



**GEOLOGICAL SURVEY OF CANADA
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National technical guidelines and best practices on landslides**

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B. Wang¹, M. Ruel², R. Couture¹, P. T. Bobrowsky¹, A. Blais-Stevens¹

¹ Natural Resources Canada, Ottawa, Ontario

² CN Rail, Montreal, Quebec

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Canadian Technical Guidelines and Best Practices Related to Landslides: A National Initiative for Loss Reduction

Chapter E: REVIEW OF EXISTING LANDSLIDE GUIDELINES

Chapter Lead: B. Wang, bwang@NRCan.gc.ca¹

Co-authors: M. Ruel², R. Couture¹, P.T. Bobrowsky¹, A. Blais-Stevens¹

¹ Natural Resources Canada, Ottawa, Ontario

² CN Rail, Montreal, Quebec

1. INTRODUCTION

Landslides involve a wide range of issues. Guidelines for dealing with such issues are therefore diverse. Such guidelines exist in a number of countries, and differ in formats, focus and target audiences. In Canada, the provinces of British Columbia and Québec have the most detailed guidelines. There are however, no national landslide guidelines in Canada. This chapter reviews, compares and evaluates many of the existing national and international guideline documents.

2. GUIDELINES DOCUMENT SEARCH AND SELECTION

On-line bibliographic databases that contain geoscience-rich literature (e.g., ScienceDirect, Scopus and GeoRef) were searched for references to landslide guideline documents. As most landslide guidelines were expected to be stand alone documents published by government and non-governmental organizations, the search focused on organizational publications rather than peer reviewed papers. General purpose Internet search engines were also used to find documents referenced on organizational websites.

This review focuses on landslide technical guidelines for professionals dealing with landslides. Some guideline documents are both technical and non-technical, and this complicated the evaluation process. Some less technical documents are included in this review, although this type of publication was not extensively searched.

A document was initially included if both the title and abstract indicated that it contained relevant information. Further screening was carried out during the review stage. Documents that reported findings of the authors' scientific research that were deemed of limited scope were excluded.

Some guideline documents encountered were not specifically written for landslides, for example, the risk management guidelines from the International Organization for Standardization (ISO, 2009), or the guidelines for open pit slope design (Read and Stacey, 2009). If such documents were deemed to provide useful reference or guidance for landslide studies, they were included.

More than 30 guideline documents from 10 countries and two international organizations were reviewed. Most documents reviewed were in English; but some in French. Guidelines written in other languages were not included in the review. As a result, it is acknowledged that some guidelines may be missing from this review. Table 1 is a summary of the guideline documents reviewed.

Table 1. List of landslide guideline documents reviewed

Country/Region	Primary Topics	Reference
Australia	Landslide zoning	AGS (2007a, b)
Australia	Landslide risk management	AGS (2000, 2007c, d)
Australia	General guide to understanding landslides	AGS (2007e)
Canada	Risk management	CSA (1997)
Canada	Risk management principles	CSA (2010a)
Canada/BC	Management of landslide-prone terrain	Chatwin et al. (1994)
Canada/BC	Landslide risk case studies in the forest sector	Wise et al. (2004)
Canada/BC	Management of landslides in the forest sector	APEGBC/ABCFFP (2008)
Canada/BC	Landslide assessments in the forest sector	ABCFFP/APEGBC (2009)
Canada/BC	Landslide assessments for residential development	APEGBC (2010)
Canada/Québec	Use of landslide maps for loss reduction	Québec (2005)
China/Hong Kong	Risk criteria for landslides	ERM HK (1998)
China/Hong Kong	Geotechnical manual for slopes	GEO (2000)
China/Hong Kong	Landslide debris-resisting barrier design	Lo (2000)
China/Hong Kong	Guide to engineered slope maintenance	GEO (2003)
China/Hong Kong	Natural terrain landslides	Ng et al. (2003)
European Union	Managing landslides in urban areas	McInnes (2000)
Germany	Disaster risk management	Kohler et al. (2004)
India	Management of landslides and snow avalanches	India (2009)
International	Landslide zoning	JTC-1 (2008)
International	Risk management principles	ISO (2009)
International	Open pit slope design	Read & Stacey (2009)
Malaysia	Slope maintenance in Malaysia	Malaysia (2006)
New Zealand	Planning policy and approval requirements	Saunders & Glassey (2007)
Switzerland	Landslide mapping and land use planning	OFAT et al. (1997)
UK/Scotland	Landslides in peat: hazard and risk assessments	Scottish Executive (2006)
USA	Landslide investigation and mitigation	TRB (1996)
USA	Landslides and planning	Schwab et al. (2005)
USA	General guide to understanding landslides	Highland & Bobrowsky (2008)
USA/California	Static and seismic slope stability assessments	ASCE L.A. Section (2002)
USA/California	Landslide management and storm damage response	Caltrans (2003)
USA/Colorado	Landslide guide for state/local government planning	Wold & Jochim (1989)
USA/Missouri	Engineering policy guidelines for slope design	Loehr et al. (2011)
USA/Utah	Evaluation of landslides	Hylland (1996)
USA/Utah	Debris flow hazards on alluvial fans	Giraud (2005)

