Geotechnical Engineering Study
Nine Canyon Road
Phase I
Benton County, Washington

December 2012

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Excellence. Innovation. Service. Value.

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Submitted To:

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22-1-02932-003

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GEOTECHNICAL ENGINEERING STUDY
NINE CANYON ROAD IMPROVEMENT PROJECT – PHASE I
BENTON COUNTY, WASHINGTON

1.0 INTRODUCTION AND SCOPE OF WORK

Shannon and Wilson, Inc. is pleased to present the results of our geotechnical engineering study for the proposed Nine Canyon Road Phase I improvements south of Kennewick in Benton County, Washington. Our scope of services included:

- Drilling eight borings;
- Excavating twelve test pits;
- Conducting laboratory testing;
- Conducting a seismic refraction survey along the alignment;
- Performing engineering analyses; and
- Preparing this report.

This report provides recommendations for earthwork and estimates the rock depth along the alignment. The seismic refraction results also indicate the rock quality and rippability during excavation.

2.0 SITE AND PROJECT DESCRIPTION

The proposed Phase I project includes improving approximately 3 miles of Nine Canyon Road from its intersection with Mills Road to approximately ¼-mile south of SR 397 (Figure 1). The improvements will include widening, modifying the horizontal and vertical alignments, improving drainage, and surfacing. Alignment modifications include eliminating a hairpin curve at the bottom of a ravine and the steep ravine entry and exit grades. The new vertical alignment will consist of an approximately 40-foot cut transitioning to an approximately 65-foot high embankment across the ravine. The grade through the cut and fill will be approximately 7 percent flattening to 2.4 percent at the bottom of the vertical curve.

Based on the proposed plan and profile, we assume that the project cut and fill quantities are generally balanced. The area west of the large cut between Stations 338 and 350 is being considered as a possible rock source.

3.0 EXPLORATIONS AND LABORATORY TESTING

The field exploration program, conducted in two phases, consisted of excavating and sampling twelve test pits, drilling and sampling eight borings, and conducting geophysical surveys along the approximately 1700 feet of the alignment. An additional seismic refraction survey was conducted in

the potential rock source area. The test pit and boring locations are shown on the enclosed plan sheets (Figure 2). The geophysical line locations are presented in the seismic refraction report. The test pits and borings were completed as part of a preliminary study started in 2009. The geophysical survey was completed as part of the current study.

3.1 Test Pits

We excavated the twelve test pits on March 23, 2009 using a tractor-mounted backhoe. Test pits extended approximately 7 to 14 feet below existing grades. The test pits were located along the centerline of the new alignment. Test pit TP-3 encountered basalt bedrock at approximately 7 feet. The excavator encountered refusal in weathered basalt at approximately 9 feet in TP-8. The remaining test pits indicated loose to medium dense SILT to the full exploration depths.

Our representative observed the test pit excavations, obtained disturbed soil samples, and prepared logs. During the excavation process, we measured the relative soil consistency using a dynamic, mini-cone penetrometer. The mini-cone uses a slide hammer to drive a conical tip into the soil. The number of hammer blows required to drive the cone 1¾-inch increments is roughly equivalent to a Standard Penetration Test (SPT) blow count. The blows per increment provide an indication of the relative soil density. The blow counts are recorded on the logs.

We obtained disturbed samples from each test pit as the excavation progressed. Samples were typically collected at approximately 4-foot intervals or a composite sample from the exposed layer. Sample locations are shown on the test pit logs.

We also estimated in situ strength using a hand-held pocket penetrometer. The estimated shear strength, where obtained, is shown on the logs. The test pit logs are presented in Appendix A.

The subsurface conditions are known only at the explorations locations on the date explored and should be considered approximate. Actual subsurface conditions may vary between test pit locations.

3.2 Borings

The borings were drilled on March 24, 25, and 26, 2009, by Environmental West Exploration under subcontract with Shannon & Wilson, Inc. The borings were advanced using a truck-mounted, Mobile B-80 drill rig with hollow-stem auger equipment through the soil overburden and diamond rock coring equipment in the underlying basalt rock. Boring depths ranged from 11.5 to 61.5 feet below the existing surface elevation.

During the drilling process, we obtained disturbed samples at 2.5 to 5-foot intervals using a split spoon sampler (Standard Penetration Test) and grab samples of the basalt cuttings. The Standard Penetration Test (SPT) consists of driving a 2-inch outside diameter split-spoon sampler 18 inches

into the soil beneath the casing with a 140-pound hammer, free-falling 30 inches. Our field personnel recorded the number of blows required to advance the split-spoon through each 6-inch increment. ASTM D 1586 defines the SPT resistance, or N-value, as the number of blows required to drive the sampler from 6 to 18 inches below the casing. The SPT N-value reported on the logs is the number of blows per one foot of penetration. We stopped the test when 50 blows achieved less than 6-inches of penetration. The SPT N-value provides an indication of the relative density or consistency of the soil and is plotted on the boring log located in Appendix B.

The SPT N-value provides an indication of the relative density or consistency of the soil and is plotted on the boring logs. The following terminology was used to describe the relative density or compactness of the subsurface soils:

SOIL DENSITY AND CONSISTENCY TERMINOLOGY

Cohesionless (granular) Soils		Cohesive (clayey) Soils	
Relative Density	**Penetration Resistance (blows per foot)**	**Relative Consistency**	**Penetration Resistance (blows per foot)**
Very Loose	Under 4	Very Soft	Under 2
Loose	4 – 10	Soft	2 – 4
Medium Dense	10 – 30	Medium Stiff	4 – 8
Dense	30 – 50	Stiff	8 – 15
Very Dense	Over 50	Very Stiff	15 – 30
		Hard	Over 30

The boring logs are presented in Appendix B. The strata boundaries were estimated in the field based on the drill rig action and the SPT sampling. The soil conditions are known only at the exploration locations on the date explored and should be considered approximate. Actual subsurface conditions between exploration locations may vary.

Rock cores were observed, measured, and placed in core boxes for shipping and handling. Our field representative determined the Rock Quality Designation (RQD) for each run. The RQD is determined by comparing the total length of core between joints greater than 4 inches to the total length of core recovered. At this site, RQDs were zero for all core runs, indicating that the rock is highly fractured.

Our representative collected disturbed samples in conjunction with SPT tests at approximately 2.5 to 5-foot intervals from each boring as the drilling progressed. Relatively undisturbed ring samples were also collected from boring B-7 using a Modified California sampler. Core was obtained from boring B-6.

3.3 Geophysical Explorations

The seismic refraction survey was conducted by our subcontractor, Geophysical Survey LLC, using a Geometrics Geode seismograph with 30 Hz geophones. Geophones were spaced 20 feet apart and data was collected at seven surficial shots on each 24 geophone spread. A 40 kilogram propelled energy generator was used as an energy source. The investigation depth was approximately 60 feet. Data was collected along two seismic lines (approximately 1650 linear feet at 20 foot geophone spacing) on or parallel to the alignment. Line 1 extended from approximately Station 315+00 to Station 324+50. Line 2 extended from approximately Stations 342+00 and 350+00 and was approximately 100 feet west of the proposed road centerline. Data was also collected on four approximately 230-foot lines perpendicular to Line 2. These lines extended east across the proposed alignment and west to the old alignment. The objective of these perpendicular lines was to identify a potential rock quarry site.

A Global Positioning System (<10cm) with VRS corrections was used to map seismic line positions and elevations. Seismic data was processed using SeisImager from Geometrics. Data processing included tomographic analysis to detect lateral velocity variations. Geophysical Consultants LLC provided a report summarizing the geophysical methods used. Survey results with interpretation are provided on 2-D velocity profiles of each seismic line and a site map with seismic line positions. The geophysical report is presented in Appendix C.

3.4 Laboratory Testing

Samples were placed in sealed plastic bags to preserve moisture content, and then transported to our office where they were examined. Our engineer reviewed the field classifications and selected representative samples for laboratory testing. Selected samples were submitted to Cooper Testing Laboratory for index property testing. The laboratory test results are presented in Appendix D. The sieve analyses were used to classify the soil. The moisture contents, compaction characteristics, and in situ unit weight were used to estimate compaction water requirements, and shrink/swell potential for earthwork quantity calculations. The CBR results were used in developing pavement recommendations. Table 1 summarizes the laboratory testing.

Table 1 – Laboratory Testing

Test Name	Method	Type of Sample	Sample Source
Moisture – Density – Porosity	ASTM D 2937	Ring Samples, SPT, and Grab Samples	Borings and Test Pits
Grain-size Distribution	ASTM D 422 & D 1140	SPT or Grab Sample	Borings and Test Pits
Moisture Density Relationship (Proctor)	ASTM D 1557	Bulk Sample	Test Pits
California Bearing Ratio (CBR)	ASTM D 1883	Bulk Sample	Test Pits
Liquid Limit – Plasticity Index	ASTM D	SPT or Grab Samples	Borings and Test Pits
Collapse Potential		Ring Sample from Modified Cal Sampler	Borings

4.0 SUBSURFACE CONDITIONS

4.1 Geology

Regional and Site Geology

Based on the *Geologic Map of the Richland 1:100,000 Quadrangle* (Reidel and Fecht, 1994), the subsurface geology in the vicinity of the Nine Canyon Road Project is comprised of, from youngest to oldest:

- Recent loess (Ql) deposits of wind-blown silt and fine sand,
- Basalt flows of the Saddle Mountains Basalt Formation of the Columbia River Basalt Group (Mv_s), and
- Older interflow deposits of fine-grained continental sedimentary deposits (Mc).

Loess (Ql): The loess deposit is comprised of wind-blown (eolian) silt and fine sand of varying plasticity. Although not observed during our field reconnaissance, volcanic ash, caliche, and tephra beds may be found interbedded within the loess deposit. The thickest loess deposits should be expected near the upper portions of the flatter slopes, while thinner loess soils should be expected within the eroded dry washes. Loess deposits were encountered throughout the project area and overlie the Saddle Mountains Basalt Member. In test pits TP-7 through TP-12, at the north end of the site, the loess may grade downward to faintly bedded fine sandy silt of the Glacial Lake Missoula Flood deposits, however this deposit was not differentiated from the loess in the field. While not encountered in the explorations, the loess deposit may directly overlie continental sedimentary deposits.

Saddle Mountains Basalt Formation (Mv_s): The basalt bedrock units of the Columbia River Basalt Group were emplaced between about 14 and 17 million years ago during Miocene time from a series of volcanic vents located in southeast Washington and northeast Oregon. The Saddle Mountains Basalt Formation is one of the youngest series of flows and contains many interbeds of continental sedimentary deposits (described below). The bottom of individual flows may contain pillow structures and abundant obsidian, which are formed when the hot lava interacted with water and/or saturated, unconsolidated soils of the continental sedimentary deposits (described below).

Continental Sedimentary Deposits (Mc): As described above, during the intervening time between individual basalt flows, fine-grained continental sediments were deposited by streams and lakes developed on top of older flows. The fine grained deposits are generally thicker and between more individual flows of the Saddle Mountain formation than other formations of the Columbia Basalt Group. The sedimentary interbeds record the subsidence of the Pasco Basin during the time period of Saddle Mountain Basalt emplacement. Bedding is near horizontal and exhibits relatively thin laminations with organic seams, indicative of subdued topography and even sedimentation of fine-grained soil. Oftentimes, these sediments were saturated when overridden by basalt flows, resulting in explosive (vesicular) and submergent (pillow lava) volcanic textures. Palagonite, an assemblage of clay minerals, is a weathering product of the rapidly cooled basalt (obsidian).

4.2 Subsurface Soil Conditions

The explorations typically encountered loose, dry, sandy SILT overlying weathered and fractured basalt. Basalt was not encountered in all of the explorations.

The overlying SILT is typically dry and loose. The moisture content of near-surface samples from the test pits ranged from 5.2 to 12.8 percent at the time of our explorations in March 2009. The average moisture content in bulk samples from ½ to 7 feet below the surface was 6.1 percent. The dry unit weight of the upper SILT was 77.9 to 95.3 pounds per cubic foot (pcf). Laboratory testing indicates the maximum laboratory dry density as determined by ASTM D 1557 – *Compaction Characteristics of Soil Using Modified Methods* is 106.5 to 111.7 pcf at optimum moisture contents of 13.8 to14.7 percent. Please see laboratory testing results in Appendix D for more details.

4.3 Subsurface Rock Profile

The proposed vertical alignment results in deep cuts (up to approximately 40 feet) between Stations335+00 and 350+00. Borings and test pits within this alignment section indicated basalt was present at approximately 6 feet below the existing surface elevation. The shallowest rock was encountered at approximately 6 feet below the surface in boring B-6. As observed in the road cut near borings B-5 and B-6, the denser basalt flows appears to have invaded the saturated continental

sedimentary deposits, as evidenced by obsidian on the bottom *and* top of the basalt. Photographs 1 through 3 in Appendix B illustrate this condition.

The basalt bedrock is medium to high strength, gray to black, fine-grained (aphanitic), moderate to highly vesicular, and moderately to highly fractured. Weathering ranges from fresh to slightly weathered to highly weathered. Both vesicularity and weathering increases with depth toward the cooling contact with the continental sedimentary deposits.

However, the basalt contact was not continuous in adjacent test pits and borings. Therefore, we conducted seismic refraction surveys parallel and perpendicular to the proposed centerline in the subject area. We also conducted a centerline survey from Station 315+00 to 325+00.

4.4 Groundwater

The explorations did not encounter groundwater. Based on well logs from the area, we anticipate groundwater is greater than 100 feet below the existing surface elevation.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 General

The following sections present earthwork and embankment and cut slope inclination recommendations. Roadway construction should be completed in accordance with Washington State Department of Transportation (WSDOT) Standard Specifications (M41-10). Based on the geophysical survey results, we do not anticipate rock excavation will be required for this project. The rock identified in the explorations exhibits a compression wave velocity well within the rippable range.

5.2 Earthwork

Organic material must be stripped from the alignment and areas receiving embankment fill. Embankment fill and backfill should be placed in accordance with WSDOT Specification 2-01 Clearing, Grubbing and Roadside Cleanup.

5.2.1 Rock Excavation

The seismic refraction survey did not identify a compression wave indicative of bedrock within the survey area. Investigative depth was between 34 and 45 feet. Based on these results, it is our opinion that rock excavation will not be necessary along this alignment. Additionally, there is little potential to obtain crushable rock within the excavation area as desired. Rock will need to be quarried at an off-alignment source. The Seismic Refraction report is presented in Appendix C.

5.2.2 Shrink, Swell, and Water Requirements

Based on the laboratory test results summarized in Section 4.2 and our experience on similar projects in the area, we estimate the loess soil will shrink approximately 20 to 25 percent from the excavation site to compacted embankment. Based on the moisture content of the soils at the time of our explorations, we estimate approximately 14 to 29 gallons of water per cubic yard (CY) will be needed to bring material to optimum moisture content depending on the in situ conditions at the time of construction. The volume of water needed for compaction will depend on the soil moisture content at excavation, and environmental conditions, i.e. weather (heat, wind) during construction.

5.2.3 Compaction

Embankments should be placed in accordance with WSDOT Section 2-03.3(14) C; Method C. Method C requires compacting each layer to a minimum of 95 percent of the maximum laboratory dry density as determined by AASHTO T-99 (ASTM D 698). Moisture content should be ±2 percent of optimum moisture content. Our experience with compacting these loess soils indicates a kneading-type compactor such as a "sheepsfoot" is most effective. If these soils become over-wet because of weather or the addition of too much water, they may be difficult to compact and stabilize. We do not recommend using vibratory-type compactors to compact the loess soils as the vibrations may pump moisture to the surface resulting in a compact but unstable condition.

5.2.4 Utility Trenching

Utility trenching should be accomplished in accordance with Washington State Department of Transportation (WSDOT)/American Public Works Association (APWA) Standard Specifications. Based on our explorations, we anticipate that conventional excavation equipment can accomplish the proposed excavations. Utility trenches should be backfilled using structural fill.

5.3 Temporary Excavations/Slopes

In our opinion, OSHA Soil Type C best describes the loose sandy silt soils. Type C soils may have maximum temporary slopes of 1.5 Horizontal to 1 Vertical (1.5H:1V).

Based on the subsurface soils encountered along the alignment, permanent cut and fill slopes should be constructed with inclinations no steeper than 2H:1V and must be protected from both wind and water erosion. Erosion protection may consist of a vegetative cover or a minimum 3 inches of coarse concrete aggregate conforming to the requirements of WSDOT Specification 9-03.1(4) c, "Concrete Aggregate AASHTO Grading No. 57." Flatter slopes for safety considerations are acceptable, and should also be protected with a vegetative cover.

Steeper slopes may be possible where competent rock is encountered. However, because of the sediments underlying the rock, the overall slope inclinations should be held to 2H:1V or flatter. We recommend design quantities be based on 2H:1V cut slopes throughout the alignment.

5.4 Pavement Section

Laboratory testing of two samples of the sandy silt subgrade soil indicate California Bearing Ratio (CBR) values of 4.6 and 10.1 when compacted to 95 percent of ASTM D 1557 or AASHTO T-180 (Modified Proctor). However, the WSDOT Standard Specifications Section 2-03.3(14)C, Method C typically requires that the subgrade and embankment be compacted to 95 percent of AASHTO T-99 (Standard Proctor). Based on the test results and our experience with similar materials, we used a CBR of 5 when evaluating the pavement section requirements. Based on a projected 20-year pavement life and an estimated 1 million Equivalent Single Axle Load (ESALs) we recommend the following minimum pavement section or equivalent combination of aggregate base and surfacing.

RECOMMENDED PAVEMENT SECTIONS (inches)			
Compacted Subgrade	Crushed Aggregate Base Course (1¼ minus)	Crushed Aggregate Top Course (5/8 minus)	Asphaltic Concrete Pavement (ACP)
12	8	4	4
12	12	4	3

6.0 LIMITATIONS

The analyses, conclusions, and recommendations contained in this report are based upon site conditions as they presently exist, and assume that the exploratory borings are representative of the subsurface conditions under all portions of the proposed structures, i.e. the subsurface conditions are not significantly different from those disclosed by the field explorations.

If subsurface conditions different from those encountered in the field explorations are observed or appear to be present, during construction beneath the 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 construction at the site, or if site conditions have changed (e.g. due to natural forces or construction at the site), we recommend that we review this report to determine the applicability of the conclusions and recommendations concerning the changed conditions.

This report was prepared for the exclusive use of Benton County and their design team, in the design and construction of the Nine Canyon Road Phase 2 project in Benton County, Washington. 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 included in this report, such as those interpreted from the boring logs and discussions of subsurface conditions.

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

The scope of services did not include any environmental assessment or evaluation regarding the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below the site, or for the evaluation of disposal of contaminated soils or groundwater, should any be encountered.

As an integral part of this report, we have prepared the attachment "Important Information about Your Geotechnical Report," (Appendix F) to help you more clearly understand its use and limitations.

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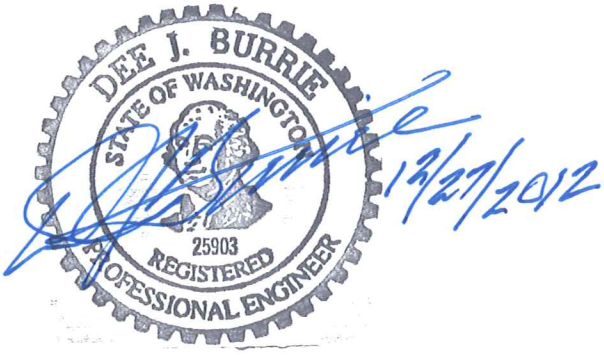
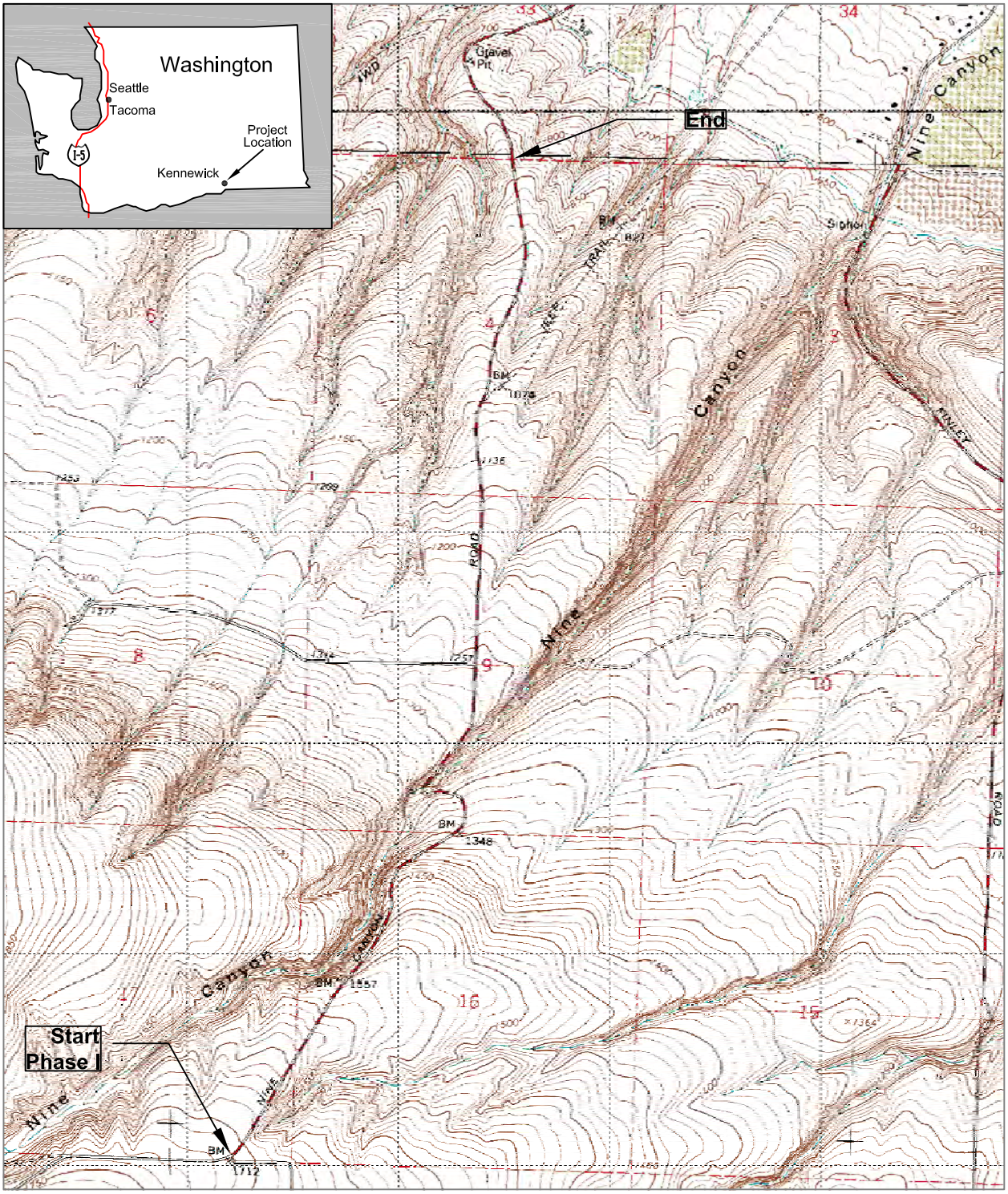


Dee J. Burrie, P.E.
Vice President



NOTE

Map adapted from 1:24,000 USGS topographic map of Pasco, WA (1992) and Nine Canyon (1964) quadrangles.

Nine Canyon Road Phase I
Benton County, Washington

VICINITY MAP

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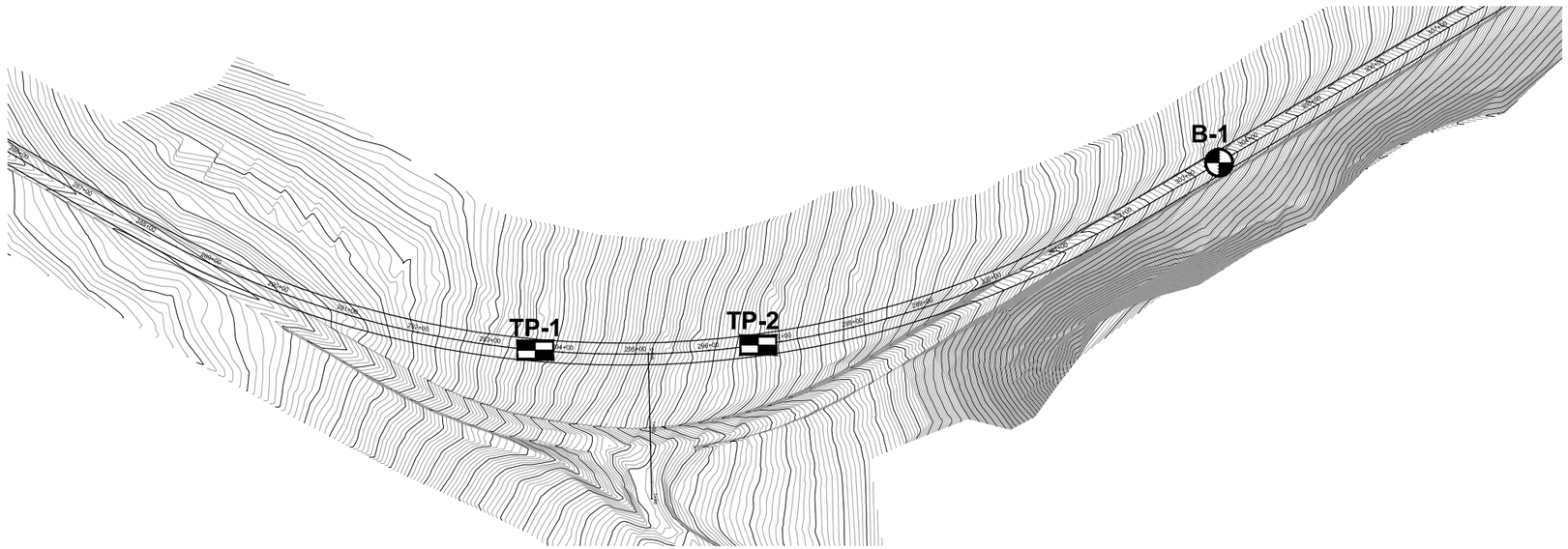
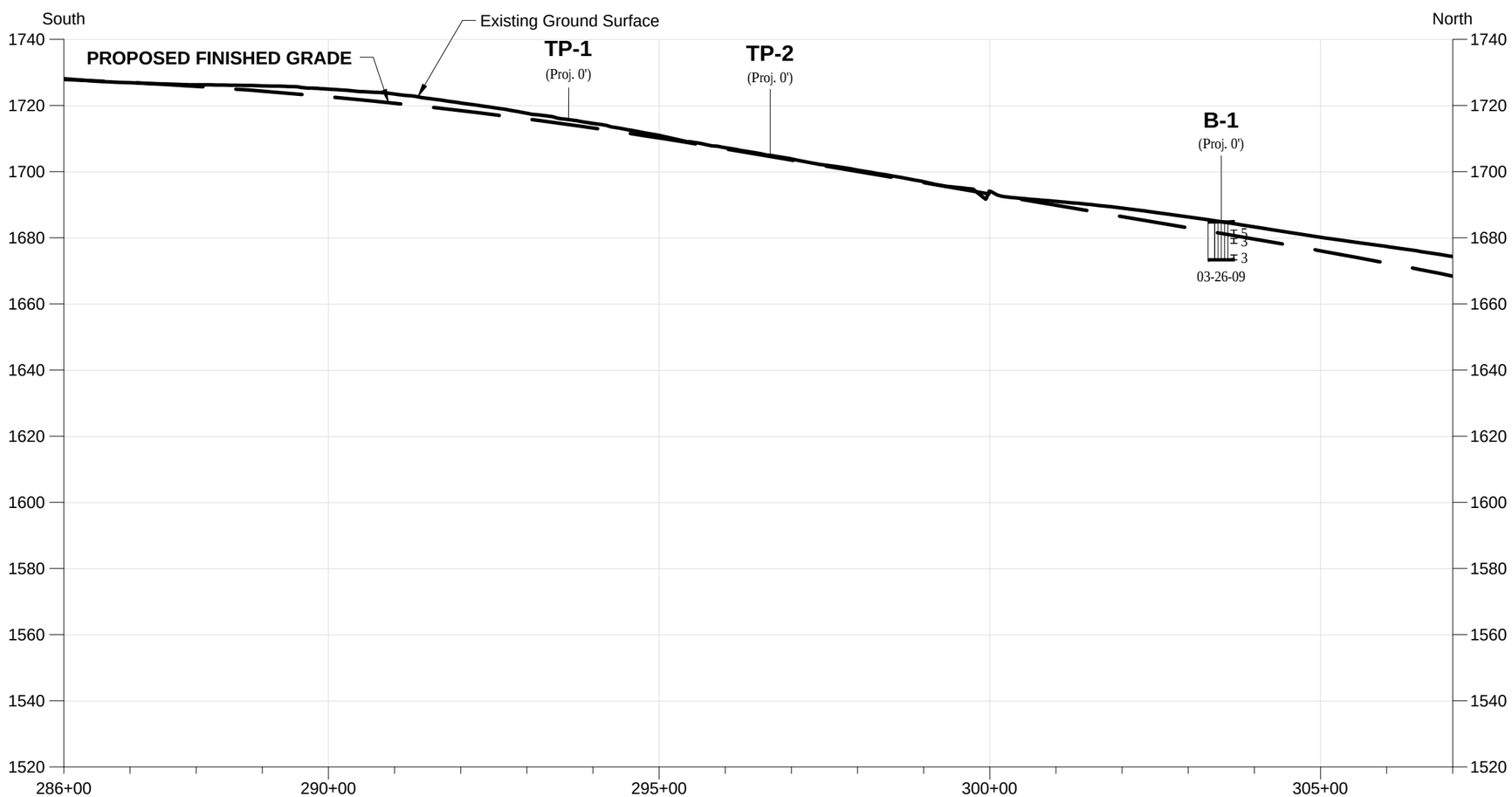
Geotechnical and Environmental Consultants

