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Workshop on Landslide Hazards and Risk Management in Canada

R. Couture

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Workshop on Landslide Hazards and Risk Management in Canada

Atelier sur l'étude et la gestion des risques de glissements de terrain au Canada

Hull (Québec)
16-18 November / Novembre 2001

Report / Rapport

Prepared by / Préparé par

Dr. Réjean Couture

Geological Survey of Canada / Commission géologique du Canada
Natural Resources Canada / Ressources Naturelles Canada

January / Janvier 2002

Natural Resources Canada Ressources naturelles Canada

Avant-propos

La tenue de l'***Atelier sur l'étude et la gestion des risques de glissements de terrain au Canada*** s'inscrit comme une des composantes majeures du projet intitulé « National Landslide Hazard Assessment ». Ce projet est sous la supervision de Mrs. Jan Aylsworth (Terrain Science Division) et est financé par le Programme « Proposal-Approval System (GSC-PAS) » de la Commission géologique du Canada. La composante « Atelier » est sous la direction de Dr. Réjean Couture. Ce projet d'une durée de trois ans consiste, outre le volet Atelier, la production de cartes de glissements de terrain à l'échelle canadienne la production d'un document synthèse sur notre compréhension actuelle des risques de glissements de terrain au Canada.

La première partie de ce présent document résume l'ensemble des discussions tenues lors de l'Atelier et se veut une réflection fidèle des résultats de ces discussions tel que présentés lors des sessions plénières. Ce document ne comporte aucune interprétation par les auteurs des résultats des discussions, pas plus pas moins.

La seconde partie présente les principales actions à prioriser et les moyens d'y parvenir tel qu'identifier par les membres du Comité Aviseur, lequel est formé par des représentants des secteurs académique, industriel et governemental. Les principales lacunes dans la capacité à réduire les risques de glissements de terrain sont également identifiées.

Ce document est disponible pour tous les canadiens via le site internet :
http://sts.gsc.nrcan.gc.ca/landslides/workshop/home_fr.asp

Foreword

The invitational Workshop on Landslide Hazard and Risk Management in Canada is one of the main components of a broader project entitled « National Landslide Hazard Assessment ». This project funded by the Geological Survey of Canada's Proposal-Approval System (GSC-PAS) is under the supervision of Mrs. Jan Aylsworth (Terrain Sciences Division). The Workshop component is lead by Dr. Réjean Couture. This 3-year project has two other components: a) National Landslide Map; and b) a formal document of current regional and thematic understanding of landslide hazards in Canada.

The first part of this document summarizes the workshop presentations and discussions as addressed in the plenary sessions. Results presented here are accurately reproduced from transcripts of discussions and do not contain any interpretation from the authors.

The second part presents the main actions to be prioritized and the means how these actions should be carried out as identified by the Advisory committee, which is formed by representatives from academia, industry, and government. Also, the main deficiencies in Canada's capacity to mitigate landslides are presented.

This document is available to all Canadians through the following web site:
http://sts.gsc.nrcan.gc.ca/landslides/workshop/home.asp

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Executive Summary

Geological Survey of Canada hosted an invitational ***Workshop on Landslide Hazards and Risk Management in Canada*** in Hull, Quebec, on 16-18 November 2001 (http://sts.gsc.nrcan.gc.ca/landslides/workshop/home.asp). The workshop was designed as a crucial step in the development of the multi-agency **Canada Landslide Loss Reduction Program** – a new Canadian government program initiated to mitigate losses due to landslides.

Workshop objectives were to:

- build on the experience of other countries where similar programs have already been implemented,
- engage stakeholders in defining the state of our knowledge of landslides and landslide hazards in Canada,
- identify gaps in that knowledge, and
- establish priorities for future activities.

Fifty people from across Canada attended the workshop, representing industry (26%), academia (16%), provincial (12%), and federal (47%) governments. The majority of attendees were active landslide specialists, but also included specialists from the fields of emergency preparedness, the insurance industry, and transportation safety. Invited keynote speakers from the USA, Italy, France, and Norway shared their own experiences, challenges, and successes in building their national landslide hazard programs and gave an important international perspective on approaches to landslide loss reduction. A number of keynote speakers representing Quebec and British Columbia presented the problems associated with landslide hazards in the two most landslide-prone regions of Canada -- the Cordillera and the St. Lawrence Lowlands, whereas a final keynote speaker discussed landslide hazards from the point of view of the insurance industry.

The workshop addressed three themes in breakout groups and plenary sessions: (1) landslide mechanisms and processes, (2) landslide mapping and hazard characterisation, and (3) landslide risk and mitigation. The results of the discussions, briefly summarised in this report, represent an important national consensus on the state-of-knowledge of landslide hazards in Canada and an agenda for future action in reducing landslide losses.

Sommaire exécutif

La Commission géologique du Canada a organisé du 16 au 18 novembre 2001 un atelier sur la gestion des risques de glissements de terrain au Canada. Cet atelier, qui s'est tenu à Hull (Québec), est une étape fondamentale dans la mise en place du Programme Canadien multisectoriel de Réduction des Pertes dues aux Glissements de terrain (http://sts.gsc.nrcan.gc.ca/landslides/workshop/home.asp).

Les principaux objectifs de l'atelier étaient :

- de s'appuyer sur les expériences étrangères en matière de gestion des risques de glissements de terrain pour orienter au mieux le futur programme canadien;
- d'inviter les participants à établir l'état des connaissances sur les glissements de terrain et sur les aléas qui y sont associés;
- d'identifier les lacunes dans notre compréhension des phénomènes et de l'analyse du risque de glissement de terrain, et finalement,
- d'établir les priorités qui détermineront les actions à prendre dans le cadre du futur programme canadien.

Cinquante personnes ont participé à l'atelier, avec la distribution sectorielle suivante: 47% provenaient du secteur public fédéral, 26% du secteur privé, 16% des universités, et 12% des secteurs publics provinciaux. L'atelier regroupait des spécialistes de différentes disciplines reliées à l'étude des glissements de terrain, mais aussi des spécialistes de la sécurité civile, de l'assurance, et de la sécurité des transports. Les présentations données par les conférenciers invités (USA, France, Italie, Norvège) ont replacé dans un contexte international les différentes approches pouvant être suivies pour réduire les risques de glissements de terrain. Ces conférences ont aussi permis de confronter utilement les expériences à la lumière des succès, mais aussi des échecs, rencontrés lors de l'élaboration, de la mise en place, et de l'opération, de tels programmes. Deux autres conférenciers représentant le Québec et la Colombie britannique ont présenté les problèmes associés aux glissements de terrain dans les deux principaux bassins de risque au Canada, la Cordillère à l'ouest, et les basses terres du Saint-Laurent à l'est. Un troisième conférencier a également exprimé le point de vue des assureurs face à la gestion des risques de glissements de terrain.

Dans le cadre de l'atelier, différents groupes de travail ont été formés pour discuter des trois thèmes suivants, les mécanismes et processus impliqués lors des glissements de terrain, l'évaluation et la cartographie de l'aléa, le risque et sa réduction. Les résultats de ces discussions, présentés en session plénière et résumés ci-après, expriment un consensus national sur l'état des connaissances des risques de glissements de terrain au Canada. Ils vont ainsi permettre d'établir un agenda en priorisant les différentes actions à prendre pour réduire les pertes dues aux glissements de terrain.

PART 1

REPORT ON THE WORKSHOP ON LANDSLIDE HAZARDS AND RISK MANAGEMENT IN CANADA

Prepared by / Préparé par

Dr. Réjean Couture
Mrs. Jan Aylsworth, Dr. Steve Evans, Dr. Didier Perret

Geological Survey of Canada / Commission géologique du Canada
Natural Resources Canada / Ressources Naturelles Canada

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1. INTRODUCTION

1.1 Introduction

In Canada, the response to landslide hazard is fragmented, reflecting the regional nature of the hazard, incomplete data, jurisdictional overlaps, diverse and competing stakeholders, and the multi-disciplinary nature of the issue. The Geological Survey of Canada (Natural Resources Canada) has taken the lead to undertake a National Landslide Hazard Assessment and to establish the inter-agency Canada Landslide Loss Reduction Program.

