REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Mill Creek Corporate Center – Buildings 221, 222, 223, and 224
Salem, Oregon

For
PacTrust
December 2, 2021

Project: PacTrust-201-06

December 2, 2021

PacTrust
15350 SW Sequoia Parkway, Suite 300
Portland, OR 97224

Attention: Matt Oyen

Report of Geotechnical Engineering Services
Mill Creek Corporate Center – Buildings 221, 222, 223, and 224
Salem, Oregon
Project: PacTrust-201-06

NV5 is pleased to submit this report of geotechnical engineering services for Buildings 221, 222, 223, and 224 of the Mill Creek Corporate Center development in Salem, Oregon. Our services were conducted in accordance with our proposal dated November 16, 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

NNP:kt
Attachments
One copy submitted (via email only)
Document ID: PacTrust-201-06-120221-geor.docx

EXECUTIVE SUMMARY

This section provides a summary of the main geotechnical considerations associated with Buildings 221, 222, 223, and 224 of the Mill Creek Corporate Center in Salem, Oregon. Our conclusions are based on the proposed conceptual site development information provided by the design team. This summary is an overview and the report should be referenced for a thorough discussion of the subsurface conditions and geotechnical recommendations for the project.

- Based on loading provided by Mackenzie and assuming new fills are less than 7 feet above current grades, the buildings can be supported by conventional spread footings bearing on 1-foot-thick granular pads on firm native soil or new structural fill on firm native soil. If new fill exceeds 7 feet, construction of buildings and other settlement-sensitive elements should be delayed until fill-induced settlement is complete.

- A topsoil/tilled zone is present in the upper 12 to 24 inches of soil over a portion of the site from past (and current) agricultural activities. In general, the tilled zone is unconsolidated and will provide poor support for foundations, fills, floor slabs, and pavement. In areas where the tilled zone will not be removed by site cuts, we recommend that the full depth of the tilled zone be improved by scarifying and re-compacting or cement amending as described in the “Design” and “Construction” sections.

- Higher plasticity soil is not uncommon with topsoil/tilled zones (tilled zone material). If topsoil/tilled soil will be used as earthwork fill material, the topsoil should be mixed with a minimum of 50 percent underlying material. An alternative approach is to cement amend the material when using as structural fill. As noted in the “Soil Amendment with Cement” section, higher cement ratios will be required.

- Based on soil and groundwater conditions, liquefaction-induced ground settlement is not a design consideration at the site.

- Groundwater was observed between 0.5 foot and 6 feet BGS in explorations completed during the wet season. These shallow depths to groundwater could impact the stormwater ponds (see discussion in the “Stormwater Ponds” section), site cuts, and foundation and utility excavations, which could require active dewatering during construction.

- Foundation drains are recommended where building footings will be at or below existing grades. In addition, floor slab drains could be required if cuts are required for buildings.

- The moisture content of the native soil is generally above that required for compaction. As discussed in the “Structural Fill” section, moisture conditioning (drying) will be required to use the material as structural fill.

- The near-surface soil is sensitive to disturbance when at a moisture content that is above optimum. Haul roads and staging areas will be necessary to prevent damage to subgrade and repair costs. A discussion of subgrade protection is included in the "Construction" section.

- Based on the soil and groundwater conditions, infiltration systems are not feasible at the site.

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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
CRBG	Columbia River Basalt Group
ESAL	equivalent single-axle load
FHWA	Federal Highway Administration
g	gravitational acceleration (32.2 feet/second^2)
H:V	horizontal to vertical
MCE	maximum considered earthquake
mil	milli-inch
OSHA	Occupational Safety and Health Administration
OSSC	Oregon Standard Specifications for Construction (2021)
pcf	pounds per cubic foot
pci	pounds per cubic inch
PG	performance grade
psf	pounds per square foot
psi	pounds per square inch
SOSSC	State of Oregon Structural Specialty Code
USDA	U.S. Department of Agriculture

1.0 INTRODUCTION

NV5 has prepared this geotechnical engineering report for use in design and construction of Buildings 221, 222, 223, and 224 of the Mill Creek Corporate Center in Salem, Oregon. The approximately 26-acre site is located south of the intersection of Truax Drive SE and Aumsville Highway SE. Figure 1 shows the site relative to existing topographic and physical features. The existing and proposed site layout (overlay) and approximate exploration locations are shown on Figure 2.

Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents.

2.0 PROJECT UNDERSTANDING

Development will include construction of four concrete tilt-up structures with footprints between 70,000 and 200,000 square feet and associated infrastructure. According to Mackenzie, maximum column and floor slab loading for the buildings will be 100 kips and 350 psf, respectively. Settlement tolerances for the buildings are 1 inch total and ½ inch differential over a 50-foot span.

We understand the buildings will be constructed in accordance with SOSSC Seismic Category 1 or 2. A site-specific seismic report is not required by the SOSSC for Seismic Category 1 or 2, nor has a report been requested by the design team and is not included in our scope.

Grading work for Buildings 221 and 222 was completed in the summer of 2021 and building construction will commence in 2022. Grading work and construction of Buildings 223 and 224 will occur at a later date. We anticipate fills for Buildings 223 and 224 could be up to 5 feet.

3.0 BACKGROUND

Based on historical aerial photography, the site was used for agricultural purposes until at least 1985. By 1994, an approximately 8,000-square-foot structure with an approximately 4- to 5-acre storage yard was constructed in the northeastern portion of the site. It appears business operations occurred at the site until approximately 2006. The building remained vacant at the site until approximately 2018 to 2019 when it was demolished.

NV5 (formerly GeoDesign, Inc.) prepared a geotechnical report for construction of Truax Drive SE in July 2019 (GeoDesign, 2019) and a geotechnical earthwork recommendations memorandum for early grading work for Buildings 221 and 222 in July 2021 (NV5, 2021). Explorations associated with previous work at the site consisted of excavating 11 test pits to depths of up to 13 feet BGS.

4.0 SCOPE OF SERVICES

The purpose of our geotechnical engineering services was to provide geotechnical engineering recommendations for use in design and construction of the proposed development. Our scope of services included the following:

- Reviewed previous geotechnical reports and explorations completed at the site.
- Reviewed readily available geotechnical and geological information for the site area.
- Prepared this geotechnical report summarizing previous explorations and laboratory testing, analyses, geotechnical design criteria, and construction recommendations, including information relating to the following:
  - Summary of the subsurface conditions at the site
  - Foundation recommendations for shallow spread footings, including allowable bearing capacity, lateral resistance parameters, and settlement (total and differential)
  - Seismic design criteria in accordance with the 2019 SOSSC and ASCE 7-16
  - Seismic hazards, including site class and liquefaction potential
  - Settlement potential
  - Recommendations for site preparation and grading, including over-excavation, general and temporary excavation, temporary and permanent slopes, fill placement and compaction criteria, suitability of on-site soil for fill, and subgrade preparation for buildings and pavement
  - Recommendations for wet weather construction
  - Groundwater conditions at the site, including recommendations for dewatering during construction and subsurface drainage
  - Recommendations for trench backfill
  - AC recommendations for roadways based on assumed traffic counts

5.0 SITE CONDITIONS

5.1 GEOLOGIC CONDITIONS

The site is located along the drainage valley of Mill Creek (Gannett and Caldwell, 1998). The valley separates the Salem Hills to the west and the Waldo Hills to the east, which are structural highs located within the larger Willamette Valley physiographic province (Orr and Orr, 1999). Turner Gap is a valley cut along the ancestral course of the North Santiam River, which emptied into the Salem Basin to the north during the late Pliocene to Pleistocene (approximately 2 million to 100,000 years before present) but is now occupied by Mill Creek.

The Waldo Hills flanking the valley are highlands underlain by basalt flows belonging to the Miocene Age (approximately 17 million to 6 million years old) CRBG, comprising a series of thick basalt flows that filled lowland areas throughout much of the northern Willamette Valley (Tolan and Beeson, 2000). In-place spheroidal weathering of the basalt is common in the shallow subsurface, producing large cobbles and boulders (or “corestones”) of less weathered basalt in a strongly decomposed matrix of residual soil.

Geologic mapping by Tolan and Beeson (2000) indicates the CRBG and younger materials are underlain by a thick assemblage of Eocene to early Miocene Age (approximately 40 million to 16 million years old) marine sedimentary rocks consisting of interbedded sandstone, siltstone, shale, and claystone. The marine sedimentary bedrock is mapped near the surface in the north-central portion of the site where tectonic uplift and erosion has removed the overlying units (Tolan and Beeson, 2000). The sedimentary bedrock is the oldest unit mapped in the region.

The USDA Web Soil Survey indicates the surficial soil at the site consists of silt and clay with variable proportions of sand and gravel to depths of up to 5 feet BGS.

5.2 SURFACE CONDITIONS

The irregular-shaped, approximately 26-acre site is located in the southeastern portion of Salem. The site is bound to Aumsville Highway SE to the northeast, the Santiam Correctional Institution to the southeast, and Truax Drive SE to the southwest and northwest. Recent grading work was completed for Buildings 221 and 222 and gravel-covered building pads are present in those locations. The remainder of the site is currently undeveloped and covered by grass and shrubs.

5.3 SUBSURFACE CONDITIONS

5.3.1 General

NV5 previously completed explorations at the site as part of work associated with Truax Drive SE and for the planned development. Field explorations consisted of excavating 11 test pits to depths of up to 13 feet BGS. The approximate exploration locations are shown on Figure 2. Logs and laboratory testing results from the explorations are presented in in Appendix A.

