January 25, 2014
HWA Project No. 2014-177-21

ESA
5309 Shilshole Avenue NW, Suite 200
Seattle, Washington 98107

Attention: Ms. Lisa Adolfson

Subject: **GEOTECHNICAL ENGINEERING INVESTIGATION**
Cheasty Trail Pilot Project
City of Seattle Parks and Recreation
King County, Washington

Dear Lisa,

In accordance with your request, HWA GeoSciences Inc. (HWA) has completed a geotechnical engineering investigation for the proposed Cheasty Mountain Bike Trail in Seattle, Washington. The purpose of our investigation was to evaluate the general geologic conditions and provide preliminary geotechnical recommendations for design and construction of proposed trail facilities. Our work included geologic field reconnaissance; review of available geologic literature, aerial photos, and topographic maps; and preparation of this letter report.

PROJECT UNDERSTANDING

It is our understanding that the Seattle Department of Parks and Recreation is implementing a pilot program that will construct a soft surface mountain bike trail and an accessible trail within the existing Cheasty Greenspace. The approximate location of the proposed trail complex is indicated in the Vicinity Map, Figure 1. The Cheasty Greenspace currently consists of 28.5 acres of wooded slopes and multiple wetlands on the east side of Beacon Hill. The approximate alignment of the proposed mountain bike trail and accessible trail are indicated in the Site and Exploration Plan, Figure 2. We understand that the proposed trail alignment will consist of a loop that will generally follow the site contours, and will cross two wetland complexes and several areas of known slope instability. The current trail concept drawings show that the wetland crossings will be facilitated with elevated boardwalk structures.

EXISTING GEOTECHNICAL INFORMATION

Stantec Consulting Services, Inc. performed a limited preliminary geotechnical investigation of the greenspace (Stantec, 2014). Stantec's investigation was limited to an online and paper study of the geotechnical aspects of the proposed trail alignment.

A soldier pile and lagging wall with tiebacks exists on the western edge of the New Rainier Vista housing development west of the P-patch. Exploration logs for design and construction documentation likely exist for this wall. We were not able to locate these documents for this study.

GENERAL GEOLOGIC CONDITIONS

The Geologic Map of Seattle indicates the Cheasty Greenspace is underlain by the typical glacial sequence of the Vashon Stade of the Fraser Glaciation (Troost et al, 2005). During the Vashon Stade, from approximately 20,000 to 13,000 years ago, the Puget lobe of the Cordilleran continental ice sheet advanced south from western British Columbia, filling the Puget Sound lowland with a maximum thickness at the latitude of Seattle of approximately 3,000 feet. During advance of the ice, the sedimentary environment of lakes distant from the ice front transitioned from non-glacial to glacial. As the ice approached, glacial flour (silt and clay) were deposited in areas of slack water. Next, advance outwash consisting mostly of clean sand with pebbles was deposited in broad fans by meltwater emanating from the glacier. As the advancing glacier overrode the advance outwash, a layer of lodgment till was deposited at the base of the ice. The till consists of an unsorted, non-stratified mixture of clay, silt, sand, gravel, and cobbles/boulders. Due to the weight of the ice, the lodgment till, advance outwash, transitional beds, and older non-glacial terrestrial deposits have been over consolidated to a very dense or hard condition. During retreat of the glacier, meltwater deposited sand and gravel, or fine grained soils depending on the flow velocity.

Post-glacial geomorphic processes have included mass-wasting of steep slopes, alluvial reworking of sediments, and formation of wetlands in poorly drained areas.

The geologic map indicates the steep hillslopes have a core consisting of transitional beds at the base, with advance outwash above, and capped by till at the very top of the slope. Mass wasting deposits were mapped across the entire slope, and consist of colluvium, landslide deposits, and alluvium from small hillside streams. Several distinct landslides are indicated by topographic relief on the geologic map. Two small slides located at and near the north end of the parcel have been recorded and are shown on Seattle Department of Planning and Development (DPD) critical areas interactive map (City of Seattle, 2007). The DPD documented slide within the greenspace is plotted at the Andover Street powerline easement at the northern boundary of the greenspace. Evidence of recent sliding was not observed in this area.

SITE CONDITIONS

Based on an available topographic map (King County imap), the slope below Cheasty Blvd, dropping down to the east, ranges from approximately 60 feet high at the north end, increasing to 100 feet in the southern portions. The terrain as observed on Lidar imagery shows drainage swales and ridges, and the ground surface is gently hummocky. Steep slope crests indicative of sidecast fill are obvious along Cheasty Blvd, the Parks materials yard, and the upper slope below Cheasty Blvd southwest of the materials yard. Aerial photos confirm the predominance of

Bigleaf Maple trees as observed on site and their similar range of size, and therefore age. An aerial photo from 1936 (as seen on imap) revealed small deciduous trees and brush with some open areas.

Slopes exceeding 40 percent were mapped by City of Seattle along portions of the southern half of the site (see Figure 2, yellow hatching). The main portion of this is along the northern slope below the materials yard and above the main stream.

SITE RECONNAISSANCE

An HWA engineering geologist and a geotechnical engineer evaluated site and surficial soil conditions on January 12, 2015 by performing a geologic reconnaissance of the site on foot along the general alignment of the proposed mountain bike trail. The alignment was traversed clockwise starting at the top of the slope just south of the existing Parks materials yard on Cheasty Blvd. Slope geomorphology, vegetation patterns, tree growth, and surficial soils were observed during the traverse for signs of slope instability. At intervals the ground surface was probed with a ½-inch diameter T-handled steel rod to observe density or cohesiveness of surficial soils. General observations and locations of note are discussed below, with specific ground observations made at waypoints (numbered on Figure 2) included in Appendix B.

The site is mostly wooded, with the vast majority of trees consisting of bigleaf maple from approximately 8 to 24 inches in diameter and 30 to 70 feet high. Some cottonwood trees were observed in the southern end of the site on a gentle slope above Columbian Way. Alders, small cedars and Douglas firs were observed as lone trees in various places. Several portions of the wooded area consisted of all bigleaf maple with understory. Understory brush and ground vegetation mainly consisted of sword fern virtually everywhere, with salal, Indian plum, and Oregon grape in various areas. Invasive English ivy was observed throughout most of the site, with many areas recently cleared of ivy and the ground covered with burlap sacks and native vegetation replanted. Invasive blackberry canes were observed, mainly along the lower slopes from the northern riparian zone, northward to the slide zone behind the soldier pile wall. Blackberries were observed in scattered places elsewhere, but not as brambles. Salmonberry was observed in the riparian zones and in other low places. These vegetative species are indicative of high soil moisture content through the year.

The entire greenspace gives the overall impression of an area that is unstable over the long term, based on steepness of slopes and uneven topography, ground water seeps, and type of forest (predominantly deciduous). The steepest observed slopes were inclined at approximately 1H:1V to 1½H:1V (Horizontal:Vertical) along heights of 15 to 25 feet, where fill was pushed out from the top of the slope at the materials yard and lawn areas to the south of the yard. The slopes mapped as exceeding 40 percent (2½H:1V) included some of the fill slopes, as well as areas downslope to the north and east of the materials yard, a section along Cheasty Blvd, and isolated areas elsewhere. Otherwise the slopes were variable in inclination over distances of tens of feet, generally between 3H:1V and 10H:1V.

Surficial soils as observed and probed predominantly consisted of loose grading to medium dense, brown, silty, gravelly sand. Probing depths ranged from 0.5 to 3 feet in the portion of the site south of the materials yard, 1 to 3.5 feet on slopes elsewhere, and 2 to 3 feet in wetland riparian areas. The soil at the surface in most slope areas was not a rich topsoil, nor was much duff accumulated. This lack of organic accumulation and topsoil formation is indicative of persistent erosion or slope instability, which may date to logging before the 1930s. The portion of critical (over 40%) slopes just north of the proposed loop in the accessible trail (at waypoint 7) had surficial soil consisting of gray, plastic silt or clay, as did the plateau on which the loop is proposed. This material appears to be fill that was spread over plateau and its edges, spilling downslope to the north and northeast. No signs of recent sliding was observed in this fill. Soils in the riparian zones consisted of soft or loose, dark brown, organic, silty sand that was saturated from ground water seepage and runoff.

