# Draft Geotechnical Report
# Aberdeen Industrial Waterline – Phase 2
# Aberdeen, Washington

March 2002

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Submitted To:
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March 29, 2002

Mr. Tim Hume
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P.O. Box 976
Olympia, WA 98507

**RE: DRAFT GEOTECHNICAL REPORT, ABERDEEN INDUSTRIAL WATERLINE-- PHASE II, ABERDEEN, WASHINGTON**

Dear Mr. Hume:

We are pleased to submit three copies of our draft report for the referenced project. This report presents the results of our subsurface explorations and geotechnical engineering studies for the Industrial Waterline Phase II project located at Aberdeen, Washington. Please review this draft report and provide us with your comments and questions. If you have any questions, please feel free to call me at (206) 695-6806 or Martin Page at (206) 695-6875.

Sincerely,

**SHANNON & WILSON, INC.**

James A. Mattoon
Engineer

JAM/jam

Enclosure: Draft Report (3 copies)

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# DRAFT GEOTECHNICAL REPORT
# ABERDEEN INDUSTRIAL WATERLINE – PHASE 2
# ABERDEEN, WASHINGTON

## 1.0 INTRODUCTION

This report presents the results of subsurface explorations and geotechnical engineering performed for the second phase of the Aberdeen Industrial Waterline project. We understand that the project will involve replacing the existing wood-stave pipe that extends from Lake Aberdeen to the Grays Harbor Paper plant. Our scope of services included geotechnical studies for the portion of the proposed alignment located between the Hoquiam-Aberdeen boundary at 28th Street and the west bank of the Wishkah River near the confluence of the Wishkah and Chehalis Rivers. This portion of the alignment is shown on the Vicinity Map, Figure 1.

We understand that this portion of the project will involve replacing the existing pipe that extends through the Port of Grays Harbor property between 28th Street and the City of Aberdeen Wastewater Treatment Plant on Division Street and along City of Aberdeen right-of-way to the Wishkah River. This portion of the alignment connects to the existing water line, which tunnels under from the east to west banks of the Wishkah River. We estimate that the alignment is roughly 15,000 feet long, as shown on the Site and Exploration Plan, Figure 2, Sheets 1 through 4. We understand the new water line will consist of a 48-inch-diameter high-density polyethylene (HDPE), steel or ductile iron pipe typically buried with 3 to 4 feet of cover. The proposed alignment follows City of Aberdeen right-of-way to Industrial Road and Henderson Street to 28th Street. The proposed alignment crosses numerous side streets, makes several crossings of active Puget Sound and Pacific Railroad (PS&P) tracks, and crosses Industrial Road twice.

The purpose of our geotechnical studies was to evaluate subsurface conditions and formulate engineering recommendations for use in the design and construction of the proposed water pipe. Our work included drilling 12 soil borings, excavating 17 test pits, and performing laboratory tests on soil samples to evaluate subsurface conditions along the proposed pipeline route. Based on the results of field explorations, review of existing data, and laboratory tests, engineering studies were performed to develop design and construction recommendations.

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# 2.0 PROJECT DESCRIPTION

## 2.1 Site Description

The project site is located in the City of Aberdeen on the north shore of Grays Harbor at the mouth of the Chehalis River valley as shown on the Vicinity Map, Figure 1. The topography along the majority of the proposed pipeline route is relatively flat except where past filling or excavation has occurred (ground surface elevations range from 13 feet to 17 feet). The most notable grade change occurs where the pipeline route follows the northern property line of the Weyerhaeuser log yard located between the City of Aberdeen Wastewater Treatment Plant and the Port of Grays Harbor.

## 2.2 Project Description

The proposed pipeline will follow the alignment shown on the Site and Exploration Plan, Figure 2. It is anticipated that the depth of trench excavations will range from 10 to 12 feet. We assume that the installation and undercrossings will be performed by conventional cut-and-cover methods. Because of right-of-way issues, the alignment is separated into two general segments.

The port segment is approximately 8,500 feet of pipe alignment beginning at the intersection of Henderson and 28th Streets to the intersection of Division and Heron Streets, as shown on Figure 2, Sheets 1 and 2. The proposed pipe alignment is in close proximity to utilities between 28th Street and Commerce Street. This segment of the proposed pipe alignment crosses numerous side streets, crosses Industrial Road twice, and makes four railroad track crossings.

The downtown segment is approximately 6,500 feet of pipe alignment between the intersection of Division and Heron Streets and the Wishkah River, as shown on Figure 2, Sheets 3 and 4. The proposed pipe alignment is not only near railroad tracks between Division Street and M Street, but also near utilities between H Street and F Street. There will be several street crossings and two railroad track crossings near Alder Street and Broadway Street.

# 3.0 SUBSURFACE EXPLORATIONS

To characterize subsurface conditions, 17 test pits were excavated and sampled and 12 soil borings were drilled and sampled along the proposed alignment at the approximate locations shown on the Site and Exploration Plan, Figure 2, Sheets 1 to 4. The test pits and soil borings were located along the portions of the proposed alignment accessible to a backhoe and a

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truck-mounted drill rig. The following sections present details of the subsurface exploration program.

### 3.1 Test Pits

The test pits, designated TP-1 through TP-17, were excavated on February 12 and March 1, 2002. The City of Aberdeen Water Department excavated the test pits using a rubber-tired backhoe. The test pits were excavated to depths of 9 to 11 feet as conditions allowed and were observed by an engineer from our firm. Our representative visually identified the exposed soils, estimated their relative density, obtained representative soil samples, and compiled a log of each exploration. The relative densities of the exposed soils were estimated based on probing the sides and bottoms of the pits with a ½-inch-diameter steel bar and by evaluating the ease or difficulty of the excavation.

Several test pits (TP-11, TP-12, TP-13, and TP-16) encountered logs, wood debris, or other obstructions through which the backhoe was unable to excavate readily. Standing water and soft organic material was observed in many test pits. Several test pits experienced caving due to the presence of groundwater and loose granular soils.

Representative soil samples were collected in jars and bags and returned to our laboratory for testing. A description of the methods and procedures used for locating, excavating, and sampling the test pits is included in Appendix A, Subsurface Explorations. The logs of the test pits are also included in Appendix A as Figures A-2 through A-18. A key to the classification terms used in the test pit logs is presented as Figure A-1.

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### 3.2 Soil Borings

To evaluate the subsurface conditions and develop parameters for our engineering studies twelve soil borings, designated B-1 through B-12, were drilled on February 14 and 15, 2002, and from February 26 to 28, 2002. The logs for the soil borings are presented as Figures A-19 through A-30 in Appendix A. The Unified Soil Classification System (USCS), as well as terminology developed by our firm, was used to classify the soils encountered in the soil borings. A key to the symbols and terms used on our boring logs is presented on Figure A-1.

Geotechnical Testing Laboratory, of Olympia, Washington, drilled the soil borings B-1 through B-8, under subcontract to Shannon & Wilson, Inc. using a truck-mounted drill rig and hollow-stem auger drilling methods. The soil borings were advanced to a depth of 20 feet.

An engineer from Shannon & Wilson, Inc. was present throughout the drilling and sampling operations for the borings. Our engineer retrieved soil samples and prepared a descriptive field log of the explorations. Soil samples were obtained at 2.5-foot intervals. A brief description of the field methods and procedures used during drilling and sampling the borings are included in Appendix A in which the logs of the explorations are presented.

### 3.3 Previous Explorations

Previous soil borings completed along the north edge of the Weyerhaeuser property were also used in our analyses of subsurface conditions. Geo-Engineers, Inc. performed these borings in October 1989. The approximately locations of these previous borings are shown on the Site and Exploration Plan, Figure 2, Sheet 2. These two soil borings, designated GE-89-1 and GE-89-9, were drilled to depths of 16.5 and 114 feet, respectively. Logs of the previous borings are included and presented as Figures A-31 and A-32 in Appendix A.

### 3.4 Potential Contamination

During the excavation of test pit TP-4, field screening was performed to evaluate the potential for hydrocarbon contamination. Field screening techniques included using a photoionization detector (PID) to measure total volatile organic hydrocarbons, visual observation (for evidence of staining) and odor. A PID reading of samples designated S-3 and S-4 indicated that volatile organic hydrocarbons were present in significant amounts. The excavated material of test pit TP-4 had a noticeable odor. Groundwater seepage collecting at the bottom of the excavation developed a surface sheen. Port of Grays Harbor employees temporarily covered the excavated material with plastic sheeting until chemical analyses were completed.

For characterizational purposes, two samples, designated TP-4-S-3 and TP-4-S-4, suspected of contamination based on field screening results, were collected at depths of 3 and 3.8 feet using disposable equipment and immediately placed into laboratory-supplied glassware and stored in a cooler. The samples were transported under proper chain-of-custody procedures to On-Site Environmental, Inc. (OSE), of Redmond, Washington, for chemical analysis. A brief discussion of the analytical results is provided in Section 6.2 and presented in the Table 1. A copy of the laboratory analytical report has been provided in Appendix D.

All of the laboratory analytical work was done in accordance with OSE's in-house Quality Assurance/Quality Control Plan. Sample analyses were performed in compliance with Ecology

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guidelines and in accordance with method requirements. No factors appeared to adversely affect data quality.

### 3.5 Groundwater Monitoring

Groundwater monitoring wells were installed in all soil borings. The monitoring wells consist of slotted and blank sections of 2-inch-diameter polyvinyl chloride (PVC) pipe. The slotted portion was installed between depths of 10 and 20 feet. The annulus surrounding the PVC pipe was backfilled with a sand filter to approximately 1-foot above the top of the slotted portion. Bentonite chips were used to fill the annulus and to seal the boring from the base of the hole to the bottom of the sand filter and from the top of the sand filter to approximately 2 feet below grade. The top 2 feet of the boring was backfilled with concrete. To protect the monitoring well from damage and vandalism, a flush-mounted (flush with the ground surface) steel monument was concreted in place over the top of the well.

### 3.6 Laboratory Testing

Laboratory tests were performed on samples retrieved from the test pits and soil borings to determine basic index and engineering properties of the soils encountered along the project alignment. All geotechnical laboratory testing was performed in the Shannon & Wilson, Inc. laboratory in Seattle, Washington. The testing program included visual classifications, water content determinations, Atterberg limits determinations, and grain-size analysis. All laboratory testing was performed in general accordance with the American Society for Testing and Materials (ASTM) standard test procedures. A brief description of the test procedures is included in Appendix B.

Laboratory testing along both segments of the alignment consisted of natural moisture content determinations on all samples from the test pits and soil borings, Atterberg limits on ten representative samples, and grain-size analysis on six representative samples. The results of the moisture content tests and Atterberg limits determinations are shown on the individual logs of the test pits and soil borings in Appendix A. Atterberg limits determinations are also presented graphically for the port and downtown segments on Figures B-1 and B-2, respectively. The results of the grain-size analysis are presented graphically for the port and downtown segments on Figures B-3 and B-4, respectively.

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# 4.0 GEOLOGY

The project alignment is located near the confluence of the Chehalis River and Grays Harbor, in what used to be active tidal flats and marine estuary of Grays Harbor. Originally, the project alignment and surrounding area consisted of shallow marshes. These areas have been improved over the years by filling to form the present onshore areas. In general, natural soil conditions consist of very soft and loose fine-grained, estuarine and alluvial sediments overlying stiff silts and medium dense to dense sands and gravels at depths of approximately 50 feet.

Portions of the estuary area were filled to approximate existing ground surface with soils excavated from the upland slopes and dredged alluvial deposits within and around the Aberdeen area. The majority of these materials were hydraulically placed and, therefore, have relatively high moisture contents, low strengths, high compressibilities, and high potential for liquefaction during a design earthquake. As a result of the different placement methods and the different source areas, the fill consists of variable soil types, which can have very different engineering properties from one location to the next.

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# 5.0 SUBSURFACE CONDITIONS

The results of our subsurface explorations and previous explorations performed by others indicate the general subsurface conditions along the pipe alignment consist of variable thicknesses of fill material overlying alluvial deposits.

## 5.1 The Port Segment

The first segment of the alignment is approximately 8,500 feet long and extends from 28th Street along Henderson Street and Industrial Road approximately follows the existing wood-stave pipe to the junction of Division and Heron Streets. The pipe alignment is shown on sheets 1 and 2 of the Site and Exploration Plan. Subsurface explorations along this segment consisted of test pits TP-1 through TP-11 and soil borings B-1 through B-4. In general, the soils that are likely to be encountered during pipeline installation consist of loose fill materials underlain by soft clayey silt (tidal mudflats). The fill material consists of quarry spalls, sand and gravel, wood debris, and dredged alluvial deposits. The fill material is variable across this portion of the alignment and may contain obstructions such as large tree stumps and logs.

### 5.1.1 Henderson Street

Test pits TP-1 and TP-2 and boring B-1 were excavated and drilled, respectively, on the north side of Henderson Street. Along this portion of the pipe alignment subsurface explorations encountered loose gravelly sand fill material, approximately 5 feet deep, overlying soft organic silt. Dredged fill material was not encountered along this portion of the pipe alignment. Abandoned steel pipes were encountered in test pit TP-1. Test pit TP-2 and boring B-1 were relocated so steel pipes were not encountered. Soils encountered in test pit TP-2 and boring B-1 were similar to backfill materials exposed in test pit TP-1, as shown on the test pit logs, Figures A-2, A-3, and A-19. Based on the results of these explorations and our review of utility drawings provided by the Port of Grays Harbor, it appears likely that the steel pipelines are present along the north side of Henderson Street and may be encountered during the installation of the industrial water pipeline. Minor to heavy groundwater seepage was encountered in both test pits.

### 5.1.2 North Side of Industrial Road

Test pits TP-3 through TP-8 and borings B-2 and B-3 were excavated and drilled, respectively, on the north side of Industrial Road. Very loose dredged fill material was encountered from approximately 2 to 10 feet in all of the above mentioned explorations with the exception of TP-3. The dredged fill material experienced moderate to rapid caving in test pits TP-5, TP-6, and TP-8, as shown on the test pit logs, Figures A-6, A-7, and A-9. Flowing water that caused caving within the dredged fill layer and transported coarse gravel was observed in test pits TP-4 and TP-7. This anomaly was possibly due to the presence of water under hydrostatic pressure in an adjacent utility backfill. Both test pits filled rapidly with water to approximately 4.5 feet below ground surface.

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### 5.1.3 South Side of Industrial Road

Test pits TP-9 through TP-11 and boring B-4 were excavated and drilled, respectively, on the south side of Industrial Road. Along this portion of the pipe alignment subsurface explorations encountered loose to medium dense gravelly sand fill material, approximately 3 to 4 feet deep, overlying medium stiff to very soft organic silt. Dredged fill material was not encountered along this portion of the pipe alignment segment. A log obstruction was encountered in test pits TP-10 and TP-11, as shown on the test pit logs, Figures A-11 and A-12. Based on the results of these subsurface explorations, it appears likely that large wood debris is

present beneath the ground surface in the vicinity of the pipe alignment. Minor to moderate groundwater seepage was encountered in the test pits.

### 5.1.4 North of Weyerhaeuser Property

Borings GE-89-1 and GE-89-9 were previously drilled along the terminal rail facilities north of the Weyerhaeuser property. Along this portion of the proposed pipe alignment subsurface explorations encountered loose sand fill material, approximately 1 to 2 feet deep, overlying medium stiff to loose or soft silty sand or sandy silt. Dredged fill material was encountered along this portion of the pipe alignment segment, as shown on the boring log GE-89-9, Figure A-32.

## 5.2 The Downtown Segment

The second 6,500 feet of the pipeline route extends from Division Street to the west bank of the Wishkah River. The pipe alignment is shown on sheets 3 and 4 of the Site and Exploration Plan. Subsurface explorations along this segment consisted of test pits TP-12 through TP-17 and soil borings B-5 through B-12. In general, the soils that are likely to be encountered during pipeline installation consist of loose fill materials underlain by soft clayey silt (tidal mudflats). The fill material consists of quarry spalls, sand and gravel, wood debris, and dredged alluvial deposits. The fill material is variable across this portion of the alignment and may contain obstructions such as large tree stumps, logs, and stacked railroad ties.

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### 5.2.1 Division Street to Alder Street

Test pit TP-12 and borings B-5 through B-8 were excavated and drilled, respectively, within the City of Aberdeen right-of-way between Division and Alder Streets. Along this portion of the pipe alignment, subsurface explorations encountered loose to very loose, gravelly sand fill material, approximately 2 to 6 feet thick, overlying very soft to soft organic silt. Dredged fill material was not encountered along this portion of the pipe alignment segment. A log obstruction was encountered in test pit TP-12, as shown on the test pit log, Figure A-13. Moderate groundwater seepage was encountered in the test pit.

### 5.2.2 Alder Street to Broadway Street

Test pits TP-13 through TP-15 and borings B-9 and B-10 were excavated and drilled, respectively, within the City of Aberdeen right-of-way between Alder and Broadway Streets. Along this portion of the pipe alignment subsurface explorations encountered loose, gravelly

sand fill material, approximately 1 to 2 feet thick, overlying loose/soft dredged fill material, approximately 2 to 3 feet thick, overlying very soft to soft organic silt. A log obstruction was encountered in test pits TP-13 and TP-15, as shown on the test pit logs, Figures A-14 and A-16. Boring B-10 drilled through wood debris that approximately ranged in depth from 1.5 to 3.5 feet, as shown on the boring log, Figure A-28. Moderate to heavy groundwater seepage was encountered in the test pits with the exception of test pit TP-15.

#### 5.2.3 Broadway Street to Wishkah River

Test pits TP-16 and TP-17 and borings B-11 and B-12 were excavated and drilled, respectively, within the City of Aberdeen right-of-way between Broadway Street and the Wishkah River. Along this portion of the proposed pipe alignment, subsurface explorations encountered loose, gravelly sand fill material, approximately 3 to 7 feet thick, overlying soft to very soft organic silt. Dredged fill material was not encountered along this portion of the pipe alignment segment. A stacked railroad tie obstruction was encountered in test pit TP-16, as shown on the test pit log, Figure A-17. Minor to heavy groundwater seepage was encountered in the test pits.

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### 5.3 Groundwater

Groundwater or wet soil was encountered at depths ranging from approximately 3 to 10 feet below the existing ground surface during subsurface explorations. The water levels in observation wells along the port and downtown segments were measured on March 19 and 20, 2002. These water levels ranged in depths of 0.5 to 5.9 feet as indicated on boring logs B-1 through B-12 (Figures A-19 through A-30). The water level in Grays Harbor fluctuates about ten feet with the tides. We expect some of these groundwater levels may fluctuate with the changes in tides and with seasonal variations in precipitation.

## 6.0 ENGINEERING STUDIES AND RECOMMENDATIONS

### 6.1 General

Based on the results of our subsurface explorations, laboratory tests, and geotechnical engineering analyses, recommendations were developed to assist in the design and construction of the proposed pipeline. In the event that soil conditions encountered during construction are significantly different from those encountered in the test pits and soil borings, we should be consulted to provide appropriate design parameters or construction recommendations for the

differing conditions. The subsequent sections of this report provide recommendations for conventional trench excavation, temporary shoring, soil contamination mitigation, dewatering, pipe bedding, and backfill.

## 6.2 Contamination Mitigation

During excavation and sampling at test pit TP-4 along Industrial Road, a hydrocarbon odor was noted in soil between 1.5 to 4 feet below ground surface (bgs). Based on the field screening results, two samples were collected and initially analyzed for petroleum hydrocarbons by the Northwest Total Petroleum Hydrocarbon—Hydrocarbon Identification method (NWTPH-HCID). No diesel- or oil-range petroleum hydrocarbons were detected in either of the two samples. Gasoline-range hydrocarbons were detected in one of the two samples (TP-4-S-4) at 26 milligrams per kilogram (mg/kg), which is below the Washington Department of Ecology (Ecology) Model Toxic Control Act (MTCA) Method A cleanup level for industrial sites of 100 mg/kg. Based on the presence of gasoline-range hydrocarbons in one of the two samples, both samples were also analyzed for lighter volatile organic compounds (VOCs) by Environmental Protection Agency method SW8260B. Low concentrations of several VOCs were detected in both samples, as shown in Table 1. For comparison purposes, Table 1 also includes the MTCA Method A industrial cleanup criterion for each detected VOC, where available. As shown in Table 1, similar types of VOCs were detected in both soil samples at concentrations below the available regulatory cleanup criterion established by Ecology. Thus, no further characterizational or remedial actions were performed at the test pit.

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While the samples of the backfill did not contain gasoline-range hydrocarbons above current cleanup standards, it is possible that other fill soils within this segment of the pipe alignment contain higher concentrations of petroleum, depending on the amount of fuel released. A contingency fund should be planned in the event that excavated soils require special treatment or off-site disposal.

**TABLE 1**
**CONTAMINATION ANALYTICAL RESULTS**

| Detected Analyte | Sample TP-4 S-3 (mg/kg) | Sample TP-4 S-4 (mg/kg) | MTCA Method A Industrial Soils Cleanup Level (mg/kg) |
|---|---|---|---|
| Diesel-range hydrocarbons | ND | ND | 2,000 |
| Oil-range hydrocarbons | ND | ND | 2,000 |
| Gasoline-range hydrocarbons | ND | 26 | 100 |
| Acetone | 0.064 | ND | NA |
| 2-Butanone | 0.016 | ND | NA |
| Toluene | 0.002 | 0.0029 | 7 |
| Ethylbenzene | 0.006 | 0.051 | 6 |
| m,p-Xylene | 0.0098 | 0.034 | 9 |
| o-Xylene | 0.0064 | 0.052 | 9 |
| Isopropylbenzene | 0.022 | 0.12 | NA |
| n-Propylbenzene | 0.023 | 0.2 | NA |
| 1,3,5-Trimethylbenzene | 0.012 | 0.18 | NA |
| 1,2,4-Trimethylbenzene | 0.048 | 0.42 | NA |
| sec-Butylbenzene | 0.019 | 0.14 | NA |
| p-Isopropylbenzene | 0.032 | 0.28 | NA |
| Naphthalene | 0.01 | ND | 5 |

Notes:
Cleanup levels shown are based on MTCA Level A cleanup for industrial/commercial sites and are for comparison only.
MTCA = Model Toxics Control Act
mg/kg = milligrams per kilogram
NA = not available
ND = not detected above the method detection limit
Only the detected analytes and their respective concentrations are presented in this table.

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### 6.3.1 General

Because the Downtown and Port segments of the proposed pipe alignment are in developed areas, we understand that trench excavation is required. Based on the information provided by Economic and Engineering Services, Inc., it is anticipated that the depth of trench excavation will range from 10 to 12 feet. The excavations should encounter soils ranging from sandy, gravelly fill, very loose to loose, sand and fine sandy silt, and very soft to soft, clayey silt

to silty clay. The main geotechnical issues for trenching are shoring, caving, groundwater control, soft subgrade material, adjacent utilities and structures, bedding and backfill, and crossings.

### 6.3.2 Trench Excavations

Based on the planned excavation depths, anticipated subsurface conditions and space limitations such as utilities, roadways, and railways along the pipe alignment, we expect that the majority of the excavations would be made using shoring to maintain vertical trench walls. In areas where there are no space limitations adjacent to the proposed pipe alignment we expect that excavations could be made using sloping sidewalls with trench boxes.

In general, our test pit excavations, with the exception of several along Industrial Road, did not experience excessive caving during the short period (30 minutes) that they were open. This is due primarily to the cohesive nature of the soils along the pipe alignment. Temporary trench side slopes ranging from 0.5 horizontal to 1 Vertical (0.5H:1V) would likely be suitable for short-term (half-day) excavations where no personnel enter the trench. Where personnel must enter the trench we recommend a minimum 1H:1V side slope or a moveable trench shoring system ("trench box"). Where caving soils and groundwater seepage are encountered, excavations may require side slopes of 1.5H:1V, or flatter, to maintain stability in the trench. If excavations are in areas were there are space limitations and/or excessive caving and groundwater seepage is encountered, shoring would be required to maintain vertical trench walls.

It is anticipated that the fill and native soils observed in the explorations can be excavated using conventional excavating equipment such as rubber-tire backhoes or tracked hydraulic excavators. The Contractor should anticipate encountering in his excavations large logs and wood debris, which will need to be removed completely from the pipe-bedding zone. Such debris should not be left in place below the pipe invert or within the sidewalls of the trench if it is closer than 2 feet from the sides of the pipe. The contractor should select excavation equipment large enough to pull out or break off logs on the order of 18 to 36 inches in diameter. Some timbers and logs will require cutting to avoid disturbance of soils outside the trench lines. Additionally, a significant amount of buried asphalt was encountered along the downtown segment. Asphalt saw cutting equipment could be necessary to make trench excavations through this area.

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In order to reduce disturbance of the subgrade soils, it is recommended that at least the last foot of excavation in all trenches be accomplished with an excavating bucket that has a flat plate over the teeth. When large logs, wood debris, rocks or other hard materials are encountered at the pipe invert elevation the objects should be removed and the excavation should be over-excavated by at least 12 inches below the invert elevation. The overexcavated zone should be backfilled with firmly tamped (compacted) structural fill, as discussed in Section 6.5, followed by bedding material. Additional bedding and backfilling details are shown on the Recommended Typical Trench Section Excavating in Dry, Figure 4.

Trench widths should be wide enough to allow for safe worker access and satisfactory compaction of backfill materials. The trench widths should also conform to the pipe manufacturer's recommendations. Typically, this width would be equal to two pipe diameters.

### 6.3.3 Trench Shoring

In some areas of the alignment such as adjacent to active railroad tracks, buried sensitive utilities, telephone/power poles and existing foundations, subsurface conditions and site limitations are such that open excavations will not be possible. Deep excavations that will remain open for extended periods should be shored to minimize the excavated and disturbed area and to prevent damage to adjacent utilities. Construction practice in this area generally utilizes either a trench box with steel sheets, or a braced, shored excavation. For relatively shallow excavations (e.g., 10 feet) a trench box is likely the most economical shoring system; however, because loose or soft soils are expected, deeper shoring systems may be necessary.

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Because the groundwater level is high in the project area, improperly shored and dewatered excavations can experience caving, bottom heave and significant settlement of adjacent ground surfaces. We recommend that interlocking steel sheet shoring or soldier-piles with steel plate lagging be used to shore excavations along Industrial Road, along PS&P railroad and the east end of River Street with nearby utilities. Dewatering with either of these shoring systems will be necessary. The selected shoring system should provide adequate protection of workers, as well as protection against damage of the adjacent buildings, utilities, streets, railroad tracks, and other facilities. The design of the actual temporary shoring system and the method of construction should be made the responsibility of the Contractor. Design of dewatering systems should be made by the Contractor on a case-by-case basis. We also recommend the Contractor be made responsible for monitoring the stability of shored excavations and taking corrective measures if any deficiencies or potentially dangerous conditions are found.

Horizontal strutting may not be permitted near the bottom of some excavations. Consequently, all sheet piles, soldier piles, and lagging should have adequate toe penetrations to withstand the excavation wall loading without lateral movements and disturbance of the supporting soils. The removal of any excavation supports should be accomplished so as to avoid creating voids below the bottom of the excavation. During the removal of excavation supports, care should be taken to reduce settlement of the pipe and backfill.

It should be understood that a "standard" trench box does not usually provide adequate support of the trench excavation slope, but instead only provides safety for workers in the trench. Because the trench box typically is placed after excavation, a significant amount of soil deformation commonly takes place along side the excavation limits. Ground movements can be severe, especially in the presence of groundwater. The Contractor should be held responsible for all damages related to ground movements. Trench boxes can be modified and fitted with driveable, watertight walls which may be driven below the bottom of the trench excavation in a similar manner as a standard sheet pile wall. Trench boxes can also be placed by excavation of the soil from within the box coupled with pushing down on the box, or allowing the box to sink under gravity as the soil is excavated from beneath. If the Contractor proposes trench boxes, it would be advisable to require the Contractor to attempt a test section using his proposed equipment and methods. The test section should be performed in an area representative of the worst soil and groundwater conditions anticipated in the area where trench boxes are proposed. Such a test section should be done prior to final acceptance of Contractor's proposed methods; the test section could be used for production if acceptable to the engineer.

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### 6.3.4 Lateral Pressures for Shoring Design

Lateral Pressures for cantilevered shoring design can be estimated assuming an equivalent fluid density of 40 pounds per cubic foot (pcf) acting against the steel lagging or sheet pile. For trench box and internally braced shoring design, the earth pressure diagram presented on Figure 3, Earth Pressures for Temporary Braced Shoring With Hydrostatic Pressure, should be used. Pressures presented in Figure 3 include hydrostatic pressure and are based on the assumption that dewatering will not significantly lower the groundwater level outside the shored excavation.

## 6.4 Dewatering Considerations

Based on our explorations, we anticipate that dewatering will be required along the proposed pipe alignment. We expect that it may be possible to control the water with sump pumps installed in the bottom of the trench along the downtown segment and portions of the port segment. Due to the granular dredged material encountered along the north side of Industrial Road, it is our opinion that sump pumps alone may not be adequate to control groundwater inflows and maintain the water level below the pipe invert elevation. It is likely that wells and/or well points will be required to adequately dewater the trench excavations along Industrial Road.

Excavations for sumps should be filled with gravel or crushed rock to reduce the amount of fines carried in the pumped water. Temporary storage in a settlement tank or basin may be required if the turbidity levels of pumped water exceed the levels established for disposal. The contractor should be prepared for significant groundwater seepage rates in areas where heavy seepage was noted in the test pit excavations. If sump pumps are not sufficient to control the water levels in the trench, other dewatering methods should be used possibly in conjunction with tight shoring such as sheetpiles. We recommend that the excavation be completely dewatered and the water level lowered to at least 2 feet below pipeline invert elevation prior to placing the pipe and bedding materials.

If water is observed coming up through the bottom of the trench excavation, or if the bottoms of the trench become soft from upwardly migrating water, immediate action is required. This action may include additional drainage measures such as sump pumps and dewatering wells within or outside the trench shoring.

The Contractor should be made responsible for controlling all surface and groundwater whenever encountered. In this regard, the Contractor should be prepared to employ ditching, sumps, trench drains, dewatering wells, well points, and any other measures as necessary to permit proper completion of work. Groundwater control will be a significant construction issue and we recommend that the Contractor employ experienced dewatering subcontractors to assist him in design and construction of trench dewatering systems.

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## 6.5 Ground Settlements Due to Trench Construction

### 6.5.1 General

It is anticipated that trench excavations for the installation of the 48-inch-diameter industrial water pipe will cause the adjacent ground surface to experience some settlements. The settlements will be induced by construction activities related to dewatering operations, trench-support installation and removal, and excavation. The magnitude of these settlements will depend upon a large number of factors including the quality of construction activities and the nature of the subsurface conditions. It should be noted that excavation- and vibration-induced ground movements cannot be evaluated to any significant degree of accuracy because the physical properties and mechanical response of the ground are difficult to predict, and the different construction procedures that the Contractor will employ are not known at this time. As a result, the settlement estimates provided represent our estimated upper and lower limits of the range of potential movements that could occur along the project alignment and should be considered for planning purposes only.

The following sections include settlement estimates due to shoring installation and removal and trench excavation.

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### 6.5.2 Settlements Due to Shoring Installation

The installation and removal of steel sheet piles, soldier piles, and lagging could cause undesirable settlements in the vicinity of the trench excavation, especially if a vibratory hammer is used for installation and removal. In general, the magnitude of the settlements will depend primarily upon the relative density of the sandy silt or silty sand and the intensity of the vibration resulting from the driving and extracting operations. It is recommended that the Contractor experiment with the hammer selected to evaluate its influence on adjacent ground settlements. If undesirable settlements occur, another type of hammer with less impact on ground settlement should be used. In our opinion, any settlements greater than 0.25-inch at existing structure locations and greater than 0.50-inch at adjacent paved areas may be considered undesirable. The sensitivity or tolerance to settlement of any particular buried utility adjacent to the excavation should be evaluated on a case-by-case basis. Structures located more than 15 to 25 feet away from the shoring operation would be less susceptible to vibration-induced settlements.

Depending on the excavation support installation and removal methods employed by the Contractor, the total estimated ground surface settlements experienced during installation could

vary between 1 to 6 inches adjacent to the excavations and decrease to 0.25 to 1-inch at a distance of about 20 feet from the excavations. These ranges were based on our experience and observations for typical excavations in very loose to loose sands and very soft to soft clay and silt. Table 2 presents estimated ground surface settlements resulting from shoring installation, trench excavation, and shoring removal for 15-foot-deep excavations.

**TABLE 2**
**STIMATED SETTLEMENTS FOR SHALLOW EXCAVATION IN ALLUVIAL DEPOSITS**

| Distance from Edge of Excavation (feet) | Estimated Settlement (inches) |
|---|---|
| 5 to 10 | 3/4 to 4 |
| 10 to 20 | 1/2 to 2 |
| 20 to 30 | 1/4 to 1 |
| 30 to 60 | 0 to 1/2 |
| beyond 60 | < 1/4 |

Note: The large settlements indicated above are based on severe ground conditions (very loose/soft soils) with the lower bound values being our estimate for average to good soil conditions (medium dense/stiff soils) and prudent construction practice.

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The above estimated settlements include settlements that would result from densification of the sandy soils during shoring installation and removal (vibration) and lateral shoring movements that would occur during trench excavation. These settlements during trench excavation can be reduced by quality workmanship and constructing a stiff shoring system with internal bracing. Settlements resulting from use of a sheet pile or soldier pile with sheet lagging system will be considerably smaller than adjacent ground settlements that will result from use of a trench box shoring system. Where adjacent ground settlements must be reduced we recommend that trench box shoring systems not be used.

### 6.5.3 Impact on Pavements/Railroad/Adjacent Utilities

Along the proposed pipe alignment, most existing buildings and other structures are located greater than 20 feet away from the anticipated trench location. Therefore, settlement-related impacts on those facilities should be minimal. The proposed pipe alignment will, however, extend parallel to and cross below numerous existing buried utilities, pavements, and railroad tracks. To protect the existing utilities, pavements, and tracks it may be necessary to use a shoring system that minimizes adjacent ground settlements. This would require use of interlocking sheet pile or a soldier pile with lagging system, as described previously. Such

trench shoring systems should be designed by a licensed engineer experienced with soft-ground shoring systems.

## 6.6 Pipe Subgrade Preparation

### 6.6.1 Pipe Subgrade, Bedding, and Initial Backfill

The majority of the proposed pipeline route will involve below-grade bearing of the pipe with 3- to 4-foot of soil cover. The following recommendations are applicable to those portions of the proposed pipeline where below grade flexible or rigid pipe installation occurs.

For conventional pipe installation, i.e. pipe that is not pile supported, disturbance of subgrade soils at the bottom of the trench excavation due to construction equipment and activities will affect support of the proposed pipe. It is anticipated that much of the soil exposed at the trench bottom will be moisture sensitive and easily disturbed. The Contractor should take all necessary steps to protect the subgrade from becoming disturbed. Proper shoring and dewatering is key to this goal. We recommend that an experienced geotechnical engineer be retained to observe and evaluate the Contractor's excavation activities to confirm that they are in compliance with the project specifications. Due to the sensitive nature of the soils and the potential presence of unsuitable subgrade materials, additional soil excavation and fill placement below the pipe invert is recommended, as discussed in the following paragraphs.

The recommended typical trench section for bedding and backfilling conventional pipelines in the dry are shown on Figure 4. Based on the soils encountered in the test pit and boring explorations, we recommend that at least 1-foot be overexcavated and replaced prior to placing the bedding material. Where very soft silty clay or clayey silt is encountered at or below the pipe invert we recommend that 1 to 2 feet of overexcavation be accomplished. Excavation below bedding should be backfilled with foundation stabilization materials (ballast) consisting of hard, durable, and sound crushed rock conforming to the gradation requirements of Washington State Department of Transportation/American Public Works Association (WSDOT/APWA) 9-03.17. This ballast rock should be lightly tamped with a backhoe bucket to reduce disturbance of the underlying soils. Prior to placing the ballast, a geotextile separator should be placed directly over the exposed subgrade soils to prevent the fine-grained native soils from mixing with and degrading the imported material. The geotextile separator should consist of a woven slit-film material with a minimum grab tensile strength (ASTM D4632) of 160 pounds and a minimum puncture resistance (ASTM D4833) of 50 pounds. If the trench bottom after

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overexcavation is unstable, 3- to 8-inch-diameter quarry spalls should be pushed into the bottom of the excavation to form a stable-working surface. Geotextile separator should be placed below the quarry spalls to further assist in stabilizing the bottom. Complete dewatering of the trench bottom should be accomplished prior to placing geotextile and ballast rock.

