

12. Geotechnical Soil Analysis Report



REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Holley Park Subdivision
33105 NE Ivy Avenue
La Center, Washington

For
Compass Group, LLC
January 14, 2019

GeoDesign Project: CompassGrp-1-01

January 14, 2019

Compass Group, LLC
PO Box 1900
Battle Ground, WA 98604

Attention: Kevin Tapani

Report of Geotechnical Engineering Services

Holley Park Subdivision
33105 NE Ivy Avenue
La Center, Washington
GeoDesign Project: CompassGrp-1-01

GeoDesign, Inc. is pleased to submit this report for the proposed Holley Park subdivision located at 33105 NE Ivy Avenue in La Center, Washington. Our services for this project were conducted in accordance with our proposal dated November 6, 2018.

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

Sincerely,

GeoDesign, Inc.



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Attachments

One copy submitted (via email only)

Document ID: CompassGrp-1-01-011419-geor.docx

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EXECUTIVE SUMMARY

The primary geotechnical considerations for the project are summarized as follows:

- The proposed buildings can be supported by conventional spread footings bearing on the native soil at the site. Spread footings should not be established on agricultural tilled zones.
- Minimum setback buffers of 25 and 50 feet should be established from the crests of the slopes in the north and south portions of the site, respectively. Buffer zones should remain undisturbed during construction, with the exception of trenches to dispose stormwater, unless additional geotechnical analysis is completed.
- Based on the results of our explorations, the soil at the site is not susceptible to liquefaction or lateral spreading.
- Site explorations encountered a tilled zone in the upper 12 to 30 inches of soil over a majority of the site from past agricultural activities. In general, the tilled zone is unconsolidated and will provide poor support for foundations, fills, floor slabs, and pavements. In roadways and beneath buildings where the tilled zone will not be removed by site cuts, we recommend that the tilled zone be improved by scarifying and re-compacting or cement treating as described in the “Construction” section.
- The near-surface soil is sensitive to disturbance when at a moisture content that is above optimum. This can result in subgrade damage during construction and significant repair costs. We recommend that the project budget include subgrade protection. A discussion of subgrade protection is included in the “Construction” section.
- Perched groundwater was observed within approximately 10 feet of the ground surface. Based on our experience, groundwater could be within 5 feet of the ground surface during the wet season. The presence of shallow groundwater will affect construction of the proposed development. Earthwork contractors should be prepared to dewater excavations at all times of the year.
- Based on the soil and groundwater conditions at the site, on-site infiltration systems are not recommended.

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Appendix B

Slope Stability Analysis

B-1

Slope Stability Analysis Results

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AC	asphalt concrete
ASTM	American Society for Testing and Materials
BGS	below ground surface
g	gravitational acceleration (32.2 feet/second ²)
HMA	hot mix asphalt
H:V	horizontal to vertical
IBC	International Building Code
MCE	maximum considered earthquake
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
PG	performance grade
psf	pounds per square foot
psi	pounds per square inch
SPT	standard penetration test
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WSS	Washington Standard Specifications for Road, Bridge, and Municipal Construction (2018)

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering evaluation for the proposed Holley Park subdivision at 33105 NE Ivy Street in La Center, Washington. The site is shown relative to surrounding features on Figure 1. Figure 2 shows the locations of our explorations for this study. Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents.

2.0 PROJECT UNDERSTANDING

The project includes construction of a residential subdivision with detached single-family houses. Based on correspondence with AKS Engineering and Forestry (AKS), site cuts and fills are expected to be 5 feet or less. Stormwater generated from the development will be treated and disposed of off site.

3.0 PURPOSE AND SCOPE

The purpose of our services was to provide geotechnical engineering recommendations for design and construction of the proposed development. The specific scope of our services is summarized as follows:

- Reviewed readily available published geologic data and our in-house files for existing information on subsurface conditions in the site vicinity.
- Coordinated and managed the field explorations, including locating utilities and scheduling subcontractors and GeoDesign field staff.
- Drilled three borings to depths between 34.7 and 46.4 feet BGS.
- Excavated 10 test pits to depths between 16.0 and 18.0 feet BGS.
- Collected soil samples for laboratory testing at select depths from the explorations.
- Classified the materials encountered in the explorations.
- Maintained a detailed log of each exploration. Observed groundwater conditions in the explorations.
- Completed a laboratory testing program that included the following:
 - Seventeen moisture content determinations in general accordance with ASTM D2216
 - Fourteen particle-size analyses in general accordance with ASTM C117 or ASTM D1140
 - Three Atterberg limits tests in general accordance with ASTM D4318
- Prepared this geotechnical report summarizing our explorations, laboratory testing, analyses, geotechnical design criteria, and construction recommendations, including information relating to the following:
 - Soil and groundwater conditions
 - Geologic hazards and slope setbacks
 - Earthwork guidelines
 - Seismic design parameters
 - Foundation
 - Pavements

4.0 SITE CONDITIONS

4.1 SURFACE CONDITIONS

The approximately 14.37-acre site is located southeast of downtown La Center, Washington. The site is bound by a small drainage and park to north; a residential subdivision to the east; undeveloped, sloping land to the south; and a large residential property to the west.

The northwest corner of the site is occupied by a residence with multiple barns and outbuildings and the remainder of the site is undeveloped and likely used for agricultural purposes. The majority of the site slopes gently to the south between elevations of approximately 130 and 115 feet, with the exception of slopes along the north and south boundaries. The site slopes are discussed in greater detail in the “Geologic Hazards” section. The site is generally covered with grass and trees are present along the north and south slopes and around the residence.

4.2 SUBSURFACE CONDITIONS

4.2.1 General

Subsurface conditions at the site were evaluated by drilling three borings (B-1 through B-3) to depths between 34.7 and 46.4 feet BGS and excavating 10 test pits (TP-1 through TP-10) to depths between 16.0 and 18.0 feet BGS. The approximate locations of the explorations are shown on Figure 2. Descriptions of the field explorations and laboratory testing programs, logs of the explorations, and results of the laboratory testing are presented in Appendix A.

4.2.2 Root and Agricultural Tilled Zones

An approximately 12- to 30-inch thick tilled zone from agricultural activities is present at the site. The zone consists of very soft to soft, brown silt with variable fractions of sand. A root zone averaging approximately 5 to 6 inches with areas up to 12 inches is present within the tilled zone.

4.2.3 Silt and Sand (Flood Deposits)

Native soil that underlies the tilled zone consists of Quaternary Age flood deposits comprised of soft to medium stiff silt and medium dense, silty sand. The sand content and stiffness of the flood deposits generally increases with depth. The flood deposits extends to depths between 25 and 30 feet BGS at the site. Laboratory testing indicates the silt has low plasticity silt and flood deposits had moisture contents between approximately 32 and 40 percent at the time of explorations.

4.2.4 Clay and Gravel (Conglomerate)

Underlying the flood deposits is Pleistocene Age conglomerate. The conglomerate consists of an approximately 5- to 10- foot-thick layer of very stiff clay underlain by dense gravel with clay and sand. Based on laboratory testing the moisture content of the conglomerate ranged from 30 to 32 percent at the time of our explorations. The conglomerate extends to the maximum depth explored of 46.4 feet BGS. Geologic mapping indicates the conglomerate is approximately 60 to 120 feet in thickness.

4.2.5 Groundwater

Groundwater was generally encountered in the explorations between depths of 10 and 14 feet BGS. A review of water well logs and groundwater mapping suggests the regional static groundwater table is 50 feet BGS or more and the groundwater encountered during the explorations is perched. Based our experience, the perched groundwater could rise to within 5 feet of the ground surface during the wet season.

4.3 GEOLOGIC HAZARDS

4.3.1 General

Site classes as defined in the IBC range from A to F, with E having the highest relative ground amplification. Site Class F requires a site-specific seismic study. Based on the results of our explorations, a Site Class D is appropriate for the site.

4.3.2 Liquefaction and Lateral Spread (Seismic Hazard Areas)

Liquefaction is caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. In general, loose, saturated sand soil with low silt and clay content is the most susceptible to liquefaction. Silty soil with low plasticity is moderately susceptible to liquefaction under relatively higher levels of ground shaking.

According to the Alternative Liquefaction Susceptibility Map of Clark County by Palmer et al. (2004), the site is described as having very low liquefaction susceptibility. Based on the results of our explorations, liquefaction is expected to be negligible at the site and is not a design consideration.

Lateral spreading is a liquefaction-related seismic hazard and occurs on gently sloping or flat sites underlain by liquefiable sediment adjacent to an open face, such as a riverbank. Liquefied soil adjacent to an open face can flow toward the open face, resulting in lateral ground displacement. There are no major open faces, and the liquefaction potential at the site is low. Accordingly, the potential for lateral spreading at the site is not a design consideration for the project.

4.3.3 Fault Rupture

Based on USGS mapping, the nearest mapped fault to the site is the Lacamas Lake fault, which is located approximately 14 miles to the southeast. As such, fault rupture is not considered a hazard at the site.

4.3.4 Landslides

4.3.4.1 Stability Analysis

According to Chapter 18.300 (Critical Areas) of the La Center Municipal Code, slopes greater than 25 percent are considered "landslide hazard areas." Based on this criteria, the slopes in the north and south portions of the site are considered landslide hazard areas. Figure 3 shows the slope percentages at the site.

Due to the presence of landslide hazard areas, stability analysis was completed to determine appropriate setbacks in accordance with the La Center Municipal Code. Analysis was completed using Slope/W by Geo-Slope International, Ltd. Slope/W performs two-dimensional limiting equilibrium analysis to compute slope stability. The factor of safety against slope failure is simplistically defined as the ratio of the forces resisting slope movement (e.g., soil strength, soil mass, etc.) to the forces driving slope movement (e.g., soil weight, water pressure). The program predicts the location and geometry of “critical failures planes.” Critical failure planes are the zones with the lowest factors of safety. A factor of safety less than 1.0 infers that the model is not in equilibrium and slope movement is likely to occur. Standard of care generally dictates that a minimum factor of safety for static and seismic conditions be 1.5 and 1.1, respectively.

Our analysis included one section (A-A') in the north portion of site and two sections (B-B' and C-C') in the south portion of the site. The locations of the analysis are shown on Figures 2 and 3 and were chosen to represent “worst case” scenarios. The subsurface conditions were based on the results of our explorations, laboratory testing, and experience with similar soil.

A conservative surcharge load of 2,000 psf was used for the entire footprint of residences and a maximum of 5 feet of fill was assumed per AKS. This is conservative where roadways are above slopes because the surcharge loading associated with the roadways would be 250 psf. A seismic coefficient of 0.135 g (one-half the site peak ground acceleration of 0.27 g) was used for the seismic condition. The configurations, soil parameters, and results of the analysis are presented in Appendix B.

4.3.4.2 Buffer Recommendation

Minimum setback buffers of 25 and 50 feet should be established from the crests of the slopes in the north and south portions of the site, respectively. Buffer zones should remain undisturbed during construction, with the exception of trenches to dispose stormwater, unless additional geotechnical analysis is completed. The locations of the buffers should be clearly shown on the project plans.

Provided design and construction of the development near the slopes are completed conformance with the recommendations of this report, it is our opinion that the proposed development will not adversely affect the short- or long-term stability of the slopes nor pose a significant risk to public safety.

4.3.4.3 Stormwater System Recommendations on Steep Slopes

Surface water should not be allowed to sheet flow onto steep slope faces. Stormwater should be collected and transferred to the base of all steep slopes in solid pipes, and angular rock should be installed at the base of the outfall pipes to dissipate energy generated from the gradient.

Granular backfill for pipes on steep slopes will create preferential flow paths for water that can generate moderate velocities within the trenches and a potential for piping. Where stormwater pipes are installed in slopes that exceed 15 percent, we recommend the trench backfill consist of fine-grained soil. If trenches are installed in the wet season and compaction of fine-grained soil

is not possible, granular backfill can be used provided cutoff trenches, consisting of low-strength concrete or high-plasticity clay, are installed every 25 feet to reduce subsurface water velocities with the pipe backfill.

Stormwater infiltration systems are not recommended for the project. We recommend that stormwater detention ponds located within 200 feet of the crest of any slope be lined with an impermeable membrane or bentonite to prevent water from infiltrating into the subsurface soil.

