

**Phase 2 Geotechnical Stability Study  
Detailed Risk Analysis  
The City of North Vancouver, BC**

**Document No. T30-2009  
GES Project No. 10002**

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Submitted by:  
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## **EXECUTIVE SUMMARY**

The City of North Vancouver (CNV) hired GES Geotech Inc. (GES) to conduct Phase II-Detailed Risk Assessment for the properties having “High” to “Very High” partial risks for landslide stability based on an earlier report prepared by BGC Engineering Ltd. (dated April 24, 2009). The scope of work was later on modified after some addition and deletion and overall 18 properties were reviewed for Detailed Risk Assessments.

This report is prepared based on the latest risk management guidelines published by Canadian Standards Association (CSA) and the Guidelines for Legislated Landslide Assessments for Proposed Residential Development in BC, revised in May 2008, and prepared by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC).

This study is based on reviewing all available background information and reports and the results of carefully planned site and laboratory investigations so as to be representative of the site conditions while resulting in minimum impact upon the properties and the environment.

A Slope Stability Analysis was carried out at each property location after reviewing all available geologic and subsurface information under static and seismic conditions.

Slope Stability Analysis was carried out for static and seismic conditions for a ground motion (earthquake) acceleration having 2% probability of exceedance in 50 years using the computer program Slope/W, which is based on Limit State Equilibrium method of analysis.

Partial Risk Ratings were interpreted based on the results of the Slope Stability Analysis and our assessment of the Vulnerability of structures within each property.

The Specific Risk Rating of each property was then measured based on our established qualitative criteria for Partial Risk Assessment under static and seismic conditions and their incorporation to define the Specific Risk Level at each property. The Specific Risk Level is a measure of risk acceptance with respect to a defined *level of landslide safety*. GES defined the Specific Risk Level into six different categories as Very Low, Low,

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Moderate, High, Very High and Extreme; for Specific Risk Levels of Very Low, Low, and Moderate there are no specific mitigation measures required.

The mitigation measures are recommended when the Specific Risk Level is High, Very High, and Extreme, and in those cases a conceptual level cost estimation assessment is provided.

Based on our assessment 14 of the 18 properties that were included in this study require further mitigation measures; the latter may be passive or active measures although the level of mitigations vary from case to case.

Out of the 18 specified properties, only four properties were evaluated as having a Specific Risk Rating of High or greater (Very High or Extreme). The Specific Risk Ratings were derived from the lower of the assessed factors of safety obtained for static and seismic conditions; ratings for seismic conditions were found to outweigh the ratings for static conditions. The Partial Risk Ratings for static and seismic conditions were developed in accordance with generally accepted geotechnical engineering practice in BC and the guidelines stipulated for Landslide Assessment by APEGBC in 2008 and 2010.

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## INTRODUCTION

The City of North Vancouver (CNV) hired GES Geotech Inc. (GES) to conduct Phase II - Detailed Risk Assessment for a specified number of properties having "High" to "Very High" partial risks for landslide stability. GES had included BGC Engineering Inc. (BGC) as a sub-consultant to GES.

Preliminary Partial Risk Assessment had been carried out by BGC under its final report issued on April 24, 2009. After finishing their initial screening phase, BGC did not find areas of imminent risk requiring immediate action. However, BGC concluded that one of the properties is having a "Very High" and 15 others are having "High" partial risks for landslide stability. These properties are outlined in Table 1 and the Partial Risk Maps, as prepared by BGC (see Appendix A).

**Table 1 - List of properties selected for Phase II studies**

#	Site Address	P <sub>H</sub> BGC	P <sub>S:H</sub> BGC	Partial Risk BGC
1	2052 MacKay Ave	HIGH	HIGH	VERY HIGH
2	2048 MacKay Ave	MODERATE	HIGH	HIGH
3	2024 MacKay Ave	MODERATE	HIGH	HIGH
4	1928 MacKay Ave	HIGH	MODERATE	HIGH
5	1900 MacKay Ave	HIGH	MODERATE	HIGH
6	837-851 Westview Cres	HIGH	MODERATE	HIGH
7	825-835 Westview Cres	HIGH	MODERATE	HIGH
8	811-823 Westview Cres	HIGH	MODERATE	HIGH
9	1956 Wolfe St	HIGH	MODERATE	HIGH
10	1732 Wolfe St	HIGH	MODERATE	HIGH
11	1716 Wolfe St	HIGH	MODERATE	HIGH
12	660 W 3rd St	Eliminated from Phase II-Detailed Risk Assessment as per advice from CNV.		
13	621 W 15th St	HIGH	MODERATE	HIGH
14	651 E 1st St	MODERATE	HIGH	HIGH
15	2116 Grand Blvd	MODERATE	HIGH	HIGH
16	2011 Grand Blvd	MODERATE	HIGH	HIGH
17	1978 Wolfe*	HIGH	LOW	MODERATE
18	1704 Wolfe*	MODERATE	MODERATE	MODERATE
19	620 W 15th Street*	LOW	HIGH	MODERATE

- These properties were added to the scope (see section 2.0)

The results of the Phase II - Detailed Risk Assessment carried out by GES show that, out of the 18 above specified properties that were included in our scope of work, there are only four properties that have been evaluated as having a specific

risk rating of High or greater (Very High or Extreme). The latter properties with High or greater than High specific risk ratings were identified with the understanding that the recommended remedial actions be implemented with respect to the attached or secondary structures associated with the remaining 14 properties. However, there are no recommendations included, explicit or implied, with regard to the party (City or property owner) that would be responsible for implementing the recommendations.

Provided that the recommendations outlined in this report with respect to the secondary or attached structures associated with the 14 remaining properties are carried out, those properties will be rendered with specific risk ratings of Moderate or Low. The said recommendations generally relate to installation of drainage systems, which typically involves connecting appropriate drainage systems to the City's storm water system.

The four properties with specific risk ratings of High, Very High or Extreme are #6 (High), #7 (High), # 11 (Extreme) and # 18 (very High). The specific risk ratings have been presented by taking account of the partial risk rating criteria for static and seismic conditions, with ratings for seismic conditions outweighing those for static conditions, in accordance with generally accepted geotechnical engineering practice in BC and the guidelines stipulated by APEGBC in 2008 and 2010. Thus, throughout the report, the specific risk rating that has been presented for each property is the more stringent of the rating derived under static and seismic conditions, namely the rating corresponding to the seismic condition.

For ease of reference as an overview of this project and our findings and conclusions, we have included Appendix I at the back of this report that contains the following three maps as visual aids for the stakeholders with responsibility and/or interest in management of risk:

1. Fig AI-1: GES Study Area – 18 Sites of High, Very High and Moderate Partial Risk Rating (as determined by BGC, 2009).
2. Fig AI-2: 4 Sites Identified by GES as High, Very High and Extreme Specific Risk Rating.
3. Fig AI-3: 6 Sites Identified by GES as Secondary Attachments with High, Very High and Extreme Specific Risk Rating.

GES wishes to make it abundantly clear that the intent of this work (reported herein) was to identify risks and recommend remedial actions, with no recommendations included, explicit or implied, with regard to the party (City or property owner) that would be responsible for implementing the recommendations; identifying the responsible party was not part of GES' mandate.

## **2.0 SCOPE OF WORK**

The scope of work was initially focused on 16 properties identified as having “High” and “Very High” risks for geotechnical instability based on the April 2009 Geotechnical Report prepared by BGC Engineering Inc.

During our kick off meeting with Tony Barber and Wolfgang Beier from the City of North Vancouver, GES was asked to do some additional slope stability and risk assessments on three other properties as listed below:

- 1978 Wolfe Street
- 1704 Wolfe Street
- 620 West 15<sup>th</sup> Street

Later on and during the course of planning for site investigations, Mr. Tony Barber, Manager, for Engineering Planning and Design from the CNV, asked to withdraw the property on 660 West 3<sup>rd</sup> Street from our list of studies as the property owner decided to carry out his own geotechnical investigations (email dated Feb 24, 2010). The list of properties included in this report is outlined in Table 1.

## **2.1 Project Study Area**

The project study area comprises 18 properties in the City of North Vancouver. These properties are located in the following areas: MacKay Creek, Thain Creek, Lower Mission Creek, Wagg Creek, Low Level Road and Grand Boulevard. These areas are shown on Figure 1.

## **2.2 Background**

The City initiated a Preliminary Landslide Risk Assessment along the east bank of Mosquito Creek in 2005. Further detailed assessment, identified that 8 of the properties were at “high” specific risk and thereafter implementation of risk mitigation works were started on those properties.

After the Mosquito Creek Studies, the City adopted a risk management approach for landslide hazards studies and consequently BGC was awarded a Preliminary Partial Risk Analysis on selected slope areas within the CNV boundaries. The objectives of this preliminary assessment were to screen and prioritize the properties based on their risk exposure to potential landslide hazards. This assessment was carried out based on the recommendations of the Canadian Standards Association (CAN/CSA Q850-97) BGC’s final report was issued on April 24, 2009.



**Figure 1- Project Study Area (Adopted from BGC Report with permission)**

Current study is based on the findings and recommendations of the April 24, 2009 report by BGC.

## 2.3 Objectives

It is our understanding that the City intends to apply the risk management approach across the City to identify and prioritize areas susceptible to landslide hazards using an accepted risk-based approach and consider mitigation measures as applicable.

This study is based on the following resources and reference documents:

- Canadian Standards Associations (CSA) guidelines for Landslide Risk Management (CAN/CSA Q850-97).
- Guidelines for Legislated Landslide Assessments for Proposed Residential Development in BC, Revised May 2008, prepared by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC).
- Earlier studies carried out by the BGC assisting the District of North Vancouver in the development and implementation of a framework for systematic management of the landslide hazard based on a risk-based approach.
- Earlier studies by Westrek Geotechnical Services carried out in two phases for the Mosquito Creek East Ravine.

The main objective of this study is to define the Specific Risk Level for the subject properties and provide recommendations to mitigate the risk to the acceptable levels.

This study will be limited to the subject properties as outlined in Table 1 and does not include the risks associated with the underground or above ground municipal utilities.

### 3.0 METHODOLOGY

Our proposed methodology was based on reviewing earlier risk based landslide stability assessment studies prepared for the City as well as the latest risk management guidelines published by CSA and APEGBC and it included the following steps, as previously outlined in our proposal:

1. Project kick-off meeting to introduce team members and delineate the proposed course of actions for further studies based on comments received from CNV representatives.
2. Review of existing reports and records that include available foundation/structural drawings for each property.
3. Site walkover to determine site accessibility for further planning of site investigations.
4. Delineate scope of field investigation (drilling) work and discuss it with CNV representatives.
5. Detailed Geotechnical Study of all 15 "high" and 1 "very high" risk properties, as identified in the April 2009 Preliminary Report. The geotechnical study included a site and laboratory investigation at the subject properties to define subsurface soil profile for further static and seismic slope stability analysis (Limit State Equilibrium Analysis).
  - a. Detailed Geotechnical Study was based on Guidelines for Legislated Landslide Assessments for Proposed Residential Development in BC, Revised May 2008, prepared by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC).
  - b. Site investigations were carried out with either small track-mounted or mobile auger rigs, thus limiting site disturbance and environmental impacts.

Prior to commencement of site investigations, the GES-BGC project team obtained from the City's representatives the underground utility locations for every property that was field investigated.

6. Slope Stability Assessment for static and pseudo-static conditions, and determination of Factors of Safety for each property.
7. Determination of Partial Risk to each structure based on the results of Slope Stability Analysis.

8. Specific Risk Analysis for "high" and "very high" risk properties, based on defining Vulnerability Rating and Specific Risk Matrix that includes determination of vulnerability at each property.
9. Provide specific recommendations or prescriptions for each individual property as necessary to reduce to acceptable levels. This will include a preliminary cost estimate (+/- 25%).
10. Provide general recommendations for existing and new developments, addressing general practice and recommended Factor of Safety for various classes of development.
11. Prepare preliminary draft report and make presentation to Mayor and Council (if required)
12. Prepare final report and make presentation to the Public.
13. Follow up meeting with individual property owners (if required)

### **3.1 Project Meeting**

A few meetings were held with City Officials and BGC to establish common ground and consensus as the project was underway, thus ensuring that our study was to the satisfaction of City officials.

### **3.2 Background Information Review**

Various sources of information were reviewed to have a better understanding about the available geologic, topographic and/or site-specific conditions for each property. The following is a summary of the sources that we reviewed during our background information review:

- BGC Engineering Inc, Geotechnical Stability Study, Preliminary Partial Risk Analysis, Final, April 24, 2009.
- Westrek Geotechnical Services Inc, Mosquito Creek Ravine East Bank Assessment, Project #: 005-051, July 19, 2006.
- Westrek Geotechnical Services Inc, Mosquito Creek East Ravine, Landslide Risk Analysis, Phase II – Detailed Study, Project #: 006-002, May 8, 2007.
- EBA Engineering Consultants Ltd, Investigation of Foundation Distress, Unit 815 – Cypress Garden, North Vancouver, February 10, 2006.

- EBA Engineering Consultants Ltd, Slope Stability Monitoring and Analysis, Cypress Gardens, North Vancouver, B.C., November 29, 2007.
- Kerr Wood Laidal Associates Ltd, Thain Creek Ravine Stability Assessment, Project No. 99.012K, April 1994.
- SNC – Lavalin, North Shore Trade Area Study, Document No. 017920-0000-30RA-0007, July 15, 2008.
- City of North Vancouver Building Permit Archive for properties under study, as provided by the City.
- Available topographic map as provided by the City of North Vancouver.

GES also reviewed earlier landslide risk analyses by Westrek Geotechnical Services (Westrek) that was carried out in two phases (phase 1 and 2) covering the eastern slope of the Mosquito Creek Ravine. These studies were conducted in July 2006 and May 2007 for the City of North Vancouver. Westrek carried out their studies based on the definition of "partial risk" and "vulnerability" for each property and the risk exposure was discussed based on the associated "specific risk". GES's current study is based on the definition of the same risk elements for each property and is in general accordance with the guidelines published by CSA and the 2008 APEGBC for landslide stability assessment. However, the criteria adopted by Westrek in their derivation of partial risk ratings for seismic conditions were based on their evaluation of the codes that were prevailing at the time of their 2006 and 2007 reports, while APEGBC's guidelines came into in 2008 and have since been updated in 2010. A comparison of the partial risk ratings for seismic conditions derived by Westrek versus those adopted herein by GES, shows that the Westrek seismic criteria were more onerous than those derived by GES; in our opinion the latter are justified because they take account of the APEGBC's most current guidelines, namely the 2008 and 2010 versions. Accordingly, it would be prudent to review Westrek's earlier recommendations (in 2006 and 2007) in light of the 2008 (and 2010) APEGBC guidelines as well as the partial risk ratings for seismic conditions presented herein by GES; this is a matter for the City of North Vancouver to consider in the context of the City's risk management protocols prevailing at this time. That said, we understand that the City did not use Westrek's seismic assessments in their management of the geotechnical risk associated with the properties along the eastern slope of Mosquito Creek.

We also reviewed earlier risk based landslide stability assessment studies prepared for the City and as well as the latest risk management guidelines published by CSA and APEGBC.

This report has relied on the information provided in BGC's report titled Preliminary Partial Risk Assessment (dated April 24, 2009) that covers the Physiographic Setting, Climate and Vegetation, Geologic Setting and Groundwater and Hydrologic Setting based on their review of Aerial Photographs and field verification.

### **3.3 Geologic Field Review**

GES carried out a field geologic study that covered MacKay Creek next to MacKay Avenue, Mosquito Creek at Westview Crescent (Cypress Gardens) and Lower Mission Creek next to Wolfe Street to collect information about the geologic setting of the sites and confirm earlier information provided by BGC.

Based on our site review at MacKay Creek and our observation of an exposed area where a small landslide scarp exists to the north of the property at 2158 MacKay Avenue (See Appendix A, Dwg. 2, BGC drawing) the subsurface soil conditions consist of Capilano Formation Sediments that comprise deep water marine silts and clays overlain by sand to coarse cobble channel-fill deltaic sediments. Our site observation shows that there is layer a of cobble and boulder (close to ground surface at about El 40 m) with sand and gravel as shown in the following photograph. Sand and gravel content increases with depth and becomes the dominant soil at depth.



**Photograph 1: Exposed scarp over the west bank of the MacKay Creek close to the property at 2158 and at about Elevation 40-45 m**

Natural spring outlets at lower elevations hint about the existence of an impermeable layer (till like material) below the sand and gravel layer.

At Westview Crescent where the Cypress Garden development is located there are two scarps at the opposite side of the river bank that clearly show the expected subsurface soil profile as shown in the following two photographs.



**Photograph 2: Thain Creek near Cypress Gardens, west bank.**

As shown in Photographs 2 and 3 the subsurface soil profile from the ground surface is sand to cobble size deposits that is underlain by alternate layers of marine silt and clay sediment that is over a layer of till like material that is exposed at elevations close to streambed.



**Photograph 3: Sand and gravel deposit that is underlain by alternate layers of marine silt and clay, Thain Creek near Cypress Gardens, east bank.**

At Lower Mission Creek and adjacent to Wolfe Street, downstream of the property 1956 and on the east bank, there is an exposed scarp at about 10 m below the ground elevation of that property that consists of firm to stiff clayey silt with gravel (till like material) as shown in the following photograph.



**Photograph 4: Exposed scarp at Lower Mission Creek next to Wolfe Street, east bank.**

Our findings from the field geologic review complemented our proposed site investigations as described in the following section.

### **3.4 Field and Laboratory Investigations**

The objectives of our field investigations were to determine the subsurface soil profile at close proximity of the study area in a way that it would cause least disturbance to existing properties.

Field investigations included solid stem auger hole, Dynamic Cone Penetration Test (DCPT) and installation of piezometer where it was deemed necessary.

Mudbay Drilling Company was selected as the contractor for field investigation because they have access to small track mount drilling machines capable of setting up at locations with limited access.

Test locations were selected based on the accessibility and proximity of the location to the properties such that they would be representative of prevailing subsurface soil profiles for further stability assessment. The site investigations consisted of 8 solid stem auger holes, 6 DCPTs together with the installation of one piezometer. A few numbers of samples were also collected for laboratory tests to determine the moisture content and plasticity indexes for fine grained material. Test holes locations are shown in Appendix B.

Field investigations were supervised and logged by GES staff and borehole logs and the results of laboratory tests are shown in Appendix C.

### **3.5 Slope Stability Analysis**

All information gathered during our site visits, Geologic Field Review (Section 3.3) and Field and Laboratory Investigations (Section 3.4) and the available topographic maps provided by the City were examined to determine the expected subsurface soil profile at each property location.

GES hired McElhanney Consulting Services Ltd. to survey ground profile at specific properties where no earlier topographic information were available. Selected profile locations with surveyed information provided by McElhanney are attached as Appendix D.

Slope stability analysis was carried out using the computer program Slope/W that is based on Limit State Equilibrium method of analysis for static and pseudo-static (seismic) conditions.

The seismic stability assessments were carried out for a ground motion having 2% probability of exceedance in 50 years, in accordance with the recommendations provided by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) in Guidelines for Legislated Assessments for Proposed Residential Developments in BC (revised may 2008). The Slope Displacement method was adopted for seismic stability assessment; this method is based on using a *displacement-based* seismic coefficient for a tolerable 15 cm of slope movement along the slip surface when the slip surface is subjected to ground motions with 2% probability of exceedance in 50 years. The recommended Factor of Safety (FS) for 15 cm of slope movement is  $FS (k_{15}) \geq 1.0$ . The recommended FS under static condition is 1.5. The *displacement-based* seismic coefficient for 15 cm ( $k_{15}$ ) was considered as 0.15g.

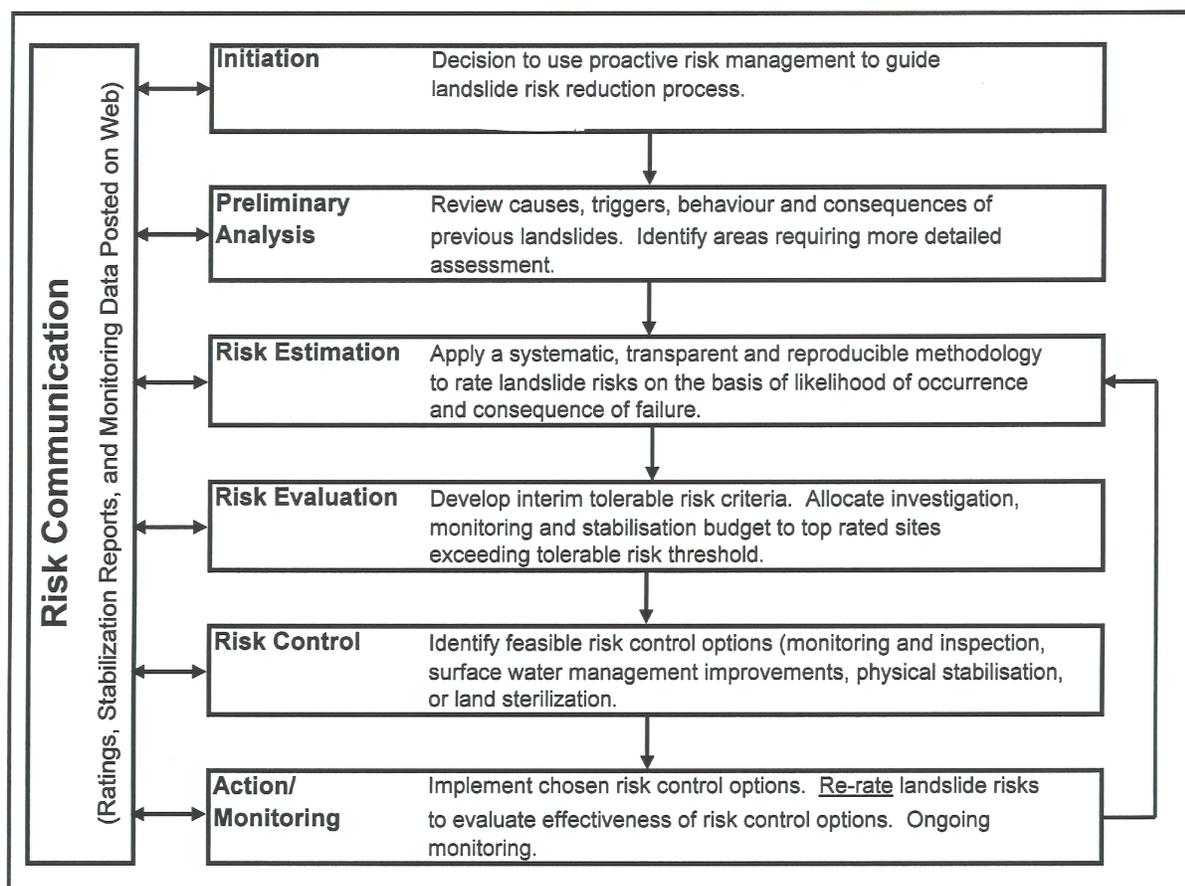
Whenever a property included a secondary structure like a patio or accessory unit, values of factors of safety were calculated separately for the main building and accessory units as the risk of occupancy may be different and it would help in providing mitigation measures that would have little or no impact on the main building.

The factors of safety from stability assessments at each property location were used as a basis for further risk analysis as described in the following section.

### 3.6 Risk Analysis and Reporting

The assessment of landslide risk assessment as defined by CSA (CAN/CSA Q850-97) is a multi-step process as outlined in Figure 2.

**Figure 2-Landslide Risk Management Program (CAN/CSA Q850-97)**



Earlier report prepared by BGC (dated April 24, 2009), was prepared to respond to the requirements of a "Preliminary Analysis" and to prioritize the areas for screening purposes.

The purpose of this report is to carry out a site specific study to determine Specific Risk for those properties with "high" to "very high" Partial Risks based on BGC's earlier report (dated April 24, 2009) and other properties that are added to our scope of work, as requested by City officials (Section 2.0).

The Specific Risk does not take into account the “number of people potentially at risk” (E); therefore it will not represent the expected number of statistical fatalities that is defined as “Risk”. However, it provides a qualitative measure of the risk to human life. The “Risk” and “Specific Risk” are defined by the following equations:

$$\text{Risk} = P_{HA} \times V \times E$$

$$\text{Specific Risk} = P_{HA} \times V$$

Where:

$P_{HA}$ : Partial Risk Factor based on slope stability assessment and the associated qualitative risk level

V: Vulnerability of the impacted people

E: The number of people potentially at risk

The  $P_{HA}$  is defined based on the results of slope stability analysis under static and seismic conditions and the results were evaluated based on qualitative criteria for static and seismic conditions.

The proposed qualitative criteria for static and seismic cases (Tables 2 and 3) were established based on the recommendations by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) in Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC (revised may 2008), our review of the earlier risk assessments by Westrek Geotechnical Services Ltd. (Report dated May 8, 2007), and the collective experience and engineering judgment of GES and BGC.

The proposed qualitative risk rating criteria for static and seismic cases are given in tables 2 and 3 as follows:

**Table 2 - Definitions of the qualitative partial risk ratings in Static Condition**

	Rating	Criteria
<b>Partial Risk to Structure under Static Condition <math>P_{HA}</math></b>	<b>Very Low</b>	<b>Factor of Safety at Structure &gt; 2.0</b>
	<b>Low</b>	<b>Factor of Safety at Structure 1.5 to 2.0</b>
	<b>Moderate</b>	<b>Factor of Safety at Structure 1.3 to 1.5</b>
	<b>High</b>	<b>Factor of Safety at Structure 1.1 to 1.3</b>
	<b>Very High</b>	<b>Factor of Safety at Structure &lt; 1.1</b>

**Table 3 -Definitions of the qualitative partial risk ratings in Seismic Condition**

	Rating	Criteria
Partial Risk to Structure under Seismic Condition $P_{HA}$	Low	Factor of Safety at Structure > 1.1
	Moderate	Factor of Safety at Structure 1.1 to 1.0
	High	Factor of Safety at Structure 0.9 to 1.0
	Very High	Factor of Safety at Structure < 0.9

### 3.7 Vulnerability and Specific Risk Assessment

The risk of damage to structure subjected to a landslide is determined based on the associated Specific Risk level that in turn depends on the *Vulnerability* of the structure. Vulnerability depends on structural stability of the structure that requires a site-specific structural assessment that is beyond the scope of this work. However, GES tried to establish a background for its assessment as described in the following paragraph.

