NW 112 -

Geotechnical and Environmental Engineering Report
Snohomish County Campus
Administration Building and Garage
Everett, Washington

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SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

At Shannon & Wilson, our mission is to be a progressive, well-managed professional consulting firm in the fields of engineering and applied earth sciences. Our goal is to perform our services with the highest degree of professionalism with due consideration to the best interests of the public, our clients, and our employees.

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EXECUTIVE SUMMARY

This report presents our analyses and recommendations for the Administration Building and Garage portion of the Snohomish County Campus.

Subsurface Conditions. The site soil consists of glacially overridden till, outwash, and lacustrine deposits. Relatively minimal amounts of fill (typically 3 to 8 feet thick) were encountered within the garage footprint. At the southwest corner of the proposed Administration Building, we encountered 28 feet of very loose fill. Advance outwash is the primary water-bearing layer encountered in the borings, and this unit appears to be under confining pressure. The advance outwash layer is about 5 to 25 feet thick and about 20 to 35 feet below grade within the garage footprint. Soil and groundwater with elevated levels of petroleum hydrocarbons was encountered at several locations within the advance outwash and the lower portion of the glacial till.

Effect on Design and Construction. The effect of the subsurface conditions on the design and construction of the Administration Building and Garage can be briefly summarized as follows:

- Temporary soil nail shoring walls are suitable for the garage excavation as long as the groundwater inflow is controlled.
- Potentially contaminated soil and groundwater must be handled and disposed of properly – this may be a long-term condition for the groundwater.
- The glacially overridden soil will support spread footing garage foundations.The design for the Administration Building is not yet underway, but the structure may require a combination foundation system (relatively shallow spread footings and deep foundations such as augercast piles or drilled shafts).

Seismic Design. The project is located in a moderately active seismic zone. In accordance with the 1997 Uniform Building Code (UBC), the site is classified as a Soil Type S_C.

Foundation Design. The garage can be supported on spread footing foundations with a maximum allowable bearing pressure of 16 kips per square foot (ksf) bearing on undisturbed glacially overridden soil. The proposed tunnel may encounter fill soils t the footing level; we recommend compacting the upper 24 inches of the existing fill and designing the footings for 3 ksf allowable bearing capacity.

Temporary Soil Nail Shoring Wall Design. Our soil nail wall design is ongoing. The shoring wall details will be provided on the soil nail plans.

Temporary Dewatering. For successful soil nail wall installation and to provide dry conditions for construction activities, we recommend a two-step dewatering system. The first step will depressurize the advance outwash aquifer using deep dewatering wells installed and operating a minimum of 14 days before excavation begins. The second step calls for vacuum extraction/well points installed from within the excavation to dewater the advance outwash for construction.

Potentially Contaminated Soil and Groundwater. Excavated soil that is potentially contaminated must be properly handled, segregated, tested, and disposed of. The prime contractor and excavation and shoring subcontractors should be familiar with the site conditions so they are prepared to address contamination in the field. Shannon & Wilson should prepare a Construction Contingency Plan to support and guide these construction activities. The groundwater from construction dewatering, soil nail wall drainage material, footing drains, and the subdrain system will also need to be properly addressed.

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERING REPORT
SNOHOMISH COUNTY CAMPUS
ADMINISTRATION BUILDING AND GARAGE
EVERETT, WASHINGTON

1.0 INTRODUCTION

This report presents the results of subsurface explorations, geotechnical and environmental laboratory testing, hydrogeological and geophysical field testing, and geotechnical engineering recommendations for the proposed Snohomish County (County) Campus Administration Building and Garage in Everett, Washington. The purpose of this study was to complete subsurface explorations at the project site and to provide geotechnical and environmental engineering conclusions and recommendations for the design and construction of the proposed facility. We presented preliminary findings and field exploration results in a technical memorandum dated June 19, 2002. On July 18, 2002, we provided preliminary groundwater control and dewatering recommendations in a memorandum.

Our work was performed in general accordance with our proposals dated January 7 and February 20, 2002; the February proposal was later revised on May 3, 2002. Tasks included in these two proposals are field explorations and preparation of a memorandum summarizing field findings, and geotechnical design services. Mr. Mike Reyder of NBBJ authorized our initial scope of work for field explorations on January 30, 2002; on May 30, 2002, Mr. Larry Goetz of NBBJ authorized our design services proposal dated May 3, 2002.

Over the course of the project, our geotechnical scope of work was expanded because we encountered potential contamination and potentially difficult groundwater conditions during drilling at the site. The work associated with contaminated soil and groundwater issues was contracted directly with the County. Our proposal to Snohomish County was dated March 21, 2002, and our contract for professional services is dated April 15, 2002. Based on conditions encountered during field explorations, we also prepared a proposal for two additional monitoring wells and in-place permeability tests, dated June 11, 2002, and for geophysical explorations, dated July 12, 2002. The groundwater proposal was authorized by Mr. Larry Goetz of NBBJ on June 12, 2002, and Mr. Jeff O'Boyle with the County verbally authorized the geophysical proposal on July 16, 2002.

3.3 Well Development and Sampling

Between May 24 and July 1, 2002, wells B-9, B-11, B-14, B-17, and B-18 were developed in order to remove turbid water from the well and to enhance the hydraulic connection with the surrounding formation. The most recent well groundwater levels are presented on the boring logs in Appendix A.

During development of wells B-14 and B-18, a slight to moderate hydrocarbon odor and/or petroleum sheen were observed. On July 3, 2002, groundwater samples were collected from B-14, B-17, and B-18 after purging approximately three well volumes of water and achieving stable field parameters. The samples were submitted to a laboratory for petroleum hydrocarbon analyses. Groundwater analytical results are discussed later in this report.

4.0 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory tests were performed on selected samples retrieved from subsurface explorations. The testing included visual classification, natural moisture content, grain-size analyses, and Atterberg Limits determinations. Laboratory testing was performed to aid in classifying the soil and to determine basic soil index properties. The laboratory results are incorporated into the borings logs presented in Appendix A. Descriptions of laboratory test procedures and a summary of the test results are presented in Appendix B, Laboratory Testing.

5.0 ENVIRONMENTAL LABORATORY TESTING

5.1 Initial Soil Testing

While drilling borings B-12, B-13, and B-16, suspected soil contamination was observed at about 13, 19, and 25 feet below ground surface (bgs), or at about elevation 130 feet based on field screening (as described in Appendix A). A soil sample was collected from each boring and submitted to CCI Analytical Laboratories in Everett, Washington for analyses. Selected analyses included petroleum hydrocarbons (by Methods NWTPH-G/BTEX and NWTPH-Dx), and total lead.

Results of the initial soil analytical testing indicated that low levels of gasoline-range petroleum hydrocarbons, and traces of toluene and ethylbenzene are present in soil at these boring locations. The test results are summarized on Table 1 at the end of the report text. No detections

exceeded Washington Model Toxics Control Act (MTCA) Method A cleanup criteria. Initial laboratory results further indicated that the detected petroleum appeared to be weathered gasoline. The environmental laboratory analytical reports are included in Appendix C.

5.2 Follow-up Soil Testing

During drilling of borings B-12A, B-16A, and B-16B we collected one soil sample from B-16A for analytical testing (petroleum hydrocarbons and lead), and found a low concentration of weathered gasoline (see Table 1). During drilling of boring B-18, field screening indicated that potentially contaminated soil was present from about 25 to 42 feet bgs (approximate elevation 131 to 114 feet). The measured groundwater level at this location is at approximately 30 feet bgs (approximate elevation 136 feet). Two soil samples were collected from B-18 for analysis. Results indicate that weathered gasoline is present at about elevation 126 feet (30 feet bgs) at 2,900 milligrams per kilograms (mg/kg), exceeding MTCA Method A cleanup criteria. No benzene, toluene, ethylbenzene, or xylenes (BTEX) were detected. Given this elevated concentration of weathered gasoline, it seems likely that a contaminant source is, or was, located in the immediate vicinity.

5.3 Groundwater Sampling and Analysis

Three groundwater samples were collected from monitoring wells B-14, B-17 and B-18 on July 3, 2002, and submitted for petroleum hydrocarbon analytical testing. No contaminants of concern were detected in B-17. However, results indicate that gasoline concentrations exceed MTCA Method A cleanup criteria for groundwater in wells B-14 and B-18. Concentrations of benzene and ethylbenzene in B-18 groundwater also exceed cleanup criteria.

Based on discussion with the analytical testing laboratory, petroleum detected in groundwater at both wells B-18 and B-14 appears to be similar product, although the petroleum chromatogram for well B-18 exhibits more weathering. This indicates that contamination at the two locations probably originated from the same source.

6.0 HYDROGEOLOGIC TESTING

Slug testing was performed to estimate the hydraulic conductivity of the site soils. Slug tests provide a point estimate of hydraulic conductivity in the immediate vicinity of the tested well; they do not provide an estimate of aquifer hydraulic conductivity on a large scale or an indication

of variations in hydraulic conductivity across the site. Slug testing was performed at wells B-9, B-14, and B-17. Well B-18 was not tested due to its poor recovery rate and the presence of strong gasoline odors in the well.

Slug tests were performed on July 1, 2002, by a Shannon & Wilson hydrogeologist. Multiple tests were performed at each well to assess the reproducibility of the groundwater level response in the well. A total of three falling head and three rising head tests each were completed at wells B-9, B-14, and B-17. Appendix D provides slug testing procedures and methodology and a summary of slug testing results. The range of hydraulic conductivity values estimated for the tested soils (using the geometric means from the Bouwer and Rice and the Cooper methods) is from about 1.2×10^{-4} to 4.3×10^{-3} centimeters per seconds (cm/s).

7.0 GEOPHYSICAL SURVEY

Because contamination is present at boring B-18 and contaminant concentrations in soil at this location indicate proximity to a source, a geophysical survey was conducted in accessible portions of the existing plaza in the vicinity of boring B-18 to look for buried objects, such as an underground storage tank (UST) or piping. Several "lines" were evaluated around the northwest corner of the existing Administration Building (near the former pump island), as well as a 50-foot-square area centered on boring B-18. Within the 50-foot-square area, a grid of lines were evaluated on an approximate 1-meter spacing in each direction.

The survey consisted of ground penetrating radar (GPR) techniques and was performed by an experienced local geophysical company, GeoRecon, under subcontract to Shannon & Wilson. The geophysical survey report is included in Appendix E. GPR is a method that provides a continuous, high resolution cross-section depicting variations in the electrical properties of the shallow subsurface. The system operates by continuously radiating a 500-megahertz (MHz) radar frequency pulse into the ground from a transducer as it is moved along a traverse. Since most of the materials are transparent to the 500 MHz radar frequency pulse, only a portion of the radar signal is reflected back to the surface. However, when the signal encounters a metal object, all of the incident energy is reflected. The resulting records can provide information regarding stratification, the thickness and extent of fill material, the location of buried objects, and changes in material conditions such as saturation. Significant amounts of fill material/debris and some soil types can inhibit the performance of the geophysical equipment.

The results of the geophysical survey did not provide definitive evidence of a UST beneath the plaza area. However, marked utilities (either marked with paint on the ground surface or shown on project survey maps) and several pipes were encountered. These pipes are likely associated with former utility services to previous site development. No contamination source was apparent in the area evaluated using GPR.

8.0 GEOLOGY

The geologic deposits present in the vicinity of the site were largely deposited during the last glacial advance, known as the Vashon Stade of the Frasier glaciation. As the Vashon ice sheet advanced from the north, drainage from Puget Sound was blocked, and glaciolacustrine silt and clay, with some sand seams, were deposited in a proglacial lake. As the glacial ice sheet advanced further, sand and some gravel (advance outwash) were deposited on top of the glaciolacustrine sediments as a broad outwash plain in front of the glacier. The advance outwash typically is gradational with the underlying glaciolacustrine deposits at the base (interbedded sand and silt) and coarsens upward to sand and then gravelly sand at the top. The glacial ice eventually overrode the area, compacting the underlying sediments and depositing lodgment till at the base of the glacier. The till is a non-sorted mixture of clay, silt, sand, and gravel with scattered cobbles and boulders.

9.0 SUBSURFACE CONDITIONS

9.1 General

The subsurface conditions at the site were evaluated based on conditions encountered in borings B-7 through B-18. A description of the soil and groundwater conditions disclosed by the borings is presented below. Figures 3, 4 and 5 present generalized subsurface profiles running north-south in the east half of the site, and east-west in the north half of the site. The locations of the borings and profiles are shown on Figure 2.

9.2 Soil

As shown on the attached subsurface profiles (Figures 3 through 5), and as described in the geology section above, the site's subsurface conditions generally consist of the following geologic layers starting from the ground surface: glacial till, advance outwash, glaciolacustrine

deposits, and glacial outwash. The glacial till generally consists of very dense, slightly gravelly to gravelly, silty sand. Advance outwash consists of very dense, slightly silty to silty sand and slightly clayey, sandy silt. The advance outwash has localized areas that are slightly gravelly to gravelly. The glaciolacustrine deposits are hard and vary from silty clay/clayey silt to slightly sandy, slightly clayey silt. These fine-grained deposits have scattered to numerous silty, fine sand partings/seams and slickensides. In some areas, scattered seams of highly plastic clay were noted in the glaciolacustrine deposits.

A few borings near the garage encountered near surface fill that was 3 to 8 feet thick. Boring B-11, located between the proposed and existing Administration Buildings, encountered 28 feet of very loose fill, which was probably placed during construction of the existing Administration Building.

9.3 Groundwater

Groundwater conditions were evaluated by observations made during drilling and by installing observation wells in borings B-9, B-11, B-14, B-17, and B-18. Wet, caving soils were encountered in borings B-12A, B-16A, and B-16B. The recent measurements indicate that the groundwater elevations in the wells range between about 106 and 126 feet, or about 26 to 36 feet below ground surface. Specifically, groundwater elevations in wells B-9 and B-17 currently range from about 106 to 115 feet, while wells B-11, B-14, and B-18 are at about 120 to 126 feet. Although no groundwater was observed during drilling of boring B-9, the groundwater level was subsequently measured about 28 feet below ground surface in the monitoring well installed at that location. Based on boring B-9, it is likely that other borings where groundwater was not observed during drilling may in fact be wet during a more extended excavation time. It was difficult to obtain definite groundwater level observations during drilling, especially where mud-rotary drilling techniques were used. Interbeds of water-bearing sand and silt may be encountered within the glaciolacustrine deposits. Overall, we anticipate that the groundwater gradient runs from west-southwest to east-northeast. Groundwater levels may fluctuate seasonally.

Where observed, groundwater was noted during drilling and groundwater levels in wells were read several times. Both the during-drilling and most recent measurements of groundwater levels are noted on the boring logs.

Advance outwash is the primary water-bearing layer encountered in the borings. This unit is under confining pressure as indicated by groundwater levels measured in the wells are above the overlying glacial till deposit contact. In general, this layer is about 5 to 25 feet thick and is about 20 to 35 feet below the ground surface across the proposed garage footprint. The advance outwash layer appears to be only 5 to 10 feet thick near Oakes Avenue.

10.0 ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

10.1 General

This report presents Administration Garage and pedestrian tunnel recommendations regarding:

- Seismic design criteria
- Earthquake-induced geologic hazards
- Footing foundations
- Lateral earth pressures and resistance
- Floor slabs
- Temporary excavation shoring
- Temporary cut slopes
- Potentially contaminated soil excavation
- Temporary dewatering
- Potentially contaminated groundwater collection, treatment, and disposal
- Permanent drainage
- Fill placement and compaction

As indicated in the list above, in addition to our geotechnical recommendations, we are also providing conclusions and conceptual recommendations regarding soil excavation and groundwater collection and treatment for potential contamination at the site, based on information we have at the time of this writing.

10.2 Seismic Design Considerations

The project is located in a moderately active seismic region. While the region has historically experienced moderate to large earthquakes (such as the April 13, 1949, magnitude 7.1 Olympia Earthquake; April 29, 1965, magnitude 6.5 Seattle-Tacoma Earthquake; and February 28, 2001, magnitude 6.8 Nisqually Earthquake) geologic evidence suggests that larger earthquakes have occurred in the recent past and will continue to occur in the future (for example, magnitude 8½ to 9 Cascadia Subduction Zone Interplate events, magnitude 7½ Seattle Fault events). We understand that the project will be designed in accordance with the 1997 Uniform Building Code

(UBC, 1997). The UBC requires that the seismicity of the region be considered in building design by requiring that structures be designed for earthquake ground motions with a 10 percent chance of being exceeded in 50 years (475-year recurrence). Accordingly, the UBC indicates that the project site is located in Seismic Zone 3 (peak ground acceleration on rock of approximately 0.3g). More recent regional ground motion studies conducted by the United States Geological Survey (USGS) indicate that the peak ground acceleration (PGA) for a 475-year recurrence in the vicinity of the site for "soft" rock conditions would be approximately 0.33g.

In addition to seismicity, the UBC also requires that the response of the subsurface soils at the site be considered in developing design earthquake ground motions. The soil profile coefficient (S-factor) is used to represent the soil conditions at the site. Because the project site is generally underlain by dense to very dense and hard soils, which are anticipated to extend to a depth of several hundred feet, we recommend that the soils at this site be characterized as a UBC Soil Profile Type S_C. The corresponding seismic coefficients C_a and C_v have values of 0.33 and 0.45, respectively. A seismic zone factor, Z, of 0.30 is recommended.

10.3 Earthquake-induced Geologic Hazards

In general, earthquake-induced geologic hazards may include liquefaction, lateral spreading, slope instability, and ground surface fault rupture. In our opinion, the potential for liquefaction and lateral spreading is not significant because of the dense/hard nature of the on-site soils. The ground surface at the site slopes gently down to the northeast, therefore, the potential for significant earthquake-induced slope instability is also low. In our opinion, the potential for ground surface fault rupture at the site is low because the nearest known fault is in the northwest-southeast trending Southern Whidbey Island Fault zone, located approximately 5 to 6 miles southwest of the site.

10.4 Footing Foundations

We recommend that spread footing foundations be used to support the proposed Administration Building Garage. Based on our borings, native, very dense and hard, glacially-overridden soil would be encountered at the lowest floor elevations (73.5 to 83.5 feet). For footings bearing in the very dense or hard, native soil, we recommend a maximum allowable bearing capacity of 16 kips per square foot (ksf); this allowable value corresponds to an ultimate bearing capacity of 32 ksf in glacial soil. The allowable value can be increased by one-third to account for wind and

seismic loading conditions. The allowable bearing capacity is based on the assumption that the subgrade preparation recommendations, which are discussed in this report are followed. We recommend a minimum footing embedment of 24 inches below the lowest adjacent grade. We also recommend a minimum width of 18 inches for continuous footings and 24 inches for column footings.

Assuming compliance with the recommendations in our geotechnical report, we anticipate that static loading settlements would be 1 to 2 inches, with differential settlements between adjacent footings or over a 20-foot span of continuous footing equal to about half the total settlement. Our June 2002 technical memorandum included an original recommendation of 12 ksf allowable bearing capacity that corresponded to static loading settlements of about ½ to ¾ inch. At the request of Skilling Ward Magnusson Barkshire, we are providing a higher allowable bearing capacity (16 ksf), which corresponds to higher anticipated static loading settlements.

The new pedestrian tunnel excavation may encounter fill from previous construction of the existing tunnel, Administration Building, or other facilities, or from the proposed sewer line installation or other utilities beneath Oakes Avenue. If the base of the new tunnel excavation encounters fill, we recommend an allowable bearing capacity of about 3 ksf. To achieve the 3 ksf bearing capacity, we recommend that the upper 24 inches of exposed fill be densely compacted to 95 percent of its Modified Proctor maximum dry density and to a dense, unyielding condition.

If the proposed Administration Building finish floor elevation remains at 145 feet, the building will likely require support from a combination of foundation types. The southwest portion of the building may require deep foundations, such as drilled shafts or augercast piles based on the presence of deep, very loose fill encountered in boring B-11. Based on borings B-7, B-8, B-12, and B-12A, the remainder of the building would likely be founded on relatively shallow spread footings. Additional foundation recommendations for the Administration Building will be provided once more design information has been established.

10.5 Lateral Earth Pressures for Permanent Walls

Lateral earth pressures may act on buried portions of the building walls. For buried building walls that are allowed to move at least 0.001 times the wall height, we recommend that a static, active, lateral earth pressure be used. For buried building walls that are not allowed to move

recommend an allowable passive pressure of 190 pcf and 130 pcf, respectively. Both the coefficient and passive pressure values above include a factor-of-safety (FS) of 1.5.

10.7 Floor Slabs

In our opinion, floor slabs for the Administration Garage and pedestrian tunnel could consist of slabs-on-grade. All fill placed under slabs-on-grade, including backfill for footing excavations, utilities, etc., should consist of properly compacted structural fill over dense/hard, native soil.

We estimate that a modulus of subgrade reaction equal to 250 pounds per cubic inch (pci) for densely compacted structural fill over properly prepared native soil and 300 pci for very dense/hard native soil could be used for design of slabs-on-grade. This recommendation assumes that proper drainage is provided beneath the floor slabs. We recommend that a system of subdrains be installed beneath the garage floor slabs. Recommendations for subdrains are presented later in this report.

10.8 Temporary Excavation Shoring

10.8.1 Overview

In general, the site is underlain by very dense/hard glacially overridden soils at relatively shallow depths. We are currently designing soil nail shoring walls for temporary support of the Administration Garage excavation. As shown on the attached generalized subsurface profiles, the water-bearing advance outwash unit is above the base of the proposed excavation. Additional zones of water-bearing material may be encountered throughout the excavation. Temporary dewatering measures will be required in order to install soil nail shoring. Because soil nailing has been chosen as the preferred shoring system, we recommend that the contractor be prepared to deal aggressively with the anticipated groundwater conditions before the excavation deepens to the groundwater level. We understand that a 20- to 25-foot-deep sanitary sewer pipeline will be trenched down the center of Oakes Avenue possibly prior to soil nail installation. The backfill and construction timing of the sewer pipeline installation may also affect the soil nail design. In general, if there are deep utilities under the surrounding streets, it is likely that there is more fill present beneath the streets than what was encountered in our borings within the site. Typically, soil nails have a closer spacing and are longer when used in fill soils. Temporary soil nail shotcrete facing may need to be thicker and have more reinforcing to

maintain stability in fill soils, and the "stand up" time and depth for each level of excavation may be limited.

With every excavation in soil, both elastic and inelastic ground displacements will occur behind the earth support system as a result of the changes in stresses within the surrounding soil mass. The displacement magnitudes are dependent on the stress-deformation properties of the soil; design lateral earth pressures; the configuration, stages, and depth of excavation; wall stiffness; spacing of soil nails; groundwater conditions; and the care and skill with which the excavation work is accomplished. The following section provides a general soil nail description. We will provide soil nail wall shoring plans separately.

10.8.2 Description of Soil Nailing

Soil nailing consists of drilling and grouting a series of steel bars or "nails" behind the excavation face and then covering the face with reinforced shotcrete. The placement of relatively closely spaced steel nails in the retained soil mass increases the shear resistance of the soil against rotational sliding, increases the tensile strength of the soil behind potential slip surfaces, and moderately increases shear resistance at a potential slip surface due to the bending stiffness of the nails.

Soil nailing is most effective in dense, granular soils and stiff, low plasticity, fine-grained soils. Soil nailing may not be cost-effective in loose granular soils, soft cohesive soils, highly plastic clays, or where uncontrolled groundwater exists above the bottom of the excavation. In general, excavation faces must be able to stand unsupported for 24 to 48 hours in order for soil nailing to be feasible. Groundwater is anticipated to be above the bottom of the excavation at the Administration Garage; therefore, temporary dewatering measures would have to be implemented prior to shoring wall construction to control groundwater and maintain a dry excavation face. Temporary dewatering is discussed later in this report.

Soil nails consist of steel bars (typically 3/4 to 1-3/8-inch diameter), which are installed by tremie grouting the nail into a predrilled hole. Soil nails are located in a square or rectangular grid pattern and are typically installed at an inclination angle of 15 degrees from horizontal. The construction sequence of a soil nail wall generally includes three steps: 1) staged excavation, 2) nail installation and select nail testing, and 3) drainage and facing construction. This sequence is repeated until the excavation and shoring is complete.

Soil nail construction is performed from the ground surface down as excavation proceeds. In general, the first row of nails is installed not more than 2 to 4 feet below the ground surface, and the bottom row of nails is not installed higher than 4 feet above the bottom of the excavation. Nails are installed in horizontal rows around the excavation perimeter after excavation proceeds 2 to 3 feet below the planned nail elevation. Excavation could proceed ahead of nail installation in the central portion of the proposed building footprint away from soil nail walls.

10.8.3 Anticipated Movements

Soil nails develop capacity when the shoring wall deflects toward the excavation. Excessive deflection could result in damage to structures and utilities adjacent to the excavation. Our experience has shown that lateral deflections with soil nail walls of lesser height but in similar soil as those anticipated at the Administration Garage are typically less than one inch. Similar vertical settlements are expected to occur at the face of the wall. Vertical settlements will decrease with distance from the wall and should be negligible beyond a distance of about the wall height. Due to the proposed excavation depth, the settlements and lateral deflections for the Administration Garage may be somewhat larger than one inch.

10.9 Temporary Cut Slopes

If temporary open cut slopes are used on site, the "safe" temporary slope for excavations will depend on the following factors: (1) the amount of groundwater seepage, (2) the soils exposed in the excavation slope, (3) the depth of the excavation, (4) surcharge loads at the top of the excavation, (5) the geometry of the excavation, and (6) the time of construction. Construction slope values required for stability and safety depend on a careful evaluation of the above factors. Because of the many variables involved, required slope values can only be estimated prior to construction. For safe working conditions and prevention of ground loss, excavation slopes should be the responsibility of the contractor because he/she will be at the job site to observe and control the work. All current and applicable safety regulations regarding excavation slopes and shoring should be followed.

Excavations can be accomplished with conventional excavating equipment, such as a dozer, front-end loader, or backhoe. The glacially overridden material may be difficult to excavate. For planning purposes, we recommend that temporary, unsupported, open-cut slopes in the glacially overridden native soil be no steeper than 1 Horizontal to 1 Vertical (1H:1V), although localized steeper slopes may be possible in areas of stable soil. Where existing fill is

encountered, we recommend that cut slopes be no steeper than 1.5H:1V. Flatter cut slopes may be required where loose soils or seepage zones are encountered during excavation. Exposed cut slopes may need to be protected with a waterproof covering during periods of wet weather to reduce sloughing and erosion.

The above recommendations are for temporary cut slopes in dry conditions. If wet conditions or uncontrolled groundwater flow is encountered, flatter slopes may be required. Based on our experience, in addition to the anticipated groundwater table, seeps and springs may be encountered, even in very dense, glacial till cut slopes. Care should be taken near the existing building footings to make sure that the open cut does not undermine the bearing capacity of the footing subgrade soils.

Also, all traffic and/or construction equipment loads should be set back from the edge of the cut slopes by a minimum of 2 feet. Excavated material, stockpiles of construction materials, and equipment should not be placed closer to the edge of any excavation than the depth of the excavation, unless the excavation is shored and such materials are accounted for as a surcharge load on the shoring system.

10.10 Excavation of Potentially Contaminated Soil

Soil and groundwater contamination are present in approximately the north half of the site (the Administration Garage). More specifically, past operations in the area of borings B-10, B-12, B-13, B-14, B-16, and B-18 (see Figure 2) have apparently resulted in the release of hydrocarbons to the soil and groundwater. Our assessment of the area's conditions is ongoing. Some of the soil and groundwater encountered in the proposed excavation will be affected by the contamination and will need to be handled and disposed of properly.

