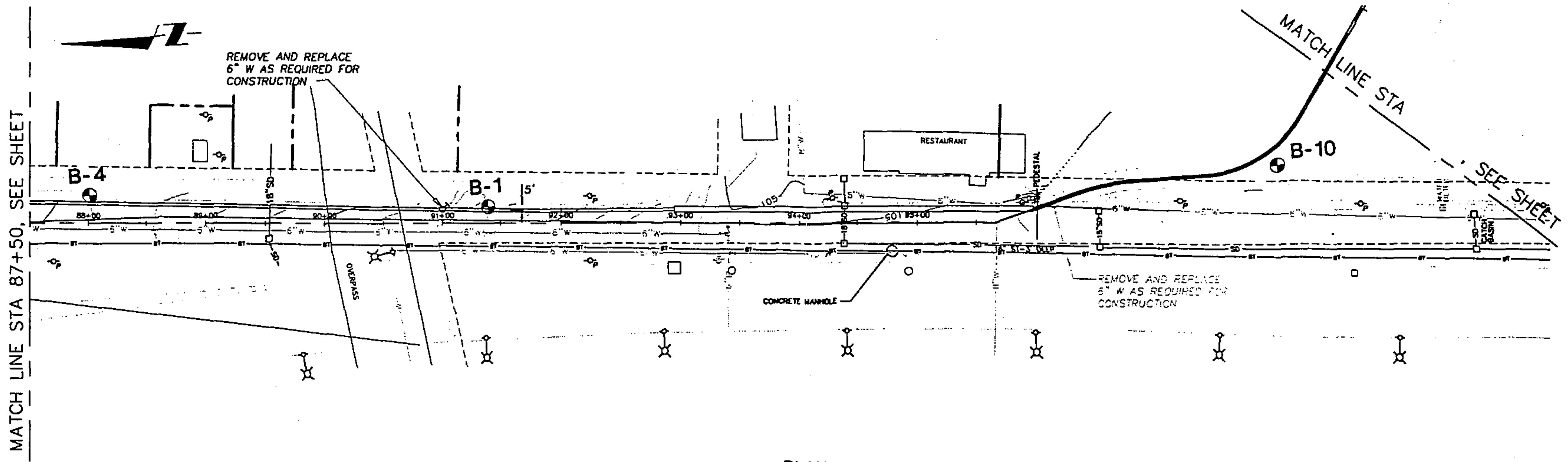
FIGURE

IS7

JOB NO.: 0-91M-11684-B-0 | DWG DATE: 02-27-2000 | SCALE: 1"=100' | DESIGN BY: HWB | FILE NAME: IS-8.DWG



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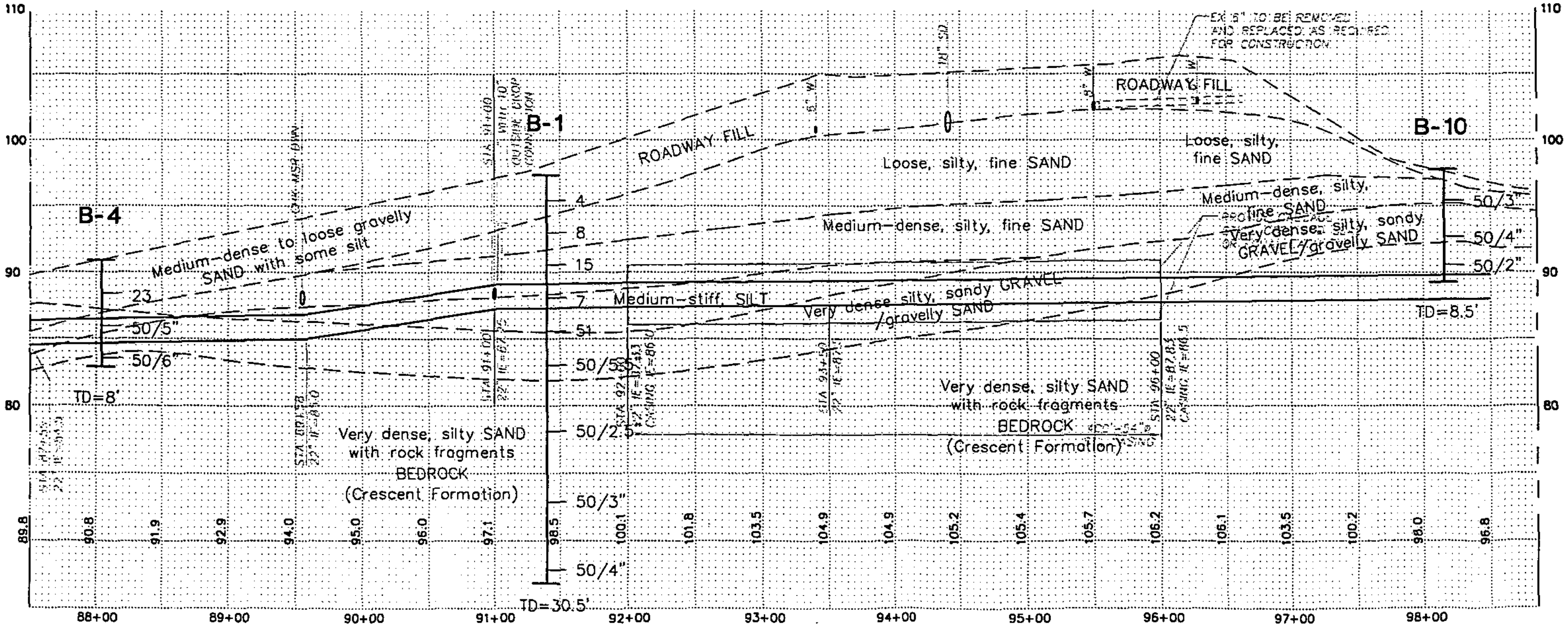
1"=100'



PROFILE
HORIZ: 1"=100'
VERT: 1"=10'

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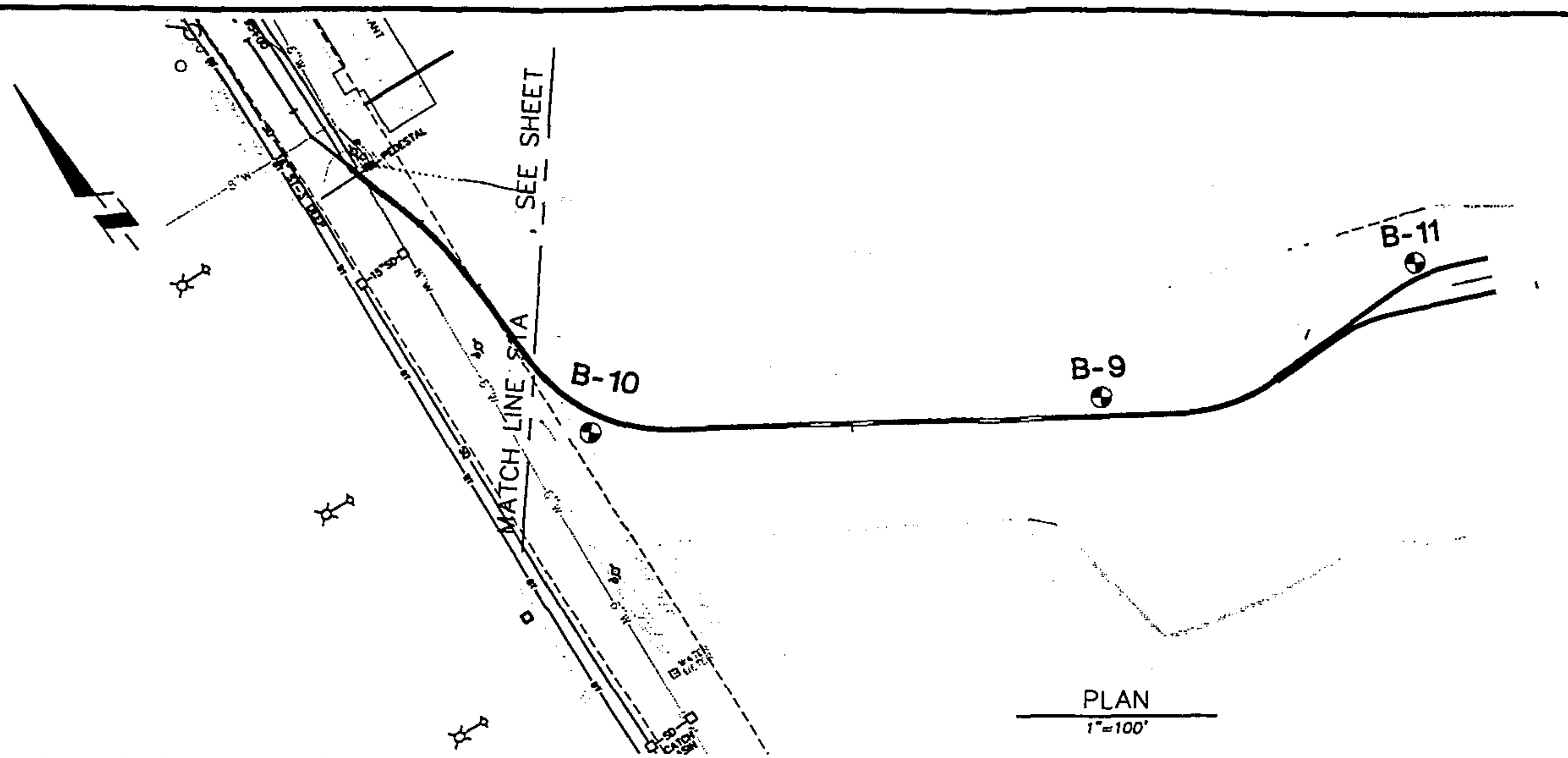
Kirkland, WA, U.S.A. 98034-6918

SITE AND EXPLORATION PLAN

LOTT – CAPITOL LAKE SOUTHERN CONNECTION
INTERCEPTOR SEWER

OLYMPIA, WASHINGTON

FIGURE
IS8



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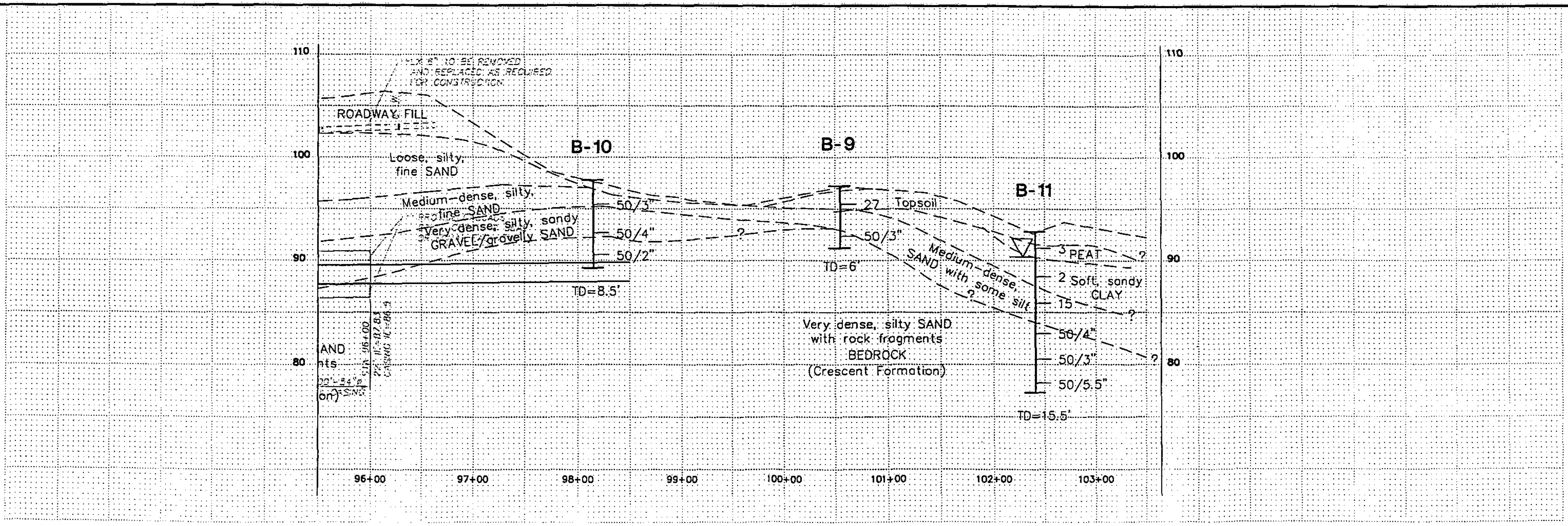

PROFILE
HORIZ: 1"=100'
VERT: 1"=10'

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SITE AND EXPLORATION PLAN

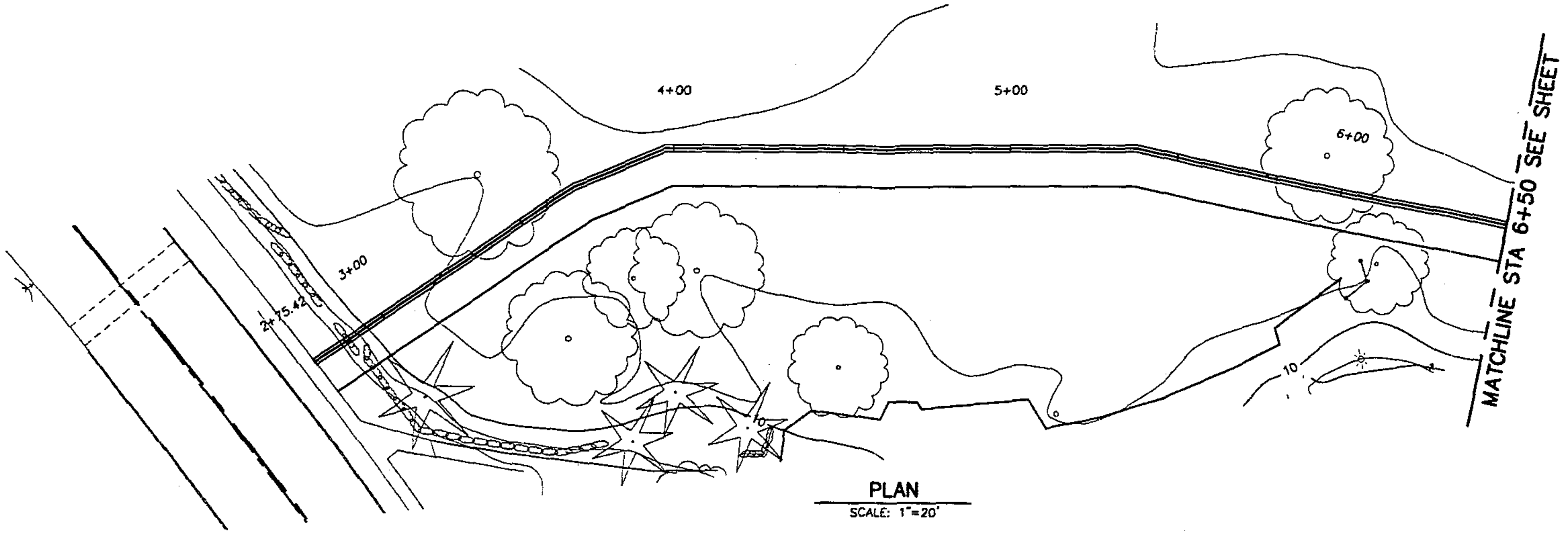
LOTT - CAPITOL LAKE SOUTHERN CONNECTION
INTERCEPTOR SEWER

OLYMPIA, WASHINGTON

FIGURE

IS9

JOB NO: 0-91M-11684-B-0 | DWG DATE: 03-07-2000 | SCALE: 1"=100' | DESIGN BY: HWB | FILE NAME: IS-9.DWG



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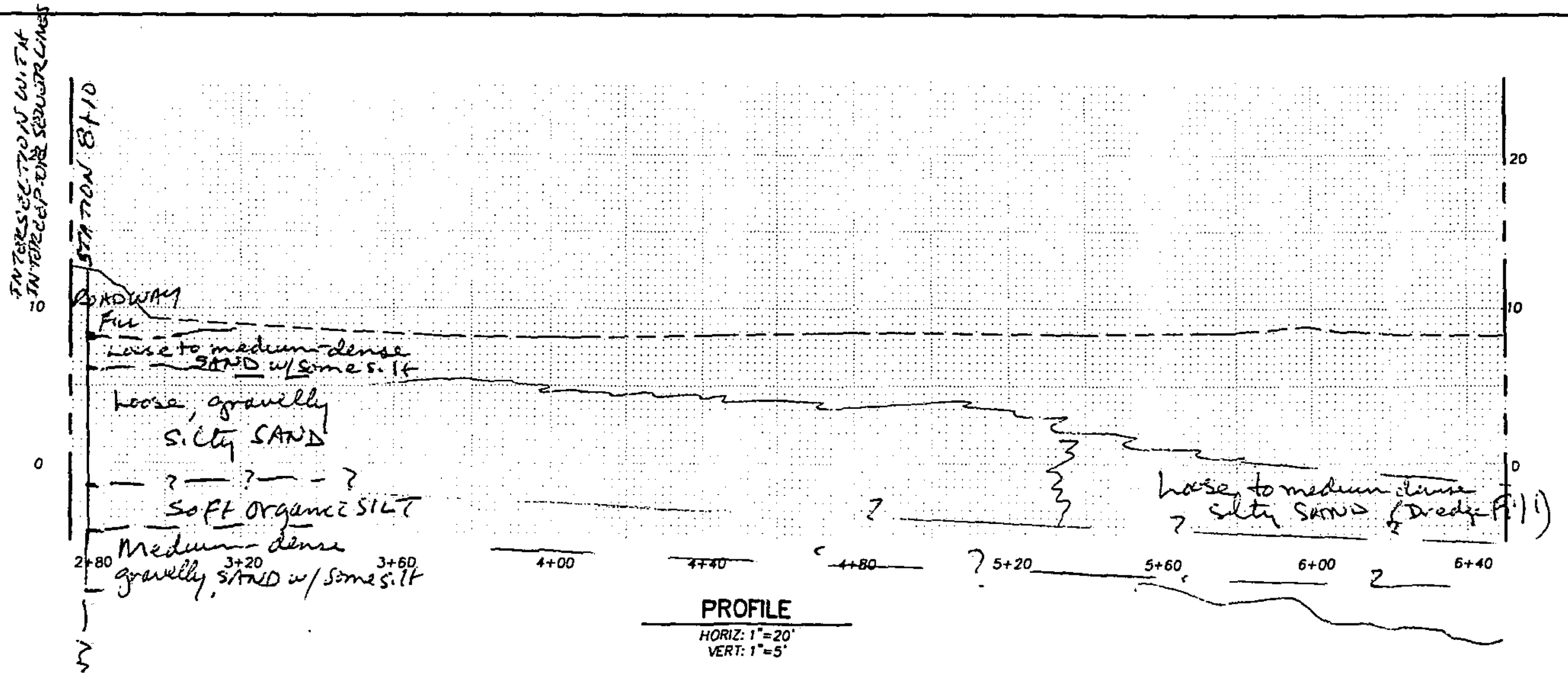

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

2

SCALE 1" = 40'

DATE: 03/27/00 XREF'S: 15770148 DWNTAGE OXS0001N CAP-PR

NO.	REVISIONS	DATE	BY	
				DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE
IF NOT SCALE ACCORDINGLY
SCALE
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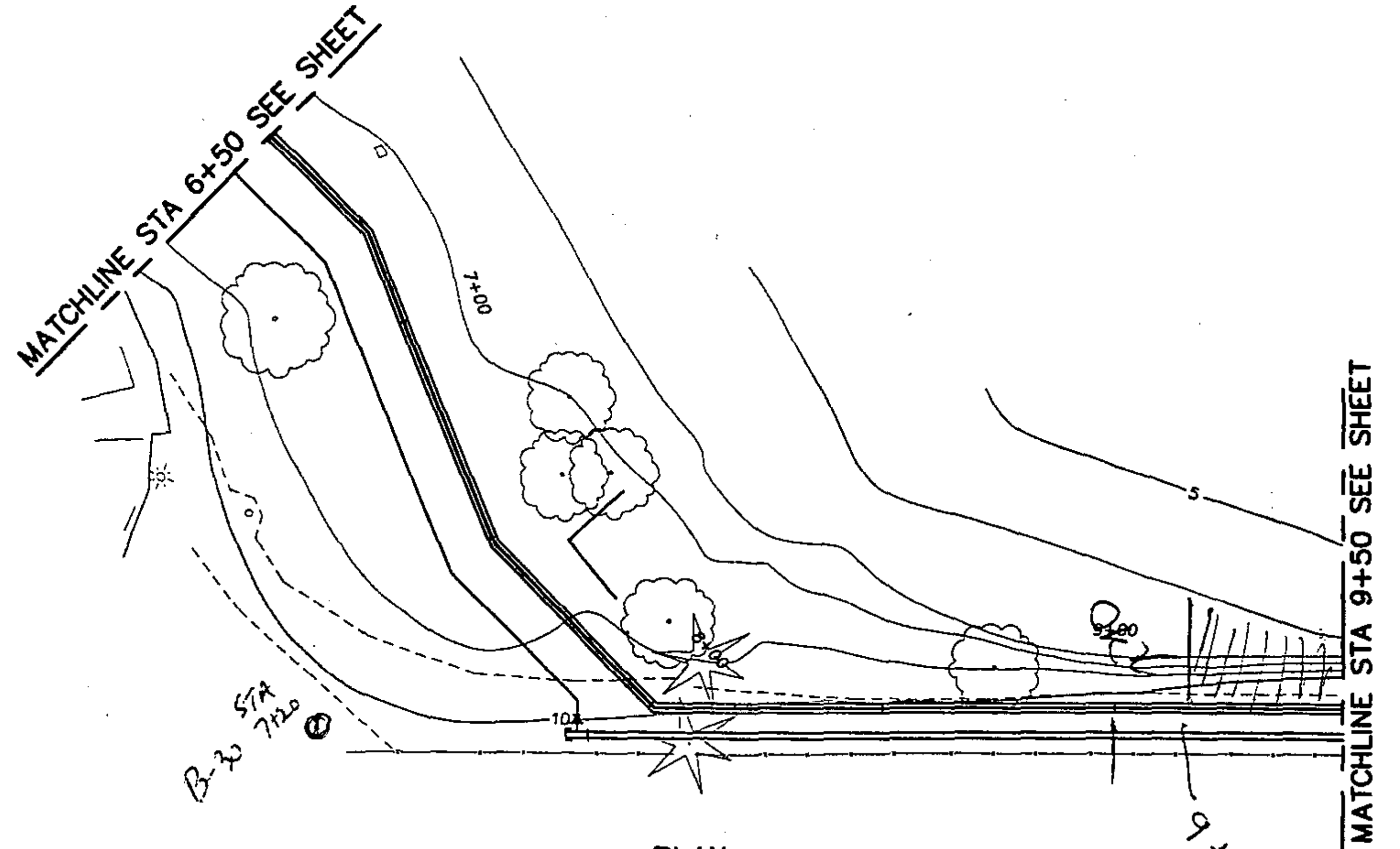
JOB NO.

FILE NAME: 15771450

SHEET NO.

FM



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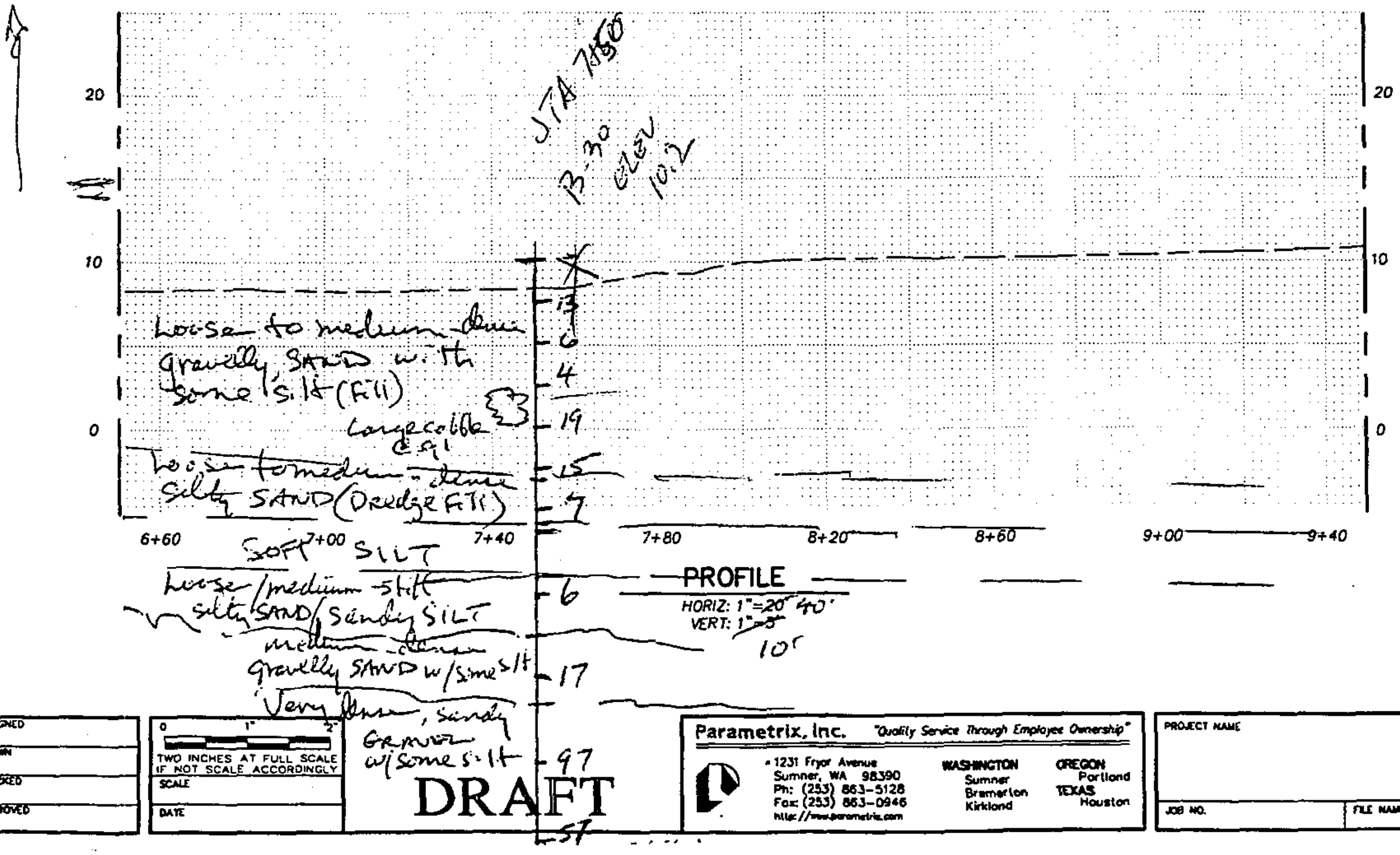

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VERT: 1"=~~5~~ 10'

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				CHECKED
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0 1" 2"
TWO INCHES AT FULL SCALE
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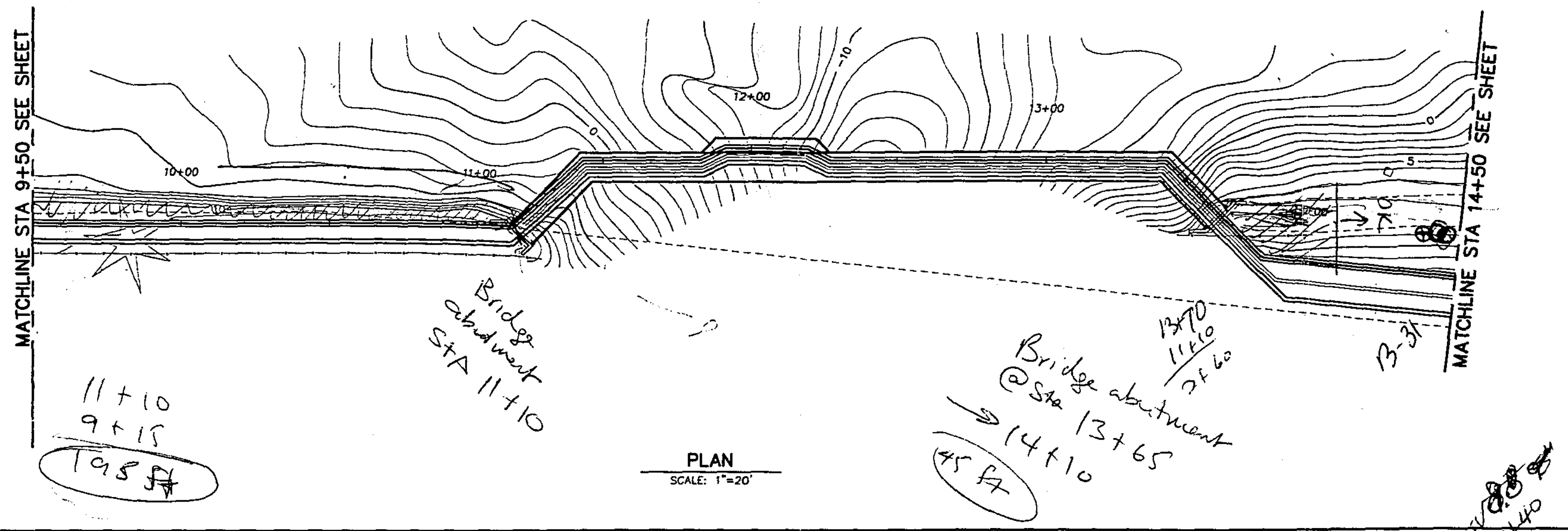
PROJECT NAME
JOB NO.
FILE NAME: 15771451

SHEET NO.
FM-7

195
+ 45
240' x 200
x 8 20/ft



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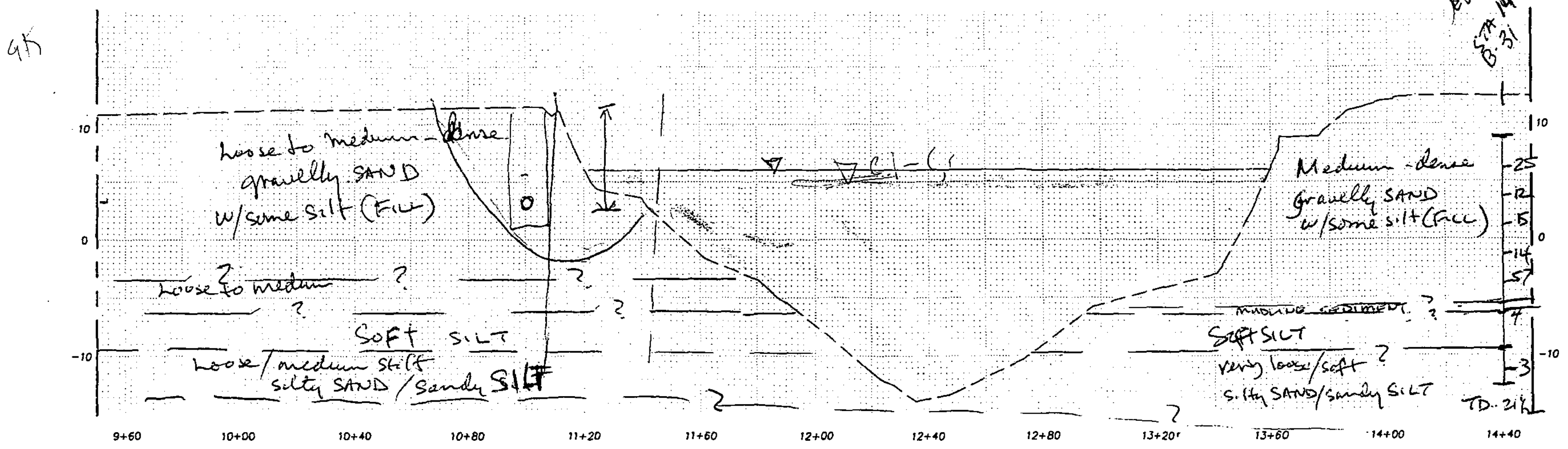

PROFILE
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VERT: 1"=5'

DATE: 07/23/00 SHEET: 15771452 DWG CAP-PR

NO.	REVISIONS	DATE	BY	DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
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SCALE
DATE

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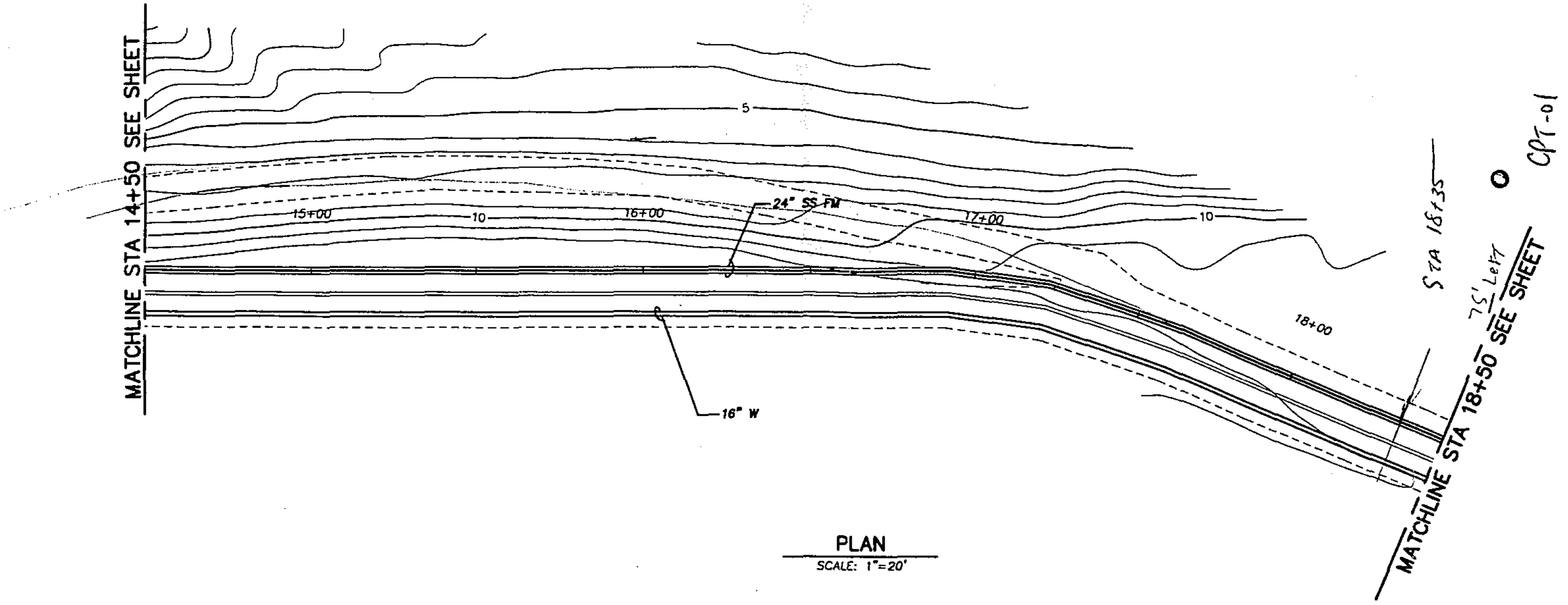
TEXAS Houston

PROJECT NAME
JOB NO.
FILE NAME: 15771452

SHEET NO.
FM3



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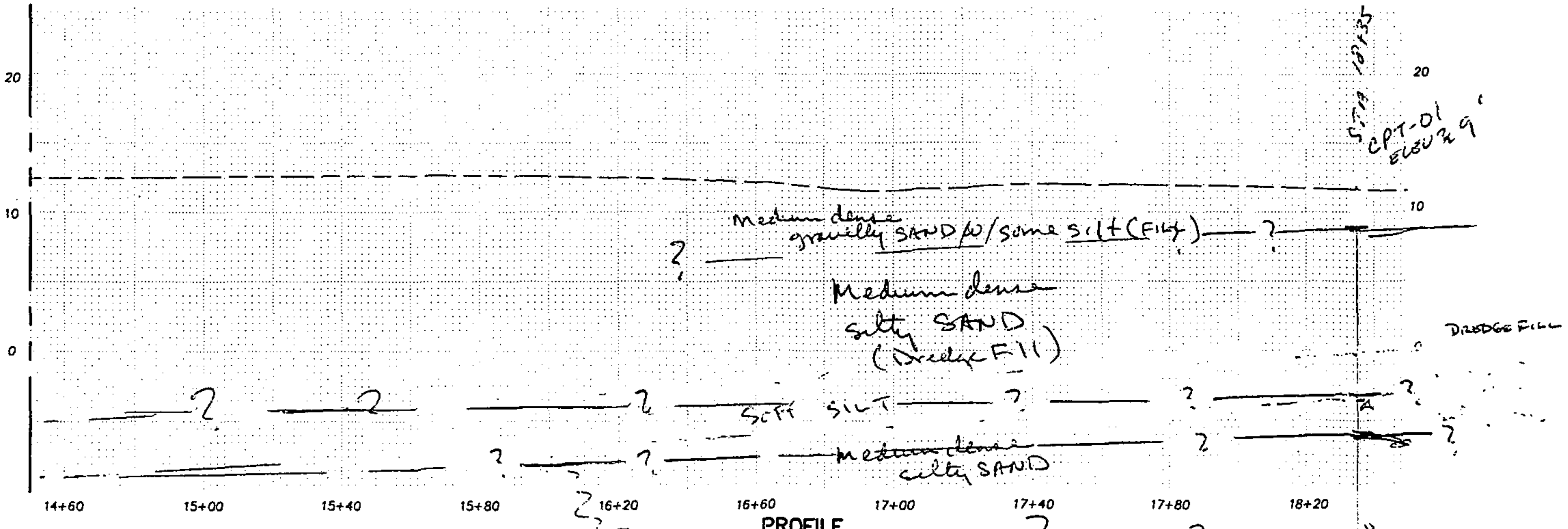

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

NO.	REVISIONS	DATE	BY	DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE
IF NOT SCALE ACCORDINGLY
SCALE
DATE

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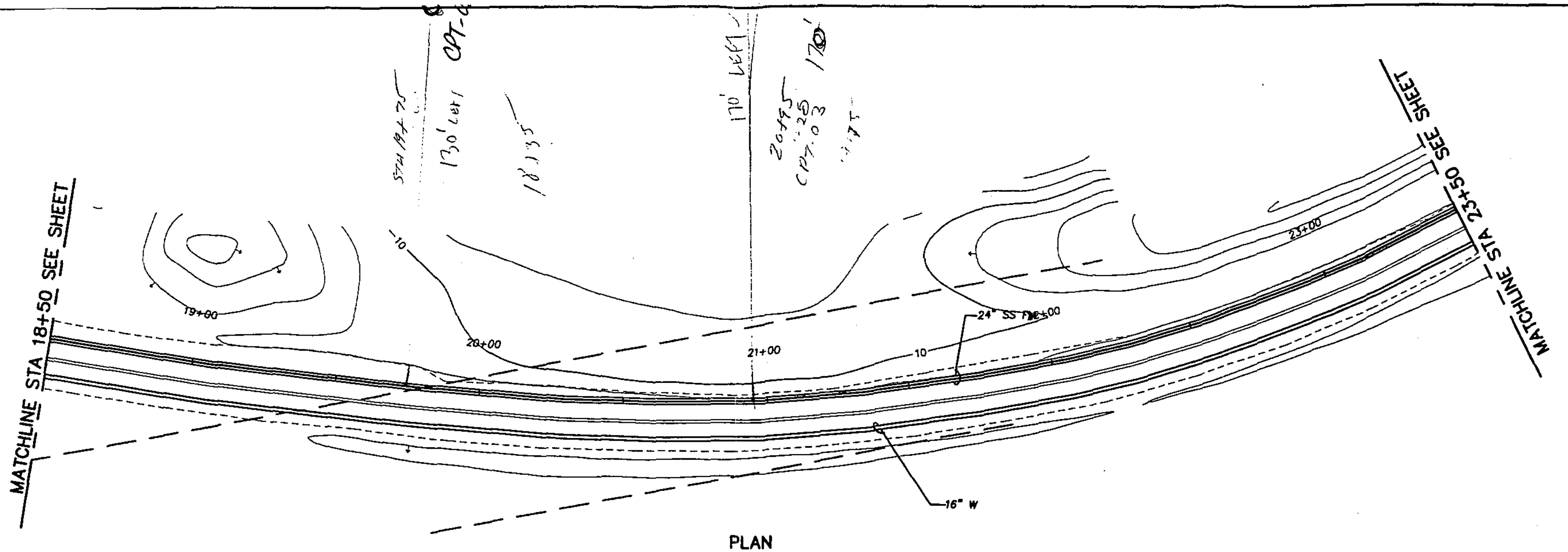
PROJECT NAME
~~FP~~ 30' TP
JOB NO.
FILE NAME: 15771453

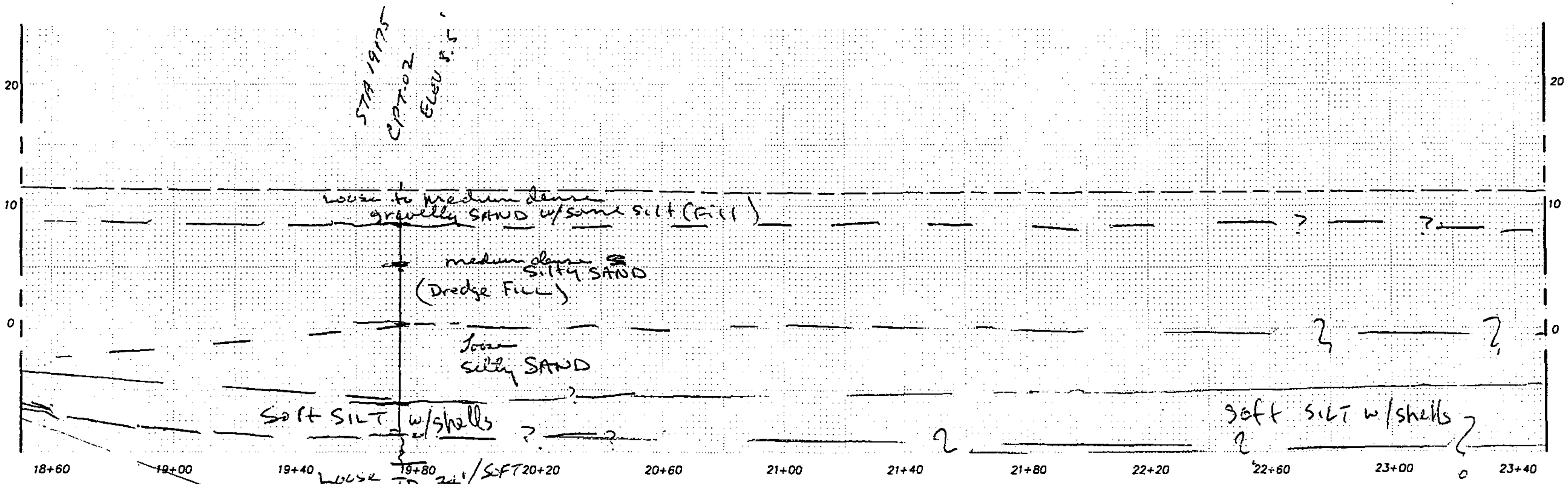
30'½

SHEET NO.
FM/4



PLAN

SCALE: 1"=20'



PROFILE

HORIZ: 1"=20'
VERT: 1"=5'

DATE: 07/27/00 XREF'S: 15770148 DWNTKE DESPROTN CAP-PR

NO.	REVISIONS	DATE	BY	DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
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SCALE
DATE

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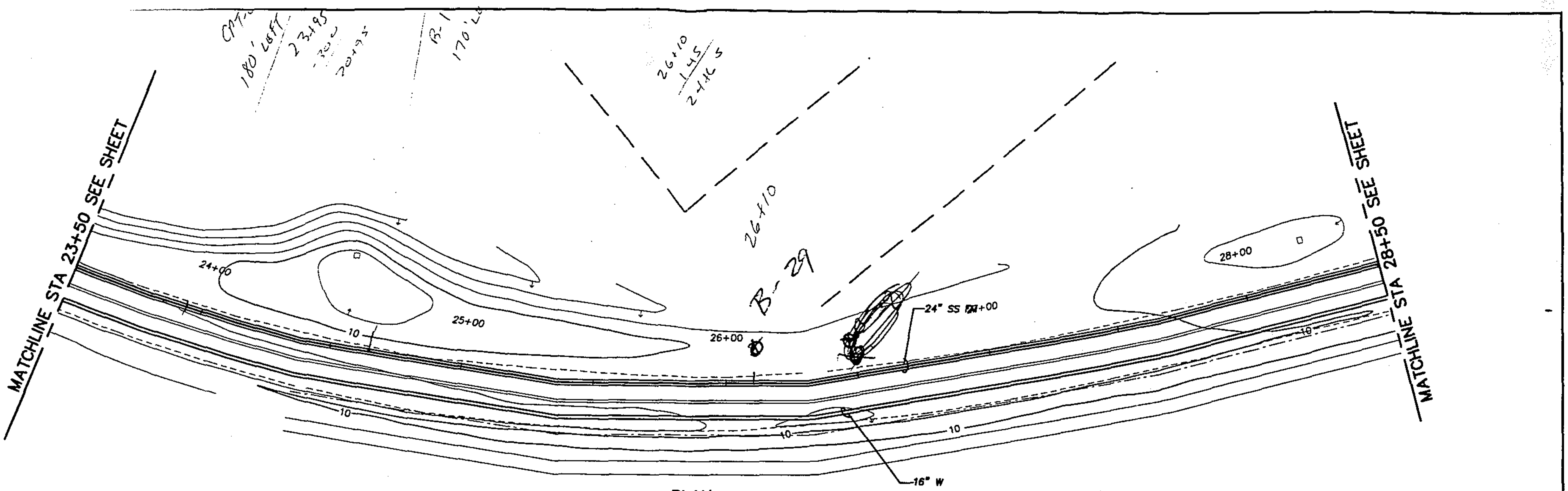
PROJECT NAME
JOB NO.
FILE NAME: 15771454

SHEET NO.
FM/5



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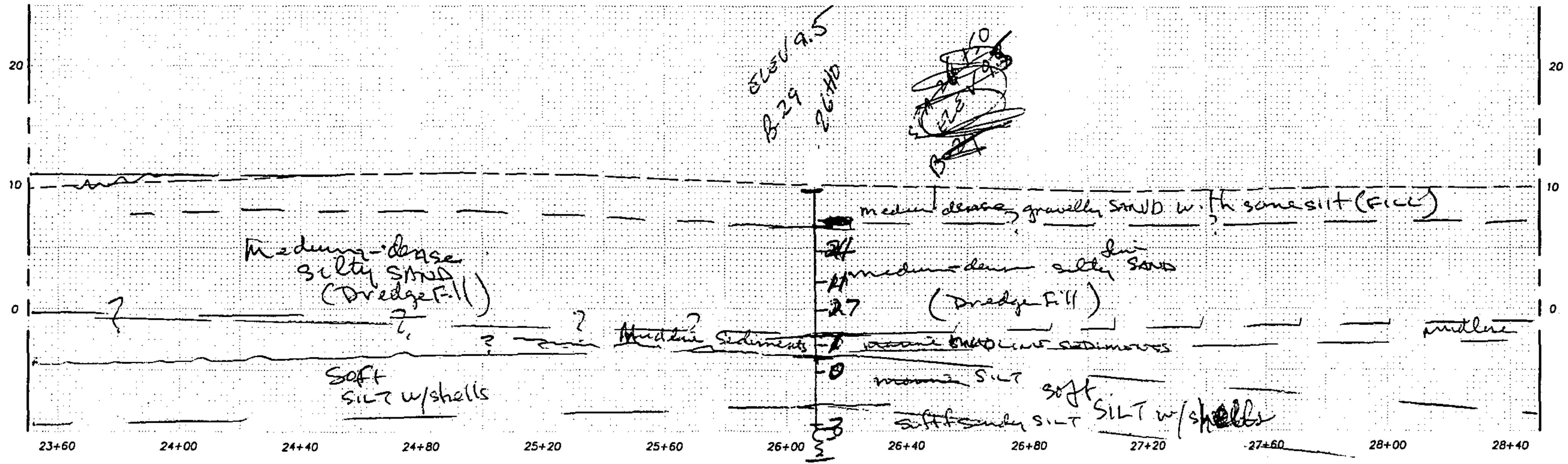
SCALE: 1"=20'



PROFILE

HORIZ: 1"=20'
VERT: 1"=5'

TD-46½'

?

TD 46½

NO.	REVISIONS	DATE	BY	
				DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE IF NOT SCALE ACCORDINGLY
SCALE
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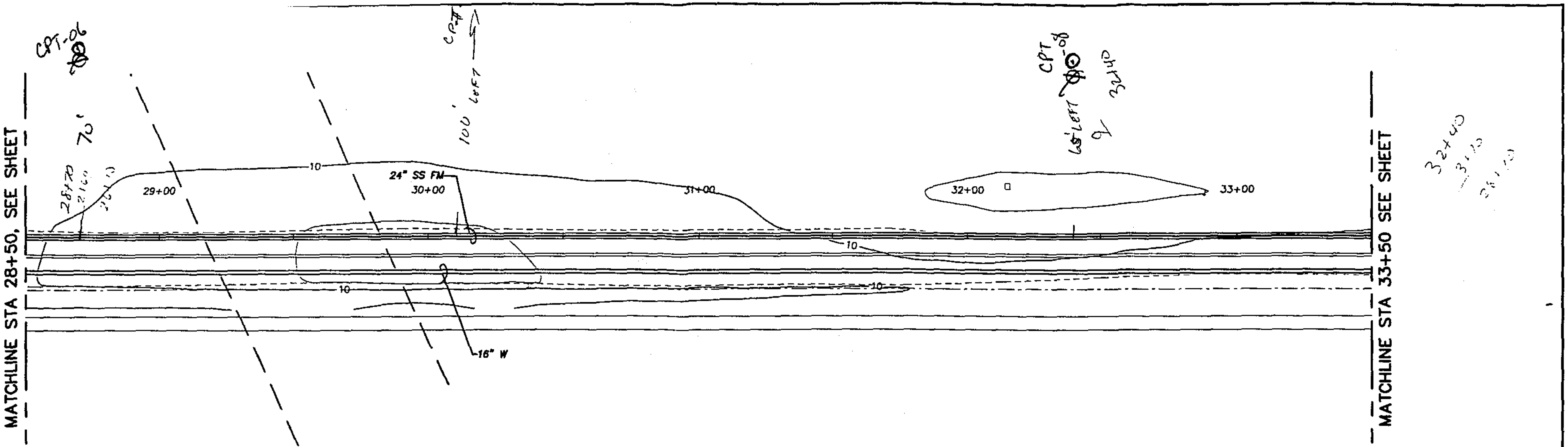
PROJECT NAME

JOB NO.

FILE NAME: 15771455

SHEET NO.
FM 6



PLAN

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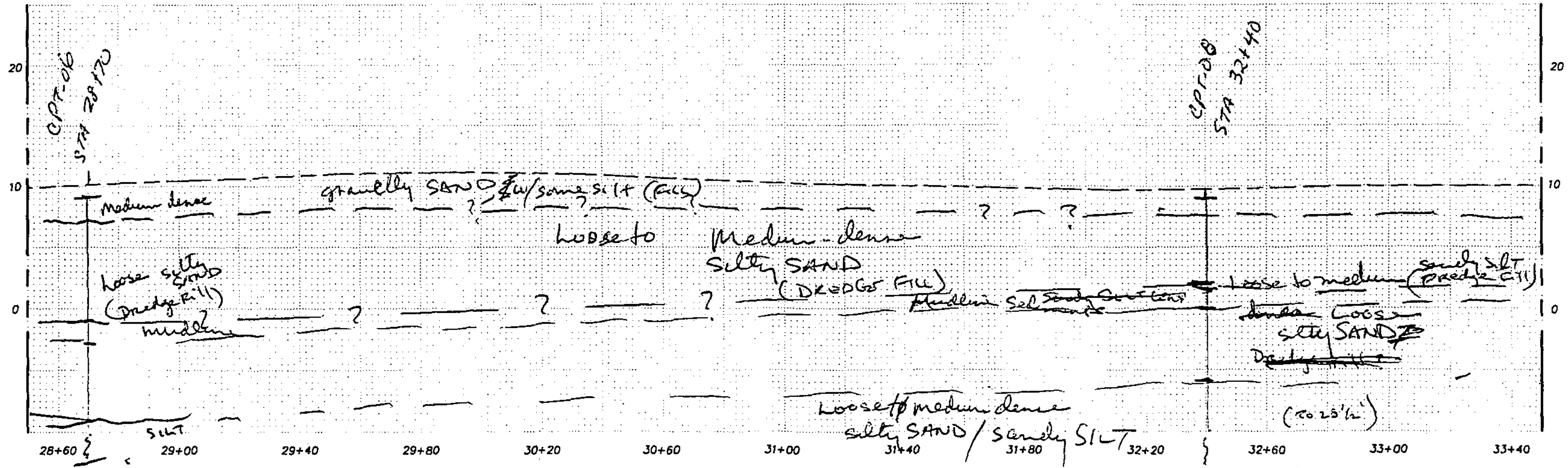

PROFILE

HORIZ: 1"=20'
VERT: 1"=5'

NO.	REVISIONS	DATE	BY	
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				DRAWN
				CHECKED
				APPROVED

0 1" 2"
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SOFT SILT

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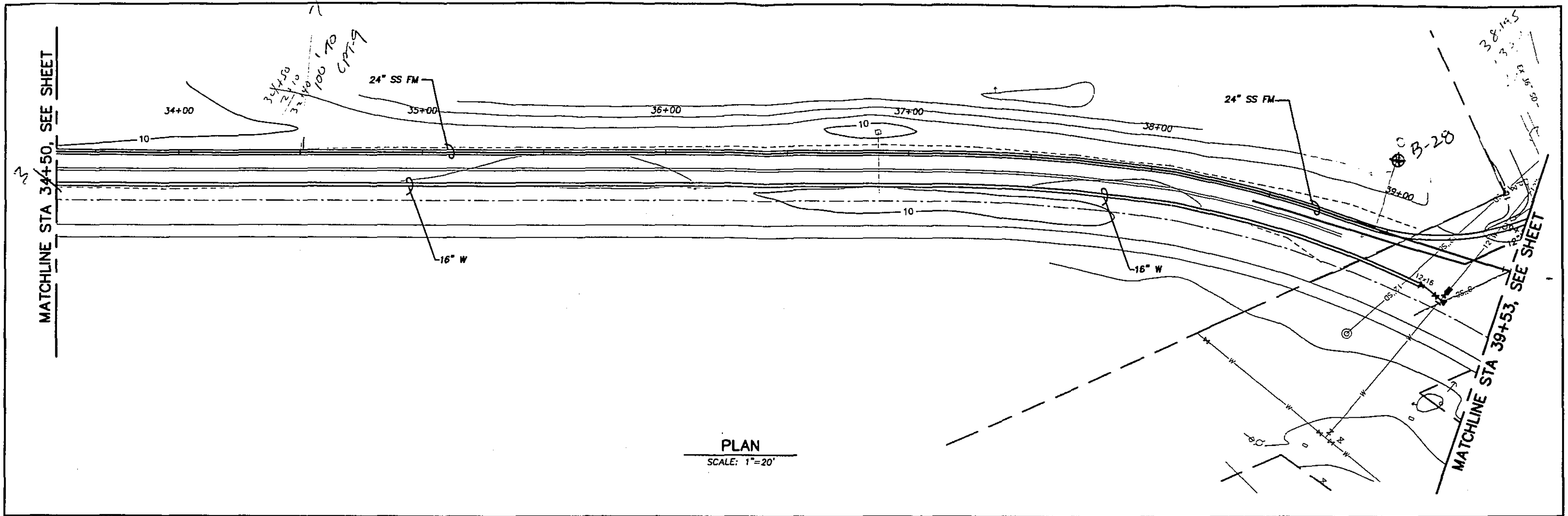
PROJECT NAME SOFT SILT
JOB NO.
FILE NAME: 15771456

SHEET NO. FM/7

DATE: 07/23/00 XREF'S: 15770148



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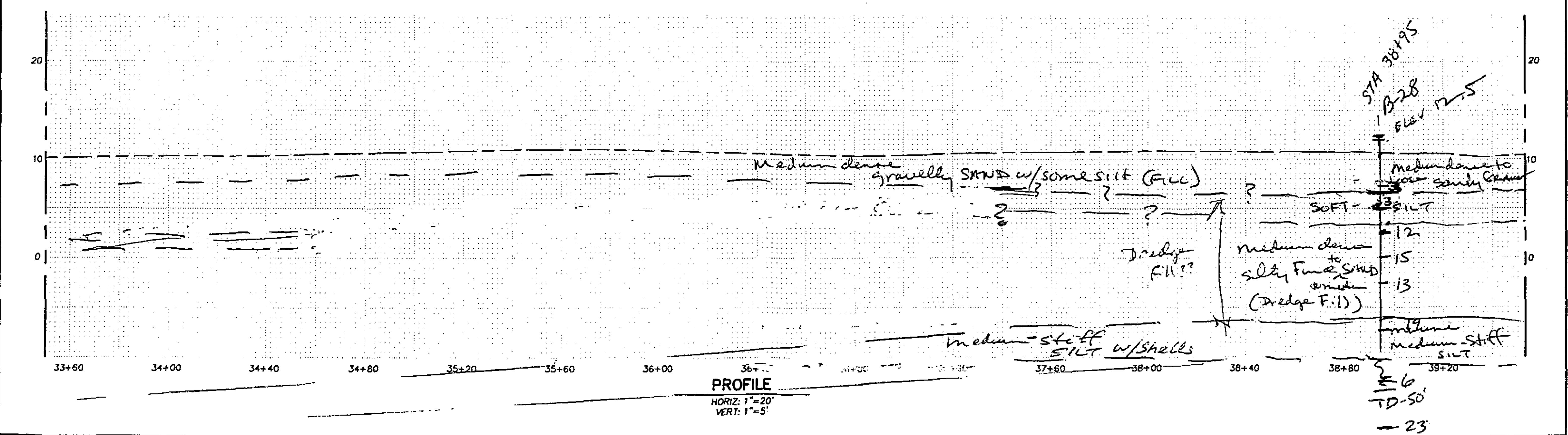

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

NO.	REVISIONS	DATE	BY	DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE IF NOT SCALE ACCORDINGLY
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FILE NAME: 15771457

SHEET NO.
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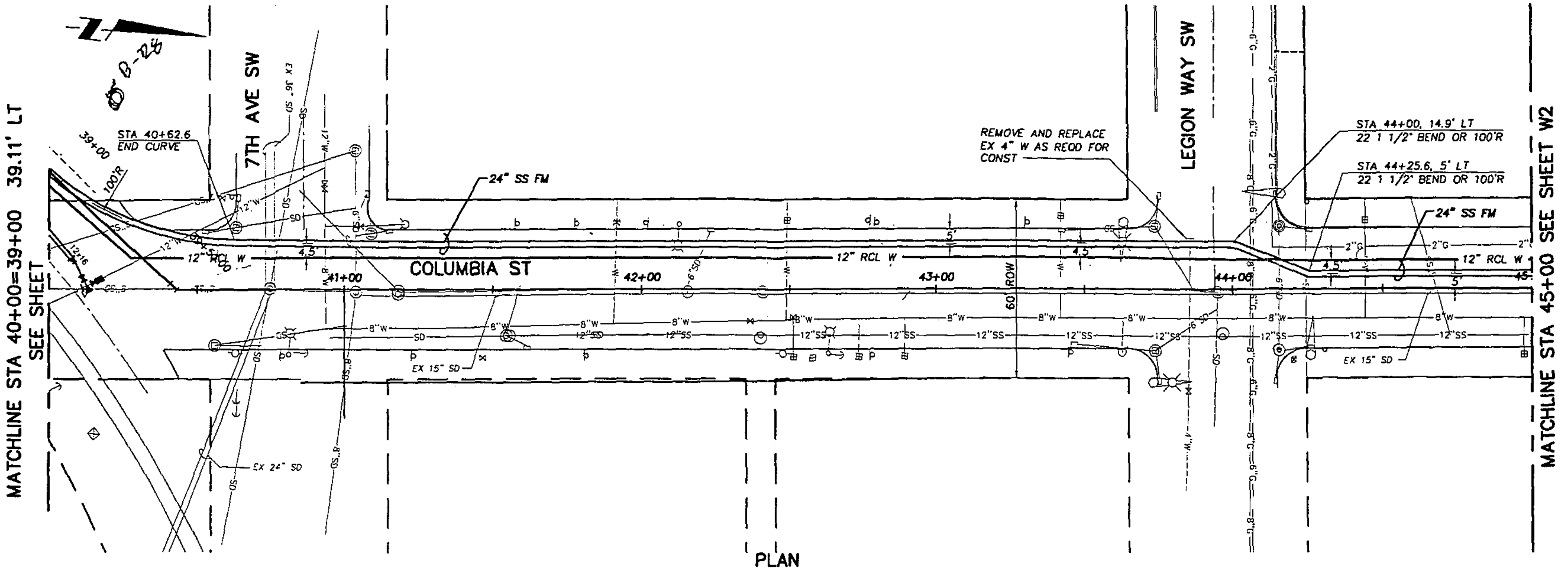

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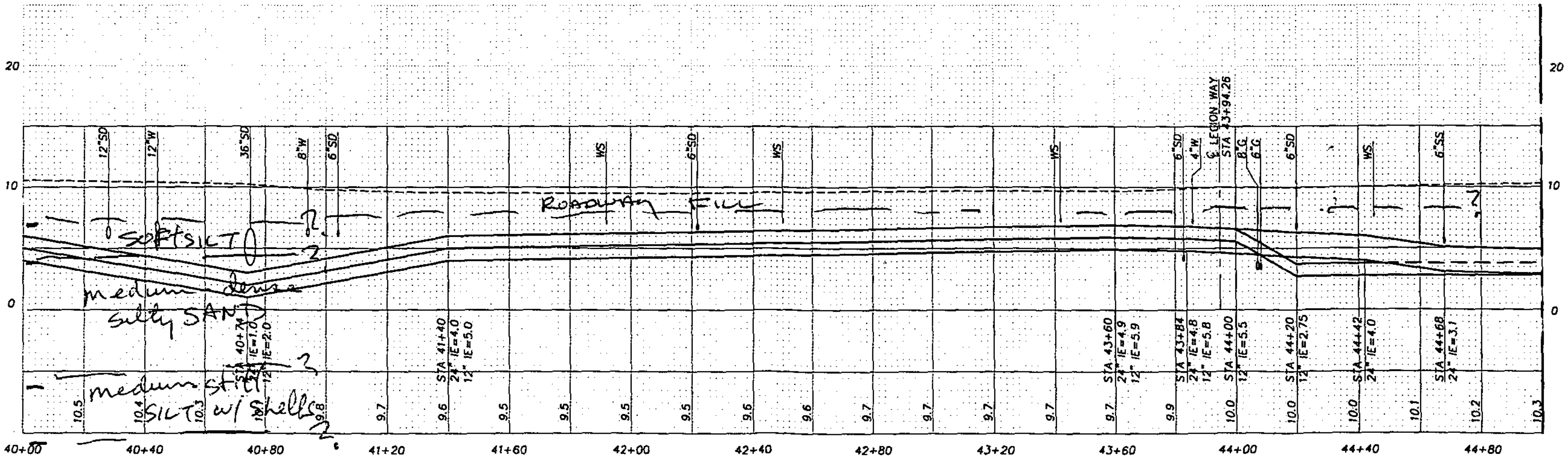

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

DATE: 07/23/00

NO.	REVISIONS	DATE	BY	
				DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE
IF NOT SCALE ACCORDINGLY
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JOB NO.

