Greg Tamblyn

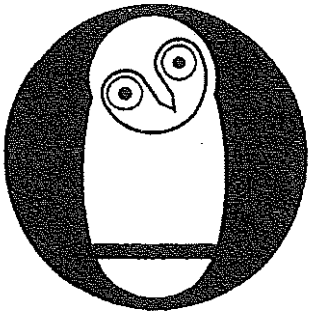
Detailed Fish Habitat, Riparian and Channel Assessment for Select Central Bulkley River Tributaries

Prepared for:

Bulkley Morice Salmonid Preservation Group
c/o Community Futures Development Corporation of Nadina

Prepared by:

Greg Tamblyn
Resource Management Consultant
Smithers, BC.
&
Matthew Jessop
British Columbia Conservation Foundation
Smithers, BC.



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PREFACE

A watershed is stream network, confined within terrestrial boundaries, flowing from the highest points of land to the point of confluence with another catchment basin. Water within the basin converges and flows downhill both underground and in branched surface channels we know as creeks, streams and rivers. These channels express themselves based on patterns of precipitation, topography, geology, and human modifications of the landscape. The amount of water flowing in a creek channel at a given time is controlled by precipitation, temperature (snowmelt) and groundwater recharge. Peak discharges, valley geomorphometry (including slope, confinement, resistance of substrata to erosion), riparian vegetation and trees which have fallen into the stream modify the shape of the channel – its width, depth, substrate, sinuosity and riffle:pool pattern. For any given slope, the greater the discharge, the greater the erosional power of the creek. This erosional power transports boulders, cobble, gravel, sand and silt from the stream bottom and the stream banks downstream. In reaches of lower slope and during times of low flow, the energy of the stream decreases and material from upstream settles out. In this way, the stream shapes the landscape.

In a natural system, a river reaches a dynamic equilibrium. This equilibrium can be disrupted by human induced land use activity – both terrestrial and aquatic. Upland land uses including land clearing for forestry, agriculture, power lines and pipelines, urban settlements and roads. Removing vegetation affects rates of surface and groundwater flow, allowing water to move through a system at a quicker rate (Gregory and Walling 1973 in Gore 1996) as the capacity of the land to hold water is compromised. Quicker movement of water through the system leads to higher peak flows and hence larger floods and a decreased capacity of the ground to hold water and recharge the stream during dry times of the year. Higher energy, and thus increased erosional force, results in erosion of stream banks, scouring of stream beds and deposition of more materials downstream.

Clearing riparian vegetation can also dramatically alter the stream environment. Riparian vegetation plays a number of key roles in the aquatic ecosystem:

- roots act like a sponge, slowly releasing water back to the creek,
- roots stabilise banks (roots can resist erosion by a factor of 20,000 compared with bare soil (Adams and Fitch 1995)),
- leaves and woody material from the trees provide nutrients and food to aquatic systems,
- terrestrial insects fall from the vegetation providing food to the stream environment,
- trees fall into the stream providing a source of large woody debris which increases complexity of the stream by creating pools, backeddies, hydraulic jumps, and
- trees shade the system to regulate temperature and light energy reaching the stream.

Human-based activities also directly affect water quantity and quality in a stream system. Water is removed from streams for drinking, irrigation, livestock watering, recreation and industrial purposes. Some of this water is discharged back into the stream as sewage or industrial effluent. Pesticides and animal wastes also leach into the streams affecting water quality.

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1.0 INTRODUCTION

Poor land-use and management activities adjacent to waterways impact the physical and the biological processes of aquatic ecosystems. Impacts to streams include modified water discharge patterns, altered channel morphology, erosion, increased sedimentation, and loss of riparian vegetation. Removal of riparian vegetation may affect stream bank stability, coarse woody debris recruitment, allochthonous nutrient addition to aquatic ecosystems, and solar radiation inputs to aquatic systems which change water temperatures and plant communities. Altering the physical structure of the stream, in turn, influences the habitat of fish and other aquatic life.

The central region of the Bulkley River watershed is an important salmon, steelhead and trout producing area. The mainstem itself contains very high value habitat due to its importance as a migration corridor for salmon and steelhead trout, and the presence of spawning and rearing habitat for salmon (Mackay & Johnston 1998). The tributaries contain spawning and rearing habitat for species including coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), pink salmon (*O. gorbuscha*), steelhead (*O. mykiss*), rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), Dolly Varden char (*Salvelinus malma*) and bull trout (*S. confluentus*) (Mackay & Johnston 1998; Mitchell 1997). Populations of steelhead trout and coho and chinook salmon are thought to be declining in the Bulkley River watershed (BCCF 1998) due to over-harvest, changing ocean conditions, and impacts of land use on fish habitat.

Land use activities have had a significant impact on many of the tributaries within the central Bulkley River watershed. Preliminary air photo analysis has indicated that high value fish habitat has been moderately to severely impacted in a large proportion of the tributaries to the central Bulkley (Mitchell 1997). Much of the habitat degradation in this part of the Bulkley River watershed is attributed to clearing vegetation to the edge of streams for agriculture and livestock uses, resulting in bank erosion and stream sedimentation. Roads, railways, residential housing and forestry activities have also contributed to degradation of the stream environments (Mitchell 1997).

Fisheries Renewal British Columbia is a provincial crown corporation established to improve fish stocks and habitat, develop new fisheries, diversify and market products and services, create jobs, and strengthen fishing communities through training, education and technological development. Standardised methodologies developed under the Watershed Restoration Program of Forest Renewal BC are an aid to assessing and improving fish habitat under Fisheries Renewal BC. These procedures include Fish Habitat Assessment Procedures (FHAP) (Johnston and Slaney 1996), Channel Assessment Procedures (CAP) (Hogan *et al.* 1996) and the Riparian Assessment Procedures (RAP) (BC 1998).

FHAP is a means of assessing watersheds for anthropogenic impacts to fish and fish habitats using a set of integrated physical and biological indicators. The assessment procedure extends from stream and river channels, to the riparian area, to upslope areas in which there is some level of connectivity to the channel. There are two levels of assessment in the FHAP. The first, known as the Overview Assessment, is a reconnaissance-level study

compiling background data and using predominately remote-sensing techniques to prioritise sub-basins and waterbodies within those sub-basins for the second level of FHAP. This is known as the Detailed (or Level 1) Assessment, which involves more detailed field surveys of the channel and riparian areas, the end result of which is the formation of restoration prescriptions to restore or rehabilitate fish habitat, or mitigate impacts on that habitat. There are four general steps in both stages of the FHAP:

1. identification of fish species at risk in the watershed;
2. quantitative and qualitative description of fish habitat conditions;
3. evaluation of fish habitat conditions; and
4. identification of opportunities for effective fish habitat rehabilitation.

The general steps in conducting a Level 1 Riparian Assessment Procedure (RAP) are similar to those of the FHAP and are as follows:

1. identification of areas of riparian loss due to anthropogenic causes;
2. quantitative and qualitative description of riparian habitat conditions;
3. evaluation of riparian habitat conditions; and
4. identification of opportunities for effective riparian habitat rehabilitation.

The Channel Assessment Procedures establish methodologies to allow a continuous description of the stream channel and stream banks and to identify disturbed channels.

Together, these assessment procedures provide a detailed overall picture and an understanding of the general and specific processes occurring within each stream and the watershed.

1.1 Purpose

The purpose of this project is to assess the impact of land use activity on the fish and fish habitat of select tributaries to the central Bulkley River, and to focus habitat restoration priorities on areas where the greatest opportunities for effective rehabilitation exist.

Specific objectives for this project are modified from those of the Fish Habitat Assessment Procedures (Johnston & Slaney 1996) and Riparian Assessment Procedures (BC, 1998):

1. to determine / confirm what fish species (and life stages) are at risk from the impacts of poor land use practices in the watershed and identify riparian areas with known or suspected impaired function;
2. to identify / confirm fish habitat and riparian areas of concern that need to be examined in quantitative field surveys.
3. to provide sufficient information to identify and prioritise restoration options, and to identify initial project objectives and scope;
4. to identify the need for any Level 2 assessments; and
5. to estimate initial budgets for restoration projects where appropriate.

1.2 Study area

This study encompasses streams in the Bulkley Valley between the communities of Telkwa and Houston in northwest British Columbia (Table 1, Figure 1). Dahlie Creek, which flows through the southern part of Smithers, is also included.

Table 1. General information for streams assessed during the overview assessment.

Stream Name[1]	Watershed Code	UTM (mouth)	Watershed Area (km^2)
East side of Bulkley R.			
McDowell Creek	460-435300	9.6060339.627658	19.4
Robin Creek	460-487900	9.6052889.637951	90.6
Lemieux Creek	460-487900-11100	9.6054537.638283	30.0
Vanderven Creek	460-487900-37600	9.6058252.637196	22.5
de Jong Creek	460-487900-37900	9.6058277.647229	11.3
Deep Creek	460-496100	9.6050840.638717	108.8
Thompson Creek	460-517700	9.6048016.640121	43.9
Vallee Creek	460-528000	9.6045134.640112	31.7
Stock Creek	460-589500	9.6032769.644552	16.3
Mathews Creek	460-593900	9.6032305.645346	11.1
West side of Bulkley R.			
Dahlie (Bigelow) Creek	460-373800-33200[2]		17.7
Helps Creek	460-437000	9.6060026.628023	35.3
"Moan Creek"	460-458800	9.6055930.631090	17.0
Coffin Creek	460-472700	9.6054830.634511	58.0
Edward Creek	460-545700	9.6040892.640589	48.6

1 Creek names in quotes are non-gazetted names.
2 This watershed code is inaccurate - watershed atlas incorrectly indicates Dahlie Creek is a tributary to Seymour Creek.

The central Bulkley watershed, as delineated in this study, covers an area of 610 km^2. The northeastern boundary consists of the gentle mountains of the southern Babine Range, while the southwestern boundary is formed by the fringes of the Telkwa Range. The creeks to the south of our study area were assessed by BCCF in 1997 (BCCF 1998).

The creeks in the central Bulkley watershed are fed by snow melt and rain. Small wetland complexes and small lakes head several of the creeks on the northwest side of the Bulkley River Valley. Some of the smaller systems run dry in the summer.

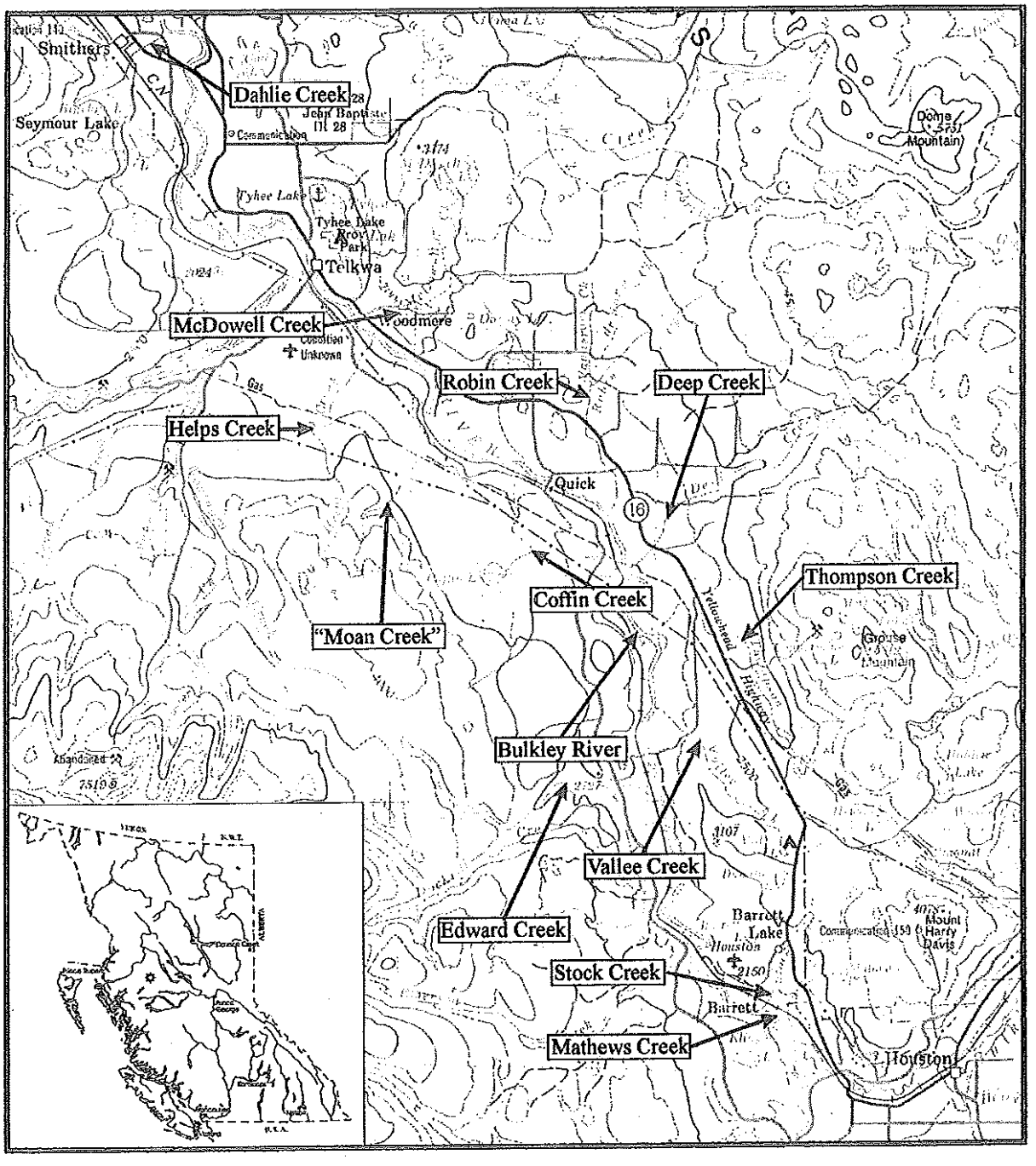


Figure 1. Location of study area showing mainstems of streams assessed
Source map: NTS 93L 1:250 000.

Three BEC subzones occur in the study area. These are stratified primarily by elevation (i.e. climate), and modified by aspect and soil types. The valley floor (approx. 540 m a.s.l.) occupies the sub-boreal spruce dry cool subzone (SBSdk). At roughly 760 m on the southwest side of the valley, and 885 m on the northeast side of the valley, the subzone shifts to the sub-boreal spruce moist cold Babine variant (SBSmc2). The streams in the study area originate in the Englemann spruce-subalpine fir moist cold subzone, which is found at elevations above approximately 1060 m (southwest) and 1130 m (northeast).

The primary soil great groups in the lower half of the watersheds in the central Bulkley are Gray Luvisol and Dystric Brunisol and Humo-Ferric Podzol in the upper halves of the watersheds.

1.3 Target Species

Numerous species of fish inhabit the central Bulkley watershed. For the purposes of our assessment, fish species or stocks at risk are the primary target species. Target species include economically and/or culturally important salmonids whose populations have declined due to past land use activities, or which are known to be sensitive to logging (Johnston and Slaney 1996) or agriculture. The following fish are the key target species in the central Bulkley watershed due to declining numbers and economic value:

- coho salmon (*Oncorhynchus kisutch*),
- chinook salmon (*O. tshawytscha*), and
- steelhead trout (*O. mykiss*).

Additional species inhabiting the creeks in the central Bulkley watershed during their lifecycle which are known to be sensitive to logging and other land use practices include:

- pink salmon (*O. gorbuscha*),
- rainbow trout (*O. mykiss*),
- cutthroat trout (*O. clarki*),
- Dolly Varden char (*Salvelinus malma*), and
- bull trout (*S. confluentus*) (Johnston and Slaney 1996).

These eight species are the target species whose habitats, distributions, and abundance are the focus of this assessment. Bull trout is a blue-listed (vulnerable) species in British Columbia and merits special attention.

1.4 Geology

The central Bulkley study area is located in the northwest corner of the Nechako Plateau. This plateau is primarily gently sloping volcanic Bedrock geology in the area is comprised primarily of volcanics of the Tertiary to Jurassic periods (AGRA 1996 in BCCF 1997) with some Tertiary sedimentary rocks along the southwestern side of the Bulkley River. The

Telkwa Formation (volcanics) dominates the Robin Creek, Deep Creek, upper Helps Creek, Coffin Creek below the lake and first few kilometres and of the Thompson Creek watersheds, while reach 2 of Thompson Creek is on the Buck Creek Formation (volcanic). The Red Rose Formation (sedimentary) underlies the lower half of Helps Creek, "Moan Creek", and the central portion of Coffin Creek. Unknown aged sedimentary rocks underlie the upper reaches of Robin and Deep creeks.

Surficial geology varies as a function of erosion and deposition prior, during, and following the most recent glaciation. The Bulkley Valley contains advance and retreat glaciolacustrine sediments sandwiching glacial till from the Fraser Glaciation (25,000 to 9,000 years ago) (Stumpf *et al.* ND). Advance glaciolacustrine sediments occur to a maximum elevation of 517 m a.s.l. in Telkwa and 575 m in Houston. Retreat sediments are found at elevations from 550 m in Telkwa to 727 m at Perow. These clays and silts are commonly overlain by colluvium deposits *(Ibid.)*.

1.5 Soils

At a macro scale, the central Bulkley has three primary soil types. Soil great groups at lower elevations are generally Gray Luvisols or Dystric Brunisols, while at the upper elevations, the great group is generally Humo-Ferric Podzols (Valentine *et al*, 1978). These soils groups correspond roughly with the biogeoclimatic (BEC) zones.

2.0 METHODS

BCCF followed methods established for Overview and Level 1 assessments in the various Watershed Restoration Technical Circulars (WRTC) (British Columbia 1998; Johnston and Slaney 1996; Hogan *et al.* 1996). The format of this report and much of the analysis is based on former watershed restoration work by the British Columbia Conservation Foundation (BCCF 1999, BCCF 1998).

2.1 Pre-field planning

2.1.1 Literature review

The first step in this project was to collect and review existing fisheries, terrain stability, water quality and water quantity information for the central Bulkley watershed area. Key information sources searched included Fisheries Information Summary System (FISS) maps and website (BC 1999a), the Ministry of Environment's water license website (BC 1999c), the "rivers files" in the office of the Skeena Region of BC Environment, and reports contained in the offices and libraries of BC Environment, Pacific Inland Resources and Nadina Community Futures. Key consultants' reports include Mitchell (1997), Triton (1997a) and Remington (1996). Colour and black and white air photos of various years were gathered from the Bulkley Forest District to obtain coverage for the study area.

2.1.2 Selecting streams for assessment

Within the study area, we prioritised streams for assessment based on an overview assessment utilising a decision matrix and a preliminary field reconnaissance of the streams from major road crossings. Mainstems and major tributaries were considered for our study. For each creek, we completed a Habitat Condition Summary Form and Preliminary Habitat Assessment Form from Johnston and Slaney (1996) and used the information on the forms in a decision matrix to prioritise reaches of streams. The matrix consisted of seven scoring categories (Table 1.). Small streams with bankful widths of 2.0 m or less and streams with low discharges during the reconnaissance in mid-August were considered low priorities regardless of their matrix score (e.g. McDowell, Matthews and Stock creeks). In larger streams, low scoring reaches between two higher scoring reaches were usually included in field assessments to provide a continuous assessment of the stream. Several high scoring reaches running through wetlands could not be assessed using the FHAP and CAP procedures and thus were not included in our assessment.

Table 2. Scoring system for decision matrix used to prioritise streams for assessment.

Category	Points				
	0	1	2	3	4
Stream Class	S4	S3	S2		
Channel Type	wetland / lake	step pool	cascade pool	riffle pool	
Fish Presence	no fish	Non-game fish	resident salmonids	anadromous salmonids, regionally important spp.	
Riparian Condition	no impacts	0-25% disturbance	26-50% disturbance	51-75% disturbance	76-100% disturbance
Potential Upslope Impacts	none	low	moderate	high	
Connectivity (Coupling)	decoupled	partially coupled	coupled		
Crossing Density (crossings / km)	points allotted = # crossings / km				

1 - # roads, railway, powerline & pipelines / km of stream

The results of the matrix are presented in Appendix A.

2.2 Field procedures

Field work occurred between September 8 and November 1, 1999. The British Columbia Conservation Foundation assessed each priority reach based on the methods for Level 1 assessments detailed in watershed restoration technical circulars No. 6, 7, and 8 (Johnston

and Slaney 1996; Hogan *et. al.* 1996; British Columbia 1998). We recorded field data onto three key forms: Integrated FHAP/CAP - Habitat Survey/Channel Morphology Data Form (Form 4) and Integrated FHAP/CAP - Channel Disturbance Level Data Form (Form 7) (Mackay 1998) and the Riparian Assessment Field Form (Form 2) (BC 1998). Trees, shrubs and herbs were identified to species. We tentatively identified willows to species when possible. We rarely identified grasses due to the lack of seeds and inflorescences.

Reaches were assessed by teams of two starting at the mouth of the creek, or, in several cases, at the reach break above an unsurveyed reach. Each crew collected data for the three assessments and counted habitat units and large woody debris (LWD) as they walked upstream. LWD tallies were based on functioning status within three size classes. Distances were measured from the stream mouth or the downstream reach break and recorded as "km+metres" (e.g. 1+345 m equals 1,345 m from the mouth or downstream reach break).

A systematic random sampling method was used to determine habitat units to be sampled. Five habitat unit types were used for the assessment: glides, riffles, pools, cascades and "others". "Others" consisted of wetlands with no defined primary channel, side channels, sloughs, beaver ponds, and areas where the channel could not be observed (e.g. beneath log jams) (Johnston and Slaney 1996). Start intervals and sampling intervals for each unit type were chosen randomly from a range of 1-15 for the start interval and 10-25 for the sampling interval (Table XX) In some smaller streams with a high rate of unit repetition, sampling intervals were doubled.

Table 3. Sampling and start intervals for the types of habitat units encountered.

Habitat Unit	Start Interval	Sampling Interval
Glide	11	25
Riffle	9	23
Pool	1	21
Cascade	8	25
Other	6	15

Each crew used identical models of field equipment and methods to gather data. Water temperatures were taken throughout each field day using alcohol thermometers. We used dipnets consisting of plastic kitchen strainers taped to broom handles and Coffelt BP-4 battery powered backpack electrofishers to capture fish when water temperatures exceeded 4°C. In lower temperature water and in complex habitats (e.g. deep pools and log jam areas), and where feasible, we set wire mesh traps baited with roe. Due to the limited habitat in which traps could be set, we could not sample fish at each sample site interval during the later stages of the study when water temperatures were low. We measured channel widths and depths using Eslon tape measures and calibrated dipnet poles. We estimated discharge using the floating method for each reach. Consecutive reaches without major tributaries were assumed to have the same discharge. Gradients and UTM co-ordinates were determined at each site using Suunto clinometers and uncorrected handheld Magellan Pioneer GPS units, respectively.

We conducted level 1 riparian assessments at 15 sites. Sites were chosen based on a modified overview riparian assessment and observations in the field. The primary purpose of the plots was to determine the site series. For streams located on private land, many of the most impacted riparian polygons are crop fields or grazing pastures. Due to the modifications to the vegetation and soil in these polygons, riparian plots in these locations would not allow us to determine original site series. To remedy this problem, we placed our plots and soil pits in relatively undisturbed riparian areas adjacent to highly impacted sites. Although this method allowed us to determine probable site series for the impacted polygons, it did not allow full assessments of the actual impacted sites. Stem tallies, disturbance indicators, and level of riparian function could not be extrapolated to the impacted polygons. Further work will have to be done in some impacted areas to determine stocking densities for riparian restoration suggestions. These plots do, however, provide some indication of the level of functioning in the lesser impacted areas along the stream and allow the determination of site series which are then used to guide riparian prescriptions.

In each plot, we followed the procedures outlined in the Riparian Assessment and Prescription Procedures technical circular (BC 1998). We used 3.99 m or 11.28 m radius plots depending on stand age. Once the plot was established, we collected the following data:

1) stem tallies for coniferous and deciduous trees in five size categories (<1.3 m height. 0.1-7.4 cm, 7.5-12.5 cm, 12.6-21.9cm and >22cm diameter at breast height (dbh));
2) species lists and percent cover and for understory plants in 4 categories (Shrubs >2 m, short shrubs, herbs and mosses);
3) snag data;
4) disturbance indicators; and
5) level of riparian function.

We dug a soil pit in a relatively root free area of each plot to a depth of 50-60 cm. We determined soil textures for each layer and classified soils to great group using Banner *et al.* (1993). Site series and deciduous seral associations were determined for each of these surrogate sites and applied to the impacted polygons. This site information was used as a foundation for riparian prescriptions.

2.3 Data Analysis

Data analysis procedures were modified from those developed by BCCF (1999). FHAP survey data and CAP data was entered into an MS Access database using the WRP data entry system (WRP DES). The results of data analysis are presented on a reach basis. Types of data analysis are described below.

1. FHAP habitat survey data analysis:

Habitat survey data was analysed for quantitative parameters (length, bankfull/wetted depths and widths, pool depths, and D (largest stone moved by flowing water)) using the weighted reach mean calculations for randomly subsampled survey data. This procedure is set out in TC#8. These values were useful in determining, among other things, LWD and pool

frequencies, and in-stream design data. Modal results were calculated for nominal data such as substrate type.

2. FHAP habitat unit data analysis:

Habitat unit tallies were used to calculate unit richness (the number of unit categories), complexity index (a measure of habitat complexity based on habitat unit class proportion and unit richness), pool frequency, and metres between pools (indicator parameters of salmonid rearing habitat condition) for each reach. The complexity index was created using a modified Simpson's Diversity Index. This ecological parameter is normally used as a descriptor of community biodiversity. The calculation for Simpson's Diversity Index was modified to produce an index of complexity by replacing the biotic terms with those for habitat unit richness and proportions of habitat by unit category. It reflects both species richness and proportional abundance. Complexity is defined here as the degree of equability among the range of habitat unit types expected for a given type of channel. The complexity of habitat units is an important indicator of the general fish habitat value of a reach. Diverse habitat types indicate the ability to support a diverse range and abundance of fish species and age classes. Since unit richness was in most cases static, the complexity index value is directly proportional to the equability of habitat unit types.

Habitat unit data was also graphed by unit category. The tally of units in each category were first standardised for comparison between reaches by dividing the unit tallies by the length of the reach (in metres). This yielded a "standard total #."

3. FHAP wood data analysis:

LWD tallies were used to determine ratios of functional to non-functional LWD, and pieces of functional LWD per bankfull width. These ratios give an indication of the role LWD plays in complexing the stream and creating diverse habitat.

4. FHAP channel data analysis:

Length of moderately to severely disturbed channel was calculated using the methods set out in the integrated CAP/FHAP field procedure (Mackay 1998).

5. FHAP design data analysis:

Median size of bed paving material, tractive force and bankfull discharge estimates were calculated for all reaches following procedures in Newbury and Gaboury (1993). The median size of bed paving material was estimated using the mean of the D_{50s} for each sample site within the reach. We estimated tractive force (τ) in kg/m^2 using the formula $\tau = d \times s$ where d is the depth of flow in metres and s is the slope of the water surface. Tractive force is an approximation for the diameter (cm) of the largest stone moved by flowing water (Newbury and Gaboury 1993). Bankfull discharge estimates were calculated based on Manning's equation. The roughness coefficient (Manning's n) at bankfull discharges was estimated using one of two methods. In cases where depth of flow was greater than three

times the median size of the bed paving material, we used Strickler's formula. In situations where depth of flow was less than three times the median size of the bed paving material, n was estimated based on the value calculated during base flows in conjunction with the field observations table in Gore (1996).

6. FHAP fish data analysis:

Age-class analysis and determination was conducted by generating fork length histograms based on class-widths of 0.5 to 1 cm. Age cohorts were determined by analysing peaks and distributions of classes, with the aid of Scott and Crossman (1973) and data from BCCF (1998; 1999) for the Bulkley River watershed. Densities (fish/m^2) by species were calculated for each habitat unit. Mean densities by species in each habitat unit category were determined by averaging the results of density calculations.

3.0 MASTER PLAN FOR REHABILITATION ACTIVITIES

The section has been copied, with minor revisions, from BCCF (1999) to ensure consistency between the central Bulkley, mid Bulkley and Morice river watershed assessments. The following comprises 1) a set of guiding principles for restoration and rehabilitation, 2) a synthesis of impact assessment results, 3) a classification of different areas by watershed position for the purpose of grouping restoration priorities, and 4) a set of physical and biological goals. For any given watershed, there are tens to thousands of sites which might exist outside of pre-disturbance conditions, and which could be considered for restoration. The purpose of this plan is to guide restoration priorities and timing, and to integrate individual restoration prescriptions with overall watershed-level goals.

3.1 Guiding Principles

The following set of eight guiding principles is drawn from the works of the Pacific Rivers Council (1996), Doppelt *et al.*(1993), Slaney and Zaldokas (1997), and Rhodes *et al.* (1994):

1) Passive restoration is the least expensive and often the most effective means of restoration, where the principal causes of impact are removed or altered so that they no longer cause an impact. The main cause of failure in active restoration projects is their implementation before the sources of disturbance have been addressed.
2) In some cases, passive restoration alone will not meet objectives, as a continued presence of physical or biological limitations may prevent complete recovery. In these cases, active restoration should proceed carefully. Projects should focus primarily on addressing the causes rather than the symptoms of degradation.
3) Instream habitat and biota are largely determined by processes occurring in the drainage basin; riparian and floodplain areas cannot be manipulated independent of this context.

4) Disturbances propagate downstream from headwater sources so that multiple sources can cause cumulative impacts. Therefore, restoration should proceed from the upslope areas to the floodplain, and the headwaters to the mainstem, where applicable.
5) Restoration should be focused where a minimal investment can influence the largest amount of high quality habitat and diversity of aquatic species. Recovery of heavily damaged will require decades to centuries. Restoration attempts in these areas are likely to prove unsuccessful in the short term (<10 years).
6) The current distribution and life history patterns of fish populations, largely governed by the nature and distribution of key habitat refuges (focal and nodal habitats) in the watershed, determine the ability of fish populations to respond to future changes in habitat. Therefore, focus should be placed on protecting these biological hotspots that are still functioning (functioning-at-risk). Restoration that first secures existing hotspots, then re-establishes similar and proximal habitat that requires little adjustment of life-history patterns, is most likely to provide the kinds of habitat critical to existing fish populations.
7) Aquatic habitat is patchy and highly variable in space and time. Fish life histories are adapted to these conditions. Restoration must not focus on producing generic or homogeneous conditions, but on producing spatial diversity and complexity.
8) Restoration must be based on natural templates and unique watershed conditions because they reflect an integration of watershed processes. This includes channel, upslope and riparian restoration, and should be mindful of how fish populations might have adapted to long-term natural disturbances (i.e. beavers).

3.2 Setting Restoration Priorities

Sub-watersheds and reaches were priorised subjectively based on a flow chart (Fig. 2) in conjunction with a decision table and risk assessment table (See section 5.0. Stream Rehabilitation Recommendations). Key flow chart criteria include biological values such as the habitat value classification of the reach (see below), the availability of refugia to re-colonise a reach once rehabilitation actions are taken, the potential of stream rehabilitation to increase numbers of primary target species (i.e. salmon), and potential risks due to uncontrollable (in the short-term) watershed processes -- e.g. low flows and water quality. Another key consideration was the level of impact to a reach or watershed. For instance, watersheds with significant widespread impacts were not seen as a top priority for rehabilitation due to the magnitude of the land use changes required to restore watershed processes.

Habitat value classifications were based on those developed by the Pacific Rivers Council (1996): Focal, Adjunct, Nodal, Contributing Area, or Lost Cause for either resident salmonids, anadromous salmonids, or both. These classifications are linked to the guiding principles outlined above. Definitions for these habitat classifications are as follows:

Focal Habitats (F): These are critical and productive keystone areas that support a diverse and abundant complement of salmonids and complex high quality habitats for multiple life stages. Position in the basin or downstream barriers may render these areas accessible only to resident species, but typically these areas can be important contributors to downstream areas as well. Focal habitats which support both resident and anadromous species are

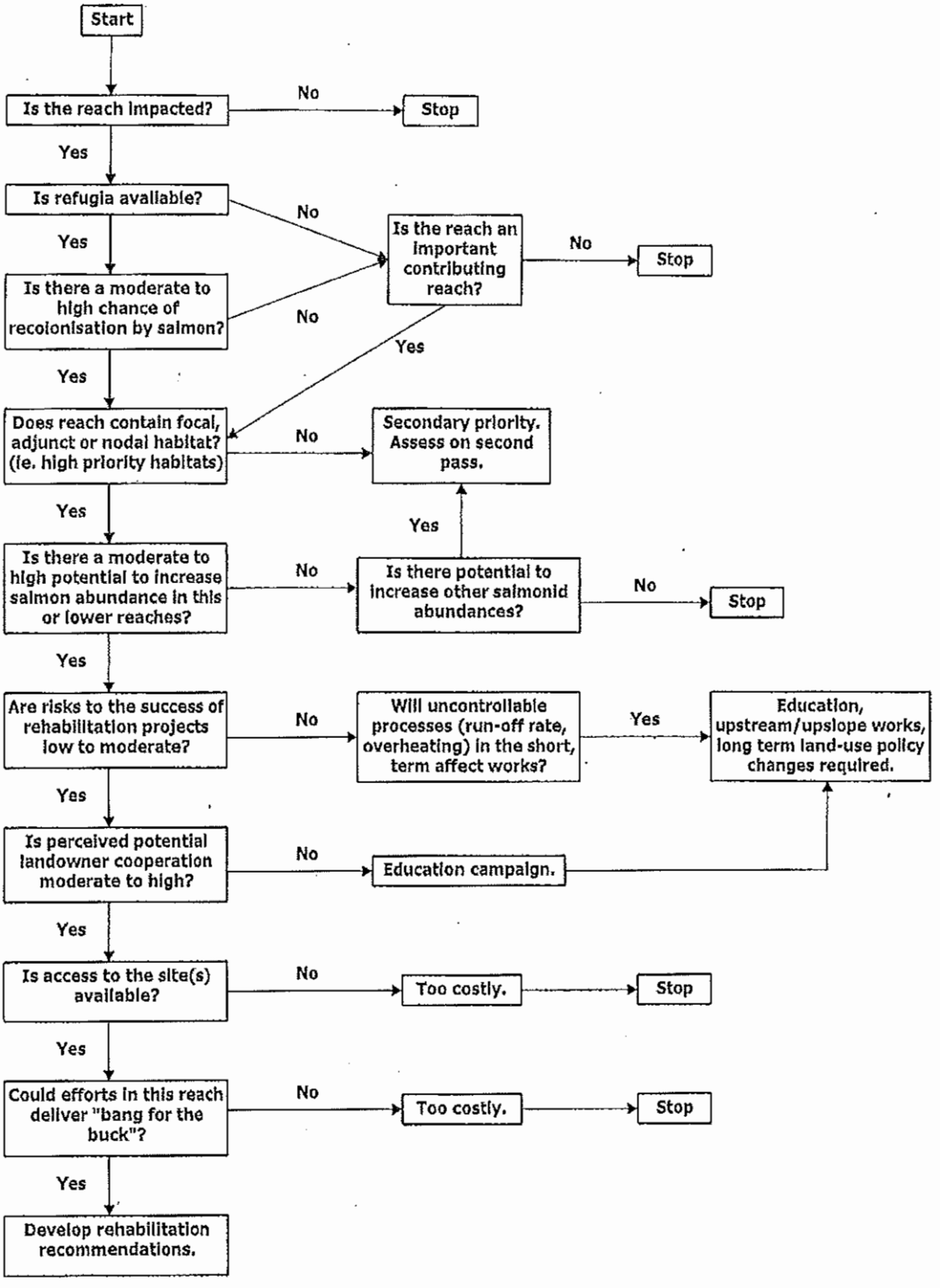


Figure 2: Decision process for determining priority reaches for rehabilitation.

particularly important in that they represent an ability to support a range of fish which overlap in their competition for habitat. These areas are a very high priority for restoration because they serve as areas from which fish will re-colonise other recovering areas, they are unusually productive and therefore are generally resilient, and they are not as highly impacted as adjacent habitats.

Adjunct Habitats (A): These are areas connected to focal habitats but which have been degraded by human activities or natural disturbances, and do not presently support a high diversity or abundance of salmonids. These areas are "functioning-at-risk". They may have some resiliency, but have been disturbed to the point where further impacts will soon lead to long term loss of ecosystem integrity. These areas are a high priority for restoration because they are physically buffered by adjacent focal habitats so that riparian and in-channel restoration stand a good chance of succeeding, the adjacent focal habitat is a good source of colonists so that biotic recovery will follow physical recovery, and because restoration in adjunct habitats can directly improve the connectivity, viability, and productivity of adjacent focal habitats.

Nodal Habitats (N): These areas are spatially separate from focal and adjunct habitats, but serve critical life-stage functions for focal/adjunct populations. They may be damaged by land-use, but still retain some of the values which support the salmonids. They are a high priority for restoration because they serve a critical function for one or more species, they are connected to other downstream areas, and they are generally productive.

Contributing Areas (CA): These areas do not support valuable habitat, but are important sources of high-quality water and stable conditions for downstream areas. These areas have a moderate priority for restoration in the context of this assessment.

Grubstake Habitats (G): These areas occur in low-elevation, heavily disturbed portions of basins. They may be expensive and require careful planning to restore, but the potential biotic benefits could be high because these areas historically supported productive populations of salmonids, particularly anadromous salmonids. These areas have generally been damaged more heavily, and will not be as biologically resilient as other areas. They have a moderate priority for restoration due to these factors, and because upstream restoration and recovery will be required before restoration here is feasible and has a higher probability of success.

Lost Cause Habitats (LC): These areas are heavily damaged, have low historic habitat value and contributing value, have confounding factors such as natural disturbances, and will be extremely expensive to rehabilitate. Passive restoration with moratoriums or extreme restrictions on land-use are the only cost-effective way that restoration will occur, and then probably not for decades or centuries. These are low priorities for restoration for obvious reasons.

4.0 RESULTS AND DISCUSSION

Northeast Tributaries to the Bulkley River

The streams along the northeastern side of the central Bulkley Valley have been heavily impacted by human activity in their lower reaches. These characteristically low gradient reaches in the valley bottom pass through extensive areas of private land. Agricultural activity has dominated the valley since settlement. Riparian vegetation has been cleared, creeks have been diverted or straightened, and wetlands have been ditched and drained to make way for hayfields and dairy and cattle farms. Water is removed from creeks under licence for irrigation, cattle watering and domestic use. Highway 16 and numerous rural roads cut through the area. The BC Hydro powerline and BC Gas pipeline cut across the southern part of the study area, prior crossing to the southwestern side of the valley north of Thompson Creek. Together these factors have modified the watershed processes, channel features and the fish habitat of each stream.

4.1 Robin Creek Watershed (460-487900)

The Robin Creek watershed is the second largest drainage we assessed. Robin Creek is fed by 15 tributaries (Triton 1997a) covering a catchment area of 90.6 km^2. Its source is "Moose Mountain" at an elevation of 1525 m a.s.l..

Virtually no historic information about fish or fish habitat exists for Robin Creek. Until our study, Triton (1997a) and BCCF (2000) have conducted the only fish distribution work on Robin Creek. Fish present in the watershed include rainbow trout, cutthroat trout, Dolly Varden char, coho salmon, chinook salmon, mountain whitefish (*Prosopium williamsoni*), lake chub (*Couesius plumbeus*), longnose dace (*Rhinichthys cataracae*), longnose sucker (*Catostomus catostomus*), northern squawfish (*Ptychocheilus oregonensis*) and lamprey (*Lampetra sp.*).

Approximately 50% of the land within this watershed is private. Primary land uses are agriculture and ranching. Approximately 500 head of cattle are raised on private land and on Crown range leases in the area (Pottinger Gaherty 1996). 17 water licences exist within the watershed (BC 1999c). The mainstem and 3 tributaries are spanned by Highway 16. Numerous secondary roads are present within the watershed.

We assessed the lower reaches of four major drainages in this system: Robin, Lemieux, de Jong and Vanderven creeks.

4.1.1 Robin Creek (460-487900)

Robin Creek is roughly 16 kilometres long (Fig. 4). The lower nine kilometres, spanning five and a half reaches, pass through private, primarily agricultural, land. Beyond this point, the stream gradient increases as the stream moves up the forested hillside.

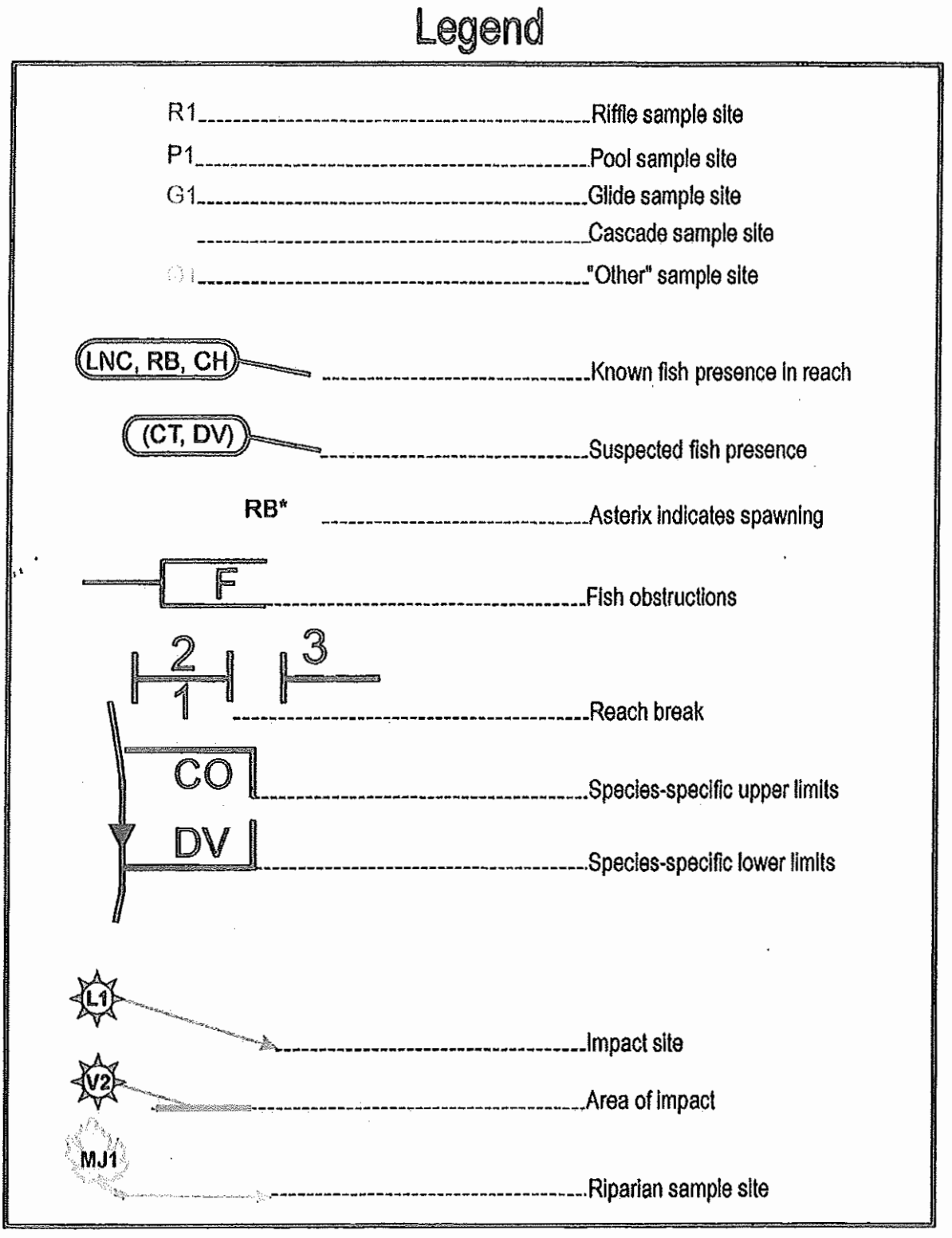


Figure 3. Legend for stream and reach maps.

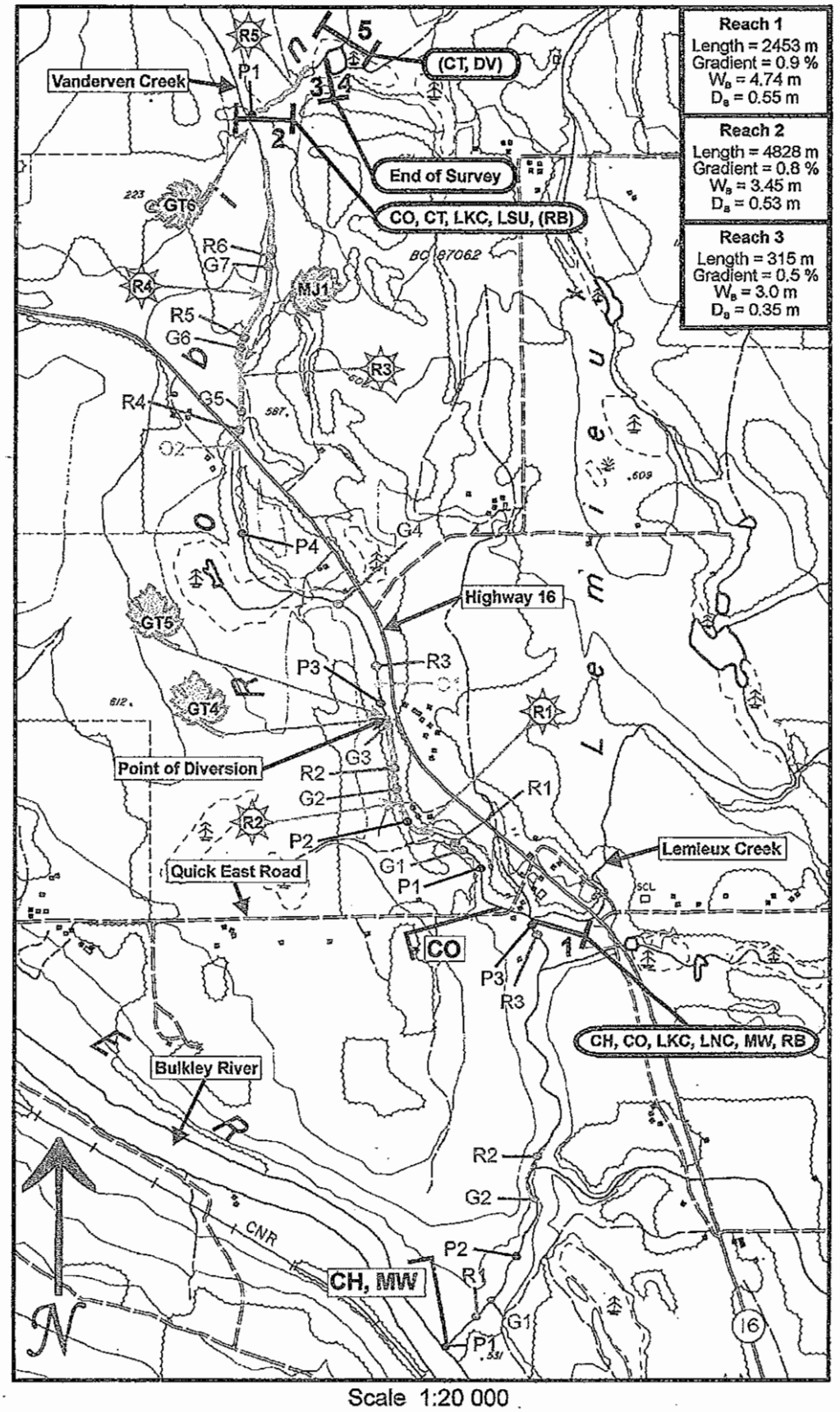


Figure 4. Map of Robin Creek showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.066 1:20 000.

Several species of salmonids use the mainstem portion of this watershed. We caught chinook salmon and mountain whitefish 10 metres upstream of the Bulkley River. These species probably use Robin Creek as a refuge from the Bulkley River. Coho salmon and rainbow trout were caught as far upstream as the Quick East Road bridge, 2.3 km upstream of the Bulkley River. Cutthroat trout have been captured as far upstream as the Upper Robin Creek Road (Triton 1997a). According to a local landowner, salmon used to reach a point above Highway 16 in reach 2.

Limited information exists on water quantity or quality for Robin Creek. No hydrometric stations or stream gauges are located on Robin Creek or anywhere in the entire Robin Creek drainage. However, the Ministry of Environment, Lands and Parks has measured discharge 17 times between 1964 and 1987. Minimum and maximum discharges recorded were 0.0001 m^3/s and 0.65 m^3/s, respectively (BC 1999b). Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. Five water licenses exist for Robin Creek. The two for domestic use and the two for stockwatering allocate a total of 4000 gallons (18.18 m^3) per day. The fifth license, for irrigation, allows 50 acre feet of water to be used annually (MELP 1999c). This amounts to approximately 514 m^3/day over a four month irrigation season. According to a local landowner, low flows are common and the creek dries-up during some summers. We found no water quality information for Robin Creek.

4.1.1.1 Reach 1

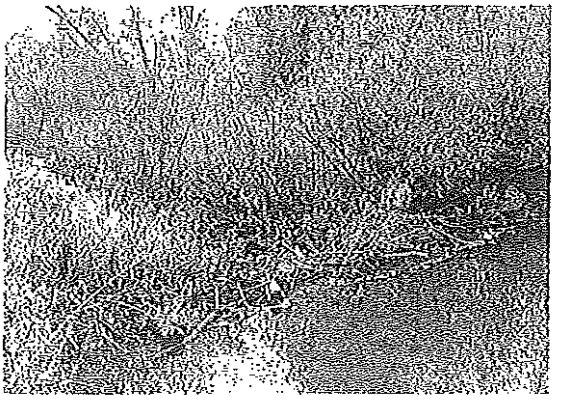
Length:	2453 m	Elevation:	530 – 551 m
Length assessed:	2453 m	Average gradient:	0.9%
Number of sites:	8	Mean W_b :	4.74 m
Number riparian plots:	0	Mean d_b:	0.55 m

Riparian Assessment

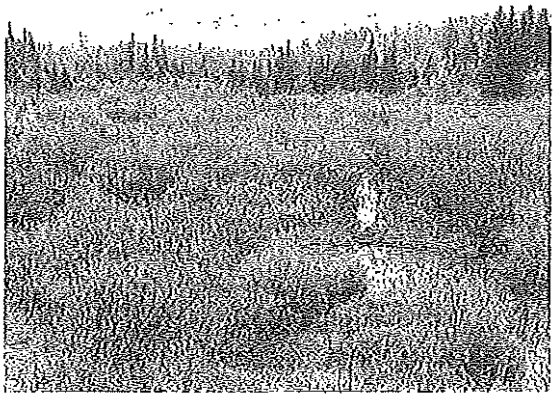
The riparian zone is intact through the majority of this reach. A hay field near the Bulkley River and cleared land near the reach break are the exceptions. Approximately 200 m of riparian vegetation has been cleared or thinned in these areas. For the majority of this low gradient reach, the riparian vegetation is a 100 m wide willow wetland confined between steep 20 m high hillsides (Fig. 5C). According to Haeussler (1998a), the site series is for this reach is SBSdk08 (Cottonwood – Dogwood – Prickly Rose). We did not sample any riparian polygons in this reach due to the relatively unimpacted nature of the riparian zone.

Figure 5. Robin Creek Reach 1: channel and riparian photos.

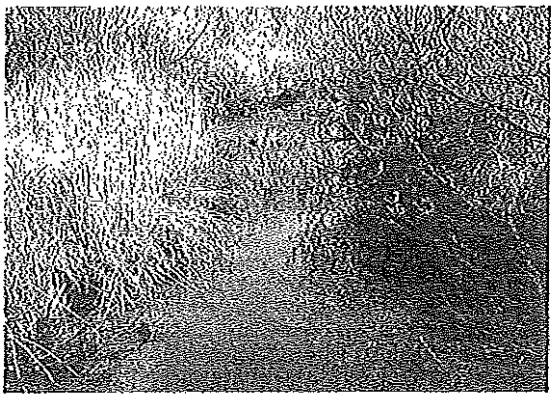
A: Upstream view of typical beaver pond habitat.



B: Downstream view of typical beaver pond habitat.



C: View of typical riparian vegetation on floodplain of stream.



D: Upstream view of glide near reach 1 and 2 break.

Channel Assessment

Reach 1 is a 2.4 kilometre long riffle-pool channel located between the Bulkley River and a point approximately 240 m downstream of the Quick East Road bridge (Fig. 4). LWD and beavers are the main channel forming and modifying factors. We observed numerous beaver dams from a point 355 m upstream of the Bulkley River to the reach break (Fig. 5A). During floods, water appears to be redirected by dams through the wetland. Channel banks are generally composed of erodible fine sediments with some areas of fines mixed with gravel or cobble.

The channel throughout this reach was slightly disturbed. Areas of partial aggradation were present between relatively stable sections. We observed no areas of moderately or severely impacted channel Signs of sedimentation including sediment wedges, sediment fingers and homogenous substrate (fines) were common, as were multiple channels. Accumulated small woody debris was observed in the upper half of the reach. A two metre diameter flat-bottomed culvert is located at a farm road crossing 255 m upstream of the Bulkley River. This culvert may become perched when a debris jam downstream washes out. Near the culvert, we observed a beaver that had been shot.

Fish and Fish Habitat Assessment

Reach 1 contains important habitat for resident and anadromous fish. It offers refuge from the Bulkley River, has a low gradient, plenty of cover, and a range of habitat types. Habitat complexity is high (3.65) (Table 4c). A chinook salmon (0+ age class) and a mountain whitefish fry were caught in the first pool of the reach, approximately 10 m upstream of the confluence with the Bulkley River. These species were not caught elsewhere in the system, suggesting that they move in and out of the Bulkley River, but do not utilise this reach to any extent. The rainbow trout we captured (0+ and 2+ age class) were also limited to the extreme lower end of the reach. Triton (1997a), however, caught rainbow trout much higher in the system in Lemieux Creek. Thus, although rainbow trout are present in the watershed, their densities are low (Table 4b). Coho salmon (0+/1+), caught throughout the reach, were the most abundant fish, likely due to the plentiful rearing and overwintering habitat. Pools, glides and slow water behind beaver dams (classified as "others") made up approximately 80% of this reach. Coho densities decrease with upstream distance, likely due to the difficulty of upstream migration for both adults and juveniles posed by the large number of beaver dams. Non-target fish species in this reach included longnose dace and lamprey.

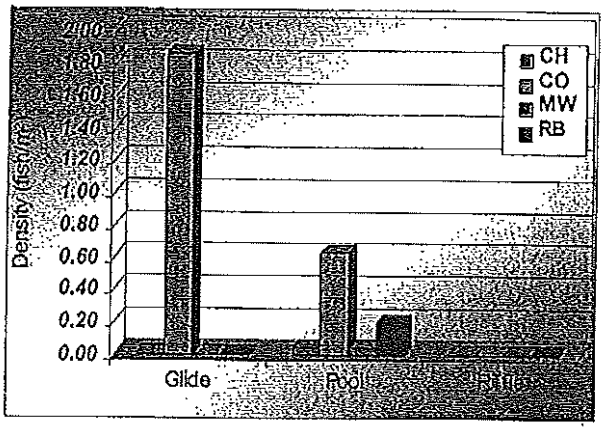
Cover consisted primarily of large and small woody debris and overhanging willows. Willows dominated the riparian area, but provided little canopy closure (~20%). Large woody debris (LWD) was relatively rare (0.16 pieces per bankful width (W_b)), 20% of which was functional, most of it small (10-20 cm wide) (Table 4a). Future LWD recruitment will be low due to the wetland nature of the riparian zone and lack of trees along the creek for many kilometres upstream.

Table 4. Summary of channel and fish habitat field data for Robin Creek, reach 1.

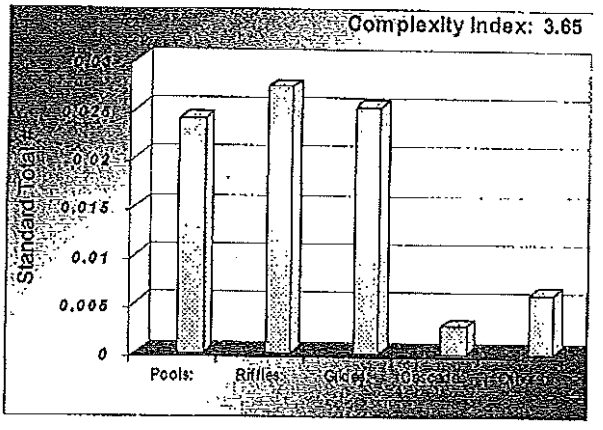
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	305	116	13	437
# Functional Pieces	43	34	9	86
# Func. Pieces / Bankful width	0.08	0.07	0.02	0.16
% Functional	14	29	69	20

b) Density of salmonids in glides, pools and riffles.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	C, G	C, S	H	AR	L	C, LWD, OV	0-20
Pool	S	S	M	AR	N	OV, SWD	0-20
Riffle	G	C	M	AR	L	OV, LWD	20-40

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
6.13	0.05	0.25	0.68	1.78	4.87

Spawning habitat is of low to moderate quality in this reach for both anadromous and resident fish. Riffles, although the most common unit, make up greater than 20% of this reach by area. Gravel was the dominant substrate in riffles and co-dominant in glides. The majority of the substrate through the reach though was fines. Access to spawning habitat is limited in some years by numerous beaver dams.

Impact synopsis

Land use upstream of this reach has not significantly damaged fish habitat. A healthy riparian zone consisting of willows and numerous beaver dams keeps the channel relatively stable (Fig. 5). Erosion upstream has likely contributed to the large amount of fine substrates in this reach. However, most of these materials are trapped behind beaver dams. High temperatures are a concern as little shading is present throughout a large part of the watershed.

Restoration suggestions

No restoration is suggested for this reach.

4.1.1.2 Reach 2

Length:	4828 m	Elevation:	551 – 604 m
Length assessed:	4828 m	Average gradient:	0.8%
Number of sites:	19	Mean W_b :	3.45 m
Number riparian plots:	3	Mean d_b:	0.53 m

Riparian Assessment

The riparian zone in reach 2 of Robin Creek has been heavily impacted. Vegetation along 80% of the creek has been cleared for agriculture and cattle grazing. Narrow bands of willow and grasses remain in some areas. We identified three sites for riparian plots (Fig. 4). Due to the absence of natural vegetation on the cleared land, each site was chosen in a relatively undisturbed area adjacent to the cleared land:

Assessment site GT4

Site series: SBSdk01a
Seral association: At-Hardhack

We chose this site for assessment as a surrogate for the cleared slopes found directly downstream for 400 metres. Although this is one of the few sites along reach 2 which is currently not utilised for agriculture, it is at a young seral stage due to previous clearing. The 3.99 m plot was 35 m from the main stream channel and 15 metres from the floodplain. Aspect was east and slope was 5%. The stocking survey found 12,400 closely spaced aspen saplings per hectare with an average height of six metres. No other trees were present. In the

understory, hardhack (*Spiraea douglasii spp. menziesii*), black twinberry (*Lonicera involucrata*), fireweed (*Epilobium angustifolium*) and grasses dominated the site. A species list is found in Appendix E. Due to the age of this stand and its distance from the creek, current levels of functioning in all aspects except surface sediment filtering are low (Table 5). Due to its distance from the creek, this site will likely not contribute substantial LWD to the stream for well over a century until conifers establish on site and mature and grow to heights exceeding 40 metres. No recent disturbances were noted.

Table 5. Riparian function summary for riparian plot GT4.

Function	Rating	Comments
LWD	L	No mature trees, all aspen saplings.
Shade	L	No mature forest.
Small organic debris (SOD)	L	Upslope site 30 to 40 m from channel.
Surf. Sed. Filter	M	Dense herb layer, 70% grass cover.
Channel stability	L	Site 30 to 40 m from channel.
Bank stability	L	Site 30 to 40 m from channel.

We dug a soil pit to a depth of 50 cm. The soil great group was Grey-Brown Luvisol. Layers to a depth of 50 cm were as follows: a 10 cm thick moder humus, an 8 cm thick Ah layer composed of silty clay and a Bt layer of hard clay. Based on descriptions contained in Banner *et al.* (1993) and Oikos and Klinka (1999), this site is the Aspen – Hardhack seral association of the Spruce-Spirea-Purple peavine (SBSdk01a) site series.

Site assessment GT5

Site series: SBSdk32
Seral association: Drummond's Willow-Blue Joint.

Riparian plot 5 is located on the floodplain within 50 metres of plot 4. We chose this site to determine the site series for the immediate streamside area cleared directly downstream for 800 metres. The edge of this 3.99 m radius plot is within 3 metres of the west side of the stream channel, fully within the 20 metre riparian reserve zone. The slope in this location was 0%. This site was a willow wetland which contained multiple channels at high flows. No trees were present. Drummond's willow (*Salix drummondiana*) to a height of 2.5 m covered 75% of the site. A species list is found in Appendix E. This type of site is not well characterised in Banner *et al.* (1993); the only described site series approximating this site was a non-forested fen/marsh (SBSdk32). Based on descriptions in Oikos and Klinka (1999) and a discussion with Mackenzie (pers. comm.), the site association is Drummond's willow – Blue joint. This seral association is representative of the natural vegetation in the lower half of this reach judging by the presence of a willow wetland at the downstream end of the reach, more willow wetland upstream and gleyed soils observed in the eroding banks downstream. The riparian zone at this site is functioning well except as a source of LWD (Table 6.).

Table 6. Riparian function summary for riparian plot GT5.

Function	Rating	Comments
LWD	L	No trees – willow wetland
Shade	M	Low overhanging willows - canopy closure is ~ 20%
Small organic debris (SOD)	M	Overhanging willows
Surf. Sed. Filter	H	Ground is virtually fully vegetated
Channel stability	M	Channel is down cutting – degraded
Bank stability	H	Rooted willows holding bank in place

This site has wet soil which is periodically flooded. The soil great group was Gleysol. Layers in the soil test pit to a depth of 60 cm were as follows: a 10 cm thick moder humus underlain by a Bg layer of silty clay with reddish brown mottling. No course material or sand was noted in the pit.

