General Disclaimer

The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the Government of British Columbia of any product or service to the exclusion of any others that may also be suitable. Contents of this report are presented as information only. Funding assistance does not imply endorsement of any statements or information contained herein by the Government of British Columbia. Uniform Resource Locators (URLs), addresses, and contact information contained in this document are current at the time of printing unless otherwise noted.

Disclaimer of Liability

With respect to documents available from this server, neither the Government of British Columbia nor any of their employees, makes any warranty, express or implied, including the warranties of merchantability and fitness for a particular purpose, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Upper Zymoetz (Copper River) WRP

Overview Fish and Riparian Assessment

Prepared for:
Ministry of Environment, Lands and Parks
Bulkley Forest District
Smithers, BC

May 1999

Prepared by:

TRITON
Environmental Consultants Ltd.

Box 88
Terrace, B.C., V8G 4A2
Phone: (250) 635-1494
Fax: (250) 635-1495

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS USED IN REPORT AND ON MAPS

Abbreviation	Definition
CH	chinook salmon *(Oncorhynchus tshawytscha)*
CO	coho salmon *(Oncorhynchus kisutch)*
SK	sockeye salmon *(Oncorhynchus nerka)*
DV	Dolly Varden char (*Salvelinus malma*)
BT	Bull Trout (*Salvelinus confluentus)*
RB or ST	rainbow or steelhead trout *(Oncorhynchus mykiss)*
CT	cutthroat trout *(Oncorhynchus clarki clarki)*
*	Indicates spawning habitat (i.e.: CO* = coho spawning location)
( )	Suspected fish presence, seasonally or year round based on access, gradient or habitat capabilities, i.e. (DV) = suspected Dolly Varden.
NFC	No fish caught
DFO	Department of Fisheries and Oceans
MELP	Ministry of Environment, Lands and Parks
FISS	Fisheries Information Summary System (DFO/MoE)
SISS	Fish Habitat Inventory and Information Program Stream Summary Catalogues
WRTC	Watershed Restoration Technical Circular
SHA	Steelhead Harvest Analysis
VO	Visual observation
FPC	Forest Practices Code
S1 - S6	Stream classifications S1 to S6 based on Ministry of Forests, Forest Practices Code, Riparian Management Area Guidebook.
ILP	Interim Locational Point (numeric)
NID	Numeric Identifier
FSZ	Fisheries Sensitive Zone
FDZ	Forestry Development Zone (refers to terrain stability maps)
TSIH	Terrestrial Sediment Input Hazard (refers to 1:250 000 scale DFO Salmon Habitat Sensitivity map for the Bulkley Forest District)
LWD	Large Woody Debris
EFU	End of Fish Use
FPC	Forest Practices Code
RMA	Riparian Management Area
FSR	Forest Service Road
M/L	Mainline (road)
BR	Branch line (road)

Executive Summary

An overview assessment of the upper Copper River watershed was completed by Triton for the Ministry of Environment, Lands and Parks, Bulkley Region in February, 1999. The purpose of the assessment was to identify forestry related impacts to fish, fish habitats and riparian areas, and to provide recommendations to guide further assessment or restoration works. A detailed background review was completed to identify all known fisheries values within the study area. A riparian assessment was completed to determine the status of riparian areas within study area. The overview assessment was an office based process, using air photo and map interpretation exclusively to identify known or potential impacts.

The Copper River is a well known producer of steelhead and has been rated as one of the top 10 steelhead fishing rivers in the province. The Copper also supports all 5 species of pacific salmon as well as resident trout, Dolly Varden and bull trout. Salmonid populations have high economic, cultural and recreational values within BC and declines in these populations (particularly steelhead and coho) throughout the province have created a need for habitat assessment and rehabilitation programs. The Copper river, with its high recreational fisheries values, is an excellent area in which to promote and protect fish productivity by implementing WRP projects.

The study area is approximately 90,000 ha, and is located within the upper Zymoetz (locally known as the Copper) River watershed. The study area was divided into 11 sub basins which were prioritized for more detailed assessments. Overall rankings of each sub-unit were established with priority given to areas where fisheries values, impact hazard potential and the potential for success (increased productivity) resulting from restoration were high. Recommendations and cost estimates for further assessments and restoration projects are provided.

The sub-units identified within the project are: Red Canyon Creek, Lee Creek, Copper Mainstem, Serb Creek, Sandstone Creek, McDonell Lake, Silvern (including Dennis and Aldrich Lakes), Mulwain Creek, Willow Creek/Hankin, Passby Creek and Coal Creek. Fisheries values within the upper Copper watershed are very high. Salmonids are present in every major basin, typically to the headwaters where gradient precludes fish use. Extensive spawning, rearing and overwintering habitats for steelhead, sockeye, coho and Dolly Varden occur, both within the valley bottom and in many of the sub-basins. Lake headed systems (Coal, Sandstone, Hankin/Willow, Silvern) typically had the highest fisheries potential among sub-units, with the exception of the Copper River mainstem and McDonell lakes chain.

A total of 131 potential impacts were identified within the study area, the majority (104 or 80%) of which were related to road crossings. Of the total potential impacts, 15 were rated as high priority sites, 41 as moderate priority and 75 as low priority. The Silvern, McDonell and Copper sub-units had the highest number of impacts, as well as the highest priority ranking for further assessment/restoration. The Red Canyon Creek, Mulwain Creek, Serb Creek, Passby Creek and Lee Creek sub-units were found to be relatively pristine and had minimal or no forestry related impacts. Overall, forestry related impacts to fisheries values within the upper Copper River appear to be low.

A preliminary assessment of road crossings was recommended, at an estimated cost of $25,000, in order to reduce and focus further work to areas where the benefits to the fishery resource would be highest. This was suggested as a cost-saving alternative to a detailed Level 1 Assessment, because many of the road crossings identified as potential impacts may not require more than a quick field check for fish passage. The estimated cost of completing Level 1 assessments for the entire study area is approximately $54,000, and a preliminary budget is provided. Two sets of maps were produced, one showing all background fisheries information and known or potential impacts, the other shows the riparian polygons identified during the riparian assessment.

1. INTRODUCTION

Triton Environmental Consultants Ltd. was retained by the Ministry of Environment, Lands and Parks to complete an overview assessment of impacts to fish, fish habitat and riparian areas of the Zymoetz watershed under the Watershed Restoration Program (WRP). The objective of WRP programs is to restore the productivity of watersheds negatively impacted by forest development and harvesting. The project is funded by Forest Renewal British Columbia (FRBC), through the Bulkley Forest District, Smithers, BC. The Zymoetz River is known locally as the Copper River, and is referred to as such in this report.

This report summarizes fish and fish habitat values within the upper Copper River watershed and describes impacts to both the fisheries resource and riparian habitats resulting from forest development and harvesting activities. Recommendations for further assessment and restoration works are provided.

1.1 Purpose and Scope

The overview assessment provides a description of forestry/anthropogenic related impacts to fish, aquatic and riparian habitats within the study area obtained by integrating existing information available from air photos and forest development plan maps with historical fisheries information. The overview assessment is intended to provide a preliminary indication of factors which may limit fish production and to focus future field studies and restoration plans on areas where substantial benefits to the fishery resource are likely. Specifically the assessment attempts to:

- determine what fish species and life stages are at risk due to impacts resulting from forest harvesting/development.
- identify areas of concern (aquatic and riparian habitats) that need to be examined in quantitative field surveys, and to
- identify preliminary restoration strategies and provide cost estimates for these strategies.

The project area was divided into sub-units which were individually assessed and then prioritized for further studies. Eleven sub-units were delineated within the study area.

1.2 Assumptions and Limitations of Study

This study was undertaken as an office based exercise, with no preliminary overflight made. The assessment of impacts and habitat conditions was limited to air photo and map interpretation and as a result, the study was restricted in both scope and accuracy. Black and white air photos, taken in 1992 (approximate scale 1:18,000) were used for the majority of sub-unit assessments and as a result, many features are not apparent and/or could not be assessed in detail. A more recent (1995) air photo mosaic of the mainstem and areas immediately adjacent, at approximately 1:4000 scale, was used to assess impacts wherever possible. The coverage of these photos was limited. Historical air photos were not available for comparison of features such as channel morphology, riparian structure and sediment contribution over time.

In several areas cutblocks have occurred within the last 7 years which do not show up on the 1992 air photos. In these cases, it was assumed that most forest development was in accordance

with the Forest Practices Code (implemented in 1995) and that fish streams were identified and protected by riparian management area classifications as appropriate. As a result, suspected impacts that were identified in areas harvested since 1995 were given low priority for further assessment.

2. STUDY AREA

The Copper River watershed arises from a chain of headwater lakes (McDonell, Dennis and Aldrich lakes) 29 km southwest of Smithers, and flows 110 km to the confluence with the Skeena River. The Copper River is a 6th order system, draining a total watershed area of approximately 2,980 km^2. Mean annual discharge for the system is approximately 105m3/s (water survey of Canada gauging station 08EF005). The study area includes the Copper River mainstem and tributaries from (and including) Red Canyon Creek to the headwaters (Figure 1). The upper Copper is within the Bulkley Range of the Hazelton Mountains. The valley is relatively flat and wide, distinct from the steep and entrenched lower Copper River and tributaries. Eleven sub-units were identified within the study area (Figure 2).

2.1 Terrain Sensitivity

The areas west of Lee and Mulwain Creeks, (which includes the Red Canyon drainage within this study area), have been identified as potentially high terrain hazards, with erodible soils and natural slope failures occurring. (MoF File #12600-25, Vol. 2, 01/01/91 to present, cited in Roberts, 1995) Roberts cites the MoF File as recommending that development generally be precluded from these areas due to the high level of concern for the sensitivity of the terrain.

Of additional concern is the instability of terrain in areas of the Hankin/Willow drainage. The allowance of clearcut logging to the edge of a ravine or slope adjacent to a cutblock, as allowed by the Forest Practices Code, may not be suitable for this planning unit. Evidence is currently present of situations where the practice may have contributed to failures directly into the Willow Creek mainstem. (Roberts, 1995)

2.2 Access

Portions of the study area can be accessed via the Hudson Bay Mountain Road and the McDonell Lake Forest Service Road (FSR), which run along the north side of the McDonell Lakes chain past Sandstone and Coal Creeks. Numerous branch roads exist from the McDonell FSR which service the Coal, Sandstone, Hankin and McDonell sub-units. Tributaries draining into the southern shores of Dennis and McDonell lakes are accessed via the Dennis South and Dennis West FSR. Lower Serb Creek is also accessible via the Dennis West FSR. The Mulwain FSR provides access to lower sections of the Mulwain Creek sub-unit. The uppermost reaches of Serb Creek, Red Canyon Creek, Mulwain Creek and some of the large unnamed tributaries to the Copper require helicopter access.

2.3 Fisheries Resources

The Copper River has high fisheries values throughout. It is noted historically as a high value steelhead stream, once rated in the top 10 steelhead fishing rivers in the province, with high rearing, spawning and overwintering values for steelhead throughout. The upper river (from the

headwaters to Limonite Creek) is currently one of only 5 Class I angling areas in the provinces (Roberts, 1995).

Fisheries Information Summary System (FISS) maps indicate salmonid distribution throughout the watershed. Pink and chum occur to a canyon approximately 6.4km upstream from the Skeena confluence, downstream of the study area. Chinook are documented to Limonite Creek, also downstream of the study area, although no barriers exist which would definitively prevent them from migrating further in the system. Within the study area the following distribution is documented: coho (*O. kisutch*) and sockeye salmon (*O. nerka*), steelhead and rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), Dolly Varden char (*Salvelinus malma*), bull trout (*Salvelinus confluentus)* and mountain whitefish (*Prosopium williamsoni*) all occur to McDonell, Dennis and Aldrich Lakes at the headwaters of the Copper River, and in accessible portions of most tributaries. Non-salmonid species found within the Copper River watershed include: sculpins (*Cottus* spp.), burbot (*Lota lota*) longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*) and peamouth chub (*Mylocheilus caurinus*).

SISS catalogue (Subdistrict #4B - Terrace) lists a mean escapement of 1860 and a maximum of 5000 sockeye for the period from 1980-89. Coho escapement was listed at a mean of 1117 and a maximum of 2000 for the same period. SISS data from 1964 - 1983 show a decreasing trend in sockeye stocks from 1978 to 1984, while coho stocks remain fairly consistent for the same time period. Recent escapement for these species was not listed.

There are no accurate escapement data or population estimates for the Copper River steelhead (Beere, M. pers comm. cited in Lewis and Buchanan, 1998). Angler catch records show a range in annual catch from a maximum of 4,377 fish in 1986/87 to a low of 258 fish in 1980/81 (Lewis and Buchanan, 1998). SISS lists a mean escapement of 2, 070 steelhead for the Copper River and a maximum escapement of 4,353 over the period of 1963-1984, however these numbers only reflect the average and maximum reported angler catches from the Steelhead Harvest Analysis (SHA) database, an annual measure of angling effort which records steelhead catch province wide. An average escapement of about 2,000 fish is a rough estimate provided by MELP and SISS, and actual escapement could be higher (Lewis and Buchanan, 1998).

2.3.1 Angling Regulations

The Copper River lies within Management Unit 6-9 of the Skeena Region (6). The Copper is a classified water from Sept. 1 to October 31, requiring that anglers purchase a classified waters license in addition to the basic angling license and steelhead stamp. A Class 1 license is required above Limonite Creek and a Class 2 below. Angling is banned from McDonell Lake downstream to the lower canyon at approximately 5 km, between January 1 and June 15. These regulations protect overwintering and spawning adult steelhead from anglers. Gear restrictions ban the use of all baits.

2.3.2 Review of Past Enhancement Attempts

In 1980, Reach 1 of Serb Creek was diverted in an attempt to improve and extend spawning habitat for steelhead in the Copper River at the outlet of McDonell Lake. The diversion was proposed because Serb Creek is often silty due to glacial input, and it was thought that the silt was negatively impacting the spawning area. The creek was diverted to enter the mainstem

approximately 500m downstream of where the stream mouth was originally located. Since the diversion, it has been discovered that steelhead spawn in lower Serb Creek. Lower Serb Creek appears to have 'blown out' several times since 1980, and currently multiple channels exist in Reach 1. The channel does not appear to be stable and numerous debris jams are visible at the mouth of Serb Creek and downstream in the mainstem. The Serb Creek diversion was not forestry related and therefore was not considered to be an impact within the scope of this study. An additional attempt at enhancement was made in 1980 when gravel was placed at the McDonell Lake outlet.

