REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Canby South
Pioneer Industrial Park
Canby, Oregon

For
TC Pursuit Services, Inc.
August 19, 2021

Project: TrammellCr-79-05

NV5

August 19, 2021

TC Pursuit Services, Inc.
1300 SW 5th Avenue, Suite 3050
Portland, OR 97201

Attention: John Varin

Report of Geotechnical Engineering Services
Canby South
Pioneer Industrial Park
Canby, Oregon
Project: TrammellCr-79-05

NV5 is pleased to submit this report of geotechnical engineering services for planned Canby South project located within the Pioneer Industrial Park in Canby, Oregon. Our services were conducted in accordance with our proposal dated May 10, 2021.

We appreciate the opportunity to be of continued service to you. Please contact us if you have questions regarding this report.

Sincerely,

NV5

Nick Paveglio, P.E.
Principal Engineer

cc: Steve Sieber, Trammell Crow Company (via email only)
Aaron Holm, Trammell Crow Company (via email only)
Greg Blefgen, VLMK Engineering + Design (via email only)

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Attachments
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EXECUTIVE SUMMARY

We understand that a one-story warehouse building (plus 184,352-square-foot mezzanine level) with a footprint of approximately 517,220 square feet is proposed. The project will include access and parking pavement as well as utilities and on-site stormwater disposal facilities. The main report should be referenced for a detailed description of the subsurface conditions and a full understanding of our geotechnical recommendations while a summary of the primary geotechnical considerations for the project is presented below.

- The building can be established on shallow foundations established on firm, undisturbed native soil or structural fill overlying firm, undisturbed native soil. The existing agricultural tilled zone should be removed if present below any foundations.

- Based on the soil and groundwater conditions at the site, liquefaction and seismic settlement will be negligible under design levels of ground shaking. Accordingly, seismic differential settlement is less than the tolerances in ASCE 7-16 and soil improvement or deep foundations are not required for the project.

- We understand stormwater disposal will be through on-site, buried infiltration basins. Infiltration systems can be designed using the infiltration rates presented in this report. There are significant differences in infiltration rates at the selected test locations and depths. It is critical that infiltration systems be located at the approximate test location and depth in order for the corresponding rates in this report to be applicable. Confirmation testing should be completed during construction and we recommend contingencies be in place if test rates do not meet design rates.

- A agricultural tilled zone extending down to depths between 10 and 18 inches BGS (typically 10 to 12 inches) was observed at the ground surface in our explorations. In order to reduce the risk of pavement and floor slab settlement, we recommend the tilled zone be improved during site preparation in areas where planned cuts do not extend to the bottom of the tilled zone. Prior to fill placement and construction, the tilled zone should be improved by removing and replacing with structural fill or scarifying and re-compacting to structural fill requirements. Cement amendment can also be performed to improve the tilled zone. Cement amendment has added benefits of providing wet weather subgrade protection and allowing a reduction in aggregate base thickness for pavement.

- The on-site soil is generally suitable for use as structural fill. Moisture conditioning (drying) and dry weather will be required to use on-site soil for structural fill. Accordingly, it will be difficult, if not impossible, to adequately compact on-site soil during the rainy season or during prolonged periods of rainfall (unless it is cement amended) and generally will not be suitable for use as structural fill during the wet season.

- Excavation in the on-site soil should generally be possible with conventional earthwork equipment. Excavation in the native gravel can be difficult due to the relatively high soil density and presence of cobbles and boulders. In addition, steep excavation cuts in the sand and gravel soil will be prone to raveling and caving.

- The on-site soil may be easily disturbed during periods of persistent precipitation or when saturated. Subgrade protection should be employed during periods of wet weather. Cement amendment should be considered to protect prepared subgrade during periods of wet weather.

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AC	asphalt concrete
ACP	asphalt concrete pavement
ADT	average daily traffic
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BGS	below ground surface
BTS	build-to-suit
ESAL	equivalent single-axle load
FHWA	Federal Highway Administration
fps	feet per second
g	gravitational acceleration (32.2 feet/second^2)
H:V	horizontal to vertical
MCE	maximum considered earthquake
NA	not applicable
OSHA	Occupational Safety and Health Administration
OSSC	Oregon Standard Specifications for Construction (2021)
PCC	portland cement concrete
pcf	pounds per cubic foot
pci	pounds per cubic inch
PG	performance grade
PIP	Pioneer Industrial Park
psf	pounds per square foot
psi	pounds per square inch
ReMi	refraction microtremor
SOSSC	State of Oregon Structural Specialty Code
SPT	standard penetration test
µm	micrometer
USGS	U.S. Geological Survey

1.0 INTRODUCTION

NV5 has prepared this geotechnical engineering report for use in design and construction of the Canby South project located within the Pioneer Industrial Park (PIP) in Canby, Oregon. The site encompasses 47.5 acres of undeveloped land and includes Tax Lots 100 and 103 of Clackamas County Assessor Map 41E03, southwest of the intersection of South Township Road and South Mulino Road. Figure 1 shows the site relative to existing topographic and physical features. Figure 2 shows the proposed site layout and our exploration locations. Explorations completed as part of our work are presented in Appendix A. Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents.

2.0 PROJECT UNDERSTANDING

We understand that a one-story building (plus 184,352-square-foot mezzanine level) with a footprint of approximately 517,220 square feet is proposed. The developer designation for the building is an HI05 (ARSC sortation center). The building will be precast or tilt-up walls with column spacing generally ranging between approximately 30 and 50 feet. The project also include access and parking pavement as well as utilities and on-site stormwater disposal facilities.

The current survey indicates that site grades vary between approximately 152 feet at the southeastern corner and 168 feet at the southwestern corner of the site. Based on the proposed finished floor elevation of 167 feet and the existing topography, cuts and fills within the proposed building footprint will be less than 2 feet and fills of at least 5 feet will be required in the southeastern corner of the site in parking areas.

Based on correspondence with Desimone Consulting Engineers, maximum building column and wall loads are as follows:

- Mezzanine Columns: Dead Load = 300 kips, Live Load = 150 kips
- Non-Mezzanine Columns: Dead Load = 85 kips, Live Load = 95 kips
- Wall Loads: Dead Load = 6 kips per lineal foot, Live Load = 3 kips per lineal foot

The build-to-suit (BTS) diligence guidelines and “Design Criteria and Outline Specification” for ARSC development also identified the following geotechnical design criteria:

- Maximum allowable static total movement shall be 1 inch for columns, walls, and slab-on-ground.
- Maximum allowable differential static settlements for soil supporting precast or tilt-up walls shall be L/500, where L is the horizontal distance between points in consideration.
- Maximum allowable differential settlement for soil supporting interior slabs or interior isolated footings shall be L/500, where L is the horizontal distance in feet between any two columns or any two other interior points on the floor slab.
- The differential settlement criteria for seismic in accordance with ASCE 7-16.

- General live loading of floor slabs is 500 psf.
- Truck pavement based upon 178 truck-trailer movements in and 178 truck-trailer movements out per day and 76 box truck movements in and 76 box truck movements out per day. Design truck-trailer classification is FHWA Class 9 with a typical loaded trailer weighing 75,000 pounds and design box truck classification is FHWA Class 5.

The project will likely include off-site improvements; however, the extent is unknown and has not been included in this report.

3.0 BACKGROUND

NV5 prepared a preliminary geotechnical evaluation for three sites within the PIP, one of which included the subject site and at that time was referenced as the Weygandt property (GeoDesign, 2018). Three nested borings were completed at the southeastern corner of the site in June 2018 to depths between 10 and 26.5 feet BGS. Infiltration testing was performed at depths of 8.5, 13.5, and 25 feet BGS, with unfactored field infiltration rates of 16.8, 17.5, and 2 inches per hour, respectively. Exploration logs from these previous explorations at the site are presented in Appendix B.

4.0 SCOPE OF SERVICES

The scope of our services was to provide geotechnical recommendations for the proposed site development. Our specific scope included the following:

- Reviewed information available in our files from previous geological and geotechnical studies conducted at and in the vicinity of the site.
- Reviewed preliminary grading plans, foundation loading, and slab loading prepared by others.
- Conducted the following exploration plan:
  - Drilled 12 borings to depths between 9 and 36.5 feet BGS within the proposed building footprint using track-mounted drilling equipment.
  - Excavated 17 test pits to depths between 8 and 18.5 feet BGS.
  - Completed nine infiltration tests.
- Completed geophysical testing profiles across the building footprint consisting of 17 seismic P-wave refraction traverses and one ReMi profile to establish shear wave velocities for seismic design parameters.
- Maintained continuous logs of the explorations and collected soil samples at representative intervals.
- Performed laboratory testing on select samples collected from the explorations:
  - Thirty-three natural moisture content determinations
  - Ten particle-size analyses
  - Two chloride, sulfate, and pH tests
- Provided recommendations for site preparation, grading and drainage, stripping depths, fill type for imported material, compaction criteria, trench excavation and backfill, use of on-site soil, and wet/dry weather earthwork.
- Provided recommendations for design and construction of shallow spread foundations, including allowable design bearing pressure and minimum footing depth and width.

- Provided recommendations for preparation of floor slab subgrade.
- Provided design criteria recommendations for retaining walls, including lateral earth pressures, backfill, compaction, and drainage.
- Provided recommendations for managing identified groundwater conditions that may affect the performance of structures or pavement.
- Provided recommendations for construction of AC pavement for on-site access roads and parking areas, including subbase, base course, and AC paving thickness.
- Provided recommendations for the 2019 SOSSC and ASCE 7-16 seismic coefficients and evaluated the risk of liquefaction at the site.
- Provided this report summarizing the results of our geotechnical evaluation.

5.0 SITE CONDITIONS

5.1 GEOLOGIC CONDITIONS

The site is located within the Willamette Valley physiographic province (Orr and Orr, 1999). Bedrock in this region consists of basalt flows emplaced approximately 15 million years ago as part of the Columbia River Basalt Group (Gannett and Caldwell, 1998; Burns et al., 1997).

During and after the Miocene Age, uplift and rotation of the Coast Range to the east created a number of closed basins within the Willamette Valley, which filled with silt, sand, and gravel of the Miocene to Pleistocene Age (14.5 million to 1 million years old) (Orr and Orr, 1999). These deposits form the majority of basin fill sediments in the Willamette Valley. This sedimentary package is generally mapped as the Sandy River Mudstone toward the lower portion of the assemblage (mostly fine-grained sandstone and mudstone) overlain by the Troutdale Formation, a series of gravel, sand, and silt, with both units deposited by the ancestral Columbia River and smaller rivers running out of the Cascade Mountains (Tolan and Beeson, 1984; Evarts et al., 2013).

The basin fill sediments are overlain by late Pleistocene Age catastrophic flood deposits. Approximately 15,000 to 12,000 years ago floods caused by the sudden drainage of large glacial lakes in western Montana swept down the Columbia River and over the lowlands of the Portland area (Allen et al., 1986), leaving behind thick accumulations of silt, sand, and gravel. These Missoula flood deposits can be divided into a fine-grained facies consisting of silt and fine sand and a coarse-grained facies with gravel- to boulder-sized material deposited in a matrix of sand and silt. In Canby, a thick (110 to 130 feet) delta of gravel and boulders was deposited as a result of the Missoula floods being channeled through the topographic gap along the Columbia River at Oregon City. These deposits are typically overlain by 5 to 10 feet of silt and sand (O'Connor et al., 2001; Burns and Coe, 2012). The total thickness of the basin fill and flood deposits in the vicinity of the site is thought to be approximately 600 to 700 feet (Gannett and Caldwell, 1998; Burns et al., 1997).

5.2 SURFACE CONDITIONS

The site is located southwest of the intersection of South Mulino Road and South Township Road in Canby, Oregon. Based on the review of historical aerial photographs, the site has a history of agricultural use dating back to at least 2000. The site was being used for grass seed crop and was covered by medium to tall grass at the time of our explorations. There was a small cluster of mature trees located in the northern portion of the site at the time of our investigation. The ground surface is generally flat to gently sloped over much of the site, except in the southeastern corner where it slopes downward to a drainage swale from approximately elevation 165 to 154 feet. A topographic map indicates that the maximum slopes are flatter than of 10H:1V.

5.3 SUBSURFACE CONDITIONS

5.3.1 General

The client BTS guidelines indicate that one subsurface exploration should be conducted within the building footprint for each 20,000 square feet of building area, which equates to 26 explorations for the proposed development. Based on the relatively shallow, dense gravel at the site, our exploration program included a reduced number of borings supplemented with geophysical testing. Geophysical testing provided a continuous profile of subsurface properties along the lines shown on Figure 2. In our opinion, the reduced number of drilled borings combined with geophysical testing provides an equivalent or better evaluation of subsurface conditions than conventional soil explorations alone and meets the BTS guidelines.

In addition, the BTS guidelines specify minimum exploration depths of twice the width of the largest shallow footing, plus 10 feet (likely greater than 20 feet BGS total). Based on experience in the site vicinity and geologic mapping, the dense gravel unit extends to depths of well over 100 feet BGS. Due to the relative density of the gravel and presence of boulders, advancing borings to the prescribed depth would be expensive and provide minimal value to the project. Geophysical testing performed at the site was able to evaluate subsurface conditions to a depth of at least 30 feet BGS, which is more effective and cost efficient than advancing borings at least 15 feet into the dense gravel. A ReMi profile was completed at the site, which confirmed (via shear wave velocity measurements) that the dense gravel extends more than 100 feet BGS.

5.3.2 Explorations and Geophysical Testing

We explored subsurface conditions at the site by drilling 12 borings (B-1 through B-12) within the building footprint to depths between 9 and 36.5 feet BGS and excavating 17 test pits (TP-1 through TP-17) to depths between 8 and 18.5 feet BGS. The exploration locations are shown on Figure 2. Descriptions of our field exploration and laboratory testing programs, the exploration logs, and results of laboratory testing are presented in Appendix A. Our knowledge of subsurface conditions is supplemented by the 2018 borings discussed in the "Background" section. Logs of the 2018 explorations are presented in Appendix B. In addition to the drilled borings, 17 seismic P-wave refraction traverses and 1 ReMi profile were performed at the site. A report providing the geophysical testing procedures and an analysis of the results is presented in Appendix C.

Based on the explorations and geophysical testing, the subsurface conditions at the site generally consist of approximately 3.5 to 29 feet of sandy silt and silty sand overlying gravel to the maximum depths explored. One exploration (TP-10) encountered a 2.3-foot-thick gravel layer at the ground surface over sandy silt and silty sand. The approximate depth to gravel is shown at each exploration location on Figure 2.

The following sections presents detailed descriptions of the subsurface soil.

5.3.3 Tilled Zone

The upper 10 to 18 inches of soil generally consists of an agricultural tilled zone with an approximately 2- to 5-inch-thick root zone. The tilled zone consists of soft to medium stiff, sandy silt and contains variable amounts of organics associated with prior cultivation.

5.3.4 Sandy Silt and Silty Sand

Layers of sandy silt and silty sand were encountered below the tilled zone to depths of approximately 3.5 to 29 feet BGS. This unit is generally 2.5 to 12 feet thick over most of the site, including the entire building pad, and increases to up to 29 feet in the southeastern corner of the site in parking areas. SPT results and field testing indicate the silt layers are generally medium stiff to stiff and the sand is generally loose to medium dense. Sand and silt proportions vary throughout this unit with silt content generally decreasing with depth.

The sand layer encountered at approximately 6 to 7 feet BGS in test pits TP-16 and TP-17 (near the drainage swale) contain less silt than observed in other explorations. Laboratory testing indicates the moisture content of the silt and sand varied between 9 and 39 percent at the time of our explorations.

5.3.5 Gravel

Dense to very dense gravel was below the silt and sand layers in most explorations to the maximum depth explored. The gravel unit contains varying proportions of boulders, cobbles, sand, and silt and trace amounts of clay. The exploration logs in Appendix A show estimated cobble and boulder percentages within the gravel. Cobble and boulder percentages are field estimates based on isolated locations within a large area and should be considered accurate to the degree implied. Gravel and sand particles are typically fine to coarse, and the gravel is subrounded. We observed minor caving of several test pit sidewalls within the gravel unit.

Laboratory testing indicates the moisture content of the gravel was between 7 and 17 percent at the time of our explorations and fines content (percent passing a U.S. Standard No. 200 sieve) is between 5 and 10 percent. The gravel unit has high strength and low compressibility characteristics.

Geophysical testing indicates similar depths to gravel as encountered in our explorations.

5.3.6 Groundwater

Groundwater was measured at a depth of approximately 30.3 feet BGS in boring B-12. Groundwater mapping completed for the PIP area (presented in Appendix D) indicates that groundwater is typically 40 to 45 feet BGS in the site vicinity. While it is possible that boring B-12 was performed in an area of localized high groundwater, we recommend using 30 feet BGS as a design groundwater level. The depth to groundwater may fluctuate in response to prolonged rainfall, seasonal changes, changes in surface topography, and other factors not observed during this study. Groundwater could become perched on low-permeability zones of silty soil during the wet season or periods of persistent rainfall but is otherwise not expected to significantly impact construction.

5.3.7 Chloride, Sulfate, and pH Testing

Two chloride, sulfate, and pH test suites were completed on select samples to determine the corrosivity of the soil at the site. One test suite was completed for the sandy silt to silty sand soil and the second was completed for the gravel. Test results are presented in Appendix E.

5.4 INFILTRATION TESTING

We understand stormwater disposal will occur by means of on-site infiltration. Infiltration testing was performed in 2018 borings B-1a, B-1b, and B-1c and recent test pits TP-4, TP-9, TP-13, TP-14, TP-15, and TP-17 in sand and gravel to assist in design of disposal facilities. Testing was performed in hollow-stem augers in the borings and directly in the open test pits. After filling the augers/pits with water they were allowed to pre-soak for one hour. At some locations/depths, infiltration occurred immediately and a soak period was not possible. In cases where water infiltrated too rapidly to obtain reliable measurements of water head, we measured the total volume of water placed in the excavation, recorded the time to fully infiltrate, and measured the approximate infiltration area to estimate infiltration rate. The final test results are summarized in Table 1. Recommendations for on-site infiltration are presented in the "Infiltration Systems" section.

Infiltration

Table 1. Infiltration Test Results

Location	Depth (feet BGS)	Approximate Elevation[1] (feet)	Soil Type at Test Depth	Measured Infiltration Rate (inches per hour)	Fines Content[2] (percent)
B-1a[3]	25	140	Silty Sand	2	21
B-1b[3]	13.5	151.5	Silty Sand with gravel	17.5	15
B-1c[3]	8.5	156.5	Silty Sand	16.8	15
TP-4	12	154	Gravel with sand, silt, cobbles, and boulders, trace clay	30	NA
TP-4	16	150	Gravel with sand, silt, cobbles, and boulders, trace clay	650	7
TP-9	9	159	Gravel with silt, cobbles, and boulders, minor sand	22	10
TP-9	13	155	Gravel silt, cobbles, and boulders, minor sand, trace clay	600	NA
TP-13	11	155	Gravel with silt, sand, and cobbles	25	8
TP-14	15	151	Gravel with sand, trace silt	37	NA
TP-14	18.5	147.5	Gravel with sand, trace silt	33	5

Table 1. Infiltration Test Results (continued)

Location	Depth (feet BGS)	Approximate Elevation[1] (feet)	Soil Type at Test Depth	Measured Infiltration Rate (inches per hour)	Fines Content[2] (percent)
TP-15	15	151	Gravel with sand, trace silt	70	NA
TP-17	17	149	Silty Sand with gravel and cobbles	28	14

1. Estimated from existing topography plan and pacing from existing site features
2. Particles finer than 75 µm by dry weight
3. From 2018 exploration

6.0 DESIGN

6.1 GENERAL

Based on the results of our subsurface exploration, laboratory testing, and geotechnical analysis, the project can be developed as planned. The following sections provide our recommendations for development.

6.2 SHALLOW FOUNDATIONS

6.2.1 General

Assuming new fill in the building footprint is less than 3 feet in the mezzanine area and 5 feet in non-mezzanine areas, the site is prepared as recommended in the "Construction" section, and the foundation loads are within the limits defined in the "Introduction" section, it is our opinion that the building can be supported on conventional spread footings bearing on undisturbed native soil or new structural fill on top of undisturbed native soil.

Foundation elements should not be supported on topsoil, tilled soil, or undocumented fill material. If present below planned footings, these materials should be removed and replaced with structural fill or improved as discussed in the "Subgrade Improvement" section.

6.2.2 Dimensions and Capacities

Continuous wall and isolated spread footings should be at least 18 and 24 inches wide, respectively. The bottom of exterior footings should be at least 18 inches below the lowest adjacent exterior grade. The bottom of interior footings should be established at least 12 inches below the base of the slab.

Footings bearing on subgrade prepared as recommended above should be sized based on an allowable bearing pressure of 2,500 psf. This is a net bearing pressure; the weight of the footing and overlying backfill can be ignored in calculating footing sizes. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads and may be doubled for short-term loads such as those resulting from wind or seismic forces.

6.2.3 Settlement

Assuming the foundation loading criteria presented in the "Project Understanding" section and that fills within the building footprint are less than 6 feet, we estimate that the post-construction settlement will be less than approximately 1 inch. Differential settlement will be less than ½ inch over 50-foot column spacing. These settlements meet the performance requirements of the BTS diligence guidelines and "Design Criteria and Outline Specification" for the project.

6.2.4 Resistance to Sliding

Lateral loads on footings can be resisted by passive earth pressure on the sides of footings and by friction on the base of the footings. Our analysis indicates that the available passive earth pressure for footings confined by on-site soil and structural fill is 275 pcf, modeled as an equivalent fluid pressure. Adjacent floor slabs, pavement, or the upper 12-inch depth of adjacent, unpaved areas should not be considered when calculating passive resistance. In addition, in order to rely on passive resistance, a minimum of 10 feet of horizontal clearance must exist between the face of the footings and any adjacent downslopes.

For footings in contact with native sand and silt, a coefficient of friction equal to 0.30 may be used when calculating resistance to sliding. This value can be increased to 0.40 if foundations are established on at least 4 inches of compacted crushed rock or the native gravel soil.

6.2.5 Subgrade Observation

All footing and floor slab subgrades should be evaluated by a representative of NV5 to evaluate the bearing conditions. Observations should also confirm that all loose or tilled zone material, organic material, unsuitable fill, prior topsoil zones, and softened subgrades (if present) have been removed. Localized deepening of footing excavations may be required to penetrate any deleterious material.

6.3 SEISMIC CONSIDERATIONS

6.3.1 Seismic Design Parameters

Seismic design criteria for this project will be based on the 2019 SOSSC and ASCE 7-16. ReMi test results indicate a shear wave velocity in the upper 100 feet (V_{s100}) of 1,434 fps. Based on ASCE 7-16 Chapter 20, the seismic site class at the site is C. Seismic design parameters for the development are presented in Table 2.

Table 2. ASCE 7-16 Seismic Design Parameters

Parameter	Short Period (T_s = 0.2 second)	1 Second Period (T_1 = 1.0 second)
MCE Spectral Acceleration, S	S_s = 0.781 g	S_1 = 0.363 g
Site Class	C	
Site Coefficient, F	F_a = 1.200	F_v = 1.500
Adjusted Spectral Acceleration, S_M	S_{MS} = 0.937 g	S_{M1} = 0.544 g
Design Spectral Response Acceleration Parameters, S_D	S_{DS} = 0.625 g	S_{D1} = 0.363 g

6.3.2 Seismic Hazards

6.3.2.1 Liquefaction

Based on the soil and groundwater conditions at the site, liquefaction and seismic settlement will be negligible under design levels of ground shaking. Accordingly, seismic differential settlement will be less than the tolerances in ASCE 7-16 and soil improvement or deep foundations are not required for the project.

6.3.2.2 Lateral Spread

Lateral spreading is a liquefaction-related seismic hazard and occurs on gently sloping or flat sites underlain by liquefiable sediment adjacent to an open face, such as a riverbank. Liquefied soil adjacent to an open face can flow toward the open face, resulting in lateral ground displacement. Because liquefaction is expected to be negligible, lateral spreading is not a design consideration for the project.

6.3.2.3 Fault Rupture

Based on USGS mapping, the closest fault to the site is the Canby-Molalla fault, which is 0.75 mile to the northeast. Accordingly, the potential for fault rupture at the site is very low.

6.4 FLOOR SLABS

Satisfactory subgrade support for building floor slabs supporting floor loads up to 500 psf is achievable, provided the subgrade is prepared in accordance with this report and fill thickness within the building footprint is generally less than 2 feet. This includes subgrade improvement as discussed in the "Subgrade Improvement" section. We recommend a minimum 6-inch-thick layer of aggregate base be placed and compacted over the prepared soil subgrade. Imported granular material placed beneath building floor slabs should meet the requirements in the "Floor Slab Aggregate Base" section. A subgrade reaction modulus of 125 pci can be used to design floor slabs that bear on the native soil.

The near-surface native soil is fine grained and will tend to maintain high moisture content. In areas where moisture-sensitive floor slab and flooring will be installed, installation of a vapor barrier is warranted in order to reduce the potential for moisture transmission through and efflorescence growth on the slab and flooring. In addition, flooring manufacturers often require vapor barriers to protect flooring and flooring adhesives and will warrant their product only if a vapor barrier is installed according to their recommendations.

Slabs should be reinforced according to their proposed use and per the structural engineer's recommendations.

6.5 RETAINING STRUCTURES

6.5.1 Assumptions

Our retaining wall design recommendations are based on the following assumptions: (1) the walls are cantilevered, gravity, or mechanically stabilized earth walls; (2) the walls are less than 10 feet in height; (3) drainage is provided behind the walls; (4) the retained soil has a slope flatter than 2H:1V; and (5) the ground surface at the toe of the wall has an inclination of flatter than 5H:1V. Re-evaluation of our recommendations will be required if the retaining wall design criteria for the project varies from these assumptions.

6.5.2 Wall Design Parameters

Permanent retaining structures free to rotate slightly around the base and with a flat backfill slope should be designed for active earth pressures using an equivalent fluid unit pressure of 35 pcf. If retaining walls are restrained against rotation during backfilling, they should be designed for an at-rest earth pressure of 55 pcf.

Seismic lateral forces can be calculated using a dynamic force equal to $7H^2$ pounds per linear foot of wall, where H is the wall height. The seismic force should be applied as a distributed load with the centroid located at 0.6H from the wall base. Footings for retaining walls should be designed as recommended for shallow foundations.

The design equivalent fluid pressure should be increased for walls that retain sloping soil. We recommend the above lateral earth pressures be increased using the factors presented in Table 3 when designing walls that retain sloping soil.

Table 3. Lateral Earth Pressure Increase Factors for Sloping Soil

Slope of Retained Soil (degrees)	Lateral Earth Pressure Increase Factor
0	1.00
5	1.06
10	1.12
20	1.33
25	1.52
30	2.27

If other surcharges (i.e., slopes steeper than 2H:1V, foundations, vehicles, etc.) are located within a horizontal distance of twice the height of the wall from the back of the wall, additional pressures will need to be accounted for in the wall design. Our office should be contacted for appropriate wall surcharges based on the actual magnitude and configuration of the applied loads.

6.5.3 Wall Drainage and Backfill

The above design parameters have been provided assuming drains will be installed behind walls to prevent hydrostatic pressures from developing. If a drainage system is not installed, our office should be contacted for revised design forces.

Backfill material placed behind the walls and extending a horizontal distance of ½H, where H is the height of the retaining wall, should consist of retaining wall select backfill placed and compacted in conformance with the “Structural Fill” section.