Bedding material for flexible pipe (HDPE) should be clean, granular materials meeting the gradation requirements specified in Section 9-03.16 of the 2000 WSDOT/APWA Standard Specifications or Class I or II of ASTM D2321. Bedding material for rigid pipe (ductile iron or steel) should be clean, granular materials meeting the gradation requirements specified in Section 9-03.15 of the 2000 WSDOT/APWA Standard Specifications. Bedding should be at least 4 inches thick below the invert of the pipe and extend up the haunches of the pipe to the 120-degree arc line of the pipe (a height above the invert equal to 0.25 times the outside diameter). Initial backfill material should meet the gradation requirements for granular bedding material. The bedding and initial backfill materials should be placed in loose lifts of 4 to 6 inches and carefully worked under and around the pipe by means of shoveling, vibration, trench tamping equipment, or other approved procedures. The bedding and initial backfill should be compacted to at least 92 percent of its maximum dry density [as determined by ASTM test designation: D 1557]. Heavy mechanical compaction equipment should not be used over the pipe until the bedding material and initial backfill are at least 1 foot above the crown of the pipe.

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### 6.6.2 Subsequent Backfill and Compaction

Sand and silty sand from the trench excavation may be used as subsequent trench backfill above the initial backfill for conventional pipe installations provided the moisture content of the material is suitable to allow for proper compaction. Based on the results of our test pits and soil borings, we expect that about 10 to 15 percent of the excavated soils along the pipeline alignment will consist of sand, silty sand, or sandy gravel that will be suitable for use as trench subsequent backfill; however, careful segregation and stockpiling of excavated soils would be necessary to re-use on-site soils. The majority of the soils encountered in the explorations consisted of silt or clay with numerous organics and debris. These soils are not suitable for use as trench backfill. The majority of trench backfill, beginning 1 foot above the top of the pipe should consist of imported sand and gravel to reduce future settlement of the backfilled areas. Imported backfill should consist of material meeting the requirements of Gravel Borrow (WSDOT/APWA 9-03.14(1)) or an approved substitution. Backfill under paved roadways may also be required to meet the requirements of the local jurisdiction, such as Grays Harbor County

Public Works. Pavement sections meeting the property owner's specifications should be provided in the project documents.

We recommend that subsequent backfill be placed and compacted in lifts with a maximum loose thickness of 10 inches. Trench backfill should be compacted to a dense and unyielding condition, and to at least 90 percent of the maximum dry density as determined by ASTM Designation: D 1557 (Modified Proctor) in nonstructural areas where post-construction settlements are tolerable. Backfill in areas underlying future pavements or other structures where settlements are not desirable should be compacted to at least 95 percent.

## 6.7 Loading on Pipes Under Streets and PS&P Railroad

The structural design of the pipe should consider the dead and live load acting on the pipe in addition to the earth loading. The dead load will include primarily the overburden pressure above the crown of the pipe. Since the soil cover would be on the order of 3 to 4 feet, full overburden pressure should be used. We recommend that a total soil unit weight of 125 pcf be used to calculate the overburden pressure. The estimated vertical soil loads on flexible and rigid 48-inch-diameter pipes are shown on Figure 6. The live loads will consist of train loading (E-70) beneath the railroad tracks and truck loading (MS-20) beneath pavements. The pipe depth beneath these structures should be determined based on the anticipated vehicle loading and the strength of the HDPE, ductile iron, or steel pipe. The railroad crossings will require the use of steel pipe casing, since HDPE does not meet railroad requirements. The pipe manufacturer should provide design specifications for minimum thickness of cover and/or other mitigation measures, such as casing, based on the strength of pipe supplied, the estimated vehicle loading and the tolerance for settlement of the pipe and cover material.

The industrial water pipeline alignment requires undercrossing of several active tracks and numerous streets. In general, we recommend an open-cut trench installation at these locations due to the high probability of encountering subsurface wood debris and groundwater.

## 6.8 Seismic Considerations

### 6.8.1 General Earthquake Hazards

Earthquake-induced hazards that may potentially affect a buried pipeline at a given site include:

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- Fault-induced ground rupture
- Liquefaction
- Lateral spreading
- Landslides
- Seismic strain and rupture

Historically ground rupture associated with faulting has been one of the major factors affecting the integrity of underground and surface structures in seismically active areas. Because there are no mapped faults in the vicinity of the proposed pipeline alignment, and because bedrock underlying the site is mantled by several hundred feet of sediment, it is unlikely that any potential faulting in the bedrock would result in rupture at the elevation of the pipeline or the ground surface. Therefore, surface rupture from fault movement is not perceived to be a design issue for this project.

Liquefaction is a phenomenon in which loose deposits of relatively clean sand existing below the water table experience a loss of internal shear strength during an earthquake and essentially became fluid-like. The potential for liquefaction along the project alignment during a strong-motion earthquake varies from low to moderate because of the presence of a high ground water table and discontinuous layers of relatively loose, cohesionless soils as well as soft cohesive soils. Therefore, liquefaction is the primary seismically induced geologic hazard that we believe might affect this project during the design-level earthquake.

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### 6.8.2 Liquefaction Hazard Assessment

The project is located in a moderately active seismic region. While the region has historically experienced moderate to large earthquakes (i.e., April 13, 1949, magnitude 7.1 Olympia Earthquake; February 28, 2001, Nisqually Earthquake), geologic evidence suggests that larger earthquakes have occurred in the recent past and will continue to occur in the future (e.g., magnitude 8½ to 9 Cascadia Subduction Zone Interplate events).

The U.S. Geological Survey (USGS) has recently completed regional probabilistic ground motion maps for the entire nation that include the more recently defined seismogenic sources. The results of their studies were posted on the Internet in November of 1996. The USGS studies indicate that for a recurrence interval of 475 years, the site peak ground acceleration (PGA) is 0.28g for structural periods of about 1.0 second and less. For our analyses factors-of-safety against liquefaction were calculated for boring Standard Penetration Test (SPT)

N-value data for a magnitude 7.5 earthquake and a peak ground acceleration of 0.30g, consistent with Uniform Building Code (UBC) seismic design criteria.

The potential for soil liquefaction along the project alignment has been evaluated using Seed's simplified empirical procedure in conjunction with the results of the SPT N-values within borings B-1 through B-12. Seed's procedure is based on observations of liquefaction for sites explored with soil borings with SPT measurements and subject to earthquakes of known magnitude and acceleration. The design method incorporates the effects of fines content on relative density as estimated with SPT measurements.

The liquefaction analyses indicate that the estuarine silty sand to sandy silt layers would liquefy under a peak ground acceleration of 0.30g and an earthquake magnitude of 7.5. The upper 30 feet of soil is more susceptible to liquefaction than deeper deposits. The results of the liquefaction analyses are shown on Figure 5. Liquefaction could cause ground settlements of up to about 10 inches; however, earthquake-induced settlement along the length of the project alignment will be highly variable.

Additionally, because of the proximity of Grays Harbor to the proposed pipe alignment, lateral spreading might occur due to liquefaction of the estuarine deposits; however, site-specific ground response analyses are required which is beyond the scope of this report.

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## 7.0 LIMITATIONS

The analyses, conclusions, and recommendations contained in this report are based on site conditions as they presently exist and further assume that the current and previous borings are representative of the subsurface conditions throughout the proposed sewer alignment, i.e., the subsurface conditions everywhere are not significant different from those disclosed by the field explorations.

If, during construction, subsurface conditions different from those encountered in the field explorations are observed or appear to be present beneath excavations, we should be advised at once so that 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, it is recommended that this report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

We recommend that we be retained to review those portions of the plans and specifications which pertain to dewatering, trench shoring and excavation, pipe foundation, railroad undercrossing, and earthwork to determine if they are consistent with our recommendations. In addition, we should also be retained to monitor construction, particularly the dewatering, shoring, trench excavation, pipe foundation preparation, earthwork, and such other field observations as may be necessary.

This report was prepared for the exclusive use of EES, Inc., and their consultants to assist in the design of the subject facility. It should be made available to prospective contractors and/or the Contractor for information on factual data only, and not as a warranty of subsurface conditions, such as those interpreted from the exploration logs and discussions of subsurface conditions included in this report. Shannon & Wilson has prepared the attached, "Important Information About Your Geotechnical Report," to assist you and others in understanding the use and limitations of our reports. This attachment is presented in the Appendix D of this report.

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Unanticipated soil conditions are commonly encountered and cannot be fully determined by merely taking soil samples from test borings. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

**SHANNON & WILSON, INC.**

_____

James A. Mattoon
Engineer

Martin W. Page, P.E.
Senior Principal Engineer

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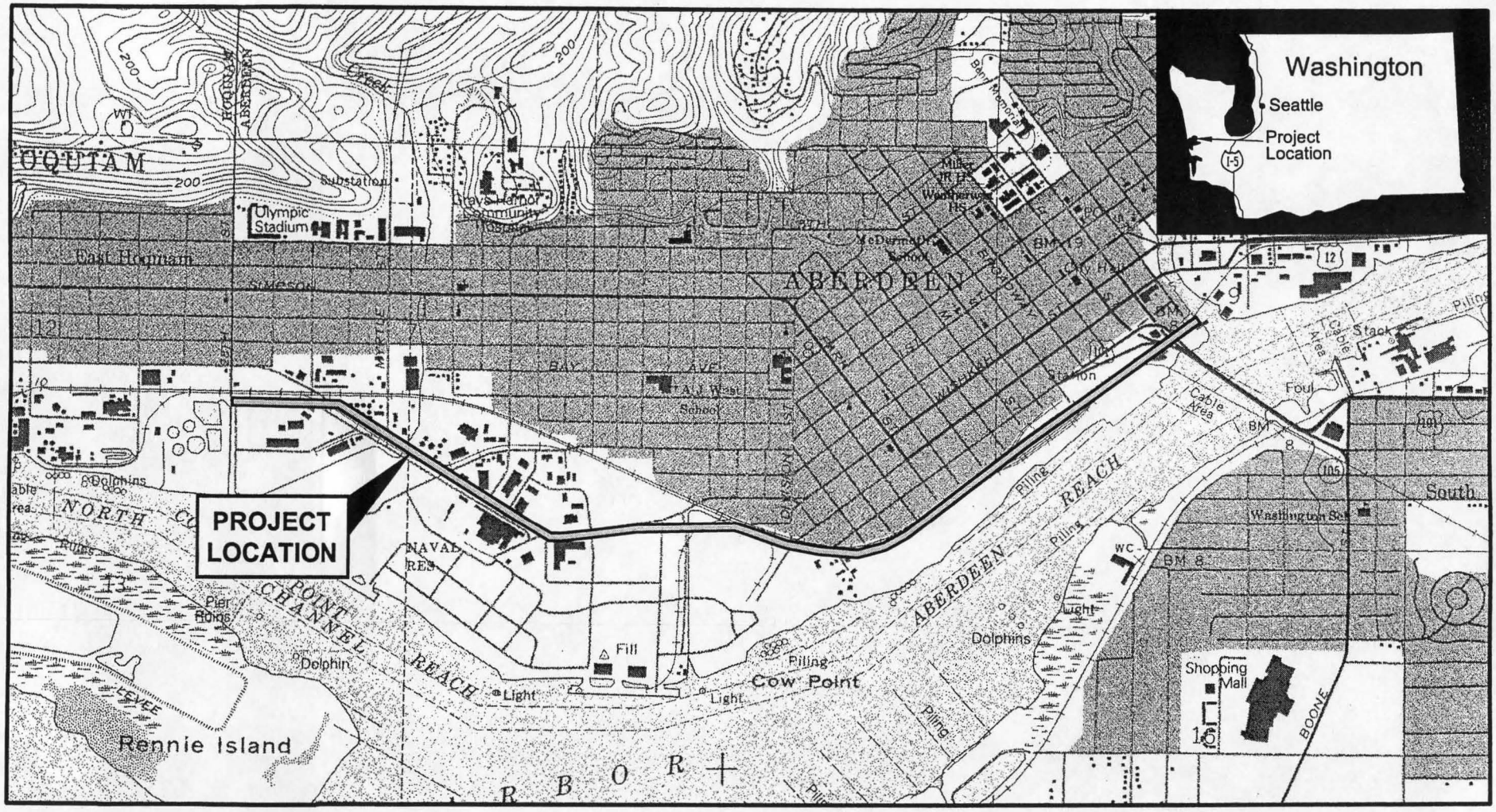


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Scale in Miles

NOTE

Map adapted from 1:24,000 USGS topographic map of Aberdeen, WA quadrangle, dated 1957, revised 1994.

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FIG. 1

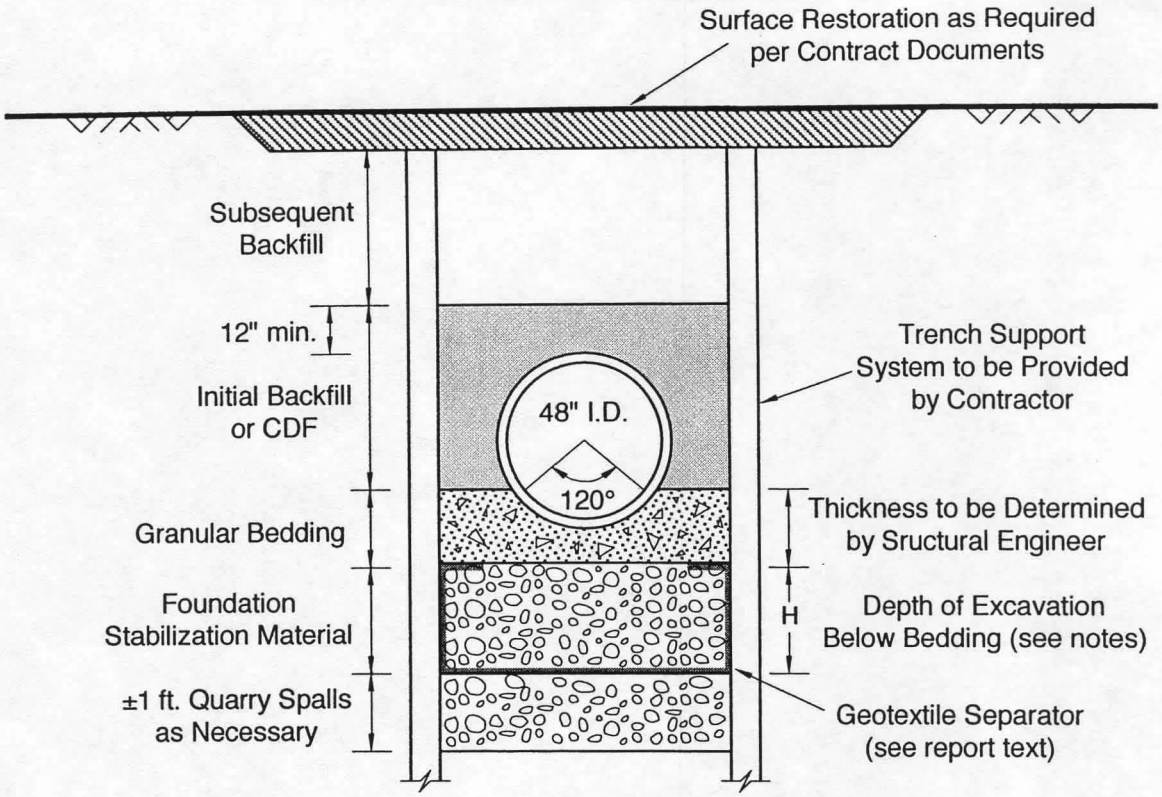
Aberdeen Industrial Water Pipeline Phase II
Aberdeen, Washington

**VICINITY MAP**

March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. 1**




Not to Scale

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NOTES

1. Estimated depth of excavation below bedding is: One Foot.

2. Foundation stabilization material should be used as required to maintain a stable subgrade or as recommended in text. Foundation stabilization material should consist of granular material free of organic matter with the following gradation (WSDOT/APWA 9-03-17):

| U.S. Standard Sieve Size | Percent Passing by Dry Weight |
|---|---|
| 2-1/2-inch | 98-100 |
| 2-inch | 92-100 |
| 1-1/2-inch | 72-87 |
| 1-1/4-inch | 58-75 |
| 3/4-inch | 27-47 |
| 3/8-inch | 3-14 |
| US No. 4 | 0-1 |

3. Granular bedding and initial backfill material, where required, should consist of granular material free of organic matter with the following gradational requirements:

Flexible Pipe (WSDOT/APWA 9-03-16)

| U.S. Standard Sieve Size | Percent Passing by Dry Weight |
|---|---|
| 3/4-inch | 100 |
| 3/8-inch | 70 - 100 |
| No. 4 | 55 - 100 |
| No.10 | 35 - 95 |
| No. 20 | 20 - 80 |
| No. 40 | 10 - 55 |
| No. 100 | 0 - 10 |
| No. 200 | 0 - 3 |

Rigid Pipe (WSDOT/APWA 9-03-15)

| U.S. Standard Sieve Size | Percent Passing by Dry Weight |
|---|---|
| 1-inch | 100 |
| 1/4-inch | 25 - 80 |
| No. 200 | 7 Max. |
| Sand Equiv. | 42 Min. |

4. Subsequent backfill should consist of select trench excavation material or imported granular material free of organic matter with the following gradational requirements (WSDOT/APWA 9-03-14(1)):

| U.S. Standard Sieve Size | Percent Passing by Dry Weight |
|---|---|
| 4-inch | 100 |
| No. 4 | 50 - 80 |
| No. 40 | 30 Max. |
| No. 200 | 7 Max. |
| Sand Equiv. | 42 Min. |

Aberdeen Industrial Water Pipeline Phase II
Aberdeen, Washington

**RECOMMENDED TYPICAL TRENCH SECTION EXCAVATING IN DRY**

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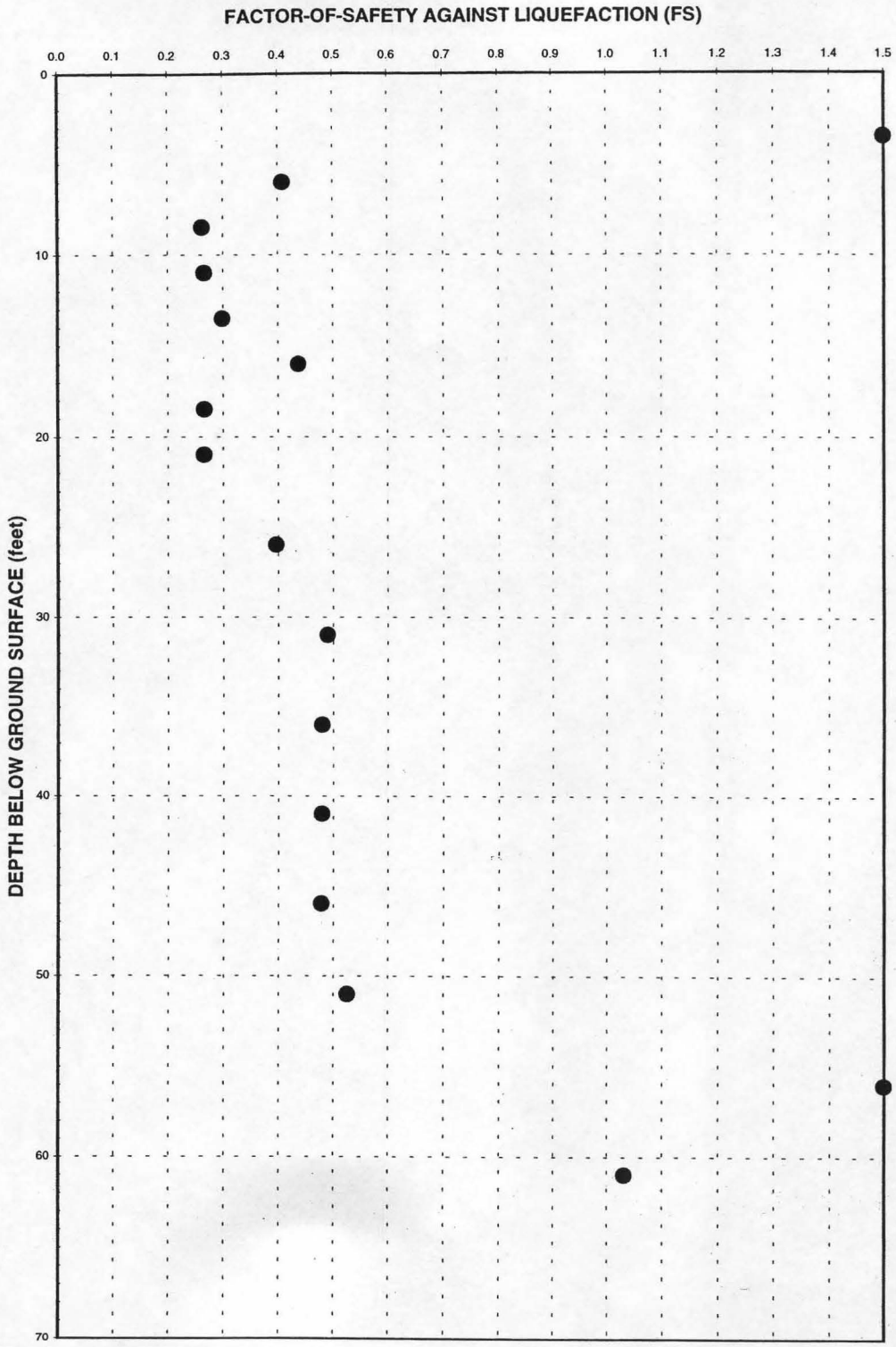
**FIG. 4**

## SUBSURFACE PROFILE

(Based on B-2/GE-89-9)

| |
|---|
| Loose, silty, slightly gravelly SAND (fill) |
| ▽ Very loose to loose, silty, f-m SAND (dredged fill) |
| Very soft to soft, slightly fine sandy, slightly clayey SILT (tidal mudflat) |
| Medium stiff, slightly sandy, slightly clayey SILT (tidal mudflat) |
| Medium dense, silty, fine SAND (alluvial deposit) |

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**NOTES:**

1. *Reference:* Youd, T.L. and Idriss, I.M., 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/ NSF Workshops on Evaluation of Liquefaction Resistance of Soils.
2. The analysis was performed for an earthquake with a magnitude of 7.5 and a peak ground acceleration of 0.30g.
3. The liquefaction resistance of a soil is dependent on its density and fines content. The fines content was estimated based on selected grain-size analyses and engineering judgement.

Aberdeen Industrial Water Pipeline Phase II
Aberdeen, Washington

**RESULTS OF LIQUEFACTION ANALYSES BORING B-2/GE-89-9**

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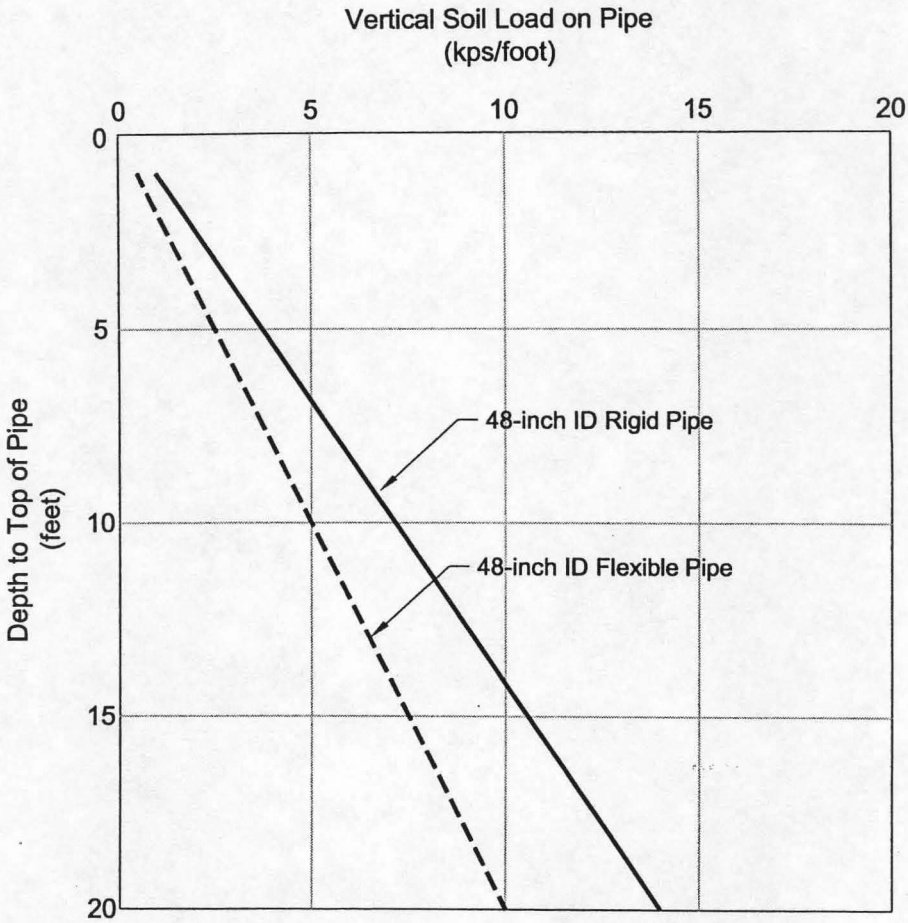
**FIG. 5**

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NOTE

Figure for estimation of soil loads only. Live surcharge loads due to MS-20 truck loadings on the surface and beneath the railroad tracks, E70 loading should also be considered for pipe design.

Aberdeen Industrial Water Pipeline Phase II
Aberdeen, Washington

**ESTIMATED VERTICAL LOADS ON PIPES**

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**FIG. 6**

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# Appendix A

# APPENDIX A

# SUBSURFACE EXPLORATION

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# APPENDIX A

# SUBSURFACE EXPLORATION

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## 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.

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

**SOIL CLASSIFICATION AND LOG KEY**

March 2002 | 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. A-1**
Sheet 2 of 2

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# LOG OF TEST PIT TP-1

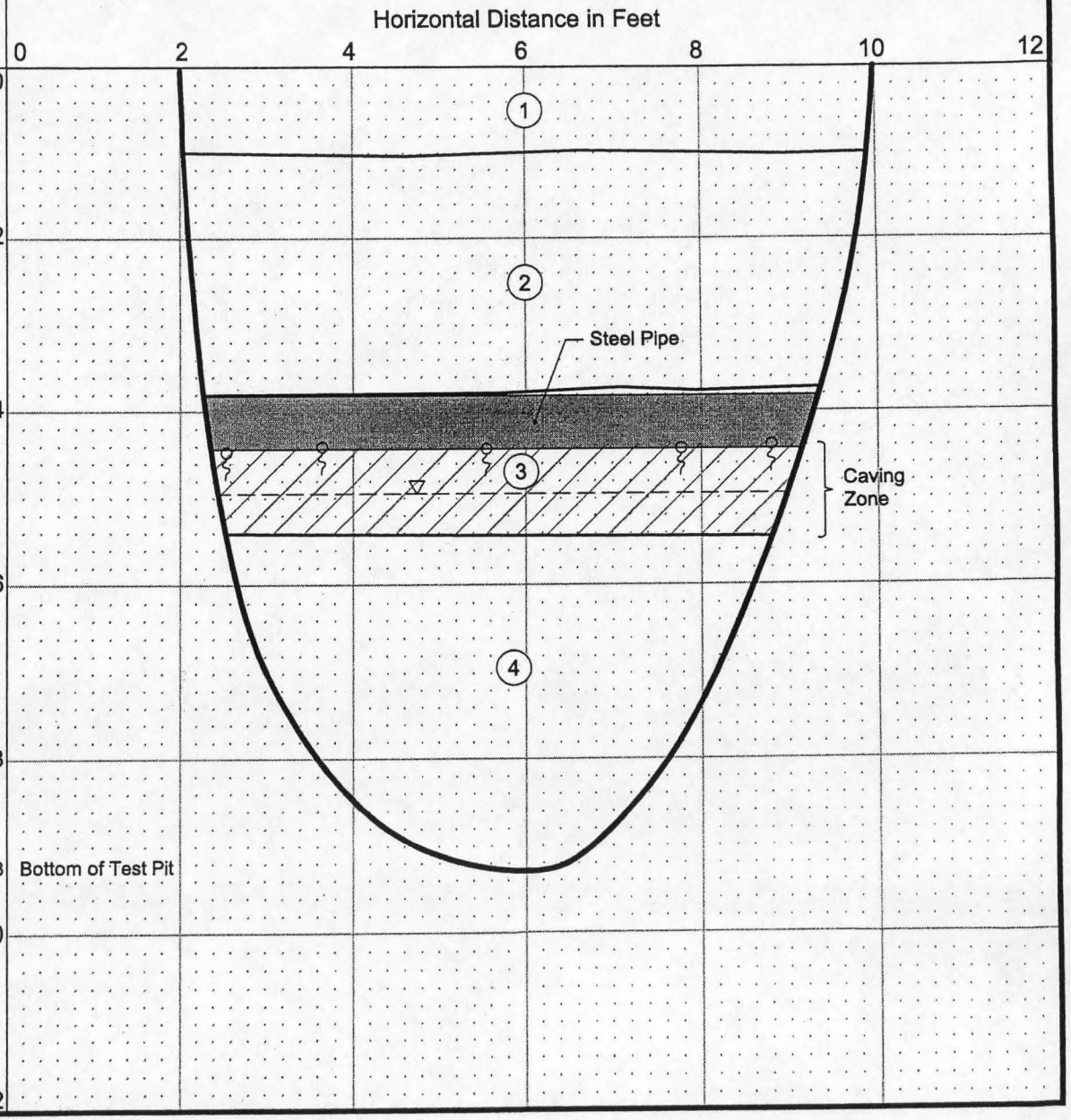
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

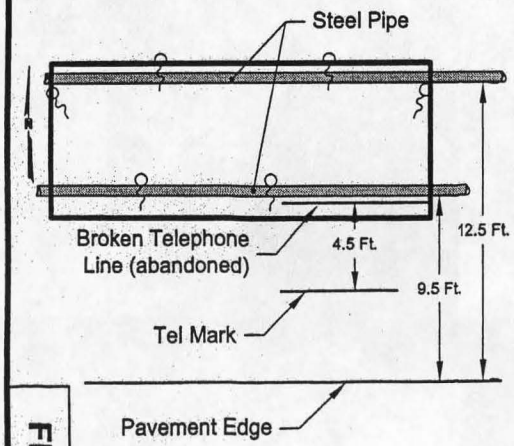
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (vegetation) | | | | 0 |
| (1) Loose, brown, slightly silty, fine gravelly SAND; moist; occasional organics; (Fill) SW-SM. | | 16.7 | S-1 | |
| (2) Loose, dark brown, slightly silty, fine gravelly SAND; moist; scattered organics; (Fill) SW-SM. | | 25.7 | S-2 | 2 |
| (3) Loose, dark gray, silty, fine to medium SAND; wet; (Fill) SP-SM. | | | | 4 |
| (4) Very soft to soft, gray, clayey SILT, trace of fine sand; wet; occasional organics; (Tidal Mudflat) OH. | ▽ | 39.6 | S-3 | |
| | | 72.0 | S-4 | 6 |
| | | | | 8 |
| | | | | 9.3 Bottom of Test Pit |
| | | | | 10 |
| | | | | 12 |

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




**PLAN VIEW**
Not to Scale

FIG. A-2

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# LOG OF TEST PIT TP-2

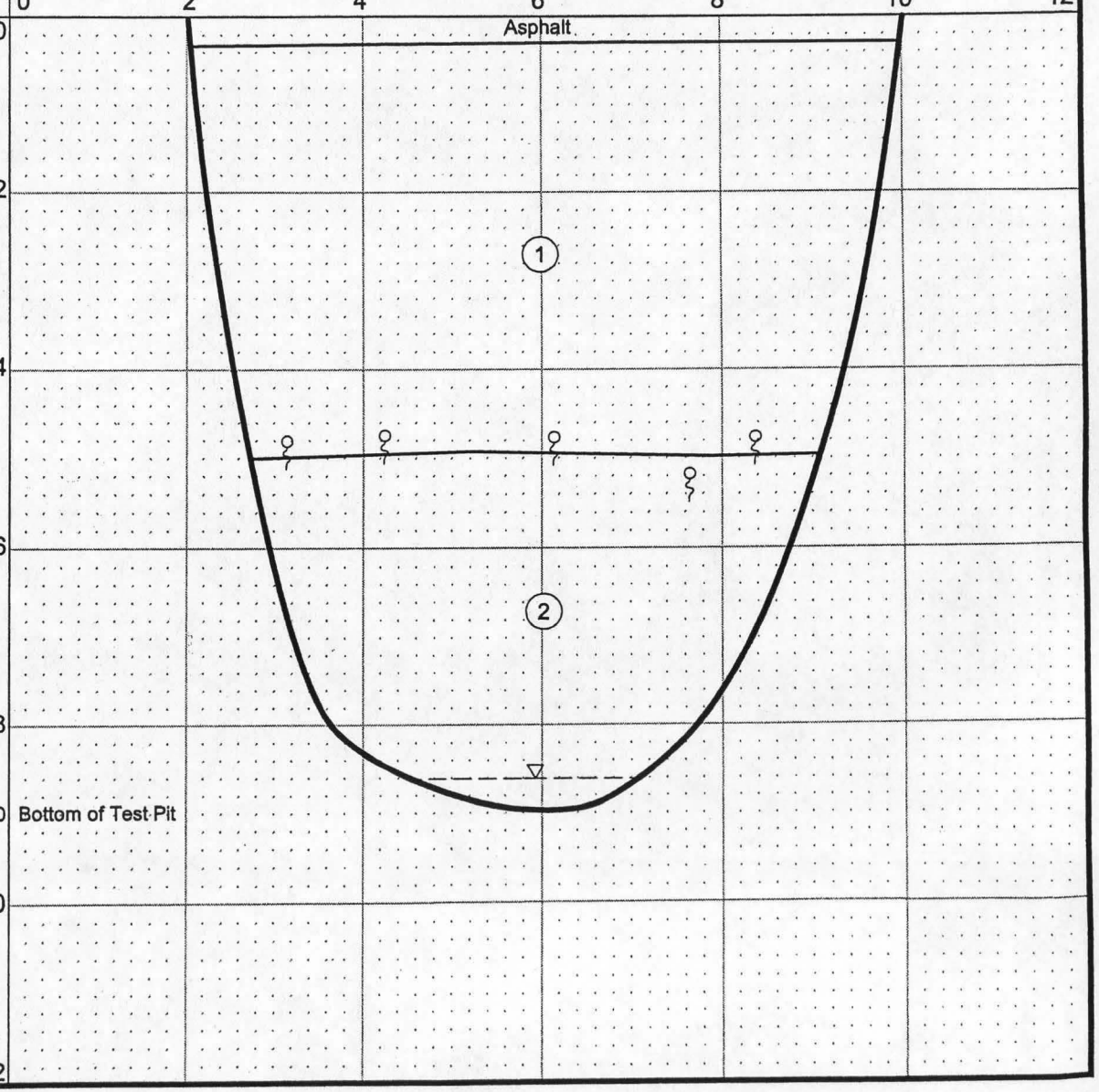
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

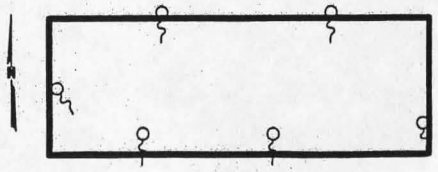
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (3-inch asphalt) | | | | 0 |
| (1) Medium dense, brown, slightly silty, sandy, fine GRAVEL; moist; scattered wood debris; (Fill) GP-GM. | | 42.8 | S-1 | 2 |
| (2) Soft, gray, fine sandy, clayey, organic SILT, trace of fine sand; moist; occasional organics; (Tidal Mudflat) OH. | | | | 4 |
| NOTE<br>Wood debris contained small diameter logs. | | | | 6 |
| | ▽ | 52.3 | S-2 | 8 |
| | | | | 9.0 Bottom of Test Pit |
| | | | | 10 |
| | | | | 12 |

