Report
Geotechnical Engineering Services
Port of Willapa Harbor
South Fork Industrial Site Development
Raymond, Washington

June 28, 2002

For
Port of Willapa Harbor
c/o Gibbs and Olson

GeoEngineers

June 28, 2002

Port of Willapa Harbor
c/o Gibbs and Olson
2604 12th Court, Suite A
Olympia, Washington 98512

Attention: Mike Wolfe

Report
Geotechnical Engineering Services
Port of Willapa Harbor
South Fork Industrial Site Development
Raymond, Washington
File No. 9538-001-01

INTRODUCTION

This report presents the results of our geotechnical evaluation of the proposed Port of Willapa Harbor South Fork Industrial Site in Raymond, Washington. Our understanding of the project is based on a site plan provided by you, conversations with you and our experience at the site.

We completed a Phase I Environmental Site Assessment (ESA) of the south part of the subject property in January 2002 for the Port of Willapa Harbor. The results of our previous work are contained in the "Phase I Environmental Site Assessment, Pacific Hardwoods Mill Site, Raymond, Washington, January 14, 2002."

The site is located in a low, relatively flat area between SR-101 and the Willapa River as shown in Figure 1. The site is bordered to the east and north by the Willapa River, to the south by SR-101 and to the west by residential properties and SR-101. We understand that the site is presently owned by the Port of Willapa Harbor. Up to four lumber mills have occupied part of the property since the early 1900s. A lumber mill formerly owned by Pacific Hardwoods exists in the south half of the site. Existing conditions at the site are shown in Figure 2.

Based on the site plan provided, we understand that the proposed improvements consist of infrastructure development. We understand that no buildings are to be constructed at the site during this phase of work. We understand the proposed improvements consist of one stormwater treatment vault, approximately 3,400 lineal feet of utility trenches (water, sanitary and storm sewers), approximately 1,500 feet of paved roadways and approximately 900 feet of gravel roadways. We understand the stormwater treatment vault may consist of an Aqui-Swirl Concentrator. The Aqui-Swirl consists of HDPE plastic and may extend up to 10 feet below

GeoEngineers, Inc.
1101 Fawcett Ave., Suite 200
Tacoma, WA 98402
Telephone (253) 383-4940
Fax (253) 383-4923
www.geoengineers.com

existing grades. The water, sewer and stormwater pipes will range in depth from 4 to 7 feet below existing grades based on information provided by you. The approximate layout of the proposed improvements are shown in Figure 3. We understand that you require geotechnical information for design of the proposed improvements.

PURPOSE AND SCOPE OF SERVICES

The purpose of our services is to evaluate subsurface soil and groundwater conditions at the site as a basis to develop geotechnical recommendations for the proposed improvements. The specific scope of services completed for this project is as follows:

1. Review readily available geotechnical reports, environmental reports and/or other relevant documents pertaining to fill, soil and groundwater conditions at the subject site.
2. Develop a health and safety plan for use by GeoEngineers personnel while performing work at the site.
3. Subcontract and observe the excavation of 12 test pit explorations in the proposed new roadways and sewers.
4. Subcontract and observe the drilling of one boring to a depth of about 59 feet in the area of a formerly proposed concrete wet well.
5. Collect 1.5-inch ID split-barrel Standard Penetration Test (SPT) samples in general accordance with American Society for Testing and Materials (ASTM) D 1586 procedures at approximately 5-foot intervals or other indicated intervals, in the boring.
6. Collect bulk samples of representative materials in the test pits.
7. Field screen a part of each soil sample for organic vapors and for evidence of petroleum-like sheen.
8. Perform geotechnical laboratory testing on soil samples collected from the boring and test pits.
9. Evaluate pertinent engineering characteristics of soil encountered in the boring and test pit explorations, based on the data.
10. Evaluate seismicity at the site and earthquake engineering aspects of the project, including potential for liquefaction of subsurface soils encountered in the explorations.
11. Provide recommendations for site preparation in the areas of the proposed improvements including evaluation of the requirements and potential problems associated with site grading, and earthwork specifications.
12. Provide preliminary recommendations for foundation support of sewer manholes.

13. Develop preliminary recommendations for foundation support for the proposed stormwater vault including allowable bearing pressures, lateral resistance values, estimates of settlement and minimum size and depth of foundations.
14. Provide general recommendations for control of groundwater in the anticipated trench and vault excavations including general shoring requirements, fill criteria and use of on-site materials as fill.
15. Provide recommendations regarding appropriate pavement sections based on the subsurface materials encountered and the anticipated traffic loads.
16. Prepare a written report including the results of the field and laboratory testing, analysis, conclusions, and recommendations.

SITE CONDITIONS

SURFACE CONDITIONS

The project site consists of approximately 24 acres of mostly undeveloped property located in the west part of Raymond, Washington as shown in Figure 1. The site is relatively flat with a slight downward slope to the east and north, to the Willapa River. Site elevations range from about 7.5 feet above Mean Sea Level (MSL) in the flatter parts of the site, to about 19.5 feet above MSL near the intersection of Wilson Street and SR-101.

The site is bordered to the east and north by the Willapa River, to the south by SR-101 and to the west by residential properties and SR-101. Our Phase I ESA revealed that up to four lumber mills have occupied parts of the property since the early 1900s. A railroad was formerly located in the approximate center of the site. The railroad was oriented east to west, the railroad tracks and ties have been removed. We understand a railroad spur from the main railroad was located in the south half of the site. We also understand that part of the proposed roadway improvements are located near or on the former railroad spur.

An existing mill complex is located north and south of the former location of the railroad. The mill was not in operation at the time of our site work. We understand the mill was formerly owned by Pacific Hardwoods. Approximately 10 buildings of various sizes existed at the site at the time of our site work. The buildings include metal and wood framed structures with concrete, wood and dirt floors. The approximate location of existing structures and roadways at the site are shown on the Site Plan, Figure 2.

The site is about 12 feet lower in elevation than Highway 101, located south and west of the site. Highway 101 was likely constructed on fill. Access to the site is gained from Highway 101 on Wilson Street. The off-ramp is constructed on fill that appears to include boulders, based on our observations. The outboard edges of the off-ramp have settled. We understand that repairs have consisted of placement of new asphalt along the edges. We observed at least three layers of asphalt repairs in this location.

Portions of the project site has been previously graded and filled. Historical aerial photographs reviewed for our Phase I ESA revealed that the north and east parts of the site were formerly occupied by the Willapa River. These areas have apparently been filled over time. Fill has also likely been placed in the former railroad and railroad spur areas. The fill previously placed at the site likely consists of wood waste, dredge material from the Willapa River, and gravel material used for ballast in the railroad grade areas.

Asphalt-paved roadways presently exist in the south part of the site, as shown in Figure 2. A gravel-covered roadway traverses the site from north to south. The remaining areas are surfaced in gravel, wood waste, or soil. Vegetation at the site generally consists of scattered low-lying weeds and grasses.

SUBSURFACE EXPLORATIONS

Subsurface conditions at the site were explored between April 9 and 10, 2002 by drilling one boring and excavating 12 test pits. The explorations were located in the field by our representative by measuring from existing site features. The approximate locations of the explorations are indicated on Figures 2 and 3. Our representative continuously monitored the explorations, maintained logs of the subsurface conditions, and obtained representative samples as needed. The soils encountered were visually classified in accordance with the system described in Figure 4, ASTM D 2488.

A part of each sample was also screened for the potential presence of petroleum contamination by water sheen and vapor testing. Indications of petroleum contamination were not observed in the soil samples, based on the field screening.