A minimum 6-inch-diameter, perforated collector pipe should be placed at the base of the walls. The pipe should be embedded in a minimum 2-foot-wide zone of angular drain rock that is wrapped in a drainage geotextile fabric and extends up the back of the wall to within 1 foot of the finished grade. The drain rock and drainage geotextile fabric should meet specifications provided in the “Materials” section. The perforated collector pipes should discharge at an appropriate location away from the base of the wall. The discharge pipe(s) should not be tied directly into stormwater drain systems, unless measures are taken to prevent backflow into the wall’s drainage system.

Settlement of up to 1 percent of the wall height commonly occurs immediately adjacent to the wall as the wall rotates and develops active lateral earth pressures. Consequently, we recommend construction of flatwork adjacent to retaining walls be postponed at least four weeks after backfilling of the wall, unless survey data indicates that settlement is complete prior to that time.

6.6 PAVEMENT

6.6.1 General

Pavement should be installed on native subgrade or new engineered fills prepared in conformance with the “Site Preparation” and “Structural Fill” sections. Our pavement recommendations are based on the following assumptions:

- Subgrade improvement occurs as discussed in the “Subgrade Improvement” section.
- The top 12 inches of soil subgrade is compacted to at least 92 percent of its maximum dry density, as determined by ASTM D1557, or until proof rolling with heavy equipment indicates that is it firm and unyielding.
- A resilient modulus of 4,500 psi for the subgrade soil and 20,000 psi is assumed for the base rock.
- The design manual provided for the project specifies pavement recommendations based on a design life of 20 years.
- Initial and terminal serviceability indices of 4.2 and 2.5, respectively.
- Reliability of 85 percent and standard deviation of 0.45.

- Fire access will consist of an imposed fire apparatus load of 75,000 pounds on an infrequent basis.
- Design traffic loading was derived from a traffic impact analysis report by (Langan, 2021) that indicated daily truck-trailer, box truck, and auto trips will be 356, 152, and 1,312 one-way trips per day, respectively.
- We have classified the truck-trailers as FHWA Class 9 vehicles and box trucks as FHWA Class 5 vehicles.
- We assume that the facility will not be a distribution hub for delivery vans.
- No growth.
- We calculated single vehicle ESAL factors of 1.692 and 2.919 for flexible and rigid pavements, respectively, based on Appendix D of the 1993 AASHTO pavement design guide.

Our recommended 20-year flexible pavement sections are provided in Tables 4 and 5 and rigid pavement sections are provided in Tables 6 and 7. We anticipate that only the entrance will carry the full traffic load, with diminishing loading as the trucks distribute through the site. We have provided recommendations for a range of truck-trailer traffic to allow the project team to assign different pavement sections in various areas of the site. The tables only show the number of truck-trailers used in each analysis. The number of box trucks was reduced in proportion to the truck-trailers in each scenario.

6.6.2 Asphalt Pavement

Our asphalt pavement design recommendations are presented in Tables 4 and 5.

Table 4. 20-Year Standard AC Pavement Sections

Traffic Levels	Trucks per Day[1]	ESALs	AC (inches)	Base Rock (inches)
Car Parking Stall	0	10,000	3.0	9
Car Travel Aisles	0	20,000	3.0	10
Truck Area 1	200	2,569,685	6.5	20
Truck Area 2	250	3,212,356	7.0	20
Truck Area 3	300	3,855,028	7.0	21
Truck Area 4	356	4,571,879	7.5	21

1. Two-way truck ADT. Truck-trailers shown only.

If the pavement subgrade is cement amended to the thicknesses indicated below and the amended soil achieves a seven-day unconfined compressive strength of at least 100 psi, the pavement can be constructed as recommended in Table 5 for 20-year design life.

Table 5. 20-Year AC Pavement Sections with Cement Amendment

Traffic Levels	Trucks per Day[1]	ESALs	AC (inches)	Base Rock (inches)	Cement Amendment[2] (inches)
Car Parking Stall	0	10,000	3.0	4	12
Car Travel Aisles	0	20,000	3.0	4	12
Truck Area 1	200	2,569,685	6.5	7	16
Truck Area 2	250	3,212,356	7.0	7	16
Truck Area 3	300	3,855,028	7.0	8	16
Truck Area 4	356	4,571,879	7.5	8	16

1. Two-way truck ADT. Truck-trailers shown only.
2. Assumes a minimum seven-day unconfined compressive strength of 100 psi.

6.6.3 PCC Pavement

We understand PCC pavement will be used within the loading bays. We assume that PCC pavement will be designed for a 20-year period. If required, PCC to AC connections should include a thickened PCC to AC pavement connection with thickened PCC of 11.0 inches and thickened AC surface of 9.0 inches in the direction of travel. For truck bays, we recommend a conservative assumption of 100 trucks per day. If PCC is used in other areas of the site, such as a guard shack, we recommend assuming up to 356 trucks per day. Additional information regarding AC to PCC pavement transitions at the guard shack can be provided if required.

The PCC, aggregate base, and cement amendment should meet the requirements outlined in the "Materials" section.

Table 6. 20-Year PCC Standard Pavement Sections

Traffic Levels	Trucks per Day[1]	ESALs	PCC (inches)	Base Rock (inches)	Maximum Joint Spacing (feet)
Truck Bays	100	2,177,870	9.0	10	14
Heavy Truck Aisles	356	7,751,897	10.5	12	16

1. Two-way truck ADT. Truck-trailers shown only.

If the subgrade is cement amended to the thicknesses indicated below and the amended soil achieves a seven-day unconfined compressive strength of at least 100 psi, the pavement can be constructed as recommended in Table 7.

Table 7. 20-Year PCC Pavement Sections with Cement Amendment

Traffic Levels	Trucks Per Day[1]	ESALs	PCC (inches)	Base Rock (inches)	Cement Amendment[2] (inches)	Maximum Joint Spacing (feet)
Truck Bays	100	2,177,870	9.0	4	12	16
Heavy Truck Aisles	356	7,751,897	10.5	4	12	16

1. Two-way truck ADT. Truck-trailers shown only.
2. Assumes a minimum seven-day unconfined compressive strength of 100 psi.

All thicknesses are intended to be the minimum acceptable.

6.6.4 Construction Considerations

All thicknesses are intended to be the minimum acceptable. Design of the recommended pavement section assumes that construction will be completed during an extended period of dry weather. Wet weather construction could require an increased thickness of aggregate base. In addition, to prevent strength loss during curing, cement-amended soil should be allowed to cure for at least four days prior to construction traffic or placing the base rock. Lastly, the amended subgrade should be protected with a minimum of 4 inches of base rock prior to construction traffic access.

Construction traffic should be limited to non-building, unpaved portions of the site or haul roads. Construction traffic should not be allowed on new pavement. If construction traffic is to be allowed on newly constructed road sections, an allowance for this additional traffic will need to be made in the design pavement section.

The aggregate base and cement-amended thicknesses (if installed) do not account for construction traffic, and haul roads and staging areas should be used as described in the “Construction” section.

6.7 DRAINAGE

6.7.1 Permanent Dewatering

Based on the preliminary grading plans and anticipated groundwater elevation, permanent dewatering systems will not be required. This includes foundation drains and sub-slab drainage.

6.7.2 Surface

Where possible, the finished ground surface around the building should be sloped away from the structure at a minimum 2 percent gradient for a distance of at least 10 feet. Downspouts or roof scuppers should discharge into a storm drain system that carries the collected water to an appropriate stormwater system. Trapped planter areas should not be created adjacent to the building without providing means for positive drainage (e.g., swales or catch basins).

6.8 INFILTRATION SYSTEMS

We understand stormwater disposal will likely be accomplished through on-site buried infiltration basins. Infiltration systems can be designed using the unfactored rates shown in Table 1. There are significant differences in infiltration rates at the selected test locations and depths. For example, the rate observed in test pit TP-4 at 12 feet BGS was approximately 30 inches per hour as opposed to 650 inches per hour at 16 feet BGS. It is critical that infiltration systems be located at the approximate test location and depth in order for the corresponding rates in Table 1 to be applicable. It is important to note that the test depths shown in Table 1 are measured from the existing ground surface and not proposed finished grades. The table also includes estimated test elevations, which are based on a topographic map provided to NV5 and pacing from existing features on site. The elevations presented should be considered accurate to degree implied.

The infiltration rates shown in Table 1 are short-term field rates and factors of safety have not been applied for the type of infiltration system being considered. Appropriate correction factors should be applied by the project civil engineer to determine long-term infiltration parameters. The infiltration system design engineer should determine and apply appropriate remaining correction factor values or factors of safety to account for degree of in-system filtration, system maintenance, vegetation, potential for siltation, etc.

The infiltration flow rate of a disposal system will diminish over time as suspended solids and precipitates in the stormwater slowly clog the void spaces between the soil particles. Eventually, the system may fail and need to be replaced. We recommend the system include an overflow that is connected to a suitable discharge point such as the storm sewer. Finally, stormwater infiltration systems will cause localized high groundwater levels; therefore, they should not be located near basement walls, retaining walls, or other embedded structures, unless these are specifically designed to account for the resulting hydrostatic pressure. The stormwater system should not be located on sloping ground, unless it is approved by a geotechnical engineer.

It is possible that isolated pockets of low-permeable soil or perched groundwater exist within the design infiltration zone. Therefore, we recommend that stormwater disposal systems be field tested to confirm the design infiltration capacity has been achieved. We recommend contingencies be in place if field rates do not meet design rates.

7.0 CONSTRUCTION

7.1 SITE PREPARATION

7.1.1 Grubbing and Stripping

As discussed in the “Site Conditions” section, the site has a history of agricultural use and is currently being used for grass seed crop. If the cluster of trees located in the northern portion of the site will be removed, root balls should be grubbed out to the depth of the roots, which could exceed 3 feet BGS. Depending on the methods used to remove the root balls, considerable disturbance and loosening of the subgrade could occur during site grubbing. We recommend that soil disturbed during grubbing operations be removed to expose firm, undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

The existing root zone should be stripped and removed from all fill areas. Based on our explorations, the average depth of stripping will be approximately 2 to 5 inches, although greater stripping depths may be required to remove localized zones of loose or organic soil. The actual stripping depth should be based on field observations at the time of construction. Stripped material should be transported off site for disposal or used in landscaped areas.

7.1.2 Subgrade Improvement

An agricultural tilled zone extending down to depths between 10 and 18 inches BGS (typically 10 to 12 inches) was observed in our explorations. Reliable strength properties are extremely difficult to predict for the topsoil/tilled zone material. There is a high risk for poor performance of floor slabs and pavement established directly over topsoil/tilled zone soil. In order to reduce the risk of settlement, we recommend the topsoil/tilled zone be improved during site preparation in areas where planned cuts do not extend to the bottom of the topsoil/tilled zone (up to 18 inches below existing grades). Prior to fill placement and construction, the topsoil/tilled zone should be improved by removing and replacing with structural fill or scarifying and re-compacting to structural fill requirements.

As discussed in the "Structural Fill" section, the native soil can be sensitive to small changes in moisture content and will be difficult, if not impossible, to compact adequately during wet weather. While scarification and compaction of the tilled zone material is the best option for subgrade improvement, it will likely only be possible during extended dry periods and following moisture conditioning of the soil. As discussed in the “Soil Amendment with Cement” section, cement amendment is an option for conditioning the soil for use as structural fill during periods of wet weather or when drying the soil is not an option. Cement amendment has an added benefit of providing subgrade protection during the wet season and reducing pavement aggregate base.

7.1.3 Subgrade Evaluation

Upon completion of stripping and subgrade stabilization, and prior to the placement of fill or pavement improvements, the exposed subgrade should be evaluated by proof rolling. The subgrade should be proof rolled with a fully loaded dump truck or similarly heavy, rubber tire construction equipment to identify soft, loose, or unsuitable areas. A member of our geotechnical staff should observe the proof rolling to evaluate yielding of the ground surface. During wet weather, subgrade evaluation should be performed by probing with a foundation probe rather than proof rolling. Areas that appear soft or loose should be improved in accordance with subsequent sections of this report.

7.1.4 Compacting Test Pit Excavations

The test pit excavations were backfilled using the relatively minimal compactive effort of the excavator’s bucket; therefore, soft spots can be expected at these locations. We recommend full-depth removal this relatively uncompacted soil be removed from the test pits. The resulting excavation should be brought back to grade with compacted structural fill.

7.2 SUBGRADE CONSIDERATIONS

The fine-grained soil present at the ground surface on this site is easily disturbed. If not carefully executed, site preparation, utility trench work, and roadway excavation can create extensive soft areas and significant repair costs can result. Earthwork planning, regardless of the time of year, should include considerations for minimizing subgrade disturbance.

If construction occurs during or extends into the wet season, or if the moisture content of the surficial soil is more than a couple percentage points above optimum, site stripping and cutting may need to be accomplished using track-mounted equipment. Likewise, the use of granular haul roads and staging areas will be necessary for support of construction traffic during the rainy season or when the moisture content of the surficial soil is more than a few percentage points above optimum. The base rock thickness for pavement areas is intended to support post-construction design traffic loads and is not designed to support construction traffic. Moreover, if construction is planned for periods when the subgrade soil is wet, staging and haul roads with increased thicknesses of base rock will be required. The amount of staging and haul road areas, as well as the required thickness of granular material, will vary with the contractor's sequencing of a project and type/frequency of construction equipment and should, therefore, be the responsibility of the contractor. Based on our experience, between 12 and 18 inches of imported granular material is generally required in staging areas and between 18 and 24 inches in haul roads areas. The contractor should also be responsible for selecting the type of material or construction of haul roads and staging areas. A geotextile fabric can be placed as a barrier between the subgrade and imported granular material in areas of repeated construction traffic to help prevent silt migration into the base rock. The imported granular material, stabilization material, and geotextile fabric should meet the specifications in the "Materials" section.

As an alternative to thickened crushed rock sections, haul roads and utility work zones may be constructed using cement-amended subgrade overlain by a crushed rock wearing surface. If this approach is used, the thickness of granular material in staging areas and along haul roads can typically be reduced to between 6 and 9 inches. This recommendation is based on an assumed minimum unconfined compressive strength of 100 psi for subgrade amended to a depth of 12 to 16 inches. The actual thickness of the amended material and imported granular material will depend on the contractor's means and methods and should be the contractor's responsibility. Cement amendment is discussed in the "Materials" section.

7.3 PERMANENT SLOPES

Permanent cut and fill slopes should not exceed 2H:1V. Access roads and pavement should be located at least 5 feet from the top of cut and fill slopes. The setback should be increased to 10 feet for buildings. The slopes should be planted with appropriate vegetation to provide protection against erosion as soon as possible after grading. Surface water runoff should be collected and directed away from slopes to prevent water from running down the face of the slope.

7.4 EXCAVATION

Excavation in the on-site soil should generally be possible with conventional earthwork equipment. Excavations in the sand and gravel soil will be prone raveling and caving. In addition, cobbles and boulders were observed in the gravel. Where encountered, cobbles and particularly boulders will result in difficult trench excavations and may require special equipment and procedures for removal. If difficult excavations are encountered, trenches may also be wider than anticipated, increasing the amount of backfill material required. The earthwork contractor should be prepared to use open-excavation techniques or approved temporary shoring when excavating on site.

7.4.1 Trenches and Shoring

Open excavation techniques may be used to excavate trenches, provided the walls of the excavation are cut at a slope of 1.5H:1V in the on-site soil and groundwater seepage is not present. If caving or seepage occurs, trench slopes may need to be flattened. In lieu of large and open cuts, approved temporary shoring may be used for excavation support. A wide variety of shoring and dewatering systems are available. Consequently, we recommend that the contractor be responsible for selecting the appropriate shoring and dewatering systems.

If box shoring is used, it should be understood that box shoring is a safety feature used to protect workers and does not prevent caving. If excavations are left open for extended periods of time, caving of the sidewalls will occur. The presence of caved material will limit the ability to properly backfill and compact the trenches. The contractor should be prepared to fill voids between the box shoring and the sidewalls of the trenches with sand or gravel before caving occurs.

If shoring is used, we recommend that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation.

7.4.2 Safety

All excavations should be made in accordance with applicable OSHA requirements and regulations of the state, county, and local jurisdiction. While this report describes certain approaches to excavation and dewatering, the contract documents should specify that the contractor is responsible for selecting excavation and dewatering methods, monitoring the excavations for safety, and providing shoring (as required) to protect personnel and adjacent structural elements.

7.5 DEWATERING

Shallow excavations are not expected to encounter the regional groundwater table, although some perched water could be encountered in some areas. The risk of encountering perched water will increase during the wet season. If perched groundwater is encountered, it should be possible to remove it by pumping from sumps.

7.6 TEMPORARY DRAINAGE

In addition to the erosion control measures (see “Erosion Control” section), during mass grading at the site, the contractor should be made responsible for temporary drainage of surface water as necessary to prevent standing water and/or erosion at the working surface. During rough and finished grading of the building site, the contractor should keep all footing excavations and building pads free of water.

7.7 MATERIALS

7.7.1 Structural Fill

7.7.1.1 General

Fill should be placed on subgrade that has been prepared in conformance with the “Site Preparation” section. A variety of materials may be used as structural fill at the site. However, all material used as structural fill should be free of organic material or other unsuitable material. A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill are provided below.

7.7.1.2 On-Site Soil

The on-site material should generally be suitable for use as general structural fill, provided it is properly moisture conditioned; free of debris, organic material, and particles over 8 inches in diameter; and meets the specifications provided in OSSC 00330.12 (Borrow Material). Moisture conditioning (drying) and extended periods of dry weather will likely be required to use on-site silt and sand soil for structural fill. It will be difficult, if not impossible, to adequately compact silt and sand soil during the rainy season or during prolonged periods of rainfall unless it is cement amended. In general, silt and sand soil should only be used as structural fill during the dry summer months. Silt and sand material should be placed in lifts with a maximum uncompacted thickness of 8 inches and compacted to not less than 92 percent of the maximum dry density, as determined by ASTM D1557.

The gravel unit contains varying proportions of silt, sand, cobbles, and boulders. Portions of the gravel containing more than approximately 10 percent silt and clay particles will be difficult to compact during periods of wet weather. Boulders and cobbles over 6 inches in diameter should be removed if the material is used as structural fill. Large equipment with high energy will be needed to adequately compact gravel soil containing cobbles. It will be difficult to evaluate gravel compaction using traditional testing methods. Compaction should be evaluated by observing the contractor's means and methods and proof rolling with heavy construction equipment.

7.7.1.3 Imported Granular Material

Imported granular material used as structural fill should be pit- or quarry-run rock, crushed rock, or crushed gravel and sand. The imported granular material should also be durable, angular, and fairly well graded between coarse and fine material; should have less than 5 percent fines (material passing the U.S. Standard No. 200 sieve) by dry weight; and should have at least two mechanically fractured faces.

Imported granular material should be placed in lifts with a maximum uncompacted thickness of 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557. During the wet season or when wet subgrade conditions exist, the initial lift should be approximately 18 inches in uncompacted thickness and should be compacted by rolling with a smooth-drum roller without using vibratory action.

7.7.1.4 Stabilization Material

Stabilization material used in staging or haul road areas or in trenches should consist of durable, 4- or 6-inch-minus pit- or quarry-run rock, crushed rock, or crushed gravel and sand. The material should have a maximum particle size of 6 inches, should have less than 5 percent by dry weight passing the U.S. Standard No. 4 sieve, and should have at least two mechanically fractured faces. The material should be free of organic material and other deleterious material. Stabilization material should be placed in lifts between 12 and 24 inches thick and compacted to a firm condition.

7.7.1.5 Trench Backfill

Trench backfill placed beneath, adjacent to, and for at least 12 inches above utility lines (i.e., the pipe zone) should consist of durable, well-graded granular material with a maximum particle size of 1½ inches, should have less than 7 percent fines by dry weight, and should have at least two mechanically fractured faces. The pipe zone backfill should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer or local building department.

Within roadway alignments, the remainder of the trench backfill up to the subgrade elevation should consist of durable, well-graded granular material with a maximum particle size of 2½ inches, should have less than 7 percent fines by dry weight, and should have at least two mechanically fractured faces. This material should be compacted to at least 92 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer or local building department. The upper 3 feet of the trench backfill should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D1557.

Outside of structural improvement areas (e.g., roadway alignments or building pads) trench backfill placed above the pipe zone may consist of general fill material that is free of organic material and material over 6 inches in diameter. This general trench backfill should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer or local building department.

7.7.1.6 Floor Slab Aggregate Base

Imported granular material used as base rock for building floor slabs should consist of ¾- or 1½-inch-minus material (depending on the application). In addition, the aggregate should have less than 5 percent fines by dry weight and have at least two mechanically fractured faces. The aggregate base should be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

7.7.1.7 Pavement Aggregate Base

Imported granular material used as base rock for pavement should consist of ¾- or 1½-inch-minus material (depending on the application). In addition, the aggregate should have less than 5 percent fines by dry weight and have at least two mechanically fractured faces. The aggregate base should be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

7.7.1.8 Retaining Wall Select Backfill

Backfill material placed behind retaining walls and extending a horizontal distance of ½H, where H is the height of the retaining wall, should consist of imported granular material as described above and should have less than 7 percent fines by dry weight. We recommend the wall backfill be separated from general fill, native soil, and/or topsoil using a geotextile fabric that meets the specifications provided below for drainage geotextiles.

The wall backfill should be compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D1557. However, backfill located within a horizontal distance of 3 feet from a retaining wall should only be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D1557. Backfill placed within 3 feet of the wall should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (such as a jumping jack or vibratory plate compactor). If flatwork (sidewalks or pavement) will be placed atop the wall backfill, we recommend the upper 2 feet of material be compacted to 95 percent of the maximum dry density, as determined by ASTM D1557.

7.7.1.9 Drain Rock Material

Drain rock should consist of angular, granular material with a maximum particle size of 2 inches. The material should be free of roots, organic material, and other unsuitable material; should have less than 2 percent by dry weight passing the U.S. Standard No. 200 sieve (washed analysis); and should have at least two mechanically fractured faces. Drain rock should be compacted to a well-keyed, firm condition.

7.7.1.10 Retaining Wall Leveling Pad

Imported granular material placed at the base of retaining wall footings should consist of select granular material. The granular material should be 1”-0 to ¾”-0 aggregate size and have at least two mechanically fractured faces. The leveling pad material should be placed in a 6- to 12-inch-thick lift and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

7.7.2 Geotextile Fabric

7.7.2.1 Subgrade Geotextile

Subgrade geotextile should conform to OSSC Table 02320-4 and OSSC 00350 (Geosynthetic Installation). A minimum initial aggregate base lift of 6 inches is required over geotextiles. All drainage aggregate and stabilization material should be underlain by a subgrade geotextile.

7.7.2.2 Drainage Geotextile

Drainage geotextile should conform to Type 2 material of OSSC Table 02320-1 and OSSC 00350 (Geosynthetic Installation). A minimum initial aggregate base lift of 6 inches is required over geotextiles.

7.7.3 Soil Amendment with Cement

7.7.3.1 General

As an alternative to the use of imported granular material for wet weather structural fill and as a subbase for the pavement section, the on-site soil can be amended with portland cement to obtain suitable support properties. Cement-amended soil can also allow for a reduction in haul road/staging area thickness used for subgrade protection during periods of wet weather. Successful use of soil amendment depends on the use of correct mixing techniques, soil moisture content, and amendment quantities. Soil amendment should be conducted in accordance with the specifications provided in OSSC 00344 (Treated Subgrade). The amount of cement used during amendment should be based on an assumed soil dry unit weight of 100 pcf.

7.7.3.2 Subbase Stabilization

Specific recommendations should be based on exposed site conditions at the time of amendment. However, for preliminary design purposes, we recommend a target strength for cement-amended subgrade for building and pavement subbase (below aggregate base) soil of

100 psi. The amount of cement used to achieve this target generally varies with moisture content and soil type. Laboratory testing prior to and/or during amendment should be used to confirm expectations; however, our experience with the on-site silt/sand indicates that generally 6 percent cement by weight of dry soil can be used when the soil moisture content does not exceed approximately 23 percent. If the soil moisture content is in the range of 23 to 35 percent, 7 to 8 percent by weight of dry soil is recommended. During the wet winter months, it is likely that soil-moisture content will exceed 23 percent. The amount of cement added to the soil may need to be adjusted based on field observations and performance. During the dry summer months, water may need to be added during tilling to appropriately condition the soil moisture content.

We recommend assuming a minimum cement ratio of 6 percent by dry weight, with higher rates as discussed above. If amendment occurs during the wet season, we recommend assuming a higher cement ratio of 7 to 8 percent.

In general, we recommend using a shrinkage factor for earthwork calculations with cement-amended on-site soil as follows.

- The moisture contents in the wetter winter through spring will likely be higher, resulting in an increased cement percentage and a corresponding shrinkage factor of 16 to 17 percent.
- The moisture contents in the dryer summer through fall will likely be lower, resulting in a decreased cement percentage and a corresponding shrinkage factor of 13 to 14 percent

We recommend cement-amendment equipment be equipped with balloon tires to reduce rutting and disturbance of the fine-grained soil. A sheepsfoot or segmented pad roller with a minimum static weight of 40,000 pounds should be used for initial compaction of the fine-grained soil without the use of vibratory action. A smooth-drum roller with a minimum applied linear force of 700 pounds per inch should be used for final compaction. The amended soil should be compacted to at least 92 percent of the achievable dry density at the moisture content of the material, as defined in ASTM D1557.

A minimum curing time of four days is required between amendment and construction traffic access. Construction traffic should not be allowed on unprotected, cement-amended subgrade. To protect the cement-amended surfaces from abrasion or damage, the finished surface should be covered with 4 to 6 inches of imported granular material.

Amendment depths for subgrade beneath buildings and pavement, haul roads, and staging areas are typically on the order of 12, 16, and 12 inches, respectively. The crushed rock typically becomes contaminated with soil during construction. Contaminated base rock should be removed and replaced with clean rock in pavement areas. The actual thickness of the amended material and imported granular material for haul roads and staging areas will depend on the anticipated traffic, as well as the contractor's means and methods and should be the contractor's responsibility.

Cement amendment should not be attempted when air temperature is below 40 degrees Fahrenheit or during moderate to heavy precipitation. Cement should not be placed when the ground surface is saturated or standing water exists.

7.7.3.3 Cement-Amended Structural Fill

On-site soil that would not otherwise be suitable for structural fill may be amended and placed as fill over a subgrade prepared in conformance with the "Site Preparation" section. The cement ratio for general cement-amended fill can generally be reduced by 1 percent (by dry weight). Typically, a minimum curing time of four days is required between amendment and construction traffic access. Consecutive lifts of fill may be amended immediately after the previous lift has been amended and compacted (e.g., the four-day wait period does not apply). However, where the final lift of fill is a building or roadway subbase material, the four-day wait period is in effect.

7.7.3.4 Other Considerations

Portland cement-amended soil is hard and has low permeability. This soil does not drain well and it is not suitable for planting. Future planted areas should not be cement amended, if practical, or accommodations should be made for drainage and planting. Moreover, cement amending soil within building areas must be done carefully to avoid trapping water under floor slabs. We should be contacted if this approach is considered. Cement amendment should not be used if runoff during construction cannot be directed away from adjacent wetlands. In general, cement amendment is not recommended during the cold weather (temperatures less than 40 degrees Fahrenheit) or during steady rainfall.