The Geological Survey of Canada (Natural Resources Canada) hosted an invitational workshop on Landslide Hazards and Risk Management in Canada at the Holiday Inn Hull-Ottawa Plaza la Chaudière in Hull, Québec from 16 to 18 November 2001.

The goals of the workshop were to: 1) summarize the state-of-knowledge of landslides and landslide risk in Canada; 2) provide a baseline of knowledge and information for the future establishment of an inter-agency Canada Landslide Loss Reduction Program; and 3) promote landslide studies in Canada to a level comparable of other developed countries in order to significantly reduce landslide risk.

1.2 Aim and Objectives

The aim and the objectives of the workshop were to:

- summarise the state-of-knowledge of landslides in Canada (understanding of landslide processes, knowledge of their spatial and temporal distribution, ability to characterise landslide hazard, and means to reduce landslide risk);
- assess the available information on landslides relative to the needs of the emergency preparedness (and other) communities in Canada;
- identify key gaps in our knowledge of landslides in Canada, both thematic and regional; and to prioritise research and technical objectives for landslides in Canada.
- build on the experience of other countries where similar programs have already been successfully implemented; and,
- engage Canadian stakeholders in defining the state of our knowledge of landslides and landslide hazards in Canada.

1.3 Themes

This workshop was an opportunity for engineers, academics, geoscientists, practitioners, planners, insurers, and other interested parties with landslide concerns to meet and share the best global information available with respect to the following themes:

- landslide processes and mechanisms,
- mapping and hazard characterization, and

- mitigation and risk management.

1.4 Participants

Over one hundred individuals from the Canadian landslide community were originally invited to this workshop. In response, fifty people from across Canada attended the workshop, representing industry (26%), academia (16%), provincial (12%), and federal (47%) governments (see list of participants in Appendix 1). The majority of attendees were active landslide specialists but also included specialists from the fields of emergency preparedness, the insurance industry, and transportation safety.

1.5 Keynote Speakers

Invited keynote speakers from the USA, Italy, France and Norway shared their collective experiences, challenges and successes in building their own national landslide hazard programs and thus provided an important international perspective and benchmark on approaches to landslide loss reduction for a Canadian perspective (Table 1).

Several keynote speakers representing Quebec and British Columbia presented the problems associated with landslide hazards in the two most landslide-prone regions of Canada -- the Cordillera and the St. Lawrence Lowlands, whereas a final keynote speaker discussed landslide hazards from the point of view of the insurance industry.

Table 1. Keynote speakers (affiliation and presentation title).

Dr. John S. Pallister	USGS-Landslide and Volcano Hazard program, Reston VA, USA	The US National Landslide Mitigation Strategy? A Framework for Loss Reduction
Dr. Fausto Guzzetti	CNR-IRPI, Perugia, Italy	Landslide Hazard and Risk Assessment: An Italian Perspective
Dr. Jean-Louis Durville	LCPC, Paris, France	La Gestion du Risque de Glissement de Terrain en France
Dr. Oddvar Langva	NGU, Oslo, Norway	Landslides and Risk Assessment Strategies in Norway
Dr. Oldrich Hungr	UBC, Vancouver, Canada	Nature Against Woman and Man – Landslide Hazards in the Canadian Cordillera
Dr. Denis Demers	MTQ, Quebec City, Canada	La Gestion des Risques de Glissements de Terrain au Québec
Mr. Paul Kovacks	IBC-ICLR, Toronto, Canada	Needs for Specific Initiatives to Enhance Public Confidence in Canada's Preparation for Future Natural Disasters

1.6 Format

The emphasis of the technical programme of the workshop focussed on discussions amongst the participants. Six discussion group periods, each one and a half hours in length, were scheduled to address various aspects of each theme. Discussions within each breakout group were facilitated by a chairman and compiled and reported by a rapporteur. At the end of each day, a plenary session provided a forum to present the results of the day's discussions in each breakout group and also provided the opportunity to discuss potential recommendations.

The following pages summarize the results of these discussions, raise the principal issues and identify the main gaps and priorities in landslide hazard and risk management in Canada. The results of the discussions, as summarised below, represent an important national consensus on the state-of-knowledge of landslide hazards in Canada and provide an agenda for future action in reducing landslide losses.

2. LANDSLIDE PROCESSES AND MECHANISMS

2.1 State of knowledge and gaps

By their occurrence and consequences, some landslide types are better studied than others in Canada, therefore our level of knowledge varies considerably amongst the various types. For instance, some landslide types such as debris flows in mountainous terrain and earth flows in sensitive clays, are far better understood than spreading or collapse failures. In general, the failure mechanism of landslides is much better understood than the post-failure behaviour. Prediction of run-out distances and time of failure are the key elements in terms hazards and risk. Following are the principal gaps identified for several types of landslides.

2.1.1 Debris flows

It is clear that the climatological and meteorological threshold conditions initiating a debris flow are poorly understood. Knowledge gaps exist in the prediction of run-out distance of debris flow and timing of occurrence, as well as information regarding the development of pore water pressures prior to and during movement. The frequency of debris flow events in the Cordillera outweigh all other mass movements combined and thus warrant the development of regional spatial prediction models.

2.1.2 Topples and rockfalls

Such types of failure are relatively well understood and well studied, but there is an obvious need to update and improve the models currently in use. At present, the "rockfall shadow angle" has been developed for preliminary hazard assessments in Canada (Evans & Hungr 1993)[1]. Alternative models for topple and rockfall failures are needed.

2.1.3 Landslides in permafrost

Very little is known about failures under permafrost conditions, especially detachment slides in the active layer. Given the geographic dominance of permafrost in Canada, improvement to this information gap is critical. The obvious influence of climate change and forest fire as landslide triggering events become key factors of investigation in northern environments.

2.1.4 Retrogressive landslides

Researchers have fairly good understanding regarding landslide mechanics in sensitive soils, but our understanding of the transformation of mass movements into retrogressive debris or earth flows is poor. Our capability of prediction of maximum retrogression distance in quick clays is much better than that for bedrock. Very little knowledge exists about the motion (volume, velocity, distance) and climatic variables that trigger such earth flows.

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[1] : Evans S.G. and Hungr O. (1993). The assessment of rockfall hazard at the base of talus slopes. Canadian Geotechnical Journal, vol. 30, No. 4: 620-636.

2.1.5 Rockslides and rapid gravitational movements (e.g. rock avalanches)
Seismic triggering and its analysis, rock mass characterization and also post-movement mechanics are some of the poorly understood aspects. This is due to our weak knowledge regarding the interior of these rock masses, given difficulties involved in drilling such failures. Other gaps included our understanding the interaction between strength, shear stress and rapidly moving materials.

2.1.6 Collapse and lateral spreading
Distribution and frequency of such failures has provided less opportunity to properly study these types of landslides in Canada and as a result very little is known about them. The triggering conditions, mechanics and behaviour favoring collapse and lateral spreading is an important avenue for further evaluation.

2.2 Other important issues

2.2.1 Climate data
It is quite obvious that the information derivable from the Canadian climate network is insufficient. This dearth in relevant and usable data is most apparent within mountainous terrain where our availability of precipitation records is either lacking or poor.

2.2.2 Improvements of current tools
Existing geological maps fail to provide details regarding material and hydrogeological parameters and properties of the bedrock. Such information is necessary to properly conduct landslide investigations. Moreover, digital elevation models currently available from base maps lack the resolution required for reliable landslide analysis.

2.2.3 Landslide monitoring
Many problems related to the inadequacy of models are due to the insufficient nature of the data derived from landslide monitoring. There is a need to have information from 'real-time' monitoring of slopes comparable to that available from the existing Canadian earthquake seismic monitoring network. Such short term and long term information will add to the robustness of landslide prediction capabilities. New technologies, such as radar interferometry, must be evaluated as likely tools to help identify slope movement and rate.

