SUBSURFACE INVESTIGATION TO DETERMINE IF IN FACT THE PROPOSED NEW RESIDENCE AT 200 39TH AVENUE NE IS IN A LANDSLIDE HAZARD AREA

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This report presents the results of our investigation to evaluate the subsurface soil profile at the proposed location of the new residence for Tom Castle and Mary Goodfellow to be constructed at 200 39th Avenue NW in Thurston County, Washington . The soils information obtained in this exploration and information presented in previous reports prepared by this firm for this project have been used to present our opinion on the site being a landslide hazard based on geotechnical evaluation.

We have reviewed the proposed development plan for the residence prepared by David Reed Cahill, AIA, the project architect. We have also reviewed the information presented in the Site Plan and Topographic Survey, Drawing ST1 and drafted September 17, 2010. Our interpretation of the proposed site development for the new residence is that the upper level will be constructed at grade with the top of slope. Two levels below the upper level will be constructed by excavation into the slope to create daylight basements and to earth shelter the two lower levels.

We have prepared two previous documents addressing geotechnical conditions for this project. Our first document is our 1 December 2008 report addressing the stability of the marine bluff and proposed location of the new single family residence. Our second document is our 12 October 2010 letter addressing comments from Thurston County Resource Stewardship Department.

The existing marine bluff on this property does not influence the proposed construction. The new residence will utilize an existing natural slope behind the 2:1 line as measured from the toe of the marine bluff. The 50-foot setback line from top of the marine bluff will not be encroached by the construction.

The discussion of site geology, erosional processes, and recommendations presented in our 1 December 2008 report are considered still to be valid.

Subsurface Conditions

The construction of the new residence will be on the slope above the marine bluff. This slope has an average slope angle of about 30 degrees. This slope angle is consistent with

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the topographic survey of the property. On 10 November 2010, we explored the subsurface conditions by a test boring located 23 feet north and 8 feet west of the northwest corner of the existing concrete slab, about the new entry area into the residence. This exploration was made using a continuous-flight, hollow-stem auger to advance the borings and to provide borehole support between sampling intervals. Samples were obtained at standard intervals using a two-inch outside diameter, split-spoon sampler driven by a pin-guided, 140-pound weight free falling 30 inches

The blows per six-inch interval were recorded. The first six-inch drive interval is allowed for seating the sampler. The blow counts for two six-inch intervals, when combined, yield the Standard Penetration Resistance (N-value) of the soils encountered in the sample interval. The number of blows required to drive the sampler the last 12 inches provides a measure of the relative density of granular soils or the consistency of cohesive soils. When the number of blows exceeds 50 for a six-inch or less advancement of the sampler, refusal is inferred. The results obtained from the Standard Penetration Test, along with other tests and geotechnical judgments, were used to develop the recommendations of this report.

You will note in the boring log, that below the Vashon outwash, all samples developed refusal within the first 6-inch drive of the sample. The exploration was drilled using an equivalent to a Mobil B-61 drill. By the time we had drilled to the minus 40 foot sample interval, we were at effective refusal for advancement of the auger.

Two soil units were found in the exploration. The upper about 8 feet are very dense sandy gravels of the Vashon recessional outwash deposits. These are fluvially deposited soils onto the Vashon recessional outwash plain. Below the outwash soils and extending for the full depth explored is very dense, cemented, overconsolidated subglacial till. We did encounter a thin lens of silty sandy gravels in the minus 25 foot sample interval between the till. In that the advance of the Vashon lobe of the Cordilleran glacier was not uniform, lenses of outwash soils are found in the till.

No ground water, seepage, or damp soils were observed in the boring. There was no indication of water or damp soils in the cutting returned to the surface. Ground water then is not present in the bearing soils. There may be seepage encountered during construction at the contact of the permeable outwash soils and the impermeable till. This seepage is not considered to have a destabilizing influence.

Landslide Hazard

The Vashon subglacial till is overconsolidated and cemented. When soils are overconsolidated, the void ratio, the ratio of soil to air, is greatly reduced. This brings the soil particles into dense packing and makes the sliding of the soil grains past each

other more difficult. The cementing of the soils also reduces the void ratio by filling air gaps with fine soil particles. A discussion of the effect of overconsolidation is presented in *Soil Mechanics in Engineering Practice*, third edition by Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri, a standard reference textbook. A discussion of overconsolidation and its effect on the angle of internal friction is also presented in Joseph E. Bowles, *Foundation Analysis and Design*, 3rd edition. This is also a standard and widely used reference textbook.

