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GEOTECHNICAL ANALYSIS AND REPORT

Prepared For Christopher Clegg & Nancy Slough
November 2012

For the Property Described As
Jefferson County Tax Parcel # 601102012

Northwest Quarter of Section 10, Township 26 North, Range 1 West, W.M.
Jefferson County, Washington

Prepared By:
Trent T. Adams, EIT
Steve S. Luxton, PE

NTI ENGINEERING & LAND SURVEYING
717 South Peabody Street
Port Angeles, WA 98362
Phone: (360) 452-8491 Fax: (360) 452-8498
Email: info@nti4u.com
Website: www.nti4u.com

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NORTHWESTERN TERRITORIES, INC.
717 SOUTH PEABODY STREET, PORT ANGELES, WA 98362
Engineers □ Land Surveyors □ Geologists
Construction Inspection □ Materials Testing

Phone (360) 452-8491 1-800-654-5545 Fax 452-8498 E-Mail: info@nti4u.com

November 20, 2012

Christopher Clegg & Nancy Slough
11215 2nd Avenue NW
Seattle, WA 98177

Subject: Geotechnical Report for Tax Parcel # 601102012, 915 Kens Way, Quilcene, WA. Located within the Northwest Quarter of Section 10, Township 26N, Range 1W, W.M., Jefferson County, WA

Dear Mr. Clegg and Others Concerned,

SUMMARY OF FINDINGS

We believe that the proposal to construct a single family residence at the subject waterfront site will pose no unreasonable threat to persons or property nor lead to a decrease in slope stability if the recommendations of this report are thoughtfully observed.

1.0 BACKGROUND AND SCOPE OF WORK

NTI Engineering and Land Surveying (NTI) was requested by property owner, Mr. Christopher Clegg, to perform a geotechnical analysis and report concerning Jefferson County Parcel # 601102012. The property lies in the Northwest Quarter of Section 10, Township 26N, Range 1W, W.M., on the Toandos Peninsula near Coyle, Washington.

Jefferson County mapping lists the parcel as having a "slight" to "high" geologic hazard due to a steep marine bluff and mapped land-sliding on the marine bluff to the west facing Dabob Bay. In Jefferson County building setbacks from the rim of marine bluffs are required to be determined by a geologist or geotechnical engineer with experience in assessment of geologic hazards. The County also requires that undisturbed vegetative buffers be defined and delineated for each site that adjoins a steep slope or bluff.

Mr. Clegg plans to use the parcel to develop a single family residence so attention was given to positioning the house with respect to the marine bluff. Additional work was carried out to determine foundation design parameters for the proposed structures. Work also included recommendations on drainage of stormwater and a brief assessment of the proposed location for wastewater facilities upslope of the proposed house site.

2.0 SITE DESCRIPTION

The site is located at 915 Kens Way, approximately 0.6 miles west of its intersection with Old Coyle Road, southeast of Quilcene, Washington. Note the map of the parcel and its relationship to Kens Way below in Figure 1.

A driveway extends from the eastern property line approximately 250 feet to the west, with a downward slope to the west at approximately 15 to 20 degrees from horizontal. Beyond the driveway, within the middle one third of the site, much of the area has been cleared of trees and is now vegetated mostly with grass and shrubs.

