FINAL REPORT

ROBERT CREEK
Watershed Assessment

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August, 2000

RECOMMENDATIONS BY THE WATERSHED ADVISORY COMMITTEE ROBERT WATERSHED
(following technical meeting #2)

The Watershed Advisory Committee technical meeting #2 was held August 3rd, 2000 and again on October 12th, 2000 at the Clearwater Forest District Office.

Attendance at Meeting on August 3, 2000

John Rogers	Slocan Group, Vavenby Division
Leverne Burnell	Slocan Group, Vavenby Division
Dave Doubek	Slocan Group, Vavenby Division
Steve Roberts	Ministry of Forests
Randall Harris	Ministry of Environment, Lands and Parks
Steve Henderson	*Integrated* Woods Services Ltd.
Jeff Guerin	*Integrated* Woods Services Ltd.

Attendance at Meeting on October 12, 2000

Greg Yeomans	Slocan Group, Vavenby Division
Kathleen Gazey	Slocan Group, Vavenby Division
Steve Roberts	Ministry of Forests
Don Geiger	Ministry of Forests
Sandy Mackenzie	Ministry of Forests
Martin Fennell	Ministry of Forests
Robert Martin	Ministry of Forests
Randall Harris	Ministry of Environment, Lands and Parks
Steve Henderson	*Integrated* Woods Services Ltd.

Conclusions and Recommendations

1. The proposed forest harvesting by Slocan Group-Vavenby Division (Slocan), Interfor, Weyerhaeuser Company Limited and the Small Business Forest Enterprise Program (refer to Table 4) has a **low** risk of impacting stream channels and aquatic resources in the Robert Creek watershed.
2. The cumulative impacts from development in the Robert Creek watershed are expected to have a low risk of impacting the stream channel and aquatic resources in the Burton Creek watershed.

3. Road deactivation or upgrade prescriptions will be completed by Slocan in year 2000 on the two priority road sites identified in the Sediment Source Survey. At priority site one, the fill slope material needs to be pulled back. The prescriptions will be completed by Slocan in year 2000. The completion of the works is required by the Fall of 2001 and will be negotiated between Slocan and the Ministry of Forests. At priority site two, a re-alignment of the tributary channel off the existing skid road would be beneficial, adjacent to reach 4 of Robert Creek. Riparian planting could also be completed at this site to help stabilize the non-cohesive bank materials. The work at priority site 2 needs to be completed by 2004, the work is the Ministry of Forests responsibility but Slocan will complete under Forest Renewal British Columbia (or similar) funding.
4. The existing channel conditions and risks associated with future development suggest that the Robert Creek watershed should have a Red Flag ECA of 30%.
5. The current condition of the fire trails adjacent to opening 96, polygon 248 and proposed CP 195-E needs to be assessed. Deactivation prescriptions will be completed by Slocan in year 2000. The prescribed works will be the Ministry of Forest's responsibility to complete prior to 2004.
6. An assessment of riparian rehabilitation (deciduous planting) potential should be completed for reach 4 of Robert Creek. This assessment and fulfillment of any recommendations will be the Ministry of Forest's responsibility to complete prior to 2004.

Yours truly,
Integrated Woods Services Ltd.

REGISTERED PROFESSIONAL FORESTER
PROVINCE OF BRITISH COLUMBIA
STEPHEN GARY HENDERSON
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Stephen Henderson, RPF
Forester and Hydrologist

EXECUTIVE SUMMARY
Robert Creek Watershed Assessment

Integrated Woods Services Ltd. was contracted by Slocan Group, Vavenby Division (Slocan), to complete a comprehensive watershed assessment for the Robert Creek watershed. Slocan and Forest Renewal British Columbia provided the funding for this project.

The objectives of the detailed watershed assessment were to:

1. Field assess the current stream channel conditions within the watershed.
2. Assess the sensitivity of the stream channels to impacts from forestry activities.
3. Identify opportunities for upslope and in-stream watershed restoration activities.
4. Provide recommendations regarding future forestry development within the watershed.

In summary, the proposed Forest Development Plan has a **low** risk of impacting the aquatic resources within the watershed, in relation to existing channel conditions and potential changes in peak flow magnitudes, sediment supply and LWD supply. This does not reflect potential impacts to channel morphology and aquatic resources that can result from harvesting within riparian areas or from increases in sediment supply. Low risk road construction practices and a minimization of stream crossings will be required to maintain this level of risk to aquatic resources.

A summary of this watershed assessment and recommendations for the Watershed Advisory Committee (WAC) are as follows:

1. The current equivalent clearcut area (ECA) in the watershed (as of Fall 2000) is relatively low (24.3%). The ECA will increase to 26.1% as of Fall 2004, if all of the proposed development in Table 4 is completed.
2. The proposed forest harvesting plan has a **low** risk of impacting stream channels and aquatic resources in the Robert Creek watershed. The cumulative impacts from development in the Robert Creek watershed are expected to have a low risk of impacting the stream channel and aquatic resources in the Burton Creek watershed.
3. Road deactivation or upgrade activities need to be completed on the two priority road sites identified in the Sediment Source Survey.
4. The regulatory agencies need to develop clearly defined management objectives and levels of acceptable risk for the watershed.
5. The existing channel conditions and risks associated with future development suggest that the Robert Creek watershed should have a Red Flag ECA of 30%.
6. Refer to the Watershed Advisory Committee recommendations at the front of this document.

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1.0 INTRODUCTION

Integrated Woods Services Ltd. was contracted by Slocan Group, Vavenby Division (Slocan) to complete a comprehensive watershed assessment for the Robert Creek watershed. This watershed was selected for further study based largely on past and proposed levels of forestry development within the drainage. Major forest licence holders with operating areas in the Robert Creek drainage include Slocan, International Forest Products (Adams Lake Lumber Division) and the Ministry of Forests' Small Business Forest Enterprise Program. Slocan and Forest Renewal British Columbia provided funding for this project.

The objectives of the detailed watershed assessments were to:

1) Field assess the current stream channel conditions.
2) Assess the sensitivity of the stream channels to impacts from forestry activities.
3) Identify opportunities for upslope and in-stream watershed restoration activities.
4) Provide recommendations regarding future forestry development within the watershed.

2.0 METHODOLOGY

The watershed assessment was completed utilizing methodologies that satisfy the requirements of the newest (April, 1999) Watershed Assessment Procedure (WAP). This newest WAP is intended to "consider the cumulative effects of forest practices on the aquatic environment" and includes a field verification component. The procedure combines analysis of stream channel and upslope watershed conditions, an assessment of stream channel sensitivities and provides recommendations regarding proposed Forest Development Plans (FDP).

Background information used in these watershed assessments included soil maps, terrain resource inventory mapping data, forest cover maps and aerial photographs (see Appendix B). Additionally, water license and fisheries data was obtained from the Ministry of Environment, Lands and Parks to provide a comprehensive source of information for the project.

Field assessments were conducted on the ground where access permitted. A field review of selected sites was completed with Ministry of Environment, Lands and Parks geomorphologist Ted Fuller. A helicopter overview flight of the watershed was completed on July 11, 2000. The stream reaches to be assessed were determined by channel characteristics, riparian condition, proximity to known or suspected sediment sources and accessibility. Both the Channel Assessment Procedure (Government of BC, 1996) and the Rosgen (1996) classification system (see Appendix C) were utilized to classify stream channel morphology and to evaluate channel sensitivity, while the Channel Assessment Procedure (CAP) was used to classify the stream channel disturbance levels. A "risk assessment approach" (see Appendix D) was developed and utilized to provide an assessment of the level of risk that forestry activities have had/will have on the aquatic resources within the specified watershed. The longitudinal profile and watershed report card are presented in Appendices E and F, respectively.