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




PLAN VIEW

FIG. A-3

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# LOG OF TEST PIT TP-3

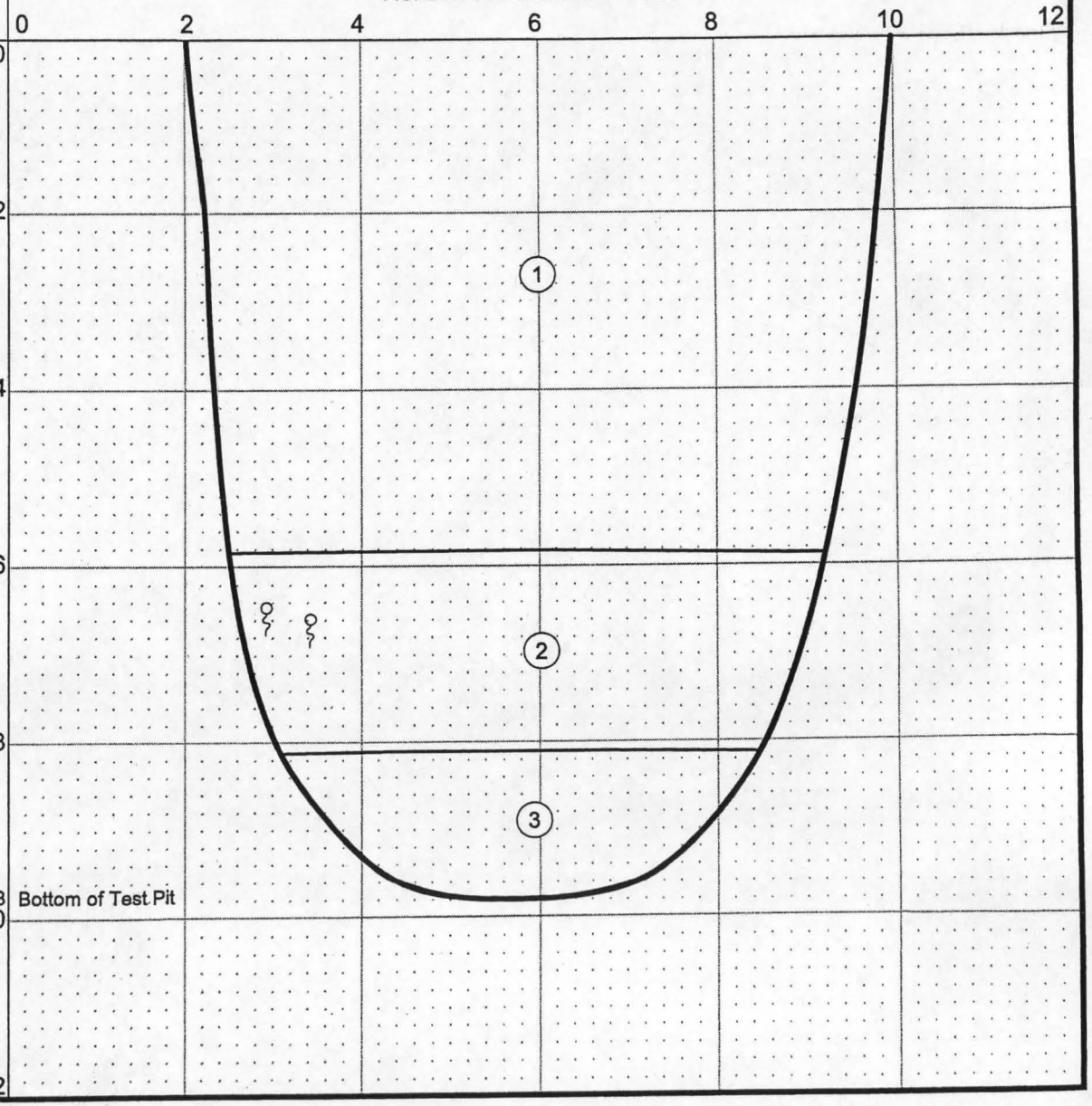
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

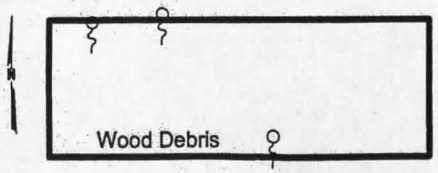
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (vegetation) | | | | 0 |
| (1) Medium dense, brown, slightly silty, sandy, fine GRAVEL; moist; scattered organics; (Fill) GP-GM. | | | | 2 |
| (2) Soft, gray, slightly clayey, organic SILT, trace of fine sand; moist; occasional organics; (Tidal Mudflat) OH. | | 24.6 | S-1 | |
| (3) Soft, gray, clayey, organic SILT, trace of fine sand; moist; organics; (Tidal Mudflat) OH. | | | | 4 |
| | | 65.9 | S-2 | 6 |
| | | 103.6 | S-3 | 8 |
| Bottom of Test Pit | | | | 9.8 |
| | | | | 10 |
| | | | | 12 |

Sketch of South Pit Side

Surface Elevation: Approx. 15 Feet




PLAN VIEW

FIG. A-4

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# LOG OF TEST PIT TP-4

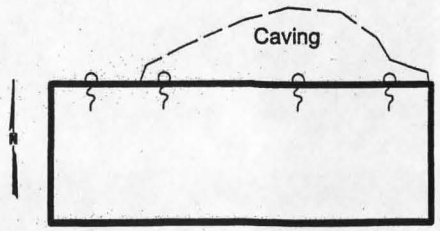
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (grassy vegetation) | | | | 0 |
| (1) Loose, brown, silty, fine to coarse gravelly SAND; moist; (Fill) SW-SM. | | 19.5 | S-1 | |
| (2) Very loose, blue gray, silty, fine to medium SAND; moist; strong petroleum odor; (Dedged Material) SM. | | | S-2 | 2 |
| | | | S-3 | |
| (3) Very soft to soft, blue gray, sandy SILT; moist; (Dredged Material) ML. | | | S-4 | 3.5 PID = 138 |
| | ▽ | | | 4 |
| | | | | 6 |
| | | | S-5 | 8 |
| | | | | 9.0 Bottom of Test Pit |
| | | | | 10 |
| | | | | 12 |

NOTE

Flowing water (transporting up to 2.5" diameter gravel) possibly due to trapped water (under hydraulic pressure) in an existing adjacent utility backfill. Pit filled with water to 4.5 feet due to this flow.




PLAN VIEW

Sketch of South Pit Side

Surface Elevation: Approx. 15 Feet

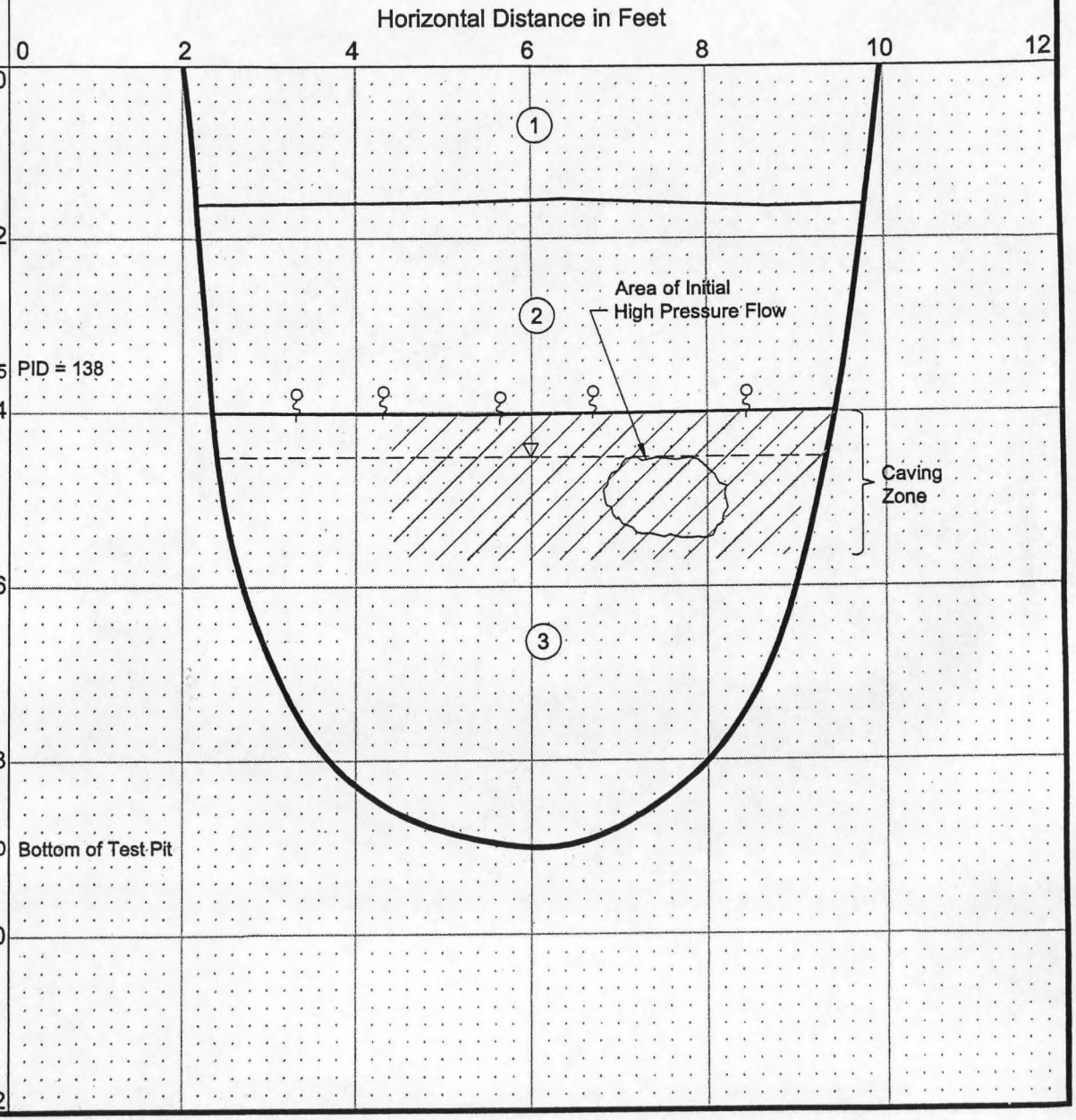



FIG. A-5

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# LOG OF TEST PIT TP-5

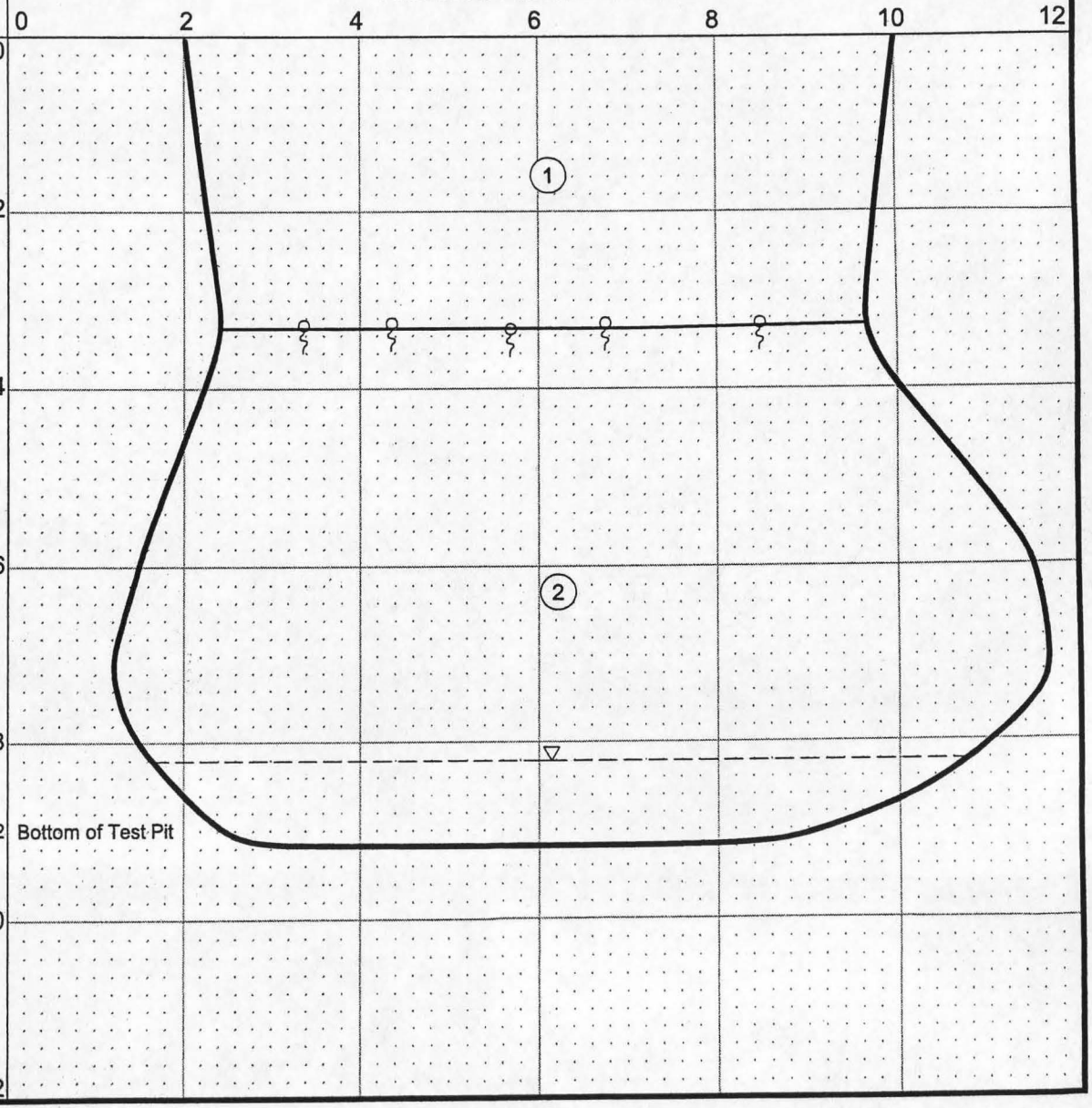
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

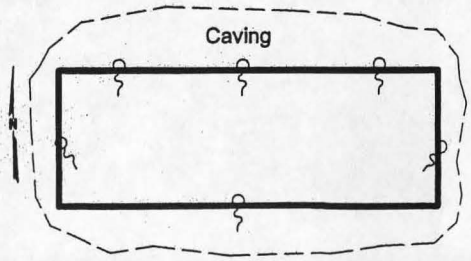
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (grassy vegetation) | | | | 0 |
| (1) Loose, brown, silty, gravelly SAND; moist; occasional organics; (Fill) SW-SM. | | | | 2 |
| (2) Very loose, blue gray, silty, fine to medium SAND; wet; (Dredged Material) SM. | | 31.1 | S-1 | 4 |
| NOTE<br>Rapid caving below 4 feet. | | | | 6 |
| | | 37.8 | S-2 | 8 |
| | | | | 9.2 Bottom of Test Pit |
| | | | | 10 |
| | | | | 12 |

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




PLAN VIEW

FIG. A-6

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# LOG OF TEST PIT TP-6

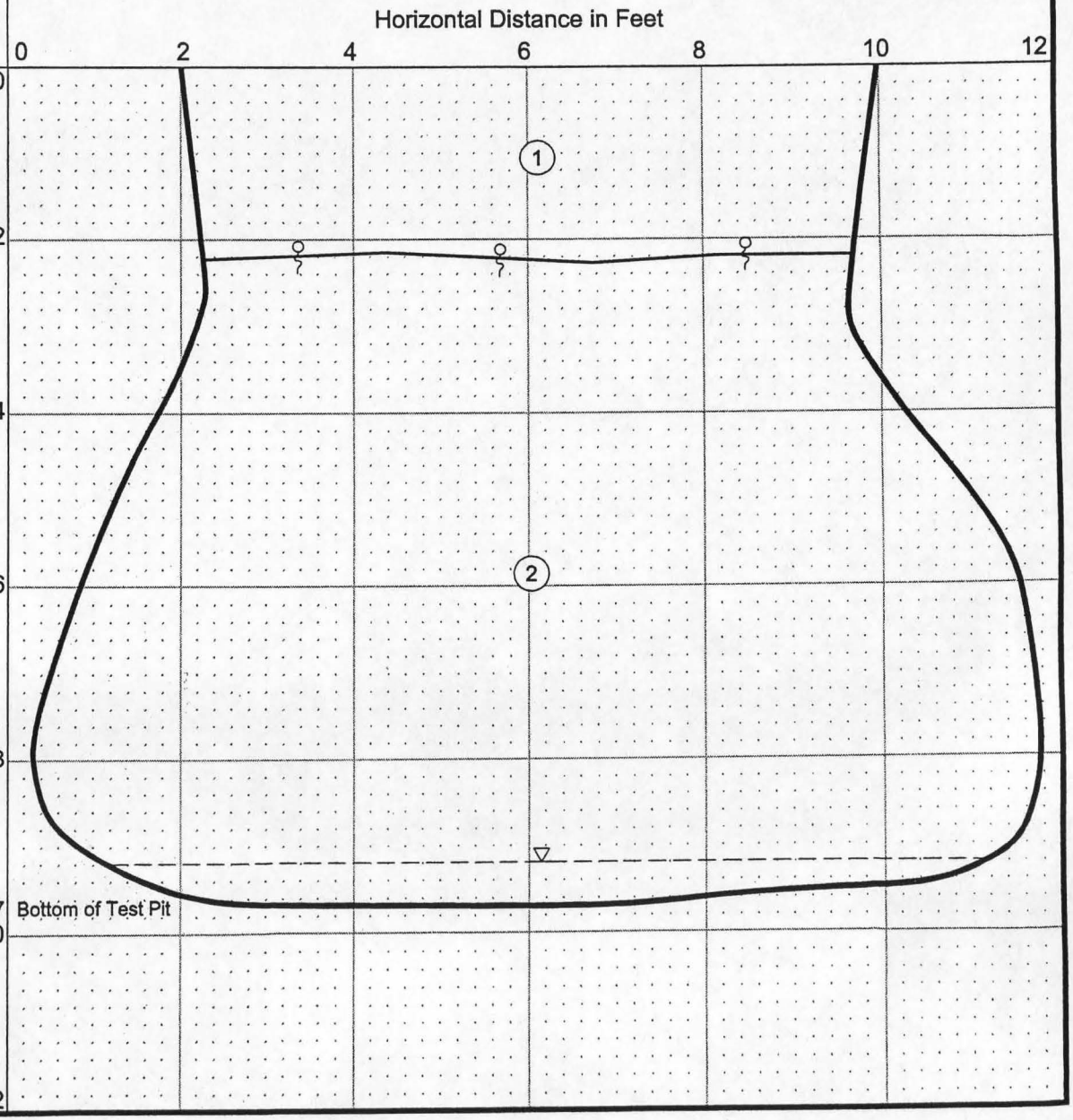
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

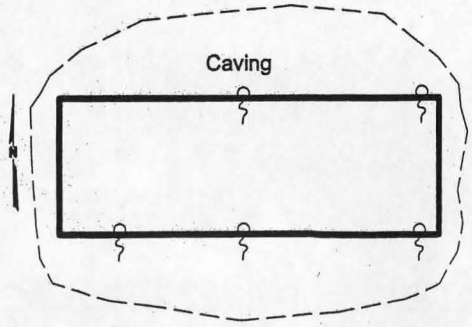
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (grass) | | | | 0 |
| (1) Loose, brown, slightly silty, sandy, fine GRAVEL; moist; (Fill) GP-GM. | | 16.3 | S-1 | |
| (2) Very loose, blue gray, slightly silty, fine to medium SAND; wet; scattered shell fragments; (Dredged Material) SM. | | | | 2 |
| NOTE<br>Rapid caving below 3 feet. | | | | 4 |
| | | | S-2 | |
| | | | | 6 |
| | | | S-3 | |
| | ▽ | | | 8 |
| | | | | 9.7 Bottom of Test Pit |
| | | | | 10 |
| | | | | 12 |

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




PLAN VIEW

FIG. A-7

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# LOG OF TEST PIT TP-7

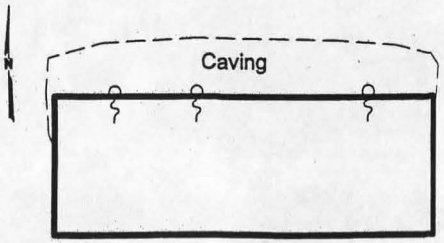
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (grass) | | | | 0 |
| (1) Loose, brown, silty, fine gravelly SAND; moist; (Fill) SW-SM. | | 23.9 | S-1 | |
| (2) Very loose, blue gray, fine sandy SILT; wet; (Dredged Material) ML. | | | | 2 |
| (3) Very soft to soft, blue gray, fine sandy, clayey SILT, trace of fine sand; moist; (Dredged Material) OL. | | | | 4 |
| | | | S-2 | |
| | ▽ | | | |
| | | 75.3 | | 6 |
| | | | S-3 | 8 |
| | | | | 10 |
| | | | | 10.6 Bottom of Test Pit |
| | | | | 12 |

**NOTE**

Flowing water (transporting coarse gravels) possibly due to trapped water (under hydraulic pressure) in an existing adjacent utility backfill. Rapid caving on north side below 5.5 feet. Pit filled with water to approximately 5 feet due to this flow.




**PLAN VIEW**

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet

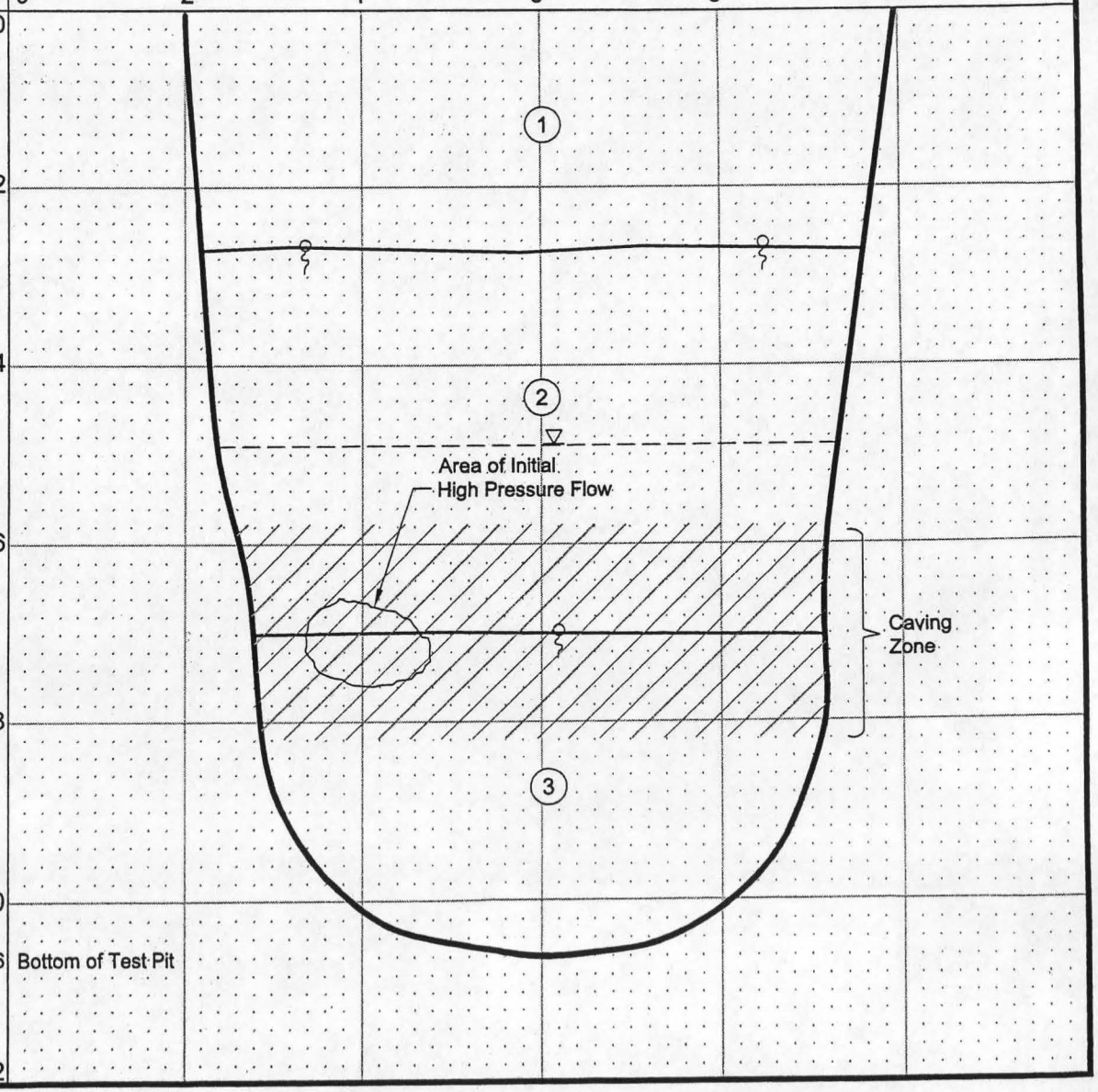



FIG. A-8

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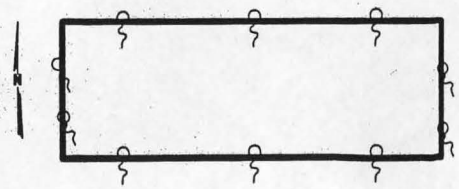
# LOG OF TEST PIT TP-8

JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (grass) | | | | 0 |
| (1) Loose, brown, silty, fine gravelly SAND; moist; (Fill) SW-SM. | | 20.8 | S-1 | |
| (2) Loose, blue gray, fine sandy SILT; wet; (Dredged Material) ML. | | | | 2 |
| (3) Soft, blue gray, slightly clayey, organic SILT, trace of fine sand; moist; (Dredged Material) OL. | | | | 4 |
| (4) Loose, gray, silty, fine to medium SAND; wet; (Dredged Material) SP-SM. | | | | 6 |
| NOTE<br>Rapid caving below 7 feet due to loose soil and groundwater seepage. | | 107.9 | S-2 | 8 |
| | ▽ | | | 10 |
| | | | | 10.3 Bottom of Test Pit |
| | | | | 12 |




PLAN VIEW

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet

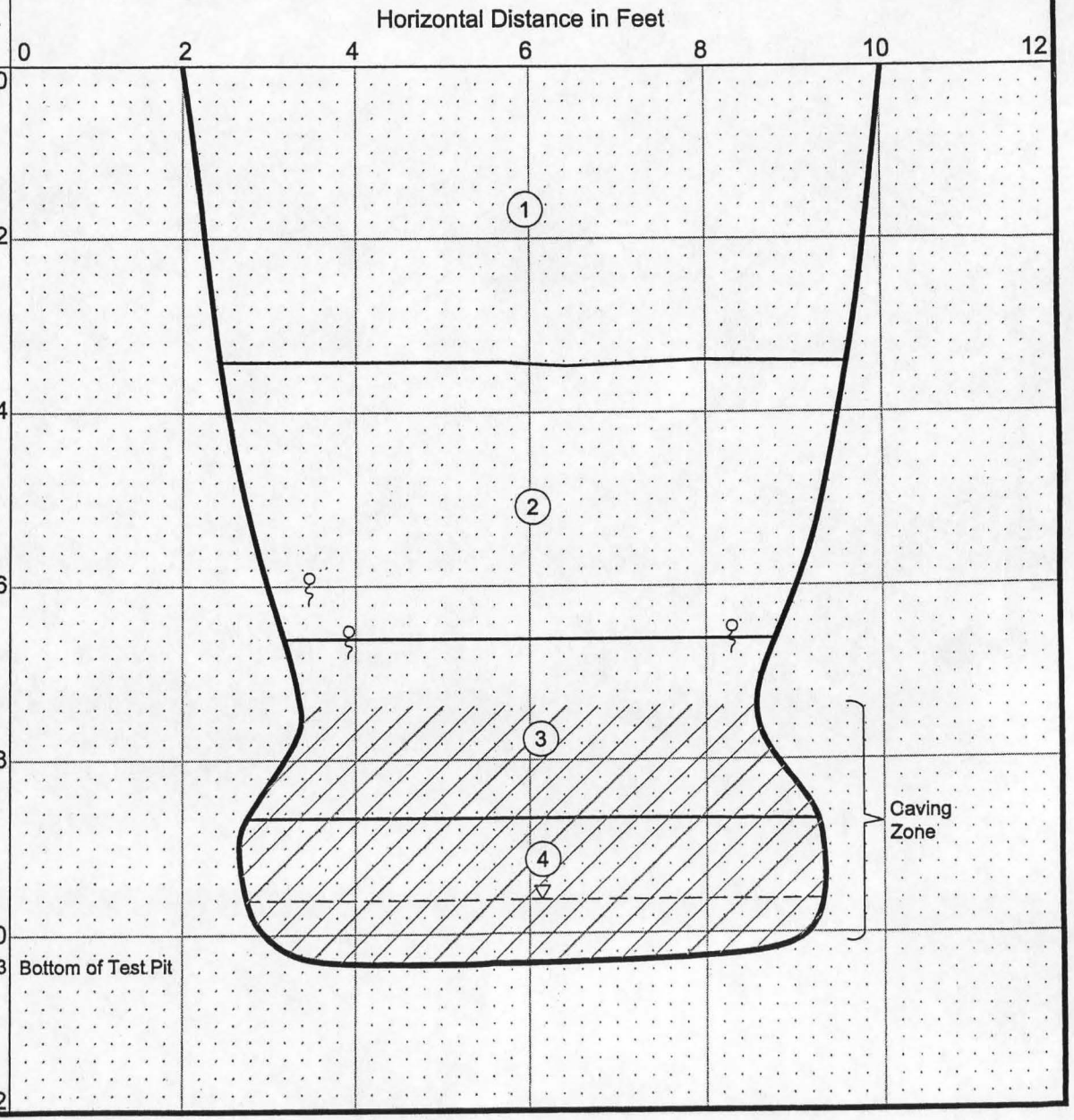



FIG. A-9

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# LOG OF TEST PIT TP-9

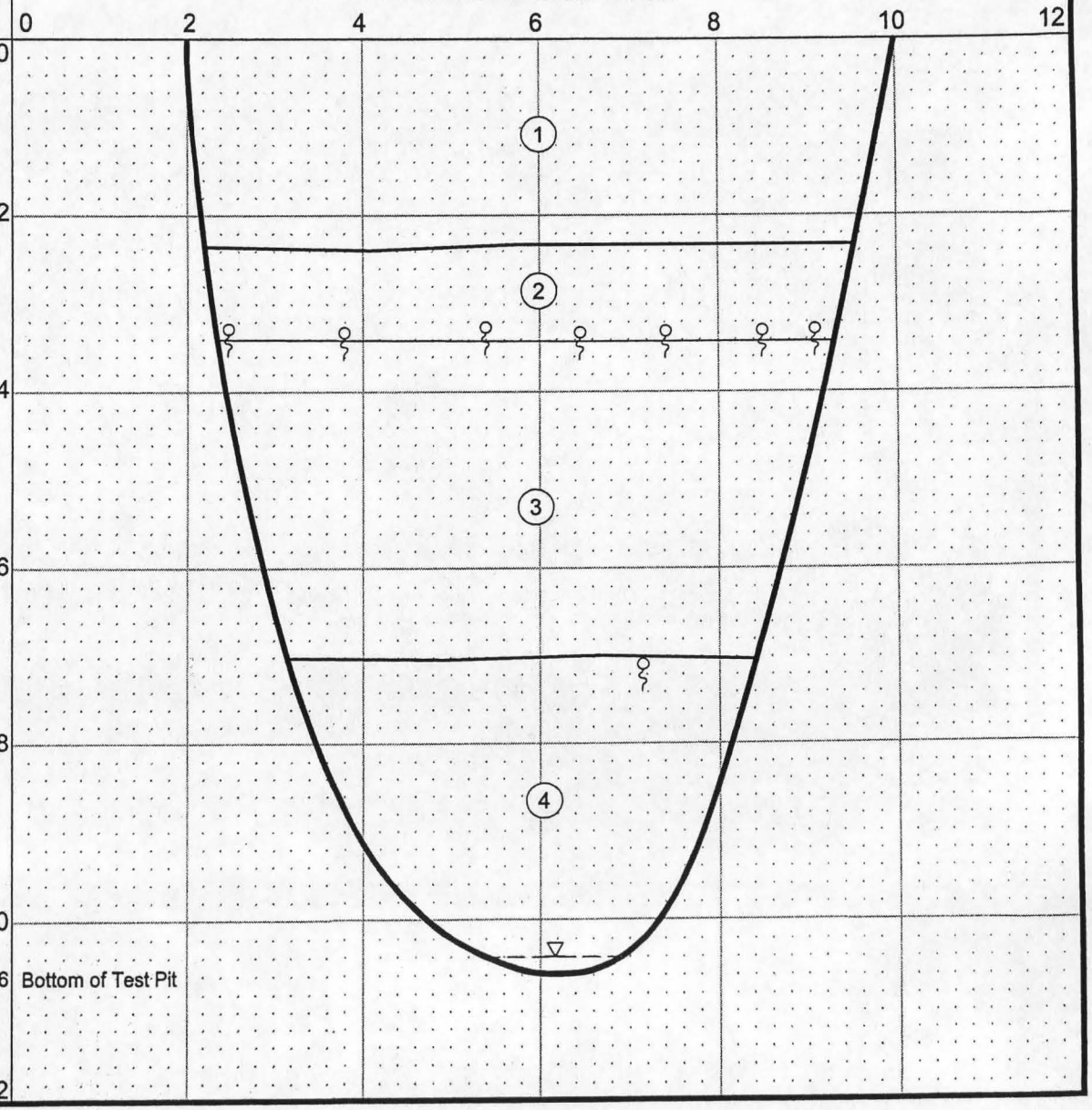
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

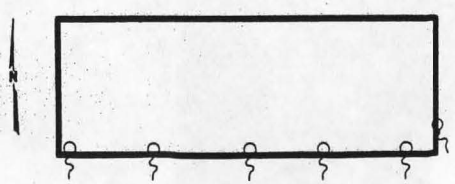
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (log yard) | | | | 0 |
| (1) Medium dense, brown, slighty silty, sandy, fine to coarse GRAVEL; moist; occasional organics, angular cobbles; (Fill) GW. | | 9.3 | S-1 | 2 |
| (2) Medium dense, brown, silty, sandy, fine GRAVEL; wet; scattered organics; (Fill) GP-GM. | | 8.9 | S-2 | 4 |
| (3) Medium stiff, gray, slightly clayey, organic SILT, trace of fine sand; moist; scattered organics; (Tidal Mudflat) OL. | | | | 6 |
| (4) Very soft to soft, gray, slightly fine sandy, slightly clayey, organic SILT; moist; scattered organics; (Tidal Mudflat) OL. | | | | 8 |
| | | 68.2 | S-3 | 10 |
| | ▽ | | | 10.6 Bottom of Test Pit |
| | | | | 12 |