3. REVIEW OF THE EXISTING GUIDELINES

Landslide loss reduction requires efforts from professionals, regulatory bodies and other stakeholders. Landslide guidelines therefore are aimed at those user groups for increasing awareness and the quality and consistency of professional practice. The landslide guidelines reviewed provide assistance to different landslide issues using different approaches; some focus on certain topics, regions or issues, others are more comprehensive or general. The following review categorizes the guidelines by common primary topics, however, most guidelines cover more than one topic. The primary topics of

the reviewed guidelines are indicated in the centre column of Table 1. The main focus of each document was subjectively identified by broadly categorizing the applicability of each document to the questions who, what, where and when as shown in Table 2.

Based on the focus of the document as determined from the above exercise, each guideline was classified into one of the following groups:

- Landslide risk management;
- Landslide zoning;
- Geotechnical assessment;
- Land use planning;
- Mitigation and remediation;
- Codes of responsibilities;
- Other guidelines

The following sub-sections review the guideline documents by group, arranged by publication date from the oldest to the most recent.

3.1 Landslide Risk Management

Landslide risk management is one of the most common topics covered in landslide guideline documents. The Geotechnical Engineering Office (GEO) of Hong Kong released an interim risk guideline for landslides and boulder falls from natural terrain (ERM Hong Kong Ltd., 1998). The document reviews the associated risk criteria available worldwide at that time. It recommends landslide and boulder fall risk assessment criteria on an interim basis for Hong Kong.

Germany published guidelines on risk analysis for disaster risk management (Kohler et al., 2004). The document is directed to emergency aid, reconstruction and food-security programs in regions threatened by natural hazards. It describes general procedures for risk analysis with three examples illustrating applications of the procedures to floods, droughts and erosion. Although the guidelines are not specific to landslides, the general procedures can be applied to landslides.

The most comprehensive risk management guideline document, tailored specifically to landslides, is the Australian Geomechanics Society's *Landslide Practice Note* (AGS, 2007c). This document provides guidelines for both regulatory bodies and practitioners. The relevant text for regulators outlines the policy and evaluation process requirements, tolerable risk criteria, and roles and responsibilities of the practitioners. Relatively detailed procedures are provided for practitioners to follow regarding landslide hazard assessment, consequence analysis, risk estimation, assessment and management. The commentary document (AGS, 2007d) provides an example of a risk evaluation case history and is a useful step-by-step illustration of how to apply the procedures.

The International Organization for Standardization (ISO) released ISO 31000 *Risk management – principles and guidelines* (ISO, 2009). The document provides generic guidance on risk management for general application. It is not specific to a particular country, industry or sector. Although it does not specifically address landslides, the document provides fundamental guidance that can be applied in landslide risk management and provides definitions and terminology for effective risk management communication.