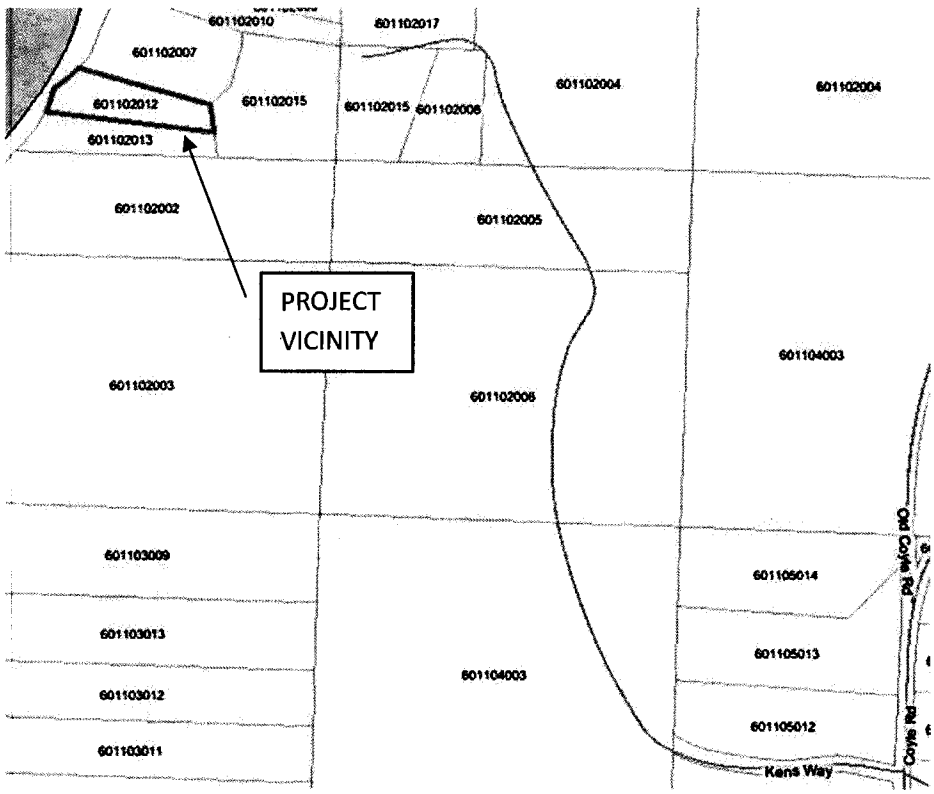

FIGURE 1 – VICINITY MAP OF SITE

At this site, the marine bluff is approximately 100 feet in height with steep, but variable slopes ranging from 40 to more than 60 degrees from horizontal. The bluff is moderately vegetated in mature Douglas fir trees and alder trees with an understory of shrubs and many sword ferns.

3.0 SITE GEOLOGY AND THE SOILS AT THIS SITE

3.1 Surficial Soil Types

The Soil Conservation Service (SCS) Soil Survey classifies the local soils as follows:

LOCATION

The upper third of the property as	Cassolary-Kitsap complex
The middle third of the property as	Dabob very gravelly sandy loam
The lower third of the property as	Cassolary sandy loam

According to the SCS, The Cassolary-Kitsap complex soils (noted as CkC below) were formed in a combination of reworked glacial and marine sediments on upland terraces. Runoff of the soil is listed as slow to medium and the hazard of water erosion is moderate. This soil is listed as moderately well drained to well drained. Permeability is said to be moderately slow to slow.

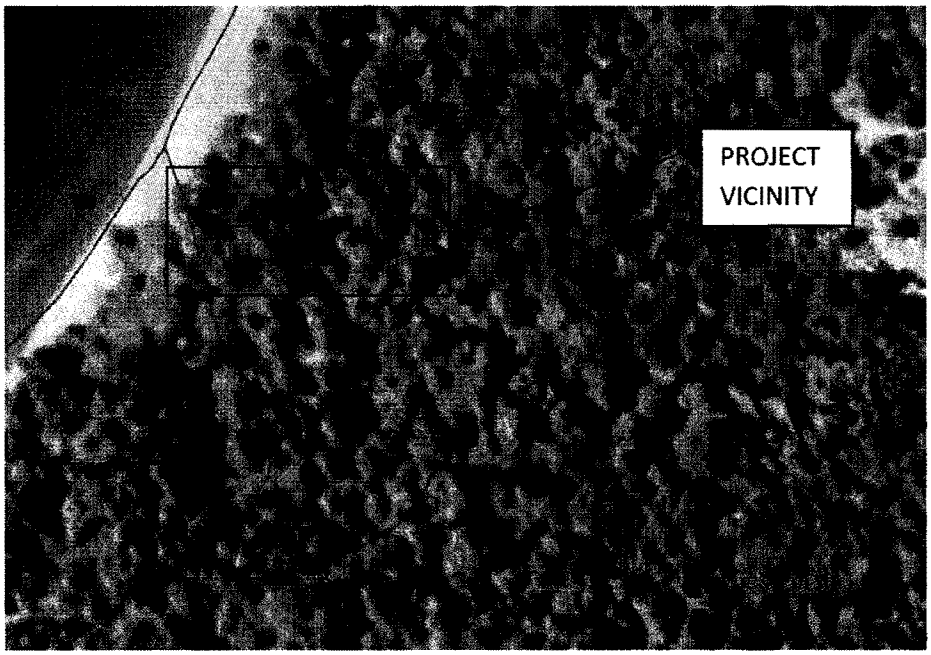

FIGURE 2 – SOIL TYPES AT THE SITE (SOIL CONSERVATION SERVICE)

The Coastal Zone Atlas of Washington (Department of Ecology) and other geologic mapping describes the soil in the area of the property as Pre-Fraser undifferentiated glacial deposits (Qpf).

