**Methodology:**

# Morice and Upper Bulkley Fisheries Sensitive Watershed Process


Lower Owen Creek Watershed

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March 31, 2011

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# EXECUTIVE SUMMARY

The Ministry of the Environment is working with Ministry of Forests and Range's Landbase Invest (LBI) program to guide the application of silviculture and/or other watershed restoration activities to benefit recovery or reduce impacts in high priority watersheds in the Morice TSA. In addition, the Ministry of Environment is in the process of designating Fisheries Sensitive Watersheds (FSW) under the Forest and Range Practices Act (FRPA) to provide effective aquatic habitat protection and maintain conditions that sustain fish populations. The Ministry of the Environment retained the services of *P. Beaudry and Associates Ltd* to assist in the identification of potential FSW candidates and develop management objectives for those selected watersheds.

The general objectives of this project are as follows:

***1)*** Identify an initial set of 25 watersheds located in the upper Bulkley and Morice watersheds that have some potential to be designated as a Fisheries Sensitive Watershed due to its significant downstream ***fisheries values*** and significant ***watershed sensitivity*** (Figure 1).

***2)*** Complete a rapid review the bio-physical characteristics of each of the 25 watersheds and select the top twelve candidates for FSW designation which are to be brought forward for consideration by a FSW selection round table (Figure 2).

***3)*** Provide an opportunity for public and other agency review of the twelve selected FSW candidates in the form of a two day workshop.

***4)*** Through the workshop process select the top 5 FSW candidates for further analysis of their biophysical conditions and complete the detailed scoring of sensitivities, hazards and risks for each watershed (Figure 3).

***5)*** Based on the completed watershed analysis of the five watersheds, recommend management objectives for each of the five watersheds that are appropriate for the Fisheries Sensitive Watershed legislation, and

***6)*** Provide watershed level guidance on both the extent and type of stand rehabilitation activities that are suitable to aid the recovery hydrologic function in consideration of landscape condition, existing and future hazards and resources at stake.

These objectives were achieved by first completing a quick overview risk assessment of the 25 "first-pass" watersheds, provided by the Ministry of the Environment (MoE), with the objective to reduce the number of candidate watersheds to twelve, i.e. those watersheds having the most significant downstream ***fisheries values*** and most significant ***watershed sensitivity***. Once selected, the characteristics of these 12 watersheds were discussed with MoE and then be brought forward by MoE to the participants of a two day workshop held in Smithers on February 2 and 3, 2011. The workshop, organized by MoE, focused on the characteristics and sensitivities of these twelve watersheds and workshop discussions were used to reduce the list down further to five watersheds with the intention of bringing these forward for FSW designation.

A more comprehensive risk analysis was then completed for each of the five selected watersheds and management strategies were developed for the protection of fish and their

habitats for these 5 watersheds recognized as having both significant downstream ***fisheries values*** and significant ***watershed sensitivity.*** This was completed within the constraints of the Fisheries Sensitive Watershed legislation.

The watershed ***risk*** assessments used for this project are based on: 1) the physical and biological ***sensitivity*** of the watershed and 2) the natural and anthropogenic ***hazards*** that are found within that watershed. A full description of this methodology is provided in Appendix 1 of this document.

Risk can be defined as the probability of harmful consequences resulting from interactions between natural or human-induced hazards and the sensitivity of a particular environment to a given hazard (or set of hazards). Risk is conventionally expressed by the following relationship:

**Risk** = Hazard * Sensitivity, where:

**Hazard** = a source of potential danger, and
**Sensitivity** = the responsiveness of a system to a particular hazard.

One of the main products of this project is the risk rating for each of the 5 watersheds. These **risk** ratings identify the probability of harmful consequences to fish and their habitat resulting from the interactions between natural and human-induced hazards and the sensitivity of that particular watershed to a set of identified hazards. Three risk ratings were assessed for each of the 5 watersheds, which included:

1) Risks of deterioration of fish habitat caused by increases in peak flows associated with watershed disturbances.

2) Risk to fish and their habitats caused by increased delivery of fine sediments to the aquatic environment, associated with watershed disturbances, and

3) Risks to fish and their habitat caused by a loss of riparian function associated with watershed disturbances.

Five individual watershed reports were produced that describe the biophysical conditions of each of the watersheds, provide the sensitivity, hazards and risks ratings within each watershed and also provide some management recommendations.

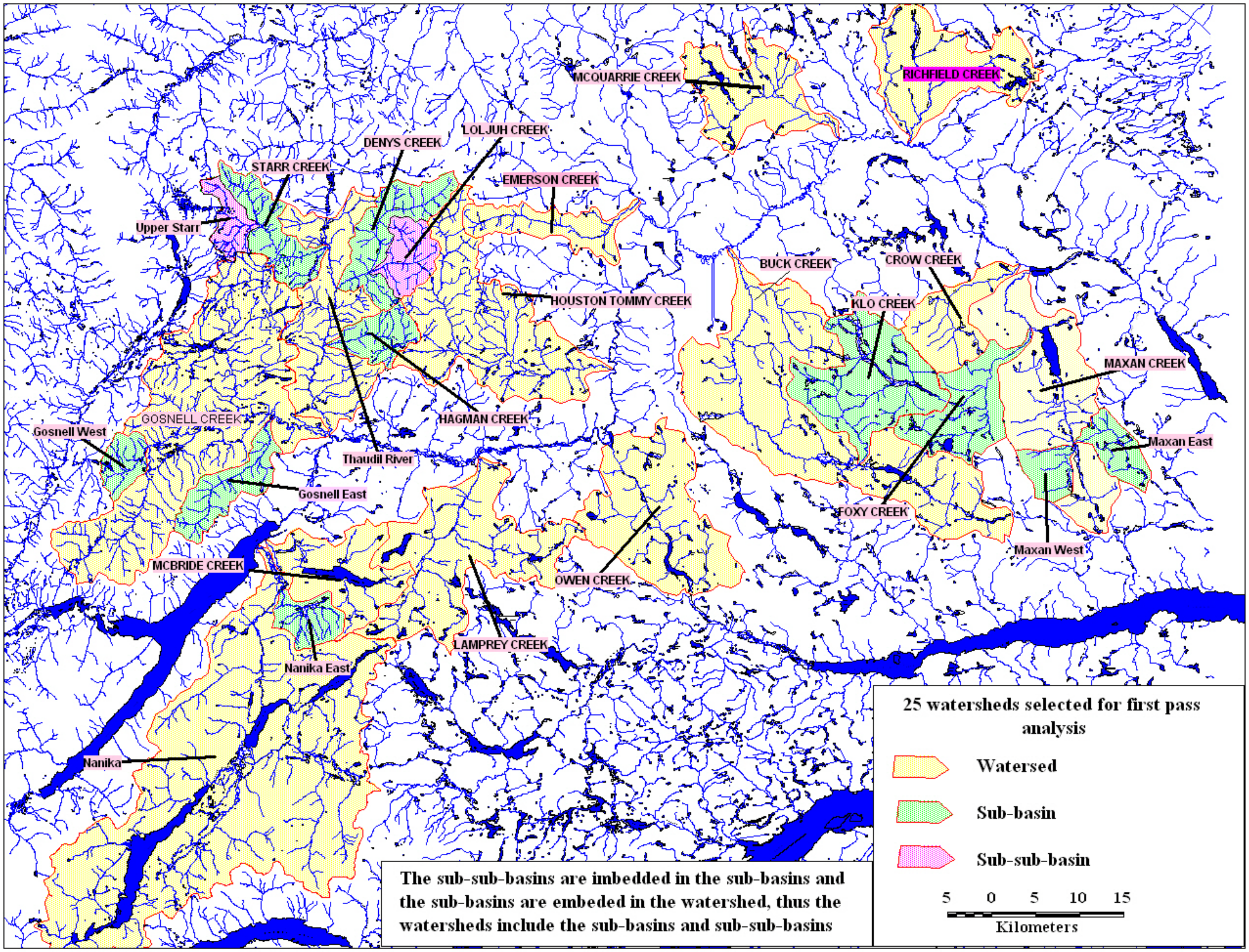


Figure 1. General location of the first 25 candidate Fisheries Sensitive Watersheds (FSW) within the Upper Bulkley – Morice watersheds.

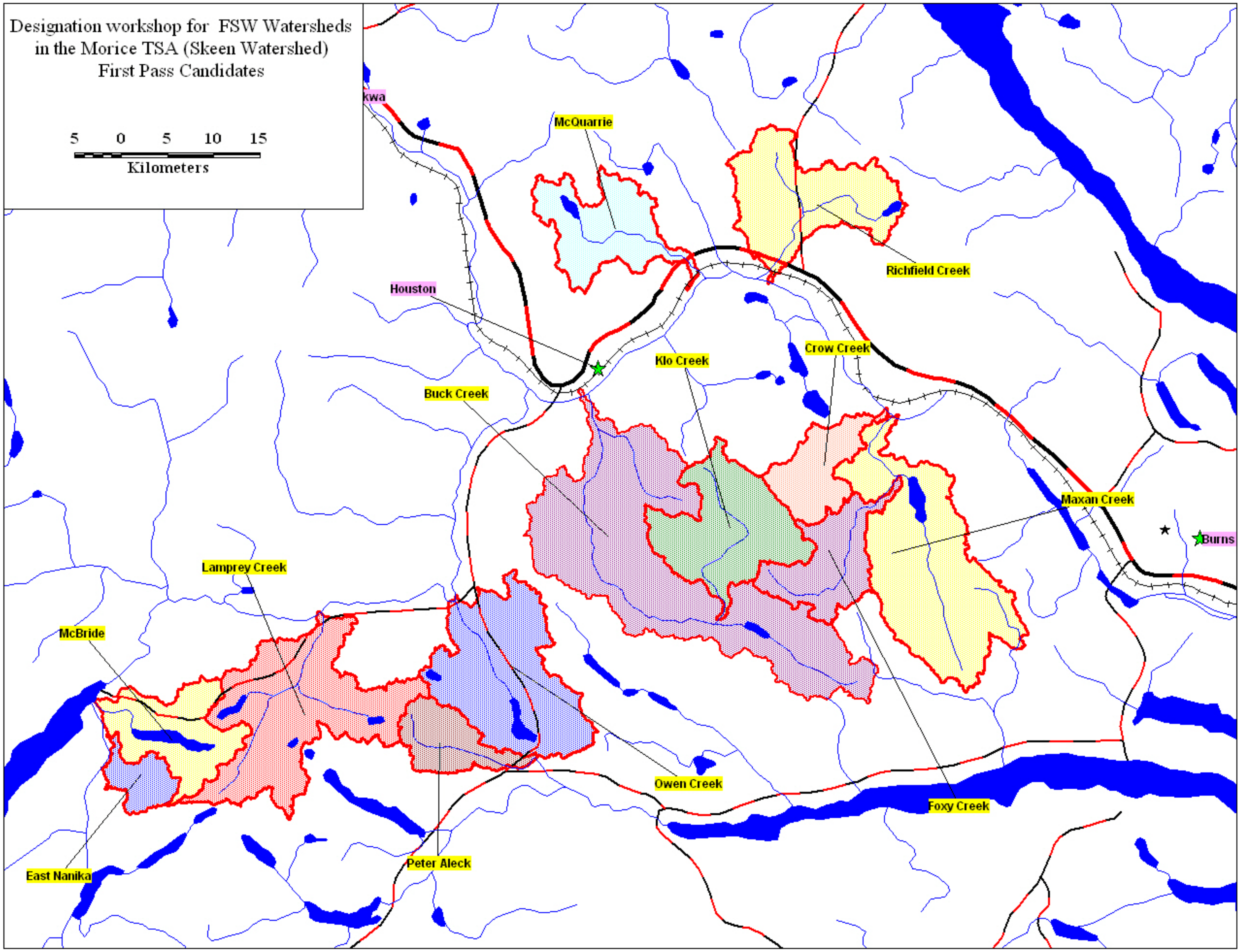


Figure 2. General location of the twelve watersheds brought forward to the FSW workshop of February 2 and 3, 2011. .