2.3 Priorities and How can we better our understanding?

2.3.1 Short-term priorities

- Increase the understanding of landslides in permafrost environments, especially with regard to energy/communication corridors.
- Improve our knowledge of the frequency/distribution of debris flows in mountainous environments.
- Focus on the retrogression prediction of earth flows.

- Better understand the flow mechanisms, flow paths, and run-out distance for rockflows, rockfall avalanches and debris flows.
- Study the impacts of erosion of shorelines and rivers (e.g. Red River Basin) and seismic loading of soil/rock slopes.
- Better communication and coordination between technical communities and with the public.
- Review successful international practices, and adopt/develop nationally the best practices guidelines, comparable to the Canadian Engineering Foundation Manual.

2.3.2 Long-term priorities

- Undertake regional studies of landslides that will lead to a better understanding of links to regional geology and landslide processes.
- Better understand the impacts of climate change and the role of El Niño on landslide occurrence.
- To develop physical modelling for a better understanding of transport mechanisms of flows and un-drained collapse of soils.
- To develop and verify numerical modelling.
- To establish a "Canadian Network of Geo-Hazards". This network could be a "Canadian Landslide Society" or a "Landslide Division" within the Canadian Geotechnical Society or developed by other agencies/organizations.

2.4 Partnerships and role of stakeholders

To achieve the workshop goals, better partnerships within and outside the landslide community, were clearly identified as a crucial element of solution. For instance, developing partnerships with climatologists is necessary in global climate change and landslides. The principal role of each sector was also pointed out:

- Industry: This is the group that often identifies the problems, and in the future must better communicate such problems to other groups. Industry plays an important role in funding and monitoring the research.
- Academia: They have a primary role in fundamental research that is gradually including applied components. Academia also has an important role in securing funding for landslide work.
- Provincial: The role of provincial agencies and departments is seen as the backbone to regional landslide research funding, landslide monitoring and communication to the public.
- Federal: The Federal government must be involved in funding research, not necessarily in mechanism and process studies, but rather standards and technology development. The Federal government must assume and maintain a coordination role in the country, with regards to standards for mapping, data collection, information systems, monitoring and communication to the public, scientists and decision makers.

Finally, the various sectors should collaborate in some fundamentals way in order to proceed with the resolution of the perceived research gaps. The various sectors must move quickly to address the successful achievement of both short and long-term priorities.

3. LANDSLIDE MAPPING AND HAZARD CHARACTERISATION

3.1 Landslide mapping: state-of-knowledge and gaps

Four important issues developed from the discussion on landslide mapping, including: 1) types of mapping, 2) scale at which mapping should be performed, 3) contribution of existing maps, and 4) validity and reliability of information on landslide maps.

3.1.1 Types of mapping

Three types of landslide mapping were recognized during discussion:

- Inventory maps, which are basic maps regarding distribution and type of landslides are the starting point of any subsequent types of mapping,
- Hazards maps, which describe the existing landslide hazard conditions and also imply a certain level of prediction, and
- Risk maps, which include the elements that are at risk as well as assign vulnerability and calculate risk.

The last type of map is considered optional but very useful. It is also important to appreciate the logical process of deriving a risk map, which must include inventory maps and hazard maps as preceding steps. Two basic frameworks to landslide hazard mapping were identified:

- Susceptibility mapping, where experts map the source areas and assess potential hazards to structures or activities that will occur given their direct association to the landslide, and
- Maps of impact, which require an intermediate step where experts identify the sources, analyse the run-out limits and assess the impact in the run-out zone.

3.1.2 Scale of mapping

Participants recognised that the scale at which the hazard would be characterized depends on the risk involved or on the value and the distribution of the elements at risk. Selection of the appropriate scale and the intensity of mapping were cited as paramount factors since they raise the issue of liability. For instance, with the manipulative capabilities of GIS, data become invalid at detailed scales when originally collected at less detailed scales. Also, it was noted that landslide mapping activity must consider different time scales, *i.e.* establishing a portrait of the existing conditions at different periods of time.

3.1.3 Role of surficial and bedrock maps

There is no doubt that surficial and bedrock maps are of fundamental relevance to landslide mapping. However, most existing maps are not necessarily sufficient. Such maps would prove more beneficial if they were enhanced with additional information on key landslide parameters, including plasticity of clays for surficial maps, or structure of rock for bedrock maps. Future maps must have a database aspect combined with a GIS multi-layer concept that should provide the additional information, for instance, drainage and processes, as well as detailed DTM. A final suggestion proposed a better integration of bedrock and surficial mapping with hazards mapping.

3.1.4 Validity and liability

Landslide mapping is a difficult process in terms of generating the information, but also in terms of the quality checking. Landslide mapping must be based on a reliable inventory process understood by all partners and information clients. Participants proposed that this inventory process must rely upon aerial photographs and/or historical data as fundamental and primarily information. All such maps must include caveats and disclaimers specifying the limitations of the data and interpretations.

3.2 Is a Landslide database needed?

A clear consensus was reached regarding the usefulness of landslide databases. Four points of discussion evolved.

3.2.1 Purpose

It is important to define the purpose of the landslide database, that is, whether it is to be used for research, outreach, an information catalogue or some other use? It is obvious that this purpose should be defined first since each end use dictates subsequent requirements. As a minimum the database should be primarily informative, and may not be useful for advanced geotechnical evaluations. Nonetheless, depending on the quantity and quality of data compiled, databases could be integrated into specific studies (*e.g.* magnitude-frequency). Without question, landslide databases are essential to further work and they also provide the benefit of raising awareness about landslides.

3.3.2 Reliability, availability, and continuity

There are concerns about "Who is going to enter information?", "Who is going to check the input?", and "Who is going to validate the data?". One of the major issues identified is the community and ability to maintain the database in the long term. Another issue is the variability of data quality and the problems associated with compiling data from different types of organizations especially give the constraints on release of data (*e.g.* permission from clients). Any landslide databases must provide information on sources, thereby providing the option for users to refer back and check on the reliability of the data.

3.2.3 What should be included in the database?

The landslide database should not capture data that are available elsewhere, for example, climate data. Following are the items that a database should contain:

- landslide type,
- magnitude,
- date and time of occurrence,
- location,
- damage and losses,
- trigger processes,
- mode of failure,
- material involved and its properties,
- illustrative material (*e.g.* photographs), and

- reference information or a contact for additional information.

3.2.4 Communication
The clear and effective dissemination of information provides the measure of success for collecting relevant landslide data. It is well known that a variety of landslide databases exist in Canada housed with individuals, institutes and organizations, but their location and access is restricted or poorly known. Efforts should be made to successfully emulate communication strategies practiced internationally (*e.g.* USA, Italy, Japan).

3.3 Standards and/or guidelines?

The need for standards or guidelines for landslide mapping and slope stability analysis was discussed at length. Results of the discussion are summarized below.

3.3.1 Landslide mapping
In general, there is no standardized procedure on how landslide mapping and hazard assessments should be undertaken. However, there are some regulations in certain province like Quebec, B.C., Alberta and Ontario. Quebec does have a provincial law on landslide risk management, whereas in British Columbia, municipal acts require landslide hazard assessments be performed for urban development. Moreover, in B.C. the Ministry of Forests (Forest Practices Code) and the Ministry of Transportation and Highways have their own guidelines in terms of landslide assessment. In Ontario, municipal plans do require evaluation and building permit requirements regarding landslide hazards. Across Canada, activities regulated by the National Energy Board and provincial oil and gas agencies have to be satisfied from a hazard and landslide assessment point of view. For instance, in Alberta, there is minor legislation at the municipal level, where the municipality identifies a safety line beyond which a developer/owner is responsible to seek a geotechnical evaluation.

3.3.2 Slope stability analysis
It was clearly expressed that a standardized methodology for slope stability analysis should not be implemented. The problem of liability was raised as the main issue regarding such standardization. For instance, lawsuits may result if analyses do not satisfy the requirements of the event, even though the analyses are technically adequate. Moreover, there is a real danger of having prescriptive protocol used by unqualified persons. Nonetheless, it was recognized that recommended protocols would prove useful for specific types of slides (sensitive clays or debris flows). Participants recognised that individuals/agencies must have the expertise to evaluate hazard assessments and determine suitability.