3.2 Field Observations at the House Site and the Bluff's Geology

Field observations confirmed the presence of the Cassolary Kitsap gravelly sand at the proposed house site. These gravelly sands were deposited as advance outwash of the Vashon Glaciation about 15,000 to 20,000 years ago. Warping of the bedding of gravel seams in the sandy outwash suggest that these deposits have been reworked by repeated glacial retreats and advances and by very slow slumping to the west.

The lowest portion of the bluff contains pre-Vashon sediments as suggested by the Coastal Zone Atlas. (Cassolary sands were not observed below the proposed house site.) Dense pre-Vashon cemented

gravel with silt was examined in an outcrop at the toe of the bluff directly below the house site. Other exposures near the toe of the bluff displayed dense pre-Vashon gravelly silt.

Directly below the house from about 20 to 70 feet above high water at the beach, a colluvium of loose gravelly sand and slide debris covers the slope. The slide debris has a slow, but persistent downslope motion (creep) as a result of cyclic water saturation and frost heave, but deeply rooted trees have found more stable materials at depth. At about 75 feet above the beach, a 10 foot high head-scarp marks the cusp of a recent slide event on the bluff. The head-scarp provided an exposure of the underlying gravelly sand with silt that was moderately dense at the surface outcrop.

Additional observations were made along a beach access track/trail lying a few hundred feet south of the critical bluff section below the proposed house site. Exposures of soil in the old road cuts showed a variety of consolidated earth materials including silty gravels, weathered siltstone similar in appearance to Twin River siltstone and dense gravelly silt. The dense and stable condition of these sediments suggests that all of these older deposits were over-ridden and consolidated by earlier glaciers.

3.3 Other Geotechnical Indicators Regarding the Bluff

Field work included a reconnaissance of the nearby region on the north and south of the subject property along the bluff's rim. No large block slides or deep seated rotation slides were noted in a traverse of about 800 feet to the north along a trail linking the several cottages and houses there. Foundations of those structures did not show cracks that would have occurred if soil motion was in progress.

No large slides were observed on the south although some slumping was evident in the upper and lowest part of the sandy soils along the old road cut south of the site. Side looking radar images (lidar) of the region do not show evidence of larger scale soil motion.

Exposure of the bluff's toe to wind-driven longshore drift at Dabob Bay is moderate at the site. The backshore area has formed into a broad sandy beach. The accumulation of sand at this reach of shoreline suggests the toe of the bluff is not heavily scoured by longshore drift here. There was no significant over-steepening of the toe of the bluff below the proposed house site due to the protection provided by the backshore beach below the proposed site. No zones of excessive ground water seepage or springs were evident on the bluff or in the vicinity.

A natural drainage swale crosses the southerly part of the subject property. Drainage from that swale has not resulted in significant erosion at the bluff. This suggested that the site is not wholly underlain by the unconsolidated sand found in test pits at the proposed house site.

3.4 Conclusions Concerning Bluff Stability and Landslide Hazard

Due to the relatively high strength of the pre-Vashon deposits which appear to underlie the bluff and the apparent absence of exess groundwater, this site appears to be free from large and dangerous rotational slides that can produce instabilities far from the bluff's rim.

A significant translational slide occurred on the bluff directly below the proposed house site in recent years. Slide debris from that event is still in motion on the slope. This slide has over-steepened a section of the bluff about 75 feet above the beach to a near-vertical condition. As a result of this geometry, the

uppermost part of the bluff appears to be vulnerable to a sudden translational slide. Such a slide event could result in a 30 foot adjustment of the bluff's rim, bringing it back roughly to the line of an existing narrow path.

Once such a slide occurred, there would probably be a long interval of erosion before another slide advanced into the property due to the only moderate rate of talus scouring at the bluff's toe. The bluff is too steep and too active to support a trail to the beach.

3.5 Recommendations on Bluff Setback and Landslide Hazard Buffer

A total setback of 85 feet from the steel fence post set on the north line of the parcel to the nearest line of the permanent foundation is recommended. Additional setback for improved safety and peace of mind is desirable at this site. Light exterior decks may extend another 16 feet toward Dabob Bay within that recommended setback.