FIG. 1

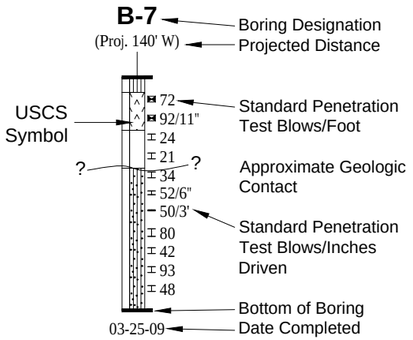


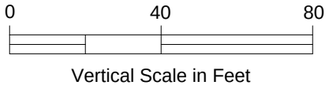


LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location





Vertical Scale in Feet

Horizontal Scale in Feet
Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

PLAN AND PROFILE

December 2012 22-1-02932-003

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FIG. 2
Sheet 1 of 9

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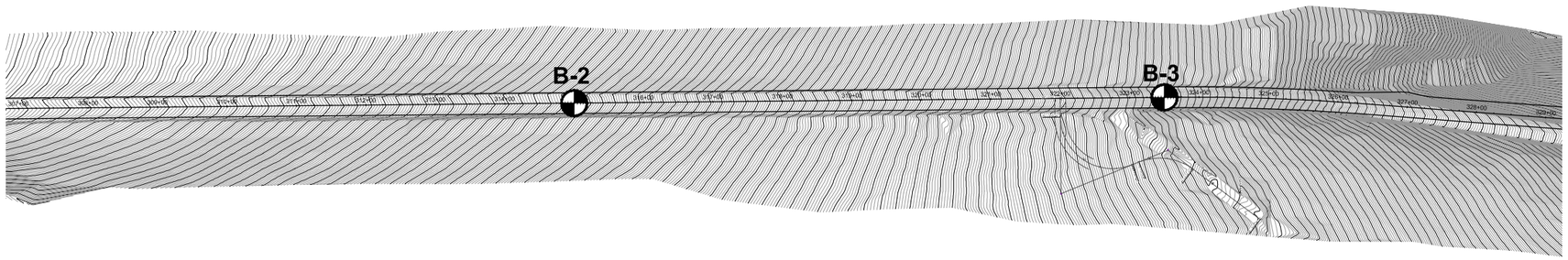

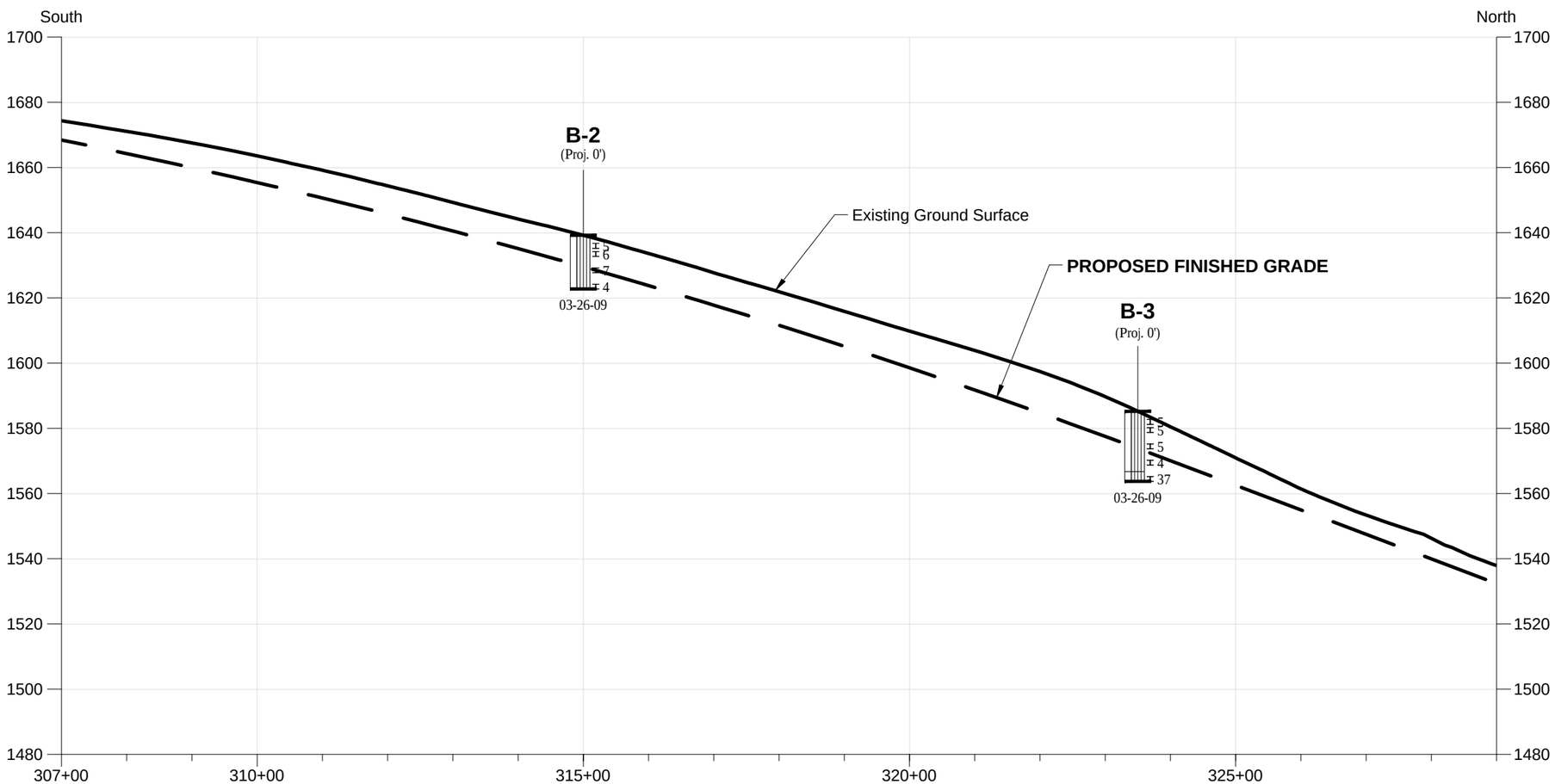

LEGEND

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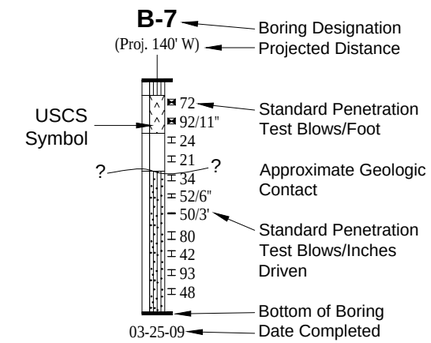

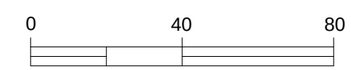

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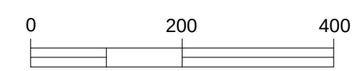

Horizontal Scale in Feet
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Nine Canyon Road
Benton County, Washington

PLAN AND PROFILE

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FIG. 2
Sheet 2 of 9

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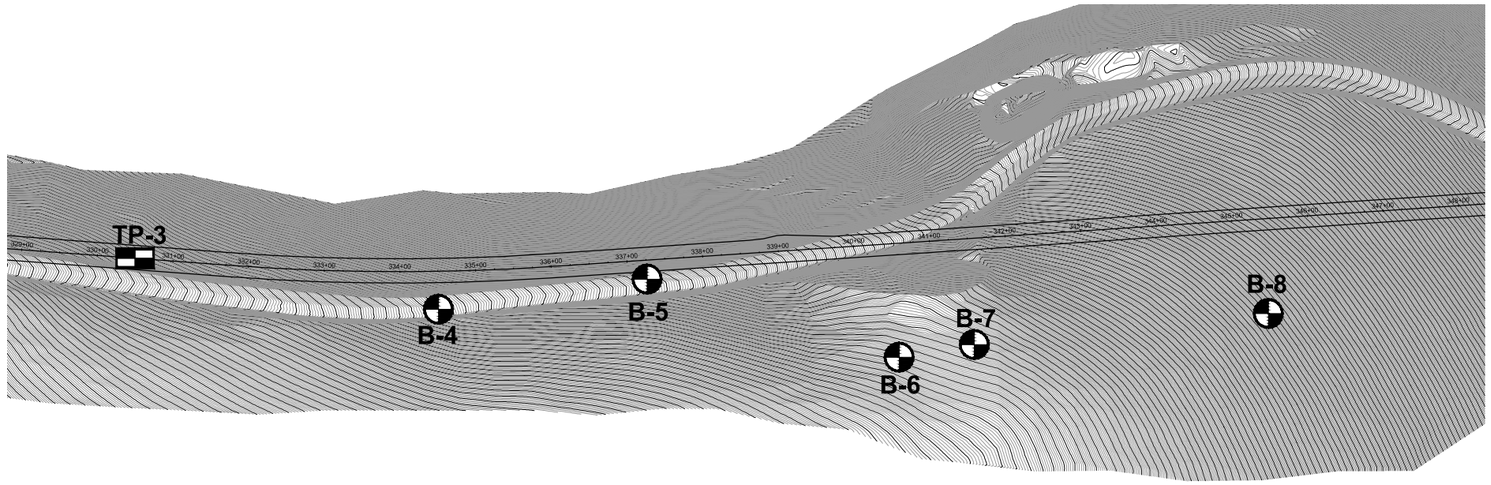

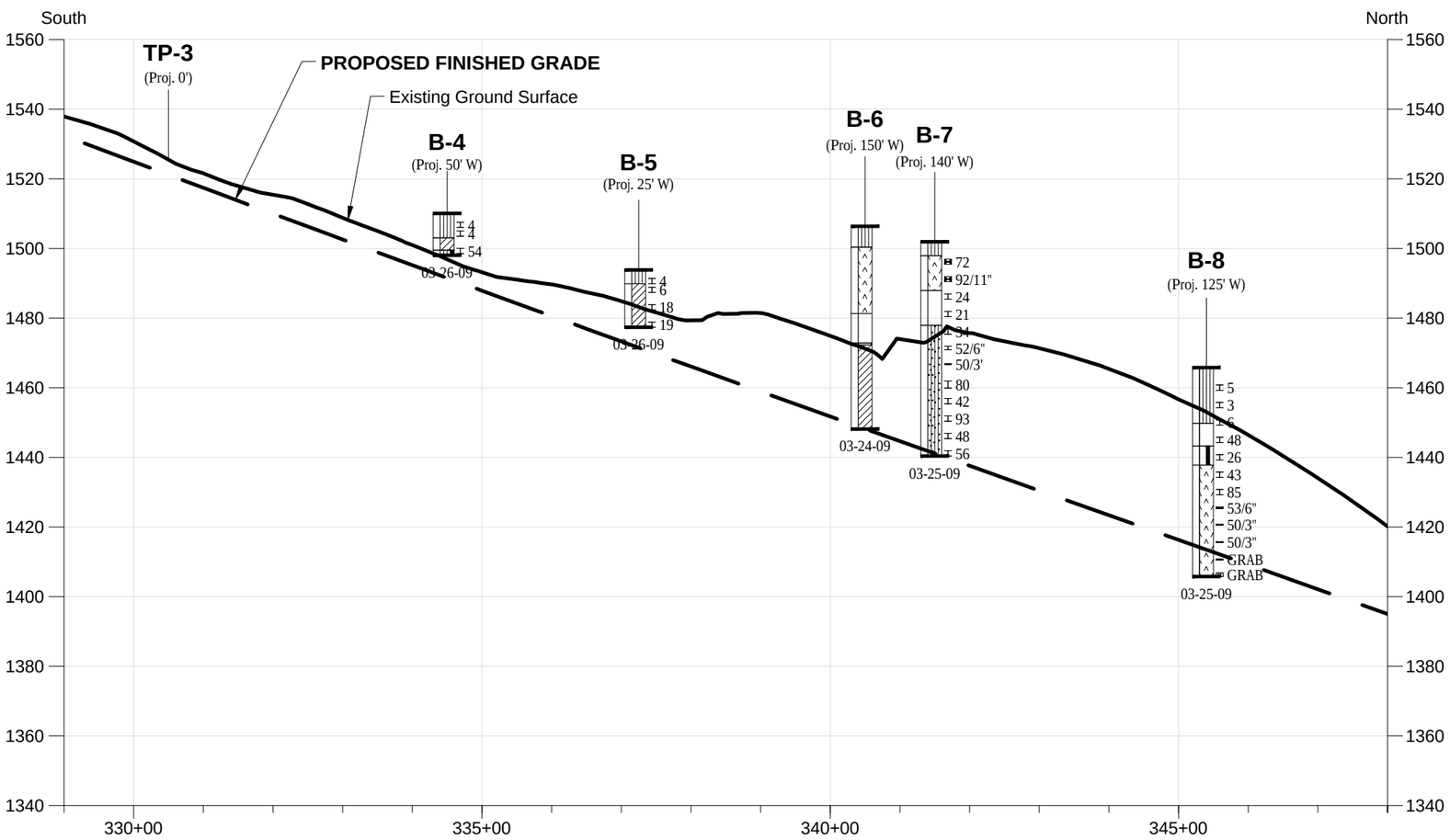

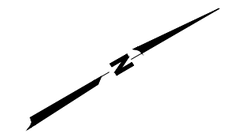

LEGEND

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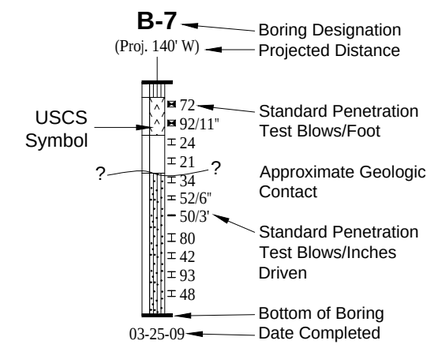

0 40 80

Vertical Scale in Feet

0 200 400

Horizontal Scale in Feet

Vertical Exaggeration = 5X

NOTE

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Nine Canyon Road
Benton County, Washington

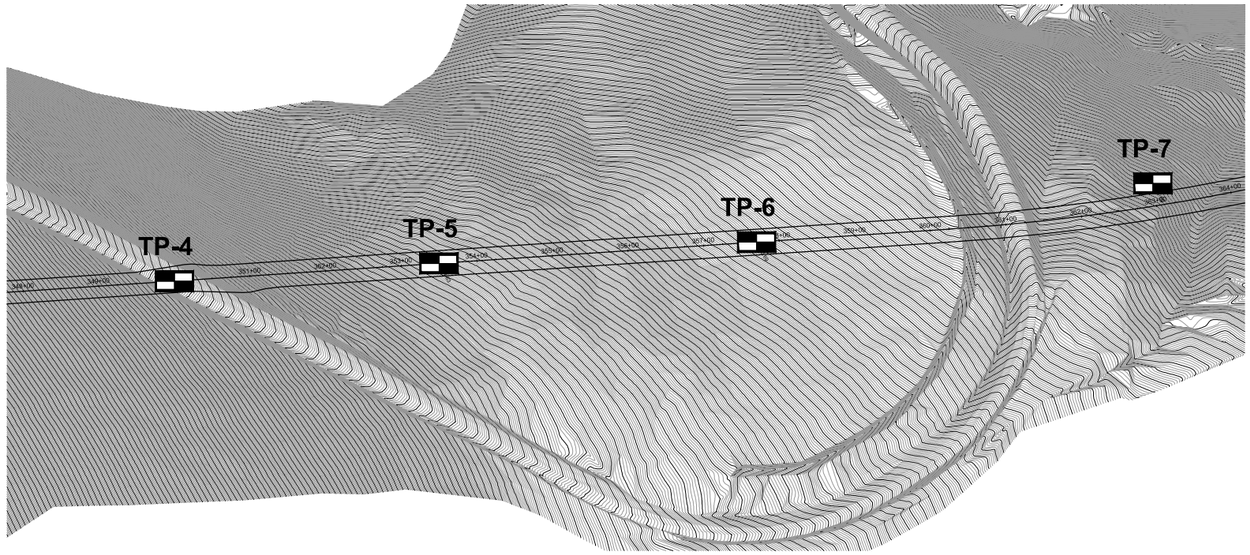
PLAN AND PROFILE

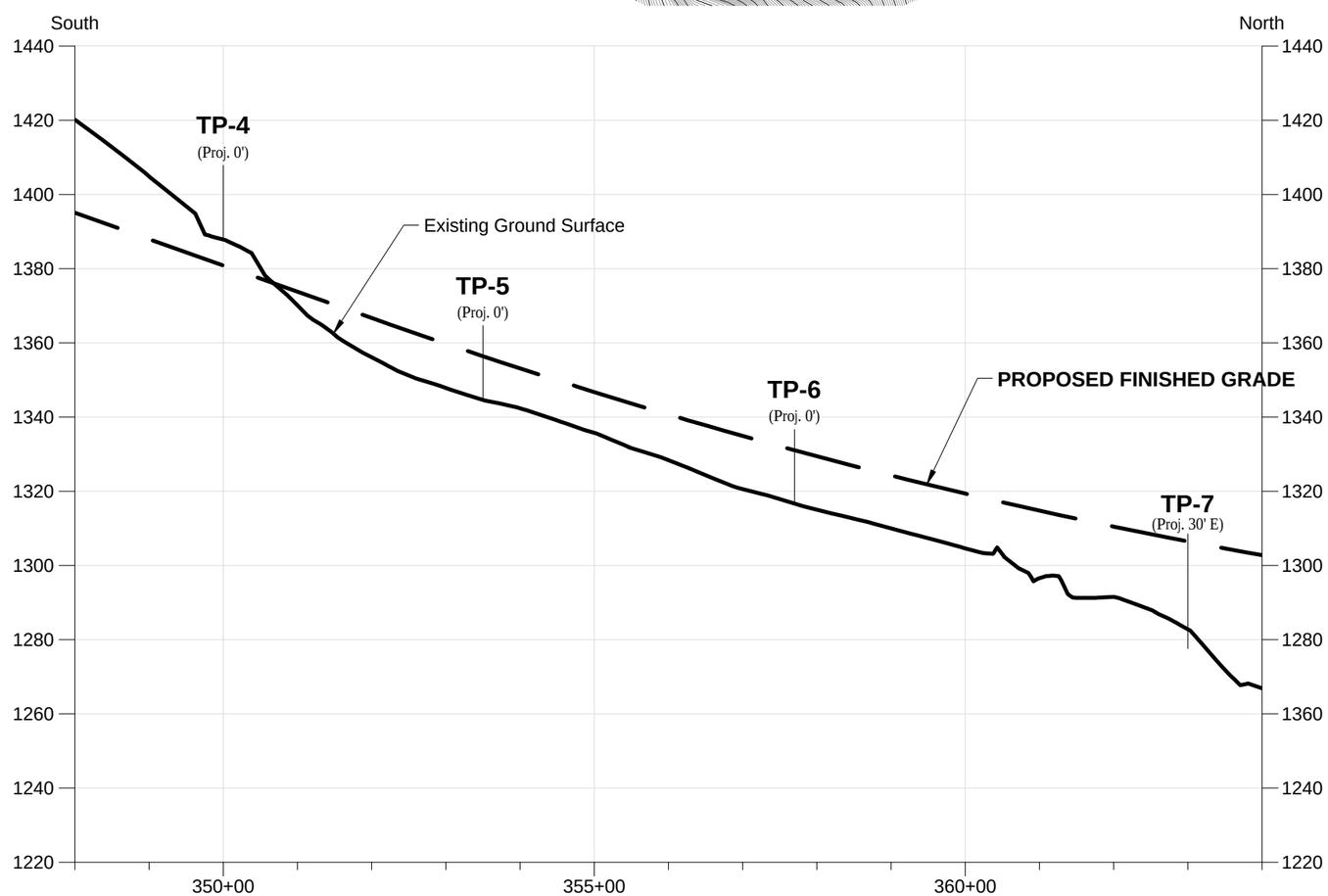
December 2012 22-1-02932-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2
Sheet 3 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac

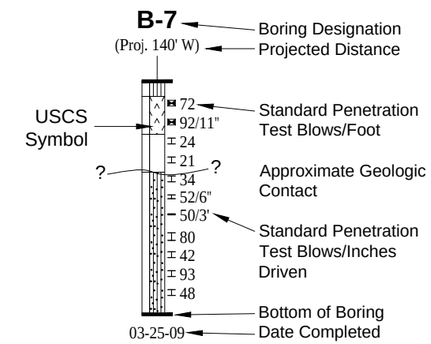


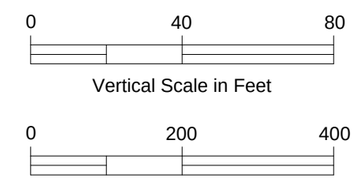


LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location





Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

PLAN AND PROFILE

December 2012 22-1-02932-003

SHANNON & WILSON, INC.
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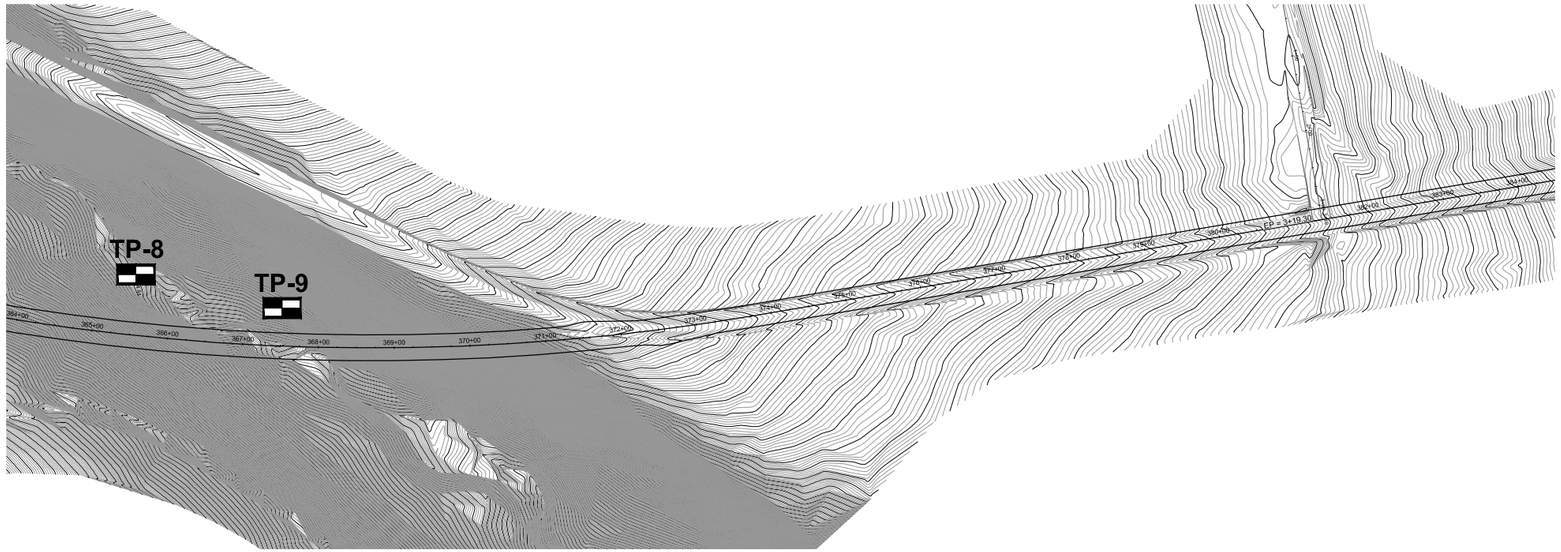
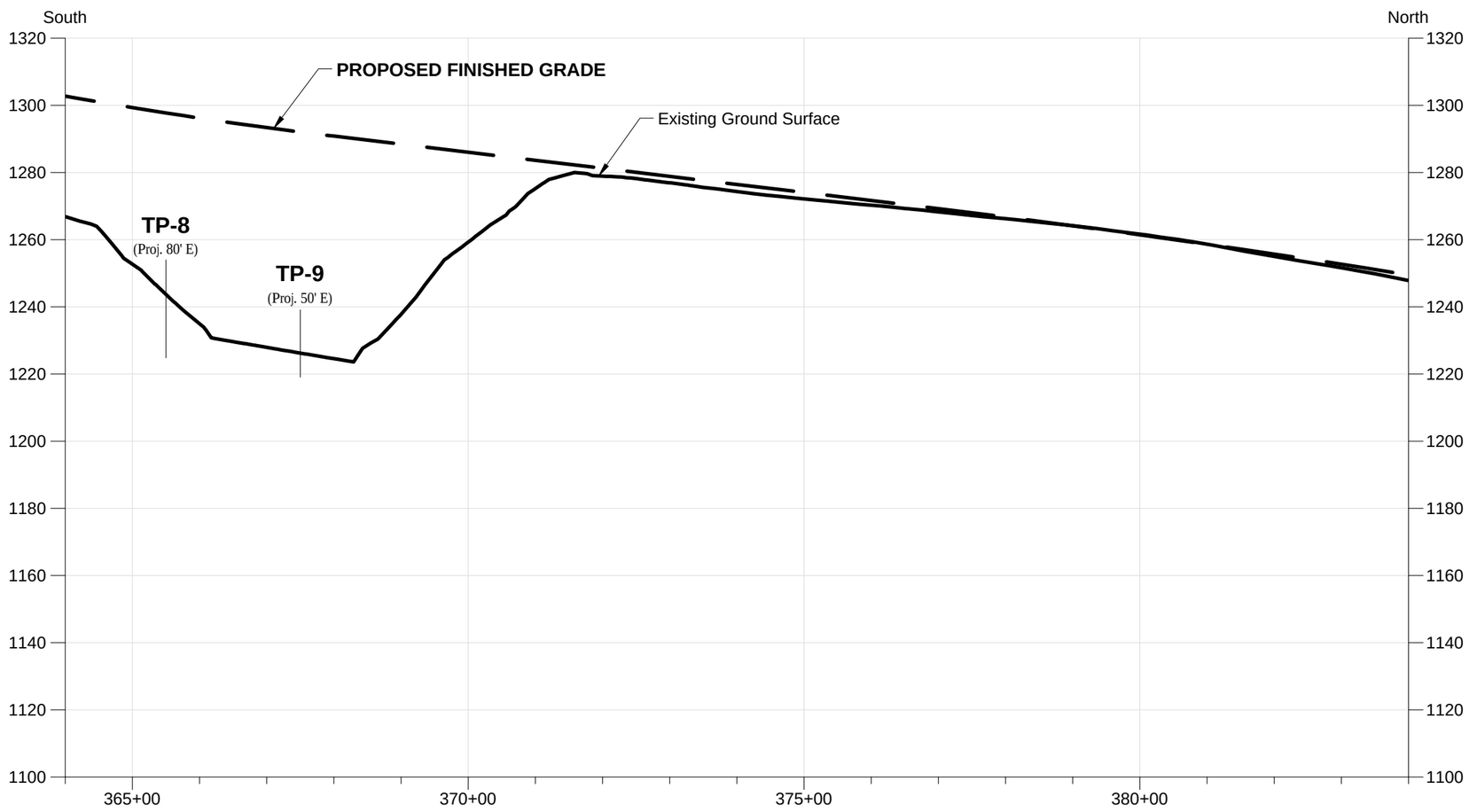
FIG. 2
Sheet 4 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac

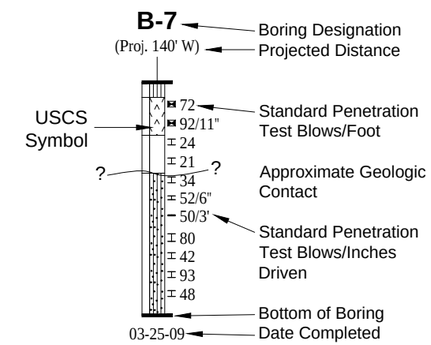




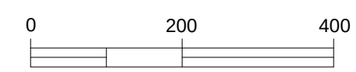
LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location



Vertical Scale in Feet



Horizontal Scale in Feet
Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

PLAN AND PROFILE

December 2012 22-1-02932-003

SHANNON & WILSON, INC.
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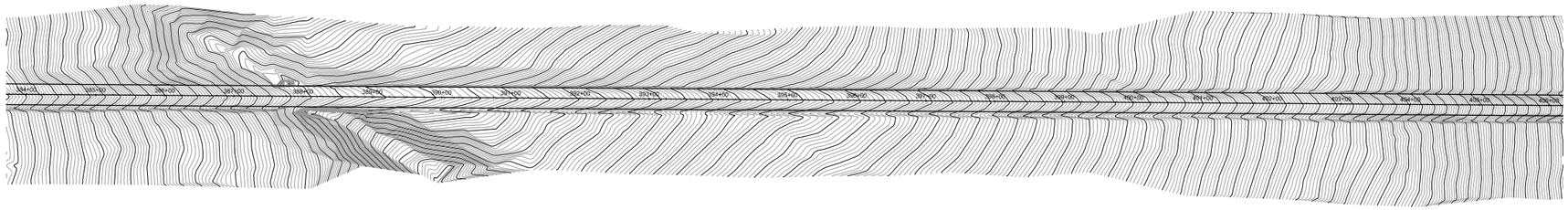
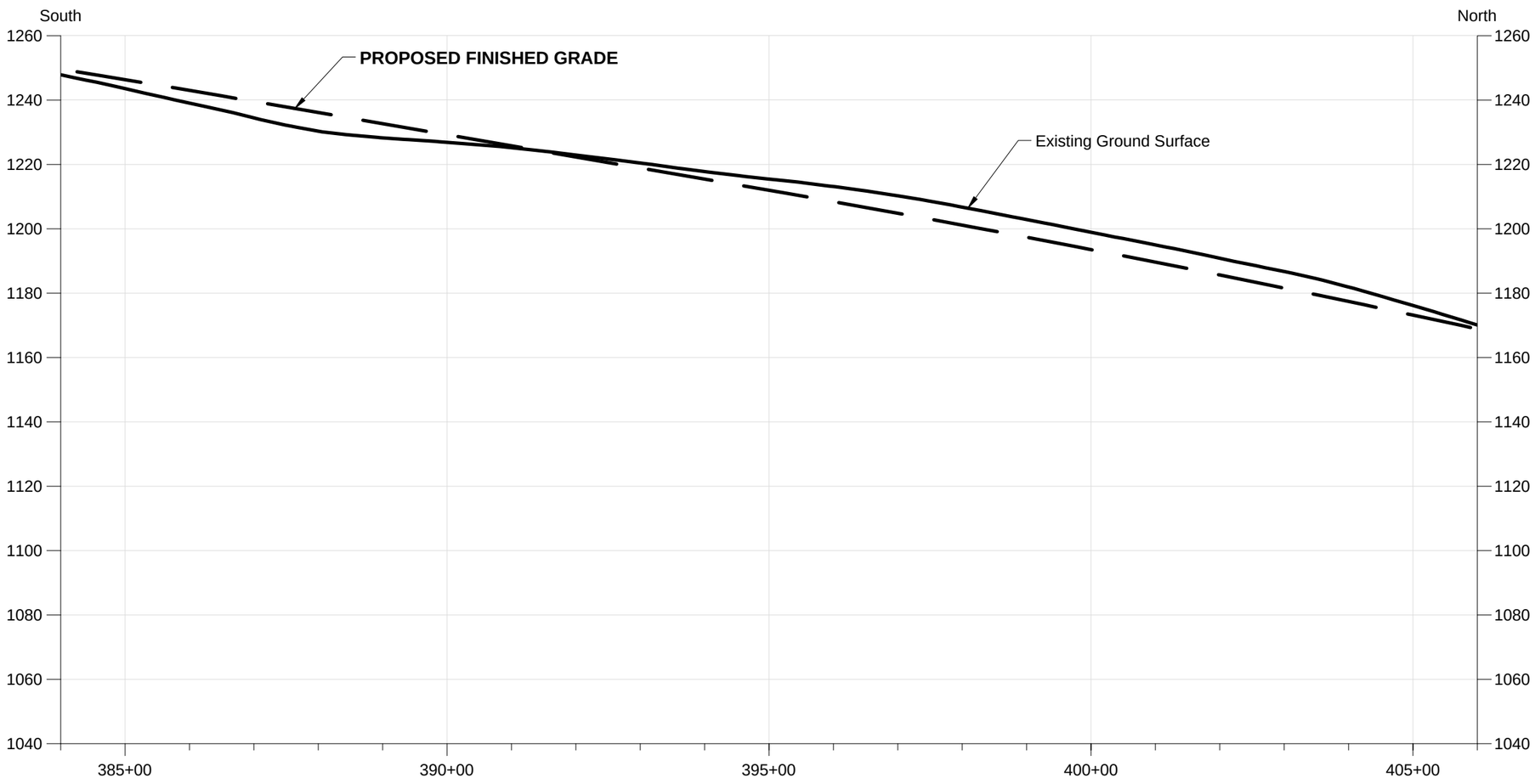
FIG. 2
Sheet 5 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac



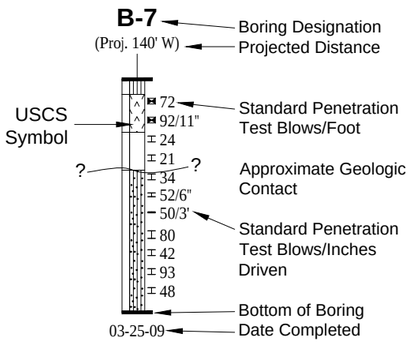


N

LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location



0 40 80

Vertical Scale in Feet

0 200 400

Horizontal Scale in Feet
Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

PLAN AND PROFILE

December 2012 22-1-02932-003

SHANNON & WILSON, INC.
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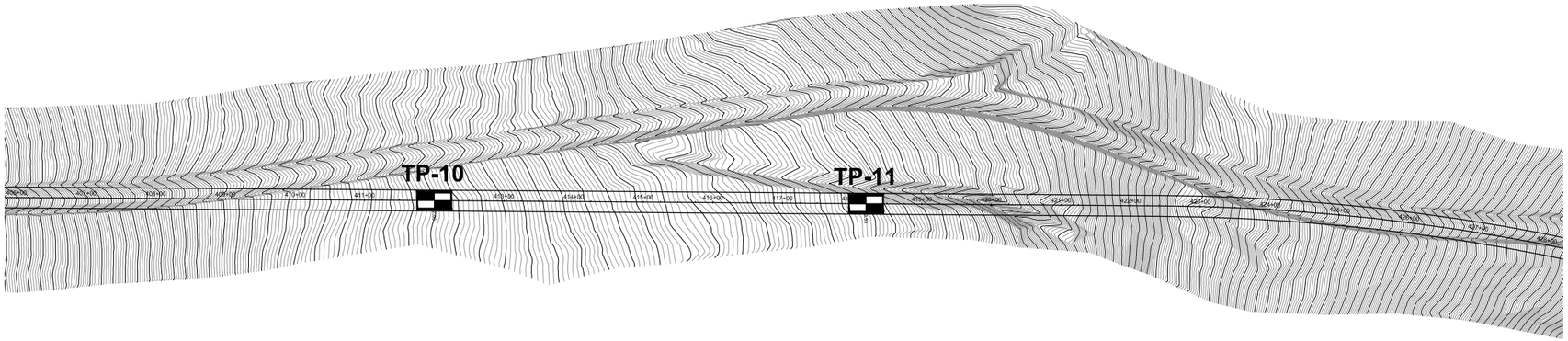
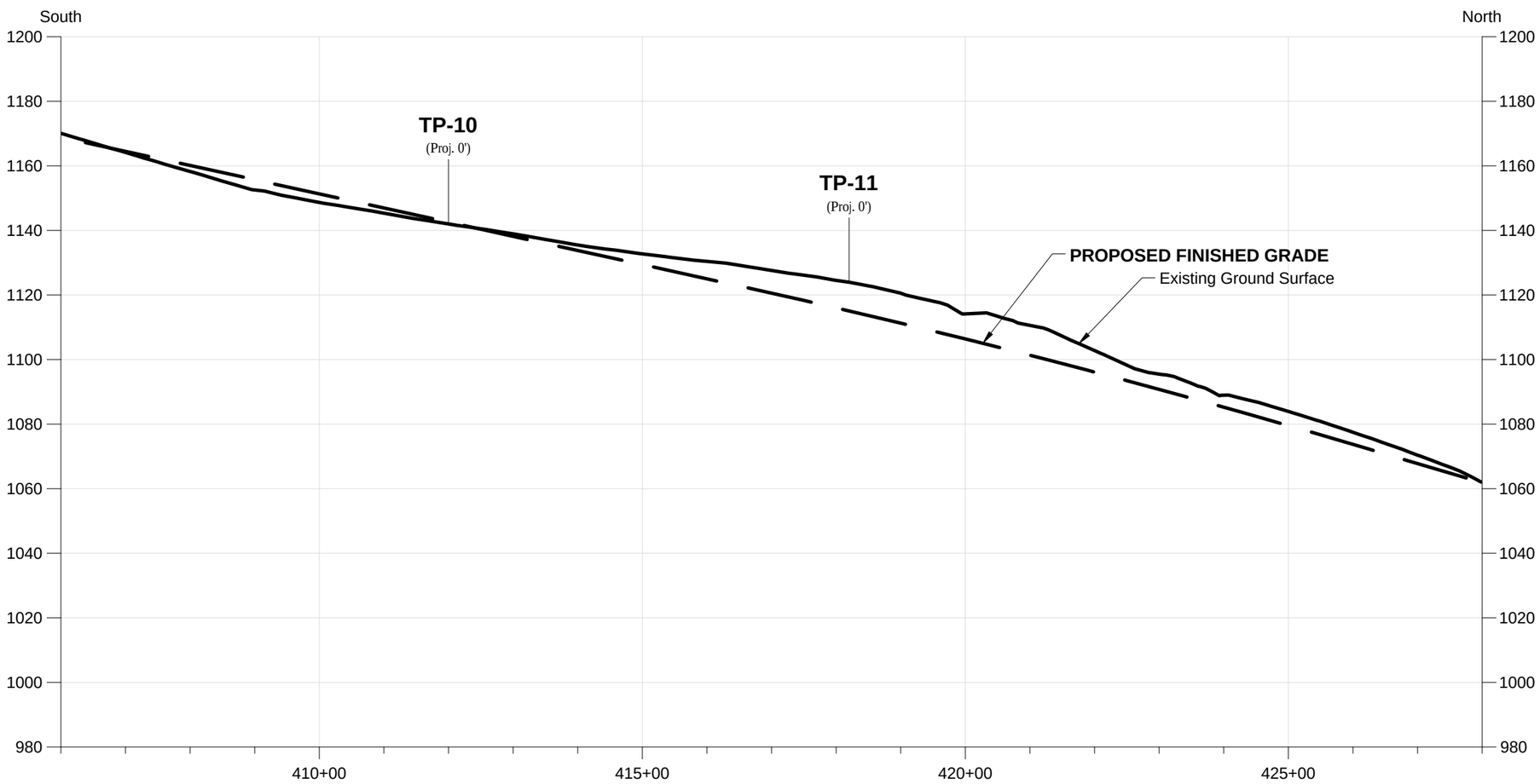
FIG. 2
Sheet 6 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac

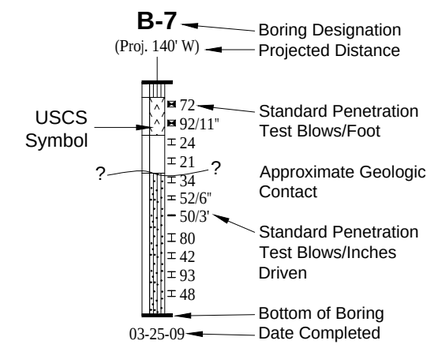




LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location



0 40 80

Vertical Scale in Feet

0 200 400

Horizontal Scale in Feet

Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

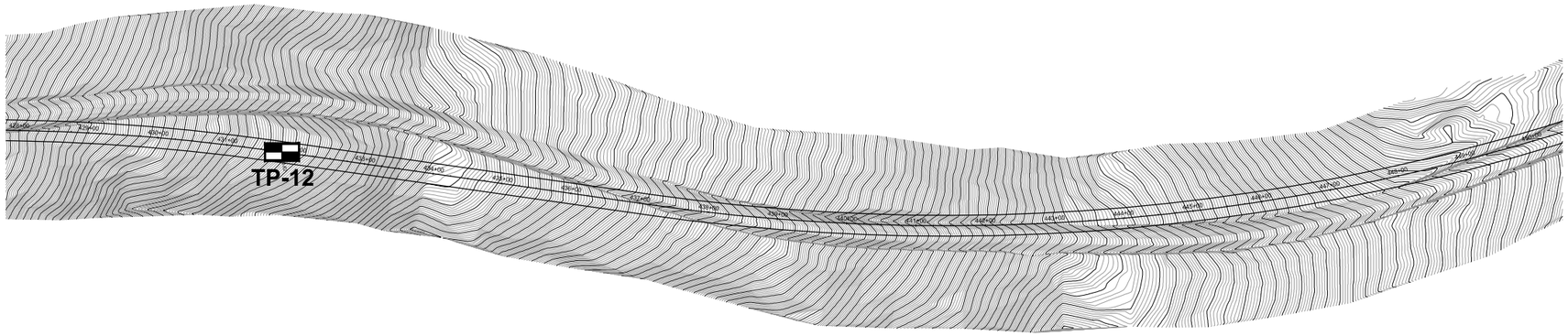
PLAN AND PROFILE

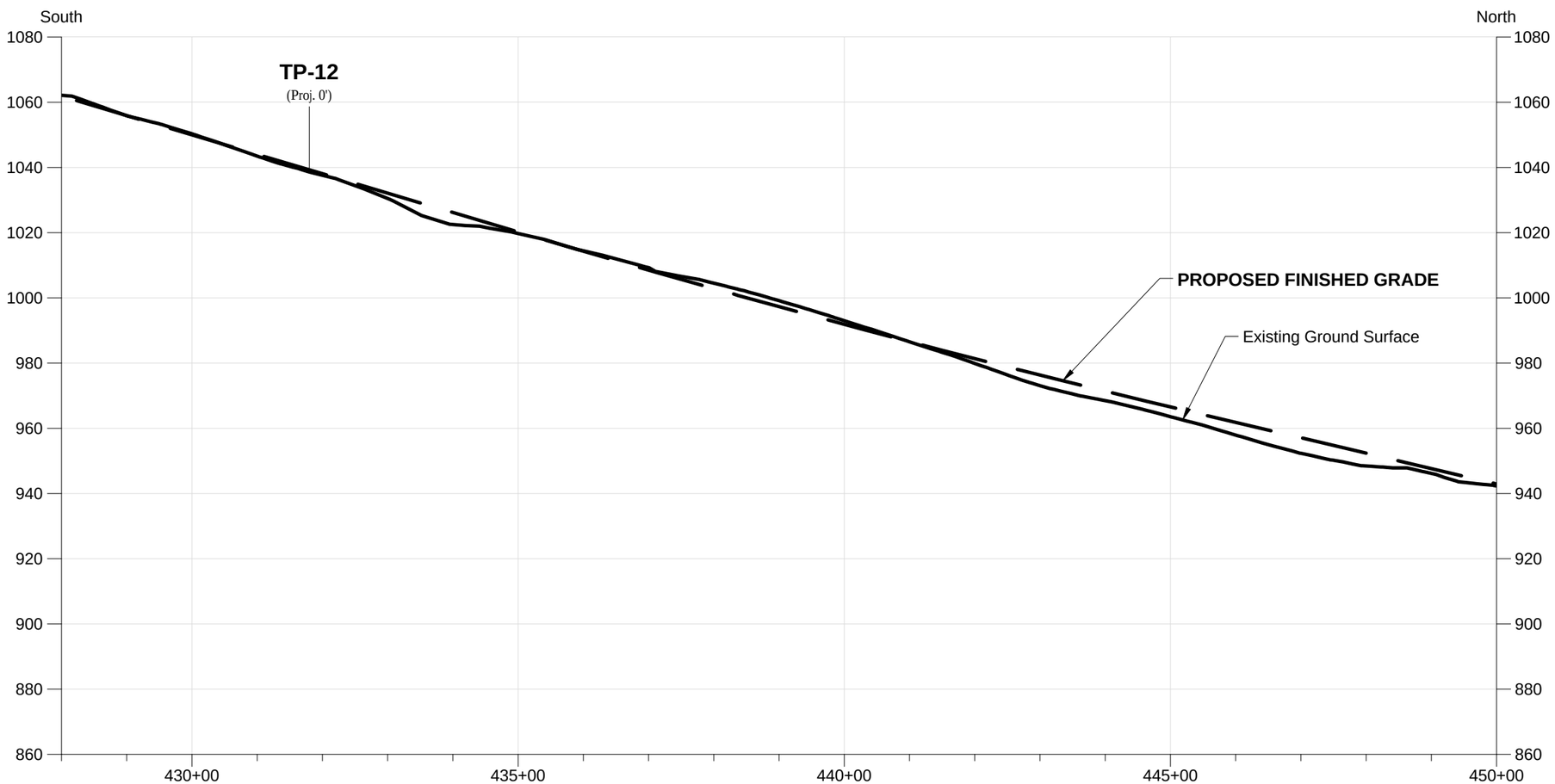
December 2012 22-1-02932-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2
Sheet 7 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac

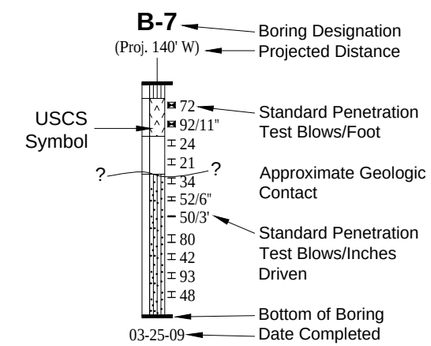




LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location



0 40 80

Vertical Scale in Feet

0 200 400

Horizontal Scale in Feet

Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

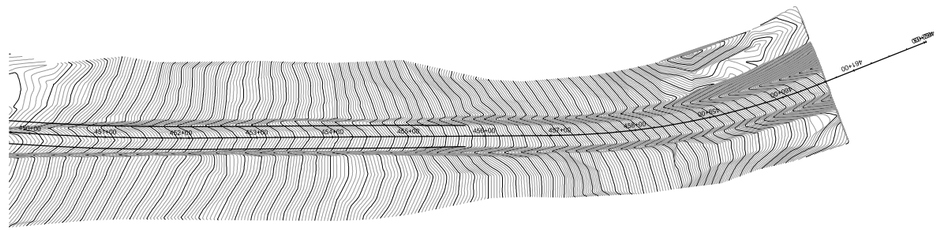
PLAN AND PROFILE

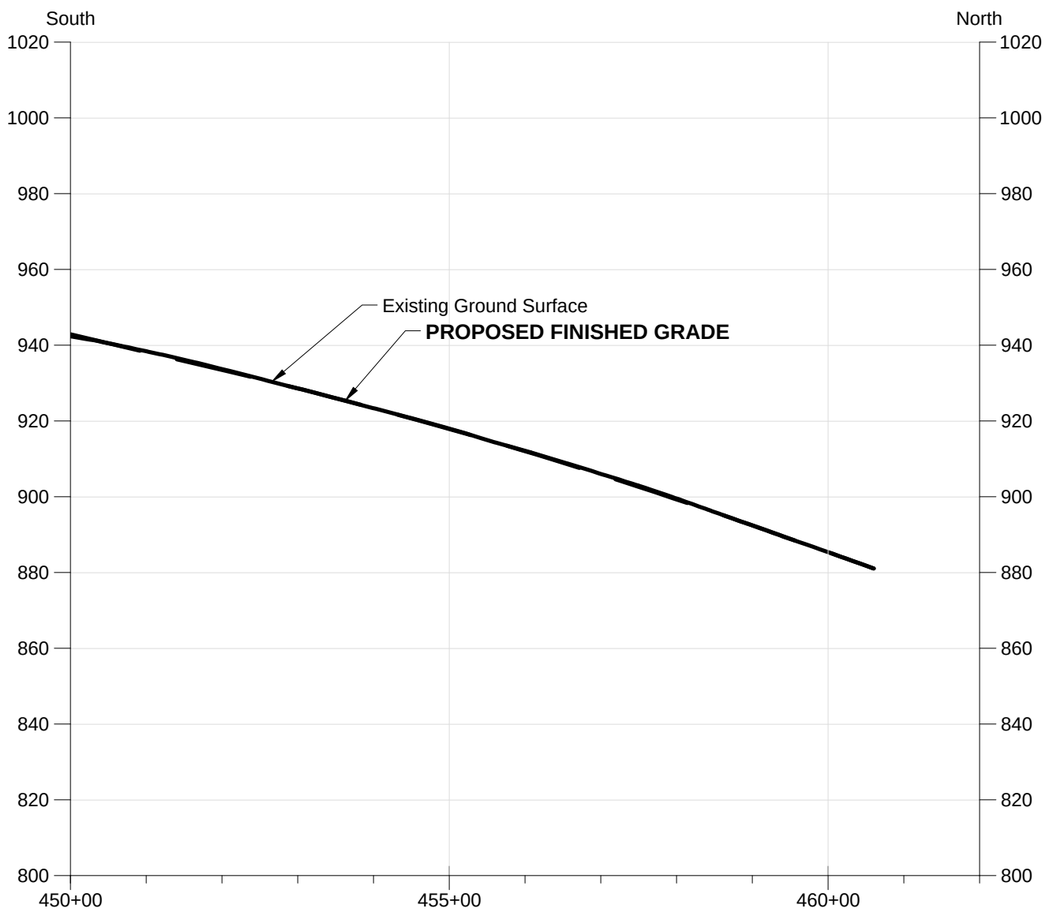
December 2012 22-1-02932-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2
Sheet 8 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac

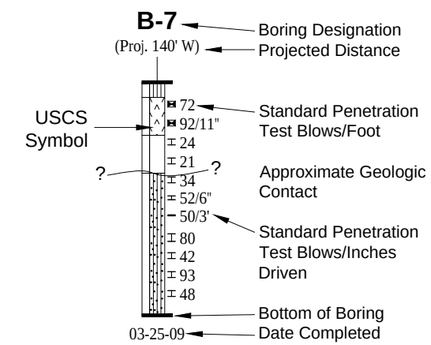




LEGEND

B-1 Boring Designation and Approximate Location

TP-1 Test Pit Designation and Approximate Location



0 40 80

Vertical Scale in Feet

0 200 400

Horizontal Scale in Feet

Vertical Exaggeration = 5X

NOTE

Base map from file *Nine Canyon_PH I.dwg* by Benton County received 12-12-12.

Nine Canyon Road
Benton County, Washington

PLAN AND PROFILE

December 2012 22-1-02932-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2
Sheet 9 of 9

Filename: J:\221\02932-003\22-1-02932-003 P & P.dwg Date: 12-26-2012 Login: bac

APPENDIX A

EXPLORATORY TEST PIT LOGS

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

USCS LEGEND 9/18/09

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

NOTES

1. Duel 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) indicates that the soil may fall into one of the two possible basic groups.

Nine Canyon Road Phase I
Benton County, Washington

SOIL CLASSIFICATION AND LOG KEY

December 2012 22-1-02932-003

SHANNON & WILSON, INC.
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FIG. A-1

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-1

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Brown, fine sandy SILT; moist; roots; (Topsoil) ML.	None Observed	6.0	S-1	0
(2) Tan, slightly clayey, slightly fine sandy SILT; moist; non-plastic; ML.			Bulk 0.5 to 7.0	3
				6
			S-2	9
				12
				15
				18

Sketch of Northeast Pit Side

Surface Elevation: Approx. ___ Ft.

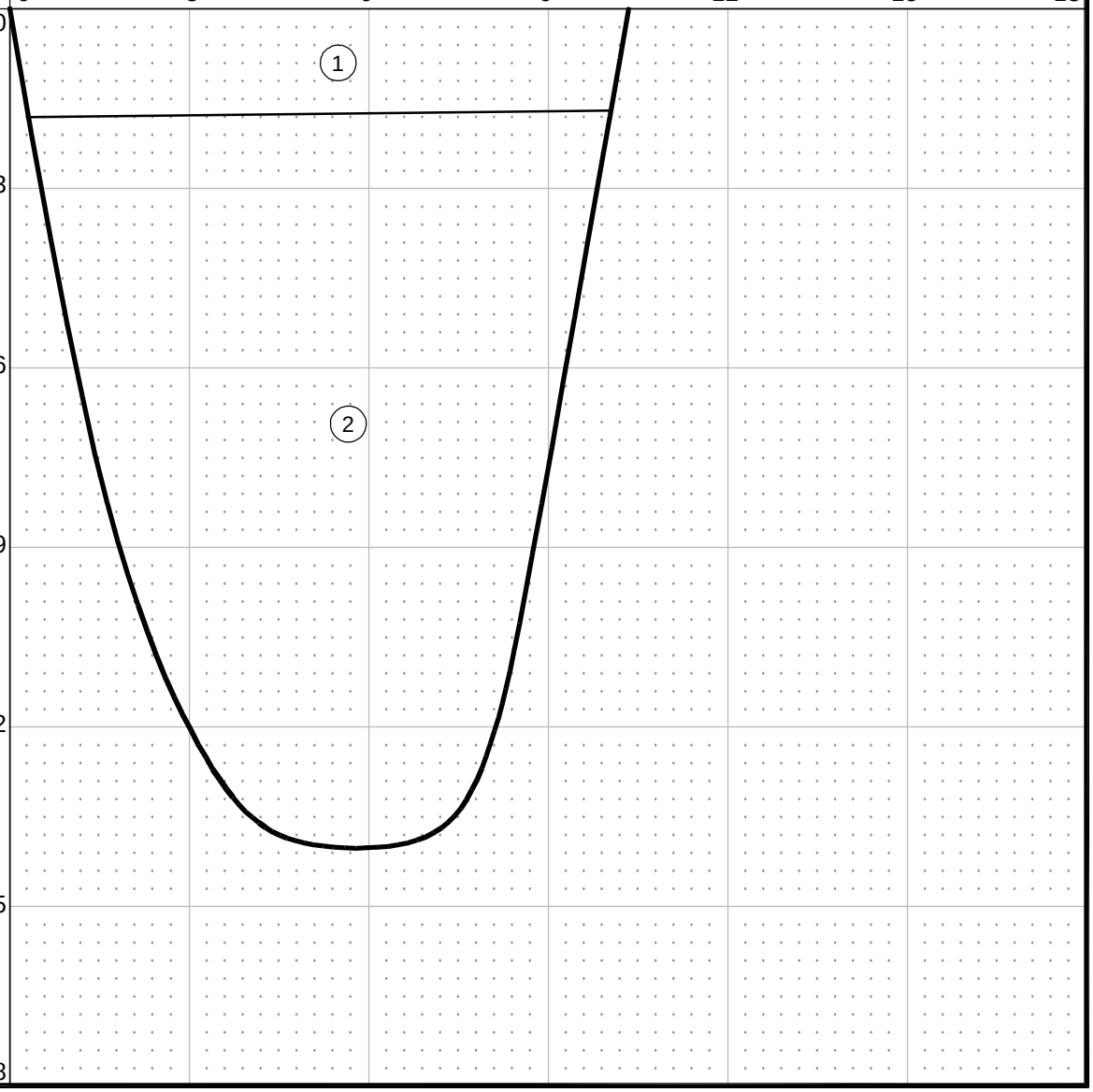


FIG. A-2

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-2

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, sandy SILT; moist; roots; (Topsoil) ML.	None Observed	5.4	S-1	0
(2) Medium stiff, tan, slightly clayey SILT, trace fine sand; moist; ML.			Bulk 0.5 to 7.0	3
				6
			S-2	9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

Horizontal Distance in Feet

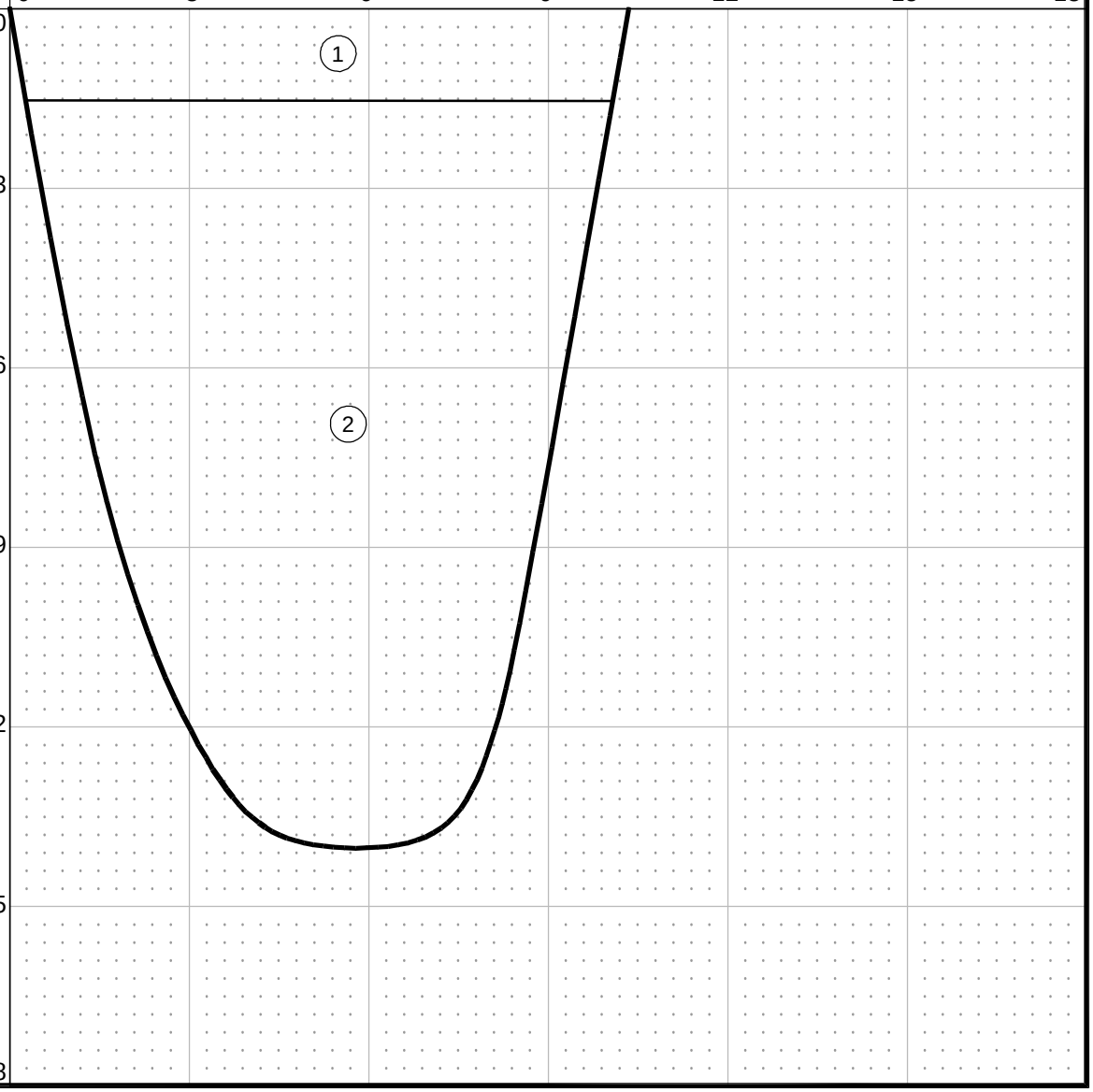


FIG. A-3

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-3

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Dark brown, organic SILT; moist; roots; (Topsoil) ML.	None Observed			0
(2) Medium stiff, brown, fine sandy SILT; moist; ML.			S-1 Tube 2.0 to 2.5	3
(3) BASALT: gray.			S-2	6
				9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

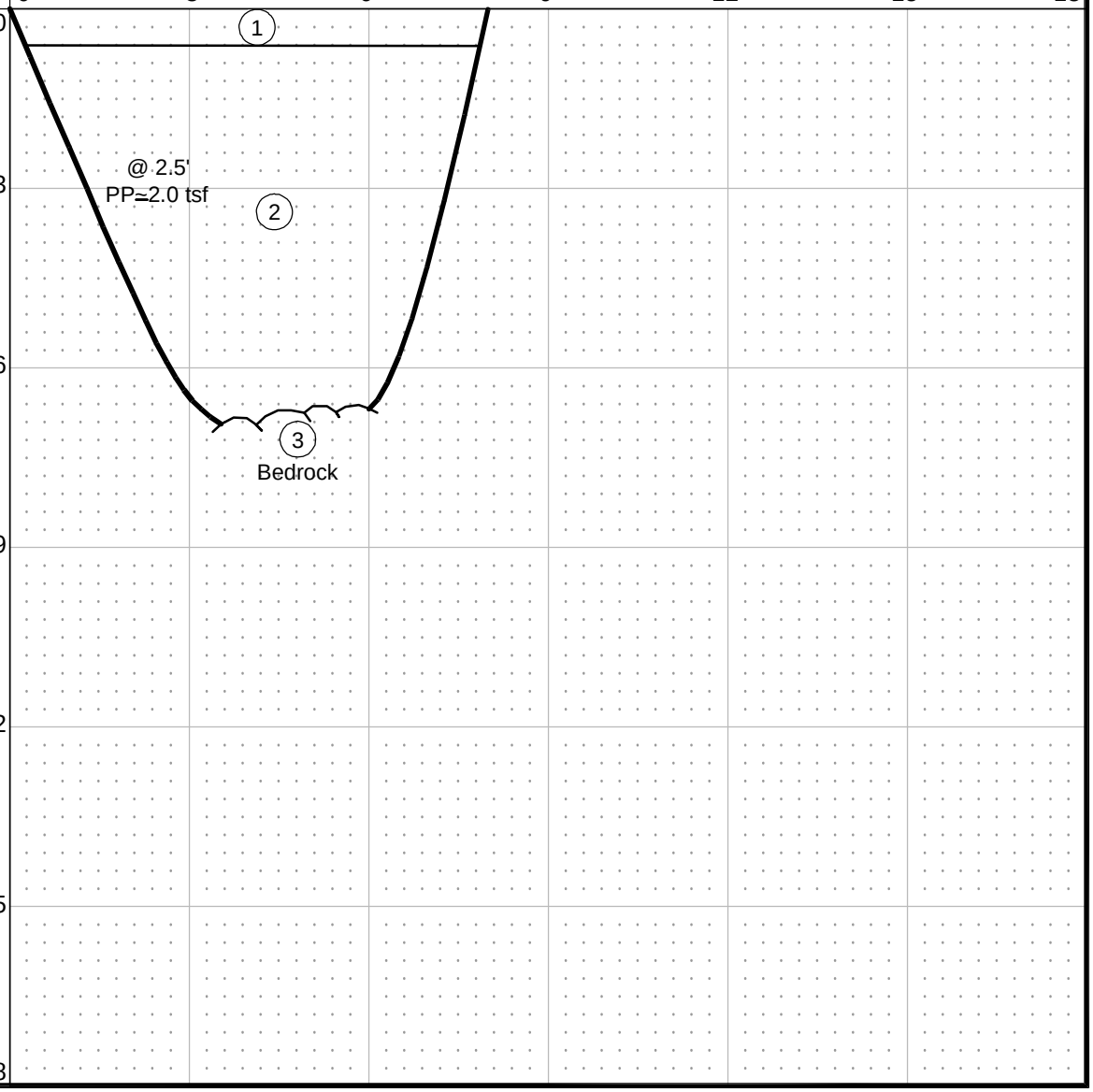


FIG. A-4

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-4

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, fine sandy SILT; moist; roots; (Topsoil) ML.	None Observed		S-1	0
(2) Medium stiff, tan, slightly fine sandy SILT; moist; non-plastic; ML.		12.8	S-2 Tube 2.8 to 3.3	3
			Bulk 0.5 to 7.0	6
			S-3	9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