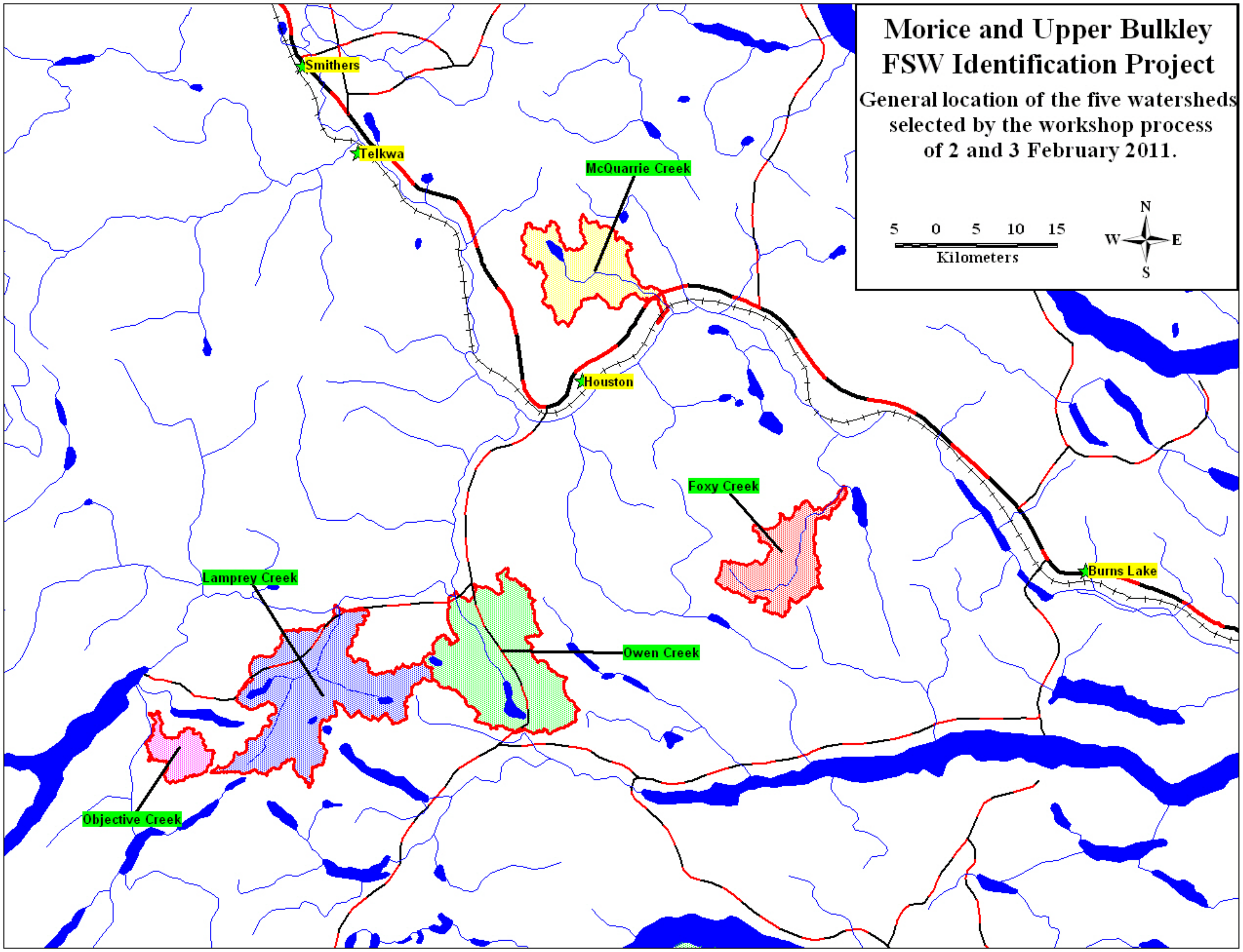


Figure 3. General Location of the five watersheds selected through the FSW workshop process.

## 1.0 INTRODUCTION

The Ministry of the Environment is working with Ministry of Forests and Range's Landbase Invest (LBI) program to guide the application of silviculture and/or other watershed restoration activities to benefit recovery or reduce impacts in high priority watersheds in the Morice TSA. In addition, the Ministry of Environment is in the process of designating Fisheries Sensitive Watersheds (FSW) under the Forest and Range Practices Act (FRPA) to provide effective aquatic habitat protection and maintain conditions that sustain fish populations.

## 2.0 OBJECTIVES OF THE PROJECT

The general objectives of this project are as follows:

***1)*** Identify an initial set of 25 watersheds located in the upper Bulkley and Morice watersheds that have some potential to be designated as a Fisheries Sensitive Watershed due to its significant downstream ***fisheries values*** and significant ***watershed sensitivity*** (Figure 1).

***2)*** Complete a rapid review the bio-physical characteristics of each of the 25 watersheds and select the top twelve candidates for FSW designation which are to be brought forward for consideration by a FSW selection round table (Figure 2).

*3)* Provide an opportunity for public and other agency review of the twelve selected FSW candidates in the form of a two day workshop.

*4)* Through the workshop process select the top 5 FSW candidates for further analysis of their biophysical conditions and complete the detailed scoring of sensitivities, hazards and risks for each watershed (Figure 3).

***5)*** Based on the completed watershed analysis of the five watersheds, recommend management objectives for each of the five watersheds that are appropriate for the Fisheries Sensitive Watershed legislation, and

***6)*** Provide watershed level guidance on both the extent and type of stand rehabilitation activities that are suitable to aid the recovery hydrologic function in consideration of landscape condition, existing and future hazards and resources at stake.

## 3.0 METHODOLOGY USED TO ACHEIVE PROJECT OBJECTIVES

For each of the five (5) watersheds selected by the workshop participants (see Objective 4 above), three different types of risks were considered and assessed, which included the following:

1) Risks of deterioration of fish habitat caused by increases in peakflows associated with watershed disturbances.

2) Risk to fish and their habitats caused by increased delivery of fine sediments to

the aquatic environment, associated with watershed disturbances, and

3) Risks to fish and their habitat caused by a loss or riparian function associated with watershed disturbances.

A watershed review report was produced for each of the five selected watersheds, which provides the data used in the risk analysis and the interpretation of that analysis.

**What is risk, as used in this project?**

Risk can be defined as the probability of harmful consequences resulting from interactions between natural or human-induced hazards and the sensitivity of a particular environment to a given hazard (or set of hazards). Risk is conventionally expressed by the following relationship:

**Risk = Hazard * Sensitivity**

where:

**Hazard** = a source of potential danger, and

**Sensitivity** = the responsiveness of a system to a particular hazard.

The main product of this project is a risk rating for each of the sub-basins of interest. This **risk** rating identifies the **probability** of harmful consequences to fish and their habitat resulting from the interactions between natural and human-induced hazards and the sensitivity of that particular watershed to a set of identified hazards.

**<u>Interpretations for Different Watershed Risk Levels</u>**

There are no textbook definitions for the different risk levels proposed for this methodology. However, it is important that the reader has a general understanding about the interpretation of a particular risk level. The definitions below should be considered as broad concepts and not scientifically defensible precise definitions.

*<u>Very Low Risk:</u>*
The combination of the extent of disturbances (i.e. the hazard) and the sensitivity of this particular watershed is very unlikely to generate any kind of fish habitat degradation.

*<u>Low Risk:</u>*
The combination of the extent of disturbances (i.e. the hazard) and the sensitivity of this particular watershed is unlikely to generate any kind of fish habitat degradation.

*<u>Moderate Risk:</u>*
The combination of the extent of disturbances (i.e. the hazard) and the sensitivity of this particular watershed is likely to generate localized, but not extensive, fish habitat degradation.

*High Risk:*
The combination of the extent of disturbances (i.e. the hazard) and the sensitivity of this particular watershed is likely to generate extensive fish habitat degradation.

*Very High Risk:*
The combination of the extent of disturbances (i.e. the hazard) and the sensitivity of this particular watershed is very likely to generate extensive fish habitat degradation.

Since the main objective of this project is the identification of Fisheries Sensitive Watersheds in the Morice TSA, we assumed that the protection of fisheries resources in these five selected watersheds is the top priority for management recommendations. With this in mind we developed management strategies that focused first and foremost on the protection of the fisheries resources. These strategies are presented in each of the 5 watershed reports.

### 3.2 Sources of Information for this project

The following sources of information were used for completing this project:

1) The professional judgment and extensive experience of each of the members of the Project Team
2) Watershed reports and photos of projects previously completed in the study area and publically available.
3) Vegetation Resource Inventory digital files available on the Government of BC LRDW website
4) Digital Topographic Maps available of the Government of Canada Website
5) Digital soils maps available on both the Government of Canada and Government of BC websites.
6) Watershed and hydrographic maps available on the LRDW website (1-20,000 scale Corporate Watershed Base (CWB)).
7) Fisheries distribution and observations available on the BC LRDW website.
8) Modelled fish crossing provided by the Ministry of the Environment
9) Digital road maps available on the BC LRDW website
10) Google Earth images (3-D)
11) Ortho-photos available on the Ministry of Forests Mapview ver6 which is publically accessible.

Table 1. Summary table of the sensitivity, hazard and risk assessments for each of the five watersheds selected by the workshop group.

| | | Increase in Peak Flows | | | | Increases in Fine Sediment | | | | Loss of Riparian Function | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Watershed Name | Watershed Size ($km^2$) | **Sensitivity Rating** | **Hazard Rating** | **Risk Score** | **Current Risk Rating** | **Sensitivity Rating** | **Hazard Rating** | **Risk Score** | **Current Risk Rating** | **Sensitivity Rating** | **Hazard Rating** | **Risk Score** | **Current Risk Rating** |
| Objective Creek | 36.6 | Mod | Mod | 8.7 | Mod | Very High | Low | 9.8 | Mod | Extreme | High | 23.2 | Very High |
| Owen | 211.14 | Mod | Mod | 9.9 | Mod | Very High | Low | 9.0 | Mod | Extreme | Very Low | 3.3 | Low |
| Foxy | 96.1 | High | Mod | 13.0 | Mod | High | Mod | 11.9 | Mod | Very High | Very Low | 3.9 | Low |
| Lamprey | 239.2 | Mod | High | 15.5 | High | Very High | High | 18.4 | High | Extreme | Low | 8.8 | Mod |
| McQuarrie | 114.6 | Very High | Low | 9.2 | Mod | Extreme | Low | 11.3 | Mod | Extreme | High | 26.7 | Very High |

# APPENDIX 1. DETAILED METHODOLOGY FOR RISK ASSESSMENT

# GENERAL METHODOLOGY

For each of the individual watersheds, three different types of risks were considered and assessed, which included the following:

1) Risks of deterioration of fish habitat caused by increases in peakflows associated with disturbances in the watershed.

2) Risk to fish and their habitats caused by increased delivery of fine sediments to the aquatic environment, associated with stream crossings, and

3) Risks to fish and their habitat caused by a loss or riparian function.

**Definition of Risk**

Risk can be defined as the probability of harmful consequences resulting from interactions between natural or human-induced hazards and the sensitivity of a particular environment to a given hazard (or set of hazards). Risk is conventionally expressed by the following relationship:

**Risk = Hazard * Sensitivity**

where:

**Hazard** = a source of potential danger, and

**Sensitivity** = the responsiveness of a system to a particular hazard.

The main product of this project is a risk rating for the Moffat Creek watershed. This **risk** rating identifies the **probability** of harmful consequences to fish and their habitat resulting from the interactions between natural and human-induced hazards and the sensitivity of that particular watershed to a set of identified hazards.