Due to the erosional mechanisms occurring here, an undisturbed vegetated buffer can add significantly to the stability of this bluff and add to the life span of the proposed house at this site. Fir and cedar trees on the slope and those at the slope's rim make important contributions to the stability of the uppermost section of the escarpment and they should be protected.

An undisturbed buffer of native plants should be established in a zone that is 50 feet in width from the rim of the bluff at this parcel. Evergreen huckleberry has done well at this site and it is an attractive and useful plant for erosion control that could be planted in the previously disturbed portion of the buffer within the parcel. This slope and buffer area will support additional Douglas fir trees and they could be added to provide a significant enhancement to long-term slope stability. The buffer and the slope itself should remain naturally vegetated and undisturbed except for the possible planting of additional native plants.

To encourage the long-term recognition of the landslide hazard buffer, the boundary of the buffer area should be marked with a permanent physical separation. This buffer separator might consist of logs, a row of trees, a hedgerow of shrubs, a low fence, or other prominent physical marking.

4.0 GEOTECHNICAL EXPLORATION

4.1 Scope of Foundation Subsurface Exploration

Test pits were dug and logged at the proposed building site to provide foundation design parameters. Three test pits of up to 5 or 6 feet in depth were excavated at the site. An operator with a min-excavator was tasked with excavating the soils to expose the subsurface conditions for analysis. Soil was also examined at the wastewater drainage test pits about 100 feet northeast of the building site.

4.2 Test Pit Excavation

Three test pits were excavated at the subject property within the vicinity of the proposed single family residence (Figure 3). Excavation was performed to a depth of approximately 6 feet, where a laer of dense gravelly sand was observed.

FIGURE 3 – EXCAVATION OF TEST PITS

4.3 Test Pit Soil Observations

Data from the three test pits at the subject property showed the following generalized soil section in the uppermost 6 feet:

SOIL PROFILE AT THE PROPOSED HOUSE SITE

DEPTH		SOIL OBSERVED
Upper 12 inches	-	Loose, dark brown, gravelly **sand loam**
12 inches to 2.5 feet	-	Loose, orange-brown, gravelly **sand** with silt and clay
2.5 feet to 6 feet	-	Loose to medium dense, brown, gravelly **sand** with silt
Below 6 feet	-	Increasingly dense, brown, gravelly **sand** with silt

4.4 Occurrence of Groundwater

The geotechnical exploration was performed on November 14, 2012 near after a prolonged summer drought at the beginning of the wet season. Groundwater was not encountered during site exploration. However, soluble iron water stains in Test Pit #1 suggested a seasonal high water table at 4 feet in depth down from the ground surface.

5.0 FOUNDATION RECOMMENDATIONS

5.1 Preparation of Subgrade Soils

Excavation for footings should be at least 3 feet in depth, so that footings will be placed on the medium dense layer of gravelly sand at that depth. Prepare footing substrate by energetic compaction of the sandy soil. If wet or soft soils are encountered, notify the undersigned Engineer.

5.2 Recommendations for Foundation Design

The sloping terrain at the location of the proposed single family is well suited for construction of daylight basement structures. This design gains from the depth of footing embedment and anchorage at the back line of the structure where the soil is the most stable and dense.

Continuous footings to carry the foundation loads should be installed to a depth of at least 3 feet below the existing ground surface. Footings at least 2 feet in width placed on soils prepared as described above at depths of 3 feet or more may be designed using the criteria below.

5.3 Recommendations for Soil Bearing Capacity

DESIGN PARAMETERS FOR FOUNDATIONS

Soil Description	-	Loose to moderately dense gravelly sand
Soil Unit Weight	-	At least 110 pounds per cubic foot
Vertical Bearing Capacity	-	2,500 pounds per square foot
Lateral Bearing Capacity	-	150 PSF Per Foot of Depth
Coefficient of Friction	-	0.25
Expected Differential Settlement	-	Less than 1" for footing subgrade prepared as noted

Daylight basements of concrete should be fully waterproofed on the outside and carefully inspected during construction. Foundation drain pipes should not be installed carelessly with up and down runs. Instead, foundation drains should be installed below any floor or crawlspace ground level and they should have a straight-line lay with a continuous fall to daylight. This work should be inspected.