In addition to our test pit explorations, we reviewed nearby water well logs from the Oregon Water Resources Department. Locations of the wells are shown on Figure 2. Logs of the wells are presented in Appendix B.

Subsurface conditions at the site consist of an up to 24 inches of topsoil/tilled zone underlain by clay and silt that extends to depths between 9 and approximately 20 feet BGS. The silt and clay are underlain by gravel. A detailed description of the subsurface conditions is provided below.

5.3.2 Topsoil/Tilled Zone

The upper 12 to 24 inches of soil generally consists of topsoil consisting of silt and clay with sand and organics that has been tilled for agricultural purposes. The topsoil includes an approximately 2- to 10-inch-thick root zone.

5.3.3 Silt and Clay

Silt and clay with varying amounts of sand and trace organics were encountered below the topsoil/tilled zone. The silt and clay are generally soft to stiff with stiffness typically increasing with depth. The silt and clay are brown-gray and moist to wet. Based on our experience, higher plasticity silt/clay may be present within the topsoil zone. The silt and clay extend to the maximum depth explored of up to 13 feet BGS, with the exception of test pits TP-2 (January 2018) and TP-5 (July 2010).

5.3.4 Gravel

Dense to very dense gravel with varying amounts of silt, clay, and sand was encountered below the silt and clay in test pit TP-2 (January 2018) and test pit TP-5 (July 2010) at depths of 9.5 and 9 feet BGS, respectively. In addition, gravel was encountered in three wells surrounding the site between depths of 7 and 20 feet BGS.

The gravel is consistent with the weathered CRBG described in the “Geologic Conditions” section. Thickness of the gravel varies in the area and, based on geologic mapping, is underlain by marine sedimentary rocks.

5.3.5 Groundwater

Groundwater seepage was encountered between 0.5 foot and 6 feet BGS in test pits completed in the wet season. Standing water was also present in portions of the site during the explorations in January 2018.

Perched water might be present at, or just below, the ground surface after prolonged periods of heavy rainfall. The depth to groundwater may fluctuate in response to seasonal changes, prolonged rainfall, changes in surface topography, and other factors not observed in this study.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on our review of the development plan and the results of explorations, laboratory testing, and analyses, it is our opinion the proposed development can be constructed at the site. The primary geotechnical considerations for the project are summarized in the “Executive Summary” section. Our specific recommendations are provided in the following sections.

7.0 DESIGN

7.1 SETTLEMENT CONSIDERATIONS

7.1.1 General

Subsurface conditions at the site consist of 9 to approximately 20 feet of silt and clay underlain by dense gravel. The silt and clay are compressible under structural and/or fill loads. Based on building column and floor slab loading described in the “Project Understanding” section, the combination of column loading, floor slab loading, and fills greater than 7 feet are sufficient to exceed the tolerable building settlement of 1 inch as described by Mackenzie. If fill height exceeds 7 feet, construction of buildings and other settlement-sensitive structures should be delayed until fill-induced settlement is complete.

Conformation of fill-induced settlement completion prior to construction of settlement-sensitive elements should be based on settlement points as described in the “Settlement Monitoring” section. Actual completion of fill-induced settlement will vary based on fill thickness; however, settlement will generally be complete within three to four months of placing fill to final grade. Paving is typically completed more than five months after placement of fill, and settlement monitoring likely will not be required in roadways or parking areas.

7.1.2 Settlement Monitoring

Settlement monitoring points can be used to monitor fill-induced settlement associated with the project. The settlement monitoring points should be installed immediately after fills reach fill grade. Settlement monitoring points should consist of fixed, ridged elements that can be protected from disturbance and can be easily surveyed. We recommend that the location of the settlement monitoring points be determined by NV5 and the contractor. For preliminary planning purposes, we recommend settlement monitoring points be installed at a rate of one per 10,000 square feet of area fill that is greater than 7 feet.

The settlement monitoring points should be surveyed twice weekly. The settlement monitoring points should be monitored using survey equipment with accuracy of 1/100th of a foot and referenced to a stationary datum established at least 500 feet from fill placement. The survey data should be supplied to NV5 within three days of the survey.

7.2 SHALLOW FOUNDATIONS

7.2.1 General

Based on the column and floor slab loads (up to 100 kips and 350 psf, respectively) and provided new fills are less than 7 feet, it is our opinion that the proposed buildings can be supported on conventional spread footings underlain by 1-foot-thick granular pads overlying the undisturbed native soil or overlying structural fill on undisturbed native soil. If new fill exceeds 7 feet above finished existing grades, construction of buildings should be delayed until fill-induced settlement is compete as described in the “Settlement Considerations” section.

Foundation elements should not be supported on topsoil/tilled zones or undocumented fill material. If present, these materials should be removed and replaced with structural fill or improved as described in this report.

As discussed in the “Drainage” section, foundation drains should be installed where foundations are at or below existing grades. If cuts are required for the buildings, floor slab drains may also be required.

7.2.2 Granular Pads

We recommend all footings be underlain by at least 12-inch-thick granular pads underlain by firm, undisturbed native soil or structural fill over undisturbed native soil. The depth of the granular pads may need to be increased to remove topsoil or potentially existing fill material. The granular pads should extend 6 inches beyond the margins of the foundations for every foot excavated below the foundations’ base grade and should consist of imported granular material as described in the “Structural Fill” section. The imported granular material should be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557, or until well keyed, as determined by one of our geotechnical staff. We recommend that a member of our geotechnical staff observe the prepared footing subgrade before placing granular pads as well.

7.2.3 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.

7.2.4 Settlement

Assuming the building loads above and provided fills are less than 7 feet, total post-construction settlement is expected to be less than 1 inch with differential settlement of up to ½ inch over a 50-foot span (for similarly loaded footings). Where fills are greater than 7 feet and when fill-induced settlement is complete prior to construction of buildings, post-construction settlement is also expected to be less than 1 inch with differential settlement of up to ½ inch over a 50-foot span.

7.2.5 Resistance to Sliding

Lateral loads on footings can be resisted by passive earth pressure on the sides of structures and by friction on the base of footings. Our analysis indicates that the available passive earth pressure for footings confined by native soil and structural fill is 300 pcf modeled as an equivalent fluid pressure. Typically, the movement required to develop the available passive resistance may be relatively large. Therefore, we recommend using a reduced passive pressure of 250 pcf equivalent fluid pressure. The passive earth pressure should be reduced to 150 pcf below groundwater levels. 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 down slopes.

For footings in contact with native soil, a coefficient of friction equal to 0.30 may be used when calculating resistance to sliding. For footings in contact with granular footing pads, a coefficient of friction equal to 0.40 may be used when calculating resistance to sliding.

7.2.6 Subgrade Observation

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

7.3 SEISMIC DESIGN CONSIDERATIONS

7.3.1 ASCE 7-16 Design Parameters

Seismic design criteria for this project will be based on the 2019 SOSSC and ASCE 7-16. Assuming a gravel contact of 20 feet BGS, the site is near the boundary of seismic Site Classes C and D. Because deep shear wave velocity testing was not performed at the site, we recommend using a seismic site class of D for design. If a seismic site class of C will result in significant cost saving to the project, NV5 can complete shear wave velocity testing to determine if a seismic site class of C can be used. Testing can be completed for a relatively small cost; however, it will not guarantee a seismic site class of C.

ASCE 7-16 Section 11.4.8 requires a ground motion hazard study in accordance with Section 21.2 for structures on Site Class D sites with S_1 greater than or equal to 0.2 g (S_1 at the site is 0.399 g). Exception 2 of ASCE 7-16 Section 11.4.8 indicates a ground motion hazard study is not required for structures on Site Class D sites with S_1 greater to or equal 0.2 g, provided the value of the seismic response coefficient C_S is determined by Eq. (12.8-2) for values of $T \leq 1.5T_s$ and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for $TL \geq T > 1.5T_s$ or Eq. (12.8-4) for $T > TL$. We anticipate the buildings will meet these requirements, but if Exception 2 is not applicable, a ground motion hazard analysis will be required. We recommend the structural engineer evaluate these requirements and exceptions to determine if the parameters for Site Class D provided in Table 1 can be used for design or if a site-specific seismic hazard evaluation is required.

Table 1. Seismic Design Parameters*

Seismic Design Parameter	Short Period (T_s = 0.2 second)	1 Second Period (T_1 = 1.0 second)
MCE Spectral Acceleration	S_s = 0.791 g	S_1 = 0.399 g
Site Class	D	
Site Coefficient	F_a = 1.184	F_v = 1.901
Adjusted Spectral Acceleration	S_{MS} = 0.936 g	S_{M1} = 0.758 g
Design Spectral Response Acceleration Parameters	S_{DS} = 0.624 g	S_{D1} = 0.506 g

* The structural engineer should evaluate code requirements and exceptions to determine if these parameters can be used for design.

If shear wave velocity testing is completed and analysis indicates a seismic site class of C is appropriate, the design parameters in Table 2 could be used.

Table 2. Seismic Design Parameters (for informational purposes only)*

Seismic Design Parameter	Short Period (T_s = 0.2 second)	1 Second Period (T_1 = 1.0 second)
MCE Spectral Acceleration	S_s = 0.791 g	S_1 = 0.399 g
Site Class	C	
Site Coefficient	F_a = 1.200	F_v = 1.500
Adjusted Spectral Acceleration	S_{MS} = 0.951 g	S_{M1} = 0.598 g
Design Spectral Response Acceleration Parameters	S_{DS} = 0.634 g	S_{D1} = 0.399 g

* Design parameters can only be used if on-site shear wave velocity testing is completed.

