NATURAL RESOURCES

# WATERSHED ASSESSMENT AND MANAGEMENT OF HYDROLOGIC AND GEOMORPHIC RISK IN THE FOREST SECTOR

VERSION 1.0
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ENGINEERS & GEOSCIENTISTS
BRITISH COLUMBIA

ASSOCIATION OF
BC FOREST PROFESSIONALS

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# PREFACE

These *Joint Professional Practice Guidelines – Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector* were prepared by a team comprising members of the Association of British Columbia Forest Professionals (ABCFP) and Engineers and Geoscientists British Columbia (Engineers and Geoscientists BC) Joint Practice Board. Members of the College of Applied Biology also contributed to the development of these guidelines by reviewing and commenting on the content of the document.

Under the *Foresters Act*, ABCFP's mandate includes upholding the public interest respecting the practice of professional forestry, and advocating for and upholding principles of stewardship of forests, forest lands, forest recourses and forest ecosystems. ABCFP's Bylaw 11: Code of Ethics, Section 11.3.1 provides that the responsibility of its members to the public is "to advocate and practice good stewardship of forest land based on sound ecological principles to sustain its ability to provide those values that have been assigned by society." Water, aquatic ecosystem health, and public safety are examples of Values assigned by society. To properly assess the potential hydrologic and geomorphic Risks to these Values from Forest Management Activities, Forest Professionals often turn to Specialist assessments for the forest lands under their management.

The primary duty of Engineers and Geoscientists BC, as defined in the *Engineers and Geoscientists Act*, is "to uphold and protect the public interest respecting the practice of professional engineering and the practice of professional geoscience." The *Engineers and Geoscientists Act* imposes a specific obligation "to establish, maintain, and enforce standards for the qualifications and practice of its members and licensees[1]." Principle 1 of the Code of Ethics requires all members of Engineers and Geoscientists BC to "hold paramount the safety, health and welfare of the public, the protection of the environment and promote health and safety within the workplace."

These guidelines were developed in response to concerns raised with respect to watershed and Hydrologic Assessments in the British Columbia (BC) forest sector, including matters related to the respective roles and responsibilities of registered professionals.

A letter to the Joint Practices Board from the Engineers and Geoscientists in the Resource Sector Division outlined concerns about current practices in Watershed and Hydrologic Assessments. This letter, dated October 31, 2013 and signed by 10 forest Hydrology practitioners from both associations, states the following:

- Currently there is no consistent guidance for forest professionals, including statutory decision makers approving Forest Stewardship Plans (FSPs), as to when and where a certain level of hydrological assessment is appropriate.
- There is no conventional definition of "hydrological assessment." So even where a hydrologic assessment is specified in an FSP, in most cases what that assessment entails is not defined. This lack of definition has resulted in the development of hydrological strategies that are not measurable or verifiable.
- The lack of guidance as to what is an appropriate hydrological assessment and when one should be carried out is resulting in serious inconsistencies in when and how hydrological assessments are used by forest professionals to meet their

[1] As defined in the *Engineers and Geoscientists Act*.

stewardship obligations and, by extension, in how well those obligations are being met.

- For example, in many FSP-mandated hydrological assessments, there is a lack of content related to the cumulative hydrological effects of forest activities on water quality, water quantity, or timing of flow at downstream elements potentially at risk.
- Under the professional reliance model currently in effect in BC, once an FSP has been approved (see bullets 1 to 4 above), a Ministry of Forests, Lands, and Natural Resource Operations District Manager cannot refuse to issue a road or cutting permit based on an inadequate hydrological assessment. Government may verify that the assessment specified in the FSP was done, but does not review or approve the assessment specifically. Therefore, it is the responsibility of the relevant professional association(s), whose members complete them, to ensure that hydrological assessments are adequate for the conditions and risks involved.

The Division's letter also proposed that the Joint Practices Board develop professional practice guidelines for Hydrologic Assessments for the forest sector.

In addition, a special investigation of community watersheds conducted by the BC Forest Practices Board found deficiencies in both the management and the assessment of these watersheds (BC Forest Practices Board 2014). The Board's recommendation related to watershed and Hydrologic Assessments stated the following:

- Ensuring the content of professional assessments is meaningful. The ABCFP and APEGBC [now Engineers and Geoscientists BC] should develop guidance for their members on the appropriate content of a watershed or hydrological assessment.

  This should include:

  – the elements necessary to address government's objectives for community watersheds including where the surface water source has changed to a groundwater source;
  – procedures for considering cumulative hydrological effects at the watershed scale;
  – integration of the needs of licensed waterworks; and
  – examples of recommendations providing clear direction for implementation. (BC Forest Practices Board 2014)

Therefore, in response to these concerns, the respective Councils of ABCFP and Engineers and Geoscientists BC directed the Joint Practices Board to establish a task force to develop guidelines for standards of practice to be followed when managing hydrologic Values and Risks in watersheds where forest planning and operations are carried out in BC. The guidelines were to include standards of practice for Members of both associations who carry out Watershed Assessments and for those who require and use Watershed Assessments to meet their legal and non-statutory stewardship requirements.

Accordingly, these guidelines set out the following standards of practice:

1. The standard of practice for Forest Professionals who are responsible for managing hydrologic and geomorphic Risks to Values, including requiring development of a watershed Risk Management framework that establishes Risk Tolerance Criteria, identifies when and what type of Specialist assessments are to be carried out, and determines how Risks are to be evaluated and managed for watershed Values (Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds).

2. The standard of practice for Members of ABCFP and Engineers and Geoscientists BC who undertake Watershed Assessments, including the disturbances and watershed processes to be investigated, which includes guidelines for carrying out Hydrologic Assessments (as distinct from Watershed Assessments) (Section 3.0 Professional Practice in Watershed Assessment).

These guidelines were written for the information of ABCFP and Engineers and Geoscientists BC Members, statutory decision makers, regulators, the public, and a range of other Stakeholders who might be involved in—or have an interest in—watershed Risk Management in BC. They provide a common level of expectation with respect to the degree of effort, due diligence, and standard of practice to be followed when managing watershed Risks and carrying out Watershed Assessments in BC. These guidelines are not a manual of procedures for conducting the various technical components of a Watershed Assessment or for prescribing Risk control measures.

In order to be consistent with both national and international standards, this document follows the current language from the Standards Council of Canada *CSA ISO 31000:2018, Risk Management – Guidelines,* which is an adoption without modification of the identically titled ISO (International Organization for Standardization) standard (CSA 2018). However, standards of practice are expected to be revised and updated as required to reflect the evolving state of practice.

There are certain situations that cannot be addressed by professional practice guidelines. There is currently no legislation that regulates total land use planning on the basis of Watershed Units, nor is there a statutory requirement for government to allocate harvesting rights on the basis of cumulative hydrologic and geomorphic effects in individual Watershed Units. In some specific watersheds and regions, government orders have been issued that express Risk tolerance for fish habitat by imposing a maximum clearcut area threshold; but except in these cases, Risk Tolerance Criteria have not been set by government for watershed Values that could be affected by forest development activities. In the absence of specific legislation on these matters, these guidelines set out a process for Forest Professionals to exercise due diligence in assessing and managing Risks in watersheds (see Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds).

These guidelines have been formally adopted by the Councils of ABCFP and Engineers and Geoscientists BC, and form part of both association's ongoing commitment to maintain the quality of services that their Members provide to clients and the public. Members remain professionally accountable for their work under the respective legislation regulating their professional work.

These guidelines outline the appropriate standard of practice at the time that they were prepared. However, this is a living document that is to be revised and updated as required in the future, to reflect the developing state of practice.

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# ABBREVIATIONS

| ABBREVIATION | TERM |
|---|---|
| ABCFP | Association of British Columbia Forest Professionals |
| BC | British Columbia |
| FSP | Forest Stewardship Plan |
| GIS | Geographic Information Systems |
| RPBio | Registered Professional Biologist |

# DEFINED TERMS

The defined terms in this section are specific to these guidelines and are capitalized throughout the document. Some of these definitions are adapted from *CSA ISO 31000:18, Risk Management – Guidelines* (CSA 2018), the *Compendium of Forest Hydrology and Geomorphology in British Columbia, Land Management Handbook 66* (*LMH 66*) (Pike et al. 2010), and the *International Glossary of Hydrology* (WMO 2012).

Members (as defined below) should indicate in their professional work what conventions they follow for terms used, and should provide definitions if they use terms other than as defined here.

Members should be aware that orders issued under the authority of the *Land Act* or *Government Actions Regulation* may have definitions of terms for watershed processes that are specific to the provisions of a particular order. The definitions are not the same in all orders, and are not necessarily the same as the conventional use of the terms. Some examples are noted in Appendix B: Legal Context.

| TERM | DEFINITION |
|---|---|
| **Assurance Statement** | A declaration signed by a Specialist assuring that the Specialist's work meets the intent and direction as provided within these guidelines. |
| **Consequence(s)** | The effect on human well-being, property, the environment, or other things of Value, or a combination of these. Consequence can be certain or uncertain and have positive or negative effects. Most commonly, Consequence is considered to be the change, loss, or damage to Risk Elements caused by a harmful event such as a flood or landslide. |
| **Engineering/Geoscience Professional** | Professional engineers, professional geoscientists, and licensees[2], who are registered or licensed by Engineers and Geoscientists BC and entitled under the *Engineers and Geoscientist Act* to engage in the practice of professional engineering or professional geoscience in British Columbia. |
| **Engineers and Geoscientists BC** | The Association of Professional Engineers and Geoscientists of the Province of British Columbia, also operating as Engineers and Geoscientists BC. |
| **Forest Management Activities** | Activities carried out by Forest Professionals and others affecting forest ecosystems including, but not limited to, forest harvesting and roads; silviculture; forest wildfire prevention, suppression, and post-wildfire Risk Management; forest pathogen suppression and post-attack rehabilitation; and right-of-way clearing. |
| **Forest Professional** | Registered professional foresters, registered forest technologists, or special permit holders who are registered with or licensed by the Association of British Columbia Forest Professionals (ABCFP) and entitled under the *Foresters Act* to engage in the practice of professional forestry in British Columbia. |

[2] The use of the term "licensees" here means as defined in the *Act*.

| TERM | DEFINITION |
|---|---|
| Geomorphology | The science of landforms with emphasis on their origin, evolution, form, and distribution across the physical landscape. |
| Hydrologic Assessment | An investigation of a particular area, site, process, or event within a Watershed Unit, consistent with Appendix F: Hydrologic Assessments of these guidelines. For the purpose of these guidelines, this type of assessment can involve a study of both hydrologic and geomorphic processes but may not include either the full scope of a Watershed Assessment or the entire area of a Watershed Unit. The objectives and scope of these assessments can vary widely, depending on the reason for the assessment. |
| Hydrologic Recovery | In these guidelines, Hydrologic Recovery refers to stand-scale interactions between forests and hydrologic processes, and means the extent to which a regenerating forest stand compares to a reference stand (typically a pre-disturbance stand) with respect to characteristics affecting streamflow response (rainfall interception, snowpack development, and ablation behaviour). |
| Hydrology | The science that deals with the waters above and below the land surfaces of the Earth; their occurrence, circulation and distribution, both in time and space; their biological, chemical, and physical properties; and their interaction with their environment. |
| Hydrometric | Pertaining to the measurement of components of the hydrological cycle including rainfall, flow characteristics of surface water, groundwater, and water quality. |
| Licensee | An individual, company, or Provincial Crown agency that has the legal right to carry out Forest Management Activities on public or private land. |
| Likelihood | The chance of something happening. Likelihood is often expressed as the chance of occurrence over a given time period using relative terms such as very low to very high or very unlikely to almost certain. "Probability" is a mathematical expression of Likelihood.<br>Note: If Specialists choose to use terms such as "hazard" that are not in these guidelines, they should define the term as it is used in their reports. The use of the term "hazard" to mean "Likelihood" is discouraged. |
| Member(s) | A Forest Professional and/or an Engineering/Geoscience Professional. |
| Mitigate | To take measures in advance to offset or reduce the Likelihood of negative effects; for example, distributing harvest areas with regard to aspect, elevation zone, or other factors to reduce the Likelihood that peak flow increases will occur, or to reduce the possible magnitude of peak flow increases, or to establish standard operating procedures for road construction to reduce the potential for instability or drainage problems. |
| Point(s) of Interest | A point identified to establish the lower limit of a drainage area that is the subject of a Watershed Assessment or Hydrologic Assessment. Typically, it is at the location of a Value of interest (e.g., a water intake); or at a stream confluence or shoreline; or at the downstream limit of a fish-bearing reach of interest. |

| TERM | DEFINITION |
|---|---|
| **Professional Biologist** | A person admitted to and registered with the College of Applied Biology as a Professional Biologist. |
| **Remediate** | To take measures to fix effects after they have occurred; for example, deactivating old unstable roads or implementing sediment control measures on active roads. |
| **Risk** | The chance of injury or loss, expressed as a combination of the Consequence of an event and the associated Likelihood of occurrence.<br>Note: If Specialists choose to use terms such as "hazard" that are not in these guidelines, they should define the term as it is used in their reports. The use of the term "hazard" to mean "Likelihood" is discouraged. |
| **Risk Analysis/Analyses** | The systematic use of information to comprehend the nature of Risk and to estimate the level of Risk. |
| **Risk Assessment** | The overall process of Risk Identification, Risk Analysis, and Risk Evaluation. |
| **Risk Element(s)** | Values that are put at Risk by an identified source of harm or potential harm. |
| **Risk Evaluation** | The process of comparing the results of Risk Analysis with Risk Tolerance Criteria to determine if the Risk is acceptable, tolerable, or unacceptable; weighs the estimated level of Risk against the expected benefits. |
| **Risk Identification** | The process of finding, recognizing, and describing Risks; involves identifying the Values, the sources of Risk (sources of potential harm), their causes, and the potential Consequences. |
| **Risk Management** | Coordinated activities to control Risks. |
| **Risk Tolerance Criteria** | References against which the significance of a Risk is evaluated. Generally, these are associated with defined qualitative or quantitative Risk levels. |
| **Specialist** | An individual with specialized training, certification, and experience in a particular occupation, practice, or branch of learning. Such individuals include but are not limited to registered professionals with specialized expertise such as fisheries, Hydrology, Geomorphology or fluvial Geomorphology, slope stability, terrain mapping, erosion control and sediment management, aquatic or riparian terrestrial habitats, water quality, windthrow, forest health, or human health; and non-professionals who may be individuals with certification in specific occupational skills.<br>Typically, the lead Specialist for a Watershed Assessment or Hydrologic Assessment would be a Specialist in Hydrology and/or Geomorphology. |
| **Stakeholder** | Any individual, group, or organization able to affect, be affected by, or believe they might be affected by, a decision or activity. Note that a decision-maker can be a Stakeholder. |
| **Subordinate** | Any person directly supervised by an Engineering/Geoscience Professional or Forest Professional who assists in the practice of the relevant profession; for example, a member-in-training, another person not registered or licensed to practice the profession(s), or another Engineering/Geoscience Professional or Forest Professional. |

| TERM | DEFINITION |
|---|---|
| **Value(s)** | The specific or collective set of natural resources and human developments in a watershed that have measurable or intrinsic worth.<br>Values can include human life and bodily harm, public and private property (including buildings, structures, lands, resources, recreational sites, and cultural heritage features), transportation systems and corridors, utilities and utility corridors, water supplies (for domestic, commercial, industrial, or agricultural use), aquatic and terrestrial habitats, visual resources, and timber. |
| **Vulnerability** | A measure of the robustness (or alternatively the fragility) of a thing of Value, and its exposure to a source of Risk. |
| **Watershed Assessment** | Identification and analysis of hydrologic and geomorphic processes in a Watershed Unit that is consistent with Section 3.0 Professional Practice in Watershed Assessment of these guidelines. |
| **Watershed Unit** | The surface drainage area upstream of a defined Point of Interest. A Watershed Assessment may be for a single Watershed Unit, or may subdivide a large drainage area into smaller Watershed Units for the purpose of the assessment. |

# ACKNOWLEDGMENTS

These guidelines were prepared by a Task Force comprising members of the Association of BC Forest Professionals (ABCFP) and Engineers and Geoscientists BC Joint Practice Board. Authorship and review of these guidelines does not necessarily indicate the individuals and/or their employers endorse everything in these guidelines.

ABCFP and Engineers and Geoscientists BC acknowledge the efforts of the Task Force, the ABCFP Professional Practice Committee, and the Engineers and Geoscientists in the Resource Sector Division in preparing this document; members of the College of Applied Biology for reviewing the document; and additional members of all three associations for providing review comments (see Appendix A: List of Authors and Reviewers).

# VERSION HISTORY

| VERSION NUMBER | PUBLISHED DATE | DESCRIPTION OF CHANGES |
|---|---|---|
| 1.0 | January 14, 2020 | Initial version. |

# 1.0 INTRODUCTION

These *Joint Professional Practice Guidelines – Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector* set out the standard of practice for Forest Professionals who are responsible for managing the hydrologic and geomorphic Risks that Forest Management Activities within their control may pose to the Values in a watershed. These guidelines also set out the standard of practice for Members of both the Association of British Columbia Forest Professionals (ABCFP) and Engineers and Geoscientists British Columbia (Engineers and Geoscientists BC) who undertake Watershed Assessments used for forest management.

These guidelines are not a manual of procedures for conducting the various technical components of a Watershed Assessment or for prescribing Risk control measures. Members have a professional obligation to maintain proficiency in any technical work they undertake, including keeping informed of advances in knowledge in their areas of practice.