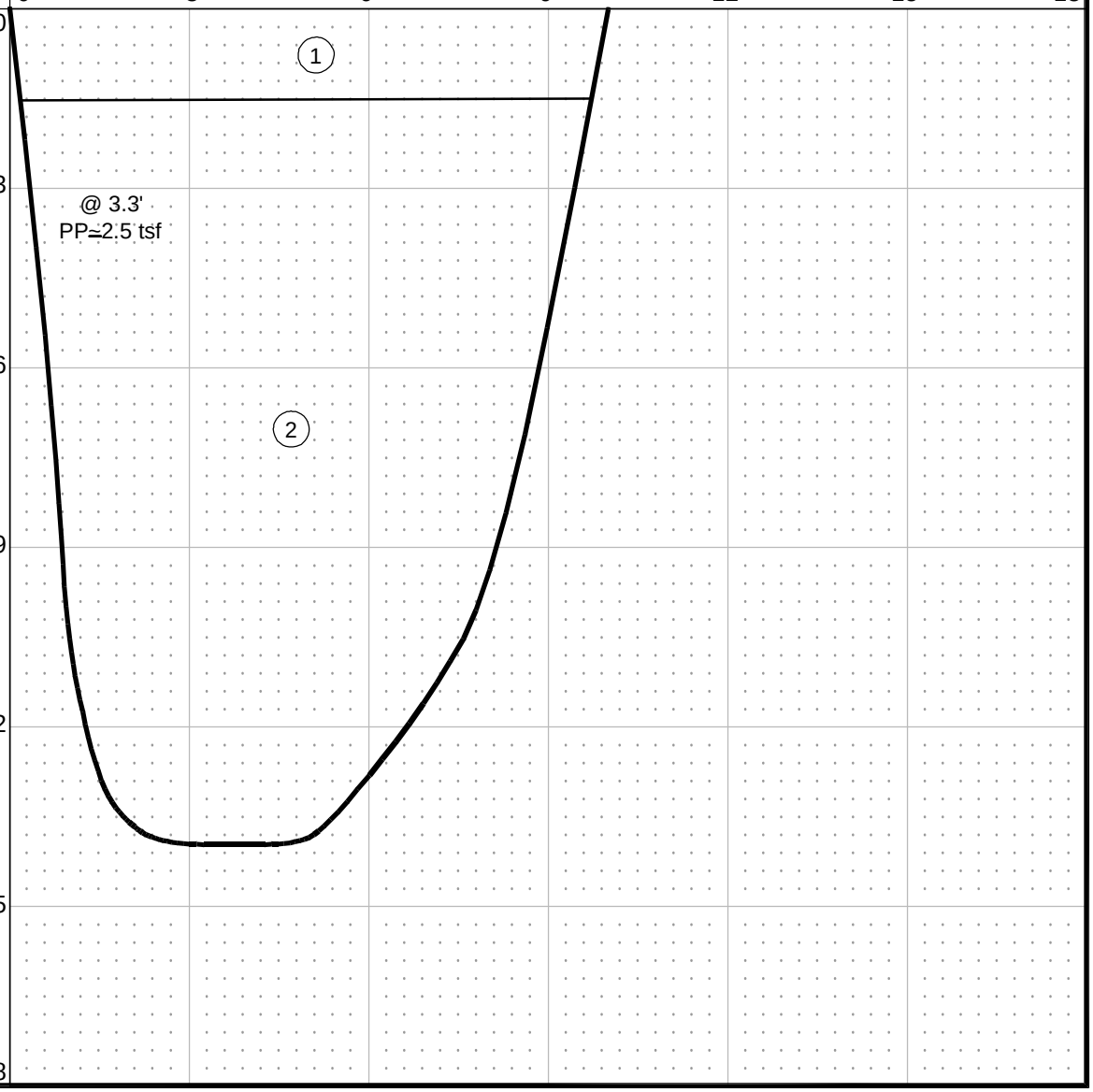


FIG. A-5

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-5

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, fine sandy SILT; moist; roots; (Topsoil) ML.	None Observed		S-1	0
(2) Tan, fine sandy SILT; moist; ML.		9.7	S-2 Tube 2.8 to 3.3	3
			S-3	6
				9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

Horizontal Distance in Feet

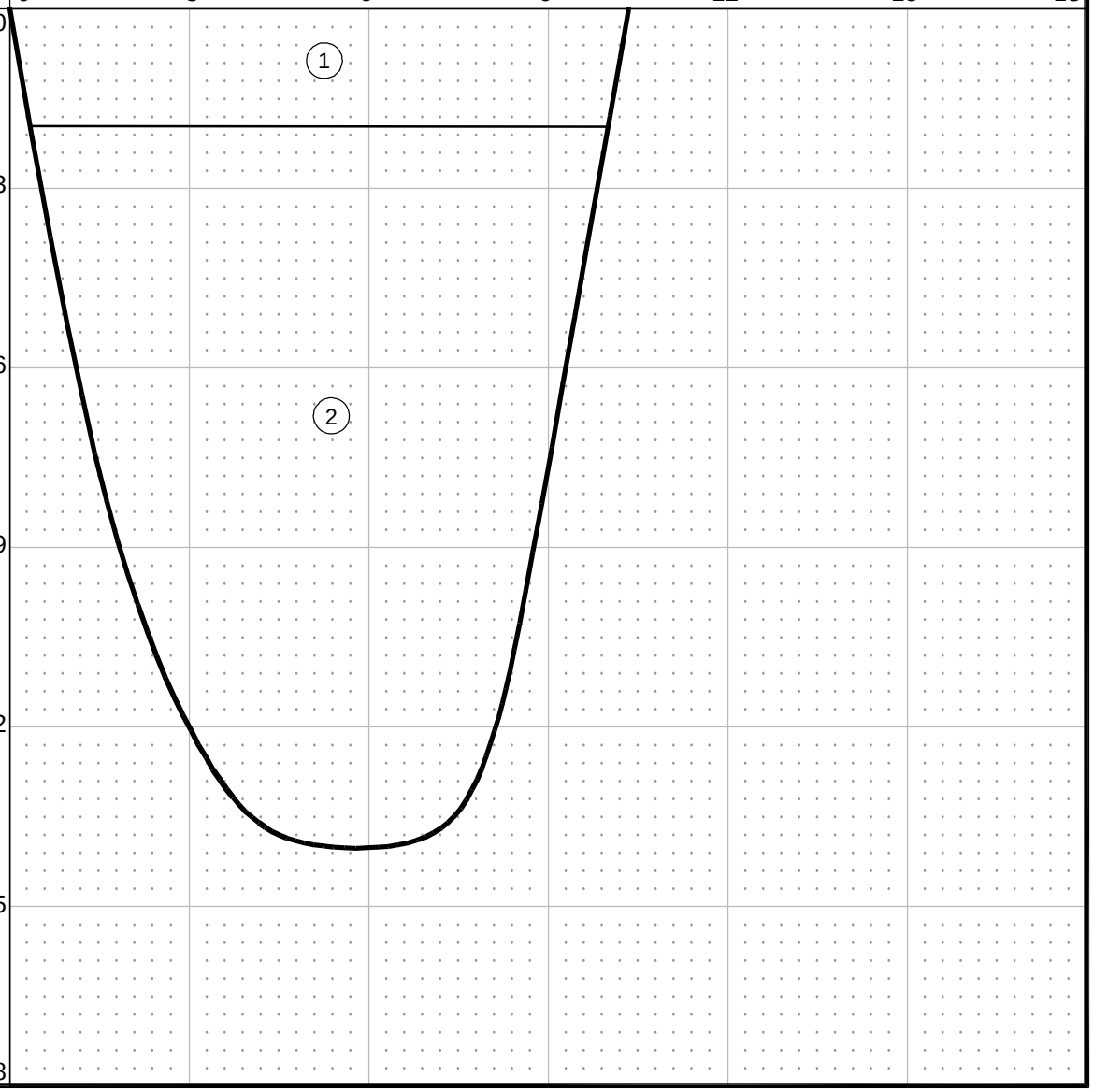


FIG. A-6

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-6

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, fine sandy SILT; moist; roots.	None Observed		S-1	0
(2) Medium stiff, tan, fine sandy SILT; moist.			S-2	6

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

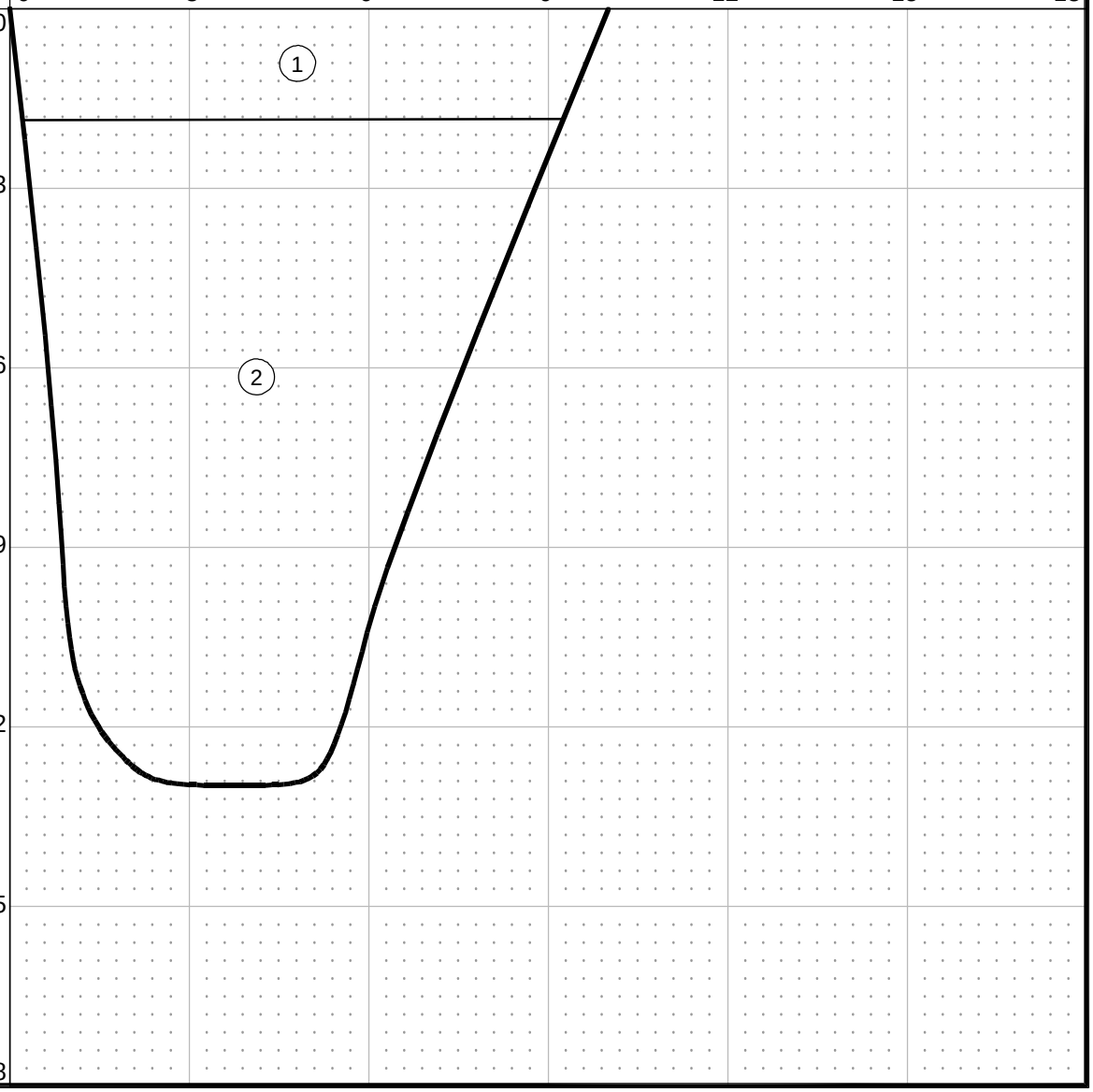


FIG. A-7

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-7

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, sandy SILT; moist; roots.	None Observed		S-1	0
(2) Tan SILT, trace gravel and fine sand; dry; non-plastic; ML.		14.6	S-2 Tube 1.8 to 2.3	3
			Bulk 0.5 to 7.0	6
			S-3	9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

Horizontal Distance in Feet

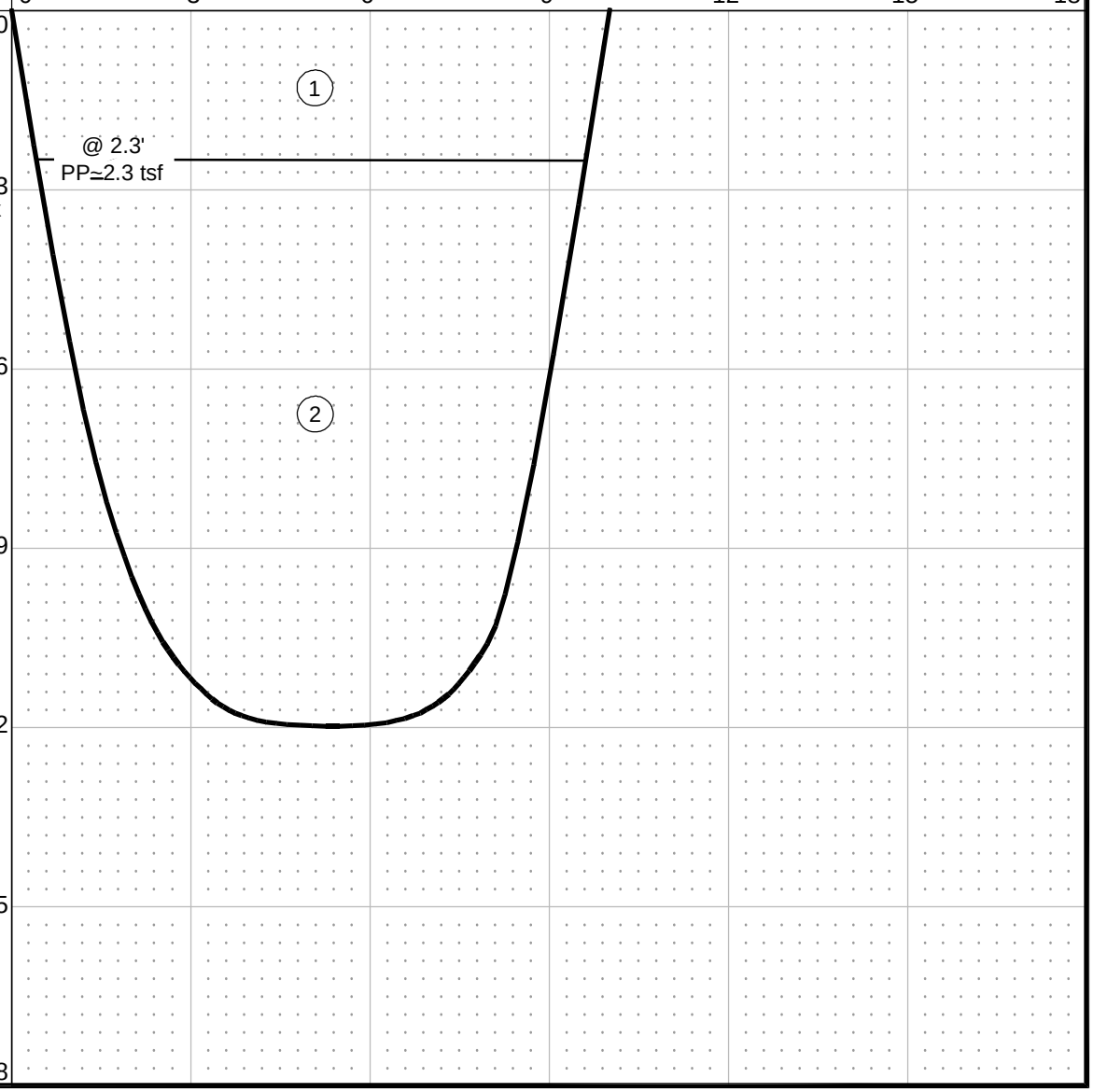


FIG. A-8

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-8

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Brown, sandy SILT; moist; (Topsoil).	None Observed		S-1	0
(2) Medium dense to dense, brown, silty, sandy GRAVEL; moist.				3
(3) BASALT: Weathered, intensely fractured.			S-2	6
				9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

Horizontal Distance in Feet

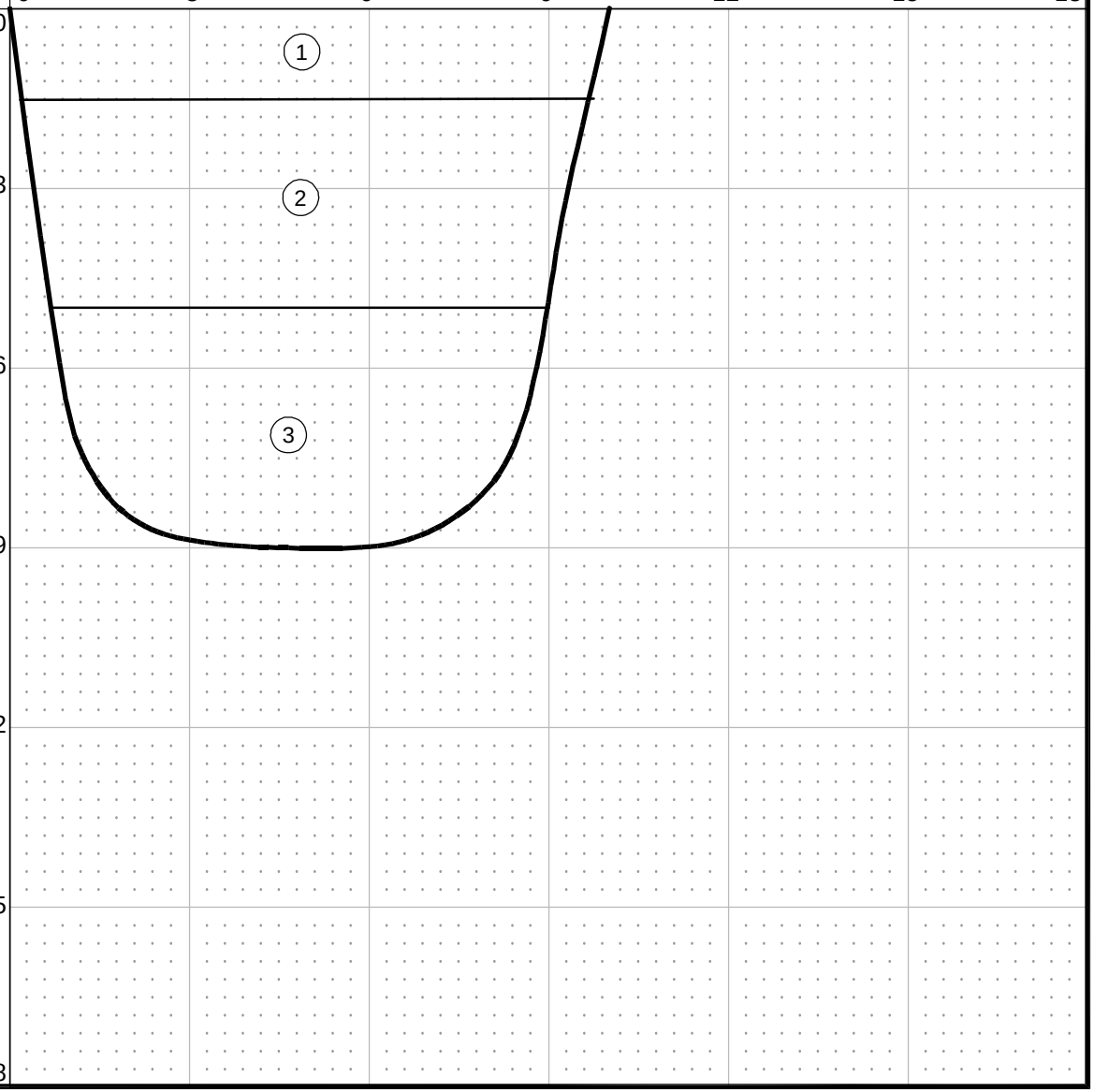


FIG. A-9

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-9

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Soft to medium stiff, brown, sandy SILT; moist; trace to slight organics; (Topsoil).	None Observed		S-1	0
(2) Tan, sandy SILT; moist; slightly gravelly below 7 feet.			S-2 Tube 1.9 to 2.4	3
		13.2	S-3 Tube 3.8 to 4.3	
			S-4	6
				9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

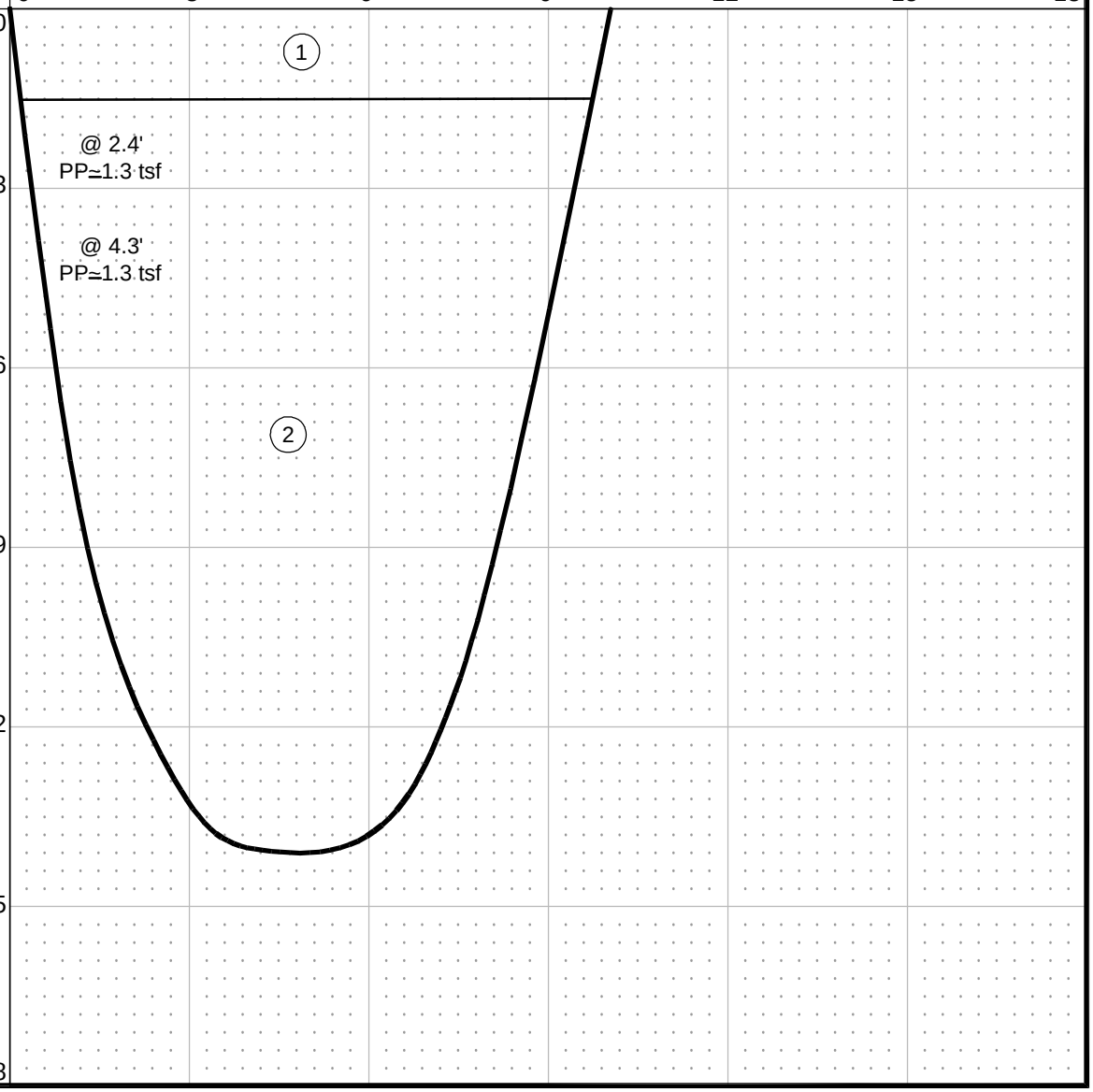


FIG. A-10

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-10

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, sandy SILT; moist; roots; (Topsoil).	None Observed		S-1	0
(2) Medium stiff, tan, sandy SILT; moist.			Bulk 0.5 to 7.0	3
				6
			S-2	9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

Horizontal Distance in Feet

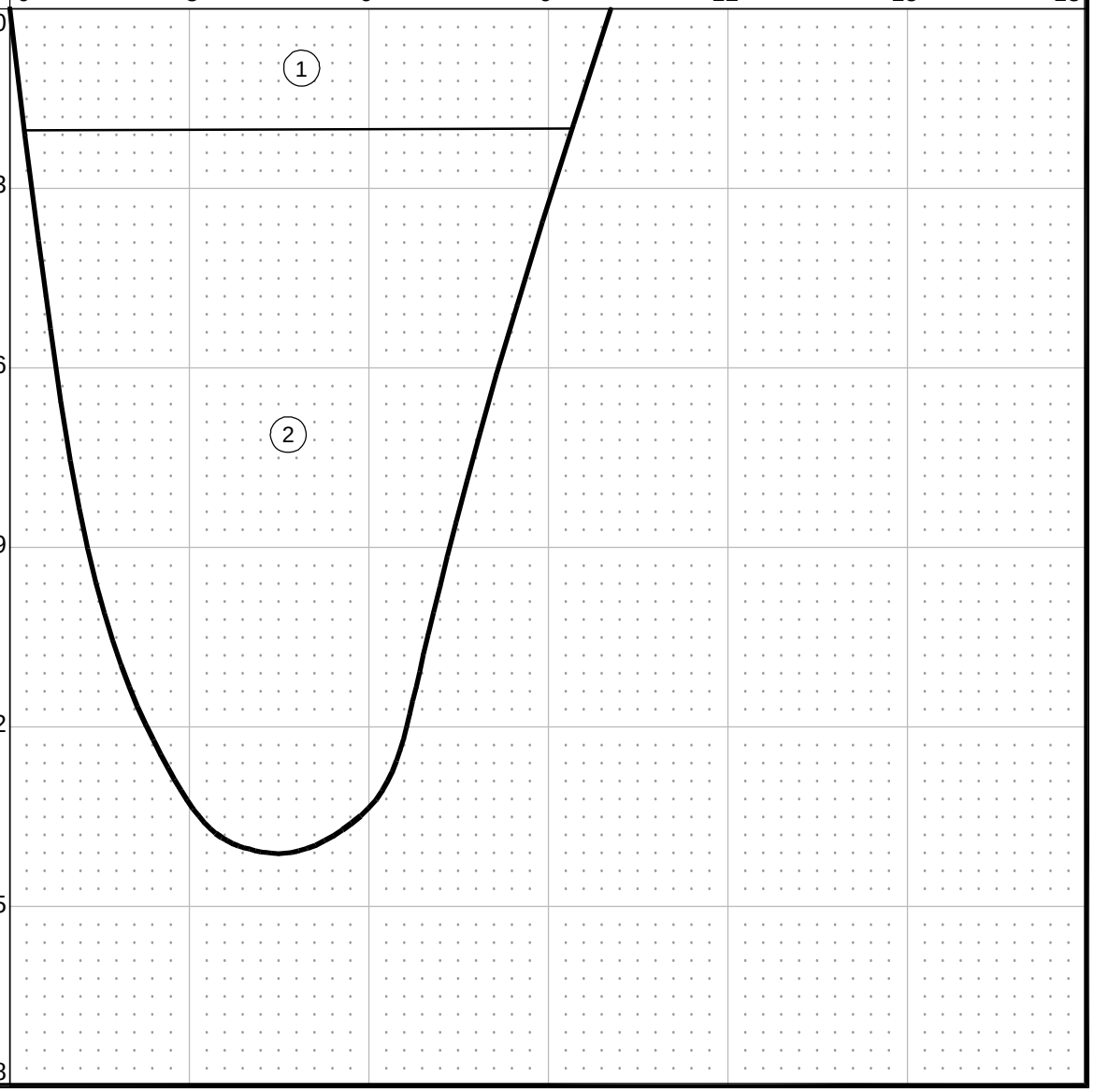


FIG. A-11

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-11

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, sandy SILT; moist; roots; (Topsoil).	None Observed	7.7	S-1	0
(2) Medium stiff, tan, slightly clayey, slightly fine sandy SILT; moist; ML.			Bulk 0.5 to 7.0	3
				6
			S-2	9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

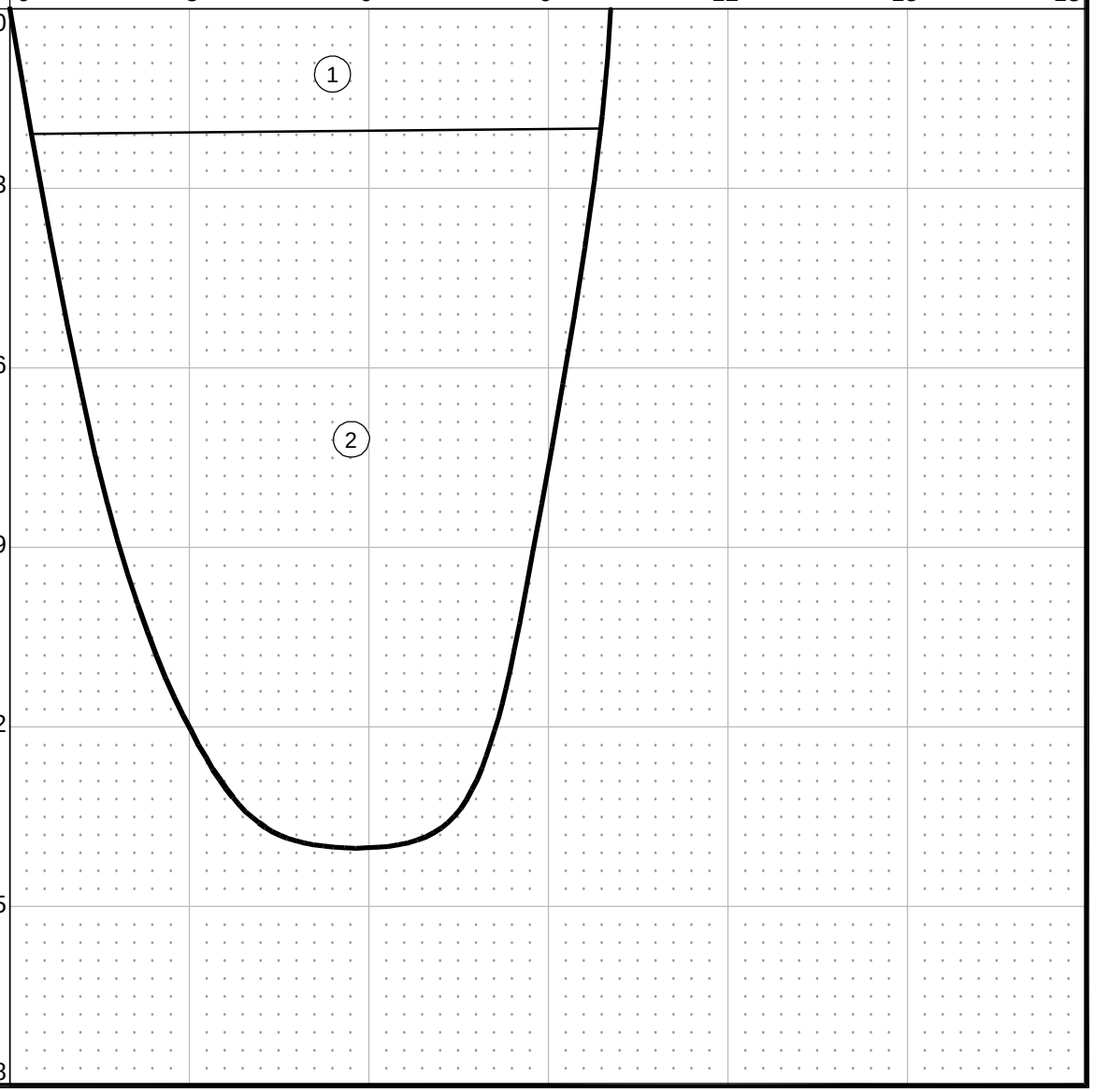


FIG. A-12

File: J:\221\02514-004\22-1-02514-004 Test Pits.dwg Date: 06-25-2009 Author: sac

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

LOG OF TEST PIT TP-12

JOB NO: 22-1-02514-004 DATE: 3-23-09 LOCATION: See Site and Exploration Plan

PROJECT: Nine Canyon Road

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Medium stiff, brown, sandy SILT; moist; roots; (Topsoil).	None Observed	5.2	S-1	0
(2) Tan, slightly clayey, fine sandy SILT; moist; ML.			Bulk 0.5 to 7.0	3
				6
			S-2	9
				12
				15
				18

Sketch of _____ Pit Side

Surface Elevation: Approx. ___ Ft.

