Hydrological Stability Assessment of the Saunders Creek and No Name Creek (Gerimi Area) Watersheds

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SUMMARY

At the request of Weldwood of Canada Limited, hydrological stability assessments of the Saunders Creek and No Name Creek watersheds were initiated in October, 2003. These two watersheds were selected due to their high Equivalent Clearcut Areas and the need to conduct mountain pine beetle salvage operations. The three components of the hydrological stability assessment are a Channel Assessment, a Riparian Assessment, and a Sediment Source Survey.

The objectives of this project are to:

1. determine the integrity and hydrological stability of the watersheds by assessing the cumulative hydrological effects of past forest management activities and other disturbances, such as fire and insect infestation;
2. monitor hydrological values to comply with commitments in Weldwood of Canada Limited’s sustainable forest management plan;
3. provide documentation of baseline conditions for comparison with the results of future assessments/monitoring.

The two watersheds were determined to be hydrologically stable. Both watersheds had occurrences of partially aggraded or degraded channels, impacted riparian zones and low hazard sediment sources. Beetle-killed stands, if left unharvested, will have little impact on the hydrologic stability of the watershed. To protect the hydrologic stability of the watershed, it is imperative that any future harvesting includes riparian protection measures, diligent road planning and building, and a comprehensive road maintenance program. Additional recommendations are provided.
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INTRODUCTION

At the request of Weldwood of Canada Limited, hydrological stability assessments of the Saunders Creek and No Name Creek watersheds were initiated in October, 2003. No Name Creek is within the Gerimi Creek timber supply block. These two watersheds were selected due to their high Equivalent Clearcut Areas (39% and 38%, respectively) and the need to conduct mountain pine beetle salvage operations. The three components of the hydrological stability assessment are a Channel Assessment, a Riparian Assessment, and a Sediment Source Survey.

The objectives of this project are to:

1. determine the integrity and hydrological stability of the watersheds by assessing the cumulative hydrological effects of past forest management activities and other disturbances, such as fire and insect infestation;
2. monitor hydrological values to comply with commitments in Weldwood of Canada Limited’s sustainable forest management plan;
3. provide documentation of baseline conditions for comparison with the results of future assessments/monitoring.

RATIONALE

Forest management activities and natural disturbances can influence watershed hydrology through their effects on water quality, water quantity and timing of runoff. The degree to which the hydrology is influenced depends on the scale and specific location of the activities. The influences can be caused by site or watershed level disturbances or changes. At both scales, the influences can become apparent soon after the activity (e.g. surface erosion) or may take decades to occur (e.g., mass wasting) or to even become evident (e.g. cumulative effects, such as changes to peak flows and fish habitat).
Not only is the scale of the activities important, but also the physical scale of the watershed. It is important to remember that large watersheds are comprised of smaller watersheds. Smaller watersheds are influenced to a greater degree by both site and watershed level disturbances due to the lack of buffering and the fact that, generally, smaller watersheds have a higher percentage of their area under forest management activity.

Water quality is most frequently influenced at the site level (e.g. roads and road building). However, increases in peak flows can lead to channel erosion and result in reduced water quality. Quantity and timing of runoff are most frequently influenced by activities at the watershed level (e.g. extensive forest harvesting), although site level diversions can also be an influence (i.e. road ditches allowing water to move from one watershed into another watershed).

Studies have shown that the hydrological response of interior watersheds to harvesting, or other disturbances, is highly variable. Water yield, peak flows, timing of peak flows and low flows may increase slightly, increase significantly, or not increase at all. No consistent relationship was found between these variables and level of forest cover removal. Peak flows with a shorter return period (e.g. 1.5 years) are most likely to increase, while those with longer return period (e.g. 25-50 years) are most likely to be unchanged. Smaller watersheds (e.g. less than 200 ha) tend to have a greater response than larger watersheds. One reason peak flows may increase in smaller watersheds is due to increased snow accumulation and decreased evapotranspiration. High road densities have also been shown to increase streamflow. The effect of roads on streamflow increases with return period, while vegetation effects decrease.

As mentioned previously, water quality, specifically sediment, is influenced primarily at the site level, although it can be influenced at the watershed level through impacts to streamflow. Sediment concentrations have been shown to increase only very slightly following
harvesting; however total export may increase due to increased flows accelerating channel and bank erosion. Sediment budget analysis shows that the sources of sediment are varied. Road building can lead to increased annual sediment yields in both small and larger watersheds for several years following construction. The magnitude of the increase is inversely related to the level of erosion control. Other sources include erosion from roads and road-related landslides. Sediment from cutblocks, not including roads, is usually minimal. Road maintenance activities can be a major source of sediment. Depending on the physical characteristics of the watershed, roads may be only a small component of the annual sediment budget. Natural sediment sources may dominate the budget.

In addition to human activity, the Quesnel Forest District has been subject to natural disturbance regimes, primarily fire and mountain pine beetle infestations. The effect of insect infestations on watershed hydrology is similar to partial cutting. Insect-killed areas are not comparable to complete openings because dead trees still protect the snow from total exposure to sun and wind. It has been found that, in insect-killed areas, water yield, peak flows and low flows may increase slightly, increase significantly, or not increase at all. Decreases have not been noted. As with harvesting, the hydrological effects of insect infestations are long-term.

The hydrological differences between mountain pine beetle infestations and forest management activities have primarily to do with sediment and debris. Roads, and their drainage structures, are an integral component of harvesting activities, and can be a major source of sediment; this source is lacking from insect infestations that are not harvested. Harvesting also tends to remove large woody debris, while infested areas have an abundant supply. Regardless of the differences, it is the intent of forest management to minimize the negative effects of forestry activities, even though the negative effects from natural disturbances may be large in comparison.
It must be remembered that watershed characteristics and climate influence streamflow in separate ways. A critical characteristic in evaluating the effects of harvesting on streamflow is the routing of water in watersheds (e.g. storage). Large watersheds may not experience changes to streamflow because they are able to buffer the hydrologic impacts of forest disturbance (e.g. greater elevation range for snowmelt). In addition to harvesting activities, natural variations in climate and the characteristics of stream channels are also factors that influence changes to stream channels. Disturbed channels with reduced large woody debris are more susceptible to erosion resulting from changes in streamflow. Climatic variability is an important influence on the temporal trends in streamflow. In south-central B.C., there is evidence that climate change has resulted in earlier spring runoff, lower summer streamflow, and higher early winter streamflow. These changes are irrespective of land-use.

Overall, the response of a watershed depends on what part of the hydrologic system is altered and by how much. Consequently, the effects of harvesting in one watershed cannot be extrapolated to another without consideration of how the hydrologic system is affected.