Effective watershed management requires:

- an understanding of watershed processes and physical characteristics, including sensitive areas, past disturbances, current condition, and potential responses to future disturbances or actions;
- future objectives for watershed condition and watershed Values;
- a defensible decision-making process for balancing Risks and benefits;
- selection of strategies and prescribed measures to achieve the objectives set for watershed condition and Values;
- oversight and quality control of these strategies and measures during implementation to ensure they are carried out as prescribed;
- monitoring to determine whether the chosen strategies and prescribed measures have had the intended results (revising as necessary); and
- re-examination of watershed condition at appropriate intervals to determine whether the watershed trend in disturbance and recovery is in line with the longer-term objectives set for the watershed.

Forest Professionals need to be aware of and understand the effects of other land use practices; however, where land use and ownership are mixed, watershed condition may be affected by factors beyond the control of Forest Professionals and forest land managers.

## 1.1 SCOPE OF THE GUIDELINES

Section 1.0 Introduction sets out the basic concepts upon which these guidelines are based and summarizes the legal context. It also describes the appropriate knowledge, skill sets, and experience that Members should have when providing professional services related to decision-making for watershed Risk Management, and when carrying out Watershed Assessments. Finally, it sets out the general professional practice expectations for Members engaged in watershed Risk Management and Watershed Assessment.

Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds explains the requirements for developing a framework for managing hydrologic and geomorphic Risks in watersheds. A framework is a written document that provides the context, scope, and standards for identifying and managing these Risks, given Forest Management Activities in a Licensee's

operating area, including when to undertake Specialist assessments and what type of Specialist assessment is required. Specialist assessments could range from site-level investigations to Watershed Assessments.

Section 3.0 Professional Practice in Watershed Assessment provides guidance for Specialists undertaking Watershed Assessments. Various other site- and area-specific assessments (including Hydrologic Assessments) may be undertaken to investigate particular processes or events within a Watershed Unit.

Consistent with the Joint Practice Board's terms of reference, these guidelines pertain to the practices of Members who are registered with ABCFP or Engineers and Geoscientists BC, and are for watershed Risk Management and Watershed Assessments associated with management of forests in British Columbia (BC). It is recognized that Watershed Assessments, or similar assessments, may be carried out for purposes other than for managing forests or undertaken by professionals from other associations. While these guidelines were not intended to address such assessments, some aspects of these guidelines may be informative in the preparation of Watershed Assessments for other purposes or done by other persons.

To be consistent with both national and international current standards, these guidelines follow language from *CSA ISO 31000:18, Risk Management – Guidelines* (CSA 2018).

Watershed Assessments completed under these guidelines may identify floodplain areas, landslides, and potentially unstable terrain within Watershed Units, and may make recommendations for those areas pertinent to watershed Risk Management for Forest Management Activities.

However, it must be noted that the assessments and analyses covered under these guidelines are not terrain stability assessments, landslide hazard assessments for residential development, flood hazard assessments or floodplain maps for residential development, or flood frequency analyses for community planning or the design of infrastructure. For those topics, refer to the following applicable professional practice guidelines:

- *Guidelines for Professional Services in the Forest Sector – Terrain Stability Assessments* (ABCFP and Engineers and Geoscientists BC 2010)
- *Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC* (Engineers and Geoscientists BC 2018a)
- *Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC* (Engineers and Geoscientists BC 2010)
- *Professional Practice Guidelines – Flood Mapping in BC* (Engineers and Geoscientists BC 2017a)

Similarly, while a Watershed Assessment or Hydrologic Assessment may comment on the potential for forest removal and regrowth to affect infiltration and groundwater, or for forest roads to intercept subsurface seepage, the assessments under these guidelines are not groundwater investigations and are not source water assessments for water supply systems under the *Drinking Water Protection Act*.

### 1.1.1 BASIC CONCEPTS

These guidelines are based on the following requirements (see Appendix B: Legal Context):

- Adherence to the *Foresters Act* [SBC 2003], Chapter 19
- Adherence to the *Engineers and Geoscientists Act* [RSBC 1996], Chapter 116
- Fulfillment of Members' professional obligations to protect the interests of the public, worker safety, and the environment
- Reliance on the training, experience, and professionalism of Members
- Involvement of Specialists with expertise in a range of disciplines where needed

The BC government granted ABCFP and Engineers and Geoscientists BC statutory authority to regulate Members working in the forest sector. This authority includes establishing, maintaining, and enforcing standards for the qualification of Members and their relevant professional activities. These guidelines were prepared by the Joint Practices Board, which comprises Members of both associations. The Joint Practices Board was mandated by the Councils of both associations, in a Memorandum of Understanding originally signed in 1994 and updated most recently in 2015, to make recommendations to the Councils on matters related to the practice overlap between the professions.

ABCFP and Engineers and Geoscientists BC recognize that the management of forested watersheds in the context of forest development, and related Risk Management decisions, are included within the definition of the practice of forestry and are not an area of practice overlap. However, Watershed Assessment as described in these guidelines is an area of practice overlap as set out in the language of the respective acts.

The provincial government regulates forest management in BC separately on Crown versus private land. The *Foresters Act* does not distinguish the practice of forestry by land ownership. Watershed management practices as described in this document must be consistent with all applicable legislation governing the practice of forestry and forest management on the area managed by the Forest Professional. These professional practice guidelines apply to Members of ABCFP and Engineers and Geoscientists BC regardless of land ownership or employment situation.

These guidelines are meant to inform Members on the relevant standards of practice at the time of their publication. In the event of any inconsistencies or contradictions between these guidelines and legislation, the latter will always prevail.

### 1.1.2 LEGAL CONTEXT

The legal context surrounding watershed management and Watershed Assessments for forest management refers to the following legislation and bylaws (also see Appendix B Legal Context):

- The acts and bylaws governing ABCFP and Engineers and Geoscientists BC
- The regulation of forest practices on Crown land under the following legislation:
  - *Forest and Range Practices Act*
  - *Forest Planning and Practices Regulation*
  - *Government Actions Regulation*
  - Legal orders established under the *Land Act*
- The *Private Managed Forest Land Act* and accompanying *Private Managed Forest Land Regulation*

As of the published date of these guidelines, Watershed Assessments are a specific legal requirement only in the *Haida Gwaii Land Use Objectives Order* (Haida Gwaii Management Council and Province of BC 2010) and the *Great Bear Rainforest Order* (BC MFLNRO 2016). They are triggered when certain thresholds are reached or before variations from specified treatments

can be made. Elsewhere in the regulatory regime, Watershed Assessments only become a legal requirement if they are committed to in an approved forest stewardship plan (FSP) as a means of addressing objectives outlined in regulations or land use orders on Crown land. Watershed Assessments are not a requirement in any part of the regulatory regime governing forest operations on private forest lands.

While Watershed Assessments are not currently a legal requirement in most circumstances, many Forest Professionals managing both Crown and private forest lands complete Watershed Assessments to meet their stewardship obligations and make informed decisions about Forest Management Activities. Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds provides guidance to Forest Professionals for developing a framework that sets out when a Watershed Assessment is needed.

The *Drinking Water Protection Act* also has implications for the stewardship obligations of Forest Professionals, though it does not impose direct requirements or limitations on forest operations. Under the *Drinking Water Protection Act*, water suppliers can be directed to undertake a source assessment that includes identifying threats. These threats may be to water quantity or quality, or may relate to the potential for damage to infrastructure. Source assessments carried out in watersheds where forest operations are taking place often identify forest operations as threats or Risks. Where threats have been identified, a Forest Professional may have a Watershed Assessment done to provide guidance for forest planning in the water supply watershed.

## 1.2 PROFESSIONAL PRACTICE EXPECTATIONS

### 1.2.1 PROFESSIONAL CONDUCT AND APPLICABILITY OF THESE GUIDELINES

These guidelines provide guidance on professional practice to Members. Failure of a Member to meet the intent of these guidelines could be evidence of unprofessional conduct, and could lead to disciplinary proceedings by the relevant professional regulatory body. However, a Member's decision not to follow one or more aspects of these guidelines does not necessarily mean that the Member fails to meet his or her professional obligations. Such judgments and decisions depend upon weighing facts and circumstances to determine whether another reasonable and prudent Member, in a similar situation, would have conducted himself or herself similarly. A Member who does not follow these guidelines is expected to explain why, and to note what steps were taken to achieve an equivalent standard of practice.

A Member must exercise professional judgment when providing professional services. As such, application of these guidelines will vary depending on the circumstances. The associations support the principle that a Member should receive fair and adequate compensation for professional services, including services provided to comply with these guidelines. However, an insufficient fee does not justify services that do not meet the intent of these guidelines. These guidelines can assist in establishing the objectives and scope of Watershed Assessments, level of service, and terms of reference of a Member's agreement with a client.

These guidelines are influenced by current provincial legislation and its application by local government, provincial case law, advances in knowledge, and evolution of general professional practices in BC. As such, they may require updating from time to time.

### 1.2.2 PRINCIPLES OF STEWARDSHIP AND SUSTAINABILITY

ABCFP's Bylaw 12.6.1 (Standards of Professional Practice – Stewardship) states that "members demonstrate stewardship by balancing present and future values against the capacity of the land to provide for those values."

Engineers and Geoscientists BC's *Professional Practice Guidelines – Sustainability* (2016) state that within their scope of practice, Engineering/Geoscience Professionals have the responsibility to:

- maintain a current knowledge of sustainability;
- integrate sustainability into professional practice;
- collaborate with peers and experts from concept to completion;
- develop and prepare clear justifications to implement sustainable solutions; and
- assess sustainability performance and identify opportunities for improvement.

The overarching premise supported throughout these guidelines is the involvement of Members from both associations in the assessment and management of forested watersheds. In setting out how this is to be achieved, these guidelines support the sustainability goals of both associations.

### 1.2.3 ROLES AND RESPONSIBILITIES

Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds and Section 3.0 Professional Practice in Watershed Assessment describe the roles and responsibilities specific to Risk Management and Watershed Assessment, respectively.

Pursuant to Engineers and Geoscientists BC Bylaw 17, a Member of Engineers and Geoscientists BC must disclose to clients, in writing, on whether or not the Member holds professional liability insurance that covers the services to be undertaken by the Member. Members of ABCFP are encouraged to make similar disclosures to their clients.

All Members must sign and seal their work and append completed Assurance Statements, and they must obtain signed Assurance Statements from Supporting Specialists, as provided in Appendix G and listed below:

- Watershed or Hydrological Assessment Assurance Statement – Registered Professional
  - Assurance Statement of a Registered Professional who is responsible for completing a Specialist assessment report.
- Supporting Specialist Assurance Statement – Registered Professional
  - Assurance Statement of a Supporting Specialist who holds professional registration when submitting supporting information or analysis that is relied upon by a Member.
- Supporting Specialist Assurance Statement – Specialist Other Than Registered Professional
  - Assurance Statement of a Supporting Specialist who does not hold professional registration when submitting supporting information or analysis that is relied upon by a Member.

### 1.2.4 SUPERVISION OF SUBORDINATES AND SPECIALISTS

A Member may delegate tasks to others who work under his or her direct supervision, or may rely on the work of other Members or non-professionals who have the skill sets necessary to complete a task and take responsibility for it. The Member who is delegating should provide sufficient direction to others on their team commensurate with their level of expertise. When seeking advice from a Specialist, the Member is responsible for checking that the Specialist is qualified and competent to give that advice, and that the advice given makes sense based on the Member's own personal knowledge and professional judgment.

The concept of direct supervision involves a Member taking responsibility for the conduct and control of the work of a Subordinate. Engineering/Geoscience Professionals must comply with *Quality Management*

*Guidelines – Direct Supervision* (Engineers and Geoscientists BC 2018b).

The Member accepts full responsibility for all work delegated to a Subordinate and must be certain that the delegated work meets the standard expected by the Member. In providing direction to a Subordinate, the Member having overall responsibility should consider:

- the complexity of the work and the level of Risk;
- which aspects of the professional work, and what proportion of those aspects, should be delegated;
- the training and experience of individuals to whom work is delegated; and
- the amount of instruction, supervision, and review required.

In the case of field work, such supervision would typically take the form of specific instructions on what to observe, check, confirm, test, record, and report back to the Member. The Member should exercise judgment when relying on delegated field observations by conducting a sufficient level of review to be satisfied with the quality and accuracy of those field observations. Engineering/Geoscience Professionals must comply with *Quality Management Guidelines – Documented Field Reviews During Implementation or Construction* (Engineers and Geoscientists BC 2018e).

There are a number of ways in which the work of different Members on a project team can be incorporated into a comprehensive document:

- The author of the assessment can include the signed and sealed reports of other Specialists who are registered professionals as appendices in the author's report. Typically, the author would incorporate the findings of the other Specialists into his or her report, with appropriate references.
- The individual Specialists' reports (where the Specialists are registered professionals) can be completed as modules, with each addressing a component of the assessment. These Specialists' reports are then compiled in an umbrella document that synthesizes the findings of the various modules.

In either case, the protocols noted above should be put in place, and each Member must sign and seal and take responsibility for his or her own work. It is also expected that Specialists submit an Assurance Statement on completion of their work (see Appendix G: Assurance Statements).

When using the work of Specialists who are not registered professionals, the author of the assessment would typically incorporate the Specialist's input into his or her professional report, appropriately referenced and with supporting information provided in an appendix, as applicable, including an Assurance Statement from the Specialist. The non-professional Specialist's input thus informs the professional report that is signed and sealed by the author.

### 1.2.5 SUPPORTING RATIONALE

Members must provide documented rationale to support their professional judgments and decisions, including methods chosen, conclusions reached, and judgments made. Forest Professionals have an obligation to demonstrate how conclusions have been reached (ABCFP 2014). Their rationales for Risk Management decisions should be based on information from Watershed Assessments and/or other Specialist assessments and analyses, and on their own knowledge and experience. The rationale explains the reasoning behind the professional judgment and recommendations.

The basis for judgments in Specialist reports can derive from findings in the scientific literature, comparison to past events in similar nearby sites, reference to other studies in the region, and other defensible explanations. Reports should clearly distinguish between what is fact (as directly observable, measurable, or verifiable) and what is inferred; and should indicate the extent of any uncertainty. Such uncertainties should be identified and discussed in the report and incorporated into rationales.

### 1.2.6 QUALITY MANAGEMENT AND DOCUMENTATION

Quality management is required for all professional work completed by Members. The purpose of quality management is to check that the completed work is technically correct and complies with applicable codes, standards, and regulatory requirements. Quality management by Members requires the implementation of suitable protocols to ensure that appropriate quality assurance and quality control reviews are completed.

#### 1.2.6.1 Forest Professionals

For ABCFP-registered Members and special permit holders or certificate holders entitled to practice in this area, the ABCFP standards of professional practice contain competence and due diligence direction to ensure the quality of professional work. Competence requires that professional practice include three essential components: knowledge, completeness and correctness, and professional care (according to ABCFP Bylaw 12.2). ABCFP Members exercise due diligence in professional practice by being prudent and doing all work with constant and careful attention (according to ABCFP Bylaw 12.5).

An ABCFP Member can exercise due diligence in professional practice by satisfying himself or herself that, according to *Standards of Professional Practice: Guidelines for Interpretation*, under the section entitled Bylaw 12.5.1 Due Diligence Standard (ABCFP 2014):

- all relevant legal requirements have been met;
- the member has a clear understanding of client or employer objectives and how they relate to other values or interests which are relevant to the work or may impact it;
- the member is personally familiar with all relevant characteristics of the area affected by the work;
- all appropriate background information has been gathered and incorporated;
- the member has consulted with all appropriate experts or specialists for those areas for which the member is not qualified to practice or express an opinion;
- when external advice is sought from a specialist, that specialist is qualified and competent to give that advice and the advice given makes sense based on the member's own personal knowledge;
- when data is collected by another person, that person is qualified and competent to collect that data and the data collected makes sense based on the member's own personal knowledge;
- sufficient data was collected to the required standards; and
- the member has made a proper assessment of risks and outcomes.

Exercising due diligence also means that:

- rationales for decisions to accept, control, or reduce Risks have been documented; and
- the Forest Professional has signed and sealed the work for which he or she is responsible.

Forest Professionals must retain all documentation, including checklists and references to standard operating procedures or other mechanisms, that demonstrates all appropriate procedures were followed and confirms all relevant steps and considerations were included. They must also retain all background information, including Specialist assessments, upon which they relied to formulate the rationale for their decisions. The requirement for documentation applies both to development of a framework and to decisions made under that framework.

#### 1.2.6.2 Engineering/Geoscience Professionals

For Engineering/Geoscience Professionals and holders of non-resident or limited licenses, a quality management program must satisfy the relevant requirements of the *Engineers and Geoscientists Act* and the Engineers and Geoscientists BC Quality Management Bylaws 14(b) (1), (2), and (3). These requirements encompass the following:

- Retention of complete project documentation for a minimum of 10 years

- Documented checks of engineering and geoscience work
- Documented field reviews (if assessments or analysis make recommendations for specific site works) to ascertain whether the significant aspects of the work are in general compliance with the plans and supporting documents
- Direct supervision
- Use of the Engineers and Geoscientists BC seal
- Requirement to follow professional practice guidelines approved by the Engineers and Geoscientists BC Council and relevant to the practice of Engineering/Geoscience Professionals

These requirements are addressed further in the following related quality management guidelines:

- *Retention of Project Documentation* (Engineers and Geoscientists BC 2018c)
- *Documented Checks of Engineering and Geoscience Work* (Engineers and Geoscientists BC 2018d)
- *Documented Field Reviews During Implementation or Construction* (Engineers and Geoscientists BC 2018e)
- *Direct Supervision* (Engineers and Geoscientists BC 2018b)
- *Use of Seal* (Engineers and Geoscientists BC 2017b)

### 1.2.7 INDEPENDENT REVIEW OF PROFESSIONAL WORK

Both ABCFP and Engineers and Geoscientists BC consider independent reviews to be an important part of quality management of professional practice. The need for and scope of an independent review is based on the professional judgment of the Member. The Specialist should consider the complexity of the hydrologic and geomorphic environment; the potential level of Risk; the availability, quality, and reliability of background information and field data; and the Specialist's training and experience. The reviewing Member should also be a Specialist who is qualified to carry out the review competently. The review should be documented in a signed and sealed letter or report from the reviewing Member that includes an assessment of the limitations and qualifications with regards to the review and its results.