The boring was advanced on April 9, 2002 using a truck-mounted hollow-stem auger drill rig at the approximate location shown on Figures 2 and 3. The boring was advanced to a depth of approximately 59 feet below ground surface (bgs). Soil samples were obtained from the borings using a 2.4-inch-inside-diameter split-barrel ring sampler driven into the soil using a 300-pound hammer free-falling a distance of 30 inches. The number of blows required to drive the sampler the last 12 inches or other indicated distance is recorded on the logs as the blow count. A key to the symbols used on the boring logs is included as Figure 5. The boring log is included as Figure 6.

Twelve test pits were completed at the site on April 10, 2002. The approximate test pit locations are shown in Figures 2 and 3. Test pits were excavated using a rubber-tired backhoe. Ten of the 12 test pits were advanced to approximately 10 feet bgs. Excavation of test pit 2 was attempted in two locations and terminated at a final depth of 4 feet bgs due to the presence of a shallow utility pipeline. Test pit 10 was terminated at approximately 2 feet bgs after our field representative was notified of an unlocated sewer line in the area. Summary test pit logs are presented as Figures 7 through 12. The densities noted on the logs are based on difficulty of excavation, our observations, experience and judgement.

The test pits were backfilled with the material derived from the excavations, and the backfill tamped in place and smoothed. The backfill was not compacted to a density consistent with structural fill, and therefore the backfill may need to be removed and recompacted when the site is developed.

LABORATORY TESTING

Soils samples obtained from the boring and test pits were transported to GeoEngineers laboratory. Representative soil samples were selected for laboratory tests to evaluate the pertinent geotechnical engineering characteristics of the site soils and to confirm our field classification. The following paragraphs provide a description of the tests performed.

The moisture content and/or density of selected samples were determined in general accordance with ASTM Test Methods D 2216 and D 2937, respectively. The test results are used to aid in soil classification and correlation with other pertinent engineering soil properties. The test results are presented on the applicable boring or test pit log.

Particle size analyses were performed on selected samples in general accordance with ASTM Test Method D 422. This test method covers the quantitative determination of the distribution of particle sizes in soils. The results of the tests were used to verify field soil classifications. Figures 13 presents the results of the analyses.

Consolidation testing was performed on one sample obtained from the boring to determine the settlement potential of the sample. The test was performed in accordance with ASTM D 2435. Consolidation test data is used to evaluate the magnitude and rate of potential soil consolidation under loading conditions. The results of the test are contained in Figure 14.

SUBSURFACE SOIL CONDITIONS

Subsurface conditions encountered in the explorations generally consist of fill overlying alluvially deposited silt with organics. The fill encountered consists of two relatively distinct materials, granular gravel fill and wood waste fill.

The underlying silt material appears to be an extensive deposit throughout the Raymond area. The silt is in a soft to very soft condition. This material is very sensitive to loads and is compressible. In addition, the silt material will be very sensitive to seismic shaking. Care must be taken when excavating into the native silt deposits.

Granular gravel fill was encountered at the ground surface in boring 1 and all test pits except 1, 10 and 12. Gravel fill encountered in the explorations generally consists of crushed rock and fine to coarse gravel with silt and sand. The depth of gravel fill ranged from approximately 1-foot in test pits 8, 9 and 11 to approximately 7 feet in test pits 6 and 7. Test pit 2 terminated in gravel fill at a depth of approximately 4 feet. Test pits 6 and 7 appear to be located either within or near the former railroad.

Fine sand and silty sand fill was encountered from the ground surface to depths between 2 and 6 feet in test pits 1, 10 and 12. Based on our knowledge of the site area, this material may consist of dredge fill. Fill consisting of silt interbedded with gravel, sand and wood fill was encountered in test pits 2, 9 and 12. Test pit 10 was terminated at 2 feet bgs in fine sand fill.

Wood debris fill was encountered beneath the granular or silt fill in test pits 4, 5, 8, 9 and 11. Wood debris encountered in the explorations consists of wood chips, wood waste, sawdust, lumber and lumber fill. The thickness of wood debris fill varied from about 4 to 5 feet and was generally observed overlying native silt and organic silt.

Two test pits (2 and 10) terminated in fill material. The remaining test pits and boring extended beyond the fill into native silt and organic silt. The silt is a low-energy alluvial deposit and likely underlies the entire site. The depth to the bottom of the deposit is unknown, but extends beyond the bottom of boring 1.

Native silt was encountered in boring 1 at a depth of approximately 5 feet bgs to the full depth explored in the boring. Native silt and organic silt was also encountered in our test pit explorations at depths ranging from between 2 and 7 feet bgs. The silt and organic silt was observed in a very soft and moist to wet condition.

GROUNDWATER

Groundwater was encountered in boring 1 and in test pits 1, 2, 4, 5, 6, 7, 11 and 12. Groundwater depths varied from approximately 2 feet bgs (test pit 2) to 7 feet bgs (test pits 5 and 12). Groundwater depths at the site will vary according to distance from the nearby surface water bodies, tidal conditions, precipitation and season. We expect that shallow groundwater will likely be encountered during excavations completed at the site.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

In our opinion, the proposed infrastructure development at this site is geotechnically feasible provided that the considerations and recommendations presented in this report are incorporated into the planned development. The alluvially deposited native soils encountered in our explorations are very soft, are highly compressible and are very susceptible to disturbance. These soils will settle under the weight of new loads. In addition these soils are highly susceptible to excavation disturbance and to moisture. It will be difficult, if not impossible to work the native soils during wet weather conditions. Therefore, we recommend that the work be performed during the normally dry time of the year (summer months). Specific recommendations concerning geotechnical elements of the project are contained in following sections of this report.

SITE PREPARATION

General

We understand some limited cuts and fills are planned at the site for drainage purposes and for preparing roadway subgrades. We also anticipate cuts to install utilities and the stormwater treatment vault. The native surficial soil and some of the fill soils encountered in our explorations have significant silt contents and are extremely moisture sensitive. These materials will be difficult, if not impossible, to operate on or compact during wet weather. Operation of heavy equipment at the site under wet conditions can be expected to result in considerable disturbance to the exposed subgrade soils. Once disturbed, the softened soils will likely have to be removed and replaced. We strongly recommend that earthwork be undertaken during periods of dry weather to reduce grading costs.

Clearing and Site Preparation

The area to be receiving new pavement and gravel surfacing should be stripped of all deleterious matter and any subsurface debris or rubble that would be in the way. We understand only limited site grading (less than 2 feet of cut) will occur in the roadway area. Prior to placement of additional fills in the pavement areas, we recommend that a member of our staff evaluate the exposed subgrade conditions. The exposed subgrade soil should be proofrolled with heavy rubber-tired equipment during dry weather or probed with a ½-inch-diameter steel rod during wet weather. Any soft, loose or otherwise unsuitable areas delineated during proofrolling or probing should be recompacted, if practical, or overexcavated to a depth of at least 2 feet and replaced with structural fill, based on the recommendations of our site representative. If deep pockets of soft or pumping soils are encountered, it may be possible to limit the depth of overexcavation by placing a non-woven geotextile fabric on the overexcavated subgrade and covering the geotextile with structural fill. The geotextile will provide additional support by bridging over the soft material, and will help reduce fines contamination into the structural fill.

STRUCTURAL FILL

General

All new fill used within the proposed roadways should be placed as structural fill. Structural fill material should be free of debris, organic contaminants, or rock fragments larger than 6 inches. Particle sizes larger than 3 inches should be excluded from the top 1-foot of fill.

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil at the time of placement. Adequate compaction cannot be achieved when the soil moisture content is more than a few percent above or below the optimum level, particularly in soils with high silt contents. As the amount of fines (material passing the No. 200 sieve) increases, soil becomes increasingly more sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve.