Based on our experience with Washington State Department of Ecology (Ecology), source removal and proper disposal of contaminated soil within the limits of the proposed excavation will likely be an appropriate soil cleanup action. We have discussed this potential action with the County and Ecology, but because we have yet to identify the source location, actual soil cleanup actions are still under consideration. Once a cleanup action is selected, we recommend that a Cleanup Action Plan summarizing proposed remedial actions be prepared for and submitted to Ecology, or that a meeting with Ecology take place to discuss proposed actions. In

addition to notifying Ecology of proposed action, a public agency is also able to request matching funds from the state to assist with cleanup costs incurred.

Given the impacts to construction, we recommend that the prime contractor and excavation and shoring subcontractors be familiar with these site conditions (via meetings, plans, specifications, or other project documents) so they are prepared to address contamination in the field. This preparation includes using appropriately trained personnel; proper segregation, handling, and disposal of contaminated soil; and collection, possible treatment, and disposal of groundwater. Proper handling, screening, storing, testing, and disposal procedures should be included in the project specifications. Shannon & Wilson should prepare a Construction Contingency Plan to help field personnel be prepared for, identify, and properly handle contaminated soil and groundwater. The Construction Contingency Plan would also address proper equipment cleaning during and/or after work within the contaminated excavation zone.

During construction, we further recommend that when excavation is occurring in the general vicinity of borings B-10, B-12, B-13, B-14, B-16, and B-18, or if another area of potential contamination is discovered during site activities, that we be on site to field screen soil for the presence of contamination. Based on sampling and analyses during field investigations to date, contaminant levels in the soil do not exceed proposed cleanup levels except at boring B-18. However, the presence of small amounts of contamination can cause an odor. Our experience is that any soils with a detectable hydrocarbon odor will not be accepted as "clean fill." As a result, some excavated soils may need to be segregated for separate disposal even if they do not exceed cleanup levels. As our assessment continues we will estimate the extent of the contaminant plume so that the contractor can plan accordingly. Field screening will assist in segregating "clean" soil from impacted soil for disposal purposes. It will also provide a basis for Ecology-required documentation that we will submit following soil removal.

10.11 Temporary Dewatering

We recommend that the groundwater inflow into the excavation be controlled for soil nailing operations and to provide dry conditions for construction activities. In our opinion, a combination of pre-excavation aquifer depressurization and construction dewatering will be required to achieve these goals. Aquifer depressurization using deep dewatering wells and beginning a minimum of 14 days prior to excavation activities would allow initial excavation activities to commence. A vacuum extraction/well point system can be subsequently installed

and operated to dewater the advance outwash as the excavation depth approaches the primary water-bearing zone and the piezometric surface in the advance outwash.

We completed a dewatering analysis for the project based on the soil and groundwater conditions described in Section 9.0 and aquifer parameters estimated from the slug testing (Section 6.0 and Appendix D). Our analysis indicates that a deep dewatering system consisting of 12 perimeter wells will be required for initial depressurization of the advance outwash aquifer. Eight wells should be installed on approximately 50-foot centers along the western-most excavation edge and along half of the northern excavation edge (western half); two wells should be installed along the south edge about 125 to 150 feet apart; and two wells should be installed along the east excavation edge near the north corner, about 80 to100 feet apart. The well diameter should be 6 to 8 inches and the maximum well depth will probably not exceed 100 feet. The total discharge from the 12-well system will likely be from 100 to 250 gallons per minute.

Following the initial depressurization, a second dewatering system consisting of a vacuum extraction/well point system, installed at an angle into the soil, would provide construction dewatering of the primary water-bearing unit (advance outwash) as the excavation approaches the piezometric surface and the top of the aquifer. The well points should be: 1) operated while continuing the use of the deep dewatering well system; 2) installed from within the excavation and around the entire perimeter of the excavation; and, 3) installed on approximately 6- to 9-foot centers, alternating with soil nail locations. The well points would be installed through and behind the existing soil nail wall excavation face and angled downward into the aquifer. Installation of the well point system should begin approximately 15 feet above the bottom of the aquifer. The total discharge from the vacuum extraction/well point system will likely be from 150 to 200 gallons per minute. Additional lifts and/or well points may be required if significant water-bearing zones are encountered below the primary water-bearing zone.

10.12 Potentially Contaminated Groundwater Collection, Treatment, and Disposal

In addition to contaminated soil, contaminated groundwater is present on site and will require action during construction. Based on the analytical test results, some of this groundwater may not be suitable for discharging directly into the sewer and would therefore require isolation for treatment and/or disposal. The construction groundwater from the soil nail drainage material, dewatering wells, well points, and any sumps that may be used, would need to be collected, analyzed (tested), possibly treated, and then disposed. If analysis indicates that the groundwater

becomes too difficult to compact or site space limitations prevent stockpiling, we recommend imported, granular structural backfill be used.

Imported, structural backfill should meet the gradation requirements of Section 9-03.14(1), Gravel Borrow, of the 1998 Washington State Department of Transportation (WSDOT) Standard Specifications. If fill is to be placed during periods of wet weather or under wet conditions, it should have the added requirement that the percentage of fines (material passing the No. 200 sieve based on wet-sieving the minus ¾-inch fraction) be limited to 5 percent. Any fines should be non-plastic.

Backfill should be placed in horizontal loose lifts not to exceed 4 inches for hand-operated compaction equipment and 8 inches for heavy compaction equipment. The fill should be compacted to at least 95 percent of its Modified Proctor maximum dry density as determined by American Society for Testing and Materials (ASTM) D 1557.

11.0 CONSTRUCTION CONSIDERATIONS

11.1 Footings

The recommended bearing pressures presented in this report require careful preparation of the footing subgrade. Footing excavations should be cleaned of all loose soil, leveled, and protected from water. If groundwater is encountered above the level of the proposed footings, temporary dewatering would be required to properly prepare footings. We recommend that temporary dewatering maintain the groundwater at least 2 feet below the level of the footing subgrade. The soils at the site contain sufficient fines to become soft and spongy when subjected to water and disturbance (from equipment or foot traffic). If construction is to take place during wet weather or under wet conditions, we recommend that the prepared footing subgrade be protected by placing a thin lean concrete "rat slab" immediately after excavation is completed.

Many of the perimeter footings may be designed to "undercut" the soil nail wall. For these footings, a shallow excavation is planned to extend below the wall and into the soil. The footing reinforcing steel will then be pushed into place and concrete pumped into the excavation. Such an approach can only be successfully constructed in dense, dry, competent soils. The condition of the soil at each perimeter footing will not be known until the excavation reaches the design depth. Specific preliminary requirements include:

- No excavation may extend more than about 4 ½ feet behind the soil nail wall face.
- No excavation beneath/behind the soil nail wall face may be more than about 3 feet in height.
- No open cut longer than 9 feet parallel to the wall face is allowed.
- Excavate alternating perimeter footings and allow the footings' structural concrete to gain sufficient strength to support the soil above it prior to excavating the intermediate footings.
- If caving occurs, immediately backfill the undercut excavation with expansive grout.
- Under no circumstances should the safety of the workers or the stability of the shored wall be put at risk during this construction operation.
- Shannon & Wilson must be on site to observe this activity.

If we have concerns about the procedures as they are underway, we will notify the County, NBBJ, and the contractor at once and discuss appropriate actions.

Each footing subgrade on the project should be evaluated by a qualified geotechnical engineer to confirm suitable bearing conditions and to determine that all loose materials have been removed. The footing evaluation should be determined prior to placing the rat slab, if used.

11.2 Soil Nails

Soil nails should be installed in a horizontal sequence with the base of the staged excavation extending a maximum of 2 to 3 feet below the level of the nail to be installed. More details will be provided in the shoring plan notes. If new utilities are installed along or near the base of the wall, the full depth of the excavation (including utility trench) should be included in the design. Any utilities to be installed behind temporary shoring walls should be installed before excavation begins or after the permanent basement walls are capable of supporting the design lateral earth pressures.

Based on our experience, we anticipate that little or no sloughing will occur in the glacial till soil if the soils are dry and unsupported heights do not exceed 6 feet. However, if the soil does not contain sufficient binder material, it may slough; no test cuts were completed during our study. Also, if groundwater seepage is encountered, flowing ground conditions and/or sloughing could

- Earthwork should be accomplished in small sections to reduce exposure to wet weather. That is, the removal of unsuitable soil, and the placement and compaction of at least 12 inches of clean, imported fill, should be accomplished on the same day. The size of equipment may have to be limited to prevent soil disturbance. In some instances, it may be necessary to excavate soils with a backhoe or equivalent equipment outfitted with a flat plate on the bucket, to reduce subgrade disturbance caused by equipment traffic.

- No fill soil should be left uncompacted and exposed to water. A smooth-drum vibratory roller, or equivalent, should roll the fill surface to promote rapid runoff of surface water.

- Soils that become too wet for compaction should be removed and replaced with clean, imported structural fill material.

- Excavation and placement of structural fill material should be observed on a full-time basis by a geotechnical engineer or engineer's representative, experienced in wet weather earthwork, to determine that all work is being accomplished in accordance with the intent of the specifications.

The above recommendations for wet weather earthwork should be incorporated into the contract specifications.

11.6 Plans and Specifications Review and Construction Observation

We recommend that Shannon & Wilson be retained to review those portions of the plans and specifications that pertain to the items discussed in this report to determine if they are consistent with our recommendations. We are available to provide specification sections to address handling, screening, storing, testing, and disposal procedures of potentially contaminated soil and groundwater. We also recommend we be retained to observe the geotechnical and environmental aspects of construction. This observation would allow us to verify the subsurface conditions as they are exposed during construction and to determine that the work is accomplished in accordance with our recommendations.

12.0 ADDITIONAL WORK

Assessment, planning, and design of the methods of addressing soil and groundwater contamination are still underway. We will prepare a Construction Contingency Plan for these conditions.

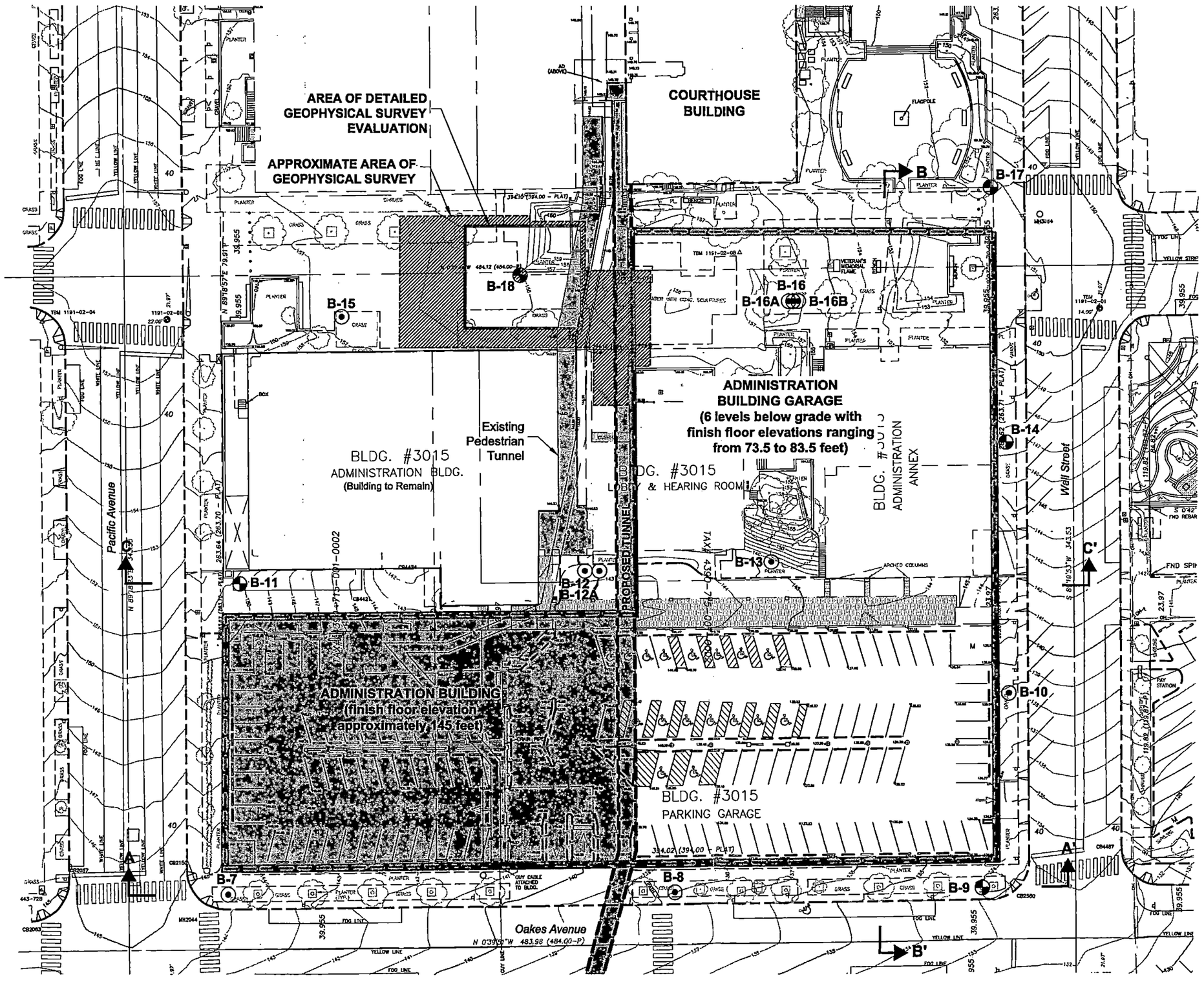
13.0 LIMITATIONS

The analyses, conclusions, and recommendations contained in this report are based on site conditions as they presently exist and further assume that the field explorations are representative of the subsurface conditions at the site, that is, the subsurface conditions everywhere are not significantly different from those disclosed by the explorations.

Within the limitation of scope, schedule, and budget, the conclusions and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical and environmental engineering principles and practices in the area at the time this report was prepared. We make no other warranty, either expressed or implied. The analyses, conclusions, and recommendations contained in this report are based on our understanding of the project and site conditions as described in the report. If, during construction, subsurface conditions different from those encountered in the field explorations are observed or appear to be present during excavations, we should be advised at once so we can review these conditions and reconsider our recommendations, where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of our conclusions and recommendations considering the changed conditions and time lapse.

We should be retained to review those portions of the plans and specifications that pertain to site preparation, earthwork, temporary shoring, temporary dewatering, footings, permanent drainage installation, and remediation system to determine if they are consistent with our recommendations. In addition, we should also be retained to monitor these tasks during construction.

This report was prepared for the exclusive use of NBBJ, Snohomish County, and members of the design team for the proposed Administration Building and Garage. It should be made available to prospective contractors for information on factual data only, and not as a warranty of subsurface conditions, such as those interpreted from the boring logs and discussions of subsurface conditions included in this report.



LEGEND

- Approximate Extent of Proposed Excavation
- B-7 ⊙ Current Boring Designation and Approximate Location
- B-9 ◔ Current Boring Designation and Approximate Location, Completed as a Monitoring Well
- A Generalized Subsurface Profile Designation and Approximate Location

NOTES

1. This figure adapted from site topographic survey by Perteet Engineering, Inc., dated 6-2001. Elevation datum NAVD 88.
2. Boring locations are based on tape measurements from existing site features and should be considered approximate.

0 50 100

Scale in Feet

Snohomish County Campus
Administration Building
Everett, Washington

SITE AND EXPLORATION PLAN

August 2002 21-1-09644-005

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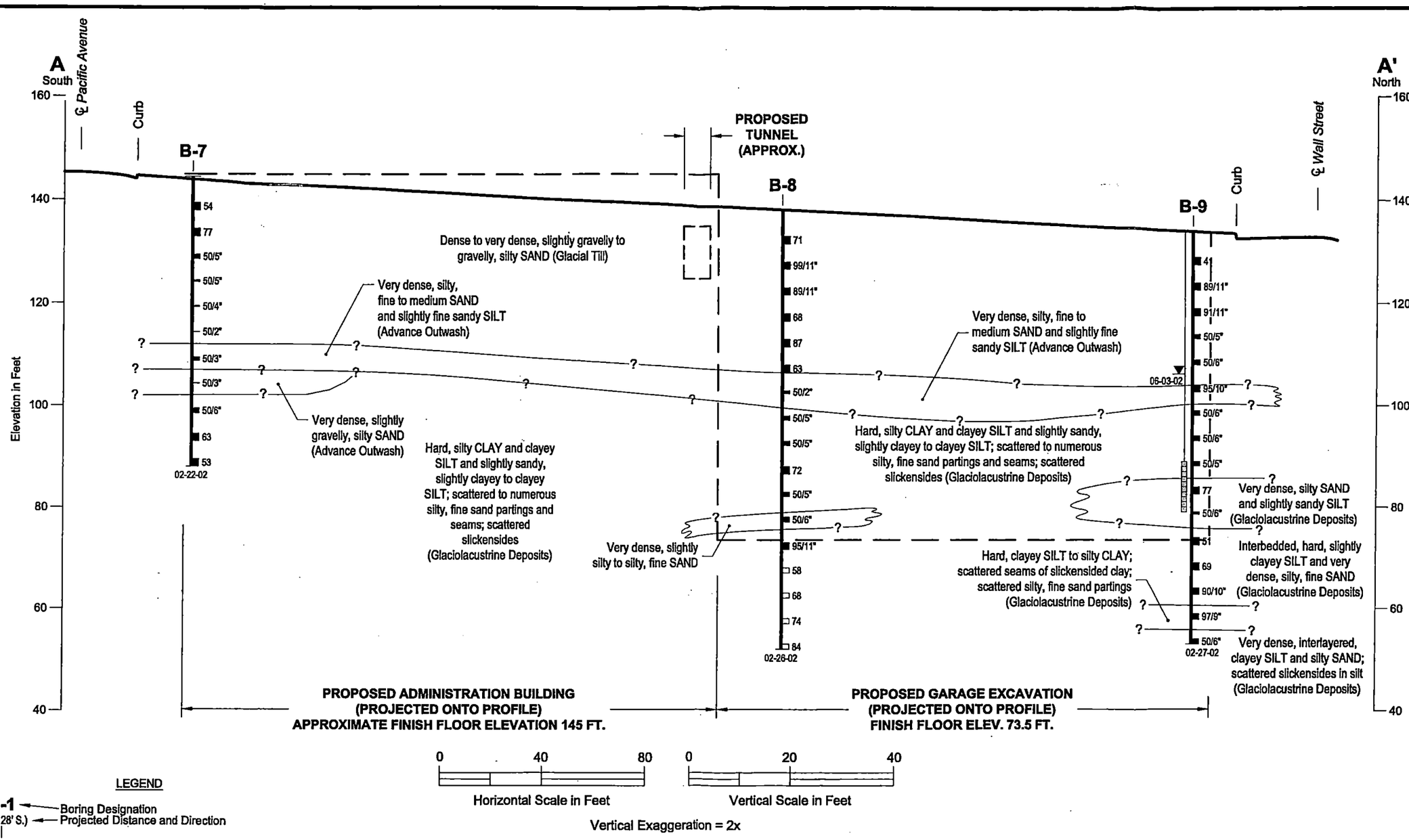
Geotechnical and Environmental Consultants

FIG. 2

File: I:\Drafting\21\09644-005\Admin Bldg\21-1-09644-005 fig 2 (8-02).dwg Date: 08-08-2002 Author: SAC



LEGEND

- B-1 (Proj. 28' S.) — Boring Designation; Projected Distance and Direction
- 66 — Standard Penetration Test Blows/Foot
- 50/6" — Standard Penetration Test Blows/Inches Driven
- 74 — Nonstandard Blow Count (See Log)
- 03-04-02 — Water Level in Monitoring Well and Date Observed
- Monitoring Well Screen
- Water Level Observed During Drilling
- ? — Approximate Geologic Contact
- 02-28-02 — Bottom of Boring; Date Completed

NOTES

1. This subsurface profile is generalized from materials observed in soil borings. Variations may exist between profile and actual conditions.
2. For clarity, this profile has been simplified. For detailed soil descriptions, refer to the boring logs.

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GENERALIZED SUBSURFACE PROFILE A-A'

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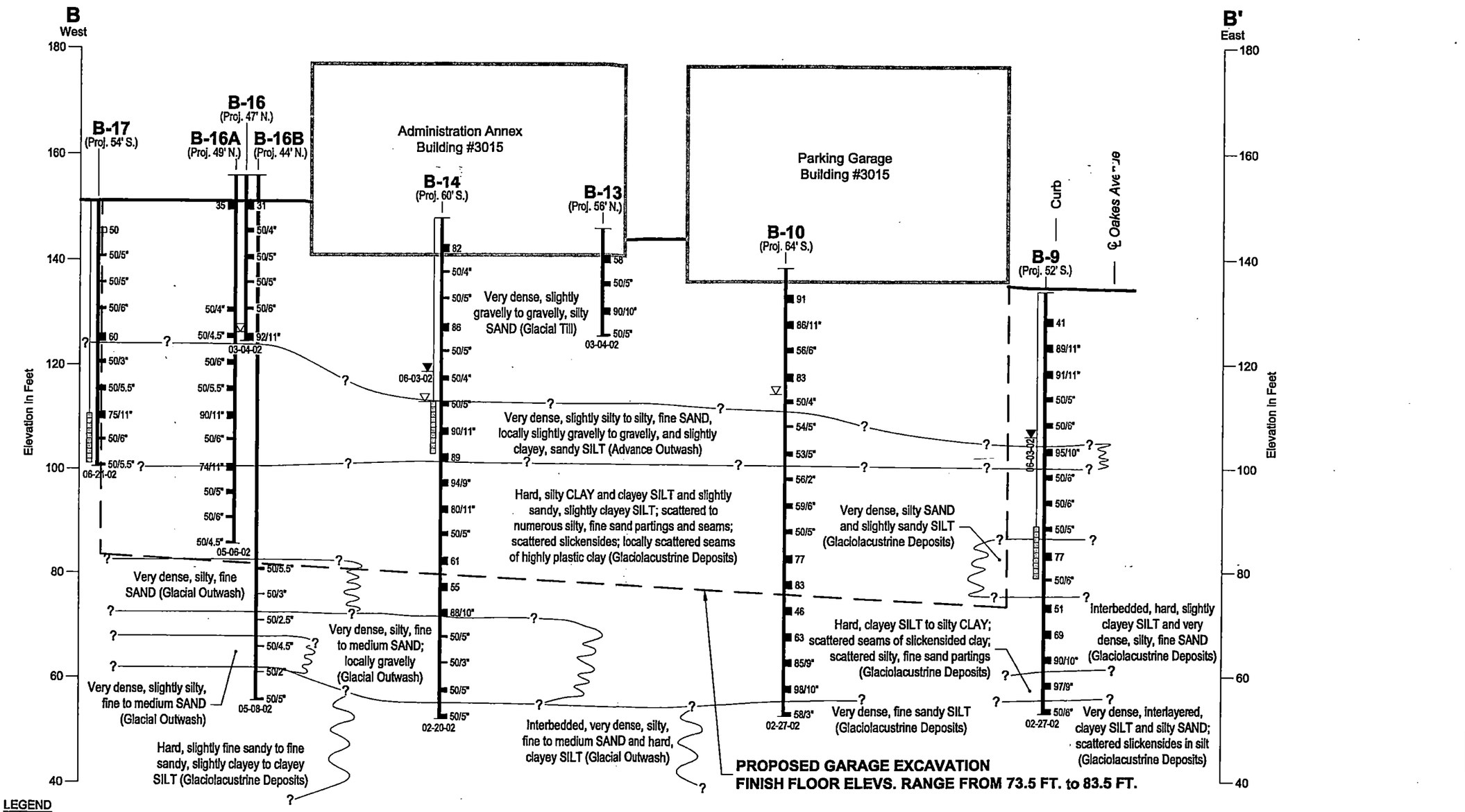
FIG. 3

File: I:\Drafting\21\09644-005\Admin Bldg\21-1-09644-005 fig 3 (8-02).dwg Date: 08-01-2002 Author: SAC



LEGEND

- B-1 (Proj. 28' S.) — Boring Designation; Projected Distance and Direction
- 66 — Standard Penetration Test Blows/Foot
- 50/6" — Standard Penetration Test Blows/Inches Driven
- 74 — Nonstandard Blow Count (See Log)
- 03-04-02 — Water Level in Monitoring Well and Date Observed
- Monitoring Well Screen
- Water Level Observed During Drilling
- Approximate Geologic Contact
- 02-28-02 — Bottom of Boring; Date Completed

0 40 80 — Horizontal Scale in Feet

0 20 40 — Vertical Scale in Feet

Vertical Exaggeration = 2x

NOTES

1. This subsurface profile is generalized from materials observed in soil borings. Variations may exist between profile and actual conditions.
2. For clarity, this profile has been simplified. For detailed soil descriptions, refer to the boring logs.

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GENERALIZED SUBSURFACE PROFILE B-B'

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FIG. 4

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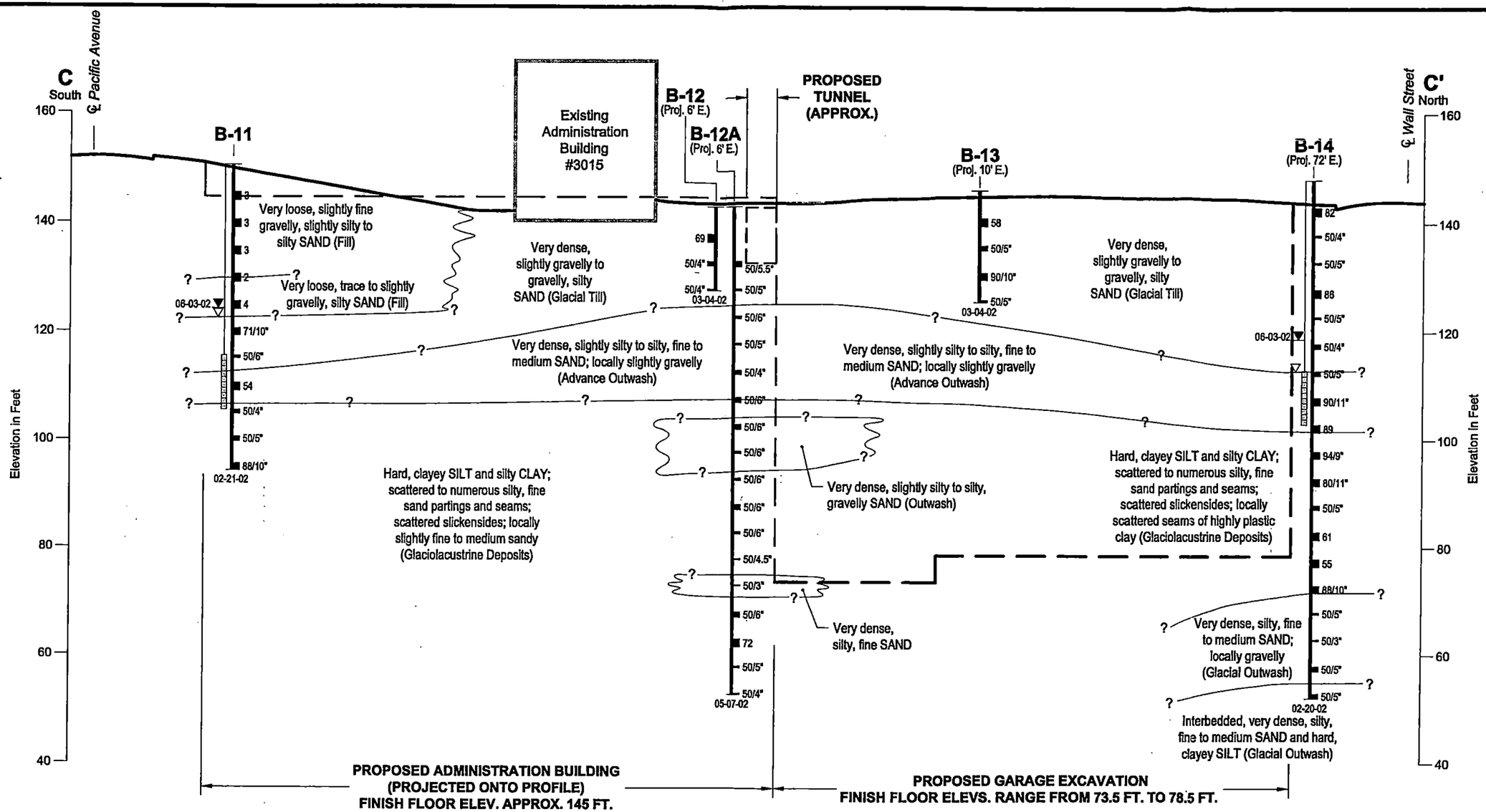

LEGEND

B-1 — Boring Designation
(Proj. 28' S.) — Projected Distance and Direction
66 — Standard Penetration Test Blows/Foot
50/6" — Standard Penetration Test Blows/Inches Driven
74 — Nonstandard Blow Count (See Log)
03-04-02 — Water Level in Monitoring Well and Date Observed
Monitoring Well Screen
Water Level Observed During Drilling
? — ? Approximate Geologic Contact
02-28-02 — Bottom of Boring Date Completed

0 40 80
Horizontal Scale in Feet

0 20 40
Vertical Scale in Feet

Vertical Exaggeration = 2x

NOTES

1. This subsurface profile is generalized from materials observed in soil borings. Variations may exist between profile and actual conditions.
2. For clarity, this profile has been simplified. For detailed soil descriptions, refer to the boring logs.

