NORTH AMERICAN TUNGSTEN CORPORATION LTD




North American Tungsten Corporation Ltd.

MACTUNG PROJECT

2006 Environmental Baseline Studies
FISHERIES AND AQUATIC RESOURCES

12000163.005

April 2007

CREATING AND DELIVERING BETTER SOLUTIONS

eba

North American Tungsten Corporation Ltd.

MACTUNG PROJECT

2006 ENVIRONMENTAL BASELINE STUDIES

FISHERIES AND AQUATIC RESOURCES

1200163.005

April 2007

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EXECUTIVE SUMMARY

North American Tungsten Corporation Ltd. (NATCL) retained EBA Engineering Consultants Ltd. (EBA) to update and supplement historic baseline fisheries and aquatic resources information at the MacTung Project Property (MacTung study area), on both the Yukon and Northwest Territories sides of the study area. The survey objective was to document fish and benthic species and habitat characteristics within the study area for future regulatory submissions leading to MacTung Project approvals and implementation.

Fisheries and aquatic sampling was conducted at nine stations in August 2006. Five stations were located on the NWT side of the project area. These stations were located on upper and lower Dale Creek (FS1, FS5), Cirque Creek (FS2), and upper and lower Tsichu River (FS3, FS4). Four stations were located on the Yukon side of the project area. These stations were located on Tributary A (FS7) and C (FS6) and on the Hess River upstream and downstream of the confluence with Tributary A (FS8, FS9).

On the Northwest Territories side of the project area, fish sampling by electrofishing resulted in no fish observations or captures at any of the sampling stations during the 2006 field program. Based on previous fisheries work on the NWT side of the project area, (AMAX 1983), Dale Creek and the Tsichu River were expected to support populations of Arctic grayling, Dolly Varden, mountain whitefish, slimy sculpins and burbot. Aerial reconnaissance surveys conducted further downstream in the area indicated no signs of impassable barriers to fish movements. It is recommended that these stations be resurveyed for a second season in 2007 to corroborate or alter the interim understanding of current fish utilization of the streams sampled.

On the Yukon side of the project area, slimy sculpins were observed by the fisheries crew in the Hess River, but not in Tributary A flowing down from the project area. The Hess River sculpins could not be captured because of safety considerations of electrofishing with a two-person crew in a deep, fast flowing river. Fish sampling should also be repeated on the Yukon side of the project area for a second season in 2007.

Stream benthic invertebrate sampling data produced a wide range of abundance, density, richness and diversity between stations and in some cases between replicated samples. Diptera was the only group represented at all stations. There appear to be some differences between invertebrate species composition in the two drainage areas surveyed. At stations FS1 to FS5 on the eastern slope of MacMillan Pass in the Northwest Territories, Plecoptera, Diptera, Hydracarina, and Copepoda dominated the benthic communities. At stations FS6 to FS9 on the western side of MacMillan Pass in Yukon Territory, Ephemeroptera, Plecopetra, Diptera and Lumbriculida dominated the benthic communities. At most stations, abundance was considered low.

Stream habitat values were generally rated as high. Station FS4 was assigned a habitat value of poor due to a naturally low pH reading of 4.65 and the presence of metal precipitates from natural sources. Station FS2 (Cirque Creek) and Station FS6 (Tributary C) were assigned habitat values of average due to their steep gradients and resulting flows. All other stations were considered to provide potentially good habitat.

Physical water quality was generally good at all stations. Station FS4 exhibited a low pH value of 4.65, stations FS4, FS6, and FS7 exhibited higher conductivity values than the other stations. Dissolved oxygen levels were high at most stations. The lowest recorded level of dissolved oxygen was 7.95 mg/L at Station FS5 in upper Dale Creek.

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1.0 INTRODUCTION

North American Tungsten Corporation Ltd. (NATCL) is considering development of a world-class tungsten deposit located near Macmillan Pass, on the border between the Northwest Territories and the Yukon (Figure 1). The mine site is located in the Selwyn Mountains at an elevation of 1,725-1,800 m a.s.l. The mine site is connected to the southern Yukon during summer months by the Canol Road, and is 650 km (400 air km) northeast of Whitehorse. The mine site is linked to the Canol Road just east of Macmillan pass by a 10 km-long access road.

NATCL retained EBA Engineering Consultants Ltd. (EBA) to update and supplement historic baseline fisheries and aquatic resources information at the MacTung Project Property (MacTung study area), on both the Yukon and Northwest Territories sides of the study area. The survey objective was to document fish and benthic species and habitat characteristics within the study area for future regulatory submissions leading to MacTung Project approvals and implementation.

2.0 ENVIRONMENTAL SETTING

2.1 GENERAL DESCRIPTION

The MacTung region is characterized by rugged mountain terrain, which forms part of the continental divide and are known as the Mackenzie Mountains. Considered a northern extension of the Rocky Mountains, the region includes some very high peaks. Climatic conditions vary with elevation and vegetation cover varies in response to elevation and exposure, with primarily alpine and subalpine open woodland zones. Barren talus slopes are also common in higher areas. The region was glaciated during the last ice advance and numerous glacial features have been identified. Permafrost is discontinuous (Environment Canada 2000). The headwaters of the Hess River are located on the Yukon side of the border and the headwaters of the Peel River are located in the NWT.

Although the majority of the MacTung Project study area is situated in an alpine environment (dominated by grasses, lichen, moss and small shrubs) or on rock-scree slopes, extensive stands of shrub communities occur nearby, including within the proposed areas for both the lower Yukon and NWT tailings pond location options. Shrub birch and willow appear to be dominant and are dense (EBA 2006). The nearest settlements are Ross River in the Yukon and Norman Wells and Tulita in the NWT.