Three areas of recent slope instability were observed:

1) **Along the fill slope around the Parks materials yard:** The fill historically spread over the crest of the slope showed signs of sliding this winter near the easternmost point. Fresh soil exposures near the top and deposits of sloughed and eroded soil down the 15- to 25-foot high slope were present.

2) **Above an existing soldier pile wall just west of Dakota St and 24th Ave S.:** This curving wall retains the toe of the forested slope within Rainier Vista common space, above a playground and the P-patch. The wall is from approximately 6 to 10 feet high and 300 feet long, with tiebacks along the eastern portion, as well as multiple clean outs in front of the wall, presumably for slope drainage piping. Two irregular slide scarps were observed at approximately 100 and 150 feet upslope from the wall. The scarps were on the order of 1 to 2 feet high and did not appear recent, being sloughed and moss-covered. Horizontal separation appeared to be less than 1½ feet at each scrap. The age of the scarps, based on appearance, is likely older than the relatively new soldier pile wall, which seems to have been built as part of the recent Rainier Vista redevelopment project. There were fewer and smaller trees in this area, likely due to past instability. However, the current trees were not tipped as would occur from deep, rotational sliding, such that in our opinion the most recent slide activity, before the wall was constructed, was relatively shallow and translational. The extent and exact locations of these scarps should be determined during project surveying.

3) **The head end of the western riparian area, below hand hole HH-5:** Ground water seepage was observed emanating in a bowl-shaped headwater area extending approximately 40 to 50 feet across. The bowl was gently sloping at the top, and increasing in slope as it transitions to a stream valley. Along the upper edge of the bowl, the slope was over-steepened to approximately 1H:1V to 1½H:1V over a height of 3 to 6 feet, with shallower slopes above. The localized over-steepening of this type is due to sloughing induced by ground water seepage. The slope progressively retreats headward

over time. This slope was vegetated and did not show recent signs of sloughing. Probing in the bowl extended only up to 3 feet, in soft, dark brown, organic sandy silt that was saturated. The probe terminated abruptly in dense gravelly sand.

SUBSURFACE EXPLORATIONS

On January 15, 2015, HWA representatives visited the site and performed a subsurface investigation consisting of six hand borings, designated HH-1 through HH-6. The hand borings were advanced to depths ranging from 2 to 5.75 feet below ground surface (bgs). Dynamic Cone Penetration (DCP) tests, were completed at four hand boring locations, to explore the relative density of near-surface soils. Each hand boring and associated DCP test was advanced and logged by an HWA engineering geologist and geotechnical engineer. Representative soil samples were obtained at selected intervals, and transported to HWA's Bothell laboratory for further examination and testing.

The DCP tests consists of a steel extension shaft assembly, with a 60 degree hardened steel cone tip attached to one end, which is driven into the subsoil by means of a sliding drop hammer. The base diameter of the cone is 20 mm (0.79 inches). The diameter of the shaft is 8 mm (0.315 inches) less than the cone, to reduce rod friction at shallow penetration depths. The DCP is driven by repeatedly dropping an 8-kg (17.6-pound) sliding hammer from a fixed height of 575 mm (22.6 inches). The depth of cone penetration is measured after each hammer drop and the in-situ shear strength of the soil is reported in terms of the DCP Index (DCI). The DCI is based on the average penetration depth resulting from 1 blow of the hammer and is reported as millimeters per blow (mm/blow). The data obtained from the DCP tests was then correlated to Standard Penetration Test (SPT) values, in order to evaluate the strength of the subgrade soils for use in evaluating the allowable bearing capacity of the site soils. The DCP data, converted to SPT, is plotted on the hand boring logs in Appendix A.

The approximate locations of each hand boring and DCP test is indicated in the Site and Exploration Plan, Figure 2. Exploration logs of the hand borings and DCP tests are shown in Figures A-2 through A-7. A legend of the terms and symbols used on the exploration logs is included on Figure A-1.

SUBSURFACE SOIL CONDITIONS

Our subsurface explorations were focused on the three proposed structures on the Site and Exploration Plan, namely a set of steps and two boardwalks. Soils encountered in our explorations at each of the three sites were very different and are described below.

Fill: Fill soils consisting of very loose to loose, brown, gravelly, silty, sand with woody debris and organics were encountered in handhole HH-1 at the proposed top of steps. This fill material appeared to have been placed during grading of the area for the materials yard just to the north.

Buried Topsoil: Buried Topsoil consisting of very loose to loose, brown, silty, sand with woody debris and organics. It is differentiated from the fill by odor and presence of abundant organic matter, and by absence of jumbled appearance. This unit was encountered in handhole HH-1 below the fill. Handhole HH-1 was terminated in this unit upon refusal on gravel. It appears that when fill was placed it was simply pushed over the top of a cleared area vegetated with blackberry brambles.

Topsoil: Topsoil very similar in consistency to the buried topsoil in HH-1 was encountered at the surface in HH-2. Handhole HH-2 was dug at near the proposed bottom of the steps at the bottom of a relatively steep change in grade. The topsoil was thin – only about six inches thick and supported the growth of blackberry brambles and weeds. This unit is also a fill as indicated by the woven geosynthetic fabric separating it from the unit below. Topsoil was more weakly developed elsewhere on slopes throughout the site, and often there was none with Colluvium at the ground surface beneath minor duff.

Weathered Advance Outwash: Loose grading to dense, silty sand was encountered in HH-2 under the geosynthetic fabric. Color, presence of rust mottling, and density indicate a high degree of weathering near surface with the degree of weathering lessening with depth. Hand hole HH-2 was terminated in this unit.

Organic Silt: Organic silt stream and wetland deposits consisting of very soft sandy silt with abundant organics were encountered at the ground surface in hand holes HH-3 and HH-4. At the locations of hand borings HH-3 and HH-4 the organic silt was so soft that the DCP sank under the weight of the hammer. These organic silt soils were encountered in both wetland areas near the proposed boardwalk locations. This soil unit is very thin – approximately 0.25 feet thick is highly compressible, and will undergo consolidation settlement under the application of load. These soils will also undergo biodegradation settlement over time as the organic material within the soil biodegrades.

Course Grained Alluvium: Course grained alluvial deposits were encountered below a depth of 0.25 feet in hand borings HH-3 and HH-4. These soils consisted of very loose grading to dense, gray, silty, fine to coarse sand and gravel.

Colluvium: Colluvium is soil that has been transported by gravity. Soil interpreted to be colluvium was encountered near the ground surface in hand holes HH-5 and HH-6, as well as observed at the surface throughout the majority of the greenspace. This soil consisted of loose, brown, very silty, gravelly SAND and was most likely derived from glacial till and advance outwash soils transported down from upslope. Colluvium was differentiated from topsoil by observing little organic content in it. This unit was differentiated from glacial till by color and relative density.

Weathered Till: Course grained deposits were encountered below a depth of 0.25 feet in hand borings HH-5 and HH-6. These soils consisted of very loose grading to dense, gray, silty, fine to coarse sand and gravel.

Glacial Till: Very dense olive gray silty gravelly sand was encountered in hand hole HH-5 below the weathered till. The transition between weathered and unweathered till is gradual and is interpreted from density and color, and the presence or absence of rust mottling.

GROUND WATER CONDITIONS

Ground water seepage was observed in several locations, most of which were closer to the bottom of slope than the top. The approximate locations in which ground water seepage was observed during our site visits are indicated in Figure 2. The exception was ground water seepage below Cheasty Blvd at the head of the large stream valley. These seepages formed the head ends of surface drainages. Based on the geologic mapping, it is likely that most of the seepage emanates from granular soils just above their contact over hard silts and clays. The presence, specific locations, and flow quantity of ground water seepage should be expected to vary seasonally.