7.3.2 Liquefaction and Lateral Spreading

Liquefaction is a phenomenon caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. The excessive buildup of pore water pressure results in the sudden loss of shear strength in a soil. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. Sand boils and flows observed at the ground surface after an earthquake are the result of excess pore pressures dissipating upwards, carrying soil particles with the draining water. In general, loose, saturated sand soil with low silt and clay content is the most susceptible to liquefaction. Low plasticity, silty sand and silt may be moderately susceptible to liquefaction under relatively higher levels of ground shaking. Liquefaction can cause seismically induced densification of subsurface soil, which can result in settlement at the ground surface.

While shallow groundwater is present at the site, the stiffness and plasticity of the silt and clay are sufficient to preclude liquefaction and it is our opinion that the risk of liquefaction and liquefaction-related hazards are not design considerations for the project.

7.4 FLOOR SLABS

Satisfactory subgrade support for building floor slabs supporting floor loads up to 350 psf can be obtained, provided the building pads are prepared as described in the “Settlement Considerations” and “Construction” sections. To help reduce moisture transmission and slab shifting, we recommend a minimum 6-inch-thick layer of floor slab base rock be placed and compacted over a subgrade that has been prepared in conformance with the “Site Preparation” section. The floor slab base rock should meet the requirements in the “Structural Fill” section and be compacted to at least 95 percent of ASTM D1557.

The near-surface native soil is fine grained and will tend to maintain a 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.

We note that foundation drains are recommended in cut areas as discussed in the "Drainage" section. If shallow groundwater conditions are encountered beneath the building pads in cut areas, we recommend a sub-slab drain system be installed beneath building floor slabs, as discussed in the "Sub-Slab Drainage" section. If the project includes highly moisture-sensitive flooring, we recommend 10- or 15-mil vapor barriers, which are often required by flooring manufacturers. Selection and design of an appropriate vapor barrier should be based on discussions among members of the design team.

Slabs should be reinforced according to their proposed use and per the structural engineer's recommendations. Load-bearing concrete slabs may be designed assuming a modulus of subgrade reaction, k, of 100 pci. If the subgrade is cement amended to a depth of at least 12 inches, the subgrade reaction can be increased to 225 pci.

The design parameters provided above assume that the floor slabs are underlain by native soil, compacted structural fill, or at least 12 inches of improved topsoil/existing fill subgrade (by means of scarification and compaction or by cement amendment). If encountered, deleterious material and oversized debris should be removed prior to compaction. If this approach is taken, it should be understood that a small risk of additional concrete distress and associated maintenance is acceptable. If this risk is not acceptable, full removal of the existing fill and replacement with structural fill will be required.

7.5 RETAINING STRUCTURES

7.5.1 Assumptions

Our retaining wall design recommendations are based on the following assumptions: (1) the walls are cantilevered walls, (2) the walls are less than 10 feet in height, (3) drainage is provided behind walls, (4) the retained soil has a slope flatter than 4H: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.

7.5.2 Wall Design Parameters

Permanent retaining structures free to rotate slightly around the base 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 $7.5H^2$ 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.

7.5.3 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, we 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.

7.6 PAVEMENT

7.6.1 Assumptions and Recommendations

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:

- 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.
- Resilient moduli of 4,500 psi and 20,000 psi for the subgrade and aggregate base, respectively.
- A 20-year design life with no growth.
- Initial and terminal serviceability indices of 4.2 and 2.5, respectively.
- Reliability of 85 percent and standard deviation of 0.4.
- Fire access will consist of an imposed fire apparatus load of 75,000 pounds on an infrequent basis.

We do not have information on the amount or type of truck traffic anticipated for the project. We have assumed truck traffic will consist of approximately 50 percent FHWA Class Group 6 (4-axle, single unit) and 50 percent FHWA Class Group 9 (tractor/trailer 3- to 4-axle).

Based on this information, we have assumed that traffic will consist of passenger cars in light traffic areas and the trucks indicated above. We assume that only the entrance will carry the full traffic load, with diminishing loading as the trucks distribute through the site. Our pavement design recommendations assuming a truck ADT between 50 and 200 through various parts of the site are provided in Table 4.

Table 4. 20-Year Standard Pavement Sections

Traffic Levels	Trucks per Day	ESALs	AC (inches)	Aggregate Base (inches)
Car Parking Stall	0	10,000	2.5	8
Car Travel Aisles	0	20,000	3	9
Truck Area	50	281,000	4.5	14
Truck Area	100	563,000	5	16
Truck Area	150	1,125,000	5.5	18
Truck Area	200	1,500,000	6	18

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 5.

Table 5. 20-Year Pavement Sections with Cement Amendment

Traffic Levels	Trucks per Day	ESALs	AC (inches)	Aggregate Base (inches)	Cement Amendment[1] (inches)
Car Parking Stall	0	10,000	2.5	4	12
Car Travel Aisles	0	20,000	3	4	12
Truck Area	50	281,000	4.5	4	16
Truck Area	100	563,000	5	4	16
Truck Area	150	1,125,000	5.5	5	16
Truck Area	200	1,500,000	6	5	16

1. Assumes a minimum seven-day unconfined compressive strength of 100 psi.

7.6.2 General Pavement 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 aggregate base. Lastly, the amended subgrade should be protected with a minimum of 4 inches of aggregate base prior to construction traffic access.

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

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 amendment thicknesses (if installed) do not account for construction traffic, and haul roads and staging areas should be used as described in the "Construction" section.

Aggregate base contaminated with fines from construction should be removed and replaced prior to placement of AC.

7.7 DRAINAGE

7.7.1 Permanent Dewatering

Pending final grading plans, permanent dewatering systems may be required if cuts are planned for the proposed development. Because grading work for Buildings 221 and 222 is complete and the locations of Buildings 223 and 224 are in lower lying area, we anticipate remaining grading will generally consist of fill.

If required, we anticipate the systems may typically consist of a series of gravel drains beneath building slab (see below) or paved areas. We recommend that NV5 review the final grading plan relative to permanent dewatering requirements.

7.7.2 Surface

Where possible, the finished ground surface around the buildings should be sloped away from the structures at a minimum 2 percent gradient for a distance of at least 5 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 buildings without providing means for positive drainage (e.g., swales or catch basins).

7.7.3 Foundation Drains

We recommend that perimeter foundation drains be installed in all areas where the finished floor grade will be at or below existing grades. The foundation drains should be constructed at a minimum slope of approximately ½ percent and pumped or drained by gravity to a suitable discharge. The perforated drainpipe should not be tied to a stormwater drainage system without backflow provisions. The foundation drains should consist of 4-inch-diameter, perforated drainpipe embedded in a minimum 2-foot-wide zone of crushed drain rock that extends to the ground surface. The invert elevation of the drainpipe should be installed at least 18 inches below the elevation of the floor slab.

If shallow groundwater conditions are encountered beneath the building pads in cut areas, we recommend a sub-slab drain system be installed beneath building floor slabs, as discussed in the “Sub-Slab Drainage” section.

Perforated collector pipes for subsurface drains should be routed to a suitable discharge point at an appropriate location away from the buildings. The discharge pipes should not be connected into the stormwater system or to other sub-drain systems, unless means for backflow prevention are installed.

The drain rock and geotextile should meet the requirements specified in the “Materials” section. The drain rock and geotextile should extend up the side of embedded walls to within a foot of the ground surface, geotextile wrapped over the top of the drain rock, as recommended in the “Retaining Structures” section.

7.7.4 Sub-Slab Drainage

In addition to the recommendations for foundation drains (see above), sub-slab drains may be necessary in cut areas. Floor slabs established below existing grades may encounter shallow groundwater conditions. Depending on the depth of the cut and depth to groundwater, a series of sub-slab drainage pipes may need to be installed. Further details regarding permanent dewatering systems will need to be developed once grading plans have been finalized and/or site conditions are exposed.

7.7.5 Stormwater Ponds

If storm ponds are planned, they should be used for treatment only and lined to prevent seepage of shallow groundwater at the site. Pond liners should be designed to resist the hydrostatic forces associated with groundwater that could rise to within 6 inches of the existing ground surface.

7.8 INFILTRATION SYSTEMS

Based on the subsurface and groundwater conditions at the site, infiltration systems are not viable for the project.

8.0 CONSTRUCTION

8.1 SITE PREPARATION

8.1.1 Demolition

Structures are not present on site; however, a prior structure was present until approximately 2018. Abandoned foundations and utilities, if present, will need to be removed and the resulting excavations backfilled. Utility lines should be completely removed or, with prior approval, grouted full if left in place. All prior or existing septic systems should be removed and water wells, if present, should be decommissioned in accordance with Oregon Water Resources Department requirements.

Drain tiles (if encountered) should also be removed or it may be possible (with prior approval) to grout in place. In general, demolished material should be transported off site for disposal.

Excavations remaining from demolition and removal of existing structures should be backfilled with compacted structural fill in accordance with recommendations in the "Structural Fill" section.

8.1.2 Grubbing and Stripping

Trees and shrubs should be removed from fill areas. In addition, 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 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 3 inches, although greater stripping depths may be required to remove localized zones of loose or organic soil. Greater stripping depths (approaching 12 inches) may be anticipated in areas with thicker vegetation and shrubs and near drainage ditches. 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.

8.1.3 Undocumented Fill

8.1.3.1 General

While not encountered in the explorations at the site, undocumented fill could be encountered during development. Due to the variable composition of the fill and the unknown methods of placement and compaction, reliable strength properties for undocumented fill are extremely difficult to predict.