A comprehensive environmental baseline study of the MacTung Project study area was prepared by AMAX Northwest Mining Company Ltd. in 1983 (AMAX 1983). This report compiled environmental data collected from 1977 to 1982. A summary of the fisheries and aquatic data are presented here.

2.1.1 Water Quality

Water quality data was acquired in the MacTung study area by AMAX between 1977 and 1981 (AMAX 1983). Water quality in Dale Creek was found to be generally good with low turbidity. Water quality in the Upper Tsichu River, upstream of the confluence with Dale Creek was found to be often acidic with pH values as low as 4.7. Metal concentrations were also higher than in Dale Creek. The headwater of the Tsichu River contains black pyrite shale from which acid rock drainage is common. Rusty Red-coloured, acidic water can be produced through oxidation of pyrite, which in turn dissolves iron and sulphate. Through contact with more alkaline water, precipitation of iron in the form of siderite ($FeCO_3$) and calcium sulphate can occur. Siderite is visible as a red stain, while calcium sulphate is a white precipitate. Both conditions are (naturally) present in the upper Tsichu River drainage.

In the lower Tsichu River, pH values were neutral or higher and metal concentrations lower, indicating that Dale Creek has a moderating effect on the poorer water quality of the upper Tsichu River. The water quality in Cirque Creek (and Cirque Lake) was excellent in terms of potability and growth and survival of fish. Turbidity was very low and metals levels were at or below detection limits.

The Hess River lies on the western slope of Macmillan Pass on the Yukon side of the project study area. A tributary of the Hess River separates the MacTung Project site from the Keele Peak area to the northwest. The water quality in the Hess River tributaries was determined to be generally good with higher conductance and dissolved solids and low alkalinity. However, the water quality in the Hess and main tributary was determined to be of better quality than was found to be the case in the feeder tributaries.

Dale Creek and Tsichu River are characterized by high and irregular flow rates. Runoff in these streams is strongly controlled by snowmelt, storm patterns, and the nature of the substrate. Because of the large extent of exposed rock at higher elevations and thin soils over much of the lower valleys, spring runoff is rapid. Although the lower elevations are not underlain by permafrost, soils were generally frozen during snowmelt, thus limiting infiltration. Stream substrates are scoured by suspended and saltating sediments, thereby minimizing colonization by aquatic plants (AMAX 1983).

2.1.2 Benthic Invertebrates

Benthic macroinvertebrate sampling was conducted on upper and lower Dale Creek and the upper and lower Tsichu River between 1977 and 1981 (AMAX 1983). . Diptera was the dominant group in terms of total abundance of organisms, followed by Plecoptera, Emphemeroptera and Trichoptera. In terms of overall community composition, Orthocladiinae and *Alloperla* sp. were the most abundant taxa, representing 31% and 30% of the individuals collected.

The greatest number of both taxa and organisms were present in Dale Creek. The upper Tsichu River had relatively fewer invertebrate taxa and organism numbers, while the numbers of taxa and organism numbers found in the lower Tsichu River distinctly fell between the values found in the other two streams. The lower abundance found in the

upper Tsichu River was determined to be probably due to siltation and the degraded physical and chemical nature of the substrate in the upper Tsichu River.

2.1.3 Fish

Fish collection data were acquired in the MacTung area between 1977 and 1981 (AMAX 1983). Six species were caught in the intensive program; Arctic grayling (*Thymallus arcticus*), Dolly Varden, (*Salvelinus malma malma*), mountain whitefish (*Prosopium williamsoni*), slimy sculpin (*Cottus cognatus*), lake trout (*Salvelinus namaycush*) and burbot (*Lota lota*). Arctic grayling accounted for 78% of all captures.

Lower Dale Creek supported good populations of Arctic grayling, Dolly Varden, and mountain whitefish. Slimy sculpins were also present and occasionally burbot. Arctic grayling comprised 82% of the fish population. Mature and immature males and females were captured, indicating that spawning and rearing potentially occurred in that reach.

2.2 2006 MACTUNG FISHERIES AND AQUATIC RESOURCES SCOPE

The general purpose of the 2006 MacTung Fisheries and Aquatic Resources Studies were to update and supplement existing baseline information regarding the fish and fish habitat conditions within the project study area

The following components of the Fisheries and Aquatic Resources Studies were conducted at all fisheries stations on Dale Creek, Tsichu River, and Cirque Creek on the NWT side of the study area, and Tributary A and C which flow into the Hess River and the Hess River on the Yukon side of the study area.

Sampling

- Fish sampling by electroshocking
- Stream macrobenthic invertebrate sampling

Fish Habitat Characteristics Measurements

- Identification of fish barriers
- determination of seasonal water flows
- determination of fish habitat values (spawning, rearing, foraging, over-wintering)

Physical Water Quality

- Dissolved oxygen (DO), pH, conductivity, and water temperature

2.3 STUDY AREA

Figure 1 illustrates the Project Area while Figure 2 shows the sampling locations which are located within the Local Study Area (the area covered by high resolution satellite imagery; 15x15 km) and the Regional Study Area.

- Five sampling locations were located on the NWT side of the project area; upper and lower Dale Creek (FS1, FS5), Cirque Creek (FS2), and upper and lower Tsichu River (FS3, FS4).
- Four sampling locations were located on the Yukon side of the study area; Tributary A (FS7) and C (FS6) and the Hess River upstream and downstream of the confluence with Tributary A (FS8, FS9).

Stations FS1 to FS5 in Cirque Creek, Dale Creek and Tsichu River are located on the eastern slope of MacMillan Pass and flow eastwards into the Peel River in the Northwest Territories. Stations FS6 to FS9 on Tributary A, C and the Hess River are located on the western side of MacMillan Pass and flow northwest into the Stewart River, Yukon Territory.