6.0 STORMWATER AND TREATED WASTE WATER MANAGEMENT

6.1 Site Classification under Puget Sound Stormwater Regulations

Stormwater management in Jefferson County is regulated by the 2005 Stormwater Management Manual for Western Washington, issued by the Washington State Department of Ecology. Under the manual's guidelines for stormwater management, this project falls under the criteria for "New Development". The proposed 1,500 square-foot single family residence and an approximately 4,300 square foot driveway leads to a total of 5,800 square feet of new and or replaced impervious surface.

This meets the criteria of a "medium" project, and thus Minimum Requirements #1 through #5 that are described in the manual should be implemented. Planning documents for stormwater management are provided in the Appendix of this report. An engineered drainage and erosion control plan should be prepared by a licensed professional to address these requirements. NTI can complete the above-mentioned requirements for stormwater management, if requested.

To reduce slope stability hazard, the driveway at site might be cross graded so that the runoff from the driveway is routed to the south to an existing swale and drainage route. Runoff reaching that swale might be detained by a series of drainage check dams for stormwater detention and some biofiltration along the route thus reducing erosion and impacts.

6.2 Drainage Facilities

Observations of the sandy soils show that there is significant soil saturation at times and treated wastewater infiltration will add to the volume of shallow groundwater. With consideration to the shallow groundwater table, the site is suited for either downspout dispersion trenches or a drainage tightline to the bluffs toe to manage stormwater runoff. These options are discussed below.

6.2.1 Downspout Dispersion System

To reduce the hazard of slope instability and to reduce stress on the slopes below, the construction of a downspout dispersion system using gravel-filled trenches is feasible. The dispersion method slows down the entry of runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits. From the outlet of a dispersion trench, a vegetative flow path of at least 50 feet of undisturbed native landscape would be necessary.

6.2.2 Drainage Pipe To The Bluff's Toe Recommended At This Site

To reduce the hazard of slope instability and to reduce stress on the slopes below, the construction of a storm drainage pipe to the toe of the slope is recommended. A fused (field welded) polyethylene pipe with high tensile capacity can be set up to provide a permanent drainage route for stormwater from rooftops and exterior paved areas adjoining the house.

6.3 Treated Wastewater Management

We recommend that all wastewater system components and drainfields be at least fifty feet from the rim of the bluff, well behind the slope buffer.

The proposed site for the drainfield lies at the northeast portion of the parcel about 100 feet east of the house. That site is free from geologic hazards in our opinion. Our observations suggest that there is sufficient soil and infiltrative capacity there to sustain a treated wastewater drainfield and the position of the drainfield, far from the bluff's rim, is desirable.

7.0 OTHER RECOMMENDATIONS

Avoid underground water pipes that may be broken leading to large discharges of water to the soil that could lead to bluff instability. The use of 200 pound per square inch pressure rated polyethylene black

pipe for water service is suggested. That pipe has substantial tensile capacity and it will not easily split or crack.

8.0 LIMITATIONS

This report applies only to the described property and it is for the exclusive use of the owners for development guidelines relating to the planned residential development at the time of the report. The site analysis and development recommendations of this report are not transferable to the adjoining or nearby properties.

This report is based upon surface and a few subsurface observations of the site and the adjoining areas. The limited study was done without the benefit of deep borings or careful measurements taken over time. Recommendations contained in this report are based upon site conditions as they existed at the time of our site exploration, and available records and data from NTI and public sources.

During construction, if subsurface or other conditions are discovered that are significantly different from those described in the report, NTI should be advised at once so that we can review the conditions and reconsider our recommendations. Unanticipated soil conditions are commonly encountered on sites containing complex glacial or fluvial geology. Such unexpected conditions may require that additional expenditures be made to attain a properly constructed project. We recommend that a contingency be established in the project budget and schedule to cover unexpected conditions.

Within the limitations of scope, schedule and budget, this report, the related field work and the recommendations herein were conscientiously completed in accordance with the principles of geotechnical science and in conformance with the professional practice of engineering. NTI provides no other warranty, neither express, nor written, herewith.

Please contact NTI Engineering & Land Surveying if you have any questions regarding the content of this report.

Sincerely yours,

STEVE S. LUXTON
STATE OF WASHINGTON
23767
REGISTERED
PROFESSIONAL ENGINEER

Steve S. Luxton, PE
Senior Geotechnical Engineer

Trent T. Adams, E.I.T
Project Manager