

Guidelines for
Legislated Landslide Assessments for
Proposed Residential Development in
British Columbia

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Prepared by

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1. INTRODUCTION

As British Columbia continues to grow in population, pressure for *residential development* in areas that are prone to *landslides*¹, or have potentially unstable slopes, will increase. For the past 30 years, various pieces of provincial legislation have required that *landslide assessments* for proposed *residential development* in *landslide-prone* areas be carried out by *Professional Engineers*. More recently, *Professional Geoscientists* have been included in some of this legislation. The legislation requires that a *Professional Engineer* or *Professional Geoscientist* indicate whether the *residential development* will be 'safe' from the effects of *landslides*.

Professional Engineers and *Professional Geoscientists* with appropriate education, training and experience have the technical ability to carry out various forms of *landslide analysis*; however, to date, guidelines for such analyses for *residential development* have not been documented. In addition, defined levels of safety from the effects of *landslides*² have not been adopted for most of BC. It is **not** the role of a *Professional Engineer* or *Professional Geoscientist* to define such levels of safety; they must be established and adopted by the local or provincial government after considering a range of societal values.

The lack of a *landslide hazard* policy was first brought to the provincial government's attention by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) almost 30 years ago in a brief outlining a "Proposed Hazard Policy for British Columbia" (APEGBC 1977; initiated by Farquharson et al 1976, see also Williams 1983).

1.1 PURPOSE OF THE GUIDELINES

This document (1) provides guidelines of professional practice for a *Professional Engineer* and *Professional Geoscientist* who carries out a *landslide analysis* for a proposed *residential development*, and (2) provides guidance to the professional as to how to relate the results of the analysis to a *level of landslide safety* for *residential development* when required by provincial legislation. Appendix D to these Guidelines provides a *Landslide Assessment Assurance Statement* that must be submitted, along with a *landslide assessment* report, to an *Approving Authority*.

Land Owners and *Development Consultants*; *Land Use Planners*, *Approving Officers* and *Building Inspectors*; *Municipalities*, *Regional Districts*, and the *Islands Trust*³; the

¹ Terms in italics are explained in Appendix A.

² For the purpose of these Guidelines, the level of safety from the effects of *landslides* is referred to as *level of landslide safety* and includes levels of acceptable *landslide hazard* and *landslide risk*.

³ *Municipalities*, *Regional Districts* and the *Islands Trust* are collectively referred to as *local governments*.

provincial government; and the general public frequently rely on such *landslide assessments*. These Guidelines may also assist those parties.

These Guidelines address typical project organization and responsibilities of the various stakeholders; professional practices that should typically be provided; quality assurance/quality control; and professional registration and education, training and experience.

These Guidelines address the elements of a *landslide assessment for residential development*; they do not describe how to carry out such an assessment.

1.2 ROLE OF APEGBC

These Guidelines have been formally adopted by the Council of APEGBC, and form part of APEGBC's ongoing commitment to maintaining the quality of services that its *Members* provide to their Clients and the general public. *Professional Engineers* and *Professional Geoscientists* are professionally accountable for their work under the Engineers and Geoscientists Act (RSBC 1996, Chapter 116, as amended), which is enforced by APEGBC.

A *Member* must exercise professional judgment when providing professional services; as such, application of these Guidelines will vary depending on the circumstances. APEGBC supports the principle that a *Member* should receive fair and adequate compensation for professional services, including services provided to comply with these Guidelines. An insufficient fee does not justify services that do not meet the intent of these Guidelines. These Guidelines may be used to assist in establishing the objectives, type of *landslide analysis*, level of effort and terms of reference of a *Member's agreement* with his/her *Client*.

By following these Guidelines a *Member* should fulfill his/her professional obligations, especially with regards to APEGBC Code of Ethics Principle 1, which is to hold paramount the safety, health and welfare of the public, protection of the environment and promote health and safety in the workplace⁴. Failure of a *Member* to meet the intent of these Guidelines could be evidence of unprofessional conduct and lead to disciplinary proceedings by APEGBC.

1.3 INTRODUCTION OF TERMS

Appendix A explains all terms shown in italics in these Guidelines. The following introduces some of the terms.

For the purpose of these Guidelines, a *Qualified Professional* is a *Professional Engineer* or *Professional Geoscientist* with appropriate education, training and experience to conduct *landslide assessments for residential development* as described in these Guidelines (refer to Section 5). Typically, such a *Professional Engineer* will be practising

⁴ APEGBC's Code of Ethics is at <http://www.apeg.bc.ca/library/actbylawscode.html>. The Code of Ethics, along with accompanying Guidelines and Commentary, are published in the current (1994) edition of APEGBC's "Guidelines for Professional Excellence."

geological engineering, mining engineering or civil engineering⁵; and such a *Professional Geoscientist* will be practising geology or *environmental geoscience*⁶.

A *landslide* is a movement of rock, debris or earth down a slope. *Landslides* can be a result of a natural sequence of events and/or human activities. *Landslides* include: rock falls, rock slumps, rock slides, rock avalanches, rock creep; debris falls, debris slides, debris flows, debris floods; earth falls, earth slumps, earth slides, earth flows, earth creep; and flow slides. Debris flows and debris floods have some characteristics of both *landslides* and floods.

A *landslide assessment* is a combination of (1) *landslide analysis* (recognition, characterization and estimation of hazard, and may include estimation of potential *consequences*), and (2) a comparison of the results of the analysis with a *level of landslide safety*. Based upon the comparison, and where required by legislation, a *Qualified Professional* must state whether the *level of landslide safety* is acceptable or unacceptable relative to an adopted *level of landslide safety*. If required, the *Qualified Professional* can make recommendations to reduce hazards and/or *consequences*. For the purpose of these Guidelines, a *landslide assessment* is the same as a *landslide hazard assessment* or *landslide risk assessment*.

As defined by various pieces of provincial legislation, *residential development* includes:

- subdivision of property
- *construction*, including *construction* of new buildings or structures, and
- structural alteration of, or addition to, existing buildings or structures.

Residential development also includes site development including, but not limited to, removing vegetation, providing access, site grading, filling, *construction* of infrastructure, installation of utilities and modification of natural drainage.

Subdivision of property can result from a number of different activities, including:

- creating several lots, or strata lots, from one or more existing properties
- consolidating two or more properties into one lot, and
- adjusting or realigning an existing property line.

Types of subdivisions include: conventional, strata, cooperative corporation/shared interest, aboriginal reserves and leases.

Therefore, *residential development* can range from alteration of, or addition to, a single house to subdivision of property containing a large number of residential lots.

A *landslide assessment* is only one aspect of the overall *residential development* process.

⁵ *Geological engineering*, mining engineering and civil engineering are disciplines of engineering registration within APEGBC.

⁶ Geology and *environmental geoscience* are disciplines of geoscience registration within APEGBC. Until 2000, APEGBC referred to the discipline of *environmental geoscience* as 'geotechnics.'

1.4 SCOPE OF THE GUIDELINES

These Guidelines apply to legislated *landslide assessments* for proposed *residential development* (refer to Appendix B for a summary of the legislative framework). These Guidelines do not address other potential natural hazards such as flooding, soil erosion, subsidence or snow avalanches, except as related to *landslides*. If a *Qualified Professional* identifies other potential hazards during a *landslide assessment*, he/she should notify the *Client* and the *Land Owner* (in situations where the *Client* is not the *Land Owner*).

It is recognized that *landslide assessments* are also carried out for other types of proposed *non-residential development* including institutional, commercial, industrial and infrastructure; sometimes as part of emergency response; and for existing residential areas for a wide variety of reasons. There is, however, no provincial legislation that pertains to *landslide assessments* for those other purposes, and therefore these Guidelines do not address them. Some of the information contained herein may, however, be relevant to such non-legislated *landslide assessments*.

Other pieces of *residential development*-related provincial legislation exist in which a *Qualified Professional*, as defined in these Guidelines, may be involved, but for whom there is no explicit professional mandate. For example:

- a *local government* developing an *Official Community Plan*, designating a Development Permit Area, or preparing a bylaw, including flood plain⁷ and zoning bylaws (*Local Government Act* (RSBC 1996, Chapter 323), and
- Integrated Land Management Bureau of BC Ministry of Agriculture and Lands (formerly Land and Water BC Inc) disposing of Crown Land (*Land Act*, RSBC 1996, Chapter 245).

In such instances, there is no legislated requirement for the involvement of a *Qualified Professional* except where such work is mandated to *APEGBC Members* by the Engineers and Geoscientists Act. These Guidelines do not address such non-legislated involvement of *Qualified Professionals*; however, some of the information contained herein may be relevant.

1.5 APPLICABILITY OF THE GUIDELINES

Notwithstanding the purpose and scope of these Guidelines, a *Qualified Professional's* decision not to follow one or more aspects of these Guidelines does not necessarily mean that he/she fails to meet his/her professional obligations. Such judgments and decisions depend upon weighing facts and circumstances to determine whether another reasonable and prudent *Qualified Professional*, in a similar situation, would have conducted himself/herself similarly.

Although the *Client* is often a *Land Owner* or *Development Consultant*, *landslide assessments* for *residential development* are usually carried out at the request of the local or provincial government. Following these Guidelines, however, does not ensure that the conclusions and recommendations contained within the *landslide assessment* report will be accepted by the local or provincial government.

⁷ Flood plains as related to *landslides*.

These Guidelines are influenced by current provincial legislation, provincial case law, advances in knowledge, and evolution of general professional practices. As such, they may require updating from time to time. Some elements of these Guidelines may have limited applicability outside British Columbia.

Landslide assessments for residential development may have to address other *geotechnical engineering*-related issues and/or forestry issues. For these issues, refer to “Guidelines for Geotechnical Engineering Services for Building Projects” (APEGBC 1998) and “Guidelines for Terrain Stability Assessments in the Forest Sector” (APEGBC 2003).

1.6 ACKNOWLEDGMENTS

These Guidelines have been prepared on behalf of APEGBC by a Committee of *Qualified Professionals* and have been reviewed by several diverse parties and stakeholders as members of an APEGBC Internal Review Task Force and an External Review Group. The authors and reviewers are listed in Appendix E. The authors thank the reviewers for their constructive suggestions. A review of this document does not necessarily indicate the reviewer and/or his employer endorses everything in the document. Any errors are the responsibility of the authors.

