PRELIMINARY GEOTECHNICAL ENGINEERING STUDY W/INFILTRATION

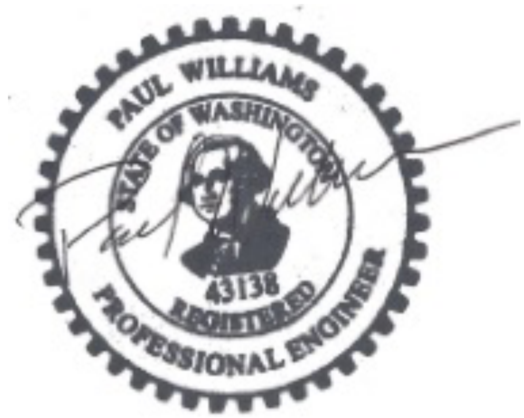
Proposed Lockwood Creek Subdivision
2313 NE Lockwood Creek Road
La Center, Clark County, WA 98629
(Parcel No.'s 209064000 and 209121000)

Prepared for:

Gravitate Capital, LLC
13563 NW Fuller Lane
Portland, OR 97229

Prepared By:

Seth A. Chandlee
President



Paul Williams, PE
Project Engineer

Project No. G0372200
{May 2022}

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Soil and Water Technologies, Inc.

Geotechnical, Monitoring, Materials Testing & Erosion Compliance

Gravitate Capital, LLC
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May 2nd, 2022
G0372200

Hello Shawn,

We are pleased to submit our report titled "Preliminary Geotechnical Engineering Study with Infiltration Testing, for the proposed Lockwood Creek Subdivision located at 2313 NE Lockwood Creek Road in La Center, Washington. This report presents the results of our field exploration, laboratory testing, and engineering analyses.

Based on the results of this study, it is our opinion that construction of the proposed residential development is feasible from a geotechnical standpoint, provided recommendations presented in this report are included in the project design.

We appreciate the opportunity to have been of service to you and look forward to working with you in the future. Should you have any questions about the content of this report, or if we can be of further assistance, please call (360) 200-8693.

Respectfully Submitted,
Soil and Water Technologies, Inc.

Seth A. Chandlee
President

Paul Williams, PE
Project Engineer

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INTRODUCTION

General

This report presents the results of the geotechnical engineering study completed by Soil and Water Technologies, Inc. (SWT) for the proposed Lockwood Creek Subdivision located in Vancouver, Washington. The general location of the site is shown on the *Vicinity Map, Figure 1.* Our approximate exploratory test pits / infiltration locations are shown in relation to the site on the *Site Plan, Figure 2.*

The purpose of this study is to explore and evaluate subsurface conditions at the site and provide geotechnical recommendations for the proposed construction based on the conditions encountered. These recommendations include site specific geotechnical parameters for foundation support, earthwork grading, stormwater infiltration, site drainage, erosion control and a seismic hazard evaluation.

Project Description

Since a preliminary site plan was not provided at the time this report was written, this report should be considered preliminary and once available, undergo further grading plan review. However, based on our recent conversation and site investigation, we anticipate that the combined 18.57-acre properties, designated tax parcel No.'s 209064000 and 209121000, will be developed into a residential subdivision. Based on existing site grades, we anticipate minimal cuts/fills ranging from 1 to 2 feet in thickness across the site. The project will also include essential underground utilities (sanitary sewer, storm, domestic water) and onsite paved roadways.

Specific structural design loads were also not available, however, based on our experience with similar projects, we anticipate that wall loads will be approximately 700 to 1,500 pounds per lineal foot (plf). Slab-on-grade floor loads will most likely range from one hundred to one hundred and fifty pounds per square foot (100-150 psf).

If any of the above information is incorrect or changes, we should be consulted to review the recommendations contained in this report. In any case, it is recommended that Soil and Water Technologies perform a general review of the final design.

SITE CONDITIONS

Surface

As shown on our *Site Plan, figure 2,* the subject site is located to the southwest of the intersection of NE Lockwood Creek Road and NE 24th Avenue, on the south side of NE Lockwood Creek Road in La Center, Washington. The subject property is bordered to the west by the newly constructed La Center Highschool, to the south by a single-family residence on land, to the east by undeveloped vacant land, and north by NE Lockwood Creek Road.

The 2-parcel site is relatively level (0-5% slope), with a gentle south-facing slope the runs adjacent to Lockwood Creek Road (5-10%) at the north side of the site. The total elevation change across the properties is about 10 feet. According to Clark County Maps Online imagery layers, the two properties were historically used as agricultural farming with an existing residence and associated structures dating back to 1955. All structures were removed between 2016 and 2018 and the site consists predominantly of field grass with a gravel parking area at the northeast corner. A gravel roadway (NE 23rd Avenue) also runs north and south between the two parcels in the center of the site.

Subsurface

On March 25th, 2022, and April 4th, 2022, we evaluated the subsurface soil conditions by excavating a total of 1 infiltration test pit (I-1) and 4 exploratory test pits, designated TP-2 through TP-5 to the maximum explored depth of 8.0 feet below the existing ground surface (bgs). All exploration locations were selected by SWT to determine subsurface conditions across the site in regard to proposed development. The approximate locations are shown on the *Site Plan, Figure 2.*

All soil was classified in general accordance with the *Unified Soil Classification System (USCS).* Soil samples obtained from the test pits were returned to our office for additional evaluation and laboratory testing. Descriptions of field and laboratory procedures are included in Appendices A and B, respectively.

The following is a generalized description of the subsurface units encountered. For a more detailed description of the conditions encountered, refer to test pit logs A2 through A4.

SURFACE MATERIALS:	Surface materials encountered in the test pits consisted of approximately 4 - 6 inches of organic topsoil, wood chips and tree roots. A tilled zone resulting from agricultural farming is present in the upper approximate 1.5 feet.
SANDY LEAN CLAY	Native sandy Lean Clay (CL) was encountered below the surface materials at each test pit to depths ranging from 0.5 to 7.0 feet bgs. Except for TP-3, which consists of silty Gravels (fill). The lean clay layer was also encountered below the sandy Fat Clay (CH) at test pits I-1 and TP-3 to depths ranging from 2.5/4.0 to 8.0 feet bgs. The sandy Lean Clay (CL) was brown, soft to stiff and in a moist condition. The moisture content of the 5 samples collected from this layer ranged from 30.8 to 36.4 percent with a fines content ranging from 58.3 to 86.7 percent. The upper ~ 1.5 feet of this layer predominantly consists of a tilled zone from agriculture farming. The expansion index of this layer is 13.
SANDY FAT CLAY	Native sandy Fat Clay (CH) was encountered below the lean Clay (CL) layer at test pits I-1 and TP-3 to depths ranging from 1.0 to 2.5/4.0 feet bgs. The sandy Fat Clay (CH) was gray/brown, stiff to very stiff and in a moist condition. The moisture content of the 3 samples collected from this layer ranged from 25.7 to 34.2 percent with a fines content ranging from 79.6 to 88.1 percent. The Atterberg limits of this layer has a liquid limit of 56 and a plasticity index of 36.

Infiltration Testing

Infiltration testing was performed at test pit I-1 at depths of 2.0 and 3.5 feet bgs. The approximate location of the infiltration test pit is shown on the *Site Plan, Figure 2.* The purpose of performing these tests was to determine if site subgrade soils are suitable for infiltration of stormwater and provide stormwater treatment and control for all onsite impervious surfaces after construction. Infiltration testing methods were performed in general accordance with 2021 Clark County Stormwater Manual requirements for the Single-Ring Falling Head Infiltration Test. The test pit was excavated to the desired depths and a 6-inch diameter PVC pipe was embedded into the exposed soil ~ 6 inches in depth. Following a minimum 4-hour pre-saturation period, the pipe was filled with water and timed as the head dropped. The test results were averaged and recorded in inches per hour (iph).