The "**sensitivity**" of the watersheds to different kinds of disturbances is defined by the bio-physical characteristics of each of the individual watersheds. Three types of disturbances and their associated sensitivities are addressed in this analysis and they include:

1. The physical sensitivity of the stream channel to increased peak flows.

2. The sensitivity of the fish and their habitat to increases in the load of fine sediment.

3. The sensitivity of the fish and their habitat to a reduction in riparian function

Numerous variables are used to define the 3 different types of "**sensitivities"** and they include indicators such as: 1) Rosgen sensitivity classification of lower stream reaches, 2) general topography and amount of steep terrain (i.e. drainage efficiency), 3) location and size of wetlands and lakes (i.e. buffer capacity), 4) general stability of lower reaches of mainstem river, 5) dominant natural disturbance types within the watershed, 6) BEC zones, 7) Dominant soil types 8) longitudinal connectivity for the downstream transport of coarse sediments and 9) fish species present in watershed.

Each of the three types of hazard classes are computed using a suite of indicators, which include: 1) the level of past harvesting activities, 2) amount of high MPB kill as defined by the extent of pine leading stands in the watershed (i.e. 70% or more pine cover), 3) moderate pine beetle kill as defined by the extent of pine mixed stands in the watershed (i.e. 30 to 69% of pine cover 4) the density of stream crossings that are likely to have fish and 5) the extent of riparian harvesting.

The **hazards** tend to be defined by disturbances within the watershed that occur on a relatively rapid timeframe and which can have a direct or indirect influence on fish habitat, e.g. extent of MPB kill or the presence of stream crossings. In contrast, the watershed **sensitivity** is defined by variables that are inherent to the watershed and do not typically change rapidly over time, e.g. location of large lakes, watershed topography and fish species present.

Detailed descriptions of how the variables are measured and scored and how the final evaluations are made are provided in the following sections of this report.

## COMPUTATION OF WATERSHED SENSITIVITY RELATIVE TO INCREASED PEAK FLOWS

The computation of the watershed sensitivity, relative to the potential for increases in peak flows (PFs), is computed as follows:

**PFs= Rs * TOP * LAT *VERT*CLIM*SYNC* NDTf**

Where:

1. **Rs** = The Rosgen stream channel sensitivity score, applied to the lower reaches of the watershed (Rosgen 1996, 2006). This is the most important component of the sensitivity score. Figure 1 (from Rosgen 2006) provides the probability of channel destabilization for different stream channel types based on the amount of disturbance in the watershed (indexed by ECA).

2. **TOP** = The watershed topography factor. This is related to the general topography of the watershed and addresses the rate of water movement through the watershed

3. **LAT** = The lateral drainage efficiency factor of the watershed (related to the number, size and location of lakes and wetlands in the watershed) This factors relates to the connectivity of the hillslopes to the stream network and the density of streams throughout the watershed.

4. **VERT =** This is the typology factor which considers general soils and bedrock types and their effect on the conductivity of water through the soil , i.e. the proportion of shallow soils over bedrock (fast) vs deep soils over fractured bedrock flow (slow).

5. **CLIM =** The influence of climate type (as indexed by Biogeoclimatic subzones) on potential for increases in peak flows cause by land disturbance. For example a rain-on-snow zone will be much more sensitive then a dry desert type.

6.**SYNC =** The flow synchronization factor. This factor considers the distribution of elevation zones in the watershed and how flows may potentially be desynchronized with a greater distribution of elevation bands. For example a flat watershed , where most of the area generates peak flows at a similar time (i.e. flows are synchronized) will be more sensitive to extensive land-use disturbances then will be a steeper watershed.

7.**NDTf** = The dominant natural disturbance type in the watershed. (NDTf). The assumption here is that a lower sensitivity rating will be given to those watersheds where large natural disturbances are frequent and the biological communities may be better adapted to frequent natural changes caused by large disturbances (e.g. wildfires, insect infestations and possibly clearcutting).

The computation of the watershed sensitivity to increased peak flows ((PFs) is based on the sensitivity rating classes and scores provided in the following tables (Table 1 to 7)

**The Rosgen Stream Channel Sensitivity Score (Rs)**

The Rosgen Stream channel classification system (Rosgen 1996, 2006) divides stream channels into 8 basic stream types based on: a) single or multi-thread channels, b) the entrenchment ratio of the channel, c) the width/depth ratio and d) the sinuosity of the channel. The system further classifies channels into 96 sub types based on the dominant channel material. Figure 2, extracted from the book *Applied River Hydrology* (Rosgen 1996), provides an illustration of the primary delineative criteria for the major stream types. Although most of the criteria are meant to be measured in the field, it is relatively easy (based on extensive professional experience) to infer the approximate values of the delineative criteria from digital orthophotos, maps, and a personal familiarity with the study areas.

Rosgen (1996) also supplies management interpretations for each of the stream types included in the classification system (**Figure 1.**, extracted from Rosgen 1996). This figure shows the probability of channel destabilization with increasing forest removal, for each of the Rosgen stream classes. The sensitivity scores, for each of the stream sensitivity classes identified by Rosgen (1996), are provided in Table 1. The USEPA has developed a watershed assessment model based on the concepts of the Rosgen channel classification system (http://www.epa.gov/warsss). This model is called the Watershed Assessment of River Stability and Sediment Supply (WARSSS). It is a comprehensive model that investigates watershed processes at a variety of scales and levels and is used to assess the risks to stream channels caused by land-use activities in the watershed. Although it is more comprehensive then the approach used for this project, it has a lot of similarities. It uses the Rosgen stream types as the basic building blocks of the assessment and defines the risk of outcomes like channel enlargement and bank erosion based on the type and activity level of different hazards in the watershed (e.g. forest removal, roads and riparian logging). This is very similar to the approach used for this project. Figure 1, which has been extracted from the WARSSS procedural handbook, illustrates how the different stream types are used to define risk relative to ECA and Roads. It is obvious from this graph that A1, A2, B1, B2 are the least sensitive channel types, while the G3-G6 and F3-F6 are the most sensitive channel types. The WARSSS system, much like the system used for this project, will identify a larger risk as the condition of a particular channel type deteriorates (e.g. reduced riparian function or geomorphic instability). The Rs for the whole watershed is usually determined by the most sensitive reach, i.e. the "weak link". If the channel shows signs of instability the sensitivity class is increased by one.

Table 1. Rosgen channel sensitivity rating table (Rs).

| Rosgen Type | SCORE (Rs) | SENSITIVITY CLASS |
|---|---|---|
| A1-Stable | 1 | Low |
| A1- Lightly unstable | 1 | Low |
| A1 - Unstable | 1 | Low |
| A2-Stable | 1 | Low |
| A2- Lightly unstable | 1 | Low |
| A2 - Unstable | 1 | Low |
| A3-Stable | 4 | Very high |
| A3- Lightly unstable | 5 | Very high |
| A3 - Unstable | 5 | Very high |
| A4-Stable | 4 | Very high |
| A4- Lightly unstable | 5 | Very high |
| A4 - Unstable | 5 | Very high |
| A5-Stable | 5 | Very high |
| A5- Lightly unstable | 5 | Very high |
| A5 - Unstable | 5 | Very high |
| A6-Stable | 5 | Very high |
| A6- Lightly unstable | 5 | Very high |
| A6 - Unstable | 5 | Very high |
| B1-Stable | 1 | Low |
| B1- Lightly unstable | 1 | Low |
| B1 - Unstable | 1 | Low |
| B2-Stable | 1 | Low |
| B2- Lightly unstable | 1 | Low |
| B2 - Unstable | 1 | Low |
| B3-Stable | 1.5 | Low |
| B3- Lightly unstable | 2 | Moderate |
| B3 - Unstable | 2.5 | Moderate |
| B4-Stable | 1.5 | Low |
| B4- Lightly unstable | 2 | Moderate |
| B4 - Unstable | 2.5 | Moderate |
| B5-Stable | 1.5 | Low |
| B5- Lightly unstable | 2 | Moderate |
| B5 - Unstable | 2.5 | Moderate |
| B6-Stable | 1.5 | Low |
| B6- Lightly unstable | 2 | Moderate |
| B6 - Unstable | 2.5 | Moderate |
| C1-Stable | 2 | Moderate |
| C1- Lightly unstable | 2.25 | Moderate |
| C1 - Unstable | 3 | High |
| C2-Stable | 2 | Moderate |
| C2- Lightly unstable | 2.25 | Moderate |
| C2 - Unstable | 3 | High |

| | | |
|---|---|---|
| C3-Stable | 3.5 | High |
| C3- Lightly unstable/disturbed | 4 | Very high |
| C3 - Unstable/disturbed | 5 | Very high |
| C4- Stable | 3.5 | High |
| C4- Lightly unstable/disturbed | 4 | Very high |
| C4 - Unstable/disturbed | 5 | Very high |
| C5- Stable | 3.5 | High |
| C5- Lightly unstable/disturbed | 4 | Very high |
| C5 - Unstable/disturbed | 5 | Very high |
| C6- Stable | 3.5 | High |
| C6- Lightly unstable/disturbed | 4 | Very high |
| C6 - Unstable/disturbed | 5 | Very high |
| D3-Stable | 3.5 | High |
| D3- Lightly unstable/disturbed | 4 | Very high |
| D3 - Unstable/disturbed | 4.5 | Very high |
| D4-Stable | 3.5 | High |
| D4- Lightly unstable/disturbed | 4 | Very high |
| D4 - Unstable/disturbed | 4.5 | Very high |
| D5-Stable | 3.5 | High |
| D5- Lightly unstable/disturbed | 4 | Very high |
| D5 - Unstable/disturbed | 4.5 | Very high |
| D6-Stable | 3.5 | High |
| D6- Lightly unstable/disturbed | 4 | Very high |
| D6 - Unstable/disturbed | 4.5 | Very high |
| E3-Stable | 2.5 | Moderate |
| E3- Lightly unstable/disturbed | 3 | High |
| E3 - Unstable/distrurbed | 4 | Very high |
| E4-Stable | 2.5 | Moderate |
| E4- Lightly unstable/disturbed | 3 | High |
| E4 - Unstable/distrurbed | 4 | Very high |
| E5-Stable | 2.5 | Moderate |
| E5- Lightly unstable/disturbed | 3 | High |
| E5 - Unstable/distrurbed | 4 | Very high |
| E6-Stable | 2.5 | Moderate |
| E6- Lightly unstable/disturbed | 3 | High |
| E6 - Unstable/distrurbed | 4 | Very high |

| | | |
|---|---|---|
| F1-Stable | 1 | Low |
| F1- Lightly unstable/disturbed | 1.25 | Low |
| F1 - Unstable/Disturbed | 2 | Moderate |
| F2-Stable | 1 | Low |
| F2- Lightly unstable/disturbed | 1.25 | Low |
| F2 - Unstable/Disturbed | 2 | Moderate |
| F3-Stable | 4 | Very high |
| F3- Lightly unstable/disturbed | 4.3 | Very high |
| F3 - Unstable/Disturbed | 5 | Very high |
| F4-Stable | 4 | Very high |
| F4- Lightly unstable/disturbed | 4.3 | Very high |
| F4 - Unstable/Disturbed | 5 | Very high |
| F5-Stable | 4 | Very high |
| F5- Lightly unstable/disturbed | 4.3 | Very high |
| F5 - Unstable/Disturbed | 5 | Very high |
| F6-Stable | 4 | Very high |
| F6- Lightly unstable/disturbed | 4.3 | Very high |
| F6 - Unstable/Disturbed | 5 | Very high |
| G1-Stable | 1 | Low |
| G1- Lightly unstable | 1.25 | Low |
| G1 - Unstable | 2 | Moderate |
| G2-Stable | 1 | Low |
| G2- Lightly unstable | 1.25 | Low |
| G2 - Unstable | 2 | Moderate |
| G3-Stable | 4 | Very high |
| G3- Lightly unstable | 4.3 | Very high |
| G3 - Unstable | 5 | Very high |
| G4-Stable | 4 | Very high |
| G4- Lightly unstable | 4.3 | Very high |
| G4 - Unstable | 5 | Very high |
| G5-Stable | 4 | Very high |
| G5- Lightly unstable | 4.3 | Very high |
| G5 - Unstable | 5 | Very high |
| G6-Stable | 4 | Very high |
| G6- Lightly unstable | 4.3 | Very high |
| G6 - Unstable | 5 | Very high |

**The Watershed Topography Score (TOPO)**

It is considered here that a watershed that has a very gentle topography will be less efficient in the transport of water downstream through the watershed and will have a slower “time to peak”, compared to a watershed that is steep with the hill slopes tightly coupled to the stream network. Consequently, a watershed with a gentle topography is considered as less sensitive to increased peak flows and large scale disturbances compared to a very steep watershed that is highly coupled to the hillslopes. The assessment is based on the review of the, TRIM maps and the digital orthophotos. The drainage efficiency factors used to “modify” the Rosgen channel sensitivity score are provided in Table 2.