3.0 WATERSHED LOCATION AND GENERAL INFORMATION

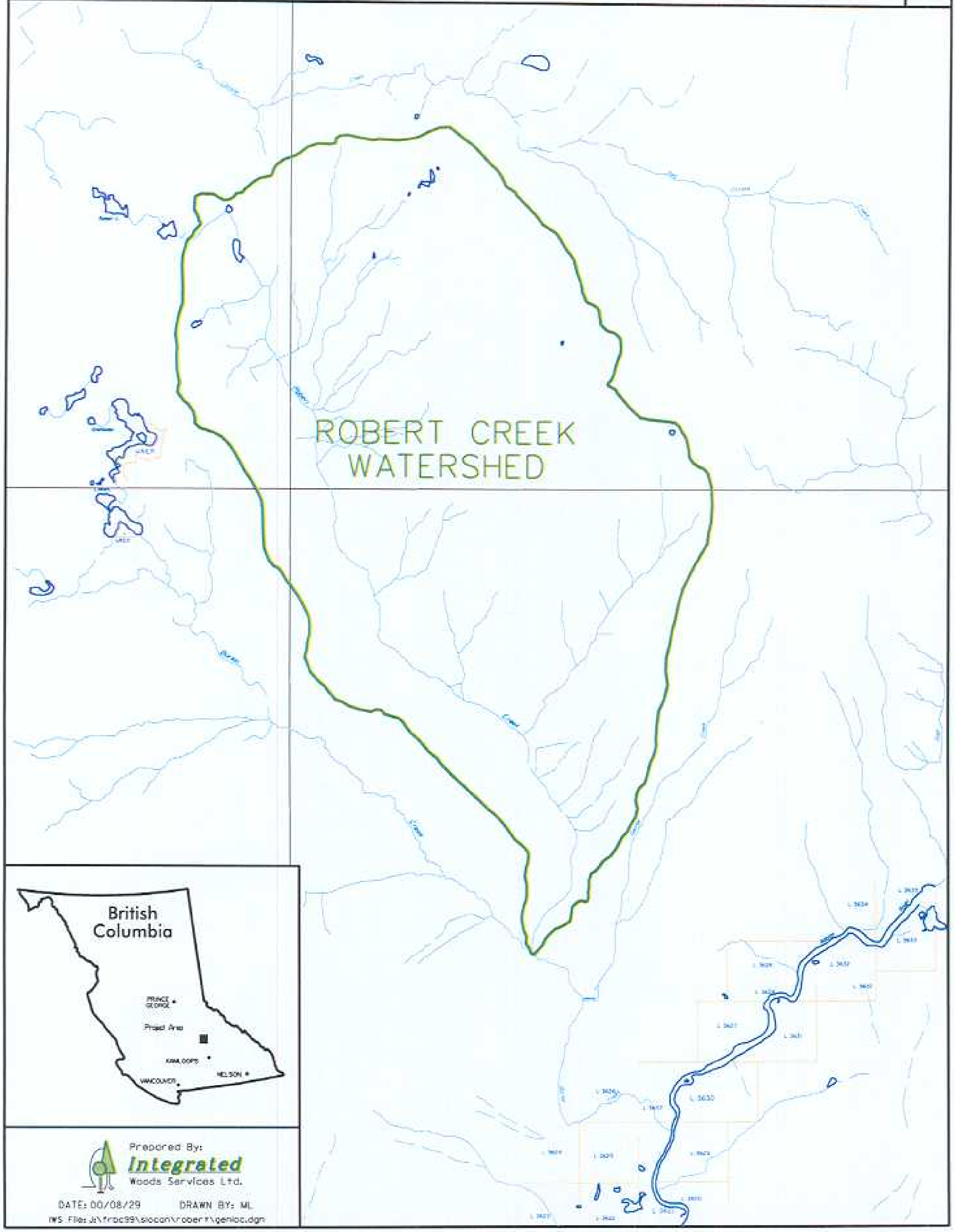
The Robert Creek watershed is located to the west of the upper Adams River, approximately 110 kilometres (km) north-northeast of Kamloops, BC (see Figure 1). Robert Creek is tributary to Burton Creek, which is tributary to the upper Adams River. The total area of the watershed is approximately 4580 hectares. Elevations in the watershed range from 575 metres (m) at the confluence of Robert Creek and Burton Creek to 1925 m in the northeast portion of the drainage.

Issues of importance in the watershed include concerns regarding channel stability and fisheries values in the lower and middle reaches of the stream. No licensed water withdrawals occur within the watershed. The Robert Creek watershed is located within the Mica Landscape Unit, which has a low biodiversity emphasis. Forest health concerns in the Robert Creek watershed presently include white pine blister rust (*Cronartium ribicola*) (L. Burnell, pers. comm., 2000), minor amounts of western balsam bark beetle (*Dryocoetes confusus*) and minor amounts of mountain pine beetle (*Dendroctonus ponderosae*) within white pine host trees (S. Pyper, pers. comm., 2000).

FIGURE 1:

GENERAL LOCATION MAP

Robert Creek Watershed



4.0 WATERSHED CHARACTERISTICS

4.1 Physiography, Climate and Hydrology

The watershed is located within the Shuswap Highlands physiographic region (Government of Canada, 1975) and the Columbia Mountains hydrologic zone (Coulson and Obedkoff, 1998). The annual peak flow regimes of watersheds in this hydrologic zone (zone 13) are dominated by nival flows (i.e. spring snowmelt), though rainfall events can also contribute significant amounts of water to these catchments. The H_{60} line[1] for the watershed was determined from a digital terrain model and is calculated to be 1213 m.

Water Survey of Canada (WSC) stream gauge data are not available for Robert Creek. The Adams River, Barriere River and Harper Creek are the only gauged streams within the local geographic area with long-term data. Review of data (up to 1995) for these streams indicates that flood events greater than the 100-year event occurred in the Barriere and Adams Rivers in 1972. A similar magnitude peak flow event occurred in Harper Creek in 1974. In the Barriere River (downstream of Sprague Creek) and the Adams River, the 1974 peak flow was approximately a 20-year event. At the mouth of the Barriere River the 1974 peak flow was a 50-year event[2]. All of these streams drain considerably larger areas than Robert Creek however. Significant flood events are known to have occurred in the local geographic area in both 1997 and 1999. These events would have contributed to the stream channel conditions observed in the watershed.

Recent research suggests that climatic and hydrologic patterns across Canada have been significantly changing over the last 25 years (Whitfield and Cannon, 2000). Trends in climatic and hydrologic variation across Canada were evaluated by a number of authors for the decades 1976-1985 and 1986-1995. The following climatic trends were observed in the southern interior of British Columbia: 1) higher temperatures in all months except February, 2) increases in spring precipitation and decreases in summer precipitation, 3) higher spring stream flows and lower summer and fall flows, 4) an earlier onset of spring run-off (Whitfield and Cannon, 2000).

[1] the elevation isoline above which 60% of the watershed is situated
[2] as determined from the BC Streamflow Inventory datasheets (March 1998)

4.2 Slopes, Aspect and Surficial Materials

The watershed is aligned in a northwest to southeast fashion and aspect within the drainage generally has an east or west component. Slopes are typically strongly rolling to very steeply sloping throughout the Robert watershed (Government of Canada, 1975). Slope categories (by percent slope) are presented in Table 1.