APEGBC thanks the BC Ministry of Public Safety and Solicitor General, Provincial Emergency Program Natural Hazards Mitigation Fund, which funded the preparation of these Guidelines; and the BC Ministry of Forests and Range, which facilitated the project.

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 COMMON FORMS OF PROJECT ORGANIZATION

Landslide assessments for subdivision approvals, development permits, building permits, and flood plain bylaw variances or exemptions are typically initiated by the local or provincial government requesting the *Land Owner* or *Development Consultant* to retain a *Qualified Professional* to carry out a *landslide assessment* and prepare a report. The *Land Owner* or *Development Consultant* then forwards that report to the requesting government body, usually an *Approving Officer*, *Building Inspector*, or Planner and/or Council of a *local government*⁸ for review and either acceptance or rejection of the conclusions and recommendations contained in the report. On occasion, the local or provincial government will directly retain a *Qualified Professional*.

Therefore, typically the *Land Owner* or *Development Consultant* is the *Client*, and the *Qualified Professional* establishes an *agreement* for professional services with that party. The *Qualified Professional* should be aware, however, that his/her report will ultimately be reviewed by an *Approving Authority*.

The *Client* should be aware that the findings of the *Qualified Professional* could possibly result in the *residential development* requiring modification, the *Approving Authority* requiring *covenants* or the *residential development* being turned down. In this regard, it is useful if the *landslide assessment* is carried out early in the *residential development* planning process.

The *Qualified Professional* should ensure that his/her role, in relation to the *Client* and the *Approving Authority*, is clearly defined. It is possible that a *Client* may not have been previously involved in *residential development*, nor previously engaged a *Qualified Professional*. In such situations the *Qualified Professional* should consider reviewing with the *Client* the typical responsibilities listed below, to assist in establishing an appropriate *agreement* for professional services and to inform the *Client* of the expectation of appropriate and adequate compensation (*APEGBC Code of Ethics Principle 5*).

2.2 RESPONSIBILITIES

Sections 2.2.1 to 2.2.3 describe some of the typical responsibilities of a *Client*, *Qualified Professional* and *Approving Authority*. Section 2.2.4 describes some of the typical responsibilities of a *Qualified Professional* when asked by an *Approving Authority* or *Client* to review a *landslide assessment* report prepared by another *Qualified Professional*.

2.2.1 The Client

The *Client* is typically the *Land Owner* or the *Development Consultant*, or occasionally the local or provincial government.

Prior to a *landslide assessment* it is helpful and will likely reduce the cost of professional services if the *Client* is knowledgeable about, and can provide the *Qualified Professional* with, the following:

⁸ *Approving Officers*, *Building Inspectors*, and Planners and Councils of *local governments* are collectively referred to as *Approving Authorities*.

- process and procedures of subdivision approvals, development permits, building permits, and flood plain bylaw variance or exemption, as applicable⁹
- legal description of the property, as registered with Land Titles and Survey Authority, and a copy of the current land registration including *covenants*
- for subdivision, a copy of the existing survey plan of the property, or the need for a survey plan, and the location of the legal property boundary markers on the ground (this may require a British Columbia Land Surveyor (BCLS))
- for subdivision, proposed subdivision plan¹⁰
- for *construction*, plans of existing buildings or structures, and location of the proposed *construction* on the ground
- for *construction*, proposed *construction* drawings
- locations of existing, proposed and anticipated *elements at risk* on and, if required, beyond the property
- in general terms, proposed and anticipated land use changes (for example logging) on and, if required, beyond the property
- information on past or existing *landslide* problems, or potentially unstable slopes
- recognition that the *landslide assessment* is based on the proposed *residential development* and changes to that development may require changes to, or invalidate, the *landslide assessment*
- relevant background information (written or otherwise) related to the property and the existing and proposed *residential development*, including previous *landslide assessment* reports conducted for the *Client* or available to the *Client*, and
- the *Qualified Professional* should have unrestricted access to and, if required, beyond the property.

With assistance from the *Qualified Professional*, the *Client* should complete an *agreement* with the *Qualified Professional* confirming scope, schedule and compensation for the *landslide assessment*; need and scope of specialty services; and need for external peer review. It is recommended that such an *agreement* include a clause that deals with potential disclosure issues due to the *Qualified Professional's* obligation under APEGBC Code of Ethics Principle 1. In certain circumstances the *Qualified Professional* may have to convey adverse *landslide risk* assessment findings to parties who may not be directly involved, but who have a compelling need to know. Following is suggested wording for such a clause:

“Subject to the following, the *Qualified Professional* will keep confidential all information, including documents, correspondence, reports and opinions, unless disclosure is authorized in writing by the *Client*. However, in keeping with APEGBC’s Code of Ethics, if the *Qualified Professional* discovers or determines that there is a material risk to the environment or the safety, health and welfare of the public or worker safety, he/she shall notify the *Client* as soon as practicable of this information and the need that it be disclosed to the appropriate parties. If the *Client* does not take the necessary steps to notify the appropriate parties in a reasonable amount of time, the *Qualified Professional*

⁹ In this regard, a *Qualified Professional* should consider beginning an assignment only after the *Client* has applied to, and received a response from, the approving jurisdiction for the proposed residential development.

¹⁰ Subdivision and construction planning are iterative processes, and therefore proposed plans may not be produced until the results of the *landslide assessment* are known.

shall have the right to disclose that information in order to fulfil his/her ethical duties and the *Client* hereby agrees to that disclosure.”

The *Client* should be aware the *Qualified Professional's* cost estimate may have to be amended during the assessment, depending on the *Qualified Professional's* findings and analysis. The *Client* should also be aware that a *landslide assessment* does not guarantee the results will be favourable for the proposed *residential development*. The cost estimate and likely results should be discussed with the *Client* prior to the assignment.

During the *landslide assessment* it is helpful if the *Client*:

- shows the *Qualified Professional* the locations of legal property boundary markers on the ground and location of the proposed *residential development*
- allows the *Qualified Professional* unrestricted access to the property, and
- obtains access, if required, to areas beyond the property.

After the *landslide assessment* it is helpful if the *Client*:

- reviews the *landslide assessment* report, and understands the limitations and qualifications that apply
- if necessary, discusses the report with the *Qualified Professional* and seeks clarification
- if desired, directs the *Qualified Professional* to complete a *Landslide Assessment Assurance Statement*, and provides the Statement and the *landslide assessment* report to the *Approving Authority*
- allows the *Qualified Professional* to confirm that his/her recommendations have been followed so that Letters of Assurance (Schedules A, B-1, B-2, C-A and C-B) under the current edition of the BC Building Code or other applicable codes can be prepared, and
- notifies the *Qualified Professional* if land use, site development or slope conditions change or vary from those described in the report.

The *Landslide Assessment Assurance Statement* and the *landslide assessment* report are the property of the *Qualified Professional* until outstanding invoices of the *Qualified Professional* are fully paid by the *Client*.

2.2.2 The Qualified Professional

The *Qualified Professional* is responsible for carrying out the *landslide assessment* and, if required, making recommendations to reduce the likelihood of *landslides* and/or *consequences*.

Prior to carrying out a *landslide assessment* the *Qualified Professional* should:

- be knowledgeable about application and approval processes; procedures of subdivision approval, development permit, building permit and flood plain bylaw variance and exemption; and applicable legislation
- confirm that he/she has appropriate training and experience to carry out a *landslide assessment* associated with the complexity of associated terrain and geology and, if not, involve required specialists

- if they exist, obtain a copy of the approving jurisdiction's guidelines for carrying out *landslide assessments* and/or for preparing *landslide assessment* reports, and
- if one exists, obtain the adopted *level of landslide safety*, or other *landslide assessment* approval criteria, for the proposed *residential development* in the approving jurisdiction.

The *Qualified Professional* and *Client* should complete an *agreement* confirming scope, schedule and compensation for the *landslide assessment*; need for and scope of specialty services; and anticipated need for an external peer review. The *Qualified Professional* should comply with the requirements of APEGBC Bylaw 17 regarding professional liability insurance.

During the *landslide assessment* the *Qualified Professional* should:

- if necessary, assist the *Client* in obtaining relevant information such as listed in Section 2.2.1
- make reasonable attempts to obtain from the *Client* and others all relevant information related to the slope stability of and, if required, beyond the property
- prior to field work, review collected information
- conduct field work within the limits of and, if necessary, beyond the property at an intensity appropriate to the method of *landslide assessment* and to meet the requirements of existing jurisdictional guidelines
- conduct the *landslide assessment* in compliance with applicable jurisdictional codes and regulations
- consider both *landslides* and their *consequences* on the *residential development*, and the *consequences* of the *residential development* on *landslides* on and, if required, beyond the property
- notify the *Client* as soon as reasonably possible if specialty services or changes in scope of work are required, and of associated changes to the original cost estimate
- write the report clearly, concisely and completely and conform, where applicable, to jurisdictional guidelines for *landslide assessment* reports
- have a draft of the report appropriately peer reviewed
- submit to the *Client* a signed, sealed and dated copy of the report, and
- if directed by the *Client*, complete a *Landslide Assessment Assurance Statement*, and provide the Statement and the *landslide assessment* report to the *Approving Authority*

After the *landslide assessment* the *Qualified Professional* should:

- clarify questions the *Client* and/or *Approving Authority* may have with regards to the *landslide assessment*, report, and/or *Landslide Assessment Assurance Statement*, and
- carry out follow up work if requested by, and by *agreement* with, the *Client*.

If aspects of the *landslide assessment* are delegated, they should only be carried out under direct supervision of the *Qualified Professional*. The *Qualified Professional* assumes full responsibility for all work delegated (refer to Section 4.2).

According to *APEGBC* Code of Ethics Principle 8, a *Member* should clearly indicate to his/her *Client* possible *consequences* if recommendations are disregarded.

To fulfill *APEGBC* Code of Ethics Principle 1 (hold paramount the safety, health and welfare of the public, the protection of the environment, and promote health and safety in the workplace) and Principle 9 (report to *APEGBC* or another appropriate agency any hazardous, illegal or unethical professional decisions or practices by a *Professional Engineer*, *Professional Geoscientist* or others if a *Client* fails or refuses to accept the conclusions and recommendations of the report), the *Qualified Professional* should:

- advise the *Client* in writing of the potential *consequences* of the *Client's* actions or inactions, and
- consider whether the situation warrants notifying *APEGBC*, the *Land Owner* (if different from the *Client*) and/or appropriate authorities.