Some of the fisheries stations correspond to the stations sampled for the 2006 Water Quality Sampling Program. FS3 is near WQ7; FS6 is near WQ1; FS7 is near WQ2; FS8 is near WQ3; and FS9 is near WQ4.

3.0 METHODS

The summer 2006 fisheries program components were conducted from August 4 to August 8, 2006. The field program was conducted by EBA's Tim Abercrombie (M.Sc., R.P.Bio.), with the assistance of Nicole Jacques. Mr. Rick Hoos (M.Sc., R.P.Bio.) developed the work plan and provided supervision. The following sections discuss the methodologies employed for the assessment of the fisheries and aquatic resources program.

3.1 FISH SAMPLING

The methodology employed was consistent with the Stream Survey Field Guide published by the Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (MOE) Fish Habitat Inventory and Information Program (1989) and by the BC Fish and Fish Habitat Inventory Standards and Procedures published by the Resource Inventory Committee (RIC 1998). Scott and Crossman (1973) was used as a reference book.

Fish sampling was conducted by electrofishing using a Smith-Root LR-24 battery powered backpack electrofisher (see Photo 2). The number of seconds fished, voltage, and frequency and pulse width were recorded. The distance fished was recorded with hip-chain and the area was estimated. At stations FS8 and FS9, on the Hess River where water was too deep and fast at the sampling sites to cross safely, electrofishing was conducted from near the edges of the river channel.

3.2 BENTHIC SAMPLING

Benthic sampling was conducted at all fisheries stations. A Hess invertebrate sampler with an area of 0.086 m^2 and a 363 μm mesh size was inserted into the shallow riffle sediments, and the sediment inside the sampler (to a depth of ~10 cm) was washed for 5 minutes (Resources Inventory Committee 1997) (see Photo 3). The contents were then transferred to a polyethylene jar and preserved with 10% phosphate buffered formalin. To eliminate

potential 'contamination', two replicate stations (for a total of three) were sampled in an upstream direction, and were separated by approximately 2 m from the previous replicate station's most upstream sub-sample site. The gradient design attempts to eliminate differences in data due to different habitat types. None–the–less, efforts were made to sample locations (and sub stations) that exhibited similar water depth, flow velocity and substrate sizes.

The preserved samples were forwarded to Sue P. Salter, R.P.Bio., of Summerland, BC, an experienced invertebrate specialist for taxonomic analysis. The guidelines for taxonomic analysis provided in the MMER Guidance Document for Aquatic Environmental Effects Monitoring (Environment Canada 2002) were followed. Re-sorts were conducted on 5 of the sub-samples, thus effectively achieving a Quality Control check on approximately 10% of the samples, as specified in the MMER Guidance Document. The taxonomic analysis generated data on abundance to the family level. These correspond to the classifications given by Thorp and Covich (1991), and Merritt and Cummins (1984).

Simpson's diversity index was used in the analysis as a measure of the diversity of the taxa present in a sample. The index takes into account both the richness and abundance of the invertebrate community. This is calculated by determining for each taxonomic group at the site, the proportion of individuals that it contributes to the total at the site. The diversity index can range from 0 to 1, with a value of 1 representing the highest diversity.

3.3 HABITAT CHARACTERIZATION

Fish habitat characterization was carried out as per the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Standards and Procedures (Stream Surveys) (RIC, 1998). Basic habitat unit types such as pool, riffle, run cascade, etc., were identified and noted within representative sections of the study streams. Within each sampling section, measurements or estimates of wetted width, channel width, depth, and substrate composition were assessed. In addition, the composition of cover provided by over-stream vegetation (OSV), undercut banks (UCB), in-stream large organic debris (LWD), pools and boulders were visually estimated and photo-documented. Riparian vegetation community structure was noted as part of the field assessment. Based on these stream habitat characteristics, observed habitat values were determined.

3.4 PHYSICAL WATER QUALITY

The physical properties of the water measured in the streams included water temperature, dissolved oxygen, specific conductivity, and pH. These properties were measured at each sample station using a calibrated YSI Multi-Function Meter and a Hanna pH probe.

3.5 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Strict quality assurance/quality control procedures were adhered to during field sampling. All sampling methodologies followed accepted professional standards and practices.

3.5.1 Field Procedures

QA/QC procedures for the Fisheries Program were employed to maintain data quality. The following is a list of the main procedures adapted from Environment Canada (1993).

- All personnel involved in field procedures were qualified for the tasks and work undertaken, and were supervised by a qualified Professional Biologist (R.P.Bio.);
- All sampling was consistent throughout the program;
- All samples were collected following the most appropriate method and sample quality was maintained to the highest standard;
- Sampling equipment was the most appropriate for the particular habitat, and was in good working order;
- All samples were labelled appropriately with the site reference, date collected, and sample type;
- All samples were appropriately preserved where necessary;
- Field personnel maintained detailed field notes for future reference; and
- Field personnel followed appropriate safety guidelines for conducting fieldwork and ensured all samples were shipped in the appropriate containers following the appropriate shipping guidelines.

4.0 RESULTS

This section presents the results of the 2006 MacTung Fisheries and Aquatic Resources baseline studies. Fish sampling, benthic sampling, fish habitat characterization, and water quality results are presented below.

4.1 FISH SAMPLING

Section 4.1 presents the results of electrofishing effort during the 2006 Fisheries and Aquatic Studies. Electrofishing data are presented in Table 1. Figure 2 illustrates the stream sampling locations. The photographs appended to the report depict the conditions at each of the sites.