Steelhead brood stock collection and hatchery operations were undertaken by MELP from 1980 - 1985 to enhance Copper River stocks. Wild brood stock were used for this project, which was designed to augment steelhead production by stocking fry to under-recruited streams in the upper watershed. A total of 287,500 fry were stocked upstream of McDonell Lake from 1981 -1985. Steelhead fry were released in Passby, Willow, Sandstone, Coal and Silvern Creeks and in the mainstem upstream of Dennis and McDonell Lakes. Colonization sites were selected on the basis of habitat quality and access. The contribution of hatchery steelhead to the sport fishery was estimated to be 296 -1929 fish, based on marked adult recaptures in the commercial fishery (Lewis and Buchanan, 1998).

SISS data indicate that chinook salmon were incubated and released just downstream of McDonell Lake in conjunction with steelhead enhancement attempts from 1981-1983. No chinook returns to the upper watershed have been documented.

2.4 Logging History

Timber harvesting and road building has been ongoing in the upper Copper River watershed from 1968 to the present. Early harvesting began the upper reaches of sub-basins (in the areas closest to Smithers) and has gradually moved downstream. Upon reviewing air photos and the available forest cover maps, the following summary of the study area logging history, has been constructed:

- The earliest logging in the Upper Copper Study Area occurred in 1968 in the vicinity of Dennis Lake.
- Clearcut logging and road building began in the Silvern Creek sub-basin in the late 1960's with most work completed from 1980 onward. Logging and road building continues today in the lower reaches of Silvern and Glacial Creeks and south of Dennis and Aldrich Lakes.
- A mainline forestry road built in approximately 1980 north of McDonell Lake and the upper Copper River provides continued access to the Passby Creek, Hankin/Willow Creek, Sandstone Creek, Coal Creek and Mulwain Creek watersheds. This road also serves several private lakefront properties on the north side of McDonell Lake, where grassland clearings are maintained.
- Logging activities in the Hankin/Willow Creek sub-basin began in 1987 near the mouth and continue today in the upper reaches of the sub-basin, north and east of Hankin Lake. Extensive streamside logging occurred in Reach 2 of Hankin/Willow Creek on private property.
- Logging activities in the Sandstone Creek sub-basin began in 1988 and are currently ongoing in the immediate vicinity of Sandstone Lake.
- Logging activities in the Passby Creek sub-basin began in 1990 near the mouth of the creek but have not continued past the first reach due to steep mountainous terrain.
- Logging activities in the Coal Creek sub-basin began in 1993 and are currently underway north and west of Louise Lake.

- Forestry activities have recently begun in the Mulwain Creek sub-basin, with the first clearcuts completed in 1995.
- Clearcut logging has recently occurred south of the Copper River between Serb and Lee Creeks.
- To date, no forestry activities have occurred in the Red Canyon Creek sub-basin.

Figure 1: Copper River watershed showing study area.

Figure 2: Sub-units within the upper Copper River watershed (adapted from 1:250K NTS Maps 103I and 93L).

3. METHODS

The Overview Assessment generally followed procedures as outlined in the Fish Habitat Assessment Procedures Manual (WRTC #8), which were to:

1. Delineate watershed/study area with identification and delineation of sub-units
2. Assemble available existing information:
   NTS maps, Air Photos, Air Photo Mosaic, Oblique Photos
   Fisheries background information (presence, distribution, abundance, habitat use).
3. Establish stream reaches.
4. Identify target species, summarize trends in fisheries abundance (where possible) and identify critical reaches/areas for target fish species.
5. Map fish distributions and important habitats (spawning, rearing, holding or overwintering).
6. Integrate background review with air photo and map interpretation to determine current habitat conditions and known or suspected impacts to important riparian or aquatic habitats.
7. Prioritize sub-units for further assessment/restoration works.
8. Suggest preliminary habitat rehabilitation or assessment strategies and cost estimates.

Detailed descriptions of methods used in the overview assessment are provided in Sections 3.1-3.7.

3.1 Sub-unit delineation

Sub-unit areas were delineated for all major creeks within the study area. The remaining area that was not included within the major basins was divided into sub-unit areas separated by geographic features (i.e.: height of land, lakes) and/or the amount of development (i.e.: number of cutblocks). Eleven (11) sub-units were identified within the study area: Copper River, Coal Cr., Hankin Cr., Lee Cr., McDonell Lake, Silvern Cr., Mulwain Cr., Passby Cr., Red Canyon Cr., Sandstone Cr. and Serb Cr. The report will identify impacts, fisheries values and riparian types by sub-unit.

With the exception of the Copper, McDonell Lake and Silvern units, the sub-units are comprised of a 3rd order or higher mainstem and the associated drainage area. The Copper River sub-unit includes the mainstem reaches 7-10 and first to third order tributaries to the mainstem that are too small to divide into a separate sub-unit. The McDonell Lake sub-unit includes all tributaries to the Copper River and McDonell Lake from Sandstone Creek to Willow Creek on the North side and between Serb Creek and Willow Creek on the south side. The Silvern sub-unit is comprised of the headwaters to the Copper River, including Silvern Creek and its tributaries, Dennis and Aldrich Lakes and their tributaries as well as the Copper Mainstem from Dennis Lake to Passby Creek.

3.2 Background Review

This project was based largely on a review of available maps and photos, as listed in Table 1. Triton completed a 1:20K fish and fish habitat inventory in the study area in 1996.

Table 1: List of all maps and photos used in this assessment

Item	Reference #
1992 Air Photos	30BCB92084: 20-47, 97-123, 166-178 30BCB92069: 97-128, 166-200, 30BCB92086: 01-31, 59-70 30BCB92087: 4-32 30BCB92091: 29-61, 122-142 30BCB92135: 226-231
1995 Air Photo Mosaic	Zymoetz River: pp. 1-40 Mulwain Creek: pp. 41-43 Coal Creek: pp. 44-52 Sandstone Creek: pp. 53-56 Hankin/Willow Creek: pp. 57-62 Passby Creek: pp.63-64 Silvern Creek: pp. 65-67
Triton 1996 Inventory TRIM-based mapsheets	93L.062, 93L.071, 93L.072, 93L.073, 93L.074, 93L.081, 93L.082, 93L.083, 93L.084, 103I.08, 103I.09
Forest Cover Maps	93L.062, 93L.071, 93L.072, 93L.073, 93L.074, 93L.081, 93L.082, 93L.083, 93L.084, 103I.08, 103I.09
FISS & Aquatic Biophysical Inventory Maps	103I/8 and 103I/9, 93L/12,13 and 14

3.2.1 Forest Harvesting / Development History

The logging history in the watershed has been reconstructed through assessment of air photos and forest cover maps and is described in Section 2.3. The objective of this assessment is to provide a qualitative rather than quantitative review, with a focus on the potential impacts of logging and road building on fish, fish habitat and riparian areas.

3.3 Evaluation of Fisheries Resources and Impacts

Existing fisheries information was collected and summarized both in this report and on 1:20K and 1:30K project maps. Important fish habitats (historically documented and suspected) including rearing, spawning and overwintering areas were identified. Sources for fish and fish habitat information included FISS maps, SISS catalogues, MELP reports, Triton reports, map interpretation and air photo analysis. Information was summarized on the Fish Distribution Summary Form (WRP Form 1) using the WRP data entry system, on the 1:20K and 1:30K project maps and in the results section. The information is summarized in the WRP database by reach for each major stream, and for smaller streams in those sub-basins with no single, dominant stream. Documented fish presence is indicated by a 'K' for 'known', and by an 'S' for 'suspected' on the form. The information from the database was exported to a Microsoft Excel file and manipulated to make the hardcopy more easily read. It is present in Appendix II. Fisheries information presented on the maps is colour coded to represent the information source.

In terms of fish habitat within the study area, the overview assessment focused on:

- target species within the project area
- critical habitats for target species within the watershed/working unit
- identifying impacts which affect critical habitats
- whether the impacts are limiting (or will limit) fish production, and
- whether sufficient quantitative data exist to plan habitat restoration projects

Critical habitats are those required by salmonids to complete their lifestyle, and include spawning and incubating areas, areas for summer rearing during low flow periods and overwintering habitats for juvenile and adult fish. The assessment attempted to determine where alienation of fish from critical habitats has occurred or where increases in levels of suspended sediments may be occurring. Excessive sedimentation can result from bank failures, road failures, road crossings and cutblocks where no riparian buffer exists. Alienation from fish habitat can result from poorly designed or installed road crossings, bank failures, slumps, debris jams and channel dewatering.

The typical salmonid life history involves the following movements / migrations:
- migration of juvenile fish to rearing areas,
- migration of juvenile and adult fish to feeding areas,
- migration of juvenile and adult fish to overwintering areas, and
- migration of adult fish to spawning habitats.

Road crossings can alienate fish from critical rearing, spawning and overwintering habitats if fish can not migrate through them in both directions and at most water levels. Road crossings can also cause increases in sediment input to important habitats downstream, such as spawning or rearing areas. Increases in suspended sediment can adversely impact fish during all stages of life. Suspended sediment can smother eggs incubating in the gravel, cause direct and indirect mortalities and illness in juvenile fish, impede visibility and feeding opportunities and generally lower fish productivity. Road crossings at or near overwintering areas may result in alienation of fish from these habitats or in decreased water quality from sediment input. Typical overwintering habitats for salmonids include deep pools, backwaters, groundwater supplied ponds, beaver ponds, marshes and side channels. The assessment attempted to identify potential rearing and overwintering areas and road crossings that may have alienated these habitats. All roads crossing known or suspected fish bearing streams were considered as a potential impact to fish and fish habitat as a result.

3.3.1 Identification of Target Species

Most salmonid species have high economic, cultural or recreational values within BC. Recent declines in these populations resulting from overfishing and/or habitat degradation have heightened the need for assessment and restoration projects such as this. Within the Upper Copper system, the following species were designated as 'target' species, or species potentially at risk from forestry related impacts:
- steelhead/rainbow trout
- coho salmon
- sockeye salmon
- Dolly Varden/bull trout

Coho salmon and steelhead trout are the primary target species within the study area. This is mainly because their populations have been in serious decline over recent years. Coho have historically had high economic value as a commercial species and both coho and steelhead have high recreational/economic value as sport fish. Sockeye salmon also have a high commercial/ economic value. The life histories of these 3 species involve a freshwater residence of 2-4 years which requires that suitable habitat be available year round and from year to year. This makes these species more vulnerable to environmental impacts than pink or chum salmon, which leave their natal streams shortly after emerging from the gravel, returning only to spawn. Bull trout are a 'blue listed' species considered 'at risk' within the province, and are therefore also a target species. Dolly Varden are included in the list of target species due to the similarities between Dolly Varden and bull trout, and the resulting overlap in habitat preferences and requirements. Other salmonid species present within the study area which have lower economic, cultural or recreational values are not considered 'target species' and are not included in the following discussions.

3.3.2 Life Histories of Target Species

3.3.2.1 Steelhead Trout

Steelhead trout are the most intensely documented fish species within the Copper River Watershed, undoubtedly due to the high value of the recreational steelhead fishery. Although no specific studies on Copper River steelhead life histories have been completed, a recent review of the status of Copper River steelhead (Lewis and Buchanan, 1998) found 18 distinct life history patterns for the species, though in general the life history of Copper River steelhead generally follows the overall pattern of other steelhead trout.

Adult steelhead migrate to freshwater during the fall and spring months and spawn during late May and June. Steelhead eggs are buried in gravel during spawning and incubate through June and July, with fry emerging from the gravel in August. Steelhead fry in the Copper River rear in freshwater and begin to smolt after 3-6 winters.

The average smolt age for Copper River steelhead is 3.6 years. Most (80%) of the Copper River steelhead spend two winters in salt water before returning to spawn. The total age of Copper River steelhead as determined from scale data (Lewis and Buchanan, 1998) ranges from five to eleven years: 99% of fish sampled were nine years old or younger. All fish nine years old or greater were repeat spawners, and 84% of fish 8 years old and older were repeat spawners. Repeat spawning was more common in females (20% had spawned more than once) than in males (11%) (Lewis and Buchanan, 1998).

3.3.2.2 Coho salmon

Coho are important as both commercial fish and food fish. They are also esteemed as a salt and freshwater sport fish in BC. Life history strategies for coho vary among drainage systems. Coho spawning timing typically occurs from September in the northern parts of the province. Coho prefer shallow streams and tributaries with small to medium sized gravel substrates for

spawning. Incubation timing varies from 35 -175 days. Newly hatched alevins remain in the spawning substrate for 2 - 3 weeks before emerging. Emergence typically occurs from March - July. Post-emergence the young remain in their natal streams near spawning sites in low flow areas or are passively displaced downstream. Juveniles gradually establish individual territories in small streams or on the margins of larger rivers. Freshwater rearing is typically 1 or 2 years. Coho begin moving to overwintering habitats such as pools and off channel habitat as water temperature drops to 7^0C. Outmigration to sea occurs in the spring following smolting. Marine residence is typically 2 years before adults return to natal streams to spawn.

3.3.2.3 Sockeye Salmon

Sockeye salmon are an important commercial and food fish in BC, and are, to a lesser extent, pursued as a sport species. Sockeye migrate through the Copper River to its headwaters to spawn in the outlet of McDonell Lake and in the mainstem between McDonell, Dennis and Aldrich Lakes. Adult migration usually occurs in two peak periods between July and October. Spawning timing for sockeye salmon varies within the province, but is typically in late summer through early fall (August - November). Spawning habitat includes lake beaches, lake inlet streams, tributaries and rivers. Preferred spawning substrate is pea sized gravel. Sockeye emerge from the gravel from March - May then moving to lake habitats (McDonell, Dennis and Aldrich lakes) for a 1-3 year rearing phase, feeding on plankton. Seaward migration takes place in April - June. Marine residence is 1- 4 years before adults return to natal streams and lakes to spawn.

3.3.2.4 Dolly Varden and Bull Trout

Dolly Varden and bull trout belong to the char family and are distributed throughout BC. Once believed to be the same fish, Dolly Varden and bull trout are now known to be separate species. These two species however, share similar life histories and habitats and are presented as one for this discussion. Life history strategies for both species are subject to variation and include both anadromous and freshwater resident forms. Bull trout are designated as a blue- listed, or 'threatened' species by the BC CDC. Dolly Varden are much more prolific than bull trout and are an important sport fish. Spawning for both occurs in the fall, from August through November. Incubation timing is October - January, ranging from 34-125 days. Hatching occurs in January or February and alevins remain in the spawning substrate for 2-3 weeks prior to emerging. Fry remain near spawning sites for 2 - 3 weeks and move to side channels and backwaters for the remainder of the year and disperse to pools and runs in larger systems over the following 1-4 years. Resident adults migrate seasonally between feeding and overwintering habitats and are found in lakes, rivers and streams.