Site assessment MJ1

Site series: SBSdk01a

Riparian plot MJ1 was located 400 metres upstream of the Highway 16 culvert (Fig. 4). We chose this site for assessment to determine the level of functioning of the relatively unimpacted vegetation along the 5-10 m high slopes within the riparian management area of this part of reach 2. The flat areas at the base of the slope, alongside the stream have been cleared for hay production. The 11.28 m radius plot was located on a relatively undisturbed 14% slope with a west aspect and came within 7 m of the creek. The stocking survey found 575 stems per hectare (sph) of spruce and 2275 sph of aspen. The two largest spruce within the plot were about 15 m tall with a dbh of greater than 22 cm. Few of the aspen within the plot were mature. Four were greater than 12.6 cm dbh with the tallest being 18 m. 70% of the aspen were saplings about 3 m tall. A species list is found in Appendix E. Current stocking density is high. This site will experience self thinning as the trees grow. We observed signs of grazing within the plot and an old grassed-in road runs between the plot and the creek. A summary of the level of riparian function of this site is found in Table 7.

Table 7. Riparian function summary for riparian plot MJ1.

Function	Rating	Comments
LWD	M	LWD function should improve with age of forest
Shade	L	Most trees in site are short. Should increase with age.
Small organic debris (SOD)	M	
Surf. Sed. Filter	M	Some exposed soil
Channel stability	L	7 m from creek edge
Bank stability	L	7 m from creek edge

We dug a soil pit to a depth of 60 cm. The soil great group was Grey Luvisol. A 14 cm mor humus layer overlaid a Bt layer of clay. Coarse fragments composed approximately 1% of the mineral soil.

Site assessment GT6

Site series: SBSdk07b

Riparian plot GT6 was located 50 m downstream of the confluence of Vanderven Creek and Robin Creek (reach break 2/3) (Fig. 4). We chose this site to determine the site series for the impacted riparian zone on Vanderven Creek. The edge of this 3.99 m radius plot was within several metres of the of the stream on a floodplain. The only trees present were 10-12 m tall Bebb's willows (*Salix bebbiana* – tentative identification). Black twinberry was the dominant shrub at this site covering 45% of the plot. A species list is found in Appendix E. As a non-treed site, the site is not well described in Banner *et al.* (1993). The site series is a seral stage of the Spruce - Horsetail poorly drained phase (SBSdk07b). This may have been the site series for reach 1 of Vanderven Creek prior to land clearing. However, the stream has down-cut 1.5 to 2 m through a large part of the property, significantly decreasing soil moistures and bank overflow.

We observed weathered signs of beaver activity at this site, indicating that beavers likely played a role in stream morphology in the past. Evidence of cattle walking through the site exists, but impacts are minimal. Some trees were cut at this site years ago. Currently, the riparian zone at site GT6 is functioning well except as a source of LWD (Table 8). The hillsides near the creek are a source of LWD.

Table 8. Riparian function summary for riparian plot GT6.

Function	Rating	Comments
LWD	L	Large willows are the only source of LWD
Shade	M	Thick willows overhang part of creek.
Small organic debris (SOD)	H	Overhanging willows
Surf. Sed. Filter	H	Site is fully vegetated apart from a seldom used cattle trail.
Channel stability	M	Channel is aggrading due to upstream bank erosion; willows help remove water energy gained in the straightened section of Vanderven Creek.
Bank stability	M	Willows provide good network of roots.

The soils at this site are wet. We located groundwater at a depth of 60 cm. The soil great group was Luvic Gleysol. A very thin (1-2 cm) mull humus layer overlaid a 15 cm clay loam Ah layer, a thin (7cm) silty clay loam and a 27 cm thick silty clay Bg layer. A sandy loam containing 60% angular to subround gravel to 4 cm was observed at a depth of 50cm.

Channel Assessment

Reach 2 is a 4.8 km long riffle-pool channel located between the Quick East Road bridge (elev. 551 m a.s.l.) and a point 1.3 km north of the Highway 16 culvert (604 m a.s.l.) (Fig. 4). Much of this reach has been modified by agricultural practices. Historically, beavers have

been active in this reach, but currently are not present except near reach 1. Channel banks are composed of erodible fine sediments.

This reach is moderately to severely disturbed by landowners. It was ranked 18th of 73 reaches based on the decision matrix used in the overview assessment (Appendix A). Large sections of the stream have been straightened and channelised (Fig. 6C). Areas of severe down-cutting and bank erosion are present, particularly in the first third of the reach (Fig. 6A) and 41% of the channel was moderately aggraded or degraded. The most common signs of disturbance include minimal pool area, lack of LWD, multiple channels and eroded banks. Cattle have access to some areas of the reach. Trampling of banks which have been stripped of riparian vegetation is contributing the erosion.

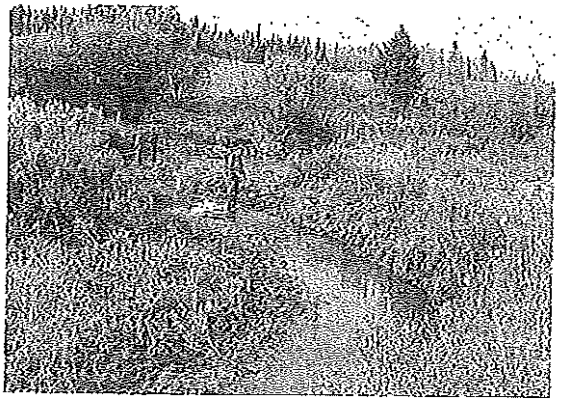
A number of localised impacts or concerns are present on this reach. A box culvert on a driveway located 976 m upstream of the reach break is undersized (Meredith pers. comm.), but is not a barrier to fish migration. 1360 m upstream of reach 1 (just upstream of site G3) (Figure 4), the stream has been diverted, perhaps by a former beaver dam, and has incised a new straight, down-cut channel with 1.5 to 2.0 m high banks through agricultural land. The 250 m long previous meandering channel among thick willows lies unused approximately 10 m to the east of the new channel. 650 m upstream of the Highway 16 culvert, the creek is forded by a bulldozed road which provides access to the field on the west bank (Figs. 6D and 6E). This widened and shallow crossing is a source of fine sediments during use and during rain events. A second ford is present 620 m further upstream. This is also a source of sediment, but appears to be used infrequently. Water in the upper part of this reach was turbid.

Fish and Fish Habitat Assessment

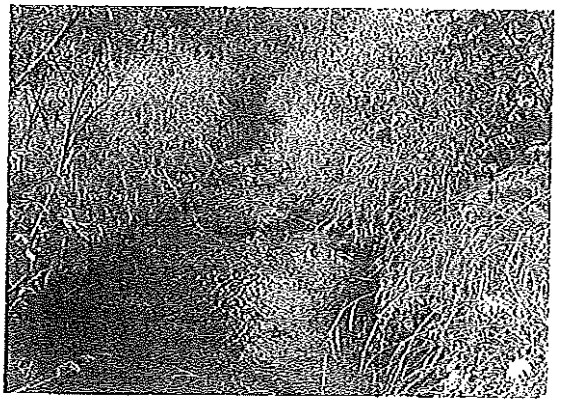
Reach 2 contains poor habitat for salmonids through much of its length. Areas in which riparian vegetation has been stripped and the channel straightened contain little habitat. Where the stream meanders and riparian vegetation still exists (wetland willows), there is fair to moderate rearing habitat, but only localised areas of spawning habitat. Glides with fine substrate materials dominate these wetland areas.

This reach harboured fewer fish species and lower fish densities than reach 1. Lamprey and lake chub were the most common fish caught. The presence of these fish in relative abundance along with the two longnose suckers captured, indicated generally poor quality salmonid habitat. Coho salmon (1+) were caught as far upstream as the pond at the Quick East Road bridge. Coho are likely present throughout the willow wetland to a point about 300 m upstream of the bridge. Local landowners indicated that adult cutthroat trout to 25 cm are caught angling from the bridge. We verified the presence of adult resident cutthroat trout in this reach when we caught a 26 cm fish at site G4, one of the few gravel / cobble sections of the creek. This fish likely resides in a large pond and wetland complex and refuge approximately 150m upstream. We observed many fish surfacing in this pond which is the only overwintering habitat in this reach. In future studies, traps should be set in this pond to determine if coho travel through the impacted channel downstream. A local landowner mentioned that adult salmon migrated upstream of the Highway 16 culvert years ago, but no longer do.

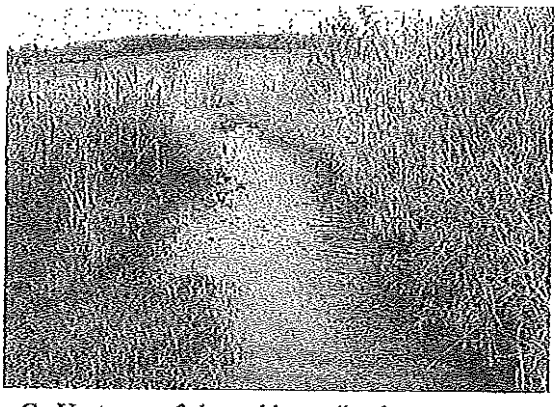
Figure 6. Robin Creek Reach 2: channel, riparian and impact photos.



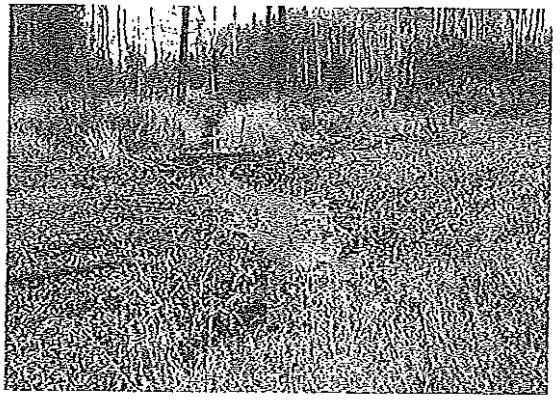
A: Upstream view of typical channel and riparian vegetation on agricultural and residential land at 0+990 m.



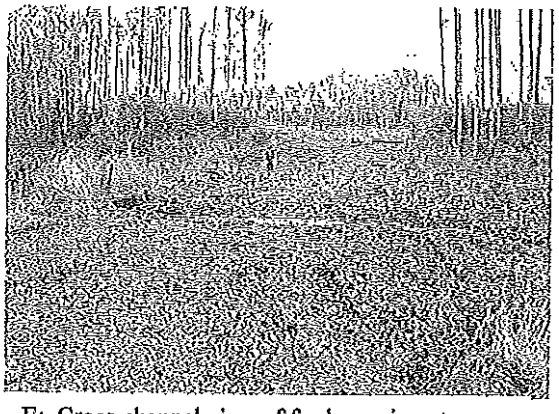
B: Upstream view of typical channel and riparian habitat at 2+138m.



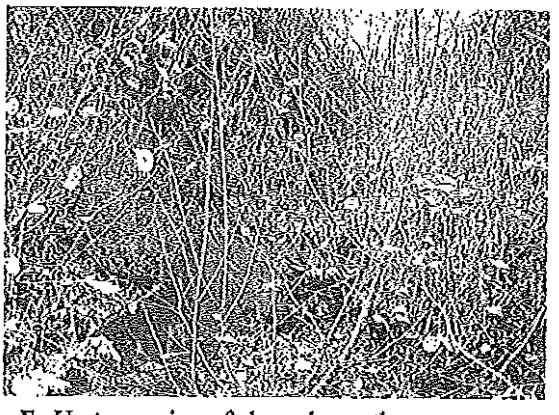
C: Upstream of channel immediately upstream of Highway 16. Note the lack of riparian trees and shrubs.



D: Upstream view of ford crossing at 3+944 m.



E: Cross-channel view of ford crossing at 3+944 m.



F: Upstream view of channel near the upper reach break. Note the dense riparian shrub cover.

Cover consisted primarily of overhanging vegetation, which, of course, was limited to the areas of the creek with riparian vegetation. Where willows dominated the riparian area, canopy closure approached 80-90%. However, a significant portion of the reach had no canopy. Large woody debris was rare (0.09 pieces per W_b), with 60% being less than 20 cm in width (Table 9a). 40 percent of the LWD was functional. Future recruitment will be limited to areas where the creek approaches aspen and spruce stands in the middle and upper sections of the reach. Farmers currently remove any LWD in the channels on their properties.

Spawning habitat is relatively rare and of fair to moderate quality for resident and anadromous salmonids throughout most of the reach. Riffles, comprising approximately 25% of the habitat in the reach, occur primarily in straightened sections of the channels. Gravel was the dominant substrate in riffles. The less disturbed sections of the reach are characterised by glides and "others" (wetlands and ponds) with fine substrates. Pools comprise only 12% of the stream by area and occur infrequently approximately every 17 bankful widths. The rarity of pools and cascades lead to a relatively low complexity index of 3.14 (Table 9b).

This reach provides habitat to other animals in addition to fish. We observed a western toad in this reach. Otters and ducks have been spotted in the creek by local landowners.

Impact synopsis

Reach 2 is one of the most impacted reaches assessed in our study. Of particular concern are the impacts to channel morphology, the perpetuation of channel disturbance and sedimentation due to extensive clearing of riparian vegetation, creek channelisation, fords and cattle use in both this reach and upstream reaches. Specific impacts include severe down-cutting and bank erosion. High water temperatures are also a concern due to lack of riparian vegetation within this reach and upstream.

Restoration suggestions

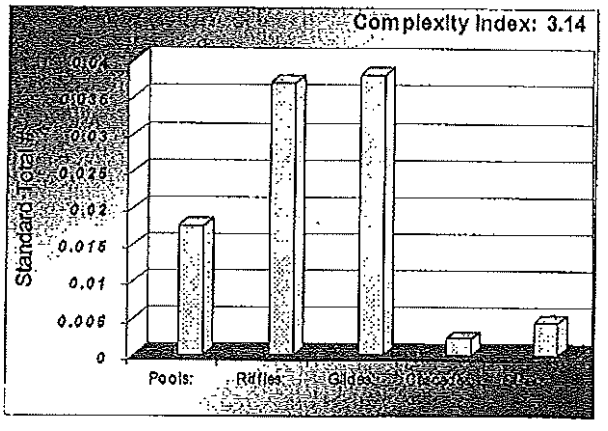
- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible without access to Crown range).
- Prevent bank erosion -- construct riffle structures, bioengineer bank stability structures (wattles, brush mattresses, etc.), re-contour banks. The costs may outweigh the benefits for these options.
- Ensure regeneration of riparian plant communities to shade the stream and introduce LWD, SWD and SOD. Planting may need to be done.
- Re-establish historical channel at 1+360 m. -- willows in the old channel may have to be pruned out prior to diversion.
- Replace existing box culvert at 0+976 m.
- Replace ford at 3+944 m with a culvert, bridge or geoweb crossing.

Table 9. Summary of channel and fish habitat field data for Robin Creek, reach 2.

a) LWD summary.

	Small (10-19cm)	Medium (20-49cm)	Large (>50cm)	Total
Total # Pieces	232	94	6	332
# Functional Pieces	77	49	4	130
# Func. Pieces / Bankful width	0.05	0.03	0.003	0.09
% Functional	33	52	67	39

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	G	C	M	AR	N	OV, C	0-20
Other	S	S	L	AR	N	OV, DP	0-20
Pool	S	S	L	AR	N	OV, C	0-20
Riffle	G	S	M	AR	H	IV, OV	0-20

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
3.68	0.05	0.23	0.68	1.22	4.26

4.1.1.3 Reach 3

Length:	400	Elevation:	604 - 611 m
Length assessed:	315	Average gradient:	0.5%
Number of sites:	1	Mean W_b :	3.0 m
Number riparian plots:	0	Mean d_b:	0.35 m

Riparian Assessment

The riparian zone in this reach is virtually non-existent. Approximately 90% has been impacted. The exception is the initial 50 m which shares the characteristics of the upper part of reach 2. In the spring of 1999, a 200 m stretch of the ditch Robin Creek flows through was widened and deepened by the landowner to prevent flooding. In the widening process, the few willows along the north bank were removed. A sparse band of willows still exists on the south bank along a fence. Reach 3, sourced in a large willow wetland with a pond (Reach 4), was channelised many years ago. Fields fringe both banks of the creek. We did not sample any riparian plots in this reach because we are assuming the site series is the same as GT6 (Site series: SBSdk07b).

Channel Assessment

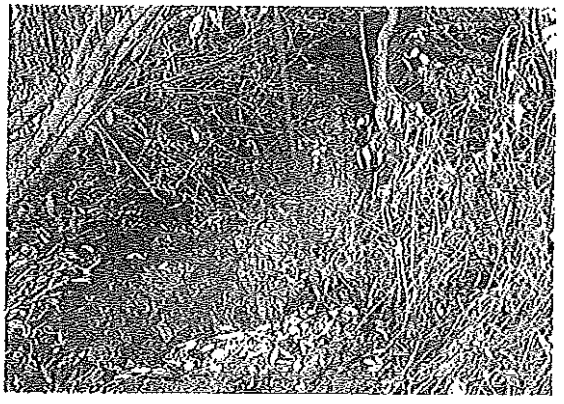
Reach 3 is a 400 metre long riffle-pool channel located approximately 1.3 km north of the Highway 16 culvert (604 m a.s.l.). This reach was channelised years ago for drainage purposes and was cleared of vegetation with an excavator in the spring of 1999. Channel banks, composed of erodible fine sediments, are steep and approximately 1 m high.

This reach is severely disturbed. Although this reach was ranked 29th of 73 reaches in the overview assessment (Appendix A), it is one of the most impacted reaches in the entire study area, primarily due to excavation through most of its short length. Only 7 pieces of LWD were noted, all in the initial 50 m of the reach within the wetland area. Banks had not begun to erode noticeably, but were a source of sediments. The water was turbid. Cattle use the lower section of the reach creek to water (Fig. 7C). This watering area is also a source of sediment to the stream.

Fish and Fish Habitat Assessment

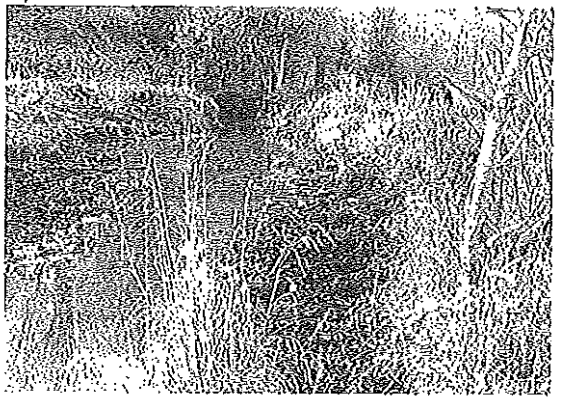
Reach 3 contains poor habitat for salmonids. In the one site we sampled, no fish were caught. No fish were observed in this reach. Cover and canopy were absent from most of the site, with the exception of the downstream 50 m of the reach and near reach 2. As noted above, LWD had been removed from most of the channel. The only source of future recruitment in the majority of the reach is the upstream wetland. Stream complexity was extremely low (complexity index of 2.51) (Table 10b), with pools and glides being the only habitat units present though much of the reach. Spawning habitat was not present in this reach. The stream bed had a homogenous texture of low compaction silts and clays.

Figure 7. Robin Creek Reach 3: channel, riparian and impact photos.



A: Upstream view of typical channel and riparian vegetation immediately upstream of the reach break.

B: Downstream view of ditched channel. Note the lack of riparian shrubs and trees.



C: Downstream view of ditched channel used as a watering area by cattle.

D: View of stream bank at 0+155 m showing the removal of soil and riparian shrubs.

Reach 4, appears to contain some moderate to good rearing and overwintering habitat. The large, relatively deep pond at the reach 3/4 break appeared to be good habitat. This pond is likely critical during low flows and in the winter and may be a refuge. Reach 4 was not assessed.

Impact synopsis

Reach 3 is one of the most impacted reaches assessed in our study. This reach was converted to a ditch years ago and was widened again in the spring of 1999. It contains virtually no natural habitat or cover. The newly excavated banks and a cattle watering area are a source of sediment to downstream reaches. Bank erosion will likely not be severe in the future because of the moderating effect on stream energy of the wetland directly upstream in reach 4. High water temperatures are also a concern due to lack of riparian vegetation within this reach and upstream.

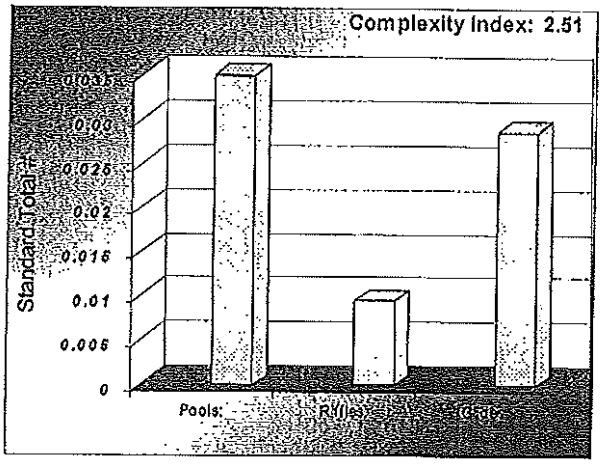
Restoration suggestions

- Work with the landowner to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream.
- Re-establish riparian vegetation to stabilise banks, while addressing flooding concerns. Pruning shrubs whose branches or trunks cause jams may be an option.

Table 10. Summary of channel and fish habitat field data for Robin Creek, reach 3.
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	7	0	0	7
# Functional Pieces	4	0	0	0
# Func. Pieces / Bankful width	0.04	0	0	0.04
% Functional	57	0	0	57

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Pool	S	S	L	AR	N	OV, C	90-100

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
1.00	0.03	0.16	0.76	0.08	1.75

4.1.2 Lemieux Creek (460-487900-11100)

Lemieux Creek discharges to a large wetland and beaver dam complex in Robin Creek, approximately 80 metres downstream from the Quick East Road bridge (Fig. 8). This 14.5 km long stream is the largest tributary to Robin Creek, draining approximately 30 km^2, or 1/3 of the Robin Creek watershed. The headwaters include sub-alpine ponds near the summit of "Moose Mountain." Lemieux Creek is composed of eight reaches (Triton 1997a). Most of the lower 9 km of the creek (reaches 1 through 5) pass through residential and agricultural properties. Forest harvesting is evident in the upper sections of reach 5. Reaches 6 through 8 are on Crown land.

We assessed 8.5 km of Lemieux Creek, encompassing reaches 1, 3 and 5. Reach 1 originates in a 3 ha pond and ends at Robin Creek. Reach 3 is a short reach connecting this pond to a small wetland and beaver pond complex upstream. Reach 5 is a transitional reach from the valley bottom to the higher gradient reaches draining "Moose Mountain." Reaches 2 and 4 are small ponds and wetlands and were not assessed during this study. We did not assess reaches 6 through 8 due to the lower degree of human impact compared with the downstream reaches.

Fish distribution in the Lemieux Creek watershed has been determined over the past three years (Tamblyn and Haines 2000; Triton 1997a). Fish have been caught as far upstream as the access road to the woodlot at the end of Morden Road, in a tributary 600m upstream of the mid part of reach 5. Cutthroat trout, rainbow trout, and Dolly Varden char were caught at this location (Triton 1997a). Coho salmon and rainbow trout were the only salmonids captured in our study. Non-target species present in the system include northern squawfish, suckers (Triton 1997a) and lake chub. Low water temperatures precluded the use of electrofishers in reaches 3 and 5. Instead, we set minnow traps in suitable locations, but caught no fish. Cutthroat trout and fish tentatively identified as Dolly Varden were observed in several locations in reach 5. The tentative identification of these fish was based on apparent spawning behaviour and the white leading edges of their pelvic and pectoral fins. A local landowner mentioned that when Lemieux Creek dries up in the summer (reach 5), fish are stranded and die.

Limited information exists on water quantity or quality for Lemieux Creek. No hydrometric stations or stream gauges are located on Lemieux Creek or anywhere in the entire Robin Creek drainage. However, the Ministry of Environment, Lands and Parks has measured discharge 3 times between 1977 and 1987. Minimum and maximum discharges recorded were 0.02 m^3/s and 1.66 m^3/s, respectively (BC 1999b). We do not know the location of these measurements. Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. Seven water licenses exist for Lemieux Creek: five irrigation and two domestic. The allocation for irrigation comprises the largest portion of the potential water withdrawal with a total of 221 acre feet annually (2270 m^3/day assuming a four month irrigation season) (BC 1999c). The total allocated for domestic use is 1500 gallons (6.8 m^3) per day. No water quality information was found for Lemieux Creek.

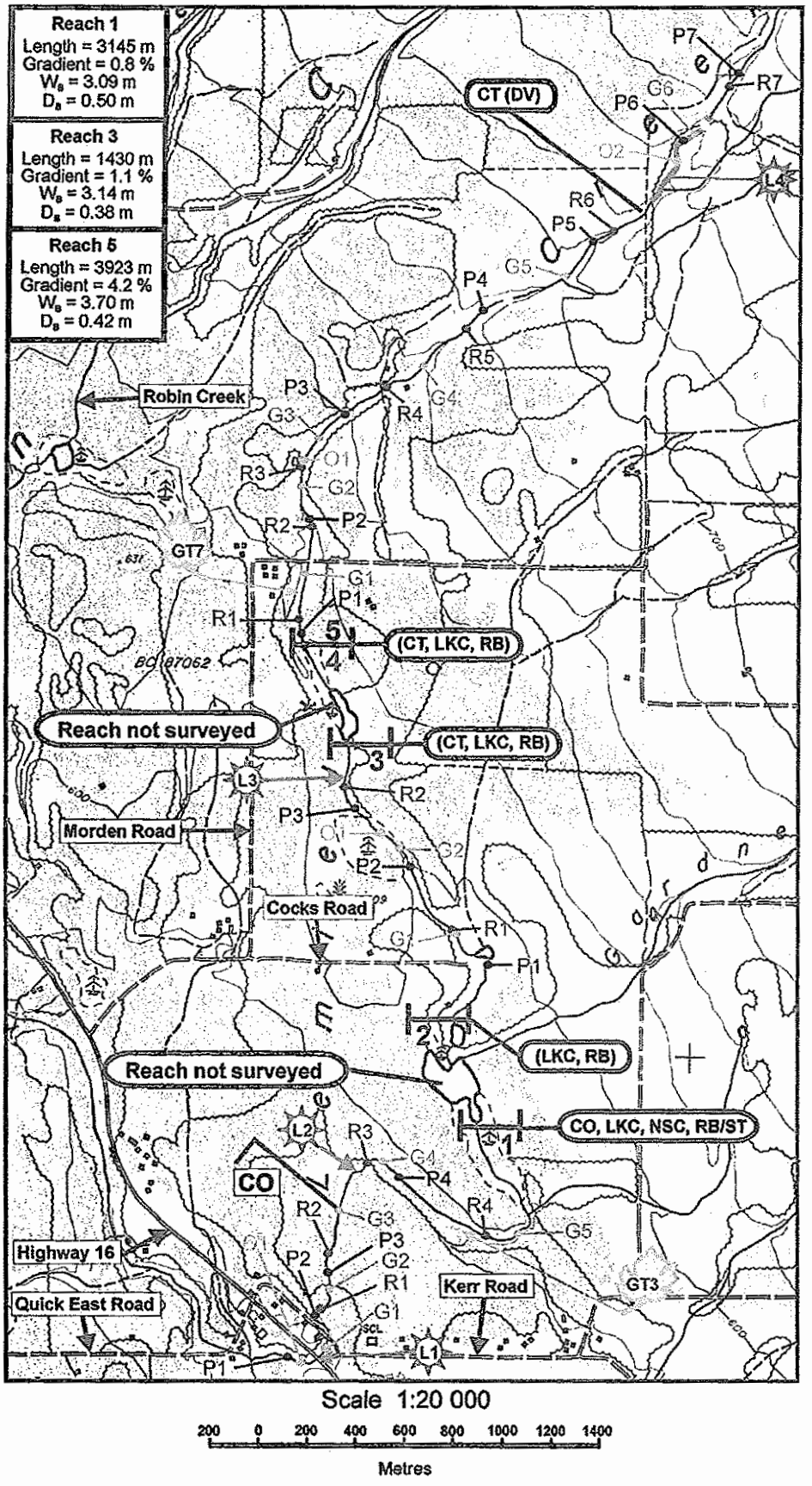


Figure 8. Map of Lemieux Creek showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.066 1:20 000.

4.1.2.1 Reach 1

Length:	2663 m	Elevation:	551 – 582 m
Length assessed:	2663 m	Average gradient:	0.8%
Number of sites:	14	Mean W_b :	3.09 m
Number riparian plots:	1	Mean d_b:	0.50 m

Riparian Assessment

The riparian zone of this reach has seen impacts from a variety of sources. Although much of the land has been cleared for agriculture and residential properties, some of the worst impacts are due to livestock grazing and watering. We observed impacts on the riparian zone along the entire reach. In the large wetland downstream of the Highway 16 culvert, mature trees have been removed for livestock grazing or future land development. Some of the debris has been piled in a windrow adjacent to a small back channel. The present riparian area is dominated by willows and red-osier dogwood (*Cornus stolonifera*) with prickly rose (*Rosa acicularis*) on the drier slopes. Upstream of the highway crossing, the riparian zone has been cleared for residential houses on the right bank and for hayfields on the left. Upstream of the Quick School Road (located 541 m upstream from Robin Creek), the riparian zone has been affected by agriculture. In several places, the riparian shrubs and trees have been completely removed. Along much of the rest of the channel, the growth of riparian vegetation is limited to the five metre wide windrows of cleared debris piled alongside the channel. The channel shows signs of instability due in part to the lack of roots in the banks and increased flows from accelerated run off. One riparian plot was chosen to approximate the typical vegetation that would occur along this reach if it were in a natural condition.

Assessment site GT3

Site series: SBSdk06
Seral association: At-Purple peavine-Canada Violet

We chose this site for assessment as a surrogate for the cleared slopes along much of this reach. This is one of the few sites along reach 1 which is not currently utilised for agriculture. The centre of this plot was roughly 25 m from the left bank of the stream. Aspect was northeast and slope was 8%. We located the 3.99 m radius plot in a representative area within the young forest at this site. The overstory consisted solely of aspen. The stocking survey found 4200 stems of aspen per hectare, 76% of which were saplings with a dbh less than 7.4 cm. The number of large trees increased with distance from the creek. Our plot contained 2 trees with a dbh greater than 22 cm (400 sph). Although the plot contained no spruce, spruce were scattered throughout the surrounding area. Relatively short black twinberry (*Lonicera involucrata*) (30% cover) and grasses dominated the site. Other relatively abundant shrubs and herbs included: snowberry (*Symphoricarpos albus*) (3%) , palmate coltsfoot (*Petasites palmatus*) (3%), Canada violet (*Viola canadensis*) (2%), prickly rose (2%), fireweed (*Epilobium angustifolium*) (2%) and black gooseberry (*Ribes*

lacustre) (2%). A species list is found in Appendix E. Due to trampling by cattle along the creek and the lack of large trees close to the creek, this site has low value in terms of riparian function (Table 11). This site will likely not contribute substantial LWD to the stream for well over a century until conifers establish on site and mature and grow to heights exceeding 30 metres.

Table 11. Riparian function summary for riparian plot GT3.

Function	Rating	Comments
LWD	L	No source of LWD exists near creek.
Shade	L	Few shrubs along creek and short trees further back limit shading.
Small organic debris (SOD)	L	Little overhanging vegetation.
Surf. Sed. Filter	M	Site is used by cattle, especially close to creek.
Channel stability	L	
Bank stability	L	Poor network of roots in bank.

We dug a 60 cm soil pit in the plot. The soil great group is Grey-Brown Luvisol. Layers were as follows: an 8 cm moder layer, an 8 cm dark brown Ah layer composed of silty clay, and a light brown/grey Bt layer of hard clay. Based on descriptions contained in Banner *et al.* (1993) and Oikos and Klinka (1999), this site is the Aspen-Purple peavine-Canada Violet seral association of the Spruce-Twinberry-Coltsfoot (SBSdk06) site series.

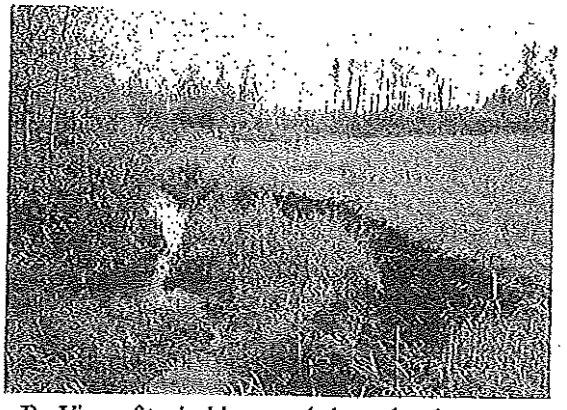
Channel Assessment

Reach 1 of Lemieux Creek is a 3.1 kilometre long riffle-pool channel located between Robin Creek and a pond which has been enhanced by Ducks Unlimited to improve wildlife habitat (H. Kerr, pers. comm.). Currently, beavers are the dominant channel forming and modifying elements of this reach (Fig. 9F). LWD would also be a major factor in creating channel complexity if mature riparian forest were still intact (Fig. 9C). Beaver dams occur at the confluence with Robin Creek and from approximately 1800 metres upstream of the confluence to the reach break. Channel banks consist of mainly erodible fines and sand with a small portion of gravels. The substrate of this reach consists of silt, sand, clay and gravel. Several sections of this reach had clay substrate. These sections were usually deeply incised with little to no riparian vegetation.

None of the channel in this reach is moderately or severely disturbed. The channel has areas of slight aggradation and one area of degradation between relatively stable beaver modified sections. Signs of sedimentation including sediment wedges and fingers and homogenous substrate (fines) were common, as were multiple channels. The lack of functional LWD is a chronic problem throughout much of this reach. Degradation occurred in an area of deeply incised channel with a primarily clay substrate.

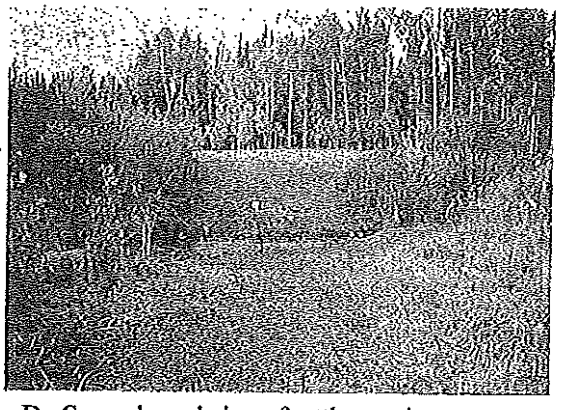
Figure 9. Lemieux Creek Reach 1: channel, riparian and impact photos.

A: Upstream view of typical channel and riparian vegetation in wetland near the confluence with Robin Creek.



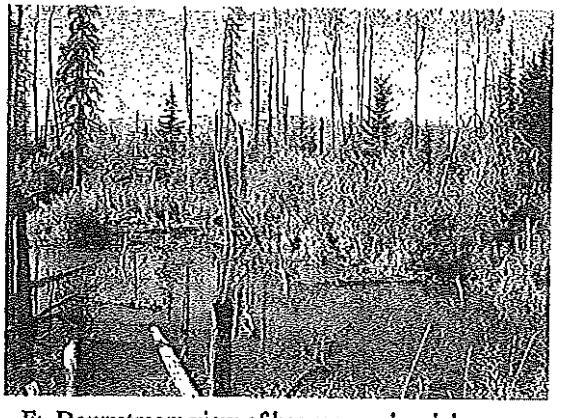
B: View of typical impacted channel and riparian habitat at 1+043 m. Note the bank shear and sediment input.

C: Downstream view of channel and riparian vegetation at 1+247 m.



D: Cross-channel view of cattle crossing at 1+522 m. Note the exposed soil and potential sediment source.

E: Downstream view of cattle crossing at 1+522 m.



F: Downstream view of beaver pond and dam at 1+830 m.

The Highway 16 culvert has a 30 cm drop onto riprap. This drop may be a barrier to upstream fish migration in certain flow conditions. An old bridge was observed in the channel 1392 m from Robin Creek. It appears to have been placed across an incised section of the channel and has since collapsed into the stream causing aggradation upstream and downstream. Other culverts and road crossings did not appear to pose difficulties to fish migration. However, a cattle and machinery ford located 1522 m upstream of Robin Creek is a large source of sedimentation and organic waste (Figs. 9D and 9E). Due to the deeply incised channel in this section, this ford is the main cattle crossing and watering site between two pastures. Cattle also use the shallow banks at this point to access the channel itself. Cattle prints and waste were observed for approximately 200 m downstream and 50 m upstream of this crossing. Bank shear and the resulting bank erosion and sedimentation is common throughout the incised sections of this reach wherever cattle are allowed to migrate along the channel.

Fish and Fish Habitat Assessment

General habitat quality in reach 1 is poor to moderate. Overwintering habitat, found in beaver ponds, is abundant in the upper and lower sections of the reach. On the other hand, rearing and spawning habitat is limited due to substrate homogeneity, low channel complexity and lack of LWD. Willows dominated the riparian area, and provided moderate canopy closure (~40%). Over-channel vegetation and undercut banks provided most of the limited cover. LWD averaged 0.14 pieces per bankfull width, all of it small (10-20 cm diameter) and medium (20-50 cm) (Table 12a). 25% of the LWD functioned in the channel. Future recruitment will be hindered by the lack of mature forest along the creek. Spawning habitat is of low to moderate quality in this reach for both anadromous and resident fish. Riffles accounted for only 14.6% of the total reach length and 1.5% of the total area. Glides were the most common unit, covering 92% of the reach area. Fines were the dominant substrate for all units except for riffles where gravels were more abundant. Subdominant substrate was mainly gravel, with cobble occurring in some riffles. Access to spawning habitat is limited in some years by numerous beaver dams in this reach and in Robin Creek. Discharge at the time of sampling was $0.05 m^3/s$.

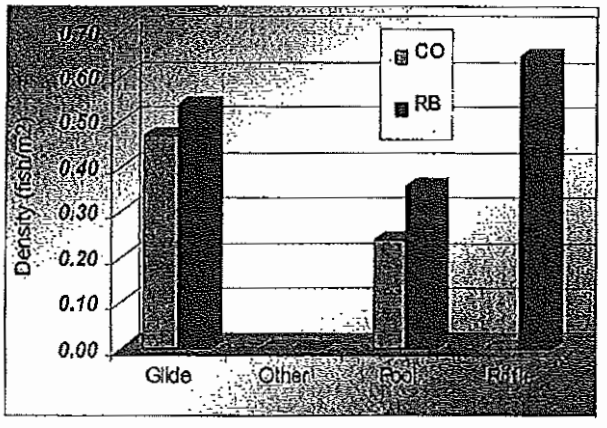
As a result of the marginal fish habitat, fish densities were moderate (Table 12b). Rainbow trout were the most abundant fish captured in this reach followed by lake chub. Coho juveniles (0+ and 1+ age-classes) were captured in pools and glides to approximately 1350 m upstream from Robin Creek. Rainbow trout fry (0+) and lake chub were caught throughout the reach. Northern squawfish were captured near the Highway 16 crossing (Triton 1997a). It is likely that the coho in this reach moved upstream from the beaver ponds in Robin Creek during high water.

Table 12. Summary of channel and fish habitat field data for Lemieux Creek, reach 1.

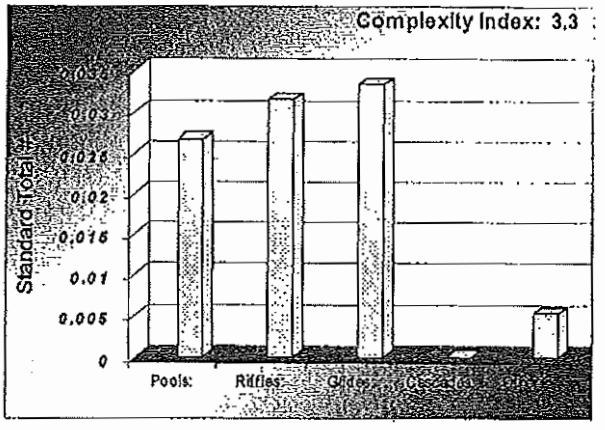
a) LWD summary.

	Small (10-19cm)	Medium (20-49cm)	Large (>50cm)	Total
Total # Pieces	392	201	0	593
# Functional Pieces	78	66	0	144
# Func. Pieces / Bankful width	0.08	0.07	0	0.14
% Functional	20	33	0	24

b) Density of salmonids in glides, pools, riffles and other habitat types.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	S	G	L	R	L	OV,C	20-40
Other	S	S	L	AR	N	LWD, OV	40-70
Pool	S	G	L	AR	N	OV, C	20-40
Riffle	G	S, C	M	R	H	OV, IV	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
3.21	0.05	0.22	0.66	1.02	4.00

Impact synopsis

Land use in this reach and upstream has damaged fish habitat. Although the channel appeared to be relatively stable, it had little complexity. LWD is rare and future recruitment will be low due to the degree of cleared land in the reach. The large amount of fine substrate in the channel is likely the result of bank shear and erosion caused by cattle trampling in conjunction with the loss stabilising riparian vegetation. A point source of sediment is the cattle crossing, located at 1522 m. Temperature extremes are also a concern as little shading exists through a large part of the watershed.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible without access to Crown range).
- Re-establish riparian vegetation to armour banks, increase LWD recruitment and shade the stream.
- Construct a hardened cattle crossing at 1+522 m (bridge or armoured geoweb crossing).

4.1.2.2 Reach 3

Length:	1430 m	Elevation:	583 – 610 m
Length assessed:	1430 m	Average gradient:	1.1%
Number of sites:	8	Mean W_b :	3.14 m
Number riparian plots:	0	Mean d_b:	0.38 m

Riparian Assessment

The riparian zone of reach 3 of Lemieux Creek has been heavily impacted. Most herbaceous and shrub plant cover immediately adjacent to the channel has been removed by cattle (Fig. 10C). Several willow wetlands are located throughout this reach, usually associated with beaver activity. Most of the riparian forest has been cleared for homesteads, pasture or hay production. In several areas, debris from field clearing has been piled in windrows parallel to the channel. These windrows are often the only areas where willow and red-osier dogwood are protected from grazing. Few mature trees are available for future LWD recruitment (Fig. 10B). Much of the LWD observed in or near the channel appeared to be remnants from the initial land clearing effort.

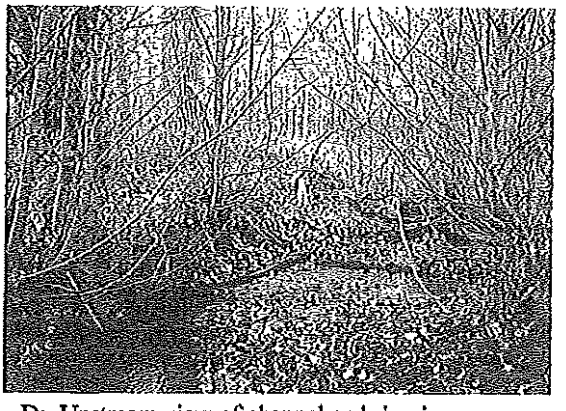
No riparian assessments were conducted in this reach. It can be assumed that the data from reach 1 may be used to approximate the expected plant communities and soil conditions for this reach.

Figure 10. Lemieux Creek Reach 3: channel, riparian and impact photos.

A: Cross-channel view of cattle watering impacts at pool sampled at 0+183.

B: Upstream view of typical channel and riparian vegetation at 0+250 m.

C: View of typical impacted channel and riparian habitat at 0+510 m. Note the bank shear and sediment input.



D: Upstream view of channel and riparian vegetation at 1+224 m.

Channel Assessment

Reach 3 is located in agricultural land between two ponds. It has a low gradient and is primarily influenced by beaver activity. Other channel complexing mechanisms are limited. The wetland nature of this reach hindered use of the standard WRP channel assessment procedures. Many indicators of disturbance, such as bar formations and scouring processes, do not manifest themselves in streams of this morphology. Nonetheless, we observed areas of slight aggradation between relatively stable beaver modified sections. Signs of sedimentation including sediment wedges and fingers and homogenous substrate (fines) were observed throughout this reach.

The channel banks are composed mainly of erodible silt, clay and sand. Bank shear and trampling by cattle is common throughout this heavily impacted reach (Fig. 10C). The substrate is dominated by silt and clay, and clay lenses are common. Gravel and cobble, where observed, were a thin veneer on top of fine particles. Riffles and fast water are limited to flows over woody debris. The channel appears to have been widened in several locations as a result of cattle and fords. Of particular note is excessive cattle use 1288 m upstream of reach 2 where the clay banks are low and stripped of vegetation. This area is a source of sediment when used by livestock and during floods and heavy rains. A small ditch parallel to a field or pasture at the upper reach break is also a source of sediment.

Fish and Fish Habitat Assessment

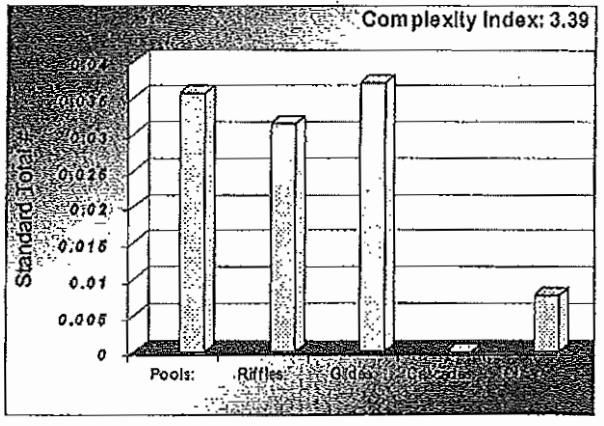
Reach 3 of Lemieux Creek contains poor habitat for all life stages of salmonids. At best it functions as a corridor linking two good overwintering areas. Rearing habitat was limited by shallow wetted depths (average 15 cm at the time of assessment) and a lack of quality instream cover (LWD, deep pools). Cover consisted primarily of overhanging vegetation, limited to the areas of the creek with riparian vegetation. Canopy closure average 20%. Large woody debris was relatively abundant (0.25 pieces per W_b), with 60% being less than 20cm in width (Table 13a). 30 percent of the LWD was functional. Future recruitment will be limited. Spawning habitat is limited by the lack of gravels and cobbles. It is likely that this reach has been continually influenced by beavers and is now down-cutting through organic debris, clay and fines left behind when previous dams were breached. Channel complexity is being enhanced by the debris from field clearing that has been pushed into the channel.

Fish sampling was limited to minnow trapping due to low water temperatures. Five traps were set over a 100 m section of stream and in a small beaver pond. One lake chub and several western toads were captured in 24 hours. We suspect rainbow and cutthroat trout are present in this reach in very low densities because of their presence upstream. It is unlikely that coho or steelhead are found this far upstream due to the cumulative effects of the many beaver dams downstream.

Table 13. Summary of channel and fish habitat field data for Lemieux Creek, reach 3.
a) LWD summary.

	Small (10-19cm)	Medium (20-49cm)	Large (>50cm)	Total
Total # Pieces	230	140	9	379
# Functional Pieces	49	62	4	115
# Func. Pieces / Bankful width	0.11	0.13	0.01	0.25
% Functional	21	44	44	30

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	G	S	L	AR	L	OV	0-20
Other	S	S	L	AR	N	IV, OV	0-20
Pool	S	S	L	AR	N	DP, OV	0-20
Riffle	G	C, S	M	AR	M	OV	20-40

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
5.00	0.05	0.17	0.62	0.74	4.19

Impact synopsis

Reach 3 is one of the most impacted reaches assessed in our study. Cattle use and widespread clearing of the riparian zone throughout the reach has impacted the channel and fish habitat. The channel lacked complex habitat and future LWD recruitment will be low. The large amount of fine substrate in the channel is likely the result of bank shear and severe erosion caused by cattle trampling in conjunction with the loss stabilising riparian vegetation. Temperature extremes are also a concern as little shading exists through a large part of the watershed.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible without access to Crown range).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream.
- If a cattle crossing is necessary, construct a hardened or geoweb crossing.

4.1.2.3 Reach 5

Length:	3923	Elevation:	610-718 m
Length assessed:	3923	Average gradient:	4.2%
Number of sites:	24	Mean W_b :	3.7 m
Number riparian plots:	1	Mean d_b:	0.42 m

Riparian Assessment

The riparian zone in this reach varies from slightly impacted to non-existent. Unlike the lower reaches, the majority of the riparian habitat in this reach is in good condition and is functional. The downstream end of the reach flows through a deciduous forest dominated by willows tentatively identified as Scouler's (*Salix scouleriana)*, mountain alder (*Alnus tenuifolia*) and black twinberry (Fig. 11B). Prickly rose, snowberry and aspen (*Populus tremuloides*) occur on drier slopes in this section. The upper half of the reach has mixed spruce, aspen and cottonwood forest. Land use is primarily agricultural in the lower part of the reach; several cutblocks exist adjacent to the upper part of the reach. Impacts are minimal and can be attributed to point sources.

Assessment site GT7

Site series: SBSdk07a
Seral association: Mountain alder - Mitrewort

This site was chosen as a representative of the relatively undisturbed lower half reach 5. The 3.99 m plot was located on a low fluvial bench between the creek and a flood channel. The site was flat to slightly convex. The overstory, covering approximately 5% of the site, consisted of Pacific Willow (*Salix lucida spp. lasiandra*) (tentative identification) up to 15 m high. No trees were located at this site. In the understory, Black twinberry (30%), snowberry, common mitrewort (*Mitella nuda*) (10%), and common horsetail (*Equisetum arvense*) (10%) dominated the site. Mountain alder, to a height of eight metres, covered less than 1% of the plot. A species list can be found in Appendix E. Current levels of functioning are moderate to high (Table 14.). LWD will come primarily from existing willows with 20 to 25 cm dbh. No recent disturbances were noted at this site.

Table 14. Riparian function summary for riparian plot GT7.

Function	Rating	Comments
LWD	M	Primarily large willows; some At and Sxw from steeper slopes along right bank.
Shade	M	
Small organic debris (SOD)	M	Overhanging shrubs.
Surf. Sed. Filter	H	Ground is virtually fully vegetated
Channel stability	M	
Bank stability	H	Rooted vegetation holding bank in place

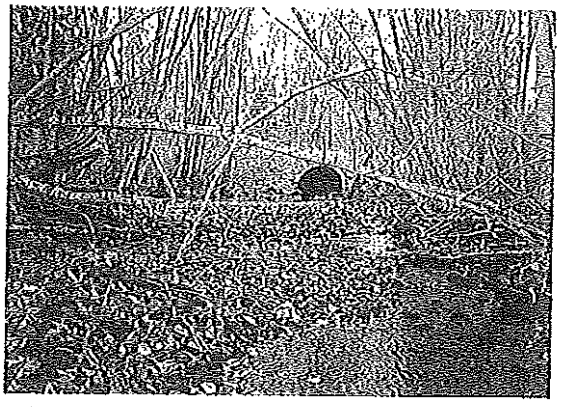
We dug a soil pit to a depth of 50 cm, where we hit groundwater. The soil great group was Dystric Brunisol. Soil layers consisted of a thin moder (<1cm), underlain by an 8 cm medium to dark brown, silt loam Ah layer with numerous roots. The remainder of the pit was parent material composed of poorly sorted fluvial sediments consisting of coarse sand, subangular to subround gravels and cobbles to 9 cm. Based on descriptions in Banner *et al.* (1993) and Oikos and Klinka (1999), this site is the Am-mitrewort seral association of the freely drained phase of the Spruce-Horsetail (SBSdk07a) site series.

Channel Assessment

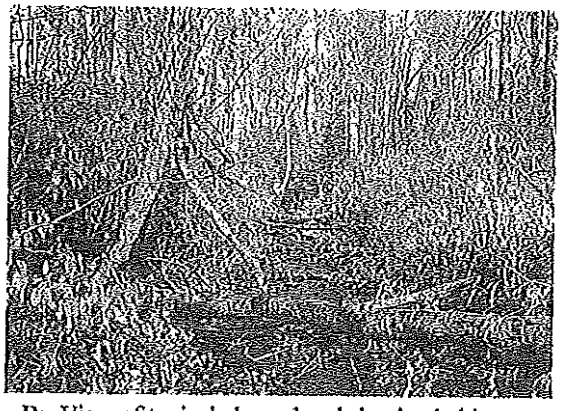
Reach 5 of Lemieux Creek is a transitional reach between high gradient mountain reaches and the valley floor. The lower part of the reach is likely the outwash fan for sediments washed from upstream. This may account for the moderate aggradation noted in the lower 500 m of the channel. Channel morphology ranges from gravel-riffle-pool in the lower section of the reach to cobble-cascade-pool at the upper reach break. The stream in this reach has an average gradient of 4.2% and is occasionally confined. LWD is the main channel forming and complexing mechanism and is available for recruitment throughout most of the reach.

The erodible channel banks consist of fines and sand in the lower 500 m of the reach. As gradient rises, the bank particle size increases to gravels and cobbles at the upstream reach break. The banks of this reach were relatively stable in comparison to reaches 1 and 3. This is a function of lower levels of livestock grazing and a healthier riparian zone. Short channelised sections of stream, occasionally with riprap, occur at road crossings and on private land to protect culverts and to prevent erosion.

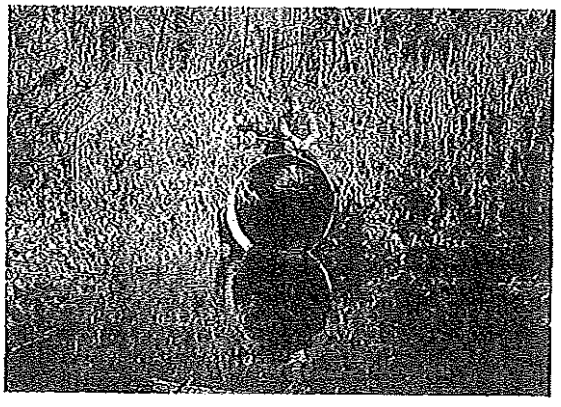
Figure 11. Lemieux Creek Reach 5: channel, riparian and impact photos.



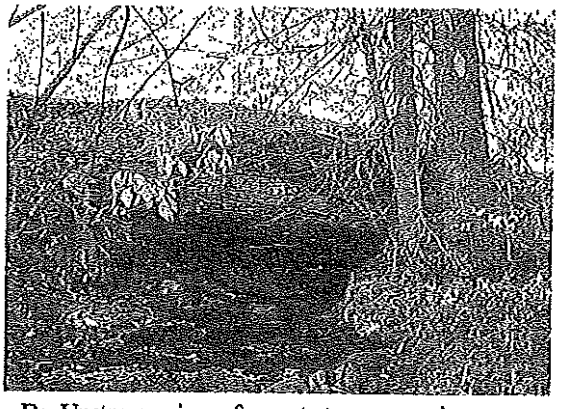
A: Upstream view of aggrading channel and riparian vegetation below Morden Road crossing at 0+230 m.



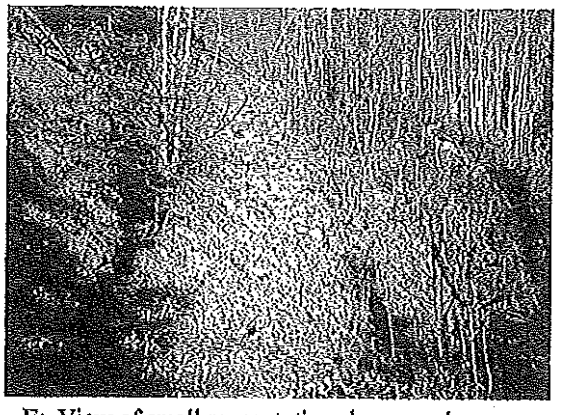
B: View of typical channel and riparian habitat at 0+449 m.



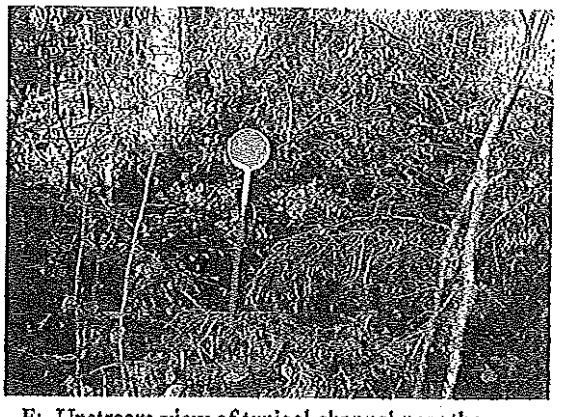
C: Upstream view of culvert at 1+130 m. The plunge pool contains adult cutthroat trout.



D: Upstream view of recent stream crossing at 2+690 m.



E: View of small revegetating slump or slope failure at 2+730 m. An access road is located at the top of the gully.



F: Upstream view of typical channel near the upper reach break.

Specific impacts to the channel include a machinery ford located 630 m upstream of the lower reach break. This ford, which appeared to be rarely used, did not significantly disturb the channel. Substrate at this site is primarily gravel and cobble. Should livestock begin using the crossing, bank stability would likely be greatly reduced, causing sedimentation. The toe of the creek bank at the ford has been reinforced with three metre long logs, which now function as undercut banks. Culverts on private land located at 1+130 m[1], 1+600 and 2+064 m may become perched in the future if backwatering structures are not installed (Fig. 11C).

Fish and Fish Habitat Assessment

Reach 5 contains areas of good spawning and rearing habitat. However, due to a gradient averaging 6% in the upper half of the reach, good habitat is patchy. A mean residual pool depth of only 39 cm indicates poor overwintering habitat. Riffles were the most abundant habitat unit, accounting for 35% and 40% of the channel area, and length, respectively. Pool frequency was once every 8.3 bankful widths. Cover was relatively high, averaging 20-25%. Over-stream vegetation and cutbank accounted for the majority of cover. LWD was relatively common in this reach, with an average of 0.35 functional pieces per bankfull width. 50% of the functional wood was 20 to 50 cm in diameter (Table 15a).

While we captured no fish, cutthroat trout were captured at the Morden Road culvert by Triton (1997a). We set minnow traps at two locations. Fish displaying spawning behaviour and colours were tentatively identified as Dolly Varden char. These fish were paired-up on what appeared to be redds. Cutthroat trout and the suspected Dolly Varden char appear to occur in very low densities in the upper half of the reach.

Impact synopsis

Reach 5 was much less disturbed than reaches 1 and 3. The moderate aggradation encountered in the lower 500 m of the reach which is partially attributed to the low gradient being a natural depositional area for the sediment washed from the higher gradient upstream reaches. Riparian vegetation, although present through most of the reach, is scarce along short lengths of the stream and in the cutblock near the upper reach break. Cattle trampling, limited to the cutblock, is causing some bank instability and sedimentation.

Restoration suggestions

- Although livestock impacts are minimal in this reach, work with the landowners to limit access to the riparian zone and the creek (e.g. off-channel watering).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream in impacted areas.
- If a livestock crossing is necessary, construct a hardened or geoweb crossing.
- Monitor culverts for signs of perching and take steps to prevent this.

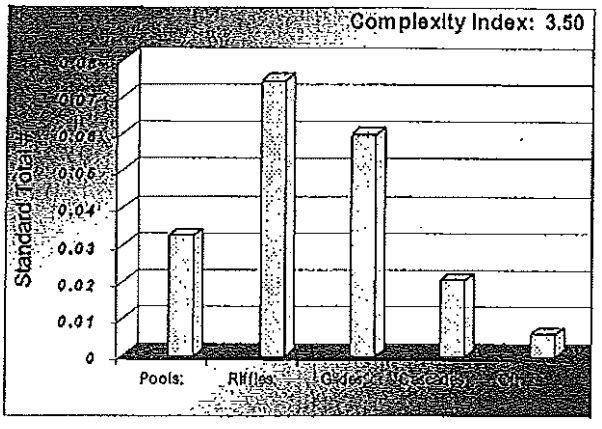
[1] This is the distance from the mouth of the creek (or downstream reach break if we are discussing any reach other than reach 1) recorded as "km+metres." In this example, 1+130 m equals 1,130 m from the mouth of the creek).

Table 15. Summary of channel and fish habitat field data for Lemieux Creek, reach 5.

a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (≥50cm)	Total
Total # Pieces	604	320	18	942
# Functional Pieces	168	190	15	373
# Func. Pieces / Bankfull width	0.16	0.18	0.01	0.35
% Functional	28	59	83	40

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	C	B	H	AR	N	C, B	20-40
Glides	G	C	M	AR	L	OV, C	40-70
Other	C, S	G	M	AR	L	OV, SWD	20-40
Pool	C, S	G, C	M	R	L	OV, DP	40-70
Riffle	C	G	H	AR	L	OV	40-70

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m²)
11.58	0.06	0.19	1.12	1.73	17.57

4.1.3 Vanderven Creek (460-407900-37600)

Vanderven Creek discharges to Robin Creek at the boundary between reaches 2 and 3 (Fig. 12). This 11.5 kilometre long stream drains 22.5 km^2, or one quarter of the Robin Creek watershed. Apart from the upper 2 km, the creek is located within private land. Logging, under the Small Business Forest Enterprise Program, has occurred in the headwaters. Currently two cutblocks exist – one logged in 1989 and the other in 1992. Vanderven Creek is composed of 6 reaches (Triton 1997a). We assessed the first reach and 700 metres of the second reach. Beyond this point, land use impacts were minimal. Note: We moved the location of reach break 1/2 approximately 550 m downstream of the location shown on the fish inventory maps (Triton 1997a).

Fish distribution information is limited to that conducted by Triton (1997a). Triton captured rainbow trout as far upstream as the Deception Lake Forest Service Road (FSR) crossing (Reach 2). Cutthroat trout were captured as far upstream as Upper Robin Creek Road. A local landowner indicated that, in the past, he had caught trout in beaver ponds approximately 3 km upstream of Upper Robin Creek Road. During our assessment, low water temperatures precluded the use of electrofishers. Instead, we set minnow traps in suitable locations from Upper Robin Creek Road to a point 20 m downstream and near the landowner's house. We captured and observed cutthroat trout near the house. We also caught a lake chub in the same area.