4.1.1 FS1 – Dale Creek

At Station FS1 in Dale Creek, no fish were observed and no fish were captured after an electrofishing effort of 1151 seconds over 209 m. The channel was narrow (8m), and water quickly flowing.

4.1.2 FS2 – Cirque Creek

At Station FS2 in Cirque Creek, no fish were observed and no fish were captured after an electrofishing effort of 458 seconds over 100 m. Electrofishing was conducted between pools within the larger boulders on a moderate gradient.

4.1.3 FS3 – Lower Tsichu River

At Station FS3 in the lower Tsichu River, no fish were observed and no fish were captured after an electrofishing effort of 2021 seconds. Approximately 529 m of shallow braided habitat on the lower Tsichu River were electrofished.

4.1.4 FS4 – Upper Tsichu River

At Station FS4 in the upper Tsichu River, no fish were observed and no fish were captured after an electrofishing effort of 1294 seconds. Approximately 250 m of shallow complexly braided habitat on the upper Tsichu River were electrofished.

4.1.5 FS5 – Lower Dale Creek

At Station FS5 in the lower Dale Creek, no fish were observed and no fish were captured after an electrofishing effort of 1172 seconds. Approximately 250 m of complex meandering habitat with good cover elements on the lower Dale Creek were electrofished.

4.1.6 FS6 –Tributary C

At Station FS6 in the upper portion of Tributary C on the Yukon side, no fish were observed and no fish were captured after an electrofishing effort of 620 seconds. Approximately 150 m of steep boulder habitat on the upper section of Tributary C on the Yukon side were electrofished.

4.1.7 FS7 –Tributary A

At Station FS7 in the lower portion of Tributary A on the Yukon side, no fish were observed and no fish were captured after an electrofishing effort of 1129 seconds. Approximately 300 m of complex meandering habitat with good cover elements on the lower portion of the Tributary A on the Yukon side were electrofished.

4.1.8 FS8 – Upper Hess River

At Station FS8 in the upper Hess River, approximately 8 slimy sculpins were observed, however none were captured. An electrofishing effort of 1347 seconds was conducted over 108 m along the south shoreline of the Hess River. In this area, the Hess River was fast flowing and electrofishing could only be conducted safely and effectively from the river's edge where the water was calm.

Table 1. Fish Sampling, Stream and Water Quality Data

k)	FS2 (Cirque Creek)	FS3 (Lower Tischiu River)	FS4 (Upper Tischiu River)	FS5 (Upper Dale Creek)	FS6 (Tributary C)	FS7 (Tributary A)	FS8 (Upper Hess River
01 44.0	N 63 16 59.3 W 130 03 40.3	N 63 17 48.2 W 129 55 42.2	N 63 16 38.7 W 129 58 53.3	N 63 16 56.6 W 129 58 44.1	N 63 17 13.2 W 130 16 11.8	N 63 18 26.3 W 130 19 09.8	N 63 19 08.2 W 130 17 2
930	August 4, 2006, 1500	August 5, 2006, 0830	August 5, 2006, 1230	August 5, 2006, 1545	August 6, 2006, 0900	August 6, 2006, 1200	August 6, 2006, 1500
gravel	boulders, cobbles, gravel	large cobbles	gravels	cobbles with some boulders and gravels	boulders with some cobbles and gravels	cobbles with gravels and fines	boulders, cobbles and gra
	4.5	20.1	17.3	7.4	7	7.2	14
	88.6	37.5	46.4	42	11.4	14.8	15
	50	70	n/a	65	40	75	n/a
	30	20	20	20	20	35	20
	20	25	15	60	10	40	10
	9.16	10.34	9.21	7.95	10.63	10.07	9.04
	81.2	84	80.1	74.5	83.7	80.2	80
	10.1	6.4	9.3	11.9	5.2	6.4	10
	111.3	176.2	264.6	135.8	311	279.2	85.3
	7.11	6.31	4.65	7.03	7.13	6.77	6.99
	0.1	0.1	0.1	0.1	0.1	0.1	0
	n/a	n/a	n/a	willow, spagnum moss, spruce	n/a	n/a	n/a
pruce, birch,	willow, spagnum moss, spruce, birch, labrador tea	willow, spagnum moss, spruce, birch, labrador tea	willow, spagnum moss, spruce, birch, labrador tea	willow, spagnum moss, spruce, birch, labrador tea	willow, spagnum moss, spruce, birch, labrador tea	willow, spagnum moss, spruce, birch, labrador tea	willow, spagnum moss, sp birch, labrador tea
	medium	medium	medium	medium	medium	medium	medium
	avergage	excellent	poor	excellent	average	excellent	excellent
	458	2021	1294	1172	620	1129	1347
e, 210-350	30Hz, 12% duty cycle, 350 volts	30Hz, 12% duty cycle, 360 volts	30Hz, 12% duty cycle, 360 volts	30Hz, 12% duty cycle, 360 volts	30Hz, 12% duty cycle, 350 volts	30Hz, 12% duty cycle, 350 volts	30Hz, 12% duty cycle, 100 volts
	100	529	250	250	150	300	108
	none	none	none	none	none	none	approximaltey 8 slimy scul observed
el, braided	Rock obstructions and steep gradient	Turbid water noted	Turbid water, fine rust coloured sediment	Meandering, with side channels, cutbanks, pools, boulders	Boulder flood plains on outside meanders. Rocks, rapids may be obstruction to fish passage	Side channels, and many cover elements. Water is a turbid blue/grey	Channel is deep, wide and flowing. Water is a turb blue/grey

4.1.9 FS9 – Lower Hess River

At Station FS9 in the lower Hess River, approximately 26 slimy sculpins and 9 Arctic grayling were observed, however, no fish were captured. An electrofishing effort of 2506 seconds was conducted over approximately 500 m of the braided section of the Hess downstream of the Tributary C. Of the observed slimy sculpins, 24 ranged from 4-6 cm, while 2 ranged from 8-10 cm in length. Of the Arctic grayling observed, 7 were juveniles ranging 2-5 cm in length and 2 adults ranging 12-15 cm in length.