FILE NAME: 15771458

SHEET NO.
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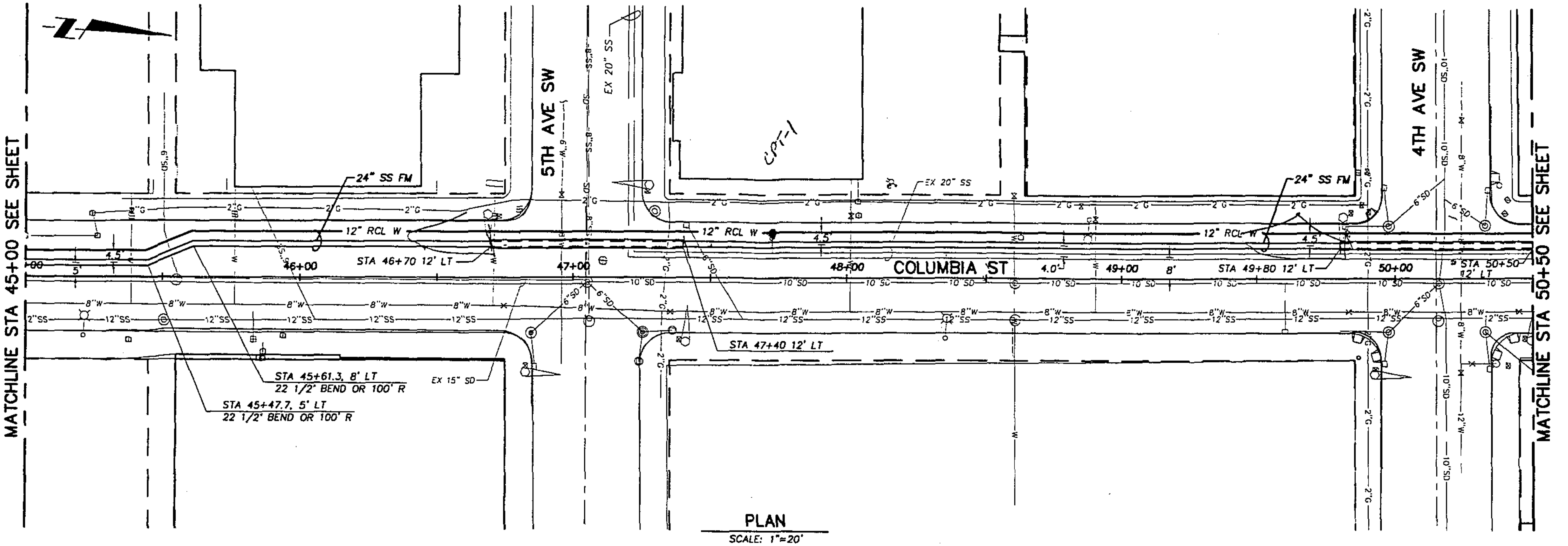

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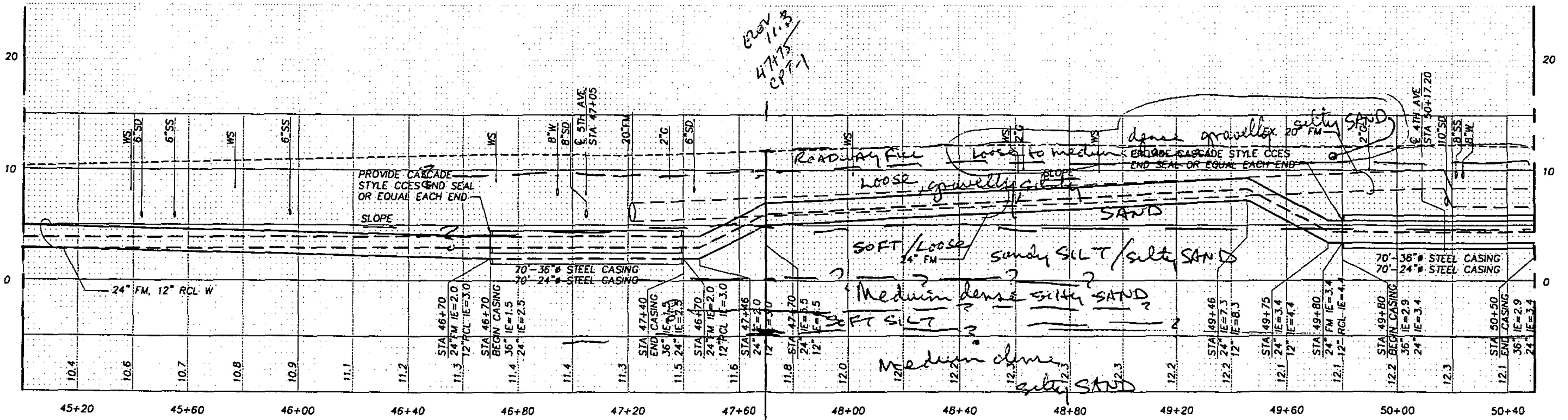

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

NO.	REVISIONS	DATE	BY

DESIGNED
DRAWN
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PROJECT NAME
JOB NO.
FILE NAME: 15771459

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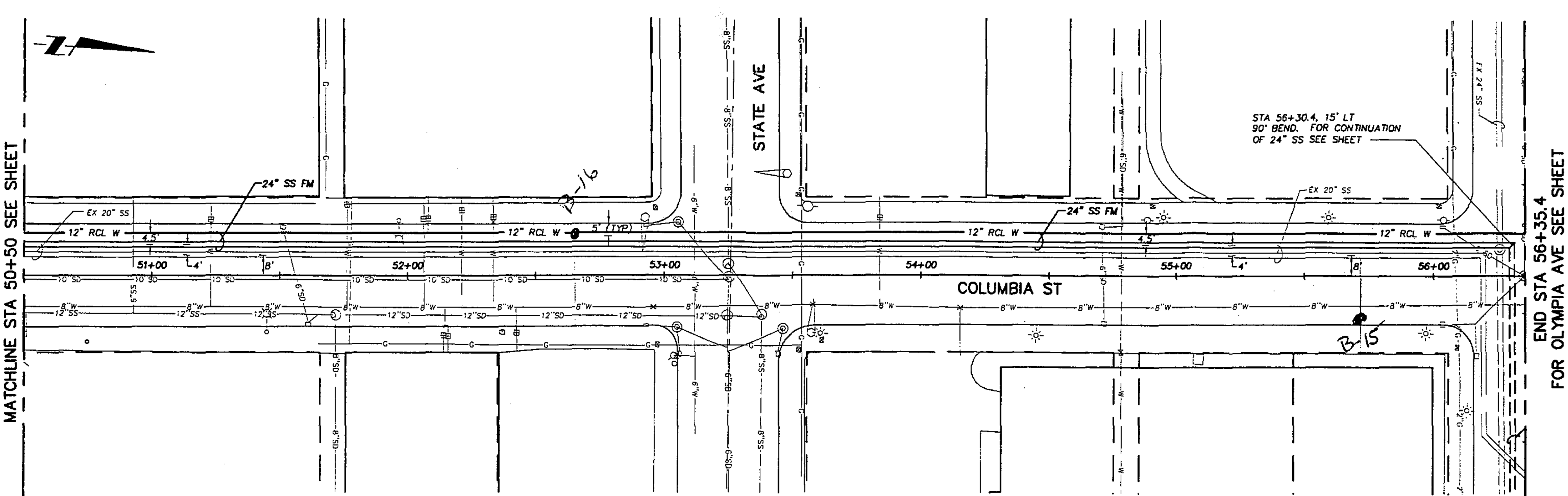
10

DATE: 01/21/00 XREF'S: 15771045 DWH7NOE DWH7NOR



PLAN

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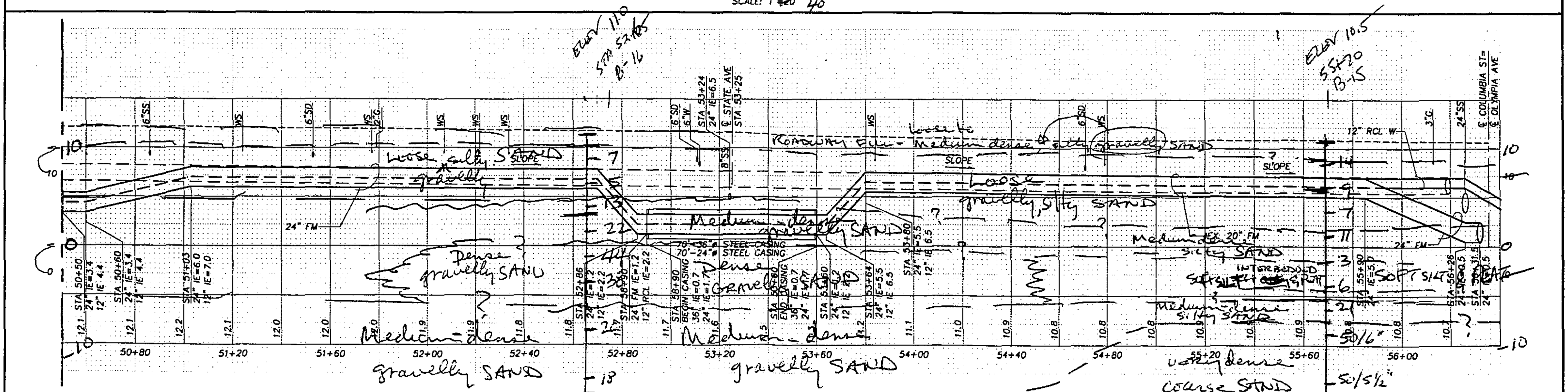

PROFILE

HORIZ: 1"=~~20'~~ 40
VERT: 1"=~~5'~~ 10

NO.	REVISIONS	DATE	BY	
				DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE IF NOT SCALE ACCORDINGLY
SCALE
DATE

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JOB NO.

FILE NAME: 15771460

SHEET NO.
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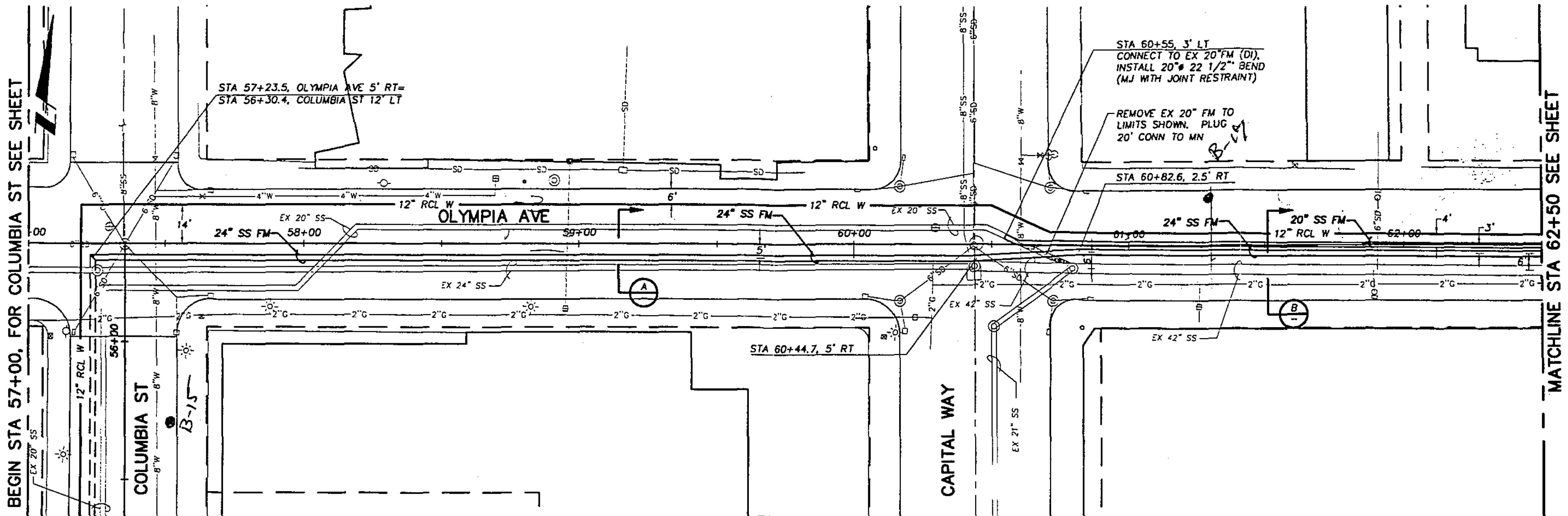

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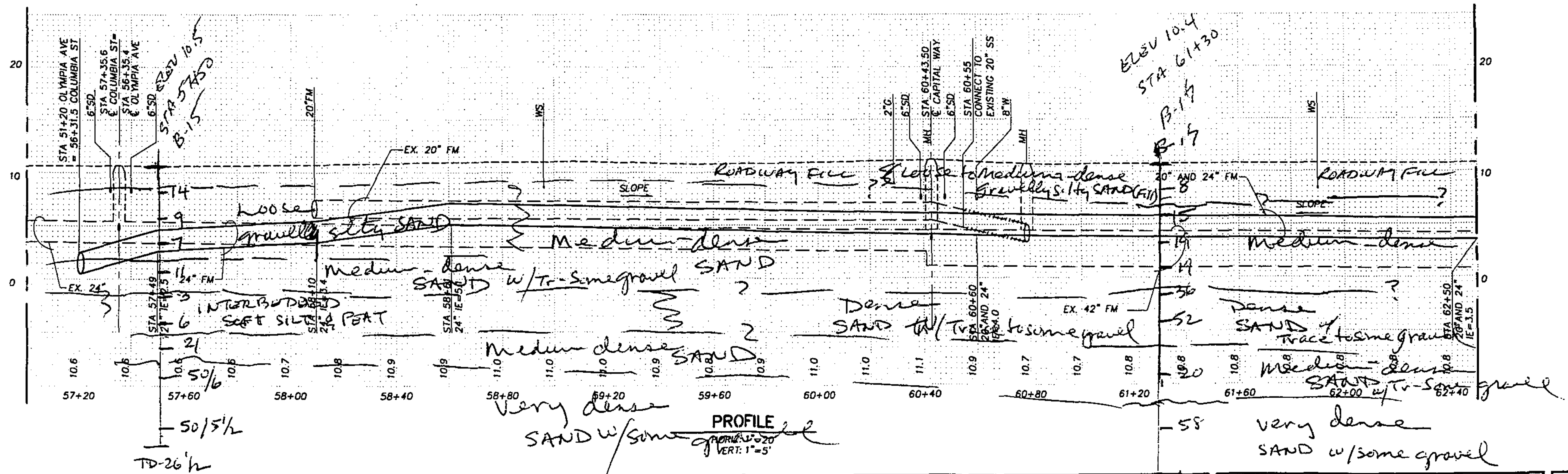

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

DATE: 02/22/00 XREF'S: 15770418 DWNTHDE DWNTHPR

NO.	REVISIONS	DATE	BY	
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				DRAWN
				CHECKED
				APPROVED

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SCALE
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JOB NO.

FILE NAME: 15771461

SHEET NO.

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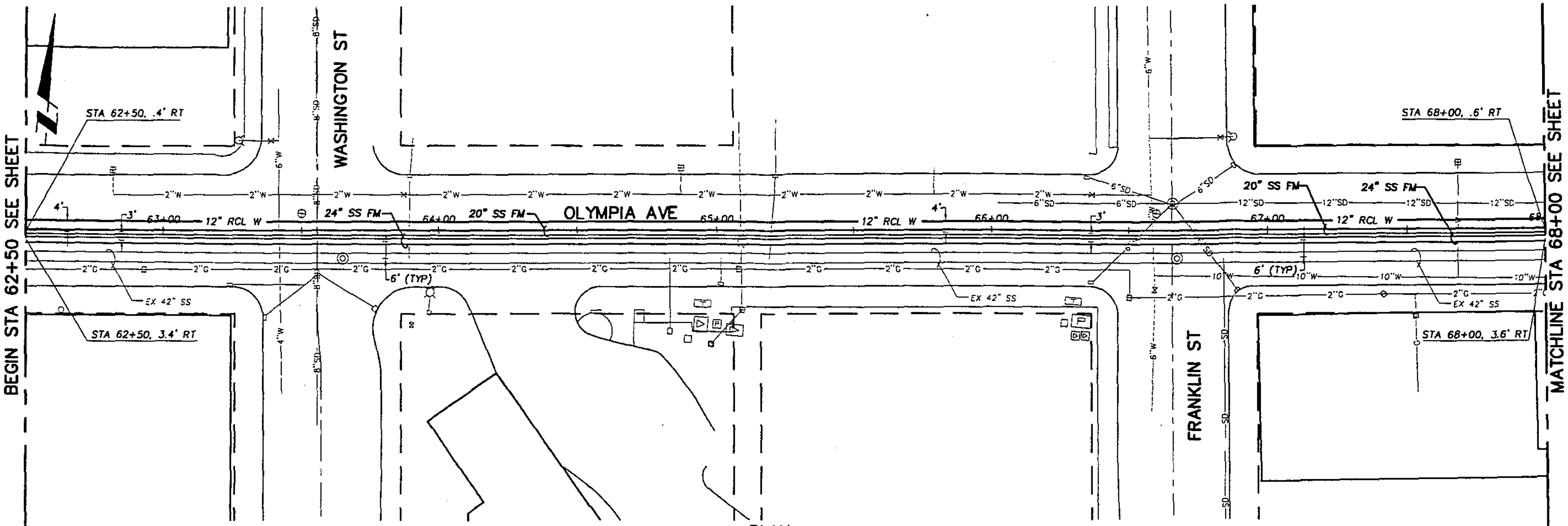

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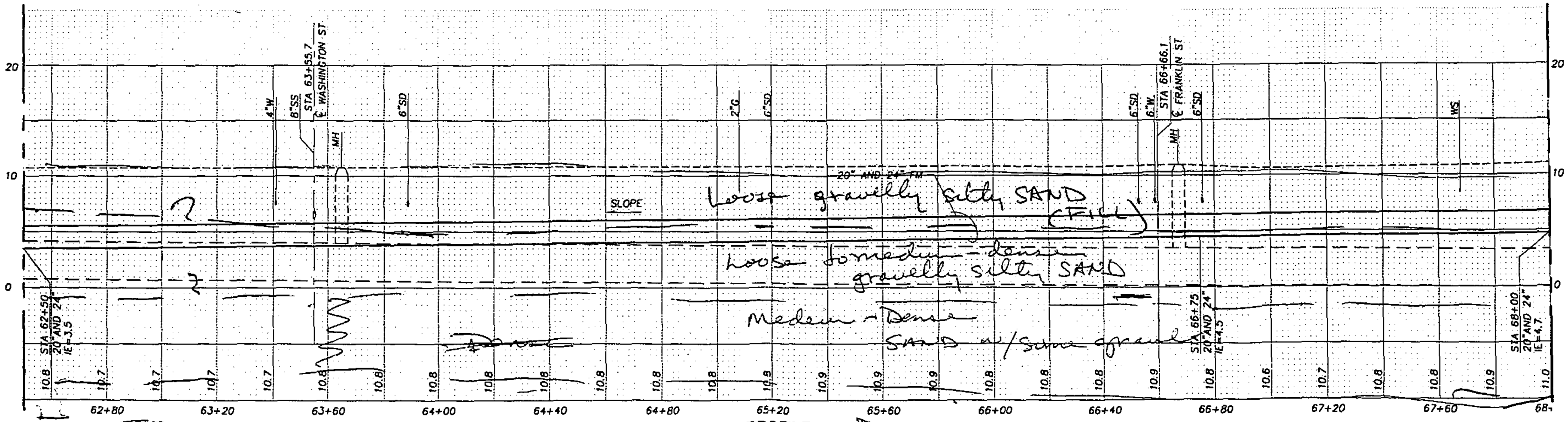

?

Loose gravelly silty SAND (FILL)

Loose to medium-dense gravelly silty SAND

?

Medium-Dense SAND w/some gravel

~~Dense~~

PROFILE
HORIZ: 1"=20'
VERT: 1"=5'

Dense SAND w/some silt to silty

Very dense

NO.	REVISIONS	DATE	BY	DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE IF NOT SCALE ACCORDINGLY
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PROJECT NAME

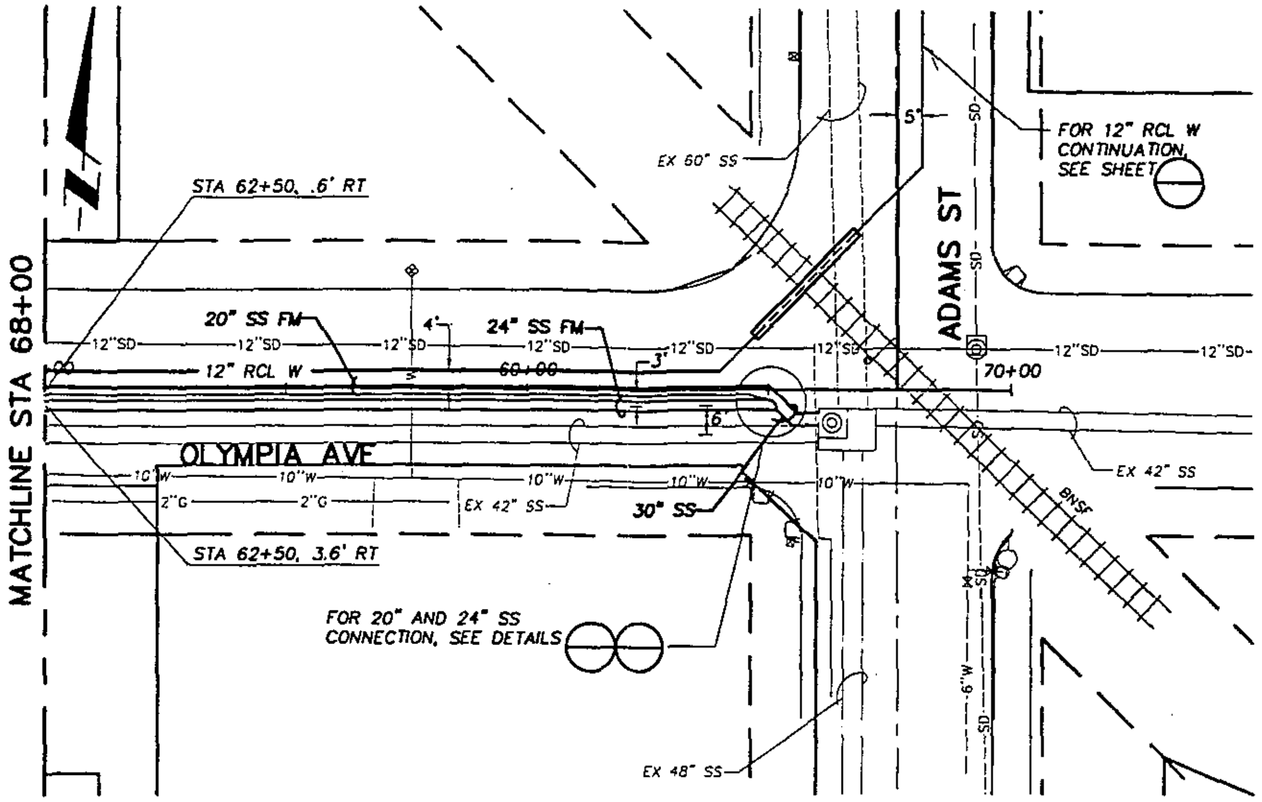
JOB NO.

FILE NAME: 15771462

SHEET NO.

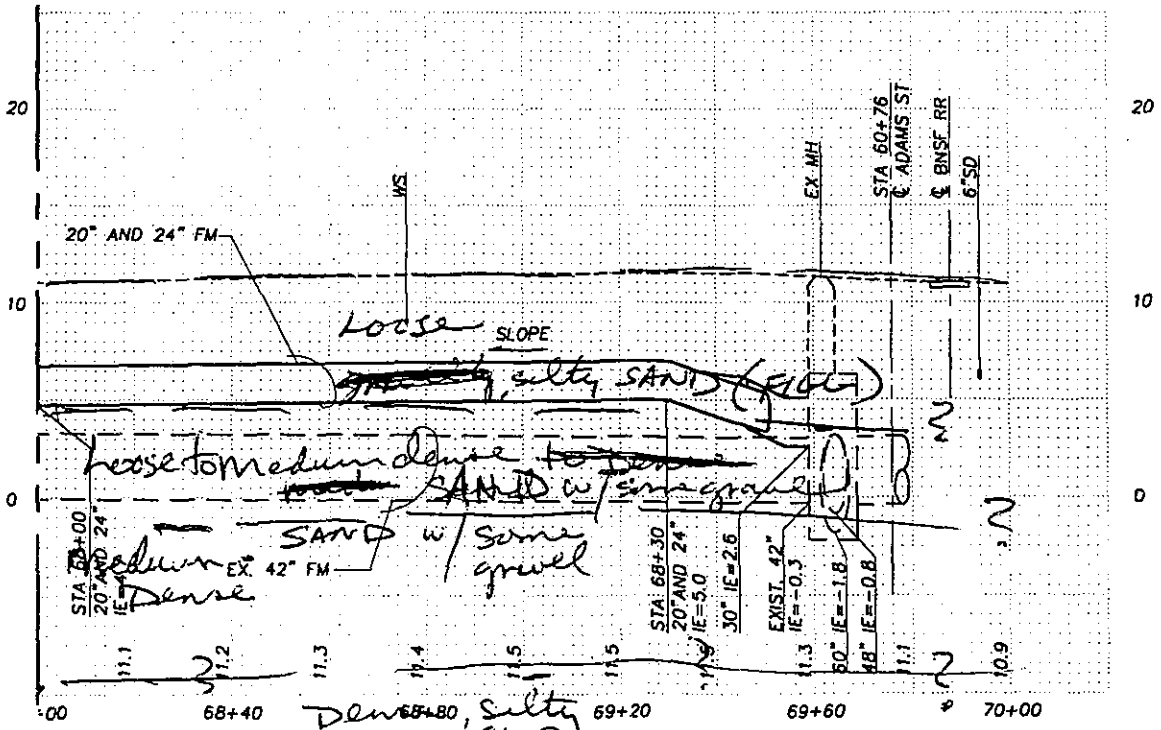
FM 13

DATE: 02/22/00 XREF'S: 15770148



PLAN

SCALE: 1"=20'



PROFILE

HORIZ: 1"=20'
VERT: 1"=5'

DATE: 07/27/00

NO.	REVISIONS	DATE	BY	
				DESIGNED
				DRAWN
				CHECKED
				APPROVED

0 1" 2"
TWO INCHES AT FULL SCALE IF NOT SCALE ACCORDINGLY
SCALE
DATE

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PROJECT NAME

JOB NO.

FILE NAME: 15771463

SHEET NO.
FM/14

APPENDIX A

EXPLORATION PROCEDURES AND INTERPRETIVE LOGS

APPENDIX A
EXPLORATION PROCEDURES AND INTERPRETIVE LOGS
9-91M-11684-B

The following paragraphs describe our procedures associated with the field explorations and field tests that we conducted for this project. Descriptive logs of our explorations are enclosed in this appendix.

Auger Boring Procedures

Our exploratory borings were advanced with a hollow-stem auger, using a truck-mounted drill rig operated by an independent drilling firm working under subcontract to AGRA. A geotechnical specialist from our firm continuously observed the borings, logged the subsurface conditions, and collected representative soil samples. All samples were stored in watertight containers and later transported to our laboratory for further visual examination and testing. After each boring was completed, the borehole was backfilled with a mixture of bentonite chips and soil cuttings, and the surface was patched with asphalt or concrete (where appropriate).

Throughout the drilling operation, soil samples were obtained at 2½- or 5-foot depth intervals by means of the Standard Penetration Test (SPT) per ASTM:D-1586. This testing and sampling procedure consists of driving a standard 2-inch-diameter steel split-spoon sampler 18 inches into the soil with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "SPT blow count." If a total of 50 blows is struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils. Where soft soils were encountered, these split-spoon samples were supplemented with Shelby tube samples. A Shelby tube consists of a 3-inch-diameter thin-wall steel tube that is pushed into the soil by means of hydraulic rams. Where gravelly soils were encountered, a 3-inch-diameter split-spoon sampler and a 300-pound hammer was utilized to improve the sample recovery, and the resulting blow counts were subsequently converted to SPT blow counts by means of energy correlations.

The enclosed *Boring Logs* describe the vertical sequence of soils and materials encountered in each boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the borings, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth is depicted on the boring log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted height on the drilling rods, and the water level measured in the borehole after the auger has been extracted.

Well Installation Procedures

Our groundwater observation wells consist of 2-inch-diameter PVC pipe, the lower 10 feet of which is finely slotted. The annular space around the slotted segment was backfilled with clean sand and gravel, and the upper portion of annulus was sealed with bentonite chips and concrete. A flush-mounted monument was placed over the top of each wellhead for protection. The as-built configuration of each observation well is illustrated on the respective *Boring Log*. Our logs also show any post-drilling groundwater levels measured in the wells, along with the date of measurement.

CPT Sounding Procedures

Our exploratory Cone Penetration Test (CPT) soundings consisted of advancing an electric piezocone penetrometer, using a truck-mounted cone rig operated by an independent firm working under subcontract to AGRA. A geotechnical engineer from our office continuously observed the CPT soundings while the data acquisition system in the cone rig automatically logged the CPT readings. After each sounding was completed, the conehole was backfilled with a mixture of sand and bentonite chips.

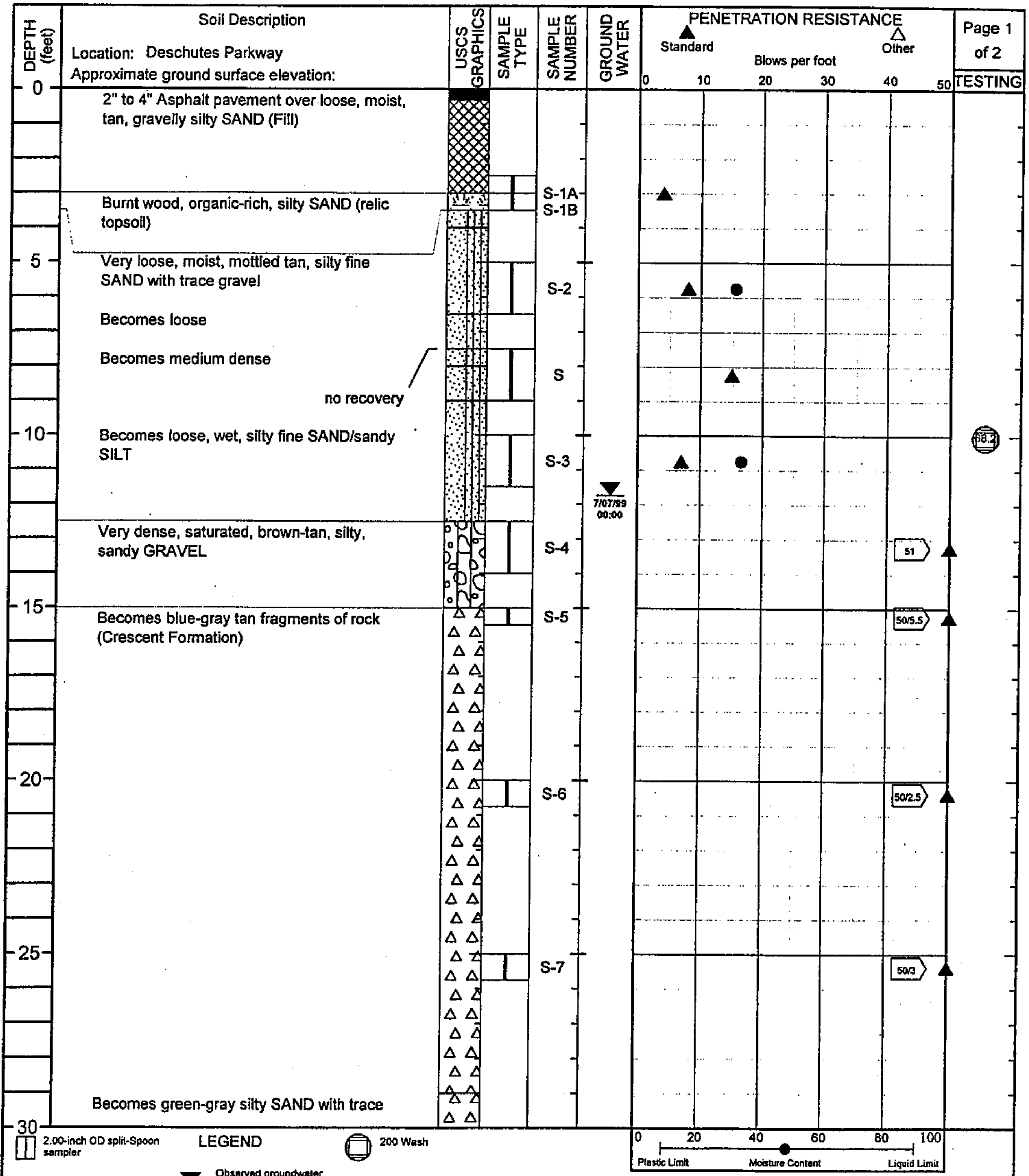
The piezocone tests were performed in general accordance with ASTM D-3441 standards using a 5-ton electric piezocone with a porous element located at the shoulder behind the cone tip. The cone consisted of a standard tip design having a 60° apex, 10 cm^2 projected area at the tip, 150 cm^2 sleeve, and was advanced at a rate of approximately 2 cm/sec. The cone tip resistance (q_T), sleeve friction (f_s), and penetration pore water pressure (u_2) were recorded continuously during the tests. In addition, downhole seismic surveys were performed in three of the six soundings at 1 meter intervals for the evaluation of shear wave velocity of the soils. Pore pressure dissipation tests were also attempted at depths where the porewater pressures were observed to be significant, for the evaluation of hydraulic conductivity of the soils. Due to the granular nature of the soils, only a few significant excessive pore water pressure readings were observed during the dissipation tests and porewater pressures dissipated relatively rapidly.

The enclosed CPT graphs present the vertical plots of q_T, f_s, u_2, and friction ratio measured in each sounding. These graphs also depict the Standard Penetration Resistance (N_{60}) corresponding to each test interval, based on published conversion charts. Many soil properties, such as soil classification, relative density, effective friction angle, and drained modulus, can be interpreted for the granular soils at the project site using published correlation charts and empirical relationships.

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-1*

Page 1 of 2

Location: Deschutes Parkway
Approximate ground surface elevation:



DEPTH (feet)	Soil Description	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE	TESTING
0	2" to 4" Asphalt pavement over loose, moist, tan, gravelly silty SAND (Fill)				
	Burnt wood, organic-rich, silty SAND (relic topsoil)	S-1A S-1B			
5	Very loose, moist, mottled tan, silty fine SAND with trace gravel	S-2			
	Becomes loose				
	Becomes medium dense no recovery	S			
10	Becomes loose, wet, silty fine SAND/sandy SILT	S-3	7/07/99 00:00		68.2
	Very dense, saturated, brown-tan, silty, sandy GRAVEL	S-4		51	
15	Becomes blue-gray tan fragments of rock (Crescent Formation)	S-5		50/5.5	
20		S-6		50/2.5	
25		S-7		50/3	
	Becomes green-gray silty SAND with trace				
30					

LEGEND

2.00-inch OD split-Spoon sampler

200 Wash

Observed groundwater level

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *07 July 1999* Logged By: *SAT*

4IN1 11684B01.GPJ WA4IN1.GDT 9/12/99

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-1*

DEPTH (feet)	Soil Description Location: Deschutes Parkway Approximate ground surface elevation:	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE ▲ Standard △ Other Blows per foot 0 10 20 30 40 50	Page 2 of 2 TESTING
30	of angular fragments of rock	△ △	I	S-8		50/4 ▲	
	Terminated at approximately 30.5 feet						
35							
40							
45							
50							
55							
60							

LEGEND

▯ 2.00-inch OD split-Spoon sampler

▼ Observed groundwater level

◯ 200 Wash

0 20 40 60 80 100

Plastic Limit ● Moisture Content Liquid Limit

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

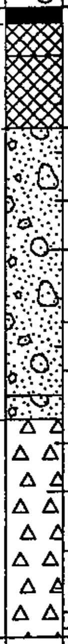
Drilling Method: HSA Hammer type: Cathead Date drilled: *07 July 1999* Logged By: *SAT*

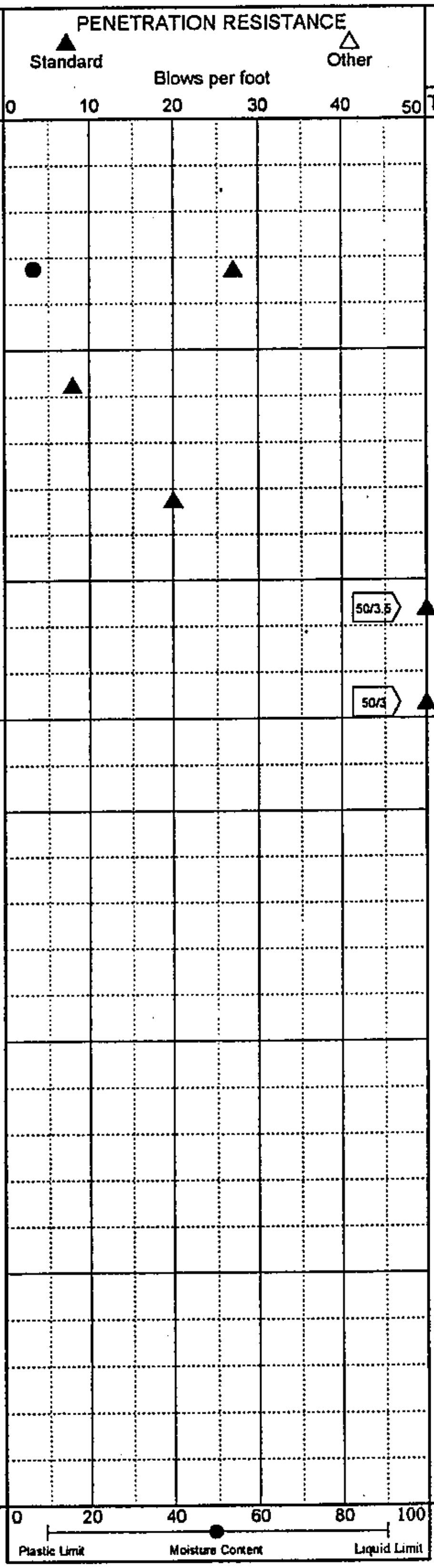
PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-2*

Page 1 of 1

Location: 50 feet south of Simmons Rd S.W.
Approximate ground surface elevation:

DEPTH (feet)	Soil Description	SAMPLE NUMBER	GROUND WATER
0	Asphalt pavement		N/E
	Loose, moist, tan, gravelly SAND with some silt (Fill)		
	loose to medium dense, moist, tan, gravelly, silty SAND	S-1	
5	Becomes loose, reddish brown-tan, silty fine SAND trace fine gravel, scattered fine roots (no recovery, from observed cuttings)	S	
	becomes medium dense	S-2	
	very dense, moist, green rock (Crescent Formation)		
10		S-3	
		S-4	
	Boring terminated at approximately 13 feet		
15			
20			
25			
30			





TESTING

LEGEND

2.00-inch OD split-Spoon sampler

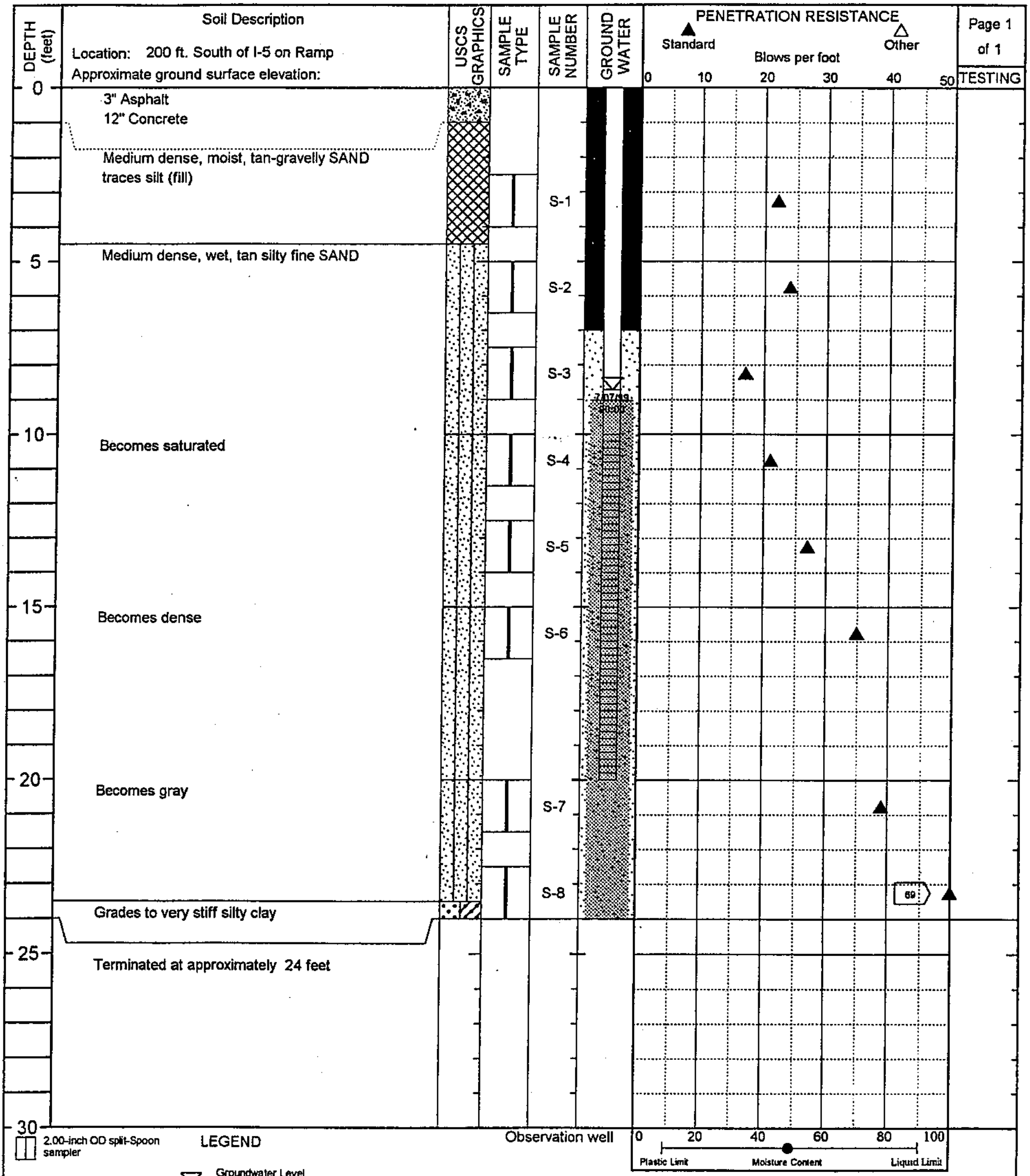
N/E No groundwater encountered

4IN1 11684B02.GPJ WA4IN1.GDT 3/10/00

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: HSA Hammer type: Cathead Date drilled: *07 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capital Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-3/MW-1*



Soil Description

Location: 200 ft. South of I-5 on Ramp

Approximate ground surface elevation:

3" Asphalt

12" Concrete

Medium dense, moist, tan-gravelly SAND traces silt (fill)

Medium dense, wet, tan silty fine SAND

Becomes saturated

Becomes dense

Becomes gray

Grades to very stiff silty clay

Terminated at approximately 24 feet

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *07 July 1999* Logged By: *SAT*

PROJECT: *LOTT Southern Connection* W.O. *9-91M-11864-B* BORING No. *B-4*

Soil Description

Location: Approximately Station 153+25
Approximate ground surface elevation:

DEPTH (feet)

0 — 3-4 inches Asphalt Pavement

Medium dense, moist, tan brown, gravelly, silty SAND

5 — Becomes very dense, gray, gravelly silty SAND

Very dense, moist, greenish-gray silty SAND with abundance of rock fragments (Crescent Formation)

Terminated at approximately 8 feet

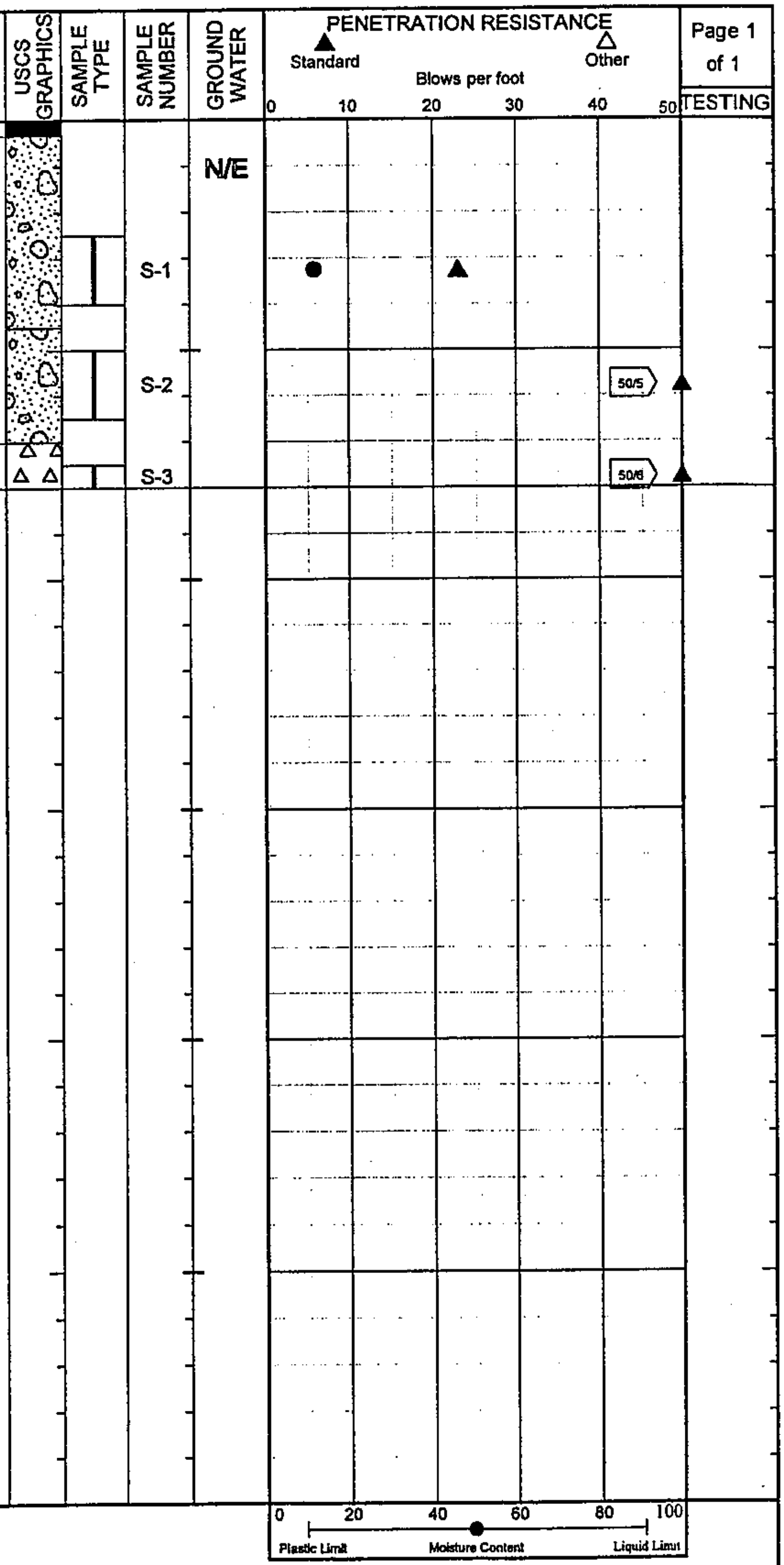
10 —

15 —

20 —

25 —

30 —



LEGEND

2.00-inch OD split-Spoon sampler

N/E No groundwater encountered

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

4IN1 11684B04.GPJ WA4IN1.GDT 9/12/99

Drilling Method: HSA Hammer type: Cathead Date drilled: *08 July 1999* Logged By: *SAT*

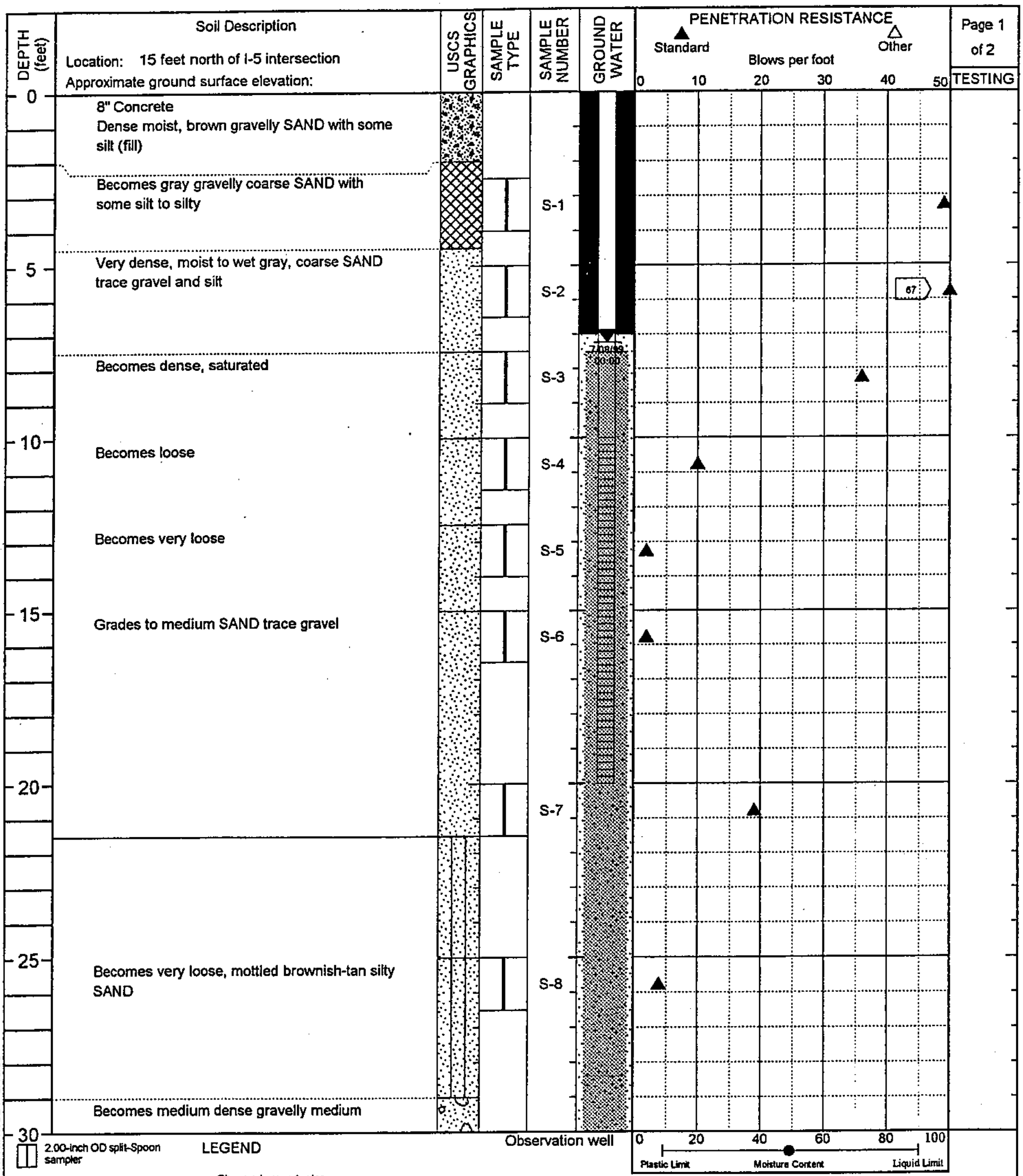
PROJECT: *LOTT Capital Lake Southern Connection* W.O. *9-91M-11864-B* BORING No. *B-5/MW-2*

Page 1 of 2

Soil Description

Location: 15 feet north of I-5 intersection

Approximate ground surface elevation:



8" Concrete

Dense moist, brown gravelly SAND with some silt (fill)

Becomes gray gravelly coarse SAND with some silt to silty

Very dense, moist to wet gray, coarse SAND trace gravel and silt

Becomes dense, saturated

Becomes loose

Becomes very loose

Grades to medium SAND trace gravel

Becomes very loose, mottled brownish-tan silty SAND

Becomes medium dense gravelly medium

LEGEND

2.00-inch OD split-Spoon sampler

Observed groundwater level

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *08 July 1999* Logged By: *SAT*

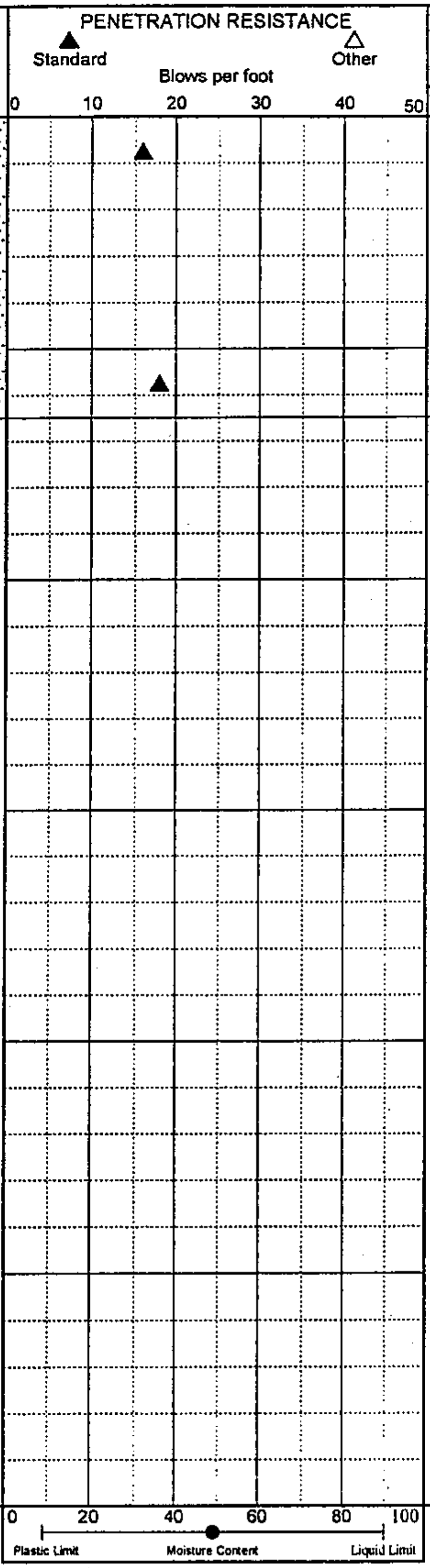
PROJECT: *LOTT Capital Lake Southern Connection* W.O. *9-91M-11864-B* BORING No. *B-5/MW-2*

Soil Description

Location: 15 feet north of I-5 intersection

Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE	Page 2 of 2 TESTING
30	SAND trace silt.			S-9			
35				S-10			
	Terminated at 36.5 feet						
40							
45							
50							
55							
60							