8.1.3.2 Foundation Areas

Undocumented fill should be removed from under new building foundations and footings should be supported on structural fill as discussed in the “Foundation Support” section.

8.1.3.3 Floor Slabs and Pavement Areas

There is a small risk for poor performance of floor slabs and pavement established directly over undocumented fill soil. To eliminate the risk of poor performance, undocumented fill should be moisture conditioned and re-compacted or removed and replaced after site stripping and cuts.

Floor slabs and pavement can be constructed on undocumented fill and topsoil, provided a small risk of distress is accepted (minor floor slab cracking and localized “bird baths” in pavement areas) and they are evaluated as described in the “Subgrade Evaluation” section. To reduce the potential for cracking, floor slabs can incorporate additional reinforcement to span areas where differential settlement occurs. This does not completely eliminate the risk for settlement; however, in our experience, it is more cost effective than removal and re-compaction (or replacement with imported structural fill).

8.1.4 Topsoil/Tilled Zone Improvement

An approximately 12- to 24-inch-deep agricultural tilled zone was observed at the ground surface 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 24 inches). 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 subgrade 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 further on in this report, 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.

8.1.5 Subgrade Evaluation

Upon completion of stripping and subgrade stabilization, and prior to the placement of fill or pavement, 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 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.

8.1.6 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 this relatively uncompacted soil be removed from the test pits to a depth of 3 feet below finished subgrade. If a test pit is located within 10 feet of a footing, we recommend full-depth removal of the uncompacted soil. The resulting excavation should be brought back to grade with compacted structural fill.

8.2 SUBGRADE CONSIDERATIONS

Shallow groundwater should be expected and the fine-grained soil present on this site is easily disturbed. Accordingly, developing this site during the winter will be considerably more difficult and we strongly recommend summer earthwork. Summer earthwork will need to consider stabilizing the site for winter building construction. Stabilization can consist of thickened rock sections and/or cement-amended subgrade as discussed below. For this site, and somewhat dependent on the construction schedule, we recommend strong considerations to using 16-inch-thick cement-amended soil for subgrade stabilization.

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. This design base rock thickness will likely not support construction traffic or pavement construction. 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 for 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.

8.3 PERMANENT SLOPES

Permanent cut and fill slopes should not exceed 2H:1V for a maximum height of 10 feet. Taller slopes or steeper slope gradients should be evaluated on a case-by-case basis. 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. 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.

8.4 EXCAVATION

8.4.1 Excavation and Shoring

The near-surface soil consists of silt and clay. Shallow groundwater seepage should be expected near the ground surface and especially during the wet season. Temporary excavation sidewalls should stand vertical to a depth of approximately 4 feet, provided groundwater seepage does not occur in the sidewalls. Open excavation techniques may be used to excavate trenches with depths between 4 and 8 feet, provided the walls of the excavation are cut at a slope of 1H:1V or flatter and groundwater seepage does not occur. Excavations should be flattened to 1½H:1V or flatter if excessive sloughing occurs. In lieu of large and open cuts or if groundwater is present, approved temporary shoring may be used for excavation support. A wide variety of shoring and dewatering systems are available. Consequently, we recommend 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 may 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 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.

8.4.2 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.

8.5 DEWATERING

8.5.1 General

Our site explorations and experience with adjacent facilities indicate that groundwater levels may rise to the ground surface, particularly during winter and spring months. Slow percolation into the native soil may also result in perched water conditions during periods of wet weather. We expect groundwater will be encountered in trench excavations and possibly during mass grading. Temporary and permanent dewatering systems will likely be required.

8.5.2 Construction Dewatering

The contractor should be responsible for temporary drainage of surface water, perched water, and groundwater as necessary to prevent standing water and/or erosion at the working surface. Because of the instability of saturated, low plasticity silt with sand, sloughing and “running” conditions can occur if the excavation extends below groundwater seepage levels. Positive control of groundwater will be required to maintain stable trench sides and base. The proposed dewatering plan should be capable of maintaining groundwater levels at least 2 feet below the base of the trench excavation (including the depth required for trench bedding and stabilization material). In addition to safety considerations, running soil, caving, or other loss of ground will increase backfill volumes and can result in damage to adjacent structures or utilities.

Flow rates for dewatering are likely to vary depending on location, soil type, and the season in which the excavation occurs. Dewatering systems should be capable of adapting to variable flows. Because of the tendency of saturated, low plasticity silt with sand to “run,” we recommend dewatering wells or well points be considered if trench excavations extend below groundwater levels. Tight-joint driven sheets in conjunction with a scaled-down dewatering program can also be an effective way to control groundwater seepage, provided the sheets are driven deep enough to control heaving conditions at the base of the excavation.

Trench dewatering will be required to maintain dry working conditions if the invert elevations of the proposed utilities encounter groundwater. Given the silt with sand present, pumping from sumps located within the trench may result in excessive sloughing, caving, or running conditions and dewatering by well points may be required. If groundwater is present at the base of utility excavations, we recommend placing 1.5 to 2 feet of stabilization material at the base of the excavation. The use of a subgrade geotextile fabric may reduce the amount of stabilization material required. The actual thickness should be based on field observations during construction. Trench stabilization material and the subgrade geotextile fabric should meet the requirements described in the “Materials” section. Trench stabilization material should be placed in one lift and compacted until well keyed.

While we have described certain approaches to excavation dewatering, it is the contractor's responsibility to select the dewatering methods.

8.5.3 Permanent Dewatering

Permanent dewatering systems may be required along the bases of cut slopes, in areas where upwelling water conditions are observed, or at other susceptible areas identified by our office in the field. Further details regarding permanent dewatering systems are provided in the “Drainage” section.

8.6 TEMPORARY DRAINAGE

In addition to 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.

8.7 MATERIALS

8.7.1 Structural Fill

8.7.1.1 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.

8.7.1.2 On-Site Soil

The material at the site should be suitable for use as general structural fill, provided it is properly moisture conditioned and free of debris, organic material, and particles over 6 inches in diameter.

Higher plasticity is not uncommon with agricultural topsoil (tilled zone material) in the area. Following stripping (estimated at approximately 6 to 8 inches), we recommend that if the topsoil material will be used as earthwork fill material, the topsoil should be mixed with a minimum of 50 percent underlying material. The alternative approach is to cement amend the material (generally the approach in areas where the cut is less than 18 inches and the material will serve as building or pavement subgrade). As noted in the “Soil Amendment with Cement” section, higher cement ratios will be required.

Based on our experience, on-site clayey and silty soil will be above optimum moisture content; therefore, moisture conditioning (drying and mixing) will be required for us as structural fill. Moisture conditioning of wet soil will be difficult given the fine-grained nature of the soil, and extended periods of dry weather will be required to aerate the soil.

When used as structural fill, the on-site soil 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.

8.7.1.3 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 exists, 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.

8.7.1.4 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.

8.7.1.5 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.

8.7.1.6 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.

8.7.1.7 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.

8.7.1.8 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 that the upper 2 feet of material be compacted to 95 percent of the maximum dry density, as determined by ASTM D1557.

8.7.1.9 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.

8.7.1.10 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 should 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.

8.7.2 Geotextile Fabric

8.7.2.1 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.

8.7.2.2 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.

8.7.3 Soil Amendment with Cement

8.7.3.1 General

As an alternative to the use of imported granular material for wet weather structural fill, an experienced contractor may be able to amend the on-site soil with portland cement to obtain suitable support properties. Successful use of soil amendment depends on the use of correct mixing techniques, soil moisture content, and amendment quantities. The amount of cement used during amendment should be based on an assumed soil dry unit weight of 100 pcf.

In addition, 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.

8.7.3.2 Subbase Stabilization

Specific recommendations based on exposed site conditions for soil amendment can be provided if necessary. 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. It is difficult to predict field performance of soil to cement amendment due to variability in soil response, and we recommend laboratory testing to confirm expectations. In general, 6 percent cement by weight of dry soil can be used when the soil moisture content does not exceed approximately 20 percent. If the soil moisture content is in the range of 25 to 35 percent, 7 to 8 percent by weight of dry soil is recommended. The amount of cement added to the soil may need to be adjusted based on field observations and performance. Moreover, depending on the time of year and moisture content levels during amendment, water may need to be applied 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. Because of the higher clay content, organic content, moisture, and the near-surface high plasticity clay, we recommend using a higher cement ratio when stabilizing topsoil zone and highly plastic clay material, likely a minimum of 7 to 8 percent. Multiple tilling passes will likely be required for the clayey soil.

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. Shallow groundwater should be expected and the fine-grained soil present on this site is easily disturbed. Accordingly, and somewhat dependent on the construction schedule, we recommend strong considerations to using 16-inch-thick cement-amended soil for subgrade stabilization.

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.

8.7.3.3 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 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 subgrade, the four-day wait period is in effect.

8.7.3.4 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 amendment of 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.

8.7.4 AC

8.7.4.1 ACP

The AC should be Level 2, ½-inch, dense ACP according to OSSC 00744 (Asphalt Concrete Pavement) and compacted to 91 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 or better. 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.

8.7.4.2 Cold Weather Paving Considerations

In general, AC paving is not recommended during the 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.

8.8 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.

9.0 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, cement amendment, footing subgrade and granular pad 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.