The temporal scale of forest management activities is also important. As mentioned previously, the effects of activities can take decades to manifest themselves, in part due to the influence of climatic variation. From a watershed stewardship point-of-view, it is prudent to put forest management activities, which are generally initially short-term, into a long-term perspective. What is done in a watershed today will have an effect for many years. For instance, roads can have a permanent effect and re-establishing the hydrologic role of a forest can take more than 70 years.

An example of large-scale harvesting of a beetle-infested area is the Bowron River watershed. Approximately 30% of the upper portion of the watershed was harvested over a ten year period. Extensive harvesting also occurred in the middle and lower portions, but at a slower rate. In addition to the extensive harvesting, the lower portion of the watershed was much more roaded than the other portions. For the Bowron River itself, no change in
streamflow was detected. It is probable that changes did occur in the tributaries, but that their cumulative change was not detectable at the watershed scale. Changes in streamflow have been measured on smaller watersheds that have been salvaged logged in the southern interior of British Columbia. A sediment source survey identified approximately 200 sources directly attributable to harvesting activities. An extensive road network on easily erodible lakebed silts resulted in significant erosion from roads. Landslide activity and large sediment sources were noted in the upper portion of the watershed where the terrain is steeper and the soils are more unstable. A channel assessment noted an increase in delivery of sediment to stream channels and a destabilization of channels, potentially due to the heavily logged streambanks.

The extensive harvesting resulted in significant impacts in tributary streams, and the upper and mid-Bowron channels. Changes in the lower Bowron River channel could not be detected at the time of the survey; however changes could be expected in a longer time frame. The impacts in the tributary streams could have been reduced or eliminated if regular planning practices had been used, including the identification of erosion prone soils, retention of riparian reserves, and planning of road systems to limit road densities.

For sound watershed management, it is critical to ensure that forest management activities are not undertaken without due regard for hydrological watershed values. Conducting a channel assessment, riparian assessment and sediment source survey will contribute significantly to documenting the hydrological integrity of the watershed.

METHODOLOGY

CHANNEL ASSESSMENT

The channel assessment was conducted using the procedures outlined in the Channel Assessment Procedure Guidebook and Field Guidebook (Anon., 1996). Channel integrity
and stability was evaluated along mainstem alluvial stream reaches and major tributary channels of the watershed. The assessment involved examining historical aerial photographs, conducting a field inspection, and carrying out site visits to selected channel reaches to identify any obvious changes in stream morphology. The components of the assessment were:

1. **Mapping**
   
   (a) Identification of major channel reach breaks.
   
   In order to be consistent with previous assessments, the reach breaks identified in the Reconnaissance Fish and Fish Habitat Inventory (Triton, 2001, 2002) were used.

   (b) Identifying the location of the following features:
   
   - major stream junctions,
   - domestic water supply intakes,
   - reach numbers, and
   - average reach gradient.

2. **Historical aerial photographic analysis**

   (a) Analysis of alluvial stream reaches to document obvious channel disturbances, locations of major sediment sources and locations of disturbed riparian areas. As per the channel assessment procedures, this could not be done for streams too small to be seen on aerial photographs.

   (b) Comparison the most recent, large scale (e.g., larger than 1:20,000 scale) aerial photographs of the watershed with those taken before logging. Three ages of photography were examined for the following characteristics:
   
   - the likely CAP classification (where this can be discerned from the aerial photographs) of all reaches;
   - any reaches with obvious channel disturbances;
   - locations of major sediment inputs; and
   - locations of disturbed riparian areas.
3. A field survey of the mainstem and major tributary streams
   (a) Using the map of the channel network and labelled reaches, a survey of the sensitive alluvial reaches was conducted. Due to overhanging tree canopy, the survey of selected reaches was conducted on the ground. Reaches were selected based on the following criteria:
   - susceptibility to disturbance (alluvial reaches);
   - accessibility;
   - sensitivity (e.g., reaches occurring at tributary junctions or gradient breaks, reaches below landslides, reaches with riparian logging).

4. The following information was recorded for each reach:
   - channel type, using the stream classification system described in the Channel Assessment Procedure Guidebook;
   - extent and type of channel disturbance;
   - overall level of disturbance, based on the field indicators of disturbance identified in that reach. The channel state ranges from stable or undisturbed, through moderately disturbed to severely disturbed.

5. If a high level of channel disturbance was observed, selected channel reaches were investigated for channel conditions and upslope causes.

The outputs of the Channel Assessment are:
1. maps showing all disturbed reaches, disturbance types, and the extent of disturbance for all mainstem streams;
2. descriptions of the stream channel types and the general sediment transport and deposition processes in the watershed;
3. descriptions of historical flood flows, historical channel change and trends in stream channel stability;
4. for the selected reaches, a reach-by-reach description of current stream channel stability and disturbance types and of the impacts of that instability on aquatic resources;
5. probable causes of any identified stream channel instability; and
6. hazard evaluation of mainstem and major tributaries (i.e. sub-basins).

**RIPARIAN ASSESSMENT**

The riparian assessment was conducted using the procedures outlined in the Riparian Assessment and Prescription Procedures (Anon., 1998). A riparian assessment determined the role of riparian vegetation and wood debris in maintaining channel stability and channel structure, and how this role has been affected by logging. The components of the assessment were:

1. an initial assessment of logged riparian areas from aerial photographs and forest cover maps;
2. identification of reaches where riparian vegetation has a critical role in channel stability (alluvial reaches previously logged);
3. field observations of channel bank erosion of logged alluvial reaches, the effectiveness of second growth to stabilize channel banks, and the presence or absence and function of large woody debris jams; and
4. a comparison of historic aerial photographs to determine the temporal trend in channel stability as the riparian zone has been logged or has revegetated.

The outputs of the Riparian Assessment are:

1. maps showing all mainstem and tributary mainstem reaches where logging of the riparian vegetation has resulted in impacts to the channel (i.e., bank erosion, channel widening, loss of functioning large woody debris, etc.);
2. a written evaluation in which the impacts related to loss of riparian vegetation are ranked as None, Low, Moderate or High; with a clear justification for the assigned level; and
3. recommendations for riparian protection.
SEDIMENT SOURCE SURVEY

The sediment source survey was conducted using the procedures outlined in the Interior Watershed Assessment Procedure Guidebook (Anon., 1999). The sediment source survey was an inventory of significant contributors of fine-grained and coarse-textured sediment within the watershed. Forestry-related sediment sources are primarily associated with landslides, gullies, stream channel bank erosion, and the road network. The components of the survey were:

(a) Point Source Survey

(a) identification of significant sediment sources observable on 1:20 000 scale (or larger scale) aerial photographs in the following categories:

- landslides and debris flows larger than 0.05 ha; Each landslide was marked from initiation point to terminus. Each landslide was numbered and cross-referenced to a spreadsheet which recorded landslide type, initiation point (including reference to cause-natural, forestry related, or other land use), delivery route, magnitude of past and ongoing sediment delivery, surficial materials, disturbed area, and degree of revegetation.
- torrented stream channels;
- gullies with evidence of sidewall or channel failure; and
- large ravelling streambank terraces.