*Vulnerability* of the structure is determined based on reviewing available construction records and development permits as provided by the CNV and our site reviews at each property location and our definition for vulnerability rating as shown in the following Table 4. A summary of the construction records is provided in Appendix E.

*Vulnerability* is rated based on the following qualitative criteria given in Table 4:

**Table 4 – Vulnerability rating criteria and definitions**

	Rating  (Loss or damage)	Criteria
Vulnerability Rating, V	Low	Foundation subgrade is till or hard ground or building is constructed on piled foundation. The landslide is not expected to undermine the building foundation or it may cause little damage.
	Moderate	The building foundation is on spread footing resting on compact to dense (firm to stiff) subgrade and it is embedded enough into the ground and is supported by stable retaining walls. The landslide may cause some damage to the building, however it is repairable.
	High	The structure is placed on loose (soft) ground and its foundation should be susceptible to undermining by landslide. The building may suffer serious damage or it may be uninhabitable on a temporary basis.

The ratings for Vulnerability, and the Partial Risk factors at each property, define the Specific Risk rating based on the proposed combinations as shown in Table 5.

**Table 5 - Specific Risk Matrix based on combined values of Vulnerability and Partial Risk Ratings**

		Vulnerability Rating		
		Low	Moderate	High
Partial Risk Rating	Very Low	<b>Very Low</b>	<b>Very Low</b>	<b>Low</b>
	Low	<b>Very Low</b>	<b>Low</b>	<b>Moderate</b>
	Moderate	<b>Low</b>	<b>Moderate</b>	<b>High</b>
	High	<b>Moderate</b>	<b>High</b>	<b>Very High</b>
	Very High	<b>High</b>	<b>Very High</b>	<b>Extreme</b>

The results of our assessment at each property is summarised in a table that is appended to this report in Appendix F.

#### **4.0 SPECIFIC RISK LEVEL AND MITIGATION REQUIREMENTS**

The specific risk level is a measure for risk acceptance with respect to a defined *level of landslide safety*.

The accepted *level of landslide safety* under static and seismic loading conditions are based on the recommendations of APEGBC in Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC (revised May 2008) and the current state of practice for landslide stability assessment (see Tables 2 and 3).

Based on the aforementioned state of practice, and published guidelines by some municipalities that defines the level of landslide safety, GES defined the specific risk level into six different categories as Very Low, Low, Moderate, High, Very High and Extreme. The target level for landslide safety is set as "Low" which means no specific mitigation measures are required.

"Moderate" level is considered as acceptable as long as there is no change in property conditions. In case some physical changes are expected, the City may ask the property owner to implement proposed mitigation measures.

The "High" and "Very High" levels mean that mitigation measures are expected to take place without any triggering element. However, GES's mandate did not include identifying the party (City or the homeowner) that would be responsible for undertaking mitigation measures.

The "Extreme" specific Risk level means that the property owner shall consider mitigation measures of the earliest possible timeline and in agreement with the City requirements.

A summary of the site conditions at each of the subject properties follows, together with respective Specific Risk rating and mitigation requirements, as applicable to each property.

#### 4.1 2052 MacKay Avenue

This property is a wood frame single-family residence with a wooden deck that is located at about 2.1 m from the edge of the slope crest. There is an accessory wooden building adjacent to the deck that overhangs the edge of the slope and is being supported by wood posts that rest over shallow concrete pads. Shallow concrete pads are over fill material that has a slope of about 45° degrees atop of a natural slope of 38° degrees. The deck of the main building is retained by non-engineered wood-logs, concrete blocks and river rocks; and some deformations were noted during the time of our site review as shown in the following photograph.



**Photograph 5: Non-engineered retaining structure in front of the wooden deck at 2052 MacKay Ave.**

During our field geologic review, GES did not find any water seepage points other than the stream outlets as shown on BGC drawings (see Appendix A).

Background information provided by the City of North Vancouver (CNV), confirms that the building is connected to the CNV sanitary sewer.

The CNV mapping does not show any connection to the CNV storm sewer and based on our site review, roof gutters' outlets from the main and accessory buildings are directed over the slope.

The specific risk of the main building and the secondary structure were calculated separately and they are rated as "**Moderate**" and "**Extreme**", respectively.

In order to mitigate the specific risk level it is our recommendation that the homeowner make sure that the secondary structure is not habitated, to the satisfaction of the City officials, and the property is connected to the city storm sewer collection or an engineered drainage collection system. In addition, we recommend replacing the existing retaining wall (Photograph 5) with an engineered retaining wall that is approved by a qualified Professional Geotechnical Engineer. This recommendation is offered in response to the deteriorating condition of the existing retaining wall even though it is not a safety issue that would affect the risk rating.

#### **4.2 2048 MacKay Avenue**

This property is adjacent to the property at 2052 MacKay Avenue and it is a one-storey wood frame building with a basement floor that is about 0.9 m below the ground level at the yard. The building is not connected to the CNV storm sewer system and roof gutters outlets are located over the slope. The closest part of the building is about 4.3 m from the edge of the slope that has an average slope of about 35° and 21 m high.

The property has an attached deck that ends at about 1.5 m from the edge of the slope. The deck is built on wooden posts that rest on concrete pads. The subsurface soil conditions are similar to the adjacent property and the deck was built on about 2 m of fill material.

The specific risk of the property is rated as "**Extreme**" as the deck is connected to the building and its proximity to the edge of the slope makes it susceptible to damage. It is our recommendation to detach the deck from the building and connect the property to the city storm sewer collection or an alternative engineered drainage collection system. This will reduce the specific risk level to "Low".

### 4.3 2024 MacKay Avenue

The property at 2024 MacKay Avenue is a one storey single-family residence with a detached accessory building. The main building is at about 8 m from the tip of the slope, however the far end of the accessory building overhangs the slope (see Photograph 6). The accessory building is considered a habitable unit and therefore the specific risk to the main building and the accessory building are calculated separately.

The main building and the accessory building are not connected to the CNV storm sewer and the collected storm sewer from the roof gutters ends up over the slope.

The specific risk of the accessory building is rated as "**Extreme**" however for the main building it is rated as "**Moderate**". The specific risk level can be decreased to "Moderate" level if the homeowner demonstrates that the accessory building is uninhabitable, to the satisfaction of the CNV. The main and the accessory buildings should be connected to the City storm sewer collection or an engineered storm sewer collection system to decrease the specific risk rating of the property to "Low".



**Photograph 6: Accessory building at 2024 MacKay Avenue.**

#### **4.4 1928 MacKay Avenue**

This is a single-family residence with one story wood frame structure and a basement level that is about 0.6 m below the ground level at the yard. The building has a two level wooden deck and the deck appears to be connected to main structure. The deck was built on wooden posts that rest on concrete pads. During the time of our site review, GES did not find any signs of movement or deformation at the deck.

The main building is at about 9 m from the edge of a 23 m high slope with an angle of about 36° and the lower deck is at about 1 m from the top of the slope and it is expected to be on at least 1 to 2 m of loose to compact fill material.

Based on the CNV mapping, this property is not connected to the CNV storm sewer system.

The specific risk calculation was carried out separately for the secondary structure and the main building and they are rated as "**Extreme**" and "**Low**", respectively.

In order to decrease the specific risk level it is recommended to separate the upper deck from the building by the addition of extra wooden posts or as required, next to the building to carry the weight of the deck to the ground and detach the deck from the main structure. The building should also be connected to the City storm sewer system or an engineered storm sewer collection system. This will decrease the specific risk rating of the property to "Low".

#### **4.5 1900 MacKay Avenue**

This property is adjacent to 1928 MacKay Avenue and it is a single-family one-storey residence with a basement that is about 1.7 to 1.8 m below the yard level.

The main property has a concrete deck (patio area) that extends over the top of the adjacent slope and it is supported by a concrete retaining wall. It is our understanding that the concrete deck and the main building are connected, although further structural assessment may be required for confirmation.

Since the time of the earlier BGC report, dated April 24, 2009, the owner has replaced the wooden deck with the concrete one as observed during GES site visit in 2010.

The main building footprint has a setback of about 5 m from the top of the slope and there is a pool next to the main building that has a setback of about 5 to 6 m from the edge of the slope.

Based on our discussion with the homeowner, additional concrete was placed around the pool area to cover the cracks around the pool deck. Therefore, during the time of our site visit, no visible cracks were observed around the pool deck or at the patio areas.

The concrete retaining wall that supports the concrete deck is cracked at several places and the crack opening and depth increases towards the edge of the slope. This suggests that settlement or some ground deformations/movements have taken place since the installation of the retaining wall.

The CNV mapping does not show any connection to the City storm sewer collection system. Based on our site review during the time of our site visits and our discussions with property owner, the property drains over the adjacent slope (including the main building, its concrete deck (patio) and around the pool area) through a number of polyethylene pipes that extend 3 to 5 m along the slope.

GES also carried out a site investigation adjacent to this property that comprised an auger drilling and DCPT test holes down to maximum depth of 4.6 m and 7.9 m respectively. Our field investigation shows that the concrete deck is placed on a

minimum 1.3 m of loose fill material that turns into compact fill material at that depth.

The specific risk rating assigned for the concrete deck at the patio area and the main building are rated as "**Extreme**" and "**Moderate**", respectively. In order to decrease the specific risk level of the main building, it is recommended to separate the concrete deck from the main building. This may require additional drilling or concrete coring to ascertain the connectivity of the concrete deck to the main building.

Based on the results of our drilling investigations, it is expected that the pool is placed over the compact fill material and therefore its specific risk level would be "Moderate". However, this should be confirmed by two or three additional drill holes at the pool area. The recommended drilling would consist of the type and nature utilized in the current investigation, namely that small-machine auger drilling and DCPT test holes would be appropriate, subject to the confirmation of a qualified Professional Geotechnical Engineer experienced in these types of investigations.

The property drainage collection system (ie, the main building, concrete deck at the patio area and the pool area) should also be connected to the City storm sewer system or an engineered storm sewer collection system to decrease the specific risk rating of the property to "Low".



**Photograph 7: Site investigations at 1900 MacKay Avenue**

#### **4.6 837-851 Westview Crescent (Cypress Gardens)**

Based on our site review and earlier field investigations by BGC, the east bank of Thain Creek and adjacent to the properties at Cypress Gardens, experienced toe erosion and surface movement at various locations. The distance between the building and the edge of the slope is variable and the closest unit (Unit 843) is at about 4 m from the top of the creek banks.

EBA installed an inclinometer down to 23.5 m depth in 2007, located adjacent to unit 851. Earlier readings carried out in 2007 were not conclusive in terms of recorded movement as it was well within the inclinometer system error levels. GES carried out a new reading of the inclinometer on July 12, 2010 (Appendix H) and it shows that little horizontal displacement (about 3 mm) have taken place with respect to last measurement carried out on Oct 2, 2007.

Based on our review of earlier topographic maps provided by CNV and our field investigations carried out close to units 811-823 and earlier observations by EBA during the installation of the inclinometer, the site was reclaimed for further development by placement of loose to compact fill material at variable depth. The observed ground displacement may be attributed to the existence of loose random and organic fill material.



**Photograph 8: Bank erosion along the east bank of Thain Creek and adjacent to the properties at Cypress Gardens**

Steep slope angles, with heights of about 10-11 m, are covered sporadically with vegetation and have susceptibility to erosion by river action (at the toe) especially

during the flood season, these are contributing elements to bank erosion next to existing buildings at Cypress Gardens.

Existing building structures at the study area are wood frame one storey buildings. Further, based on the information provided by CNV, the storm sewer is not connected to the City storm collection system and it is being released directly to Thain Creek.

The specific risk rating is considered as "**High**". In order to improve the specific risk rating, the proposed mitigation measures consist of bank protection of Thain Creek. This will be achieved by placement of riprap protection along the edge of the stream at selected locations, installation of gabion retaining walls at higher elevations, and continuous monitoring of the inclinometer on a biannual basis. It is also our recommendation to revisit the storm collection system upon the installation of the gabion retaining walls.

#### **4.7 825-835 Westview Crescent (Cypress Gardens)**

These properties are located adjacent to building units 837 to 851 as described in the earlier section. The bank erosion elements as described in earlier section persist and active shallow sliding was noted at the steepest part of the bank slopes.

The existing buildings are one-storey wood frame structures and it is our understanding that they were built on loose fill material. The minimum distance of existing structures are about 5.3 m from the edge of the slope and based on the information provided by CNV, the storm sewer is not connected to the City storm collection system and it is being released directly on to Thain Creek.

Bank slopes next to the buildings are covered with sporadic vegetation cover and Thain creek is actively eroding the toe of the slopes.

The specific risk rating is considered as "**High**". In order to improve the risk rating, the proposed mitigation measures consist of bank protection of Thain Creek. Bank protection will be a combination of riprap protection along the edge of stream to protect it from the erosion action of the stream and the installation of gabion retaining walls at higher elevations to protect the adjacent property from movement toward the stream banks. Continuous monitoring of the inclinometer is recommended on a biannual basis to ensure the retaining wall system is working properly. It is also our recommendation to revisit the storm collection system upon the installation of the gabion retaining walls.

#### **4.8 811-823 Westview Crescent (Cypress Gardens)**

These properties are adjacent to the properties described in earlier part (units 825 to 835) and they are located to the north of the Westview Shopping Mall. EBA carried out an earlier site investigation next to the Unit 815 to address the foundation distress at this location (dated 2006). The report refers to unsuitable fill material and organic soil underneath the foundation that is compatible with GES site observations during our 2010 site investigations at Cypress Garden.

The existing buildings are one-storey wood frame structures and it is our understanding that they were built on loose fill material. The minimum distance of existing structures are about 5.3 m from the edge of the slope and based on the information provided by CNV, the storm sewer is not connected to the City storm collection system and it is being released directly on to Thain Creek.

Bank slopes next to these buildings are about 5° to 10° degrees gentler than the bank slopes for the earlier two series of townhomes (as described in sections 4.6 and 4.7).

The specific risk rating is considered as "**Moderate**". In order to improve the specific risk rating, the proposed mitigation measures are consistent with our earlier recommendations for the adjacent units at Cypress Gardens. However no bank protection is anticipated for implementation. Continuous monitoring of the inclinometer on a biannual basis is recommended and the property should be connected to an engineered storm collection system in order to decrease the risk level to "Low".

#### **4.9 1956 Wolfe Street**

The main building is at about 6 m from the edge of the slope and there is a patio in front of the building the edge of the patio is about 2.2 m from the top of a 17 m and 35° to 40° degrees slope. The yard and the slope are covered with vegetation and a few cracks and displacements were noted along the top of the slope. Although the edge of the patio is close to the edge of slope, it rests over the ground level and it is not attached to the main building.

Based on our review of earlier topographic information, the building is placed on minimum 2 m of fill material and based on our site investigation in the vicinity of the site, the fill was placed over 4 to 6 m of clayey Silt to silty Clay material. The water level at the site during the time of our site investigations was at about 2.2 m from the ground surface.

The building is a one-storey wood frame structure with a basement floor and a sundeck that was added after the construction of the main building. Sundeck was built on wood posts that rest on concrete pads and the displacements of the wood posts were evident during the time of our review. The wood posts of the sundeck show evidence of shallow surface movements that could be attributed to locally unstable and loose ground conditions that could intensify during rainy season.

Our review of the available historic records provided by the City, does not show any record of the connection to the City storm sewer collection system and the City mapping of the utilities in the area does not show any connection either.

The specific risk rating of the main structure is considered as "**Moderate**". However, this condition may change if the cracks retrogress toward the main building and consequently change the specific risk of the structure. Therefore, it is recommended to install survey monuments at 2 different locations close to the patio and survey their movements on a yearly basis for the first 3 years. The survey frequency may be revisited upon the review of the first few years' data.

The monitoring of the slope shall be accompanied by installation of an engineered collection system for storm water and/or connection to the City storm water system.

It is also our recommendation to upgrade the sundeck by placing the wood posts on concrete pads/piers that are minimum 0.5 m into the ground. It is necessary to implement this recommendation in order to maintain the Moderate specific risk rating for this property.

#### **4.10 1732 Wolfe Street**

The main building was built over 50 years ago and it has a new wooden deck that has been replaced the older deck since earlier report published by BGC (dated April 24, 2009). The new deck is at about 6 m from the edge of the slope and it is placed on small wooden posts that rest on a concrete pad. During the time of our review, GES did not find any evidence of surface movements of the wood posts.

GES carried out an auger and a DCPT hole to the south of the property and next to the adjacent lot (1716 Wolfe Street). Our site investigation shows that there is about 3 m of loose fill material at the location of our drill holes.

The building is a one-storey wood frame structure that is placed on a basement floor. The CNV mapping of the underground utilities does not show any connection to the City storm collection system.

Based on the results of slope stability analysis and our vulnerability assessments for the deck and the main building, the specific risk for the main building and the deck are rated as "**Low**".

Although there is not any evidence of instability at the existing structure or the wooden deck, it is our recommendation that the City should verify the drainage collection system of the property with the owner to make sure that proper drainage is provided for the property to prevent progressive deterioration in the future.

No further mitigation measures are recommended for this property at this time.

#### **4.11 1716 Wolfe Street**

This property is located adjacent to the property at 1732 Wolfe Street where GES carried out a site investigation as explained in the above section of this report.

The main property is a one storey old wood frame structure with a basement level that is located at about 3.2 m from the edge of a 15 m, 35° to 40° degree slope. The supporting wood posts for the upper deck appears to be out of plumb and wood posts have cracks that extend along the wood posts and their depths may reach the other side of the wood posts.

Based on our field investigations at the adjacent property (1732 Wolfe Street), the thickness of loose fill material at the edge of the slope next to the wooden posts is expected to be between 2 to 4 m.

During GES site visits and earlier site visits by BGC, a few cracks and shallow depressions were noted close to the edge of the slope at the backyard area.

Based on our slope stability analysis and the assessment of the building vulnerability, the specific risk of the structure is rated as "**Extreme**".

GES recommends an evaluation of the structural stability of the existing structure due to poor conditions of the wooden posts.

Other than the required structural stability requirements that will be evaluated and recommended by a structural engineer, our recommended landslide stability mitigation measure includes removal of fill materials at the backyard and down-slope from the wooden posts of building (see Photo 10) together with installation of an engineered retaining wall covering the width of the property.



**Photograph 9: Façade of the building facing the adjacent slope at property 1716 Wolfe Street**

#### **4.12 621 West 15<sup>th</sup> Street**

The building is a two storey building with a basement floor and it is about 5 m away from the edge of an 18 m, 38° degrees slope. The basement walls are about 0.6 to 0.8 m above the ground and it appears that the wood frame structure rests on these walls. There were no sign of crack or settlement around the building and based on the available CNV mapping of the underground utilities, there is no connection to the City storm sewer collection system.

Limited fill materials are expected to be around the driveway and parking area. Based on our site investigation on the vicinity of the site only limited loose fill material expected to exist at this site and this is compatible with our site observations during our site visits.

The results of our stability analysis and vulnerability assessment of the building show that the specific risk rating of the building is "**Low**".

Although there is not any evidence of instability at the existing structure, it is our recommendation that the City should verify the drainage collection system of the property with the owner to make sure that proper drainage is in place for the property to prevent progressive deterioration in the future. No other further action would be required at this time.

#### **4.13 651 East 1<sup>st</sup> Street**

This property has a one-storey wood frame structure that was built on a basement floor with concrete retaining wall. There is a wooden deck attached to the structure that is at about 2 m distance from an existing retaining wall. The retaining wall is a non-engineered masonry retaining wall with maximum height of about 1 m.

During the time of our site visit, GES did not find any evidence of past sliding or ground displacement and the wood posts that support the wooden deck did not show any signs of misalignment.

GES also planned a site investigation at the subject site. Site investigation was carried out at the yard and next to adjacent slope. Auger hole hit refusal at about maximum depth of 0.9 m after four attempts. It is our conclusion that the building was built on a hardpan/rock foundation.

The specific risk for the site is considered as "**Moderate**". To decrease the risk exposure level to "Low" it is recommended to connect the storm collection system of the building to the City storm sewer collection system or an alternative engineered drainage collection system.

#### **4.14 2116 Grand Boulevard**

The property is located on a terraced slope and the main building is a wood frame structure that at one side is at about 2 m from the crest of a landscaped slope that is 7-8 m in height. The slope is vegetated and masonry and rock-stacked retaining walls exist over the slope. There is an 8 m wide bench at the end of the slope that is about 5 m above Grand Boulevard.

The closest part of the building to the crest of the slope is a greenhouse that is supported with a non-engineered retaining wall. Based on our conversation with the homeowner the greenhouse area is not being used as a residence.

During the time of our site visit, a few cracks were noted over the side steps of the building. However, we did not find any evidence of instability or slope movement and it appears that building is most likely built on till or hard-pan. Some fill material is expected to exist behind the shallow retaining walls over the slope.

The existing drawings by the City do not show a connection to the storm sewer collection system.

The specific risk rating of the main residence area is considered as "**High**" as there is a possibility of slope failure that may pass through the greenhouse. As explained earlier, neither GES nor BGC found any evidence of slope movement. Therefore it is our recommendation to monitor the slope movement by the installation of a couple of surface survey monuments at the crest of the slope. The survey monuments shall be monitored on a yearly basis for the first 3 years. Any mitigation measures shall be decided upon the interpretation of the surveying data that may include the removal of loose fill material in front of the greenhouse area and the construction of an engineered earth retaining wall to support the greenhouse area. In any circumstances, the homeowner shall satisfy the City Officials that this area will not be used for residence.

Although there is not any evidence of instability at the existing structure, it is our recommendation that the City verify the drainage collection system of the property with the owner and ascertain as to whether proper drainage is in place for the property, thus helping prevent progressive deterioration in the future.

#### **4.15 2011 Grand Boulevard**

The property is located down the slope of Grand Boulevard embankment. The slope has about 5.5 m height and its steepness is about 29° degrees.

The building is a one-storey wood frame structure over a basement level and it is located down the toe of a slope from Grand Boulevard that has been cut by about 1m and is being protected by concrete blocks and a dry rock-stacked retaining wall. Existing information does not show any connection to the City storm sewer collection. The slope adjacent to the building is covered with vegetation that helps the stability of the slopes. GES did not record any evidence of past slides, soil displacements or instability over the slope.

GES also carried out a site investigation with an auger hole down to 6.7 m and a DCPT hole down to 1.8 m depth where refusal was encountered. The subsurface soil mostly consists of dense to very dense coarse-grained material down to the end of the auger hole at 6.7 m depth.

Although there is not any evidence of instability at the existing structure, it is our recommendation that the City should verify the drainage collection system of the

property with the owner and ascertain as to whether proper drainage is in place for the property, thus helping prevent progressive deterioration in the future.

The specific risk of the property is considered as "**Low**" and therefore no further action is recommended at this time.

#### **4.16 1978 Wolfe Street**

This property is one of the scope additions to the initial scope of work for current studies. The building is a one-storey wood frame structure that was built over a basement floor (around 1977), as per our discussion with homeowner during our site visit and available documents from the City.

The building is at about 6.5 m distance from the crest of adjacent slope and a few cracks were noted over the concrete pavement a few meters away from the front door.

GES also carried out a site investigation over the paved entrance to this property that comprises an auger hole and a DCPT hole, both down to 7.3 m depth. Based on our site investigations, there is about 1.8 m of loose to compact coarse grained fill material that overlies 1.5 m of firm to stiff clayey Silt material (native soil). This Silt layer becomes soft to firm for the next 1.8 m and turn to firm to very stiff down to end of the hole at 7.3 m depth where it hit refusal.

Based on available mapping of the underground utilities, provided by the City, this property is not connected to the City storm sewer collection system.

The specific risk rate of the property is considered as "**Low**" based on the results of our slope stability analysis and vulnerability assessments.

Although there is not any evidence of instability at the existing structure, it is our recommendation that the City verify the drainage collection system of the property with the owner and ascertain as to whether proper drainage is in place for the property, thus helping prevent progressive deterioration in the future. No other further action is recommended for this property.

#### **4.17 1704 Wolfe Street**

This property is another addition to the initial scope of work for Phase II, Geotechnical Stability Study, Detailed Risk Assessment. The building is an old (more than 80 years old) one-storey building that was built over a basement level.

Based on our discussion with the property-owner and the available documents from the City, the property has undergone some renovations at the basement level to make it habitable (around 1997).

The building is located at about 3.1 m distance from the edge of a non-engineered wooden retaining wall that has a few continuous cracks and there were signs of deterioration of wooden bars. The retaining wall has a maximum height of about 0.6 m and it is stretched along the building width with variable height.

The building frame was built on a concrete retaining wall that is all around the basement level. Centennial Geotechnical Engineers Ltd. carried a site investigation at the property location in 1997 to provide recommendations for foundation design of the two perimeter wall footings to the south and east of the property. Their site investigation revealed that the property rests on variable fill height that may reach 0.6 to 0.9 m of loose fill material. They also mentioned about 1 to 3 inches of settlement at the location of columns and walls.

Based on our discussion with the property owner, the existing drainage ends into an existing concrete manhole next to the structure that drains away to the adjacent creek.

It is not clear though whether the underpinning of the structure – as proposed by Centennial – has happened and whether the south and west perimeter wall footings were placed over the native medium dense silty fine Sand. The specific risk rating of the property is considered as **“Very High”** and further mitigation measures should therefore be undertaken. The recommended mitigation action would be the replacement of the wooden retaining wall with an engineered retaining wall to support the east end of the building. The construction of the retaining wall may require underpinning of the structure during the construction of the retaining wall, if earlier underpinning of the structure is not in place or is considered insufficient. This should be evaluated prior to construction of the retaining wall.

#### **4.18 620 W 15<sup>th</sup> Street**

There are three building units on this property and there is a deck that provides a common area between the building units.

Our slope stability assessment was carried out for the worst-case condition that represents the slope adjacent to the unit located to the north of the property (Photograph 11). This building unit is located less than 3 m from the edge of adjacent slope that has maximum gradient of 45° degrees and maximum height of about 14 m.