10.0 LIMITATIONS

We have prepared this report for use by PacTrust 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 conceptual 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

Nick Paveglio, P.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
86690
OREGON
May 8, 2012
NICHOLAS N. PAVEGLIO
EXPIRES: 12/31/22

REFERENCES

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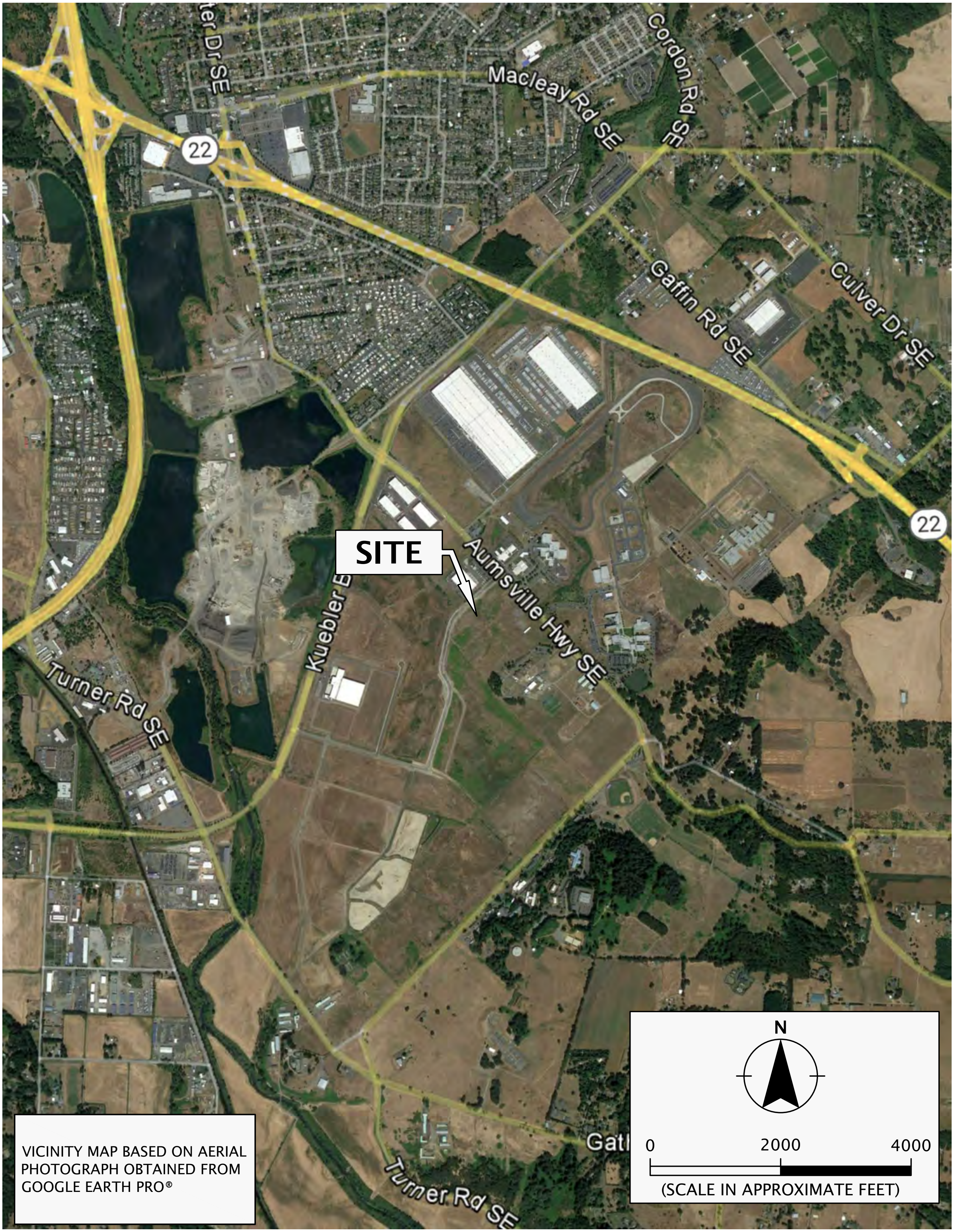
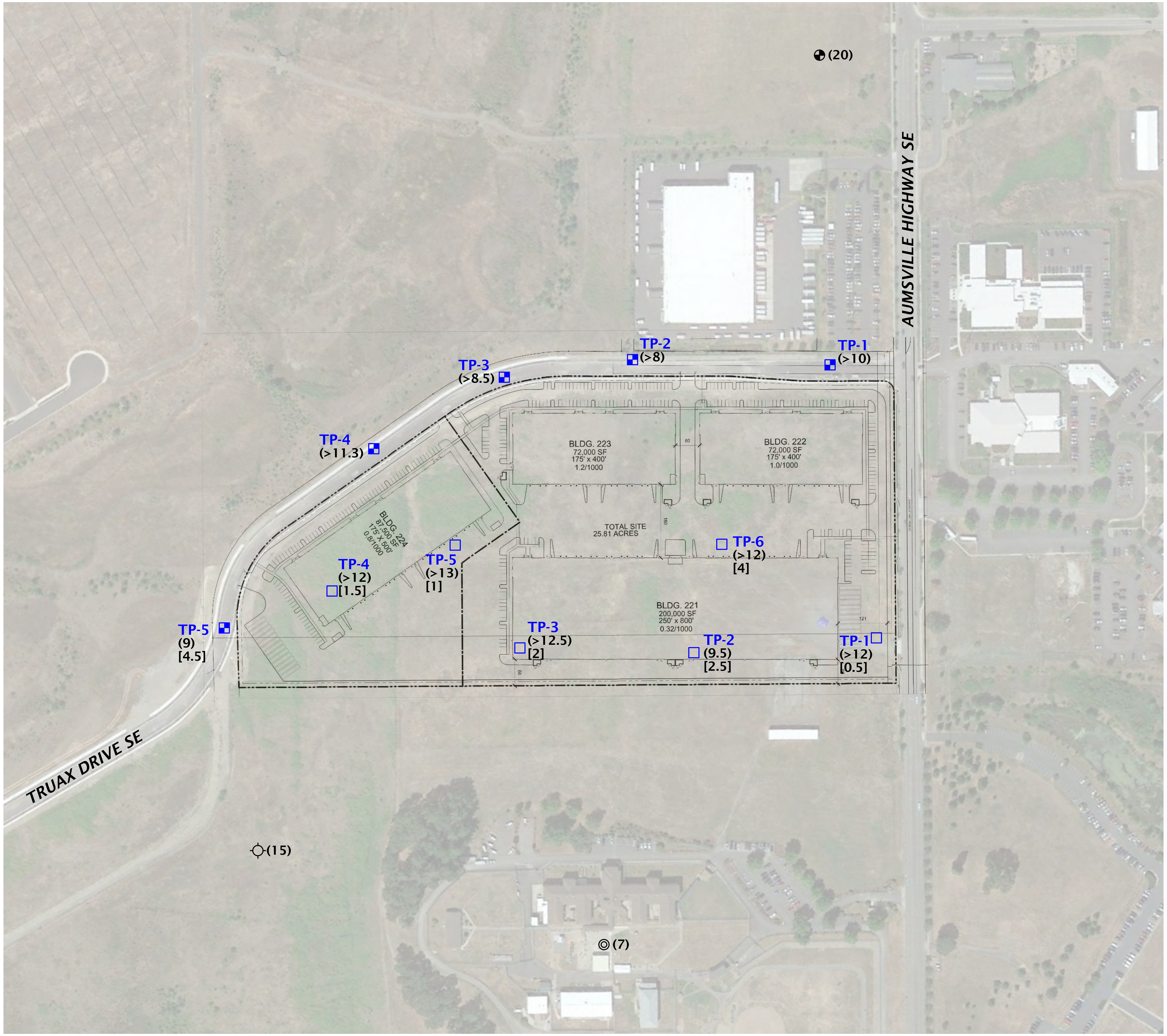
FIGURES



VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

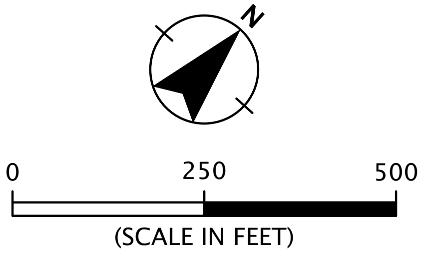
Printed By: aday | Print Date: 12/1/2021 5:16:28 PM
File Name: J:\M-R\PacTrust\PacTrust-201\PacTrust-201-06\Figures\CAD\PACTRUST-201-06-VM01.dwg | Layout: FIGURE 1

PACTRUST-201-06	**VICINITY MAP**	
DECEMBER 2021	MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224 SALEM, OR	**FIGURE 1**



LEGEND:

TP-1 ▚	TEST PIT (GEODESIGN, 2010)
TP-1 ☐	TEST PIT (GEODESIGN, 2018)
◕	MARI_66591 WELL LOG
◎	MARI_53396 WELL LOG
⌖	MARI_69908 WELL LOG
(>12)	DEPTH TO GRAVEL (FEET BGS)
[0.5]	DEPTH TO PERCHED GROUNDWATER, WHERE OBSERVED (FEET BGS)



NOTES:

1. SITE PLAN BASED ON IMAGE OF PROPOSED SITE LAYOUT DATED OCTOBER 31, 2021 PROVIDED BY PACTRUST.
2. AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO NOVEMBER 29, 2021.

FIGURE 2

SITE PLAN

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

PACTRUST-201-06

DECEMBER 2021

NV5

Printed By: aday | Print Date: 12/1/2021 5:16:33 PM
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APPENDIX A

APPENDIX A

PREVIOUS EXPLORATIONS

This appendix contains logs of 11 test pits and associated laboratory testing previously completed at the site by GeoDesign. Locations of the test pits are shown on Figure 2.