Ground water was observed in three of our explorations. Handholes HH-3 and HH-4 were dug in a wetland. Water levels observed in each hand hole were at ground surface, and 1 foot below ground surface respectively. Seepage was observed from saturated soils below 3 feet below ground surface in HH-6.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

Construction of the accessible trail and mountain bike trail is feasible from a geotechnical standpoint but will require some modifications to avoid areas of observed instability and seepage. If properly designed, we do not anticipate that construction of the proposed trail will result in increased slope instability. However, specific attention will need to be paid to the final trail alignment, grades, drainage and surfacing to limit the amount of maintenance required to maintain a functional and environmentally friendly trail system.

Several wetland crossings will likely require the construction of boardwalk structures. We anticipate that these boardwalks structures will be founded on small diameter pin pile foundations or proprietary foundation systems such as diamond pier foundations.

The proposed stair structure located near the Jefferson Entry is underlain by poor subgrade soils that are prone to future settlement and earth movement. This stair structure will likely require over excavation and replacement of the poor subsurface soils or will need to be supported on pin pile foundations to avoid future damage due to settlement and earth movement.

Several specific issues that will need to be considered during final design of the proposed trail system are indicated in detail below.

SLOPE STABILITY

The majority of the site is mapped as having mass wasting deposits at the surface, consisting of colluvium, landslide deposits, and alluvium from small streams. The majority of the site surficial soils appear to consist of loose colluvium, to typical depths of 1 to 3 feet. Three areas of slope instability were observed in the greenspace, as noted in the Site Reconnaissance section above. The area displaying exposed scarps, above the soldier pile wall, is the only location in which we observed evidence of recent deep-seated sliding. This area can be assumed to be effectively mitigated by the soldier pile wall at the toe, protecting the Rainier Vista open space and homes. We anticipate that deep-seated rotational failures in the vicinity of the existing retaining wall are unlikely to occur, however we were not able to evaluate the stability of the wall and surround slope. We recommend further geotechnical review of the intended purpose of the soldier pile wall and its design and construction records.

The potential for shallow colluvial landslides should be anticipated everywhere throughout the site, particularly in areas with greater than 40 percent slopes. The only recent evidence of such instability was observed where fill had been placed over the crest of an existing slope.

Soil creep appears to be the most prevalent means of downslope soil movement across the site. Based on the mostly upright nature of the trees on site, slope creep appears to have affected trees primarily early in life, after the site was exposed to runoff and erosion associated with historic clearing, burning, and/or landsliding.

Measures to minimize impacts of the trails to slope stability and vice versa include:

- Routing the trail outside of the three noted areas of instability,
- Avoiding steep slopes (greater than 40 percent, or 2.5H:1V) where possible,
- Avoiding ground water seepage zones where possible,
- Minimizing cut heights where the trails must traverse steel slopes,
- Minimizing steepness of trail grades, and
- Installing and maintaining suitable drainage features.

TRAIL ALIGNMENT

In general, the proposed mountain bike trail alignment is appropriate. However, specific modifications to the trail alignment should be considered during final design. We recommend that the trail alignment be modified to avoid locations of identified groundwater seepage and observed slope instability.

One possible trail alignment modification that should be considered is in the immediate vicinity of the proposed southern wetland crossing. At the southern wetland crossing, the proposed boardwalk is to be located directly upslope from a bowl like topographic feature exhibiting significant ground water seepage. Based on subsurface soil and slope conditions, a boardwalk may not be necessary if the trail is located at least 25 feet (horizontally) upslope from the seepage area. This modification should be considered further as part of final design of the trail system.

Below Cheasty Boulevard and north of the materials yard, the proposed mountain bike trail crosses a boggy wetland area similar to the other two. Rerouting the trail around would be the simplest solution. If this is not feasible, another board walk structure or perhaps a log ride may be used to cross the structure.

The fill slope below the materials yard shows evidence of sloughing. Drainage facilities from the yard are discharged out over the proposed accessible trail loop. We recommend dispersing the drainage from the yard in an area below the trails. Further we recommend moving the trail as far from toe of slope as practicable. Alternatively, the slope up to the materials yard could be laid back to greater than 2.5H:1V.

Any alignment modifications should be completed in accordance with the recommendations provided by the International Mountain Bike Association (IMBA). The IMBA recommends limiting trail grades to a maximum of 15% with an average grade not to exceed 10% to limit the potential for surface erosion. We recommend that IMBA's recommendations for grade be followed for the design of the Cheasty Mountain bike trail. The proposed trail appears to meet these recommendation as the maximum grade shown in the preliminary plans is 8%. The IMBA also recommends that trails be designed to follow slope contours to avoid concentrated surface water flows along the trail. The current preliminary alignment indicates that the proposed Cheasty Mountain bike trail is proposed to predominantly follow contour lines and only cut across the slopes at wide angles where required.

The accessible trail crossing of the slide area above the soldier pile wall may require careful route selection to avoid or minimize crossings of the scarps. Wherever the accessible trail must cross a scarp, future maintenance of the trail surface due to differential movement should be expected. This could be minimized by over-excavating the upper 2 feet of existing soil and compacting the resulting subgrade before placing a layer of geogrid with 1¼-inch minus crushed ledge rock compacted over it. Alternatively, the scarps could be bridged by boardwalks and the scarps be preserved and interpreted.

DRAINAGE RECOMMENDATIONS

Soils that become exposed on slopes are prone to erosion from rainfall and runoff. Trail surfaces that are steep with a high proportion of fine-grained soils at the surface are especially prone to erosion from bike traffic during both dry and wet conditions. Trail sections should be sloped no more than 15% to minimize the potential of erosion. The preliminary trail layout indicates grades as steep as 5 and 8 percent for some sections, with the remainder presumably shallower. Permanent erosion control measures for cuts and fills will need to be undertaken, and would likely consist of perennial plantings and matting or mulching.

Ground water seepage zones and the resulting surface runoff were observed at a number of places along the trail corridor. Specifically these were observed near waypoints 4, 9, 14 (surface pipeline for stormwater), 21 (in or adjacent to deep-seated slide area), 25 (north riparian zone), and 27 (south riparian zone). Other areas of seepage could become apparent during and after trail construction. The trail should not be constructed with wet crossings of seepage or runoff, as bicycle and foot traffic will cause disturbance of wet soils that will result in rutting and erosion of the trail (requiring higher maintenance) and silty runoff (impacting wetlands and streams down gradient).

At locations where crossing seepage or runoff cannot be avoided, measures to prevent wet crossings include boardwalks (see section below), culverts, and rock drainage blankets. Also, perched ground water seepage is often intercepted by trail cuts where seepage may not have been apparent at the ground surface. Shallow ditching or perforated pipes along the cut side of the trail with tight-lined culverts or other diversions to the opposite side would serve to collect this seepage. Trail surface runoff should be diverted by typical methods for trails in wet, steep forested areas such as inclining the trail outward where possible and, in areas of high runoff, inclining the trail to the upslope side to a ditch and tight-lining runoff beneath the trail.

MOUNTAIN BIKE TRAIL SURFACING

The near surface soils along the proposed maintain bike trail alignment are highly variable but generally consist of very loose and highly moisture sensitive soils. The appropriate mountain bike trail surfacing will likely vary along the alignment and will be dependent on the subsurface soils, slope conditions, seepage conditions, trail grade and the anticipated trail usage. The IMBA outlines multiple levels of trail surfacing options (in increasing order) to maintain trail functionality through varying conditions. It is likely that some if not all of these options will need to be implemented into the trail design during the final design process.

- **Microtopography Modification:** Compacted native soil comprises the trail surfacing. This approach uses onsite materials to create raised trail surface, causeways, basins, and mounds with the goal of maximizing drainage. Flatter areas are most suitable for this approach.