The above actions should be taken particularly if loss of life and/or other significant negative *consequences* are a possibility, or if workplace safety or the environment is potentially jeopardized.

2.2.3 The Approving Authority

Even though most *landslide assessments* are carried out for a *Land Owner* or *Development Consultant*, the local or provincial government typically initiates the requirement for an assessment and is the *Approving Authority*. As previously noted, an *Approving Authority* can be an *Approving Officer*, *Building Inspector*, or Planner and/or Council of a *local government*.

Before the *landslide assessment* is initiated it is helpful if the *Approving Authority*:

- informs the *Client* why a *landslide assessment* is required
- informs the *Client*, if applicable, of the adopted *level of landslide safety for residential development* in the approving jurisdiction, and
- provides the *Client* with guidelines, if they exist, for carrying out a *landslide assessment* and/or preparing a *landslide assessment* report.

After the *landslide assessment* it is helpful if the *Approving Authority*:

- reviews the *Landslide Assessment Assurance Statement* and the *landslide assessment* report, and
- if necessary, discusses the Statement and report with the *Qualified Professional* and seeks clarification.

The *Approving Authority* may be guided by the Municipal Insurance Association of British Columbia's document "Guidelines for Planners, Approving Officers and Building Inspectors for Landslide-Prone Areas in British Columbia" (Skemer 2002).

2.2.4 Reviews of Landslide Assessment Reports

A *Qualified Professional* may be engaged by an *Approving Authority* to carry out an independent external peer review of a *landslide assessment* report and *Landslide Assessment Assurance Statement* prepared by another *Qualified Professional*. Less frequently, a *Client* may ask for such a review. This type of review is not the same as an internal or external peer review carried out at the request of the *Qualified Professional*

prior to submitting the report to his/her *Client* and/or the Approving Authority (refer to Section 4.3).

In order for the reviewing *Qualified Professional* to carry out an appropriate review, it is helpful if the requesting *Approving Authority* or *Client*:

- is aware of the *APEGBC Code of Ethics Principle 7*; specifically, guideline (c), which states that a *Member* should not, except in cases where review is usual and anticipated, evaluate the work of a fellow *Member* without the knowledge of, and after communication with, that *Member* where practicable
- provides the reviewing *Qualified Professional* with a copy of the *landslide assessment* report and *Landslide Assessment Assurance Statement*, necessary background information, and the reason for the review
- reviews the review letter or report, and
- if necessary, discusses the review letter or report with the reviewing *Qualified Professional* and seeks clarification.

The reviewing *Qualified Professional* should consider whether there may be a conflict of interest and act accordingly (*APEGBC Code of Ethics Principle 4*), and conduct himself/herself with fairness, courtesy and good faith towards colleagues and provide honest and fair comment (*APEGBC Code of Ethics Principle 7*).

Following guideline (c) of *APEGBC Code of Ethics Principle 7*, the reviewing *Qualified Professional* should:

- if authorized to do so, inform the *Qualified Professional* who prepared the *landslide assessment* report and *Landslide Assessment Assurance Statement* of the review, and the reasons for the review, and document in writing that the *Qualified Professional* was so informed
- ask the *Qualified Professional* who prepared the report if the reviewing *Qualified Professional* should know about unreported circumstances that may have limited or qualified the *landslide assessment*, the *Statement* and/or the report, and
- with the *Client's* authorization, contact the *Qualified Professional* who prepared the report and *Statement* if the results of the review identify safety or environmental concerns, in order to allow the opportunity for the *Qualified Professional* to comment prior to further action.

The review should be appropriately documented in a letter or a report. The reviewing *Qualified Professional* should submit a signed, sealed and dated review letter or report including:

- limitations and qualifications with regards to the review, and
- results and/or recommendations arising from the review.

The reviewing *Qualified Professional* should clarify any questions the *Approving Authority* or *Client* may have with regards to the review letter or report.

Occasionally, a *Qualified Professional* is retained to provide a second opinion. This role goes beyond that of reviewing the work of the original *Qualified Professional*. The second *Qualified Professional* should carry out sufficient pre-field work, field work, analysis and comparisons, as required, to accept full responsibility for his/her *landslide assessment*.

3. GUIDELINES FOR PROFESSIONAL PRACTICE

As noted in Section 1, a *landslide assessment* is a combination of (1) *landslide analysis* (recognition, characterization and estimation of hazard, and may include estimation of potential *consequences*), and (2) a comparison of the results of the analysis with a *level of landslide safety*.

A *landslide analysis* can either be a *landslide hazard* analysis or *landslide risk* analysis. The Canadian Standards Association (CAN/CSA-Q850-97) defines a hazard as “a source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these.” *Landslide risk* considers both *landslide hazard* and potential *consequences* to *elements at risk* (elements of social, environmental and economic value, including human well-being and property)¹¹.

A *landslide assessment* compares the result of a *landslide analysis* with a *level of landslide safety* to determine if the *residential development* will be ‘safe’ from the effects of *landslides*. As noted in Appendix C, no province-wide defined *level of landslide safety* has been adopted. Only a few *local governments* in the province have adopted defined *levels of landslide safety*.

The following sections provide guidelines for carrying out *landslide analyses* and, where a defined *level of landslide safety* has been adopted, for carrying out *landslide assessments*. Where a defined *level of landslide safety* has not been adopted, guidance is provided to assist the *Qualified Professional* in fulfilling the requirements of the provincial legislation.

Appendix D to these Guidelines is a *Landslide Assessment Assurance Statement* that must be completed, signed, sealed and dated; and submitted by the *Qualified Professional*, along with the *landslide assessment* report, to the *Approving Authority*.

3.1 INITIATION

3.1.1 Phases of a Landslide Assessment

A *landslide assessment* typically involves the following phases:

- initiation: determination of objectives, type of *landslide assessment*, level of effort, study area
- collection and review of background information
- *landslide hazard* or *landslide risk* analysis
- comparison of the results of the *landslide analysis* with a *level of landslide safety*
- if requested, recommendations to reduce *landslide hazards* and/or *landslide risks*, and
- reporting.

¹¹ Other definitions of hazard and risk exist. The choice of definitions rests with the *Qualified Professional*, although the definitions should be included in the *landslide assessment* report.

These Guidelines follow the steps in the Canadian Standards Association's risk management process from initiation to risk control, but exclude the action/monitoring phase (CAN/CSA-Q850-97).

The following sub-sections provide professional practice guidelines for the above phases. The information in this section can assist in defining the scope of the *landslide assessment*. However, it is not intended to be exhaustive, and professional judgment is required when adding to or subtracting from specific phases.

3.1.2 Objectives

The objectives of a *landslide assessment* are often defined by legislated requirements for either subdivision approval, development permit, building permit, or flood plain bylaw variance or exemption.

The *Qualified Professional* should be aware of applicable legislated requirements. He/She should also be aware of the *level of landslide safety* that has been adopted by the approving jurisdiction, and jurisdictional guidelines for carrying out *landslide assessments* and/or preparing the *landslide assessment* report.

3.1.3 Type of Landslide Assessment

The objectives of a *landslide assessment for residential development* will determine whether a *landslide hazard* or *landslide risk* assessment is appropriate.

A *landslide hazard* assessment:

- recognizes and characterizes *landslides* (active, inactive, dormant and potential) within and, if required, beyond the *residential development*
- estimates associated *landslide hazards*, and
- compares estimated hazards with a *level of landslide safety* adopted by the approving jurisdiction.

A *landslide risk* assessment, in addition to a *landslide hazard* analysis:

- identifies existing and, where anticipated, future *elements at risk*
- estimates potential *consequences* to those *elements at risk*, and
- compares estimated risks with a *level of landslide safety* adopted by the approving jurisdiction.

3.1.4 Level of Effort

The appropriate level of effort of a *landslide assessment* is a function of the objectives and type of assessment along with size of the study area; stability and geological and geotechnical complexity of the terrain; type of *residential development*; *elements at risk*; and availability, quality and reliability of background information and field data.

Overview *landslide assessments* are typically map-based using available provincial topographic maps at 1:20,000 or larger (more detailed) scales, or larger scale topographic maps prepared specifically for the project (e.g. 1:5,000 to 1:10,000 scale). Overview *landslide assessments* usually require at least a reconnaissance intensity of field work, but depending on the purpose and mapping scale they may require a greater intensity of field work. They delineate zones of *landslide hazard* and/or *landslide risk* where further field work is required or, with a greater level of effort, they can delineate

potential *landslides* and potential hazards and/or risks. Results can then be compared with an adopted *level of landslide safety*.

Detailed *landslide assessments* are typically field work intensive. The study area is typically ground traversed at a detailed intensity level, areas prone to *landslides* are delineated and characterized, and estimates of hazard or risk are made. Some detailed *landslide assessments* may require one or more specialty services as described in Section 3.9. Accompanying maps or plans are typically larger (more detailed) than 1:5,000 scale. The results can then be compared with an adopted *level of landslide safety*.

It is sometimes useful to use a phased approach of *landslide assessment*, trending from overview to more detailed.

3.1.5 Study Area

Landslide assessments for residential development are either carried out for a parcel of land (in the case of subdivision approvals or flood plain bylaw variance or exemption) or for a specific site (in the case of development permits or building permits). The study area should be determined by the size of the parcel of land or the size of a specific site, as well as the stability and geological and geotechnical complexity of the terrain involved, and the type of existing and *residential development*. The study area should not necessarily be limited to the property or to the specific site, but may include other properties or sites that could potentially affect, or be affected by, slope instability.

Some types of *landslides* can travel long distances. If it is possible that *landslides* from remote sources such as upper watershed areas, glacial lakes, dammed lakes and volcanoes could affect the *residential development*, the study area should also include such areas where appropriate.

3.2 BACKGROUND INFORMATION

Prior to field work, the *Qualified Professional* should collect, possibly with the help of the *Client*, available existing information associated with the study area. The *Qualified Professional* should consider the following, and their respective levels of reliability, as possible sources of existing information:

- large and small scale topographic and cadastral maps
- maps that show existing and proposed infrastructure such as transportation routes, utilities, surface drainage and in-ground disposal of storm water
- airphotos of different years (historical to present) and scales
- terrain maps, terrain stability maps, *landslide inventories*, *landslide hazard maps* and reports
- bedrock and surficial geology, and seismic maps and reports
- water well records and hydrogeology reports
- in areas of logging: forest cover maps, forest development/stewardship plans, watershed assessments, terrain stability assessments, past and proposed forest road *construction* and logging, and other relevant logging-related information
- flood plain mapping and alluvial fan mapping
- evidence and history of wildfires in the area
- other resource inventory maps and reports
- previous development, including residential and non-residential, and associated infrastructure, and

- previous geological, geotechnical and *landslide assessment* reports that address the study area and, if available, neighbouring areas.