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0	Soft to medium stiff, brown CLAY (CL), minor silt, trace sand and organics (rootlets); moist to wet (topsoil to 12 inches, 2-inch-thick root zone).		PP	☒		Slow groundwater seepage observed at 0.5 foot. PP = 0.5 tsf
	very soft to soft, light gray-brown with gray mottles at 1.0 foot		PP			PP = <0.25 tsf
	medium stiff at 2.0 feet					
2.5			PP	☒		PP = 1.0 tsf
	stiff, without organics at 3.0 feet		PP			PP = 1.5 tsf
	light brown at 4.0 feet					
5.0	Stiff, light brown with gray mottled SILT (ML), minor clay, trace sand; moist.	5.0				
			PP	☒		PP = 1.5 tsf
	soft to medium stiff at 7.0 feet					
7.5			PP			PP = 0.5 tsf
	soft at 9.0 feet					
	Soft to medium stiff, light brown SILT (MH), minor clay, trace sand; moist.	9.5				
10.0				☒		
	Exploration completed at a depth of 12.0 feet.	12.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
12.5						
15.0						
17.5						
20.0					0 50 100	

EXCAVATED BY: K&E Excavating

LOGGED BY: JCH

COMPLETED: 01/26/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

PACTRUST-201-06

JANUARY 2018

TEST PIT TP-1

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

FIGURE A-1

TEST PIT LOG - 1 PER PAGE PACTRUST-201-06-TP1_6.GPJ GEODESIGN.GDT PRINT DATE: 12/1/21:SN:KT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0	Medium stiff, brown SILT (ML), minor to some clay, trace sand and organics (rootlets); moist to wet (topsoil to 24 inches, 2-inch-thick root zone).		PP PP	☒		PP = 0.5 tsf PP = 0.5 tsf
2.5	Stiff, light gray-brown CLAY (CL), minor silt, trace sand; moist.	2.0	PP PP	☒		PP = 1.5 tsf Moderate groundwater seepage observed at 2.5 feet. Clay tile at 2.5 feet. PP = 1.75 tsf
5.0 7.5	Stiff, light brown with gray mottled SILT (ML), minor clay, trace sand; moist.	5.0	PP PP	☒		PP = 2.0 tsf PP = 1.75 tsf
10.0	Very dense, red-brown with black mottled, clayey GRAVEL (GC), minor sand, trace silt; moist, gravel is angular (weathered sandstone).	9.5		☒		
12.5 15.0 17.5 20.0	Exploration terminated at a depth of 11.0 feet due to refusal with CAT 316 excavator with small, smooth-plated bucket.	11.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.

0 50 100

EXCAVATED BY: K&E Excavating

LOGGED BY: JCH

COMPLETED: 01/26/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC

15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

PACTRUST-201-06

JANUARY 2018

TEST PIT TP-2

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

FIGURE A-2

TEST PIT LOG - 1 PER PAGE PACTRUST-201-06-TP1_6.GPJ GEODESIGN.GDT PRINT DATE: 12/1/21:SN:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0		Medium stiff, dark brown SILT (ML), minor clay, trace sand and organics (rootlets); moist to wet (topsoil to 20 inches, 2-inch-thick root zone).					Moderate caving observed from 0.0 to 2.0 feet.
				PP	☒		PP = 0.5 tsf
				PP			PP = 0.75 tsf
		light gray-brown, some clay at 1.7 feet					Slow groundwater seepage observed from 2.0 to 2.5 feet.
2.5				PP			PP = 1.0 tsf
				PP	☒		PP = 1.25 tsf
		stiff, without organics at 4.0 feet					
5.0		stiff to very stiff, light yellow-brown at 5.0 feet					
		medium stiff to stiff at 6.0 feet					
				PP			PP = 1.75 tsf
7.5							
					☒		
10.0							
12.5		Exploration completed at a depth of 12.5 feet.	12.5				Surface elevation was not measured at the time of exploration.
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: K&E Excavating

LOGGED BY: JCH

COMPLETED: 01/26/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC

15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

PACTRUST-201-06

JANUARY 2018

TEST PIT TP-3

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

FIGURE A-3

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Soft to medium stiff, brown SILT (ML), minor clay, trace sand and organics (rootlets); moist (topsoil to 20 inches, 3-inch-thick root zone).					Minor caving observed from 0.0 to 2.0 feet.
				PP	☒		PP = 0.75 tsf
				PP			PP = 0.5 tsf Slow groundwater seepage observed from 1.5 to 2.0 feet.
		medium stiff, light gray-brown at 1.7 feet					
2.5				PP			PP = 1.5 tsf
					☒		
		stiff, without organics at 3.5 feet		PP			PP = 2.5 tsf
		light yellow-brown; massive at 4.5 feet					
5.0							
		soft to medium stiff at 5.5 feet					
		medium stiff to stiff at 7.0 feet			☒		
7.5				PP			PP = 1.25 tsf
10.0							
					☒		
		Exploration completed at a depth of 12.0 feet.	12.0				Surface elevation was not measured at the time of exploration.
12.5							
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: K&E Excavating

LOGGED BY: JCH

COMPLETED: 01/26/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC

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Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

PACTRUST-201-06

JANUARY 2018

TEST PIT TP-4

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

FIGURE A-4

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0	▥	Stiff, dark brown SILT (ML), minor clay, trace sand and organics (rootlets); moist to wet (topsoil to 18 inches, 2-inch-thick root zone).		PP	☒		Minor caving observed from 0.0 to 2.0 feet. PP = 1.25 tsf Moderate groundwater seepage observed from 1.0 to 1.5 feet.
	▨	Stiff, gray-brown CLAY (CL), minor silt, trace sand and organics (rootlets); moist to wet.	1.5	PP			PP = 1.25 tsf
2.5	▨						
	▨			PP PP	☒		PP = 1.5 tsf PP = 1.5 tsf
5.0	▨						
	▥	Stiff, light yellow-brown SILT (ML), minor clay, trace sand; moist.	5.5				
	▥			PP			PP = 1.75 tsf
	▥				☒		
7.5	▥						
10.0	▥						
	▥	Stiff, light yellow-brown SILT (MH), minor clay, trace sand; moist.	10.5				
	▥				☒		
12.5	▥						
		Exploration completed at a depth of 13.0 feet.	13.0				Surface elevation was not measured at the time of exploration.
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: K&E Excavating

LOGGED BY: JCH

COMPLETED: 01/26/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

PACTRUST-201-06

JANUARY 2018

TEST PIT TP-5

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

FIGURE A-5

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0	▥	Medium stiff, gray-brown SILT (ML), minor gravel and clay, trace sand and organics (rootlets); moist to wet (topsoil to 21 inches, 2-inch-thick root zone).		PP PP	☒		PP = 0.75 tsf PP = 1.0 tsf
	▥	light gray-brown at 1.8 feet					
2.5	▥			PP			PP = 1.0 tsf
	▨	Stiff, light gray-brown CLAY (CL), minor silt; moist.	3.0	PP	☒		PP = 1.75 tsf Slow groundwater seepage observed at 4.0 feet.
5.0	▨						
	▥	Stiff, light brown SILT (MH), minor clay, trace sand; moist.	6.0				Slow groundwater seepage observed at 6.0 feet.
7.5	▥			PP			PP = 1.5 tsf
	▥				☒		
10.0	▥						
		Exploration completed at a depth of 12.0 feet.	12.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
12.5							
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: K&E Excavating

LOGGED BY: JCH

COMPLETED: 01/26/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC

15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

PACTRUST-201-06

JANUARY 2018

TEST PIT TP-6

MILL CREEK CORP. CTR. BLDGS 221, 222, 223, 224
SALEM, OR

FIGURE A-6

TEST PIT LOG - 1 PER PAGE PACTRUST-201-06-TP1_6.GPJ GEODESIGN.GDT PRINT DATE: 12/1/21:SN:KT

TP-1

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
0.0	Soft to medium stiff, brown, sandy SILT with organics (ML); moist (18-inch-thick tilled zone).					
	Medium stiff to stiff, gray mottled brown SILT (ML), minor sand, trace clay; moist.	1.5	PP			PP = 3.0 tsf
2.5				☒		
5.0						
7.5				☒	●	
						No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
10.0	Exploration completed at a depth of 10.0 feet.	10.0				Surface elevation was not measured at the time of exploration.
12.5						

TP-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
0.0	Soft to medium stiff, brown, sandy SILT with organics (ML); moist (6-inch-thick root zone, 18- to 24-inch-thick tilled zone).					
2.5	Medium stiff to stiff, gray mottled brown SILT (ML), minor sand, trace clay; moist.	2.0	PP	☒		PP = 2.25 tsf
5.0						
						No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
7.5	Exploration completed at a depth of 8.0 feet.	8.0				Surface elevation was not measured at the time of exploration.
10.0						
12.5						

EXCAVATED BY: Dan J. Fischer Excavating, Inc.   LOGGED BY: CLR   COMPLETED: 07/02/10

EXCAVATION METHOD: backhoe (see report text)

GEODESIGN INC

15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

MACKENZIE-190-02

AUGUST 2010

TEST PIT

MILL CREEK INDUSTRIAL PARK - A STREET
SALEM, OR

FIGURE A-1

TP-3

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
0.0		Soft to medium stiff, brown, sandy SILT with organics (ML), trace clay; moist (6-inch-thick root zone, 12- to 18-inch-thick tilled zone).	1.5				
2.5		Medium stiff to stiff, gray mottled brown SILT (ML), trace sand and clay; moist.		PP			PP = 2.0 tsf
5.0				P200	☒	●	P200 = 98%
7.5							No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
		Exploration completed at a depth of 8.5 feet.	8.5				Surface elevation was not measured at the time of exploration.
10.0							
12.5							