Table 1: Slope Categories for the Robert Creek Watershed

Slope Category (%)	Area (ha)	Percent of Watershed (%)
0-10	616	13
11-25	1474	32
26-60	1956	43
60+	534	12
Total	4580	100

Numerous types of surficial materials occur within the Robert watershed. Fluvioglacial materials predominantly occur adjacent to the stream channel of Robert Creek in reaches 1, 2 and 5. These materials also occur adjacent to the upper half of reach 5 and adjacent to other stream channels in the drainage. Colluvial deposits occur on and/or adjacent to the steep valley walls throughout the watershed. Morainal deposits occur in areas of rolling terrain and also on some steep valley slopes. Organic materials occur in several relatively small areas in the north and northeast portion of the watershed.

4.3 Other Watershed Attributes

Wildfire, pests, pathogens and windthrow are natural disturbance regimens associated with the upland ecosystems found within the watershed. Any of these disturbances can potentially affect stream channels via changes in rates of watershed run-off, large woody debris recruitment to the channel or sediment production/transport. Three different biogeoclimatic subzones/variants are present in the watershed. The Interior Cedar-Hemlock variant (ICHmw3) occurs at the lower elevations, the Sub-Boreal Spruce subzone (SBSmm) occurs at mid-elevations and the Engelmann Spruce-Subalpine Fir variant (ESSFwc2) occurs at higher elevations. High intensity, stand-initiating fires generally resulted in the cycling of forest stands in the ICH and the SBS subzones present in the watershed. These ecosystems generally consisted of a landscape mosaic of even-aged regenerating stands ranging in size from a few hectares to thousands of hectares. The ESSFwc2 ecosystem generally consists of uneven-aged or multi-storied even-aged stands that historically experienced small disturbances, resulting in the death of individual trees or small patches of trees.

The physical appearance and characteristics of a stream channel result from the continuous adjustment of the stream boundaries to the magnitude of stream discharge, and sediment/debris production occurring in the watershed (Rosgen, 1996). Stream characteristics are further modified by the influence of stream bed and bank materials, watershed topography and geomorphology. Changes in stream morphology will occur over time in response to variations (of a natural or anthropogenic nature) in supply of water, sediment or debris.

Changes in watershed hydrology and sediment production have been documented in watersheds, following the occurrence of wildfires (Cheng, 1980; Cheng and Bondar, 1984). A number of burns have been documented in the Robert Creek drainage over the last 50 years. Wildfires occurred in 1953 and 1960 and an escaped burn occurred in 1986. The total area mapped as burns within the watershed is approximately 370 ha (8% of the watershed area).

5.0 SEDIMENT SOURCE SURVEY

International Forest Products Ltd. (Adams Lake Lumber Division) commissioned Silvatech Consulting Ltd. to complete a sediment source survey (SSS) for the Gollen and Burton Planning Units (March, 1998). This SSS included the Robert Creek drainage and it was utilized in the completion of the watershed assessment. No moderate or high risk sites were identified within the Robert Creek watershed at the time of the survey. Roads identified as Branch 2 - Spurs 7, 7-A and 7-A1 (3.43 km total) in the SSS are scheduled for deactivation. These roads were constructed as fire access roads for the escaped burn adjacent to reach 4 of Robert Creek.

Only two road-related priority sites were identified during the completion of the watershed assessment. The first site is located on Road 2 just outside of the Robert Creek watershed and consists of a road segment exhibiting tension cracks (D. Geiger, pers. comm., 2000). The second site occurs on an unmapped skid road, adjacent to reaches 3 and 4. This site has stream flow from a tributary to Robert Creek eroding the road surface (see photo 1).

Only two large sediment sources were identified from the aerial photograph review and during the overview flight. Both sources are directly coupled to stream channels. Sediment source (SS) #1 is coupled directly to reach 5 of Robert Creek, while SS #2 is coupled directly to the largest tributary to Robert Creek (see photo 2). The materials from this site may contribute to the sediment aggradation just upstream of the confluence of this tributary and Robert Creek. A number of potential sediment sources identified on the aerial photographs are labeled as rock in the forest cover database. These sites were not included in the sediment source survey.

Downstream of a large rock waterfall, moderate to severe levels of channel degradation have occurred in the largest tributary to Robert Creek (see photo 3). The channel of this tributary is significantly downcut, while the lower segment of the stream is now a multi-thread channel. Four larger channels and numerous smaller channels now deliver the stream flow into Robert Creek. The lower stream reach occurs on an alluvial fan that was logged to both banks in 1985. A prescribed burn followed harvesting activities within the cutblock. The stream channel has severely downcut (prior to 1997) over a distance of about 150 m. Sediment aggradation at the toe of the fan then causes the channel to take on a multi-thread pattern, with one of the channels following an existing road (priority site #2). Both fine and coarse textured-sediment from this stream was delivered to the lower reaches of Robert Creek. It is possible that a mass wasting event (identified as sediment source #2) initiated the destabilization of the lower reach of this stream. As the stream appears to be a single-thread channel on the pre-harvest aerial photographs, it is also possible that the forestry activities resulted in the destabilization of the lower reaches of this tributary.

6.0 WATERSHED RISK ASSESSMENT WORKSHEETS

Table 2: Equivalent Clearcut Areas and Peak Flow Indices[3]

Watershed	ECA (%)		Peak Flow Index (PFI)	
	Fall 2000	Fall 2004	Fall 2000	Fall 2004
Robert Creek	24.3	26.1	0.34	0.36

Table 3: Total Watershed Area Harvested

Watershed	Total Area Harvested (%)	
	Fall 2000	Fall 2004
Robert Creek	34.4	38.7

Table 4: Proposed Forestry Development (including 'information' blocks)

Watershed	CP-Block	Silv. System	Gross Area (ha)	Net Area (ha)	Licensee
Robert	425	3 pass - CC	240.6	84.2	Slocan
Robert	426-1	2 pass - CCR	43.8	30.0	Slocan
Robert	426-2	3 pass - CC	84.5	30.0	Slocan
Robert	A56801	CC	9.1	9.1	SBFEP
Robert	195-E	CC	9.3	9.3	Weyco
Robert	Info	-	15.4	15.4	Interfor
Robert	Info	-	9.6	9.6	Interfor
Total			**412.3**	**187.6**	

[3] ECA and PFI calculations are based upon net areas for proposed harvesting

Table 5: Characteristics of the Assessed Stream Reach Segments

Stream & Reach	Dominant morphology and disturbance levels*	Rosgen stream types	Stream reach sensitivity to:			Hillslope connectivity
			Increased peak flows (1 to 5)	Increased sediment supply (1 to 5)	Decreased LWD supply (1 to 5)	
Robert-1	RP-CP: 0-1	Cb-A	3	3	4	Mod.-High
Robert-2	RP-CP: 1-2	C-B	4	4	4	Moderate
Robert-3	CP-SP: 1-2	Ba-A	3	3	3	Moderate
Robert-4	RP: 1-2	C-B	4	4	4	Moderate

Disturbance Levels
0 = stable
1 = partial disturbance
2 = moderate disturbance
3 = severe disturbance

Sensitivity Levels
1 = 'Very Low'
5 = 'Very High'

Table 6: Effects of Forestry Activities in the Watershed and Risk to Aquatic Resources

Stream & Reach	Probability that forestry activities will cause changes to[1]:			LEVEL OF RISK to the aquatic environment caused by changes to[2]:			Dominant land use activity[3]
	Peak flows (1 to 5)	Sedimen t supply (1 to 5)	LWD supply (1 to 5)	Peak flows	Sedimen t supply	LWD supply	
Robert-1	2	2	1	B	B	A	HL
Robert-2	2	2	3	C	B	D	FH/HL
Robert-3	2	2	2	B	B	B	FH/HL
Robert-4	2	2	4	C	B	D	FH/HL