Occasionally, a Member is retained to provide a second opinion, which goes beyond the scope of reviewing the work of the original Member. The second Member should carry out sufficient pre-field work, field work, assessment, and comparisons, as required, to accept full responsibility for his or her second opinion findings.

## 1.3 EDUCATION, TRAINING, AND EXPERIENCE

Professional qualification and competence refers to having sufficient knowledge, ability, and experience to suitably undertake and complete the necessary tasks. Members must adhere to their respective codes of ethics and have the appropriate education, training, and experience consistent with the services being provided.

By maintaining appropriate professional qualifications and competence, Members ensure they are capable of addressing matters undertaken on their clients' behalf, thereby upholding the integrity of professional forestry, engineering, and geoscience practice and maintaining the confidence of stakeholders of those professions. A Member who offers specialty services requires education, training, and experience in that area of specialty. Members who undertake professional work without being qualified by training or experience may be subject to disciplinary action.

Professional qualification and competence in a subject area is gained from a combination of the following sources:

- Formal study such as university courses, or equivalent knowledge gained from short courses, workshops, and self-study

- Work experience, usually with mentoring by a senior professional with relevant expertise
- Typically, a minimum of five years of work experience in a field of practice working under the supervision or mentoring of a senior professional
- Continuing professional development, such as keeping up-to-date with emerging literature, research, and studies; attending conferences, workshops, seminars, and technical presentations; reading new texts and periodicals; reading relevant web content; and participating in field trips

Where a Member does not have the required knowledge and skills for a particular professional activity, the required knowledge and skills can be brought together using a team approach. Each team Member must be qualified and competent in his or her own tasks and have an understanding of how his or her work fits within the overall objectives of the team. The Member coordinating the team must also have sufficient knowledge to assess the accuracy of the results provided by each team Member to achieve the intended outcome.

### 1.3.1 FOREST PROFESSIONAL LEADING THE DEVELOPMENT OF A WATERSHED RISK MANAGEMENT FRAMEWORK

In these guidelines, the term "Forest Professional" refers to the Member of ABCFP with the responsibility for making forest management decisions on watershed Values, and "Specialist" refers to Members of either association or non-Members who undertake watershed, hydrologic, or other assessments to support the Forest Professional.

A Forest Professional who leads the development of a watershed Risk Management framework (Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds) must be a Member in good standing of ABCFP. The Member should have experience leading interdisciplinary teams and working with Stakeholders; have a basic understanding of watershed processes and management; and have good communication and technical writing skills. The Forest Professional is responsible for establishing the scope of Watershed Assessments and other Specialist assessments, for understanding sources of Risk and Consequences in determining acceptable Risk, for accepting or not accepting recommendations, and for balancing multiple Values in all final decisions regarding activities in a watershed.

### 1.3.2 SPECIALIST COMPLETING OR LEADING A WATERSHED ASSESSMENT

It is generally accepted that forest Hydrology is an interdisciplinary field practiced by Members of several professions with varied academic backgrounds.

Members of ABCFP and Engineers and Geoscientists BC undertaking Watershed Assessments in BC (Section 3.0 Professional Practice in Watershed Assessment) should have demonstrated knowledge of fundamental hydrologic and fluvial processes at both forest stand/stream reach and watershed scales; forest ecology; resource management; cumulative hydrologic effects; data analysis; and report writing. They must also have the ability to apply scientific principles and judgment to evaluate watershed condition and disturbance (see Appendix C: Skill Set for Undertaking Watershed Assessments).

A Member leading a Watershed Assessment normally has a graduate degree in science, an applied science or equivalent degree with a focus on forest Hydrology and/or Geomorphology (or a relevant discipline such as geoscience, engineering, or forestry), and at least five years of professional experience. If a Member does not have a graduate degree or equivalent, he or she is expected to involve an appropriately qualified senior Specialist. This Specialist will either undertake a peer review or complete those aspects of the assessment and analyses for which the Member does not have the required training. All Watershed Assessments completed by a less-experienced professional should be reviewed by a qualified professional.

The skills required of a Specialist completing or leading a particular Watershed Assessment vary, depending on the key issues. For example, if terrain stability, sediment sources, or channel morphology are likely to be most significant, then it would be appropriate for the Specialist to have a strong background in Geomorphology or fluvial Geomorphology with a working knowledge of hydrologic processes. If stream flow change is likely to be the most pressing concern, then the Specialist would normally have a strong background in forest Hydrology with a working knowledge of geomorphic processes. All Members conducting Watershed Assessments should have good communication and technical writing skills.

If a Specialist does not have the full range of expertise for a particular assessment, a team approach is recommended that includes Specialists with expertise and qualifications in those areas.

It is the responsibility of all Members to practice only within the scope of their expertise and to recommend that the Forest Professional engage other more appropriately qualified professionals when necessary.

Refer to Section 1.2.4 Supervision of Subordinates and Specialists for more information about incorporating the work of other Specialists.

# 2.0 PROFESSIONAL PRACTICE IN MANAGEMENT OF HYDROLOGIC AND GEOMORPHIC RISKS IN FORESTED WATERSHEDS

This section sets out the standard of professional practice for Forest Professionals who are responsible for managing hydrologic and geomorphic Risks in forested watersheds.

As outlined in Figure 1: Framework for the Management of Hydrologic and Geomorphic Risk below, Risk Management requires a framework that:

- is appropriate in the context of the Licensee's organization, regulatory environment, and physical extent of operations;
- identifies the watershed Values that could be put at Risk by management actions or outside influences (the sources of harm) including climate change (Risk Identification);
- estimates the existing Risk level and the change in Risk that could be caused by additional disturbance (Risk Analysis);
- establishes Risk Tolerance Criteria for the identified Values (a step in Risk Evaluation);
- sets out a logical process for comparing Risk levels to the Risk Tolerance Criteria (Risk Evaluation);
- identifies measures to avoid, limit, or reduce Risk (Risk treatment);
- provides for communication with affected parties both within the Licensee's organization and potentially affected parties outside the Licensee's organization (Section 2.5 External Communication); and
- includes a monitoring and review process to check the effectiveness of the system (Section 2.6 Monitoring and Verifying Outcomes).

## 2.1 FRAMEWORK FOR THE MANAGEMENT OF HYDROLOGIC AND GEOMORPHIC RISK

A framework is a written document that provides the context, scope, and standards for managing Risks from Forest Management Activities in a Licensee's operating area. A framework is intended to optimize the use of organizational resources by focusing on the greatest efforts on the areas of greatest concern.

In managing Risks to watershed Values, the following principle should apply:

- As the severity of Consequence increases, the degree of caution applied to Risk Management also increases.

Depending on the size and complexity of the Licensee's operating area, a Licensee may have a single framework that applies to all operating areas, or separate frameworks for individual operations and watersheds. A framework can apply to a Licensee's holdings throughout the province or to a specific area such as a woodlot. If objectives have been set by the provincial government for a watershed, the framework

must incorporate those objectives. For Watershed Units that have experienced impacts from historic logging practices, natural disturbances, or watershed processes, it is desirable to have management objectives that allow for recovery of watershed function and Values.

A framework that applies to a small area or individual Watershed Unit may be quite simple. However, if a single framework is to be applied over a large area, it may need to accommodate a wide variety of hydrologic regimes, geomorphic conditions, watershed Values, and societal concerns.

Areas of special emphasis in this type of framework would typically include the following:

- Watersheds that provide community water supplies
- Watersheds where there are potentially high Consequences for non-forest development, such as residential, commercial, or industrial development, or critical agricultural or public infrastructure
- Watersheds designated by law as being of special significance (such as fisheries-sensitive watersheds)
- Watersheds with red-listed aquatic species or with especially sensitive, degraded, or productive fish habitat

A checklist to assist with developing a framework is in Appendix D: Example of a Watershed Risk Management Framework Checklist.

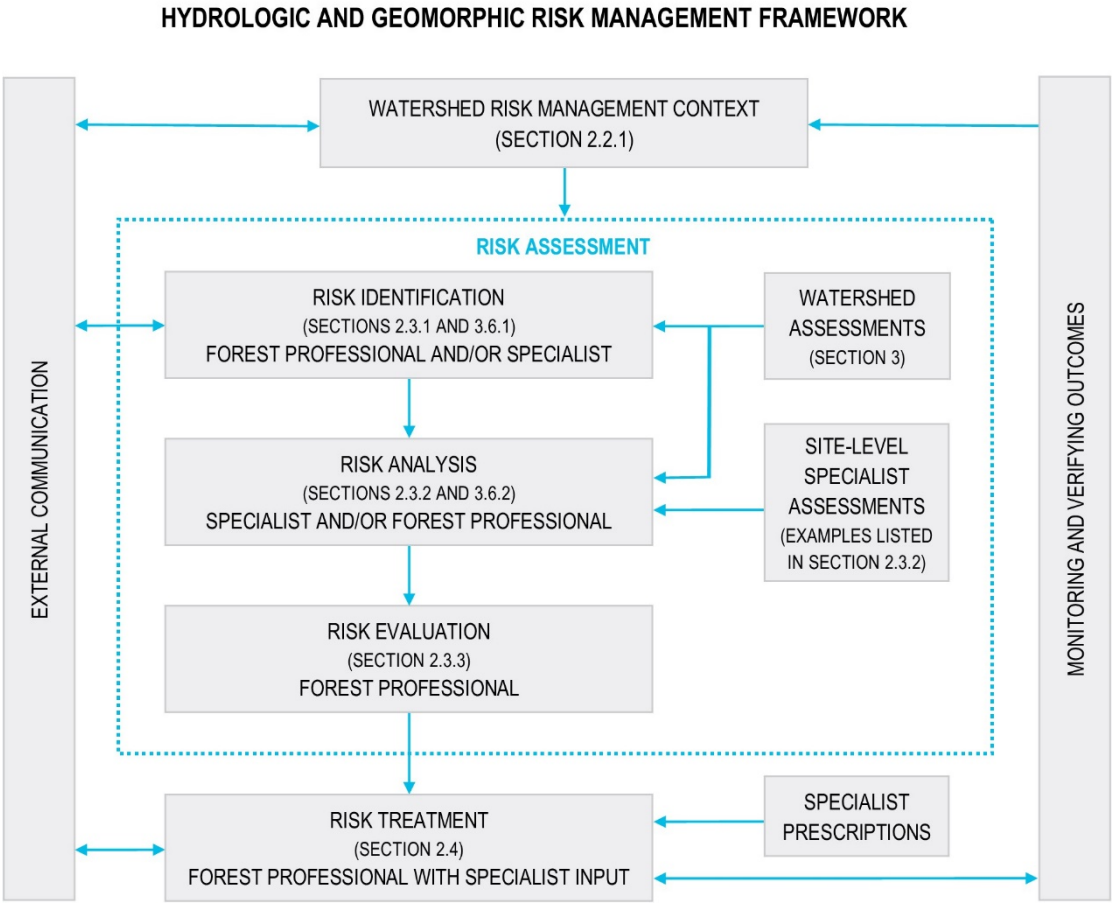


*Figure 1: Framework for the Management of Hydrologic and Geomorphic Risk*

Note: Adapted from CSA ISO 31000:18, Risk Management – Guidelines (CSA 2018).

## 2.2 RISK MANAGEMENT

### 2.2.1 WATERSHED RISK MANAGEMENT CONTEXT

A Risk Management framework should consider the Licensee's internal organizational context and should:

- set out roles and responsibilities for application of the framework, communication protocols, lines of authority, and decision-making responsibilities within the Licensee's organization, including decisions associated with various levels of Risk;
- integrate with other organizational systems the Licensee may have, such as quality control, reporting systems, document management, and environmental management;
- integrate with operational strategies or standard operating procedures that a Licensee may have in place that are relevant to watershed processes (e.g., a terrain stability management model [Engineers and Geoscientists BC 2008], road construction and maintenance standards and procedures);
- document resources the organization has available to support the framework; and
- identify any limiting factors.

A framework should consider the external regulatory contexts of the Licensee's operating area and should:

- consider public health and safety, worker safety, public infrastructure, the property of others, and other Values required to be considered by legislation (for example, subjects indicated in the *Forest and Range Practices Act,* Sections 149 and 150, for lands those sections apply to);
- identify and align with
  - the regulatory regime applicable to the Licensee's operating area under the framework (for example, legislation applicable to private managed forest land and Crown land tenures),
  - regulatory operational rules that may be specific to the operating area (for example, *Government Actions Regulation* orders for land use objectives or identified resource features, such as community watersheds or fisheries-sensitive watersheds), and
  - other existing watershed or management objectives, management systems, or commitments that a Licensee may have in place (such as FSPs and certification programs); and
- define the geographic area to which the framework applies.

Good professional practice supports a framework that considers the physical context of the Licensee's operating area, including:

- identifying major Watershed Units, such as regional climate, dominant stream flow regime, general geomorphic and terrain characteristics, biogeoclimatic zones, and typical forest types and hydrologic characteristics; and
- noting any specific challenges in the operating area, such as multiple land uses or tenure holders in Watershed Units.

### 2.2.2 MULTIPLE TENURES IN A WATERSHED

Watershed management faces particular challenges when forest tenures and land ownership in a Watershed Unit are fragmented, and when there are multiple forest tenures and/or land uses such as agricultural, industrial, commercial, or residential development. There is currently no general legislation that regulates total land use planning on the basis of Watershed Units, nor is there a statutory requirement for government to consider cumulative hydrologic effects when issuing harvesting rights.

Where a Licensee's operating area is only part of a Watershed Unit, the framework should provide guidance to the Forest Professional for making Risk-based planning decisions in this situation. Members are not expected to assume responsibility for matters beyond their scope of authority. However, neither can

Forest Professionals ignore the potential for harm to be caused by Forest Management Activities under their direction.

Where there are multiple forest management or land tenures in a Watershed Unit, the most desirable and professionally responsible outcome is that the Forest Professional engages the cooperation of those who manage other tenures with respect to Risk Management in the watershed. This could be achieved, for example, by sharing information and conducting joint Watershed Assessments and Risk Analyses, or by mutually agreeing on Risk Tolerance Criteria and Risk mitigation strategies.

The framework should indicate what course to take to achieve this cooperation. If this course is unsuccessful, the Forest Professional must document the efforts made and provide a rationale for decisions made for the Licensee's operations in the absence of a Risk Management strategy that covers the total watershed. In keeping with ABCFP's Code of Ethics, if the Forest Professional believes that a practice is detrimental to good stewardship of forest land (Bylaw 11.3.4), or to the safety, health, and welfare of the public (Bylaw 11.3.10), then the Forest Professional must notify the responsible person promptly. An ABCFP Practice Bulletin on the Duty to Resolve or Report provides direction to Forest Professionals in such circumstances.

### 2.2.3 RISK TOLERANCE CRITERIA

The framework should identify the types of harm that could affect the Values as a result of Forest Management Activities, and the Consequences that would be of concern (the Risk tolerance). When setting Risk Tolerance Criteria, different Risk Elements (e.g., human safety, infrastructure, ecological Values) should be evaluated separately (see Appendix E: Supplementary Examples of Risk Assessment).

The Risk Management framework should either identify the Values to be considered or describe a procedure by which these are identified. Identification of Values may arise from the Licensee's existing information base; from targeted assessments, inventories, or government data sources; and through communication with local governments, First Nations, non-governmental Stakeholders, and others. A framework is intended to optimize the use of organizational resources by focusing on Specialist assessments where Forest Management Activities may have a potential detrimental effect on watershed Values.

A Value becomes a Risk Element when a source of harm, or potential harm, to the Value is identified.

At this time, Risk tolerance thresholds have not been set by government for watershed Values that could be affected by forest development activities. Thus, it rests with the Forest Professional developing the framework to exercise due diligence in defining Risk Tolerance Criteria. The definition of due diligence includes ensuring Forest Professionals have properly assessed Risks and outcomes and consulted the appropriate expert or Specialists in those areas where they are not qualified (ABCFP 2014).

In determining Risk Tolerance Criteria for Values in a framework (e.g., human safety, water quality and supply, ecology, infrastructure), a Forest Professional should recognize in the framework that those deriving direct economic benefits from forest harvesting may have different levels of Risk tolerance than others who could be affected by Forest Management Activities but do not benefit directly from them. The framework should provide guidance regarding the establishment of Risk Tolerance Criteria for specific Values that considers both the accuracy and uncertainty of available information. Criteria set in a framework for acceptable or tolerable Risk should take into consideration the relative severity of the Consequences, the ability to Mitigate the Consequences with Risk control measures, and the possibility and practicability of remediating Consequences should they occur.

In future, levels of acceptable, tolerable, and unacceptable Risk set in a framework should be consistent with any standards that may be set by the provincial government and any precedents set in case law.

### 2.2.4 ADDRESSING CLIMATE CHANGE IN WATERSHED RISK MANAGEMENT

Climate change is expected to affect forest stand structure, tree growth, and species distribution as a result of ecological responses currently underway, including a higher frequency of wildfire, insect attack and disease, increased moisture stress, and changes in the growing season.

Combined with increased variability in weather, these changes may also affect hydrologic and geomorphic processes. For example, terrain stability may change (improve in some regions and worsen in others) in conjunction with changes in precipitation, snowmelt patterns, windthrow, and forest species. Stream hydrographs are expected to continue adjusting in response to changes in temperature and precipitation. Depending on the stream flow regime, forest cover changes may exacerbate or compensate for these hydrograph changes.