4.3.5 Erosion Hazard

The USDA Web Soil Survey indicates that the surficial soil at the site consists of Gee, Hillsboro, and Odne silt loam. The survey describes these soils as having very low to low permeability and slight to very severe erosion hazard when the soil is left bare, depending on slope gradient. Based on our experience with similar soils, the erosion hazard is moderate to very severe when the soil is left bare and where slope gradients are steeper than 15 percent. Where slope gradients are less than 15 percent, erosion hazard is low to moderate

Currently, the ground surface at the site is covered with grass, brush, and trees. We consider the site (in its current state) to have a low to moderate erosion hazard. The proposed development of the site will remove much of the existing vegetation in the development area. This will temporarily increase the erosion hazard to moderate to severe. It is our understand that disturbance to slopes steeper than 25 percent will not occur during construction; therefore, very severe erosion hazards should not be present. During construction of the proposed development, erosion control measures as discussed in this report and as recommended by the project civil engineer shall be employed.

With a properly implemented erosion control plan, the impact of erosion on the site during construction should be minimal and easily mitigated as part of finished grading. If suitable erosion control measures are implemented and maintained throughout construction until a new vegetative cover is established, there should be little or no adverse impact to the overall stability of the site or to neighboring sites.

Upon completion of the proposed development, the majority of the development area will either be covered with pavement, sidewalks, or homes or will be landscaped with conventional residential ornamental shrubs and ground cover. We anticipate the open space areas will remain covered with native vegetation. Surface run-off will be greatly decreased due to the collection of surface water from the streets and roof tops. The collected run-off will then be directed to the stormwater detention pond in the southwest corner of the site. In our opinion, these final "built-out" conditions will result in a low future erosion hazard.

5.0 DESIGN

5.1 FOUNDATION SUPPORT

5.1.1 Bearing Capacity

The proposed buildings can be supported on conventional spread footings bearing on undisturbed native soil or structural fill overlying undisturbed native soil. Foundation elements should not be supported on agricultural till. If present, the agricultural till should be removed and replaced with structural fill.

5.1.2 Bearing Capacity

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 should be embedded so that a minimum of 10 feet of horizontal clearance exists between the toe of the footing and any adjacent slopes.

Footings bearing on native silt or new structural fill on native soil should be designed assuming an allowable bearing pressure of 2,000 psf. This is a net bearing pressure; the weight of the footing and overlying backfill can be ignored in calculating footing sizes. Also, the allowable bearing pressures apply to the total of dead plus long-term live loads and can be increased by one-half for short-term loads, such as those resulting from wind or seismic forces.

Total post-construction foundation settlement should be less than 1 inch, with differential settlement between similarly loaded foundations of less than ½ inch.

5.1.3 Resistance to Sliding

Lateral loads on footings can be resisted by passive earth pressure on the sides of the structure and by friction on the base of the footings. An unfactored passive earth pressure of 350 pcf can be used for footings confined by firm native soil. Adjacent floor slabs, pavement, or the upper 12-inch depth of adjacent unpaved areas should not be considered when calculating passive resistance. In order to rely on passive resistance, a minimum of 10 feet of horizontal clearance must exist between the face of the footings and adjacent downslopes.

For footings in contact with the native soil, a coefficient of friction equal to 0.35 may be used when calculating resistance to sliding.

5.1.4 Subgrade Observation

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

5.1.5 Construction Considerations

If footing excavations are conducted during wet weather conditions, we recommend that a minimum of 3 inches of granular material be placed and compacted until well keyed at the base

of the footing excavations. The granular material reduces water softening of silt-rich subgrade soil, reduces subgrade disturbance during placement of forms and reinforcement, and provides clean conditions for the reinforcing steel.

5.2 SEISMIC DESIGN CRITERIA

Table 1 provides seismic design parameters in accordance with IBC 2015. We selected a Site Class D based the results of explorations and testing.

Table 1. IBC 2015 Seismic Design Parameters

Parameter	Short Period ($T_s = 0.2$ second)	1 Second Period ($T_1 = 1.0$ second)
MCE Spectral Acceleration, S	$S_s = 0.890$ g	$S_1 = 0.397$ g
Site Class	D	
Site Coefficient, F	$F_a = 1.144$	$F_v = 1.606$
Adjusted Spectral Acceleration, S_M	$S_{MS} = 1.018$ g	$S_{M1} = 0.638$ g
Design Spectral Response Acceleration Parameters, S_D	$S_{DS} = 0.679$ g	$S_{D1} = 0.425$ g

5.3 FLOOR SLABS

Satisfactory subgrade support for building floor slabs supporting up to 100 psf area loading can be obtained provided the building pad is prepared as described in the “Construction” section. The floor slab be supported on at least 6 inches of imported granular material to aid as a capillary break and to provide uniform support. The imported granular material should be placed and compacted as described in the “Structural Fill” section.

Exterior slabs, such as those for patios, walkways, driveways, and garages, should be structurally independent from the building foundations. Expansion joints should be provided between floor slabs and foundations. This will allow minor movement of the slabs to occur as a result of vehicular loading, tree root growth, seasonal soil shifting, and other factors, while reducing the potential for slab cracking around the perimeter. Interior slabs may be tied to the building’s foundation system. Slabs should be reinforced according to their proposed use and per the structural engineer’s recommendations.

5.4 RETAINING STRUCTURES

5.4.1 Assumptions

Our retaining wall design recommendations are based on the following assumptions: (1) the walls consist of conventional, cantilevered retaining walls, (2) the walls are less than 8 feet in height, (3) the backfill is drained and consists of imported granular material, and (4) the backfill has a slope flatter than 4H:1V. Re-evaluation of our recommendations will be required if the retaining wall design criteria for the project varies from these assumptions.

5.4.2 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 $7H^2$ pounds per linear foot of wall, where H is the wall height. The seismic force should be applied as a distributed load with the centroid located at $0.6H$ from the wall base. Footings for retaining walls should be designed as recommended for shallow foundations.

If 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.

5.4.3 Wall Drainage and Backfill

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

Backfill material placed behind the walls and extending a horizontal distance of $\frac{1}{2}H$, 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 drainage system of the wall.

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 that 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.

5.5 DRAINAGE

5.5.1 Temporary

During work 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 site, the contractor should keep all pads and subgrade free of ponding water.

5.5.2 Surface

The ground surface at finished pads should be sloped away from their edges at a minimum 2 percent gradient for a distance of at least 5 feet. Roof drainage from the buildings should be directed into solid, smooth-walled drainage pipes that carry the collected water to the storm drain system. Trapped planter areas should not be created adjacent to roadways and structures without providing means for positive drainage (e.g., swales or catch basins).

5.5.3 Subsurface

Based on the soil and groundwater conditions, it is prudent to install perimeter drains around the buildings. Drains should consist of a filter fabric-wrapped, drain rock-filled trench that extends at least 12 inches below the lowest adjacent grade (i.e., slab subgrade elevation). A perforated pipe should be placed at the base to collect water that gathers in the drain rock. The drain rock and filter fabric should meet specifications outlined in the “Materials” section. Discharge for the footing drain should not be tied directly into the stormwater drainage system, unless mechanisms are installed to prevent backflow.

5.5.4 Stormwater Infiltration

Based on the subsurface and groundwater conditions at the site, on-site infiltration systems are not recommended for the development.

5.6 PERMANENT SLOPES

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

5.7 PAVEMENTS

Pavements for new roadways will be installed as part of the development. Pavements should be installed on improved agricultural till, firm native soil, structural fill, or cement-treated subgrade prepared in conformance with the “Site Preparation” and “Materials” sections.

The pavement section will be in conformance with City of La Center standard detail ST-14. Based on explorations and testing, the AASHTO soil classification at the site is A-5, resulting in a section of 0.35 foot of AC over 0.90 foot of aggregate base. If the roadway is constructed during the wet season and the subgrade is cement treated, a reduction in aggregate base may be suitable. GeoDesign should be contacted to provide recommendations if cement treated. AC and aggregate base should meet the requirements in the “Materials” section.

The material thicknesses are intended to be minimum acceptable values for the final condition. The aggregate base thickness does not account for construction traffic, and haul roads and staging areas should be used as described in the “Construction” section.

6.0 CONSTRUCTION

6.1 SITE PREPARATION

The existing topsoil zone should be stripped and removed from all fill areas. Based on our explorations, the average depth of stripping will be approximately 5 to 6 inches, although greater stripping depths will be required to remove localized zones of loose or organic soil. Greater stripping depths (approaching 12 inches) are anticipated in areas with thicker vegetation and shrubs, in all forested areas, and along the base of draws. 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.

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 the root balls, considerable disturbance and loosening of the subgrade could occur during site grubbing. We recommend that soil disturbed during grubbing operations be removed to expose firm, undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

6.1.1 Tilled Zone

An approximately 12- to 36-inch-thick agricultural tilled zone was observed directly beneath the ground surface in our explorations over a majority of the site. We recommend that the tilled zone be improved during site preparation in areas where cuts do not remove the tilled zone. Prior to fill placement and construction, the tilled zone should be improved by removing and replacing with structural fill or scarifying and compacting as structural fill.

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.

6.1.2 Subgrade Evaluation

Upon completion of stripping and prior to the placement of any structural fill or pavement, the exposed subgrade should be evaluated by proof rolling to identify soft, loose, or unsuitable areas. Proof rolling should be conducted with a fully loaded dump truck or similar heavy, rubber tire construction equipment. Qualified personnel should observe proof rolling to evaluate yielding of the ground surface. The subgrade should be evaluated by probing with a foundation probe when the subgrade is too wet. If soft or yielding subgrade is identified, the subgrade should be excavated and replaced with structural fill.

6.2 CONSTRUCTION CONSIDERATIONS

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

If construction occurs during or extends into the wet season, or if the moisture content of the surficial soil is more than a couple percentage points above optimum, site stripping and cutting may need to be accomplished using track-mounted equipment. Likewise, the use of granular haul roads and staging areas will be necessary for support of construction traffic during the rainy season or when the moisture content of the surficial soil is more than a few percentage points above optimum. The 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. 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. Stabilization material may be used as a substitute provided the top 4 inches of material consists of imported granular material. The actual thickness will depend on the contractor's means and methods and should be the contractor's responsibility. In addition, a geotextile fabric should be considered to assist in developing a barrier between the subgrade and imported granular material in areas of repeated construction traffic. 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 subgrades 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.

6.3 TEMPORARY SLOPES

Temporary slopes less than 10 feet high should be no steeper than 1½H:1V, provided groundwater seepage does not occur. If slopes greater than 10 feet high are required, GeoDesign should be contacted to make additional recommendations. We recommend a minimum horizontal distance of 5 feet from the edge of the existing improvements to the top of the temporary slope. All cut slopes should be protected from erosion by covering them during wet weather. If sloughing or instability is observed, the slope should be flattened or supported by shoring. Excavations should not undermine adjacent utilities, foundations, walkways, streets, or other hardscapes unless special shoring or underpinned support is provided.

6.4 EROSION CONTROL

The on-site soil is susceptible to erosion. Consequently, we recommend that slopes be covered with an appropriate erosion control product if construction occurs during periods of wet weather. We recommend that all slope surfaces be planted as soon as practical to minimize erosion. 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.

6.5 EXCAVATION

6.5.1 General

Perched groundwater was generally observed between depths of 10 and 14 feet BGS in the explorations. Based on our experience in the area, perched groundwater could be present within approximately few feet of the ground surface during the wet season. Cuts in the near-surface soil should be readily completed with conventional excavation equipment. Temporary excavation sidewalls should stand vertical to a depth of approximately 4 feet, provided groundwater seepage is not observed 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 and groundwater seepage is not present. Excavations should be flattened to 1½H:1V or 2H:1V if excessive sloughing or raveling occurs. If groundwater is present, caving and raveling could occur. In lieu of large and open cuts, approved temporary shoring may be used for excavation support. A wide variety of shoring and dewatering systems are available. Consequently, we recommend that the contractor be responsible for selecting the appropriate shoring and dewatering systems.

If box shoring is used, it should be understood that box shoring is a safety feature used to protect workers and does not prevent caving. If the 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 that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation. All excavations should be made in accordance with applicable OSHA and state regulations.

6.5.2 Dewatering

Dewatering may be required for excavations at the site, particularly during the wet season. If encountered, pumping from a sump located within the trench may be effective in dewatering localized sections of trench. However, this method is unlikely to prove effective in dewatering long sections of trench or large excavations. In addition, the sidewalls of trench excavations will need to be flattened or shored if seepage is encountered.

Where groundwater seepage into shored excavations occurs, we recommend placing at least 1 foot to 2 feet of stabilization material at the base of the excavations. Trench stabilization material should meet the requirements provided in the “Structural Fill” section.

We note that these recommendations are for guidance only. Dewatering of excavations is the sole responsibility of the contractor, as the contractor is in the best position to select these systems based on their means and methods.

6.6 MATERIALS

6.6.1 Structural Fill

Fills should only be placed over subgrade that has been prepared in conformance with the “Site Preparation” section. A variety of material may be used as structural fill at the site. However, all material used as structural fill should be free of organic matter or other unsuitable material and should meet the specifications provided in WSS 9-03 – Aggregates, depending on the application. A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill are provided below.