The existing fill material may be re-used for structural fill during dry weather conditions, provided the material is at a moisture content suitable for proper compaction. The existing native soil at the site can be used for structural fill only if the material can be properly moisture conditioned to achieve proper compaction. The material will likely need to be aerated to achieve a suitable moisture content even during dry weather conditions.

Fill Placement

All fill must be placed in thin lifts so that uniform compaction can be achieved throughout the entire lift thickness. In general, granular soils with less than 5 percent fines can be placed in lifts of about 12 inches or less (loose thickness). A soil with a higher fines content may necessitate thinner lifts. Each lift must be compacted prior to placing the subsequent lift.

All structural fill should be uniformly compacted in horizontal lifts to at least 95 percent of the maximum dry density (MDD) determined in accordance with ASTM D-1557 (modified Proctor). Pavement subgrade soils and utility trench backfill should be compacted to at least 90 percent of the MDD up to within the upper 2 feet; the upper 2 feet should be compacted to at least 95 percent. Compaction must be achieved by mechanical means. No jetting, ponding, or flooding will be allowed for compaction. During fill and placement, a suitable number of in-place density tests should be performed concurrently with the fill operations to check that the required compaction is being achieved.

UTILITY TRENCHES

General

We understand that approximately 3,400 lineal feet of utility trenches will be installed as a part of the infrastructure development. We also understand that the trenches will be located approximately five feet outside the roadway prism. In addition, we understand most of the trenches will vary in depth between 4 to 6 feet below existing grades. Approximately 120 feet of trench will be about 7 feet deep.

Based on our knowledge of the site, it is possible that the trench excavations could encounter obstructions in the form of wood planking and/or wood pilings. The probability of encountering wood pilings is probably most likely north of the former railroad right of way, based on aerial photographs reviewed for the Phase I ESA portion of the project.

If pilings are encountered we recommend that the piles be cut off a minimum of two feet below the bottom of the excavation. The piles must not be pulled from the excavation. Pulling of the piles could result in significant soil disturbance.

We anticipate that shoring will be required to install the utilities and manholes to the intended depths. All shoring must comply with the provisions of Title 296 Washington Administrative Code (WAC), Part N, "Excavation, Trenching and Shoring." The contractor performing the work must have the primary responsibility for protection of workmen and adjacent improvements, deciding whether or not to use shoring, and for establishing the safe inclination for open-cut

slopes. Based on anticipated site conditions, we recommend sheet pile walls, ground freezing, or caisson construction techniques be considered. We also recommend that the contractor conducting the work be experienced working in soft soil conditions.

Pipe Bedding and Backfill

Based on our test pits, we expect soils at the base of the trench excavations will likely consist of native silt. It is possible that trench excavation bottoms near test pits 6 and 7 will consist of existing granular fill.

As previously stated, the underlying native silt soil is highly compressible and susceptible to disturbance and settlement. We recommend that the bottom two feet of trench be backfilled using a sandy gravel bedding material with a compacted unit weight of about 130 pcf. The fill should fully encapsulate the utility pipe. The bedding material should be placed in loose lifts not exceeding 8-inches, and be compacted to 90 percent of the soil MDD. The bedding fill should meet the specifications presented in the "Structural Fill" section of this report.

We recommend that a lightweight fill, such as wood chips or hog fuel, be used to backfill the trenches to a depth about 1-foot below final subgrades. The lightweight fill should have a unit weight of about 60 pcf and should be compacted to a firm condition. The trench excavations can then be topped with approximately 1-foot of native silt soil compacted to 95 percent of the MDD.

We expect settlement of the proposed pipeline will be less than one inch provided the soils at the base and sidewalls of the excavation are not unduly disturbed during installation and if the recommended trench backfill sequence is followed.

Manholes

We expect that most of the manhole structures proposed for the infrastructure development will extend to the native silt soils. We recommend that the manholes be founded on two feet of sandy gravel bedding material with a compacted unit weight of about 130 pcf. The bedding material should be placed in loose lifts not exceeding 8-inches, and be compacted to 95 percent of the soil MDD. The bedding fill should meet the specifications presented in the "structural fill" section of this report.

We recommend that a lightweight fill, such as wood chips or hog fuel, be used to backfill around the manholes to a depth about 1-foot below final subgrades. The lightweight fill should have a unit weight of about 60 pcf and should be compacted to a firm condition. The manhole excavations can then be topped with approximately 1-foot of native silt soil compacted to 95 percent of the MDD.

STORMWATER VAULT

General

We understand that you intend to install a stormwater vault in the approximate location shown in Figure 3. We also understand that the stormwater vault will likely consist of an Aqua-Swirl Concentrator, manufactured by AquaShield. The vault is of HDPE plastic construction, is about 8.5 feet in height and about 4.5 feet in diameter. We understand that the vault may be seated so that the top of the vault will be approximately 2.5 feet below planned ground surface. We anticipate that the base of the vault will extend into the native silt soils below the surficial layer of fill.

We anticipate that shoring will be required to install the stormwater vault to the intended depths. All shoring must comply with the provisions of Title 296 Washington Administrative Code (WAC), Part N, "Excavation, Trenching and Shoring." The contractor performing the work must have the primary responsibility for protection of workmen and adjacent improvements, deciding whether or not to use shoring, and for establishing the safe inclination for open-cut slopes. Based on anticipated site conditions, we recommend sheet pile walls, ground freezing, caisson construction techniques or drilled shaft construction techniques be considered.

Construction Considerations

We recommend that the base of the stormwater vault excavation be filled with approximately six inches of granular fill with a compacted unit weight of about 130 pounds per cubic foot (pcf). The base material should be placed as structural fill in accordance with the specifications included in this report. We also recommend that a reinforced concrete slab, approximately six inches thick and extending beyond the edge of the proposed vault a distance sufficient to balance hydrostatic uplift, be installed around the base of the vault. The weight and configuration of the slab should be sufficient to resist hydrostatic uplift of the vault. We recommend that the area around the vault be backfilled with lightweight fill material with an approximate unit weight of 60 pcf. The lightweight fill should be compacted in even lifts to a firm condition.

CONSTRUCTION DEWATERING

We anticipate that dewatering will likely be necessary to construct the planned improvements at the site. Groundwater levels encountered in our explorations ranged from 2 to 7 feet bgs. Groundwater levels will vary at the site according to season, tidal conditions and precipitation. In addition, the amount of groundwater seepage into planned excavations should be expected to vary across the site. Granular fill and wood fill are more permeable than the underlying native silt deposit and will produce higher water flows.

The level of effort required for dewatering will depend to a great extent on the time of year during which construction is accomplished. Based on our experience in the area, groundwater levels are likely higher during the wet season. More extensive dewatering measures will be necessary during periods of high groundwater levels. If dewatering during construction is used,

we recommend the water levels be maintained a minimum of 1-foot below the bottom of the excavations.

It is the contractors' responsibility to review the data presented in this report, perform any additional investigations and tests deemed necessary to characterize the soil and groundwater conditions at the site, and to develop independent conclusions regarding the design, construction and operation of the dewatering system.

SEISMIC CONSIDERATIONS

The 1997 Uniform Building Code (UBC) recommends that the design earthquake for this site be based on a 10 percent probability of exceedance in 50 years. The design earthquake that corresponds to this probability of exceedance has a Richter magnitude of 7.5 and a peak horizontal ground acceleration of about 0.30 g, where g is the gravitational constant. Based on UBC Table 16-J, the soil profile for the project site is best characterized as Type S_E.

Liquefaction is a loss of strength which certain soils experience when subjected to cyclic stresses, such as would occur during an earthquake. In general, soils which are susceptible to liquefaction include loose to medium dense sands and silty sands which are below the water table.