3.4 Reach Analysis

Major streams within sub-units and streams with known fisheries information were assigned reaches as per the procedures outlined in the Fish Habitat Assessment Procedures WRTC #8, and are shown on project maps. Where appropriate, existing reach break information taken from aquatic biophysical maps was used. Reach breaks were assigned based on major changes in: channel morphology, confinement, discharge (i.e.: at major confluences) and gradient.

During the initial stages of reach analysis, and for draft versions of the maps and database reach breaks were identified with numerical identifiers, (NIDs). These identifiers will be replaced with UTM coordinates generated during the digitization of the map information, for final report and database submission.

Overview Habitat Condition Form (WRP Form 2)

Form 2 was completed for mainstem reaches within each sub-unit and for smaller streams and tributaries where fisheries values and potential impacts were observed. The form is used to generally describe existing habitat conditions within each reach. Characteristics assessed and detailed on the form include: channel gradient, width, type (morphology), stability (aggrading, degrading or stable), barriers, off-channel habitats and riparian structure. Reaches were also assessed for the following indicators of recent channel disturbance (from WRTC #8):

- extensive areas of scour, riffle zones, unvegetated bars and sediment wedges.
- elevated mid-channel bars
- limited pool frequency and extent
- multiple channels
- eroding banks
- isolated off channel areas
- large woody debris (LWD) parallel to banks (not functioning) or in recently formed jams.

The Form 2 information in the WRP database was transferred to a Microsoft Excel table and is present in Appendix II.

The assessment of reach habitat conditions was quite limited due to the year (1992) and scale (approximately 1:18,000) of the air photos used. In particular, indicators of recent channel disturbance may have changed over the last 7 years, and can not be considered to be 100% accurate. Channel widths generated from the assessment can only be considered rough estimates and will require ground truthing.

3.5 Impact Assessment

The assessment of impacts within the study area involved integrating information from the WRP database Forms 1 (Fish Distribution Summary) and 2 (Habitat Condition Summary), with map, air photo and existing information, and completing Form 3 (Preliminary Habitat Assessment Form). All impacts visible on air photos, documented in existing literature, or suspected from a detailed air photo and map review were identified and further assessment or restoration options were suggested. At the overview level, estimation of restoration potential is difficult and generally involves ground-truthing of the suspected impact site before restoration plans can be developed. The WRP Form 3 is described in detail below.

Preliminary Habitat Assessment Form (WRP Form 3)

This form was used to summarize known or suspected impacts and to assign priority ratings for impacts. Although the form is set up to record impacts and assign priorities for each reach, we modified the procedure and assigned priorities for each impact, and later generated a priority rating for the reach. The form was limiting in that it is set up for sub-basins with one mainstem only. The form does not contain a 'stream name' column, which would greatly facilitate data

entry. To overcome this problem, the data entry was modified for tributary streams and sub-basins with no single mainstem. The location of each impact was identified in both the 'Sub-Basin' column and by a descriptor in the 'Major Impact' column on the form. The name of the sub-basin is identified, and the specific stream location of each impact is given in brackets by either a watershed code or an interim locational point (ILP). In cases where the impact is present on a smaller tributary stream which is not uniquely identified by ILP or watershed code, the description of the impact includes a brief description of the tributary's location with relation to its confluence with an identified stream.

Form 3 involves rating habitat value and upslope impacts for each reach. Upslope Impact potential was determined using terrain stability maps (Forest Development Zone and DFO Bulkley Forest District Salmon Habitat Sensitivity maps). Habitat value was rated as High, Moderate or Low, and was determined by analysis of channel characteristics (stability, morphology, gradient, off-channel areas) and depended on the presence of critical species or habitats for critical species within the reach. For instance, reaches with target species and known or suspected habitats for target species were rated as high value, reaches with no known fisheries values and unfavorable habitat for salmonids (i.e.: short, steep, intermittent streams, headwater streams) were rated as low value.

Impacts were assessed by air photo and map interpretation. The assessment attempted to identify areas of: excessive channel aggradation or degradation, sediment input, fines in the substrate, organic debris, channel instability, failing road structures, loss of riparian function and fish passage concerns. Impacts within each reach were subjectively rated as high, medium, or low priority based on the presence (or absence) of target species or critical habitats for target species in the vicinity, and on the severity of the impact or suspected impact. For example, a large bank failure upstream of a documented spawning area would be rated as a high priority impact, whereas a road crossing that might alienate only a short distance of steep, intermittent stream would be rated as a low priority impact. Road crossings that potentially blocked access to critical habitats for target species would be rated as high priority.

All intersections between fish habitat and forest development (roads, cutblocks etc.) were considered to be potential impacts. All road crossings on fish bearing or suspected fish bearing streams were identified as suspected impacts because they have the potential to obstruct fish passage and may be a source of sediment to the stream, as described earlier. Crossings were rated as low, moderate or high priority depending on the quantity and quality of habitats that were potentially alienated. Crossings with bridges were generally assigned a low priority because fish passage was assumed to be unobstructed.

The Form 3 information in the WRP database was transferred to a Microsoft Excel table and is present in **Appendix II.**

3.6 Prioritizing Sub-Units

The ranking of sub-units for further assessment priority was a 4 stage process as follows:

Step 1: Each impact was identified, assessed and given a priority ranking (H/M/L) based on the known or suspected hazard of the impact to fish and fish habitat, (see section 3.4)
Step 2: Each reach was then given a priority rating (H/M/L) based on the number, type and severity of impacts occurring.
Step 3: Each sub-unit was given a priority rating through subjective analysis of :

- resource habitat values for the entire sub-unit
- upslope impact potential (as determined at the reach level) for the sub-unit
- total # of impacts for the sub-unit (as determined in Step 1)
- the number of impacts in each priority category (as determined in Step 1)
- reach priority ratings (as determined in Step 2).
- the need for riparian assessments

Sub unit priority ratings ranged from 'Very Low' for sub-units where no impacts were observed, to 'High' for sub-units with a high number of impacts.
Step 4: The priority rating for the sub-unit was used to develop sub-unit *rankings*. Sub-units were ranked against one another for further assessment in consideration of:

- the number and rating of impacts within the sub-unit
- the technical and logistical feasibility of further assessment and/or rehabilitation of impacted areas
- cost of assessment/rehabilitation, and
- the overall benefit to be gained from further assessment/restoration work

3.6.1 Sub-Unit Descriptions

General physical characteristics, fisheries values and impacts were described for each sub-unit. Additional information from Roberts (1995) Forestry Development Zones (FDZ) Map and Base Criteria was used for undeveloped sub-units. The FDZ maps provide interpretations of terrain stability and surface erosion potential maps and highlight areas of high concern for timber harvesting and road building. Roberts (1995) findings were integrated for sub-units where little or no forest development has occurred (Serb, Lee, Mulwain and Red Canyon). These sub-unit descriptions include reference to Roberts (1995) 'red' or 'orange' zones, as shown on the FDZ maps. A 'red zone' is an area where actively unstable terrain exists with a potential for forest development to impact water quality and fisheries values. In the 'red' zones it is recommended that no development be planned, however special cases may allow development after careful field evaluation by a qualified terrain specialist. An 'orange zone' is an area where terrain is actively unstable, and forest operations may proceed if field evaluation by a qualified terrain specialist allows.

A 1:250 000 scale DFO Salmon Habitat Sensitivity Map for the Bulkley Forest District, (February 1998) was consulted to give an indication of upslope impact potential throughout the project area. The map shows Terrestrial Sediment Input Hazard (TSIH) areas (high, moderate, low) linked to salmon habitat for the upper Copper watershed. TSIH maps were reviewed and a general description of the type of terrain found within sub-units where development has occurred is provided.

3.6.2 Impact Assessment - Riparian Areas

The objectives of the riparian assessment were to:

- identify and prioritize riparian areas with impaired functioning, and,
- recommend future field assessments for impacted areas.

The future field assessments are required to determine the level of functioning of impacted areas, evaluate the potential for rehabilitation and develop restoration/rehabilitation prescriptions using appropriate silviculture treatments. The process of riparian impact assessment involved map and air photo review, mapping of riparian vegetation types (RVTs), classification of visible riparian zones according to four impact categories (no impact, known or observed impact, suspected impact or unknown impacts (data not available), prioritization of impacts and development of recommendations and costs for further assessment. The assessment of riparian areas generally followed the overview procedure outlined in WRTC #6 with some minor modifications that are described below.

In addition to simply identifying impact sites, a key objective of this study was to identify specific locations where future assessments and restoration works are required within the scope of the WRP mandate. Throughout the assessment process the following were considered:

- Where did logging occur in reserve zones?
- Is second growth vegetation growing and at what stage and density?
- Where impacts have occurred, have natural restoration process fulfilled objectives that would be part of a restoration plan?
- Is the restoration or assessment within the potential budgets of any funding agency?
- Where should field assessments be carried out to determine the functioning condition of the riparian zones?
- What are the technical requirements and estimated costs of the next step in assessment or restoration?

The study area encompasses hundreds of streams, with the majority being first and second order, that have many kilometers of riparian zones. To reduce the scope of the task we focused our assessment effort only on riparian zones along fish bearing streams that were located adjacent to or within harvested cutblocks. Riparian zones not associated with previous harvesting were not assessed since WRP funding is geared towards assessing and repairing harvesting related damages to stream and riparian areas. Riparian zones located adjacent to S1 to S3 (fish bearing, less than 20% gradient) streams and located within or adjacent to harvested cutblocks were examined for tree cover, buffer width and stand structure. Riparian zones adjacent to S4 to S6 streams were not assessed in detail since FPC regulations do not require a reserve zone and logging is permitted across these streams. As well, at the landscape and watershed level, the critical habitats for fish are not found in S4 to S6 streams and limited funding for riparian restoration efforts should be concentrated on areas adjacent to the high value fish habitats within S1 to S3 streams. Point source impacts such as bridge crossings and culvert locations were not assessed as riparian impacts but were noted in the reach and fish habitat impact assessment.

The assessment involved examination of the available air photos, (1992 black and white photos at approximately 1:18,000 scale, 1995 colour air photo mosaic of mainstems at approximately 1:4000 scale, and aerial oblique photos taken by Triton in August to October, 1997). Forest Development Plan maps and TRIM maps were used to identify streams with riparian areas adjacent to, or within cutblocks. Previously harvested cutblocks were identified, mapped and assigned cutblock polygon numbers, while impacted riparian polygons were mapped and assigned unique numbers which incorporated the cutblock polygon number.

Impact Definition

Due to the small scale (1:18,000) and black and white resolution of the air photos, the best and most visible indication of riparian impairment was the absence of mature coniferous forest within the riparian reserve zone. Consequently, we defined an impact to the riparian zone as either of the following:

- removal of mature timber and loss of forest cover within the riparian reserve zones due to logging on one or both banks of a fish bearing stream. Riparian functioning is significantly impaired for several reasons after riparian vegetation is removed including the loss of seed sources, loss of windfall and LWD inputs, decrease in bank and channel stability, reduction or elimination of stream shading, loss of litterfall and organic material inputs, decrease in runoff retention, decrease in soil retention, increase in erosion and decrease in water quality, decrease in complex terrestrial habitats.
- establishment and growth of predominantly deciduous vegetation within the reserve zone after logging. The presence of deciduous vegetation (typically alder) indicates a degree of functional recovery from clear cutting but within deciduous dominated riparian zones the key riparian functions (wood supply, shading, bank and channel stability, biodiversity attributes) will not match mature forest functioning.

Impact Categories

Four categories were utilized in assessing riparian areas: known or observed impact, suspected impact, no impact and unknown impacts (data not available).

- Known impacts

Impaired riparian function is visible on 1992 air photos due to stream bank logging or deciduous regrowth. These riparian polygons will require field assessment to determine functioning condition and determine rehabilitation options and feasibility.

- Suspected impacts

Impaired riparian function is likely, but it is not possible to completely determine from the available air photos. The impaired riparian function may exist due to very narrow buffer strips or only partial regrowth of riparian forest. These riparian polygons will likely require field assessment to determine functioning condition and determine rehabilitation options and feasibility.

- No impacts

Riparian areas where the buffer zone appears adequate for the stream classification or no logging is located along the riparian zone and no forest development impacts were observed. This is the default condition for most riparian areas in which riparian function is assumed to be highly

functional due to the presence of mature forest. For the sake of clarity on the attached maps all riparian areas which were mature forest or had adequate riparian buffers were not coloured separately and a riparian polygon number was not assigned. No further work is required for these riparian areas. This reduced the expense and time to map none impacted riparian areas.

- Unknown impacts

Areas where Forest Development Plan maps indicate logging occurred after 1992, but the cutblocks are not visible on the 1992 air photos and no evaluation of the status of the riparian zone could be made. These riparian polygons require additional air photo analysis, using more recent air photos, prior to assigning a known/suspected/no impact category. These may require field assessment if additional air photo review indicates known or suspected impacts. We attempted to obtain more recent (1996-1998) air photos to reduce the number of unknown sites by contacting the contract monitor but no air photos were available from Ministry of Forests files for further review. These air photos were not available in time for draft report production, but may be examined before a final report is produced if photos are available. It is anticipated that this will reduce the proportion of unknown riparian sites.

The summary of riparian assessments is presented in the results section and riparian impact data sheets are located in Appendix II.

3.7 Mapping

1:20K and 1:30K Trim maps were annotated manually for the draft version of this report. These maps used digital generations of the TRIM database stream and road layers as the base on which all information was recorded. Fisheries information was presented on one set of maps, impacts on another. These have been combined into one set of maps including fisheries information and impacts as the final deliverable. Fisheries information was transferred to working maps using a colour coding scheme as follows:

- orange - identifies FISS maps as the information source
- green - identifies Aquatic Biophysical maps as the information source
- red - Triton/MELP 1:20K Fish and Fish Habitat Inventory maps as the information source
- blue - MELP /Triton Skeena Fisheries Report SK-102 as the information source

Streams are identified on the maps with a watershed code label placed at the mouth. Those streams that were identified as impacted, but for which watershed codes do not exist, are labeled instead with an ILP. Reach breaks were assigned by the procedure described in Section 3.3 and are indicated by a standard reach break symbol and labeled with a numeric identifier, (NID), for GIS purposes. Identified impacts are labeled on the maps with an alpha-numeric code that is linked to the 'Preliminary Habitat Assessment Form'.

Cutblock polygons were mapped and annotated according to the status (proposed or harvested) on the riparian impact maps with unique cutblock polygon numbers assigned. Riparian polygons were mapped and coloured according to impact category (known, suspected, unknown). Riparian areas with no colour or polygon number are by default not impacted (no adjacent logging or adequate mature forest buffer) and require no further assessment.