Limited information exists on water quantity or quality for Vanderven Creek. No hydrometric stations or stream gauges are located on Vanderven Creek, or anywhere in the entire Robin Creek drainage. Triton estimated discharge to be 0.13 m^3/s at the Upper Robin Creek Road in early July, 1997. We estimated discharge near the creek mouth at the time of sampling to be 0.01 m^3/s. We estimated bankful discharge to be 0.64 – 1.4 m^3/s based on channel measurements from reaches 1 and 2A. Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. One water licenses exist for Vanderven Creek. This irrigation licence allows the use of 75 acre feet annually, or 758 m^3/day over a four month irrigation season. According to a local landowner, low flows are common and the creek dries-up during some summers. We found no water quality information for Vanderven Creek.

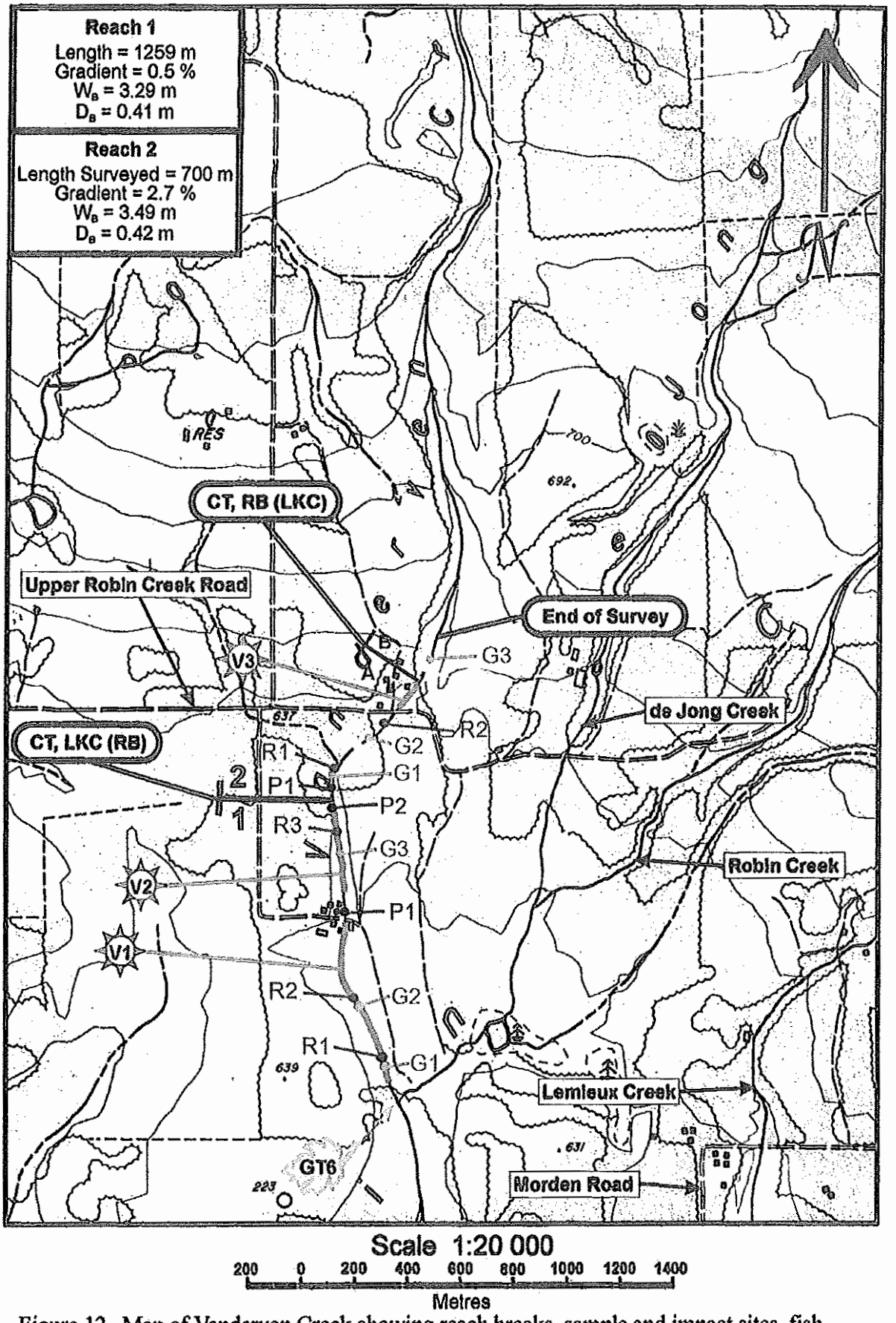


Figure 12. Map of Vanderven Creek showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.066 1:20 000.

4.1.3.1 Reach 1

Length:	1290 m	Elevation:	604 - 630 m
Length assessed:	1290 m	Average gradient:	0.5 %
Number of sites:	8	Mean W_b :	3.3 m
Number riparian plots:	0	Mean d_b:	0.4 m

Riparian Assessment

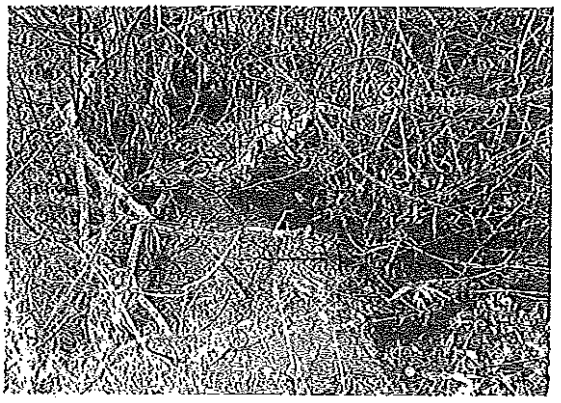
The riparian zone of reach 1 of Vanderven Creek has been severely impacted. Most of the streamside vegetation has been removed by the landowner to prevent flooding or for agriculture or dairy cow pasture. Much of the lower 550 metres of the channel has been stripped clean of trees and shrubs, including 300 m during the spring of 1999 when the channel was re-excavated (Fig. 13B). The first trees occur in a 100 m long row of large spruce, aspen and cottonwood lining the creek 720 m upstream of the stream mouth near a house and storage shed. Upstream of this point, a narrow band of thinned-out willows line the creek for another 150 m. For the remainder of the reach, willow coverage is sparse (Fig. 13E). This reach exemplifies the importance of riparian vegetation in stabilising banks and the channel. Severe bank erosion is present in the upper half of the reach where the willows have been removed.

No riparian assessments were conducted in this reach. No natural sites were present near the creek. We are assuming that data from riparian plot GT6, located only metres downstream of the confluence of Vanderven Creek with Robin creek can be used to approximate the pre-impacted plant communities and soil conditions for this reach. However, the water table has been lowered dramatically within reach 1 due to channel excavation and down-cutting, and ditching the land. Altered groundwater conditions may mean that original plant communities may no longer grow along this reach.

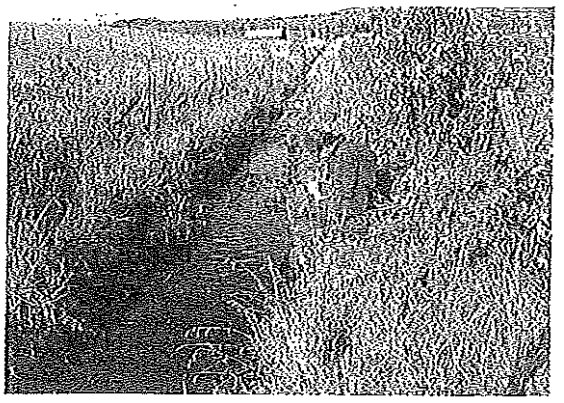
Channel Assessment

Reach 1 of Vanderven Creek is a low gradient 1.3 km long gravel-riffle-pool channel located on agricultural land. Ranked 3rd in the overview assessment matrix, this reach was verified in the field to be one of the most impacted reaches in our study area (Appendix A). Apart from the extreme upper and lower end of the reach, the channel has been straightened in the past, with the lower 700 metres being re-excavated within the past several years. LWD and willow branches crossing the creek are removed by the land owner. Both these actions are an attempt to prevent debris jams and to facilitate the movement of water through the channel to prevent flooding. Willows in the upper half of the reach are currently the dominant channel stabilising elements of this reach. Channel banks consist of erodible silts, clays and sand with small amounts of gravel in some areas. Banks in the lower half of the creek are exposed from fresh excavation, or are covered in thick grasses. The upper third of the reach is deeply incised with banks up to two metres high (Fig. 13D). Channel substrate is primarily gravel and fines. In the lower part of the reach, fines fill the spaces between the gravel. Riffle structures composed of angular gravel, cobbles and small boulders, and installed up to 20 years ago, were observed in a 130 m stretch of channel between 0+850 m and 0+979m. We do not know who installed these riffles.

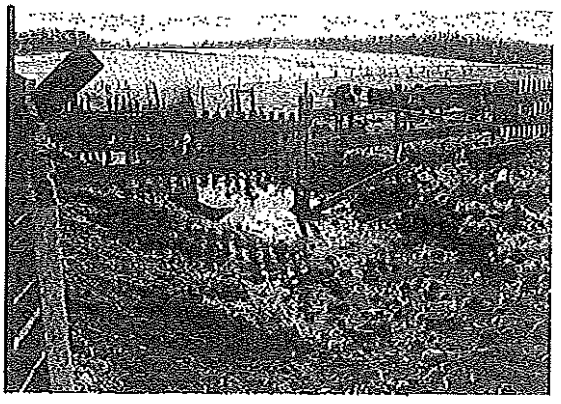
Figure 13. Vanderven Creek Reach 1: channel, riparian and impact photos.



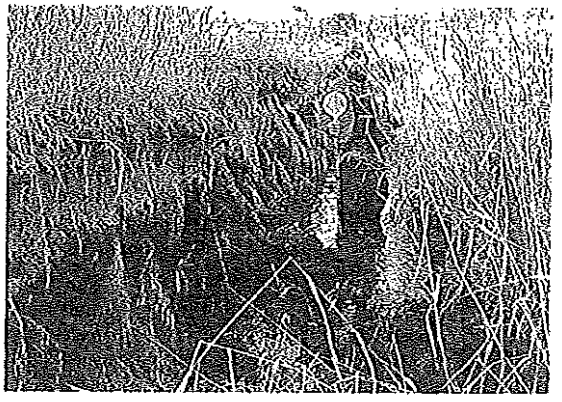
A: Downstream view of typical channel and riparian vegetation in willow wetland at 0+045 m.



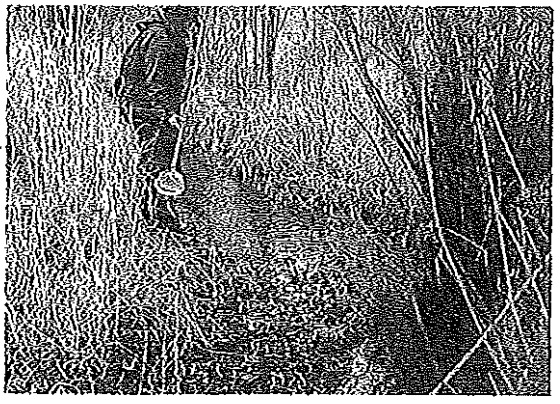
B: Upstream view of ditched channel at 0+165 m. Note the homogenous channel and the lack of riparian shrubs and trees.



C: View of cattle watering enclosure at 0+687 m.



D: Upstream view of incised channel and a source of sediment at 1+050 m.



E: Upstream view of channel and riparian vegetation at 1+143 m.

F: Upstream view of cattle impacts to the channel downstream at 1+260 m near the upper reach break.

Approximately 70% of the channel is moderately degraded. Newly excavated portions of the reach are obviously significantly different from a natural channel, but rank only as moderately degraded based on descriptions in the *Channel Assessment Procedure Field Guidebook*. Signs of disturbance include lack of functional LWD, bank erosion, down-cutting and minimal pool area. At 1+234 m, a trenched ditch from the field to the west directs drainage water into the creek. The ditch is down-cutting through the stream bank, causing erosion, and hence, is a source of sediment to the creek.

In addition to a lack of riparian vegetation and channel excavation, dairy cows are impacting the creek channel. Access by cattle to large sections of the creek for watering is contributing to bank erosion and is causing bank sheer, particularly in the upper half of the reach. In addition, cow use is widening the creek near the upper end of the reach. Finally, cow feces in the creek may be impacting water quality. Feces was particularly prevalent the fenced cattle pen across from the barn and immediately downstream of the access road to the barn (Fig. 13C).

Fish and Fish Habitat Assessment

General habitat quality in reach 1 is poor to moderate. Little rearing habitat exists in the lower half of the reach, but improves in the presence of riparian vegetation. Channel complexity is low. Cover for fish, primarily overhanging vegetation, averages less than 5% of the channel and canopy closure is low (<20%). We observed only 13 pieces of LWD in the reach, 10 of which were functional. This equates to an extremely low 0.03 functional pieces per bankfull width, most of it small (Table 16a). Future recruitment will be hindered by the lack of forest along the creek. Moderate spawning habitat for resident salmonids exists in the riffles, particularly in the upper section of the reach. However, due to stream channelisation, high water velocities during spring spawning may destroy redds. Furthermore, sediments from bank erosion may settle out and suffocate eggs. Riffles, most common in areas of recent excavation of the stream, accounted for approximately one-third of the reach area. Glides, the dominant habitat unit, covered over half of the reach, while pools were rare and covered less than 10% of the area. Overwintering habitat is absent from this reach.

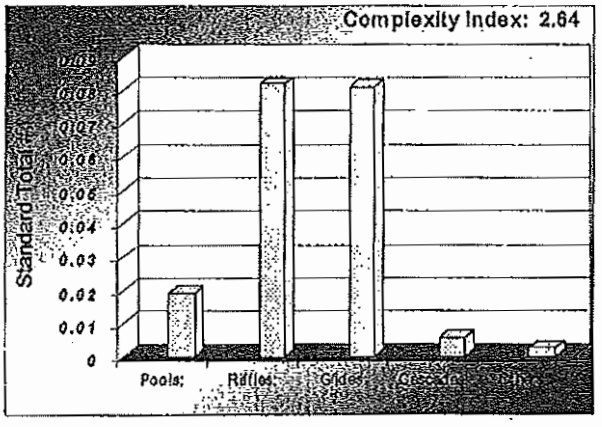
Fish densities in the reach appeared to be low. We captured only five fish in five minnow traps set for 23.5 hours in the middle section of the reach where moderately good riparian vegetation existed. Four cutthroat trout were caught (estimated 1+ and 2+ age classes) along with one lake chub. At least two, and perhaps three additional (15-25cm) cutthroat trout were observed swimming in the area in which traps were set.

Table 16. Summary of channel and fish habitat field data for Vanderven Creek, reach 1.

a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	9	3	1	13
# Functional Pieces	7	2	1	10
# Func. Pieces / Bankful width	0.02	0.01	0.003	0.03
% Functional	78	67	100	77

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	G	S	L	AR	N	OV	0-20
Pool	G	S	L	AR	N	OV, C	20-40
Riffle	G	S	L	R	H	OV	0-20

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
2.75	0.05	0.18	0.48	0.64	2.03

Impact synopsis

Land use in this reach and upstream has severely impacted fish habitat. Much of the channel has been straightened and the riparian vegetation has been removed or thinned along the entire reach as a flood control measure. LWD was extremely rare and the channel has little complexity. The banks of the degraded channel are slumping and eroding in areas due to a combination of channelisation increasing the power of the creek, loss stabilising riparian vegetation, and cattle trampling. High temperatures may be a concern in the lower part of the reach due to lack of canopy closure.

Restoration suggestions

- Work with the landowner to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible without access to Crown range).
- Re-establish riparian vegetation to stabilise the banks, increase LWD recruitment and shade the stream. Plant tree species if shrubs choking the channel cause a flood concern. Protect or preserve the remaining shrubs. Pruning shrubs whose branches or trunks cause jams may be an option.
- Decrease energy of the stream by constructing riffle structures. Must ensure bank stability to prevent further erosion (fascines, brush mattresses, etc.) prior to instream work. The riffle structures installed approximately 20 years ago are still functioning in the channel.
- Use the existing bridge for cattle movement or if a further cattle crossing is necessary, construct a hardened or geoweb crossing.

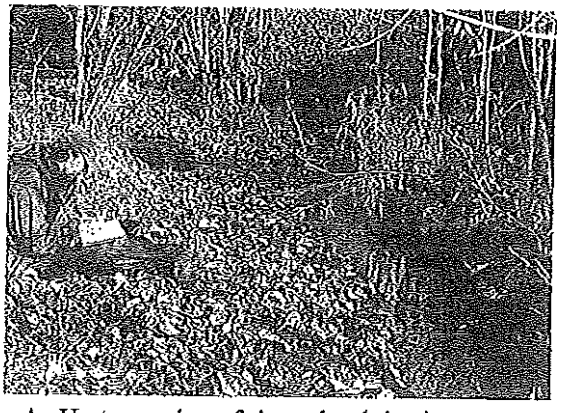
4.1.3.2 Reach 2A

Length:	4.5 km	Elevation (assessed):	630 - 653 m
Length assessed:	700 m	Average gradient:	2.7 %
Number of sites:	8	Mean W_b :	3.5 m
Number riparian plots:	0	Mean d_b:	0.4 m

Riparian Assessment

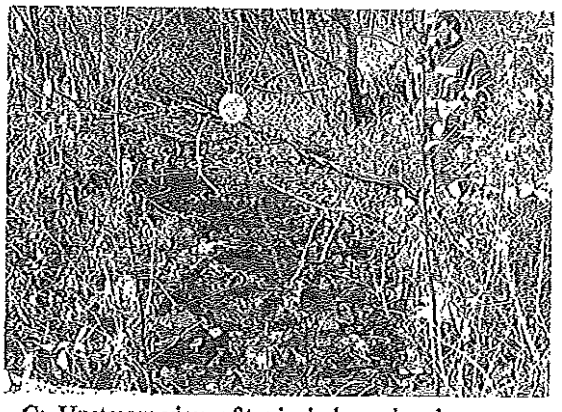
The riparian zone of reach 2A is much healthier than in reach 1. Below Upper Robin Creek Road, the creek is occasionally confined as it meanders between embankments spaced 8-10 metres apart. Riparian vegetation within this "gully" is relatively unimpacted shrub. Willows, alder and sapling spruce compose the larger vegetation in this area. On the bench above the gully riparian vegetation has been cleared for fields. Vegetation no longer exists on some outside meander bends where the banks have eroded. With nothing to anchor these banks, erosion will likely continue. For the initial 120 metres upstream of the Upper Robin Creek Road, riparian vegetation consists of a two to three metre wide band of willows on each side of the creek. Upstream of this point, in reach 2B, the stream cuts through a 50 m wide "gully" containing mature deciduous forest with large willows and aspen.

Figure 14. Vanderven Creek Reach 2A: channel, riparian and impact photos.



A: Upstream view of channel and riparian vegetation at 0+079 m.

B: View of bank erosion and large substrate particle size at 0+280 m.



C: Upstream view of typical channel and riparian conditions at 0+600 m.

No riparian assessments were conducted in this reach due to the relatively good condition of the riparian zone compared with much of the rest of the lower reaches of the Robin Creek watershed.

Channel Assessment

Reach 2 of Vanderven Creek is a moderate gradient 4.5 km long cobble-cascade-pool channel. Within the initial 700 m of the reach we assessed, gradient averaged 2.7%. The first 565 m of the channel is moderately impacted. The remaining 135 m of the reach we assessed was slightly disturbed. 120 m of channel immediately upstream of the Upper Robin Creek Road has been straightened, but meanders are present in the forest upstream of this point. LWD and willows are the dominant channel forming and stabilising elements of this reach. Channel banks consist of erodible fines, gravels and cobbles. Channel substrate is primarily gravel and cobble.

Approximately 60% of the channel in section 2A is moderately disturbed. The lower 140 m is moderately aggraded as evidenced by mid-channel bars, multiple channels, eroding banks, minimal pools and minimal LWD. Localised areas of aggradation occur behind LWD and intertwined willow branches crossing the creek. About half of the rest of the reach is moderately degraded as indicated by minimal pool area, extensive riffles and disturbed stone lines. The straightening of the channel upstream of the road is likely the main contributor to the downstream bank erosion and degradation (Fig. 14B).

The creek has sufficient power at high flows to scour the bed and banks. We observed bank erosion in some outside meander bends along the two metre high stream banks. Trampling by cattle in several locations in the first 300 m of the reach appears to be contributing to bank and bed destabilisation. In some areas, trampling is creating sources of sediment. Cattle use in this reach is relatively low, apart from a crossing used by cattle and all-terrain vehicles at 0+140 m. Continued undisturbed growth of the willow, alder and spruce along the creek should help protect the banks from erosion in the future.

Fish and Fish Habitat Assessment

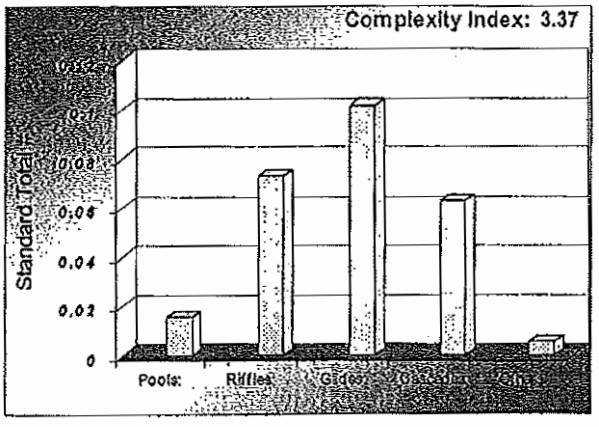
General habitat quality in the assessed portion of reach 2 is poor to moderate. More rearing habitat is available here than in reach 1 because cover, LWD and channel complexity has increased. Cover, primarily overhanging vegetation, cutbank and boulders, averages 15%. Canopy closure is very high, with a modal value greater than 90%. We observed a moderate amount of functional LWD (0.31 functional pieces of per bankfull width), most of it small (Table 17a). The LWD, particularly the larger pieces, are likely relics from pre-land clearing. LWD will decrease in the future as recruitment will be limited to larger willows unless larger species grow up along the creek. Despite the relative abundance of LWD, pools account for only approximately 4% of the area of the reach, with an average frequency of one pool per 19 bankfull widths. Spawning habitat for resident salmonids exists in small pockets in the riffles and glides of this reach where bed compaction is low to moderate. Riffles and glides compose 32% and 40%, respectively, of the area of the reach. Cascades account for the remaining 24%, providing many areas of supercritical flow which is important for some aquatic insects and for maintaining oxygen concentrations in the water. Overwintering habitat is absent from the section of the reach we assessed.

Table 17. Summary of channel and fish habitat field data for Vanderven Creek, reach 2A.

a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	69	16	3	88
# Functional Pieces	49	12	2	63
# Func. Pieces / Bankful width	0.24	0.06	0.01	0.31
% Functional	71	75	67	72

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascades	G	C	L	AR	L	OV, B	90-100
Glides	G	C	M	R	L	OV, C	70-90
Pool	S	G	L	AR	N	C, OV	90-100
Riffle	G	C	L	R	L	OV	90-100

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
7.00	0.06	0.19	0.97	1.42	11.31

Fish densities in the reach appeared to be low. We failed to capture any fish in five minnow traps set for approximately 24 hours in a 20 m section of creek downstream of Upper Robin Creek Road. We did, however, see one fish during the assessment. Triton (1997a) caught cutthroat trout immediately upstream of the road and rainbow trout approximately 4 km upstream. At this upper site, Triton observed suitable spawning substrate for trout and good rearing habitat in the form of deep pools, cutbanks and overstream vegetation.

Impact synopsis

Land use in this reach has impacted fish habitat. However, impacts are much less severe than downstream due to the presence of roughly five metres of riparian vegetation on each side of the creek. The channel has been straightened upstream of Upper Robin Creek Road which contributes to degradation and erosion downstream. Small LWD is relatively common, but pools are extremely rare. Cattle access to the lower part of the reach is contributing to some bank instability and sediment input. 125 m upstream of the road, land use impacts on the stream are minimised due to the large distance of fields from the creek.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible without access to Crown range).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream. Plant tree species if shrubs choking the channel cause a flood concern. Protect or preserve the remaining shrubs. Pruning shrubs whose branches or trunks cause jams may be an option.
- Decrease energy of the stream by constructing riffle structures, for example. Must ensure bank stability to prevent further erosion (fascines, brush mattresses, etc.) prior to instream work. The riffle structures installed approximately 20 years ago are still functioning in the channel.
- Use bridge in reach 1 for cattle crossing. If a cattle crossing is necessary, construct a hardened or geoweb crossing.

4.1.4 de Jong Creek (460-487900-37900)

de Jong Creek discharges to reach 4 of Robin Creek within a wide, flat, shrubby riparian area (Fig.). This 9.3 km long stream is the smallest of the streams we assessed in the Robin Creek drainage with an area of 11.3 km^2. The lower 2.5 km flows through agricultural land, as does a 400 meter section approximately two kilometres further upstream. Logging, under the Ministry of Forests' Small Business Forest Enterprise Program, has occurred in the upper reaches of the watershed. Currently two cutblocks exist – one logged between 1993 and 1995 and the other in 1998. de Jong Creek is composed of 3 reaches (Triton 1997a). We assessed the first reach and section A of reach 2, comprising the lower 1200 m of reach 2.

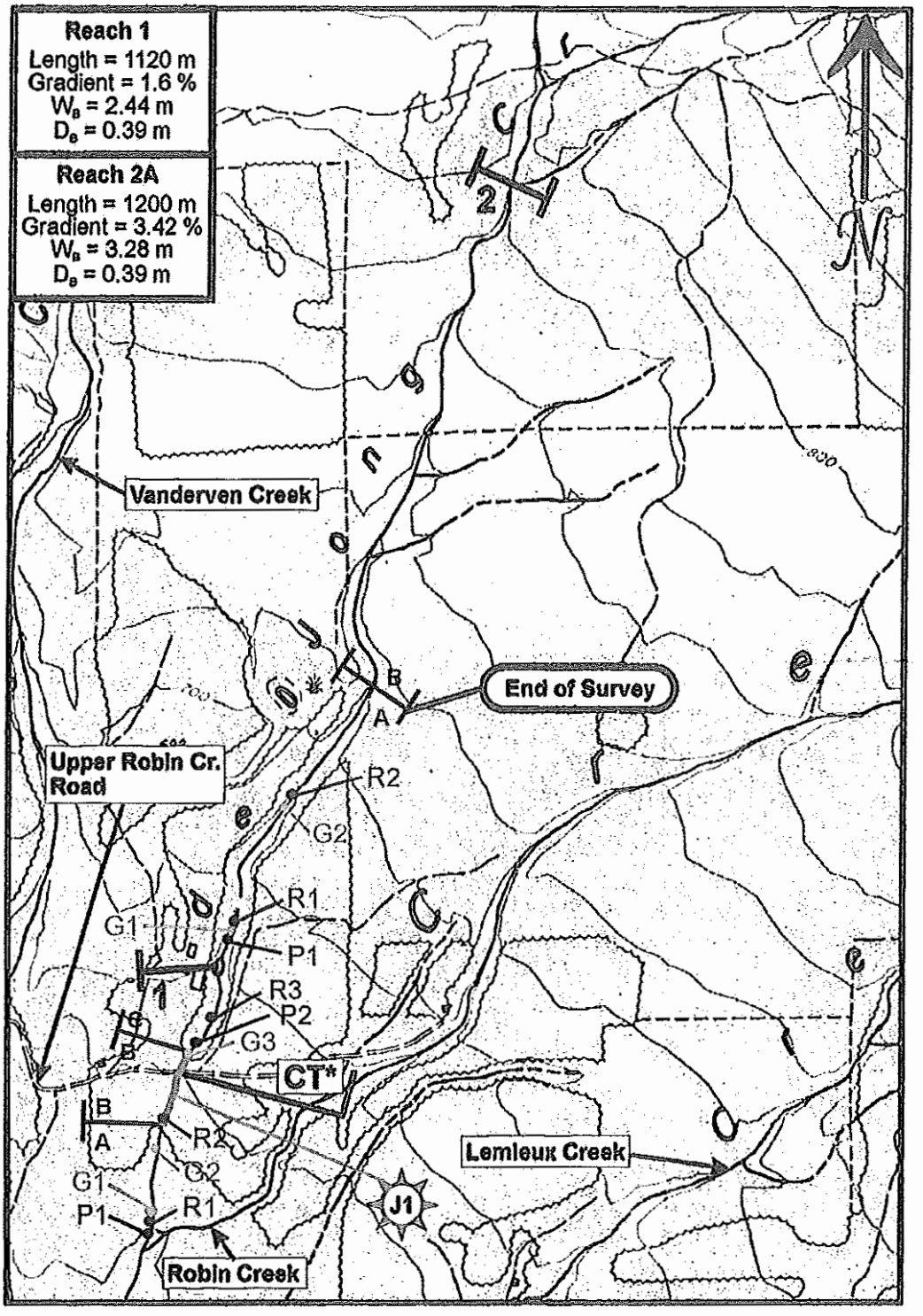


Figure 15. Map of de Jong Creek showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.066 1:20 000.

Fish distribution information is limited to that conducted by Triton (1997a) and in the autumn of 1999 by BCCF (Tamblyn and Haines 2000). Triton caught cutthroat trout several hundred metres upstream of the Upper Robin Creek Road. BCCF captured a juvenile cutthroat trout in the headwaters of the system about 9 km upstream of the confluence with Robin Creek. During our assessment, low water temperatures precluded the use of electrofishers. Instead, we set minnow traps in suitable locations within 120 metres downstream of the Upper Robin Creek Road. We did not capture any fish in this location.

Limited information exists on water quantity or quality for de Jong Creek. No hydrometric stations or stream gauges are located on de Jong Creek, or anywhere in the entire Robin Creek drainage. Triton estimated discharge to be 0.09 m^3/s at the Upper Robin Creek Road in early July, 1997. BC Environment has measured discharge twice. Measurements ranged from 0.0004 m^3/s in July 1981 to 0.2832 m^3/s in May 1965. We did not measure discharge due to constraints placed on us by the landowner. We estimated bankful discharge to be 0.73 to 1.35 m^3/s in reaches 1 and 2A, respectively. Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. Three water licences exist for de Jong Creek. They allow the storage of 3 acre feet of water and the use of 5000 gallons per day (22.7m^3) for stock watering. According to a local landowner, low flows are common and the stream dries-up during some summers. He is concerned that future forest harvesting activity in the headwaters will further affect his water flows. We found no water quality information for de Jong Creek.

4.1.4.1 Reach 1

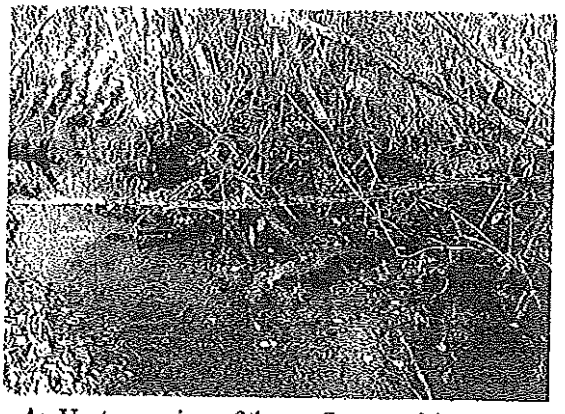
Length:	1120	Elevation:	618 - 658 m
Length assessed:	1120	Average gradient:	1.6%
Number of sites:	8	Mean W_b :	2.44 m
Number riparian plots:	0	Mean d_b:	0.39 m

Riparian Assessment

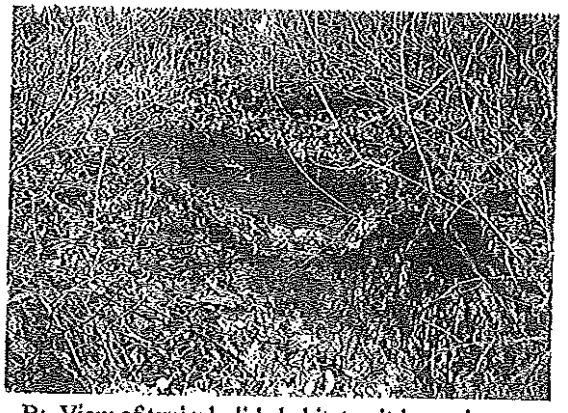
The riparian zone of reach 1 of de Jong Creek ranges from unimpacted to severely impacted. Section A, the lower 485 m of the creek, flows through a young mixed forest of occasional cottonwood, paper birch and spruce with a thick shrub cover (Fig. 16A). Many of the spruce were logged years ago as evidenced by stumps. The upper 280 m of the reach (section C), located in a "gully" has a healthy riparian area consisting of thick shrubs among young to mature spruce, cottonwood and aspen. In the middle 350 m of the reach, section B, the riparian zone separating the creek from fields generally consists of a 5 to 25 m band of cottonwoods with a reduced understory. In some areas, particularly for 50 m upstream of Upper Robin Creek Road, riparian vegetation has been stripped to the stream bank. This area suffers from extensive cattle use.

No riparian assessments were conducted in this reach due to the wishes of the landowner. Site series is likely a mix of Cottonwood-Dogwood-Prickly rose (SBSdk08) and well drained Spruce – Horsetail (SBSdk07a).

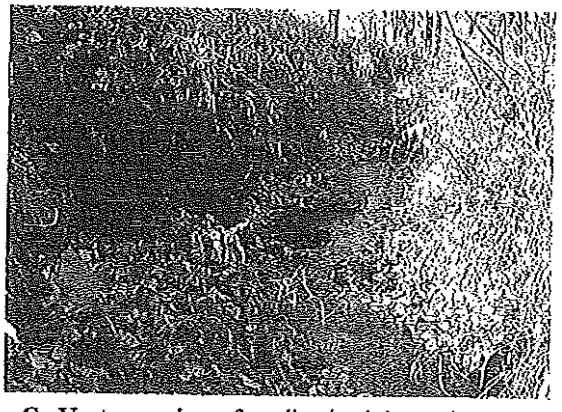
Figure 16. de Jong Creek Reach 1: channel, riparian and impact photos.



A: Upstream view of the confluence of de Jong Creek (left) with Robin Creek.

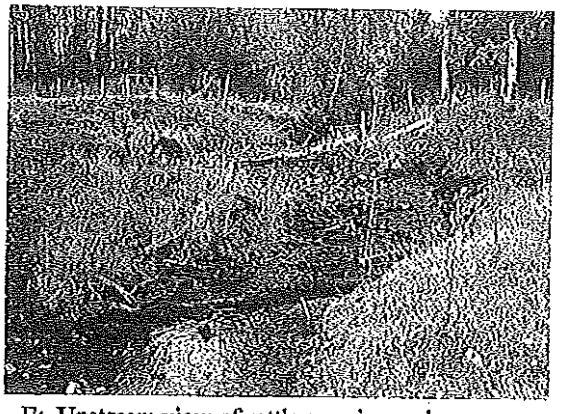


B: View of typical glide habitat unit in section 1A at 0+402 m.

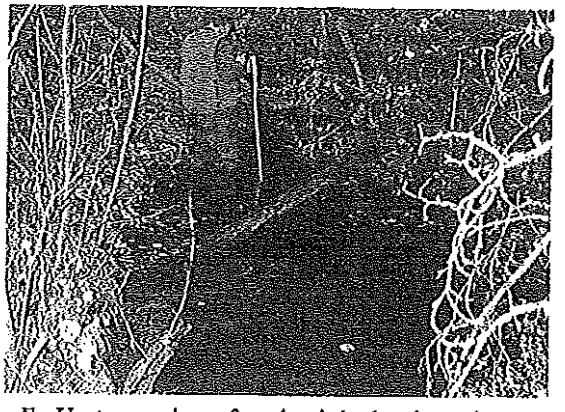


C: Upstream view of eroding bank in section 1B at 0+533 m.

D: View of artificial pond in section 1B at 0+720 m.



E: Upstream view of cattle crossing and watering area in section 1B at 0+823.



F: Upstream view of pool unit in the channel at 0+895 m in section 1C.

Channel Assessment

Reach 1 of de Jong Creek is a low gradient 1.1 km long gravel-riffle-pool channel located on agricultural land. The lower and upper sections are influenced primarily by LWD, riparian vegetation and willow jams from dead or prostrate willow branches, while the middle section is influenced most by human activity. The upper part of section A is slightly to moderately aggraded as a result of sediment settling out from the degraded section B. The lower 200 m of section A is the only stable portion of the channel in this reach. Parts of section B and C appear to have been straightened many years ago. Section B is the most highly impacted, as was predicted by the 10th place ranking of this section in the overview assessment (see Appendix A). Much of section B is moderately degraded and eroding banks from 0.5 to 2 m high are common in the initial 200 m of the section. Signs of disturbance include lack of functional LWD, bank erosion, extensive riffles, minimal pool area, and extensively scoured zones. The right bank has been diked in the lower part of section B. The channel of section C is slightly aggrading in the lower 65 metres and slightly degrading in the remaining 215 metres. An old dike is present along the left bank in the upper part of this section. Channel banks consist of erodible silts, clays and sand, with small amounts of gravel in section A. Gravel is more common in section B, and cobble is found in some of the banks of section C. Channel substrate is primarily gravel and fines.

A few areas of specific concern exist in this reach, particularly in section B. Eroded banks at 0+533 m, 0+600 m and 0+658 m are contributing sediment to the system (Fig. 16C). The first evidence of cows in the creek occurs at 0+720 m next to a pond for water storage (Fig 16D). However, extensive cattle use is limited to a 50 metre stretch above Upper Robin Creek Road. The creek channel is very wide and shallow at a cattle crossing located at 0+823 m (Fig. 16E). Trampled banks and widened creek are contributing sediment to the creek at this location.

Fish and Fish Habitat Assessment

General habitat quality in reach 1 is poor to moderate. Rearing habitat, generally governed by channel complexity, was moderate in the lower and upper section and poor in section B. Cover for fish, primarily overhanging vegetation and cutbank, averaged 15% of the channel. Canopy closure was high (71-100%) except in section B where it is less than 20%. We observed a relatively large amount of LWD in the reach, primarily in sections A and C. 62% of this was functional, one third of a medium size class, and the rest small (Table 18A). Although the average was relatively high (at 0.4 functional pieces per bankfull width) compared with the rest of the Robin Creek drainage, pools comprised only approximately 20% of the reach by area. Extensive riffles in section B and part of section C helped decrease riffle:pool ratios. Future LWD recruitment should be good in section C and moderate in section A. Cottonwoods, if left to fall into the creek in section B, will eventually help increase LWD levels in this section. Spawning habitat for resident salmonids is limited to small patches through most of the reach. Overwintering habitat is poor to moderate, being limited to some of the deeper pools and undercut banks.

Fish densities in the reach appeared to be low. We did not observe or capture any fish despite setting six minnow traps for 23 hours. A 70 cm falls above a 55 cm plunge pool at 0+676 m may be a barrier to upstream fish migration. Occurring in erodible silts and clays, this falls appears to be the result of extensive downcutting. Downstream of this point, the channel is deeply incised, while above, the banks are relatively stable and low. Evidence from other studies (Triton 1997a: Tamblyn and Haines 2000) and Vanderven Creek, suggest cutthroat trout are present in the reach. Fish may overwinter downstream in the large pond in reach 4 of Robin Creek.

Impact synopsis

Land use in this reach has impacted fish habitat. The middle 350 m section of the reach has experienced the greatest impacts. In much of this section, the riparian vegetation has been thinned, LWD is rare, the channel has been straightened and is downcutting and the banks are eroding. These factors combine to reduce stream complexity and fish habitat both in this section and downstream. Heavy cattle use in the upper part of this section is contributing to bank instability and sedimentation. The remaining 765 m of the reach is relatively unimpacted. The riparian zone is healthy and LWD is common.

Restoration suggestions

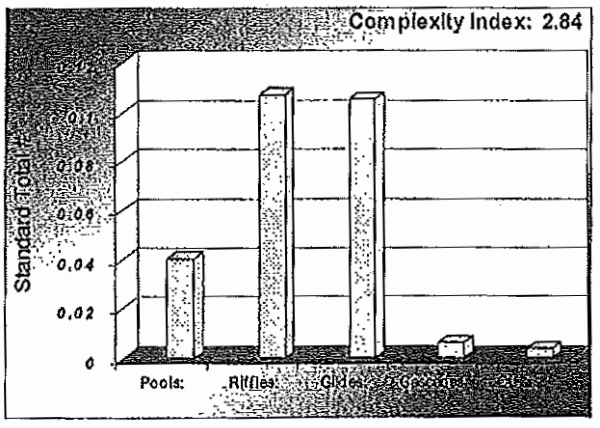
- Work with the landowner to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible without access to Crown range).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream. Plant tree species if shrubs choking the channel cause a flood concern. Protect or preserve the remaining shrubs. Pruning shrubs whose branches or trunks cause jams may be an option.
- Decrease energy of the stream by constructing riffle structures in reach 2B. Must ensure bank stability to prevent further erosion (fascines, brush mattresses, etc.) prior to instream work.
- If a cattle crossing is necessary, construct a hardened or geoweb crossing.
- This reach may not be a good candidate for rehabilitation due to potential unwillingness by the landowner to partake in any activities on his land.

Table 18. Summary of channel and fish habitat field data for de Jong Creek, reach 1.

a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	205	101	7	313
# Functional Pieces	124	68	3	195
# Func. Pieces / Bankful width	0.25	0.14	0.01	0.40
% Functional	60	67	43	62

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	G	S-C	M	R	L	C, OV	70-90
Pool	G	S	M	AR	N	C, OV	90-100
Riffle	G	S	M	AR	L	OV	40-70

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
4.38	0.05	0.17	0.76	0.73	6.3

4.1.4.2 Reach 2A

Length:	1200 m	Elevation (assessed):	658 - 780 m
Length assessed:	1200 m	Average gradient:	3.4%
Number of sites:	6	Mean W_b :	3.28
Number riparian plots:	0	Mean d_b:	0.39 m

Section A of reach 2 is distinguished from the rest of the reach by land use. The land at the top of the valley walls has been cleared for agriculture.

Riparian Assessment

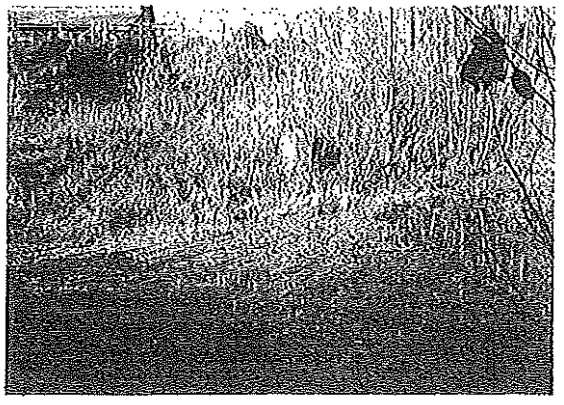
The riparian zone of reach 2A of de Jong Creek is in relatively good condition (Fig. 2B, 2C). The creek flows through a 70 to 80 m wide valley with an intact young to mature mixed forest of spruce, aspen and cottonwood. The cleared land on the flats above the valley walls affects the LWD recruitment only when the stream comes close to the valley wall. The riparian zone in general, appears to function well.

No riparian assessments were conducted in this reach as it was in relatively good condition. Site series is a mix of well drained Spruce – Horsetail (SBSdk07a) and Cottonwood-Dogwood-Prickly rose (SBSdk08).

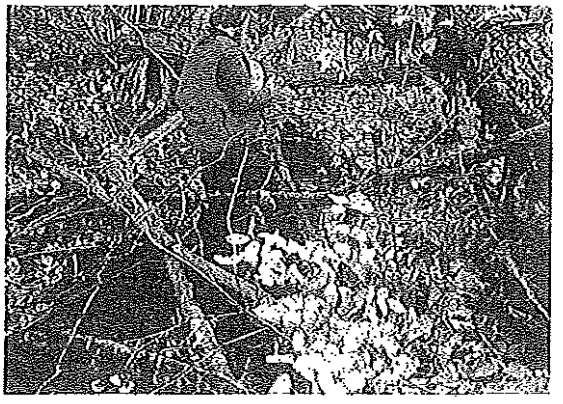
Channel Assessment

Reach 2A is a moderate gradient 1.2 km long cobble-riffle-pool channel located on agricultural land. LWD and jams are the primary channel complexing mechanisms. Virtually the entire section was slightly aggraded; the exception was a 100 m mid-channel segment showing signs of moderate aggrading. Common signs of disturbance included sediment wedges, minimal pool area and multiple channels. Functioning LWD was also rare in a 350 m segment of channel in the lower half of the section. Many of the pools were shallow, and appeared to be infilling from aggradation. This infilling is likely natural, but we did observe several point sources that are contributing material to the stream. A road crossing (1+148 m) used for cattle and potentially for farm equipment has widened the creek significantly and may be contributing small amounts of sediment (Fig 17D). A larger source is the erosion of a short stretch of an old road bed along the left bank immediately upstream of the crossing. Channel banks consist of erodible fines and gravel with some areas of cobble. Another potential anthropogenic sediment source is a 1992-95 cutblock that comes close to the creek several kilometres upstream. We did not assess this block, but according to the Forest Service, it was partially cut and there are no records of eroding banks. Channel substrate material was heterogeneous, ranging from fines to boulders, but is primarily gravel and cobbles.

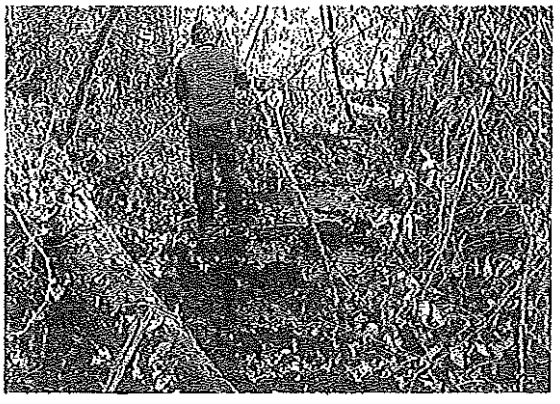
Figure 17. de Jong Creek Reach 2A: channel, riparian and impact photos.



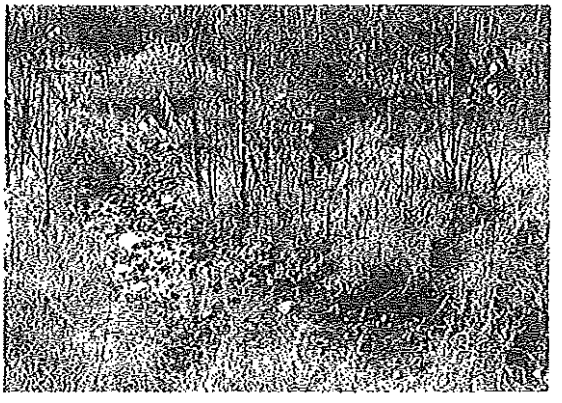
A: View of pond and well head at 0+072 m.



B: View of typical channel conditions at 0+185 m. Note the abundant nonfunctional LWD spanning the channel.



C: Upstream view of channel and riparian conditions at 0+260 m. Note the dense shrub cover and large substrate particle size.



D: Downstream view of impacted channel and riparian habitat at 1+160 m. Note the braided channel and aggradation upstream of the road crossing.

The channel has been slightly modified in the past by land owners. The lower 100 m of the reach appears to have been diverted and straightened years ago and an old dike exists along the left bank. A small dam at 0+072 m is backing up water into a small licensed storage pond (Fig. 17A). Although the primary purpose of this pond is stockwatering, it appears to provide rearing and overwintering habitat to wintering salmonids. The only sign of cattle in this section of the reach was at the upper road crossing.

Fish and Fish Habitat Assessment

General habitat quality in reach 2A is moderate. An estimated 68% of the habitat is riffles and runs leading to relatively low habitat complexity and variety (CI 3.10) (Table 19b). Cover for fish, primarily overhanging vegetation, with some boulder, cutbank and woody debris, averaged 5 to 10%. Canopy closure is generally moderate, but ranges from less than 20% to over 70%. Reach 2A, like reach 1, contains a watershed high 0.42 functional pieces of LWD per bankfull width (Table 19a). In fact, LWD numbers were almost identical, despite a greater degree of intact riparian zone in reach 2A. 60% of the LWD observed was functional with 25% of a medium size class, and the rest small. Despite the good LWD levels, pools comprised less than 20% of the reach with a frequency of one poll per 20 bankfull widths. A general lack of deep pools and deep cutbanks lead to poor overwintering in this reach apart from the storage pond at 0+072 m. Spawning habitat is moderate. Most glides and riffles have patches of suitable gravels and appropriate anticipated spring flow conditions for spawning of resident fish.

Fish densities in the reach are likely to be low judging from densities elsewhere in the Robin Creek drainage. We did not sample for fish. Low water temperatures prevented electrofishing and instructions from the landowner combined with little accessible suitable habitat discouraged the setting of minnow traps. Evidence from other studies (Triton 1997a, Tamblyn and Haines 2000) and Vanderven Creek, suggest cutthroat trout are present in the reach.

Impact synopsis

This reach is relatively unimpacted compared with the rest of the Robin Creek watershed. The riparian zone is intact. LWD is common and future recruitment should be satisfactory. Cattle use is limited to a crossing at the upper end of the reach. The channel itself is aggrading, resulting in pool infilling and associated habitat loss.

Restoration suggestions

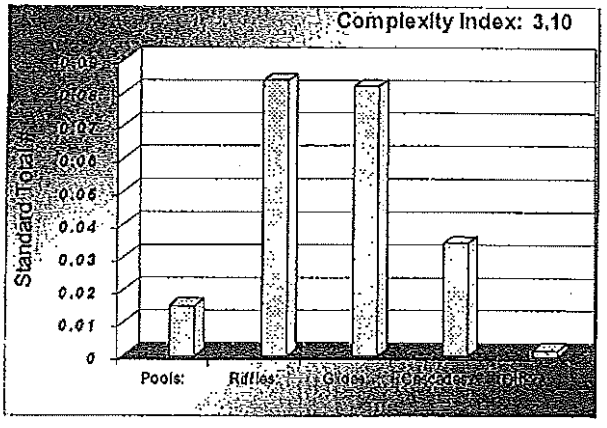
We do not recommend restoration in this reach due to higher priorities elsewhere.

Table 19. Summary of channel and fish habitat field data for de Jong Creek, reach 2A.

a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	179	65	4	248
# Functional Pieces	113	37	2	152
# Func. Pieces / Bankful width	0.31	0.10	0.01	0.42
% Functional	63	57	50	61

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	C	B	M	AR	N	B, OV	0-20
Glide	G	C, S	M	R	L	OV, B	40-70
Pool	C	B	H	AR	N	C, SWD	40-70
Riffle	G	C	M	AR	L	OV	20-40

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
6.83	0.06	0.17	1.05	1.35	13.32

4.2 Deep Creek (460-496100)

Deep Creek is a third order (at 1:50 000 scale) stream draining the southwestern slopes of the Babine Mountain Range. This system is lake-headed and flows in a southwesterly direction to join the Bulkley River approximately 11 km upstream of the Walcott bridge. The drainage area of 109 km^2 makes Deep Creek the largest sub-basin in our study area. This stream consists of 17 reaches (Triton 1997a) and is approximately 24 km long. Reach 1 flows through agricultural land used for cattle and horse grazing, and is crossed by several roads including Highway 16. Several residences and hayfields were also located along this reach. Reaches 2 and 3 flow through land owned by, or leased to, cattle ranches. Two small cutblocks were observed on the Forest Cover Map 93L.067. One block, approximately 14 hectares in area and harvested in 1986, is mapped as spanning Deep Creek in reach 3. It appears as if this streamside harvest occurs upstream of a small wetland. The second block, 15 hectares in area and cut in 1989, is located on a hillside approximately 400 m from the channel. The remaining upper reaches flow through Crown land. No other forest harvest was observed.

We assessed reach 1 and the lower 1.1 km of reach 2 for a total distance of approximately 8 km. Reach 1 is a lower gradient reach that flows from the small canyon that confines reach 2 to a small alluvial fan on the floodplain of the Bulkley River. Reach 2 is a higher gradient reach with a very narrow floodplain confined by steep side-walls. Due to the steep nature of the gully walls, cattle use of reach two was minimal. We did not survey further due to the lack of human impacts and the relative lack of fish habitat in this cascade-pool channel. Reach 3 consists of a series of wetlands and flows from a 10 m cascade or falls (Triton 1997a) at the upstream reach break. The remaining reaches alternate between wetlands, ponds or lakes and fluvial channels. Reach 11 is Farewell Lake which is the largest body of water in the Deep Creek sub-basin.

Fish distribution for the Deep Creek watershed was assessed by Triton (1997a) and confirmed by our study for reach 1 and part of reach 2. Spawning pink salmon were observed from the Bulkley River upstream for approximately one kilometre. Chinook and coho salmon juveniles were captured in minnow traps or by electrofishing throughout reach 1 to within 500 m of reach 2. Rainbow trout juveniles were captured throughout assessed area. Due to the proximity and ease of access to the Bulkley River mainstem it may be assumed that most of these juveniles are steelhead fry (Tredger 1982). Dolly Varden char were first captured 4.5 km from the Bulkley River. Cutthroat trout were captured in a tributary to reach 3 (Triton 1997a), however, none were observed in Deep Creek itself. The 10 m high cascade or falls at the reach 3/4 break is the upstream limit to anadromous fish. Rainbow trout and cutthroat trout were captured upstream of the falls (Triton 1997a). Other species found in the Deep Creek watershed include longnose dace and lamprey near the confluence with the Bulkley River and an unknown minnow (potentially redside shiner based on the photograph) found near Farewell Lake (*Ibid.*).

Environment Canada operated hydrometric station, 08EE022, on Deep Creek for two years during 1978 and 1979. These data show that peak flow occurs during May with maximum and minimum daily discharges of 8.2 m^3 and 0.01 m^3 per second, respectively (Triton 1997a).

Ministry of Environment staff also measured discharge over several years and at several locations (BC 1999b). We estimated discharge at the time of sampling to be 0.66 m^3 per second. A MELP data logger was observed in the channel in reach 1 near the reach break, however, information from this gauge was unavailable at the time of writing (Meredith, pers. comm.). Six water licences have been issued for Deep Creek. Five of these are for irrigation with a total of 236 000 m^3 or 190 acre feet allocated annually. This equates to approximately 1970 m^3 per day over a four month irrigation period. One domestic licence exists for an allocation of 1000 gallons per day (4.5 m^3 per day) or 1660 cubic metres per year (BC 1999c). No water quality information was available for this system.

4.2.1 Reach 1

Length:	6941 m	Elevation:	537 - 630 m
Length assessed:	6941 m	Average gradient:	1.5%
Number of sites:	28	Mean W_b :	10.0 m
Number riparian plots:	3	Mean d_b:	0.8 m

Riparian Assessment

Impacts on the riparian zone from a variety of sources were observed along the entire reach. Although much of the land has been cleared for agriculture and residential properties, some of the most severe impacts are due to livestock grazing and watering. The section of stream downstream of Highway 16 has suffered from historic cattle grazing, but is currently only used for hay production, vegetable gardens and grazing by several horses. The riparian zone upstream of the highway has been used primarily for cattle grazing. Several hay fields and three residences are adjacent to the channel in this reach. In areas where cattle pasture is the primary land use, riparian shrubs have been stripped from most of the stream bank. In areas where the riparian vegetation is relatively intact, red-osier dogwood, mountain alder, aspen, black cottonwood, saskatoon and several willow species form the dominant shrub cover. Mature forest along most of the reach consists of large cottonwood. We observed few mature conifers during our study. Many may have been harvested during the initial homesteading and clearing of the area. Future conifer growth is largely regulated by cattle grazing. Where cattle impacts are limited a good crop of seedlings is present in the understory. Channel and bank instabilities were commonly observed in areas with reduced riparian understory. The lack of root masses and vegetative cover protecting the soil in combination with the shearing and compaction caused by animals' hooves has caused slumps and bank failures throughout most of this reach.

We chose three sites for riparian assessment (Fig. 18).

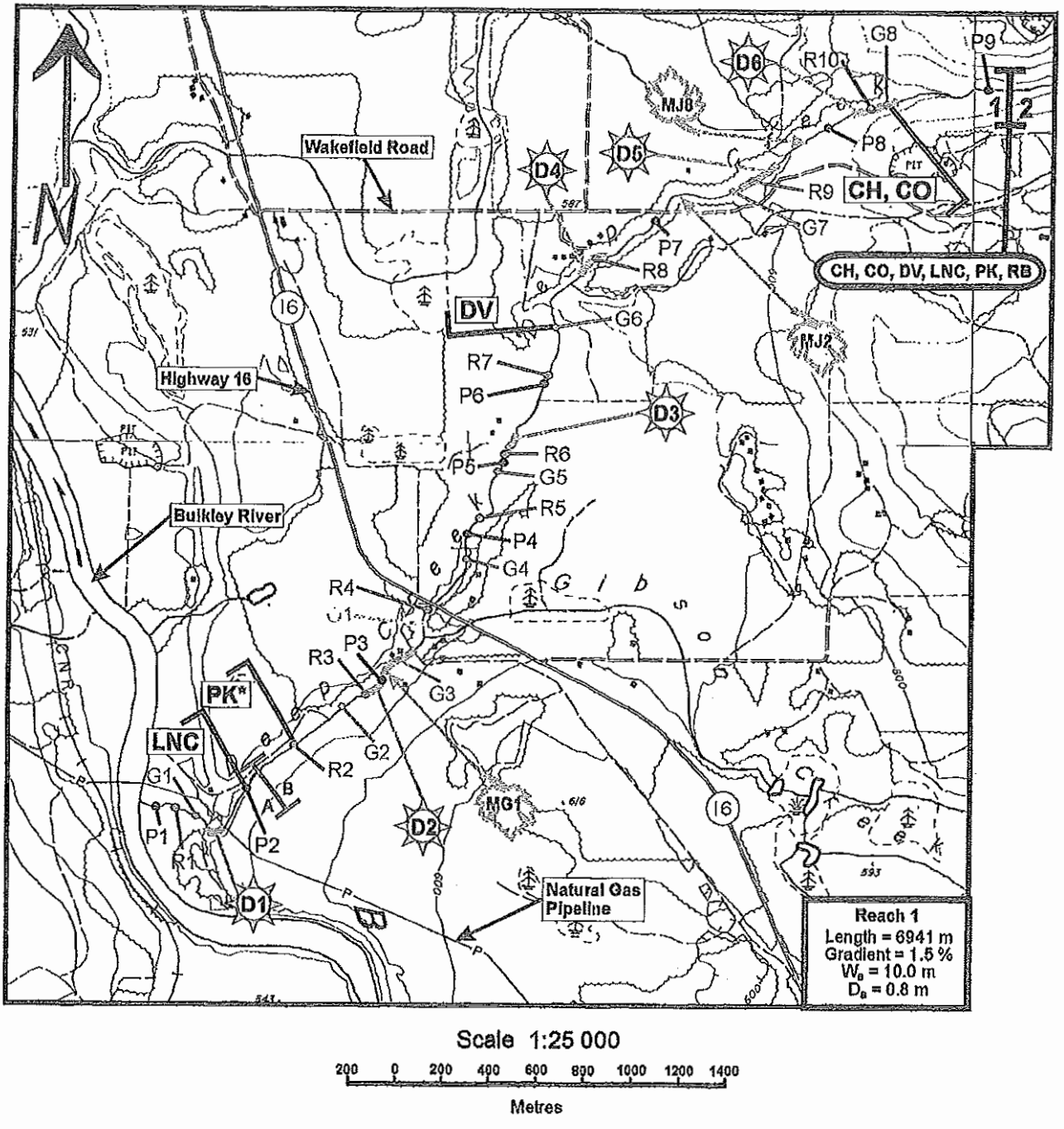


Figure 18. Map of Deep Creek, reach 1, showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source maps: TRIM 93L.056, 066, 067 1:20 000.

Assessment site MG1

Site series: SBSdk08 (disturbed)
Seral association: Act - Dogwood - Prickly rose

This site was chosen to represent the lower benches of the Deep Creek floodplain below Highway 16. We selected it based on its relative lack of disturbance and its relationship to nearby impacted sites. The centre of this plot was approximately 12 m from the left bank of the stream on a meander approximately 300 m downstream from the Farewell Bridge. Aspect was north and the slope was 7%. The 11.28 m radius plot was located in an area that was relatively undisturbed and yet near the creek. The site was elevated approximately 2 m from the waters surface. The forest of this site was young and dominated by aspen with a few black cottonwood and spruce in the plot. Occasional lodgepole pine saplings were located nearby. The stocking survey found 4400 aspen stems per hectare of which 4225 were aspen saplings less that 7.4 cm dbh. Three spruce between 7.5 and 20 cm dbh were in our plot and we observed several more in the area. The largest spruce was approximately 25 m high and could be effective LWD in the future. Black twinberry and prickly rose were the dominant shrubs (5% cover each). Grasses (60% ground cover) were the dominant plant in the herb layer. Other shrubs and herbs observed in the plot include: common dandelion (*Taraxacum officinale*) (2%), fireweed (1%) and an unidentified willow species approximately 5 m tall (1%). A species list can be found in Appendix E. This site offers a good template of the expected plant community on the mid to high bench floodplain of reach 1. The riparian function of this site was moderate overall due to the lack of mature trees (Table 20). LWD recruitment from this site will be low for over 100 years until conifers re-establish (if the floodplain is not overly active). However, large cottonwood near this site could become LWD within several decades.

Table 20. Riparian function summary for riparian plot MG1.

Function	Rating	Comments
LWD	L	No trees in plot with dbh >22 cm.
Shade	L-M	Mountain alder acting as overstory in this area.
Small organic debris (SOD)	M	
Surf. Sed. Filter	H	Dense cover by grasses.
Channel stability	M	Plot ~ 12 m from creek.
Bank stability	M	Diverse shrub cover.

We dug a 70 cm soil pit in the plot. The soil great group is Dystric Brunisol. Layers were as follows: a 1-5 cm mullmoder layer, a 10 cm dark brown Ah layer composed of silty loam, and a light brown Bm layer of loam with some lenses of dark brown material similar to the Ah soil. Based on descriptions contained in Banner *et al.* (1993), the site series is the Act - Dogwood - Prickly rose (SBSdk08). This determination agrees with the work done by Haeussler (1998).