2. Sediment Hazard from Roads

(a) identification of sediment sources from roads, observable on 1:20 000 (or larger scale) aerial photographs. These sources included:

- slides from road fills;
- long unvegetated road fillslopes;
- unstable or large unvegetated cutslopes;
- erosion at crossing structures;
- road sections with steep grades that connect to streams; and
- road sections close to or encroaching on stream channels.

(b) mapping of road information on TRIM base map. If available, terrain stability or soil erosion mapping was overlaid on this map, showing areas of high to very high hazard of instability or erosion.

(c) production of a table describing each source and the relative level of sediment delivery. The significance of a sediment source depended on the capability of the receiving water to transport the incoming sediment downstream. Relatively small sediment sources can have a major effect on small streams, whereas much larger sources can have minimal effect on large stream channels. Some sources produced sediment on an ongoing basis, such as wash from an active haul road or chronic erosion of a road fill, whereas others were discrete events that produce a large quantity at the time of occurrence but little after that. The description of the sediment sources indicates which sources are chronic and which are discrete events.

The outputs of the Sediment Source Survey are:

1. maps showing major point sources of sediment (material originating from relatively localized areas, commonly streambanks, gullies and landslides); and the road network that identifies road elements with high chronic sediment delivery to streams.

2. tables that lists the following information for each point source:
   
   (a) type of disturbance (e.g., landslide, gully, terrace bank, etc.);
   
   (b) location of disturbance;
   
   (c) origin (clearcut, road, natural);
   
   (d) degree of revegetation on disturbed areas; and
   
   (e) sediment delivery to a stream.
RESULTS & DISCUSSION

SAUNDERS CREEK

Physical Description of Watershed

The Saunders Creek watershed is located approximately 48 km northwest of Quesnel, B.C. It is situated within mapsheets 093G036 and 093G046. Its watershed code is 100-507600.

The outlet of the creek is at its confluence with the Fraser River. The watershed is a 4th order basin, with an elevation range of 520 m to 980 m, and a total area of 5,339 ha (Table 1). The watershed has primarily low rolling terrain with some linear wetlands. The watershed is oriented along a north-south axis and has a dendritic drainage pattern in the lower half and a rectangular pattern in the upper half. A dendritic pattern develops when the regolith and bedrock are relatively uniform to erosion, resulting in a branching pattern similar to a tree. A rectangular pattern develops in faulted areas where streams follow the fault lines, with tributaries joining at almost right angles.

TABLE 1. Physical Parameters of Watershed

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>Stream Order</th>
<th>Mainstem Length (km)</th>
<th>Average Mainstem Gradient (%)</th>
<th>Drainage Density (km/km²)</th>
<th>Unstable Terrain¹ Area (ha)</th>
<th>Unstable Terrain¹ %³</th>
<th>Erodible Terrain² Area (ha)</th>
<th>Erodible Terrain² %³</th>
</tr>
</thead>
<tbody>
<tr>
<td>5339</td>
<td>4</td>
<td>20.00</td>
<td>2.1</td>
<td>2.9</td>
<td>223</td>
<td>4</td>
<td>357</td>
<td>7</td>
</tr>
</tbody>
</table>

¹ unstable terrain = within TFL 5: terrain stability Class IV & V (Weldwood of Canada Ltd.); outside TFL 5: 60% slopes (none occurring)
² erodible terrain = within TFL 5: erosion potential Class H & VH (Weldwood of Canada Ltd.); outside TFL 5: ESA – S (none occurring)
³ % = total area of unstable or erodible terrain, as a percentage of total area of sub-basin or watershed

The mainstem channel is 20.0 km long and descends from an elevation of 950 m to 520 m at its outlet, for an overall stream gradient of 2.1%. The drainage density (i.e. the total length of all streams divided by total watershed area) is 2.9 km/km², which is indicative of a
potentially rapid transferral of upstream impacts to downstream reaches. However, given the low stream gradient, the transferral is moderate.

The soils are predominantly lacustrine and susceptible to erosion and slope failures. Approximately 4% of the watershed area is classified as unstable, located along the mainstem channel and major tributaries in the lower one-third of the watershed. All of the unstable terrain is classified as erodible. An additional 3% of the watershed area is classified as erodible. Most of this additional area is located either immediately southwest of the outlet or along the mainstem just past the northern extent of the unstable terrain. At these locations, the mainstem and tributary channels are partially or completely coupled to adjacent hillslopes. Coupling refers to the potential for sediment to enter the stream channel (Anon., 1996). For partially coupled channels, only a portion of the sediment mobilized on hillslopes directly enters the channel. Sediment delivery is primarily by debris flows or persistent erosion from steep surrounding slopes, with some buffering by the valley flat. For coupled channels, most or all of the sediment can directly enter the channel. Sediment delivery is primarily by landslides from steep surrounding slopes, with no valley flat to buffer the impact.

A fish and fish habitat inventory was conducted in 2001 (Triton, 2001). Reaches 1 (S2), 2 (S3) and 3 (S3) of Saunders Creek (total length 12.0 km, 60% of total mainstem length) and reach 1 (S2) of ILP 842 (1.3 km), a major tributary, provide high value spawning and rearing habitat for rainbow trout. Higher catches of rainbow trout were found in these reaches due to greater channel size and water volume. No fisheries sensitive zones were identified and there is limited concern with respect to protecting sensitive or important fish habitat. Many streams have been impacted by past forest harvesting, but this does not appear to currently affect fish habitat and no restoration is required, with one exception. This will be discussed in the Sediment Source Survey section.
Channel Assessment

The mainstem channel and major tributaries have a sinuous channel pattern. The mainstem channel is small, with a width of 7.1 m and a bankfull depth of less than 0.7 m approximately 120 m upstream from its confluence with the Fraser River. The lower 120 m of the channel has experienced widening due to beaver activity. The mainstem and major tributary channels are classified as erodible, low gradient and narrow (i.e. drainage network classification CA1bii).