TP-4

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
0.0		Soft to medium stiff, brown, sandy SILT with organics (ML), trace clay; moist (10-inch-thick root zone, 12- to 18-inch-thick tilled zone).	1.5				
2.5		Medium stiff to stiff, gray mottled brown SILT (ML), minor sand, trace clay; moist.		PP	☒	●	PP = 3.25 tsf
5.0							
7.5							
10.0							No groundwater seepage observed to the depth explored. No caving observed to the depth explored.
		Exploration completed at a depth of 11.3 feet.	11.3				Surface elevation was not measured at the time of exploration.
12.5							

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: CLR COMPLETED: 07/02/10

EXCAVATION METHOD: backhoe (see report text)

GEODESIGN INC 15575 SW Sequoia Parkway - Suite 100 Portland OR 97224 Off 503.968.8787 Fax 503.968.3068	MACKENZIE-190-02	**TEST PIT**
	AUGUST 2010	MILL CREEK INDUSTRIAL PARK - A STREET SALEM, OR
		FIGURE A-2

TP-5

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
0.0		Soft to medium stiff, brown, sandy SILT (ML); moist (8-inch-thick root zone, 18-inch-thick tilled zone).					
		Medium stiff to stiff, gray mottled brown SILT (ML), minor sand, trace clay; moist.	1.5				
2.5				PP			PP = 2.25 tsf
					☒	●	Moderate groundwater seepage observed at 4.5 feet.
5.0							
7.5							
		becomes dark gray-brown with gray mottles, sandy at 8.0 feet			☒		
		Dense to very dense, gray-brown GRAVEL with sand (GP), trace clay; wet, cemented, rounded to subrounded.	9.0		☒		Moderate caving observed at 9.0 feet.
10.0		Dense to very dense, gray-brown GRAVEL with sand (GP); wet, rounded to subrounded.	10.0				
					☒		Surface elevation was not measured at the time of exploration.
12.5		Exploration completed at a depth of 11.5 feet.	11.5				

~~TP-6~~

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT (%) 0 50 100	COMMENTS
~~0.0~~		~~Medium stiff, light brown-gray, sandy SILT (ML); moist (8-inch-thick root zone, 12- to 14-inch-thick tilled zone).~~					
		~~Very stiff to hard, brown mottled gray SILT with sand (MH), some clay; moist.~~	~~1.2~~		☒		
~~2.5~~		~~Medium stiff to stiff, gray mottled brown SILT (ML), minor sand, trace clay; moist.~~	~~2.5~~	~~PP~~			~~PP = 2.0 tsf~~
~~5.0~~							
					☒	●	
~~7.5~~							
~~10.0~~							~~No groundwater seepage observed to the depth explored.~~ ~~No caving observed to the depth explored.~~
~~12.5~~		~~Exploration completed at a depth of 12.0 feet.~~	~~12.0~~				~~Surface elevation was not measured at the time of exploration.~~

0 50 100

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: CLR COMPLETED: 07/02/10

EXCAVATION METHOD: backhoe (see report text)

GEODESIGN INC 15575 SW Sequoia Parkway - Suite 100 Portland OR 97224 Off 503.968.8787 Fax 503.968.3068	MACKENZIE-190-02	TEST PIT	
	AUGUST 2010	MILL CREEK INDUSTRIAL PARK - A STREET SALEM, OR	FIGURE A-3

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 (PERCENT)	PLASTIC LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)
TP-1	7.0		38							
TP-3	5.0		34				98			
TP-4	2.0		31							
TP-5	4.0		34							
~~TP-6~~	~~6.0~~		~~33~~							
~~TP-7~~	~~4.0~~		~~32~~							

LAB SUMMARY MACKENZIE-190-02-TP1_8.GPJ GEODESIGN.GDT PRINT DATE: 8/12/10:KT

GEODESIGN INC

15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
Off 503.968.8787 Fax 503.968.3068

MACKENZIE-190-02

AUGUST 2010

SUMMARY OF LABORATORY DATA

MILL CREEK INDUSTRIAL PARK - A STREET
SALEM, OR

FIGURE A-5

APPENDIX B

APPENDIX B

WATER WELL LOGS

This appendix contains water well logs near the site obtained from the Oregon Water Resources Department. Locations of the wells are shown on Figure 2.

STATE OF OREGON

GEOTECHNICAL HOLE REPORT

MARI 53396

(as required by OAR 690-240-035)

Received date 9/21/1998

(1) OWNER/PROJECT

Hole No.

Co.Job No. B-1

Name OREGON STATE CORRECTIONAL FACILITY

Street 3405 DEER PARK DRIVE SE

City SALEM State OR Zip 97310

(2) TYPE OF WORK

☒ New ☐ Alter (Recondition) ☐ Alter (Repair)

☐ Deepening ☒ Abandonment

(3) CONSTRUCTION

☐ Rotary Air ☐ Hand Auger ☐ Hollow Stem Auger

☐ Rotary Mud ☐ Cable Tool ☒ Push Probe Other

(4) TYPE OF HOLE

☒ Uncased Temporary ☐ Cased Permanent

☐ Uncased Permanent ☐ Slope Stabilit Other

(5) USE OF HOLE

SOIL SAMPLING

(6) BORE HOLE CONSTRUCTION

Special Standards ☐ Depth of completed well 12 ft.

HOLE

Diameter	From	To
2.00	0.00	12

SEAL

From	To	Material	Amount	Seal Grout Weight	Units
0.00	12.00	Bentonite	18.00		P

Backfill placed from ft. TO ft. Material

Filter pack placed from ft. TO ft. Size in.

(7) CASING/SCREEN

Screen ☐

(8) WELL TEST

Permeability Yield GPM

Conductivity PH

Temperature of water °F/C Depth artesian flow found ft.

Was water analysis done? ☐

By Whom?

Depth of strata to be analyzed. From ft. to ft.

Remarks

Name of supervising Geologist/Engineer

(9) LOCATION OF HOLE By legal description

County Marion Latitude Longitude

Township 8.00 S Range 2.00 W

Section 8 SE 1/4 NW 1/4

Tax lot Lot Block Subdivision

Legal desc:

Street Address of Well (or nearest address)

SAME

MAP with location indentified must be attached

(10) STATIC WATER LEVEL

Ft. below land surface. Date

Artesian Pressure lb/sq. in. Date

(11) SUBSURFACE LOG

Ground Elevation ft.

Material	From	To	SWL
SILT	0	7	
SILT & WEATHERED ROCK	7	12	

Date started 9/7/1998 Completed 9/7/1998

(12) ABANDONMENT LOG

Date started Completed

Professional Certification

(to be signed by a licensed water supply or monitoring well constructor, or registered geologist or civil engineer).

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License or Registration Number 10402