Additionally, local and provincial governments and others are implementing climate change adaptation initiatives that alter forest management practices in specific zones and regions of BC. For example, fuel-management measures in wildland fire-interface zones (e.g., shaded fuel breaks, fire-resistant tree species, and creation of open stands in high-Risk fire areas) have implications for watershed Hydrology. Members should be aware of these developments by consulting ABCFP and Engineers and Geoscientists BC websites and other appropriate Member communications and resources.

Changes in forest species, regeneration patterns, and growth rates are also expected to affect rates of post-disturbance Hydrologic Recovery. These changes are relevant to Risk Tolerance Criteria set in the framework, Risk control measures and assumptions made in Specialist assessments, and levels of uncertainty faced in assessing and managing hydrologic and geomorphic Risks when planning forest development. For example, if landslide frequency increases as a result of increased frequency and intensity of rainstorms, a framework could call for revisiting Risk Tolerance Criteria for potential landslides to affect stream channels and watershed Values. Another example is, if extreme floods are occurring more frequently, this could affect targets set in a framework for recovery of floodplains destabilized by historic floodplain logging. Forest Professionals should confirm that Specialist assessments adequately consider projected forest changes when identifying or analyzing Risks, and should also consider how these changes affect the length of time a Specialist assessment remains valid.

## 2.3 RISK ASSESSMENT

Risk Assessment comprises the steps of Risk Identification, Risk Analysis, and Risk evaluation (CSA 2018), as illustrated in Figure 1: Framework for the Management of Hydrologic and Geomorphic Risk above.

- **Risk Identification** involves identifying and describing sources of Risk and the potential Consequences.
- **Risk Analysis** estimates the level of Risk, typically as an expression of the severity of the Consequence combined with Likelihood of occurrence.
- **Risk Evaluation** compares the Risk levels estimated in a Risk Analysis with the Risk Tolerance Criteria.

Both Forest Professionals and Specialists have roles in Risk Identification and Risk Analysis, while Risk Evaluation is the responsibility of Forest Professionals only.

Section 2.8 Responsibilities addresses the role of the Forest Professional in Risk Assessment.

### 2.3.1 RISK IDENTIFICATION

The Forest Professional is responsible for identifying watershed Values and their locations. Risks to watershed Values associated with Forest Management Activities can arise from:

- changes in streamflow regime, including the frequency, magnitude, volume, and timing of flows;
- increases in fine and coarse sediment delivery to streams;
- loss or introduction of wood into streams;
- mass-wasting events (e.g., landslides, erosion);
- changes in riparian vegetation that affect channel processes and quality of aquatic habitat; and
- the collective effects of all of the above.

A Forest Professional can choose a phased approach, which may involve retaining a Specialist to undertake an office review of existing information to:

- identify potential sources of Risk;
- review whether any or all aspects of the existing information require updating; or
- characterize a large watershed at an overview level for the purpose of identifying where a more detailed review or Specialist assessments should be focused.

Based on the identified sources of Risk, the framework should provide guidance to the Forest Professional on how to select the appropriate type and scope of Specialist assessments in order to estimate Risk levels with an adequate level of confidence. The framework should indicate when site-level or targeted assessments are needed and when a Watershed Assessment is needed (see Section 3.0 Professional Practice in Watershed Assessment). Possible triggers in a framework for conducting Watershed Assessments should also include any commitments made in formal plans (e.g., forest stewardship plans) or corporate policy, and any regulatory directives (e.g., *Land Act* regulations or *Government Actions Regulation* orders).

The Forest Professional, in consultation with the Specialist(s), should then identify the necessary resources and the most effective approach to adequately investigate the hydrologic and geomorphic processes affecting or affected by Forest Management Activities, and the consequent effects on Values.

The Forest Professional is responsible for obtaining the required information from the appropriate Specialists to make defensible decisions consistent with the level of Risk and the objectives for the watershed. The Forest Professional is also expected to use resources wisely and cost-effectively. The framework should provide guidance on determining the need for and scope of Specialist assessments and inventories to inform Risk Assessment, and should integrate with other Risk Assessment guidance that the Licensee may have in place for other considerations such as terrain stability, windthrow, streams, fans, floodplains, snow avalanches, or karst.

### 2.3.2 RISK ANALYSIS

A Risk Analysis to inform forest management decisions evaluates both the existing Risk level (e.g., the potential for stream flow change to occur as a Consequence of past disturbance in the watershed), and the change in Risk that might be caused by further disturbance (e.g., future forest harvesting scenarios) or recovery.

The Forest Professional may include certain Risk Analyses for watershed-scale effects such as stream flow change in the scope of a Watershed Assessment (Section 3.0 Professional Practice in Watershed Assessment), and have site-level assessments done to make Risk decisions on specific roads and harvest areas. Examples of site-level assessments that include Risk Analyses are terrain stability assessments, windthrow assessments, Hydrologic Assessments (Appendix F: Hydrologic Assessments), and geotechnical assessments of old roads. For some sources of Risk, such as stream flow change, data limitations or limited scientific knowledge about the region may result in considerable uncertainty in Risk estimates.

### 2.3.3 RISK EVALUATION

The Forest Professional evaluates Risk by comparing the existing Risk, plus the change in Risk (if applicable) estimated in the Risk Analysis, to the Risk Tolerance Criteria that outline the Consequences of concern established in the framework (see Section 2.2.3 Risk Tolerance Criteria). On the basis of this comparison, the framework should provide guidance for determining whether the Risks are acceptable, tolerable, or unacceptable, and who within the Licensee's organization is responsible for this decision.

The Forest Professional may seek input or further investigation from Specialists to elaborate on Consequences; for example, to more clearly determine the nature of the effects on watershed Risk Elements and the type of harm that could result (see Appendix E: Supplementary Examples of Risk Assessment).

The Forest Professional then considers whether the Risks can be kept within acceptable or tolerable limits with available mitigative measures. If this is not practical, then the proposed activity is scaled back or withdrawn.

In making Risk-based decisions, the Forest Professional should take into account uncertainties with respect to the accuracy of information available, and uncertainties inherent in assumptions used for identification and analysis of Risk. In some situations, Risk Evaluation may involve balancing the Risks of carrying out the forest management activity against the Risks that would occur if the forest management activity were not carried out. An example would be increasing watershed area disturbed above an established threshold through forest salvage, versus increasing the Likelihood of negative forest health agents (e.g., insect infestation, disease) and fire.

When evaluating Risk, the Forest Professional must consider the results of all relevant Specialist assessments and analyses, and also consider the societal factors on which the Risk tolerance levels are based.

## 2.4 RISK TREATMENT

### 2.4.1 DEFINING RISK CONTROL MEASURES

Once Risk has been evaluated and it has been determined that measures for reducing Risk are required, the Forest Professional considers the options available for Risk control.

Measures for reducing Risk are aimed at either reducing the Likelihood of occurrence or reducing the severity of the Consequence. Some Risk control measures are undertaken at the planning stage and are incorporated into forest harvesting and road layout plans. Others involve standard measures, practices, and procedures to Mitigate Risk and promote consistency in carrying out forest operations. In some instances, allowing time for recovery of geomorphic and hydrologic processes may be an effective means of remediating Risk.

In most cases, if the Risks associated with Forest Management Activities are deemed unacceptable, they are managed by avoiding, limiting, or reducing the source of Risk. Less commonly, the Vulnerability of Risk Elements is reduced through protection measures. Occasionally, Licensees seek other solutions for offsetting Risk.

Examples of measures to avoid, limit, or reduce sources of Risk include the following:

- Road maintenance, deactivation, and sediment management measures to control erosion and limit muddy runoff
- Windthrow treatments of wind-susceptible cutblock boundaries in proximity to Values of concern
- Limiting harvesting on steep terrain to areas that meet acceptable Risk Tolerance Criteria for landslides and snow avalanche initiation zones
- Limiting harvest levels in watershed zones where logging could cause an unacceptable Likelihood of stream flow changes
- Remedial work on old roads to stabilize over-steepened fill slopes and restore drainage patterns

Examples of reducing the Vulnerability of a Risk Element include increasing the capacity of an existing bridge or building a debris flow deflection berm to protect Risk Elements on a fan.

When relying on a Risk control measure, the Forest Professional should consider past performance, including whether or not a particular treatment has been successful at achieving the objective, and also whether the Licensee's organization has been consistent in carrying out prescribed measures as intended by the Forest Professional.

Key questions to assist with Risk Evaluation and selecting Risk control measures are included in Appendix E: Supplementary Examples of Risk Assessment.

### 2.4.2 OVERSIGHT AND QUALITY CONTROL OF RISK TREATMENTS

A Licensee must follow specific quality control practices and procedures within their organization related to Risk control, including the following:

- Reviewing checklists against measures prescribed in watershed management strategies, FSPs, or Specialist assessments such as terrain stability assessment
- Communicating the objectives and intent of the measures in relation to watershed Values with contractors and company staff
- Conducting field reviews and/or inspections during site works, and signing off on constructed works (Engineers and Geoscientists BC and ABCFP 2014)

It is the Forest Professional's responsibility to check that practices and procedures relied upon for Risk control are in place and are effective for their intended purpose. If the systems are not in place in the Licensee's organization to reliably deliver Risk control measures, the Forest Professional should advise the Licensee that due diligence may not be met with respect to Risk Management.

## 2.5 EXTERNAL COMMUNICATION

For a Forest Professional to meet his or her obligations to manage for watershed Values assigned by society (ABCFP 2014), it is the Forest Professional's responsibility to be aware of relevant concerns regarding possible forest management activity effects on watershed Values and specific Risk Elements.

Through communication with First Nations, government, and non-government Stakeholders, Forest Professionals must make a reasonable effort to gather the full range of interests (ABCFP 2009). The need to incorporate a specific communication protocol into a Risk framework depends on whether the Licensee already has communication protocols in place for other purposes. The Forest Professional should confirm that these are sufficient and, if not, pursue greater engagement.

In certain circumstances, a Forest Professional may have to convey adverse findings to parties who may not be directly involved, but who have a compelling need to know (for example, the Risk to human life or property of a debris flow identified during the course of a Specialist's investigation). In keeping with the ABCFP Code of Ethics, if a Forest Professional discovers or is made aware that there is a material Risk to the environment or to the safety, health, and welfare of the public, the Forest Professional has a responsibility to draw these Risks to the attention of the appropriate authorities.

## 2.6 MONITORING AND VERIFYING OUTCOMES

Forest Professionals are required, as part of their professional practice standards, to produce measurable and verifiable professional work, and to be able to provide a rationale for the methods used in measuring and verifying outcomes (ABCFP 2014).

When monitoring the outcomes of specific Risk Management strategies affecting natural processes in a watershed, the objective is to evaluate the effectiveness of those strategies in achieving the intended outcomes, and to check for unintended outcomes. When interpreting monitoring information, the uncertainties and unknowns with respect to the methods of measurement and causes of change must be stated. Where other forest management and non-forest activities, or a changing climate, could affect watershed conditions and Risks, it may not be possible to separate the effects of Forest Management Activities that Forest Professionals can control from those that they cannot.

Where Risks are high, or changes in hydrologic or geomorphic processes need to be quantified, an effective monitoring design that incorporates spatial and temporal variability is required to enable the attribution of specific effects. For example, when tracking the trend of recovery or disturbance in a floodplain, monitoring may include either comparisons of air photo series over time, direct field observations, or measurements at established monitoring sites.

## 2.7 IMPLEMENTING AND UPDATING A WATERSHED RISK MANAGEMENT FRAMEWORK

Plans for implementing a watershed Risk Management framework should include the following:

- Roles and responsibilities for applying the framework and implementing results from Specialist assessments
- Training of, and communication with, individuals who carry out practices on which the success of Risk control measures rely, such as contractors and operators who implement development plans
- An independent review process consistent with good professional practice

The framework should provide for revisiting watershed condition at appropriate intervals (depending on the tenure) to see whether the objectives set for the watershed are being met.

In addition, the framework should identify other circumstances that would trigger a review of watershed condition and/or management strategies, such as the following:

- Monitoring results have suggested unintended outcomes
- Natural events have caused a material change in watershed condition
- Forest management or non-forest activities have changed the Risks to Values and elements of concern
- There have been advances in scientific knowledge or methods of analysis
- New findings on climate change have warranted revisiting the hydrologic analysis

The framework should contain provisions for updates as experience is gained with the framework; as new information becomes available; if there are changes to Values or Risk Elements in the area to which the framework applies; and in response to regulatory

changes, case law, or professional practices requirements. Updates may also be required following reviews of the effectiveness of Risk Tolerance Criteria and Risk control measures in achieving the desired outcomes.

## 2.8 RESPONSIBILITIES

### 2.8.1 FOREST PROFESSIONALS

A Forest Professional who develops a Risk Management framework is responsible for defining the content of the framework, and for implementing, updating, and signing off on the framework (see Section 2.1 Framework for the Management of Hydrologic and Geomorphic Risk). Any components that are developed by Specialists must be signed off by those professionals. A management representative of the Licensee may also sign off on the framework.

In a large operation with multiple Values and a complex physical environment, a Forest Professional may establish a framework development team that includes the following participants:

- Other Forest Professionals with specific operational roles in the organization
- Specialists who contribute advice on areas such as groundwater, Geomorphology, Hydrology, water supply infrastructure, water quality, terrain stability, windthrow, or aquatic ecosystem health
- A management representative who can provide input on corporate expectations, Risk tolerance, and systems and quality control within the organization for delivery of the intended measures, and who may request a legal review of the framework document
- Individuals who are responsible for conducting activities under standard operating procedures or practices that affect watershed objectives (e.g., road construction and maintenance practices, production, hauling)

In a smaller operation with a limited operating area, a single Forest Professional may develop a more limited framework and may also be the person who implements it. A Forest Professional would usually consult with a Hydrology or Geomorphology Specialist in developing even a simple framework. In either case, all Forest Professionals must make sure that their watershed management decisions meet the professional requirements concerning the public interest and their professional obligations (ABCFP 2014).

When working under a framework, the Forest Professional is responsible for obtaining input from Specialists when specific expertise is required to inform forest management decisions, and for having the Specialist undertake a study of suitable scope and level of effort. Specialist input is needed when the information required for a Risk decision is beyond the expertise of the Forest Professional. The type and scope of Specialist assessments that may be required will depend on the hydrologic and geomorphic characteristics of the operating area, the Values involved, and the Licensee's management plan.

When retaining Specialists, the Forest Professional should:

- complete an agreement with the Specialist confirming the scope, schedule, and compensation for the work to be done; the need for and scope of other specialty services; the need for external independent reviews if anticipated; distribution and ownership of all work products; and confidentiality of data if applicable;
- provide clear terms of reference to the Specialist regarding the purpose of the assignment; any insurance or certifications required; and the reports, maps, documents, or other records that are required to be submitted by the Specialist;
- indicate the intended use of the Specialist's information;

- indicate whether the Specialist's work will be relied upon by the Forest Professional, in which case the Specialist will be required to submit an Assurance Statement; and
- confirm with the Specialist what circumstances may cause a change to the scope of work and associated costs.

When a Forest Professional is engaging multiple Specialists to form a project team, the Forest Professional should clarify the role of each Specialist, including who is the lead Specialist (if the lead is not the Forest Professional); set up protocols for communication, information sharing, and reviews between the Specialists; and, in consultation with the Specialists, decide on how the individual Specialist reports will be integrated. This will avoid both gaps and duplication of work, as there may be overlap in the areas of expertise of individual Specialists.

If there are differences of professional opinion between the Specialists, the Forest Professional should set out a process for resolving these differences where possible. Members are expected to make their best efforts to resolve differences of professional opinion. If they cannot be resolved, the Forest Professional should set out how these differences are to be addressed in the Specialists' reports, which might include external independent reviews by Members who are not part of the project team.

While an individual Specialist assessment may be focused on a specific concern or information need, the Forest Professional still has the responsibility for considering the full range of Values and for seeking the appropriate Specialist input needed to inform those additional Risk decisions.

### 2.8.2 SPECIALISTS

When retained by a Forest Professional, the Specialist is responsible for:

- clarifying the purpose and scope of work with the Forest Professional;
- informing the Forest Professional of the project information that he or she requires;
- advising the Forest Professional of the level of effort required to meet the Forest Professional's objective for the study;
- informing the Forest Professional of the Consequences of inadequate investigation if the agreed scope of work is limited;
- maintaining an independent objective perspective in carrying out the assessment and providing advice; and
- signing an Assurance Statement on completion of his or her work.

A Specialist who is registered with ABCFP or Engineers and Geoscientists BC is responsible for:

- verifying to the Forest Professional or author that he or she has the necessary skills and professional qualifications to complete or contribute to the work; and
- conforming to all professional obligations associated with the work, including completing the work to an acceptable professional standard, and signing, sealing, and taking responsibility for professional work that he or she has completed.

A Specialist who is not registered with ABCFP or Engineers and Geoscientists BC is responsible for:

- adhering to the requirements for membership of his or her professional organization (if applicable), including following the organization's Code of Ethics and practice guidelines/standards;
- ensuring he or she possesses the required expertise and works within the scope of practice defined in his or her profession;

- verifying to the Forest Professional or author that he or she has the necessary skills, training, and experience to complete or contribute to the aspects of the assessment or analysis being done, including providing evidence of academic or technical certifications and/or insurance, as applicable; and
- providing records, notes, reports, or other information as requested by the Forest Professional or lead Specialist.

One example of a Specialist registered with another association is a Professional Biologist (RPBio) registered with the College of Applied Biology.

The Specialist should confirm with the Forest Professional what services are included in the cost estimate. If a change to the scope of work and associated costs becomes necessary, this must be communicated to the Forest Professional as soon as practicable.

Where information gaps are identified, the Specialist should confirm with the Forest Professional whether other Specialists will be brought into the team to fill those gaps, or whether the gaps will be noted for further work.