- **Foundation Modification:** The trail bed is excavated to place a layer of drain rock that is then overlain by native soil that is placed to form the trail surfacing. If the fines content is high in the native soils, migration of fines into the drainage layer could result in loss of drainage functionality of the rock over time. Wrapping the drainrock in a non-woven geotextile separator fabric adds expense but would add longevity without significantly increasing effort.

- **Surface Modification:** Place imported material for the trail surfacing. Our experience indicates that a well-graded crushed surfacing top course from a ledge rock source with a non-plastic fines content of around 10% works well for supporting wheeled trail uses (e.g. wheelchairs and bicycles) without scattering. Gravel sources of Crushed Surfacing Top Course (CSTC) provide the correct gradation but the rounded faces don't provide the interlock between particles necessary to minimize scattering. Proprietary products are available that improve the compatibility and or cohesion of native soils.

- **Elevated Wooden Structures:** Two boardwalks are already planned to form common sections for the mountain bike trail and the accessible trail.

- **Extreme Measures:** These include methods familiar to road construction such as ditches and culverts, collection and tight-line, and re-grading. IMBA puts the aforementioned geotextile in this category as well.

TRAIL MAINTENANCE

Continued maintenance of the mountain bike trail will be necessary to maintain the functionality of the trail system, protect the adjacent wetland areas from increased sedimentation due to erosion, and to reduce impacts to slope stability. Maintenance of the trail surface can be minimized by good alignment selection; suitable trail inclination, earthwork and drainage measures; and regular maintenance of drainage measures. The type and frequency of the required maintenance will depend on several factors including trail use, final trail alignment, and inclinations of the trail sections. Steeper trail sections generally require more frequent maintenance than flatter trail alignments.

STRUCTURES

It is our understanding that the prosed trail alignment will require structures to facilitate two wetland crossing and a stairway. Each of these structures will require special geotechnical considerations with respect to foundation support. General design recommendations are provided below. Additional evaluations of these structures should be completed as part of final design of the proposed trail system.

- **Boardwalk Foundations for Wetland Crossings**

  It is our understanding that the proposed trail alignment will require two wetland crossings. These crossings are currently anticipated to consist of elevated boardwalk structures. The depths to bearing soils was observed to be less than 4 feet at both crossing locations. Therefore, we recommend supporting the proposed boardwalk structures on vertically driven pin-piles or on proprietary Diamond Pier® foundations.

  Pin piles are commonly used for support of lightly loaded facilities such as the proposed boardwalk structures. Typically, pin piles come in the form of 2, 3, 4 or 6-inch diameter schedule 80 pipes. These vertical elements generally provide axial load capacities ranging from 2 to 15 tons, depending on the size of pile used. Hammers commonly used for driving consist of hand portable pneumatic jack or breaker hammers, for the smallest pipe sizes, to excavator-mounted pneumatic or hydraulic hammers for the larger sizes. Given the limited access conditions of the two proposed wetland crossings, we would recommend using a pin pile diameter of 2 inches. Two inch pin piles can be driven to an allowable capacity of 2 tons per pile with conventional hand portable jack hammers. The nominal pile capacity of pin pile foundations are normally rated on the basis of pile penetration rate per minute for a specified hammer size and operating energy, but actual capacities are verified by field load testing of a representative number of driven elements.

For the boardwalk structures that are proposed, we anticipate that the pin pile lengths of the order of 10 to 20 feet will be necessary to achieve sufficient resistance and load capacity. It is to be appreciated that given their small diameters, pin piles typically provide very little lateral load resistance, and bracing will need to be employed to mobilize multiple piles and provide suitable structural frame stiffness in the upper parts of the piles. Battering of pipe sections would also provide for greater resistance to lateral loading effects and should be utilized for selected support elements.

As an alternative to pin pile foundations, proprietary foundation systems employing small diameter and short pile sections are locally available. Details and information on one system, referred to as a Diamond Pier® (by Pin Foundations, Inc.) can be obtained from their website: *www.diamondpiers.com*. In general, these foundations comprise precast surface foundation blocks that include four battered sleeves for pile insertion at orthogonal orientation. We understand that the largest pile size employed with this system is nominally 2-inch diameter, and that pile lengths are usually less than about 5 feet. Capacities of this foundation unit are reported to be on the order of 2 tons per unit, but need to be determined by a design engineer during final design.

- **Stair Steps near Jefferson Entry**
  Proposed steps near the Jefferson Entry will descend an approximately 6 foot tall slope to provide access to the mountain bike trail from the accessible trail. The subsurface soils in this area are such that we would expect significant settlement of the stairs structure if founded directly on the subgrades soils. These settlements may be significant enough to cause damage to ridged stair structure over time. If the proposed stairs are to consist of a ridged system, we would recommend that they be founded on pipe pile foundations or the subgrade soils be adequately over excavated and replaced with compacted structural fill prior to construction.

LIMITATIONS

We have prepared this report for ESA and the City of Seattle Parks Department and their agents for use in preliminary design of a portion of this project. It should be noted that this report is based on site reconnaissance and limited subsurface explorations. The conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and may not be detected by a geotechnical study. We expect that additional geotechnical evaluations will be required as the proposed trail system is taken from preliminary design to final design. If, during

LIST OF FIGURES (FOLLOWING TEXT)

Figure 1 Site Plan
Figure 2 Site and Exploration Plan

LIST OF APPENDICES

APPENDIX A **FIELD EXPLORATIONS**

Figure A-1 Legend of Terms and Symbols Used on Exploration Logs
Figures A-2 - A-7 Logs of Hand Holes HH-1 through HH-6

APPENDIX B **FIELD WAYPOINT NOTES**

References:

American Trails Association, (2015). “Trail Design and Construction” http://www.americantrails.org/resources/trailbuilding/Rio-Grande-Trail-Surfacing.html (Jan. 19, 2015)

City of Seattle. (2007) “DPD GIS Web Portal” http://web1.seattle.gov/dpd/maps/dpdgis.aspx (Jan. 6, 2015)

International Mountain Bike Association, (2015). “Designing and Building All Weather Trails” https://www.imba.com/resources/trail-building (Jan. 19, 2015)

King County, (2015). “iMAP – Property Information” http://web1.seattle.gov/dpd/maps/dpdgis.aspx (Jan. 6, 2015)

Troost, K.G., et al, (2005). “The Geologic Map of Seattle – a Progress Report” U.S.G.S. Open-File Report 2005-1206.

Washington State Department of Natural Resources, (2015). “Subsurface Geology Information System” <http://www.dnr.wa.gov/researchscience/topics/geosciencesdata/pages/geology_portal.aspx> (Jan. 6, 2015)

future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA 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, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, express 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 substances in the soil, surface water, or ground water at this site.

This firm does not practice or consult in the field of safety engineering. We do not direct the contractor's operations, and cannot be responsible for the safety of personnel other than our own on the site. As such, the safety of others is the responsibility of the contractor. The contractor should notify the owner if he considers any of the recommended actions presented herein unsafe.

We appreciate this opportunity to be of service.

Sincerely,

HWA GeoSciences Inc.