Table 2. Watershed topography rating table (TOPO).

| **Description of the watershed** | **Topography Factor (TOPO)** |
|---|---|
| Gently rolling with very wide uncoupled floodplains | 0.6 |
| Hilly, gentle mountains, generally uncoupled with wide valley flats | 0.75 |
| Mountainous with localized steepness | 1.0 |
| Generally steep and coupled | 1.25 |
| Very steep and tightly coupled | 1.40 |

**The Watershed Lateral Drainage Efficiency Score (LAT)**

It is considered here that a watershed that has numerous lakes and swamps near the mouth of the river will have more of a buffering capacity for peak flows than a watershed that does not have any lakes or swamps. Consequently, a watershed with no lakes or swamps is considered as being more sensitive to increased peak flows. As the area of lakes/swamps increases throughout the watershed, the sensitivity is considered to decrease. This is an important factor that has the potential to decrease the sensitivity of a watershed substantially. The drainage efficiency factor is used to “modify” the Rosgen channel sensitivity score are provided in Table 3

Table 3. Watershed drainage efficiency rating table (LAT).

| **Description of Watershed Characteristics relative to abundance of lakes and wetlands** | **Drainage efficiency and lateral connectivity (LAT)** |
|---|---|
| Numerous lakes, or one big lake, near outlet (big reduction in sensitivity) low drainage density | 0.8 |
| Numerous lakes that are scattered throughout watershed, low to moderate drainage density | 0.9 |
| Moderate amount of lakes scattered throughout watershed with moderate to high drainage density. | 1.0 |
| Few lakes/swamps that are scattered throughout watershed with high drainage density | 1.05 |
| No lakes, very high drainage density | 1.1 |

**The Watershed Typology Score (VERT)**

The typology factor considers general soils and bedrock types and their effect on the conductivity of water through the soil, i.e. the proportion of shallow horizontal flow (fast) vs deep bedrock flow (slow). It is considered that the efficiency of movement of water through the watershed decreases with the depth of porous soils and fractured bedrock.

Table 4. Watershed typology rating table (VERT).

| Description of the watershed | Typology Factor Soils and bedrock relative to vertical vs horizontal drainage (VERT) |
|---|---|
| Very deep porous soils with fractured bedrock | 0.9 |
| Deep porous soils with fractured bedrock | 0.95 |
| Shallow soils with fractured bedrock or deep soils with solid bedrock | 1.0 |
| Moderately shallow soils with solid bedrock | 1.05 |
| Very shallow soils and solid bedrock | 1.10 |

**The Watershed Flow Synchronization Score (SYNC)**

The flow synchronization factor. This factor considers the distribution of elevation zones in the watershed and how flows may potentially be desynchronized with a greater distribution of elevation bands. For example a flat watershed , where most of the area generates peak flows at a similar time (i.e. flows are synchronized) will be more sensitive to extensive land-use disturbances then will be a steeper watershed.

Table 5. Watershed flow synchronization rating table (SYNC).

| % of watershed in the same 300 me elevation band | Flow Synchronization Factor (SYNC) |
|---|---|
| There is no 300 m elevation band that contains more than 10% of watershed | 0.9 |
| Only 10 to 30% of watershed is in any given 300 m elevation band | 0.95 |
| Only 30 to 60% of watershed is in any given 300 m elevation band | 1.0 |
| 60 to 90% of watershed is in the same 300 m elevation band | 1.05 |
| Almost the entire watershed is in the same elevation band (i.e. very flat watershed) | 1.10 |

**The Natural Disturbance Type Score (NDTf)**

The dominant natural disturbance type in the watershed. (NDTf). The assumption here is that a lower sensitivity rating will be given to those watersheds where large natural disturbances are frequent and the biological communities may be better adapted to frequent natural changes caused by large disturbances (e.g. wildfires, insect infestations and possibly clearcutting).

Table 6. Watershed natural disturbance type rating table (NDTf).

| Dominant NDT Type in watershed | Natural Disturbance factor (NDTf) |
|---|---|
| NDT 5 - Alpine tundra and subalpine park land ( less sensitive because better adapted to being disturbed) | 0.93 |
| NDT 4 - Frequent stand maintaining fires, (less sensitive because better adapted to frequent disturbance) | 0.96 |
| NDT 3 - Frequent stand initiating fires, (a bit less sensitive) | 1.0 |
| NDT 2 - Infrequent stand-initiating events (minor increase in sensitivity) | 1.05 |
| NDT 1 - Rare stand initiating events (increase in sensitivity) | 1.08 |

**The Watershed Peak Flow Climate Generation Score (CLIM)**

This indicator refers to the influence of climate type (as indexed by Biogeoclimatic subzones) on potential for increases in peak flows cause by land disturbance. For example a rain-on-snow zone will be much more sensitive then a dry desert type.

Table 7. Watershed climate type rating table (CLIM).

| **BEC Zone** | **Weight for BEC Peak Flow Generation Index** | | **Justification for Peak Flow Generation Weight Selection** |
|---|---|---|---|
| | **Rank**<br>**1**= Logging in this zone generates the biggest increases in peak flows<br>**14**= Logging in this zones causes the least effect on increases in peak flows | **Score (CLIM)**<br>(Score is scaled from 0 to 1, where 1 is biggest impact and 0 would be no impact at all) | |
| MH | High | 1.1 | Deepest snowpack and rain on snow zones |
| ICH | High | 1.1 | Wet climate with potentially lots of snow, not that much different than MH |
| ESSF | High | 1.1 | Deep snowpacks and thus the effect of logging on snow accumulation and melt can be significant. Not that much different than ICH and ESSF |
| MS | High | 1.1 | Climate is wet and snowy (less than ESSF, but more than SBS) |
| SBS | High | 1.1 | Not a huge annual precipitation, but significant snowpack |
| CWH | Moderate | 1.0 | Lots of rain, but not much snow. Thus effects of tree removal are less, but still significant |
| CDF | Moderate | 1.0 | Lots of rain, but virtually no snow |
| SWB | Moderate | 1.0 | Although winters are long, snowpacks are not that deep. |
| BWBS | Low-Mod | 0.85 | Although winters are long, snowpacks are not that deep. |
| SBPS | Low | 0.65 | Very dry and low snowpack, but completely forested. |
| IDF | Low | 0.65 | Most of the zone is relatively dry with generally more rain than snow. |
| PP | Very Low | 0.30 | Very dry and low snowpack, not much logging potential in PP |
| BG | Very Low | 0.30 | Minimal logging in this zone |
| AT | Very Low | 0.30 | No logging in this zone |

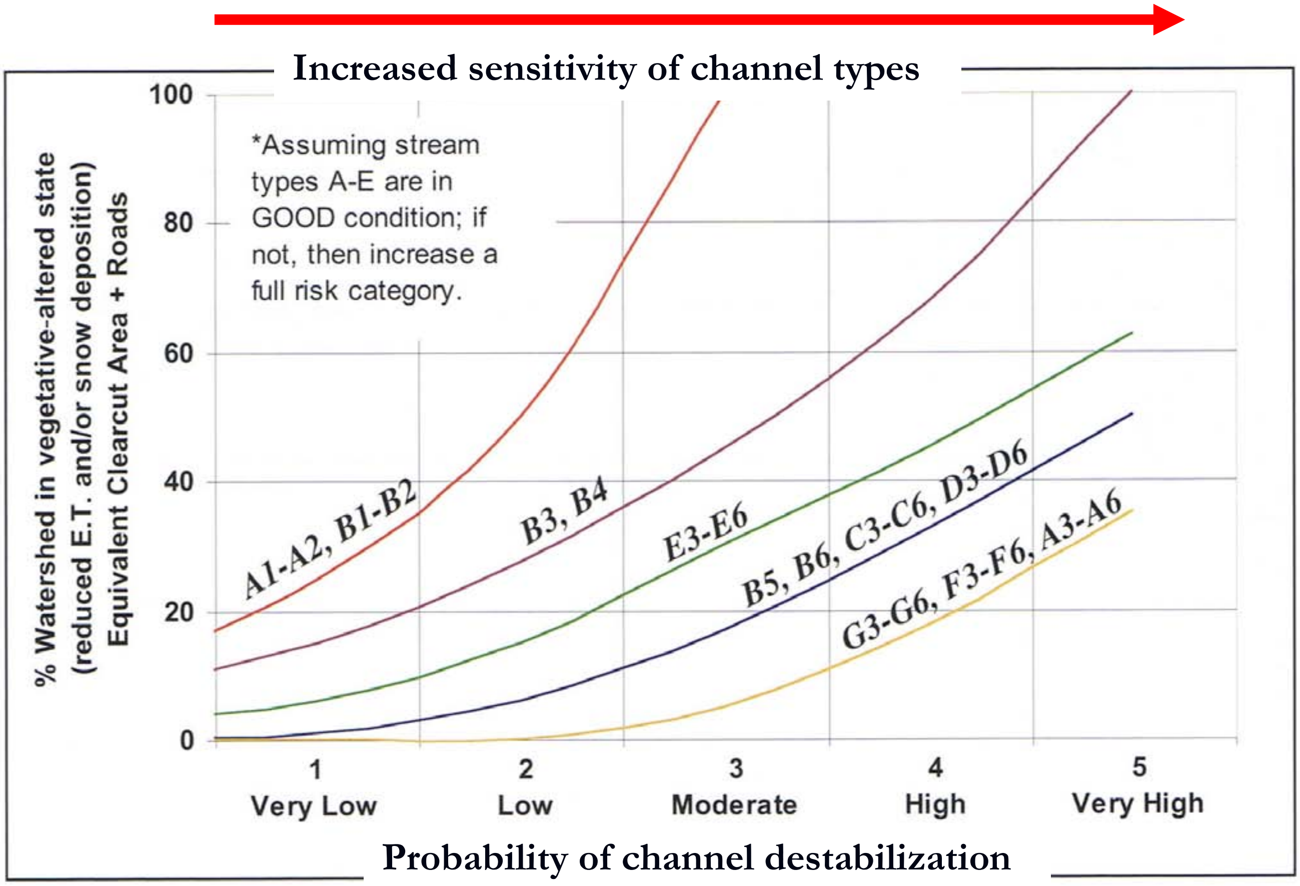


Figure 1. Probability of stream channel destabilzation and accelerated bank erosion associated with increases in equivalent clearcut area, for different Rosgen stream types (adapted from Rosgen 2006).

