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TOLKO INDUSTRIES LTD., LAVINGTON
INTERIM INTERIOR WATERSHED
ASSESSMENT PROCEDURE
UPPER CREIGHTON CREEK and
FERRY CREEK

Project No. 0808-98-90481

March 1999

INTERIM INTERIOR WATERSHED ASSESSMENT PROCEDURE
UPPER CREIGHTON CREEK and FERRY CREEK

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Submitted to:

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Project No. 0808-98-90481

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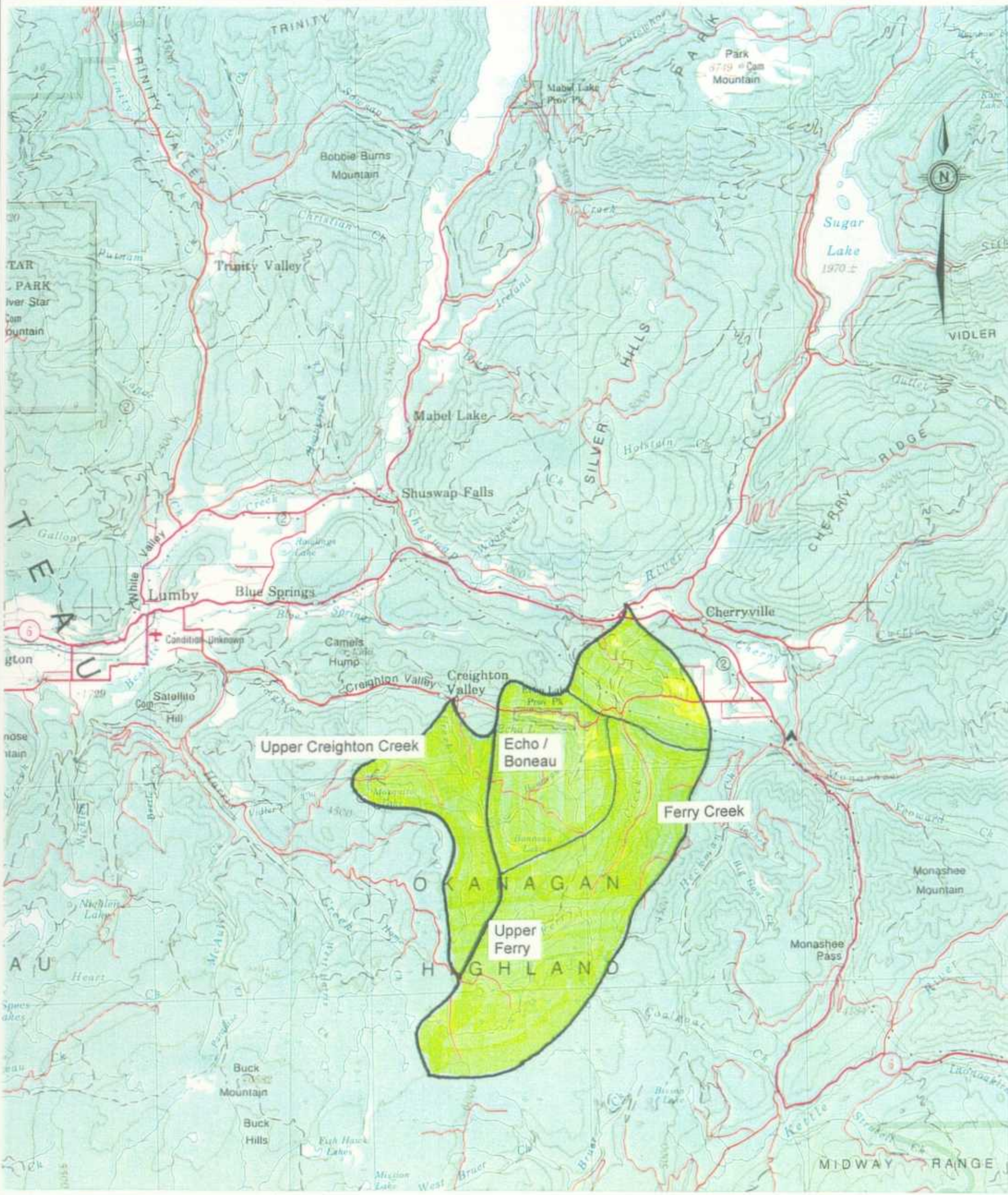

EBA Engineering Consultants Ltd.				PROJECT: INTERIM INTERIOR WATERSHED ASSESSMENT PROCEDURE	
CLIENT: TOLKO INDUSTRIES LTD.				TITLE: LOCATION MAP UPPER CREIGHTON AND FERRY CREEKS	
DATE: 99/03/19	DWN.: MH	CHKD.: BG	FILE NO.:	0808-98-90481	FIGURE 1

1.0 INTRODUCTION

At the request of Ian Widdows, of Tolko Industries Ltd. (Tolko), EBA Engineering Consultants Ltd. (EBA) was retained to conduct an Interim Interior Watershed Assessment Procedure (IWAP), for the Upper Creighton Creek and Ferry Creek Watersheds. Tolko reported the Department of Fisheries and Oceans had requested that an IWAP be completed to assess the possiblity that forestry developments in the upper watersheds were impacting anadromous fisheries and recent channel instabilities on private lands, lower in the watersheds. Data on the actual occurrences of fish in the watersheds is sparse, but a fish inventory is currently being carried out for all the study areas.

The watersheds are located in the Vernon Forest District, about 15 to 20 km west of Lumby, B.C., on the south side of the Shuswap River. They share a common drainage divide, and flow predominately from the south to the north. The Upper Creighton watershed is defined by that part of Creighton Creek that flows north to the Creighton Valley floodplain (Figure 1). Drainage from the study area flows west in the Creighton Valley, joining with Bessette Creek at Lumby, and ultimately draining into the Sushwap River south of Mabel Lake.

The Ferry Creek Watershed has two main tributaries, Upper Ferry Creek and Bonneau Creek. Their confluence is about 5 km upstream of the confluence of Ferry Creek and the Shuswap River, which occurs about 4 km west of Cherryville.

Tolko has a forest license tenure over most of Ferry Creek and the northeast portion of Upper Creighton Creek. Riverside Forest Products Ltd., Lumby Division (Riverside), has a forest license covering the west portion and the headwater area of Upper Creighton Creek, and area in upper Ferry Creek.

The Upper Creighton Creek watershed has an area of about 35.5 km^2. The Ferry Creek watershed has an area of 145.3 km^2.

2.0 METHODOLOGY

This assessment generally followed the suggested guidelines for watershed assessments in the *Standards Agreement for the Interim Interior Watershed Assessment Procedure,* Watershed Restoration Program, 1998. The object was to assess the current watershed condition relative to impacts of forest development, and potential impacts of proposed future development. It consists of three parts: the watershed report card, a sediment source survey, and a reconnaissance channel assessment.

2.1 Watershed Report Card

The watershed report card is compiled from TRIM, terrain stability, forest cover and forest development plan (FDP) maps and air photos and includes the following "environmental indicators":

1. Percentage of watershed harvested (%).
2. Equivalent clearcut area (ECA). The ECA was calculated as the sum of the clearcut area below the H60[1] line and the clearcut area above the H60 line times 1.5. (% and km^2). The calculations do not include private land, either for total watershed area, or for harvesting. There are 19.1 km^2 of private land in the Ferry Creek watershed and 4.3 km^2 of private land in the Bonneau Creek watershed.
3. Total road density (km/km^2).
4. Length of road as high sediment source (HSS – km). The HSS was calculated as that road length crossing polygons defined on the Terrain Stability Mapping as having both a high or very high surface erosion potential and a high or very high sediment transport potential.
5. Total number of landslides entering streams. This was divided into natural or forest development related landslides.
6. Length of road on unstable slopes (km). This was determined from the development maps as the length of road traversing polygons defined on the Terrain Stability Mapping as having a Terrain Stability Class of IV or V.
7. Number of stream crossings of roads, as determined from TRIM (streams) and FDP (roads).
8. Length of stream logged to stream bank (km and %). This value was taken from The development maps and TRIM (streams). Areas of older logging where it was judged that riparian function was largely restored are discussed in the Channel Assessment section and Reach Descriptions for each watershed..
9. Length of stream with severely disturbed channel (km and %), was calculated from the ReCAP assessment and includes only the portion of the mainstem examined in the helicopter overflight.

Hazard indices: low, < 0.5; moderate 0.5 to 0.7; and high > 0.7; were assigned using the procedures outlined in the Interior Watershed Assessment Procedure Guidebook, Forest Practices Code of BC, September 1995.

The report card impact indicators address 3 issues: peak flows, sediment delivery, and channel/riparian effects. The effects of all 3 issues on channel condition are dealt with directly in subsequent parts of this study, namely the sediment source

[1] The H60 line is the elevation above which 60 percent of the watershed area is located. It is assumed that the upper 60 percent of the watershed is still covered in snow when stream flows begin rising during spring runoff. Therefore land use changes which affect snow accumulation and melt rates are considered more significant above this level.

survey and reconnaissance channel assessment. These map-based results should be considered a rough estimate of potential impacts, and can serve as an indication as to where problems might exist or develop. The results of the SSS and ReCAP, which are developed with direct observations of conditions on the ground, should take precedence over the results of the report card.

A watershed report card was prepared for the Upper Creighton watershed. A separate report card was prepared for the two main tributaries Ferry Creek – Bonneau and Upper Ferry Creeks - and another for the whole Ferry Creek watershed, down to the Shuswap River.

The report card analysis was performed using GIS, once including forest development to the end of 1998, and again for this development plus any development proposed to the end of 2003.

2.2 Sediment Source Survey (SSS)

A sediment source survey is an overview assessment of the roads and landslides in a watershed, using airphotos, aerial reconnaissance and limited field assessments to determine mass wasting (landslides) and soil erosion hazards and the risks of sediment from these sources to the stream channels

Prior to fieldwork, 1:18,000, 1994 colour and 1984 black and white airphoto coverage of the watersheds, along with Forest Development, Forest Cover and TRIM maps were reviewed. Three days were spent on a field reconnaissance, carried out in conjunction with the channel assessment. Seven hours of helicopter time were used for an airborne overview of all roads and landslides, along with all channel mainstems. Approximately 55 sites were ground truthed in the field, primarily on roads.

Landslide hazards (low, moderate and high) indicate the relative likelihood of a landslide occurring. The surface erosion hazard (low, moderate, high) was determined by the depth and width of erosional rills observed on road surfaces and in ditches. The consequence was considered high if site conditions were such that sediment from a landslide or surface erosion would directly impact a perennial tributary or main channel; moderate if sediment would be deposited in an ephemeral channel or on a valley flat adjacent to the channel; and low if there was no potential connectivity between the sediment source and any channel. These designations correspond to the terms “coupled”, “partially coupled” and “uncoupled” used in the reconnaissance channel assessment procedure. Streambank sediment sources were generally erosion of natural sideslopes and roads adjacent to the creeks.

The risk to the channel and fish habitat was as determined as the product of the hazard and consequence, according to Table 13, Forest Road Engineering

Guidebook, Forest Practices Code of British Columbia, 1995, p118. A work priority of high was assigned to all high and very high risk sites. Moderate and low work priorities correspond to the assigned risk. A detailed assessment of conditions is recommended for all high work priority sites, and general comments relating to probable rehabilitation activities are made in the summary tables.

Where many individual roads and spurs were located on similar low hazard and low risk terrain, the roads were grouped as a single unit.

Results are summarized in Road Risk summary tables (Tables 1-1,2 and 3) and a Landslide summary table (Table 2). Streambank sediment sources are summarized from the ReCAP in Table 3. All these potential sediment sources are included in the SSS Maps 1, 3, 5.

2.3 Reconnaissance Channel Assessment (ReCAP) and Riparian Impact

2.3.1 Classifying Channel Reaches

Each of the three watersheds examined in this study were divided into sub-basins and a residual based on stream ordering using 1:20,000 TRIM mapsheets. Only reaches in the mainstem portion of the channel were examined. The mainstem of the channel includes the highest order channel in the residual watershed and the highest order channel in each sub-basin. Channel networks are partitioned into distinct reaches to provide a systematic framework within which to assess channel characteristics and to compare consistent channel types throughout a watershed.

A reach is a fundamental channel unit defined as a section of channel having a homogeneous channel pattern, valley flat-channel relations, and discharge (Kellerhals, *et al.*, 1976). Reaches were determined using a combination of aerial photograph interpretation and TRIM based, 1:20,000 scale map observations. The main criteria for determining reach breaks were channel gradient, confinement and channel form. Reaches were then modified based on information collected in the helicopter overflight conducted in the field and, where roads permitted, ground observations at stations on the creeks.
Reaches not examined in the helicopter overflight were not given a channel morphology or disturbance rating. Reaches not observed on the helicopter overflight are still shown on the ReCAP maps (Maps 2, 4, 6). Both natural and forestry-related disturbances were recorded for each reach examined in the helicopter overflight. The classification of channel reaches examined in the helicopter overflight in the Upper Creighton, Bonneau and Ferry Creek watersheds are summarized in Form 1(a-c). Reach locations are indicated on the ReCAP maps (Maps 2, 4, 6) and on the stream profiles for each watershed (Figures 3, 4, 6).

Eleven reaches were delineated in the Upper Creighton Creek residual; one reach was delineated in each of sub-basins B, C, and D; and five reaches were delineated in sub-basin A. The eleven reaches in the residual, the five reaches in sub-basin A and the one reach in sub-basin C were examined during a helicopter overflight conducted November 2 and 3, 1998. Reaches in sub-basins B and D were not examined in the helicopter survey as it was thought that characteristics of these reaches were represented by other reaches already being examined.

Two reaches were delineated in the Bonneau Creek residual; six reaches in sub-basin A; two reaches in sub-basin B; an one reach was delineated in sub-basin C. The six reaches in sub-basin A, the two reaches in sub-basin B and the two reaches in the Bonneau Creek residual were examined during the helicopter overflight. The reach in sub-basin C was not examined in the helicopter survey as it was thought that other reaches already being examined represented characteristics of this reach.

Thirteen reaches were delineated in the Ferry Creek residual, one reach in each of sub-basin A, B, and E, two reaches in sub-basin C and 3 reaches in sub-basin D. Only the thirteen reaches in the residual were examined during the helicopter overflight and these were further divided into Lower and Upper Ferry Creek at the confluence with Bonneau Creek (the end of Reach 5). Reaches in sub-basins A, B, C, D and E were not examined in the helicopter survey as it was thought that characteristics of these reaches were represented by other reaches already being examined.

2.3.2 Classifying Riparian Impact

The objectives of the riparian assessment are to map those portions of stream reaches where riparian function has been lost or impaired as a result of activities related to forest harvesting. Harvested areas were identified using forest cover maps, forest cover polygon attributes and aerial photographs for each channel reach delineated above. Only harvested areas adjacent to the mainstem of each channel examined in the helicopter overflight were assessed, unless areas with impacts related to forestry were encountered (i.e. road construction and agricultural land development). Channel reaches were further subdivided into distinct riparian vegetation types, stand species and disturbance types using the terminology and tables supplied in the Interim Interior Watershed Assessment guidebook (June, 1998) as follows:

Riparian Vegetation Types:

INIT (initial succession)	Earliest successional stage (0-1 year)
SH (shrub herb)	Early successional stage (1-20 years)
PS (pole sapling)	Trees > 10 m tall, densely stocked (20-40 years)
YF (young forest)	Forest canopy forms distinct layers (40-80 years)
MF (mature forest)	Canopy comprised of mature trees (80-250 years)
OF (old forest)	Old trees (250 + years)

Stand Species

d (deciduous dominated)	>75% deciduous
c (coniferous dominated)	> 75% conifers
m (mixed)	No component > 75%

Disturbance Types:

L	Logging	**I**	Insects
B	Beaver	**O**	Flooding
W	Windthrow	**F**	Fire
S	Slope failure	**R**	Road
A	Agriculture		

An estimated level of riparian function (NONE to HIGH) was then determined based on the most limiting factor in the disturbed area as follows:

Limiting Factors:

LWD
SHADE
SURFICIAL SEDIMENT FILTER
BANK STABILITY

2.3.3 Aerial Photograph Assessment

The most recent aerial photographs examined were taken in 1994. These were compared to aerial photographs taken in 1984. General assessments can be made on stream channels with widths of 20 metres or more as these are often wide enough to be visible on 1:20,000 scale aerial photographs. No general assessments could be made on stream channel morphology based on air photo examination, as there were no visible stream channel sections in any of the three watersheds. The watersheds contain only "small and intermediate channel morphologies (less than 20 m)." Form 2 (a-c) summarizes the length of mainstem channel downstream of logging with erodible and non-erodible banks for Upper Creighton, Bonneau and Ferry Creeks, respectively, and if large channel morphologies were present in the watershed, would indicate the length of channel with altered channel morphology. Form 3 (a-c) provides information on both the potential and observed channel impact values (CIV), based on the results calculated in Form 2. In the case of the three watersheds examined in this project, observed CIV's were all rated as LOW as no channel was visible from the air photos and all potential CIV's were rated as HIGH for the same reason. This meant that all channel reaches delineated on the air photos prior to fieldwork required a ReCAP assessment. Forms 1-3 were completed for only those reaches were a helicopter overflight was conducted.