# 3.0 PROFESSIONAL PRACTICE IN WATERSHED ASSESSMENT

## 3.1 OBJECTIVES

Watershed Assessments inform the Risk Identification and Risk Analysis steps in a watershed Risk Management framework (see Figure 1: Framework for the Management of Hydrologic and Geomorphic Risk).

The rationale for pursuing a Watershed Assessment may be based on a variety of information, including a field review of trigger indicators (e.g., GIS-generated riparian logging or stream crossing indicators), reported issues in the watershed, overview-level office-based characterization of the Watershed Unit, or commitments made in an FSP or other planning process (see Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risk in Forested Watersheds).

This section sets out the professional responsibilities for Members of ABCFP and Engineers and Geoscientists BC who undertake Watershed Assessments. It does not provide technical procedures for conducting the various components of a Watershed Assessment. Members have a professional obligation to maintain proficiency in any technical work they undertake, including keeping informed of advances in science in their area of practice.

The objectives for a Watershed Assessment vary with the purpose of the assessment, the complexity of the watershed, the nature of the sources of Risk, the watershed Values, and the Forest Professional's specific requirements as set out in the framework. Most commonly, a Watershed Assessment provides recommendations to a forest Licensee that assists the Licensee in avoiding unacceptable Consequences from its forest management practices.

The objectives of a Watershed Assessment include some or all of the following:

- Characterizing a Watershed Unit to determine baseline conditions for future comparison
- Determining the present physical condition of a Watershed Unit, the extent of past natural and anthropogenic disturbance, and current recovery trends
- Tracking trends over time with respect to collective hydrologic and geomorphic effects from forest and non-forest development, fire or extreme floods, and/or other land uses
- Identifying sources of Risk to Values of interest in the watershed
- Assessing the change in Risks to Values from proposed Forest Management Activities
- Providing input to guide forest management planning
- Determining watershed condition and trend, in order to identify and prioritize restoration opportunities and select management strategies that promote recovery of geomorphic and hydrologic processes

A Watershed Assessment involves the following:

- Investigating watershed characteristics, channel characteristics, geomorphic and hydrologic processes, sensitivity to disturbance, and disturbance history
- Undertaking analyses appropriate for the scope and purpose of the study, which may include

analyzing Hydrometric and climate data; estimating Hydrologic Recovery of regenerating forest stands, landslide frequency, and rates of sediment production; and characterizing Risk sources and Consequences pertaining to the Values of interest

- Evaluating and synthesizing the above information to allow the Specialist to draw conclusions and develop guidance or recommendations to meet the purpose of the study

Some watersheds may include smaller watersheds, or be near to other watersheds, that have available streamflow and environmental data sets that can be analyzed and incorporated into the Watershed Assessment. However, many watersheds have limited or no hydrologic data available or even regional studies for comparison. Some data can be acquired from complementary studies, such as channel and sediment source surveys, source water assessments, and terrain stability assessments.

## 3.2 VALUES AND RISK ELEMENTS

A Watershed Assessment may be undertaken to address a particular Value, such as a community water supply, or to address multiple Values. If the scope of the Watershed Assessment does not include the full range of Values present in the watershed, then this should be stated in the terms of reference and in the Specialist's report. Regardless of the scope of a particular Watershed Assessment, the Forest Professional remains responsible for considering the full range of Values, and for seeking appropriate Specialist input needed to inform those additional Risk decisions.

A Value becomes a Risk Element when a source of harm or potential harm to the Value is identified.

Some Values may have multiple aspects with different vulnerabilities, each of which could be a Risk Element. For example, if the Value of concern is a community water supply, that could include the physical infrastructure (e.g., intake, reservoirs, treatment plant, distribution system) in addition to water quality, quantity, and timing of flows. A Watershed Assessment for a community water supply should therefore evaluate the potential for Forest Management Activities to affect each of these aspects. Additionally, in the case of a designated Community Watershed or Water Supply Area, if the water system infrastructure has substantially changed since the watershed was designated (for example, moving from a surface water intake to a groundwater source), then the Watershed Assessment should note this and consider whether the Risk Elements and sources of Risk may have changed.

If, during the investigation, the Specialist discovers Values that the Forest Professional may be unaware of, the Specialist should confirm with the Forest Professional whether these additional Values should be addressed in the Watershed Assessment.

## 3.3 WATERSHED CHARACTERISTICS

The Watershed Unit encompasses the catchment area that drains to defined Point(s) of Interest. Depending on the purpose of the Watershed Assessment, a Point of Interest could be a shoreline, stream confluence, or location of a Value of interest such as a water intake. The Specialist delineates or confirms watershed sub-units as appropriate for the watershed processes and Risk Elements.

A Watershed Assessment would typically comment on the potential significance of forest removal and forest regeneration on processes such as infiltration, soil moisture, and surface and subsurface flow, as well as on the potential for forest roads to intercept seepage and enhance surface flows.

The Specialist compiles and reviews existing background information to characterize the Watershed Unit (Pike and Wilford 2013). Relevant information can include the following:

- Mapping, imagery, and spatial data
- Anthropogenic information (e.g., roads, land ownership, water intakes/diversions, reservoirs)
- Climate, Hydrometric, water quality and other data
- Existing reports
- Physiographic information (e.g., bedrock, terrain, landslide hazard, topography, streams, forest cover)

The Specialist should consider the date, scale, reliability, and accuracy of background information, and the potential effects that unreliable and inaccurate information could have on the assessment.

## 3.4 DISTURBANCE REGIME AND RECOVERY

Disturbance refers to changes in the physical state of a watershed due to hydrologic, geomorphic, and other watershed processes and their variability over time. Disturbance can be caused by natural or human activity. The Specialist characterizes the disturbance regime and ranks the relative importance of different sources of disturbance to identify and describe Risk sources, and to develop rationales to support his or her conclusions regarding sources of Risk to Values.

Watershed disturbance derives from inherent landscape characteristics, land use impacts, and climatic events. The agents of natural disturbance include wildfires, insects, disease, windstorms, rainstorms, snow avalanches, and flood events, all of which are affected by a changing climate. Some disturbances are caused by a single event (such as a wildfire), while others result from ongoing processes (such as mass wasting in a dynamic mountainous environment).

In addition to natural disturbance, land use activities alter the vegetative cover, can disrupt hydrologic and geomorphic processes, and can directly damage channels. Examples of such activities include forest harvesting; road construction; agriculture; mines and quarries; linear corridors such as pipelines, transmission lines, and railroads; and other residential, commercial, and industrial development.

The Specialist considers recovery from past disturbances when interpreting both current watershed condition and longer-term trends, and the potential effects of additional Forest Management Activities. This is important information for the Forest Professional when assigning Risk Tolerance Criteria for new activities, and for setting watershed condition objectives. The Specialist should indicate the methods and criteria used to assess recovery.

Aspects of recovery assessed by the Specialist typically include the following:

- Revegetation of sediment sources, including landslide paths, stream escarpments, eroded gullies, and trails; and road cut slopes, fill slopes, and ditch lines
- Hydrologic Recovery of regenerating forest stands with respect to characteristics affecting streamflow response (rainfall interception, snowpack accumulation and ablation)
- Riparian vegetation regrowth (including on stream banks and bars) and its contribution to reducing channel bank erosion, improving channel planform stability, increasing slope stability of adjacent gully sidewalls, and supplying large wood
- Alterations in channel morphology caused by historic logging practices, landslides, wildfires, or extreme floods with respect to sediment loading, bedload transport, and channel structure (stone lines, steps, pools); and changes to the presence and function of wood in the channel

Watershed sensitivity is the Likelihood that watershed condition will be affected by disturbances. It considers the potential for changes in watershed processes, such as runoff and sediment generation, and the potential for associated changes in stream channels and/or water quality. It is distinct from the Vulnerability of Values and Risk Elements.

In determining watershed sensitivity to disturbance, the Specialist considers watershed characteristics such as the following:

- Hydrologic factors, including climate, peak flow regime, runoff response, and surface water storage (lakes, icefields, wetlands), and the extent of permeable surficial deposits that may provide groundwater storage for contribution to base flows
- Terrain stability factors, including climatic zone and relative exposure to landslide-causing storms, geomorphic susceptibility to landslides and erosion, presence of natural landslides, extent of potentially unstable terrain in the watershed, and hillslope connectivity to waterbodies
- Stream sensitivity factors, including the extent of alluvial stream channels, presence of fans, and presence and extent of floodplains, wetlands, and estuaries

The Specialist considers these factors together with the disturbance history and recovery in the watershed, when commenting on Risk tolerance thresholds and recommending management strategies to meet objectives for watershed condition.

## 3.5 CLIMATE CHANGE

Evidence of climate change is widespread and has implications for rates of watershed disturbance and hydrologic processes. For example, shifts attributed to climate change include changes in flood characteristics, increased landslide occurrence, and increased delivery of sediment to channel networks.

The Watershed Assessment should discuss and address such implications in the Risk Analysis and final recommendations, and provide rationales based on current science.

For the purposes of a Watershed Assessment, the Specialist should:

- use supplementary tools (e.g., ClimateBC_Map mapping software [Centre for Forest Conservation Genetics 2018]; Wang et al 2016 methodology; Pacific Climate Impacts Consortium online tools [PCIC 2019]) and information to determine how climate variables are expected to change in future within the study area;
- interpret the climate change information in the context of watershed processes in the study area, and discuss how potential changes may pose Risks to Values in the future; and
- discuss the expanded uncertainty in sources of Risk linked to hydrologic and geomorphic processes associated with the projected climate futures in the study area.

Engineers and Geoscientists BC requires its Members to stay informed about the changing climate and consider potential impacts in their professional work. ABCFP requires its Members to expand their awareness and develop competencies that enable adequate consideration of the effects of climate change on forests while seeking new approaches to adapt in their practices (ABCFP 2014). The Forest Professional and the Specialist should consider the changes in Risk that could result from these shifts and the time frames over which they could become significant.

## 3.6 COMPONENTS OF A WATERSHED ASSESSMENT RELATED TO RISK

Risk Assessment comprises the steps of Risk Identification, Risk Analysis, and Risk Evaluation (CSA 2018), as illustrated in Figure 1: Framework for the Management of Hydrologic and Geomorphic Risk and as discussed in Section 2.3 Risk Assessment.

- **Risk Identification** involves identifying and describing sources of Risk and the potential Consequences.
- **Risk Analysis** estimates the level of Risk, typically as an expression of the severity of the Consequence combined with Likelihood of occurrence.
- **Risk Evaluation** compares the Risk levels estimated in a Risk Analysis with Risk Tolerance Criteria.

Both Forest Professionals and Specialists contribute to Risk Identification and Risk Analysis, while Risk Evaluation is the responsibility of Forest Professionals only (see Section 2.0 Professional Practice in Management of Hydrologic and Geomorphic Risks in Forested Watersheds). Therefore, this section of these guidelines focuses only on Risk Identification and Risk Analysis by a Specialist as part of a Watershed Assessment.

### 3.6.1 RISK IDENTIFICATION

A Watershed Assessment identifies and characterizes sources of Risk to the Value(s) from natural hydrologic and geomorphic processes, natural and/or human-induced disturbances, and the collective effects of these processes.

Hydrologic and geomorphic processes that are identified as having the potential to harm a specific Value are a source of Risk. But it should be noted that what can harm one Value may actually benefit another. For example, large wood in a stream system can threaten infrastructure (e.g., bridges, water intakes, reservoirs) and may increase flood levels and trigger channel migration that erodes private property. However, the supply of large wood is also essential for aquatic habitat structure and channel morphology in alluvial stream channels.

Risk to watershed Values may arise from the following sources:

- Changes in timing, magnitude, and frequency of stream flows
- Increases or decreases in fine and coarse sediment in streams
- Loss or introduction of wood into streams
- Mass-wasting events (landslides, debris flows, erosion)
- Changes in riparian vegetation that affect channel processes and quality of aquatic habitat
- The collective effects of all the above

The Specialist characterizes the above sources of Risk and determines their location within the watershed, and then considers each of these watershed responses relative to the Value of concern to determine whether it presents a Risk to that Value. If it does, then the Value is an element in relation to that Risk source.

Examples of Risk Identification completed in a Watershed Assessment include the following:

- The potential for stream flow and channels to change due to natural and human-induced changes in the watershed and to affect a Value of concern
- The potential for low flows to decline, affecting adequacy of community water supplies and aquatic ecology
- The potential for landslide (as indicated by the landslide history):
  - Zones of steep, potentially unstable terrain, combined with hillslope connectivity to streams or other Values of concern
  - Sections of old roads on steep slopes, combined with sediment delivery potential to a Value of concern
- The potential for a Value located on a fan to be affected by debris floods or debris flows caused by

natural events, or by Forest Management Activities in the catchment area upstream of the fan or on the fan surface

- The potential for loss of riparian vegetation to compromise wood supply to the stream, bank erosion resistance, and sidewall stability of slopes adjacent to stream channels
- The potential for sediment from erosion of road cuts, fill slopes, and ditch lines to degrade water quality or aquatic habitat
- The potential for sediment generation from traffic on stream-adjacent roads to degrade water quality

The relative importance of these Risk sources varies, depending on regional conditions and watershed characteristics. For example, in regions of the province with snow-melt–dominated peak flows, forest removal may be a primary concern; whereas, in outer coastal watersheds subject to extreme rainstorms, landslide occurrence may be the primary concern. The identified Risk sources, together with the disturbance and recovery history, are recorded in the Watershed Assessment and may help to inform the Forest Professional's decisions on Risk Tolerance Criteria for watershed Values (e.g., for future effects on fish habitat found to be already degraded).

Depending on the purpose of the Watershed Assessment, other Risk sources may need to be considered; for example, the effects on water quality caused by the release of substances such as hazardous materials, acid rock drainage, pathogens, or nutrients. Where this is the case, the scope of the assessment should reflect these aspects and the appropriate Specialists should be included in the project team.

Risk Identification also includes considering Risks associated with future forest development. The Specialist considers both the existing state of disturbance and recovery and the changes that are expected to arise from future forest development activities.

In identifying and describing sources of Risk, the Specialist should, as appropriate for the scope of the assessment:

- use current science and methods to evaluate sources of Risk, and indicate the methods and criteria used;
- analyze available climate and Hydrometric data and interpret the significance of the findings in relation to stream flow regimes and possible responses to disturbance;
- quantify the various Risk sources to the extent that it is meaningful to do so and indicate the uncertainties around the analysis; and
- undertake field checking of Risk sources that were identified in the office review (see Section 3.3 Watershed Characteristics).

### 3.6.2 RISK ANALYSIS

Risk Analyses for forest planning are done both at the watershed scale and at the site level. For some kinds of Risk sources, the Watershed Assessment provides strategic-level Risk ratings and identifies where site-level Risk Assessments are required for forest planning.

The Forest Professional uses results from both watershed-level and site-level Risk Analyses to complete Risk Evaluation, and incorporates those results into the harvest and road plans. Examples of watershed-scale Risk Analyses include changes in streamflow and water quality. Site-level Risk Analyses include terrain stability assessments, windthrow assessments, Hydrologic Assessments of fans, geotechnical assessments of old roads, and sediment control plans for stream-adjacent roads. Additional examples of watershed-scale and site-level Risk Analyses are available in Appendix E: Supplementary Examples of Risk Assessment and Table E - 2: Examples of Risk Analyses Done at Strategic and Site Levels for Planning of Forest Management Activities.

For sources of Risk associated with stream-flow change, limitations in climate and Hydrometric data and scientific knowledge relevant to the region may result in considerable uncertainty in estimates of Risk levels. Risk Analysis may range from a quantitative approach in data-rich situations to professional opinion in others. The Specialist should clearly report the level of confidence accompanying Risk ratings and communicate the uncertainty to the Forest Professional.

Whereas Risk Identification determines whether a Value may be affected by a particular source of harm, it does not necessarily describe the nature of the effect. A Specialist undertaking a Watershed Assessment examines the physical effects that the various Risk sources could have on the Risk Elements.

A Forest Professional will often need detailed information on these Consequences to evaluate the identified Risks against Risk Tolerance Criteria in the framework. Therefore, in the scope of a Watershed Assessment, the Forest Professional may in some cases ask for an expanded determination of Consequences and the nature of harm that could be done to the Risk Element(s). More advanced determinations of Consequence may require the involvement of other Specialists. Expanded determination of Consequences may take into account the Vulnerability and worth of Risk Elements and/or other factors, such as replaceability, magnitude and duration of harm, and feasibility of remedies. (Wise et al 2004 and Appendix E of these guidelines).

Risk ratings combine the Likelihood of occurrence with the severity of the Consequence. It is not sufficient to describe these with only qualitative ratings. The Specialist should also clearly describe the nature of the hydrologic or geomorphic events and the physical effects they could have on the Values. The Forest Professional needs a clear indication of the nature of the events that could cause harm and the kind of harm that could be done to the Values.

## 3.7 FIELD WORK

The Specialist must exercise professional judgment in determining the extent of field work appropriate to the type and scope of the Watershed Assessment, while considering the availability and accuracy of background information.

Watershed Assessments typically take a phased approach, beginning with an office review of imagery, background reports, information in the public domain, and spatial data products, and followed by field verification. Where there is limited background information, more field work may be needed.

Field sites are identified from the office review and may include input from the Forest Professional or other team Specialists. Field sites could include the following:

- Stream reaches potentially affected by landslides, historic logging, or other land uses (e.g., agriculture, recreational vehicle use)
- Alluvial fans and floodplains
- Risk Elements, such as water intake structures, fish habitat, and recreation features and facilities
- Instream or riparian restoration sites
- Steep and stream-adjacent road sections
- Landslides
- Stream crossings, ditchwater flows, and water diversions
- Cutblocks to check status of regeneration
- Deactivation or rehabilitation measures on roads

Access may limit the extent and timing of the field work, particularly in watersheds with private land holdings, extensive road deactivation, and few drivable roads, or in remote areas where field reconnaissance must be conducted by helicopter. Limitations on field work should be indicated in the Specialist's report.