3.8 Further Assessment, Restoration and Rehabilitation Planning

Priority areas for Level 1 Detailed Field Assessments and initial assessment requirements were established. Estimates include: the type of work required (ground verification, stabilization, fish passage), manpower requirements, estimated costs by sub-unit.

Preliminary field assessment cost estimates were developed for high priority impact sites and for all impacted sub-units. A preliminary budget showing resources required to complete further work was developed.

4. RESULTS

The results of the overview assessment are presented in the following sections. The discussion includes descriptions of critical habitats identified for target species in order to place the prioritization assigned to impacts in context with the potential for adverse effects to the fisheries resource. Sub-unit descriptions follow. Each sub-unit is presented individually with a description of the unit and a discussion of the fisheries values and potential impacts specific to that unit. The impacts identified in each sub-unit are discussed in conjunction with the priority and ranking for restoration work assigned to each area. The riparian assessment is discussed independently.

4.1 Critical Habitats Identified Within the Study Area

4.1.1 Steelhead

Steelhead overwinter in McDonell Lake and in deeper areas throughout the mainstem (predominately downstream of the study area). Most of the Copper River steelhead spawn in the upper 20km of the river, 15% of fish spawn at the outlet of McDonell Lake and 30% appear to spawn in tributary streams within the study area. Serb Creek, Willow Creek, Coal Creek as well as the mainstem in the vicinity of Coal and Sandstone creeks have all been identified as important spawning areas. (Lewis and Buchanan, 1998). Steelhead are suspected to spawn in Sandstone Creek, however a barrier at the mouth was noted in 1978 (Humphries and Morely, 1978 cited in Lewis and Buchanan, 1998). The barrier was not evident on 1992 or 1995 air photos, and may no longer exist.

Juvenile steelhead rear throughout the mainstem and in accessible sections of tributaries. The highest densities of juvenile steelhead within the study area have been measured in reaches 6 and 7 of the Copper River mainstem (to the confluence of Serb Creek) and in Coal Creek (Lewis and Buchanan, 1998). Mainstem side channels in reaches 6 (downstream of Red Canyon Creek) and 7 (from Red Canyon Creek to McDonell Lake outflow) provided the best rearing habitat for steelhead parr, whereas fry were equally abundant in side and main channel habitats (Bustard, 1993 cited in Lewis and Buchanan, 1998). Steelhead/rainbow trout rearing is known in Sandstone creek, Red Canyon Creek and Mulwain Creek.

4.1.2 Coho

Coho are found throughout the Copper River watershed, probably occurring in all accessible low gradient habitat. Within the upper Copper river, coho are well distributed. Coho spawning is documented in the mainstem at the outflow of McDonell Lake and between McDonell and Dennis lakes. Coho spawning is also documented in the lower reach of Passby Creek. Coho probably spawn in Coal Creek, Sandstone Creek, Silvern Creek and in the mainstem reaches.

Critical rearing and overwintering areas for coho most likely include the off channel habitats adjacent to the mainstem between McDonell, Aldrich and Dennis lakes, and in the lakes themselves. Critical coho rearing/overwintering areas probably occur in the mainstem and off channel habitats within the Serb Creek (Reach 3), Coal Creek and Willow/Hankin Creek sub-units.

4.1.3 Sockeye

Sockeye utilize the mainstem Copper River between McDonell, Dennis and Aldrich lakes for spawning, as well as several inlet streams to these lakes. Sockeye spawning documented in lower Silvern Creek and at the outlet to McDonell Lake. The lake habitats provide critical rearing areas for sockeye.

4.1.4 Dolly Varden/Bull Trout

Dolly Varden are a prolific species, found throughout the study area. Dolly Varden usually prefer a smaller spawning substrate than do pacific salmon or steelhead, and therefore spawning locations occur in many of the smaller tributary streams within the project area. Dolly Varden spawning is noted in Silvern Creek, in inlets to the McDonell Lakes chain, and in tributaries to Red Canyon Creek, Coal Creek, Sandstone Creek, Mulwain Creek and smaller tributaries to the Copper River mainstem. Dolly Varden can inhabit higher gradient habitats than some salmonid species and as a result are found exclusively in the steeper upper reaches of many small to medium sized tributaries and in the upper portions of Silvern and Mulwain sub-units. It was expected that bull trout would occupy similar habitats, however known bull trout habitats include mainstem and tributaries within the Lee Creek and Red Canyon Creek sub-units.

4.2 Sub-Unit Descriptions and Impacts

Individual sub-unit assessments are provided in the following sections. These assessments are based on the methodology described previously in Section 3. Each sub-unit section provides a brief description of the mainstem, fisheries values and describes the number and types of impacts within the basin. A priority ranking for the sub-unit with respect to the other sub-units, ranging from 1 for lowest priority to 11 for highest priority, is provided. Riparian Management Area (RMA) classifications are provided for mainstem reaches where known. The impact description also includes a summary of FDZ terrain stability 'red' and 'orange' zones (zones where development is not advised due to high terrain instability) (Roberts, 1995) for non-developed basins. Bulkley Forest District DFO Salmon Habitat Sensitivity maps showing Terrestrial Sediment Input Hazard areas (TSIH) were consulted and areas of concern are noted. Table 2 provides an overview of physical attributes and forestry development for all 11 sub-units.

The Silvern and McDonell Sub-units are unique from the other 9 in that they do not contain a single, dominant stream. Instead, they are contain many smaller streams which have been identified either by watershed code or by ILP number. These two sub-units have been assessed in a manner consistent with the others, but the results are presented slightly differently. The other 9 sub-units contain a summary table in their results sections which details a summary of the impacts for the sub-unit separated by mainstem reach. The Silvern and McDonell sub-units do not have this reach distinction shown. The impact summary tables for these two units only give the totals for the entire unit.

Table 2: Overview of physical characteristics and harvesting for all sub-units.

Sub-unit	Major Stream(s)	Mainstem Length(s) (km)	Stream Order	Sub-Unit Area (ha)	Number of Cutblocks	Number of impacts	Estimated % of Sub-unit Logged
Silvern/Dennis Lake	Silvern Creek Copper River	11.0 - Silvern	Silvern Creek, 3rd Copper, 5th	14000	40	40	11
McDonell Lake	Copper River	19.6	Copper, 5th	6200	44	30	11
Copper	Copper	110 (49 km are within the study area)	6th	10,000	21	21	8
Coal	Coal Creek	13	4	5400	17	18	19
Hankin/Willow	Willow Creek	14.5	4	4800	22	15	25
Sandstone	Sandstone Creek	10.5	3	2100	11	4	17
Passby	Passby Creek	15	4	4300	2	2	2
Serb	Serb Creek	29	4	15400	1	1	0.1
Red Canyon	Red Canyon Creek	15.4	5	9200	0	0	0
Lee	Lee Creek	17.4	4	6500	0	0	0
Mulwain	Mulwain Creek	21	5	11500	1	0	0.5

4.2.1 Copper River Mainstem 440-00000

Total Impacts: 21

4.2.1.1 Sub-Unit Description

The Copper sub-unit is approximately 10, 000 ha and encompasses the area between the Mulwain and Coal sub-units on the north side of the Copper River and the Serb and Lee sub-units on the south side (Figure 2). The mainstem is 46 km in length within the study area and was labeled with Km posts (in upstream ascending order) for locational reference starting at Red Canyon Creek, Km 0.

The mainstem Copper River was divided into stream reaches as follows:

- Reach 7 - from Red Canyon Creek to Serb Creek (Km 0-22.2)
- Reach 8 - from Serb Creek to McDonell Lake (Km 22.2-
- Reach 9 - McDonell Lake
- Reach 10 - from McDonell Lake to Dennis Lake
- Reach 11- Dennis Lake
- Reach 12 - from Dennis Lake to Aldrich Lake
- Reach 13 - Aldrich Lake
- Reach 14 - upstream of Aldrich Lake

(Reaches 1 - 6, downstream of the project area, were taken from Aquatic Biophysical maps)

All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3. A sub-unit summary table (Table 3) follows the impact discussion, (Section 4.3.1.3).

4.2.1.2 Fisheries Values

All of the mainstem reaches within the upper Copper have high fish habitat and fish production values. Reach 8 is well documented as an important steelhead spawning location and FISS maps indicate that sockeye and coho also spawn here. Reach 10 is very low gradient, and meanders through valley bottom wetland-type habitat. Reach 10 contains some of the highest value fish habitat within the upper Copper. Spawning areas exist for all target species and excellent rearing and overwintering areas exist in the mainstem and off-channel areas. The reach is stable with flow and temperature moderated by Aldrich and Dennis lakes upstream. Reach 12 is similar to Reach 10, meandering through low gradient valley bottom wetland habitat between lakes. Reach 12 also has very high fisheries values, with spawning and rearing areas for all species found in the project area. Reach 14 is mostly low gradient and meandering with excellent off channel rearing and overwintering habitat.

McDonell, Dennis and Aldrich Lakes provide important rearing habitats for sockeye and important overwintering habitats for adult steelhead. Other salmonid species undoubtedly use the lakes for rearing and overwintering as well.

4.2.1.3 Impact Discussion

Reach 7

The Copper is confined and has steep banks throughout Reach 7. No logging or forest development has occurred within a kilometer of the mainstem from Km 0 - Km 16. A wildfire disturbance (date unknown) is visible at 8 - 13.5 km on the north side of the river. Several natural disturbances and impacts occur within this reach. A large bank failure, directly impacting the stream at approximately 13 km (the Copper / Coal confluence) appears to be fire-related. Two other natural large bank failures occur between 15 and 16 km. The Copper South FSR crosses the mainstem at 19.8 km. The road on the north side of the crossing has failed on a sharp corner and the slump has landed directly in the Copper River. Deciduous vegetation is regenerating on the failure (see page 17 in the photomosaic), but it should be checked for stability and sediment input and is rated as a high priority for assessment. The road crossing does not appear to be impacting the stream, but was noted as low priority for assessment due to the potential input of sediment.

LWD piles occur on the banks and bars from Km 13 - 22, but are particularly dense at the Serb Creek confluence. These debris accumulations are probably a result of the wildfire on the steep north bank, and the Serb Creek diversion, as it appears that the lower end of Serb Creek periodically blows out through sections mature forest.

Extensive red, or no development zones, are present upslope in Reach 7, however they are several kilometers from the mainstem, and the upslope impact potential is low.

Reach 8

No impacts to this reach were noted.

Reach 9

McDonell Lake. Impacts to lakeshore and lake tributaries are described in the McDonell Lake sub-unit section.

Reach 10

No major impacts were noted within this reach. The McDonell Lake FSR runs parallel to the mainstem throughout the reach but a substantial buffer exists between the main channel and the road. The road approaches the river at ~33.2 km, does not alienate any potential fish habitat from the mainstem or impact the stream channel. The Dennis West FSR crosses the mainstem just downstream of Dennis Lake. This bridge crossing doesn't appear to impact the stream, and was rated as low priority for further assessment.

Reach 12

No impacts were noted in this reach.

Reach 15

One impact, a road crossing at approximately 45km was rated as high priority for further assessment.

4.2.1.4 High Priority Impacts

Of the 21 total impacts identified in the Copper sub-unit, 3 have been assessed as high priority. Impact ***C35***, located on the Copper River mainstem between the 19 and 20 km markers on the map, is a road failure with evidence of excessive exposed soils which are expected to contribute high levels of sediment into the river during rain events.

Impact ***C16*** was identified on an unnamed tributary to the Copper, (WSC 440-787100-). This impact is a road crossing occurring in a 'red zone'. A washed out section may be causing excessive sedimentation. Additionally, the road may be cutting off side channels and small unmapped fish streams.

Impact ***D25*** is located in reach 15 of the Copper mainstem (upstream of Aldrich Lake near the 45km marker on the map). The channel has been logged over at this location and destabilization of banks and excessive sediment recruitment are anticipated in an area with very high fisheries values.

Table 3: Summary of impacts and impact priority for reaches within Copper sub-unit.

Reach	Impact ID	Resource Habitat Value (H/M/L)	Upslope Impact Potential (H/M/L)	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Riparian concerns/ assessments required?	Reach Priority Rating (H/M/L)
7	C1, C2 C3,C4 C5,C6 C7,C8 C9,C10 C11,C13 C14,C15 C16,C17 C18,C19 C35	H	M	19	2	6	11	Yes	M
10	D10	H	L	1			1		L
14	D25	H	M	1	1				M
Total for Sub-Unit		**Very High**	**Mod.**	**21**	**3**	**6**	**12**		**Mod.**

4.2.1.5 Priority Ranking

Priority Rating for the Sub-Unit: Moderate with 3 high priority impacts
Priority Ranking among Sub-Units (1-11): **2**

4.2.2 Red Canyon Creek 440-638200

Total Impacts: 0

4.2.2.1 Sub-Unit Description

The Red Canyon sub-unit is 9,200 ha, and pristine. The mainstem is approximately 15.5 km long and was divided into 3 reaches. The mainstem can be characterized as having confined, low (1.5%) gradient, aggrading riffle-pool type morphology throughout Reach 1. The channel is between 50 and 100m wide, and islands and bars occur throughout. The end of fish use for the system is a 30m chute/cascade, located just upstream of the Reach 1/ Reach 2 break. Reaches 2 and 3 are steeper (3-16%), confined, have numerous barriers and no fisheries values.

All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3.

4.2.2.2 Fisheries Values

Fish values in Reach 1 of the mainstem are rated as high due to the presence of spawning steelhead. Natural siltation probably reduces the productivity of this system. Access into Red Canyon Creek from the mainstem is unimpeded and therefore the system may contain all species found in the mainstem in addition to those listed.
Reach 1: RB, ST, CT, DV, BT. ST spawning near confluence.

4.2.2.3 Impact Discussion

The Red Canyon Creek sub-unit is pristine, and currently no forest development or forestry related impacts to fish habitat or riparian areas exist. The system; however, is a naturally high producer of suspended sediment to the Copper River. The source of the suspended sediment appears to bank failures in a left bank tributary to Reach 1 at 4.8 km.

Other bank failures may exist within the sub-unit which may not have been visible on air photos. A highly unstable 'red' zone exists on the right bank, stretching from the Copper confluence to 2.5 km. A left bank tributary at 5.8 km is also within a red zone. Reach 3 has extensive red zones in riparian areas. Steeper upslope areas throughout are red zones.