[1] Probability of change = The probability that past or proposed forestry activities will change any of the three channel morphology controlling processes

i.e. 1 = 'Very Low' probability of change outside of natural limits
5 = 'Very High' probability of change outside of natural limits

[2] Level of risk: A = Very Low; B =Low, C = Moderate, D = High, E = Very High

[3] Land-use: A/R = agriculture/ranching
LG = light grazing
HL = historical logging
FH = forest harvesting

7.0 INTERPRETATIONS AND RECOMMENDATIONS

7.1 Watershed Management Objectives and Defined Level of Acceptable Risk

The watershed management objectives have not been specifically defined by regulatory agencies for this watershed. Prevention of accelerated stream bank and stream bed erosion, particularly along the lower and middle reaches of the mainstem channel, is presumed to be the primary management objective. It is also assumed that management objectives include maintaining and/or enhancing the fish habitat that exists within the watershed. The acceptable level of risk for this watershed has not been specified by regulatory agencies.

7.2 Recommendations for the Forest Development Plan

7.2.1 Existing Channel Conditions

The existing levels of disturbance observed within the stream channel varied between stream reaches and stream segments. Only low levels of disturbance were observed in reach 1 of Robert Creek (see photos 4 & 5). The upstream end of reach 1 is highly entrenched, with cascade-pool morphology dominating. Entrenchment decreases in the lower half of the reach, channel gradients are reduced and riffle-pool morphology appears to dominate (see photo 6). Channel complexity appeared to be high, with a frequent occurrence of large woody debris in the channel.

Reach 2 was observed at the upper and lower ends of the reach. Disturbance levels were low (see photos 7 & 8) to moderate in the upper segment of the reach. The moderately disturbed areas were associated with debris jams in the upper portion of the reach (see photo 9). Multi-channels, channel widening, channel braiding and sediment wedges were observed in this segment. The majority of this reach was selectively logged to one or both banks in 1968. The forest cover database lists this polygon (opening 60, polygon 520) as not satisfactorily restocked. Mature forest often occurs in the riparian areas within this polygon however.

Reach 3 (cascade-pool morphology) was assessed as partially to moderately disturbed downstream of the Road 2 crossing (see photo 10). Disturbance coincided with an old bridge site and disturbance indicators included bank erosion, channel widening and mid-channel sediment deposits at the old bridge site. Channel degradation and disturbed stone lines were also observed within this segment downstream of the site. Bridge stringers were observed within the stream channel downstream of the old crossing. The channel type changed to step-pool morphology upstream of the Road 2 crossing and this segment was assessed as stable. An unusually high frequency of sand was observed in the substrate of this reach. This material came from a tributary stream that is laterally unstable and which is situated on an alluvial fan. The confluence of this tributary with Robert Creek occurs at the upstream end of reach 3.

The channel becomes unentrenched just upstream of the reach 3-4 break. Reach 4 was logged to one or both banks in 1968 for most of the reach length (opening 60, polygons 411 and 519). Only low levels of disturbance were observed in the lower reach (see photos 11 & 12). A number of beaver dams occur within this reach resulting in disturbances to flow and sediment transport patterns. The first beaver dam is approximately 180 m upstream of the reach 3-4 break.

Due to restricted access to the stream channel and the limited amount of development near Robert Creek, the channel in the upper watershed was assessed solely from the helicopter overview flight. The mainstem channel in reaches 5 through 8 consists of segments of low gradient wetland and riffle-pool morphology joined by steeper, cascade-pool and occasional step-pool segments. Low levels of disturbance in the channel were generally noted in these reaches. Only one large sediment source (SS #1) was observed adjacent to the channel in these reaches, with the exception of some talus slopes in reaches 4 and 5. Channel aggradation (i.e. sediment bars) was noted in lower reach 5 downstream of sediment source #1 with extensive riffle and reduced channel complexity. The stream channel was not visible upstream of the wetland in the middle of reach 6.

7.3.1 Peak flow risks

There are a number of concerns related to potential peak flow increases in the Robert Creek watershed. These concerns include the sensitivity of some stream reaches to peak flow increases, the existing levels of stream channel disturbance observed in some stream segments, and the existing extent and location of some forest harvesting in the watershed.

The channel types occurring in the lower and middle watershed are largely of the "B and C" types, within the Rosgen stream classification system. The "B" types are described as moderately entrenched streams with moderate gradients, sinuosity and width/depth ratio (Rosgen, 1996). The

"C" channel types are described as slightly entrenched with high sinuosity and moderate to high width/depth ratio. While "B" type channels with substrate of predominantly cobble or coarser materials are relatively insensitive to disturbance[4], the gravel dominated "B" channels are moderately sensitive to increased water and/or sediment supply. The "C" type channels with predominantly gravel or sand substrate are considered to be highly sensitive to increased water and/or sediment supply and disturbance of riparian vegetation (Rosgen, 1996).

The existing and proposed ECA's (and their corresponding peak flow indices) are a not a significant concern in regards to potential peak flow increases. The proposed levels of forest harvesting have only a low probability of increasing peak flow magnitudes in the Robert Creek watershed. Inherent channel sensitivities and the current levels of disturbance in some stream segments are a concern however.

Road densities above H_{60} are currently at a moderate level[5] in the watershed but are projected to increase further. Potential changes/alterations in natural drainage patterns and run-off rates are a concern when high road densities exist within a watershed, in addition to increased sediment production and delivery.

Levels of risk, related to potential increases in peak flow magnitudes, are **low** to **moderate** throughout the assessed reaches of Robert Creek watershed. These risk levels in the various stream reaches result from moderate to high channel sensitivities combined with a low probability of increases in peak flows related to forestry activities.

From the perspective of managing for peak flow increases and accelerated stream bank erosion, the proposed Forest Development Plan (FDP) will not result in a change from the current **low** and **moderate** risk levels in the Robert Creek watershed. Overall, the proposed FDP is acceptable within a **moderate** risk level, relative to potential peak flow increases.

[4] includes increases in stream flow magnitude or sediment supply
[5] as outlined in Interior watershed assessment conversion table (Government of BC, 1995)

7.3.2 Sediment supply risks

Some stream channels types found within the Robert Creek watershed are moderately to highly sensitive to an increased sediment supply. The high sensitivity is inherent in these channels due to the nature of the stream bank and bed materials and other channel characteristics such as slope and sediment storage/transport capabilities. The probability that forestry activities have increased the fine and coarse-textured sediment supply to Robert Creek is low in the upper watershed areas.

The number of existing stream crossings (10) in the watershed is relatively low. The numbers of existing stream crossings was determined from forest cover maps, aerial photographs and field observations. There are only 2 stream crossings that cross the mainstem of Robert Creek.

One new stream crossing and 10.0 km of new road construction is proposed in the Forest Development Plan. New road construction has the potential to increase the supply of fine sediment to the watercourses in the watershed. Re-vegetation of exposed soils within 12 months of disturbance needs to occur. This will ensure that erosion and subsequent sediment transport is minimized during the first few years of active service, when sediment yields are typically high.

The overall road density (km of road /km^2 of area) in the Robert Creek watershed will be low, following implementation of the proposed forest harvesting plan. It is recommended that road maintenance and/or road deactivation activities be undertaken to reduce sediment delivery to stream channels from the existing road network in the watershed.