Landslide assessment reports from neighbouring areas can be useful to the *Qualified Professional* and, in this regard, the local and provincial governments are encouraged to make such reports available to the *Qualified Professional*.

Information can also be obtained from published and non-published sources from various federal and provincial agencies, *local governments* and other local sources.

For *landslide assessments* of larger areas, purchasing or obtaining project-specific information, in addition to existing background information, may be useful. Examples are airphotos, high-resolution satellite imagery, and LiDAR (Light Detection and Ranging) images that can be used for geological and geomorphological mapping and/or topographical mapping.

Background information should be reviewed prior to undertaking subsequent phases, and the *Qualified Professional* should consider the reliability of such information. If information is known to be available and the *Qualified Professional* did not (or was not able to) obtain it, the circumstances should be reported.

3.3 FIELD WORK

Landslide assessments rely to a large extent on field work. Field work is often preceded by office-based interpretation of airphotos and possibly other imagery and mapping that can be used to identify, verify and characterize terrain conditions, *landslides* and potentially unstable slopes, and *elements at risk*.

The intensity of field work depends on the objectives, type of *landslide assessment* and level of effort along with the size of the study area; stability and geological and geotechnical complexity of the terrain; type of *residential development*; *elements at risk*; and availability, quality and reliability of background information.

Depending on the above, intensity of field work can range from:

- reconnaissance or overview site visit, to detailed examination of the entire study area, to detailed measurements of profiles and cross sections and other surveys
- reconnaissance fly-overs to detailed and systematic foot traverses, and
- surface observations to subsurface investigations and specific tasks such as dendrochronological studies and/or laboratory analyses of soil or rock samples.

The *Qualified Professional* must exercise professional judgment when determining the intensity of field work and which specific areas to visit in the field. Field work should consider different types of *landslides* and potentially unstable slopes within and, if required, beyond the *residential development*. Rugged or difficult-to-access terrain should not deter required field work in areas with questionable slope stability. As part of determining supporting rationale, field work should review areas of past instability and should assess the possible causes of such instability.

Complex geological conditions can have a profound effect on the slope stability of a *residential development*, and frequently such geological complexity is hidden. The *Qualified Professional* should recognize the potential for slope instability. Such

recognition can be initially based on local experience and review of background airphotos, but typically also requires experienced, quality field work.

The *Qualified Professional* should appropriately record field observations and results of field investigations. Ground photographs, stereo ground photographs, videos and/or GPS landmarks should be considered as means of documentation.

If there are specific areas or sites of importance, or if a building envelope or *covenant* boundary is to be recommended, temporary survey markers should be located and appropriately labelled during the field work. The *Qualified Professional* should consider recording these areas or sites by means of photographs (with temporary survey markers in place) or GPS landmarks.

Landslide assessments depend to a great extent on observation and evaluation of underlying geological conditions by experienced *Qualified Professionals*. The delegation of field work to a less experienced engineer, geoscientist, technologist or technician, under the supervision of a *Qualified Professional*, should be done judiciously (refer to Section 4.2).

3.4 LANDSLIDE HAZARD AND LANDSLIDE RISK ANALYSES

3.4.1 Methods of Landslide Analysis

The first step in a *landslide analysis* is to recognize and characterize the *landslides* (active, inactive, dormant and potential), within and, if required, beyond the *residential development*. The next step is to analyze, either quantitatively or qualitatively, the hazard and, for a risk analysis, the potential *consequences* to an element at risk.

Landslide hazard can be estimated in a number of ways that include, but are not limited to, estimating 1) likelihood or probability of occurrence of a *landslide*, or (2) *factor of safety* of a slope, then combining the results with some estimate, either empirical or analytical, of *landslide* runoff.

Common methods of estimating *landslide risk* include, but are not limited to, risk matrices, event tree decomposition and quantitative risk analysis (QRA), including the use of F-N (frequency-number of fatality) plots.

The choice of which analytical method to use depends on a number of factors including whether the parcel of land or specific site of interest is upslope, downslope or on the slope being analyzed; configuration of the slope; and most likely type of *landslide*. The choice also depends on the level of hazard and *elements at risk*. The selected method must provide results that are scientifically defensible and can be used for comparison with a *level of landslide safety*. If they exist, the *Qualified Professional* should follow jurisdictional guidelines for carrying out a *landslide analysis*.

The *landslide analysis* should clearly state assumptions made, including a description of the proposed *residential development*. The analysis should also provide a clear description of the magnitude and intensity of the *landslides* that are envisioned, including parameters such as velocity and flow depth that are useful to describe the destructiveness of the *landslide* at various locations along the slide, fall or flow path.

Generally, any *landslide analysis* method requires a good deal of professional judgment, and assumptions should be carefully considered and clearly stated in the *landslide assessment* report.

3.4.2 Quantitative vs Qualitative

Landslide hazard and *landslide risk* analyses can be carried out, and the results can be expressed, either quantitatively or qualitatively. Quantitative estimates use numerical values or ranges of values, while qualitative estimates use relative terms such as high, moderate and low. Both quantitative and qualitative estimates can be based on either objective (statistical or mathematical) estimates or subjective (professional judgmental or assumptive) estimates, or some combination of both.

No standard definitions exist for relative qualitative terms. Therefore, to avoid ambiguity, such terms must be defined with reference to quantitative values or ranges of values.

Quantitative estimates may be no more accurate than qualitative estimates. The accuracy of an estimate does not depend on the use of numbers. Rather, it depends on whether the components of *landslide hazard* and *landslide risk* analyses have been appropriately considered; and on the availability, quality and reliability of required data.

The decision whether to carry out and report the results of a *landslide analysis* quantitatively or qualitatively also depends on how the adopted *level of landslide safety* is expressed, and/or the requirements of the *Approving Authority*.

3.4.3. Consideration of Changed Conditions

Landslide analysis requires consideration of changes to existing conditions, including:

- changes to slope geometry from either natural geomorphic processes or human activities
- changes to groundwater and/or surface flow patterns from either natural changes in precipitation trends and runoff patterns, or human activities and urban development
- changes in land use and/or changes resulting from resource development
- natural processes such as earthquakes (ground shaking, ground motion and liquefaction) and volcanoes, and
- wildfires and beetle infestation on treed slopes.

3.5 LANDSLIDE ASSESSMENT

To complete a *landslide assessment*, the *Qualified Professional* must compare the results of the *landslide analysis* with a *level of landslide safety*. Ideally, the level of safety used for comparison should be a defined *level of landslide safety* that has been adopted by the approving jurisdiction.

As noted in Appendix C, the statements “that the land may be used safely for the use intended” and “that development may safely occur” used in provincial legislation and associated guidelines are not considered defined. Only a few *local governments* in the province have adopted a defined *level of landslide safety*.

In addition, although words such as “certify” and “guarantee” are used in everyday language, they have specific legal meanings and *Qualified Professionals* should avoid the use of such words. *APEGBC* considers that when a *Qualified Professional* signs,

seals and dates a document he/she is certifying that document, although it is recognized that this view is not held by all *Approving Authorities*.

When preparing *landslide assessment* reports for jurisdictions that **have** adopted a defined *level of landslide safety*, the *Qualified Professional* should refer to that level, and follow jurisdictional guidelines for carrying out a *landslide assessment*. For example, if an approving jurisdiction has adopted a *level of landslide safety* of 10% probability in 50 years of a *landslide* affecting a proposed building, the *Qualified Professional* could use language such as:

“[I, we or the name of the firm] estimate the likelihood of a *landslide* occurring and affecting the proposed building site is low, which is defined as having a probability of less than 10% in 50 years. The [approving jurisdiction] has adopted a 10% probability in 50 years of a *landslide* affecting a building as its *level of landslide safety*. Therefore, as required by the [refer to Act and section], it is [my, our or the name of the firm’s] professional opinion that the land may be used safely for the use intended.”

A statement such as that above should refer to the assumptions used in *landslides analysis* (refer to Section 3.4.1).

If the *Qualified Professional* cannot make a statement in support of the proposed *residential development*, he/she should state the reason for being unable to make such a statement.

When preparing *landslide assessment* reports for approving jurisdictions that **have not** adopted defined *levels of landslide safety*, the *Qualified Professional* should follow the appropriate jurisdictional guidelines for carrying out a *landslide assessment*, but whenever possible he/she should avoid use of statements such as “certify that the land may be used safely for the use intended” or “that development may safely occur.”

Although *APEGBC* does not agree with using undefined statements such as “that the land may be used safely for the use intended” and “that development may safely occur” until there are defined *levels of landslide safety*, where *Approving Authorities* require such statements the *Qualified Professional* should define or qualify the term ‘safe’ in relation to:

- method of *landslide hazard* or *landslide risk* analysis used
- appropriate regional, provincial and/or national guidelines, and
- specific provincial legislation (Act and section) under which the *landslide assessment* report is being prepared.

The *Qualified Professional* should ask his/her professional liability insurer if there could be coverage issues relating to providing such *landslide assessments*.

If the *Client* directs the *Qualified Professional* to submit the *landslide assessment* report to an *Approving Authority*, the *Qualified Professional* must also complete, sign, seal and date a *Landslide Assessment Assurance Statement* (Appendix D to these Guidelines) and submit it along with the *landslide assessment* report. The Statement is patterned after BC Building Code Schedules B-1, B-2 and C-B.

3.6 MEASURES TO REDUCE LANDSLIDE HAZARDS AND/OR LANDSLIDE RISKS

If unacceptable *levels of landslide safety* are identified it may be appropriate, and required, that the *Qualified Professional* provide recommendations for measures to reduce *landslide hazards* and/or *landslide risks*. Measures can be ‘passive’ such as *covenants* or relocation of proposed buildings, or ‘active’ such as stabilization or protective works. Residual risks, or those that remain should the recommendations be implemented, should be estimated and clearly explained.

Design of stabilization or protective works may be beyond the scope of the *landslide assessment*, and may be considered a specialty engineering service. Ideally, conceptual designs should be submitted to the *local government* for approval in principle before time and effort is expended on detailed designs. Stabilization or protective works must not transfer *landslide hazards* and/or *landslide risks* to other properties.