2.3.4 Field Assessments

Fieldwork was carried out by means of a helicopter survey conducted on November 2 and 3, 1998 and ground observations on November 2, 3 and 4, 1998. The weather on these days was partly cloudy and 5-10°C. The overview channel assessment was by observation from the helicopter and a video recording taken concurrently that was re-examined in the office several times post field work. A GPS (Global Positioning System) navigation system was also used at the time of the helicopter survey so that precise ground locations of notable features could also be recorded. The ReCAP channel assessment was carried out in accordance with Attachment 2 of the Interim Interior Watershed Assessment Procedure (June, 1998), the Channel Assessment Procedure and Channel Assessment field guidebooks (MOF/MOELP, 1996) and channel morphologies were determined using the terminology and tables supplied in the field guidebook as follows:

Code	*Morphology*	*Sub-code*	*Bed material*	*LWD*
RP	Riffle-pool	RPg-w	Gravel	Functioning
RP	Riffle-pool	RPc-w	Cobble	Functioning
CP	Cascade-pool	CPc-w	Cobble	Present, minor function
CP	Cascade-pool	CPb	Boulder	Absent
SP	Step-pool	SPb-w	Boulder	Present, minimal function
SP	Step-pool	SPb	Boulder	Absent
SP	Step-pool	SPr	Boulder-block	Absent

Riparian vegetation classes, disturbance types and limiting factors were also checked during the heli-overflight.

It should also be noted that an important factor in channel sensitivity to disturbance is the relative significance of natural sediment sources compared to forestry-related sources (MOF/MOELP, Channel Assessment Procedure Guidebook, 1996). The helicopter overflight examined all channel disturbances regardless of whether they were natural or forestry-related. These disturbances were then further examined using the video recording to decipher the forestry-related disturbances and these are discussed in the Channel Assessment sections of this report for each watershed assessed.

3.0 PHYSIOGRAPHY AND GEOLOGY

The Upper Creighton and Ferry Creek watersheds are located in the Okanagan Highlands of the Interior Plateau physiographic region (Holland, 1976) They are comprised of gently sloping upland areas dissected by steeply incised stream channels. Downstream of the study area, the rivers flow through broad valleys with wide floodplains. The elevations of the watersheds range from 500m (Ferry) and 800m (Creighton) to about 1800m.

In the upland, headwaters areas, stream channel gradients are commonly < 5% and hillslopes generally range from flat to 35%. These upland areas are often swampy, contain numerous small lakes, and are underlain by till and organic rich soils in the swampy areas.

The lowest sections of Upper Creighton and Bonneau Creeks are in the IDF(mw1) biogeoclimatic zone. Lower and mid-Upper Ferry Creek are in the ICH(mw2)zone. The flat to gently sloping upland plateau is in the ESSF(xc) and there is a narrow band of MS(mm) just below the plateau.

In the areas of steeply incised stream valleys, which occur adjacent to the stream mainstems and their major tributaries, hillslopes are commonly moderately steep (50 to 70%) with locally steeper sections. They are underlain by till of various thickness, or a till, or till and bedrock-derived, colluvium veneer to mantle, overlying bedrock.

The area is underlain by Tertiary plateau basalts and related volcaniclastic sediments, Jurrasic granitic intrusions, Triassic metasediments (argillite, limestone and conglomerate), and Proterozoic basement rocks of the Shuswap Metamorphic complex (gneiss, micaceous schist and marble). Notable are vertical rock bluffs and large talus slopes in Tertiary basalts (Photos 21, 22, 24) in the Upper Creighton, Bonneau and Upper Ferry Creek watersheds. Associated with these Tertiary basalts are several very large lateral-spreading type slope failures.

4.0 CLIMATE AND HYDROLOGY

The Upper Creighton Creek and Ferry Creek Watersheds are in the Thompson-Okanagan Hydrologic Zone, near the boundary with the Shuswap Highlands Hydrologic Zone. The long term normal precipitation at Lumby, the nearest climate station to these watersheds, is about 625mm per year, with about 25% falling as snow and 75% as rain. Data from nearby stations[2] indicate that total precipitation increases as one moves eastward through the Okanagan Highlands and the percentage of total precipitation falling as snow increases as one moves higher in elevation. The H60 line for the Upper Creighton and Upper Ferry Creek watersheds are at about 1254 and 1240 metres respectively. It is estimated that total annual precipitation for these watersheds would be about 900 to 1000 mm with over 50% falling as snow.

Streamflow characteristics for Creighton and Ferry Creek are typical of areas where the dominant hydrological process in the watershed is the annual spring snowmelt event. Streamflows rise in late March or early April and peak in May or early June.

For Ferry Creek, streamflow records were available from a station near its confluence with the Shuswap River, for a period from 1959 to 1977 (17 years). A flood-frequency analysis had been carried out (Figure 2, from AES, 1990). The maximum daily mean was recorded on June 01, 1972 with a value of 27.9 m^3/s and a return period of 30 years. The 100-year maximum daily mean flood was estimated to be 30 m^3/s.

A very short length of streamflow record was available for Lower Creighton Creek - from 1959 to 1965 (7 years). The maximum monthly mean in this period was recorded in May, 1959 with a value of 1.88 m^3/s. The maximum daily mean recorded was on May 23, 1959 with a value of 3.94 m^3/s. Extrapolating from the longer period of record for Ferry Creek, the maximum daily mean flood probably occurred in early June, 1972 and was about 7.3 m^3/s, with a return period of 30 years.

The existence of generally flat-lying swampy upland area is thought to be significant in terms of hydrologic response to climatic inputs. Swamps will act as a storage areas, with some capacity to attenuate larger precipitation events, resulting in watersheds that are less "flashy", ie., the streamflows will react more slowly to precipitation, with lower stream peak streamflow values than watersheds without swamps or other water retention areas. This can also result in a slow release of water following the spring freshet, and in less extreme summer low flows.

5.0 CREIGHTON CREEK

5.1 Watershed Issues

Tolko reported that their concerns about Upper Creighton Creek related to fisheries habitat issues and the reported occurrence of debris flooding and overbank sediment deposition on the lower Creighton Creek floodplain.

[2] Climatic conditions are extrapolated from stations with data records of 25 years or longer at Lumby Sigalet Rd (560m) near Lumby, and Joe Rich Creek (875m) and McCulloch (1250m), both about 50 km southwest of the study area, in the Thompson-Okanagan Hydrologic Zone.

For the purposes of this study, Creighton Creek has been divided into upper and lower sections with only the upper portion of the creek being investigated in this project. The watershed lies within the operating area of both Tolko and Riverside. Upper Creighton Creek covers an area of 35.5 km^2 and its length is approximately 14.3 km. Based on stream ordering, Upper Creighton Creek is a third order watershed and was sub-divided into 4 second order sub-basins and the residual. For the purposes of the ReCAP only the mainstem of the channel needed to be assessed.

Denison Lake, in the upper portion of the watershed, is stocked with rainbow trout and therefore it is assumed that fish are located downstream (personal communication with Sean Cluff, Ministry of Forests, Vernon District, 1999). It is not known, however, whether fish reside upstream of Denison lake. A fish inventory in Creighton Creek is being conducted concurrently (personal communication with Daryl Arsenault, EBA Engineering, Kelowna, 1998).

Harvesting in Upper Creighton Creek watershed commenced in the 1970's and has continued into the 1990's. No water licenses are currently held in the Upper Creighton Creek watershed.

5.2 Watershed Assessment Report Card

Table 1. WATERSHED REPORT CARD: UPPER CREIGHTION CREEK

Impact Indicators	Status of Development		Hazard Index	
	Existing	Existing plus Proposed	Existing	Proposed
Watershed area (km²)	35.5	35.5		
Harvested area (km²)	9.9	12.5		
Percent watershed harvested (%)	27.7	35.2		
ECA : above H60 (weighted x 1.5)	4.9	7.1		
below H60	2.6	4.2		
Total	7.5	11.3		
ECA (% watershed area)	21	32	.35	.53
Road Density (km/km²)	1.3	1.6	.45	.53
High sediment source: length of road (km)	.16	.26		
road density (km/km²)	.005	.007	<.1	<.1
Number of landslides entering streams: Natural (including bank erosion)	20			
Forestry related	3			
Potentially unstable slopes:road length (km)	0	0		
road density(km/km²)	0	0	0	0
Number of stream crossings:	12	15		
Number/ km²	.34	.42	.43	.52
Length of stream logged to streambank (%)	9.92	10.62	0.33	0.35
Length of stream with severely disturbed channel (%)	1.7		0.3	

Peak Flows (ECA): The hazard index for the existing development is low, and at the low end of the moderate scale for proposed development.

Sediment Delivery (road density, high sediment source, potentially unstable slopes, landslides, and stream crossings): Almost all hazards indices are low to very low. The hazard indices for stream crossings and road density are at the low end of the moderate hazard class. There was little evidence from roads and crossings visited as part of the SSS and ReCAP that significant channel impacts are resulting from these developments.

Channel/riparian: The hazard indices are low for both length of stream logged to stream bank and for length of stream with severely disturbed channel. Note that the length of severely disturbed channel was calculated from the ReCAP and only includes channel reaches examined in the helicopter overflight. Not all of the reaches in the mainstem have been included in the calculations. Both of these indicators are discussed further in the ReCAP results.

5.2.1 ECA Recommendations for Proposed Developments

Based on the ECA hazard indices and the low "flashiness" predicted for the watershed, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows.

5.3 Sediment Source Survey

The results of the SSS are summarized in Tables 1-1 (roads) and Table 2 (landslides), Table 3 (summary of streambank sediment sources), and Map 1, Sediment Source Survey (SSS) map for Upper Creighton Creek.

Streambank erosion is almost all of natural origin. Almost all the forest roads in the watershed are on flat to gently sloping terrain, with low landslide and surface erosion hazards, and low risk and work priorities.

Only section 1 and 2 or the Bonneau FSR (Map 1), totalling 1.5 km of a total of 44.8 km of roads in the watershed, have drainage problems and landslides that impact or potentially impact the creek. Further assessment and remediation was recommended only for these road sections (see Table 1-1 for details).

Several large to very large, active to inactive (relic), earth and rock slump and possibly lateral spreading type landslides were noted. Slide S50 is a currently active natural earth slump and has the potential to contribute substantial amounts of sediment to, and even fill the existing channel of Creighton Creek.

It was concluded that forestry developments to date have not resulted in any appreciable increase in sediment loading over natural background levels to channels.

5.3.1 Recommendations for Proposed Developments

In general, the report card and SSS indicate that if road developments and harvesting proceed with practices equal those undertaken in the past, the proposed road development would not be expected to result any appreciable sediment delivery to stream channels.

However, any development which has any potential to impact the active slump feature (S50) and the presumably inactive bedrock based slump and lateral-spreading type slides (S41, S42, S43 and RS51) should not proceed until a detailed assessment of the potential hazards and risks associated with these features is carried out by a professional with experience in these types of slope failures. This includes any development upslope of, and in the hydrologic contributing area to, any of these features.

Specifically this includes proposed Riverside Cutting Permits CP317-5, 6, and 8 (S43, S50 and adjacent areas), and Tolko CP 350-5 (RS 51), and CP 350-2 and 3 (S42, S43).

5.4 Channel Assessment

Detailed reach descriptions for Upper Creighton Creek are included in Appendix A1. Reach breaks and disturbance summaries are found on both the ReCAP map (Map 2) and the stream profile constructed from 1:20,000 TRIM data (Figure 3). A summary of forestry related disturbances and recommendations for further detailed assessment are outlined below. Recommendations were generally limited to identification of reaches requiring a detailed Channel Assessment Procedure (CAP).

The majority of the Creighton Creek residual runs through an entrenched gully where adjustments in channel morphology are limited. Large woody debris is not abundant in the lower reaches of Upper Creighton Creek but increases upstream and is common in the reaches on the upper plateau. This is likely a function of gradient more than supply. Disturbances observed in the creek were primarily naturally occurring with blocks (angular particles > 256 mm) and rubble (angular particles 2 – 256 mm) being deposited below bedrock outcrops regularly in the residual. Harvesting and roads adjacent to the creek were observed infrequently in the residual and often in sub-basin A.

Only 1.7% (204 m) of the residual was judged as highly disturbed (AS) and 2% (61 m) of sub-basin A totaling 1.7% of the total channel length examined in the helicopter survey. Moderate disturbances were observed in 1.3% (195 m) of the length examined with all of this being found in sub-basin A. Partial disturbances were found in both the residual (272 m) and in sub-basin A (500 m) totaling 5% of the channel length examined. No logging-related disturbances were observed in sub-basin C.

Riparian function in sub-basin A has been compromised in parts of the tributary with no riparian buffer remaining in some cases and abundant windthrow resulting in shade being a limiting factor.

It is recommended that Reach 1 in the residual and Reach 2 in sub-basin A be examined in a detailed CAP as severe disturbances were found in both reaches. Fish presence or absence in sub-basin A should be determined and, if no fish are found, a detailed channel assessment is not required here as no appreciable sediment flux from sub-basin A was observed entering the residual. If fish are found, windthrow in the creek may promote fish habitat, however, the riparian function of this reach should be examined. The riparian function in Reach 1 in the residual should also be examined as continued bank erosion may further limit riparian function.

6.0 BONNEAU CREEK

6.1 Watershed Issues

Bonneau Creek is a third order tributary of Ferry Creek. It flows northeast from Bonneau Lake to its confluence with Ferry Creek. The Echo Lake subdrainage forms a tributary of Bonneau Creek. Echo Lake was included in the report card, but not in the SSS, as any sedimentation caused by forestry developments would be deposited in the lake, and there would be no cumulative downstream effects.

Tolko reported that their concerns about Bonneau Creek related to local fisheries and debris flooding issues and possible cumulative impacts to Ferry Creek, including fisheries habitat issues and the reported occurrence of a debris flooding and overbank sediment deposition on the lower Ferry Creek floodplain.

The Bonneau Creek watershed lies entirely within the Tolko operating area. It has an area of 36.8 km^2 and a length of 9.3 km. The Bonneau watershed was divided into three subbasins and the residual.

The elevation of the Bonneau Creek watershed ranges from 700 to 1640 metres. It consists of a small gently sloping upper plateau with a moderately steep gully and large flat lying terrace at mid-watershed, that is now being used as agricultural land. Another moderate to moderately steep gully continues below the terrace to the confluence with Ferry Creek.

Bonneau Lake, in the uppermost part of the watershed, is stocked with rainbow trout and fish have been observed to the confluence with Ferry Creek (personal communication with Sean Cluff, Ministry of Forests, Vernon District, 1999). The preliminary phase of a fish inventory in the watershed is being conducted concurrently with this study. Harvesting in Bonneau Creek commenced in the 1970's and has continued into the 1990's. No water licenses are currently held in the watershed.

6.2 Watershed Assessment Report Card

Table 2: WATERSHED REPORT CARD: BONNEAU CREEK (including Echo Lake)

Impact Indicators	Status of Development		Hazard Index	
	Existing	Existing Plus Proposed	Existing	Proposed
Watershed area (km^2) Harvested area (km^2) Percent watershed harvested (%)	32.5 8.2 25.1	32.5 10.1 29.6		
ECA : above H60 (weighted x 1.5) below H60 Total	6.9 0.6 7.5	9.7 0.7 10.4		
ECA (% watershed area)	23	32	.38	.53
Road Density (km/km^2)	1.4	1.6	.47	.55
High sediment source: length of road (km) road density (km/km^2)	2.6 .08	2.6 .08	.4	.4
Number of landslides entering streams: Natural (including bank erosion) Forestry related Private Land	2 1 1			
Potentially unstable slopes : road length (km) road density(km/km^2)	2.1 .064	2.1 .064	.2	.2
Number of stream crossings: number Number/ km^2	8 .25	9 .28	.3	.35
Length of stream logged to streambank (%)	4.67	5.0	0.16	0.17
Length of stream with severely disturbed channel(%)	6.0		0.5	

Peak Flows (ECA): The hazard index for the existing development is low, and at the low end of the moderate scale for proposed development.

Sediment Delivery (road density, high sediment source, potentially unstable slopes, landslides, and stream crossings): Almost all hazard indices are low to very low. The hazard index for road density is at the low end of the moderate hazard class. There was little evidence from roads and crossings visited as part of the SSS and ReCAP that significant channel impacts are resulting from these developments.

Channel/riparian: The hazard index for length of stream logged is low and for length of severely disturbed channel is on the low side of medium. It should be noted that severely disturbed sections of Bonneau Creek were found in Reach 2 in the residual. This is private agricultural land. Only channel reaches examined during the helicopter overflight have been included in the calculation. Both riparian and channel indications are discussed further in the ReCAP results.

6.2.1 ECA Recommendations for Proposed Developments

Based on the ECA hazard indices the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows. The cause of debris flooding on the agricultural terrace is suspected to be due to road construction on private lands, but this should be investigated to rule out the possibility that the disturbance is caused by elevated peakflows (see SSS below).

6.3 Sediment Source Survey

The results of the SSS are summarized in Tables 1-2 (roads) and Table 2 (landslides), Table 3 (summary of streambank sediment sources), and Map 3, Sediment Source summary map for Bonneau Creek.

Only 2 instances of streambank erosion were noted, both believed to be of natural origin. Only one small landslide was noted, probably originating from skid trail drainage in a cutblock, with little current downslope impact. Some poor maintenance was noted on roads located on moderately sloping ground underlain by erodible glaciofluvial deposits with the potential to lead to surface erosion. But the benchy nature of the terrain prevented significant sediment transport, resulting in a moderate risk and work priority rating.