Liquefiable soils were not encountered in our explorations. However, the subsurface silt soils are soft to very soft and highly compressible. These soils will deform and likely settle under the design earthquake. Based on this, we recommend that flexible connections be considered where the pipes connect to rigid structures such as buildings or vaults.

PAVEMENT DESIGN

General

The approximate distribution of proposed new paved areas is shown in Figure 3. Based on plans provided by you, we understand that approximately 1,500 lineal feet of new paved roadway will be created at the site. The proposed paved roadway consists of the north-south access road starting just south of the intersection of Peters Street and Wilson Street and continuing north to just past test pit 9. We understand the two east-west spur roadways off of the central road will be surfaced in gravel, based on information provided by you. We recommend that subgrades in proposed pavement areas be prepared as previously described in the "Site Preparation" section of this report.

Two pavement sections were derived based on differing soil conditions along the alignment. In general, a thicker section of existing gravel fill appears to exist at test pits 6 and 7, therefore the proposed pavement section is slightly thinner in this area than in the areas north and south of these test pits. Test pits 6 and 7 are located north and south of the former railroad.

Assumptions

The following parameters were assumed to derive the representative pavement sections.

- 75 trucks per day. We assume these would be a combination of single, tandem and trailer trucks (used an average ESAL value).
- 10-year design life with no traffic growth.
- The Mr of subsurface silt, organic silt and wood debris is 6,000 pounds per square inch (psi).

Pavement Section 1

Pavement Section 1 is for the proposed roadway at test pit locations 2, 3, 4, 8 and 9. Test pits 2 through 4 and located in the south half of the site. Test pits 8 and 9 are located in the north end of the proposed roadway alignment. Based on the test pit data, we assumed one to two feet of existing gravel fill overlying silt, organic silt or wood debris. Based on information provided by you, we assume between 0 and 12+ inches of the existing gravel fill will be left in place.

Our proposed pavement design consists of 4 inches asphalt over 2 to 11 inches of base course over the existing 0 to 12+ inches subbase. The distribution of proposed material thicknesses is shown on Table 1.

TABLE 1
PAVEMENT SECTION 1
DESIGN RECOMMENDATIONS

Asphalt (in.)	Base Course (in.)	Subbase (existing gravel) (in.)
4	11	0 – 6
4	6	6 – 12
4	4	12 – 24

Pavement Section 2

Pavement Section 2 is for the roadway at test pit locations 6 and 7. These test pits are located in the approximate center of the proposed alignment. We assume 7 feet of existing gravel fill over native silt or organic silt, based on the test pits. Based on information provided by you, we assume the majority of gravel fill (4+ feet) will be left in place. Our proposed design consists of 4 inches of asphalt over 2 inches of base course over the existing gravel as subbase.

Immediate settlement estimates are provided in Table 2 and are based on the amount of new material placed on site. Because long-term (secondary) settlement is likely still occurring due to existing fill on site, we were not able to determine future settlement estimates.

TABLE 2
ESTIMATED SETTLEMENT (short term)

Scenario	Approx. Settlement (in.)
Overexcavate and Replace Equal Amount	1
Place at Grade (TP-6 and 7)	0.15
Place at Grade (TP-2,3,4,8 and 9)	2.5 – 4.5

LIMITATIONS

We have prepared this report for the exclusive use of the Gibbs & Olson and the Port of Willapa Harbor.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix A titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

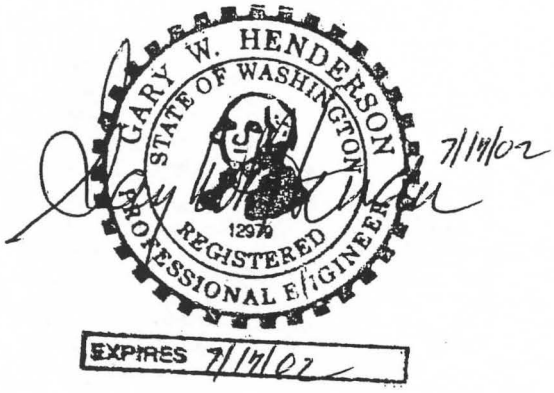
We appreciate the opportunity to be of service to you on this project. Should you have any questions regarding this report or if we can be of additional service, please call.

Yours very truly,

GeoEngineers, Inc.

Teresa Dugger by SWH.