Lastly, the new Oregon Department of Environmental Quality requirements under 1200C permits include additional requirements for routing and testing runoff from sites where cement amendment is used.

7.7.4 Pavement

7.7.4.1 ACP

The AC should be Level 2, ½-inch, dense ACP in parking areas and Level 3, ½-inch, dense ACP in heavy truck areas according to OSSC 00744 (Asphalt Concrete Pavement). The AC should be compacted to 92 percent of the theoretical maximum density of the mix, as determined by AASHTO T 209. The minimum and maximum lift thicknesses are 2 and 3 inches, respectively, for ½-inch ACP. Asphalt binder should be performance graded and conform to PG 64-22. The binder grade should be adjusted depending on the aggregate gradation and amount of recycled asphalt pavement and/or recycled asphalt shingles in the contractor's mix design submittal.

7.7.4.2 Cold Weather Paving Considerations

In general, AC paving is not recommended during cold weather (temperatures less than 40 degrees Fahrenheit). Compacting under these conditions can result in low compaction and premature pavement distress.

Each AC mix design has a recommended compaction temperature range that is specific for the particular AC binder used. In colder temperatures, it is more difficult to maintain the temperature of the AC mix as it can lose heat while stored in the delivery truck, as it is placed, and in the time between placement and compaction. In Oregon, the AC surface temperature during paving should be at least 40 degrees Fahrenheit for lift thickness greater than 2.5 inches and at least 50 degrees Fahrenheit for lift thickness between 2 and 2.5 inches.

If paving activities must take place during cold weather construction as defined above, the project team should be consulted and a site meeting should be held to discuss ways to lessen low compaction risks.

7.7.4.3 PCC

PCC should be Class 4000, 1½-inch paving concrete according to OSSC 02001 (Concrete) with a minimum 28-day flexural strength of 600 psi. The length-to-width ratio for any panel should be at least 0.80 and should not exceed 1.25. Pavement for the guard shack should be constructed as plain concrete pavement with 1.5-inch doweled joints and 16-foot maximum joint spacing in general accordance with OSSC 00755 (Plain Concrete Pavement). Joints in truck bays should have a maximum 14-foot joint spacing. Reinforcing and specifications should be provided by the site civil and structural engineering team.

7.8 EROSION CONTROL

The site soil is susceptible to erosion; therefore, erosion control measures should be carefully planned and in place before construction begins. Surface water runoff should be collected and directed away from slopes to prevent water from running down the slope face. Erosion control measures (such as straw bales, sediment fences, and temporary detention and settling basins) should be used in accordance with local and state ordinances and the project 1200C permit.

8.0 OBSERVATION OF CONSTRUCTION

Satisfactory foundation and earthwork performance depends to a large degree on quality of construction. Sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. Subsurface conditions observed during construction should be compared with those encountered during the subsurface exploration. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect if subsurface conditions change significantly from those anticipated.

We recommend that NV5 be retained to observe earthwork activities, including stripping, proof rolling of the subgrade and repair of soft areas, footing subgrade preparation, final proof rolling of the pavement subgrade and base rock, and AC placement and compaction, and performing laboratory compaction and field moisture-density tests.

9.0 LIMITATIONS

We have prepared this report for use by TC Pursuit Services, Inc. and members of the design and construction teams for the proposed project. The data and report can be used for bidding or estimating purposes, but our report, conclusions, and interpretations should not be construed as warranty of the subsurface conditions and are not applicable to other nearby building sites.

Exploration observations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The site development plans and design details were preliminary at the time this report was prepared. When the design has been finalized and if there are changes in the site grades or location, configuration, design loads, or type of construction, the conclusions and recommendations presented may not be applicable. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification.

The scope does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in this report for consideration in design.

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

♦ ♦ ♦

We appreciate the opportunity to be of service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

NV5

Scott McDevitt, P.E., G.E.
Associate Engineer

Nick Paveglio, P.E.
Principal Engineer

REFERENCES

Allen, J.E., Burns, M., and Sargent, S.C., 1986, Cataclysms on the Columbia. Timber Press, Portland, Oregon: 211p.

ASCE, 2016. Minimum Design Loads for Buildings and Other Structures. ASCE Standard ASCE/SEI 7-016. American Society of Civil Engineers.

Burns, W.J., and Coe, D.E., 2012, Missoula Floods – Inundation Extent and Primary Flood Features in the Portland Metro Area. Oregon Department of Geology and Mineral Industries, IMS-36.

Burns, S., Growney, L., Broderson, B., Yeats, R.S., and Popowski, T.A., 1997, Map showing faults, bedrock geology, and sediment thickness of the western half of the Oregon City 1:100,000 quadrangle, Washington, Multnomah, Clackamas, and Marion Counties, Oregon. Oregon Department of Geology and Mineral Industries, IMS-4, scale 1:100,000.

Evarts, R.C., O'Connor, J.E., and Tolan, T.L., 2013, Geologic Map of the Washougal Quadrangle, Clark County, Washington and Multnomah County, Oregon. U.S. Geological Survey Scientific Investigations Map 3257.

GeoDesign, Inc., 2018. *Preliminary Geotechnical Engineering Services; Lewelling Property, Zimmer/Borg Property, Weygandt Property; Pioneer Industrial Park; Canby, Oregon,* dated August 2, 2018. GeoDesign Projects: TrammellCr-77-01, TrammellCr-78-01, and TrammellCr-79-01

Gannett, M.W., and Caldwell, R.R., 1998, Geologic Framework of the Willamette Lowland Aquifer System, Oregon and Washington. U. S. Geological Survey Professional Paper 1424-A, 32p, 8 plates.

Lanagan, 2021. *Traffic Impact Analysis Amendment; Canby South Development; S Township Road; Canby, OR,* dated August 4, 2021. Lanagan Project: 700103401

O'Connor, J.E., Sarna-Wojcicki, A., Wozniak, K.C., Polette, D.J., and Fleck, R.J., 2001, Origin, Extent and Thickness of Quaternary Geologic Units in the Willamette Valley, Oregon. U.S. Geological Survey Professional Paper 1620, 62 p.

ODOT, 2021. *Oregon Standard Specifications for Construction,* Oregon Department of Transportation, 2021 Edition.

Orr, E.L. and Orr, W.N., 1999, Geology of Oregon. Kendall/Hunt Publishing Company, Iowa: 254 p.

State of Oregon 2019 Structural Specialty Code.

Tolan, T.L., and Beeson, M.H., 1984, Intracanyon Flows of the Columbia River Basalt Group in the Lower Columbia Gorge and Their Relationship to the Troutdale Formation. GSA Bulletin 95 (4), pp. 463 to 477.

FIGURES

NV5	TRAMMELLCR-79-05	VICINITY MAP	
	AUGUST 2021	CANBY SOUTH CANBY, OR	FIGURE 1

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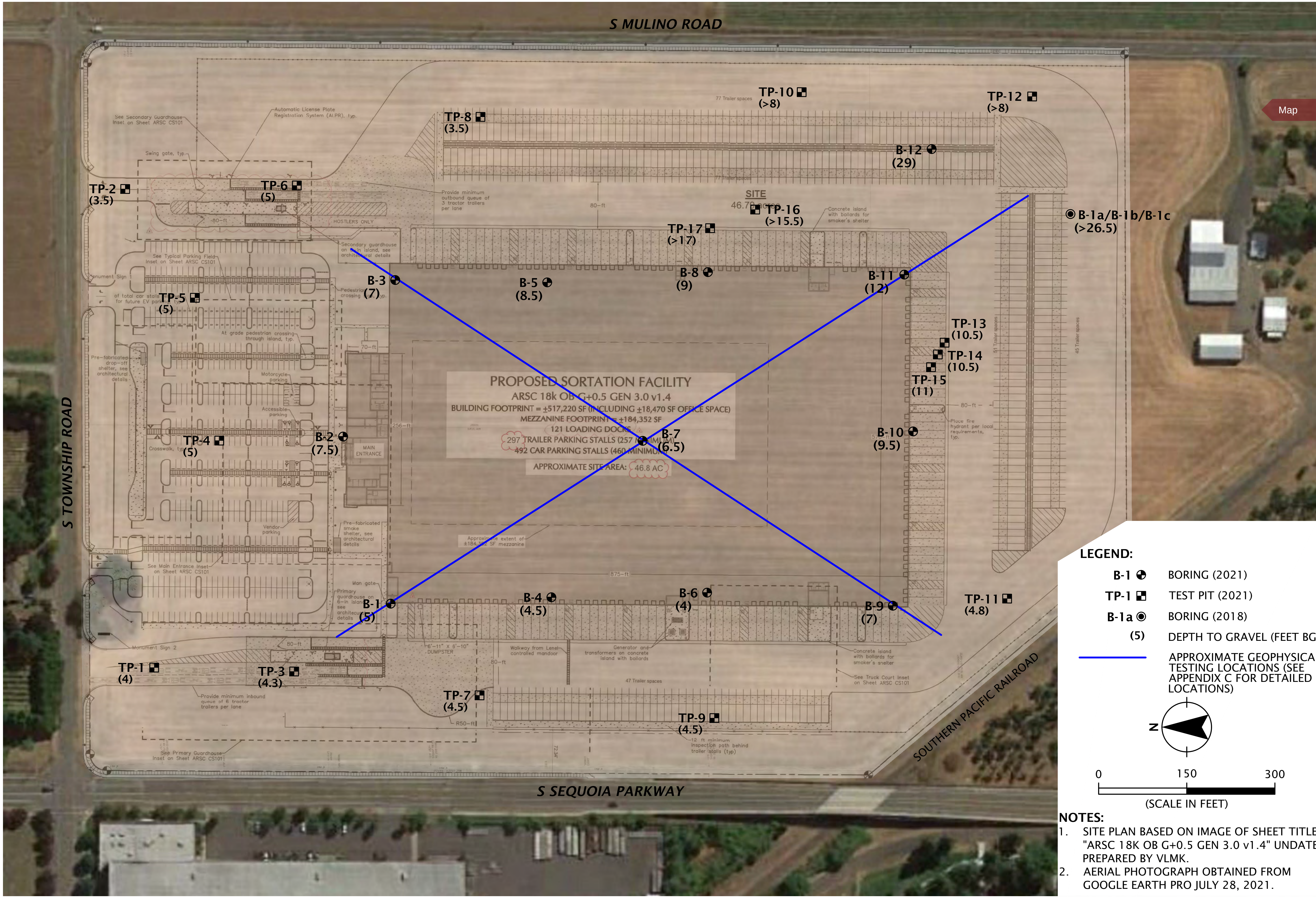
File Name: J:\S-Z\TrammellCr\TrammellCr-79\TrammellCr-79-05\Figures\CAD\TrammellCr-79-05-VM01.dwg | Layout: FIGURE 1



NV5

TRAMMELLCR-79-05

AUGUST 2021

SITE PLAN

CANBY SOUTH
CANBY, OR

FIGURE 2

Map

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APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

GENERAL

We explored subsurface conditions at site by drilling 12 borings (B-1 through B-12) to depths between 9 and 36.5 feet BGS and excavating 17 test pits (TP-1 through TP-17) to depths between 8 and 18.5 feet BGS. Drilling services were provided by Holt Services, Inc. on May 26 through 28, 2021 using hollow-stem auger or mud rotary techniques. Test pit services were provided by Dan J. Fischer Excavating, Inc. on July 9 and 19, 2021 using a backhoe. The exploration logs are presented in this appendix. Figure 2 shows the exploration locations relative to proposed site features. Past exploration logs at the site are presented in Appendix B. The geophysical testing report is presented in Appendix C.

SOIL SAMPLING

A member of NV5's staff observed the explorations. We collected representative samples of the various soils encountered during drilling for geotechnical laboratory testing. Samples were collected from the borings using 1½- or 3-inch-inside diameter split-spoon SPT sampler in general accordance with ASTM D1586. The samplers were driven into the soil with a 140-pound automatic trip hammer free falling 30 inches. The sampler was driven a total distance of 18 inches. The number of blows required to drive the sampler the final 12 inches is recorded on the exploration logs, unless otherwise noted. Representative disturbed samples of soil observed in the test pit explorations were collected from the test pit walls and base using the trackhoe or backhoe bucket. Sampling methods and intervals are shown on the exploration logs.

The average efficiency of the automatic SPT hammer used by Holt Services, Inc. was 97 percent. The calibration testing results are presented at the end of this appendix.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the "Exploration Key" (Table A-1) and "Soil Classification System" (Table A-2), which are presented in this appendix. The exploration logs indicate the depths at which the soils or their characteristics change, although the change actually could be gradual. If the change occurred between sample locations, the depth was interpreted. Classifications are shown on the exploration logs.

LABORATORY TESTING

CLASSIFICATION

The soil samples were classified in the laboratory to confirm field classifications. The laboratory classifications are shown on the exploration logs if those classifications differed from the field classifications.

MOISTURE CONTENT

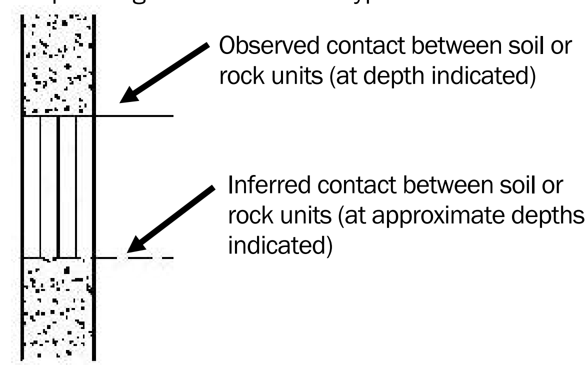
The natural moisture content of select soil samples was determined in general accordance with ASTM D2216. The natural moisture content is a ratio of the weight of the water to soil in a test sample and is expressed as a percentage. The test results are presented in this appendix.

PARTICLE-SIZE ANALYSIS

We completed particle-size analysis on select soil samples in order to determine the particle size distribution. The test determined percent fines (passing the U.S. Standard No. 200 sieve) in general accordance with ASTM D1140 and C117. The test results are presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
	Location of sample collected in general accordance with ASTM D1586 using Standard Penetration Test (SPT) with recovery
	Location of sample collected using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D1587 with recovery
	Location of sample collected using Dames & Moore sampler and 300-pound hammer or pushed with recovery
	Location of sample collected using Dames & Moore sampler and 140-pound hammer or pushed with recovery
	Location of sample collected using 3-inch-outside diameter California split-spoon sampler and 140-pound hammer with recovery
	Location of grab sample
	Rock coring interval
	Water level during drilling
	Water level taken on date shown

Graphic Log of Soil and Rock Types



GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density	RES	Resilient Modulus
DS	Direct Shear	SIEV	Sieve Gradation
HYD	Hydrometer Gradation	TOR	Torvane
MC	Moisture Content	UC	Unconfined Compressive Strength
MD	Moisture-Density Relationship	VS	Vane Shear
NP	Non-Plastic	kPa	Kilopascal
OC	Organic Content		

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

NV5 | EXPLORATION KEY | TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOIL			
Relative Density	**Standard Penetration Test (SPT) Resistance**	**Dames & Moore Sampler (140-pound hammer)**	**Dames & Moore Sampler (300-pound hammer)**
Very loose	0 – 4	0 – 11	0 – 4
Loose	4 – 10	11 – 26	4 – 10
Medium dense	10 – 30	26 – 74	10 – 30
Dense	30 – 50	74 – 120	30 – 47
Very dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL				
Consistency	**Standard Penetration Test (SPT) Resistance**	**Dames & Moore Sampler (140-pound hammer)**	**Dames & Moore Sampler (300-pound hammer)**	**Unconfined Compressive Strength (tsf)**
Very soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 – 4	3 – 6	2 – 5	0.25 – 0.50
Medium stiff	4 – 8	6 – 12	5 – 9	0.50 – 1.0
Stiff	8 – 15	12 – 25	9 – 19	1.0 – 2.0
Very stiff	15 – 30	25 – 65	19 – 31	2.0 – 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION	
Term	**Field Test**
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS					
Secondary granular components or other materials such as organics, man-made debris, etc.					
Percent	**Silt and Clay In:**		**Percent**	**Sand and Gravel In:**	
	Fine-Grained Soil	**Coarse-Grained Soil**		**Fine-Grained Soil**	**Coarse-Grained Soil**
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

NV5

SOIL CLASSIFICATION SYSTEM

TABLE A-2

BORING B-1

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0	Stiff, brown, sandy SILT (ML), trace organics (rootlets); moist, sand is fine to medium (11-inch-thick tilled zone, 3-inch-thick root zone).	166.0	P200	8	P200 = 56%
5	Dense, brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	161.0 / 5.0		43	
	medium dense, with cobbles at 8.0 feet			17	Very hard drilling from 8.0 feet to end of boring.
	very dense at 9.0 feet				
10				120/4"	
	Exploration completed at a depth of 10.3 feet.	155.7 / 10.3			
	Hammer efficiency factor is 97 percent.				

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40 feet. Chart scale: 0, 50, 100.

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC%

GRAPHIC LOG | SAMPLE

DRILLED BY: Holt Services, Inc. | LOGGED BY: L. Gose | COMPLETED: 05/28/21

BORING METHOD: mud rotary (see document text) | BORING BIT DIAMETER: 4 7/8 inches

NV5

TRAMMELLCR-79-05

AUGUST 2021

BORING B-1

CANBY SOUTH
CANBY, OR

FIGURE A-1

BORING B-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	SAMPLE	BLOW COUNT	MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0	Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to medium (14-inch-thick tilled zone, 3-inch-thick root zone).	167.0				
2.5			Sample	9	●	
5	brown-gray at 5.0 feet		Sample	5		
7.5	Very dense, dark gray-brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	159.5 / 7.5	Sample	61		
10	dense at 10.0 feet		Sample	47		Very hard drilling from 10.0 feet to end of boring.
15	very dense at 15.0 feet		Sample	65		
16.5	Exploration terminated at a depth of 16.5 feet due to refusal on gravel. Hammer efficiency factor is 97 percent.	150.5 / 16.5				

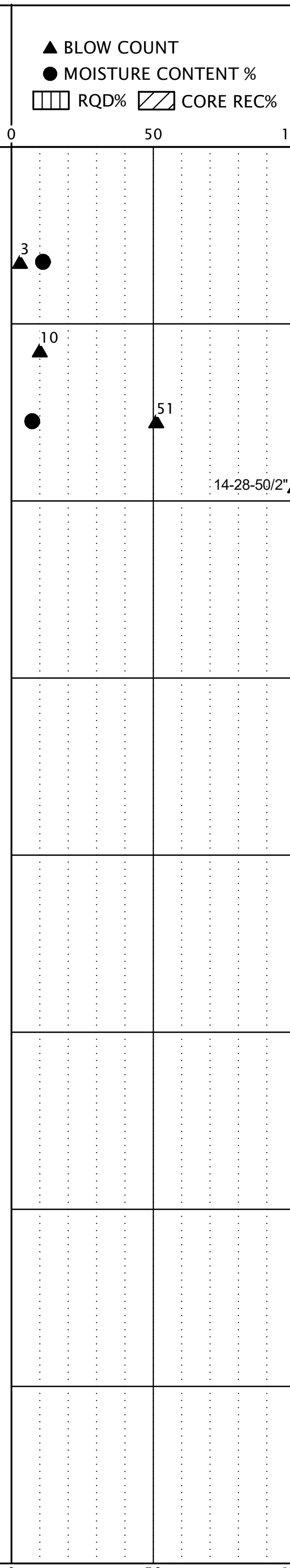
Legend: ▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (scale 0–100)

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/26/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5	TRAMMELLCR-79-05	BORING B-2	
	AUGUST 2021	CANBY SOUTH CANBY, OR	FIGURE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	BLOW COUNT / MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0	Very loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to medium (12-inch-thick tilled zone, 3-inch-thick root zone).	165.0	P200	3	P200 = 23%
5	medium dense at 5.0 feet			10	
7	Very dense, gray GRAVEL with sand and cobbles (GP), trace silt; moist, sand is fine to coarse.	158.0 / 7.0		51; 14-28-50/2"	Approximately 40% cobbles in cuttings (up to 3 inches in diameter) from 8.0 to 9.0 feet.
10.2	Exploration completed at a depth of 10.2 feet. Hammer efficiency factor is 97 percent.	154.8 / 10.2			



DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/27/21

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 6 1/4 inches

NV5

TRAMMELLCR-79-05

AUGUST 2021

BORING B-3

CANBY SOUTH
CANBY, OR

FIGURE A-3

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
0		Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine (11-inch-thick tilled zone, 2-inch-thick root zone).	166.0			8	
5		Very dense, dark gray-brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	161.5 / 4.5			69	
		Medium dense, brown, silty SAND (SM); moist, sand is fine to medium.	159.0 / 7.0			24	
10		Very dense, brown GRAVEL with silt, sand, and cobbles (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	157.0 / 9.0			58	
		Exploration completed at a depth of 11.5 feet. Hammer efficiency factor is 97 percent.	154.5 / 11.5				
15							
20							
25							
30							
35							
40							

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/27/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5

TRAMMELLCR-79-05

AUGUST 2021

BORING B-4

CANBY SOUTH
CANBY, OR

FIGURE A-4

BORING LOG - NV5 - 1 PER PAGE TRAMMELLCR-79-05-B1_12-TP1_17.GPJ GDI_NV5.GDT PRINT DATE: 8/12/21:SN:KT

Depth (feet)	Material Description	Elevation / Depth	Testing	Blow Count	Moisture Content %	Installation and Comments
0	Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to medium (10-inch-thick tilled zone, 4-inch-thick root zone).	165.0		6		
5			P200	7	●	P200 = 20%
7.0	Medium dense, brown, silty SAND (SM); moist, sand is fine to medium.	158.0 / 7.0		27		
8.5	Medium dense, brown-gray GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded.	156.5 / 8.5		31		
11.5	Exploration completed at a depth of 11.5 feet. Hammer efficiency factor is 97 percent.	153.5 / 11.5				

Legend: ▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/26/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5 | TRAMMELLCR-79-05 | AUGUST 2021

BORING B-5

CANBY SOUTH
CANBY, OR

FIGURE A-5

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0		Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine (12-inch-thick tilled zone, 3-inch-thick root zone).	167.0				
					■	▲ 22	
5		Dense, gray GRAVEL with sand (GP), trace silt; moist, gravel is fine to coarse and subrounded.	163.0 / 4.0		■	▲ 41	
		very dense, with cobbles at 6.5 feet			■	● ▲ 109	Infiltration test attempted at 7.5 and 8.0 feet. Zero water infiltration was observed, possibly due to auger being nested on a cobble.
10		Exploration completed at a depth of 9.0 feet. Hammer efficiency factor is 97 percent.	158.0 / 9.0				
15							
20							
25							
30							
35							
40							

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/27/21

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 6 1/4 inches

NV5	TRAMMELLCR-79-05	**BORING B-6**
	AUGUST 2021	CANBY SOUTH CANBY, OR — **FIGURE A-6**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0	Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to medium (10-inch-thick tilled zone, 3-inch-thick root zone).	167.0				
	medium dense at 4.0 feet				9	
5	dense at 5.0 feet				● 37	
	Dense, brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	160.5 / 6.5			46	
10	very dense at 10.0 feet				37-82-120/1"	
	Exploration completed at a depth of 11.1 feet.	155.9 / 11.1				
	Hammer efficiency factor is 97 percent.					
15						
20						
25						
30						
35						
40						

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/28/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5	TRAMMELLCR-79-05	BORING B-7	
	AUGUST 2021	CANBY SOUTH CANBY, OR	FIGURE A-7

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0		Loose, brown, silty SAND (SM), trace organics (rootlets); moist (10-inch-thick tilled zone, 4-inch-thick root zone).	166.0				
					■	▲ 9, ●	
5		without organics at 5.0 feet			■	▲ 6	
		with gravel at 7.5 feet			■	● ▲ 27	
		Dense, brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	157.0 / 9.0				
10					■	▲ 31	
15		very dense at 16.0 feet			■	▲ 51	
		Exploration completed at a depth of 16.5 feet. Hammer efficiency factor is 97 percent.	149.5 / 16.5				
20							
25							
30							
35							
40							

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/26/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5 | TRAMMELLCR-79-05 | AUGUST 2021

BORING B-8

CANBY SOUTH
CANBY, OR

FIGURE A-8

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	BLOW COUNT / MOISTURE CONTENT % / RQD% / CORE REC% (0–50–100)	INSTALLATION AND COMMENTS
0	Very loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine (11-inch-thick tilled zone, 3-inch-thick root zone).	167.0	P200		▲ 3; ● moisture content	P200 = 45%
5	medium dense, trace gravel at 5.0 feet				▲ 17	
7.0	Very dense, gray-brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	160.0 / 7.0			▲ 54	
10					▲ 56	
11.5	Exploration completed at a depth of 11.5 feet. Hammer efficiency factor is 97 percent.	155.5 / 11.5				
15						
20						
25						
30						
35						
40						

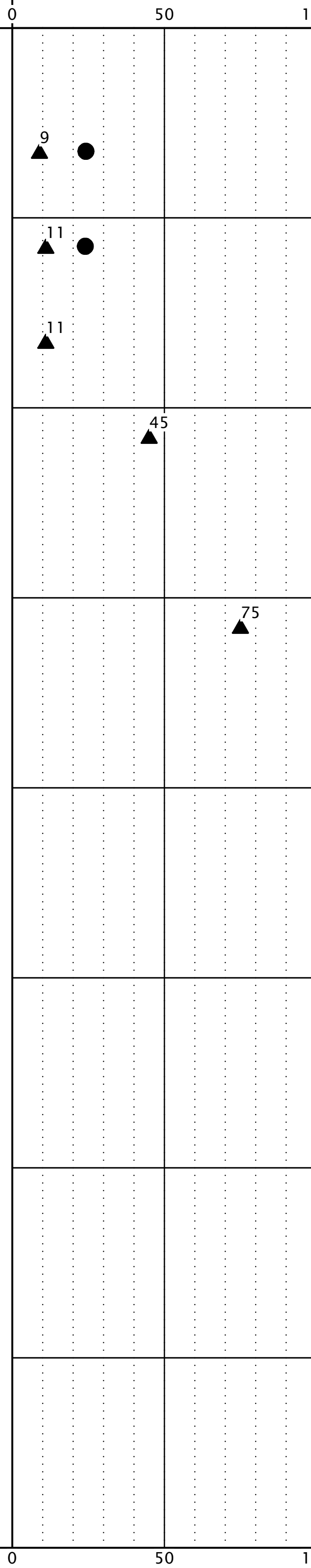
DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/27/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5 | TRAMMELLCR-79-05 | **BORING B-9**

AUGUST 2021 | CANBY SOUTH CANBY, OR | **FIGURE A-9**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC%	INSTALLATION AND COMMENTS
0		Stiff, brown, sandy SILT (ML), trace organics (rootlets); moist, sand is fine (12-inch-thick tilled zone, 3-inch-thick root zone).	166.0			9	
5		Medium dense, brown, silty SAND (SM); moist, sand is fine to medium.	161.5 / 4.5			11, 11	
10		Dense, brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	156.5 / 9.5			45	
15		very dense, with cobbles at 15.0 feet				75	Hard drilling at 15.0 feet.
		Exploration terminated at a depth of 16.5 feet due to refusal on dense gravel. Hammer efficiency factor is 97 percent.	149.5 / 16.5				



DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/26/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5

TRAMMELLCR-79-05	**BORING B-10**	
AUGUST 2021	CANBY SOUTH CANBY, OR	**FIGURE A-10**

BORING B-11

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	BLOW COUNT	MOISTURE CONTENT %
0	Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to medium (12-inch-thick tilled zone, 3-inch-thick root zone).	165.0	9	●
4.5	Loose, brown SAND with silt (SP-SM), trace organics (rootlets); moist, sand is fine to coarse.	160.5 / 4.5	16	
7.5	medium dense at 7.5 feet		21	
9.5	Medium dense, brown, silty SAND (SM); moist, sand is fine to coarse.	155.5 / 9.5	13	●
12.0	Medium dense, brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	153.0 / 12.0	27	
20.0	very dense at 20.0 feet		14-21-50/3"	
21.3	Exploration completed at a depth of 21.3 feet. Hammer efficiency factor is 97 percent.	143.7 / 21.3		

TESTING | SAMPLE | ▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100) | INSTALLATION AND COMMENTS

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/28/21

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5

TRAMMELLCR-79-05

AUGUST 2021

BORING B-11

CANBY SOUTH
CANBY, OR

FIGURE A-11

BORING B-12

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH
0	Loose, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to medium (16-inch-thick tilled zone, 3-inch-thick root zone).	158.0
4.5	Very loose, dark brown SAND with silt (SP-SM); moist, sand is fine to medium.	153.5 / 4.5
7.5	medium dense, dark gray at 7.5 feet	
10.0	with gravel; sand is fine to coarse at 10.0 feet	
23.0	Medium dense, brown, silty SAND (SM); wet, sand is fine.	135.0 / 23.0
27.0	with gravel at 27.0 feet	
29.0	Dense, dark gray GRAVEL with sand (GP), trace silt; wet, gravel is fine to coarse and subrounded, sand is fine to coarse.	129.0 / 29.0
36.5	Exploration completed at a depth of 36.5 feet.	121.5 / 36.5
	Hammer efficiency factor is 97 percent.	

▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (scale 0 – 50 – 100)

Sample Depth (ft, approx.)	Blow Count	Moisture Content
2.5	5	
5	3	●
7.5	13	
10	21	●
12.5	15	
15	21	
20	28	
25	25	●
30	48	
35	34	

INSTALLATION AND COMMENTS

▼ 30.3 feet, after drilling

DRILLED BY: Holt Services, Inc. LOGGED BY: L. Gose COMPLETED: 05/28/21

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 6 1/4 inches

NV5	TRAMMELLCR-79-05	BORING B-12
	AUGUST 2021	CANBY SOUTH CANBY, OR
		FIGURE A-12

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Loose to medium dense, brown, silty SAND (SM), trace organics (roots); dry to moist, sand is fine (12-inch-thick tilled zone, 3-inch-thick root zone).	164.0	PP PP			PP = >4.5 tsf PP = >4.5 tsf
					☒	●	
2.5				PP PP			PP = >4.5 tsf PP = >4.5 tsf
		minor gravel at 3.5 feet		P200	☒	●	P200 = 39%
		Dense, brown GRAVEL with silt and cobbles (GP-GM), minor sand; dry to moist, gravel is fine to coarse and subrounded to subangular, cobbles are approximately 30%.	160.0 4.0	PP			PP = >4.5 tsf
5.0							
7.5							
		Exploration completed at a depth of 8.0 feet.	156.0 8.0				No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc.
LOGGED BY: J. Martinez
COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-1

CANBY SOUTH
CANBY, OR

FIGURE A-13

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	COMMENTS
0.0	Stiff, brown, sandy SILT (ML), trace organics (rootlets); dry to moist, sand is fine (12-inch-thick tilled zone, 2-inch-thick root zone). very stiff at 1.5 feet without organics at 2.5 feet	163.0	PP PP PP	☒	PP = 2.0 tsf PP = 2.0 tsf PP = 4.5 tsf
3.5	Dense, brown GRAVEL with silt and cobbles (GP-GM), minor sand; dry to moist, gravel is fine to coarse and subrounded to subangular, cobbles are approximately 15%. with boulders at 6.0 feet	159.5 3.5			Minor caving observed at 5.0 feet.
8.0	Exploration completed at a depth of 8.0 feet.	155.0 8.0			No groundwater seepage observed to the depth explored.

Depth scale (feet): 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

● MOISTURE CONTENT %: 0, 50, 100

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-2

CANBY SOUTH
CANBY, OR

FIGURE A-14

TEST PIT LOG - NV5 - 1 PER PAGE TRAMMELLCR-79-05-B1_12-TP1_17.GPJ GDI_NV5.GDT PRINT DATE: 8/12/21:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Loose to medium dense, brown, silty SAND (SM), trace organics; dry (18-inch-thick tilled zone, 2-inch-thick root zone).	167.0	PP			PP = 0.0 tsf
				PP			PP = 0.0 tsf
				PP	☒		PP = 0.25 tsf
2.5				PP			PP = 0.25 tsf
				PP			PP = 0.25 tsf
		trace gravel, without organics at 3.8 feet	162.7 / 4.3				
5.0		Dense, brown GRAVEL with silt and cobbles (GP-GM), minor sand; dry to moist, gravel is fine to coarse and subrounded, cobbles are approximately 20%.					Minor caving observed at 6.0 feet.
7.5							
		Exploration completed at a depth of 8.0 feet.	159.0 / 8.0				No groundwater seepage observed to the depth explored.
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-3

CANBY SOUTH
CANBY, OR

FIGURE A-15

TEST PIT LOG - NV5 - 1 PER PAGE TRAMMELLCR-79-05-B1_12-TP1_17.GPJ GDI_NV5.GDT PRINT DATE: 8/12/21:KT

TP-4 Log

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0	Stiff, brown, sandy SILT (ML), trace organics (rootlets); dry to moist, sand is fine to medium (10-inch-thick tilled zone, 4-inch-thick root zone).	166.0	PP	☒		PP = 1.0 tsf
			PP			PP = 1.25 tsf
3.5	Medium dense, brown, silty SAND (SM); moist, sand is fine to coarse.	162.5 / 3.5		☒		
5.0	Dense, brown GRAVEL with silt, sand, cobbles, and boulders (GP-GM), trace clay; moist, gravel is fine to coarse and subrounded, sand is fine to coarse, cobbles are approximately 20%, boulders are approximately 15%.	161.0 / 5.0		☒		
9.0	gray-brown at 9.0 feet			☒		
12.0				☒		Infiltration test at 12.0 feet.
15.0						Increasing cobble and boulder content.
16.0	Exploration completed at a depth of 16.0 feet.	150.0 / 16.0	P200	☒	●	Infiltration test at 16.0 feet. P200 = 7% No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/09/21

EXCAVATION METHOD: trackhoe (see document text)

NV5	TRAMMELLCR-79-05	**TEST PIT TP-4**	
	AUGUST 2021	CANBY SOUTH CANBY, OR	**FIGURE A-16**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Loose to medium dense, brown, silty SAND (SM), trace organics (rootlets); dry, sand is fine to medium (15-inch-thick tilled zone, 3-inch-thick root zone).	164.0	PP			PP = 0.5 tsf
				PP PP	☒		PP = 1.5 tsf PP = 2.0 tsf
2.5		without organics at 4.0 feet					
5.0		Dense, brown GRAVEL with silt and cobbles (GP-GM), minor sand; dry to moist, gravel is fine to coarse and subrounded to subangular, cobbles are approximately 10%.	159.0 5.0				Minor caving observed at 6.0 feet.
7.5		Exploration completed at a depth of 8.0 feet.	156.0 8.0				No groundwater seepage observed to the depth explored.
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0						0 50 100	

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-5

CANBY SOUTH
CANBY, OR

FIGURE A-17

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Medium stiff to stiff, brown, sandy SILT (ML), trace organics (rootlets); dry to moist, sand is fine (18-inch-thick tilled zone, 3-inch-thick root zone). very stiff at 1.5 feet without organics at 3.0 feet	162.0	PP PP PP PP PP	☒	●	PP = 2.0 tsf PP = 2.5 tsf PP = >4.5 tsf PP = >4.5 tsf PP = >4.5 tsf
5.0		Dense, brown GRAVEL with silt (GP-GM), minor sand; dry to moist. with cobbles; cobbles are approximately 10% at 6.0 feet	157.0 / 5.0				Minor caving observed at 6.0 feet.
8.0		Exploration completed at a depth of 8.0 feet.	154.0 / 8.0				No groundwater seepage observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-6

CANBY SOUTH
CANBY, OR

FIGURE A-18

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	MOISTURE CONTENT %	COMMENTS
0.0	Loose to medium dense, brown, silty SAND (SM), trace organics (rootlets); dry, sand is fine (18-inch-thick tilled zone, 4-inch-thick root zone).	167.0	PP			PP = 0.0 tsf
			PP			PP = 0.0 tsf
			PP	☒	●	PP = 0.25 tsf
2.5			PP			PP = 0.25 tsf
			PP			PP = 0.25 tsf
	without organics at 3.5 feet					
	Dense, brown-dark brown, silty SAND (SM), trace gravel; moist, gravel is fine.	163.2 / 3.8	PP	☒		PP = 2.5 tsf
5.0	Dense, brown GRAVEL with silt and cobbles (GP-GM), minor sand; moist, gravel is fine to coarse and subrounded, cobbles are approximately 10%.	162.5 / 4.5				
7.5	Exploration completed at a depth of 8.0 feet.	159.0 / 8.0				No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
10.0						
12.5						
15.0						
17.5						
20.0						
22.5						
25.0						
27.5						
30.0						

Moisture content scale: 0 50 100

EXCAVATED BY: Dan J. Fischer Excavating, Inc.
LOGGED BY: J. Martinez
COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-7

CANBY SOUTH
CANBY, OR

FIGURE A-19

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Loose to medium dense, brown, silty SAND (SM), trace gravel and organics (roots); dry to moist, sand is fine (18-inch-thick tilled zone, 4-inch-thick root zone). without gravel at 1.5 feet without organics at 3.0 feet	155.0		☒	●	
3.5		Dense, brown GRAVEL with silt and cobbles (GP-GM), minor sand; moist, gravel is fine to coarse and subrounded, cobbles are approximately 20%.	151.5 / 3.5				Minor caving observed at 5.0 feet.
8.0		Exploration completed at a depth of 8.0 feet.	147.0 / 8.0				No groundwater seepage observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5	TRAMMELLCR-79-05	**TEST PIT TP-8**	
	AUGUST 2021	CANBY SOUTH CANBY, OR	**FIGURE A-20**

TP-9 Log

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Loose to medium dense, brown, silty SAND (SM), trace organics (rootlets); dry to moist, sand is fine to medium (12-inch-thick tilled zone, 4-inch-thick root zone).	168.0		☒		
4.5		Dense, brown GRAVEL with silt, cobbles, and boulders (GP-GM), minor sand; moist, gravel is fine to coarse and subrounded, sand is fine to coarse, cobbles are approximately 20-30%.	163.5 / 4.5		☒ ☒ ☒		
9.0				P200	☒	●	Infiltration test at 9.0 feet. P200 = 10%
10.0		trace clay at 10.0 feet					
13.0		Exploration completed at a depth of 13.0 feet.	155.0 / 13.0				Infiltration test at 13.0 feet. No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/09/21

EXCAVATION METHOD: trackhoe (see document text)

NV5	TRAMMELLCR-79-05	TEST PIT TP-9	
	AUGUST 2021	CANBY SOUTH CANBY, OR	FIGURE A-21

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Medium dense to dense, brown GRAVEL with silt and sand (GP-GM), trace organics (rootlets); dry, sand is fine (18-inch-thick tilled zone, 3-inch-thick root zone).	153.0		⊠		
2.5		without organics at 2.0 feet	150.7 / 2.3	PP			PP = >4.5 tsf
		Stiff, brown, sandy SILT (ML); dry to moist.	149.2 / 3.8	PP	⊠	●	PP = 0.25 tsf
5.0		Medium dense, dark brown, silty SAND (SM); moist.					
7.5							
		Exploration completed at a depth of 8.0 feet.	145.0 / 8.0				No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05	**TEST PIT TP-10**	
AUGUST 2021	CANBY SOUTH CANBY, OR	**FIGURE A-22**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	MOISTURE CONTENT %	COMMENTS
0.0	Medium stiff to stiff, light brown, sandy SILT (ML), trace organics (rootlets); dry to moist, sand is fine (12-inch-thick tilled zone, 3-inch-thick root zone). very stiff at 1.0 foot without organics at 3.0 feet	167.0	PP PP PP PP PP PP	☒		PP = 2.25 tsf PP = 2.25 tsf PP = >4.5 tsf PP = 4.5 tsf PP = 4.5 tsf PP = 4.5 tsf
	Medium dense, brown, silty SAND (SM); moist.	163.0 / 4.0	PP	☒	●	PP = 1.5 tsf
5.0	Dense, brown GRAVEL with silt, sand, and cobbles (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse, cobbles are approximately 5%.	162.2 / 4.8				
	Exploration completed at a depth of 8.0 feet.	159.0 / 8.0		☒		No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

Moisture content scale: 0, 50, 100

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-11

CANBY SOUTH
CANBY, OR

FIGURE A-23

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 / 50 / 100)	COMMENTS
0.0		Medium dense, brown, silty SAND (SM), trace organics (rootlets); dry (18-inch-thick tilled zone, 3-inch-thick root zone).	150.0		⊠	●	
2.5		dark brown; moist at 3.5 feet			⊠		
5.0		without organics at 4.5 feet					Minor caving observed at 6.0 feet.
7.5		Exploration completed at a depth of 8.0 feet.	142.0 / 8.0				No groundwater seepage observed to the depth explored.
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/19/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-12

CANBY SOUTH
CANBY, OR

FIGURE A-24

TEST PIT LOG - NV5 - 1 PER PAGE TRAMMELLCR-79-05-B1_12-TP1_17.GPJ GDI_NV5.GDT PRINT DATE: 8/12/21:KT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0–50–100)	COMMENTS
0.0	Loose to medium dense, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to coarse (14-inch-thick tilled zone, 5-inch-thick root zone).	166.0		☒ ☒		
7.0	Medium dense, dark brown-gray SAND with silt (SP-SM); moist, sand is fine to coarse.	159.0 / 7.0		☒		
10.5	Medium dense, dark gray GRAVEL with silt, sand, and cobbles (GP-GM); moist, gravel is fine to coarse and subrounded, sand is fine to coarse, cobbles are approximately 15%.	155.5 / 10.5				
11.0	Exploration completed at a depth of 11.0 feet.	155.0 / 11.0	P200	☒	●	Infiltration test at 11.0 feet. P200 = 8% No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/09/21

EXCAVATION METHOD: backhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-13

CANBY SOUTH
CANBY, OR

FIGURE A-25

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Dense, brown, silty SAND (SM), trace organics (rootlets); moist, sand is fine to coarse (14-inch-thick tilled zone, 5-inch-thick root zone).	166.0				
7.0		Medium dense, dark brown-gray SAND with silt (SP-SM); moist, sand is fine to coarse.	159.0 / 7.0				
10.5		Medium dense, gray GRAVEL with sand (GP), trace silt; moist, gravel is fine to coarse, sand is fine to coarse.	155.5 / 10.5				
15.0					☒		Infiltration test at 15.0 feet.
18.5		Exploration terminated at a depth of 18.5 feet due to refusal on boulders.	147.5 / 18.5	P200	☒	●	Infiltration test at 18.5 feet. P200 = 5% No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: J. Martinez

COMPLETED: 07/09/21

EXCAVATION METHOD: trackhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-14

CANBY SOUTH
CANBY, OR

FIGURE A-26

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Medium dense, brown, silty SAND (SM); moist, sand is fine to coarse.	166.0				
7.5		Medium dense, dark brown-gray SAND with silt (SP-SM); moist, sand is fine to coarse.	158.5 / 7.5				
11.0		Medium dense, dark gray GRAVEL with sand (GP), trace silt; moist, gravel is fine to coarse and subrounded, sand is fine to coarse.	155.0 / 11.0				
15.0		Exploration completed at a depth of 15.0 feet.	151.0 / 15.0		⊠		Infiltration test at 15.0 feet. No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/09/21

EXCAVATION METHOD: trackhoe (see document text)

NV5

TRAMMELLCR-79-05

AUGUST 2021

TEST PIT TP-15

CANBY SOUTH
CANBY, OR

FIGURE A-27

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Medium stiff, brown, sandy SILT (ML), trace organics; moist, sand is fine to coarse (15-inch-thick tilled zone, 4-inch-thick root zone).	165.0		☒		
2.5							
		Medium dense, brown, silty SAND (SM); moist, sand is fine to coarse.	161.5 / 3.5		☒		
5.0							
		Medium dense, gray SAND (SP); moist, sand is fine to coarse.	159.0 / 6.0		☒		
7.5							
10.0		with gravel and cobbles at 10.0 feet			☒		
12.5		minor gravel at 12.0 feet			☒		
15.0							
		Exploration completed at a depth of 15.5 feet.	149.5 / 15.5				No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

0 50 100

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/09/21

EXCAVATION METHOD: trackhoe (see document text)

NV5

TRAMMELLCR-79-05

TEST PIT TP-16

AUGUST 2021

CANBY SOUTH
CANBY, OR

FIGURE A-28

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Stiff, brown, sandy SILT (ML), trace organics; moist, sand is fine to coarse (12-inch-thick tilled zone, 4-inch-thick root zone).	166.0		☒ ☒		
6.5		Medium dense, gray, silty SAND with gravel and cobbles (SM); moist, sand is fine to coarse.	159.5 / 6.5		☒ ☒		
17.0		Exploration completed at a depth of 17.0 feet.	149.0 / 17.0	P200	☒	●	Infiltration test at 17.0 feet. P200 = 14% No groundwater seepage observed to the depth explored. No caving observed to the depth explored.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: J. Martinez COMPLETED: 07/09/21

EXCAVATION METHOD: trackhoe (see document text)

NV5 | TRAMMELLCR-79-05 | AUGUST 2021

TEST PIT TP-17

CANBY SOUTH
CANBY, OR

FIGURE A-29

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	2.5	163.5	23				56			
B-1	5.0	161.0	13							
B-2	2.5	164.5	23							
B-3	2.5	162.5	11				23			
B-3	7.0	158.0	7							
B-4	2.5	163.5	22							
B-4	5.0	161.0	17							
B-5	5.0	160.0	21				20			
B-6	7.5	159.5	12							
B-7	5.0	162.0	26							
B-8	2.5	163.5	39							
B-8	7.5	158.5	18							
B-9	2.5	164.5	30				45			
B-10	2.5	163.5	24							
B-10	5.0	161.0	24							
B-11	2.5	162.5	26							
B-11	10.0	155.0	29							
B-12	5.0	153.0	30							
B-12	10.0	148.0	14							
B-12	25.0	133.0	30							
TP-1	1.5	162.5	9							
TP-1	3.5	160.5	10				39			
TP-4	16.0	150.0	8				7			
TP-6	1.5	160.5	10							
TP-7	1.5	165.5	9							
TP-8	1.5	153.5	9							
TP-9	9.0	159.0	10				10			

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
TP-10	4.0	149.0	12							
TP-11	4.0	163.0	14							
TP-12	1.5	148.5	10							
TP-13	11.0	155.0	10				8			
TP-14	18.5	147.5	10				5			
TP-17	17.0	149.0	11				14			

Robert Miner Dynamic Testing, Inc.
Dynamic Measurements and Analyses for Deep Foundations

July 24, 2018

Mr. Dale Abernathy
Holt Services, Inc.
10621 Todd Rd. East
Edgewood, WA 98372

Re: Penetration Test Energy Measurements
Mobile B-57 Rig No. 5, Mobile Auto Hammer
Bore Hole: Yard Test Hole, June 15, 2018
Holt Services Yard, Edgewood, Washington

RMDT Job No. 18F19

Dear Mr. Abernathy,

This letter presents energy transfer measurements made during Standard Penetration Tests for the drill hole and drill rig referenced above. Robert Miner Dynamic Testing, Inc. (RMDT) made dynamic measurements with a Pile Driving Analyzer® as a hammer advanced the NW rod during sampling with a split spoon sampler.

The purpose of RMDT's testing was the measurement of energy transferred to the drill rods. Measurements were made on a section of NW gauge rod at the top of the drill string. Strain gages and accelerometers on the rod were connected to a Pile Driving Analyzer® (PDA) which generally processed acceleration and strain measurements from each hammer blow and stored both the measurements and computed results. Measurements and data processing generally followed the ASTM D 4633-16 standard. Energy transfer past the gage location, EFV, was computed by the PDA using force and velocity records as follows:

$$EFV \quad {}_a^b \; F(t)\; v(t)\; dt$$

The value "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value. Appendix A contains more information on our measurement equipment and methods of analysis. The EFV energy calculation is identical to the EMX energy result discussed in Appendix A. The EFV and EMX values apply to the sensor location near the top of the rod.

TEST DETAILS

On June 15, 2018, a single boring was advanced at the maintenance yard of Holt Services in Edgewood, Washington. The drill rig used during sampling was a truck mounted Mobile B-57 auger unit manufactured by Mobile Drill International and referred to as Rig 5 by the operator. RMDT observed a tag on the rig indicated the rig Serial No. Is 2015 -25. The B-57 unit drilled to six depth intervals ranging from 20 to 60 ft below ground surface and SPT tests were

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

completed through hollow-stem augers at each of 6 depths. The rod used to advance the spoon at each sample depth had a diameter matching that of NW rod. The automatic hammer in use during our testing was manufactured by Mobile Dill International and appeared to use a chain drive powered by a hydraulic motor, with the ram and chain drive enclosed within an outer casing.

RESULTS

A summary of testing and monitoring results is given in Table 1. The tabulated results include the starting sample depth, the penetration resistance, the number of hammers blows in our data set, measured energy transfer, EFV, the computed transfer efficiency, ETR, and the hammer blow rate, BPM. Appendix B contains detailed numeric results for each individual test.

Energy measurements must be divided by the theoretical free fall energy of the hammer to obtain an efficiency. A 140 lb ram raised 30 inches above an impact surface has 350 lb-ft of potential energy. Thus, the transfer energy results for sampling with the 140 lb ram may be divided by 350 lb-ft to yield the ratio of the delivered energy to the nominal potential energy. This efficiency ratio, ETR, is given for each sample interval as a percent efficiency.

Table 1. Summary of Test Details and Results for the 140-lb ram and Split Spoon Sampler

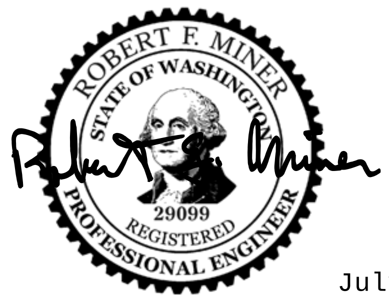
Sample Starting Depth	Penetration Resistance (Blow/Set)	Number of Blows in Data Set	Average Transfer Energy EFV (lb-ft)	Average Transfer Efficiency ETR (percent)	Average Hammer Blow Rate BPM (blow/min)
20 ft	6/1 ft	6	336	96	45
25 ft	38/1 ft	38	343	98	51
40	20/1 ft	20	344	98	48
50 ft	40/1 ft	40	337	96	48
55 ft	16/1 ft	16	341	97	48
60 ft (1)	9/ 1.3 ft	8	345	99	39
Average for Split Spoon samples:			**341**	**97**	**47**

Note (1): Because only 5 blows were required for the first 1.5 ft of sample at 60 ft starting depth, that sample was advanced a total of 1.8 ft so that our data set at this depth would include more hammer blows. Due to poor measurement quality, one of the nine blows comprising the final 1.3 ft was excluded from our data set.

Six sample returns were monitored while the 140 lb ram and standard split spoon sampler were in use. The overall average ETR and hammer blow rate was 97 percent and 47 blows per minute, respectively.

It was a pleasure to assist you and to participate on this project with the staff of Holt Services Inc. Please do not hesitate to contact us if you or other project participants have any questions about this report.

Sincerely,



July 24, 2018

Robert Miner, P.E.

Robert Miner Dynamic Testing, Inc.

APPENDIX B

APPENDIX B

PREVIOUS EXPLORATIONS

This appendix contains exploration logs completed at the site in 2018. Locations of the explorations are shown on Figure 2. The logs are discussed in the "Background" section.

BORING B-1a

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	BLOW COUNT / MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0.0	Very loose, light brown, silty SAND (SM); dry, sand is fine (12- to 14-inch-thick tilled zone, 4-inch-thick root zone).					
2.5				Sample	1	
4.5	Medium dense, light brown, silty SAND (SM); moist, sand is fine to medium.	4.5				
5.0				Sample	11	
7.5	gray at 7.5 feet			Sample	18	
10.0				Sample	17	
14.0	Dense, gray, silty SAND with gravel (SM); moist, sand is fine to coarse, gravel is fine to coarse.	14.0				Driller Comment: gravel at 14.0 feet.
15.0				Sample	32	
16.5	Medium dense, gray, silty SAND (SM); moist, sand is fine to medium.	16.5				
20.0						

Legend: ▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: A. Ferrero COMPLETED: 06/26/18

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 4 inches

GEODESIGN INC
9450 SW Commerce Circle - Suite 300
Wilsonville OR 97070
503.968.8787 www.geodesigninc.com

TRAMMELLCR-79-01

AUGUST 2018

BORING B-1a

WEYGANDT PROPERTY
CANBY, OR

FIGURE A-1

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
20.0		(continued from previous page)				23	
22.5							
25.0				P200		22	Infiltration test at 25.0 feet. P200 = 21%
26.5		Exploration completed at a depth of 26.5 feet. Hammer efficiency factor is 81.2 percent.	26.5				Surface elevation was not measured at the time of exploration.
27.5							
30.0							
32.5							
35.0							
37.5							
40.0							

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: A. Ferrero COMPLETED: 06/26/18

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 4 inches

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE / BLOW COUNT / MOISTURE CONTENT % / RQD% / CORE REC% (0–50–100)	INSTALLATION AND COMMENTS
0.0	Medium dense, gray, silty SAND (SM); moist, sand is fine to medium.				
12.5				14	
13.5	Medium dense, gray, silty SAND with gravel (SM); moist, sand is fine to coarse, gravel is fine to medium.	13.5	P200	19	Infiltration test at 13.5 feet. P200 = 15%
15.0	Exploration completed at a depth of 15.0 feet. Hammer efficiency factor is 81.2 percent.	15.0			Surface elevation was not measured at the time of exploration.
20.0					

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: A. Ferrero COMPLETED: 06/26/18

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 4 inches

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AUGUST 2018

BORING B-1b

WEYGANDT PROPERTY
CANBY, OR

FIGURE A-2

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
0.0		Medium dense, gray, silty SAND (SM); moist, sand is fine to medium.					
2.5							
5.0							
7.5							Infiltration test at 8.5 feet. P200 = 15%
				P200		21	
10.0		Exploration completed at a depth of 10.0 feet. Hammer efficiency factor is 81.2 percent.	10.0				Surface elevation was not measured at the time of exploration.
12.5							
15.0							
17.5							
20.0						0 50 100	

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: A. Ferrero COMPLETED: 06/26/18

BORING METHOD: hollow-stem auger (see document text) BORING BIT DIAMETER: 4 inches

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1a	2.5		10							
B-1a	5.0		14							
B-1a	25.0		25				21			
B-1b	13.5		16				15			
B-1c	8.5		18				15			

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TRAMMELLCR-79-01

AUGUST 2018

SUMMARY OF LABORATORY DATA

WEYGANDT PROPERTY
CANBY, OR

FIGURE A-4

APPENDIX C

APPENDIX C

GEOPHYSICAL TESTING

This appendix presents the geophysical report prepared by Atlas Technical Consultants, LLC. Testing included 17 seismic P-wave refraction traverses and 1 ReMi profile. The P-wave refraction traverses were used to the estimate the contact between the silt/sand and gravel, and the ReMi profile was used to determine the shear wave velocity profile in the upper 100 feet of soil (V_{s100}) at the site for seismic site class determination.