Horizontal Distance in Feet

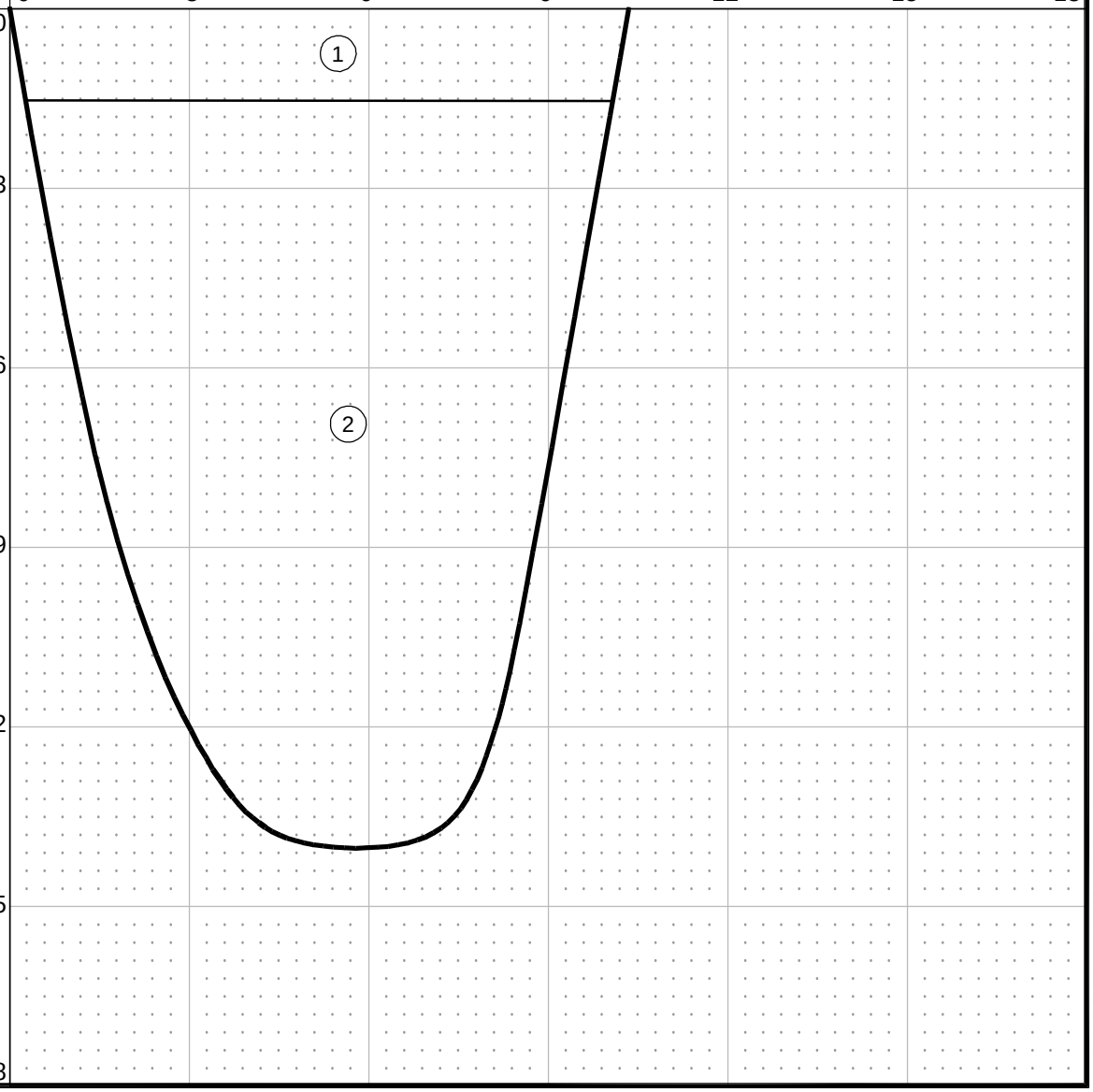


FIG. A-13

APPENDIX B

EXPLORATORY BORING LOGS AND PHOTOGRAPHS

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

USCS LEGEND 9/18/09

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

NOTES

1. Duel 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) indicates that the soil may fall into one of the two possible basic groups.

Nine Canyon Road Phase I
Benton County, Washington

SOIL CLASSIFICATION AND LOG KEY

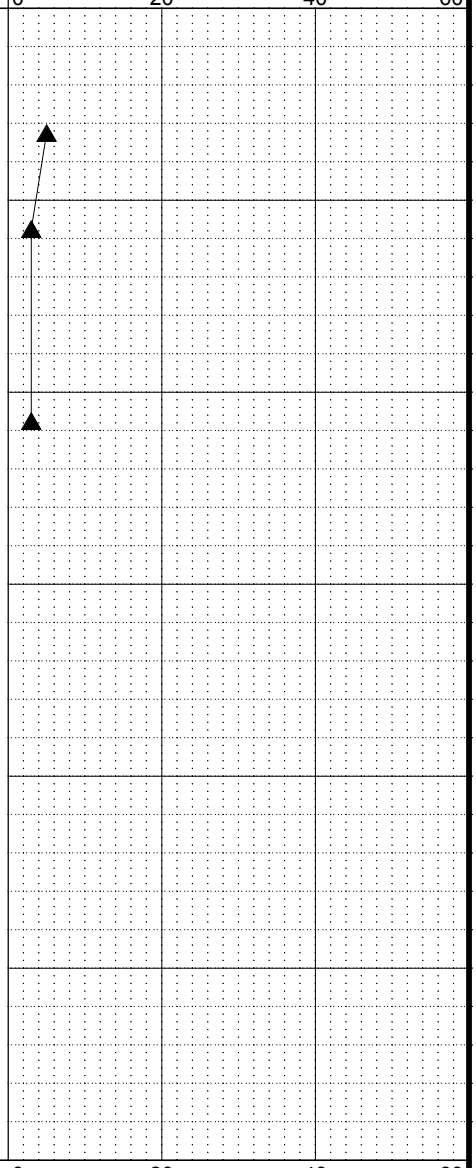
December 2012 22-1-02932-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-1

Total Depth:	*11.5 ft.*	Northing:		Drilling Method:	*Hollow Stem Auger*	Hole Diam.:	*3.18 in.*
Top Elevation:	~	Easting:		Drilling Company:	*Environmental West*	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	*Mobile B-80*	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water	Depth, ft.	PENETRATION RESISTANCE (blows/foot) ▲ Hammer Wt. & Drop: *140 lbs / 30 inches*
Loose to very loose, brown, sandy SILT; moist; ML.			1 2 3	None Observed During Drilling	5 10 15 20 25	
BOTTOM OF BORING COMPLETED 3/26/2009	11.5					



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-1

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-2

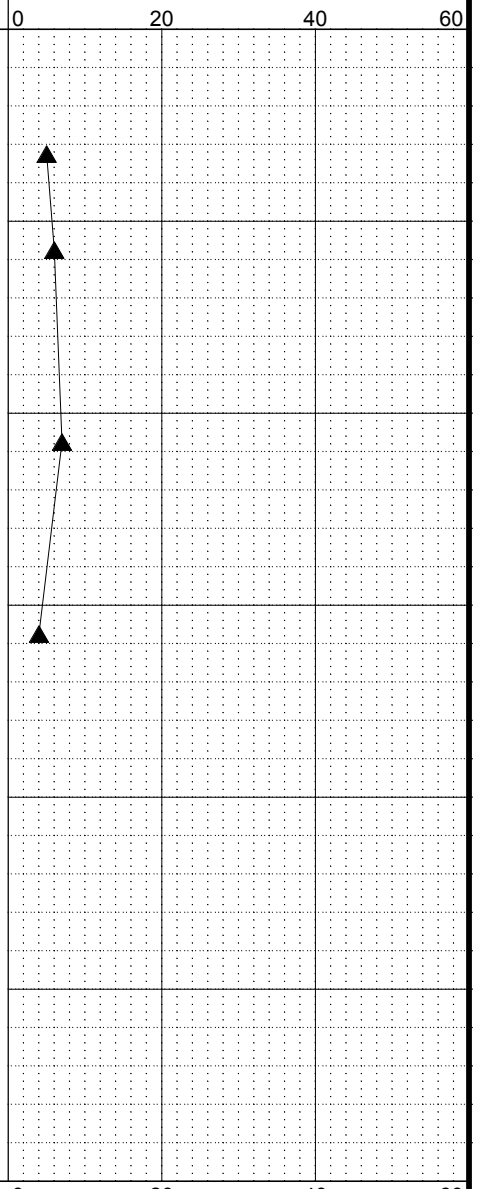
MASTER LOG_E 22-02932.GPJ SHAN_WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	16.5 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water	Depth, ft.
Loose to very loose, brown, sandy SILT; moist; ML.			1, 2, 3, 4	None Observed During Drilling	
BOTTOM OF BORING COMPLETED 3/26/2009	16.5				

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)

● % Water Content

LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-2

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-3

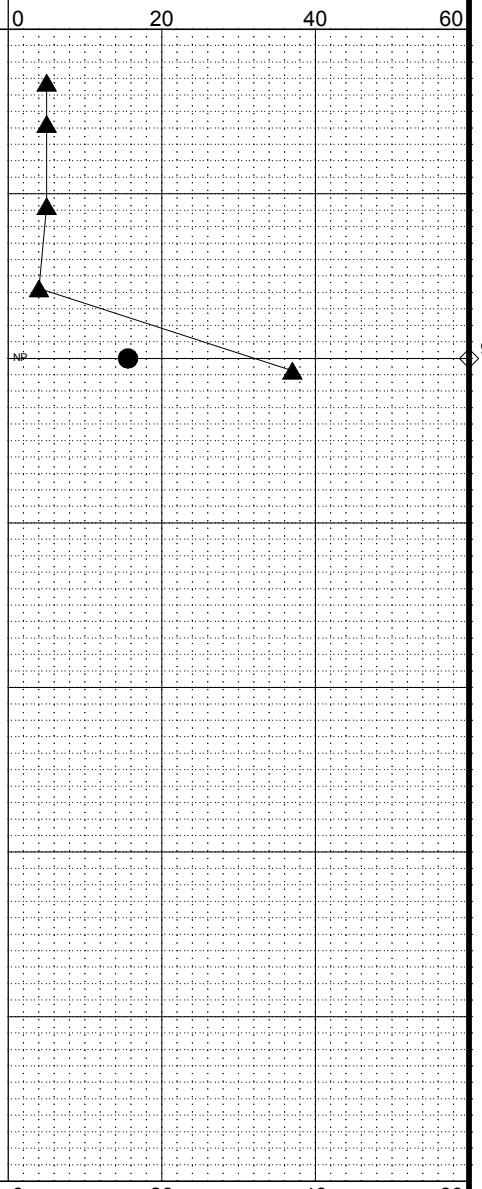
MASTER LOG E 22-02932.GPJ SHAN WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	21.5 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water	Depth, ft.
Loose, brown, sandy SILT; moist; ML.			1, 2, 3, 4	None Observed During Drilling	
Dense, tan, slightly fine sandy SILT; moist; non-plastic; ML.	18.5		5		
BOTTOM OF BORING COMPLETED 3/26/2009	21.5				

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-3

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-4

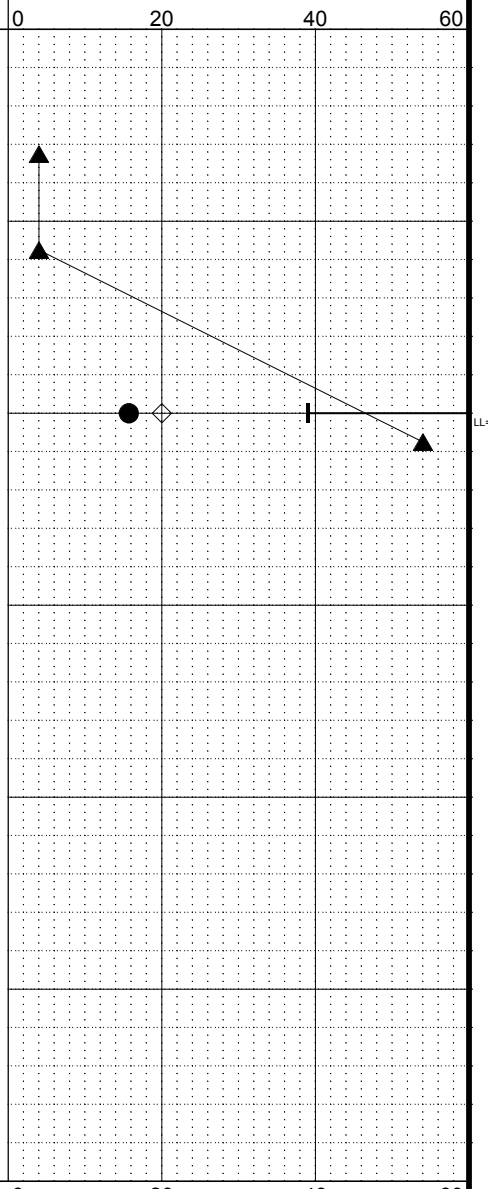
MASTER LOG E 22-02932.GPJ SHAN WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	12 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water	Depth, ft.
Loose, brown, sandy SILT; moist; ML.			1, 2	None Observed During Drilling	
Stiff, tan CLAY; moist; (Palagonite) CL.	7.0				
Very dense, greenish-gray, silty to clayey, medium to coarse sandy, fine to coarse GRAVEL; moist; very highly plastic fines, angular basalt fragments; (Decomposed to Weathered Basalt) GM/GC.	10.5 12.0		3		
BOTTOM OF BORING COMPLETED 3/26/2009					

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-4

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-5

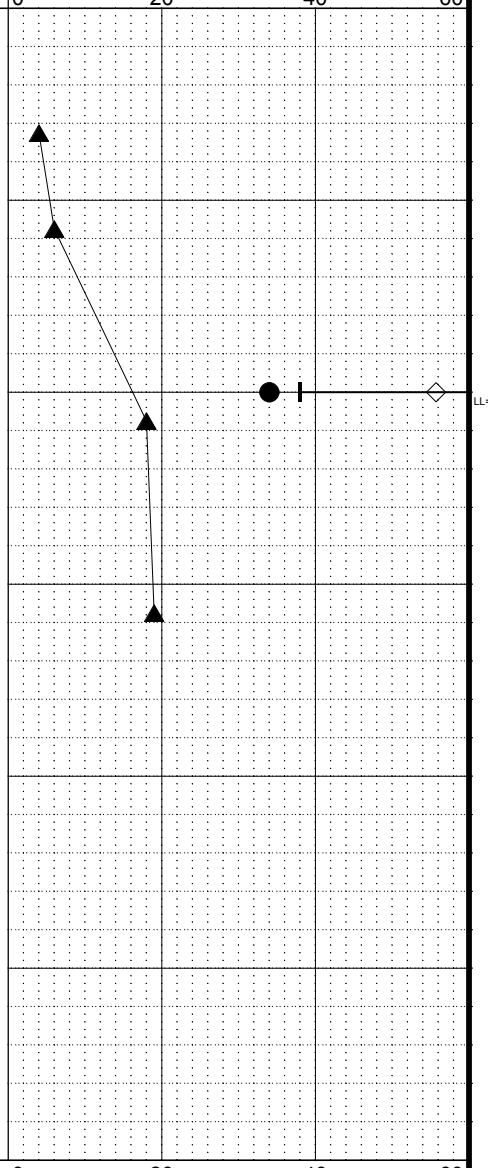
MASTER_LOG_E 22-02932.GPJ SHAN_WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	16.5 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
ASPHALT (+/- 2 inches).	0.2
BASEROCK: Sandy GRAVEL (+/- 2 inches) (Fill).	0.3
Loose, brown, sandy SILT; moist; ML.	
Medium stiff, white to greenish-gray, fine to coarse sandy SILT, trace of fine to coarse gravel; moist; high plasticity; (Palagonite) CL.	4.0
BOTTOM OF BORING COMPLETED 3/26/2009	16.5

Samples: 1, 2, 3, 4

Ground Water: None Observed During Drilling



LEGEND

* Sample Not Recovered

Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-5

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-6

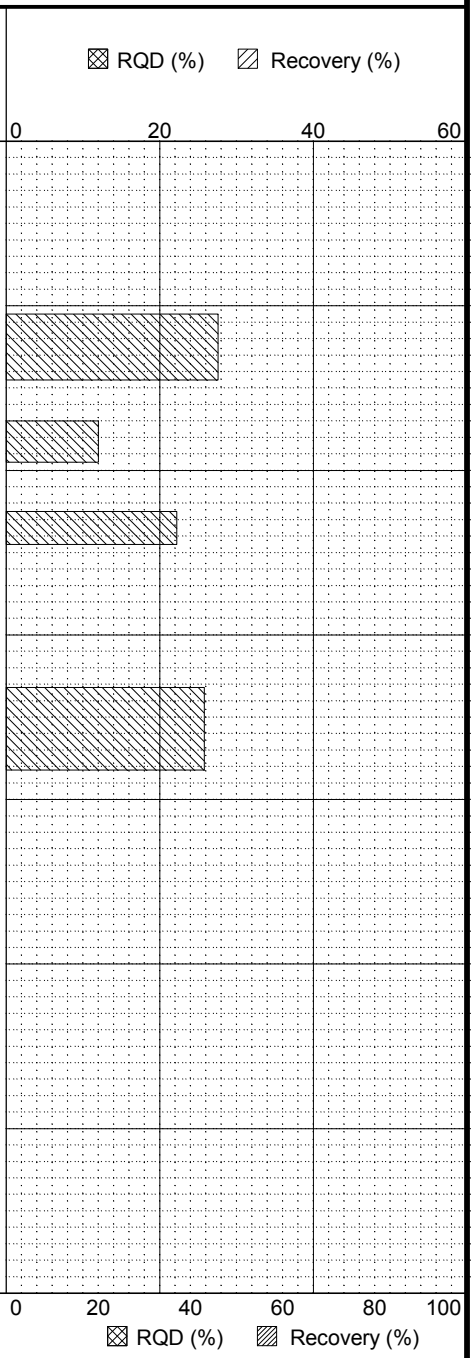
MASTER_LOG_E 22-02932.GPJ SHAN_WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	58.2 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL/ROCK DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Loose, brown, sandy SILT; moist; ML.	
BASALT: Moderate strength, gray, moderately to highly weathered, vesicular.	6.0
LOESS: Very low strength, light gray, medium-grained, moderately weathered.	25.0
BASALT: Low strength, gray, highly weathered.	33.5
Soft, tan CLAY; moist; (Palagonite) CL.	34.0
BOTTOM OF BORING COMPLETEC 3/24/2009	58.2

Samples: R-1, R-2, R-3, R-4, R-5, R-6, R-7, R-8, R-9, R-10, R-11, R-12, R-13

Ground Water: None Observed During Drilling



LEGEND

* Sample Not Recovered

Rock Core

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-6

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-7

MASTER_LOG_E 22-02932.GPJ SHAN_WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	61.5 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

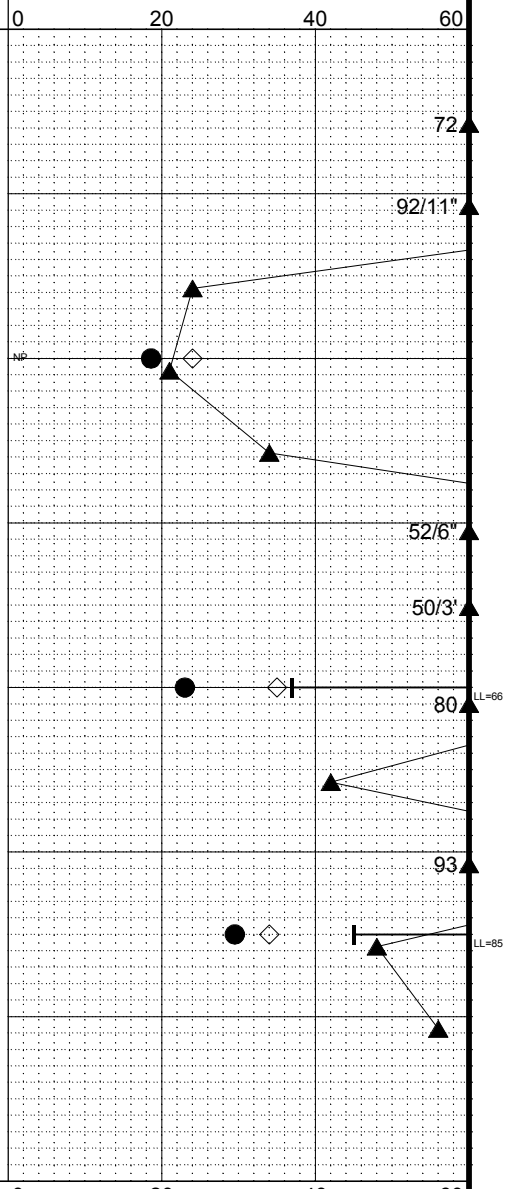
SOIL DESCRIPTION	Depth, ft.
Very loose to loose, brown, sandy SILT; moist; ML.	4.0
BASALT: Moderate strength, gray, weathered, vesicular.	14.0
LOESS: Very low strength, light gray, medium-grained, moderately weathered.	24.0
Hard, tan CLAY; moist; (Palagonite) SM.	61.5
BOTTOM OF BORING COMPLETED 3/25/2009	

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Symbol | Samples | Ground Water: None Observed During Drilling | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

- * Sample Not Recovered
- Modified California Sampler
- Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-7

June 2009 | 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-8

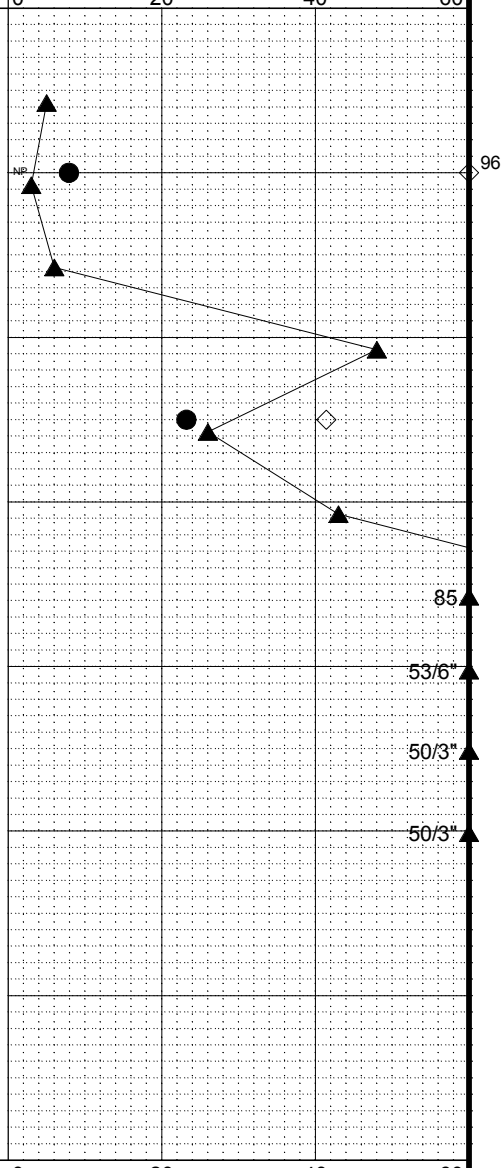
MASTER_LOG_E 22-02932.GPJ SHAN_WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Total Depth:	60 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	3.18 in.
Top Elevation:	~	Easting:		Drilling Company:	Environmental West	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	Mobile B-80	Hammer Type:	
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION	Depth, ft.
Very loose to loose, light brown, trace to slightly fine sandy SILT; moist; non-plastic; ML.	
Dense, brown, silty SAND; moist; (Weathered Basalt) (Palagonite).	16.0
Very stiff, reddish-brown and tan, fine to coarse gravelly, fine to coarse sandy SILT/CLAY; moist; (Palagonite) MH.	22.5
BASALT: Medium strength, low vesicularity, moderated weathered.	28.0
BOTTOM OF BORING COMPLETED 3/25/2009	60.0

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Symbol | Samples | Ground Water: None Observed During Drilling



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Modified California Sampler
- Grab Sample

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Nine Canyon Road
Benton County, Washington

LOG OF BORING B-8

June 2009 22-1-02514-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-9

MASTER_LOG_E 22-02932.GPJ SHAN_WIL.GDT 12/21/12 Log: OXL Rev: CAW Typ: LKD

Appendix B – Photographs

Photo 1 – Obsidian at bottom of basalt

Photo 2 – Continental sediment – basalt interface

Photo 3 – Cut face showing basalt and continental sediment interface

Photo 4 - Core from Boring B-6 (8.5 to 19.3 feet)

Photo 5 - Core from B-6 (19.5 – 34.2 feet)

Photo 6 - Core from B-6 (34.2 to 58.2 feet)

APPENDIX C

GEOPHYSICAL SURVERY
SEISMIC REFRACTION REPORT

Geophysical Survey LLC
2200 W 8th Place
Kennewick, Washington 99336

December 12, 2012

Dee Burrie
Shannon & Wilson Inc.
303 Wellsian Way
Richland, WA

Re: ***Seismic Refraction Survey***
Phase I 9 Canyon Road
Benton County, Washington

Mr. Burrie:

Geophysical Survey LLC conducted a seismic refraction survey at the quarry located off of Beck Road in Benton County, Washington on December 4 & 5, 2012. The objective of the survey was to detect the top of bedrock.

Methodology

Seismic Refraction

The seismic refraction method is based on the measurement of the travel time of seismic waves refracted at the interfaces between subsurface layers of different velocity. Seismic energy is provided by a source ('shot') located on the surface. The source of the seismic energy is a 16 lb. sledgehammer.

Energy radiates out from the shot point, either travelling directly through the upper layer (direct arrivals), or travelling down to and then laterally along higher velocity layers (refracted arrivals) before returning to the surface. This energy is detected on surface using a linear array (or spread) of geophones spaced at regular intervals. Beyond a certain distance from the shot point, known as the cross-over distance, the refracted signal is observed as a first-arrival signal at the geophones (arriving before the direct arrival). Observation of the travel-times of the direct and refracted signals provides information on the depth profile of the refractor.

Shots are deployed beyond both ends of the geophone spread in order to acquire refracted energy as first arrivals at each geophone position. Additional shots are deployed throughout the geophone spread.

Data are recorded on a seismograph and later downloaded to computer for analysis of the first-arrival times to the geophones from each shot position. Travel-time versus distance

graphs are then constructed and velocities calculated for the overburden and refractor layers through analysis of the direct arrival and T-minus graph gradients. Depth profiles for each refractor are produced by an analytical procedure based on consideration of shot and receiver geometry and the measured travel-times and calculated velocities. The final output comprises a depth profile of the refractor layers and a velocity model of the subsurface.

FIELD SURVEY

Mapping Control

Line shotpoints were mapped with a DGPS (differential global positioning system) with decimeter accuracy (<10cm).