3.4 Education and communication

The need for a formalized public education program on landslides was clearly addressed. The program should build and consolidate on existing initiatives and networks (*e.g.* Non-

Governmental Organisations, Canadian Geoscience Council) and reach all the levels (federal, provincial, municipal, school board) of government. The primary objective of the education program is to develop the awareness of landslides. The key element is educating the public and decision-makers, hence reliance on the internet is imperative. Other proposals included the use of education as a tool to promote involvement of registered professionals working on landslides and promote better compensation of landslide professionals, especially given the high degree of responsibility they carry in providing conclusions to clients.

3.5 Priorities and how can we better our current approaches?

- It was clearly recognized that the adequacy, accessibility, reliability and validation of data/databases available through existing and future landslide maps are paramount issues. Such issues must be addressed in the development of technical tools.
- The long-term usefulness of a landslide database and other resources to ensure their continuity, accessibility, utility and relevance is essential and requires a commitment from the Federal government.
- A landslide inventory process cannot be automated and slope stability mapping requires people with excellent qualifications, experience and skill sets.
- The need for a best practice type of procedures was expressed, however such procedures must be recognized as general guidelines rather than standards.
- Finally, the creation of landslide inventories in Canada should proceed based on the lessons learned from other countries further advanced in this field (e.g. Norway, Italy, USA, Japan).

4. LANDSLIDE RISK AND MITIGATION

4.1 Landslide risk assessment

4.1.1 Definition and situation in Canada
The participants defined the notion of risk as:

Risk = Probability of hazard x Consequences of event

It was concluded that Canadians are just starting Landslide Risk Assessment (LRA), the perception is we are behind other G8 countries. At the provincial level, some agencies are doing better than others:

- B.C. Hydro is probably the leader in quantitative LRA in Canada. The forest industry in B.C. is also very active.
- Hydro-Québec started quantitative landslide risk assessments about two years ago.
- In 2002, the Ministry of Transportation in Québec is planning to implement more landslide risk assessments. The Department of Highways in Alberta is also active.
- Railway and pipeline companies are leading the industry representatives.
- Often, LRA are only applied for large multi-million dollar projects (e.g. offshore drilling), but they should be applied to smaller projects in the future.

4.1.2 Quantitative Risk Analysis (QRA) and alternatives tools
The greatest limitation of QRA is the determination of "probability", *i.e.* assigning numerical probability values to non-recurring events like landslides. QRA are not necessarily more accurate than the other types of assessments, but because they are numerical, they prove more useful for communication purposes. It was recognized that standard methods for QRA are desirable, but that the methodologies and criteria used for the QRA must be well documented.

The following existing tools and alternative means can be used to improve landslide risk assessments:

- Geology maps, Quaternary dating, and aerial photographs are very useful tools.
- It is suggested that Canadian Standards Association's standards (*e.g.* CAN/CSA #Q850-97) can be useful for terminology.
- Concept of landslide magnitude/frequency should be scrutinized.
- Landslide databases and inventories will assist in the determination of the probability or likelihood of landslide occurrence on a regional basis.
- Detailed and complete records of losses and damages allow better assessments of consequences.
- Computer programs and numerical modeling cases where reliable event records exist are lacking (*e.g.* modelling of run-out distance).
- Using expanding tools of GIS and hazard maps.

4.1.3 How can we improve landslide risk assessments?

Participants suggested that Landslide Risk Assessments be integrated to a national standard framework, which would include terms of reference to guide work to produce risk maps and hazard maps. The establishment of guidelines to achieve greater consistency in hazard assessments and the development of an effective, consistent landslide nomenclature were cited as means of improving LRA. The publication of proposed LRA methods and the development of a detailed legal framework for risk assessment for Canada is also needed.

Some specific minimal requirements for Landslide Risk Assessments are also identified:

- The first and foremost requirement to carry out a good risk assessment is experience, backed with basic skills. It still requires very expert judgment to derive a reliable probability estimate.
- High quality field data, as well as a basic understanding of the processes that are responsible for the observed data.
- Landslide Risk Assessment must be a team effort because of the diversity of variables involved.
- LRA is based on probability of failure and therefore history of previous landslides as documented in an inventory or database, but also identifying all the elements at risk and their respective vulnerabilities. So, connection between the hazard and the consequence is essential to good risk assessment.
- Finally, it is important that the liability for carrying out landslide risk assessments should be borne by those who benefit from the development, and not by those who do the landslide risk assessments as is currently expected.

4.2 The notion of "acceptable risk"

A lot of discussion was generated about the idea of having "a harmonized acceptable risk in Canada", but no consensus was reached. Some stated that it would be premature considering the level of understanding and expertise we have regarding landslides at this point. Also, considering that the variability of geological materials and that the processes behind LRA are so variable across the country, a harmonized acceptable risk is neither feasible nor desirable.

On the other hand, some argued there is a need for some harmonization of standards. However, deciding what is an acceptable level of risk nation-wide is not a decision for engineers and scientists, but rather a socio-political matter.

4.3 Impacts of climate change on landslide risk

Despite the underlined uncertainty about the direct impacts of climate change on landslide occurrence in Canada, it is well known that climate change will lead to temperature and precipitation changes. The greatest impacts of warming will be felt in

areas with permafrost. Effects of climate change on warm permafrost are ongoing. Glacier retreat is also a good indicator of ongoing climate warming in Canada.

Precipitation effects are more problematical since it is not certain that a wetter climate will necessarily result in more landslides, although this is highly likely. As a result of climate change, there is a higher probability of extreme events that will increase risks. The workshop participants recognize that the confidence in predicting future precipitation changes will be reduced because of the climate change, therefore the level of uncertainty will increase, as will the associated risk. Thus, it was suggested that a good temporal landslide inventory and database is essential to properly document the effects of climate change.

4.4 Role of stakeholders

Six major sectors or groups of stakeholders were identified and their principal roles regarding landslide risk and mitigation are listed below.

4.4.1 Owners

Owners include, for instance, railway companies, individual property owners, and so on. Owners are recognized as the group that must assume much of the liability, and should:

- Take some of the responsibility for the landslide database and inventory, as well structural mitigation.
- Consider involvement in non-structural monitoring warning systems.
- Keep funding and implementing some of the landslide risk assessments.
- Develop Emergency Preparedness Plans (EPPs).

4.4.2 Consultants

Identified as the sector that carries out most landslide risk assessments and designs most of the structural mitigation. As a result, consultants should therefore:

- Provide relevant feedback to all the other groups.
- Become more involved in university-liaison research and thus have access to grants for specific landslide research projects.

4.4.3 Academia

This group is involved primarily in fundamental and some applied research, both in engineering and geoscience, in addition to graduate and undergraduate education. Academics are therefore able to:

- Objectively criticize what is happening in the industry and government.
- Conduct fundamental research that advances science.
- Become involved with structural engineers, who, although dealing with different materials, are very experienced in risk assessment.

4.4.4 Provincial Agencies

Provincial agencies already play important roles, which should be reinforced.

- Responsible for non-structural mitigation, such as bylaws, regulations and guidelines, Emergency Preparedness Plans (EPPs), and enforcement aspects of public safety.
- Responsible to establish standards covering earthquake engineering design, floodplain mapping, landslide hazard zoning, and regional probability mapping.
- Should continue to fund various mitigation works, such as floodplain dyking, debris flow containment structures, snow-avalanche deflection berms.
- Responsible to provide fundamental data. May also be custodian of databases.
- Required to provide funding for research and provide technical support.
- Expected to co-ordinate activities with the federal government to avoid duplication of effort.
- Responsible for the safety and maintenance of their own infrastructure.

4.4.5 Federal

The Federal government has an important coordination role, lead role in both fundamental and applied research, as well as a funding group.