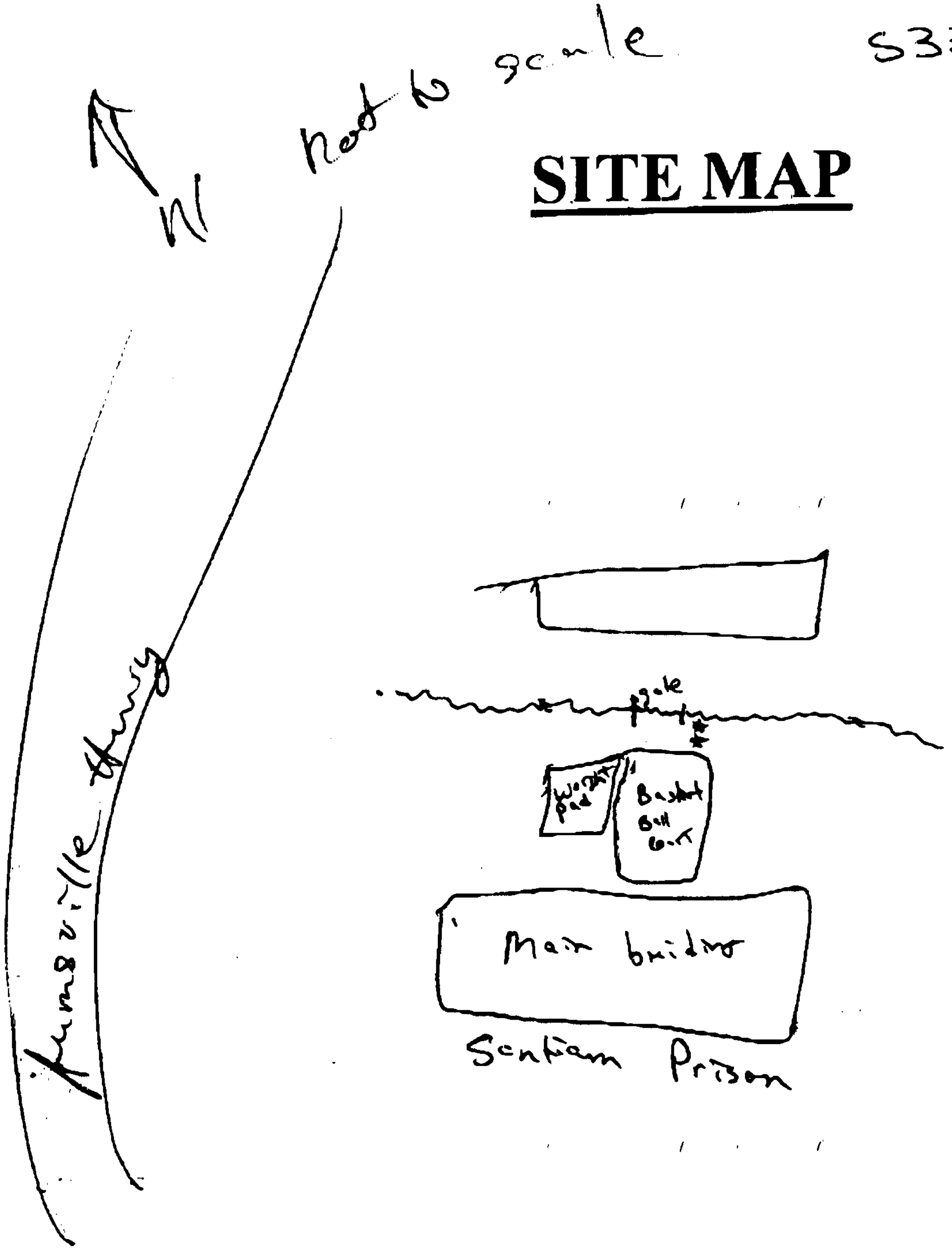
Signed By KEITH VIDOS Date

Affiliation GEO TECH EXPLORATIONS

THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

Marion
S3396-S3397

SITE MAP



MARI 66591

STATE OF OREGON
GEOTECHNICAL HOLE REPORT
(as required by OAR 690-240-0035)

11/17/2016

(1) OWNER/PROJECT

Hole Number B6

PROJECT NAME/NBR: 2-666/MILL CREEK DEVELOPMENT

First Name MATT Last Name OYEN

Company PACTRUST

Address 15350 SW SEQUOIA PKWY #300

City PORTLAND State OR Zip 97224

(2) TYPE OF WORK

☒ New ☐ Deepening ☒ Abandonment

☐ Alteration (repair/recondition)

(3) CONSTRUCTION

☐ Rotary Air ☐ Hand Auger ☐ Hollow stem auger

☒ Rotary Mud ☐ Cable ☐ Push Probe

☐ Other

(4) TYPE OF HOLE:

● Uncased Temporary ○ Cased Permanent

○ Uncased Permanent ○ Slope Stablity

○ Other

Other:

(5) USE OF HOLE

GEOTECHNICAL

(6) BORE HOLE CONSTRUCTION

Special Standard ☐ (Attach copy)

Depth of Completed Hole 25.00 ft.

BORE HOLE			SEAL				
Dia	From	To	Material	From	To	Amt	sacks/ lbs
4.87	0	25	Bentonite Chips	0	25	5	S

Backfill placed from ft. to ft. Material

Filter pack from ft. to ft. Material Size

(7) CASING/SCREEN

Casing	Screen	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐

(8) WELL TESTS

○ Pump ○ Bailer ○ Air ○ Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration(hr)

Temperature °F Lab analysis ☐ Yes By

Supervising Geologist/Engineer

Water quality concerns? ☐ Yes (describe below) TDS amount

From	To	Description	Amount	Units

(9) LOCATION OF HOLE (legal description)

County MARION Twp 8.00 S N/S Range 2.00 W E/W WM

Sec 8 NW 1/4 of the NW 1/4 Tax Lot 105

Tax Map Number Lot

Lat ° ' " or 44.89686111 DMS or DD

Long ° ' " or -122.96566667 DMS or DD

○ Street address of hole ● Nearest address

4027 AUMSVILLE HWY SE SALEM, OR 97317

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Predeepening			☐	
Completed Well			☐	

Flowing Artesian? ☐

WATER BEARING ZONES

Depth water was first found

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
					☐	
					☐	
					☐	
					☐	
					☐	

(11) SUBSURFACE LOG

Ground Elevation

Material	From	To
Silt & Clay	0	20
Gravels & Cobbles	20	25

Date Started 11/8/2016 Completed 11/8/2016

(12) ABANDONMENT LOG:

Material	From	To	Amt	sacks/ lbs
Bentonite Chips	0	25	5	S

Date Started 11/8/2016 Completed 11/8/2016

Professional Certification (to be signed by an Oregon licensed water or monitoring well constructor, Oregon registered geologist or professional engineer).

I accept responsibility for the construction, deepening, alteration, or abandonment work performed during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License/Registration Number 10563 Date 11/17/2016

First Name FORD Last Name STIGALL

Affiliation WESTERN STATES SOIL CONSERVATION, INC.

GEOTECHNICAL HOLE REPORT - continuation page

MARI 66591

11/17/2016

(6) BORE HOLE CONSTRUCTION

BORE HOLE

Dia	From	To

SEAL

Material	From	To	Amt	sacks/ lbs

FILTER PACK

From	To	Material	Size

(7) CASING/SCREENS

Casing	Screen	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐

(8) WELL TESTS

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)

Water Quality Concerns

From	To	Description	Amount	Units

Comments/Remarks

Driller: David Buchanan

(10) STATIC WATER LEVEL

Water Bearing Zones

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	

(11) SUBSURFACE LOG

Material	From	To

(12) ABANDONMENT LOG

Material	From	To	Amt	sacks/ lbs

GEOTECHNICAL HOLE REPORT - Map with location identified must be attached and shall include an approximate scale and north arrow

MARI 66591

11/17/2016

Map of Hole

MARI 69908

STATE OF OREGON
GEOTECHNICAL HOLE REPORT
(as required by OAR 690-240-0035)

6/11/2021

(1) OWNER/PROJECT

Hole Number B2

PROJECT NAME/NBR: CAPSTONE-16-03

First Name Last Name
Company GEO DESIGN - OWNER'S REP
Address 9450 SW COMMERCE CIRCLE-SUITE 300
City WILSONVILLE State OR Zip 97070

(2) TYPE OF WORK

☒ New ☐ Deepening ☒ Abandonment
☐ Alteration (repair/recondition)

(3) CONSTRUCTION

☐ Rotary Air ☐ Hand Auger ☐ Hollow stem auger
☒ Rotary Mud ☐ Cable ☐ Push Probe
☐ Other

(4) TYPE OF HOLE:

● Uncased Temporary ○ Cased Permanent
○ Uncased Permanent ○ Slope Stablity
○ Other
Other:

(5) USE OF HOLE

GEOTECHNICAL SOIL

(6) BORE HOLE CONSTRUCTION

Special Standard ☐ (Attach copy)

Depth of Completed Hole 30.00 ft.

BORE HOLE			SEAL				
Dia	From	To	Material	From	To	Amt	sacks/ lbs
4.87	0	30	Bentonite Chips	0	30	6	S

Backfill placed from ft. to ft. Material
Filter pack from ft. to ft. Material Size

(7) CASING/SCREEN

Casing	Screen	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐

(8) WELL TESTS

○ Pump ○ Bailer ○ Air ○ Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration(hr)

Temperature °F Lab analysis ☐ Yes By
Supervising Geologist/Engineer
Water quality concerns? ☐ Yes (describe below) TDS amount

From	To	Description	Amount	Units

(9) LOCATION OF HOLE (legal description)

County MARION Twp 8.00 S N/S Range 2.00 W E/W WM
Sec 8 NW 1/4 of the SW 1/4 Tax Lot 104
Tax Map Number Lot
Lat ° ' " or 44.88984444 DMS or DD
Long ° ' " or -122.96382222 DMS or DD
○ Street address of hole ● Nearest address

DEER PARK DRIVE SE

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Predeepening			☐	
Completed Well			☐	

Flowing Artesian? ☐
WATER BEARING ZONES
Depth water was first found

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
					☐	
					☐	
					☐	
					☐	
					☐	

(11) SUBSURFACE LOG

Ground Elevation

Material	From	To
Silt w/ Clay	0	15
Gravel	15	30

Date Started 5/17/2021 Completed 5/17/2021

(12) ABANDONMENT LOG:

Material	From	To	Amt	sacks/ lbs
Bentonite Chips	0	30	6	S

Date Started 5/17/2021 Completed 5/17/2021

Professional Certification (to be signed by an Oregon licensed water or monitoring well constructor, Oregon registered geologist or professional engineer).

I accept responsibility for the construction, deepening, alteration, or abandonment work performed during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License/Registration Number 10690 Date 6/11/2021
First Name SHARON Last Name STIGALL
Affiliation WESTERN STATES SOIL CONSERVATION, INC.

ORIGINAL - WATER RESOURCES DEPARTMENT
THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

Form Version:

GEOTECHNICAL HOLE REPORT - continuation page

MARI 69908

6/11/2021

(6) BORE HOLE CONSTRUCTION

BORE HOLE

Dia	From	To

SEAL

Material	From	To	Amt	sacks/ lbs

FILTER PACK

From	To	Material	Size

(7) CASING/SCREENS

Casing	Screen	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
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○	○		☐				○	○	☐	☐
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○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐
○	○		☐				○	○	☐	☐

(8) WELL TESTS

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)

Water Quality Concerns

From	To	Description	Amount	Units

Comments/Remarks

Dave Buchanan drilled the boring

(10) STATIC WATER LEVEL

Water Bearing Zones

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	

(11) SUBSURFACE LOG

Material	From	To

(12) ABANDONMENT LOG

Material	From	To	Amt	sacks/ lbs

GEOTECHNICAL HOLE REPORT - Map with location identified must be attached and shall include an approximate scale and north arrow

MARI 69908

6/11/2021

Map of Hole

NV5

Delivering Solutions
Improving Lives