4.2.2.4 Priority Ranking

Priority Rating for the Sub-Unit: Low with no observed impacts
Priority Ranking among Sub-Units (1-11): **10**

4.2.3 Mulwain Creek - 440-638200

Total Impacts: 0

4.2.3.1 Sub-Unit Description

The Mulwain Creek sub-unit is 11, 500 ha, the third largest in the study area. A minimal amount of forest development has occurred within this sub-unit, and no forestry related impacts to fish habitat or riparian areas were identified. Mulwain Creek is a 5th order stream, 25.9 km in length, with 56 tributary streams. The mainstem was divided into 3 reaches and can be characterized as having low (<3%) gradient riffle-pool type morphology throughout.

Mulwain Creek was previously classified as an S2 in Reach 2, based on an average channel width of 14 meters and as an S3 in Reach 3 based on an average channel width of 2 meters (Triton, 1998). The tributaries to this stream range in size from S2 to S4, with the upper reaches of some tributaries classified as non fish bearing due to the presence of barriers or steep gradient (Triton, 1998).

All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3.

4.2.3.2 Fisheries Value

Mulwain Creek has high fisheries values throughout.
Reach 1: DV, CT, ST, RB present. ST spawning near confluence. Triton (1996) also noted good spawning habitat for salmonids in Reach 1.
Reach 2: DV, RB, CT. RB spawning noted at 14.6 km, DV spawning in tributaries.
Reach 3: CT, RB, DV to headwaters. RB spawning just downstream of the lake, DV and RB spawning in tributaries.

4.2.3.3 Impact Discussion

No impacts have been noted in the Mulwain sub-basin as it is largely pristine. One cutblock is located on the valley wall of the left bank at 2.5 km, but no associated impacts were noted. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) shows large areas rated as high and moderate throughout. Highly unstable FDZ 'red' zones occur from 1- 8 km on Mulwain adjacent to the mainstem on both banks. Several natural bank failures were also noted in Reach 1. Any development in the area should be undertaken in consideration of the high potential for adverse impacts to salmonid habitat.

The potential for future impact is high due to terrain instability as stated above.

4.2.3.4 Priority Ranking

Priority rating for sub-unit: Very Low, no impacts.
Priority ranking among sub-units (1-11): **9**

4.2.4 Lee Creek - 440-667900

Total Impacts: 0

4.2.4.1 Sub-Unit Description

The Lee Creek sub-unit is 6500 ha and pristine, no forestry development or related impacts have occurred. Lee Creek is a 4th order stream, 17.4 km in length with moderate fisheries resource values. The mainstem was divided into 4 reaches. Lee Creek can be characterized as having low (<3%) gradient, aggrading riffle-pool type morphology throughout. Off channel habitats are abundant in this system.

All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3.

4.2.4.2 Fisheries Values

Fish have unimpeded access from the Copper mainstem and it is assumed that all species present in the mainstem may use Lee Creek. Extensive wetland and off channel habitats for rearing and overwintering occur throughout reaches 2-4.
Reaches 1 and 2: BT, DV present.
Reach 3: BT present.
Reach 4: Spawning habitat for an unidentified species was noted.

4.2.4.3 Impact Discussion

No impacts have been noted in the pristine Lee Creek sub-basin. Extensive areas of highly unstable FDZ 'red' zones occur adjacent to the mainstem and in steep upslope areas (mostly associated with tributaries) from 3.5 km to the headwaters. Numerous 'orange' zones exist also occur in upslope areas from 3.5 km to the headwaters. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) does not show any high TSIH zones within the Lee Creek sub-unit. Any future development in this basin should proceed in consideration of possible downstream impacts of these orange zones.

4.2.4.4 Priority Ranking

Priority rating for sub-unit: Very Low, no impacts.
Priority ranking for sub-unit (1-11): **11**

4.2.5 Serb Creek - 440-815000

Total Impacts: 1

4.2.5.1 Sub-Unit Description

The Serb Creek sub-unit is 15, 400 ha, the largest within the study area. Fisheries resources within the Serb sub-unit were rated as high. Very little development has occurred in this area, and impacts are minimal. Less than 1% of the sub-unit area has been harvested. One forestry related impact was identified in Serb Creek within the first reach. Serb Creek is a 4th order stream, 29 km long, and was divided into 4 reaches. Lower Serb Creek appears to have 'blown out' several times since the Serb Creek diversion in 1980, and currently multiple channels exist in Reach 1. The channel does not appear to be stable and numerous debris jams are visible at the mouth of Serb Creek and downstream in the mainstem. Serb Creek can be characterized as having low gradient, riffle-pool type morphology throughout. Extensive off-channel areas occur in wetlands adjacent to Reach 3. A 1m falls is noted at 6.8 km but is not a barrier to salmonid migration. A falls at 21 km is the upstream limit of fish use for the system.

Triton (1996) identified the entire upper watershed as a naturally disturbed zone, with a huge flood zone identified at **Z69(**located at 20.5km on the Serb Creek mainstem) and newly formed banks identified at **Z76** (located on a right bank tributary to Serb Creek at 11.5km**)**
All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3. A sub-unit summary table follows the impact discussion, (Section 4.3.5.3).

4.2.5.2 Fisheries Values

Serb Creek appears to have high fisheries values throughout reaches 1-3. Fish and fish habitat presence by reach is provided below:
Reach 1: DV, ST, CT and BT present. ST spawning.
Some off channel rearing/overwintering areas occur.
Reaches 2 and 3: ST, DV, BT and CT present.
Spawning habitat for ST and CO suspected in Reach 2. DV spawning in tributaries to Reach 3.
Excellent rearing/overwintering opportunities in off channel areas in Reach 3.
Reach 4: DV are the only species documented.

4.2.5.3 Impact Discussion

The north side of a tributary to Reach 1 has been logged (not shown on air photos). The impact is assumed to be a low priority because the cutblock occurred post 1995 and fish streams should have been protected by the forest practices code riparian management area guidelines.

Highly unstable terrain, or FDZ 'red' zones, occur adjacent to the mainstem on the left bank in Reach 2 from ~1.5 to 3 km. Patches of red zone are also present on steeper upslope areas on the left bank of Reach 2. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) shows areas of high TSIH occurring throughout upslope areas on the right (south) bank of Serb Creek in Reaches 3 and 4. Upslope areas on the left bank is a moderate TSIH zone in Reach 3. Any development plans for the Serb sub-unit should consider the highly unstable terrain in upslope areas in Reaches 2-4, and the high downstream impact potential to salmonid habitat.

Table 4: Summary of impacts and impact priority for reaches within Serb sub-unit.

Reach	Impact ID	Resource Habitat Value (H/M/L)	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Reach Priority Rating (H/M/L)
1	B2	H	L	1	0	0	1	L
Total for Sub-Unit		**H**	**L**	**1**	**0**	**0**	**1**	**L**

4.2.5.4 Priority Ranking

Priority rating for sub-unit: Low, only one low priority impact.
Priority ranking for sub-unit (1-11): **8**

4.2.6 Coal Creek - 440-741100

Total Impacts: 18

4.2.6.1 Sub-Basin Description

The Coal sub-unit is 5400 ha, and approximately 19% of the sub-unit area has been harvested. Coal Creek is 14 km in length, and flows southwest from its headwaters at Louise Lake. Coal Creek is characterized by low gradient, stable riffle pool morphology and periodic channel confinement. The basin is fed by 33 tributary streams, almost all of which are fish bearing. Coal was divided into 5 reaches with 18 impacts/suspected impacts identified within reaches 1-4. No impacts were identified in reach 5. Reach 1 extends from the confluence with the Copper River to a 2m falls at 4.6 km. The falls are not a barrier to fish migration.

The mainstem of Coal Creek was previously assigned an RMA classification of S2 in Reach 1 based on an average channel width of 7.4m; reaches 3 and 5 were previously assigned an RMA classification of S4, based on channel widths of 1.4 and 1 meters respectively (Triton, 1998). All tributaries are S3 and S4 sized streams, with only 13 reaches classified as non fish bearing due to steep gradient (Triton, 1998).

All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3. A sub-unit summary table follows the impact discussion, (Section 4.3.6.3).

4.2.6.2 Fisheries Values

Coal Creek has high fisheries values throughout. One of the highest densities of juvenile steelhead measured in the Copper system was in Coal Creek (Lewis and Buchanan, 1998). Many of the tributaries to this system contain a number of small lakes, ponds and wetlands which probably provide critical off-channel rearing and overwintering habitat. Reach 5 and the upper

reaches of a number of tributaries are associated with large wetlands that were previously identified as fisheries sensitive zones (Triton, 1998). Fish and fish habitat presence by reach is provided below:
Reaches 1 and 2 : ST, CO, CT, RB, DV present. ST spawning.
Good off-channel rearing areas.
Reach 3: DV, ST, RB, (CT)
Reach 4, Louise Lake: DV, ST, RB, (CT)
Reach 5: CT

4.2.6.3 Impact Discussion

Seventeen (17) cutblocks occur within the sub-unit, 5 of which do not show up on 1992 air photos. Adequate buffer zones appear to be present on cutblocks, roads and landings. Natural bank failures occur upslope just downstream of Louise Lake and several natural bank failures are present directly into the creek near the R1/2 break. The cutblock just downstream of the natural bank failures may have a high upslope impact potential. Actively unstable terrain, FDZ 'orange' zones were identified along both banks from 0 - 3 km. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) also show high TSIH areas within the first 3 km of Coal Creek.

Reach 1 Impacts: 10 - road crossings
All of the impacts noted for this reach were suspected rather than known, with no major problems noted. Five road crossings occurring on left bank tributaries are all are rated as low priority for assessment. One road crossing on the mainstem at 2.3 km upstream from the Copper was rated as moderate priority. A right bank tributary to Reach 1 (ILP 361) had 4 road crossing related impacts, all rated as low priority.
Upslope impact potential for reach: Low

Reach 2 Impacts: 1 - road crossing
Road crossing over left bank tributary - priority low.
Upslope impact potential for reach: Moderate

Reach 3 Impacts: 5 - road crossings
4 road crossings occur on tributaries to Reach 3 of Coal Creek. All are rated as low priority.
1 road crossing on the mainstem is also rated as a low priority.
Upslope impact potential for reach: Moderate

Reach 4 Impacts: 1 - road crossing
Road crossing over a right bank tributary with a low priority assignment
Upslope impact potential for reach: Low

Table 5: Summary of impacts and impact priority for reaches within Coal Creek sub-unit.

Reach	Impact ID	Resource Habitat Value (H/M/L)	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Reach Priority Rating (H/M/L)
1	O1,O2,O3 O4,O5,O6	H	L	10	0	0	10	L

	O7,O8,O9 O10							
2	O11	H	M	1	0	0	1	L
3	O12,O15,O18 O19,O20	H	M	5	0	0	5	L
4	O16,O17	M	L	2	0	0	2	L
Total for Sub-unit		**H**	**Moderate**	**18**	**0**	**0**	**18**	**Mod.**

4.2.6.4 Priority Ranking

Priority rating: Low (17 of 18 impacts rated low)
Priority ranking among sub-units (1-11): **5**

4.2.7 Sandstone Creek - 440-767000

Total Impacts: 4

4.2.7.1 Sub-Unit Description

The Sandstone sub-unit is the smallest sub-unit within the working area, with an area of 2100 ha. The sub-unit includes Sandstone Creek and a second order tributary to the Copper located just downstream of the Copper/Sandstone confluence (at 16.1 km).

Sandstone Creek is approximately 10.5 km in length, is fed by 13 tributaries, and was divided into 3 reaches, including Sandstone lake, Reach 2. Sandstone Creek is a moderate (2-8%) gradient stream with occasional channel confinement. Channel morphology can be characterized as stable riffle-pool type throughout. Reach 3, upstream of the lake, is low gradient (2%), unconfined and flows through a network of previously identified fisheries sensitive wetlands (Triton, 1998). Sandstone Lake and Reach 3 of Sandstone Creek provide excellent rearing habitat. A beaver dam, located at 500m upstream in Reach 1, is probably not a barrier to adult migration.

The mainstem of Sandstone Creek was previously assigned an RMA classification of S3 in Reach 1, based on an average channel width of 4.1m, and as an S3 in Reach 3, based on an average channel width of 1.5m (Triton, 1998). The remaining unsampled tributaries appear to be S4 sized streams.

All information specific to the reaches within this sub-unit can be found in Appendix II on Forms 1, 2 and 3. A sub-unit summary table follows the impact discussion, (Section 4.3.7.3).

4.2.7.2 Fisheries Values

The Sandstone sub-unit has high fisheries values based on steelhead spawning and overwintering potential, and the presence of target species throughout.
Reach 1: CT, DV, RB. ST spawning suspected throughout.
Reach 2, Sandstone Lake: DV, CT, RB. Good overwintering/rearing habitat for all species.

Reach 3: RB. Good rearing habitat.

4.2.7.3 Impact Discussion

Two cutblocks exist on the east side of Sandstone between 2 and 5 km, (harvested since 1992) which did not show up on air photos. These are set well back from the mainstem and no impacts to the stream are expected. Two cutblocks within the lower portion Reach 1 were assessed and both appear to have adequate riparian buffer zones, and therefore no impacts related to these cutblocks were identified. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) shows areas of high TSIH throughout the left bank for approximately half of Reach 1, and moderate TSIH areas on the right bank, downstream of Sandstone lake between km 2 and km 4, the remainder of the sub-unit has low TSIH.

All impacts observed in the Sandstone sub-basin were road crossings in Reach 1. The first road crossing is located at approximately 600m upstream of the Copper and appears to be a culvert crossing. The crossing should be checked for fish passage and the road should be checked as a possible source of sedimentation. The road crossing was rated as a moderate priority for assessment.

Three road crossings on left bank tributaries to Sandstone Creek were identified as potential impacts. Two of these crossings do not alienate fish from critical habitats, but may be a source of sediment. These two crossings were rated as low priority for assessment. The third crossing occurs on a known fish bearing stream (Dolly Varden - stream class S4) and may alienate fish from 1.2 km of habitat upstream. This impact was rated as moderate priority for assessment.
Upslope impact potential for reach: Low

Table 6: Summary of impacts and impact priority for reaches within Sandstone sub-unit.

Reach	Impact ID	Resource Habitat Value (H/M/L)	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Reach Priority Rating (H/M/L)
1	E1,E4,E5,E9	M	L	4	0	2	2	L
Total for Sub-unit		**M**	**Low**	**4**	**0**	**2**	**2**	**Low**

4.2.7.4 Priority Ranking

Priority rating = low (low number of impacts, no high priority impacts)
Priority ranking among sub-units (1-11): **6**

4.2.8 Passby Creek - 440-893000

Total Impacts: 2

4.2.8.1 Sub-Unit Description

The Passby Creek sub-unit is 4300 ha: 2 cutblocks exist, covering approximately 2% of the sub-unit area. Passby Creek is a 4th order stream, is 15 km long and is fed by 38 tributary streams. Passby was divided into 5 reaches. Passby Creek is characterized by low (2-5%) gradient habitat

with riffle pool morphology throughout reaches 1-3. A 2 meter high beaverdam in Reach 2 was noted in the background review. Reach 4 is a small lake which probably does not support fish due to a gradient barrier downstream. Reach 5 is a steep (25% gradient), short reach which probably does not support fish. A large side channel roughly 720 m in length occurs in Reach 1. This side channel has been identified as a fisheries sensitive zone previously (Triton, 1998).