- To provide guidelines, standards and establish legislation and enforcement to protect the public.
- To provide funding for research and provide technical support.
- Responsible for provision of fundamental data. Should be custodian of nationally relevant databases.
- The Geological Survey of Canada is identified as the agency that must play the coordination role in landslide hazard identification and mapping.
- Responsible for the safety and maintenance of their own infrastructure.
- Responsible for national Emergency Preparedness Plans (EPPs).
- Should be involved in the mapping of hazards, and in some cases, the funding of structural mitigation works.
- Responsible for more national and regional studies and to provide a co-ordinating role with provincial authorities carrying out more regional scale studies.
- The Canadian Standards Association has a very important role to play with regard to terminology.

4.4.6. Others

- Regional Districts or local governments: To co-ordinate hazard studies in specific problem areas, with some authority for code enforcement.
- Canadian Geoscience Council: To raise landslide issues as research priorities in the earth sciences.
- Canadian Geotechnical Society: To disseminate results of landslide hazard studies and to organise geotechnical conferences.
- Insurers: To help the landslide community in evaluating risks and assist in the enforcement of proper risk control measures.
- Citizens: To be more involved in hazard awareness (*e.g.* home-owners associations).

5. CONCLUSION

Listed here are the general conclusions of the workshop and the identified main actions that should be undertaken by all parties interested by landslides in Canada.

- **Education**: A greater need was expressed for public and government education by increasing their awareness of landslide hazard, probability, and risk.
- **Mitigation**: A need was expressed to establish non-structural mitigation strategies (e.g. the new Quebec legislation).
- **Knowledge**: A greater need was expressed for the collection of relevant data, monitoring of existing landslides and unstable slopes and the assessment of changes, thereby providing a greater ability to warn and a more diligent ability to assess landslide hazards properly.
- **Research**: A greater need was expressed to increase research, teaching and promoting better engineering, and thus increasing our ability to reduce risk and vulnerability and improve building resilience. At the same time, we are cautioned not to reinvent the wheel.
- **Communication**: A greater need was expressed to communicate results, share experience and expertise (nationally and internationally) through the web, publications, workshops, short courses and conferences.
- **Collaboration**: A greater need was expressed for closer collaboration within the landslide community, but also with relevant individuals and groups outside the community. We can learn considerably from other nations and cultures.

PART 2

STRATEGIES FOR LANDSLIDE HAZARD REDUCTION AND RISK MANAGEMENT IN CANADA

Prepared by / Préparé par

The members of the Advisory Committee
Les membres du Comité Aviseur

Mr. Timothy Keegan
(Canadian Pacific Railway / Canadien Pacific)

Dr. Peter Bobrowsky
(British Columbia Geological Survey)

Mr. Doug Vandine
(VanDine Geological Engineering Ltd.)

Dr. David M. Cruden
(University of Alberta)

Mrs. Janice Aylsworth
(Geological Survey of Canada / Commission géologique du Canada)

Dr. Réjean Couture
(Geological Survey of Canada / Commission géologique du Canada)

Dr. Stephen G. Evans
(Geological Survey of Canada / Commission géologique du Canada)

Dr. Didier H. Perret
(Geological Survey of Canada / Commission géologique du Canada)

compiled by / et compilé par

Dr. Réjean Couture
Geological Survey of Canada / Commission géologique du Canada
Natural Reosurces Canada / Ressources naturelles Canada

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1. INTRODUCTION

The organising committee of the *Workshop on Landslide Hazards and Risk Management in Canada* have asked representatives from different sectors (e.g. academia, industry, provincial and federal agencies) who attended the workshop to contribute to the final report of the workshop by being a member of an Advisory Committee. This committee consists of by these representatives together with the four members of the organizing committee. The members of the Advisory Committee are Dr. D.M. Cruden (University of Alberta), T. Keegan (Canadian National Railway), P. Bobrowsky (Geological Survey of Canada), D.VanDine (Vandine Geological Engineering Inc.), Mrs J. Aylsworth, Dr. S.G. Evans, Dr. D. Perret, and Dr. R. Couture from Natural Resources Canada.

The role of the Advisory Committee is to prepare Part II of the final report of the workshop. Part II is a crucial document that consists of a broad perspective on landslide issues in Canadian society and, as we discussed at the workshop, it hopefully provides guidance for future activities in the field, including follow-up activities to our workshop.

The tasks of the Advisory Committee are fivefold;

1. To identify the five main actions that should be prioritised in respective sectors;
2. To propose the means how those five actions should be carried out;
3. To identify the main deficiencies in Canada's capacity to mitigate landslides;
4. To summarise from their own perspective what the most important outcomes of the workshop should be and recommendations for future action (i.e. where do we go from here?); and
5. Any remaining important issues.

Responses to these questions provided by the members of the Advisory Committee are compiled hereafter.

2. MAIN ACTIONS TO PRIORITISE AND MEANS TO BE IMPLEMENTED

Six main actions have been identified by the advisory committee as priorities to be implemented: 1) Canadian coordination initiative; 2) Guidelines; 3) Research on landslide and Canadian inventory; 4) Landslide risk scenario; 5) Training; and 6) Communication and partnership.

2.1 Canadian coordination initiative

2.1.1 Action

The needs to establish a balanced cross-discipline and cross-sector coordination for landslide hazard and risk management in Canada have been recognized. It has been suggested that a federal coordination body be instituted to oversee the coordination of all aspects of landslides in Canada. This coordination body, as well as the Canadian landslide community, should work through existing technical societies, professional learned societies, and committees to synthesize and exchange the considerable new knowledge it is generating.

2.1.2 Means

The formation of a national standard framework would be an initiative for achieving this proposed action. Geological Survey of Canada has been identified to chair a cross-sector strategic steering committee for landslide hazard and risk management in Canada. This committee would be governed by the content of its mission statement, which should expressed a clear vision and goals, and would have authority, among other things, to allocate research funding, guide the development of a landslide risk library, provide terms of reference to guide work to produce risk and hazard maps, provide consistent nomenclature and definitions, provide detailed legal framework for risk assessment, and schedule workshops.

This national framework or steering committee must closely collaborate with technical committees existing in Canada, such as the Canadian Geotechnical Society's Technical Committee on Landslides, and those abroad, such as the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), the International Association for Engineering Geology and Environment (IAEG), and new organizations through the International Consortium on Landslides (ICL) and UNESCO-IUGS (International Geological Correlation Program-IGCP).

2.2 Guidelines

2.2.2 Action

Following the first action identified above, and more specifically here, guidelines on landslide should be developed. Guidelines include adoption of a suitable standard nomenclature or terminology, mapping and investigation methodologies, and input into defining landslide risk assessments.

2.2.2 Means

A major effort has been done at the international level through the International Decade for Natural Disaster Reduction (IDNDR, 1990-2000) and the International Union of Geological Sciences (IUGS) to establish standard terminologies. The Canadian landslide community has made significant contributions to this effort through publications (WP/WLI, 1993, Turner and Schuster, 1996, Dikau et al., 1996).

Guidelines for decision makers in terms of managing all types of risk issues (including injury or damage to health, property, the environment) already exist in Canada through the CAN/CSA-Q850-97 standard. Therefore, it is suggested to adopt this risk management standard and apply it for the landslide risk in Canada. Since the Technical Committee on Risk Management that oversees the development of the standard has not had representation from the geo-science field, the landslide steering committee, as proposed above, should sit on this Technical Committee on Risk Management and provide input for the next version of Q850-97 standard.

The leadership from the Geological Survey of Canada would be valuable in promoting the wider use of these standards.

2.3 Research on landslides and Canadian inventory

2.3.1 Action

More research initiatives are the key element in the success of Canada's capability to reduce landslide risk. Research should focus on:

- processes and mechanisms, driven by lack of knowledge in different areas for different types of landslides;
- new technology for the study of landslides;
- influence of climate, regional and global change;
- regional landslide mapping and studies;
- landslide monitoring;
- mitigation action.

The need to develop and sustain a central library on landslide risk has been recognized. This central library would exist through relational databases (current and future) and be supported by Geographical Information Systems (GIS) and web technologies. For instance, landslide hazard mapping in a GIS format would be extremely useful for the sharing of hazard information between stakeholders.