This building unit is a three-storey wood frame structure that rests on concrete retaining wall all around the building. Limited fill material may exist at the site and it is expected to be less than 1m.



**Photograph 10: Building unit located to the north of the property at 620 West 15<sup>th</sup> Street**

The building unit located to the southeast of the property is at close distance from the adjacent slope (Photograph 12) and is protected by a concrete retaining structure. GES did not find any cracks or evidence of displacement over the retaining structure or the deck that rests on this retaining wall.



**Photograph 11: Building unit located to the south of the property supported with a concrete retaining wall at 620 West 15<sup>th</sup> Street.**

The deck that connects the building units to the south, north and west was built on concrete columns and girders that are founded well into the ground and during the time of our site review, GES did not find any evidence of cracks or movement over the existing deck structure.

The most critical unit in this property is the one located to the north of the property and the specific risk associated to this building unit is rated as "**Moderate**". The specific risk for all other building units is considered as "**Low**".

In order to decrease the risk level to "Low", connection to the City storm sewer system or an alternative engineered storm collection system is recommended.



**Photograph 12: The deck that connects the three building units at 620 West 15<sup>th</sup> Street was built on concrete columns and girders.**

## **5.0 GENERAL RECOMMENDATIONS FOR MITIGATION MEASURES**

As detailed in the foregoing sections, the Phase II - Detailed Risk Assessment shows that, out of the 18 above specified properties described above, only four properties are evaluated as having a specific risk rating of High or greater (Very High or Extreme), as long as the remedial actions recommended are implemented with respect to the attached or secondary structures associated with each subject property. Further, provided that the recommendations outlined in this report with respect to the secondary or attached structures associated with the 14 remaining properties are carried out, those properties will subsequently be rendered with specific risk ratings of Moderate or Low. The said recommendations generally relate to installation of drainage systems, which typically involves connecting appropriate drainage systems to the City's storm water system.

The four properties with specific risk ratings of High, Very High or Extreme are identified in Table 1 as #6 (with a High specific risk), #7 (with a High specific risk), # 11 (with a Extreme specific risk) and # 18 (with a Very High specific risk). The specific risk ratings were derived from the lower of the assessed factors of safety obtained for static and seismic conditions; ratings for seismic conditions were found to outweigh the ratings for static conditions. The partial risk ratings for static and seismic conditions were developed in accordance with generally accepted geotechnical engineering practice in BC and the guidelines stipulated for Landslide Assessment by APEGBC in 2008 and 2010.

Moreover, all existing or new structures that are placed close to the slope (10 m or less from the crest of the slope) may be susceptible to excessive landslide risk. Therefore, GES has prepared the following general recommendations to help the homeowners and the CNV to improve the risk exposure and take appropriate measures to address potential stability issues.

1. Surface runoff from the property (including structures and hard surfaces) shall be collected properly and connected to the City storm sewer system or alternative engineered storm collection system. The areas close to the edge of the slope shall be properly drained or connected to the storm collection system to prevent any ponding of water close to the edge of the slope. The importance of addressing the drainage issues cannot be over emphasized as the assessed specific risk ratings for each property are based on each property having proper drainage of surface runoff to an engineered storm collection system or the City storm sewer system. As such, implementation of a proper drainage system shall form one of the requirements of an application for a building permit for renovations and/or additions to existing buildings.

2. The slope and the property conditions may change and the risk of the exposure to landslide may change accordingly. It is important for the City to advise existing and future homeowners about the risk of landslide susceptibility and arrange for

regular (eg, annual) inspection of those properties located close to the edge of a slope to make sure that site conditions are not changing for the worse.

3. All new retaining walls that will be within 10 m from the edge of the slope for stability purpose, or landscape retaining walls that are located within 3 m from the edge of the slope, shall be designed or approved by a qualified Professional Geotechnical Engineer. Proper attention to drainage of retaining walls located close to the edge of the slope cannot be over emphasized.

4. Habitable structures shall be located at least 10 m away from the edge of the slope, unless otherwise specified based on a site specific review. A qualified Professional Geotechnical Engineer shall be retained to review and approve the design of mitigative measures for landslide stability considerations.

5. The City should not permit any additional fill over the existing slopes and shall remove yard waste and other debris from the slope and improve the slope conditions for natural vegetation growth, unless approved otherwise by a qualified Professional Geotechnical Engineer.

## **6.0 CONCEPTUAL LEVEL COST ESTIMATION**

GES has reviewed each property under this review and provided the specific risk associated with existing structures and provided (the most) sensible options for improving the site condition to reduce the risk exposure to an acceptable (risk) level.

Although other options are certainly available, our recommendations are limited to the option(s) that seems the most viable one for the homeowner. Accordingly, our cost estimates represent the recommended option, which to the best of our current understanding is the preferable option for the homeowner. Our estimates are ballpark (preliminary) estimates that help the homeowner to evaluate their options. Therefore, GES encourages each homeowner to discuss their specific case with specialty contractors and make sure that they are offered the best option that is in their best interest.

Our preliminary estimated costs for the recommended mitigation measures for each property are tabulated and presented in Appendix G and they are expected – at the time of writing this report – to be within +/-25 percent of actual costs.

## **7.0 LIMITATIONS**

The recommendations presented in this report are based on GES's interpretation and understanding of current site conditions and other information provided by the City of North Vancouver at the time of writing this report. To properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the report in its entirety. We cannot be responsible for use, by any party, of portions of the report without reference to the whole report. In addition, any variations in structure locations or anticipated loading from those utilized in this report should be brought to our attention immediately; as such changes may affect our recommendations.

## 8.0 CLOSURE

This report has been completed for the exclusive use of the City of North Vancouver and its agents for the properties listed in Table 1 of this report and located within the City of North Vancouver, BC. Any use of the information contained in this report by third parties or for other than the intended purpose must *first* be approved in writing by GES. However, we understand that the City of North Vancouver intends to make this report public for the benefits of current property owners and prospective purchasers, and as such the report may be relied upon only based on the site and climatic conditions during the time of our field reconnaissance and investigations, which conditions may very well vary in the future. Accordingly, third party use of the information and recommendations contained in this report will be the responsibility of such third party users.

We trust that this report satisfies your current requirements. However, if you have any questions or require any further information, please contact us.

Yours truly,

**GES GEOTECH INC.**



For Farid Emadi, MSc, P.Eng.  
Senior Engineer



Mahmoud Mahmoud, PhD, P.Eng.  
President

FE/MM/SS/msm

RF 111227 CNV - Phase II-Geotechnical Stability Study-Detailed Risk Analysis, N Van, BC-Final.docx

# **Appendix A**

Partial Risk Maps prepared by BGC based on  
Preliminary Studies

# LEGEND

-  LARGE LANDSLIDE BOUNDARY- INTERPRETED FROM AERIAL PHOTOGRAPHS
-  LARGE LANDSLIDE BOUNDARY- OBSERVED DURING GROUND INSPECTION
-  LARGE LANDSLIDE SCARP- INTERPRETED FROM AERIAL PHOTOGRAPHS
-  LARGE LANDSLIDE SCARP- OBSERVED DURING GROUND INSPECTION
-  SMALL LANDSLIDE SCARP AND TRACK- INTERPRETED FROM AERIAL PHOTOGRAPHS
-  SMALL LANDSLIDE SCARP AND TRACK- OBSERVED DURING GROUND INSPECTION
-  SURFACE WATER EROSION SCAR- INTERPRETED FROM AERIAL PHOTOGRAPHS
-  SURFACE WATER EROSION SCAR- OBSERVED DURING GROUND INSPECTION
-  CITY BOUNDARY
-  STRUCTURE
-  STRUCTURES FLAGGED FOR FIELD INSPECTIONS BY SCREENING STUDY
-  VERY HIGH PARTIAL RISK STRUCTURE
-  HIGH PARTIAL RISK STRUCTURE
-  MODERATE PARTIAL RISK STRUCTURE
-  FILL- INTERPRETED FROM AERIAL PHOTOGRAPHS
-  FILL- OBSERVED DURING GROUND INSPECTION
-  PROPERTY BOUNDARIES
-  SPRING
-  STREETS
-  CREEKS
-  MAJOR CONTOUR

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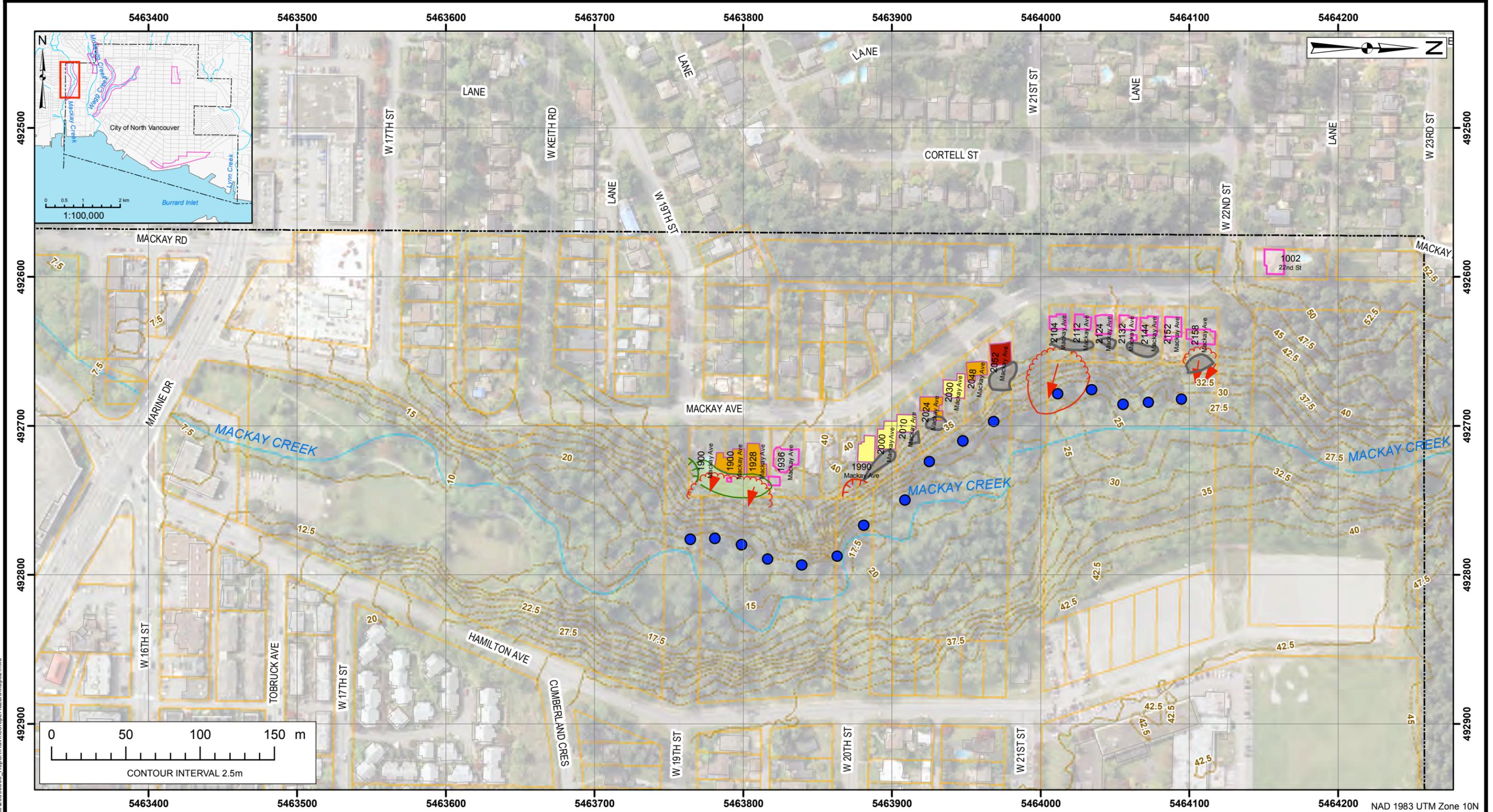


PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis

TITLE: Partial Risk Map  
Legend

CLIENT: City of North Vancouver

PROJECT No.:	DWG No.:	REV.:
0600-001	1	



REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

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CHECKED:	MP
APPROVED:	MP

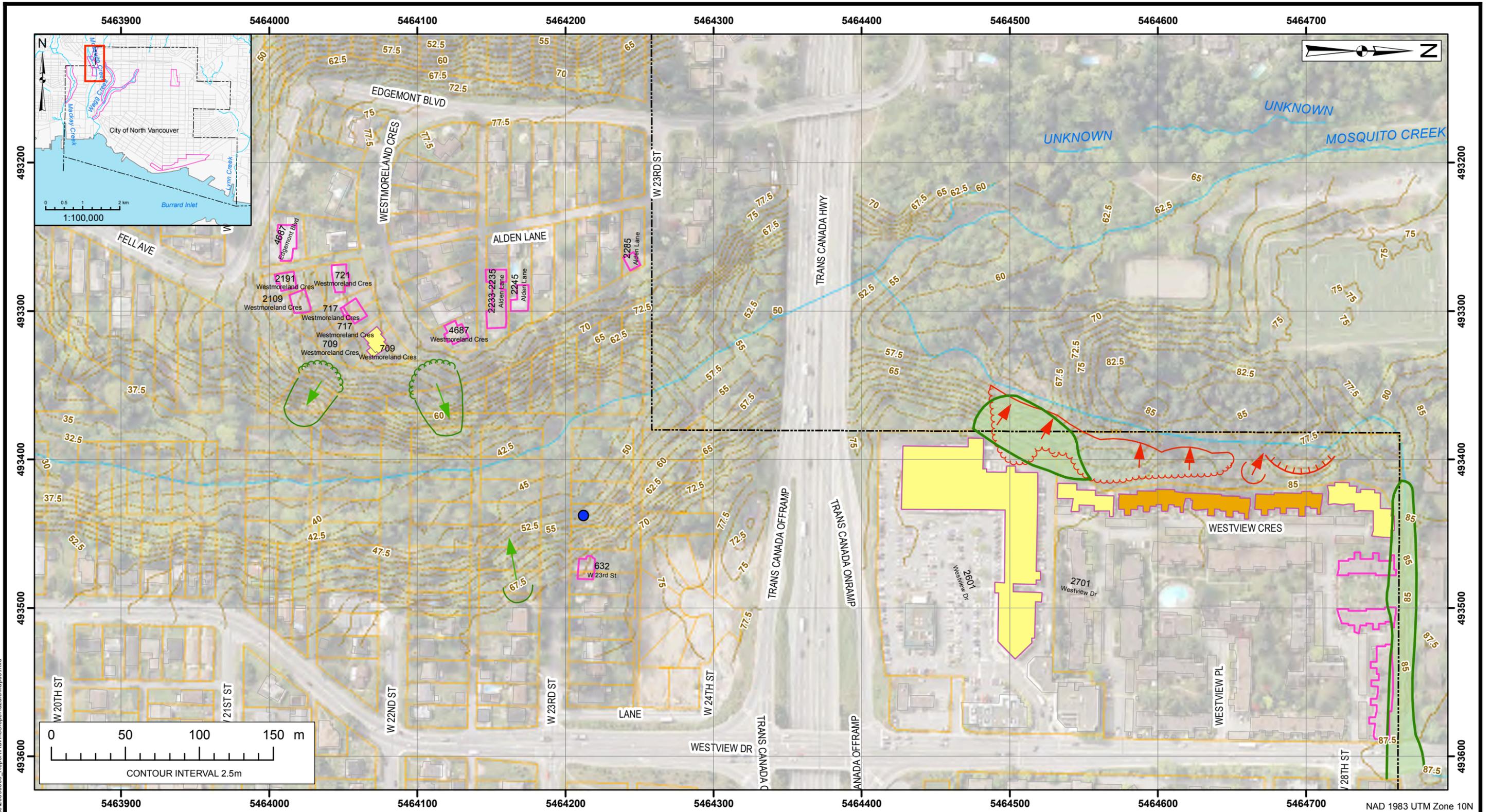
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CLIENT: City of North Vancouver

PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis		
TITLE: Partial Risk Map Mackay Creek		
PROJECT No.: 0600-001	DWG No.: 2	REV.:

X:\Projects\0600 City North Van\001\Workspace\0600\0306\_Report\Rev\Rev\SlopeHazard\Map2.mxd



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DATE:	APR 2009
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CLIENT: City of North Vancouver

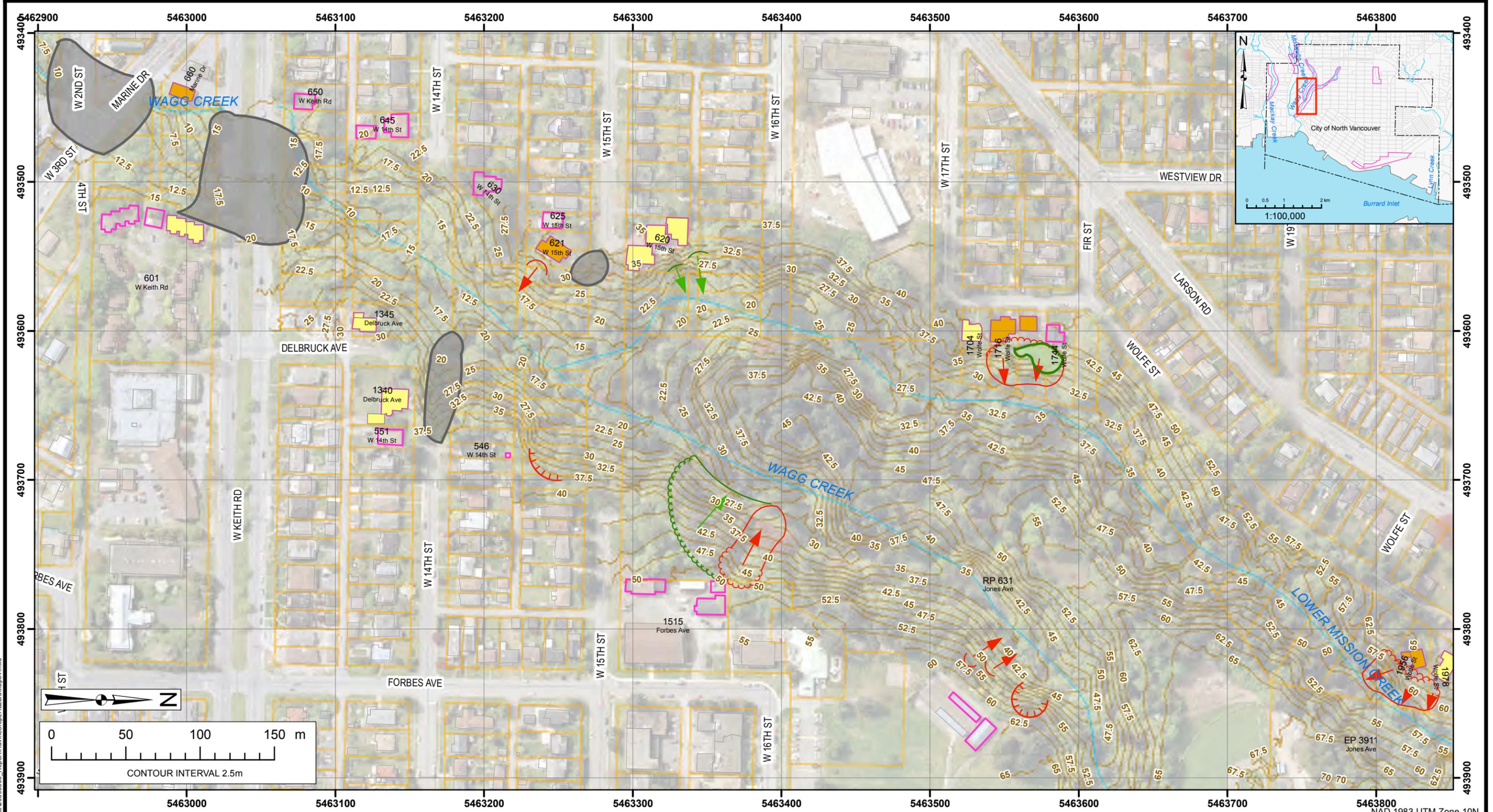
PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis

TITLE: Partial Risk Map  
Mosquito Creek

PROJECT No.:	0600-001	DWG No.:	3	REV.:	
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REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

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CLIENT: City of North Vancouver

PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis		
TITLE: Partial Risk Map Wagg Creek South		
PROJECT No.: 0600-001	DWG No.: 4	REV.:

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APPROVED:	MP

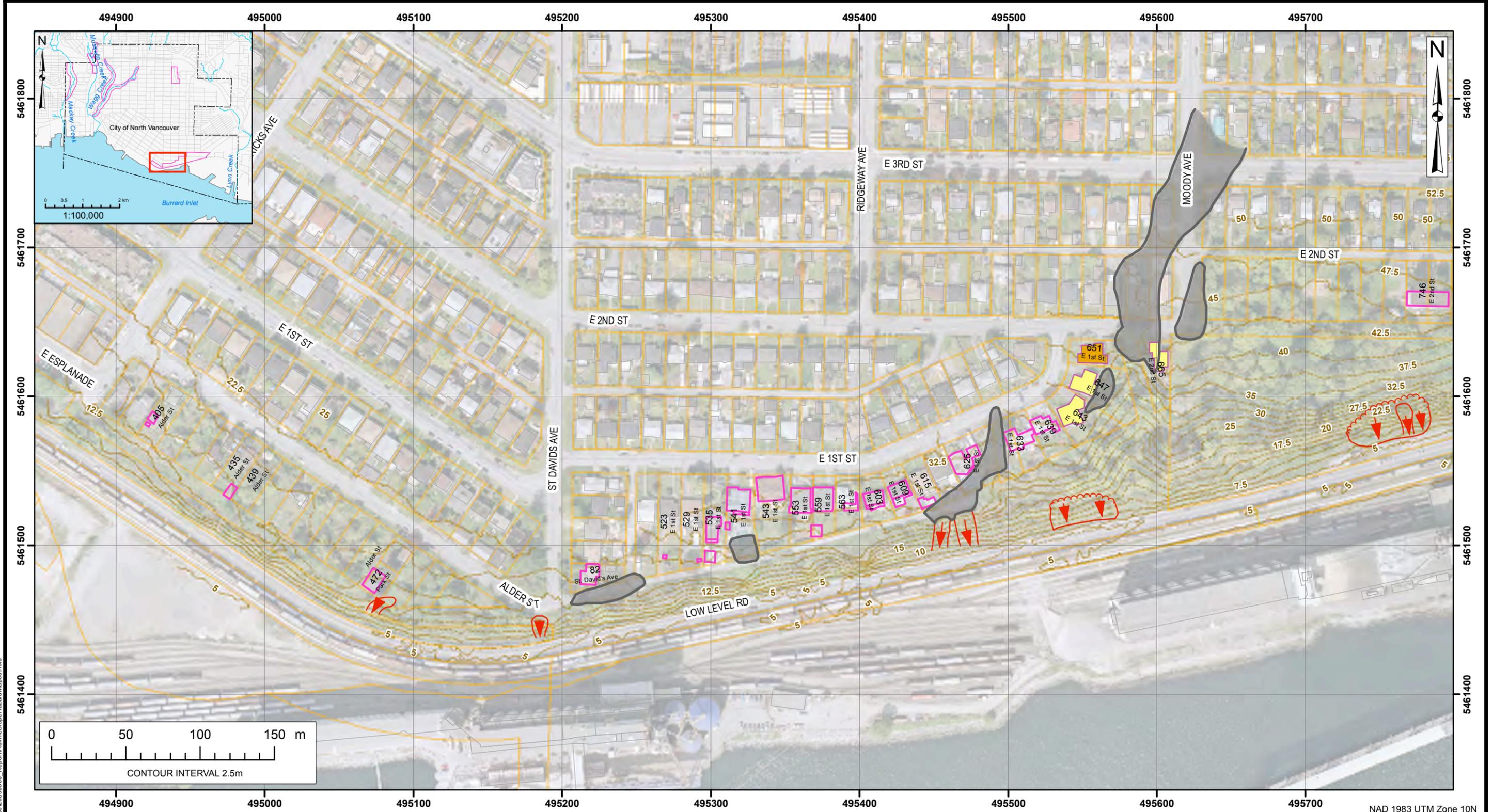
PROFESSIONAL SEAL:

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: City of North Vancouver

PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis		
TITLE: Partial Risk Map Wagg Creek North		
PROJECT No.: 0600-001	DWG No.: 5	REV.:

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DATE:	APR 2009
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CHECKED:	MP
APPROVED:	MP

