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Project No. 0405-001-02

Mr. Jozsef L. Dioszeghy, P.Eng.
District North Vancouver
355 West Queens Road
North Vancouver, BC
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Dear Sir,

RE: SLOPE STABILITY ANALYSES AT 2205 BERKLEY AVENUE

This letter presents the results of a slope stability evaluation for the house and back yard located at 2205 Berkley Avenue.

GEOTECHNICAL SITE INVESTIGATION

Following the landslide, a geotechnical site investigation was carried out, which included completion of topographic surveys, test pits, cone penetration tests, shallow and deep drill holes, laboratory testing, and installation and monitoring of piezometers. The results have been used to establish the slope geometry, soil stratigraphy, shear strength and groundwater conditions necessary for slope stability modelling.

SLOPE STABILITY MODEL CALIBRATION

A stratigraphic cross section through the property was developed for the purpose of slope stability modelling (Figure 1).

Limit equilibrium slope stability analyses were carried out using the commercially available software GeoStudio 2004-Slope/W, produced by Geo-Slope International. The Morgenstern-Price method was used to determine the factor of safety against failure for trial slip surfaces.

Soil strength parameters were determined based on visual classification, cone penetration testing, laboratory testing, and engineering judgement. Slope/W's 'Auto Locate' function was used to identify the slip surface with the lowest factor of safety along each cross section.

A number of 'reality checks' were carried out, including verification that:

- groundwater levels measured in the piezometers matched observations of seepage around the headscarp of the landslide;
- the factor of safety under the highest groundwater conditions measured by the piezometers following the landslide exceeded 1.0; and
- the predicted failure geometry (depth and maximum distance from slope crest) in the back yard of 2205 Berkley was similar to that produced by the 1979 landslide at the northwest boundary of that property.

FACTORS OF SAFETY AGAINST SLOPE FAILURE AFFECTING THE SUBJECT HOUSE

Once the slope stability model was calibrated, additional analyses were undertaken to evaluate the factor of safety against failure along hypothetical slip surfaces that were forced to intersect the edge of the house on the subject property. Groundwater conditions measured on June 7, 2005 (the most recent data) and on March 21, 2005 (the highest groundwater conditions observed since piezometer installation) were used in the analyses. Additional analyses were carried out using groundwater conditions 0.5 m higher than observed on March 21. This level was selected arbitrarily so as to evaluate the sensitivity of the analyses to an elevated water table. Table 1 summarizes the results:

Table 1. Calculated FOS for Slip Surfaces Intersecting the House at 2205 Berkley

Cross Section	Property	June 7, 2005 Groundwater Level	March 21, 2005 Groundwater Level	March 21, 2005 Groundwater Level + 0.5 m
D-D'	2205 Berkley	2.8	2.7	2.6

FACTORS OF SAFETY AGAINST SLOPE FAILURE AFFECTING THE BACK YARD

It is important to note that the factors of safety presented in Table 1 and the slip surface geometries shown in Figure 1 do not represent critical slip surfaces or minimum factors of safety near the edge of the escarpment. Shallower slip surfaces located closer to the edge of the escarpment have lower factors of safety than those presented in Table 1. For example, the factor of safety on the critical slip surface for cross section D-D' under March 21, 2005 groundwater levels is about 1.2, compared to a factor of safety of 2.7 for a slip surface that is forced to pass deeper into the slope and intersect the house at 2205 Berkley.

Additional slope stability modelling was undertaken to determine the water levels that would likely trigger a landslide in the back yard of 2205. The analyses suggest water levels would have to be about 1.8 m higher than measured on March 21, 2005 (Figure 2). The resulting landslide could extend up to 6 m east into the back yard of the property, and could have an initial volume of between 250 and 500 m^3. Detailed runout modelling for this hypothetical landslide has not been carried out, but depending on the direction the slide travels it appears that the debris could reach some of the properties at the base of the escarpment, including 2290, 2296, 2430 and 2440 Chapman Way, and 2318 and 2336 Treetop Lane. Not all of the

properties would be impacted by a single landslide, nor would structural damage be anticipated on all properties. 2318 and 2336 Treetop Lane appear most likely to be impacted and most likely to sustain structural damage, should another landslide initiate from the back yard of 2205 Berkley Avenue.

RECOMMENDATIONS

Standard geotechnical engineering practice requires permanent slopes be designed with a minimum factor of safety of 1.5. Factors of safety of 1.3 are sometimes accepted for slopes where the consequences of failure are low, or where a loss of strength during shearing is not anticipated. Neither of these conditions applies along the Berkley-Riverside escarpment, thus BGC recommends adopting a factor of safety of 1.5 as the minimum acceptable level for house occupation.