Approximately 5.5 km of reach 1 of the mainstem is within or bordered by unstable terrain and 6.4 km is within or bordered by erodible terrain. The hillslopes and stream channels within this zone are partially or completely coupled. Coarse sediment from the hillslopes where the coupling occurs can easily enter into the channels and be transported downstream. Stream channels outside of this zone are primarily decoupled, so coarse sediment does not easily enter into the channels for transport downstream.

Six naturally occurring small stream bank failures are located within the unstable/erodible zone. The stream is capable of carrying relatively large amounts of water, given its size and gradient. It is probable that large sediment (e.g. gravel) is readily transported from the naturally occurring stream bank failures during these high flow events. There is no evidence of historical flooding.

An analysis of historical air photos was completed using four ages of photography:

<table>
<thead>
<tr>
<th>Year</th>
<th>Flight Line(s)</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>BC2662, BC2663</td>
<td>1:15,840</td>
</tr>
<tr>
<td>1980</td>
<td>BC80016, BC80017</td>
<td>1:20,000</td>
</tr>
<tr>
<td>1999</td>
<td>BCB99030, BCB99031</td>
<td>1:15,000(outside TFL 5)</td>
</tr>
<tr>
<td>2001</td>
<td>SRS6467</td>
<td>1:20,000(within TFL 5)</td>
</tr>
</tbody>
</table>
The analysis indicates that since 1959 the morphology of the mainstem and major tributary channels has not greatly changed. Sediment deposition along reach 1 of the mainstem within the unstable/erodible zone increased slightly between 1959 and 2001. Increased sediment accumulations at the confluence were not observed over this time period. There is a large gravel bar formation at the confluence resulting from a naturally occurring major slump (approximately 1.5 km$^2$) into the Fraser River immediately north of the confluence. According to the historical air photos, this slump occurred prior to 1959. The mainstem and major tributary channels in the remainder of watershed were not clearly visible on the air photographs due to their small size and overhanging vegetation. Changes in their morphology could not, therefore, be observed, with one exception. Localized flooding has developed along the low gradient (<2%) streams in the upper portion of the watershed (above reach 3 of the mainstem) where multiple beaver dams have been built in areas harvested since 1959, when no harvesting was noted in the watershed. Other beaver dams occur below this reach, but are not as prevalent.

Fourteen sites along the mainstem and major tributaries were examined in the field. In addition, information from the fish and fish habitat inventory (Triton, 2001) was used to determine the morphology at an additional 44 sites. Channels in active logging blocks were not assessed. Reach 1 of the mainstem channel has a riffle-pool channel morphology, with primarily cobble and gravel bed material. The remainder of the mainstem channel and the major tributaries have a riffle-pool channel morphology, with primarily gravel bed material. Large woody debris is present throughout most of the channels and is a controlling factor in morphology, particularly in deposition and scour patterns. Portions of reach 1 within the unstable/erodible zone are partially aggraded, with coarse sediment from naturally occurring bank erosion and landslides (see Sediment Source Survey section). There are other minor occurrences of partially aggraded or degraded channel throughout the remainder of the mainstem. The majority of the stream channels are classified as stable. The repeating series of beaver dams on several channels in the upper portion of the watersheds are significantly affecting streamflow. There was no evidence of moderately or severely disturbed stream
channels, consequently the Channel Impact Value is low, resulting in a low hazard for the watershed (Table 2).

TABLE 2. Mainstem Channel Impact Value

<table>
<thead>
<tr>
<th>Total mainstem channel length (km)</th>
<th>Total mainstem channel length downstream of logging (km)</th>
<th>Length of altered small and intermediate channel morphology (km)</th>
<th>Total length of altered channel morphology (km)</th>
<th>Observed changes (total altered length / total length)</th>
<th>Channel mainstem Channel Impact Value (CIV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0 - low</td>
</tr>
</tbody>
</table>

Riparian Assessment

There has been significant harvesting of riparian zones throughout the watershed (Table 3). The majority of the harvesting was done prior to 1980 in small S3 and S4 streams. This level of harvesting represents a high hazard for potential impact to riparian condition and function.

No temporal trends in channel stability as the riparian zone was logged and revegetated were visible during a comparison of historic air photographs, partially due to the small size of the stream channels.

TABLE 3. Harvested Riparian Zone

| Classification | Length of Channel (km) | Harvested Riparian Zone | Length (km) | %
|----------------|------------------------|-------------------------|-------------|---
| S2             | 8.6                    | 2.1                     | 24 (17% pre-1980) |
| S3             | 13.6                   | 5.5                     | 40 (29% pre-1980) |
| S4             | 7.4                    | 4.3                     | 58 (30% pre-1980) |
| S5             | 0.2                    | 0.0                     | 0           |
| S6             | 123.7                  | 80.4                    | 65 (32% pre-1980) |

\(^{1}\% = \text{percentage of channel length}
Harvested riparian zones were examined on the ground while conducting the Channel Assessment, and during a helicopter reconnaissance. Channels in active logging blocks were not examined. Riparian zones harvested pre-1980 in S4 and S6 channels experienced a significant reduction in sources for LWD. Riparian function and condition are returning, including sources for LWD, as the zones regenerate. The regeneration and revegetation are stabilizing the stream banks. Zones harvested post-1980 in S4 channels experienced only a moderate reduction in sources for LWD and riparian function and condition are returning. The stream banks are stabilized by the regeneration and revegetation. Riparian zones harvested in S2 and S3 channels are not lacking in sources of LWD and the banks are stable. A significant amount of blowdown across the mainstem channel was noted along the mainstem at mid-reach 2.

It is speculated that the prevalent beaver activity in the upper portion of the watershed is due to the abundance of deciduous revegetation along the harvested streams. The beaver activity is preventing the pre-logging riparian zones of some channels from returning to normal function due to significant flooding. The mainstem above mid-reach 4 is especially impacted in this way.

**Sediment Source Survey**

The sediment source survey consisted of a point source survey (i.e. landslides) and a survey of sediment sources from roads. The road survey consisted of rating each sediment source within a sediment production class and a sediment delivery class to produce an overall sedimentation hazard.

Seven landslides were identified (Table 4), five of which were in unstable terrain. In addition to the seven landslides, there are six naturally occurring small stream bank failures located within the unstable/erodible zone. A road failure and an open slope failure are rated
as having a high magnitude of sediment delivery directly into the stream channel. It is recommended that these landslides be examined by a geoscientist for possible rehabilitation.