Teresa A. Dugger, P.E.
Geotechnical Engineer



Stephen W Helvey

Stephen W. Helvey, P.G.
Senior Engineering Geologist

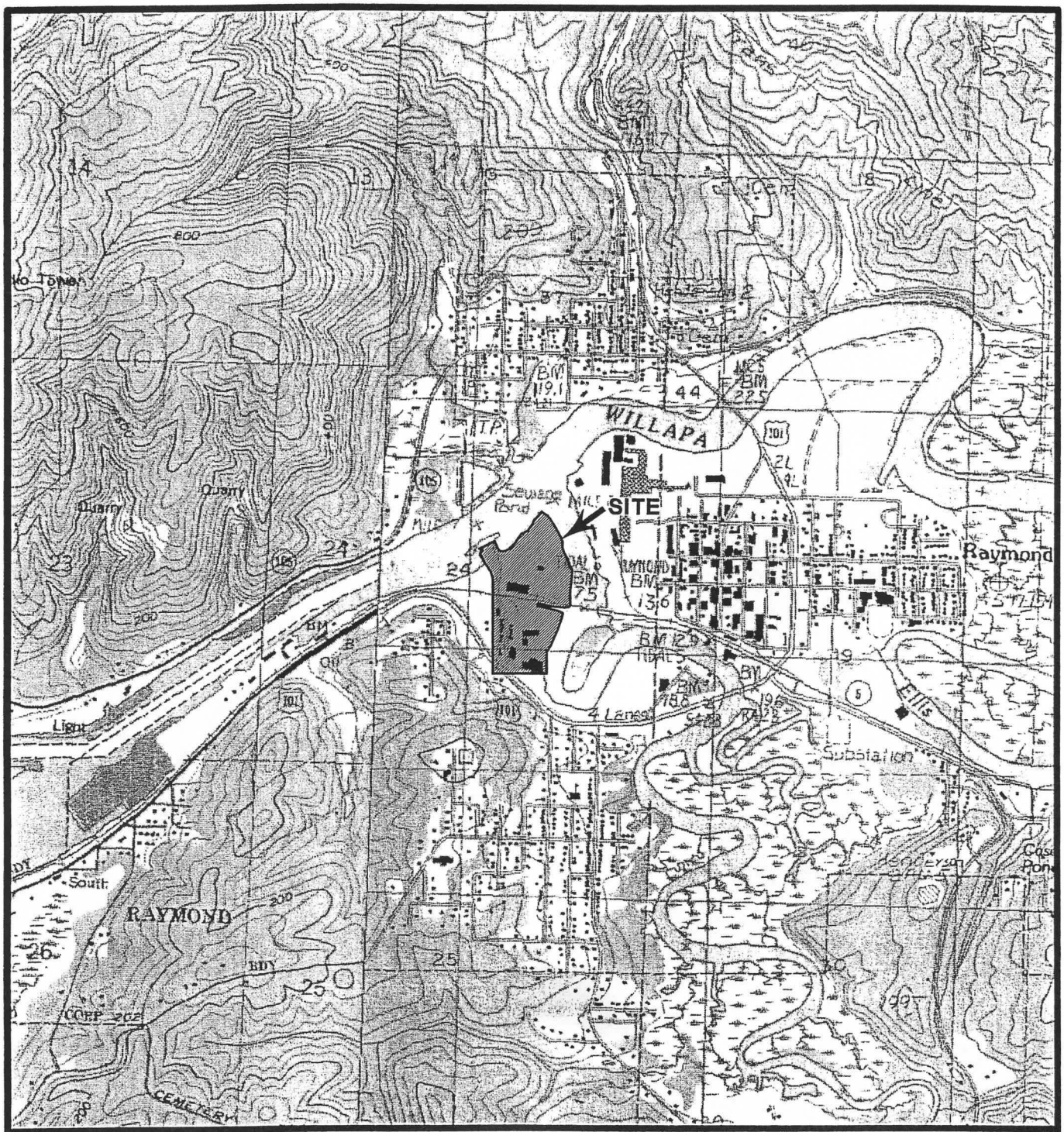
Gary W Henderson

Gary W. Henderson, P.E.
Principal

TAD:SWH:GWH:tw
TACO\9\9538001\01\Finals\953800101R.Doc

Attachments:
- Figure 1 – Vicinity Map
- Figure 2 – Site Plan
- Figure 3 – Site Plan – Proposed Conditions
- Figure 4 – Soil Classification System
- Figure 5 – Key to Boring Log Symbols
- Figure 6 – Log of Boring
- Figures 7 through 12 – Log of Test Pits
- Figure 13 – Sieve Analysis Results
- Figure 14 – Consolidation Test Results
- Appendix A – Report Limitations and Guidelines for Use

P:\9538001\01\CAD\VICINITY1



0 2000 4000

SCALE IN FEET

N

Notes: 1. The locations of all features shown are approximate.

2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.

Reference: Sure Maps! Raster Maps— USGS based quadrangles.

9538-001-01 SWH:RJW 06/26/02

Geo Engineers

VICINITY MAP

FIGURE 1

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More Than 50% Retained on No. 200 Sieve	GRAVEL More Than 50% of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More Than 50% of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More Than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less Than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or More	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-93.
2. Soil classification using laboratory tests is in general accordance with ASTM D2487-98.
3. Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water

Wet - Visible free water or saturated, usually soil is obtained from below water table

GeoEngineers

SOIL CLASSIFICATION SYSTEM

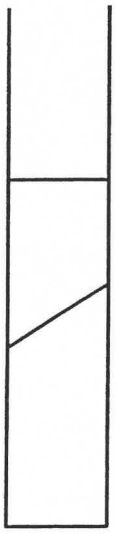
FIGURE 4

File No. 9538-001-01 TAD:GWH:tw 06/25/02

LABORATORY TESTS

AL	Atterberg Limits
CP	Compaction
CS	Consolidation
DS	Direct shear
GS	Grain size
%F	Percent fines
HA	Hydrometer Analysis
SK	Permeability
SM	Moisture Content
MD	Moisture and density
SP	Swelling pressure
TX	Triaxial compression
UC	Unconfined compression
CA	Chemical analysis

SOIL GRAPH:



SM Soil Group Symbol (See Note 2)

Distinct Contact Between Soil Strata

Gradual or Approximate Location of Change Between Soil Strata

Water Level

Bottom of Boring

BLOW COUNT/SAMPLE DATA:

Blows required to drive a 2.4-inch I.D. split-barrel sampler 12 inches or other indicated distances using a 300-pound hammer falling 30 inches.

- 22 Location of relatively undisturbed sample
- 12 Location of disturbed sample
- 17 Location of sampling attempt with no recovery

Blows required to drive a 1.5-inch I.D. (SPT) split-barrel sampler 12 inches or other indicated distances using a 140-pound hammer falling 30 inches.

- 10 Location of sample obtained in general accordance with Standard Penetration Test (ASTM D-1586) procedures
- 26 Location of SPT sampling attempt with no recovery

Location of grab sample

"P" indicates sampler pushed with weight of hammer or against weight of drill rig.

NOTES:

1. The reader must refer to the discussion in the report text, the Key to Boring Log Symbols and the exploration logs for a proper understanding of subsurface conditions.
2. Soil classification system is summarized in Figure 4.

File No. 9538-001-01 TAD:GWH:tw 06/25/02

Geo Engineers

KEY TO BORING AND TEST PIT LOG SYMBOLS

FIGURE 5

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

Date Drilled	04/09/02	Logged By	KWG	Contractor	Holt Drilling
Drill Method	4-inch Hollow-Stem Auger	Equipment	Mobile B-61	Drill Bit	Carbide Teeth
Sample Method	2.4-inch ID Split Barrel	Hammer Data	300 lb. Hammer/30-inch Drop	Location	Near Existing Pump Station
Total Depth (ft)	59	Elevation (ft)	Not Measured	Datum: System:	N/A

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0						GM	Gray silty fine to coarse gravel with sand (dense, moist) (fill)			
		1	33	☒				7		23% Passing No. 200 Sieve
5						ML	Gray sandy silt with trace of organic material (very soft, wet) (native)			
		2	1	■				93	48	
10						SM	Gray silty fine sand, occasional gravel (very loose, wet) (native)			
		3	0	☒						
15						ML	Gray silt with trace of organic material (very soft, wet)			
		4	1	☒						
20										
		5	1	■				79	54	
25										
		6	0	☒						
30										
		7	1	■			Trace of wood	93	47	
35										

Note: See Figure 5 for explanation of symbols

GEI GENERAL BORING 9538001B.GPJ GEI_CORP.GDT 6/25/02 9538-001-01

Geo Engineers

LOG OF BORING B-1

FIGURE 6

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35											35
		8	1	■						CS	
40											40
		9	1	■				37	82		
45						SM	Gray silty fine sand (very loose, wet) (native)				45
		10	1	■							
50											50
		11	3	■				37	83		
55											55
		12	1	■							
60							Boring completed at a depth of 59.0 feet on 04/09/02. Groundwater encountered at a depth of 3.5 feet during drilling.				60
65											65
70											70
75											75

Note: See Figure 5 for explanation of symbols

GEI GENERAL BOR 9538001B.GPJ GEI_CORP.GDT 6/25/02 9538-001-01

GeoEngineers

LOG OF BORING B-1
(Continued)

FIGURE 6

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

LOG OF TEST PIT TP-01

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				SM	Brown silty fine to coarse sand with wood and boulder-sized asphalt debris and metal (loose, moist) (fill)					0
	1	☒								
5				ML	Gray silt with organic material (very soft, wet) (native) ∇					5
10	2	☒			Test pit completed at a depth of 10.0 feet on 04/10/02. Rapid groundwater seepage observed at a depth of 6.0 feet. No caving observed. Disturbed soil samples obtained at depths of 4.0 and 10.0 feet.					10
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-02

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				GP	Crushed rock (fill)					0
				GP-GM	Brown sandy fine to coarse gravel with silt (medium dense, moist) (fill) ∇					
				ML	Gray silt (very soft, wet) (fill)					
				GP	Gray fine to coarse gravel (medium dense, wet) (fill)					
5					Test pit completed at a depth of 4.0 feet on 04/10/02 over a utility. Moderate groundwater seepage observed at a depth of 2.0 feet. Minor caving observed at depths between 2.0 and 4.0 feet.					5
10										10
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

Geo Engineers

LOG OF TEST PIT

FIGURE 7

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

LOG OF TEST PIT TP-03

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				GP	Brown-black sandy fine to coarse gravel (medium dense, moist) (fill)					0
				ML	Gray silt with sand and organic material (very soft, moist) (native)					
5										5
	1	⊠								
10					Test pit completed at a depth of 10.0 feet on 04/10/02. No groundwater seepage observed. No caving observed. Disturbed soil sample obtained at a depth of 7.0 feet.					10
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-04