Table 8. Determination of the peak flow sensitivity rating class based on the sensitivity scores.

| Sensitivity Rating | Sensitivity Score |
|---|---|
| Extreme | greater than or equal to 5.5 |
| Very High | 4.5 to 5.49 |
| High | 3.5 to 4.49 |
| Moderate | 2.5 to 3.49 |
| Low | 1.5 to 2.49 |
| Very Low | less than 1.49 |

**COMPUTATION OF WATERSHED SENSITIVITY RELATIVE TO INCREASES IN FINE SEDIMENT**

The sensitivity to increased fine sediment (FSs) is computed as follows:

**FSs = FSHs * LAT_CON* TOPOG*SOIL_TYPE* CLIMfs**

1. **FSHs** = The sensitivity of the fish species present in the watershed according to the classification developed by the Watershed Evaluation Tool (Appendix 1)
2. **LAT_CON=** The lateral connectivity of the overall watershed to transport fine sediment to the point of interest (it is related to the number, size and location of lakes and wetlands in the watershed).
3. **TOPOG=** The relative overall steepness of the watershed relative to the efficiency of the watershed in transporting fine sediment to the point of interest (a steeper watershed will transport sediment to the point of interest much better than a flat watershed).
4. **SOIL_TYPE=** The influence of soil type on the erosivity of the soil. Soil Types considered include: coarse textured till, fine textured till, colluviums, glacio-lacustrine and glacio-fluvial.
5. **CLIMfs** =The influence of climate type (as indexed by Biogeoclimatic subzones) on the potential for increases in fine sediment caused by land disturbance. This variable is mostly based on the amount and intensity o rainfall that characterizes a particular biogeoclimatic zone.

**Fish Species Sensitivity Score (FSHs)**

Although it is possible for increases in fine sediments from surface erosion within the watershed to have a direct impact on channel morphology, in general the increases are not large enough for this to happen. Consequently, the stream channel type and its stability are not the main factors that drive the sensitivity of the stream channel to increased inputs of fine sediments. Increases in fine sediments (or suspended sediments) tend to have more of a direct impact on the biological organisms within the stream, than they do on the physical de-stabilizing of the stream channel. Consequently, the main factor used for determining sensitivity to increased loads of fine sediment is the species of fish present in the watershed and their relative sensitivities to disturbance, rather than the Rosgen stream channel type. Information about species present in the watershed are obtained from either from inventory records or the modelled species distribution using observation data that that was developed for the WET tool. Table 9 below is used to determine the fish species sensitivity score. These scores have been adapted from the species sensitivities scores used in the Ministry of the Environment Watershed Evaluation Tool (WET) (Appendix 1)

Table 9. Fish Species Sensitivity Scores based on the WET Procedure.

| Fish Species | Fish Species Sensitivity Score | MoE Relative Sensitivity |
|---|---|---|
| 01-Bull trout | 5 | 1 |
| 02- Dolly Varden | 5 | 1 |
| 03-Coho Salmon | 4.7 | 0.94 |
| 04 - Chinook Salmon | 4.4 | 0.88 |
| 05 - Coastal Cutthroat | 4.4 | 0.88 |
| 06 - Cutthroat trout | 4.4 | 0.88 |
| 07 - Mountain Whitefish | 4.4 | 0.88 |
| 08- Westslope Cutthroat Trout | 4.4 | 0.88 |
| 09- Artic Greyling | 4.05 | 0.81 |
| 10- Burbot | 4.05 | 0.81 |
| 11- Lower Koootenay Burbot | 4.05 | 0.81 |
| 12- Steelhead | 4.05 | 0.81 |
| 13- Williston Lake Artic Greyling | 4.05 | 0.81 |
| 14- Northern Mountain Sucker | 3.75 | 0.75 |
| 15- Rainbow Trout | 3.75 | 0.75 |
| 16- Salish Sucker | 3.75 | 0.75 |
| 17- Artic Cisco | 3.45 | 0.69 |
| 18- Broad Whitefish | 3.45 | 0.69 |
| 19- Chum Salmon | 3.45 | 0.69 |
| 20- Coastrange Sculpin | 3.45 | 0.69 |
| 21-Kokanee | 3.45 | 0.69 |
| 22-Lake Trout | 3.45 | 0.69 |
| 23-Morrison Creek lamprey | 3.45 | 0.69 |
| 24-Shorthead Sculpin | 3.45 | 0.69 |
| 25-Sockeye Salmon | 3.45 | 0.69 |
| 26-Lake whitefish | 3.15 | 0.63 |
| 27-Least Cisco | 3.15 | 0.63 |
| 28-Longfin Smelt | 3.15 | 0.63 |
| 29-Longnose sucker | 3.15 | 0.63 |
| 30-Mottled Sculpin | 3.15 | 0.63 |
| 31-Nooksack dace | 3.15 | 0.63 |
| 32-Pacific Lamprey | 3.15 | 0.63 |

| | | |
|---|---|---|
| 33-Round white fish | 3.15 | 0.63 |
| 34-Torrent Sculpin | 3.15 | 0.63 |
| 35-Lake Cisko | 2.8 | 0.56 |
| 36-Longnose Dance | 2.8 | 0.56 |
| 37-Pygmy Longfin smelt | 2.8 | 0.56 |
| 38-River Lamprey | 2.8 | 0.56 |
| 39-Slimy Sculpin | 2.8 | 0.56 |
| 40-Western Brook Lamprey | 2.8 | 0.56 |
| 41-Chislemouth | 2.5 | 0.5 |
| 42-Eulachon | 2.5 | 0.5 |
| 43-Lake Chub | 2.5 | 0.5 |
| 44-Northern Pearl dace | 2.5 | 0.5 |
| 45-Pink salmon | 2.5 | 0.5 |
| 46-Prickly Sculpin | 2.5 | 0.5 |
| 47-Pygmy whitefish | 2.5 | 0.5 |
| 48-Spoonhead sculpin | 2.5 | 0.5 |
| 49-White sucker | 2.5 | 0.5 |
| 50-Brasy Minnow | 2.2 | 0.44 |
| 51-Bridgelip Sucker | 2.2 | 0.44 |
| 52-Brook Stickleback | 2.2 | 0.44 |
| 53-Flathead Chub | 2.2 | 0.44 |
| 54-Lake Lamprey | 2.2 | 0.44 |
| 55-Largescale Sucker | 2.2 | 0.44 |
| 56-Peamouth Chub | 2.2 | 0.44 |
| 57-Redside Shiner | 2.2 | 0.44 |
| 58-Speckled Dace | 2.2 | 0.44 |
| 59-Troutperch | 2.2 | 0.44 |
| 60-Umatilla dace | 2.2 | 0.44 |
| 62-Walleye | 2.2 | 0.44 |
| 63-American Shad | 1.9 | 0.38 |
| 64-Cultus lake Sculpin | 1.9 | 0.38 |
| 65-Green Sturgeon | 1.9 | 0.38 |
| 66-Ninespine Stickleback | 1.9 | 0.38 |
| 67-Northern Pike-minnow | 1.9 | 0.38 |
| 68-White Sturgeon | 1.9 | 0.38 |
| 69-Goldeye | 1.55 | 0.31 |

| | | |
|---|---|---|
| 70-leopard Dace | 1.55 | 0.31 |
| 71-Spottail shiner | 1.55 | 0.31 |
| 72-Finscale Dace | 1.25 | 0.25 |
| 73-Northern Pike | 1.25 | 0.25 |
| 74-Northern Redbelly Dace | 1.25 | 0.25 |
| 75-Emerald shiner | 0.95 | 0.19 |
| 76-Threespine Stickleback | 0.95 | 0.19 |
| 77-Yellow Perch | 0.95 | 0.19 |

**Lateral Connectivity Factor (LAT_CON)**

This factor is very similar in concept to the LAT described in the previous section of this document. However, in this case the factor values are a little different because large lakes and swamps are somewhat more efficient at buffering the downstream transport of fine sediment then they are buffering the transport of peak flows (but not as effective as buffering the transport of coarse sediments). The fine sediment transport buffer factor is used to "modify" the fish sensitivity score.

Table 10. Fine sediment transport buffer factors used to "modify" the fish species sensitivity score.

| Description of Watershed Characteristics relative to abundance of lakes and wetlands | Fine Sediment Transport Buffer factor for lower reaches (LAT_CON) |
|---|---|
| Numerous lakes, or one big lake, near outlet (big reduction in sensitivity) | 0.80 |
| Numerous lakes that are scattered throughout watershed | 0.9 |
| Moderate amount of lakes scattered throughout watershed | 1.0 |
| Few lakes that are scattered throughout watershed | 1.1 |
| No lakes (no reduction in sensitivity) | 1.2 |

**The Fine Sediment Topography Factor (TOPOG)**

The fine sediment topography factor is similar in concept as the peak flow drainage efficiency factor described in the previous section of this document. However, this factor considers the general shape of the watershed and the connectivity of the hill slopes to the stream network and the efficiency of the hill slope to deliver fine sediment to the stream network. The assessment is based on the review of the TRIM maps, digital orthophotos and Google Earth imagry. The fine sediment drainage efficiency factors used to "modify" the fish species sensitivity score are provided in Table 11.

Table 11. Fine Sediment Drainage Efficiency factors used to "modify" the Fish Species Sensitivity score.

| Description of the watershed | Fine Sediment Drainage Efficiency Factor (Topog) |
|---|---|
| Gently rolling with very wide uncoupled floodplains and low drainage density (small reduction in sensitivity) | 0.65 |
| Hilly, gentle mountains, generally uncoupled with low to moderate drainage density. | 0.75 |
| Mountainous with localized steepness with moderate to high drainage density. | 1.0 |
| Generally steep and coupled with high drainage density | 1.25 |
| Very steep and tightly coupled with very high drainage density (no reduction in sensitivity) | 1.5 |

**The Soil Type Factor (SOIL_TYPE)**

This factor considers the influence of soil type on the erosivity of the soil. Soil Types considered include: coarse textured till, fine textured till, colluviums, glacio-lacustrine and glacio-fluvial.

Table 12. Soil_type factors for different soil type

| Density of stream crossings on fish streams | Score for Coarse till | Score for Medium till | Score for Fine till | Score for Glacio-Fluvial | Score for Glacio-Lacustrine | Score for Colluvium |
|---|---|---|---|---|---|---|
| < 0.04 Xings/km^2 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 0.04 to 0.06 Xings/km^2 | 0.33 | 0.4125 | 0.495 | 0.3696 | 0.594 | 0.28 |
| 0.07 to 0.10 Xings/km^2 | 0.66 | 0.825 | 0.99 | 0.7392 | 1.188 | 0.55 |
| 0.11 to 0.20 Xings/km^2 | 0.99 | 1.2375 | 1.485 | 1.1088 | 1.782 | 0.83 |
| 0.21 to 0.30 Xings/km^2 | 1.32 | 1.65 | 1.98 | 1.4784 | 2.376 | 1.10 |
| 0.31 to 0.40 Xings/km^2 | 1.65 | 2.0625 | 2.475 | 1.848 | 2.97 | 1.38 |
| 0.41 to 0.50 Xings/km^2 | 1.98 | 2.475 | 2.97 | 2.2176 | 3.564 | 1.65 |
| 0.51 to 0.60 Xings/km^2 | 2.31 | 2.8875 | 3.465 | 2.5872 | 4.158 | 1.93 |
| 0.61 to 0.70 Xings/km^2 | 2.64 | 3.3 | 3.96 | 2.9568 | 4.752 | 2.20 |
| 0.71 to 0.80 Xings/km^2 | 2.97 | 3.7125 | 4.455 | 3.3264 | 5.346 | 2.48 |
| 0.81 to 0.90 Xings/km^2 | 3.3 | 4.125 | 4.95 | 3.696 | 5.94 | 2.75 |
| 0.91 to 1.00 Xings/km^2 | 3.63 | 4.5375 | 5.445 | 4.0656 | 6.534 | 3.03 |
| 1.01 to 1.10 Xings/km^2 | 3.96 | 4.95 | 5.94 | 4.4352 | 7.128 | 3.30 |
| 1.11 to 1.20 Xings/km^2 | 4.29 | 5.3625 | 6.435 | 4.8048 | 7.722 | 3.58 |
| 1.21 to 1.30 Xings/km^2 | 4.62 | 5.775 | 6.93 | 5.1744 | 8.316 | 3.85 |
| 1.31 to 1.40 Xings/km^2 | 4.95 | 6.1875 | 7.425 | 5.544 | 8.91 | 4.13 |
| 1.41 to 1.50 Xings/km^2 | 5.28 | 6.6 | 7.92 | 5.9136 | 9.504 | 4.40 |
| 1.51 to 1.60 Xings/km^2 | 5.61 | 7.0125 | 8.415 | 6.2832 | 10.098 | 4.68 |
| 1.61 to 1.70 Xings/km^2 | 5.94 | 7.425 | 8.91 | 6.6528 | 10.692 | 4.95 |
| 1.71 to 1.80 Xings/km^2 | 6.27 | 7.8375 | 6 | 7.0224 | 11.286 | 5.23 |
| 1.81 to 1.90 Xings/km^2 | 6.6 | 8.25 | 6 | 7.392 | 11.88 | 5.50 |
| 1.91 to 2.00 | 6.93 | 8.6625 | 6 | 7.7616 | 12.474 | 5.78 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Xings/km^2 | | | | | | |
| 2.00 to 2.11 Xings/km^2 | 7.26 | 9.075 | 6 | 8.1312 | 13.068 | 6.05 |
| 2.11 to 2.20 Xings/km^2 | 7.59 | 9.4875 | 6 | 8.5008 | 13.662 | 6.33 |
| 2.21 to 2.30 Xings/km^2 | 7.92 | 9.9 | 6 | 6 | 14.256 | 6.60 |
| >=2.31 Xings/km^2 | 8.25 | 10.3125 | 6 | 6 | 14.85 | 6.88 |

| | |
|---|---|
| Very Low = | < 1.51 |
| Low = | 1.51 to 2.50 |
| Moderate = | 2.51 to 3.50 |
| High = | 3.51 to 4.5 |
| Very High = | 4.51 to 5.5 |
| Extreme = | >5.5 |