4.2 BENTHIC SAMPLING

The following section presents the results of benthic invertebrate community surveys completed during the MacTung 2006 Fisheries and Aquatic Studies. The sample locations are depicted in Figure 2. The benthic invertebrate raw data are presented in Appendix A

Results from the benthic invertebrate community survey are summarized in Table 2, 3 and 4 and Figures 3a and 3b. Benthic invertebrate community composition of major invertebrate groups at each site is presented in Table 2 and illustrated in Figures 3a and 3b. Table 3 shows abundance per replicate, site and mean abundance of each area. Table 4 provides a summary of the results, including the arithmetic mean, the standard error, the standard deviation, and the minimum and maximum values for density, taxa richness, and Simpson's Diversity Index at each of the nine sampling areas.

4.2.1 FS1 – Dale Creek

At Station FS1 in Dale Creek, benthic samples indicated three groups dominated the community composition. Plecoptera represented 47.1% of genera present. Diptera represented 27.1% of genera and Copepoda represented 20.0% of genera. Mean abundance at Station FS1 was 23 individuals. Mean density at Station FS1 was 271 individuals/m^2. Mean species richness was 7 and mean diversity (Simpson's index) was 0.695.

4.2.2 FS2 – Cirque Creek

At Station FS2 in Cirque Creek, benthic samples indicated two groups were present in significant numbers while one group dominated the community composition. Copepoda represented 83.0% of genera and Diptera represented 16.0% of genera present. Mean abundance at Station FS2 was 194 individuals with great variability between the three replicates. Mean density at Station FS2 was 2256 individuals/m^2. Mean species richness was 4 and mean diversity (Simpson's index) was 0.372.

UNITY COMPOSITION

FS-1		FS-2		FS-3		FS-4		FS-5		FS-6		FS-7		FS-8	
#IND	%	#IND	%	#IND	%	#IND	%	#IND	%	#IND	%	#IND	%	#IND	%
1	1.4	0	0.0	0	0.0	0	0.0	0	0.0	71	45.8	2	33.3	40	27.2
33	47.1	4	0.7	2	11.1	0	0.0	11	3.4	70	45.2	0	0.0	25	17.0
0	0.0	1	0.2	0	0.0	0	0.0	2	0.6	0	0.0	0	0.0	20	13.6
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
19	27.1	93	16.0	9	50.0	6	85.7	308	95.1	7	4.5	4	66.7	29	19.7
1	1.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2	2.9	0	0.0	2	11.1	0	0.0	3	0.9	1	0.6	0	0.0	2	1.4
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	2.0
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	3.9	0	0.0	28	19.0
0	0.0	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
14	20.0	483	83.0	5	27.8	1	14.3	0	0.0	0	0.0	0	0.0	0	0.0
70		582		18		7		324		155		6		147	