Based on these guidelines and the results of the slope stability analyses reported in Table 1, BGC recommends that the residence at 2205 Berkley may be occupied on a permanent basis, provided ongoing monitoring and water management conditions are met, as outlined below.

BGC's occupation recommendation is conditional upon:

a) continued operation of a full-time rainfall and piezometer monitoring program, including protocols for re-evacuation that are maintained 24 hours per day and seven days per week until such time as a long-term mitigation strategy is developed and implemented; and,
b) continued effective control of roof and driveway surface runoff into the storm sewer system.

While the house at 2205 Berkley is not expected to be impacted by a landslide, the back yard of the residence and properties located below the lot could be. Risks from such a landslide can be reduced through piezometer and rainfall monitoring, slope inspection, and control of surface runoff as described above, or through physical slope remediation such as the installation of retaining walls.

At this time, it is not known if the potential for landslides originating from the back yard of 2205 Berkley is greater or less than at other properties along the escarpment; nor is it known if the consequences and risks from such a landslide are greater or less than they are elsewhere. Therefore, it may be prudent to complete a landslide risk assessment and a prioritisation of remedial works for the entire escarpment prior to committing to undertake physical slope remediation activities at 2205 Berkley.

LIMITATIONS

The discussion on slope stability in this report is based on factual information gathered from site investigations, monitoring and laboratory testing, as well as on geotechnical engineering judgment. Further detailed geotechnical investigations on the subject properties or within several hundred metres around them could lead to the discovery of information that will materially influence the slope stability analyses reported here. This is a reality in geotechnical engineering practice, which stems from the need to characterize geological uncertainty at specific reporting junctures with limited information. The reader must accept that this is the standard of geotechnical engineering practice, and its inherent limitations are not unique to

the study reported here.

This study addresses static, near-surface slope stability at the west side of 2205 Berkley Avenue, specifically the factor of safety regarding retrogression of the immediately adjacent escarpment to the extent that it undermines the foundation of the house. It does not consider possible deep-seated failure mechanisms or earthquake loadings. Further, it does not address personal safety issues related to more localized retrogression (i.e. shallow sloughing) of the escarpment into the back yard at 2205 Berkley. Detailed analyses of runout of landslides onto properties on or below the Berkley Avenue escarpment have not been undertaken.

The results are applicable to the period from June through approximately mid October 2005, by which time it is BGC's understanding that the results reported here will be superseded by a long-term mitigation strategy.

BGC prepared this letter for the District of North Vancouver. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of report preparation. Any use of this report, or reliance which is placed on this report by anyone other than the District of North Vancouver, is the responsibility of that person or party. BGC accepts no responsibility for damages, if any, suffered by any person or party, other than the District of North Vancouver, as a result of decisions made or actions taken based on this report. BGC also does not assume any liability for possible losses in property value that may result from this report.

Yours sincerely,
BGC ENGINEERING INC.
per:

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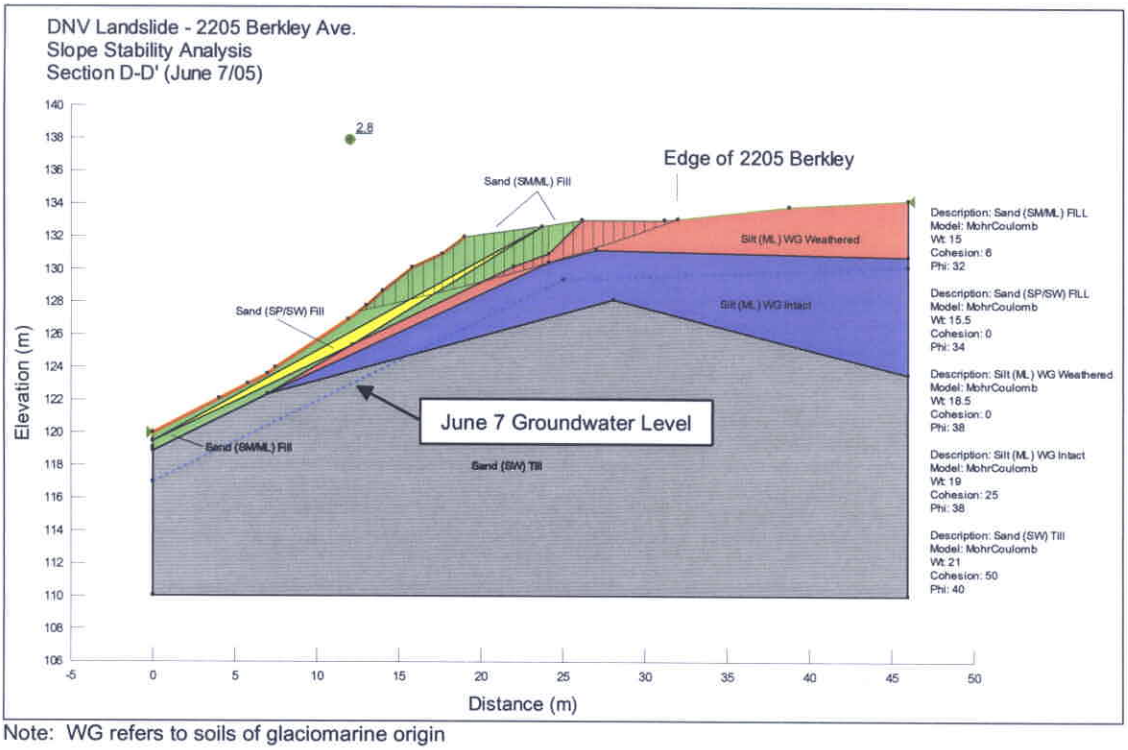
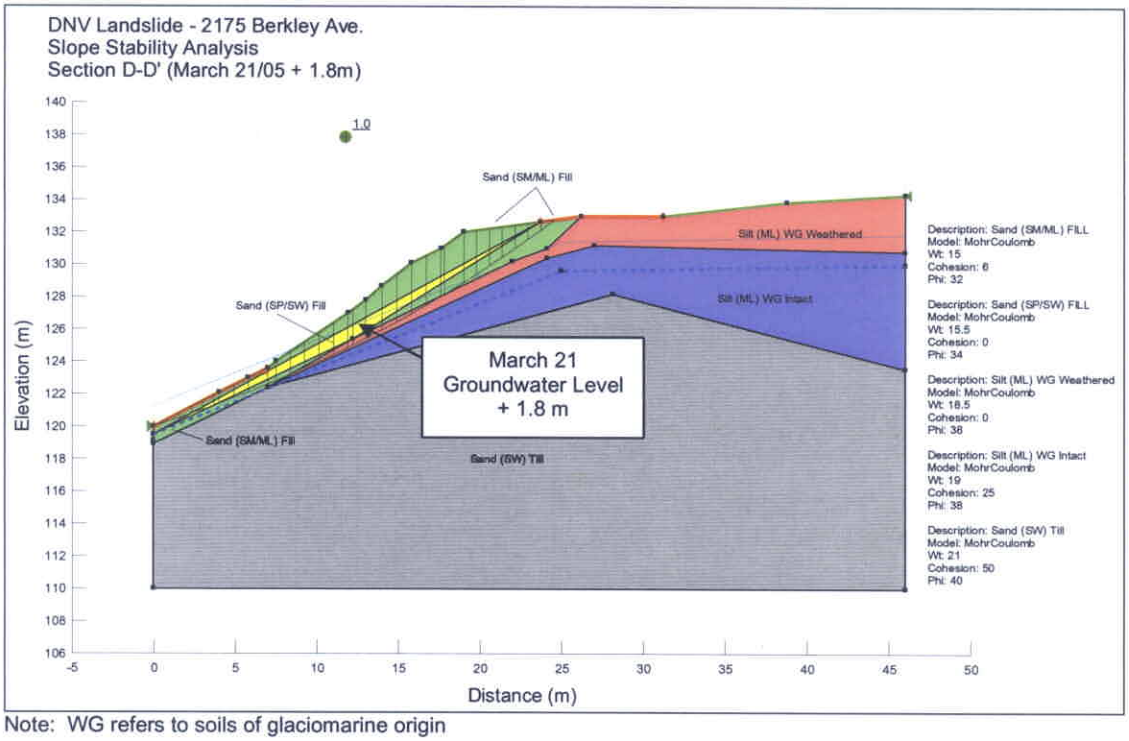
KWS/mjp

Figure 1. Slope Stability Analysis for Slides Impacting the House at 2205 Berkley Avenue



Note: WG refers to soils of glaciomarine origin

Figure 2. Slope Stability Analysis for Slides Impacting the Back Yard at 2205 Berkley



Note: WG refers to soils of glaciomarine origin