2.3.2 Means

Better partnerships need to be encouraged within the landslide community in the investigation of landslides. Union of the complementary interests of different partners and the compensation of deficiencies (e.g. private sector organizations may not have the time for long-term or regional investigations, whereas universities typically do not have

the funds) through mutual exchange would be a possible avenue for success in research. For instance, a number of cost-sharing mechanisms are available under Natural Sciences and Engineering Research Council (NSERC)'s auspices.

Also, liaison would be required with Environment Canada, provincial agencies and the GSC earthquake notification systems in the integration of data for optimized production of landslide hazard maps.

The information in a national inventory or library and the collection and synthesis of descriptions of landslides would need to be strictly standardized and should be managed by a custodian such as the Geological Survey of Canada. However, this initiative should be undertaken with the collaboration of existing technical committees in Canada and moved forward sooner rather than later in a timely fashion.

2.4 Landslide risk scenario

2.4.1 Action

It is suggested to adopt a broader approach that addresses the entire risk scenario, including the hazard, the peril and the loss. Moreover, emphasis should be on the prediction of future landslides both temporally and spatially.

2.4.2 Means

The primary factors that make up the risk scenarios that would result in losses would include:

- The temporal and spatial characteristics of climatic events and trends;
- The temporal and spatial anthropogenic activities and, some cases, animal activities;
- The terrain (topography, geology, geomorphology, river morphology)
- The ground hazard (the condition and circumstance of the ground that raises the likelihood or severity of loss)

The integration of all these factors should be considered to properly achieve the reduction of landslide loss in Canada. This would require cross discipline collaboration between geoscientists, geotechnical engineers, river hydrologists, meteorologists and others. As well, this would require the participation of various Federal and Provincial departments such as Environment Canada, Natural Resources Canada and others.

One of the key elements of the solution is to be more proactive with ongoing slope movements:

> *"Surgery for sick slopes needs to develop in the same way as the medical profession. Careful documentation of outcomes, publicly available, and much practice on cadavers. At present, we are unable to document the benefits of early interventions of most kinds" (D.M. Cruden).*

2.5 Training

2.5.1 Action
Training on all aspects of landslide at university level should be implemented. This would provide young landslide professionals with better skills for assessing landslide hazards and risks. Ongoing training, perhaps through Continued Professional Development (CPD) for the established professional is also recommended.

2.5.2 Means
The establishment of scholarships, sponsored by government and industry, would increase Canada's capability to respond to landslide hazard and risk management needs.

2.6 Communication and partnerships

2.6.1 Action
Communication with public, as well as all stakeholders and parties interested in landslides (e.g. insurance companies) needs to be developed and become more efficient.

Partnerships between stakeholders must be facilitated and encouraged with the objective to enhance our capability in solving problem related to landslides.

2.6.2 Means
Almost all stakeholders in landslide hazard risk areas lack the necessary resources to develop effective risk management programs and would benefit tremendously from partnerships. Therefore, standardized hazard and risk maps, GIS databases and future workshops would facilitate the formation of some key partnerships.

3. MAIN DEFICIENCIES IN CANADA'S CAPACITY TO MITIGATE LANDSLIDE

A series of deficiencies in Canada's capacity to mitigate landslide have been identified by members of the Advisory Committee. These deficiencies include:

- Lack of coherent leadership amongst the various sectors or stakeholders;
- The multi-disciplinary nature of the issue;
- The diverse regional nature of the hazards;
- Incomplete records;
- Liability concerns;
- Incomplete understanding of interrelationship between climatic conditions and landslide events;
- Too much emphasis on the landslide event by itself. The landslide is usually the last link in a chain of events that makes up the risk scenario that leads to loss. It is

of limited value to focus on one link if the intent is to reduce the adverse effects from the end event;

- Too much emphasis on landslides that have occurred in the past. The emphasis should be on predicting and thereby preventing or reducing severity of the future events. The concept that what happened in the past will happen in the future does not really apply to most landslide events;
- Competition between consultants.

4. MOST IMPORTANT OUTCOMES OF THE WORKSHOP AND RECOMMENDATIONS FOR FUTURE ACTIONS

The most important outcomes from the workshop or recommendations for future actions are:

- should be a clear understanding of the state of practice for landslide hazard and risk management in Canada and the development of a mission statement that provides this initiative with a clear vision and road map to guide and sustain the process;
- Build on the sense of a community brought together to solve a chronic problem. The last 10 years have clearly demonstrated that competitive enterprise models do not describe how organizations can work together most effectively for the public good. The benefits of proactive risk management are not all captured on balance sheets.
- The workshop has clearly demonstrated that the Canadian landslide community wishes and needs to get together much more often. Similar national and regional workshops should be organized on a regular basis. This has been seen as an excellent way of communication amongst key stakeholders.