Table 2. Broad categories of guideline documents reviewed

Country/Region	Reference	Who		What				Where				When							
		Engineers/Geoscientists/Professionals	General public/non-technical audience	Land use planners	Regulators	Responsibilities	Land use planning	Zoning	Risk assessment/management	Site investigation/failure mechanisms	Mitigation/remediation	Proposed development areas	Developed areas	Potentially unstable slopes	Landslides occurred	All stages of land use planning	When slope failure is a concern	When risk management is needed	After a landslide has occurred
Australia	AGS (2000, 2007c, d)	●	●	●	●	●	●	●	○	○	●	●	●	○	●	●	●	○	●
Australia	AGS (2007a, b)	●	●	●	●	●	●	○	○	○	●	●	○	○	●	●	●	○	○
Australia	AGS (2007e)		●	○	○	○	○		○	○	○	○	○		●		○	○	
Canada	CSA (1997)	●	○	○	●	○	○	●		○	○	○		○	●	●			
Canada	CSA (2010)	●	○	○	●	○	○	●		○	○	○		○	●	●			
Canada/BC	Chatwin et al (1994)	○	○	○	○	○	○	○	○	○	○	○	○	○	●			○	
Canada/BC	Wise et al. (2004)	●	○			○	○	●	○	○	●	○	●		●	●	○		
Canada/BC	APEGBC/ABCFP (2008)	●		●	●				○	○	○	○	○	○	●	○		○	
Canada/BC	ABCFP/APEGBC (2009)	●		●	●				○	○	○	○	○		●			○	
Canada/BC	APEGBC (2010)	●	○	●	●	●		●	○	●	●	●	●	●	●	○		○	
Canada/Quebec	Quebec (2005)	○	●	○		●	●	○		●	●	●	○	●	●	●	○	○	
China/Hong Kong	ERM HK (1998)	●	○	○		○		●	○	○	○	○	○		●	●	●	●	
China/Hong Kong	GEO (2000)	●							●	●	○	○	●	●	○	●		●	
China/Hong Kong	Lo (2000)	●				○			○	●	○	○	●	○	○	●		●	
China/Hong Kong	GEO (2003)	○			○				○	○		●	●	○	●				
China/Hong Kong	Ng et al (2003)	●	○	○	○	●	○	○	●	●	○	○	○	○	○	●	○	○	
European Union	McInnes (2000)	○	○	○	○	○	○	○	○	○	○	○	●	○	○	●		○	
Germany	Kohler et al. (2004)			○	○			●	○					○	○	●		○	
India	India (2009)	○		●	●			○	○	○	○	○			●	○		○	
International	JTC-1 (2008)	●	●	●	●	●	●	○		○	●	●	○	○	●	●	●	○	
International	ISO (2009)	●	○	○	●	○		●		○	○	○		○	●	●			
International	Read & Stacy (2009)	●						●	●	●	○		●	○	○	●		○	
Malaysia	Malaysia (2006)	○			○				○	○		●	●		○	●			
New Zealand	Saunders & Glassey (2007)	○	●	●	●	●		○		○	●		○	●	●	○		○	
Switzerland	OFAT et al. (1997)	●	○	○	○	○	●	○	●	○	○	●	○	○	○	●	○	○	
UK/Scotland	Scottish Executive (2006)	●	○	○		○		○	●	●	○	○	○	○	○	●	○	○	
USA	TRB (1996)	●						○	●	●	○	○	●	●	○	●	○	●	
USA	Schwab et al. (2005)		○	●	○	●		○		○	●		○	●	●	○		●	
USA	Highland & Bobrowsky (2008)		●	○	○	○				○	○	○			●		○		
USA/California	ASCE L.A. Section (2002)	●	○	○	○	○	○	●	●	○	○	●	○	○	●		○	●	
USA/California	Caltrans (2003)	○		○	○			○	●		●	○	○		●		○	●	
USA/Colorado	Wold & Jochim (1989)		○	○	●	○	○	○	●	○	○	○	○	○	○	●	○	○	
USA/Missouri	Loehr et al. (2011)	●		○				●	●	●	○	●	○	●	●			●	
USA/Utah	Hylland (1996)	●						●	○	○	○	○	○		●		○	○	
USA/Utah	Giraud (2005)	●	●	○		○	○	○	●	○			○	○	○	○		●	

Legend: ● More applicable; ○ Applicable; Blank: Less applicable or not applicable

The Canadian Standard Association (CSA) originally published a Canadian generic standard for risk management (CSA, 1997). After the release of ISO 31000 (ISO, 2009), CSA announced its adoption of ISO 31000 as the Canadian national standard on risk management (CSA, 2010a). CSA is also in the process of updating its 1997 standard as a supplement to CSA (2010a). The updated version will provide guidance for implementing the international standard taking into account the needs of Canadian stakeholders. A draft version was released for review in early 2010 (CSA, 2010b). As of late 2011 a final version has not been published.