Assessment site MJ2

Site series: SBSdk08 (disturbed)
Seral association: Act - Dogwood - Prickly rose

We chose this site to approximate the expected plant communities found on the active floodplain of Deep Creek upstream of the highway. The channel in this area has been impacted by cattle grazing, trampling and watering. Our site was located opposite an area of such impacts. The centre of the plot was approximately 0.5 m above and 7 m away from the waters edge. The 3.99 m radius plot was located on the left bank of Deep Creek 70 m upstream of the Wakefield Bridge. The site had received some cattle use, but was the least impacted area in the vicinity. Its aspect of this flat site was northeast. The riparian forest was dominated by large black cottonwood stems and one 8 m high spruce was observed nearby. The stocking survey indicated that cottonwood stems at densities of 1200 stems per hectare, two-thirds with a dbh greater than 22 cm and one-third less than 1.3 m in height. The largest cottonwood was estimated to be approximately 35 m high. Mountain alder and red-osier dogwood were the dominant shrubs with 5% and 10% cover, respectively. The dominant herb species was an unidentified grass (likely a needle grass, *Stipa* sp.) which formed a dense layer covering approximately 60% of the plot. Other common shrub and herb species included saskatoon (*Amelanchier alnifolia*) (2%), prickly rose (1%), one-sided wintergreen (*Orthilia secunda*) and bluejoint grass (*Calamagrostis canadensis*) (2% each), purple peavine (*Lathyrus nevadensis*), rosy twisted stalk (*Streptopus roseus*), false Solomon's-seal (*Simalcina racemosa*), common mitrewort (*Mitella nuda*) and great northern aster (*Aster modestus*) (1% each). A complete species list is found in Appendix E. Again, this floodplain site may be too active to support conifers to maturity, however, the large cottonwoods will contribute functionally to the channel when they fall. Overall, riparian function was moderate to high (Table 21).

Table 21. Riparian function summary for riparian plot MJ2.

Function	Rating	Comments
LWD	M-H	All trees are cottonwood.
Shade	H	Plot centre is 7 m from creek.
Small organic debris (SOD)	M	Few shrubs & trees immediately adjacent to the creek.
Surf. Sed. Filter	H	Dense layer of grasses.
Channel stability	M	
Bank stability	L	Cattle grazing has weakened banks and removed veg.

We dug a 60 cm soil pit in the plot. The soil great group is Brunisol. Layers were as follows: a 6 cm moder layer and a 7 cm light yellow-brown Bm layer composed of loamy sand. The parent material beginning approximately 13 cm below the surface was composed of alluvial deposits and consisted of 30% cobbles, 30% gravels and 40% sand. Based on descriptions contained in Banner *et al.* (1993) the site series here is the Act - Dogwood - Prickly rose (SBSdk08). This determination agrees with the site series classification done by Haeussler (1998).

Assessment site MJ8

Site series: SBSdk08
Seral association: Act - Dogwood - Prickly rose

This site was chosen as a relatively undisturbed surrogate for the nearby heavily grazed riparian area. The site was located on an old point bar on the first bench above the stream, approximately 0.5 m above the surface of the water. Plot centre was 6 m from the bank. The aspect of the 3.99 m plot was east and the slope was 4%. No trees with a dbh greater than 21.9 cm were located in our plot. Spruce was the dominant tree species at this site, however, mountain alder was functioning as an overstory species. Three mountain alder between 19 and 22 cm dbh and up to 12 m high were observed in this plot. Black cottonwood and spruce saplings up to 7.4 cm dbh were also observed in the plot. Several mature cottonwood trees were growing near the plot. The stocking survey indicated densities of 600 spruce stems and 600 cottonwood stems per hectare. 200 of these trees would be spruce between 12.6 and 21.9 cm dbh while the rest would be spruce and cottonwood saplings less than 12.6 cm dbh.. Shrub cover in our plot was good with 15% coverage by a tall layer of mountain alder and 20% cover from by red-osier dogwood. Black twinberry (5%), and devil's club (*Oplopanax horridus*) (3%) were the only other shrubs in our plot. Prickly rose and common snowberry were observed in the area, but not in the site. Oak fern (*Gymnocarpium dryopteris*) (5%), an unidentified aster species (2%), bluejoint (1%), cow parsnip (*Heracleum lanatum*) (1%) and palmate coltsfoot (1%) were the dominant herbaceous species in our plot. A complete species list is found in Appendix E. The riparian function of this site was moderate overall (Table 22) due to the active nature of the floodplain, and to a lesser degree, cattle grazing. Conifers will not likely contribute substantial LWD to the channel, however, large cottonwood trees will serve the same purpose in years to come.

Table 22. Riparian function summary for riparian plot MJ8.

Function	Rating	Comments
LWD	L	Few mature trees, most of which were alder.
Shade	M	Alder giving good canopy closure over stream.
Small organic debris (SOD)	M	Mostly deciduous from alder and dogwood.
Surf. Sed. Filter	M	Some areas of exposed soil due to cattle use.
Channel stability	M	
Bank stability	L	Cattle impacts reducing stability.

We dug a 55 cm soil pit in the plot. The soil great group is Dystric Brunisol. Layers were as follows: a 4 to 6 cm moder layer intermixed slightly with an approximately 25 cm deep light brown-grey Bm layer composed of loamy sand. The parent material consisted of alluvial deposits composed of 60% gravel, 10% cobble, 5% stones and 25% sand. Based on descriptions contained in Banner *et al.* (1993), the site is the Act - Dogwood - Prickly rose (SBSdk08). This determination agrees with the work done by Hauessler (1998).

Channel Assessment

Reach 1 of Deep Creek is a riffle-pool channel approximately seven kilometres long. It originates at the downstream end of a canyon and flows through agricultural land to the

confluence with the Bulkley River. LWD is the primary channel complexing mechanism, however, beaver activity was observed near the Bulkley confluence and at three kilometres upstream. A large beaver dam complex that had been flooding fields on the Bulkley floodplain was destroyed during the floods in the spring of 1997 (T. Kirsch pers. comm.). A section break at 0+780 metres indicates the extent of the Bulkley River floodplain. The dominant substrate of section 1A was gravels with cobbles being sub-dominant. The erodible banks were composed mainly of fines (silt, sand and clay) and a small portion of gravels. Section 1B had a substrate consisting of cobbles and gravels in equal proportions and the gravel and fine textured banks were erodible.

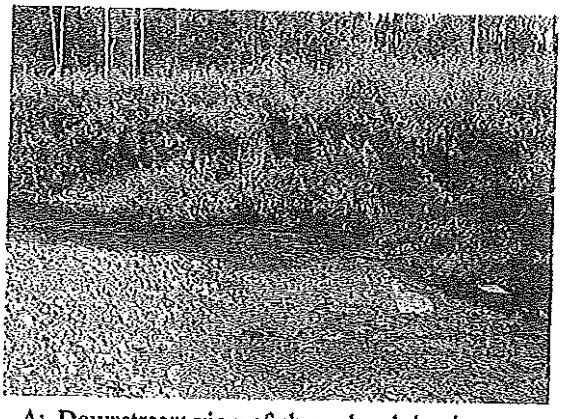
We observed moderate to severe channel impacts over approximately 41% of reach 1. Section 1A was moderately aggraded over its entire length. This section occurs on a double floodplain and has been influenced by beavers. The resulting inherent channel instability combined with the activity of beavers has allowed much channel migration and active channel movement (Figs. 19A, 20A). Common indicators of disturbance in this section include extensive and elevated bars as well as eroding banks. Land clearing has led to low levels of LWD in portions of the reach. Nonetheless, LWD was more common on average (0.66 functional pieces per bankfull width) than any other system we assessed. An avulsion, partially caused by beavers at 2+926 metres has created an area of moderate aggradation and degradation. Cattle grazing has contributed to the aggradation caused by two avulsions between 3+593 m and 3+715 m (Figs. 20C, D, E, F). A further section of channel from 3+640 metres to 4+544 metres has been heavily influenced by agricultural activities. In addition, the channel has been entrained and possibly diverted to protect farmland.

Many of the current channel impacts can be attributed to cattle access to the riparian zone and stream banks and resulting loss of riparian forest and vegetation by agriculture. Many areas at which cattle are allowed unrestricted access to the channel are showing signs of channel widening and aggradation as the banks become shallower and material is moved into the channel. These areas are less complex and have shallower water than areas used less often by cattle.

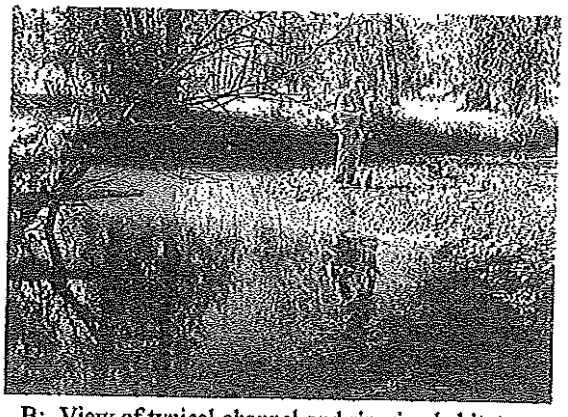
Fish and Fish Habitat Assessment

General habitat quality in reach 1 is moderate to good. Deep pools found throughout the lower two thirds of the reach offer good overwintering habitat with good access to food. Pools were more common in this reach than in any other reach assessed (one pool every 4.3 bankfull widths). Spawning habitat was generally good in this reach with glides offering excellent spawning opportunities for anadromous species and moderate spawning opportunities for resident species. Glides accounted for approximately 40% of the channel length and area. Rearing habitat is also good in the glides and pools. Canopy closure averaged approximately 10% of the wetted channel and instream cover was dominated by overstream vegetation. Boulders were the sub-dominant form of instream cover. LWD averaged 0.66 pieces of functional wood per channel width with only 8% of the functional pieces being large (greater than 50 cm diameter) (Table 23a). In total 30% of the wood was functional.

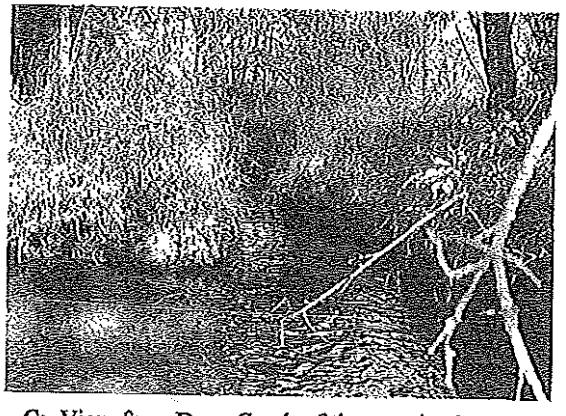
Figure 19. Deep Creek Reach 1: channel, riparian and impact photos.



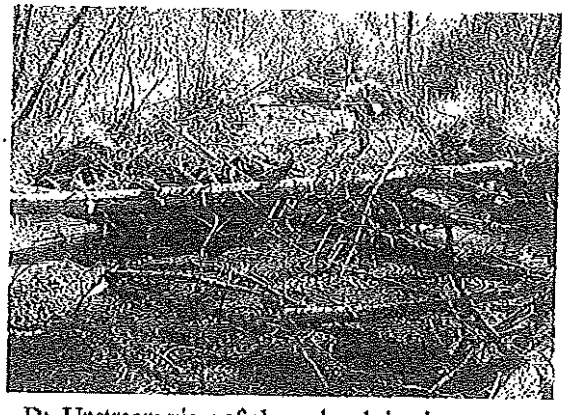
A: Downstream view of channel and riparian vegetation on the Bulkley River floodplain at 0+065 m.



B: View of typical channel and riparian habitat at 1+945 m. Note the large point bar.



C: View from Deep Creek of the mouth of Gibson Creek at 2+390m. Gibson Creek is the largest tributary to Deep Creek.



D: Upstream view of channel and riparian habitat at 3+150. Note the extensive aggradation.

E: Upstream view of channel and exposed clay slope at 6+012 m.

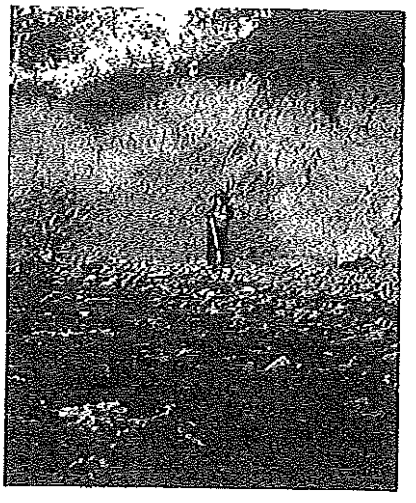
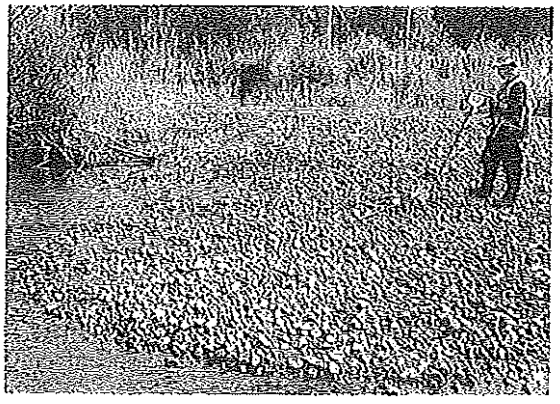
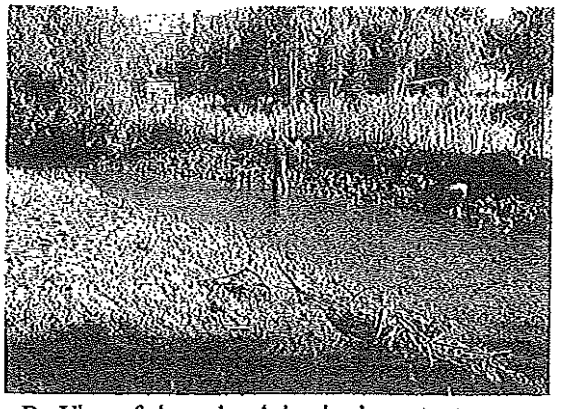


Figure 20. Deep Creek Reach 1: impact photos.

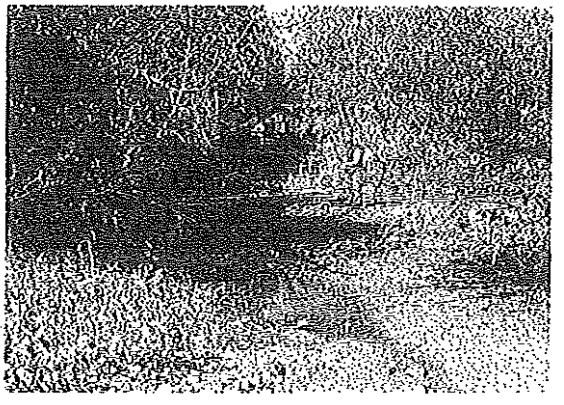


A: View of large unvegetated point bar at 0+443 m, downstream of the natural gas pipeline.

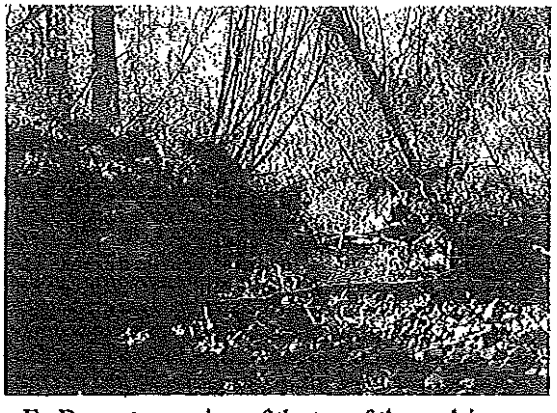


B: View of channel and riparian impacts at 1+945 m, near a private residence. Note the free access to the channel by livestock.

C: Downstream view of the top of the avulsion at 3+620 m. Note the incised banks and exposed roots in the new channel.



D: View of the abandoned channel at 3+593 m, near the landowner's barn. This was the main channel prior to the avulsion and channel straightening.



E: Downstream view of the top of the avulsion at 3+715 m. Note the incised banks and exposed roots in the new channel.

F: Downstream view of the abandoned channel at 3+715 m. This was the main channel prior to the avulsion.

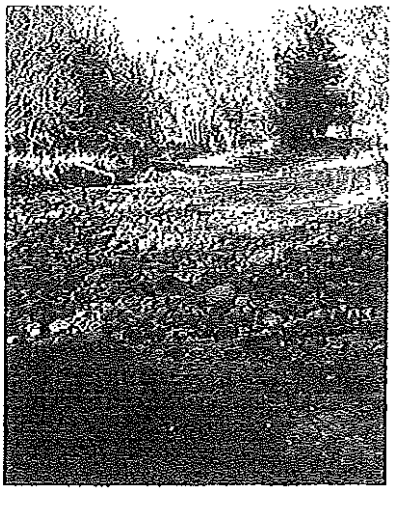
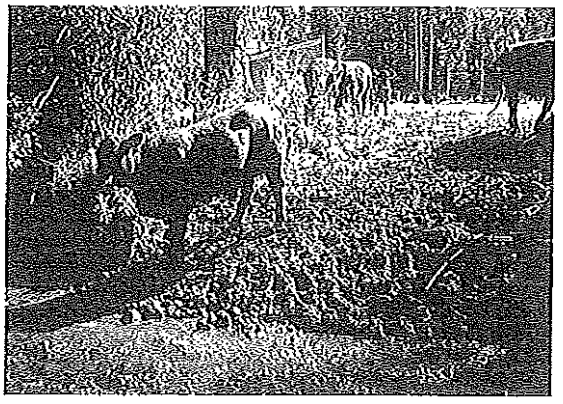
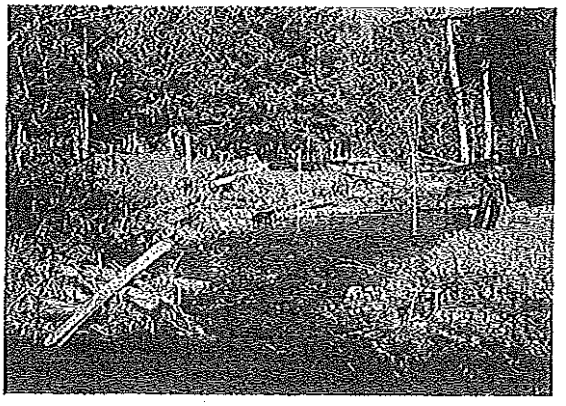


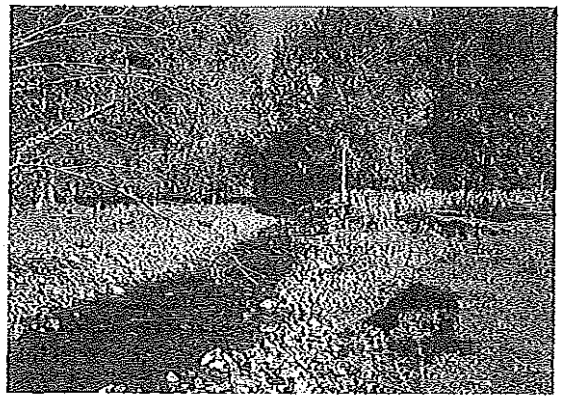
Figure 20 cont. Deep Creek Reach 1: impact photos.



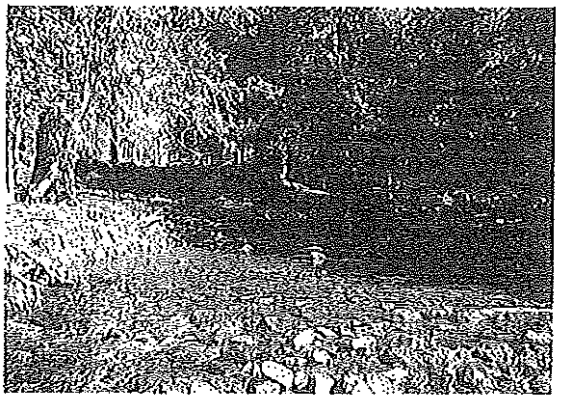
F: View of a main cattle ford and watering area at 3+715 m. Note the exposed soil on the trail.



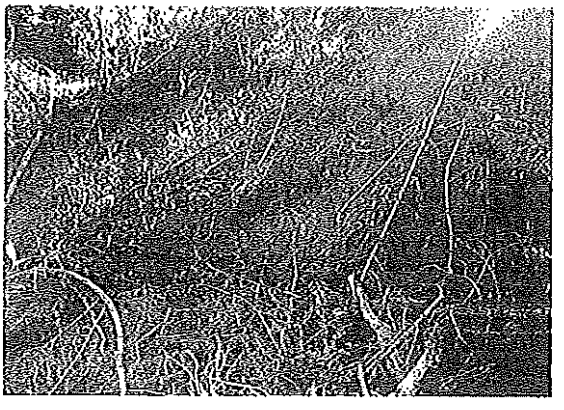
G: View of the outside of a meander bend armoured by the landowner with LWD to prevent erosion.



H: Upstream view of channel and riparian impacts at 6+325 m. Note the lack of riparian vegetation and LWD and the poor condition of the banks.



I: View of a well used cattle watering area and ford at 6+435. Note the exposed soil and poor bank structure.



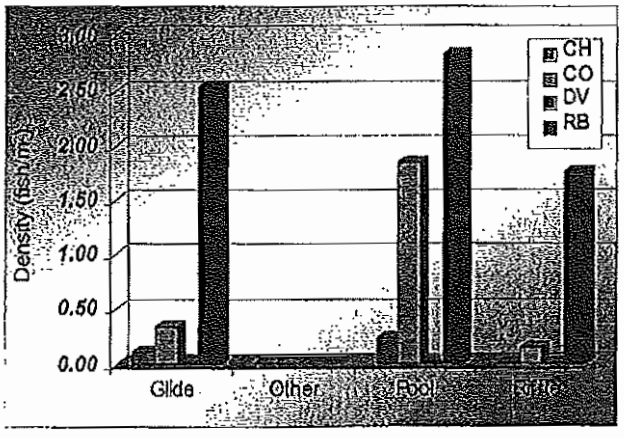
J: View of a hydraulic failure of a clay bank at 6+540 m. This is a source of fine sediments and SWD.

Table 23. Summary of channel and fish habitat field data for Deep Creek, reach 1.

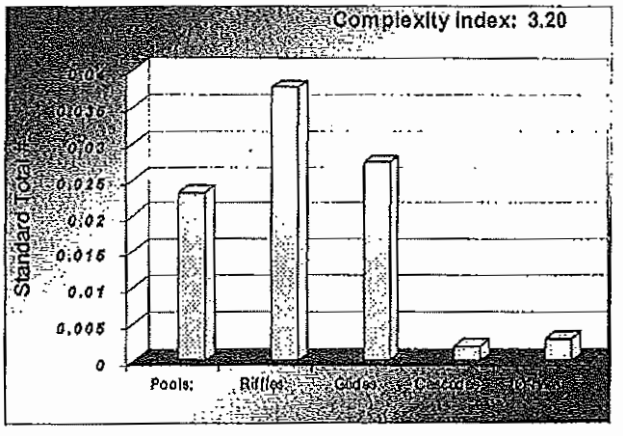
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	797	516	116	1429
# Functional Pieces	158	208	68	434
# Func. Pieces / Bankful width	0.24	0.32	0.10	0.66
% Functional	20	40	59	30

b) Density of salmonids in glides, pools , riffles and other habitat types.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	G	C	H	AR	H	B, OV	0-20
Other	S	S	L	N	N	OV	0-20
Pool	G	S	H	AR	L	OV, LWD, C, B	0-20
Riffle	C	C	H	AR	L	OV	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
13.21	0.06	0.39	1.08	9.08	13.21

Fish densities were relatively high in reach 1 of and it supported the greatest diversity of salmonids in our study (Table 23b). We observed pink salmon spawners upstream from the Bulkley for approximately one kilometre. Rainbow trout or steelhead juveniles (0+ to 3+) were the most abundant fish we captured. Previous studies have shown that in streams with good access to the Bulkley River and with suitable habitat it can be assumed that approximately 70% of the juvenile rainbow trout are steelhead fry and smolts (Tredger 1982). Coho salmon (0+, 1+) were quite abundant in glides and pools. Minnow trapping of pools in Deep Creek captured many more fish than electrofishing the same habitat unit. Chinook salmon juveniles (0+, 1+) were often observed in the same habitat as coho, but in lower abundances. We caught chinook and coho throughout reach 1 to a point approximately 6.5 km upstream from the Bulkley River. Dolly Varden char were observed in low densities beginning 4.5 km upstream from the Bulkley. We also captured longnose dace in section 1A, near the Bulkley River confluence.

Impact synopsis

Land use in this reach has damaged fish habitat. The channel was relatively unstable and had reduced complexity. Coniferous LWD recruitment is limited over much of the reach and future recruitment may be low due to cattle grazing. For the same reason, the banks along this reach are unstable and actively eroding causing sedimentation and aggradation. Restoration opportunities will likely be best focussed on livestock management.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible in some cases, without access to Crown range).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream. Protect existing vegetation.
- Construct bridges or hardened cattle crossings at critical fords. Encourage cattle to use existing bridges.

4.3.2 Reach 2

Length:	5800 m	Elevation:	630 - 860 m
Length assessed:	1123 m	Average gradient:	3.4%
Number of sites:	3	Mean W_b :	9.7 m
Number riparian plots:	0	Mean d_b:	0.98 m

Riparian Assessment

The riparian zone of reach 2 is relatively intact and the overstory consists of aspen, alder, pine and spruce growing on steep gully walls. The floodplain in the section surveyed was approximately 30 metres wide. Cattle grazing does occur in this reach, however, animal

densities appear to be low. We observed several trails along the approximately 70% sloped gully walls and some prints on the floodplain. No land clearing or forest harvest has occurred in this reach. Several areas of bank failure and slumping were found in the section we surveyed. These slumps appeared to be rotational failures of predominantly clay banks.

Channel Assessment

Reach 2 is a cascade-pool channel approximately 5.8 km long that flows through a deep gully (Fig. 21). LWD is the main channel complexing and formation element in this reach. The coupled gully walls also play a large role in forming the channel. Material eroded from the walls could cause the channel to migrate across the narrow floodplain. The average gradient of the section surveyed was 3.5% and the gradient calculated from maps of the entire reach is 4.0%. Based on the information gathered at three sites, the dominant substrate was boulder. The subdominant varied by habitat type: sand in the pool, gravel in the glide and cobble in the riffle. The mean diameter of the largest particle be moved by water was 24 cm. The banks were considerably more incised (average bankfull depth was 1.0 m) than in reach 1 and were composed mainly of erodible gravels and cobbles with sand, silt and some boulders interspersed throughout. The average bankfull width was 6.4 m for the riffle and glide we sampled. The pool had a bankfull width of 16.3 m and was located in an area of heavy aggradation. This pool width was not typical of the reach averages.

A lack of functional LWD and extensive riffles and cascades were observed throughout the section surveyed. Moderate channel disturbance levels were observed for approximately 39% of this section. The disturbed area included indicators such as elevated mid-channel bars, multiple and abandoned channels, disturbed stone lines and eroding banks. Several mature cottonwood and spruce trees had fallen and diverted the channel which caused considerable aggradation and channel migration (Fig. 22B). The channel migration caused more trees to fall which created more diversions and further channel movement.

Most impacts in the surveyed section of reach 2 appeared to be natural. Cattle may aggravate erosion in some areas, but in a minor way. A side channel at 0+147 m has been excavated to channel water to the intake for a 30 cm irrigation pipe (Fig. 22A). A dam at the upstream end regulates water flow into the channel. No water was flowing through the intake channel at the time of the survey. A series of overflow pipes were located in the bank separating the artificial channel from the mainstem.

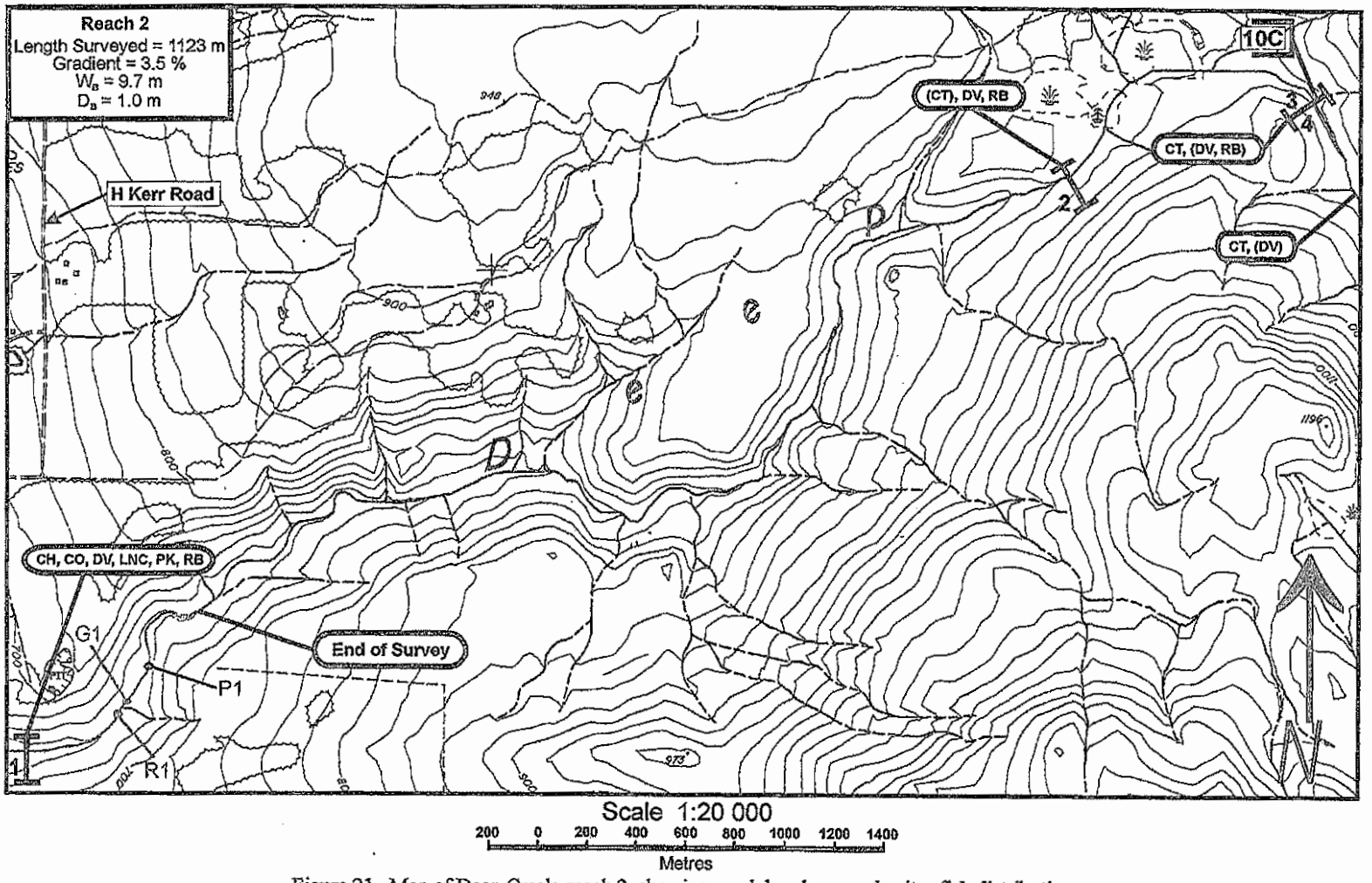
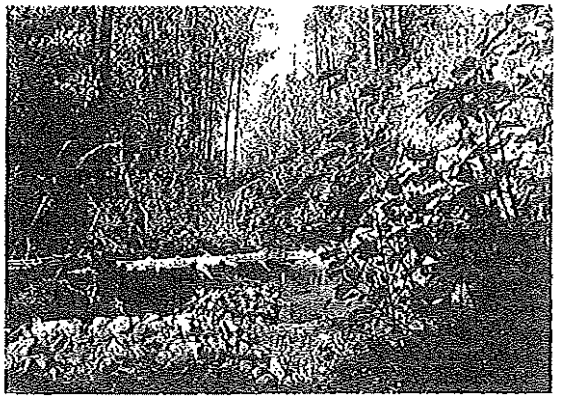
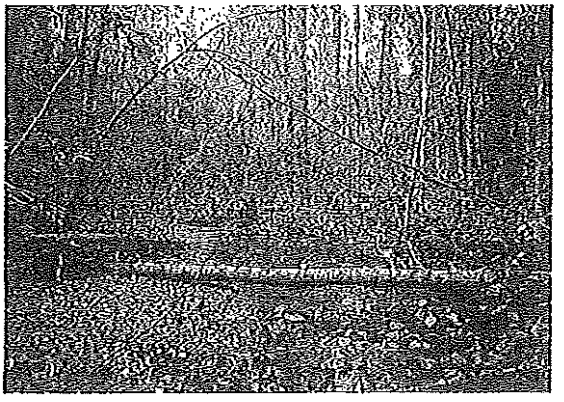


Figure 21. Map of Deep Creek, reach 2, showing reach breaks, sample sites,fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.067 1:20 000.

Figure 22. Deep Creek Reach 2: channel, riparian and impact photos.

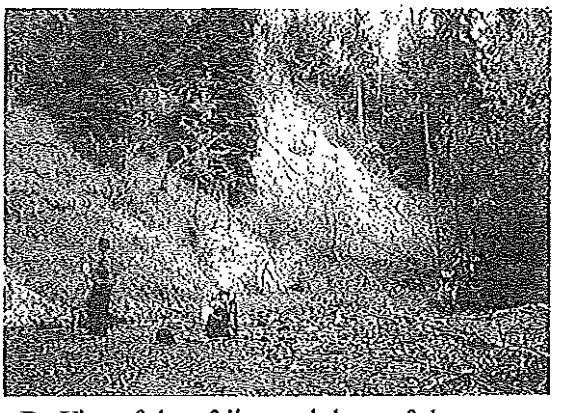


A: Downstream view of the top of the channel used to fill the 30 cm irrigation pipe at 0+147 m. The Deep Creek mainstem is to photo left.



B: Downstream view of active channel migration and aggradation at 0+285 m.

C: View of a hydraulic failure of a clay bank at 0+375 m. Note the clay flowing into the channel.



D: View of slope failure and slump of clay bank into the channel at 1+120 m. This slope is a source of LWD recruitment.

Fish and Fish Habitat Assessment

Habitat quality for the section of reach 2 we assessed was moderate. Overwintering habitat, found in pools was moderate. Pools were more common than in any other reach we assessed (one every 3.7 bankfull widths). They accounted for 24% of the channel area. Some of these pools offer good overwintering habitat, however, the majority are too shallow and have little cover. Rearing habitat was moderate due to the large number of riffles and cascades in relation to the number of glides and pools. Many of the glides at the time of our survey were short due to the cascade-pool morphology of the channel. Spawning habitat is likely the limiting factor to fish production in this reach due to the scarcity of smaller substrate particles. Small areas of spawning gravels were observed at the tail-outs of several pools. We did not observe any gravel beds of sufficient area for anadromous fish. Riffles were the most abundant of the habitat units counted (35% of the total number of units), however, they did not contain substrate suitable for spawning. The tail-outs of glides and pools contained most of the gravel in the section surveyed. Riffles occupied approximately 12% of the total wetted channel area and glides accounted for 23%. LWD from cottonwood, aspen, spruce and lodgepole pine was available for recruitment throughout the section surveyed and in some places had recently entered the channel. A mix of was available on the floodplain and on the gully slopes. Canopy closure averaged around 20% for the section surveyed and instream cover consisted of boulders, SWD and LWD. There were 0.35 pieces of functional LWD per bankfull width. 37% of the LWD counted in the channel was functional and 15% of this was greater than 50 cm in diameter (Table 24a).

Fish densities were moderate in the section of reach 2 we assessed and diversity was low (Table 24b). The glide we sampled contained 22 rainbow trout for a density of 0.6 fish per m^2. The pool contained 21 rainbow trout and one Dolly Varden char for densities of 0.51 and 0.02 fish per m^2 respectively. The sampled riffle contained 12 rainbow trout at a density of 0.8 fish per m^2. The rainbows ranged in age from 0+ up to adults and the Dolly Varden was 0+. No salmon were captured in this reach. We electrofished two additional pools outside our sampling regime to determine if other fish were present. Although we shocked some excellent holding and rearing habitat among rootwads and along substantial cutbanks, we caught nothing other than rainbows and Dolly Varden char. In another study, cutthroat trout were captured in tributaries to reach 3 of Deep Creek (Triton 1997a).

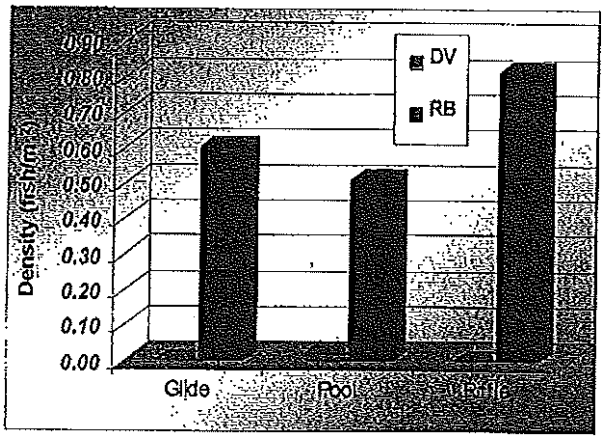
Perforated metal drums had been placed over the intakes of the irrigation line at 0+147 m in order to prevent fish being sucked into the pipe.

Table 24. Summary of channel and fish habitat field data for Deep Creek, reach 2.

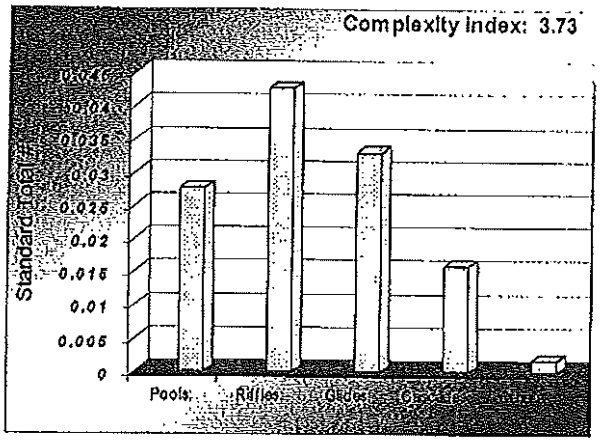
a) LWD summary.

	Small (10-19cm)	Medium (20-49cm)	Large (≥50cm)	Total
Total # Pieces	73	21	13	107
# Functional Pieces	23	11	6	40
# Func. Pieces / Bankful width	0.20	0.10	0.05	0.35
% Functional	32	52	46	37

b) Density of salmonids in glides, pools and riffles.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	B	G	H	R	L	B	0-20
Pool	R	S	M	R	L	LWD, SWD	0-20
Riffle	B	C	H	R	L	B, SWD	20-40

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
23.67	0.07	0.44	1.58	14.98	33.21

Impact synopsis

Land use in reach 2 of Deep Creek consists of low density cattle grazing and migration. The channel in the section we surveyed appeared mainly stable except for the aggradation caused by the introduction of LWD to the channel. The resultant channel migration and new channel formation is creating complexity in a reach where salmonid habitat may be somewhat limited by gradient and channel morphology. Mature coniferous trees are available for recruitment as are large cottonwood and aspen. The riparian vegetation is relatively intact and has not been heavily grazed. Several slumps and failures were observed and they are a source of fines due to the high clay content of the soils. The channel feeding the 30 cm irrigation pipe located at 0+147 m should be screened at its upstream end to prevent fish access. The relatively low level of impact, the steepness of the gully and the lack of easy access will likely preclude restorative works for this reach.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering on the plateau above the gully).
- Develop a grazing strategy to minimise impacts to the stream.
- Install a screen at the upstream end of the intake channel for the irrigation pipe.

4.3 Thompson Creek (460-517700)

Thompson Creek is a third order stream (at 1:50 000 scale) flowing down the valley between Grouse Mountain and Hungry Hill. It joins the Bulkley River approximately 5.5 km upstream from the footbridge over the Bulkley at Walcott. This S3 stream originates from small sub-alpine ponds and lakes on the southwestern slopes of Grouse Mountain. It flows through Fishpan Lake and also receives water from Coppermine Lake. The drainage area of this sub-basin is 44 km^2 and is one of the larger basins in our study. The stream flows southwest to Fishpan Lake, then north-northwest to the Dieleman homestead where it gradually turns west and south to the Bulkley River. Three reaches have been assigned to Thompson Creek including Fishpan Lake (Triton 1997a). During our field work we discovered that the channel had been diverted upstream of the mapped reach 1/2 break as mapped by Triton (1997a) and no longer flowed in the mapped location. We subsequently moved the reach break upstream to the point of diversion (Fig. 23). Reach break analysis was not done for the section of channel upstream of Fishpan Lake. Most of the channel flows through private, agricultural land except for a small section immediately downstream of Fishpan Lake, which flows through Crown land.

We surveyed approximately 12.6 km of Thompson Creek including all of reach 1 and 7030 m of reach 2. We did not assess the final 600 m of reach 2 due to time constraints, limited fish habitat, few impacts and good riparian cover. The lower section of Thompson Creek, located on the Bulkley River floodplain, contained several major beaver dams and pond complexes, while the remaining 80% of the reach was fluvial in nature. Reach 2 is a steeper gradient reach that collects water from several small, seasonal tributaries draining the western slopes of Grouse Mountain. Reach 3 is Fishpan Lake and was not assessed.

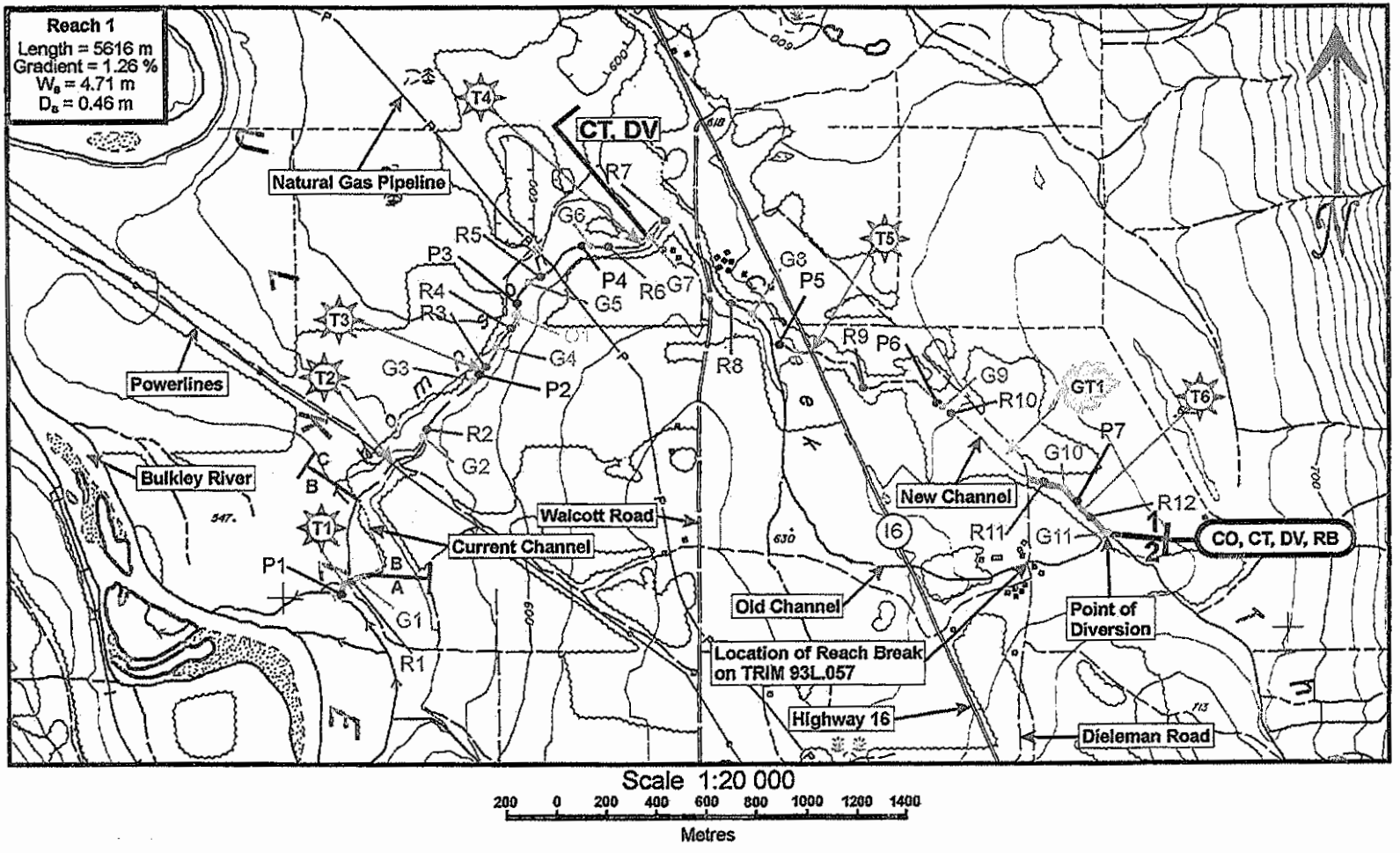


Figure 23. Map of Thompson Creek, reach 1, showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source maps: TRIM 93L.056, 057 1:20 000.

Prior to our study little was known about fish distribution in Thompson Creek. Fishpan Lake, also known as "Government Lake" had been stocked with 26 000 rainbow trout fry from 1955 to 1958 (BC Environment Lake Files). A reconnaissance inventory of the lake in 1959 found only rainbows. Other studies have found rainbows at the Highway 16 crossing (Seefried 1998) and cutthroat trout, rainbow trout and Dolly Varden char in Fishpan Lake (Triton 1997a). A reconnaissance level inventory of Coppermine Lake found no fish. The outlet disappears underground immediately downstream of the lake (Klohn-Crippen 1997). We captured coho salmon upstream to approximately 0+200 m in reach 2. We also caught cutthroat and rainbow trout and Dolly Varden char. Spawning Dolly Varden were observed in low abundance throughout the upper section of reach 1 and all of reach 2.

Little information was discovered on water quality for Thompson Creek, however, it is suspected that poor water quality conditions may occur in the spring when material from feedlots is flushed into the channel. No hydrometric stations or stream gauges are located in the Thompson Creek watershed. However, the Ministry of Environment, Lands and Parks has measured discharge 11 times between 1976 and 1981. Minimum and maximum discharges recorded were 0.002 m^3/s and 0.9 m^3/s, respectively (BC 1999b). We do not know the location of these measurements. We estimated discharges in reaches 1 and 2 to be 0.06 m^3/s and 0.05 m^3/s respectively using the floating object method. Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. Two irrigation and three domestic water licenses exist for Thompson Creek. The allocation for irrigation comprises the largest portion of the potential water withdrawal with a total of 120 acre feet annually (1329 m^3/day assuming a four month irrigation season). The total allocated for domestic use is 38.6 m^3 per day (MELP 1999c).

4.3.1 Reach 1

Length:	5616 m	Elevation:	547 – 655 m
Length assessed:	5616 m	Average gradient:	1.3%
Number of sites:	14	Mean W_b :	4.7 m
Number riparian plots:	1	Mean d_b:	0.5 m

Riparian Assessment

We observed riparian impacts of varying severity along much of the reach. The riparian vegetation has been cleared for agriculture, residences, forestry and road, pipeline and power line crossings. The majority of the land along the channel has been cleared for hayfields and pasture. Cattle grazing in the riparian zone occurs from the confluence with the Bulkley River and continues upstream to the reach break at the channel diversion. Some small areas of the channel have very thick riparian shrub cover, particularly upstream of Highway 16 in the new channel. These willow, alder and red-osier dogwood thickets effectively prevent cattle access. Large beaver dam and wetland complexes occurring at 0+200 m, 2+248 m, 2+712 m and 3+807 m also reduce cattle access to the channel. These wetlands are dominated by willow species, red-osier dogwood and black twinberry shrubs. The stream

banks at the power line road crossing at 0+850 m have been denuded of vegetation and the channel has been widened to 15 m due to the ford (Fig 25A). Cattle and vehicles use this crossing. This area is used as a ford for vehicles driving along the BC Hydro access road and as a ford and watering area for cattle. The section of channel immediately upstream from the highway at 3+870 m to the private road crossing at 5+091 m flows through some mature spruce and pine forest. This is part of the new channel formed after the stream was diverted at the upstream reach break. Some of the coniferous trees in this area have been selectively harvested. The channel upstream of this area is almost devoid of riparian shrubs and shows signs of instability due in part to the lack of roots in the banks and increased flows from accelerated run off. This is also the area where cattle appear to have had the greatest impacts on the stream. One riparian plot was chosen to approximate the typical vegetation that would occur along the upper portion of the reach if it were in a natural condition.

Assessment site GT1

Site series: SBSdk07a
Seral association: Spruce-Horsetail, freely drained phase

We chose this site for assessment in order to replicate conditions that may have been present prior to land clearing and other modifications. It was located on the right bank in a small stand of riparian forest approximately 240 m downstream of the private road crossing located at 5+091 m. This area is one of the few remaining portions of relatively intact riparian forest in reach 1 upstream of the highway and acts as a source of LWD. The stream in this section flows through a new channel as a result of the diversion at the upstream reach break and is moderately to severely aggraded.

The centre of our 11.28 m plot was approximately 18 m from the stream. The aspect was southwest and the slope of the site was 2%. The overstory contained spruce, black cottonwood and trembling aspen. Twenty to thirty metre wide shrub dominated openings occurred between clumps of mature spruce and cottonwood trees. The stocking survey found 225 cottonwood per hectare. An estimated one-third of these have diameters greater than 22 cm and the remainder are saplings less than 12.5 cm dbh. Spruce occurred in densities of 225 stems per hectare, however only 25 of these trees would be less than 12.5 cm dbh. 600 aspen saplings less than 12.5 cm dbh were predicted to occur per hectare. The primary shrub cover in the plot included the following species: black twinberry (25% cover), red raspberry (5%), prickly rose (2%), mountain alder (1%) and three willow species (including one tentatively identified as Barclay's willow, *Salix barclayi*) (~1% total). Common and abundant herbs included bluejoint grass (10%), fireweed (10%), common horsetail (5%), Canada thistle (*Cirsium arvense*) (5%), reed canarygrass (*Phalaris arundinacea*) (2%), and western meadowrue (*Thalictrum occidentale*) (1%). A complete species list form this site can be found in Appendix E. This site has high to moderate value in terms of riparian function (Table 25).

Table 25. Riparian function summary for riparian plot GT1.

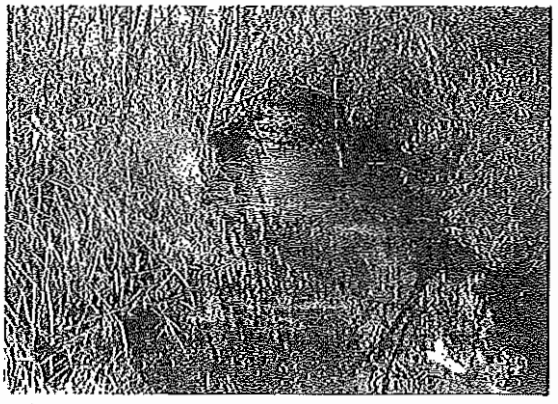
Function	Rating	Comments
LWD	H	Mature, mixed riparian forest
Shade	M	Mature trees set back from stream
Small organic debris (SOD)	H	Abundant shrub and deciduous tree cover
Surf. Sed. Filter	H	Diverse and dense herb layer with little exposed soil
Channel stability	M	Stream flowing through recent channel = aggraded
Bank stability	H	Dense root system to maintain soil and bank cohesion

We dug a 70 cm soil pit in our plot. The soil great group is Dystric Brunisol. Layers were as follows: a 10 cm moder layer, a 6 cm dark brown Ah layer composed of silty clay and charred wood, and a light brown juvenile Bt layer of silty clay loam greater than 50 cm deep. Based on descriptions contained in Banner *et al.* (1993), this site is the freely drained phase of the Spruce-Horsetail (SBSdk07a) site series.

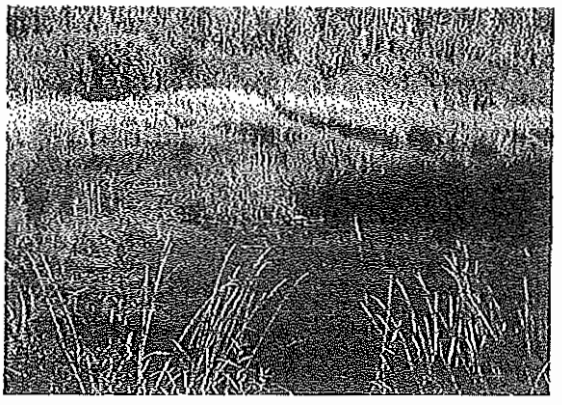
Channel Assessment

Reach 1 of Thompson Creek is a 5.6 km long riffle-pool channel that starts at a point of diversion approximately 1800 m upstream of the Highway 16 culvert. The confluence with the Bulkley River side channel occurs approximately 5.3 km upstream of the footbridge over the Bulkley at Walcott. The reach was divided into three sections based on beaver activity and land use. Section 1A is 200 m long and is located on the Bulkley River floodplain. Based on air-photo interpretation, the floodplain in this area is very active with a history of side channel formation on the alluvial fan of Thompson Creek. Section 1B is 415 m long and is characterised by extensive beaver dams, ponds and wetlands at the base of the Bulkley River floodplain banks. Section 1C is a more confined, alluvial reach with typical riffle-pool morphology and several sections of beaver activity. The upper portion of this section appears to have been an ephemeral or seasonal channel at one point, but is now the main stream channel due to diversion of the stream. This diversion is likely several decades old based on the culvert capacities at the Highway 16 crossings. The "new" channel has considerably larger culverts than the "old" channel. A dam and dyke structure located upstream of the Dieleman homestead (at 5+616 m) is used to divert some water back to the original channel to water the cattle in the winter stockyard (Dieleman pers. comm.). Beavers and LWD are currently the main channel forming and complexing agents, although LWD is less common in the upper kilometre of the reach. Channel banks consist mainly of erodible fines and sand with a small portion of gravels. The substrate of this reach is composed of gravel and sand, with cobbles occurring in the cascades. The bank texture and the substrate particle size tend to become coarser as the elevation increases in this reach.

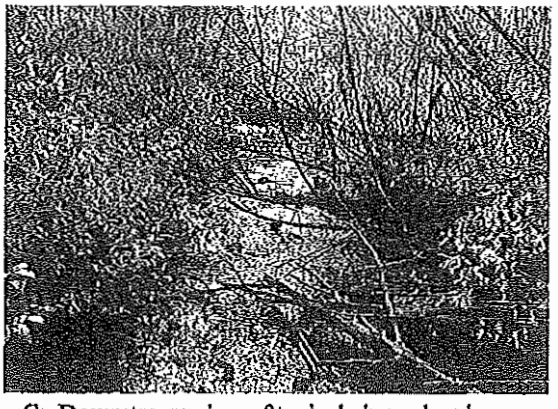
Figure 24. Thompson Creek Reach 1: channel and riparian photos.



A: Upstream view of typical channel and riparian conditions in section 1A at 0+147 m.

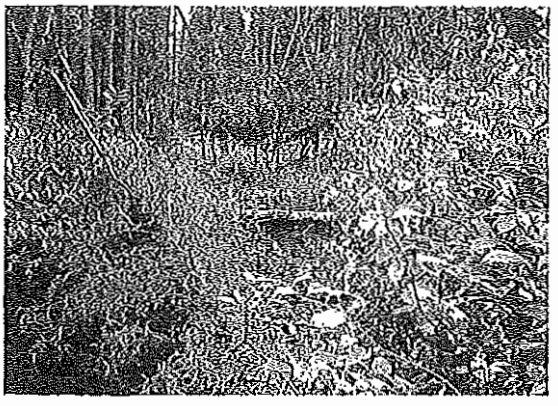


B: View of beaver ponds in section 1B.

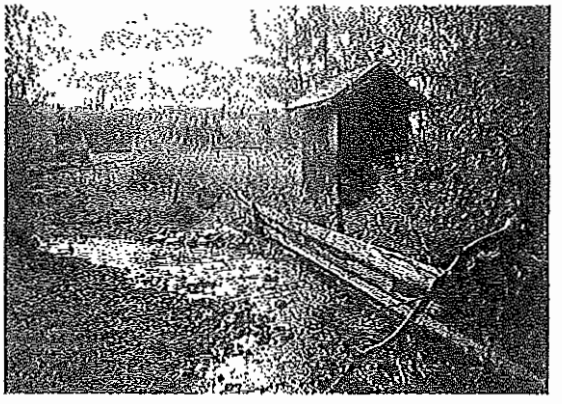


C: Downstream view of typical channel and riparian conditions in section 1C at 0+798 m.

D: Upstream view of the dry channel at 4+557 m. This was the main channel prior to the stream diversion at the reach 1/2 break.

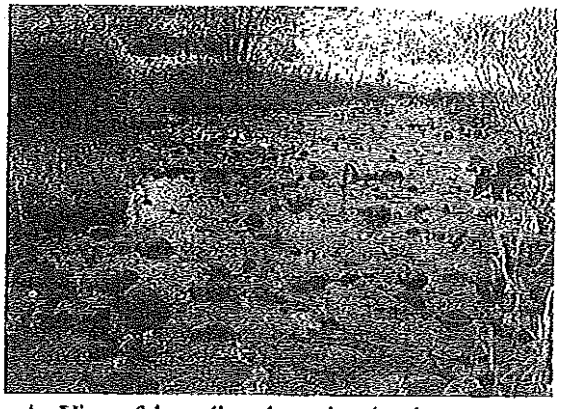


E: Upstream view of the current channel and riparian conditions at 4+638 m. This became the main channel after the stream was diverted.

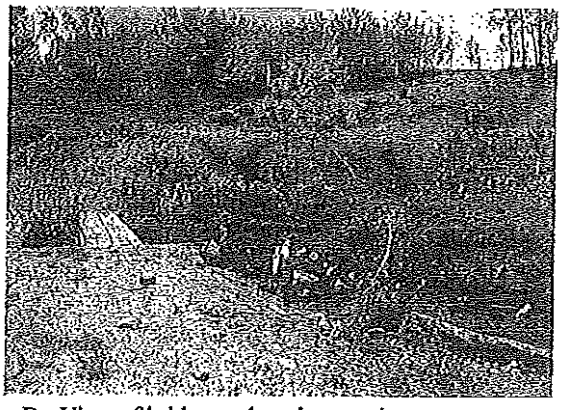


F: Upstream view of the reach 1/2 break. The sandbags in the centre of the photo are at the top of the historical channel.

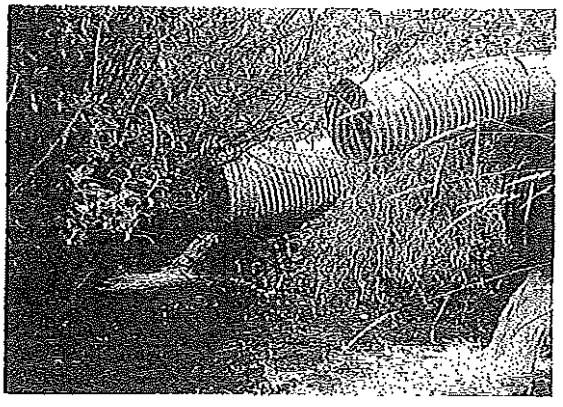
Figure 25. Thompson Creek Reach 1: impact photos.



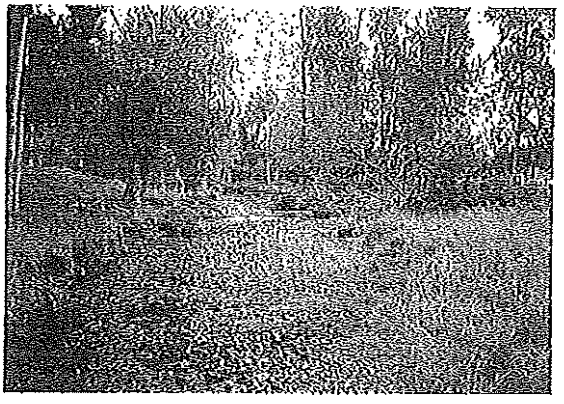
A: View of degrading channel under the power line crossing at 0+850 m. The channel is 15 m wide at this point.



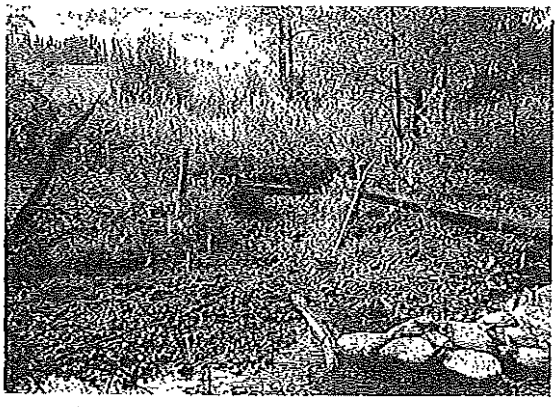
B: View of bridge and cattle watering area at 1+415 m.



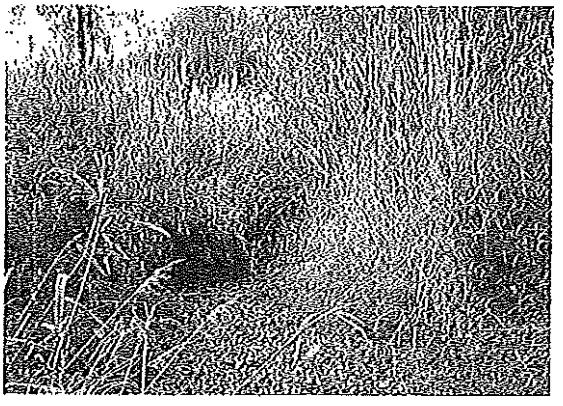
C: View of the culverts below Highway 16. They are perched approximately 30 cm.



D: Upstream view of aggrading channel caused by cattle trampling and watering at 5+334 m.



E: View of the mouth of the historical channel at the point of diversion. The photo was taken from the centre of the current channel.



F: Downstream view of the historical channel approximately 5 m downstream from the point of diversion. Note the abundant gravel substrate.