6.6.2 On-Site Soil

The on-site soil is suitable for structural fill provided it is free of organic matter and unsuitable materials. Based on laboratory testing results, the moisture content of the on-site soil is above the optimum required for compaction at the time of our explorations and moisture conditioning, including drying and mixing, will be required to use the on-site soil for structural fill. Accordingly, extended dry weather and sufficient area to dry the soil will be required to adequately condition the soil for use as structural fill. The on-site fine-grained soil should not be used as structural fill during the wet season.

When used as structural fill, the on-site fine-grained 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.

6.6.3 Imported Granular Material

Imported granular material used during periods of wet weather, for building pad subgrades, and for staging areas should be pit- or quarry-run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in WSS 9-03.9(1) – Ballast, WSS 9-03.14(1) – Gravel Borrow, or WSS 9-03.14(2) – Select Borrow. The imported granular material should be fairly well graded between coarse and fine material, have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, and have a minimum of two mechanically fractured faces.

Imported granular material should be placed in lifts with a maximum uncompacted thickness of 8 to 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557. During the wet season or when wet subgrade conditions exist, the initial lift should be approximately 18 inches in uncompacted thickness and should be compacted with a smooth-drum roller without using vibratory action.

Where imported granular material is placed over wet or soft soil subgrades, we recommend a geotextile be placed as a barrier between the subgrade and imported granular material. Depending on site conditions, the geotextile should meet the specifications provided in WSS 9-33.2(1) – Geotextile Properties (Table 3) for soil separation or stabilization. The geotextile should be installed in conformance with WSS 2-12 – Construction Geosynthetic.

6.6.4 Stabilization Material

Stabilization material used to create haul roads for construction traffic or at the base of unstable trenches should consist of pit- or quarry-run rock or crushed rock. The material should have a maximum particle size of 6 inches and less than 5 percent by dry weight passing the

U.S. Standard No. 4 sieve, have at least two mechanically fractured faces, and be free of organic matter and other deleterious material. Material meeting the specifications provided in WSS 9-27.3(6) – Stone is generally acceptable for use. Stabilization material should be placed in lifts between 12 and 18 inches thick and compacted to a firm condition with a smooth-drum roller without using vibratory action.

Where the stabilization material is used to stabilize soft subgrade beneath pavements or construction haul roads, a geotextile should be placed as a barrier between the soil subgrade and the imported granular material. Geotextile is not required where stabilization material is used at the base of utility trenches.

6.6.5 Trench Backfill

Trench backfill placed beneath, adjacent to, and for at least 2 feet above utility lines (i.e., the pipe zone) should consist of well-graded, granular material with a maximum particle size of 1½ inches and less than 7 percent by dry weight passing the U.S. Standard No. 200 sieve and should meet the specifications provided in WSS 9-03.12(3) – Gravel Backfill for Pipe Zone Bedding. 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 or beneath proposed or future building pads, the remainder of the trench backfill should consist of well-graded, granular material with a maximum particle size of 2½ inches and less than 7 percent by dry weight passing the U.S. Standard No. 200 sieve and should meet the specifications provided in WSS 9-03.19 – Bank Run Gravel for Trench Backfill. 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 2 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 organics and material over 6 inches in size and meets the specifications provided in WSS 9-03.14(3) – Common Borrow and WSS 9-03.15 – Native Material for Trench Backfill. 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.

Refer to the “Geologic Hazards” section for a discussion of trench backfill on slopes.

6.6.6 Aggregate Base Rock

Imported granular material placed beneath pavements and floor slabs should be clean crushed rock or crushed gravel and sand that are fairly well graded between coarse and fine. The granular material should not contain deleterious material, should have a maximum particle size of 1½ inches, should meet the specifications provided in WSS 9-03.9(3) – Crushed Surfacing and WSS 9-03.10 – Aggregate for Gravel Base, should have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, and should have a minimum of two mechanically fractured faces. The imported granular material should be placed in one lift and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

6.6.7 Retaining Wall Select Backfill

Backfill material placed behind retaining walls and extending a horizontal distance of $\frac{1}{2}H$, where H is the height of the retaining wall, should consist of select granular material that meets the requirements provided in WSS 9-03.12(2) – Gravel Backfill for Walls. We recommend the select granular 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 walls 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 pavements) 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.

6.6.8 Geotextile Separation Fabric

A geotextile separation fabric will be required at the interface of the existing soil and imported granular material beneath the proposed walls. In addition, geotextile fabric may be required where soft subgrade is encountered. The separation fabric should meet the specifications provided in WSS 9-33.2(1) – Geotextile Properties (Table 3) for soil separation. The geotextile should be installed in conformance the specifications provided in WSS 2-12 – Construction Geosynthetic.

6.6.9 AC

6.6.9.1 General

The AC pavement should conform to WSS 5-04 - Hot Mix Asphalt. AC should consist of $\frac{1}{2}$ -inch HMA. The asphalt cement binder should be PG 64-22 Performance Grade Asphalt Cement conforming to WSS 9-02.1(4) – Performance Graded Asphalt Binder. The layer thickness should be 2.0 to 3.5 inches. The job mix formula should meet the requirements for non-statistical $\frac{1}{2}$ -inch HMA (WSS 5-04 – Hot Mix Asphalt and WSS 9-03.8 – Aggregates for Hot Mix Asphalt) and be compacted to 91 percent of the maximum specific gravity or as required by the local jurisdiction in public right-of-way areas.

6.6.9.2 Cold Weather Paving Considerations

In general, AC paving is not recommended during cold weather (temperatures less than 40 degrees Fahrenheit). Compacting under these conditions can result in low compaction and premature pavement distress. Each AC mix design has a recommended compaction temperature range that is specific for the particular AC binder used. In colder temperatures, it is more difficult to maintain the temperature of the AC mix as it can lose heat while stored in the delivery truck, as it is placed, and in the time between placement and compaction. 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 2.0 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.

6.4.9 Soil Amendment with Cement

6.4.9.1 General

As an alternative to the use of imported granular material or as an alternative to scarification and compaction during wet periods, an experienced contractor may be able to amend the on-site fine-grained soil with portland cement to obtain suitable support properties. It is generally less costly to amend on-site soil than to remove and replace soft soil with granular material. Based on the moisture contents, soil types, and processing speed, cement amendment would be more suitable at this site than lime amendment. The amount of cement used during treatment should be based on an assumed soil dry unit weight of 100 pcf.

6.4.9.2 Subbase Stabilization

Specific recommendations based on exposed site conditions for soil amending 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. Generally, 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 9 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.

For pavement subbase, we recommend assuming a minimum cement ratio of 6 percent (by dry weight). If the soil moistures are in excess of 30 percent, a cement ratio of 7 to 8 percent will likely be needed. Due to the higher organic content and moisture, we recommend using a cement ratio of 8 percent when stabilizing topsoil (tilled) zone material for building and pavement subbase and anticipate that the cement will need to be applied in two 4 percent applications followed by multiple tilling passes with each application.

We recommend cement-spreading equipment be equipped with balloon tires to reduce rutting and disturbance of the fine-grained soil. A static 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. 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 treatment and construction traffic access. Construction traffic should not be allowed on unprotected, cement-amended subgrade. To protect the cement-treated surfaces from abrasion or damage, the finished surface should be covered with 4 to 6 inches of imported granular material.

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

Cement amending 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.

6.4.9.3 *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 treatment and construction traffic access. Consecutive lifts of fill may be treated 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 for the final lift of cement-amended soil.

6.4.9.4 *Other Considerations*

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

7.0 OBSERVATION OF CONSTRUCTION

Satisfactory earthwork and foundation performance depends to a large degree on the quality of construction. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated. In addition, 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.

8.0 LIMITATIONS

We have prepared this report for use by Compass Group, LLC and members of the design and construction teams for the proposed development. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Soil explorations 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 not finalized 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 should be retained to review our conclusions and recommendations and to provide a written evaluation or modification.

The scope of our services 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 our report for consideration in design.

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

GeoDesign, Inc.



Nick Paveglio, P.E.
Senior Associate Engineer



Brett A. Shipton, P.E.
Principal Engineer



Signed 01/14/2019

REFERENCES

Clark County GIS, 2018. Website: <http://gis.clark.wa.gov/imf/imf.jsp?site=digitalatlas>.

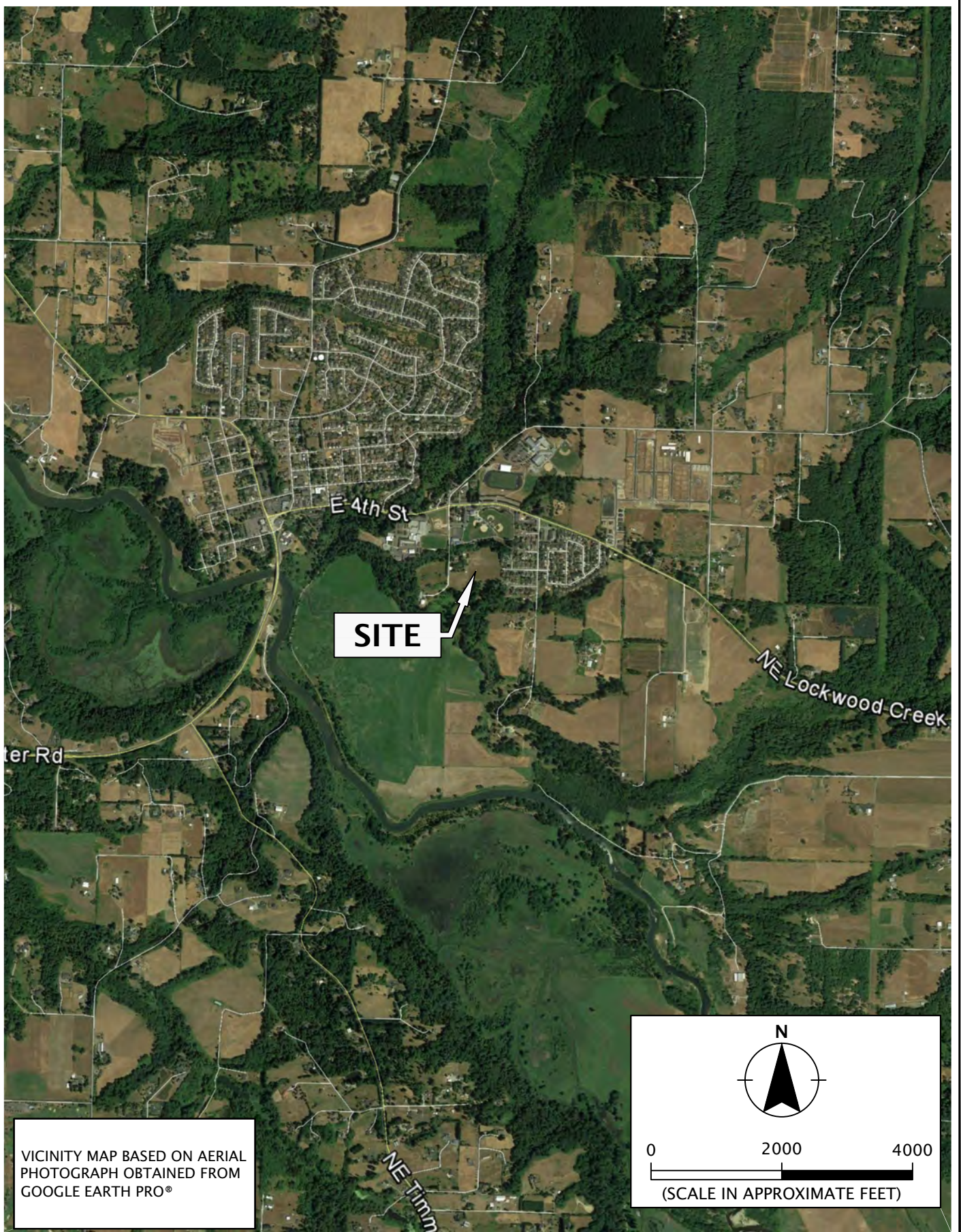
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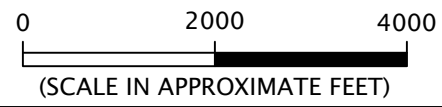
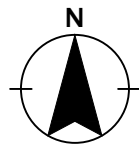
Washington State Department of Transportation, 2018. Standard Specifications for Road, Bridge, and Municipal Construction, M41-10.