The most significant problem was noted on private land, on and adjacent to the mid-elevation terrace. A road paralleled the Bonneau mainstem just upslope of the terrace, and a debris flood/flow deposit of sediment onto the terrace, was noted below this section of creek. The agricultural development also appears to have diverted the creek from its original channel, where flows may be subsurface, and it is not clear if any downstream transport of sediment is currently possible. Private land was not investigated on the ground in this project.

There has reportedly been some stream enhancement work carried out in Reach 6 of sub-basin A, where the creek flows along an old skid trail. It was reported that the creek flow becomes subsurface downstream of this point, therefore it was not considered a sediment delivery issue (see Appendix A2).

6.3.1 Recommendations for Proposed Developments

In general, the report card and SSS indicate that if forestry road developments and harvesting proceed with practices equal to those undertaken in the past on crown land, no appreciable increase in sediment delivery to stream channels would be expected.

The cause of debris flow/flooding, and other possible channel disruptions on private land should be investigated to rule out the possibility that upslope developments are having an impact beyond what the results of this investigation would suggest.

6.4 Channel Assessment

Detailed reach descriptions for Bonneau are included in Appendix A2. Reach breaks and disturbances summaries are found on both the ReCAP map (Map 4) and the stream profile constructed from 1:20,000 TRIM data (Figure 4). A summary of forestry related disturbances and recommendations for further detailed assessment are outlined below. Recommendations were generally limited to identification of reaches requiring a detailed Channel Assessment Procedure (CAP).

Very few disturbances were observed in the upstream reaches of the Bonneau Creek watershed. A large part (approximately 4150 metres, 41%) of the mainstem runs through private property on agricultural lands. Sub-basin A exends to Bonneau Lake and is characterized by cobble-pool and step-pool morphologies which are generally well developed.

Channel avulsions and eroding banks in the residual, however, have lead to a lack of pools observed in this area during the helicopter overflight. This disturbance is most likely related to agricultural development given the lack of significant logging-related disturbances observed upstream. In sub-basin A, the creek flows on old skid trails in Reach 6 for approximately 300 metres.0 Some stream enhancement work was undertaken in 1998 (personal communication with Sean Cluff, Ministry of Forests, Vernon District, 1999) in Reach 6 which is likely to address this problem. Aggradation adjacent to logging related wood debris in the creek in Reach 3 is the result of a 65 m section of the reach logged to stream side. In sub-basin B, just upstream of the residual an area of extensive riffles has resulted from a diversion of the creek for about a 50 m onto an old, adjacent road which extends upslope from private land (See SSS).

Severe disturbances (AS) in the Bonneau Creek mainstem were observed only in Reach 2 of the residual totaling 6% (595 m) of the length examined in the helicopter overflight and 12% of the total length of the residual. Moderate disturbances (AM and DM) were observed to an equal extent in the residual, sub-basin A and sub-basin B, totaling 7% (710 m) of the length of stream examined in the helicopter survey.

The consequences resulting from channel avulsions and eroding banks in Reach 2 are high because the reach runs through private land. Recommendations for a detailed CAP are restricted to the severely disturbed reaches which includes Reach 2 in the residual. Based on our observations, however, it is recommended that drainage adjacent to old road and skid trails in Reach 1 in sub-basin B and Reach 6 in sub-basin A be examined more closely. Riparian function in Reach 2 should also be examined during the detailed CAP.

7.0 UPPER FERRY CREEK

7.1 Watershed Issues

Tolko reported that their concerns about Upper Ferry Creek related to local fisheries and debris flooding issues and possible cumulative impacts to Lower Ferry Creek, including fisheries habitat issues and the reported occurrence of debris flooding and overbank sediment deposition on the lower Ferry Creek floodplain.

Ferry Creek flows north through a flat upland plateau, then through a long, gently to moderately sloping valley bottom with moderately steep valley sides to its confluence with the Shuswap River, west of Cherryville, B.C. It ranges in elevation from 500 to 1900 metres. For the purposes of this study, only the section of Ferry Creek upstream of its confluence with Bonneau Creek has been examined in detail for the SSS and ReCAP.

The total area of the upper watershed is approximately 85 km^2, containing operating areas of both Tolko and Riverside. Based on stream ordering Ferry Creek is a fourth order watershed with 5 third order sub-basins including Bonneau Creek. The residual in both Upper and Lower Ferry Creek were examined in the helicopter survey conducted in the watershed.

Fisheries information revealed that fish are present in the watershed from the headwaters at Ferry Lake to the mouth at the Shuswap River with rainbow trout and sculpin being caught (personal communication with Daryl Arsenault, EBA Engineering, 1998). A perched culvert below Highway 6 does not allow anadromous fish in the Shuswap River to migrate upstream into the Ferry Creek system (personal communication with Ian Widdows, Tolko Industries Ltd., 1998). The preliminary phase of a fish inventory in the watershed is being conducted concurrently with this project. Harvesting in the watershed commenced in the 1970's and has continued into the 1990's. No water licenses are currently held in the Ferry Creek watershed.

7.2 Watershed Assessment Report Card

Table 3: WATERSHED REPORT CARD: UPPER FERRY CREEK

Impact Indicators	Status of Development		Hazard Index	
	Existing	Existing Plus Proposed	Existing	Proposed
Watershed area (km^2) Harvested area (km^2) Percent watershed harvested (%)	84.9 16.6 19.6	84.9 23.4 27.6		
ECA : above H60 (weighted x 1.5) below H60 Total	20.7 2.0 22.7	23.3 2.1 28.4		
ECA (% watershed area)	27	33	.45	.55
Road Density (km/km^2)	.95	1.04	.34	.38
High sediment source: length of road (km) road density (km/km^2)	7.3 .085	8.1 .095	.43	.48
Number of landslides entering streams: Natural (including bank erosion) Forestry related	7 18			
Potentially unstable slopes : road length (km) road density(km/km^2)	9.2 .074	10.1 .118	.25	.4
Number of stream crossings: Number/ km^2	73 .86	77 .91	.95	1.0
Length of stream logged to streambank	12.49	12.74	0.42	0.42
Length of stream with severely disturbed channel	0		0	

Peak Flows (ECA): The hazard index for existing development is low, and in the low end of the moderate hazard class for proposed development. The ReCAP found no evidence of channel degradation due to elevated peak flows in Upper Ferry Creek. Lateral channel mobility and instability in the lower reaches of Upper Ferry Creek are considered indications of excess sediment, relative to flows.

Sediment Delivery (road density, high sediment source, potentially unstable slopes, landslides, and stream crossings): All hazard indices, except stream crossings per km^2 are low. The hazard index for stream crossings per km^2 is very high. While several poorly deactivated or maintained crossings or ephemeral creeks were noted in the SSS (TP 12, 19, 22), there was little evidence of sediment being transported appreciable distances or into main channels, as discussed below in the Section 7.3, SSS.

Channel/riparian: The hazard indices are low for both length of stream logged to streambank and for length of stream with severely disturbed channel. Note that the length calculated for severely disturbed channel only includes channel reaches examined in the helicopter overflight. Not all of the reaches in the mainstem have been included in the calculations. Both of these indicators are discussed further in the ReCAP results.

7.2.1 ECA Recommendations for proposed Developments

Based on the ECA hazard indices, and the lack of evidence in the ReCAP for effects of elevated peak flows in the channel, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows.

7.3 Sediment Source Survey

The results of the SSS are summarized in Tables 1-3 (roads) and Table 2 (landslides), Table 3(summary of streambank sediment sources), and Map 5 Sediment Source summary map for Ferry Creek.

High Work Priority Sites

There are several high work priority road alignments. One is on FE4, Sec. 2 (Map 5). The road crosses an ephemeral creek in a steep gully and has sloughing cutslopes, and water directed across the road onto fillslopes supported by organic material (Photos 7-9). There is judged to be a high risk here, and upgrading of road drainage and some pullback is recommended. Little sediment has been transported to the main channel to date from the existing fillslope failure.

FE6 is newly constructed road, also crossing an ephemeral creek with steep gully sidewalls underlain by till and glaciofluvial silt and sand. Cutslope sloughing has infilled the ditch and water is directed onto large fillslopes in which tension cracks are evident (Photos 15,16). There is a high risk, and upgrading drainage and possibly some pullback is recommended. This has not been a significant downslope sediment source to date.

The Upper Ferry Creek residual is paralleled by the Ferry Creek FSR for about 13 km. At 8 locations, totaling about 200 metres in channel length, the creek is or recently has been eroding the road fill or the underlying alluvial sediment that the road is constructed on (see details in Section 7.4 below, and Table 3). Rip-rap has been installed in a few locations. Sediment from this source is deposited directly into the main Ferry Creek channel. These sites are assigned a very high risk and high work priority. An additional 7 sites along the road have fillslope failures depositing sediment onto the narrow floodplain of Upper Ferry Creek. These sites are assigned a high risk and work priority.

In the ReCAP it is estimated that about 2% of the total channel length of the Upper Ferry Creek residual (Map 6, ReCAP map), is moderately to partially disturbed. Disturbances observed may be partially the result of road erosion

Mitigation of all the high work priority sites is recommended. This will generally mean rip-rapping and possibly some drainage control.

No high risk landslides were noted except for the one on FE4, Sec.2, that is discussed above.

Moderate Work Priority Sites

There are 25 km of road judged to have a moderate risk and work priority. These areas generally have some road related surface erosion or slope stability issue, but because of the small extent of the problem, or the benchy nature of the terrain, little sediment has been transported to perennial channels to date. It was also judged that there is not a high likelihood of that happening in the future, and no further assessment was recommended.

On road FE8 there is a large earth slump resting on the road prism, blocking access (Photos 12 and 13). A particle size analysis of a near surface soil sample was carried out (Figure 5). It had 48.5 % silt and clay and over 24% clay. This is a very high percentage of fine grained material, and it can be expected that high road cuts through this kind of soil will result in similar slopes failures. These kind of large, relatively deep-seated earth slumps are difficult to remediate. Fortunately, almost no sediment is moving beyond the immediate road prism and the slide may stabilize where it is. A second road surface is located a short distance downslope and would likely prevent further sediment movement. However, if the toe of the slide is removed to gain access, further movement of the slide is likely, and it will prove difficult to keep the road open for any length of time.

If the road is to be re-opened to access CP 326-4, it is recommended that an engineered fill be constructed to limit cut slope height, or the road be relocated. The extent of these soils, or the presence of other steep slope sections which would require a high cut slope are not known for existing road FE8, or the proposed extension to access CP 326-4. An assessment by a qualified geotechnical professional is recommended to prevent further problems along this road. This slide has had no impact on any channel to date, nor is any expected in the future, if it is managed properly.

A large (>1 km) lateral-spreading type landslide (RS 52) has deferred block CP326-1 located in it. While it is probable that this is a relic feature (Evans, 1983), the area should be assessed by a qualified professional with experience in these types of slope failures before any development proceeds.

7.3.1 Recommendations for Proposed Developments

Except for streambank-road prism erosion along the Ferry Creek FSR, there is little evidence of significant sediment sources originating from forestry developments, and most of the recommendations made above address potential problems.

No further development is proposed adjacent to the mainstem. The existing streambank sediment sources should be rehabilitated, as recommended above.

The soils along the access roads to the CP 334 blocks (erodible glaciofluvial) and CP 326 (very fine-grained) are both difficult. It is EBA's judgement that roads can safely be constructed through these terrains, but better engineering will have to be applied to prevent a recurrence of the types of problems existing along these roads. Because only one additional stream crossing is proposed along both these headings, the risk is more to operational efficiency than to sediment delivery to stream channels.

7.4 Reconnaissance Channel Assessment

Detailed reach descriptions for Upper Ferry Creek are included in Appendix A3. Reach breaks and disturbance summaries are found on both the ReCAP map (Map 6) and the stream profile constructed from 1:20,000 TRIM data (Figure 6). A summary of forestry related disturbances and recommendations for further detailed assessment are outlined below. Recommendations were generally limited to identification of reaches requiring a detailed Level II CAP.

The Upper Ferry Creek residual extends from the confluence with Bonneau Creek upstream for more than 18 km to the upper plateau. Ferry Creek is wide and multi-channeled in many sections through Reaches 6 and 7 (and Reach 1 and 5 in Lower Ferry Creek) where the rarely confined channel shows a high degree of lateral mobility. It is not known whether this is naturally occurring or a result of unstable lateral migration due to forestry-related aggradation (see recommendations below). Ferry Creek becomes steeper and more entrenched throughout Reach 10 and reaches the upper plateau at the upstream end of Reach 11. Disturbances upstream of Reach 9 are rarely observed and those seen were judged to be naturally occurring.

The majority (65%) of the Upper Ferry Creek residual flows adjacent to the Ferry Creek Forest Service Road and the limited number of channel disturbances observed in the heli-overflight were often associated with this road. Several small road failures were observed where flow in the creek was undermining roadbed material. These failures account for approximately 1% (204 m) of the Upper Ferry residual being judged as moderately disturbed (AM). Several other small slides which were road-related but only partially coupled to the creek (debris deposition was in the valley bottom but not in the creek) were also observed especially in Reaches 8 and 9 and these result in approximately 1% (138 m) of the Upper Ferry residual being partially disturbed. If channel widening is assumed to be forestry-related this would result in an additional 19% (3496 m) of the residual being moderately disturbed (a total of 20%).

To address this question, a detailed CAP has been recommended for Reach 6 where evidence of forestry-related sedimentation (in particular, erosion from the adjacent road) may be more obvious than from that observed in the helicopter overflight and minimal ground stations. Reach 6 shows a large amount (62%) of the reach being judged as moderately disturbed due to road erosion and multi-channeled flows.

Severe disturbances related to forestry were not observed in any of the reaches examined in Upper Ferry Creek. Road erosion in Reaches 6, 8 and 9 is expected to continue and therefore measures will have to be undertaken to stabilize sections of the road and minimize sediment input into the creek in the future. This issue is dealt with in more detail in the Sediment Source Survey section of this report.

Riparian function in areas where road disturbances have been indicated on the map should also be examined. The majority of these are in Reach 9. The proximity of the road to the creek may be resulting in a lower delivery rate of LWD to the channel. This may be the reason why very little in stream LWD was observed downstream of Reach 9. Another reason for the lack of in stream LWD may be the multi-channeled flow observed in Ferry Creek which results in stream widths approaching 20 metres in some areas. In-stream LWD does not play such an important role in channel complexity at these widths. Harvested areas adjacent to Upper Ferry Creek were examined in air photos and in the heli-overflight and all areas showed hydrological recovery rates of 90% with riparian function being judged as high.

8.0 FERRY CREEK

8.1 Watershed Report Card

Table 4: WATERSHED REPORT CARD: FERRY CREEK (all, incl. Lower Ferry, Bonneau/Echo and Upper Ferry)

Impact Indicators	Status of Development		Hazard Index	
	Existing	Existing Plus Proposed	Existing	Proposed
Watershed area (km^2) Harvested area (km^2) Percent watershed harvested (%)	126.3 30.2 24	126.3 33.5 27		
ECA : above H60 (weighted x 1.5) below H60 Total	27.8 4.4 32.2	32.0 4.5 37.2		
ECA (% watershed area)	25	29	.42	.49
Road Density (km/km^2)	1.3	1.4	.43	.47
High sediment source: length of road (km) road density (km/km^2)	10.5 .08	11.3 .09	.4	.45
Number of landslides entering streams: Natural Forestry related	See Upper Ferry			
Potentially unstable slopes : road length (km) road density(km/km^2)	9.2 .07	10.0 .08	.23	.27
Number of stream crossings Number/ km^2	93 .74	98 .78	.84	.88
Length of stream logged to streambank	21.37	21.96	.71	.73
Length of stream with severely disturbed channel	1.8		.28	

Peak Flows (ECA): The hazard indices for both existing and proposed development are low. The ReCAP found little evidence of channel degradation due to elevated peak flows in Upper or Lower Ferry Creek. Lateral channel mobility and instability in the lower reaches of Ferry Creek are considered indications of excess sediment, relative to flows.

Sediment Delivery (road density, high sediment source, potentially unstable slopes, landslides, and stream crossings): All hazard indices, except stream crossings per km^2 are low. The hazard index for stream crossings per km^2 is very high. See Section 7.3, the SSS for Upper Ferry Creek for a discussion of sediment delivery issues from that part of the watershed.

Channel/riparian: The hazard index for length of stream logged to streambank is on the low side of high. Observations from the helicopter overflight indicate that the harvested areas in the residual portion of Ferry Creek all have hydrological recovery rates of at least 90%. This likely lowers the hazard index for Ferry Creek to moderate. However, harvested areas upslope have not been examined in the riparian assessment and therefore this conclusion has not been quantified. The hazard index for length of stream with severely disturbed channel is low as only moderate disturbances were observed in the helicopter overflight.

8.1.1 ECA Recommendations for proposed Developments

Based on the ECA hazard indices, and the lack of evidence in the ReCAP for effects of elevated peak flows in the channel, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows.

8.2 Channel Assessment

Lower Ferry Creek

Reaches 1 through 5 in Lower Ferry Creek were not examined in detail as only a brief helicopter overflight was conducted and no ground stations were visited. It is unclear whether the lateral instability observed in Reaches 1, 5, 6, and 7 is due to naturally high sediment inputs that promote channel migration across the floodplain or whether it is caused by elevated sediment inputs from the bank/road erosion in the Upper Ferry mainstem. A detailed CAP has been recommended for Reach 6, in the Upper Ferry, where conditions are similar to Reach 5 of the Lower Ferry Creek residual, to address this question. The results of that investigation can be extrapolated to Reach 5.