LEGEND

2.00-inch OD split-Spoon sampler

Observed groundwater level

Observation well

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

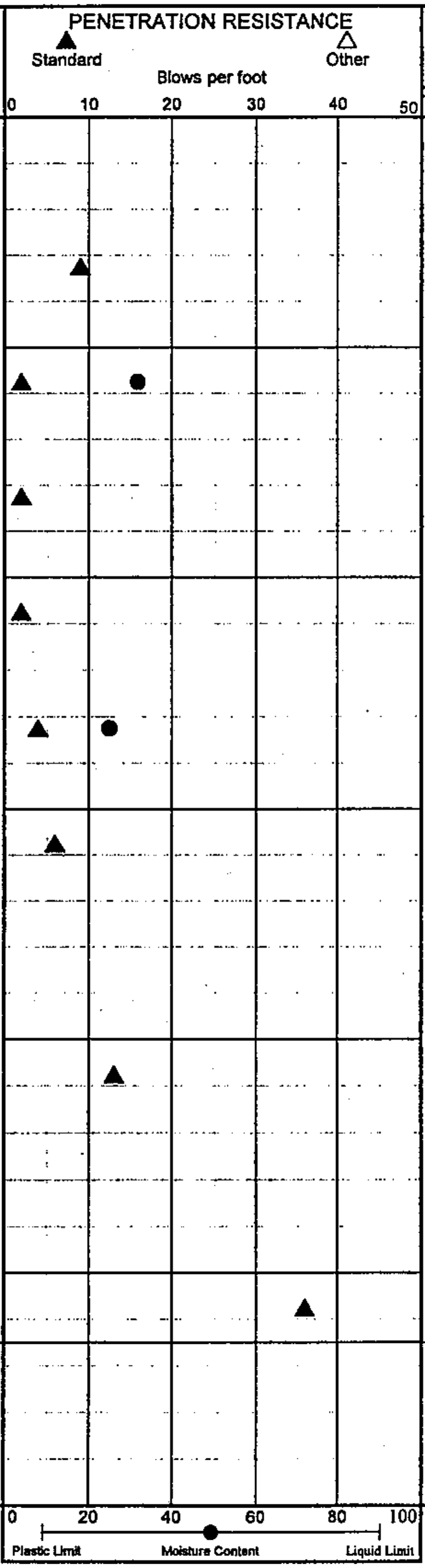
Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *08 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-6*

Page 1 of 1

Location: Station 125 + 65
Approximate ground surface elevation:

DEPTH (feet)	Soil Description	SAMPLE NUMBER	GROUND WATER	TESTING
0	8" Concrete			
	8-12" loose, moist, brown, gravelly, silty SAND (fill)			
	Loose, wet, gray, medium SAND trace silt and gravel	S-1		
5	Very loose, dark brown, silty fine SAND with some gravel	S-2		▦
			∇ 7/09/99 00:00	
	Becomes saturated trace gravel	S-3		
10	Becomes tan to mottled tan	S-4		
	Becomes fine SAND with some gravel	S-5		▦
15	Becomes loose	S-6		
	Medium dense, gray, saturated, coarse SAND some fine gravel, trace silt.			
20		S-7		
25	Becomes dense	S-8		
	Terminates at approximately 26.5 feet			
30				



LEGEND

2.00-inch OD split-Spoon sampler

▦ Grain Size Analysis

∇ Groundwater Level Fluctuation

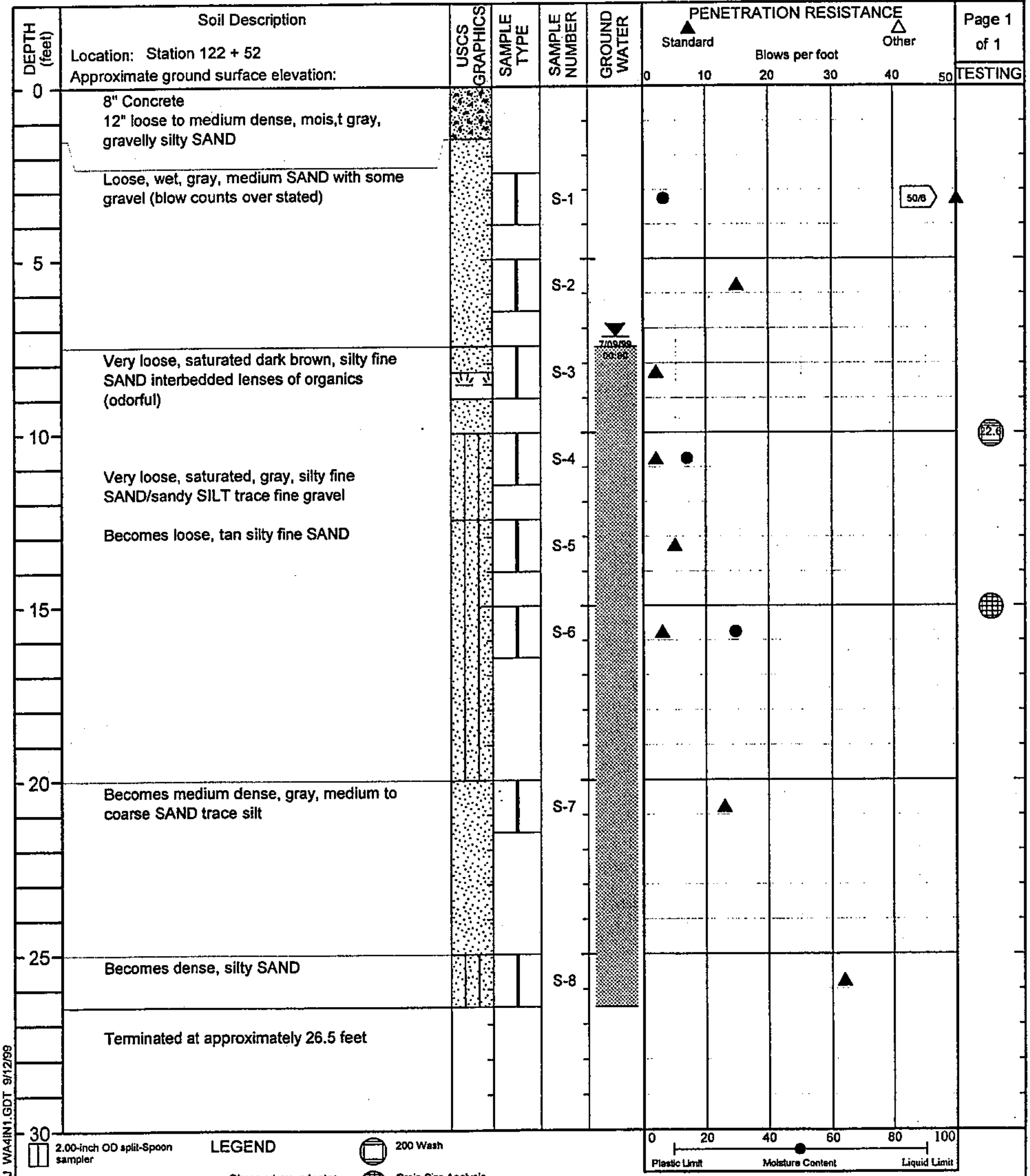
AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

4IN1 11684B06.GPJ WA4IN1.GDT 9/12/99

Drilling Method: HSA Hammer type: Cathead Date drilled: *09 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection*

W.O. *9-91M-11684-B* BORING No. *B-7*



Soil Description	SAMPLE NUMBER
Location: Station 122 + 52 Approximate ground surface elevation:	
8" Concrete 12" loose to medium dense, mois,t gray, gravelly silty SAND	
Loose, wet, gray, medium SAND with some gravel (blow counts over stated)	S-1 S-2
Very loose, saturated dark brown, silty fine SAND interbedded lenses of organics (odorful)	S-3
Very loose, saturated, gray, silty fine SAND/sandy SILT trace fine gravel	S-4
Becomes loose, tan silty fine SAND	S-5 S-6
Becomes medium dense, gray, medium to coarse SAND trace silt	S-7
Becomes dense, silty SAND	S-8
Terminated at approximately 26.5 feet	

LEGEND

□ 2.00-inch OD split-Spoon sampler

▼ Observed groundwater level

□ 200 Wash

⊕ Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

4IN1 11684B07.GPJ WA4IN1.GDT 9/12/99

Drilling Method: HSA

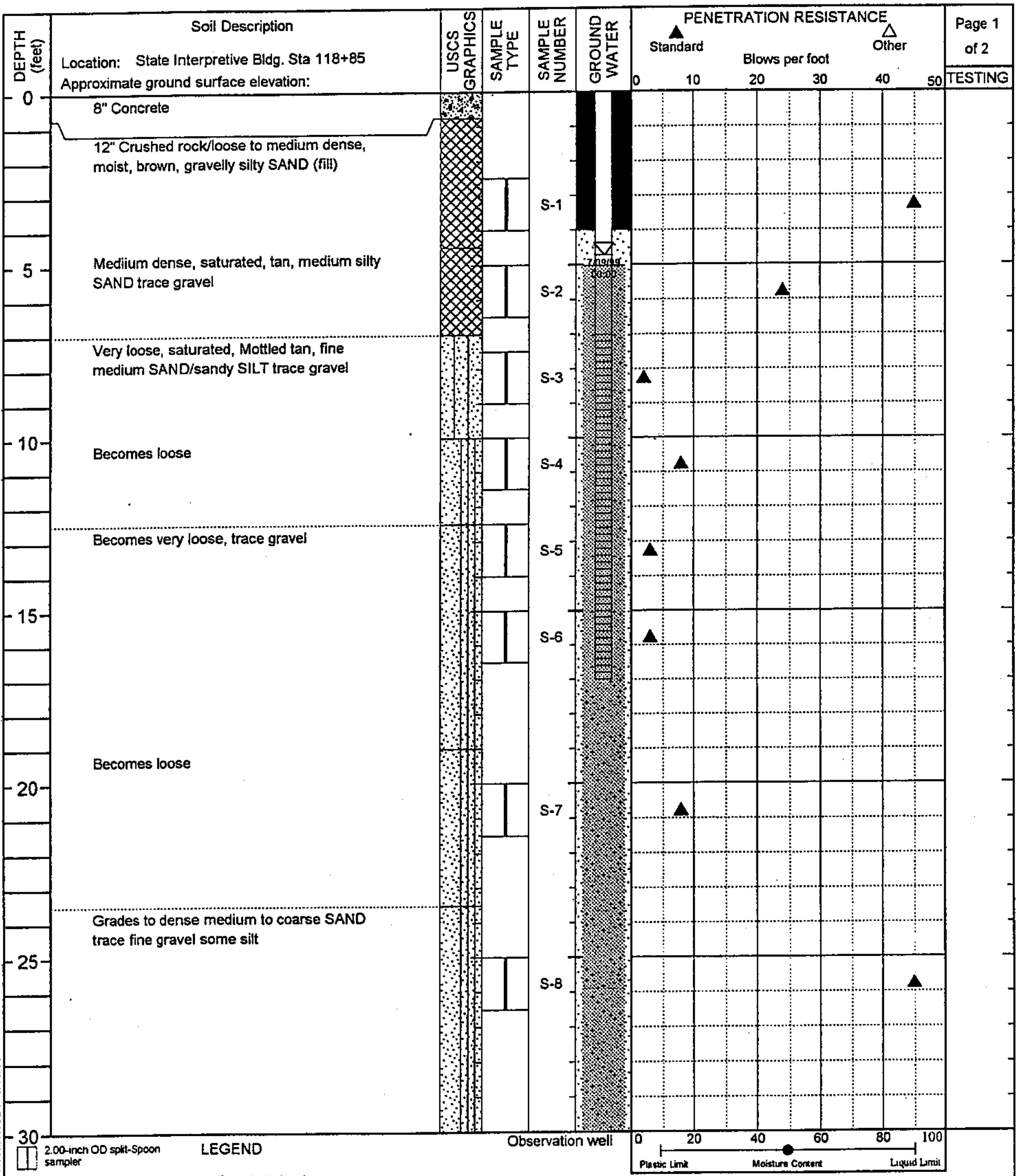
Hammer type: Cathead

Date drilled: *09 July 1999*

Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-8/MW-3*

Location: State Interpretive Bldg. Sta 118+85
Approximate ground surface elevation:



8" Concrete

12" Crushed rock/loose to medium dense, moist, brown, gravelly silty SAND (fill)

Mediium dense, saturated, tan, medium silty SAND trace gravel

Very loose, saturated, Mottled tan, fine medium SAND/sandy SILT trace gravel

Becomes loose

Becomes very loose, trace gravel

Becomes loose

Grades to dense medium to coarse SAND trace fine gravel some silt

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *09 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-8/MW-3*

DEPTH (feet)	Soil Description Location: State Interpretive Bldg. Sta 118+85 Approximate ground surface elevation:	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE ▲ Standard △ Other Blows per foot 0 10 20 30 40 50	Page 2 of 2 TESTING
30				S-9		54 ▲	
	Terminated at approximately 31.5 feet						
35							
40							
45							
50							
55							
60							

0 20 40 60 80 100

Plastic Limit — ● Moisture Content — Liquid Limit

2.00-inch OD split-Spoon sampler

LEGEND

Observation well

▽ Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

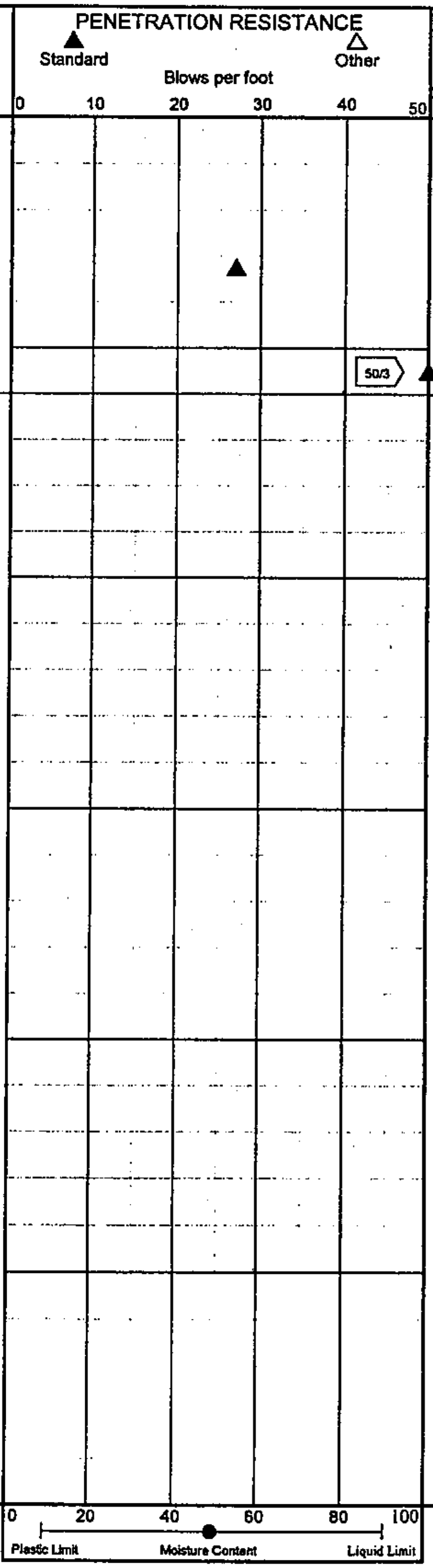
Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *09 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-9*

Page 1 of 1

Location: 255' west of bridge (middle of walkway)
Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
0	2" pavement over 2-4" loose, moist, gray, gravelly silty SAND over loose to medium dense, moist, tan, silty SAND with scattered fine roots (Topsoil)				N/E	
	Medium dense, moist, mottled gray with trace gravel			S-1		
5	Very dense, gray-greenish gray rock fragments, refusal on bedrock (Crescent Formation)			S-2		
	Terminated at approximately 6 feet					
10						
15						
20						
25						
30						



LEGEND

▯ 2.00-inch OD split-Spoon sampler

N/E No groundwater encountered

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

4IN1 11684B09.GPJ WA4IN1.GDT 9/12/99

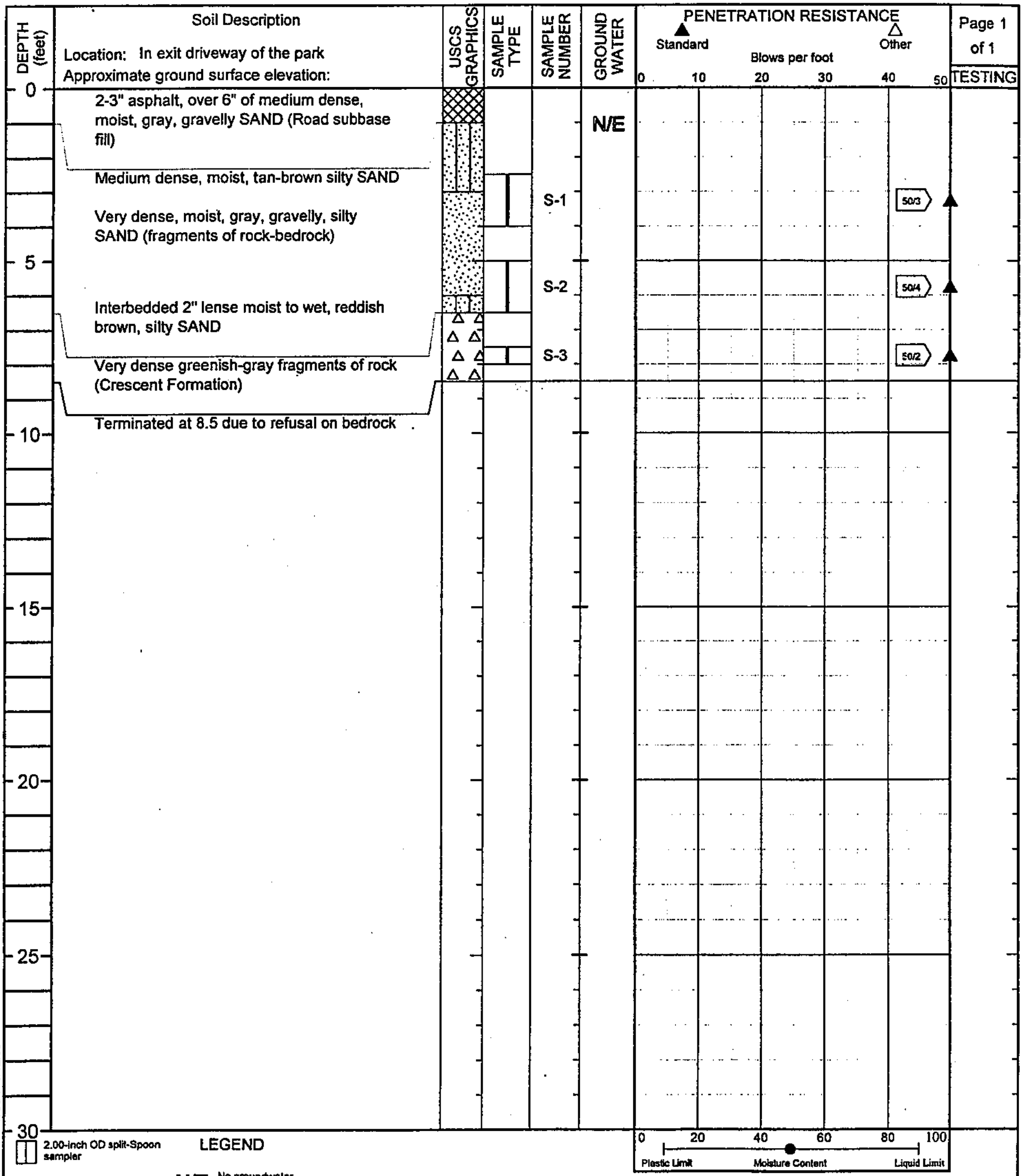
Drilling Method: HSA Hammer type: Cathead Date drilled: *12 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-10*

Location: In exit driveway of the park

Approximate ground surface elevation:

Page 1 of 1



2-3" asphalt, over 6" of medium dense, moist, gray, gravelly SAND (Road subbase fill)

Medium dense, moist, tan-brown silty SAND

Very dense, moist, gray, gravelly, silty SAND (fragments of rock-bedrock)

Interbedded 2" lense moist to wet, reddish brown, silty SAND

Very dense greenish-gray fragments of rock (Crescent Formation)

Terminated at 8.5 due to refusal on bedrock

Sample Number	Ground Water	Penetration Resistance
	N/E	
S-1		50/3
S-2		50/4
S-3		50/2

LEGEND

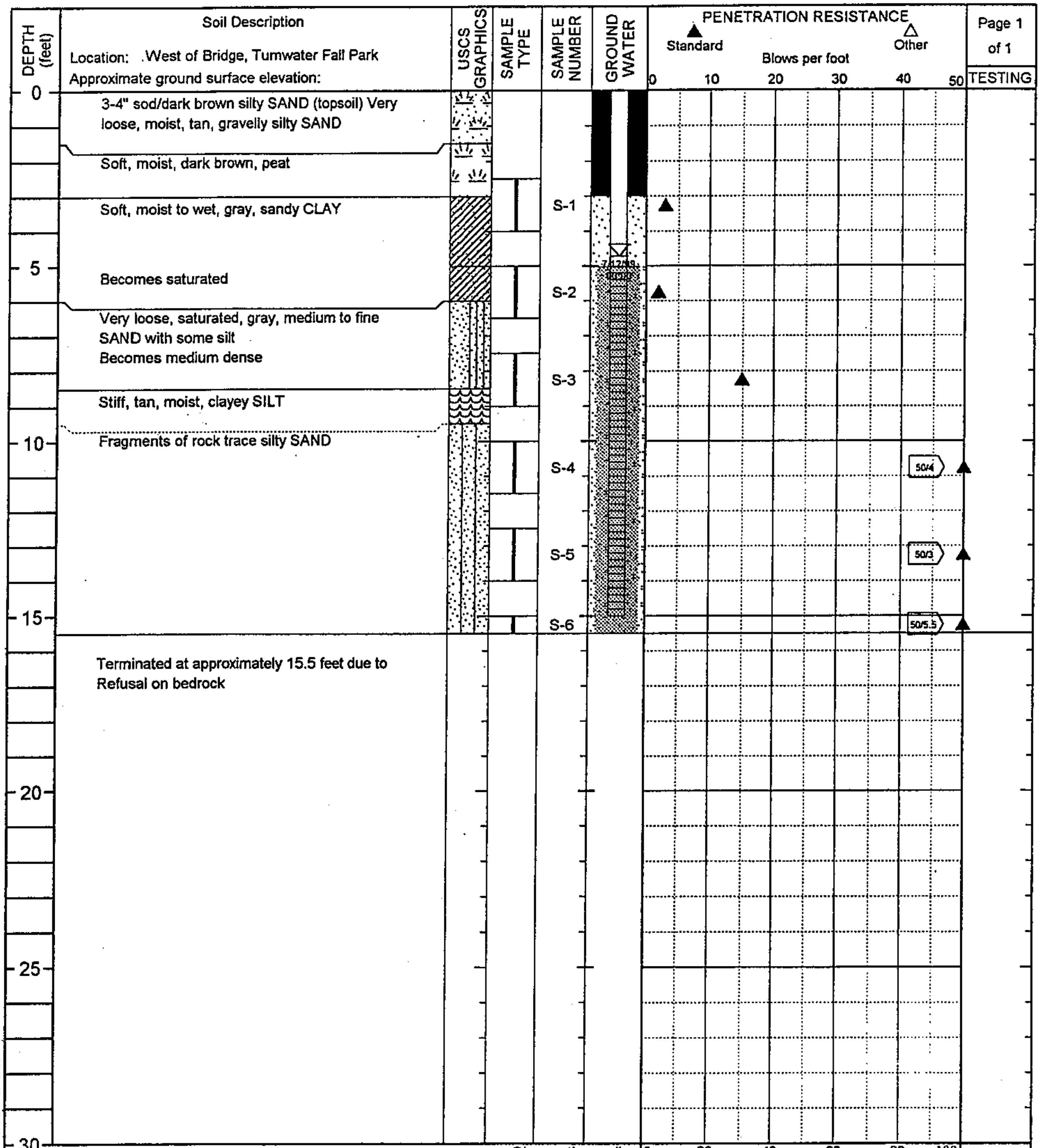
▯ 2.00-inch OD split-Spoon sampler

N/E No groundwater encountered

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *12 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-11/MW-4*



Location: .West of Bridge, Tumwater Fall Park
Approximate ground surface elevation:

3-4" sod/dark brown silty SAND (topsoil) Very loose, moist, tan, gravelly silty SAND

Soft, moist, dark brown, peat

Soft, moist to wet, gray, sandy CLAY

Becomes saturated

Very loose, saturated, gray, medium to fine SAND with some silt
Becomes medium dense

Stiff, tan, moist, clayey SILT

Fragments of rock trace silty SAND

Terminated at approximately 15.5 feet due to Refusal on bedrock

2.00-inch OD split-Spoon sampler

LEGEND

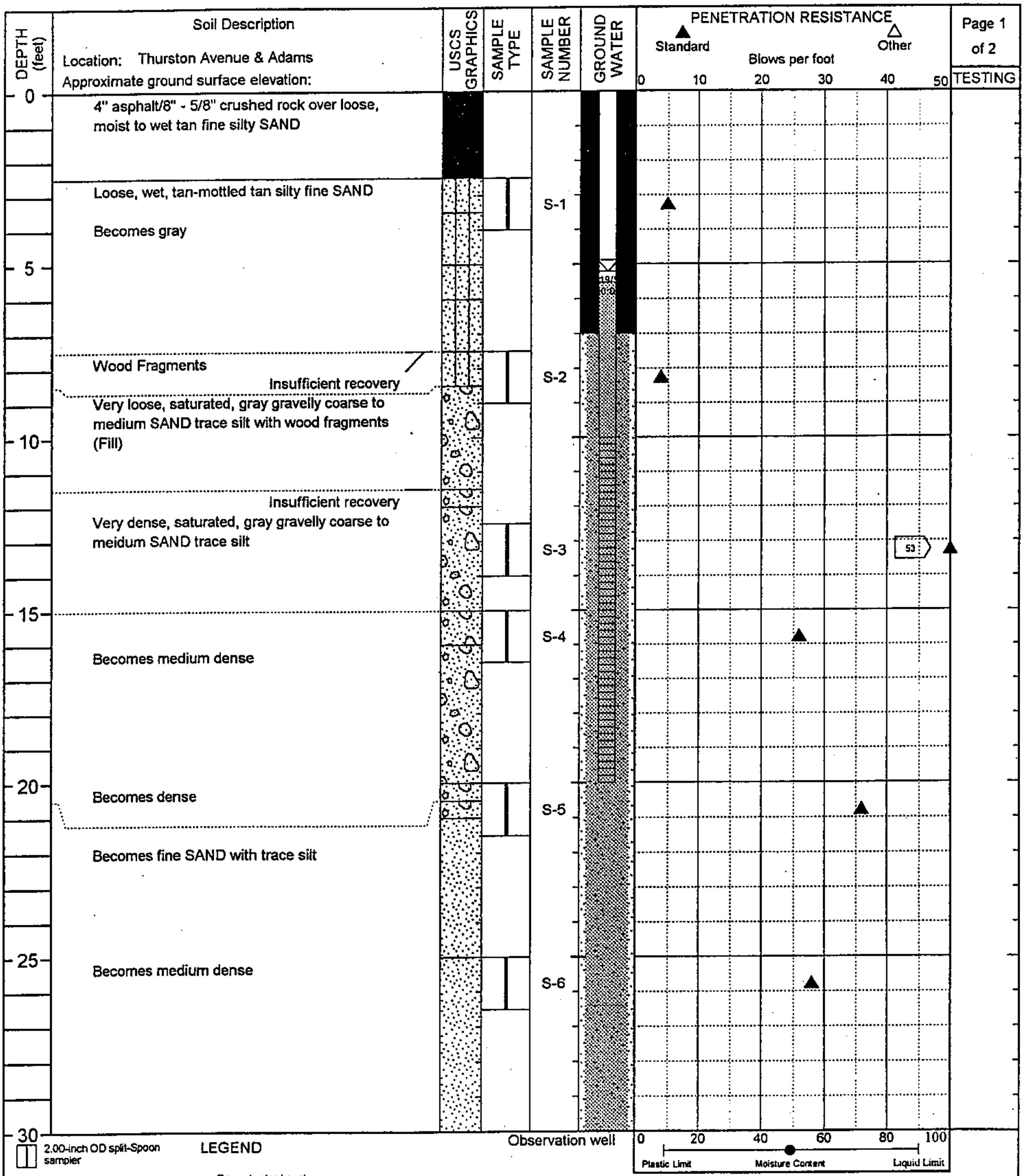
Observation well

▽ Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *12 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-12/MW-5*



Soil Description

Location: Thurston Avenue & Adams

Approximate ground surface elevation:

4" asphalt/8" - 5/8" crushed rock over loose, moist to wet tan fine silty SAND

Loose, wet, tan-mottled tan silty fine SAND

Becomes gray

Wood Fragments

Insufficient recovery

Very loose, saturated, gray gravelly coarse to medium SAND trace silt with wood fragments (Fill)

Insufficient recovery

Very dense, saturated, gray gravelly coarse to meidum SAND trace silt

Becomes medium dense

Becomes dense

Becomes fine SAND with trace silt

Becomes medium dense

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

4IN1 11684B12.GPJ WA4IN1.GDT 3/10/00

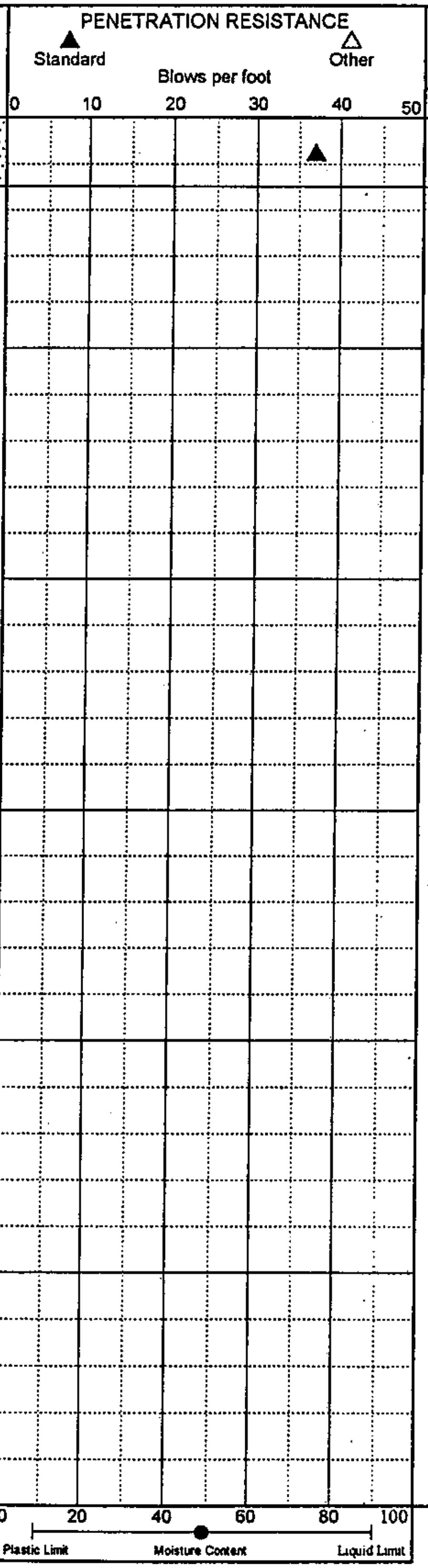
AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *19 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-12/MW-5*

DEPTH (feet)	Soil Description Location: Thurston Avenue & Adams Approximate ground surface elevation:	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	Becomes dense	▨	▯	S-7	▨	
	Terminated at approximately 31.5 feet					
35						
40						
45						
50						
55						
60						

Page 2 of 2



[ ] 2.00-inch OD split-Spoon sampler

LEGEND

▽ Groundwater Level Fluctuation

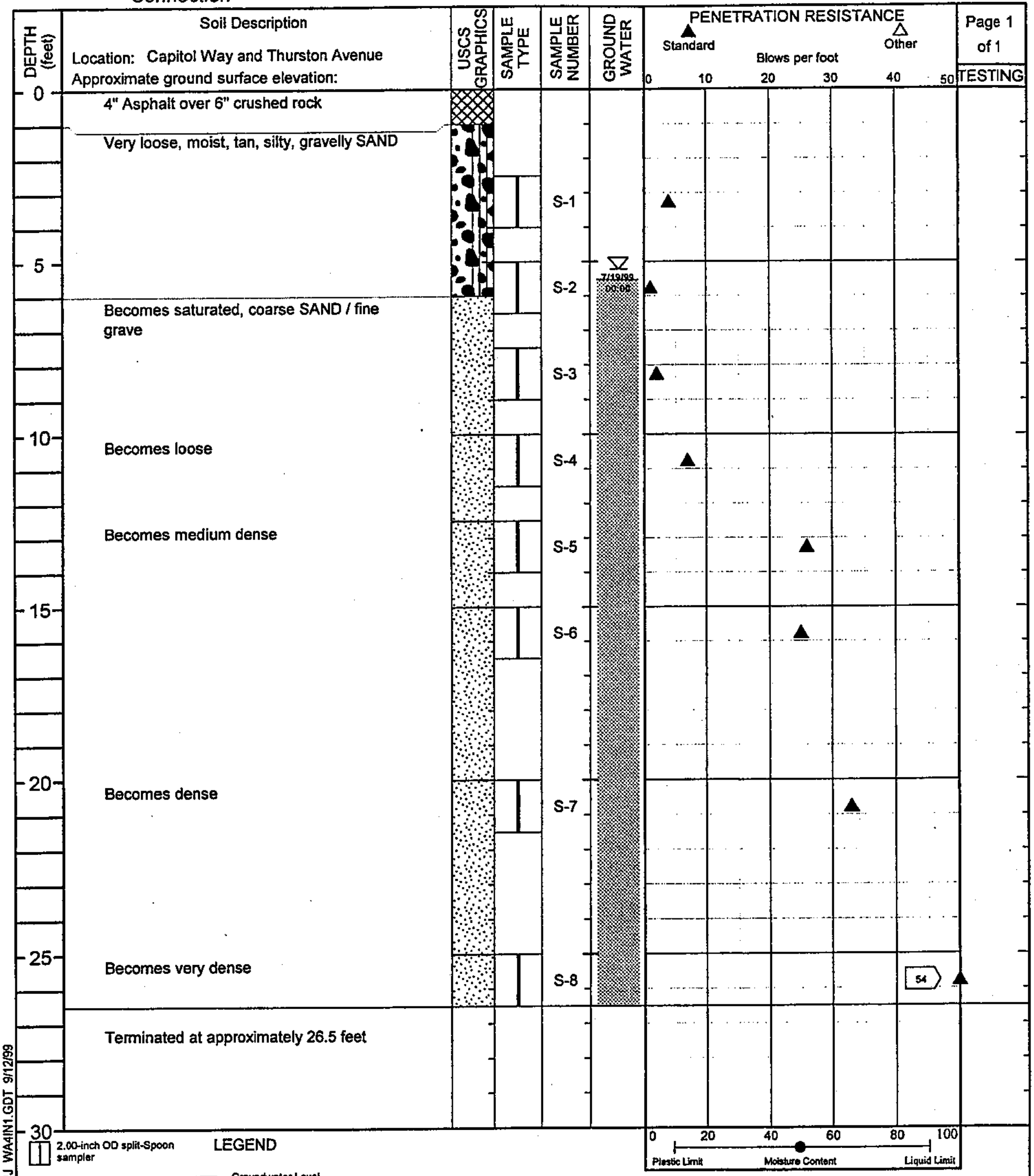
Observation well

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *19 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-13*

Location: Capitol Way and Thurston Avenue
Approximate ground surface elevation:



4" Asphalt over 6" crushed rock

Very loose, moist, tan, silty, gravelly SAND

Becomes saturated, coarse SAND / fine grave

Becomes loose

Becomes medium dense

Becomes dense

Becomes very dense

Terminated at approximately 26.5 feet

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *19 July 1999* Logged By: *SAT*

4IN1 11684B13.GPJ WA4IN1.GDT 9/12/99

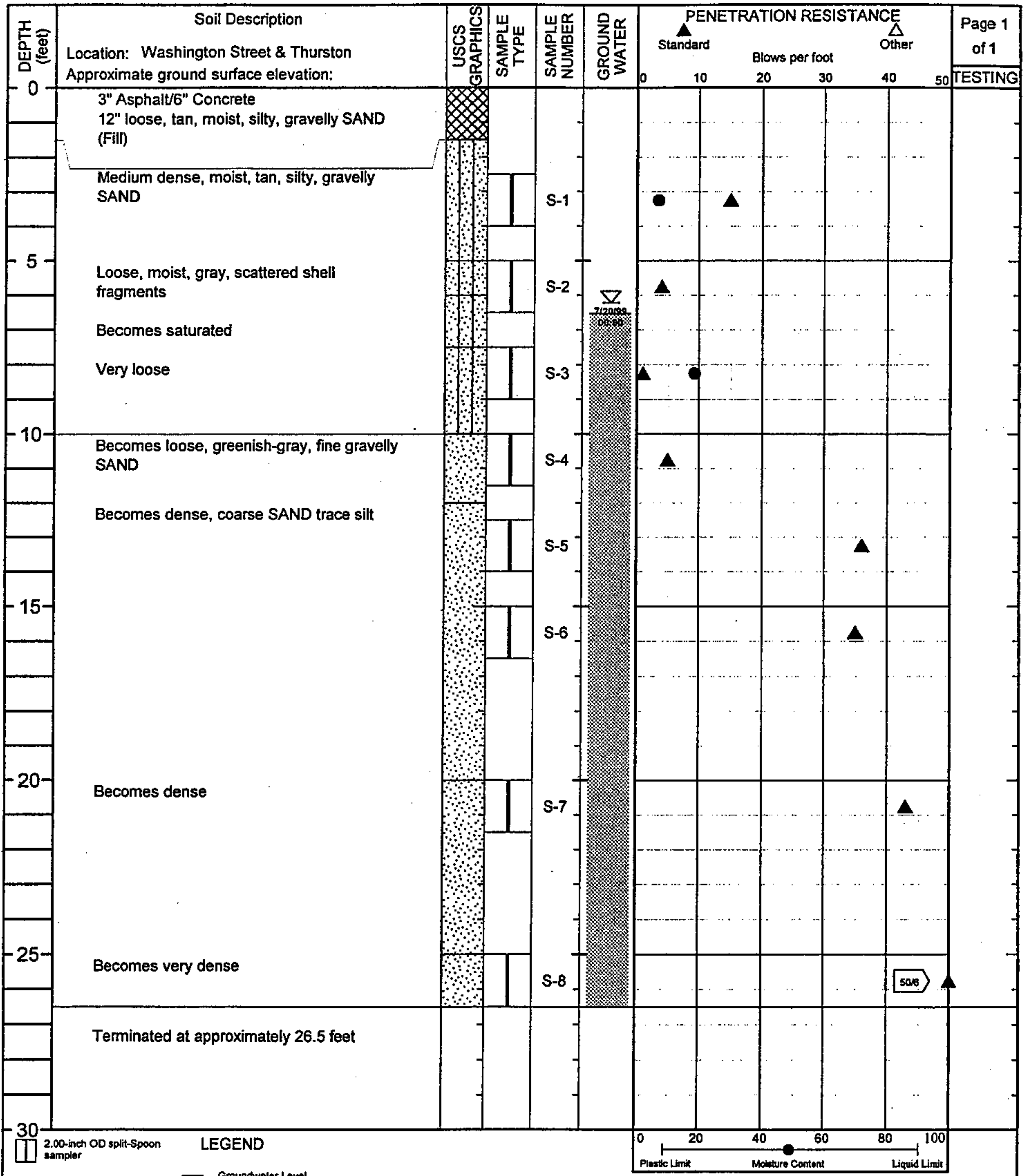
PROJECT: *LOTT Capitol Lake Southern Connection*
W.O. *9-91M-11684-B* BORING No. *B-14*

Page 1 of 1

Soil Description

Location: Washington Street & Thurston

Approximate ground surface elevation:



Soil Description	Sample Number
3" Asphalt/6" Concrete 12" loose, tan, moist, silty, gravelly SAND (Fill)	
Medium dense, moist, tan, silty, gravelly SAND	S-1
Loose, moist, gray, scattered shell fragments	S-2
Becomes saturated	
Very loose	S-3
Becomes loose, greenish-gray, fine gravelly SAND	S-4
Becomes dense, coarse SAND trace silt	S-5
	S-6
Becomes dense	S-7
Becomes very dense	S-8
Terminated at approximately 26.5 feet	

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

4IN1 11684B14.GPJ WA4IN1.GDT 9/12/99

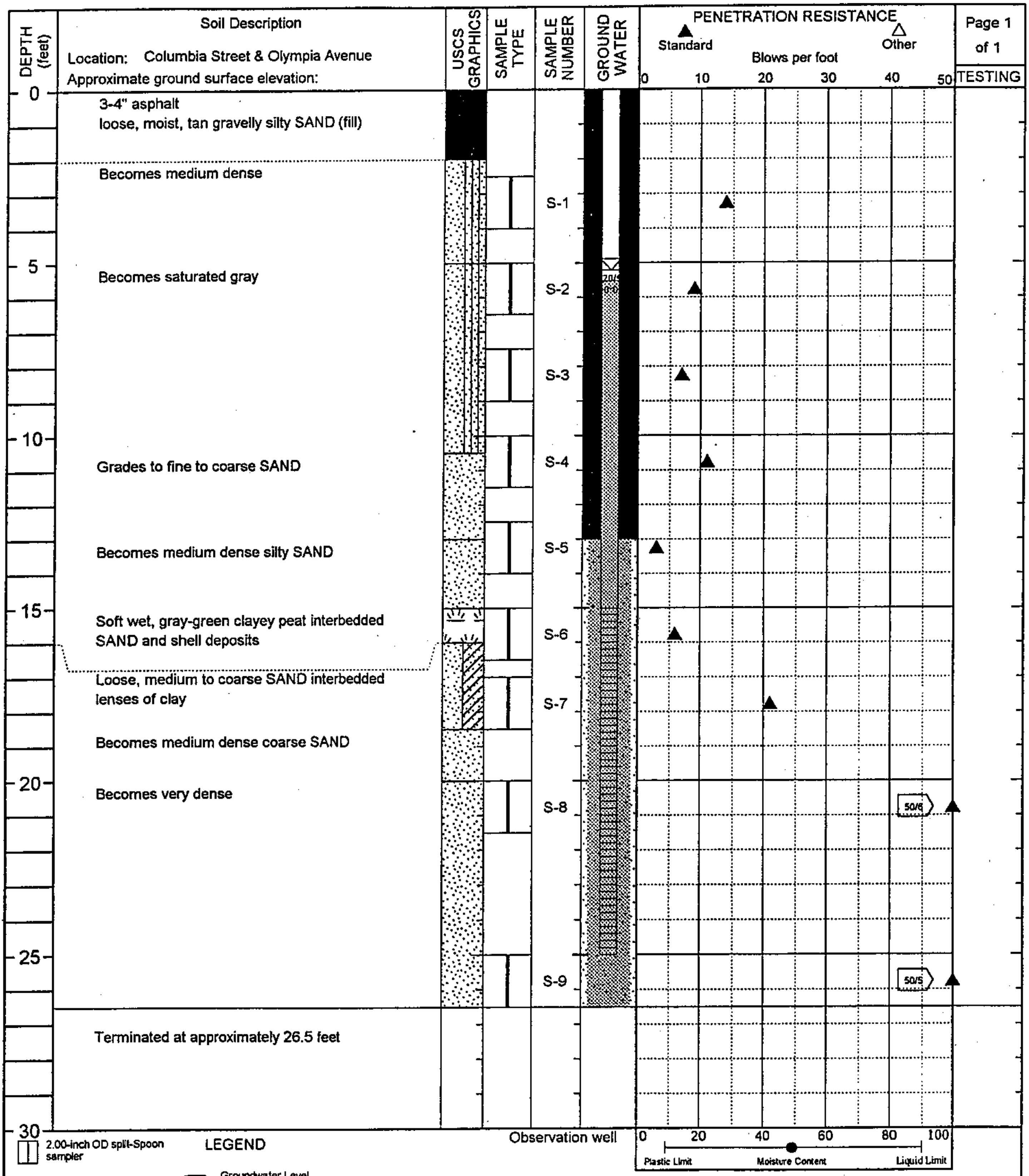
Drilling Method: HSA
Hammer type: Cathead
Date drilled: *20 July 1999*
Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-15/MW-6*

Soil Description

Location: Columbia Street & Olympia Avenue

Approximate ground surface elevation:



3-4" asphalt

loose, moist, tan gravelly silty SAND (fill)

Becomes medium dense

Becomes saturated gray

Grades to fine to coarse SAND

Becomes medium dense silty SAND

Soft wet, gray-green clayey peat interbedded SAND and shell deposits

Loose, medium to coarse SAND interbedded lenses of clay

Becomes medium dense coarse SAND

Becomes very dense

Terminated at approximately 26.5 feet

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

4IN1 11684B15.GPJ WA4IN1.GDT 3/10/00

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

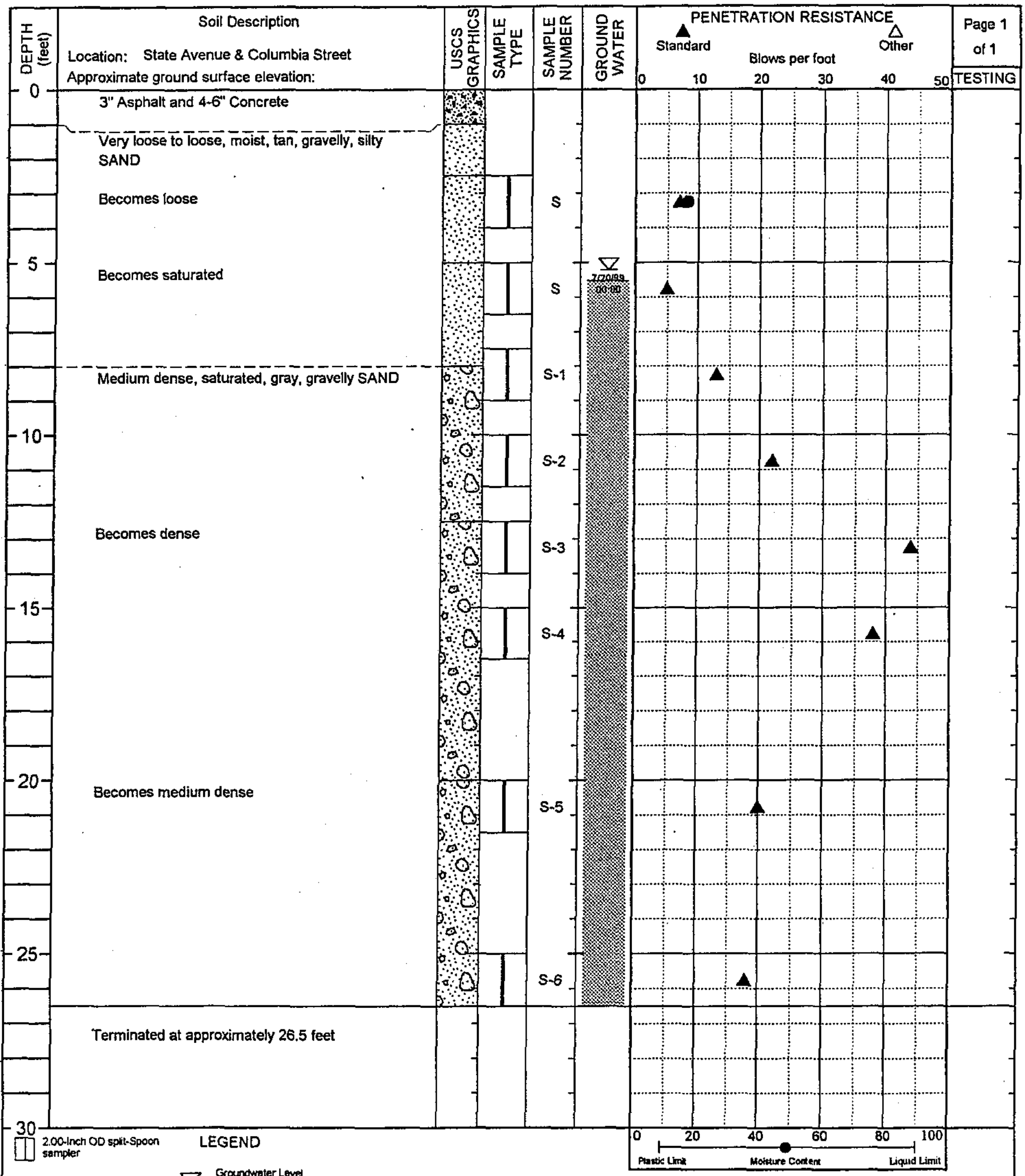
Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *20 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-16*

Page 1 of 1

Location: State Avenue & Columbia Street

Approximate ground surface elevation:



Soil Description	SAMPLE NUMBER
3" Asphalt and 4-6" Concrete	
Very loose to loose, moist, tan, gravelly, silty SAND	
Becomes loose	S
Becomes saturated	S
Medium dense, saturated, gray, gravelly SAND	S-1
	S-2
Becomes dense	S-3
	S-4
Becomes medium dense	S-5
	S-6
Terminated at approximately 26.5 feet	

LEGEND

2.00-Inch OD split-Spoon sampler

Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

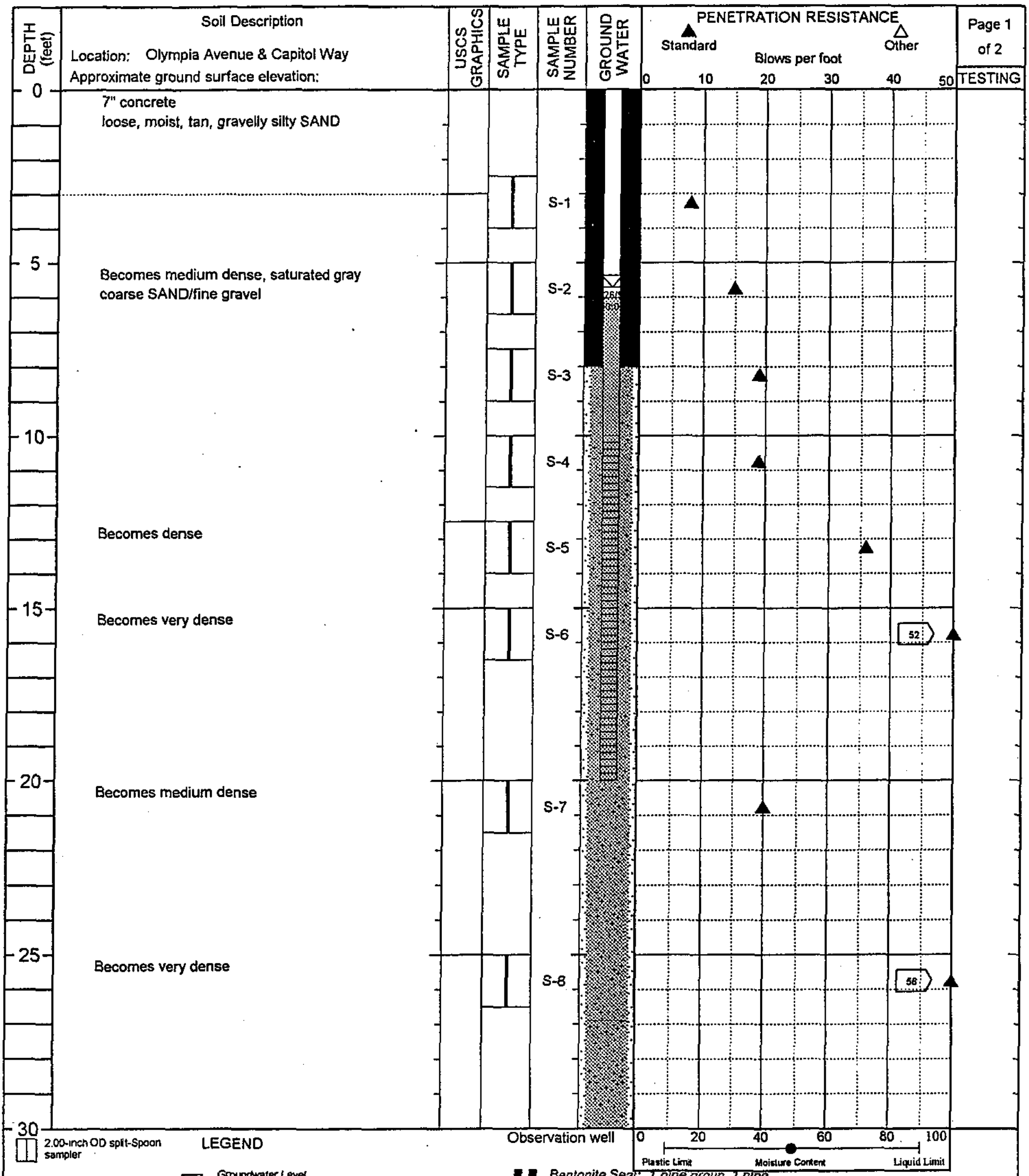
Drilling Method: HSA Hammer type: Cathead Date drilled: *20 July 1999* Logged By: *SAT*

4IN1 11684B16.GPJ WA4IN1.GDT 3/10/00

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-17/MW-7*

Page 1 of 2

Location: Olympia Avenue & Capitol Way
Approximate ground surface elevation:



0 – 7" concrete
loose, moist, tan, gravelly silty SAND

5 – Becomes medium dense, saturated gray coarse SAND/fine gravel

Becomes dense

15 – Becomes very dense

20 – Becomes medium dense

25 – Becomes very dense

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

Filter Pack: Bottom of hole

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

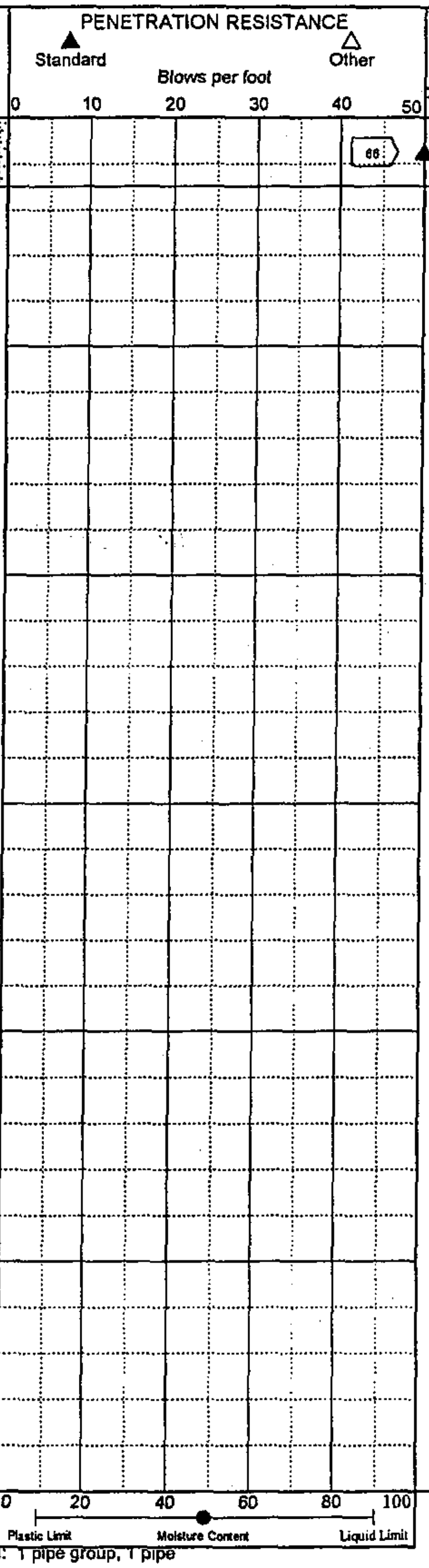
Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *26 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-17/MW-7*

Location: Olympia Avenue & Capitol Way

Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE ▲ Standard △ Other Blows per foot 0 10 20 30 40 50	Page 2 of 2 TESTING
30			▮	S-9	▨	66 ▲	
	Terminated at approximately 31.5 feet						
35							
40							
45							
50							
55							
60							



LEGEND

▯ 2.00-inch OD split-Spoon sampler

▽ Groundwater Level Fluctuation

Observation well

▮▮ Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

Filter Pack: Bottom of hole

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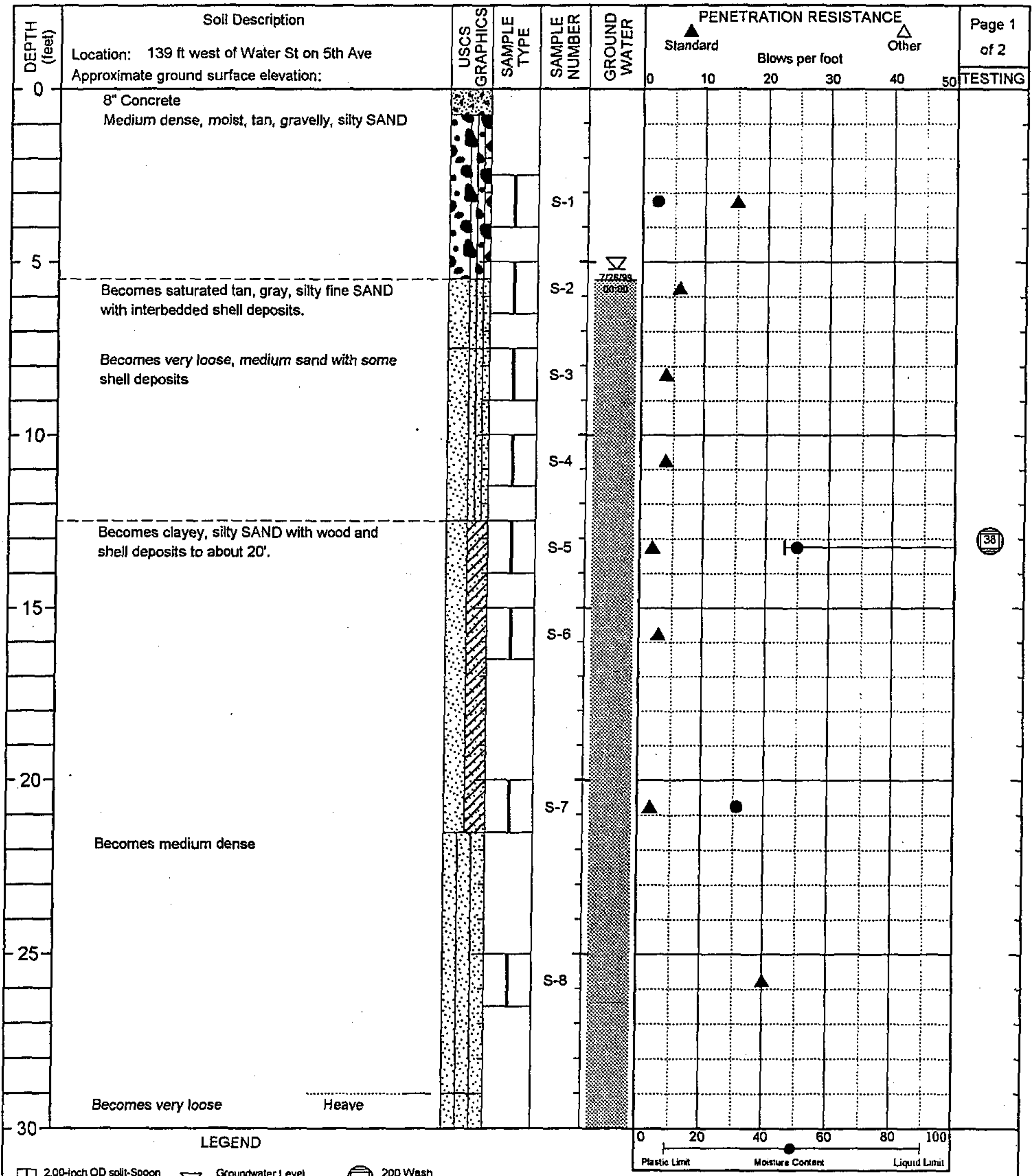
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *26 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-18*



Soil Description

Location: 139 ft west of Water St on 5th Ave

Approximate ground surface elevation:

8" Concrete

Medium dense, moist, tan, gravelly, silty SAND

Becomes saturated tan, gray, silty fine SAND with interbedded shell deposits.

Becomes very loose, medium sand with some shell deposits

Becomes clayey, silty SAND with wood and shell deposits to about 20'.