The final kilometre of reach 1 (4+608 m to 5+616 m) was moderately to severely aggraded. This aggradation corresponded with the "new" channel. The stream was moderately aggraded for 480 m downstream of the bridge on Dieleman's property at 5+091 m. Indicators of disturbance included homogenous bed texture (fines), sediment fingers and wedges, elevated mid-channel bars and multiple channels. Few cattle impacts were noted in this portion of the reach. Above the bridge, we observed severe channel aggradation for 525 m. The combination of the stream adjusting to its "new" channel combined with cattle access to the creek resulted in the extreme channel disturbance including extensive and elevated bars, extensive riffles, minimal pool area, multiple and abandoned channels, disturbed stone lines, eroding banks and a lack of functional LWD. Cattle are the primary cause of channel disturbance, with bank erosion and channel widening evident where they gather in the stream to drink.

Beginning from the Bulkley River confluence and moving upstream, specific channel impacts include: At 0+850 m the stream is crossed by BC Hydro power lines and access road. The channel is approximately 15 m wide at this point and cattle have been using this area as a ford. At 2+673 m, fences direct cattle to the creek for watering. The culverts under Walcott Road at 3+275 m are perched 40 cm above riprap at the outlet. The Highway 16 culverts at 3+830 m are perched 40 cm over small plunge pools. The old channel diversion at 5+616 m has diverted the stream and created a new channel.

Fish and Fish Habitat Assessment

General habitat quality in reach 1 is moderate. Overwintering habitat and refugia, found in beaver ponds, is abundant throughout the reach. Pools were relatively common, occurring every 7.8 bankfull widths. They were small though and only comprised 6% or the area of the reach. Rearing and spawning habitat were moderately abundant with a riffle to glide ratio of 1.1. LWD was lacking for much of the lower 1.5 km , but was moderately abundant over the rest of the reach (0.36 pieces per bankfull width) (Table 26a). 31% of the wood counted was functional and we observed only 13 large pieces (>50 cm diameter). Future LWD recruitment will be limited for the lower 1800 m and from 5+100 m to the reach 1/2 break. Over-stream vegetation and LWD provided most of the cover for fish. Spawning habitat is of moderate quality in this reach for both anadromous and resident fish. Riffles were the most common unit and accounted for 32% of the total reach length and 34% of the total area. 54% of the channel area was occupied by glides. Gravels were the dominant substrate for most units. Access to spawning habitat in the upper kilometre of reach 1 and reach 2 may be limited in some years by the numerous beaver dams in this reach and the perched culverts at Highway 16. Discharge at the time of sampling was 0.06 m^3/s.

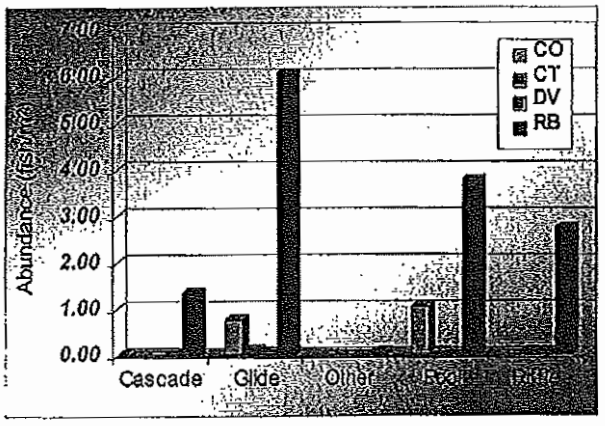
Fish abundances were moderately high downstream of Highway 16. Rainbow trout or steelhead juveniles (0+ to 2+) were the most abundant fish we captured (Table 26b). In streams with good access to the Bulkley River and with suitable habitat approximately 70% of the juvenile rainbow trout may be steelhead (Tredger 1982). Coho salmon juveniles (0+, 1+) were the next most abundant species we captured. Although common near the Bulkley, their density decreased with distance upstream. Dolly Varden char (0+, 1+) and cutthroat trout (0+ to 2+) began appearing during our sampling efforts at 2.8 km upstream from the Bulkley River, also in low densities. We saw several spawning pairs of Dolly Varden char on redds upstream from 4+825 m.

Table 26. Summary of channel and fish habitat field data for Thompson Creek, reach 1.

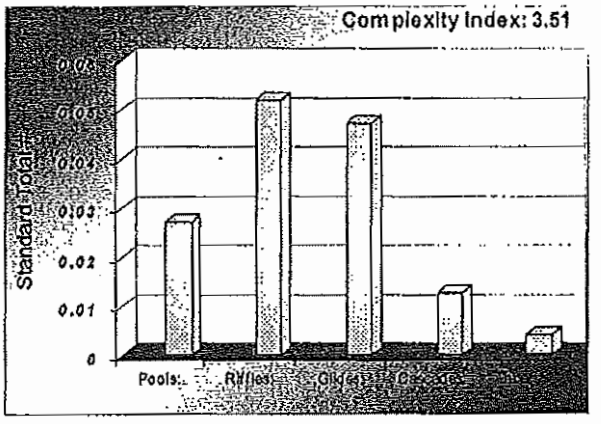
a) LWD summary.

	Small (10-19cm)	Medium (20-49cm)	Large (>50cm)	Total
Total # Pieces	923	435	27	1385
# Functional Pieces	245	167	13	425
# Func. Pieces / Bankful width	0.21	0.14	0.01	0.36
% Functional	27	38	48	31

b) Density of salmonids in cascades glides, pools, riffles and other habitat types.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	C	G	M	AR	N	B, OV	40-70
Glide	G	G	M	AR	L	OV, B, LWD	40-70
Other	S	S	L	AR	N	OV, C	0-20
Pool	G, S	S, G	M	AR	L	OV, C, LWD	0-20
Riffle	G	S	M	AR	H	OV, SWD	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
9.47	0.06	0.21	0.69	1.51	6.00

Impact synopsis

Land use in this reach has damaged fish habitat, riparian habitat and channel integrity. LWD is found in moderate quantities and future recruitment in some parts of the reach will be low. Cattle grazing the riparian area are damaging riparian vegetation and are causing bank shear and channel widening, resulting in increased sediment load. Cattle impacts are particularly abundant at the power line crossing and above 5+100 m.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible in some cases, without access to Crown range).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream. Protect existing vegetation.
- Construct bridges or hardened cattle crossings at critical fords. Encourage cattle to use existing bridges.
- Ensure that potential water diversions through the old channel do not reduce or impair existing salmon habitat in the current channel.
- Monitor water quality and prevent nutrient loading due to livestock waste being flushed into the channel during freshet.

4.3.2 Reach 2

Length:	7690 m	Elevation:	655 – 803 m
Length assessed:	7037 m	Average gradient:	1.9%
Number of sites:	45	Mean W_b :	3.8 m
Number riparian plots:	3	Mean d_b:	0.5 m

Riparian Assessment

The majority of the riparian zone of reach 2 is functioning relatively well. However, impacts from several land uses do exist throughout this reach (Fig. 26). Land clearing for agriculture, livestock use of the riparian zone, and one harvested cut block have influenced the riparian zone. Riparian function in the lower 500 m is perhaps the most lowest within the reach (Fig. 27A). Most trees have been cleared from this area and shrubs and herbaceous plant have been heavily grazed on both banks. Cattle grazing in the riparian zone and trampling of the stream banks is moderate to a fence at 0+851 m. Upstream of this fence, mature coniferous and mixed forest dominate a riparian zone in which cattle activity is reduced until 2+027 m. Between 2+027 m and 2+157 m, the trees have been thinned along the left bank. Much of the understory has been grazed or trampled and is functioning poorly as a sediment filter or bank stabilising agent. Forestry impacts are limited to a 170 m section of the right bank that has been cleared to the stream at 1+337 m. The largest clearing in the reach occurs at 3+745 m and extends upstream for approximately 1.7 km. Although most of the trees have been

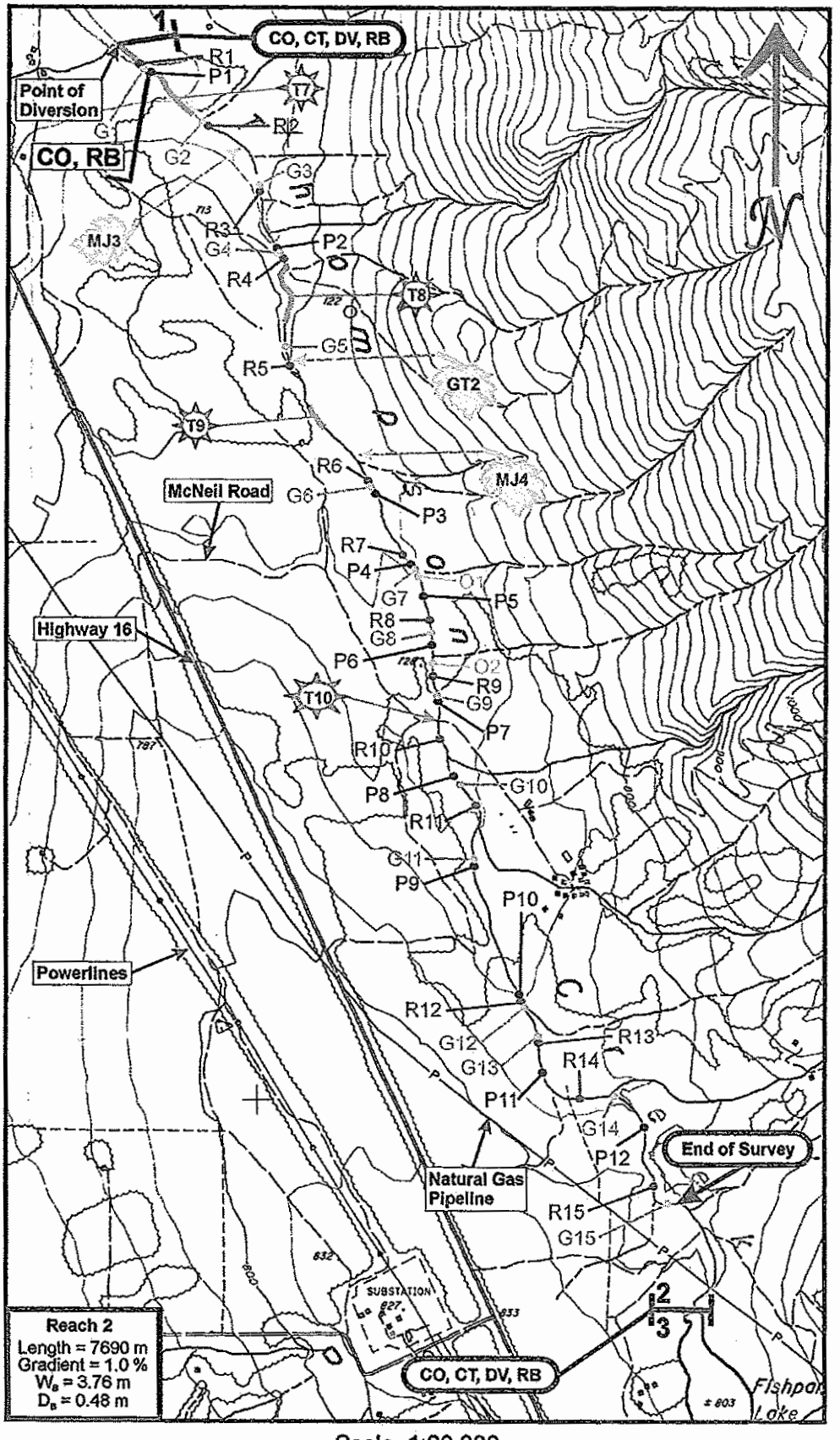


Figure 26. Map of Thompson Creek, reach 2, showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.057 1:20 000.

removed along this section for hay fields, a 5 - 10 m wide band of willows and other shrubs remains along both sides of the creek. These shrubs are providing some riparian function and is helping to add complexity to the channel. However, LWD recruitment in the future will be low through this area. The remainder of the channel flows through mixed mature forest with generally little riparian damage.

Assessment site MJ3

Site series: SBSdk06
Seral association: Spruce-Twinberry-Coltsfoot

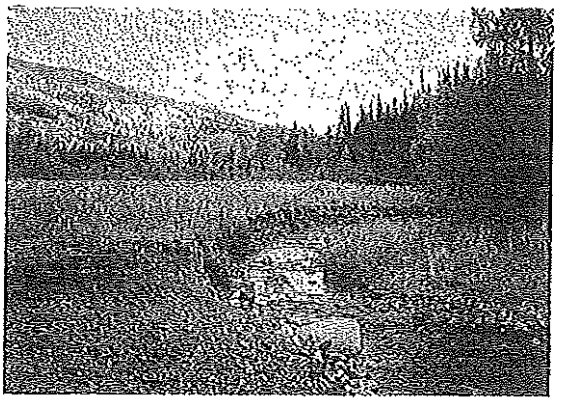
We chose this site, roughly 800 m upstream of the reach break, as a surrogate for the cleared slopes that occur in several section of this reach. The plot centre was located approximately 10 m from the left streambank on a northeast facing, 35% slope. The overstory consisted of spruce, lodgepole pine and black cottonwood. The stocking survey indicated that 2200 spruce, 400 pine and 400 cottonwood occur per hectare in this area. 1400 of the spruce and all of the pine and cottonwood were classed as overstory. The plot contained no tall shrubs (> 2 m high) and few were seen in the area. The only shrubs observed in the plot were prickly rose and thimbleberry (*Rubus parviflorus*), both with less than 1% coverage. Herbaceous plant cover was also limited: oak fern (5%), palmate coltsfoot (3%), bunchberry (*Cornus canadensis*) (1%) and one sided wintergreen (1%). Total moss coverage was approximately 4%. A complete species list for this site can be found in Appendix E. The riparian function of the site was moderate to high due to a sparse herb layer under mature forest canopy (Table 27). This site acts as a good template for riparian communities and indicates function for similar sites along the reach.

Table 27. Riparian function summary for riparian plot MJ3.

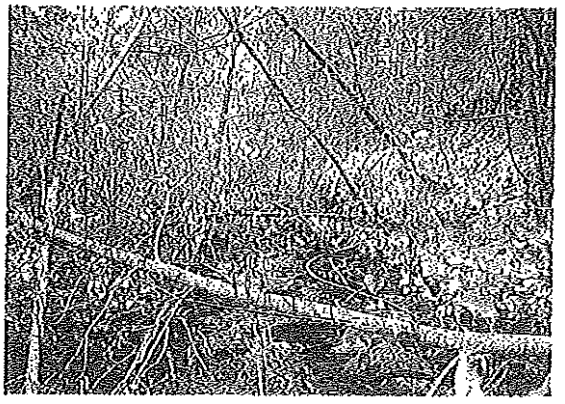
Function	Rating	Comments
LWD	H	Abundant supply of mature conifers.
Shade	H	Mature trees growing to waters edge, steep slope.
Small organic debris (SOD)	H	Abundant leaf litter and twigs and branches available.
Surf. Sed. Filter	M	Minimal herb cover and some cattle grazing.
Channel stability	M	
Bank stability	M	Poorly developed shrub layer - fewer root systems.

We dug a 75 cm soil pit in our plot. The soil great group is Grey Luvisol. Layers were as follows: an 8 cm mor layer, a 25 cm brownish Bt layer composed of fine silty loam, and a layer of hard clay to the bottom of the pit. Based on descriptions contained in Banner *et al.* (1993), this site is the Spruce-Twinberry-Coltsfoot (SBSdk06).

Figure 27. Thompson Creek Reach 2: channel, riparian and impact photos.

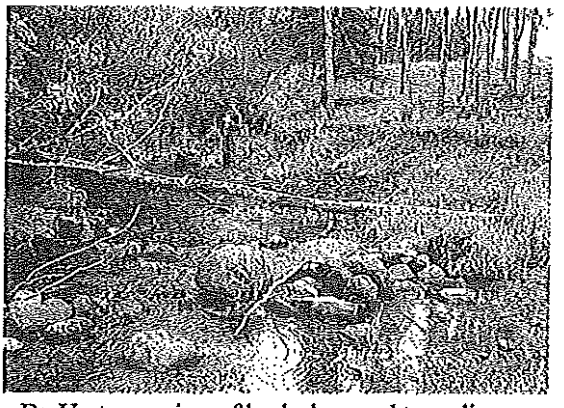


A: Upstream view of typical impacted channel and riparian habitat 0+276 m.

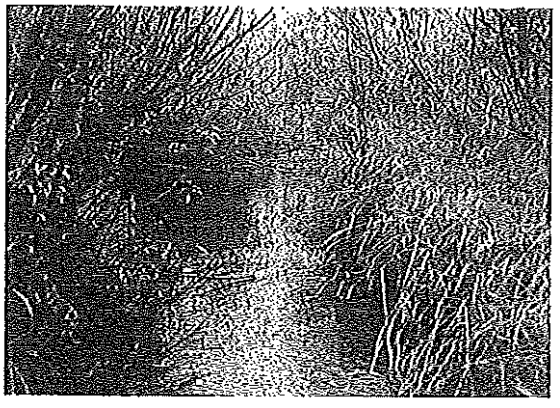


B: Upstream view of typical channel and riparian habitat at 1+250 m.

C: Upstream view of channel and forest harvest at 1+337 m. Note the debris and widened channel caused by multiple bridge washouts and channel fording.



D: Upstream view of bank shear and trampling at 2+077 m. Note the relatively intact riparian vegetation at photo left.



E: View of typical channel and riparian conditions in the wetland section of this reach at 3+777 m.

F: Upstream view of culvert under McNeil Road at 4+149 m. The culvert is perched 20 cm and has no plunge pool below it.

Assessment site GT2

Site series: SBSdk07a
Seral association: Spruce-Horsetail, freely drained phase

This site was chosen in order to approximate the plant communities and soil conditions found along the creek in a recently harvested cutblock. Our site was located approximately 450 m upstream from the access road to Coppermine Lake and was about 15 m from the right bank of the stream. The aspect of the 11.28 m radius plot was west and the slope was 9%. The overstory in the plot consisted of spruce, lodgepole pine and black cottonwood. The dominant tree species was spruce and the representative height was estimated at 33 m for a tree of 38 cm dbh. The stocking survey estimated that 525 spruce, 25 pine and 50 cottonwood with a dbh greater than 12.6 cm occurred per hectare at this riparian site. We observed only one spruce sapling in the plot. No tall shrubs (> 2 m high) occurred in our plot. Prickly rose (10% cover), trailing twinflower (*Linnaea borealis*) (7%), black gooseberry (5%), red-osier dogwood (2%), trailing raspberry (*Rubus pubescens*) (2%) and red raspberry (*R. ideaus*) (1%) were the most common shrubs in the plot. Common herbaceous plants included common horsetail and meadow horsetail (*Equisetum pratense*) (20% for both species combined), bunchberry (20%), wild strawberry (*Fragaria virginiana*) (2%), palmate coltsfoot (2%), common mitrewort (1%) and bluejoint grass (1%). Approximately 60% of the ground within the plot was covered by mosses. For a complete list of the species in this plot see Appendix E. Riparian function of this site was high despite some cattle grazing and migration through the area (Table 28). Blowdown was also common in the area.

Table 28. Riparian function summary for riparian plot GT2.

Function	Rating	Comments
LWD	H	Abundant mature trees, limited regeneration.
Shade	H	Abundant mature trees and shrubs.
Small organic debris (SOD)	M	
Surf. Sed. Filter	H	Dense cover of herbs and mosses.
Channel stability	H	Good root system of shrubs and trees.
Bank stability	H	

We dug a 55 cm soil pit in the plot. The soil great group is a Brunisol. Layers were as follows: a 10 cm moder layer, a 15 cm dark brown Ah layer composed of silty clay, and a 30 cm light brown Bt layer of silty clay loam. Charred wood was present at the transition between the humus and Ah layers. Based on descriptions contained in Banner *et al.* (1993), the site series here is the Spruce-Horsetail, freely drained phase (SBSdk07a).

Assessment site MJ 4

Site series: SBSdk07b
Seral association: Spruce-Horsetail, poorly drained phase

This site was selected as a substitute for similar sites in the area that have been disturbed by cattle grazing and forestry. It was located on the right bank, approximately 900 m upstream of the access road to Coppermine Lake and 70 m downstream from a small bridge and well used cattle watering area. Plot centre was 5 m from the stream, at the toe of a 3 m high slope on a saturated floodplain. The site faced southwest at a slope of 3%. The overstory consisted of spruce (to 24 m in height and 31 cm dbh) with some mountain alder. Based on the stocking survey, 200 mature spruce (>22 cm dbh) were present per hectare. 200 spruce between 7.5 and 12.5 cm dbh and 1400 spruce seedlings per hectare also occur. Tall alder shrubs up to 12 m high covered 5% of the plot. Shrubs under 2 m high included prickly rose (5% cover), mountain alder (4%), black twinberry (4%) and black gooseberry (2%). Herbaceous cover consisted mainly of common horsetail (10%), palmate coltsfoot (3%), bunchberry (1%), purple peavine (1%), wild strawberry (1%) and lady fern (*Athyrium filix-femina*) (1%). See Appendix E for a complete species list for this site.

Riparian function was moderate (Table 29). Few mature trees and a sparse shrub layer are limiting factors. This site will likely not contribute substantial LWD to the stream for well over a century until conifer seedling regeneration layer matures. However, the high water table and poor drainage may inhibit the growth of large trees. Cattle grazing, watering and migrating along the riparian zone in this area has caused some channel widening and additional loss of riparian function. Some blowdown was also observed in the area.

Table 29. Riparian function summary for riparian plot MJ4.

Function	Rating	Comments
LWD	M	Few mature trees.
Shade	M	Few mature trees.
Small organic debris (SOD)	M	Few mature trees and sparse shrub cover.
Surf. Sed. Filter	H	Low relief, dense herb and moss layer.
Channel stability	M	
Bank stability	M	Cattle have damaged banks.

We dug a 90 cm soil pit in the plot. The soil great group is Humic Gleysol. Layers were as follows: a 3 cm moder layer, a 40 cm black Ah layer composed of silt and a dark grey saturated Bg layer. Water filled the bottom third of our soil pit almost as quickly as we could dig. Based on descriptions contained in Banner *et al.* (1993), the site series for the plot is the Spruce-Horsetail, poorly drained phase (SBSdk07b).

Channel Assessment

Reach 2 stretches for 7.7 km along virtually the entire valley between Grouse Mountain and Hungry Hill as far as Fishpan Lake. Channel morphology is riffle-pool and LWD is the primary channel forming mechanism. Upstream of McNeil Road, the creek meanders within a thin band of riparian willows between agricultural fields for approximately 1.7 km. The erodible banks are composed mainly of gravel, sand and fines, with the occasional cobble and boulder. Chief substrate constituents are gravel and fines. Cobbles and small boulders were relatively common in the lower two kilometres and the upper kilometre of the reach.

Nineteen percent, or 1.3 km of reach 2 was moderately aggraded. This aggradation can be at least partially attributed to accelerated run-off, bank instability and erosion from cattle trampling and land clearing. Aggradation between 1+300 m and 1+337 m appears to be the result of washouts of the old Coppermine Lake road crossing. Common indicators of channel disturbance in these sections of reach 2 were as follows: sediment fingers and wedges, extensive and elevated bars, minimal pool area, multiple channels, eroding banks and a lack of functional LWD.

Beginning from the reach break at the channel diversion and moving upstream, specific channel impacts include:

- Moderate aggradation and bank instability at from the reach break to 0+500 m.
- The road crossing and cutblock at 1+337 m which are contributing to moderate aggradation.
- Eroding banks from 2+027 m to 2+157 m are introducing sediment to the channel.
- The culvert under McNeil Road is perched approximately 20 cm above a riprap embankment and may be a barrier to upstream fish migration during most flows.

Fish and Fish Habitat Assessment

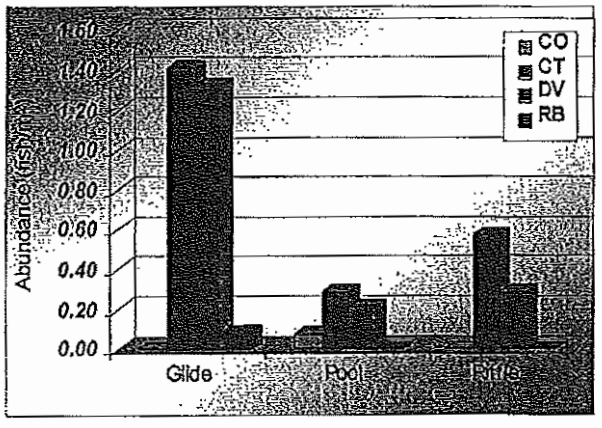
Fish habitat in reach 2 is generally of moderate quality. Overwintering habitat is limited to a few large deep pools with good cutbanks. The primary refugia in the stream is likely Fishpan Lake. However, we do not know the severity of winter kill in this lake. Pools were quite common throughout most of the reach, occurring every 6.7 bankfull widths, and covering almost one-third of the area of the reach. Rearing habitat was common, with glides occupying 40% of the wetted area of the channel. A lack of functional LWD was chronic throughout most of this reach, but recruitment possibilities are relatively good in areas where coniferous riparian forest remains along both banks. 43% of the LWD observed in the creek was functioning. This equates to 0.35 pieces of functional LWD per bankful width (Table 30a). Cover for fish was predominantly over-stream vegetation and instream boulders. LWD and undercut banks also provided some cover. Spawning habitat was of moderate quality through most of the reach, with the exception of the first two kilometres where the substrate was quite large. Gravel was the dominant substrate in the reach and riffles accounted for approximately one-quarter of the wetted channel area. Pockets of both anadromous and resident spawning habitat were observed downstream from boulders and in riffles and pool tailouts/glides. Access to spawning habitat in the upper kilometre of reach 1 and in reach 2 may be limited in some years by the numerous beaver dams in reach 1. A 0.7 m high small woody debris jam at 2+112 m may be a temporary barrier to upstream fish migration. Discharge at the time of sampling was 0.05 m^3/s.

Table 30. Summary of channel and fish habitat field data for Thompson Creek, reach 2.

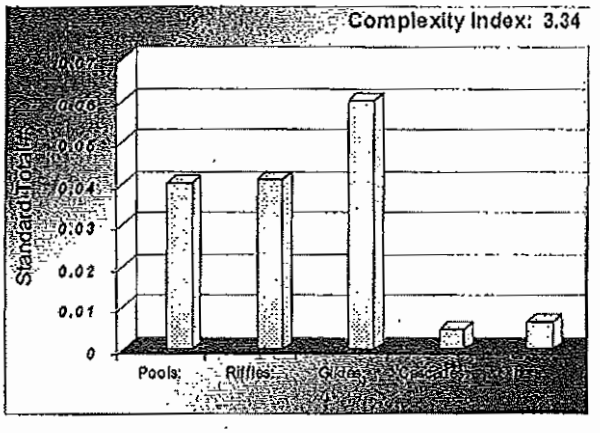
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	974	470	76	1520
# Functional Pieces	355	252	49	656
# Func. Pieces / Bankful width	0.19	0.13	0.03	0.35
% Functional	36	54	64	43

b) Density of salmonids in glides, pools and riffles.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	B	C	H	AR	N	B	0-20
Glide	G	S	M-H	R	L	OV	0-20
Other	S	S	L	AR	N	OV, LWD	70-90
Pool	G, S	G,S	L	AR	N	OV, C	40-70
Riffle	G	S	H	AR	H	OV, B	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
8.51	0.06	0.21	0.66	1.19	5.30

Fish were rare in this reach. Cutthroat trout (0+ to 2+ age classes) were the most abundant species we captured followed by Dolly Varden char (0+ to 2+). Several pairs of spawning Dolly Varden were observed on or near redds in the lower section of reach 2 in the few areas of good spawning habitat. Cutthroat trout were the only fish captured in the upper 2.5 km of the sampled portion of the reach. We caught one coho (1+) in a pool at 0+168 m. Although we caught no coho further upstream, these fish may be found in deep pools as far as McNeil Road. We also caught only one rainbow trout (1+) in this reach. Resident salmonids may rear and overwinter in Fishpan Lake. However, the populations of fish in the lake are unknown.

Impact synopsis

Riparian habitat, fish habitat, and channel integrity in this reach have been moderately affected by land use. Riparian areas that have been cleared or thinned for agriculture and cattle activities in and around the creek are the primary sources of channel impacts. Cattle trampling is causing bank shear and channel widening which is increasing sediment loads to the stream. In addition, persistent cattle presence in the riparian zone is retarding the recovery of vegetation that, if left to grow, could alleviate some of the sedimentation and bank stability issues. Logging has also influenced the health of the stream by removing riparian forest. This has caused moderate localised aggradation and contributed to downstream impacts.

Restoration suggestions

- Work with the landowners to limit cattle access to the riparian zone and the creek (e.g. off-channel watering).
- Develop a grazing strategy to minimise impacts to the stream (this may not be possible in some cases, without access to Crown range).
- Re-establish riparian vegetation to stabilise banks, increase LWD recruitment and shade the stream. Protect existing vegetation.
- Construct bridges or hardened cattle crossings at critical fords. Encourage cattle to use existing bridges.
- Improve fish passage at McNeil Road if Fishpan Lake is suitable for overwintering habitat (i.e. no winterkill).

Southwest Tributaries to the Bulkley River

We assessed four streams along the southwest side of the Bulkley Valley: Helps, "Moan," Coffin and Dahlie creeks. Land use in these watersheds is primarily logging, with the exception of Dahlie Creek, which is an urban stream. Considerable portions of the Coffin and "Moan" creek watersheds along with the mid-reaches of Helps Creek have been logged. All cutblocks are replanted and many are "free to grow." Although extensive forest road networks are present, many of these roads have been deactivated and an access management plan has been developed for Pacific Inland Resources who has the logging rights to this area (Sterling Wood Group 1995a,b). Agricultural activity is limited to the lower reaches of Helps Creek and the upper reaches of Hubert Creek, its major tributary. Crown range cattle

use was most apparent along the powerline right-of-way at "Moan" and Coffin Creeks. The natural gas pipeline right of way also crosses these streams. The CN tracks cross the lower reaches of all streams on this side of the Bulkley Valley. Together, these land uses have altered stream channel features, riparian function and fish habitat to varying degrees in all four streams.

4.4 Helps Creek (460-437000)

Helps Creek is a third order stream (at 1:50 000) scale originating on the eastern slopes of the Telkwa Range. It joins the Bulkley River approximately four kilometres upstream of Telkwa and drains an area of 35 km^2. It is 10 km long and has been assigned eight reaches (Triton 1997a). Reaches 1 through 5 are low gradient reaches flowing through several wetlands and ponds (Fig. 28). Reaches 6, 7 and 8 are steeper and confined. A 10 m high water fall at the reach 7/8 break marks the upstream limit of fish distribution. Reach 8 is confined in a gully and has a steep gradient. The lower two kilometres flow through privately owned agricultural land. Logging is the main land use in the mid to upper portions of the stream. Several clearcuts span the channel or are located immediately adjacent to the stream. We briefly assessed all of reaches 1 and 2 and the lower 200 m of reach 3. We terminated the assessment at this point due to the inability of our methodology to assess wetland morphologies. Due to poor road conditions and road deactivation efforts, we could not access the upper reaches. The wetlands and ponds through which much of Helps Creek flows were judged to be adequate buffers for any impacts caused by land use upstream.

Many studies have determined fish distribution in Helps Creek. Luscar Coal (formerly Manalta Coal) has commissioned several including the Telkwa Coal Project Report (in press). Information from the project is not currently available to the public (Flemming pers. comm.). Available studies indicate that coho and chinook salmon, steelhead, rainbow trout, cutthroat trout, Dolly Varden char, burbot, longnose dace, redside shiner and longnose sucker are found in the system (BC 1999a, Triton 1997a). Coho and steelhead juveniles have been captured at the Lawson Road culvert. Cutthroat and rainbow trout were captured up to reach 5 of Helps Creek and in Hubert Creek. Dolly Varden were observed in the mainstem near the 6/7 reach break (Triton 1997a). We captured mountain whitefish in reach 2.

Limited information exists on water quantity or quality for Helps Creek. A series of staff gauges is located at the Lawson Road crossing. The data from these gauges was not available at the time of writing. Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. We estimated discharge in reach 2 to be approximately 0.13 m^3/s at the time of sampling. No water licenses exist for Helps Creek. No water quality information was available for Helps Creek.

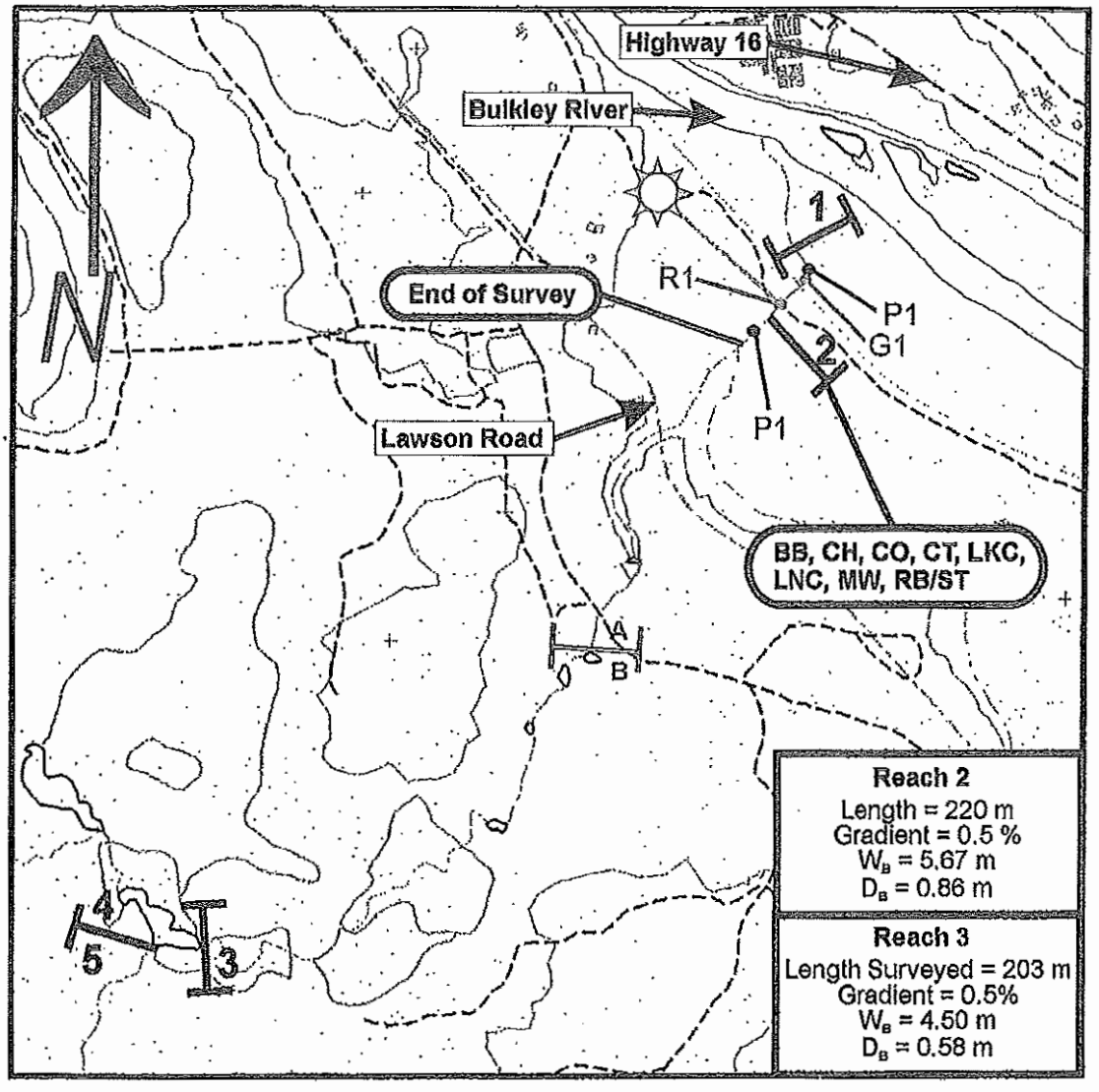


Figure 28. Map of Helps Creek showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.065 1:20 000.

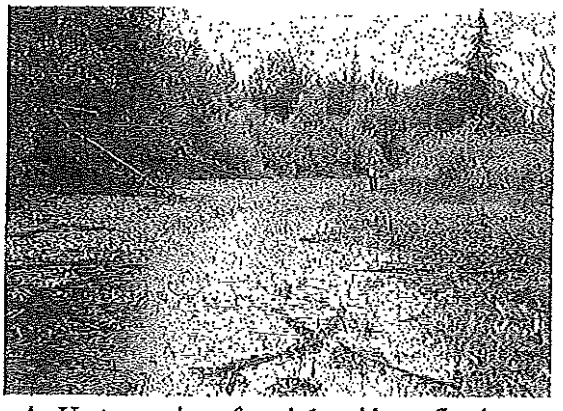
4.4.1 Reach 1

Reach 1 is a 300 m long remnant side- or back-channel of the Bulkley River. The channel is approximately 15 m wide. It is backwatered by the Bulkley River (Fig. 29A, B). The discharge from Helps Creek is supplemented by groundwater from the Bulkley floodplain. Access to the Bulkley River is excellent and this channel is a critical refuge, rearing, and overwintering area for all salmonids. No fish sampling or channel or riparian assessments were carried out in this short reach. Coho, chinook, steelhead, rainbow trout, cutthroat trout, Dolly Varden char and mountain whitefish have all been captured upstream of this reach. The channel has abundant instream vegetation, occasional functional LWD and the substrate is mainly fines. No spawning habitat was observed in the reach. Riparian forest was limited and consisted of sparse trembling aspen, black cottonwood, lodgepole pine and spruce. Shrub cover was moderate and included willows, red-osier dogwood and prickly rose.

4.4.2 Reach 2

Reach 2 of Helps Creek is a short section of fluvial channel linking the reach 1 back-channel to the large wetland comprising reach 3. Reach 2 is 220 m long and flows under the CN tracks and through an old road embankment (Fig. 29D). The culverts under the tracks were passable to fish and the deactivated road crossing offered one of the only areas of substrate suitable for anadromous salmonid spawning. This reach contains moderate rearing and overwintering habitat in its lower end where the channel is deep and abundant cover is present. Spawning habitat occurs in this reach and is suitable for resident and anadromous salmonid species. We captured coho (0+, 1+), chinook (0+), rainbow trout (0+), cutthroat trout (2+) and mountain whitefish (1+) in the glide and pool we sampled. Functional LWD was relatively scarce (0.23 functional pieces per bankfull width). However, 33% of the functional wood had a diameter of 50 cm or greater (Table 31a). Limited LWD is available for recruitment and the riparian vegetation along this reach consisted mainly of willows, red-osier dogwood, alder and grasses.

Figure 29: Helps Creek: channel, riparian and impact photos.

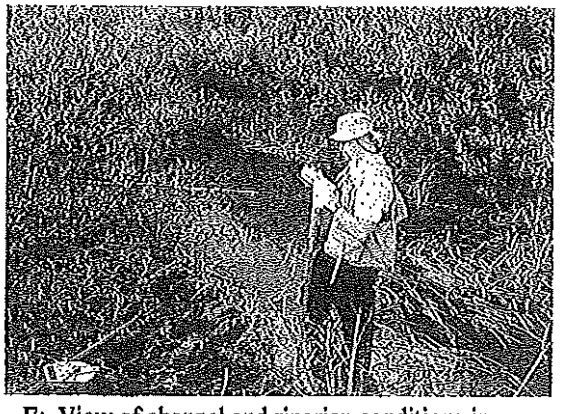


A: Upstream view of reach 1, a side- or flood-channel of the Bulkley River.

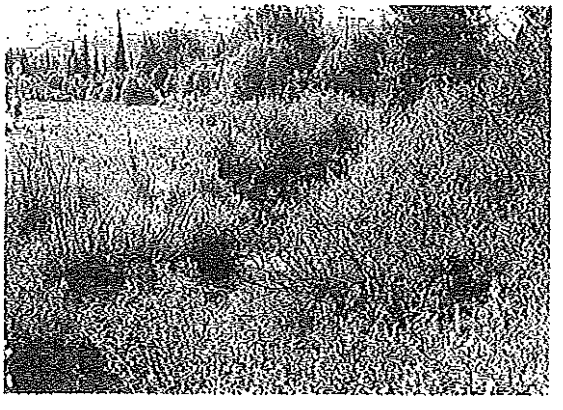
B: Downstream view of the mouth of reach 1. The Bulkley River is in the background.

C: Upstream view of typical channel and riparian habitat at 0+030 of reach 2. The CN tracks and culvert are in the background.

D: Upstream of deactivated road crossing at 0+161 m in reach 2.



E: View of channel and riparian conditions in reach 3.



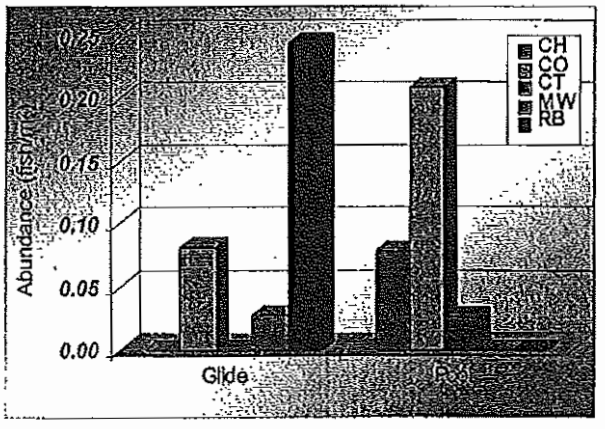
F: View of reach 3 from a bench overlooking the stream. Note the large channel, riparian shrubs and the cleared area.

Table 31. Summary of channel and fish habitat field data for Helps Creek, reach 2.

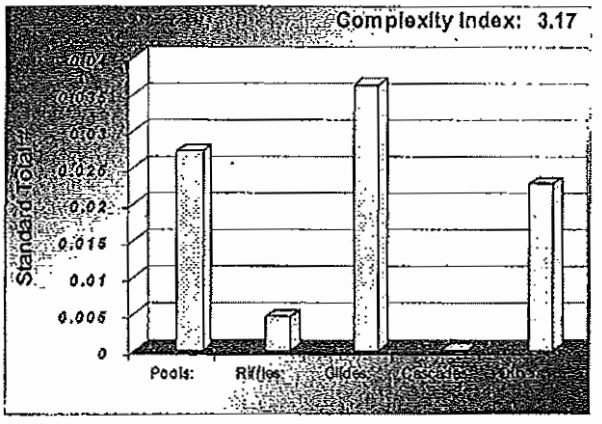
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	5	5	4	14
# Functional Pieces	4	2	3	9
# Func. Pieces / Bankful width	0.10	0.05	0.08	0.23
% Functional	80	40	75	64

b) Density of salmonids in glides, pools and other habitat types.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	G	S	L	AR	L	IV, OV	0-20
Other	S	S	L	AR	N	IV, LWD	20-40
Pool	G	S	L	AR	N	IV, C	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

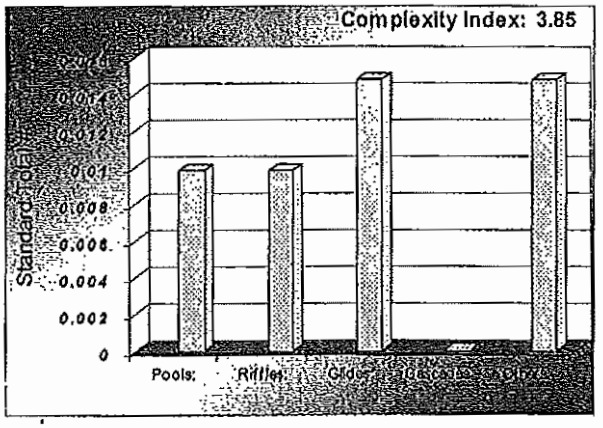
D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
3.33	0.05	0.37	0.75	3.63	4.28

4.4.3 Reach 3

Reach 3 is a three kilometre long wetland reach with beaver dam influenced morphology (Fig. 29F). It originates in a beaver pond and wetland complex in the middle of the Helps Creek drainage basin. We assessed the lower 200 m of this reach. This reach likely contains limited spawning habitat due to its wetland nature and fine substrate. However, rearing and overwintering habitat in the form of beaver ponds is abundant. We captured coho (0+, 1+) in a pool 60 m upstream of the reach break. Cover for fish consists of overstream vegetation and deep pools. LWD is in limited supply due to the lack of mature trees in the riparian zone which is dominated by willows. Red-osier dogwood, mountain alder, black twinberry and hardhack are also common streamside shrubs. Reach 3 upstream of our assessment is crossed by power lines and by Lawson Road. The culvert under Lawson Road has a wire mesh beaver barrier or debris catcher on the upstream end. The mesh is too small to allow migration of adult fish.

Table 32. Summary of channel and fish habitat field data for Helps Creek, reach 3.

a) Relative habitat unit frequency and index of habitat complexity.



b) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Pool	S	G	L	AR	N	IV, OV	0-20

c) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
1.00	0.03	0.26	1.05	2.74	2.90

Impact synopsis

Impacts in the lower reaches of Helps Creek were relatively minor. Perhaps the largest impact is to the riparian zone, which has been cleared along much of the creek to Lawson Road. This will influence LWD recruitment in the future. The deactivated road crossing in reach 2 may be contributing some sediments, but erosional power through this reach is low. A watershed assessment conducted in 1996 concluded that there was no evidence of impacts from logging causing significant problems to the watershed (Saimoto 1996). The screen on the upstream end of the Lawson Road culvert is a barrier to adult fish migration.

Restoration suggestions

- Remove screen on upstream end of Lawson Road culvert or replace with one that allows adult fish passage.

4.5 Unnamed Creek ("Moan Creek") (460-458800)

This unnamed creek, locally known as "Moan Creek" (Mackay pers. comm.), flows from the easternmost slopes of the Telkwa Range. It is a second order stream (at 1:50 000 scale) and flows in a northeasterly direction to join the Bulkley River approximately 4.5 km upstream of the footbridge over the Bulkley at Quick (Fig. 30). "Moan Creek" is approximately 10 km long and originates from a series of wetlands and ponds located between the headwaters of the Helps and Coffin Creek systems. The drainage area of this system is 17 km^2, making it the one of the smallest sub-basins assessed during our study. Four reaches were assigned to this creek (Triton 1997a). "Moan Creek" flows through Crown land and it is crossed by several roads, two power lines and a pipeline. Free range cattle grazing occurs on the power line and pipeline right of ways.

We assessed the lower two reaches of "Moan Creek" for a total of 2.9 km. Reach 1 is a partially confined reach, while reach 2 is a higher gradient, confined, partially coupled section of stream. Reach 3 consists of the canyon section of the stream and has relatively low fisheries values. Reach 4 is a lower gradient reach that collects discharge from the headwater wetlands and ponds. We did not assess the upper two reaches of this stream due to poor access and a lack of anthropogenic impacts observed on air photos.

Minimal information exists on the fish distribution in "Moan Creek". Cutthroat trout and rainbow trout were captured upstream of the Lawson Road crossing during a previous study (Triton 1997a). We captured coho and chinook salmon below the CN Rail tracks on the Bulkley floodplain and we caught cutthroat trout, rainbow trout, Dolly Varden char and bull trout throughout the rest of the reaches we surveyed. No other fish species were encountered, however, it is likely that longnose dace use the lower 15 m downstream of the railroad tracks as refuge from the Bulkley River.

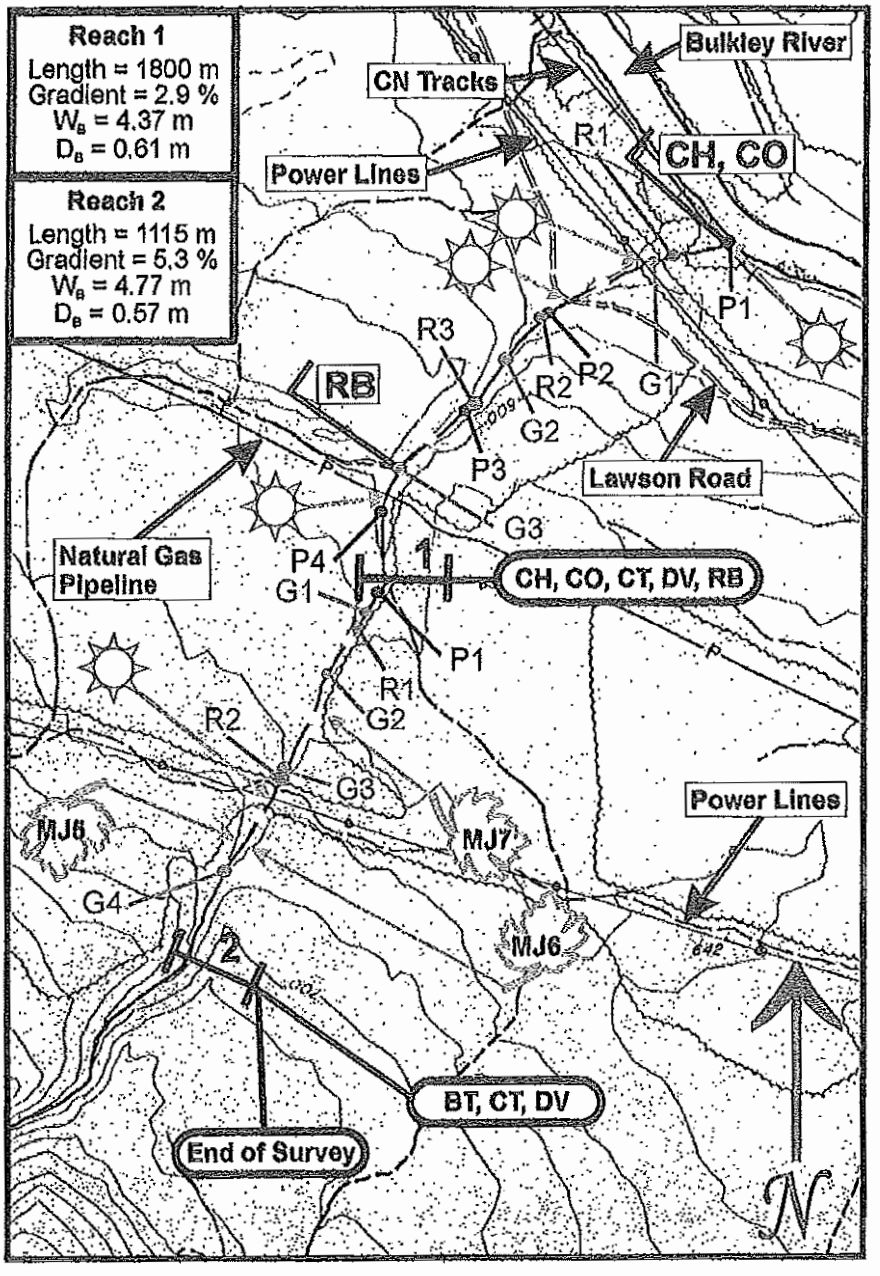


Figure 30. Map of "Moan Creek" showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.066 1:20 000.

No information exists regarding water quality or quantity for this system. No hydrometric stations or stream gauges are located on "Moan Creek". Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. We estimated discharge in reaches 1 and 2 to be 0.07 m^3/sec and 0.02 m^3/sec, respectively, using the floating object method. No water licenses exist for "Moan Creek".

4.5.1 Reach 1

Length:	1800 m	Elevation:	519 – 606 m
Length assessed:	1800 m	Average gradient:	4.8%
Number of sites:	11	Mean W_b :	4.37 m
Number riparian plots:	0	Mean d_b:	0.61 m

Riparian Assessment

The riparian zone has been impacted by several sources including cattle grazing, forestry and crossings of the stream. Free range cattle grazing has occurred along several sections of this reach. A section of riparian zone between 0+200 m and 0+700 m has been moderately grazed. As has an area above and below the natural gas pipeline crossing at 1+641 m. The right of way for the pipeline is used as a migration corridor as cattle move from one pasture to another. This has delayed the recovery of the riparian community disturbed during the installation of the pipeline. The riparian vegetation has been cleared for the CN Rail tracks, a small power line crossing and Lawson Road. Two cutblocks have been harvested to the edge of the gully through which this reach flows, beginning immediately upstream of the natural gas pipeline. The harvested areas impose on the riparian zone near the upstream reach break where approximately 20 m of forest remains on either bank. Channel instability was observed in areas where the riparian vegetation had been removed to the stream banks. Functional LWD was limited in the lower kilometre of the reach, despite a healthy riparian forest.

Overstory species along this reach consisted of spruce and black cottonwood on the narrow floodplain. Paper birch, trembling aspen and lodgepole pine occurred on the drier slopes in the stream gully. Common shrub species included willows, mountain alder, red-osier dogwood, prickly rose, black twinberry and highbush cranberry. No riparian assessments were conducted for this reach, however, the data from the plots in reach 2 may be used to estimate conditions for sites of similar slope, aspect and position in relation to the channel.

Channel Assessment

Reach 1 of "Moan Creek" is a 1.8 km long reach with an average gradient of 2.9%. Channel morphology is cascade-pool except for the lower 386 m which is riffle-pool. Cobble and gravel are the dominant substrate materials. The erodible banks are composed of gravel and sand with cobble occurring in the upper portion of the reach. LWD is the main channel

forming and complexing agent. It is unlikely that beavers would find much suitable habitat in the lower three reaches of "Moan Creek".

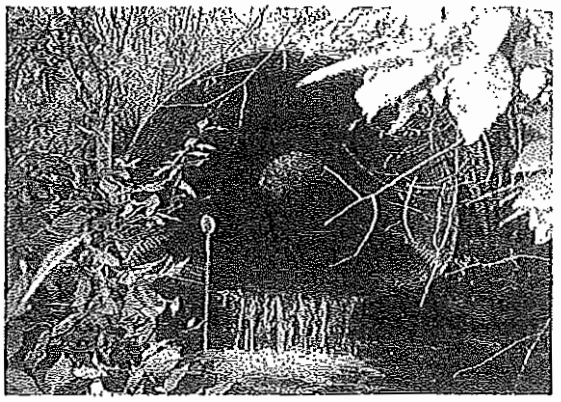
Fifty-two percent (930 m) of the reach was moderately aggraded. These aggraded sections were usually associated with anthropogenic sources such as the power lines at 0+282 m, the Lawson Road culvert and the natural gas pipeline (Fig. 31B, D). An area of recent channel migration occurred at 1+109 m where multiple channels flowed through the riparian forest. Common indicators of disturbance included extensive and elevated bars, extensive riffles and cascades, multiple channels and eroding banks. A lack of functional LWD was chronic throughout the lower kilometre of this reach.

Point source impacts to the channel include the following: A perched culvert at the CN tracks immediately upstream from the Bulkley River (Fig. 31A). A power line or telephone line crossing at 0+282 m being used as a cattle migration route has widened the channel and contributed to downstream aggradation. The culvert under Lawson Road is perched and constricts water flow which is also contributing to aggradation upstream and downstream of the crossing. The natural gas pipeline at 1+641 m is a source of sediment due to the combined effects of the installation and cattle grazing in the right of way. A channel was dug to divert the flow away from the work site. This diversion channel has now become the permanent channel (Fig. 31F). The toes of the banks have been armoured with LWD which is now becoming undercut. The formation of this new channel has increased the amount of sediment and bedload available to the stream in this area which, in turn, has contributed to the aggradation downstream. Cattle grazing and trampling the banks at this crossing is also widening the channel.

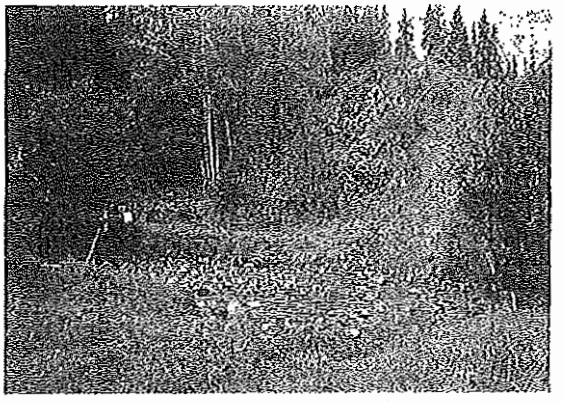
Fish and Fish Habitat Assessment

The quality of the fish habitat in reach 1 is generally moderate. Although pools were abundant(1 every 5.5 bankfull widths), they were often shallow or small due to large bed paving material. Thus overwintering habitat quality is low to moderate. Rearing habitat, located in glides and pools, was abundant. Combined, these two habitat types comprised 38% of the channel area. Spawning habitat, though, was limited. Pool and glide tailouts and the occasional low gradient riffle contained small areas of spawning gravel. Instream cover elements consisted of undercut banks, SWD and LWD in pools and glides and of boulders and overstream vegetation in riffles and cascades. The canopy closure, of 40%, was moderate. Overall LWD function was moderate to high in this reach. 50% of the LWD within the channel was functional and there were 0.4 pieces of functional wood per bankfull width (Table 33a). Only 5% of the functional wood was in the large (>50 cm diameter) size class. Abundant LWD is available for recruitment in the mature riparian forest along most of this reach. Discharge at the time of sampling was 0.07 m^3/s.

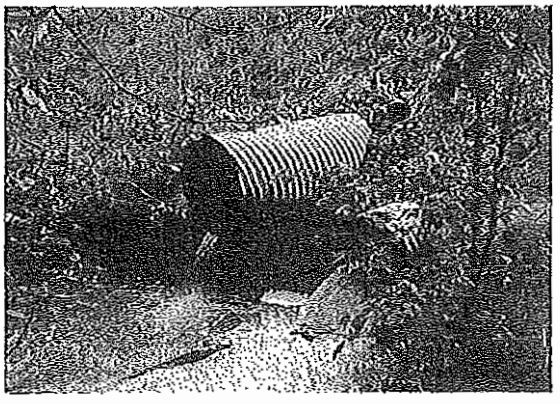
Figure 31: "Moan Creek" Reach 1: channel, riparian and impact photos.



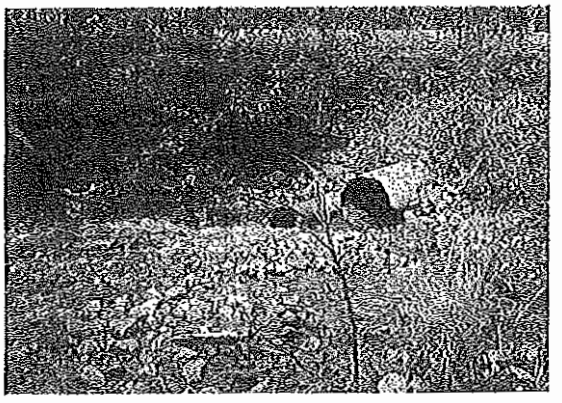
A: View of the culvert under the CN tracks at 0+015 m. Note the 55 cm plunge into the pool.



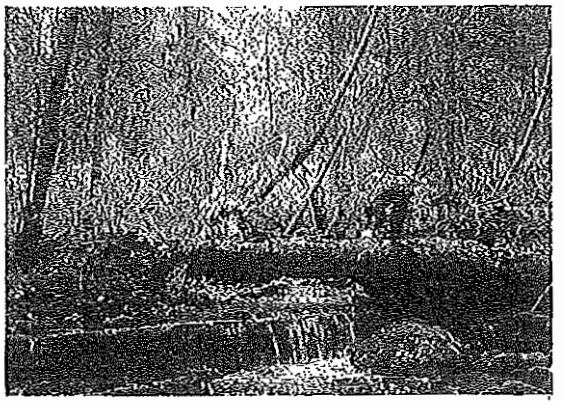
B: View of the telephone or power line crossing at 0+282 m. Note the cattle path through the widening channel.



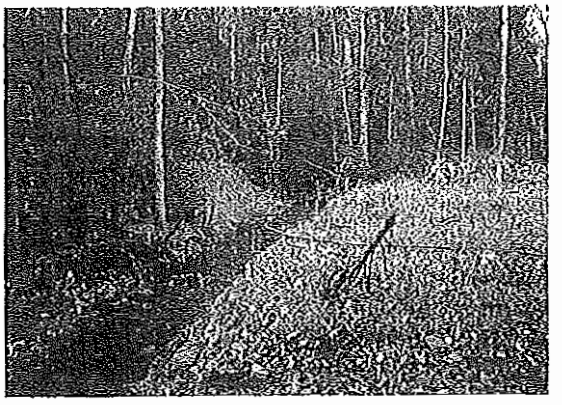
C: View of perched culverts under Lawson Road at 0+687 m. The culvert with the main flow (photo right) is undersized.



D: View of aggradation upstream of the Lawson Road culverts at 0+687 m.



E: Upstream view of typical channel and riparian vegetation at 0+960 m. Note the functional LWD and mossy substrate.



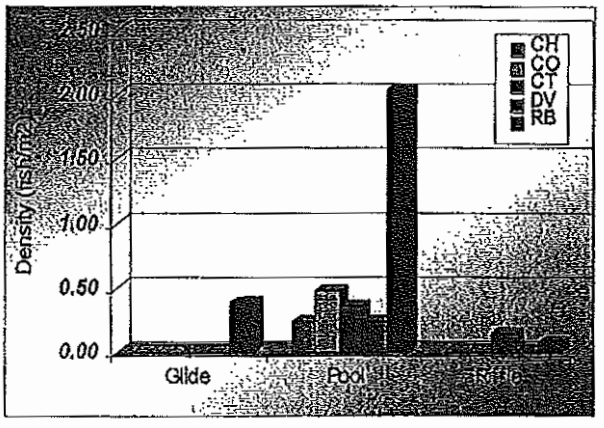
F: Downstream view of the diverted channel at the natural gas pipeline crossing at 1+641 m. Note the channel homogeneity and the lack of cover.

Table 33. Summary of channel and fish habitat field data for "Moan Creek", reach 1.