FIGURES

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



GEODESIGN INC
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COMPASSGRP-1-01

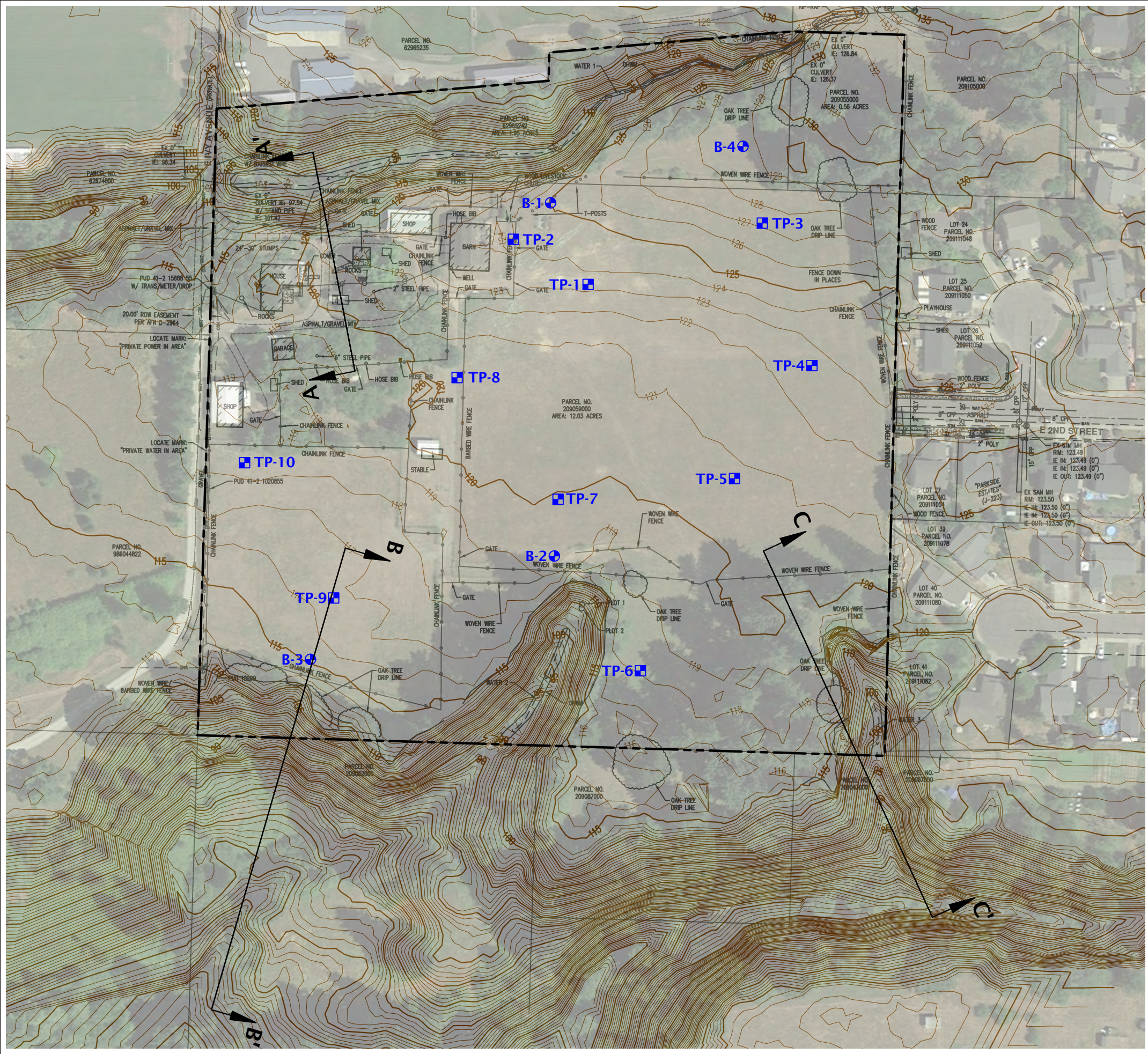
JANUARY 2019

VICINITY MAP

HOLLEY PARK SUBDIVISION
LA CENTER, WA

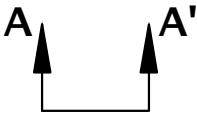
FIGURE 1

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LEGEND:

- SITE BOUNDARY
- BORING
- TEST PIT
- EXISTING TOPOGRAPHY (1-FOOT INTERVALS; 5-FOOT INDEX CONTOURS)
- CROSS SECTION

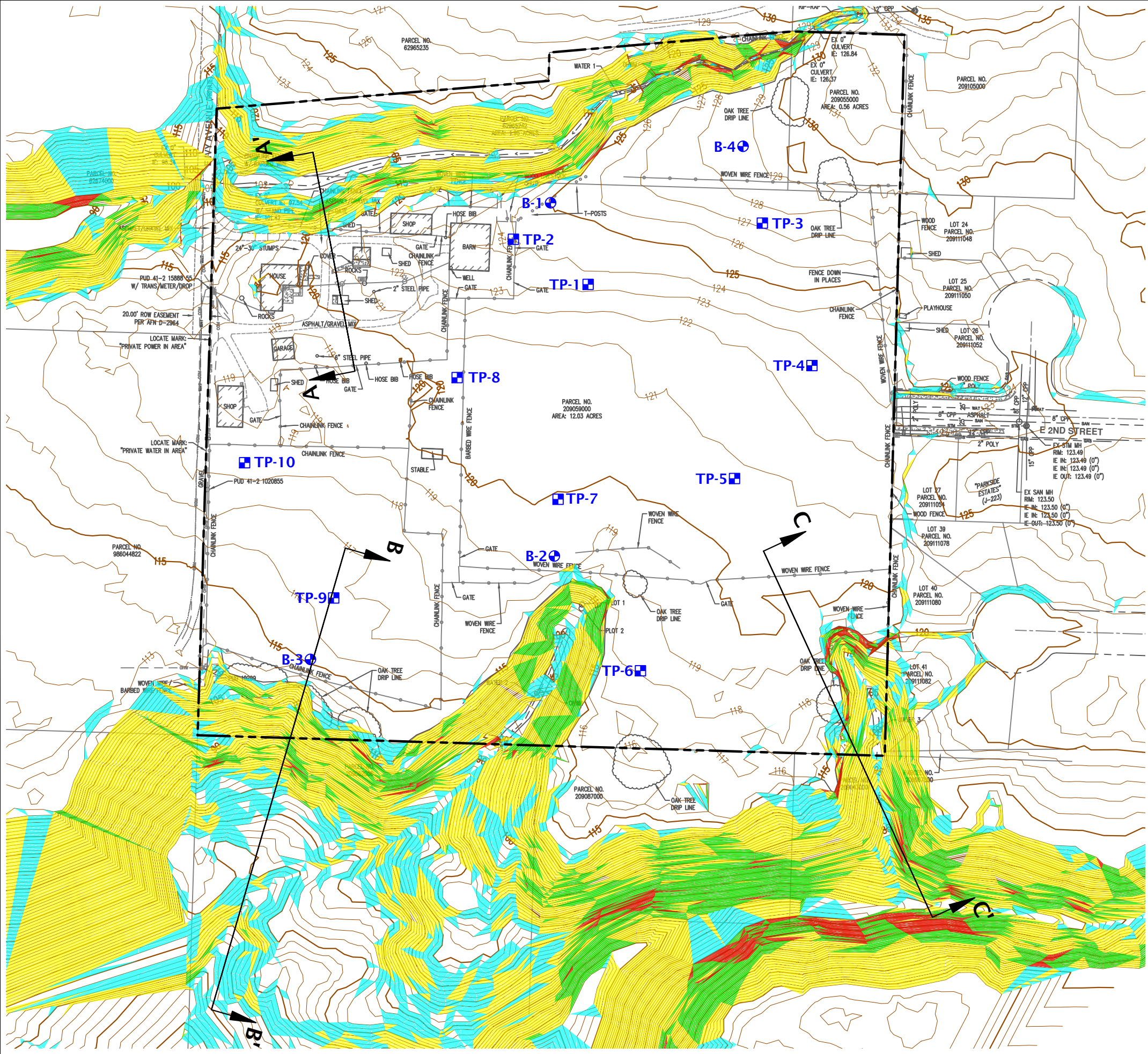


(SCALE IN FEET)

- NOTES:**
- SITE PLAN BASED ON DRAWING FROM AKS ENGINEERING & FORESTRY, LLC JANUARY 3, 2019.
 - AERIAL IMAGE OBTAINED FROM GOOGLE EARTH PRO JANUARY 7, 2019.

COMPASSGRP-1-01	SITE PLAN	FIGURE 2
	HOLLEY PARK SUBDIVISION LA CENTER, WA	
JANUARY 2019		
 703 Broadway Street - Suite 650 Vancouver WA 98660 360.693.8416 www.geodesigninc.com		

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LEGEND:

- SITE BOUNDARY
- B-1 BORING
- TP-1 TEST PIT
- 125 EXISTING TOPOGRAPHY (1-FOOT INTERVALS; 5-FOOT INDEX CONTOURS)
- A A' CROSS SECTION

SLOPES TABLE		
COLOR	MINIMUM SLOPE	MAXIMUM SLOPE
	15%	24.9%
	25%	49.9%
	50%	74.9%
	75%	>75%

NOTE:
 1. SITE PLAN BASED ON DRAWING FROM AKS ENGINEERING & FORESTRY, LLC JANUARY 3, 2019.

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

We explored subsurface conditions at the site by drilling three borings (B-1 through B-3) and excavating 10 test pits (TP-1 through TP-10). The borings were drilled to depths between 34.7 and 46.4 feet BGS, and the test pits were excavated to depths between 16.0 and 18.0 feet BGS. Drilling services were provided by Dan Fisher Excavating, Inc. of Forest Grove, Oregon. Excavation services were provided by Tapani Underground, Inc. of Battle Ground, Washington. The exploration logs are presented in this appendix.

The locations of the explorations are shown on Figure 2. Locations were determined in the field by pacing and taping from existing site features. This information should be considered accurate only to the degree implied by the methods used.

A member of our geotechnical staff observed the explorations. We collected representative samples of the various soils encountered in the explorations for geotechnical laboratory testing.

SOIL SAMPLING

Samples were collected from the borings using 1½-inch-diameter split-spoon SPT samplers in general accordance with ASTM D1586. The samplers were driven into the soil with a 140-pound automatic trip hammer free-falling 30 inches. The sampler was driven a total distance of 18 inches. The number of blows required to drive the sampler the final 12 inches is recorded on the exploration logs, unless otherwise noted. Disturbed samples of the soil observed in the test pits were collected from the walls or base of the test pits using the excavator bucket. Sampling methods and intervals are shown on the exploration logs.

SOIL CLASSIFICATION

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

LABORATORY TESTING

CLASSIFICATION

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

MOISTURE CONTENT










We tested the natural moisture content of select soil samples in general accordance with ASTM D2216. The test results are presented in this appendix.

PARTICLE-SIZE ANALYSIS

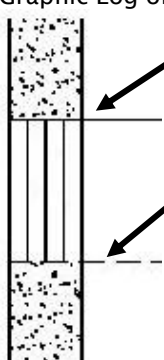
We completed particle-size analysis on select soil samples in order to determine the distribution of soil particle sizes. The testing consisted percent fines determination (percent passing the U.S. Standard No. 200 sieve) analyses completed in general accordance with ASTM C117 or ASTM D1140.