Becomes medium dense

Becomes very loose Heave

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level *Fluctuation*

200 Wash

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: HSA Hammer type: Cathead Date drilled: *26 July 1999* Logged By: *SAT*

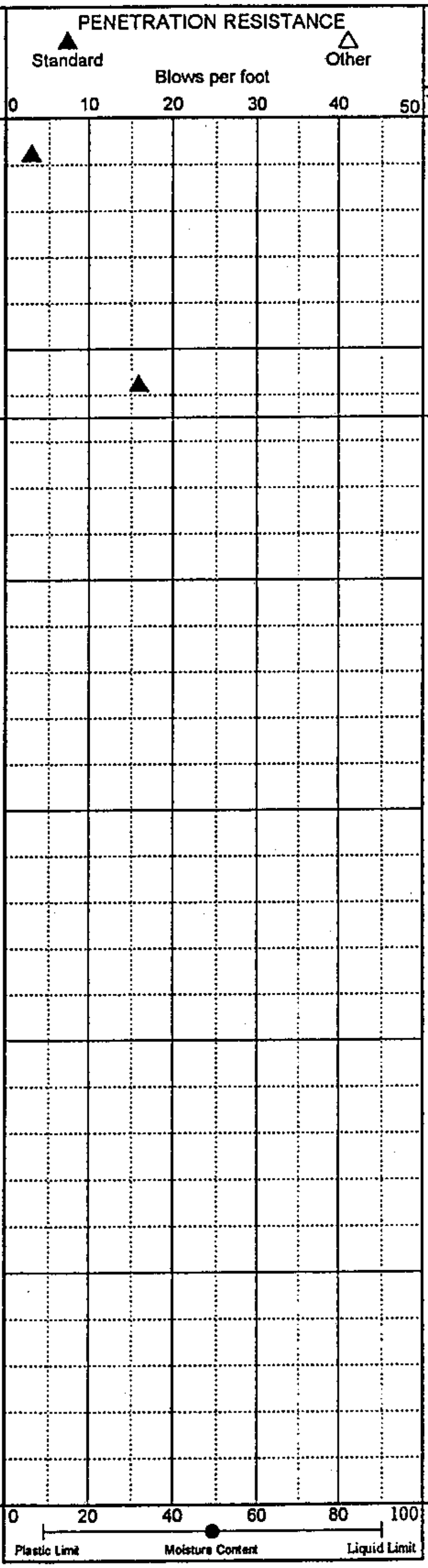
PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-18*

Page 2 of 2

Location: 139 ft west of Water St on 5th Ave

Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30				S-9		
35	Becomes medium dense			S-10		
	Terminated at approximately 36.5 feet					
40						
45						
50						
55						
60						



LEGEND

2.00-inch OD split-Spoon sampler

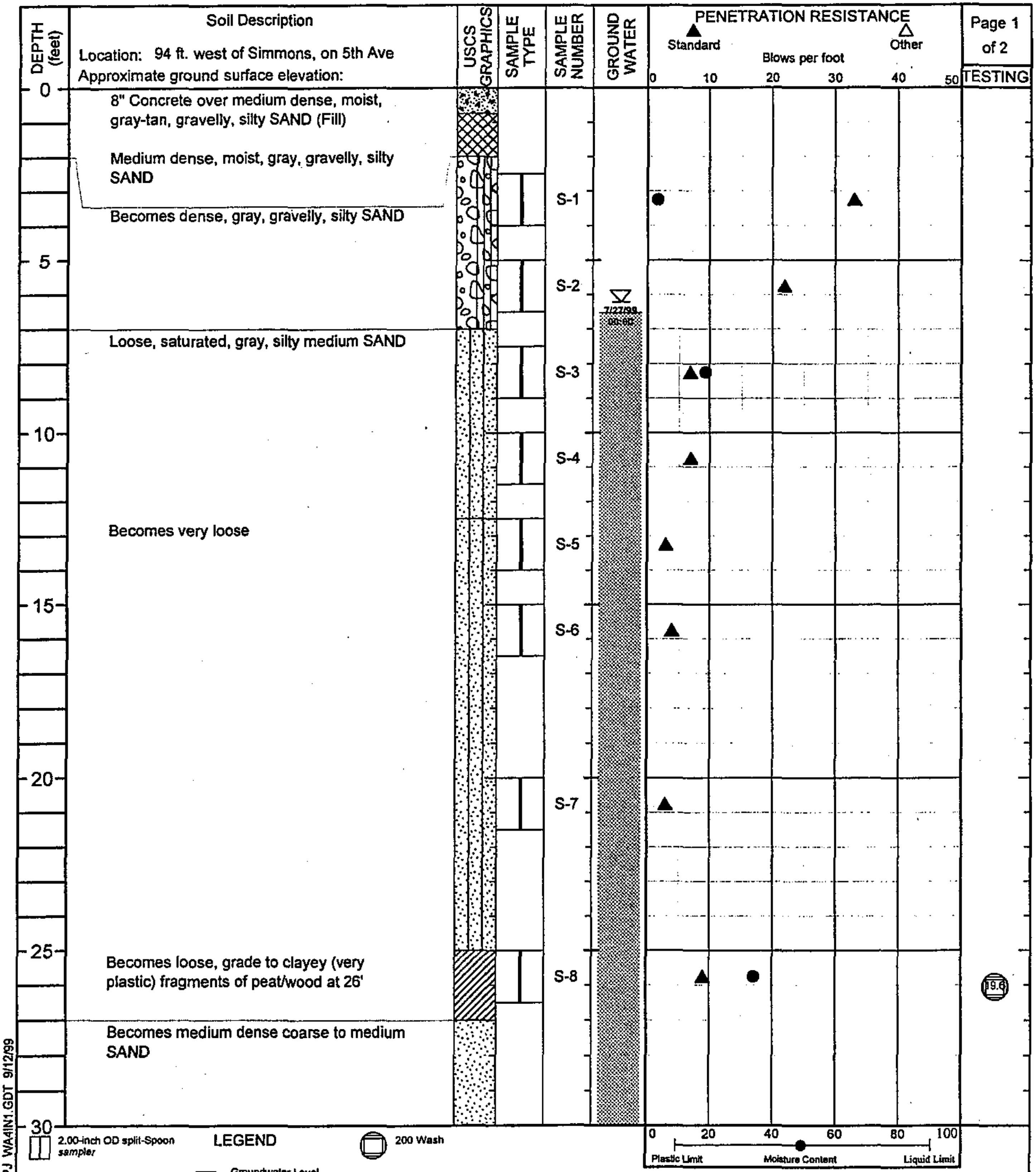
Groundwater Level Fluctuation

200 Wash

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: HSA Hammer type: Cathead Date drilled: *26 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-19*



Soil Description

Location: 94 ft. west of Simmons, on 5th Ave

Approximate ground surface elevation:

8" Concrete over medium dense, moist, gray-tan, gravelly, silty SAND (Fill)

Medium dense, moist, gray, gravelly, silty SAND

Becomes dense, gray, gravelly, silty SAND

Loose, saturated, gray, silty medium SAND

Becomes very loose

Becomes loose, grade to clayey (very plastic) fragments of peat/wood at 26'

Becomes medium dense coarse to medium SAND

LEGEND

2.00-inch OD split-Spoon sampler

200 Wash

Groundwater Level Fluctuation

4IN1 11684B19.GPJ WA4IN1.GDT 9/12/99

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *26 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-19*

DEPTH (feet)	Soil Description Location: 94 ft. west of Simmons, on 5th Ave Approximate ground surface elevation:	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE ▲ Standard △ Other Blows per foot 0 10 20 30 40 50	Page 2 of 2 TESTING
30		▨	│	S-9	▨	▲	
	Terminated at approximately 31.5 feet						
35							
40							
45							
50							
55							
60							

LEGEND

☐ 2.00-inch OD split-Spoon sampler

200 Wash

▽ *Groundwater Level Fluctuation*

0 20 40 60 80 100

Plastic Limit Moisture Content Liquid Limit

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *26 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-20/MW-8*

Page 1 of 2

DEPTH (feet)

Soil Description

Location: 245' S.W. of 5th Ave Bridge

Approximate ground surface elevation:

0

12" Concrete

Dense, moist tan-gray gravelly silty SAND (fill), trace cobbles

5

Becomes wet medium dense, bluish gray

Becomes loose, saturated clayey/silty gravelly SAND

10

Becomes very loose

15

Becomes medium to coarse SAND with fine gravel

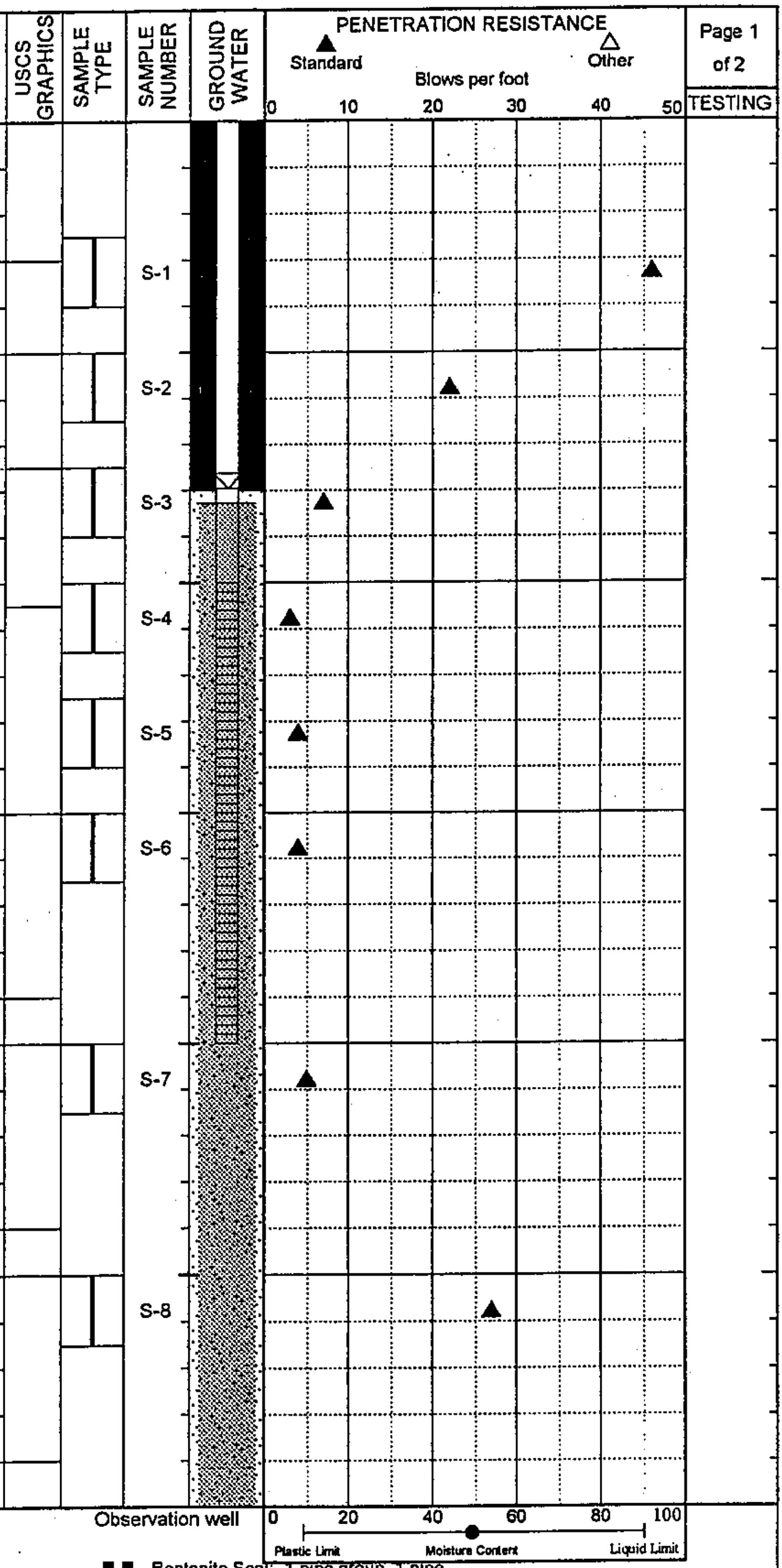
20

Becomes medium dense

25

Becomes silty fine SAND

30



▯ 2.00-inch OD split-Spoon sampler

LEGEND

▽ Groundwater Level Fluctuation

▌▌ Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1[illegible]

Slotted Pipe: 1 pipe group

Filter Pack: Bottom of hole

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *27 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-20/MW-8*

Location: 245' S.W. of 5th Ave Bridge
Approximate ground surface elevation:

Page 2 of 2

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE ▲ Standard △ Other Blows per foot (0–50)	TESTING
30	Becomes silty fine SAND		▯	S-9	▨	▲ 20	
	Terminated at approximately 31.5 feet						
35							
40							
45							
50							
55							
60							

LEGEND

▯ 2.00-inch OD split-Spoon sampler

▽ *Groundwater Level Fluctuation*

Observation well

0 20 40 60 80 100
Plastic Limit — Moisture Content — Liquid Limit

▮▮ *Bentonite Seal: 1 pipe group, 1 pipe*

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

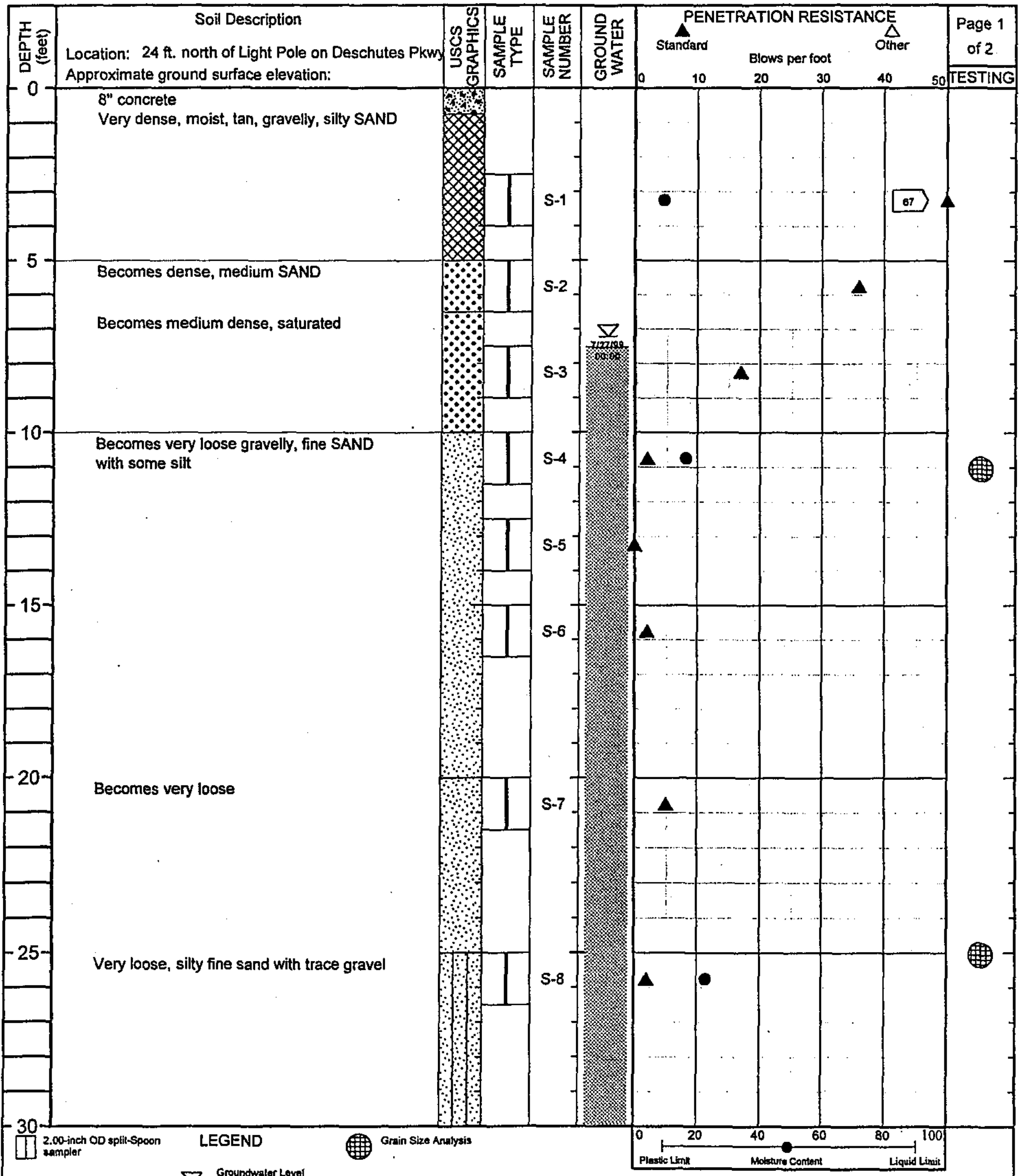
Filter Pack: Bottom of hole

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *27 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-21*

Location: 24 ft. north of Light Pole on Deschutes Pkwy
Approximate ground surface elevation:



Depth (feet)	Soil Description	Sample Number
0	8" concrete Very dense, moist, tan, gravelly, silty SAND	S-1
5	Becomes dense, medium SAND	S-2
	Becomes medium dense, saturated	S-3
10	Becomes very loose gravelly, fine SAND with some silt	S-4
		S-5
15		S-6
20	Becomes very loose	S-7
25	Very loose, silty fine sand with trace gravel	S-8

LEGEND

▯ 2.00-inch OD split-Spoon sampler

▽ Groundwater Level Fluctuation

⊕ Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

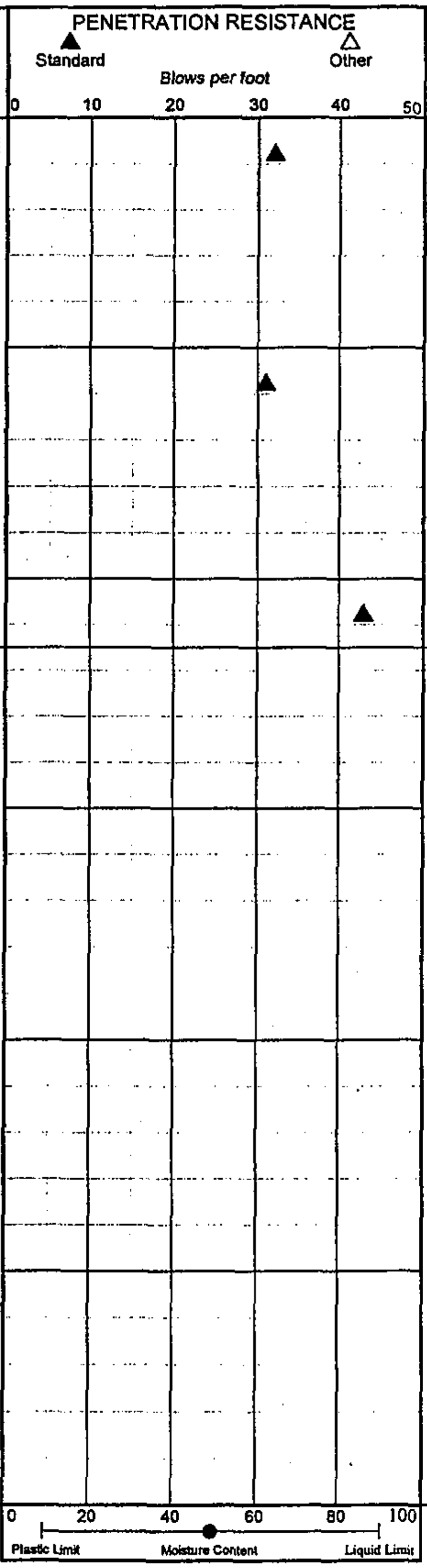
Drilling Method: HSA Hammer type: Cathead Date drilled: *27 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-21*

Page 2 of 2

Location: 24 ft. north of Light Pole on Deschutes Pkwy
Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	Dense medium sand					
				S-9		
35						
				S-10		
40						
				S-11		
	Terminated at approximately 41.5 feet					
45						
50						
55						
60						



LEGEND

2.00-inch OD split-Spoon sampler

Grain Size Analysis

Groundwater Level Fluctuation

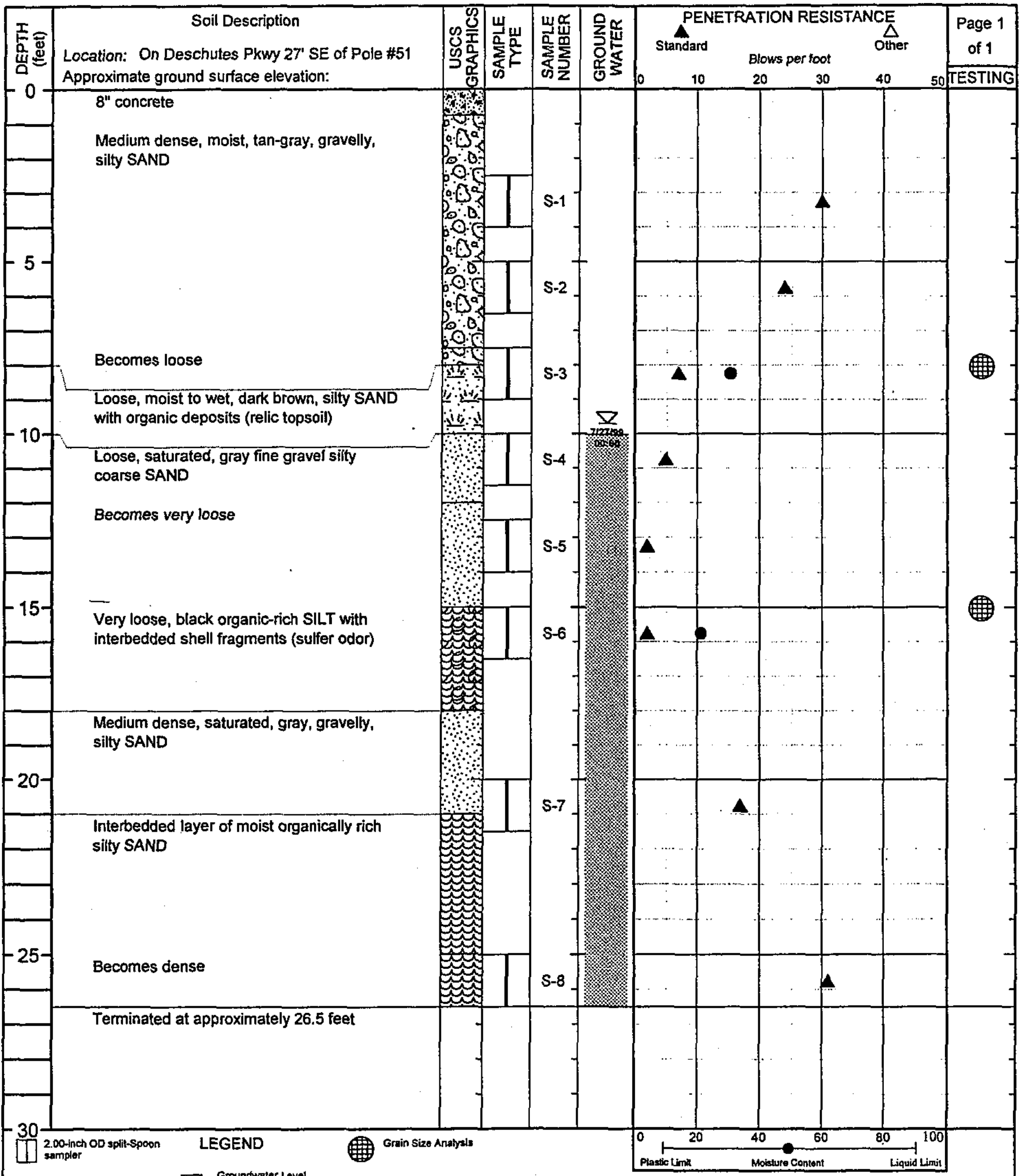
AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *27 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-22*

Location: On Deschutes Pkwy 27' SE of Pole #51

Approximate ground surface elevation:



8" concrete

Medium dense, moist, tan-gray, gravelly, silty SAND

Becomes loose

Loose, moist to wet, dark brown, silty SAND with organic deposits (relic topsoil)

Loose, saturated, gray fine gravel silty coarse SAND

Becomes very loose

Very loose, black organic-rich SILT with interbedded shell fragments (sulfer odor)

Medium dense, saturated, gray, gravelly, silty SAND

Interbedded layer of moist organically rich silty SAND

Becomes dense

Terminated at approximately 26.5 feet

LEGEND

▯ 2.00-inch OD split-Spoon sampler

⊞ Grain Size Analysis

▽ Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

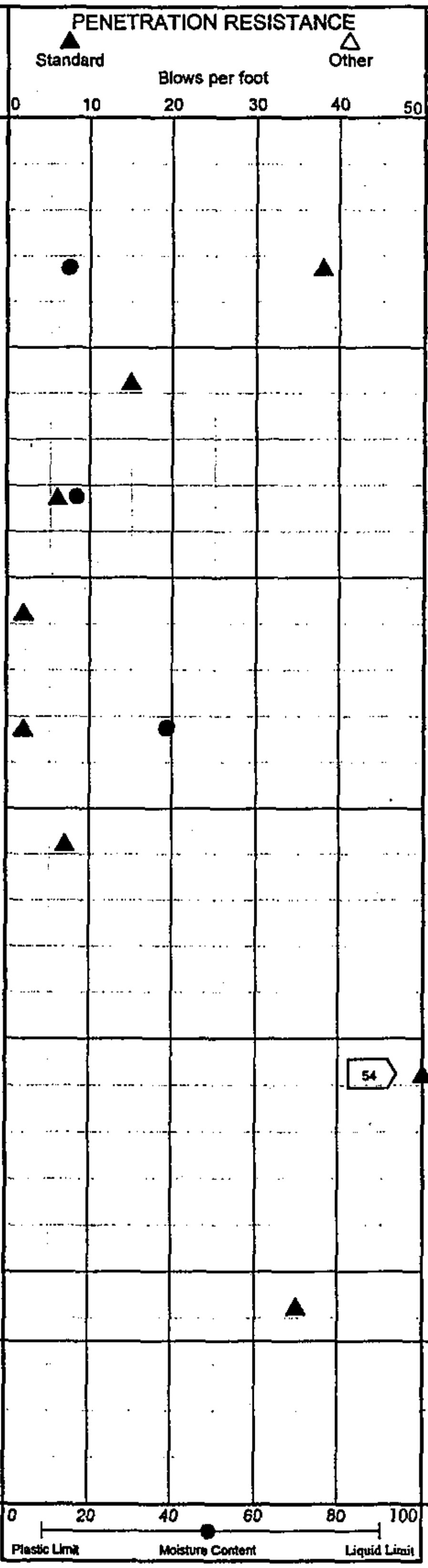
Drilling Method: HSA Hammer type: Cathead Date drilled: *27 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-23*

Location: 34 ft south of pole #46
Approximate ground surface elevation:

Page 1 of 1

DEPTH (feet)	Soil Description	SAMPLE NUMBER	GROUND WATER	TESTING
0	8" concrete dense, moist, tan, gravelly, silty SAND			
2.5	dense, moist, gray, silty SAND with scattered gravel	S-1		
5	Becomes medium dense wet to saturated	S-2	▽ 7/28/99 00:00	
7	becomes loose, medium to fine SAND	S-3		⊕
10	Becomes very loose	S-4		
12.5	Very loose, saturated, dark brown, silty fine SAND with shell deposits some gravel	S-5		⊕
15	Becomes loose, gray mottled tan	S-6		
20	Very dense, tan, medium SAND trace silt	S-7		
25		S-8		
26.5	Terminated at approximately 26.5 feet			



LEGEND

▯ 2.00-inch OD split-Spoon sampler

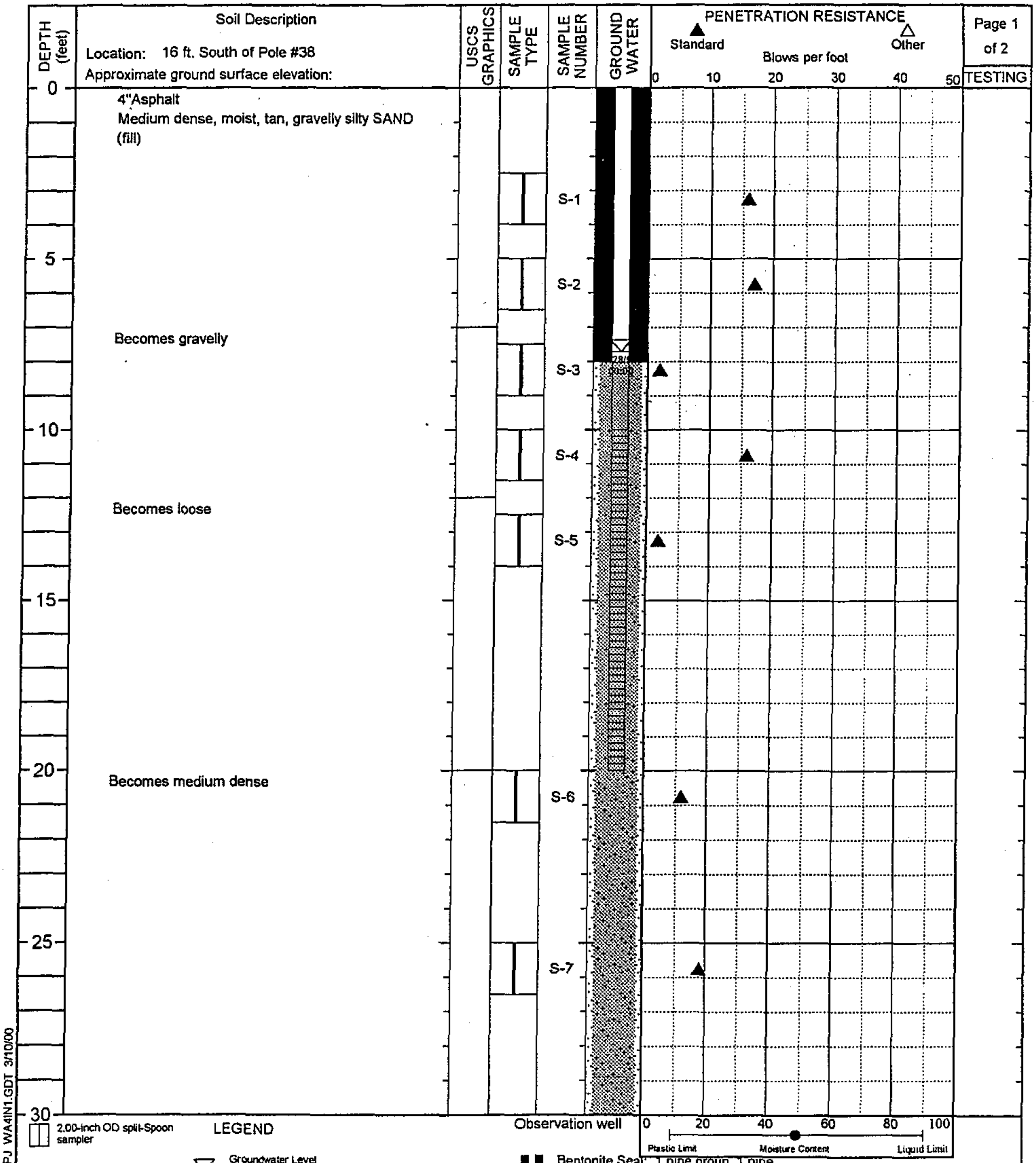
▽ Groundwater Level Fluctuation

⊕ Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *28 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-24/MW-9*



Location: 16 ft. South of Pole #38

Approximate ground surface elevation:

4"Asphalt

Medium dense, moist, tan, gravelly silty SAND (fill)

Becomes gravelly

Becomes loose

Becomes medium dense

LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

Filter Pack: Bottom of hole

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger *Hammer type:* CatHead *Date drilled:* *28 July 1999* *Logged By:* *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-24/MW-9*

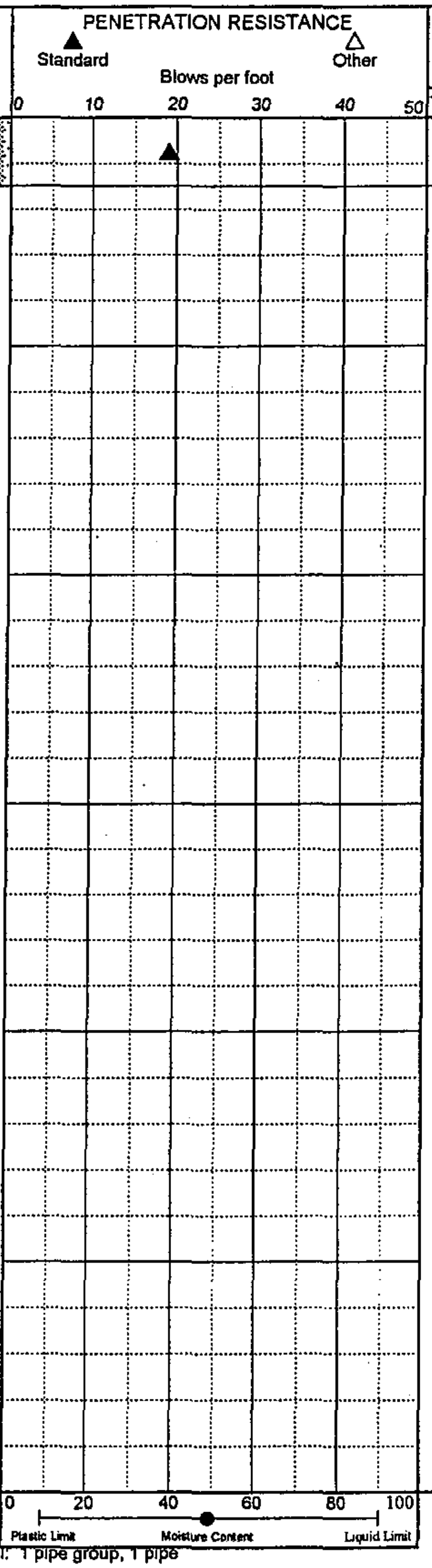
Page 2 of 2

Soil Description

Location: 16 ft. South of Pole #38

Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30			▮	S-8	▨	
	Terminated at approximately 31.5 feet					
35						
40						
45						
50						
55						
60						



LEGEND

▯ 2.00-inch OD split-Spoon sampler

▽ Groundwater Level Fluctuation

Observation well

▮▮ Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

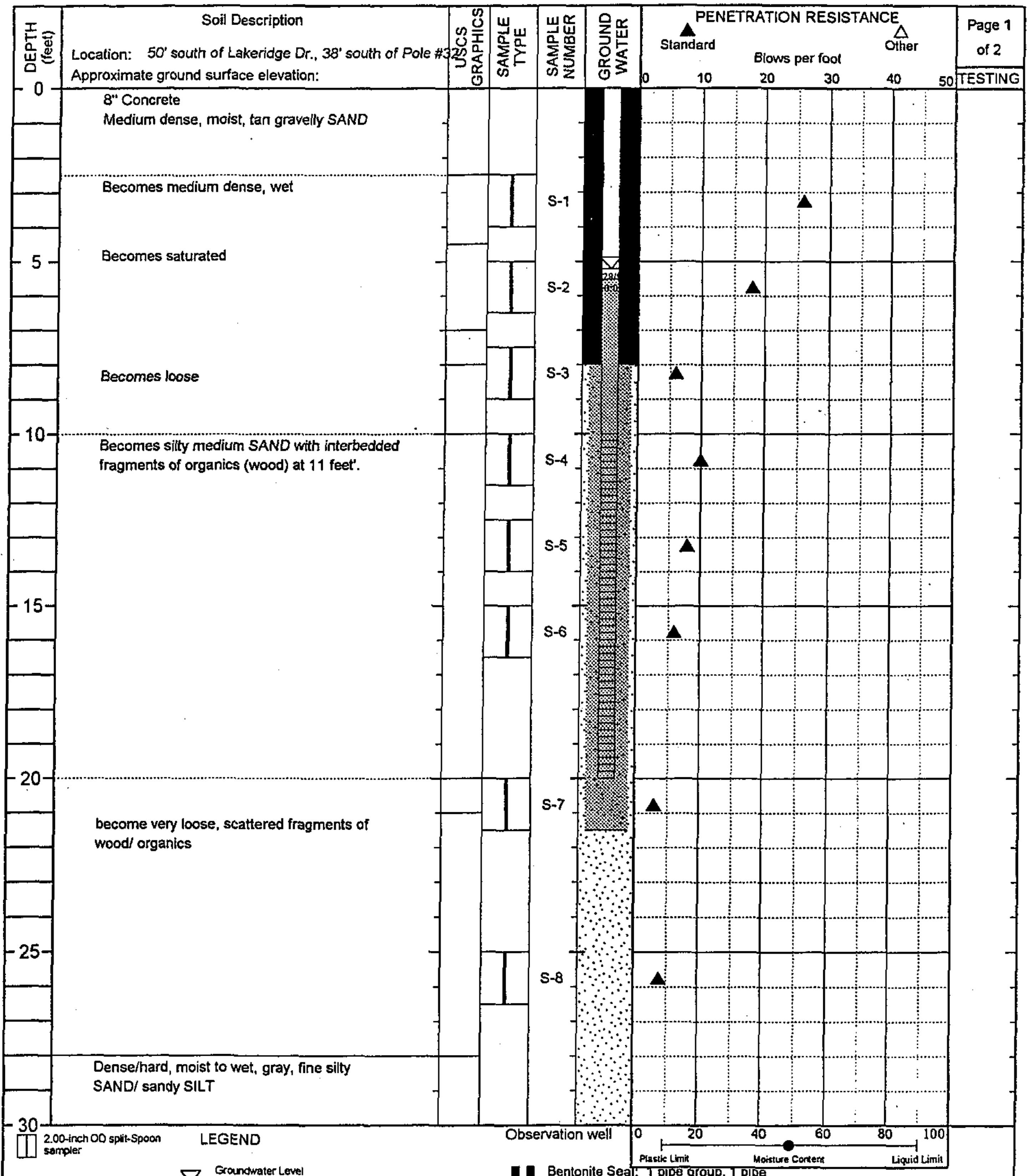
Filter Pack: Bottom of hole

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

4IN1 11684B24.GPJ WA4IN1.GDT 3/10/00

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *28 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-25/MW-10*



Location: *50' south of Lakeridge Dr., 38' south of Pole #32*

Approximate ground surface elevation:

8" Concrete
Medium dense, moist, tan gravelly *SAND*

Becomes medium dense, wet

Becomes saturated

Becomes loose

Becomes silty medium *SAND* with interbedded fragments of organics (wood) at 11 feet'.

become very loose, scattered fragments of wood/ organics

Dense/hard, moist to wet, gray, fine silty SAND/ sandy SILT

LEGEND

2.00-inch OD split-Spoon sampler

▽ Groundwater Level Fluctuation

Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

Filter Pack: Bottom of hole

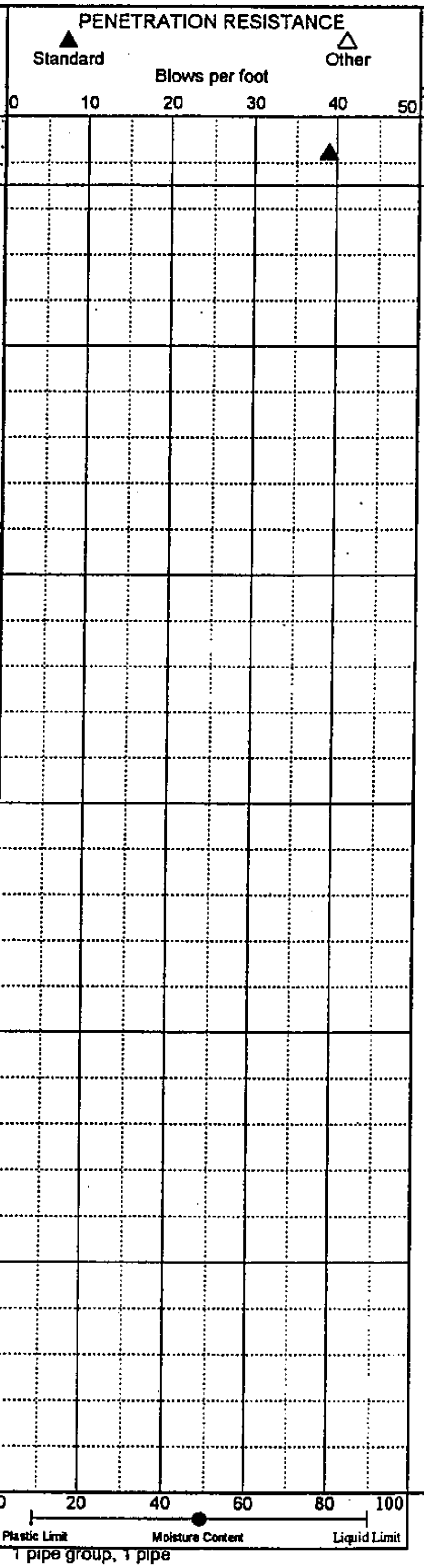
AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *28 July 1999* Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-25/MW-10*

DEPTH (feet)	Soil Description Location: 50' south of Lakeridge Dr., 38' south of Pole #32 Approximate ground surface elevation:	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30				S-9		
	Boring terminated at 21.5 feet					
35						
40						
45						
50						
55						
60						

Page 2 of 2



LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

Observation well

Bentonite Seal: 1 pipe group, 1 pipe

Filter Pack: 1 pipe group, 1 pipe

Slotted Pipe: 1 pipe group, 1 pipe

Filter Pack: Bottom of hole

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Hollow Stem Auger Hammer type: CatHead Date drilled: *28 July 1999* Logged By: *SAT*

4IN1 11684B25.GPJ WA4IN1.GDT 3/10/00

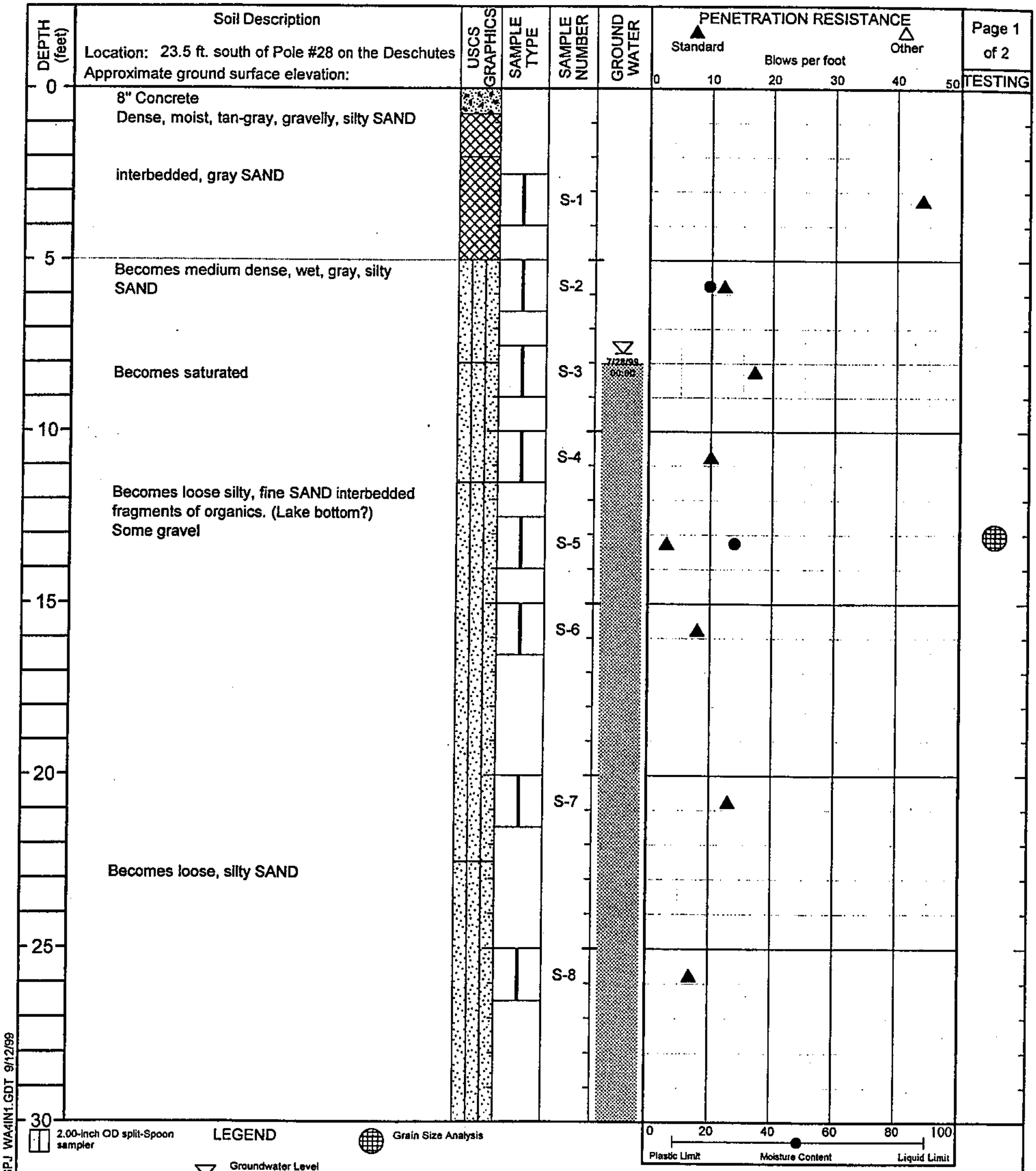
PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-26*

Page 1 of 2

Soil Description

Location: 23.5 ft. south of Pole #28 on the Deschutes

Approximate ground surface elevation:



8" Concrete

Dense, moist, tan-gray, gravelly, silty SAND

interbedded, gray SAND

Becomes medium dense, wet, gray, silty SAND

Becomes saturated

Becomes loose silty, fine SAND interbedded fragments of organics. (Lake bottom?) Some gravel

Becomes loose, silty SAND

LEGEND

2.00-inch OD split-Spoon sampler

Grain Size Analysis

Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *28 July 1999* Logged By: *SAT*

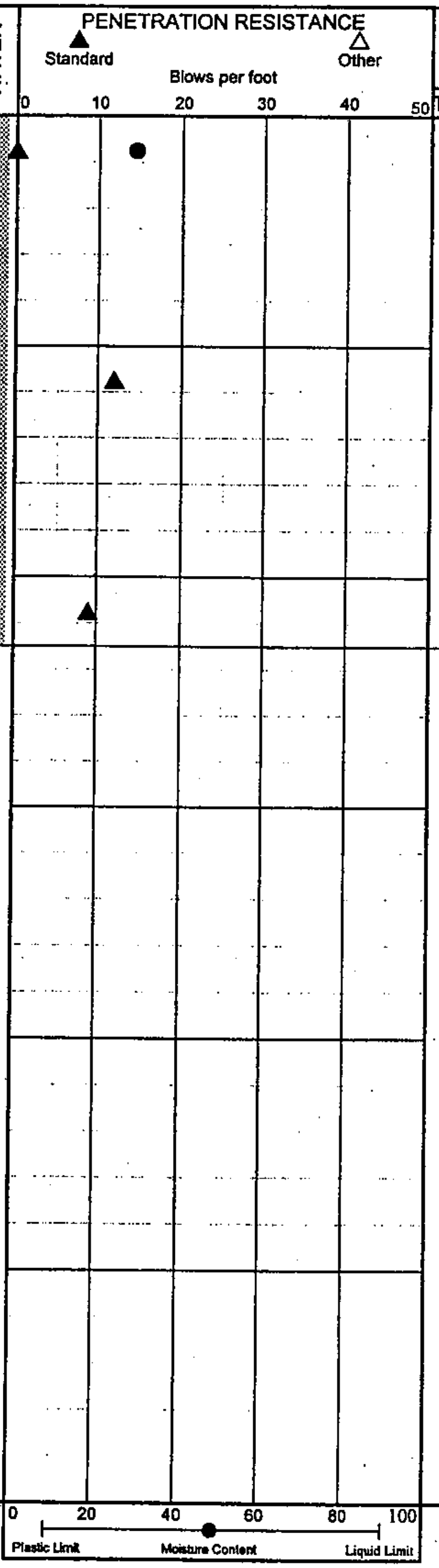
4IN1 11684B26.GPJ WA4IN1.GDT 9/12/99

PROJECT: *LOTT Capitol Lake Southern Connection*　　W.O. *9-91M-11684-B*　　BORING No. *B-26*

Page 2 of 2

Location: 23.5 ft. south of Pole #28 on the Deschutes
Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	bceomes very loose			S-9		▦
35	Becomes medium dense			S-10		
40	Becomes loose			S-11		
	Terminated at 41.5 feet					
45						
50						
55						
60						



LEGEND

2.00-inch OD split-Spoon sampler

▦ Grain Size Analysis

Groundwater Level Fluctuation

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

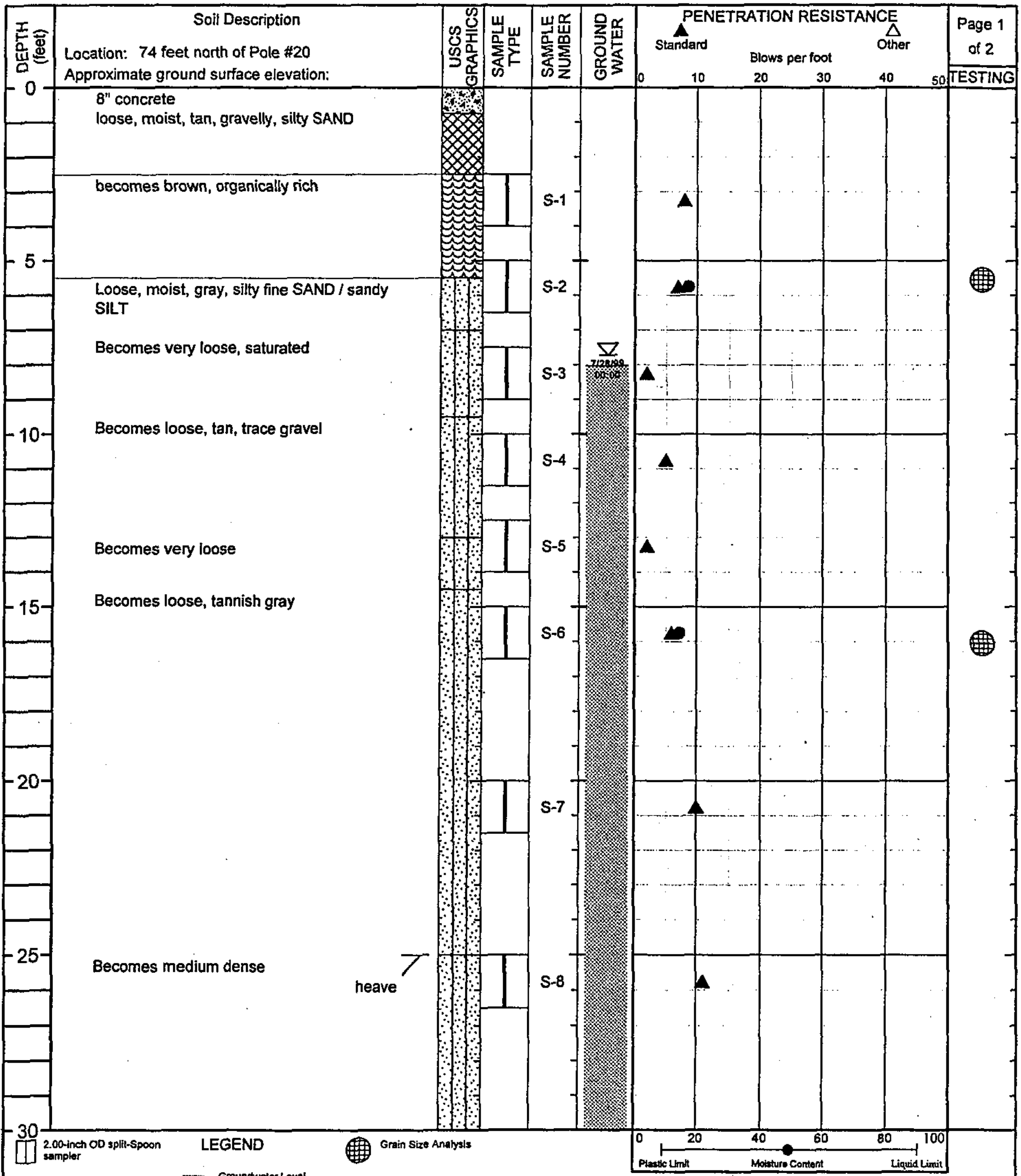
Drilling Method: HSA　　Hammer type: Cathead　　Date drilled: *28 July 1999*　　Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection*　　W.O. *9-91M-11684-B*　　BORING No. *B-27*

Page 1 of 2

Location: 74 feet north of Pole #20

Approximate ground surface elevation:



8" concrete

loose, moist, tan, gravelly, silty SAND

becomes brown, organically rich

Loose, moist, gray, silty fine SAND / sandy SILT

Becomes very loose, saturated

Becomes loose, tan, trace gravel

Becomes very loose

Becomes loose, tannish gray

Becomes medium dense

heave

LEGEND

▯ 2.00-inch OD split-Spoon sampler

▽ Groundwater Level Fluctuation

⊕ Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

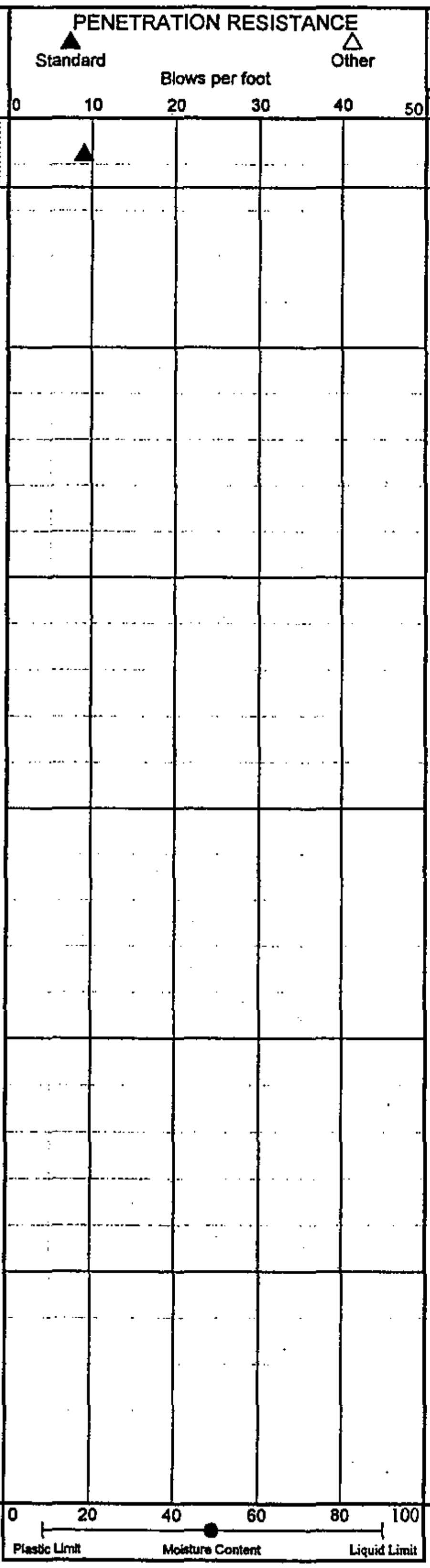
Drilling Method: HSA　　Hammer type: Cathead　　Date drilled: *28 July 1999*　　Logged By: *SAT*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-27*

Page 2 of 2

Location: 74 feet north of Pole #20
Approximate ground surface elevation:

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	Becomes loose			S-9		
	Terminated at approximately 31.5 feet.					
35						
40						
45						
50						
55						
60						



LEGEND

2.00-inch OD split-Spoon sampler

Groundwater Level Fluctuation

Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
115 South 8th Street
Tacoma, Washington 98402-5203

Drilling Method: HSA Hammer type: Cathead Date drilled: *28 July 1999* Logged By: *SAT*

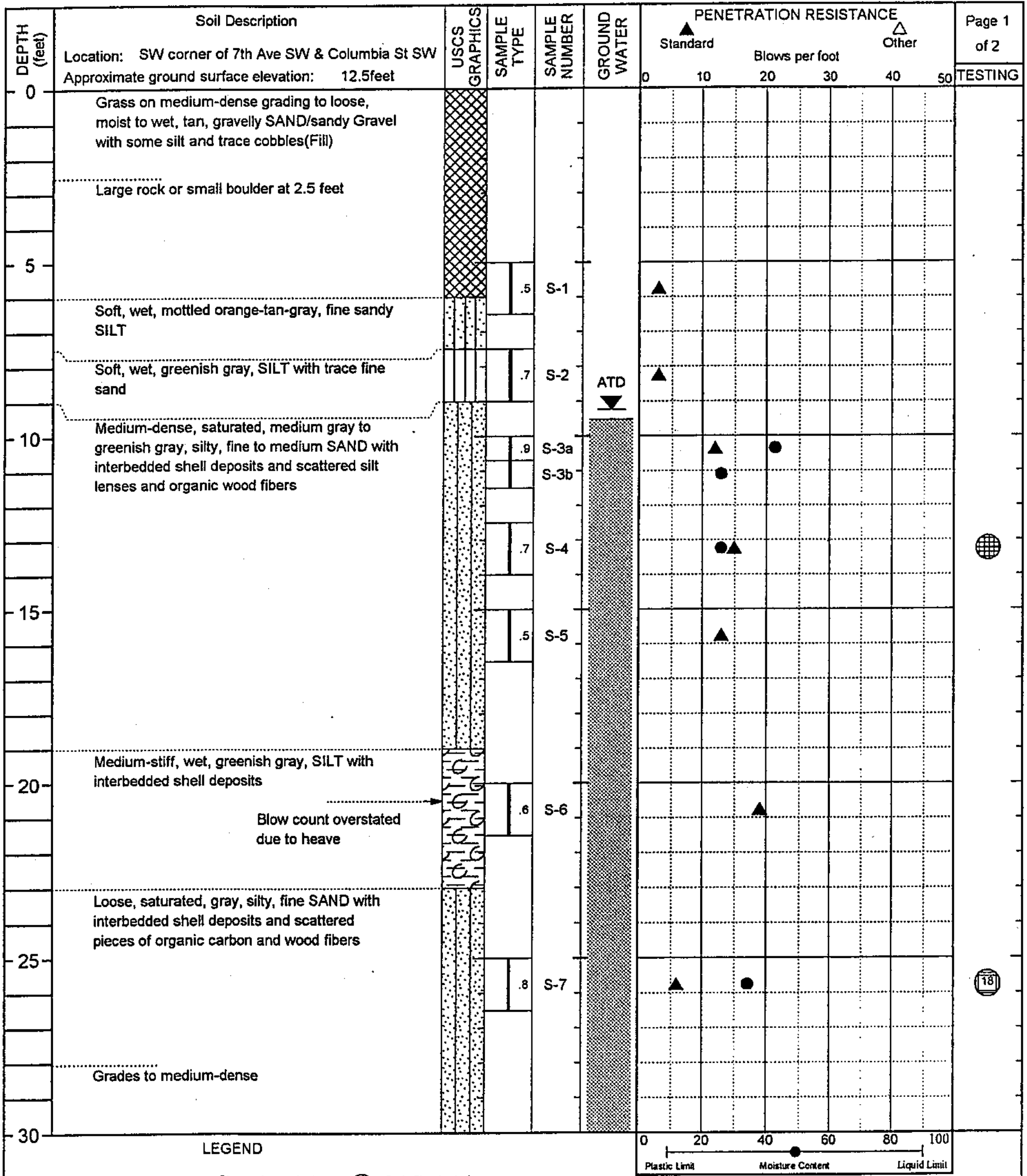
4IN1 11684B27.GPJ WA4IN1.GDT 9/12/99

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-28*

Page 1 of 2

Location: SW corner of 7th Ave SW & Columbia St SW

Approximate ground surface elevation: 12.5feet



Grass on medium-dense grading to loose, moist to wet, tan, gravelly SAND/sandy Gravel with some silt and trace cobbles(Fill)