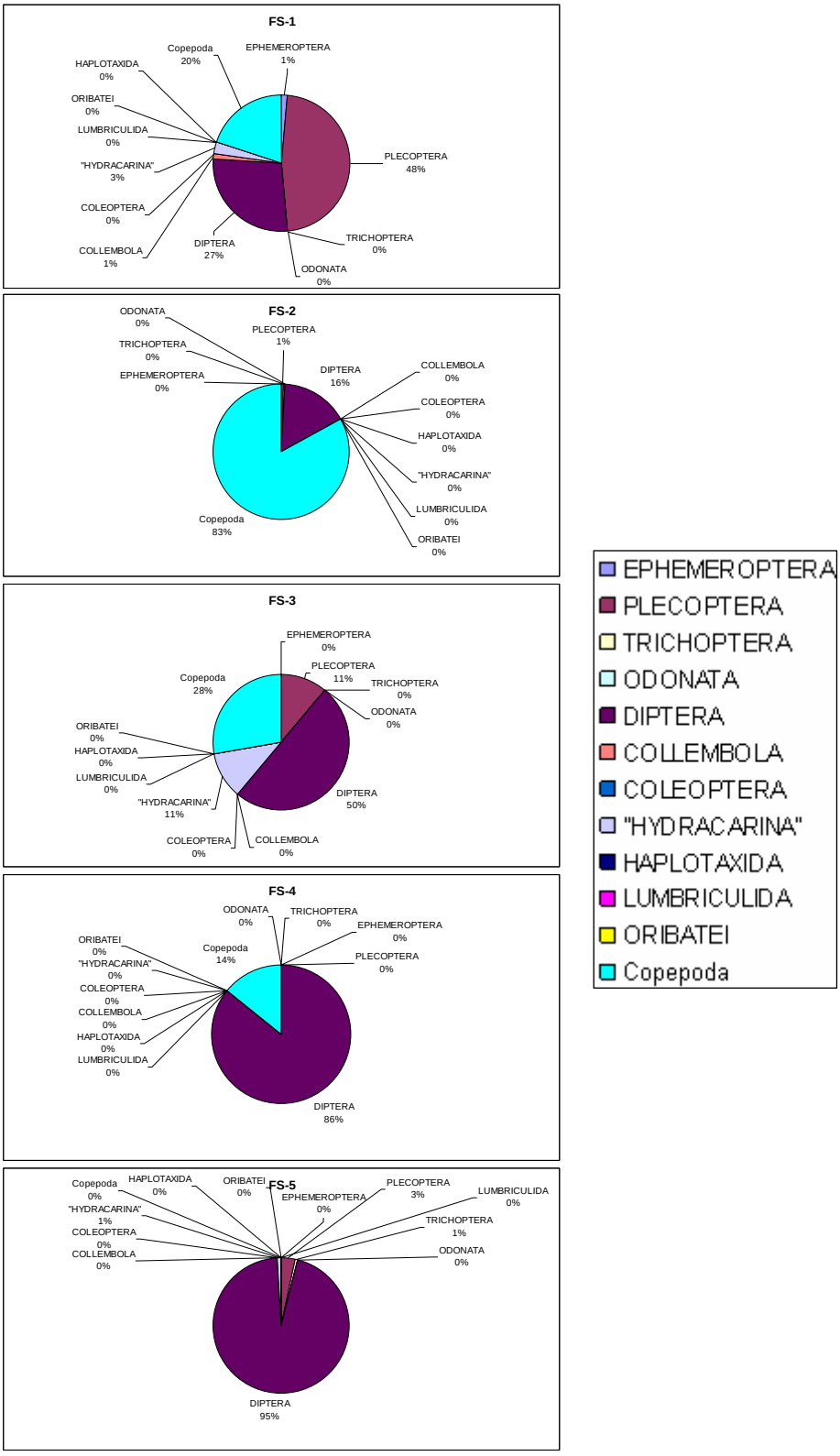

Figure 3a. Benthic invertebrate community composition for stations on the eastern slope of Macmillan Pass (FS1-FS5).

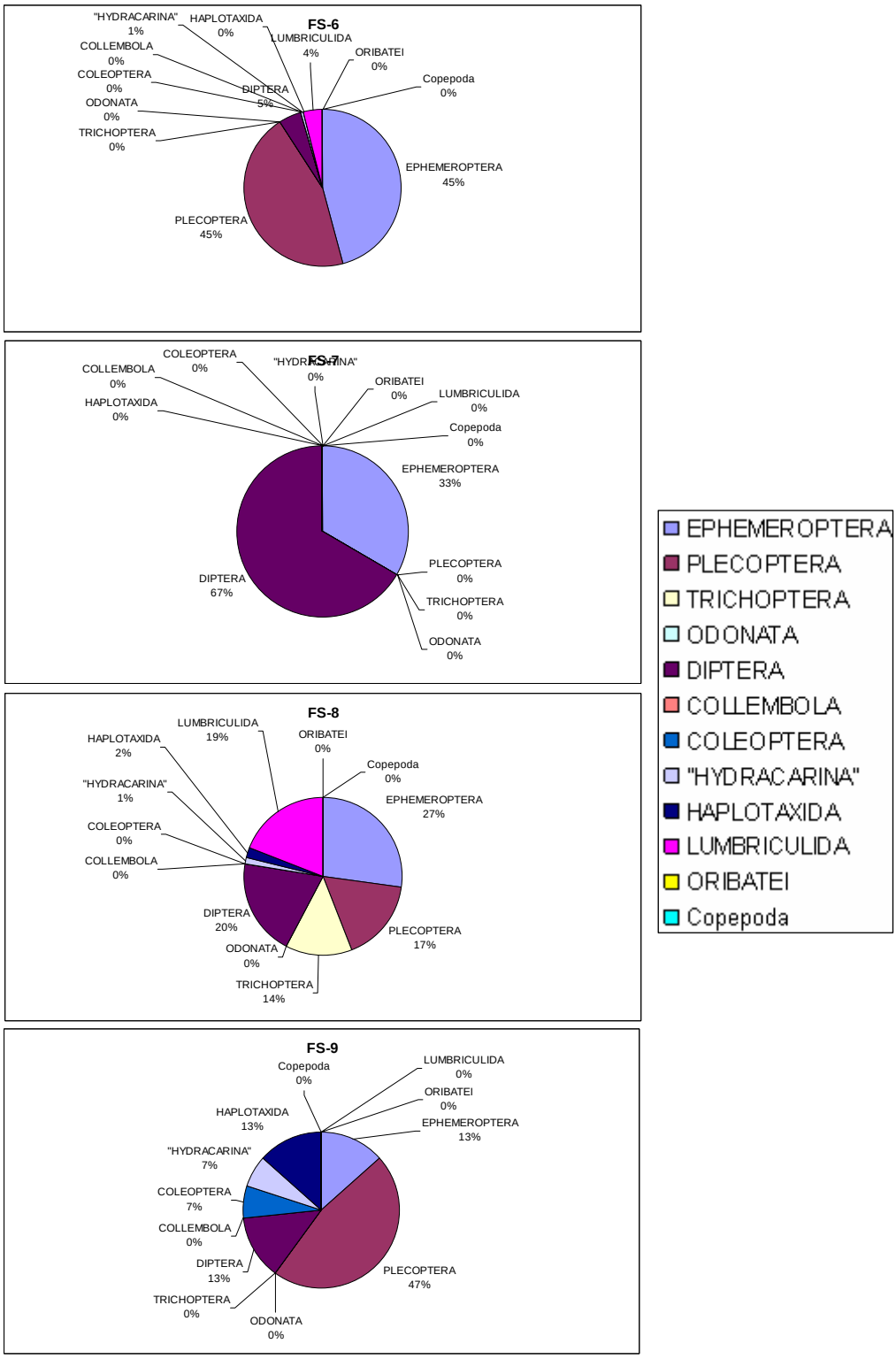

Figure 3b: Benthic invertebrate community composition for stations on the western slope of Macmillan Pass (FS6-FS9).