ATTERBERG LIMITS

The plastic limit and liquid limit (Atterberg limits) of select soil samples were determined in accordance with ASTM D4318. The Atterberg limits and the plasticity index were completed to aid in the classification of the soil. The test results are presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
	Location of sample obtained in general accordance with ASTM D 1586 Standard Penetration Test with recovery
	Location of sample obtained using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D 1587 with recovery
	Location of sample obtained using Dames & Moore sampler and 300-pound hammer or pushed with recovery
	Location of sample obtained using Dames & Moore and 140-pound hammer or pushed with recovery
	Location of sample obtained using 3-inch-O.D. California split-spoon sampler and 140-pound hammer
	Location of grab sample
	Rock coring interval
	Water level during drilling
	Water level taken on date shown

Graphic Log of Soil and Rock Types




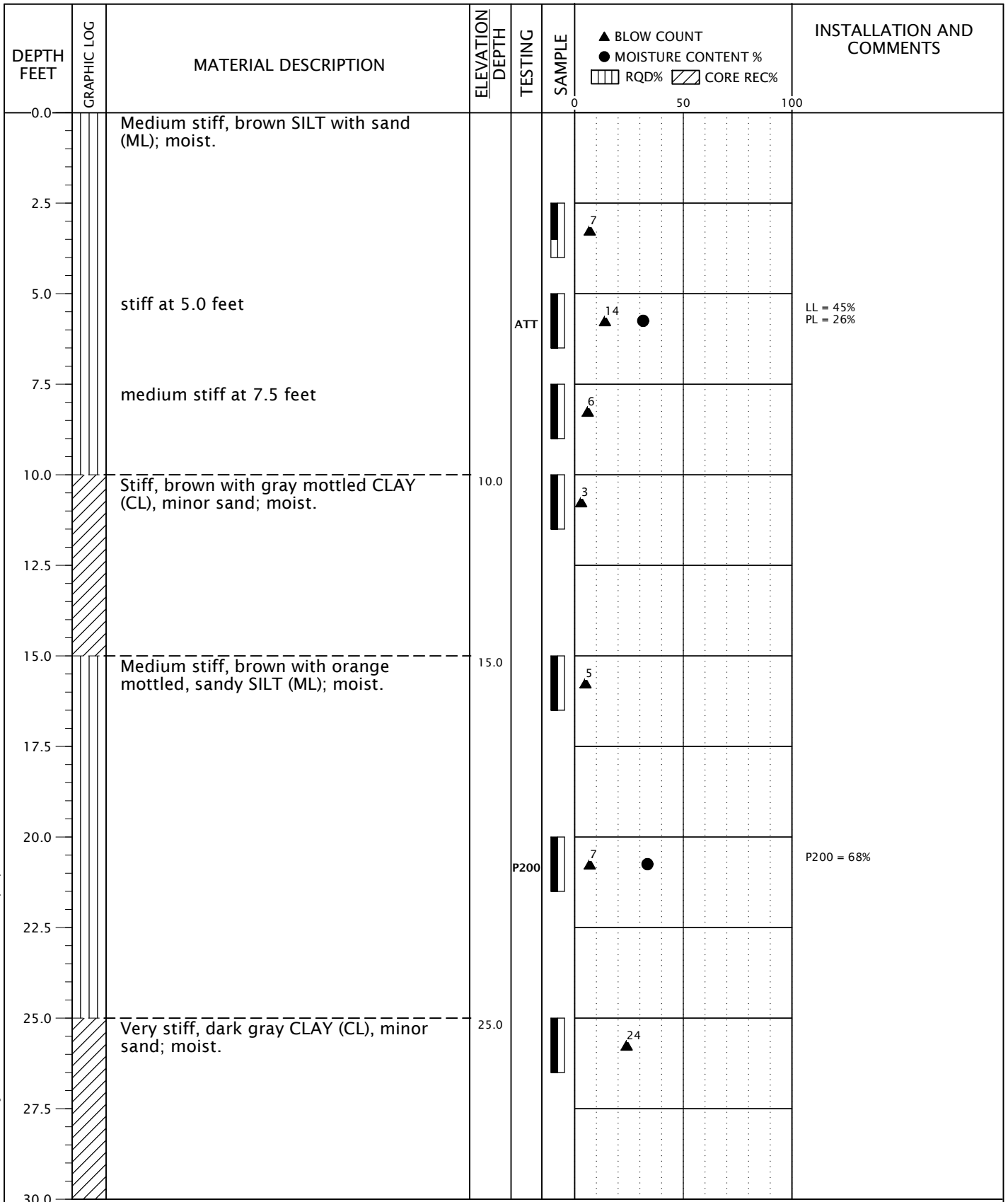
GEOTECHNICAL TESTING EXPLANATIONS

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

ENVIRONMENTAL TESTING EXPLANATIONS

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

RELATIVE DENSITY - COARSE-GRAINED SOIL									
Relative Density		Standard Penetration Resistance		Dames & Moore Sampler (140-pound hammer)		Dames & Moore Sampler (300-pound hammer)			
Very Loose		0 - 4		0 - 11		0 - 4			
Loose		4 - 10		11 - 26		4 - 10			
Medium Dense		10 - 30		26 - 74		10 - 30			
Dense		30 - 50		74 - 120		30 - 47			
Very Dense		More than 50		More than 120		More than 47			
CONSISTENCY - FINE-GRAINED SOIL									
Consistency		Standard Penetration Resistance		Dames & Moore Sampler (140-pound hammer)		Dames & Moore Sampler (300-pound hammer)		Unconfined Compressive Strength (tsf)	
Very Soft		Less than 2		Less than 3		Less than 2		Less than 0.25	
Soft		2 - 4		3 - 6		2 - 5		0.25 - 0.50	
Medium Stiff		4 - 8		6 - 12		5 - 9		0.50 - 1.0	
Stiff		8 - 15		12 - 25		9 - 19		1.0 - 2.0	
Very Stiff		15 - 30		25 - 65		19 - 31		2.0 - 4.0	
Hard		More than 30		More than 65		More than 31		More than 4.0	
PRIMARY SOIL DIVISIONS					GROUP SYMBOL		GROUP NAME		
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)			GW or GP		GRAVEL		
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)			GW-GM or GP-GM		GRAVEL with silt		
					GW-GC or GP-GC		GRAVEL with clay		
		GRAVEL WITH FINES (> 12% fines)			GM		silty GRAVEL		
					GC		clayey GRAVEL		
					GC-GM		silty, clayey GRAVEL		
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)			SW or SP		SAND		
		SAND WITH FINES (≥ 5% and ≤ 12% fines)			SW-SM or SP-SM		SAND with silt		
					SW-SC or SP-SC		SAND with clay		
		SAND WITH FINES (> 12% fines)			SM		silty SAND		
SC					clayey SAND				
SC-SM					silty, clayey SAND				
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50			ML		SILT		
					CL		CLAY		
					CL-ML		silty CLAY		
		Liquid limit 50 or greater			OL		ORGANIC SILT or ORGANIC CLAY		
					MH		SILT		
					CH		CLAY		
	OH			ORGANIC SILT or ORGANIC CLAY					
	HIGHLY ORGANIC SOIL					PT		PEAT	
MOISTURE CLASSIFICATION			ADDITIONAL CONSTITUENTS						
Term		Field Test		Secondary granular components or other materials such as organics, man-made debris, etc.					
dry	very low moisture, dry to touch	Percent	Silt and Clay In:		Percent	Sand and Gravel In:			
			Fine-Grained Soil	Coarse-Grained Soil		Fine-Grained Soil	Coarse-Grained Soil		
moist	damp, without visible moisture	< 5	trace	trace	< 5	trace	trace		
		5 - 12	minor	with	5 - 15	minor	minor		
wet	visible free water, usually saturated	> 12	some	silty/clayey	15 - 30	with	with		
		> 30			> 30	sandy/gravelly	Indicate %		
 703 Broadway Street - Suite 650 Vancouver WA 98660 360.693.8416 www.geodesigninc.com			SOIL CLASSIFICATION SYSTEM				TABLE A-2		



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BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches



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COMPASSGRP-1-01

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BORING B-1

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-1

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % ▨ RQD% ▩ CORE REC%	INSTALLATION AND COMMENTS
30.0		medium stiff at 30.0 feet			0		
32.5		Very dense, gray with yellow mottled, clayey GRAVEL with sand (GC); moist to wet.	33.0		6		
35.0		Exploration terminated at a depth of 34.7 feet due to auger refusal. Hammer efficiency factor is unknown. SPT completed using two wraps with a cathead.	34.7			37-50/2'	Surface elevation was not measured at the time of exploration.
37.5							
40.0							
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							

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COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches



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COMPASSGRP-1-01

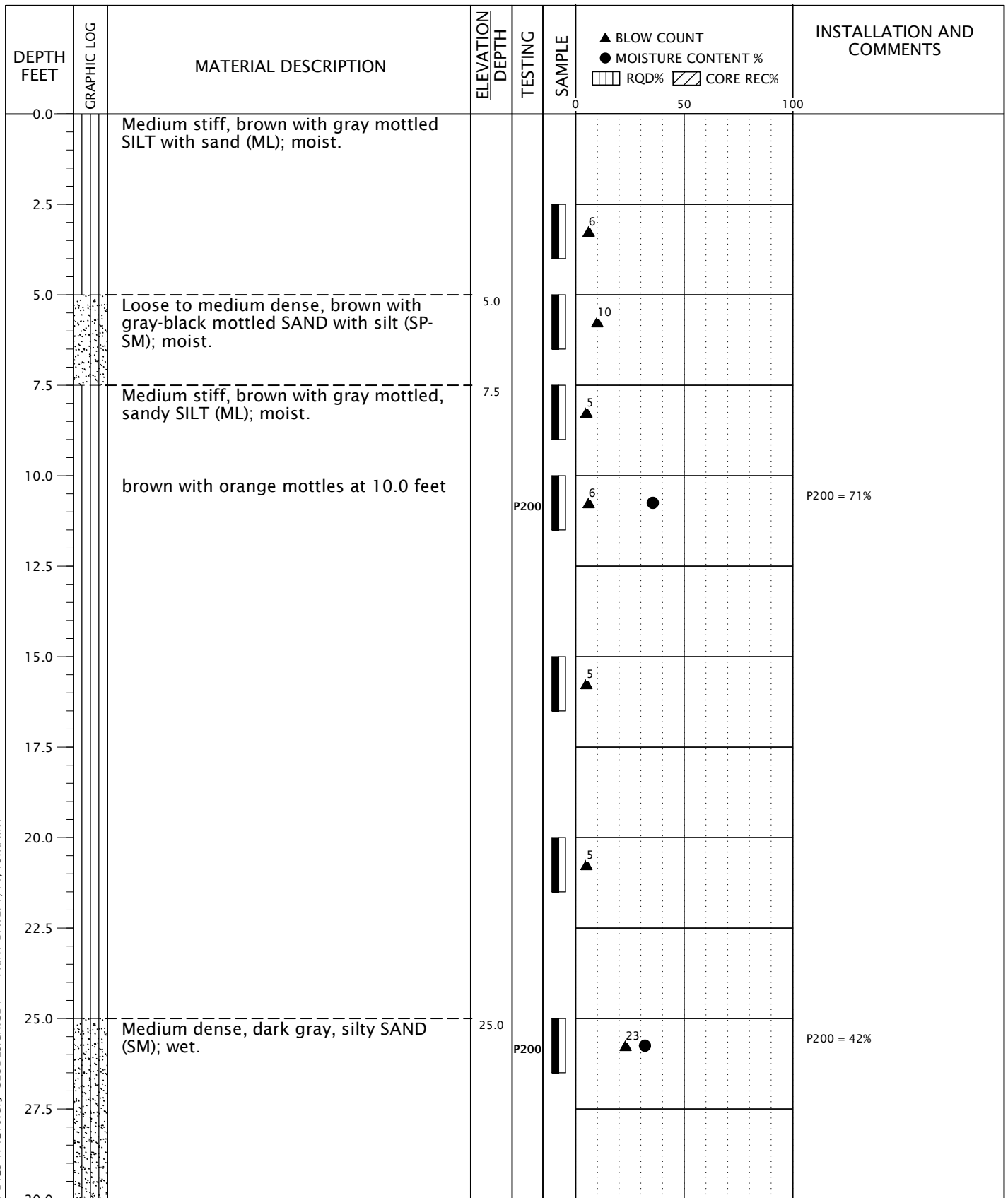
JANUARY 2019

BORING B-1
(continued)