Seismic Refraction Data Acquisition

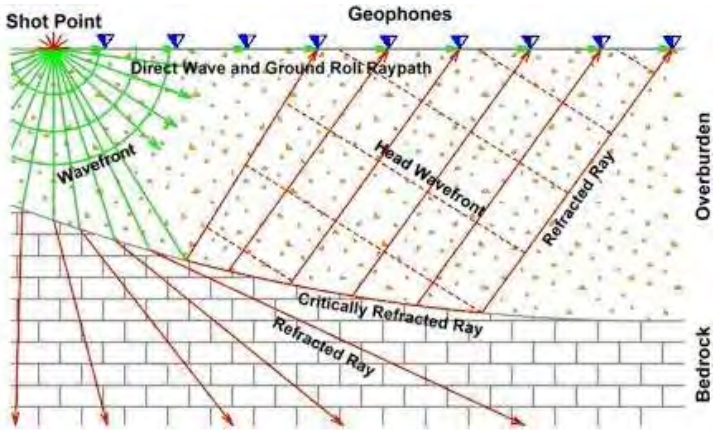
Seismic data were recorded on twenty four 30Hz geophones spaced 10 feet apart using a Geometrics Geode seismic controller. Five shotpoints per 24 geophone spread were collected and digitally recorded on a laptop computer.

Seismic data was interpreted using SeisImager 2D software V4.2 from Geometrics. A layered earth model was created using a time term inversion. The time term model was used as an initial model for tomographic analysis which iteratively traces rays through the model with the goal of minimizing the RMS error between the observed and calculated traveltimes.

RESULTS AND INTERPRETATION

Figures 1 & 2 show the location of each seismic shot point overlaid on aerial imagery. Tomographic velocity contours are shown on Figures 3-5.

The seismic data does not display compression velocities indicative of bedrock throughout the survey area. Depth of investigation was between 34 feet and 45 feet. While boring/test pit data shows basalt at shallow depths in select places the basalt layer is not present in the refraction data. Seismic refraction data relies on the critically refracted wave producing a head wavefront as displayed in the image below. Isolated lenses of basalt will not result in a critically refracted wave and would not be detectable by seismic refraction methods.



Critically Refracted Seismic Wave 1

CLOSURE

Geophysical surveys performed as part of this survey may or may not successfully detect or delineate any or all subsurface objects or features present. Locations, depths and scale of buried objects or subsurface features mapped as a result of this survey are a result of geophysical interpretation only, and should be considered as confirmed, actual, or accurate only where recovered by excavation or drilling.

Geophysical Survey LLC performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of the study described within.

Thank you for the opportunity to work with Shannon & Wilson. Please feel free to call if you have questions or need additional information.

Respectfully,

Geophysical Survey LLC

Mark Villa L.G.
Geophysicist

References: Redpath, Bruce B., (1973) . "Seismic Refraction Exploration for Engineering Site Applications." *Tech Report E-73-4*, U.S. Army Engineer Waterways Experiment Station Explosive Excavation Research Laboratory

Seismic Refraction Survey

Phase I 9 Canyon

Benton County, Washington

LIST OF FIGURES

Figure 1	Site Map South
Figure 2	Site Map North
Figure 3	Seismic velocity model Line 1-4
Figure 4	Seismic velocity models Lines 5-7 & 12
Figure 5	Seismic velocity model Line 8-10

Legend

703 Seismic shot point

Geophone (phones 1 & 24 shown)

Seismic line

1 Inch = 100 Feet

0 100

US State Plane Washington South
NAD83CORS96

FIGURE 1
Site Map
9 Canyon Phase I
Benton County, WA

Legend

*703 Seismic shot point

Geophone (phones 1 & 24 shown)

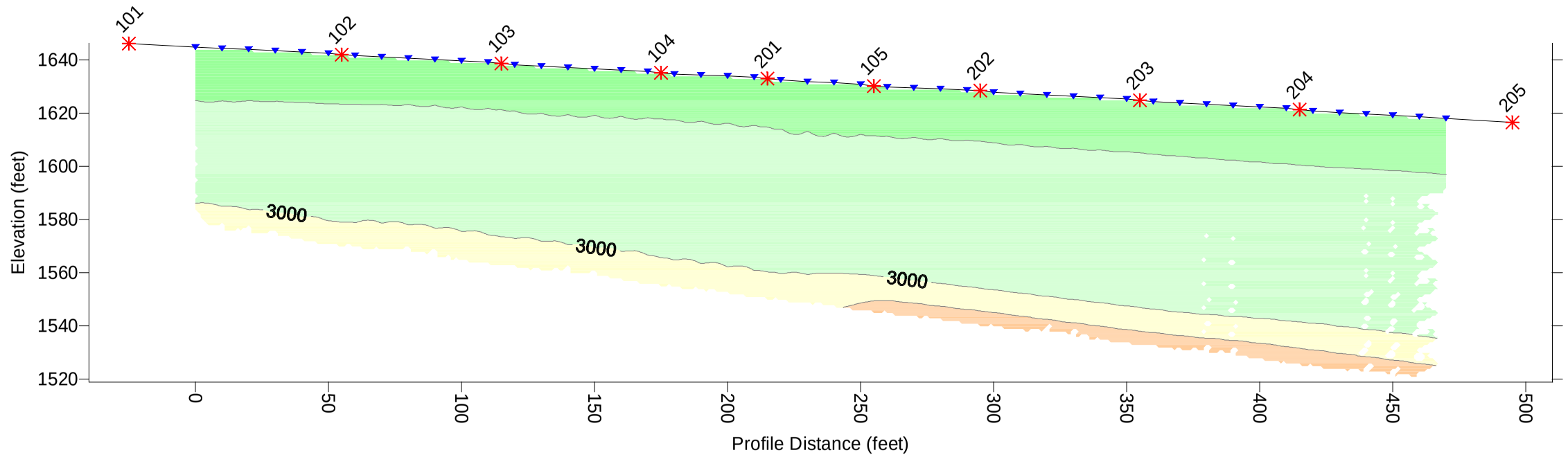
Seismic line

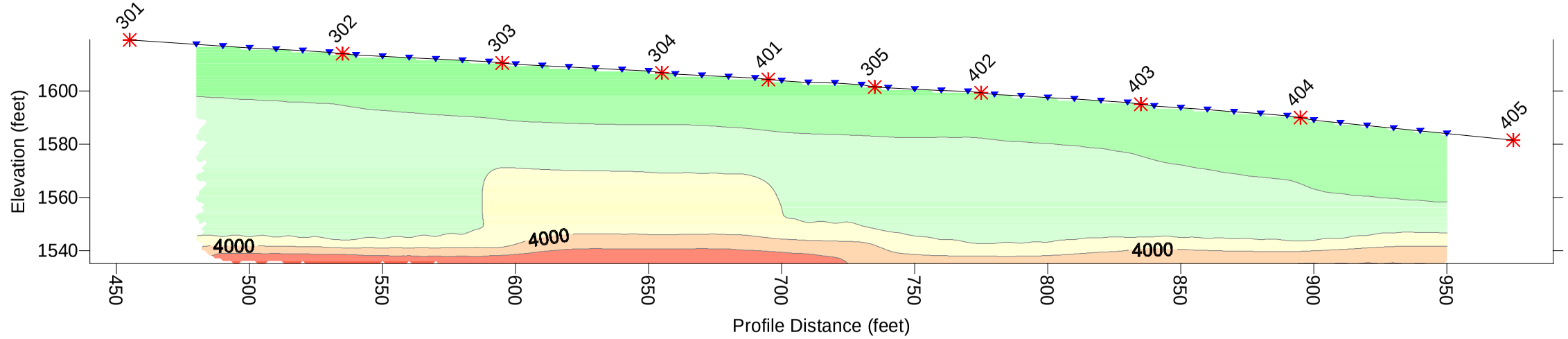
1 Inch = 100 Feet

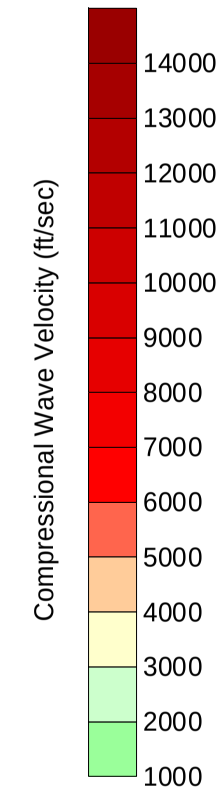
0 100

US State Plane Washington South
NAD83CORS96

FIGURE 2
Site Map
9 Canyon Phase I
Benton County, WA







LEGEND

Shot Point

Geophone

1 Inch = 50 Feet

0 25 50

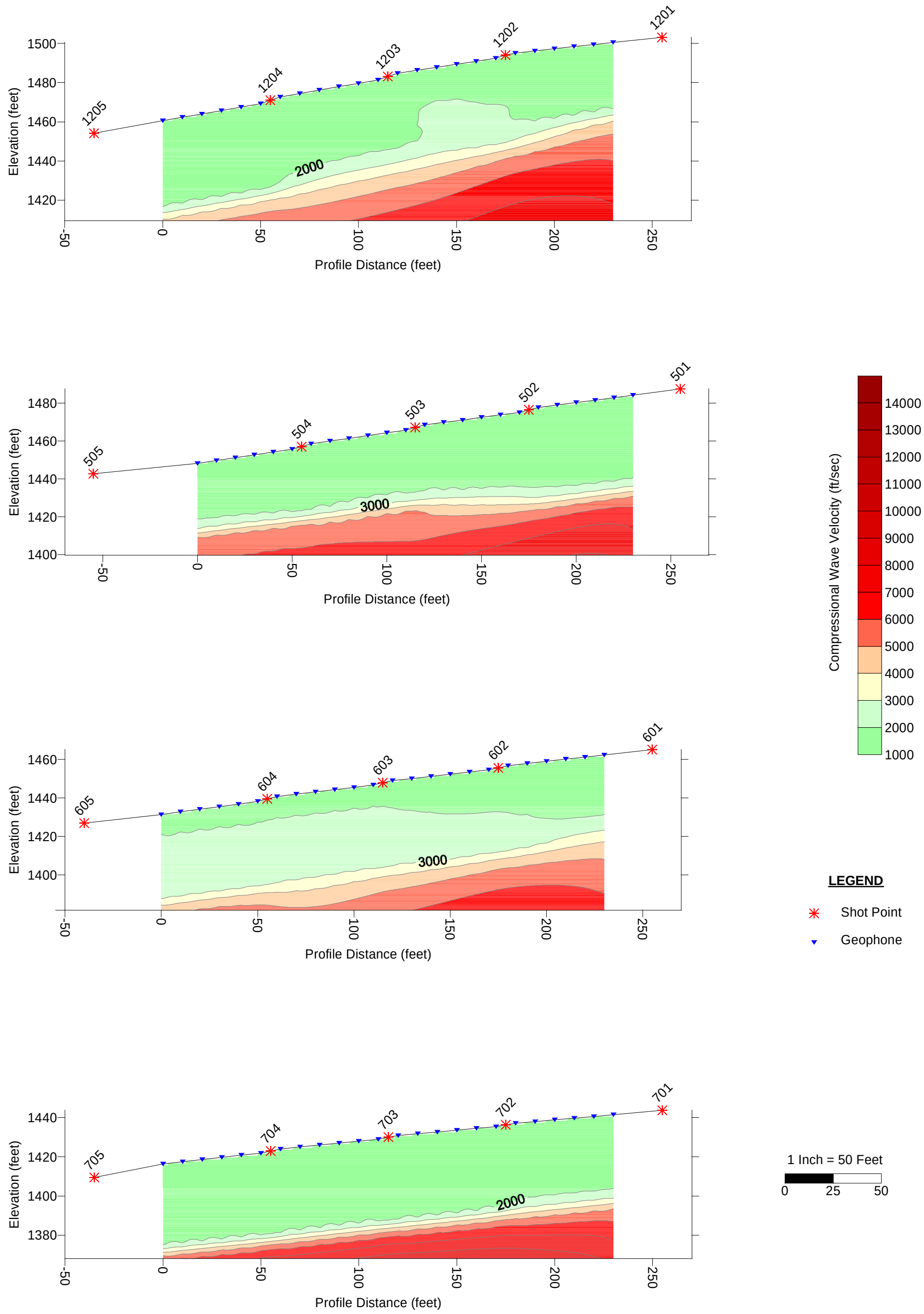
Prepared by:

GEOPHYSICAL SURVEY LLC

Prepared for:

SHANNON & WILSON, INC.

FIGURE 3
Seismic Velocity Contours
Line 1-4
9 Canyon Road Phase I
Benton County, WA



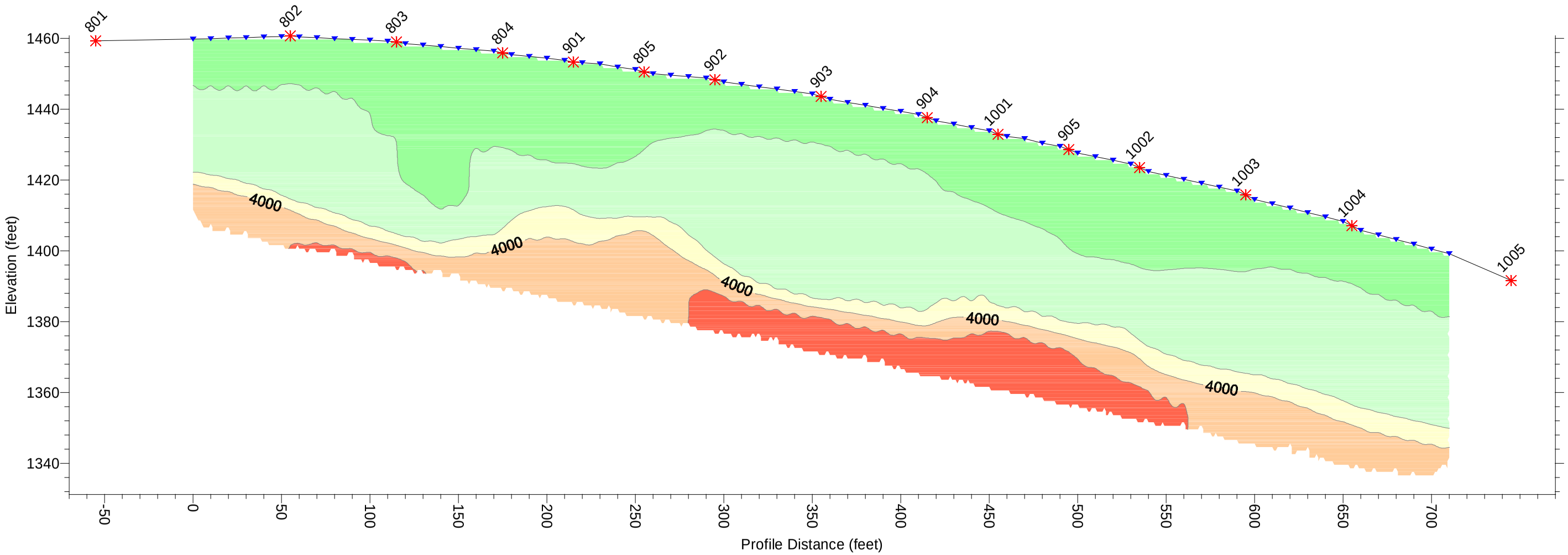
Prepared by:

GEOPHYSICAL SURVEY LLC

Prepared for:

SHANNON & WILSON, INC.

FIGURE 4
Seismic Velocity Contours
Lines 5-7 & 12
9 Canyon Road Phase I
Benton County, WA

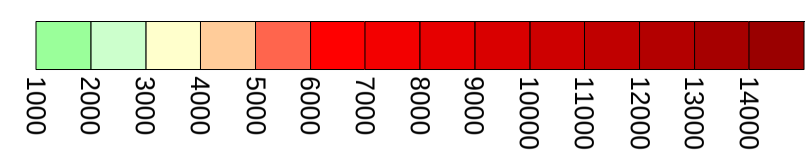


LEGEND

Shot Point

Geophone

Compressional Wave Velocity (ft/sec)



1 Inch = 60 Feet

0 30 60

Note: Vertical exaggeration 2:1

Prepared by:

GEOPHYSICAL SURVEY LLC

Prepared for:

SHANNON & WILSON, INC.

FIGURE 5
Seismic Velocity Contours
Line 8-10
9 Canyon Road Phase I
Benton County, WA

APPENDIX D

LABORATORY TESTING

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

Job No: 645-005b **Date:** 05/07/09
Client: Shannon & Wilson, Inc. **By:** RU
Project: Nine Canyon Road - 22-1-02514-004

Boring:	TP-01	TP-02	TP-04	TP-05	TP-11	TP-12		
Sample:	Bulk	Bulk	S2	S2	Bulk	Bulk		
Depth, ft:	0.5-7.0	0.5-7.0	2.8-3.3	2.8-3.3	0.5-7.0	0.5-7.0		
Visual Description:	Brown SILT	Brown SILT	Brown Sandy SILT	Brown SILT w/ Sand	Brown SILT	Brown SILT w/ Sand		
Actual G_s								
Assumed G_s			2.70	2.70				
Total Vol cc			151.6	150.9				
Vol Solids,cc			85.6	69.7				
Vol Voids,cc			66.0	81.2				
Moisture, %	6.0	5.4	12.8	9.7	7.7	5.2		
Wet Unit wt, pcf			107.5	85.5				
Dry Unit wt, pcf			95.3	77.9				
Saturation, %			44.9	22.4				
Porosity, %			43.5	53.8				
Air filled Poros.,%			24.0	41.7				
Water filled Poros.,%			19.5	12.1				
Void Ratio			0.77	1.16				
Series	1	2	3	4	5	6	7	8

Note: If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

The Zero Air-Voids curves represent the dry density at 100% saturation for each value of specific gravity

COOPER TESTING LABORATORY

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

Job No: 645-005a **Date:** 05/07/09
Client: Shannon & Wilson, Inc. **By:** RU
Project: Nine Canyon Road - 22-1-02514-004

Boring:	B-3	B-4	B-5	B-7	B-7	B-7	B-8	B-8
Sample:	S5	S3	S3	S4	S8	S11	S2	S5
Depth, ft:	20-21.5	10-11.5	10-11.5	20-21.5	40-42.0	55-56.5	10-11.5	25-26.5
Visual Description:	Brown SILT	Greenish Gray Elastic Silty GRAVEL w/ Sand	Greenish Gray Sandy Elastic SILT	Light Greenish Gray Silty SAND	Olive Gray Elastic Silty SAND	Brown Elastic Silty SAND w/ Gravel	Brown SILT	Red Clayey SAND w/ Gravel
Actual G_s								
Assumed G_s					2.70			
Total Vol cc					434.1			
Vol Solids,cc					244.0			
Vol Voids,cc					190.2			
Moisture, %	15.6	15.7	34.0	18.6	23.0	29.5	7.9	23.2
Wet Unit wt, pcf					116.6			
Dry Unit wt, pcf					94.8			
Saturation, %					79.6			
Porosity, %					43.8			
Air filled Poros.,%					8.9			
Water filled Poros.,%					34.9			
Void Ratio					0.78			
Series	1	2	3	4	5	6	7	8

Note: If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

The Zero Air-Voids curves represent the dry density at 100% saturation for each value of specific gravity

Particle Size Distribution Report

% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	3.3	41.0	33.4	22.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	98.4		
#4	96.7		
#10	82.6		
#30	71.8		
#40	68.9		
#50	66.6		
#100	62.0		
#200	55.7		
0.0433 mm.	49.8		
0.0312 mm.	45.5		
0.0201 mm.	41.1		
0.0118 mm.	36.3		
0.0084 mm.	34.1		
0.0060 mm.	31.1		
0.0043 mm.	28.9		
0.0031 mm.	25.9		
0.0022 mm.	22.9		
0.0011 mm.	21.1		

* (no specification provided)

Soil Description

Greenish Gray Sandy Elastic SILT

Atterberg Limits

PL= 37.8 LL= 65.7 PI= 27.9

Coefficients

D_{85}= 2.38 D_{60}= 0.118 D_{50}= 0.0440
D_{30}= 0.0051 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

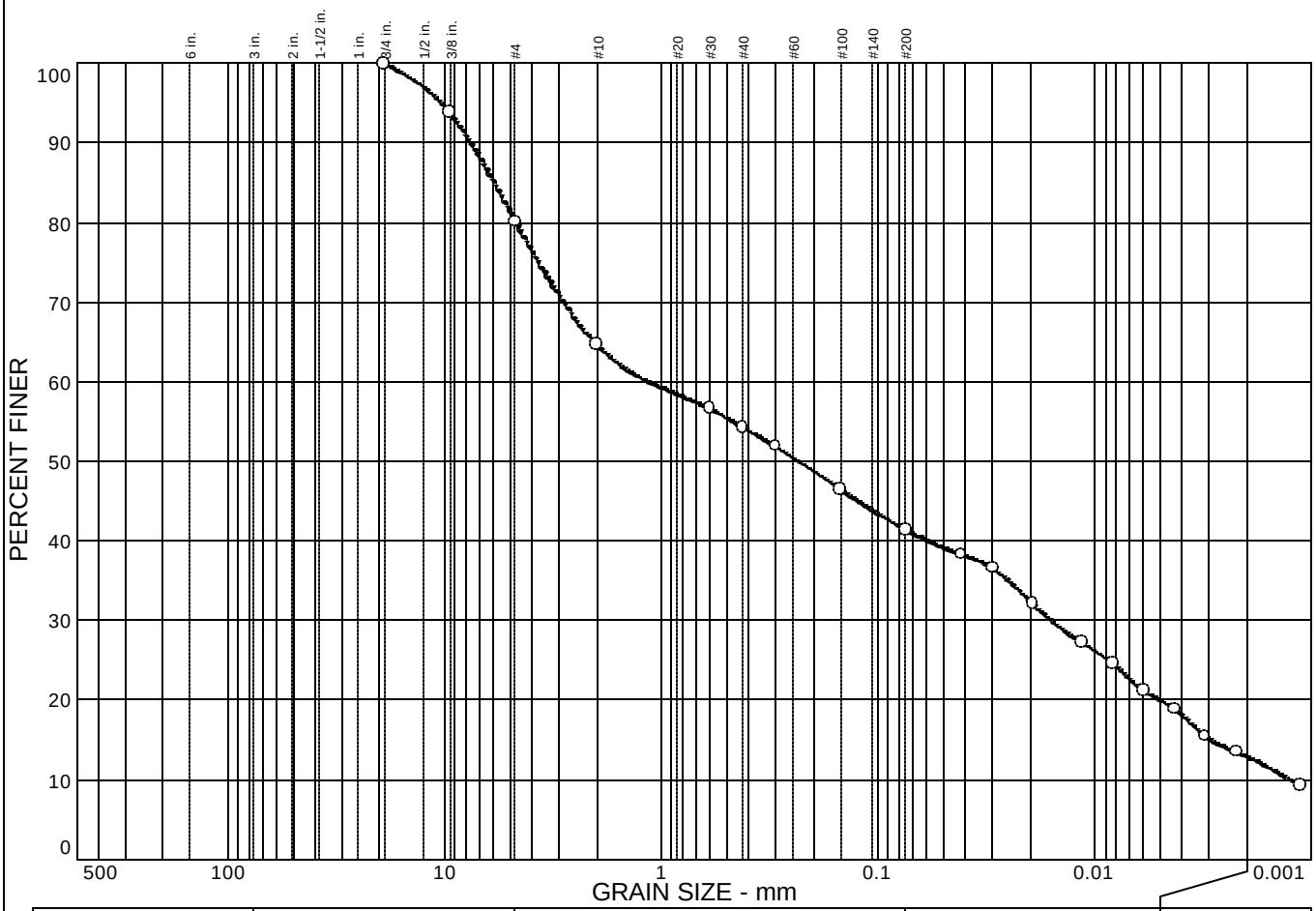
Sample No.: S-3 **Source of Sample:** B-5 **Date:**
Location: **Elev./Depth:** 10.0-11.5'

COOPER TESTING LABORATORY

Client: Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

Project No: 645-005 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	19.9	38.7	28.5	12.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	93.8		
#4	80.1		
#10	64.7		
#30	56.6		
#40	54.3		
#50	51.9		
#100	46.5		
#200	41.4		
0.0416 mm.	38.3		
0.0298 mm.	36.6		
0.0194 mm.	32.1		
0.0116 mm.	27.2		
0.0083 mm.	24.6		
0.0060 mm.	21.2		
0.0043 mm.	18.9		
0.0031 mm.	15.5		
0.0022 mm.	13.5		
0.0011 mm.	9.2		

* (no specification provided)

Soil Description

Red Clayey SAND w/ Gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 5.96 D_{60}= 1.15 D_{50}= 0.233
D_{30}= 0.0159 D_{15}= 0.0029 D_{10}= 0.0013
C_u= 912.72 C_c= 0.17

Classification

USCS= AASHTO=

Remarks

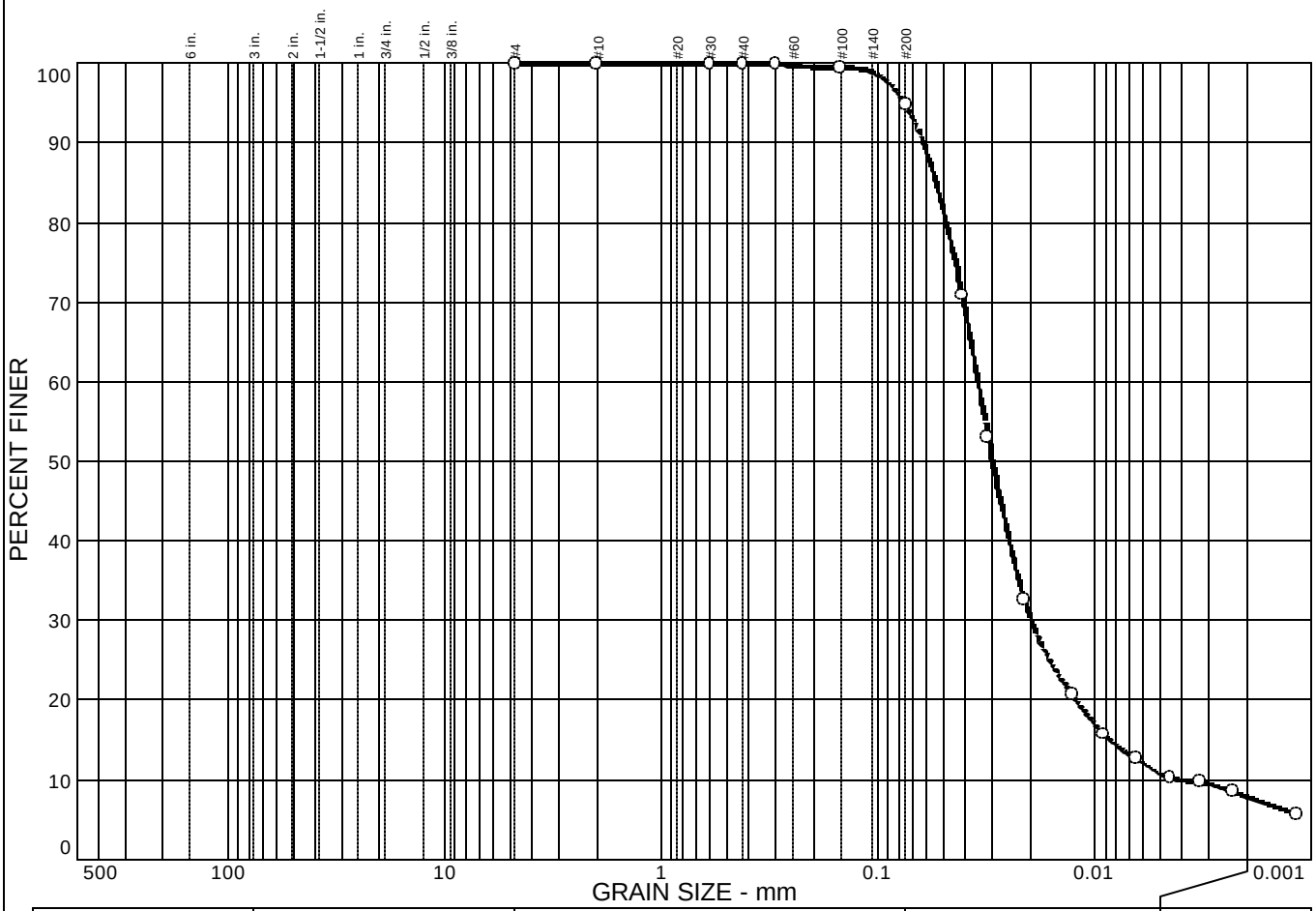
Sample No.: S-5 **Source of Sample:** B-8 **Date:**
Location: **Elev./Depth:** 25.0-26.5'

COOPER TESTING LABORATORY

Client: Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

Project No: 645-005 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	5.2	87.0	7.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#30	100.0		
#40	99.9		
#50	99.9		
#100	99.4		
#200	94.8		
0.0413 mm.	70.9		
0.0314 mm.	53.0		
0.0213 mm.	32.6		
0.0128 mm.	20.7		
0.0091 mm.	15.7		
0.0065 mm.	12.7		
0.0045 mm.	10.2		
0.0033 mm.	9.7		
0.0023 mm.	8.5		
0.0012 mm.	5.7		

* (no specification provided)

Soil Description

Brown SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0546 D_{60}= 0.0349 D_{50}= 0.0299
D_{30}= 0.0198 D_{15}= 0.0086 D_{10}= 0.0042
C_u= 8.29 C_c= 2.66