A small lake in mainstem reach 4 resulted from the construction of a dam on the mainstem prior to 1974. A sawmill was located at this site also. The area around the lake was harvested between 1964 and 1968, so it is probable that the dam was built at that time. The dam has partially failed, resulting in a 5 m high eroding bank, which is a significant source of fine sediment. A beaver dam is now controlling the water level in the lake. This site could also be an opportunity for rehabilitation.

TABLE 4. Results of point source survey

<table>
<thead>
<tr>
<th>Landslide No. &amp; Location</th>
<th>Type</th>
<th>Initiation Point</th>
<th>Sediment Delivery To Stream</th>
<th>Magnitude of Sediment Delivery</th>
<th>Surficial Material(^1)</th>
<th>Disturbed Area (ha)(^2)</th>
<th>Degree of Revegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Tributary ILP800 Reach 1</td>
<td>landslide</td>
<td>open slope failure</td>
<td>not into channel</td>
<td>low</td>
<td>silty gravel</td>
<td>0.05</td>
<td>none</td>
</tr>
<tr>
<td>L2 Mainstem Reach 1</td>
<td>landslide</td>
<td>open slope failure</td>
<td>into channel</td>
<td>low</td>
<td>silty gravel</td>
<td>0.05</td>
<td>high</td>
</tr>
<tr>
<td>L3 Mainstem Reach 1</td>
<td>landslide</td>
<td>road</td>
<td>into channel</td>
<td>high</td>
<td>silty gravel</td>
<td>0.24</td>
<td>high</td>
</tr>
<tr>
<td>L4 Mainstem Reach 1</td>
<td>landslide</td>
<td>open slope failure</td>
<td>into channel</td>
<td>high</td>
<td>silty gravel</td>
<td>0.12</td>
<td>low</td>
</tr>
<tr>
<td>L5 Tributary ILP832 Reach 1</td>
<td>landslide</td>
<td>road</td>
<td>into channel</td>
<td>low</td>
<td>silty gravel</td>
<td>0.05</td>
<td>moderate</td>
</tr>
<tr>
<td>L6 Mainstem Reach 1</td>
<td>landslide</td>
<td>cutblock</td>
<td>into channel</td>
<td>moderate</td>
<td>silty gravel</td>
<td>0.05</td>
<td>none</td>
</tr>
<tr>
<td>L7 Mainstem Reach 4</td>
<td>landslide</td>
<td>old dam site</td>
<td>into channel</td>
<td>high</td>
<td>silty gravel</td>
<td>0.03</td>
<td>none</td>
</tr>
</tbody>
</table>

\(^1\) surficial materials – estimated, based on literature
\(^2\) estimated from air photographs, maps and photographs taken from helicopter
The survey of sediment sources from roads identified seven sources (Table 5). None are located in the unstable/erodible terrain. Even though all the sources contribute sediment directly to the streams, the production of sediment is low (estimated at less than 2 m³ per year) and consequently the hazard ratings are low. In general, the roads within the watershed are on gentle slopes, requiring little cut and fill construction. The majority of the roads in the watershed, especially in the upper half, are over 30 years old. Many are revegetating. Recommended remedial action is directed at reducing the potential delivery of sediment to the channel or in protecting the road system. It is recommended that these sources be monitored as part of the regular road maintenance program and remediation be undertaken if sediment production increases.

![Table 5](https://example.com/table5.png)

<table>
<thead>
<tr>
<th>Sediment Source</th>
<th>Description</th>
<th>Hazard Rating</th>
<th>Recommendations for Potential Remediation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS1</td>
<td>Erosion around small (460 mm) overflow culvert</td>
<td>low</td>
<td>Replace with larger culvert (preferred), otherwise armour</td>
</tr>
<tr>
<td>SS2</td>
<td>Erosion of road surface and ditch around culvert</td>
<td>low</td>
<td>Culvert not aligned with stream channel and hanging beyond road prism – replace culvert</td>
</tr>
<tr>
<td>SS3</td>
<td>Erosion of road surface</td>
<td>low</td>
<td>Section of road appears to be built on organic debris; possibly fixed due to malfunctioning culvert at SS2; rebuild road section</td>
</tr>
<tr>
<td>SS4</td>
<td>Ditch erosion and erosion around hanging culvert</td>
<td>low</td>
<td>Pool forming; culvert and ditch need armouring</td>
</tr>
<tr>
<td>SS5</td>
<td>Ditch erosion</td>
<td>low</td>
<td>No action required</td>
</tr>
<tr>
<td>SS6</td>
<td>Old road crossing – culvert pulled</td>
<td>low</td>
<td>No action required</td>
</tr>
<tr>
<td>SS7</td>
<td>Old road crossing – bridge removed</td>
<td>low</td>
<td>No action required</td>
</tr>
</tbody>
</table>

It was noted during the field survey that in several locations, new road works have been undertaken within the past two years. Road crossings have been armoured, and new culverts and bridges have been installed. These road works significantly decrease the potential for sediment to enter the streams.
In addition to the field survey, a mapping exercise was undertaken to identify the hazards of several indicator parameters. Roads and harvested areas situated on unstable or erodible terrain have a greater probability of failing and becoming sediment sources, especially if they are near streams. Road densities on unstable or erodible terrain, including densities within 100 m of streams, range from 0.01 km/km² to 0.06 km/km² (Tables 6 & 7). These densities are considered a low sediment hazard rating. In addition, densities of harvested areas on unstable or erodible terrain are also considered to be low hazard (Tables 6 & 7).

The presence of landslides is an indicator of the potential for future landslides to occur. Given that six landslides were identified within the unstable terrain, the sediment hazard relating to landslides is moderate.

Active stream crossings can be sediment sources due to ditchlines draining into the stream channel and the possibility of non-functioning structures (e.g. culverts). The densities of crossings on all streams represent a high sediment hazard (Table 8). However, the majority of the crossings are on small S6 streams, which are less likely to deliver sediment. A more accurate measurement is to identify only those crossings on the mainstem channel and major tributaries. In this case, the sediment hazard due to crossings is moderate.

Combining the results of the sediment source survey with those of the mapping exercise indicate that the overall sediment hazard for the unstable terrain zone is moderate-high, and the hazard for the remainder of the watershed is low.

It is important to note the relative significance of the sediment sources. The road related sources contribute less sediment directly to stream channels than naturally occurring stream bank erosion and bank failures. The high spring snow melt and storm flows would accelerate the occurrence of the bank failures and erosion. The road sources tend to contribute only finer sediments, whereas the stream banks are sources of not only finer sediment, but also gravel and cobbles. From a forest hydrology perspective, even though a significant portion
of the sediment is naturally occurring, efforts must still be made to minimize the impact of roads.