The combination of moderate and high channel sensitivities with low probabilities of increased sediment supply result in **low** risk levels for this risk assessment category. **Low** levels of risk to the aquatic environment, associated with past increases in sediment supply, exist in the upper watershed areas.

In summary, the proposed forestry development does not pose more than a **low** risk to aquatic resources, relative to an increase in coarse-textured sediment supply.

7.3.3 LWD supply risks

Large woody debris appears to be important in most reaches of Robert Creek for controlling sediment storage, energy dissipation and stable channel morphologies. Fisheries values in the stream are dependent on an adequate supply of LWD over both the short and long-term. It is for these reasons that the stream channels have been all rated as having a moderate to high sensitivity to a reduction of LWD supply.

Extensive portions of the riparian forests in reaches 2, 3 and 4 of Robert Creek were select harvested in 1968. A significant proportion of the LWD observed functioning in the stream channel was the butt ends of large diameter, western red cedar (relatively resistant to rot). While LWD frequencies may have been elevated from naturally occurring levels, negative impacts to channel morphology were not observed. Clearcutting to both banks of the stream occurred in some segments of reaches 3 and 4. Retention of some stems adjacent to the stream in reach 3 will provide for some LWD recruitment to this reach. Long-term recruitment of LWD to the lower third of reach 4 will be greatly reduced until a mature riparian conifer stand is re-established. The upper two-thirds of the stream reach was select logged and appears to have stocking densities (of mature trees) lower than in undisturbed areas.

Riparian areas adjacent to Robert Creek in the upper watershed have been generally unaffected by past forest harvesting. There is very little forestry development adjacent to the main stream channel or its tributaries upstream of reach 4. Forest stands are almost exclusively of age-class 4 (61-80 years) or older with considerable amounts of riparian vegetation comprised of age-class 8 or 9 forest stands.

In stream reaches 1 and 3, the levels of risk to aquatic resources associated with LWD supply decreases are **very low** and **low**, respectively. The risk to aquatic resources caused by decreases in LWD supply is **high** in stream reaches 2 and 4. The impacts to these reaches occurred when there was no legal requirement to provide for a riparian reserve zone (i.e. prior to enactment of the Forest Practices Code of BC).

The location of the proposed forest harvesting in the Robert Creek watershed will not result in reductions in LWD supply to the stream channels and is therefore acceptable.

8.0 CONCLUSIONS

Protection of aquatic resource values in the watershed is dependent on the minimization of accelerated stream channel disturbance and the maintenance of water quality/quantity. Fisheries values in the watershed (and downstream in Burton Creek and the Adams River) are a significant concern.

The proposed forest harvesting plan will result in an ECA increase of 1.8% in the Robert Creek watershed. The extent and location of the proposed harvesting activities will not generate a level of risk to aquatic resources in a specific reach greater than **moderate** in the peak flow risk assessment category, in the Robert watershed. The level of risk does not increase as a result of the proposed harvesting.

The level of risk to aquatic resources associated with an increase in the supply of coarse-textured sediment is **low** in the Robert Creek watershed. The proposed forest harvesting activities do not pose more than a **low** risk to aquatic resources, in regard to increased coarse-textured sediment supply.

The calculated risk to aquatic resources resulting from decreased LWD supply is **moderate** or **high** in many stream reaches. However, the location of the proposed forest harvesting in the Robert Creek watershed should not result in reductions in LWD supply to the stream channels and is therefore acceptable.

Overall, the cumulative effect of changes to peak flows, sediment supply and LWD supply that could result from implementing the proposed Forest Development Plan is judged to be a **low** risk in the Robert Creek watershed. This does not reflect potential impacts to channel morphology and aquatic resources that can result from harvesting riparian areas or from an increase in sediment supply. Low risk road construction practices and minimization of stream crossings will be required to maintain a lower level of risk to aquatic resources.

8.1 In-Stream Work Opportunities

No moderate or high priority opportunities for in-stream works were identified within the mainstem of Robert Creek. Riparian planting could be undertaken within the NSR blocks adjacent to reaches 2 and 4. Lower reach 4 would be the higher priority for this type of work. Re-alignment of the tributary channel (priority site #2) to restrict stream flow down the existing skid road would be beneficial, adjacent to reach 4 of Robert Creek. Riparian planting could also completed at this site to help stabilize the non-cohesive bank materials. The presence of numerous beaver dams in reach 4 and LWD jams in reach 3 of Robert Creek was noted during the assessment. Removal of these structures is not considered a priority for in-stream works.

8.2 Upslope Work Opportunities

There are opportunities for productive and cost-effective watershed restoration activities within the upland portions of this watershed. As many stream channels are highly sensitive to increases in coarse-textured sediment supply, minimization of accelerated sediment inputs to stream channels in the watershed would be beneficial with respect to aquatic resources. To this end, the completion of road deactivation activities on the road priority site # 2 is recommended.

8.3 Summary and Recommendations for the Watershed Advisory Committee (WAC)

A summary of this watershed assessment and recommendations for the WAC are as follows:

1. The current equivalent clearcut area (ECA) in the watershed (as of Fall 2000) is relatively low (24.3%). The ECA will increase to 26.1% as of Fall 2004, if all the proposed development in Table 4 is completed.
2. The proposed forest harvesting plan has a **low** risk of impacting stream channels and aquatic resources in the Robert Creek watershed. The cumulative impacts of development in the Robert Creek watershed are expected to have a low risk of impacting the stream channel and aquatic resources in the Burton Creek watershed.
3. Road deactivation or upgrade activities need to be completed on the two priority road sites identified in the Sediment Source Survey.
4. The regulatory agencies need to develop clearly defined management objectives and levels of acceptable risk for the watershed.
5. The existing channel conditions and associated risks with future development suggest the Robert Creek watershed should have a Red Flag ECA of 30%.
6. Refer to the Watershed Advisory Committee recommendations at the front of this document.

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APPENDICES

APPENDIX A

Photographs from the WAP

Photo 1: Priority site #2, tributary to Robert Creek flowing down road surface

Photo 2: Sediment source #2, upslope of tributary to Robert Creek

Photo 3: Tributary to Robert Creek, extensive degradation

Photo 4: Reach 1 of Robert Creek, relatively undisturbed

Photo 5: Reach 1 of Robert Creek, just downstream of reach 2

Photo 6: Reach 1 of Robert Creek, just upstream of Burton Creek

Photo 7: Reach 2 of Robert Creek, partial disturbance

Photo 8: Reach 2 of Robert Creek, partial disturbance

Photo 9: LWD jam downstream of reach 2-3 break on Robert Creek

Photo 10: Reach 3 of Robert Creek, partial disturbance

Photo 11: Reach 4 of Robert Creek, historic logging to both banks

Photo 12: Reach 4 of Robert Creek, logged to both banks and with beaver dams just upstream

APPENDIX B

List of Aerial Photographs and Maps Utilized

Aerial Photographs Utilized:

1975

BC7790: No. 27-30, 66-73, 122-127

1997

30BCC97068: No. 167-170, 200-205
30BCC97072: No. 22-28, 105-109
30BCC97081: No. 207-209, 222-225

Maps Utilized:

Forest Cover and TRIM Mapsheets

82M.053, 82M.063

Soil Maps

82M/NW (Soil and Terrain Report for the Seymour Arm Map Area)

APPENDIX C

Key to the Rosgen Stream Classification System

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/ Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.4	<.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.4	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

TABLE 4-1 General stream type descriptions and delineative criteria for broad-level classification (Level I).