3.2 Landslide Zoning

Switzerland published guidelines for landslide mapping and land use planning (OFAT et al., 1997). The document targets three groups with specific objectives: (1) to guide geotechnical specialists in their practice for the evaluation of landslides; (2) to assist politicians in their decision process on land use planning; and (3) to inform land owners of the potential hazards that can affect their properties. The proposed methodology is based on basic risk management principles. The recommended process starts with landslide identification, followed by an evaluation of frequency and consequences. Mitigation measures, including emergency planning, are recommended. The document is easy to read and offers a relatively comprehensive overview of landslides and associated potential preparatory causes. It provides basic tools and a standard methodology and terminology, with examples for developing hazard maps and land use planning throughout Switzerland.

The Australian landslide zoning guidelines (AGS, 2007a) are perhaps the most comprehensive guidelines on that topic. The document, along with its companion commentary document (AGS, 2007b), provides guidance on landslide susceptibility, hazard and risk zoning for land use planning. A list of definitions, terminology, descriptions of the types and levels of landslide zoning are provided and various landslide zoning methods are described. Geotechnical evaluations, GIS-based techniques and landslide inventory are briefly discussed. The document specifies levels of zoning required, with the corresponding scales of zoning maps, for different applications. The Australian landslide zoning guidelines were endorsed by an international body, JTC-1: a joint International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), International Association for Engineering Geology (IAEG) and International Society for Rock Mechanics (ISRM) Technical Committee on Landslides and Engineered Slopes. JTC-1 adopted the Australian landslide zoning guidelines with minor modification for international implementation (JTC-1, 2008).

3.3 Geotechnical Assessment

Geotechnical investigation is necessary to understand the mechanics of slope failures and to develop appropriate mitigation. Mostly driven by engineering applications, guidelines for geotechnical investigation of slopes are widely available and typically contain relatively detailed technical procedures.

The Utah Geological Survey (USA) published *Guidelines for evaluating landslide hazards in Utah* (Hylland, 1996). The guidelines assist geologists and geotechnical engineers in carrying out landslide studies and to help with technical reviews of hazard evaluation reports. They set out requirements for three levels of landslide hazard evaluations: (1) geological evaluations, (2) preliminary geotechnical evaluations, and (3) detailed geotechnical evaluations. They also outline requirements for landslide evaluation reports. The guidelines address rotational and translational slides and, to a certain extent, liquefaction-induced slope failures of regional interest in the state of Utah.

The Hong Kong *Geotechnical Manual for Slopes* (GEO, 2000) is one of the most comprehensive documents, providing very detailed guidance on standard practices for design, construction and maintenance of engineered slopes. The manual covers topics such as local geology, site investigation, laboratory testing, groundwater, slope design, instrumentation and maintenance. Although the document is focused on slopes local to Hong Kong, international geotechnical professionals can benefit from this document given its detailed geotechnical procedures for slope stability and landslide investigations. Note that the first edition of this manual was published in 1979. It was updated in 1984, then reprinted in 1991, 1994, 1997 and 2000. The 2000 reprint indicates that more up-to-date guidance was progressively given in later GEO publications that supersede or supplement those provided in the manual. A list of such publications is included in an addendum at the end of the 2000 reprint.

The guidelines from California (USA) for investigating and mitigating landslide hazards (ASCE L.A. Section, 2002) provide guidance on geotechnical procedures for landslide mitigation. The document is focused on slope stability and displacement associated with seismic events. Although the document acknowledges that there is no consensus on appropriate seismic slope deformation analysis, it does provide useful information on the mitigation of landslides induced by earthquakes.

The international guidelines for open pit mine slope design (Read and Stacey, 2009) provide detailed procedures and methodologies to investigate and design open pit slopes. The guidelines include many state-of-the-art techniques and approaches for studying rock slopes. Although the document is focused on open pit slopes, it is useful as it provides general geomechanical principles applicable to other slopes.

Most recently, the Missouri Department of Transportation (USA) released an *Engineering Policy Guidelines for Design of Earth Slopes* (Loehr et al, 2011). The document provides provisions for design of soil and rock slopes commonly encountered in transportation rights-of-way. Although it is relatively brief, the document specifies some detailed procedures such as special slope stability design with factored parameters and serviceability limit state design. The commentary attached to the document provides supplemental information to the provisions. The document provides policy-type guidelines, although it has not been formally adopted by the Missouri Department of Transportation and does not constitute a standard, specification or regulation.