Classification

USCS= AASHTO=

Remarks

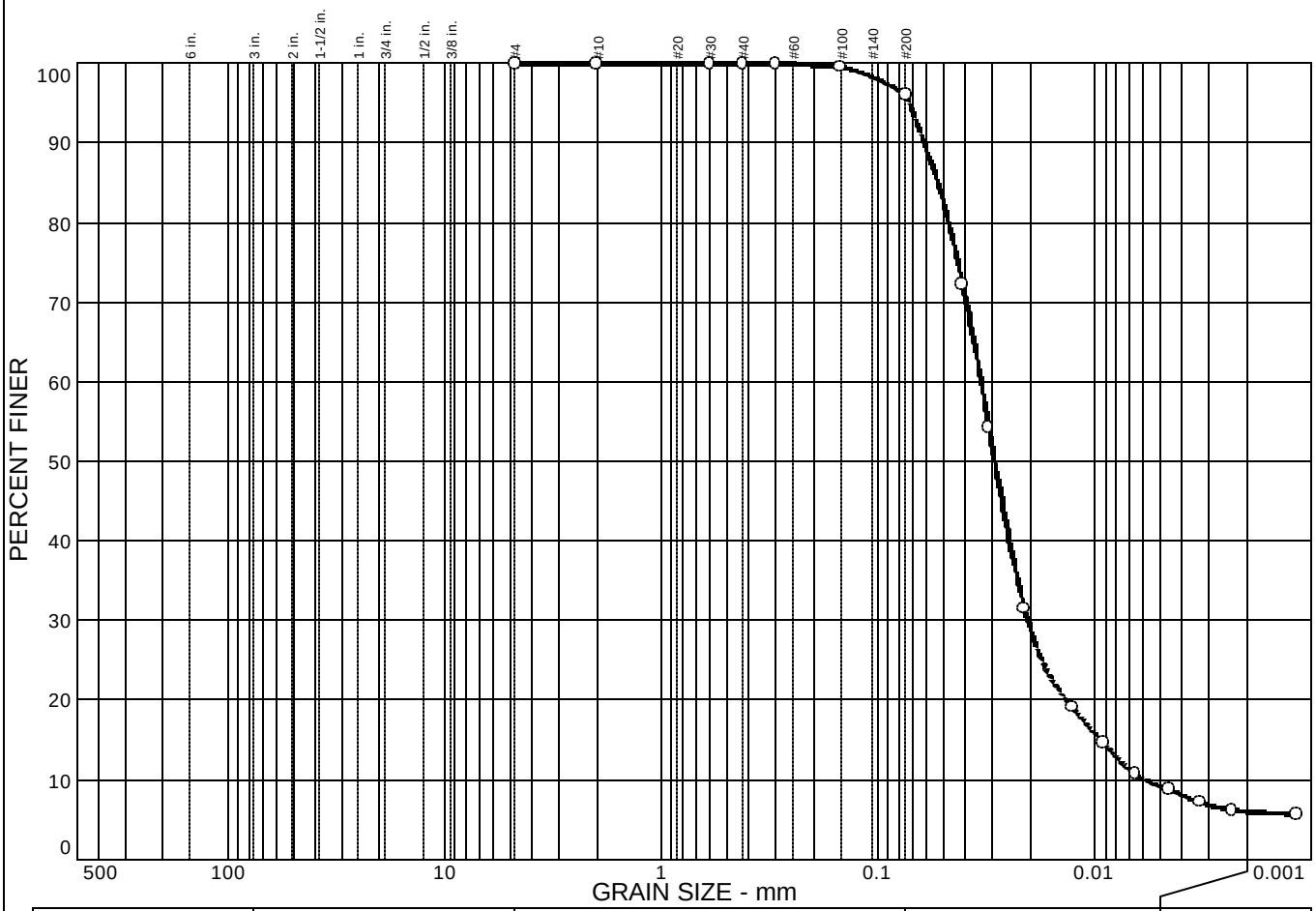
Sample No.: Bulk **Source of Sample:** TP-01 **Date:**
Location: **Elev./Depth:** 0.5-7.0'

COOPER TESTING LABORATORY

Client: Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

Project No: 645-005 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	3.9	90.1	6.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#30	99.9		
#40	99.9		
#50	99.9		
#100	99.6		
#200	96.1		
0.0411 mm.	72.2		
0.0312 mm.	54.3		
0.0214 mm.	31.5		
0.0128 mm.	19.1		
0.0092 mm.	14.6		
0.0066 mm.	10.7		
0.0045 mm.	8.7		
0.0033 mm.	7.2		
0.0023 mm.	6.2		
0.0012 mm.	5.7		

* (no specification provided)

Soil Description

Brown SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0537 D_{60}= 0.0339 D_{50}= 0.0293
D_{30}= 0.0206 D_{15}= 0.0095 D_{10}= 0.0060
C_u= 5.69 C_c= 2.10

Classification

USCS= AASHTO=

Remarks

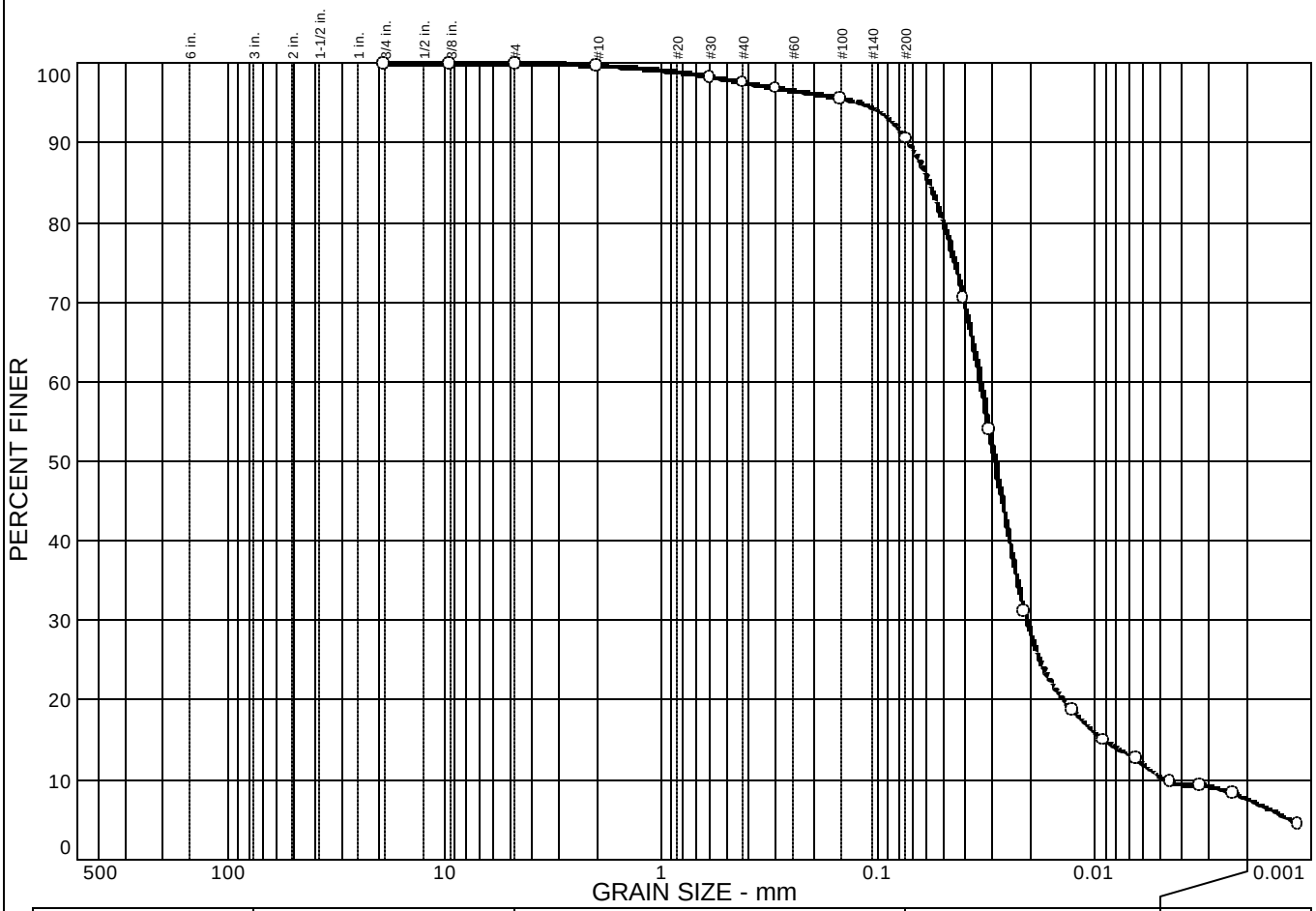
Sample No.: Bulk **Source of Sample:** TP-02 **Date:**
Location: **Elev./Depth:** 0.5-7.0'

COOPER TESTING LABORATORY

Client: Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

Project No: 645-005 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	9.4	83.0	7.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	100.0		
#4	100.0		
#10	99.7		
#30	98.3		
#40	97.6		
#50	96.9		
#100	95.6		
#200	90.6		
0.0408 mm.	70.6		
0.0310 mm.	54.0		
0.0213 mm.	31.1		
0.0128 mm.	18.8		
0.0091 mm.	15.0		
0.0065 mm.	12.6		
0.0045 mm.	9.7		
0.0033 mm.	9.3		
0.0023 mm.	8.3		
0.0012 mm.	4.5		

* (no specification provided)

Soil Description

Brown SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0585 D_{60}= 0.0340 D_{50}= 0.0292
D_{30}= 0.0208 D_{15}= 0.0091 D_{10}= 0.0048
C_u= 7.10 C_c= 2.65

Classification

USCS= AASHTO=

Remarks

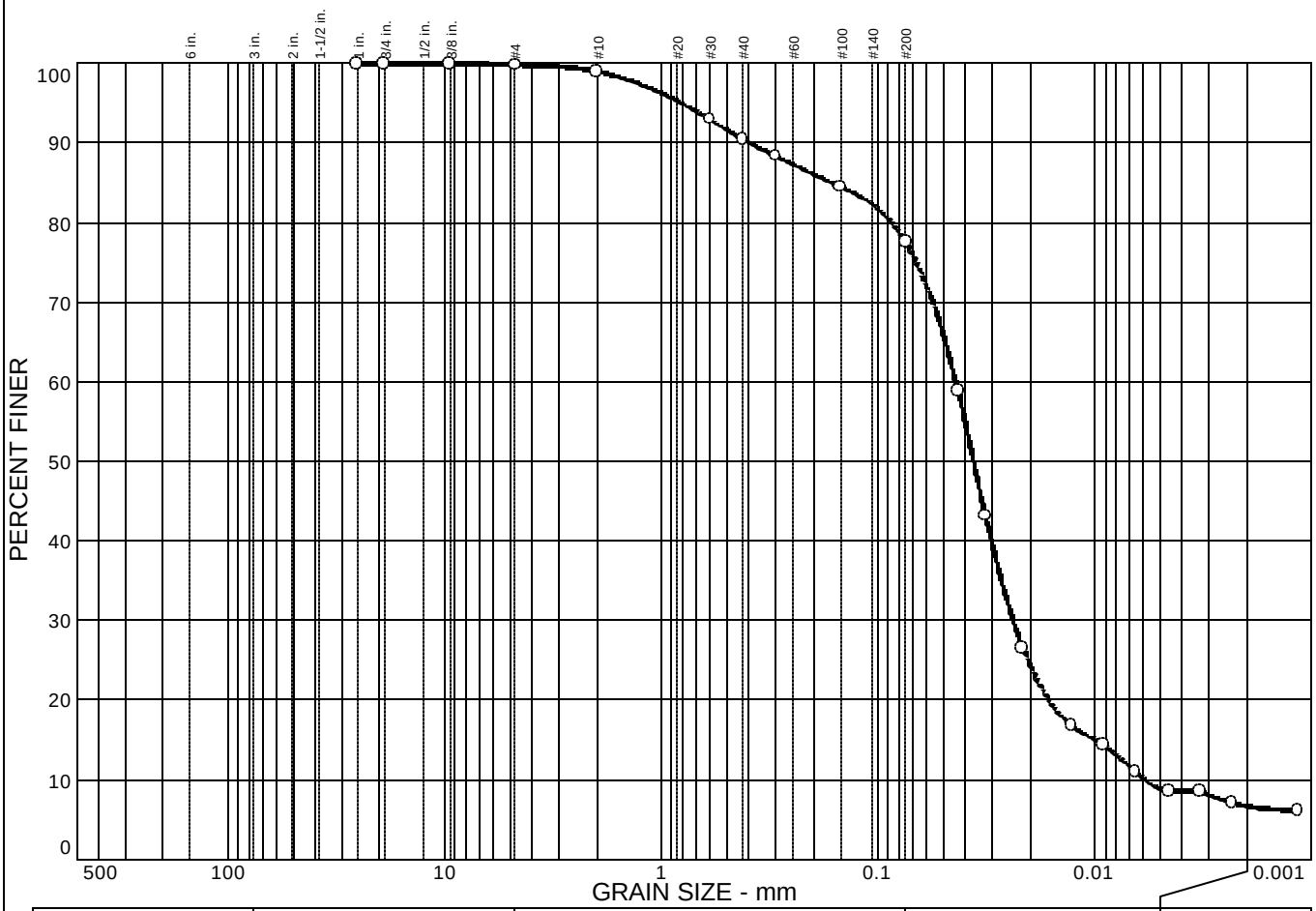
Sample No.: Bulk **Source of Sample:** TP-11 **Date:**
Location: **Elev./Depth:** 0.5-7.0'

COOPER TESTING LABORATORY

Client: Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

Project No: 645-005 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.2	22.3	70.8	6.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	99.9		
3/8 in.	99.9		
#4	99.8		
#10	99.0		
#30	93.0		
#40	90.5		
#50	88.4		
#100	84.5		
#200	77.5		
0.0432 mm.	58.8		
0.0324 mm.	43.2		
0.0217 mm.	26.6		
0.0129 mm.	16.8		
0.0092 mm.	14.4		
0.0066 mm.	11.0		
0.0046 mm.	8.5		
0.0033 mm.	8.5		
0.0023 mm.	7.1		
0.0012 mm.	6.1		

* (no specification provided)

Soil Description

Brown SILT w/ Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.164 D_{60}= 0.0443 D_{50}= 0.0367
D_{30}= 0.0240 D_{15}= 0.0100 D_{10}= 0.0059
C_u= 7.50 C_c= 2.20

Classification

USCS= AASHTO=

Remarks

Sample No.: **Source of Sample:** TP-12 **Date:**
Location: **Elev./Depth:** 0.5-7.0'

COOPER TESTING LABORATORY

Client: Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

Project No: 645-005 **Figure**

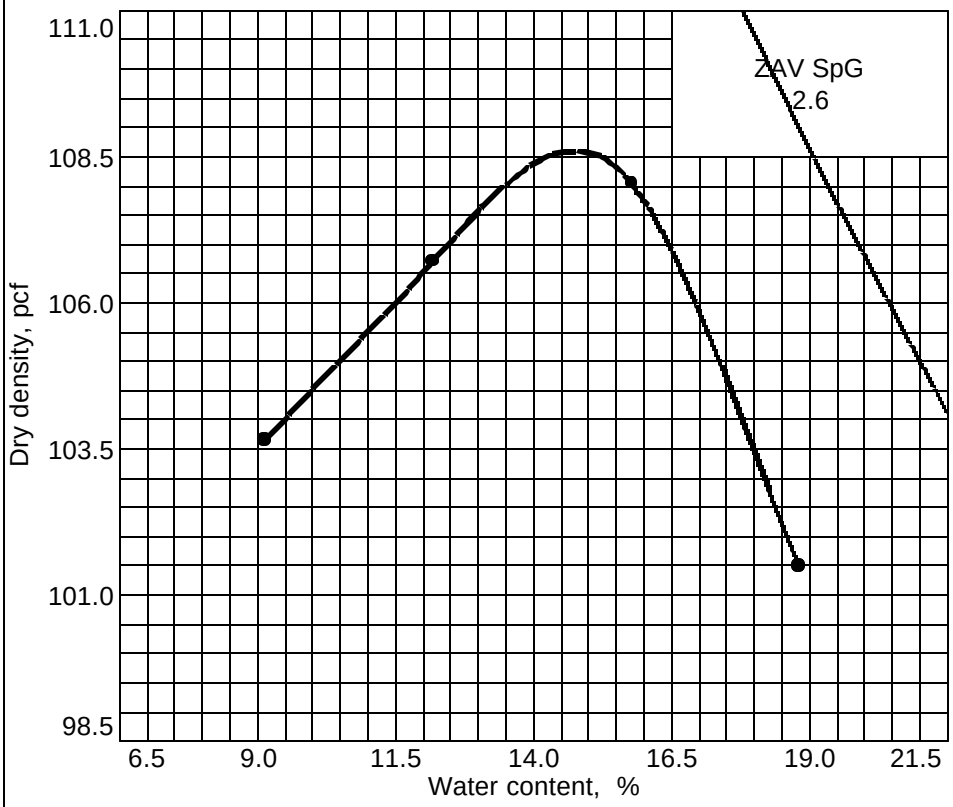
#200 Sieve Wash Analysis
ASTM D 1140

Job No.:	645-005	**Project No.:**	22-1-02514-004	**Run By:**	MD
Client:	Shannon & Wilson, Inc.	**Date:**	5/11/2009	**Checked By:**	DC
Project:	Nine Canyon Road				

Boring:	B-3	B-4	B-7	B-7	B-7	B-8	TP-04	TP-07
Sample:	S5	S3	S4	S8	S11	S2	Bulk	Bulk
Depth, ft.:	20-21.5	10-11.5	20-21.5	40-42	55-56.5	10-11.5	0.5-7.0	0.5-7.0
Soil Type:	Brown SILT	Greenish Gray Elastic Silty GRAVEL w/ Sand	Light Greenish Gray Silty SAND	Olive Gray Elastic Silty SAND	Brown Elastic Silty SAND w/ Gravel	Brown SILT	Brown SILT	Brown SILT
Wt of Dish & Dry Soil, gm	366.5	517.6	411.5	348.8	513.7	485.9	191.6	630.5
Weight of Dish, gm	180.5	318.2	311.5	83.7	317.2	312.9	62.3	278.3
Weight of Dry Soil, gm	186.0	199.4	100.0	265.1	196.5	173.0	129.3	352.2
Wt. Ret. on #4 Sieve, gm	0.0	106.9	3.2	27.9	36.9	0.0	0.0	18.0
Wt. Ret. on #200 Sieve, gm	19.0	160.6	75.8	172.1	130.2	7.4	13.8	20.6
% Gravel	**0.0**	**53.6**	**3.2**	**10.5**	**18.8**	**0.0**	**0.0**	**5.1**
% Sand	**10.2**	**26.9**	**72.6**	**54.4**	**47.5**	**4.3**	**10.7**	**0.7**
% Silt & Clay	**89.8**	**19.5**	**24.2**	**35.1**	**33.7**	**95.7**	**89.3**	**94.2**

Remarks: As an added benefit to our clients, the gravel fraction may be included in this report. Whether or not it is included is dependent upon both the technician's time available and if there is a significant enough amount of gravel. The gravel is always included in the percent retained on the #200 sieve but may not be weighed separately to determine the percentage, especially if there is only a trace amount, (5% or less).

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-00 Method A Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		**Sp.G.**	2.7
LL		**PI**	
%>No.4		**%<#200**	
USCS		**AASHTO**	

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.41	8.59	8.44	8.19		
WM	4.42	4.42	4.42	4.42		
WW + T #1	552.80	535.10	580.20	525.50		
WD + T #1	503.60	475.80	503.80	489.60		
TARE #1	99.60	100.10	97.80	96.30		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	12.2	15.8	18.8	9.1		
DRY DENSITY	106.7	108.1	101.5	103.7		

TEST RESULTS	**Material Description**
Maximum dry density = 108.6 pcf Optimum moisture = 14.7 %	Brown SILT

Project No. 645-005 **Client:** Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

● **Source:** TP-01&TP-02 **Sample No.:** Composite **Elev./Depth:** 0.5-7.0'

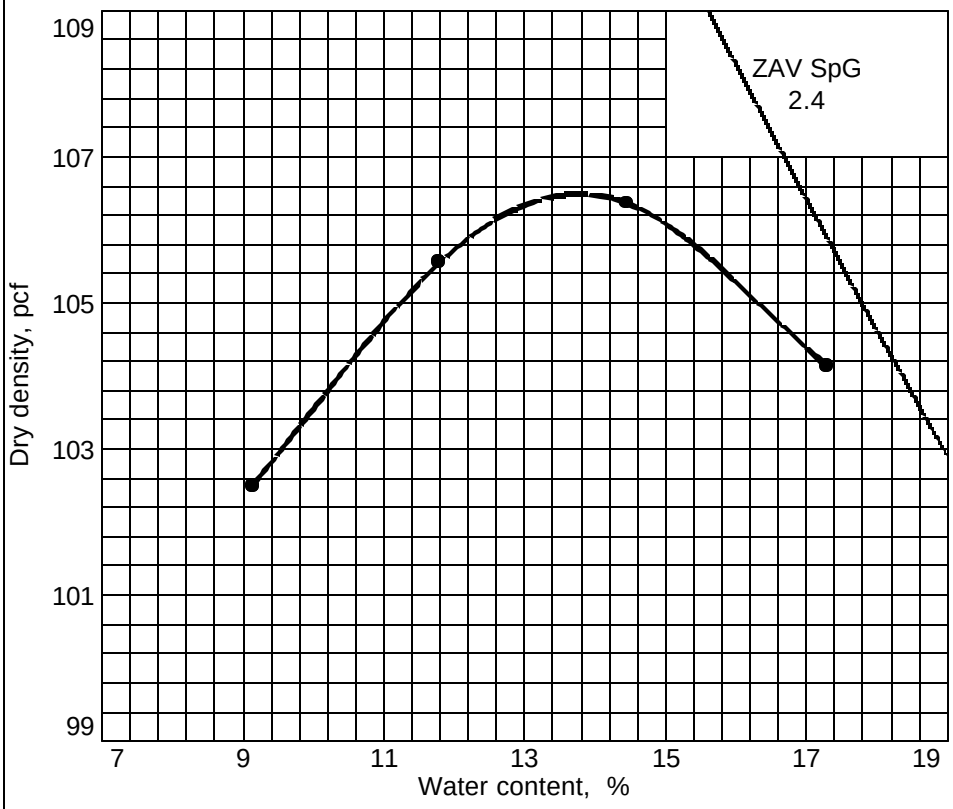
Remarks:

COMPACTION TEST REPORT

COOPER TESTING LABORATORY

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-00 Method C Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 56
Mold Size: .075 cu.ft.
Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM _____ **Sp.G.** 2.7
LL _____ **PI** _____
%>3/4 in. _____ **%<#200** _____
USCS _____ **AASHTO** _____

TESTING DATA

	1	2	3	4	5	6
WM + WS	14.30	14.76	15.04	15.07		
WM	5.91	5.91	5.91	5.91		
WW + T #1	985.10	1087.10	1134.30	1250.00		
WD + T #1	919.40	993.60	1016.80	1094.90		
TARE #1	200.40	200.10	203.40	197.40		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	9.1	11.8	14.4	17.3		
DRY DENSITY	102.5	105.6	106.4	104.1		

TEST RESULTS	**Material Description**
Maximum dry density = 106.5 pcf Optimum moisture = 13.8 %	Brown SILT

Project No. 645-005 **Client:** Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

● **Source:** TP-04&TP-07 **Sample No.:** Composite **Elev./Depth:** 0.5-7.0'

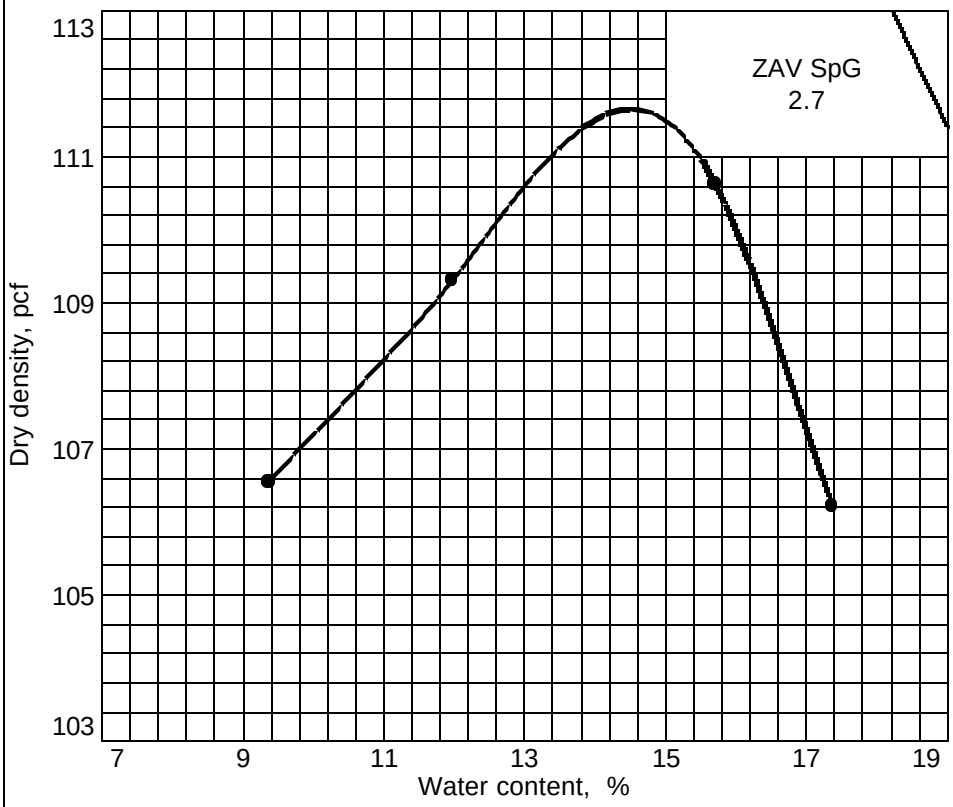
Remarks:

COMPACTION TEST REPORT

COOPER TESTING LABORATORY

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-00 Method C Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 56
Mold Size: .075 cu.ft.
Test Performed on Material Passing 3/4 in. **Sieve**

Soil Data

NM		**Sp.G.**	2.7
LL		**PI**	
%>3/4 in.		**%<#200**	
USCS		**AASHTO**	

TESTING DATA

	1	2	3	4	5	6
WM + WS	14.65	15.09	15.51	15.26		
WM	5.91	5.91	5.91	5.91		
WW + T #1	981.80	1101.30	1125.50	1449.20		
WD + T #1	914.60	1005.00	1000.20	1264.50		
TARE #1	197.20	200.30	202.50	200.70		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	9.4	12.0	15.7	17.4		
DRY DENSITY	106.6	109.3	110.6	106.2		

TEST RESULTS	**Material Description**
Maximum dry density = 111.7 pcf Optimum moisture = 14.5 %	Brown SILT

Project No. 645-005 **Client:** Shannon & Wilson, Inc.
Project: Nine Canyon Road - 22-1-02514-004

● **Source:** TP-11,12

Remarks:

COMPACTION TEST REPORT

COOPER TESTING LABORATORY

Figure

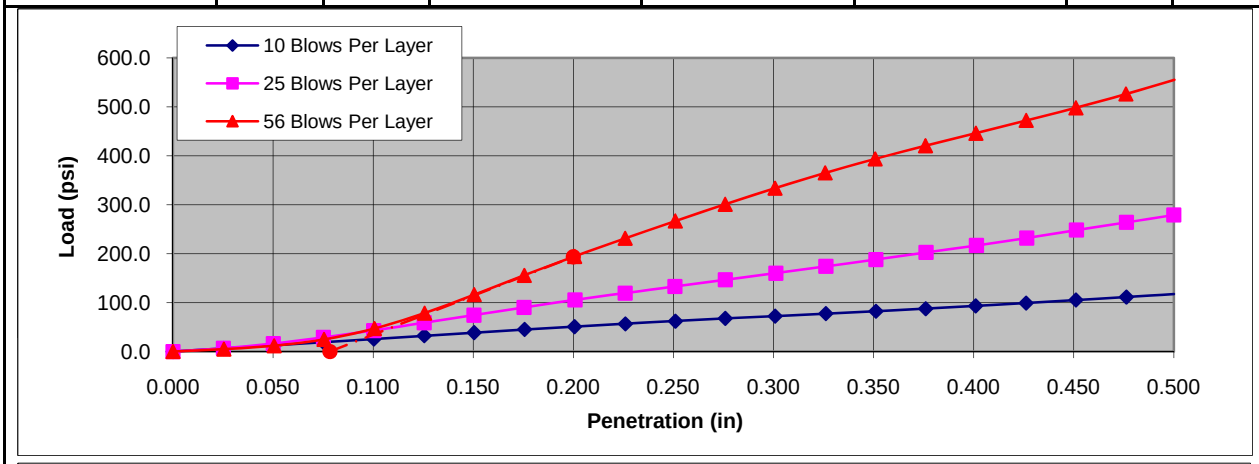
California Bearing Ratio ASTM D 1883

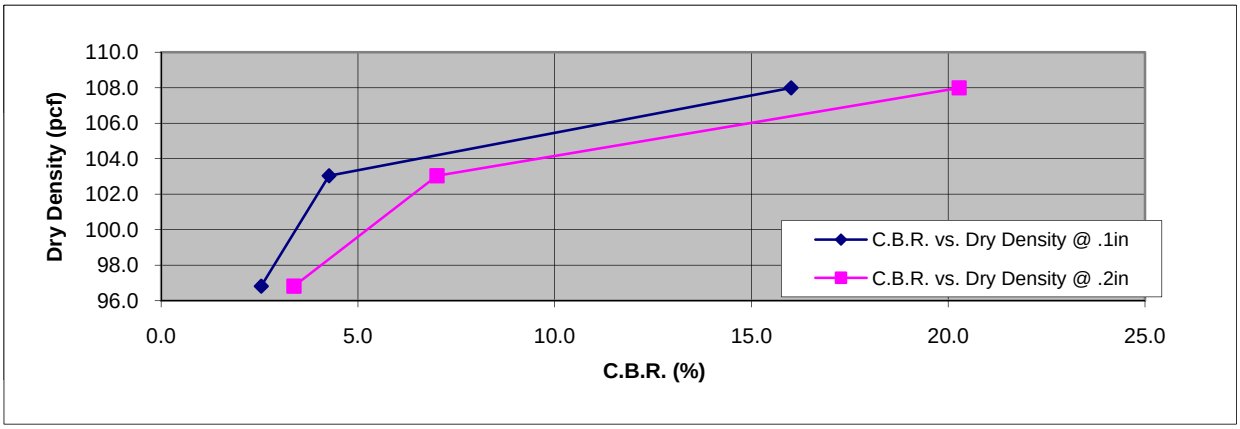
CTL Job No.:	645-005	**Boring:**	TP-01 & TP-02	**Date:**	5/11/2009
Client:	Shannon & Wilson	**Sample:**	Composite	**Tested :**	PJ
Project Name:	Nine Canyon Road	**Depth (ft.):**	0.5-7.0	**Checked:**	DC
Project No:	22-1-02514-004				
Visual Description:	Brown SILT				

Maximum Dry Density (pcf):	108.6	Optimum Moisture Content (%):	14.7	Required In Field Density (% of max):	95
Maximum Density & Optimum Moisture Obtained By:	ASTM D1557	Sample Condition:	Soaked	Surcharge Weight (kg):	4.54
Percent Retained on 3/4in. Sieve:		Remarks:	The CBR at 0.2 inches was greater than the CBR at 0.1 inches. The confirmatory test was not run.		