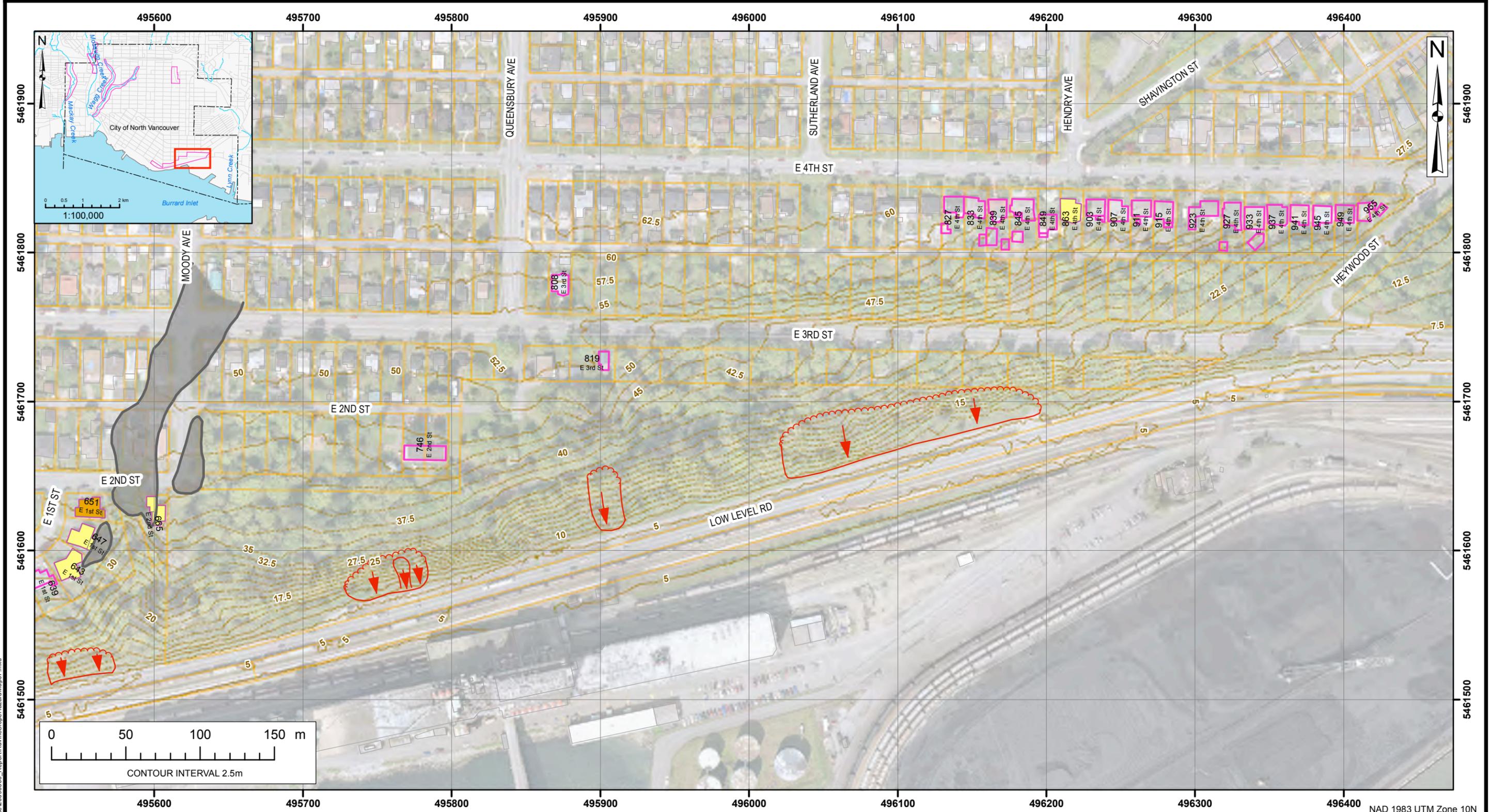
PROFESSIONAL SEAL:

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CLIENT: City of North Vancouver

PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis		
TITLE: Partial Risk Map Low Level Road South		
PROJECT No.: 0600-001	DWG No.: 6	REV.:

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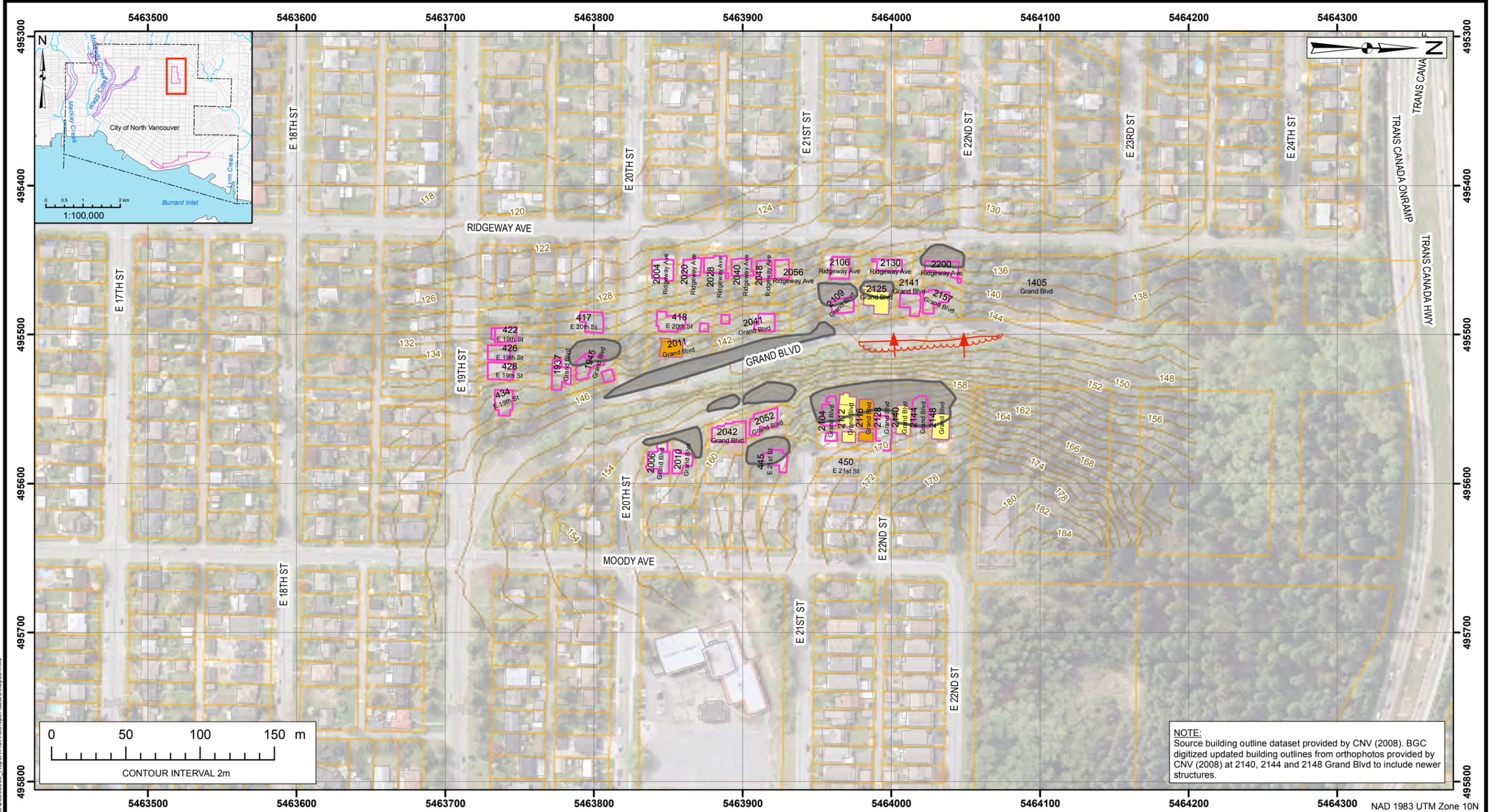
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CLIENT: City of North Vancouver

PROJECT: Geotechnical Stability Study, Preliminary Partial Risk Analysis		
TITLE: Partial Risk Map Low Level Road North		
PROJECT No.:	DWG No.:	REV.:
0600-001	7	

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DATE:	APR 2009
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APPROVED:	MP

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CLIENT: City of North Vancouver

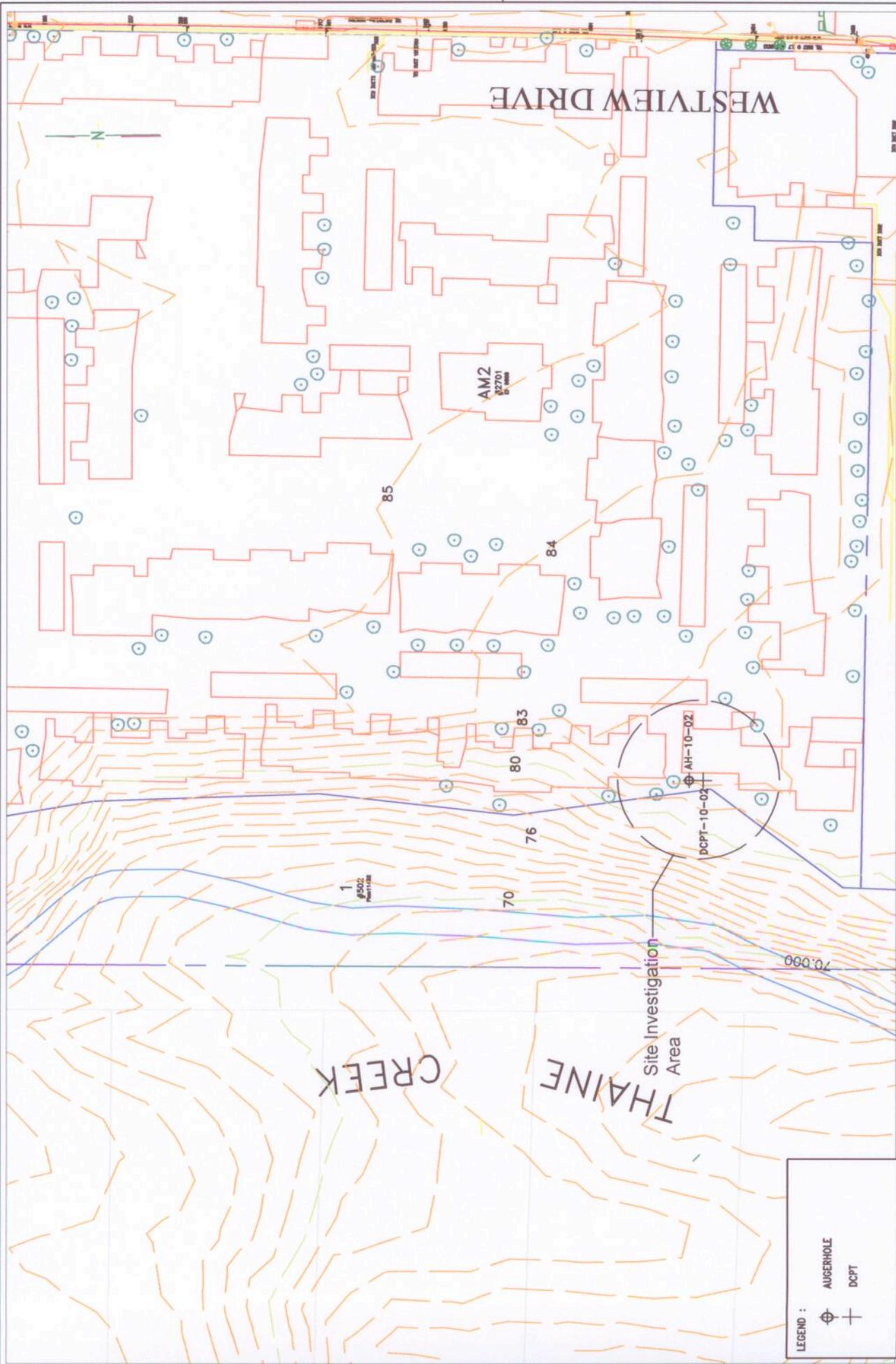
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TITLE: Partial Risk Map Grand Blvd		
PROJECT No.:	DWG No.:	REV.:
0600-001	8	

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# Appendix B

Test Holes Location Maps





**LEGEND :**

- AUGERHOLE
- DCPT

**NOTES :**

- Drawing shows approximate locations of testholes and the topographic features are not representative of existing conditions.

DESIGNED	FE	DATE	REV DATE	DESCRIPTION	INITIAL
DESIGNED	FE	2010/06/14			
DRAWN	FA	2010/06/14			
CHECKED	FE	2010/06/14			
APPROVED	UM	2010/06/14			

**CITY OF NORTH VANCOUVER**

**PHASE II GEOTECHNICAL STABILITY STUDY  
DETAILED RISK ANALYSIS**

LOCATION PLAN - AH-10-02/DCPT-10-02  
CYPRESS GARDENS, N. VAN. BC

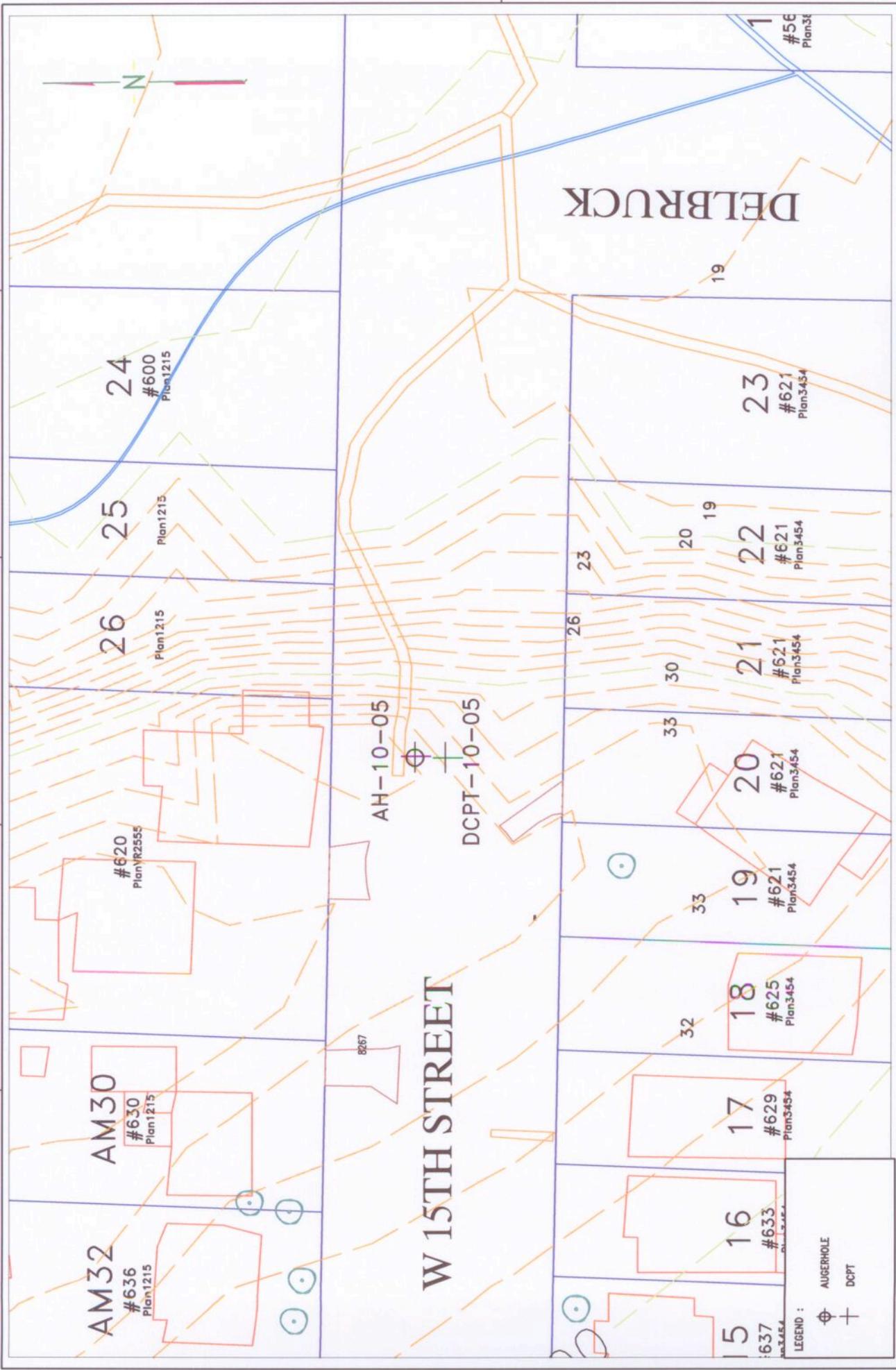
SCALE: 10002

DRAWING NO. 2

GLOBAL EARTH SOLUTIONS  
GEOTECH INC.







**CITY OF NORTH VANCOUVER**

**PHASE II GEOTECHNICAL STABILITY STUDY  
 DETAILED RISK ANALYSIS**

LOCATION PLAN - AH-10-05/DCPT-10-05  
 621 W15TH STREET, N. VAN., BC

10002

5



REV	DATE	DESCRIPTION	INITIAL

DESIGNED	FE	DATE	2010/06/14
DRAWN	FA	DATE	2010/06/14
CHECKED	FE	DATE	2010/06/14
APPROVED	MM	DATE	2010/06/14

PROFESSIONAL OF RECORD

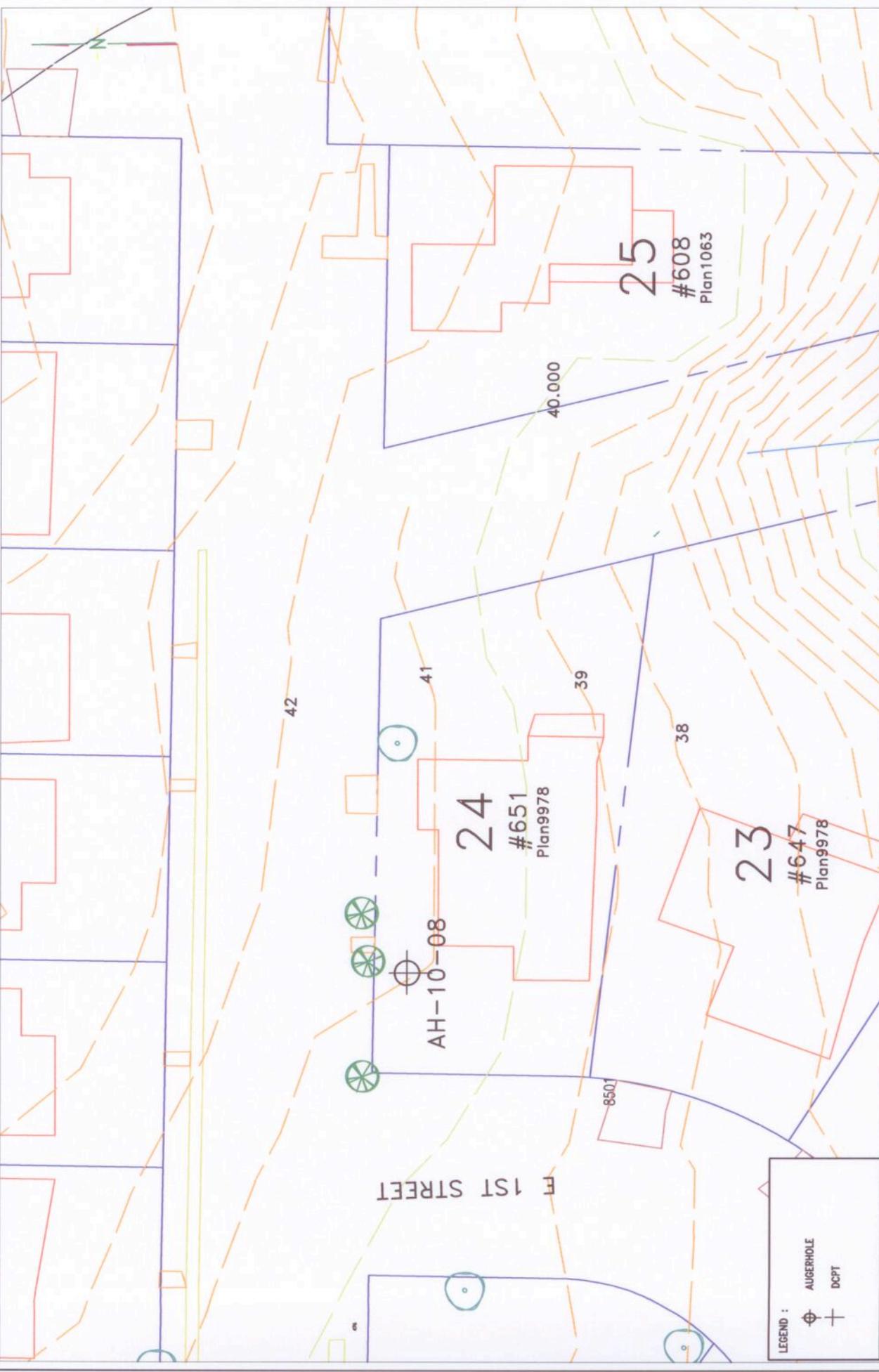
ORIGINAL

NOTES:

1. Drawing shows approximate locations of testholes and the topographic features are not representative of existing conditions.







**LEGEND :**

- AUGERHOLE
- DCPT

**NOTES :**

1. Auger hole location changed 3 times after hitting refusal.
2. Drawing shows approximate locations of testholes and the topographic features are not representative of existing conditions.

DESIGNED: FE  
 DRAWN: FA  
 CHECKED: FE  
 APPROVED: MM

REV	DATE	DESCRIPTION	INITIAL

REV	DATE	DESCRIPTION	INITIAL

REV	DATE	DESCRIPTION	INITIAL



**CITY OF NORTH VANCOUVER**

**PROJECT TITLE**  
 PHASE II GEOTECHNICAL STABILITY STUDY  
 DETAILED RISK ANALYSIS

**LOCATION TITLE**  
 LOCATION PLAN - AH-10-08  
 651 E 1ST STREET, N. VAN., BC

**REV PROJECT NO.** 10002  
**CLIENT PROJECT NO.** 10002  
**SCALE** 8  
**DRAWING NO.** 8  
**REV**

# **Appendix C**

Field Investigation Bore Hole Logs and Laboratory Test Results



**GES Geotech Inc.**

**Borehole no. AH-10-01  
CNV Landslide Hazard Assesment, Phase II**

Location: 2052 Mackay Ave., North Vancouver			Project # 10002
Drilling Method: Solid Stem, 5.5" Auger			Ground EL: -
Coordinate: See SI Plan		Driller Operators: Dave, Rick	Borehole depth (ft): 5.5
Weather: Cloudy with sunny breaks	Temperature: 5-10 (C)	GWT @ Drilling(ft): n/a	Checked by: MM
Driller Contractor: Mudbay Drilling, M5T Drilling Machine		Drill Date: March 31, 2010	Logged by: FE

Depth	GWT	Piezometer	DCPT. blow/ft				Blows Per 6"	SPT-N	Type	No.	Strata	USCS	Soil Description
			0	20	40	60							
0	GWT not encountered										PT	Dark brown to brown, Organic soil mixed with sand and gravel, loose, dry	
5												EoH @ 5.5' due to hitting refusal.	
10													
15													
20													
25													
30													
35													

**Remarks:**  
1. Drilling locations were changed four times due to hitting refusal between 3' to 5.5' depth.

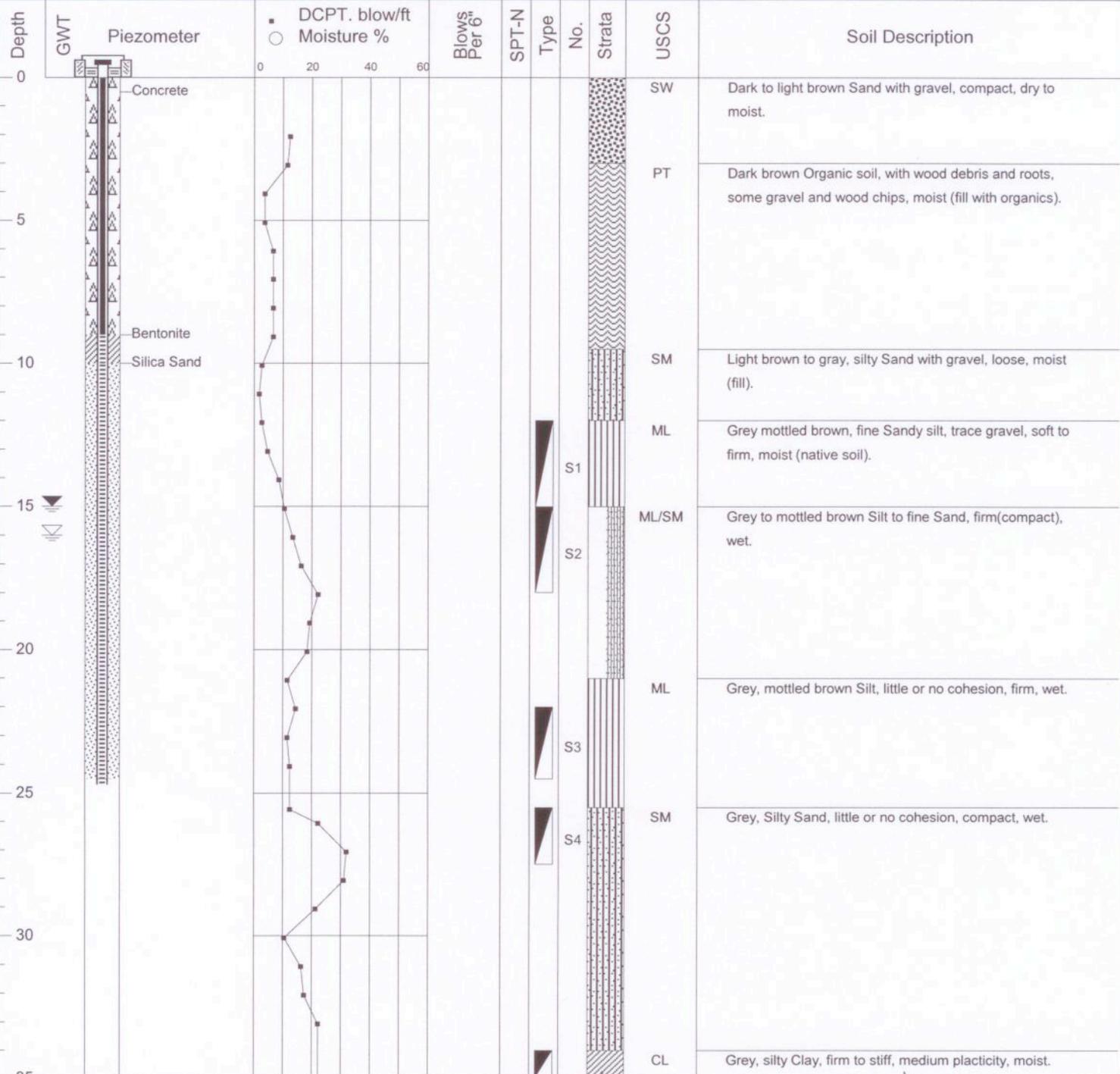
SuperLog CivilTech Software, USA www.civiltech.com File: C:\Documents and Settings\Mahmoud\My Documents\Ferdinand\DNV-Risk Assessment\CNV 809-811 AH-10-02.log Date: 13/07/2010



# GES Geotech Inc.

## Borehole no. AH-10-02 CNV Landslide Hazard Assesment, Phase II

Location: Cypress Gardens, Westview Drive, North V		Project # 10002
Drilling Method: Solid Stem, 5.5" Auger		Ground EL: -
Coordinate: See SI Plan.	Driller Operators: Dave, Rick	Borehole depth (ft): 41.5
Weather: Cloudy with sunny break	Temperature: 5-10 (C)	GWT @ Drilling(ft): 15-16
Driller Contractor: Mudbay Drilling, M5T Drilling Machine		Checked by: MM
Drill Date: March 31, 2010		Logged by: FE



**Remarks:**

1. Auger hole drilling hit refusal at 41.5' depth.
2. DCPT hole hit refusal at 39.5' depth.
3. A standpipe piezometer was installed after the end of drilling with slotted portion from 9' to 24.5' depth.