Summary

The fish and fish habitat inventory did not identify any fisheries sensitive zones and it had limited concern with respect to protecting sensitive or important fish habitat.

The results of the channel assessment showed that there was no evidence of historical flooding and that the morphology of the mainstem and major tributary channels has not significantly changed over time. Localized flooding was noted in the upper portion of the watershed due to beaver activity. The majority of the assessed stream channels are classified as stable, with some channels being partially aggraded or degraded. There was no evidence of moderately or severely disturbed stream channels, resulting in a low hazard for the watershed.

The results of the riparian assessment showed that there has been significant harvesting of riparian zones throughout the watershed, primarily in small S3 and S4 streams prior to 1980. Riparian function and condition are returning. The beaver activity in the upper portion of the watershed is preventing the pre-logging riparian zones of some channels from returning to normal function due to flooding.

Three landslides identified in the sediment source survey are considered high hazard. Two occur in unstable terrain and one is an old dam site. The survey of sediment sources from roads identified seven sources, none of which are located in the unstable/erodible terrain. The hazard ratings for these sites are low. The overall sediment hazard is moderate-high in the unstable terrain and low in the remainder of the watershed.
Overall, the watershed is hydrologically stable. Any increases in stream flows due to harvesting have not adversely impacted the stream channels. The impacts to stream channels have resulted from three sources: (1) harvested riparian zones; (2) beaver activity; and (3) sediment from landslides, roads and road crossings. Beetle-killed stands, if left unharvested, will have little impact on the hydrologic stability of the watershed. To protect the hydrologic stability of the watershed, it is imperative that any future harvesting includes riparian protection measures, diligent road planning and building, and a comprehensive road maintenance program.

Recommendations

1. The three high hazard landslides should be examined by a geoscientist for possible rehabilitation.
2. Where feasible, existing roads and stream crossings located on unstable or erodible terrain that are potentially unstable should be deactivated, if in accordance with higher level plans and if technically feasible.
3. A regular road maintenance program, including culvert and ditch maintenance, is critical on existing non-deactivated roads to ensure proper drainage, thereby mitigating the possibility of road failure and sediment delivery. New road works should be inspected following the first major storm event to ensure that they are not acting as sediment sources.
4. The sediment sources from roads should be monitored as part of the regular road maintenance program and remediation be undertaken if sediment production increases.
### TABLE 6. Road and Harvested Area Density on Unstable Terrain

<table>
<thead>
<tr>
<th>Area (km²)</th>
<th>Road on Unstable Terrain¹</th>
<th>Road on Unstable Terrain within 100 m of Stream</th>
<th>Harvested Area on Unstable Terrain</th>
<th>Harvested Area on Unstable Terrain within 100 m of Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length (km)</td>
<td>Density (km/km²)</td>
<td>Length (km)</td>
<td>Density (km/km²)</td>
</tr>
<tr>
<td>53.4</td>
<td>1.6</td>
<td>0.03</td>
<td>0.6</td>
<td>0.01</td>
</tr>
</tbody>
</table>

¹ unstable terrain = terrain stability Class IV & V

### TABLE 7. Road and Harvested Area Density on Erodible Terrain

<table>
<thead>
<tr>
<th>Area (km²)</th>
<th>Road on Erodible Terrain¹</th>
<th>Road on Erodible Terrain within 100 m of Stream</th>
<th>Harvested Area on Erodible Terrain</th>
<th>Harvested Area on Erodible Terrain within 100 m of Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length (km)</td>
<td>Density (km/km²)</td>
<td>Length (km)</td>
<td>Density (km/km²)</td>
</tr>
<tr>
<td>53.4</td>
<td>3.1</td>
<td>0.06</td>
<td>1.4</td>
<td>0.03</td>
</tr>
</tbody>
</table>

¹ erodible terrain = terrain stability Class H & VH

### TABLE 8. Landslides and Stream Crossings

<table>
<thead>
<tr>
<th>Area (km²)</th>
<th>Landslides</th>
<th>Active Crossings on All Streams</th>
<th>Active Crossings on Mainstem and Major Tributaries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (#)</td>
<td>Density (#/km²)</td>
<td>Number (#)</td>
</tr>
<tr>
<td>53.4</td>
<td>6</td>
<td>0.11</td>
<td>141</td>
</tr>
</tbody>
</table>
NO NAME CREEK (GERIMI AREA)

Physical Description of Watershed

The No Name Creek watershed is located approximately 31 km southeast of Quesnel, B.C. It is situated within mapsheets 093B080 and 093B090. The watershed being assessed (watershed code 160-216700) is located within the Gerimi Creek timber supply block and is situated immediately south of the gazetted Gerimi Creek (watershed code 160-180800).

The outlet of the creek is at its confluence with the Quesnel River. The watershed is a 3rd order basin, with an elevation range of 560 m to 1,280 m, and a total area of 3,786 ha (Table 9). The watershed is on a predominantly southwest facing slope (average slope 11%), and has limited topographic relief. There are two major wetlands, both associated with beaver activity. The watershed has a pinnate drainage pattern in the lower two-thirds and a dendritic pattern in the upper one-third. A dendritic pattern develops when the regolith and bedrock are relatively uniform to erosion, resulting in a branching pattern similar to a tree. A pinnate pattern is similar to a dendritic pattern, but with less branching.

TABLE 9. Physical Parameters of Watershed

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>Stream Order</th>
<th>Mainstem Length (km)</th>
<th>Average Mainstem Gradient (%)</th>
<th>Drainage Density (km/km²)</th>
<th>Unstable Terrain</th>
<th>Erodible Terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>3786</td>
<td>3</td>
<td>11.5</td>
<td>4.9</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1 unstable terrain = 60% slopes
2 erodible terrain = ESA – S
3 % = total area of unstable or erodible terrain, as a percentage of total area of sub-basin or watershed

The mainstem channel is 11.5 km long and descends from an elevation of 1,130 m to 560 m at its outlet, for an overall stream gradient of 4.9%. The drainage density (i.e. the total length of all streams divided by total watershed area) is 1.2 km/km², which is indicative of a
potentially moderate transferral of upstream impacts to downstream reaches. However, given the fairly steep average gradient, the transferral is moderate-to-rapid.

Due to a lack of terrain stability mapping or soils mapping, unstable terrain was defined as slopes greater than 60% and erodible soils were defined as ESA – S. There were no slopes greater than 60%, hence no terrain was classified as unstable. Only a small pocket of erodible soil (less than 1% of the watershed area) was located at the confluence of the first major tributary with the mainstem reach 1. However, field observations showed the lower reaches of the mainstem and the major tributary to be partially or completely coupled to adjacent hillslopes. Coupling refers to the potential for sediment to enter the stream channel (Anon., 1996). For partially coupled channels, only a portion of the sediment mobilized on hillslopes directly enters the channel, whereas for coupled channels, most or all of the sediment can directly enter the channel.