Stabilization or protective works that are constructed to reduce *landslide hazards* and/or *landslide risks* on multiple properties may require ongoing operation and maintenance that may have to be approved by the local and/or provincial government, possibly including the provincial Inspector of Dikes. In addition, the local and/or provincial government may require permanent access to such works.

3.7 REPORT

Written reports are the means by which the *Qualified Professional* communicates the results of his/her *landslide assessment* to the *Client* and, along with the *Landslide Assessment Assurance Statement*, to the *Approving Authority*. Report formats will vary depending on the objective, type of *landslide hazard* or *landslide risk* analysis, and level of effort. If they exist, the *Qualified Professional* should follow jurisdictional guidelines for preparing the *landslide assessment* report. The *Qualified Professional* should consider reviewing the format and contents of the *landslide assessment* report with the *Client* and the *Approving Authority* prior to finalizing the report.

Typically, a *landslide assessment* report should include the following:

- legal description of the property
- location map or description of property relative to well known geographic features
- objectives, method of *landslide hazard* or *landslide risk* analysis, and level of effort
- list of background information available, collected and reviewed, and its relevance
- terrain or physical description of the study area
- map or plan of the property including topography, natural features, existing structures, roads, infrastructure and surface drainage
- description of proposed *residential development*
- methods and intensity of field work
- observations of topography, geology, *landslide* processes and *elements at risk*
- if applicable, adopted *level of landslide safety* used for comparison
- results of the *landslide assessment*
- conclusions, accompanied by supporting rationale
- recommendations, if requested and as required, to reduce the *landslide hazards* and/or *landslide risks*

- an estimate of the associated residual risks if the recommendations are implemented
- if required, recommendations for further work and requirements for future inspections, and by whom
- definitions of qualitative terms, technical terms, concepts and variables
- other information as specified in the *agreement* with the *Client*, or as required in jurisdictional guidelines
- references, including maps and airphotos, and
- limitations and qualifications of the assessment and report, assumptions, error limits and uncertainties.

Reports should be accompanied by drawings, figures, sketches, photographs, test hole or test pit logs, laboratory test results, other tables and/or other support information as required. Graphic information should be consistent with the information in the text. Maps or plans should delineate the areas of *landslide hazard* and *landslide risk* in relation to existing and proposed *residential development*.

The report should be clearly written with sufficient detail to allow the *Client*, *Approving Authority* and others reviewing the report to understand the methods, information used and supporting rationale for conclusions and recommendations, without necessarily visiting the property or site. *Landslide assessment* reports are frequently included as part of a *covenant* on the Title, and should be written accordingly.

The Municipal Insurance Association of British Columbia (Skermer 2002) recommends an independent external peer review of the report if the *Approving Authority* feels the report is inadequate. Most *Approving Authorities* require the *Client* to bear the costs of such independent reviews. In some instances, a field visit by the reviewing *Qualified Professional* may be warranted, and the necessity of such a visit should be at the discretion of the reviewer.

A peer review of the *landslide assessment* report, prior to its submission to the *Client* and *Approving Authority*, is strongly encouraged as part of the quality assurance/quality control program (refer to Section 4).

3.8 LIMITATIONS AND QUALIFICATIONS OF A LANDSLIDE ASSESSMENT

The limitations and qualifications of a *landslide assessment* depend on the objectives; method of *landslide hazard* or *landslide risk* analysis; level of effort; size of the study area; stability and geological and geotechnical complexity of the terrain; type of *residential development*; *elements at risk*; availability, quality and reliability of background information and field data; intensity of field work; experience and local experience of the *Qualified Professional*; and whether or not a defined *level of landslide safety* has been adopted by the approving jurisdiction.

Although field work associated with a *landslide assessment* can provide reasonable coverage of the study area, field work may not cover the entire study area or all areas potentially affected by the *residential development*. The extent of field work should be described in the report.

Many aspects of a *landslide assessment* are qualitative and subjective based on observed, inferred and assumed conditions. Only some *landslide assessments* include subsurface investigations, sampling, instrumentation, monitoring and laboratory testing.

Conclusions and recommendations are based on the assumption that standard methods of *residential development* will be followed. Non-standard development, design and/or *construction* recommendations should be clearly described. Substandard practices of *construction* may render the conclusions and recommendations invalid.

A *landslide assessment* is prepared to obtain a subdivision approval, a development permit, a building permit, or a flood plain bylaw variance or exemption. The assessment and the associated report is typically one early step in the *residential development* process. Usually, more detailed planning and/or engineering design is required to continue the development process.

A *landslide assessment* cannot be relied on in perpetuity. Although both the *Client* and the *Qualified Professional* should attempt to anticipate reasonable changes that could affect the results of the *landslide assessment*, the 'shelf life' of a *landslide assessment* report depends on the occurrence of subsequent *landslides*, changes in land use, site development, *Land Owner* neglect or the discovery of previously unknown information.

Limitations and qualifications, including those associated with background information, assumptions, sources of error and ranges of values, should be described clearly in the report.

3.9 SPECIALTY SERVICES

For some *landslide assessments* for *residential development*, specialty services may be required. Such services may include:

- detailed slope stability analysis
- piezometer and/or slope indicator installation and monitoring
- *landslide* runout modeling
- hydraulic discharge modeling
- magnitude/frequency modeling
- investigation of specific *landslides*
- investigation for, and design of, slope stabilization works
- investigation for, and design of, structural protective works
- investigation for, and design of, debris flow control structures
- subsurface drainage design, and
- *landslide* rehabilitation.

Specialty services may be beyond the scope of some *landslide assessments*. The *Client* should not expect such services to be automatically included in a *landslide assessment*. This should be clear in the *agreement* between the *Qualified Professional* and the *Client*. If, during the course of the *landslide assessment*, the *Qualified Professional* identifies a need for specialty services, he/she should advise the *Client*, and either revise the scope of work or recommend another appropriately *Qualified Professional* to carry out the specialty service or services.

A *Professional Engineer* must take responsibility for the above specialty services that involve 'design.'

4. QUALITY ASSURANCE/QUALITY CONTROL

A *Qualified Professional* should carry out quality assurance/quality control (QA/QC) for all phases of his/her *landslide assessments*.

4.1 APEGBC QUALITY MANAGEMENT BYLAWS

As a minimum, a QA/QC program must satisfy the requirements of *APEGBC* Quality Management Bylaws 14(b) (1), (2) and (4) with regards to:

- retention of complete project files for a minimum of 10 years
- in-house checks of designs as standard procedure, and
- field reviews to confirm that *construction* of slope stabilization or structural protective works are in general conformance with the recommendations of the *Qualified Professional*.

4.2 DIRECT SUPERVISION

The Engineers and Geoscientists Act (Section 1 (1)) states that direct supervision means taking responsibility for the control and conduct of the engineering or geoscience work of a subordinate. With regards to direct supervision, the *Qualified Professional* having overall responsibility should consider:

- geological and geotechnical complexity of the terrain and level of *landslide hazards* and/or *landslide risks*
- which aspects of the *landslide assessment*, and how much of those aspects, should be delegated
- training and experience of individuals to whom work is delegated, and
- amount of instruction, supervision and review required.

Field work is one of the most critical aspects of a *landslide assessment*. Therefore, careful consideration must be given to delegating field work. Due to the complexities and subtleties of *landslide assessments*, direct supervision of field work is difficult and care must be taken to ensure that delegated work meets the standard expected by the *Qualified Professional*. Such direct supervision could typically take the form of specific instructions on what to observe, check, confirm, test, record and report back to the *Qualified Professional*. The *Qualified Professional* should exercise judgment when relying on delegated field observations by conducting a sufficient level of review to be satisfied with the quality and accuracy of those field observations.

4.3 INTERNAL AND EXTERNAL PEER REVIEW

The QA/QC program should include, as appropriate, an internal and/or external peer review of the *landslide assessment* project and report before it is submitted to the *Client* and/or the *Approving Authority*. An internal peer review is carried out by another *Qualified Professional*, usually in the same firm. An external peer review is carried out by a *Qualified Professional* who is independent and may be a specialist.

The level of peer review should be discussed with the *Client* but based on the professional judgment of the *Qualified Professional*. Considerations should include the stability and geological and geotechnical complexity of the terrain; type of *residential development; elements at risk*; availability, quality and reliability of background information and field data; and the *Qualified Professional's* training and experience.

The external peer review process should be more formal than an internal review and it should be appropriately documented. An external reviewer should submit a signed, sealed and dated letter or report, to be either included with the report or put on file, that includes the following:

- limitations and qualifications with regards to the review, and
- results of the review.

For both internal and external peer reviews, the name of the reviewing *Qualified Professional* should be identified in the *landslide assessment* report.

When an external peer review is carried out, the *Qualified Professional* who signed the *landslide assessment* report remains the Engineer of Record or Geoscientist of Record.

The internal or external peer review discussed above is not the same as an independent review by a *Qualified Professional* who is retained by an *Approving Authority*, or sometimes a *Client*, to review a *landslide assessment* report after it has been submitted (refer to Section 2.2.4).

5. PROFESSIONAL REGISTRATION; EDUCATION, TRAINING AND EXPERIENCE

5.1 PROFESSIONAL REGISTRATION

As summarized in Appendix B of these Guidelines, the following are the professional registration requirements for legislated *landslide assessments* for proposed *residential development* in BC:

- Land Title Act (Section 86(1)(d)(i)) indicates that *landslide assessments* for subdivision approval should be carried out by a *Professional Engineer* or *Professional Geoscientist* “experienced in *geotechnical engineering*”
- *Local Government Act* (Section 920(11)) indicates that, for a development permit, the *local government* may require a report from a *Professional Engineer* “with experience relevant to the applicable matter”
- Community Charter (Section 56(1)) indicates that *landslide assessments* for *construction* should be carried out by a *Professional Engineer* or *Professional Geoscientist* “with experience or training in geotechnical study and geohazard assessments”
- *Local Government Act* (Section 910(5)) indicates that, for flood plain bylaw exemption, a *Professional Engineer* or *Professional Geoscientist* “experienced in *geotechnical engineering*” is required
- The provincial document associated with the *Local Government Act* (Section 910) (Ministry of Water, Land and Air Protection, c2004) indicates that a qualified professional is a *Professional Engineer* or *Professional Geoscientist* with “*geotechnical engineering* experience and expertise in river engineering and hydrology, and in appropriate cases, ... debris flow ... processes.”