In Reaches 1 and 5, large woody debris jams and their associated sediment wedges were also observed but were assumed to occur naturally and therefore were not considered when making recommendations for detailed channel assessments. These debris jams are all small and flows in the creek are diverted around them. The wide, multi-channeled flow accounts for approximately 33% of the Lower Ferry Creek residual being judged as moderately disturbed. Therefore no recommendations for a detailed channel assessment have been made.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Creighton Creek

It was concluded that forestry developments to date have not resulted in any appreciable increase in sediment loading over natural background levels to channels. There has been riparian disturbance in Tributary A due to harvesting up to the stream channel and windthrow of narrow riparian reserves. There is little evidence of sediment delivery to the mainstem as a result of this disturbance. If the fish inventory identifies fish presence in Tributary A, then a detailed CAP is recommended in Reach 2 of Tributary A. The only other reach with some severely disturbed sections is on private land in Reach 1 of the residual, and a detailed CAP is recommended here.

Based on the ECA hazard indices and the low "flashiness" predicted for the watershed, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows.

An avulsion had occurred, reportedly in 1998, lower in the Creighton Creek floodplain, downstream of the study area. The available evidence does not point to forestry developments in the Upper Creighton Creek watershed being a significant factor in causing this disturbance.

Development which has any potential to impact the active slump feature (S50) and the presumably inactive bedrock based slump and lateral-spreading type slides (S41, S42, S43 and RS51) should not proceed until a detailed assessment of the potential hazards and risks associated with these features is carried out by a professional with experience in these types of slope failures. This includes proposed Riverside Cutting Permits CP317-5, 6, and 8 (S43, S50 and adjacent areas), and Tolko CP 350-5 (RS 51), and CP 350-2 and 3 (S42, S43).

9.2 Bonneau Creek

Based on the low ECA hazard indices, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows. In general, the report card and SSS indicate that if forestry road developments and harvesting proceed with practices equal to those undertaken in the past on crown land, no appreciable increase in peak flows or sediment delivery to stream channels would be expected.

The cause of debris flow/flooding, and other possible channel disruptions on private land (Reach 2 in the residual) should be investigated to rule out the possibility that upslope developments are having an impact beyond what the results of this investigation would suggest. A detailed CAP was recommended for Reach 2 of the residual.

It is recommended that the channel adjacent to trails in Reach 1 in sub-basin B (partially disturbed sections) and Reach 6 in sub-basin A (moderately disturbed sections) be examined for drainage problems as, in both areas, streamflow has been diverted onto the road for short sections. It was reported that stream enhancement works had been undertaken in 1998 in Reach 6, which may have addressed this issue in that reach.

9.3 Upper Ferry Creek

Based on the ECA hazard indices, and the lack of evidence in the ReCAP for effects of elevated peak flows in the channel, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows.

Except for streambank-road prism erosion along the Ferry Creek FSR, there is little evidence of significant sediment sources originating from forestry developments, and most of the recommendations made in Section 7.3 address potential, not past or existing problems.

No further development is proposed adjacent to the mainstem, but the road is expected to be maintained for access throughout the watershed. The existing streambank sediment sources should be rehabilitated, as recommended in Section 7.3.

It was unclear if channel widening in Reaches 1, 5, 6 and 7 were related to forestry developments. Although only moderate disturbances were observed, a detailed CAP was recommended for Reach 6 to see if the observed erosion of the Ferry Creek FSR is having a significant downstream impact. In any case, it is recommended that road sections currently being eroded be protected by rip-rap.

The channel can be expected to migrate through these reaches, and this should be monitored. New sections of road may be subject to erosion and would require mitigative measures.

9.4 Ferry Creek

As the focus of this investigation was on upstream areas, only the watershed report card was done for the whole watershed, including Upper Ferry residual, Bonneau and Echo Lake and the Lower Ferry residual. A brief helicopter overview was made of the Lower Ferry residual channel. No SSS was carried out for the Lower Ferry residual but a brief ReCAP was conducted.

Based on the ECA hazard indices, and the lack of evidence in the ReCAP for effects of elevated peak flows in the channel, the current and proposed levels of harvesting are judged to be acceptable in terms of impacts on peakflows.

The issue of the cause of channel widening in Reach 5 should be addressed in the recommended detailed CAP for Reach 6 in the Upper Ferry drainage, where conditions are similar.

Refer to the conclusions for the ReCap and SSS for Upper Ferry and Bonneau (Sections 9.2 and 9.3) for a discussion of impacts on the main tributaries.

10.0 CLOSURE

EBA trusts that this report satisfies your present requirements. Should you have any questions or comments, please contact our office at your convenience.

Yours sincerely,

EBA ENGINEERING CONSULTANTS LTD.

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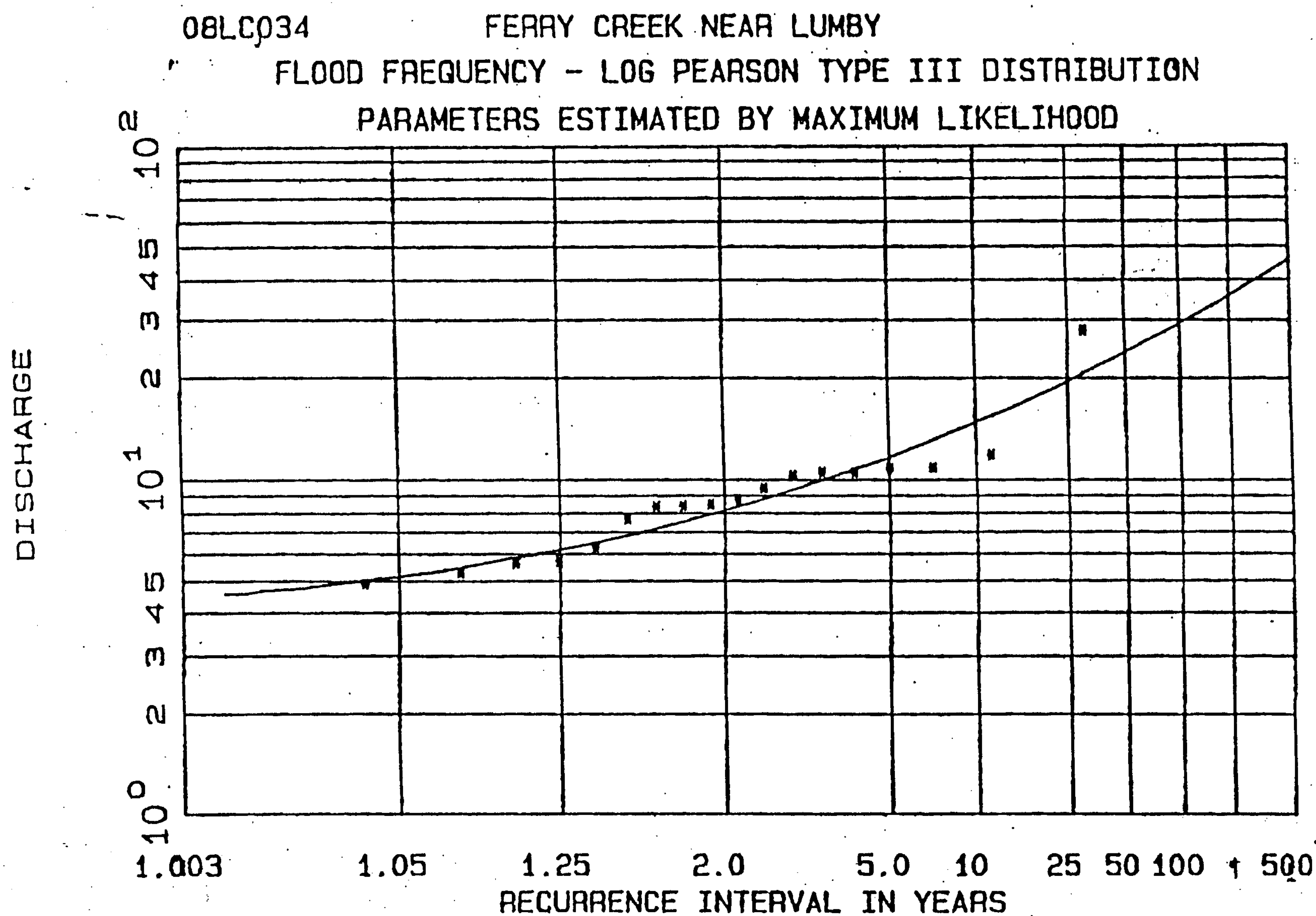
FIGURE 2



08LC034
FERRY CREEK NEAR LUMBY
FLOOD FREQUENCY - LOG PEARSON TYPE III DISTRIBUTION
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD
DISCHARGE
10^2
5
4
3
2
10^1
5
4
3
2
10^0
1.003
1.05
1.25
2.0
5.0
10
25
50
100
500
RECURRENCE INTERVAL IN YEARS

Figure 3. Upper Creighton Creek Stream Profile (TRIM)

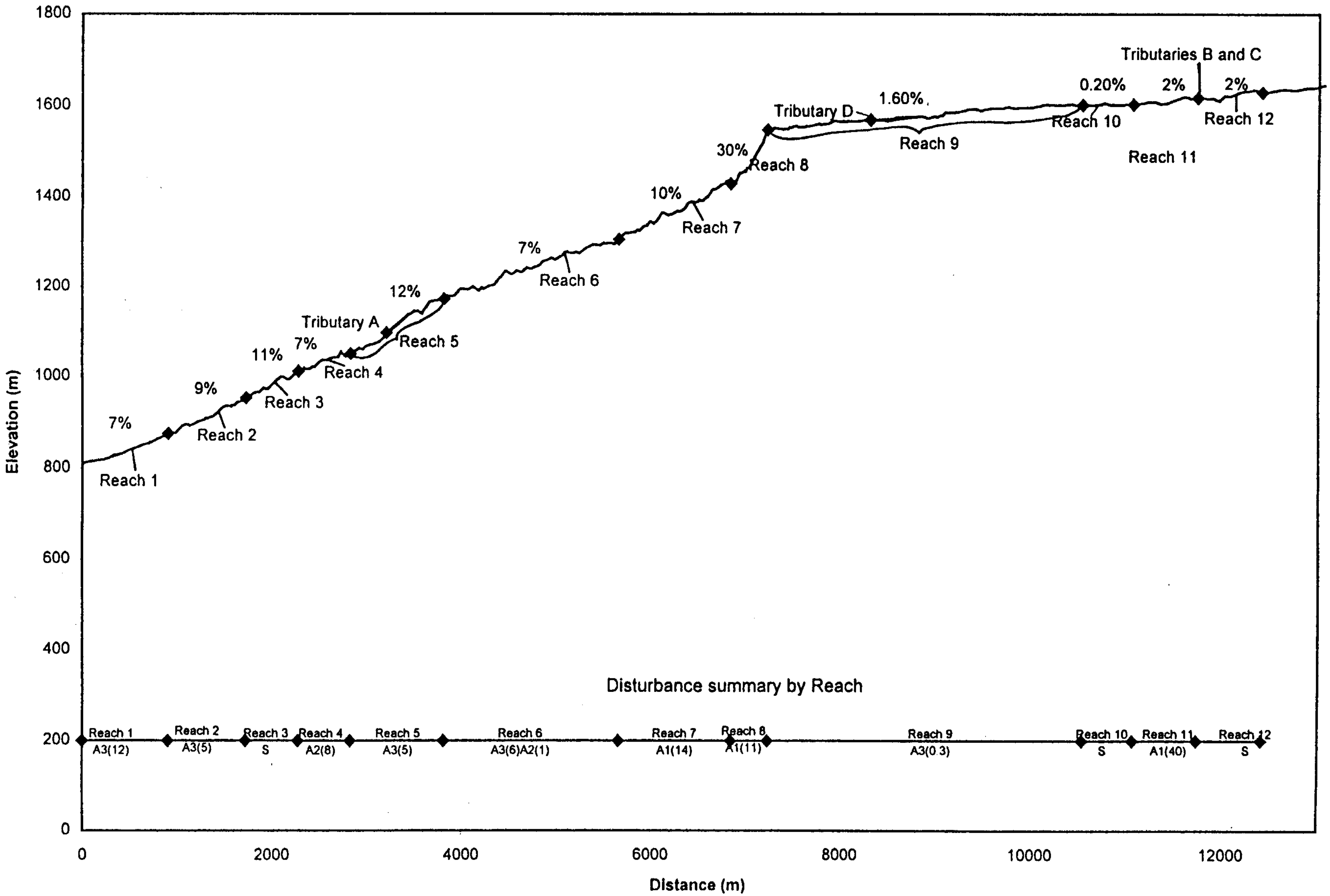
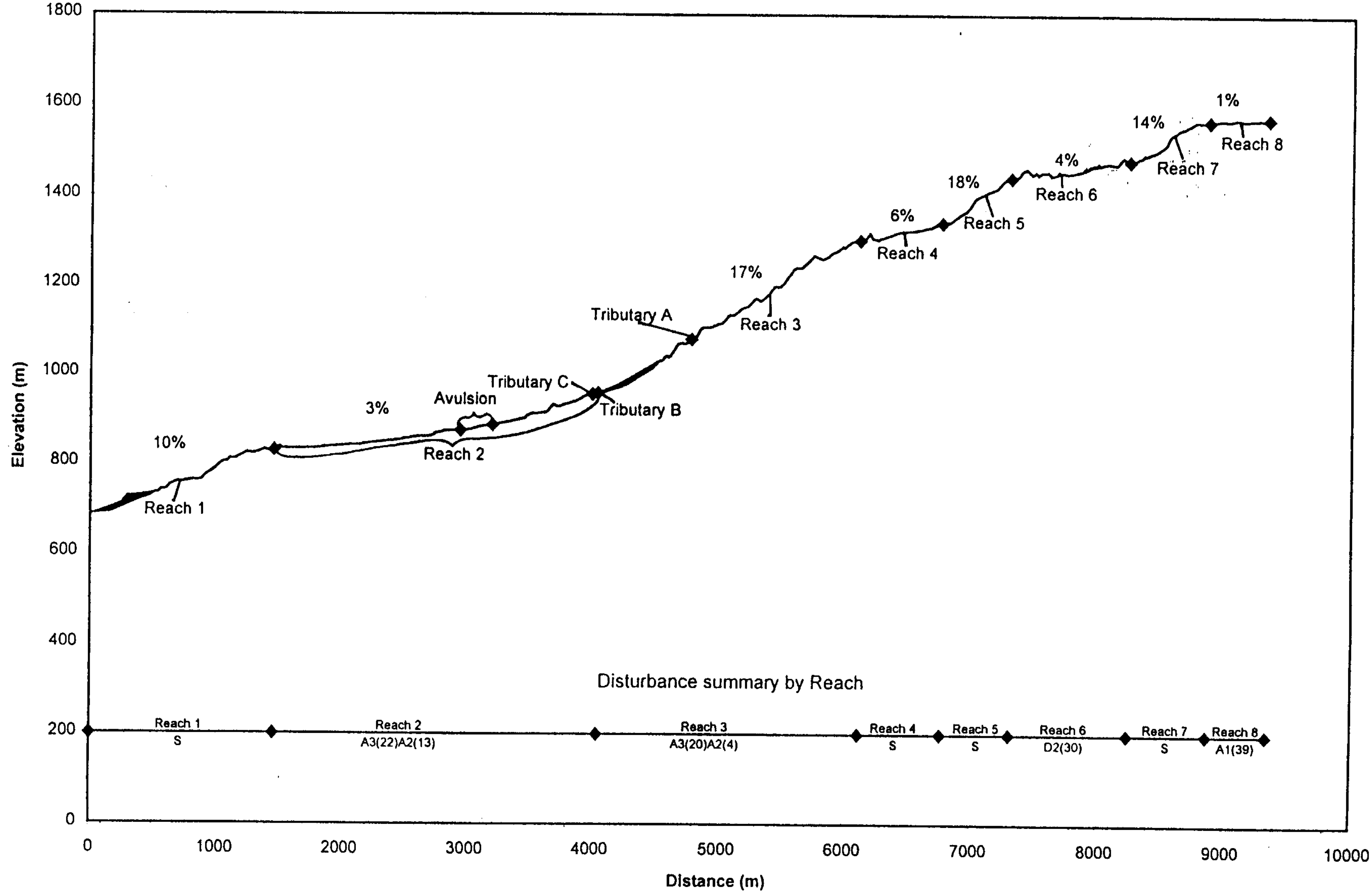
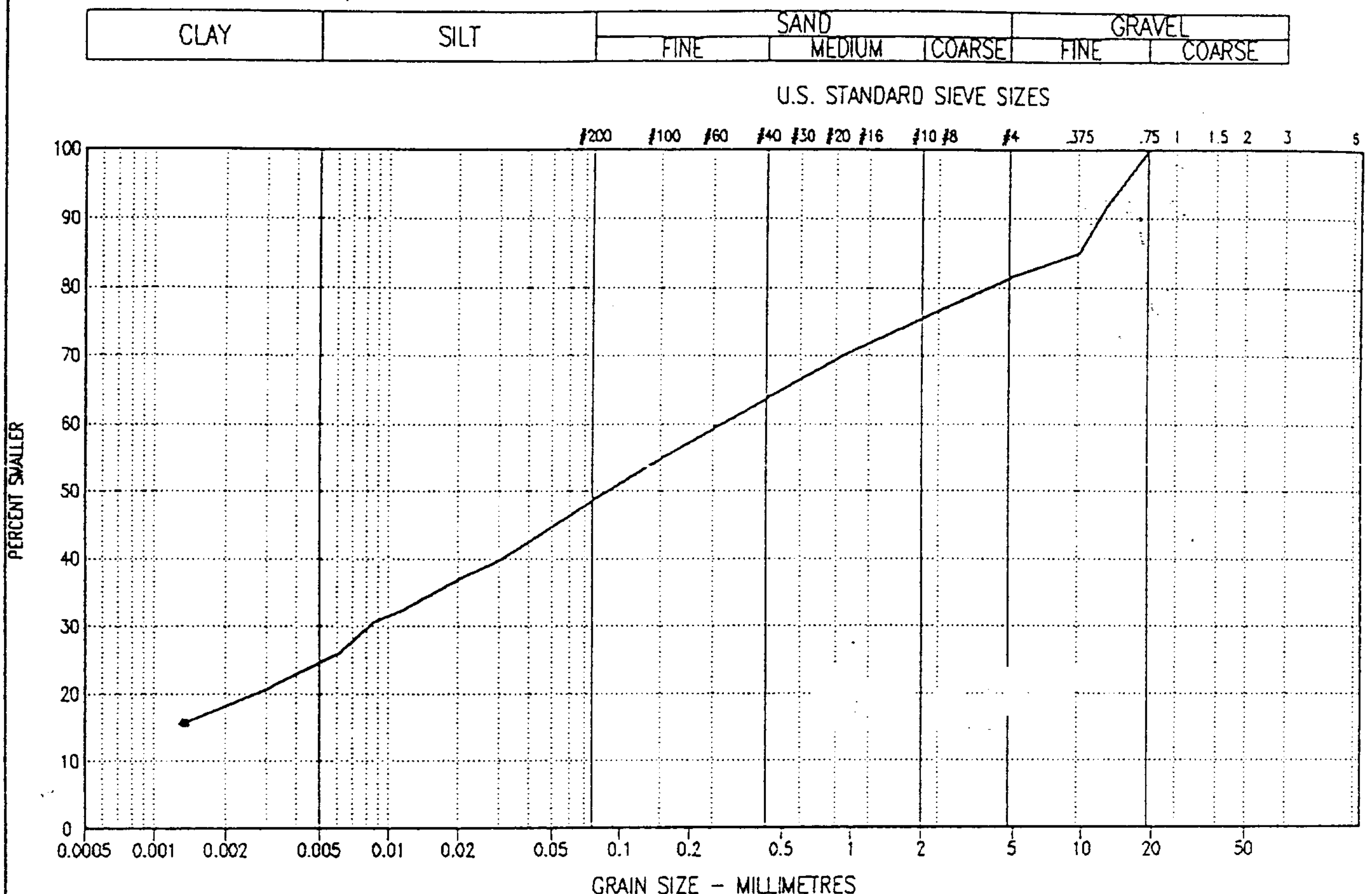