3.4 Land Use Planning

The *Landslides Hazards and Planning, a Planning Advisory Service Report* released by the American Planning Association (Schwab et al., 2005) is a useful guideline for land use planners. It describes how landslide risk can be minimized by appropriate development planning. It provides a comprehensive guide to identifying landslides as well as the legal and administrative tools for mitigation common to the United States of America. Many examples in the document demonstrate how communities have successfully incorporated landslide information into their planning process.

New Zealand Geological and Nuclear Sciences (GNS) published *Guidelines for assessing planning policy and consent requirements for landslide prone land* (Saunders and Glassey, 2007). The guidelines are primarily for land use planners and provide non-prescriptive guidance on how landslides can be incorporated into risk-based planning policy and approval requirements. They propose a risk-based approach to land use planning and approval. The approach considers landslide recurrence interval and a *building-importance category* of a proposed building site. The approach does not guarantee that a building will not suffer damage from a landslide, but determines if the risk of damage is sufficiently low to be acceptable.

3.5 Mitigation and Remediation

Many of the landslide guideline documents reviewed provide guidance on mitigation or remediation. They typically address these topics at different levels of detail and use approaches that are consistent with their intended focus. Such documents often address region-specific mitigation and remediation issues. Landslide mitigation and remediation is also a topic of those guideline documents associated with geotechnical investigations discussed in Section 3.3.

The Colorado Geological Survey (USA) published a guide on landslide loss reduction for state and local government planning (Wold and Jochim, 1989). The document was also published by the USA Federal Emergency Management Agency the same year. It provides a *practical and politically feasible guide* for officials involved in landslide mitigation. The document introduces basic concepts about landslides, and presents landslide identification, assessment, mapping and loss-reduction techniques and steps to prepare landslide mitigation plans. It also provides information on available resources and offers suggestions on the formation of an interdisciplinary mitigation planning team and a permanent state natural hazards mitigation organization.

Landslides: Investigation and Mitigation published by the USA Transportation Research Board (TRB, 1996) describes procedures and techniques for investigating and mitigating a wide variety of landslides, in both soil and rock, natural and engineered slopes. It supersedes previous versions published in 1958 and 1978. The document provides comprehensive guidance on a broad range of landslide topics that are grouped into five parts: principles, investigations, analysis, mitigation and special cases. Although discussed in this section, the document provides many details on topics in other categories, such as landslide zonation, risk assessment and geotechnical investigation.

The Hong Kong Geotechnical Engineering Office released a report on natural, terrain landslide debris-resisting barrier design (Lo, 2000). This document reviews design methodologies for landslide debris-resisting barriers, including rock/boulder fences, gabions, reinforced concrete retaining walls, earth fill berms and check dams. The document reviews methods to estimate debris mobility and debris impact loads for use in engineering design. The identified approaches form interim guidelines for application to landslide debris barrier design.

The Hong Kong Geotechnical Engineering Office issued a *Guide to Slope Maintenance* in 2003 (GEO, 2003). This document recommends a standard of good practice for the maintenance of engineered slopes and retaining structures, disturbed terrain features and natural terrain hazard mitigation structures. It supersedes an earlier version published in 2000. The guidelines are aimed at geotechnical engineers, and are not intended to be mandatory. The document details the procedures and requirements for slope monitoring, inspection and maintenance. It also provides forms for slope maintenance records. The Public Works Department of Malaysia issued a modified version of GEO (2003) for implementation in Malaysia (Malaysia, 2006).

The Hong Kong Geotechnical Engineering Office also issued a set of guidelines for natural terrain hazard studies (Ng et al., 2003). The document describes the requirements and approaches for natural terrain hazard studies and summarizes the design requirements for appropriate mitigation. It recognizes the importance of studying and dealing with natural terrain hazards before project development, rather than addressing the problem as a response. As such, the document emphasizes terrain hazard screening procedures and criteria, approaches for studying different types of hazards (for example rock falls, deep-seated slides and debris flows), and strategies for risk mitigation.