TABLE 3: ABUNDANCE PER REPLICATE, STATION AND MEAN ABUNDANCE AT EACH STATION				
Station	Replicate	Abundance (Total # Ind / Rep)	Mean Abundance	Abundance (Total # Ind / Site)
FS1	1	20	23	70
	2	23		
	3	27		
FS2	1	10	194	582
	2	16		
	3	556		
FS3	1	8	6	18
	2	4		
	3	6		
FS4	1	2	2	7
	2	0		
	3	5		
FS5	1	205	108	324
	2	103		
	3	16		
FS6	1	60	52	155
	2	64		
	3	31		
FS7	1	2	2	6
	2	1		
	3	3		
FS8	1	41	49	147
	2	37		
	3	69		
FS9	1	4	5	15
	2	8		
	3	3		

TABLE 4. DESCRIPTIVE STATISTICS FOR BENTHIC COMMUNITY SURVEYS FOR ALL STATIONS

Variable		FS1	FS2	FS3	FS4	FS5	FS6	FS7	FS8	FS9
Density (m^2) n=3	Mean	271	2256	70	27	1256	601	23	570	58
	Median	267	186	70	23	1198	698	23	477	47
	Standard Deviation	41	3646	23	29	1100	209	12	203	31
	Standard Error	24	2105	13	17	635	121	7	117	18
	Minimum	233	116	47	0	186	360	12	430	35
	Maximum	314	6465	93	58	2384	744	35	802	93
Richness n=3	Mean	7	4	4	2	8	8	2	13	4
	Median	7	5	5	2	9	8	2	13	4
	Standard Deviation	1	2	2	2	4	2	1	2	1
	Standard Error	0	1	1	1	2	1	1	1	0
	Minimum	6	2	2	0	4	6	1	11	3
	Maximum	7	6	6	3	11	10	3	14	4
Simpson's Diversity Index n=3	Mean	0.695	0.372	0.655	0.000	0.502	0.757	0.389	0.872	0.660
	Median	0.725	0.240	0.778	0.000	0.479	0.758	0.500	0.880	0.667
	Standard Deviation	0.070	0.341	0.243	0.000	0.067	0.003	0.347	0.028	0.094
	Standard Error	0.041	0.197	0.140	0.000	0.039	0.002	0.200	0.016	0.054
	Minimum	0.615	0.117	0.375	0.000	0.450	0.753	0.000	0.841	0.563
	Maximum	0.745	0.760	0.813	0.000	0.578	0.759	0.667	0.896	0.750

4.2.3 FS3 – Lower Tsichu River

At Station FS3 in the lower Tsichu River, benthic samples indicated the presence of four groups within the community. Diptera represented 50.0% of genera present. Copepoda represented 27.8% of genera and Plecoptera and Hydracarina each represented 11.1%. Mean abundance at Station FS3 was 6. Mean density at Station FS3 was 70 individuals/m^2. Mean species richness was 4 and mean diversity (Simpson's index) was 0.655.

4.2.4 FS4 – Upper Tsichu River

At Station FS4 in the upper Tsichu River, benthic samples indicated the presence of only two groups within the community. Diptera represented 85.0% of genera present. Copepoda represented 14.3% of genera. Mean abundance at Station FS4 was 2. Mean density at Station FS4 was 27 individuals/m^2. Mean species richness was 2 and mean diversity (Simpson's index) was 0 (indicating very low).

4.2.5 FS5 – Lower Dale Creek

At Station FS5 in lower Dale Creek, benthic samples indicated the dominance of one group within the community. Diptera represented 95.1% of genera present. Plecoptera was also present and represented 3.4% of genera. Mean abundance at Station FS5 was 108. Mean density at Station FS5 was 1256 individuals/m^2. Mean species richness was 8 and mean diversity (Simpson's index) was 0.502.

4.2.6 FS6 – Tributary C

At Station FS6 in Tributary C, benthic samples indicated the dominance of two groups within the community. Ephemeroptera represented 45.8% of genera present and Plecoptera represented 45.2% of genera. Mean abundance at Station FS6 was 52. Mean density at Station FS6 was 601 individuals/m^2. Mean species richness was 8 and mean diversity (Simpson's index) was 0.757.

4.2.7 FS7 – Tributary A

At Station FS7 in Tributary A, benthic samples indicated the presence of two groups within the community. Diptera represented 66.7% of genera present and Ephemeroptera represented 33.3% of genera. Mean abundance at Station FS7 was 2. Mean density at Station FS7 was 23 individuals/m^2. Mean species richness was 2 and mean diversity (Simpson's index) was 0.389.

4.2.8 FS8 – Upper Hess River

At Station FS8 in the upper Hess River, benthic samples indicated a more diverse community composition. Ephemeroptera represented 27.2% of genera present, Diptera represented 19.7% of genera present, Lumbriculida represented 19.0% of genera present, Plecoptera represented 17.0% of genera present, and Tricoptera represented 13.6% of genera present. Mean abundance at Station FS8 was 49. Mean density at Station FS8 was 570 individuals/m^2. Mean species richness was 13 and mean diversity (Simpson's index) was 0.872.

4.2.9 FS9 – Lower Hess River

At Station FS9 in the lower Hess River, benthic samples indicated a diverse community but not abundant. Plecoptera represented 46.7% of genera present, Ephemeroptera, Diptera and Haplotaxida were all represented 13.3% of genera present, Hydracarina, and Coleoptera each represented 6.7% of genera present. Mean abundance at Station FS9 was 5. Mean density at Station FS9 was 58 individuals/m^2. Mean species richness was 4 and mean diversity (Simpson's index) was 0.660.