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				GP	Gray crushed rock (dense, moist) (fill)					0
				WD	Wood waste/lumber (fill) ∇					
5										5
				OL	Brown organic silt (soft, wet)					
10	1	⊠			Test pit completed at a depth of 10.0 feet on 04/10/02. Rapid groundwater seepage observed at a depth of 4.0 feet. Minor caving observed at depths between 3.0 and 6.5 feet. Disturbed soil sample obtained at a depth of 10.0 feet.					10
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

GEI TEST PIT LOGS 9538-001T.GPJ GEI_CORP.GDT 6/25/02 9538-001-01

Geo Engineers

LOG OF TEST PIT

FIGURE 8

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

LOG OF TEST PIT TP-05

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				GP	Reddish brown crushed rock (dense, moist) (fill)					0
				GP	4- to 6-inch diameter angular crushed rock (quarry spalls) (dense, moist) (fill)					
	1	☒		WD	Wood chips (fill)					
5										5
				OL	Brown organic silt (very soft, wet) (native) ∇					
10	2	☒								10
					Test pit completed at a depth of 10.0 feet on 04/10/02. Rapid groundwater seepage observed at a depth of 7.0 feet. Minor caving observed at depths between 3.0 and 4.0 feet. Disturbed soil samples obtained at depths of 3.5 and 10.0 feet.					
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-06

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				GP	Brown sandy fine to coarse gravel (dense, moist) (fill)					0
	1	☒		GP	Gray sandy fine to coarse gravel (dense, moist) (fill)					
5					∇					5
				OL	Brown organic silt (very soft, wet) (native)					
10										10
					Test pit completed at a depth of 10.0 feet on 04/10/02. Moderate groundwater seepage observed at a depth of 5.0 feet. No caving observed. Disturbed soil sample obtained at a depth of 2.0 feet.					
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

GEI TEST PIT LOGS .T.GPJ GEI_CORP.GDT 6/25/02 9538-001-01

Geo Engineers

LOG OF TEST PIT

FIGURE 9

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

LOG OF TEST PIT TP-07

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

Depth in Feet	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes
0				GP	Brown crushed rock (loose, moist) (fill)				
				GP	Gray crushed rock (medium dense, moist) (fill)				
5	1	☒		OL	Brown organic silt (very soft, wet) (native)				
10					Test pit completed at a depth of 10.0 feet on 04/10/02. Moderate groundwater seepage observed at a depth of 4.0 feet. No caving observed. Disturbed soil sample obtained at a depth of 7.0 feet.				
15									
20									

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-08

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

Depth in Feet	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes
0				GP	Brown crushed rock (loose, moist) (fill)				
	1	☒		WD	Wood chips mixed with sawdust and lumber (fill)				
5	2	☒		ML	Gray silt with organic material and trace of sand (very soft, wet) (native)				
				OL	Brown organic silt (very soft, wet) (native)				
10	3	☒			Test pit completed at a depth of 10.0 feet on 04/10/02. Rapid groundwater seepage observed at a depth of 3.5 feet. Minor caving observed at depths between 1.0 and 5.0 feet. Disturbed soil samples obtained at depths of 2.0, 6.0, and 10.0 feet.				
15									
20									

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

GEI TEST PIT LOGS ...JIT.GPJ GEI_CORP.GDT 6/25/02 9538-001-01

Geo Engineers

LOG OF TEST PIT

FIGURE 10

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

LOG OF TEST PIT TP-09

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				GP	Crushed rock (loose, moist) (fill)					0
				ML	Mottled reddish-brown sandy silt (soft, moist) (fill)					
	1	☒								
				WD	Wood waste/lumber/logs (fill)					
5				OL	Brown organic silt (very soft, wet) (native)					5
10										10
					Test pit completed at a depth of 11.0 feet on 04/10/02. No groundwater seepage observed. No caving observed. Disturbed soil sample obtained at a depth of 2.0 feet.					
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-10

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

DEPTH IN FEET	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes	DEPTH IN FEET
0				SP	Gray fine to coarse sand with gravel (very dense, moist) (fill)					0
					Test pit terminated at a depth of 2.0 feet on 04/10/02 over a utility. No groundwater seepage observed. No caving observed.					
5										5
10										10
15										15
20										

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

GEI TEST PIT LOGS 9538-001-01.GPJ GEI_CORP.GDT 6/25/02

Geo Engineers

LOG OF TEST PIT

FIGURE 11

Project	Job Number	Location
Port of Willapa Harbor	9538-001-01	Raymond, WA

LOG OF TEST PIT TP-11

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

Depth in Feet	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes
0				GP	Crushed rock (dense, moist) (fill)				
				WD	Wood waste/lumber/sawdust/logs				
	1	☒							
5				OL	Gray organic silt (very soft, wet) ∇				
10	2	☒							
					Test pit completed at a depth of 10.0 feet on 04/10/02. Rapid groundwater seepage observed at a depth of 6.0 feet. Minor caving observed at depths between 3.0 and 6.0 feet. Disturbed soil samples obtained at depths of 4.0 and 10.0 feet.				
15									
20									

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-12

Date Excavated: 4/10/02 Logged by: KWG

Equipment: Rubber-Tired Extendahoe Surface Elevation (ft): Not Measured

Depth in Feet	Sample No.	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Pocket Penetrometer (Tons/ft²)	Field Vane Shear (psf)	Other Tests And Notes
0	1	☒		SP-SM	Brown fine to coarse sand with silt, occasional gravel (loose, moist) (fill)				
				WD	Wood waste/lumber/logs (fill)				
	2	☒		WD	Dimensional lumber with gray organic silt (soft, moist) (fill)				
5				OL	Brown organic silt (very soft, wet) ∇				
10	3	☒							
					Test pit completed at a depth of 10.0 feet on 04/10/02. Minor groundwater seepage observed at a depth of 7.0 feet. No caving observed. Disturbed soil samples obtained at depths of 0.6, 3.0, and 10.0 feet.				
15									
20									