The Department of Transportation of California (USA) released draft guidelines for landslide management and storm damage response (Caltrans, 2003). The guidelines are specific to the Highway 1 corridor along California's Big Sur Coast. They address a range of strategies and actions for effective partnership and collaborative decision-making among stakeholders to improve the process of managing landslides along the highway. The document provides an overview of geology and landslides along the corridor, landslide management programs, processes and strategies, and many

techniques available for landslide mitigation and remediation. Although the guidelines are of local/regional focus, they provide a useful reference for application to other similar settings.

Scotland published a best practice guide for landslides in peat (Scottish Executive, 2006). The document provides guidance on the methods for identifying, mitigating and managing peat-related landslides. This guide describes field and laboratory investigation methods, hazard analysis, risk assessment and mitigation measures. It provides an overview of unique peat failure mechanisms and triggering factors, guidance on desk studies, field investigations, slope stability analysis, and reporting. The guide is concise and provides a valuable reference for professionals, especially for those who work with peat.

3.6 Codes of Responsibilities

Several Canadian provincial guidelines specify responsibilities for professionals and other parties involved with landslide investigations and assessments. For example, the *Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia* was first issued by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) in 2006 and revised in 2008 and 2010 (APEGBC, 2010). The guidelines are for APEGBC members, land owners and approving authorities. They outline relatively detailed geotechnical procedures related to seismic slope stability and deformation analysis.

Two other British Columbia guidelines address terrain stability management (APEGBC/ ABCFP, 2008) and terrain stability assessment (ABCFP/APEGBC, 2009) in the British Columbia forest sector. The management guidelines set out general guidelines of professional practice for establishing, implementing and updating stability management models. The assessment guidelines specify professional obligations and guidance for professional practice.

3.7 Other Guidelines

Some guidelines do not easily fit the groups discussed above, but do provide guidance for landslide loss reduction.

In 1991, the British Columbia Ministry of Forests published a *Land management handbook for the Management of Landslide-prone Terrain in the Pacific Northwest* and updated it in 1994 (Chatwin et al., 1994). The handbook provides information on landslide processes, techniques for recognition of landslide-prone terrain, measures to manage unstable terrain, and road deactivation and re-vegetation of unstable terrain. It was designed to be carried in the field by agency and industry personnel as a handy reference.

Supported by the European Union, a guideline on *Managing Ground Instability in Urban Areas* was published by the Isle of Wight Centre for the Coastal Environment, UK (McInnes, 2000). The document provides guidance for managing ground instability. It targets a range of groups from scientists to land use planners and decision-makers. The guideline highlights the need to increase awareness of the range of methods available to mitigate ground instability. It encourages landslide assessment at the land use planning stage, and illustrates examples of good practice for the European Union and elsewhere.

The British Columbia Ministry of Forests issued a *Land management handbook* on landslide risk case studies (Wise et al., 2004). This handbook provides a common framework for landslide risk management based on the general framework for risk management described in CSA (1997) and AGS (2000). It also provides a basis for a common understanding of terms and concepts for effective communication among forest resource managers, terrain stability (landslide) professionals, and stakeholders. The document relies on eight case studies to demonstrate risk analysis and assessment

procedures for forestry cut-blocks, roads, gullies, and alluvial fans. It provides useful reference and guidance for both qualitative and quantitative risk management methods.

A guideline for the interpretation and use of existing landslide maps was published by the Québec provincial government (Québec, 2005). The guideline helps local authorities in the Lac St-Jean area interpret and use hazard maps produced by the provincial government to help improve the safety of residents. It offers a very brief overview of existing landslide risk management tools and elaborates on common causes and triggering factors of the most common landslide types in the region. A particular emphasis is given to Champlain Sea clay. It also provides a basic and practical list of what to do and what not to do when dealing with slopes, because up to 40% of slope failures in the area are triggered by human activity (Québec, 2005). The document also provides a list of the minimum requirements for a geotechnical report when further investigation is required.

In addition to the landslide zoning and risk management guidelines already discussed, the Australian Geomechanics Society also released a set of *GeoGuides* (AGS, 2007e). These documents are aimed at home owners, developers and others who are unfamiliar with landslides. A total of 11 *GeoGuides* are included in the set, each as a stand-alone document uniquely formatted so that it can be printed on two sides of a single A4 sized sheet. Basic concepts about landslides and critical information of importance to a non-technical audience are concisely described in the documents.