Appendix 1

List of participants

Name / Nom	Organization / Affiliation	Address / *Adresse*	Email / *Courriel*
Aston, T.	Canadian Geoscience Council	7, Birch Lane, Chelsea (QC) J9B 1C8	allaric@cyberus.ca
Aylsworth, J.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	Jan.aylsworth@nrcan.gc.ca
Barlow, P.	AMEC Earth & Environmental Ltd	4810 - 93 Street Edmonton, AB T6E 5M4	pete.barlow@amec.com
Blais-Stevens, A.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	ablais@nrcan.gc.ca
Bobrowsky, P.T.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	Peter.bobrowsky@nrcan.gc.ca
Boon, J.,	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	jboon@nrcan.gc.ca
Bovis, M.J.	University of British Columbia	Dept. of Geography, 1984 West Mall, Vancouver, BC, V6T 1Z2	Mbovis@geog.ubc.ca
Brooks, G.R.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	Greg.brooks@nrcan.gc.ca
Carpentier, M.	Natural Resources Canada	Policy Dept., GSC, 601 Booth St. Ottawa (ON) K1A 0E8	monique.carpentier@nrcan.gc.ca
Cavers, D.	AMEC Earth & Environmental Ltd	2227 Douglas Road, Burnaby (BC) V5C 5A9	dcavers@amec.com
Chiasson, P.	Université de Moncton	Dept. de génie civil, Moncton (NB) E1A 3E9	chssp@umoncton.ca
Chung, Chang-Jo	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	chang-jo.chung@nrcan.gc.ca
Couture, R.	Ressources naturelles Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	Rcouture@nrcan.gc.ca
Cruden, D.M.	University of Alberta	Dept. Civil & Environmental Engineering, 220 Civil Electrical Building, Edmonton (AB) T6G 2G7	dmcruden@civil.ualberta.ca
Demers, D.	Ministère des Transports du Québec	930, Chemin Ste-Foy, 5ième Etage Québec (QC) G1S 4X9	Ddemers@mtq.gouv.qc.ca
Durville, J.-L.	Laboratoire Central des Ponts et Chaussées	58, Boulevard Lefebvre - F 75732 Paris Cedex 15	durville@lcpc.fr
Dyke, L.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	ldyke@nrcan.gc.ca
Egginton, P.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	paul.egginton@nrcan.gc.ca
Evans, S.G.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	Evans@nrcan.gc.ca
Falkiner, L.	Insurance Bureau of Canada	151 Yonge Street, Suite 1800, Toronto, Ontario M5C 2W7	lfalkiner@iclr.org
Geertsema, M.	British Columbia Ministry of Forests	1011-4th Avenue Prince George (BC) V2L 3H9	marten.geertsema@gems3.gov.bc.ca
Gerath, B.	Thurber Group	Suite 200, 1445 West Georgia St. Vancouver (BC) V6G 2T3	Bgerath@van.thurbergroup.com
Grondin, J.	Transport Canada	Safety & Security, 330 Sparks St. 10th floor, Place de Ville Tower C, Ottawa (ON) K1A 0N5	Grondij@tc.gc.ca
Guzzetti, F.	CNR-IRPI	Via Madonna Alta, 126, 06128 Perugia, Italy	F.Guzzetti@irpi.pg.cnr.it
Hungr, O.	University of British Columbia	Dept. Earth & Ocean Sciences, 6339 Stores Road, Vancouver (BC) V6T 1Z4	Ohungr@eos.ubc.ca
Jakob, M.	Kerr Wood Leidal Associates Ltd	139 West 16th Street North Vancouver (BC) V7M 1T3	mjakob@kwl.bc.ca
Keegan, T.	Canadian National Railway	10004, 104e Avenue, 16th Floor Edmonton (Alberta) T5J 0K2	keegan@cn.ca
Kovacs, P.	Insurance Bureau of Canada	151 Yonge Street, Suite 1800, Toronto, Ontario M5C 2W7	pkovacs@ibc.ca
Langva, O.	Norwegian Geological Survey	Norway, c/o: Atlantic Geoscience Center, 1 Challenger Drive (P.O. Box 1006) Dartmouth B2Y 4A2	longva@agc.bio.ns.ca
Law, T.K.	Carleton University	1125 Colonel By Drive, Mackenzie Building, Ottawa ON K1S 5B6	tim_law@carleton.ca
Lawrence, T.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	ted.lawrence@nrcan.gc.ca
Lemmen, D.	Natural Resources Canada	Geological Survey of Canada, 601 Booth St. Ottawa (ON) K1A 0E8	don.lemmen@nrcan.gc.ca
Lewkowicz, A.	Université d'Ottawa	Dept. of Geography, 60 rue Université, CP450 Succ. A Ottawa (ON) K1N 6S5	alewkowi@uottawa.ca
Lister, D.	B.C. Ministry of Transportation and Highways	Terrain Evaluation Advising Engineer 940 Blanshard St. Victoria V8W 3E6	don.lister@gems3.gov.bc.ca
Mackay, C.H.	Canadian Pacific Railway	Suite 600, Gulf Canada Square , 401 9th Avenue SW, Calgary (AB) T2P 4Z4	Clive_mackay@cpr.ca
Moore, D.	BC Hydro	6911 Southpoint Drive Podium A02 Burnaby (BC) V3N 4X8	Dennis.moore@bchydro.bc.ca
Pallister, J.S.	USGS-Landslide and Volcano hazards Program	12201 Sunrise Valley Drive, M.S. 908, Reston VA 20192	jpallist@usgs.gov
Perret, D.	Natural Resources Canada	Commission géologique du Canada, 880 chemin, Ste-Foy C.P. 7500, Ste-Foy (QC) G1V 4C7	Didier.perret@nrcan.gc.ca
Phillips, R.	OCIPEP - BPIEPE	122 Bank St., Ottawa (ON) K1A 0W6	robert.phillips@ocipep.gc.ca
Piper, D.	Natural Resources Canada	Atlantic Geoscience Center, 1 Challenger Drive (P.O. Box 1006) Dartmouth B2Y 4A2	dpiper@nrcan.gc.ca
Ruel, M.	Canadian National Railway	935, rue de La Gauchetière Ouest,Montréal (Québec) H3B 2M9,	Mario.ruel@cn.ca
Singhroy, V.	Natural Resources Canada	588 Booth Street, Ottawa (ON) K1A 0Y7	vern.singhroy@nrcan.gc.ca
Skermer, N.	EBA Engineering Consultants Ltd.	Sunlife Plaza, Suite 550, 1100 Melville St., Vancouver (BC) V6E 4A6	nskermer@eba.ca
Skirrow, R.	Alberta Transportation	4999, 98th Avenue, Edmonton (AB) T6B 2X3	roger.skirrow@gov.ab.ca
Sonnichsen, G.	Natural Resources Canada	Atlantic Geoscience Center, 1 Challenger Drive (P.O. Box 1006) Dartmouth B2Y 4A2	gsonic@nrcan.gc.ca
Stead, D.	Simon Fraser University	Department of Earth Sciences, 8888 University Drive Burnaby (BC) V5A 1S6	dstead@sfu.ca
Therriault, A.	Natural Resources Canada	Policy Dept., GSC, 601 Booth St. Ottawa (ON) K1A 0E8	ann.therriault@nrcan.gc.ca
Touileb, B.	Hydro-Québec	800 Maisonneuve Est, Montréal (QC) H2L 4M8	Touileb.Bachir.N@hydro.qc.ca
VanDine, D.	VanDine Geological Engineering ltd.	267 Wildwood Avenue, Victoria (BC) V8S 3W2	Vandine@islandnet.com
Whitney, L.	Natural Resources Canada	588 Booth Street, Ottawa (ON) K1A 0Y7	les.whitney@nrcan.gc.ca

Appendix 2

List of questions in breakout groups

GLISSEMENTS DE TERRAIN : MÉCANISMES ET PROCESSUS

LANDSLIDE MECHANISMS AND PROCESSES

1.Quel est l'état de nos connaissances actuelles dans ce domaine par types de glissement de terrain dans les sols et les roches (incluant les facteurs déclencheurs)? Qualifier et commenter. / *Qualify and comment on the current state-of-knowledge in this field by landslide types in rock and soils (including triggers)?*

2. Quelle est la contribution de chacun des secteurs (industrie, gvts fédéral & provinciaux, universités, autres) dans la compréhension des processus et mécanismes des glissements de terrain? / *What is the contribution of each sector (industry, academia, provincial and federal agencies, others) in understanding landslide mechanisms and processes?*

3. Quelles sont les lacunes à combler? / *What are the gaps to be filled?*

4. Quelles sont les priorités visés à court (1 à 5 ans) et long terme (>10 ans) pour combler les lacunes identifiées à la question 3.(≈ 5 de chaque)? / *What are the short- and long-term priorities to meet the needs in question 3. (≈ 5 of each)?*

5. Comment pourrait-on améliorer notre compréhension des processus et mécanismes des glissements de terrain / *How can we better our understanding of landslide mechanisms and processes?*

6. Autres sujets/questions qui méritent d'être discutés*? / Any other issues that need to be discussed?*

MÉTHODES D'ÉVALUATION DE L'ALÉA ET CARTOGRAPHIE

LANDSLIDE MAPPING AND HAZARD CHARACTERISATION

1. Quelle est la relation entre l'occupation des terres et les activités s'y déroulant (e.g. foresterie, développement urbain) et le type de cartographie (danger, l'aléa, et/ou le risque)? / *What is the relationship between the land use/activity (e.g.*

forestry, urban development) and the type of landslide mapping (e.g. danger, hazards, and/or risk)?

2. Quel est l'apport de la cartographie des dépôts de surface et de la roche en place à l'évaluation/cartographie de l'aléa? / *What is the contribution of surficial and bedrock geology mapping to landslide hazards mapping?*

3. Quels sont les plus importants critères/exigences lors de la cartographie de glissements de terrain liée aux projets à échelle régionale (e.g. développement urbain, résidentiel), aux projets linéaires (oléoduc, intégrité de corridor de transport et de communication), et aux projets ponctuels (e.g. infrastructures essentielles, centrale de production d'énergie)? / *What are the most important requirements/criteria for landslide mapping in terms of small-scale areal project (e.g. land use development, subdivision), linear project (e.g. lifeline integrity, pipeline), and « point » project (e.g. critical infrastrcuture, power plant) ?*

4. Est-ce que les bases de données sur les glissements de terrains sont utiles? Quelles sont exigences minimales pour qu'une base de données soit utile? / *Are landslide databases useful? What are the minimum requirements for a useful database?*

5. Existe-t-il des normes et réglements sur la gestion et l'occupation du territoire dans votre province en relation avec les glissements de terrain? Si oui, décrivez brièvement. Si non, commentez sur un tel besoin. *Are there any laws and standards on land occupancy management related to landslides in your province? If yes, describe briefly. If not, comment on such a need.*

6. La cartographie des glissements de terrain passe souvent par l'analyse de stabilité des pentes, devrait-il y avoir une méthodologie détaillée à respecter? *Landslide mapping often involves slope stability analysis, should there a standard methodology to be implemented?*