Large rock or small boulder at 2.5 feet

Soft, wet, mottled orange-tan-gray, fine sandy SILT

Soft, wet, greenish gray, SILT with trace fine sand

Medium-dense, saturated, medium gray to greenish gray, silty, fine to medium SAND with interbedded shell deposits and scattered silt lenses and organic wood fibers

Medium-stiff, wet, greenish gray, SILT with interbedded shell deposits

Blow count overstated due to heave

Loose, saturated, gray, silty, fine SAND with interbedded shell deposits and scattered pieces of organic carbon and wood fibers

Grades to medium-dense

LEGEND

- 2.00-inch OD split-Spoon sampler
- Observed groundwater level
- Grain Size Analysis
- 200 Wash

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

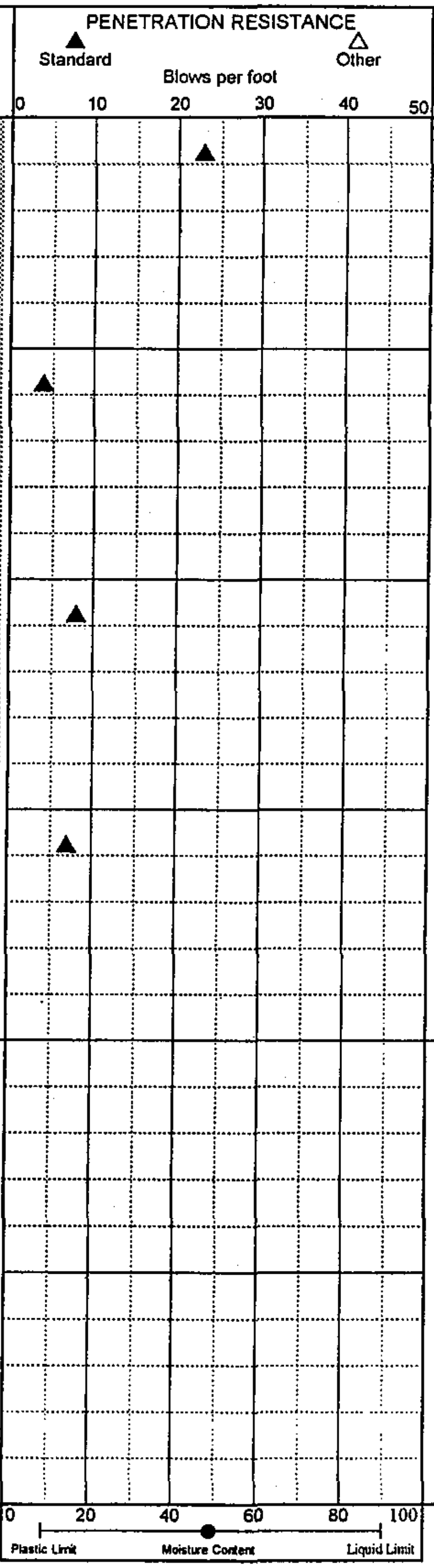
Drilling Method: HSA Hammer type: Cathead Date drilled: *30 November1999* Logged By: *HWB*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-28*

Location: SW corner of 7th Ave SW & Columbia St SW

Approximate ground surface elevation: 12.5feet

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	As described above		.8	S-8		
	Soft to medium-stiff, wet, greenish gray, SILT with trace of fine sand and organic wood					
35			1.0	S-9		
40			1.0	S-10		
	Medium-stiff, wet, medium gray, SILT with scattered Peat/organics					
45			.5	S-11		
	Loose to medium-dense, saturated, medium gray, fine to medium SAND with some silt No sample due to severe heave		1.0	S-12		
50	Boring terminated at approximately 50 feet due to severe heave in the borehole					
55						
60						



LEGEND

- ▯ 2.00-inch OD split-Spoon sampler
- ▼ Observed groundwater level
- ⊕ Grain Size Analysis
- ▢ 200 Wash

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

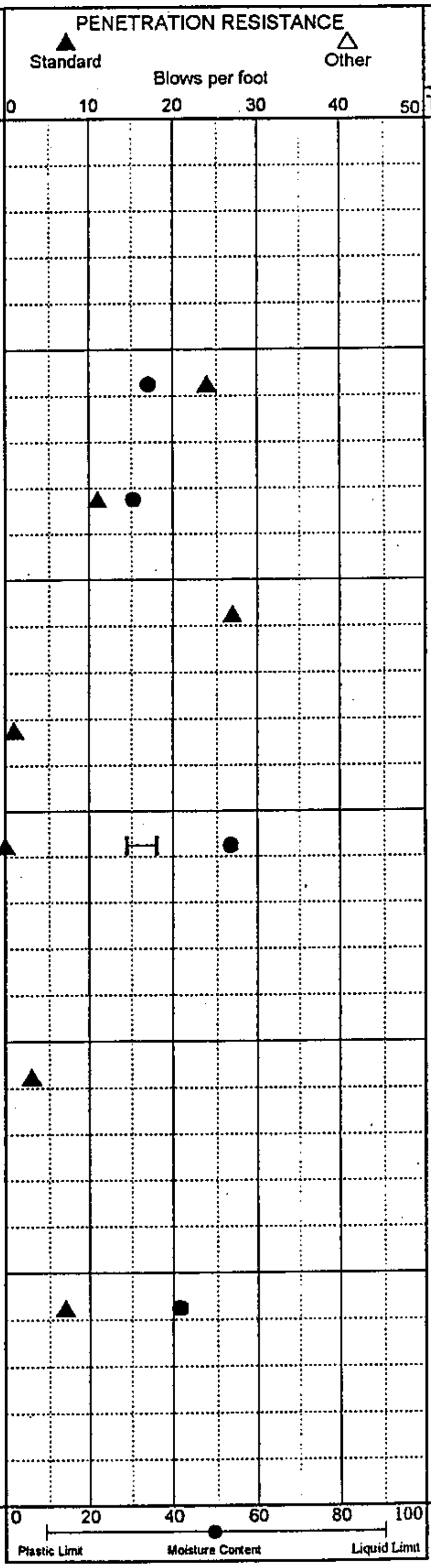
Drilling Method: HSA Hammer type: Cathead Date drilled: *30 November1999* Logged By: *HWB*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-29*

Page 1 of 2

Location: SW corner of Heritage Park onW side of rd
Approximate ground surface elevation: 9.5feet

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
0	Medium-dense, wet, tan, silty, gravelly SAND/sandy GRAVEL(Fill)					
	Medium-dense, wet, medium to dark gray, silty, fine SAND with trace to some organics and wood fibers(Dredge Fill)					
5			.3	S-1		
	Becomes wet to saturated		.4	S-2	ATD ▼	⊕
10			.2	S-3		
	Very soft/very loose, saturated, blackish gray, sandy SILT/ silty, fine SAND with some organics and wood debris(Mudline Sediments)		1.0	S-4		
	Very soft, wet, greenish gray, SILT with interbedded shell fragments					
15			1.0	S-5		
	Very soft to soft, wet, medium-gray, fine sandy SILT with trace to some organic carbon and wood fibers					
20			.3	S-6		
	Grades into medium-stiff/loose, fine sandy SILT/silty, fine SAND					
25			.7	S-7		54
	Stiff, wet, greenish gray and gray mix, SILT with trace fine sand, organics and shell fragments					
30						



LEGEND

▯ 2.00-inch OD split-Spoon sampler

▼ Observed groundwater level

⊕ Grain Size Analysis

▢ 200 Wash

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

4IN1 LOTT29.GPJ WA4IN1.GDT 3/10/00

Drilling Method: Mud Rotary Hammer type: Cathead Date drilled: *30 November 1999* Logged By: *HWB*

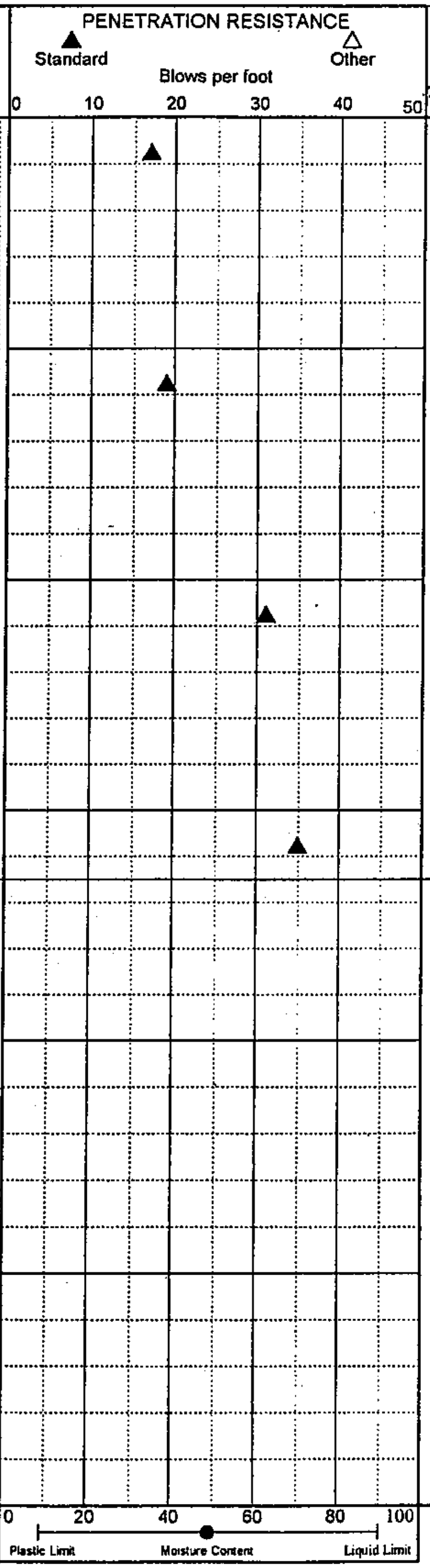
PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-29*

Page 2 of 2

Location: SW corner of Heritage Park onW side of rd

Approximate ground surface elevation: 9.5feet

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	As described above		.7	S-8		
	Interbedded medium-dense, saturated, medium-gray, silty, fine SAND with trace organics with stiff to very stiff, wet to saturated, fine snady SILT with some organics					
35			.7	S-9		
	Dense, saturated, medium-gray, silty, fine SAND with scattered organics					
40			.1	S-10		
45			.3	S-11		
	Boring terminated at approximately 46.5 feet					
50						
55						
60						



LEGEND

2.00-inch OD split-Spoon sampler

Observed groundwater level

Grain Size Analysis

200 Wash

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11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Mud Rotary Hammer type: Cathead Date drilled: *30 November 1999* Logged By: *HWB*

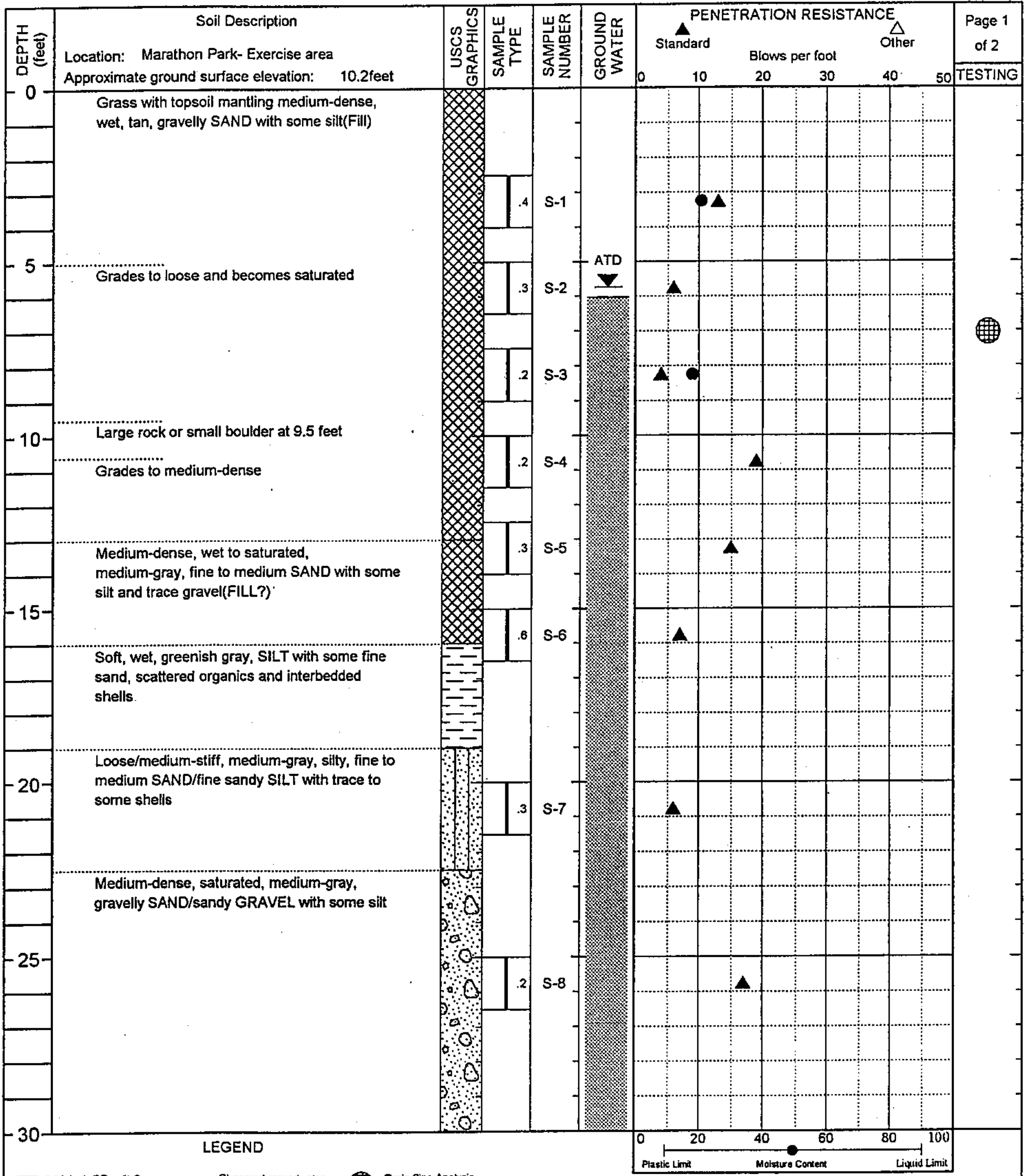
PROJECT: *LOTT Capitol Lake Southern Connection*

W.O. *9-91M-11684-B* BORING No. *B-30*

Page 1 of 2

Location: Marathon Park- Exercise area

Approximate ground surface elevation: 10.2feet



Grass with topsoil mantling medium-dense, wet, tan, gravelly SAND with some silt(Fill)

Grades to loose and becomes saturated

Large rock or small boulder at 9.5 feet

Grades to medium-dense

Medium-dense, wet to saturated, medium-gray, fine to medium SAND with some silt and trace gravel(FILL?)

Soft, wet, greenish gray, SILT with some fine sand, scattered organics and interbedded shells

Loose/medium-stiff, medium-gray, silty, fine to medium SAND/fine sandy SILT with trace to some shells

Medium-dense, saturated, medium-gray, gravelly SAND/sandy GRAVEL with some silt

LEGEND

▯ 2.00-inch OD split-Spoon sampler

▼ Observed groundwater level

⊕ Grain Size Analysis

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11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

Drilling Method: Mud Rotary Hammer type: Cathead Date drilled: *01 December 1999* Logged By: *HWB*

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-30*

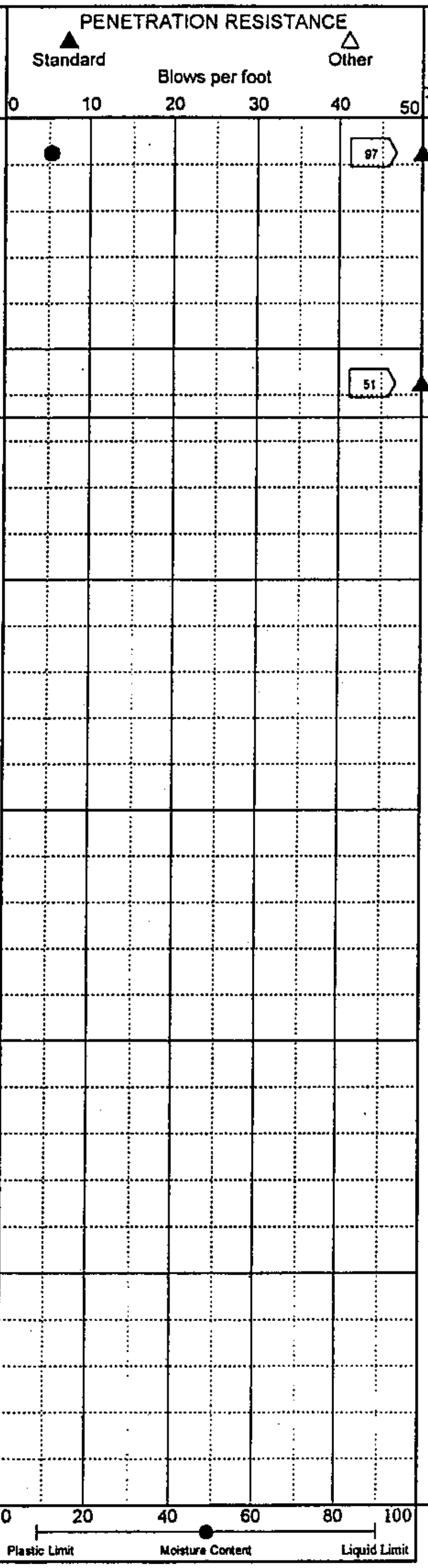
Page 2 of 2

Soil Description

Location: Marathon Park- Exercise area

Approximate ground surface elevation: 10.2feet

DEPTH (feet)	Soil Description	USCS GRAPHICS	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
30	Very dense, saturated, medium-gray, sandy GRAVEL/gravelly SAND with some silt Blow count may be overstated due to gravels		.6	S-9	▨	🌐
35			.4	S-10	▨	
	Boring terminated at approximately 36.5 feet					
40						
45						
50						
55						
60						



LEGEND

☐ 2.00-inch OD split-Spoon sampler

▼ Observed groundwater level

🌐 Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

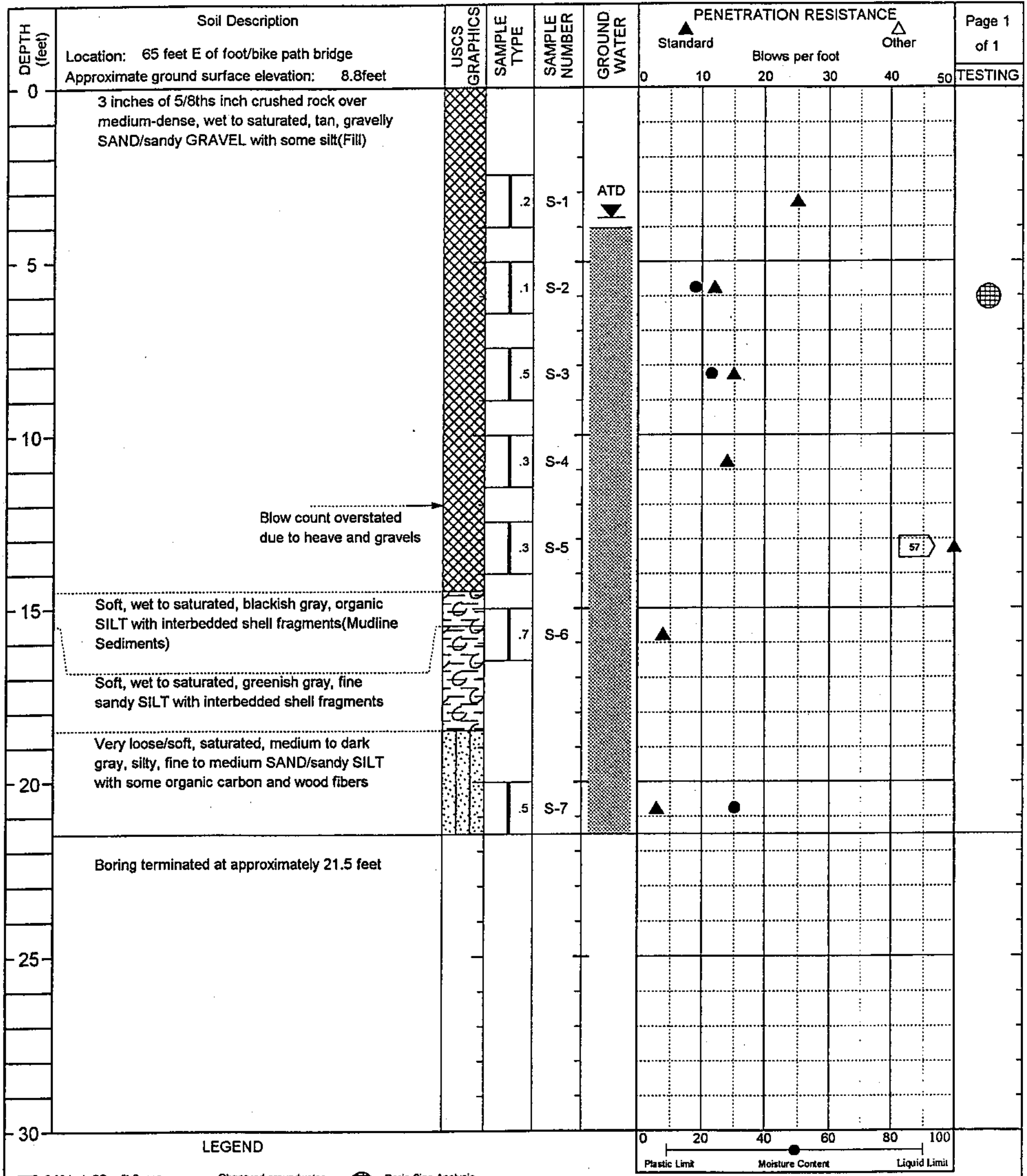
Drilling Method: Mud Rotary Hammer type: Cathead Date drilled: *01 December 1999* Logged By: *HWB*

4IN1 LOTT30.GPJ WA4IN1.GDT 3/10/00

PROJECT: *LOTT Capitol Lake Southern Connection* W.O. *9-91M-11684-B* BORING No. *B-31*

Location: 65 feet E of foot/bike path bridge

Approximate ground surface elevation: 8.8feet



3 inches of 5/8ths inch crushed rock over medium-dense, wet to saturated, tan, gravelly SAND/sandy GRAVEL with some silt(Fill)

Blow count overstated due to heave and gravels

Soft, wet to saturated, blackish gray, organic SILT with interbedded shell fragments(Mudline Sediments)

Soft, wet to saturated, greenish gray, fine sandy SILT with interbedded shell fragments

Very loose/soft, saturated, medium to dark gray, silty, fine to medium SAND/sandy SILT with some organic carbon and wood fibers

Boring terminated at approximately 21.5 feet

LEGEND

▯ 2.00-inch OD split-Spoon sampler

▼ Observed groundwater level

⊕ Grain Size Analysis

AGRA
ENGINEERING GLOBAL SOLUTIONS
11335 N.E. 122nd Way Suite 100
Kirkland, Washington 98034-6913

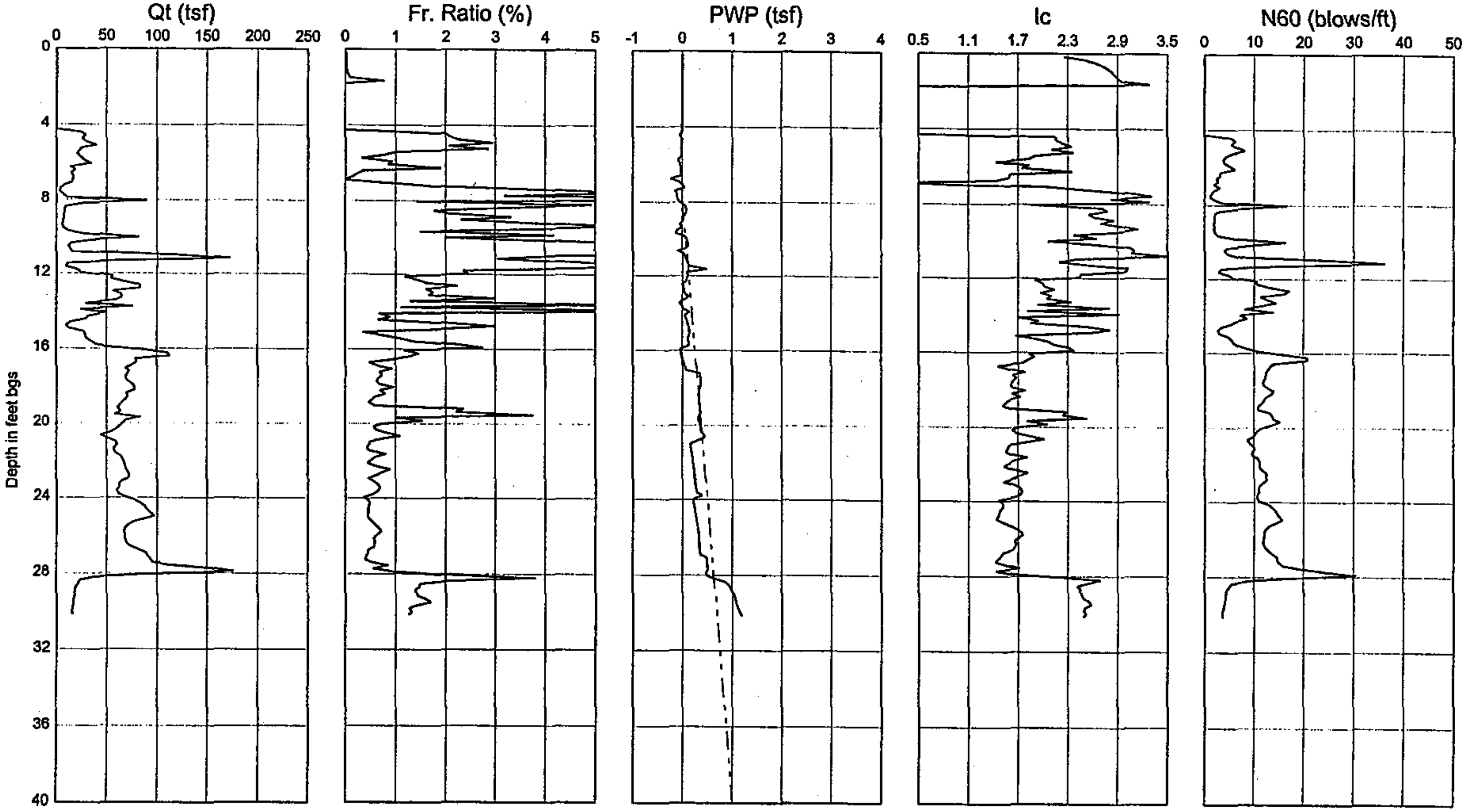
Drilling Method: Mud Rotary Hammer type: Cathead Date drilled: *01 December 1999* Logged By: *HWB*

Cone Penetration Test - CPT-1

Test Date : Jul 21, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B DATE: March 1, 2000 DRAWN BY: Keith Brown

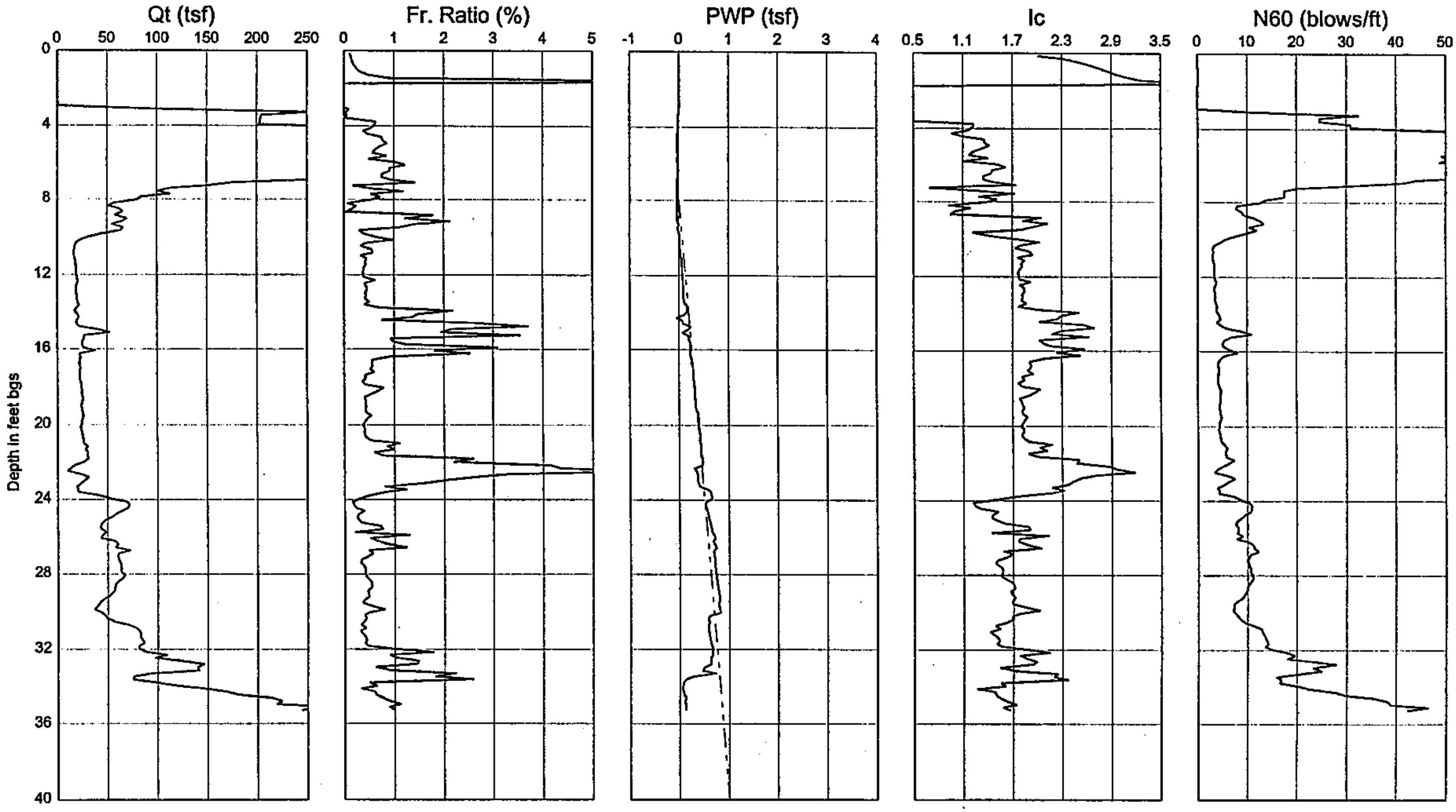
AGRA E & E

Cone Penetration Test - CPT-2

Test Date : Jul 21, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B DATE: March 1, 2000 DRAWN BY: Keith Brown

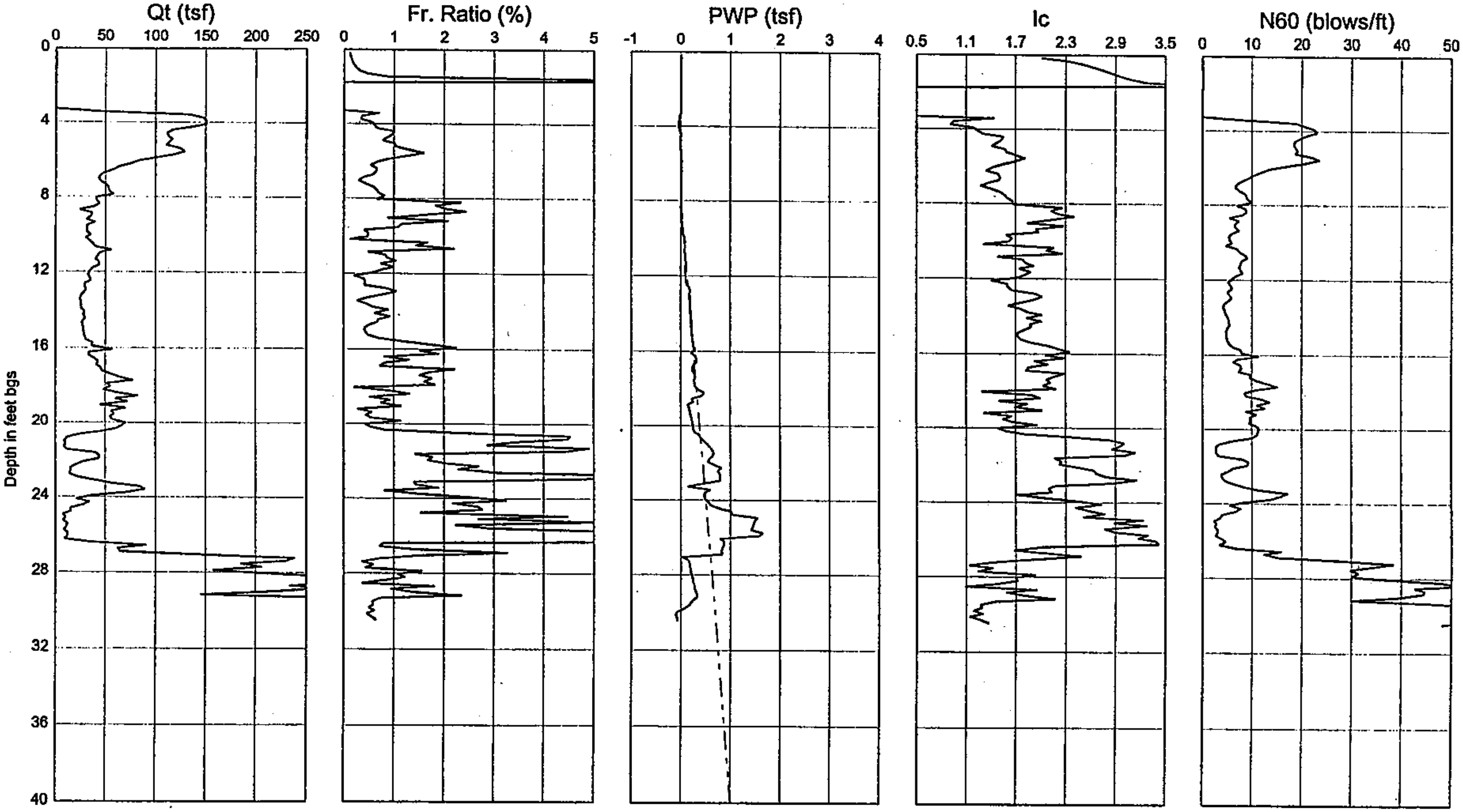
AGRA E & E

Cone Penetration Test - CPT-3

Test Date : Jul 21, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B DATE: March 1, 2000 DRAWN BY: Keith Brown

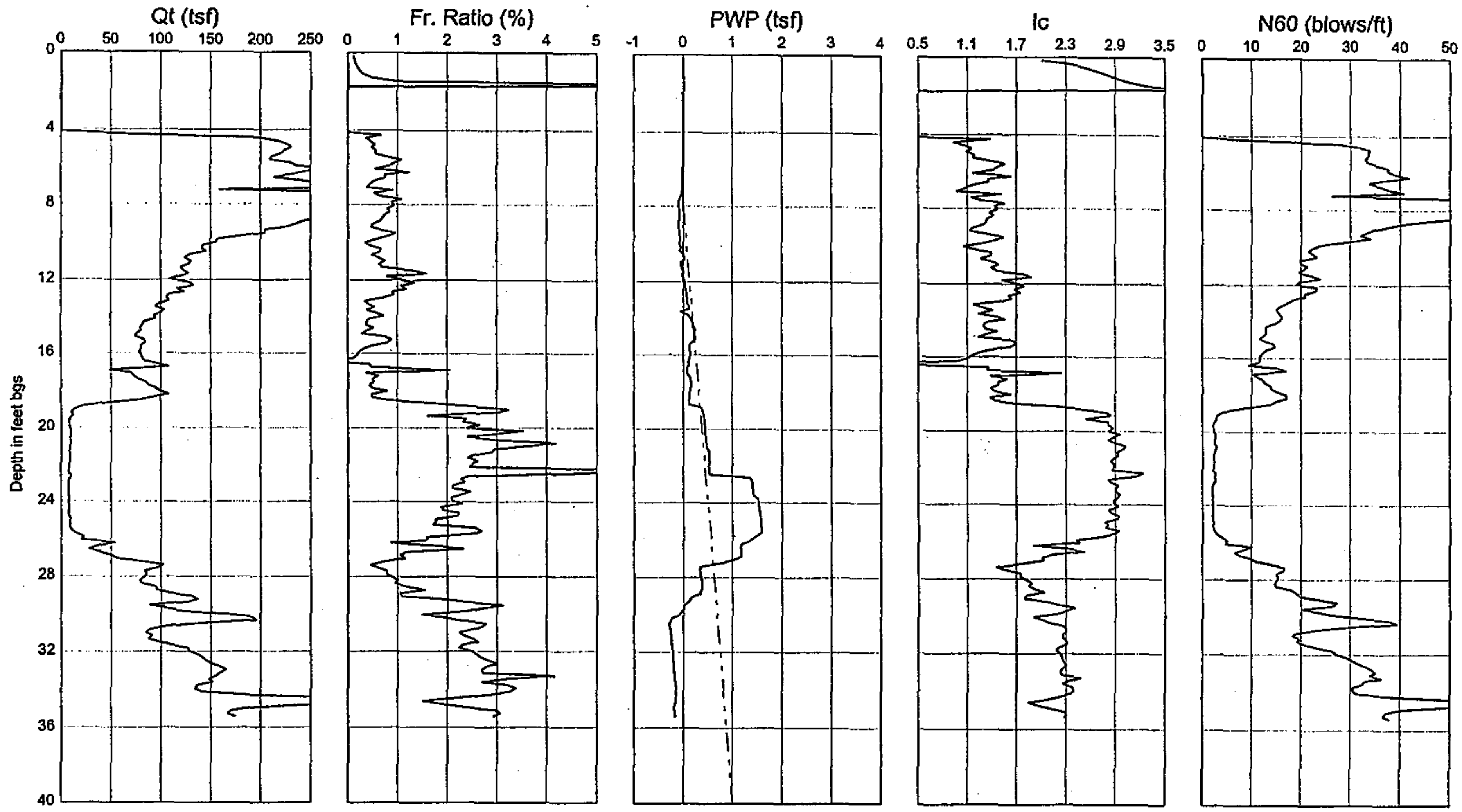
AGRA E & E

Cone Penetration Test - CPT-4

Test Date : Jul 21, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B
DATE: March 1, 2000
DRAWN BY: Keith Brown

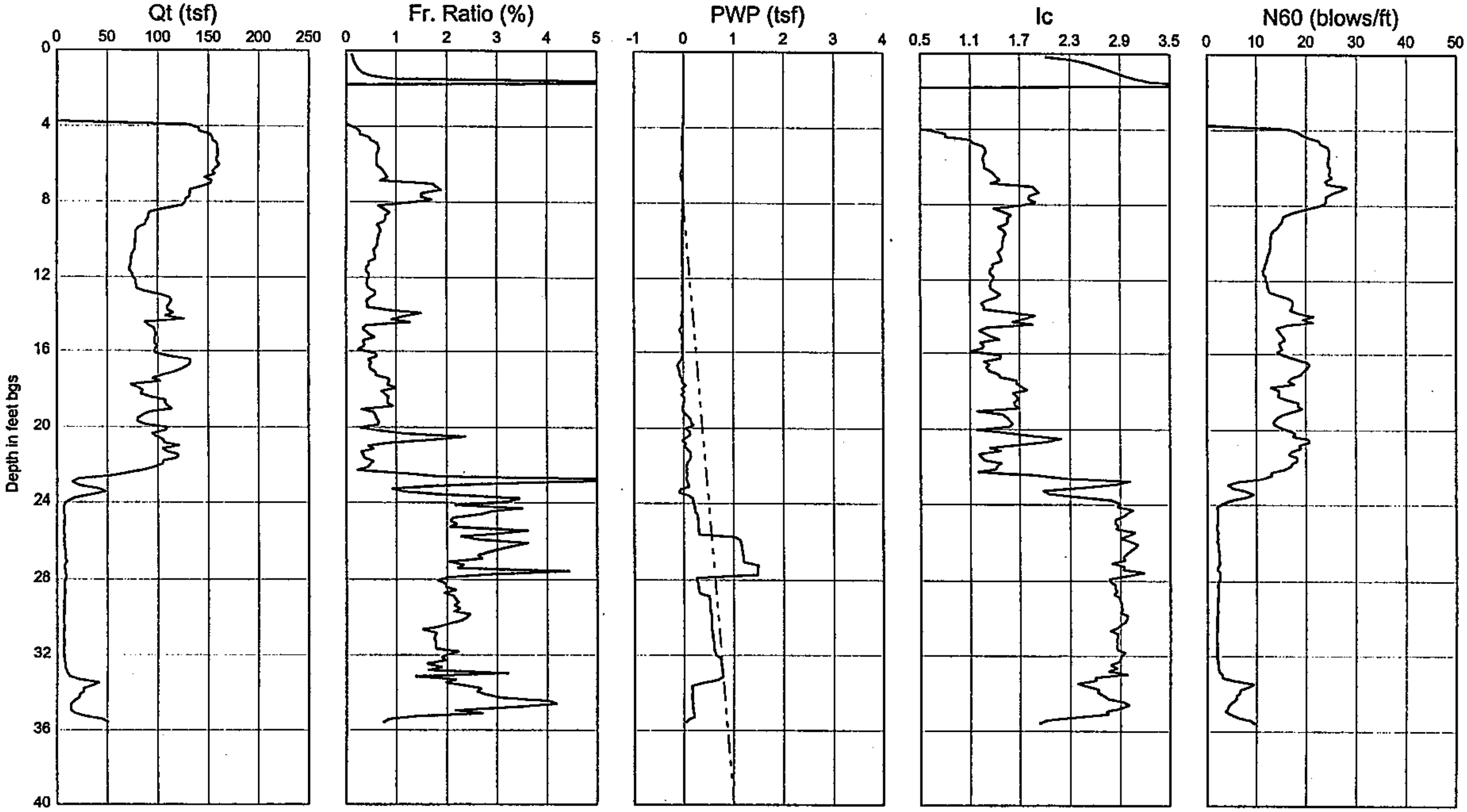
AGRA E & E

Cone Penetration Test - CPT-4a

Test Date : Jul 23, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B DATE: March 1, 2000 DRAWN BY: Keith Brown

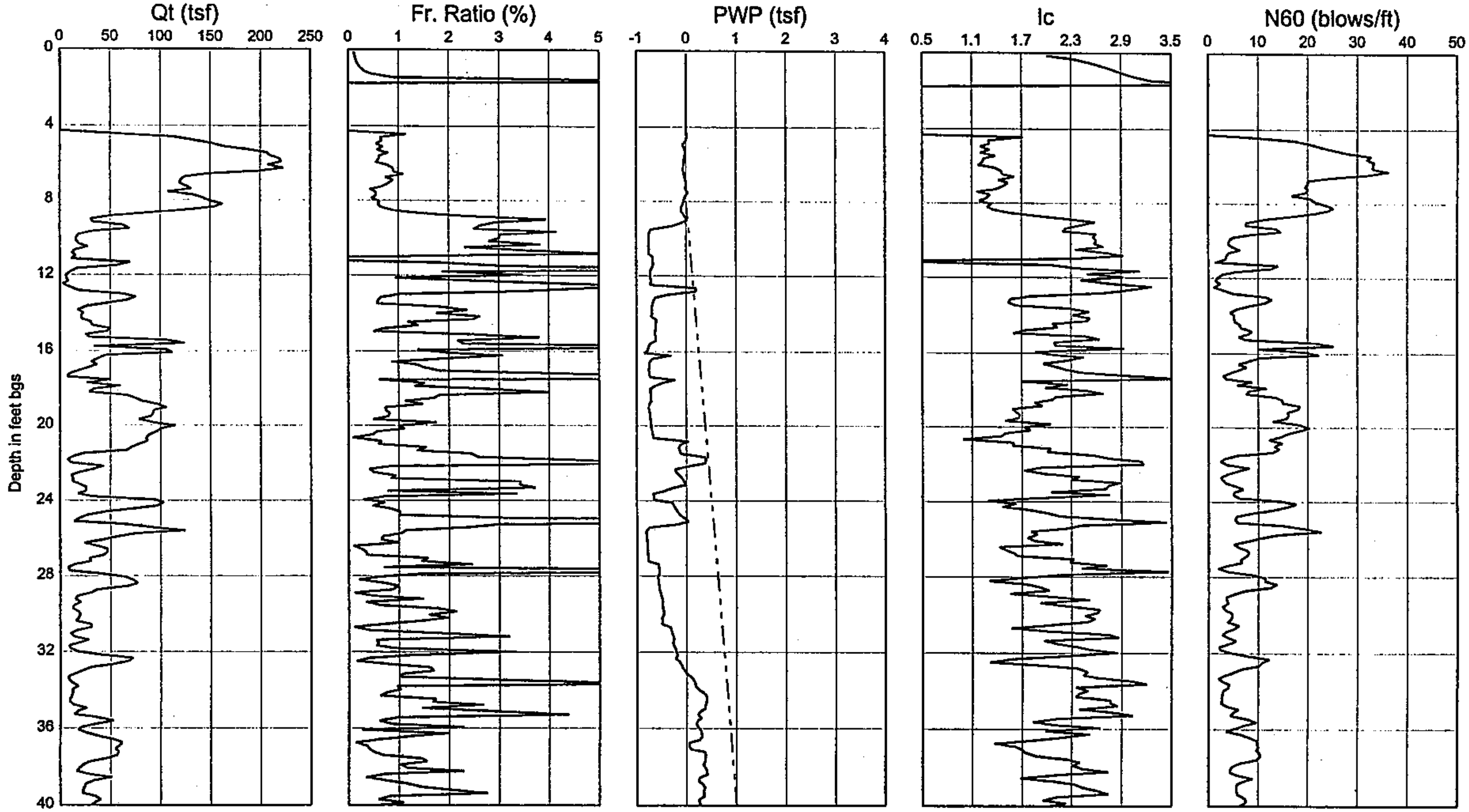
AGRA E & E

Cone Penetration Test - CPT-5

Test Date : Jul 23, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B DATE: March 1, 2000 DRAWN BY: Keith Brown

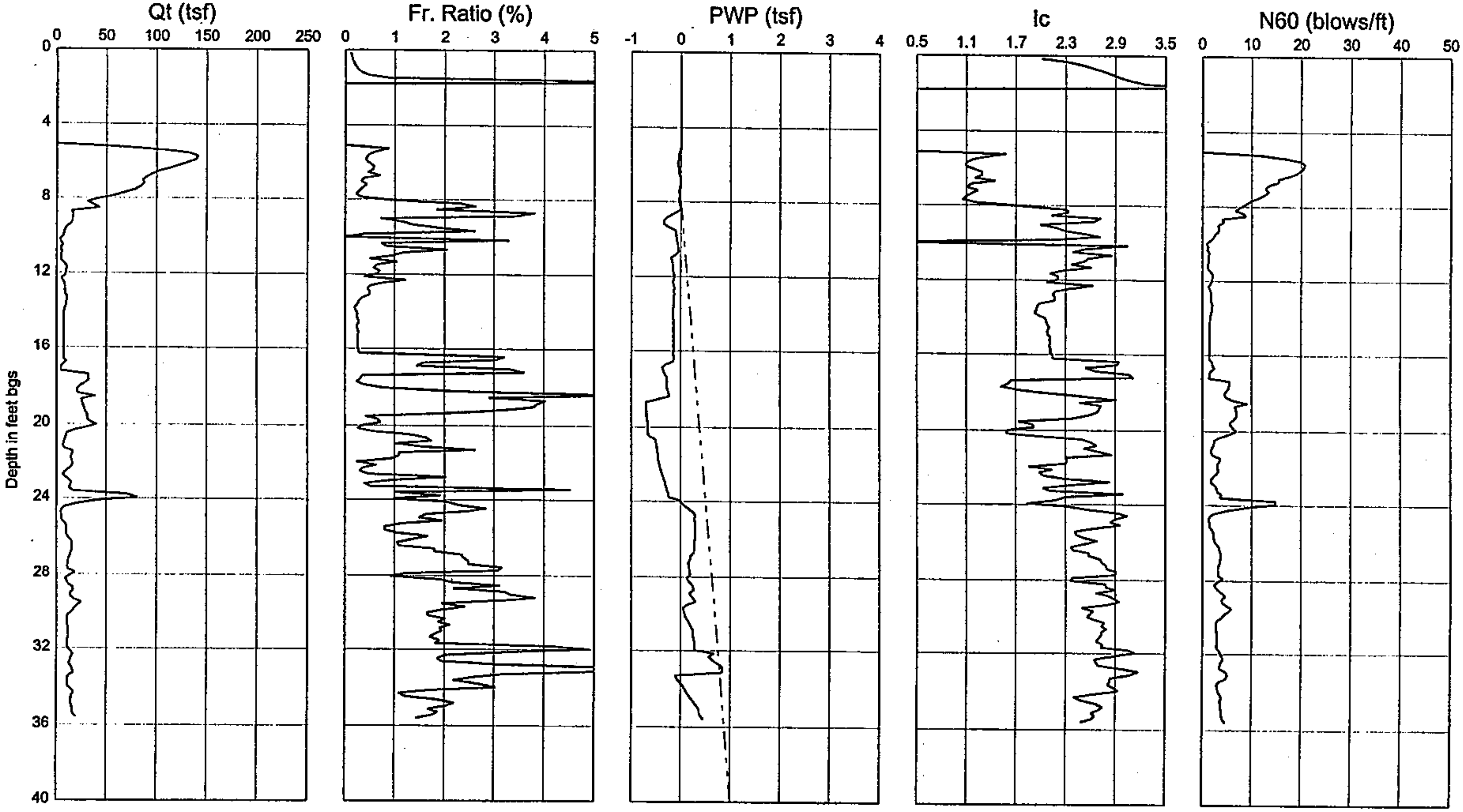
AGRA E & E

Cone Penetration Test - CPT-6

Test Date : Jul 23, 1999
Location : LOTT Capitol Lake Southern Extension

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 8.00



Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

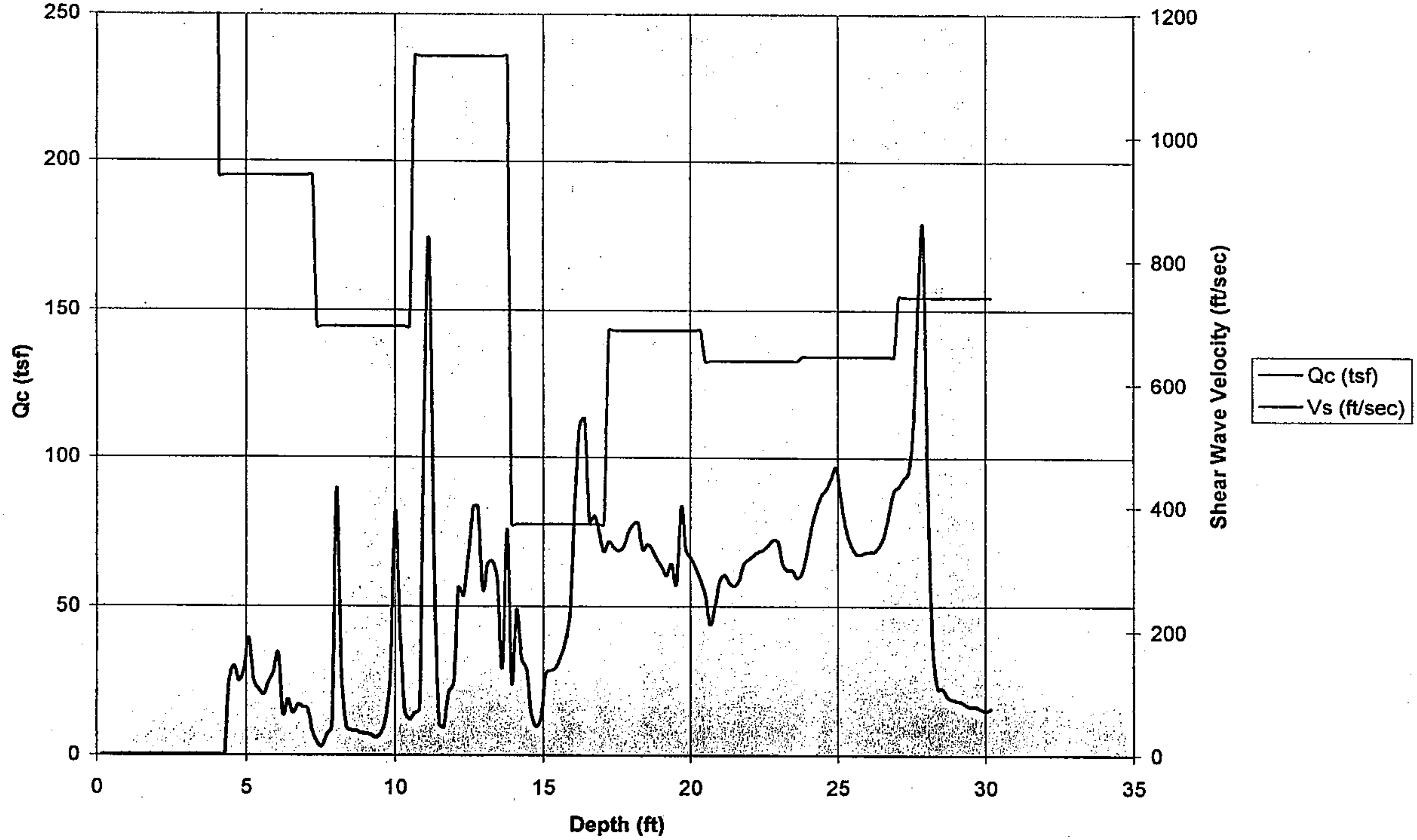
After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 9-91M-11684-B DATE: March 1, 2000 DRAWN BY: Keith Brown

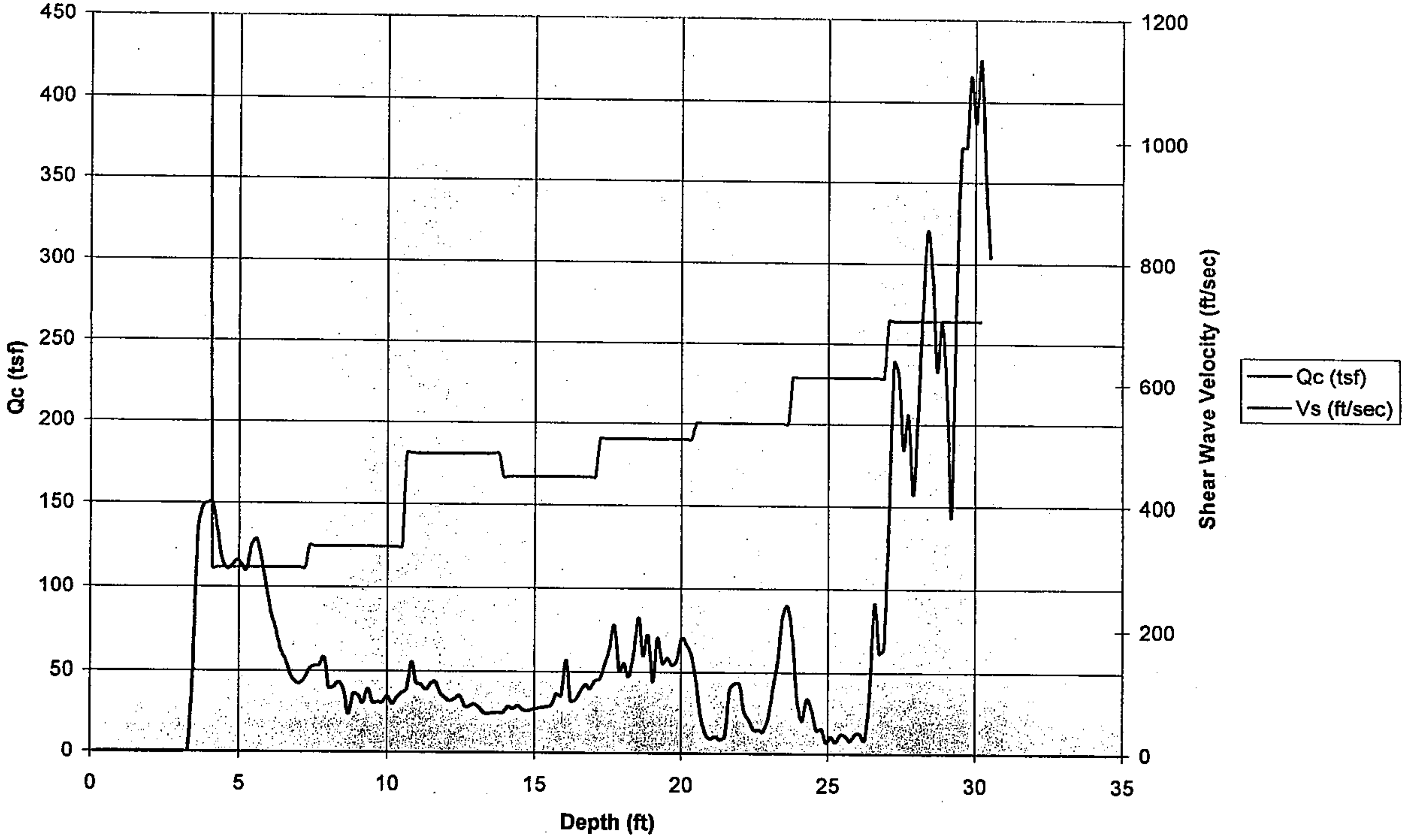
AGRA E & E

CPT-1

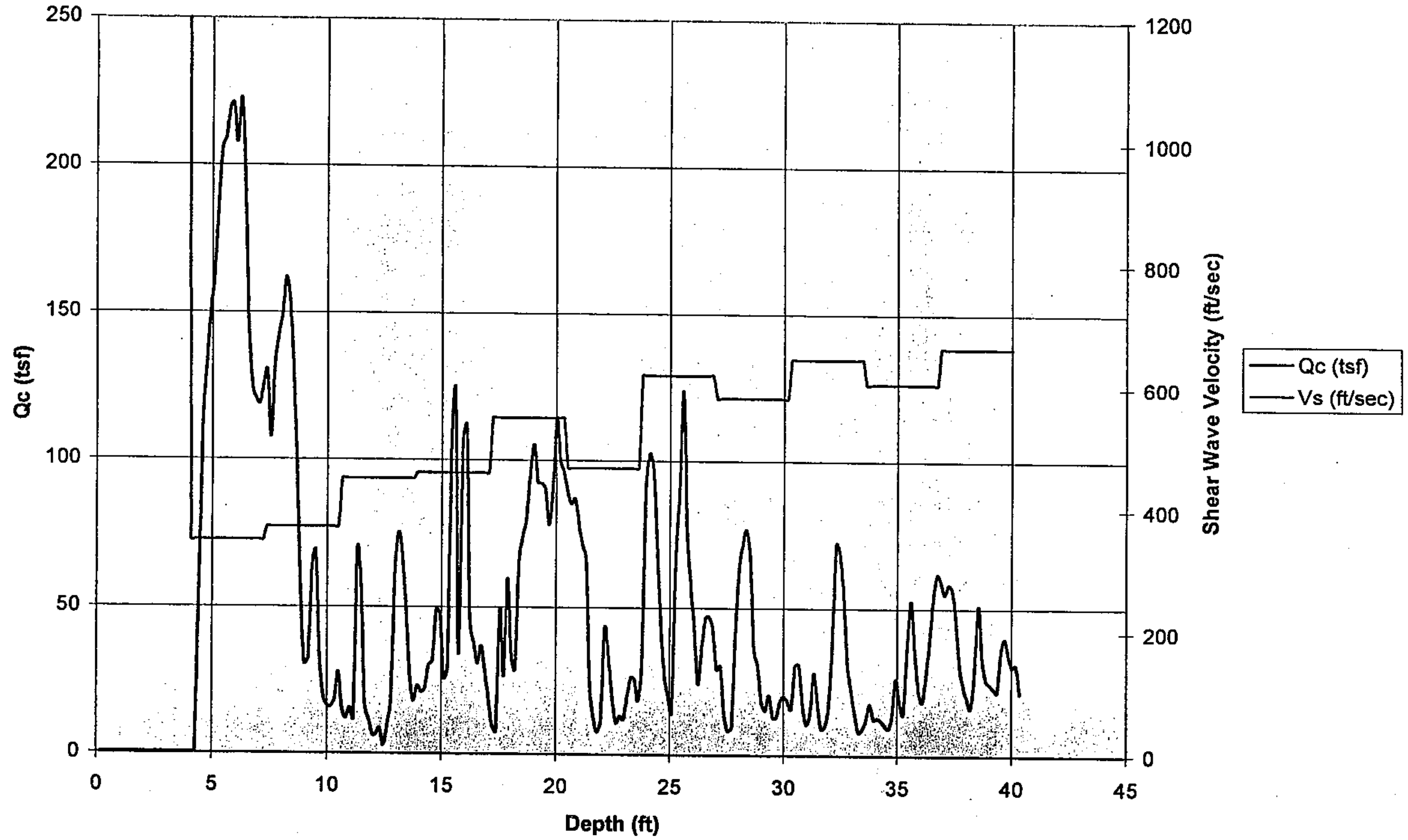


250
200
150
100
50
0
Qc (tsf)
1200
1000
800
600
400
200
0
Shear Wave Velocity (ft/sec)
0
5
10
15
20
25
30
35
Depth (ft)
Qc (tsf)
Vs (ft/sec)