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GENERALIZED SUBSURFACE PROFILE C-C'

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FIG. 5

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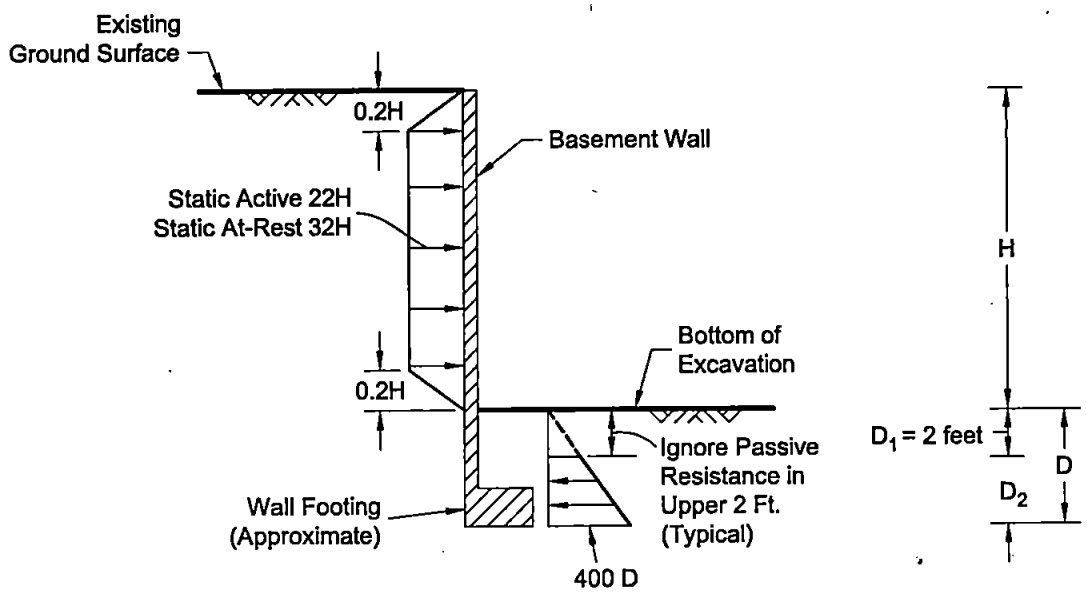

Not to Scale

NOTES

1. All Earth Pressures are in units of pounds per square foot. The earth pressure diagram applies to the garage permanent walls with either a multiple-level tieback wall or a soil nail shoring wall.
2. Lateral pressures for traffic surface surcharges should be added to the earth pressures given above.
3. If a sloping grounds surface exists, the earth pressures should be adjusted.
4. The recommended pressure diagrams are based on a continuous wall system.
5. Free drainage is assumed behind the wall.
6. Static apparent earth pressures given above are for native glacially overridden soil. For compacted structural backfill, we recommend 24H and 36H for static active and at-rest conditions, respectively.
7. If temporary soil nail walls are used, we recommend that the permanent basement wall design be based on the active, apparent earth pressure. If a top-down permanent soil nail wall is installed, we recommend that the structural engineer evaluate whether the active or the at-rest apparent earth pressure is most appropriate.

LEGEND

H = Wall Height (Ft.)

D, D_1, D_2 = Embedment Depths (Ft.)

32H, 22H = Static Apparent Earth Pressure for Native Glacial Soil

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ADMINISTRATION GARAGE LATERAL EARTH PRESSURE PERMANENT WALL DESIGN CRITERIA

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FIG. 6

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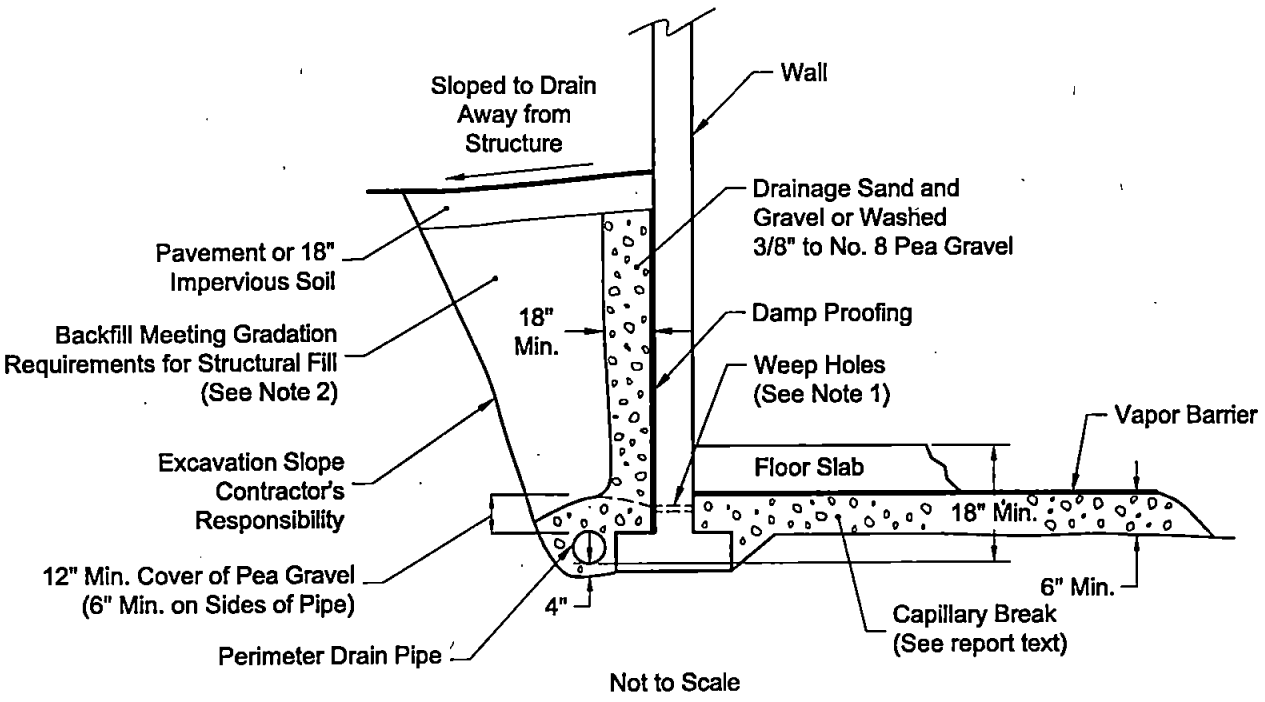

Not to Scale

MATERIALS

Drainage Sand & Gravel with the Following Specifications:

Sieve Size	% Passing by Weight
1-1/2"	100
3/4"	90 to 100
1/4"	75 to 100
No. 8	65 to 92
No. 30	20 to 65
No. 50	5 to 20
No. 100 (by wet sieving)	0 to 2 (non-plastic)

PERIMETER DRAIN PIPE

4" minimum diameter perforated or slotted pipe; tight joints; sloped to drain (6"/100' min. slope); provide clean-outs.

Perforated pipe holes (3/16" to 3/8" dia.) to be in lower half of the pipe with lower quarter segment unperforated for water flow.

Slotted pipe to have 1/8" maximum width slots.

NOTES

1. Capillary break beneath floor slab should be hydraulically connected to perimeter drain pipe. Use of 1-inch diameter weep holes as shown is one applicable method.
2. Structural fill should meet WSDOT Gravel Borrow Specification 9-03.14(1) but should have a maximum size of 3 inches, and should not have more than 5% fines (by weight based on minus 3/4" portion) passing No. 200 sieve (by wet sieving) with no plastic fines during wet conditions or wet weather.
3. Backfill within 18" of wall should be compacted with hand-operated equipment. Heavy equipment should not be used for backfill, as such equipment operated near the wall could increase lateral earth pressures and possibly damage the wall.
4. All backfill should be placed in layers not exceeding 4" loose thickness for light equipment and 8" for heavy equipment and densely compacted. Beneath paved or sidewalk areas, compact to at least 95% Modified Proctor maximum dry density (ASTM: D1557, Method C or D). Otherwise compact to 90% minimum.
5. See report text for discussion of filter fabric / filter material requirements below the capillary break.

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TYPICAL BACKFILLED WALL PERIMETER DRAIN AND BACKFILL

August 2002 21-1-09644-005

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FIG. 7

File: I:\Drafting\21\109644-005\Admin Bldg\21-1-09644-005 fig 7.dwg Date: 08-08-2002 Author: CNT

APPENDIX A

FIELD EXPLORATIONS

APPENDIX A

FIELD EXPLORATIONS

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LIST OF FIGURES

Figure No.

LIST OF FIGURES (cont.)

Figure No.

APPENDIX A

FIELD EXPLORATIONS

A.1 GENERAL

The field exploration program for the Snohomish County Campus Administration Building and Garage consisted of drilling and sampling 15 borings. The approximate exploration locations are shown on the Site and Exploration Plan (Figure 2) in the main text of the report. The locations of our borings were determined by taping from site features. The elevations of the borings were determined by plotting the boring locations on the site topographic survey. All the boring locations and elevations should be considered accurate to the degree implied by the method used.

A representative from Shannon & Wilson, Inc. was present throughout the field exploration period to observe the drilling and sampling operations, retrieve representative soil and groundwater samples for subsequent laboratory testing, and to prepare descriptive field logs of the explorations. Soils were classified in general accordance with the American Society for Testing and Materials (ASTM) Designation: D 2488 Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The current exploration logs presented in Figures A-2 through A-16 represent our interpretation of the contents of the field logs and the results of geotechnical laboratory testing. Figure A-1 presents a key to our classification of the materials encountered.

A.2 BORINGS

The borings were advanced at selected locations around the site where access was available. All of the borings were drilled with a truck-mounted or track-mounted drill rig. The borings were advanced to depths ranging from 15.3 to 100.4 feet.

A.2.1 Drilling

Ten borings (B-7 through B-12, and B-13 through B-16) were completed by Gregory Drilling, of Redmond, Washington, under subcontract to Shannon & Wilson, Inc., between February 19 and March 4, 2002, using either a truck-mounted CME-85 drill rig or a track-mounted CME-45C drill rig. Drilling was accomplished using a combination of hollow-stem auger and mud rotary drilling techniques. Hollow-stem auger borings are drilled using a 3.25-inch or 4.25-inch inside-diameter continuous flight auger. Samples are retrieved

from within the hollow-stem. Mud rotary borings are advanced by circulating thick drilling mud from the rig down through standard 2-5/8-inch outside-diameter NX rods to a 2-15/16-inch or 3-7/8-inch-diameter tri-cone bit at the bottom of the borehole. The drilling mud is a mixture of bentonite powder and water. Cuttings are transported from the bottom of the borehole to the surface by drilling mud flowing between the drilling rods and the sides of the borehole. The cuttings are deposited in a settling tank at the ground surface and the mud is recirculated. After completion of drilling and sampling, all borings except B-9, B-11, and B-14 were sealed with bentonite grout and chips. Monitoring wells were installed in borings B-9, B-11, and B-14. Contamination was observed in Borings B-12, B-13, and B-16 during drilling; these borings were terminated before reaching design depth.

Because contamination was encountered during the drilling of borings B-12, B-13, and B-16, three additional borings (B-12A, B-16A, and B-16B) were advanced with an environmental driller to advance the boring to proposed drill depth and evaluate the vertical extent of contamination at the boring locations. These three additional borings were drilled by Holt Drilling of Puyallup, Washington, under subcontract to Shannon & Wilson, Inc., between May 6 and 10, 2002. A track-mounted, limited access drill rig was used to advance the borings using hollow-stem auger and mud rotary drilling techniques. After completion of drilling and sampling, borings B-12A and B-16A were sealed with drilling mud and bentonite chips and boring B-16B was sealed with bentonite grout and chips. Potentially contaminated soil was drummed, labeled, and left on site. Boring B-16A was terminated early because the driller was unable to continue to depth with hollow-stem auger acting as casing because mud circulation was lost through the augers used to case the hole. B-16B was later completed to proposed drill depth.

Based on the saturated sandy conditions encountered during drilling of borings B-16A and B-16B, hydrogeologic testing was conducted to evaluate the potential water volume that may be encountered during construction. Cascade Drilling, Inc., of Woodinville, Washington, under subcontract to Shannon & Wilson, Inc., drilled borings B-17 and B-18 on June 21, 2002, to 50.5 and 45.8 feet, respectively. Both borings were completed as monitoring wells.

A.2.2 Soil Testing and Sampling

Disturbed samples were obtained in conjunction with the Standard Penetration Test (SPT). SPTs were performed in general accordance with ASTM Designation D 1586, Standard Method for Penetration Testing and Split-Barrel Sampling of Soils. SPTs were generally performed at 5-foot intervals starting at 5 feet below ground surface. The SPT consists of

driving a 2-inch outside-diameter, split-spoon sampler a distance of 18 inches into the bottom of the borehole with a 140-pound hammer falling 30 inches. The number of blows required for the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). This value is an empirical parameter that provides a means for evaluating the relative density, or compactness, of granular soils and the consistency, or stiffness, of cohesive soils. These values are plotted at the appropriate depths on the boring logs included in this appendix. Generally, whenever 50 or more blows were required to cause 6 inches or less of penetration, the test was terminated, and the number of blows and the corresponding penetration was recorded. The N-values are plotted on the boring logs presented on Figures A-2 through A-16.

A.2.3 Monitoring Well Installation

As part of the investigation, several monitoring wells were installed to evaluate groundwater conditions that may be encountered during construction. Additionally, because a water-bearing formation was encountered within the proposed garage excavation footprint, two wells were installed to perform slug testing. Monitoring wells were installed in borings B-9, B-11, B-14, B-17, and B-18. In borings drilled using hollow-stem auger methods, the well screen and riser pipe was installed through the augers. In borings drilled using a mud rotary drilling rig, the drilling mud was pumped from the hole prior to installation of the well screen and riser pipe.

The monitoring wells were constructed of new, commercially fabricated, threaded, flush-jointed, 2-inch-diameter Schedule 40 polyvinyl chloride (PVC). Well screen consisted of new, commercially fabricated, threaded, 10-foot-long, flush-jointed, 2-inch-diameter, 0.01-inch-wide machine-slotted screen. A silica sand filter pack was poured in the annular space between the boring and the well screen to about 2 to 3 feet above the screen. A minimum 2-foot-thick bentonite seal was placed in the annulus above the filter pack to within 3 feet of the surface. The wells were completed flush with the elevation of the surrounding grade by placing an 8-inch-diameter flush-mount steel monument over the top of the borehole. The steel monuments were set in-place with quick set concrete.

A.2.4 Well Development

Well development was performed at borings B-9, B-11, B-14, B-17, and B-18 between May 24 and July 1, 2002, to improve the hydraulic connection between the aquifer and the screened portion of the monitoring well. The development procedure consisted of a combination

of surging and pumping. The saturated screened section of each observation well was surged and pumped simultaneously to remove water, drilling mud and sediment from the bottom of the well. Development equipment consisted of a Waterra™ 2-inch-diameter, Acetal surge block/check-valve combination attached to the bottom of a dedicated section of semi-rigid high-density polyethylene (HDPE) tubing, operated by an electric Waterra™ motor. Immediately prior to the start of development, each well was checked for the presence of floating free product using a new HDPE bailer. The sediment load of the purged groundwater was measured periodically by filling a container and observing the amount of sediment that settled out. Wells were pumped until there was no further observed improvement in water quality. A total of about 21.5 to 100 gallons were evacuated from each of the wells. A gasoline odor and slight sheen was observed during the development of B-14 and B-18. Purged groundwater from borings B-17 and B-18 was placed in labeled drums and stored in the site drum staging area.

A.2.5 Groundwater Observations

Where observed, groundwater was noted during drilling. Groundwater levels from borings B-9, B-11, and B-14 were also read on April 30, 2002, and after well development on June 3, 2002. Levels were measured on July 1, 2002, prior to slug testing in B-9, B-14, and B-17; levels were also measured in B-14, B-17, and B-18 prior to sampling on July 3, 2002. Both the during-drilling and the most recent groundwater level measurements are noted on the boring logs. Typically, groundwater levels are 26 to 30 feet below the existing ground surface. Two notable exceptions are in boring B-17, where the monitoring well groundwater level was measured about 35 feet below ground surface, and in boring B-12A where groundwater was observed about 13 feet below ground surface during drilling. Also, no groundwater was observed during drilling of boring B-9, but when the monitoring well was read, the groundwater level was measured about 28 feet below ground surface. Based on boring B-9, it is likely that other borings where groundwater was not observed during drilling may in fact be wet during a more extended excavation time.

A.3 FIELD SCREENING AND ENVIRONMENTAL SAMPLING METHODOLOGY

Selected soil samples were retrieved and field screened for the potential presence of contamination. Field screening methods included photoionization detector (PID) measurements, visual observations, and olfactory observations. Several samples were selected for chemical analysis based on field screening results, sample depth, and depth to groundwater (if encountered).

No potential sources of contamination were anticipated during the initial drilling phase. Therefore, field screening was conducted in the shallow soils of borings B-9 through B-12 and B-13 through B-16 (generally the uppermost 10 to 20 feet). Based on the presence of impacted soil, soil from subsequent borings (B-12A, B-16A, B-16B, B-17, and B-18) was field screened throughout the boring or to 5 to 10 feet below the groundwater level if the screening did not indicate the potential for contamination.

A.3.1 PID Measurements

PID measurements were made to screen for volatile organic vapors such as gasoline and solvents. PID measurements were obtained by passing the instrument directly over the soil sample or by performing a headspace measurement. Readings of 2 parts per million (ppm) or more above background were considered suspect.

A.3.2 Visual Observations

Visual observations (such as sheen, or gray or black discoloration) of soil samples and groundwater were recorded on the boring logs.

A.3.3 Olfactory Observations

Olfactory observations were recorded when noted. Soil was not intentionally smelled for contamination.

A.3.4 General Soil Sampling and Sample Handling

All environmental soil samples were collected using disposable sampling equipment and immediately placed into laboratory-provided glassware. Each sample was identified with a unique sampling number, immediately logged and sealed in plastic bags, and then placed into a cooler and maintained at 4°C (± 2°C). Sample information was recorded on chain-of-custody forms that accompanied the samples to the laboratory. Samples were maintained under chain-of-custody until delivered to the analytical laboratory, CCI Analytical Laboratory (CCIAL) of Everett, Washington.

A.3.5 Groundwater Sampling

Where groundwater sampling was performed (borings B-14, B-17, and B-18), sampling took place at least 24 hours after well development. The well was then slowly purged using a disposable, HDPE bailer suspended on nylon cord to remove standing water so that a

representative sample of groundwater was collected. A minimum volume equivalent of three times the casing volume was removed. Purge water was drummed with the development water and left on site. Field parameters (pH, specific conductance, turbidity, and temperature) were measured before, during, and after purging, and before sample collection. New nylon rope and bailers were used at each well. The bailer was lowered slowly and gently into contact with the water in the well, retrieved smoothly and the slowly emptied into the sample container.

Groundwater samples submitted to the analytical laboratory were handled in accordance with procedures described above.

A.4 ANALYTICAL METHODS

Selected soil samples were analyzed for one or more of the following: petroleum by Methods Northwest Total Petroleum Hydrocarbons as Diesel – Extended (NWTPH-Dx) and Northwest Total Petroleum Hydrocarbons as Gasoline (NWTPH-Gx); benzene, toluene, ethylbenzene, and xylenes (BTEX) by U.S. Environmental Protection Agency (EPA) Method 8021B; BTEX by EPA Method 8260; and total lead by EPA method 7420/7421. A total of six soil samples and three groundwater samples were submitted for testing.

Analytical work was performed by CCIAL in accordance with their in-house Quality Assurance/Quality Control Plans. Sample analyses were performed in compliance with Environmental Protection Agency (EPA) analytical methods and Washington State Department of Ecology guidelines. Samples were analyzed within specified holding times. Laboratory test results are presented a table after the main report text and are contained in Appendix C.

A.5 DECONTAMINATION METHODS

All non-disposable equipment that was used during sampling of environmental borings was steam cleaned prior to use. Downhole equipment and samplers used during sampling of environmental borings were also cleaned between each location. All other non-dedicated sampling equipment, including all split-barrel samplers, spoons, spatulas, trowels, and bowls, and other stainless steel equipment used for field activities, were decontaminated by washing with a detergent and rinsing equipment completely with water.

A.6 REFERENCE

American Society for Testing and Materials (ASTM), 2002, Annual book of ASTM standards: Soil and rock, building stone; geosynthetics: Philadelphia, Penn., v. 04.08.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 40 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WLI	Water level indicator

GRAIN SIZE DEFINITION

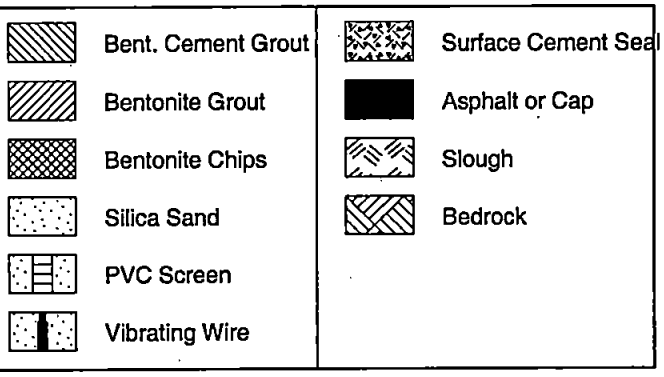
DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.8 mm)
SAND*	
- Fine	#200 to #40 (0.8 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sands and gravels, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS



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SOIL CLASSIFICATION AND LOG KEY

August 2002 21-1-09644-005

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 2

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From ASTM D 2487-98 & 2488-93)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

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SOIL CLASSIFICATION AND LOG KEY

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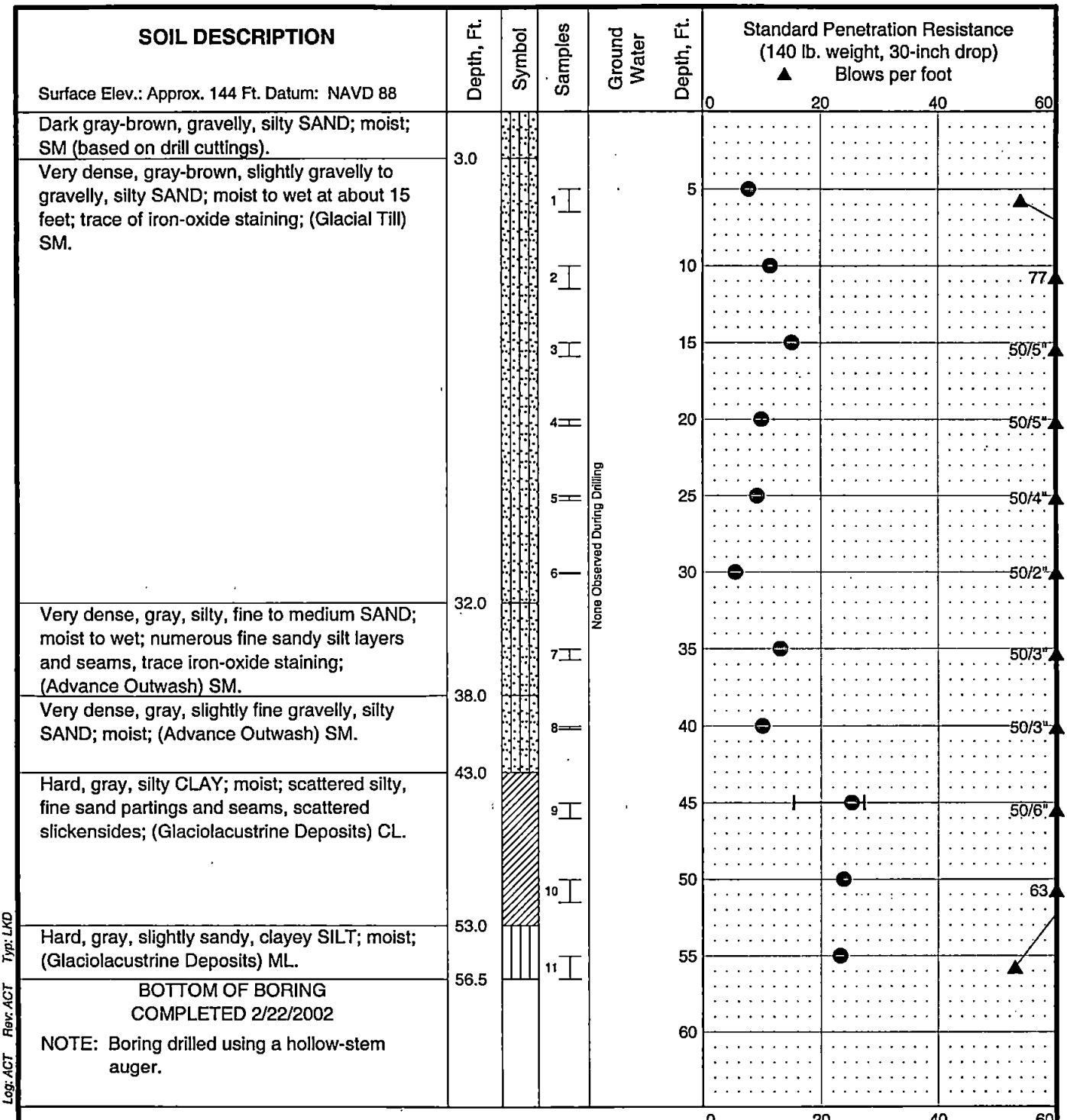
FIG. A-1
Sheet 2 of 2



NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-7

August 2002 | 21-1-09644-002

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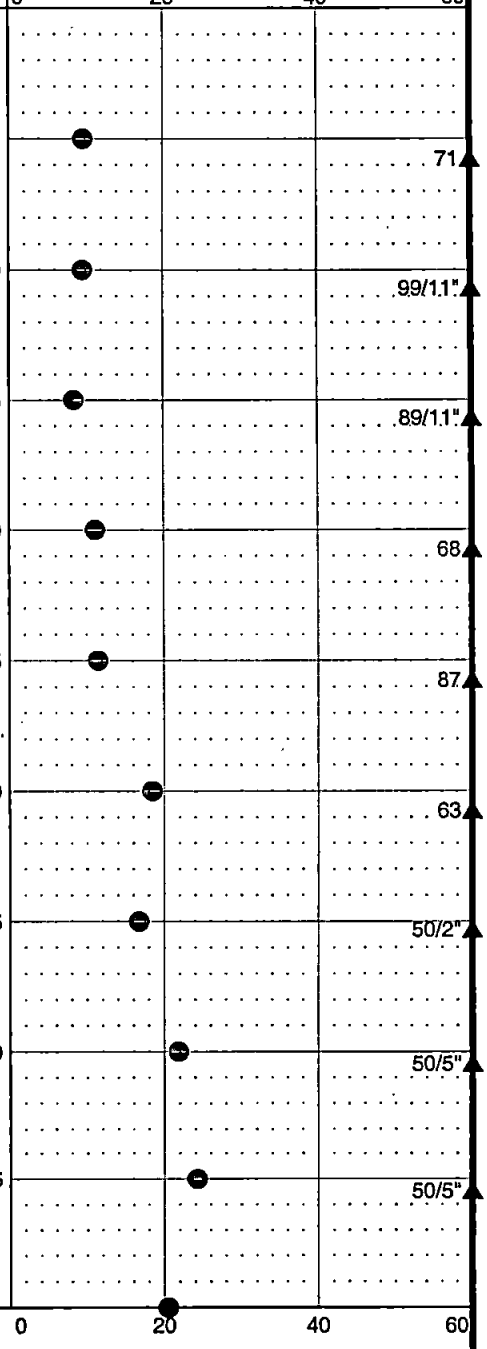
FIG. A-2

Log: ACT Rev: ACT Typ: LKD

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 138 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water Depth, Ft.
Very dense, gray-brown, slightly gravelly to gravelly, silty SAND; moist; grass at surface, scattered iron-oxide staining; (Glacial Till) SM.			1 2 3 4 5	None Observed During Drilling
Very dense, gray, silty, fine SAND and slightly fine sandy SILT with fine sand seams; moist; (Advance Outwash) SM/ML.	31.0		6 7	
Very dense, gray, clayey SILT; moist to wet; scattered to numerous silty, fine sand partings and seams, scattered silty clay seams, locally trace of fine gravel; (Glaciolacustrine Deposits) ML.	38.0		8 9	

CONTINUED NEXT PAGE



LEGEND

* Sample Not Recovered

I Standard Penetration Test

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
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LOG OF BORING B-8

August 2002 21-1-09644-002

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FIG. A-3
Sheet 1 of 2

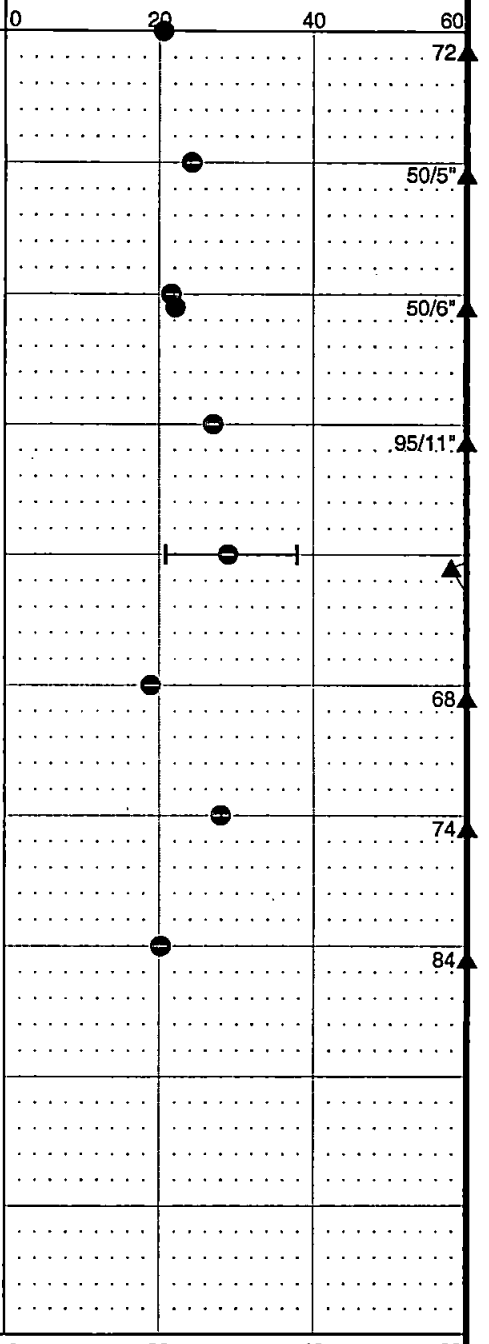
Log: ACT Rev: ACT Typ: LKD

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 138 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water Depth, Ft.
- grading to silty CLAY and clayey SILT; trace of gravel; CL/ML - sample 11 interbedded to laminated silty CLAY and fine sandy SILT; CL/ML			10 11	
Very dense, gray, slightly silty to silty, fine SAND; wet; SM/SP-SM.	60.5		12	
Hard, gray, silty CLAY; moist to wet; scattered to numerous silty, fine sand partings and seams; (Glaciolacustrine Deposits) CL.	63.0		13 14 15 16	
BOTTOM OF BORING COMPLETED 2/26/2002	86.0		17	

NOTES:

1. Samples 14 through 17 were driven only 12 inches; the blow count shown represents two times the second 6-inch increment blow count.
2. Hollow-stem auger advanced to 5 feet, then mud-rotary techniques were used to drill the hole.



LEGEND

• Sample Not Recovered

I Standard Penetration Test

● % Water Content

Plastic Limit |—●—| Liquid Limit

Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-8

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FIG. A-3
Sheet 2 of 2

Log: ACT Rev: ACT Typ: LKD

MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 134 Ft. Datum: NAVD 88	Depth, Ft.
Dense to very dense, gray-brown, slightly gravelly to gravelly, slightly silty to silty SAND; moist to wet at about 15 feet; trace iron-oxide staining; (Glacial Till) SW-SM/SM.	
Very dense, gray, layers of gravelly, silty SAND and fine sandy SILT; moist to wet; scattered seams of clean sand; (Advance Outwash) SM/ML.	29.0
Hard, gray, silty CLAY, trace of sand and slightly sandy, slightly clayey to clayey SILT; moist to wet; scattered to numerous silty, fine sand partings; (Glaciolacustrine Deposits) CL/ML.	33.0
CONTINUED NEXT PAGE	48.0

Symbol | Samples | Ground Water | Depth, Ft.

7/1/2002

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot

Depth, Ft.	Blows per foot
5	
10	89/11"
15	91/11"
20	50/5"
25	50/6"
30	95/10"
35	50/6"
40	50/6"
45	50/5"

0 20 40 60

LEGEND

- Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-9

August 2002 21-1-09644-002

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FIG. A-4
Sheet 1 of 2

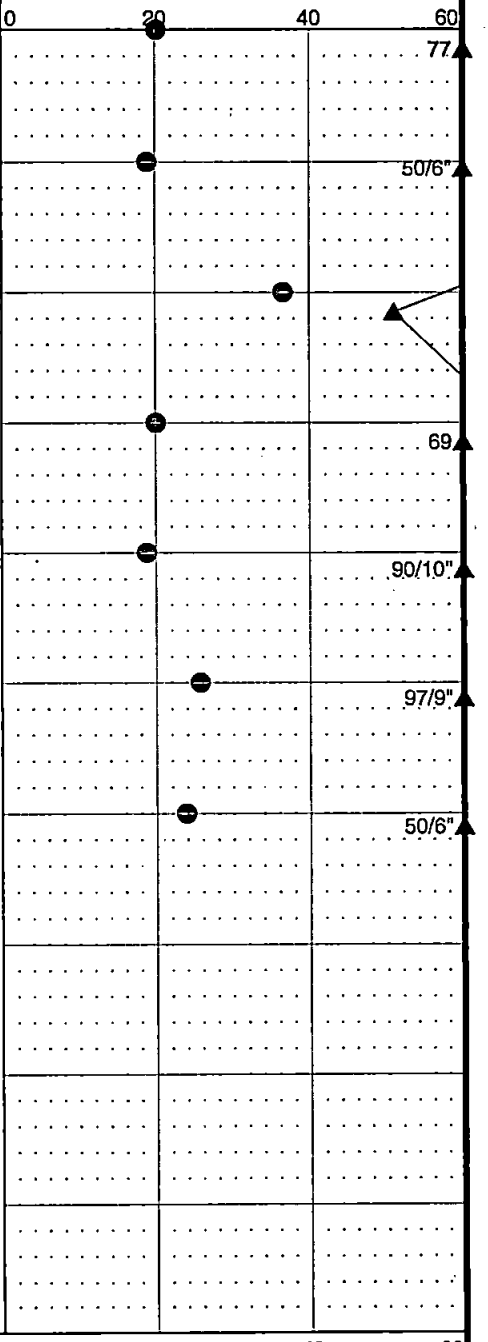
Log: ACT Rev: ACT Typ: LKD

MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 134 Ft. Datum: NAVD 88	Depth, Ft.
Very dense, gray, silty, fine SAND and slightly fine sandy SILT interbedded with clayey SILT; moist; (Glaciolacustrine Deposits) SM/ML.	53.0
Very dense, gray, silty, fine to medium SAND, trace of fine gravel; wet; SM.	58.0
Interbedded, hard, gray, slightly clayey SILT and very dense, silty, fine SAND; moist; (Glaciolacustrine Deposits) ML/SM.	
- moist to wet near 65 feet	73.0
Hard, gray, clayey SILT to silty CLAY; moist; scattered seams of slickensided highly plastic clay and scattered silty, fine sand partings; (Glaciolacustrine Deposits) ML/CL.	78.0
Very dense, gray, interlayered clayey SILT and silty SAND, trace of gravel; moist; scattered slickensides in silt, iron oxide staining; (Glaciolacustrine Deposits) SM/ML.	81.0
BOTTOM OF BORING COMPLETED 2/27/2002	
NOTE: Hollow-stem auger was advanced to 30 feet, then mud-rotary techniques were used to drill the hole.	

Symbol | Samples | Ground Water | Depth, Ft.

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well
- % Water Content
- Plastic Limit — Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above; is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-9

August 2002 21-1-09644-002

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FIG. A-4
Sheet 2 of 2

Log: ACT Rev: ACT Typ: LKD

MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 138 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot 0 20 40 60
Very dense, gray-brown, slightly gravelly to gravelly, silty SAND; moist; trace iron-oxide staining; (Glacial Till) SM.			1	None Observed During Drilling	5 — 91
			2		10 — 86/11"
			3		15 — 56/6"
- hydrocarbon odor noted in the laboratory in Sample 4			4		20 — 83
Very dense, gray, silty, gravelly SAND; moist to wet; (Glacial Till) SM.	23.0		5		25 — 50/4"
Very dense, gray, slightly clayey, sandy SILT and slightly clayey, silty SAND; moist to wet; scattered silty, fine sand seams; (Advance Outwash) SM/ML.	27.0		6		30 — 54/5"
			7		35 — 53/5"
Hard, gray, slightly sandy, slightly clayey SILT and slightly clayey SILT, trace of sand; scattered seams of silty, fine sand; scattered slickensides; (Glaciolacustrine Deposits) ML.	38.0		8		40 — 56/2"
			9		45 — 59/6"
CONTINUED NEXT PAGE					0 20 40 60

Log: RT Rev: ACT Typ: LKD

MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 8/2/02

LEGEND

- • Sample Not Recovered
- I Standard Penetration Test
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-10

August 2002 21-1-09644-002

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FIG. A-5
Sheet 1 of 2

SOIL DESCRIPTION Surface Elev.: Approx. 138 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot
			10		50/5"
Hard, gray, silty CLAY; moist; numerous silt partings; bedded; (Glaciolacustrine Deposits) CL.	53.0		11		77
Very dense, gray, slightly silty to silty, fine to medium SAND; wet; SP-SM.	60.0 60.8		12		83
Hard, gray, silty CLAY to clayey SILT, trace of sand; moist; scattered to numerous silty, fine sand partings, scattered seams of highly plastic clay, grades less plastic with depth, occasional slickensides; (Glaciolacustrine Deposits) CL/CH/ML.			13		
			14		63
			15		85/9"
			16		98/10"
Very dense, gray, fine sandy SILT; moist; scattered iron-oxide staining; (Glaciolacustine Deposits) ML.	83.0 85.8		17		58/3"
BOTTOM OF BORING COMPLETED 2/27/2002					

NOTES:

1. The moist to wet nature of the soil and the presence of a hydrocarbon odor in Sample 4 suggest that groundwater may be present about 20 to 25 feet below ground surface.
2. Mud-rotary techniques were used to drill the hole.

Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot

0 20 40 60

55 60 65 70 75 80 85 90 95

0 20 40 60

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

LEGEND

• Sample Not Recovered

I Standard Penetration Test

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-10

August 2002 21-1-09644-002

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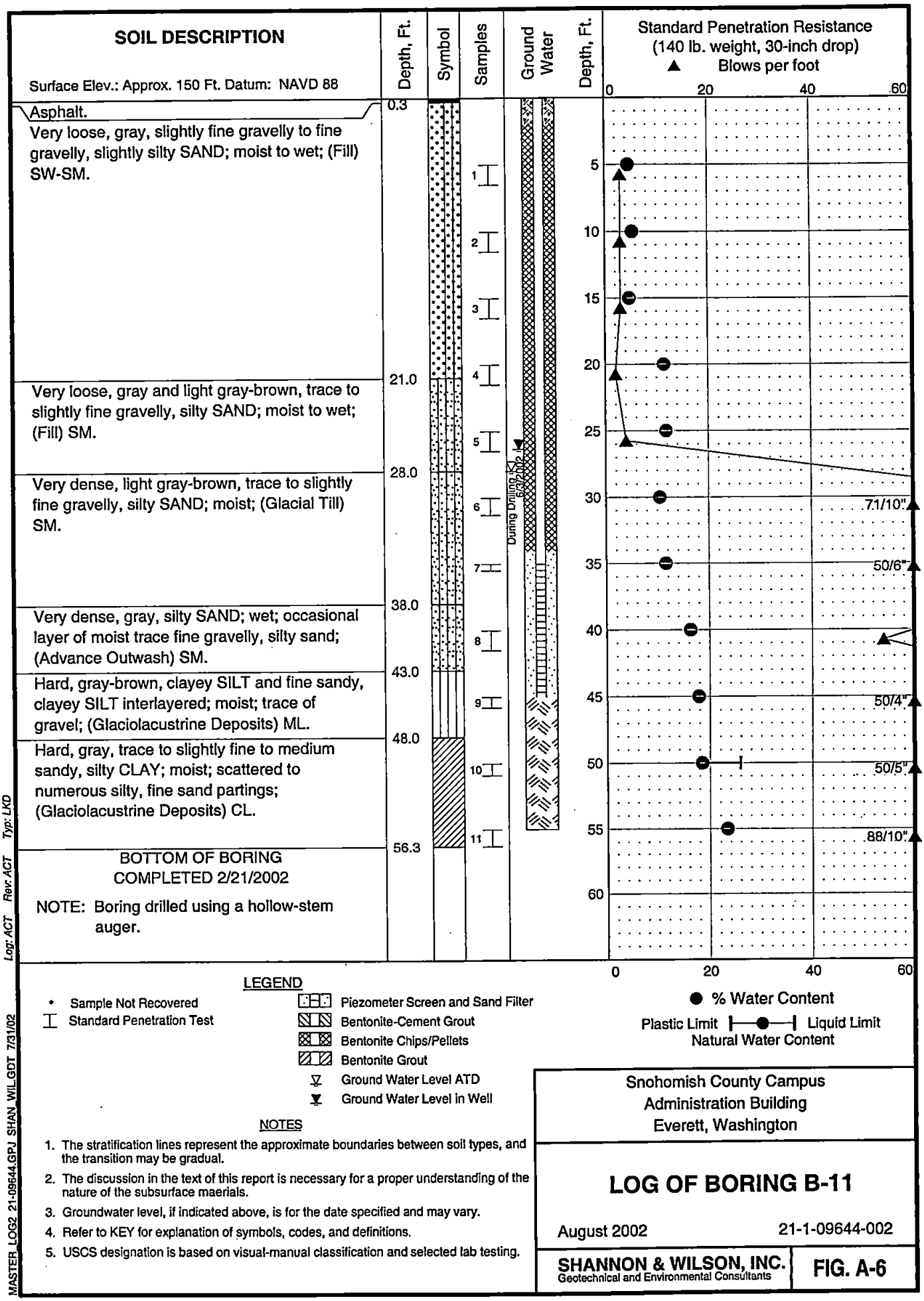
FIG. A-5
Sheet 2 of 2

Log: RT Rev: ACT Typ: LKD

MASTER LOG2 21-09644.GPJ SHAN_WILGDT 8/2/02


SOIL DESCRIPTION
Surface Elev.: Approx. 150 Ft. Datum: NAVD 88
Depth, Ft.
Symbol
Samples
Ground Water
Depth, Ft.
Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
Blows per foot
0
20
40
60
Asphalt.
0.3
Very loose, gray, slightly fine gravelly to fine gravelly, slightly silty SAND; moist to wet; (Fill) SW-SM.
21.0
Very loose, gray and light gray-brown, trace to slightly fine gravelly, silty SAND; moist to wet; (Fill) SM.
28.0
Very dense, light gray-brown, trace to slightly fine gravelly, silty SAND; moist; (Glacial Till) SM.
38.0
Very dense, gray, silty SAND; wet; occasional layer of moist trace fine gravelly, silty sand; (Advance Outwash) SM.
43.0
Hard, gray-brown, clayey SILT and fine sandy, clayey SILT interlayered; moist; trace of gravel; (Glaciolacustrine Deposits) ML.
48.0
Hard, gray, trace to slightly fine to medium sandy, silty CLAY; moist; scattered to numerous silty, fine sand partings; (Glaciolacustrine Deposits) CL.
56.3
BOTTOM OF BORING
COMPLETED 2/21/2002
NOTE: Boring drilled using a hollow-stem auger.
During Drilling 6/3/2002
1
2
3
4
5
6
7
8
9
10
11
5
10
15
20
25
30
35
40
45
50
55
60
71/10"
50/6"
50/4"
50/5"
88/10"
0
20
40
60
% Water Content
Plastic Limit
Liquid Limit
Natural Water Content
LEGEND
Sample Not Recovered
Standard Penetration Test
Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
Ground Water Level ATD
Ground Water Level in Well
NOTES
1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.
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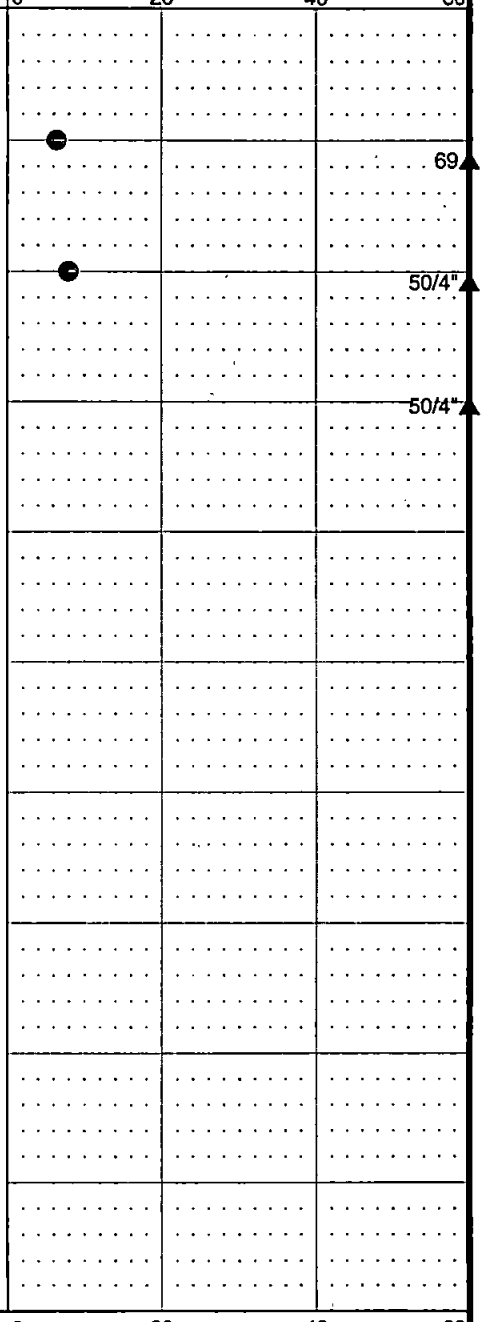
LOG OF BORING B-11
August 2002
21-1-09644-002
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
FIG. A-6
MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 143 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.
Asphalt.	0.1				None Observed During Drilling	
Very dense, gray-brown, slightly gravelly to gravelly, silty SAND; moist; (Glacial Till) SM.			0	1		
Very dense, gray-brown, slightly gravelly to gravelly, silty SAND; moist to dry; hydrocarbon odor below 13.5 feet, PID = 900+ ppm (15 - 15.3 feet); (Glacial Till) SM.	10.5		0	2		
BOTTOM OF BORING COMPLETED 3/4/2002	15.3		900	3		

NOTES:

1. Boring was terminated at 15.3 feet because field screening suggested the presence of petroleum hydrocarbon contamination.
2. Boring drilled using a hollow-stem auger.



LEGEND

* Sample Not Recovered

I Standard Penetration Test

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-12

August 2002 21-1-09644-002

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FIG. A-7

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 143 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot
Asphalt.	0.1					
Very dense, gray-brown, trace to slightly gravelly, silty, fine to medium SAND, trace of clay; moist to wet below 10 feet; mottled iron-oxide staining; (based on limited sampling, drill cuttings, and boring B-12) (Glacial Till) SM.			0	1	During Drilling ▽	50/5.5"
- strong hydrocarbon odor during drilling, trace odor below 15 feet			0	2		50/5"
Very dense, gray, slightly silty to silty, fine to medium SAND; wet; slightly fine gravelly, silty sand below 30 feet; (Advance Outwash) SP-SM/SM.	17.5		0	3		50/6"
			0	4		50/5"
			0	5		50/4"
Hard, gray, clayey SILT to silty CLAY, trace of sand; moist to wet; scattered to numerous silty, fine to medium sand partings and seams; (Glaciolacustrine Deposits) ML/CL.	35.5		0	6		50/6"
			0	7		50/6"
Very dense, gray, slightly silty to silty, gravelly SAND; moist to wet; (Outwash) SW-SM/SM.	43.0		0	8		50/6"
	48.0					

CONTINUED NEXT PAGE

Log: ACT Rev: ACT Typ: LKD

LEGEND

- • Sample Not Recovered
- ⌶ Standard Penetration Test
- ▽ Ground Water Level ATD
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-12A

August 2002 21-1-09644-005

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FIG. A-8
Sheet 1 of 2

MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 8/2/02

SOIL DESCRIPTION Surface Elev.: Approx. 143 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot
Hard, gray, slightly clayey to clayey SILT; moist to wet; scattered silty, fine sand partings; (Glaciolacustrine Deposits) ML.	52.0		0	9		50/6"
Hard, gray, silty CLAY grading to slightly fine sandy, clayey SILT; moist; scattered fine sand seams; (Glaciolacustrine Deposits) CL/ML.				10		50/6"
				11		50/6"
				12		50/4.5"
Very dense, gray, silty, fine SAND; moist to wet; SM.	68.0			13		50/3"
Hard, gray, silty CLAY to clayey SILT; moist; scattered to numerous silty, fine sand seams; layer of silty, gravelly sand at 75 feet; scattered highly plastic slickensided seams; (Glaciolacustrine Deposits) CL/ML.	72.0			14		50/6"
				15		72
				16		50/5"
BOTTOM OF BORING COMPLETED 5/8/2002	90.3			17		50/4"

NOTES:
1. Boring drilled by installing casing to 5 feet and using mud-rotary techniques.
2. Drilled to 85 feet on the first day. On second day, driller had to redrill from 70 to 85 feet.

Log: ACT Rev: ACT Typ: LKD

LEGEND

- Sample Not Recovered
- Standard Penetration Test
- Ground Water Level ATD
- % Water Content
- Plastic Limit — Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-12A

August 2002 21-1-09644-005

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FIG. A-8
Sheet 2 of 2

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 8/2/02

SOIL DESCRIPTION Surface Elev.: Approx. 146 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.
Very dense, gray-brown, slightly gravelly to gravelly, silty SAND; moist; wet seam at approximately 15 feet; scattered fine sandy silt pockets; slight hydrocarbon odor below 19 feet, PID = 153 ppm (20 - 20.4 feet); ivy at ground surface; (Glacial Till) SM.			0 0 0	1 2 3	None Observed During Drilling	
BOTTOM OF BORING COMPLETED 3/4/2002	20.4		153	4		

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot

0 20 40 60

5 10 15 20 25 30 35 40 45

50/5"
90/10"
50/5"

NOTES:

1. Boring was terminated at 20.4 feet because field screening suggested the presence of petroleum hydrocarbon contamination.
2. Boring drilled using a hollow-stem auger.