DONALD J. HULING
STATE OF WASHINGTON
46961
REGISTERED
PROFESSIONAL ENGINEER

Donald J. Huling

for

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Geotechnical Engineer, Principal

Brad Thurber
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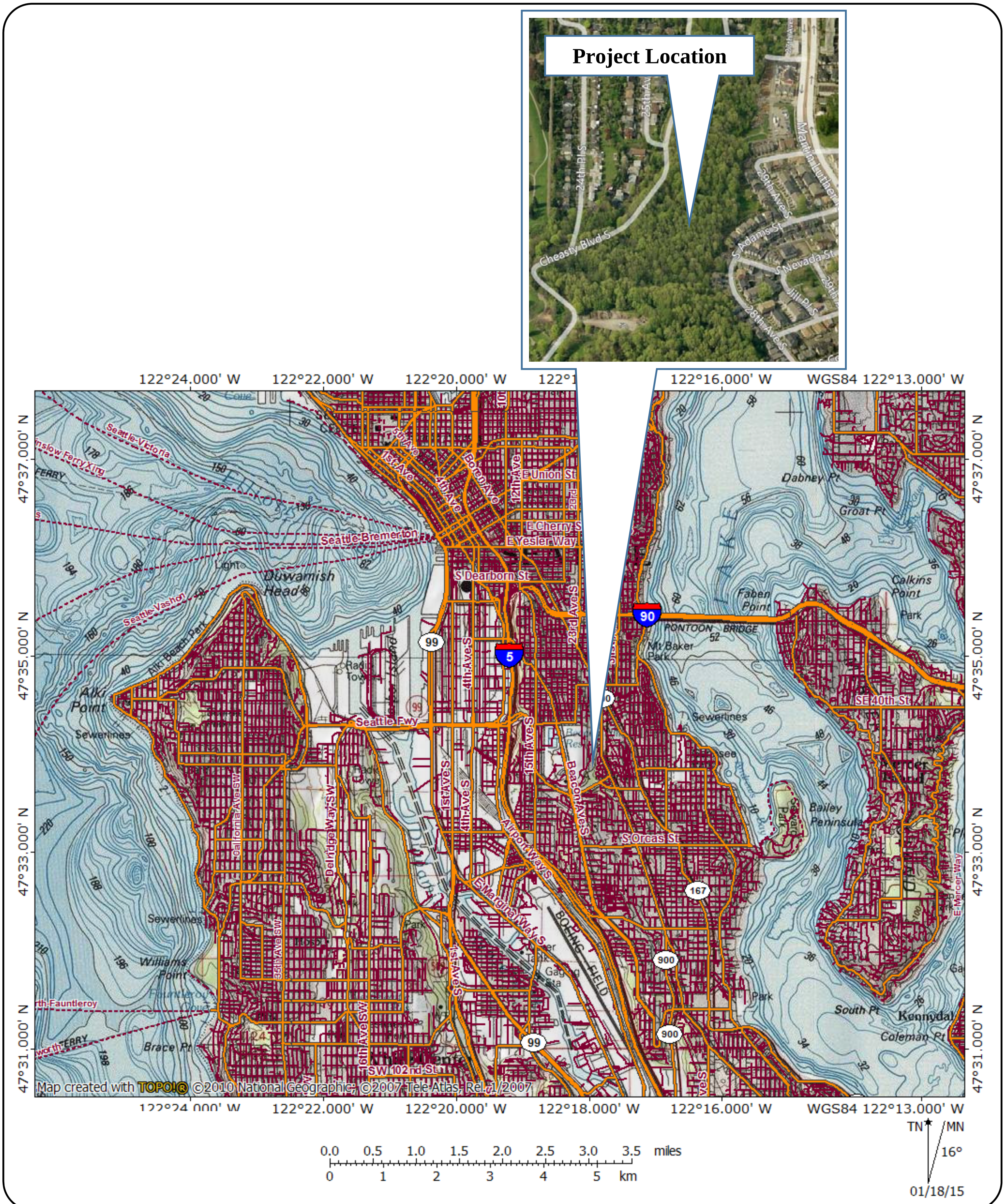


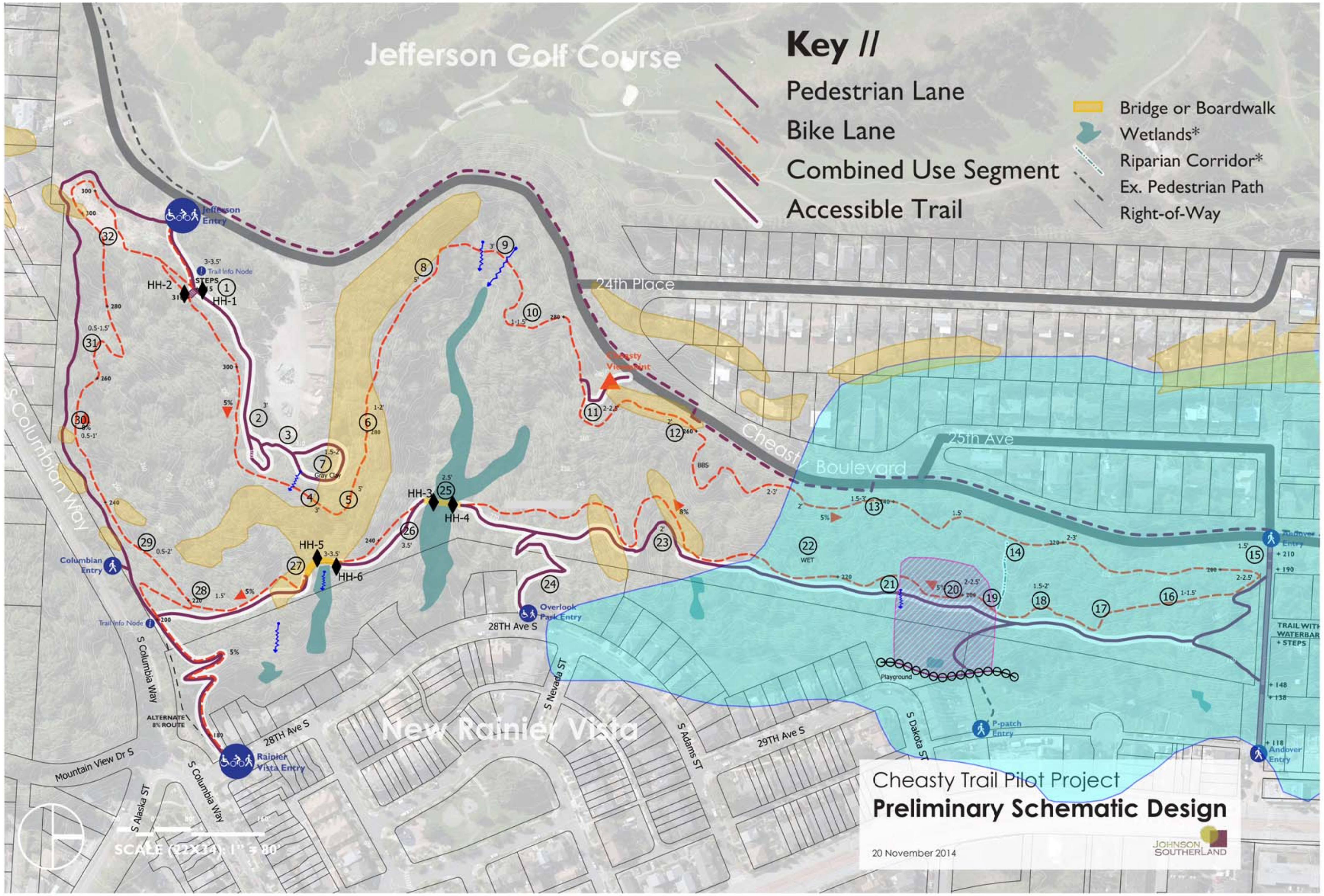
VICINITY MAP

CHEASTY GREENSPACE
MOUNTAIN BIKE TRAIL
SEATTLE, WASHINGTON

HWA GEOSCIENCES INC.

FIGURE NO.
1

PROJECT NO.
2014-177



LEGEND

- (32) Field waypoint (notes in report).
- HH-4 ◆ Handhole designation and approximate location.
- Groundwater seepage and runoff
- Mapped Steep Slope Area
- Mapped Potential Slide Area
- Approximate Area of Observed Slide Features
- 1-1.5' Probe depth, in feet
- Solder Pile wall

0 125 250 375 500

SCALE IN FEET

BASE MAP PROVIDED BY: ESA

HWA GEOSCIENCES INC.

CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL
SEATTLE, WASHINGTON

SITE AND EXPLORATION PLAN

DRAWN BY	FIGURE #
EFK	2
CHECK BY	PROJECT #
DH/BT	
DATE:	
01.16.14	2014-177-21

S:\2014 PROJECTS\2014-P177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL\CAD 2014-177\HWA 2014-177.DWG <Fig 2> Plotted: 1/19/2015 5:53 AM

APPENDIX A
FIELD EXPLORATIONS

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils	Gravel and Gravelly Soils	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
	More than 50% of Coarse Fraction Retained on No. 4 Sieve		GP	Poorly-graded GRAVEL
		Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
More than 50% Retained on No. 200 Sieve Size	Sand and Sandy Soils	Clean Sand (little or no fines)	SW	Well-graded SAND
	50% or More of Coarse Fraction Passing No. 4 Sieve		SP	Poorly-graded SAND
		Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit, LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
PID	Photoionization Device Reading
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
SG	Specific Gravity
TC	Triaxial Compression
TV	Torvane Approx. Shear Strength (tsf)
UC	Unconfined Compression

SAMPLE TYPE SYMBOLS

- 2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
- Shelby Tube
- 3-1/4" OD Split Spoon with Brass Rings
- Small Bag Sample
- Large Bag (Bulk) Sample
- Core Run
- Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

- Groundwater Level (measured at time of drilling)
- Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)

Components are arranged in order of increasing quantities.

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

HWA GEOSCIENCES INC.

Cheasty Trail Pilot Project
Seattle, Washington

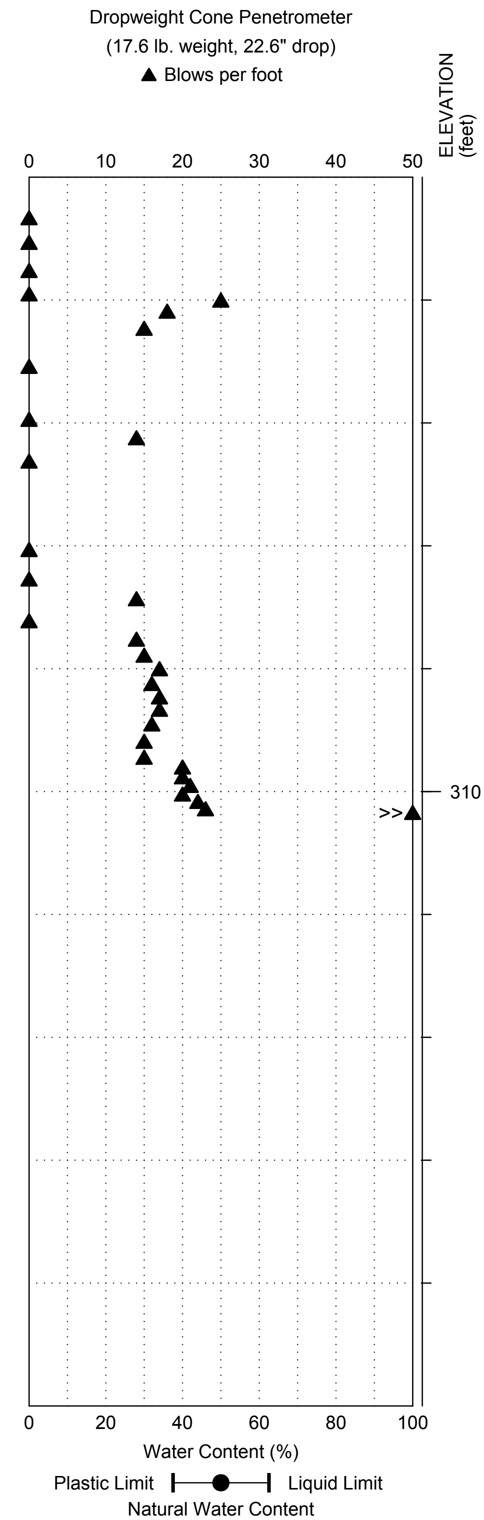
LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2014-177-21 FIGURE: A-1

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl
SURFACE ELEVATION: 315.0 ± feet

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0			Sod.					
		SM	Loose, olive brown, silty SAND, with gravel and woody debris, moist. **(FILL)** Large Gravel.		S-1			
					S-2			
					S-3			
			Soft to medium stiff, rust mottled olive gray, sandy SILT jumbled with brown silty SAND, with organics and traces of wood and charcoal fragments, moist. Loose, red brown, silty SAND, moist.					
5			Loose, dark gray brown, silty SAND, with abundant woody fragments and blackberry vine fragments, moist. Woody odor. **(BURIED TOPSOIL)** Gravels. Peaty odor. Loose, dark gray brown, silty SAND, with soft, yellow brown chunks of SILT, moist.		S-4			
			Hand hole terminated at 5.75 feet bgs on large gravel. No ground water seepage was observed.					
10								



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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Seattle, Washington

BORING:
HH-1

PAGE: 1 of 1

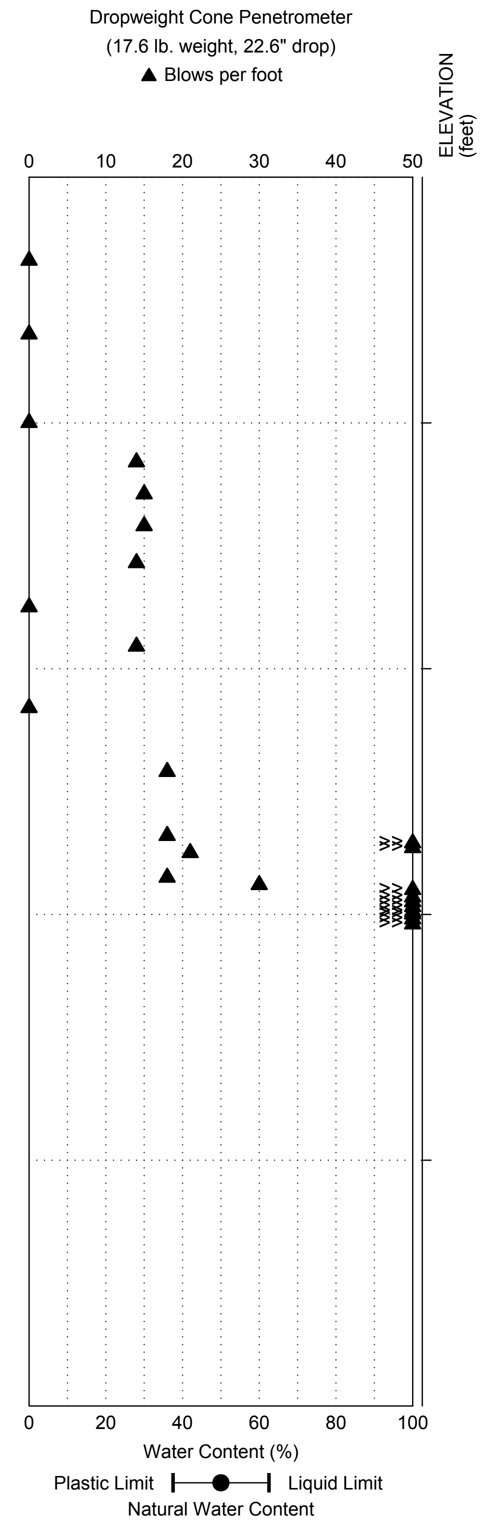
PROJECT NO.: 2014-177-21 FIGURE: A-2

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl
SURFACE ELEVATION: 310.0 ± feet

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER	ELEVATION (feet)
0			Loose, brown, silty, SAND, with gravel and organics, moist. **[TOPSOIL]**		S-1				
		SM	Woven geosynthetic. **[WEATHERED ADVANCE OUTWASH]**						
			Loose, dark yellow brown, silty SAND, with gravel, moist.		S-2				
			Medium dense to dense, rust mottled yellow brown, silty SAND, with rootlets and gravel, moist. Large gravels.		S-3				
		SP SM	Medium dense to dense, olive gray, slightly silty to silty, gravelly, SAND, moist.		S-4				
5									

Hand hole terminated on gravels at 3.25 feet bgs.
No ground water seepage was observed.



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HWA GEOSCIENCES INC.