Sketch of South Pit Side

Surface Elevation: Approx. 15 Feet



PLAN VIEW

FIG. A-10

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# LOG OF TEST PIT TP-10

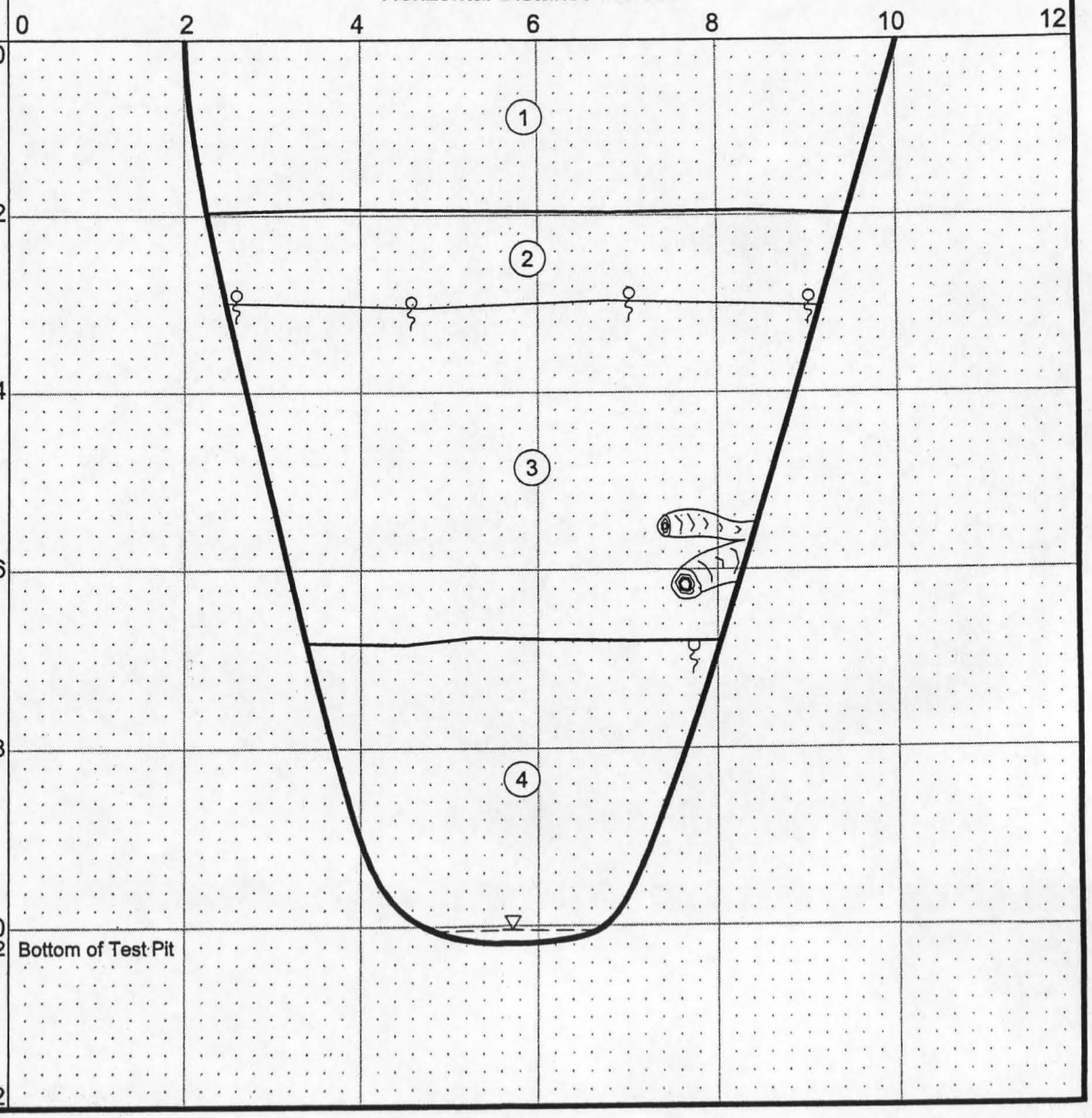
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

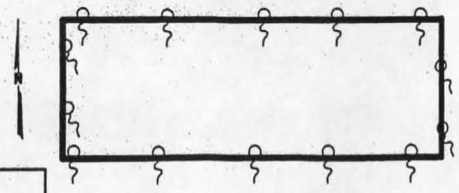
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (log yard) | | | | 0 |
| (1) Medium dense, dark brown, slightly silty, sandy, fine to coarse GRAVEL; moist; scattered organics, angular cobbles; (Fill) GW. | | 15.6 | S-1 | 2 |
| (2) Medium dense, brown, silty, fine gravelly SAND; moist; scattered organics and wood debris; (Fill) SW-SM. | | 29.7 | S-2 | 4 |
| (3) Medium stiff, gray, fine sandy, slightly clayey, organic SILT, trace of fine sand; moist; scattered organics; (Tidal Mudflat) OL. | | 51.6 | S-3 | 6 |
| (4) Very soft to soft, gray, slightly fine sandy, slightly clayey, organic SILT; moist; scattered organics (Tidal Mudflat) OL. | | | | 8 |
| NOTE<br>Wood debris contained logs, sawdust, and lumber scraps. | | 63.2 | S-4 | 10 |
| | ▽ | | | 10.2 Bottom of Test Pit |
| | | | | 12 |

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet



PLAN VIEW

FIG. A-11

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# LOG OF TEST PIT TP-11

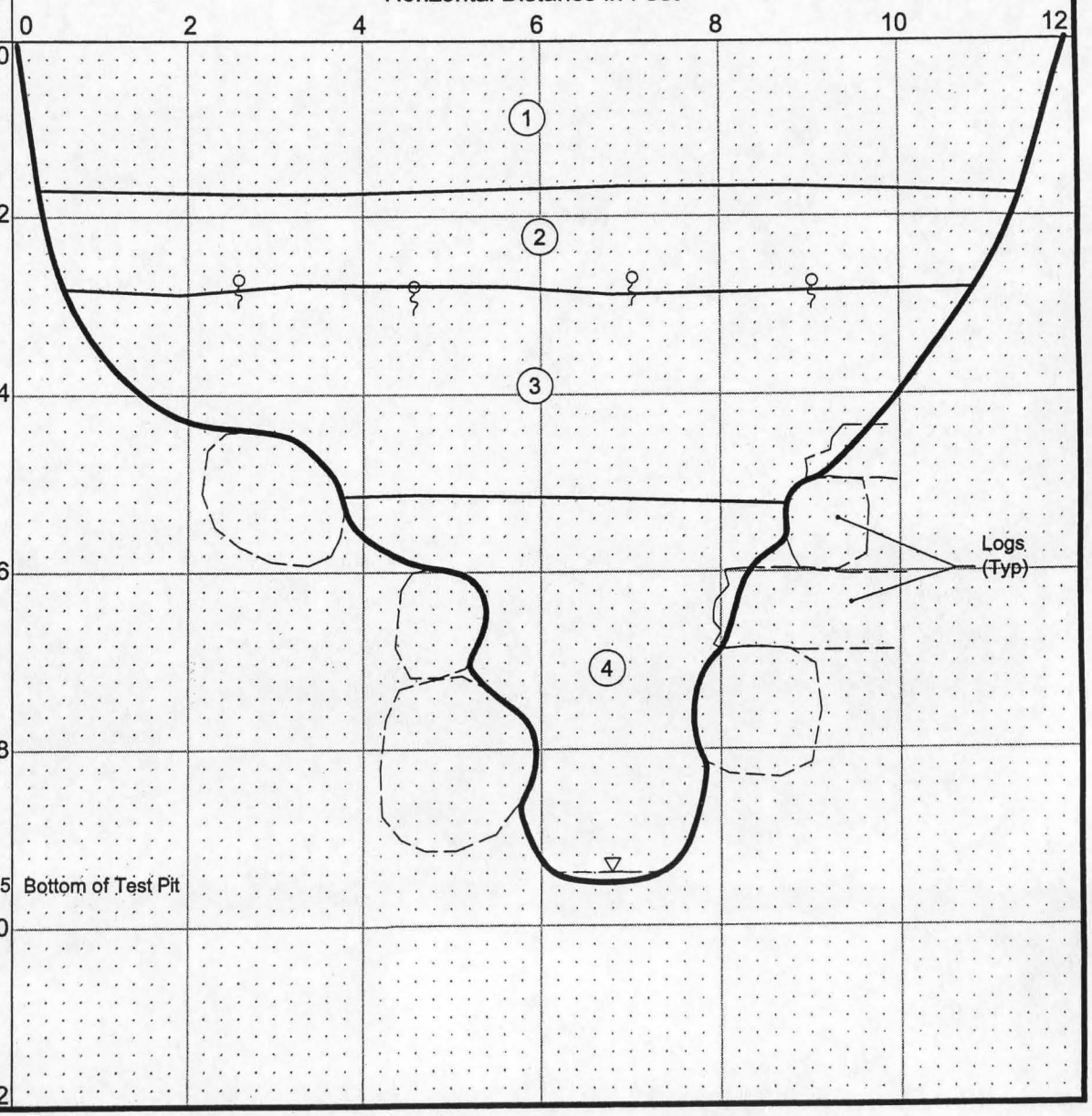
JOB NO: 21-1-08713-005 DATE: 2-12-02 LOCATION: See Site and Exploration Plan

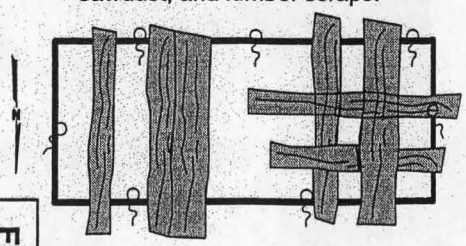
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| Surface (log yard) | | | | |
| (1) Medium dense, brown, slightly silty, sandy, fine to coarse GRAVEL; moist; scattered organics, angular cobbles; (Fill) GW. | | 50.9 | S-1 | |
| (2) Medium dense, brown, slightly silty, sandy, fine to coarse GRAVEL; wet; numerous organics and wood debris; angular shaped gravels (Fill) GW. | | 49.6 | S-2 | |
| (3) Medium stiff, gray, slightly clayey, organic SILT, trace of fine sand; moist; numerous organics; exposed logs; (Tidal Mudflat) OL. | | | | |
| (4) Very soft to soft, gray, slightly fine sandy, slightly clayey, organic SILT moist; numerous organics; exposed logs; (Tidal Mudflat) OL. | | | | |
| NOTE<br>Wood debris contained logs, sawdust, and lumber scraps. | | | | |
| | ▽ | 93.8 | S-3 | |
| | | | | 9.5 Bottom of Test Pit |

Sketch of South Pit Side

Surface Elevation: Approx. 15 Feet



PLAN VIEW

FIG. A-12

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Geotechnical and Environmental Consultants

# LOG OF TEST PIT TP-12

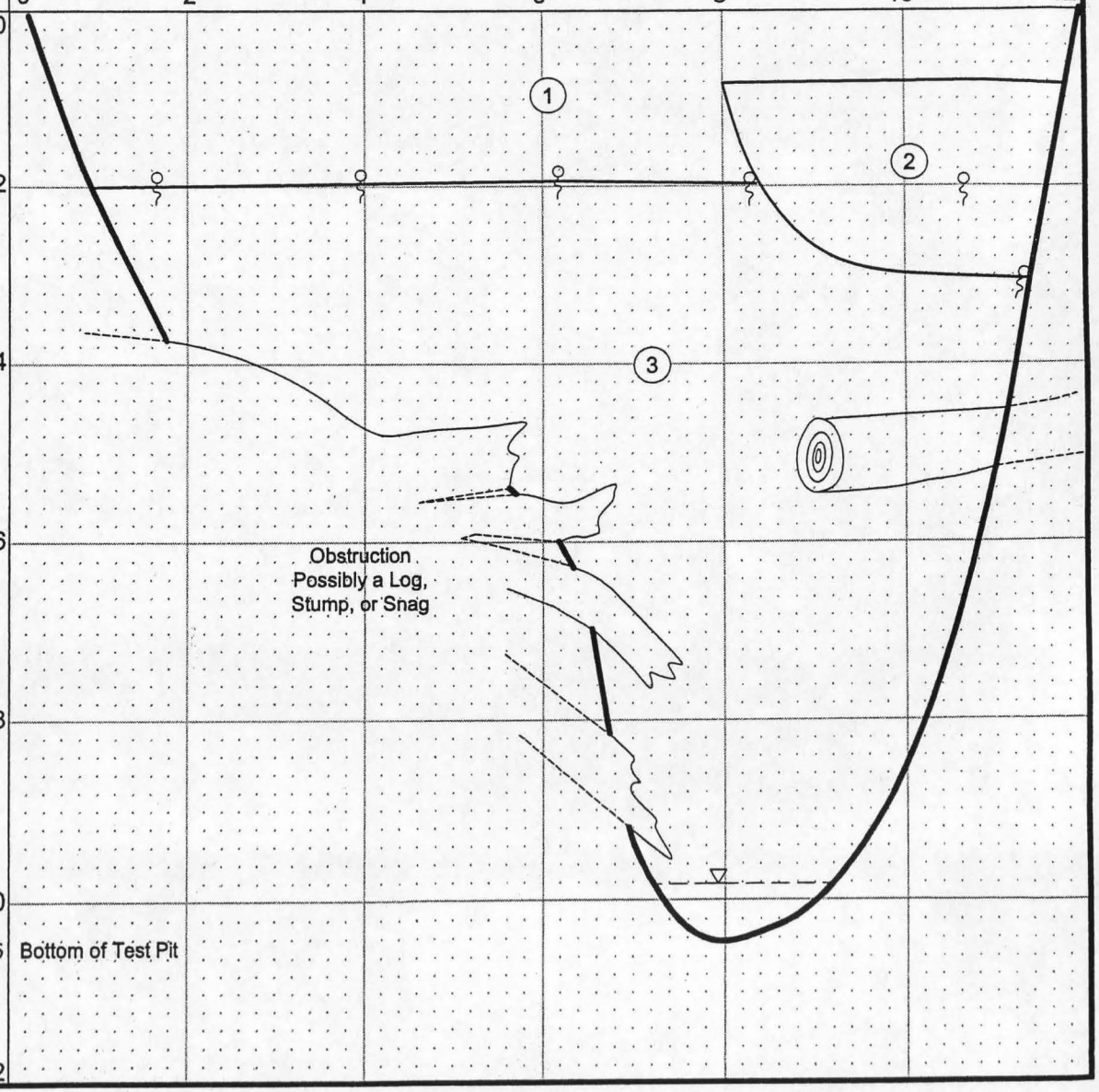
JOB NO: 21-1-08713-005 DATE: 3-1-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| (1) Loose, dark brown, silty, gravelly SAND; moist; (Fill) SW-SM. | | | | 0 |
| (2) Loose, gray, quarry spalls (3 to 6") mixed with silty, sandy GRAVEL; moist; scattered organics; (Fill) GP. | | | | 2 |
| (3) Soft, gray, clayey SILT; wet; scattered to numerous organics; wood debris from 5 to 10 feet; (Tidal Mudflat) ML. | | | S-1 | |
| | | | | 4 |
| | | | S-2 | |
| | | | | 6 |
| | | | | 8 |
| | ▽ | | S-3 | 10 |
| | | | | 10.5 Bottom of Test Pit |
| | | | | 12 |

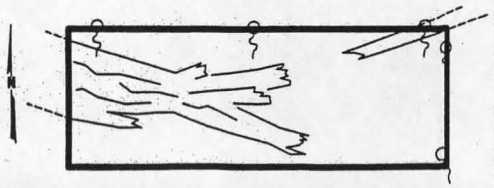
Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




NOTE

Wood debris contained logs, stump, or snag.



PLAN VIEW

FIG. A-13

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**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

# LOG OF TEST PIT TP-13

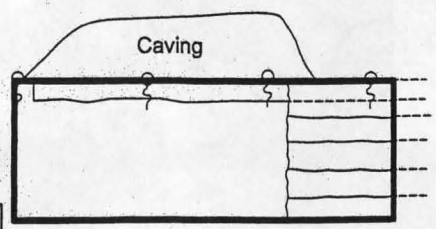
JOB NO: 21-1-08713-005 DATE: 3-1-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| (1) Loose, dark brown, silty, gravelly SAND; moist; (Fill) SW-SM. | | | | 0 |
| (2) Loose, blue gray, slightly silty, gravelly SAND; wet; (Dredged Material) SW-SM. | | | | 2 |
| (3) Soft, gray, slightly sandy, slightly gravelly, clayey SILT; wet; occasional red bricks; scattered organics; scattered roots; numerous wood debris; (Tidal Mudflat) ML. | | | | 4 |
| (4) Soft, gray, clayey SILT; wet; numerous organics; occasional roots; (Tidal Mudflat) ML. | ▽ | | | 6 |
| | | | S-1 | 8 |
| | | | S-2 | 10 |
| | | | | 10.5 Bottom of Test Pit |
| | | | | 12 |

NOTES

1. Wood debris contained logs and lumber scraps.
2. Caving of the north side of the test pit occurred when the west end of the log was undermined during excavation.




PLAN VIEW

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet

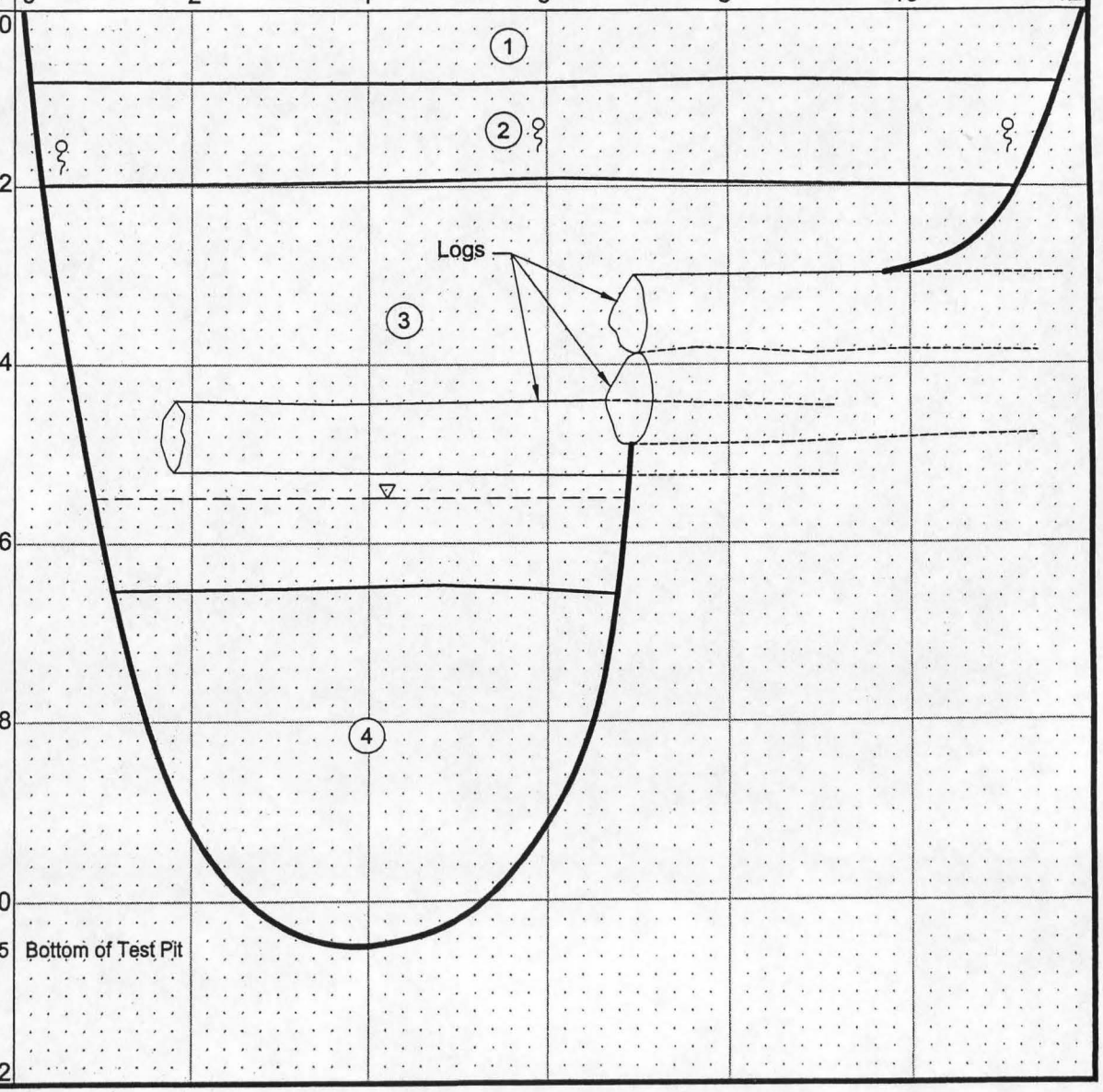



FIG. A-14

File: I:\Drafting\211\08713-005\21-1-08713-005 TP 12-17.dwg Date: 03-19-2002 Author: cnk

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

# LOG OF TEST PIT TP-14

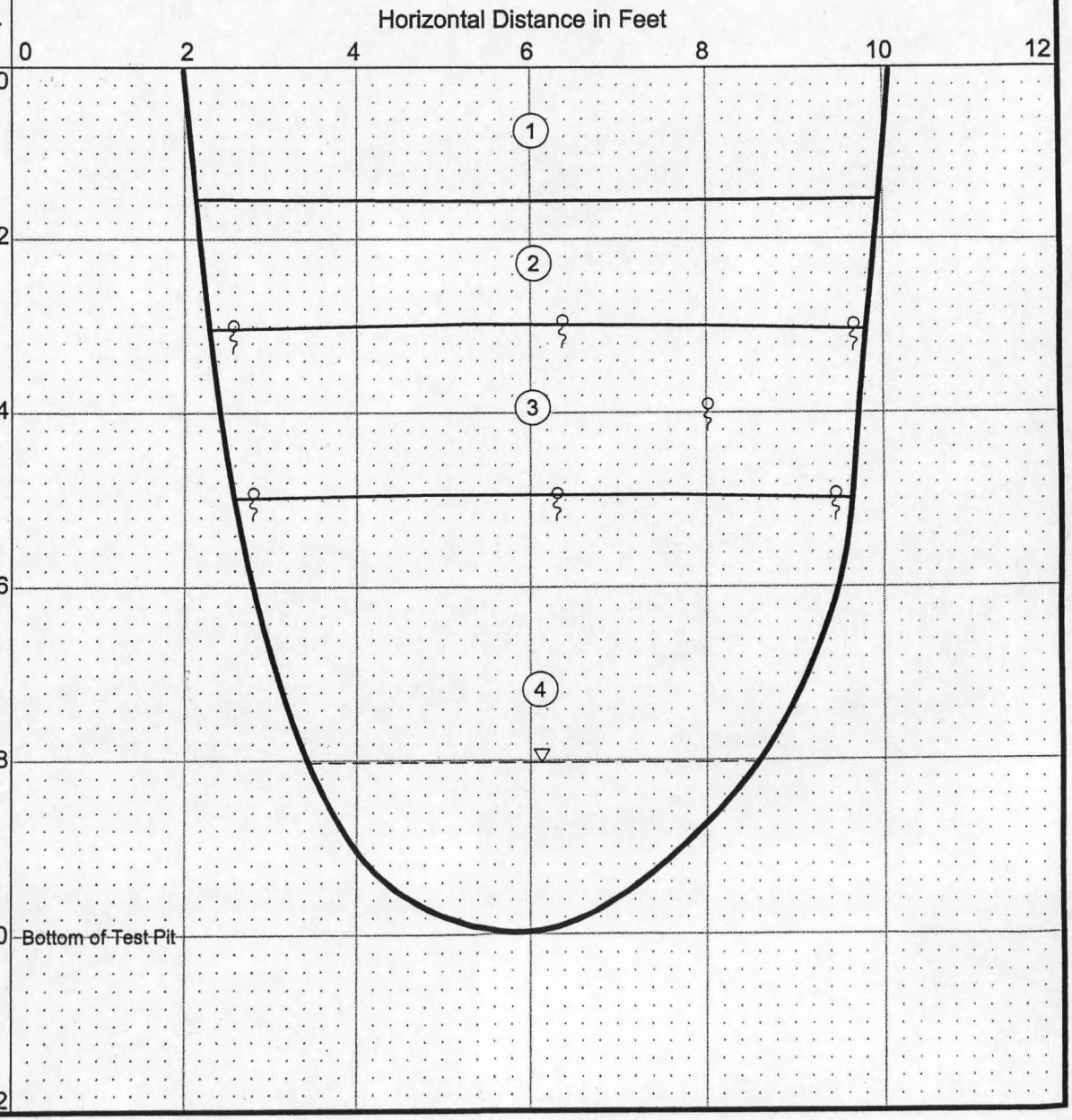
JOB NO: 21-1-08713-005 DATE: 3-1-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| (1) Loose, dark brown, silty, gravelly SAND; moist; occasional wood debris; (Fill) SW-SM. | | | | 0 |
| (2) Loose, brown, silty, gravelly SAND; moist to wet; occasional roots; (Fill) SW-SM. | | | | 2 |
| (3) Loose, blue gray, silty, fine to medium SAND; wet; (Dredge Material) SP-SM. | | | | 4 |
| (4) Soft, gray, clayey SILT, trace of fine to medium sand; wet; numerous organics; scattered roots; (Tidal Mudflat) ML. | | | | 6 |
| | | | S-1 | |
| | ▽ | | | 8 |
| | | | S-2 | |
| | | | | 10 Bottom of Test Pit |
| | | | | 12 |

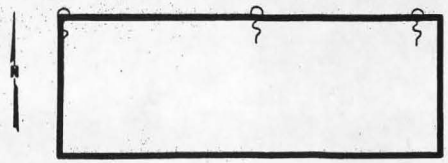
Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




NOTE

Wood debris contained wood chips, sawdust, and lumber scraps.



PLAN VIEW

FIG. A-15

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Geotechnical and Environmental Consultants

# LOG OF TEST PIT TP-15

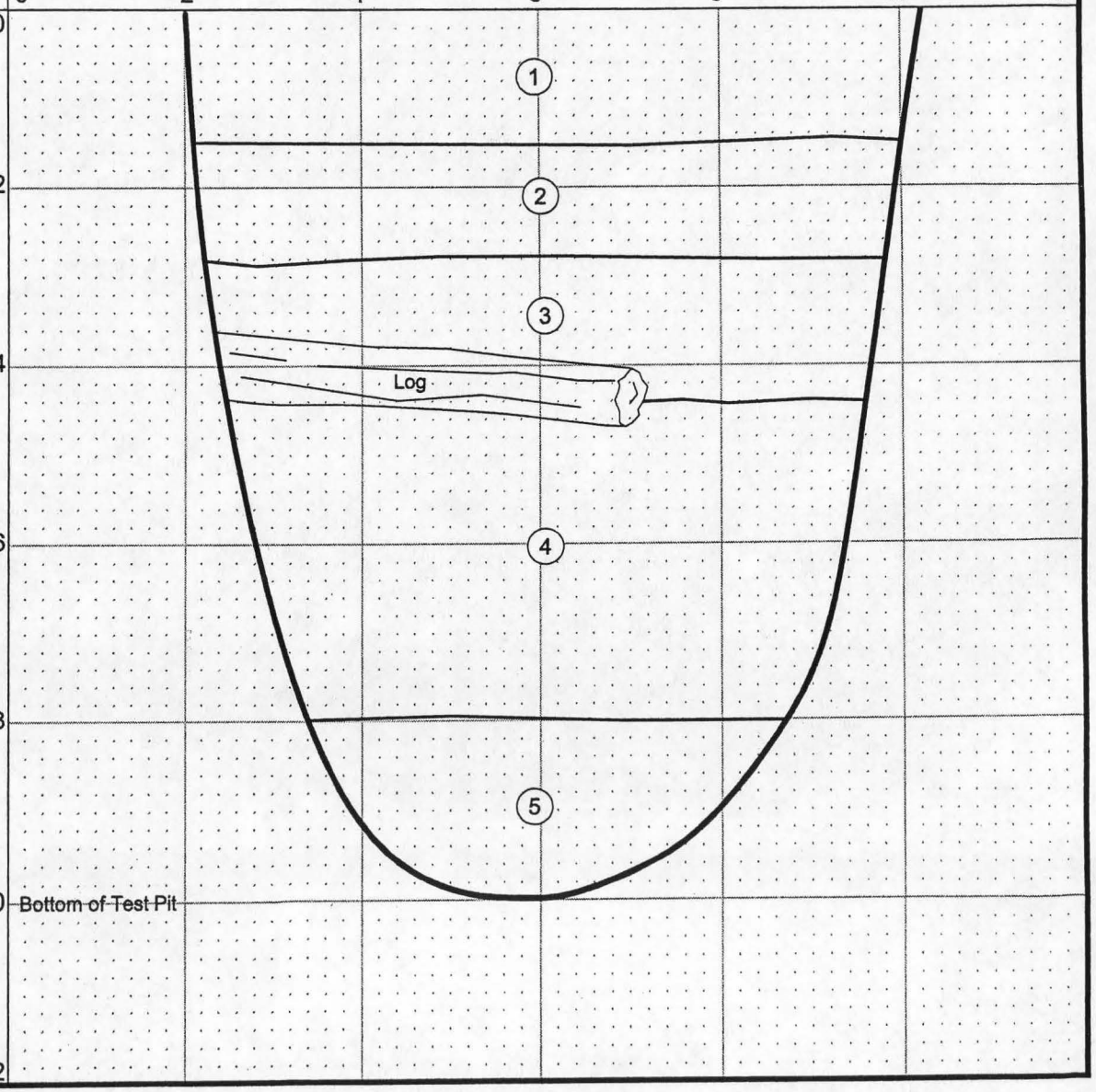
JOB NO: 21-1-08713-005 DATE: 3-1-02 LOCATION: See Site and Exploration Plan

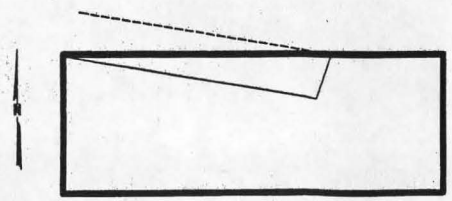
PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| (1) Loose, dark brown, silty, sandy GRAVEL; moist; occasional organics; (fill) GP. | None Observed During Excavation | | | 0 |
| (2) Loose, blue gray, silty, fine to medium SAND; moist; (Dredged Material) SP-SM. | | | | 2 |
| (3) Soft, blue gray, clayey SILT, trace of fine sand; moist; scattered organics; (Dredged Material) ML. | | | S-1 | |
| (4) Soft, gray, clayey SILT; moist; occasional organics; (Tidal Mudflat) ML. | | | | 4 |
| (5) Soft, gray, silty CLAY; moist; scattered organics; (Tidal Mudflat) ML. | | | S-2 | 6 |
| | | | | 8 |
| | | | S-3 | 10 Bottom of Test Pit |
| | | | | 12 |

Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet



PLAN VIEW

FIG. A-16

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**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

# LOG OF TEST PIT TP-16

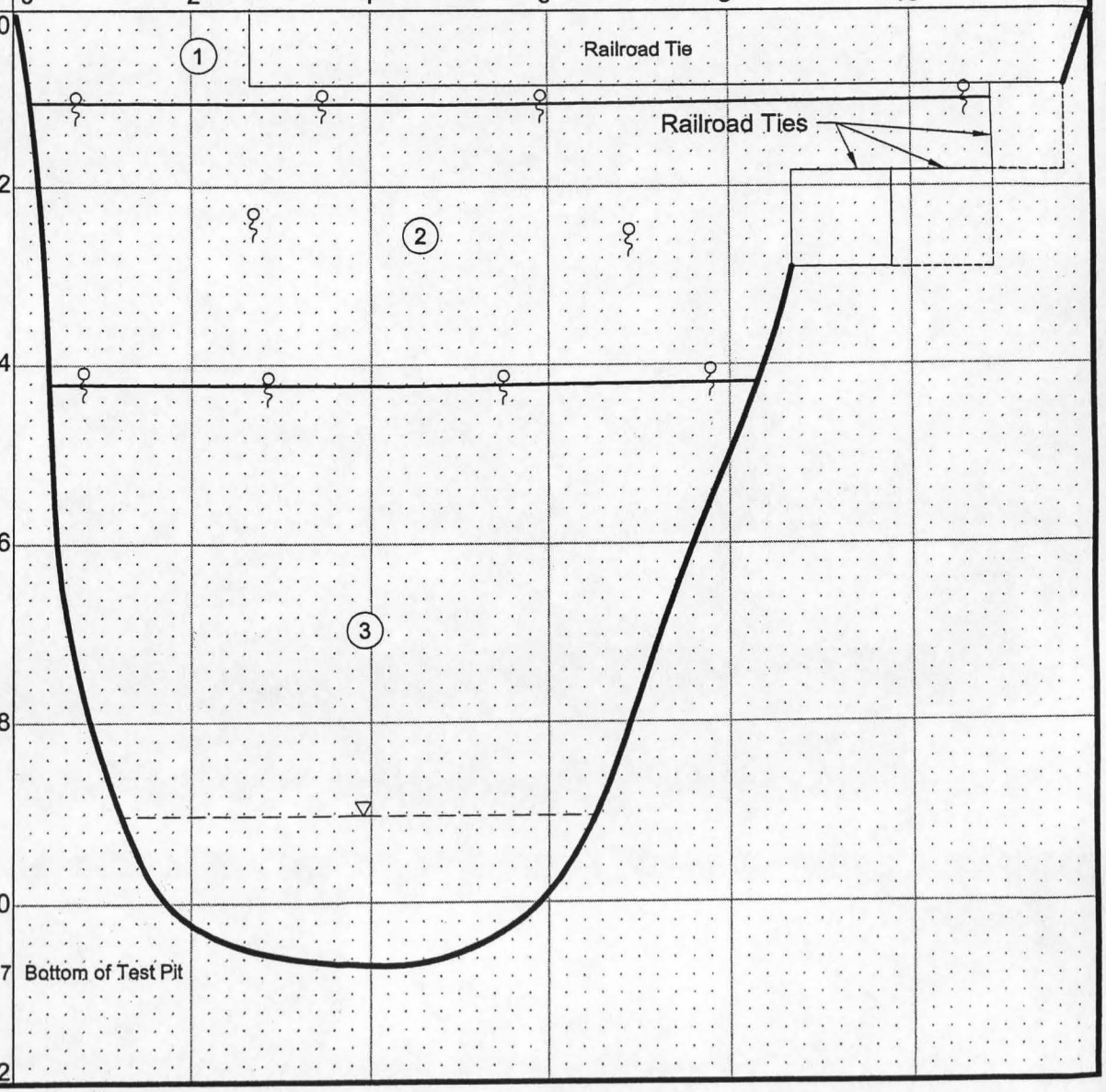
JOB NO: 21-1-08713-005 DATE: 3-1-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| (1) Loose, dark brown, silty, gravelly SAND; moist; numerous organics; (Fill) SW-SM. | | | | |
| (2) Loose, brown, silty, gravelly SAND; wet; numerous wood debris; scattered organics; (Fill) SW-SM. | | | | |
| (3) Soft, gray, clayey SILT, trace of fine sand; moist to wet; occasional wood debris; numerous organics; scattered organics; (Tidal Mudflat) ML. | | | | |
| | | | S-1 | 8 |
| | ▽ | | S-2 | |
| | | | | 10 |
| | | | | 10.7 Bottom of Test Pit |
| | | | | 12 |

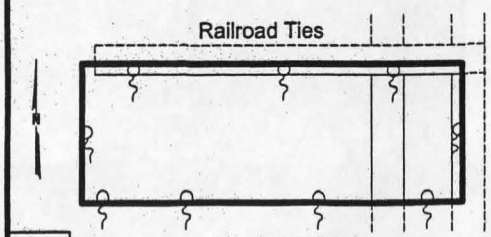
Sketch of North Pit Side

Surface Elevation: Approx. 15 Feet




NOTE

Wood debris contained railroad ties, logs, sawdust, and lumber scraps.