A *Professional Engineer* as described above is typically registered with APEGBC in the discipline of *geological engineering*, mining engineering or civil engineering.

A *Professional Geoscientist* as described above is typically registered with APEGBC in the discipline of geology or *environmental geoscience*¹². Although the Land Title Act and the *Local Government Act* refer to a *Professional Geoscientist* “experienced in *geotechnical engineering*,” by definition a geoscientist is not experienced in engineering. APEGBC interprets the Land Title Act and the *Local Government Act* to mean a “*Professional Geoscientist* experienced in geotechnical study,” similar to that expressed in the Community Charter.

Not all *Professional Engineers* registered in the disciplines of *geological engineering*, mining engineering or civil engineering are necessarily appropriately knowledgeable in *geotechnical engineering*, geohazard assessments, river engineering, hydrology and/or debris flow processes. Similarly, not all *Professional Geoscientists* registered with APEGBC in the disciplines of geology or *environmental geoscience* are necessarily knowledgeable in geotechnical study, geohazard assessments and debris flows. It is the responsibility of the *Professional Engineer* or *Professional Geoscientist* to determine whether he/she is qualified by training or experience to undertake and accept responsibility for legislated *landslide assessments* for proposed *residential development* (APEGBC Code of Ethics Principle 2).

¹² Until 2000, APEGBC referred to the discipline of *environmental geoscience* as ‘geotechnics.’

As noted previously, as the complexity of the terrain increases, site characterization and a sound understanding of the geology and geological/geomorphological processes becomes more critical.

With regards to the distinction between professional engineering and professional geoscience, following is an excerpt under Principle 2 of the Code of Ethics Guidelines (APEGBC 1994; amended in 1997):

“The professions are distinct and registration in one does not give a *member* the right to practice in the other; however, the Association recognizes that there is some overlap of the practices of engineering and geoscience.

Nothing in this principle authorizes a *professional engineer* to carry on an activity within the area of professional geoscience which goes beyond the practice of professional engineering and nothing in this principle authorizes a *professional geoscientist* to carry on an activity within the area of professional engineering which goes beyond the practice of professional geoscience.”

On this basis, the *Qualified Professional* who provides designs such as reinforced or mechanically stabilized slopes, retaining walls and other geotechnical structures to reduce *landslide hazards* and/or *landslide risks* requires registration with APEGBC as a *Professional Engineer*. The *Qualified Professional* who investigates or interprets complex geological conditions, geomorphic processes and geochronology in support of *landslide assessments* is typically registered with APEGBC as a *Professional Geoscientist* in the discipline of geology or *environmental geoscience*, or as a *Professional Engineer* in the discipline of *geological engineering*.

5.2 EDUCATION, TRAINING AND EXPERIENCE

Landslide assessments, as described in these Guidelines, require minimum levels of education, training and experience in many overlapping areas of engineering and geoscience. A *Qualified Professional* must adhere to APEGBC Code of Ethics Principle 2 (to undertake and accept responsibility for professional assignments only when qualified by training or experience), and therefore must evaluate his/her qualifications and possess appropriate education, training and experience consistent with the services provided.

Education, training and experience can vary depending on the *Qualified Professional's* background and whether specialty services are being provided. Whether carrying out a *landslide assessment* or providing specialty services, appropriate experience can only be gained by working under the direct supervision of a suitably knowledgeable and experienced *Professional Engineer* or *Professional Geoscientist*.

Minimum qualifications for a *Qualified Professional* or a team of professionals who carry out *landslide assessments* for *residential development* should include education, training and experience in bedrock geology, surficial geology, geomorphology, hydrology and groundwater geology, airphoto interpretation, soil and rock mechanics, and *landslide hazard* and *landslide risk* analyses.

As the complexity of the terrain increases, and depending on the location in the province, the minimum qualifications should be supplemented by training and experience in additional subject areas as required such as Quaternary geology, structural geology, petrology, sedimentology, permafrost, slope stability analysis,

landslide mitigation and remediation, and site investigation methods. Specialists may have to be retained to provide experience in some of the above subject areas.

The academic training for the above skill sets can be acquired through formal university or college courses, or through continuing professional development. There may be some overlap in courses and specific courses may not correlate to specific skill sets.

A *Qualified Professional* should also remain current, through continuing professional development, with the evolving topics of *landslide assessments* and specialized services offered (refer to *APEGBC Code of Ethics Principle 6*). Continuing professional development can include taking formal courses; attending conferences, workshops, seminars and technical talks; reading new texts and periodicals; searching the web; and participating in field trips.

6. REFERENCES AND RELATED DOCUMENTS

Not all of the following documents are referenced in the text. Some are related sources of useful information. Where documents are known to be available on the world wide web, they are noted as [web].

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APPENDIX A: GLOSSARY OF SELECTED TERMS

The explanation of the terms in this appendix are specific to these Guidelines. All references in the text to these terms are italicized.

Agreement

A contract or terms of engagement, whether formal (written) or informal (verbal or implied), between the *Client* and the *Qualified Professional*, or his/her company, for conducting a *landslide assessment*.

APEGBC

The Association of Professional Engineers and Geoscientists of British Columbia.

Approving Authority

Approving Officers, *Building Inspectors*, or Planners and/or Councils of *local governments*.

Approving Officer

An official who is appointed under the Land Title Act (Section 77) and acts independently to (1) ensure that subdivisions comply with provincial acts and regulations and local bylaws, and (2) protect the best interests of the public. There are four jurisdictions of *Approving Officers* in British Columbia:

Approving Officers	Appointed by	Jurisdiction
Municipal <i>Approving Officers</i>	Municipal Councils	Subdivision approvals within Municipal boundaries
<i>Regional District</i> and <i>Islands Trust Approving Officers</i>	<i>Regional District</i> Boards or the <i>Islands Trust</i> Council	Subdivision approvals within the boundaries of those <i>local governments</i> that have assumed the rural subdivision approving authority*
<i>BC Ministry of Transportation Approving Officers</i>	Provincial Cabinet	Subdivision approvals outside Municipal boundaries and within those <i>Regional Districts</i> and the <i>Islands Trust</i> boundaries that have not assumed the rural subdivision approving authority*
Nisga'a Lands <i>Approving Officers</i>	Nisga'a Lisims Government	Subdivision approvals within Nisga'a Lands, including Nisga'a Village Lands

*As of February 2006 no *Regional District*, nor the *Islands Trust*, has assumed responsibility for rural subdivision approvals, and therefore that authority is still held by the *BC Ministry of Transportation*.

BC Ministry of Transportation (MOT)

The provincial ministry, and its predecessors under different names, responsible for rural subdivision approvals outside municipal boundaries and within those *Regional Districts* and the *Islands Trust* boundaries that have not assumed the rural subdivision approving authority. As of February 2006 no *Regional District*, nor the *Islands Trust*, have assumed responsibility for rural subdivision approvals, and therefore that authority is still held by the *MOT*.

Under the Land Title Act (Sections 75(1) and 80) there are three situations where the *MOT* must approve subdivision plans in *local government* jurisdictions:

- subdivision adjacent to a controlled access highway in municipal or rural areas
- highway component of *Regional District* or *Islands Trust* approved subdivisions, and
- granting relief from access to water pursuant to the Land Title Act in rural or incorporated areas.

Building Inspector

An individual appointed by a *local government* to administer its building bylaw within the context of the BC Building Code or, in the case of the City of Vancouver, the Vancouver building bylaw. The *Islands Trust* does not have *Building Inspectors*.

Client

An individual or company who engages a *Qualified Professional* to conduct a *landslide assessment*.

Consequence

A result or effect on human well-being, property or the environment due to a *landslide* occurring.

Construction

Either new *construction* of a building or structure, or the structural alteration of or addition to an existing building or structure. *Construction* does not include the repair of an existing building or structure.

Covenant

A registered *agreement*, established by the Land Title Act (Section 219), between a *Land Owner* and the local or provincial government that sets out certain conditions for a specific property with regards to building use, building location, land use, property subdivision and property sale.

Development Consultant

An individual or company retained by a *Land Owner* to plan and oversee development of a parcel of land or to look after the affairs of the land. This individual or company may be an Architect, a BC Land Surveyor, a Civil (Land Development) Engineer, a Land Use Planner, a Realtor or a family member.

Elements at risk

Things of social, environmental and economic value, including human well-being and property, that may be affected by a *landslide*.

Environmental geoscience

The application of geology and related earth sciences to obtain information on, and an understanding of, geological materials, processes and structures as needed for engineering and environmental investigation, analysis and design. Also, a discipline of *APEGBC* professional registration that includes geoscientists who practice *environmental geoscience*, and who typically identify themselves as Environmental Geoscientists, Geomorphologists, Hydrogeologists, Groundwater Geologists, Terrain Scientists and/or Engineering Geologists. Until 2000, *APEGBC* referred to *environmental geoscience* as 'geotechnics.'

Factor of safety

As related to slope stability, the ratio of the shear strength of the soil or rock that comprise the slope divided by the shear stresses within the slope.

Geological engineering

The application of a combination of geology, engineering and related disciplines to the investigation, analysis and design involving rock, soil, water and mineral resources for engineering and environmental projects. Also a discipline of *APEGBC* professional registration.

Geotechnical engineering

The application of soil mechanics, rock mechanics, engineering geology and related disciplines to the investigation, analysis and design involving rock, soil, and water for engineering and environmental projects. Professionals who practice *geotechnical engineering* are typically registered with APEGBC as Civil Engineers, Mining Engineers and/or Geological Engineers.

Islands Trust

The autonomous *local government*, established by the *Islands Trust Act*, with land use planning and regulatory authority similar to those of a *Regional District* but without the role of building inspection. The *Islands Trust* has broad authority for coordinating work with other agencies, organizations and groups. The *Islands Trust* area covers the islands and waters between the British Columbia mainland and southern Vancouver Island, including Howe Sound and as far north as Comox. Indian Reserves are not included in the *Islands Trust* area.

Land Owner

An individual or company identified as the owner on the title of the land registered in a Land Title Office.

Landslide

A movement of rock, debris or earth down a slope. Landslides can be a result of a natural sequence of events and/or human activities.