Cheasty Trail Pilot Project
Seattle, Washington

BORING:
HH-2

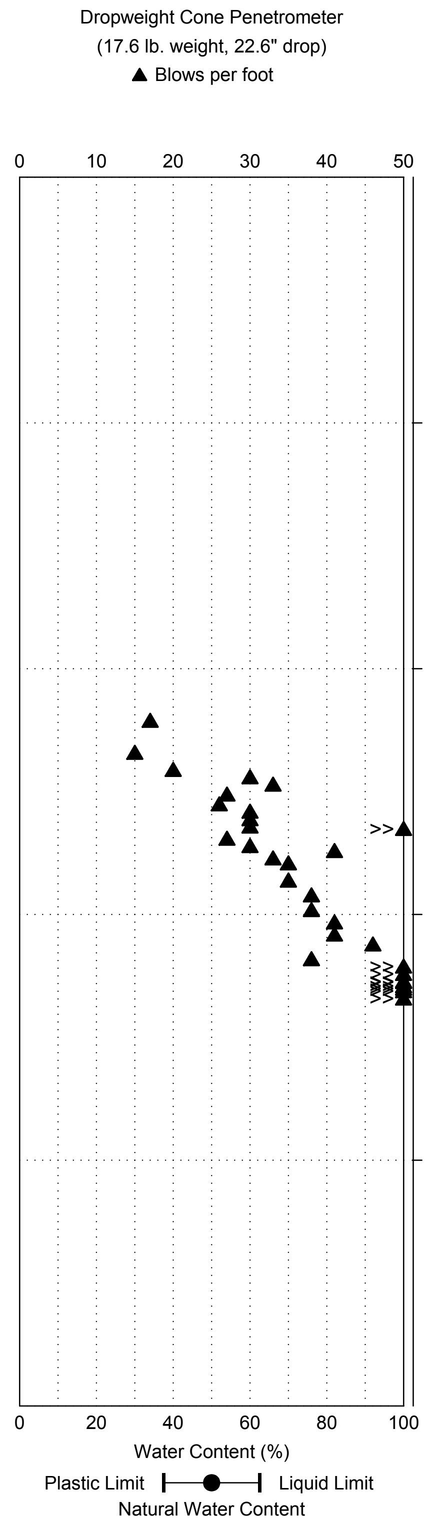
PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-3

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl
SURFACE ELEVATION: 220.0 ± feet

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER	ELEVATION (feet)
0		OL	Very soft, dark brown, ORGANIC SILT, wet. Organic odor. **[ORGANIC SILT]**		S-1				
		SM	Loose, gray, silty SAND, with gravels and dark brown silty pockets, wet. **(COARSE GRAINED ALLUVIUM)**		S-2				
			Grades medium dense to dense.						
			Hand hole terminated at 3 feet bgs on gravels. Ground water at ground surface.						
5									



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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Cheasty Trail Pilot Project
Seattle, Washington

BORING:
HH-3

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-4

BORING-DSM 2014-177.GPJ 1/19/15

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl
SURFACE ELEVATION: 220.0 ± feet

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER	ELEVATION (feet)
0		OL	Very soft, dark brown, ORGANIC SILT, wet. Organic odor. **(ORGANIC SILT)**						
		SM	Loose, gray, silty SAND, with gravels and dark brown silty pockets, wet. **(COARSE GRAINED ALLUVIUM)** Caving.					▽	
			Hand hole terminated at 2 feet bgs on gravels. Ground water seepage observed 1 foot bgs.						
5									

Dropweight Cone Penetrometer
(17.6 lb. weight, 22.6" drop)
▲ Blows per foot
0 10 20 30 40 50

0 20 40 60 80 100
Water Content (%)
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Trail Pilot Project
Seattle, Washington

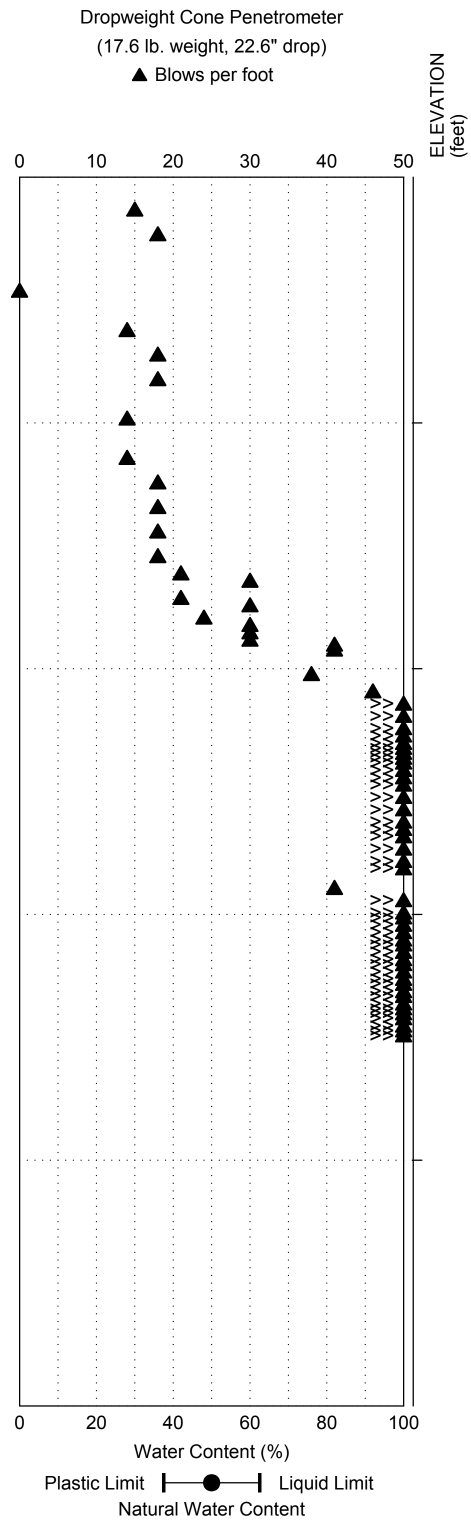
BORING:
HH-4

PROJECT NO.: 2014-177-21 FIGURE: A-5

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl
SURFACE ELEVATION: 260.0 ± feet

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SM	Loose grading to dense, brown, very silty, gravelly, SAND, with roots, moist. **[COLLUVIUM]**		S-1			
		SM	Grades to light olive brown color with rust mottling. **[WEATHERED TILL]**		S-2			
					S-3			
		SM	Grades less moist. Rust mottling absent. **[GLACIAL TILL]**					
			Hand hole terminated. Hard digging. No ground water seepage observed.					
5								



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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BORING:
HH-5

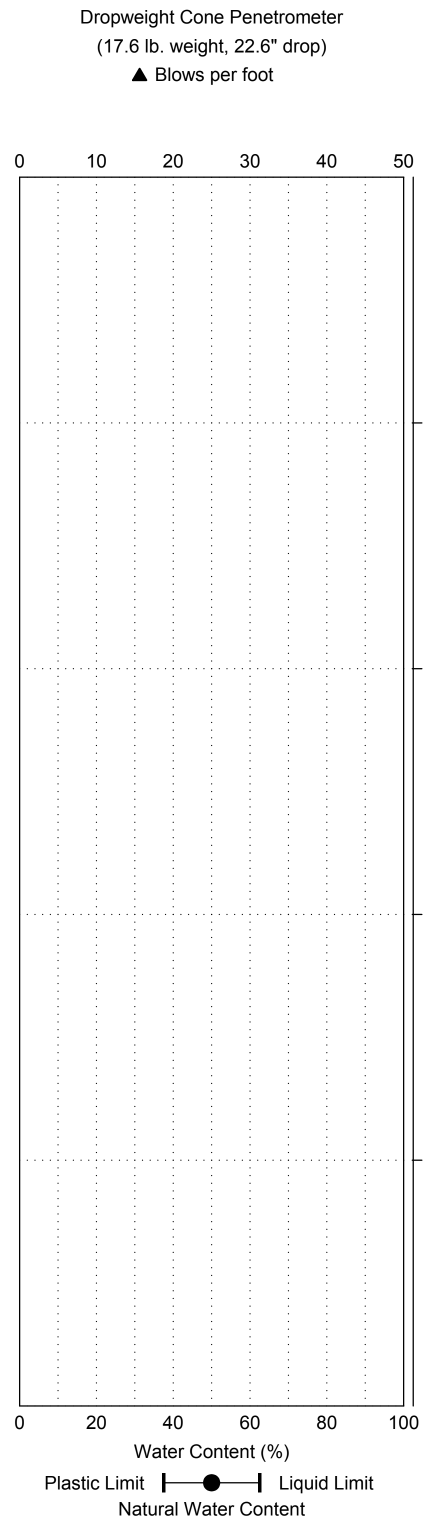
PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-6