In general, P-wave velocities less than approximately 2,500 to 3,000 fps correspond to silt and sand and velocities greater than 2,500 to 3,000 fps correspond to gravelly soil. The testing results show good agreement among the exploration logs with gravel contacts generally between 5 and 15 feet BGS within the building footprint.

The ReMi profile shows the V_{s100} at the site is 1,434 fps, which corresponds to an ASCE 7-16 seismic site class of C.

GEOPHYSICAL EVALUATION

TRAMMELLCR-79-05

Canby, Oregon

PREPARED FOR:

NV5, Inc.
703 Broadway Street, Suite 650
Vancouver, WA 98660

PREPARED BY:

Atlas Technical Consultants, LLC
15115 SW Sequoia Street, Suite 130
Portland, OR 97224

July 30, 2021

15115 SW Sequoia Parkway, Suite 130
Portland, Oregon 97224
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July 30, 2021

Atlas No. 421016SWG
Report No. 1

MR. SCOTT MCDEVITT, P.E.
NV5, INC.
703 BROADWAY STREET, SUITE 650
VANCOUVER, WA 98660

**Subject: Geophysical Evaluation
TRAMMELLCR-79-05
Canby, Oregon**

Dear Mr. McDevitt:

In accordance with your authorization, Atlas has performed a geophysical evaluation for the TRAMMELLCR-79-05 project located in Canby, Oregon. Specifically, our evaluation consisted of performing seventeen seismic P-wave refraction traverses and one refraction microtremor (ReMi) profile at the project site. The purpose of our study was to develop subsurface velocity profiles through the collection of P-wave and Shear-wave data to be used for the design and construction of a new building, and to estimate the migration of a gravel bed across the study area. Our field services were conducted on June 1 through June 3, 2021. This data report presents our methodology, equipment used, analysis, and results.

We appreciate the opportunity to be of service on this project. Should you have any questions please contact the undersigned at your convenience.

Respectfully submitted,
Atlas Technical Consultants LLC

REGISTERED OREGON PATRICK F. LEHRMANN G2722 GEOLOGIST

Andrew Baird
Project Geophysicist

Patrick F. Lehrmann, R.G. (CA, OR), P.Gp. (CA)
Principal Geologist/Geophysicist

ASB:TSW:pfl:ds

Distribution: Scott McDivett at Scott.McDivett@NV5.com

CONTENTS

FIGURES

1. INTRODUCTION

In accordance with your authorization, Atlas performed a geophysical evaluation for the TRAMMELLCR-79-05 project located in Canby, Oregon (Figure 1). Specifically, our evaluation consisted of performing seventeen seismic P-wave refraction traverses and one refraction microtremor (ReMi) profile at the project site. The purpose of our study was to develop subsurface velocity profiles through the collection of P-wave and Shear-wave data to be used for the design and construction of a new building, and to estimate the migration of a gravel bed across the study area. Our field services were conducted on June 1 through June 3, 2021. This data report presents our methodology, equipment used, analysis, and results.

2. SCOPE OF SERVICES

Our scope of services included:

- Performance of seventeen seismic P-wave refraction traverse at the project site.
- Performance of one refraction microtremor (ReMi) traverse at the project site.
- Compilation and analysis of the data collected.
- Preparation of this data report presenting our results and conclusions.

3. SITE AND PROJECT DESCRIPTION

The project site is located southeast of the intersection of Sequoia Parkway and South Township in Canby, Oregon. Specifically, the seismic traverses were orientated along southwest-northeast and northwest-southeast alignments located east of South Sequoia Parkway. The study area occupied a wheat grass field, and is bounded by roadways and a railway. Figures 2 and 3 depict the general site conditions in the study area.

4. STUDY METHODOLOGY

4.1 P-wave

A seismic P-wave (compression wave) refraction study was conducted at a portion of the project site to develop subsurface velocity profiles of the study area. The seismic refraction method uses first-arrival times of refracted seismic waves to estimate the thicknesses and seismic velocities of subsurface layers. Seismic P-waves generated at the surface, using a hammer and plate, are refracted at boundaries separating materials of contrasting velocities. These refracted seismic waves are then detected by a series of surface vertical component 14.5-Hz geophones and recorded with a 24-channel Geometrics Geode Exploration Seismograph. The travel times of the seismic P-waves are used in conjunction with the shot-to-geophone distances to obtain thickness and velocity information on the subsurface materials.

Seventeen seismic P-wave lines (SL-1 through SL-17) were conducted at the study area. The general location and length of the line was predetermined by you and your office and adjusted where needed to account for surface conditions. The P-wave lines were 150 feet in length. Shot points (signal generation locations) were conducted along the lines at the ends, midpoint, and intermediate points between the ends and the midpoint.

The seismic refraction theory requires that subsurface velocities increase with depth. A layer having a velocity lower than that of the layer above will not generally be detectable by the seismic refraction method and, therefore, could lead to errors in the depth calculations of subsequent layers. In addition, lateral variations in velocity, such as those caused by core stones, intrusions or boulders can also result in the misinterpretation of the subsurface conditions. In general, the effective depth of evaluation for a seismic refraction traverse is approximately one-third to one-fifth the length of the spread.

4.2 ReMi

The ReMi technique uses recorded surface waves (specifically Rayleigh waves) that are contained in background noise to develop a shear-wave velocity profile of the study area down to a depth, in this case, of approximately 100 feet. The depth of exploration is dependent on the length of the line and the frequency content of the background noise. The results of the ReMi method are displayed as a one-dimensional sounding which represents the average condition across the length of the line. The ReMi method does not require an increase of material velocity with depth; therefore, low velocity zones (velocity inversions) are detectable with ReMi.

Our ReMi study included the use of a 24-channel Geometrics Geode seismograph and 24, 4.5-Hz vertical component geophones. The geophones were spaced 10 feet apart for a total line length of 230 feet. Fifteen records, each 32 seconds long, were recorded and then downloaded to a computer.

5. DATA ANALYSIS

5.1 P-wave

The collected data was processed using SIPwin (Rimrock Geophysics, 2003), a seismic interpretation program, and analyzed using SeisOpt Pro (Optim, 2008). SeisOpt Pro uses first arrival picks and elevation data to produce subsurface velocity models through a nonlinear optimization technique called adaptive simulated annealing. The resulting velocity model provides a tomography image of the estimated geologic conditions. Both vertical and lateral velocity information is contained in the tomography model. Changes in layer velocity are revealed as gradients rather than discrete contacts, which typically are more representative of actual conditions.

5.2 ReMi

The collected data was processed using SeisOpt® ReMi™ software (© Optim LLC, 2008), which uses the refraction microtremor method (Louie, 2001). The program generates phase-velocity dispersion curves for each record and provides an interactive dispersion modeling tool where the users determine the best fitting model. The result is a one-dimensional shear-wave velocity model of the site with roughly 85 to 95 percent accuracy.

6. RESULTS AND CONCLUSIONS

As previously indicated, seventeen seismic P-wave traverses and one ReMi line were conducted as part of our study. Figures 4.1through 4.17 present the P-wave and Shear-wave velocity models generated from our analysis, respectively. Based on the results of the P-wave study, it appears as though the project site is underlain by low velocity materials (i.e., alluvium, topsoil, fill, etc.) in the shallow near surface and relatively velocity materials, likely gravel, at depth. Distinct vertical and lateral velocity variations are evident in the model. Moreover, the degree of weathering and the depth to possible bedrock appears to be variable across the study area.

The results of the ReMi study in Figure 5 present a one-dimensional Shear-wave profile down to a depth of 100 feet. The average characteristic site Shear-wave velocity down to a depth of 100 feet is 1,434 feet per second. The values recorded onsite correspond to a site class 'C' (IBC 2018). It should be noted the ReMi results represent the average condition across the length of the line.

Table 1 – ReMi Results

Line No.	Depth (feet)	Shear Wave Velocity (feet/second)
RL-1 (W-E)	0-4	765
	4-15	886
	15-30	1501
	30-39	1728
	39-50	1604
	50-64	1548
	64-81	1653
	81-100	1806

7. LIMITATIONS

The field evaluation and geophysical analyses presented in this report have been conducted in general accordance with current practice and the standard of care exercised by consultants performing similar tasks in the project area. No warranty, express or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be present. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluations will be performed upon request.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Atlas should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document. This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

8. SELECTED REFERENCES

Mooney, H.M., 1976, Handbook of Engineering Geophysics, dated February.

Telford, W.M., Geldart, L.P., Sheriff, R.E., and Keys, D.A., 1976, Applied Geophysics, Cambridge University Pres.

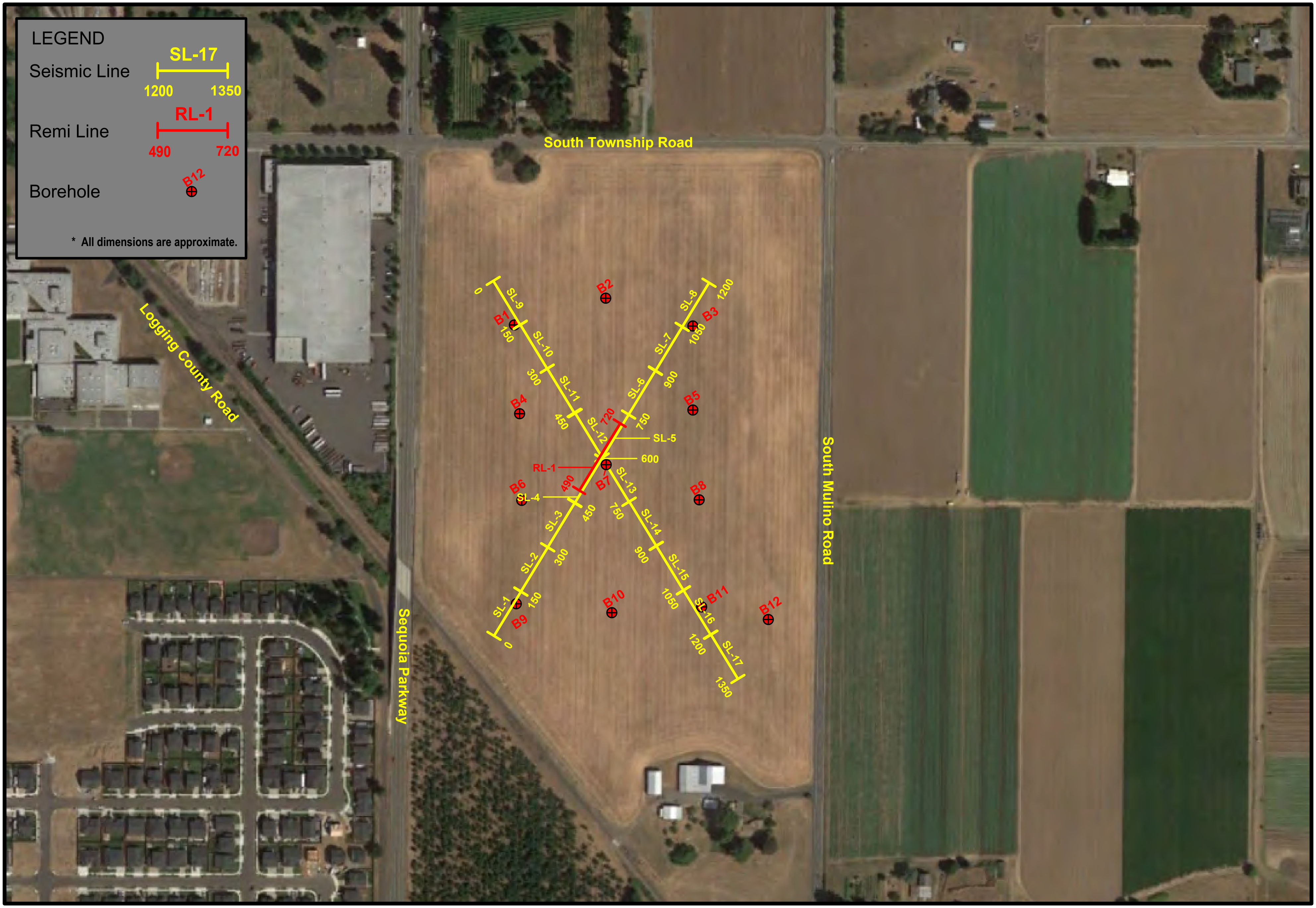
Optim, Inc., 2008, SeisOpt Pro, V-5.0.

Louie, J, N., 2001, Faster, Better, Shear-Wave Velocity to 100 Meters Depth From Refraction Microtremor Arrays: Bulletin of the Seismological Society of America, v. 91, p. 347-364.

Rimrock Geophysics, 2003, Seismic Refraction Interpretation Program (SIPwin), V-2.76.

International Building Code (IBC), 2018, International Code Council (ICC), Oregon Structural Specialty Code (OSSC)

SITE LOCATION MAP	N	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG — Date: 07/21	ATLAS Figure 1



SEISMIC LINE LOCATION MAP

N

TRAMMELLCR-79-05
Canby, Oregon

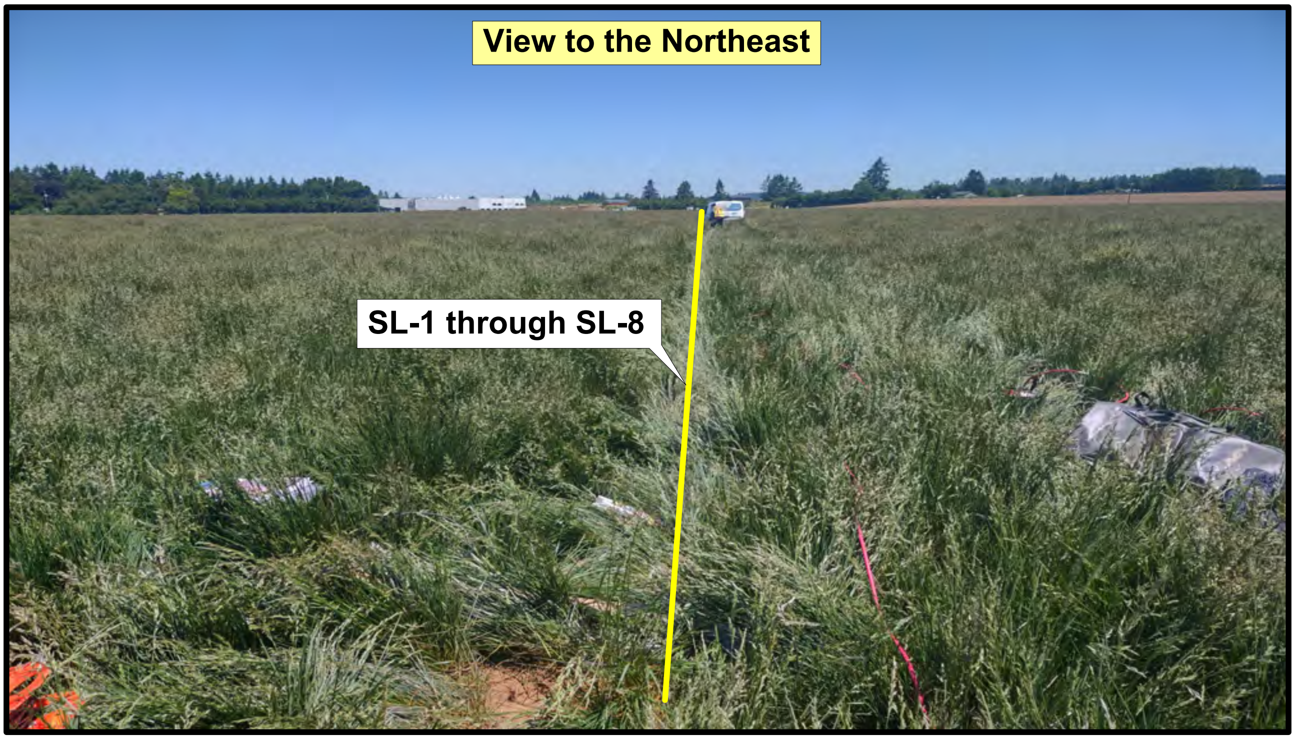
Project No.: 421016SWG | Date: 07/21

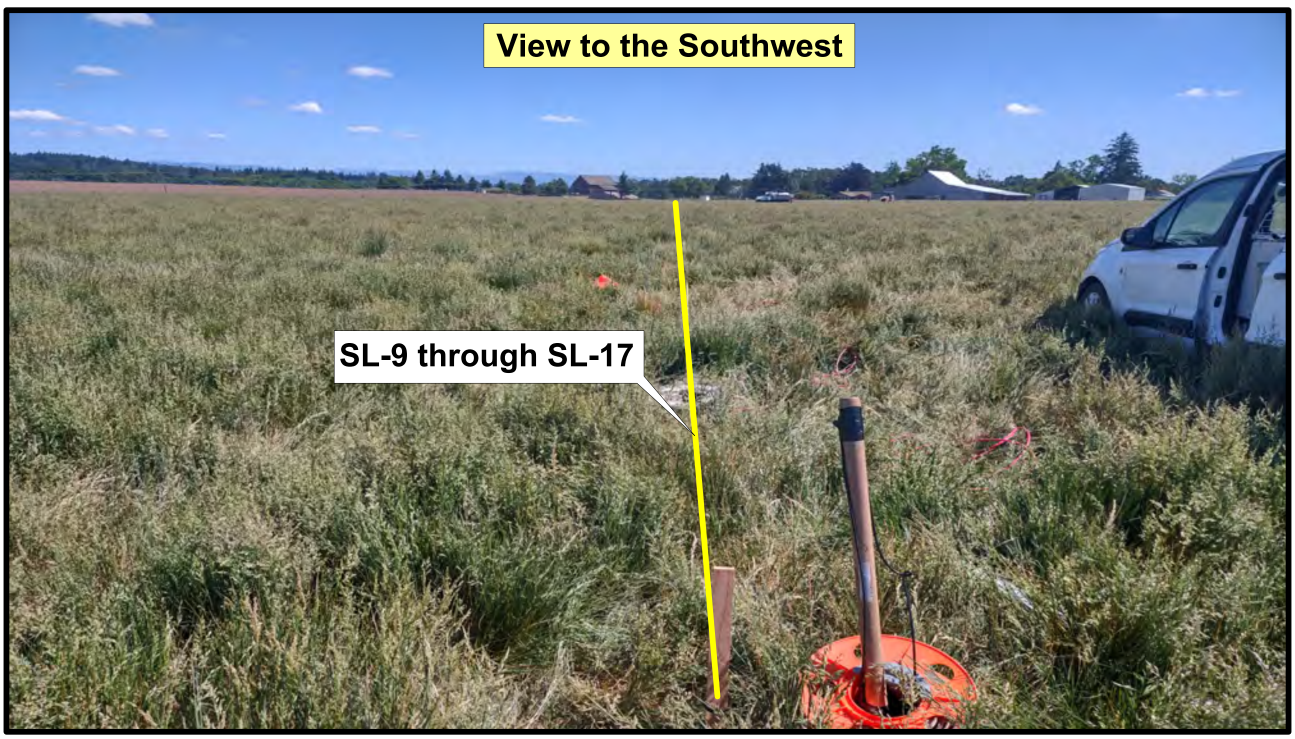
ATLAS

Figure 2

0 400 800

approximate scale in feet





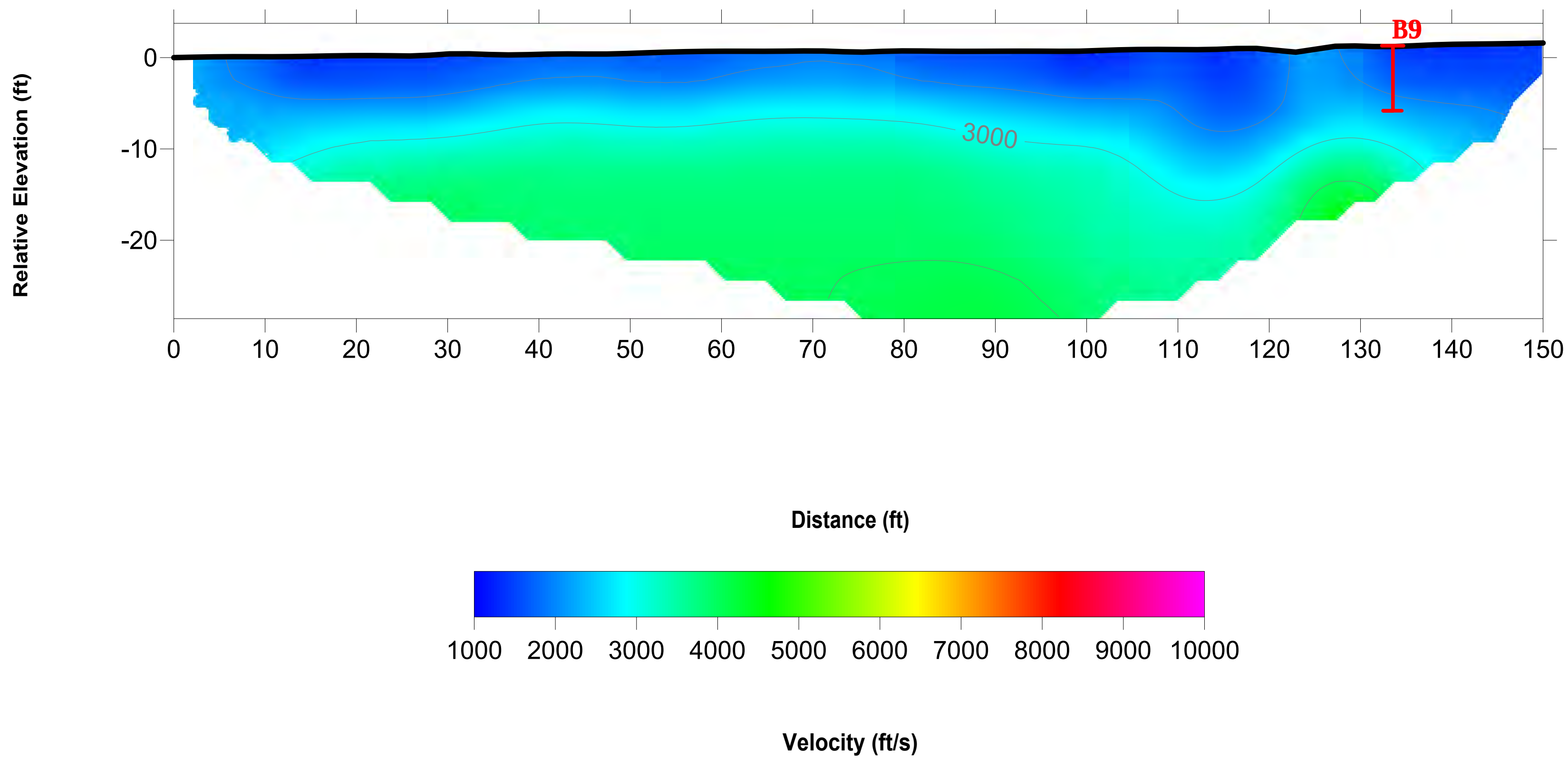
SITE PHOTOGRAPHS	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG — Date: 07/21	ATLAS Figure 3

TOMOGRAPHY MODEL

LEGEND

B9 — Approximate Depth to Gravel Level

SL-1

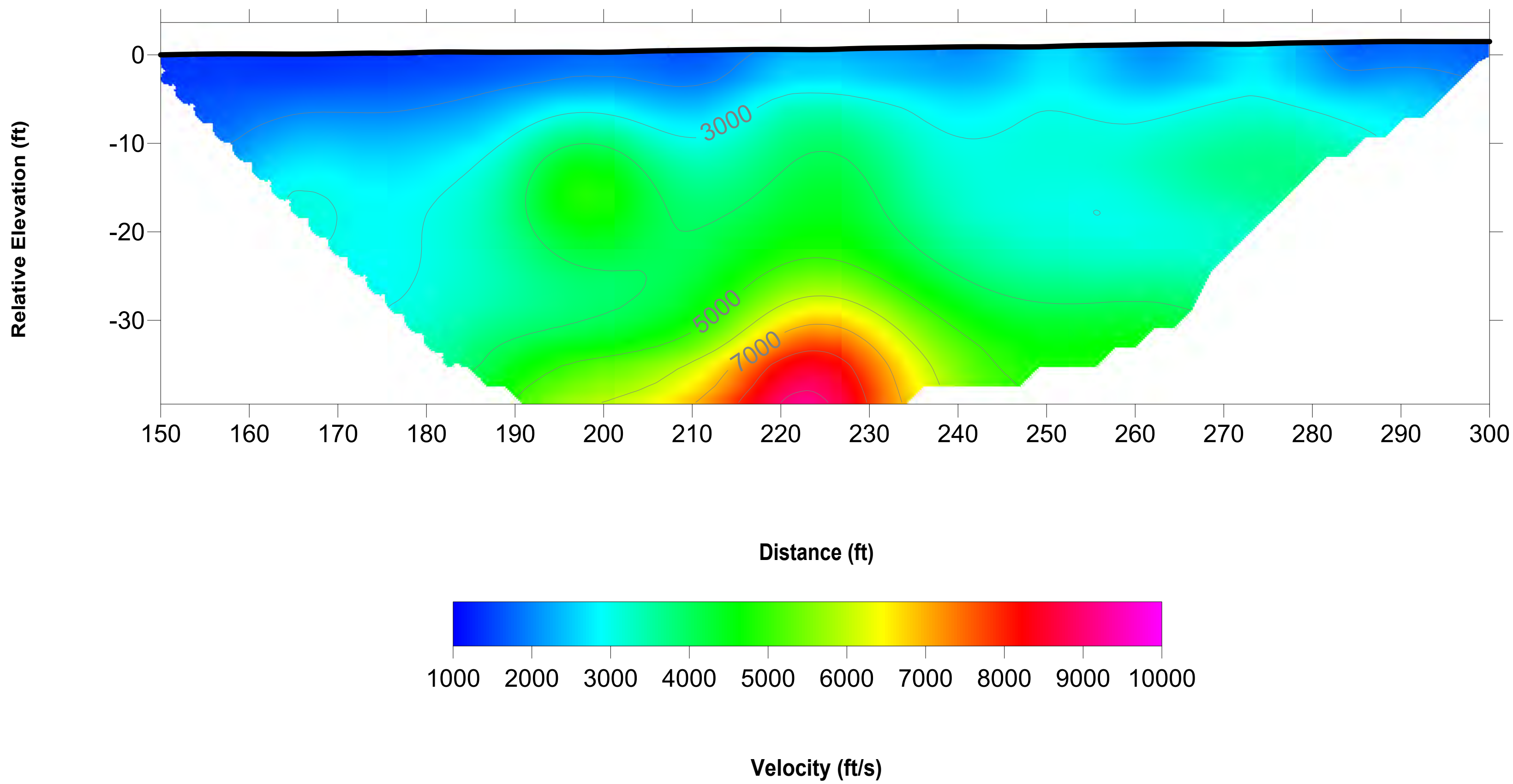


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.1
	Project No.: 421016SWG	Date: 07/21	