4.2.8.2 Fisheries Values

Fisheries values in Passby Creek are high, based on the presence of target species and the suspected presence of spawning habitats for these species.
Reach 1:CO, ST, CT, DV, RB. Suspect spawning for all species.
Reach 2 : DV, ST spawning at the Reach 1 / Reach 2 break is documented.
Reach 3: DV (CO, CT, RB).
Reach 4 , lake: Fish presence in the lake is unlikely due to a gradient barrier downstream.
Reach 5: Suspect no fish present.

4.2.8.3 Impact Discussion

Two impacts, (1 road crossing and 1 cutblock) were identified within Reach 1 and were rated as low and moderate priority for assessment. No impacts occur in reaches 2 -5.

At 0.9 km upstream from the Copper on the mainstem a road crossing with a bridge occurs. Fish passage is not a concern because of the bridge; however, the crossing may be a source of sediment to the stream. The crossing was rated as low priority for assessment. At 1.5 km logging has occurred close to the stream, and there is the potential for a slide or sediment input - rated as moderate priority for assessment. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) shows areas of high TSIH between 2.5 and 5 km on both banks, and from 5 km to 11 km on right bank upslope areas, and nearing the stream at 10 -12 km. Both bank are shown to have moderate TSIH from 5 to 10 km.
Upslope impact potential for reach: Low

Table 7: Summary of impacts and impact priority for reaches within Passby sub-unit.

Reach	Impact ID	Resource Habitat Value (H/M/L)	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Reach Priority Rating (H/M/L)
1	P2,P1	M	L	2	0	1	1	L
Total		**M**	**L**	**2**	**0**	**1**	**1**	**L**

4.2.8.4 Priority Ranking

Priority rating = low (low number of impacts, no high priority impacts)
Priority ranking among sub-units (1-11): **7**

4.2.9 Silvern Creek 440-955300-

Total Impacts: 40

4.2.9.1 Sub-Unit Description

This sub-unit is separated from the McDonell sub-unit at the confluence of Passby Creek and includes the Copper River, Dennis and Aldrich Lakes, Silvern Creek and all streams within the Copper River headwaters. The sub-unit is 14,000 ha, and has 40 cutblocks and several major roads. Approximately 11% of the sub-unit has been harvested. Reach and impact descriptions for the Copper River mainstem are included in the Copper Sub-unit section. Impacts to Silvern Creek and all tributaries within the sub-unit are described in this section.

Silvern Creek is 11.8 km in length, has 27 tributaries and drains 2 headwater lakes Silvern Lake is fish bearing and surrounded by wetlands previously identified as fisheries sensitive zones(Triton, 1998). Reach 1 of Silvern Creek is 4 km long, has an average gradient of 1.5 % and is unconfined. The channel is stable with riffle pool morphology and gravel substrate. A moderate amount of off channel habitat occurs in the lower end of the reach. Reaches 2 and 3 have moderate (5 - 10%) gradient, are confined and have stable cascade pool type morphology with boulder substrate dominant. Reach 4 is the first of two fish-bearing lakes in this watershed. Reach 5 is unconfined and has low gradient, Reach 6 is Silvern Lake. Reach 7 is the creek headwaters, 1 km in length with steep (20%) stepped pool type morphology. Reach 7 is likely not fish bearing due to its gradient.

The mainstem of Silvern Creek was previously classified as an S2 in reaches 1 and 2 based on channel widths of 8.7 and 10.80 meters respectively; Reach 3 was classified as S3, with a channel width 4.43 meters (Triton, 1998). Reach 5 is probably an S3 stream with a channel width ranging from 1.5-5m. Many of the tributaries to Silvern Creek are very steep and have been classified as non-fish bearing based on gradient alone (Triton, 1998).

4.2.9.2 Fisheries Values

Fisheries values are very high within the Silvern sub-unit. Spawning areas occur for cutthroat trout, Dolly Varden, rainbow trout, sockeye, steelhead and probably for coho occur between McDonell and Dennis Lakes and between Dennis and Aldrich Lakes. The lakes and off-channel habitats throughout this sub-unit most likely serve as important rearing and overwintering habitats for the same species.

Silvern Creek:
Silvern Creek has high fisheries values, based on the presence of both coho and sockeye salmon, and known spawning habitats for sockeye and Dolly Varden.
Reach 1: SK, CO, DV present. SK, DV spawning
CO and ST spawning suspected.
Reach 2: CO, DV present. CO spawning suspected.
Reach 3: No fish documented, DV present upstream.
Reaches 4 -6: DV (CO)
Reach 7: Likely fish bearing immediately adjacent to lake only.

4.2.9.3 Impact Discussion

Impacts to Silvern Creek Mainstem

Total: 5
A cutblock impact with logging to stream banks in Reach 1 (no buffer) was rated as high priority. A road crossing at 1.5 km on the mainstem (bridge) was rated as low priority and 3 cutblocks on right bank tributaries with low fisheries values were assigned low priority. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) shows areas of high and moderate TSIH between approximately 5 and 7 km.

Other Impacts in the Silvern Sub unit
Total: 35
The main access road for the area follows the north bank of the Copper River past Dennis and Aldrich lakes. A branch crosses Copper mainstem at 36.1 and splits, to continue west towards McDonell Lake and east along the south side of Dennis Lake. These roads cross numerous tributaries to the Copper mainstem as well as inlet streams to Dennis and Aldrich Lakes. 35 potential impacts were identified, as described in Table 8 below. Areas with high TSIH occur in upslope areas on the south side of the Silvern sub-unit, and between approximately 5 and 8 km upstream on upper Silvern Creek.

4.2.9.4 High Priority Impacts

Eight of the forty total impacts in the Silvern Sub-unit have been assessed as high priority. Three road crossings near the mouths of unnamed tributaries to the Copper River (WSC 440-929000-, WSC 440-944700 and a tributary to WSC 440-950000-) have been labeled as impacts ***D7, D9 and D11*** respectively. Each of these impacts is potentially acting as a barrier to fish movement. In addition to this, impact ***D7*** is located immediately adjacent to an historically observed cutthroat and Dolly Varden spawning location.

Four additional road crossings on tributary streams in this sub-unit have been identified in connection with logging over stream channels. Impacts ***D8*** (on WSC 440-934200-), ***D12*** (on WSC 440-440-950000-), ***D20 and D22*** (both on WSC 440-964800-) have all been assessed as high potential for excessive sedimentation input from the road crossings as well as a loss of riparian vegetation and stream cover due to the logging activity over the streams. ***D22*** is located at an historically observed Dolly Varden and rainbow trout spawning site, and cutthroat trout and Dolly Varden have been captured in the immediate vicinity of ***D8 and D12*** respectively.

One of the impacts identified on the Silvern Creek mainstem has been assigned a high priority status. Logging has occurred over the channel at impact ***D50*** (between the 1 and 2 km markers on the map) . The loss of riparian vegetation and potential for stream warming at this location could significantly impact on the sockeye and Dolly Varden spawning habitat noted approximately 200m downstream.

Table 8: Summary of impacts and impact priority for Silvern sub-unit

Impact ID	Overall Habitat Value	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Sub-Unit Priority Rating (H/M/L)
D61,D63, D53,68,D5, D6,D7,D8, D16,D9,	H	M	40	8	14	18	H

D17,D11, D12,D13, D14,D18, D15,D50, D51,D56, D57,D58, D19D20, D22,D23, D24,D21, D62,D64, D65,D1,D2 D3,D4,D66 D67,D60, D55,D54							

4.2.9.5 Priority Ranking

Priority rating = High with 40 impacts in total
Priority ranking among sub-units (1-11): **1**

4.2.10 McDonell Lake

Total Impacts: 30

4.2.10.1 Sub-Unit Description

The McDonell Lake sub-unit is 6,200 ha, encompassing the area from Serb Creek to Hankin/Passby Creek on the south side, and from Sandstone Creek to Hankin on the north side (see figure 2). The sub-unit includes McDonell Lake and all inlet streams to the lake, as well as some tributaries to the Copper River mainstem in reaches 7, 8 and 10. Twenty-seven 1st to 3rd order tributaries are included in the sub-unit. The Copper River mainstem and McDonell Lake are discussed separately in the Copper sub-unit section.

4.2.10.2 Fisheries Values

Fisheries values within this sub-unit are very high, and mostly contained within the mainstem Copper River and McDonell Lake, as discussed previously. In addition to the habitat contained within the mainstem Copper reaches, the sub-unit tributary streams contain: RB, DV, SK, CT and probably CO. DV spawning is documented in 5 inlet streams, SK spawning occurs in at least 2 streams, RB and CT spawning occurs in two separate streams. Refer to the fisheries map for location details (Appendix V). In streams where fish presence is not documented, it is assumed that salmonid use occurs.

4.2.10.3 Impact Discussion

The majority of impacts within the McDonell sub-unit are road crossing related. The Dennis South FSR runs along the south shore of McDonell Lake and the McDonell FSR runs along the north shore of the lake. These roads cross most of the inlet streams to McDonell Lake. A total of 14 road crossing related impacts were identified, 10 road crossing and cutblock combination related impacts were identified and 5 cutblock related impacts were identified. The impact priority for the sub-unit is described in the table below. The Bulkley Forest District Habitat Sensitivity Map (TSIH map) showed high and moderate TSIH zones occurring in upslope areas on the south side of McDonell Lake, no TSIH zones are shown for the north side of the lake.

4.2.10.4 High Priority Impacts

Although the total number of impacts for this sub-unit is high, only one of these has been assigned a high priority status. Impact ***M6***, located on Copper River tributary 440-813000-, has been identified as a potential barrier to fish movement and sediment source at the present road crossing. The confluence of this stream and the Copper mainstem has historical citations of sockeye, coho and steelhead spawning: habitat which may be adversely affected by sediment input from this crossing. Additionally, resident rainbow trout are known to be present upstream of the crossing.

Table 9: Summary of impacts and impact priority for McDonell sub-unit

Impact ID	Overall Habitat Value	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Sub-Unit Priority Rating (H/M/L)
M2,M5,M1 M3,M4, M6,M7, M8,M16, M17,M18, M19,M20, M21,M11, M10,M23, M24,M26, M27,M9, M12,M13, M14,M15, M22,M25, M28,M29, M30	H	M	30	1	13	16	M

4.2.10.5 Priority Ranking

Priority rating = Moderate with 1 high priority impact
Priority ranking among sub-units (1-11): **2**

4.2.11 Hankin/Willow Creek Sub-Unit 440-891300

Total Impacts: 15

4.2.11.1 Sub-Unit Description

This sub-unit includes Hankin Lake and Willow Creek. Willow Creek was divided into 5 reaches, with Hankin Lake at its headwaters in Reach 4 and a smaller lake occurring in Reach 2. The stream channel is low gradient (<4%) throughout the sub-unit, with stable riffle-pool type morphology. Reaches 1 and 3 were previously assigned RMA classifications of S2 (5-20m channel widths).

4.2.11.2 Fisheries Values:

Fisheries values within the Hankin/Willow sub-unit are very high, based on coho and steelhead spawning habitats in Reach 1 and good potential overwintering and rearing habitats for salmonids in the two lakes.
Reach 1: CT, ST, CO, DV, RB. ST and CO spawning.
Reach 2, Unnamed Lake: CT,CO, DV,RB
Reach 3: CO, CT, DV, RB (ST)
Reach 4, Hankin Lake: RB (CT, DV)
Reach 5: No fish presence documented.

4.2.11.3 Impacts Discussion:

Total : 15
This sub-unit has the highest percentage of harvested area within the project area; 22 cutblocks cover approximately 25% of the sub-unit. Cutblocks in this sub-unit appear to have large buffer zones,

however, and no impaired riparian function was noted. There are no areas of high terrestrial sediment input hazard indicated in the Hankin/Willow sub-unit. An area linked to salmon habitat, located to the Southwest of Hankin Creek were identified as moderated hazard.

Reach 1 Impacts:
1 road crossing (bridge) at 1 km upstream, is not a fish passage issue, but is a potential source of sediment, and was rated as moderate priority for assessment. A road crossing on known fish bearing tributary to Reach 1 was also rated as moderate priority. A landslide directly into reach 1 of Willow was identified as a high priority impact due to the high levels of sediment input resulting from the failure.
Upslope impact potential for reach: Moderate

Reach 2 Impacts:
Unnamed Lake, no impacts.

Reach 3 Impacts:
In Reach 3 the mainstem (Willow Creek) has been logged over for a distance of 1.5 km between Km 4 and Km 5.5. This is private land, and is used for agriculture. The area was rated as high priority for assessment, due to the high fisheries values of the creek.
A road crossing at 7.1 km on the mainstem may be a source of sediment, was rated as low priority for assessment.
A right bank tributary at 6.6 km had 2 identified impacts, both road crossings. Fish values are unknown and these were rated as low priority.
A left bank tributary at 5.7 km (ILP 370) known to contain Dolly Varden has 2 road crossings, rated as moderate priority for assessment because several kilometers of habitat exist upstream, and fish passage should be confirmed. Tributary ILP 371 also had 1 road crossing rated as moderate priority.
A tributary to ILP 371 was harvested in 1998, the cutblock did not show on air photos but the impact was assumed to be a low priority, having been protected by the appropriate FPC RMA classification.
A road crossing a right bank tributary at 8.5 km with known rainbow trout presence was rated at low priority as only 300m of potential habitat exists upstream of crossing.
Upslope impact potential for reach: High

Reach 4 Impacts:
Hankin Lake, no impacts.

Reach 5 Impacts:
1 road crossings at 10.5 km was rated as low priority, due to moderate to low fisheries values in the reach. At 11.2 km on the mainstem a road crossing and a cutblock to the stream edge with no buffer occur - rated as low priority due to moderate to low fisheries values in the reach.
Upslope impact potential: Moderate

4.2.11.4 High Priority Impacts

Three high priority impacts have been identified in the Hankin/Willow sub-unit. An open ford crossing of the mainstem between 0 and 1 km has been identified as impact ***H14.*** The direct

habitat degradation caused by this crossing is present in conjunction with historically observed coho spawning activity immediately upstream, and coho presence immediately downstream.

A landslide identified on the mainstem between the 2km and 3km markers on the map is labeled as impact ***H15***. The sediment input from this landslide has been classified as a high priority due to the presence of coho spawning areas downstream.