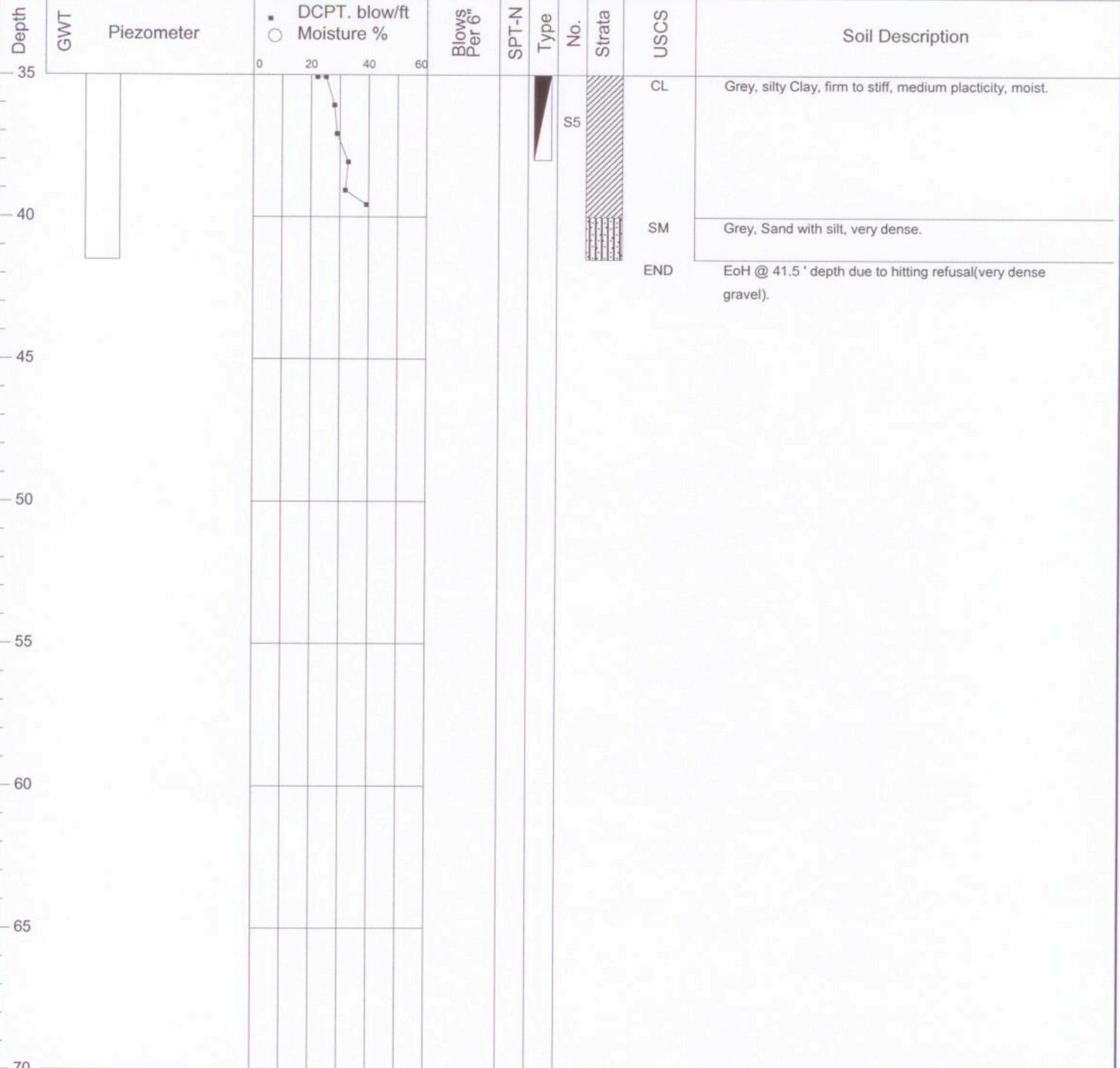
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 SuperLog CivilTech Software, USA www.civiltech.com



# GES Geotech Inc.

## Borehole no. AH-10-02 CNV Landslide Hazard Assesment, Phase II

Location: Cypress Gardens, Westview Drive, North V		Project # 10002
Drilling Method: Solid Stem, 5.5" Auger		Ground EL: -
Coordinate: See SI Plan.	Driller Operators: Dave, Rick	Borehole depth (ft): 41.5
Weather: Cloudy with sunny break	Temperature: 5-10 (C)	GWT @ Drilling(ft): 15-16
Driller Contractor: Mudbay Drilling, M5T Drilling Machine		Checked by: MM
Drill Date: March 31, 2010		Logged by: FE



Remarks:

1. Auger hole drilling hit refusal at 41.5' depth.
2. DCPT hole hit refusal at 39.5' depth.
3. A standpipe piezometer was installed after the end of drilling with slotted portion from 9' to 24.5' depth.

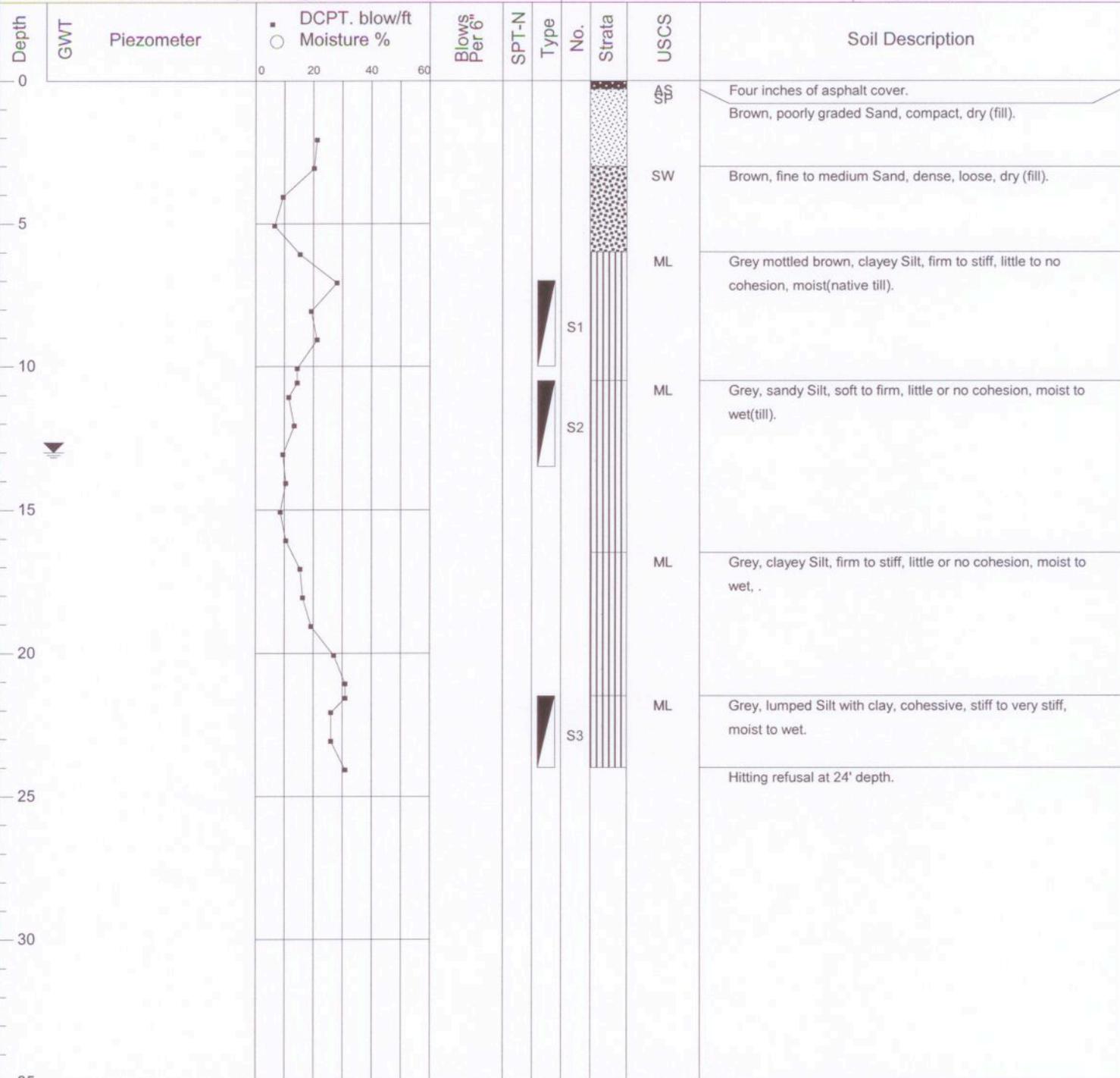
SuperLog CivilTech Software, USA www.civiltech.com File: C:\Documents and Settings\Mahmoud\My Documents\Ferdinand\DNV-Risk Assessment\Proposal\CNV 809-811 AH-10-03.log Date: 13/07/2010



**GES Geotech Inc.**

**Borehole no. AH-10-03**  
**CNV Landslide Hazard Assesment, Phase II**

Location: 1978 Wolfe Street, North Vancouver	Project # 10002
Drilling Method: Solid Stem, 5.5" Auger	Ground EL: -
Coordinate: See SI Plan	Driller Operators: Dave, Rick
Weather: Cloudy	Borehole depth (ft): 24'
Temperature: 5-10(C)	Checked by: MM
Driller Contractor: Mudbay Drilling, M10T Drilling Machine	Logged by: FE
GWT @ Drilling(ft): 13'	
Drill Date: April 1, 2010	



**Remarks:**

1. Hit groundwater table at 13' depth.
2. Auger hole hit refusal at 24' depth and DCPT hole hit refusal at 26' depth.
3. The hole plugged with bentonite chips, 1.5' below the ground surface and covered with asphalt upto the ground surf

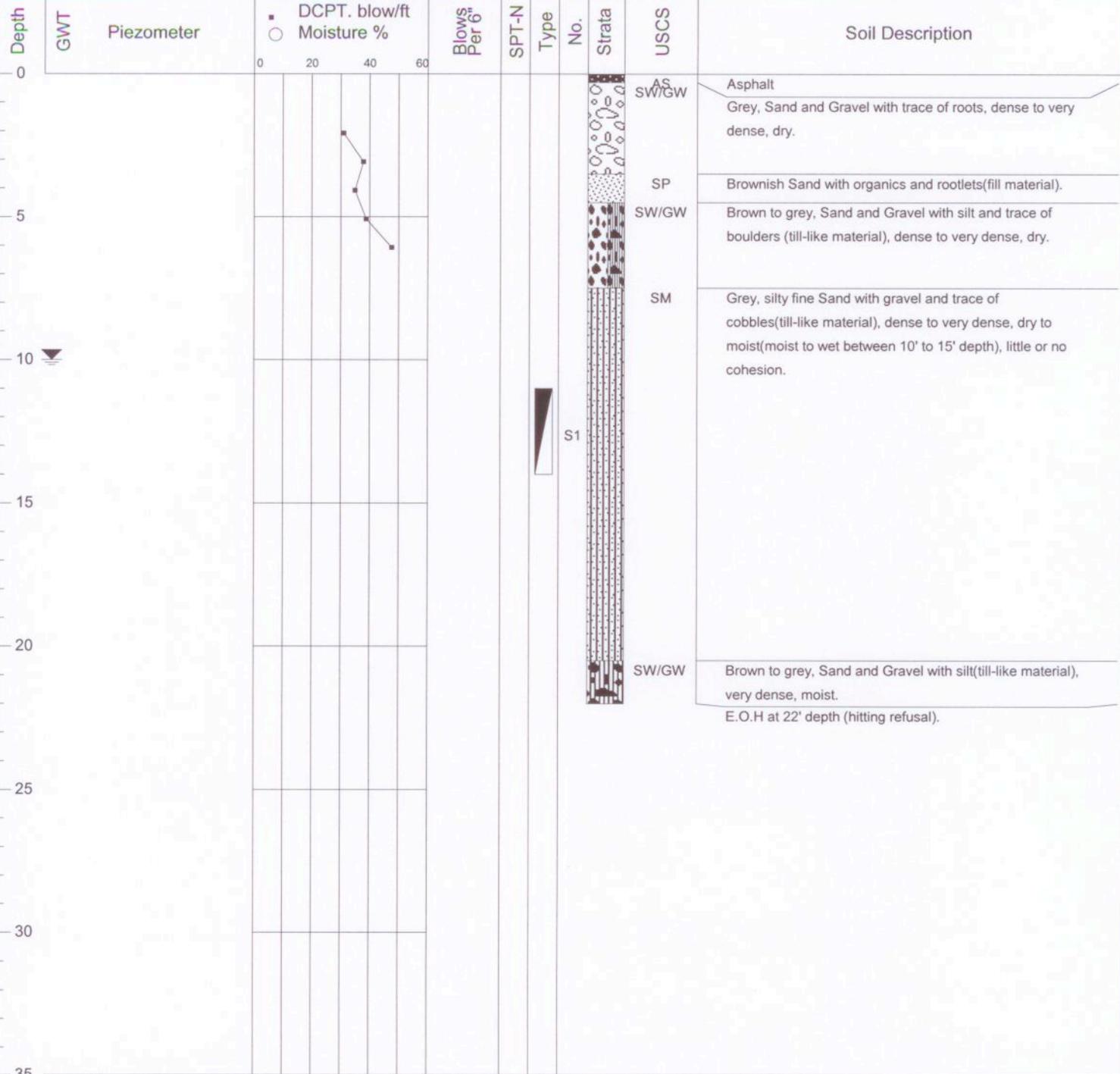
Date: 13/07/2010  
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 SuperLog CivilTech Software, USA www.civiltech.com



# GES Geotech Inc.

## Borehole no. AH-10-04 CNV Landslide Hazard Assesment, Phase II

Location: 2011 Grand Blvd., North Vancouver		Project # 10002
Drilling Method: Solid Stem, 5.5" Auger		Ground EL: -
Coordinate: See SI Plan	Driller Operators: Dave, Rick	Borehole depth (ft): 22
Weather: Cloudy	Temperature: 3-9 (C)	GWT @ Drilling(ft): 10
Driller Contractor: Mudbay Drilling, M5T Drilling Machine		Checked by: MM
Drill Date: April 1, 2010		Logged by: FE



Remarks:

- Groundwater table encountered at 10' depth.
- DCPT hole hit refusal at about 2' in the first two tries and it hit at 6'8" in 3rd try.

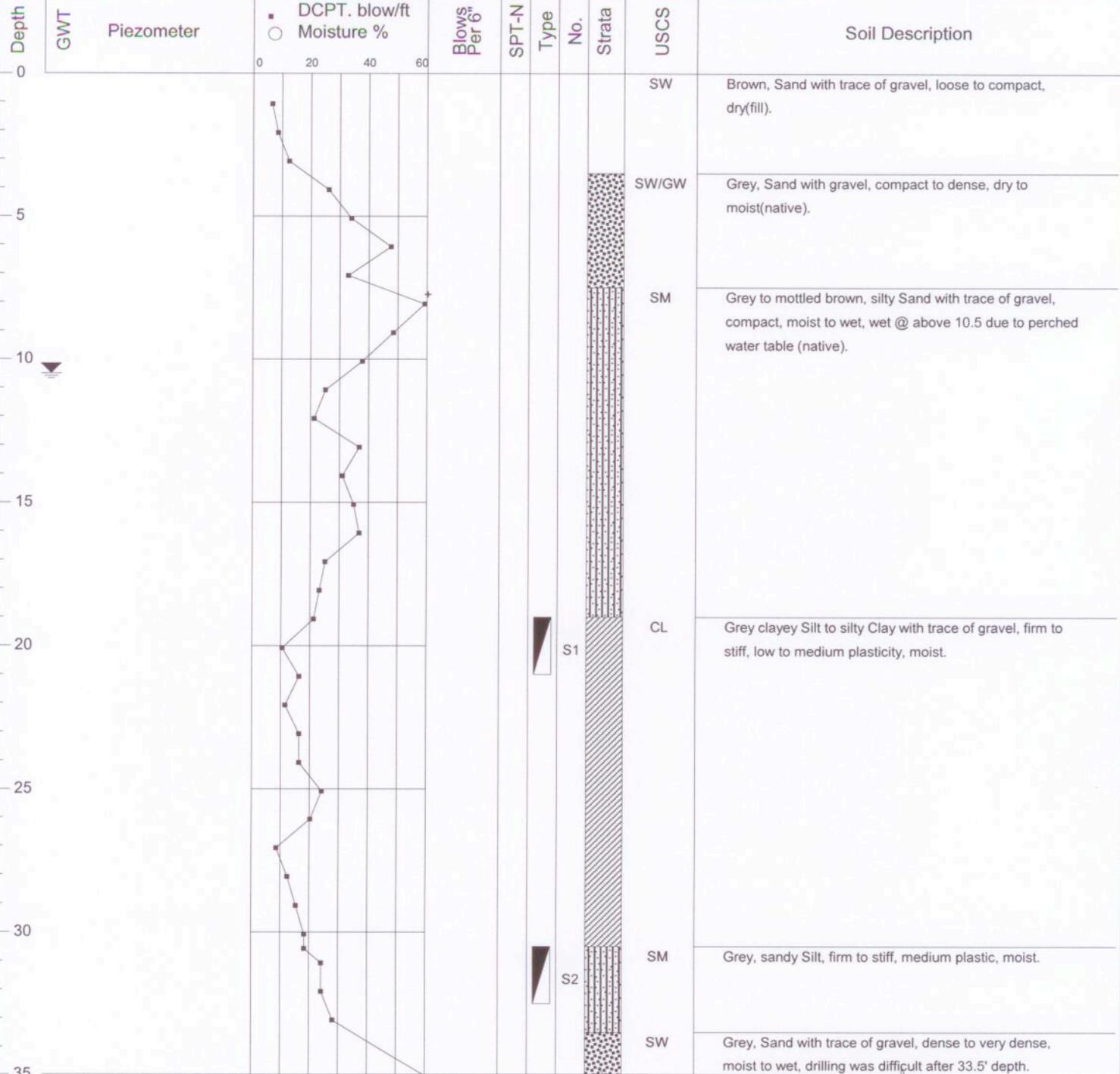
Date: 13/07/2010  
 File: C:\Documents and Settings\Mahmoud Mahmoud\My Documents\Ferdinand\DW-Risk Assessment\Proposal\CNV 809-811 AH-10-05.log  
 SuperLog CivilTech Software, USA www.civiltech.com



# GES Geotech Inc.

## Borehole no. AH-10-05 CNV Landslide Hazard Assesment, Phase II

Location: W15th Street, North Vancouver		Project # 10002
Drilling Method: Solid Stem, 5.5" Auger		Ground EL: -
Coordinate: See SI Plan.		Driller Operators: Dave, Rick
Weather: Cloudy with sunny break		Borehole depth (ft): 35
Temperature: 6-12 (C)		Checked by: MM
Driller Contractor: Mudbay Drilling, M5T Drilling Machine		Logged by: FE
		Drill Date: April 5, 2010



- Remarks:
1. Hit a perched water table at about 10.5' depth.
  2. Auger hole hit refusal at 35' depth.
  3. DCPT hole hit refusal at 32.5' depth.

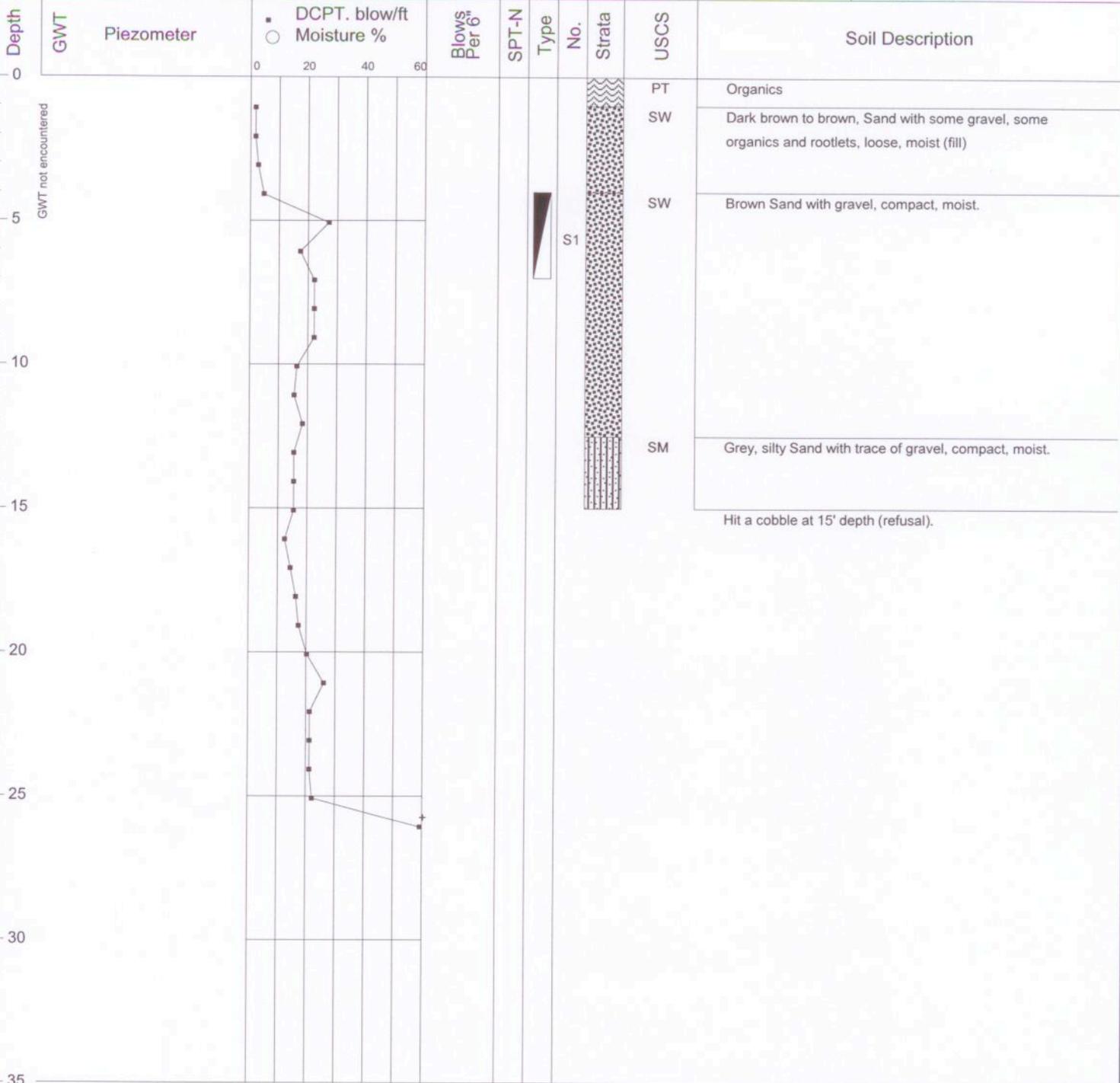
SuperLog CiviTech Software, USA www.civitech.com File: C:\Documents and Settings\Mahmoud\My Documents\Mahmoud\Risk Assessment\CNV 809-811 AH-10-06.log Date: 13/07/2010



# GES Geotech Inc.

## Borehole no. AH-10-06 CNV Landslide Hazard Assesment, Phase II

Location: 1900 Mackay Ave., North Vancouver		Project # 10002
Drilling Method: Solid Stem, 5.5" Auger /DCPT		Ground EL: -
Coordinate: See SI Plan	Driller Operators: Dave, Rick	Borehole depth (ft): 15
Weather: Outcast w/scattered shower	Temperature: 5-10	GWT @ Drilling(ft): n/a
Driller Contractor: Mudbay Drilling, M1.3T Drilling Machine		Checked by: MM
Drill Date: April 5, 2010		Logged by: FE



Remarks:  
 1. Auger hole hit refusal at 15' depth.  
 2. DCPT hole hit refusal at 26' depth.