TOMOGRAPHY MODEL

SL-2

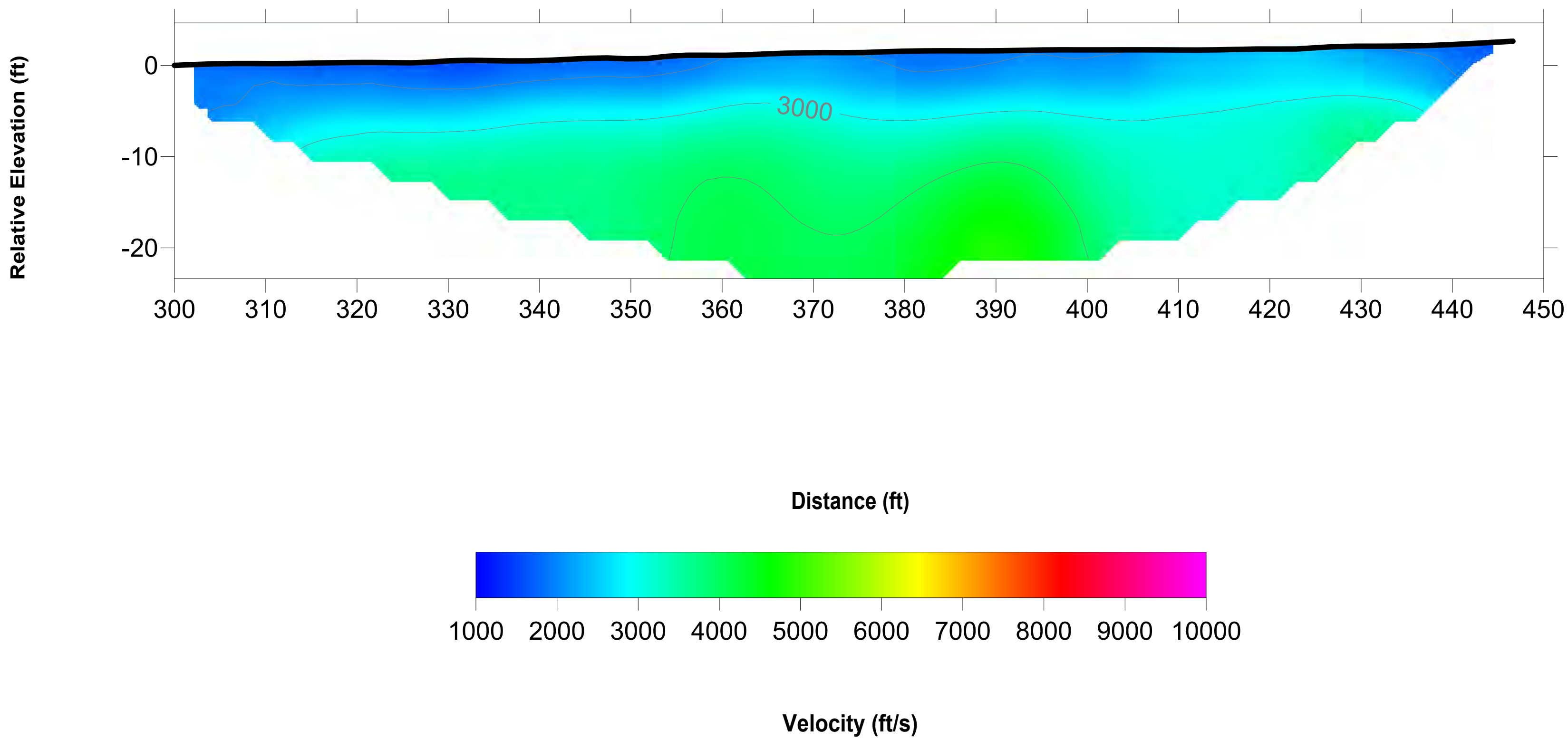


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG — Date: 07/21	ATLAS Figure 4.2

TOMOGRAPHY MODEL

SL-3

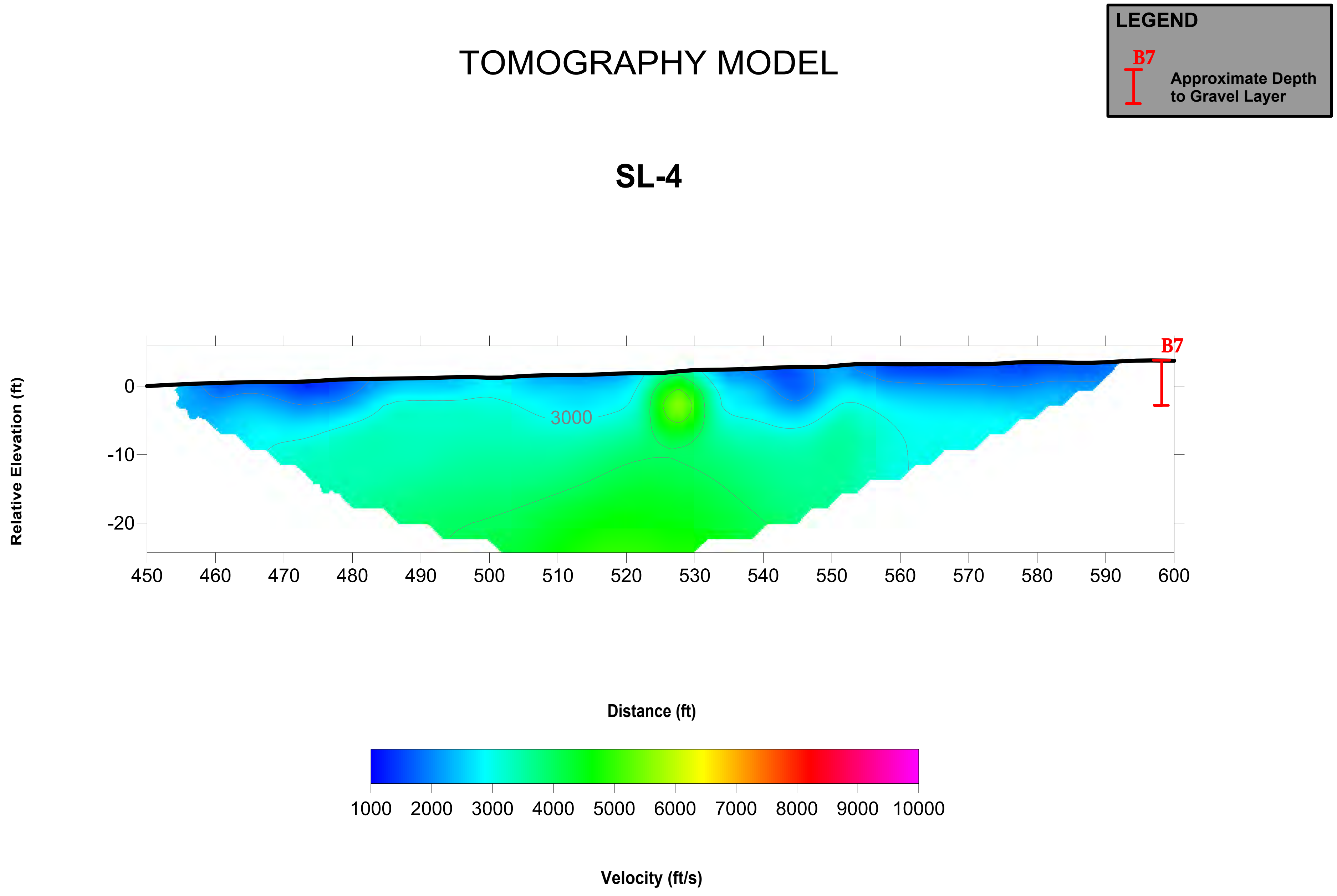


SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon	ATLAS Figure 4.3
	Project No.: 421016SWG / Date: 07/21	

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-4

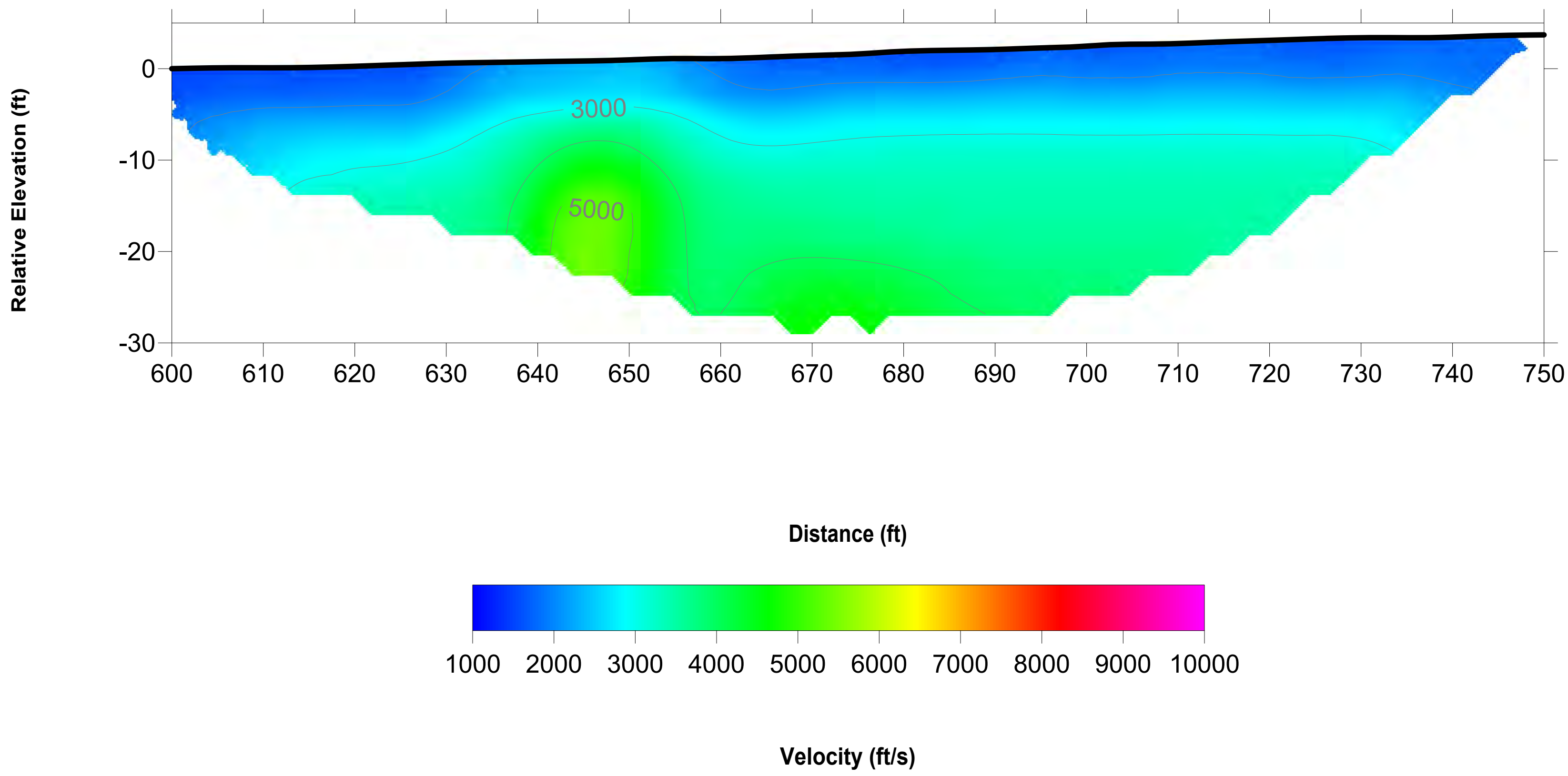


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG Date: 07/21	ATLAS Figure 4.4

TOMOGRAPHY MODEL

SL-5

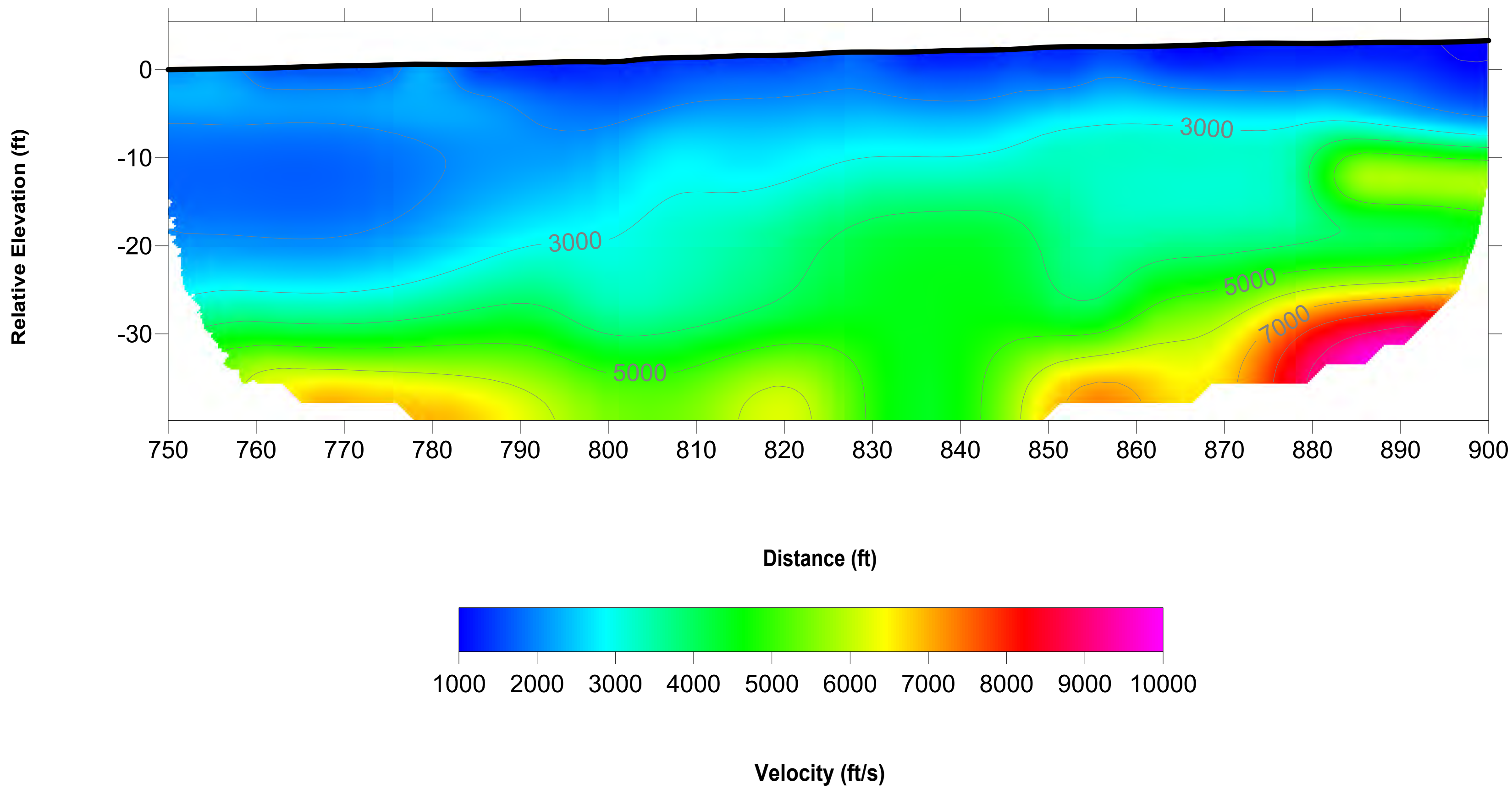


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.5
	Project No.: 421016SWG	Date: 07/21	

TOMOGRAPHY MODEL

SL-6

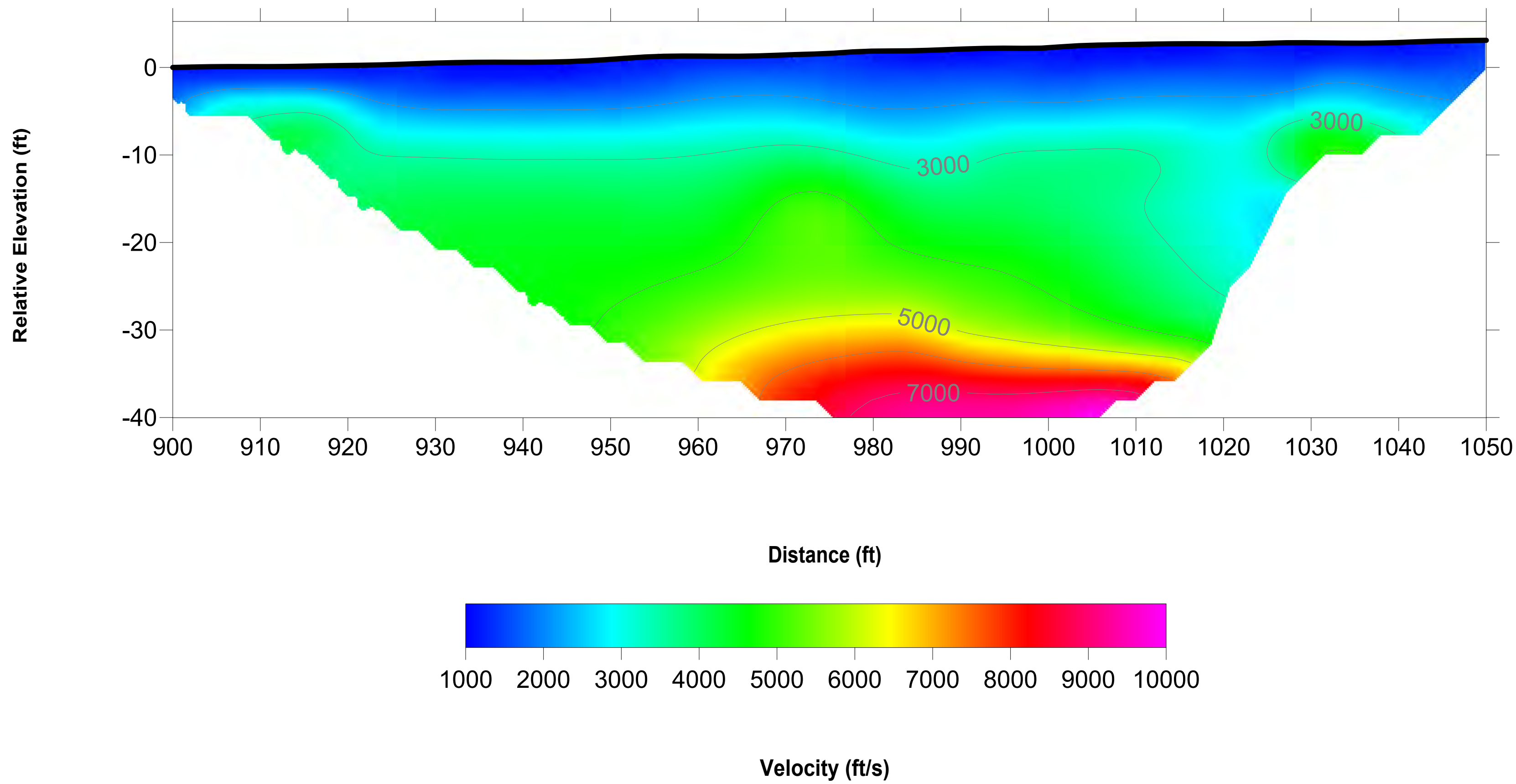


SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.6
	Project No.: 421016SWG	Date: 07/21	

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-7

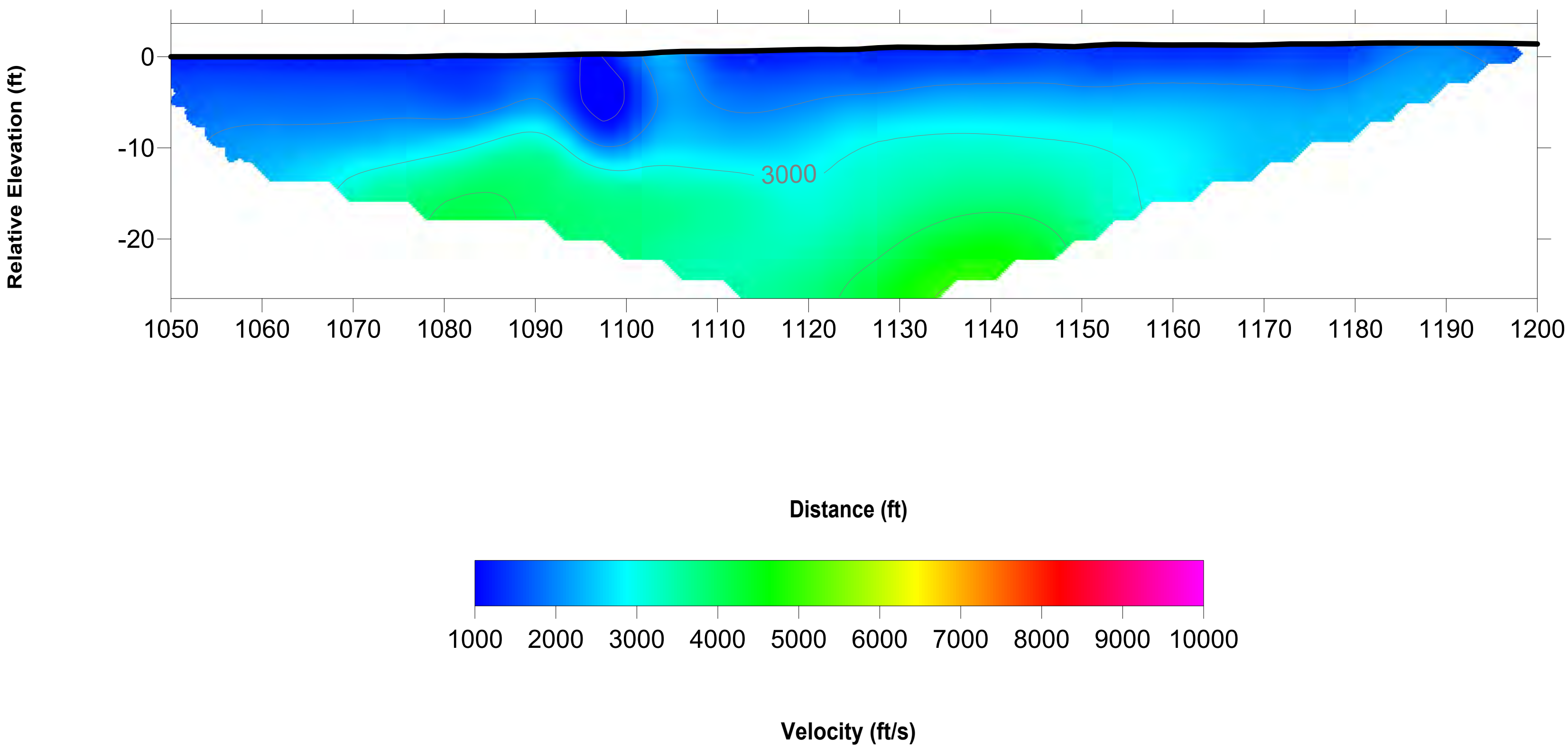


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG / Date: 07/21	ATLAS Figure 4.7

TOMOGRAPHY MODEL

SL-8



Note: Contour Interval = 1,000 feet per second

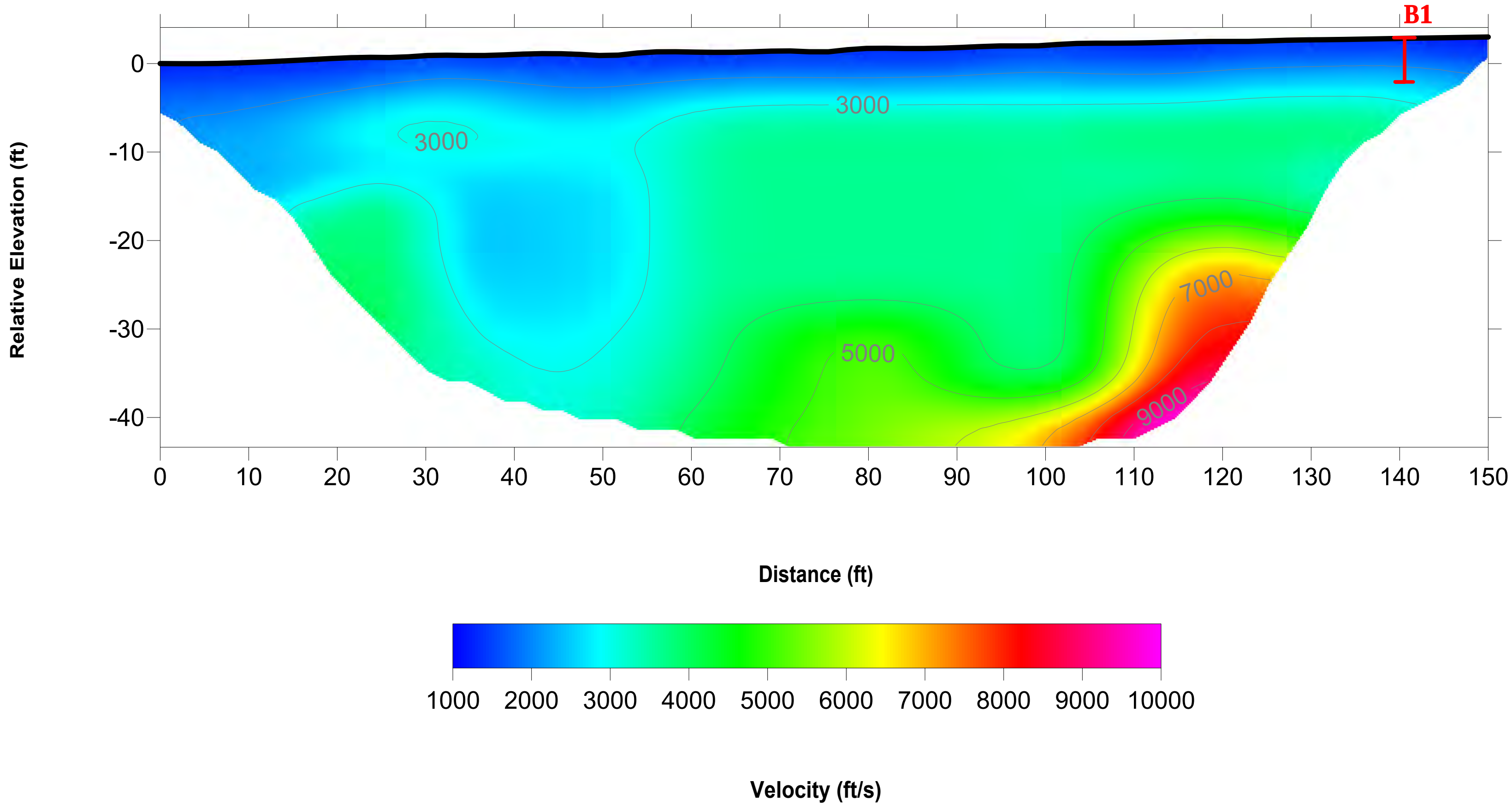
SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG / Date: 07/21	ATLAS Figure 4.8