The Landslide Handbook: a guide to understanding landslides was published jointly by the United States and Canadian geological surveys (Highland and Bobrowsky, 2008). Written specifically for the non-technical community, this document includes significant technical information, from the identification and classification of landslides, to monitoring and mapping methods, to options for stabilizing slopes. The guideline aims to help educate, inform and guide those individuals affected by or concerned with slope instability but are lacking sufficient technical expertise to know where to proceed next. The document was written for an international audience and has been published in English, Mandarin, Japanese, Portuguese and Spanish.

India released the *National Disaster Management Guidelines – Management of Landslides and Snow Avalanches* (India, 2009) to help direct its management plans and policies. The guidelines identify areas that require special attention and indicate which appropriate activities including hazard zonation mapping, geological and geotechnical investigations, landslide risk management, and monitoring are required. The document outlines regulatory and non-regulatory frameworks with defined time schedules for all activities identified.

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5. REFERENCES

- ABCFFP/APEGBC, 2009. Guidelines for terrain stability assessments in the forest sector, Association of British Columbia Forest Professionals/Association of Professional Engineers and Geoscientists of British Columbia, 25p.
- APEGBC, 2010. Guidelines for legislated landslide assessments for proposed residential developments in BC, Association of Professional Engineers and Geoscientists of British Columbia, 75p.

- APEGBC/ABC FP, 2008. Guidelines for management of terrain stability in the forest sector, Association of Professional Engineers and Geoscientists of British Columbia / Association of British Columbia Forest Professionals, 17p.
- ASCE Los Angeles (L.A.) Section Geotechnical Group, 2002. Recommended procedures for implementation of DMG special publication 117 guidelines for analyzing and mitigating landslide hazards in California. A publication of the Southern California Earthquake Center. 132 p.
- Australian Geomechanics Society (AGS), 2000. Landslide risk management concepts and guidelines. Sub-committee on landslide risk management, Australian Geomechanics, March 2000, pp. 49-92.
- Australian Geomechanics Society (AGS), 2007a. Guideline for landslide susceptibility, hazard and risk zoning for land use planning, Australian Geomechanics, Vol. 42, No. 1, pp. 13-36.
- Australian Geomechanics Society (AGS), 2007b. Commentary on guideline for landslides susceptibility, hazard and risk zoning for land use planning, Australian Geomechanics, Vol. 42, No. 1, pp. 37-62.
- Australian Geomechanics Society (AGS), 2007c. Practice note guidelines for landslide risk management, Australian Geomechanics, Vol. 42, No. 1, pp. 63-114.
- Australian Geomechanics Society (AGS), 2007d. Commentary on practice note guidelines for landslide risk management, Australian Geomechanics, Vol. 42, No. 1, pp. 115-158.
- Australian Geomechanics Society (AGS), 2007e. The Australian GeoGuides for slope management and maintenance, Australian Geomechanics, Vol. 42, No. 1, pp. 159-182.
- Caltrans, 2003. Guidelines for landslide management and storm damage response, California Department of Transportation. 78 p.
- Canadian Standard Association (CSA), 1997. Risk management: Guidelines for decision-makers, a national standard of Canada. CAN/CSA-Q850-97. 46p.
- Canadian Standard Association (CSA), 2010a. Risk management – principles and guidelines. National Standard of Canada, CAN/CSA-ISO 31000-10. 24 p.
- Canadian Standard Association (CSA), 2010b. Draft Standard CAN/CSA-Q850, Implementation of CAN/CSA-ISO 31000, 2nd Edition of CSA Standard CAN/CSA Q850, 37p.
- Chatwin, S.C., Howes, D.E., Schwab, J.W. & Swanston, D.N., 1994. A guide for management of landslide-prone terrain in the Pacific Northwest. B.C. Ministry of Forests Land Management Handbook #18. 220 p.
- ERM Hong Kong Ltd., 1998. Landslides and boulder falls from natural terrain: Interim risk guidelines. Government of Hong Kong, Geotechnical Engineering Office, GEO Report No. 75. 183 p.
- Geotechnical Engineering Office (GEO), 2000. Geotechnical manual for slopes (2nd Edition, 4th reprint). Government of Hong Kong publication. 300 p.
- Geotechnical Engineering Office (GEO), 2003. Geoguide 5: Guide to slope maintenance (3rd Edition). Government of Hong Kong publication. 132 p.
- Giraud, R.E. 2005. Guidelines for the geologic evaluation of debris-flow hazards on alluvial fans in Utah. Miscellaneous publication 05-6, Utah Geological Survey. 20 p.
- Highland, L.M. and Bobrowsky, P.T. 2008. The landslide handbook – A guide to understanding landslides. USGS Circular 1325. 129 p.
- Hylland, M.D. (editor), 1996. Guidelines for evaluating landslide hazards in Utah. Utah Geological Survey Circular 92. 16 p.
- India, 2009. National disaster management guidelines – Management of landslides and snow avalanches, a publication of the National Disaster Management Authority, Government of India. 144 p.
- International Organization for Standardization (ISO), 2009. Risk management – principles and guidelines, ISO 31000, 24p.
- JTC-1, 2008. Guidelines for landslide susceptibility, hazard and risk zoning for land use planning. Engineering Geology, Vol. 102, pp. 85-98.