Figure 4. Bonneau Creek Stream Profile (TRIM)



PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (ft)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
•—•	280-2 Ferry Creek Road FE8 TP23	0.00	24.2	24.3	32.7	18.8	–	–	

Project: 0808-98-90981 Date Tested: 98/11/17 BY: RS

Tested in accordance with ASTM D422 unless otherwise noted.

Figure 6. Ferry Creek Stream Profile (TRIM)

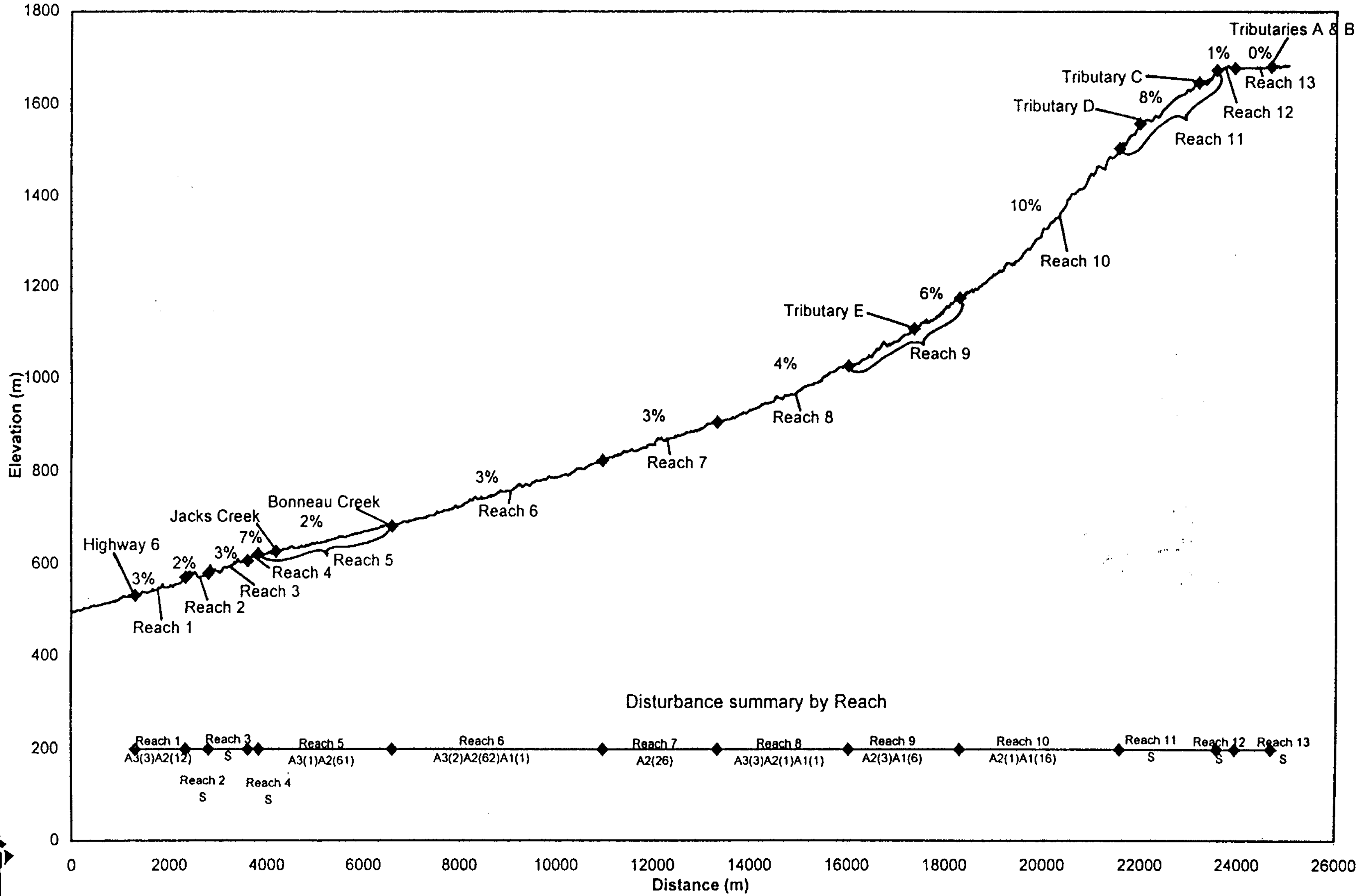


Photo 1. Upper Creighton Creek, Southern Upland Plateau.

Photo 2. Upper Creighton Creek, Southern Upland Plateau. Typical road/stream crossing.

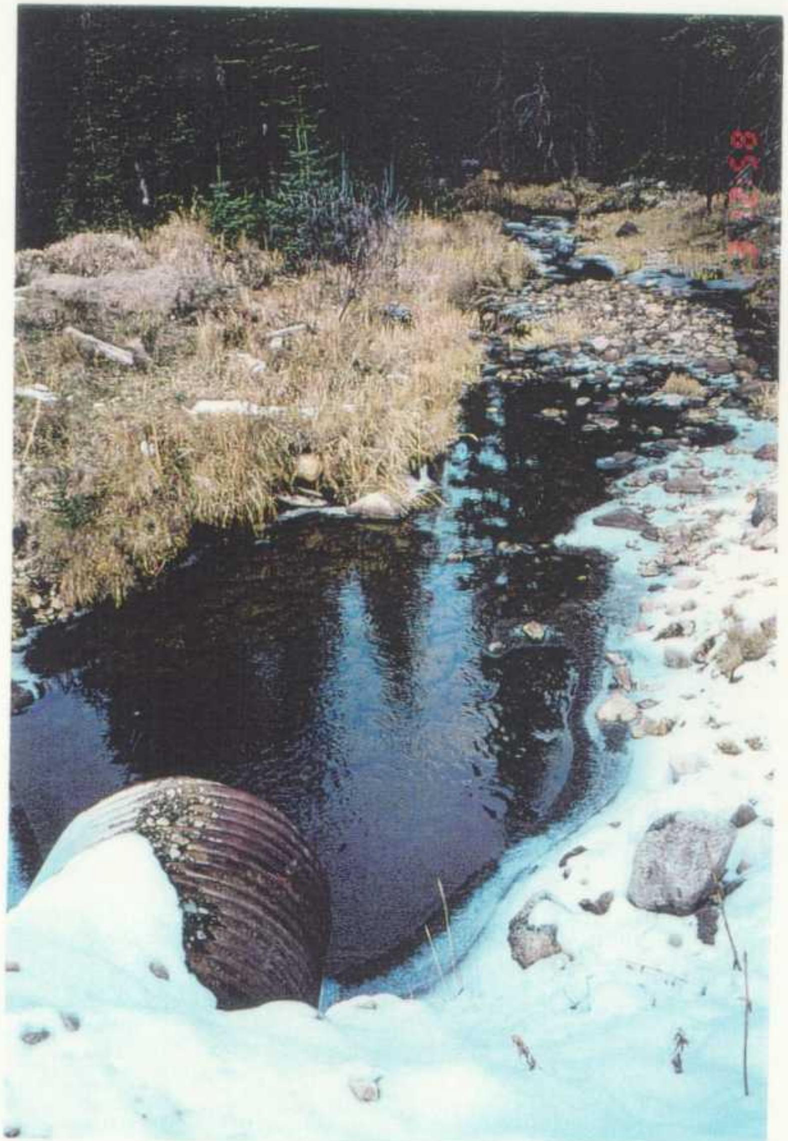


Photo 4. Upper Creighton Creek, West Tributary. Typical gentle to moderately sloping terrain. Main channel of Tributary A in foreground.

Photo 3. Upper Creighton Creek, Southern Upland Plateau. Typical stream reach.

Photo 5. Upper Creighton Creek, West Tributary. Typical creek/road crossing. Low slope and stream gradients.

Photo 6. Upper Ferry Creek, Road FE4, Section 1. Semi-permanent deactivation. Frequent water bars.

Photo 7. FE4, Section 2. Sloughed cutslope. No functioning ditch. Blocked culverts intakes.

Photo 8. FE4. Fillslope supported by organics and trees, on 80% sideslopes of gully connected to Reach 7 of Ferry Creek (see Photo 9).

Photo 9. FE4. Failed fillslope into a gully connected to Reach 7 of Ferry Creek. Near TP11.

Photo 10. FE7, TP12. No culvert at gully crossing. Water and sediment crossing the road. Potential for failure below the road (see Photo 11).

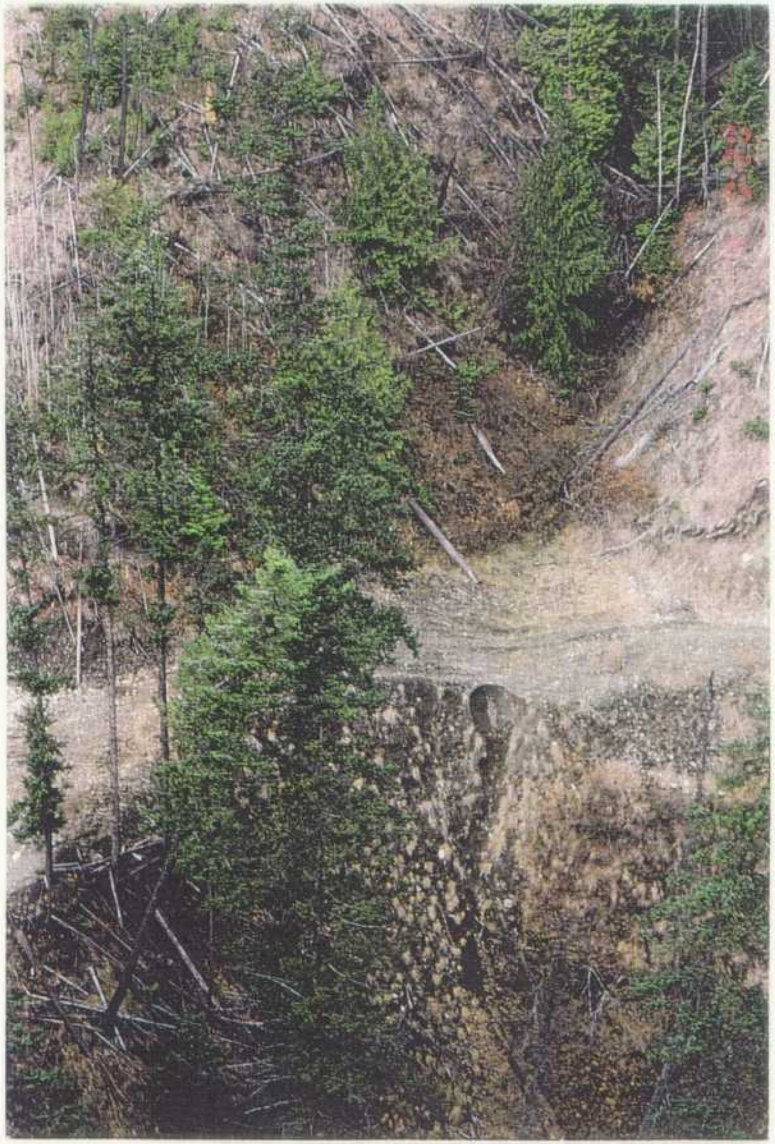


Photo 12. FE8, TP23. Large slump in fine grained soils. No sediment transfer below lower road. Road is blocked by the toe of the slide.

Photo 11. FE7, TP13. No culvert at gully crossing. Water across road initiating fillslope failure.

Photo 13. FE8, TP23. Back scarp of large earth slump (see Photo 12).

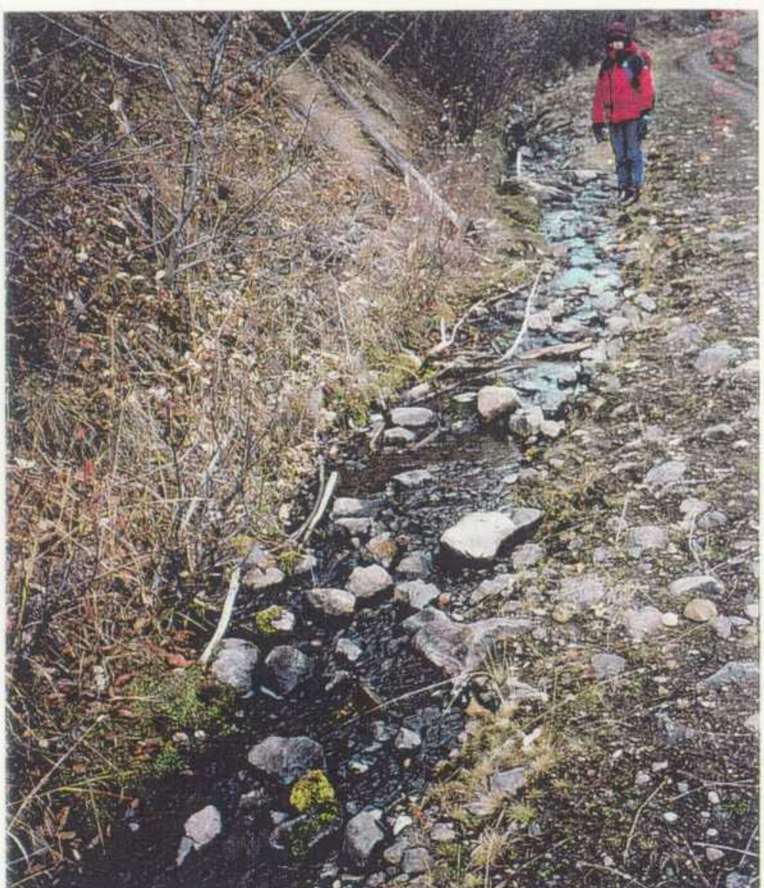


Photo 14. BS, TP14. Creek flow diverted down ditchline. Run-out on flat bench.

Photo 15. FE6, TP48. Sloughing cutslope, no functioning ditch. Low road grade crossing gully sidewalls. Water draining to fillslope – see Photo 16.

Photo 16. FE6, TP48. Long tension crack in large fill leading into ephemeral gully.

Photo 17. BN9. Road alignments on moderately steep (30 to 50%) slopes. Little sediment movement to perennial streams.