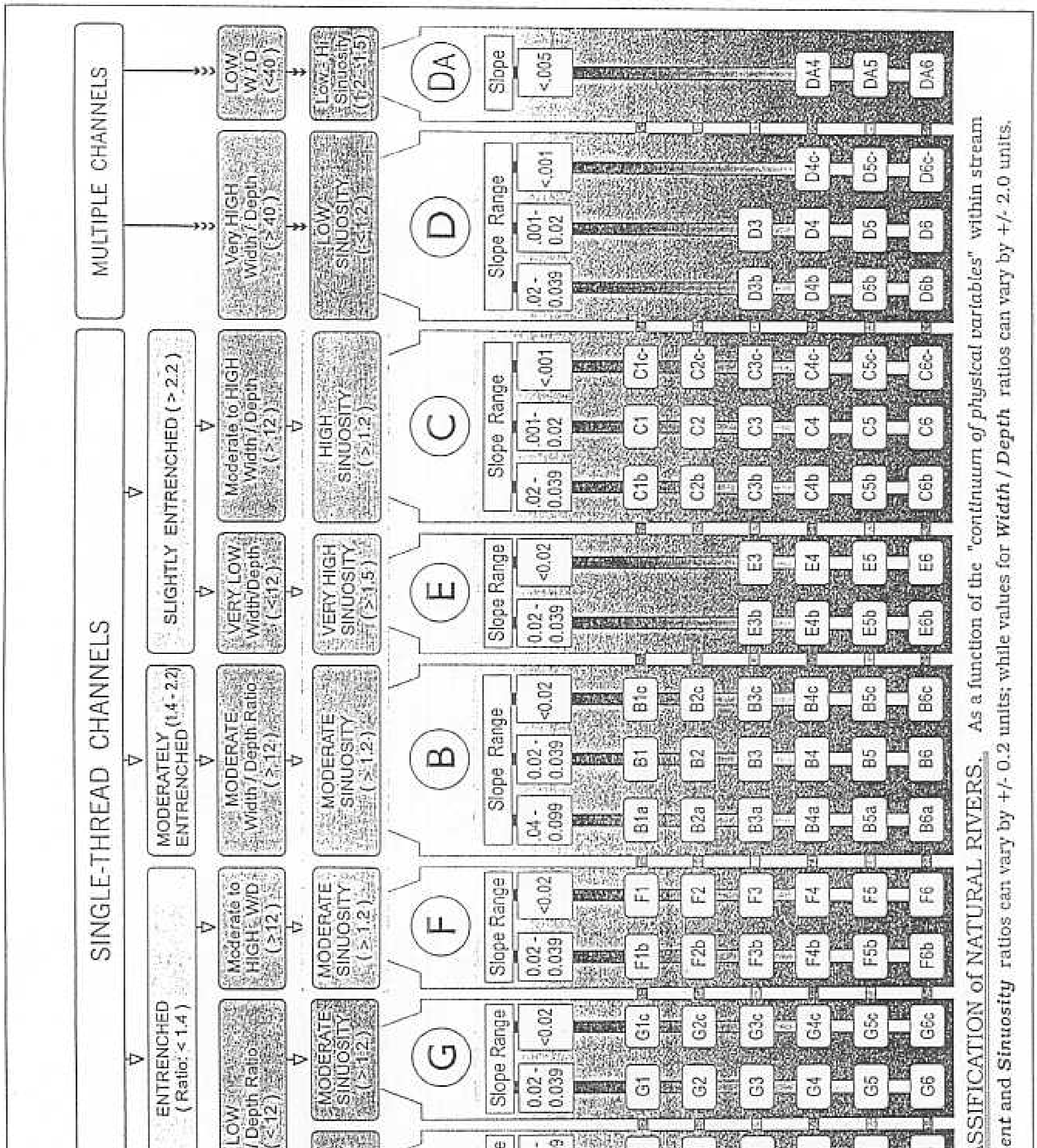


FIGURE 5-3. Classification key for natural rivers.

Stream type	Sensitivity to disturbance[a]	Recovery potential[b]	Sediment supply[c]	Streambank erosion potential	Vegetation controlling influence[d]
A1	very low	excellent	very low	very low	negligible
A2	very low	excellent	very low	very low	negligible
A3	very high	very poor	very high	very high	negligible
A4	extreme	very poor	very high	very high	negligible
A5	extreme	very poor	very high	very high	negligible
A6	high	poor	high	high	negligible
B1	very low	excellent	very low	very low	negligible
B2	very low	excellent	very low	very low	negligible
B3	low	excellent	low	low	moderate
B4	moderate	excellent	moderate	low	moderate
B5	moderate	excellent	moderate	moderate	moderate
B6	moderate	excellent	moderate	low	moderate
C1	low	very good	very low	low	moderate
C2	low	very good	low	low	moderate
C3	moderate	good	moderate	moderate	very high
C4	very high	good	high	very high	very high
C5	very high	fair	very high	very high	very high
C6	very high	good	high	high	very high
D3	very high	poor	very high	very high	moderate
D4	very high	poor	very high	very high	moderate
D5	very high	poor	very high	very high	moderate
D6	high	poor	high	high	moderate
Da4	moderate	good	very low	low	very high
DA5	moderate	good	low	low	very high
DA6	moderate	good	very low	very low	very high
E3	high	good	low	moderate	very high
E4	very high	good	moderate	high	very high
E5	very high	good	moderate	high	very high
E6	very high	good	low	moderate	very high
F1	low	fair	low	moderate	low
F2	low	fair	moderate	moderate	low
F3	moderate	poor	very high	very high	moderate
F4	extreme	poor	very high	very high	moderate
F5	very high	poor	very high	very high	moderate
F6	very high	fair	high	very high	moderate
G1	low	good	low	low	low
G2	moderate	fair	moderate	moderate	low
G3	very high	poor	very high	very high	high
G4	extreme	very poor	very high	very high	high
G5	extreme	very poor	very high	very high	high
G6	very high	poor	high	high	high

a Includes increases in streamflow magnitude and timing and/or sediment increases.
b Assumes natural recovery once cause of instability is corrected.
c Includes suspended and bedload from channel derived sources and/or from stream adjacent slopes.
d Vegetation that influences width/depth ratio-stability.

TABLE 8-1. Management interpretations of various stream types (*Rosgen, 1994*)

APPENDIX D

Philosophy and Application of the Risk Matrix Approach

(Developed by P. Beaudry, 1999)

PHILOSOPHY AND APPLICATION OF THE RISK ASSESSMENT APPROACH

The risk assessment approach establishes a level of risk of detrimental impacts to the aquatic resources that may be caused by forestry activities. The risk assessment is based on the evaluation of two components and the use of a *Risk Matrix*. The first component of the risk assessment evaluates the sensitivity of a particular stream reach to a change in a specific hydrologic or geomorphic process. This assessment is qualitative and is ranked on a scale of 1 to 5 (i.e. Very Low to Very High). An example would be that: "a bedrock-controlled channel has a 'Very Low' sensitivity to changes in peak flows".

The second component assesses the probability that forestry activities within the watershed will significantly change some specific hydrologic or geomorphic process. The assessment is also qualitative and the probability of change is ranked on a scale of 1 to 5 (i.e. Very Low to Very High). An example of this type would be: "there is a 'Very High' probability that there will be a significant increase in snowmelt generated peak flows if 100% of the forest above the H_{60} line is harvested in an Interior watershed".

The risk assessment value is generated by combining the "sensitivity" rating with the "probability of change" rating on the Risk Matrix. The risks are also scaled from Very Low to Very High. Risk matrices have been developed for three categories of watershed processes: 1) changes in peak flows, 2) changes to the sediment supply and 3) changes to the supply of large woody debris (LWD). The "sensitivity" and the "probability of change" ratings are established by analyzing the assessment information collected from maps, aerial photographs, fieldwork and other relevant data.