A fish and fish habitat inventory was conducted in 2001 (Triton, 2002). Reaches 1, 2 and 3 (all S3), with a total length of 5.3 km (46% of total mainstem length), provide moderate to high quality rearing habitat for rainbow trout. No fisheries sensitive zones were identified and there is limited concern with respect to protecting sensitive or important fish habitat. Many streams have been impacted by past forest harvesting, but this does not appear to currently affect fish habitat and no restoration is required.
Channel Assessment

The mainstem channel and major tributaries have a sinuous channel pattern. The mainstem channel is small, with a width of 7.4 m and a bankfull depth of less than 0.6 m at its confluence with the Quesnel River. In the lower 200 m, there are multiple old channels resulting from re-routing of the channel. The mainstem and major tributary channels are classified as erodible, low gradient and narrow (i.e. drainage network classification CA1bii).

Approximately 1.2 km of reach 2 of the mainstem, above the first tributary, is bordered by steep terrain. The hillslopes and stream channel within this zone are completely coupled. Coarse sediment from the hillslopes where the coupling occurs directly enters into the channels and is transported downstream. Stream channels outside of this zone are primarily decoupled or only partially coupled, so coarse sediment does not easily enter into the channels for transport downstream.

Four naturally occurring small stream bank failures are located within this zone. The stream is capable of carrying relatively large amounts of water, given its size and gradient. It is probable that large sediment (e.g. gravel) is readily transported from the naturally occurring stream bank failures during these high flow events. There is no evidence of historical flooding.

An analysis of historical air photos was completed using three ages of photography:

<table>
<thead>
<tr>
<th>Year</th>
<th>Flight Line(s)</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>BC2343, BC2344, BC2361,</td>
<td>1:15,840</td>
</tr>
<tr>
<td></td>
<td>BC 2362</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>BC85009</td>
<td>1:20,000</td>
</tr>
<tr>
<td>1997</td>
<td>BCC97069, BCC97070</td>
<td>1:15,000</td>
</tr>
</tbody>
</table>

The analysis indicates that since 1957 the morphology of the mainstem and major tributary channels have not visibly changed. Increased sediment accumulations at the confluence were
not observed over this time period. The mainstem and major tributary channels were not clearly visible on the air photographs due to their small size and overhanging vegetation. Changes in their morphology could not, therefore, be observed, with one exception. Localized flooding and wetland development (approx. 12 ha) have occurred in reach 4 of the mainstem due to beaver dams which have been built recently. Two other beaver-related wetlands occur in the watershed; a small wetland (approx. 6 ha) in reach 4 of the first tributary and a large wetland (approx. 30 ha) in reach 7 of the mainstem.

Eleven sites along the mainstem and major tributaries were examined in the field. In addition, information from the fish and fish habitat inventory (Triton, 2002) was used to determine the morphology at an additional 11 sites. Channels in active logging blocks were not assessed. Reaches 1 and 2 of the mainstem channel, and reaches 1 and 2 of two major tributaries, have a cascade-pool channel morphology, with primarily cobble and gravel bed material. The remainder of the mainstem channel and the major tributaries have a riffle-pool channel morphology, with primarily gravel bed material. Large woody debris is present throughout most of the channels and is a controlling factor in morphology, particularly by trapping sediment, and influencing deposition and scour patterns. The lower portion of reach 1 of the mainstem, below the bank failures, has partially aggraded with coarse sediment from the naturally occurring bank erosion (see Sediment Source Survey section). There are other minor occurrences of partially aggraded or degraded channel throughout the remainder of the mainstem. The majority of the stream channels are classified as stable. There was no evidence of moderately or severely disturbed stream channels, consequently the Channel Impact Value is low, resulting in a low hazard for the watershed (Table 10).

TABLE 10. Mainstem Channel Impact Value

<table>
<thead>
<tr>
<th>Total mainstem channel length (km)</th>
<th>Total mainstem channel length downstream of logging (km)</th>
<th>Length of altered small and intermediate channel morphology (km)</th>
<th>Total length of altered channel morphology (km)</th>
<th>Observed changes (total altered length / total length)</th>
<th>Channel mainstem Channel Impact Value (CIV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.53</td>
<td>3.22</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0 - low</td>
</tr>
</tbody>
</table>
Riparian Assessment

There has been some harvesting of riparian zones throughout the watershed (Table 11). The majority of the harvesting has been done since 1999. This level of harvesting represents a low to moderate hazard for potential impact to riparian condition and function.

No temporal trends in channel stability as the riparian zone was logged and revegetated were visible during a comparison of historic air photographs, partially due to the small size of the stream channels.

TABLE 11. Harvested Riparian Zone

<table>
<thead>
<tr>
<th>Classification</th>
<th>Length of Channel (km)</th>
<th>Harvested Riparian Zone Length (km)</th>
<th>%¹ – Hazard²</th>
</tr>
</thead>
<tbody>
<tr>
<td>S3</td>
<td>15.2</td>
<td>0.3</td>
<td>2 - L</td>
</tr>
<tr>
<td>S4</td>
<td>7.6</td>
<td>1.6</td>
<td>21 - M</td>
</tr>
<tr>
<td>S5</td>
<td>0.0</td>
<td>0.0</td>
<td>0 - L</td>
</tr>
<tr>
<td>S6</td>
<td>23.3</td>
<td>4.9</td>
<td>21 - M</td>
</tr>
</tbody>
</table>

¹ % = percentage of channel length
² L = Low (≤ 12%), M = Moderate (13 to 21%)

Harvested riparian zones were examined on the ground while conducting the Channel Assessment, and during a helicopter reconnaissance. Channels in active logging blocks were not examined. Riparian zones harvested in small S4 and S6 channels experienced a significant reduction in sources for LWD. Riparian function and condition are returning, including sources for LWD, as the zones regenerate. The regeneration and revegetation are stabilizing the stream banks. Zones harvested in larger S4 and S3 channels did experienced only a moderate reduction in sources for LWD, and riparian function and condition is returning. The stream banks are stabilized by the regeneration and revegetation.
Sediment Source Survey

The sediment source survey consisted of a point source survey (i.e. landslides) and a survey of sediment sources from roads. The road survey consisted of rating each sediment source within a sediment production class and a sediment delivery class to produce an overall sedimentation hazard.