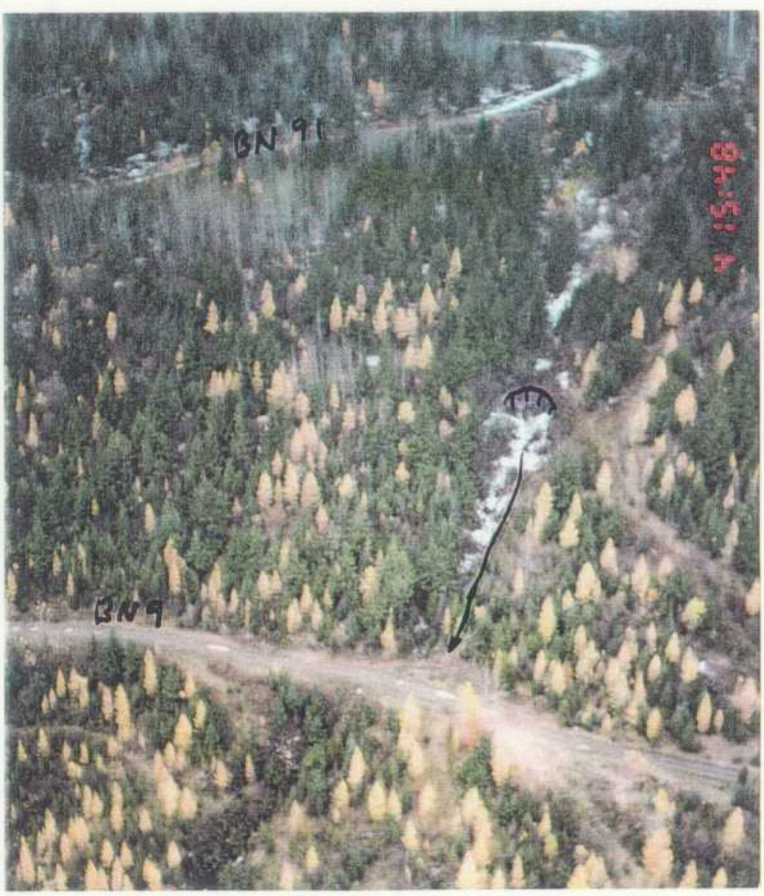


Photo 18. BN9. Old midslope failure from skid trail drainage? Appears greened-up with little current sediment movement (see Photo 19).

Photo 21. S43, Columnar Tertiary basalt in mid-Creighton Creek watershed.

Photo 22. S43, basalt scarp and talus slopes. Harvesting proposed just below foot of exposed talus.

Photo 23. S50. Earth slump ~170m wide, adjacent to Creighton Creek.

Photo 24. RS 52. Creighton Creek. Possible very large relic lateral spreading slide in Tertiary Volcanics.

Table 1-1. Road Risks and Work Priorities: Upper Creighton Creek

Road or Area Name	Section	Length (km)	Photo	Road Condition	Hazard: Landslide	Hazard: Surface Erosion	Consequence	Risk[1]	Work Priority	Detailed Assess.	Comments
Flat upland plateau: southern portion of watershed including subasins B,C,D and residual areas.		11.0	1,2,3	Terrain flat to gently sloping with low channel gradients. Road gradients generally <5%.	L	L	L	L	L		
West tributary, subasin A and residual areas on west side of Creighton Creek		26.0	3,4	Terrain gentle to moderate sloping with low channel gradients. Slope morphology terraced to benchy, with moderate sloping scarps and flat to gentle benches. Road gradients generally <10%. Some cutslope sloughing. Little or no surface erosion on road sfc or ditches.	L	L	L	L	L		Clean ditches to remove sloughed material.
Bonneau Lake FSR (BLFSR)	1	1.0		Road on 75% slope in erodible galciofluvial sand and gravel Fillslope failures at Slide 1 High fillslopes supported by trees, organic. Slide 1A, just upgrade of partially blocked culvert. Rill erosion in ditch >3 cm deep. Slide 3, off end of switchback originating in fill, transport in erodible glaciofluvial material. Cutslope slough blcoking ditch 25m upgrade. TP 38. Partially blocked and crushed culvert. Hillslope 45%. Could concentrate flow downgrade towards switchback at Slide 3.	H	M	H	VH	H	Yes	Road maintenance and upgrade required. Drainage improvement, clean ditshes, repair culverts, pullback of fillslope.
Bonneau Lake FSR (outside watershed))	2	0.5		No culvert for 375m upgrade of switchback. Rill erosion 20cm deep by 100cm wide, on 15% road grade. Slope below switchback 50%.	L	H	M	H	H	Yes	Correct drainage. Install culverts, waterbars.
Bonneau Lake FSR	3	6.3		Long continuous descending 10 to 15% grade across 20 to 30% slopes.	L	M	L	L	L		Check drainage structures, ditches, culverts.

1. Risk is the product of the consequence value and the highest hazard value.

Table 1-2. Road Risks and Work Priorities: Bonneau Creek

Road or Area Name	Section	Length (km)	Photo	Road Condition	Hazard		Consequence	Risk[1]	Work Priority	Detailed Assess	Comments
					Landslide	Surface Erosion					
Private Land		5.5		Not traversed. Road crosses primarily agricultural land, with channel disturbance due to land cultivation and road building. Large recent avulsion debris flood/flow) from Bonneau mainstem at southern extent of priveate lands, probably due poor drainage, erosion or road paralleling creek.	H?	H?	?	?	H?		See Channel Assessment: Investigate channel, roads, agriculture development.
Bonneau North (BN) Main from west end of watershed to junction with BN 9 and BN9 and Spurs BN91 and BN 92.		10.0	17 18,19 20	Road contours on 30 to 50% sideslopes, underlain by erodible silt, sand and gravel, glaciofluvial to ablation till deposits. Many low consequence problems - sloughing cut and fill slopes(TP26, 29, 33), poor ditchblock (TP28) but benchy terrain prevents sediment transport. High backround sediment delivery from erodible gully sidewalls (TP 27) and bank erosion (S20, 21) of Bonneau mainstem. TP 33: Crossing of old small debris flow by BN 92, originating upslope of BN 9. Currently little sediment movement below road prism. TP32: 2 drainage trenches through erodible landing. Benchy terrain below. Low likelihood of sediment movement to channels. Trenches may erode with high flows of freshet.	L L L	M M M	M M M	M M M	M M M		Check drainage from skid trail in block, culvert operation on crossings of BN9 and BN92. Monitor for erosion. Armour or relocate culverts to sides of landing if neccessary.
BN Main and upland rolling plateau above 1400m: BN6, BNA, BNA1, BNA2 , BS9		12.0		Gently sloping, rolling to benchy terrain, limits sediment transport over any distance. Several abandoned meltwater channels. No crossings of perrenial channels.	L	L	L	L	L		

1. Risk is the product of the consequence value and the highest hazard value.

Table 1-3 Road Risks and Work Priorities: Upper Ferry Creek

Road or Area Name	Section	Length (km)	Photo	Road Condition	Hazard		Conse-quence	Risk[1]	Work Priority	Detailed Assess	Comments
					Landslide	Surface Erosion					
HE 23, HE23B		4.0		Not field assessed. On gentle sloping to rolling upland plateau. Some sections adjacent to steep gully headwalls. Diversion of water possible onto steeper downslope areas.	M	L	L	L	L		Assess for possible drainage diversion into downslope gullies.
FE 4	1	3.4	6	Semi-permanent deactivation. Frequent water bars	L	L	L	L	L		
FE 4	2	4.2	7,8,9	At southern end: 70 to 90 % sideslopes to ephemeral gullies. Sloughing cutslopes filling ditches and blocking culverts. No culverts or cross ditches at swales. Large fillslopes supported by organics. Fillslope failure into ephemeral gully connected to Reach 7, Ferry Creek.	H	M	M	H	H	Yes	Upgrade drainage structures. Some pullback.
HE 4		4.5		Not field assessed. On gentle sloping to rolling upland plateau. Some sections adjacent to steep gully headwalls. Diversion of water possible onto steeper downslope areas, into gullies.	M	L	M	M	M		Check for possible drainage diversion into downslope gullies.
FE 6		1.5		Recent road construction: crossing of steep gully sidewalls, gully channel gradient 35 to 40%, ephemeral flow. High road cut in till overlying interbedded glaciofluvial silt and sand. Cutslope sloughing to fill ditch. No drainage functioning on road. Saturation, tension cracks on large fill slope. Landslide and surface erosion potential.	H	H	M	H	H	Yes	Restore drainage in ditchline with "french drain" to prevent fill saturation. Remove excess fill if signs of instability continue.
FE 7		2.5	10,11	North End: TP 12,13. Gully crossings with no culverts. Potential and existing small slope failures. Currently sediment transport for a short distance in gullies at present, no sediment transport to Ferry Creek. South End: Near junction with Ferry FSR. Small fillslope failures (S48), potentially to creek. Some x-ditches on at start of road.	M M	M M	M M	M M	M M		Upgrade drainage structures. Armoured cross-ditches. Check that cross-ditches have corrected drainage problems originally causing fillslope failures.
FE 8		3.5	12,13	Large earth slump caused by road undercutting toe of slope in very fine grained soils - 24% clay, 24% silt (See grain size analysis, Figure 5). Slopes adjacent to slide 75%, 35% above slide. Road blocked, but no sediment transport below road prism.	H	L	L	M	M	Yes	The risk of sediment delivery to any channel is low from this slide. However, this section of road is planned to be used to access future development (CP326-4). Removing the toe of the slide to gain access will only reactivate slide movement. Either relocation of the road or an engineered fill is recommended through this section. See Section 7.3 of report. Assess entire road section for possible similar potential failures.

1. Risk is the product of the consequence value and the highest hazard value.

Table 1-3 cont. Road Risks and Work Priorities: Upper Ferry Creek

Road or Area Name	Section	Length (km)	Photo	Road Condition	Hazard: Landslide	Hazard: Surface Erosion	Consequence	Risk[1]	Work Priority	Detailed Assess	Comments
Bonneau South (BS) System: BS Main, and Spurs BS 3,4, 8, and 9. BNC and BNC1. West side of Ferry Creek, between 1300 and 1600m elevation.		14.5	14 15 16	Gently sloping, rolling to benchy terrain, limits sediment transport over any distance. Localized problems noted below. TP 14: Large planned diversion of water by self-armoured ditch down 10% gradient road. Flow disperses on flat bench downslope. TP 19: Creek crosses road. No drainage structure. Fine grained materials and gentle, benched slopes limit sediment transport potential. TP 22: Road crosses gully. Poorly armoured cross ditch.	L	H	L	**M**	**M**	**Yes**	Upgrade creek crossings, crossditch, armour. Currently little sediment delivery to main channels.
Southern Upland Plateau. Above 1600m elevation.		29.0		Hillslope gradients generally flat to <5%. Low channel gradients.	L	L	L	**L**	**L**		
Ferry Creek FSR (FCFSR): From Creighton Valley road junction to bridge at TP 50. Includes CAP reaches 6 and 7.	1	6.6		Road parallel and close to Ferry Creek mainstem. In 4 locations totaling 175m creek eroding road prism and underlying alluvial sediment with sediment delivery directly into creek. Some armouring in place. Earth slump in fine-grained glaciolacustrine material. Sediment in ditch. Slide being drained?	L	H	H	**VH**	**H**	**Yes**	Address road prism erosion; rip-rap with large enough material to withstand peak flows.
					L	L	L	**L**	**L**	**No**	
				Road parallel and close to Ferry Creek mainstem. Over 97 % of road length no sediment delivery issues to creek or floodplain. Localized problems outlined below.	L	H	H	**VH**	**H**	**Yes**	Address road prism erosion; rip-rap with large enough material to withstand peak flows.
				In 3 short (10-20m) locations totaling creek eroding road prism and underlying alluvial sediment with sediment delivery directly into creek.							
				In 7 short (~10m) locations slumps in road fill depositing sediment onto floodplain. In one location (S326) about 80m long section of road fill failing onto floodplain.	L	H	M	**H**	**H**	**Yes**	
				At S33, a plugged culvert has resulted in severe road erosion from high flows. Self-armoured. Gravel deposited in floodplain and creek. Possibly small debris flow.	M?	H	H	**VH**	**H**	**Yes**	Replace with larger culvert. Check road BS upslope not diverting flows into this gully.
FCFSR: Crossing at TP 50 to end. Includes CAP reaches 8 and 9.	2	6.5		At TP40, low berm at bridge abutment and sharp bend in creek makes an avulsion from the creek onto road possible at high flows. A small avulsion has occurred.	L	M	H	**H**	**H**	**Yes**	Rebuild berm on north side of road with large angular boulders.

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Table 2. Landslides and Surface Erosion Sources

This table lists landslides that have some chance of impacting either an ephemeral or perennial channel.
It does not list the bank and road prism erosion sources that are adjacent to main stems.
Those sources are described in the Channel Assessment Procedure, shown on the Sediment Source Survey map, and discussed in the report.

	Number	Description	Photo	Natural (N) Forestry (F)	Hazard	Conse-quence	Risk	Detailed Assess.	Comments
Creighton Creek Watershed									
S	1	Debris slide		F, road	H	L	M		
S	1A	Debris slide, road drainage, fillslope		F, road	H	H	VH	**Yes**	Possible failure to creek.
S	3	Debris slide, road drainage		F, road	H	H	VH	**Yes**	
S	41, 42	Relic slump, rockfall, possibly in sedimentry rocks.		N	?	H	**H?**	**Yes** (see text)	Assess by qualified professional with experience in deep-seated landslides before developing proposed CP350.
S	43	Rockfall (talus) from columnar Terriary basalt.	21,22	N	?	H	**H?**	**Yes** (see text)	Assess by qualified professional with experience in deep-seated landslides before developing proposed CP317-5,6,8.
S	50	Earth slump on north side of Creighton mainstem	23	N	H	H	VH	**Yes**	Assess by qualified professional with experience in deep-seated landslides before developing uplsope areas.
RS	51	Possible Relic ,very large rock slump in Tertiary volcanics.	24	N	?	?	?	**YES** (see text)	Assess by qualified professional with experience in deep-seated landslides before developing CP 325-1 and 350-5.
Upper Ferry Creek Watershed									
S	44	Small earth slump in glaciolacustrine?, above Ferry FSR		F?	H	L	**M**		Slide being drained to stabilize.

1. Risk is the product of the consequence value and the highest hazard value.

Table 2. Landslides and Surface Erosion Sources

	Number	Description	Photo	Natural (N) Forestry (F)	Hazard	Conse-quence	Risk	Detailed Assess.	Comments
S	45	FE4, Sec2. Failed fill slope into ephemeral gully	9	F, road	H	M	**H?**	**Yes** (see text)	Assess south end of FE4, Sec2 for similar potential problems, stabilize fills (drainage control and/or pullback), grass-seed or bioengineer to prevent erosion.
S	46	Small fillslope failures from landing, end of FE42		F, road	M?	M	**M**		Not field assessed, road deactivated. Check that drainage corrected, fill slope stabilized
S	47	Large earth slump. FE8.	12,13	F, road	H	L	**M**	**Yes** (see text)	See Comments in Road RiskTable 2-2, Road FE8.
S	48	Small fillslope failures from FE7		F, road	L	H?	**M**		Problem addressed by x-ditching to correct drainage.
RS	52	Relic ,very large rock slump in Tertiary volcanics.		N	?	?	**?**	(see text)	Deffered block 326-1 in middle of mapped (Golders, 1998) relic slide. Assess before development proceeds.
	Bonneau Creek Watershed								
S	49	Debris flow/avulsion		Private Land, Road	H?	M/	**H?**	**Yes**	Not investigated in field. Overbank sediment deposits observed. Downstream Bonneau Creek crosses flat terrace nd may be subsurface in agricultural land , limiting any sediment movement.
S	53	TP 33: Crossing of old small debris flow by BN 92, originating upslope of BN 9. Currently little sediment movement below road prism.		F, skid trail ?	L	M/	**M**		Check drainage from skid trail in block, culvert operation on crossings of BN9 and BN92.