The Land Title Act (Section 86) refers to the following natural hazards: “flooding, [soil] erosion, land slip and [snow] avalanche.” The *Local Government Act* (Section 920) refers to: “flooding, mud flows, torrents of debris, [soil] erosion, land slip, rock falls, subsidence, tsunami, [snow] avalanches or wildfire.” The Community Charter (Section 56) refers to: “flooding, mud flows, debris flows, debris torrents, [soil] erosion, land slip, rock falls, subsidence and [snow] avalanche.” These Guidelines address only the *landslides* (referred to as “land slips, debris flows, debris torrents, mud flows and rock falls”) in the above lists. They do not address the other natural hazards except as they relate to *landslides*.

For the purpose of these Guidelines, *landslides* include: rock falls, rock slumps, rock slides, rock avalanches, rock creep; debris falls, debris slides, debris flows, debris floods; earth falls, earth slumps, earth slides, earth flows, earth creep; and flow slides. Debris flows and debris floods have some characteristics of both *landslides* and floods.

Landslide analysis

A combination of recognition, characterization and estimation of the *landslide hazard*, and may include estimation of potential *consequences*.

Landslide assessment

A combination of (1) *landslide analysis* and (2) a comparison of the results of the analysis with a *level of landslide safety*. For the purpose of these Guidelines, a *landslide assessment* is the same as a *landslide hazard* assessment or *landslide risk* assessment.

Landslide Assessment Assurance Statement

The Statement for submission, along with a *landslide assessment* report, to an *Approving Authority*. Attached as Appendix D to these Guidelines.

Landslide hazard

The Canadian Standards Association (CAN/CSA-Q850-97) defines a hazard as “a source of potential harm, or a situation with a potential for causing harm, in terms of human injury;

damage to health, property, the environment, and other things of value; or some combination of these.” *Landslide hazard* includes, but is not limited to, estimating (1) likelihood or probability of occurrence of a *landslide* or (2) *factor of safety* of a slope, then combining the results with some estimate, either empirical or analytical, of *landslide* runout.

Landslide risk

An estimate of *landslide hazard* and potential *consequences* to an element at risk.

Level of landslide safety

Level of safety from the effects of *landslides*, including levels of acceptable *landslide hazard* and *landslide risk*.

Local government

Municipalities, *Regional Districts* and, in some cases, the *Islands Trust*.

Member

Professional Engineer or *Professional Geoscientist*. A *Member* of the Association of Professional Engineers and Geoscientists of British Columbia.

Municipality

A corporation into which the residents of an area are incorporated under the *Local Government Act* or another Act, or the geographic area of the municipal corporation.

Official Community Plan

A statement of objectives and policies to guide decisions on planning and land use management within the area covered by the plan, respecting the purposes of the *local government (Local Government Act Part 26, Division 2)*.

Professional Engineer

An Engineer who is a registered or licensed *member* in good standing with APEGBC and typically is registered in the disciplines of *geological engineering*, mining engineering or civil engineering, which are designated disciplines of professional engineering.

Professional Geoscientist

A Geoscientist who is a registered or licensed *member* in good standing with APEGBC and typically is registered in the disciplines of geology or *environmental geoscience*, which are designated disciplines of professional geoscience. Until 2000, APEGBC referred to the discipline of *environmental geoscience* as ‘geotechnics.’

Qualified Professional

A *Professional Engineer* or *Professional Geoscientist* with the appropriate level of education, training and experience to conduct *landslide assessments* for *residential development* as described in these Guidelines.

Regional District

One of 28 districts incorporated under that *Local Government Act*, or the geographic area of the district, that has authority to enact subdivision servicing and zoning bylaws.

Residential development

As defined by various pieces of provincial legislation, either (1) the subdivision of property, (2) the new *construction* of a building or structure, or (3) the structural alteration of, or addition to, an existing building or structure.

APPENDIX B: LEGISLATIVE FRAMEWORK

Proposed *residential development* in British Columbia is governed by several provincial statutes. The statutes that require *landslide assessments* by *Qualified Professionals* include: the Land Title Act (RSBC 1996, Chapter 250); *Local Government Act* (RSBC 1996, Chapter 323); and the Community Charter (RSBC 2003, Chapter 26). The following sub-sections summarize the framework; the actual legislation should be referred to for details. These Guidelines were prepared between September 2005 and February 2006, and the above referenced statutes may have changed thereafter.

B.1 LAND TITLE ACT (SECTION 86) – SUBDIVISION APPROVALS

The Land Title Act (Section 86) contains provisions for “refusing to approve” a subdivision “if the *Approving Officer* considers the land is subject, or could reasonably be expected to be subject, to flooding, [soil] erosion, land slip or [snow] avalanche.” These Guidelines only address *landslides* (referred to as land slips) in the above list. They do not address the other natural hazards, except as related to *landslides*.

The Land Title Act (Section 86) also indicates that if the land to be subdivided is subject, or could reasonably be expected to be subject, to *landslides*, as a condition of subdivision approval the *Approving Officer* may require either or both of the following:

- a report “certified” by a *Professional Engineer* or *Professional Geoscientist* “experienced in *geotechnical engineering*” that “the land may be used safely for the use intended” and/or
- one or more registered *covenants* restricting the use of the land.

B.2 LOCAL GOVERNMENT ACT (SECTIONS 919.1 AND 920) – DEVELOPMENT PERMITS

The *Local Government Act* (Sections 919.1 and 920) states that a *local government Official Community Plan* may establish a Development Permit Area for a number of reasons, one of which is to protect development from “hazardous conditions.” Hazardous conditions include “flooding, mud flows, torrents of debris, [soil] erosion, land slip, rock falls, subsidence, tsunami, [snow] avalanches or wildfire.” These Guidelines only address *landslides* (mud flows, debris torrents¹³, land slip and rock falls) in the above list. They do not address the other natural hazards, except as related to *landslides*.

A development permit may be required by a *local government* before *residential development* can occur within a Development Permit Area. Before issuing a development permit, the *local government* may require a report “certified by a *Professional Engineer* with experience relevant to the applicable matter, to assist the *local government* in determining what conditions or requirement ... it will impose in the permit” (Section 920). Typically a Planner and/or the Council of a *local government* reviews the *Professional Engineer’s* report, and then determines what conditions or requirements to include in the development permit.

Development permits and building permits are different. Development permits precede building permits and both may be required in jurisdictions that have an *Official Community Plan* and where *residential development* may be exposed to *landslides*.

¹³ For the purpose of these Guidelines debris flows, debris torrents and mud flows are collectively considered as debris flows.

B.3 COMMUNITY CHARTER (SECTION 56) – BUILDING PERMITS

The Community Charter (Section 56) contains provisions for not issuing a building permit “if a *Building Inspector* considers that *construction* would be on land that is subject to or is likely to be subject to flooding, mud flows, debris flows, debris torrents, [soil] erosion, land slip, rock falls, subsidence or [snow] avalanche.” These Guidelines only address *landslides* (mud flows, debris flows, debris torrents, land slips and rock falls) in the above list. They do not address the other natural hazards, except as related to *landslides*.

The Community Charter (Section 56) indicates that if *construction* is on land that is subject, or is likely to be subject, to *landslides*, as a condition of a building permit the *Building Inspector* may require a “certified” report by “(a) a *Professional Engineer* or (b) a *Professional Geoscientist* with experience or training in geotechnical study and geohazard assessments” that “the land may be used safely for the use intended.”

The *Building Inspector* may issue a building permit if:

- a *Qualified Professional* reports the land may be used safely for the use intended if the land is used in accordance with conditions specified in his/her report, and
- there is a registered *covenant* restricting the use of the land.

If the *Qualified Professional* determines the land may not be used safely for the use intended, the *Building Inspector* must not issue a building permit.

B.4 LOCAL GOVERNMENT ACT (SECTION 910) – FLOOD PLAIN BYLAW VARIANCES OR EXEMPTIONS

The *Local Government Act* (Section 910) addresses *construction* requirements in relation to flood plains and states that “a *local government*, in making bylaws under this section, must (a) consider the provincial guidelines, and (b) comply with the provincial regulations and a plan or program the *local government* has developed under those regulations.” To date, there are no such provincial regulations and therefore no *local government* plans or programs developed under regulation.

Section 910 does not refer specifically to *landslides*; however, the provincial document “Flood Hazard Area Land Use Management Guidelines” (Ministry of Water, Land and Air Protection, 2004), which guides a *local government* in making bylaws under Section 910, addresses debris flows, a type of *landslide* as defined in these Guidelines. The flood hazard guidelines state that, although development should be discouraged in areas prone to debris flows, “consent to develop [variance] may be granted, with standard requirements as established for alluvial fan in section 3.3 [of those guidelines], where:

- there is no other land available, and
- where an assessment of the land by a suitably qualified professional indicates that development may occur safely.”

Section 910 also indicates that a *local government* may grant a bylaw exemption if it considers it advisable and considers that the exemption is consistent with the provincial guidelines, or has received a report that the land may be used safely for the use intended, certified by:

- a *Professional Engineer* or *Professional Geoscientist* experienced in *geotechnical engineering*, or

- a person in a class prescribed by the minister in the *Local Government Act* (Section 910); however, to date no class of persons has been prescribed.

Typically a Planner and/or the Council of a *local government* reviews the *Professional Engineer's* or *Professional Geoscientist's* report, and then determines what conditions or requirements to include in the bylaw or exempt from the bylaw.

The provincial document "Flood Hazard Area Land Use Management, Guidance for Selection of Qualified Professionals and Preparation of Flood Hazard Assessment Reports" ((Ministry of Water, Land and Air Protection, c2004) indicates that a qualified professional is:

- a *Professional Engineer* or *Professional Geoscientist* with *geotechnical engineering* experience and expertise in river engineering and hydrology, and in appropriate cases, ... debris flow ... processes.

APPENDIX C: REVIEW OF LEVELS OF LANDSLIDE SAFETY

As used in these Guidelines, the term *level of landslide safety* includes levels of acceptable *landslide hazard* and *landslide risk*.

Levels of landslide safety are determined by society, not individuals. Therefore, for *residential development*, the levels must be established and adopted by the local or provincial government after consideration of a range of societal values. Some *Land Owners* may feel a government-adopted *level of landslide safety* is too high, while others are willing to live with an 'unacceptable' *level of landslide safety*.

A *Qualified Professional* should not be expected to establish a *level of landslide safety*, although he/she may provide a useful role in advising the local or provincial government that wishes to do so.

The following sub-sections briefly review some aspects of *levels of landslide safety* in British Columbia and nationally.