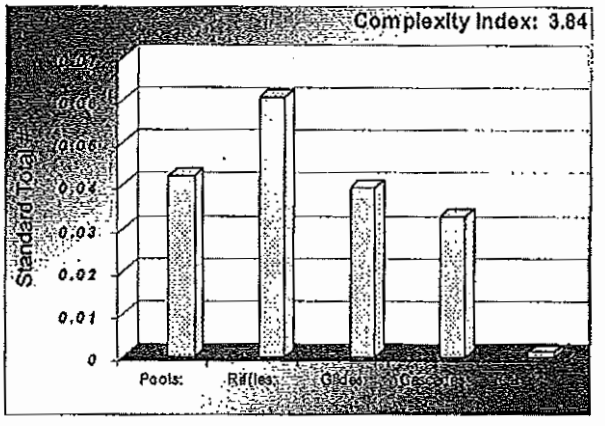
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	118	231	14	363
# Functional Pieces	67	105	9	181
# Func. Pieces / Bankful width	0.16	0.25	0.02	0.43
% Functional	57	45	64	50

b) Density of salmonids in glides, pools and riffles.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	B	C	H	AR	N	B	20-40
Glide	C	G	H	AR	L	C, B, SWD	20-40
Pool	G, S	G	M	R	M	C, LWD, OV	40-70
Riffle	C	G	H	A	L	B, OV, SWD	20-40

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
17.50	0.06	0.27	1.09	2.88	17.55

The plunge pool below the culvert under the railroad tracks contained the greatest abundance and diversity of fish. This was the only site where we caught juvenile coho and chinook salmon (0+). These fish were likely using this pool as an off-channel rearing area of the Bulkley River. The culvert is a potential barrier to fish migration during most flow regimes. We caught rainbow trout (0+, 1+), cutthroat trout (0+) and Dolly Varden char (1+, 2+) throughout the reach upstream of the culvert at the railroad tracks. Fish densities and abundances were low in all types of habitat we assessed (Table 33b). Densities for rainbow trout, the most abundant species, ranged from 0.07 fish per m^2 in riffles to 0.38 fish per m^2 in glides. No fish were caught in cascades in this reach. Due to the proximity to the Bulkley River mainstem it may be assumed that most of these juveniles are steelhead fry (Tredger 1982), provided that spawners can navigate the culverts. The large substrate particle size and potential barrier at the CN tracks may prevent coho from using this reach as spawning habitat and the stream is likely too small for chinook spawners.

Potential barriers to fish migration include the CN culvert at 0+015 m, which is perched approximately 55 cm above the plunge pool below. The Lawson Road culverts at 0+687 m are perched approximately 30 cm above the channel.

Impact synopsis

Land use has had low to moderate effects on fish habitat and riparian vegetation in this reach. The impact sites are all point sources at crossings. Cattle grazing, when combined with land clearing for right of ways, is causing accelerated aggradation and sedimentation of the channel. The riparian reserves along the cutblocks inn this reach appear to be adequate. The perched culverts are barriers to fish migration, particularly juveniles.

Restoration suggestions

- Construct bridges or hardened cattle crossings at critical fords if cattle densities warrant it.
- Re-establish riparian vegetation to stabilise banks.

4.5.1 Reach 2

Length:	1115 m	Elevation:	606–678 m
Length assessed:	1115 m	Average gradient:	6.5%
Number of sites:	10	Mean W_b :	4.77 m
Number riparian plots:	3	Mean d_b:	0.57 m

Riparian Assessment

Several sources of impacts to the riparian zone were observed in this reach. A set of power lines cross the channel at 0+684 m, free range cattle grazing occurs in the cutblocks beside the channel and logging has occurred along approximately 40% of the riparian zone. Cattle also use the power line crossing as a ford and watering area. Within the power line right of

way, all vegetation has been cut back and riparian function has been severely compromised. This area is degrading and the channel is downcutting. No opportunity exists for future LWD recruitment. The riparian reserve zones beside the cutblocks were generally 10 to 20 m wide. The exception was a several metre wide leave strip in areas along the left bank of the creek upstream of the power lines. Three riparian sites were assessed in this reach in order to estimate the conditions and riparian function of disturbed land of similar characteristics.

Site assessment MJ7

Site series: SBSdk06
Seral association: Spruce-Twinberry-Coltsfoot

Riparian plot MJ7 was located on a bench above "Moan Creek" approximately 25 m from the right bank of the stream, well within the 40 m riparian management area. The 11.28 m plot was placed within a cutblock that was logged in 1986 and 1988 and planted with spruce and lodgepole pine in 1989. We chose this site to determine the site series for the logged area that parallels the creek from the power lines downstream approximately 500 m to the natural gas pipeline. The aspect of the site was northeast and it faced away from the channel on a 3% slope. The channel flowed in a northwesterly direction here. Two black cottonwood trees located on the gradient break to the "Moan Creek" floodplain were the only mature stems in the plot. These trees were both greater than 22 cm dbh. The representative tree was estimated to be 33 m high and had a dbh of 46 cm. The stocking survey indicated that 50 mature cottonwood trees per hectare should occur on similar sites. The dominant trees in the plot were spruce saplings. The stocking survey indicated a density of 950 spruce saplings per hectare. Four pine saplings were observed in the plot (100 sph). With 1050 coniferous sph, the cutblock appears to be adequately restocked. This site had well developed shrub and herb layers. Red-osier dogwood grew to a height of 2.3 m and covered 4% of the plot. Short shrubs included black twinberry (10% cover), prickly rose (2%), thimbleberry (2%) and highbush cranberry (1%). Herbaceous plant cover consisted mainly of fireweed (25%), bluejoint (5%) and blue wildrye (*Elymus glaucus*) (2%). A complete species list for this site can be found in Appendix E. Due to the distance from the plot to the creek, this site has low values in terms of riparian function (Table 34). The regeneration occurring in the site will help shade the stream and stabilise the channel during bankfull floods. The site will not contribute substantial amounts of LWD for many years until conifers grow to heights exceeding 30 m.

Table 34. Riparian function summary for riparian plot MJ7.

Function	Rating	Comments
LWD	L	Plot centre is 25 m from stream.
Shade	L	Vegetation will eventually help to shade the creek.
Small organic debris (SOD)	L	Plot centre is 25 m from stream.
Surf. Sed. Filter	H	Dense herb layer, site slopes away from channel.
Channel stability	M	Shrubs and herbs will help stabilise during floods.
Bank stability	L	Plot centre is 25 m from stream.

We dug a 70 cm soil pit in the plot. The soil great group is Eutric or Dystric Brunisol. Layers were as follows: a 9 cm moder humus layer intermixed with a 40 cm loamy sand Bm layer and a layer of clay greater than 25 cm deep. Based on descriptions contained in Banner *et al.* (1993), the site series is Spruce-Twinberry-Coltsfoot (SBSdk06).

Assessment site MJ5

Site series: SBSdk06
Seral association: Spruce-Twinberry-Coltsfoot

We chose this site for assessment in order to predict the riparian function and vegetation communities of similarly disturbed sites that occur in this reach. The plot was located on a small fluvial terrace approximately 8 m from the stream. It was on the left bank, approximately 150 m upstream from the power line crossing. This site was logged, mechanically prepared and planted in 1985 and was brushed and weeded in 1987. The site also appeared to have been burned, perhaps as part of the site preparation. Cattle now use this area for grazing. The aspect of the 3.99 m radius plot was east and the slope was 22%. The overstory consisted of two young spruce trees approximately 18 cm in diameter and 13 m tall. The stocking survey indicated 400 spruce trees between 12.6 and 21.9 cm per hectare and 600 spruce seedlings per hectare. With a stocking of 1000 sph, this site appears to be adequately restocked, although competition from shrubs is high. Several paper birch and black cottonwood were observed nearby, but not in the plot. The plot also contained varied and dense shrub and herb layers. Tall shrubs greater than 2 metres in height included red-osier dogwood (20% cover), mountain alder (3%) and highbush cranberry (1%). The short shrub layer consisted of thimbleberry (25%), devil's club (15%), black twinberry (10%) and prickly rose (2%). Common herbaceous plants included common horsetail (10%), one-sided wintergreen (5%), bunchberry (1%), fireweed (1%) and oak fern (1%). A complete species list can be found in Appendix E. Due to the lack of mature trees and a recent history of disturbance, this site has moderate value in terms of riparian function (Table 35).

Table 35. Riparian function summary for riparian plot MJ5.

Function	Rating	Comments
LWD	M	Limited number of mature trees due to forest harvest.
Shade	M	Few mature trees, but good shrub cover.
Small organic debris (SOD)	M	Few mature trees, but good shrub cover.
Surf. Sed. Filter	H	
Channel stability	M	Channel aggrading.
Bank stability	M	Channel aggrading.

We dug a 60 cm soil pit in the plot. The soil great group is Regosol. Layers were as follows: a 10 cm mor humus layer overlaying fluvial parent material consisting of 60% sand, 25% gravel and 15% stones. Based on descriptions contained in Banner *et al.* (1993), the site series is the Spruce-Twinberry-Coltsfoot (SBSdk06).

Assessment site MJ6

Site series: SBSdk06
Seral association: Spruce-Twinberry-Coltsfoot

This site was chosen to represent the steep-sided, relatively undisturbed gully walls that occur along much of this stream. The 11.28 m radius site occupied the entire slope from the top of the gully to the toe of the slope on the small floodplain of "Moan Creek." The aspect was west and the slope was 65%. The plot centre was 12 m from the left bank of the stream. This site was located opposite plot MJ5, approximately 150 m upstream of the power line crossing. Logging has occurred above, to the edge of the gully. The cutblock was logged in 1976 and 1980, mechanically prepared in 1982, and planted in 1983. Blow down is common in the forest remaining along the face of the gully and the humus layer contained charcoal, evidence of a relatively recent fire history. The overstory was dominated by paper birch, but also included spruce and lodgepole pine. Subalpine fir (*Abies lasiocarpa*) seedlings and saplings occurred in the understory of the plot. The stocking survey indicated 175 birch, 25 spruce and 50 pine with diameters greater than 12.6 cm per hectare. The representative birch was estimated to be 22 m high and had a 36 cm dbh. Common tall shrubs included red-osier dogwood (5% cover), Douglas maple (*Acer glabrum*) (4%), mountain alder (2%) and willow (1%). The short shrub layer consisted of thimbleberry (10%), highbush cranberry (5%), twinflower (2%) and prickly rose (1%). Common herbs and mosses included one-sided wintergreen (3%), purple peavine (2%), fireweed (1%), ragged moss (*Brachythecium* sp.) (2%) and club moss (*Lycopodium* sp.) (1%). A complete species list for this site can be found in Appendix E. Due to the distance of the plot from the channel, the dominance by deciduous species and the blow down this site has moderate value in terms of riparian function (Table 36).

Table 36. Riparian function summary for riparian plot MJ6.

Function	Rating	Comments
LWD	M	Fairly low stocking and mostly deciduous trees.
Shade	M	Plot centre approx. 14 m from stream.
Small organic debris (SOD)	M	Deciduous trees approx. 20 m from stream.
Surf. Sed. Filter	H	
Channel stability	M	Channel aggrading.
Bank stability	M	Channel aggrading.

A 65 cm soil pit was dug in our plot. The soil great group is a skeletal Brunisol. Layers were as follows: a 5 to 9 cm mor humus layer; a 45 cm light brown-grey Bm layer composed of 65% sandy loam, 20% gravel and 15% stones; and a hard clay layer with embedded stone and gravel. The site series appears to be the Spruce-Twinberry-Coltsfoot (SBSdk06) (Banner pers. comm.).

Channel Assessment

The channel morphology of reach 2 of "Moan Creek" is mainly cobble-cascade-pool. A small section of channel at the lower reach break had riffle-pool characteristics. The dominant substrate particle size of this reach was cobble. Gravel was subdominant in glides and riffles and boulders were subdominant in cascades. The erodible banks consisted of fines, sand and cobble in the lower half of the reach, and cobble, gravel and boulders in the upper half. Bank material and substrate particle size increased with gradient near the upstream reach break. LWD is the primary channel forming mechanism in this reach. Small cascades and falls were observed when functional LWD and SWD trapped sediment and raised the stream bed upstream of the wood. These small falls and cascades can be barriers to upstream fish migration during low flows.

Several sections of channel were moderately aggraded or degraded. The aggraded sections totalled 360 m or 32% of the reach length and occurred throughout the reach. Common channel disturbance indicators for these sections include sediment wedges, extensive and elevated bars, extensive riffles and cascades, minimal pool area and multiple channels. The degraded section, under the power lines, was 86 m long and occupied 8% of the reach. This area was characterised by extensive scouring, extensive riffles and cascades, minimal pool area and a lack of functional LWD. Material transported downstream from the crossing is collecting downstream of the right of way.

The main point source impact to the channel in this reach is the power line crossing and ford at 0+684 m (Fig. 32 D). The degradation at this site is caused in part to the weakening of the banks due to the lack of riparian vegetation. At the ford, vehicles and cattle have widened the channel. Fine sediment is also introduced to the channel during rain storms as surface runoff flows down the ruts left by off-road vehicles and cattle. Persistent trimming and brushing of vegetation limits the riparian function in this section. Allowing shrubs and small trees to grow taller along the channel would help restore some of the riparian function.

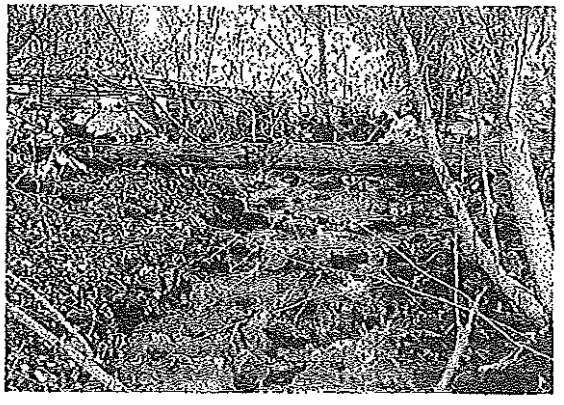
Fish and Fish Habitat Assessment

The fish habitat quality in reach 2 was poor to moderate. Overwintering habitat in the form of pools was limited. Pools occurred every 13 bankfull widths on average and were shallow and small, occupying only 7% of the channel's wetted area. The large substrate particle size of this reach did not allow deep scour pools to form. Rearing habitat was moderately abundant in this reach due to a large number of glides which accounted for approximately 26% of the reach area. Spawning habitat was limited throughout this reach. Glides and riffles contained small areas of spawning gravel. Cascades were the most numerous units we counted. They accounted for 48% of the reach area. Average canopy closure was 40% and cover for fish consisted of overstream vegetation, LWD and boulders and the average canopy closure was 40%. Functional LWD is abundant (0.63 pieces per bankfull width) (Table 37A), attesting to the health of the riparian zone. 11% of the functional wood was in the large (>50 cm diameter) size class. Ample LWD is available for recruitment in the mature riparian forest along most of this reach. Discharge at the time of sampling was 0.02 m^3/s.

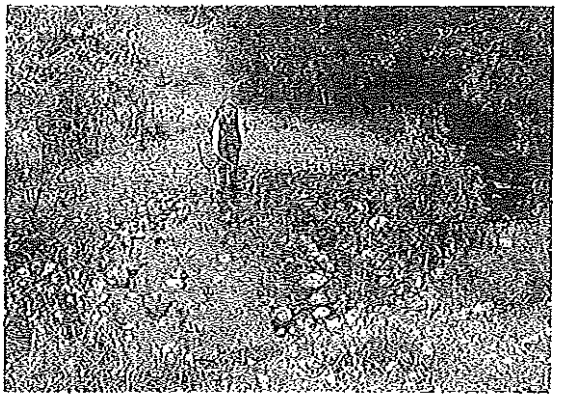
Figure 32. "Moan Creek" Reach 2: channel, riparian and impact photos.

A: Downstream view of channel at 0+107 m. Note the abundant SWD and shrub cover.

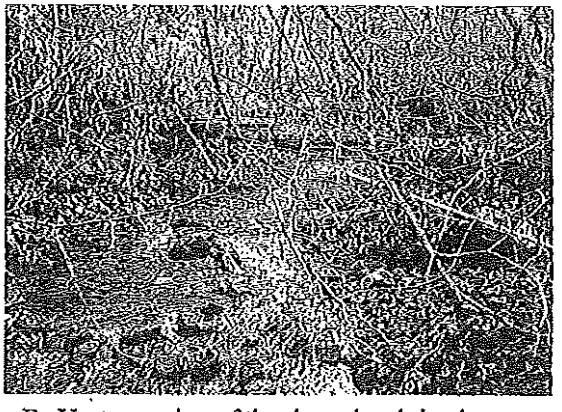
B: View of a potential temporary barrier to fish migration, 60 cm high, at 0+215 m. This feature was typical of the reach.



C: Upstream view of typical channel and riparian conditions at 0+412 m.



D: View of the road crossing under the power lines at 0+684 m. This is a frequently used vehicle and cattle crossing.



E: Upstream view of the channel and riparian conditions at 1+025 m.

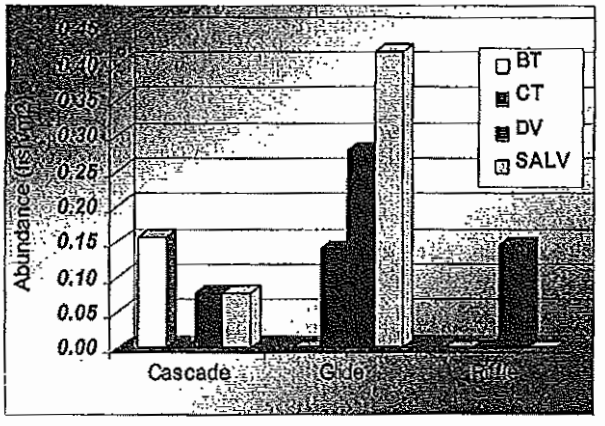
F: Upstream view of reach 3 from the reach break.

Table 37. Summary of channel and fish habitat field data for "Moan Creek", reach 2.

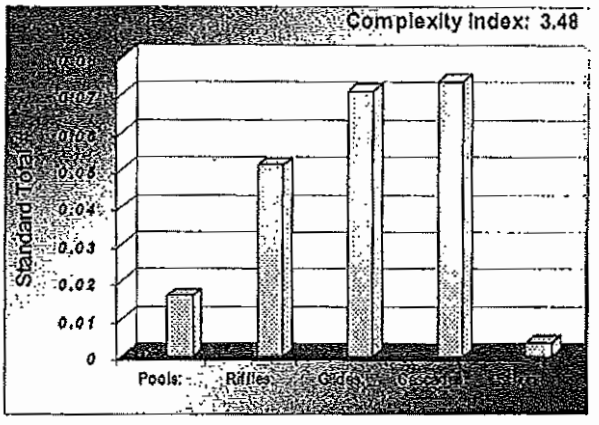
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	196	207	21	424
# Functional Pieces	50	83	16	149
# Func. Pieces / Bankful width	0.21	0.35	0.07	0.63
% Functional	26	40	76	35

b) Density of salmonids in cascades, glides and riffles.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	C	B	M	AR	N	B, OV, LWD	70-90
Glide	C	G	M	AR	L	LWD, OV	0-20
Pool	G	C	M	AR	N	OV, LWD	0-20
Riffle	C	G	M	R	L	OV, B	40-70

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (ft/s)	Bankfull Discharge(m³/s)	Tractive Force (kg/m²)
13.00	0.06	0.26	1.51	4.12	30.32

Fish occurred in low densities and abundances. We only captured 11 fish: cutthroat trout (0+), Dolly Varden char (1+ to 3+) and bull trout (1+, 2+). We also captured four char less than 55 mm long (0+). We did not identify these to species in order to minimise stress due to excessive handling. Several of the Dolly Varden required the use of the linear discriminate function to determine species. Densities ranged from a low of 0.08 Dolly Varden per m^2 in cascades to 0.42 unidentified char per m^2 in glides (Table 37b).

No permanent barriers to fish migration were observed in this reach. Several small falls formed by LWD or SWD are temporary and may wash away during a flood (Fig. 32B).

Impact synopsis

Land use impacts on the stream are relatively minor. Point source impacts from cattle grazing and watering, land clearing for right of ways and fording of the stream by cattle and vehicles are disturbing localised areas of channel and adding sediment. Although riparian zones have been compromised to some extent by past logging, riparian function along most of the reach is moderate to high. Our assessment conclusions support a 1996 preliminary watershed assessment that found few impacts to streams related to logging in this watershed (Saimoto 1996).

Restoration suggestions

- Allow riparian vegetation to re-establish under the power lines.
- Develop hardened (geoweb) crossing and recontour channel at the access road crossing.

4.6 Coffin Creek (460-472700)

Coffin Creek is a third order stream (at 1:50 000) scale that joins the Bulkley River approximately 1.2 km upstream from the footbridge at Quick (Fig. 33). This 17 km long stream drains an area of 58 km^2 located on the southeast slopes of the Telkwa Range. The headwaters originate from meltwater and groundwater sources and from subalpine ponds and wetlands. Coffin Lake, the largest lake in our study area at 68.4 ha, is a mid-basin lake surrounded by large wetland complexes. Coffin Lake mitigates any land use impacts that occur upstream. The entire watershed occurs on Crown land and logging is the major land use. The stream is crossed by power lines and their access roads, a natural gas pipeline and several roads. Free range cattle grazing occurs along the power line right of way and in the riparian zone of Coffin Creek downstream to the natural gas pipeline crossing.

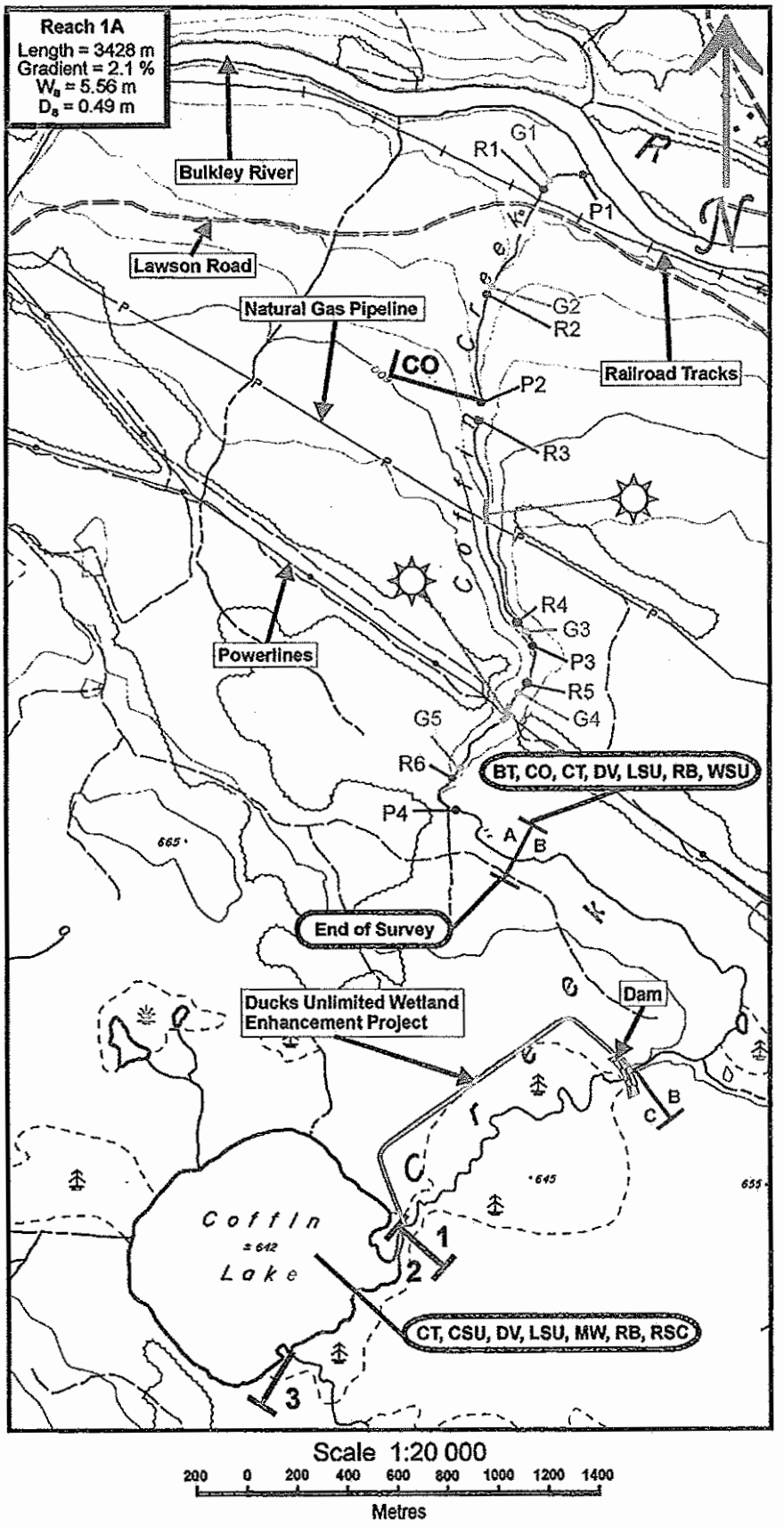


Figure 33. Map of Coffin Creek showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source maps: TRIM 93L.056, 066 1:20 000.

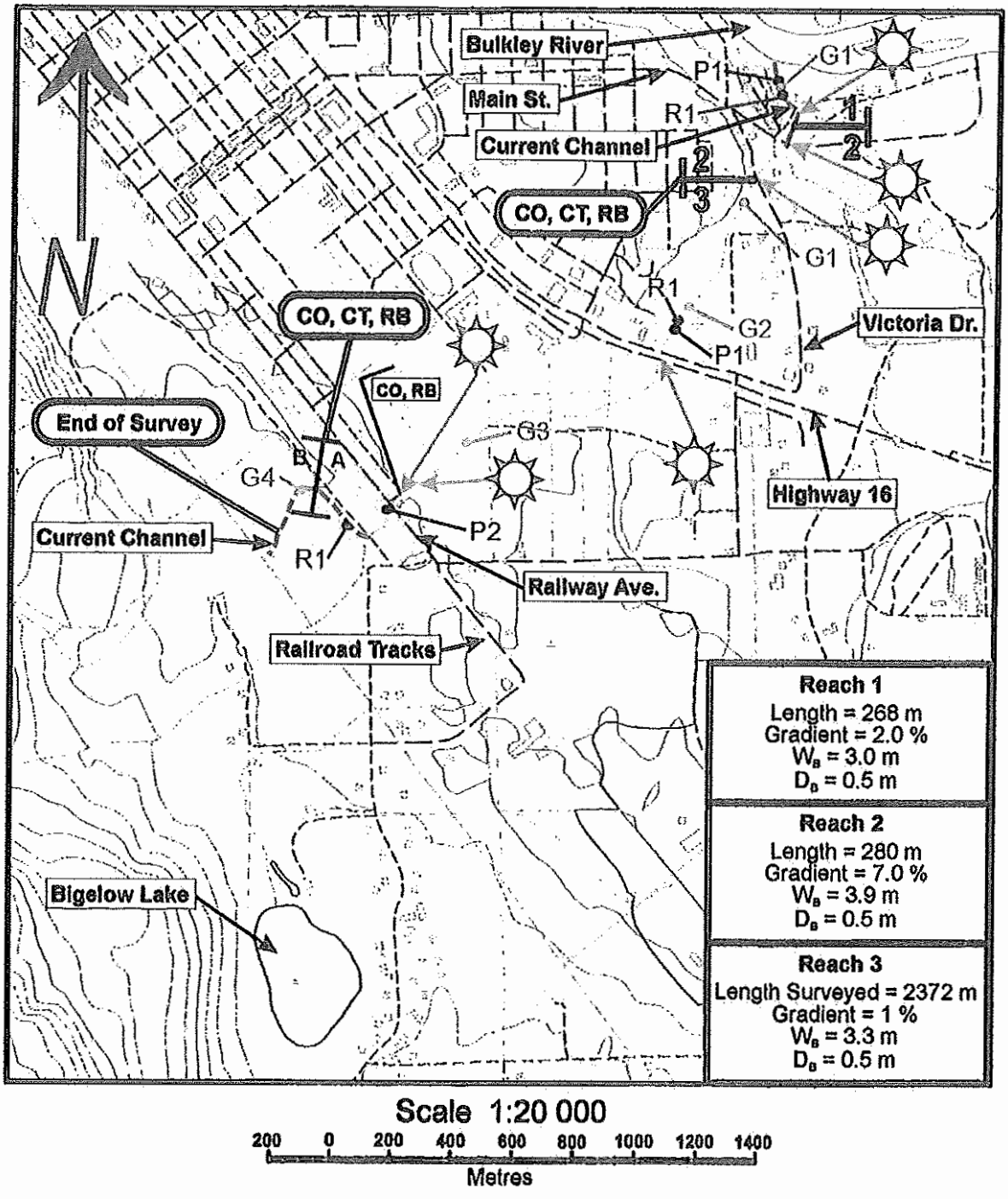


Figure 35. Map of Dahlie Creek, showing reach breaks, sample and impact sites, fish distribution and other features. See Fig. 3 for legend. Source map: TRIM 93L.075 1:20 000.

Seven reaches were assigned to Coffin Creek (Triton, 1997a). We divided reach 1 into three sections based on air photo interpretation. Section 1A consists of the confined fluvial channel that descends from the small plateau that contains Coffin Lake to the Bulkley River. We assessed section 1A only. Section 1B is a 1.6 km long large channel flowing through a beaver influenced wetland and section 1C is a wetland enhanced by Ducks Unlimited and MELP in order to increase wildlife habitat. The channel has been dammed and long back-channels have been excavated. Reach 2 is Coffin Lake and reach 3 is an unconfined reach flowing from the toe of the slope at the base of the Telkwa Range. Reach 4 is confined and has a gradient of approximately 9%. There is a 10 m high set of falls at the reach break between reaches 4 and 5. These falls mark the upstream limit of fish distribution in this watershed (Triton, 1997a). Reaches 5 and 7 are confined and coupled and reach 6 flows through several small wetlands and ponds. We did not assess the reaches upstream of Coffin Lake because roads in the area have been deactivated (Sterling Wood Group 1995a).

Fish distribution in Coffin Creek has been determined through several studies. A reconnaissance lake inventory captured longnose and largescale suckers, redside shiners, rainbow trout, cutthroat trout and Dolly Varden char in Coffin Lake. Additionally, traps set in the Coffin Creek mainstem caught rainbow trout, cutthroat trout, coho salmon and unidentified dace. Trapping in an inlet stream captured Dolly Varden char (Hatlevik 1985). Mountain whitefish have also been captured in Coffin Lake (BC 1999a). No fish were captured in Coffin Creek upstream of the falls between reaches 4 and 5 (Triton, 1997a). Our study found bull trout, coho, rainbow trout, longnose sucker and white sucker in section 1A.

Limited information exists on water quality or quantity for Coffin Creek. No hydrometric stations are located on Coffin Creek or anywhere on the west side of the Bulkley Valley in this area. Based on two years of data from Deep Creek (1978/79), the nearest Environment Canada hydrometric station (08EE022), peak flow occurs in May (Triton 1997a), corresponding with spring snow melt. We estimated discharge to be 0.6 m^3/sec by using the floating object method. One water licence exists for Coffin Creek. This licence is issued to Ducks Unlimited and the Ministry of Environment, Wildlife Branch and is for 709 acre-feet or 2.6 million cubic metres per year. The licence allows storage or conservation of water behind a dam built to raise the water level of Coffin Lake and increase the wetland area surrounding it (MELP 1999b). We estimated discharge to be 0.6 m^3/sec using the floating object method. No water quality information was found for Coffin Creek.

4.6.1 Reach 1A

Length:	3428 m	Elevation:	521 – 626m
Length assessed:	3428 m	Average gradient:	3.1%
Number of sites:	17	Mean W_b :	5.6 m
Number riparian plots:	0	Mean d_b:	0.5 m

Riparian Assessment

The riparian zone has been affected to a small degree by land uses including cattle grazing, stream crossings and forestry. Cattle sign was observed from 2+322 m upstream to the section break. A small herd appears to use this area. A fence and gate at the ford of Coffin Creek under the power lines prevents cattle from using this portion of the channel from the west. The riparian forest has been cleared to the stream banks for the railroad tracks at 0+294 m, Lawson Road at 0+336 m, the natural gas pipeline at 1+790 m and the power line right of way at 2+680 m. Logging has occurred along much of the section, but has not had a significant impact on the channel or the riparian vegetation. A cutblock immediately upstream of Lawson Road was harvested in 1975 and 1977, planted in 1985 and 1986 and brushed and weeded in 1992. This block spans the channel along the Lawson Road right of way. Willows form a thick riparian zone for the initial 70 m upstream of Lawson Road. A series of cutblocks beginning at the natural gas pipeline were harvested in 1976. The logging has occurred to the edge of the gully leaving approximately 30 to 60 m of riparian forest on both banks. Some windthrow was observed along the top of the gully in the logged areas. LWD function was good throughout section 1A and ample trees are available for future recruitment except at the various crossings.

Overstory species in the riparian forest of this reach consisted of spruce and black cottonwood on the narrow floodplain. Trembling aspen and lodgepole pine occurred on the drier slopes that confined the channel in the gully. Common shrub species included willows, mountain alder, red-osier dogwood, prickly rose, black twinberry and highbush cranberry. No riparian assessments were conducted for this reach.

Channel Assessment

Reach 1A is a partially confined cascade-pool and riffle-pool channel that originates in a large wetland below Coffin Lake. The average gradient of this reach is 3.1% and the dominant substrate is cobble with gravel being subdominant. The erodible banks of this stream are composed mainly of gravel, cobble and sand. LWD is the main channel forming and complexing agent for this reach.

745 m or 22% of this section is moderately aggraded. Most of the aggradation is associated with anthropogenic sources. The natural gas pipeline at 1+790 m is causing aggradation downstream for approximately 100 m (Fig. 34C). Sediment and bedload is being transported from the new channel through which the stream flows at the crossing and deposited downstream. Logs, keyed into the banks in order to armour the channel at this site, are becoming undercut and are acting as cutbanks. Blowdown from the cutblock on the left bank is causing accelerated channel migration and multiple channels for 300 m between 2+102 m and 2+372 m. The blowdown is trapping abundant spawning gravel and adding stream complexity. The channel is aggraded from the power line right of way beginning at 2+680 m to the access road ford at 2+746 m. The channel is slightly degraded in the right of way above the ford. The ford is used by crews working on the power lines, hunters, off-road vehicles and cattle. Approximately 80 m of moderate aggradation occurs at 3+014 m. A cutblock 300 m upstream may be contributing to increased levels of LWD in the channel due to blowdown.

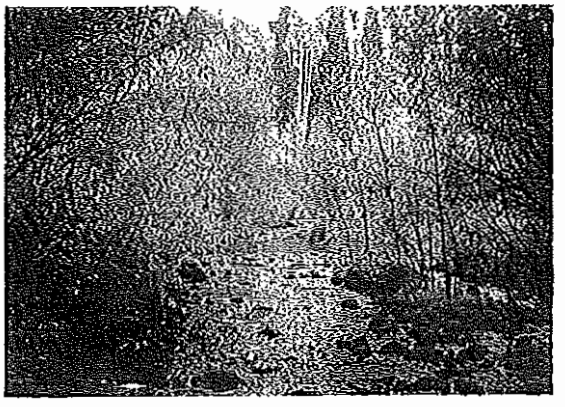
Figure 34. Coffin Creek Reach 1A: channel, riparian and impact photos.

A: Downstream view of channel and riparian vegetation at 0+188 m. Note the functional LWD in the background.

B: Upstream view of typical channel and riparian conditions at 1+597 m. Note the LWD spanning the channel.

C: Upstream view of the historical channel at the natural gas pipeline diversion at 1+790 m. The Coffin Creek mainstem is to the photo right.

D: Upstream view of the current channel at the pipeline diversion. The old channel is to the photo left. Photo taken from the same spot as Photo C.



E: Upstream view of the power line right of way. Note the lack of mature trees.

Fish and Fish Habitat Assessment

Fish habitat in reach 1A is generally moderate. Overwintering habitat is limited, but is abundant in the wetland sections 1B and 1C upstream. Only 16% of the wetted area was occupied by pools (one pool per 7.5 bankfull widths), many of which were shallow and of poor quality. The mean residual depth of pools we sampled was 35 cm. The large substrate particle size of this reach did not allow for the formation of deep scour pools. Rearing habitat was moderate. This section had abundant short glides, which occupied 24% of the wetted area of the channel. Cover elements consisted of overstream vegetation and boulders. The average canopy closure of the channel was approximately 40%. Although limited spawning gravel was observed in the units we sampled, we observed several sections of channel that contained abundant gravel associated with abundant functional LWD. Smaller substrate particles such as gravel and sand are trapped upstream of functional LWD and small scour pools are created below it. The areas of abundant LWD were typically caused by blowdown from the edges of cutblocks. LWD was abundant with 0.56 pieces of functional wood occurring every bankfull width and 31% of all the wood counted being functional (Table 38A). 14% of the functional wood was greater than 50 cm in diameter. LWD is available for recruitment along most of the section surveyed. Discharge at the time of the survey was 0.6 m^3/sec.

Fish densities for all fish other than rainbow trout were moderate (Table 38). Up to 70% of the rainbow trout (0+ to 3+) captured throughout the section may be steelhead juveniles based on the habitat available and the access from the Bulkley River (Tredger 1982). Coho salmon (0+, 1+) were captured in glides (0.07 fish per m^2)and pools (0.77 fish per m^2) upstream to 1+147 m. We caught one 3+ bull trout in a riffle at 1+177 m. No permanent barriers to fish migration were observed in this section.

Impact synopsis

Land use in this section has minimal impact on fish habitat. The channel is aggrading overall but shows good complexity (complexity index: 3.67). Abundant LWD in the channel and considerable recruitment opportunities exist in the riparian zone. Cattle impacts are minimal and logging appears to have been conducted outside the 50 m riparian management area for most of the creek. Coffin Lake appears to mitigate impacts from the extensive logging that has occurred in the headwaters of this system. The natural gas pipeline crossing and the power line crossing and right of way are causing localised aggradation and are sources of increased sediment and bedload.

Restoration suggestions

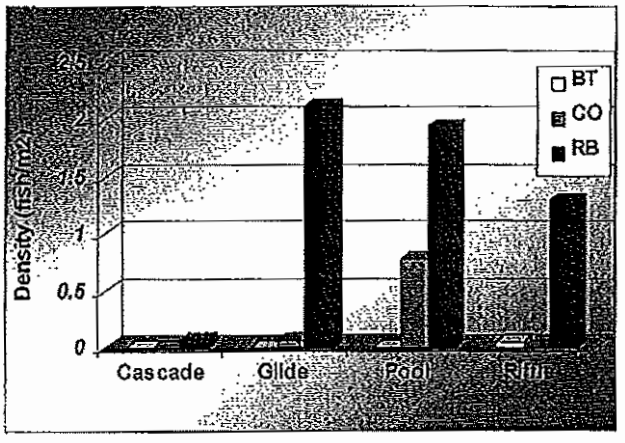
- Construct hardened crossing (geoweb) at power line right of way if cattle use warrants. Allow riparian shrubs to re-establish at road crossing and on road itself.
- Ensure riparian vegetation re-establishes at the pipeline crossing.

Table 38. Summary of channel and fish habitat field data for Coffin Creek, reach 1A.

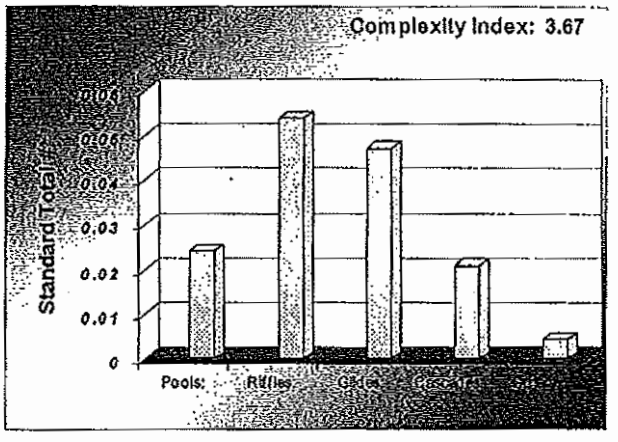
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	574	474	87	1135
# Functional Pieces	149	150	50	349
# Func. Pieces / Bankful width	0.24	0.24	0.08	0.56
% Functional	26	32	57	31

b) Density of salmonids in cascades, glides, pools and riffles.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	C	G	M	AR	L	OV, B	0-20
Glide	C	G, B	H	AR	L	OV, B	20-40
Pool	C, G	C	M	AR	L	LWD	40-70
Riffle	C	G	M-H	AR	L	OV, B	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (Kg/m^2)
17.53	0.06	0.22	0.83	2.23	10.11

4.7 Dahlie Creek (460-373800-33200)

Dahlie Creek is a second order stream (at 1:50 000 scale) flowing from the southeastern slopes of Hudson Bay Mountain through the town of Smithers. It joins the Bulkley River on the southeast side of town, approximately 2.2 km downstream of the Highway 16 crossing. This stream was mapped incorrectly on provincial 1:20 000 scale Terrain and Resource Inventory Mapping (TRIM) sheets and the federal 1:50 000 scale National Topographic Service (NTS) maps. The TRIM mapping is the most accurate except for the mapped confluence with the Bulkley River and the channel upstream of the CN railroad tracks. The mapped channel at the CN tracks may contain water during the spring floods. The NTS coverage shows Dahlie Creek flowing into Bigelow Lake and no outlet is mapped. In fact Dahlie Creek does not flow into Bigelow Lake and should have been assigned a unique watershed code. See Fig. 35 for the correct location of the lower three reaches.

Dahlie Creek drains an area of approximately 18 km^2 and the mainstem is mapped as being about 8.2 km long. We assigned reach breaks in the field based mainly on channel morphology and gradient. Reach 1 is 268 m long and is located on the Bulkley River floodplain. Reach 2 is a high gradient reach 280 m long that links the bench above the Bulkley to the floodplain. Reach 3 is a low gradient reach flowing from the wetland upstream of the CN tracks. We assessed reaches 1 and 2 and to 2+370 m of reach 3, halting the survey in a large wetland. All three reaches flow through the town of Smithers and adjacent land use reflects the "urban" nature of the creek. Little original riparian forest remains and shrub cover along much of the channel is reduced. The section of Dahlie Creek that we assessed is crossed by 7 roads and 1 set of railroad tracks. Trails and paths parallel much of reach 3 and cross the creek several times. Several residences and a ball park are located immediately adjacent to the channel as is the Willowvale subdivision. The stream receives discharge from storm sewers, road run-off and surface flow from cleared land. Several ditches also contribute flow.

Limited information is available regarding fish distribution. The only records in the Fisheries Inventory Summary System (BC 1999a) were for Bigelow Lake which shares the same watershed code as Dahlie Creek. A previous study found juvenile coho salmon (*Oncorhynchus kisutch*) throughout the stream to a point just upstream of Highway 16 and rainbow trout (*O. mykiss*) to the Victoria Street crossing (Bustard 1999). No fish were captured in the summer of 1997 immediately upstream of Highway 16 (Triton 1997b). A class at Chandler Park School has been rearing coho fry and releasing them into the channel as part of the Salmonids in the Classroom program (Donas pers. comm.; Butz pers. comm.). The fish being raised originate from Toboggan Creek stock. There is no record of any recent adult returns to Dahlie Creek, however, spawning coho were seen below the Railway Ave. culverts approximately 20 years ago (Cobb pers. comm.). Low water temperatures precluded the use of electrofishers in this creek. Instead, we set minnow traps in suitable locations and caught coho, rainbow trout and cutthroat trout (*O. clarki*). A coho overwintering habitat study has been commissioned by the Town of Smithers for the winter of 1999/2000 (Malcolm pers. comm.). The data from this study was not available at the time of writing.

Limited information exists on water quantity or quality for Dahlie Creek. No hydrometric stations or stream gauges are located on Dahlie Creek. However, the Ministry of Environment, Lands and Parks has measured discharge once in 1976 and once in 1995. Minimum and maximum discharges recorded were 0.06 m^3/s and 0.3 m^3/s, respectively (BC 1999b). We do not know the location of these measurements. This creek may have also been known as Bigelow Creek, which does have several discharge measurements. These measurements were taken at the twin culverts at Railway Avenue (0.99 m^3/s) and the culverts under Highway 16 (0.86 m^3/s) on May 4, 1976. We estimated discharge in reach 3 to be approximately 0.03 and 0.09 m^3/s in two locations using the floating object method. A recent study by Ducks Unlimited has calculated discharges. This data was not available at the time of writing. One current water licence exists for Dahlie Creek for a domestic withdrawal of 500 gallons or 2.3 m^3 per day. The Town of Smithers has also applied for an unspecified amount of water to be conserved or stored. The application process is still ongoing at this time. Virtually no water quality information is available for Dahlie Creek. Triton measured a pH of 7.7 and a conductivity of 100 µmhos in July of 1997 (Triton 1997b). These point source data do not provide enough information to draw any conclusions about the general water quality of this creek. The Town of Smithers has recently initiated a study of water quality in this creek. This study is scheduled to last at least one year (Malcolm pers. comm.).

4.7.1 Reach 1

Length:	268 m	Elevation:	465 – 471 m
Length assessed:	268 m	Average gradient:	3.7%
Number of sites:	3	Mean W_b :	3.0 m
Number riparian plots:	0	Mean d_b:	0.5 m

Riparian Assessment

The riparian zone of this short reach on the Bulkley River floodplain has been impacted over the years, but is still functioning reasonably well. Mature conifers are sparse along the entire length of the reach, however, black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and mountain alder (*Alnus tenuifolia*) are common. A small section near the upper reach break contains some mature hybrid white spruce (*Picea glauca x engelmannii*) and is contributing some large woody debris (LWD) to the channel that may eventually function to add habitat complexity to the channel. This reach is crossed by Riverside Drive and a small foot bridge and several homesteads and residences are located adjacent to the channel. Most of the land is privately owned. The riparian vegetation is dominated by willows (*Salix* sp.), red-osier dogwood (*Cornus stolonifera*) and mountain alder. Common herbaceous plants included scouring rush (*Equisetum hyemale*), common horsetail (*E. arvense*), Sitka burnet (*Sanguisorba canadensis* ssp. *latifolia*), great northern aster (*Aster modestus*), reed canarygrass (*Phalaris arundinacea*), fireweed (*Epilobium angustifolium*) and false solomon's seal (*Simalcina racemosa*).

Channel Assessment

Reach 1 of Dahlie Creek is 268 metres long and is located on the Bulkley River floodplain. Its lower 150 m has a riffle-pool morphology with a gravel substrate. The channel banks of reach 1 consist of erodible fines, sand and gravel. The main channel forming element in this reach is LWD. The upstream reach break occurs at the gradient transition where the channel descends from the terrace above the Bulkley floodplain.

Channel impacts to this reach were minimal. The upper 80 m of this reach was moderately aggraded, likely caused by the settling out of material washed down from reach 2. Indicators of channel disturbance in this reach include sediment fingers and wedges, elevated mid-channel bars, multiple channels, minimal pool area and a lack of LWD. The latter two indicators are chronic problems throughout the first three reaches of Dahlie Creek.

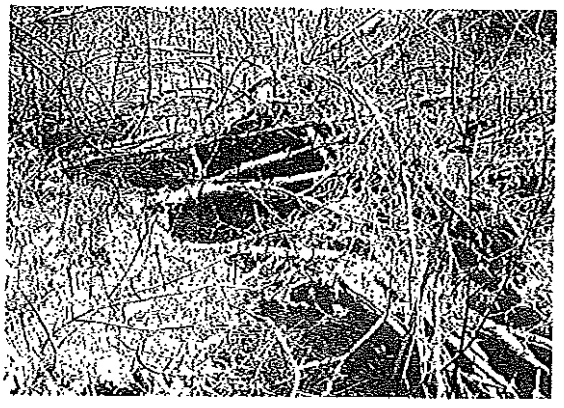
At 0+144 m, a foot bridge crossed the creek. This bridge will likely be washed away during the next major flood. The three culverts under Riverside drive (0+200 m) were backwatered and had approximately 10 cm of fine sediment in them (Fig. 36B). Some aggradation was observed upstream of these culverts. The culverts themselves do not appear to pose a channel stability or fish passage problems. At 0+235 m, a 30 cm high weir was deflecting water from the channel into an 80 cm wide ditch down to a pond on private land (Fig. 36C).

Fish and Fish Habitat Assessment

General habitat quality in reach 1 is moderate. Overwintering and refuge habitat, found in pools, is scarce. Spawning habitat is moderate for both resident and anadromous salmon and trout species. Rearing habitat is moderate with much of the channel consisting of glides. However, few pools exist and overall habitat complexity was extremely low (2.57) (Table 39b). Willows, dogwood and alder dominated the riparian area and provided moderate canopy closure (~40%). Over-stream vegetation and small woody debris (SWD) provided the majority of the cover. We counted 14 pieces of LWD in the channel, eight of which were functional (57%). No large wood greater than 50 cm in diameter was observed. LWD frequency was a very low 0.09 pieces per bankfull width. Future LWD recruitment will be limited due to the lack of mature forest in this reach. Spawning habitat was located in riffles which were the most common unit and occupied approximately 56% of the wetted area. Glides occupied 40% of the wetted area, but had limited spawning gravel. Gravel and fines were the dominant and sub-dominant substrate particle types in this reach. Discharge at the time of sampling was 0.09 m^3/s and 0.03 m^3/s in reach 3.

We did not set fish traps in this reach. Fish densities and abundances would likely be low to moderate in this reach due to the lack of good habitat. We expect juvenile coho salmon and rainbow trout to be the dominant species. Juvenile chinook salmon (*O. tshawytscha*) would likely use this reach as refuge when the Bulkley River is in flood. There are no barriers to upstream or downstream fish migration in this reach.

Figure 36. Dahlie Creek Reaches 1 and 2: channel, riparian and impact photos.



A: Upstream view of channel at 0+125 m of reach 1. Note the dense riparian shrub cover.

B: Upstream view of the culverts under Riverside Drive at 0+200 m in reach 1.

C: View of a small stone weir, 30 cm high, diverting flow to a small channel at 0+235 m in Reach 1. The diversion channel flows into a small pond.

D: Upstream view of small falls, 60 cm high, below Main St. culvert at 0+077m in reach 2. The culvert under Main St. is in the background.

E: Upstream view of reach 2 from the Main St. crossing. The gradient of this site is 7%.

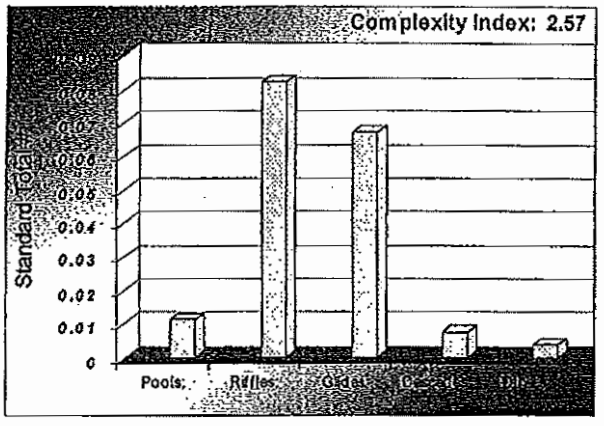
F: Upstream view of culvert under Victoria Dr. at 0+270 m in reach 2. This culvert is perched 75 cm during most flow conditions.

Table 39. Summary of channel and fish habitat field data for Dahlie Creek, reach 1.

a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (>50cm)	Total
Total # Pieces	8	6	0	14
# Functional Pieces	4	4	0	8
# Func. Pieces / Bankful width	0.05	0.05	0	0.09
% Functional	50	67	0	57

b) Relative habitat unit frequency and index of habitat complexity.



c) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	S	G	M	R	L	OV, SWD	40-70
Pool	G	S	L	AR	N	OV, SWD	0-20
Riffle	G	S	M	AR	H	OV, SWD	20-40

d) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
5.33	0.05	0.20	0.86	1.17	8.25

Impact synopsis

Land use in this reach and upstream has damaged fish habitat. Although the channel appeared to be relatively stable, it had little complexity. LWD is rare and future recruitment will be low due to the degree of cleared and privately owned land in the reach. The large amount of fine substrate in the channel is likely the result of upstream erosion and surface runoff from the streets and parking lots of Smithers. No point sources of sedimentation were observed.

Restoration suggestions

- Manage waste water from town of Smithers by using settling ponds or retention/detention structures in reach 3 to minimise peak flows and moderate base flows. It may be possible to "piggy-back" a project with proposed Town of Smithers/Ducks Unlimited project.
- Restore flow to main channel from diversion at 0+235 m.
- Re-establish riparian forest wherever possible.
- Remove garbage and trash from stream.
- Introduce channel complexing structures to stream where possible.

4.4.2 Reach 2

Length:	280 m	Elevation:	471–490 m
Length assessed:	280 m	Average gradient:	6.8%
Number of sites:	1	Mean W_b :	3.9 m
Number riparian plots:	0	Mean d_b:	0.5 m

Riparian Assessment

Reach 2 of Dahlie Creek begins at Victoria Drive and flows to approximately halfway between Riverside Drive and Main Street. Like reach 1, the riparian zone of reach 2 has also been impacted by humans. Riparian vegetation has been cleared for power lines, roads and private residences and some shrubs have been cut along the creek. Below the Main Street extension, alder and occasional black cottonwood were the dominant overstory species. Several paper birch (*Betula papyrifera*) and spruce trees occupied the riparian zone above Main Street, as did the dominant willow and alder. However, few mature trees are available for future LWD recruitment. Shrub cover consisted of red-osier dogwood, prickly rose (*Rosa acicularis*), black twinberry (*Lonicera involucrata*) and cottonwood saplings below Main Street with the addition of saskatoon (*Amelanchier alnifolia*) and red raspberry (*Rubus idaeus*) upstream of Main Street. Common herbaceous plants included scouring rush, Sitka burnet, reed canarygrass, fireweed, great northern aster and common horsetail.

Channel Assessment

The morphology of reach 2 changes from a steep riffle-pool channel below Main Street to a cascade-pool channel from Main Street upstream to Victoria Drive. The main channel

forming element of this partially confined reach would be LWD if abundant mature riparian forest remained. Currently it appears as if channel formation and complexing occur during freshet when the stream is in flood and avulsions and channel migration occur due to excessive peak flows. The erodible channel banks consist of gravel, sand and limited cobbles. The dominant substrate is cobble and gravel and boulders are sub-dominant.

The channel was moderately disturbed in this reach. The lower 100 m of this reach was slightly aggraded as indicated by minimal pool area, elevated mid-channel bars, multiple channels and a lack of functional LWD. The upper 180 m of the channel was slightly degraded with extensive riffles and cascades, minimal pool area, disturbed stone lines, abandoned channels and a lack of functional LWD. The channel between Main Street and Victoria Drive was essentially a long cascade with gradients reaching 10 to 12% in several places. The Main Street culvert will become perched when the SWD jam currently creating a pool downstream of the culvert washes away (Fig. 36D). The crossing at Victoria Drive was passable to fish at the time of the survey. A temporary dam of leaves and SWD had created a pool and was backwatering the culvert (Fig 36F). When this dam decomposes or is washed away during the next flood, the culvert will be perched up to 75 cm (Gibson, pers. comm.).

Fish and Fish Habitat Assessment

Fish habitat is poor for much of reach 2. The lower 100 m of channel contained all the spawning, refuge and overwintering habitat and much of the rearing habitat. This section had abundant over-stream cover by willows and other shrubs. The dominant cover for fish was over-channel vegetation and SWD or boulders. 54% of the wood was functional and there were 0.31 pieces of functional wood every bankfull width (Table 40a). Most of the functional LWD was present below Main Street. Some of this wood had been cut out of the stream, likely to reduce the risk of flooding and channel migration. Only one of the 12 pieces of wood greater than 50 cm in diameter was functional. Future LWD recruitment is limited due to the lack of mature forest along this reach.

Cascades and riffles characterised most of the reach, resulting in poor fish habitat.. Pools, although the most numerous unit in the reach, were small and shallow and were located below cobble and boulder steps. The largest pools, below Victoria Drive, were created by a temporary dam of leaves and sticks. Glides were moderately abundant, but like the pools, were small and shallow, providing little rearing or refuge habitat.

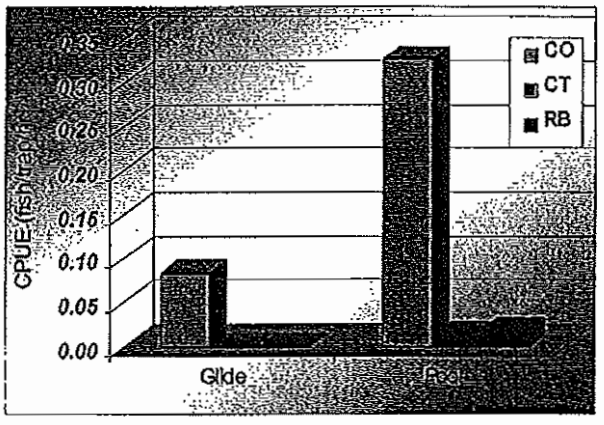
Due to low water temperatures we set minnow traps for 24 hours in several locations instead of electrofishing. We were able to set traps in areas of slower and deeper water, where fish are most likely to be found. We set four traps in glides and a pool between Main Street and the reach 1/2 break and caught 25 juvenile coho (0+ age class), one rainbow trout (0+) and one cutthroat trout (0+). We also trapped the pool below Victoria Drive with four traps. This was our most productive site in the Dahlie system. We caught 35 coho (0+ and two 1+), 2 rainbows (0+) and 2 cutthroat trout (0+) in these pools. These pools, however, are temporary. Our catch per unit of effort for reach 2 of Dahlie Creek was 0.36 fish per trap per hour for pools and 0.08 fish per trap per hour in glides (Table 40b).

Table 40. Summary of channel and fish habitat field data for Dahlie Creek, reach 2.

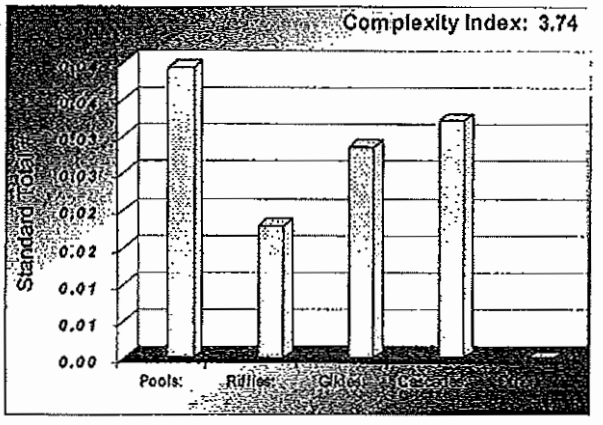
a) LWD summary.

	Small (10-19cm)	Medium (20-49cm)	Large (≥50cm)	Total
Total # Pieces	13	16	12	41
# Functional Pieces	9	12	1	22
# Func. Pieces / Bankfull width	0.13	0.17	0.01	0.31
% Functional	69	75	8	54

b) Catch per unit of effort for minnow traps set for 24 hours in glides and pools.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Cascade	C	G	M	AR	N	OV, B	20-40

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m³/s)	Tractive Force (kg/m²)
15.00	0.06	0.20	1.43	2.52	31.50

Barriers to fish migration occur at the Main Street road crossing where a small falls 60 cm high occurs downstream of the culvert. This culvert may become perched further once the SWD jam disappears and the stream begins downcutting again. The portion of channel between Main Street and Victoria likely acts as a barrier itself. The high gradient and low flows during the summer may limit fish movement up this section. The culvert at Victoria Drive is also a major barrier to fish migration. It is perched approximately 75 cm during most flow conditions (Gibson pers. comm.).

Impact synopsis

Land use in this reach and upstream has damaged fish habitat. Although the channel appeared to be relatively stable, it had little complexity. LWD is rare and future recruitment will be low due to the degree of cleared land in the reach. Peak flows may create flow regimes that are difficult for fish to withstand and low summer and autumn base flows may prevent upstream migration. The two road crossings are barriers to fish migration during most flow conditions.

Restoration suggestions

- Manage waste water from town of Smithers by using settling ponds or retention/detention structures in reach 3 to minimise peak flows and moderate base flows. It may be possible to "piggy-back" a project with proposed Town of Smithers/Ducks Unlimited project.
- Re-establish riparian forest wherever possible.
- Remove garbage and trash from stream.
- Improve fish passage through culverts at Main Street and Victoria Drive.
- Improve fish passage up the section between Main St. and Victoria Dr. This option will be expensive and will require extensive instream work.

4.7.3 Reach 3

Length:	3000 m	Elevation:	490-530 m
Length assessed:	2372 m	Average gradient:	1.3%
Number of sites:	8	Mean W_b :	3.3 m
Number riparian plots:	0	Mean d_b:	0.5 m

Riparian Assessment

Reach 3 of Dahlie Creek flows three kilometres from the gradient break at the foot of Hudson Bay Mountain to Victoria Drive. We divided this reach into two sections based on land use and channel morphology. Section 3A is 2260 m long and flows from a large wetland upstream of the CN Rail tracks to Victoria drive. We assessed approximately 200 m of the wetland in section 3B. Section 3A flows through land used for residences, commercial businesses and transportation corridors. Much of the riparian forest has been cleared or thinned and shrubs are the dominant vegetation cover. All of the riparian shrubs and small trees have been cut and placed in the channel in the CN Rail yard.

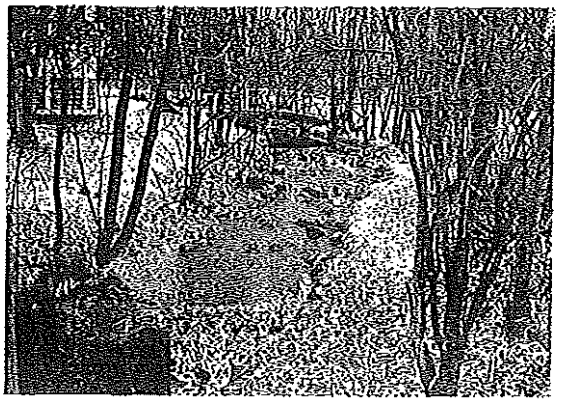
Very few mature, native trees remain in the riparian zone in this section (Fig. 37a,b,d,f). The dominant riparian overstory vegetation is mountain alder and a variety of willow species. Very few black cottonwood, spruce or trembling aspen were observed and most of these were young trees or pole saplings. Common shrubs included red-osier dogwood, black twinberry, red raspberry, prickly rose, hardhack (*Spiraea douglasii* ssp. *menziesii*), highbush cranberry (*Viburnum edule*), saskatoon and the occasional common snowberry (*Symphoricarpos albus*). Herbaceous plant cover included purple peavine (*Lathyrus nevadensis*), horsetails (*Equisetum* sp.), fireweed, cow parsnip (*Heracleum lanatum*), Canada thistle (*Cirsium arvense*), grasses, sedges (*Carex* spp.), wild strawberry (*Fragaria virginiana*), large-leaved avens (*Geum macrophyllum*) and lady fern (*Athyrium filix-femina*). The overstory layer in wetland section 3B consisted of a higher density of mature trees including cottonwood, willows and alder with aspen occurring on the drier sites. Shrub cover included young alder, aspen, spruce and willows, red-osier dogwood, black twinberry, highbush cranberry with prickly rose and snowberry in the drier aspen forest. Commonly observed herbs included scouring rush, common horsetail, wild strawberry, fireweed, great northern aster and lady fern.