The Specialist should record the extent of field investigation and sites visited, dates of field work, field personnel, field methods, means of access, conditions at time of field assessment (e.g., weather, ground cover, flood level), and any limitations that may have affected the assessment (e.g., access to private property, physical barriers, roads grown in or inaccessible, snow cover, washouts, high stream flows). A good photographic record can help to support the Specialist's rationale statements.

## 3.8 RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

The Specialist presents conclusions on current watershed condition and recovery trend, on identified Risks to watershed Values, and on the possible significance of those Risks. Conclusions are drawn by synthesizing results from background information, field investigation, data analyses, current science, and reports/information from other Specialists (if available and relevant).

Recommendations for watershed management must follow logically from the conclusions that are based on this synthesis, and must tie back to the objectives of the Watershed Assessment. The rationale for the conclusions and recommendations must be clear and must be consistent with current scientific knowledge.

The Specialist presents the findings of the Watershed Assessment, including:

- the results of a specific Risk Analysis, if included in the scope of the Watershed Assessment;
- knowledge gaps and the assessments or inventories that would fill those gaps;
- recommendations for site-level investigations and Risk Analyses needed for the Forest Professional to complete the Risk Evaluation of planned Forest Management Activities; and
- options for specific management strategies for future harvesting and roads to avoid Consequences of concern.

The Specialist should comment on the potential for climate change to:

- shift hydrologic regimes, providing the implications for watershed Values;
- alter trends in recovery from disturbances;
- exacerbate the Risks identified; and
- change Risk scenarios in the future.

## 3.9 WATERSHED ASSESSMENT REPORT

Report content will vary, depending on the objectives and scope of the Watershed Assessment. Typical sections and content include, but are not limited to the following:

- Scope
  - The purpose and objectives of the assessment, including Values and Risk Elements that were considered, and who commissioned the assessment
- Methods
  - The information used in the assessment, including that provided by the Forest Professional
  - Definitions of terms used (particularly those that may have more than one meaning in the literature), references or manuals referred to, and protocols followed for classification conventions
  - The methods, standards, conventions, and guidelines followed or referred to with respect to specific aspects of the assessment
  - The extent of the field work, methods used, and any conditions that may have limited the work
  - The assessment team, including other Specialists and reviewers, if applicable

- Results, conclusions, recommendations, and limitations
  - Results of investigations and analyses completed as part of the work
  - Appropriate maps, figures, photographs, tables, or other supporting information suitable for the scale and scope of the assessment
  - Rationales clearly linked to findings in the investigation
  - Conclusions developed by evaluating and synthesizing background materials, analyses, and field findings
  - Recommendations or options for Risk control measures following from the conclusions and as applicable to the scope of the study
  - Assumptions, uncertainties, and limitations of the study, including the need for follow-up work

The report should be clearly written with sufficient detail to:

- allow the Forest Professional and other Specialists reading the report to understand the methods, information used, and supporting rationale for conclusions and recommendations;
- enable the Forest Professional to understand the sources of Risk and Risk levels, and be able to either undertake an evaluation in relation to Risk tolerance or seek the appropriate site-specific assessments for Risk Analyses; and
- allow the Forest Professional to implement the recommendations and evaluate options provided.

The Specialist should identify where he or she has relied on the work of other professionals, and should integrate the relevant work into the report, including clarifying any associated limitations. If Specialists use terms such as “hazard” that are not in these guidelines, they must define the term as it is used in their reports. The use of the term “hazard” to mean “Likelihood” is discouraged.

The report should include a statement of limitations. The following are examples of items typically addressed under limitations:

- Standard of care followed while carrying out the analysis
- Data availability
- Level of confidence in different aspects of the analysis
- Assumptions and uncertainties in the various analyses and judgments made in the report
- Scope limitations due to multiple Licensees
- Factors that may have limited the assessment, such as restricted access, quality of background information, and terrain or weather conditions at the time of the field work
- Restrictions on the use of the report (e.g., to the client or Licensee for its intended purpose)

Some aspects of a Watershed Assessment may be qualitative and subjective based on observed conditions. The report should distinguish between what is fact—that which is physically observed, measured, and verifiable; what is inferred from observations of physical conditions, data analysis, and findings in the scientific literature; and what is uncertain or unknown.

In choosing and applying quantitative methods of analysis, the Specialist should acknowledge the assumptions and limitations of the methods and data, and take them into consideration when interpreting the results and advising the Forest Professional. If numerical values are provided in a report, the Specialist should indicate the basis for those numbers and how they were determined.

It is the Specialist’s responsibility to be aware of current scientific literature and new studies as they emerge, and to consider the science in the context of the Watershed Unit that is the subject of the assessment. For example, in the future, hydrologic models may become an important aspect of Watershed Assessment and the Specialist should stay informed on these new developments

A Watershed Assessment cannot be relied on in perpetuity. Although the Specialist should attempt to anticipate reasonable changes that could affect the results of the assessment, the length of time the assessment will be valid depends on natural processes that occur over time, and on changes in land use and site development not anticipated in the assessment. The Specialist should indicate under what conditions the Watershed Assessment will apply and what circumstances may render the assessment no longer reflective of the watershed condition.

## 3.10 RESPONSIBILITIES

As discussed in Section 1.3.2 Specialist Completing or Leading a Watershed Assessment, the required technical strengths of a Specialist carrying out or leading a Watershed Assessment may depend on what the key issues are expected to be.

### 3.10.1 SPECIALISTS

When retained to undertake a Watershed Assessment, the Specialist is responsible for:

- clarifying the scope of work with the Forest Professional;
- agreeing on terms of engagement, including ownership and distribution of work products and confidentiality;
- confirming with the Forest Professional what Values are to be considered and how Consequences are to be defined for the Values of interest;
- confirming whether the scope of the assessment includes evaluating the change in Risk that would result from a proposed plan for harvest areas and roads;
- informing the Forest Professional of the project information that he or she requires;
- advising the Forest Professional of the level of effort required to meet the Forest Professional's objectives for the study, including the extent of field investigation required;
- confirming with the Forest Professional what services are included in the cost estimate, and what circumstances may cause a change to the scope of work and associated costs;
- informing the Forest Professional of the Consequences of inadequate investigation if the agreed scope of work is limited;
- verifying to the Forest Professional that he or she has the necessary skills and professional qualifications to complete the Watershed Assessment;
- identifying to the Forest Professional any aspects of a project that are beyond his or her expertise and noting whether the involvement of other Specialists is needed for the purpose and objectives of the assessment; for example, expertise in water quality issues associated with human health such as water chemistry and pathogens, or Specialists in aquatic ecology;
- maintaining an independent and objective perspective when carrying out the assessment and providing advice; and
- on completion of the Specialist's work, signing an Assurance Statement.

The need for additional Member or non-Member Specialists will depend on the purpose of the assessment and the expertise required to address the project objectives. For example, if objectives include assessing potential impacts on fish populations and/or fish habitat, then a fish biologist (e.g., a Registered Professional Biologist, or RPBio) would usually be involved at the Risk Identification phase to characterize the fish populations and vulnerabilities, and at the Risk Analysis phase to determine the likely Consequences of disturbances on these Values.

In some cases, a review of an existing Watershed Assessment may find that only certain aspects require updating. The Specialist should clarify with the Forest Professional what aspects are to be updated, the level of effort required, and any limitations this may place on the Specialist's assessment.

In certain circumstances, the Specialist may have to convey adverse findings to parties who may not be directly involved, but who have a compelling need to know (for example, a debris flow or flood Likelihood identified during the Specialist's investigation). In keeping with the respective Codes of Ethics of ABCFP and Engineers and Geoscientists BC, if in the course of a Watershed Assessment the Specialist discovers or determines that there is a material Risk to the environment or to the safety, health, and welfare of the public, the Specialist has a professional responsibility to draw this to the attention of the Forest Professional responsible for the project and, if necessary, to the authorities with jurisdiction over land use in the area.

### 3.10.2 FOREST PROFESSIONALS

The Forest Professional is responsible for the following:

- Setting out the scope of work with the Specialist, including:
  - confirming the study area;
  - developing terms of reference that are suitable for the intended purpose of the assessment, such as addressing specific concerns for a community water supply or for commitments made in an FSP;
  - identifying Values to be considered;
  - confirming with the Specialist how Consequences are defined;
  - determining whether the purpose of the Watershed Assessment is to provide guidance for forest planning, and whether it includes review of a specific proposed plan;
  - establishing the level of effort and method of field investigation;
  - deciding whether a phased approach will be used;
  - defining the scope of Risk Identification and Risk Analysis;
  - confirming with the Specialist how knowledge gaps are to be addressed (i.e., whether they are to be identified in the Watershed Assessment as a need for follow-up work, or whether the scope of the Watershed Assessment is to include these further investigations, inventories, or other Specialist assessments); and
  - confirming whether the assessment is to prescribe specific measures or to provide options to reduce or Mitigate identified Risks.
- If there are other Licensees or land owners in the Watershed Unit, informing the Specialist of whether field access to these lands is available, and whether arrangements have been made with the other Licensees or land owners to share information.
- If information is not being shared by other Licensees, confirming with the Specialist what information will be used, what level of effort will be required in investigating these other areas, and how these areas will be addressed in the Specialist's report.
- Putting in place an agreement with the Specialist as described in Section 2.8.1 Forest Professionals.

# 4.0 REFERENCES AND RELATED DOCUMENTS

Documents cited in Sections 1.0 to 3.0 of these guidelines appear in Section 4.1 References; documents cited in appendices appear in a reference list at the end of each corresponding appendix.

Related documents that may be of interest to users of this guideline but are not formally cited elsewhere in this document appear in Section 4.2 Related Documents.

## 4.1 REFERENCES


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## 4.2 RELATED DOCUMENTS

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# 5.0 APPENDICES

# APPENDIX A: LIST OF AUTHORS AND REVIEWERS

These guidelines were prepared by a Task Force comprising members of the Association of BC Forest Professionals (ABCFP) and Engineers and Geoscientists British Columbia Joint Practices Board.

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# APPENDIX B: LEGAL CONTEXT

This appendix summarizes the legal context for Watershed Assessments; the actual current legislation should be referred to for details. These guidelines were prepared between July 2015 and October 2018, and the statutes or policy statements discussed in this section may have changed since they were first referenced.

Only in the *Haida Gwaii Land Use Objectives Order* (Haida Gwaii Management Council and Province of BC 2010) and the *Great Bear Rainforest Order* (BC MFLNRO 2016) are Watershed and Hydrologic Assessments a specific legal requirement, which is triggered when certain thresholds are reached or before variations from the specified treatments can be made.

Elsewhere in the regulatory regime, Watershed or Hydrologic Assessments only become a legal requirement when they are committed to in an approved Forest Stewardship Plan on Crown land. Watershed or Hydrologic Assessments are not a requirement in any part of the regulatory regime governing forest operations on private forest lands.

The defined terms in this appendix are specific to these guidelines and are capitalized throughout the document. See the list of Defined Terms at the front of these guidelines for full definitions.

## B1 PROFESSIONAL ACTS AND BYLAWS

The bylaws of the Association of British Columbia Forest Professionals (ABCFP) and of Engineers and Geoscientists British Columbia (Engineers and Geoscientists BC) require Members to protect the environment and the health and safety of the public. These are obligations, regardless of who owns the land or how forest operations are regulated on that land. Watershed analysis and management help Members meet those obligations.

### B1.1 FORESTERS ACT AND BYLAWS

The ABCFP Code of Ethics (Bylaw 11.3.1) requires Members "to advocate and practice good stewardship of forest land based on sound ecological principles to sustain its ability to provide those Values that been assigned by society"; and (Bylaw 11.3.3) requires Members "to seek to balance the health and sustainability of forests, forest lands, forest resources, and forest ecosystems with the needs of those who derive benefits from [them]".

### B1.2 ENGINEERS AND GEOSCIENTISTS ACT AND BYLAWS

Principle 1 of the Engineers and Geoscientists BC Code of Ethics requires Members to "hold paramount the safety, health and welfare of the public, the protection of the environment, and promote health and safety within the workplace."

## B2 FOREST AND RANGE PRACTICES ACT AND REGULATIONS

The *Forest and Range Practices Act* [SBC 2002], Chapter 69 governs forest practices on Crown land. Section 150.2 gives the Lieutenant Governor in Council broad general powers for prescribing requirements in relation to community watersheds.

The *Government Actions Regulation* and *Forest Planning and Practices Regulation*, under the *Forest and Range Practices Act*, establish objectives for community watersheds and for fisheries-sensitive watersheds, and state the requirement of Forest Stewardship Plans to address these objectives.

Neither the *Forest and Range Practices Act* nor the regulations (*Government Actions Regulation*, *Forest Planning and Practices Regulation*) specify a requirement for Watershed Assessments to be completed; however, if a Forest Stewardship Plan commits to carrying out Watershed or Hydrologic Assessments as a means of meeting the objectives, then that commitment becomes a legal requirement upon approval of the Forest Stewardship Plan. Similarly, if a Forest Stewardship Plan commits to Watershed or Hydrologic Assessments as a means of meeting objectives in orders for higher-level land use plans, then they also become a legal requirement.

## B3 LAND ACT

Section 93.4 of the *Land Act* [RSBC 1996], Chapter 245 (referenced on February 22, 2016 for these guidelines) provides authority for the Minister to establish objectives for the purposes of the *Forest and Range Practices Act*. Objectives that were previously established under the *Forest Practices Code of British Columbia Act* are continued under Section 93.8 of the *Land Act*.

The land use objectives orders for Cariboo-Chilcotin, Clayoquot Sound, Haida Gwaii, and Great Bear Rainforest were made under the *Land Use Objectives Regulation* authorized by Section 93.4 of the *Land Act*. Higher level plan orders that continue from the *Forest Practices Code of British Columbia Act* include those for the Vancouver Island, Kootenay Boundary, and Revelstoke higher level plan areas. Some of these orders contain language specific to avoiding impacts to hydrologic and/or geomorphic processes.

For example, the Vancouver Island Land Use Plan Higher Level Plan Order designates enhanced forestry zones that are intended "to increase the short-term availability of timber," subject to a number of provisions, including not significantly impacting "specific hydrologic…values" and "avoid or mitigating adverse hydrologic impacts…in watersheds with significant sensitivity or significant fisheries values."

The Great Bear Rainforest and Haida Gwaii orders have provisions to protect fans and floodplains, and to sustain natural hydrologic processes. In these orders, fans and floodplains are protected regardless of whether or not they are fish-bearing.

## B4 HAIDA GWAII LAND USE OBJECTIVES ORDER AND GREAT BEAR RAINFOREST ORDER

The orders for both the Haida Gwaii and the Great Bear Rainforest ecosystem-based management areas (in the respective 2010 and 2016 versions referenced for these guidelines) set thresholds or prescribe minimum treatments for many objectives. For some objectives, it is possible to harvest above the thresholds or vary the treatment, provided certain conditions are met. One such condition is that Watershed or Hydrologic Assessments be completed by a qualified professional. The Great Bear Rainforest order (BC MFLNRO 2016) has such a provision in the objectives for important fisheries watersheds, Type 1 and Type 2 aquatic habitat, upland streams, and active fluvial units. The Haida Gwaii order (Haida Gwaii Management Council and Province of BC 2010) includes this provision in the objectives for upland streams and sensitive watersheds.

Specialists conducting Watershed Assessments should be aware that each order includes definitions specific to that order. The definitions are not necessarily the same for both orders, and are not necessarily the same as the conventional use of the term.

For example, an equivalent clearcut area in the Great Bear Rainforest order is defined to mean "an indicator that quantifies the percentage of the forested portion of a watershed that has been altered by harvesting, fires, insects or disease and has not recovered to a state of Hydrologically Effective Greenup"; whereas an equivalent clearcut area in the Haida Gwaii order is defined to mean "an indicator which expresses, as a percentage of an entire watershed, the degree to which

regenerating forest stands are hydrologically similar to clearcuts, relative to the hydrologic status of the original stands."

Similarly, the Great Bear Rainforest order defines an active fluvial unit to mean "an active floodplain, where water flows over land in a normal flood event, and includes low and medium benches and the hydrogeomorphic zone of an active fan." The Haida Gwaii order defines an active fluvial unit to mean "an active floodplain, where water flows over land in a 1 in 100 year flood event, and includes low and medium benches and the zone of an active fan where active hydrogeomorphic processes are currently evident or would likely be initiated if harvesting and/or road building were to occur."

## B5 PRIVATE MANAGED FOREST LAND ACT AND REGULATION

The *Private Managed Forest Land Act* [SBC 2003], Chapter 80, and the accompanying *Private Managed Forest Land Council Regulation* govern forest practices on private land that is classified as managed forest land under the *Assessment Act*.

Neither the act nor the regulation (referenced on July 7, 2015 for these guidelines) requires Watershed Assessments to be carried out; both have provisions for protecting water quality and fish habitat including specifying numbers and sizes of trees to be retained along streams.

## B6 DRINKING WATER PROTECTION ACT

The *Drinking Water Protection Act* [SBC 2001], Chapter 9 (referenced on July 7, 2015 for these guidelines), regulates drinking water supplies for the purpose of protecting public health. It does not require Licensees to undertake Watershed Assessments in water supply areas and does not impose limits on forest harvesting activities; but it does provide authority for a drinking water officer to order that a water supplier prepare an assessment of the drinking water source.