LEGEND

* Sample Not Recovered
I Standard Penetration Test

0 20 40 60

● % Water Content
Plastic Limit |—●—| Liquid Limit
Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-13

August 2002 21-1-09644-002

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FIG. A-9

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 148 Ft. Datum: NAVD 88	Depth, Ft.
Very dense, light gray-brown, trace to slightly fine gravelly, silty SAND; moist; grass at ground surface; (Glacial Till) SM.	
Very dense, gray, slightly silty, gravelly SAND; wet; (Advance Outwash) SW-SM.	35.0
Very dense, gray, slightly silty SAND, trace of gravel, and silty, fine to medium SAND; moist to wet; scattered seams of silt and silty clay; (Advance Outwash) SW-SM/SM.	38.0
Hard, gray, silty CLAY and clayey SILT; moist to wet; scattered fine sand partings and seams, scattered slickensides; (Glaciolacustrine Deposits) CL/ML.	46.0
- grading to interbedded silty CLAY and fine sandy SILT; wet	

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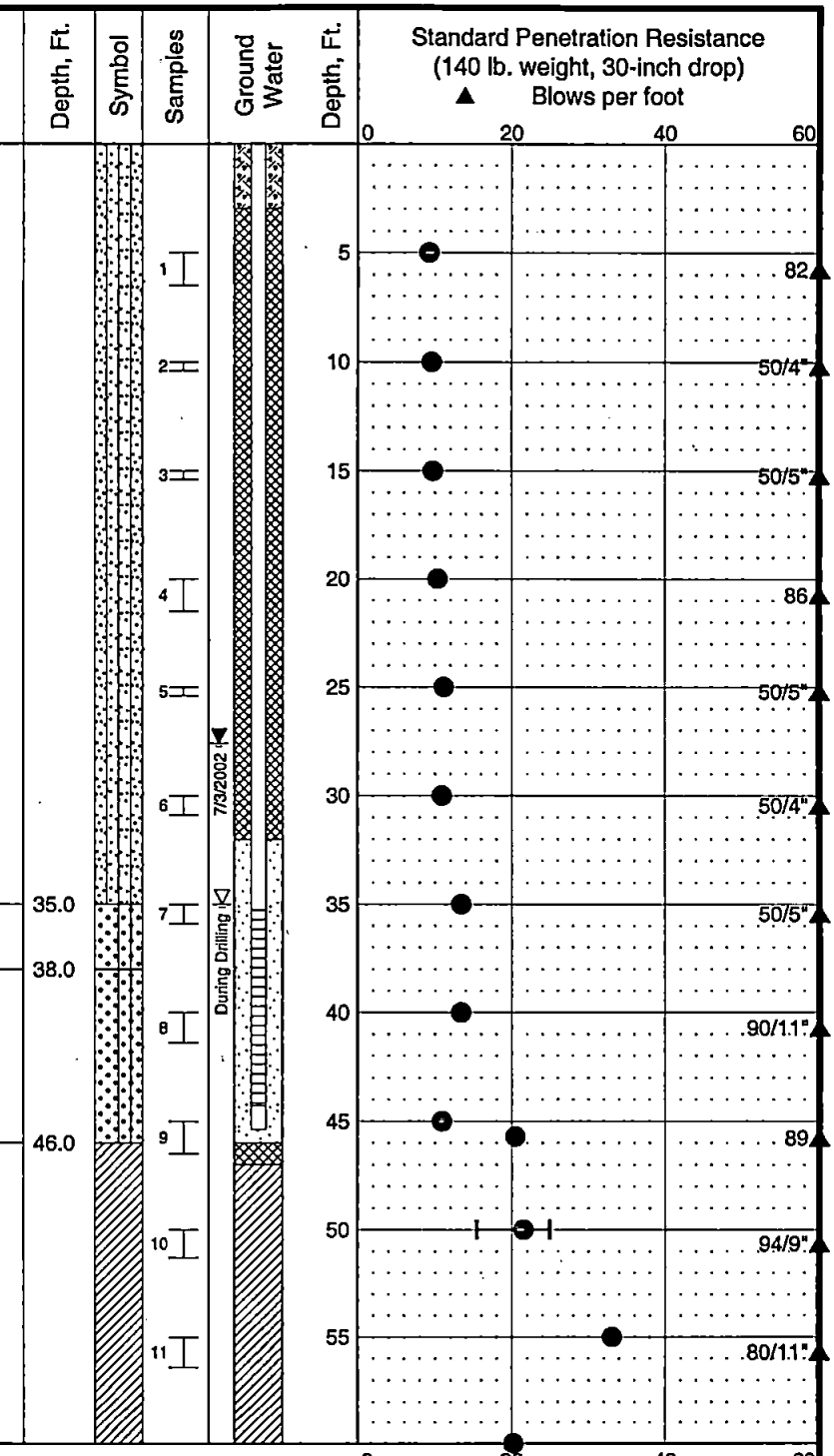

LEGEND

- • Sample Not Recovered
- I Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in Well
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-14

August 2002 21-1-09644-002

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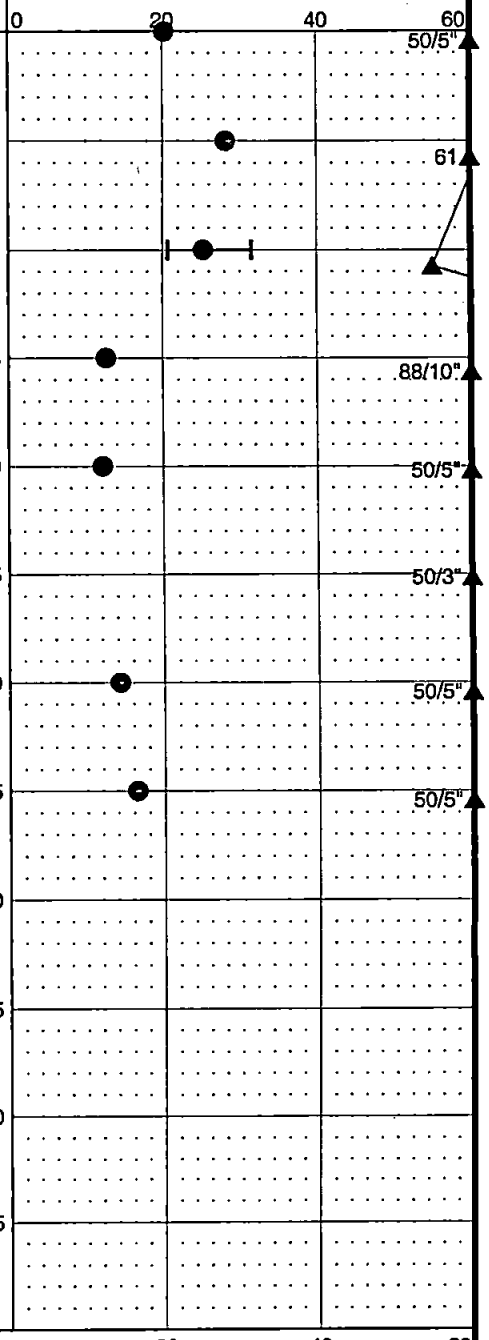
FIG. A-10
Sheet 1 of 2

Log: ACT Rev: ACT Typ: LKD
MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 8/9/02

SOIL DESCRIPTION Surface Elev.: Approx. 148 Ft. Datum: NAVD 88	Depth, Ft.
- grading to silty CLAY with numerous fine sand partings; moist - grading to hard, silty CLAY, trace of sand	
Hard and very dense, gray, sandy, silty CLAY to silty, clayey, gravelly SAND; moist; (Glacial Outwash?) CL/SC.	76.0 78.0
Very dense, gray-brown, silty, fine to medium SAND, trace of gravel; moist; trace iron-oxide staining; locally gravelly; (Glacial Outwash) SM.	
Interbedded, very dense, gray-brown, silty, fine to medium SAND and hard, clayey SILT, trace of sand; moist; (Glacial Outwash) SM/ML.	93.0 95.9
BOTTOM OF BORING COMPLETED 2/20/2002 NOTE: Hollow-stem auger advanced to 5 feet, then mud-rotary techniques were used to drill the hole.	

Symbol | Samples | Ground Water | Depth, Ft.

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- • Sample Not Recovered
- I Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-14

August 2002 21-1-09644-002

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FIG. A-10
Sheet 2 of 2

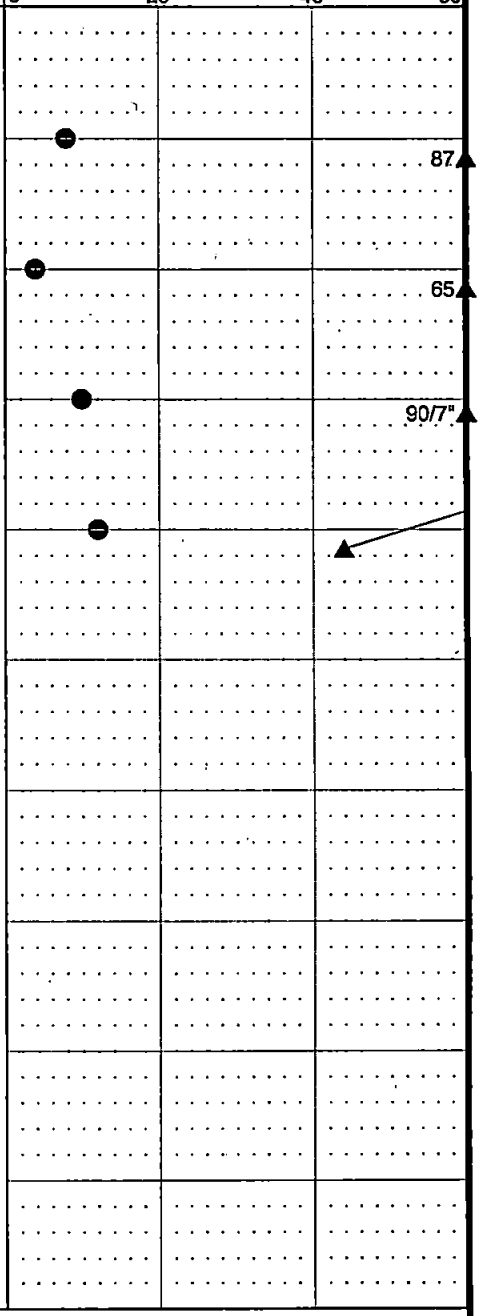
MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 8/9/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 157 Ft. Datum: NAVD 88	Depth, Ft.
Grass.	0.5
Very dense, light gray-brown, silty SAND, trace of fine gravel; moist; (Glacial Till) SM.	
Very dense, brown SAND, trace of silt; dry to moist; SP.	8.0
Dense to very dense, gray-brown, trace to slightly fine gravelly, silty SAND; moist; SM.	13.0
BOTTOM OF BORING COMPLETED 2/22/2002	21.5
NOTE: Boring drilled using a hollow-stem auger.	

Symbol

Samples: 1, 2, 3, 4

Ground Water Depth, Ft.: None Observed During Drilling



LEGEND

- Sample Not Recovered
- Standard Penetration Test
- % Water Content
- Plastic Limit — Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-15

August 2002 21-1-09644-002

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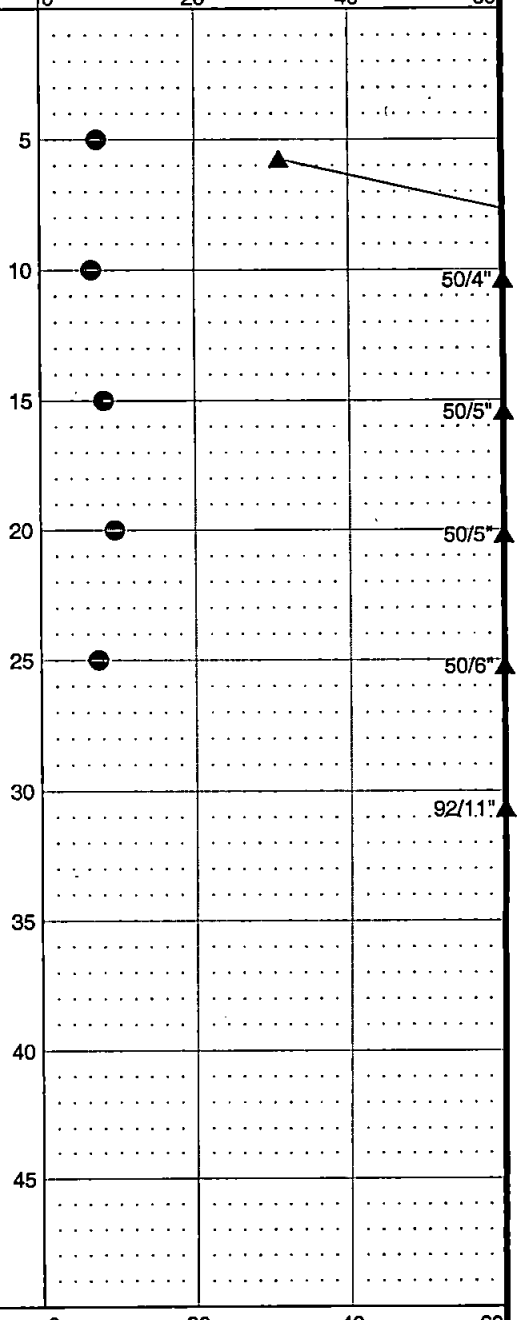
FIG. A-11

Log: ACT Rev: ACT Typ: LKD

MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 156 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water Depth, Ft.
Medium dense to dense, dark brown, gravelly, silty SAND; dry to moist; grass at surface, scattered organics; (Weathered Glacial Till or Fill) SM.			5	1	
Very dense, light gray-brown, slightly gravelly to gravelly, silty SAND; moist to wet; layer of fine to coarse sand, trace of silt at 30 feet; hydrocarbon odor below 25 feet, PID = 600+ ppm (30 - 31.4 feet); (Glacial Till) SM.	8.0		0	2	
			0	3	
				4	
				5	
BOTTOM OF BORING COMPLETED 3/4/2002	31.4		600	6	During Drilling ▽

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



NOTES:

1. Boring was terminated at 31.4 feet because field screening suggested the presence of petroleum hydrocarbon contamination.
2. Boring drilled using a hollow-stem auger.

LEGEND

- • Sample Not Recovered
- ▽ Ground Water Level ATD
- I Standard Penetration Test
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
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LOG OF BORING B-16

August 2002 21-1-09644-002

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FIG. A-12

MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 156 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.
Medium dense to dense, dark brown, gravelly, silty SAND; moist; grass at surface; SM.			0	1		
Very dense, light gray-brown, gravelly, slightly silty to silty SAND, trace of clay; moist; hydrocarbon odor below 28 feet; (based on boring B-16 and limited sampling in B-16A) (Weathered Glacial Till to Glacial Till) SM.	8.0		0	2		
Very dense, gray, silty, fine to medium SAND; moist; wet below 35 feet; strong hydrocarbon odor (30.6 to 43 feet), slight hydrocarbon odor (43 to 56 feet); (Advance Outwash) SM.	30.6		1200	3		
			323	4	During Drilling ▽	
Very dense, gray, slightly silty, gravelly SAND; moist to wet; (Advance Outwash) SP-SM.	38.0		44	5		
	48.0		0	6		

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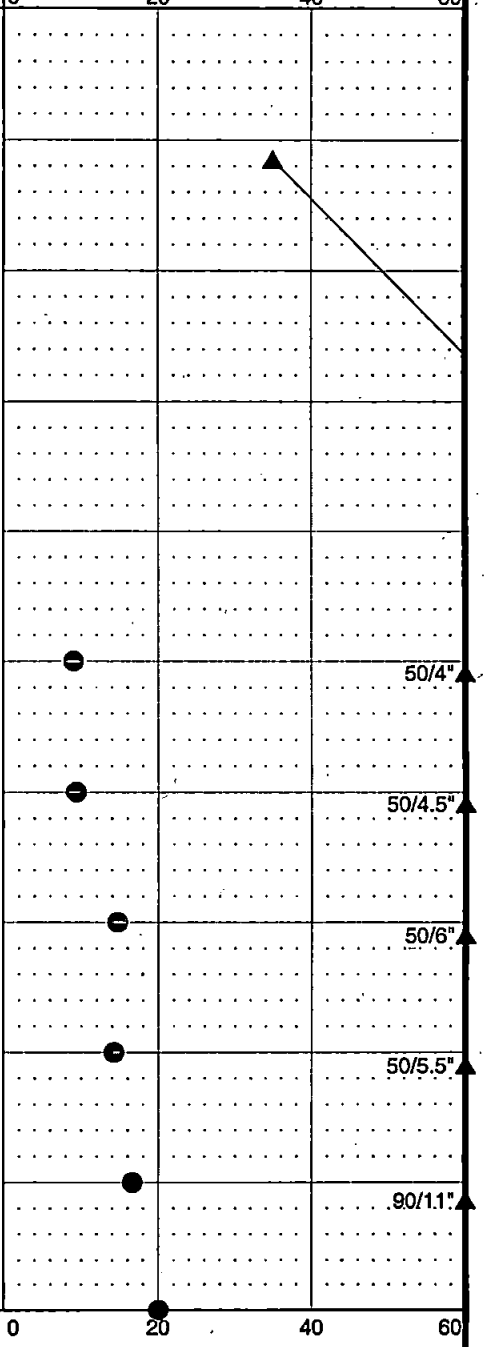
Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



LEGEND

- Sample Not Recovered
- Standard Penetration Test
- ▽ Ground Water Level ATD
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
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LOG OF BORING B-16A

August 2002 21-1-09644-005

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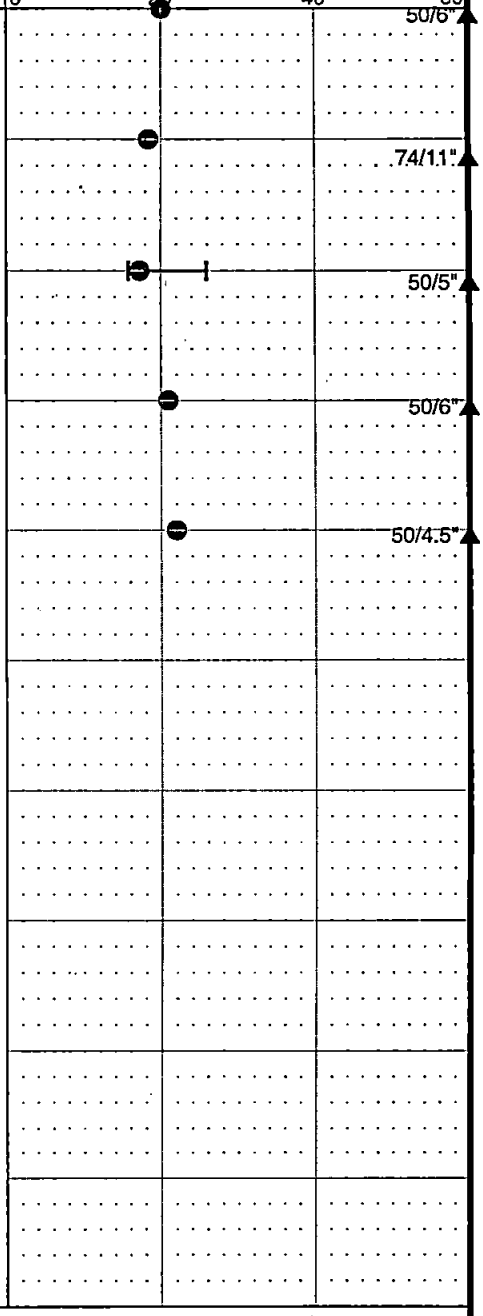
FIG. A-13
Sheet 1 of 2

Log: ACT Rev: ACT Typ: LKD
MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 156 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water Depth, Ft.
Very dense, gray, silty, fine SAND and fine sandy SILT; moist to wet; (Advance Outwash) SM/ML.			0	7	
- grading to slightly silty, fine to medium SAND; 3 feet of heave in auger at 55 feet	56.0		0	8	
Hard, gray, laminated, silty CLAY and clayey SILT, trace of sand; moist; scattered to numerous silty, fine sand partings and seams, wet; (Glaciolacustrine Deposits) CL/ML.			0	9	
- began mud-rotary drilling at 60 feet			0	10	
BOTTOM OF BORING COMPLETED 5/6/2002	70.4			11	

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



NOTES:

1. Boring drilled to 60 feet with hollow-stem auger. Mud-rotary was used to 70.4 feet. Lost mud circulation through auger bolt holes. Abandoned hole. Will redrill as boring B-16B.
2. Driller chose to remove all the augers before backfilling hole. Hole collapsed up to 15 feet.

LEGEND

- • Sample Not Recovered
- ⌶ Standard Penetration Test
- ▽ Ground Water Level ATD
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
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LOG OF BORING B-16A

August 2002 | 21-1-09644-005

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FIG. A-13
Sheet 2 of 2

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 156 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot 0 20 40 60
Boring drilled down to 75 feet prior to sampling. This boring is a continuation of boring B-16A.					5 10 15 20 25 30 35 40 45

CONTINUED NEXT PAGE

LEGEND

* Sample Not Recovered

I Standard Penetration Test

0 20 40 60

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
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LOG OF BORING B-16B

August 2002 21-1-09644-005

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FIG. A-14
Sheet 1 of 3

MASTER LOG2 21-09644.GPJ SHAN WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 156 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water
Very dense, gray, silty, fine SAND and fine sandy SILT; wet to moist; (Glacial Outwash) SM.	73.0		1	
Very dense, gray, slightly gravelly, slightly silty to silty SAND; moist; (Glacial Outwash) SM/SW-SM.	83.0		2 3	
Very dense, gray, slightly silty, fine to medium SAND; moist; (Glacial Outwash) SP-SM.	88.0		4	
Hard, gray, slightly fine sandy to fine sandy, clayey SILT; wet; (Glaciolacustrine Deposits) ML.	93.0		5	

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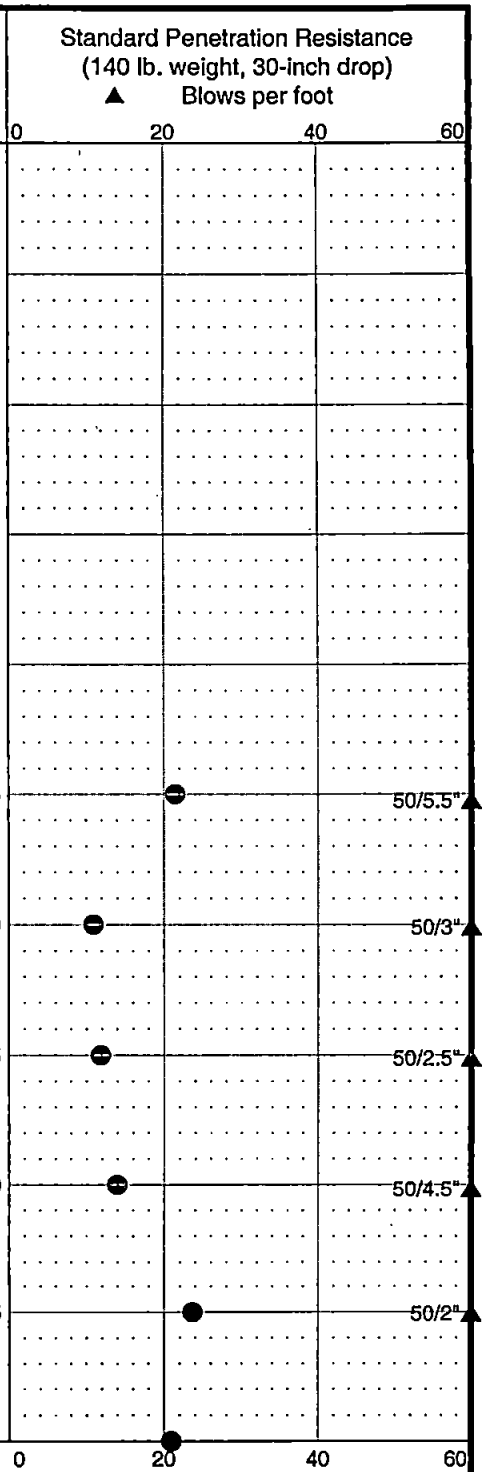

LEGEND

* Sample Not Recovered

I Standard Penetration Test

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
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LOG OF BORING B-16B

August 2002 21-1-09644-005

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FIG. A-14
Sheet 2 of 3

MASTER LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02 Log: ACT Rev: ACT Typ: LKD

SOIL DESCRIPTION Surface Elev.: Approx. 156 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	Samples	Ground Water Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot 0 20 40 60
	100.4		6		50/5" ▲
BOTTOM OF BORING COMPLETED 5/10/2002					
NOTES: 1. Boring drilled by installing casing to 5 feet and using mud-rotary techniques. 2. Drilled to 80 feet on first day. Drilled to 95 feet on second day; site use limitations prevented further sampling and drilling. 3. On third day, driller sampled at 95 feet, then had to redrill from 25 to 95 feet when the borehole caved in. Hole completed on third day.					
				105	
				110	
				115	
				120	
				125	
				130	
				135	
				140	
				145	

0 20 40 60

LEGEND

* Sample Not Recovered

I Standard Penetration Test

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-16B

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FIG. A-14
Sheet 3 of 3

Log: ACT Rev: ACT Typ: LKD

MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 7/31/02

SOIL DESCRIPTION Surface Elev.: Approx. 151 Ft. Datum: NAVD 88	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water	Depth, Ft.	Standard Penetration Resistance (140 lb. weight, 30-inch drop) ▲ Blows per foot
Brown, slightly gravelly to gravelly, slightly silty to silty, fine SAND; moist; (Fill) SP-SM/SM. (Based on drill cuttings.)	4.0						
Very dense, gray-brown, slightly gravelly to gravelly, silty, fine SAND; moist; minor iron-oxide staining; (Glacial Till) SM.			0	1		5	
			0	2		10	50/5"
			0	3		15	50/5"
	20.1		0	4		20	50/6"
Very dense, gray-brown, silty, fine SAND, trace of gravel; moist; (Advance Outwash) SM.							
	26.0		0	5		25	60
Very dense, gray-brown, slightly gravelly to gravelly, slightly silty, fine to medium SAND; moist; (Advance Outwash) SP-SM.			0	6		30	50/3"
- wet below 32.5 feet			0	7	During Drilling 7/8/2002	35	50/5.5"
	38.0						
Very dense, gray-brown, slightly gravelly, silty SAND interbedded with hard, brown, silty CLAY below 43 feet; moist to wet; (Advance Outwash) SM/CL.			0	8		40	75/1.1"
			0	9		45	50/6"
	50.5		0	10		50	50/5.5"
BOTTOM OF BORING COMPLETED 6/21/2002						55	
NOTE: Boring drilled using hollow-stem auger technique.							

0 20 40 60

LEGEND

- • Sample Not Recovered
- 3.25" O.D. Split Spoon Sample
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-17

August 2002 21-1-09644-006

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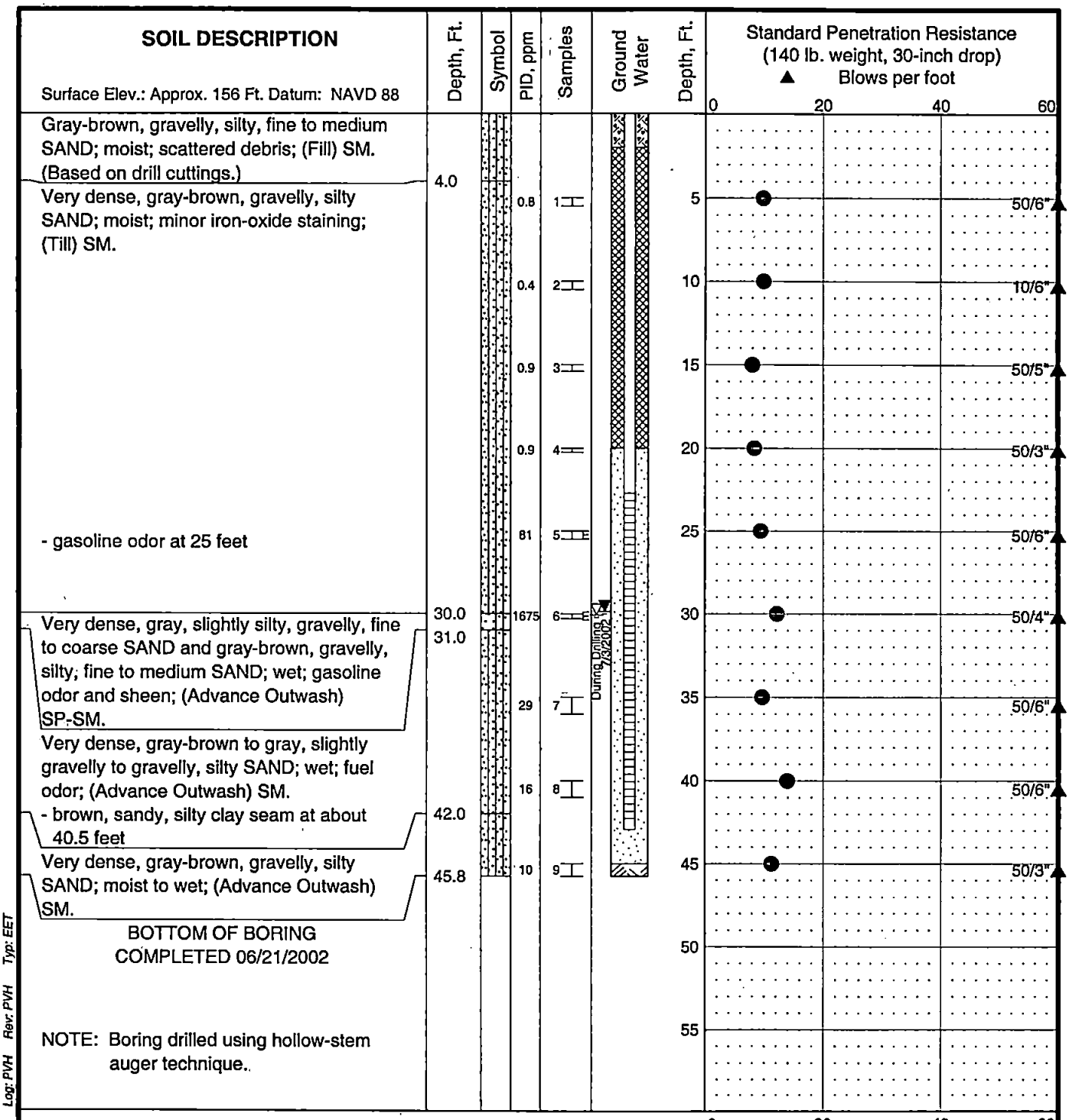
FIG. A-15

Log: PVH Rev: PVH Typ: EET

MASTER LOG2 21-09644.GPJ SHAN_WILGDT 8/2/02



Log: PVH Rev: PVH Typ: EET

LEGEND

- • Sample Not Recovered
- E Environmental Sample Obtained
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well
- ● % Water Content
- Plastic Limit ⊢●⊣ Liquid Limit
- Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface maerials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of symbols, codes, and definitions.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING B-18

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FIG. A-16

MASTER_LOG2 21-09644.GPJ SHAN_WIL.GDT 8/7/02

Appendix B

APPENDIX B

GEOTECHNICAL LABORATORY TESTING

APPENDIX B

GEOTECHNICAL LABORATORY TESTING

TABLE OF CONTENTS

LIST OF FIGURES

Figure No.