Channel Assessment

Reach 3 is essentially an old ditch draining the southeast side of Smithers. This ditch, however, has some characteristics of a natural stream and does contain fish. This reach has a gravel-riffle-pool morphology, but lacks meanders. In this type of channel, the main channel forming elements would normally be LWD and beavers. However, little large functional wood is present in the stream and future recruitment opportunities are limited.. The urban nature of this creek precludes the re-colonisation of beavers. Because these functional features are absent from the system, the channel has little variety or complexity. Much of the channel is degraded with homogenous bed texture, minimal pool area and a lack of functional LWD being the most common indicators of disturbance. The banks of the channel were composed of erodible fines and sand with limited gravel. The areas nearest road crossings and culverts tended to be riprapped and were non-erodible.

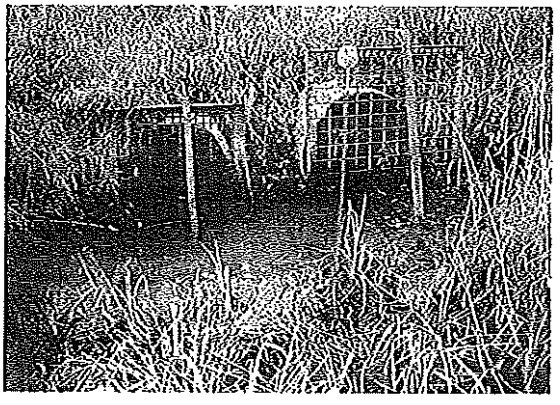
The channel between Victoria Drive and the Frontage Road / Highway 16 culverts is straight and is diked in areas. The Perimeter Trail runs alongside the edge of the creek for much of this distance. Several 30 cm storm sewers and small bank failures were observed in this area. Two small watercourses or ditches contributing flow from the wetland area on the north bank of the stream below Nadina Place are sources of fine sediment and possible contaminants from road runoff. Upstream of the highway, bank erosion near Elks Park is also contributing sediment to the channel during high flows. This erosion may be the result of increased flow velocities from the Railway Avenue culverts and a steep, riprapped area directly downstream of the culverts. The creek passes through five culverts. Three are barriers or potential barriers to fish migration: Victoria Drive, Highway 16 and Railway Avenue. The Railway and Victoria Drive culverts are perched and are barriers to fish at all life stages (Fig. 37e). The highway culverts are blocked at the upstream end by a series of steel bars acting as a debris catcher (Fig. 37c). These bars are spaced too close together to allow upstream passage of adult fish and were trapping leaf litter creating a temporary barrier for juvenile fish.

Figure 37. Dahlie Creek Reach 3: channel, riparian and impact photos.

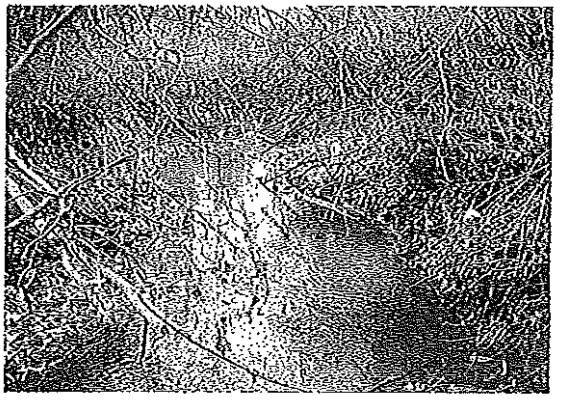


A: Upstream view of the stream flowing through private land. The photo was taken from Victoria Dr. at 0+000 m.

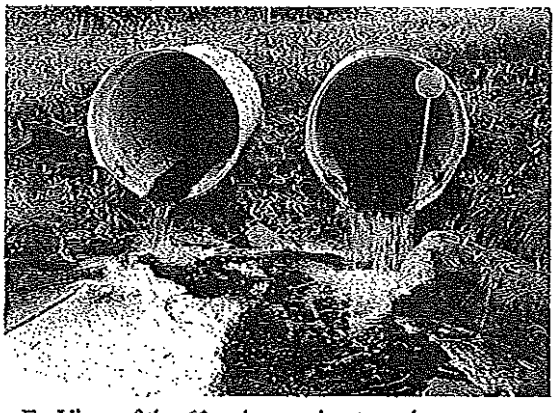
B: View of typical channel and riparian habitat below Highway 16 at 0+476 m.



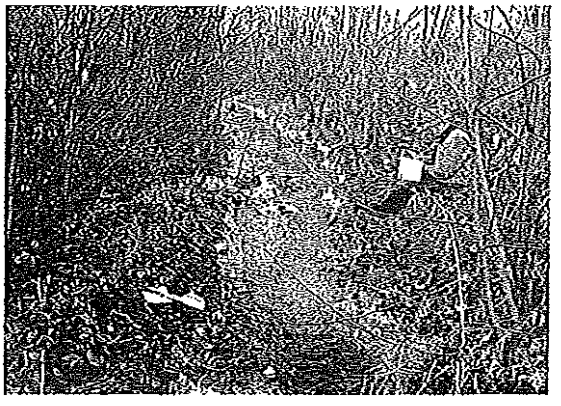
C: Upstream view of culverts under Highway 16. Note the screens that would prevent adult salmon migration.



D: View of typical channel and riparian vegetation habitat upstream of Highway 16 at 1+461 m.



E: View of the 60 m long culverts under Railway Ave. Note the 30 cm plunge.



F: Upstream view of the typical channel in the ditch beside CN access road at 1+963 m.

Fish and Fish Habitat Assessment

Fish habitat is generally poor for most of reach 3. Spawning habitat, and potentially overwintering habitat are limiting factors to fish production. Rearing habitat was reasonably abundant, but of moderate quality at best. Glide are the main areas of rearing in this reach and comprise approximately 70% of the length of the channel. Many of the glides showed reduced complexity due to reduced riparian cover, homogenous substrate and bank material, and a lack of LWD and. Glides are also likely to function as overwintering habitat because pools are infrequent. One pool occurs approximately every 26 bankful widths, accounting for about 7% of the wetted channel area. In natural systems, pools generally occur one every five to seven bankfull widths (Newbury and Gaboury 1993). Spawning habitat was limited to a few riffles with gravel substrate. Most of this habitat was observed upstream of the 16th Avenue culvert in the Willowvale subdivision and upstream of the CN Rail culverts. Cover for fish consisted of overstream vegetation and undercut banks. LWD was sparse, with only 0.08 pieces of functional wood per bankfull width, three-quarters of which was small (< 20 cm in diameter) (Table 39b). Little opportunity exists for future LWD recruitment.

We set traps in glides and pools at five locations throughout section 3A. Four traps were set at each site. No fish were caught immediately downstream of the Frontage Road. Three coho (0+, 1+) and one rainbow trout (0+) were caught immediately upstream of Highway 16. Nine coho (0+, 1+) were captured upstream of the 16th Avenue culverts. Five coho (1+) and three cutthroat trout (0+) were caught immediately downstream from the culverts at Railway Avenue. Finally, four cutthroat trout (0+) were caught between Railway Avenue and the culvert under the CN Rail tracks. The CPUE for section 3A of Dahlie Creek was a low 0.05 fish per trap per hour in both glides and pools.

Impact synopsis

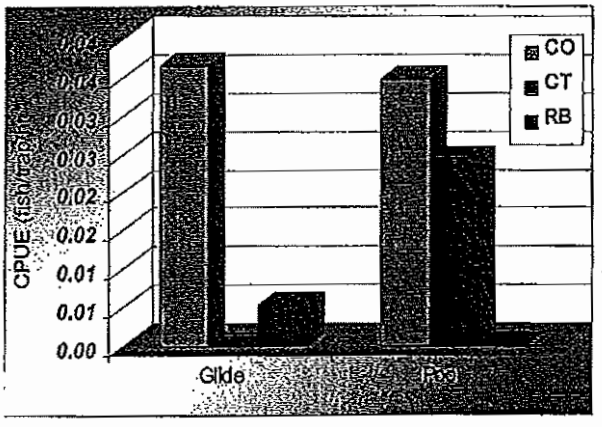
Reach 3A, was the most heavily disturbed reach we assessed in Dahlie Creek. The channel is an old ditch and is thus lacking most of the channel features found in a natural stream. Channel complexity is low and limited potential for future LWD recruitment exists due to a lack of mature riparian forest. The stream flows through residential and commercial areas and riparian zone has been removed, thinned or otherwise disturbed through much of the reach. All shrubs along the stream within the CN railyard were cleared in 1999. The stream passes through 5 culverts. three of which are barriers to fish migration.. Ditches and storm sewers entering the channel are introducing sediment and potential contaminants into the channel during freshet and storms. Unstable banks were observed in the wetland area below Nadina Place, near the Frontage Road and near Elks Park. We observed garbage and trash in the stream for much of the length surveyed.

Table 41. Summary of channel and fish habitat field data for Dahlie Creek, reach 3.

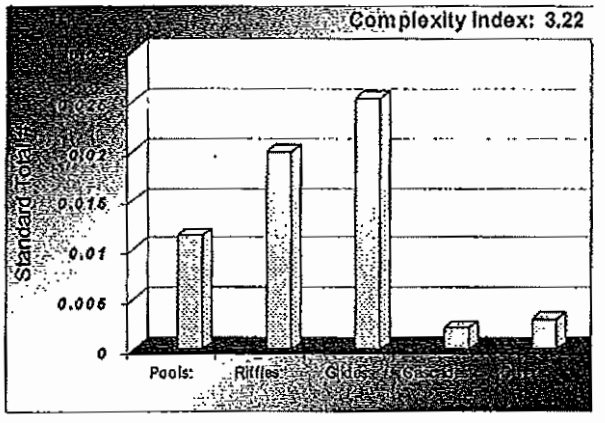
a) LWD summary.

	Small (10-19cm)	Medium (20-49 cm)	Large (≥50cm)	Total
Total # Pieces	103	30	0	133
# Functional Pieces	43	12	0	55
# Func. Pieces / Bankful width	0.06	0.02	0	0.08
% Functional	42	40	0	41

a) Catch per unit of effort for minnow traps set for 24 hours in glides and pools.



c) Relative habitat unit frequency and index of habitat complexity.



d) Summary of channel and fish habitat parameters by unit category.

Unit Category	Dominant Substrate	Subdom. Substrate	Bed Compaction	Spawning Gravel Type	Spawning Gravel Amount	Dominant Cover Types	Canopy Closure Category (%)
Glide	S	G	L	AR	N	OV, C	20-40
Pool	S	G	M	AR	L	DP, C	0-20
Riffle	G	S	M	AR	M	OV, C	0-20

e) Basic hydrologic information for reach at bankfull flows (approximations).

D (cm)	Manning's n	Hydraulic Radius (m)	Velocity (m/s)	Bankfull Discharge (m^3/s)	Tractive Force (kg/m^2)
4.12	0.05	0.21	0.71	1.18	4.90

Restoration suggestions

- Integrate DFO Land Development Guidelines into the Smithers Official Community Plan. Ensure new developments manage or treat waste water and surface runoff.
- Prior to proceeding with any fish habitat rehabilitation efforts, results from water quality monitoring and fish overwintering studies needs to be examined.
- Manage surface runoff from Town of Smithers by using settling ponds or retention/detention structures in reach 3 to minimise peak flows and moderate base flows. It may be possible to "piggy-back" a project with proposed Town of Smithers/Ducks Unlimited project.
- Public education and stewardship
    - Work with community stewardship groups including Stream Keepers, school groups (can work with Salmonids in the Classroom program).
    - Place signs similar to those found along Chicken Creek along the stream.
    - Build a small, interpretative park, salmon/wildlife viewing area
    - Educate new owners of properties in the Willowvale subdivision about the importance of keeping the creek clean and of not dumping wastes or chemicals down the street drains.
- Re-establish riparian forest wherever possible.
- Remove garbage and trash from stream.
- Alter the debris screens at the upper end of the Highway 16 culverts to allow upstream adult fish passage.
- Backwater culvert at Victoria Drive to allow fish passage.
- If four-laning highway occurs, improve fish passage: daylight culvert, reduce gradient or backwater, install larger, fish friendly culvert.
- Add complexity to channel between Victoria Drive and Highway 16. Large woody debris placement and riffle structures are two options.
- Stabilise banks and ditches near Frontage Road.

5.0 STREAM REHABILITATION RECOMMENDATIONS

Sub-watersheds and reaches were priorised (Table 42) using a flow chart (Fig. 2) in conjunction with a decision table and risk assessment table (Tables 43,44). We considered biological values, impact levels and risks when ranking stream reaches. Each reach was ranked either as a first, second, or third priority for rehabilitation. We have expanded on the restoration ideas listed in the Results and Discussion for only the first priority streams: Deep, Thompson and Dahlie creeks (see Appendix F: Rehabilitation Recommendations and Appendix G: Riparian Rehabilitation Recommendations). We included Dahlie Creek as a priority stream based on the desire of local groups to establish salmon populations in this creek. Second priority streams (i.e. the Robin Creek watershed) had little potential to increase salmon populations due to the watershed characteristics. Impacts in these creeks were widespread and require significant land use changes across the watershed to rehabilitate processes linked to channel form and fish habitat. Stream stewardship education and emphasis on best management practices is required as an initial step toward rehabilitating

these streams. Should landowners be willing to alter land use practices and work with community groups, opportunities exist to greatly improve the general health of the watershed. While rehabilitation opportunities exist in third priority streams, these reaches were not deemed to provide the best "bang for the buck."

We prefer to use the term "rehabilitation" as opposed to "restoration" for our recommendations. Restoration generally infers that the overall objective of prescriptions is to return an area or resource to its original state, and that such an objective is technically feasible (Johnston and Moore 1995). Due to the continuing land use in our priority reaches, the original state of the land and watershed processes cannot be fully restored. Thus we suggest ways to work within current constraints to rehabilitate, or improve, watershed function and thus fish habitat.

Stream or fish habitat restoration has traditionally treated the symptoms of problems and not their root causes (Beech & Bolton 1999; Imhof *et al.* 1996; PRC (1996); Rhodes *et al.*, 1994). These treatments are often short-lived or cause additional problems downstream (e.g. riprapping banks which may speed up water flow and increase downstream erosion). Prior to money being spent on local "band-aid" type projects, hydrologic and biological processes must be restored.

Our stream rehabilitation recommendations are based on an ecosystem or watershed approach which focuses on fixing the causes of the problems in an attempt to re-establish system structure and function, and thus system integrity. Because the priority reaches are impacted heavily by agriculture or urban development, our approach to stream rehabilitation differs somewhat from that usually employed for forestry related restoration activities. Of primary importance is working jointly with landowners to modify current damaging land use practices. Unique opportunities exist to promote best management practices and stewardship ideals. The next highest priority is to rehabilitate up-slope and riparian areas. We feel that at this time, risks are too high to focus on in-stream works.

Note: Our rehabilitation recommendations (Appendices F and G) are preliminary and need to be fine-tuned once landowners are consulted. The recommendations are organised by reach and sub-watershed. Because of the uncertainty to what rehabilitation methods land owners will agree to, preliminary cost estimates are only included for some of the recommendations.

Table 42. Priority reaches for rehabilitation.

Sub-watershed	Reaches	Priority	Comments
Deep Creek	1	1	Reach 1 has high risks which need to be addressed.
Thompson Creek	1,2	1	Less potential for salmon, but fewer risks than Deep Creek
Dahlie Creek	1,2,3	1	Default priority creek due to community interest.
Robin Creek	All	2	Highly impacted system with high risks. Land use modifications are required.
Lemieux Creek	All	2	
de Jong Creek	All	2	
Vanderven Creek	All	2	
Deep Creek	2	2	Tributaries flowing from north side should be assessed.
Helps Creek	1,2,3	3	Few restoration opportunities – reach three is a wetland.
Moan Creek	1,2	3	Low potential to increase salmon populations. Restoration opportunities primarily point source. Many roads deactivated.
Coffin Lake Creek	1,2	3	Low potential to increase salmon populations. Restoration opportunities primarily point source. Many roads deactivated.

Table 43. Qualitative summary of biological values, impacts and risks for each sub watershed reach.

Sub-Watershed	Reach	Habitat Type	Priority* (PRC Method)	Refugia Present	Fish Habitat Quality (Limiting) Rearing	Spawning	Overwintering	Salmonid Diversity	Salmonid Abun.	Salmonid access (recolonise)	Level of Impact	% Mod-Sev. Ag/Deg.	Land Use	Sediment. Risk	General Risk
Robin	1	Nodal	H	H	M-H	L-M	H	M-H	M	M	L-M	0	M	L	M
	2	Adjunct	H	M	L	L	M	L	L	L-M	H	41	H	H	H
	3	Grubstake	L-M	M	L	L	L	L	L	L-M	H	0	H	H	M
Lemieux	1	Adjunct	H	H	H	L	H	L-M	L	H	H	0	H	H	M-H
	3	Adjunct	H	M	L	L	H	L	L	M	H	0	H	H	H
	5	Adjunct	H	M	M	M	L-M	L	L	M	L-M	37	M	L	M-H
Vanderven	1	Grubstake	L-M	L-M	L-M	L-M	L	L	L	L-M	H	69	H	H	H
	2A	Nodal	H	L	M	L-M	L	L	L	L-M	M	54	M	M	M
de Jong	1	Nodal	M	L-M	L-M	L-M	L-M	L	L	L-M	H	40	H	H	H
	2	Nodal	M	L-M	M	M	L	L	L	L-M	L	8	L-M	M	L
Deep	1	Nodal	H	M-H	H	H	M	H	H	H	H	40	H	H	H
	2	Nodal	H	M	M	M	L	M	M	M-H	L-M	39	M	M	M
Thompson	1	Nodal	H	M-H	M	M	H	M-H	M	H	H	18	H	H	M
	2	Adjunct	H	M	L-M	M	L-M	M	L	M	M	18	M-H	H	M
Helps	1	Nodal	H	H	H	L	H	H	?	H	L-M	0	M	L	L
	2	Nodal	H	H	H	L	H	H	?	H	M	0	M-H	L	L
	3	Nodal	H	H	H	L	H	M-H	?	H	M	0	M	L	L
Moan	1	Adjunct	H	L-M	M	M	L	M-H	L-M	L	H	52	H	H	L
	2	Adjunct	H	L	M	L	L	M	L	L	H	40	H	H	M
Coffin	1	Adjunct	H	H	M	L	M	M-H	M	H	M	22	M	M	M

* = Pacific Rivers Council priority suggestions based on type of habitat.

Table 44. Summary of current potential risks to each reach which need to be considered prior to conducting rehabilitation work.

		High Temps	Upstream sediment	Road washout	Cattle in creek	Cattle eating riparian	Peak Flows	Base flows	Overall Risk
Robin	1	H	H	L	L	L	M	H	M
	2	H	H	L/M	M (PS)	H	H	H	H
	3	H	M	L	M (PS)	H	M	H	M
Lemieux	1	H	M	L	M	H	M	H	M-H
	3	H	M	L	H	H	M	H	H
	5	H	M	M	M (PS)	L	H	H	M-H
Vanderven	1	H	H	L	H	H	H	H	H
	2A	L	M	L	M	M	M	H	M
de Jong	1	H	H		M	M	H	H	H
	2	L	L	L	L	L	M	H	L
Deep	1	M	H	L-M	H	H	M-H	H	H
	2	M	H	L	M	L	M-H	M	M
Thompson	1	M	M	M (2)	M	M	M-H	M	M
	2	M	M	M (1)	M	M	M	M	M
Helps	1	M	L	L	L	L	L	M	L
	2	M	L	M	L	L	L	M	L
	3	M	L	M	L	L	L	M	L
Moan	1	L	M-H	L (PL)	M	L	M	M	L
	2	L	H	M	L	L	M-H	M	M
Coffin	1	M	M	M	M	M	L-M	M	M

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7.0 PERSONNAL COMMUNICATION

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Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 4
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: "MOAN" CREEK
Watershed Code: 460-458800-00000
Survey Date: 99/09/17
Crew: MJ,GG

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A32	RPcw	A1						P	P					P			P		
2	1	A	194	A32	RPgw	A2				P		P	P	P				P			P		
3	1	A	386	A324	CPcw	A1						P	P					P			P		
4	1	A	613	A324	CPcw	A2				P		P	P	P				P			P		
5	1	A	633	A32	RPgw	A2				P		P		P	P			P			P		
6	1	A	800	A324	CPcw	A1						P	P	P				P			P		
7	1	A	1070	A312	CPcw	A2				P		P	P	P	P			P					
8	1	A	1360	A342	CPcw	A1						P		P				P					
9	1	A	1480	A342	CPcw	S																	
10	1	A	1539	A32	CPcw	A2				P		P		P	P		P	P			P		
11	1	A	1800	A324	CPcw	A1				P				P				P					
12	2	A	0	A1423	RPcw	D1			P			P	P										
13	2	A	50	A4321	RPcw	D1			P			P	P										
14	2	A	105	A2143	CPcw	A2			P	P		P	P	P	P								
15	2	A	155	A124	CPcw	D1						P	P			P							
16	2	A	215	A123	CPcw	A2			P	P		P	P	P	P								
17	2	A	295	A421	CPcw	A1						P	P										
18	2	A	365	A124	CPcw	D1					P	P	P										
19	2	A	450	A2143	CPcw	A2			P	P		P	P	P	P		P						
20	2	A	590	A2314	CPcw	A1			P			P	P	P	P		P						
21	2	A	684	A432	CPcw	D2					P	P	P			P					P		
22	2	A	770	A43521	CPb	A2						P	P	P	P								
23	2	A	860	A43521	CPb	S						P	P								P		
24	2	A	950	A432	CPcw	A1				P		P	P	P	P								
25	3	A	1115	A543	SPb	S																	

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 1
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: COFFIN LAKE
Watershed Code: 460-472700-00000-00000-0000-0000-000-000-000-000-000-000
Survey Date: 99/09/20
Crew: RH, GT, MJ, GG

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A1243	RPgw	A1						P	P					P		P			
2	1	A	50	A2134	RPcw	A1						P	P		P		P	P					
3	1	A	370	A21	RPcw	A1						P	P										
4	1	A	470	A21	RPcw	D1						P	P		P	P		P					
5	1	A	522	A21	CPcw	A1						P	P			P							
6	1	A	680	A214	CPcw	D1						P	P		P	P							
7	1	A	733	A214	CPcw	A1			P			P	P	P	P					P			
8	1	A	931	A4321	CPcw	D1						P	P			P		P					
9	1	A	1090	A4321	CPcw	A1						P	P					P	P				
10	1	A	1120	A4321	CPcw	D1						P	P					P					
11	1	A	1157	A431	CPcw	A1						P	P										
12	1	A	1200	A4321	CPcw	D1						P	P					P					
13	1	A	1330	A23	CPcw	A1			P			P	P										
14	1	A	1360	A453	CPcw	D1						P	P					P					
15	1	A	1450	A453	CPb	D1						P	P					P			P		
16	1	A	1547	A32	RPcw	S						P											
17	1	A	1690	A324	CPcw	A2						P		P	P			P					
18	1	A	1997	A324	CPcw	S							P								P		
19	1	A	2097	A32	CPcw	A2				P		P	P	P	P			P					
20	1	A	2387	A32	CPcw	A1						P	P	P									
21	1	A	2680	A32	CPcw	A2						P	P	P		P		P			P		
22	1	A	2746	A342	CPcw	D1						P	P			P		P			P		
23	1	A	2836	A324	RPgw	S							P	P							P		
24	1	A	2956	A342	CPcw	D1						P	P			P					P		
25	1	A	3014	A321	RPgw	A2						P	P	P	P								
26	1	A	3096	A321	RPgw	A1						P		P	P								

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 10
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: DAHLIE CREEK
Watershed Code: 460-373800-33200-00000-0000-0000-000-000-000-000-000-000
Survey Date: 99/10/29
Crew: GT,MJ

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A123	RPgw	A1	P						P								P		
2	1	A	90	A123	RPgw	A1							P								P		
3	1	A	189	A123	RPgw	A2		P	P				P	P	P						P		
4	2	A	0	A231	RPcw	A1							P	P							P		
5	2	A	42	A213	RPgw	A1							P	P	P						P		
6	2	A	99	A342	CPcw	D1						P	P			P	P				P		
7	3	A	0	A234	RPgw	A1							P								P		
8	3	A	85	A12	RPgw	D1	P						P								P		
9	3	A	469	A12	RPgw	D1					P		P					P			P		
10	3	A	715	A12	RPgw	S	P						P								P		
11	3	A	929	N2	RPgw	S	P						P								P		
12	3	A	985	A12	RPgw	D1	P	P					P								P		
13	3	A	1695	N2	RPgw	D2					P	P				P					P		
14	3	A	1743	N3	RPgw	D3	P						P								P		
15	3	A	1805	A12	RPgw	D1															P		
16	3	A	1843	N	RPgw	D2	P														P		
17	3	A	1879	A123	RPgw	S																	
18	3	A	1927	N	RPgw	S															P		
19	3	A	1946	A23	RPgw	A1						P	P								P		
20	3	A	2095	A21	RPgw	S	P						P								P		
21	3	B	2209	A1	RPgw	S	P								P						P		

APPENDIX E. RIPARIAN PLANTS

Site No: MG1

Species Name	Common Name	% Cover
	Unidentified Grasses	60
Lonicera involucrata	Black twinberry	5
Rosa acicularis	Prickly Rose	5
Taraxacum officinale	Dandelion	2
Salix sp.		1
Epilobium angustifolium	Fireweed	1
Vicea americana	American vetch	<1
Ribes lacustre	Black gooseberry	<1
Equisetum arvense	Common horsetail	<1
Heracleum lanatum	Cow parsnip	<1
Lathyrus ochroleucus	Creamy Peavine	<1
Aster modestus	Great northern aster	<1
Viburnum edule	Highbush cranberry	<1
Geum macrophyllum	Large leaved avens	<1
Alnus tenuifolia	Mountain Alder	<1
Palmate coltsfoot	Palmate coltsfoot	<1
Symphoricarpos albus	Snowberry	<1
Thalictrum occidentale	Western Meadowrue	<1

Site No: GT1

Species Name	Common Name	% Cover
Lonicera involucrata	Black Twinberry	25
Calamagrostis canadensis	Bluejoint Grass	10
Epilobium angustifolium	Fireweed	10
Cirsium arvense	Canada Thistle	5
Equisetum arvense	Common horsetail	5
Rubus idaeus	Raspberry	5
Populus tremuloides	Trembling Aspen	5
Rosa acicularis	Prickly Rose	2
Phalaris arundinacea	Reed Canary Grass	2
Alnus tenuifolia	Mountain Alder	1
Thalictrum occidentale	Western Meadowrue	1
Salix sp.		<1
Vicea americana	American Vetch	<1
Salix barclayi.	Barclay'sWillow – tentative ID	<1
Ribes lacustre	Black Gooseberry	<1
Heracleum lanatum	Cow Parsnip	<1
Lathyrus ochroleucus	Creamy Pea Vine	<1
Galeopsis tetrahit	Hemp nettle	<1
Viburnum edule	High Bush Cranberry	<1
Urtica dioica	Stinging Nettle	<1

Site No: GT2

Species Name	Common Name	% Cover
	Moss	60
Cornus canadensis	Bunchberry	20
Equisetum pratense and E. arvense	Horsetail (Meadow & Common)	20
Rosa acicularis	Prickly Rose	10
Linnaea borealis	Trailing Twin Flower	7
Ribes lacustre	Black Gooseberry	5
Petasites palmatus	Palmate coltsfoot	2
Cornus stolonifera	Red osier dogwood	2
Rubus pubescens	Trailing raspberry	2
Fragaria virginiana	Wild Strawberry	2
Calamagrostis canadensis	Bluejoint Grass	1
Mitella nuda	Common mitrewort	1
Rubus idaeus	Raspberry	1
Lonicera involucrata	Black twinberry	<1
Cirsium vulgare	Bull thistle	<1
Viburnum edule	Cranberry	<1
	Fern	<1
Aster ciliotatus	Fringed aster	<1
Geum macrophyllum	Largeleaved avens	<1
Galium boreale	Northern Bed Straw	<1
Amelanchier alnifolia	Saskatoon	<1
Aster conspicuus	Showy Aster	<1
Dryopteris expansa	Spiny Wood Fern	<1
Urtica dioica	Stinging Nettle	<1
Achillea millefolium	Yarrow	<1

Site No: GT3

Species Name	Common Name	% Cover
	Mosses	50
	Grasses	30-35
Lonicera involucrata	Twinberry	30
Rhytidiadelphus triquetrus	Electrified cat's tail moss	10
Petasites palmatus	Palmate coltsfoot	3
Symphoricarpos albus	Snowberry	3
Ribes lacustre	Black gooseberry	2
Viola canadensis	Canada violet	2
Epilobium angustifolium	Fireweed	2
Rosa acicularis	Prickly rose	2
Vicea americana	American vetch	1
Heracleum lanatum	Cow parsnip	1
Spiraeadouglasii spp. menziesii	Pink spirea (hardhack)	1
Ribes laxiflorum	Trailing black current	1
Achillea millefolium	Yarrow	1
Lathyrus ochroleucus	Creamy peavine	<1
Aster ciliolatus	Fringed aster	<1
Aster modestus	Great northern aster	<1
Lathyrus nevadensis	Purple peavine	<1
Sonchus arvensis	Sow thistle	<1
Galium triflorum	Sweet scented bedstraw	<1

Site No: GT4

Species Name	Common Name	% Cover
	Grasses	70
Spiraea douglasii spp. Menziesii	Pink Spirea hardhack	35
	Moss layer	25
Lonicera involucrata	Twinberry	20
Epilobium angustifolium	Fireweed	15
Rosa acicularis	Prickly rose	3
Aster ciliolatus	Fringed aster	2
Geum macrophyllum	Large leaved avens	<1
Galium boreale	Northern bedstraw	<1
Sonchus arvensis	Sow thistle	<1
Fragaria virginiana	Wild strawberry	<1
Achillea millefolium	Yarrow	<1

Site No: GT5

Species Name	Common Name	% Cover
Salix drummondiana	Drummond's willow – tentative ID	75
	Grasses	40
	Mosses	25
Carex sp.	Sedges	<5
Lonicera involucrata	Black Twinberry	1
Mitella pentandra	5 stamened mitrewort	<1
Heracleum lanatum	Cow parsnip	<1
Epilobium angustifolium	Fireweed	<1
Viburnum edule	Highbush cranberry	<1
Geum macrophyllum	Large leaved avens	<1
Urtica dioica	Stinging nettle	<1
Salix sp.	Unidentified willow	<1

Site No: GT6

Species Name	Common Name	% Cover
Lonicera involucrata	Black Twinberry	45
	Grasses – short	30
	Mosses	20
Rubus idaeus	Red raspberry	5
Ribes lacustre	Black gooseberry	2
	Grasses – Tall	2
Geum macrophyllum	Large leaved avens	2
Urtica dioica	Stinging nettle	1
Heracleum lanatum	Cow Parsnip	<1
Epilobium angustifolium	Fireweed	<1
Aster modestus	Great northern aster	<1
Angelica genuflexa	Kneeling Angelica	<1
Gymnocarpium dryopteris	Oak fern	<1
Petasites palmatus	Palmate coltsfoot	<1
Rosa acicularis	Prickly Rose	<1
Cornus stolonifera	Red-osier dogwood	<1
Symphoricarpos albus	Snowberry	<1

Site No: GT7

Species Name	Common Name	% Cover
Lonicera involucrata	Black Twinberry	30
	Moss bryophytes	20
Mitella nuda	Common mitrewort	10
	Short grass	10
Symphoricarpos albus	Snowberry	10
Equisetum arvense	Comon Horsetail	5
Salix lucida spp. lasiandra	Pacific willow	5
Aster modestus	Great Northern Aster	1
Geum macrophyllum	Large leaved avens	1
Ribes lacustre	Black gooseberry	<1
Cornus canadensis	Bunchberry	<1
Heracleum lanatum	Cow parsnip	<1
Aster ciliolatus	Fringed aster	<1
Galeopsis tetrahit	Hemp Nettle	<1
Ranunculus uncinatus	Little Buttercup	<1
Alnus tenuifolia	Mountain Alder	<1
Petasites palmatus	Palmate coltsfoot	<1
Rosa acicularis	Prickly Rose	<1
Osmorhiza purpurea	Purple sweet cicily	<1
Rubus idaeus	Red raspberry	<1
Urtica dioica	Stinging Nettle	<1
Galium triflorum	Sweet scented bedstraw	<1
Fragaria virginiana	Wild strawberry	<1

Site No: MJ1

Species Name	Common Name	% Cover
Rosa acicularis	Prickly Rose	5
Elymus glaucus	Blue wildrye grass	2
Symphoricarpos albus	Snowberry	2
Salix bebbiana	Bebbs Willow	1
Lonicera involucrata	Black Twinberry	1
Epilobium angustifolium	Fireweed	1
Petasites palmatus	Palmate coltsfoot	<1
Spiraea pyramidata	Pyramid spirea	<1

Site No: MJ2

Species Name	Common Name	% Cover
Cornus stolonifera	Red osier dogwood	10
Calamagrostis canadensis	Bluejoint	2
Orthilia secunda	One-sided wintergreen	2
Amelanchier alnifolia	Saskatoon	2
Rosa acicularis	Prickly rose	1
Lathyrus nevadensis	Purple peavine	1

Site No: MJ3

Species Name	Common Name	% Cover
Gymnocarpium dryopteris	Oak fern	5
Petasites palmatus	Palmate coltsfoot	3
Pleurozium schreberi	Red-stemmed feathermoss	2
Cornus canadensis	Bunchberry	1
Ptilium crista castrensis	Knight's plume	1
Rhytidiadelphus triquetrus	Electrified cat's-tail moss	<1
Rosa acicularis	Prickly Rose	<1
Rubus parviflorus	Thimbleberry	<1

Site No: MJ4

Species Name	Common Name	% Cover
Equisetum arvense	Common Horsetail	10
Alnus tenuifolia	Mountain Alder (>2m)	5
Rosa acicularis	Prickly Rose	5
Lonicera involucrata	Black Twinberry	4
Alnus teniufolia	Mountain alder (Short shrub)	4
Petasites palmatus	Palmate coltsfoot	3
Cornus canadensis	Bunchberry	1
Ptilium crista castrensis	Knight's plume	1

Site No: MJ5

Species Name	Common Name	% Cover
Rubus parviflorus	Thimbleberry	25
Cornus stolonifera	Red osier dogwood	20
Oplopanax horridus	Devil's club	15
Equisetum arvense	Horsetail	10
Lonicera involucrata	Twinberry	10
Brachythecium sp.	Ragged moss	5
	Leafy mosses	3
Alnus tenuifolia	Mountain Alder	3
Cornus canadensis	Bunchberry	1
Viburnum edule	High bush cranberry	1
Gymnocarpium dryopteris	Oak fern	1
Pleurozium schreberi	Red-stemmed feathermoss	1

Site No: MJ6

Species Name	Common Name	% Cover
Rubus parviflorus	Thimbleberry	10
Viburnum edule	Highbush cranberry	5
	Moss	5
Cornus stolonifera	Red Osier Dogwood	5
Acer glabrum	Douglas maple	4
Orthilia secunda	One-sided wintergreen	3
Alnus tenuifolia	Mountain alder	2
Lathyrus nevadensis	Purple peavine	2
Linnaea borealis	Twinflower	2
Epilobium angustifolium	Fireweed	1
Rosa acicularis	Prickly Rose	1
Ribes lacustre	Black Gooseberry	<1
Oplopanax horridus	Devil's club	<1
Smilacina racemosa	False soloman's seal	<1
Gymnocarpium dryopteris	Oakfern	<1
Shepherdia canadensis	Soopolallie	<1

Site No: MJ7

Species Name	Common Name	% Cover
Epilobium angustifolium	Fireweed	25
Lonicera involucrata	Twinberry	10
Cornus stolonifera	Rod osier dogwood	4
Rosa acicularis	Prickly rose	2
Brachythecium sp.	Ragged moss	1
Salix sp.		<1
Vicea americana	American vetch	<1
Sonchus arvensis	Perrenial Sow thistle	<1
Rubus idaeus	Raspberry	<1
Amelanchier alnifolia	Saskatoon Berry	<1

Site No: MJ8

Species Name	Common Name	% Cover
Cornus stolonifera	Red osier dogwood	20
Gymnocarpium dryopteris	Oak fern	5
Lonicera involucrata	Twinberry	5
Oplopanax horridus	Devil's club	3
Heracleum lanatum	Cow parsnip	1
Petasites palmatus	Palmate coltsfoot	1
Rhytidiadelphus triquetrus	Electrified cat-tail moss	<1
	Leafy mosses	<1

Deep Creek – Reach 1

Watershed level objective. To improve the overall health of the watershed and salmonid fish habitat by:

- altering land use practices on private land,
- restoring riparian function to stream, and
- decreasing sources of sediment to the stream.

Reach 1 of Deep Creek flows through private land. The impacts in this reach are chronic and arise from historic and current land use practices in the watershed. For rehabilitation to succeed, landowners need to be part of the solution. Therefore, the first step in rehabilitating Deep Creek is to contact the landowners within the watershed. The results of the fish habitat, channel and riparian assessments should be shared, after which landowner interest and willingness to co-operate in rehabilitation efforts should be gauged. Adoption of watershed stewardship principles including best management practices for cattle, and in some cases, altering present cattle grazing management, will be required in order for the processes that have been impacted in this watershed to recover. Solutions can usually be found that benefit both the landowners and the streams. A long-term plan addressing landowner concerns and clearly outlining objectives and strategies to rehabilitate the creek will be necessary to help ensure the health of the stream and land improves in the future. Landowners and government representatives should be involved in the planning process. Monitoring of water quality, riparian function, and possibly invertebrate populations should be a component of this plan.

Rehabilitation priorities:

1. Consultations with land owners. Information sharing and education. Landowners should be encouraged to keep existing riparian zones. There is a need to protect what remains because prevention of problems is much cheaper than restoration.
2. Cattle management to protect creek and riparian zone.
3. Bank stabilisation and riparian planting.
4. In-stream works.

The rehabilitation ideas outlined in this appendix and Appendix G address four of the six impact sites in the mainstem of Deep Creek (D6, D4, D3, D2). The remaining impacted sites may recover on their own (D1) or recover once cattle management issues are addressed (D5).

Deep Creek Reach 1

Rehabilitation Recommendation: Deep #1

- Note: To be implemented in conjunction with Riparian Rehabilitation Recommendation: Deep #1 (see Appendix G).

Location: Impact site D6. Upper part of reach 1. The lower end of the site is a fence located 1050 m upstream of the Wakefield Road Bridge. The upper extent is 240 m upstream.

Access: Wakefield Road from Highway 16 to a "Y" 300 m past the Wakefield Road Bridge. Proceed to the left through the gate (first obtain permission from Harold Kerr), and continue for another 500 m. Turn left into the first large clearing on the left and proceed down the cattle road to the creek.

Land Tenure: Private (Kerr Cattle Company)

TRIM/Forest Cover Mapsheet: 93L066

Forest Cover Polygon: 826, 812

Flightline and Air Photo Number: 30BCC 687 No. 79

Site Photo: Heavily grazed and cleared riparian area with eroding banks at the lower end of the site (Figs. 20H and I.)

Impact Description: Land clearing and cattle grazing has removed much of the riparian vegetation along this section of the creek. Large cottonwoods exist in part of the area, but understory vegetation is heavily grazed. Riparian function is severely impacted. Cattle trampling and lack of rooted vegetation is resulting in bank destabilisation and erosion.

Objectives:

- to rehabilitate the riparian zone and riparian function, and
- to reduce bank erosion and subsequent sediment loading from this site.

Biological Benefits:

- reduced sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat,
- improved water quality,
- improved overhead cover, shade, and source of small organic debris, and
- recruitment of LWD into the stream to increase stream complexity over the long-term.

Proposed Rehabilitation strategies:

A. Work with the Kerr Cattle Company to develop strategies to encourage cattle to congregate away from the riparian zone and the creek. Options include:
   - Improving livestock distribution:
     ⇒ off-channel watering,
     ⇒ salt lick placement in uplands away from riparian zone,
     ⇒ feed placement, and
     ⇒ temporary or permanent fencing.
   - Developing a grazing strategy (see Meehan 1991, Fitch and Adams, 1995 and contact district agriculturist for strategies appropriate for local conditions). Such a strategy should cover the private property and crown range areas leased to the Kerr Cattle Company.
   - Local sources of cattle impacts include 5+300 (right bank), 5+630 (right bank), 6+350 (both banks), 6+435 (right bank) and 6+814 (right bank).

B. Once cattle are removed from the riparian zone, much of the riparian zone at this site will re-establish on its own. Planting is required between 6+324 and 6+425 in an overgrazed clearing (see riparian rehabilitation recommendation #1).

C. At the current cattle ford, construct a hardened or geowebbed crossing to minimise bank erosion. Channel is currently degraded and cobble is the dominant bed paving material (D = 23 to 26 cm). Due to the solid substrate, we recommend geoweb be used on the approaches to the stream, but not in the stream bed. Gravel (size will be dependent on the size of the "cells" in the type of geoweb chosen) should be placed over the web to a total depth of thirty cm (including geoweb thickness). Approach slope should be 6H:1V to minimise drift of gravel into the stream. Banks of the approach should be sloped to 3H:1V and planted with native sedge or grass (*Carex mertensi* – Mertens' sedge, *Elymus glaucus* - Blue wildrye, or *Calamagrostis canadensis* - Bluejoint) to minimize erosion. Seeding densities should be approximately 3000 seeds / m^2. Seeds can be broadcast onto the slopes or raked in.

Survey and Design Work (Tasks/Costs)

Costs for improvements to cattle distribution will depend on option(s) chosen in consultation with the landowner combined with the level of volunteer effort available.

The cattle crossing is the only works for which a task breakdown and cost estimate is appropriate at this time. Design specifications, material sizing, and site surveys to ensure works will meet MELP durability requirements for a 1 in 50 year flood event. Plan, profile and cross-sectional diagrams will be produced by an engineer once the site is surveyed.

Workplan:

Duty	Worker	# Person Days	Rate	Cost
Project Planning & disc. w. landowner	Project coordinator	1	$500	$500
Site survey	Hydrol. or Engin Tech.	1	$350	$350
Drawings and Design	Engineer	1	$700	$700
Approvals / Permits	Project coordinator	1	$500	$500
Implementation	Backhoe + operator*	0.5	$600	$300
	Project coordinator	1	$500	$500
	Fish. Tech with gear	1	$350	$350
Final Report	Project coordinator	1	$500	$500
Monitoring + report	Project coordinator	2	$500	$1000
Total Labour				**$4,700**

Disbursements			
Item	# units	$/unit	Cost
Silt screen	1/5 roll	$500	$100
Mileage (km)	350	$0.38	$133
Geotextile	1/5 roll	$500	$100
Geoweb	2 rolls	$500	$1,000
Anchoring stakes			$100
Gravel / small cobble	10 yards		$100
Seed	<1kg		$200
Misc.			$500
Total Disbursements			**$2,233**

* Costs may be reduced marginally if the landowner volunteers a backhoe, straw bales and his time.

Total Cost Estimate: $6933.

Environmental Protection Measures:

- In-stream work measures outlined in *Skeena Region: In-stream work windows and measures* (1999) will be followed.
- A fisheries technician will act as environmental monitor and will be on-site at all times during in-stream work periods. This tech will be responsible for fish salvage and will net off the site to prevent fish from entering the site. This technician can help lay the geotextile and geoweb and save hiring an extra labourer.
- An environmental orientation will be conducted with all on-site personnel prior to work being started.
- All contractors/subcontractors will be required to carry their own spill response equipment, as per BC Environment guidelines. Machine operators will be required to ensure machines do not leak.
- Straw bales and silt fences will be used to mitigate sedimentation of stream.
- Work will stop in the event of heavy rain and exposed soil will be covered.

Approvals Required: Approvals from the following agencies should be sought starting 90 days prior to the commencement of work:

- DFO and MELP Habitat Protection Branch referral,
- Fish collection permit, MELP Habitat Protection Branch, DFO, and
- Water Act Section 9 notification and approval, MELP Water Management Branch.

Seasonal Timing: Coho and chinook salmon, rainbow trout and Dolly Varden char can be expected at the site. Fisheries Sensitive Zone in-stream work window for the salmon is June 1 to August 15, for Dolly Varden is June 1 to November 15, and for rainbow trout is September 1 to May 15. Thus no window exists for this work and special permission must be granted by the designated environmental officer.

Rehabilitation Recommendations: Deep #2

Location: Impact site D4. Approximately 500 m downstream of the Wakefield Road bridge, near the buildings on Tony Vandenberg's property (4+800 to 4+960 m).

Access: Wakefield Road from Highway 16. Travel east along Wakefield road for 1.3 km and turn right into driveway. Proceed down driveway to house. Contact landowner prior to accessing land.

Land Tenure: Private (Tony Vandenberg)

TRIM/Forest Cover Mapsheet: 93L066

Forest Cover Polygon: 812

Flightline and Air Photo Number: 30BCC 687 No. 79

Impact Description: Cattle grazing has removed much of the understory vegetation beneath mature cottonwoods along this section of the creek. Riparian function is heavily impacted. Cattle trampling and lack of rooted vegetation is resulting in bank destabilisation and erosion. Exposed soil at the main cattle ford is a source of sediment to the creek.

Objectives:

- to rehabilitate the riparian zone and riparian function, and
- to reduce bank erosion and subsequent sediment loading from this site.

Biological Benefits:

- reduced of sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat,
- improved water quality,
- improved overhead cover, shade, and source of small organic debris, and
- regenerated cottonwood which will be a source of future LWD.

Proposed Rehabilitation strategies:

Rehabilitation at this site will focus on low-cost, passive techniques.

A. Work with Tony Vandenberg to develop strategies to encourage cattle to congregate away from the riparian zone and the creek. Options include:
   - Improving livestock distribution:
     ⇒ off-channel watering,
     ⇒ salt lick placement in uplands away from riparian zone,
     ⇒ feed placement, and
     ⇒ temporary or permanent fencing.
   - Developing a grazing strategy is an option, but will likely not be necessary for this area (see Meehan 1991, Fitch and Adams, 1995 and contact district agriculturist for strategies appropriate for local conditions).
   - An existing bridge near the current cattle in-stream crossing could be used as an alternative crossing which will help keep cattle out of the creek. Use of the existing

bridge will not cost the landowner anything, but will require techniques to encourage the cattle to use the crossing.

B. Once cattle are removed from the riparian zone, the riparian zone will be left to re-establish on its own.
C. A water intake stand pipe located on an outside meander needs protection from erosion. It is currently partially protected with rock and tires. Options to help protect this water intake could be developed as part of the negotiations with the landowner to modify cattle practices.

Survey and Design Work (Tasks/Costs): Costs for improvements to cattle distribution will depend on option(s) chosen combined with the level of volunteer effort available.

Approvals Required: No approvals are required unless in-stream work to protect the water intake is undertaken. If in-stream work is proposed in the future, permits must be obtained from:

- DFO and MELP Habitat Protection Branch referral,
- Fish collection permit, MELP Habitat Protection Branch, DFO, and
- Water Act section 9 notification and approval, MELP Water Management Branch.

Rehabilitation Recommendation: Deep #3

Location: Impact site D3. Middle of reach 1 (3+593 to 3+725 m) on Gar Garton's property.

Access: Turn onto the driveway across from the Farewell Creek Road on the west side of Deep Creek. Follow the driveway to the house. Contact landowner prior to accessing land.

Land Tenure: Private (Gar Garton)

TRIM/Forest Cover Mapsheets: 93L056/66

Forest Cover Polygon: 139 (93L056) and 811 (93L066)

Flightline and Air Photo Number: 30BCC 687 No. 57

Site Photos: Avulsions and old channels (Figs. 20C, D, E, F) and cattle ford with exposed soil on banks (Fig. 20G).

Impact Description: Two significant avulsions within 120 m of one another occurred during floods in 1997. The result has been a straightening of the channel and an increase in the speed and erosional force of the creek. The large meanders which have been bypassed contain some good areas of fish habitat. These meanders may only contain water now during high waters. The lower avulsion may have been caused by the straightening of the channel and construction of a bridge which constricts water flow immediately upstream of the impact site. The formation of the new channels in conjunction with the bursting of beaver dams downstream in 1997 (Garton, pers. comm.) has resulted in significant amounts of aggradation for 670 m downstream. These new channels could be a significant source of sediment to the creek for many years as a new channel forms.

A cattle crossing at a ford at the upper end of the upstream avulsion (3+715 m) is another source of sediment to the creek. Cattle appear to have free access to the channel and sections of limited riparian vegetation exist.

Objectives:

- to restore original stream pattern in avulsed areas,
- to arrest erosion of banks in meanders in order to protect property,
- to rehabilitate the riparian zone and riparian function, and
- to reduce bank erosion and subsequent sediment loading from this site.

Biological Benefits:

- reduced sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat,
- recovered fish habitat lost due to avulsions,
- reduced the speed and erosive power of the creek and therefore, reducing loss of fish habitat,
- improved overhead cover, shade, and source of small organic debris, and
- improved water quality.

Proposed Rehabilitation strategies:

In all suggested strategies, the landowner must be involved and his concerns addressed.

A. Work with Gar Garton to determine concerns about restoring flow to the original channel. Property along the outside corners of the meanders was eroding property and getting close to buildings. The landowner may be hesitant to restore water flow back to where it may threaten his buildings. Should the landowner be willing to look at the option of restoring flow to the original channel, a level 2 assessment should be conducted for the site. Insufficient information is available from the level 1 assessment to determine the appropriate method of protecting the banks. Although details will be clarified following a level 2 site assessment, the general proposed prescription is to block and partially infill the new channels, redirecting the flow into the old meander channels. Depending on stability of the banks, the downstream ends the new channels could be left as off channel habitat to be used during times of high water. The outside meander bends will be stabilised using the appropriate technique given the cause of the erosion (hydraulic vs. geotechnical) and the type of instability in the system. Bank slopes and hydraulic forces at the site need to be calculated following a survey of the site. A method integrating rock placement and vegetation may be appropriate given the limited ability to regrade banks. Riffle structures could be installed upstream of both avulsion sites to diminish water energy and provide fish habitat once upstream sedimentation sources are mitigated.

B. Work with Gar Garton to develop strategies to discourage cattle use of the creek and riparian zone. Options include
   - Improving livestock distribution:
     ⇒ off-channel watering,
     ⇒ salt lick placement in uplands away from riparian zone,
     ⇒ feed placement, and
     ⇒ temporary or permanent fencing.
   - Developing a grazing strategy (see Meehan 1991, Fitch and Adams, 1995 and contact district agriculturist for strategies appropriate for local conditions).

C. Once cattle are removed from the riparian zone, we recommend passive riparian rehabilitation because the riparian zone at this site should re-establish on its own.
   - A bridge located 75 m downstream of the present cattle fording location could be used as a permanent cattle crossing. The trail to the present crossing should be blocked-off and replanted with grasses and shrubs.

Survey and Design Work (Tasks/Costs)

Costs for improvements to cattle distribution will depend on option(s) chosen combined with the level of volunteer effort available.

Costs and schedule for returning flow to the original channel will depend on method used. However, rough estimates for a level 2 assessment are presented on the next page.

Workplan:

Duty	Worker	# Person Days	Rate	Cost
Site Visit and prep	Geoscientist	1	$600	$600
Site visit	Biologist	1	$500	$500
Rough design options or detailed design for one option	Engineer	1.5	$700	$1050
Final Report	Geoscientist	1.5	$600	$900
Misc. disbursements				$250
Total				**$3,300**

The geoscientist should determine slope stability and erosion pattern of the site and discuss options or improving fish habitat with the biologist. The geoscientist and biologist can work together to survey the site in order to produce a map and calculate gradients. This will save having a separate survey crew come to the site at a cost of $100 / hr.

Environmental Protection Measures: Should in-stream work proceed following a level 2 assessment, the following measures should be considered:

- In-stream work measures outlined in *Skeena Region: In-stream work windows and measures* (1999) will be followed.
- A fisheries tech will act as environmental monitor and will be on-site at all times during in-stream work periods. This tech will be responsible for fish salvage and will net off the site to prevent fish from entering the site.
- An environmental orientation will be conducted with all on-site personnel prior to work being started.
- All contractors/subcontractors will be required to carry their own spill response equipment, as per BC Environment guidelines. Machine operators will be required to ensure machines do not leak.
- Straw bales and silt fences will be used to mitigate sedimentation of stream.
- Work will stop in the event of heavy rain and exposed soil will be covered.

Approvals Required: Approvals from the following agencies should be sought starting 90 days prior to the commencement of work:

- DFO and MELP Habitat Protection Branch referral,
- Fish collection permit, MELP Habitat Protection Branch, DFO, and
- Water Act section 9 notification and approval, MELP Water Management Branch.

Seasonal Timing: Coho and chinook salmon, rainbow trout and Dolly Varden char can be expected at the site. Fisheries Sensitive Zone in-stream work window for the salmon is June 1 to August 15, for Dolly Varden is June 1 to November 15, and for rainbow trout is

September 1 to May 15. Thus no window exists for this work and special permission must be granted by the designated environmental officer.

Risks: Should outside banks in meanders continue to erode following rehabilitation work, resulting in lost property, the company responsible for the restoration works may be held liable.

Rehabilitation Recommendation: Deep #4

- Note: To be implemented in conjunction with Riparian Rehabilitation Recommendation: Deep #3 (see Appendix G).

Location: Impact site D2. Reach 1 downstream of Highway 16. The site extends from in front of Kirsch residence upstream for 220 m on left bank.

Access: Turn south onto Farewell Creek road from Highway 16 and park on flat after passing barn. Contact landowner prior to accessing land.

Land Tenure: Private (Robert Kirsch).

TRIM/Forest Cover Mapsheet: 93L.056

Forest Cover Polygon: 127

Flightline and Air Photo Number: 30BCC 687 No. 57

Site Photo: Eroded left bank from 1997 flood. Landowner has "armoured" the bank with small cobble (Fig. 20B).

Impact Description:

Sections of a 220 m length of the left bank of the creek is eroding and is a source of sediments. Riparian vegetation was cleared to make a field and the remaining thin band of willows remaining were washed away during the high water of 1997.

Objectives:

- to rehabilitate the riparian zone and riparian function, and
- to reduce bank erosion and subsequent sediment loading from this site.

Biological Benefits:

- reduced sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat, and
- improved overhead cover, shading and small organic debris.

Proposed Rehabilitation strategies:
(Assuming 150 m of the 220 length of stream will need to be stabilised)

Install wattles and geotextile to stabilise banks. Use locally available willows growing along the creek as a source. Preferred species include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow *(S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). Collect live willows whips and conduct work in the spring before bud burst or in autumn after buds have set. Tie cuttings with butts alternating into bundles 15-20 cm in diameter and 3-5 m long. Bind every 40 cm, or at an appropriate distance to hold bundles together.

Re-contour bank to a 1.5H:1V slope using an excavator or backhoe and set wattles into trenches at the toe and the top of the bank. Place willow branches beneath the toe wattle facing out and downstream (Donat, 1995). Secure wattles with 60 cm long wooden pegs

driven through the centre of the wattle and spaced every 0.75 m. Cover the brush wattles with soil and walk on bundles while infilling to help pack soil in. Place biodegradable geotextile between wattles to minimise erosion until the plants root. Plant 0.8 m long willow whips spaced 1 m apart through slits cut in the geotextile. Whips should be buried in 55-60 cm soil, leaving a minimum of two buds exposed.

This technique is labour intensive, but is great for a community project. Once willows are collected, building and installing the wattles will take approximately 1 hr/m (Donat, 1995). The willows growing at the site may need pruning after 2 or 3 years. Planting of cottonwood and spruce behind the bank stabilisation project is outlined in Riparian Restoration Recommendation: Deep #3.

Workplan:

Duty	Worker	# Person Days	Rate	Cost
Project Planning & disc. w. landowner	Project coordinator	3	$500	$1,500
Assess site	Plant ecologist	0.5	$550	$275
	Geoscientist	0.5	$600	$300
Drawings and design	Engineer	1	$700	$700
Approvals / Permits	Project coordinator	1	$500	$500
Collect materials	Volunteers	20	$0	
Fish salvage and environmental monitoring	Fish. Tech with gear	3	$350	$1,050
Implementation	Backhoe operator*	1	$600	$600
	Project coordinator	3	$500	$1,500
	Volunteers	20	$0	
Final Report	Project coordinator	1	$500	$500
Monitoring + reporting for 3 years	Biologist or geoscientist	3	$500	$1,500
Total Labour				**$8,425**

Disbursements			
Item	# units	$/unit	Cost
Straw bales	20	$5	$100
Silt screen			$250
Mileage (km)	910	$0.38	$346
Geotextile	1	$500	$500
Wooden stakes (1"x2")	400	$0.65	$260
Photos	4	$25	$100
Misc.			$500
Total Disbursements			**$2,056**

* Costs may be reduced marginally if the landowner volunteers a backhoe, straw bales and his time.

Total Cost Estimate = $10,481

Environmental Protection Measures:

- In-stream work measures outlined in *Skeena Region: In-stream work windows and measures* (1999) will be followed.
- A fisheries tech will act as environmental monitor and will be on-site at all times during in-stream work periods. This tech will be responsible for fish salvage and will use a combination of straw bales and silt screens to stop silt from entering the stream.
- An environmental orientation will be conducted with all on-site personnel prior to work being started.
- All contractors/subcontractors will be required to carry their own spill response equipment, as per BC Environment guidelines. Machine operators will be required to ensure machines do not leak.
- Work will stop in the event of heavy rain and exposed soil will be covered.

Approvals Required: Approvals from the following agencies should be sought starting 90 days prior to the commencement of work:

- DFO and MELP Habitat Protection Branch referral,
- Fish collection permit, MELP Habitat Protection Branch, DFO, and
- Water Act section 9 notification and approval, MELP Water Management Branch.

Seasonal Timing: Coho and chinook salmon, rainbow trout and Dolly Varden char can be expected at the site. Fisheries Sensitive Zone in-stream work window for the salmon is June 1 to August 15, for Dolly Varden is June 1 to November 15, and for rainbow trout is September 1 to May 15. Thus no window exists for this work and special permission must be granted by the designated environmental officer.

Thompson Creek Reaches 1 and 2

Watershed level objective. To improve the overall health of the watershed and salmonid fish habitat by:

- altering land use practices on private land,
- restoring riparian function to stream, and
- decreasing sources of sediment to the stream.

Reaches 1 and 2 of Thompson Creek flow through private land. The impacts in this reach are chronic and arise from historic and current land use practices in the watershed. For rehabilitation to succeed, landowners need to be involved in developing solutions. Therefore, the first step in rehabilitating Thompson Creek, like Deep Creek, is to contact the landowners within the watershed. The results of the fish habitat, riparian and channel assessments should be shared, after which landowner interest and willingness to co-operate in rehabilitation efforts should be gauged. Adoption of watershed stewardship principles including best management practices for cattle, and in some cases, altering present cattle grazing management, will be required in order for the processes that have been impacted in this watershed to recover. Solutions can usually be found that benefit both the landowners and the streams. A long-term watershed plan addressing landowner concerns and clearly outlining objectives and strategies to rehabilitate the creek will be necessary to help ensure the health of the stream and land improves in the future. Landowners and government representatives should be involved in the planning process. Monitoring of water quality, riparian function, and possibly invertebrate populations should be a component of this plan.

Rehabilitation priorities:

1. Consultations with land owners. Information sharing and education. Landowners should be encouraged to keep existing riparian zones. There is a need to protect what remains because prevention of problems is much cheaper than restoration.
2. Cattle management to protect creek and riparian zone.
3. Bank stabilisation and riparian planting.
4. Improve fish passage at culverts.
5. Other in-stream works.

The rehabilitation ideas outlined in this appendix and Appendix G address four of the nine impact sites in the mainstem of Thompson Creek (T6, T7, T3 & T9). The remaining impacted sites may recover on their own (T8) or recover once cattle management issues are addressed (T1, T2, T4). Two sites (T5, T10) require culvert replacement or backwatering to improve fish passage.

Thompson Creek Reaches 1 and 2

Rehabilitation Recommendation: Thompson #1

- Note: To be implemented in conjunction with Riparian Rehabilitation Recommendation: Thompson #1 (see Appendix G).

Location: Impact sites T6 & T7 (upper part of reach 1 & lower part of reach 2). The lower end of the site T6 is located immediately upstream of the box culvert at 5+091 m. The upper end is located at 0+430 m in reach 2. The total length of the site is 955 m.

Access: Dieleman Road east off Highway 16, straight through the stockyard and the old homestead to the box culvert. For access to reach 2, turn east past the homestead and proceed through the field to the fence line. Contact landowner prior to accessing land.

Land Tenure: Private (William Dieleman).

TRIM/Forest Cover Mapsheet: 93L057

Forest Cover Polygons: 435, 439, 441

Flightline and Air Photo Number: 30BCB 91183 No. 42

Site Photos: Grazed and widening channel in T6 (Fig. 25D), old channel at reach break (Fig. 24F) and cleared land and bank failure in T7 (Fig. 27A)

Impact Description: Land clearing and cattle grazing has removed much of the riparian vegetation along this section of the creek. Large cottonwoods, spruce and willows exist in part of the area, but understory vegetation is heavily grazed. Riparian function is impacted, severely in some cases. Cattle trampling and lack of rooted vegetation is resulting in bank destabilisation, erosion and channel widening.