All soil was classified following the *Unified Soil Classification System* (USCS) and the *AASHTO Soil Classification System (M145).* The following table provides the field coefficient infiltration test results and associated laboratory testing:

Location	USCS Soil Type	Approx. Depth to Groundwater	WWHM	Depth (ft.)	% Passing #200 sieve	% Moisture content	Field Coefficient of Permeability
I-1	**CH**	**Not encountered to 8.0 ft. bgs**	**SG-4**	**2.0**	**88.1**	**32.7**	**0.08 iph**
I-1	**CH**	**Not encountered to 8.0 ft. bgs**	**SG-4**	**3.5**	**87.1**	**34.2**	**0.05 iph**

(USCS) Unified Soil Classification System / (CH) – Clay with sand (high plasticity)
(WWHM) Western Washington Hydrology Model / Soil Group 4 (poorly drained soils)

The coefficients of permeability presented were calculated using Darcy's law in accordance with the 2021 CCSWM, but do not include base correction factors or system design correction factors as required by the guidelines. Additionally, it is recommended that the designer also include additional correction factors to account for the level of maintenance, type of system, vegetation, siltation, etc.

Based on the subsurface conditions encountered, the slow rate of infiltration and our laboratory test results, it is our opinion that the low permeable native sandy fat Clay (CH) encountered in test pit I-1, and across the site, ***is not suitable*** for the infiltration of stormwater and will require alternative management.

Groundwater

Due to the wet time of year and above-average rainfall, light to medium groundwater seepage was encountered in test pit TP-2, TP-4, and TP-5 at depths ranging from 2.0 to 5.0 feet bgs Based on our review of Clark County Maps Online and the Department of Ecology well log database, static groundwater exceeds 30 feet in depth. However, the groundwater monitoring wells (piezometer) installed by Columbia West Engineering at the adjacent school property indicates groundwater depths of 3 feet bgs. during the months of April, 2018.

It is important to note that groundwater conditions are not static; fluctuations may be expected in the level and seepage of flow depending on the season, amount of rainfall, surface water runoff, and other factors. Generally, the groundwater level is higher and seepage rate is greater in the wetter winter months (typically October through May).

General Regional Geology

General information about geologic conditions and soil in the vicinity of the site was obtained by reviewing the USGS Geologic Map of Washington-Southwest Quadrant, WA. State Department of Natural Resources, (Geologic Map GM-34, 1987) and the Geologic Map of the Vancouver Quadrangle, Washington & Oregon, (DLNR), Open File Report 87-10 and the USDA web soil survey.

In the Late Pleistocene (17 -13 kya), a series of floods caused by the failure of the ice dam at Glacial Lake Missoula in western Montana caused the deposition of suspended sediments after the floodwaters became hydraulically dammed north of the confluence of the Columbia and Lewis Rivers. Fine-grained sediments were deposited when the flood waters slowed down and deposited a series of distinct layers described as unconsolidated silty Sand, Silt, and Clay.

The native material encountered in our exploratory test pits consists predominantly fine-grained Clay (CL & CH) with sand consistent with cataclysmic-flood deposits, which represent weathered Late Pleistocene fine-grained sedimentary flood deposits attributed to Gee silt loam (GeB) and Odne silt loam (OdB) soil series. Both soil series consist predominately of fine-grained clays and silts with low to very low permeability and are moisture sensitive.

GEOLOGIC HAZARDS

The following provides a geologic hazard review for the subject site. The purpose of this investigation was to determine if geologic hazards are present on the site, and if so, to provide recommendations to mitigate their impacts on development. The geologic hazard review as based on our site reconnaissance and subsurface explorations, as well as a review of publicly available published literature and maps.

Seismic Hazards

The following seismic hazards have been considered as part of our geologic hazards review for the project site. Seismic hazards pertain to areas that are subject to risk of earthquake-induced damage. These hazards include ground shaking/motion amplification, soil liquefaction, geologic fault rupture, and landslides.

Ground Motion Amplification

According to the "Site Class Map layer of Clark County MapsOnline, the proposed site is designated as a seismic Site Class "C". However, based on our subsurface explorations and laboratory test results, it is our opinion that a Site Class "D" is appropriate for use at the site. This designation indicates that some amplification of seismic activity may occur during a seismic event based on the subsurface soil conditions encountered.

Liquefaction

Structures are subject to damage from earthquakes due to direct and indirect action. Shaking represents direct action. Indirect action is represented by foundation failures and is typified by liquefaction. Liquefaction occurs when soil loses all shear strength for short periods of time during an earthquake. Ground shaking of sufficient duration then results in the loss of grain-to-grain contact as well as a rapid increase in pore water pressure. This causes the soil to assume the physical properties of a fluid.

To have potential for liquefaction a soil must be loose, cohesion-less (generally sands and silts), below the groundwater table, and must be subjected to sufficient magnitude and duration of ground shaking.

According to the "Liquefaction Susceptibility" layer of Clark County MapsOnline, the site is mapped as having a "very low" liquefaction susceptibility. Due to the medium stiff to stiff and predominately fine-grained soils encountered in our test pits, and the absence of near surface groundwater, it is our professional opinion that soil liquefaction and induced differential settlement will not occur at the subject site during a moderate to strong seismic event and that a "very low" susceptibility is adequate for the site.

It should be noted that directly south of the site, at a distance of approximately 0.35 mile, an area of moderate to high potential for liquefaction is indicated by Clark County MapsOnline. Additional testing would need to be performed to determine the liquefaction potential of the onsite soils and is beyond our scope of work for this report.

Fault Rupture

According to USGS Earthquake Hazards Program, there are a total of three major fault zones in the vicinity of the site that have the potential to cause or induce soil liquefaction and/or settlement. These faults are the Portland Hills Fault, Lacamas Lake-Sandy River Fault, and the Cascadia Subduction Zone. However, there are no historically active faults located in close proximity to the site. Due to the stiff soil conditions encountered in our test pits and distance from the mapped fault, a fault rupture in not considered a hazard at the site.

Seismic Design Criteria:

According to Clark County MapsOnline, supportive foundation soils encountered at the site are classified as a type “C” soil. However, based on our test pit explorations and laboratory testing, a type “D” soil is more appropriate for the site. For more detail regarding soil conditions refer to the soil logs in Appendix A of this report.

The seismic design criteria for this project found herein is based on the International Building Code (IBC) 2018 and the USGS website. A summary of IBC seismic design criterion is below.

Table 1. 2018 IBC Seismic Design Parameters		
Location (45.8587037, -122.6470354)	**Short Period**	**1-Second**
Maximum Credible Earthquake Spectral Acceleration	S_s = 0.796 g	S_1 = 0.374 g
Site Class	D	
Site Coefficient	F_a = 1.181	F_v = 1.926
Adjusted Spectral Acceleration	S_{MS} = 0.941 g	S_{M1} = 0.72
Design Spectral Response Acceleration Parameters	S_{DS} = 0.627 g	S_{D1} = 0.48

g – acceleration due to gravity

Due to the Site Class “D” designation and the long period MCES (S1) value exceeding 0.2 g, the structural engineer must apply the site-specific ground motion increases outlined in Section 11.4.8 of ASCE 7-16, including an increased of 50 percent to the seismic base shear coefficient, C_S. As an alternative to applying these conservative increases to the ground motions, a site-specific ground motion hazard analysis may be performed, however such an analysis was not included in the scope of this study.