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-1

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT



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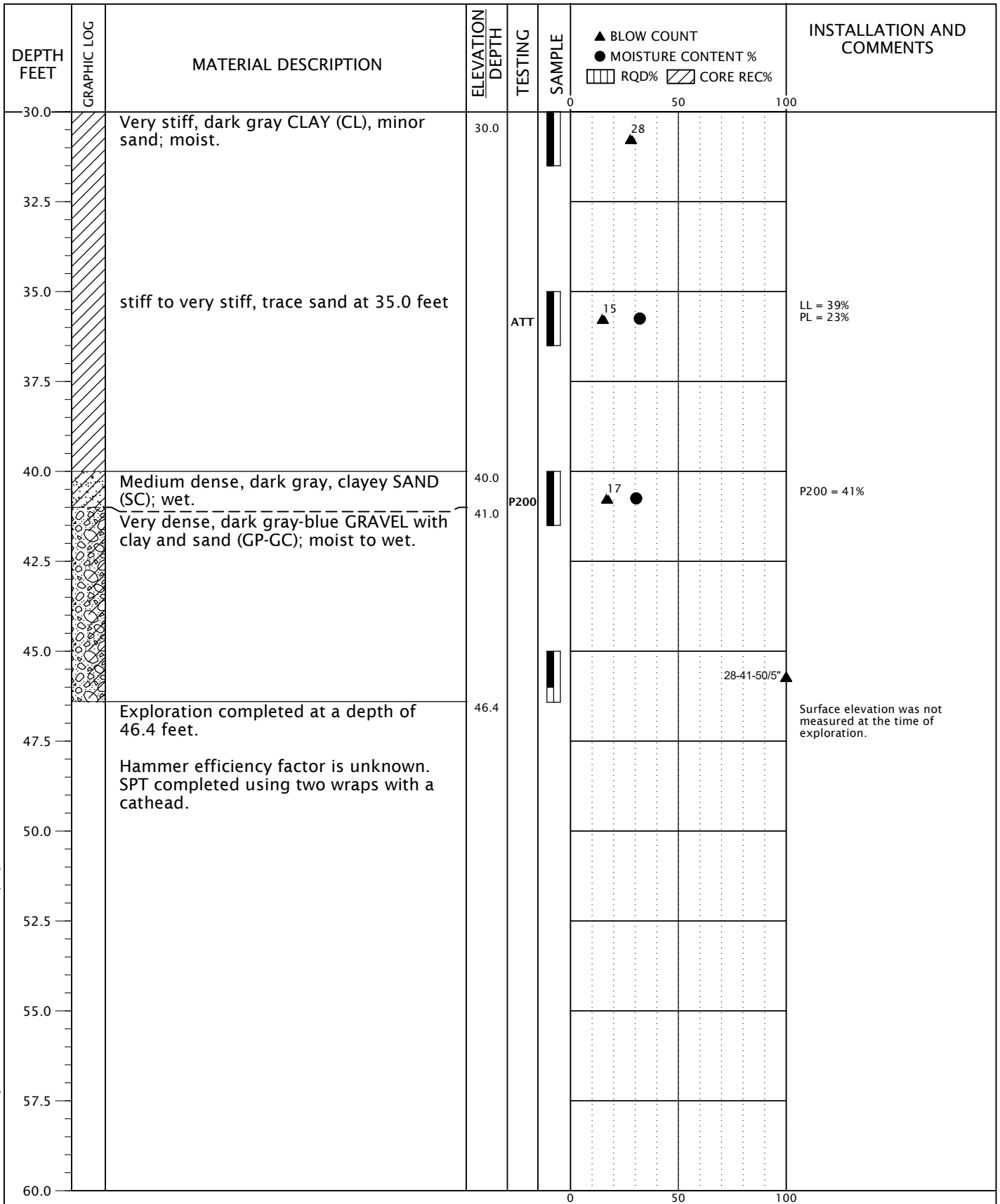
COMPASSGRP-1-01

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BORING B-2

HOLLEY PARK SUBDIVISION
 LA CENTER, WA

FIGURE A-2



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BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches



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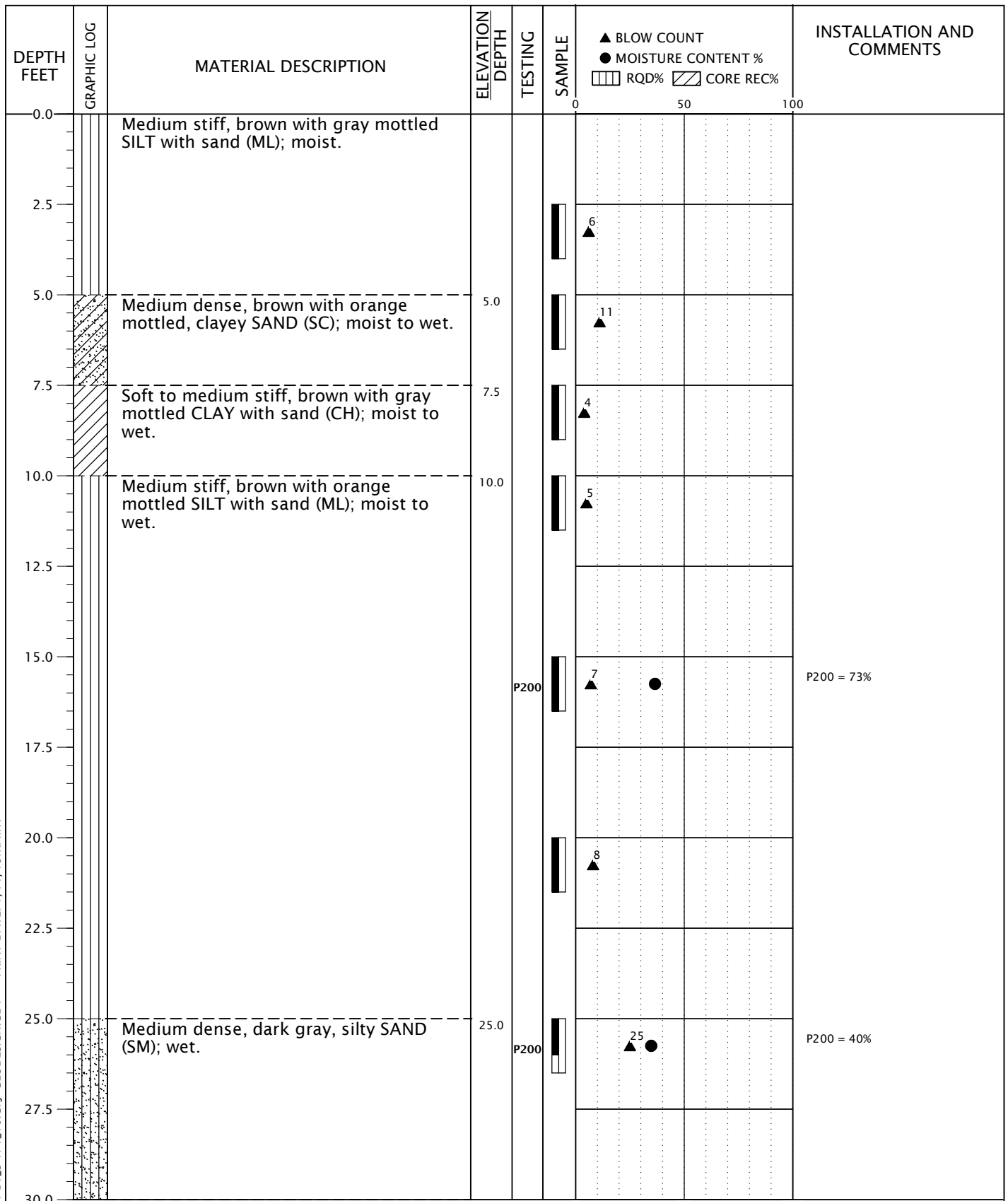
BORING B-2
(continued)

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-2

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19;KM:KT



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BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches



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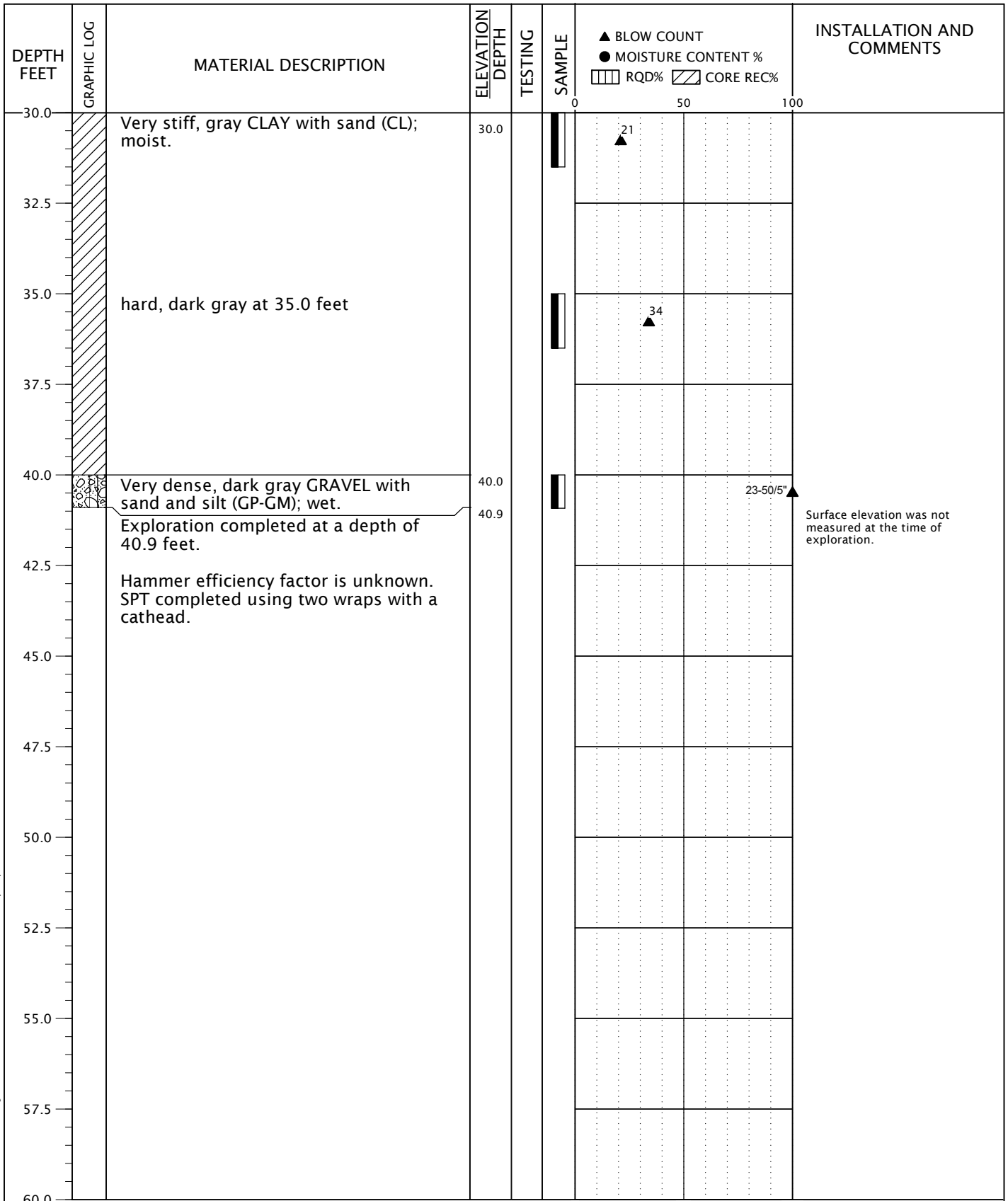
COMPASSGRP-1-01

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BORING B-3

HOLLEY PARK SUBDIVISION
 LA CENTER, WA

FIGURE A-3



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COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches



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COMPASSGRP-1-01

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BORING B-3
(continued)

HOLLEY PARK SUBDIVISION
 LA CENTER, WA

FIGURE A-3

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %	COMMENTS
0.0		Soft, brown SILT (ML), minor sand and organics; moist (24-inch-thick tilled zone, 5-inch-thick root zone).		PP			PP = 0.25 tsf
2.5		without organics at 2.0 feet		P200	☒	●	P200 = 91%
				PP			PP = 0.25 tsf
5.0							
7.5		medium stiff, brown with orange and gray mottles, sandy at 8.0 feet		PP	☒		PP = 0.75 tsf
10.0							
12.5							
13.0		Medium dense, brown with orange mottled, silty SAND (SM); moist.	13.0		☒		Slow groundwater seepage observed at 14.0 feet.
15.0					☒		
17.5		Exploration completed at a depth of 17.0 feet.	17.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-1

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-4

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %			COMMENTS
						0	50	100	
0.0		Soft, brown SILT (ML), minor sand and organics; moist, sand is fine (12-inch-thick tilled zone, 6-inch-thick root zone).		PP					PP = 0.25 tsf
2.5		very stiff, brown with gray mottles, without organics at 2.5 feet		PP	☒				PP = 3.0 tsf
5.0									
7.5		soft, sandy at 7.0 feet		PP	☒				PP = 0.5 tsf
10.0									
12.5									Slow groundwater seepage observed at 12.0 feet.
14.0		Medium dense, brown with orange mottled, silty SAND (SM); moist.	14.0	P200	☒		●		P200 = 40%
15.0									
17.5		Exploration completed at a depth of 17.0 feet.	17.0						No groundwater seepage observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0									
22.5									
25.0									
27.5									
30.0									

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

TEST PIT TP-2

JANUARY 2019

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-5

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %	COMMENTS
0.0		Soft, brown SILT (ML), minor sand and organics; moist (30-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
				PP	☒		PP = 0.25 tsf
2.5		very stiff, brown with gray-orange mottles, without organics at 2.5 feet		PP	☒		PP = 3.5 tsf
5.0							
7.5							
10.0							
12.5		sandy at 12.0 feet		P200	☒	●	P200 = 68% Slow groundwater seepage observed at 13.0 feet.
13.5		Medium dense, brown-orange, silty SAND (SM); moist.	13.5		☒		
15.0		brown-dark gray at 15.0 feet					
17.0		Exploration completed at a depth of 17.0 feet.	17.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