This risk assessment procedure works very well to satisfy the requirements of the newest Watershed Assessment Procedure (released April 1999). On page 11 of this document it states that: "the Hydrologist will use the report card, together with the field assessment maps, to develop hazard ratings for peak flow, sediment sources, riparian function and channel stability. He or she will then use these ratings in making specific recommendations for the Forest Development Plan".

The results of the risk matrix approach provide an assessment of the real level of risk to the aquatic resources in a specific watershed. This is very different than the original "hazard indices" provided by the Level 1 Watershed Assessment Procedure (Government of BC, 1996). While the hazard indices only assessed potential hazards, the risk matrix provides an assessment of the real level of risk that exists for a specific watershed. The real risk is based on detailed field work, past and proposed land-use activities, specific characteristics of the watershed, the channel assessment and the local climate and hydrology. In the old Interior Watershed Assessment Procedure (IWAP), this type of detailed approach was intended to be used only on those watersheds that were identified as having a "medium" or "high" potential hazard (i.e. a Level 1 hazard index greater than 0.5) and disturbed stream channels. This type of detailed analysis was previously termed a Level 3 watershed assessment. The new WAP does not identify different levels of assessment, but rather directs the hydrologist to complete one comprehensive assessment (Government of BC, 1999). The field component of the new procedure is based on reconnaissance-level assessments, however.

Resource values and management objectives for the watershed will determine the level of risk that is acceptable. The acceptable level of risk is a management and socio-economic decision made by resource agencies, based on specific watershed management objectives that are set prior to beginning the assessment. The acceptable level of risk is not a technical decision made by the consulting hydrologist in isolation. However, in general, forest harvesting activities that generate "Very Low" or "Low" levels of risk should not negatively impact aquatic resources.

A "moderate" level of risk (i.e. the gray zone between low and high) needs to be carefully interpreted in the context of the management objectives. For example, if there are very high or unique fisheries values in the watershed (bull trout, for example) and the acceptable level of risk has been defined as low, then some changes to the Forest Development Plan should be considered. These changes should focus directly on the particular "hazard" that has been identified as creating the unacceptable level of risk. For example, if the LWD risk is moderate because of past forest harvesting activities, then the goal should be to reduce the LWD risk, but not necessarily by reducing harvesting. This may be achieved by initiating something like riparian area planting through the Watershed Restoration Program (WRP). If the peak flow risk is moderate then this may lead to specific rate of cut constraints, or possibly re-distribution of cutblocks within the watershed. It is important to remember that the type of constraint imposed must be directly related to the management objectives in the watershed and the acceptable level of risk identified by the resource agencies. Broad, non-specific constraints are generally not effective and may result in activities that don't necessarily protect the aquatic resources in an effective manner.

"High" or "Very High" levels of risk (in any one of the three particular categories) suggest that past and future harvesting activities could lead to significant negative impacts to the aquatic resources. In such cases, the Forest Development Plan may have to be re-designed, if the level of risk is deemed unacceptable to meet the specific management objectives for a particular watershed. Another possibility is to initiate restoration activities in older, harvested areas to mitigate the effects of proposed harvesting activities.

It is of the utmost importance to understand that the management decisions that are made relative to the results of the "risk assessment" must be made in the context of clear and specific watershed management objectives. These objectives are generally defined by the resource agencies (i.e. Ministry of Forests, Ministry of Environment, Lands and Parks, Department of Fisheries and Oceans, Ministry of Health).

Table 1: RISK MATRIX[1] for *PEAK FLOW CHANGES*

		Sensitivity of the stream reach to increases in peak flows				
		1	**2**	**3**	**4**	**5**
Potential for increased peak flows	**1**	A	A	A	B	B
	2	A	B	B	C	C
	3	A	B	C	D	D
	4	A	B	C	D	E
	5	A	C	D	E	E

[1] "Risk" refers to the level of risk imposed on aquatic resources from past and proposed forestry activities in the watershed. The risk matrix on this page only considers the risks associated with increases in snowmelt generated peak flows. These flows are the channel forming flows for most of the areas in the Interior region of British Columbia. The five levels of risk are defined as follows:

A = Very Low
B = Low
C = Moderate
D = High
E = Very High

- The sensitivity of the stream reach to increases in peak flows is a subjective designation. It is determined based on the results of the field-based channel assessments and the morphological characteristics of the reach such as stream gradient (s), stream width (W_b), bed and bank materials, size of largest stream bed particle (D), stream depth (d) and entrenchment ratio (ER). The level of disturbance in the reach is also assessed, using the methodology proposed by the Government of BC (1996). The reach is also classified using the system proposed by Rosgen (1996). The Rosgen classification system is also used to assist in the designation of the sensitivity of the stream reach.

- The potential for increased snowmelt generated peak flows was assessed based on the amount of forest harvesting and hydrological recovery in the watershed (i.e. ECA), the distribution of cutblocks within the watershed, the general aspect of the proposed cutblocks and the relative proximity of the cutblocks to a watercourse. Although no strict algorithm was developed to make this assessment, the following general rules and conceptual model were applied:

  a) A Peak Flow Index less than 25 yielded a "very low" potential for increased peak flows (i.e. a value of 1).

  b) A Peak Flow Index between 25 and 39 yielded a "low" potential for increased peak flows (i.e. a value of 2).

  c) A Peak Flow Index between 40 and 54 yielded a "moderate" potential for increased peak flows (i.e. a value of 3).

  d) A Peak Flow Index between 55 and 70 yielded a "high" potential for increased peak flows (i.e. a value of 4).

  e) A Peak Flow Index greater than 70 yielded a "very high" potential for increased peak flows (i.e. a value of 5).

  f) If most of the proposed cutblocks had a southerly aspect then the designation would be more conservative (e.g. an ECA of 25 with south aspect cutblocks could yield a "moderate" potential).

  g) Based on the concept of a "variable source area", if most of the cutblocks were located close to streams, then the designation would more conservative.

  h) The conceptual modeling is based on recent research results that have been obtained in watershed research trials in the Prince George Forest Region (Beaudry and Gottesfeld, in press; Beaudry and Floyd, 1999).

Table 2: RISK MATRIX[1] for *SEDIMENT SUPPLY CHANGES*

		Sensitivity of the stream reach to increases in sediment supply				
		1	**2**	**3**	**4**	**5**
Potential for increased delivery of sediment	**1**	A	A	A	B	B
	2	A	A	B	B	C
	3	A	B	C	C	D
	4	A	B	C	D	E
	5	A	C	D	E	E

[1] "Risk" refers to the level of risk imposed on aquatic resources from past and proposed forestry activities in the watershed. The risk matrix on this page only considers the risks associated with increases in sediment supply to the stream channel. The amount of sediment delivered to a stream channel can play a large role in shaping the channel, as it must respond to the amount of water and sediment it transports. Channels tend to become wider, shallower and less sinuous where the influx of coarse material has been appreciable (Knighton, 1984; Sullivan et al., 1987; Hogan et al., 1998). The five levels of risk have been defined as follows:

A = Very Low
B = Low
C = Moderate
D = High
E = Very High

- The sensitivity of the stream reach to increases in sediment supply is a subjective designation. It is determined based on the results of the field-based channel assessments and the morphological characteristics of the reach such as stream gradient (s), stream width (W_b), bed and bank materials, size of largest stream bed particle (D), stream depth (d) and entrenchment ratio (ER). The level of disturbance in the reach is also assessed using the methodology proposed in Government of BC (1996). The reach is also classified using the system proposed by Rosgen

(1996). The Rosgen classification system is also used to assist in the designation of the sensitivity of the stream reach.