Two major types of landslides mechanisms are discussed. These processes are different from the thin wedge failures common to the marine bluff. One type of major landslide is a rotation type of failure. These typically develop when we find a stiff or firm soil profile over a hard stratum. The usual triggering mechanism is ground water. This soil profile does not exist in the proposed building area. The second major type of landslide occurs in stratified deposits where the soil profiles have dipping beds, usually towards the toe of slope. This sliding develops when competent soil material slides on strata of low strength materials. Usually this sliding is related to saturation of the low strength material and/or removal of soil from the low strength material by the piping of fines. This soil condition does not exist at this site and is not a risk.

Slope stability is controlled by the angle of internal friction of the soils forming the slope. At this site, the construction will occur on a natural 30 degree on average slope. Table 3-2 Empirical values of soils based on the standard penetration number (N-value) in Bowles *Foundation Analysis and Design* is used to estimate the angle of internal friction. This table is based on normally consolidated fine saturated sands. Using the N-values from the boring, we find that the estimated angle of internal friction is greater than 35 degrees. With the subglacial till being both overconsolidated and cemented and having many properties similar to those of lean concrete, the estimated angle of internal friction based on unconfined compression testing is in the 50 to 60 degree range. This unconfined testing is conservative, as we find many marine bluffs with full height exposures of subglacial till standing safely at steep slope angles approaching 90 degrees.

It is our opinion, based on the soil profile, research, and field observation, that the slope is not a landslide hazard. We have no geotechnical objection to the construction of the residence on this slope if the recommendations presented by this firm are included in the design. The natural slope angle is at least one-half of the expected actual angle of internal friction and meets minimum industry standard for slope stability. There are computer programs that a slope stability analysis can be performed, but these programs are marginal when overconsolidated and cemented soils with unit weights in the 135 p.c.f. range are analyzed.

Construction Recommendations

The recommendations presented in our 1 December 2008 report for construction, especially drainage, should be incorporated in the project design. To ensure soil support for slope side footings under seismic loading, we do recommend a minimum setback from the slope of two feet from slope face of footing to exposed slope. This setback will protect the soil support for the footing from loss due to soil shearing under major seismic loading.

The owner should expect higher than typical excavation costs to create the benches into the slope for foundation support. The excavation of the subglacial till will be slow, especially if small excavation equipment is used.

No excavated soils are to be side cast over the natural slopes. Excavated subglacial till is a marginal soil to use for the creation of compacted fill sections due to plastic fines. These soils will rapidly become unsuitable when allowed to become saturated. We recommend that the excavated soil be disposed of off site, especially if work is attempted in the rainy season. Even the exposed surface of the cut benches will slowly "mud up" when exposed to rain. To protect the bearing surface and to minimize the generation of silt-laden water from the excavation, we recommend the placement of a thin lift of compacted crushed rock to create a work platform. If site work is conducted during the dry season, then the use of a crushed rock section would not be necessary to protect the exposed soils.

Limits of Liability

BRADLEY-NOBLE GEOTECHINCAL SERVICES is responsible for the opinions and conclusions contained in this report. These are based on the data relating only to the specific project and locations discussed herein.

This report was prepared with the standard and accepted practices of our industry. In the event conclusions and recommendations based on these data are made by others, such conclusions and recommendations are not the responsibility of the soils engineer or engineering geologist unless he has been given an opportunity to review them and concurs in such conclusions or recommendations in writing.

The analysis and recommendations submitted in this report are based upon the data obtained in the exploration at the location indicated in this report. This report does not reflect any variations that may occur between these explorations. The nature and extent of variations between explorations my not become evident until construction is underway.

BRADLEY-NOBLE GEOTECHNCIAL SERVICES

Report prepared by:

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7 December 2010

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1129
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JOB# 08.11-10
DATE: 11-10-2010
TESTING BY: D. Strong

Tom Castle-Mary GoodFellow

Boring 1

0

Surface elev. approx. 76' based on site's topographic map
Blows per 6" drive for N value
No ground water or water bearing zones found for full depth of the exploration

Vashon outwash

17-27-30
N=57

Very dense reddish-brown sandy gravels

-8' Contact between outwash & till

-10'

50 for 1.5"
N=100t

Very dense gray subglacial till

Vashon till

50 for 3.5"
N=100+

Very dense gray subglacial till

Hard drilling

-20'

50 for 3"
N=100+

Very dense gray subglacial till

Lens of silty sandy gravels

Hand drilling

50 for 4"
N=100+

Very dense gray silty sandy gravels

Hard drilling

-30'

50 for 4.5"
N=100+

Very dense gray subglacial till

Hard slow drilling

50 for 1.5"
N=100+

Very dense gray subglacial till

Hard slow drilling

50 for 1"
N=100+

Very dense gray subglacial till

-35'

Vertical scale 1.0 inch to 5.0 feet

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