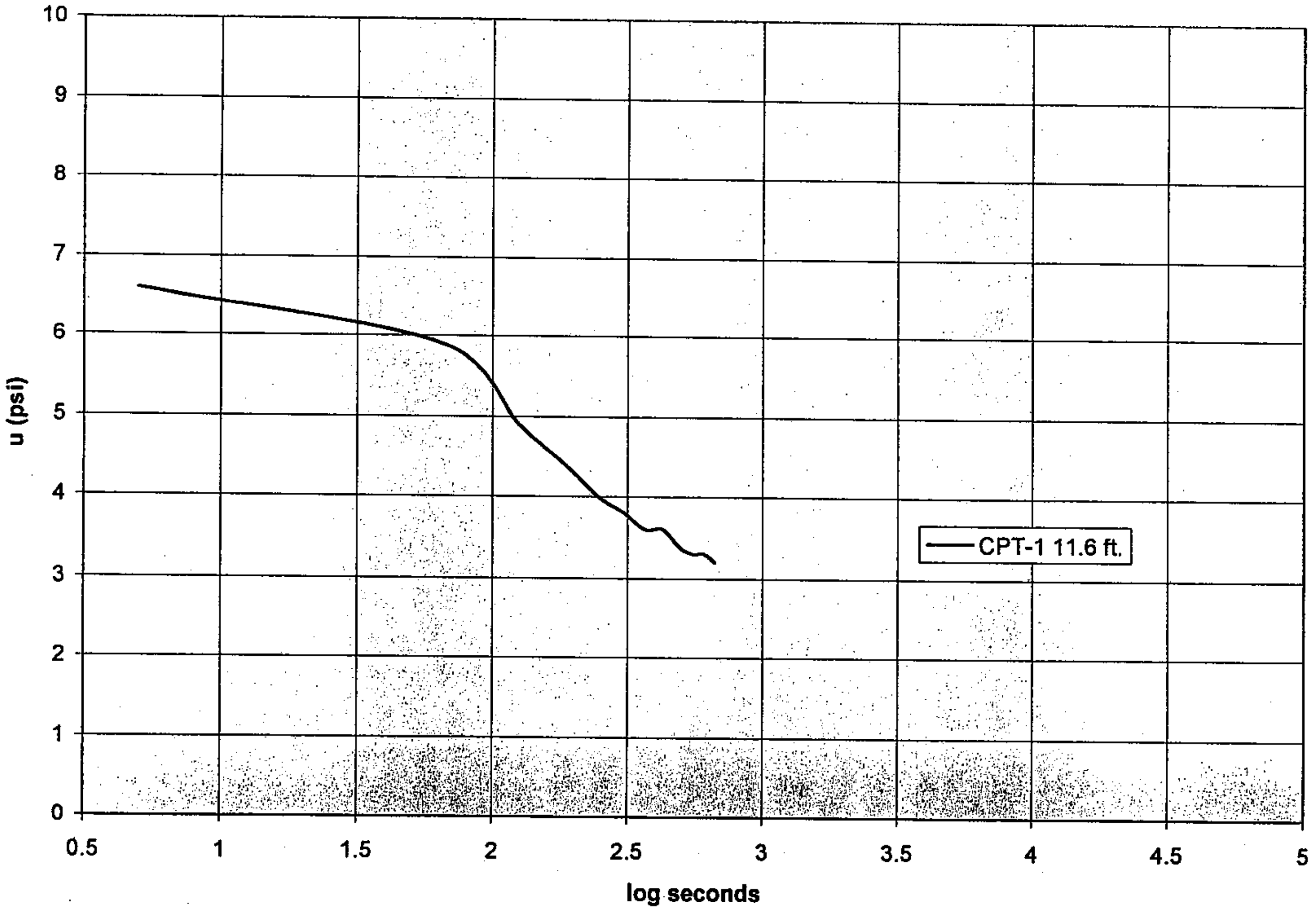
CPT-3


450
400
350
300
250
200
150
100
50
0
Qc (tsf)
1200
1000
800
600
400
200
0
Shear Wave Velocity (ft/sec)
0
5
10
15
20
25
30
35
Depth (ft)
Qc (tsf)
Vs (ft/sec)

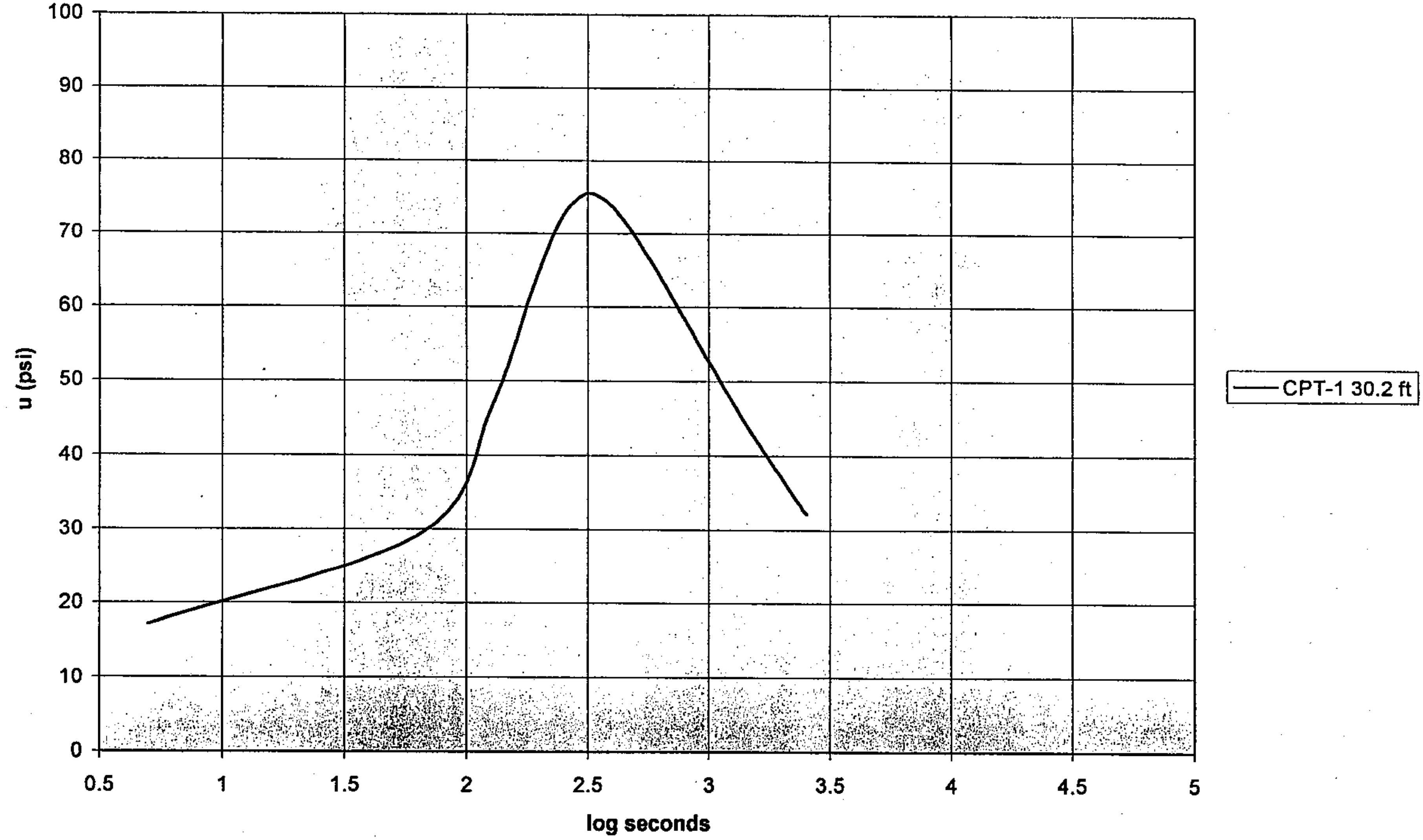
CPT-5


Qc (tsf)
250
200
150
100
50
0
Depth (ft)
0
5
10
15
20
25
30
35
40
45
Shear Wave Velocity (ft/sec)
1200
1000
800
600
400
200
0
Qc (tsf)
Vs (ft/sec)

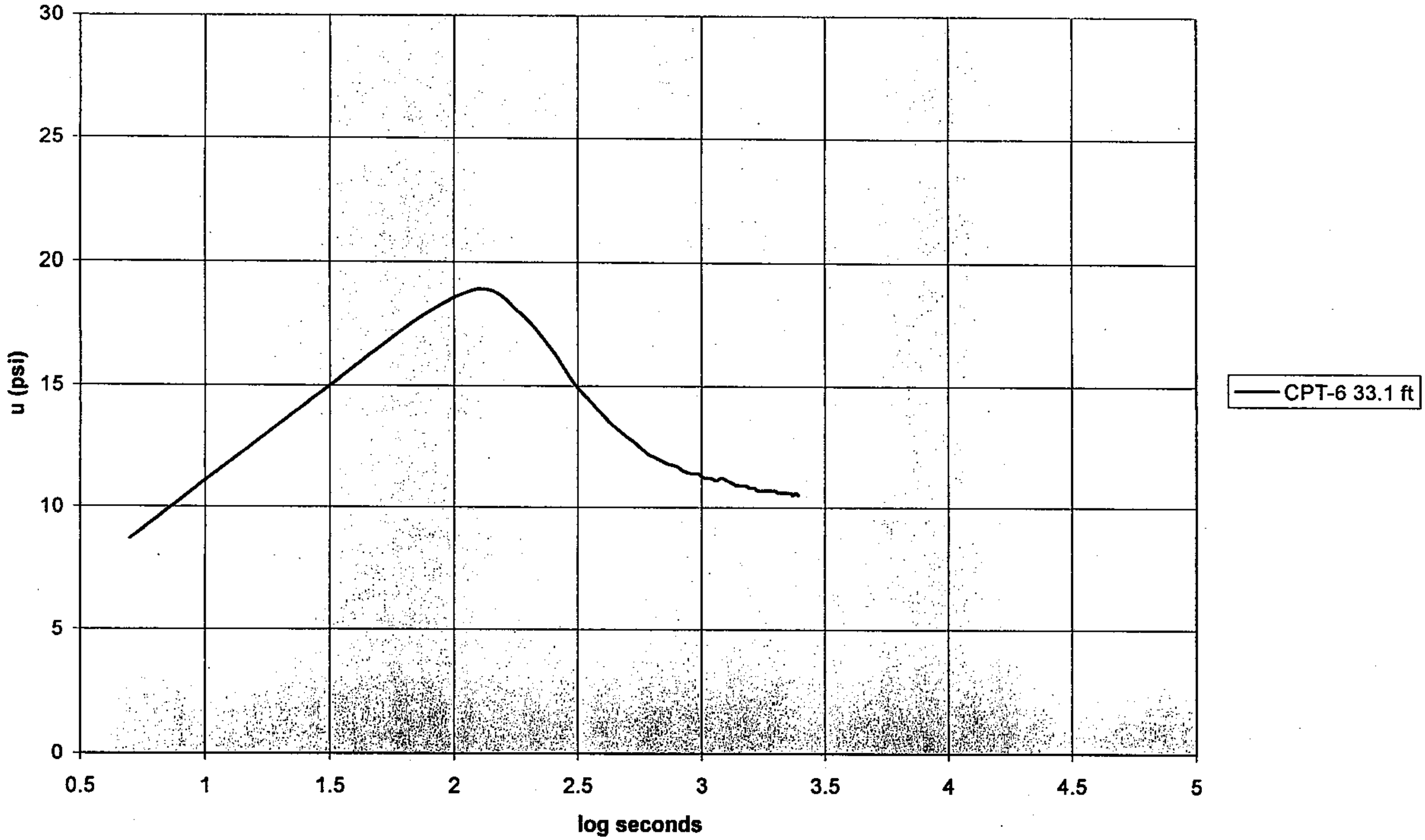
Dissipation Test: CPT-1 @ 11.6 ft.



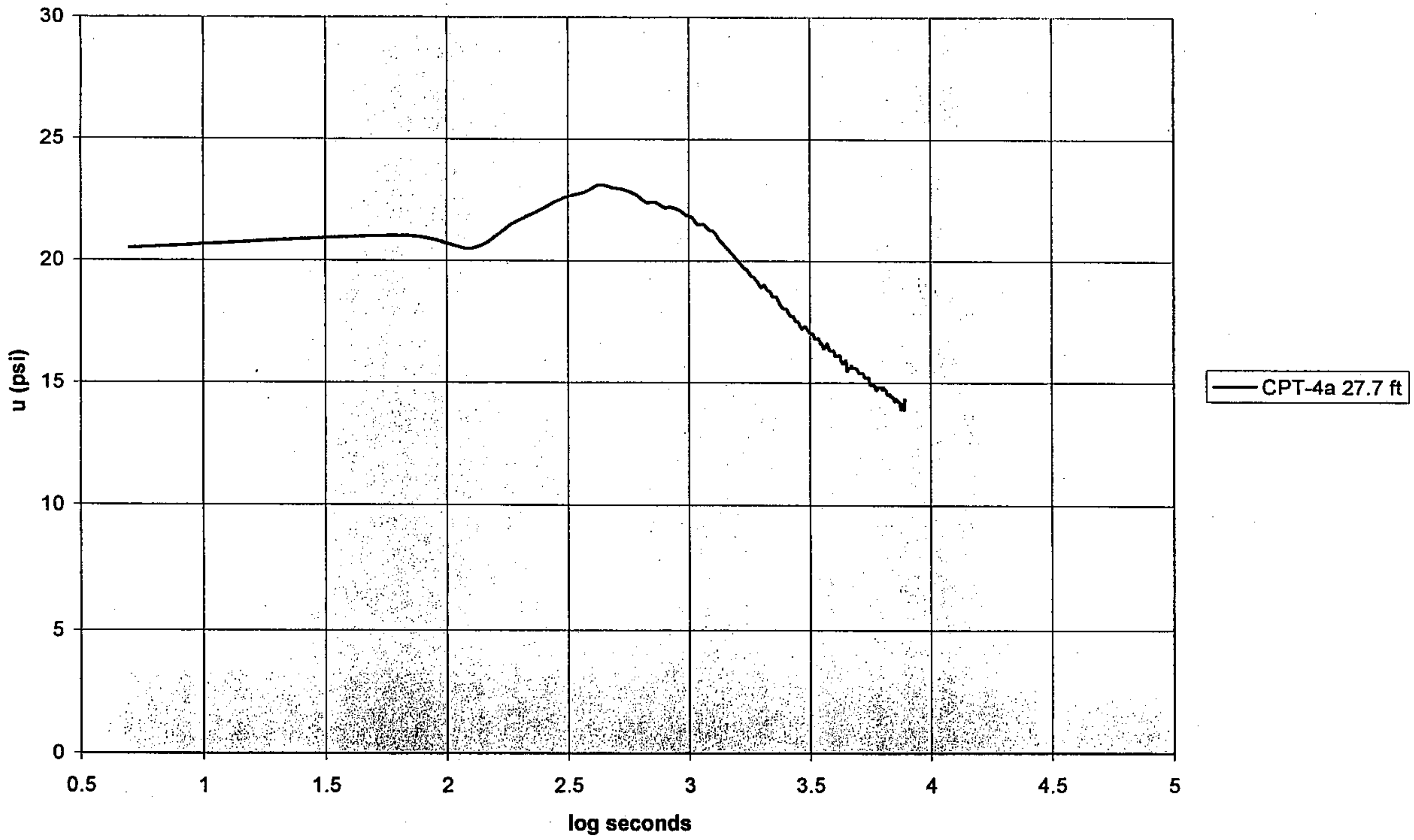
Dissipation Test: CPT-1 @ 30.2 ft.



Dissipation Test: CPT-6 @ 33.1 ft



Dissipation Test: CPT-4A



RECORD OF SUBSURFACE EXPLORATION
BORING NO. 201

Sheet 1 **of** 2
Job No. 9615

Project: Deschutes Parkwav Renovation
Boring Location: Sta 67+20, 30' L
Ground Water Depth: Not Noted
Surface Elevation: Not Noted
Date: ____
Datum: ____
Date Started: 4/18/96
Date Completed: 4/18/96

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▒	Brown Gravelly Fine to Coarse SAND (SW)		SS-1	20	10.4		
		5					
			SS-2	15	16.1		
		10					
			SS-3	12	17.1		
		15					
	16'						
▧	Grey Clayey SILT (ML)		SS-4	4	46.6		t/v=0.30 tsf
		20					
			SS-5	2	45.0		t/v=0.20 tsf
		25					
	27 1/2'						
▥	Grey SILT (ML) Occasionally Varved w/Fine Sand		SS-6	39	28.1		
		30					
			SS-7	54	33.2		
		35					
			SS-8	72	32.1		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 201

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
			SS-9	71	32.5		
		45					
			SS-10	50/4"	29.1		
	Grey SILT (ML), Occasionally Varved w/Fine Sand	50					
			SS-11	89	30.2		
		55					
	59'		SS-12	63	33.6		
	Bottom of Boring	60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 202

Sheet 1 of 2

Job No. 9615

Project: Deschutes Parkway Renovation

Boring Location: Sta 69+20, 30' L

Ground Water Depth: Not Noted **Date:** ______ **Date Started:** 4/18/96

Surface Elevation: Not Noted **Datum:** ______ **Date Completed:** 4/18/96

Symbo	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Brown Fine to Coarse SAND & Fine to Coarse GRAVEL (GW)		SS-1	14	14.4		
	6'	5					
			SS-2	2	28.4		
	Brown Fine to Coarse SAND (SW) Wood Noted	10					
			SS-3	5	20.4		
	16'	15					
			SS-4	2	45.1		t/v=0.20 tsf
		20					
	Grey Clayey SILT (ML)		RS-5	Push	50.0		t/v=0.20 tsf
		25					
			RS-6	Push	51.0		
	31'	30					
	Grey Very Silty Fine to Medium SAND (SM)		SS-7	3	27.6		
	36'	35					
	Grey Sandy Fine to Coarse GRAVEL (GW)		SS-8	50/5"	14.0		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 202

Sheet 2 of 2
Job No. 9615

Symbo	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Grey Sandy Fine to Coarse GRAVEL (GW)						
			SS-9	82	33.0		LL=35.0% PI=4.1%
	Grey SILT (ML)	45					
	49'		SS-10	63	30.7		
	Bottom of Boring	50					
		55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 203

Sheet 1 of 2
Job No. 9615

Project: Deschutes Parkway Renovation
Boring Location: Sta 71+20, 30' L
Ground Water Depth: Not Noted **Date:** ____ **Date Started:** 4/19/96
Surface Elevation: Not Noted **Datum:** ____ **Date Completed:** 4/19/96

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▒	Brown Slightly Silty Gravelly Fine to Coarse SAND (SW)		SS-1	9	--		Bag Sample 0-5' Gradation
		5					
			SS-2	2	16.7		
		10					
			SS-3	2	18.4		
		15					
			SS-4	8	21.1		
	21'	20					
▨	Grey Clayey SILT (ML)		SS-5	1	49.2		t/v=0.20 tsf
		25					
			SS-6	2	48.5		t/v=0.25 tsf
		30					
			RS-7	Push	56.2		Consol Direct Shear LL=55.0% PI=20.4% t/v=0.25 tsf
		35					
			SS-8	7	58.4		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 203

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Grey Clayey SILT (ML) 42'						
░	Grey Fine to Medium SAND (SP)		SS-9	11	28.5		
		45					
			SS-10	50/4"	19.6		
		50					
	54'		SS-11	50/3"	26.7		
	Bottom of Boring	55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 204

Sheet 1 of 2

Project: Deschutes Parkway Renovation
Job No. 9615
Boring Location: Sta 72+30, 60' L
Ground Water Depth: Artesian
Date: 4/19/96
Date Started: 4/19/96
Surface Elevation:
Datum: ____
Date Completed: 4/19/96

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨			SS-1	2	34.9		
▨		5					
▨			SS-2	2	56.2		t/v=0.20 tsf
▨		10					
▨			SS-3	1	52.0		t/v=0.20 tsf
▨		15					
▨			SS-4	1	55.5		t/v=0.10 tsf
▨		20					
▨	Grey Clayey SILT (ML)						
▨			SS-5	5	57.8		t/v=0.10 tsf
▨		25					
▨			SS-6	2	64.2		t/v=0.05 tsf LL = 66.0% PI = 28.8%
▨		30					
▨			SS-7	1	46.4		t/v=0.20 tsf
▨	36'	35					
░	Grey Fine to Medium SAND (SP)		SS-8	12	20.7		
░		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 204

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Grey Fine to Medium SAND (SP)		SS-9	53	20.9		Gradation
▨		45					
▨	49'		SS-10	50/5"	11.9		
	Bottom of Boring	50					
		55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 205

Sheet 1 **of** 2
Job No. 9615

Project: Deschutes Parkway Renovation
Boring Location: Sta 74+30, 30' L
Ground Water Depth: Artesian **Date:** 4/22/96 **Date Started:** 4/22/96
Surface Elevation: Not Noted **Datum:** _____ **Date Completed:** 4/22/96

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Brown Gravelly Fine to Coarse SAND (SW)		SS-1	7	11.9		Bag Sample 0 - 2 1/2' Gradation
	6'	5					
			SS-2	2	22.7		
	Brown Fine to Medium SAND (SP)	10					
			SS-3	6	21.5		
	16'	15					
			SS-4	2	20.5		
	Brown Fine to Coarse SAND (SW)	20					
	23'						
	Grey Sandy SILT (ML)		SS-5	12	42.1		t/v=0.30 tsf
	26'	25					
			SS-6	35	23.7		
		30					
	Grey Fine to Medium SAND (SP)		SS-7	16	44.8		
		35					
			SS-8	11	28.9		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 205

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Grey Fine to Medium SAND (SP) 45'		SS-9	56	22.2		
		45					
▨	Grey Gravelly Fine to Medium SAND (SP) 49'		SS-10	77	6.5		
	Bottom of Boring	50					
		55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 206

Sheet 1 of 2
Job No. 9615

Project: Deschutes Parkway Renovation
Boring Location: Sta 76+90, 30' L
Ground Water Depth: Not Noted   Date: _____   Date Started: 4/23/96
Surface Elevation: Not Noted   Datum: _____   Date Completed: 4/23/96

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Brown Sandy Fine to Coarse GRAVEL (GW)		SS-1	16	11.1		
		5					
			SS-2	5	15.0		
		10					
	13 1/2'		SS-3	19	15.9		
	Grey Clayey SILT (ML)	15					
			SS-4	3	53.9		
	21'	20					
	Grey Fine to Coarse SAND & Fine to Coarse GRAVEL (GW) w/Silty Seams		SS-5	6	17.4		
		25					
			SS-6	50/5"	12.8		
		30					
			SS-7	41	26.9		
	36'	35					
	PEAT and Grey CLAY (CL)		SS-8	22	78.4		
	39 1/2'						
	Grey Fine to Medium SAND (SP)	40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 206

Sheet 2 **of** 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Grey Fine to Medium SAND (SP) 44'		SS-9	16	32.0		
	Bottom of Boring	45					
		50					
		55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 207

Sheet 1 of 2
Job No. 9615

Project: Deschutes Parkway Renovation
Boring Location: Sta 78+90, 30' L
Ground Water Depth: Not Noted
Date: _____
Date Started: 4/23/96
Surface Elevation: Not Noted
Datum: _____
Date Completed: 4/23/96

Symbo	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Brown Fine to Coarse SAND (SW)		SS-1	13	12.3		
		5					
			SS-2	3	17.6		
	11'	10					
	Grey Fine to Coarse SAND & Fine to Coarse GRAVEL (GW) Wood Noted		SS-3	3	16.4		
	16'	15					
	Grey Clayey SILT (ML) w/Shells		SS-4	6	51.1		t/v=0.15 tsf
	21'	20					
	Grey Gravelly Fine to Coarse SAND (SW)		SS-5	11	14.2		
		25					
			SS-6	50/6"	18.1		
		30					
	33'						
	Grey Varved SILT, PEAT and Fine SAND (ML)		SS-7	15	25.2		
		35					
			SS-8	16	59.5		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 207

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▥	Grey Varved SILT, PEAT & Fine SAND (ML) 43 1/2'		SS-9	30	26.9		
		45					
▒	Grey Gravelly Fine to Medium SAND (SP) 49'		SS-10	28	19.7		
	Bottom of Boring	50					
		55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 208

Sheet 1 of 2
Job No. 9615

Project: Deschutes Parkwav Renovation
Boring Location: Sta 47+30, 30' R
Ground Water Depth: Not Noted **Date:** _____ **Date Started:** 4/23/96
Surface Elevation: Not Noted **Datum:** _____ **Date Completed:** 4/23/96

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Brown Fine to Medium SAND (SP)		SS-1	9	17.5		
		5					
			SS-2	3	11.3		
		10					
	13 1/2'		SS-3	4	18.3		
▨	WOOD, PEAT and TOPSOIL	15					
	16'						
▨	Grey Silty Fine SAND (SM)		SS-4	7	19.8		
		20					
	23'		SS-5	2	76.9		
		25					
▨	PEAT, Grading to Organic SILT & Fine SAND (OH - SP)		SS-6	5	42.0		
		30					
	31'						
▨	Grey Silty Fine SAND (SM)		SS-7	14	19.7		
		35					
			SS-8	6	19.8		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 208

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Grey Silty Fine SAND (SM) 44'		SS-9	8	22.7		
	Bottom of Boring	45					
		50					
		55					
		60					
		65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 209

Sheet 1 of 2

Job No. 9615

Project: Deschutes Parkwav Renovation

Boring Location: Sta 101 + 00 34' R

Ground Water Depth: Not Noted

Date: 4/24/96

Date Started: 4/24/96

Surface Elevation: Not Noted

Datum: _____

Date Completed: 4/24/96

Symbo	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Brown Gravelly Fine to Coarse SAND (SW)		SS-1	24	9.9		
		5					
			SS-2	4	14.9		
		10					
			SS-3	2	25.4		
	16'	15					
	Grey Fine to Medium SAND (SP)		SS-4	3	24.5		
		20					
	23'						
	Grey Sandy Fine to Coarse GRAVEL (GW)		SS-5	17	20.3		
	26'	25					
	Grey Clayey GRAVEL (GC)		SS-6	3	32.0		
	31'	30					
	Grey Gravelly Fine to Coarse SAND (SW)		SS-7	34	19.6		
	36'	35					
	Grey Slightly Silty Fine to Medium SAND (SP)		SS-8	15	32.2		
		40					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 209

Sheet 2 of 2
Job No. 9615

Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
▨	Grey Slightly Silty Fine to Medium SAND (SP) 42'						
▨			SS-9	19	28.5		
	Grey Gravelly Fine to Medium SAND (SP)	45					
			SS-10	21	19.8		
	51'	50					
▨			SS-11	62	17.0		
		55					
	Grey Sandy Fine to Coarse GRAVEL (GW)		SS-12	50/3"	--		
		60					
	64'		SS-13	50/6"	30.6		
	Bottom of Boring	65					
		70					
		75					
		80					

RECORD OF SUBSURFACE EXPLORATION
BORING NO. 210

Sheet 1 of 1
Job No. 9615

Project: Deschutes Parkway Renovation
Boring Location: Sta 84 + 00 28' L
Ground Water Depth: Not Noted
Surface Elevation: Not Noted

Date: _____
Datum: _____

Date Started: 4/24/96
Date Completed: 4/24/96

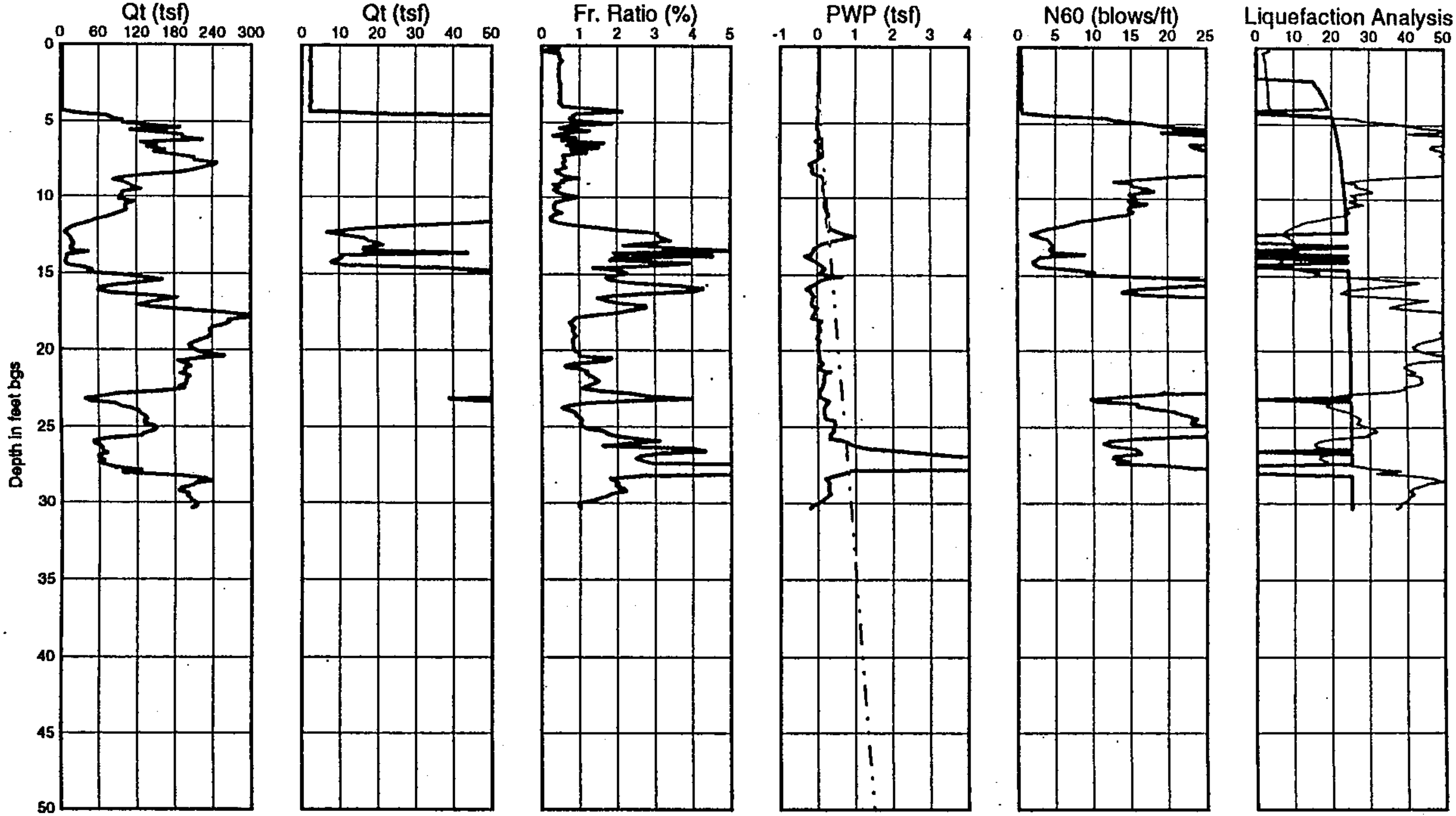
Symbol	Description	Depth	Sample	Blows Per Ft.	m.c.		Other
	Brown to Grey Slightly Gravelly Fine to Coarse SAND (SW)		SS-1	63	13.1		
		5					
			SS-2	8	21.0		
		10					
			SS-3	6	24.2		
		15					
	16'						
	Brown Fine to Medium SAND (SP)		SS-4	98	24.7		
		20					
			SS-5	77	24.0		
		25					
	29'		SS-6	50/5"	25.2		
	Bottom of Boring	30					
		35					
		40					

Cone Penetration Test - CPT-01

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a =0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Keith Brown

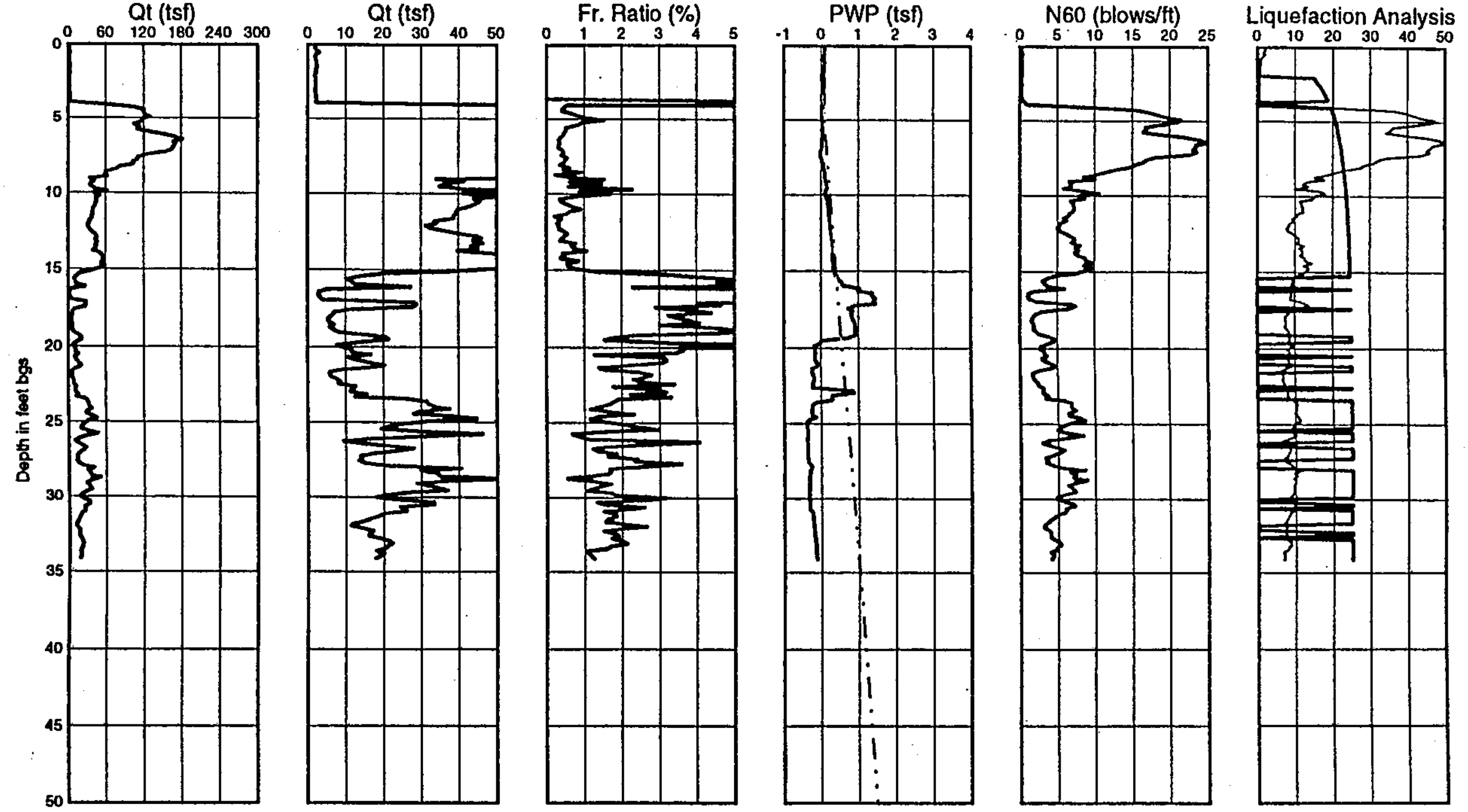
Milbor-Pita, Inc.

Cone Penetration Test - CPT-02

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a =0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Keith Brown

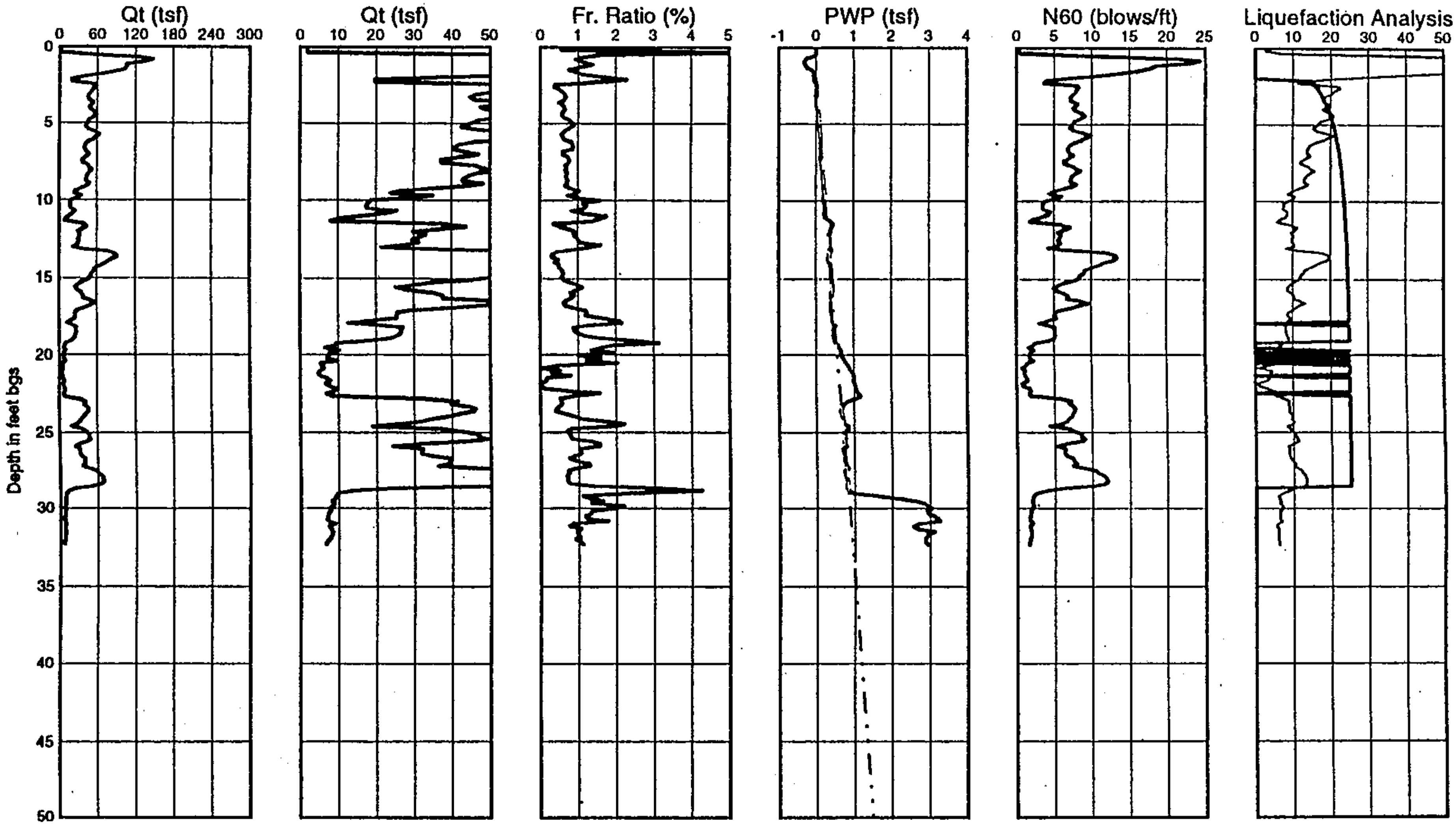
Milbor-Pita, Inc.

Cone Penetration Test - CPT-06

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a = 0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Kellh Brown

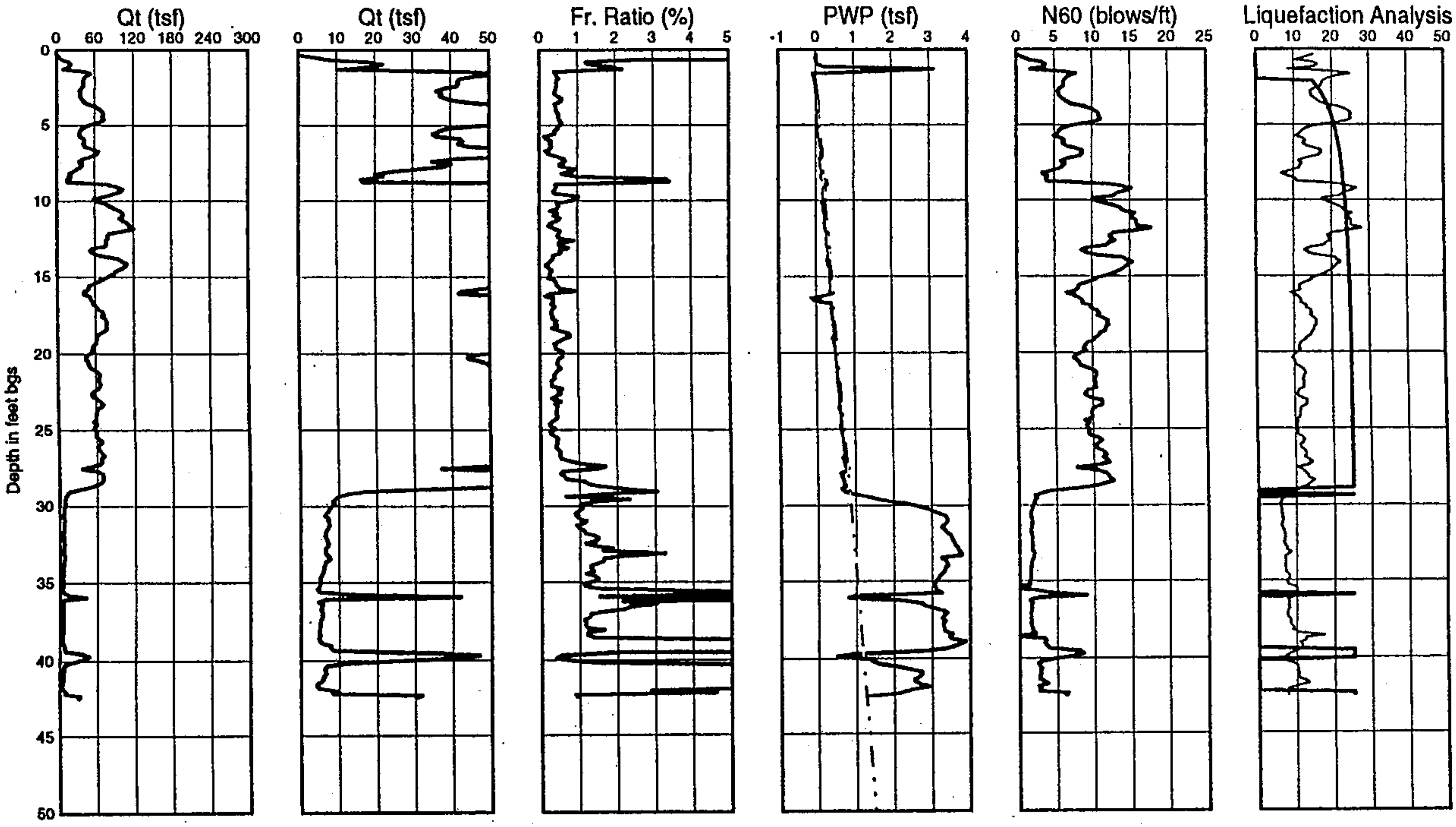
Milbor-Pita, Inc.

Cone Penetration Test - CPT-08

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Signav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a =0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Keith Brown

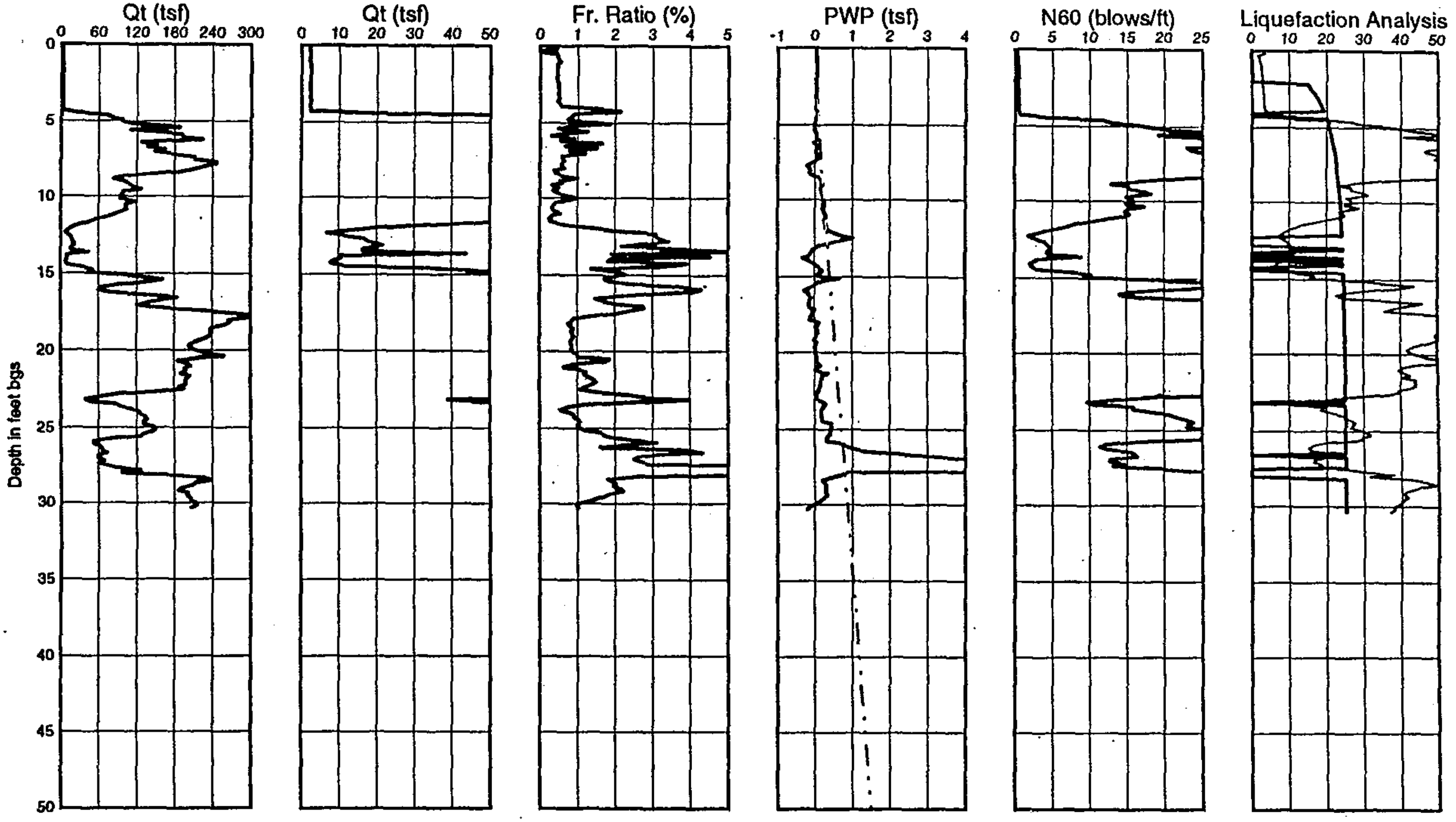
Milbor-Pita, Inc.

Cone Penetration Test - CPT-01

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a =0.3

PROJECT NO. SC-111 *DATE: January 13, 1996* *DRAWN BY: Keith Brown*

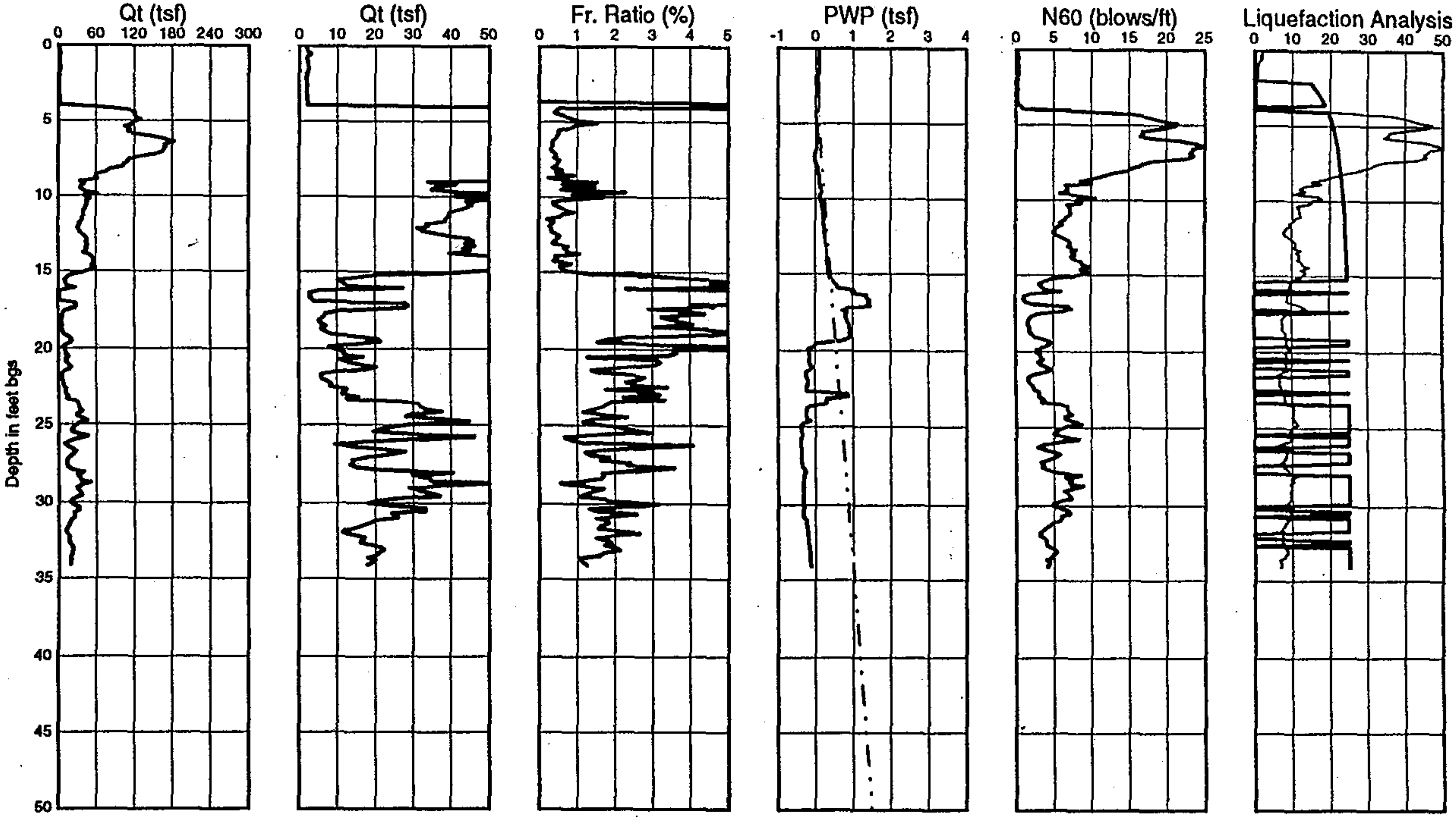
Milbor-Pita, Inc.

Cone Penetration Test - CPT-02

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; - a =0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Keith Brown

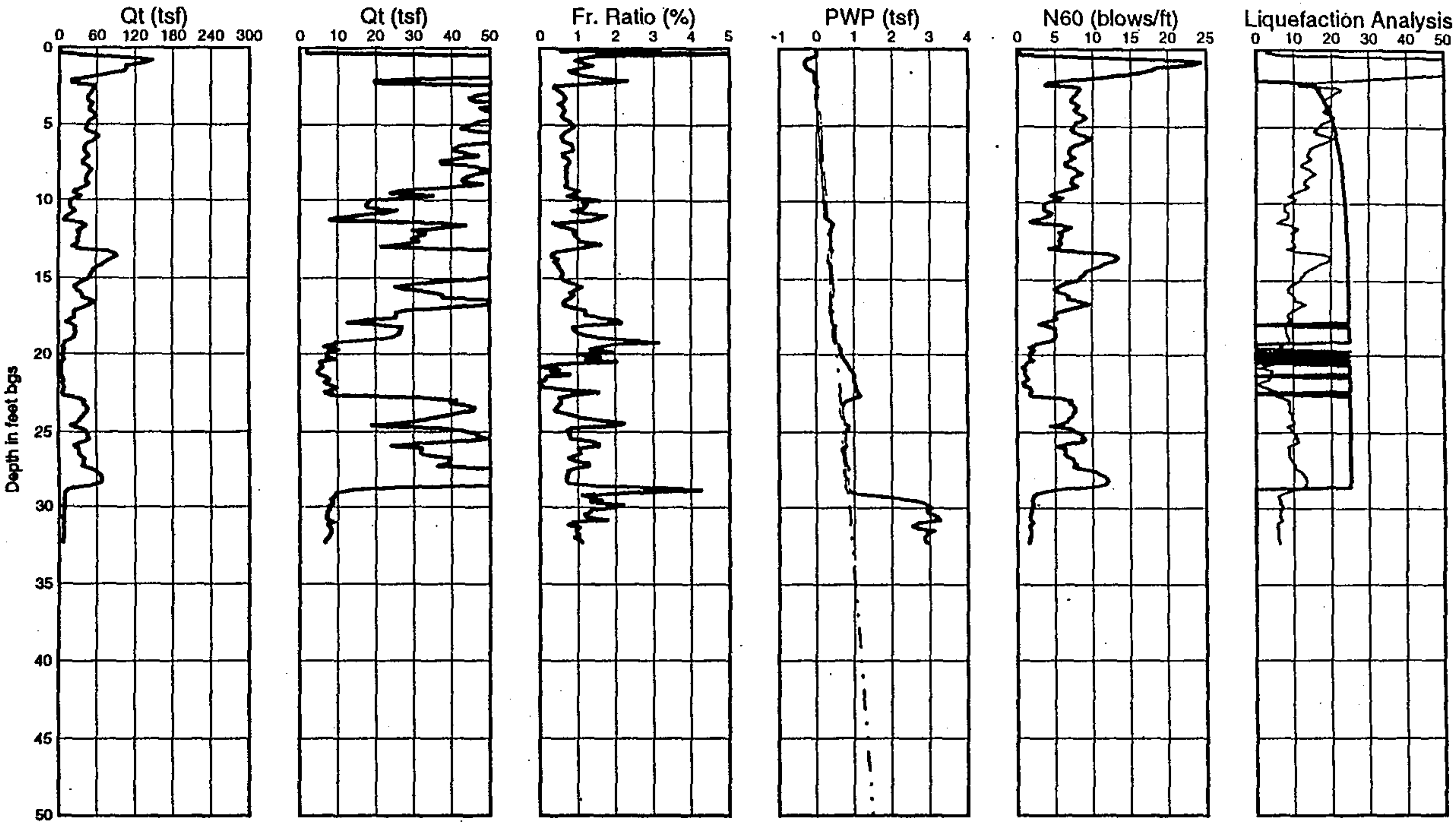
Milbor-Pita, Inc.

Cone Penetration Test - CPT-06

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*Ff/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a =0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Keith Brown

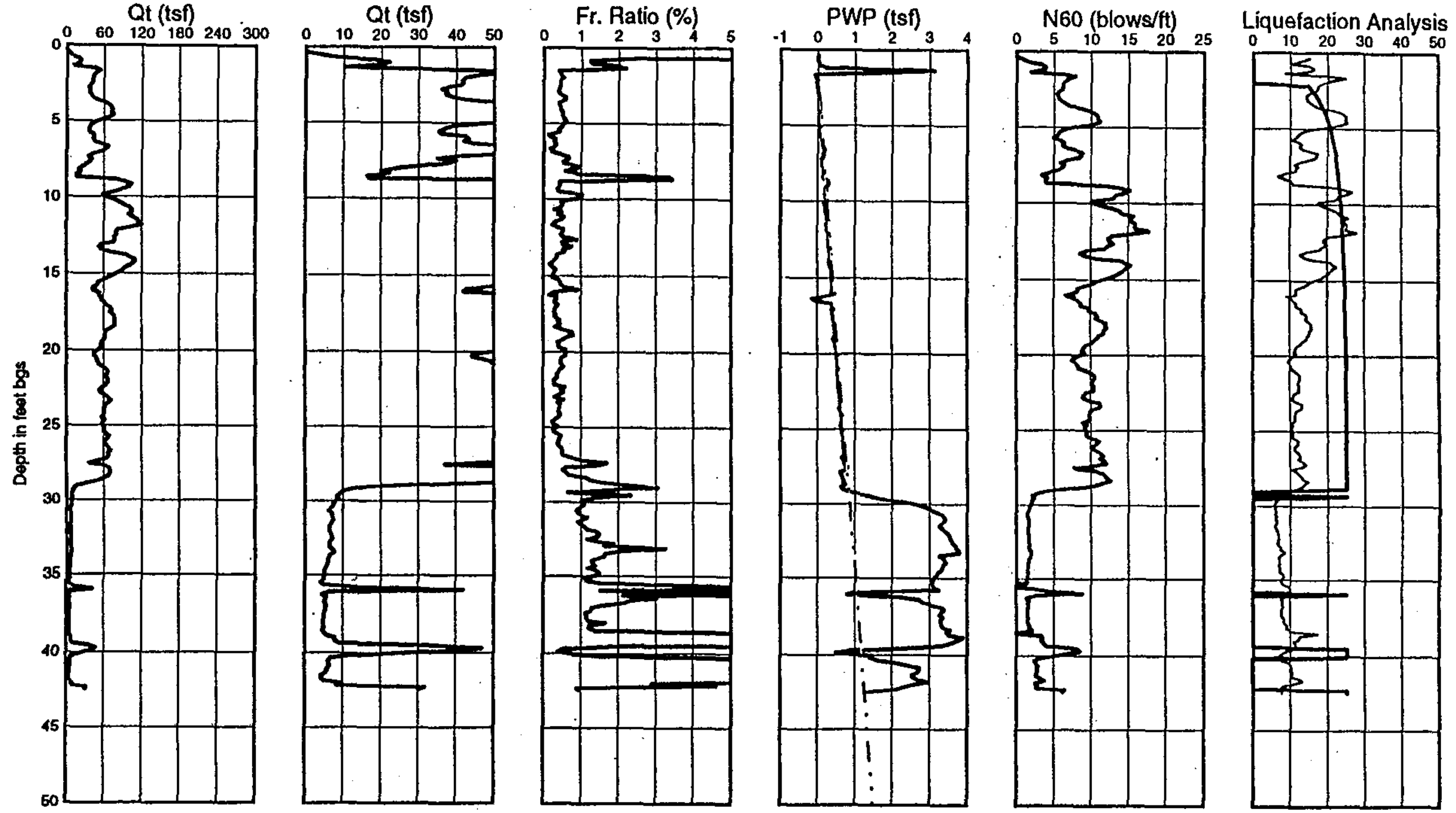
Milbor-Pita, Inc.