1. Risk is the product of the consequence value and the highest hazard value.

TABLE 3. Summary of Streambank Sediment Sources

Possible sediment source	Watershed/Reach Number	Stream Coupling	Type of sediment source	Cause
1	Upper Creighton/1	Uncoupled	Surficial	Road
2	Upper Creighton/1	Coupled	Surficial	Road
3	Upper Creighton/1	Coupled	Surficial	Road
4	Upper Creighton/2	Coupled	Surficial	Natural
5	Upper Creighton/2	Coupled	Surficial	Natural
6	Upper Creighton/3	Coupled	Talus	Natural
7	Upper Creighton/3	Coupled	Talus	Natural
8	Upper Creighton/3	coupled	Talus	Natural
9	Upper Creighton/4	Coupled	Surficial	Natural
10	Upper Creighton/5	Coupled	Talus and blocks	Natural
11	Upper Creighton/5	Coupled	Talus and blocks	Natural
12	Upper Creighton/5	Coupled	Talus and blocks	Natural
13	Upper Creighton/5	Coupled	Talus and blocks	Natural
14	Upper Creighton/6	Coupled	Surficial	Natural
15	Upper Creighton/7	Coupled	Talus and blocks	Natural
16	Upper Creighton/7	Coupled	Talus and blocks	Natural
17	Upper Creighton/8	Coupled	Blocks and talus	Natural
18	Upper Creighton/8	Coupled	Blocks and talus	Natural
19	Upper Creighton/8	Coupled	Blocks and talus	Natural
20	Bonneau/3	Coupled	Surficial	Natural?
21	Bonneau/3	Coupled	Surficial	Natural?
22	Ferry/6	Coupled	Alluvial or roadbed	Road
23	Ferry/6	Coupled	Alluvial or roadbed	Road
24	Ferry/6	Coupled	Alluvial or roadbed	Road
25	Ferry/6	Coupled	Alluvial or roadbed	Road
26	Ferry/8	Coupled	Surficial	Forestry
27	Ferry/8	Partially coupled	Alluvial or roadbed	Road
28	Ferry/8	Partially coupled	Alluvial or roadbed	Road
29	Ferry/8	Coupled	Alluvial	Natural
30	Ferry/9	Partially coupled	Surficial	Road/forestry
31	Ferry/9	Partially coupled	Surficial	Road/forestry
32	Ferry/9	Partially coupled	Suficial	Road/forestry
33	Ferry/9	Coupled	Surficial	Road/forestry
34	Ferry/9	Partially coupled	Surficial	Road/foresty
35	Ferry/9	Coupled	Surficial	Road
36	Ferry/9	Partially coupled	Alluvial or roadbed	Road
37	Ferry/10	Coupled	Talus and blocks	Natural
38	Ferry/10	Coupled	Surficial	Natural
39	Ferry/10	Coupled	Surficial	Natural
40	Ferry/10	Coupled	Surficial	Natural

CAP Form 1a: Classifying Channel Reaches for Upper Creighton Creek

WATERSHED CODE (45-digit)	SUB-BASIN	REACH NUMBER	UTM ZONE	NORTHING (OF BEGINNING OF REACH)	EASTING (OF BEGINNING OF REACH)	REACH LENGTH (m)	DRAINAGE NETWORK CLASS	IS CAP RECOMMENDED?
128-8355-541-518-000-000-000-000-000-000-000-000	Creighton Creek Residual	1	11	5563592	373491	905	CA1ii	Yes
		2	11	5562833	373785	816	CA2ii	No
		3	11	5562111	373930	553	CB2bii	No
		4	11	5561636	374044	553	CA1ii	No
		5	11	5561138	373909	984	CB2bii	No
		6	11	5560425	374083	1847	CA1ii	No
		7	11	5558868	374918	1185	CA2ii	No
		8	11	5557894	375274	391	CB3bii	No
		9	11	5557350	375546	3312	CA1ii	No
		10	11	5555539	374386	526	CA1i	No
		11	11	5555194	374336	674	CA1ii	No
	Sub-basin C	12	11	5554671	373985	668	CA1ii	No
	Sub-basin A	1	11	5560792	373802	263	CB3bii	No
		2	11	5560733	373586	1261	CA1ii	Yes
		3	11	5560775	372509	548	CA1i	No
		4	11	5560797	371866	425	CA2i	No
		5	11	5560816	371568	369	CA1i	No

CAP Form 1b: Classifying Channel Reaches for Bonneau Creek

WATERSHED CODE (45-digit)	SUB-BASIN	REACH NUMBER	UTM ZONE	NORTHING (OF BEGINNING OF REACH)	EASTING (OF BEGINNING OF REACH)	REACH LENGTH (m)	DRAINAGE NETWORK CLASS	IS CAP RECOMMENDED?
128-8355-611-238-000-000-000-000-000-000-000-000	Bonneau Creek residual	1	11	5562674	381563	1455	CA2ii	No
		2	11	5562237	380403	2587	CA1ii	Yes
	Sub-basin A	3	11	5560011	379330	2066	CA2ii	No
		4	11	5559280	377629	656	CA1ii	No
		5	11	5559077	377051	545	CA2i	No
		6	11	5558719	377020	936	CA1i	No
		7	11	5558040	376291	625	CA2ii	No
		8	11	5557516	376094	472	CA1ii	No
	Sub-basin B	1	11	5560011	379330	490	CA2ii	No
		2	11	5559610	379068	272	CA3i	No

CAP Form 1c: Classifying Channel Reaches for Ferry Creek

WATERSHED CODE (45-digit)	SUB-BASIN	REACH NUMBER	UTM ZONE	NORTHING (OF BEGINNING OF REACH)	EASTING (OF BEGINNING OF REACH)	REACH LENGTH (m)	DRAINAGE NETWORK CLASS	IS CAP RECOMMENDED?
128-8355-611-000-000-000-000-000-000-000-000-000	Lower Ferry Creek Residual	1	11	5567028	382451	1306	CA1ii	No
		2	11	5566093	381955	463	CB1bii	No
		3	11	5564848	381783	807	CA1ii	No
		4	11	5565337	381446	225	CB1bii	No
		5	11	5565169	381569	2760	CA1ii	No
	Upper Ferry Creek Residual	6	11	5562698	381555	4379	CA1ii	Yes
		7	11	5558883	382731	2362	CA1ii	No
		8	11	5556848	381612	2685	CA1ii	No
		9	11	5554722	380242	2289	CA1ii	No
		10	11	5553055	378843	3281	CA2ii	No
		11	11	5550655	377159	2001	CA2ii	No
		12	11	5549168	376472	363	CA1ii	No
		13	11	5548961	376260	731	CA1i	No

CAP Form 2a: General Assessment of Channel Morphology for Upper Creighton Creek

	Length of Mainstem Channel				
SUB-BASIN	(a) TOTAL	(b) DOWNSTREAM OF LOGGING	(c) TOTAL b WITH NON-ERODABLE CHANNELS	(d) LENGTH OF b WITH ERODABLE AND VISIBLE CHANNELS	(e) LENGTH OF d WITH ALTERED CHANNEL MORPHOLOGY
Sub-basin A	2866	2866	263	0	0
Sub-basin C	668	668	0	0	0
Upper Creighton Residual	11746	11746	1928	0	0
Total Watershed	15280.00	15280.00	2191.00	0.00	0.00

Prepared by EBA Engineering Consultants

CAP Form 2b: General Assessment of Channel Morphology for Bonneau Creek

	Length of Mainstem Channel				
SUB-BASIN	(a) TOTAL	(b) DOWNSTREAM OF LOGGING	(c) TOTAL b WITH NON-ERODABLE CHANNELS	(d) LENGTH OF b WITH ERODABLE AND VISIBLE CHANNELS	(e) LENGTH OF d WITH ALTERED CHANNEL MORPHOLOGY
Sub-basin A	4566	4094	0	0	0
Sub-basin B	762	490	0	0	0
Bonneau Creek residual	4776	4776	0	0	0
Total Watershed	10104.00	9360.00	0.00	0.00	0.00

Prepared by EBA Engineering Consultants

CAP Form 2c: General Assessment of Channel Morphology for Ferry Creek

	Length of Mainstem Channel				
SUB-BASIN	(a) TOTAL	(b) DOWNSTREAM OF LOGGING	(c) TOTAL b WITH NON-ERODABLE CHANNELS	(d) LENGTH OF b WITH ERODABLE AND VISIBLE CHANNELS	(e) LENGTH OF d WITH ALTERED CHANNEL MORPHOLOGY
Upper Ferry Creek Residual	18091	18091	0	0	0
Lower Ferry Creek Residual	5561	5561	688	0	0
Total Watershed	23652.00	23652.00	688.00	0.00	0.00

CAP Form 3a: General Assessment of Channel Impact Values Upper Creighton Creek

	Channel Impact			
	Observed		***Potential***	
SUB-BASIN	**OBSERVED CHANGES (e/a)**	**OBSERVED CIV**	**POTENTIAL CHANGES [(b-c) - (d-e)] / a**	**POTENTIAL CIV**
Sub-basin A	0.000	Low	0.908	High
Sub-basin C	0.000	Low	1.000	High
Upper Creighton Residual	0.000	Low	0.836	High
Total Watershed	0.000	Low	0.857	High

CAP Form 3b: General Assessment of Channel Impact Values for Bonneau Creek

	Channel Impact			
	Observed		Potential	
SUB-BASIN	OBSERVED CHANGES (e/a)	OBSERVED CIV	POTENTIAL CHANGES [(b-c) - (d-e)] / a	POTENTIAL CIV
Sub-basin A	0.000	Low	0.900	High
Sub-basin B	0.000	Low	0.640	High
Bonneau Creek Residual	0.000	Low	1.000	High
Total Watershed	0.000	Low	0.926	High

Prepared by EBA Engineering Consultants

CAP Form 3c: General Assessment of Channel Impact Values for Ferry Creek

	Channel Impact			
	Observed		Potential	
SUB-BASIN	OBSERVED CHANGES (e/a)	OBSERVED CIV	POTENTIAL CHANGES [(b-c) - (d-e)] / a	POTENTIAL CIV
Upper Ferry Creek Residual	0.000	Low	1.000	High
Lower Ferry Creek Residual	0.000	Low	0.870	High
Total Watershed	0.000	Low	0.971	High

Prepared by EBA Engineering Consultants

APPENDIX A: Channel Assessment – Detailed Reach Descriptions

A1: Creighton Creek

Residual

Reach 1: This reach is approximately 900 metres in length, extending from the alluvial flood plain of lower Creighton Creek to the start of the confined channel upslope. Channel width varies between 5 and 10 metres. The average reach gradient is 7% and it is characterized by CPc morphology.

Disturbances in this reach include two road-related slides (Possible Sediment Source (PSS) 2 and 3, see Table 3) coupled with the creek, approximately 30 and 35 metres wide, respectively and one road-related slide (PSS 1, Table 3) uncoupled with the creek. A sediment wedge, approximately 50 m in length, observed further upstream in this reach was not related to the road slides. These disturbance indicators give rise to approximately 12% of the reach being highly aggraded.

The riparian vegetation in this reach is characterized by mainly MFc with agricultural disturbances (approximately 350 metres in length) and a section of YFm with logging disturbances. The overall level of riparian function was judged to be moderate in Reach 1 based on bank stability in the channel. The creek is running through its own erodible fan deposits, occasionally removing (by bank erosion) the thin zone (< 2 m) of riparian vegetation which exists on both sides of the creek throughout the lower section of this reach.

Reach 2: The dominant morphology in Reach 2 is CPb, with an average channel gradient of 9% and a bankfull width of 5-10 metres. This reach shows good channel complexity with very few disturbances and none were related to forestry. Reach 2 is approximately 820 metres in length with 5% of the reach showing a section of high aggradation due to a LWD jam 30 m in length and 2 small slides (PSS 4 and 5, Table 3) approximately 8 and 10 metres in length coupled with the creek.

Reach 3: Reach 3 is characterized by a SPb channel morphology with a large part of the bed and bank material being comprised of bedrock. The overall channel state in this reach is judged as stable with steps and pools being well developed. The average reach gradient is 11%, the length is approximately 550 m and the average channel width is between 3 and 8 metres. Three small bedrock slides were observed in this reach (PSS 6, 7 and 8, Table 3) and contribute rubble size material (angular particles between 2 and 256 mm) to the creek. These slides are not forestry-related.

Reach 4: Channel morphology in Reach 4 is dominated by CPb-w with LWD functioning to only a limited extent. Although not limited in supply, the relative importance of LWD in steeper morphologies for channel complexity is less than in those with shallower morphologies. Reach 4 has an average gradient of 7%, a length of approximately 550 m and widths between 3 and 8 metres.

Only minor disturbances were observed in this reach. Two sediment wedges, 30 and 15 metres in length, result in 8% of the reach being moderately aggraded. One of the sediment wedges was formed as a result of a small slide from the adjacent bank (PSS 9, Table 3) which was not forestry-related. The other may have been the result of a LWD jam in the creek, although this debris is no longer present and assumed to be unrelated to forestry.

Reach 5: Reach 5 extends through a bedrock canyon and contains a series of drops and pools in SPb(c)-w morphology. At least four small waterfalls (1-2 m in height) were observed within this reach. One of the falls is greater than 2 metres in height and appears to be a possible barrier to fish. This should be determined by a qualified professional in fisheries biology. The average channel width in Reach 5 is less than 8 metres.

Four small bedrock slides were observed in this reach (PSS 10-13, Table 3) with rubble and block size material (angular particles greater than 256 mm) reaching the creek sporadically and to a minor extent. None of these are considered sediment sources to the creek and all are naturally occurring. A sediment wedge, comprised mainly of gravel, approximately 45 m in length that has developed downstream of the mouth of tributary A, has resulted in 5% of this reach being judged as highly aggraded. Logging in Sub-basin A may have contributed some of this sediment to the creek. Reach 5 has an average gradient of 12% and a length of 980 m.

Reach 6: Reach 6 has a channel morphology dominated by CPb-w and is confined to the gully through which it flows and has widths of 3 to 5 metres. In general, pools are well developed and woody debris is providing some channel structure. The average reach gradient is 7% and the length is approximately 1850 metres.

A small slide in surficial material (PSS 14, Table 3), approximately 10 m in length, a small LWD jam and associated sediment wedge 15 metres in length, and 90 metres of windthrow, result in 6% of this reach being highly aggraded and 1% being moderately aggraded. The area of windthrow is adjacent to a cutblock where a thin (< 10 m) riparian buffer was left and the loss of riparian vegetation on the creek's left bank has occurred. Abundant windthrow in the creek will likely give rise to aggradation in this reach although this has not occurred at present.

The riparian function for this 90 metre section of the creek has been judged as low. Another area of Reach 6 adjacent to a cutblock with a thin (< 15 m) riparian buffer has also contributed an increased volume of windthrow to the creek. Most of the riparian vegetation still remains, however sparsely vegetated areas were observed resulting in shade limitations and therefore the riparian function for this section of the creek has been judged as moderate. No aggradation has occurred in this section of the reach. The overall riparian function for Reach 6 is judged as high.

***Reach** 7*: Channel gradient in Reach 7 increases to an average of 10% with a SPb(c)-w morphology. The length of the reach is approximately 1185 metres and the width is between 2 and 5 metres. Two bedrock slides (PSS 15 and 16, Table 1) were observed adjacent to the creek inputing rubble and blocks for a length of approximately 170 metres (14%) of the reach. The rubble and blocks in this reach have caused the creek to alter its course slightly within the shallow gully through which it flows and some infilling of pools has occurred. Therefore the disturbance has been judged as partially aggraded (A1). Both of these slides, however, occur naturally and sporadically and are not considered fine-grained sediment sources. The riparian vegetation consists of an area of MFc-W (~ 300 m in length) where windthrow has occurred adjacent to the cutblock described in Reach 6 which extends into Reach 7. The area of windthrow disturbance has been rated with a riparian function of moderate due to the more sparsely vegetated bank and shade limits.

Reach 8: Reach 8 is characterized by a channel gradient of 30% and SPb(r) morphology with LWD occasionally present but with minimal influence on morphology. The length of this reach is approximately 390 m and the width is between 2 and 4 metres. Both bed and bank material are commonly bedrock with three small bedrock slides (PSS 17-19, Table 3) observed. The slides contribute block size and some rubble size material to the creek sporadically for a distance of approximately 40 metres, are not considered a sediment source and are naturally occurring. The deposition of block and rubble material to the creek has resulted in the infilling of some pools and therefore 11% of the reach is judged as partially aggraded. No harvesting has occurred in this reach and therefore an assessment of riparian function was not required.

Reach 9: Reach 9 (with an average reach gradient of 2%) shallows significantly from Reach 8 as the channel enters the upper plateau of the Creighton Creek watershed. The length of Reach 9 is approximately 3310 m, the width is between 1.5 and 3 metres and the dominant channel morphology is RPc-w. A LWD jam 10 m in length was the only channel disturbance noted in the reach. This was not related to logging as windthrow occurs frequently and naturally in the upper reaches of the watershed and no riparian harvesting has occurred in this reach. However, it results in 0.3% of the reach being highly aggraded.

Reach 10: This reach is characterized by open, wetland vegetation, an unconfined channel and a channel morphology of RPg. In stream LWD was not observed in this reach due to supply limits in this open wetland area. Reach 10 is 525 m, its width is between 1.5 and 3 metres and its gradient averages 0.2%. No disturbances were observed in this reach and therefore the channel was judged to be stable. Riparian vegetation is comprised of wetland grasses and no harvesting has occurred in this reach.

Reach 11: Reach 11 is dominated by RPc-w morphology, an average reach gradient of 2% and a length of approximately 675 m. The channel width in this reach is less than 1.5 metres. Several pools and minimal riffle areas were observed . A cutblock adjacent to the creek has increased the supply of windthrow to the creek in this area, resulting in 40% (270 m) of the reach being partially aggraded. Riparian vegetation in the area adjacent to the cutblock is characterized by SH-LW with logging and windthrow disturbances resulting in a low to moderate riparian function due to shade limiting factors.

Sub-basin C

Reach 12: This reach is very similar in all characteristics to Reach 11, and its length is 670 m. This reach extends from the confluence with the tributary from Sub-basin B upstream to the end of the mainstem of Sub-basin C. The overall channel state of Reach 12 is judged as stable and no riparian logging has occurred.

Sub-basin A

Reach 1: This reach extends from the confluence with the Creighton Creek residual up a steep gully to the flatter plateau. It is characterized by a SPb(r) morphology with bedrock dominating both bank and bed materials. The average gradient of this reach is 35%, its width is between 2 and 4 metres and its length is 265 metres. The overall channel state was judged as stable and no riparian logging has occurred.

Reach 2: Reach 2 is characterized by a CPc-w morphology with an average width between 2 and 4 metres. This tributary extends from the steep gradients in Reach 1 to the upper plateau of Sub-basin A. The reach has an average channel gradient of 8% and a length of 1260 m.

Two sections of windthrow (60 and 195 metres in length) located adjacent to a forestry road and cutblock were observed in the reach and two smaller areas of windthrow unrelated to logging were observed in the reach. Although sediment deposition is taking place slowly behind these areas at this time, the decrease in stream velocity due to these disturbances results in 17% of the reach being moderately aggraded and 5% of the reach being judged as highly aggraded. The riparian vegetation is MFc-WRL adjacent to the road and logged areas with a low riparian function in these areas due to shade limiting factors.

Reach 3: The length of Reach 3 is 550 m, the average gradient is 4% and the dominant morphology is CPc-w. Channel widths observed in this reach are generally less than 1.5 m. A section of windthrow 315 metres in length has resulted in 57% of this reach being partially aggraded as sediment deposition is taking place slowly around the debris.