**Climate factor for generating fine sediment (CLIMfs)**

This indicator refers to the influence of climate type (as indexed by Biogeoclimatic subzones) on the potential for increases in fine sediment caused by land disturbance. This variable is mostly based on the amount and intensity of rainfall that characterizes a particular biogeoclimatic zone.

Table 13. Watershed climate type rating table (CLIMfs) for fine sediment transport (from rainiest to driest).

| **BEC Zone** | **Weight for Fine Sediment Generation Index** | |
|---|---|---|
| | **"Rain" Rank** | **Score (CLIMfs)** |
| MH | Very High | 1.2 |
| ICH | Very High | 1.2 |
| CWH | Very High | 1.2 |
| CDF | Very High | 1.2 |
| ESSF | High | 1.1 |
| MS | High | 1.1 |
| SWB | High | 1.1 |
| BWBS | Moderate | 1.0 |
| SBS | Moderate | 1.0 |
| SBPS | Low | 0.90 |
| IDF | Low | 0.90 |
| PP | Very Low | 0.80 |
| BG | Very Low | 0.80 |
| AT | Very Low | 0.80 |

Table 14. Determination of the watershed Fine Sediment sensitivity rating class based on the fine sediment sensitivity scores.

| Sensitivity Rating | Sensitivity Score |
|---|---|
| Extreme | greater than or equal to 5.5 |
| Very High | 4.5 to 5.49 |
| High | 3.5 to 4.49 |
| Moderate | 2.5 to 3.49 |
| Low | 1.5 to 2.49 |
| Very Low | less than 1.49 |

## COMPUTATION OF WATERSHED SENSITIVITY RELATIVE TO LOSSES IN RIPARIAN FUNCTION

The sensitivity of a stream channel to a reduction in riparian function is dependent on multiple factors which includes the fish species that reside in the channel, the morphology of the channel and its dependence on Large Woody Debris inputs, its general aspect (i.e. temperature considerations) and the regional climate.

The sensitivity of the stream channel to a reduction in riparian function (RFs) is computed as follows:

**RFs = FSHs *LWD* ASPECT* CLIMrf**

1. **FSHs** = The sensitivity of the fish species present in the watershed according to the classification developed by the Watershed Evaluation Tool (Appendix 1)
2. **LWD=**The Large Wood Debris sensitivity score is based on the Rosgen stream class of the lower reaches of the watershed. According to Rosgen (1996, 2006) different channel types have varying sensitivities to a loss of LWD inputs.
3. **ASPECT=** Different channel aspects are more or less sensitive to a decrease in shade caused by a reduction in riparian function.
4. **CLIMrf** =The influence of climate type (as indexed by Biogeoclimatic subzones) on the potential for increases in critical stream temperatures caused by a reduction in riparian functions. This variable is mostly based on the temperature regime that characterizes a particular biogeoclimatic zone.

### Fish Species Sensitivity Score (FSHs)

Different fish species have different sensitivities to disturbances in the watershed, such as a reduction in riparian function. The main factor used for determining the sensitivity to a loss in riparian function is the species of fish present in the watershed. Table 9 is used to determine the fish species sensitivity score. These scores have been adapted from the species sensitivities scores used in the Ministry of the Environment Watershed Evaluation Tool (WET) (Appendix 1).

### The Large Woody Debris Sensitivity Score (LWD)

The Rosgen Stream channel classification system (Rosgen 1996, 2006) divides stream channels into 8 basic stream types and further into 6 sub-types. The sensitivity of each channel type to a loss in riparian function is discussed in the Rosgen documentation. The sensitivity scores, for each of the stream sensitivity classes identified by Rosgen (1996), are provided in Table 15.

Table 15. Sensitivity of different stream channel types to a loss in riparian function and their corresponding LWD scores.

| Rosgen Stream Type | LWD Score | Sensitivity to loss of Riparian Function |
|---|---|---|
| A | 0.7 | Very Low |
| B1-B2 | 0.8 | Low |
| B3-B6 | 1.15 | High |
| C1-C2 | 1 | Moderate |
| C3-C6 | 1.25 | Very High |
| D3-D6 | 1 | Moderate |
| DA | 1.25 | Very High |
| E3-E6 | 1.25 | Very High |
| F1-F2 | 0.8 | Low |
| F3-F6 | 1 | Moderate |
| G1-G2 | 0.8 | Low |
| G3-G6 | 1.15 | High |

**The Aspect Sensitivity Score (ASPECT)**

Depending the aspect of a stream channel it may be more or less sensitive to the loss of shade created by a loss in riparian function. For example a south facing aspect will generally be more sensitive, while a north facing aspect will be less sensitive. Score for the aspect variable are provided in Table 16.

Table 16. Sensitivity of different stream channel aspects to a loss in riparian function and their corresponding ASPECT scores.

| Dominant aspect of main stream channel | Loss of Shade Sensitivity Class | Sensitivity Score (ASPECT) |
|---|---|---|
| North | Very High | 0.90 |
| East | High | 0.95 |
| Flat | Moderate | 1.0 |
| West | Low | 1.05 |
| South | Very Low | 1.1 |

**Climate factor for generating fine sediment (CLIMfs)**

This is used to address the influence of climate type (as indexed by Biogeoclimatic subzones) on the potential for increases in fine sediment caused by land disturbance. This variable is mostly based on the amount and intensity o rainfall that characterizes a particular biogeoclimatic zone.

Table 17. Watershed climate type rating table (CLIMrf) for loss of riparian function.

| **BEC Zone** | Sensitivities of Different climate types to loss of Riparian Function | |
|---|---|---|
| | **“Critical” Stream Temperature Rank** | **Score (CLIMrf)** |
| IDF | Very High | 1.2 |
| PP | Very High | 1.2 |
| SBS | High | 1.1 |
| ICH | Moderate | 1.0 |
| CWH | Moderate | 1.0 |
| CDF | Moderate | 1.0 |
| MS | Moderate | 1.0 |
| MH | Low | 0.9 |
| ESSF | Low | 0.9 |
| SWB | Low | 0.9 |
| BWBS | Low | 0.9 |
| SBPS | Low | 0.9 |
| BG | Very Low | 0.80 |
| AT | Very Low | 0.80 |

Table 18. Determination of watershed sensitivity to a loss in riparian function.

| **Riparian Function Sensitivity Rating** | **Riparian Function Sensitivity Score** |
|---|---|
| Extreme | greater than or equal to 5.5 |
| Very High | 4.5 to 5.49 |
| High | 3.5 to 4.49 |
| Moderate | 2.5 to 3.49 |
| Low | 1.5 to 2.49 |
| Very Low | less than 1.49 |

## DETERMINATION OF HAZARD RATING FOR DIFFERENT HAZARD TYPES

The three different watershed hazard ratings developed for this assessment are a direct function of the extent and location of different kinds of disturbances within the watershed. The three hazards relate directly to the following processes:

1) The Peak flow hazard considers the potential of the disturbances within the watershed to alter peak flow regimes and thus possibly impair fish habitat or cause flooding and road management problems,

2) The Fine Sediment hazard considers the potential of the disturbances in the watershed to increase erosion and sediment delivery to the aquatic network, especially where there is a high likelihood of fish presence and

3) The Reduction in Riparian Function hazard considers the potential of the disturbances in the watershed to reduce riparian function.

The disturbances that are used in the computation of the different hazards include all land-use disturbances in the watershed (logging, range, roads and riparian removal) and the disturbance caused by the Mountain Pine Beetle (MPB). Three variables are quantified in the process of determining the watershed hazard ratings. These variables are measured using maps and orthophotos in a GIS environment. For additional precision, the GIS process can be followed by ground-truthing and refinement of the GIS measurements and interpretations through an overview helicopter flight. The variables include: 1) the calculation of the "Hydrologically Equivalent Disturbed Area" (HEDA), 2) the density of stream crossings and stream crossings that are likely fish bearing and 3) the percentage of riparian that is functionally impaired. The calculation process for each of these variables is provided in the next sub-sections of this document. Note that the weight of the different scores is based largely upon professional judgment and past research experience working in a wide variety of watersheds in the MPB infected areas

**Determination of Peak Flow Hazard Rating as Indexed by HEDA**

The peak flow hazard in a watershed is a function of the amount of disturbance within that watershed, which includes disturbances caused by logging, insects, fire, mining, agriculture and urbanization. This hazard is indexed by computing the "Hydrologically Equivalent Disturbed Area" (HEDA) for the watershed. This calculation is completed by adding up all of the hydrologically equivalent areas in the watershed as per the example provided in **Error! Reference source not found.**. The equivalency factors for the disturbed stand were obtained from the Watershed Assessment Procedure guidebook (Government of BC, 1999), while those for the Mountain Pine Beetle affected stands were obtained from the MPB snow survey work I completed in 2006 and 2007 (Beaudry P., 2006, 2007, 2007b). The different levels of the Peak Flow Hazard ratings are defined in **Error! Reference source not found.**.

Table 19. Example of the calculation of the "Hydrologically Equivalent Disturbed Area" in a hypothetical watershed of 1500ha in size.

| Stand Type | Stand Area in Hectares (a) | HEDA Multiplication factor (b) | "Hydrologically Equivalent Disturbed" area (ha) (a) X (b) |
|---|---|---|---|
| Recent Clearcut or other non-recovered land-use related disturbance with a stand height of less than 3 m. | 125 | 1.0 | 125 |
| Land-use related disturbance with a stand height greater or equal to 3 m and less than 5 m. | 85 | 0.75 | 63.75 |
| Land-use related disturbance with a stand height greater or equal to 5 m and less than 7 m. | 92 | 0.50 | 46 |
| Land-use related disturbance with a stand height greater or equal to 7 m and less than 9 m. | 65 | 0.25 | 16.25 |
| All non-pine stands greater than 9 m in height | 390 | 0.0 | 0 |
| Mature pine-leading stands (greater or equal to 70% pine composition) | 180 | 0.5 | 90 |
| Mature pine-mixed stands (pine composition is between 31 and 69%) | 78 | 0.2 | 15.6 |
| Mature pine-minor stands (pine composition is 30% or less) | 132 | 0.0 | 0 |
| Other areas in watershed (e.g. lakes, alpine, rivers, swaps, grasslands etc) | 353 | 0.0 | 0 |
| **Total hydrologically equivalent disturbed area (ha)** | | | **356.6** |
| **Total hydrologically equivalent disturbed area (% of watershed)** | | | **23.8** |

The "stand type" data are obtained from the Vegetation Resource Inventory (VRI) files and the recent cutblock files are obtained from the Land and Resource Data Warehouse (LRDW). Each VRI polygon within a given watershed is queried to determine the stand type, the type of disturbance, date of disturbance and current stand height.