One of the purposes of the assessment is to assess threats to drinking water. Some of these assessments done by water suppliers have identified forest harvesting activities as a threat. The drinking water officer has broad powers under the *Drinking Water Protection Act* to order that assessments be done, to direct the scope of the assessment, and to order that joint assessments be done if more than one water supplier uses the same water source. The drinking water officer may also order the water supplier to prepare an assessment response plan if the source assessment identified threats to drinking water.

Part 4 of the *Drinking Water Protection Act* prohibits any person from introducing into a water supply any substance which could cause the owner of the water system to have to limit use of the water because of a possible threat to health. However, it specifically exempts this prohibition from applying to persons carrying out an activity that has been lawfully authorized or regulated by other regulations. Forest harvesting activities authorized under the *Forest and Range Practices Act* or under the *Private Managed Forest Land Act* would presumably fall under this exemption, because those acts have specific provisions for protection of drinking water sources. Additionally, Forest Professionals need to keep in mind their stewardship obligations with respect to the public benefit.

## B5 REFERENCES


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# APPENDIX C: SKILL SET FOR UNDERTAKING WATERSHED ASSESSMENTS

# SKILL SET FOR UNDERTAKING WATERSHED ASSESSMENTS

Members undertaking Watershed Assessments in BC (Section 3.0 Professional Practice in Watershed Assessment of these guidelines) should have the following skill sets. Note that in a particular Watershed Assessment, the required skill set will vary, depending on the key issues and the complexity of the watershed.

| | |
|---|---|
| 1.0 | BASIC REQUIREMENT |
| | Graduate degree in Science or Applied Science, or equivalent |
| 2.0 | SUBJECT AREAS AND EQUIVALENT LEVEL OF KNOWLEDGE |
| 2.1 | INTRODUCTORY UNIVERSITY-LEVEL COURSES OR TECHNOLOGY PROGRAM EQUIVALENTS |
| | Water resource science |
| | Air photo interpretation |
| | Field geology |
| | Field surveying/field techniques/field measurements |
| | Soil science/soil physics/forest soils/soil mechanics |
| | Slope stability analysis |
| | Weather and climate |
| 2.2 | INTRODUCTORY AND ADVANCED UNIVERSITY-LEVEL COURSES |
| | Forest Hydrology/engineering Hydrology/surface Hydrology |
| | Geomorphology/landforms/surficial geology/quaternary geology/fluvial Geomorphology |
| | Hydrogeology/groundwater geology/water quality |
| | Data analysis and statistics |
| 2.3 | GENERAL FAMILIARITY AND UNDERSTANDING OF SUBJECT MATTER |
| | BC Terrain Classification System/terrain stability mapping classification for forestry |
| | Biogeoclimatic Ecosystem Classification (BEC) system |
| | Forest access systems/forest harvesting systems/silvicultural systems |
| | Forest health/forest science/forest ecology/plant-water relationships |
| | GIS/CADD/cartography/digital information sources/modelling/remote sensing |
| | Aquatic habitats/fish biology/aquatic ecology |
| | Risk Assessment methods used in forest management |
| 2.4 | FAMILIARITY AND UNDERSTANDING OF SUBJECT MATTER, SPECIFIC TO REGION |
| | Relationships among Hydrology, meteorology, and terrain |
| | Soil characteristics and stability behaviour |
| | Fluvial processes and influences of vegetation, sediment input, and stream flow change |
| | Common road construction, harvesting, and silvicultural systems |
| | Landform characteristics and terrain response to road construction |
| | Types and causes of landslides associated with forest development |
| | Windthrow occurrence and influence on slope stability and stream channel morphology |
| 3.0 | FIELD EXPERIENCE |
| | Typically, a Member with suitable experience would have five years of experience relevant to watershed processes and forest Hydrology with a strong field component. Less-experienced Members should involve an appropriately qualified Specialist. |
| | Field experience in the region to gain an understanding of regional stream flow regimes; fluvial morphology, regional surficial geology, and stream channel response to disturbances caused by forest development |

NOTE: The defined terms in this table are specific to these guidelines and are capitalized. See the list of Defined Terms at the front of these guidelines for full definitions.

# APPENDIX D: EXAMPLE OF A WATERSHED RISK MANAGEMENT FRAMEWORK CHECKLIST

# EXAMPLE OF A WATERSHED RISK MANAGEMENT FRAMEWORK CHECKLIST

NOTE: This list provides examples only; other items may be required for a particular operating area.

| PRELIMINARY CHECKLIST FOR DEVELOPING A WATERSHED RISK MANAGEMENT FRAMEWORK | | | |
|---|---|---|---|
| Forest Professional: | *[name, position title]* | | |
| Other team members as applicable: | *[name, professional designation or position]* | | |
| Area/operations that WRMF is to apply to: | *[describe]* | | |
| **REGULATORY CONTEXT THAT APPLIES TO OPERATING AREA** | | APPLICABLE | ADDRESSED |
| – *Private Managed Forest Land Act*, *Forest and Range Practices Act*, and associated regulations | | | |
| – Land use orders *[list]* | | | |
| – Special designations (Community Watershed, Fisheries Sensitive Watershed, other) | | | |
| **OTHER MANAGEMENT CERTIFICATION AND MODELS *[LIST]*** | | | |
| – Environmental or organizational management certifications, ISO/CSA | | | |
| – Terrain stability management model | | | |
| **WATERSHED VALUES (OR CLASSES OF WATERSHED VALUES) *[LIST]*** | | | |
| – Human life and safety | | | |
| – Aquatic habitat (may have sub-classes, including channel and floodplain stability) | | | |
| – Community, agricultural, industrial, or commercial water supplies; licensed domestic water intakes | | | |
| – Infrastructure (e.g., highways, railways, pipelines, power lines, industrial facilities) | | | |
| – Communities or other non-forest development located on fans, in floodplains, or downstream or downslope of Licensee's activities | | | |
| – Forest Values (e.g., soil productivity, forest stands) | | | |
| **RISK TOLERANCE CRITERIA – CONSEQUENCES OF CONCERN FOR EACH OF THE VALUES, AND TOLERABLE RISK LEVELS** | | | |
| – For each Value, Consequences that the Licensee/Forest Professional considers unacceptable | | | |
| – Signing authorities in Licensee's organization for different levels of Risk | | | |
| – See examples in Appendix E of these guidelines | | | |
| **COMMUNICATIONS** | | | |
| – Internal in Licensee organization and external with Stakeholders and regulatory authorities | | | |
| – Other Licensees/forest land owners operating in the same watershed(s) | | | |
| **PROCESS FOR ASSESSING AND EVALUATING RISKS TO VALUES** | | | |
| – Policies/procedures for how to identify and analyze Risks, when to use Specialists, and what type of Specialist assessments to undertake, and for making Risk decisions | | | |
| **PRACTICES AND PROCEDURES FOR SITE WORKS TO LIMIT RISKS *[LIST]*** | | | |
| – Standard operating procedures for road construction and stream crossing structures, sediment management, and working around streams | | | |
| **OVERSIGHT AND QUALITY CONTROL FOR RISK CONTROL MEASURES *[LIST]*** | | | |
| – Policy/procedure setting out when oversight and quality control measures are needed to ensure that site works are done as intended in plans prepared by Forest Professionals or Specialists | | | |
| **SUPPORTING RESOURCES *[LIST]*** | | | |
| – Existing assessments and reports | | | |
| – Watershed geodatabase | | | |
| **REVIEWING AND UPDATING THE FRAMEWORK** | | | |
| – Timeframe or circumstances that would require review, updates, or revisions to the framework | | | |
| **OTHER CONSIDERATIONS SPECIFIC TO LICENSEE'S OPERATIONS** | | | |
| *Date* | *Comments* | | |

**NOTE**: The defined terms in this table are specific to these guidelines and are capitalized. See the list of Defined Terms at the front of these guidelines for full definitions.

# APPENDIX E: SUPPLEMENTARY EXAMPLES OF RISK ASSESSMENT

## E1 RISK IDENTIFICATION

Risk Identification involves identifying the Values that are present and any sources of harm or potential harm to those Values. Table E - 1 below gives an example of Risk Identification for a forest Licensee's operations in a watershed. In this example, the Licensee's land base in the watershed includes several separate parcels that are not contiguous; therefore, Risk Identification includes determining what Values are present and which of those would or would not be affected by the Licensee's operations.

The defined terms in this appendix are specific to these guidelines and are capitalized throughout the document. See the list of Defined Terms at the front of these guidelines for full definitions.

## E2 RISK ANALYSIS

Risk Analysis estimates the level of Risk to a Value as the nature of harm that could be done to the Value (the Consequence) combined with the Likelihood of that harm occurring.

Risk Analyses are done at several scales. "Strategic level," as used here, refers to assessments at a larger scale (for example 1:20,000), and are often primarily office-based with limited field reconnaissance. "Site level" refers to a finer scale (for example 1:5,000) used for harvest and road plans issued for the conduct of the activity, and involves more extensive field investigation.

Risk Analyses related to stream flows and stream flow change are done in watershed-scale assessments. Watershed Assessments also typically determine strategic-level Risk ratings for other disturbances and activities and identify where further Risk Analyses need to be done at the site level. However, there may be times when a Forest Professional chooses to include certain site-level investigations and Risk Analysis in the scope of a Watershed Assessment. Table E - 2: Examples of Risk Analyses Done at Strategic and Site Levels for Planning of Forest Management Activities gives examples of strategic and site-level input to Risk Analysis.

Risk matrices similar to Figure E - 1: Conceptual Risk Diagram can be a useful tool for preliminary Risk screening, or for conceptually representing categories of acceptable and unacceptable Risk for various Values. They are constructed by defining categories of different severity for Values or Risk Elements, such that each square in Figure E - 1 corresponds to a defined Risk category.

Risk relationships and Risk matrices may be expressed differently for different Values. Examples of matrices used in British Columbia (BC) for analyzing Risks are in Wise et al. 2004, BC MOF 2002, and BC MOFLNRO 2018. The Public Infrastructure Engineering Vulnerability Committee (PIEVC 2011) uses Risk matrices to estimate level of Risk according to a scoring procedure, then goes on to more advanced Risk Evaluation for high Risk categories. Other agencies such as the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development and the BC Ministry of Transportation and Infrastructure are also developing guidance for estimating Risk and incorporating climate change effects into design of infrastructure.

Risk Analysis often requires more specific determination of Consequences and the nature of harm than is conceptually represented in simple Risk matrices. When a Forest Professional retains a Specialist to do a Risk Analysis, it is important that the Forest Professional and the Specialist understand and agree on the scope and level of effort of the analysis;

for example, whether it is to be a partial or more detailed Risk Analysis and to what extent Consequences are to be determined. Table E - 3: Examples Identifying Consequences of Concern to Assist with Risk Analysis gives examples of Consequences of concern identified for the purpose of estimating Risk levels and setting Risk Tolerance Criteria.

## E3 RISK EVALUATION

Risk Evaluation compares the Risk level estimated in Risk Analysis with Risk Tolerance Criteria, to determine if the Risk is acceptable, tolerable, or unacceptable. Risk control measures typically are directed at reducing either the Likelihood of occurrence or the severity of the Consequence.

Risk Evaluation and selection of Risk control measures often require greater consideration of the possibility and practicability of mitigative or remedial measures than can be determined from Risk matrices. A "critical questions" approach can be helpful to Risk Analysis, Risk Evaluation, and selection of Risk treatments.

Following are examples of questions to ask when assessing Risk:

- What is the Vulnerability of the Value to identified sources of Risk?
- What is the nature of harm and the potential magnitude and duration of harm?
- Would the Value be rendered unusable or unsafe?
- What is the potential cost Consequence to the Licensee?
- Are harm mitigation or remediation measures feasible?
- Is the Value transferable?
- What are the uncertainties in the Risk Assessments and in the possible harm mitigation or remediation measures?
- What is the potential for damage to the Licensee's corporate reputation?
- What is the Likelihood of success of harm mitigation measures over the short and long term?
- If harm mitigation measures rely on practices or standard operating procedures, what is the track record at achieving the intended results?
- Are oversight and quality control measures in place to be sure that the mitigation measure being relied upon will be carried out as intended?

## E4 EXAMPLES OF RISK TOLERANCE CRITERIA

Several BC municipalities (North Vancouver, Squamish, and Chilliwack) have adopted quantitative geohazard Risk criteria, primarily related to human fatalities and residences (Engineers and Geoscientists BC 2010 and 2012).

When Risks to residences and other infrastructure with human safety Risk Elements (for example, highways, other occupied buildings) are present, the Forest Professional can refer to these precedents in developing Risk Tolerance Criteria.

*Table E - 1: Example – Risk Identification for ACME Ltd. Operations by Watershed Unit for Rapid River Watershed*

| WATER-SHED UNIT | TOTAL AREA | ACME AREA | | RISK ELEMENTS | POTENTIAL TO BE AFFECTED BY ACME OPERATIONS |
|---|---|---|---|---|---|
| | ha | ha | % | | |
| **Total Watershed** | 23,500 | 7,385 | 31% | Anadromous and resident fish habitats | Potential to be affected by riparian condition along streams on ACME land; by sediment from ACME operations upslope and upstream from fish habitat; and by increased peak flows or shifts in timing of stream flows from ACME harvesting.<br>*NOTE: Land use activities by other forest Licensees and landowners also have the potential to affect fish habitat in the watershed (sediment, riparian, stream flows).* |
| **Lower Valley** | 3,500 | 0 | 0 | Rural residential, agriculture lands on floodplain<br>River crossings on floodplain (highway, railway, pipeline, public road) | Potential to be affected by increased flood magnitudes and/or flood frequencies caused by harvesting on ACME lands upstream.<br>*NOTE: Land use activities by other forest Licensees and landowners also have the potential to affect peak flows in the floodplain.* |
| **Mid-Valley** | 3,000 | 180 | 6% | Reservoir on tributary creek | Not affected by ACME activities; ACME does not have operating area upslope or upstream of the reservoir. |
| **Upper Valley** | 5,500 | 2,200 | 40% | Investment in in-stream restoration works | Potential to be affected by windthrow and sediment from ACME's adjacent operations. |
| **Basin 1** | 8,000 | 4,480 | 56% | Power transmission line | Potential to be affected by harvesting of steep terrain on ACME land upslope of towers. |
| **Basin 2** | 3,500 | 525 | 15% | Water intake and reservoir, property of others | Potential to be affected by sediment or landslides from ACME roads upslope of these Risk Elements.<br>*NOTE: Land use activities by other forest Licensees and landowners also have the potential to affect these Risk Elements.* |

**NOTE**: The scope of a particular Watershed Assessment may not include Risk Analyses for all Values in the watershed. The Forest Professional still has responsibility for managing Risk to all Values.

*Table E - 2: Examples of Risk Analyses Done at Strategic and Site Levels for Planning of Forest Management Activities*

| SOURCE OF RISK | STRATEGIC LEVEL AND SITE LEVEL INPUT TO RISK ANALYSIS |
|---|---|
| Stream flow change:<br>• Increased peak flows<br>• Decreased low flows<br>• Shifts in timing of flows | Watershed Assessment: Estimates potential for stream flow change and Risk Analysis for effects on watershed Values; part of comprehensive watershed scale assessment<br>Hydrologic Assessment: Risk Analysis of stream flows only; does not include other aspects of Watershed Assessment |
| Possible landslides from existing roads affecting Values | Watershed Assessment: Provides strategic-level identification of landslide Likelihood for existing road sections and Values that could be affected<br>Site-level assessment: Risk Analysis from field geotechnical assessment of road condition to analyze Risk and prescribe remedial measures |
| Hydrologic and geomorphic processes affecting Values on fans | Watershed Assessment: Provides strategic-level identification of fan landforms, Values on fans, and geomorphic/ hydrologic processes in catchment area upstream of fan<br>Site-level assessment: Risk Analysis from field investigation to estimate Likelihood of debris flows/debris floods initiating and affecting Values on fan (LMH 57, LMH 61) |
| Windthrow in riparian buffers along cutblock boundaries | Watershed Assessment: Provides strategic-level identification of windthrow occurrence and effects on existing riparian buffers; potential to affect stream channels<br>Site-level assessment: Risk Analysis done in windthrow assessment of cutblock boundaries |
| Sediment sources affecting water intake or fish habitat | Watershed Assessment: Provides strategic-level identification of sediment sources, connectivity to stream, and Likelihood of affecting intake (e.g., landslides, roads, eroding stream escarpments, channel sediment, runoff from haul roads)<br>Site-level assessment: Risk Analysis from field investigation of individual sediment sources to streams, to estimate Risk levels and prescribe measures for managing sediment (e.g., sediment management plan for haul roads) |
| Collective effects of multiple Risk sources | Watershed Assessment: Identifies interactions between hydrologic/geomorphic processes and forest /non-forest development; provides strategic-level Risk ratings for combined effects<br>Site-level assessment: Risk Analysis from field investigation of sites potentially affected by these interactions. |
| Climate change | Watershed Assessment: Provides strategic-level view of climate change effects on hydrologic/geomorphic processes; e.g., changes in snowpack, precipitation, storm intensity, timing of snowmelt, length of low water periods; and the potential for these changes to affect Values<br>Risk Analysis: Select time frame relevant to the Value; e.g., Risks to temporary culverts may be low, whereas Risks to bridges with a long life span may be significant to bridge design |

*Table E - 3: Examples Identifying Consequences of Concern to Assist with Risk Analysis*

Note: This table presents examples only and does not imply an intended Risk tolerance.