No landslides were identified. There are four naturally occurring small stream bank failures located within reach 2 of the mainstem.

The survey of sediment sources from roads identified four sources (Table 12). None are located in the steep or erodible terrain. Even though all the sources contribute sediment directly to the streams, the production of sediment is low (estimated at less than 2 m³ per year) and consequently the hazard ratings are low. In general, the roads within the watershed are on gentle slopes, requiring little cut and fill construction. Recommended remedial action is directed at reducing the potential delivery of sediment to the channel or in protecting the road system. It is recommended that these sources be monitored as part of the regular road maintenance program and remediation be undertaken if sediment production increases.

TABLE 12. Results of sediment source survey of roads

<table>
<thead>
<tr>
<th>Sediment Source</th>
<th>Description</th>
<th>Hazard Rating</th>
<th>Recommendations for Remediation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS1</td>
<td>Ditch erosion and erosion around hanging culvert</td>
<td>low</td>
<td>Pool forming; culvert and ditch need armouring</td>
</tr>
<tr>
<td>SS2</td>
<td>Erosion of road surface and ditch around culvert</td>
<td>low</td>
<td>Reshape road to promote surface drainage or add cross-drain; armour culvert</td>
</tr>
<tr>
<td>SS3</td>
<td>Failing culvert and road bed erosion</td>
<td>low</td>
<td>Culvert too short and blocked by rock; replace culvert</td>
</tr>
<tr>
<td>SS4</td>
<td>Old bridge</td>
<td>low</td>
<td>Old bridge being used by equipment; replace if use is to continue</td>
</tr>
</tbody>
</table>

It was noted during the field survey that in several locations, new road works have been undertaken within the past two years. Road crossings have been armoured, and new culverts
have been installed. These road works significantly decrease the potential for sediment to enter the streams.

In addition to the field survey, a mapping exercise was undertaken to identify the hazards of several indicator parameters. Roads and harvested areas situated on steep or erodible terrain have a greater probability of failing and becoming sediment sources, especially if they are near streams. No roads or harvested areas were located on steep or erodible terrain. Consequently, the sediment hazard rating is low.

The presence of landslides is an indicator of the potential for future landslides to occur. Given that no landslides were identified, the sediment hazard relating to landslides is low.

Active stream crossings can be sediment sources due to ditchlines draining into the stream channel and the possibility of non-functioning structures (e.g. culverts). The densities of crossings on all streams represent a high sediment hazard (Table 13). However, 10 of the crossings are on small S6 streams, which are less likely to deliver sediment. A more accurate measurement is to identify only those crossings on the mainstem channel and major tributaries. In this case, the sediment hazard due to crossings is low.

TABLE 13. Stream Crossings

<table>
<thead>
<tr>
<th>Area (km²)</th>
<th>Active Crossings on All Streams</th>
<th>Active Crossings on Mainstem and Major Tributaries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (#)</td>
<td>Density - Hazard (#/km²)</td>
</tr>
<tr>
<td>37.9</td>
<td>23</td>
<td>0.61 - H</td>
</tr>
</tbody>
</table>

1 H = High (≥ 60), L = Low (≤ 40)

Combining the results of the sediment source survey with those of the mapping exercise indicate that the overall sediment hazard for the watershed is low to moderate.

It is important to note the relative significance of the sediment sources. The road related sources contribute less sediment directly to stream channels than naturally occurring stream
bank erosion and bank failures. The high spring snow melt and storm flows would accelerate
the occurrence of the bank failures and erosion. The road sources tend to contribute only
finer sediments, whereas the stream banks are sources of not only finer sediment, but also
gravel and cobbles. From a forest hydrology perspective, even though a significant portion
of the sediment is naturally occurring, efforts must still be made to minimize the impact of
roads.

Summary

The fish and fish habitat inventory did not identify any fisheries sensitive zones and it had
limited concern with respect to protecting sensitive or important fish habitat.

The results of the channel assessment showed that there was no evidence of historical
flooding and that the morphology of the mainstem and major tributary channels has not
significantly changed over time. Localized flooding and wetland development were noted in
the upper portion of the watershed due to beaver activity. The majority of the assessed
stream channels are classified as stable, with some channels being partially aggraded or
degraded. The lower portion of the mainstem, just above the confluence, has partially
aggraded with coarse sediment from the naturally occurring bank erosion. There was no
evidence of moderately or severely disturbed stream channels, resulting in a low hazard for
the watershed.

The results of the riparian assessment showed that there has been moderate harvesting of
riparian zones throughout the watershed, primarily in small S4 and S6 streams. Riparian
function and condition are returning. The hazard potential is low to moderate.

No landslides were identified in the sediment source survey. The survey of sediment sources
from roads identified four sources, none of which are located in unstable/erodible terrain.
The hazard ratings for these sites are low. The overall sediment hazard for the watershed is low to moderate.

Overall, the watershed is hydrologically stable. Any increases in stream flows due to harvesting have not adversely impacted the stream channels. The impacts to stream channels have resulted from two sources: (1) harvested riparian zones; and (2) sediment from landslides, roads and road crossings. Beetle-killed stands, if left unharvested, will have little impact on the hydrologic stability of the watershed. To protect the hydrologic stability of the watershed, it is imperative that any future harvesting includes riparian protection measures, diligent road planning and building, and a comprehensive road maintenance program.

Recommendations

1. Where feasible, existing roads and stream crossings located on unstable or erodible terrain that are potentially unstable should be deactivated, if in accordance with higher level plans and if technically feasible.

2. A regular road maintenance program, including culvert and ditch maintenance, is critical on existing non-deactivated roads to ensure proper drainage, thereby mitigating the possibility of road failure and sediment delivery. New road works should be inspected following the first major storm event to ensure that they are not acting as sediment sources.

3. The sediment sources from roads should be monitored as part of the regular road maintenance program and remediation be undertaken if sediment production increases.
REFERENCES


Triton. 2002. Reconnaissance (1:20,000) fish and fish habitat inventory of the Gerimi Creek (WSC:160-180800), lower Victoria Creek (WSC: 100-481100-48200), and Swift River (WSC: 100-481100) planning areas. Triton Environmental Consultants Ltd. for: Weldwood of Canada Limited, Quesnel, B.C.

Triton. 2001. Reconnaissance (1:20,000) fish and fish habitat inventory of the TFL 5 planning area – WSCs: 100 (Fraser River), 170 (Blackwater River). Triton Environmental Consultants Ltd. for: Slocan Group, Tolko Industries Ltd., Weldwood of Canada Limited, and West Fraser Mills, Quesnel, B.C.