TEST PIT TP-3

JANUARY 2019

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-6

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %			COMMENTS
						0	50	100	
0.0		Very soft, brown SILT with sand and organics (ML); moist (12-inch-thick tilled zone, 6-inch-thick root zone). medium stiff to stiff, gray with orange mottles, without organics at 1.0 foot		PP					PP = 0.25 tsf
2.5				PP	☒				
5.0									
7.5									
10.0									
12.5		Medium dense, brown with orange mottled, silty SAND (SM); moist.	12.0		☒				Slow groundwater seepage observed at 12.0 feet.
15.0		dark gray at 15.0 feet			☒				
17.5									
18.0		Exploration completed at a depth of 18.0 feet.	18.0						No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0									
22.5									
25.0									
27.5									
30.0									

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-4

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-7

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %	COMMENTS
0.0		Soft, brown SILT with sand and organics (ML); moist (24-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
2.5		soft to medium stiff, brown with gray mottles, without organics at 2.0 feet very stiff at 3.0 feet		PP	☒		PP = 1.0 tsf
5.0				ATT PP	☒	●	PP = 2.75 tsf LL = 49% PL = 25%
7.5							
10.0							
12.5		medium stiff; wet at 11.0 feet		P200	☒	●	Groundwater seepage observed at 11.0 feet. P200 = 54%
15.0		Medium dense, dark gray, silty SAND (SM); moist.	15.0		☒		
17.5		Exploration completed at a depth of 17.0 feet.	17.0				No caving was observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-5

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-8

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %			COMMENTS
						0	50	100	
0.0		Soft, brown SILT with sand and organics (ML); moist, sand is fine (12-inch-thick tilled zone, 6-inch-thick root zone). brown with gray mottles, without organics at 1.0 foot		PP					PP = 0.25 tsf
2.5				PP	☒				
5.0		medium stiff at 5.0 feet							Slow groundwater seepage observed at 4.0 feet. Minor caving observed at 4.0 feet.
10.0				P200	☒		●		P200 = 94%
15.0					☒				
17.5		Exploration completed at a depth of 17.0 feet.	17.0						Surface elevation was not measured at the time of exploration.
20.0									
22.5									
25.0									
27.5									
30.0									

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

TEST PIT TP-6

JANUARY 2019

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-9

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %			COMMENTS
						0	50	100	
0.0		Very soft, brown SILT with sand and organics (ML); moist (12-inch-thick tilled zone, 6-inch-thick root zone). medium stiff to stiff, brown with gray-orange mottles, without organics at 1.0 foot							
2.5			PP	☒					PP = 1.0 tsf
5.0									
7.5					☒				
10.0				PP	☒				PP = 0.75 tsf
12.5									
13.0		Medium dense, light brown, silty SAND (SM); moist. orange at 14.0 feet	13.0		☒				Slow groundwater seepage observed at 13.0 feet.
15.0									
17.5									
18.0		Exploration completed at a depth of 18.0 feet.	18.0						No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0									
22.5									
25.0									
27.5									
30.0									

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-7

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-10

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %	COMMENTS
0.0		Soft, brown SILT with sand and organics (ML); moist, sand is fine (24-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
2.5		without organics at 2.0 feet		P200 PP	☒	●	P200 = 85% PP = 2.0 tsf
5.0							
7.5							
10.0					☒		Slow groundwater seepage observed at 11.0 feet.
12.5							
14.0		Medium dense, light brown-gray SAND with silt (SP-SM); moist.	14.0		☒		
15.0							
17.5							
18.0		Exploration completed at a depth of 18.0 feet.	18.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0							
22.5							
25.0							
27.5							
30.0							

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

TEST PIT TP-8

JANUARY 2019

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-11

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %			COMMENTS
						0	50	100	
0.0		Very soft, brown SILT with sand and organics (ML); moist, sand is fine (24-inch-thick tilled zone, 12-inch-thick root zone). soft to medium stiff, gray with orange mottles, without organics at 2.0 feet		PP					PP = 0.25 tsf
2.5				PP	☒				
5.0									
7.5									
10.0		brown, sandy at 9.0 feet			☒				
10.0				P200	☒		●		Slow groundwater seepage observed at 10.0 feet. P200 = 62%
12.5									
15.0		Medium dense, brown with orange mottled, silty SAND (SM); moist.	15.0		☒				
16.0		Exploration completed at a depth of 16.0 feet.	16.0						No caving observed to the depth explored.
17.5									Surface elevation was not measured at the time of exploration.
20.0									
22.5									
25.0									
27.5									
30.0									

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

TEST PIT TP-9

JANUARY 2019

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-12

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-BJ_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19-KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %			COMMENTS
						0	50	100	
0.0		Very soft, brown SILT with sand and organics (ML); moist, sand is fine (24-inch-thick tilled zone, 18-inch-thick root zone).		PP	☒				PP = 0.25 tsf
2.5		without organics at 2.0 feet							
		medium stiff at 3.0 feet		PP	☒				PP = 0.75 tsf
5.0									
7.5									
10.0		light brown, sandy at 10.0 feet			☒				
12.5					☒				Slow groundwater seepage observed at 12.0 feet.
15.0		Medium dense, brown with orange mottled, silty SAND (SM); moist.	15.0	P200	☒	●			P200 = 44%
16.5		Exploration completed at a depth of 16.5 feet.	16.5						No caving observed to the depth explored.
17.5									Surface elevation was not measured at the time of exploration.
20.0									
22.5									
25.0									
27.5									
30.0									

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)



COMPASSGRP-1-01

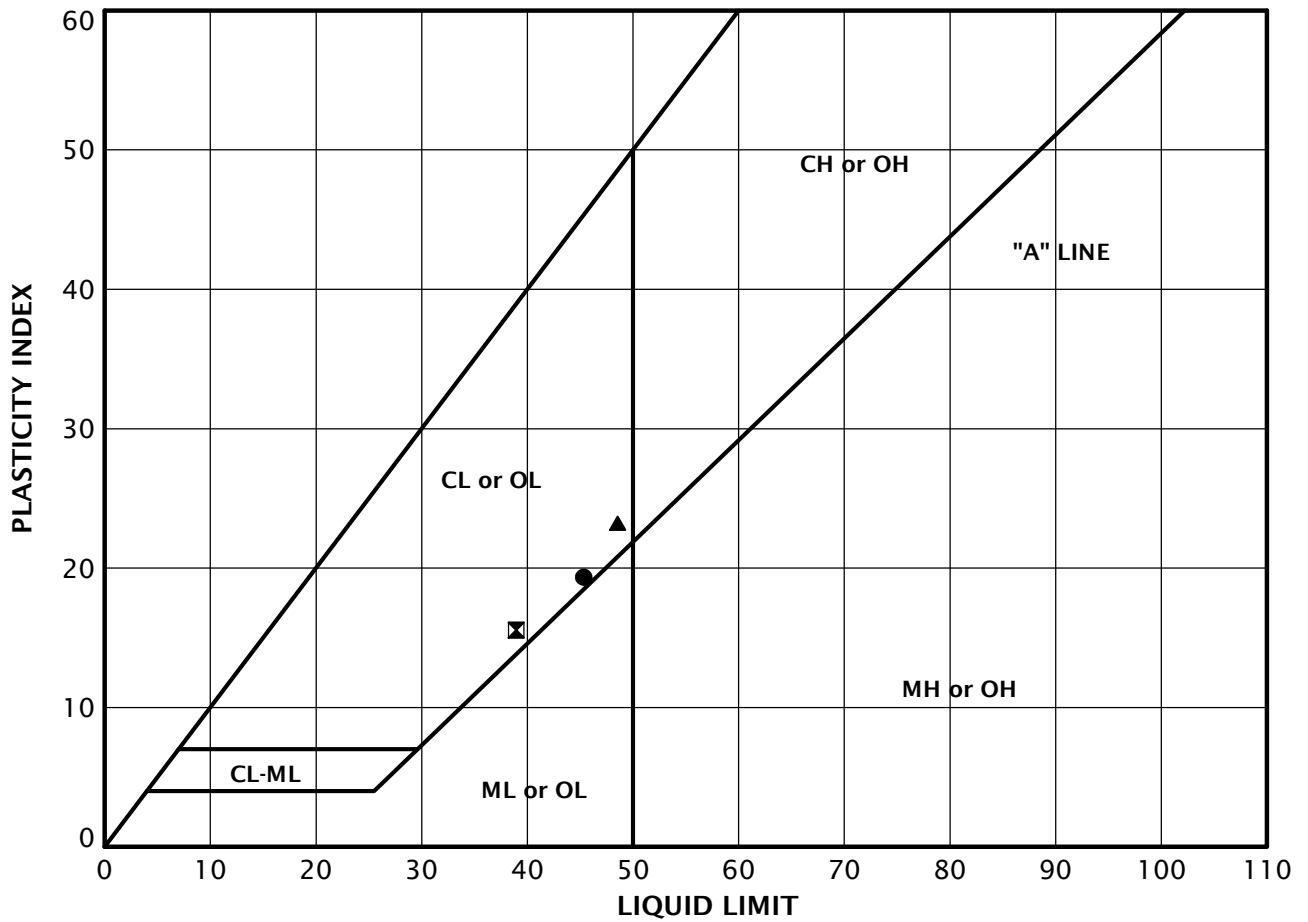
TEST PIT TP-10

JANUARY 2019

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-13


ATTERBERG_LIMITS 7 COMPASSGRP-1-01-B1_3-TPI_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KT



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-1	5.0	32	45	26	19
⊠	B-2	35.0	32	39	23	16
▲	TP-5	3.0	32	49	25	24

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	5.0		32				45	26	19	
B-1	20.0		33			68				
B-2	10.0		36			71				
B-2	25.0		32			42				
B-2	35.0		32				39	23	16	
B-2	40.0		30			41				
B-3	15.0		37			73				
B-3	25.0		35			40				
TP-1	2.0		39			91				
TP-2	14.0		37			40				
TP-3	12.0		40			68				
TP-5	3.0		32				49	25	24	
TP-5	11.0		39			54				
TP-6	10.0		40			94				
TP-8	2.0		36			85				
TP-9	10.0		34			62				
TP-10	15.0		34			44				

LAB SUMMARY COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KT

 703 Broadway Street - Suite 650 Vancouver WA 98660 360.693.8416 www.geodesigninc.com	COMPASSGRP-1-01	SUMMARY OF LABORATORY DATA	
	JANUARY 2019	HOLLEY PARK SUBDIVISION LA CENTER, WA	FIGURE A-15

APPENDIX B

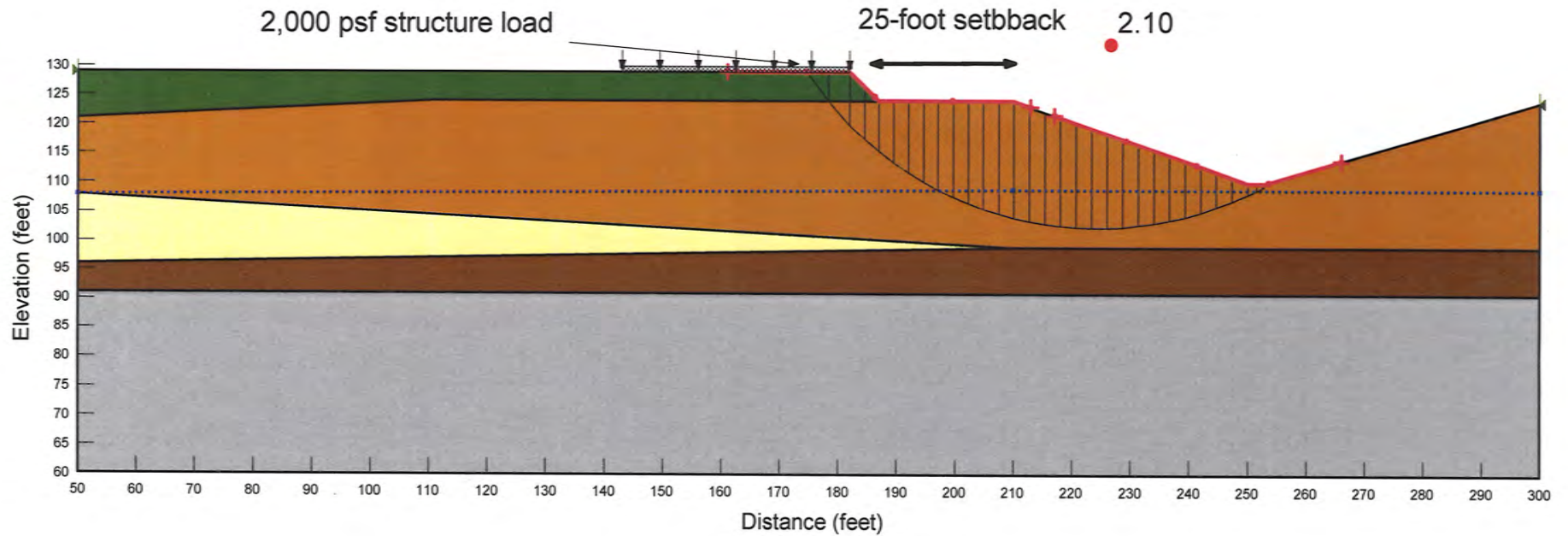
APPENDIX B

SLOPE STABILITY ANALYSIS

This appendix contains the outputs of the slope stability analysis from the software program Slope/W by GeoStudio. The locations of the analyzed sections are shown on Figures 2 and 3 and a discussion of the results is present in the main report.

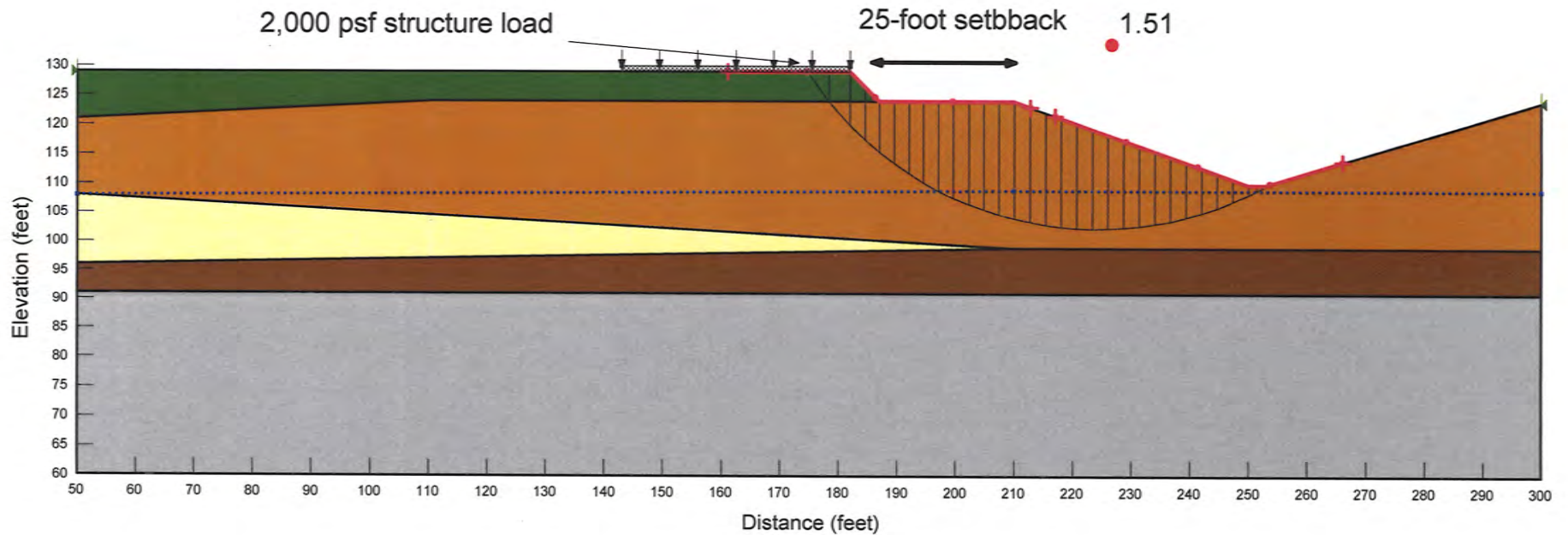
Holley Park North Slope Stability Analysis - Section A-A' Static Condition Horz Seismic Coef.: 0

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
■	Dense Gravel	Mohr-Coulomb	125	0	37
■	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
■	Medium Stiff Silt	Mohr-Coulomb	110	50	30
■	Stiff Clay	Mohr-Coulomb	115	100	32
■	Structural Fill	Mohr-Coulomb	120	0	32



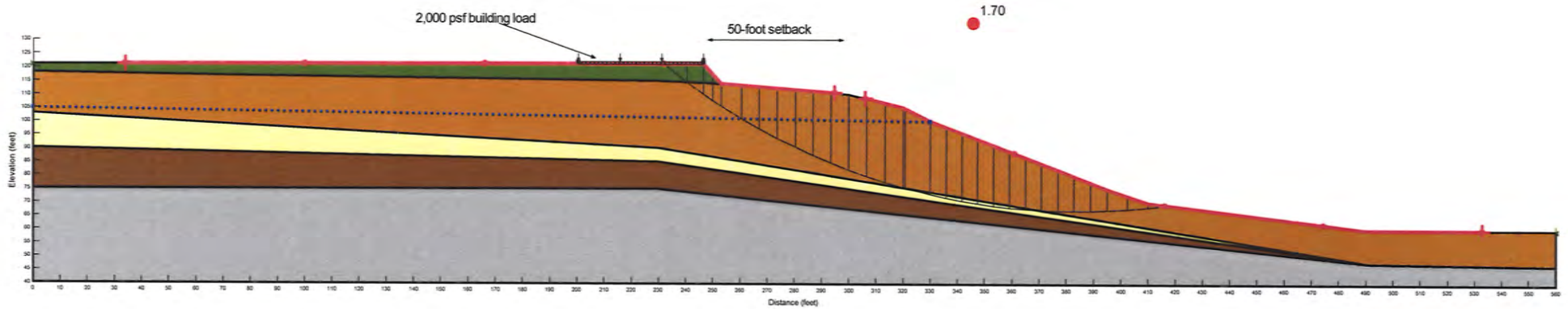
Holley Park North Slope Stability Analysis - Section A-A' Seismic Condition Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Dense Gravel	Mohr-Coulomb	125	0	37
	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
	Medium Stiff Silt	Mohr-Coulomb	110	50	30
	Stiff Clay	Mohr-Coulomb	115	100	32
	Structural Fill	Mohr-Coulomb	120	0	32



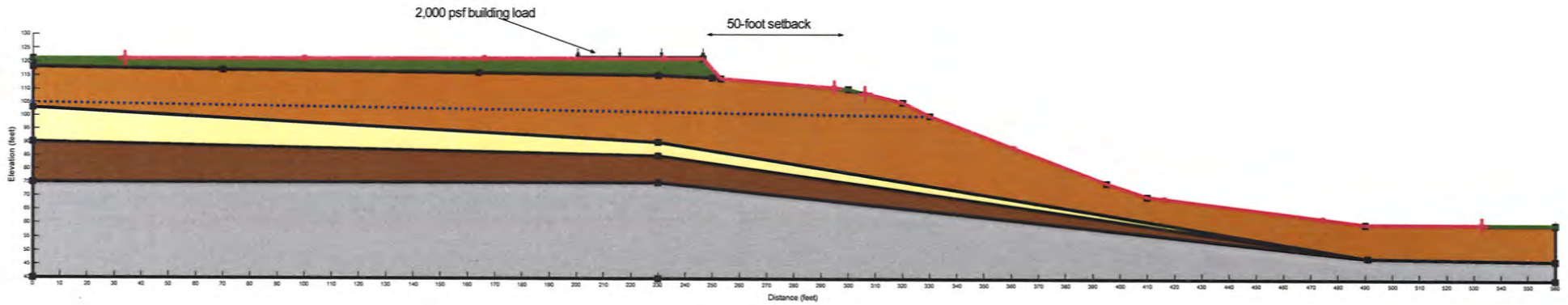
Holley Park
 Slope Stability Analysis - Section B-B'
 Static Condition
 Horz Seismic Coef.: 0

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Grey	Dense Gravel	Mohr-Coulomb	125	0	37
Yellow	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
Orange	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
Brown	Stiff Clay	Mohr-Coulomb	115	100	32
Green	Structural Fill	Mohr-Coulomb	120	0	32



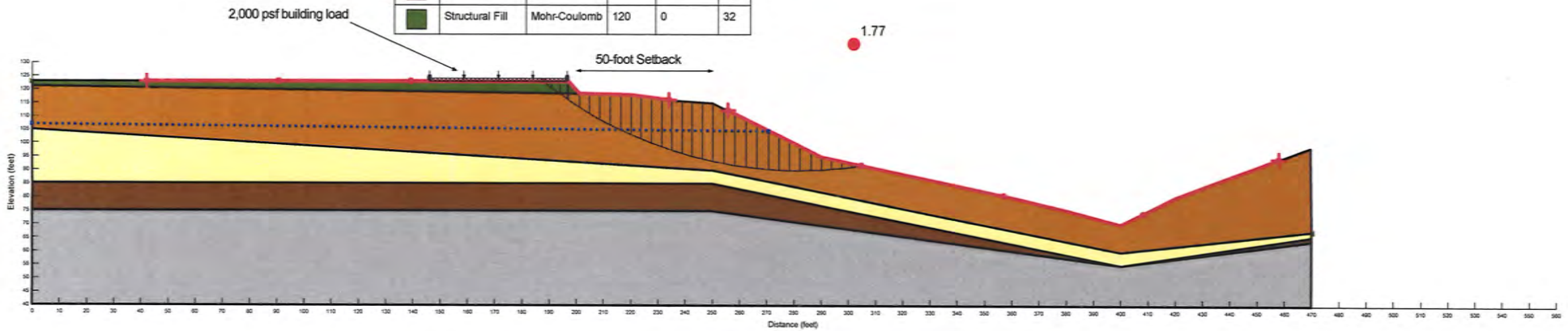
Holley Park
 Slope Stability Analysis - Section B-B'
 Seismic Condition
 Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Grey	Dense Gravel	Mohr-Coulomb	125	0	37
Yellow	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
Brown	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
Dark Brown	Stiff Clay	Mohr-Coulomb	115	100	32
Green	Structural Fill	Mohr-Coulomb	120	0	32



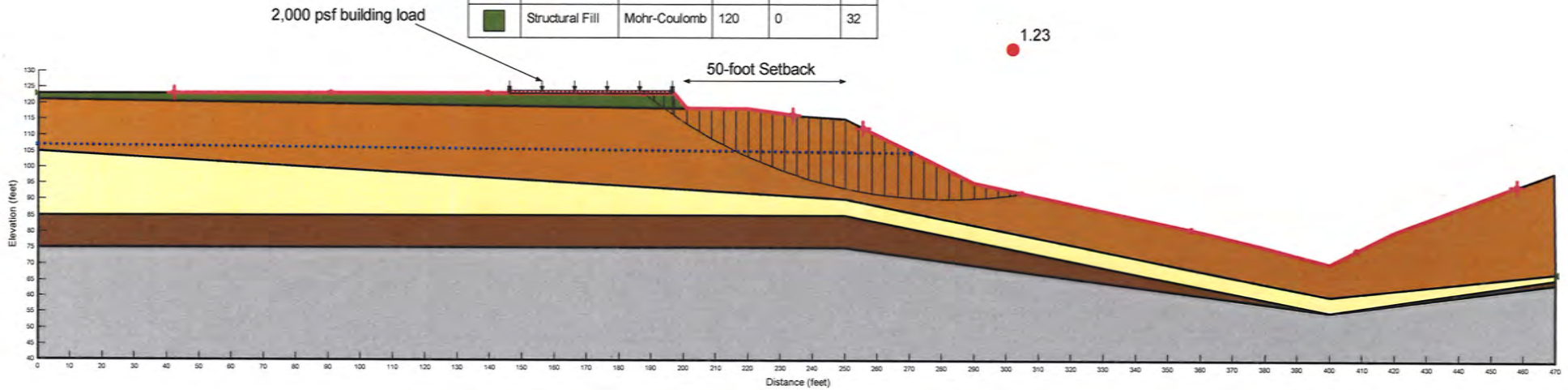
Holley Park
 Slope Stability Analysis - Section C-C'
 Static Condition
 Horz Seismic Coef.: 0

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	Phi (°)
Grey	Dense Gravel	Mohr-Coulomb	125	0	37
Yellow	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
Brown	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
Dark Brown	Stiff Clay	Mohr-Coulomb	115	100	32
Green	Structural Fill	Mohr-Coulomb	120	0	32



Holley Park
 Slope Stability Analysis - Section C-C'
 Seismic Condition
 Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
Grey	Dense Gravel	Mohr-Coulomb	125	0	37
Yellow	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
Orange	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
Brown	Stiff Clay	Mohr-Coulomb	115	100	32
Green	Structural Fill	Mohr-Coulomb	120	0	32



Holley Park
 Slope Stability Analysis - Section B-B'
 Seismic Condition
 Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	Phi (°)
Grey	Dense Gravel	Mohr-Coulomb	125	0	37
Yellow	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
Light Brown	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
Dark Brown	Stiff Clay	Mohr-Coulomb	115	100	32
Green	Structural Fill	Mohr-Coulomb	120	0	32