PLAN VIEW

FIG. A-17

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**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

# LOG OF TEST PIT TP-17

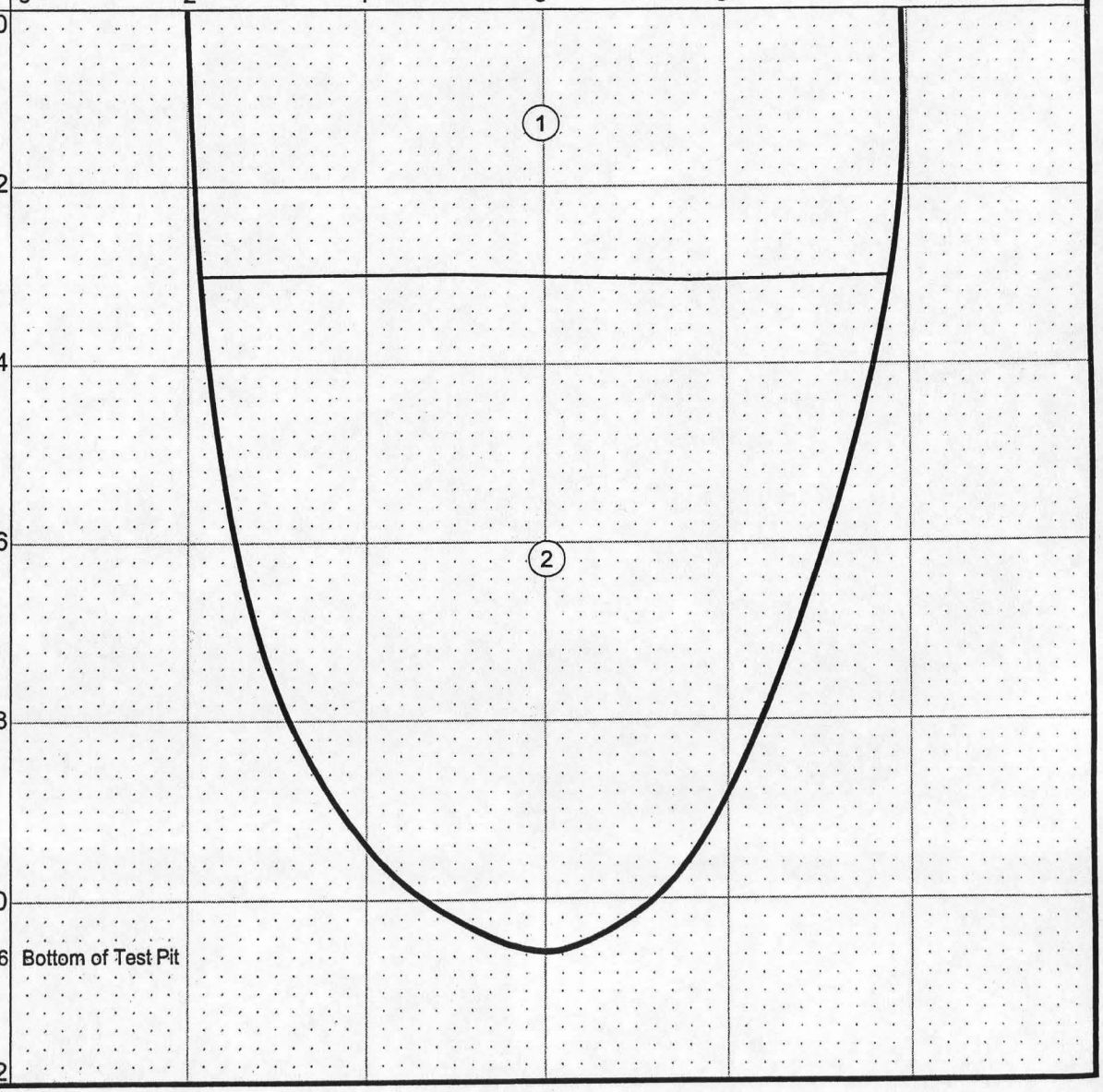
JOB NO: 21-1-08713-005 DATE: 3-1-02 LOCATION: See Site and Exploration Plan

PROJECT: Aberdeen Industrial Water Pipeline Phase II

| SOIL DESCRIPTION | Ground Water | % Water Content | Samples | Depth, Ft. |
|---|---|---|---|---|
| (1) Loose, brown, silty, gravelly SAND; moist; occasional red brick; (Fill) SW-SM. | None Observed During Excavation | | | 0 |
| (2) Soft, gray, clayey SILT; moist; scattered organics; occasional wood debris; 6-inch organic seams at 3 and 5-foot depths; (Tidal Mudflat) ML. | | | S-1 | 2 |
| | | | | 4 |
| | | | | 6 |
| | | | S-2 | 8 |
| | | | | 10 |
| | | | | 10.6 Bottom of Test Pit |
| | | | | 12 |

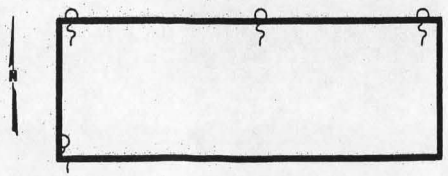
Sketch of South Pit Side

Surface Elevation: Approx. 15 Feet




NOTE

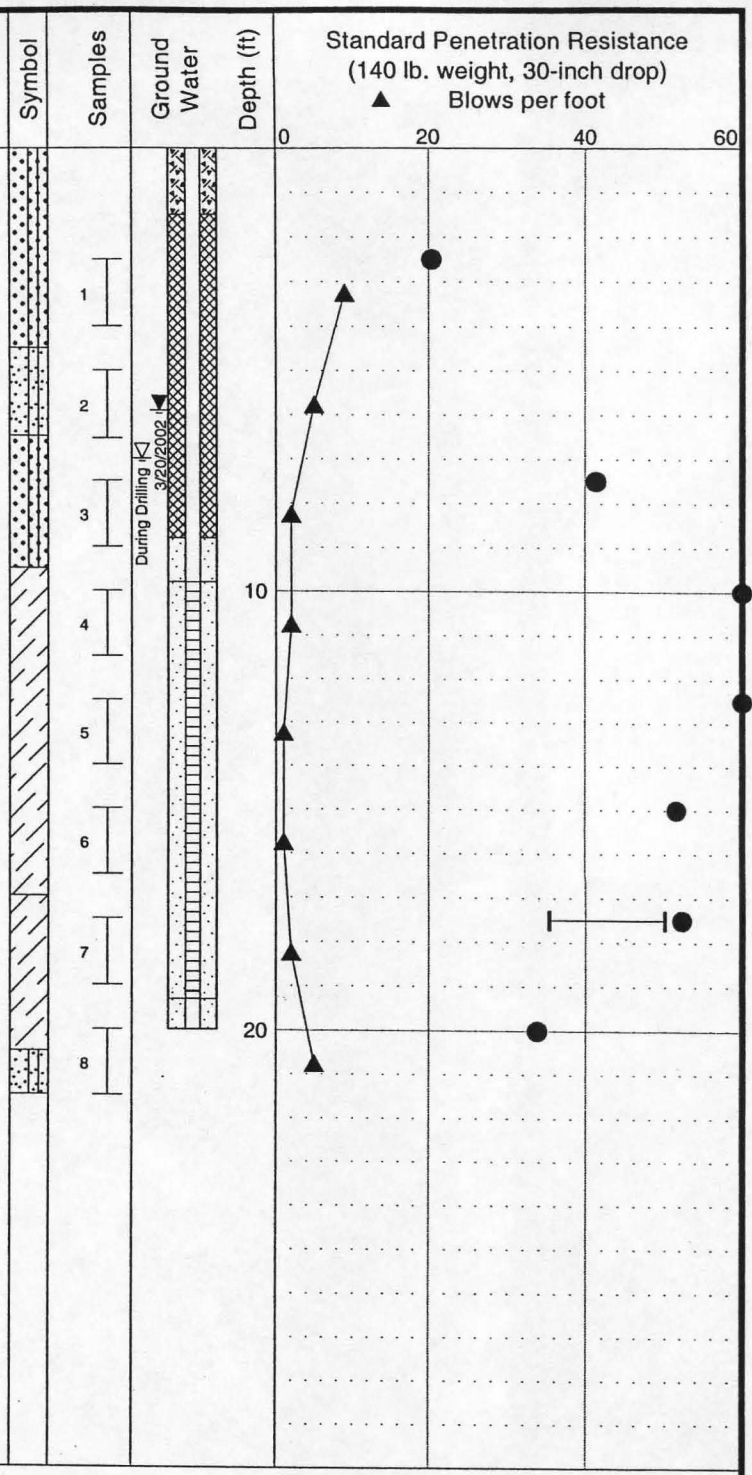
Wood debris contained small diameter logs.




PLAN VIEW

FIG. A-18

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth (ft) |
|---|---|
| Loose, brown, silty, fine gravelly SAND; moist; (Fill) SW-SM. | |
| Loose, gray, silty, fine to medium SAND; wet; (Fill) SP-SM. | 4.5 |
| Loose, brown, silty, fine gravelly SAND; wet; (Fill) SW-SM. | 6.5 |
| Soft to very soft, gray, clayey, slightly fine sandy SILT; moist; scattered to numerous organics; (Tidal mudflats) OH. | 9.5 |
| Soft, gray, slightly clayey, fine sandy, organic SILT; wet; scattered organics; (Tidal mudflats) OH. | 17.0 |
| Loose, gray, slightly clayey, silty, fine to medium SAND; wet; (Alluvial deposit) SP-SM. | 20.5<br>21.5 |
| BOTTOM OF BORING<br>COMPLETED 02/14/2002 | |




LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- Surface Seal
- Annular Sealant
- Piezometer Screen
- 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 materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.

Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

# LOG OF BORING B-1

March 2002 | 21-1-08713-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

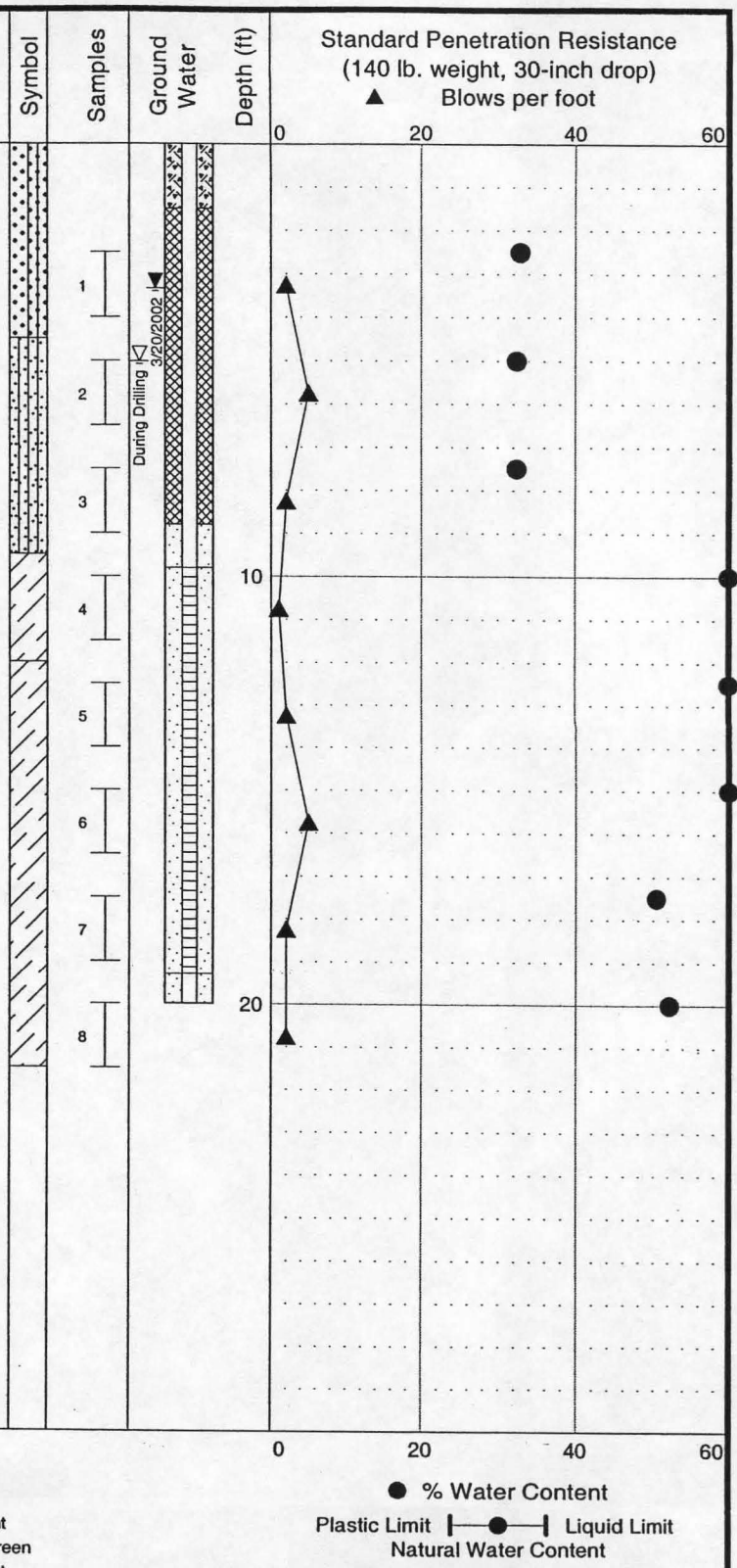
FIG. A-19

MASTER_LOG 21-08713-004.GPJ OLD 2001 SHANWIL TEMPLATE.GDT 3/24/02 Rev: Typ: EET

## SOIL DESCRIPTION

Surface Elevation: Approx. 15 Ft.

| Depth (ft) | Soil Description |
|---|---|
| | Very loose, brown, silty, slightly fine gravelly SAND; moist; (FIII) SW-SM. |
| 4.5 | Loose to very loose, blue-gray, silty, fine to medium SAND; wet; occasional organics; (Dredged material) SM. |
| 9.5 | Very soft, gray, slightly fine sandy, slightly clayey, organic SILT; wet; scattered organics; (Tidal mudflat) OH. |
| 12.0 | Soft gray, slightly fine sandy, slightly clayey, organic SILT; wet; occasional organics; (Tidal mudflat) OH. |
| 21.5 | BOTTOM OF BORING COMPLETED 02/14/2002 |




### LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- Surface Seal
- Annular Sealant
- Piezometer Screen
- 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 materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.

Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

# LOG OF BORING B-2

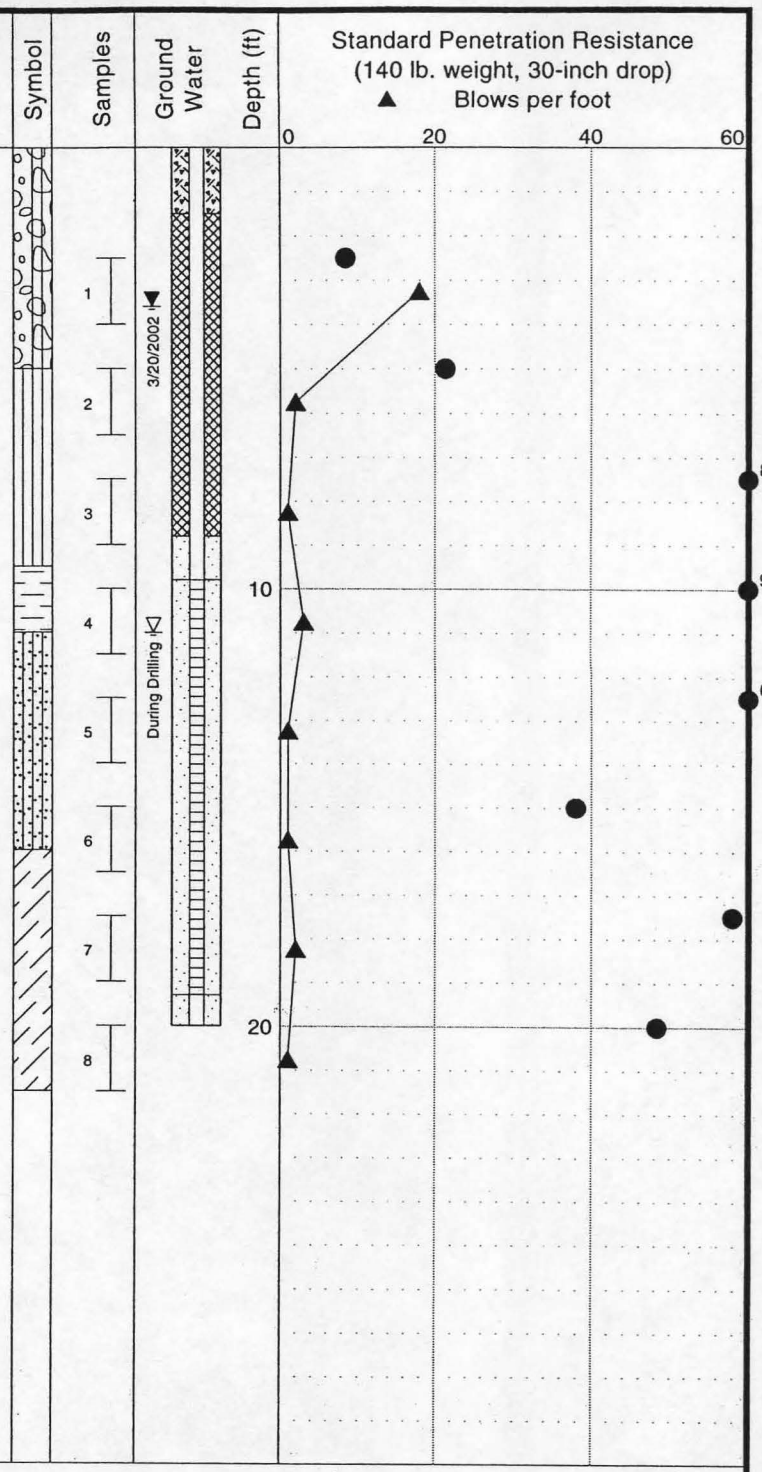
March 2002 | 21-1-08713-004

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. A-20**

MASTER_LOG 21-08713-004.GPJ OLD 2001 SHANWIL TEMPLATE.GDT Rev: Typ: EET

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth (ft) |
|---|---|
| Medium dense, brown, silty, sandy, fine GRAVEL; moist; (Fill) GP-GM. | |
| Soft to very soft, gray, slightly clayey, fine sandy SILT; wet; (Dredged material) ML. | 5.0 |
| Soft, blue-gray, slightly clayey, organic SILT, trace of fine sand; wet; (Dredged material) OL. | 9.5 |
| Loose to very loose, blue-gray, silty, fine SAND; wet; scattered shell fragments and organics; (Dredged material) SM. | 11.0 |
| Soft to very soft, gray, slightly fine sandy, slightly clayey, organic SILT; wet; occasional shell fragments; (Tidal mudflat) OH. | 16.0 |
| BOTTOM OF BORING COMPLETED 02/14/2002 | 21.5 |




LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- Surface Seal
- Annular Sealant
- Piezometer Screen
- 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 materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.

Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

# LOG OF BORING B-3

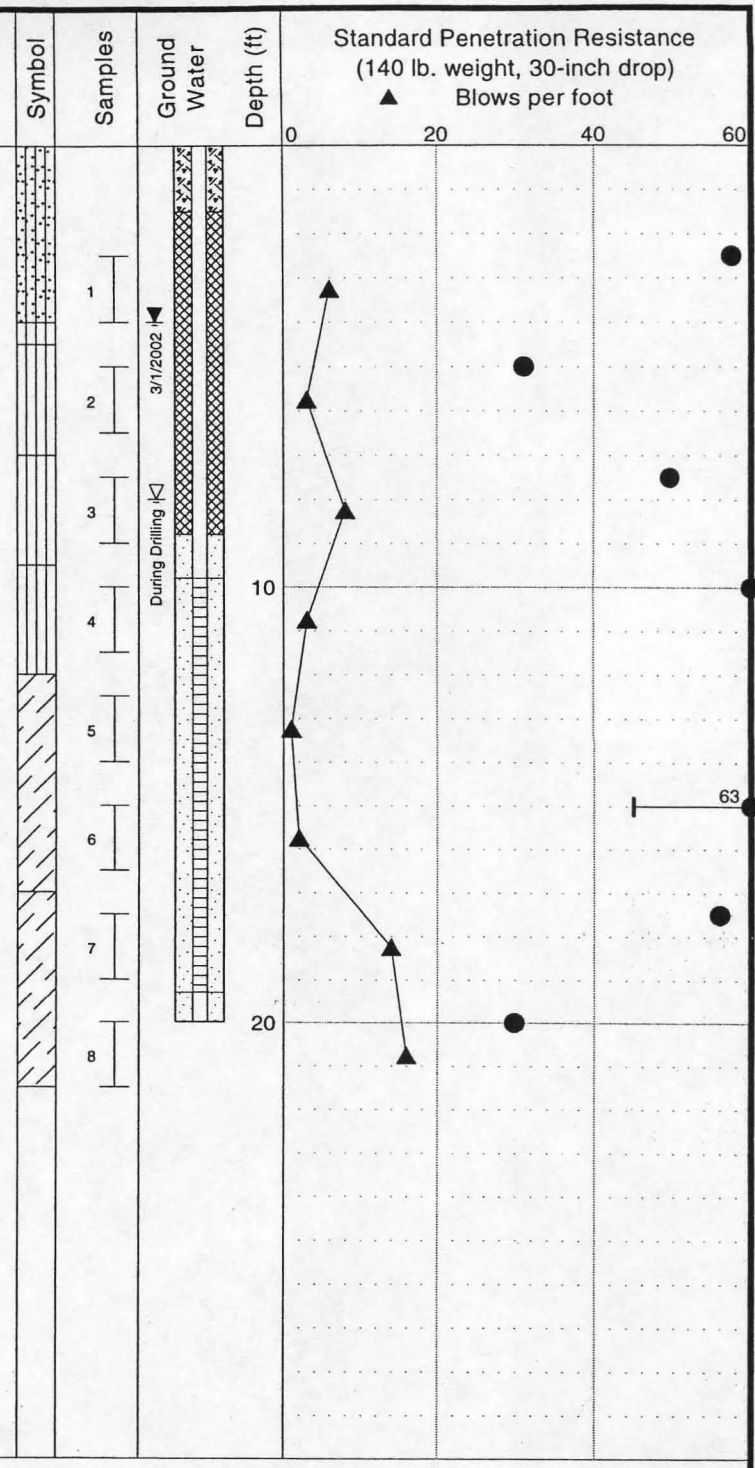
March 2002 21-1-08713-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-21

MASTER LOG 21-08713-004.GPJ OLD 2001 SHANWIL TEMPLATE.GDT 3/21/02 Rev: Typ: EET

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth (ft) |
|---|---|
| Loose, brown, silty, gravelly SAND; moist; scattered organics; (Fill) SM. | |
| Medium stiff, gray, slightly clayey, slightly fine sandy SILT; moist; (Tidal mudflat) ML. | 4.0 |
| Soft, gray, slightly clayey, slightly fine sandy SILT; moist; numerous organics; (Tidal mudflat) ML. | 4.5 |
| Medium stiff, gray, fine sandy SILT; wet; organics, wood debris (possible log); ML. | 7.0 |
| Soft, gray, fine sandy SILT; wet; organics; (Tidal mudflat) ML. | 9.5 |
| Very soft to soft, gray, slightly clayey, organic SILT, trace of fine sand; wet; scattered organics; (Tidal mudflat) OH. | 12.0 |
| Stiff to very stiff, gray, slightly fine sandy, slightly clayey, organic SILT; moist; occasional shell fragments; (Tidal mudflat) OH. | 17.0 |
| BOTTOM OF BORING COMPLETED 02/15/2002 | 21.5 |




LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- Surface Seal
- Annular Sealant
- Piezometer Screen
- 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 materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.

Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

# LOG OF BORING B-4

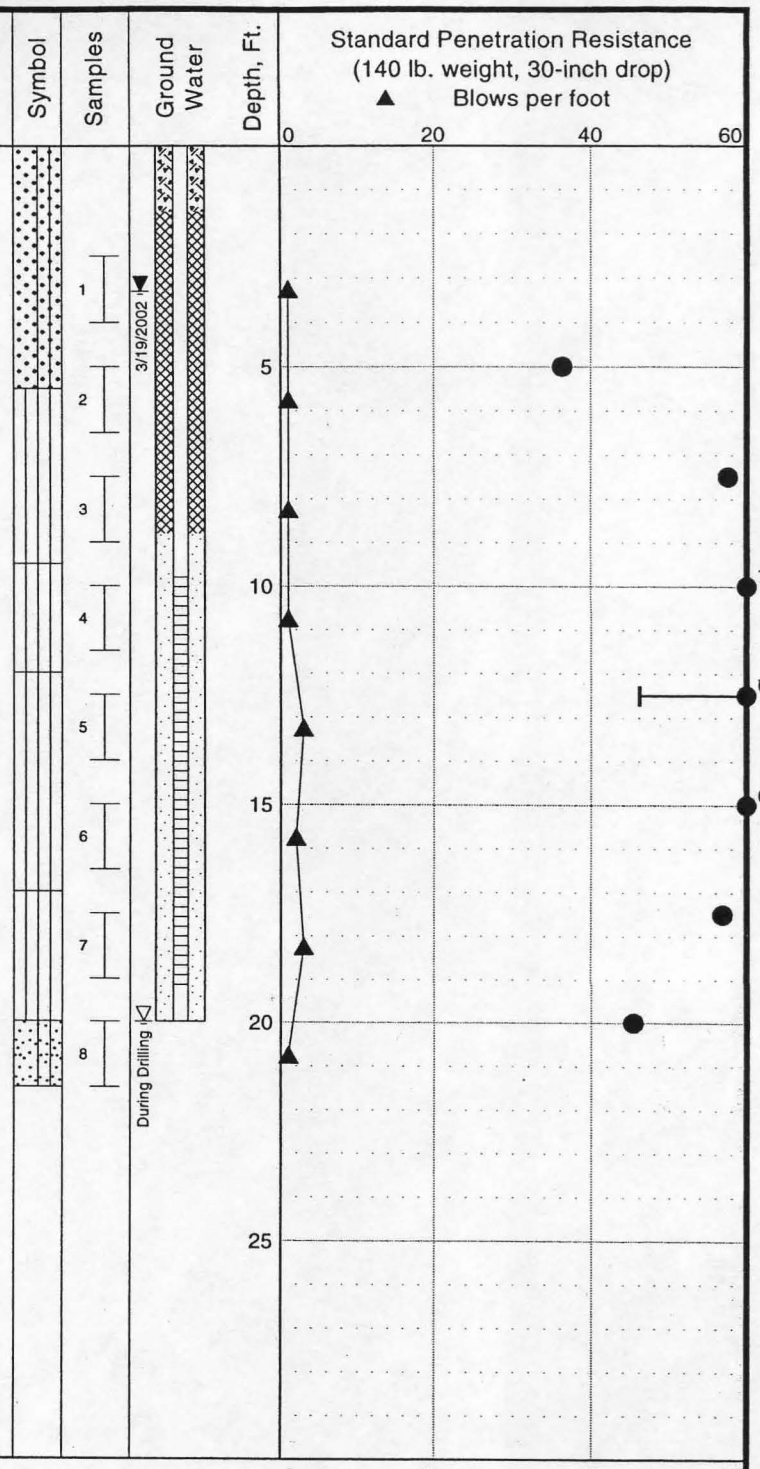
March 2002 21-1-08713-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-22

MASTER_LOG 21-08713-004.GPJ OLD 2001 SHANWIL TEMPLATE.GDT 4/24/02 Rev: Typ: EET

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Very loose, brown, silty, fine gravelly SAND; moist; scattered organics; (Fill) SW-SM. | |
| Very soft, gray, slightly fine to medium sandy, clayey SILT; moist; trace of fine gravel; occasional organics; wood debris at 8.5 feet; (Tidal mudflat) ML. | 5.5 |
| Very soft, gray, slightly fine sandy, clayey SILT; moist; scattered organics; (Tidal mudflat) ML. | 9.5 |
| Soft, gray, clayey SILT; moist; occasional organics; (Tidal mudflat) ML. | 12.0 |
| Soft, gray, clayey SILT; moist; trace of fine sand; (Tidal mudflat) ML. | 17.0 |
| Very loose, gray, silty, fine to medium SAND; wet; SP-SM. | 20.0 |
| BOTTOM OF BORING<br>COMPLETED 2/28/2002 | 21.5 |




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
- ● % Water Content
- Plastic Limit ├─●─┤ Liquid Limit
- Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-5

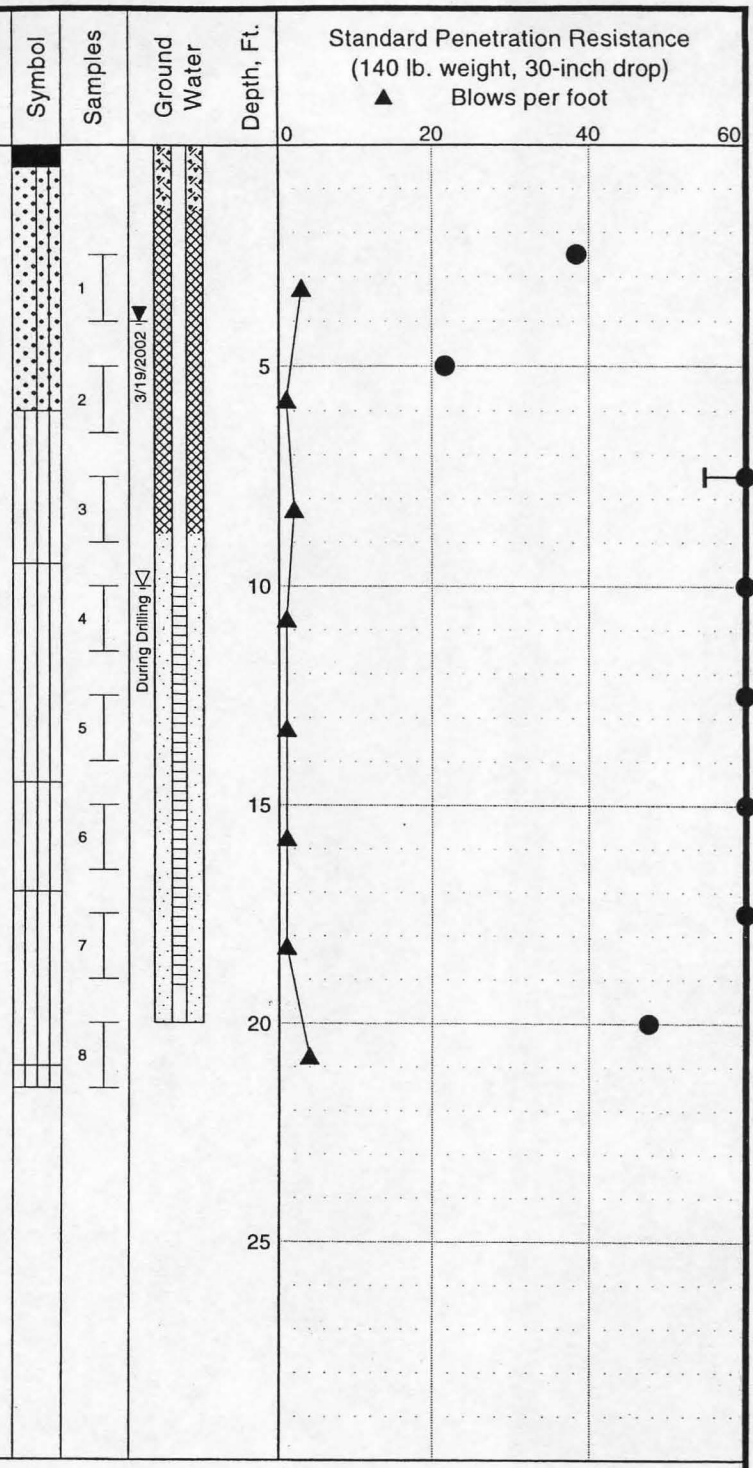
March 2002 | 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. A-23**

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Asphalt. | 0.5 |
| Very loose, brown, silty, gravelly SAND; moist; trace of organics; SW-SM. | 6.0 |
| Soft, gray, slightly fine sandy, silty CLAY; moist; occasional organics; (Tidal mudflat) ML. | 9.5 |
| Very soft, gray, clayey SILT; wet; occasional organics; scattered fine to medium sand seams; (Tidal mudflat) ML. | 14.5 |
| Very soft, gray, slightly fine sandy, clayey SILT; wet; occasional organics; (Tidal mudflat) ML. | 17.0 |
| Very soft, gray, clayey SILT; wet; (Tidal mudflat) ML. | 21.0 |
| Soft to medium stiff, gray, slightly clayey SILT; moist; occasional organics; wood debris; trace of fine sand; (Tidal mudflat) ML. | 21.5 |
| BOTTOM OF BORING<br>COMPLETED 2/28/2002 | |




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
- ● % Water Content
- Plastic Limit ├─●─┤ Liquid Limit
- Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-6

March 2002 | 21-1-08713-005

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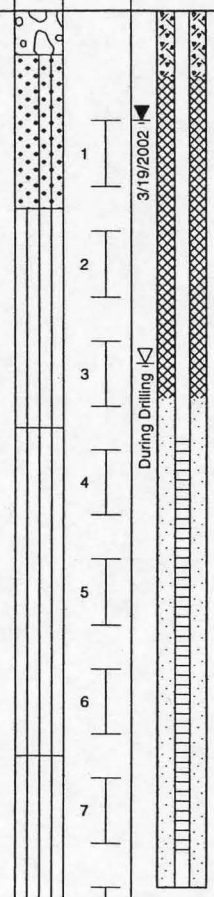
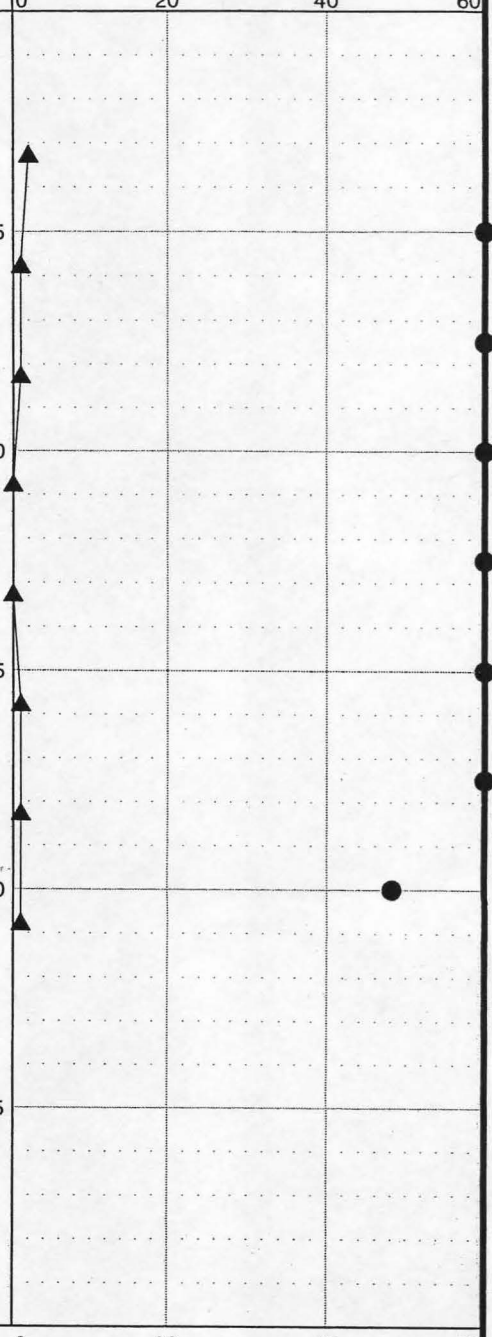
FIG. A-24

MASTER LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Dense, gray Quarry spall (3- to 6-inch) mixed with silty, sandy GRAVEL; moist; (Fill) GP. | 1.0 |
| Loose, brown, silty, gravelly SAND; moist; trace of organics; SW-SM. | 4.5 |
| Very soft, gray, slightly fine sandy, slightly clayey SILT; moist to wet; occasional organics; (Tidal mudflat) ML. | 9.5 |
| Very soft, gray, trace to slightly fine sandy, clayey SILT; moist to wet; numerous organics from 9.5 to 12 feet; (Tidal mudflat) ML. | 17.0 |
| Very soft, gray, slightly fine sandy, slightly clayey to clayey SILT; wet; occasional organics; wood debris at 18.5 feet; (Tidal mudflat) ML. | 21.5 |
| BOTTOM OF BORING<br>COMPLETED 2/26/2002 | |