| VALUES/RISK ELEMENTS | CONSIDERATIONS | CONSEQUENCES OF CONCERN | LICENSEE'S INTENDED OUTCOME |
|---|---|---|---|
| Public safety, public infrastructure, facilities, occupied buildings | Civil or even criminal liability<br>No remedy for loss of life<br>Potentially high financial costs to remedy damage or loss | Possible injury or loss of life<br>Destruction of Risk Element<br>Damage to Risk Element | No injury or loss of life<br>Damage or loss of facilities or infrastructure kept within defined limits |
| Community water intake | Legal liability<br>Potential costs to remedy damage or need for increased treatment | Physical damage to water intake<br>Prolonged turbidity event | Avoid liability to Licensee of increased treatment costs or damage to treatment facilities |
| Instream restoration works or research monitoring sites | Loss of investment<br>Remedies may or may not be possible<br>Legal liability if instream work | Destruction of instrumented monitoring sites<br>Destruction of instream restoration works | Loss of investment is avoided<br>Violations of applicable environmental legislation are avoided |
| Mainline forest roads with public use | Extent of public use, importance of road link<br>Remedy: access can be restored | Unsafe conditions for road users<br>Access cut off to community or high public use area | Safe road conditions and/or loss of access restored within a defined time frame |
| Habitat critical to fish life processes | Legal liability (provincial and federal legislation)<br>Remedies may or may not be possible | Material adverse effect, permanent destruction of habitat, degradation of habitat that is more than transitory | Violations of applicable environmental legislation are avoided<br>Habitat degradation is not sustained past a defined period |
| Riparian buffer for LWD, channel stability | LWD may enter stream reach from upstream or upslope sources<br>Effect on channel stability depends on extent of loss of riparian buffer | Channel erosion, instability resulting from loss of riparian buffer<br>Loss of long-term LWD supply | Loss of riparian buffer does not result in channel instability<br>Sufficient long-term supply of LWD is maintained |

**NOTE**: LWD = large woody debris

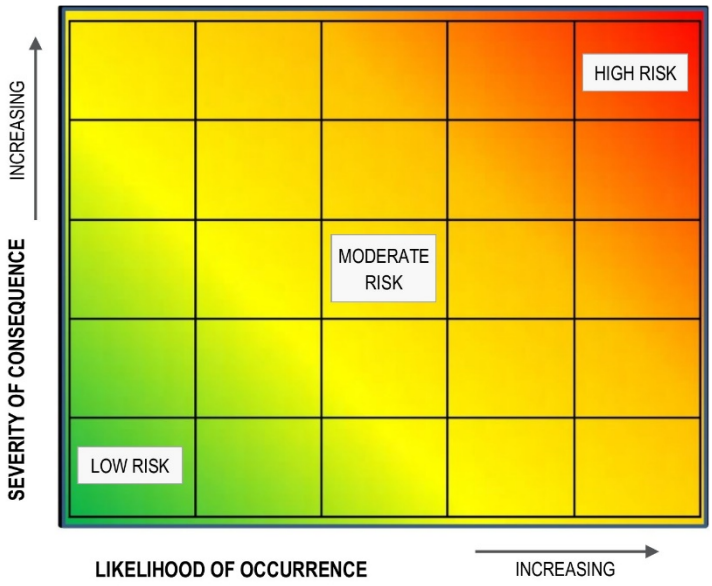


*Figure E - 1: Conceptual Risk Diagram*

Note: Adapted from PIEVC 2011, Figure 6.

## E5 REFERENCES

BC Ministry of Forests (BC MOF). 2002. Forest Road Engineering Guidebook. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. [Appendix 10]. https://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/Road/FRE.pdf.

BC Ministry of Forests, Lands and Natural Resource Operations (BC MOFLNRO). 2018. Engineering Manual. [Appendix 6.1]. Victoria, BC: MOFLNRO.

Engineers and Geoscientists BC. 2010. Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia. [Appendix C]. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2019 Apr 16]. https://www.egbc.ca/Practice-Resources/Professional-Practice-Guidelines.

Engineers and Geoscientists BC. 2012. Guidelines for Legislated Flood Assessments in a Changing Climate in BC. [Section 3.7.3 and Appendix F, Section 5.1]. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2019 Apr 16]. https://www.egbc.ca/Practice-Resources/Professional-Practice-Guidelines.

Public Infrastructure Engineering Vulnerability Committee (PIEVC). 2011. Engineering Protocol. Ottawa, ON: Engineers Canada.

Wise MP, Moore GD, VanDine DF (editors). 2004. Landslide Risk Case Studies In Forest Development Planning and Operations. B.C. Min. For., Res. Br., Victoria, B.C. Land Manage. Handb. No. 56. 116 pp.

## E6 RELATED DOCUMENTS

BC MFLNRO. 2013. Review of Landslide Management in British Columbia. Province of British Columbia. Internal document (unpublished). 59 pp.

# APPENDIX F: HYDROLOGIC ASSESSMENTS

This appendix should be read in conjunction with Section 1.0 Introduction of these guidelines.

The defined terms in this appendix are specific to these guidelines and are capitalized throughout the document. See the list of Defined Terms at the front of these guidelines for full definitions.

## F1 PURPOSE AND SCOPE OF HYDROLOGIC ASSESSMENTS

A Hydrologic Assessment is not a comprehensive Watershed Assessment. Hydrologic Assessments are carried out to investigate site-specific concerns related to a disturbance (natural or development-related) that has occurred, or to assess the potential impacts from development or an event that has not yet occurred.

A Hydrologic Assessment is an investigation of a specific area, site, process, or event within a Watershed Unit; for example:

- assessment of a specific watershed process such as stream flow;
- assessment of a specific area within a Watershed Unit, such as an individual or group of cutblocks (e.g., in order to meet the objectives of land use plans or address a specific issue);
- assessment of the effects of a hydrologic or geomorphic event such as an extreme flood on a specific Risk Element, such as a water intake, structure, constructed spawning channel, or high Value habitat reach;
- assessment of the potential effect of a proposed cutblock or road on a specific Risk Element; and
- assessment of specific feature such as a fan or floodplain to determine the hydrogeomorphically or fluvially active portion of the feature so as to assess the Risk to Values on the feature and/or to develop appropriate strategies for harvesting or road construction (Wilford et. al 2005, Wilford et. al 2009).

Depending on the purpose of the assessment, the scope could vary widely. A Hydrologic Assessment could be based on air photo interpretation and review of office information, or it could include detailed field work.

A Hydrologic Assessment should:

- clearly define the purpose and scope of the project;
- choose a methodology and level of effort appropriate for the project objectives and scope of the study;
- compile and use relevant background information;
- conduct field investigation appropriate for the purpose of the project;
- define terms used, references or manuals referred to, and protocols followed for classification conventions;
- evaluate and synthesize background materials, analyses, and field findings;
- develop rationales clearly linked to findings in the investigation;
- connect conclusions and results to the purpose of the project; and
- state assumptions, uncertainties, and limitations of the study, including the need for follow-up work.

## F2 THE WATERSHED UNIT

If the study area is not an entire Watershed Unit above a Point of Interest, then the subject site should be put into the context of the Watershed Unit in which it is contained.

Watershed hydrologic characteristics should be described, at least at an overview level; for example, regional climate zone and typical peak flow regime (snowmelt, rain, rain-on-snow) or biogeoclimatic zone. Relief features that may influence stream flows or the site or stream reach in question, such as lakes, ponds, wetlands, artificial flow controls, diversions, stormwater systems, or water extraction, should be noted. The extent of existing land use modification (residential, commercial, industrial, agricultural) throughout the Watershed Unit may be important.

It is helpful to include a map delineating approximate boundaries of the Watershed Unit and showing the study area within that Watershed Unit.

The intent of considering the study area in the context of the Watershed Unit is:

- to understand the relative importance of the subject site, even if it is a small site; for example, in a Watershed Unit that has been extensively impacted by human activities or natural processes, small intact stream reaches may have a disproportionate importance for fish habitat;
- to identify whether changes in the assessment area caused by operations could have an impact on Values downstream in the Watershed Unit;
- to identify whether changes anticipated in the assessment area caused by operations will contribute to cumulative effects downstream; and
- to identify whether processes elsewhere in the Watershed Unit could affect or are affecting the subject site.

Depending on the nature of the study and its purpose, more in-depth discussion of watershed processes, or involvement of a Specialist, may be needed to properly assess the significance of the site of interest.

## F3 HYDROLOGIC ASSESSMENTS OF PROPOSED CUTBLOCKS

Hydrologic Assessments of proposed cutblocks are often done in response to objectives set in higher level plans, such as in enhanced forestry zones. Depending on the site, the primary concern may be water quality and/or water quantity (flow), fish habitat condition, or cumulative effects on streams downslope or downstream of the cutblock.

A Hydrologic Assessment in a large block, such as in an enhanced forestry zone, may address the following:

- The potential for greater extent of “green” roads, more stream crossings, and greater transport of sediment from ditches and road crossings into small streams
- Increased sediment transport to streams and increased scour or erosion in small streams due to increased runoff
- Greater lengths of riparian buffers exposed to windthrow
- Additional factors that should be considered in a terrain stability assessment, such as the greater extent of harvested steep slopes that may be subject to post-harvesting landslides, and the greater lengths of boundaries along gullies or escarpments that could increase the Likelihood of boundary-edge landslides or gentle over steep landslides

Hydrologic Assessments of proposed cutblocks should consider the following:

- Potential effects on downstream Values/Risk Elements
- Whether there are specific watershed management strategies in place from previous plans or Specialist assessments, and whether they still reasonably represent the current condition of the Watershed Unit containing the subject site
- Whether the proposed operations may contribute to unacceptable cumulative effects; for example, by considering how significant the proposed operation is relative to processes upstream and downstream

Field work for a Hydrologic Assessment of a cutblock may need to extend to examination of downstream sites and/or Values.

## F4 LIMITATIONS AND QUALIFICATIONS OF ASSESSMENT

The report should indicate the limitations of the assessment. Examples of items typically addressed under limitations include the following:

- The standard of care followed while carrying out the assessment
- The level of confidence in different aspects of the assessment
- Factors that may have limited the assessment, such as restricted access, quality of background information, terrain, or weather conditions at the time of the field work
- Restriction of the use of the report to the client for its intended purpose

Some aspects of Hydrologic Assessments may be qualitative and subjective based on observed conditions. The report should distinguish between what is fact—that which is physically observed, measured, and verifiable; what is inferred from observations of physical conditions, data analysis, or findings in the scientific literature; and what is uncertain or unknown.

A Hydrologic Assessment cannot be relied on in perpetuity. Although the Member should attempt to anticipate reasonable changes that could affect the results of the assessment, the length of time the assessment will be valid depends on natural processes that occur over time; or on changes in land use or site development not anticipated in the assessment. The Member should indicate over what time frame and under what conditions the Hydrologic Assessment will apply, and what circumstances may render the assessment no longer reflective of the site conditions.

## F5 EXAMPLE CHECKLIST FOR HYDROLOGIC ASSESSMENT REPORTS

Checklists and templates are valuable tools in quality control of professional work. Table F - 1 below includes examples of checklist points for the content of a Hydrologic Assessment report.

The information may be presented under different headings or in a different order. Not all may apply to a particular report. Content of standard templates used for reports should be checked in every case, to be sure that the content is relevant and accurate for the particular assessment.

*Table F - 1: Example Checklist For Hydrologic Assessment Reports*

| REPORT SECTION | SUGGESTED CONTENT |
|---|---|
| INTRODUCTION | ☐ Client or employer (the person who commissioned the assessment)<br>☐ Physical site location<br>☐ Purpose and scope of assessment (be specific)<br>☐ Question(s) the client/employer wants answered<br>☐ List of project tasks and level of effort<br>☐ Values to be considered (e.g., fish, water intake, infrastructure, property of others, buildings)<br>☐ If the author notices public health, safety, and/or environment concerns outside the scope of the assessment, how and by whom are they to be addressed |
| ASSESSMENT TEAM | ☐ Primary author and reviewer<br>☐ Other team members (if applicable)<br>☐ External peer reviewers (if applicable) |
| INFORMATION USED IN THE ASSESSMENT | ☐ Include the source, date, and scale for all information<br>☐ Imagery (type, scale, and date), spatial data, climate/Hydrometric information, fish data, topographic mapping, bedrock/surficial geology, inventories (e.g., watersheds, streams, soils, vegetation, terrain, fish), previous reports or studies, surveys by others<br>☐ Information provided by client/employer |
| METHODS | ☐ Any documents or reference sources, such as guidelines, handbooks, technical bulletins, or terminology conventions that were followed or referred to with respect to specific aspects of the assessments<br>☐ Extent of field investigation, dates of field work, who conducted the field work, means of access (e.g., vehicle, all-terrain vehicle, on foot, helicopter), methods of field measurements (e.g., range finder, hip chain, tape measure, hand-held inclinometer)<br>☐ Conditions at the time of field assessment (e.g., high flow, low flow, raining, snowing, ground conditions clear, some snow cover present)<br>☐ Methods of analyses<br>☐ Any limitations that affected the assessment (e.g., access to private property of others, physical barriers, grown in, snow cover, washouts, high stream flows, availability or quality of information) |
| WATERSHED OVERVIEW | ☐ Size, topography, relief, general climatic/hydrologic environment, existing land uses, waterbodies (e.g., streams, lakes, wetlands, ponds)<br>☐ Indicate the subject site in the context of the watershed, if the study does not encompass the entire watershed<br>☐ Watershed character and disturbances (e.g., mass wasting, landslides, wildfires, erosion, road conditions, significant zones for hydrologic response [e.g., elevation zones, aspects], stream channel types and condition, floodplains, fans, riparian condition, forest cover)<br>☐ Conditions potentially affecting hydrologic response or channel hydraulics (e.g., existing channel or floodplain alteration, armouring, diversions, channel constrictions, instream structures, pipes/effluent, culverts, flow controls or diversions, water extraction) |
| ANALYSES – EXAMPLES (AS APPLICABLE) | ☐ Climate and Hydrometric data<br>☐ Hydrologic Recovery<br>☐ Risk to Values of interest |

| REPORT SECTION | SUGGESTED CONTENT |
|---|---|
| RESULTS/CONCLUSIONS | ☐ Should follow logically from background material, field observations, and analysis<br>☐ Should refer back to project objectives<br>☐ Should include rationales for judgments made |
| RECOMMENDATIONS OR OPTIONS TO MANAGE RISK | ☐ Should follow logically from results and conclusions<br>☐ Should refer back to project objectives |
| LIMITATIONS | ☐ Should indicate any factors that may have limited the assessment<br>☐ Typically restrict the use of the report to the client/employer for its intended purpose<br>☐ Indicate over what time frame and under what the conditions the assessment will apply, and under what circumstances it may no longer represent site conditions |
| FIGURES, MAPS, AND TABLES | ☐ Typically includes a location map showing the subject site(s) relative to watershed boundaries and other important features<br>☐ May include tables presenting, for example, climate or Hydrometric data, field data for stream reaches<br>☐ May include photographs, indicating date taken, direction facing (upstream/downstream, compass direction), and an object to show scale in the photograph, where appropriate |
| ASSURANCE STATEMENT | ☐ To be signed and submitted along with final report |

## F6 REFERENCES


Wilford DJ, Sakals ME, Grainger WW, Millard TH, Giles TR. 2009. Managing forested watersheds for hydrogeomorphic risks on fans. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. 61. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh61.htm.

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# APPENDIX G: ASSURANCE STATEMENTS

This appendix contains examples of the following documents:

- Watershed or Hydrologic Assessment Assurance Statement – Registered Professional
- Supporting Specialist Assurance Statement – Registered Professional
- Supporting Specialist Assurance Statement – Specialist other than Registered Professional

# WATERSHED OR HYDROLOGIC ASSESSMENT
# ASSURANCE STATEMENT – REGISTERED PROFESSIONAL

**Note:** This Statement is to be read and completed in conjunction with the *Professional Practice Guidelines – Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector* and is to be provided for Watershed Assessments or Hydrologic Assessments.

To: [the client] Date: _____

_____

_____
Name and designation

With reference to the following project area:

_____
Name and location of project area

The undersigned hereby gives assurance that he/she is a Registered Professional:

Name of Registered Professional: _____

Professional designation: _____

Professional association: _____

I have signed, sealed and dated the attached

- ☐ Watershed Assessment report, or
- ☐ Hydrologic Assessment report

in general accordance with the *Joint Professional Practice Guidelines – Watershed Assessment and Management of Hydrologic and Geomorphic Risk in the Forest Sector* and the scope of work in **Attachment A**.

| Signature, seal, and date |
| --- |
| |

# SUPPORTING SPECIALIST ASSURANCE STATEMENT – REGISTERED PROFESSIONAL

To: [the client] Date: _____

_____

_____
Name and designation

With reference to the following project area:

_____
Name and location of project area

The undersigned hereby gives assurance that he/she is a Registered Professional:

Name of Specialist: _____

Professional designation: _____

Professional association: _____

This is to advise that I have completed the following work [or attachment with scope of work], and have submitted signed and sealed documents to the client in respect of the work completed by me:

_____

_____

I confirm that I have liaised as required with the client, lead Specialist, or Forest Professional for the purposes of my services.

I hereby give my assurance that I am a Registered Professional and that the work undertaken on this project by me falls within my area of professional expertise.

| Signature, seal, and date |
| --- |
| |

# SUPPORTING SPECIALIST ASSURANCE STATEMENT – SPECIALIST OTHER THAN REGISTERED PROFESSIONAL

To: [the client] Date: _____

_____

_____
Name and designation

With reference to the following project area:

_____
Name and location of project area

The undersigned hereby gives assurance that he/she has the following qualifications for the work undertaken:

Name of Specialist: _____

Area of specialization: _____

Qualifications: _____
*Include relevant academic background, certifications or technical memberships, as applicable. Attach additional documents if needed.*

This is to advise that I have completed the following work [or attachment with scope of work], and have submitted such records to the client as he/she requested in respect of the work completed by me:

_____

_____

I confirm that I have liaised as required with the client, lead Specialist, or Forest Professional for the purposes of my services.

I hereby give my assurance that I am qualified and competent to carry out the work I have undertaken on this project.

| Signature and date |
| --- |
| |

# NOTES:

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