Impact ***H2*** has been identified in connection with logging activity over the stream channel for a distance of approximately 4km. A road crossing is also present. Excessive sedimentation from the roads and loss of riparian vegetation and stream cover at this location is a high priority due to the very high value of the fish habitat on this stream.

Table 10: Summary of impacts and impact priority for Hankin/Willow sub-unit

Reach	Impact ID	Resource Habitat Value (H/M/L)	Upslope Impact Potential	Total # of Impacts	Total # of High Priority Impacts	Total # of Moderate Priority Impacts	Total # of Low Priority Impacts	Reach Priority Rating (H/M/L)
1	H4,H1 H14,H15	H	M	4	2	1	1	L
3	H2,H3 H5,H6 H7,H8 H9,H10 H11	H	H	9	1	4	4	M
5	H12,H13	L	M	2	0	0	2	L
Total for Sub-Unit		**H**	**M**	**15**	**3**	**5**	**7**	**M**

4.2.11.5 Priority Ranking

Priority rating = Moderate with 2 high priority impacts
Priority ranking among sub-units (1-11): **4**

4.3 Riparian Assessment

The riparian assessment focused on determining riparian vegetation types (polygons), identifying impacted/suspected impacted riparian areas, specifically adjacent to fish-bearing waters, and in guiding future field assessments. Three major riparian vegetation types were found within the study area, and are described below. Overall results from the riparian impact assessment are summarized by impact type and by sub-basin (Table 12) and are shown on the maps in Appendix V. Impacts were totalled for each sub-basin and a relative ranking for sub-basins was established based on the number of known, suspected and unknown impacts in each. Rankings are used to guide further assessment and/or restoration efforts. Costs and planning for detailed riparian assessments of the most impacted sub-basins are detailed in the final report section: Summary and Recommendations.

4.3.1 Riparian Vegetation Types

Within the upper Copper River watershed a mix of tree species, tree ages and stand structures were observed. Three dominant riparian vegetation types were observed, two of which are directly influenced by human and forest harvesting activity (Shrub and Mature forest). The vegetation types are briefly described in Table 11. The forest cover maps did indicate the presence of 20 to 80 year old lodgepole pine forests (young forest and pole sapling RVTs) within the study area but these did not occur in the riparian zones of fish bearing streams in conjunction with recent harvesting and are not described below. The majority of Shrub RVTs were associated with recently harvested cutblocks which are at varying stages of planting and regrowth but several of the shrub RVTs encompass range land in upper Hankin Creek and along McDonell Lake. These RVTs appeared to be on private land and would not be considered for detailed riparian assessments but are more of a mix of permanent grassland and deciduous/conifer mix than the typical replanted cutblock. The Riparian Map shows the location of the RVTs for cutblocks and categorized riparian polygons (known/suspected/unknown impacts) in the Zymoetz watershed.

Table 11: Descriptions of RVTs associated with impacted fish bearing streams in the Zymoetz Watershed.

RVT I.D. #	RVT Title	Description
1	Shrub and herbaceous (SH)	Any area of deciduous or coniferous vegetation in the early stages of growth (up to 20 yrs of age). As viewed on an airphoto, the ground is visible between trees. There is not a consistent uniform blanket of vegetation. Typically the shrub stage is observed as the early successional stage in recently harvested cutblocks and contains a mix of regenerating conifers and deciduous trees. A few shrub RVTs were range land. This RVT is most frequently associated with forest development and harvested cutblocks.
2	Mature forest (coniferous) (MFC)	A uniform group of coniferous trees (coniferous trees account for >75%) from 80-250 yrs old. Appear on airphotos as a forest where individual trees can be distinguished. The ground is likely visible through the canopy. This RVT accounted for greater than 90% of the vegetation types within the study area. This RVT is not indicated on the map since the majority of the map is of this type.
3	Wetland (WT)	A swamp, marsh or other similar area that supports natural vegetation that is distinct from the adjacent uplands area. Usually contains open water and wetland vegetation types. Typically associated with off-channel habitats and fisheries sensitive zones, this RVT is not associated with forest development.

4.3.2 Riparian Impact Summary and Sub-basin Impacts

All categorized riparian impacts (known/suspected/unknown) were recorded on forms during air photo review along with relevant stream classification, impact length, stand structure and logging history. The forms are presented in the Appendices for each impact and the summarized total number of impacts of each type are presented in the table and sub-basin descriptions below. Riparian zones alongside fish bearing creeks that contained adequate mature forest and buffer width were considered unimpacted and are not reported below.

In general, the known and suspected impacts are concentrated in basins with extensive road development and cutblocks logged in the late 1980's and early 1990's. The known or suspected riparian zones may have recovered partial functioning and tree recruitment since 1992 but will still be impaired. Basins with unknown conditions have recently (1993-1998) been developed and no air photo information was available. Basins with no known or suspected riparian impacts contain very little forestry activity but forest development is planned for the future and if conducted according to FPC regulations will ensure that reserve zones will be maintained to avoid impacts.

A large number of riparian polygons were associated with forest harvesting which occurred after 1992, the date of the air photos we reviewed. In these circumstances riparian impacts from logging could not be assessed using the forest cover and trim maps alone and the unknown (indeterminate) category was assigned to the riparian polygons. Since the Forest Practices Code was enacted in 1995, mandatory reserve zones of mature forest must be left alongside S1 to S3

fish bearing creeks. It is reasonable to assume that for riparian polygons associated with 1996 or later logging, adequate riparian reserve zones were left to ensure effective riparian functioning. This would require verification on recent (1997, 1998) air photos and would reduce the number of polygons of unknown condition. The riparian polygons associated with 1992 to 1995 logging may not have been given riparian reserve zones or adequate buffers and are a higher priority for clarification of the unknown status of the reserve zone. In addition, these 1992-1995 cutblocks are typically located near low order (first, second) and further from higher order streams which contain critical habitats.

Table 12: Riparian Impacts Identified within each Sub-basin in the Upper Zymoetz Watershed

Sub-basin	Known Impacts	Suspected Impacts	Unknown Condition	Total
Silvern Creek	11	7	9	27
Copper River	5	2	11	18
Hankin/Willow Creek	1	5	4	10
McDonell Lake	0	4	8	12
Sandstone Creek	0	1	3	4
Coal Creek	0	0	12	12
Lee Creek	0	0	0	0
Red Canyon Creek	0	0	0	0
Serb Creek	0	0	0	0
Passby Creek	0	0	0	0
Mulwain Creek	0	0	0	0
Total	17	19	47	73

There are no forestry related riparian impacts in the Serb, Lee, Passby, Red Canyon or Mulwain sub-units. Several wetland polygons are annotated on the riparian assessment maps where fisheries sensitive zones occur. The sub-basins with impacts are listed below from highest to lowest impacted sub-basin. Further assessment steps are described in the Summary and Recommendations section for Silvern, Hankin/Willow and Copper sub-basins.

SILVERN Sub-basin

There are eleven known forestry related riparian impacts in the Silvern sub-basin, seven suspected impacts and nine potential riparian impacts of unknown condition. Of the eleven known impacts, 107-57, 108-60, 119-71, 120-72, 121-73, 126-76 and 127-77 affect riparian areas 0.2 to 0.9 km long, on both banks of S3 tributaries to the Copper River. Known impacts 117-68, 117-69, and 118-70, affect riparian areas 0.3 to 0.7 km long on one bank of S2 and S3 tributaries to the Copper River. Known impact 126-74 affects 0.5 km of one bank of an S2 tributary to Silvern Creek. Suspected impact 106-56 affects both banks of an S3 tributary to the Copper River for 0.3 km; suspected impacts 103-53, 107-58, 108-59, 113-65, 116-67, and 126-65 affect the riparian areas of one bank of S2 and S3 tributaries to the Copper River.

COPPER Sub-basin

There are five known forestry related riparian impacts in the Copper River sub-basin, two suspected impacts and nine potential riparian impacts of unknown condition. Of the five known impacts, four are approximately 0.2 km long and located on the north bank of Reach 7 of the Copper River. The fifth known impact, labeled 21-5, is located on an S3 tributary to Reach 7 of the Copper River. This impact is 0.4 km long and affects the riparian area on both sides of the creek. The two suspected impacts, 135-80 and 137-82, are both located on the north bank of Reach 7 of the Copper River and are approximately 0.2 km long.

HANKIN/WILLOW Sub-basin

There is one known forestry related impact in the Hankin/Willow Creek sub-basin, five suspected impacts and four potential riparian impacts of unknown condition. The known impact, 83-43, affects both sides of an S2 tributary to Hankin/Willow Creek, for 0.6 km. Suspected impacts in polygons 83-41 and 83-44 affect riparian areas on both sides of S2 tributaries to Hankin/Willow Creek for approximately 0.7 km. Suspected impact 88-45 affects both sides of an S3 tributary for 0.6 km, while suspected impacts 85-46 and 95-47 affect the riparian areas of one side of class S3 tributaries.

McDONELL Sub-basin

There are five suspected forestry related riparian impacts in the McDonell Lake sub-basin, and seven potential riparian impacts of unknown condition. Of the five suspected impacts, impact 79-40 is 0.3 km long and affects the riparian areas on both sides of an S3 creek. The suspected impact labeled 74-37 is 0.9 km long and may affect the riparian function of the McDonell Lake foreshore. The three other suspected impacts only occur in patches, affecting riparian areas from 0.3 to 1.8 km in length along the McDonell Lake foreshore and the north bank of Reach 8 on the Copper River. These impacts may be associated with private land that is used for ranching and subsequent assessment would be important but may be difficult to complete. Cattle may be affecting the riparian condition in these polygons.

SANDSTONE Sub-basin

There is one suspected forestry related impact in the Sandstone Creek sub-basin, and three potential riparian impacts of unknown condition. The suspected impact, 49-30, is located in Reach 1 of Sandstone Creek and may impact the riparian functioning of one bank of the creek for 0.6 km.

COAL Sub-basin

There are twelve potential riparian impacts of unknown condition in the Coal Creek sub-basin.
RVT polygons for requiring further assessment are detailed in Table 14 which can be found in Section 5: Summary and Recommendations. These polygons have been identified for further assessment as they contain known impacts and do not appear to be supporting young forests.

5. SUMMARY AND RECOMMENDATIONS

Fisheries values within the project area are well documented and very high. Fish use extends to the headwaters of nearly every sub-unit, with the exception of Red Canyon Creek. What is exceptional about the upper Copper watershed, relative to the lower portion, is that anadromous fish use extends into upper reaches of nearly all major streams. Tributaries to the lower Copper River (downstream of Red Canyon Creek) are typically steep and entrenched, with fish use limited to the valley bottom, and barriers preventing fish access into upper reaches. In the upper Copper River watershed, tributary streams contain extensive lengths of low gradient riffle-pool type habitat accessible to anadromous fish. Very few barriers to upstream migration exist. As a result, steelhead and coho spawning habitats are probably occur in all major sub-units. Extensive off-channel rearing and overwintering habitats occur within the Copper River mainstem in the valley bottom, and in the Coal Creek sub-unit. Numerous lakes in the area improve both the quantity and quality of fish habitat available, and nearly all of the lakes are accessible to anadromous fish. Lakes function to moderate water temperatures, quality and flow, providing stability by buffering streams against sudden or 'flashy' flows, and providing a steady water supply to habitats downstream, which can be critical during low flow periods in the summer. Lakes within the area also provide critical rearing areas for sockeye and excellent overwintering habitats for adult steelhead.

Overall, it appears that potential logging related impacts to fisheries resources in the Upper Copper watershed are low, especially in consideration of the size of the area and the values of fish habitats throughout. Nearly all of the potential impacts identified at the overview level were road crossing or riparian zone related, and compared to other watersheds with extensive forest development virtually no impacts such as forestry related landslides, road failures, or bank failures were noted.

The top three priority sub-units in terms of restoration potential are Silvern, Copper and McDonell. The Silvern, Copper, McDonell and Hankin/Willow sub-units also had the highest number of impacts, and have equal access potential by road. Coal, Sandstone, Passby and Serb sub-units are, in descending order, next highest priority. No further assessments are required for Mulwain, Lee and Red Canyon Creeks as they are pristine, however development in these areas should consider unstable terrain as identified on the FDZ maps. Table 13 provides a summary of sub-unit rankings determined during the overview process.

Table 13: Results of Sub-unit prioritization and ranking

Overall ranking (1= highest priority, 11 = lowest priority)	Sub - unit	Total Impacts	Riparian Assessments Required?	Sub-unit restoration priority (H/M/L) *(tentative)*
1	Silvern	40	Yes	High
2	Copper	21	Yes	Moderate
3	McDonell	30	No	Moderate
4	Hankin/Willow	15	Yes	Moderate
5	Coal	18	No	Moderate
6	Sandstone	4	No	Low
7	Passby	2	No	Low
8	Serb	1	No	Low
9	Mulwain	0	No	Very Low
10	Red Canyon	0	No	Very Low
11	Lee	0	No	Very Low
Total		**131**		

Serb, Red Canyon, Lee and Mulwain Creek sub-units, which have had minimal or no forestry development and/or impacts to date require special development planning consideration. Any development planning in these sub-units should refer to the information presented by Roberts (1995) regarding terrain stability and surface erosion potential. Roberts (1995) FDZ maps indicate red zones where terrain is "steep and prone to active or recurrent landslides" with a "high to extreme potential for continued or accelerated mass movement during and following conventional logging operations" in sections throughout these sub-units. The recommendation in Roberts (1995) for planning in sensitive areas with red zones is that "no development can be carried out in red zones unless it has been proven otherwise by a qualified terrain specialist".

The majority of logging in the area has occurred recently, and adequate buffer zones usually occur where cutblocks are near fish bearing streams. It is unknown whether most road crossings are impacting fish habitat, as the scale of the photos is too small to allow accurate assessment. If fish are able to migrate past crossings, either as adults to spawn or as juveniles migrating upstream to rear, than the impact of the crossing is likely nil. If fish are unable to migrate past these crossings *and* important spawning and/or rearing habitat upstream is available, then the impact could be very high.

We recommend a 2 phase assessment of these road crossings using the sub-unit rankings as a guide for areas containing the crossings in the greatest need of attention. The first phase being an evaluation, using standard fish passage criteria from the Fish Stream Crossing Guidebook (MoF, 1996), DFO or MELP, of whether fish passage was obstructed. If there is a problem, the assessment would evaluate whether the quantity and quality of fish habitat upstream justified restoring fish access into the alienated habitat. If so, then a 2nd phase of detailed design and costing of mitigation would occur. Given the potentially high impact of fish passage problems at culverts, we recommend that this 1st phase be completed throughout the study area. Given the relative simplicity of the exercise, it could be done for a relatively low cost, and be combined with ground truthing of other potential impacts. This initial phase will reduce the number of

potential crossing impacts to a smaller number of **actual** crossing related impacts, for which detailed cost estimates for restoration can be prepared.