Cone Penetration Test - CPT-08

Test Date : Dec 18, 1995
Location : Heritage Park, Olympia, Washington

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 0.00
Water Table Depth : 2.00



Qt normalized for
unequal end area effects

Qt normalized for
unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1993)

N60 after Jefferies and Davies (1993)
Light line is estimated N60 including
silt and overburden corrections
Heavy line is N60 required to resist
liquefaction
M = 6.5; a =0.3

PROJECT NO. SC-111 DATE: January 13, 1996 DRAWN BY: Keith Brown

Milbor-Pita, Inc.

APPENDIX B

LABORATORY PROCEDURES AND RESULTS

APPENDIX B
LABORATORY PROCEDURES AND RESULTS
9-91M-11684-B

The following paragraphs describe our procedures associated with the laboratory tests that we conducted for this project. Graphical results of certain laboratory tests are enclosed in this appendix.

Visual Classification Procedures

Visual soil classifications were conducted on all samples in the field and on selected samples in our laboratory. All soils were classified in general accordance with the United Soil Classification System, which includes color, relative moisture content, primary soil type (based on grain size), and any accessory soil types. The resulting soil classifications are presented on the exploration logs contained in Appendix A.

Moisture Content Determination Procedures

Moisture content determinations were performed on representative samples to aid in identification and correlation of soil types. All determinations were made in general accordance with ASTM:D-2216. The results of these tests are shown on the exploration logs contained in Appendix A.

Atterberg Limit Determination Procedures

Atterberg limits are used primarily for classifying and indexing cohesive soils. The liquid and plastic limits, which are defined as the moisture contents of a cohesive soil at arbitrarily established limits for liquid and plastic behavior, respectively, were determined for selected samples in general accordance with ASTM:D-4318. The results of these tests are presented on the enclosed Atterberg limit graphs and on the exploration logs contained in Appendix A.

200-Wash Analyses Procedures

A "200-wash" is a procedure in which the fine-grained soil fraction is separated from the sand and gravel by washing the soil on a U.S. No. 200 sieve. A 200-wash was performed on selected soil samples obtained from our explorations in general accordance with ASTM:D-1140. The results of these analyses were used in soil classifications and are shown on the boring logs in Appendix A, and are presented in this appendix.

Grain Size Analysis Procedures

A grain size analysis indicates the range of soil particle diameters included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM:D-422. The results of these tests are presented on the enclosed grain-size distribution graphs and were used in soil classifications shown on the exploration logs contained in Appendix A.

MOISTURE CONTENT AND INPLACE DENSITY

ASTM: D2216-92, D1140-97, D2937-94

Job Name: CAPITAL LAKE SEWER
Job Number: 9-91M-11684-B
Date: 08/13/99

Page 1

ID Number:	2851.1	2851.2	2851.3	2851.4	2851.5	2851.6	2851.7	2851.8	2851.9	2851.10
Exploration:	B-1	B-1	B-2	B-3	B-4	B-5	B-5	B-6	B-6	B-7
Sample Number:	S-2	S-3	S-2	S-1	S-1	S-5	S-8	S-2	S-5	S-1
Depth:	5.0''-7.5'	10.0'-11.5'	2.5'-4.0'	2.4'-4.0'	2.5'-4.0'	12.5'-14.0'	25.0'-26.5'	5.0'-7.5'	12.5'-14.0'	2.5'-4.0'
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash		68.2%					21.5%			
Wet sample + tare:	232.4	410.3	302.8	201.9	292.7	139.9	236.2	127.6	168.2	133.8
Dry sample + tare:	181.0	349.6	284.8	191.3	263.6	122.9	195.9	99.3	136.8	126.7
Water:	51.4	60.7	18.0	10.6	29.1	17.0	40.3	28.30	31.4	7.1
Tare:	16.1	166.0	10.1	16.3	15.9	10.1	10.0	10.1	10.0	16.2
Moisture Content:	31.2%	33.1%	6.6%	6.1%	11.7%	15.1%	21.7%	31.7%	24.8%	6.4%

ID Number:	2851.11	2851.12	2851.13	2851.14	2851.15	2851.16	2851.17	2851.18	2851.19	2851.20
Exploration:	B-7	B-7	B-8	B-8	B-12	B-13	B-13	B-14	B-14	B-15
Sample Number:	S-4	S-6	S-3	S-5	S-1	S-1	S-4	S-1	S-3	S-1
Depth:	10.0'-11.5'	15.0'-15.5'	7.5'-9.0'	12.5'-14.0'	2.5'-4.0'	2.5'-4.0'	10.0'-11.5'	2.5'-4.0'	7.5'-9.0'	2.5'-4.0'
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash	22.6%		35.6%							
Wet sample + tare:	293.4	558.7	204.8	421.3				205.3	291.9	170.1
Dry sample + tare:	258.7	522.6	163.0	383.1				192.7	281.0	163.0
Water:	34.7	36.1	41.8	38.2	0.0	0.0	0.0	12.6	10.9	7.1
Tare:	9.9	400.1	10.1	221.2				10.1	222.3	10.0
Moisture Content:	13.9%	29.5%	27.3%	23.6%				6.9%	18.6%	4.6%

ID Number:	2851.21	2851.22	2851.23	2851.24	2851.25	2851.26	2851.27	2851.28	2851.29	2851.30
Exploration:	B-15	B-16	B-17	B-18	B-18	B-18	B-19	B-19	B-19	B-20
Sample Number:	S-5	S-1	S-1	S-1	S-5	S-7	S-1	S-3	S-8	S-1
Depth:	12.5'-14.0'	2.5'-4.0'	2.5'-4.0'	2.5'-4.0'	12.5'-14.0'	20.0'-21.5'	2.5'-4.0'	7.5'-9.0'	25.0'-26.5'	2.5'-4.0'
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash	64.3%				38.0%				19.6%	
Wet sample + tare:	314.3	304.5	315.6	365.0	383.7	417.5	574.3	179.8	320.3	628.8
Dry sample + tare:	247.8	262.3	300.6	355.7	308.9	356.6	568.8	152.9	294.9	595.7
Water:	66.5	42.2	15.0	9.3	74.8	60.9	5.5	26.9	25.4	33.1
Tare:	165.4	10.0	165.3	158.2	159.3	162.0	400.2	10.1	220.1	10.3
Moisture Content:	80.7%	16.7%	11.1%	4.7%	50.0%	31.3%	3.3%	18.8%	34.0%	5.7%

Reviewed by: S.E. Agaukroad

AGRA Earth and Environmental, Inc.

MOISTURE CONTENT AND INPLACE DENSITY

ASTM: D2216-92, D1140-97, D2937-94

Job Name: CAPITAL LAKE SEWER
Job Number: 9-91M-11684-B
Date: 08/13/99

ID Number:	2851.31	2851.32	2851.33	2851.34	2851.35	2851.36	2851.37	2851.38	2851.39	2851.40
Exploration:	B-20	B-20	B-21	B-21	B-21	B-22	B-22	B-23	B-23	B-23
Sample Number:	S-3	S-6	S-1	S-4	S-8	S-3	S-6	S-1	S-3	S-5
Depth:	7.5'-9.0'	15.0'-16.5'	2.5'-4.0'	10.0'-11.5'	25.0'-26.5'	7.5'-9.0'	15.0'-16.5'	2.5'-4.0'	7.5'-9.0'	2.5'-4.0'
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash	8.5%									
Wet sample + tare:	255.0	371.5	386.9	200.3	138.1	420.1	221.0	253.8	208.1	88.7
Dry sample + tare:	247.2	344.8	355.6	173.6	114.2	359.7	184.1	222.3	179.7	68.4
Water:	7.8	26.7	31.3	26.7	23.9	60.4	36.9	31.50	28.4	20.3
Tare:	162.7	219.9	10.0	9.9	10.0	162.9	10.1	10.1	10.0	16.1
Moisture Content:	9.2%	21.4%	9.1%	16.3%	22.9%	30.7%	21.2%	14.8%	16.7%	38.8%

ID Number:	2851.41	2851.42	2851.43	2851.44	2851.45	2851.46	2851.47	2851.48	2851.49	2851.50
Exploration:	B-24	B-24	B-24	B-25	B-25	B-25	B-26	B-26	B-26	B-27
Sample Number:	S-1	S-3	S-7	S-3	S-5	S-8	S-2	S-5	S-9	S-2
Depth:	2.5'-4.0'	7.5'-9.0'	25.0'-26.5'	7.5'-9.0'	12.5'-14.0'	25.0'-26.5'	5.0'-6.5'	2.5'-14.0'	30.0'-31.5'	5.0'-7.5'
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash						59.2%				
Wet sample + tare:	386.9	147.9	195.0	133.3	239.8	267.9	337.6	125.0	243.2	92.1
Dry sample + tare:	362.8	123.6	176.3	117.0	167.7	213.1	284.5	101.4	192.3	80.9
Water:	24.1	24.3	18.7	16.3	72.1	54.8	53.1	23.6	50.9	11.2
Tare:	10.2	16.1	16.0	16.5	10.2	9.8	9.9	16.1	16.5	16.1
Moisture Content:	6.8%	22.6%	11.7%	16.2%	45.8%	27.0%	19.3%	27.7%	29.0%	17.3%

ID Number:	2851.51									
Exploration:	B-27									
Sample Number:	S-6									
Depth:	15.0'-16.5'									
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash										
Wet sample + tare:	389.7									
Dry sample + tare:	360.0									
Water:	29.7									
Tare:	155.8									
Moisture Content:	14.5%									

Reviewed by: S. E. Bzeulwood

AGRA Earth and Environmental, Inc.

MOISTURE CONTENT AND INPLACE DENSITY

ASTM: D2216-92, D1140-97, D2937-94

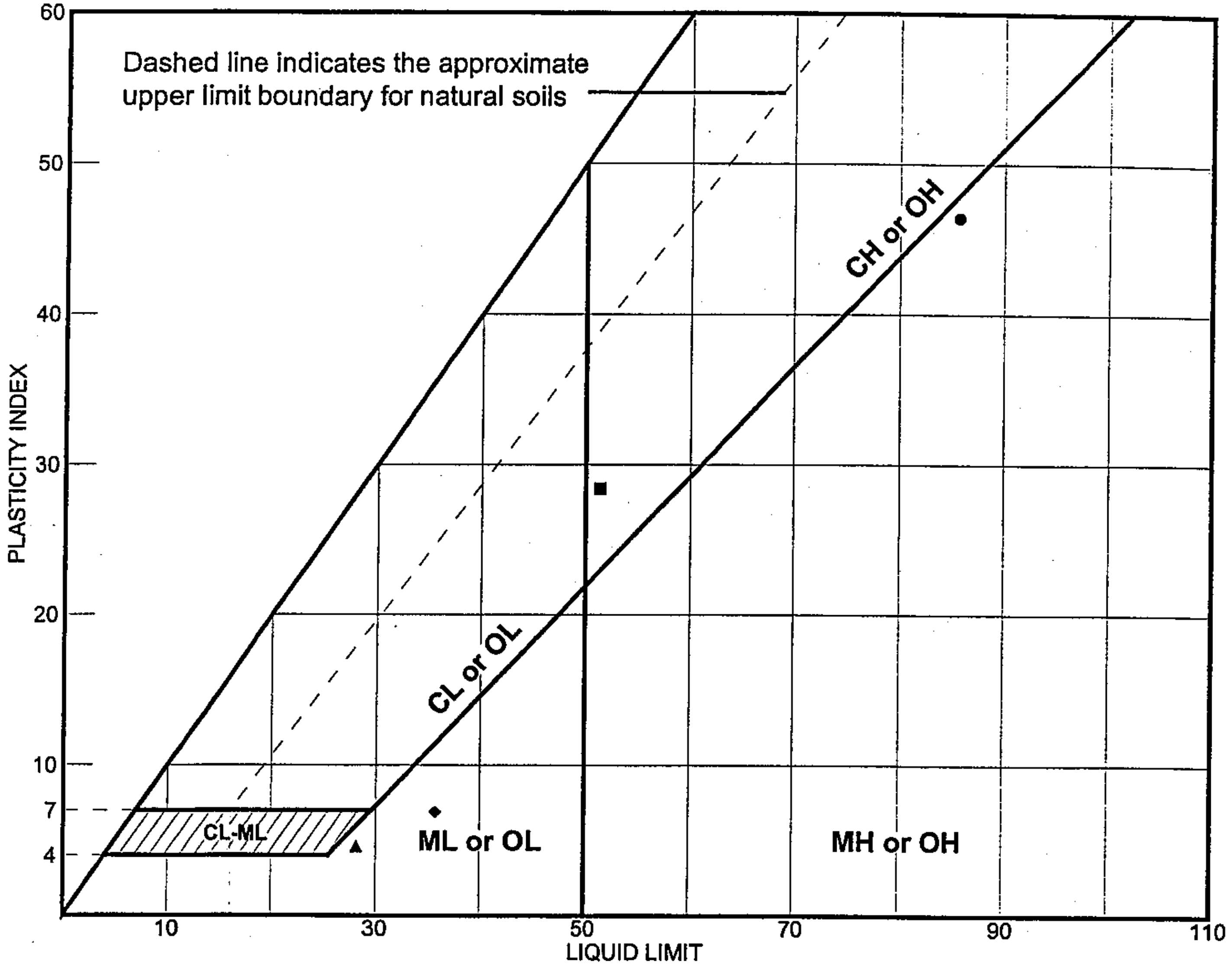
Job Name: LOTT CAPITOL LAKE SOUTHERN CONNECTION
Job Number: 9-91M-11684-B
Date: 01/27/00
Page 3

ID Number:	3129.1	3129.1	3129.2	3129.3	3129.4	3129.5	3129.7	3129.8.	3129.9.1	3129.17.1
Exploration:	B-28	B-28	B-28	B-28	B-29	B-29	B-29	B-29	B-30	B-31
Sample Number:	S-3a	S-3b	S-4	S-7	S-1	S-2	S-5	S-7	S-1	S-3
Depth:	10.1'-10.3'	10.3'-11.5'	12.5'-14.0'	25.0'-26.5'	5.0'-6.5'	7.5'-9.0'	15.0'-16.5'	25.0'-26.5'	2.5'-4.0'	7.5'-9.0'
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash				17.8%				54.4%		
Wet sample + tare:	199.5	269.6	302.8	332.3	177.6	192.9	274.1	282.2	213.2	205.5
Dry sample + tare:	187.4	244.6	273.9	289.2	172.2	184.2	236.4	246.9	203.7	198.0
Water:	12.1	25.0	28.9	43.1	5.4	8.7	37.7	35.3	9.5	7.5
Tare:	158.9	159.2	162.5	163.5	156.4	155.8	165.9	161.9	157.7	165.3
Moisture Content:	42.5%	29.3%	25.9%	34.3%	34.2%	30.6%	53.5%	41.5%	20.7%	22.9%

ID Number:	3129.2									
Exploration:	B-31									
Sample Number:	S-7									
Depth:	20.0'-21.5'									
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash	23.9%									
Wet sample + tare:	255.4									
Dry sample + tare:	232.6									
Water:	22.8									
Tare:	157.7									
Moisture Content:	30.4%									

ID Number:										
Exploration:										
Sample Number:										
Depth:										
Wet weight:										
Dia. of sample:										
Length of Sample:										
Volume (cf):										
Wet Density:										
Dry Density:										
-#200 Wash										
Wet sample + tare:										
Dry sample + tare:										
Water:										
Tare:										
Moisture Content:										

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●		B-15 / S-5	12.5-14'	80.7%	39.3	85.7	46.4	MH
■		B-18 / S-5	12.5-14'	50.0%	23.0	51.4	28.4	SC
▲		B-25 / S-8	25-26.5'	27.0%	23.6	28.2	4.6	ML
◆		B-29 / S-5	15-16.5'	53.5%	28.8	35.7	6.9	ML

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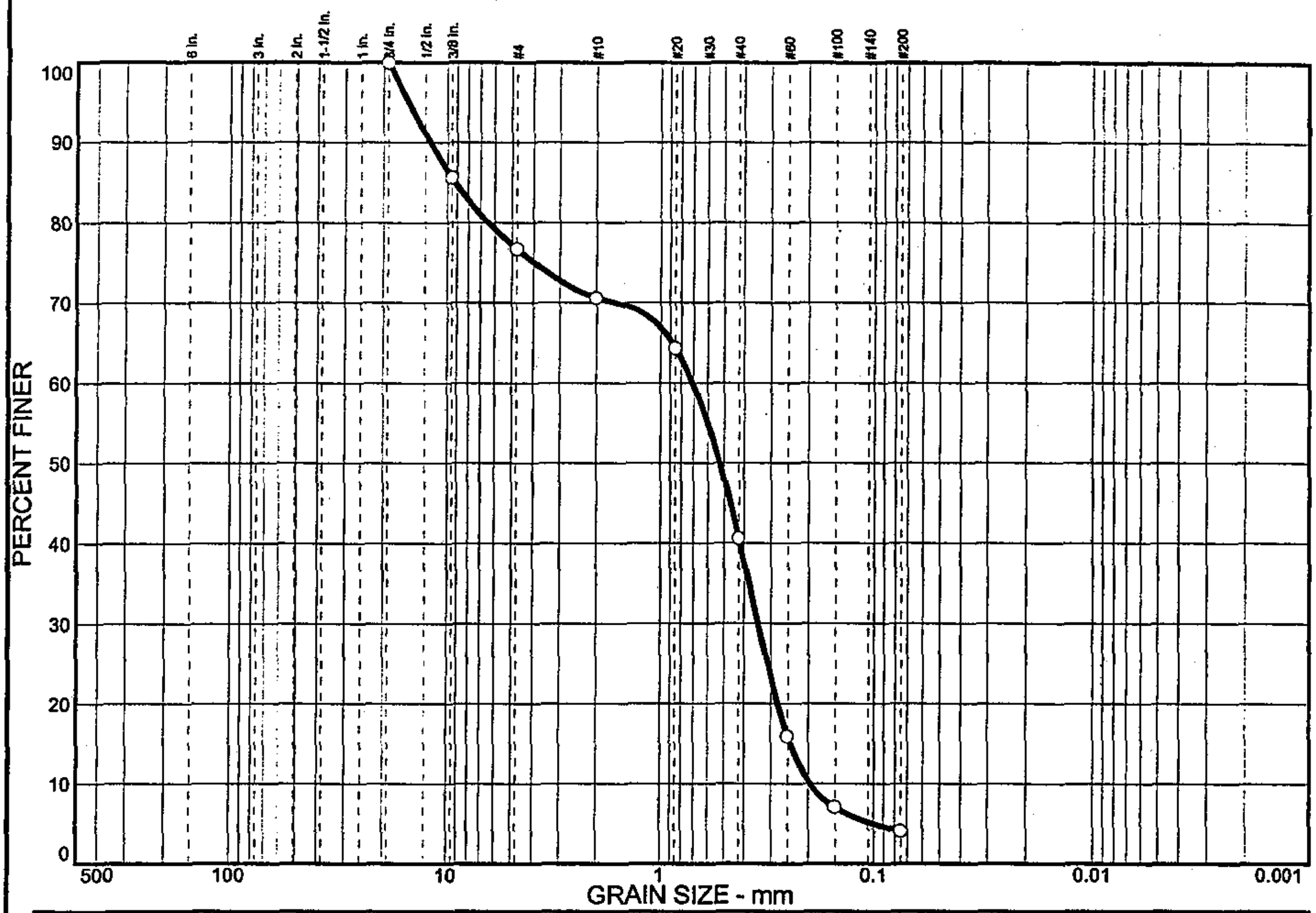
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: LOTT CAPITAL LAKE SOUTHERN CONNECTION

Project No.: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	23.3	72.6	4.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	85.6		
#4	76.7		
#10	70.6		
#20	64.3		
#40	40.6		
#60	15.9		
#100	7.1		
#200	4.1		

* (no specification provided)

Soil Description

Gravelly sand trace silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 9.19 D_{60}= 0.707 D_{50}= 0.526
D_{30}= 0.344 D_{15}= 0.243 D_{10}= 0.196
C_u= 3.61 C_c= 0.85

Classification

USCS= AASHTO=

Remarks

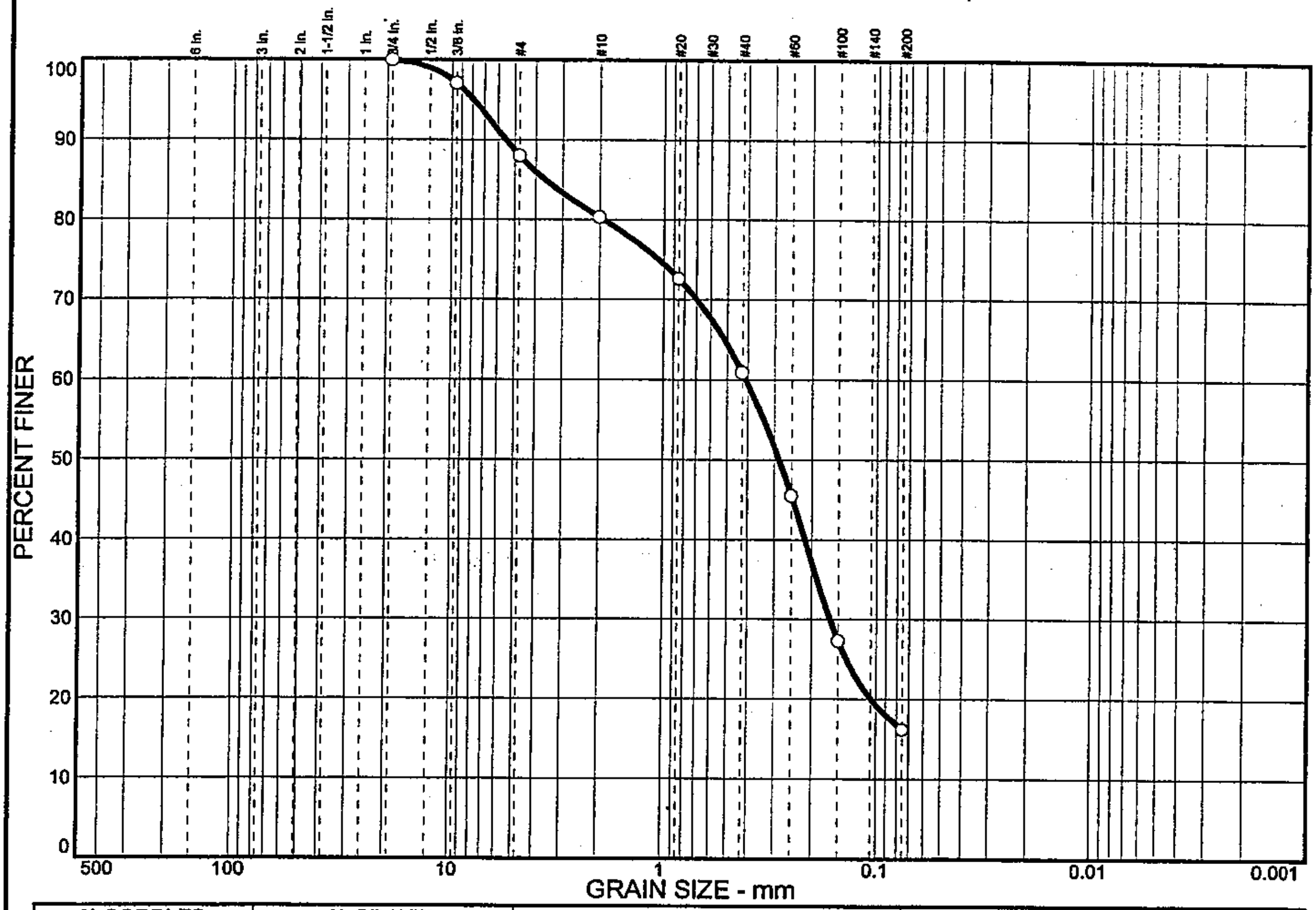
Tested by: AL
Reviewed by: ML

Sample No.: #2851.29 **Source of Sample:** **Date:** 8-13-99
Location: B-5 / S-5 **Elev./Depth:** 12.5-14'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	12.0	71.8	16.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	97.1		
#4	88.0		
#10	80.3		
#20	72.6		
#40	60.9		
#60	45.5		
#100	27.3		
#200	16.2		

* (no specification provided)

Soil Description

Silty fine sand some gravel

Atterberg Limits

PL=
LL=
PI=

Coefficients

D_{85}= 3.62
D_{60}= 0.409
D_{50}= 0.285
D_{30}= 0.164
D_{15}=
D_{10}=
C_u=
C_c=

Classification

USCS=
AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.27
Location: B-6 / S-2
Source of Sample:
Date: 8-13-99
Elev./Depth: 5.0-7.5'

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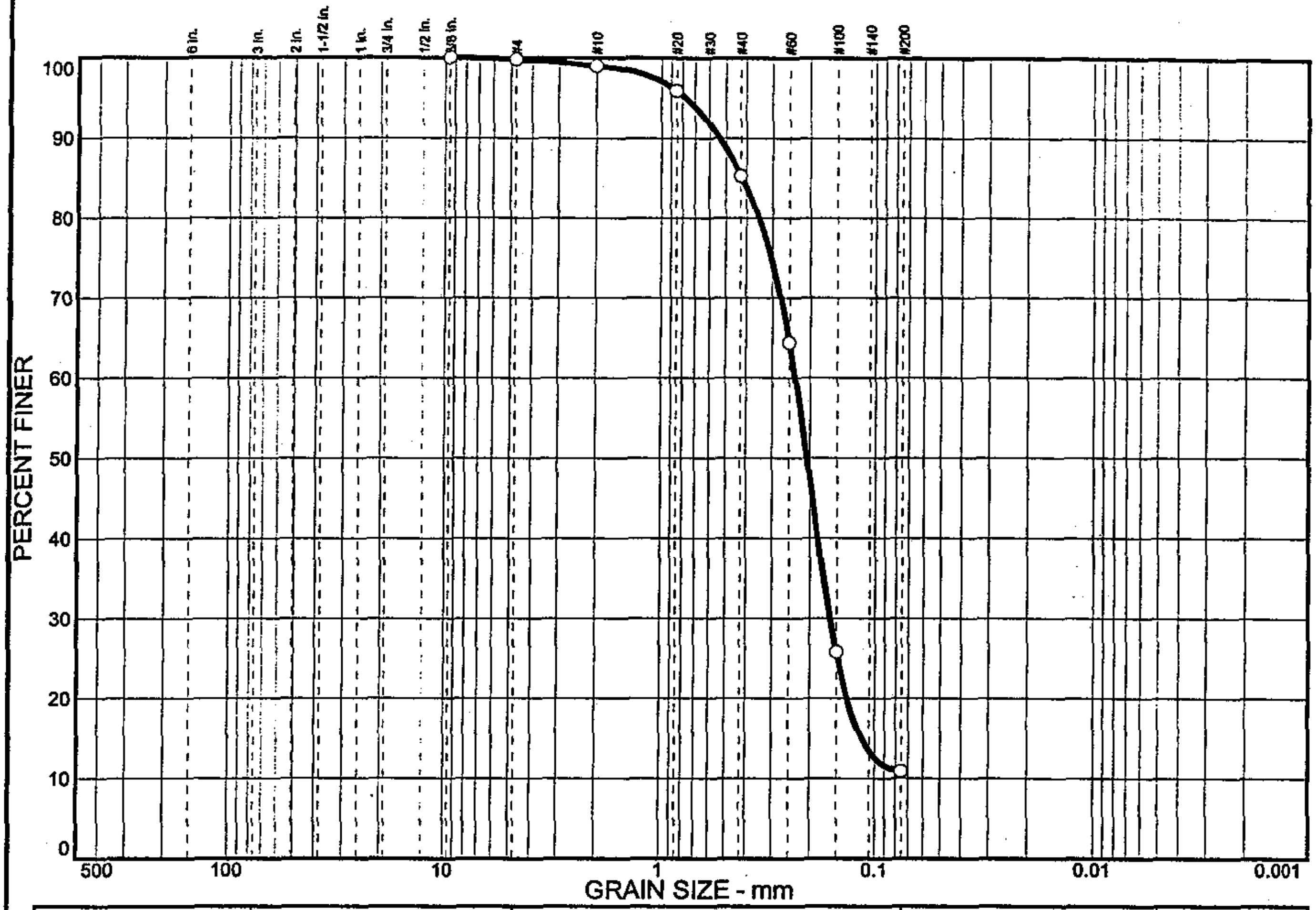
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.2	88.9	10.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	99.8		
#10	99.0		
#20	95.9		
#40	85.3		
#60	64.4		
#100	25.8		
#200	10.9		

* (no specification provided)

Soil Description

Fine sand some silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.420 D_{60}= 0.235 D_{50}= 0.207
D_{30}= 0.160 D_{15}= 0.115 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.28
Location: B-6 / S-5
Source of Sample:
Date: 8-13-99
Elev./Depth: 12.5-14'

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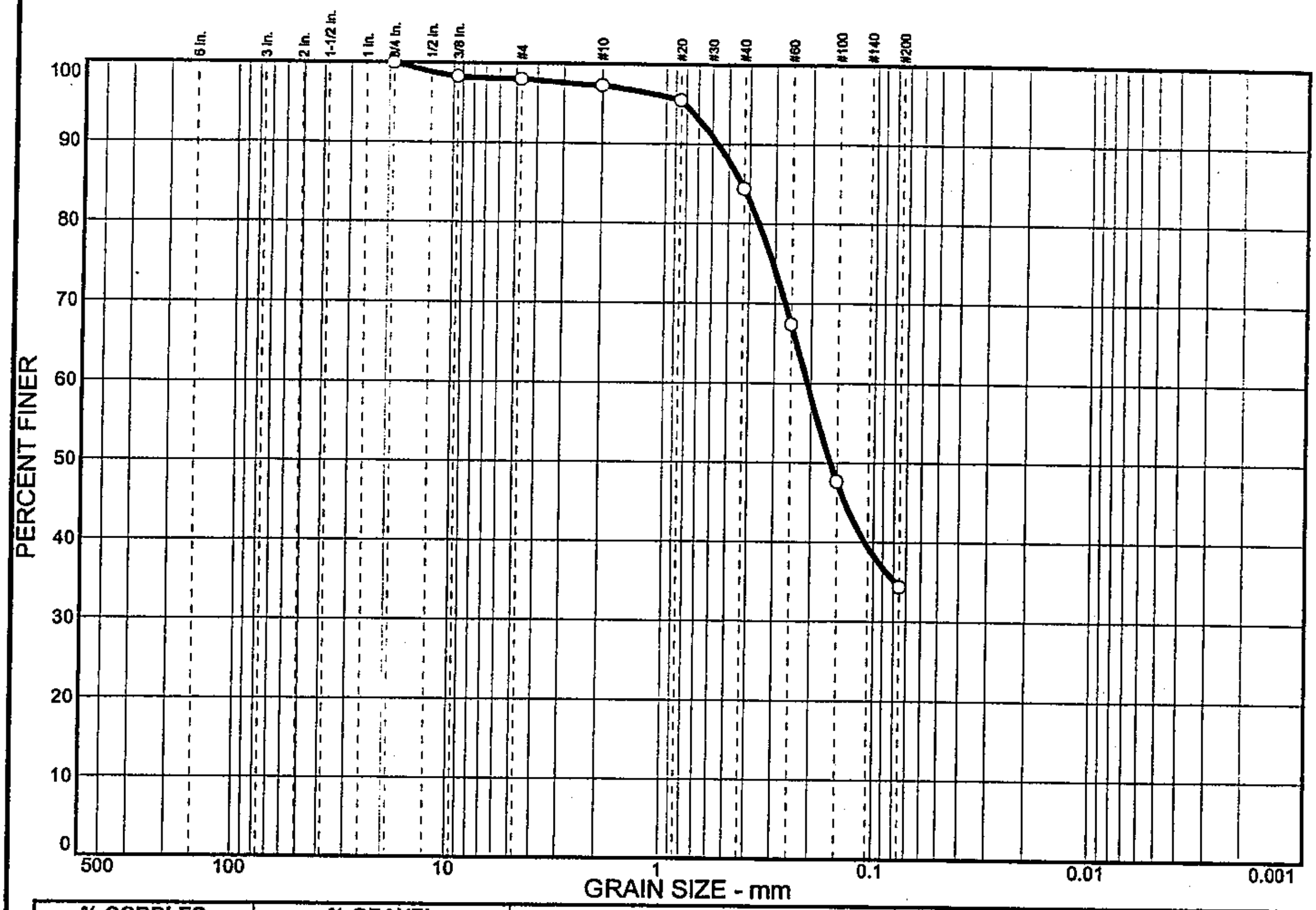
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	2.0	63.6	34.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	98.3		
#4	98.0		
#10	97.3		
#20	95.5		
#40	84.4		
#60	67.4		
#100	47.6		
#200	34.4		

* (no specification provided)

Soil Description

Silty fine sand trace gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.436 D_{60}= 0.208 D_{50}= 0.161
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

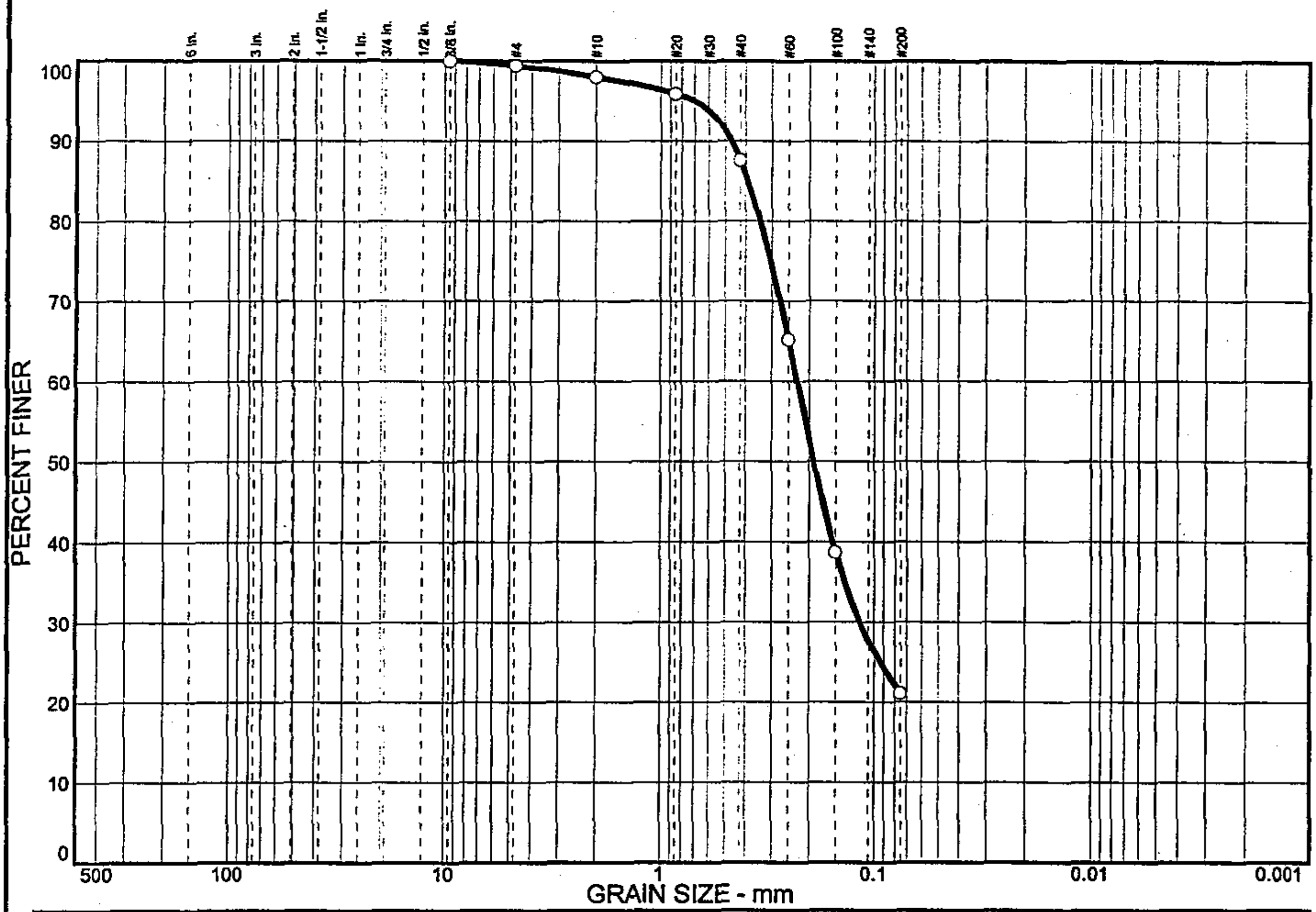
Tested by: AL
Reviewed by: ML

Sample No.: #2851.26
Location: B-7 / S-6
Source of Sample:
Date: 8-13-99
Elev./Depth: 15-16.5'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.6	78.3	21.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	99.4		
#10	98.0		
#20	95.9		
#40	87.6		
#60	65.2		
#100	38.7		
#200	21.1		

* (no specification provided)

Soil Description

Silty fine sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.390 D_{60}= 0.227 D_{50}= 0.189

D_{30}= 0.116 D_{15}= D_{10}=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL

Reviewed by: ML

Sample No.: #2851.23 **Source of Sample:** **Date:** 8-13-99

Location: B-8 / S-5 **Elev./Depth:** 12.5-14'

AGRA Earth & Environmental

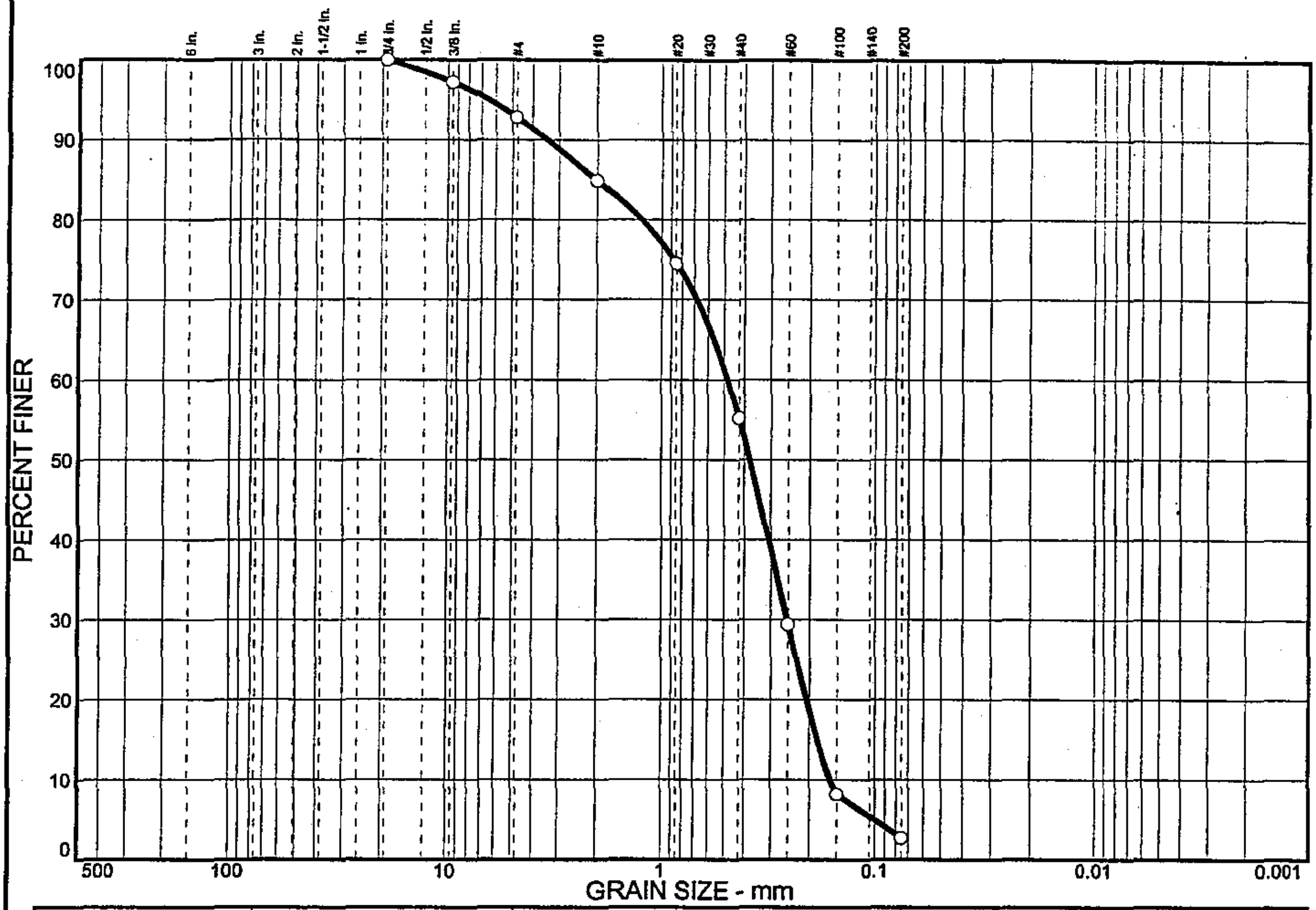
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX

Project: CAPITAL LAKE SEWER

Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	7.2	90.1	2.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	97.2		
#4	92.8		
#10	84.9		
#20	74.5		
#40	55.2		
#60	29.4		
#100	8.2		
#200	2.7		

* (no specification provided)

Soil Description

Sand some gravel trace silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 2.02 D_{60}= 0.482 D_{50}= 0.377

D_{30}= 0.253 D_{15}= 0.183 D_{10}= 0.160

C_u= 3.02 C_c= 0.83

Classification

USCS= AASHTO=

Remarks

Tested by: AL

Reviewed by: ML

Sample No.: #2851.51

Location: B-20 / S-6

Source of Sample:

Date: 8-13-99

Elev./Depth: 15-16.5'

AGRA Earth & Environmental

ENGINEERING GLOBAL SOLUTIONS

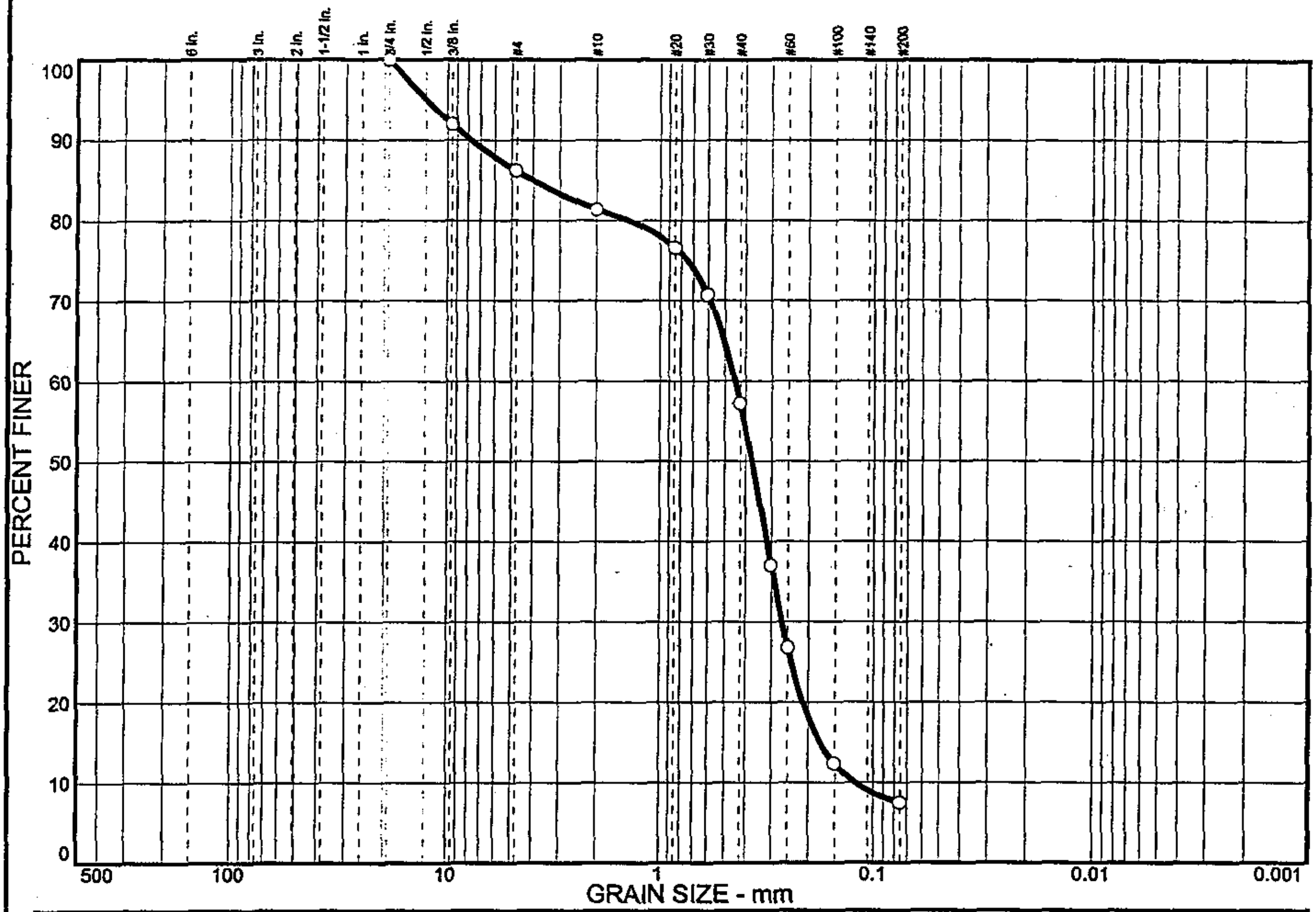
Client: PARAMETRIX

Project: CAPITAL LAKE SEWER

Project No: 11684-B

Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	13.8	78.7	7.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	92.0		
#4	86.2		
#10	81.4		
#20	76.6		
#30	70.7		
#40	57.2		
#50	37.0		
#60	26.8		
#100	12.4		
#200	7.5		

* (no specification provided)

Soil Description

Gravelly fine sand some silt
MC: 16.3%

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 3.97 D_{60}= 0.450 D_{50}= 0.373
D_{30}= 0.266 D_{15}= 0.175 D_{10}= 0.121
C_u= 3.72 C_c= 1.30

Classification

USCS= AASHTO=

Remarks

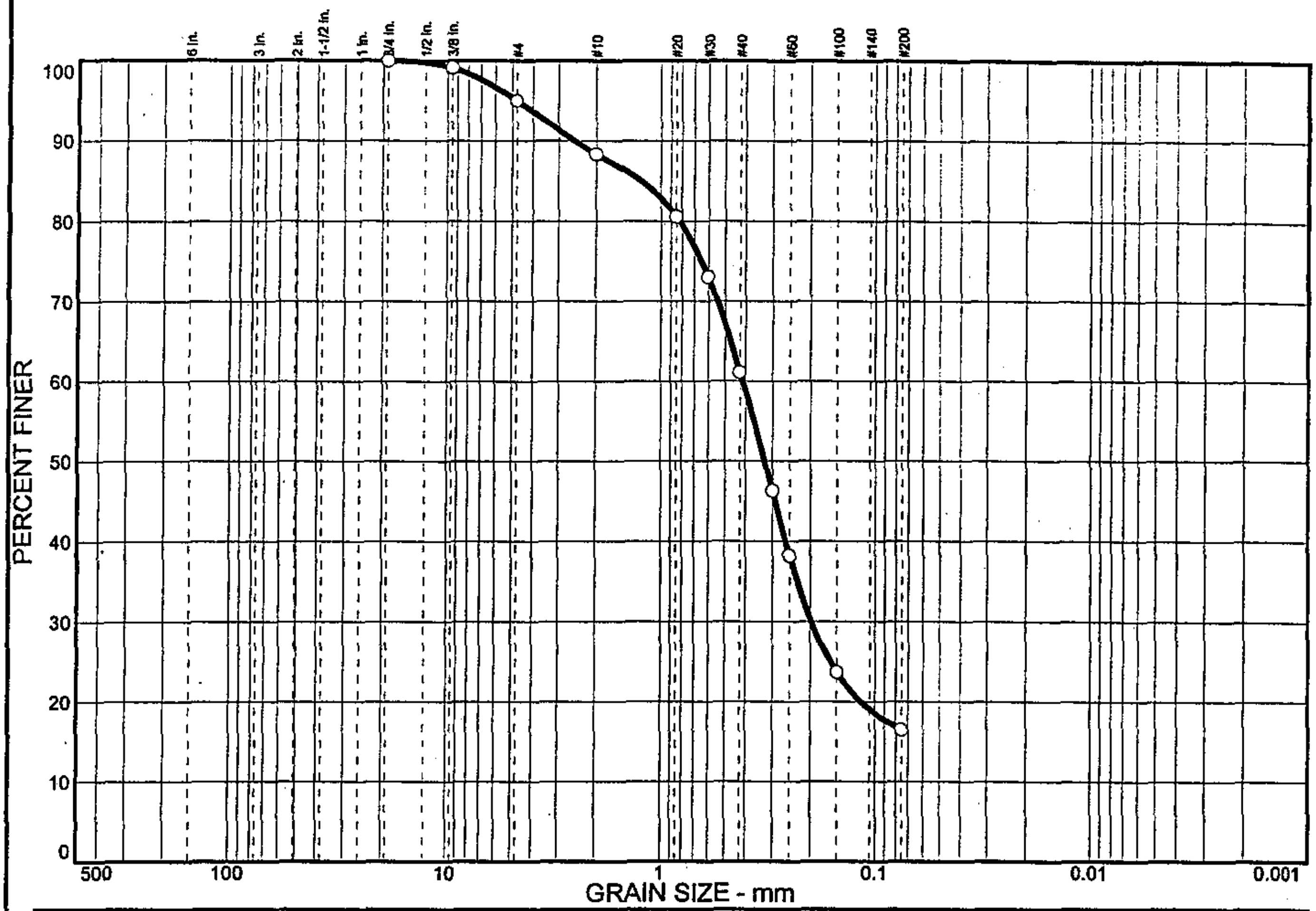
Tested by: JW,AL
Reviewed by: ML

Sample No.: #2851.4
Location: B-21 / S-4
Source of Sample:
Date: 8-5-99
Elev./Depth: 10-11.5'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	5.0	78.5	16.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	99.1		
#4	95.0		
#10	88.3		
#20	80.6		
#30	73.0		
#40	61.1		
#50	46.3		
#60	38.2		
#100	23.7		
#200	16.5		

* (no specification provided)

Soil Description

Silty fine sand trace gravel
MC: 22.9%

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 1.23 D_{60}= 0.413 D_{50}= 0.326
D_{30}= 0.197 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: JW,AL
Reviewed by: ML

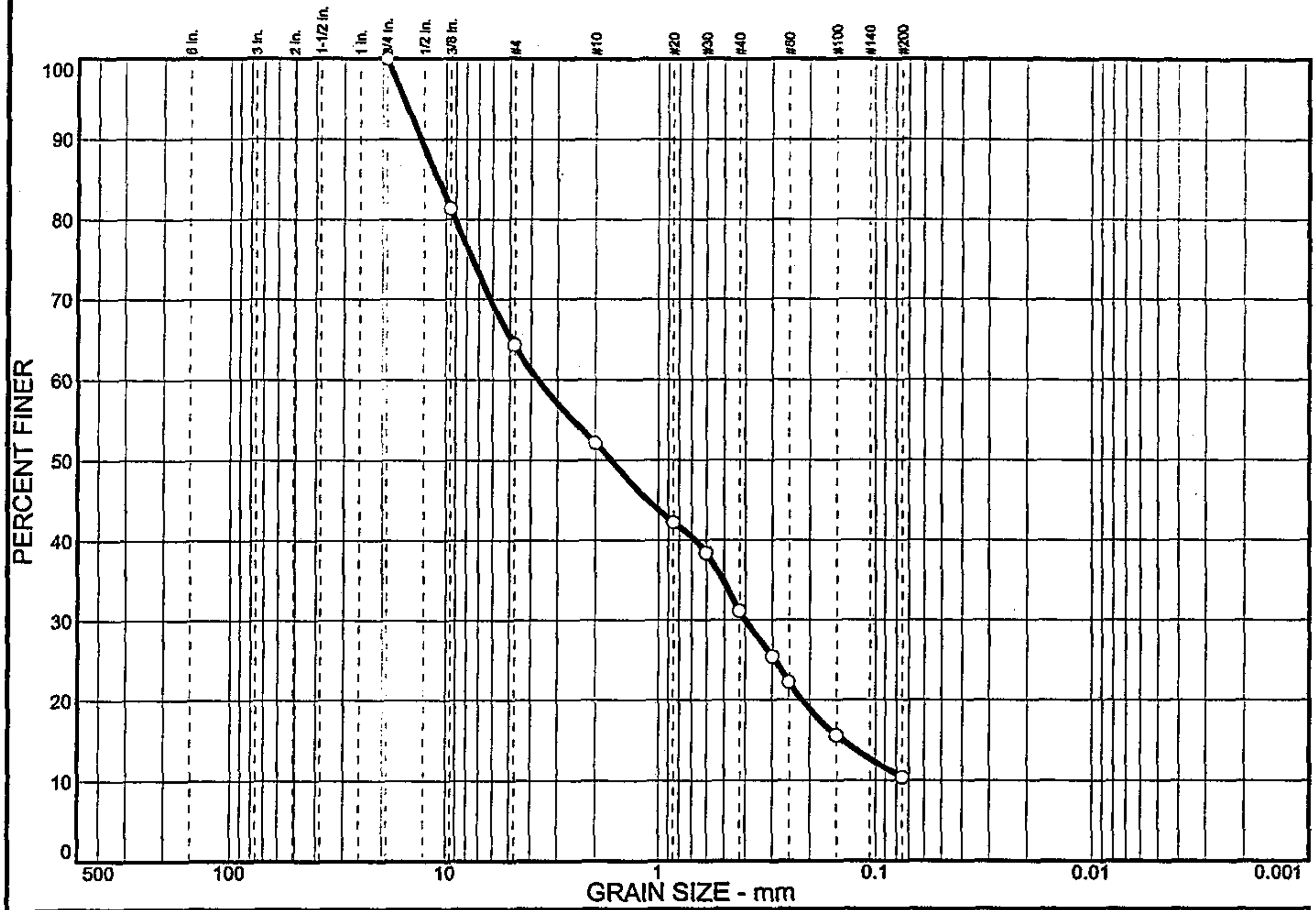
Sample No.: #2851.5 **Source of Sample:** **Date:** 8-5-99
Location: B-21 / S-8 **Elev./Depth:** 25-26.5'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER

Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	35.7	53.9	10.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	81.4		
#4	64.3		
#10	52.1		
#20	42.2		
#30	38.4		
#40	31.1		
#50	25.4		
#60	22.2		
#100	15.6		
#200	10.4		

* (no specification provided)

Soil Description

Gravelly sand some silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 10.9 D_{60}= 3.71 D_{50}= 1.69
D_{30}= 0.401 D_{15}= 0.141 D_{10}=
C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.6
Location: B-22 / S-3
Source of Sample:
Date: 8-12-99
Elev./Depth: 7.5-9.0'

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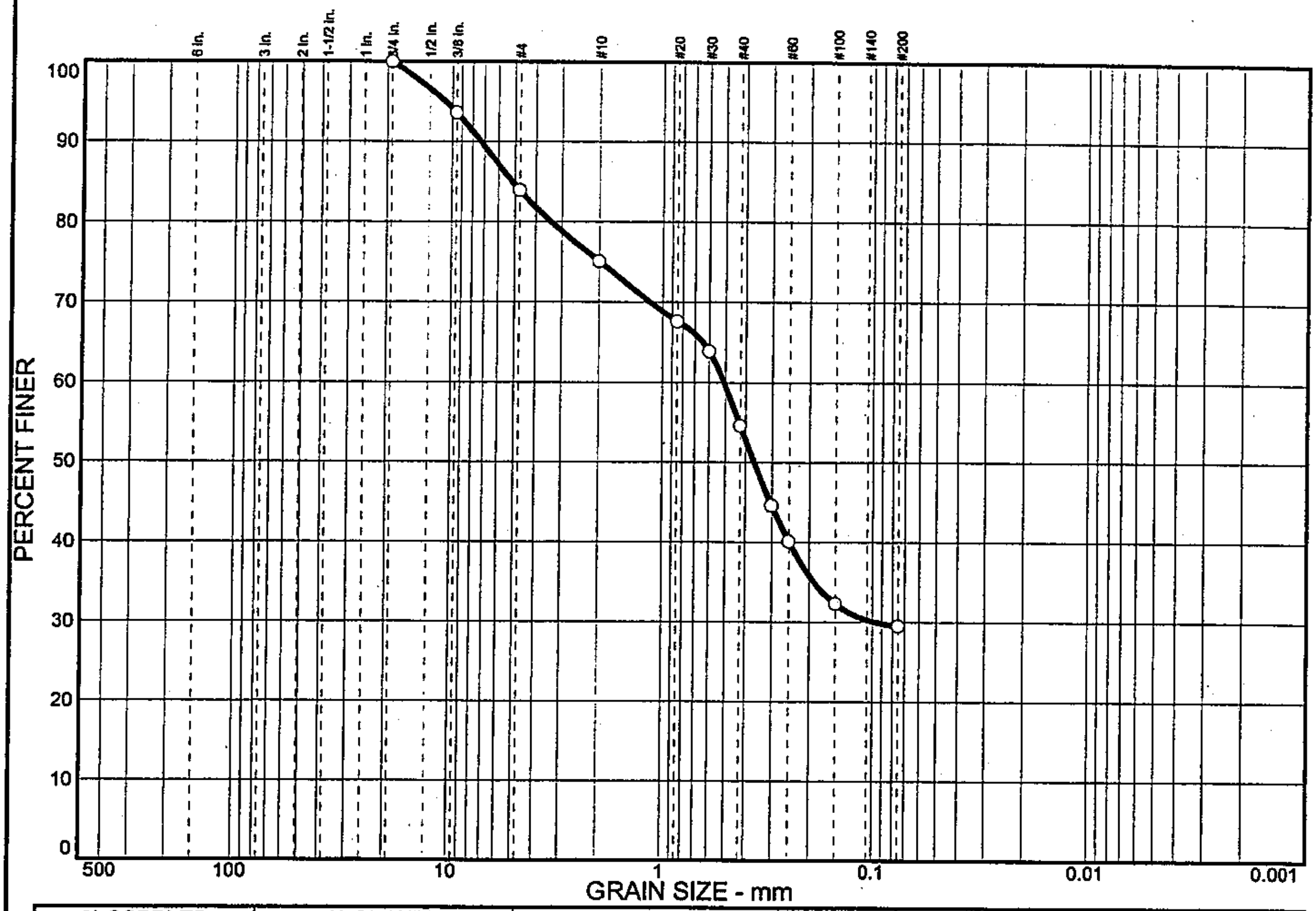
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	16.1	54.4	29.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	93.6		
#4	83.9		
#10	75.1		
#20	67.6		
#30	63.9		
#40	54.6		
#50	44.6		
#60	40.1		
#100	32.3		
#200	29.5		

* (no specification provided)

Soil Description

Silty gravelly sand
MC: 21.2%

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 5.16 D_{60}= 0.510 D_{50}= 0.364
D_{30}= 0.0974 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