Sample Information

Number of Blows per Layer	Dry Density (pcf)		Moisture Content (%)		Expansion (%)	C.B.R. (%)	
	Before Soaking	After Soaking	Before Soaking	After Soaking		@ 0.1in.	@ 0.2in.
10	96.8	94.7	16.2	24.9	2.2	2.5	3.4
25	103.0	100.7	16.2	21.4	2.3	4.3	7.0
56	108.0	105.7	15.6	18.8	2.2	16.0	20.3





C.B.R. at Required In Field Density (%)	
@ 0.1in	4.6
@ 0.2in	7.4

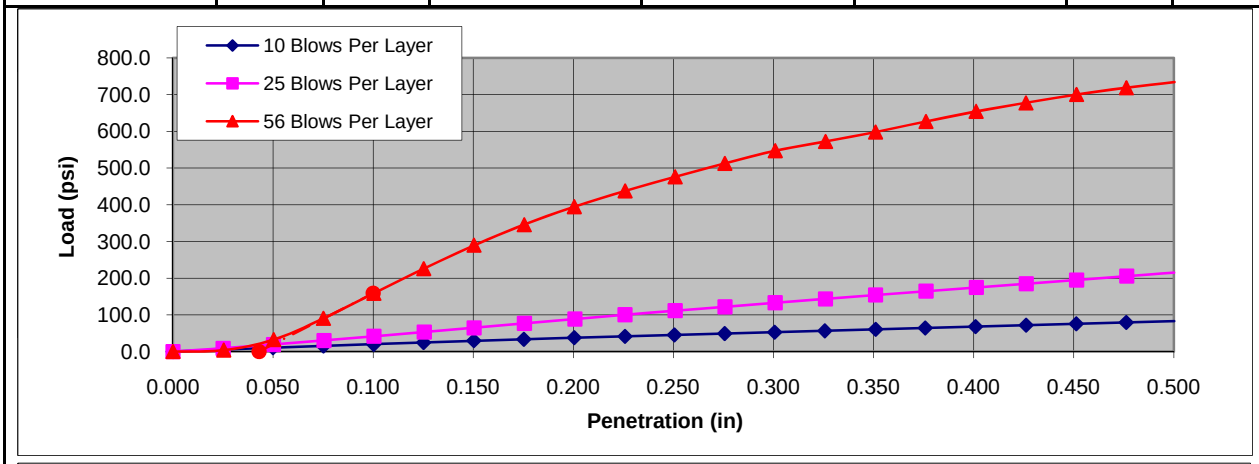
California Bearing Ratio ASTM D 1883

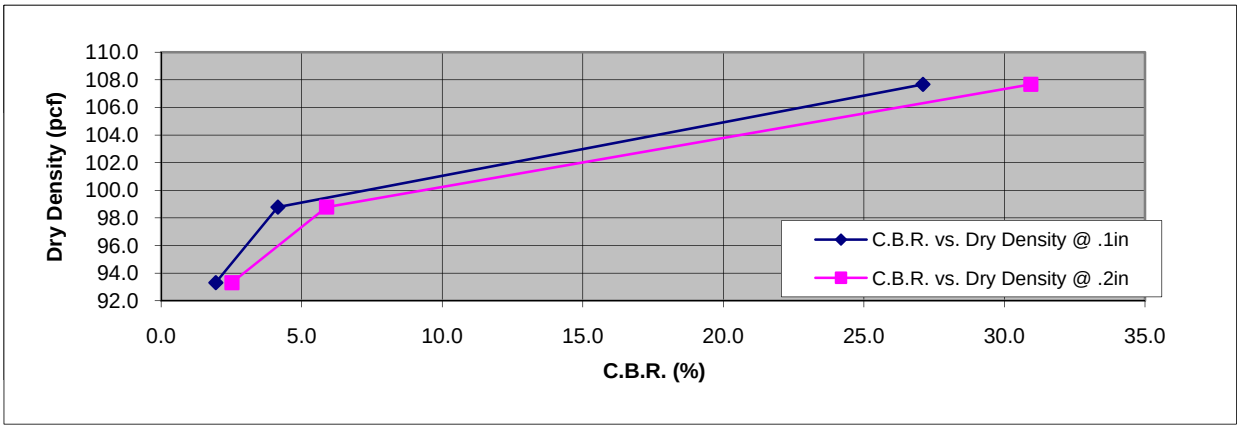
CTL Job No.:	645-005B	**Boring:**	TP-04 & TP-07	**Date:**	5/11/2009
Client:	Shannon & Wilson	**Sample:**	Composite	**Tested :**	PJ
Project Name:	Nine Canyon Road	**Depth (ft.):**	0.5-7.0	**Checked:**	DC
Project No:	22-1-02514-004				
Visual Description:	Brown SILT				

Maximum Dry Density (pcf):	106.5	Optimum Moisture Content (%):	13.8	Required In Field Density (% of max):	95
Maximum Density & Optimum Moisture Obtained By:	ASTM D1557	Sample Condition:	Soaked	Surcharge Weight (kg):	4.54
Percent Retained on 3/4in. Sieve:		Remarks:	The CBR at 0.2 inches was greater than the CBR at 0.1 inches. The confirmatory test was not run.		

Sample Information

Number of Blows per Layer	Dry Density (pcf)		Moisture Content (%)		Expansion (%)	C.B.R. (%)	
	Before Soaking	After Soaking	Before Soaking	After Soaking		@ 0.1in.	@ 0.2in.
10	93.3	92.0	13.5	26.4	1.4	1.9	2.5
25	98.8	97.0	13.8	23.7	1.8	4.2	5.9
56	107.7	106.2	13.5	19.2	1.4	27.1	30.9





C.B.R. at Required In Field Density (%)	
@ 0.1in	10.1
@ 0.2in	12.4

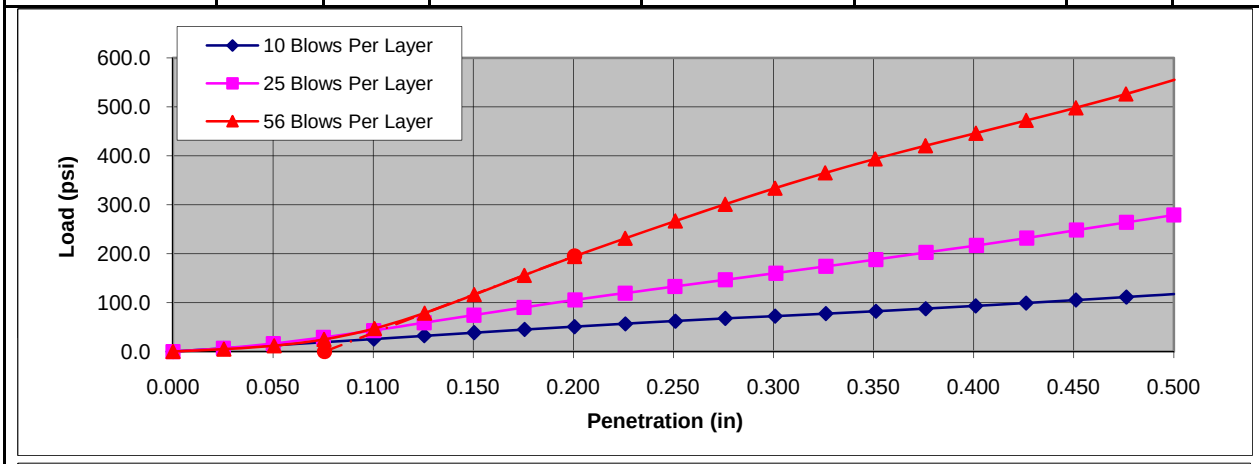
California Bearing Ratio ASTM D 1883

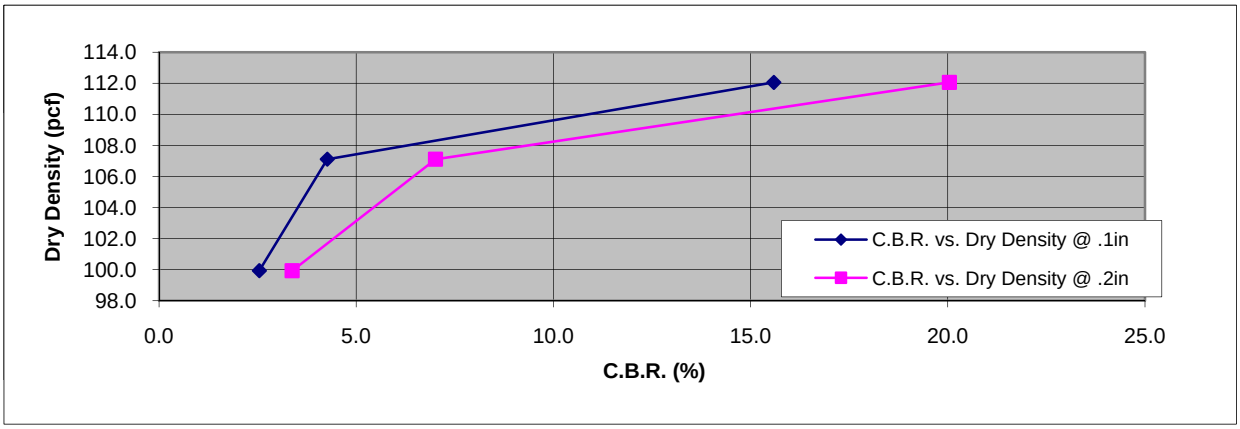
CTL Job No.:	645-005	**Boring:**	TP-11 & TP-12	**Date:**	5/11/2009
Client:	Shannon & Wilson	**Sample:**	Composite	**Tested :**	PJ
Project Name:	Nine Canyon Road	**Depth (ft.):**	0.5-7.0	**Checked:**	DC
Project No:	22-1-02514-004				
Visual Description:	Brown SILT				

Maximum Dry Density (pcf):	111.7	Optimum Moisture Content (%):	14.5	Required In Field Density (% of max):	95
Maximum Density & Optimum Moisture Obtained By:	ASTM D1557	Sample Condition:	Soaked	Surcharge Weight (kg):	4.54
Percent Retained on 3/4in. Sieve:		Remarks:	The CBR at 0.2 inches was greater than the CBR at 0.1 inches. The confirmatory test was not run.		

Sample Information

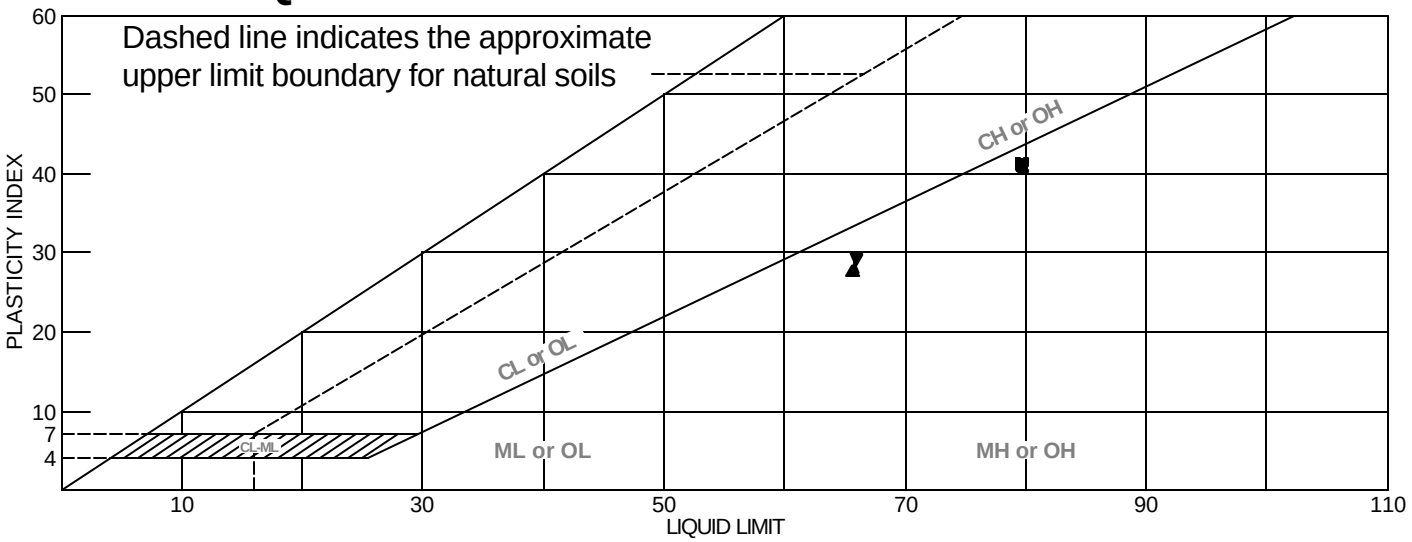
Number of Blows per Layer	Dry Density (pcf)		Moisture Content (%)		Expansion (%)	C.B.R. (%)	
	Before Soaking	After Soaking	Before Soaking	After Soaking		@ 0.1in.	@ 0.2in.
10	99.9	92.4	14.7	23.1	8.1	2.5	3.4
25	107.1	97.9	14.4	20.0	9.4	4.3	7.0
56	112.1	103.2	14.4	17.3	8.6	15.6	20.0

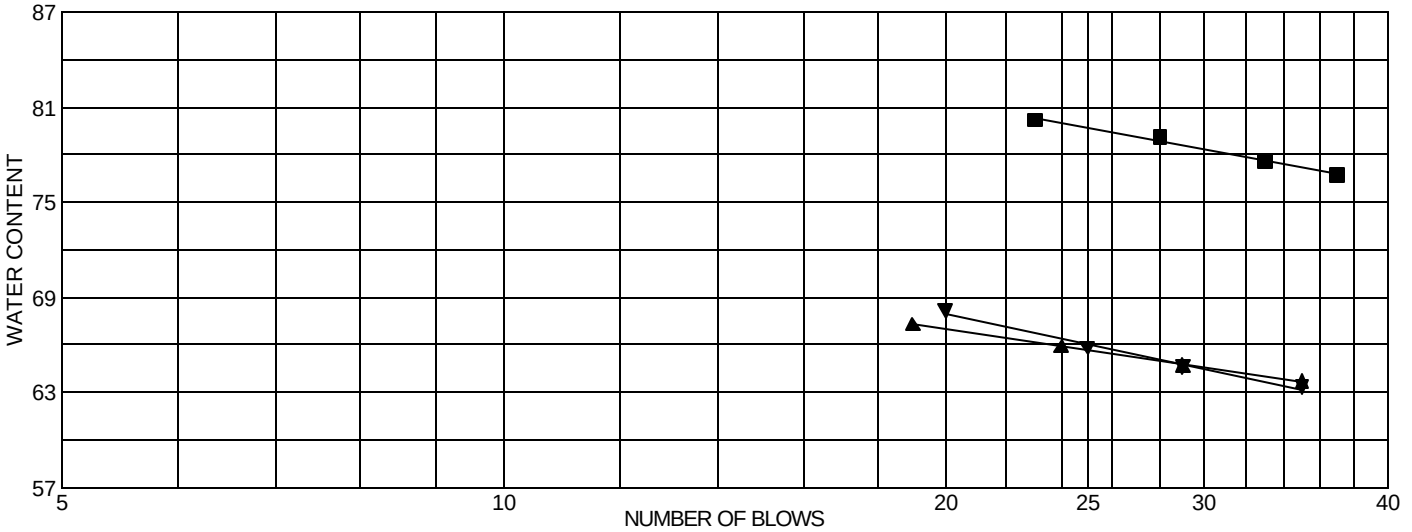




C.B.R. at Required In Field Density (%)	
@ 0.1in	4.5
@ 0.2in	7.5

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown SILT		NP	NP			
■	Greenish Gray Elastic Silty GRAVEL w/ Sand	79.7	38.5	41.2			
▲	Greenish Gray Sandy Elastic SILT	65.7	37.8	27.9	68.9	55.7	MH
◆	Light Greenish Gray Silty SAND		NP	NP			
▼	Olive Gray Elastic Silty SAND	66.0	36.8	29.2			

Project No. 645-005 **Client:** Shannon & Wilson, Inc.

Project: Nine Canyon Road - 22-1-02514-004

●	**Source:** B-3	**Sample No.:** S-5	**Elev./Depth:** 20.0-21.5'
■	**Source:** B-4	**Sample No.:** S-3	**Elev./Depth:** 10.0-11.5'
▲	**Source:** B-5	**Sample No.:** S-3	**Elev./Depth:** 10.0-11.5'
◆	**Source:** B-7	**Sample No.:** S-4	**Elev./Depth:** 20.0-21.5'
▼	**Source:** B-7	**Sample No.:** S-8	**Elev./Depth:** 40.0-42.0'

Remarks:

● Could not roll out. Sample slides in bowl. Non-plastic.

■

▲

◆ Could not roll out. Sample slides in bowl. Non-plastic.

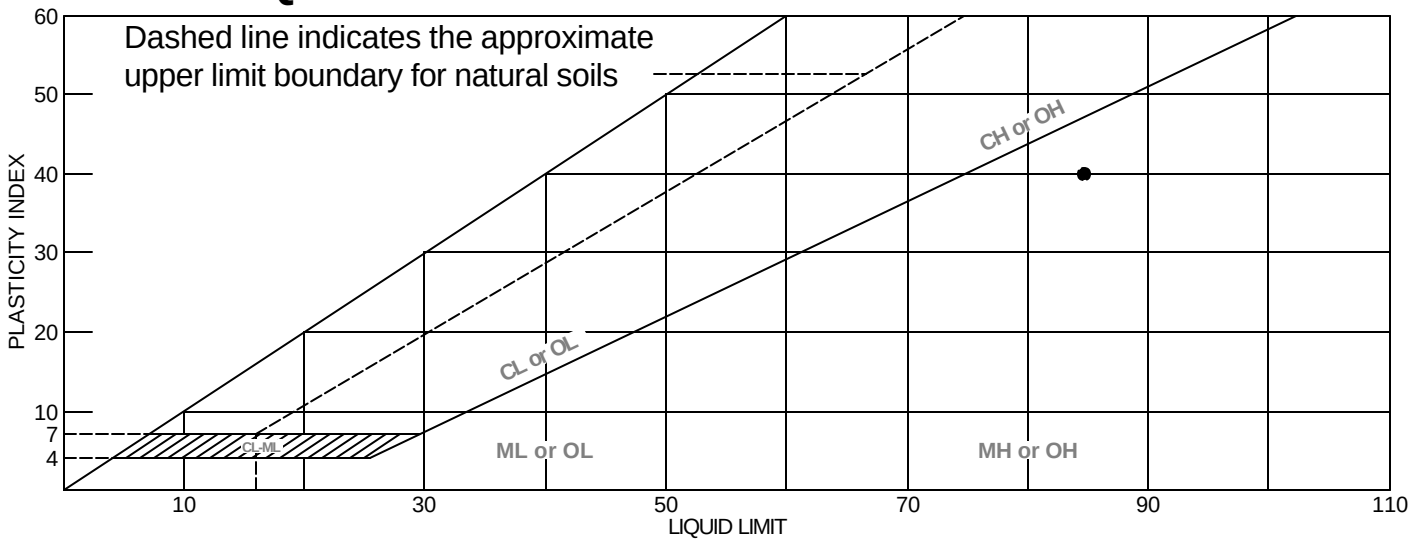
▼

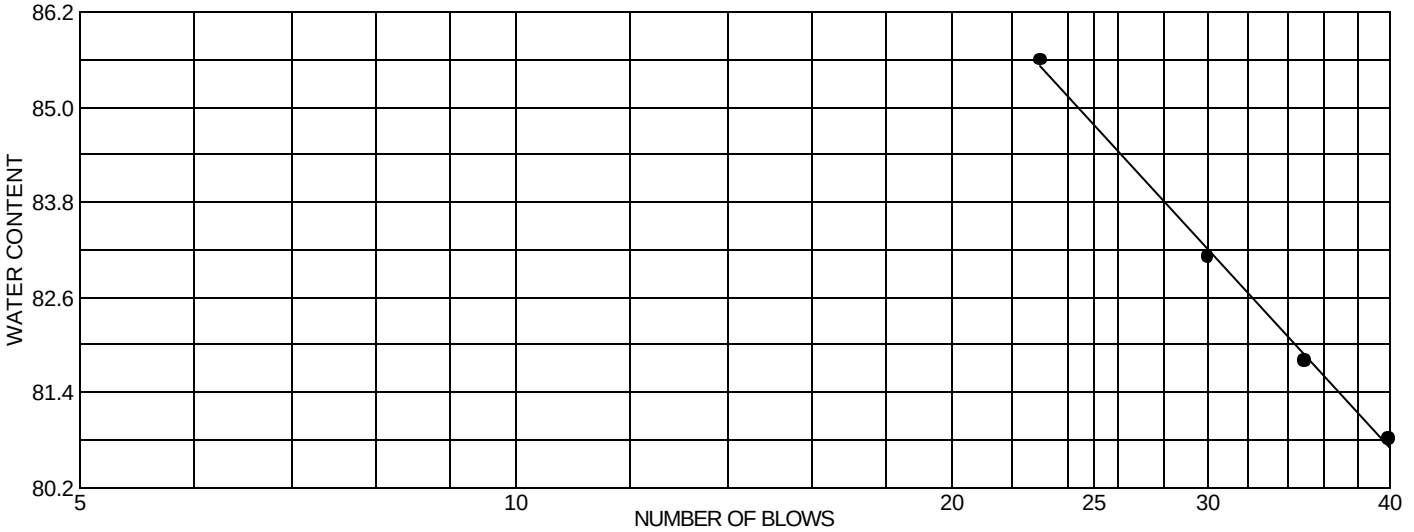
LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown Elastic Silty SAND w/ Gravel	84.8	44.9	39.9			
■	Brown SILT		NP	NP			
▲	Brown SILT		NP	NP			
◆	Brown SILT		NP	NP			

Project No. 645-005 **Client:** Shannon & Wilson, Inc.

Project: Nine Canyon Road - 22-1-02514-004

● **Source:** B-7 **Sample No.:** S-11 **Elev./Depth:** 55.0-56.5'
■ **Source:** B-8 **Sample No.:** S-2 **Elev./Depth:** 10.0-11.5'
▲ **Source:** TP-04 **Sample No.:** Bulk **Elev./Depth:** 0.5-7.0'
◆ **Source:** TP-07 **Sample No.:** Bulk **Elev./Depth:** 0.5-7.0'

Remarks:

●
■ Could not roll out. Sample slides in bowl. Non-plastic.
▲ Could not roll out. Sample slides in bowl. Non-plastic.
◆ Could not roll out. Sample slides in bowl. Non-plastic.

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

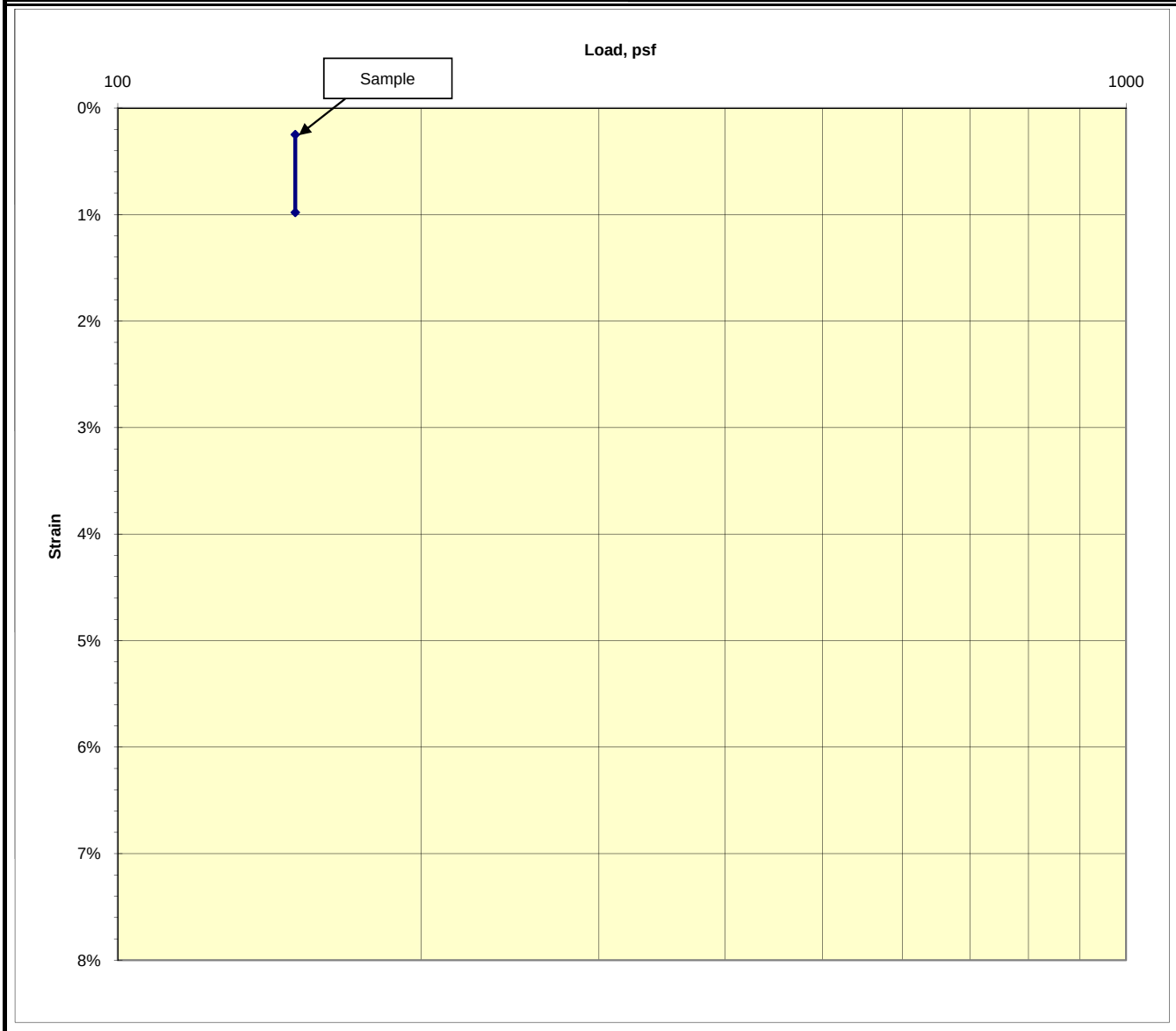
Figure

Collapse Test Report

Job No.:	645-005	**Boring:**	TP-07	**Date:**	5/5/2009
Client:	Shannon & Wilson, Inc.	**Sample:**	S-2	**Tested By:**	MD
Project:	Nine Canyon Road **Proj. No.:** 22-1-02514-004	**Depth, ft.:**	1.8-2.3	**Checked:**	DC
Soil Description:	Brown Sandy SILT w/ surface organics/ SILT w/ Sand				

Load, psf	150	150							
Deformation, in.:	0.0025	0.0098							

	Initial	**Final**		Remarks:
Moisture Content %	14.6%	31.7%	**Load at Collapse, psf**	
Dry Density, pcf	86.8	87.7	**150**	
Void Ratio	0.943	0.924	**% Collapse**	
Saturation %	41.7%	92.6%	**0.73%**	
Specific Gravity -	**Assumed:**	2.7	**Measured:**	

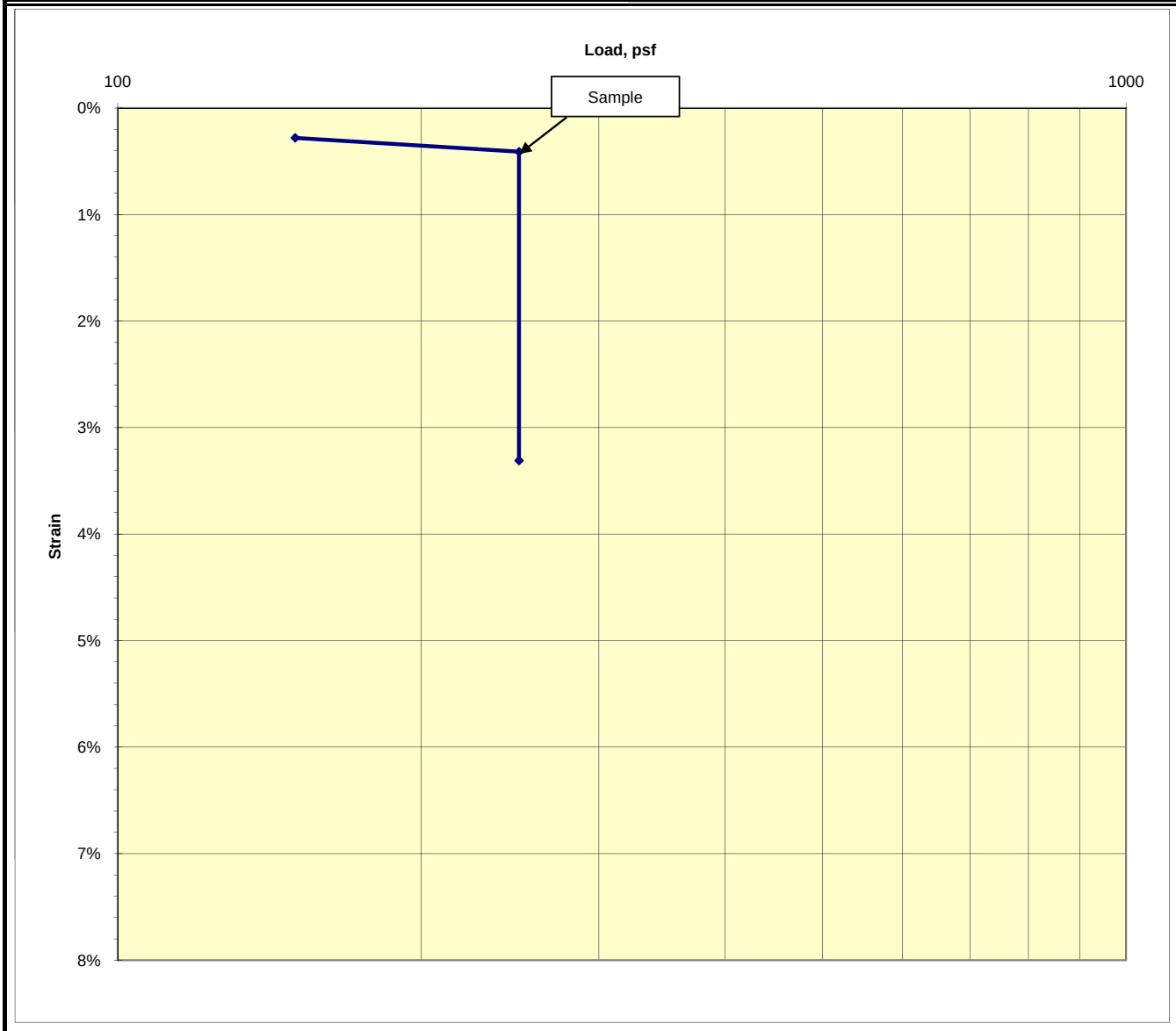


Collapse Test Report

Job No.:	645-005	**Boring:**	TP-09	**Date:**	5/5/2009
Client:	Shannon & Wilson, Inc.	**Sample:**	S-3	**Tested By:**	MD
Project:	Nine Canyon Road **Proj. No.:** 22-1-02514-004	**Depth, ft.:**	3.8-4.3	**Checked:**	DC
Soil Description:	Brown Sandy SILT near Silty SAND, trace surface organics				

Load, psf	150	250	250						
Deformation, in.:	0.0028	0.0041	0.0331						

	Initial	**Final**		Remarks:
Moisture Content %	13.2%	35.2%	**Load at Collapse, psf**	
Dry Density, pcf	80.3	83.0	**250**	
Void Ratio	1.102	1.032	**% Collapse**	
Saturation %	32.4%	92.1%	**2.91%**	
Specific Gravity -	**Assumed:**	2.7	**Measured:**	



APPENDIX E

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNCIAL ENGINEERING REPORT

Important Information About Your Geotechnical/Environmental Report

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

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

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

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

SUBSURFACE CONDITIONS CAN CHANGE.

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

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

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

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

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

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

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

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

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

Final boring logs developed by the consultant are based on 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