Notes: The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

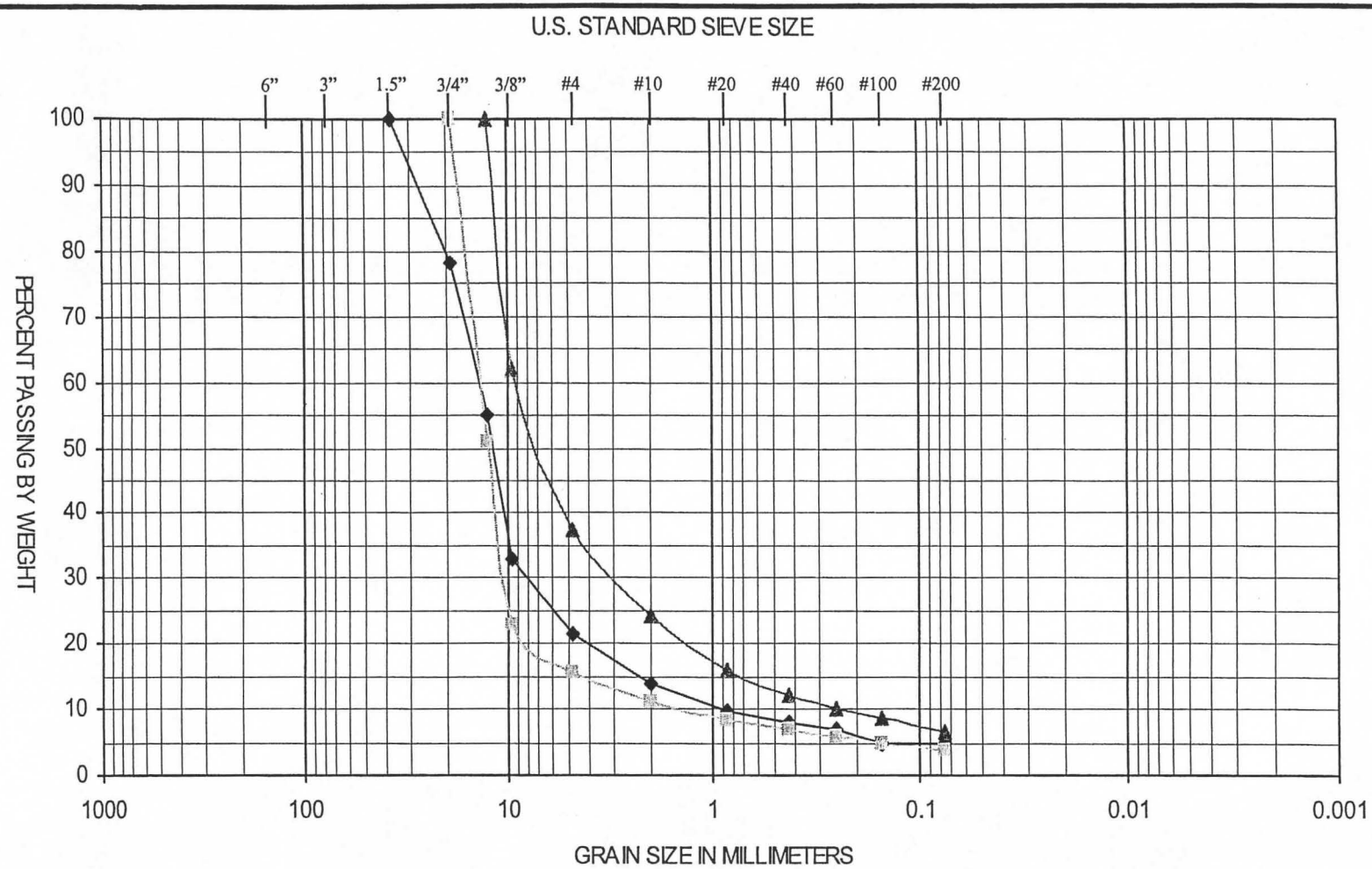
GEI TEST PIT LOG ...T.GPJ GEI_CORP.GDT 6/25/02 9538-001-01

Geo Engineers

LOG OF TEST PIT

FIGURE 12

9538-001-01 SWH:GWH:tw 06/25/02 (953800101S.ppt)



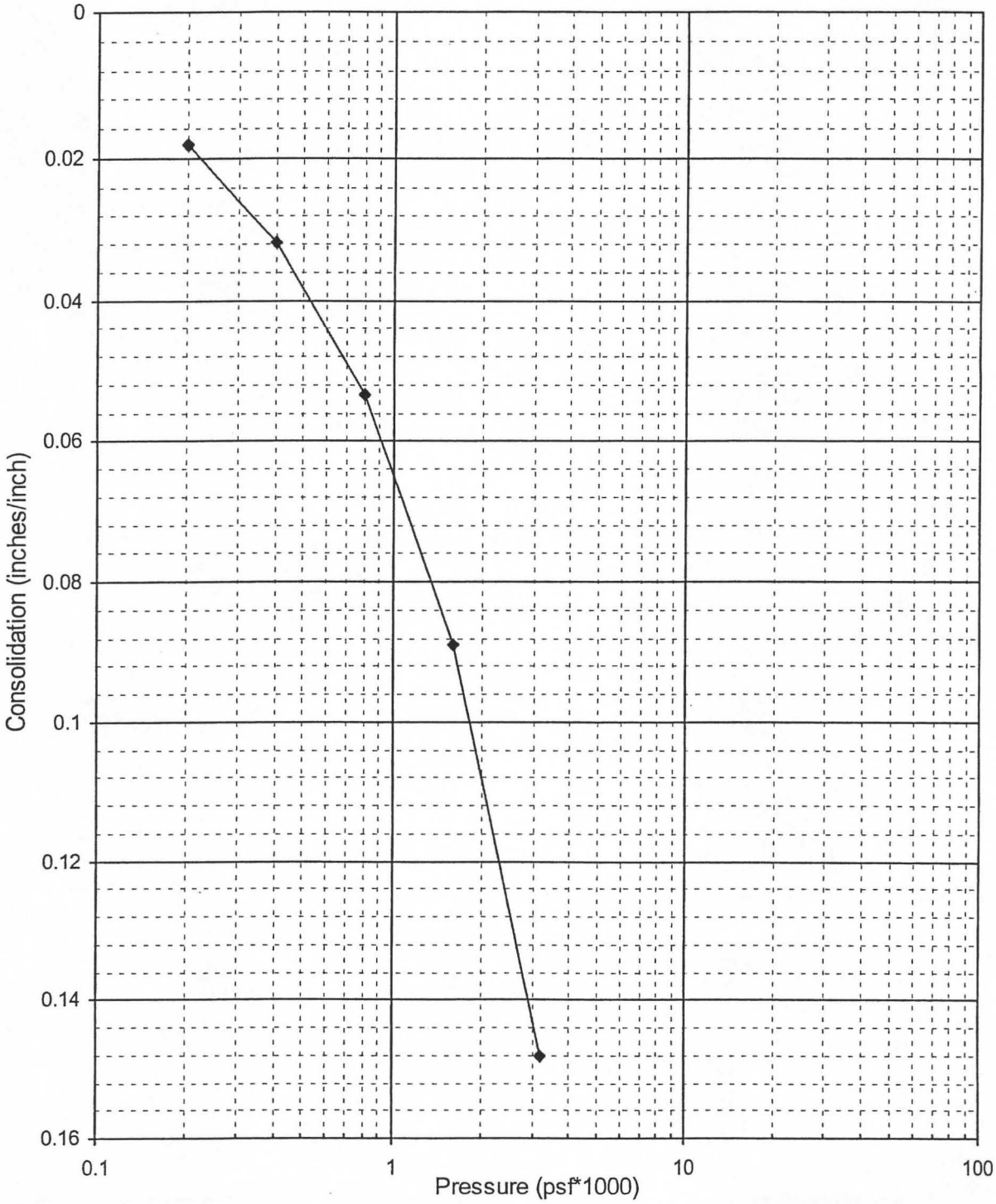
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	TEST PIT NUMBER	SAMPLE DEPTH (FEET)	SOIL CLASSIFICATION
◆	1	2.5	Gray poorly graded gravel with sand (GP)
□	2	1.25	Gray poorly graded gravel (GP)
▲	3	.75	Gray poorly graded gravel with silt and sand (GP-GM)