7. Quelles sont les lacunes à combler? / *What are the gaps to be filled?*

8. Quelles sont les priorités visées à court (1 à 5 ans) et long terme (>10 ans) pour combler les lacunes identifiées à la question 7. (≈ 5 de chaque)? / *What are the short- and long-term priorities to meet the needs in question 7. (≈ 5 of each)?*

9. Devrait-on avoir un programme public d'éducation des glissements de terrain? / *Do we need a formalized public education program? By whom and what media?*

10. Autres sujets/questions qui méritent d'être discutés? / *Any other issues that need to be discussed?*

RÉDUCTION DU RISQUE ET MITIGATION

LANDSLIDE RISK AND MITIGATION

11. Où en est-on dans l'évaluation des risques de glissement de terrain au Canada? Quels sont les outils disponibles? Qu'en est-il de la formalisation de l'approche risque? / *What is the status of landslide risk assessment in Canada? What are the tools available? What is necessary to formalize the risk approach?*

12. Sait-on comment évaluer le risque? *Do we know how to assess landslide risk?*

13. Quelles sont les limites des analyses quantitatives de risque et identifier les alternatives? *What are the limits of Quantitative Risk Assessment (QRA) and what are the alternatives?*

14. Quelles sont les plus importantes exigences concernant l'évaluation des risques de glissements de terrain? / *What are the most important requirements for landslide risk assessment?*

15. A-t-on une définition clair de ce qu'est un «événement dévastateur» (en relation avec travaux d'ingénierie)? / *What is an «damaging event » (design event)?*

16. Quel devrait être le rôle de chacun des intervenants de la société (différents paliers de gouvernement, secteur privé, secteur académique, et autres) dans la réduction des risques liés aux glissements de terrain? *What should be the role of each stakeholder (fed., prov., academia, industry, and others) in the risk reduction and mitigation?*

17. Devrait-on avoir une harmonisation du risque acceptable au Canada? / *Should we have a harmonization of acceptable risk in Canada?*

18. Quel serait l'influence du changement climatique sur les risques de glissements de terrain au Canada? / *How would the climate change impact on landslide risk in Canada?*

19. Comment la communauté technique canadienne peut-elle réduire l'aléa ou les conséquences des glissements de terrain, ou les deux? / *Can the Canadian technical communauty reduce hazards or consequences or both? How?*

20. Autres sujets/questions qui méritent d'être discutés? *Any other issues that need to be discussed?*

Appendix 3

Comments from participants

Fausto Guzzetti, CNR-IRPI, Perugia, Italy
"...It was a very interesting experience. I am afraid I have learned more than what I was able to give you from our experience. Thanks also for the organization and logistic that were nothing less than perfect."

Antoni Lewkowicz, Ottawa University
"Thank you for organising the workshop. It was a great success."

Marten Geertsema, BC Forest
"I would like to congratulate you on organizing a productive and very important workshop. I thoroughly enjoyed it."

Doug VanDine, VanDine Geological Engineering Ltd.
"It was an excellent workshop."

David Piper, Atlantic Geoscience Center, Nova Scotia
"...I found the workshop interesting and useful (...) thank you for the excellent organization."

Peter Bobrowsky, Geological Survey of British Columbia
"Excellent synergy developed in the meeting amongst the participants that facilitated positive progress on the tabled issues."

Nigel Skermer, Geotechnical Consulting Engineer
"I found this workshop fairly hard work, but extremely interesting and stimulating."

Robert Gerath, Thurber Group
"Super conference which should be repeated every two years or so."

Oldrich Hungr, University of British Columbia
"This was an excellent meeting, very well prepared and run."

Appendix 4

Participants' level of satisfaction regarding the organisation of the workshop

Atelier sur l'étude et la gestion des risques de glissement de terrain au Canada

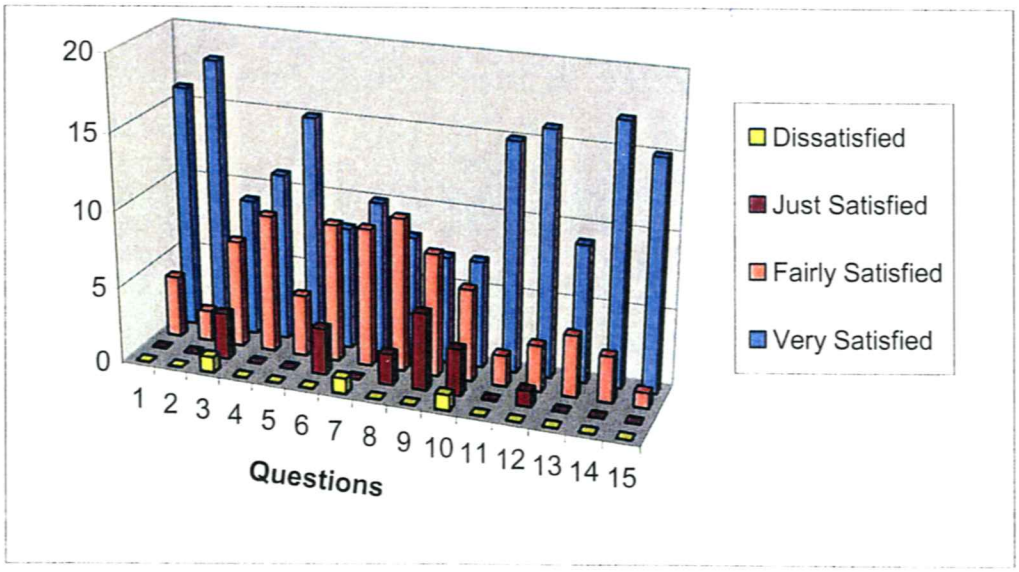
Workshop on Landslide Hazards and Risk Management in Canada

Hull (QC), 16-18 Nov. 2001

Êtes-vous très satisfait (1), moyennement satisfait (2), peu satisfait (3), ou pas du tout satisfait (4) concernant...? / *Are you very satisfied (1), fairly satisfied (2), just satisfied (3) or dissatisfied (4) regarding...?*

1. Format de l'atelier / *Workshop format* ( )
2. Nombre de participants / *Number of participants* ( )
3. La répartition des participants selon les divers secteurs (université, industrie, Provinces, fédéral, autres) / *Distribution of participants within in each sector (academia, industry, provinces, Federal, others)* ( )
4. Le temps consacré aux conférenciers invités versus aux groupes de discussion / *Time ratio between keynote speakers and breakout groups* ( )
5. La qualité des présentations / *Quality of keynote presentations* ( )
6. La durée des groupes de discussions / *Time dedicated to breakout groups* ( )
7. Le rôle des présidents des groupes de discussions / *Role of chaipersons in the breakout groups* ( )
8. Le format et la durée des sessions plénières / *Format and duration of Plenary sessions* ( )
9. Le type et le nombre de questions dans les groupes de discussions / *Type and number of questions in the breakout groups* ( )
10. Le format et la durée de la session de clôture / *Format and duration of the wrap-up session* ( )
11. Service d'interprétation simultannée / *Simultaneous interpretation Service* ( )
12. Service technique audio-visuel / *Audio-visual technical service* ( )
13. L'excursion au glissement de Lemieux / *Field trip to Lemieux landslide* ( )
14. La qualité des repas / *Quality of meals* ( )
15. Qualité des chambres à l'hôtel / *Quality of hotel rooms* ( )

Results



Fieldtrip at the 1993 Lemieux Landslide, Ontario

Excursion au glissement de terrain de Lemieux de 1993, Ontario

18 Nov. 2001

Photo : M. Geertsema

Upper row / Première rangée :R. Gerath, J. Grondin, D. Stead, M. Bovis, L. Whitney, O. Langva, D. Perret, S. Evans, T. Lawrence, D. Cruden, T. Keegan.
Middle row / Deuxième rangée : T. Aston, F. Guzzetti, D. Moore, R. Couture, O. Hungr, D. Cavers, D. Lister, D. Demers.
Lower row / Troisième rangée : J. Aylsworth, D. VanDine, P. Barlow, M. Ruel, N. Skermer.