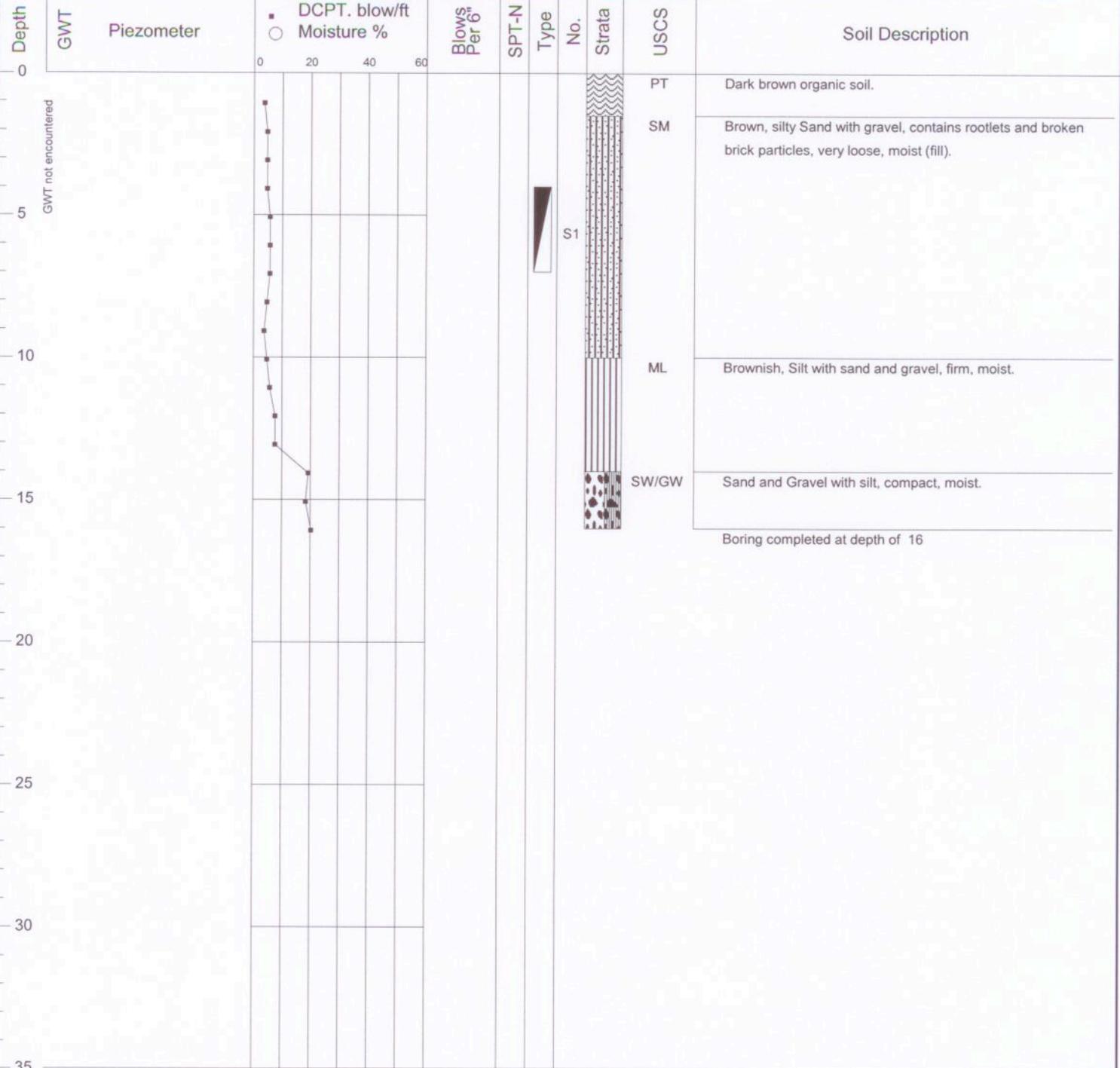
SuperLog CivilTech Software, USA www.civiltech.com File: C:\Documents and Settings\Mahmoud\My Documents\My Documents\Ferdinand\DNV-Risk Assessment\Proposal\CNV 809-811 AH-10-07.log Date: 13/07/2010



# GES Geotech Inc.

## Borehole no. AH-10-07 CNV Landslide Hazard Assesment, Phase II

Location: 1732 Wolfe Street., North Vancouver		Project # 10002
Drilling Method: Solid Stem, 5.5" Auger /DCPT		Ground EL: -
Coordinate: See SI Plan.	Driller Operators: Dave, Rick	Borehole depth (ft): 15
Weather: Rainy	Temperature: 4-9(C)	GWT @ Drilling(ft): n/a
Driller Contractor: Mudbay Drilling, M1.3T Drilling Machine		Logged by: FE
Drill Date: April 6, 2010		Checked by: MM



**Remarks:**

1. Auger hole hit refusal at 16' depth.
2. DCPT location were changed 3 times due to hitting rock between 2' - 4' depth.
3. DCPT hole hit refusal at 16' at 3rd tryout.

Date: 13/07/2010  
 File: C:\Documents and Settings\Mahmoud Mahmoud\My Documents\Ferdinand\DNV-Risk Assessment\Proposal\CNV 809-811 AH-10-08.log  
 SuperLog CivilTech Software, USA www.civiltech.com



# GES Geotech Inc.

## Borehole no. AH-10-08 CNV Landslide Hazard Assesment, Phase II

Location: 651 E 1st Street, North Vancouver			Project # 10002
Drilling Method: Solid Stem, 5.5" Auger /DCPT			Ground EL: -
Coordinate: See SI Plan.		Driller Operators: Dave, Rick	Borehole depth (ft): 3
Weather: Cloudy with sunny breaks	Temperature: 7-11(c)	GWT @ Drilling(ft): n/a	Checked by: MM
Driller Contractor: Mudbay Drilling, M1.3T Drilling Machine		Drill Date: April 6, 2010	Logged by: FE

Depth	GWT	Piezometer	DCPT. blow/ft				Blows Per 6"	SPT-N	Type	No.	Strata	USCS	Soil Description
			0	20	40	60							
0											PT	Organic soil, light to dark brown silty sand with an increasing gravel content with depth.	
3												EoH @ 3' due to hitting refusal.	
5	GWT not encountered												
10													
15													
20													
25													
30													
35													

Remarks:

1. Changed auger drilling location was changed 3 times after hitting refusal before 3' depth.
2. At fourth location, augerhole drilling hit refusal (gravel/rock) at about 3' depth.
3. DCPT hole was cancelled (hard pan).

## Phase 2-Geotechnical Stability Study Detailed Slope Stability and Risk Analysis Summary of Laboratory Test Results

#	Bore Hole		Sample		Lab Description	Unified Class. Symbol	Moisture Content, %	LL	PL	PI
	No.	Type	Name	Depth, ft						
1	AH1-10-03	Grab	S1	7-10	Light brown, mottled Silt, some clay, trace fine sand	ML	25.7	30.3	24.9	5.4
2	AH1-10-03	Grab	S2	11-14	Light brown, mottled sandy Silt	ML	27	not tested		
3	AH1-10-02	Grab	S3	21-24	Light brown, Silt, some clay, trace sand	ML	24.9	24.9	21	3.9
4	AH1-10-02	Grab	S5	34-38	Grey, Silt/Clay, trace gravel and fine sand	CL	31	30	20.6	9.4

C:\Users\User\Desktop\GES geotech\10002-CNV-Detailed Risk Analysis\Workfiles\SI and lab\Appendix C, Lab Tests Summary.xls\Sheet1

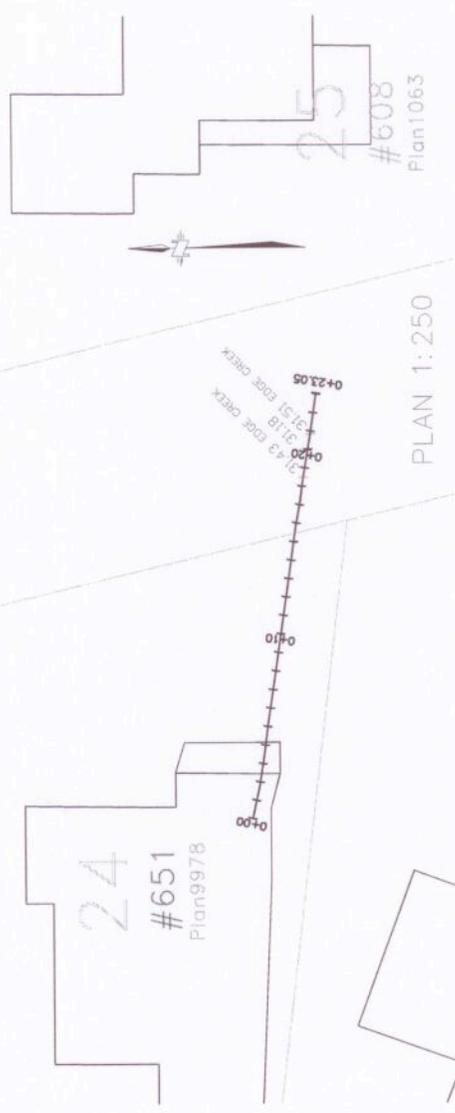
**Note:**

Laboratory tests were carried out by Stantec on April 1 and April 6, 2010.

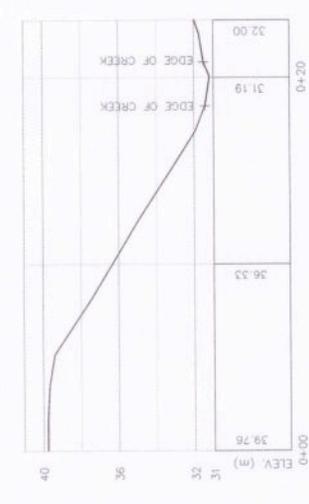
# **Appendix D**

Topographic profile at Different Properties by McElhanney





PLAN 1:250

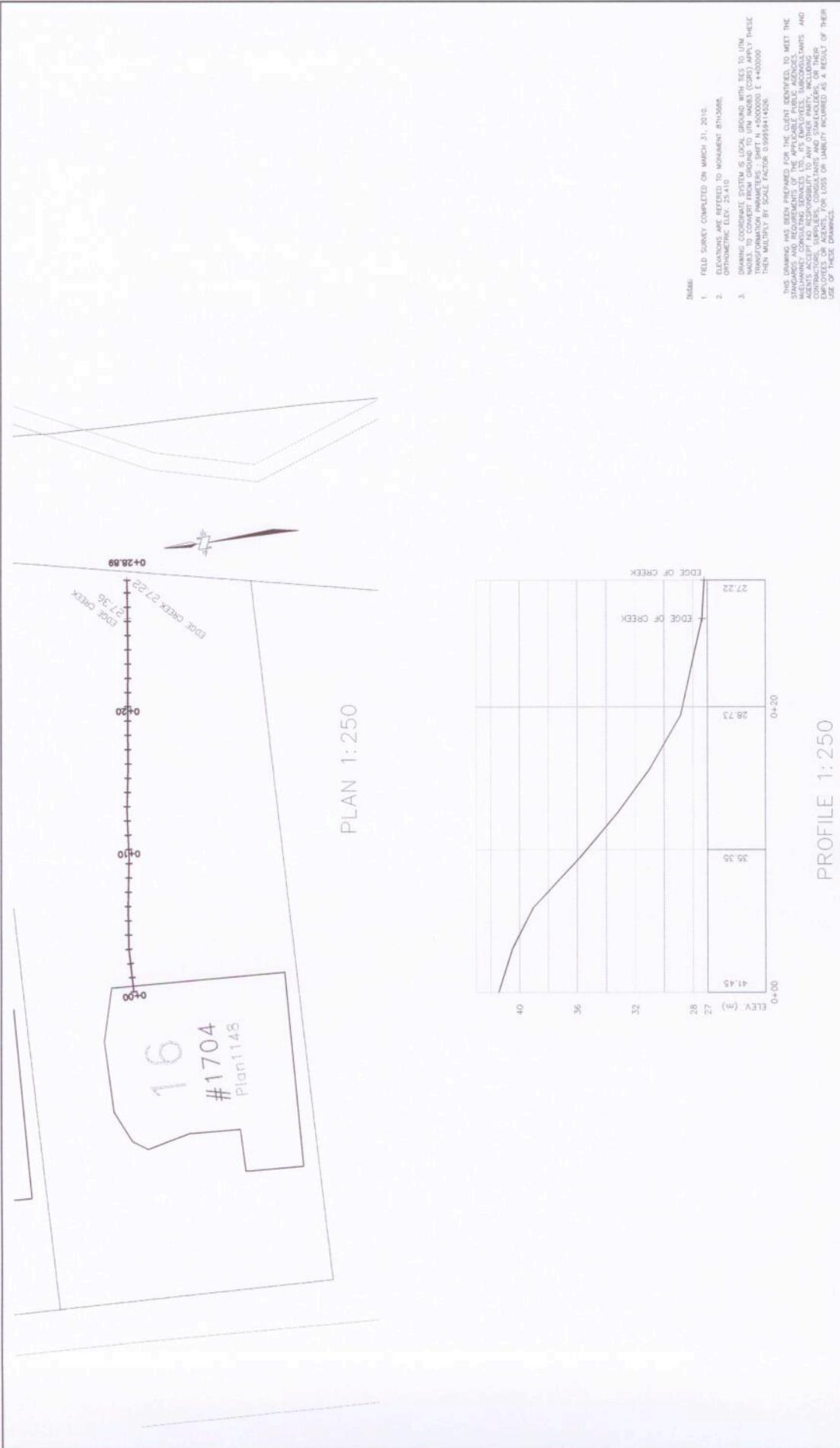


PROFILE 1:250

- NOTES:
1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.
  2. ELEVATIONS ARE REFERRED TO MONUMENT STATIONARY ORTHOMETRIC ELEVATION 25.140.
  3. DRAWING COORDINATE SYSTEM IS LOCAL. GROUND WITH TIES TO UTM SHOULD BE CONVERTED FROM GROUND TO UTM MODELS (CGRS) APPLY THESE TRANSFORMATION PARAMETERS: SHIFT X = +400000.00 E = +400000.00 THEN MULTIPLY BY SCALE FACTOR 0.99999543828.

THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED, TO MEET THE STANDARDS AND REQUIREMENTS OF THE PROFESSIONAL ENGINEERING AND SURVEYING ACT, 1993. THE CLIENT, BY ACCEPTING THIS DRAWING, ACCEPTS FULL RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING EMPLOYEES OR AGENTS, FOR LOSS OR LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>McElhanney</b> McElhanney Consulting Services Ltd. 100-7888 Bayview Avenue Scarborough, ON M1B 4Y6 TEL: (416) 491-0000 FAX: (416) 491-0000		Designer: _____ Drawn: # _____ Checked: _____ Date: 04/08/2010 Surveyed: 04/08/2010	<b>GES Geotech Incorporated</b> 651 FIRST STREET SUITE 200 NORTH WILSONVILLE, ONTARIO	Project No.: 02075-0 base Scale: as shown unless otherwise noted
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DATE: 03/31/2010

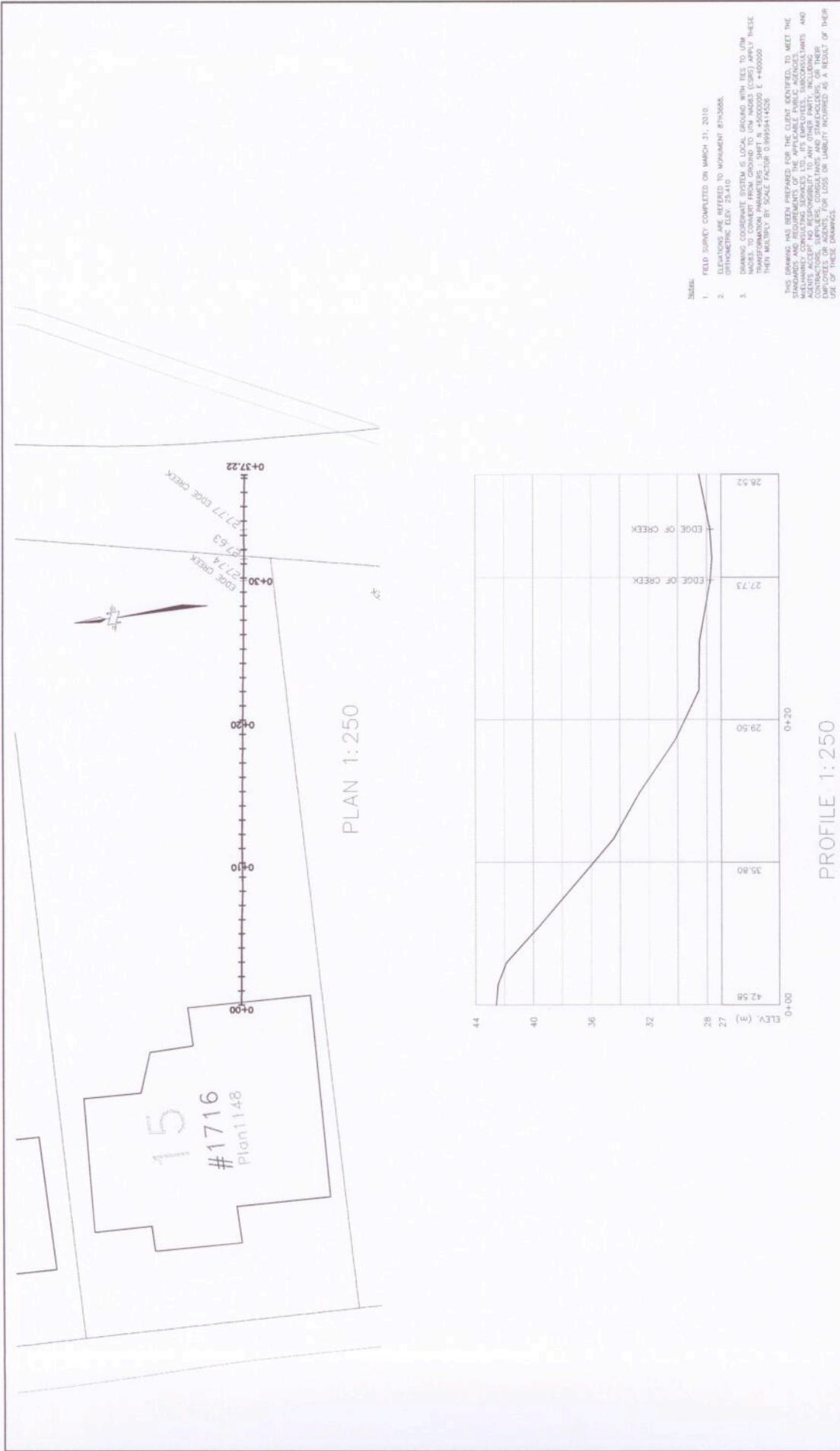
1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.

2. READINGS ARE REFERRED TO MONUMENT 871-3888. ORTHOMETRIC ELEV. 25.410

3. DRAWING COORDINATE SYSTEM IS LOCAL GROUND WITH BESS TO UTM MARKS. TO CONVERT FROM GROUND TO UTM MARKS (CGRS) APPLY THESE TRANSFORMATION PARAMETERS: SHIFT N +5000000.00 E +400000.00 SCALE FACTOR 0.99999443528

THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT (BOUYGUE) TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC ASSOCIATION. THE CLIENT (BOUYGUE) IS RESPONSIBLE FOR THE DESIGN, CONSTRUCTION AND MAINTENANCE OF THE PROJECT. THE CLIENT (BOUYGUE) AND AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING EMPLOYEES OR AGENTS, FOR LOSS OR DAMAGE INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>McElhanney</b> McElhanney Consulting Services Ltd. 100 West Bank Road Mechanicsville, VA 23103 FAX: 804-893-0300		Directed By: _____ Drawn: _____ Checked: _____ Surveyed: 03/30/10 Date: 03/31/2010	GCS Geotech Incorporated 1704 WOLFE STREET FARMINGTON, CT 06031	Project No.: 02075-0_base Date: 03/31/2010
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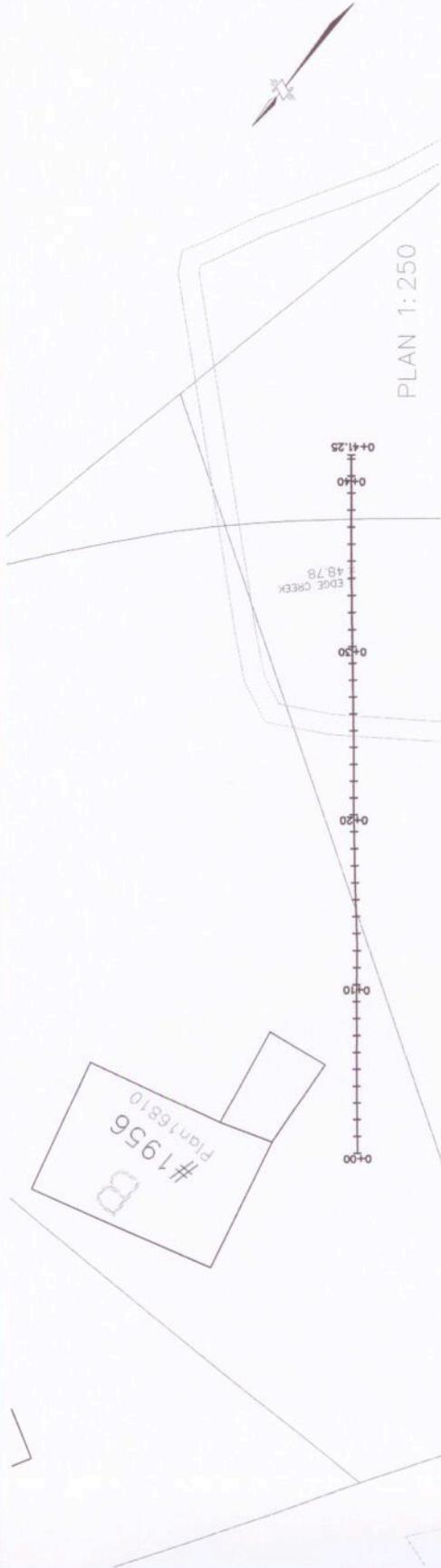


NOTES:

1. FIELD SURVEY COMPLETED ON MARCH 31, 2010
2. ALL ELEVATIONS ARE REFERRED TO MONUMENT #1703885, ORTHOMETRIC ELEVATION 25.110.
3. DRAWING COORDINATE SYSTEM IS LOCAL. WORKING WITH THE TO UNITS. TO CONVERT FROM GROUND TO UNITS (CGRS) APPLY THESE TRANSFORMATION PARAMETERS: SHIFT X: +5000000.0 E: +6000000.0 THEN MULTIPLY BY SCALE FACTOR 0.9999944326

THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED. TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC AUTHORITIES, AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING CONTRACTORS, FOR ANY ERRORS, OMISSIONS, OR INADEQUACIES, OR DAMAGES OR LOSSES, OR LOSS OF INDEMNITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>McElhanney</b> McElhanney Consulting Services Ltd. 1716 WOLFE STREET VANCOUVER, BC V6L 1K9 TEL: 604-683-8800		Checked by: _____ Drawn: # _____ Date: 08/08/2010		Project: _____ Survey: 04/00		Scale: _____ Date: 08/08/2010		Project No.: 02075-0_base Scale: 1:250	
<b>GES Geotech Incorporated</b> 1716 WOLFE STREET <b>TOPOGRAPHIC SURVEY</b> 1716 WOLFE STREET SLOPE STABILITY STUDY NORTH VANCOUVER				Author: _____ Date: _____				Scale: _____ Date: _____	



PLAN 1:250

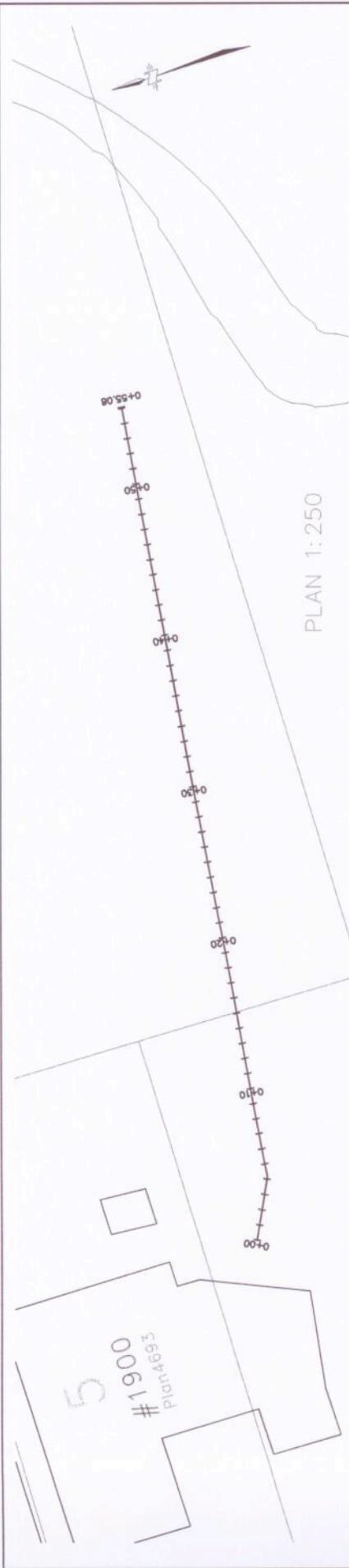


PROFILE 1:250

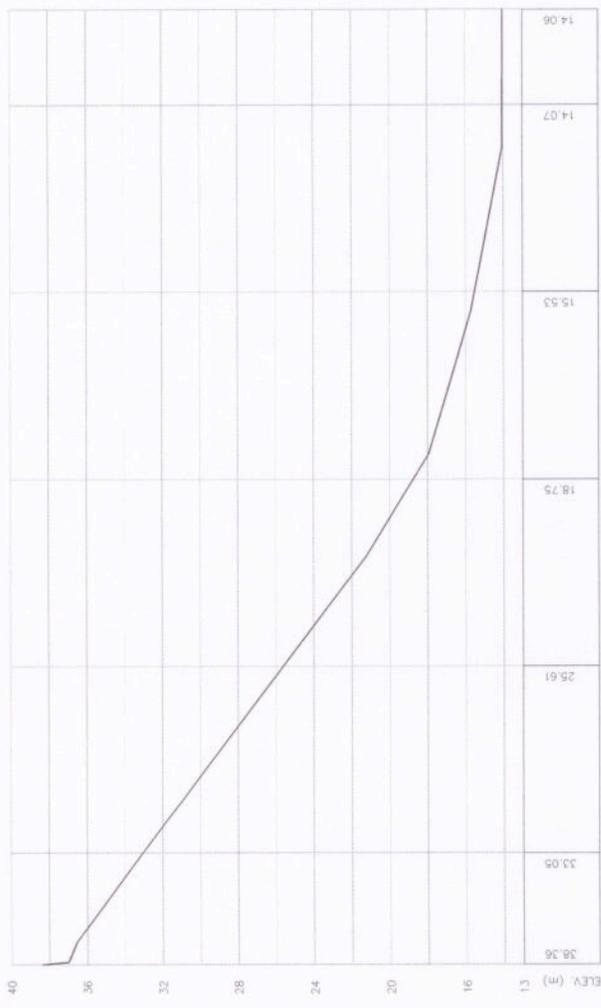
- NOTE:
1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.
  2. ELEVATIONS ARE REFERRED TO MONUMENT 8753688, GEODENSIC ELEV. 25410
  3. DRAWING COORDINATE SYSTEMS LOCKED DOWN WITH NAD 83 (79) TRANSFORMATION TO UTM NAD83 (2011) USING THESE TRANSFORMATION PARAMETERS: SHEET N. +5000000 E. +4000000 THEN MULTIPLY BY SCALE FACTOR 0.9999941428.

THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC AGENCIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND CONTRACTORS, SUPPLIERS, CONSULTANTS AND STAKEHOLDERS OF THEIR OWN ACCORDANCE WITH ANY APPLICABLE REGULATIONS OR STANDARDS. THE USER OF THESE DRAWINGS ACCEPTS ALL LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>GES Geotech Incorporated</b> 601 100 Main Street, Vancouver BC V6C 2K6		Drawing No. 2113-20075-B <b>02075-0 base</b> <small>BASELINE PLAN ONLY - NOT FOR CONSTRUCTION</small>	
<b>TOPOGRAPHIC SURVEY</b> 1856 WOLFE STREET BLOCK STABILIZATION NORTH VANCOUVER		Date: APR 08, 2010 Drawn: # Surveyed: 04/08	
<b>McElhanney</b> McElhanney Consulting Services Ltd. <small>100 - 780 Bay Street          Vancouver, BC V6B 2M6</small>		Registered Professional Engineer P.Eng. 000000000	
No. _____ Date _____ Revision _____	No. _____ Date _____ Revision _____	No. _____ Date _____ Revision _____	No. _____ Date _____ Revision _____



PLAN 1:250

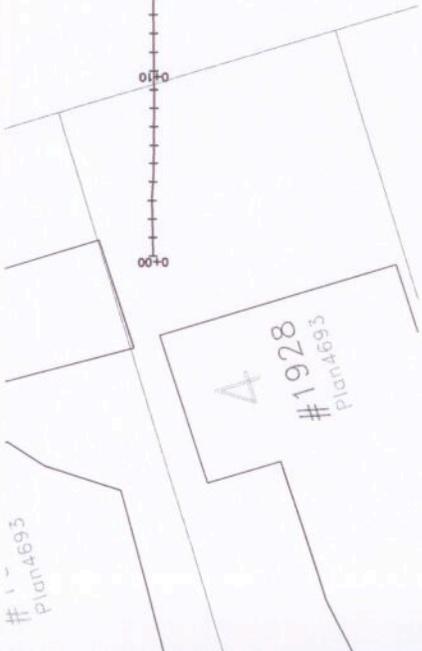


PROFILE 1:250

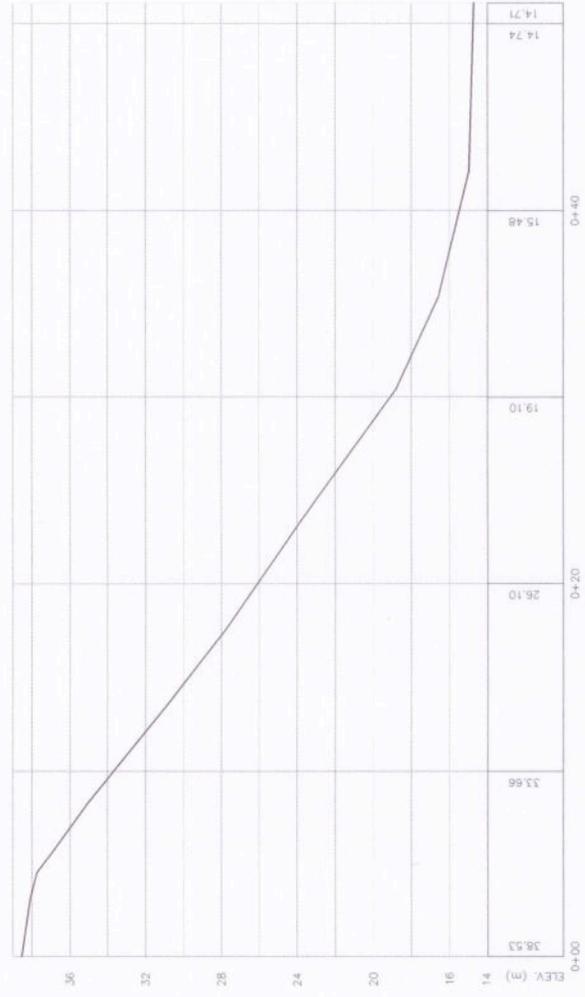
- NOTE:
1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.
  2. ELEVATIONS ARE REFERRED TO MONUMENT 67433800. CORNERING ELEV. 25.418.
  3. ALL POINTS ARE LOCATED BY LOCAL BENCH MARKS TO ILM. MARKS TO CONVERT FROM CHORD TO ILM MARKS (CORS) APPLY THESE TRANSFORMATION PARAMETERS: SHIFT N +5000000.0 E +400000.0 THEN MULTIPLY BY SCALE FACTOR 0.9999814226.
- THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT PROVIDED TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC AGENCIES. THE CLIENT ACCEPTS ALL RESPONSIBILITY FOR THE ACCURACY OF THE DATA. CONTRACTORS, SUPPLIERS, CONSULTANTS AND STAKEHOLDERS, ON THEIR OWN ACCOUNT, ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING THE CLIENT, FOR LOSS OR LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

GES Geotech Incorporated 1900 MACKAY STREET NORTH VANCOUVER		Date: 09/28/2010 Surveyed: 09/02/2010
TOPOGRAPHIC SURVEY 1900 MACKAY STREET NORTH VANCOUVER		Drawn: # Checked: W Surveyed: 09/02/2010
McElhanney McElhanney Consulting Services Ltd. 100-1080 WEST 4TH AVE VANCOUVER, BC V6E 3K6 TEL: 604-683-2800		Client: 2112-02075-0 Drawing: 02075-0_base

# 11 -  
pluidid  
699474693



PLAN 1:250

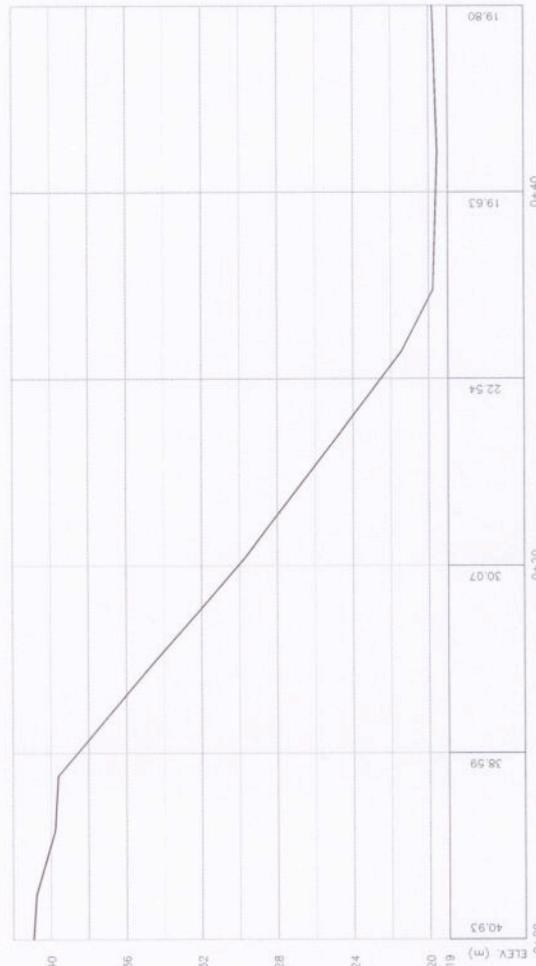
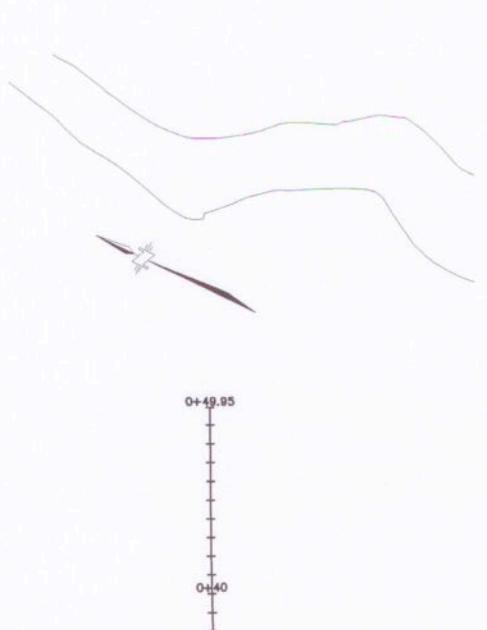


PROFILE 1:250

NOTE: THIS DRAWING WAS PREPARED FOR THE CLIENT EMPLOYED TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC AGENCIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE ACCURACY OF THE DATA AND FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS. CONTRACTORS, SUPPLIERS, CONSULTANTS AND STAKEHOLDERS OR THEIR AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING THE CLIENT, FOR LOSS OR DAMAGE INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

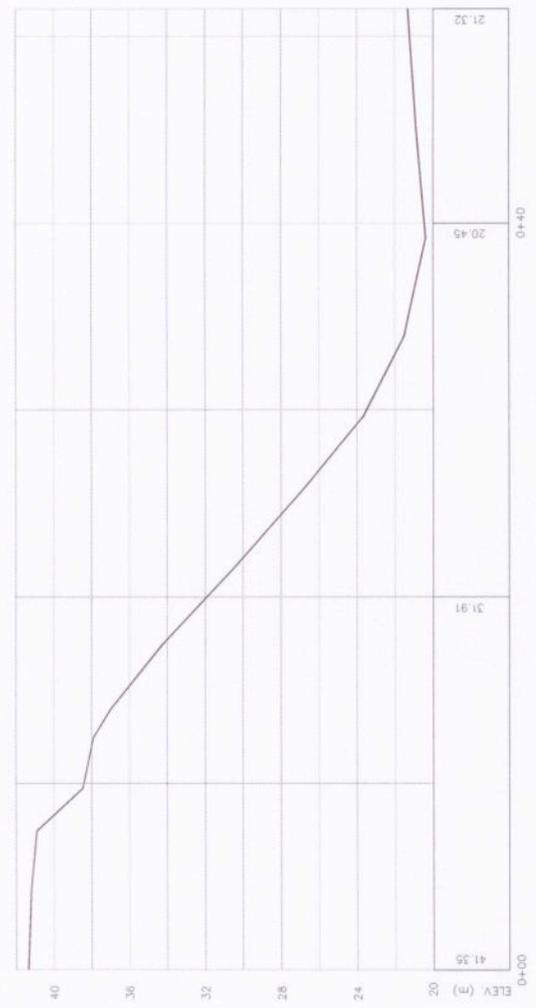
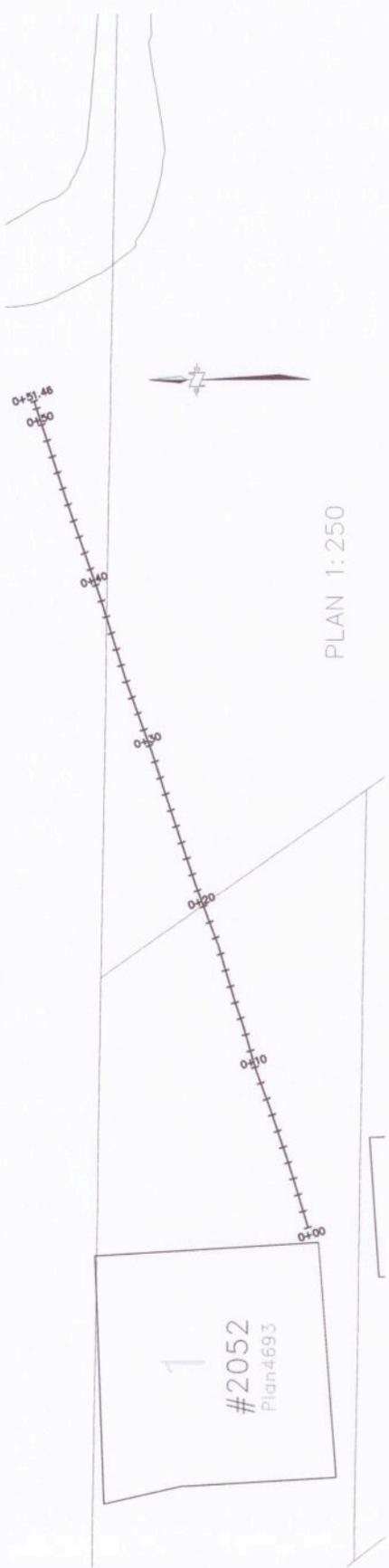
THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT EMPLOYED TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC AGENCIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE ACCURACY OF THE DATA AND FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS. CONTRACTORS, SUPPLIERS, CONSULTANTS AND STAKEHOLDERS OR THEIR AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING THE CLIENT, FOR LOSS OR DAMAGE INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>GES Geotech Incorporated</b> 85110 Main Street, Toronto, ON, M2H 1A1		Date: 03/31/2010 Drawing No: <b>02075-0_base</b>	
<b>TOPOGRAPHIC SURVEY</b> 1928 MACKAY STREET SLOPE GRADIENT STUDY NORTH UNCOVERED		Project No: 02075-0	
Designer: Drawn: #	Checked: # Surveyed: (M/D)	Date: 03/31/2010	Project: 02075-0
<b>McElhanney</b> McElhanney Consulting Services Ltd. 1000 Lakeshore Blvd. West Toronto, ON M8Z 1R9 Tel: 416-491-8800		Project: 02075-0	



- NOTE:
1. FIELD SURVEY COMPLETED ON MARCH 31, 2019.
  2. ELEVATIONS ARE REFERRED TO MONUMENT STATIONARY ORTHOMETRIC ELEVATION 25.140.
  3. DRAWING COORDINATE SYSTEM IS LOCAL GROUND WITH BCS TO UTM MARKS TO CONVERT FROM GROUND TO UTM MARKS (CGRS). APPLY THESE TRANSFORMATION PARAMETERS: SHIFT N +500000.00 E +400000.00 WITH A SCALING FACTOR 0.9999941628.
- THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED, TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE PUBLIC ACCOUNTING ACTS AND REGULATIONS. THE SURVEYOR AND HIS/HERS ASSOCIATES, AGENTS, AND EMPLOYEES ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING EMPLOYERS OR AGENTS, FOR LOSS OR LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>McElhanney</b> McElhanney Consulting Services Ltd. 1000 WILSON AVENUE WILSON, ONTARIO M3H 2B8 CANADA		Design # Draw # Date Scale	Checked # Surveyed # Date Scale	02075-0 base 2024 MACKAY STREET BLOCK 2000000000 LOT 10000000000	2113-02075-1 02075-0 base DATE OF PRINTING: 2019.03.28
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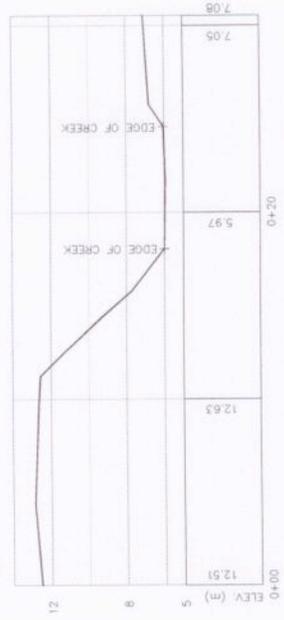
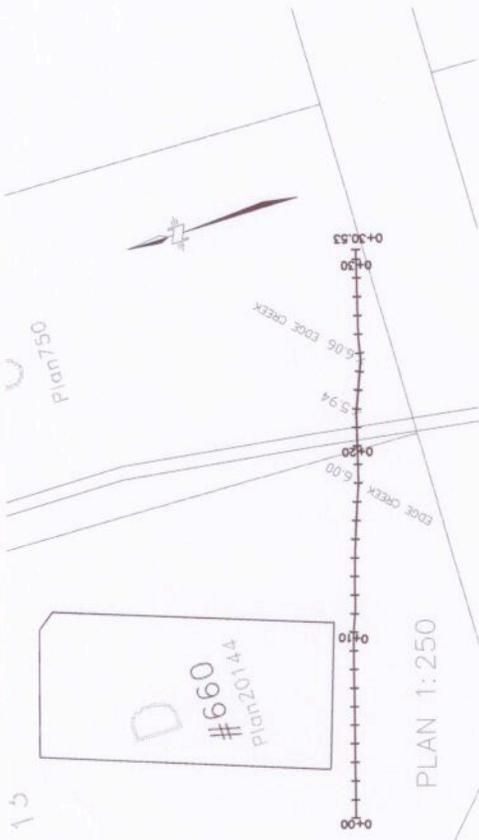


1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.  
 2. ELEVATIONS ARE REFERRED TO MONUMENT 87MMSB. ORTHOMETRIC ELEV. 25.410.  
 3. DRAWING COORDINATE SYSTEM IS LOCAL GROUND WITH BESS TO UTM MASKS TO CONVERT FROM GROUND TO UTM MASKS (CGRS) APPLY THESE TRANSFORMATION PARAMETERS: SPT N +4000000 E +4000000 (SEE MAPSHEET OF SOLE PROJECT 89999911526).

THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED TO MEET THE STANDARDS AND REQUIREMENTS OF THE PROFESSIONAL ENGINEERING AND SURVEYING ACT. THE CLIENT ACCEPTS FULL RESPONSIBILITY FOR THE ACCURACY AND VALIDITY OF THE DATA AND INFORMATION PROVIDED TO ANY OTHER PARTY, INCLUDING EMPLOYEES OR AGENTS, FOR LOSS OR LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

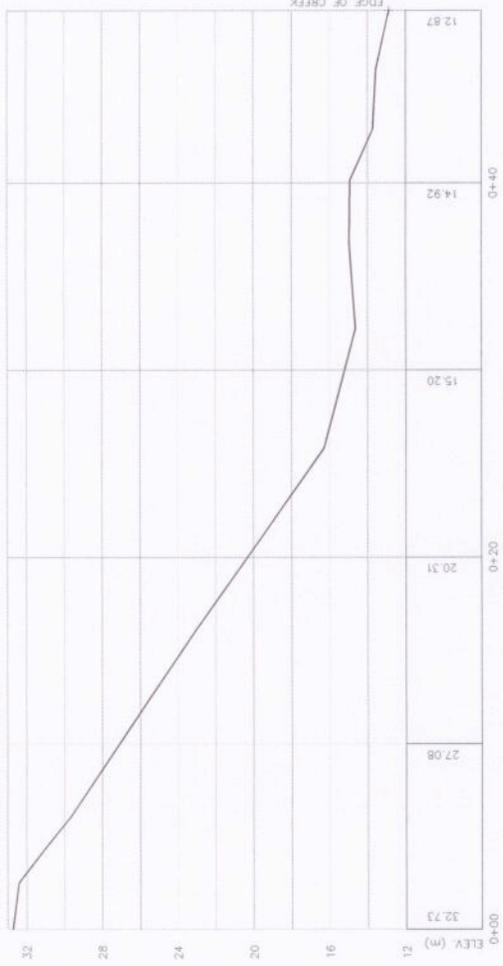
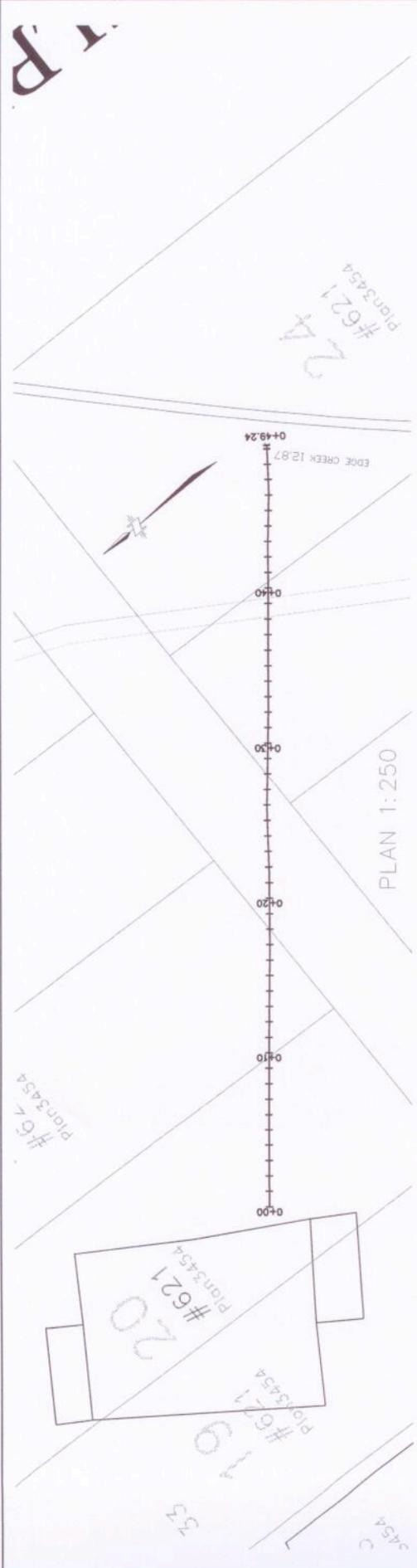
<b>McElhanney</b> <b>McElhanney Consulting Services Ltd.</b> <small>100-788 (Main) Road        WILLOWDALE, ON. M2B 1A1        P: 416-882-8200        F: 416-882-0200</small>		Original Drawn: # Surveyed: 09/03 Checked: # Date: APR 08, 2010	<b>GES Geotech Incorporated</b> <small>100-100 Lakeshore Blvd. Willowdale, ON. M2B 1A1</small> <b>TOPOGRAPHIC SURVEY</b> 2052 MACKAY STREET <small>SCHEMATIC STUDY          CONSULTATION ONLY</small>	Scale: 1:250 Date: 04/08/2010 Project: 02075-0_base Client: 2112-0075-01 Drawn:
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- NOTE:
1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.
  2. ELEVATIONS ARE REFERRED TO MONUMENT 67N5886, ORTHOMETRIC ELEV. 25.410.
  3. DRAWING COORDINATE SYSTEM IS LOCAL GRIDING WITH BEES TO UTM ZONES TO CONVERT FROM GRID TO UTM ZONES (CRS) APPLY THESE TRANSFORMATION PARAMETERS: SHEET N = +500000.0 E = +400000.0 THEN MULTIPLY BY SCALE FACTOR 0.999941438.
- THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED, TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE REGULATORY AGENCIES. THE CLIENT AND THE CONSULTANT SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING EMPLOYEES OR AGENTS, FOR LOSS OF LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

GCS Geotech Incorporated 1000 Highway 104 <b>TOPOGRAPHIC SURVEY</b> <b>660 THIRD STREET</b> SLOPE STABILITY STUDY NORTH WESLOUGH		Date: 04/08/2010 Drawn: # Surveyed: M/Y Checked: # Surveyed: M/Y	Scale: 1:250 Project No.: 02075-0_base Date: 04/08/2010
<b>McElhanney</b> McElhanney Consulting Services Ltd. <small>INC. - TRUSTED PARTNER</small> <small>UNIVERSITY OF TORONTO</small> <small>PA 04-880-8282</small>			
15 D #660 Plan 20144			
PLAN 1:250			
PROFILE 1:250			
12 8 5 0+00 ELEV. (m)			
7.05 5.97 12.63 0+20			
7.06 0+30.53 6.06 5.94 6.00 EDGE CREEK EDGE CREEK			



1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.
2. ELEVATIONS ARE REFERRED TO MONUMENT BENCH MARK, OPTHMETRIC, ELEV. 25.410.
3. DRAWING COORDINATE SYSTEM IS LOCAL GRIDING WITH EES TO UTM TRANSFORMATION PARAMETERS: SRTM N = 5000000.0 E = 400000.0 WITH FACTOR OF SCALE FACTOR 0.999994428.
- THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED, TO MEET THE REQUIREMENTS OF THE CLIENT. THE CLIENT HAS BEEN ADVISED OF THE LIMITATIONS OF THIS DRAWING AND HAS ACCEPTED THE SAME. THE CLIENT'S EMPLOYEES AND AGENTS ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING EMPLOYEES OR AGENTS, FOR LOSS OF LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

<b>McElhanney</b> McElhanney Consulting Services Ltd. 100-7800 Bayview Road Scarborough, ON M1S 2M4 TEL: 416-491-8800 FAX: 416-493-0200		Registered: Drawn: # Checked: # Surveyed: M(B)	Date: 08/08/2010	Project No.: E117-00750-0 <b>02075-0_base</b> <small>SCALE OF 1:250 FOR PLAN VIEW, 1:250 FOR PROFILE</small>
<b>GES Geotech Incorporated</b> 8811-150 Avenue Road, Unit 100, WILLOWDALE, ONT. M2H 1G4		<b>TOPOGRAPHIC SURVEY</b> 621 FIFTEENTH STREET MARKHAM, ONTARIO L3R 9V7		



- NOTE:
1. FIELD SURVEY COMPLETED ON MARCH 31, 2010.
  2. ELEVATIONS ARE REFERRED TO MONUMENT 67N-388A. ORTHOMETRIC ELEV 25.410
  3. DRAWING COORDINATE SYSTEM IS LOCAL GRIDING WITH BSS TO UTM MARKS. TO CONVERT FROM GRID TO UTM MARKS (CGRS) APPLY THESE TRANSFORMATION PARAMETERS: SHIFT N: +5400000.0 E: +400000.0 HIGH: MULTIPLY BY SCALE FACTOR 0.999941403.
- THIS DRAWING HAS BEEN PREPARED FOR THE CLIENT IDENTIFIED TO MEET THE STANDARDS AND REQUIREMENTS OF THE APPLICABLE REGULATORY AGENCIES AND AGENCIES ACCEPT NO RESPONSIBILITY TO ANY OTHER PARTY, INCLUDING EMPLOYEES OR AGENTS, FOR LOSS OR LIABILITY INCURRED AS A RESULT OF THEIR USE OF THESE DRAWINGS.