GEOTECHNICAL DESIGN RECOMMENDATIONS

General

Based on the results of our study, it is our opinion the proposed residential development can be constructed as planned, provided the geotechnical recommendations contained in this report are incorporated into the final design. The following sections present detailed recommendations and parameters pertaining to the geotechnical engineering design for this project.

Foundations

Based on the encountered subsurface soil conditions, preliminary building design criteria, and assuming compliance with the preceding *Site Earthwork and Grading* section, the proposed residential building foundations should be supported on 12 inches of compacted crushed rock above a properly prepared native subgrade or compacted structural fill. Due to the high plasticity and heterogeneous condition of soil, it is recommended that the foundations bear on crushed aggregate. See *Site Earthwork and Grading* sections for soil preparation prior to form installation.

Individual spread footings or continuous wall footings providing support for the proposed buildings may be designed for a maximum allowable bearing value of 1,500 pounds per square foot (psf). Footings for one level structures should be at least 12 inches in width. Footings for two level structures should be at least 15 inches in width. Footings for three level structures should be at least 18 inches in width. All footings should extend to a depth of at least twelve (12) inches below the lowest adjacent finished sub grade.

These basic allowable bearing values are for dead plus live loads and may be increased one-third for combined dead, live, wind, and seismic forces. Lateral loads can be resisted by friction between the foundation and the supporting sub grade or by passive earth pressure acting on the buried portions of the foundation. For the latter, the foundations must be poured "neat" against the existing soil or back filled with a compacted fill meeting the requirements of structural fill.

- Passive Pressure = 305 pcf (equivalent fluid weight)
- Coefficient of Friction = 0.28

It is estimated that total and differential footing settlements for the relatively light residential building will be approximately one and one-half inches, respectively. It is recommended that an SWT representative be contacted to reevaluate removal limits during building construction and observe the condition of footing soils prior to the installation of forms/rebar.

Slab on Grade

If concrete floor slabs are desired, then any disturbed soils must be re-compacted prior to pouring concrete. Satisfactory subgrade support for lightly loaded building floor slabs can be obtained on the undisturbed native soil or on engineered structural fill. A subgrade modulus of 125 pounds per cubic inch (pcf) may be used to design floor slabs. If desired, it is recommended that the slab subgrade be evaluated by a geotechnical engineer to verify bearing conditions.

A minimum 6-inch-thick layer of free draining fill should be placed and compacted over the prepared subgrade to assist as a capillary break and blanket drain. It is also suggested that nominal reinforcement such as "6x6-10/10" welded wire mesh be employed, near midpoint, in new concrete slabs. In areas where slab moisture is undesirable, a vapor barrier such as a 6-mil plastic membrane should be placed beneath the slab.

Exterior concrete slabs that are subject to vehicle traffic loads should be at least 6 inches in thickness. It is also suggested that nominal reinforcement such as "6x6-10/10" welded wire mesh be installed, near midpoint, in new exterior concrete slabs and paving. Fiber mesh concrete may be used in lieu of welded wire mesh.

Dewatering

Our subsurface investigation indicates that groundwater seepage was encountered at depths ranging from 2.0 to 5.0 feet below the existing ground surface and will fluctuate in response to precipitation. Excavations that extend below the groundwater level may result in caving or heaving. This may require pumping to temporarily reduce the amount of groundwater present to allow for the installation of underground utilities or the placement and compaction of structural fills. The contractor should consider the use of a network of ditches and sumps, into which water can flow to be pumped out of the excavation.

The depth and dewatering time will need to be determined at the time of construction and adjusted depending on site conditions. If water is encountered, the contractor should be prepared and is responsible for appropriate dewatering and discharge methods. Unprotected working should not be allowed near temporary un-shored excavations until groundwater levels have been stabilized and shoring, such as lagging, has been installed.

Site Drainage

During earthwork construction, a plan for the collection and conveyance of surface water to an appropriate management facility should be in place to control runoff. Final site grading should direct surface water off the site to prevent standing/ponding water and away from proposed buildings, structures and/or roadway. Water should also not be allowed to stand in any area where buildings or foundations are to be constructed. Loose surfaces should be sealed at the end of each workday by compacting the surface to reduce the potential of moisture infiltrating into and degrading the exposed soil.

The ground should be sloped at a gradient of a minimum of 2 percent for a distance of at least 10 feet away from the buildings. We suggest that a foundation footing drain be installed around the perimeter of all buildings. The drain should consist of a 4-inch diameter perforated pipe and installed in an envelope of clean drain rock or pea gravel wrapped with free draining filter fabric. The drain should be a minimum of one-foot-wide and one-foot-deep with sufficient gradient to initiate flow. The drain should be routed to a suitable discharge area. Details for the footing drain have been included as *Figure 3, Typical Footing Subdrain Detail.*

Under no circumstances should the roof down spouts be connected to the perimeter building drain. We suggest that clean outs be installed at several accessible locations to allow for the periodic maintenance of the drain system.

Pavement Areas

Hot mix asphalt (HMA) and crushed rock base (CRB) materials should conform to WSDOT specifications. All pavement area subgrades should consist of compacted native soil or engineered structural fill and be compacted to at least 95 percent of the modified proctor, determined by ASTM D1557. The subgrade conditions should be assessed and tested by SWT prior to the placement of the roadway aggregate section. This includes nuclear gauge density testing and proof-rolling observations with a fully loaded haul truck or equivalent. Any soft areas identified during the proof rolling process should be removed to a competent subgrade and replaced with compacted crushed aggregate.

Based on our laboratory testing, visual observations and local knowledge of soil types in the area, the subgrade soils shall be considered an AASHTO soil type A-4 to A-7. Based on the anticipated traffic loading, we recommend that a minimum of 4 inches of AC underlain by 12 inches of compacted CRB be applied at all public right-of-way and road improvement areas.

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements have the potential to saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section.

The subgrade and the pavement surface should have a minimum ¼ inch per foot slope to promote drainage. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the base layer.

CONSTRUCTION RECOMMENDATIONS

Site Earthwork and Grading

Clearing and Grubbing:

Prior to grading, the project area should be cleared of all rubble, trash, debris, etc. Any buried organic debris, undocumented fill or other unsuitable material encountered (soft soils) during subsequent excavation and grading work should also be removed. Excavations for removal of any existing footings, slabs, walls, utility lines, tanks, and any other subterranean structures should be processed and backfilled in the following manner:

- Clear the excavation bottom and side cuts of all loose and/or disturbed material.
- Once the organic topsoil has been adequately removed (~ 4 to 6 inches), the upper 1.5 feet of native soil (tilled zone) shall be scarified to a competent subgrade (stiff Clay) and dried to within 2 percent *above* its optimal moisture content and re-compacted in 8–10-inch lifts. Density testing shall be performed prior to placement of additional fill.
- Structural fill shall be placed in loose lifts not exceeding 8 inches in thickness and compacted with adequate equipment (eg. segmented pad roller) to at least 95% of the ASTM D-1557 laboratory test standard.
- Prior to placing backfill, the excavation bottom should be dried or moisture conditioned to within 2 percent of the optimum moisture content and compacted to at least 95 percent of the ASTM D-1557 laboratory test standard.
- Backfill should be placed, moisture conditioned (i.e., watered and/or aerated as required and thoroughly mixed to a uniform, near optimum moisture content), and compacted by mechanical means in approximate 6-inch lifts. The degree of compaction obtained should be at least 95 percent of the ASTM D-1557 laboratory test standard, as applicable.
- Any large trees should be removed from any fill areas. Any remaining root balls, possibly reaching 3+ feet in depth, should be adequately removed and backfilled with approved structural fill. We recommend an SWT representative observe the removal and provide monitoring and density testing of compacted structural fill/backfill at all removal areas.

It is also critical that any surficial subgrade materials disturbed during initial demolition and clearing work be removed and/or re-compacted during subsequent site preparation earthwork operations.

It is important to note that all soft undocumented fill, if present, is to be over-excavated to a competent subgrade and replaced with suitable structural fill. Supporting the proposed buildings on homogeneous material will significantly decrease the potential for differential settlement across the foundation area. In order to create uniform subgrade support conditions, in the vicinity of undocumented fill areas if encountered, the following earthwork operations are recommended:

- Over-excavate existing soils to a competent native subgrade below the bottom of the proposed foundations. The excavations should extend at least one-half width laterally beyond the foundation footprint, or as constrained by existing structures. In addition, native soil removal shall extend to a minimum depth so that a maximum 2:1 ratio of differential structural fill thickness is maintained below all building spread foundation systems.
- The fill soils placed shall consist of clean soils with an expansion index (EI) less than twenty (20), and be free of organic material, debris, and rocks greater than 3 inches in maximum diameter. Based on the field observations and laboratory testing, the existing native soil consisting of Silt (ML) with sand and the underlying Clay (CH) with sand is suitable for use as structural fill so long as the material is within two percent (2%) of its optimum moisture content prior to compaction.
- The backfill shall consist of minimum ninety-five percent (95%) compacted fills (Note: ASTM D1557). In addition to the relative compaction requirements, all fills shall be compacted to a firm non-yielding condition.
- Import soils should be sampled, tested, and approved by SWT prior to arrival on site. Imported soils shall consist of clean soils (EI of 20 or less) free from vegetation, debris, or rocks larger than three inches in maximum dimension.

Subgrade Verification and Proof Rolling

After clearing and grading the site, it is possible that some localized areas of soft, wet or unstable sub grade may still exist. Before placement of any roadway base rock, the subgrade should be scarified 8 inches in depth and compacted with suitable compaction equipment. Yielding areas that are identified should be excavated to medium dense/stiff material and replaced with compacted two inch-minus clean crushed rock. All building and pavement areas should be compacted to a dense non-yielding condition with suitable compaction equipment. This phase of earthwork compaction shall be performed prior to the placement of any structural fill, at the bottom of all foundation excavations and along the roadway subgrade, before the placement of base rock.

Wet Weather Construction & Moisture Sensitive Soils:

Field observations and laboratory testing indicates that the upper subsurface soil layer at the site consists of native lean Clay (CL) with sand and is a fine-grained moisture sensitive material. As such, in an exposed condition, moisture sensitive soil can become disturbed during normal construction activity, especially when in a wet or saturated condition. Once disturbed, in a wet condition, these soils will be unsuitable for support of foundations, floor slabs and roadways.

Therefore, where soil is exposed and will support new construction, care must be taken not to disturb their condition. Equipment traffic should be minimized across exposed soils to reduce the amount of disturbance and creation of excess soft wet soil. If disturbed soil conditions develop, the affected soil must be removed and replaced with structural fill. The depth of removal will be dependent on the depth of disturbance developed during construction. Covering the excavated area with plastic and refraining from excavation activities during rainfall will minimize the disturbance and decrease the potential degradation of supportive soils.

If construction proceeds during wet weather condition, roadway base sections may require to be increased or stabilized with 2–6-inch gabion/ballast with no fines. Soil cement treatment may also be required to provide a stable roadway or building subgrades. If this is considered, SWT should be contacted to provide the appropriate recommendations based on the soil moisture conditions and collect the necessary samples to perform laboratory testing to determine the optimum soil:cement ratio.

Erosion Control

If construction extends into the winter "rainy" season, earthwork activities are feasible if proper erosion control measures are implemented to minimize degradation to both native and structural fill soils. Due to the relatively flat topography of the site, erosion hazards are likely to be low. All surface stormwater, if encountered, should be captured and directed away from structural areas by means of site-specific erosion control measures including conveyance trenches, straw wattles, sediment fences, temporary sediment ponds etc.

Expansive/Shrink Soil Capacity

Laboratory testing of the native lean Clay (CL) with sand at depths ranging from 1.0/1.5 feet to the maximum explored depth of 8.0 feet bgs, indicates this soil has an Expansion Index (EI) of 13. An EI of 13 suggests a very low to low potential for soil shrinking and swelling. However, the importance for adequate soil conditioning during the placement and compaction of structural fill is essential. Soils with a high plasticity index such as the fat Clay (CH), which was also encountered across the site, should be placed and compacted with a moisture content at ~ 2 percent above its optimum moisture to avoid the potential for shrinking or swelling over time.

It is recommended that earthwork grading of expansive soils be closely monitored by an experienced geotechnical engineer or their representatives. To help avoid soil swelling, regulating soil moisture content and mixing of expansive clays with less plastic soils should be properly conditioned during fill placement and compaction.

Utility Support and Backfill

Based on the conditions encountered, the soil to be exposed by utility trenches should provide adequate support for utilities. Utility trench backfill is a concern in reducing the potential for settlement along utility alignments, particularly in pavement areas. It is also important that each section of utility line be adequately supported in the bedding material. The backfill material should be hand tamped to ensure support is provided around the pipe haunches.

Fill should be carefully placed and hand tamped to about twelve inches above the crown of the pipe before any compaction equipment is used. The remainder of the trench backfill should be placed in lifts having a loose thickness of eight inches. Utility trench backfill should consist of *WSDOT 9-03.19 Bank Run Gravel for Trench Backfill* or *WSDOT 9-03.14(2) Select* Borrow with a maximum particle size of 2-1/2-inches.

A typical trench backfill section and compaction requirements for load supporting and non-load supporting areas is presented on *Figure 4, Utility Trench Backfill Detail*.

Temporary Excavations

The following information is provided solely as a service to our client. Under no circumstances should this information be interpreted to mean that SWT is assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred. In no case should excavation slopes be greater than the limits specified in local, state and federal safety regulations. The contractor should be aware that excavation and shoring should conform to the requirements specified in the applicable local, state, and federal safety regulations, such as OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations. We understand that such regulations are being strictly enforced, and if not followed, the contractor may be liable for substantial penalties.

Based on the information obtained from our field exploration and laboratory testing, the onsite soils expected to be encountered in excavations will most likely consist of native lean Clay and fat Clay. These soils encountered are classified predominately as a type "A" soil. Therefore, temporary excavations and cuts greater than four feet in height, should be sloped at an inclination no steeper than 3/4H:1V (horizontal to vertical).

If slopes of this inclination, or flatter, cannot be constructed, or if excavations greater than four feet in depth are required, temporary shoring may be necessary. This shoring would help protect against slope or excavation collapse and would provide protection to workmen in the excavation. If temporary shoring is required, we will be available to provide shoring design criteria, if requested.

LIMITATIONS

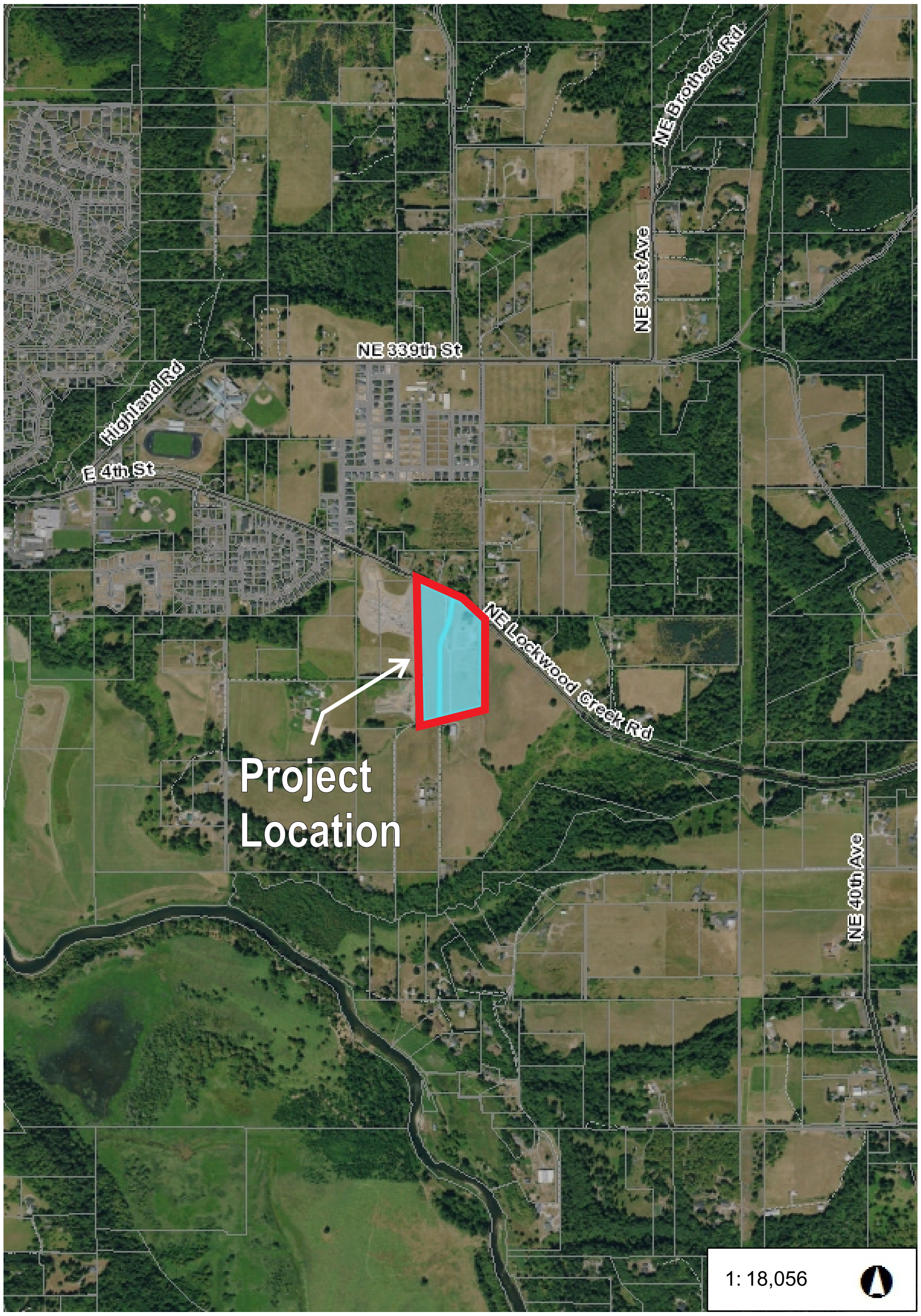
Our recommendations and conclusions are based on the site materials observed, selective laboratory testing, engineering analyses and other design information provided to Soil and Water Technologies as well as our experience and engineering judgment. The conclusions and recommendations are professional opinions derived in a manner consistent with that level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty is expressed or implied.

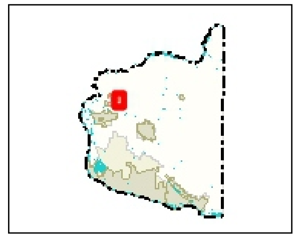
The recommendations submitted in this report are based upon the data obtained from our test pits. Soil and groundwater conditions between the test pits may vary from those encountered. The nature and extent of variations may not become evident until construction. If variations do appear, Soil and Water Technologies should be requested to reevaluate the recommendations contained in this report and to modify or verify them in writing prior to proceeding with the proposed construction.

Temporary construction excavation and site safety are the sole responsibility of the construction contractor who also is solely responsible for the means, methods, and sequencing of construction operations. We are providing the following information only as a service to our client for planning purposes by their design team. Under no circumstances should the information provided herein be interpreted to mean that SWT is assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

VICINITY MAP

NW Lockwood Creek Subdivision





Legend

- Taxlots
- All Roads
  - Interstate
  - State Route
  - Arterial
  - Forest Arterial
  - Minor Collector
  - Forest Collector
  - Private or Other
- Cities Boundaries
- Urban Growth Boundaries

Notes:

Parcel No.'s 209121000 & 209064000

3,009.3 0 1,504.67 3,009.3 Feet

WGS_1984_Web_Mercator_Auxiliary_Sphere
Clark County, WA. GIS - http://gis.clark.wa.gov

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Vancouver, WA 98660
PH: (360) 200-8693
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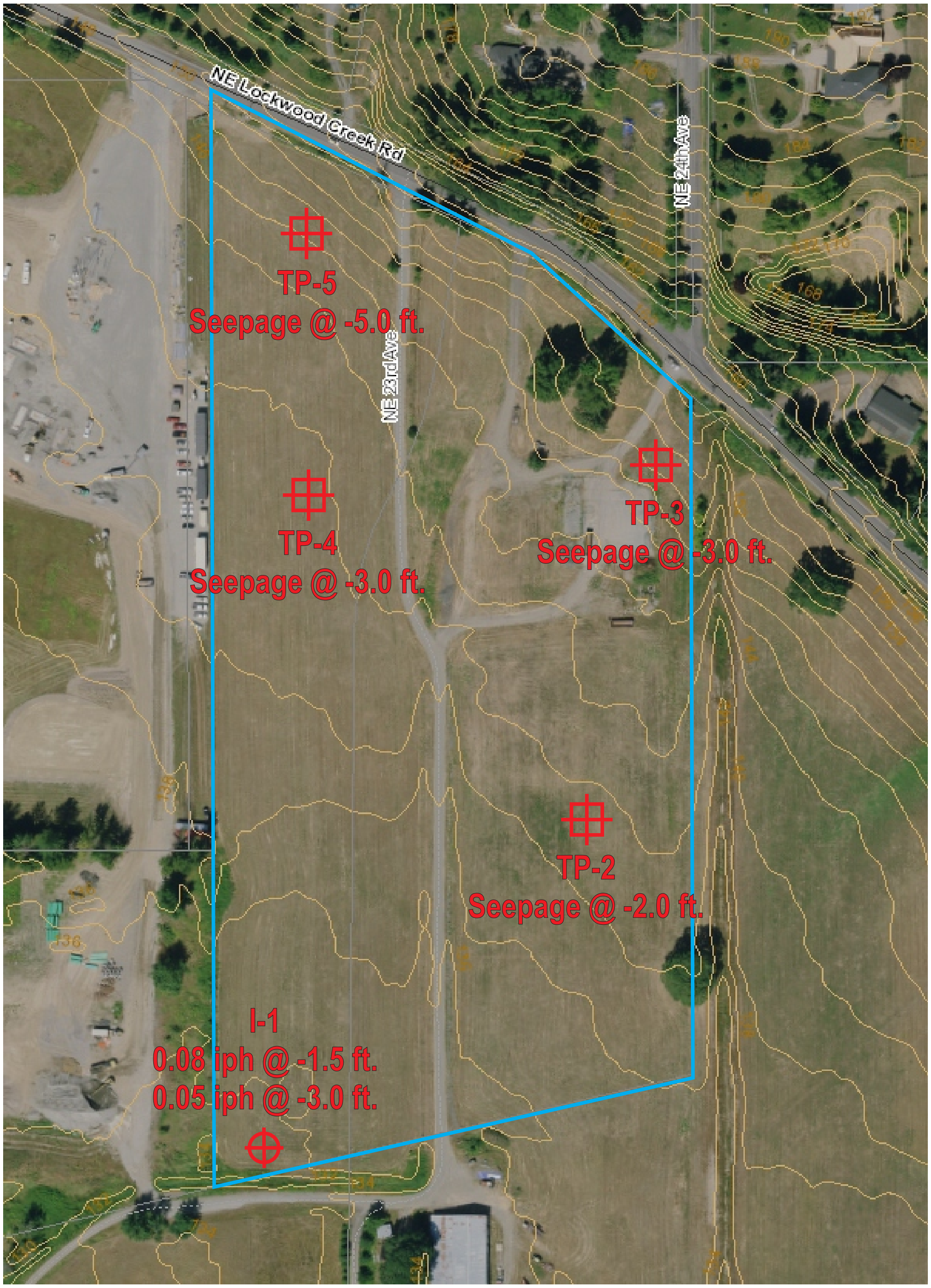
CLIENT:	Gravitate Capital, LLC	*DRAWN:*	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	*DATE:*	4/5/2022
		FIGURE:	1
		PRO. #:	G0372200

SITE MAP

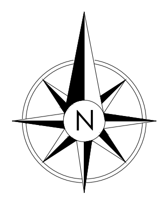


Legend

I-1 Approximate Infiltration Test Pit Location

TP-2 Approximate Test Pit Location

iph - Inches Per Hour



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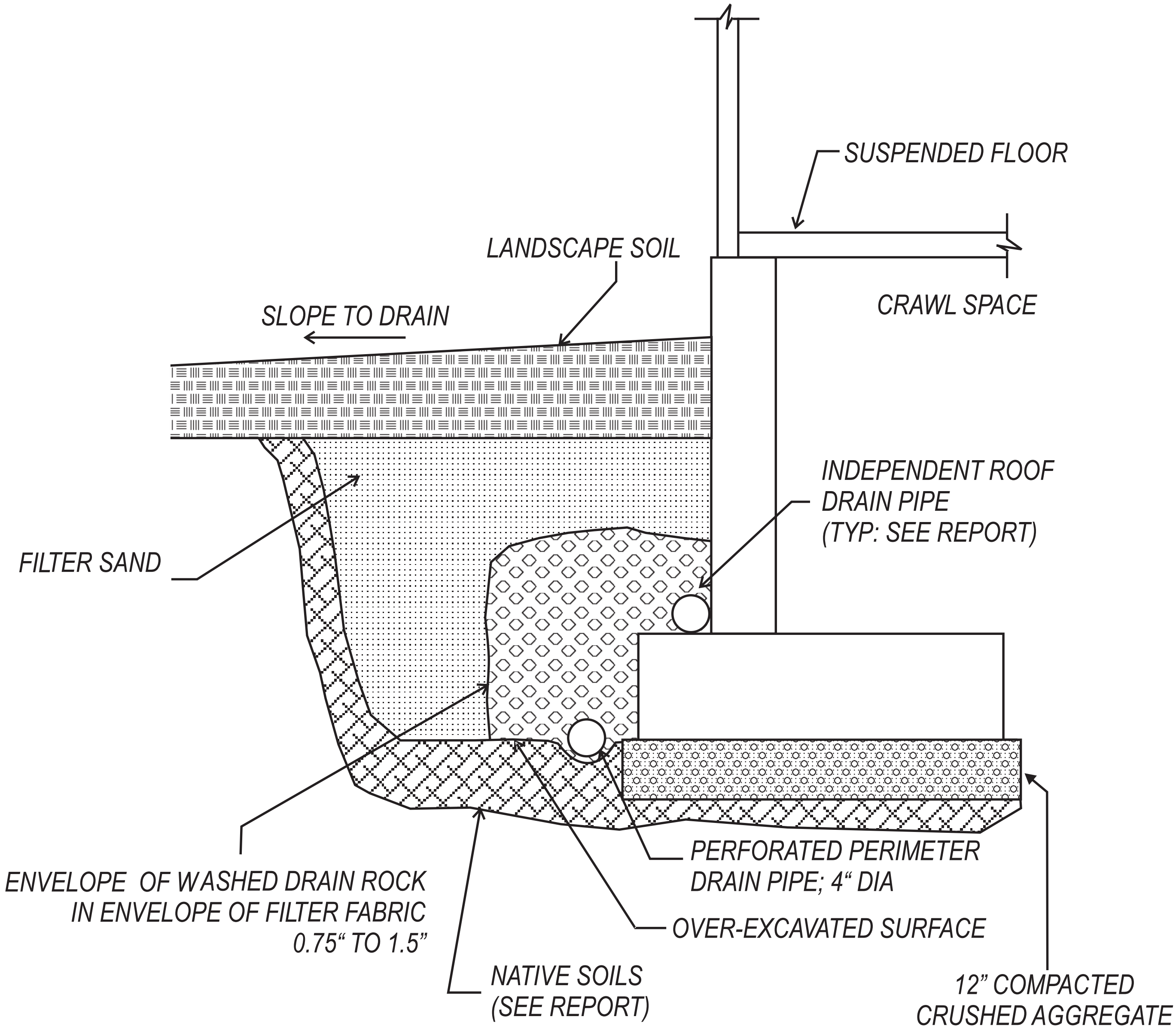
CLIENT:	Gravitate Capital, LLC	*DRAWN:*	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	*DATE:*	3/8/2022
		FIGURE:	2
		PRO. #:	G0262200



NOTES:

1. FILTER SAND - FINE AGGREGATE FOR PORTLAND CEMENT; SECTION 9=03.1(2)
2. PERFORATED OR SLOTTED RIGID PVC PIPE WITH A POSITIVE DRAINAGE GRADIENT
3. FOOTINGS INSTALLED ABOVE 12" COMPACTED CRUSHED AGGREGATE; 95% OF MODIFIED PROCTOR (ASTM D1557)

TYPICAL SUSPENDED FOOTING DETAIL

Not to Scale

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CLIENT:	Gravitate Capital, LLC	DRAWN:	RN
PROJECT:	Lockwood Creek Subdivision	DATE:	4/10/2022
	2313 NE Lockwood Creek Road	FIGURE:	3
	La Center,WA 98629	PRO. #:	G0372200

APPENDIX A

(FIELD EXPLORATION)

FIELD EXPLORATION

Our field exploration was performed on March 25th and April 4th, 2022. Subsurface conditions at the site were explored by excavating a total of 1 infiltration test pit (I-1) and 4 test pits TP-2 – TP-5 with an excavator and hand auger to the maximum explored depth of 7.0 feet below the existing ground surface.

The approximate test pit locations were determined by the Soil and Water Technologies, Inc. by pacing from existing site features. These approximate locations are shown on the *Site Plan, Figure 2.*

The field exploration was monitored by Soil and Water Technologies, who classified the soil encountered and maintained a log of each test pit, obtained representative samples, and observed pertinent site features. Representative soil samples were placed in sealed plastic bags and returned to the laboratory for further examination and testing.

All samples were visually classified in accordance with the Unified Soil Classification System (USCS), which is presented on *Plate A1*. Logs of the test pits are presented in *Appendix A*. The final logs represent our interpretations of the field logs and the results of the laboratory tests on field samples. The stratification lines on the logs represent the approximate boundaries between soil types. In fact, the transitions may be more gradual.

UNIFIED SOIL CLASSIFICATION SYSTEM LEGEND

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTION
Coarse Grained Soils More Than 50% Material Larger Than No 200 Sieve Size	Gravel and Gravelly Soils More Than 50% Coarse Fraction Retained on No 4 Sieve	Clean Gravels (little or no fines)		GW gw	Well-Graded Gravels, Gravel-Sand Mixtures Little or no Fines
				GP gp	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
		Gravels with Fines (appreciable amount of fines)		GM gm	Silty Gravels, Gravel-Sand-Silt Mixtures
				GC gc	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sand and Sandy Soils More Than 50% Coarse Fraction Passing No 4 Sieve	Clean Sand (little or no fines)		SW sw	Well-graded Sands, Gravelly Sands Little or no Fines
				SP sp	Poorly-Graded Sands, Gravelly Sands Little or no Fines
		Sands with Fines (appreciable amount of fines)		SM sm	Silty Sands, Sand-Silt Mixtures
				SC sc	Clayey Sands, Sand-Clay Mixtures
Fine Grained Soils More Than 50% Material Smaller Than No 200 Sieve Size	Silts and Clays	Liquid Limit Less than 50		ML ml	Inorganic Silts and Very Fine Sands, Rock Flour, Silty-Clayey Fine Sands; Clayey Silts w/ slight Plasticity
				CL cl	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean
				OL ol	Organic Silts and Organic Silty Clays of Low Plasticity
	Silts and Clays	Liquid Limit Greater than 50		MH mh	Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils
				CH ch	Inorganic Clays of High Plasticity, Fat Clays
				OH oh	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils				PT pt	Peat, Humus, Swamp Soils with High Organic Contents

Topsoil		Humus and Duff Layer
Fill		Highly Variable Constituents

SAMPLING DESCRIPTIONS

- Grab Sample
- SPT Drive Sampler (ASTM D1586)
- Shelby Tube Push Sampler (ASTM D1587)
- Dames and Moore Drive Sampler (ASTM D3550)

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CLIENT:	Gravitate Capital, LLC	DRAWN:	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	DATE:	4/10/2022
		PLATE:	A1
		PRO. #:	G0372200

LOG OF TEST PIT **I-1**

ELEVATION: **133 +/- feet**
EXPLORATORY EQUIPMENT: **Track-Hoe**
DATE: **3/25/2022**

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200	NOTES
0–1		brown, soft, moist sandy **lean Clay (CL)**				4” organic topsoil
2	●	brown/gray, stiff to very stiff sandy **Fat Clay (CH)** moist		32.7	88.1	Infiltration Testing - 0.08 iph @ 2.0 ft. bgs
3.5	●			34.2	87.1	Infiltration Testing - 0.05 iph @ 3.5 ft. bgs
4–8		brown, stiff sandy **Lean Clay (CL)** moist		32.6	84.3	{AASHTO A-7-6(34) {mottling}

Bottom of test pit at 8.0 feet below existing ground surface (bgs).
No groundwater encountered.

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CLIENT:	Gravitate Capital, LLC	DRAWN:	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	DATE:	4/6/2022
		PLATE:	A2
		PRO. #:	G0372200

LOG OF TEST PIT **TP-2**

ELEVATION: **140 +/- feet**
EXPLORATORY EQUIPMENT: **Track-Hoe**
DATE: **3/25/2022**

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200	NOTES
0.5	●			27.9	83.6	6" organic topsoil {till zone - soft from -0.5' to -1.0'}
1						
2	●	▼ gray/brown, soft to stiff sandy **Lean Clay (CL)** moist		30.8	86.7	{perched seepage @ 2.0 ft. bgs}
3						{EI - 13}
4						{1.5 tsf on penetrometer}
5						

Bottom of test pit at 5.0 feet below existing ground surface (bgs).
Perched seepage encountered .

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CLIENT:	Gravitate Capital, LLC	*DRAWN:*	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	*DATE:*	4/8/2022
		PLATE:	A3
		PRO. #:	G0372200

LOG OF TEST PIT **TP-3**

ELEVATION: **150 +/- feet**
EXPLORATORY EQUIPMENT: **Track-Hoe**
DATE: **3/25/2022**

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200	NOTES
1	•	soft, silty **Gravels** fill		-	-	
2	•	gray, medium stiff, moist sandy **Fat Clay (CH)** native		25.7	79.6	
3 4	•	gray/brown, stiff sandy **Lean Clay (CL)** moist		35.8	75.5	{mottling}

Bottom of test pit at 4.5 feet below existing ground surface (bgs).
No groundwater encountered.

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CLIENT:	Gravitate Capital, LLC	DRAWN:	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	DATE:	4/8/2022
		PLATE:	A4
		PRO. #:	G0372200

LOG OF TEST PIT **TP-4**

ELEVATION: **142 +/- feet**
EXPLORATORY EQUIPMENT: **Track-Hoe**
DATE: **4/4/2022**

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200	NOTES
0–4	● (at ~2.5 ft)	gray/ brown, medium stiff to stiff sandy **Lean Clay (CL)** moist; ▼ (at 3 ft); native		- / 36.4	- / 58.3	{till zone - med. stiff from -0.5' to -1.5'} {Dry PCF - 81.0} {perched seepage @ 3.0 ft. bgs}

Bottom of test pit at 4.0 feet below existing ground surface (bgs).
No groundwater encountered.

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CLIENT:	Gravitate Capital, LLC	DRAWN:	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	DATE:	4/8/2022
		PLATE:	A5
		PRO. #:	G0372200

LOG OF TEST PIT **TP-5**

ELEVATION: ***146 +/- feet***
EXPLORATORY EQUIPMENT: ***Track-Hoe***
DATE: ***4/4/2022***

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200	NOTES
1						4" organic topsoil {till zone - soft from -0.5' to -1.5'}
2–3	●	gray/brown, soft to stiff sandy **Lean Clay (CL)** moist		34.5	34.5	
4–5	▼					{perched seepage @ 5.0 ft. bgs}
6–7		native				

Bottom of test pit at 7.0 feet below existing ground surface (bgs).
No groundwater encountered.

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CLIENT:	Gravitate Capital, LLC	DRAWN:	RN
PROJECT:	Lockwood Creek Subdivision 2313 NE Lockwood Creek Road La Center,WA 98629	DATE:	4/8/2022
		PLATE:	A6
		PRO. #:	G0372200

APPENDIX B

(LABORATORY TESTING)

LABORATORY TESTING

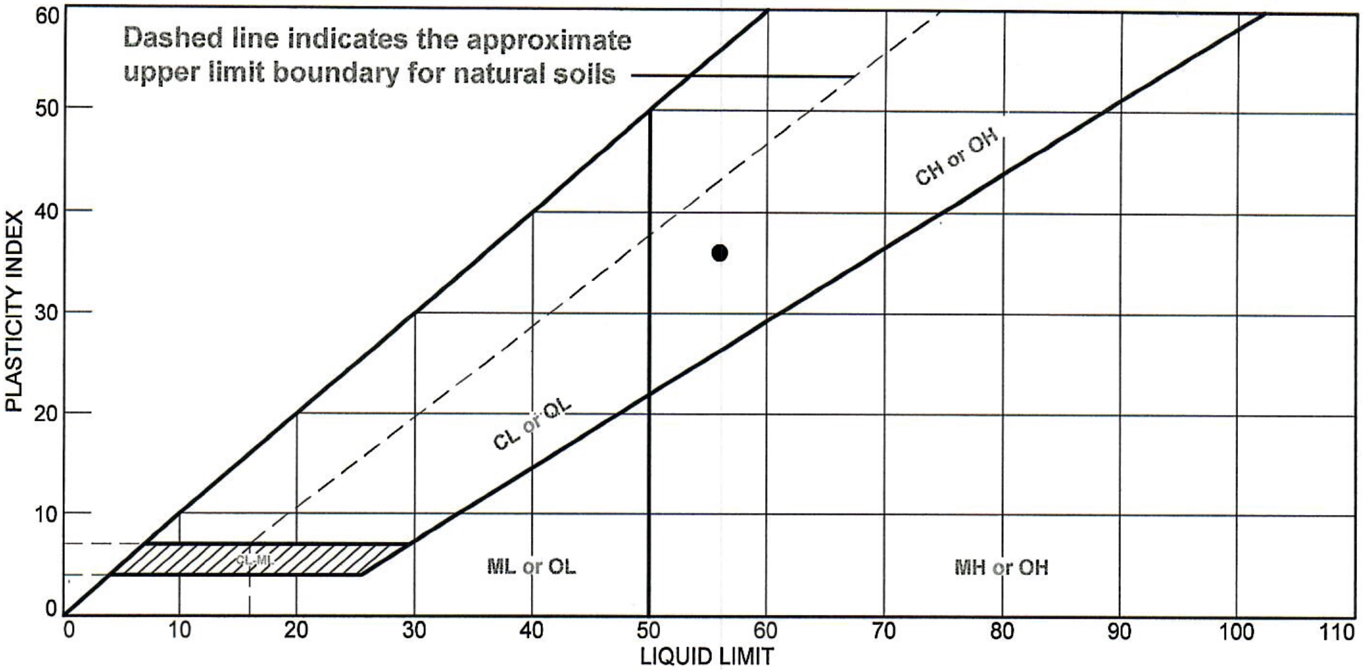
Laboratory tests were conducted on representative soil samples to verify or modify field soil classifications, and to evaluate the general physical properties and engineering characteristics of the soils encountered.

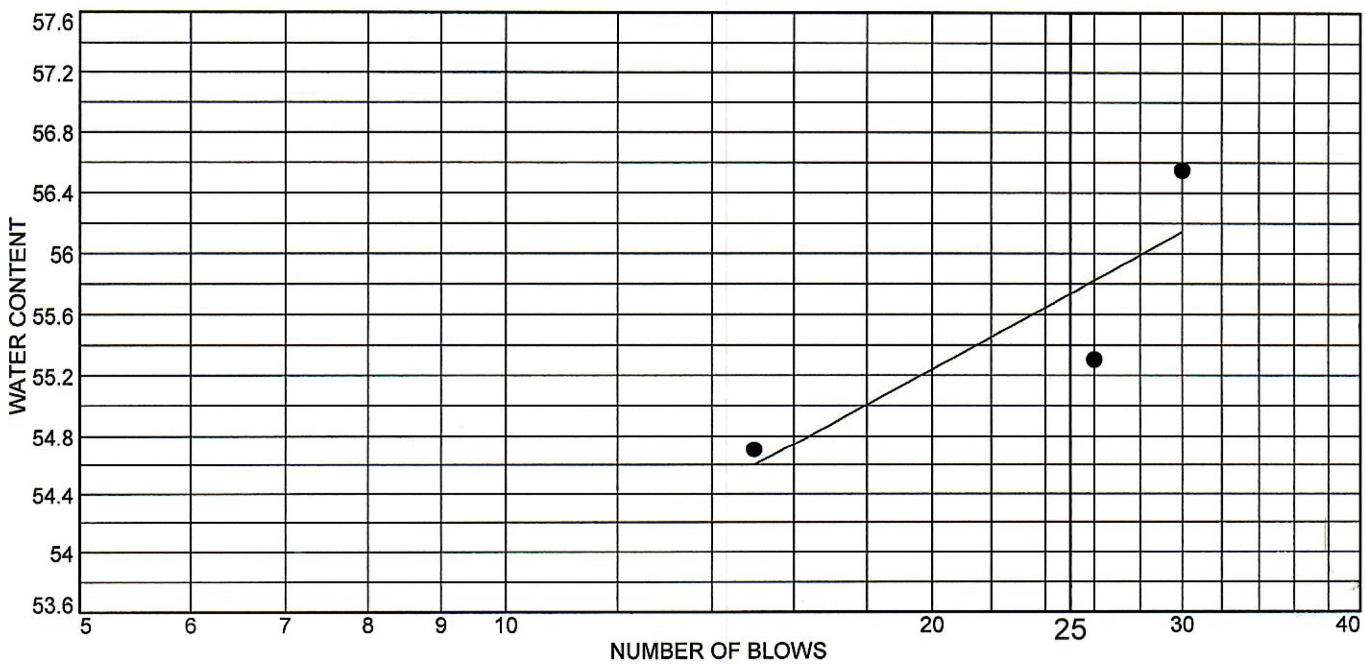
The following provides information about the testing procedures performed on representative soil samples:

- Moisture Content Tests (ASTM D2216) were performed on representative samples encountered in each test pit at each soil horizon.
- Sieve Analysis - No. 200 wash (ASTM C117) was performed on representative samples encountered in test pits I-1 and TP-2 - TP-5.
- Atterberg Limits (ASTM D4318) was performed on a representative soil sample encountered in test pits TP-4.
- Expansion Index (ASTM D4829) was performed on a representative soil sample encountered at I-1
- Moisture Content & Dry Density (ASTM D2216/D2937 was performed at TP-4.

The results of laboratory tests performed on specific samples are provided at the appropriate sample depth on the individual test pit logs. However, it is important to note that some variation of subsurface conditions may exist. Our geotechnical recommendations are based on our interpretation of these test results.

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	fat Clay	56	20	36	100	88.12	SC

Project No. G0372200 **Client:** Gravitate Capital, LLC

Project: Lockwod Creek Subdivision

Source of Sample: Native **Depth:** TP-1 @ 3.5

Sample Number: 370

Remarks:

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Figure LPL-1

Tested By: JPT

swt
Soil and Water Technologies, Inc.
Geotechnical, Construction Monitoring, Materials Testing & Erosion Consulting Services

Gravitate Capital, LLC
13563 NW Fuller Ln
Portland, OR 97229

April 20th, 2022
G0372200

Project: **Lockwood Creek Subdivision**
Report: **Expansion Index of Soil**
Figure 1; EI-1

Sample Identification

Testing was performed in accordance with the standards indicated. Our laboratory test results are summarized in the following table.

Laboratory Testing

Expansion Index of Soils (ASTM D4829)	
Test	**TP-2 @ 2.0 in. Test Results**
Initial Moisture Content, (%)	12.0
Initial Dry Unit Weight, (pcf)	102.3
Initial Height of Specimen, (inches)	1.00
Initial Dial Gauge Reading (inches)	0.0158
Final Dial Gauge Reading (inches)	0.0160
Initial Degree of Saturation, (%)	50.1
Final Moisture Content, (%)	31.7
Expansion Index, *EI*	13, Very Low