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

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-7

March 2002 | 21-1-08713-005

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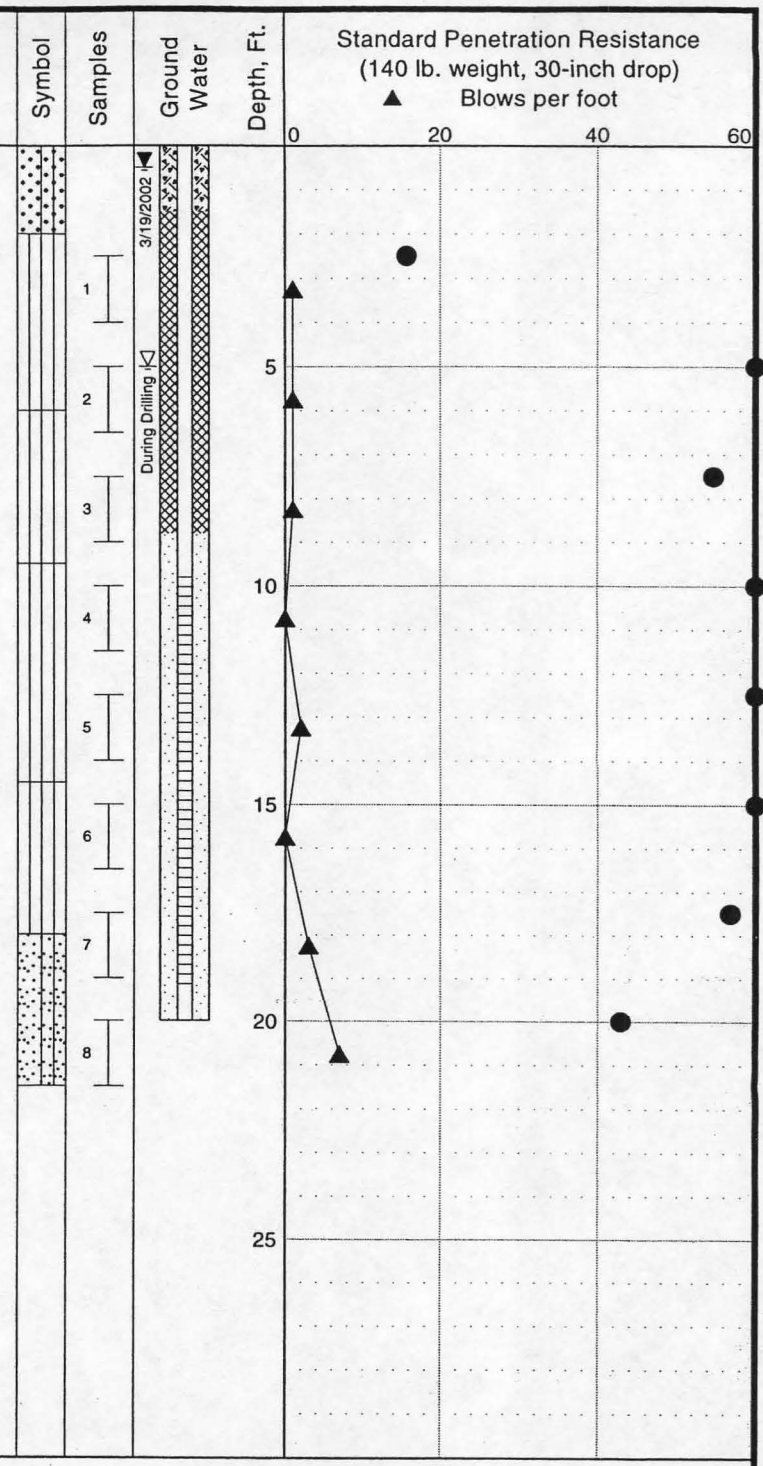
FIG. A-25

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Very l oose, brown, silty, fine gravelly SAND; moist; (Fill) SW-SM. | 2.0 |
| Very soft, gray, slightly fine gravelly, slightly sandy, clayey SILT; moist; oxidation (rust coloring); scattered organics; (Tidal mudflat) ML. | 6.0 |
| Very soft, gray, clayey SILT; wet; trace of fine gravel and fine to medium sand; scattered organics; (Tidal mudflat) ML. | 9.5 |
| Very soft to soft, gray, slightly fine sandy, clayey SILT; wet; numerous organics; (Tidal mudflat) ML. | 14.5 |
| Very soft, gray, slightly fine sandy, clayey SILT; wet; occasional organics; (Tidal mudflat) ML. | 18.0 |
| Very loose to loose, gray, slightly clayey, silty, fine to medium SAND; wet; occasional organics; SP-SM. | 21.5 |
| BOTTOM OF BORING<br>COMPLETED 2/26/2002 | |




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
- ● % Water Content
- Plastic Limit ├─●─┤ Liquid Limit
- Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-8

March 2002 | 21-1-08713-005

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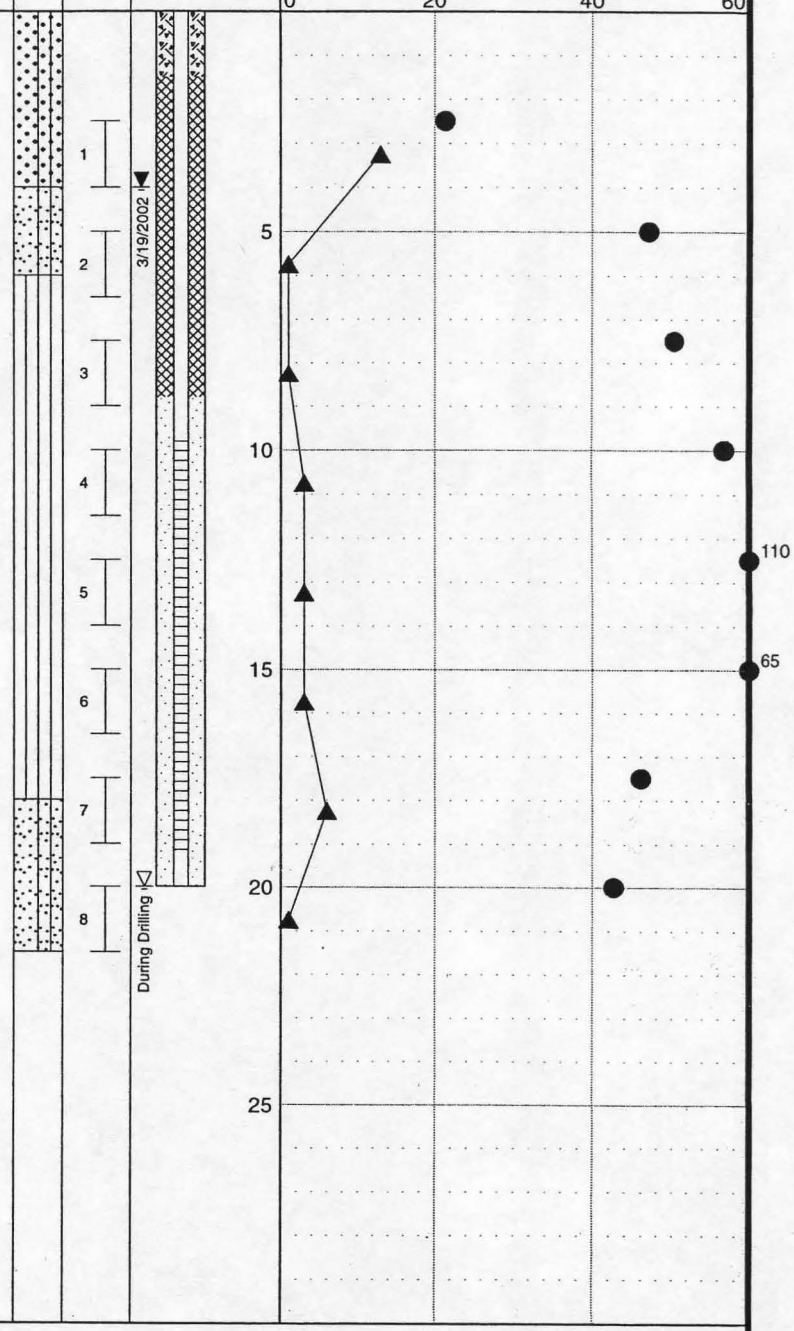
FIG. A-26

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

## SOIL DESCRIPTION

Surface Elevation: Approx. 15 Ft.

| Description | Depth, Ft. |
|---|---|
| Medium dense, brown, silty, slightly gravelly SAND; moist; occasional organics; (fill) SW-SM. | 4.0 |
| Very loose, blue-gray, slightly clayey, silty, fine to medium SAND; moist; (Dredged material) SP-SM. | 6.0 |
| Very soft to soft, gray, clayey SILT; moist; scattered organics; wood debris from 12 to 16 feet; (Tidal mudflat) ML. | 18.0 |
| Loose to very loose, gray, silty, fine to medium SAND; moist to wet; SP-SM. | 21.5 |
| BOTTOM OF BORING COMPLETED 2/26/2002 | |




### 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
- ● % Water Content
- Plastic Limit ├─●─┤ Liquid Limit
- Natural Water Content

### NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-9

March 2002 | 21-1-08713-005

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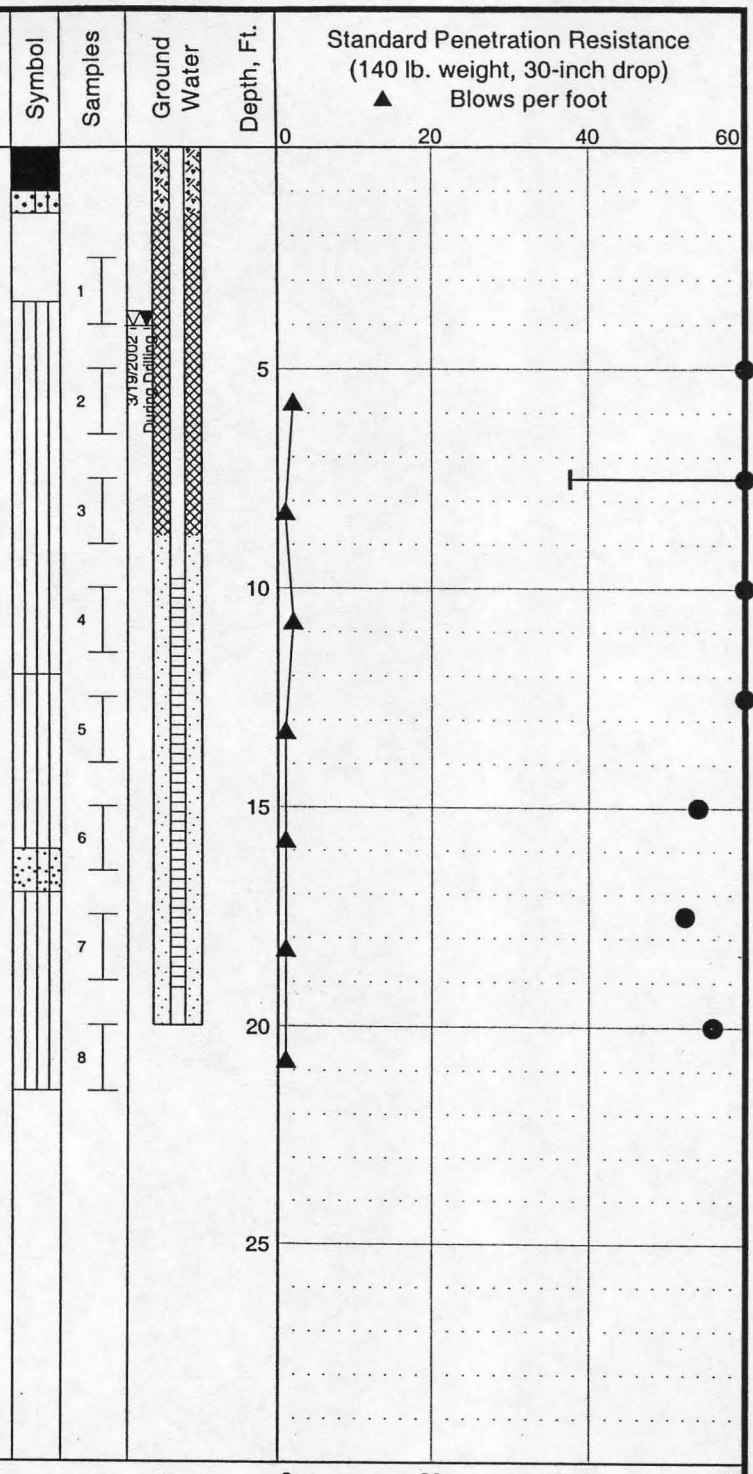
**FIG. A-27**

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Asphalt. | |
| Loose, dark brown, silty, gravelly SAND; moist; (Fill) SW-SM. | 1.0 |
| Wood debris. | 1.5 |
| Very soft to soft, gray, silty CLAY; wet; scattered organics; (Tidal mudflat) ML. | 3.5 |
| Very soft, gray, clayey SILT; wet; scattered organics; (Tidal mudflat) ML. | 12.0 |
| Very loose, gray, slightly clayey, silty, fine to medium SAND; wet; (Alluvial deposit) SP-SM. | 16.0 |
| Very soft, gray, slightly fine sandy to trace fine sandy, clayey SILT; wet; (Tidal mudflat) ML. | 17.0 |
| BOTTOM OF BORING COMPLETED 2/27/2002 | 21.5 |




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

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-10

March 2002 | 21-1-08713-005

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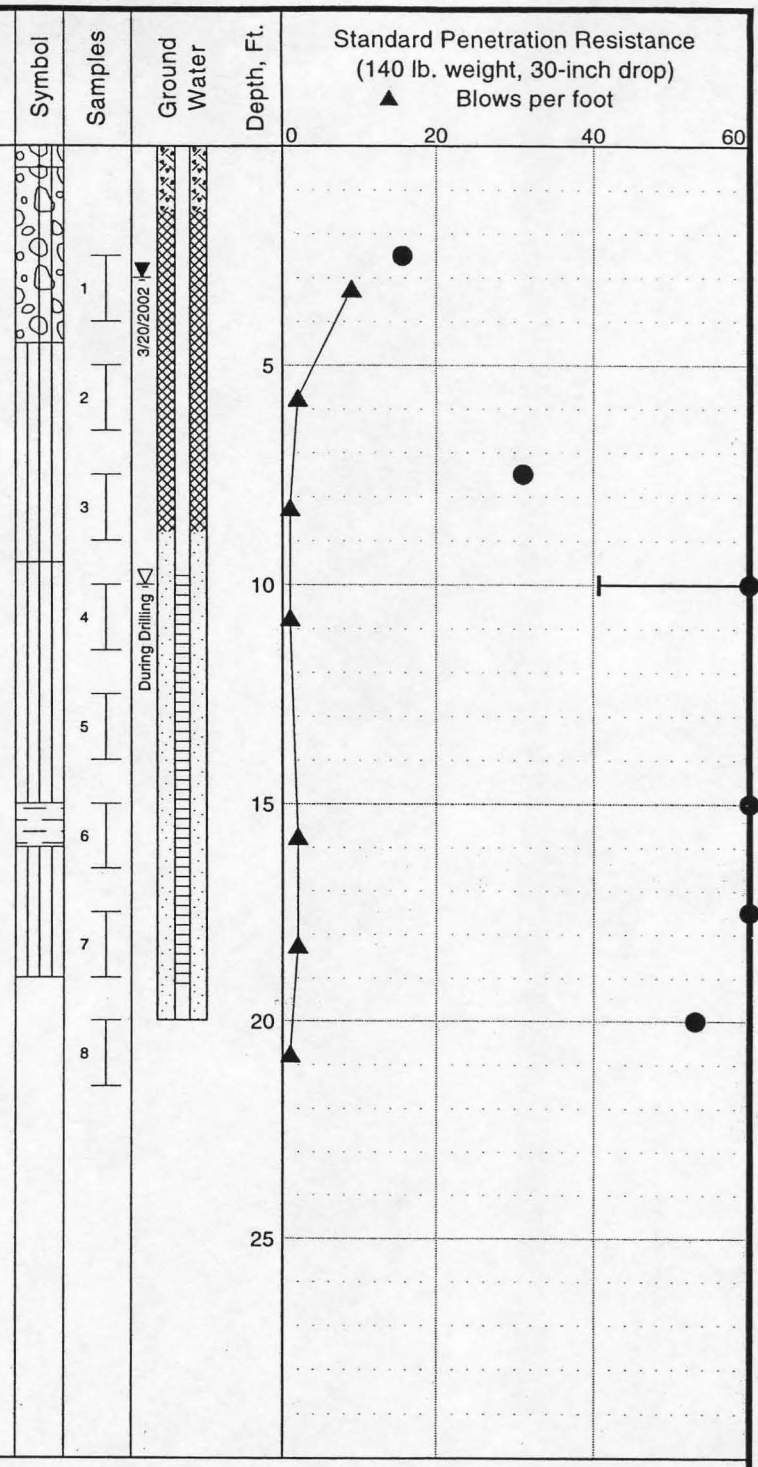
FIG. A-28

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Medium dense, dark brown, silty, sandy GRAVEL; moist; (Fill) GP-GM. | 0.5 |
| Loose, gray, slightly silty, sandy GRAVEL; moist; (Fill) GP-GM. | 4.5 |
| Very soft, gray, slightly fine sandy, slightly clayey SILT; moist; scattered organics; (Tidal mudflat) ML. | 9.5 |
| Very soft, gray, silty CLAY; moist; scattered organics; wood debris from 10 to 12 feet; (Tidal mudflat) ML. | 15.0 |
| Very soft, dark brown, organic SILT; moist; (Tidal mudflat) OL. | 16.0 |
| Soft to very soft, gray, clayey to slightly clayey SILT; moist; scattered organics; wood debris from 18 to 19 feet; ML. | 19.0 |
| BOTTOM OF BORING<br>COMPLETED 2/27/2002 | |




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
- ● % Water Content
- Plastic Limit ├─●─┤ Liquid Limit
- Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-11

March 2002 | 21-1-08713-005

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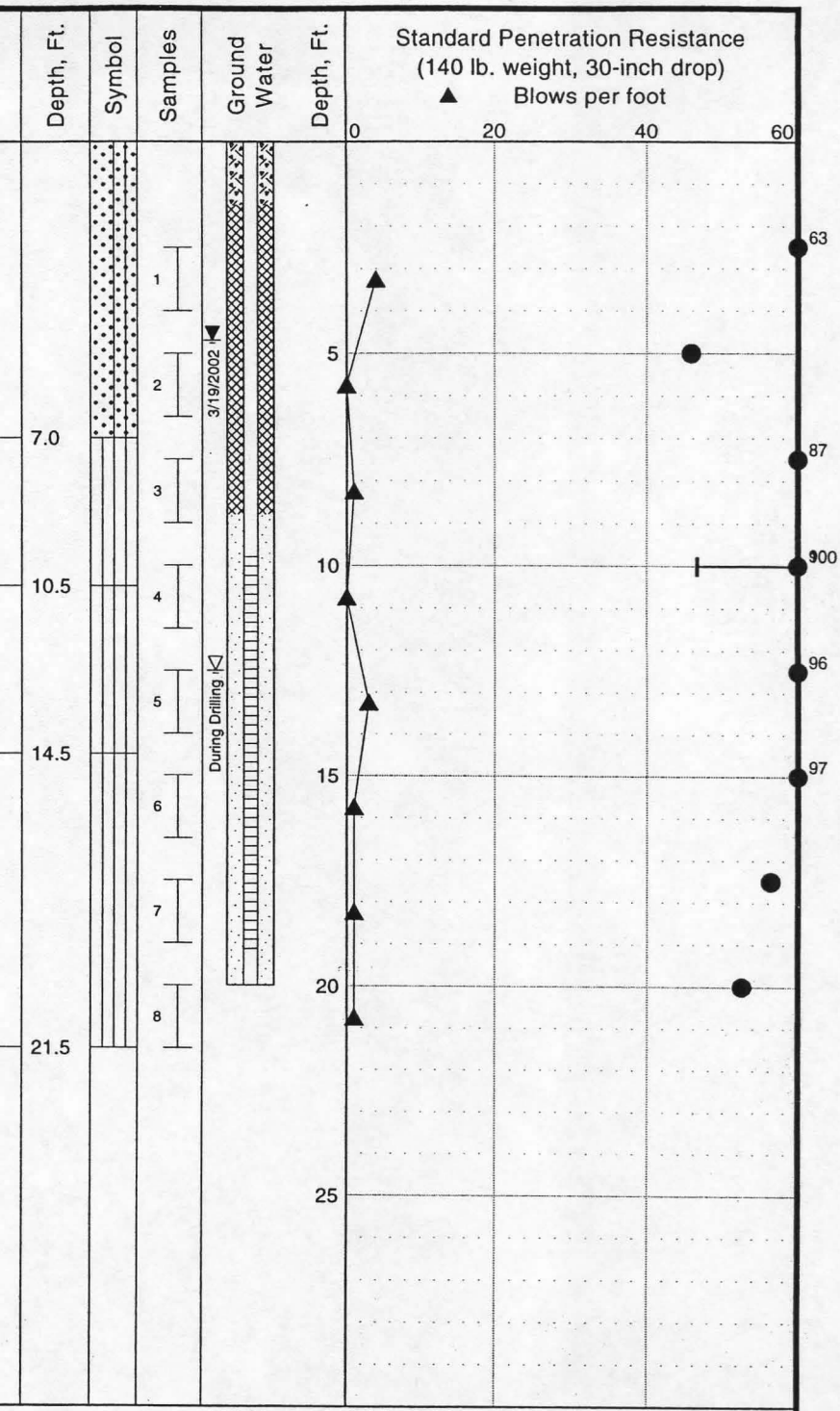
FIG. A-29

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

| SOIL DESCRIPTION<br>Surface Elevation: Approx. 15 Ft. | Depth, Ft. |
|---|---|
| Loose, dark brown, silty, gravelly to slightly gravelly SAND; moist; occasional organics; (Fill) SW-SM. | |
| Very soft, gray, slightly fine sandy, clayey SILT; moist; scattered organics; wood debris; (Tidal mudflat) ML. | 7.0 |
| Very soft, gray, slightly fine sandy, silty CLAY; moist; occasional organics; wood debris at approximately 14 feet; (Tidal mudflat) ML. | 10.5 |
| Very soft, gray, slightly fine sandy, clayey SILT; moist; scattered to occasional organics; wood debris from 14.5 to 16 feet; ML. | 14.5 |
| BOTTOM OF BORING<br>COMPLETED 2/27/2002 | 21.5 |




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

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

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

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

# LOG OF BORING B-12

March 2002 | 21-1-08713-005

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**FIG. A-30**

MASTER_LOG2 21-08713-005.GPJ SHAN_WIL.GDT 3/21/02 Log: JXM Rev: JXM Typ: LKD

## BORING NO. 89-1

| Depth in Feet | Lab Tests | Moisture Content | Dry Density | Blow-Count | Samples | Group Symbol | Description |
|---|---|---|---|---|---|---|---|
| | | | | | | | Surface Elevation: 18.6 FEET |
| 0 | | | | | | ML | LIGHT BROWN ORGANIC SILT WITH GRAVEL (MEDIUM STIFF TO VERY STIFF, MOIST) |
| | | | | 27 | □ | | |
| 5 | M | 123 | | 25 | ■ | | |
| | | | | 4 | ■ | SM | GRAY SILTY FINE SAND (LOOSE, MOIST TO WET) |
| 10 | | | | 3 | □ | | |
| | | | | | | ML | GRAY SILT WITH ORGANICS (MEDIUM STIFF, MOIST) |
| 15 | MD | 89 | 48.3 | 7 | ■ | | |
| 20 | | | | | | | BORING COMPLETED AT 16.5 FEET ON 6/14/89<br>GROUND WATER ENCOUNTERED AT 10.0 FEET |

DEPTH IN FEET

Note: See Figure A-2 for Explanation of Symbols

GeoEngineers

LOG OF BORING

FIGURE A-3

102-30-3 NLP:JEB:RBK 6/30/89

# BORING NO. 89-9

Surface Elevation: 21.5 FEET

| Depth in Feet | Lab Tests | Moisture Content | Dry Density | Blow-Count | Samples | Group Symbol | Description |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | SM | BROWN SILTY FINE SAND WITH ROOTS, WOOD DEBRIS AND OCCASIONAL GRAVEL (LOOSE, MOIST) |
| | M | 47 | | 25 | ■ | ML | GRAY SILT WITH ORGANICS AND OCCASIONAL GRAVEL INTERBEDDED WITH GRAY SILTY FINE SAND (VERY STIFF, MOIST) |
| 5 | | | | 50/5" | ⊠ | GP | GRAY FINE GRAVEL WITH SAND AND FINE SILT (DENSE, WET) |
| 10 | | | | | | SP-SM | DARK GRAY FINE SAND WITH SILT (LOOSE, WET) |
| | | | | 9 | ■ | ML | GRAY SILT WITH OCCASIONAL WOOD CHIPS, ORGANIC DEBRIS AND A TRACE OF SAND (STIFF TO MEDIUM STIFF, WET) |
| 15 | M | 68 | | 5 | ■ | | |
| 20 | | | | 10 | ■ | | |
| 25 | MD | 45 | 74.5 | 9 | ■ | | |
| 30 | | | | 5 | ■ | | |
| 35 | MD | 48 | 72.1 | 7 | ■ | | |
| 40 | | | | | | | |

Note: See Figure A-2 for Explanation of Symbols

Geo Engineers

LOG OF BORING

FIGURE A-11

02-30-3 NLP:JEB:RBK 6/30/89

## BORING NO. 89-9
(Continued)

| DEPTH IN FEET | Lab Tests | Moisture Content | Dry Density | Blow-Count | Samples | Group Symbol | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 40 | | | | | | | |
| | | | | 7 | ■ | | |
| 45 | | | | | | | |
| | MD | 51 | 70.6 | 8 | ■ | | |
| 50 | | | | | | | |
| | | | | 12 | ⊠ | | |
| 55 | | | | | | | |
| | | | | | | SM | GRAY SILTY FINE SAND (MEDIUM DENSE, WET) |
| | MD | 37 | 83.3 | 20 | ■ | | |
| 60 | | | | | | | |
| | | | | | | ML | GRAY SILT WITH A TRACE OF SAND (STIFF, WET) |
| | | | | 18 | ■ | | |
| 65 | | | | | | | |
| | MD | 54 | 67.1 | 12 | ■ | | |
| 70 | | | | | | | |
| | | | | | | SM | GRAY SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, WET) |
| | | | | 19 | ■ | | |
| 75 | | | | | | | |
| | MD | 40 | 78.7 | 19 | ■ | | |
| 80 | | | | | | | |

Note: See Figure A-2 for Explanation of Symbols

Geo Engineers

LOG OF BORING

FIGURE A-12

102-30-3 NLP:JEB:RBK 6/30/89

## BORING NO. 89-9
(Continued)

| DEPTH IN FEET | TEST DATA: Lab Tests | Moisture Content | Dry Density | Blow-Count | Samples | Group Symbol | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| 80 | | | | | | ML | GRAY SILT WITH A TRACE OF SAND (STIFF, WET) |
| | | | | 14 | ■ | | |
| 85 | | | | | | | |
| | | | | 12 | ■ | | |
| 90 | | | | | | | |
| | | | | 21 | ■ | | |
| 95 | | | | | | | |
| | MD | 49 | 70.7 | 12 | ■ | | |
| 100 | | | | | | | |
| | | | | 15 | ■ | | |
| 105 | | | | | | SP-SM | GRAY FINE TO MEDIUM SAND WITH SILT, GRAVEL AND WOOD CHIPS (VERY DENSE, WET) |
| | MD | 19 | 106.6 | 63 | ■ | | |
| 110 | | | | | | | |
| | | | | 89 | ■ | | |
| 115 | | | | | | | |

BORING COMPLETED AT 114.0 FEET ON 6/17/89
GROUND WATER ENCOUNTERED AT 5.0 FEET

Note: See Figure A-2 for Explanation of Symbols

Geo Engineers

LOG OF BORING

FIGURE A-13

102-30-3 NLP:JEB:RBK 6/30/89

# Appendix B

# APPENDIX B

# GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

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# APPENDIX B

# GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

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| B-3 | Grain Size Distribution |
| B-4 | Grain Size Distribution |


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# APPENDIX B

# GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

## B.1 VISUAL CLASSIFICATION

Each of the soil samples recovered from the test pits and borings was visually reclassified in our 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). These ASTM standards use the Unified Soil Classification System (USCS). The USCS is described on Figure A-1. The visual classification made using this system allows for convenient and consistent comparison of soils from widespread geographic areas.

The individual sample classifications have been incorporated into the test pit and boring logs presented on Figures A-2 through A-30.

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## B.2 WATER CONTENT DETERMINATION

The natural water content of all soil samples recovered from the field explorations was determined in general accordance with ASTM Designation D 2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of natural water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength.

Water contents are plotted on the test pit and boring logs.

## B.3 SIEVE ANALYSIS

Grain-size analyses were performed on selected samples in general accordance with ASTM Designation D 422, Standard Method for Particle-Size Analysis of Soils. Three general procedures to determine the grain-size distribution of a soil sample include sieve analysis, hydrometer analysis, and combined analysis. For this project, only sieve analyses were performed.

Grain-size distribution is used to assist in classifying soils and to provide correlation with soil properties including permeability, capillary action, and sensitivity to moisture. Results of the grain-size analyses are plotted on grain-size distribution curves presented in Figures B-3 and B-4. Along with each grain-size distribution is a tabulated summary containing the sample classification, percentage of fines passing the No. 200 sieve, and natural water content.

## B.4 ATTERBERG LIMITS DETERMINATION

Atterberg limits tests were performed on selected fine-grained samples to determine soil plasticity. The tests were performed 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). The results of these tests are shown graphically on the boring logs in Appendix A, and plotted on the Plasticity Chart (Figures B-1 and B-2) presented in Appendix B.

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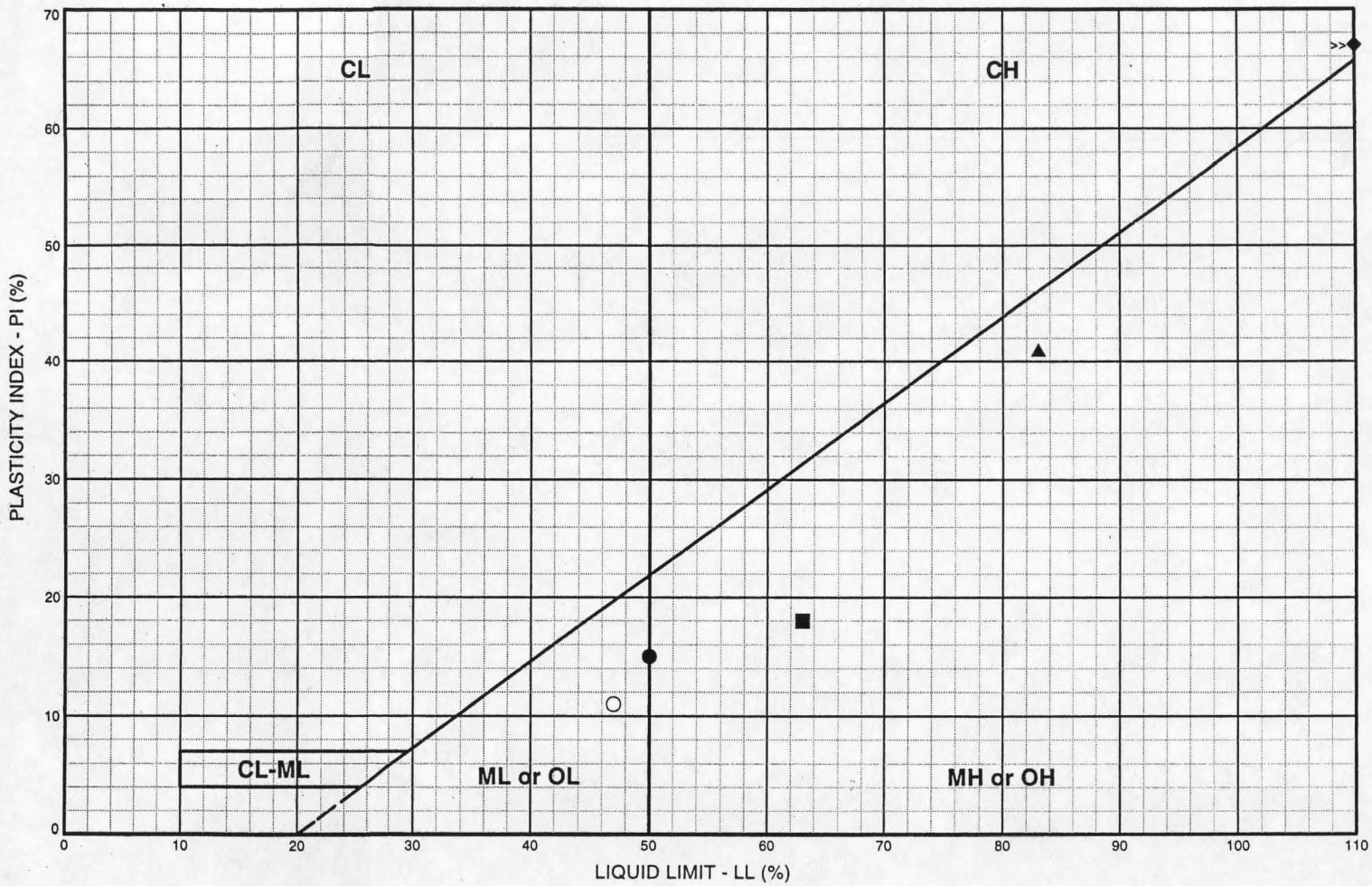


## LEGEND

**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-1, S-7 | 17.5 | OH | Gray, slightly fine sandy, slightly clayey, organic SILT; scattered organics | 50 | 35 | 15 | 52.3 | |
| ■ B-4, S-6 | 15.0 | OH | Gray, slightly clayey, organic SILT, trace of fine sand; scattered wood debris | 63 | 45 | 18 | 66.2 | |
| ▲ TP-1, S-4 | 6.9 | OH | Gray, clayey, organic SILT, trace of sand | 83 | 42 | 41 | 72.0 | |
| ◆ TP-8, S-2 | 8.3 | OH | Gray, slightly clayey, organic SILT | 113 | 46 | 67 | 107.9 | |
| ○ TP-9, S-3 | 9.2 | OL | Gray, slightly clayey, organic SILT | 47 | 36 | 11 | 68.2 | |

Aberdeen Industrial Water Pipeline Phase II
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**PLASTICITY CHART**