APPENDIX B

GEOTECHNICAL LABORATORY TESTING

B.1 INTRODUCTION

This appendix contains descriptions of the procedures and the results of geotechnical laboratory tests completed on the soil samples obtained from the explorations for the design of the Snohomish County Campus Administration Building and Garage. The samples were tested to determine basic index properties and engineering characteristics of the site soils. Laboratory testing was completed at the Shannon & Wilson, Inc. laboratory in Seattle, Washington, in May and June 2002.

B.2 VISUAL CLASSIFICATION

Soil samples obtained from the explorations were visually classified in the laboratory using a system based on the American Society for Testing and Materials (ASTM) Designation: D 2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). This visual classification allows for convenient and consistent comparison of soils from widespread geographic areas.

The sample classifications have been incorporated into the soil descriptions on the exploration logs presented in Appendix A.

B.3 WATER CONTENT DETERMINATION

Water content determinations were performed in general accordance with ASTM Designation D 2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures on all of the retrieved geotechnical soil samples. Water contents are plotted on the boring logs presented in Appendix A.

B.4 GRAIN-SIZE DISTRIBUTION

Grain-size analyses were completed on selected samples to determine their grain-size distributions. The tests were performed in general accordance with ASTM Designation D 422,

Standard Method for Particle-Size Analysis of Soils. Generally, the grain-size analyses consisted of the coarse-grained fraction of the samples only, and were obtained by sieving (sieve analysis).

The grain-size distributions were used to assist in classifying soils and to provide correlations with soil properties. Results of the grain-size analyses are plotted on the grain-size distribution curves presented in Figures B-1 through B-3. Along with the grain-size distribution is a tabulated summary containing the sample description and the natural water content.

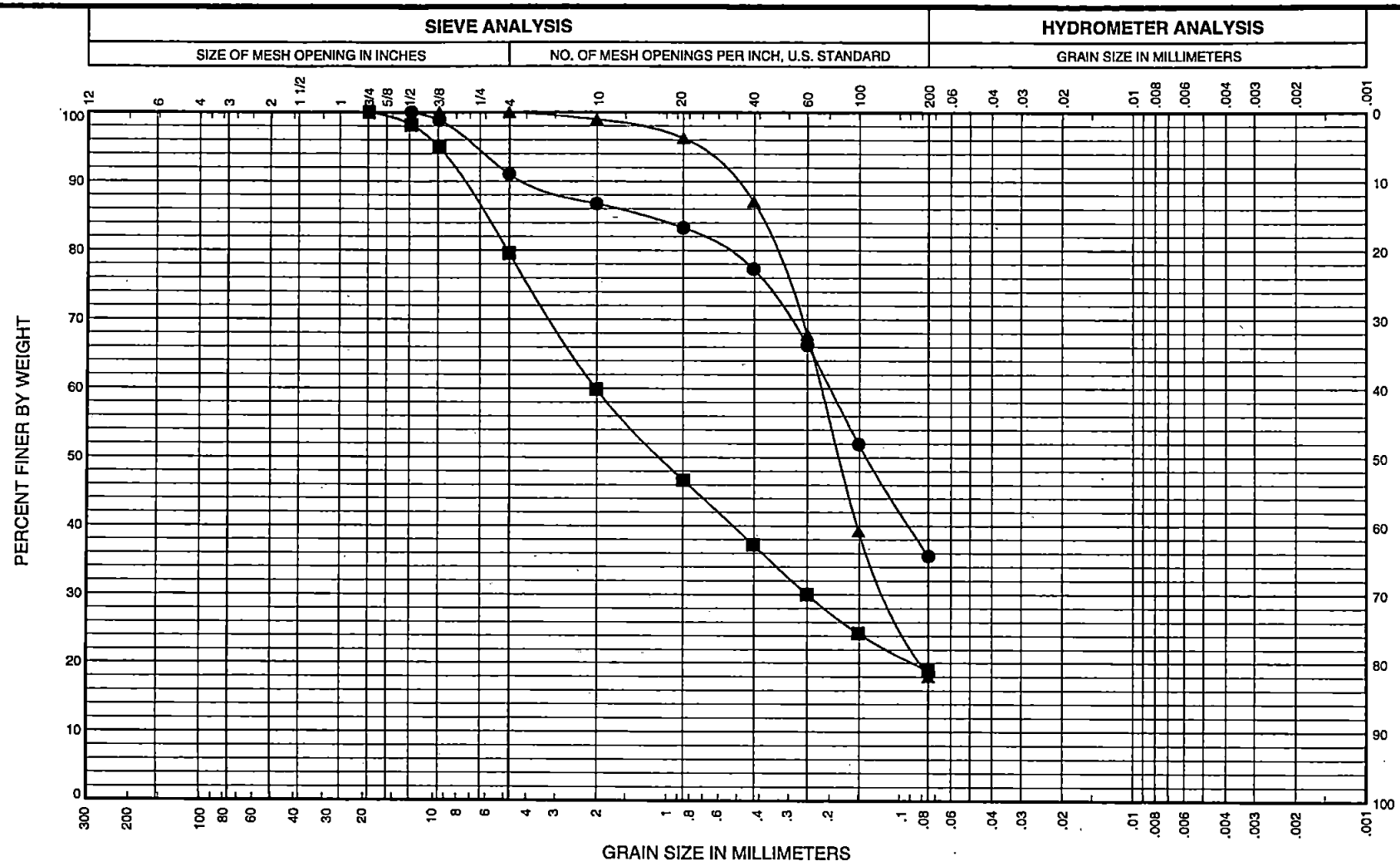
B.5 ATTERBERG LIMITS DETERMINATIONS

Liquid and plastic Atterberg Limits were determined on selected samples of fine-grained soil obtained in the borings in general accordance with ASTM Designation D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI=LL-PL). They are generally used to assist in classification of soils, indicate soil consistency (when compared with natural water content), and provide correlation to soil properties including compressibility and strength.

The results of the Atterberg Limits determinations are shown on the appropriate borings logs in Appendix A, and on the plasticity chart presented in Figures B-4 through B-6.

B.6 REFERENCE

American Society for Testing and Materials (ASTM), 2002, Annual book of ASTM standards: Soil and rock, building stone; geosynthetics: Philadelphia, Penn., v. 04.08.



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● B-7, S-2	10.0	SM	Gray-brown, slightly gravelly, silty SAND	35.6	11.4			
■ B-8, S-3	15.0	SM	Gray-brown, silty, gravelly SAND	18.8	8.4			
▲ B-9, S-11	55.0	SM	Gray, silty, fine to medium SAND	18.0	19.0			

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GRAIN SIZE DISTRIBUTION
BORINGS B-7 TO B-9

June 2002 21-1-09644-002

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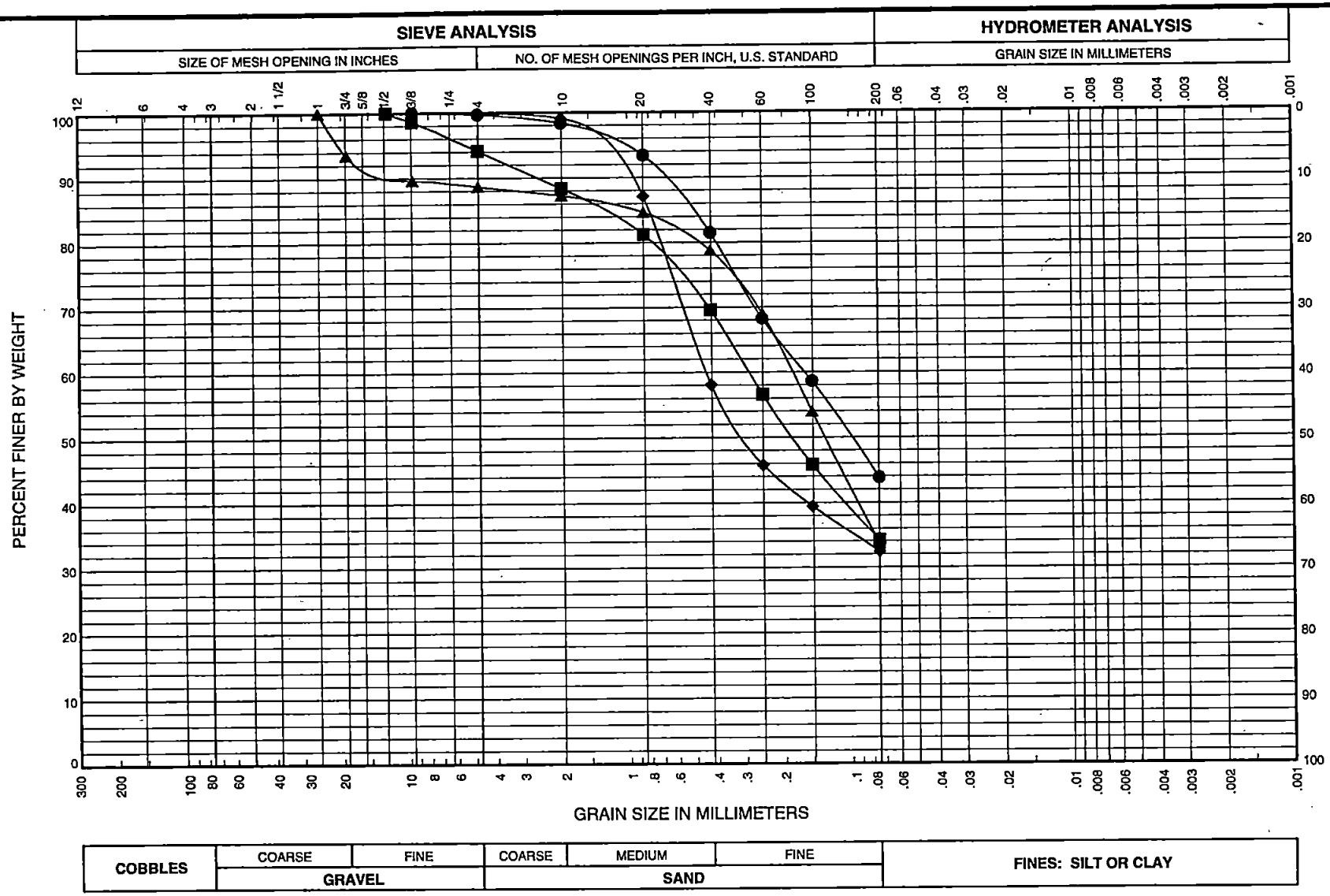
FIG. B-1

FIG. B-1

GSAMAIN1 21-09644.GPJ SHAN_WIL.GDT 6/18/02



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● B-10, S-7	35.0	SM	Gray, silty, fine to medium SAND	43.8	17.2			
■ B-11, S-6	30.0	SM	Gray-brown, slightly gravelly, silty SAND	34.2	10.5			
▲ B-12A, S-5	30.0	SM	Gray, slightly gravelly, silty SAND	33.6	15.8			
◆ B-14, S-18	90.0	SM	Gray-brown, silty, fine to medium SAND	32.4	14.3			

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GRAIN SIZE DISTRIBUTION
BORINGS B-10 TO B-14

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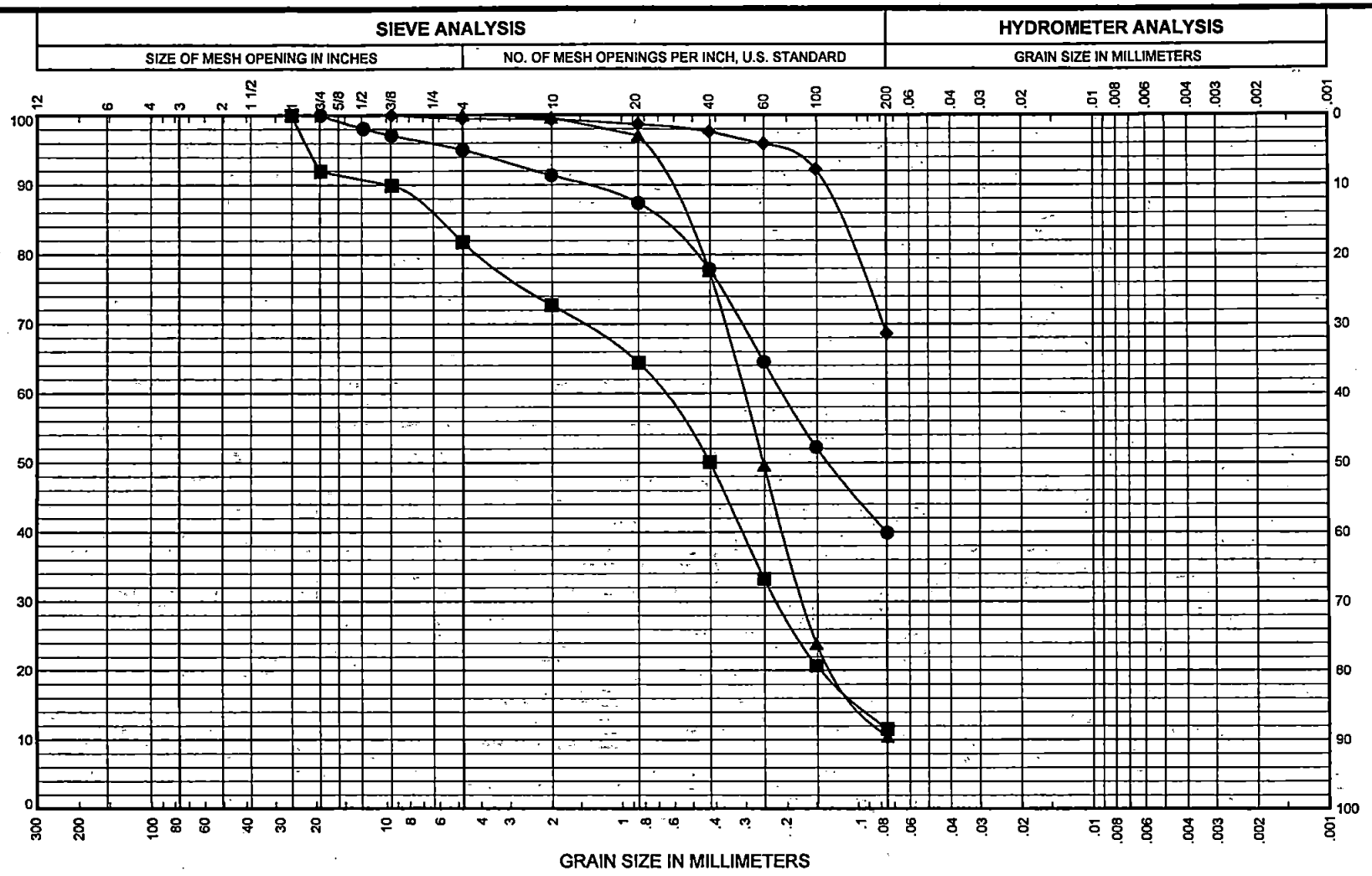
FIG. B-2

FIG. B-2

GSAMAIN1 21-09644.GPJ SHAN WIL.GDT 6/18/02



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● B-15, S-4	20.0	SM	Gray-brown, slightly gravelly, silty SAND	39.9	12.0			
■ B-16A, S-5	40.0	SP-SM	Gray, slightly silty, gravelly SAND	11.5	14.3			
▲ B-16A, S-8	55.0	SP-SM	Gray, slightly silty, fine to medium SAND	10.4	18.4			
◆ B-16B, S-1	75.0	ML	Gray, fine sandy SILT	68.6	21.5			

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GRAIN SIZE DISTRIBUTION
BORINGS B-15 TO B16B

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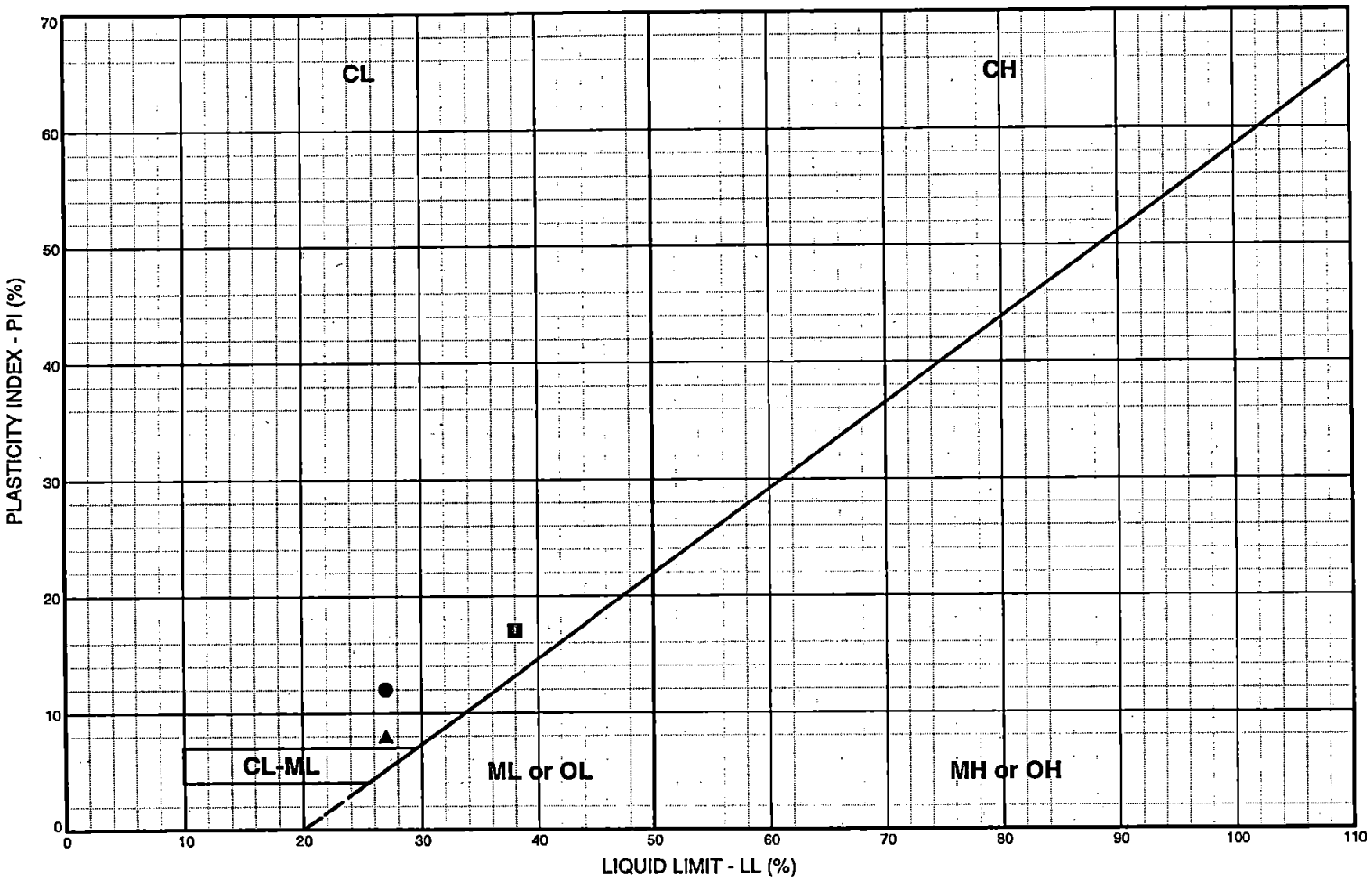
FIG. B-3

FIG. B-3



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● B-7, S-9	45.0	CL	Gray, sandy, silty CLAY	27	15	12	25.2	
■ B-8, S-14	70.0	CL	Gray, silty CLAY	38	21	17	28.9	
▲ B-9, S-8	40.0	CL	Gray, silty CLAY, trace of sand	27	19	8	25.5	

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PLASTICITY CHART
BORINGS B-7 TO B-9

June 2002 21-1-09644-002

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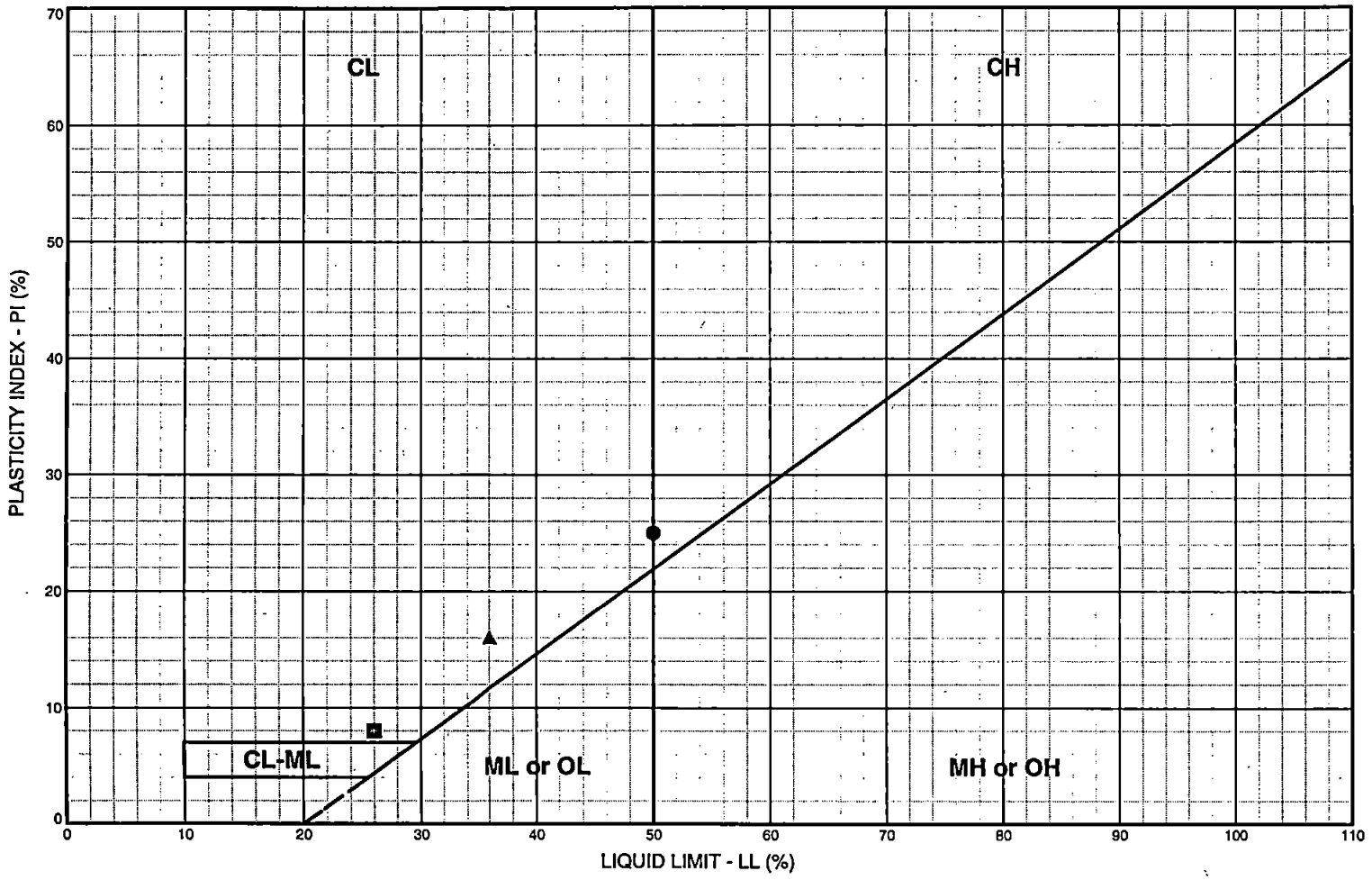
FIG. B-4

FIG. B-4



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● B-10, S-13	65.0	CH	Gray, silty CLAY, trace of sand; scattered fine sand partings	50	25	25	27.3	
■ B-11, S-10	50.0	CL	Gray, silty CLAY, trace of sand	26	18	8	18.5	
▲ B-12A, S-10	55.0	CL	Gray, silty CLAY	36	20	16	23.6	

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PLASTICITY CHART
BORINGS B-10 TO B-12A

June 2002 21-1-09644-002

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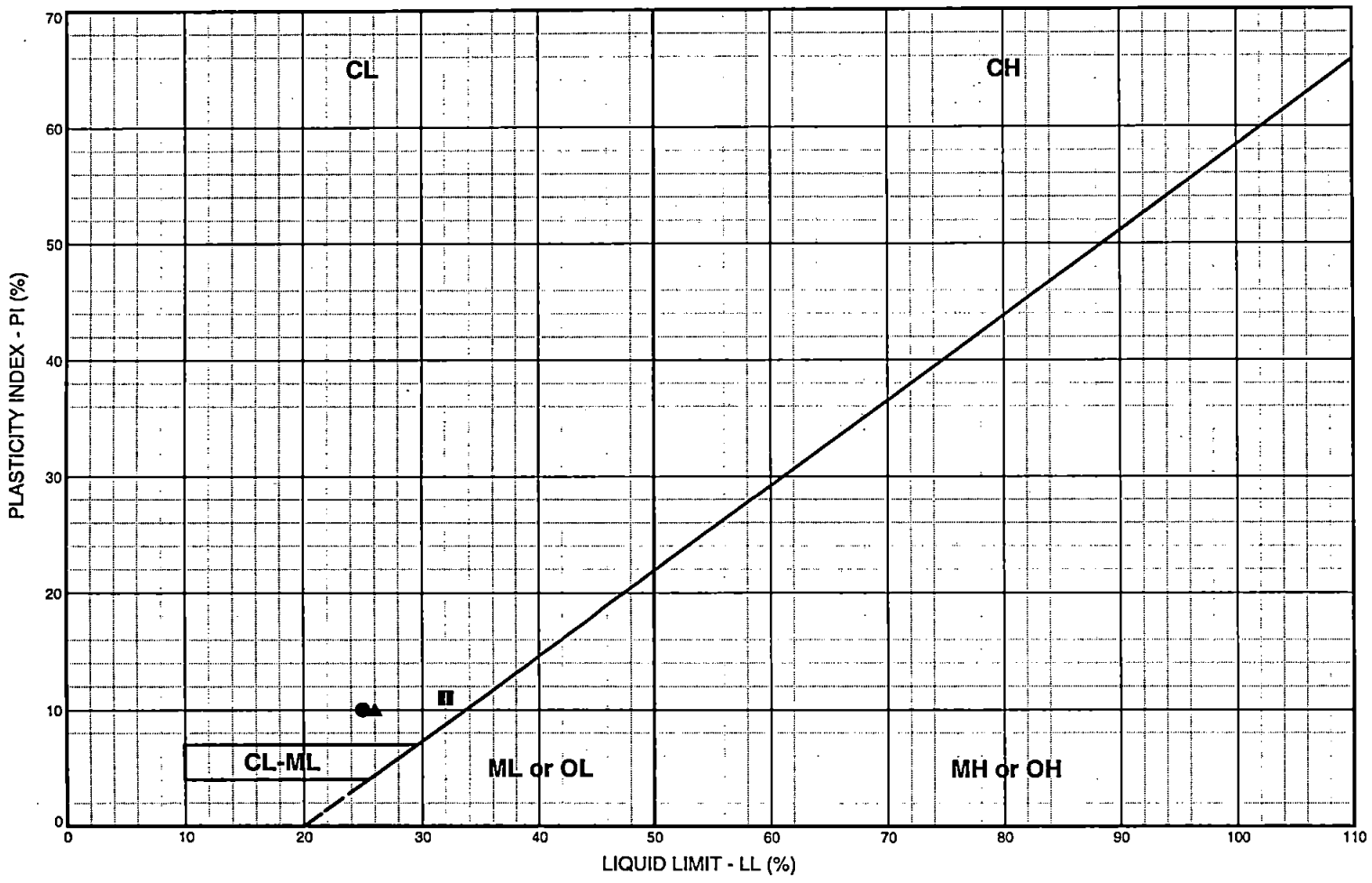
FIG. B-5