Logging adjacent to the creek in a large part of this reach has resulted in one section being designated SH-LW (approximately 300 m) as almost no riparian vegetation was left at all resulting in a low riparian function due to LWD supply and shade limits. Other sections of the reach include PS + YFm-L riparian vegetation with a riparian function of moderate to high and MFc-W with a riparian function of high to moderate. Both of these areas have minor shade limits due to sparse vegetation in some areas of the reach. The overall riparian function for Reach 3 has been judged as moderate.

Reach 4: Reach 4 increases in gradient to an average of 13% with widths of less than 1.5 metres. The dominant channel morphology is SPc-w with good pool development between steps. Woody debris plays only a minor role in the morphological complexities of this reach. The length of Reach 4 is 425 m. The overall channel rating for this reach is stable. Windthrow in the creek was observed although not to the extent it was seen downstream. The riparian area is classified as MFc-W with a high riparian function rating. Although a riparian buffer was left adjacent to the creek (> 10 m), the observed windthrow is likely a result of adjacent cutblocks.

Reach 5: This short reach, 370 m in length, extends to the end of the mainstem in sub-basin A. The gradient is 1%, the dominant morphology is RPc and widths are less than 1.5 m. Because a large portion of the reach has been logged to the creek on both sides of the bank, the riparian vegetation is SH-L with LWD recruitment being the limiting factor due to the loss of any riparian vegetation. The riparian function of this area is low to none. The lack of functioning LWD in the creek has resulted in minimal pool development and therefore 51% of this reach has been judged as partially degraded.

Appendix A2: Bonneau Creek

Residual

Reach 1: Reach 1 extends from the confluence with Ferry Creek upstream to the agricultural lands adjacent to Echo Lake. The reach is approximately 1455 metres in length, has a width between 2 and 5 metres, and an average channel gradient of 10%. The dominant channel morphology is CPc and the reach has been judged to be stable as no disturbance indicators were observed in the heli-overflight.

Both logging and agricultural disturbances were evident in the riparian vegetation in this reach. Riparian vegetation ranged from none to MFm with the supply of LWD limiting the riparian function. Based on observations from the helicopter, the overall riparian function for this reach was judged to be moderate.

Reach 2: The dominant channel morphology in Reach 2 is RPc and very little in stream functioning LWD was observed. The primary reason for this is the loss of some or all riparian vegetation due to agricultural disturbances in most of this reach. The average channel gradient is 3%, the reach has an approximate length of 2590 metres, and the width is between 2 and 5 metres.

Eroding banks (360 m), two channel avulsions (270 m (shown on the ReCAP map) and 55 m), and de-watering (270 m) within this reach give rise to 22% of the reach being judged as highly aggraded and 13% being judged as moderately aggraded. A section of this reach was not observed at all in the heli-overflight and may be the result of subsurface flows.

A thin riparian (< 2 m) mixed forest comprised of young and mature trees is discontinuously observed along this reach. Some logging has occurred at the upstream end of Reach 2 in the past but this area was judged to have a 90% hydrological recovery rate and observations from the helicopter indicated that riparian vegetation is now dominantly MFc. The overall level of riparian function for this reach was judged to be low to moderate based on agricultural development with shade and LWD supply being limiting factors.

Sub-basin A

Reach 3: Reach 3 begins at the confluence of Sub-basin B and continues upstream to a flatter plateau. It is characterized by SPb-w morphology with LWD occasionally present but having minimal influence on morphology. The gradient of Reach 3 averages 17%, its width is between 2 and 5 metres, and its length is approximately 2065 metres.

Two small slides (PSS 20 and 21, Table 3) which impact 20 and 8 metres of the creek may be the result of eroding banks but do not appear to be logging-related. Logging to the edge of the creek on both banks has resulted in approximately 65 metres of wood debris deposition in the creek which will likely lead to aggradation upstream. These disturbance indicators give rise to 1% of the reach being judged as highly aggraded and 4% of the reach being moderately aggraded.

Riparian disturbances in Reach 3 include the 65 metres where harvesting on both sides of the creek has removed all riparian vegetation, a section of MFc with windthrow disturbances and a section of MFc which has been logged in the past. In the latter of these, logging has left a large portion of the riparian untouched and therefore no limiting function has been indicated. The overall level of riparian function for the reach was judged to be high except in the 65 m length of channel where function has been rated as none due to recent logging.

Reach 4: This reach has an average channel gradient of 6%, an approximate length of 655 metres and a CPc-w channel morphology. Channel width is between 2 and 5 metres. The overall channel state was judged to be stable with cascades and pools being well-developed. Harvesting has occurred adjacent to the creek. Like Reach 3, however, most of the riparian vegetation still remains and therefore this area has a riparian vegetation class of MFc-L. A section of MFm with windthrow disturbances was observed within this reach and the mixed stand types are likely the result of historical harvesting. Despite the logging in this reach, the overall level of riparian function was judged as high based on observations from the helicopter.

Reach 5: Reach 5 has also been judged to have an overall stable channel. The dominant channel morphology in this reach is SPb-w with developed pools and LWD occasionally present but with minimal influence on morphology. The average gradient is 18% and the width is less than 1.5 metres. This reach has an approximate length of 545 metres. Historical logging in a portion of this reach has likely resulted in the dominant riparian vegetation type of MFm with windthrow disturbances. The riparian function of this reach has been judged as high.

Reach 6: The dominant channel morphology in Reach 6 is CPc-w with an average gradient of 4%. The length of this reach is approximately 935 metres, the width is less than 1.5 m and approximately 290 metres of the reach was not observed from the helicopter. Upon consultation with the Ministry of Forests it was confirmed that flow in this portion of the creek is subsurface and dead fish have been observed upstream (personal communication with Sean Cluff,, Ministry of Forests, Vernon District, 1999).

Further upstream in this reach, the creek was found wandering on and adjacent to an old skid trail and the extensive riffles and minimal pool area resulted in 30% of this reach being judged as moderately degraded. Stream enhancement in this area was reported to have taken place in 1998 which may be addressing this issue. Logging within the reach has resulted in riparian vegetation dominated by SH+YFc-LR. This area was judged to have a moderate to low level of riparian function based on the road disturbance. Shade and LWD supply are limited in some portions of the reach.

Reach 7: Reach 7 climbs to an average gradient of 14% and has a stable SPb-w channel morphology. The length of this reach is approximately 625 metres and the average channel width increases again to between 1.5 and 4 metres. Logging adjacent to a portion of Reach 7 has resulted in riparian vegetation that is dominated by SH and some YFc. The overall riparian function was judged to be moderate with LWD supply being limited due to sparse vegetation.

Reach 8: Reach 8 flattens to an average gradient of less than 1%, extends 460 metres to Bonneau Lake and is dominated by a RPg-w morphology. A LWD jam at the downstream end of this reach has resulted in a widening of the channel to greater than 3 metres in some areas and loss of channel structure for a distance of approximately 180 metres upstream. Therefore, this reach is partially aggraded for 39% of its length. LWD jams are common in low gradient morphologies and are an important part of channel complexity. It is not thought that the LWD jam is the result of logging activity. Riparian logging has not occurred in this reach.

Sub-basin B

Reach 1: The average gradient for Reach 1 is 13% and its dominant channel morphology is CPb(c)-w. In stream wood debris is present but has minimal influence on channel morphology. Channel widths in Reach 1 are between 2 and 5 metres and its approximate length is 490 metres.

In general the reach has well developed pools and cascades, however, extensive riffles with minimal pool area are observed at the downstream end of this reach and result from the creek flowing for about 50 metres on an old road due to a road washout. Consequently 10% of the reach is judged as moderately degraded.

Trees harvested in the lower parts of this reach have reached stand heights equivalent to a 90% hydrological recovery. Riparian vegetation observed in the disturbed area is now dominantly MFc-LR. The overall level of riparian function for this reach was determined to be moderate based on the road disturbance observed from the helicopter as shade and LWD supply are limited in the area where the channel is now on the road.

Reach 2: This reach has a stable channel rating based on heli-overflight observations. The average gradient in Reach 2 is 25%, with an approximate length of 270 metres and a width of less than 1.5 metres. The dominant channel morphology observed was SPb-w with wood debris having very little influence on channel morphology. No riparian disturbances were observed in this reach.

Appendix A3: Upper Ferry Creek

Residual

Reach 6: This long reach (4380 m) has an average gradient of 3% and a channel morphology of RPc. The channel is rarely confined through Reach 6 and therefore has a degree of lateral mobility. In stream functioning LWD was observed rarely, however channel widths varied between 5 and 15 metres and LWD plays a less important role morphologically in wider channels. In general, Reach 6 shows well developed pools, however several small areas showed disturbances.

The creek has eroded the adjacent logging road in four places, impacting approximately 20, 76, 40 and 30 metres in length (PSS 22-25, Table 3). Some of these areas have already been rip-rapped to protect the road from further damage. Sediment eroded from the road has been deposited in the creek. Flows in Ferry Creek, however, appear sufficient to move this finer grained material downstream as little evidence of deposition remains. Wide (15-20 m), multi-channeled sections of the creek were observed 3 times in this reach with one section extending greater than 2 km in length and the other two affecting 65 and 200 metres of the creek. Three LWD jams and their associated sediment wedges were also observed impacting 30 , 8 and 30 m of the creek. A small section of windthrow was also observed in the creek with sediment being deposited slowly around it. These disturbances result in 2% of the reach being highly aggraded and 62% of the being moderately aggraded.

Two sections of historical logging in this reach have a 90% hydrological recovery. They have been classified as YFm + MFm-L and MFc(m) + YFc-L with riparian function being judged as high in both areas. In one area of the reach, the creek comes very close to the logging road (for a length of approximately 900 m) and only a thin (<2 m) riparian strip remains. This has been called MFc + SH-R where the SH vegetation dominates the right bank of the creek. Riparian function here has been judged as moderate based on LWD supply and shade limits.

Reach 7: Reach 7 is approximately 2360 metres in length, has an average reach gradient of 3%, widths between 5 and 20 metres and a channel morphology of CPc. As in Reach 6, in stream functioning LWD is not common, the channel is rarely confined and therefore has a degree of lateral mobility. A large section (approximately 1200 m in length) of Reach 7 is very close to the road and only a thin (<2 m) riparian strip remains on the left bank of the creek. This section has been called MFc + SH-R and has been judged to have a moderate riparian function similar to that described in Reach 6. Channel widening (to widths of 10 – 20 m) and multi-channeled flows for a distance of approximately 600 metres results in 26% of this reach being classified as moderately aggraded. A small LWD jam and sediment wedge, only 8 m in length, affects less than 0.5% of the reach.

Reach 8: This reach has a channel morphology of CPc with in stream LWD occurring rarely, an average channel gradient of 4%, and an approximate length of 2685m. Channel widths are between 5 and 10 metres. The reach shows good development of pools and is generally in very good condition.

Four possible sediment sources related to the adjacent logging road were observed in this reach. Two of these impact 8 and 20 metres of the creek and are coupled to the creek (PSS 26 and 29, Table 3). The other two (PSS 27 and 28, Table 3)are road-related but partially coupled with the creek in that debris has been deposited on the narrow floodplain rather than into the creek itself. The potential exists for this debris to be mobilized if the creek alters its course to the right and runs adjacent to the road. Two sediment wedge sand associated with jams (8 and 10 m) were also observed in this reach. The overall channel state has been judged as essentially undisturbed with 1% being highly aggraded, 1% being moderately aggraded, and 1% being partially aggraded.

The proximity of the road to the creek in one area, 700 metres in length, has resulted in a moderate riparian function and vegetation dominated by MFc + SH-R where SH is found between the road and the creek. Past harvesting adjacent to the creek in one area has a 90% hydrological recovery and observations from the helicopter indicate that riparian vegetation is dominantly MFc + PS-L with a high riparian function.

Reach 9: The entire length of this reach (2290 m) is very close to the road with only a thin (<2 m) riparian strip being left between the road and the creek. The riparian vegetation has therefore been called MFc + SH-R with a moderate riparian function rating for the whole reach.

Channel morphology in Reach 9 is CPc-w, the average reach gradient is 6% and widths are between 3 and 10 metres. In stream LWD is present but only plays a minor morphological role in this reach. Although the overall morphology is relatively undisturbed in this reach, at least 6 partially coupled road and/or forestry related slides were observed reaching the valley bottom but not the creek (PSS 30-32, 34 and 36, Table 3). Most of these slides did not impact more than 10 metres of the valley bottom. One of these (PSS 36), however, could potentially impact the creek for a length of approximately 80 m if flows in the creek are diverted to the right side of the valley bottom. One small road-related slide is coupled with the creek (PSS 35, Table 3) and impacts the creek for only 10 m distance. Slide 33 is also forestry /road related and coupled to the creek. Widening of the channel (widths of 8 to 15 m) has occurred for approximately 50 metres in this reach. These disturbances result in the reach being judged to be 3% moderately aggraded and 6% partially aggraded.

Reach 10: Reach 10 has a channel morphology of SPb(c)-w, an average channel gradient of 10% and an approximate length of 3280 metres. Channel widths are between 3 and 8 metres. The channel becomes steeper and more entrenched as the upstream end of this reach is approached. Pool development observed from a ground station visited at the downstream end of the reach was good.

Disturbances observed in Reach 10 were all naturally occurring. Three slides in surficial material were observed coupled to the creek in this reach (PSS 38-40, Table 3). One large, naturally occurring slide (PSS 37, Table 3) affects approximately 520 metres of this reach contributing block and rubble size material to the creek. The rubble and blocks have caused the creek to alter its course at least 5 to 10 metres toward the left side of the valley bottom and therefore the disturbance has been judged as partially aggraded (A1). A small LWD jam and associated sediment wedge was also observed and assumed to be naturally occurring as no riparian harvesting has occurred in this reach. These disturbances result in 1% of the creek being moderately aggraded and 16% being partially aggraded.

Reach 11: Reach 11 has an average gradient of 8%, is approximately 2000 metres in length and has a dominant channel morphology of SPb. The width of the channel is between 2 and 6 metres. No disturbance indicators were observed during the heli-overflight and therefore the overall channel state was judged to be stable.

Reach 12: This reach extends for approximately 365 metres from the crest of the Ferry Creek upper plateau. It has an average gradient of 1% and a channel morphology of RPc(g). Riparian vegetation is sparse on the upper plateau and therefore very little in stream LWD was observed. Channel disturbances were not observed in this reach and therefore the reach was judged to be stable. Riparian disturbances were found in the reach and based on observations from the helicopter riparian vegetation was designated as SHc + YFc-L and given a moderate riparian function due to LWD supply limitations.

Reach 13: Reaches 12 and 13 are typical of channel reaches in the upper plateau area of both the Ferry and Creighton Creek watersheds. Reach 13 is characterized by open, wetland vegetation, an unconfined, irregular meandering channel and a channel morphology of RPg with no in stream LWD observed controlling channel structure. Its gradient averages less than 1% and its length is approximately 730 metres. Neither channel or riparian disturbances were noted in this reach and therefore the overall channel state was judged as stable.

Appendix A4: Lower Ferry Creek

Residual

Reach 1: Reach 1 extends from Highway 6 upstream for a length of 1300 metres. Widths in this reach are between 5 and 15 metres. Downstream of Highway 6 was not assessed in this project and Reaches 1 through 5 were not assessed in detail (i.e., only a brief helicopter survey was conducted). Reaches 1-5 are part of what has been termed Lower Ferry Creek. The average gradient of Reach 1 is 3% and the dominant channel morphology is CPc. In general, channel morphology is stable with good pool development.

Very little in stream woody debris was observed in this reach, however, two LWD jams and associated sediment wedges impact 20 and 15 metres of the creek. A section of the reach where multiple channels and widening were observed affect 160 metres of the creek. These disturbances result in 3% of this reach being judged as highly aggraded and 12% being judged as moderately aggraded. Both logging and agricultural disturbances in the downstream section of this reach have resulted in sparse riparian vegetation comprised of YFm and riparian function in this area has been judged as moderate due to shade and LWD recruitment being limited in areas of sparse vegetation.

Reach 2: This reach is dominated by bedrock in bank and bed material and has a channel morphology of SPb. The average gradient, 2% for this reach, was determined from stream profiling using TRIM based mapsheets. This reach is short, 460 metres, and therefore it is assumed that the scale of mapping was too small to represent this short steeper section. Based on observations from the helicopter, Reach 2 was assumed to have an average gradient greater than 10% and average widths between 3 and 8 m. The channel state was judged to be stable.

Reach 3: Reach 3 has a length of approximately 805 m, an average gradient of 3%, and a channel morphology of CPc-w. Channel widths in Reach 3 are between 5 and 10 metres. No disturbances were observed in the helicopter overflight and therefore this reach was judged to be stable.

Reach 4: This reach was similar to Reach 2 with bedrock dominating bed and bank material. Bedrock cliffs were observed in this reach and the average reach gradient was at least 7% (may not be representative based on scale of mapping to determine gradient as described above). The length of Reach 4 is only 225 metres, its overall channel state was judged to be stable and its channel morphology is SPb(r).

Reach 5: The dominant channel morphology in Reach 5, as determined from the helicopter, is CPc. Its approximate length is 2760 m and its average gradient is 2%. Three sections of channel widening and multi-channel flow result in 61% of the reach being judged as moderately aggraded. Observations of two debris jams and associated sediment wedges result in 1% of the reach being highly aggraded. Two areas of past logging have a 90% hydrological recovery (YFm-L and YFc-L) and observations from the helicopter did not reveal any riparian dysfunction along the reach. The overall riparian function was therefore judged as high.