- The potential for increased delivery of sediment to the stream channel was assessed based on the density and location of roads, the number of stream crossings, the surficial materials in the watershed, the local climate, stream density and the level of coupling of the hillslopes to the stream channel.

Table 3: **RISK MATRIX**[1] for *LARGE WOODY DEBRIS SUPPLY CHANGES*

		Sensitivity of the stream reach to decreases in large woody debris supply				
		1	**2**	**3**	**4**	**5**
Potential for decreased supply of large woody debris	**1**	A	A	A	A	A
	2	A	A	B	C	C
	3	A	B	C	D	E
	4	A	C	D	D	E
	5	B	C	D	E	E

[1] "Risk" refers to the level of risk imposed on aquatic resources from past and proposed forestry activities in the watershed. The risk matrix on this page only considers the risks associated with decreases in the supply of large woody debris to the stream channel. Many small, low gradient stream channels are very dependent on the supply of Large Woody Debris (LWD) for the maintenance of stream channel diversity and complexity and ultimately maintaining good fish habitat. The removal of the riparian forest, either through forest harvesting, grazing or agriculture, can have a significant detrimental impact on the long-term stability and productivity of the stream channel. The five levels of risk have been defined as follows:

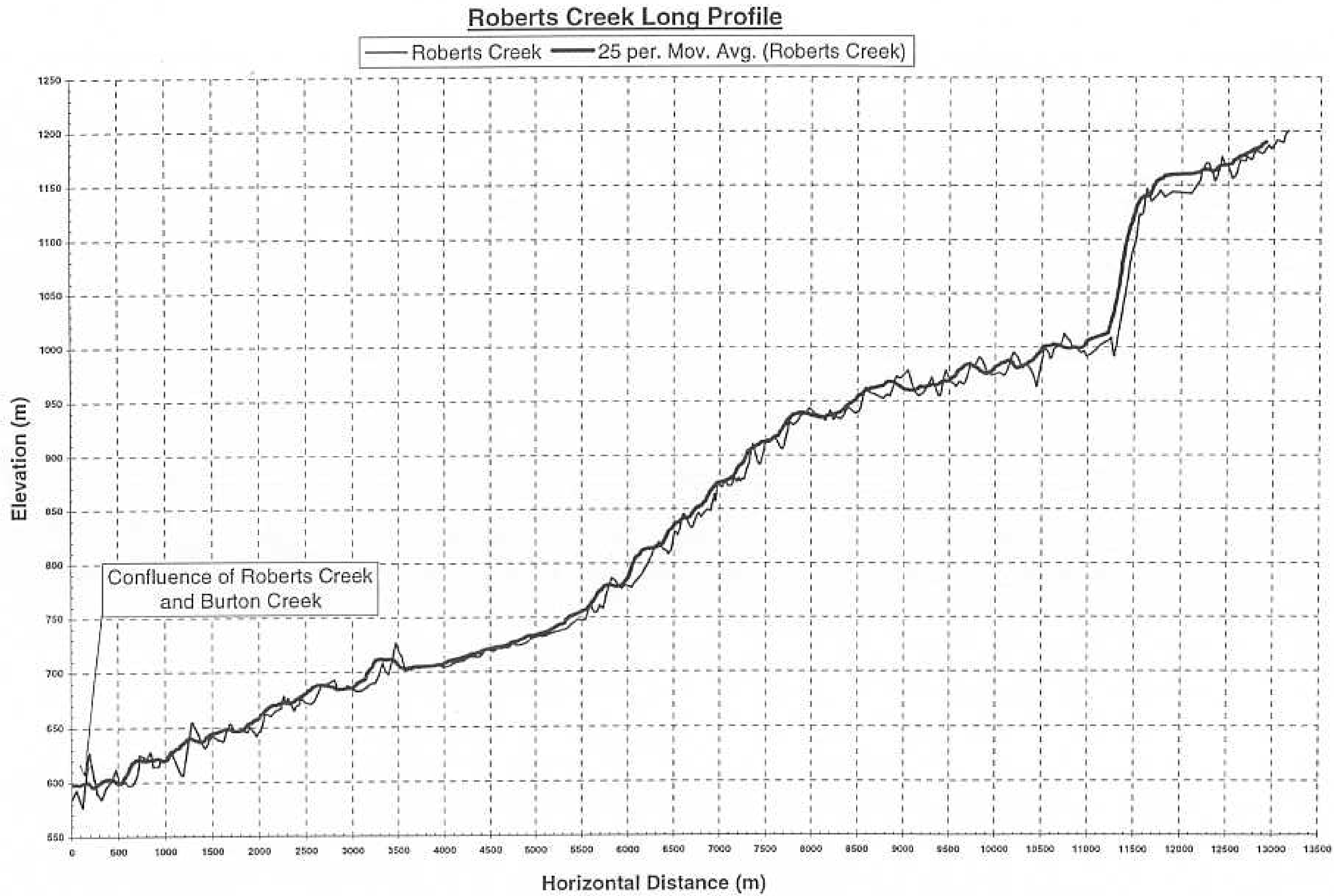
A = Very Low
B = Low
C = Moderate
D = High
E = Very High

- The sensitivity of the stream reach to decreases in the supply of LWD is a subjective designation. It is determined based on the results of the field-based channel assessments and the morphological characteristics of the reach such as stream gradient (s), stream width (W_b), bed and bank materials and stream depth (d). The methodology proposed in Government of BC (1996) and the stream classification system proposed by Rosgen (1996) are used as tools to help determine the level of sensitivity to a significant decrease in the supply of LWD to the stream channel.

- The potential for a significant reduction in the supply of LWD to the stream channel was assessed based on the level of riparian harvesting that has occurred along the mainstem of the stream channel. This riparian harvesting could be as a result of past forest harvesting activities (i.e. prior to enactment of the Forest Practices Code of British Columbia Act) or grazing or agriculture.

APPENDIX E

Longitudinal Profile



Roberts Creek Long Profile
Roberts Creek
25 per. Mov. Avg. (Roberts Creek)
Elevation (m)
Horizontal Distance (m)
Confluence of Roberts Creek and Burton Creek
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000
13500

APPENDIX F

Watershed Report Card

Watershed Report Card

Watershed: Robert Creek (4580 ha)

1. Total Area Harvested (Fall 2000): 34.4%
2. Total Area Harvested (Fall 2004): 38.7%
3. ECA (Fall 2000): 24.3%
4. ECA (Fall 2004): 26.1%
5. Total Road Density (Fall 2000): 0.876 km/km^2
6. Total Road Density (Fall 2004): 1.094 km/km^2
7. Length of High Risk Road: 0 km
8. Number of Landslides Entering Streams: 1
9. Length of Road on Unstable Terrain[1] (Fall 2000): 5.695 km
10. Length of Road on Unstable Terrain (Fall 2004): 5.883 km
11. Number of Stream Crossings in Watershed (Fall 2000): 10
12. Length of S1-S4 Stream with Highly Impacted Riparian Forest[2]: 0.4 km (both banks)
0.4 km (one bank)
13. Length of Assessed Stream Channel with Moderate or Severe Disturbance: 0.150 km

[1] unstable terrain = slopes greater than 60% and/or polygons identified as Es or E2s in forest cover database
[2] determined from aerial photographs, forest cover maps and field observations

APPENDIX G

Watershed Assessment Map