- Kohler, A., Julich, S. & Bloemertz, L., 2004. Guidelines: Risk analysis – a basis for disaster risk management. Danaher, P. (Translator). German Society for Technical Cooperation (GTZ), Federal Ministry for Economic Cooperation and Development (Germany). 73 p.
- Lo, D.O.K., 2000. Review of natural terrain landslide debris-resisting barrier design. Hong Kong Geotechnical Engineering Office report No. 104. 91 p.
- Loehr, J.E., Bowders, J.J., Ge, L., Likos, W.J., Luna, R., Maerz, N., Rosenblad, B.L. and Stephenson, R.W., 2011. Engineering policy guidelines for design of earth slopes. Report prepared for Missouri Department of Transportation (MoDOT), Oct. 2011. Report CMR12004. 19 p.
- Malaysia, 2006. Guidelines on slope maintenance in Malaysia. Slope Engineering Branch, Public Works Department Malaysia, 118 p.
- McInnes, R., 2000. Managing ground instability in urban areas: A guide to best practice. A publication of Isle of Wight Centre for the Coastal Environment (UK). 80 p.
- Ng, K.C., Parry, S., King, J.P., Franks, C.A.M. and Shaw, R. 2003. Guidelines for natural terrain hazard studies. Government of Hong Kong, Geotechnical Engineering Office, GEO Report No. 138. 138 p.
- OFAT, OFEE, OFEFP, 1997. Prise en compte des dangers dus aux mouvements de terrain dans le cadre de l'aménagement du territoire. Recommandations. Office fédéral de l'aménagement du territoire (OFAT), Office fédéral de l'économie des eaux (OFEE), Office fédéral de l'environnement, des forêts et du paysage (OFEFP), OCFIM Nr. 310.023f, Berne, Switzerland. 42 p.
- Québec, 2005. Cartographie des zones exposées aux glissements de terrain dans les dépôts meubles – Guide d'utilisation des cartes de zones de contraintes et d'application du cadre normative - Saguenay-Lac-Saint-Jean. Gouvernement du Québec. 65 p.
- Read, J. and Stacey, P. (Editors), 2009. Guidelines for open pit slope design, CSIRO Publishing. 496 p.
- Saunders, W. and Glassey, P. (Compilers), 2007. Guidelines for assessing planning policy and consent requirements for landslide prone land, GNS Science Miscellaneous Series 7. 71p.
- Schwab, J.C., Gori, P.L. and Jeer, S. (editors). 2005. Landslide hazards and planning. American Planning Association Planning Advisory Service Report #533/534. 208 p.
- Scottish Executive, 2006. Peat landslide hazard and risk assessments – Best practice guide for proposed electricity generation developments. Published by Scottish Executive, ISBN 0-7559-6378-4. 72 p.
- Transportation Research Board (TRB), 1996. Landslides: investigation and mitigation. Turner, A.K. and Schuster, R.L. (editors). U.S. National Academy Press. 673p.
- Wise, M.P., Moore, G.D. and VanDine, D.F. (editors). 2004. Landslide risk case studies in forest development planning and operations. B.C. Ministry of Forests Land Management Handbook No. 56, 119p.
- Wold, R.L. Jr. and Jochim, C.L. 1989. Landslide loss reduction: A guide for state and local government planning. A Colorado Geological Survey Special Publication #33. 50p.