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl
SURFACE ELEVATION: 230.0 ± feet

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER	ELEVATION (feet)
0		SM	Loose, brown, very silty, gravelly, SAND, with roots, moist. **(COLLUVIUM)**						
		SM	Loose, light yellow brown, silty, fine to medium SAND, with gravels, moist. **(WEATHERED TILL)**						
					S-1				
					S-2				
			Grades to medium dense, olive brown, silty, fine to medium SAND, moist.						
			Becomes wet, rust mottled.						
			Hand hole terminated at 4 feet bgs on gravels. Ground water seepage observed at 3 feet bgs.						
5									



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Trail Pilot Project
Seattle, Washington

BORING:
HH-6

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-7

APPENDIX B
FIELD WAYPOINT NOTES

Appendix B
Field Waypoint Notes

Specific field observations are noted below, by waypoint as numbered on Figure 2.

1) Proposed staircase, at the edge of an obvious fill area. The slope is up to 1H:1V and approximately 6 feet high in vicinity of proposed stairs. The soils probed 2 to 2.5 feet at the toe and up to 3.5 feet at the crest.

2) Materials yard / promontory, SE crest of slope: Slope is 1H:1V and steeper; up to 25 feet high. Ground at toe and mid-slope probe 3 feet. Proposed trail route is relatively flat-lying to gently rolling terrain, beyond the promontory slope toe.

3) Storm pipe down 1:H1V slope, down from materials yard. Pipe discharge feeds small ravine straight out from eastern tip of promontory. Some Ecology blocks containing materials at crest of promontory lean out approx. 15 to 20 degrees – likely due to soft fill at crest with materials pushed up to blocks.

4) Probes approx. 3 feet. Loose, brown, silty, fine gravelly SAND, moist. No topsoil.

5) Steep Slope critical area: Probes up to 5 feet. Vegetation is bigleaf maple, sword fern, huckleberry. Maples not swayed.

6) (Steep Slope criticial area, continued): Soil at surface is gray, sandy CLAY, moist, in 5-foot wide area that looks like slough from 25 feet upslope from the terrace above, where it covers the ground and is an obvious fill. A cut made by shovel, it appeared, was up to 3 feet high in this material, with minimal sloughing. Probed 1 to 2 feet.

7) Proposed accessible trail small loop on terrace: Probes 1 to 2 feet; at surface is gray CLAY, moist (Fill). Within native vegetation restoration area (burlap bag surfacing and tree / shrub replantings).

8) Probes 5 feet; brown, slightly gravelly, silty SAND, moist.

9) Head of stream valley (East wetland / riparian area). Standing water. Probes 3 feet; loose, brown, silty, slightly gravelly SAND, wet.

10) “Ridgelet”; probes 1 to 1.5 feet. Bigleaf maple, sword ferns, salmonberry (the latter indicating wetter soils). Some maples are swayed or leaning downslope.

11) Proposed Cheasty Viewpoint: On a “ridgelet”. Probes from 1 to 2.5 feet. No sloughing evident on side slopes.

12) Slope below Cheasty Blvd is approx. 1.5H:1V to 2H:1V for approx. 10 foot height, then is shallower downslope.

13) Steep road embankment across from 25th. Approx. 8 feet high at 1H:1V and steeper. Obvious embankment fill, as slope immediately below is shallower (3H:1V and less). Probes 3 feet. Maples, Indian plum, salal, sword fern.

14) 8” ADS storm pipe (at mapped riparian zone). Surface soils not wet. Vegetation similar as noted at #13, and all the way to the north end of greenspace.

15) NW corner of greenspace property, S. Andover St alignment.Powerlines and a casual trail extend east along the northern property line.

16) Probes 1 to 1.5 feet; loose, brown, slightly gravelly, silty SAND, moist. Typical soil as observed starting beyond fill at #7. Bigleaf maple, one 14-inch diameter cedar, Indian plum, sword fern.

17) West of Lilac St end. Probes 3 feet. Slope is generally 4H:1V, with 3H:1V in spots.

18) Drainage swale; no surface water. Probes 2 feet in swale, 1.5 to 2 feet on slope to south.

19) 8-inch corregated ABS plastic pipe. Abundant blackberries in approx. 100-foot across area. Some sword ferns surviving beneath.

20) In line with driveway at south end of P-patch: Probes 2 to 2.5 feet typically, and one spot to 4 feet. Brown, silty SAND with scattered gravel, moist.

LANDSLIDE SCARP, LOWER: Located 50 feet or more above solider pile wall. Approx. 1 to 2 feet high, at least 45 feet long and curving. Face of scarp appears partly raveled and is moss-covered, indicating it is at least several years old. There are standing maples and alders in this vicinity, no bare soils. Apparent south end of scarp curves eastward toward soldier pile wall below. Soil above scarp probes to 1.5 feet. Soil below scarp probes 2 to 3 feet. Scarp soil: Loose, brown, slightly gravelly, silty SAND, moist (Colluvium).

LANDSLIDE SCARP, UPPER: At approx. 50 feet upslope from lower scarp. Also 1 to 2 feet high, and is discontinuous and subtle. Appears more moss covered and therefore older than the lower scarp.

21) Seepage / runoff, in line with northern yards along Dakota St.

22) Low area with blackberries; just upslope from proposed trails.

23) Probes 2 feet.

24) Viewpoint Park. Stormwater drainage flowing through concrete viewing structure.

25) Stream (mapped northern wetland / riparian area): Proposed boardwalk to cross stream / wetland. Probes 2 to 2.5 feet in dark brown, organic, sandy SILT, wet (Alluvium) terminating in medium dense to dense sand, along 40 to 50 foot transect of wetland. Stream channel is up to 2 feet wide, incised up to 6 inches deep in the dark brown sandy silt, probes 2 feet to medium dense gravelly sand.

26) Probes up to 3.5 feet. Loose, brown, slightly gravelly, silty SAND, moist (Colluvium).

27) Stream (southern wetland / riparian area): Surface soils very wet; ground water seepage “bowl” area approx. 50 feet in diameter, becomes narrower riparian zone downslope. Probes 3 to 3.5 feet in dark brown, organic, sandy SILT, wet, terminating in medium dense sand and gravelly sand. Edges of bowl are oversteepened for approx. 3 to 6 foot height, at approx. 1H:1V. This appears due to slope retreat from ground water seepage. Slopes above the oversteepened portion do not who evidence of sliding and are shallower, generally at 3:H1V and less.

28) At ridge “corner” with house lots and Columbian Way. Probes approx. 1.5 feet.

29) From #28 to here: Bigleaf maple, Indian plum, salal, Oregon grape, sworde fern, holly. Probes 0.5 to 2 feet. Brown, gravelly, silty SAND, moist. Gravel shows on surface in casual footpath.

30) Fairly flat area. Probes 0.5 to 1.5 feet. Cottonwoods to 30-inch diameter, and salmonberry indicate wetter soil conditions, probably from ground water seepage.

31) Restoration area; proposed switchback. Probes 0.5 to 1.5 feet.

32) Gently sloping top of slope, adjacent to Cheasty Blvd. Restoration plantings in fill area – 8 to 10 foot high fill embankment for trail to cross; 1H:1V at steepest.