Given the reduced funds available for WRP projects, this phased approach would ensure that future funds are quickly directed towards areas that will make the most difference in restoring fish habitat. A standard WRP Level I assessment of priority sub-basins is a time consuming labour intensive data collection exercise that may not lead to significant restoration activities. The amount of funds required for ground truthing road crossings and other impacts is relatively easy to estimate. Any person experienced in watershed restoration can quickly determine whether an identified potential impact is a problem or not. If it is determined that the crossing is not a problem, the assessment should proceed no further. If it is a problem, then a very brief analysis of the scope of the problem could be done to provide preliminary priority setting. We estimate the costs for this 1st phase assessment to be approximately $25,500, details are provided in Table 15. This study should be carried out in the July-August period, to evaluate low flow conditions. If it is completed later, then fewer options for proceeding to Phase 2 would be available.

The 2nd phase would be driven by the results of Phase 1, and we recommend it be completed in the following fiscal year. We recommend this long time line as the costs for detailed survey and design can be quite high, and these funds may not be available for next year. Accurate budget numbers, linked to fixing real fish problems, will be an output of Phase 2, and will be easier to justify to funding agencies.

The advantage of this approach is that WRP efforts are continually refocused on areas where problems exist for fish, and minimal funds are spent documenting where there isn't a problem. If the scope of problems are low in the upper Copper, then the money spent assessing them will be appropriately low.

It is important to reiterate at this point that this assessment was limited to an office review and was largely based on 7 year old photos. All impacts identified require ground truthing to confirm. Many of the road crossings identified as potential impacts may or may not have fish passage problems, impacts may be more or less severe than it appears, and impacts may have changed significantly over the last 7 years. However, the area appears to be functioning well, and any forest development occurring since the implementation of the Forest Practices Code in 1995 should have considered fisheries resources and protected them accordingly.

Further Riparian Assessments

The next step for riparian assessments is to conduct Level 1 Assessments at the impact locations identified in the Silvern, Copper, and Hankin sub-units to determine the extent of riparian impairment and identify appropriate restoration strategies. The Level 1 would require a botanist or forester and technician experienced with silviculture data collection who would refine overview impact assessments, assess riparian functioning (vegetation, soils, stream channel), identify poorly functioning riparian zones and develop rehabilitation prescriptions. This would be lead to a prioritized list of impacted sites requiring rehabilitation and the site specific preliminary restoration prescriptions.

The impacted riparian areas which should be ground checked are listed in Table 14 below. Approximate cost estimates are provided in Appendix III and are shown on Table 14. The cost estimates are intended to reflect visiting one to two sites per day with a reporting phase built in (budgeted as one field day being equal to one reporting day).

Table 14: RVT Polygon Candidates for Further Assessment and Cost Estimates

Sub-basin	Riparian Polygon Number	Description	Next Step	Cost Estimate - includes field and office portion (see Appendix III)
Silvern Creek	120-72,108-60 119-71,121-73 126-76,126-77 107-57	Stream classes S1, S2 & S3 logged on both banks for 0.4-0.9 km	Assess area for riparian functioning and coniferous component. Possible reintroduction of conifers.	$ 7150
Silvern Creek	117-68, 118-70 126-74, 117-69	Stream classes S2 & S3 logged on one bank for 0.3-0.7 km	Assess for tree densities and for a coniferous understory.	(included above)
Hankin/Willow Creek	83-43	Stream class S2 logged on both banks for 0.6 km	Assess area for riparian functioning and coniferous component. Possible reintroduction of conifers.	$ 650
Copper River	21-5	Stream class S3 logged on both banks for 0.4 km	Assess area for riparian functioning and coniferous component.. Possible reintroduction of conifers.	$ 3250
Copper River	133-78, 134-79 136-81, 138-83	Stream class S1 logged on both banks for 0.2 km	Assess area for riparian functioning and coniferous component. Possible reintroduction of conifers.	(included above)

5.1 Cost Analysis of Recommendations

Details of the estimated costs for recommended further road assessments as discussed in the previous section are given below for each impacted sub-unit.

Table 15: Estimated costs to complete preliminary assessments of road crossings throughout the project area.

Sub-Unit	Total Potential Road Crossing Impacts	Days required to assess	Field Technicians	Professional Fees	Truck (based on rate of $250/day, includes fuel)	Miscellaneous Equipment and Supplies	Reporting Costs	Total
Coal	18	3.6	2	$ 2,520	$ 900	$ 100	$ 700	$ 4,220
Copper	18	3.6	2	$ 2,520	$ 900	$ 100	$ 700	$ 4,220
Hankin	11	2.2	2	$ 1,540	$ 550	$ 100	$ 350	$ 2,540
McDonell	24	4.8	2	$ 3,360	$ 1,200	$ 100	$ 1,050	$ 5,710
Passby	1	0.2	2	$ 140	$ 250	$ 50	$ 350	$ 790
Sandstone	4	1.0	2	$ 700	$ 250	$ 50	$ 350	$ 1,350
Silvern	29	5.8	2	$ 4,060	$ 1,450	$ 100	$ 1,050	$ 6,660
Total for all sub-units	**105**	**21**		**$ 14,840**	**$ 5,500**	**$ 600**	**$ 4,550**	**$ 25,490**

High priority impact sites are listed in Table 16, below. The cost of a ground assessment for all high priority sites is estimated at approximately $5,725, costing details are provided in Table 17. The highest priority impacts within this group are:

- C35 - a road failure on the McDonell FSR that appears to be directly impacting the mainstem Copper River,
- C16 - a road wash-out on a tributary (440-787100) to the Copper River which is within a FDZ 'red zone',
- H14 - an open road crossing impacting Reach 1 of Willow Creek, and,
- H15 - a landslide potentially impacting coho spawning habitat in Willow Creek.

Cost estimates for level 1 type assessments of all impacts, including riparian assessments, within each sub-unit are provided in Appendix III. Costs were based on the estimates of time required to complete field assessments, plus miscellaneous expenses, truck costs and reporting time which was estimated as equal to the number of field days. Day rates were assigned at $350/day for a field technician/biologist, and are based on a field day of 10 hours. The following time estimates for preliminary impact assessment were used:

Assess road crossing for fish passage: 5 sites/day
Assess road crossing and associated cutblock for potential impacts: 3 sites/day
Assess riparian areas: 2 sites/ day
Assess cutblock related impacts, other identified impacts: 4 sites /day
Reporting - each field day (or portion) as equal to one reporting day (or portion)

The total cost for a Level 1 type assessment of all potential impacts, including riparian assessments within the project area is estimated at approximately $54,000, a costing budget is in Appendix III. Amongst sub-units, Silvern had the highest overall costs for Level 1 assessments at approximately $20,00 followed by the McDonell and Copper sub-units at approximately $10,400 and $9,900 respectively. The Hankin sub-unit was estimated at approximately $5,600 for further assessment of all known impacts and riparian areas. These 4 sub-units had the highest priority for further assessment, and the cost to complete assessments for the 4 sub-units is estimated at $45,830 which represents 85% of the cost to complete assessments for the entire upper watershed.

Table 16: High priority impact sites identified within the upper Copper River watershed.

SUB BASIN	STREAM ID	REACH NUMBER	HABITAT VALUE	UPSLOPE IMPACT POTENTIAL	IMPACT ID#	DESCRIPTION	PRIORITY	ASSESSMENT REQUIRED
HANKIN/ WILLOW	WILLOW	1	H	M	H14	OPEN ROAD CROSSING PRESENT IN REACH 1 OF HANKIN/WILLOW MAINSTEM WHERE VEHICLES PRESENTLY DRIVE THROUGH THE CREEK	VERY HIGH	UPGRADE OF THE ROAD CROSSING TO FISH PASSAGE STANDARDS. MAY BE PRIVATE.
HANKIN/ WILLOW	WILLOW	1	H	H	H15	A LANDSLIDE DIRECTLY INTO REACH 1 OF HANKIN /WILLOW IS CAUSING A HIGH LEVEL OF SEDIMENT INPUT	VERY HIGH	ASSESS FOR STABILITY, REGENERATION AND SEDIMENT INPUT.
COPPER	440-787100	1	M	H	C16	A ROAD ALONG THE RIGHT BANK FROM .6 - 3.5 KM. A WASHED OUT SECTION OF THE ROAD IS ALSO OBSERVABLE. CROSSING IS IN A RED ZONE.	VERY HIGH	CHECK FOR SEDIMENTATION, EROSION, SLUMPING AND WASH-OUT.
COPPER	COPPER	7	H	M	C35	ROAD HAS FAILED ON CORNER AND SLID DIRECTLY INTO THE COPPER.	VERY HIGH	ASSESS FOR STABILITY, REGENERATION AND SEDIMENT INPUT. APPEARS TO HAVE SOME DECIDUOUS REGENERATION. BIOENGINEERING POTENTIAL.
MCDONELL	440-813000	1	H	M	M6	A ROAD CROSSING 300M FROM THE MOUTH	H	CHECK FOR FISH PASSAGE AT ROAD CROSSING
SILVERN	440-929000	1	M	M	O7	A ROAD CROSSING AT THE REACH 1/2 BREAK	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING
SILVERN	440-934200	1	M	M	D8	A ROAD CROSSING AND LOGGING OVER THE CREEK AT 1 KM UPSTREAM FROM THE MOUTH. THERE ARE SPAWNING AND REARING CONCERNS AT THIS IMPACT	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING)
SILVERN	440-944700	1	H	M	D9	A ROAD CROSSING 800M FROM THE MOUTH. THERE ARE SPAWNING AND REARING CONCERNS AT THIS IMPACT	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING
SILVERN	TRIB TO 440-950000	1	H	M	D11	A LEFT BANK TRIB ENTERING 440-950000- AT 300M FROM THE MOUTH HAS A ROAD CROSSING 400M UPSTREAM FROM ITS MOUTH. THERE ARE SPAWNING AND REARING CONCERNS AT THIS IMPACT	H	CHECK FOR FISH ACCESS, SEDIMENTATION AND SLUMPING
SILVERN	440-95000	1	H	M	D12	A ROAD CROSSING AND IS LOGGED OVER 600M FROM THE MOUTH . THERE ARE SPAWNING AND REARING CONCERNS AT THIS IMPACT	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING
SILVERN	440-964800	1	M	M	D20	HAS BEEN LOGGED OVER AND HAS A ROAD CROSSING 1.8KM FROM THE MOUTH	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING (N.B.- THERE ARE SPAWNING AND REARING CONCERNS AT THIS IMPACT)
SILVERN	440-964800	1	H	M	D22	A ROAD CROSSING AND LOGGING OVER THE CREEK 1.7KM UPSTREAM FROM THE MOUTH	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING
SILVERN	SILVERN	1	H	M	D50	LOGGING OVER SILVERN CREEK 1500M UPSTREAM FROM DENNIS LAKE	H	BANK STABILIZATION AND RIPARIAN RESTORATION
HANK/WILL (-891300)	WILLOW	3	H	H	H2	LOGGING OVER THE STREAM FOR 4KM. (A ROAD CROSSING IS ALSO PRESENT)	H	CHECK FOR BARRIERS AND SOURCES OF SEDIMENTATION
COPPER /SILVERN	COPPER	14?	H	M	D25	THE COPPER RIVER MAINSTEM HAS BEEN LOGGED OVER	H	CHECK FISH ACCESS, SEDIMENTATION AND SLUMPING

Table 17: Estimated budget for further assessment and restoration work for High Priority areas.

Activity	Total High Priority Impacts	Days Required to assess	Field Technicians	Technician Fees	Truck (based on rate of $250/day, includes fuel)	Miscellaneous Equipment and Supplies	Total
Assess High Priority Impacts Related to Road Crossings	6	2.0	2	$1,400	$500.00	$500.00	$ 2,400
Assess High Priority Impacts Related to Cutblock and Road Crossing at same location	5	2.0	2	$1,400	$500.00	$ -	$ 1,900
Assess High Priority Impacts Related to Cutblocks Only	3	1.0	2	$700	$250.00	$ -	$ 950
Assess Other High Priority Impacts	1	0.5	2	$350	$125.00	$ -	$ 475
Totals	**14**	**5**	**8**	**$3,850**	**$1,375**	**$500**	**$ 5,725**

6. REFERENCES

Argent, H.W. and Poulin, V.A. 1997. Stream Crossing Guidebook for Fish Streams. A Working Draft for 1997/1998.

Department of Fisheries and Oceans. 1991. Fish Habitat Inventory and Information Program Stream Summary (SISS) Catalogue Subdistrict #4B, Terrace. North Coast Division Fisheries Branch.

Lewis, A.F. and S. Buchanan. 1998. Zymoetz River Steelhead: Summary of Current Data and Status Review, 1997. Skeena Fisheries Report SK-102.

Ministry of Environment, Lands and Parks and Department of Fisheries and Oceans. 1995. Fisheries Information Summary System (FISS) Maps (1:50,000).

Ministry of Environment, Lands and Parks and Ministry of Forests. 1998. Riparian Assessment and Prescription Procedures. Watershed Restoration Technical Circular No. 6. Province of British Columbia, Watershed Restoration Program.

Ministry of Forests. 1996. Channel Assessment Procedures Guidebook.

Roberts, B. 1995. Resource Development in the Upper Zymoetz River Catchment: a review of issues affecting the Class I fishery attributes of the Zymoetz River. Prepared for the Ministry of Forests, Bulkley Forest District, Smithers, BC.

Triton Environmental Consultants Ltd. 1998. Reconnaissance (1:20,000) Level Fish and Fish Habitat Inventory in the Bulkley T.S.A. (Working Unit # 11 - Zymoetz). Prepared for Pacific Inland Resources, Smithers, BC.

Johnston, N. and P. Slaney. 1996. Fish Habitat Assessment Procedures. Watershed Restoration Technical Circular No. 8. Province of British Columbia, Ministry of Environment, Lands and Parks, Watershed Restoration Program.

7. APPENDICES

Appendix I: Oblique Photos

Page 1 obliques

Page 2 obliques

Page 3 obliques

Appendix II: WRP Database Tables (Forms 1, 2 and 3), Riparian Polygon Results Table

Appendix III: Preliminary Budget for Level 1 Assessments by Sub-Unit.

Appendix IV: 1995 RJA Forestry Bound Photo Mosaic for the Upper Copper (included under separate cover)

Appendix V: Fisheries Impacts and Riparian Polygon Maps (included separately)