FIG. B-5



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● B-14, S-10	50.0	CL	Gray, silty CLAY, trace of sand	25	15	10	21.5	
■ B-14, S-14	70.0	CL	Gray, silty CLAY, trace of sand	32	21	11	25.3	
▲ B-16A, S-9	60.0	CL	Gray, fine sandy, silty CLAY	26	16	10	17.3	

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PLASTICITY CHART
BORINGS B-14 TO B-16A

June 2002 21-1-09644-002

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FIG. B-6

FIG. B-6

APPENDIX C

ENVIRONMENTAL LABORATORY REPORTS

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 3/12/02
CCIL JOB #: 203025
CCIL SAMPLE #: 2
DATE RECEIVED: 3/6/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-004 SNO CO
CLIENT SAMPLE ID: B-16, S-6 3/4/02 0951

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	91	MG/KG	3/7/02	LAH
MTBE***	EPA-8021	ND(<0.1)	MG/KG	3/6/02	LAH
BENZENE	EPA-8021	ND(<0.03)	MG/KG	3/6/02	LAH
TOLUENE	EPA-8021	0.07	MG/KG	3/6/02	LAH
ETHYLBENZENE	EPA-8021	0.1	MG/KG	3/6/02	LAH
XYLENES	EPA-8021	ND(<0.2)	MG/KG	3/6/02	LAH
TPH-SEMIVOLATILE RANGE	NWTPH-DX	ND	MG/KG	3/6/02	RAB
LEAD	EPA-6010	ND(<6)	MG/KG	3/7/02	CMH

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY HIGHLY WEATHERED GASOLINE

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 6 MG/KG
DIESEL RANGE REPORTING LIMIT IS 25 MG/KG
LUBE OIL RANGE REPORTING LIMIT IS 50 MG/KG

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ANY POSITIVE MTBE RESULT SHOULD BE CONFIRMED BY GC/MS ANALYSIS

APPROVED BY: CNH

8620 Holly Drive • Everett, WA 98208 • 425 356-2600 • FAX 425 356-2626 • Seattle 206 292-9059

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 3/12/02
CCIL JOB #: 203025
CCIL SAMPLE #: 3
DATE RECEIVED: 3/6/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-004 SNO CO
CLIENT SAMPLE ID: B-12, S-3 3/4/02 1148

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	38	MG/KG	3/6/02	LAH
MTBE***	EPA-8021	ND(<0.1)	MG/KG	3/6/02	LAH
BENZENE	EPA-8021	ND(<0.03)	MG/KG	3/6/02	LAH
TOLUENE	EPA-8021	ND(<0.05)	MG/KG	3/6/02	LAH
ETHYLBENZENE	EPA-8021	ND(<0.05)	MG/KG	3/6/02	LAH
XYLENES	EPA-8021	ND(<0.2)	MG/KG	3/6/02	LAH
TPH-SEMIVOLATILE RANGE	NWTPH-DX	ND	MG/KG	3/6/02	RAB
LEAD	EPA-6010	ND(<6)	MG/KG	3/7/02	CMH

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY HIGHLY WEATHERED GASOLINE

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 3 MG/KG
DIESEL RANGE REPORTING LIMIT IS 25 MG/KG
LUBE OIL RANGE REPORTING LIMIT IS 50 MG/KG

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ANY POSITIVE MTBE RESULT SHOULD BE CONFIRMED BY GC/MS ANALYSIS

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LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 3/12/02
CCIL JOB #: 203025
CCIL SAMPLE #: 4
DATE RECEIVED: 3/6/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-004 SNO CO
CLIENT SAMPLE ID: B-13, S-4 3/4/02 1348

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	ND	MG/KG	3/11/02	LAH
MTBE***	EPA-8021	ND(<0.1)	MG/KG	3/11/02	LAH
BENZENE	EPA-8021	ND(<0.03)	MG/KG	3/11/02	LAH
TOLUENE	EPA-8021	ND(<0.05)	MG/KG	3/11/02	LAH
ETHYLBENZENE	EPA-8021	ND(<0.05)	MG/KG	3/11/02	LAH
XYLENES	EPA-8021	ND(<0.2)	MG/KG	3/11/02	LAH
TPH-SEMIVOLATILE RANGE	NWTPH-DX	ND	MG/KG	3/7/02	RAB
LEAD	EPA-6010	ND(<6)	MG/KG	3/7/02	CMH

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 3 MG/KG
DIESEL RANGE REPORTING LIMIT IS 25 MG/KG
LUBE OIL RANGE REPORTING LIMIT IS 50 MG/KG

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ANY POSITIVE MTBE RESULT SHOULD BE CONFIRMED BY GC/MS ANALYSIS

APPROVED BY: 

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CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 3/12/02
CCIL JOB #: 203025

DATE RECEIVED: 3/6/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-004 SNO CO

QUALITY CONTROL RESULTS

SURROGATE RECOVERY

CCIL SAMPLE ID	ANALYTE	SUR ID	% RECV
203025-01	NWTPH-GX	TFT	*
203025-01	EPA-8021	TFT	*
203025-01	NWTPH-DX	C25	78
203025-02	NWTPH-GX	TFT	60
203025-02	EPA-8021	TFT	87
203025-02	NWTPH-DX	C25	80
203025-03	NWTPH-GX	TFT	66
203025-03	EPA-8021	TFT	68
203025-03	NWTPH-DX	C25	65
203025-04	NWTPH-GX	TFT	83
203025-04	EPA-8021	TFT	85
203025-04	NWTPH-DX	C25	79

* SURROGATE DILUTED OUT OF CALIBRATION RANGE

APPROVED BY: _____

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

400 N. 34th Street, Suite 100
Seattle, WA 98103
(206) 632-8020
(206) 695-6777 Fax

1500 Olive Blvd., Suite 276
St. Louis, MO 63141
(314) 872-8170
(314) 872-8178 Fax

2055 Hill Road
Fairbanks, AK 99709
(907) 479-0600
(907) 479-5691 Fax

5430 Fairbanks Street, Suite 3
Anchorage, AK 99518
(907) 561-2120
(907) 561-4483 Fax

303 Wellsian Way
Richland, WA 99352
(509) 946-6309
(509) 946-6580 Fax

CHAIN-OF-CUSTODY RECORD

Laboratory CCI Page 1 of 1
Attn:

Analysis Parameters/Sample Container Description
(include preservative if used)

Sample Identity	Lab No.	Time	Date Sampled	Comp.	Grab	NWTPH-G/BTEX	NTWPH-Dx	Total Pb				Total Number of Containers	Remarks/Matrix
B-6, S-2	1	1352	2/4/02		X	X	X	X RUSH THIS ONLY (*)				2	SOIL
B-16, S-6	2	0951	3/4/02		↓	↓	↓	↓				3	↓
B-12, S-3	3	1148	3/4/02		↓	↓	↓	↓				2	↓
B-13, S-4	4	1348	3/4/02		↓	↑ test from jar (1)	↓	← test From jar (2)				2	↓

Project Information

Project Number: 21-1-09649-00
Project Name: Sno Co
Contact: A TIRAO
Ongoing Project? Yes ☒ No ☐
Sampler: ACT

Sample Receipt

Total Number of Containers: 4
COC Seals/Intact? Y/N/NA:
Received Good Cond./Cold:
Delivery Method:
(attach shipping bill, if any)

Instructions

Requested Turnaround Time: STD — RUSH one (*) sample to meet hold times!
Special Instructions: please provide copy of coc w/ final lab report

Relinquished By: 1.	Relinquished By: 2.	Relinquished By: 3.
Signature: Time: 0930	Signature: Time:	Signature: Time:
Printed Name: AGNES TIRAO Date: 3/6/02	Printed Name: Date:	Printed Name: Date:
Company: S&W	Company:	Company:

Received By: 1.	Received By: 2.	Received By: 3.
Signature: Time: 1030	Signature: Time:	Signature: Time:
Printed Name: Rick Bagan Date: 3/6/02	Printed Name: Date:	Printed Name: Date:
Company: CCIAL	Company:	Company:

Distribution: White - w/shipment - returned to Shannon & Wilson w/ laboratory report
Yellow - w/shipment - for consignee files
Pink - Shannon & Wilson - Job File

fax initial/draft results to A Tirao — don't rush Pb unless req'd by hold time!

F-19-91/UR

No.

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 5/21/02
CCIL JOB #: 205079
CCIL SAMPLE #: 1
DATE RECEIVED: 5/14/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-004
CLIENT SAMPLE ID: B16A-S2 5/6/02 1020

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	13	MG/KG	5/16/02	LAH
MTBE***	EPA-8021	ND(<0.1)	MG/KG	5/16/02	LAH
BENZENE	EPA-8021	ND(<0.03)	MG/KG	5/16/02	LAH
TOLUENE	EPA-8021	ND(<0.05)	MG/KG	5/16/02	LAH
ETHYLBENZENE	EPA-8021	ND(<0.05)	MG/KG	5/16/02	LAH
XYLENES	EPA-8021	ND(<0.2)	MG/KG	5/16/02	LAH
TPH-SEMIVOLATILE RANGE	NWTPH-DX	ND	MG/KG	5/16/02	AIB
LEAD	EPA-6010	ND(<5.1)	MG/KG	5/17/02	RAB

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY HIGHLY WEATHERED GASOLINE

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 3 MG/KG
DIESEL RANGE REPORTING LIMIT IS 25 MG/KG
LUBE OIL RANGE REPORTING LIMIT IS 50 MG/KG

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ANY POSITIVE MTBE RESULT SHOULD BE CONFIRMED BY GC/MS ANALYSIS

APPROVED BY: _____

8620 Holly Drive • Everett, WA 98208 • 425 356-2600 • FAX 425 356-2626 • Seattle 206 292-9059

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 5/21/02
CCIL JOB #: 205079

DATE RECEIVED: 5/14/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-004

QUALITY CONTROL RESULTS

SURROGATE RECOVERY

CCIL SAMPLE ID	ANALYTE	SUR ID	% RECV
205079-01	NWTPH-GX	TFT	69
205079-01	EPA-8021	TFT	67
205079-01	NWTPH-DX	C25	82

APPROVED BY: _____

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CCI Analytical Laboratories, Inc.
8620 Holly Drive
Everett, WA 98208
Phone (425) 356-2600
(206) 292-9059 Seattle
(425) 356-2626 Fax

Chain Of Custody/ Laboratory Analysis Request

CCI Job# (Laboratory Use Only)

Date 5/13/2002 Page 1 Of 1

PROJECT ID: 21-1-09644-004
REPORT TO COMPANY: Shannon & Wilson Inc
PROJECT MANAGER: Agnes Tirao
ADDRESS: 400 N 34th St Ste 100
Seattle WA 98103
PHONE: 206 632 8020 FAX: 206 695 6777
INVOICE TO COMPANY:
ATTENTION:
ADDRESS:
P.O. NUMBER CCI QUOTE:

SAMPLE I.D.	DATE	TIME	TYPE	LAB#	NWTPH-GX	BTEX	NWTPH-DX	NWTPH-HCID	EPA 8021 ☐ 602 ☐	EPA 8010 ☐ 601 ☐	EPA 8260 ☐ 624 ☐	EPA 8270 ☐ 625 ☐	EPA 8081/8082 ☐ 608 ☐ PCB only ☐ Pest only ☐	Metals Priority Pollutant ☐ RCRA ☐ TAL ☐	Metals Other (Specify) Pb only	TCLP-Metals ☐ VOA ☐ Semi-Vol ☐ Pest ☐ Herbs ☐	OTHER (Specify)	NUMBER OF CONTAINERS	RECEIVED IN GOOD CONDITION?
1. B16A-S2	5/6/2002	1020	SOIL		X	X	X								X			1	
2.																			
3.																			
4.																			
5.																			
6.																			
7.																			
8.																			
9.																			
10.																			

SPECIAL INSTRUCTIONS

SIGNATURES (Name, Company, Date, Time):

1. Relinquished By: Agnes Tirao, S&W, 5/13/2002 1700
Received By: [signature] CCIAL 5/14/02 1430
2. Relinquished By:
Rece

TURNAROUND REQUESTED in Business Days*

Organic, Metals & Inorganic Analysis
10 Standard | 5 | 3 | 2 | 1 | SAME DAY

Fuels & Hydrocarbon Analysis
5 Standard | 3 | 1 | SAME DAY

OTHER:
Specify:

roun less grd m ush

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N 34TH ST, SITE 100
SEATTLE, WA 98103

DATE: 6/28/02
CCIL JOB #: 206099
CCIL SAMPLE #: 1
DATE RECEIVED: 6/21/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006
CLIENT SAMPLE ID: B-18, S-5 6/21/02 1144

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	ND	MG/KG	6/25/02	ZMB
MTBE***	EPA-8021	ND(<0.1)	MG/KG	6/25/02	ZMB
BENZENE	EPA-8021	ND(<0.03)	MG/KG	6/25/02	ZMB
TOLUENE	EPA-8021	ND(<0.05)	MG/KG	6/25/02	ZMB
ETHYLBENZENE	EPA-8021	ND(<0.05)	MG/KG	6/25/02	ZMB
XYLENES	EPA-8021	ND(<0.2)	MG/KG	6/25/02	ZMB
TPH-SEMIVOLATILE RANGE	NWTPH-DX	ND	MG/KG	6/25/02	NST

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 3 MG/KG
DIESEL RANGE REPORTING LIMIT IS 25 MG/KG
LUBE OIL RANGE REPORTING LIMIT IS 50 MG/KG

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ANY POSITIVE MTBE RESULT SHOULD BE CONFIRMED BY GC/MS ANALYSIS

APPROVED BY: _____

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CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N 34TH ST, SITE 100
SEATTLE, WA 98103

DATE: 6/28/02
CCIL JOB #: 206099
CCIL SAMPLE #: 2
DATE RECEIVED: 6/21/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006
CLIENT SAMPLE ID: B-18, S-6 6/21/02 1149

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	2900	MG/KG	6/26/02	ZMB
MTBE***	EPA-8021	ND(<10)	MG/KG	6/26/02	ZMB
BENZENE	EPA-8021	ND(<3)	MG/KG	6/26/02	ZMB
TOLUENE	EPA-8021	ND(<5)	MG/KG	6/26/02	ZMB
ETHYLBENZENE	EPA-8021	ND(<5)	MG/KG	6/26/02	ZMB
XYLENES	EPA-8021	ND(<20)	MG/KG	6/26/02	ZMB
TPH-SEMIVOLATILE RANGE	NWTPH-DX	ND	MG/KG	6/25/02	AIB

NOTES: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY HIGHLY WEATHERED GASOLINE
DIESEL RANGE REPORTING LIMIT RAISED DUE TO VOLATILE RANGE OVERLAP

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 300 MG/KG
DIESEL RANGE REPORTING LIMIT IS 130 MG/KG
LUBE OIL RANGE REPORTING LIMIT IS 50 MG/KG

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

*** ANY POSITIVE MTBE RESULT SHOULD BE CONFIRMED BY GC/MS ANALYSIS

APPROVED BY: _____

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ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N 34TH ST, SITE 100
SEATTLE, WA 98103

DATE: 6/28/02
CCIL JOB #: 206099

DATE RECEIVED: 6/21/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006

QUALITY CONTROL RESULTS

SURROGATE RECOVERY

CCIL SAMPLE ID	ANALYTE	SUR ID	% RECV
206099-01	NWTPH-GX	TFT	105
206099-01	EPA-8021	TFT	99
206099-01	NWTPH-DX	C25	103
206099-02	NWTPH-GX	TFT	*
206099-02	EPA-8021	TFT	*
206099-02	NWTPH-DX	C25	104

* SURROGATE DILUTED OUT OF CALIBRATION RANGE

APPROVED BY: _____

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CCI Analytical Laboratories, Inc.
8620 Holly Drive
Everett, WA 98208
Phone (425) 356-2600
(206) 292-9059 Seattle
(425) 356-2626 Fax

Chain Of Custody/ Laboratory Analysis Request

CCI Job# (Laboratory Use Only)

Date 6-21-02 Page 1 Of 1

PROJECT ID: 21-1-09644-006
REPORT TO COMPANY: Shannon & Wilson, Inc.
PROJECT MANAGER: Agnes Tinao
ADDRESS: 400 N 34th St, Ste 100
Seattle WA 98103
PHONE: 206-632-8020 FAX: 206-695-6777
INVOICE TO COMPANY:
ATTENTION:
ADDRESS:
P.O. NUMBER CCI QUOTE:

SAMPLE I.D.	DATE	TIME	TYPE	LAB#	NWTPH-GX	BTEX	NWTPH-DX	NWTPH-HCID	EPA 8021 ☐ 602 ☐	EPA 8010 ☐ 601 ☐	EPA 8260 ☐ 624 ☐	EPA 8270 ☐ 625 ☐	EPA 8081/8082 ☐ 608 ☐ PCB only ☐ Pest only ☐	Metals Priority Pollutant ☐ RCRA ☐ TAL ☐	Metals Other (Specify)	TCLP-Metals ☐ VOA ☐ Semi-Vol ☐ Pest ☐ Herbs ☐	OTHER (Specify)	NUMBER OF CONTAINERS	RECEIVED IN GOOD CONDITION?
1. B-18, S-5	6/21/02	1144	S		X	X	X										1	1	
2. B-18, S-6	6/21/02	1149	S		X	X	X										1	1	
3.																			
4.																			
5.																			
6.																			
7.																			
8.																			
9.																			
10.																			

Call for requested testing. (HOLD) - 4oz Gl

SPECIAL INSTRUCTIONS X Added via FAX by A. Tinao 6/24/02

SIGNATURES (Name, Company, Date, Time):

1. Relinquished By: Paul L. Van Hoorne SFLU 6/21/02 1506
Received By: Jennifer Bowman CCIA 6/21/02 1506
2. Relinquished By:
Rece

TURNAROUND REQUESTED in Business Days*

Organic, Metals & Inorganic Analysis
10 Standard | 5 | 3 | 2 | 1 | SAME DAY

Fuels & Hydrocarbon Analysis
5 Standard | 3 | 1 | SAME DAY

OTHER:
Specify:

aroun less ard n Rush

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 7/12/02
CCIL JOB #: 207024
CCIL SAMPLE #: 1
DATE RECEIVED: 7/3/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006 SNOHOMISH COUNTY CAMPUS
CLIENT SAMPLE ID: TRIP BLANK 7/3/02 1200

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	ND	UG/L	7/12/02	LAH
MTBE	EPA-8021	ND(<3)	UG/L	7/12/02	LAH
BENZENE	EPA-8021	ND(<1)	UG/L	7/12/02	LAH
TOLUENE	EPA-8021	ND(<1)	UG/L	7/12/02	LAH
ETHYLBENZENE	EPA-8021	ND(<1)	UG/L	7/12/02	LAH
XYLENES	EPA-8021	ND(<3)	UG/L	7/12/02	LAH

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 50 UG/L

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY: _____

8620 Holly Drive • Everett, WA 98208 • 425 356-2600 • FAX 425 356-2626 • Seattle 206 292-9059

CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 7/12/02
CCIL JOB #: 207024
CCIL SAMPLE #: 2
DATE RECEIVED: 7/3/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006 SNOHOMISH COUNTY CAMPUS
CLIENT SAMPLE ID: B-17,GW-1 7/3/02 1316

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	ND	UG/L	7/12/02	LAH
MTBE	EPA-8021	ND(<3)	UG/L	7/12/02	LAH
BENZENE	EPA-8021	ND(<1)	UG/L	7/12/02	LAH
TOLUENE	EPA-8021	ND(<1)	UG/L	7/12/02	LAH
ETHYLBENZENE	EPA-8021	ND(<1)	UG/L	7/12/02	LAH
XYLENES	EPA-8021	ND(<3)	UG/L	7/12/02	LAH
TPH-DIESEL RANGE	NWTPH-DX	ND	UG/L	7/12/02	AIB
TPH-OIL RANGE	NWTPH-DX	ND	UG/L	7/12/02	AIB

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 50 UG/L
DIESEL RANGE REPORTING LIMIT IS 130 UG/L
LUBE OIL RANGE REPORTING LIMIT IS 250 UG/L

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY: _____

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CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 7/19/02
CCIL JOB #: 207024
CCIL SAMPLE #: 3
DATE RECEIVED: 7/3/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006 SNOHOMISH COUNTY CAMPUS
CLIENT SAMPLE ID: B-14,GW-1 7/3/02 1422

MTBE REPORT AMENDED TO INCLUDE EPA-8260

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	6800	UG/L	7/12/02	LAH
METHYL T-BUTYL ETHER	EPA-8260	ND(<2)	UG/L	7/16/02	PDC
BENZENE	EPA-8260	310	UG/L	7/18/02	PDC
TOLUENE	EPA-8260	74	UG/L	7/16/02	PDC
ETHYLBENZENE	EPA-8260	890	UG/L	7/18/02	PDC
M+P XYLENE	EPA-8260	670	UG/L	7/18/02	PDC
O-XYLENE	EPA-8260	13	UG/L	7/16/02	PDC
TPH-DIESEL RANGE	NWTPH-DX	ND	UG/L	7/12/02	AIB
TPH-OIL RANGE	NWTPH-DX	ND	UG/L	7/12/02	AIB

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY LIGHTLY WEATHERED GASOLINE

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 500 UG/L
DIESEL RANGE REPORTING LIMIT IS 130 UG/L
LUBE OIL RANGE REPORTING LIMIT IS 250 UG/L

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY: _____

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CCI
ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 7/19/02
CCIL JOB #: 207024
CCIL SAMPLE #: 4
DATE RECEIVED: 7/3/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006 SNOHOMISH COUNTY CAMPUS
CLIENT SAMPLE ID: B-18,GW-1 7/3/02 1529

MTBE REPORT AMENDED TO INCLUDE EPA-8260

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
TPH-VOLATILE RANGE	NWTPH-GX	2900	UG/L	7/12/02	LAH
METHYL T-BUTYL ETHER	EPA-8260	ND(<2)	UG/L	7/16/02	PDC
BENZENE	EPA-8260	ND(<2)	UG/L	7/16/02	PDC
TOLUENE	EPA-8260	ND(<2)	UG/L	7/16/02	PDC
ETHYLBENZENE	EPA-8260	43	UG/L	7/16/02	PDC
M+P XYLENE	EPA-8260	51	UG/L	7/16/02	PDC
O-XYLENE	EPA-8260	2	UG/L	7/16/02	PDC
TPH-DIESEL RANGE	NWTPH-DX	ND	UG/L	7/12/02	AIB
TPH-OIL RANGE	NWTPH-DX	ND	UG/L	7/12/02	AIB

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY WEATHERED GASOLINE

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES OR AS FOLLOWS:
GASOLINE(VOLATILE RANGE) REPORTING LIMIT IS 250 UG/L
DIESEL RANGE REPORTING LIMIT IS 130 UG/L
LUBE OIL RANGE REPORTING LIMIT IS 250 UG/L

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY: _____

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ANALYTICAL
LABORATORIES, INC.

CERTIFICATE OF ANALYSIS

CLIENT: SHANNON & WILSON, INC.
400 N. 34TH STREET, SUITE 100
SEATTLE, WA 98103

DATE: 7/19/02
CCIL JOB #: 207024

DATE RECEIVED: 7/3/02
WDOE ACCREDITATION #: C142

CLIENT CONTACT: AGNES TIRAO

CLIENT PROJECT ID: 21-1-09644-006 SNOHOMISH COUNTY CAMPUS

QUALITY CONTROL RESULTS

SURROGATE RECOVERY

CCIL SAMPLE ID	ANALYTE	SUR ID	% RECV
207024-01	NWTPH-GX	TFT	105
207024-01	EPA-8021	TFT	105
207024-02	NWTPH-GX	TFT	109
207024-02	EPA-8021	TFT	109
207024-02	NWTPH-DX	C25	59
207024-03	NWTPH-GX	TFT	108
207024-03 (BENZENE, ETHYLBENZENE, M,P-XYLENE)	EPA-8260	1,2-DCE-d4	92
207024-03 (METHYL T-BUTYL ETHER, TOLUENE, O-XYLENE)	EPA-8260	1,2-DCE-d4	106
207024-03	NWTPH-DX	C25	57
207024-04	NWTPH-GX	TFT	93
207024-04	EPA-8260	1,2-DCE-d4	96
207024-04	NWTPH-DX	C25	53

APPROVED BY: _____

8620 Holly Drive • Everett, WA 98208 • 425 356-2600 • FAX 425 356-2626 • Seattle 206 292-9059

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

400 N. 34th Street, Suite 100
Seattle, WA 98103
(206) 632-8020
(206) 695-6777 Fax

11500 Olive Blvd., Suite 276
St. Louis, MO 63141
(314) 872-8170
(314) 872-8178 Fax

2055 Hill Road
Fairbanks, AK 99709
(907) 479-0600
(907) 479-5691 Fax

5430 Fairbanks Street, Suite 3
Anchorage, AK 99518
(907) 561-2120
(907) 561-4483 Fax

303 Wellsian Way
Richland, WA 99352
(509) 946-6309
(509) 946-6580 Fax

CHAIN-OF-CUSTODY RECORD

Laboratory CCI
Attn: Rick Bagan

Analysis Parameters/Sample Container Description
(include preservative if used)

Sample Identity	Lab No.	Time	Date Sampled	Comp.	Grab	40ml GVOA/HCl NWTPH-Gx/BTEX	1/2 L AG NWTPH-Dx					Total Number of Containers	Remarks/Matrix
Trip Blank	1	1200	7-3-02		X	1						1	Iced/Water
B-17, GW-1	2	1316	↓		X	3	1					4	↓
B-14, GW-1	3	1422			X	3	2					5	
B-18, GW-1	4	1529	↓		X	3	2					5	

Project Information

Project Number: 21-1-09644-00C
Project Name: Snohomish County Cac
Contact: Agnes Tirao
Ongoing Project? Yes ☐ No ☒
Sampler: Paul VanHorne

Sample Receipt

Total Number of Containers:
COC Seals/Intact? Y/N/NA:
Received Good Cond./Cold:
Delivery Method: Co. personnel
(attach shipping bill, if any)

Turnaround Instructions

Requested Turnaround Time: By Next Friday 7/12/02
Special Instructions:

Relinquished By: 1.
Signature: Paul L. VanHorne Time: 1615
Printed Name: Paul L. VanHorne Date: 7/3/02
Company: SAW

Relinquished By: 2.
Signature: Time:
Printed Name: Date:
Company:

Relinquished By: 3.
Signature: Time:
Printed Name: Date:
Company:

Received By: 1.
Signature: Time: 1615
Printed Name: Date: 7-3-02
Company: CCI

Received By: 2.
Signature: Time:
Printed Name: Date:
Company:

Received By: 3.
Signature: Time:
Printed Name: Date:
Company:

Distribution: White - w/shipment - returned to Shannon & Wilson w/ laboratory report
Yellow - w/shipment - for consignee files
Pink - Shannon & Wilson - Job File

F-19-91/UR

No.