C.1 BRITISH COLUMBIA

This is not a thorough review of provincial and regional *levels of landslide safety*. If they exist, the *Qualified Professional* should obtain the current adopted *level of landslide safety* in the approving jurisdiction. The *Qualified Professional* should not assume that a *level of landslide safety* in one jurisdiction is applicable to another.

In British Columbia, the only province-wide adopted *level of landslide safety* is the statement "that the land may be used safely for the use intended" associated with the Land Title Act (Section 86) for subdivision approvals, the Community Charter (Section 56) for building permits and the *Local Government Act* (Section 910) for flood plain bylaw exemption. Although the statement has been included in various pieces of provincial legislation for over 30 years, the word 'safely' has never been defined.

For flood plain variances, the "Flood Hazard Area Land Use Management Guidelines" (Ministry of Water, Land and Air Protection, 2004), associated with the *Local Government Act* (Section 910(3)(a)), states that a *Qualified Professional* must indicate "that development may safely occur." The word 'safely' is not defined.

What is considered 'safe' in one jurisdiction may not be considered 'safe' in another. What is considered 'safe' at one point in time may not be considered 'safe' at another. What is considered 'safe' to one *Qualified Professional*, one *Client* or one *Approving Authority* may not be 'safe' to another. In addition, the term 'safe' can imply a total absence of hazard or risk, which is seldom the case.

The current edition of the BC Building Code (1998) and the edition in preparation (as of February 2006) does not mention *landslide safety* for buildings. It states only "Where a foundation is to rest on, in or near sloping ground, this particular condition shall be provided for in the design" (Section 4.2.4.7).

In 1973, BC Supreme Court Justice Thomas Berger ruled that the possibility of a major *landslide* between Squamish and Whistler was unacceptable to a proposed *residential development*. He based his judgment, in part, on a return period of 10,000 years for a major

landslide (Berger 1973). The Berger ruling set a precedent of a *level of landslide safety* at an annual probability of less than 0.0001 for a major *landslide* affecting a *residential development*.

Sometime between 1978 and 1993 the *BC Ministry of Transportation (MOT)* began to ask *Qualified Professionals* who carry out *landslide assessments* for proposed subdivisions “to think in terms of a 10% probability in 50 years” (approximately equivalent to an annual probability of 1:475, or approximately 1:500, or a return period of 500 years or 0.002) (*MOT 1993*)¹⁴.

MOT’s web-based “Guide to Rural Subdivision Approval” (*MOT 2005*, Section 2.3.1.07) states that a *Professional Engineer* (a *Professional Geoscientist* is not included in this document, but is included in the governing Land Title Act) should:

- determine if there is a hazard
- determine extent of any hazard
- identify building sites free from hazard, or when risk could be rendered acceptable.

The *MOT* guide does not provide a *level of landslide safety* other than the phrase “free from hazard,” which as noted previously is seldom the case.

In the 1990s, what is presently the Fraser Valley Regional District published *levels of landslide safety* for that *Regional District* for various types of natural hazards for a range of *residential development* (Cave 1992a, revised 1993). These *levels of landslide safety*, which are current today, were based on:

- Mr. Justice Thomas Berger’s 1973 unacceptable *landslide* return period of 10,000 years for a proposed subdivision
- the 200-year return period for provincially sponsored flood-proofing¹⁵, and
- the *MOT’s* 1993 guideline of 10% probability in 50 years.

In 1999, the Regional District of Fraser-Fort George adopted a *level of landslide safety* similar to *MOT’s* 1993 guideline.

C.2 CANADA

There is no nationally adopted *level of landslide safety*.

The National Building Code of Canada 2005 (NRCC 2005) provides nothing beyond the BC Building Code statement “Where a foundation is to rest on, in or near sloping ground, this particular condition shall be provided for in the design.”

The Canadian Foundation Engineering Manual (Canadian Geotechnical Society ((CGS), 2006) is a companion document to the National Building Code of Canada 2005. Although the document emphasizes foundation engineering, not *landslides*, it contains several references to *landslides*:

- the possibility of *landslides* should always be considered, and it is best to avoid building in a *landslide* area or potential *landslide* area, and

¹⁴The *MOT* guideline of “10% probability in 50 years” is 5 times greater than the “2% in 50 years” probability of exceedence of an earthquake (refer to Section C.2). The former is, however, for consideration of approvals of residential development while the latter is for design of earthquake-resistant buildings.

¹⁵ Although the processes of debris flows and debris floods overlap between *landslides* and flooding, the provincial level of flooding safety (a 200-year return period) does not apply to debris flows or debris floods.

- when a potential *landslide* area is identified, the area should be investigated thoroughly and designs and *construction* procedures should be adopted to improve the stability.

CGS 2006 does not indicate a *level of landslide safety*. It does however, address limit equilibrium analysis and factors of safety. Although limit state design is now mandatory for foundation design (NRCC 2005), limit equilibrium analysis and factors of safety remain applicable for *landslide analysis*. From CGS 2006:

- factors of safety reflect past experience under similar conditions
- the greater the potential *consequences* and/or the higher the uncertainty, the higher the design *factor of safety* should be, and
- over time, similar factors of safety have become common to geotechnical design throughout the world.

CGS 2006 does not provide a range of factors of safety that address *landslides* specifically; however, based on data from Terzaghi and Peck (1948 and 1967), that document indicates factors of safety for earthworks (engineered fills) that range from 1.3 to 1.5, and for unsupported excavations (engineered cuts) that range from 1.5 to 2.0. CGS 2006 indicates a lower *factor of safety* may be acceptable if:

- a particularly detailed soil investigation has been carried out
- where the analysis is supported by well documented local experience
- where geotechnical instrumentation to measure pore pressure and movement is provided and monitored at regular intervals to check the slope behaviour, or
- where slope failure would have only limited *consequences*.

CGS 2006 also addresses earthquake loading, and indicates:

- NRCC 2005 now requires use of the 2475-year earthquake (2% chance of exceedance in 50 years) for earthquake-resistant **design** purposes
- *factor of safety* of a slope under static conditions must be significantly greater than 1.0 to accommodate earthquake loads, and
- acceptable *factor of safety* depends on the uncertainty in the analysis, the soil parameters and the magnitude and duration of seismic excitation, in addition to the potential *consequences* of slope failure.

A number of other *geotechnical engineering* manuals and textbooks, generally non-Canadian, provide some guidance to factors of safety related to *landslides*.

APPENDIX D: LANDSLIDE ASSESSMENT ASSURANCE STATEMENT

Note: This Statement is to be read and completed in conjunction with the *APEGBC Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia, 2006* ("APEGBC Guidelines") and is to be provided for *landslide assessments* for the purposes of the *Land Title Act*, *Community Charter* or the *Local Government Act*. Italicized words are defined in the *APEGBC Guidelines*.

To: The Approving Authority

Date: _____

Jurisdiction and address

With reference to (check one):

- Land Title Act (Section 86) – Subdivision Approval
- Local Government Act* (Sections 919.1 and 920) – Development Permit
- Community Charter (Section 56) – Building Permit
- Local Government Act* (Section 910) – Flood Plain Bylaw Variance
- Local Government Act* (Section 910) – Flood Plain Bylaw Exemption

For the Property:

Legal description and civic address of the Property

The undersigned hereby gives assurance that he/she is a *Qualified Professional* and is a *Professional Engineer* or *Professional Geoscientist*.

I have signed, sealed and dated, and thereby certified, the attached *landslide assessment* report on the Property in accordance with the *APEGBC Guidelines*. That report must be read in conjunction with this Statement. In preparing that report I have:

Check to the left of applicable items

- ___ 1. Collected and reviewed appropriate background information
- ___ 2. Reviewed the proposed *residential development* on the Property
- ___ 3. Conducted field work on and, if required, beyond the Property
- ___ 4. Reported on the results of the field work on and, if required, beyond the Property
- ___ 5. Considered any changed conditions on and, if required, beyond the Property
- 6. For a *landslide hazard analysis* or *landslide risk analysis* I have:
 - ___ 6.1 reviewed and characterized, if appropriate, any *landslide* that may affect the Property
 - ___ 6.2 estimated the *landslide hazard*
 - ___ 6.3 identified existing and anticipated future *elements at risk* on and, if required, beyond the Property
 - ___ 6.4 estimated the potential *consequences* to those *elements at risk*
- 7. Where the *Approving Authority* has adopted a *level of landslide safety* I have:
 - ___ 7.1 compared the *level of landslide safety* adopted by the *Approving Authority* with the findings of my investigation
 - ___ 7.2 made a finding on the *level of landslide safety* on the Property based on the comparison
 - ___ 7.3 made recommendations to reduce *landslide hazards* and/or *landslide risks*
- 8. Where the *Approving Authority* has **not** adopted a *level of landslide safety* I have:
 - ___ 8.1 described the method of *landslide hazard analysis* or *landslide risk analysis* used

- ___8.2 referred to an appropriate and identified provincial, national or international guideline for *level of landslide safety*
- ___8.3 compared this guideline with the findings of my investigation
- ___8.4 made a finding on the *level of landslide safety* on the Property based on the comparison
- ___8.5 made recommendations to reduce *landslide hazards* and/or *landslide risks*
- ___9. Reported on the requirements for future inspections of the Property and recommended who should conduct those inspections.

Based on my comparison between

Check one

- the findings from the investigation and the adopted *level of landslide safety* (item 7.2 above)
- the appropriate and identified provincial, national or international guideline for *level of landslide safety* (item 8.4 above)

I hereby give my assurance that

Check one

- for subdivision approval, as required by the Land Title Act (Section 86), "that the land may be used safely for the use intended"

Check one

- with one or more recommended registered *covenants*.
- without any registered *covenant*.
- for a development permit, as required by the *Local Government Act* (Sections 919.1 and 920), my report will "assist the *local government* in determining what conditions or requirements under [Section 920] subsection (7.1) it will impose in the permit"
- for a building permit, as required by the Community Charter (Section 56), "the land may be used safely for the use intended"

Check one

- with one or more recommended registered *covenants*.
- without any registered *covenant*.
- for flood plain bylaw variance, as required by the "Flood Hazard Area Land Use Management Guidelines" associated with the *Local Government Act* (Section 910), "the development may occur safely."
- for flood plain bylaw exemption, as required by the *Local Government Act* (Section 910), "the land may be used safely for the use intended."

Name (print)

Signature

Date

Address

Phone

(Affix Professional seal here)

If the *Qualified Professional* is a member of a firm, complete the following.

I am a member of the firm _____
and I sign this letter on behalf of the firm. (Print name of firm)

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