TOMOGRAPHY MODEL

LEGEND

B1 Approximate Depth to Gravel Layer

SL-9

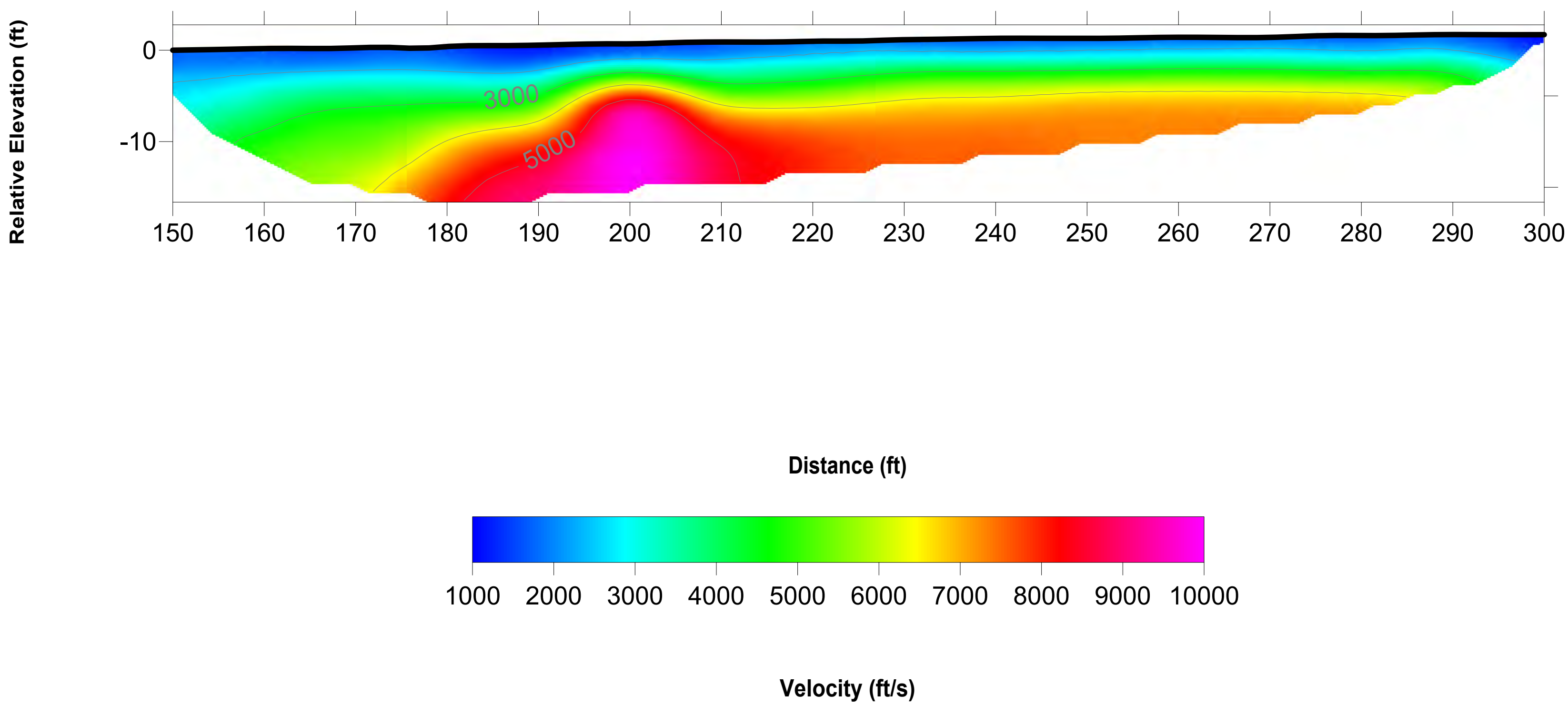


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG / Date: 07/21	ATLAS Figure 4.9

TOMOGRAPHY MODEL

SL-10

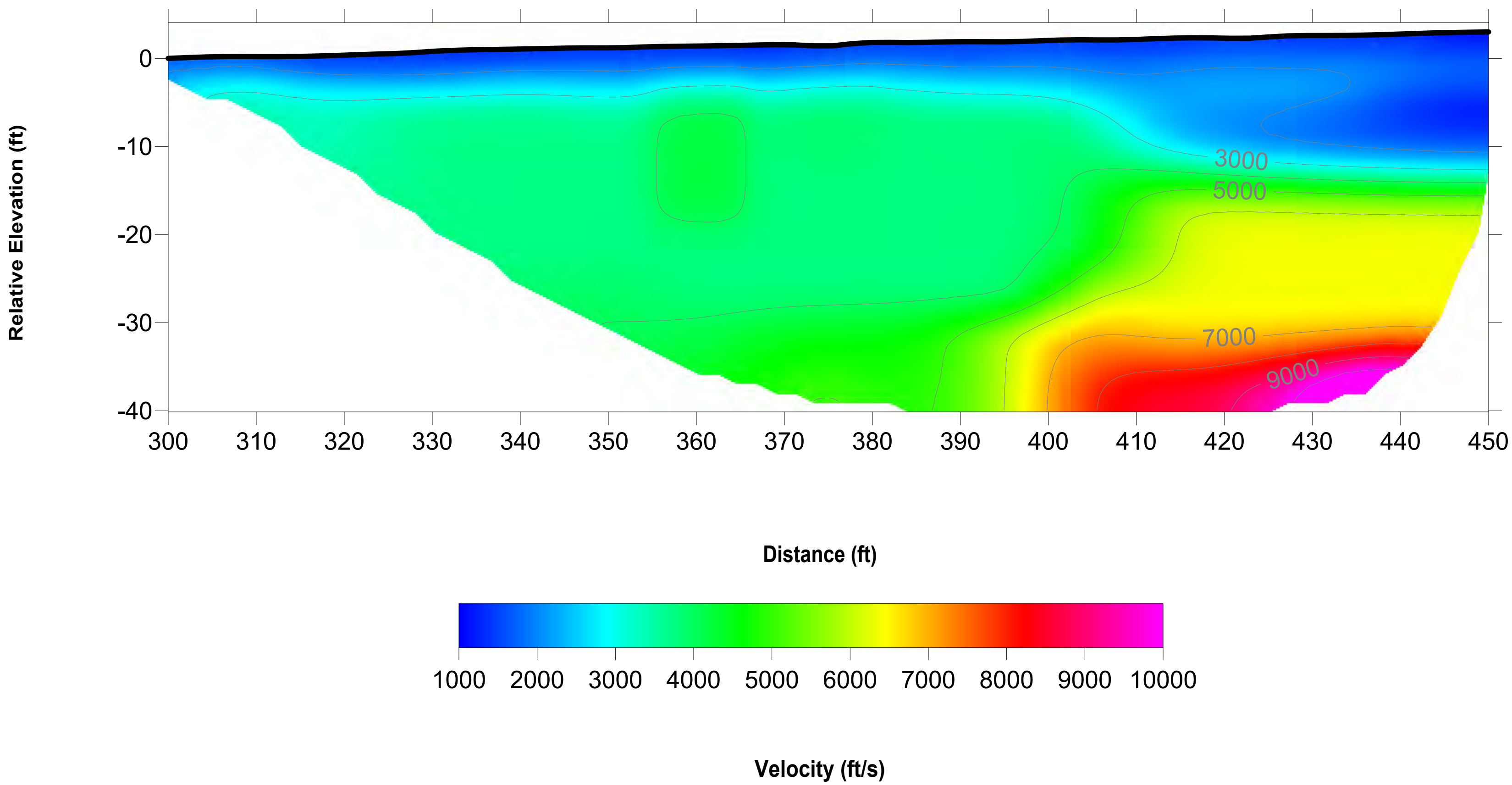


SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.10
	Project No.: 421016SWG	Date: 07/21	

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-11

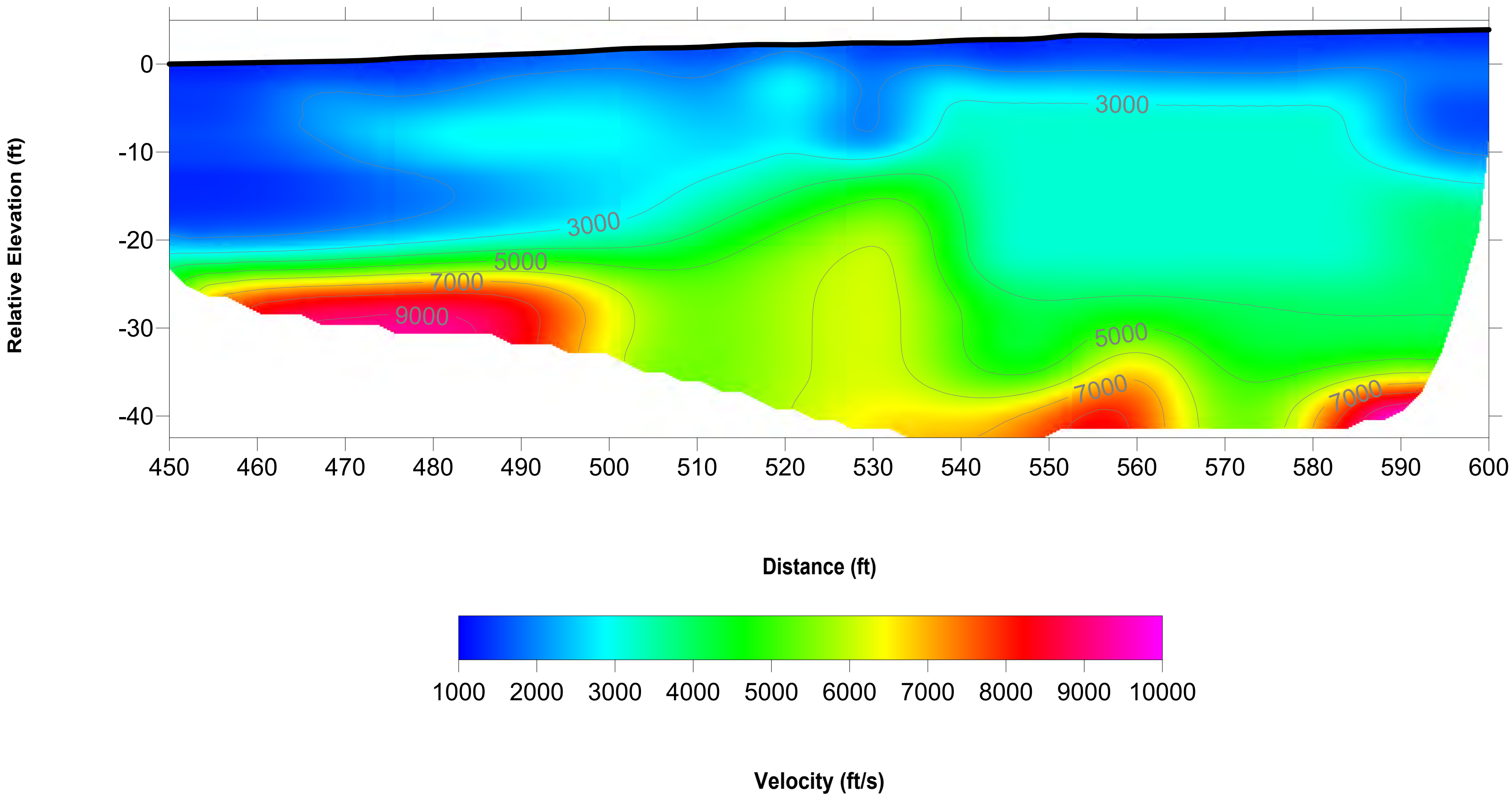


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG — Date: 07/21	ATLAS Figure 4.11

TOMOGRAPHY MODEL

SL-12



Note: Contour Interval = 1,000 feet per second

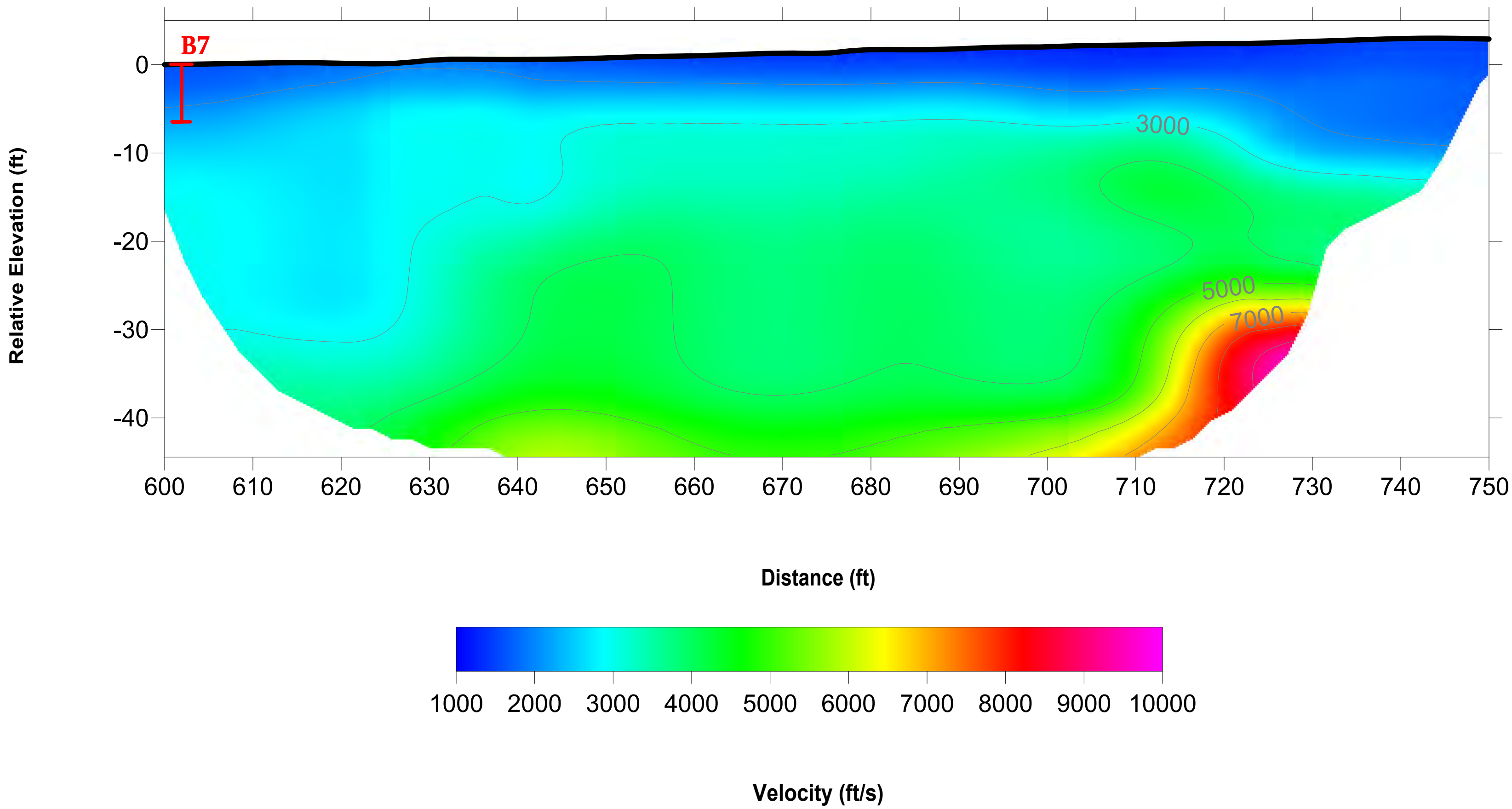
SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.12
	Project No.: 421016SWG	Date: 07/21	

TOMOGRAPHY MODEL

LEGEND

B7 — Approximate Depth to Gravel Layer

SL-13

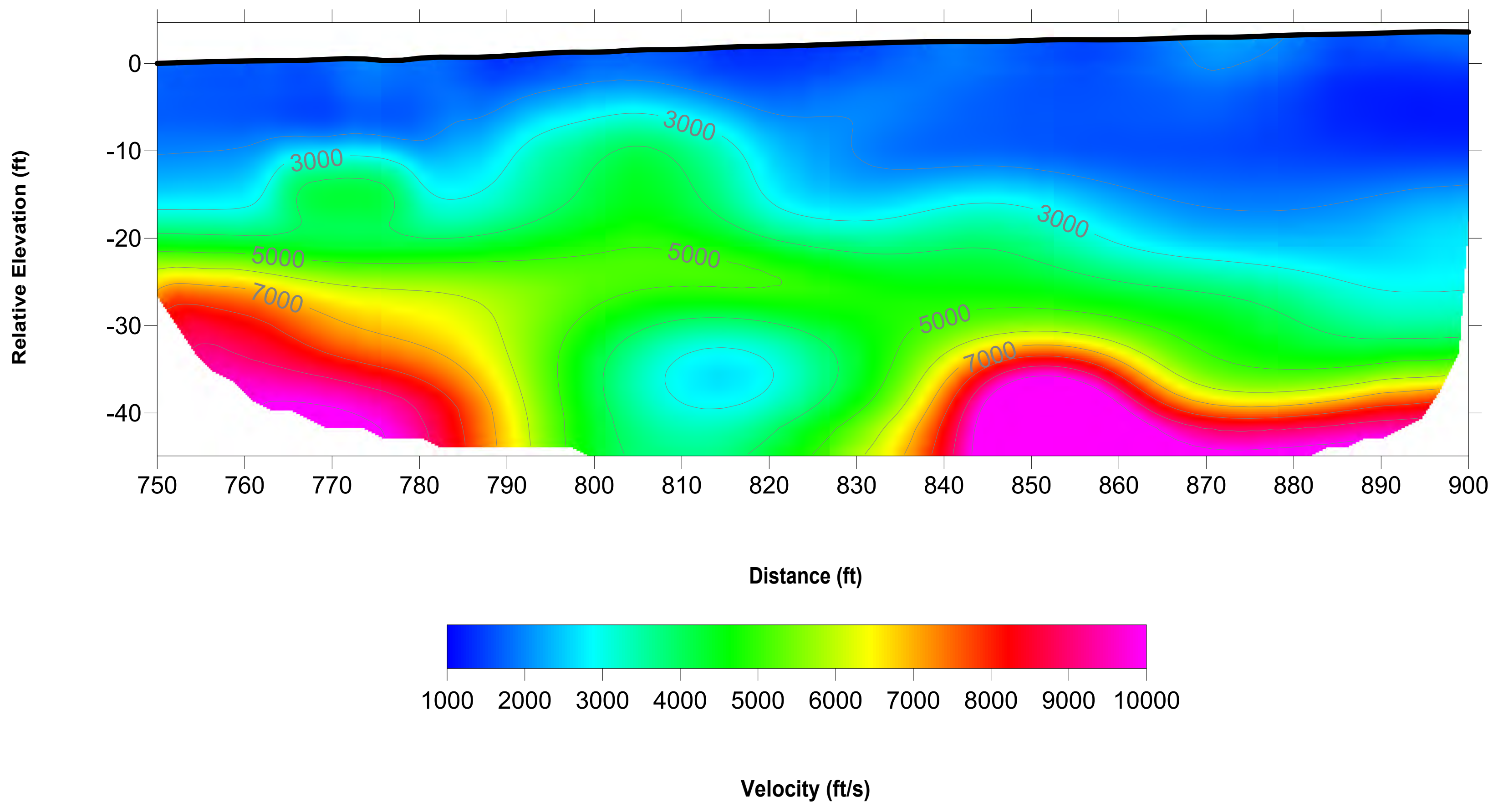


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG — Date: 07/21	ATLAS Figure 4.13

TOMOGRAPHY MODEL

SL-14

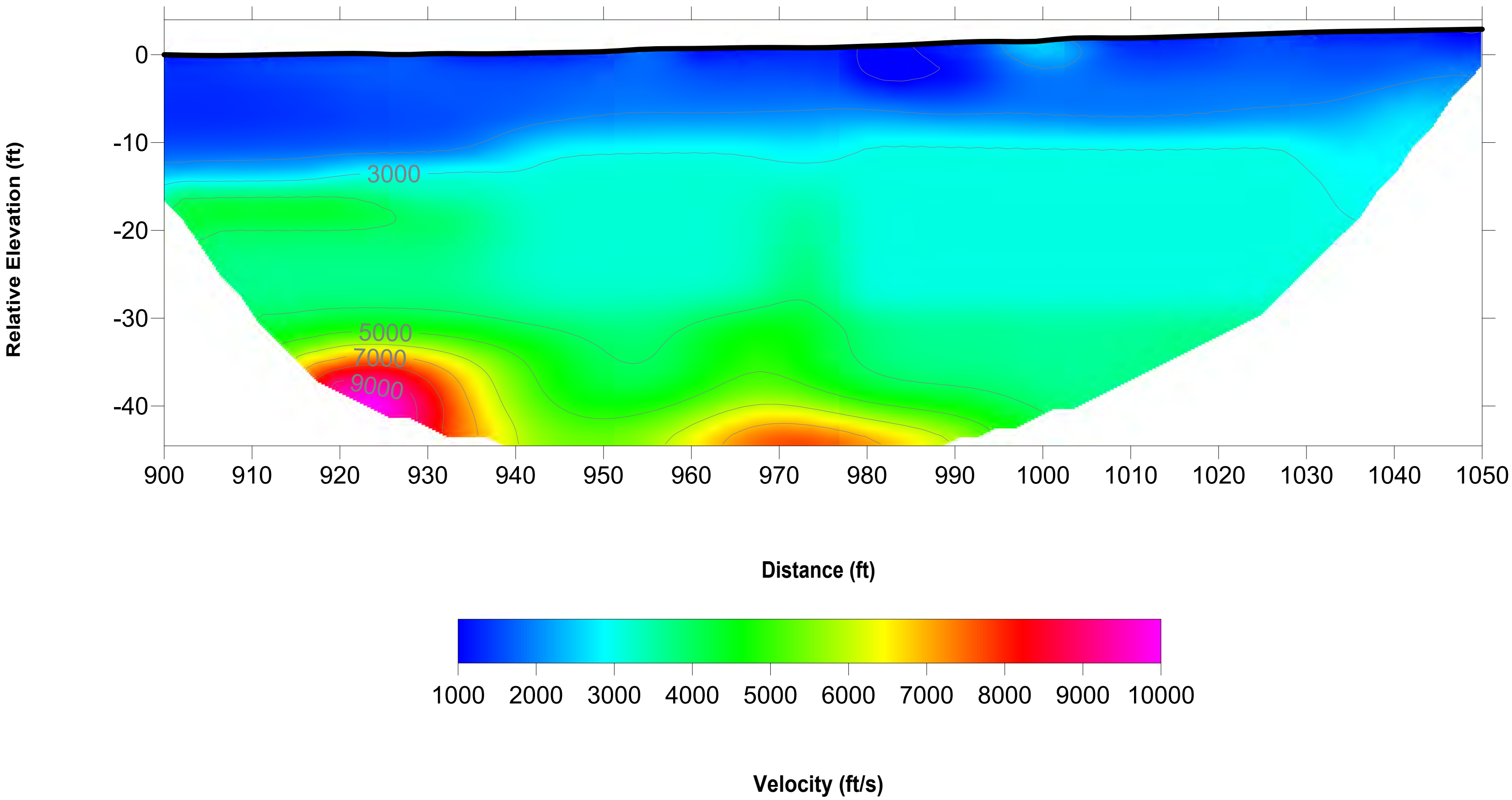


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.14
	Project No.: 421016SWG	Date: 07/21	

TOMOGRAPHY MODEL

SL-15



Note: Contour Interval = 1,000 feet per second

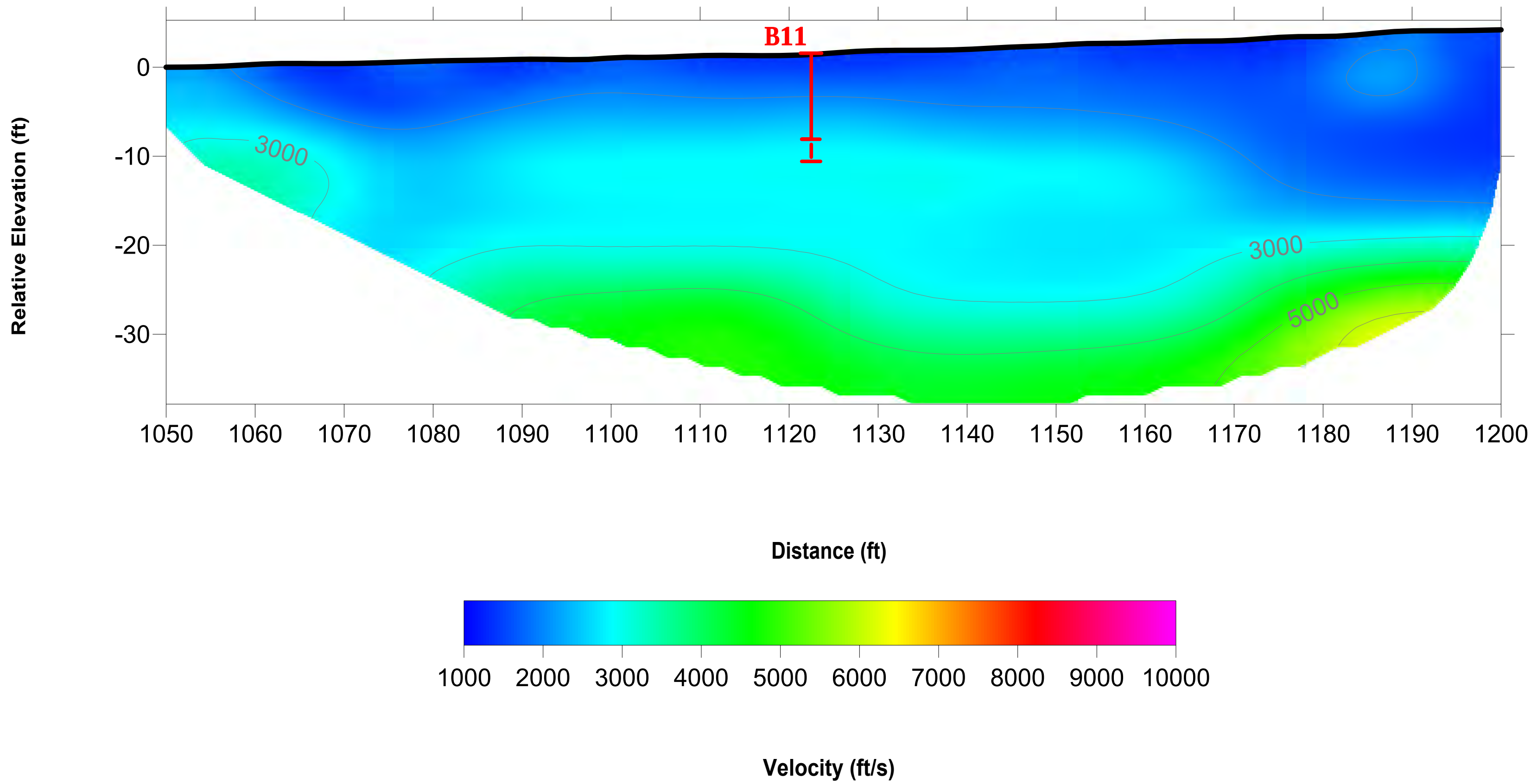
SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.15
	Project No.: 421016SWG	Date: 07/21	