Table 20. Peak Flow Hazard Ratings.

| Hydrologically Equivalent Disturbed Area (HEDA) in a watershed (expressed as a percentage of entire watershed) | Peak Flow Hazard Score | Peak Flow Hazard Ratings |
|---|---|---|
| < 5% | 0.25 | **Very Low** |
| 5 to 14% | 1 | **Very Low** |
| 15 to 19% | 2 | **Low** |
| 20 to 24% | 2.5 | **Low** |
| 25 to 29% | 2.75 | **Moderate** |
| 30 to 34% | 3 | **Moderate** |
| 35 to 39% | 3.5 | **Moderate** |
| 40 to 44% | 4 | **High** |
| 44 to 49% | 4.5 | **High** |
| 50 to 54% | 5 | **Very High** |
| 54 to 59% | 5.75 | **Very High** |
| >= 60% | 6 | **Extreme** |

**Determination of Fine Sediment Hazard Rating, as indexed by the Stream Crossing Density**

There is abundant literature throughout North America that clearly shows that stream crossings can potentially be the biggest hazard to fish and their habitats. They are a potential source of fine sediment to the aquatic environment and a potential barrier to fish passage if not properly constructed. If sized improperly, and unable to effectively pass high flows, they can cause significant damage to the stream channel, both upstream and downstream of the crossing. **Error! Reference source not found.** provides the scoring for different values of this indicator.

Table 21. Definition of SCD scores which contribute to the calculation of the fine sediment hazard

| **Density of stream crossings that likely have fish (from MoE Fish Crossing Model) (#/km$^2$ of watershed)** | **Fine Sediment Hazard Score** | **Fine Sediment Hazard Ratings** |
|---|---|---|
| <= 0.10 Xings/km^2 | 0 | Very Low |
| 0.11 to 0.20 Xings/km^2 | 0.25 | Very Low |
| 0.21 to 0.30 Xings/km^2 | 0.5 | Very Low |
| 0.31 to 0.40 Xings/km^2 | 0.75 | Very Low |
| 0.41 to 0.50 Xings/km^2 | 1 | Low |
| 0.51 to 0.60 Xings/km^2 | 1.25 | Low |
| 0.61 to 0.70 Xings/km^2 | 1.5 | Low |
| 0.71 to 0.80 Xings/km^2 | 1.75 | Low |
| 0.81 to 0.90 Xings/km^2 | 2 | Moderate |
| 0.91 to 1.00 Xings/km^2 | 2.25 | Moderate |
| 1.01 to 1.10 Xings/km^2 | 2.5 | Moderate |
| 1.11 to 1.20 Xings/km^2 | 2.75 | Moderate |
| 1.21 to 1.30 Xings/km^2 | 3 | High |
| 1.31 to 1.40 Xings/km^2 | 3.25 | High |
| 1.41 to 1.50 Xings/km^2 | 3.5 | High |
| 1.51 to 1.60 Xings/km^2 | 3.75 | High |
| 1.61 to 1.70 Xings/km^2 | 4 | Very High |
| 1.71 to 1.80 Xings/km^2 | 4.25 | Very High |
| 1.81 to 1.90 Xings/km^2 | 4.5 | Very High |
| 1.91 to 2.00 Xings/km^2 | 4.75 | Very High |
| 2.00 to 2.11 Xings/km^2 | 5 | Extreme |
| 2.11 to 2.20 Xings/km^2 | 5.25 | Extreme |
| 2.21 to 2.30 Xings/km^2 | 5.5 | Extreme |
| >=2.31 Xings/km^2 | 5.75 | Extreme |

**Determination of Loss of Riparian Function Hazard Rating.**

The hazard caused by a significant "reduction in riparian functions" was determined by measuring the "percent riparian removal of mainstem" which is measured on the digital orthophoto. The determination of the score was based on a combination of this number and professional opinion.

## DETERMINATION OF RISK RANKINGS FOR THE DIFFERENT HAZARD LEVELS IN THE WATERSHED

The determination of the risk rating, for a given hazard, is based on the sensitivity of the watershed (i.e. it's inherent characteristics) and the hazard score (based on extent of natural and land-use disturbance). The "Risk" is computed as The Hazard * The Sensitivity and the result is illustrated using the cross matrix provided in **Error! Reference source not found.**.

Table 22. Matrix used to determine the Risk to fish and their habitats based on the Hazard and Sensitivity scores for a given hazard.

| WatershedSensitivity | | Hazards (i.e. disturbances such as ECA, Roads and Riparian logging) | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Very Low | | | | | | | Low | | | | Moderate | | | | High | | | | Very High | | | | Extreme | | | |
| | | **0** | **0.25** | **0.5** | **0.75** | **1** | **1.25** | **1.5** | **1.75** | **2** | **2.25** | **2.5** | **2.75** | **3** | **3.25** | **3.5** | **3.75** | **4** | **4.25** | **4.5** | **4.75** | **5** | **5.25** | **5.5** | **5.75** | **6** | **6.25** | **6.5** |
| Very Low | **0** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **0.25** | 0.00 | [illegible] | [illegible] | 0.19 | 0.25 | 0.31 | 0.38 | 0.44 | 0.50 | 0.56 | 0.63 | 0.69 | 0.75 | 0.81 | 0.88 | 0.94 | 1.00 | 1.06 | 1.13 | 1.19 | 1.25 | 1.31 | 1.38 | 1.44 | 1.50 | 1.56 | 1.63 |
| | **0.5** | 0.00 | [illegible] | [illegible] | 0.38 | 0.50 | 0.63 | 0.75 | 0.88 | 1.00 | 1.13 | 1.25 | 1.38 | 1.50 | 1.63 | 1.75 | 1.88 | 2.00 | 2.13 | 2.25 | 2.38 | 2.50 | 2.63 | 2.75 | 2.88 | 3.00 | 3.13 | 3.25 |
| | **0.75** | 0.00 | 0.19 | 0.38 | 0.56 | 0.75 | 0.94 | 1.13 | 1.31 | 1.50 | 1.69 | 1.88 | 2.06 | 2.25 | 2.44 | 2.63 | 2.81 | 3.00 | 3.19 | 3.38 | 3.56 | 3.75 | 3.94 | 4.13 | 4.31 | 4.50 | 4.69 | 4.88 |
| | **1** | 0.00 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 3.25 | 3.50 | 3.75 | 4.00 | 4.25 | 4.50 | 4.75 | 5.00 | 5.25 | 5.50 | 5.75 | 6.00 | 6.25 | 6.50 |
| | **1.25** | 0.00 | 0.31 | 0.63 | 0.94 | 1.25 | 1.56 | 1.88 | 2.19 | 2.50 | 2.81 | 3.13 | 3.44 | 3.75 | 4.06 | 4.38 | 4.69 | 5.00 | 5.31 | 5.63 | 5.94 | 6.25 | 6.56 | 6.88 | 7.19 | 7.50 | 7.81 | 8.13 |
| | **1.5** | 0.00 | 0.38 | 0.75 | 1.13 | 1.50 | 1.88 | 2.25 | 2.63 | 3.00 | [illegible] | [illegible] | [illegible] | [illegible] | 4.50 | 4.88 | 5.25 | 5.63 | 6.00 | 6.38 | 6.75 | 7.13 | 7.50 | 7.88 | 8.25 | 8.63 | 9.00 | 9.38 | 9.75 |
| Low | **1.75** | 0.00 | 0.44 | 0.88 | 1.31 | 1.75 | 2.19 | 2.63 | 3.06 | 3.50 | 3.94 | 4.38 | 4.81 | 5.25 | 5.69 | 6.13 | 6.56 | 7.00 | 7.44 | 7.88 | 8.31 | 8.75 | 9.19 | 9.63 | 10.06 | 10.50 | 10.94 | 11.38 |
| | **2** | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 5.50 | 6.00 | 6.50 | 7.00 | 7.50 | 8.00 | 8.50 | 9.00 | 9.50 | 10.00 | 10.50 | 11.00 | 11.50 | 12.00 | 12.50 | 13.00 |
| | **2.25** | 0.00 | 0.56 | 1.13 | 1.69 | 2.25 | 2.81 | 3.38 | 3.94 | 4.50 | 5.06 | 5.63 | 6.19 | 6.75 | 7.31 | 7.88 | 8.44 | 9.00 | 9.56 | 10.13 | 10.69 | 11.25 | 11.81 | 12.38 | 12.94 | 13.50 | 14.06 | 14.63 |
| | **2.5** | 0.00 | 0.63 | 1.25 | 1.88 | 2.50 | 3.13 | 3.75 | 4.38 | 5.00 | 5.63 | 6.25 | 6.88 | 7.50 | 8.13 | 8.75 | 9.38 | 10.00 | 10.63 | 11.25 | 11.88 | 12.50 | 13.13 | 13.75 | 14.38 | 15.00 | 15.63 | 16.25 |
| Moderate | **2.75** | 0.00 | 0.69 | 1.38 | 2.06 | 2.75 | 3.44 | 4.13 | 4.81 | 5.50 | 6.19 | 6.88 | 7.56 | 8.25 | 8.94 | 9.63 | 10.31 | 11.00 | 11.69 | 12.38 | 13.06 | 13.75 | 14.44 | 15.13 | 15.81 | 16.50 | 17.19 | 17.88 |
| | **3** | 0.00 | 0.75 | 1.50 | 2.25 | 3.00 | 3.75 | 4.50 | 5.25 | 6.00 | 6.75 | 7.50 | 8.25 | 9.00 | 9.75 | 10.50 | 11.25 | 12.00 | 12.75 | 13.50 | 14.25 | 15.00 | 15.75 | 16.50 | 17.25 | 18.00 | 18.75 | 19.50 |
| | **3.25** | 0.00 | 0.81 | 1.63 | 2.44 | 3.25 | 4.06 | 4.88 | 5.69 | 6.50 | 7.31 | 8.13 | [illegible] | [illegible] | [illegible] | 11.38 | 12.19 | 13.00 | 13.81 | 14.63 | 15.44 | 16.25 | 17.06 | 17.88 | 18.69 | 19.50 | 20.31 | 21.13 |
| | **3.5** | 0.00 | 0.88 | 1.75 | 2.63 | 3.50 | 4.38 | 5.25 | 6.13 | 7.00 | 7.88 | 8.75 | 9.63 | 10.50 | 11.38 | 12.25 | 13.13 | 14.00 | 14.88 | 15.75 | 16.63 | 17.50 | 18.38 | 19.25 | 20.13 | 21.00 | 21.88 | 22.75 |
| High | **3.75** | 0.00 | 0.94 | 1.88 | 2.81 | 3.75 | 4.69 | 5.63 | 6.56 | 7.50 | 8.44 | 9.38 | 10.31 | 11.25 | 12.19 | 13.13 | 14.06 | 15.00 | 15.94 | 16.88 | 17.81 | 18.75 | 19.69 | 20.63 | 21.56 | 22.50 | 23.44 | 24.38 |
| | **4** | 0.00 | 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 | 11.00 | 12.00 | 13.00 | 14.00 | 15.00 | 16.00 | 17.00 | 18.00 | 19.00 | 20.00 | 21.00 | 22.00 | 23.00 | 24.00 | 25.00 | 26.00 |
| | **4.25** | 0.00 | 1.06 | 2.13 | 3.19 | 4.25 | 5.31 | 6.38 | 7.44 | 8.50 | 9.56 | 10.63 | 11.69 | 12.75 | 13.81 | 14.88 | 15.94 | 17.00 | 18.06 | 19.13 | 20.19 | 21.25 | 22.31 | 23.38 | 24.44 | 25.50 | 26.56 | 27.63 |
| | **4.5** | 0.00 | 1.13 | 2.25 | 3.38 | 4.50 | 5.63 | 6.75 | 7.88 | 9.00 | 10.13 | 11.25 | 12.38 | 13.50 | 14.63 | 15.75 | 16.88 | 18.00 | 19.13 | 20.25 | 21.38 | 22.50 | 23.63 | 24.75 | 25.88 | 27.00 | 28.13 | 29.25 |
| Very High | **4.75** | 0.00 | 1.19 | 2.38 | 3.56 | 4.75 | 5.94 | 7.13 | 8.31 | 9.50 | 10.69 | 11.88 | 13.06 | 14.25 | 15.44 | [illegible] | [illegible] | [illegible] | 20.19 | 21.38 | 22.56 | 23.75 | 24.94 | 26.13 | 27.31 | 28.50 | 29.69 | 30.88 |
| | **5** | 0.00 | 1.25 | 2.50 | 3.75 | 5.00 | 6.25 | 7.50 | 8.75 | 10.00 | 11.25 | 12.50 | 13.75 | 15.00 | 16.25 | 17.50 | 18.75 | 20.00 | 21.25 | 22.50 | 23.75 | 25.00 | 26.25 | 27.50 | 28.75 | 30.00 | 31.25 | 32.50 |
| | **5.25** | 0.00 | 1.31 | 2.63 | 3.94 | 5.25 | 6.56 | 7.88 | 9.19 | 10.50 | 11.81 | 13.13 | 14.44 | 15.75 | 17.06 | 18.38 | 19.69 | 21.00 | 22.31 | 23.63 | 24.94 | 26.25 | 27.56 | 28.88 | 30.19 | 31.50 | 32.81 | 34.13 |
| | **5.5** | 0.00 | 1.38 | 2.75 | 4.13 | 5.50 | 6.88 | 8.25 | 9.63 | 11.00 | 12.38 | 13.75 | 15.13 | 16.50 | 17.88 | 19.25 | 20.63 | 22.00 | 23.38 | 24.75 | [illegible] | [illegible] | [illegible] | 30.25 | 31.63 | 33.00 | 34.38 | 35.75 |
| Extreme | **5.75** | 0.00 | 1.44 | 2.88 | 4.31 | 5.75 | 7.19 | 8.63 | 10.06 | 11.50 | 12.94 | 14.38 | 15.81 | 17.25 | 18.69 | 20.13 | 21.56 | 23.00 | 24.44 | 25.88 | 27.31 | 28.75 | 30.19 | 31.63 | 33.06 | 34.50 | 35.94 | 37.38 |
| | **6** | 0.00 | 1.50 | 3.00 | 4.50 | 6.00 | 7.50 | 9.00 | 10.50 | 12.00 | 13.50 | 15.00 | 16.50 | 18.00 | 19.50 | 21.00 | 22.50 | 24.00 | 25.50 | 27.00 | 28.50 | 30.00 | 31.50 | 33.00 | 34.50 | 36.00 | 37.50 | 39.00 |
| | **6.25** | 0.00 | 1.56 | 3.13 | 4.69 | 6.25 | 7.81 | 9.38 | 10.94 | 12.50 | 14.06 | 15.63 | 17.19 | 18.75 | 20.31 | 21.88 | 23.44 | 25.00 | 26.56 | 28.13 | 29.69 | 31.25 | 32.81 | 34.38 | 35.94 | 37.50 | 39.06 | **40.63** |
| | **6.5** | 0.00 | 1.63 | 3.25 | 4.88 | 6.50 | 8.13 | 9.75 | 11.38 | 13.00 | 14.63 | 16.25 | 17.88 | 19.50 | 21.13 | 22.75 | 24.38 | 26.00 | 27.63 | 29.25 | 30.88 | 32.50 | 34.13 | [illegible] | [illegible] | [illegible] | **40.63** | **42.25** |
| | **6.75** | 0.00 | 1.69 | 3.38 | 5.06 | 6.75 | 8.44 | 10.13 | 11.81 | 13.50 | 15.19 | 16.88 | 18.56 | 20.25 | 21.94 | 23.63 | 25.31 | 27.00 | 28.69 | 30.38 | 32.06 | 33.75 | 35.44 | 37.13 | 38.81 | **40.50** | **42.19** | **43.88** |
| | **7** | 0.00 | 1.75 | 3.50 | 5.25 | 7.00 | 8.75 | 10.50 | 12.25 | 14.00 | 15.75 | 17.50 | 19.25 | 21.00 | 22.75 | 24.50 | 26.25 | 28.00 | 29.75 | 31.50 | 33.25 | 35.00 | 36.75 | 38.50 | **40.25** | **42.00** | **43.75** | **45.50** |