March 2002 21-1-08713-004

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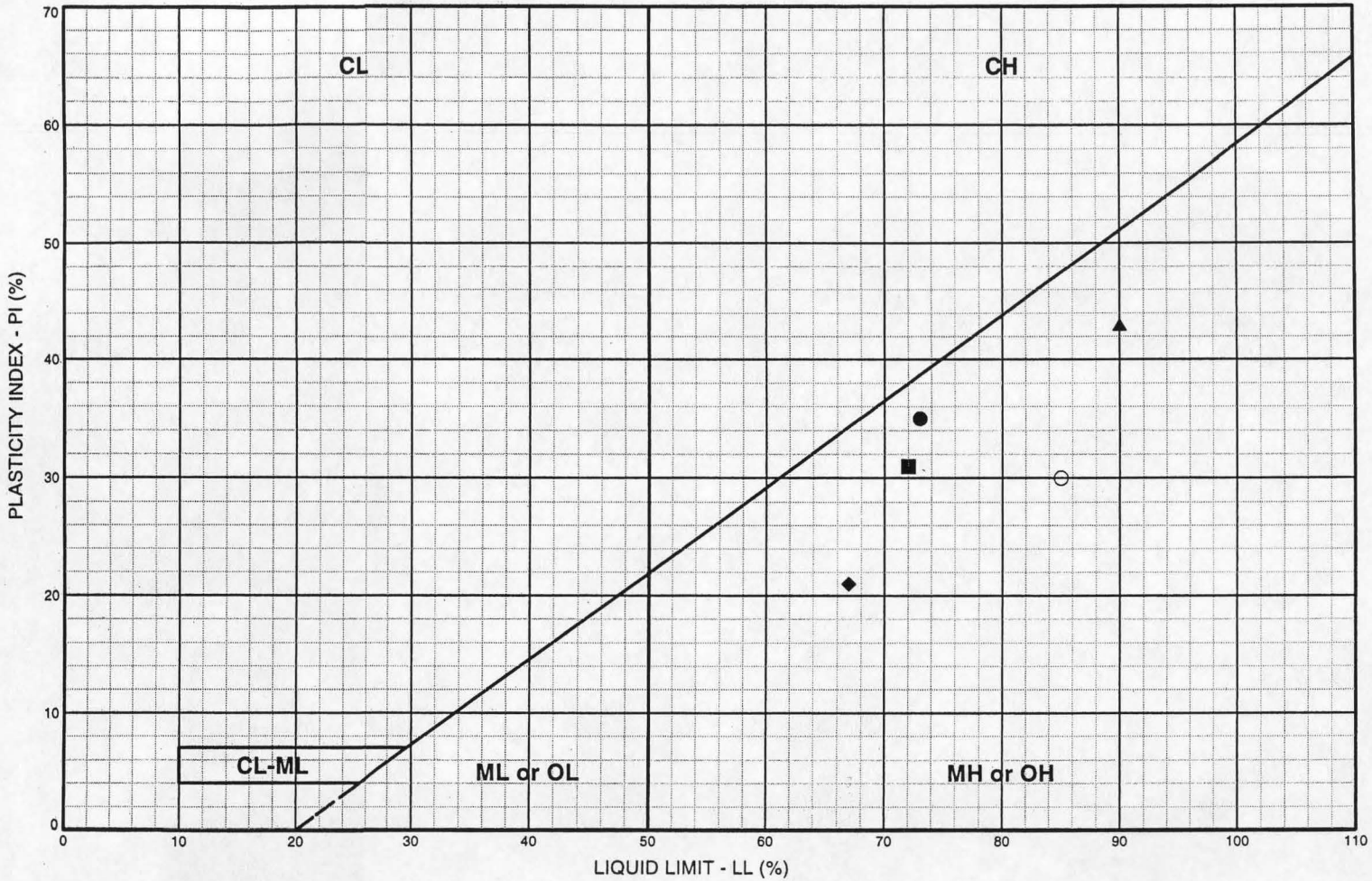
**FIG. B-1**

FIG. B-1

ATTMAIN1 21-08713-004.GPJ SHAN_WIL.GDT 3/19/02




## 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-3 | 7.5 | MH | Gray-brown, clayey SILT; trace of fine gravel | 73 | 38 | 35 | 85.2 | |
| ■ B-11, S-4 | 10.0 | MH | Gray-brown, clayey SILT | 72 | 41 | 31 | 71.0 | |
| ▲ B-12, S-4 | 10.0 | MH | Gray-brown, clayey SILT; scattered wood debris | 90 | 47 | 43 | 99.7 | |
| ◆ B-5, S-5 | 12.5 | MH | Gray-brown, clayey SILT | 67 | 46 | 21 | 69.9 | |
| ○ B-6, S-3 | 7.5 | MH | Gray-brown, clayey SILT; wood debris | 85 | 55 | 30 | 74.7 | |

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

**PLASTICITY CHART**

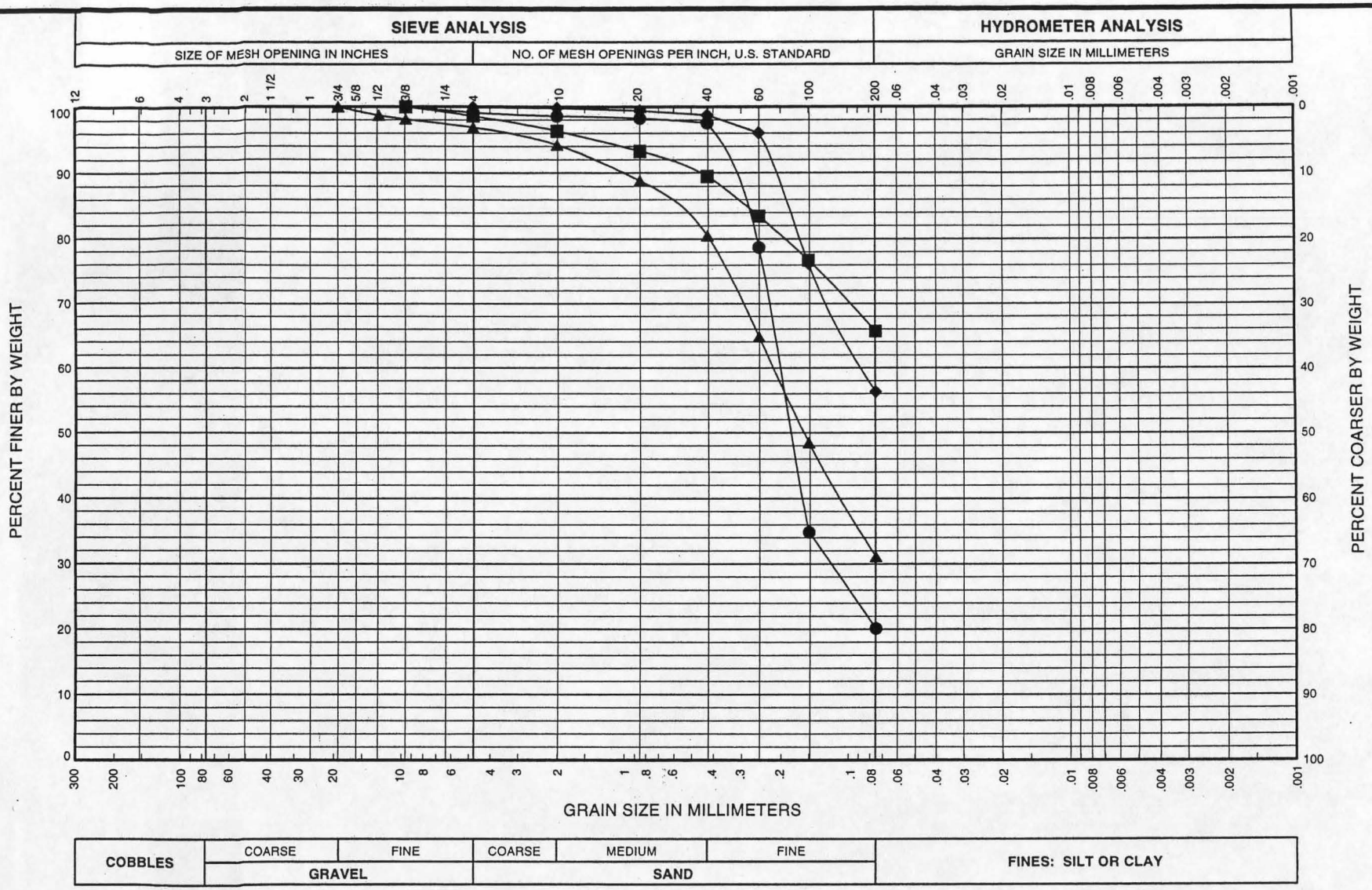
March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. B-2**

FIG. B-2

ATTMAIN1 21-08713-005.GPJ SHAN_WIL.GDT 3/19/02




| BORING AND SAMPLE NO. | DEPTH (feet) | U.S.C.S. SYMBOL | SAMPLE DESCRIPTION | FINES % | NAT. W.C. % | LL % | PL % | PI % |
|---|---|---|---|---|---|---|---|---|
| ● B-3, S-6 | 15.0 | SM | Gray, silty, fine SAND, trace of gravel; scattered shell fragments and wood debris | 20.1 | 38.0 | | | |
| ■ TP-4, S-5 | 8.5 | ML | Blue-gray, sandy SILT, trace of gravel; scattered wood debris | 65.7 | 38.8 | | | |
| ▲ TP-6, S-3 | 6.6 | SM | Blue-gray, silty SAND, trace of gravel; numerous shells; scattered wood debris | 31.1 | 42.8 | | | |
| ◆ TP-7, S-2 | 4.3 | ML | Blue-gray, fine sandy SILT; scattered organcis | 56.3 | 40.2 | | | |

Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

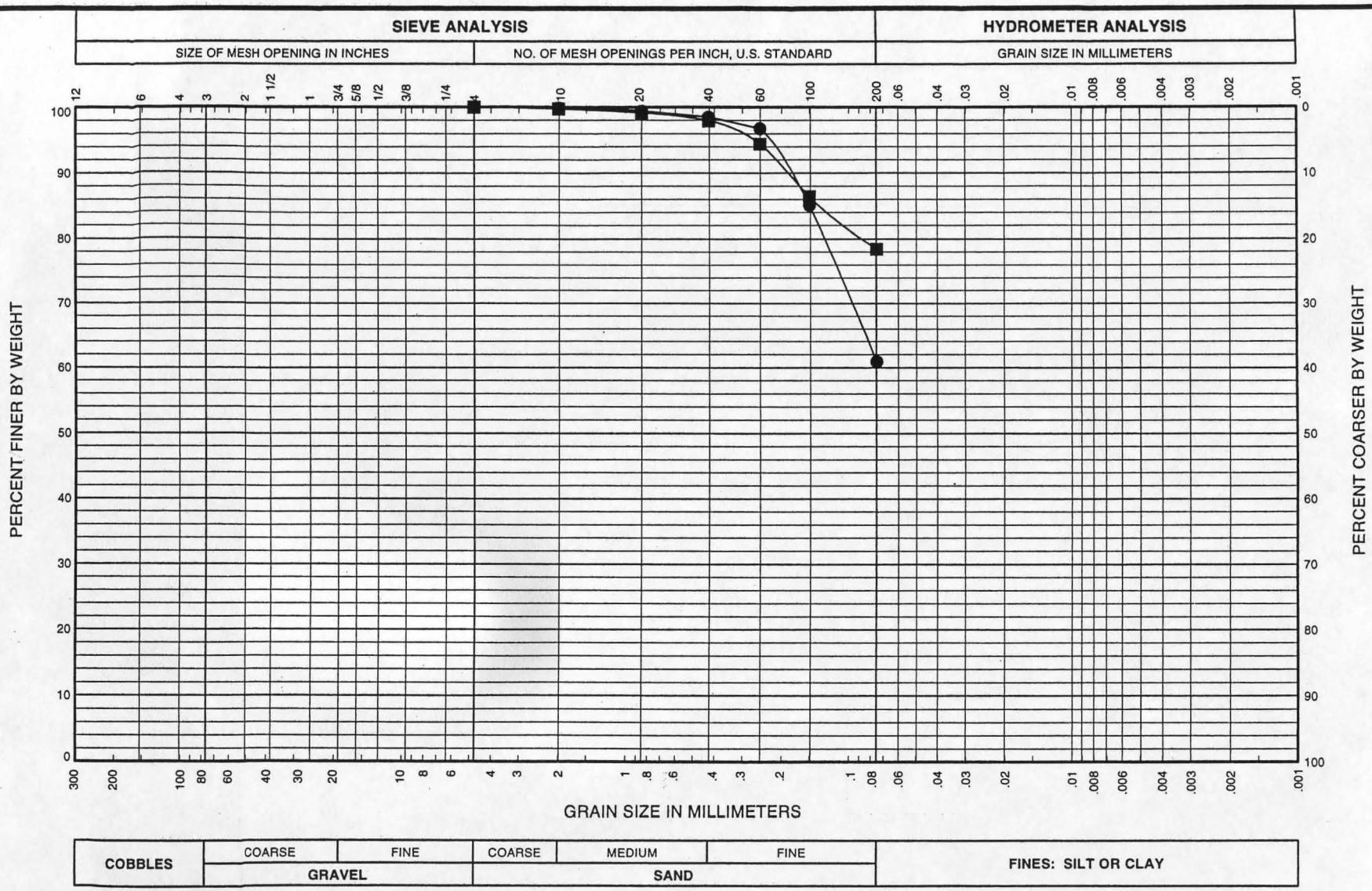
## GRAIN SIZE DISTRIBUTION

March 2002 | 21-1-08713-004

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. B-3**

FIG. B-3




| BORING AND SAMPLE NO. | DEPTH (feet) | U.S.C.S. SYMBOL | SAMPLE DESCRIPTION | FINES % | NAT. W.C. % | LL % | PL % | PI % |
|---|---|---|---|---|---|---|---|---|
| ● B-10, S-6 | 15.0 | ML | Gray, fine sandy SILT; scattered organics | 60.9 | 54.0 | | | |
| ■ B-8, S-7 | 17.5 | ML | Gray, fine sandy SILT; scattered organics | 78.5 | 56.8 | | | |

Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

## GRAIN SIZE DISTRIBUTION

March 2002 21-1-08713-005

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-4

FIG. B-4

# Appendix C

# APPENDIX C

# ANALYTICAL DATA

Draft

**OnSite Environmental Inc.**
Analytical Testing and Mobile Laboratory Services

February 15, 2002

Ann Marie Johnson
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, WA 98103

Re: Analytical Data for Project 21-1-08713-004
Laboratory Reference No. 0202-079

Dear Ann Marie:

Enclosed are the analytical results and associated quality control data for samples submitted on February 13, 2002.

The standard policy of OnSite Environmental Inc. is to store your samples for 30 days from the date of receipt. If you require longer storage, please contact the laboratory.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning the data, or need additional information, please feel free to call me.

Sincerely,

for David Baumeister
Project Manager

Enclosures

14648 NE 95th Street, Redmond, WA 98052 • (425) 883-3881 • Fax (425) 885-4603

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**NWTPH-HCID**

| | |
|---|---|
| Date Extracted: | 2-14-02 |
| Date Analyzed: | 2-14-02 |
| Matrix: | Soil |
| Units: | mg/Kg (ppm) |

| Client ID: | TP-4 S-3 | TP-4 S-4 |
|---|---|---|
| Lab ID: | 02-079-01 | 02-079-02 |
| Gasoline: | ND | Gasoline Range Hydrocarbons |
| PQL: | 26 | 26 |
| Diesel Fuel: | ND | ND |
| PQL: | 65 | 64 |
| Heavy Oil: | ND | ND |
| PQL: | 130 | 130 |
| Surrogate Recovery: | | |
| o-Terphenyl | 97% | 110% |

Flags:

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**NWTPH-HCID**
**METHOD BLANK QUALITY CONTROL**

| | |
|---|---|
| Date Extracted: | 2-14-02 |
| Date Analyzed: | 2-14-02 |

| | |
|---|---|
| Matrix: | Soil |
| Units: | mg/Kg (ppm) |

| | |
|---|---|
| Lab ID: | MB0214S1 |

| | |
|---|---|
| Gasoline: | ND |
| PQL: | 20 |
| Diesel Fuel: | ND |
| PQL: | 50 |
| Heavy Oil: | ND |
| PQL: | 100 |
| Surrogate Recovery: | |
| o-Terphenyl | 104% |

Flags

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**VOLATILES by EPA 8260B**
Page 1 of 2

| | |
|---|---|
| Date Extracted: | 2-13-02 |
| Date Analyzed: | 2-13-02 |
| Matrix: | Soil |
| Units: | mg/Kg (ppm) |
| Lab ID: | 02-079-01 |
| **Client ID:** | **TP-4 S-3** |

| **Compound** | **Results** | **Flags** | **PQL** |
|---|---|---|---|
| Dichlorodifluoromethane | ND | | 0.0013 |
| Chloromethane | ND | | 0.0013 |
| Vinyl Chloride | ND | | 0.0013 |
| Bromomethane | ND | | 0.0013 |
| Chloroethane | ND | | 0.0013 |
| Trichlorofluoromethane | ND | | 0.0013 |
| 1,1-Dichloroethene | ND | | 0.0013 |
| Acetone | 0.064 | | 0.0065 |
| Iodomethane | ND | | 0.0065 |
| Carbon Disulfide | ND | | 0.0013 |
| Methylene Chloride | ND | | 0.0065 |
| (trans) 1,2-Dichloroethene | ND | | 0.0013 |
| Methyl t-Butyl Ether | ND | | 0.0013 |
| 1,1-Dichloroethane | ND | | 0.0013 |
| Vinyl Acetate | ND | | 0.0065 |
| 2,2-Dichloropropane | ND | | 0.0013 |
| (cis) 1,2-Dichloroethene | ND | | 0.0013 |
| 2-Butanone | 0.016 | | 0.0065 |
| Bromochloromethane | ND | | 0.0013 |
| Chloroform | ND | | 0.0013 |
| 1,1,1-Trichloroethane | ND | | 0.0013 |
| Carbon Tetrachloride | ND | | 0.0013 |
| 1,1-Dichloropropene | ND | | 0.0013 |
| Benzene | ND | | 0.0013 |
| 1,2-Dichloroethane | ND | | 0.0013 |
| Trichloroethene | ND | | 0.0013 |
| 1,2-Dichloropropane | ND | | 0.0013 |
| Dibromomethane | ND | | 0.0013 |
| Bromodichloromethane | ND | | 0.0013 |
| 2-Chloroethyl Vinyl Ether | ND | | 0.0065 |
| (cis) 1,3-Dichloropropene | ND | | 0.0013 |
| Methyl Isobutyl Ketone | ND | | 0.0065 |
| Toluene | 0.0020 | | 0.0013 |
| (trans) 1,3-Dichloropropene | ND | | 0.0013 |
| 1,1,2-Trichloroethane | ND | | 0.0013 |
| Tetrachloroethene | ND | | 0.0013 |
| 1,3-Dichloropropane | ND | | 0.0013 |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**VOLATILES by EPA 8260B**
Page 2 of 2

Lab ID: 02-079-01
**Client ID: TP-4 S-3**

| Compound | Results | Flags | PQL |
|---|---|---|---|
| 2-Hexanone | ND | | 0.0065 |
| Dibromochloromethane | ND | | 0.0013 |
| 1,2-Dibromoethane | ND | | 0.0013 |
| Chlorobenzene | ND | | 0.0013 |
| 1,1,1,2-Tetrachloroethane | ND | | 0.0013 |
| Ethylbenzene | 0.0060 | | 0.0013 |
| m,p-Xylene | 0.0098 | | 0.0026 |
| o-Xylene | 0.0064 | | 0.0013 |
| Styrene | ND | | 0.0013 |
| Bromoform | ND | | 0.0013 |
| Isopropylbenzene | 0.022 | | 0.0013 |
| Bromobenzene | ND | | 0.0013 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.0013 |
| 1,2,3-Trichloropropane | ND | | 0.0013 |
| n-Propylbenzene | 0.023 | | 0.0013 |
| 2-Chlorotoluene | ND | | 0.0013 |
| 4-Chlorotoluene | ND | | 0.0013 |
| 1,3,5-Trimethylbenzene | 0.012 | | 0.0013 |
| tert-Butylbenzene | ND | | 0.0013 |
| 1,2,4-Trimethylbenzene | 0.048 | | 0.0013 |
| sec-Butylbenzene | 0.019 | | 0.0013 |
| 1,3-Dichlorobenzene | ND | | 0.0013 |
| p-Isopropyltoluene | 0.032 | | 0.0013 |
| 1,4-Dichlorobenzene | ND | | 0.0013 |
| 1,2-Dichlorobenzene | ND | | 0.0013 |
| n-Butylbenzene | ND | | 0.0013 |
| 1,2-Dibromo-3-chloropropane | ND | | 0.0065 |
| 1,2,4-Trichlorobenzene | ND | | 0.0013 |
| Hexachlorobutadiene | ND | | 0.0065 |
| Naphthalene | 0.010 | | 0.0013 |
| 1,2,3-Trichlorobenzene | ND | | 0.0013 |

| Surrogate | Percent Recovery | Control Limits |
|---|---|---|
| Dibromofluoromethane | 91 | 65-125 |
| Toluene, d8 | 86 | 77-116 |
| 4-Bromofluorobenzene | 104 | 67-133 |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**VOLATILES by EPA 8260B**
Page 1 of 2

Date Extracted: 2-13-02
Date Analyzed: 2-13-02

Matrix: Soil
Units: mg/Kg (ppm)

Lab ID: 02-079-02
**Client ID: TP-4 S-4**

| Compound | Results | Flags | PQL |
|---|---|---|---|
| Dichlorodifluoromethane | ND | | 0.0013 |
| Chloromethane | ND | | 0.0013 |
| Vinyl Chloride | ND | | 0.0013 |
| Bromomethane | ND | | 0.0013 |
| Chloroethane | ND | | 0.0013 |
| Trichlorofluoromethane | ND | | 0.0013 |
| 1,1-Dichloroethene | ND | | 0.0013 |
| Acetone | ND | | 0.0064 |
| Iodomethane | ND | | 0.0064 |
| Carbon Disulfide | ND | | 0.0013 |
| Methylene Chloride | ND | | 0.0064 |
| (trans) 1,2-Dichloroethene | ND | | 0.0013 |
| Methyl t-Butyl Ether | ND | | 0.0013 |
| 1,1-Dichloroethane | ND | | 0.0013 |
| Vinyl Acetate | ND | | 0.0064 |
| 2,2-Dichloropropane | ND | | 0.0013 |
| (cis) 1,2-Dichloroethene | ND | | 0.0013 |
| 2-Butanone | ND | | 0.0064 |
| Bromochloromethane | ND | | 0.0013 |
| Chloroform | ND | | 0.0013 |
| 1,1,1-Trichloroethane | ND | | 0.0013 |
| Carbon Tetrachloride | ND | | 0.0013 |
| 1,1-Dichloropropene | ND | | 0.0013 |
| Benzene | ND | | 0.0013 |
| 1,2-Dichloroethane | ND | | 0.0013 |
| Trichloroethene | ND | | 0.0013 |
| 1,2-Dichloropropane | ND | | 0.0013 |
| Dibromomethane | ND | | 0.0013 |
| Bromodichloromethane | ND | | 0.0013 |
| 2-Chloroethyl Vinyl Ether | ND | | 0.0064 |
| (cis) 1,3-Dichloropropene | ND | | 0.0013 |
| Methyl Isobutyl Ketone | ND | | 0.0064 |
| Toluene | 0.0029 | | 0.0013 |
| (trans) 1,3-Dichloropropene | ND | | 0.0013 |
| 1,1,2-Trichloroethane | ND | | 0.0013 |
| Tetrachloroethene | ND | | 0.0013 |
| 1,3-Dichloropropane | ND | | 0.0013 |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**VOLATILES by EPA 8260B**
Page 2 of 2

Lab ID: 02-079-02
**Client ID: TP-4 S-4**

| Compound | Results | Flags | PQL |
|---|---|---|---|
| 2-Hexanone | ND | | 0.0064 |
| Dibromochloromethane | ND | | 0.0013 |
| 1,2-Dibromoethane | ND | | 0.0013 |
| Chlorobenzene | ND | | 0.0013 |
| 1,1,1,2-Tetrachloroethane | ND | | 0.0013 |
| Ethylbenzene | 0.051 | | 0.0013 |
| m,p-Xylene | 0.034 | | 0.0026 |
| o-Xylene | 0.052 | | 0.0013 |
| Styrene | ND | | 0.0013 |
| Bromoform | ND | | 0.0013 |
| Isopropylbenzene | 0.12 | | 0.0013 |
| Bromobenzene | ND | | 0.0013 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.0013 |
| 1,2,3-Trichloropropane | ND | | 0.0013 |
| n-Propylbenzene | 0.20 | | 0.0013 |
| 2-Chlorotoluene | ND | | 0.0013 |
| 4-Chlorotoluene | ND | | 0.0013 |
| 1,3,5-Trimethylbenzene | 0.18 | | 0.0013 |
| tert-Butylbenzene | ND | | 0.0013 |
| 1,2,4-Trimethylbenzene | 0.42 | | 0.064 |
| sec-Butylbenzene | 0.14 | | 0.0013 |
| 1,3-Dichlorobenzene | ND | | 0.0013 |
| p-Isopropyltoluene | 0.28 | | 0.064 |
| 1,4-Dichlorobenzene | ND | | 0.0013 |
| 1,2-Dichlorobenzene | ND | | 0.0013 |
| n-Butylbenzene | ND | | 0.0013 |
| 1,2-Dibromo-3-chloropropane | ND | | 0.0064 |
| 1,2,4-Trichlorobenzene | ND | | 0.0013 |
| Hexachlorobutadiene | ND | | 0.0064 |
| Naphthalene | ND | | 0.0013 |
| 1,2,3-Trichlorobenzene | ND | | 0.0013 |

| Surrogate | Percent Recovery | Control Limits |
|---|---|---|
| Dibromofluoromethane | 91 | 65-125 |
| Toluene, d8 | 90 | 77-116 |
| 4-Bromofluorobenzene | 82 | 67-133 |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**VOLATILES by EPA 8260B**
**METHOD BLANK QUALITY CONTROL**
Page 1 of 2

| | |
|---|---|
| Date Extracted: | 2-13-02 |
| Date Analyzed: | 2-13-02 |
| Matrix: | Soil |
| Units: | mg/Kg (ppm) |
| Lab ID: | MB0213S1 |

| Compound | Results | Flags | PQL |
|---|---|---|---|
| Dichlorodifluoromethane | ND | | 0.0010 |
| Chloromethane | ND | | 0.0010 |
| Vinyl Chloride | ND | | 0.0010 |
| Bromomethane | ND | | 0.0010 |
| Chloroethane | ND | | 0.0010 |
| Trichlorofluoromethane | ND | | 0.0010 |
| 1,1-Dichloroethene | ND | | 0.0010 |
| Acetone | ND | | 0.0050 |
| Iodomethane | ND | | 0.0050 |
| Carbon Disulfide | ND | | 0.0010 |
| Methylene Chloride | ND | | 0.0050 |
| (trans) 1,2-Dichloroethene | ND | | 0.0010 |
| Methyl t-Butyl Ether | ND | | 0.0010 |
| 1,1-Dichloroethane | ND | | 0.0010 |
| Vinyl Acetate | ND | | 0.0050 |
| 2,2-Dichloropropane | ND | | 0.0010 |
| (cis) 1,2-Dichloroethene | ND | | 0.0010 |
| 2-Butanone | ND | | 0.0050 |
| Bromochloromethane | ND | | 0.0010 |
| Chloroform | ND | | 0.0010 |
| 1,1,1-Trichloroethane | ND | | 0.0010 |
| Carbon Tetrachloride | ND | | 0.0010 |
| 1,1-Dichloropropene | ND | | 0.0010 |
| Benzene | ND | | 0.0010 |
| 1,2-Dichloroethane | ND | | 0.0010 |
| Trichloroethene | ND | | 0.0010 |
| 1,2-Dichloropropane | ND | | 0.0010 |
| Dibromomethane | ND | | 0.0010 |
| Bromodichloromethane | ND | | 0.0010 |
| 2-Chloroethyl Vinyl Ether | ND | | 0.0050 |
| (cis) 1,3-Dichloropropene | ND | | 0.0010 |
| Methyl Isobutyl Ketone | ND | | 0.0050 |
| Toluene | ND | | 0.0010 |
| (trans) 1,3-Dichloropropene | ND | | 0.0010 |
| 1,1,2-Trichloroethane | ND | | 0.0010 |
| Tetrachloroethene | ND | | 0.0010 |
| 1,3-Dichloropropane | ND | | 0.0010 |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**VOLATILES by EPA 8260B**
**METHOD BLANK QUALITY CONTROL**
Page 2 of 2

Lab ID: MB0213S1

| Compound | Results | Flags | PQL |
|---|---|---|---|
| 2-Hexanone | ND | | 0.0050 |
| Dibromochloromethane | ND | | 0.0010 |
| 1,2-Dibromoethane | ND | | 0.0010 |
| Chlorobenzene | ND | | 0.0010 |
| 1,1,1,2-Tetrachloroethane | ND | | 0.0010 |
| Ethylbenzene | ND | | 0.0010 |
| m,p-Xylene | ND | | 0.0020 |
| o-Xylene | ND | | 0.0010 |
| Styrene | ND | | 0.0010 |
| Bromoform | ND | | 0.0010 |
| Isopropylbenzene | ND | | 0.0010 |
| Bromobenzene | ND | | 0.0010 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.0010 |
| 1,2,3-Trichloropropane | ND | | 0.0010 |
| n-Propylbenzene | ND | | 0.0010 |
| 2-Chlorotoluene | ND | | 0.0010 |
| 4-Chlorotoluene | ND | | 0.0010 |
| 1,3,5-Trimethylbenzene | ND | | 0.0010 |
| tert-Butylbenzene | ND | | 0.0010 |
| 1,2,4-Trimethylbenzene | ND | | 0.0010 |
| sec-Butylbenzene | ND | | 0.0010 |
| 1,3-Dichlorobenzene | ND | | 0.0010 |
| p-Isopropyltoluene | ND | | 0.0010 |
| 1,4-Dichlorobenzene | ND | | 0.0010 |
| 1,2-Dichlorobenzene | ND | | 0.0010 |
| n-Butylbenzene | ND | | 0.0010 |
| 1,2-Dibromo-3-chloropropane | ND | | 0.0050 |
| 1,2,4-Trichlorobenzene | ND | | 0.0010 |
| Hexachlorobutadiene | ND | | 0.0050 |
| Naphthalene | ND | | 0.0010 |
| 1,2,3-Trichlorobenzene | ND | | 0.0010 |

| Surrogate | Percent Recovery | Control Limits |
|---|---|---|
| Dibromofluoromethane | 83 | 65-125 |
| Toluene, d8 | 85 | 77-116 |
| 4-Bromofluorobenzene | 90 | 67-133 |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

## VOLATILES by EPA 8260B
## MS/MSD QUALITY CONTROL

Date Extracted: 2-13-02
Date Analyzed: 2-13-02

Matrix: Soil
Units: mg/Kg (ppm)

Lab ID: 02-046-05

| Compound | Spike Amount | MS | Percent Recovery | MSD | Percent Recovery | RPD | Flags |
|---|---|---|---|---|---|---|---|
| 1,1-Dichloroethene | 0.0500 | 0.0283 | 57 | 0.0272 | 54 | 3.9 | |
| Benzene | 0.0500 | 0.0425 | 85 | 0.0405 | 81 | 4.8 | |
| Trichloroethene | 0.0500 | 0.0501 | 100 | 0.0483 | 97 | 3.6 | |
| Toluene | 0.0500 | 0.0490 | 98 | 0.0472 | 94 | 3.7 | |
| Chlorobenzene | 0.0500 | 0.0459 | 92 | 0.0447 | 89 | 2.6 | |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**NWTPH-Gx**

| | |
|---|---|
| Date Extracted: | 2-19-02 |
| Date Analyzed: | 2-19-02 |

Matrix: Soil
Units: mg/Kg (ppm)

| | |
|---|---|
| Client ID: | **TP-4 S-4** |
| Lab ID: | 02-079-02 |

| | **Result** | Flags | PQL |
|---|---|---|---|
| TPH-Gas | **32** | | 6.4 |

| | |
|---|---|
| Surrogate Recovery: | |
| Fluorobenzene | 82% |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**NWTPH-Gx**
**METHOD BLANK QUALITY CONTROL**

Date Extracted: 2-19-02

Date Analyzed: 2-19-02

Matrix: Soil
Units: mg/Kg (ppm)

Lab ID: MB0219S1

| | **Result** | Flags | PQL |
|---|---|---|---|
| TPH-Gas | **ND** | | 5.0 |
| Surrogate Recovery: | | | |
| Fluorobenzene | 93% | | |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**NWTPH-Gx**
**DUPLICATE QUALITY CONTROL**

Date Extracted: 2-19-02
Date Analyzed: 2-19-02

Matrix: Soil
Units: mg/Kg (ppm)

| Lab ID: | 02-048-01 | 02-048-01 | | |
|---|---|---|---|---|
| | **Original** | **Duplicate** | **RPD** | **Flags** |
| TPH-Gas | **ND** | **ND** | NA | |
| Surrogate Recovery: | | | | |
| Fluorobenzene | 74% | 74% | | |

Date of Report: February 15, 2002
Samples Submitted: February 13, 2002
Lab Traveler: 02-079
Project: 21-1-08713-004

**% MOISTURE**

Date Analyzed: 2-13-02

| Client ID | Lab ID | % Moisture |
|---|---|---|
| TP-4 S-3 | 02-079-01 | 23 |
| TP-4 S-4 | 02-079-02 | 22 |

OnSite Environmental Inc.

DATA QUALIFIERS AND ABBREVIATIONS

A - Due to a high sample concentration, the amount spiked is insufficient for meaningful MS/MSD recovery data.

B - The analyte indicated was also found in the blank sample.

C - The duplicate RPD is outside control limits due to high result variability when analyte concentrations are within five times the quantitation limit.

D - Data from 1:____ dilution.

E - The value reported exceeds the quantitation range, and is an estimate.

F - Surrogate recovery data is not available due to the high concentration of coeluting target compounds.

G - Insufficient sample quantity for duplicate analysis.

H - The analyte indicated is a common laboratory solvent and may have been introduced during sample preparation, and be impacting the sample result.

I - Compound recovery is outside of the control limits.

J - The value reported was below the practical quantitation limit. The value is an estimate.

K - Sample duplicate RPD is outside control limits due to sample inhomogeniety. The sample was re-extracted and re-analyzed with similar results.

L - The RPD is outside of the control limits.

M - Hydrocarbons in the gasoline range (toluene-napthalene) are present in the sample.

O - Hydrocarbons outside the defined gasoline range are present in the sample; NWTPH-Dx recommended.

P - The RPD of the detected concentrations between the two columns is greater than 40.

Q - Surrogate recovery is outside of the control limits.

S - Surrogate recovery data is not available due to the necessary dilution of the sample.

T - The sample chromatogram is not similar to a typical _____.

U - The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

V - Matrix Spike/Matrix Spike Duplicate recoveries are outside control limits due to matrix effects.

W - Matrix Spike/Matrix Spike Duplicate RPD are outside control limits due to matrix effects.

X - Sample extract treated with a silica gel cleanup procedure.

Y - Sample extract treated with an acid cleanup procedure.