LEGEND

B11 Approximate Depth to Gravel Layer

TOMOGRAPHY MODEL

SL-16

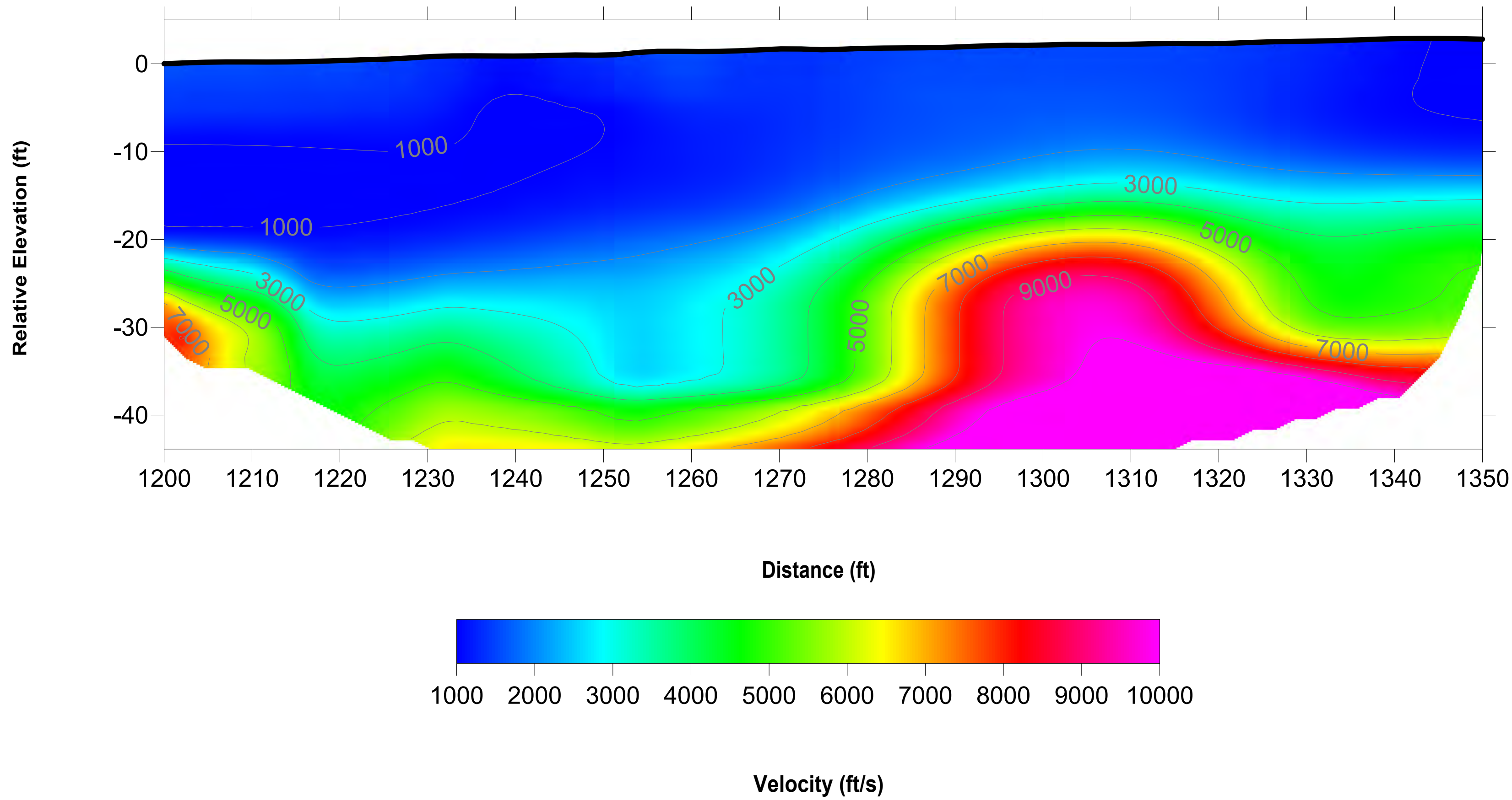


Note: Contour Interval = 1,000 feet per second

SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon		ATLAS Figure 4.16
	Project No.: 421016SWG	Date: 07/21	

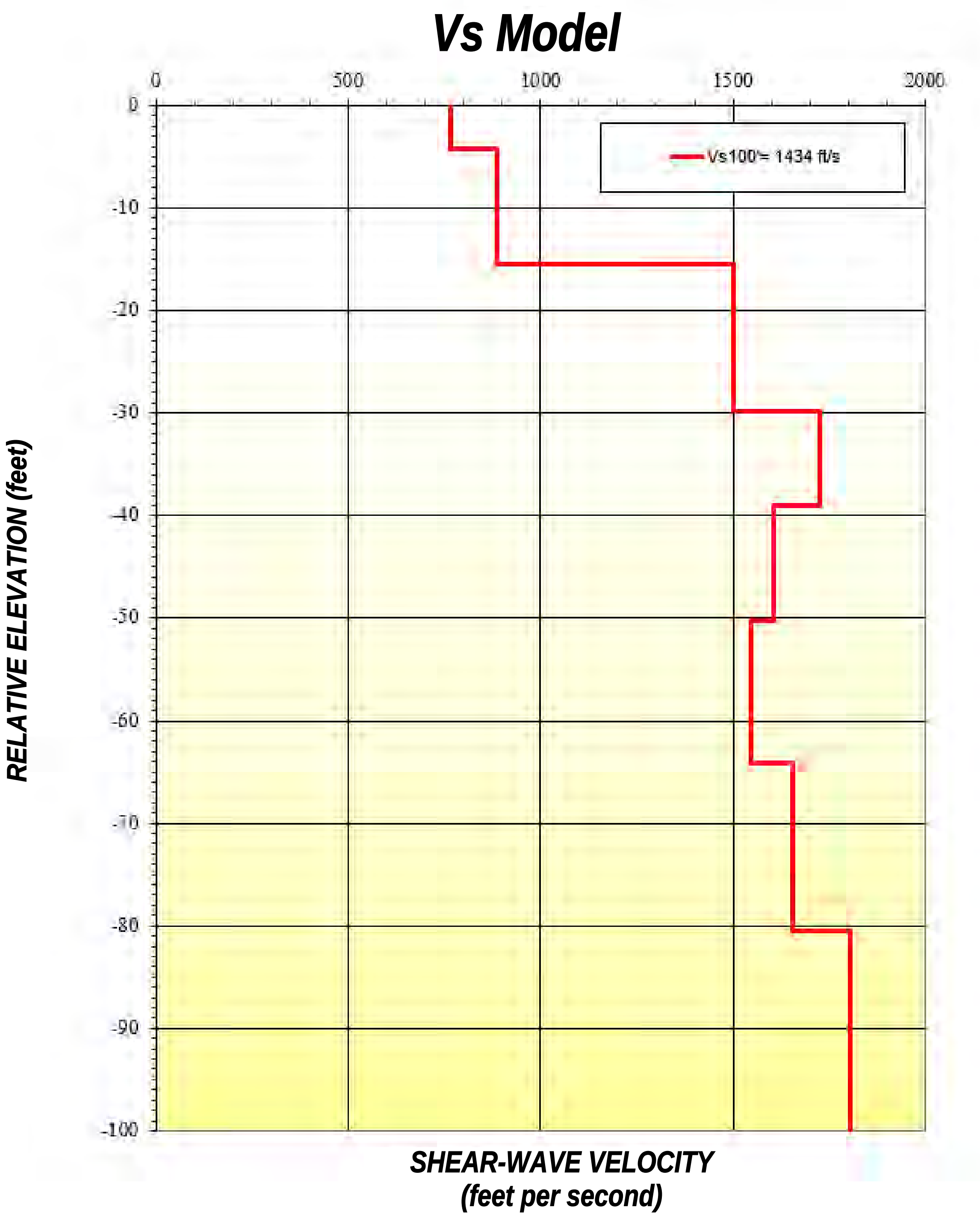
TOMOGRAPHY MODEL

SL-17



SEISMIC PROFILE	TRAMMELLCR-79-05 Canby, Oregon Project No.: 421016SWG / Date: 07/21	ATLAS Figure 4.17

Note: Contour Interval = 1,000 feet per second



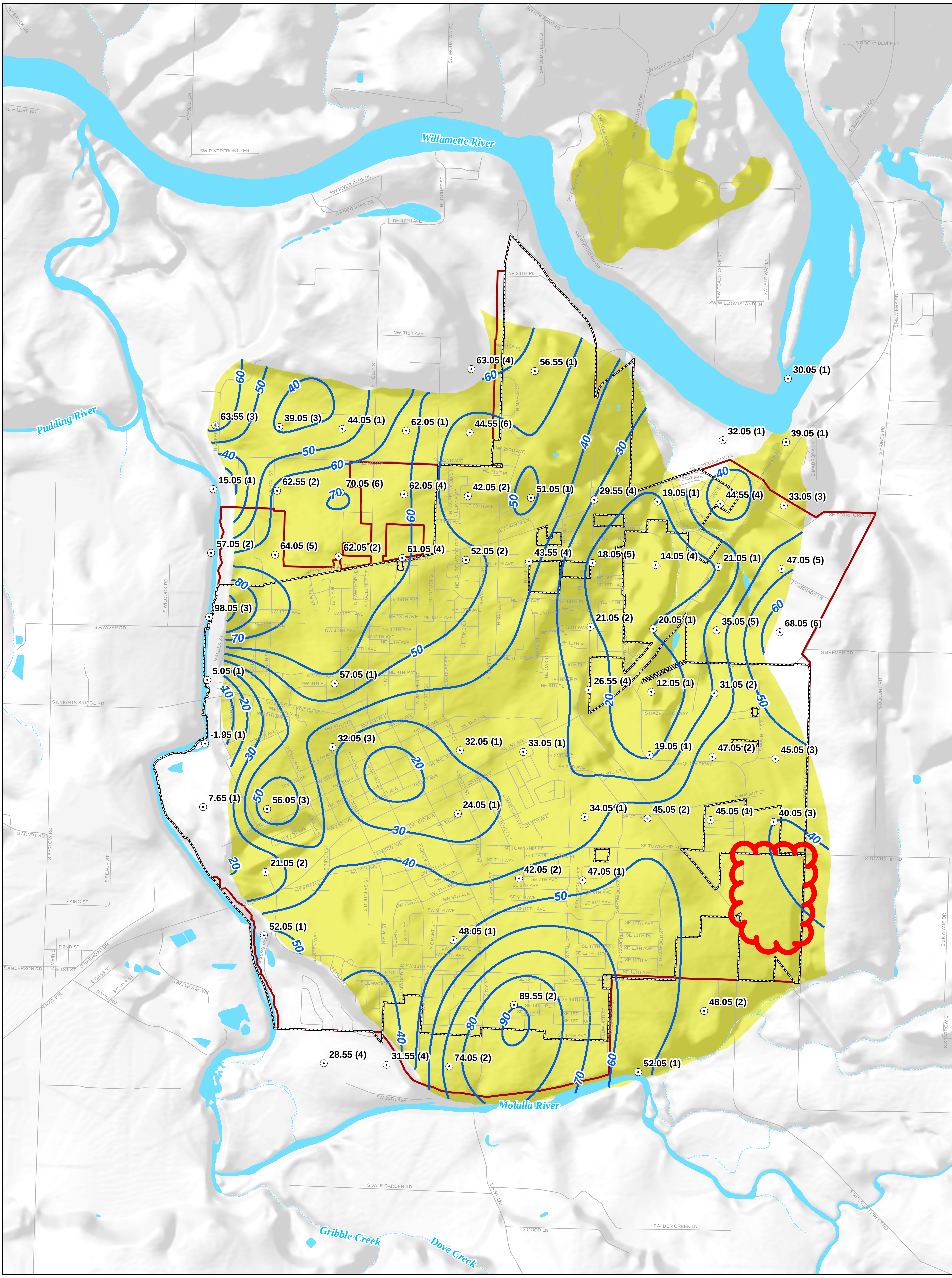
ReMi RESULTS **RL-1**	TRAMMELLOCR-79-05 Canby, Oregon	ATLAS Figure 5
	Project No.: 421016SWG — Date: 07/21	

APPENDIX D

APPENDIX D

DEPTH TO SEASONAL HIGH GROUNDWATER

This appendix contains groundwater mapping completed for the PIP area by GSI Water Solutions, Inc. in 2013.



LEGEND

Well Location (centroid of 1/4 1/4 section)
- Number represents depth to groundwater
- Number in parenthesis represents number of observations

Static Depth to Water Contours

Streets

Watercourses

Waterbodies

All Other Features

Qfc - Catastrophic flood deposits, coarse grained facies

Canby City Limits

Canby Urban Growth Boundary

MAP NOTES:
Date: August 28, 2013
Data Sources: OWRD, USGS, METRO RLIS, OGIC,
Elevation data based on NGVD 1927 vertical datum

FIGURE 4

Depth to Seasonal High Groundwater

City of Canby

Groundwater Protectiveness Demonstration

N

0 1,000 2,000 3,000

Feet

GSI Water Solutions, Inc.

APPENDIX E

APPENDIX E

CHLORIDE, SULFATE, AND PH TESTING

This appendix presents the results of chloride, sulfate, and pH testing completed for the project by Specialty Analytical.

Specialty Analytical
9011 SE Jannsen Rd
Clackamas, OR 97015
TEL: (503) 607-1331
Website: www.specialtyanalytical.com

August 18, 2021

Scott McDevitt
NV5
9450 SW Commerce Cr
Suite 300
Wilsonville, OR 97070
TEL: (503) 968-8787
FAX:

RE: Canby/ TrammellCr-79-05 Order No.: 2108093

Dear Scott McDevitt:

There were no problems with the analysis and all data for associated QC met EPA or laboratory specifications, except where noted in the Case Narrative, or as qualified with flags. Results apply only to the samples analyzed. Without approval of the laboratory, the reproduction of this report is only permitted in its entirety.

If you have any questions regarding these tests, please feel free to call.

Sincerely,

Marty French
Lab Director

Specialty Analytical

WO#: **2108093**
Date Reported: **8/18/2021**

CLIENT: NV5
Project: Canby/ TrammellCr-79-05

Lab ID: 2108093-001 **Matrix:** SOIL
Client Sample ID TP-1@1.5' + TP-6@1.5' **Collection Date:** 7/19/2021

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLORIDE ION IN SOIL				**D512**	**SW9056PR**	Analyst: **NK**
Chloride	ND	0.749		mg/Kg	1	8/17/2021 2:29:43 PM
WATER SOLUBLE SULFATE ION				**T290-95**	**SW9056PR**	Analyst: **NK**
Sulfate	23.9	0.749		mg/Kg	1	8/17/2021 2:29:57 PM
CORROSIVITY BY PH				**SW9045D**		Analyst: **JRH**
pH	5.42	1.00		pH Units	1	8/12/2021 2:43:28 PM

Lab ID: 2108093-002 **Matrix:** SOIL
Client Sample ID TP-3@1.5' + TP-7@4.0' **Collection Date:** 7/19/2021

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLORIDE ION IN SOIL				**D512**	**SW9056PR**	Analyst: **NK**
Chloride	1.87	0.749		mg/Kg	1	8/17/2021 3:14:43 PM
WATER SOLUBLE SULFATE ION				**T290-95**	**SW9056PR**	Analyst: **NK**
Sulfate	21.9	0.749		mg/Kg	1	8/17/2021 3:14:57 PM
CORROSIVITY BY PH				**SW9045D**		Analyst: **JRH**
pH	5.66	1.00		pH Units	1	8/12/2021 2:45:28 PM

Qualifiers: H Holding times for preparation or analysis exceeded R RPD outside accepted recovery limits

QC SUMMARY REPORT

WO#: **2108093**

8/18/2021

Specialty Analytical

Client: NV5

Project: Canby/ TrammellCr-79-05 **TestCode:** **CL_ASTM_S**

Sample ID: **CCV1-R41474** SampType: **CCV** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: RunNo: **41474**

Client ID: **CCV** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533075**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	19.8	0.250	20.00	0	98.8	90	110				

Sample ID: **MB-R41474** SampType: **MBLK** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: RunNo: **41474**

Client ID: **PBS** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533076**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.250									

Sample ID: **LCS-R41474** SampType: **LCS** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: RunNo: **41474**

Client ID: **LCSS** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533077**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	9.92	0.250	10.00	0	99.2	80	120				

Sample ID: **2108093-001ADUP** SampType: **DUP** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: **8/17/2021** RunNo: **41474**

Client ID: **TP-1@1.5' + TP-6@1.** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533079**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.739						0	0	20	RRF

Qualifiers: H Holding times for preparation or analysis exceeded R RPD outside accepted recovery limits

QC SUMMARY REPORT

WO#: **2108093**

8/18/2021

Specialty Analytical

Client: NV5

Project: Canby/ TrammellCr-79-05

TestCode: **CL_ASTM_S**

Sample ID: **2108093-001ADUP** SampType: **DUP** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: **8/17/2021** RunNo: **41474**

Client ID: **TP-1@1.5' + TP-6@1.** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533079**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID: **2108093-001AMS** SampType: **MS** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: RunNo: **41474**

Client ID: **TP-1@1.5' + TP-6@1.** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533080**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	29.2	0.749	29.98	0.2998	96.5	75	125				

Sample ID: **CCV2-R41474** SampType: **CCV** TestCode: **CL_ASTM_S** Units: **mg/Kg** Prep Date: RunNo: **41474**

Client ID: **CCV** Batch ID: **18384** TestNo: **D512** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533082**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	19.7	0.250	20.00	0	98.3	90	110				

Qualifiers: H Holding times for preparation or analysis exceeded R RPD outside accepted recovery limits

QC SUMMARY REPORT

WO#: **2108093**

8/18/2021

Specialty Analytical

Client: NV5

Project: Canby/ TrammellCr-79-05 **TestCode:** **PH_S**

Sample ID: **2108093-001ADUP**		SampType: **DUP**		TestCode: **PH_S**		Units: **pH Units**		Prep Date:			RunNo: **41431**			
Client ID: **TP-1@1.5' + TP-6@1.**		Batch ID: **R41431**		TestNo: **SW9045D**				Analysis Date: **8/12/2021**			SeqNo: **532468**			

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
pH	5.53	1.00						5.420	2.01	20	

Qualifiers: H Holding times for preparation or analysis exceeded R RPD outside accepted recovery limits

QC SUMMARY REPORT

Specialty Analytical

WO#: **2108093**

8/18/2021

Client: NV5

Project: Canby/ TrammellCr-79-05

TestCode: **T290_95**

Sample ID: **CCV1-R41475** SampType: **CCV** TestCode: **T290_95** Units: **mg/Kg** Prep Date: RunNo: **41475**

Client ID: **CCV** Batch ID: **18384** TestNo: **T290-95** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533083**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	18.9	0.250	20.00	0	94.5	90	110				

Sample ID: **MB-R41475** SampType: **MBLK** TestCode: **T290_95** Units: **mg/Kg** Prep Date: RunNo: **41475**

Client ID: **PBS** Batch ID: **18384** TestNo: **T290-95** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533084**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	ND	0.250									

Sample ID: **LCS-R41475** SampType: **LCS** TestCode: **T290_95** Units: **mg/Kg** Prep Date: RunNo: **41475**

Client ID: **LCSS** Batch ID: **18384** TestNo: **T290-95** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533085**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	9.50	0.250	10.00	0	95.0	80	120				

Sample ID: **2108093-001ADUP** SampType: **DUP** TestCode: **T290_95** Units: **mg/Kg** Prep Date: **8/17/2021** RunNo: **41475**

Client ID: **TP-1@1.5' + TP-6@1.** Batch ID: **18384** TestNo: **T290-95** **SW9056PR** Analysis Date: **8/17/2021** SeqNo: **533087**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	25.2	0.739						23.90	5.14	20	

Qualifiers: H Holding times for preparation or analysis exceeded R RPD outside accepted recovery limits

QC SUMMARY REPORT

Specialty Analytical

WO#: **2108093**
8/18/2021

Client: NV5
Project: Canby/ TrammellCr-79-05 **TestCode:** **T290_95**

Sample ID: **2108093-001ADUP**	SampType: **DUP**	TestCode: **T290_95**	Units: **mg/Kg**	Prep Date: **8/17/2021**	RunNo: **41475**
Client ID: **TP-1@1.5' + TP-6@1.**	Batch ID: **18384**	TestNo: **T290-95**	**SW9056PR**	Analysis Date: **8/17/2021**	SeqNo: **533087**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID: **2108093-001AMS**	SampType: **MS**	TestCode: **T290_95**	Units: **mg/Kg**	Prep Date:	RunNo: **41475**
Client ID: **TP-1@1.5' + TP-6@1.**	Batch ID: **18384**	TestNo: **T290-95**	**SW9056PR**	Analysis Date: **8/17/2021**	SeqNo: **533088**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	50.2	0.749	29.98	23.90	87.6	70	130				

Sample ID: **CCV2-R41475**	SampType: **CCV**	TestCode: **T290_95**	Units: **mg/Kg**	Prep Date:	RunNo: **41475**
Client ID: **CCV**	Batch ID: **18384**	TestNo: **T290-95**	**SW9056PR**	Analysis Date: **8/17/2021**	SeqNo: **533090**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sulfate	18.8	0.250	20.00	0	94.1	90	110				

Qualifiers: H Holding times for preparation or analysis exceeded R RPD outside accepted recovery limits

Specialty Analytical
9011 SE Jannsen Rd
Clackamas, Oregon 97015
TEL: 503-607-1331 FAX: 503-607-1336
Website: www.specialtyanalytical.com

Sample Receipt Checklist

Client Name NV5 | Work Order Number 2108093

RcptNo: 1 | Date and Time Received 8/12/2021 12:20:48 PM | Received by: Mandy Wehe

Completed by | Reviewed by:

Completed Date: 8/12/2021 | Reviewed Date: 8/13/2021 9:37:13 AM

Carrier name: Client

Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	Not Present ☐
Are matrices correctly identified on Chain of custody?	Yes ☑	No ☐	
Is it clear what analyses were requested?	Yes ☑	No ☐	
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Samples in proper container/bottle?	Yes ☑	No ☐	
Were correct preservatives used and noted?	Yes ☑	No ☐	NA ☐
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
Were container lables complete (ID, Pres, Date)?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Was an attempt made to cool the samples?	Yes ☐	No ☑	NA ☐
All samples received at a temp. of > 0° C to 6.0° C?	Yes ☐	No ☑	NA ☐
Response when temperature is outside of range:	Approved by client.		
Preservative added to bottles:			
Sample Temp. taken and recorded upon receipt?	Yes ☑	No ☐	To 37.5 ºC
Water - Were bubbles absent in VOC vials?	Yes ☐	No ☐	No Vials ☑
Water - Was there Chlorine Present?	Yes ☐	No ☐	NA ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	NA ☑
Are Samples considered acceptable?	Yes ☑	No ☐	
Custody Seals present?	Yes ☐	No ☑	
Traffic Report or Packing Lists present?	Yes ☐	No ☑	
Airbill or Sticker?	Air Bill ☐	Sticker ☐	Not Present ☑
Airbill No:			
Sample Tags Present?	Yes ☐	No ☑	
Sample Tags Listed on COC?	Yes ☐	No ☑	
Tag Numbers:			
Sample Condition?	Intact ☑	Broken ☐	Leaking ☐

Case Number: | SDG: | SAS:

Adjusted? ________ Checked by

Any No and/or NA (not applicable) response must be detailed in the comments section be

Specialty Analytical
9011 SE Jannsen Rd
Clackamas, Oregon 97015
TEL: 503-607-1331 FAX: 503-607-1336
Website: www.specialtyanalytical.com

Sample Receipt Checklist

Client Contacted? ☐ Yes ☑ No ☐ NA Person Contacted: Comments:

Contact Mode: ☐ Phone: ☐ Fax: ☐ Email: ☐ In Person:

Client Instructions:

Date Contacted: Contacted By:

Regarding:

CorrectiveAction:

www.specialtyanalytical.com

Specialty Analytical
9011 SE Jannsen Rd
Clackamas, OR 97015
Phone: 503-607-1331
Fax: 503-607-1336

Chain of Custody Record

Date: 8/11/21 Page: of:

Project Name: Canby Soulut

Project No: TrammellCr-79-05 PO No:

Collected by: JAM

State Collected: OR ☑ WA ☐ OTHER

Report To (PM): Scott McDevitt

PM Email: Scott.McDevitt@NV5.com

Client: NV5

Address: 9450 SW Commerce Cr Suite 300

City, State, Zip: Wilsonville, OR 97070

Telephone: 503 968-8787

AP Email: Scott.McDevitt@NV5.com

Laboratory Project No (internal): 2108093

Temperature on Receipt: 37.5 °C

Cooling: no Shipped Via: client

Custody Seal: Y / (N) Intact / Broken Cooler / Bottle

MDL ☐ TIER IV ☐ EDD ☐

Sample Disposal: ☐ Return to client ☑ Disposal by lab (after 60 days)

Requested Tests

	Sample Name	Sample Date	Sample Time	Sample Matrix*	# of Containers	pH	Soluble Sulfates	Chloride										Comments
1	TP-1@1.5' + TP-6@1.5'	7/19/21		S	1	✓	✓	✓										
2	TP-3@1.5 + TP-7@4.0'	7/19/21		S	1	✓	✓	✓										
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

*Matrix: A=Air, AQ=Aqueous, L=Liquid, O=Oil, P=Product, S=Soil, SD=Sediment, SL=Solid, W=Water, DW=Drinking Water, GW=Ground Water, SW=Storm Water, WW=Waste Water, M=Miscellaneous

Turn-around Time: Standard (5-7 Business): ☑ 3 Day: ☐ 2 Day: ☐ Next Day: ☐ Same Day: ☐

Expedited turn-around requests should be coordinated in advance

Relinquished	Date/Time	Received	Date/Time
x [signature]	8/12/21 1200	x [signature]	8/12/21 1200
x		x	
x		x	

Definitions:

KEY TO FLAGS

A: This sample contains a Gasoline Range Organic not identified as a specific hydrocarbon product. The result was qualified against gasoline calibration standards.

A1: This sample contains a Diesel Range Organic not identified as a specific hydrocarbon product. The result was qualified against diesel calibration standards.

A2: This sample contains a Lube Oil Range Organic not identified as a specific hydrocarbon product. The result was qualified against lube oil calibration standards.

A3: The results was determined to be Non-Detect based on hydrocarbon pattern recognition. The product was carry-over from another hydrocarbon type.

A4: The product appears to be aged or degraded.

B: The blank exhibited a positive result greater than the reporting limit for this compound.

CN: See Case Narrative.

E: Result exceeds the calibration range for this compound. The result should be considered an estimate.

F: The positive result for this hydrocarbon is due to single component contamination. The product does not match any hydrocarbon in the fuels library.

FS: Follow-up testing is suggested.

G: Result may be biased high due to biogenic interferences. Clean up is recommended.

H: Sample was analyzed outside recommended holding time.

HT: At client’s request, samples was analyzed outside of recommended holding time.

HP: Sample was analyzed outside recommended holding time due to VOA having pH >2.

J: The results for this analyte is between the MDL and the PQL and should be considered an

Definitions:

estimated concentration.

K: Diesel result is biased high due to amount of Oil contained in the sample.

L: Diesel result is biased high due to amount of Gasoline contained in the sample.

M: Oil result is biased high due to amount of Diesel contained in the sample.

N: Gasoline result is biased high due to amount of Diesel contained in the sample.

MC: Sample concentration is greater than 4x the spiked value, the spiked value is considered insignificant.

MI: Result is outside control limits due to matrix interference.

NH: Sample matrix is non-homogeneous

MSA: Value determined by Method of Standard Addition.

O: Laboratory Control Standard (LCS) exceeded laboratory control limits but meets CCV criteria. Data meets EPA requirements.

Q: Detection levels elevated due to sample matrix.

R: RPD control limits were exceeded

RF: Duplicate failed due to result being at or near the method-reporting limit.

RP: Matrix spike values exceed established QC limits; post digestion spike is in control.

S: Recovery is outside control limits.

SC: CCV or LCS exceeded high recovery control limits, but associated samples are non-detect. Data meets EPA requirements.

SL: LCS exceeded recovery control limits, but associated MS/MSD passing. Data meets EPA requirements.

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Improving Lives