GCS Geotech Incorporated 620 FIFTEENTH STREET NORTH WILSON, BC V1N 1S5		Date: 04/08/2010 Drawn: [Blank] Checked: [Blank] Surveyed: [Blank]	Date: 04/08/2010 Drawn: [Blank] Checked: [Blank]
<b>McElhanney</b> McElhanney Consulting Services Ltd. 620 FIFTEENTH STREET NORTH WILSON, BC V1N 1S5		Project No: 02075-0_base Scale: 1:250	

# **Appendix E**

A Summary of the City Archive Review for Background  
Construction Records at each Property

**SUMMARY OF BACKGROUND INFORMATION FOR EACH PROPERTY DERIVED FROM THE CITY ARCHIVE**

#	Site Address	Summary notes
1	2052 Mackay Ave	<ul style="list-style-type: none"> <li>- March 1963, Permission granted to get connected to Sanitary Sewer of the City</li> <li>- A note referring to a guest cottage with septic field on the property.</li> </ul>
2	2048 Mackay Ave	<ul style="list-style-type: none"> <li>- City address change from 2044 Mackay Ave to 2048 Mackay Ave.</li> <li>- July 1970, Permission granted to get connected to Sanitary Sewer of the City</li> <li>- July 1970, Property owner requested to enclose the porch next to the slope as dining area, no response</li> <li>- July 1970, Property owner requested to add a bedroom and bathroom downstairs-No response</li> <li>- Oct 1969, Permission granted to get connected to Sanitary Sewer of the City</li> <li>- No information about the connection to the city storm sewer</li> </ul>
3	2024 Mackay Ave	<ul style="list-style-type: none"> <li>- March 1965, Connection to the City sewer was granted.</li> <li>- May 1970, Connection to the City sewer was granted.</li> <li>- Storm sewer end up to the creek</li> <li>- Storm sewer end up to the creek</li> <li>- Storm sewer end up to the creek</li> </ul>
4	1928 Mackay Ave	<ul style="list-style-type: none"> <li>- Dec 1970-Erosion of the creek bank and further slippage of the bank adjacent to the townhouses</li> <li>- Bank stabilization adjacent to the creek and to the west of the shopping centre was recommended by Geotech consultants</li> </ul>
5	1900 Mackay Ave	<ul style="list-style-type: none"> <li>- Info sent on Aug 2001 for evaluating slope failure and dangerous trees.</li> <li>- No information about the connection to the city storm sewer</li> </ul>
6	837-851 Westview Cres.	<ul style="list-style-type: none"> <li>- Mar 1993, Comments about the existence of fill material(drywall disposal) viewed from the Mahon Park and possible contamination of the creek.</li> <li>- No storm connection to city storm sewer</li> </ul>
7	825-835 Westview Cres.	<ul style="list-style-type: none"> <li>- Oct 1965, proposal to connect the house to Sanitary sewer</li> <li>- No records on storm sewer</li> </ul>
8	811-823 Westview Cres.	<ul style="list-style-type: none"> <li>- This site was eliminated from Phase II-Detailed Risk Assessment as per advice from CNV.</li> <li>- Garage and lane extension issued in 2006, S of the property next to lane</li> <li>- No info is provided</li> </ul>
9	1956 Wolfe St	<ul style="list-style-type: none"> <li>- The building was built on concrete retaining wall based on available drawings</li> <li>- Centennial Geotechnical Engineers Ltd. carried out a site investigation and a geotech report in 1997.</li> <li>- thhshghsdffh</li> </ul>
10	1732 Wolfe St	<ul style="list-style-type: none"> <li>- A permit issued that includes the "restoration" of the house (Dec 1989).</li> </ul>
11	1716 Wolfe St	
12	660 W 3rd St	
13	621 W 15th St	
14	651 E 1st St	
15	2116 Grand Blvd	
16	2011 Grand Blvd	
17	1978 Wolfe	
18	1704 Wolfe	
19	620 W 15th Street	

# Appendix F

Specific Risk Level at Each Property Location

## Phase 2-Geotechnical Stability Study Detailed Slope Stability and Risk Analysis

#	Site Address	P <sub>H</sub>	P <sub>S,H</sub>	Partial Risk	Building Dist.	Attached/ Secondary Structure's Dist	Partial Risk Assessment in Bldg <sup>2</sup>		Partial Risk Assessment, Attached/Secondary Structure <sup>2</sup>		Vulnerability		Specific Risk	
							Static Cond.	EQ Cond.	Static Cond.	EQ Cond.	bldg	Attached/ Secondary Structure	Bldg w Attached/Se condary Structure	Bldg
		BGC	BGC	BGC	m	m								
1	2052 Mackay Ave	HIGH	HIGH	VERY HIGH	7.3	0	Moderate	Moderate	Very High	Very High	Mod	High	Extreme	Mod
2	2048 Mackay Ave	MODERATE	HIGH	HIGH	4.3	1.5	Moderate	Moderate	Very High	Very High	Low	High	Extreme	Low
3	2024 Mackay Ave	MODERATE	HIGH	HIGH	6.4	0	Moderate	Moderate	Very High	Very High	Mod	High	Extreme	Mod
4	1928 Mackay Ave	HIGH	MODERATE	HIGH	9	1	Moderate	Moderate	Very High	Very High	Low	High	Extreme	Low
5	1900 Mackay Ave	HIGH	MODERATE	HIGH	4.7	0	High	High	Very High	Very High	Low	High	Extreme	Mod
6	837-851 Westview Cres	HIGH	MODERATE	HIGH	4	n/a	High	High	n/a	n/a	Mod	n/a	High	
7	825-835 Westview Cres	HIGH	MODERATE	HIGH	5.3	n/a	Moderate	High	n/a	n/a	Mod	n/a	High	
8	811-823 Westview Cres	HIGH	MODERATE	HIGH	5.3	n/a	Moderate	Moderate	n/a	n/a	Mod	n/a	Mod	
9	1956 Wolfe St	HIGH	MODERATE	HIGH	6	2.2	Moderate	Moderate	Not attached		Mod	n/a	Mod	
10	1732 Wolfe St	HIGH	MODERATE	HIGH	9	6	Low	Low	Low	Low	Mod	Mod	Low	Low
11	1716 Wolfe St	HIGH	MODERATE	HIGH	3.2	n/a	High	Very High	n/a	n/a	High	n/a	Extreme	
12	660 W 3rd St	MODERATE	HIGH	HIGH	This site was eliminated from Phase II-Detailed Risk Assessment as per advice from CNV.									
13	621 W 15th St	HIGH	MODERATE	HIGH	5	n/a	Low	Low	n/a	n/a	Mod	n/a	Low	
14	651 E 1st St	MODERATE	HIGH	HIGH	4.5	1	Low	Low	Moderate	Moderate	Mod	Mod	Mod	Low
15	2116 Grand Blvd	MODERATE	HIGH	HIGH	n/a	n/a	Moderate	Moderate	n/a	n/a	Mod	High	High	Mod
16	2011 Grand Blvd	MODERATE	HIGH	HIGH	n/a	n/a	Low	Low	n/a	n/a	Mod	n/a	Low	
17	1978 Wolfe	HIGH	LOW	MODERATE	6.5	n/a	Moderate	Moderate	n/a	n/a	Low	n/a	Low	
18	1704 Wolfe	MODERATE	MODERATE	MODERATE	3	n/a	High	High	n/a	n/a	High	n/a	Very High	
19	620 W 15th Street	LOW	HIGH	MODERATE	3	n/a	High	High	n/a	n/a	Low	n/a	Mod	

Macintosh HD:Users:sadafsanii\Desktop:GES:CNV PROJECT 10002:CNV Appendix:[Appendix F - Specific Risk Level at Each Property Location.xls]FE's Risk Final

### Definations of the qualitative partial risk ratings in Static Condition

Partial Risk to Structure under Static Condition P(HA)	Rating	Criteria
	Very Low	Fs >= 2.0
	Low	1.5 <= Fs < 2.0
	Moderate	1.3 <= Fs < 1.5
	High	1.1 <= Fs < 1.3
Very High	Fs < 1.1	

### Definations of the qualitative partial risk ratings in Seismic Condition(as per APEGBC Guidelines)

Partial Risk to Structure under Seismic Condition P(HA)	Rating	Criteria
	Low	Fs >= 1.1
	Moderate	1.0 <= Fs < 1.1
	High	0.9 <= Fs < 1.0
Very High	Fs < 0.9	

### Specific Risk Matrix based on combined values of Vulnerability and Partial Risk Ratings

		Vulnerability Rating		
		Low	Moderate	High
Partial Risk Rating	Very Low	Very Low	Very Low	Low
	Low	Very Low	Low	Moderate
	Moderate	Low	Moderate	High
	High	Moderate	High	Very High
	Very High	High	Very High	Extreme

Last Updated: July 19, 2010-FE

### Notes:

- Factor of safety of 1.0 is equivalent to a deformation of 0.15 m(or less) for a seismic event of 2475-year return period.
- Partial risk assessments are based on the slope stability calculations as per above criteria for static and seismic conditions.

# Appendix G

Mitigation Measures and Estimated Costs

**Phase 2-Geotechnical Stability Study  
Detailed Slope Stability and Risk Analysis  
Mitigation Measures and Estimated Costs**

#	Site Address	Specific Risk		Proposed Mitigation Measures		Estimated costs, \$	
		Bldg w Attached/ Secondary Structure	Bldg	Passive Measures	Active Measures		
1	2052 Mackay Ave	Extreme	Mod	Secondary Building shall be uninhabitable.	Replace existing retaining wall with an engineered wall.	< \$50,000	
2	2048 Mackay Ave	Extreme	Low		Detach the secondary structure from the main building.	< \$30,000	
3	2024 Mackay Ave	Extreme	Mod	Secondary Building shall be uninhabitable.	Connection to the City Storm sewer or engineered release of storm sewer to the stream	n/a	
4	1928 Mackay Ave	Extreme	Low		Detach the secondary structure from the main building.	< \$30,000	
5	1900 Mackay Ave	Extreme	Mod		Detach the secondary structure from the main building.		
6	837-851 Westview Cres	High			Installation of gabion retaining wall and add rip rap.	< \$40,000	
7	825-835 Westview Cres	High			Installation of gabion retaining wall and add rip rap.	< \$40,000	
8	811-823 Westview Cres	Mod			Connection to the City Storm sewer or engineered release of storm sewer to the stream	n/a	
9	1956 Wolfe St	Mod			Connection to the City Storm sewer or engineered release of storm sewer to the stream	n/a	
10	1732 Wolfe St	Low	Low		n/a	n/a	
11	1716 Wolfe St	Extreme			Installation of an MSE wall Replacement of the structural wooden posts	< \$60,000	
12	660 W 3rd St	This site was eliminated from Phase II-Detailed Risk Assessment as per advice from CNV.					
13	621 W 15th St	Low			n/a	n/a	
14	651 E 1st St	Mod	Low		Connection to the City Storm sewer or engineered release of storm sewer to the stream	n/a	
15	2116 Grand Blvd	High	Mod		Installation of two survey monuments over the edge of slope Monitoring and recording the movement for the 1 <sup>st</sup> ,3 years		
16	2011 Grand Blvd	Low			n/a	n/a	
17	1978 Wolfe	Low			n/a	n/a	
18	1704 Wolfe	Very High			Installation of an MSE wall	< \$50,000	
19	620 W 15th Street	Mod			Connection to the City Storm sewer or engineered release of storm sewer to the stream	n/a	

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**Notes:**

n/a: not applicable

# Appendix H

Cumulative Displacement of Inclinometer at Cypress Garden  
(GES reading on July 12, 2010)

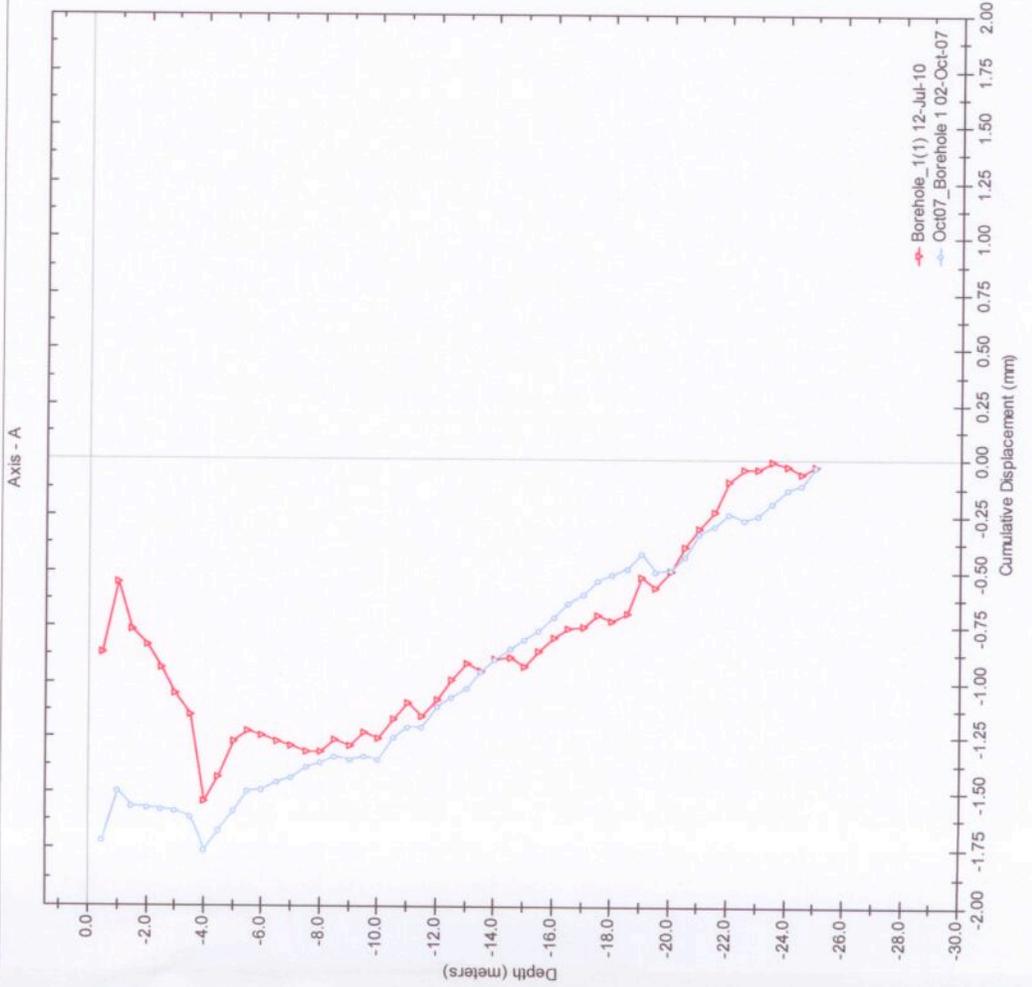
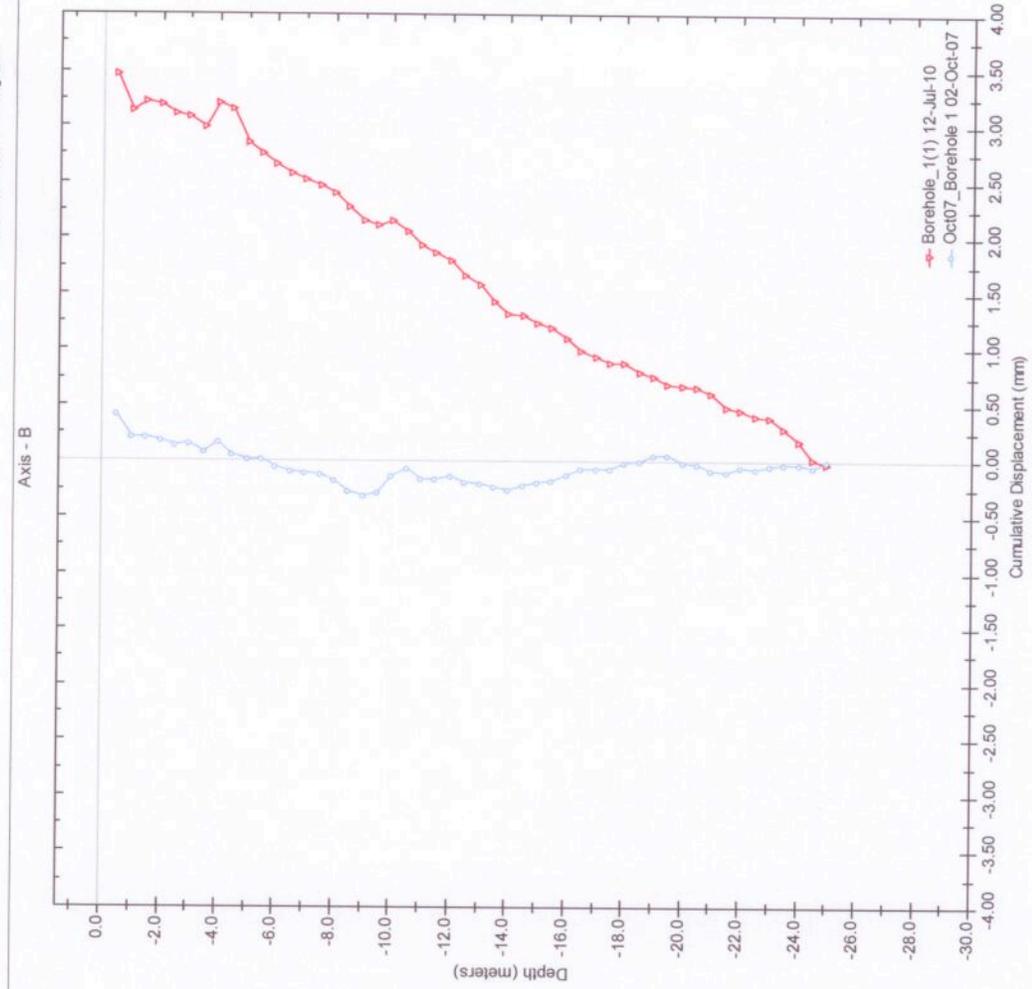
# CUMULATIVE DISPLACEMENT

RST Instruments Ltd.

Borehole : Borehole\_1  
 Project : CNW Inclinator  
 Location :  
 Northing :  
 Easting :  
 Collar :

Inclinanalysis v.2.35

Spiral Correction : N/A  
 Collar Elevation : 0.0 meters  
 Borehole Total Depth : 25.0 meters  
 North Groove Azimuth :  
 Base Reading : 2007 Feb 05 13:30  
 Axis A Azimuth : 0.0 degrees



# Appendix I

Situational Map of Properties/Secondary Attachments

**SITUATIONAL MAP: REPORT**

LAST UPDATE: 2011-04-28 - 10:12:12 AM

**CNV - Phase II-Geotechnical Stability Study-Detailed Risk Analysis, N Van, BC / Study / 2011-04-21 / 10:00:00**

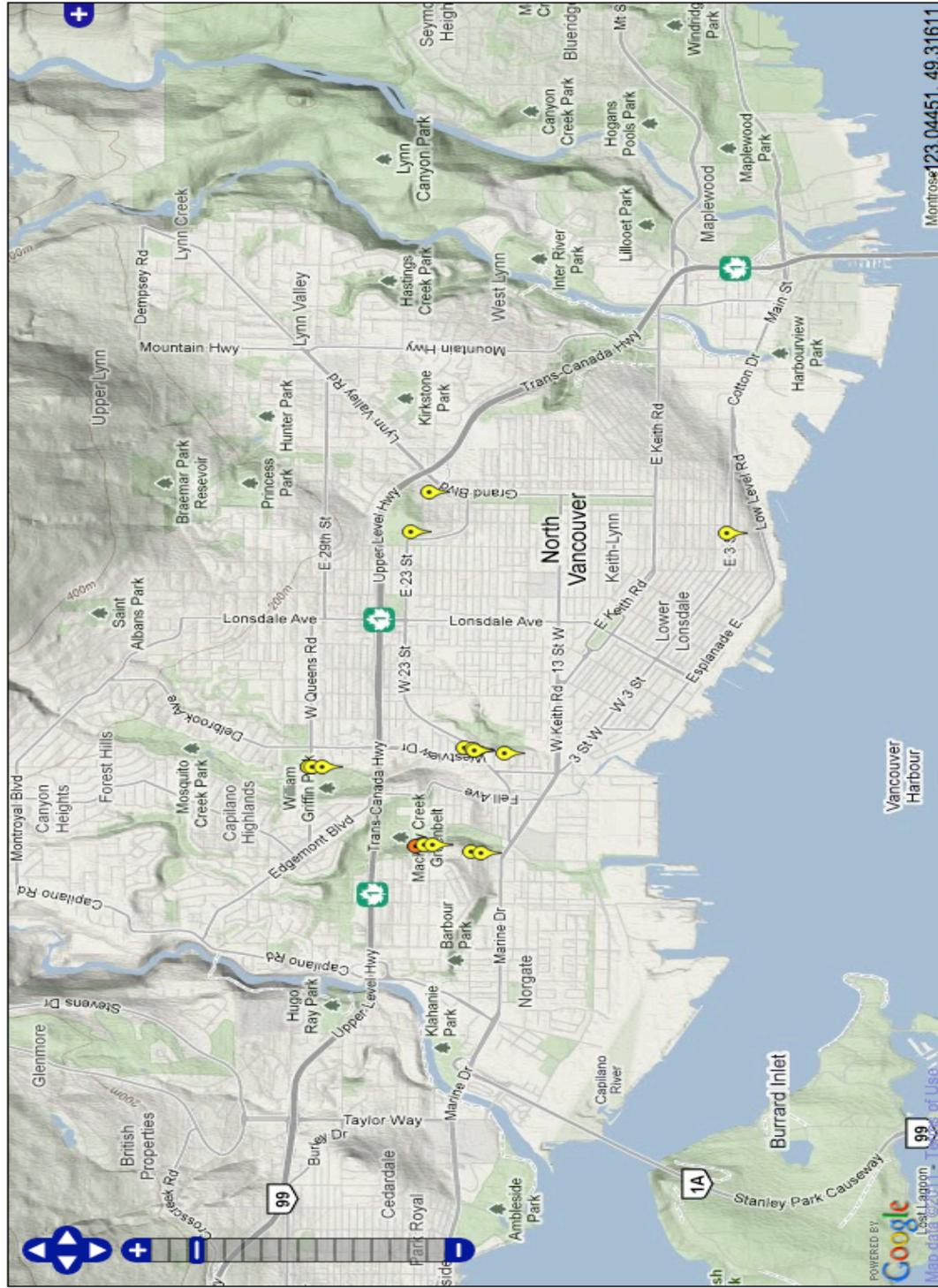


Figure AI-1: GES Study Area; 18 sites of High, Very High, and Moderate Partial Risk Rating (as determined by BGC, 2009)



**SITUATIONAL MAP: REPORT**

LAST UPDATE: 2011-04-28 - 10:12:12 AM

**CNV - Phase II-Geotechnical Stability Study-Detailed Risk Analysis, N Van, BC / Study / 2011-04-21 / 10:00:00**

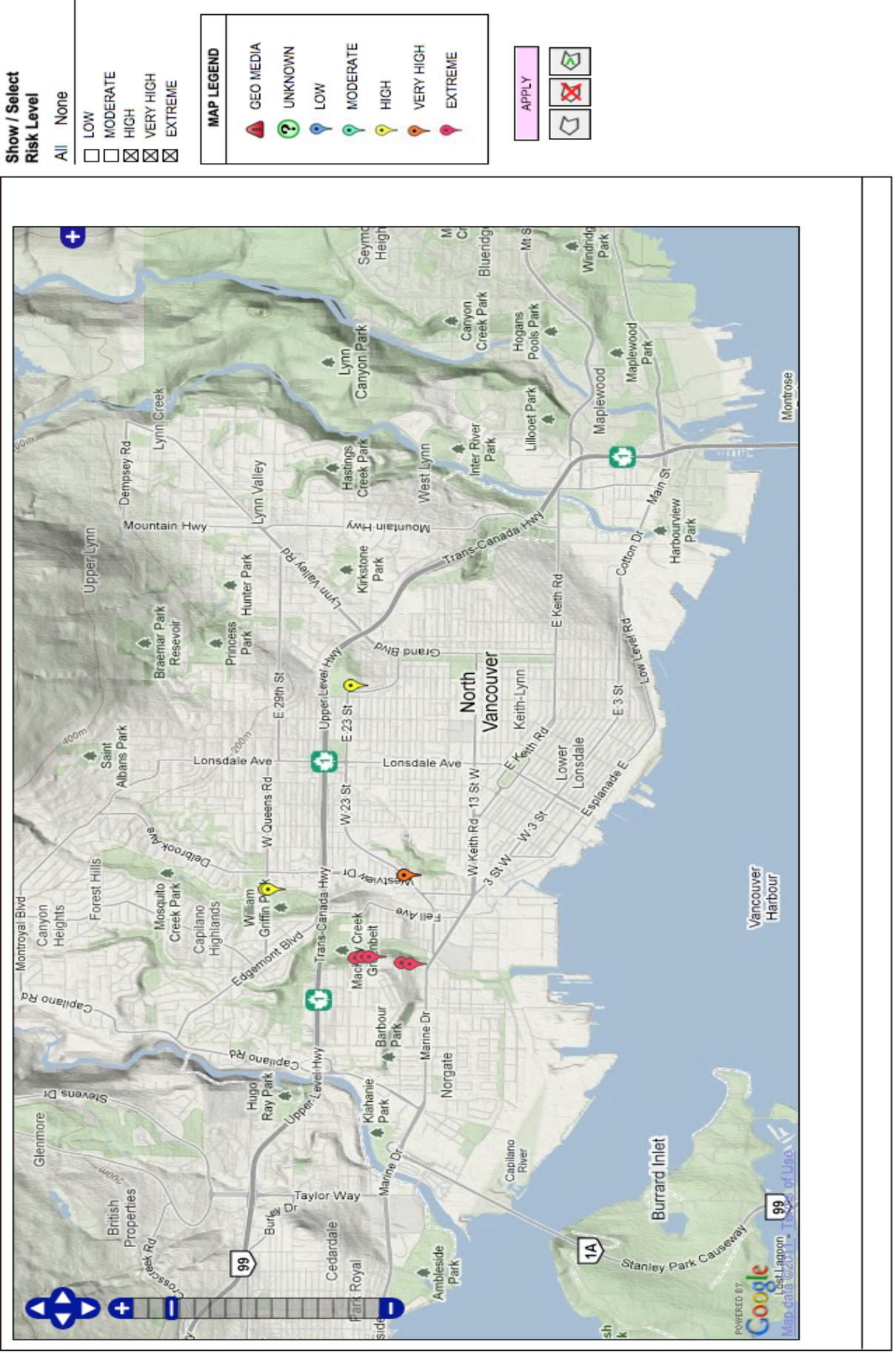


Figure AI-3: 10 Sites identified by GES as Secondary Attachments having High, Very High, and Extreme Specific Risk Rating