Geo Engineers

SIEVE ANALYSIS RESULTS

FIGURE 13



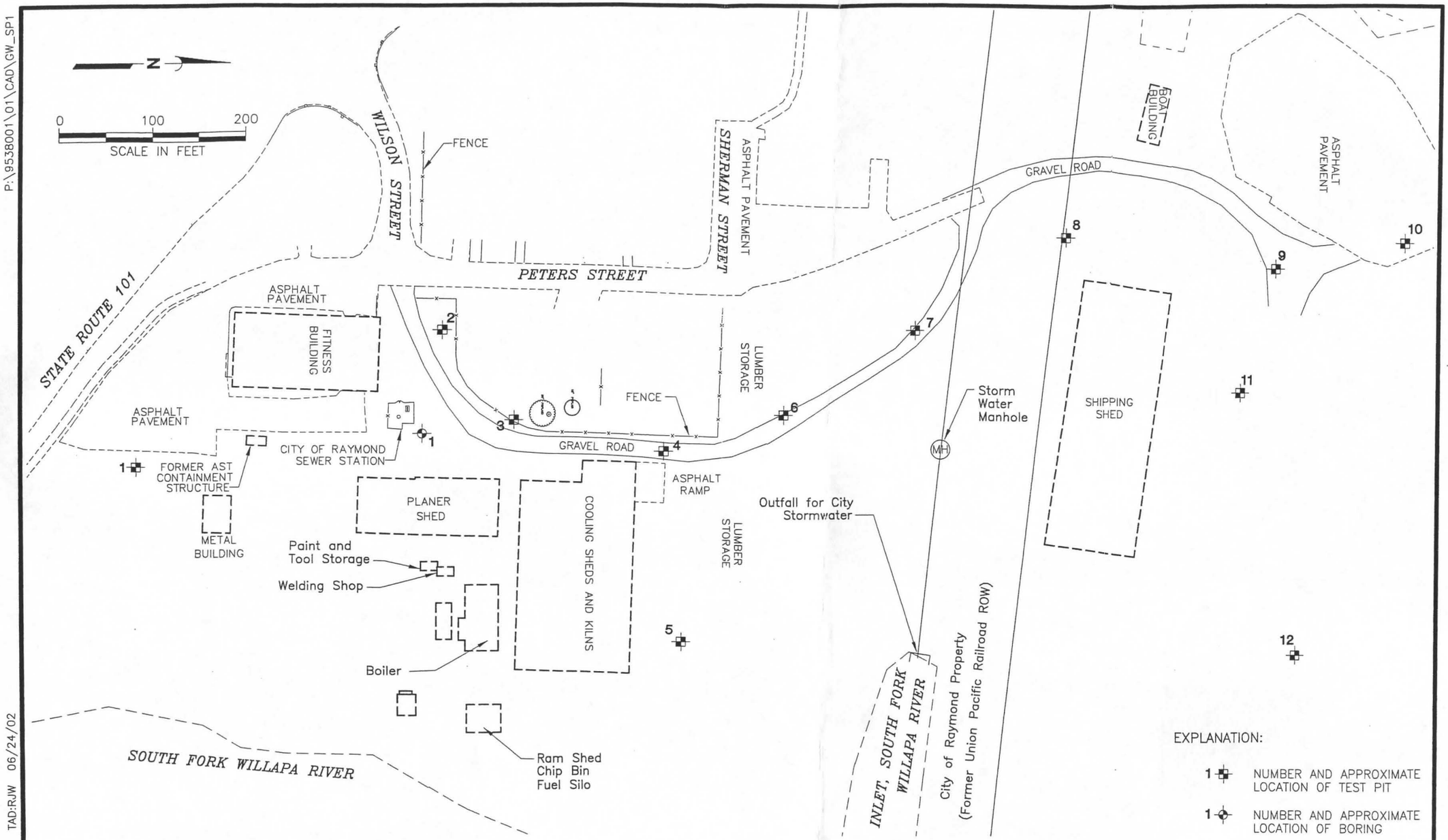
BORING NUMBER	SAMPLE DEPTH (FEET)	SOIL CLASSIFICATION	INITIAL MOISTURE CONTENT	INITIAL DRY DENSITY (LBS/FT³)
B-1	37.5	Brown organic silt (OH)	106.9	N/A

9538-001-01 SWH:JRS:jrs 06/25/02 (consol.ppt)

GeoEngineers

CONSOLIDATION TEST RESULTS

FIGURE 14



Notes: 1. The locations of all features shown are approximate.

2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.

Reference: Base drawing from AutoCAD file, "Existing.DWG", provided by Gibbs and Olson.

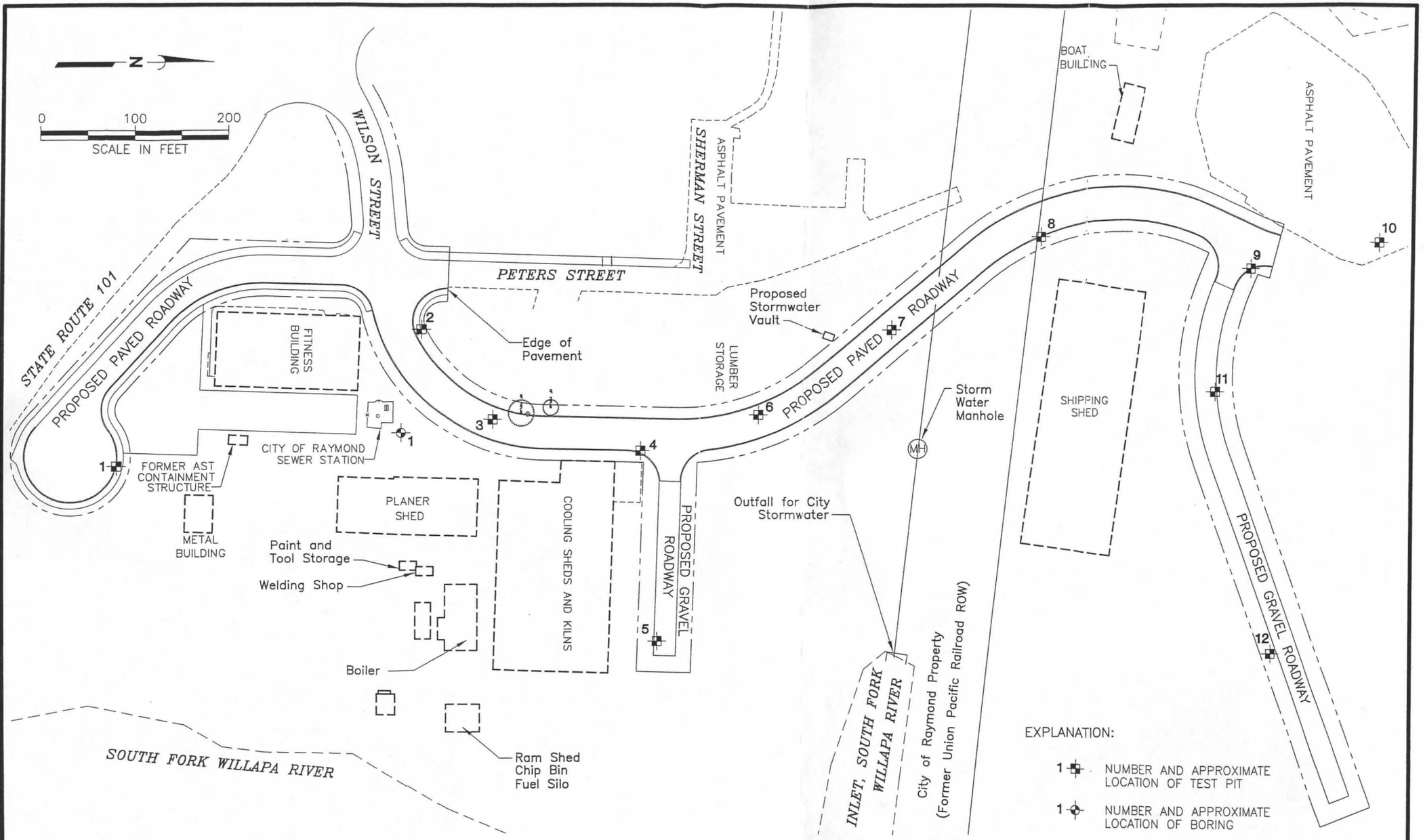
Geo Engineers

SITE PLAN-EXISTING CONDITIONS

FIGURE 2

P:\9538001\01\CAD\GW_SP1

9538-001-01 TAD:RJW 06/24/02



Notes: 1. The locations of all features shown are approximate.

2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.

Reference: Base drawing from AutoCAD file, "Existing.DWG", provided by Gibbs and Olson.

Geo Engineers

SITE PLAN-PROPOSED CONDITIONS

FIGURE 3

P:\9538001\01\CAD\GW_SP2

9538-001-01 SWH:RJW 06/24/02