Z -

ND - Not Detected at PQL
MRL - Method Reporting Limit
PQL - Practical Quantitation Limit
RPD - Relative Percent Difference

# Appendix D

# APPENDIX D

# IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

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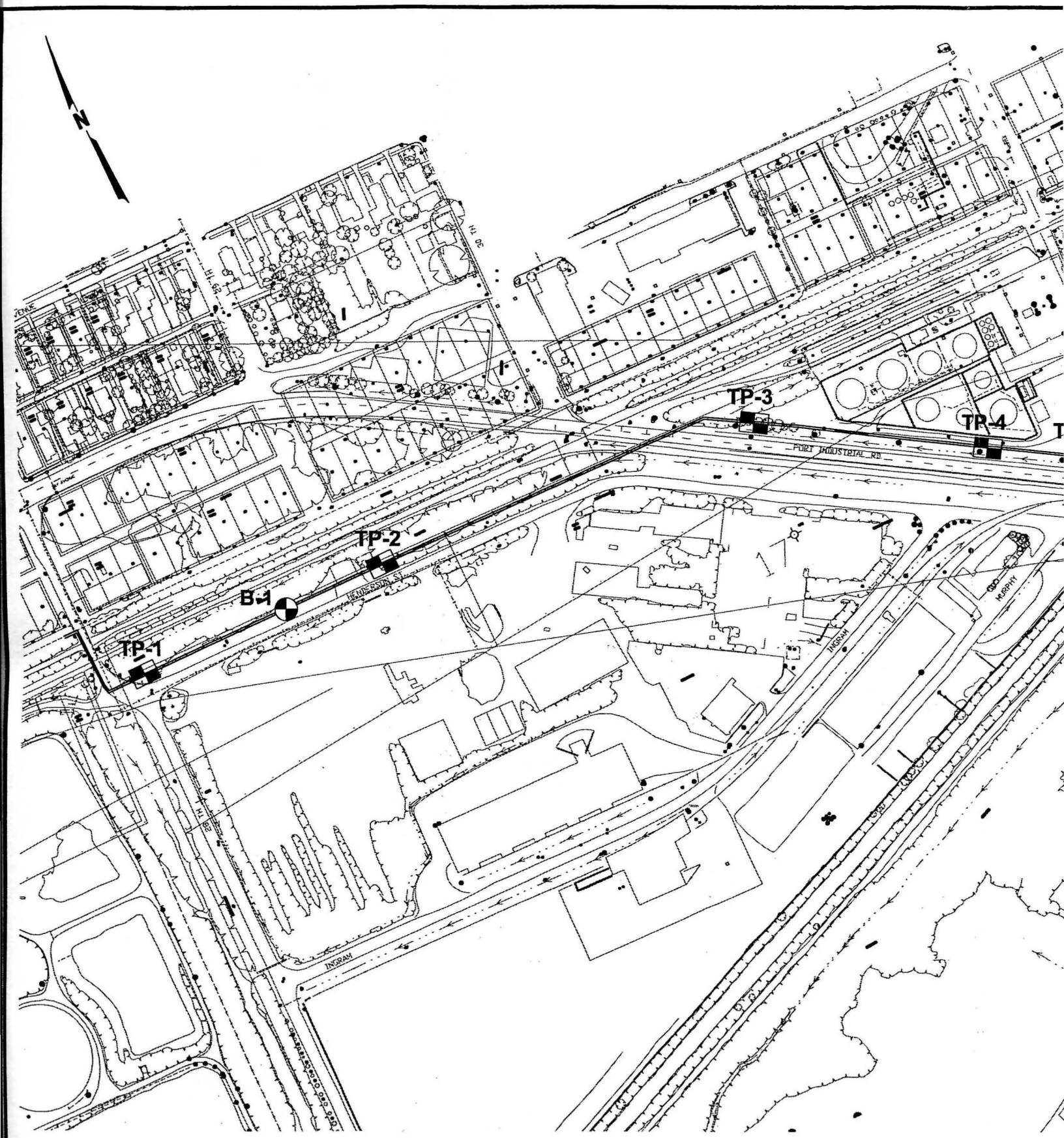



LEGEND

**B-1** Boring Designation and Approximate Location

**TP-1** Test Pit Designation and Approximate Location

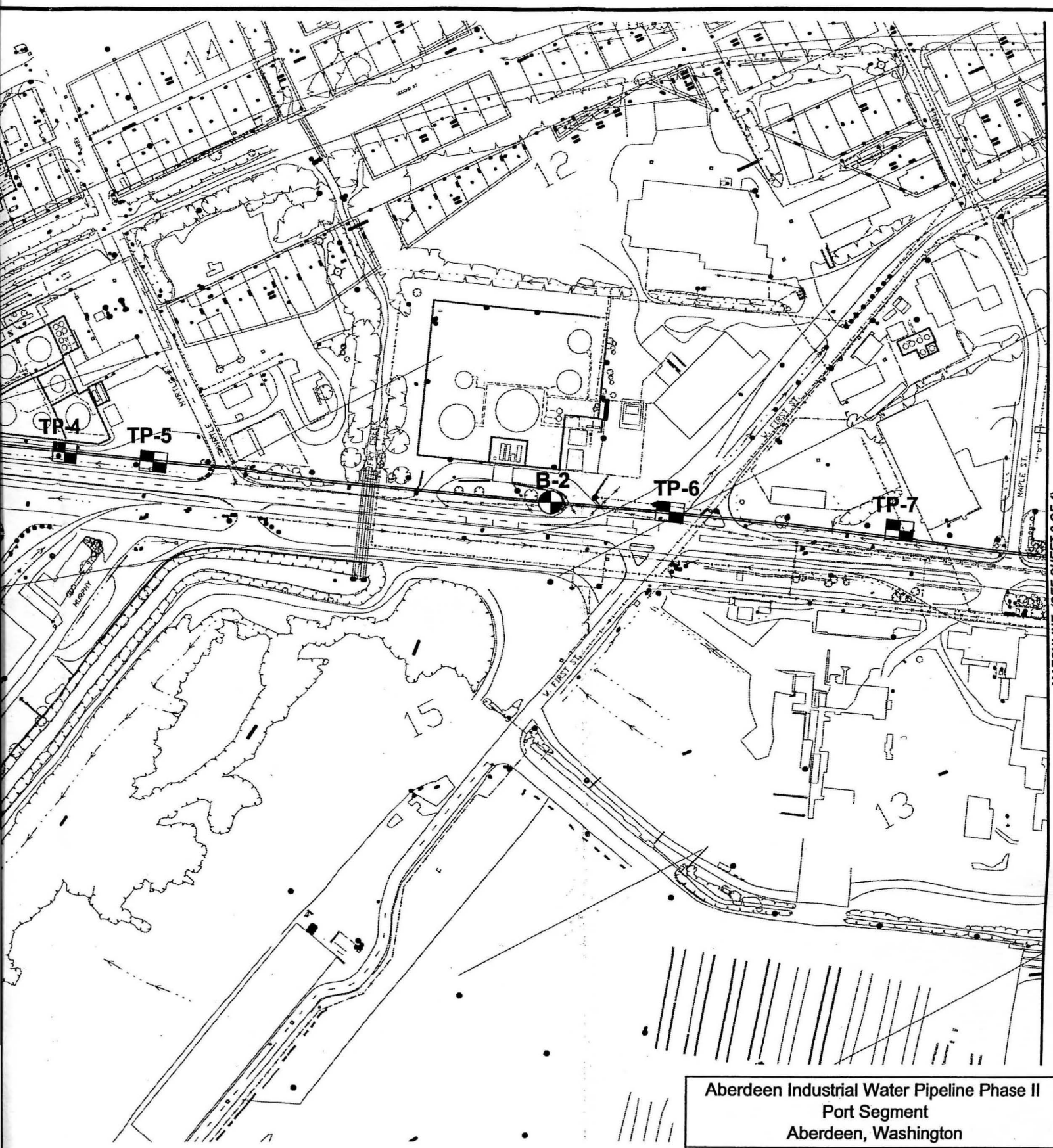
**GE-89-1** Previous Boring Designation and Approximate Location (GeoEngineers, 1989)

0 250

Scale in Feet

NOTE

Base map provided by c




250 500

Scale in Feet

NOTE

e map provided by client.

DRAFT

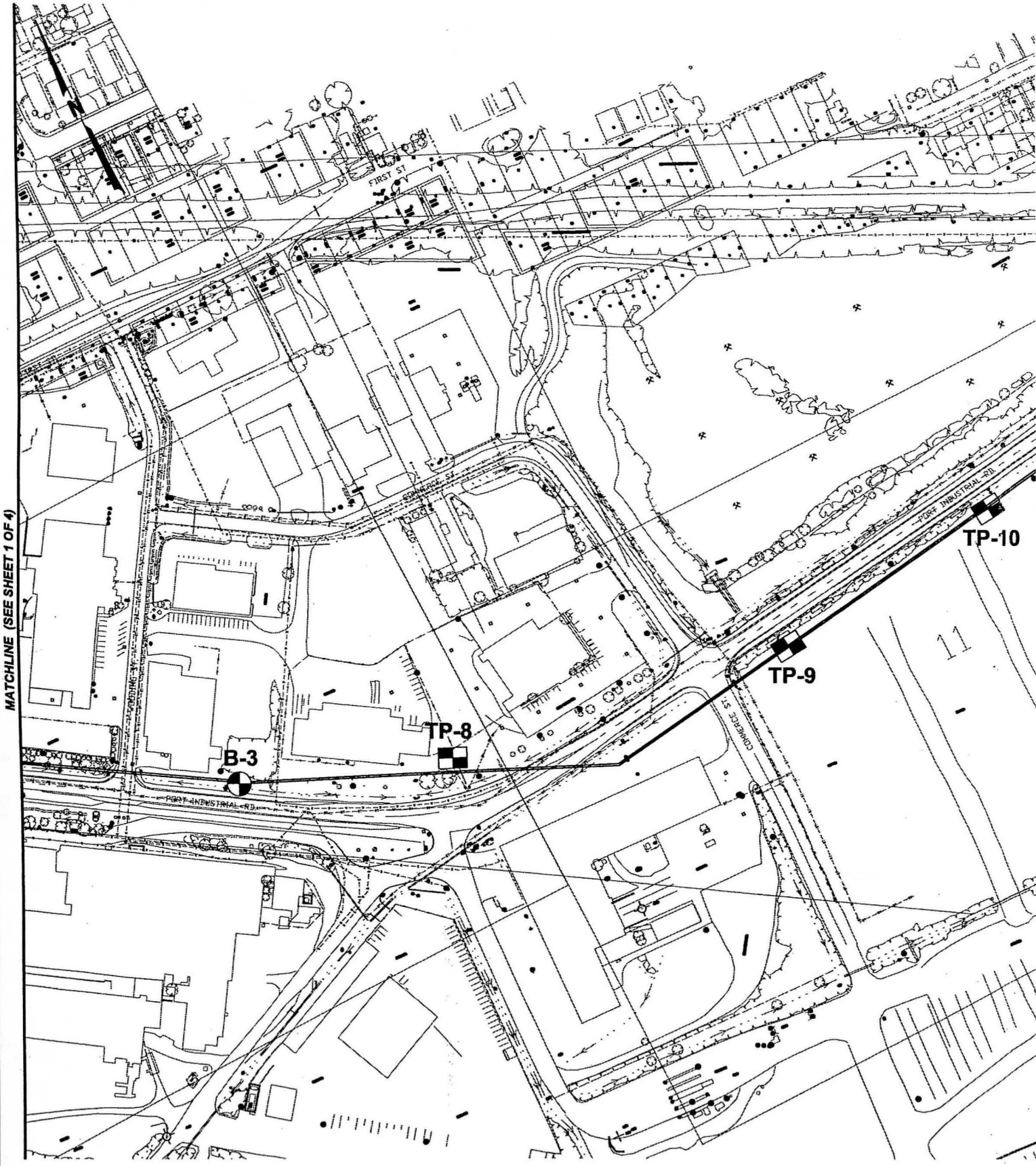
Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

**SITE AND EXPLORATION PLAN**

March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. 2**
Sheet 1 of 4




MATCHLINE (SEE SHEET 1 OF 4)

LEGEND

B-1 Boring Designation and Approximate Location

GE-89-1 Previous Boring Designation and Approximate Location (GeoEngineers, 1989)

TP-1 Test Pit Designation and Approximate Location

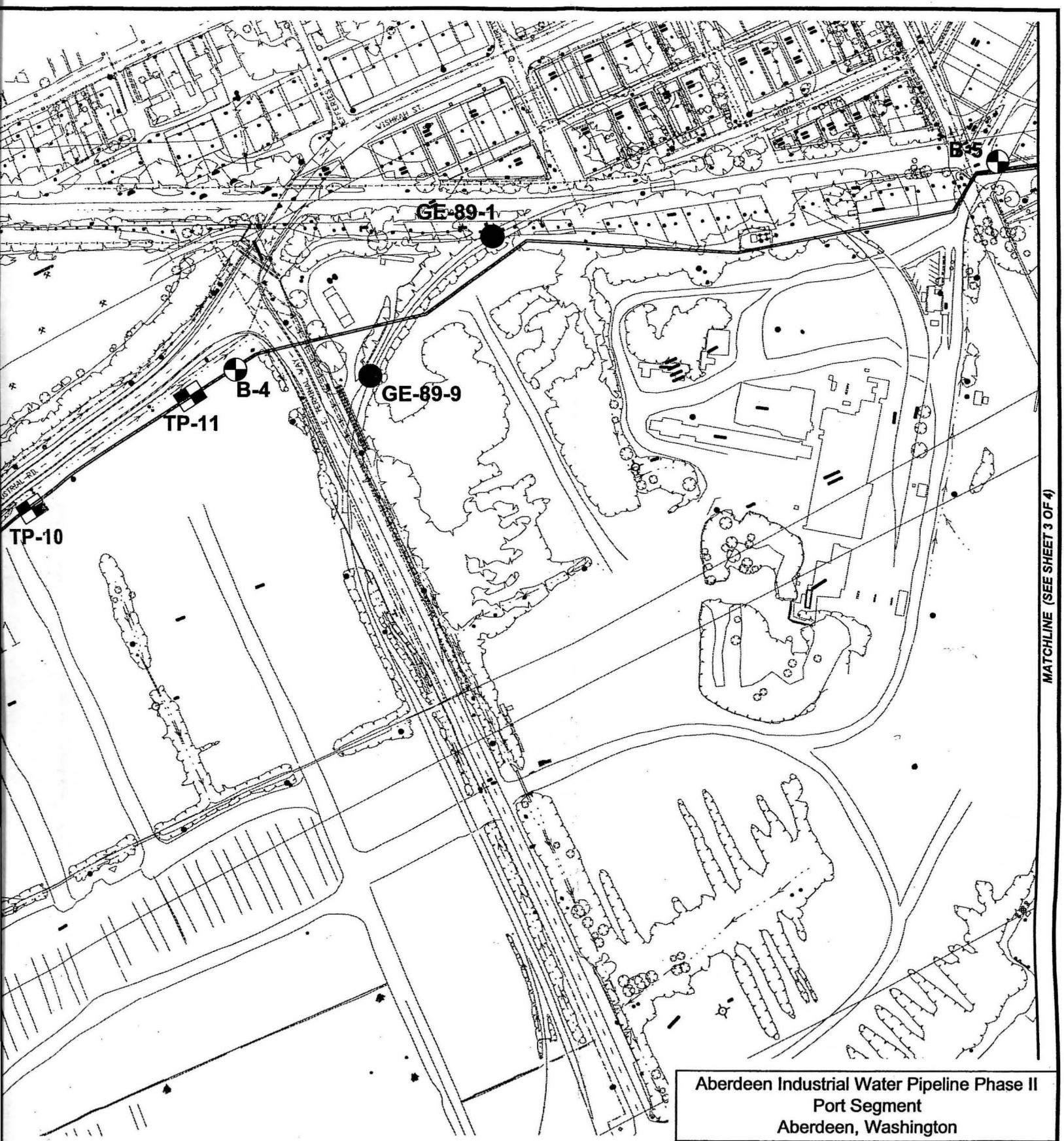
0 250

Scale in

NOTE

Base map provi

File: I:\Drafting\211\08713-005\21-1-08713-005 Fig 2.dwg Date: 03-19-2002 Author: cnk




250 500

Scale in Feet

NOTE

e map provided by client.

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Aberdeen Industrial Water Pipeline Phase II
Port Segment
Aberdeen, Washington

**SITE AND EXPLORATION PLAN**

March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
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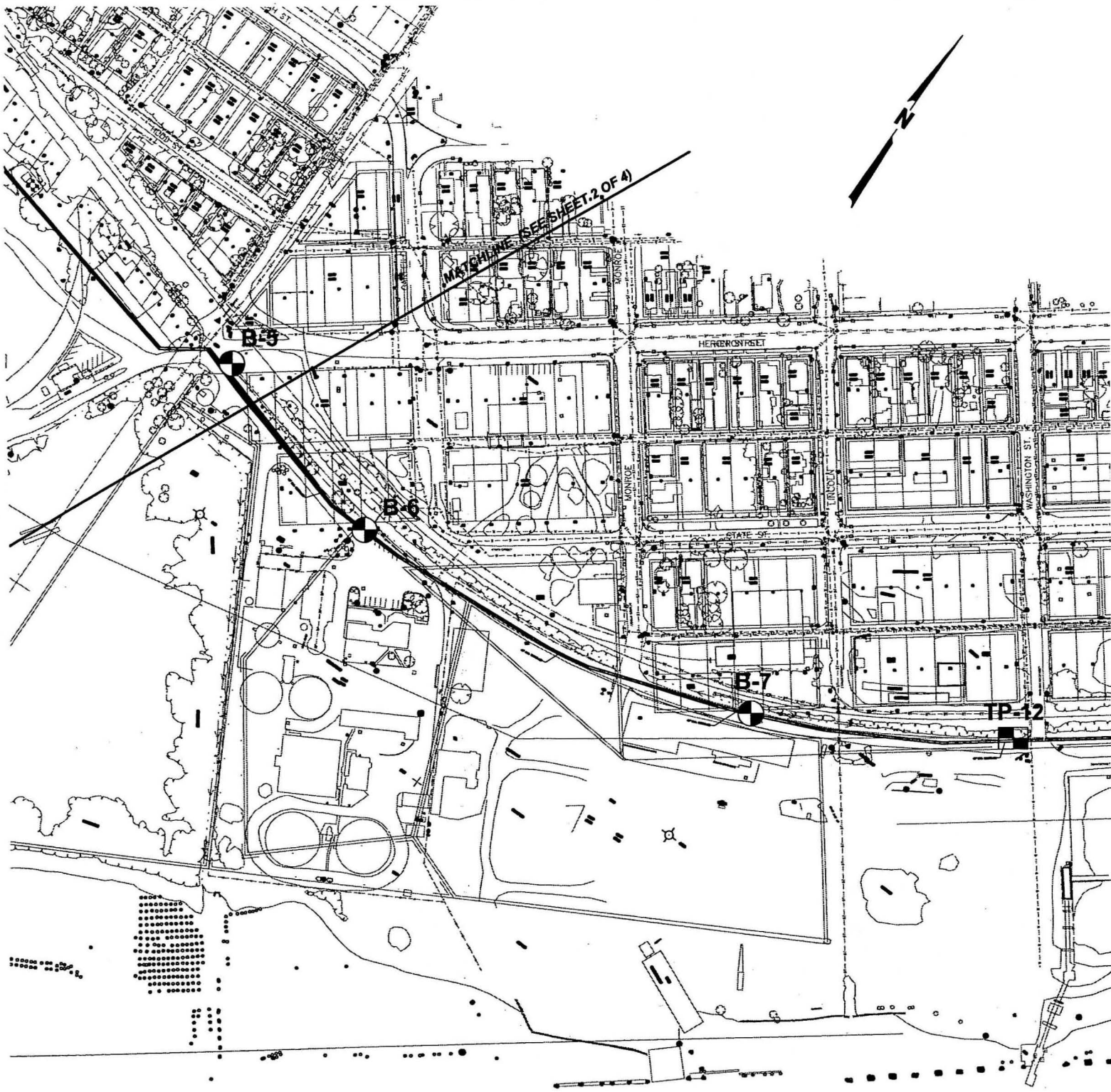
**FIG. 2**
Sheet 2 of 4




LEGEND

B-1 Boring Designation and Approximate Location

GE-89-1 Previous Boring Designation and Approximate Location (GeoEngineers, 1989)

TP-1 Test Pit Designation and Approximate Location

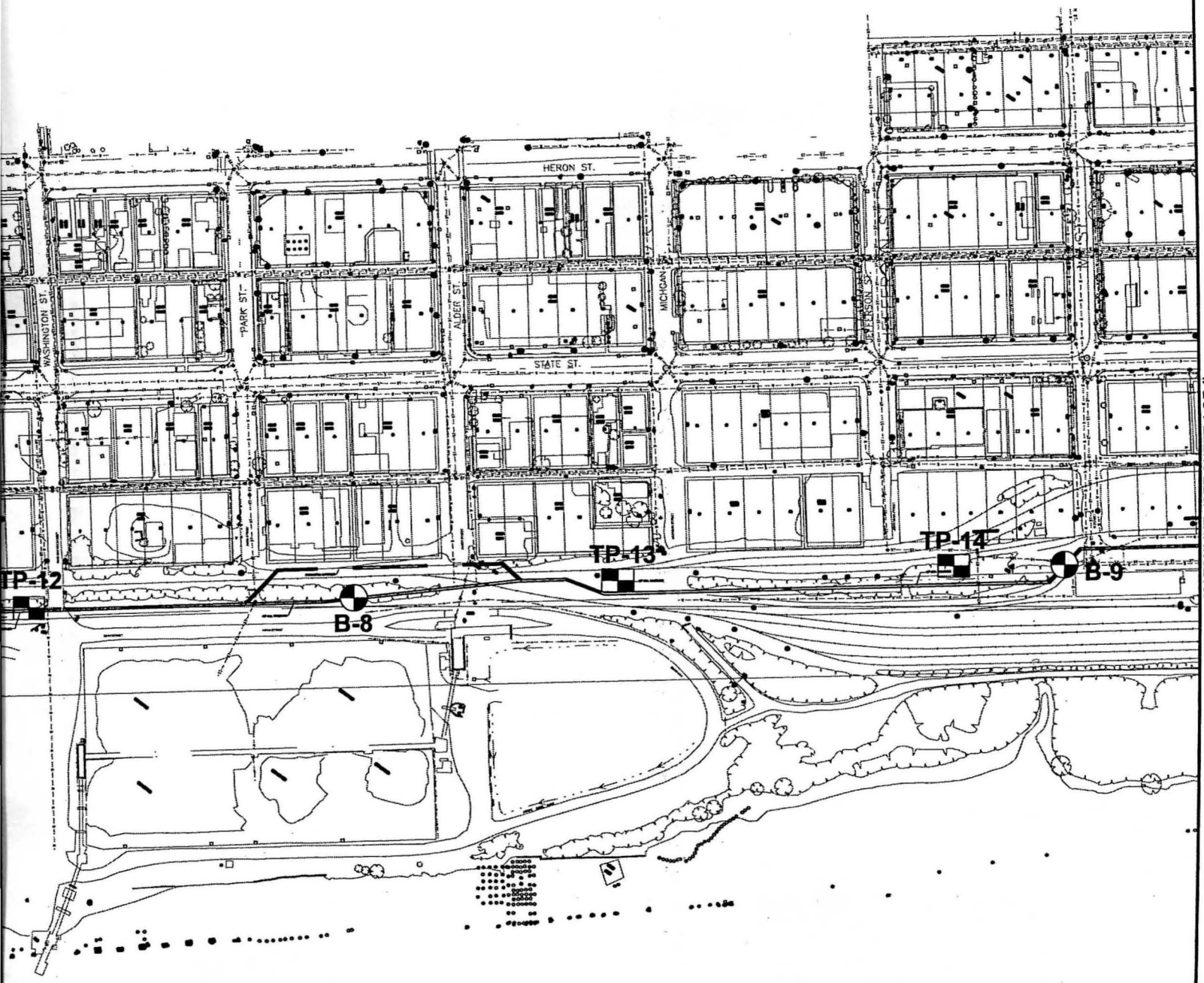
0 250

Scale in Feet

NOTE

Base map provided

File: I:\Drafting\211\08713-005\21-1-08713-005 Fig 2.dwg Date: 03-19-2002 Author: cnk




250 500

Scale in Feet

NOTE

e map provided by client.

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Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

**SITE AND EXPLORATION PLAN**

March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
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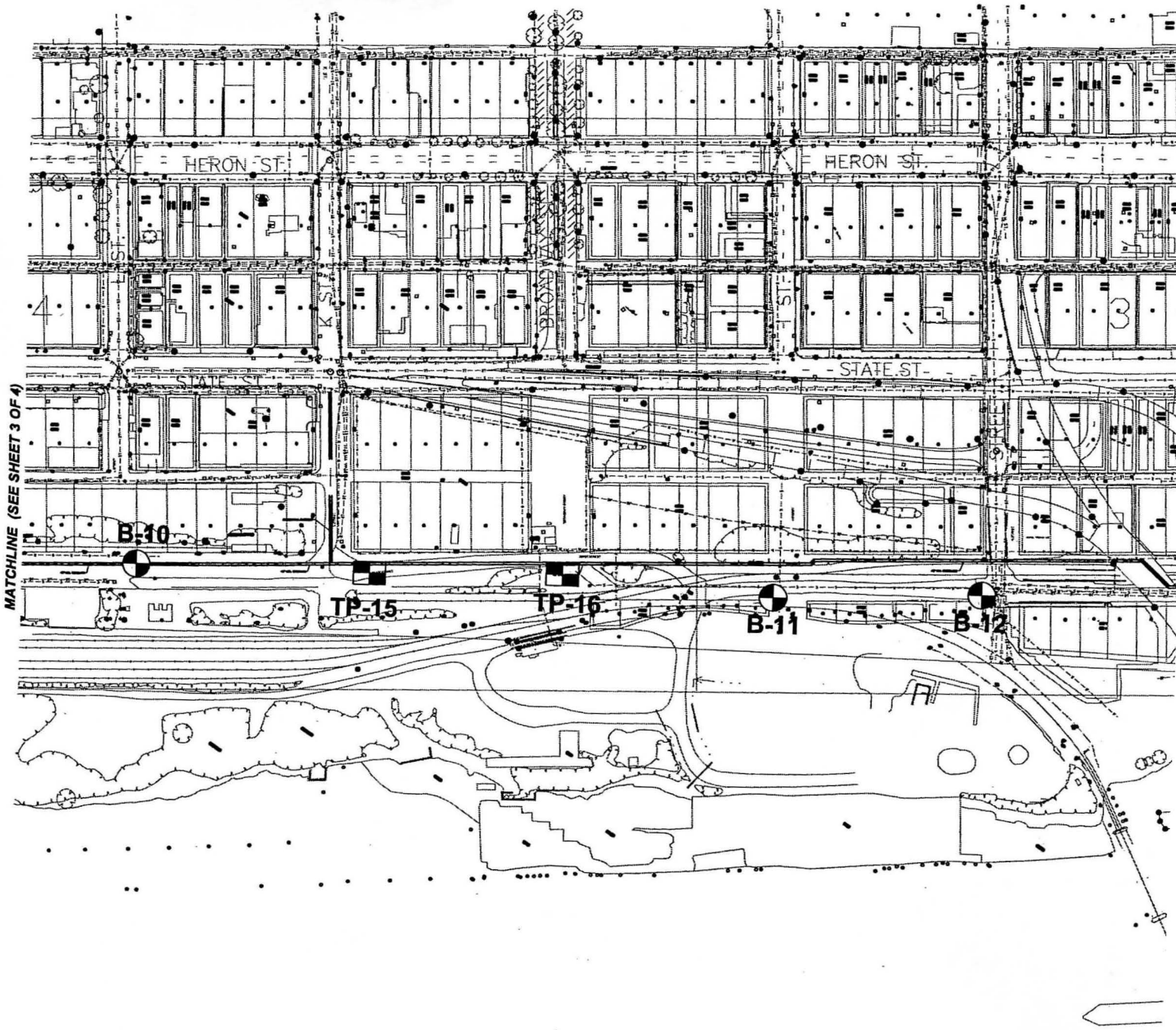
**FIG. 2**
Sheet 3 of 4




LEGEND

B-1 Boring Designation and Approximate Location

GE-89-1 Previous Boring Designation and Approximate Location (GeoEngineers, 1989)

TP-1 Test Pit Designation and Approximate Location

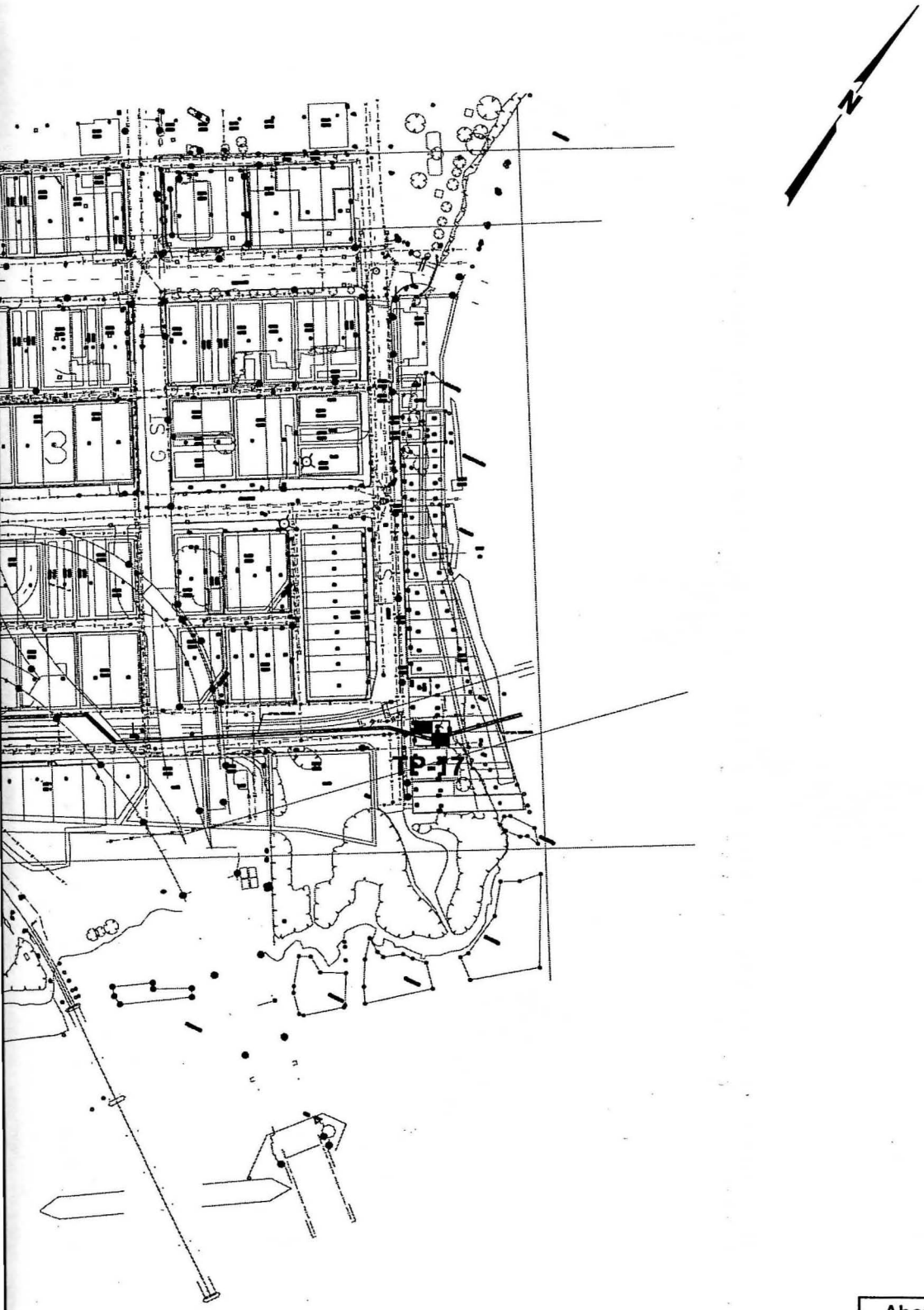
0 250

Scale in Fee

NOTE

Base map provided

File: I:\Drafting\211\08713-005\21-1-08713-005 Fig 2.dwg Date: 03-19-2002 Author: cnk




250 500

Scale in Feet

NOTE

map provided by client.

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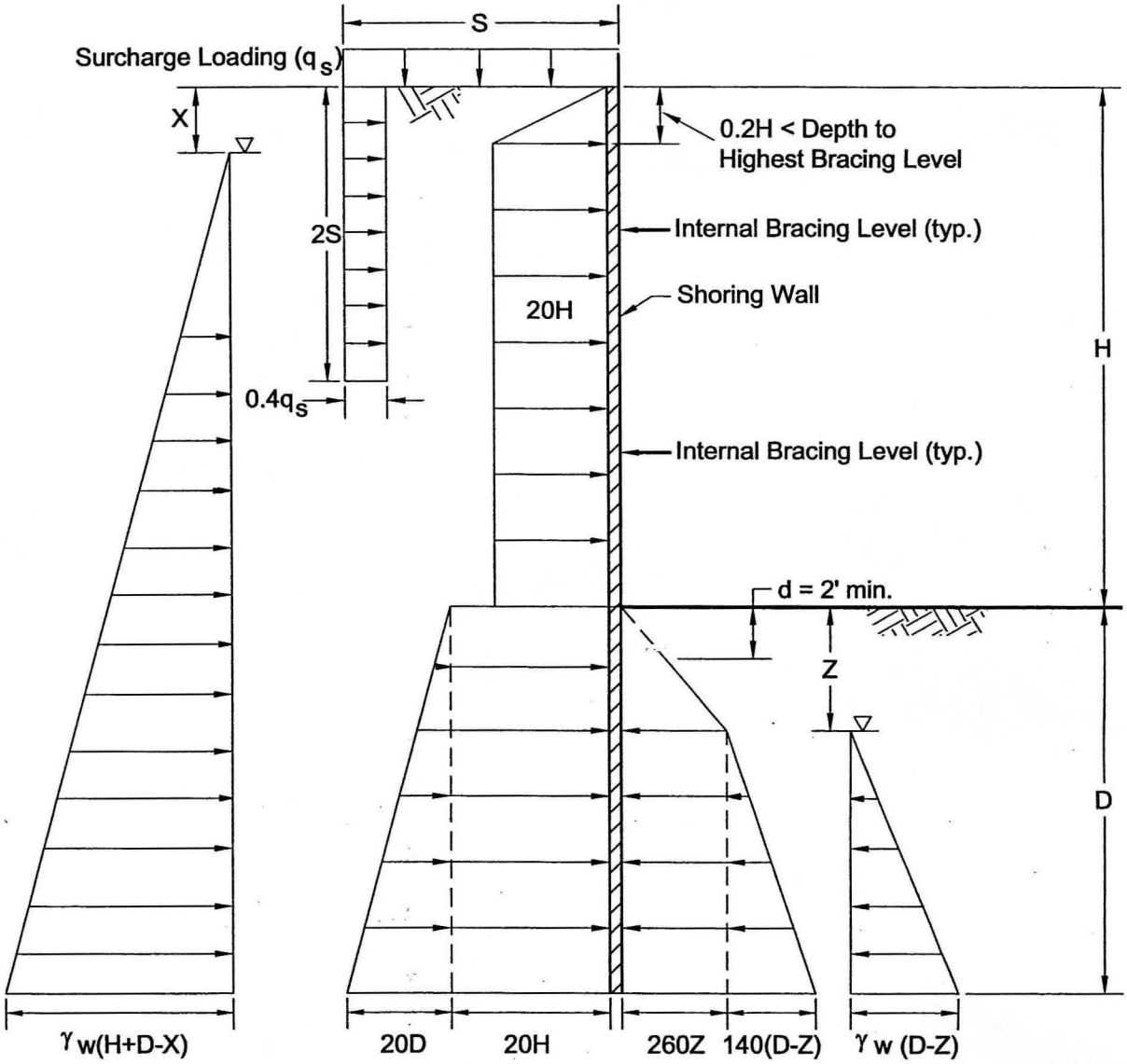
Aberdeen Industrial Water Pipeline Phase II
Downtown Segment
Aberdeen, Washington

**SITE AND EXPLORATION PLAN**

March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. 2**
Sheet 4 of 4




File: I:\Drafting\211\08713-005\21-1-08713-005 fig 3.dwg Date: 03-19-2002 Author: cnk

## NOTES

1. Groundwater level inside excavation maintained at least 2 feet below bottom of excavation at all times.

2. Groundwater level outside excavation should be based on groundwater levels observed in the soil borings.

3. Pressures are in pounds per square foot (psf).

4. Passive pressures include a factor of safety of 1.5.

5. Embedment for kickout resistance should be determined by horizontal force equilibrium below the lowest brace, then increased 20 percent. To prevent piping D/(H-X) should be at least 0.75. Design pile embedment should be the greater of the two.

6. If soldier piles with lagging are used, apply active pressure over the width of the soldier piles below bottom of excavation and apply passive resistance over twice the width of the piles or the spacing of piles, whichever is smaller.

## LEGEND

$\gamma_W$ = Unit Weight of Water = 62.4 pcf

$q_S$ = Surcharge Due to Traffic, Construction Equipment and Other Loadings

H = Depth of Excavation Below Present Ground Surface Feet, Including Overexcavation Depth, If Required

S = The Extent of Surcharge Loading Behind the Shoring Wall, Feet

Z = Depth of Water Below Bottom of Excavation, Inside Excavation = 2 Feet Minimum

X = Depth of Water Below Ground Surface, Outside Excavation

D = Depth of Pile Embedment Below Bottom of Excavation, Feet

d = Zone in Which Passive Pressure Should be Ignored, Recommended d = 2 Feet

$\nabla$ = Groundwater Level

DRAFT

Aberdeen Industrial Water Pipeline Phase II
Aberdeen, Washington

**EARTH PRESSURES FOR TEMPORARY BRACED SHORING WITH HYDROSTATIC PRESSURE**

March 2002 21-1-08713-005

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

**FIG. 3**

# 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.

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## 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

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