Very Low Risk Region <2.26

Low Risk Region 2.26 to 7.0

Mod Risk Region 7.01 to 13.5

High Risk Region 13.51 to 22.5

Very High Risk 22.51 to 33.0

Extreme Risk > 33

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**. APPENDIX 2.**. Fish Sensitivity Score Determined by the Provincial WET Tool



## Appendix 2: Relative Sensitivities and TEScores for Species Included in the Watershed Evaluation Tool

TE Scores are assigned to species according to their global (G) and provincial (S) rankings as follows:

| | S1 | S2 | S3 |
|---|---|---|---|
| G1 | 7 | – | – |
| G2 | 6 | 5 | – |
| G3 | 5 | 4 | 3 |
| G4 | 4 | 3 | 2 |
| G5 | 3 | 2 | 1 |

| Common name | Scientific name | Relative Sensitivity | T&E Score |
|---|---|---|---|
| Dolly Varden | *Salvelinus malma* | 1.00 | 1 |
| Bull Trout | *Salvelinus confluentus* | 1.00 | 3 |
| Coho Salmon | *Oncorhynchus kisutch* | 0.94 | |
| Coastal Cutthroat Trout | *Oncorhynchus clarki clarki* | 0.88 | 2 |
| Westslope Cutthroat Trout | *Oncorhynchus clarki lewisi* | 0.88 | 2 |
| Chinook Salmon | *Oncorhynchus tshawytscha* | 0.88 | |
| Mountain Whitefish | *Prosopium williamsoni* | 0.88 | |
| Cutthroat Trout | *Oncorhynchus clarki* | 0.88 | |
| Arctic Grayling | *Thymallus arcticus* | 0.81 | |
| Burbot | *Lota lota* | 0.81 | |
| Inconnu | *Stenodus leucichthys* | 0.75 | 1 |
| Northern Mountain Sucker | *Catostomus platyhyncus* | 0.75 | 1 |
| Rainbow Trout | *Oncorhynchus mykiss* | 0.75 | |
| Broad Whitefish | *Coregonus nasus* | 0.69 | 3 |
| Arctic Cisco | *Coregonus autumnalis* | 0.69 | 3 |
| Shorthead Sculpin | *Cottus confusus* | 0.69 | 2 |
| Coastrange Sculpin | *Cottus aleuticus* | 0.69 | |
| Chum Salmon | *Oncorhynchus keta* | 0.69 | |
| Lake Trout | *Salvelinus namaycush* | 0.69 | |
| Sockeye Salmon | *Oncorhynchus nerka* | 0.69 | |
| Least Cisco | *Coregonus sardinella* | 0.63 | 2 |
| Pacific Lamprey | *Lampetra tridentata* | 0.63 | 0 |
| Mottled Sculpin | *Cottus bairdi* | 0.63 | |
| Torrent Sculpin | *Cottus rhotheus* | 0.63 | |
| Longfin Smelt | *Spirinchus thaleichthys* | 0.63 | |
| Longnose Sucker | *Catostomus catostomus* | 0.63 | |
| Lake Whitefish | *Coregonus clupeaformis* | 0.63 | |
| Round Whitefish | *Prosopium cyclindraceum* | 0.63 | |
| Lake Cisco | *Coregonus artedii* | 0.56 | 3 |
| Western Brook Lamprey | *Lampetra richardsoni* | 0.56 | |
| River Lamprey | *Lampetra ayresi* | 0.56 | |
| Slimy Sculpin | *Cottus cognatus* | 0.56 | |
| Longnose Dace | *Rhynichthys cataractae* | 0.56 | |
| Eulachon | *Thaleichthys pacificus* | 0.50 | 2 |
| Chiselmouth | *Acrocheilus alutaceus* | 0.50 | 1 |

| Common name | Scientific name | Relative Sensitivity | T&E Score |
|---|---|---|---|
| Northern Pearl Dace | *Margariscus margarita* | 0.50 | 1 |
| Prickly Sculpin | *Cottus asper* | 0.50 | |
| Spoonhead Sculpin | *Cottus ricei* | 0.50 | |
| Lake Chub | *Couesius plumbeus* | 0.50 | |
| Pink Salmon | *Oncorhynchus gorbuscha* | 0.50 | |
| Pygmy Whitefish | *Prosopium coulteri* | 0.50 | |
| White Sucker | *Catostomus commersoni* | 0.50 | |
| Speckled Dace | *Rhynichthys osculus* | 0.44 | 3 |
| Umatilla Dace | *Rhynichthys umatilla* | 0.44 | 3 |
| Brassy Minnow | *Hybognathus hankinsoni* | 0.44 | |
| Brook Stickleback | *Culaea inconstans* | 0.44 | |
| Bridgelip Sucker | *Catastomus columbianus* | 0.44 | |
| Largescale Sucker | *Catostomus macrocheilus* | 0.44 | |
| Flathead Chub | *Platygobio gracilis* | 0.44 | |
| Peamouth Chub | *Mylocheilus caurinus* | 0.44 | |
| Redside Shiner | *Richardsonius balteatus* | 0.44 | |
| Troutperch | *Percopsis omiscomaycus* | 0.44 | |
| Walleye | *Stizostedion vitreum* | 0.44 | |
| Ninespine Stickleback | *Pungitius pungitius* | 0.38 | 3 |
| Green Sturgeon | *Acipenser medirostris* | 0.38 | |
| Northern Pike-minnow | *Ptychocheilus oregonensis* | 0.38 | |
| American Shad | *Alosa sapidissima* | 0.38 | |
| White Sturgeon | *Acipenser transmontanus* | 0.38 | |
| Spottail Shiner | *Notropis hudsonius* | 0.31 | 3 |
| Goldeye | *Hiodon alosoides* | 0.31 | 1 |
| Leopard Dace | *Rhynichthys falcatus* | 0.31 | |
| Finescale Dace | *Phoxinus neogaeus* | 0.25 | |
| Northern Pike | *Esox lucius* | 0.25 | |
| Northern Redbelly Dace | *Phoxinus eos* | 0.25 | |
| Emerald Shiner | *Notropis atherinoides* | 0.19 | 3 |
| Threespine Stickleback | *Gasterosteus aculeatus* | 0.19 | |
| Yellow Perch | *Perca flavescens* | 0.19 | |
| ***Subspecies, populations and life history variants*** | | | |
| Williston Lake Artic Grayling* | *Thymallus arcticus* | 0.81 | 3 |
| Lower Kootenay Burbot | *Lota lota* | 0.81 | 3 |
| Steelhead | *Oncorhynchus mykiss* | 0.81 | |
| Salish Sucker* | *Catostomus* sp. | 0.75 | 7 |
| Kokanee | *Oncorhynchus nerka* | 0.69 | |
| Morrison Creek Lamprey* | *Lampetra richardsoni marifaga* | 0.69 | 3 |
| Nooksack Dace* | *Rhinichthys* sp. | 0.63 | 5 |
| Pygmy Longfin Smelt* | *Spirincus* sp. | 0.56 | 7 |
| Lake Lamprey | *Lampetra macrostoma* | 0.44 | 7 |
| White Sturgeon populations* | *Acipenser transmontanus* sp. | 0.38 | 4 |
| Cultus Lake Sculpin* | *Cottus* sp. | 0.31 | 7 |
| Threespine Stickleback populations* | *Gasterosteus* sp. | 0.19 | 7 |

* See BC Conservation Data Centre for details.