Appendix D

Appendix D

APPENDIX D

SLUG TESTING

APPENDIX D

SLUG TESTING

TABLE OF CONTENTS

TABLE

Table No.

LIST OF FIGURES

Figure No.

APPENDIX D

SLUG TESTING

D.1 INTRODUCTION

Slug tests were performed at three wells, which are listed with the results in Table D-1, Slug Test Summary. A slug test provides a relatively low-cost means of estimating the horizontal hydraulic conductivity of the saturated sediments immediately surrounding the screened zone of a well. The influence of a slug test extends only a short distance into the soils surrounding a well screen and the area tested is relatively small compared with that influenced by a pumping test.

Two analytical methods were used in evaluating the slug test data. These were the Bouwer and Rice (1976) method and modified by Bouwer (1989) (Bouwer and Rice Method), and the Cooper et al. (1967) method (Cooper Method).

D.2 SLUG TEST METHOD ASSUMPTIONS

As with most aquifer testing solutions, assumptions must be regarding the well construction and the nature of the saturated soils to be analyzed. Both the Bouwer and Rice and Cooper methods assume the following:

1. The well is in full hydraulic connection with the surrounding soils.
2. The water table, or piezometric surface (for confined hydrogeologic systems), is horizontal and static (non-fluctuating) prior to the test.
3. The saturated material has an infinite lateral extend.
4. The saturated material is homogeneous and isotropic.
5. Head losses due to water entering the well (well losses) are negligible.
6. The storage in the well is negligible.

The Bouwer and Rice method also assumes that the position of the water level around the well, and thus the aquifer-saturated thickness, does not change during the test. The Cooper solution assumes that the well screen fully penetrates the aquifer.

The Bouwer and Rice method was developed for use with fully or partially penetrating wells screened in unconfined aquifers; however, the method is also appropriate for confined or stratified aquifers if the top of the screen is some distance below the upper confining layer. The Cooper method was developed for wells that fully penetrate confined aquifers. Both solutions allow for determination of the horizontal hydraulic conductivity of the aquifer (K).

D.3 SLUG TEST DATA ANALYSIS

Several parameters describing the well and subsurface geometry must be estimated for slug test analyses. Well dimension details were measured directly when possible, or were taken from the logs of the project borings.

For the Bouwer and Rice solution, the well casing radius, the borehole radius, the saturated screened interval, the static water level and the location of the bottom of the water-bearing zone are required to estimate K. The water-bearing zone at each well is considered to be bounded above by the static water level and below by a material of lower permeability. In our analyses, the depth to the base of the water-bearing zone used in the calculations was based on the subsurface conditions encountered at the boring, or when such a unit was not encountered, on the total borehole depth. If a well screen partially penetrated a lower permeability zone above or below the water-bearing zone of interest, the effective screen length used in the calculation was below the water-bearing zone of interest, the effective screen length used in the calculations was reduced to that located adjacent to the water-bearing zone. The effective radius over which the head loss is dissipated is also required for this analysis. This value depends on the geometry of the flow system and is estimated using type curves published by Bouwer and Rice (1976).

For the Cooper solution, parameters required for the analysis include the well casing radius, the well screen radius, the initial increase or decrease in water level induced by the slug entering or leaving the well, and the thickness of the water-bearing zone. Because the solution assumes full aquifer penetration, the length of the well screen located adjacent to the water-bearing zone was used as the aquifer thickness (b).

The slug test data were reduced to a format suitable for spreadsheet and graphical analyses. For the Bouwer and Rice solution, the log of the change in water level (head change) within the well casing was plotted against the time since the start of the test. Theoretically, the early to mid-time data should plot approximately on a single straight line (on a semi-log plot), with the slope of the line being used in the Bouwer and Rice calculation of K. Data typically deviates from a straight

line: (1) at early times due to splash effects (associated with the slug entering or leaving the water column) or filter pack interference; and (2) at late times because drawndown of the groundwater level around the well becomes increasingly significant as the test progresses, violating the Bouwer and Rice assumption that head changes around the well are negligible. Figures D-1 through D-3 shows the data formatted for the Bouwer and Rice method.

For the Cooper solutions, the ratio of the water level's deviation from static water level to the initial water level displacement was plotted against the log of beta, a dimensionless time parameter. These data were then compared to type curve published by Cooper et al. (1976) to obtain values for the transmissivity (T) of the water-bearing zone. Hydraulic conductivity values were then estimated from T and b (K=T/b). The curves for the Cooper method are not shown in this memo. However, the results of the analyses using both the Bouwer and Rice and Cooper methods are included in Table D-1.

D.4 SLUG TEST RESULTS

The range of hydraulic conductivity values estimated for the tested soils (using the geometric means from the Bouwer and Rice and the Cooper methods) is from about 1.2×10^{-4} to 4.3×10^{-3} centimeters per seconds (cm/s).

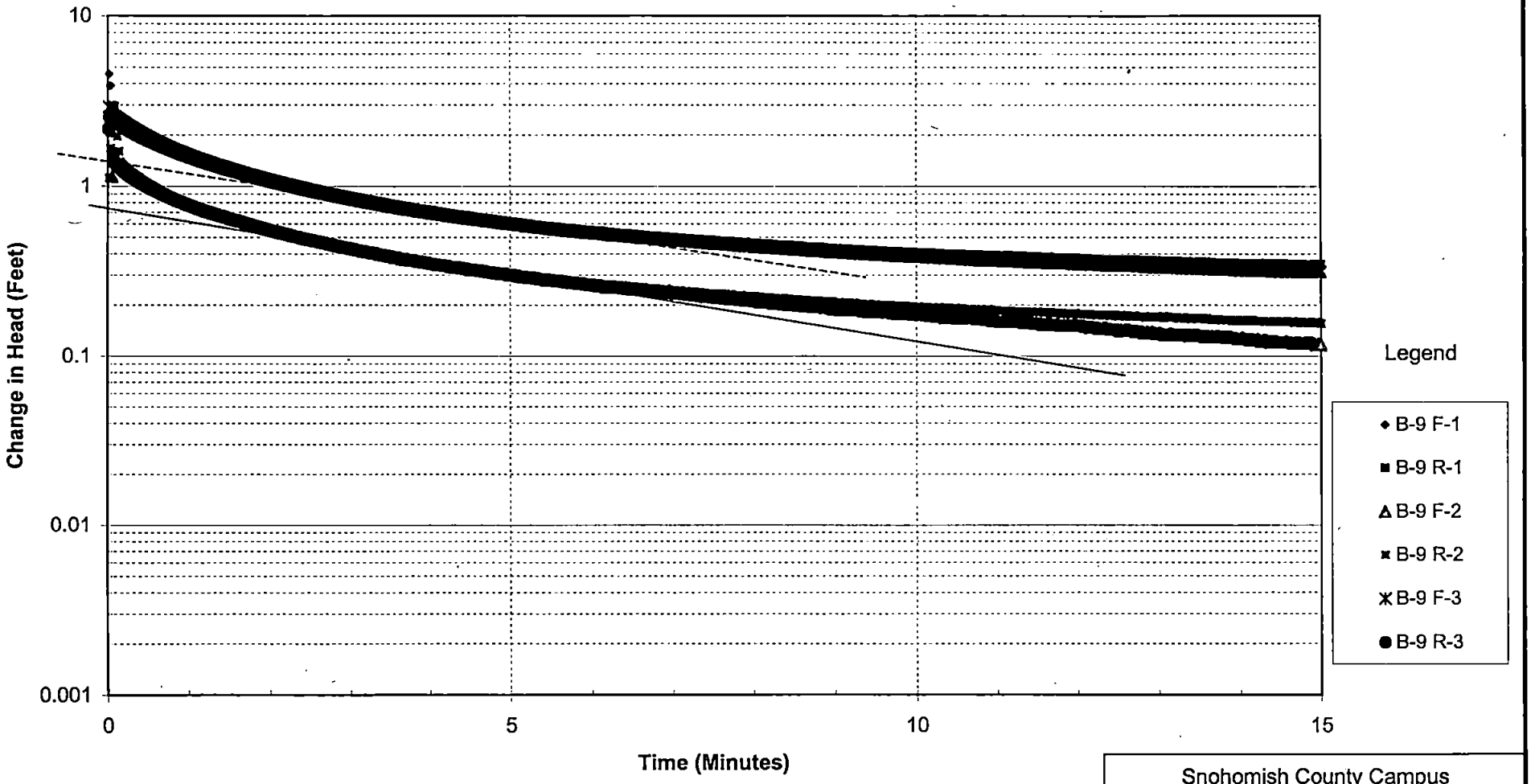
D.5 REFERENCES

Bouwer, H, and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research. v. 12, p. 423-428.

Bouwer, H., 1989, The Bouwer and Rice slug test – an update. Ground Water, v. 27, p. 304-309.

TABLE D-1
SLUG TEST SUMMARY

Monitoring Well Designation	Slug Test Type and Number	Bouwer & Rice Method	Cooper Method	Interpreted Primary Soil Classification Tested
		Hydraulic Conductivity (K) (cm/sec)	Hydraulic Conductivity (K) (cm/sec)	
B-9	Falling Head Test 1	1.14E-04	3.68E-04	SM/ML
	Falling Head Test 2	1.53E-04	2.15E-04	
	Falling Head Test 3	1.22E-04	3.47E-04	
	Rising Head Test 1	9.72E-05	5.21E-04	
	Rising Head Test 2	1.28E-04	2.08E-04	
	Rising Head Test 3	1.11E-04	3.47E-04	
	Geometric Mean	**1.20E-04**	**3.18E-04**	
B-14	Falling Head Test 1	1.34E-03	4.09E-03	SM/SW-SM
	Falling Head Test 2	1.34E-03	4.29E-03	
	Falling Head Test 3	1.31E-03	4.57E-03	
	Rising Head Test 1	1.28E-03	4.09E-03	
	Rising Head Test 2	1.36E-03	4.57E-03	
	Rising Head Test 3	1.23E-03	4.32E-03	
	Geometric Mean	**1.31E-03**	**4.32E-03**	
B-17	Falling Head Test 1	2.38E-04	5.06E-04	SM/CL
	Falling Head Test 2	2.77E-04	9.23E-04	
	Falling Head Test 3	2.32E-04	8.20E-04	
	Rising Head Test 1	2.51E-04	1.32E-03	
	Rising Head Test 2	2.63E-04	1.12E-03	
	Rising Head Test 3	2.52E-04	7.38E-04	
	Geometric Mean	**2.52E-04**	**8.64E-04**	



NOTE:

1. Legend data denotes boring designation and method of slug testing, either Falling Head (F) or Rising Head (R). Multiple tests are designated by the final digit.
2. Solid straight line represents best fit line for the maximum value for hydraulic conductivity. Dashed line straight line represents best fit line for the minimum value for hydraulic conductivity.

FIG. D-1

Snohomish County Campus
Administration Building
Everett, Washington

SLUG TESTS
BORING B-9

August 2002 21-1-09644-005

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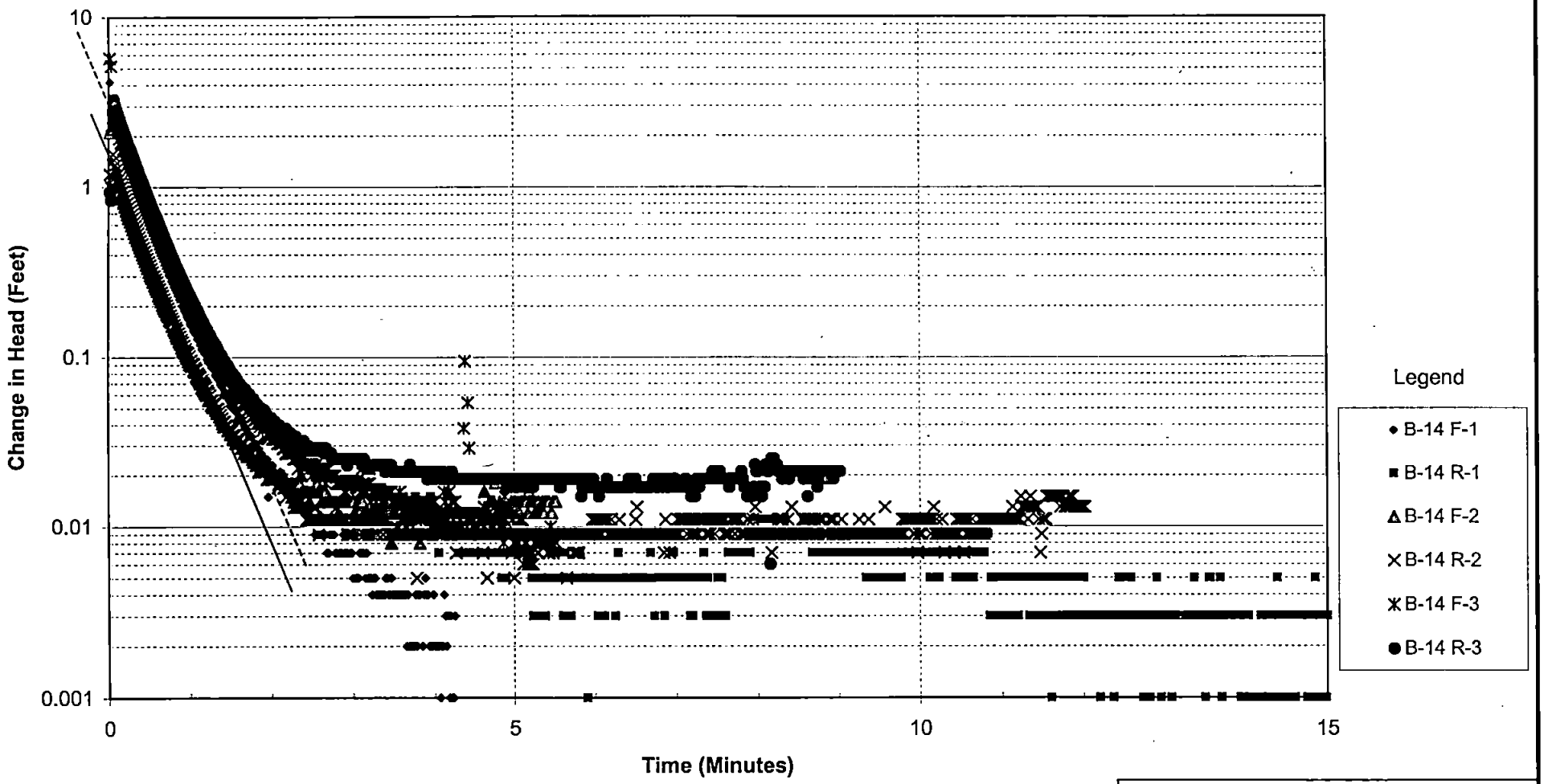
FIG. D-1



NOTE:

1. Legend data denotes boring designation and method of slug testing, either Falling Head (F) or Rising Head (R). Multiple tests are designated by the final digit.
2. Solid straight line represents best fit line for the maximum value for hydraulic conductivity. Dashed line straight line represents best fit line for the minimum value for hydraulic conductivity.

FIG. D-2

Snohomish County Campus
Administration Building
Everett, Washington

SLUG TESTS
BORING B-14

August 2002 21-1-09644-005

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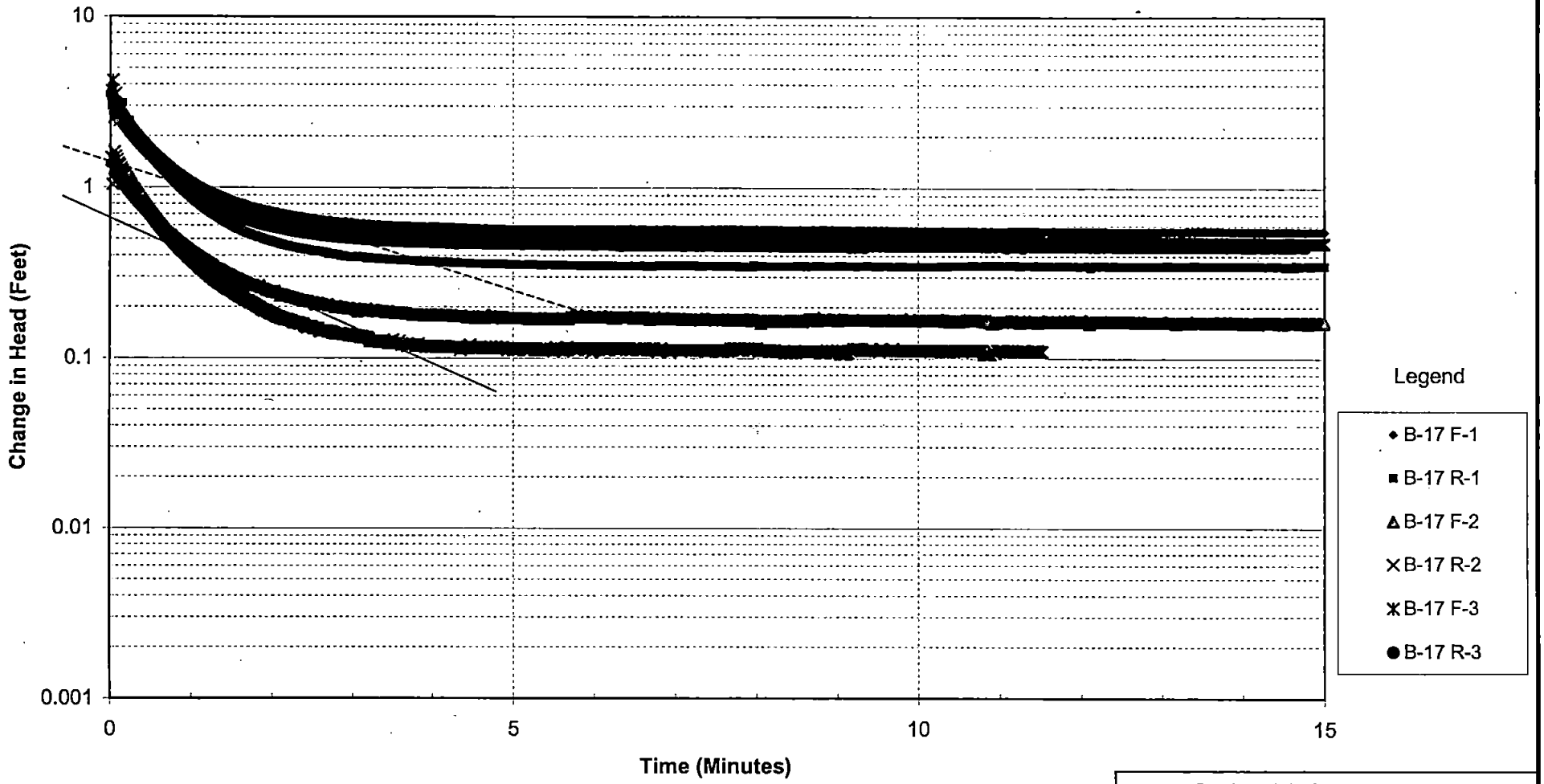
FIG. D-2



NOTE:

1. Legend data denotes boring designation and method of slug testing, either Falling Head (F) or Rising Head (R). Multiple tests are designated by the final digit.
2. Solid straight line represents best fit line for the maximum value for hydraulic conductivity. Dashed line straight line represents best fit line for the minimum value for hydraulic conductivity.

FIG. D-3

Snohomish County Campus
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Everett, Washington

SLUG TESTS
BORING B-17

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FIG. D-3

Appendix E

Appendix E

APPENDIX E

GEOPHYSICAL SURVEY REPORT

GEO RECON INTERNATIONAL

applied geophysics

August 6, 2002
J02-726/J

Shannon & Wilson
400 N 34th Street
Seattle, WA 98103

RE: UST Search
Everett City Facilities

This letter reports the results of a geophysical exploration for orphan underground storage tanks (UST) adjacent to the site of Borehole 18, between the Mission Building and the Administration Building Garage, on the vacated Rockefeller Ave. A gasoline service station at one time occupied the eastern side of the street, opposite BH-18. Product was found in BH-18. The work was completed on July 25,2002.

Results of the Survey

No evidence of an underground storage tank was found during the survey.

Pipes were located during the survey. The locations of the found pipes are shown on Figure 1 attached to this report. In addition a buried, apparent erratic boulder was located as shown on the figure. Other large gravel was also noted during the survey.

A 15 metre (49.2 ft) GPR grid was run around BH-18, with BH-18 as the center of the grid. The lines were run at 1-metre intervals, both in the North-South and East-West directions. In addition, GPR lines were run over the adjacent area, outside of the grid.

Partial identifications of the pipe functions were determined from the construction drawings and marks from the location survey.

No evidence of product piping was found in the grassy area in front of the Administration Building.

Methods

The Ground Penetrating Radar (a GSSI, SIR System 3) utilized a 500 Mega-Hertz antenna. The GPR antenna used for this investigation transmits a 2 nano-second (ns)

pulse at a frequency of 500 Mega-Hertz for the selected scan rate of 8 times per second. When the signal encounters a change in electrical properties (a change in electrical permittivity), a portion of the signal energy is reflected back to the surface. The reflected signal received by the antenna, is digitally processed and recorded on a chart recorder in an amplitude-threshold format. The character of the reflection is used to interpret the source of the reflection.

It is noted that many targets may have similar GPR signatures due to similarity in shape, for example a buried log and a UST. Without corroborative evidence (e.g. an EM or magnetic signature) it may be difficult to classify a target as a UST by the GPR signature alone.

A UST will produce, in cross-section, a hyperbolic reflection. A traverse parallel to the centerline of the UST will show a horizontal (if there is no velocity or elevation change along the traverse) reflection, with hyperbolic signatures at both ends of the UST. The hyperbolic signature is the result of "seeing" the tank before the center of the antenna is over the tank. Distortions in the images can be created by adjacent reflectors, which may affect location and identification of the image.

The GPR records were recorded at a full-scale sweep of 80 nano-seconds, and have 8 nano-seconds between horizontal time marks. The top of the recording is marked at one metre (3.28 ft) intervals. The depth of an object is determined by the electro-magnetic wave propagation rate (inverse of wave velocity) of the site materials. The recorded time is two-way time, that is the time down to the surface and then back to the antenna. The two-way time is estimated to be between 5 to 6 nano-seconds per foot, or an estimated 1.3 to 1.6 feet between the horizontal time lines. The electro-magnetic velocity may vary across the site, both horizontally and vertically.

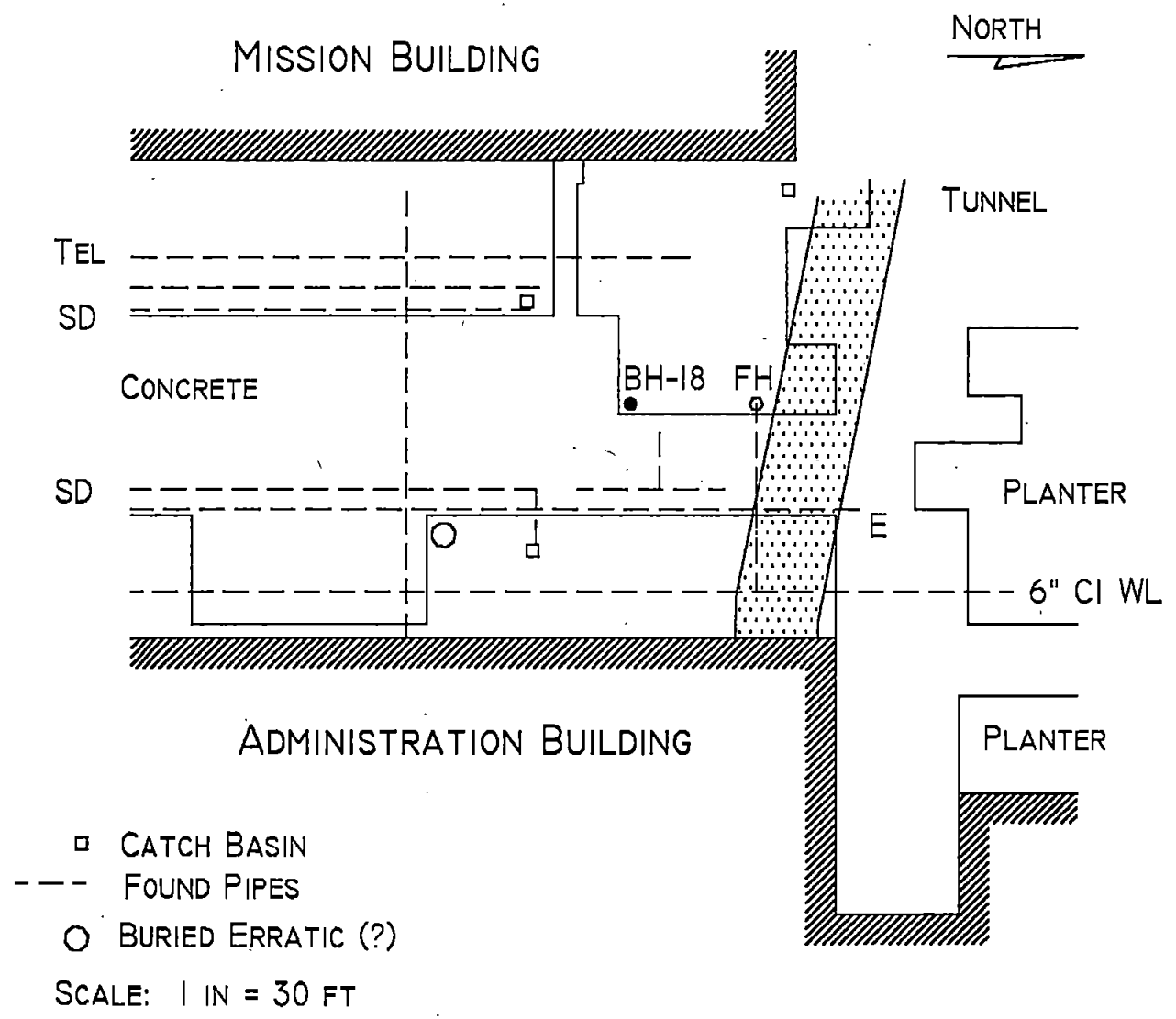
The information presented in this report is based upon geophysical measurements made by generally accepted methods and field procedures, and our interpretation of these data. The presented information is based upon our best estimate of subsurface conditions considering the geophysical results and all other information available to us. These results are interpretive in nature and are considered to be a reasonably accurate presentation of the existing conditions within the limitations of the method or methods employed.

We trust that the above is sufficient for your requirements. Please let us know if you have any questions or if we may be of further assistance.

For Geo-Recon International

John M Musser

John M Musser
Principal Geophysicist



Exploration Plan	Everett City Facilities - At Borehole 18 (July 25, 2002)

GPR Survey
J02-726/J

Geo-Recon International

FIG. 1

Appendix F

APPENDIX F

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-09644-005

Date: August 9, 2002
To: Mr. Larry Goetz
NBBJ

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland