GeoPacific Engineering, Inc.

Real-World Geotechnical Solutions
Investigation • Design • Construction Support

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Project No. 05-9549

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SUBJECT: PRELIMINARY GEOTECHNICAL AND POTENTIAL LANDSLIDE HAZARD STUDY RIDGECAP ESTATES SUBDIVISION PORTLAND, OREGON

This report presents the results of a preliminary geotechnical engineering and potential landslide hazard study conducted by GeoPacific Engineering, Inc. (GeoPacific) for the above referenced project. The purpose of our investigation was to evaluate subsurface conditions at the site and provide general geotechnical recommendations for site development and construction. The site is designated as lying within the City of Portland "Potential Landslide Hazard Area". Our work was performed in accordance with GeoPacific Engineering, Inc.'s (GeoPacific) proposal letter No. P2685 dated December 1, 2005. This preliminary report can be finalized once a grading plan is available for review.

PROJECT INFORMATION

Location:	The subject site is located at 429 NW Skyline Boulevard in Multnomah County, Oregon (see Figure 1).
Owner:	Prent Hicks
Civil Engineer:	Land Tech, Inc., 8835 SW Canyon Lane, Suite 402, Portland, OR
Jurisdictional Agency:	City of Portland, Oregon

SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The subject site is approximately 6.3 acres and located at 429 NW Skyline Boulevard in Multnomah County, Oregon (see Figure 1). The site is situated on the flank of a broad ridgetop at an elevation ranging between about 1,096 and 1,224 feet above mean sea level. Slopes on the site generally range between 15% to 30% grade with localized steeper slopes inclining up to 55% grades on the southwestern margin. The eastern margin of the property borders a steep roadcut along NW Skyline Boulevard, where grades incline up to 100%. The site is bordered on the east by NW Skyline Boulevard with residential development to the north and west. A communication tower facility is located due south of the site. Two homes, a detatched apartment, and an outbuilding currently exist on the property. Site vegetation consists generally of grasses and sparse trees. Dense undergrowth is present on the slopes of the northern and eastern boundaries.

The proposed subdivision includes 15 lots for single family homes, construction of approximately 1,150 lineal feet of new streets, and associated utilities. Although a grading plan has not been finalized, the project will likely incorporated retaining walls. Specific plans for homes are not yet finalized; however we anticipate that they will be daylight basement homes with wood framed garages and tall crawlspaces due to the sloping topography of the proposed building pads. It is our understanding that the existing structures will be removed.

SITE GEOLOGY

The subject site lies within the Willamette Valley/Puget Sound physiographic province, a broad structural depression situated between the Coast Range on the west and the Cascade Range on the east. A series of discontinuous faults subdivide the Willamette Valley into a mosaic of fault-bounded, structural blocks (Yeats et al., 1996). The subject site is situated on an uplifted structural block that forms the Portland Hills Anticline.

The site is situated on Pliocene to Pleistocene age (5.3 million to 8,000 years ago) volcanic vent underlain by the Boring Lava geologic unit (Beeson et al., 1991). The Boring Lava is a series of basalt and basaltic andesite lava flows that also include cinder cones at eruptive centers. The lava flows typically exhibit blocky, columnar fractures and include vesicular flow tops. Where highly weathered, the upper portions of the Boring Lava are decomposed to a distinctive red-brown clayey silt known as laterite or residual soil.

Overlying the Boring Lava is Quaternary age (last 1.6 million years) loess, a windblown silt deposit that blankets older rocks throughout the Portland Hills (Madin, 1990). In the Portland Hills, the loess deposit generally ranges between 5 feet and greater than 100 feet thick. The loess consists of massive silt with localized buried paleosols indicating numerous depositional episodes associated with catastrophic flooding events in the Willamette Valley, the last of which occurred about 10,000 years ago.

SUBSURFACE CONDITIONS

On December 12, 2006, GeoPacific explored subsurface conditions on the site by excavating seven exploratory test pits at the locations shown on Figure 2. The test pits were located in the field by taping distances from apparent property corners and other site features. As such, the locations should be considered approximate. A GeoPacific geologist continuously monitored the field exploration program and logged the test pits. Soils were classified in general accordance with the Unified Soil Classification System (USCS). During exploration, our geologist also noted geotechnical conditions such as soil consistency, moisture, and groundwater conditions. Logs of the test pits are attached to this report. The observed conditions and soil properties are summarized below.

Fill – Moderately organic undocumented fill was encountered in test pit TP-5. The fill was limited to the upper 3 feet and generally consisted of dark brown SILT (ML) with glass and dish fragments. Although not encountered during our exploration, we believe other areas of fill may exist on the site, especially in the vicinity of the existing structures and driveways.

Topsoil – The ground surface is underlain by topsoil in all test pits except TP-5. Generally, the topsoil consists of dark brown, moderately to highly organic SILT (OL-ML) that extends 9 to 30 inches below the ground surface.

Loess– Loess was encountered beneath the topsoil (and fill in test pit TP-5) and typically consisted of micaceous, light brown clayey SILT (ML) with weak orange and gray mottling. The loess is medium stiff to very stiff. Field pocket penetrometer measurements indicate an approximate unconfined compressive strength of 1.0 to 4.5 tons/ft^2. The silt extends from 4.5 to 11 feet below the ground surface and to the maximum depth of exploration in test pits TP-4 and TP-7 (12.5 and 10.5 feet below the ground surface, respectively).

Residual Soil of Boring Lava– Residual soil is the result of in-situ weathering of a former rock mass. This change from rock to soil occurs very slowly and without lateral movement. At this site, the contact between the residual soil and the overlying loess is gradational over a few inches. The residual soil encountered during our investigation generally consisted of reddish-brown clayey SILT (ML) to silty CLAY (CL) with trace weathered basalt fragments and scoria. Residual soil was encountered as shallow as 4.5 feet below the ground surface (in test pit TP-3) and extends to the maximum depth of exploration in all test pits except TP-4 and TP-7.

Boring Lava– An outcrop of gray basalt is present at the surface in the northern portion of lot 12 and was encountered at a depth of 11 feet in test pit TP-3. The vesicular basalt belongs to the Pliocene to Pleistocene age (about 5.3 million to 8,000 years ago) Boring Lava and is likely present at varying depths throughout the site. On the southwestern portion of the site, the estimated rock hardness classification of the basalt is medium-hard (R3) to hard (R4). Practical refusal on medium-hard (R3) to hard (R4) basalt was encountered with an 8-ton trackhoe at a depth of 11 feet in test pit TP-3.

Soil Moisture and Groundwater

On December 12, 2005, the soil moisture conditions observed in test pits ranged from damp to moist. No groundwater was encountered in test pits. Common soil mottling indicates that seasonal perching and vertical migration of infiltrating surface water typically occurs at the site. It is anticipated that groundwater conditions will vary depending on the season, local subsurface conditions, changes in site utilization, and other factors.

SLOPE STABILITY

For the purpose of evaluating slope stability, we: (1) reviewed regional 1:24,000 scale topography by the U.S. Geological Survey and published geologic mapping, (2) reviewed 1:60 scale topographic survey mapping of the site by Land Tech, Inc., (3) performed a geological reconnaissance of the site, and (4) evaluated subsurface soil conditions in exploratory test pits. Published geologic mapping shows no mapped landslides on or adjacent to the site (Madin, 1990; Beeson et al., 1991). Regional relative earthquake hazard mapping by the Oregon Department of Geology and Mineral Industries identifies the site vicinity as having a low susceptibility to liquefaction hazard with low ground motion amplification (Mabey et al., 1993). The majority of the site is mapped as having slopes exceeding 15% with the eastern portion of the site (Lots 5 through 10) having a moderate relative earthquake hazard (Mabey et al., 1993).

Slopes in the vicinity of the proposed homes range from approximately 13% (Lot 4) to about 45% grade (Lot 6). Grades tend to steepen towards the back of the lots and a cutslope of 1H:1V is present in the road right-of-way along NW Skyline Boulevard (Figure 2). Slope geomorphology at the site is generally smooth and uniform - consistent with relative stability. Subsurface explorations indicate the site is underlain by stiff to very-stiff, clayey SILT (ML) to silty CLAY (CL) residual soil, and hard basalt bedrock. These materials are generally characterized by moderate to high shear strength and a relatively high resistance to slope instability. However, areas of potential instability are present on and adjacent to the site. Potential instability areas are discussed below.

A scarp-like feature from an ancient landslide is present in the northeast portion of the property (Lots 5 and 6). The approximate dimensions of the slide are 150 feet wide by 250 feet long. Slide debris was not encountered in our subsurface investigations. Exploration at the head of the scarp (test pit TP-5) and adjacent to the scarp (test pit TP-6) indicate at least 5 feet of loess was removed from the slope as a result of the landslide. It is our opinion the majority of the slide mass was removed from the site as a result of the landslide.

Slopes on the southwestern portion of the site (Lots 14, 15, and Tract "B") are steep and exhibit bowl-shaped topography. A flat area containing trees with irregularly bent trunks is present approximately 50 feet southeast of the southwestern property corner (Figure 2). Subsurface explorations in the southwestern portion of the property indicate bedrock is present at a depth of 11 feet (test pit TP-3).

Lots on the eastern portion of the property are moderately sloping (approximately 21% grade) and steepen to approximately 85% towards NW Skyline Boulevard. Cutslopes along the NW Skyline Boulevard road right-of-way are as steep as 1H:1V.

Slope instability in the Portland Hills most often occurs in developed areas during periods of heavy precipitation. Storm water runoff should be collected, controlled, and discharged to a storm utility pipe or other suitable outlet – infiltration of stormwater should be avoided due to the potential for slope instability.

CONCLUSIONS AND RECOMMENDATIONS

Results of this study indicate that the proposed residential development on the majority of the site is geotechnically feasible provided that the recommendations in this and future geotechnical reports are incorporated into the design and construction phases of the project. The proposed development should not adversely affect, nor be adversely affected by adjoining properties, provided the project plans and our recommendations for site grading are followed and adequate construction monitoring is implemented during earthwork operations. This conclusion assumes that cuts and fills will mostly be kept less than 10 feet vertical. Deeper cuts and fills should be specifically reviewed. Infiltration of storm water should be avoided due to the potential for slope instability. In our opinion, the greatest geotechnical constraint for project development is the presence of steep slopes. The steeper sloping portions of the site may be susceptible to deep-seated slope instability such that mitigating measures may be necessary to provide adequate stability for structures in certain areas, as discussed in other sections of this report.

With the current lot configuration, we anticipate that seven of the fifteen lots are suitable for conventional shallow foundations. The remaining lots may require deep foundations such as drilled piers or driven pilings. Lot specific geotechnical investigations and/or reviews will be necessary to determine appropriate foundation types for specific house plans. At present, a detailed grading plan has not been finalized. Also, it is unknown if retaining walls will be planned and, if so, the retaining wall types and heights. We recommend further geotechnical review once specific building plans and grading plans are known for each lot. GeoPacific can provide additional input regarding retaining wall design at that time.

Preliminary recommendations are presented below for various aspects of project construction including: slope stability, site preparation, permanent cut and fill slopes, keyways and benching for embankment fills, engineered fill, erosion control considerations, excavating conditions and utility trenches, utilities, pavement construction, retaining walls, anticipated foundations and seismic design.

Slope Stability

Our preliminary investigation indicates that slopes on the majority of the subject site are generally underlain by stiff to very stiff soil and basalt bedrock characterized by a moderate to high resistance to slope instability. However, due to the presence of localized areas that are potentially susceptible to deep seated slope instability, the following lots are likely to require in-depth geotechnical investigation and/or geotechnical review. Our recommendations for these lots can be finalized once a grading plan is available for review.

Ancient Landslide (Lots 5 through 8): Due to the presence of an old landslide feature in the northeastern portion of the site (Lots 5 and 6) and similar slope morphology along the eastern property margin (Lots 7 and 8), we recommend lot specific geotechnical investigations and/or review to determine appropriate foundation types for specific house plans.

Southeastern Slopes (Lots 9 and 10): A geotechnical review should be performed for Lots 9 and 10 due to the presence of steep slopes towards the back of the lots and very steep slopes along NW Skyline Boulevard.

Southwestern Slopes (Lots 13 through 15): We recommend a geotechnical review of the final grading plan and proposed house plans for Lots 13 through 15 prior to home construction due to the presence of steep slopes and irregular slope morphology in the southwestern portion of the site. Deep foundations may be required for the above mentioned lots to minimize slope instability hazards.

General: Homes on hillside lots require additional maintenance measures because they are subject to natural slope processes such as runoff, erosion, shallow soil sloughing, soil creep, perched groundwater, etc. An abbreviated checklist of common Do's and Don'ts recommended for maintaining hillside homesites is attached. This checklist should be provided to the builder and homeowner, who are responsible to maintain the property adequately. The primary measures include maintaining vegetation on the slope face and protecting the slope from surface water runoff, to reduce the potential for minor sloughing and erosion. Surface water should be controlled and under no circumstance should water be allowed to flow uncontrolled over the slope face.

Site Clearing and Preparation

Areas of proposed buildings, streets, and areas to receive fill should be cleared of vegetation and any organic and inorganic debris. Existing buried structures such as septic tanks, should be demolished and any cavities structurally backfilled. Inorganic debris should be removed from the site. Organic materials from clearing should either be removed from the site or placed as landscape fill in areas not planned for structures.

Organic-rich topsoil should then be stripped from construction areas of the site or where engineered fill is to be placed. The estimated average necessary depth of removal in undisturbed areas for moderately organic soils is about 12 to 18 inches. Localized deeper stripping, or tilling and root-picking may be necessary to remove thick topsoil and abundant roots around trees. The final depth of soil removal will be determined on the basis of a site inspection after the stripping/ excavation has been performed. Stripped topsoil should be stockpiled only in designated areas and stripping operations should be observed and documented by the geotechnical engineer or his representative.

Any remaining undocumented fills and subsurface structures (tile drains, basements, driveway and landscaping fill, old utility lines, septic leach fields, etc.) should be removed and the excavations backfilled with engineered fill. Fill was encountered at the surface near the old evacuation scarp (test pit TP-5) and we anticipate that areas of undocumented fill likely exist in the vicinity of the existing structures.

Once stripping of a particular area is approved, the area must be ripped or tilled to a depth of 12 inches, moisture conditioned, root-picked, and compacted in-place prior to the placement of engineered fill or crushed aggregate base for pavement. Exposed subgrade soils should be evaluated by the geotechnical engineer. For large areas, this evaluation is normally performed by proof-rolling the exposed subgrade with a fully loaded scraper or dump truck. For smaller areas where access is restricted, the subgrade should be evaluated by probing the soil with a steel probe. Soft/loose soils identified during subgrade preparation should be compacted to a firm and unyielding condition, over-excavated and replaced with engineered fill (as described below), or stabilized with rock prior to placement of engineered fill. The depth of overexcavation, if required, should be evaluated by the geotechnical engineer at the time of construction.

Engineered Fill

Grading for the proposed development should be performed as engineered grading in accordance with Appendix Chapter J of the International Building Code (IBC) and the recommendations of this and future geotechnical reports. Imported fill material must be approved by the geotechnical engineer prior to its arrival on site. Oversize material greater than 6 inches in size should not be used within 3 feet of foundation footings, and material greater than 12 inches in diameter should not be used in engineered fill.

Engineered fill should be compacted in horizontal lifts not exceeding 8 inches using standard compaction equipment. We recommend that engineered fill be compacted to at least 90% of the maximum dry density determined by Modified Proctor AASHTO T-180 or equivalent. Field density testing should conform to ASTM D2922 and D3017, or D1556.

Proper test frequency and earthwork documentation usually requires daily observation and testing during stripping, rough grading, and placement of engineered fill. Engineered fill should be periodically observed and tested by GeoPacific. Typically, one density test is performed for at least every 2 vertical feet of fill placed or every 500 yd^3, whichever requires more testing. Because the standard of practice is to perform testing on an on-call basis, we recommend that the earthwork contractor be held contractually responsible for test scheduling and frequency.

Earthwork is usually performed in the summer months, generally mid-June to mid-October, when warm dry weather is available for proper moisture conditioning of soils. Earthwork performed during the wet-weather season will probably require expensive measures such as cement treatment or imported granular material to compact fill to the recommended engineering specifications. If wet weather earthwork is planned, GeoPacific should be contacted for additional recommendations.

Permanent Cut and Fill Slopes, Embankment Fill Keyways and Benching

Engineered fill on sloping areas inclining steeper than 20% grade should be constructed on a keyway and benches in accordance with the typical detail shown in Figure 3. Keyways should have a minimum depth of 2 feet and minimum width of 10 feet. Additional removals of potentially unstable soils may be required depending on conditions observed during construction. Both benches and keyways should be roughly horizontal in the down slope direction, but may slope up to 20% grade along topographic contour. Keyways sloping more than 20% grade along topographic contour should be benched.

The keyway should include a subdrain consisting of a minimum 3-inch-diameter, ADS Heavy Duty grade (or equivalent), perforated plastic pipe enveloped in a minimum of 3 cubic feet per lineal foot of 2"- ½", open-graded gravel drain rock wrapped with geotextile filter fabric (Mirafi 140N or equivalent). GeoPacific should inspect keyways, subdrains and benching prior to fill placement. Areas of potential seepage observed during construction may require a rock blanket drain in the keyway bottom.

We recommend that permanent cut slopes be constructed no steeper than 2H:1V (Horizontal:Vertical). Permanent fill slopes along roadways may be constructed as steep as 1.5H:1V, provided they are constructed of compacted granular fill material such as 1½"-0 crushed rock and/or 4-inch minus quarry rock. Fill slopes should be overbuilt a minimum of 3 feet horizontally beyond finish grade and then trimmed back to finish grade as shown in Figure 5 in order to achieve a well compacted slope face.

Erosion Control Considerations

Due to the presence of moderately steep to steep slope gradients, we consider the potential for adverse erosion during construction to be moderate to high. Erosion at the site during construction can be minimized by implementing the project erosion control plan specified by the civil engineer, which typically includes the use of straw bales, bio-bags, and silt fences. If used, these erosion control devices should be in place and remain in place throughout site preparation and construction.

Areas of exposed soil requiring immediate and/or temporary protection against exposure should be covered with either mulch or erosion control netting/blankets. Areas of exposed soil requiring permanent stabilization should be seeded with an approved grass seed mixture, or hydroseeded with an approved seed-mulch-fertilizer mixture. Cut and fill slopes should be seeded or planted as soon as possible after construction, so that vegetation has time to become established before the onset of the next wet-weather season.

Excavating Conditions and Temporary Excavations

Based on subsurface test pit explorations, we anticipate that the planned excavation depths will most likely be achievable with conventional heavy equipment. Difficult excavating conditions in basalt bedrock may be encountered in localized areas where deep trenches are planned. All temporary cuts in excess of 4 feet in height should be sloped in accordance with U.S. Occupational Safety and Heath Administration (OSHA) regulations (29 CFR Part 1926), or be shored. At the time of our exploration, native soils at the site were generally classified as Type

B Soil. Temporary excavation side slope inclinations as steep as 1H:1V may be assumed for planning purposes. This cut slope inclination is applicable to excavations above the water table only. Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. Actual slope inclinations at the time of construction should be determined by the contractor based on safety requirements and actual soil and groundwater conditions.

Vibrations created by traffic and construction equipment may cause some caving and raveling of excavation walls. In such an event, lateral support for the excavation walls should be provided by the contractor to prevent loss of ground support and possible distress to existing or previously constructed structural improvements.

Utilities

PVC pipe should be installed in accordance with the procedures specified in ASTM D2321. We recommend that structural trench backfill be compacted to at least 90% of the maximum dry density determined by Modified Proctor AASHTO T-180 or equivalent. Initial backfill lift thickness for a ¾"-0 crushed aggregate base may need to be as great as 4 feet to reduce the risk of flattening underlying flexible pipe. Subsequent lift thickness should not exceed 1 foot. If imported granular fill material is used, then the lifts for large vibrating plate-compaction equipment (e.g. hoe compactor attachments) may be up to 2 feet, provided that proper compaction is being achieved and each lift is tested. Use of large vibrating compaction equipment should be carefully monitored near existing structures and improvements due to the potential for vibration-induced damage.

Adequate density testing should be performed during construction to verify that the recommended relative compaction is achieved. Typically, one density test is taken for every 4 vertical feet of backfill on each 200-lineal-foot section of trench. Franchise utility trenches are generally not compacted unless they are located near a structural area. Trench spoils spread over lots should be kept to a minimum.

Pavement Construction

Table 1 presents our recommended minimum pavement section for dry weather construction conditions. The recommended pavement sections were formulated using the Crushed Base Equivalent method and assuming a Traffic Index of 4.0 for on-site streets. The Traffic Index is generally appropriate for minor residential streets and cul-de-sacs. The project engineer or architect should review the assumed traffic indices to evaluate their suitability for this project. Changes in anticipated traffic levels will affect the corresponding pavement section.

In new pavement areas, native soil subgrade should be ripped or tilled to a minimum depth of 12 inches, moisture conditioned, and recompacted in-place to at least 95 percent of ASTM D1557 (Modified Proctor) or equivalent. In order to verify subgrade strength, we recommend proof-rolling directly on subgrade with a loaded dump truck during dry weather and on top of base course in wet weather. Soft areas that pump, rut, or weave should be stabilized prior to paving. If pavement areas are to be constructed during wet weather, our firm should review subgrade at the time of construction so that condition specific recommendations can be provided. Wet weather pavement construction is likely to require soil amendment or geotextile fabric and an increase in base course thickness.

Table 1 - Recommended Minimum Dry Weather Pavement Sections

Material Layer	Minimum Thickness (inches)	Compaction Standard
Asphaltic Concrete (AC)	3	92% of Rice Density (top lift) 91% of Rice Density (lower lifts) AASHTO T-209
Crushed Aggregate Base ¾"-0 (leveling course)	2	95% of Modified Proctor ASTM D1557
Crushed Aggregate Base 1½"-0	8	95% of Modified Proctor ASTM D1557
Recommended Subgrade	12	95% of Modified Proctor or approved native

During placement of pavement section materials, density testing should be performed to verify compliance with project specifications. Generally, one subgrade, one base course, and one AC compaction test is performed for every 100 to 200 linear feet of paving.

Retaining Walls

Although a final grading plan has not been finalized, it is likely the project will incorporate retaining walls. GeoPacific can provide wall design calculations and construction details for some wall types after wall type and configuration have been finalized, if requested.

Anticipated Foundations

We anticipate that Lots 1 through 4, 11, 12, and 13 are suitable for conventional shallow foundations. The remaining lots are likely to require deep foundations such as drilled piers or driven pilings. Lot specific geotechnical investigations and/or reviews will be necessary to determine appropriate foundation types for specific house plans. Geotechnical design and construction criteria for individual house foundations will be provided on a case by case basis once the house plans and grading plan has been finalized.

Permanent Below-Grade Walls

Although specific house plans have not been finalized, we anticipate some of the homes will incorporate permanent below-grade walls.

Lateral earth pressures against below-grade retaining walls depend upon the inclination of the back-slope, degree of wall restraint, type of backfill, method of backfill placement, degree of backfill compaction, drainage provisions, and magnitude and location of any surcharge loads. At-rest soil pressure is exerted on a subsurface wall when the wall is restrained against rotation. Such restraint may be the result of an inherently stiff wall or if the wall is braced by rigid structural elements. In contrast, active soil pressure will be exerted on a subsurface wall if the top of the wall is allowed to rotate or yield.

For this project, it is anticipated that subsurface walls will not be restrained. The recommendations in the table below assume no adjacent surcharge loading. If the walls will be subjected to the influence of surcharge loading within a horizontal distance less than the height of the wall, the walls should be designed for the surcharge loading, using a suitable method.

Cantilever Retaining Wall Lateral Force Design Parameters

Soil Phi	26° (Retaining Native)	34° (Retaining Granular Fill)
Soil Unit Weight	115 pcf	125 pcf
Backslope	Level	Level
%g	0.15	0.15
Static EFP	42pcf	32 pcf
Recommended Seismic EFP	**50 pcf**	**39 pcf**

The recommendations assume that drainage provisions, as described below, will be included in the design of the walls. Accordingly, the recommended lateral earth pressures do not include hydrostatic pressure. Adequate drainage of below-grade walls is critical to long-term performance. For embedded structural walls, we recommend prefabricated geosynthetic drain panels be placed behind the wall, extending the full height of the wall. The drain panels should be Miradrain G100N or an approved equivalent. These drainage panels should be at least 12 inches wide and placed on 5-foot centers.

Drainage at the base of the wall should consist of a minimum 4-inch diameter perforated pipe, surrounded in pea gravel. The prefabricated vertical drain sheets should be wrapped around the perforated pipe. Where used adjacent to the structure, drains for below-grade walls may replace perimeter footing drains. All water collected by the toe drains should be directed under control to a positive and permanent discharge system such as the storm sewer.

Drains

In addition to retaining wall drains, a subdrain in the free draining granular fill at about 15 feet depth below existing ground is considered necessary to dewater the base of the loess soils in the vicinity of the proposed homes. The depth of the daylight basement can be maximized to reduce the depth of overexcavation required. The subdrain should consist of a drainage system consisting of 4-inch diameter, perforated, rigid plastic pipe embedded in a minimum of 4 feet vertical of clean, free-draining sand and gravel or 2"- ½" drain rock. The use of flexible, thin-walled, corrugated plastic pipe should be avoided. The drain pipe and surrounding drain rock should be wrapped in non-woven geotextile (Mirafi 140N, or approved equivalent) to minimize the potential for clogging and/or ground loss due to piping. Water collected from the footing drains should be directed into the local storm drain system or other suitable outlet. A minimum 0.5 percent fall should be maintained throughout the drain and non-perforated pipe outlet. Down spouts and roof drains should not be connected to the foundation drains in order to reduce the potential for clogging and/or introduction of roof drain water into the subsurface. The footing drains should include clean-outs to allow periodic maintenance and inspection. Grades around the proposed structure should be sloped such that surface water drains away from the building.

Seismic Design

Structures should be designed to resist earthquake loading in accordance with the methodology described in section 1615 of the State of Oregon 2004 Structural Specialty Code (OSSC) Amendments to the 2003 International Building Code (IBC). The maximum considered earthquake ground motion for short period and 1.0 second period spectral response may be determined from map Figures 1615(1) and 1615(2) of the State of Oregon 2004 Structural Specialty Code (OSSC) or the 2003 National Earthquake Hazard Reduction Program (NEHRP) "Recommended Provisions for Seismic Regulations for New Buildings and Other Structures" published by the Building Seismic Safety Council. We recommend Site Class D be used for design per the OSSC, Table 1615.1.1. Using this information, the structural engineer can select the appropriate site coefficient values (F_a and F_v) from Tables 1615.1.2(1) and 1615.1.2(2) of the 2003 IBC to determine the maximum considered earthquake spectral response acceleration for design of the project.

Soil liquefaction is a phenomenon wherein saturated soil deposits temporarily lose strength and behave as a liquid in response to earthquake shaking. Soil liquefaction is generally limited to loose, granular soils located below the water table. Following development, on-site soils will consist predominantly of engineered fill and native stiff to very stiff fine-grained soils that are not considered susceptible to liquefaction. Therefore, it is our opinion that special design or construction measures are not required to mitigate the effects of liquefaction.

UNCERTAINTY AND LIMITATIONS

We have prepared this report for the client, for use on this project only. The report should be provided in its entirety to prospective contractors for bidding and estimating purposes; however, the conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Inconsistent conditions can occur between explorations that may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, GeoPacific should be notified for review of the recommendations of this report, and revision of such if necessary.

Within the limitations of scope, schedule and budget, GeoPacific attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology at the time the report was prepared. No warranty, expressed or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous or toxic substances in the soil, surface water, or groundwater at this site.

We appreciate the opportunity to be of service.

Sincerely,

GEOPACIFIC ENGINEERING, INC.

Beth K Rapp

Beth K. Rapp
Staff Geologist

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Attachments: Maintenance of Hillside Homesites
Figure 1 – Site Location Map
Figure 2 – Site Layout and Exploration Plan
Figure 3 – Fill Slope Detail
Test Pit Logs (TP-1 through TP-7)

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MAINTENANCE OF HILLSIDE HOMESITES

All homes require a certain level of maintenance for general upkeep and to preserve the overall integrity of structures and land. Hillside homesites require some additional maintenance because they are subject to natural slope processes, such as runoff, erosion, shallow soil sloughing, soil creep, perched groundwater, etc. If not properly controlled, these processes could adversely affect your or neighboring properties. Although surface processes are usually only capable of causing minor damage, if left unattended, they could possibly lead to more serious instability problems.

The primary source of problems on hillsides is uncontrolled surface water runoff and blocked groundwater seepage which can erode, saturate and weaken soil. Therefore, it is important that drainage and erosion control features be implemented on the property, and that these features be maintained in operative condition (unless changed on the basis of qualified professional advice). By employing simple precautions, you can help properly maintain your hillside site and avoid most potential problems. The following is an abbreviated list of common Do's and Don'ts recommended for maintaining hillside homesites.

<u>Do List</u>

1. Make sure that roof rain drains are connected to the street, local storm drain system, or transported via enclosed conduits or lined ditches to suitable discharge points away from structures and improvements. In no case, should rain drain water be discharged onto slopes or in an uncontrolled manner. Energy dissipation devices should be employed at discharge points to help prevent erosion.

2. Check your roof drains, gutters and spouts to make sure that they are clear. Roofs are capable of producing a substantial flow of water. Blocked gutters, etc., can cause water to pond or run off in such a way that erosion or adverse oversaturation of soil can occur.

3. Make sure that drainage ditches and/or berms are kept clear throughout the rainy season. If you notice that a neighbor's ditches are blocked such that water is directed onto your property or in an uncontrolled manner, politely inform them of this condition.

4. Locate and check all drain inlets, outlets and weep holes from foundation footings, retaining walls, driveways, etc. on a regular basis. Clean out any of these that have become clogged with debris.

5. Watch for wet spots on the property. These may be caused by natural seepage or indicate a broken or leaking water or sewer line. In either event, professional advice regarding the problem should be obtained followed by corrective action, if necessary.

6. Do maintain the ground surface adjacent to lined ditches so that surface water is collected in the ditch. Water should not be allowed to collect behind or flow under the lining.

<u>Don't List</u>

1. Do not change the grading or drainage ditches on the property without professional advice. You could adversely alter the drainage pattern across the site and cause erosion or soil movement.

2. Do not allow water to pond on the property. Such water will seep into the ground causing unwanted saturation of soil.

3. Do not allow water to flow onto slopes in an uncontrolled manner. Once erosion or oversaturation occurs, damage can result quickly or without warning.

4. Do not let water pond against foundations, retaining walls or basements. Such walls are typically designed for fully-drained conditions.

5. Do not connect roof drainage to subsurface disposal systems unless approved by a geotechnical engineer.

6. Do not irrigate in an unreasonable or excessive manner. Regularly check irrigation systems for leaks. Drip systems are preferred on hillsides.

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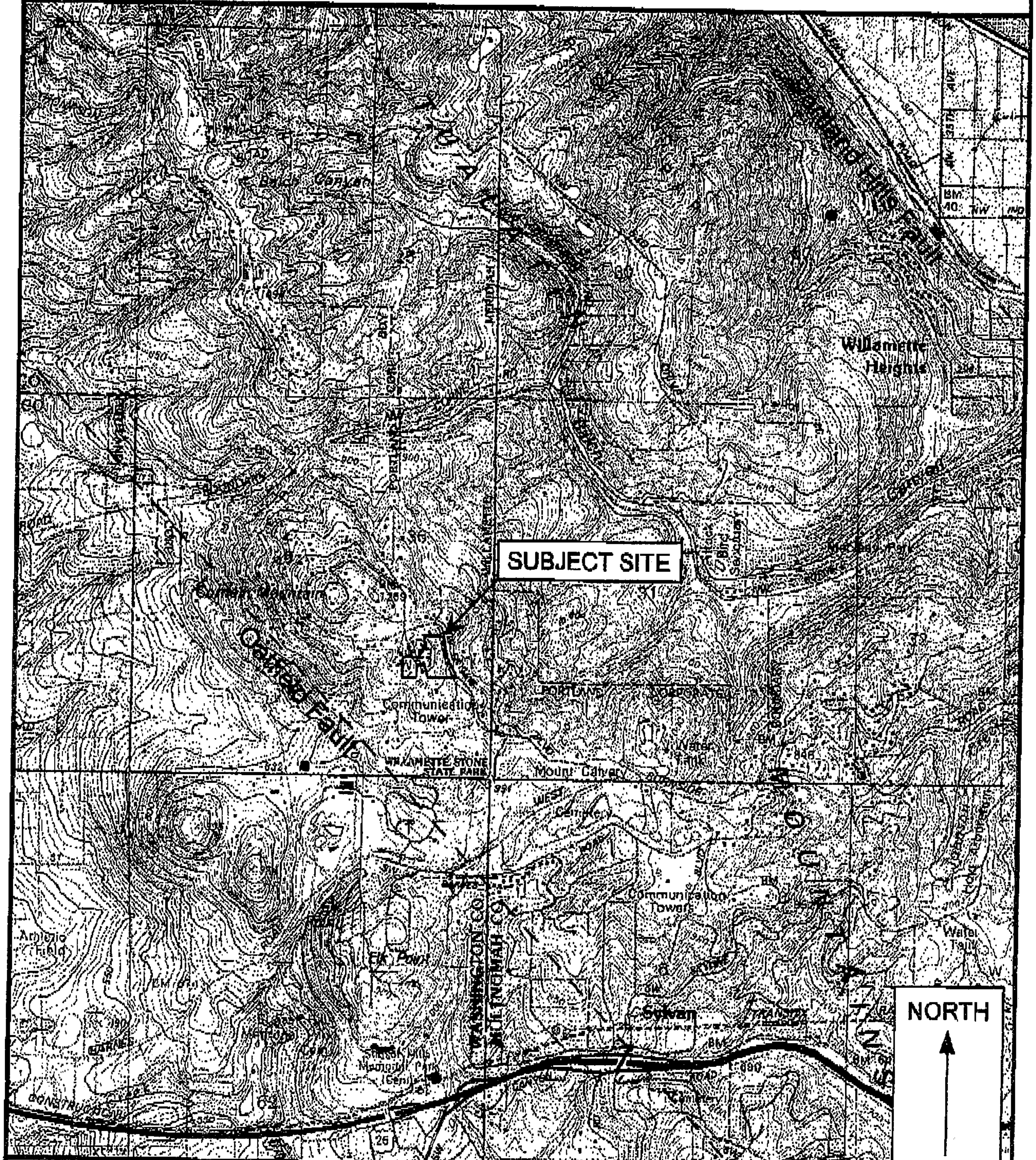
VICINITY MAP



Legend

Approximate Scale 1 in = 2,000 ft

Date: 03/15/06
Drawn by: EKR

Base maps: U.S. Geological Survey 7.5 minute Topographic Map Series, Linnton, Oregon Quadrangle, 1990
U.S. Geological Survey 7.5 minute Topographic Map Series, Portland, Oregon Quadrangle, 1990

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	FIGURE 1

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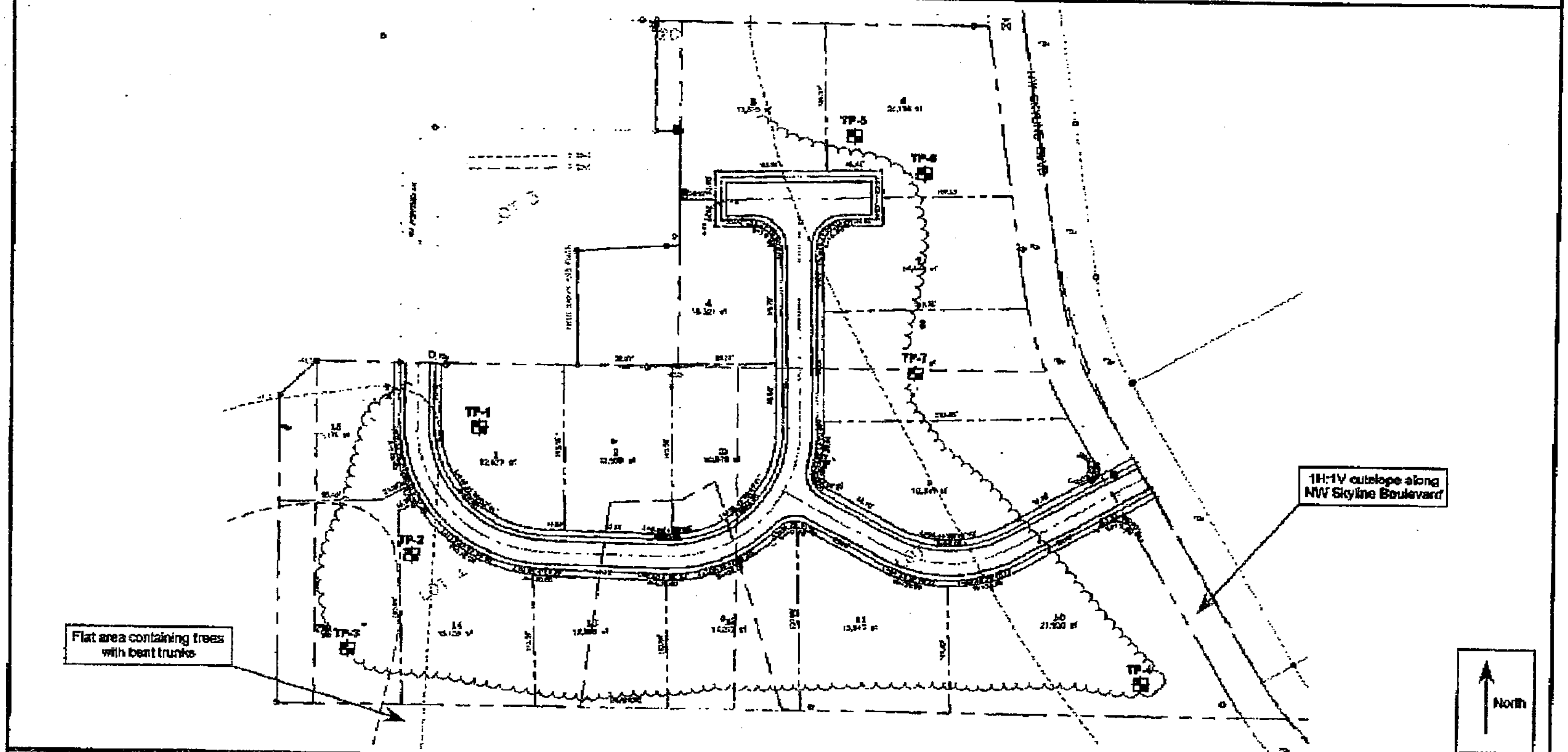
SITE PLAN WITH EXPLORATIONS



Legend

TP-1 Test Pit Designation and Approximate Location

0 80' 160'
APPROXIMATE SCALE 1"=80'

Project: Ridgecap Estates Subdivision Portland, Oregon	Job No: 05-9549	Drawn by: EKR	Date: 03/15/06	FIGURE 2

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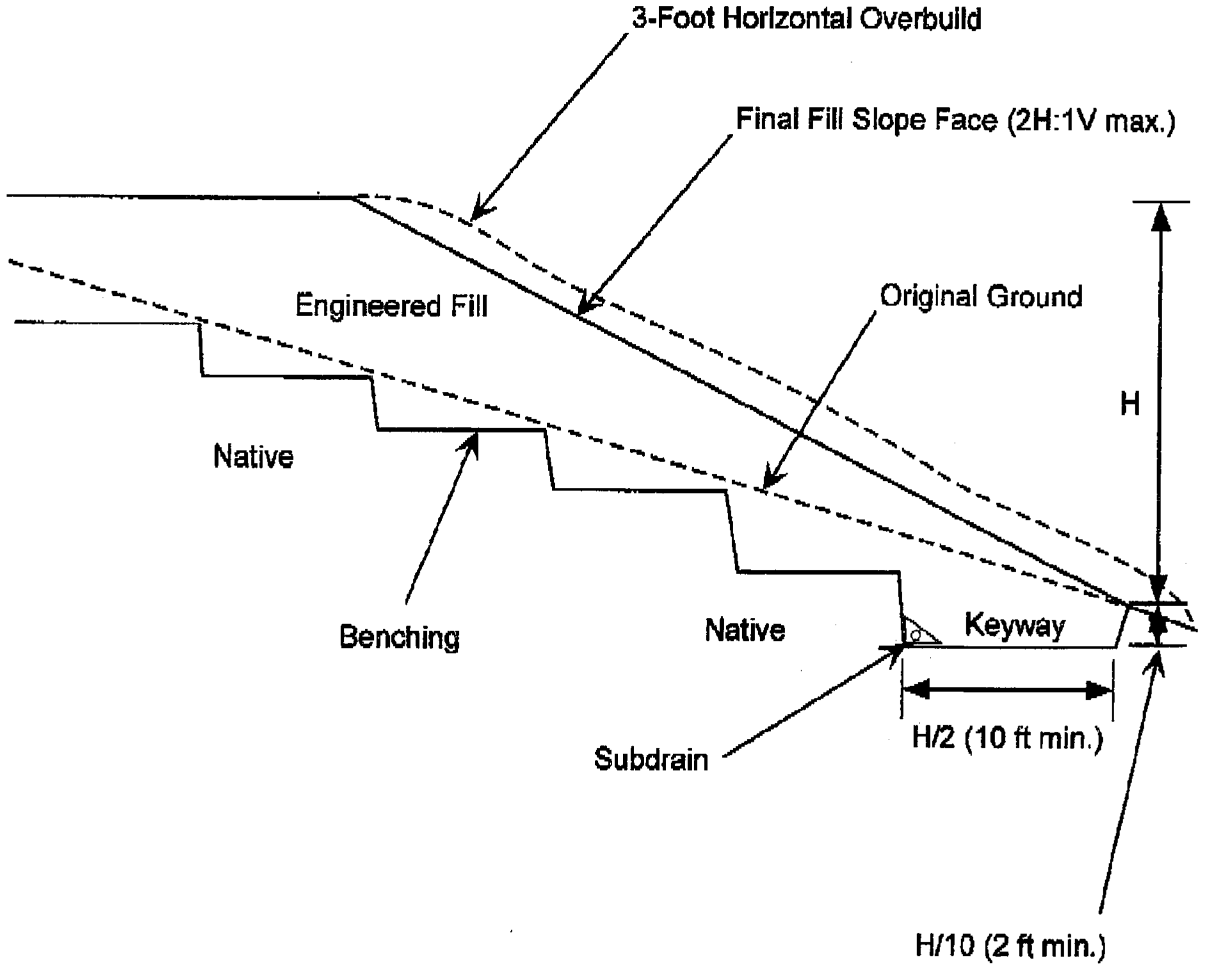
FILL SLOPE DETAIL

TYPICAL KEYWAY, BENCHING & FILL SLOPE DESIGN



Recommended subdrain is minimum 3-inch-diameter ADS Heavy Duty grade (or equivalent), perforated plastic pipe enveloped in a minimum of 3 cubic feet per lineal foot of 2" to 1/2" open-graded gravel drain rock wrapped with geotextile filter fabric (Mirafi 140N or equivalent).

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05 - 9549	FIGURE 3

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TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. TP- 1

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
						Moderately organic SILT (OL-ML), brown, 3-inch thick root mat, loose, damp (Topsoil)
1	1.0					
2	3.5					
3	4.5					
4	4.5					
5						Very stiff, clayey SILT (ML), light brown, weak orange and gray mottling, micaceous, black staining, damp (Loess Deposit)
6						
7						
8						
9						
10						
11						Clayey SILT (ML) to silty CLAY (CL), reddish-brown, moist (Residual Soil)
12						Test Pit Terminated at 12 feet Note: No seepage or groundwater encountered.
13						
14						
15						
16						
17						

LEGEND

Bag Sample (100 to 1,000 g) · Bucket Sample (5 Gal. Bucket) · Shelby Tube Sample · Seepage · Water Bearing Zone · Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1190 feet

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TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. TP-2

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
0–2						Highly organic SILT (OL), dark brown, 7-inch thick root mat, rootlets to depth of 16 inches, well developed peds, loose, damp (Topsoil)
3	2.0					
4	4.0					
2–10						Very stiff, clayey SILT (ML), light brown, orange and gray mottling, micaceous, uniform texture, damp to moist (Loess Deposit)
10–12						Stiff, clayey SILT (ML) to silty CLAY (CL), reddish-brown, black staining, moist (Residual Soil)
12						Test Pit Terminated at 12 feet Note: No seepage or groundwater encountered.

LEGEND: Bag Sample (100 to 1,000 g); Bucket Sample (5 Gal. Bucket); Shelby Tube Sample; Seepage; Water Bearing Zone; Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1155 feet

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TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. TP-3

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
1						Highly organic SILT (OL), dark brown, 4-inch thick root mat, roots throughout upper 20 inches, loose, well developed peds, damp to moist (Topsoil)
2	1.0					
3	1.0					Stiff to very stiff, SILT (ML), trace clay, light brown, orange and gray mottling, micaceous, manganese staining, damp to moist (Loess Deposit)
4	2.5					
5						
6						
7						
8						Silty CLAY (CL) to clayey SILT (ML), with fragments of weathered dark gray vesicular basalt and red scoria, reddish-brown, damp to moist (Residual Soil)
9						
10						
11						
12						Practical refusal on medium hard (R3) to hard (R4) basalt at 11 feet. Note: No seepage or groundwater encountered.
13						
14						
15						
16						
17						

LEGEND

100 to 1,000 g Bag Sample | 5 Gal. Bucket Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1110 feet

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TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. TP-4

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
1	1.5					Moderately organic SILT (OL-ML), brown, 3-inch thick root mat, trace roots throughout upper 24 inches, loose, well developed peds, damp (Topsoil)
2	1.5					
3	2.5					
4	3.5					
5						Very stiff, SILT (ML), trace clay, light brown, orange and gray mottling, micaceous, uniform texture throughout, damp (Loess Deposit)
6						
7						
8						
9						
10						
11						
12						Color change to reddish-brown and moist at 12 feet
13						Test Pit Terminated at 12.5 feet
14						Note: No seepage or groundwater encountered.
15						
16						
17						

LEGEND

100 to 1,000 g Bag Sample; 5 Gal. Bucket Bucket Sample; Shelby Tube Sample; Seepage; Water Bearing Zone; Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1130 feet

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TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. TP-5

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
1	0.5					Highly organic SILT (OL), with glass and dish fragments, dark brown, roots throughout, soft, damp to moist (Fill)
2	0.5					
3	0.5					
4	>4.5					Very stiff, SILT (ML), light brown, weak orange and gray mottling, micaceous, damp (Loess Deposit)
5						
6						
7						Stiff, clayey SILT (ML) to silty CLAY (CL) with fragments of weathered dark gray vesicular basalt (up to 6 inch diameter) and rounded to subrounded red scoria, reddish-brown, damp to moist (Residual Soil)
8						
9						
10						
11						Test Pit Terminated at 11 feet Note: No seepage or groundwater encountered.
12						
13						
14						
15						
16						
17						

LEGEND

100 to 1,000 g — Bag Sample; 5 Gal. Bucket — Bucket Sample; Shelby Tube Sample; Seepage; Water Bearing Zone; Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1194 feet

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TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. TP-6

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
1	1.0					Moderately organic SILT (OL-ML), dark brown, 3-inch root mat, loose, damp (Topsoil)
2	0.5					
3	4.5					
4	3.5					
5						Very stiff, SILT (ML), light brown, orange and gray mottling, micaceous, uniform texture throughout, damp (Loess Deposit)
6						
7						
8						
9						
10						Clayey SILT (ML) to silty CLAY (CL), trace dark gray vesicular basalt fragments, reddish-brown, damp (Residual Soil)
11						Test Pit Terminated at 11 feet
12						Note: No seepage or groundwater encountered.
13						
14						
15						
16						
17						

LEGEND

100 to 1,000 g — Bag Sample; 5 Gal. Bucket — Bucket Sample; Shelby Tube Sample; Seepage; Water Bearing Zone; Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1188 feet

GeoPacific Engineering Inc
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Tel: (503) 598-8445 Fax: (503) 598-8705

TEST PIT LOG

Project: Ridgecap Estates Subdivision Portland, Oregon	Project No. 05-9549	Test Pit No. **TP-7**

Depth (ft)	Pocket Penetrometer (tons/ft²)	Sample Type	In-Situ Dry Density (lb/ft³)	Moisture Content (%)	Water Bearing Zone	Material Description
1	1.5					Moderately organic SILT (ML), brown, 4-inch thick root mat, trace roots throughout, loose, damp (Topsoil)
2	2.0					
3	3.0					
4	3.5					Very stiff, SILT (ML), light brown, weak orange and gray mottling, micaceous, damp (Loess Deposit)
5						
6						
7						
8						
9						
10						Color change to reddish-brown at 10 feet
11						Test Pit Terminated at 10.5 feet
12						Note: No seepage or groundwater encountered.
13						
14						
15						
16						
17						

LEGEND

500 to 1,000 g Bag Sample · 5 Gal. Bucket Bucket Sample · Shelby Tube Sample · Seepage · Water Bearing Zone · Water Level at Abandonment

Date Excavated: 12/12/05
Logged By: B. Rapp
Surface Elevation: 1180 feet