Objectives:

- to rehabilitate the riparian zone and riparian function,
- to reduce bank erosion and subsequent sediment loading from this site, and
- to eventually increase habitat complexity with the natural recruitment of LWD to the channel.

Biological Benefits:

- reduced sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat,
- improved water quality,
- improved overhead cover, shade, and source of small organic debris, and
- improved LWD recruitment into the stream to increase stream complexity over the long-term.

Proposed Rehabilitation strategies:

A. Work with the Dieleman family to develop strategies to encourage cattle to congregate away from the riparian zone and the creek. Options include:
   - Improving livestock distribution:
     ⇒ off-channel watering,
     ⇒ salt lick placement in uplands away from riparian zone,
     ⇒ feed placement, and
     ⇒ temporary or permanent fencing.
   - Developing a grazing strategy (see Meehan 1991, Fitch and Adams, 1995 and contact district agriculturist for strategies appropriate for local conditions). Such a strategy should cover the private property and crown range areas used by the Dieleman family.
   - Local sources of cattle impacts: Reach 2 - 0+200 m to 0+430 m (right bank) and 0+278 m (both banks).

B. Once cattle are removed from the riparian zone, much of the riparian vegetation at this site will re-establish on its own over time. Planting is required between 0+200 m and 0+430 m in reach 2 in an overgrazed clearing (see Riparian Rehabilitation Recommendation: Thompson #1).

Along the eroded banks between 0+200 and 0+430 m, stabilise banks using wattles, live staking of willows and geotextile. Use locally available willows from the Bulkley Valley as a source. Preferred species include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow *(S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). Collect live willow whips and conduct work in the spring before bud burst or in autumn after buds have set (depends on timing of additional riparian planting, see Riparian Rehabilitation Recommendation: Thompson #1). Tie cuttings with butts alternating into bundles 15-20 cm in diameter and 3-5 m long. Bind every 40 cm, or at an appropriate distance to hold bundles together.

Re-contour bank to a 2H:1V slope using an excavator or backhoe and set wattles into trenches at the toe and the top of the bank. Place willow branches beneath the toe wattle facing out and downstream (Donat, 1995). Secure wattles with 60 cm long wooden pegs driven through the centre of the wattle and spaced every 0.75 m. Cover the brush wattles with soil and walk on bundles while infilling to help pack soil in. Place biodegradable geotextile between wattles to minimise erosion until the plants root. Plant 0.8 m long willow whips spaced 1 m apart through slits cut in the geotextile. Whips should be buried in 55-60 cm soil, leaving a minimum of two buds exposed. Due to the large size of this site, the project could be done over two years with the first year acting as a trial.

This technique is labour intensive, but is great for a community project. Once willows are collected, building and installing the wattles will take approximately 1 hr/m (Donat, 1995). The willows growing at the site may need pruning after 2 or 3 years.

Planting of cottonwood and spruce behind the bank stabilisation project is outlined in Riparian Restoration Recommendation: Thompson #1.

C. At the current cattle ford (0+278 m, reach 2), construct a geowebbed crossing to minimise bank erosion. Due to the gravel and cobble substrate, we recommend geoweb be used on the approaches to the stream, but not in the stream bed. Gravel (4 to 8 cm diameter) should be placed over the web to a total depth of thirty cm (including geoweb thickness). Approach slope should be 6H:1V to minimise drift of gravel into the stream. Banks of the approach should be sloped to 3H:1V and planted with native sedge or grass (*Carex mertensi* – Mertens' sedge, *Elymus glaucus* - Blue wildrye, or *Calamagrostis canadensis* - Bluejoint) to minimize erosion. Seeding densities should be approximately 3000 seeds / m^2. Seeds can be broadcast onto the slopes or raked in.

Survey and Design Work (Tasks/Costs)

Costs for improving cattle distribution and / or developing a grazing strategy will depend on option(s) chosen in consultation with the landowner combined with the level of volunteer effort available.

A rough task breakdown and cost estimate is presented on the next page for the cattle crossing and bank stabilisation project. Since cost savings exist by doing the projects together, we have combined the two projects into one. The costs assume the entire bank stabilisation work will be completed in one year. Design specifications, material sizing, and site surveys to ensure works will meet MELP durability requirements for a 1 in 50 year flood event. Plan, profile and cross-sectional diagrams will be produced by an engineer once the site is surveyed.

Monitoring: Structures should be checked at the end of the first three growing seasons or after major flood events. The landowners may also monitor the stability of the structures.

Workplan:

Duty	Worker	# Person Days	Daily Rate	Cost
Project Planning & disc. with landowner	Project coordinator	4	$500	$2,000
Assess site (bank)	Plant ecologist	0.5	$550	$275
	Geoscientist	0.5	$600	$300
Site survey (crossing)	Hydrol. or Engin Tech.	2	$350	$700
Drawings and Design	Engineer	2	$700	$1,400
Approvals / Permits	Project coordinator	1	$500	$500
Collect plant material	Volunteers	20 - 30	$0	
Fish Salvage / Env. monitor	Fish. Tech with gear	3	$350	$1,050
Implementation	Backhoe + operator*	2	$600	$1200
	Project coordinator	5	$500	$2500
	Volunteers	20 - 30	$0	$0
Final Report	Project coordinator	2	$500	$1000
Monitoring & reports for 3 years	Biol. / geoscientist	3	$500	$1500
Total Labour				**$12,425**

Disbursements			
Item	**# units**	**$/unit**	**Cost**
Wattles			
Wooden stakes	640	$0.65	$416
Silt screen (rolls)	1/5	$500	$100
Crossing			
Geoweb (rolls)	2	$500	$1,000
Anchoring stakes			$100
Gravel / small cobble	10 yards		$100
Seed	<1kg		$100
Both			
Straw bales*	40	$5	$200
Mileage (km)	1100	$0.38	$418
Geotextile (rolls)	2	$500	$750
Photos	4	$25	$100
Misc			$750
Total Disbursements			**$4,034**

* Costs may be reduced marginally if the landowner volunteers a backhoe, straw bales and his time.

Total Cost Estimate: $16,459.

Environmental Protection Measures:

- In-stream work measures outlined in *Skeena Region: In-stream work windows and measures* (1999) will be followed.
- A fisheries technician will act as environmental monitor and will be on-site at all times during in-stream work periods. This tech will be responsible for fish salvage and will ensure fish do not enter the site.
- An environmental orientation will be conducted with all on-site personnel prior to work being started.
- All contractors/subcontractors will be required to carry their own spill response equipment, as per BC Environment guidelines. Machine operators will be required to ensure machines do not leak.
- Straw bales and silt fences will be used to mitigate sedimentation of stream.
- Work will stop in the event of heavy rain and exposed soil will be covered.

Approvals Required: Approvals from the following agencies should be sought starting 90 days prior to the commencement of work:

- DFO and MELP Habitat Protection Branch referral,
- Fish collection permit, MELP Habitat Protection Branch, DFO, and
- Water Act Section 9 notification and approval, MELP Water Management Branch.

Seasonal Timing: Coho salmon, rainbow trout, cutthroat trout and Dolly Varden char can be expected at the site. Fisheries Sensitive Zone in-stream work window for the salmon is June 1 to August 15, for Dolly Varden is June 1 to November 15, and for rainbow trout is September 1 to May 15. Thus no window exists for this work and special permission must be granted by the designated environmental officer.

Rehabilitation Recommendation: Thompson #2

- Note: To be implemented in conjunction with Riparian Rehabilitation Recommendation: Thompson #2 (see Appendix G).

Location: Impact site T3. 1415 m upstream of the Bulkley River side channel, 1860 m downstream of Walcott Road. The impact site is 20 m long.

Access: Walcott Road from Highway 16. Travel south along Walcott Road for 1.7 km. Turn right at residence and ask landowner for precise directions to this crossing. Contact landowners prior to accessing land.

Land Tenure: Private (James Berkery) (Access may be via Lies Rouw's land).

TRIM/Forest Cover Mapsheet(s): 93L056

Forest Cover Polygon: 212

Flightline and Air Photo Number: 30BCB 91112 No. 90

Site Photo: Bridge and eroding banks at cattle crossing and watering area at 1+415 m (Fig. 25B).

Impact Description: Cattle use has removed the riparian shrubs and trees along this section of the creek. Riparian function is heavily impacted. Trampling and lack of rooted vegetation is resulting in bank destabilisation and erosion. Exposed soil at the main cattle ford and watering area is a source of sediment to the creek.

Objectives:

- to reduce bank erosion and subsequent sediment loading from this site and
- to rehabilitate the riparian zone and riparian function.

Biological Benefits:

- reduced sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat,
- improved water quality, and
- improved overhead cover, shade, and source of small organic debris.

Proposed Rehabilitation strategies:

A. Work with James Berkery and / or current lease holder (may be the Dielemans) to develop strategies to encourage cattle to congregate away from the riparian zone and the creek. Options include:

- Improving bridge at the site to enable cattle to cross. The bridge requires a full deck to be built prior to allowing cattle use and cattle will need to be encouraged to use the crossing. Prior to completing the bridge deck, an engineer should determine if the load rating of the bridge and that bridge construction is adequate to withstand the weight of cattle. The landowner should sign a waiver indicating that deck improvements will not affect the bridge's capacity to conduct water in any way in order to release people from any legal action should the bridge be washed away.

- Use the existing road in combination with the bridge for cattle migration. Some fencing may be required.
- Off-channel watering may be an viable option to provide water at the valley bottom without causing damage to the riparian zone.

B. Once cattle are removed from the riparian zone, the banks should be stabilised. We recommend a combination of brush mattress and tree plug planting with riprap at the toe to protect the bridge downstream. See Riparian Rehabilitation Recommendation: Thompson #2.

- Survey and design by a hydrologist / geoscientist/ engineer to verify material sizing and design specifications.
- Recontour slope with a backhoe to a slope of 3:1. Riprap (20 cm rock) should be placed along the outside stream bank to a depth slightly greater than bankful depth (a total of approximately 50 cm) for a linear distance of 10 - 15 m.
- Install a 1.5 - 2 m wide brush mattress consisting of willow on the bank above the riprap. For the remainder of the site upstream of the riprapped section, place a brush mattress with a live fascine at the base, extending to the bottom of the creek. Work will have to be done in the spring prior to bud-burst, or if the ground is frozen and stakes cannot be driven 0.8 to 1m into the ground, the project must be done in the autumn during plant dormancy. Vegetation, once grown, will help slow water during high flows through this area.
- Upslope of the brush mattress, plant aspen and spruce (see Riparian Rehabilitation Recommendation: Thompson #2).
- Fencing may be required to keep cattle out of the rehabilitation area.

Survey and Design Work (Tasks/Costs)

Costs for improving cattle distribution and / or developing a grazing strategy will depend on option(s) chosen in consultation with the landowner combined with the level of volunteer effort available.

The following tables show rough estimated costs for decking the bridge, riprapping and installing a brush mattress. Design specifications and material sizing, will ensure works meet MELP durability requirements for a 1 in 50 year flood event. Plan, profile and cross-sectional diagrams will be produced by an engineer once the site is surveyed. We suggest that collection of cottonwood and aspen cuttings be conducted at the same time as collections for the brush mat the time. However, the extra time to collect the cottonwood and aspen cuttings are not included in the workplan on the next page.

Workplan:

Duty	Worker	# Person Days	Daily Rate	Cost
Project Planning + disc. w. landowner	Project coordinator	2	$500	$1,000
Site survey / riprap sizing	Hydrol. / Engin Tech.	1	$350	$350
Assess bridge	Engineer	1	$700	$700
Approvals / Permits	Project coordinator	1	$500	$500
Collect plant material[1]	Volunteers	10	$0	
Implementation	Backhoe + operator[2]	0.5	$600	$300
	Project coordinator	1.5	$500	$750
	Environmental monitor	1	$350	$350
	Volunteers	5 to 10	$0	
Final Report	Project coordinator	1.5	$500	$750
Monitoring + reports for 3 years	Biol. / geoscientist	3	$500	$1,500
Total Labour				**$6,200**

Disbursements			
Item	**# units**	**$/unit**	**Cost**
Crossing			
3"x8"x16' planks	12	$31	$372
4"x4" cross brace	2	$8	$16
Bank stabilisation			
Straw bales	20	$5	$100
Rip rap (cubic yards)[2]	4		$100
stakes (1.2m)	48	$2	$96
Jute rope	2	$4	$8
Mileage (km)	700	$0.38	$266
Both			
Photos	3	$25	$75
Misc			$500
Total Disbursements			**$1,533**

1 Time estimate does not include collection of cuttings for live planting.
2 Costs may be reduced marginally if the landowner volunteers a backhoe, straw bales, armouring rock and his time.

Total Cost Estimate: $7,733.

Monitoring: Conduct walk-through assessment each year in the late summer, or following a large flood to determine the success of this bank stabilisation strategy and to determine cattle use of the bridge.

Environmental Protection Measures:

- In-stream work measures outlined in *Skeena Region: In-stream work windows and measures* (1999) will be followed.
- A fisheries technician will act as environmental monitor and will be on-site at all times during in-stream work periods. This tech will be responsible for fish salvage and will net off the site to prevent fish from entering the site. This technician can help lay the geotextile and geoweb and save hiring an extra labourer.
- An environmental orientation will be conducted with all on-site personnel prior to work being started.
- All contractors/subcontractors will be required to carry their own spill response equipment, as per BC Environment guidelines. Machine operators will be required to ensure machines do not leak.
- Straw bales and silt fences will be used to mitigate sedimentation of stream.
- Work will stop in the event of heavy rain and exposed soil will be covered.

Approvals Required: Approvals from the following agencies should be sought starting 90 days prior to the commencement of work:

- DFO and MELP Habitat Protection Branch referral,
- Fish collection permit, MELP Habitat Protection Branch, DFO, and
- Water Act Section 9 notification and approval, MELP Water Management Branch.

Seasonal Timing: Coho salmon, rainbow trout, cutthroat trout and Dolly Varden char can be expected at the site. Fisheries Sensitive Zone in-stream work window for the salmon is June 1 to August 15, for Dolly Varden is June 1 to November 15, and for rainbow trout is September 1 to May 15. Thus no window exists for this work and special permission must be granted by the designated environmental officer.

Rehabilitation Recommendation #3

- Note: To be implemented in conjunction with Riparian Rehabilitation Recommendation: Thompson #3 (see Appendix G).

Location: Impact site T9. Reach 2 (2+027 m to 2+157 m).

Access: From Highway 16, turn east onto McNeil Road. Drive approximately 800 m and turn left onto side road. Proceed past boulder if possible, or walk into field in field near old homestead 600 m from McNeil Road. Follow the edge of the clearing on the right to the creek. The bottom of the site is at the bridge. Contact landowner prior to accessing land.

Land Tenure: Private (William Dieleman).

TRIM/Forest Cover Mapsheets: 93L057

Forest Cover Polygons: 458, 451

Flightline and Air Photo Number: 30BC 91183 No. 42

Site Photo: Bank shear and cleared land on left bank at 2+027 m (Fig. 27D).

Impact Description: Land clearing on the left bank has removed riparian vegetation, resulting in reduced bank stability and stream cover. Cattle grazing the banks and watering in the stream have caused further bank weakening and erosion.

Objectives:

- to reduce bank erosion and subsequent sediment loading from this site,
- to narrow and deepen the channel over the long term, and
- to rehabilitate the riparian zone and riparian function.

Biological Benefits:

- improved bank stability,
- reduced sediment deposition downstream on spawning gravels and less sediment infilling of pools, thus increasing rearing and possibly overwintering habitat,
- improved overhead cover, shade, and source of small organic debris, and
- improved water quality.

Proposed Rehabilitation strategies:

Work with the Dieleman family to develop strategies to encourage cattle to congregate away from the riparian zone and the creek. Options include:

- Improving livestock distribution:
  - ⇒ off-channel watering,
  - ⇒ continue with salt lick placement in uplands away from riparian zone,
  - ⇒ feed placement, and
  - ⇒ temporary or permanent fencing. The fence at the upstream end of the site needs to be repaired and will help keep cattle out of the wet area upstream of the site.
- Planting will accelerate recovery of riparian vegetation at this site (see Riparian Rehabilitation Recommendation: Thompson #3).

In all suggested strategies, the landowner must be involved and his or her concerns addressed.

Survey and Design Work (Tasks/Costs)

Costs for improvements to cattle distribution will depend on option(s) chosen combined with the level of volunteer effort available.

Approvals Required: No approvals are required.

Monitoring: Conduct walk-through assessments each year for 3 years in the late summer to determine plant performance and survival, and cattle influence on the site. Manual brushing or thinning may be required.

Dahlie Creek Reaches 1, 2 and 3

We assessed Dahlie Creek to determine fish habitat quality and the feasibility of creating a public viewing area for spawning salmon. Our conclusion is that this stream would not be suitable for a salmon viewing facility. The primary reason is that a 150 m long section of the creek between Main Street and Victoria Drive has a gradient of 8-12%, and is a barrier to the migration of spawning salmon under all but perfect conditions. Some steelhead may be able to negotiate the steep climb, but their upstream movement would be hampered under most flow conditions by perched culverts. On the rare occasion, coho salmon do spawn in reach 3. Adult salmon were apparently seen in the stream approximately 20 years ago (Cobb pers. comm.) and juvenile coho salmon were found in the creek approximately a decade ago (Bustard, pers. comm.), prior to any juvenile releases to the stream. However, we can state with a high degree of confidence that the juvenile salmon we captured in reaches 2 and 3 were released by students from Chandler Park Middle School through the Salmonids in the Classroom program of the Department of Fisheries and Oceans.

Despite the lack of current salmon use of Dahlie Creek, resident rainbow trout and cutthroat trout are present and numerous opportunities exist to improve the general fish habitat and health of the creek. Due to its location within Smithers, community demonstration projects would have high educational values.

Priorities for rehabilitation:

- ensure that Land Development Guidelines for the Protection of Aquatic Habitat encouraging the growth of streamside (riparian) vegetation and development setbacks are incorporated into the Smithers Official Community Plan. A proactive approach to avoiding problems is much cheaper in the long run than restoring systems once they have been impacted,
- create fish passage through culverts and up steep reach,
- reduce sediment loading into the creek,
- create spawning habitat for resident fish, and
- restore riparian function to stream.

Additional creek based community projects:

- clean refuse from creek,
- install educational signs, and
- paint fish beside storm drains to draw attention to the connection of drains with the creek.

The scope of the study on Dahlie Creek does not include detailed rehabilitation recommendations. We instead have listed rehabilitation options starting on the next page. Should efforts to rehabilitate Dahlie Creek continue, all sites will have to be surveyed and engineering drawings be completed. Such efforts should be delayed until water quality and overwintering studies scheduled for 2000 are complete.

Table F-1. Options to improve fish access and habitat in Dahlie Creek.

Issue	Impact	Priority	Location	Options	Pros	Cons
Fish Passage	Perched culvert	H	Main St.	A. Backwater with riffle structure / weir	Relatively inexpensive, will help control erosion downstream of the culvert. Pool habitat will be created directly downstream of culvert.	Potential sedimentation if upstream sediment sources are not addressed.
				B. Replace culvert	Upgrade capacity to meet 100 year flood flows. Will provide good fish passage.	Expensive.
	Perched culvert	H	Victoria Dr.	See Main Street culvert.		
	Screened culvert	H	Hwy 16	A. Remove screens and replace with trash racks placed upstream of the culvert.	Technically simple and inexpensive. Will allow adult fish passage. Will prevent leaves and small debris from clogging the upper end of the culvert.	None.
				B. Replace culvert	Upgrade capacity to meet 100 year flood flows; best fish passage.	Very expensive; road delays on highway.
	Steep Reach	M	Between Main St. and Victoria Dr.	Create pools to provide resting areas to aid upstream adult fish migration and create rearing / overwintering habitat for juveniles.	Will aid with upstream migration of adult fish to recolonise stream.	On private property. Work will have to be done by hand due to difficult access.
	Perched culvert	M	Railway Ave.	Replace culvert	Allow fish passage, although very long. Will allow access to some areas of good upstream spawning and rearing habitat.	Very expensive. Questionable whether benefits would justify costs.

Table F-1 continued. Options to improve fish access and habitat in Dahlie Creek.

Issue	Impact	Priority	Location	Options	Pros	Cons
Sedimentation of stream	Sedimentation from Frontage Road Ditch wetland below Nadina Place	H	From Frontage Road, 200 m downstream.	Determine source of sedimentation and address this source.	May be the least expensive option. Preventing problems at the source is preferred to a "band-aid" approach.	
				Create a storage pond within the wetland to let sediment settle out.	Provide wildlife habitat; or off channel fish habitat.	Expensive
	Elks park stream banks	M-H	Elks Park	A. Riprap banks	Solid armouring will protect bank.	Expensive, provides minimal fish habitat
				B. Use plantings – wattles, live slope gratings OR integrate riprap or LWD and live planting together (Slaney and Zaldokas, 1997; Donat 1995)	More natural, will provide function to creek. Depending on method, may be relatively inexpensive. Good community project with education potential.	Integrated methods can be expensive. Some methods may not provide enough support on a steep slope.
				C. Construct plunge pool at downstream end of Railway Ave. culvert to slow water.	Will create fish habitat. May be a sediment storage location.	
				D. Replace or redirect 0.2 m concrete drainage pipe from Elks Park which is helping to erode bank.	May help stop erosion.	Unknown if pipe is still in use or what other drainage options exist for the fields.

Monitoring: Perform a stocking and brush survey at the end of the first growing season to determine survival and tree performance. Permanent sample plots with monitoring at least once per year is recommended, especially if this site is a community pilot project. Cattle influence on the area should be assessed. Manual brushing may be required. Planted trees may require thinning after a decade.

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Gravel bars and toe of bank.	100 m	Dormant willow cuttings (80 cm with 3 cm butt diam.) Keep in water prior to planting. Plant to a depth of 55 cm leaning downstream.	None required. Cuttings to be inserted into manually driven pilot holes.	Early May prior to flooding. If site is too wet, plant in autumn once plants are dormant. Later spring may be an option if plants are collected prior to bud burst and stored in a freezer until used.	1 m apart	120
1-10 m	0.2 ha	Cottonwood cuttings 80 cm long with 3 cm diam. butt. Bury 55 cm into soil.	Manually spot scarify a $1m^2$ area (56 cm radius) and remove roots of competing vegetation; place 90 cm x 90 cm brush mats around planted cuttings.	Early May to correspond with willow planting.	1 m apart	To be determined with site visit and development of a prescription.
		Hybrid spruce styroblock stock. Plant on elevated microsites.	See cottonwood.		Spacing to be determined based presence of elevated microsites. Spruce should be 1-2 m from cottonwood.	To be determined.

* This estimate includes a 20% contingency for damaged stock.

Riparian Rehabilitation Recommendation: Deep #2

Reach: Deep Creek Reach 1

Location: Impact site D5 (5+630 to 5+805 m)

Land Tenure: Private (Kerr Cattle Company). Contact landowner to access land.

TRIM/Forest Cover Mapsheet: 93L066

Forest Cover Polygon: 812

Flightline and Air Photo Number: 30BCC 687 No. 79

Closest riparian assessment sites: MJ2, MJ8

Site Series / structural stage: SBSdk08 / Mature deciduous

Soil type: Dystric Brunisol

Area to be treated: 175 m long * 2 m wide * 2 banks = 0.07 ha

Riparian Class: S2: RMA = 50 m, RRZ = 30, RMZ = 20m

Objectives:

- promote overhanging shrubs to provide bank stability, shade, small organic debris and surface filtering, and
- stabilise stream channel by establishing deep rooting deciduous and coniferous species.

Overview:
The riparian area between 5+630 and 5+805 m has been heavily grazed by cattle. Mature cottonwood provide some riparian function, but the shrub / herb layer is sparse. Bank stability, small organic debris, and vegetation cover for fish is lacking. We suggest willow cuttings be planted along the gravel bars, and at the toes of banks. Preferred species include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow (*S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). This fast growing pioneer vegetation will help protect the stream banks from erosion, provide small organic debris and shade the creek. Roots will catch sediments which will help build the banks. Passive restoration is suggested for the remainder of the riparian zone as shrubs and herbs are expected to return naturally once cattle distribution issues are addressed (See Rehabilitation Recommendation Deep #1).

We suggest visiting this site while determining options for cattle management within the riparian zone with the Kerr Cattle Company. At this time, an accurate estimate of numbers of willows required can be made. A riparian assessment at this site will help determine the need to plant additional cottonwood and perhaps spruce in order to enhance long-term LWD recruitment.

Risks: Frost, flooding, drought, cattle grazing.

Monitoring: Conduct walk-through assessments for three years in the late summer to determine plant performance and cattle influence.

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Gravel bars and toe of bank.	175 m	Dormant willow cuttings (80 cm with 3 cm butt diam.) Keep in water prior to planting. Plant to a depth of 55 cm leaning downstream.	None required. Cuttings to be inserted into manually driven pilot holes.	Early May prior to flooding. Try to plan for year when floods are not expected to be high. If site is too wet, plant in fall once plants are dormant. Later spring may be an option if plants are collected prior to bud burst and stored in a freezer until used.	1 m apart	Up to 420.

* This estimate includes a 20% contingency for damaged stock.

Riparian Rehabilitation Recommendation: Deep #3

- Note: to be implemented in conjunction with Rehabilitation Recommendation Deep #4 (see Appendix F).

Reach: Deep Creek Reach 1

Location: Impact site D2 (1+700 to 2+290 m)

Land Tenure: Private (Robert Kirsch). Contact landowner to access land.

TRIM/Forest Cover Mapsheet: 93L056

Forest Cover Polygon: 127

Flightline and Air Photo Number: 30BCC 687 No. 57

Close riparian assessment sites: MG1

Site Series / structural stage: SBSdk08 / Herb, shrub

Soil type: Dystric Brunisol

Area to be treated: approximately 350 m long * 10 m wide *2 banks = 0.7 ha

Riparian Class: S2: RMA = 50 m, RRZ = 30, RMZ = 20m

Site Photo: Thinned or cleared riparian areas (see Figs. 19B and 20B).

Objectives:

- promote overhanging shrubs to provide bank stability, shade, small organic debris and surface filtering,
- provide source of long-term LWD, and
- stabilise stream channel by establishing deep rooting deciduous and coniferous species

Overview:

A cleared area with limited riparian vegetation between 1+700 m and the Farewell Road Bridge at 2+290 m will require riparian planting to rehabilitate riparian function. Width of the replanted area will depend on negotiations with the landowner. We will assume a 10 m riparian zone. Although this is much less than the 30 m riparian reserve zone required by the Forest Practices Code, re-establishing a wider zone may be impractical given the circumstances. Black cottonwood whips and hybrid spruce will be planted in a nurse-tree shelterwood system between 3 and 10 m from the bank to increase shading and provide a long-term source of LWD. Within 2 m of the creek bank, cottonwood cuttings will be interspersed with red osier dogwood (*Cornus stolonifera*) (on mid bench) or willow (on low bench) every 20 m. All cuttings should be made at a 45° angle and come from 1st or 2nd year growth. Preferred species of willow include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow (*S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). Bebb's willow (*S. bebbiana*) may also be an option if it is common along the creek. Willow species found growing in the area should be given preference. Scouler's willow (*S. scouleriana*) should be avoided as it requires special treatment to root (Triton 1993).

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Gravel bars and toe of bank.	175 m	Dormant willow cuttings (80 cm with 3 cm butt diam.) Keep in water prior to planting. Plant to a depth of 55 cm leaning downstream.	None required. Cuttings to be inserted into manually driven pilot holes.	Early May prior to flooding. Try to plan for year when floods are not expected to be high. If site is too wet, plant in fall once plants are dormant. Later spring may be an option if plants are collected prior to bud burst and stored in a freezer until used.	1 m apart	Up to 420.

* This estimate includes a 20% contingency for damaged stock.

Riparian Rehabilitation Recommendation: Deep #3

- Note: to be implemented in conjunction with Rehabilitation Recommendation Deep #4 (see Appendix F).

Reach: Deep Creek Reach 1

Location: Impact site D2 (1+700 to 2+290 m)

Land Tenure: Private (Robert Kirsch). Contact landowner to access land.

TRIM/Forest Cover Mapsheet: 93L056

Forest Cover Polygon: 127

Flightline and Air Photo Number: 30BCC 687 No. 57

Close riparian assessment sites: MG1

Site Series / structural stage: SBSdk08 / Herb, shrub

Soil type: Dystric Brunisol

Area to be treated: approximately 350 m long * 10 m wide *2 banks = 0.7 ha

Riparian Class: S2: RMA = 50 m, RRZ = 30, RMZ = 20m

Site Photo: Thinned or cleared riparian areas (see Figs. 19B and 20B).

Objectives:

- promote overhanging shrubs to provide bank stability, shade, small organic debris and surface filtering,
- provide source of long-term LWD, and
- stabilise stream channel by establishing deep rooting deciduous and coniferous species

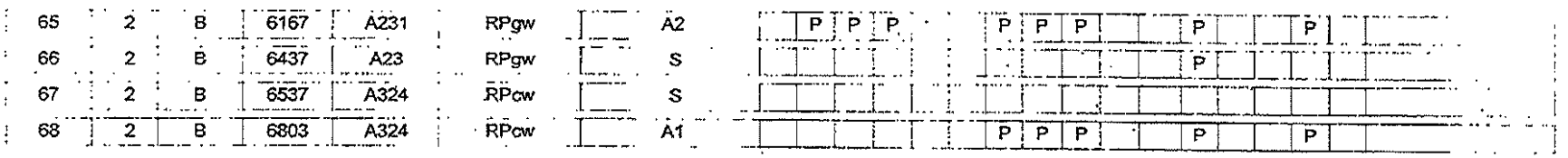
Overview:

A cleared area with limited riparian vegetation between 1+700 m and the Farewell Road Bridge at 2+290 m will require riparian planting to rehabilitate riparian function. Width of the replanted area will depend on negotiations with the landowner. We will assume a 10 m riparian zone. Although this is much less than the 30 m riparian reserve zone required by the Forest Practices Code, re-establishing a wider zone may be impractical given the circumstances. Black cottonwood whips and hybrid spruce will be planted in a nurse-tree shelterwood system between 3 and 10 m from the bank to increase shading and provide a long-term source of LWD. Within 2 m of the creek bank, cottonwood cuttings will be interspersed with red osier dogwood (*Cornus stolonifera*) (on mid bench) or willow (on low bench) every 20 m. All cuttings should be made at a 45° angle and come from 1st or 2nd year growth. Preferred species of willow include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow (*S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). Bebb's willow (*S. bebbiana*) may also be an option if it is common along the creek. Willow species found growing in the area should be given preference. Scouler's willow (*S. scouleriana*) should be avoided as it requires special treatment to root (Triton 1993).

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 2
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: HELPS CREEK
Watershed Code: 460-437000-00000-00000-0000-0000-000-000-000-000-000-000
Survey Date: 99/09/08
Crew: MJ, GT, GG, RH

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	2	A	0	A1	RPgw	S																	
2	2	A	152	A34	RPgw	S												P					
3	2	A	161	A1	RPgw	S	P								P								
4	3	A	0	A1	RPgw	S									P								


65 2 B 6167 A231 RPgw A2
66 2 B 6437 A23 RPgw S
67 2 B 6537 A324 RPcw S
68 2 B 6803 A324 RPcw A1

29	1	C	3275	A312	RPgw	D1						P	P								P		
30	1	C	3510	A321	RPgw	S						P									P		
31	1	C	3807	A123	RPgw	S																	
32	1	C	3916	A12	RPgw	S																	
33	1	C	4047	A123	RPgw	A1									P						P		
34	1	C	4608	A231	RPgw	A2	P	P	P					P	P								
35	1	C	5091	A32	RPgw	A3				P		P	P	P	P	P		P			P		
36	1	C	5216	A31	RPgw	A3				P		P	P	P	P		P	P					
37	2	A	0	A32	RPgw	A2				P		P	P		P			P			P		
38	2	A	420	A324	RPcw	A1						P	P		P			P			P		
39	2	A	600	A342	CPcw	A1			P				P	P	P			P			P		
40	2	A	1000	A32	RPcw	A1			P				P	P	P								
41	2	A	1200	A342	CPcw	A1							P	P	P								
42	2	A	1300	A342	CPcw	A2		P	P	P			P	P	P	P		P			P		
43	2	A	1936	A213	RPgw	A1							P	P	P								
44	2	A	2027	A125	RPgw	A1			P			P		P	P			P		P			
45	2	A	2231	A125	RPgw	A1			P	P				P	P			P		P			
46	2	B	2587	A12	RPgw	D1	P						P		P			P			P		
47	2	B	2727	A12	RPgw	A1									P					P			
48	2	B	2877	A12	RPgw	A1	P						P		P								
49	2	B	2927	A12	RPgw	S									P						P		
50	2	B	3162	A12	RPgw	S								P	P						P		
51	2	B	3507	A12	RPgw	A1									P			P			P		
52	2	B	3727	A1	RPgw	S								P	P								
53	2	B	3777	A12	RPgw	A1			P				P	P	P				P				
54	2	B	3977	A12	RPgw	D1					P							P			P		
55	2	B	4159	A12	RPgw	S															P		
56	2	B	4277	A12	RPgw	S						P	P					P			P		
57	2	B	4437	A12	RPgw	D1						P	P					P			P		
58	2	B	4577	A12	RPgw	A1						P	P								P		
59	2	B	4657	A12	RPgw	D1					P	P	P		P			P		P	P		
60	2	B	4757	A12	RPgw	S																	
61	2	B	4927	A12	RPgw	A1						P	P	P	P						P		
62	2	B	5247	A12	RPgw	D1					P	P	P										
63	2	B	5337	A321	RPgw	A1				P				P	P			P			P		
64	2	B	5947	A231	RPgw	S												P					

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 3
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: THOMPSON CREEK
Watershed Code: 460-517700-00000-00000-0000-0000-000-000-000-000-000-000
Survey Date: 99/09/21
Crew: MJ,GT,GG,RH

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A1	RPgw	S																	
2	1	A	25	A123	RPgw	D1							P					P		P	P		
3	1	A	125	A12	RPgw	D1			P			P	P								P		
4	1	B	200	A12	L	S																	
5	1	B	500	A12	L	S																	
6	1	C	615	A1234	CPcw	D1						P	P			P		P		P	P		
7	1	C	937	A1234	CPcw	A1						P	P	P	P								
8	1	C	961	A1234	CPcw	D1						P	P				P	P					
9	1	C	1045	A1234	CPcw	D1						P	P		P	P		P					
10	1	C	1069	A231	RPgw	A1				P		P	P	P				P		P	P		
11	1	C	1135	A234	CPcw	D1						P	P					P		P	P		
12	1	C	1190	A231	CPcw	A1				P		P	P					P					
13	1	C	1230	A12345	CPcw	D1						P	P					P	P		P		
14	1	C	1370	A21	RPgw	S															P		
15	1	C	1420	A123	CPcw	D1																	
16	1	C	1452	A12	RPgw	A1									P					P			
17	1	C	1585	A21	RPcw	S						P	P							P	P		
18	1	C	1708	A12	RPgw	A1						P	P	P	P					P			
19	1	C	1950	A12	RPgw	A1				P		P	P	P	P			P					
20	1	C	2140	A1243	RPcw	D1						P	P					P			P		
21	1	C	2248	A12	L	A1																	
22	1	C	2275	A124	RPgw	A1						P	P										
23	1	C	2350	A124	RPcw	S					P	P	P		P			P					
24	1	C	2436	A12	RPcw	D1					P	P	P								P		
25	1	C	2750	A12	RPcw	S							P		P								
26	1	C	3034	A12	RPgw	D1					P	P	P										
27	1	C	3066	A1245	RPgw	A1								P	P					P			
28	1	C	3163	A41	RPcw	D1					P	P	P			P							

29	1	B	6032	A213	RPgw	D1	P						P			P					P		
30	1	B	6214	A32	RPgw	A1			P	P				P	P			P			P		
31	1	B	6324	A32	RPcw	D1	P						P			P		P			P		
32	1	B	6941	A32	RPcw	A1								P	P			P			P		
33	2	A	0	A342	CPcw	A1						P	P	P		P		P			P		
34	2	A	57	A3425	CPcw	D1						P	P			P		P			P		
35	2	A	147	A321	RPgw	A2						P	P	P	P	P	P	P			P		
36	2	A	590	A432	CPcw	S						P	P								P		
37	2	A	700	A342	CPcw	A1						P	P	P	P						P		
38	2	A	890	A342	CPb	S						P									P		
39	2	A	1008	A342	CPb	A1						P		P	P						P		

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 9
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: DEEP CREEK
Watershed Code: 460-496100-00000-00000-0000-0000-000-000-000-000-000-000
Survey Date: 99/09/11
Crew: GT,MJ,GG,RH

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A32	RPgw	A2				P								P			P		
2	1	A	120	A13	RPgw	A2			P	P				P				P			P		
3	1	A	188	A231	RPgw	A2		P		P				P				P			P		
4	1	A	390	A123	RPgw	A2				P				P			P	P			P		
5	1	B	780	A321	RPgw	A1							P					P			P		
6	1	B	1403	A231	RPcw	D1					P		P			P		P			P		
7	1	B	1604	A231	RPgw	A1							P					P			P		
8	1	B	1648	A31	RPcw	D1																	
9	1	B	1709	A13	RPgw	D1	P						P					P		P			
10	1	B	1945	A3421	RPgw	D1	P						P	P				P			P		
11	1	B	2166	A1	RPgw	D1								P			P	P					
12	1	B	2420	A1	RPgw	A1			P			P	P										
13	1	B	2540	A12	RPgw	A1						P	P					P		P			
14	1	B	2690	A1	RPgw	D1						P								P			
15	1	B	2926	A123	RPgw	A2			P	P		P					P	P	P	P			
16	1	B	3595	A123	RPgw	D2					P	P	P						P				
17	1	B	3620	NA	RPgw	S																	
18	1	B	3640	A32	RPgw	A3				P				P	P		P	P	P		P		
19	1	B	4038	A231	RPgw	A2								P				P			P		
20	1	B	4338	A231	RPgw	A3				P				P			P	P	P		P		
21	1	B	4544	A324	RPgw	A1						P	P					P			P		
22	1	B	4653	A32	RPgw	A3			P					P				P			P		
23	1	B	4964	A312	RPgw	A1						P		P				P			P		
24	1	B	5277	A342	RPgw	A1			P					P				P			P		
25	1	B	5390	A342	RPgw	D1	P					P	P	P		P		P			P		
26	1	B	5581	A231	RPgw	A2				P			P	P	P			P			P		
27	1	B	5721	A231	RPgw	A1								P							P		
28	1	B	5930	A231	RPgw	A2				P			P	P				P			P		

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Gravel bars and toe of bank.	130 m	Dormant willow cuttings (60-80 cm with 2-3 cm butt diam.) Keep in water prior to planting. Bury to a depth equivalent to ¾ of cutting length (lean downstream), leaving at least 2 buds exposed.	None required. Cuttings to be inserted into manually driven pilot holes.	Early May prior to flooding or in the in the autumn once plants are dormant. Later spring may be an option if plants are collected prior to bud burst and stored in a freezer until used.	In bundles of 3, 1 m apart.	470 willow whips.
1-10 m	0.13 ha	Rooted aspen from nursery.	Manually brush and screef a $1m^2$ area (56 cm radius) using a grub hoe or shovel and remove roots of competing vegetation; place 90 cm x 90 cm brush mats around planted cuttings. In areas with little competing vegetation, brush mats may not be necessary.	Early May (see above)	A plant ecologist or forester should determine spacing for clusters.	To be determined with site visit and development of a prescription.
		Hybrid spruce styroblock stock.	Spruce to be planted in clumps using a planting shovel. Place brush mats around the planted cuttings to discourage growth of competing plants.	Early May (see above)	Numbers per site will be determined by a plant ecologist or forester. Spruce should not be planted on low-bench or wet areas.	To be determined with site visit and development of a prescription.

* This estimate includes a 20% contingency for damaged stock.

Risks: Frost, flooding, drought, voles (consider using vole collars), cattle trampling, and competition from other plants.

Monitoring: Conduct walk-through assessments each year for three years in the late summer to determine plant performance and survival and the cattle influence on the site. Manual brushing may be required. Planted trees may require thinning after a decade.

Riparian Rehabilitation Recommendation #3

- Note: To be implemented in conjunction with Rehabilitation Recommendation: Thompson #3 (see Appendix F).

Reach: Thompson Creek Reach 2

Location: Impact site T9. Reach 2 (2+027 m to 2+157 m)

Land Tenure: Private (William Dieleman). Contact landowner to access land.

TRIM/Forest Cover Mapsheet: 93L057

Forest Cover Polygons: 458, 451

Flightline and Air Photo Number: 30BC 91183 No. 42

Closest riparian assessment sites: GT2 (downstream) and MJ4 (upstream)

Site Series / Structural stage: SBSdk06 (GT2) / Initial (Left bank)

Soil type: Dystric Brunisol (at GT2)

Area to be treated: approximately 130 m long * 10 m wide *right bank = 0.13 ha

Riparian Class: S3: RMA = 40 m, RRZ = 20, RMZ = 20m

Site Photo: Bank shear and cleared land on right bank at 2+077 m (Fig. 27D).

Objectives:

- promote overhanging shrubs to provide bank stability, shade, small organic debris and surface filtering, and
- increase the potential for sources of long-term LWD, thus increasing cover and stream complexity.

Overview:
Cattle move down from an upslope pasture to water from the left bank of the creek between 2+027 m and 2+157 m. Through most of the site, trees are absent or rare, and the herb layer has been grazed or trampled and is functioning poorly as a sediment filter and bank stabilising agent.

Width of the replanted area will depend on negotiations with the landowner. We will assume a 10 m riparian zone. A wide riparian zone may be agreed upon. Along the bars and banks, plant willow where shrubs are no longer growing. Preferred species of willow include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow (*S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). Bebb's willow (*S. bebbiana*) may also be an option if it is common along the creek. Willow species found growing in the area should be given preference. Scouler's willow (*S. scouleriana*) should be avoided as it requires special treatment to root (Triton 1993). All cuttings should be made at a 45° angle and come from 1st or 2nd year growth. In a band one to 10 m from the bank, in areas with an initial stand structure, several clusters of hybrid spruce will be planted among planted trembling aspen (*Populus tremuloides*) to increase shading and to provide LWD in the future.

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Gravel bars and toe of bank (Left bank)	20 m	Dormant willow cuttings (80 cm with 3 cm butt diam.) Keep in water prior to planting. Plant to a depth of 55 cm leaning downstream.	None required. Cuttings to be inserted into manually driven pilot holes.	Early May prior to flooding. If site is too wet, plant in autumn once plants are dormant. Due to the small area to be planted, later spring may be an option if plants are collected prior to bud burst and stored in a freezer until used.	1 m apart	50
Upslope of brush mat on right bank (3-10 m) and 1-10 on right bank.	0.2 ha	Cottonwood and aspen cuttings 80-120 cm long with 3 cm diam. butt (shorter nearer to stream). Bury ¾ of cutting length into soil.	Manually spot scarify a $1m^2$ area (56 cm radius) and remove roots of competing vegetation; place 90 cm x 90 cm brush mats around planted cuttings.	Early May to correspond with willow planting and brush mattress installation.	To be determined in site prescription	To be determined upon additional site visit. Plant cottonwood in lower areas and aspen further up on slope.

* This estimate includes a 20% contingency for damaged stock.

Riparian Rehabilitation Recommendation: Thompson #2

- Note: to be implemented in conjunction with Rehabilitation Recommendation: Thompson #2 (see Appendix F).

Reach: Thompson Creek Reach 1

Location: Impact site T3 (1+420 to 1+440 m)

Land Tenure: Private (James Berkery) (access may be via Lies Rouw's land). Contact landowners to access land.

TRIM/Forest Cover Mapsheet(s): 93L056

Forest Cover Polygon: 212

Flightline and Air Photo Number: 30BCB 91112 No. 90

Closest riparian assessment sites: N/A

Site Series / structural stage: Adjacent south-facing slope is SBSdk81. Site series for the creek edge is unknown. Structural stage is Initial.

Area to be treated: 20 m long * approx. 10 m wide * 2 banks = 0.02 ha

Riparian Class: S3: RMA = 40 m, RRZ = 20 m, RMZ = 20 m

Objectives:

- promote overhanging shrubs to provide bank stability, shade, small organic debris and surface filtering, and
- establish source of LWD in future.

Overview:
The riparian area between 1+420 and 1+440 m has been cleared and grazed by cattle. This site is also used as a cattle crossing and watering area. The banks are slumping and eroding. Shading, small organic debris, and vegetation cover for fish is lacking. Rehabilitation Recommendation: Thompson #2 outlines the placement of riprap and a brush mattress on the outside corner of the stream at this site. Upslope of the brush mattress and upslope of the opposite bank plant live cuttings from cottonwood and aspen. We suggest willow cuttings be planted along the toe of the bank on the inside corner. Preferred species include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow (*S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). This fast growing pioneer vegetation will help protect the stream banks from erosion, provide small organic debris and shade the creek. Roots will catch sediments which will help build the banks.

Risks: Frost, flooding, drought, competition from grasses and weeds such as Canada thistle (*Cirsium arvense*) and cattle grazing.

Monitoring: Conduct walk-through assessments for at least three years in the late summer to determine plant performance and cattle influence. Willows may require pruning. Planted trees may require thinning after a decade. The landowner could potentially keep an eye on tree growth.

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Stream banks	230 m	See Rehabilitation Recommendation: Thompson #1.				
1-10 m (for 0+200 to 0+430 m)	0.35 ha	Cottonwood cuttings 200 cm long with 3 cm diam. butt.	Insert 5 cottonwood cuttings into a 140 cm deep hole dug by a tracked backhoe (wheeled if ground is hard), leaving 60 cm of cutting exposed. A deep hole will allow roots to access the water table and a 60 cm exposed stem will provide some protection from competing plants.	Depends on state of field. If too wet in early spring to allow backhoe access without damaging soil, plant in autumn after buds have set.	Clusters to be spaced 3 m apart.	1380 for one bank. 690 for the other bank assuming half will be planted.
		Hybrid spruce styroblock stock.	Use backhoe bucket to spot scarify a 1 m by 1 m area between the cottonwood clusters.	To be planted immediately after the cottonwood.	Spruce to be planted every 3 m (1.5 m from each cottonwood clusters.	276 for one side. 138 for the other bank assuming half will be planted. .

* This estimate includes a 20% contingency for damaged stock.

soil disturbance when wet, planting should be done in the fall when the ground is harder and plants are dormant.

The area from the reach break to 0+200 m contains some young and mature trees. A stocking assessment is required in this area to determine planting requirements.

Risks: Frost, flooding, drought, voles (consider using vole collars), cattle grazing.

Monitoring: Perform a stocking and brush survey at the end of the first growing season to determine survival and tree performance. Permanent sample plots with monitoring at least once per year is recommended for several years. Cattle influence on the area should be assessed. Manual brushing may be required. Planted trees may require thinning after a decade. The landowner may be able to keep an eye on tree growth.

Horses in the area will have to be kept away from the planted areas.

In current areas of overstocked pole-saplings, thinning should be considered to proper stocking levels to release the growing trees.

Risks: Frost, flooding, drought, voles. Consider using vole collars.

Monitoring: Perform a stocking and brush survey at the end of the first growing season to determine survival and tree performance. Permanent sample plots with monitoring at least once per year is recommended for several years. Manual brushing may be required. Planted trees may require thinning after a decade.

Riparian Rehabilitation Recommendation: Deep #3

- Note: to be implemented in conjunction with Rehabilitation Recommendation Deep #4 (see Appendix F).

Reach: Deep Creek Reach 1

Location: Impact site D2 (1+700 to 2+290 m)

Land Tenure: Private (Robert Kirsch). Contact landowner to access land.

TRIM/Forest Cover Mapsheet: 93L056

Forest Cover Polygon: 127

Flightline and Air Photo Number: 30BCC 687 No. 57

Close riparian assessment sites: MG1

Site Series / structural stage: SBSdk08 / Herb, shrub

Soil type: Dystric Brunisol

Area to be treated: approximately 350 m long * 10 m wide *2 banks = 0.7 ha

Riparian Class: S2: RMA = 50 m, RRZ = 30, RMZ = 20m

Site Photo: Thinned or cleared riparian areas (see Figs. 19B and 20B).

Objectives:

- promote overhanging shrubs to provide bank stability, shade, small organic debris and surface filtering,
- provide source of long-term LWD, and
- stabilise stream channel by establishing deep rooting deciduous and coniferous species

Overview:

A cleared area with limited riparian vegetation between 1+700 m and the Farewell Road Bridge at 2+290 m will require riparian planting to rehabilitate riparian function. Width of the replanted area will depend on negotiations with the landowner. We will assume a 10 m riparian zone. Although this is much less than the 30 m riparian reserve zone required by the Forest Practices Code, re-establishing a wider zone may be impractical given the circumstances. Black cottonwood whips and hybrid spruce will be planted in a nurse-tree shelterwood system between 3 and 10 m from the bank to increase shading and provide a long-term source of LWD. Within 2 m of the creek bank, cottonwood cuttings will be interspersed with red osier dogwood (*Cornus stolonifera*) (on mid bench) or willow (on low bench) every 20 m. All cuttings should be made at a 45° angle and come from 1st or 2nd year growth. Preferred species of willow include Pacific willow (*Salix lasiandra)*, Drummond's willow (*S. drummondiana)* and Sitka willow (*S. sitchensis*). These species are common in exposed gravel bars and riparian thickets (SKR and Oikos 1999; Triton 1993). Bebb's willow (*S. bebbiana*) may also be an option if it is common along the creek. Willow species found growing in the area should be given preference. Scouler's willow (*S. scouleriana*) should be avoided as it requires special treatment to root (Triton 1993).

Summary:

Distance from Creek	Net area / length	Species and size	Site prep	Timing	Spacing	Amount*
Gravel bars and toe of bank.	175 m	Dormant willow cuttings (80 cm with 3 cm butt diam.) Keep in water prior to planting. Plant to a depth of 55 cm leaning downstream.	None required. Cuttings to be inserted into manually driven pilot holes.	Early May prior to flooding. Try to plan for year when floods are not expected to be high. If site is too wet, plant in fall once plants are dormant. Later spring may be an option if plants are collected prior to bud burst and stored in a freezer until used.	1 m apart	Up to 420.

* This estimate includes a 20% contingency for damaged stock.

APPENDIX A. OVERALL RATINGS AND RANKINGS FROM OVERVIEW ASSESSMENT AND DECISION MATRIX

Stream	Reach	Reach Length (m)	Matrix Score	Ranking	Comments
Helps	2	150	25.30	1	S3, CH and CO present, short reach, 2 crossings
Unnamed	1	1400	15.86	2	Steep gully, 6.2% gradient
Vanderven	1	1800	15.10	3	
McDowell	1	4200	14.95	4	CO present at Bulkley R., small creek, low priority
Unnamed	2	1200	14.67	5	Steep gully, 6% gradient
Thompson	1B	4300	14.00	6	Length for all of reach 1
Helps	3A	1200	13.70	7	Several crossings
Helps	6	2800	13.40	8	Heavily logged, no access
Deep Creek	1	5000	12.90	9	
de Jong	1B	600	12.20	10	
Stock	2	1000	12.00	11	Small creek, low priority
Coffin	1B	1950	12.00	12	Large channel through logged wetland
Edward	4	4200	12.00	13	Logged, but poor access
Helps	1	300	12.00	14	S2 classification, side/back channel of Bulkley R.
McDowell	2	2200	12.00	15	Small creek, low priority
Mathews	3	2100	11.90	16	S4 classification - low priority
Lemieux	5	3800	11.79	17	
Robin	2	4200	11.74	18	
Mathews	2	600	11.70	19	S4 classification - low priority
Deep Creek	2	5800	11.50	20	
Vallee	5A	2500	11.40	21	S4 - low priority
Coffin	1A	2950	11.40	22	Heavily logged
Lemieux	1	2400	11.25	23	
Stock	3	1500	11.20	24	
Unnamed	3	4600	11.00	25	Steep gully, 10.5% gradient
Stock	4	2600	11.00	26	S4 - low priority
Edward	2	2000	11.00	27	
Edward	3	7400	11.00	28	
Robin	3	400	11.00	29	
Thompson	2	6400	10.80	30	
Robin	1	2000	10.50	31	
de Jong	2A	980	10.50	32	
Vallee	2C	1200	10.30	33	
Gibson	3	1000	10.00	34	Heavily impacted riparian, access issues
Helps	7	1400	10.00	35	15% gradient, no access
Lemieux	3	1200	10.00	36	Heavily impacted riparian
Edward	1	1400	9.63	37	
McDowell	5	1600	9.63	38	
Vallee	1	4400	9.50	39	
Robin	6B	1200	9.50	40	
Stock	1	700	9.40	41	
Gibson	1	1800	9.00	42	
McDowell	3	2800	9.00	43	

Stream	Reach	Reach Length (m)	Matrix Score	Ranking	Comments
Vanderven	5	1800	9.00	44	
Mathews	1	1300	8.80	45	Small stream with little flow in summer
Vallee	2B	1600	8.60	46	
Helps	5	1600	8.60	47	
Deep Creek	4	1400	8.00	48	
Stock	5	600	8.00	49	S4 - low priority
Robin	6C	2050	8.00	50	
de Jong	3	6000	7.80	51	
Vanderven	2	4000	7.50	52	
Vanderven	6	2700	7.50	53	S4 - low priority
Deep Creek	3	1200	7.00	54	
Thompson	1A	4300	7.00	55	Length for all of reach 1
Vallee	2A	900	7.00	56	
Vallee	5B	1300	7.00	57	S4 - low priority
Lemieux	2	400	7.00	58	Pond/wetland
Lemieux	4	200	7.00	59	Pond/wetland
de Jong	2B	1700	7.00	60	
Gibson	2	1300	6.00	61	
Vallee	3	1000	6.00	62	Wetland
Robin	5	400	6.00	63	
Robin	6A	350	6.00	64	
Vanderven	4	900	6.00	65	
Coffin	1C	1500	5.00	66	Large channel through wetland
de Jong	1A	400	5.00	67	
Helps	3B	1800	4.00	68	Wetland
Helps	4	110	4.00	69	Lake/pond, no access
McDowell	4	400	3.00	70	Lake/pond
Robin	4	100	3.00	71	
Vallee	4	600	0.00	72	Lake
Vanderven	3	190	0.00	73	
Dahle	1	268			Level 1 assessment by default
Dahle	2	280			Level 1 assessment by default
Dahle	3A	2600			Level 1 assessment by default

= Level 1 assessment conducted

APPENDIX B. SUMMARY OF KEY REACH CHARACTERISTICS

Stream	Reach	Riparian Function	LWD Function	Functional LWD/ Wb	Pool Frequency	Pool/Wb ratio	Comp Index
Robin	1	M-H	M	0.16	L		3.65
	2	L	L	0.09	L	12	3.14
	3	L	L	0.04	L	0	2.51
Lemieux	1	L	L	0.14	L	12	3.3
	3	L	L	0.25	M	9	3.39
	5	M-H	M	0.35	M	8.4	3.5
Vanderven	1	L	L	0.03	L	16.4	2.64
	2A	M	M	0.31	L	19	3.37
deJong	1	L-M	M	0.42	M	11	2.84
	2	H	M-H	0.42	L	20	3.1
Deep	1	L-M	M-H	0.66	H	4.3	3.2
	2	M-H	M	0.35	H	3.7	3.73
Thompson	1	L-M	L	0.36	H	7.8	3.51
	2	M	M	0.35	H	6.7	3.34
Helps	1	M	L				
	2	L-M	L	0.31	H	4.8	3.17
	3	M	L-M		H		3.85
Moan	1	M-H	M	0.43	H	5.5	3.84
	2	M-H	M	0.63	L	13.2	3.48
Coffin Lk	1	M-H	M	0.56	H	7.5	3.67

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 5
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: ROBIN CREEK
Watershed Code: 460-487900-00000
Survey Date: 99/10/01
Crew: MJ,GT,GG,RH

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A321	RPgw	A1												P			P		
2	1	A	355	A12	L	S	P	P	P						P								
3	1	A	588	A24	RPgw	A1		P	P						P						P		
4	1	A	719	A12	L	S	P	P	P						P								
5	1	A	829	A123	RPgw	A1		P	P						P								
6	1	A	885	A12	L	S	P	P	P						P								
7	1	A	1061	A12	RPgw	A1		P	P					P	P								
8	1	A	1278	A12	L	S	P	P	P						P								
9	1	A	1418	A12	RPgw	A1	P		P					P	P		P		P	P			
10	1	A	1963	A12	RPgw	S									P					P			
11	1	A	2298	A12	RPgw	A1									P					P			
12	2	A	0	A12	L	S														P			
13	2	B	360	A12	RPgw	S	P													P			
14	2	B	451	A12	RPgw	A1								P				P			P		
15	2	B	785	A12	RPgw	A2								P				P			P		
16	2	B	1250	A123	RPcw	D2					P							P			P		
17	2	B	1375	A12	RPgw	D1					P										P		
18	2	B	1415	A12	RPgw	D2					P				P			P	P				
19	2	B	1455	A12	RPgw	A1								P	P								
20	2	B	1574	A12	RPgw	D1					P		P					P			P		
21	2	B	1700	A12	RPgw	A1							P		P						P		
22	2	B	1876	A12	L	S																	
23	2	B	2070	A12	RPcw	S															P		
24	2	B	2213	A12	L	S																	
25	2	B	2271	A12	RPgw	A1							P		P								
26	2	C	2350	A12	L	S																	
27	2	D	2880	A12	RPgw	S	P																
28	2	D	3050	A12	RPgw	A1							P					P			P		

29	2	D	3178	A12	RPgw	S								P		P								
30	2	D	3315	A12	RPgw	A2							P	P					P			P		
31	2	D	3750	A12	RPcw	A2							P	P	P	P	P		P			P		
32	2	D	4648	A12	RPcw	A1													P			P		
33	3	A	0	A12	RPgw	S										P								
34	3	A	52	A12	U	S																		
35	3	A	247	A12	U	S																		

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 6
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: LEMIEUX CREEK
Watershed Code: 460-487900-11100-00000-0000-0000-000-000-000-000-000-000
Survey Date: 99/10/02
Crew: MJ,RH

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A12	L	S	P								P		P				P		
2	1	A	200	A12	RPgw	S	P	P	P						P		P				P		
3	1	A	460	A12	RPgw	S	P	P	P												P		
4	1	A	920	A312	RPgw	A1		P	P	P				P				P			P		
5	1	A	1157	A123	RPgw	D1	P				P	P	P					P			P		
6	1	A	1250	A123	RPgw	A1		P										P			P		
7	1	A	1650	A12	RPgw	A1	P	P	P						P								
8	1	A	1830	A12	L	S									P								
9	1	A	2240	A12	RPgw	A1	P	P	P						P			P					
10	1	A	2663	A12	L	S																	
11	3	A	0	A12	L	S	P											P					
12	3	A	170	A12	RPgw	S	P	P										P			P		
13	3	A	192	A12	L	S	P											P					
14	3	A	280	A12	RPgw	A1		P	P									P			P		
15	3	A	530	A12	RPgw	S	P	P										P					
16	3	A	1160	A12	RPgw	A1		P	P					P				P					
17	5	A	0	A12	RPgw	A1		P		P				P	P								
18	5	A	190	A12	RPgw	A2		P	P	P		P	P	P							P		
19	5	A	500	A241	RPcw	A2				P		P	P	P	P	P		P	P		P		
20	5	A	1650	A234	CPcw	D1						P	P			P					P		
21	5	A	1850	A234	RPcw	A1						P	P	P	P			P			P		
22	5	A	2150	A234	CPcw	A1						P		P	P			P					
23	5	A	2800	A342	CPcw	D1						P	P			P							
24	5	A	3550	A324	RPcw	A1				P				P	P								
25	5	A	3700	A324	CPcw	D1						P	P			P							

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 7
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: VANDERVEN CREEK
Watershed Code: 460-487900-37600
Survey Date: 99/10/15
Crew: GT,GG

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A12	RPgw	S															P		
2	1	A	73	A123	RPgw	D2						P	P								P		
3	1	A	541	A123	RPgw	D2							P								P		
4	1	A	825	A123	RPgw	D1												P		P	P		
5	1	A	975	A12	RPgw	D2												P			P		
6	1	A	1097	A12	RPgw	A1							P	P	P						P		
7	1	A	1234	A12	RPgw	D1												P			P		
8	2	A	0	A123	RPgw	A2							P	P	P			P			P		
9	2	A	140	A1234	RPcw	D1								P		P		P			P		
10	2	A	270	A1432	RPcw	D2								P		P		P					
11	2	A	360	A3421	RPcw	A1				P													
12	2	A	420	A3421	CPcw	D2						P	P			P					P		
13	2	B	565	A3142	CPcw	D1						P	P			P					P		
14	2	B	631	A3142	CPcw	A1							P		P						P		

Integrated FHAP/CAP Field Procedure- Channel Disturbance Level Report

Form Number: 8
Forest District: BULKLEY
Watershed Name: CENTRAL BULKLEY
Sub-Basin Name: DEJONG CREEK
Watershed Code: 460-487900-37900
Survey Date: 99/10/14
Crew: GT,GG

Detail #	Reach	Section	Distance	Bank Type	Channel Type	Disturbance Level	S1	S2	S3	S4	S5	C1	C2	C3	C4	C5	B1	B2	B3	D1	D2	D3	Photo Roll/Frame
1	1	A	0	A12	RPgw	S														P			
2	1	A	200	A21	RPgw	A2			P				P					P		P			
3	1	A	335	A12	RPgw	A1			P				P		P								
4	1	A	426	A321	RPgw	A2								P	P						P		
5	1	B	485	A132	RPgw	D2					P	P	P					P			P		
6	1	B	610	A132	RPcw	D2					P	P	P						P		P		
7	1	C	841	A12	RPcw	D1					P	P	P			P					P		
8	1	C	905	A1243	RPcw	A1				P			P		P					P	P		
9	2	A	0	A1234	RPcw	A1			P				P		P	P		P	P		P		
10	2	A	560	A312	RPcw	A2			P	P			P		P						P		
11	2	A	660	A123	RPcw	A1			P						P						P		
12	2	A	870	A1243	RPcw	A1			P				P								P		