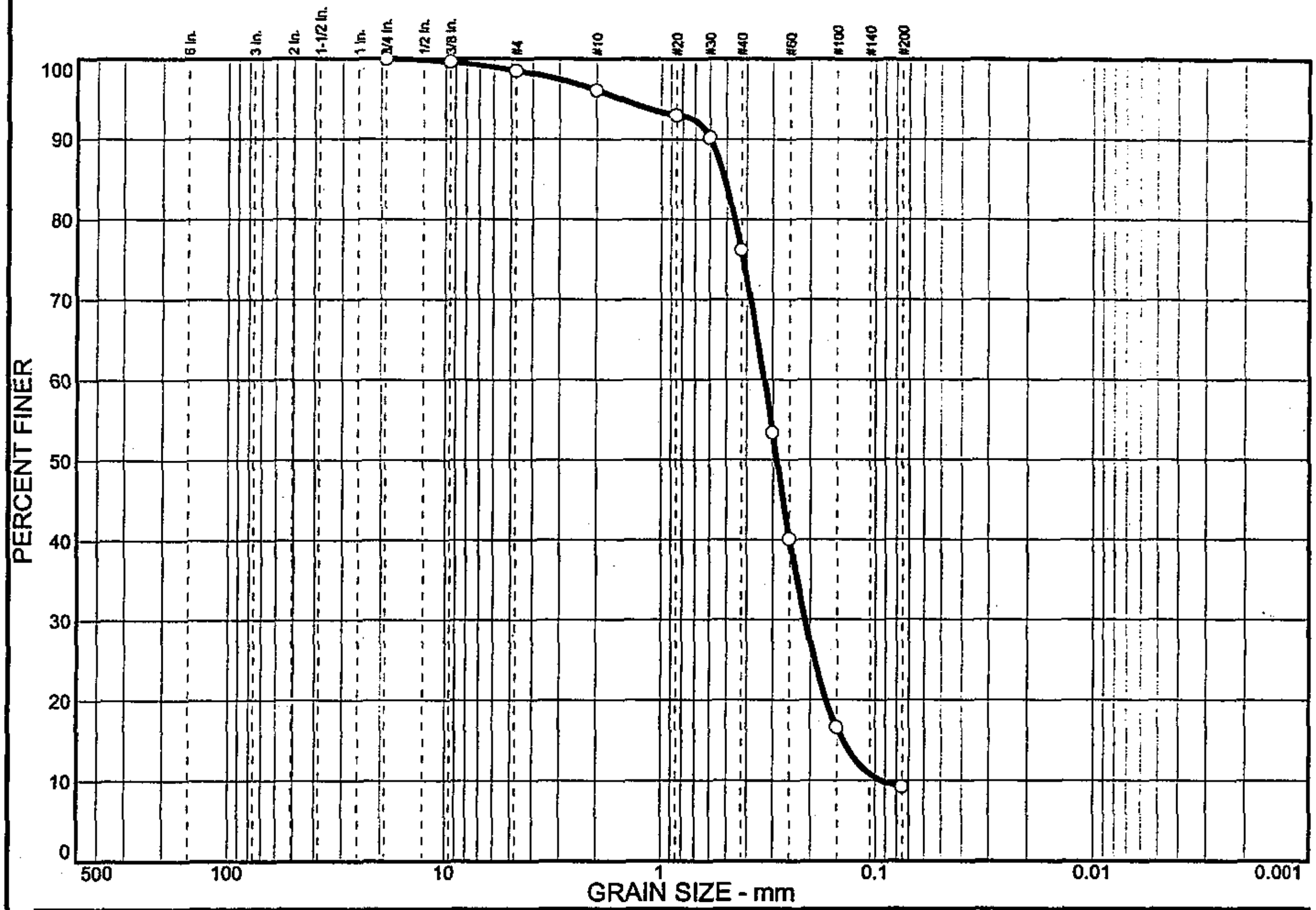
Tested by: AL,JW
Reviewed by: ML

Sample No.: #2851.7
Location: B-22 / S-6
Source of Sample:
Date: 8-5-99
Elev./Depth: 15-16.5'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	1.5	89.3	9.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	99.6		
#4	98.5		
#10	96.1		
#20	93.0		
#30	90.2		
#40	76.2		
#50	53.4		
#60	40.1		
#100	16.6		
#200	9.2		

* (no specification provided)

Soil Description

Fine sand some silt trace gravel
MC: 16.7%

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.509 D_{60}= 0.329 D_{50}= 0.287
D_{30}= 0.211 D_{15}= 0.140 D_{10}= 0.0934
C_u= 3.52 C_c= 1.46

Classification

USCS= AASHTO=

Remarks

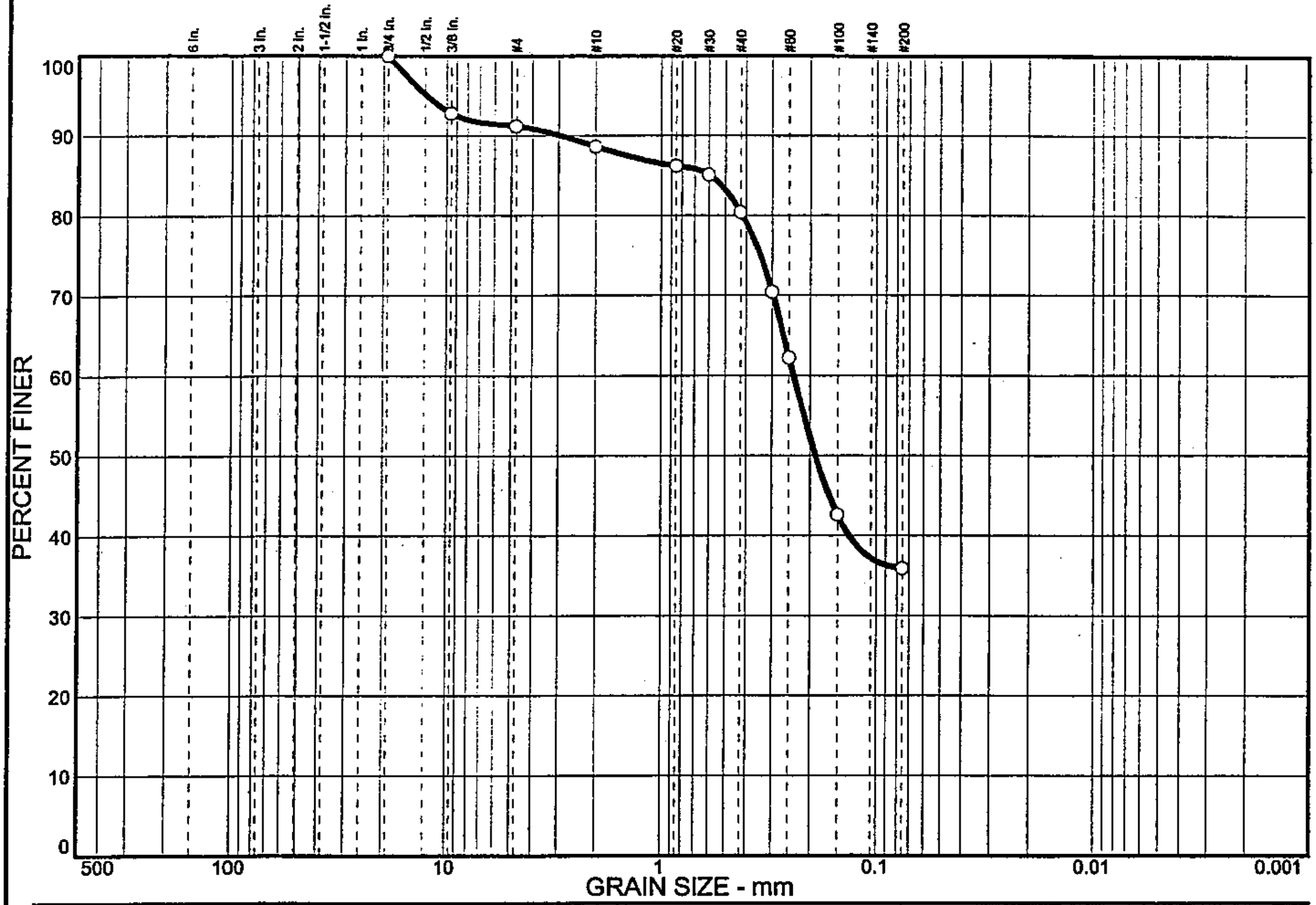
Tested by: JW,AL
Reviewed by: ML

Sample No.: #2851.9 **Source of Sample:** **Date:** 8-5-99
Location: B-23 / S-3 **Elev./Depth:** 7.5-9.0'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	8.8	55.3	35.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	92.8		
#4	91.2		
#10	88.6		
#20	86.2		
#30	85.1		
#40	80.4		
#50	70.4		
#60	62.2		
#100	42.6		
#200	35.9		

* (no specification provided)

Soil Description

Silty fine sand some gravel
MC: 39.2%

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.592 D_{60}= 0.238 D_{50}= 0.188
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: JW,AL
Reviewed by: ML

Sample No.: #2851.10 **Source of Sample:** **Date:** 8-5-99
Location: B-23 / S-5 **Elev./Depth:** 2.5-4.0'

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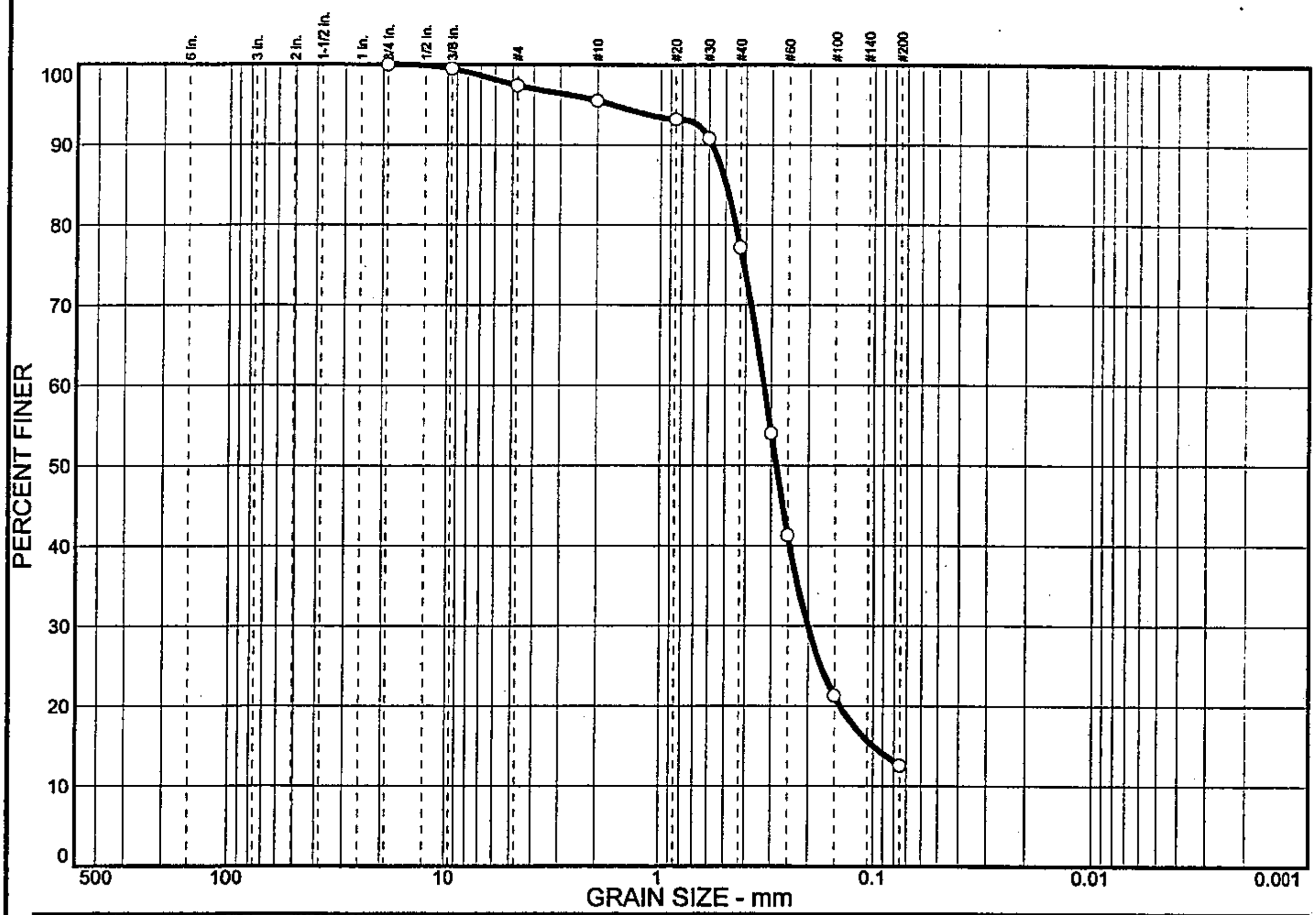
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	2.6	84.8	12.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	99.5		
#4	97.4		
#10	95.5		
#20	93.2		
#30	90.8		
#40	77.2		
#50	54.0		
#60	41.3		
#100	21.3		
#200	12.6		

* (no specification provided)

Soil Description

Silty fine sand trace gravel
MC: 22.6%

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.498 D_{60}= 0.326 D_{50}= 0.284
D_{30}= 0.200 D_{15}= 0.0992 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL,JW
Reviewed by: ML

Sample No.: #2851.12
Source of Sample:
Date: 8-5-99
Location: B-24 / S-3
Elev./Depth: 7.5-9.0'

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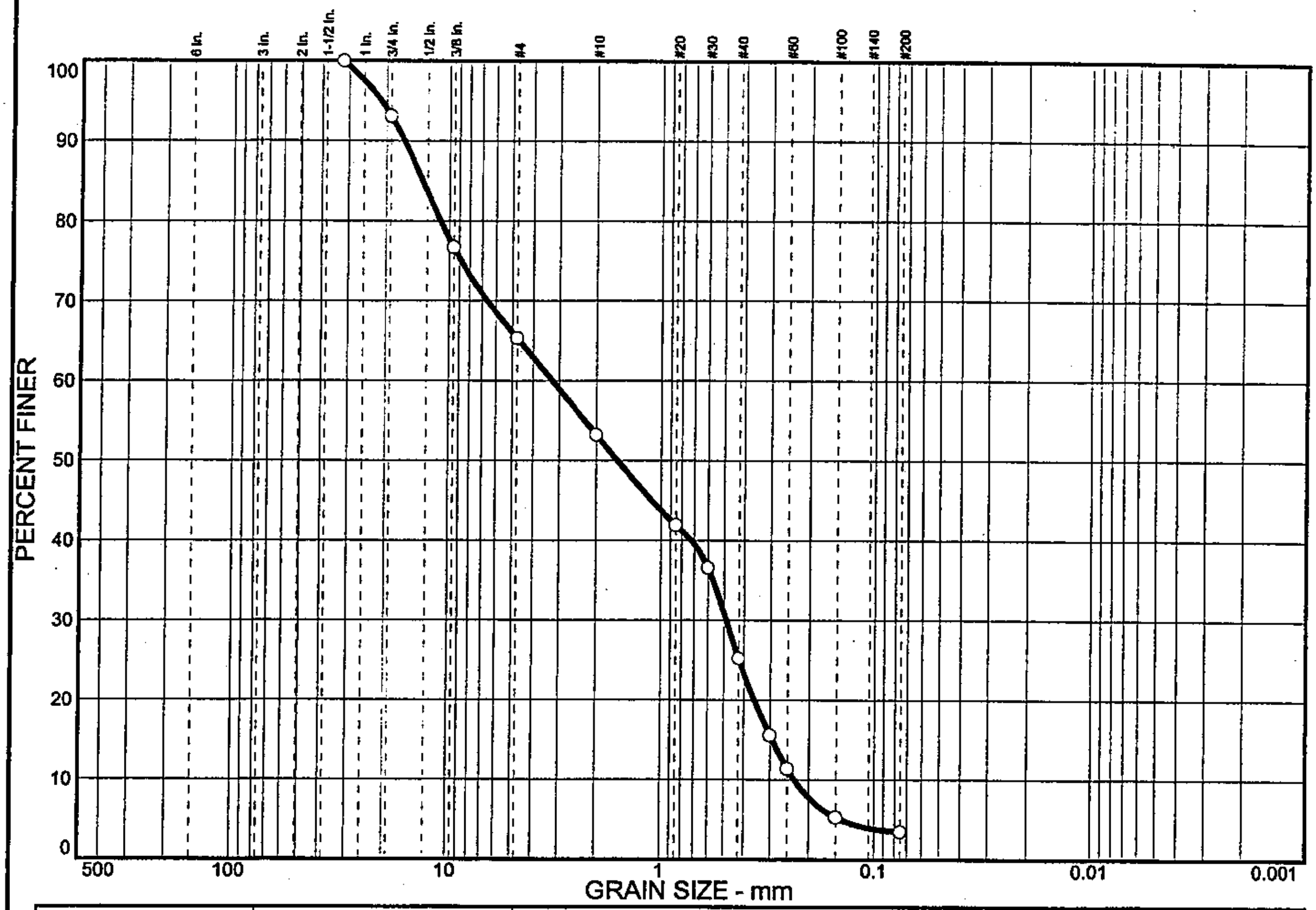
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	34.7	61.8	3.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.25 in.	100.0		
.75 in.	93.1		
.375 in.	76.7		
#4	65.3		
#10	53.2		
#20	41.9		
#30	36.6		
#40	25.2		
#50	15.6		
#60	11.4		
#100	5.3		
#200	3.5		

* (no specification provided)

Soil Description

Gravelly sand trace silt

Atterberg Limits

PL=
LL=
PI=

Coefficients

D_{85}= 13.4
D_{60}= 3.24
D_{50}= 1.60
D_{30}= 0.488
D_{15}= 0.293
D_{10}= 0.232
C_u= 13.96
C_c= 0.32

Classification

USCS=
AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.13
Location: B-24 / S-7
Source of Sample:
Date: 8-12-99
Elev./Depth: 25.26.5'

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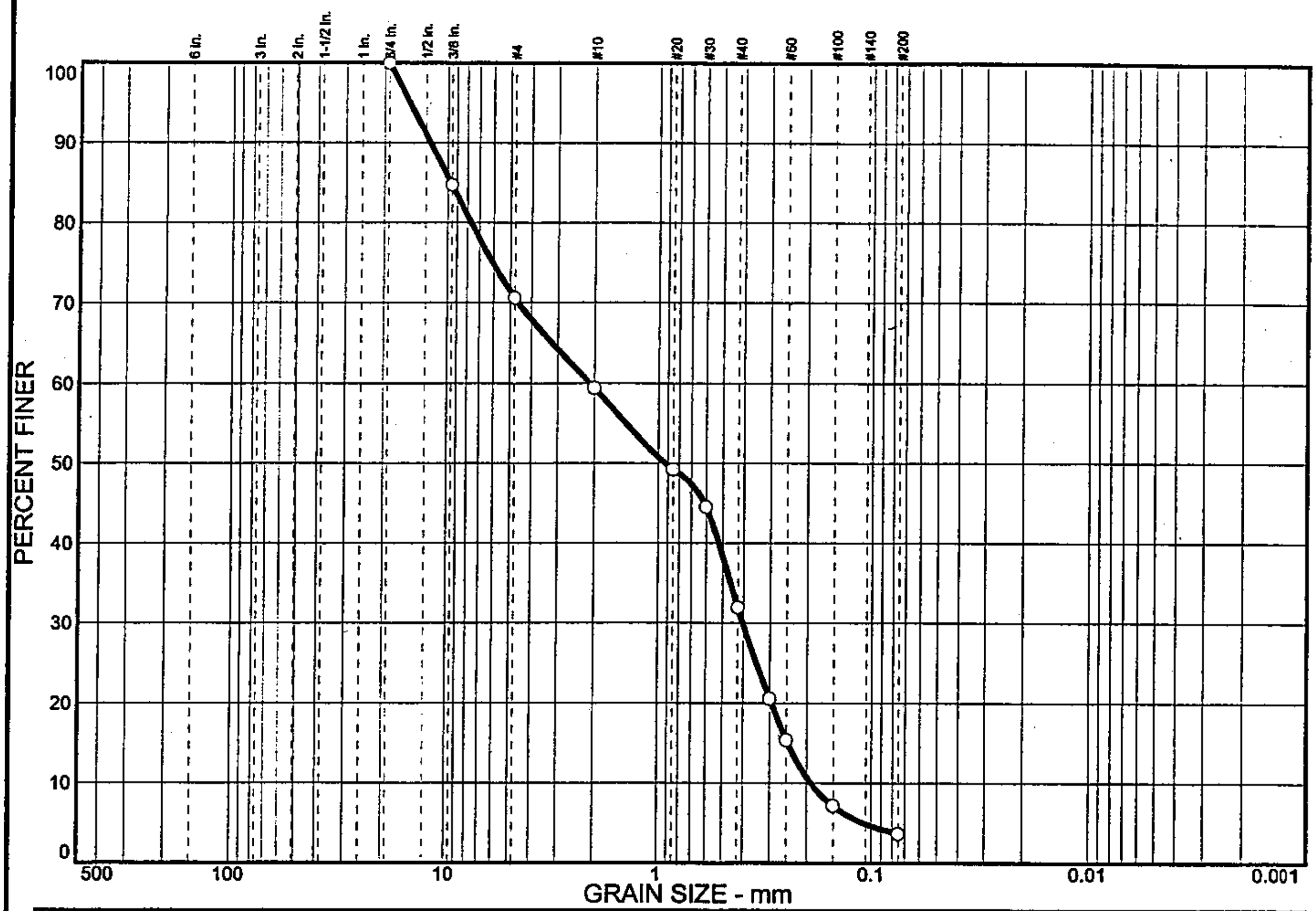
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	29.4	66.9	3.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	84.7		
#4	70.6		
#10	59.4		
#20	49.2		
#30	44.5		
#40	31.9		
#50	20.6		
#60	15.4		
#100	7.2		
#200	3.7		

* (no specification provided)

Soil Description

Gravelly sand trace silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 9.66 D_{60}= 2.10 D_{50}= 0.928
D_{30}= 0.404 D_{15}= 0.246 D_{10}= 0.191
C_u= 11.02 C_c= 0.41

Classification

USCS= AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.14
Location: B-25 / S-3
Source of Sample:
Date: 8-12-99
Elev./Depth: 7.5-9.0'

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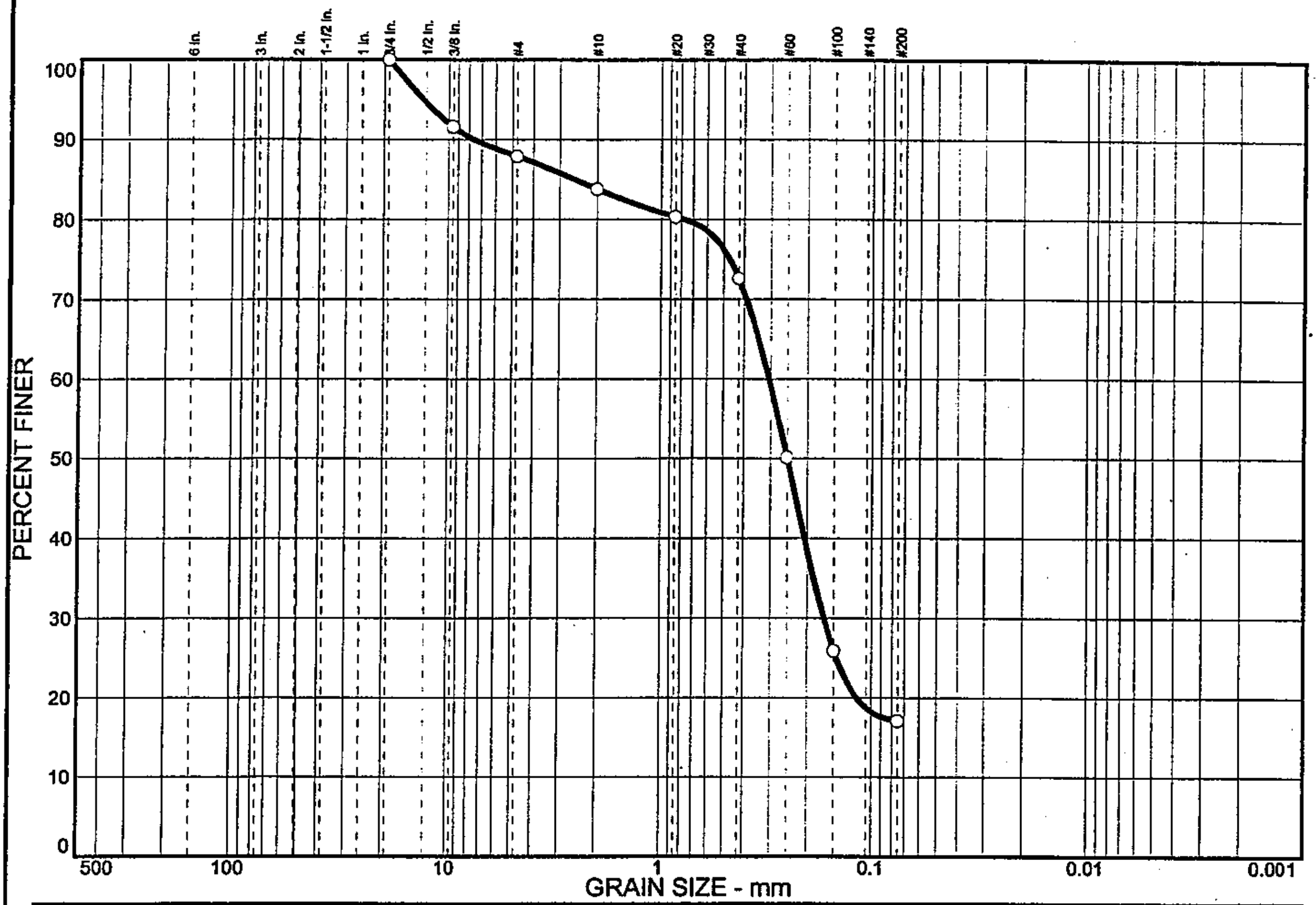
Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	12.1	70.8	17.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	91.6		
#4	87.9		
#10	83.8		
#20	80.3		
#40	72.6		
#60	50.1		
#100	25.9		
#200	17.1		

* (no specification provided)

Soil Description

Silty sand some gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 2.56 D_{60}= 0.305 D_{50}= 0.250
D_{30}= 0.167 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.15
Location: B-25 / S-5
Source of Sample:
Date: 8-12-99
Elev./Depth: 12.5-14'

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Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	12.2	47.6	40.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	94.4		
#4	87.8		
#10	83.5		
#20	80.0		
#40	70.6		
#60	58.8		
#100	47.5		
#200	40.2		

* (no specification provided)

Soil Description

Silty sand some gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 3.03 D_{60}= 0.263 D_{50}= 0.171
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.18
Source of Sample:
Date: 8-13-99
Location: B-26 / S-5
Elev./Depth: 12.5-14'

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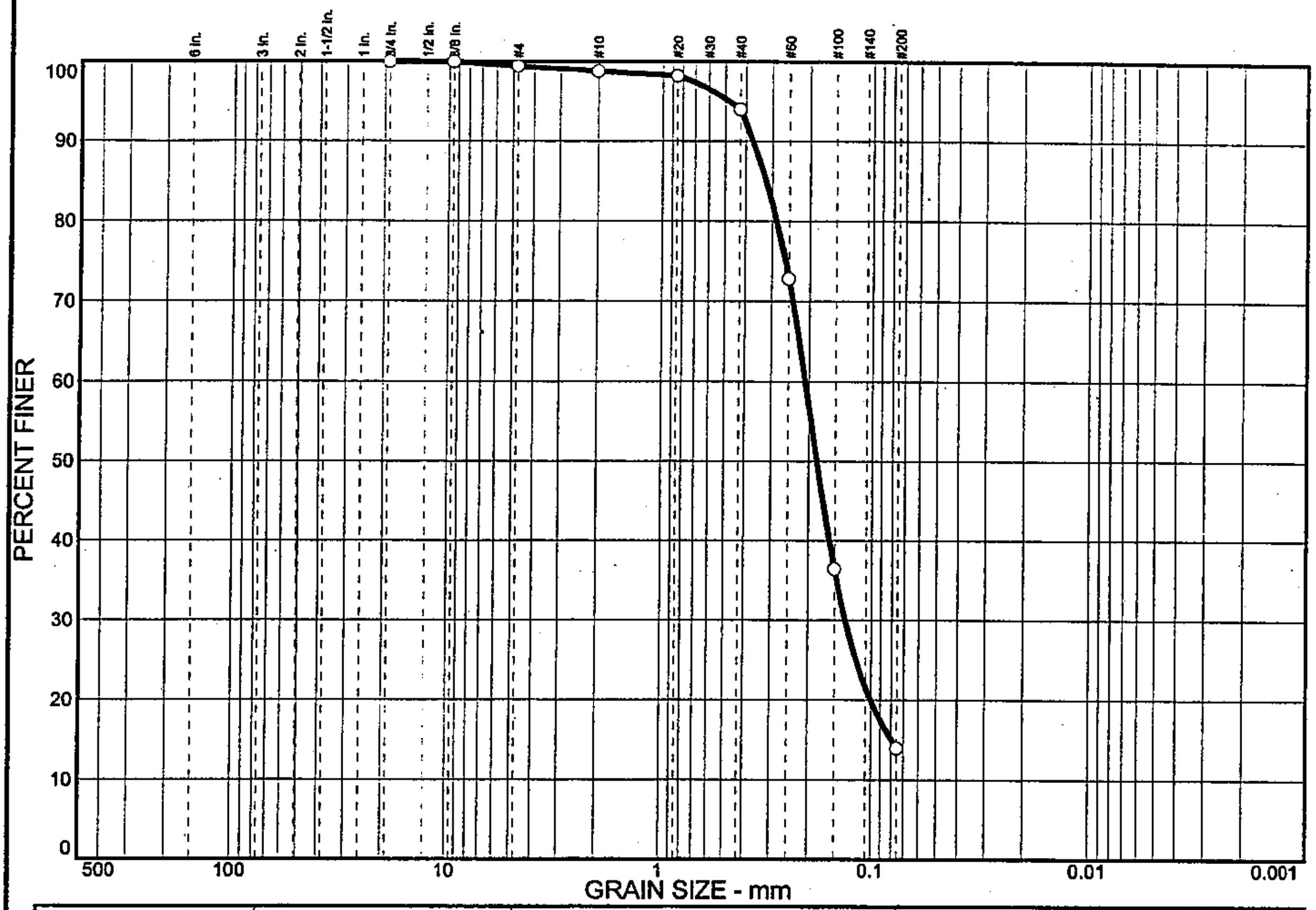
Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.6	85.4	14.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	100.0		
#4	99.4		
#10	98.8		
#20	98.2		
#40	94.0		
#60	72.8		
#100	36.4		
#200	14.0		

* (no specification provided)

Soil Description

Silty fine sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.321 D_{60}= 0.208 D_{50}= 0.182

D_{30}= 0.133 D_{15}= 0.0792 D_{10}=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL

Reviewed by: ML

Sample No.: #2851.19

Location: B-26 / S-9

Source of Sample:

Date: 8-13-99

Elev./Depth: 30-31.5'

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ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX

Project: CAPITAL LAKE SEWER

Project No: 11684-B

Plate

Grain Size Analysis Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	10.4	57.2	32.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	89.6		
#10	86.2		
#20	82.9		
#40	71.2		
#60	55.9		
#100	48.0		
#200	32.4		

* (no specification provided)

Soil Description

Silty fine sand some gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 1.18 D_{60}= 0.293 D_{50}= 0.173

D_{30}= D_{15}= D_{10}=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Tested by: AL
Reviewed by: ML

Sample No.: #2851.20 **Source of Sample:** **Date:** 8-13-99
Location: B-27 / S-2 **Elev./Depth:** 5.0-7.5'

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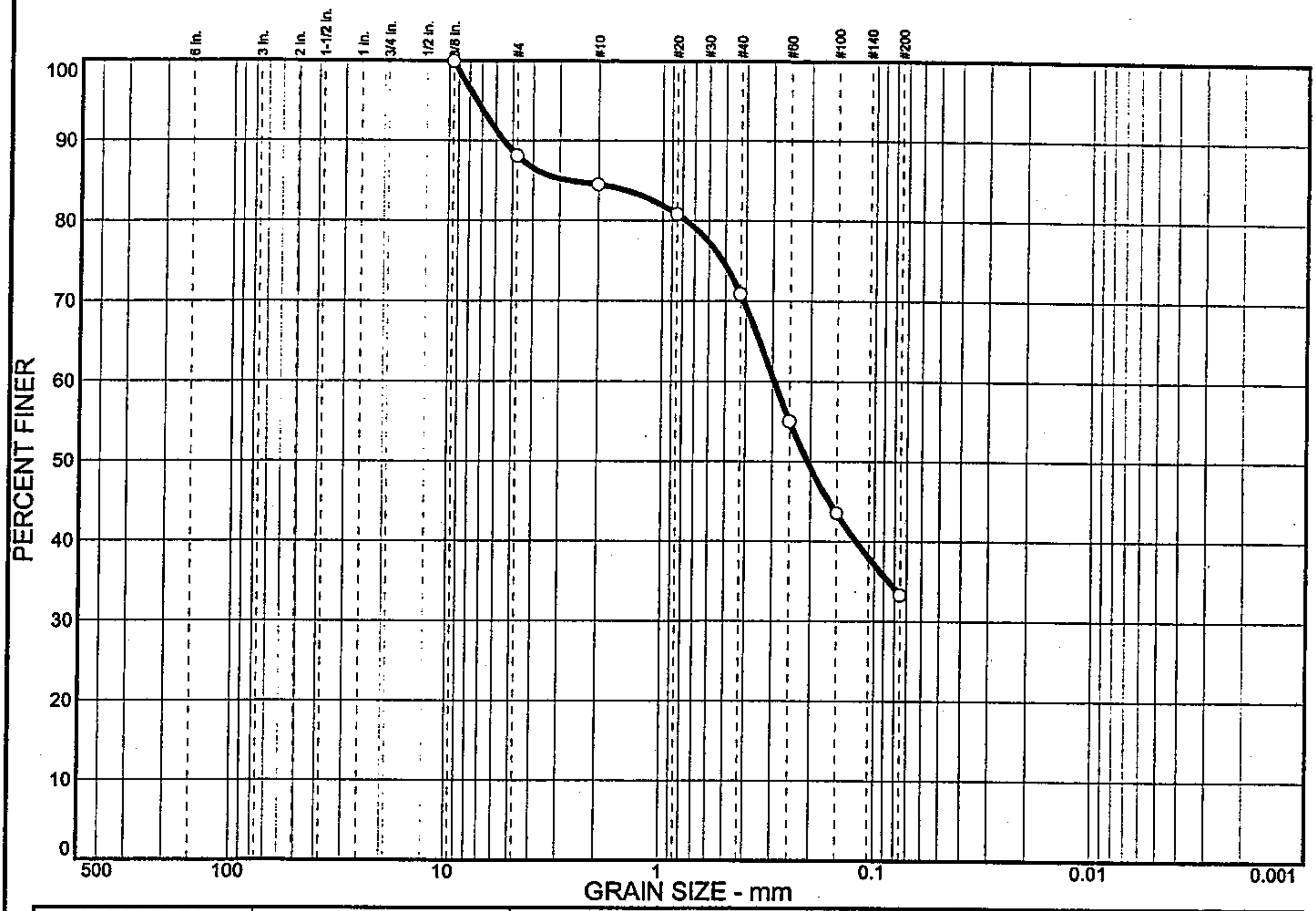
Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B **Plate**

Grain Size Analysis Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	11.9	54.8	33.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	88.1		
#10	84.5		
#20	80.8		
#40	70.9		
#60	55.0		
#100	43.5		
#200	33.3		

* (no specification provided)

Soil Description

Silty fine sand some gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 2.74 D_{60}= 0.295 D_{50}= 0.206
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

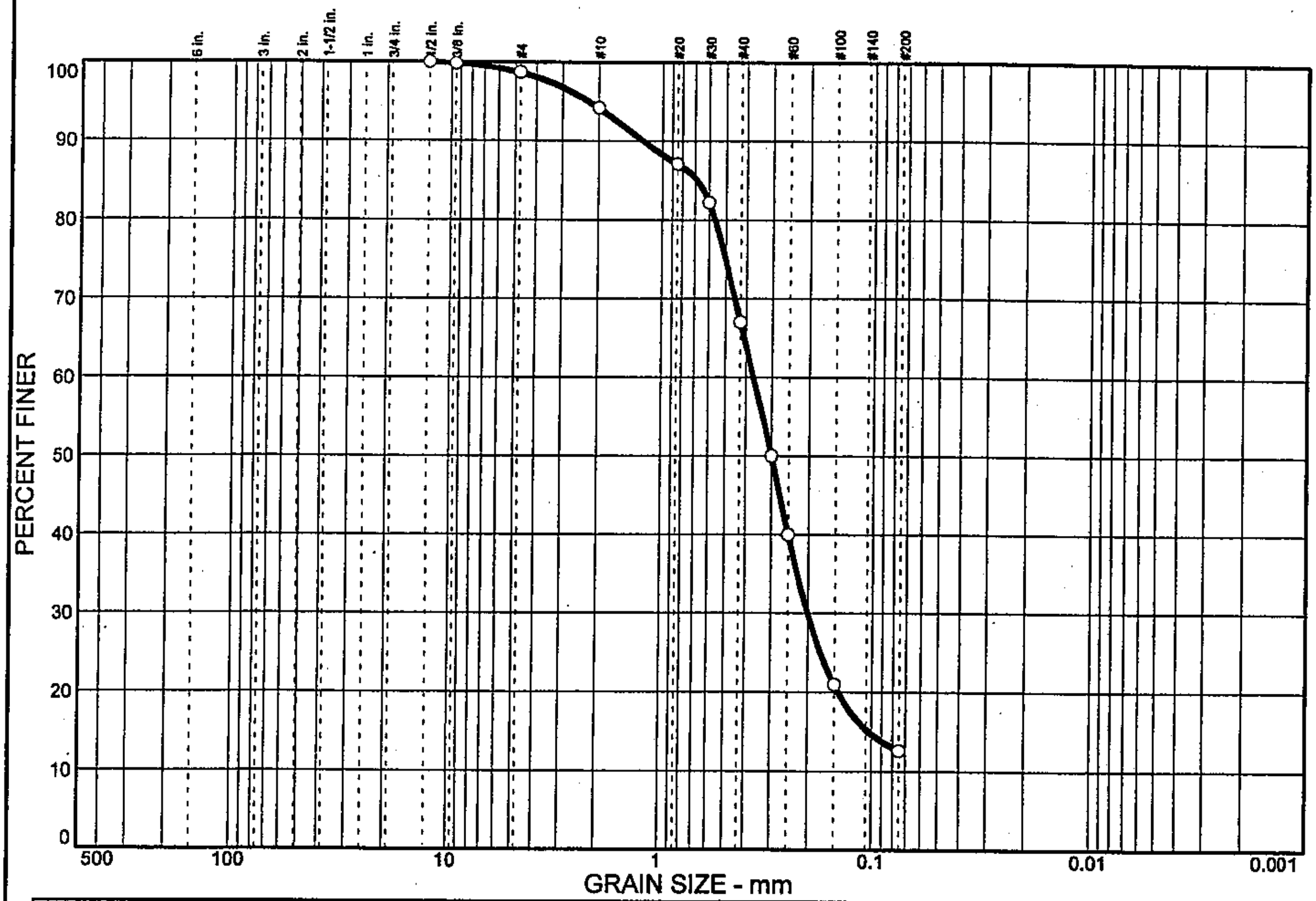
Tested by: AL
Reviewed by: ML

Sample No.: #2851.21
Location: B-27 / S-6
Source of Sample:
Date: 8-13-99
Elev./Depth: 15-16.5'

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: CAPITAL LAKE SEWER
Project No: 11684-B
Plate

Particle Size Distribution Report



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	1.3	86.1	12.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.50 in.	100.0		
.375 in.	99.8		
#4	98.7		
#10	94.2		
#20	87.1		
#30	82.2		
#40	67.0		
#50	50.0		
#60	40.0		
#100	21.0		
#200	12.6		

* (no specification provided)

Soil Description

Bray/Brown Silty Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.681 D_{60}= 0.367 D_{50}= 0.300
D_{30}= 0.201 D_{15}= 0.103 D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

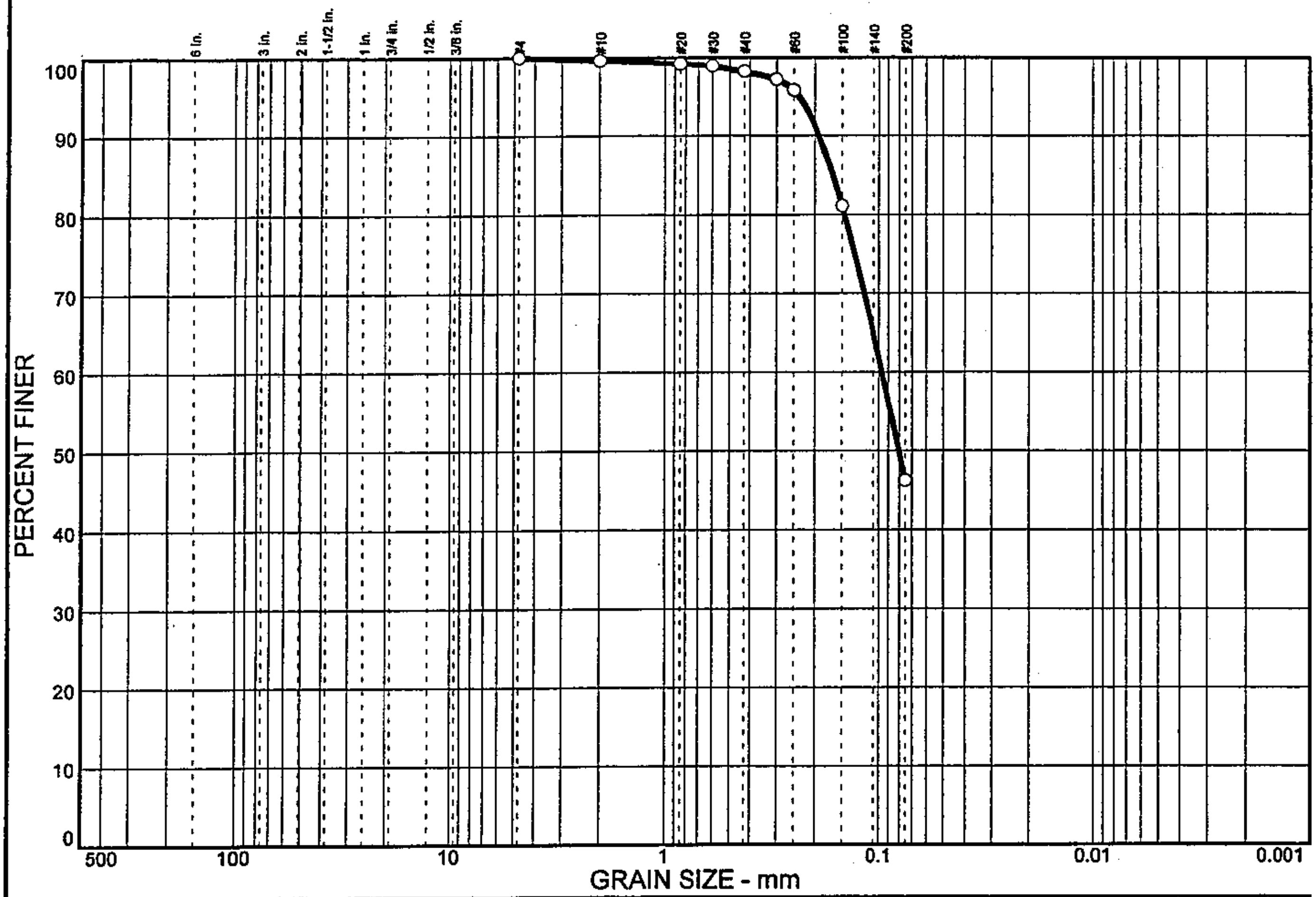
Tested by: JW, AL, JR
Reviewed by: SEA
ASTM: C136-96a, D1140-97, D2216-92

Sample No.: #3129.1 & .2 **Source of Sample:** **Date:** 01/27/00
Location: B-28 / S-3, 10.0-11.5' / S-4, 12.5-14.0' **Elev./Depth:**

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: LOTT CAPITOL LAKE SOUTHERN CONNECTION
Project No: 9-91M-11684-B **Plate** 1

Particle Size Distribution Report



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	53.8	46.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.6		
#20	99.2		
#30	98.9		
#40	98.2		
#50	97.2		
#60	95.8		
#100	81.1		
#200	46.2		

* (no specification provided)

Soil Description

Gray/Brown Silty Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.166 D_{60}= 0.0968 D_{50}= 0.0804
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

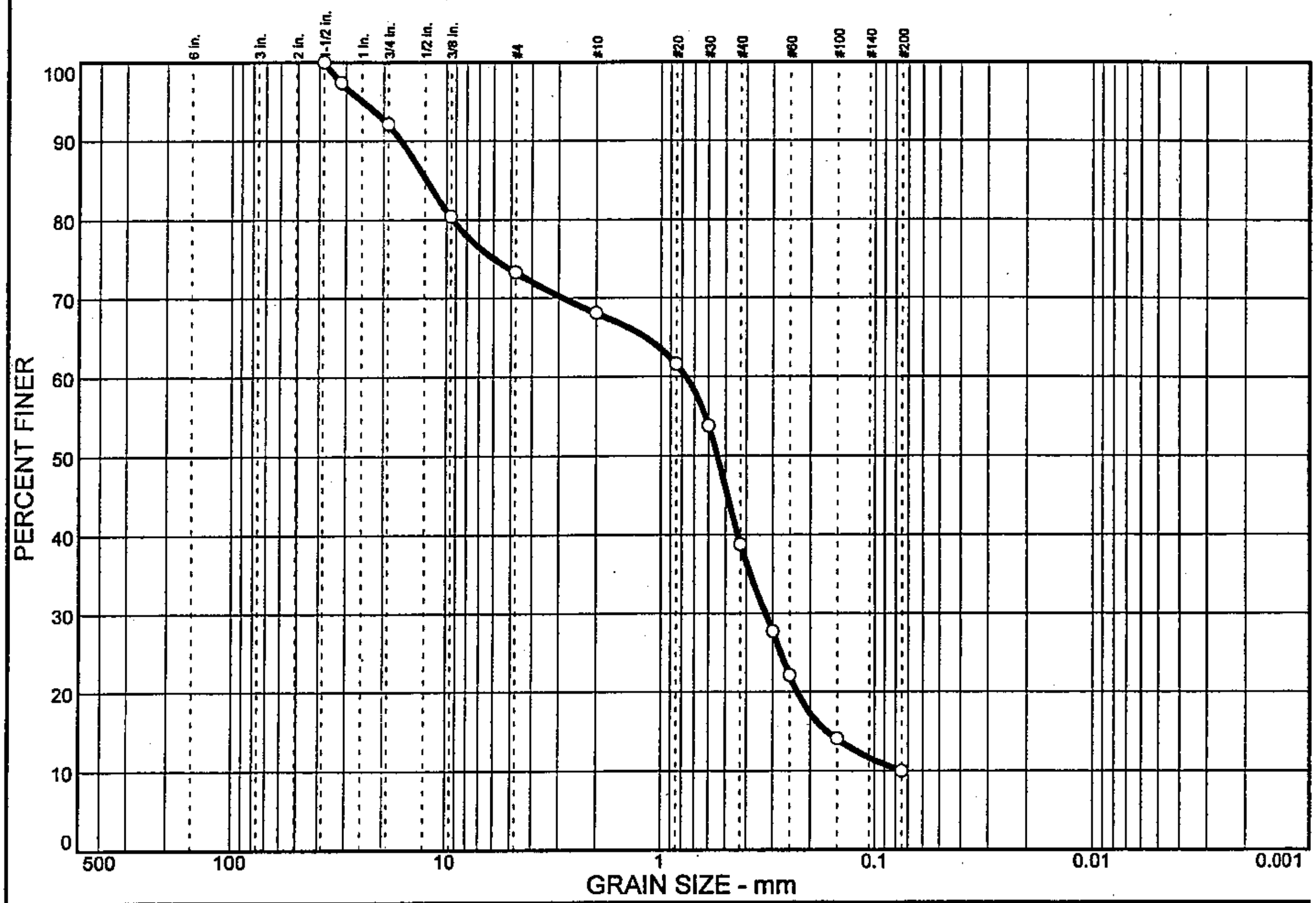
Tested by: JW, AL, JR
Reviewed by: SEA
ASTM: C136-96a, D1140-97, D2216-92

Sample No.: #3129.4,.5,.6 **Source of Sample:** **Date:** 01/27/00
Location: B-29 / S-1,5.0-6.5'/S-2,7.5-9.0'/S-3,10.0-11.5' **Elev./Depth:**

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

Client: PARAMETRIX
Project: LOTT CAPITOL LAKE SOUTHERN CONNECTION
Project No: 9-91M-11684-B **Plate** 1

Particle Size Distribution Report



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	26.7	63.3	10.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5 in.	100.0		
1.25 in.	97.4		
.75 in.	92.1		
.375 in.	80.4		
#4	73.3		
#10	68.1		
#20	61.6		
#30	53.8		
#40	38.8		
#50	27.7		
#60	22.1		
#100	14.1		
#200	10.0		

* (no specification provided)

Soil Description

Gravelly Sand, Trace Silt

Atterberg Limits

PL=
LL=
PI=

Coefficients

D_{85}= 12.4
D_{60}= 0.765
D_{50}= 0.546
D_{30}= 0.324
D_{15}= 0.166
D_{10}= 0.0750
C_u= 10.20
C_c= 1.83

Classification

USCS= SW-SM
AASHTO=

Remarks

Tested by: JW, AL, JR
Reviewed by: SEA
ASTM: C136-96a, D1140-97, D2216-92

Sample No.: #3129.9-.12, .15-.19 **Source of Sample:**
Date: 01/27/00
Location: B-30/S-1-S4; B-31/S-1-S-5
Elev./Depth:

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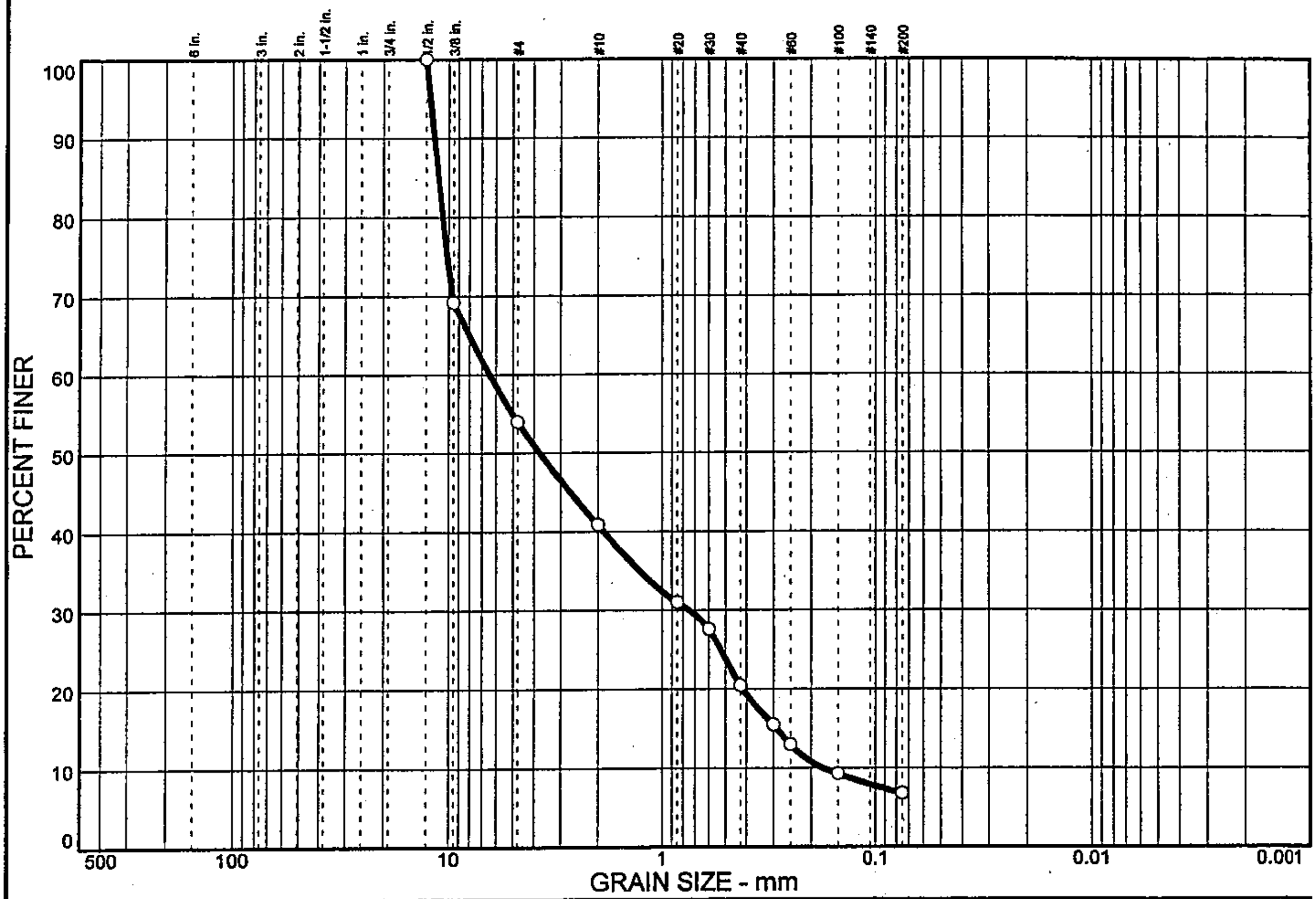
Particle Size Distribution Report



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	46.0	47.2	6.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.50 in.	100.0		
.375 in.	69.2		
#4	54.0		
#10	40.9		
#20	31.0		
#30	27.6		
#40	20.5		
#50	15.5		
#60	13.0		
#100	9.3		
#200	6.8		

* (no specification provided)

Soil Description

Gray Gravelly Sand, Trace Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 11.2 D_{60}= 6.40 D_{50}= 3.74
D_{30}= 0.743 D_{15}= 0.289 D_{10}= 0.174
C_u= 36.73 C_c= 0.50

Classification

USCS= SP-SM AASHTO=

Remarks

Tested by: JW, AL, JR
Reviewed by: SEA
ASTM: C-136-96a, D1140-97, D2216-92

Sample No.: #3129.13, .14 **Source of Sample:** **Date:** 01/27/00
Location: B-30 / S-9, 30.0-31.5' / S-10, 35.0-36.5' **Elev./Depth:**

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Project: LOTT CAPITOL LAKE SOUTHERN CONNECTION
Project No: 9-91M-11684-B **Plate** 1

APPENDIX C

ENVIRONMENTAL SCREENING PROCEDURES, RESULTS, AND LABORATORY CERTIFICATES

APPENDIX C
ENVIRONMENTAL SCREENING PROCEDURES, RESULTS, AND LABORATORY CERTIFICATES
9-91M-11684-B

Field Screening Procedures

Upon collection, each sample was divided into analytical laboratory, field laboratory, and field screening samples. Each analytical laboratory sample was immediately placed in laboratory-prepared glassware and stored in a chilled cooler for storage and transport to our subcontract laboratory under strict chain-of-custody (COC) procedures. Field screening samples were placed into sealable, polyethylene bags and allowed to warm prior to being screened for volatile compounds using a Thermo Environmental Instruments Model 580B photoionization detector (PID).

The PID is inserted into the bag containing the soil. The highest digital readout value displayed by the instrument is then recorded for each sample. The value indicates the total vapor concentration of volatile organic compounds. The PID is not capable of determining the presence of a specific species of volatile organic compound. Rather, this method of field-screening is used as a qualitative approach for comparing conditions between sampling intervals.

Soil Boring Sampling Procedures

Sampling tools were decontaminated with a washing of soapy water between sampling events. All augers, sampling tools, and other equipment was thoroughly decontaminated with a pressure-washing of warm soapy water between borings.

Groundwater Sampling Procedures

Groundwater samples were collected from the three downtown monitoring wells on September 1, 1999. Prior to sampling, a minimum of 5 volumes of water was purged using a disposable PVC bailer. Groundwater samples were collected by the standard purge-and-bailer method and samples were placed into laboratory-prepared glassware bottles appropriate for the analyses to be performed and were stored in a chilled cooler for storage and transport to our Portland, Oregon laboratory under strict chain-of-custody procedures.

TABLE C-1
SUMMARY OF ANALYTICAL TESTING RESULTS: SOIL
LOTT CAPITOL LAKE – SOUTHERN CONNECTION
OLYMPIA, WASHINGTON
AGRA PROJECT NO. 9-91M-11684-B

Sample Number	Date Collected	WTPH – D Extended		TPH - G (ppm)	Benzene (ppm)	Toluene (ppm)	Ethylbenzene (ppm)	Total Xylenes (ppm)
		Diesel (ppm)	Heavy Oil (ppm)					
B-12/S-1B	7/19/99	<25	<100	ND	ND	ND	ND	ND
B-13/S-3	7/19/99	<25	<100	ND	ND	ND	ND	ND
B-14/S-2	7/20/99	<25	<100	ND	ND	ND	ND	ND
B-15/S-1	7/20/99	<25	130	8.0	ND	ND	ND	ND
B-16/S-1	7/20/99	<25	<100	ND	ND	ND	ND	ND
B-17/S-2	7/26/99	<25	<100	ND	ND	ND	ND	ND
B-18/S-2	7/26/99	<25	<100	ND	ND	ND	ND	ND
B-19/S-3	7/26/99	<25	<100	ND	ND	ND	ND	ND
MTCA Method "A" Cleanup Level		200	200	100	0.5	40	20	20

WTPH-D Extended = Total petroleum hydrocarbons, diesel range (C12 - C24) and heavy oil range (>C24)
TPH-G = Gasoline range petroleum hydrocarbons by Washington State Method WTPH-G
Benzene, Toluene, Ethylbenzen, and Total Xylenes by EPA Method 8020
ND = *Compound was not detected, below laboratory method detection limits*
MTCA = Washington State Model Toxics Control Act, Method "A" Cleanup Guidelines
All concentrations are reported in parts per million (ppm = mg/Kg)

TABLE C-2
SUMMARY OF ANALYTICAL TESTING RESULTS: GROUNDWATER
LOTT CAPITOL LAKE – SOUTHERN CONNECTION
OLYMPIA, WASHINGTON
AGRA PROJECT NO. 9-91M-11684-B

Sample Number	Date Collected	WTPH – D Extended		TPH - G (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Total Xylenes (ppb)	Total Lead (ppb)
		Diesel (ppb)	Heavy Oil (ppb)						
MW-5	7/19/99	<0.25	<0.50	517	55	<0.50	35.8	79.5	41
MW-6	7/19/99	<0.25	<0.50	<50	<0.50	<0.50	<0.50	<0.50	39
MW-7	7/20/99	<0.25	<0.50	<50	<0.50	<0.50	<0.50	<0.50	76
MTCA Method "A" Cleanup Level		1000	1000	1000	5	40	30	20	5

WTPH-D Extended = Total petroleum hydrocarbons, diesel range (C12 - C24) and heavy oil range (>C24)
TPH-G = Gasoline range petroleum hydrocarbons by Washington State Method WTPH-G
Benzene, Toluene, Ethylbenzen, and Total Xylenes by EPA Method 8020
ND = Compound was not detected, below laboratory method detection limits
MTCA = Washington State Model Toxics Control Act, Method "A" Cleanup Guidelines
All concentrations are reported in parts per billion (ppb = mg/Kg)
Shaded areas are results in excess of cleanup limits

APPENDIX D

REFERENCES

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9-91M-11684-B

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