4.3 HABITAT CHARACTERIZATION

Habitat characterization of fisheries stations was conducted during the MacTung 2006 Fisheries and Aquatic Studies. Habitat characterization was conducted at the fisheries stations designated FS1 through FS9 which are depicted in Figure 2. Stations FS1 through

FS5 were located on the NWT side of the study area and stations FS6 through FS9 were located on the Yukon side of the study area. Table 1 presents habitat information. Photos 5-37 depict the habitat characteristics at the fisheries stations.

4.3.1 FS1 – Dale Creek

Dale Creek originates at an approximate elevation of 2,200 m, however most of the watercourse lies at lower elevations. The watercourse is east–flowing and meanders. downstream into the Tsichu River, NWT.

Station FS1 is located in close proximity to Water Quality Station WQ6 and the Dale Creek Hydrometric Station. At FS1, Dale Creek had a narrow wetted width of 8.0 m and an equal channel width. The substrates of the channel were predominantly composed of small cobbles with large and small gravels. The water surface was almost entirely flowing with water depths of about 50 cm. The gradient ranged between 0.6 and 1.6% (AMAX 1982). There were no apparent obstructions to fish passage and vegetation cover amounted to approximately 5%, all of which consisted of overhanging willow vegetation.

Riparian vegetation was predominantly willow (*Salix* sp.), sedge (*Carex* spp.) and sphagnum moss (*Sphagnum* spp.) with scrub birch (*Betula glandulosa*) and lichen (*Cladonia* sp., *Cladina* sp., and *Cetraria* sp.) on the terraces (high bench). Photos 5-7 depict the habitat characteristics of Station FS1.

4.3.2 FS2 – Cirque Creek

The Cirque Creek headwaters lie on the Yukon/ NWT border at elevations ranging from 1,800 to 2,200 m. The watercourse is east flowing and the outflow from Cirque Lake is by way of ground seepage filtered through rock debris. Cirque Creek flows into Dale Creek 3.7 km downstream from Cirque Lake.

At Station FS2, Cirque Creek had a narrow wetted width (4.5 m) and a large channel flood plain (88.6 m). The channel substrates predominantly consisted of large boulders and cobbles with water depths ranging from 30-50 cm. The gradient was a steep 6.7% (AMAX 1982) and falls and rock obstruction occur between small pools. Cover amounted to approximately 20%, consisting of boulders, deep pools and undercut banks.

Riparian vegetation was predominantly willow, sedge and sphagnum moss, with scrub birch and lichen on the terraces (high bench). Photos 8-11 depict the habitat characteristics of Station FS2.

4.3.3 FS3 – Lower Tsichu River

The habitat characteristics of the Lower Tsichu River, located downstream of the Dale Creek and Tsichu confluence were similar to that of Dale Creek. The meandering and braided channel of the lower Tsichu River provides ideal fish habitat.

Station FS3 is located near Water Quality Station WQ7. At FS3, the Tsichu River had a wetted width of 20.1 m and a channel width of 37.5 m. The substrates of the channel were

predominantly composed of large cobbles with some boulders, smaller cobbles and gravels. The water surface was 20% pool, 10% run and 70% riffle, with water depths approximately 20 cm in the riffles and 70 cm in the pools. Cover for fish habitat amounted to approximately 25% and consisted of deep pools and boulders. Side channels also provide additional cover areas. No obstructions to fish passage were identified.

Riparian vegetation was predominantly willow, sedge and sphagnum moss, with scrub birch and lichen on the terraces (high bench). Photos 12-15 depict the habitat characteristics present at Station FS3.

4.3.4 FS4 – Upper Tsichu River

Physically, the habitat characteristics of the Upper Tsichu River upstream of its confluence with Dale Creek were similar to that of lower Dale Creek. The channel is meandering and braided, however the degraded water quality (due to low pH and natural mineralization in the area) and resulting coloration and precipitates create unique habitat conditions.

Station FS4 is located on the Tsichu River upstream of its confluence with Dale Creek. At FS4, the Tsichu River had a wetted width of 17.3 m and a channel width of 46.4 m. The substrates of the channel were predominantly composed of large and small gravels with some small cobbles and fines. The water surface was 10% pool, 70% run and 20% riffle, with water depths approximately 20 cm in the riffles, 50 cm in the run, and 1 m in pools. Cover for fish habitat amounted to approximately 15% and consisted of deep pools. Side channels also provided additional cover areas. No obstructions to fish passage were identified. Of note at Station FS4 was the rust coloured water and rusty precipitates in the side channels and slower flowing water areas.

Riparian vegetation was predominantly willow, sedge, and sphagnum moss with scrub birch and lichen on the terraces (high bench). Photos 16-19 depict the habitat characteristics present at Station FS4.

4.3.5 FS5 – Lower Dale Creek

Lower Dale Creek provided what appears to be ideal fish habitat. The meandering and braided channel was modified by beaver activity and provided potentially suitable spawning, rearing, feeding, and nesting areas. At its confluence with the Tsichu River, deeper pools were present.

Station FS5 is located 300-400 m upstream of the confluence with the Tsichu River. At FS5, Dale Creek had a narrow wetted width of 7.4 m and a channel width of 42 m. The substrates of the channel were predominantly composed of large cobbles with some boulders, smaller cobles and gravels. The water surface was 40% pool, 40% run and 20% riffle, with water depths approximately 20 cm in the riffles and 65 cm in the pools. Cover for fish habitat amounted to approximately 60% and consisted of deep pools, undercut banks, boulders and instream vegetation. Small falls observed downstream of Station FS5 could be an obstruction to fish passage.

Riparian vegetation was predominantly willow, sedge, and sphagnum moss with scrub birch and lichen on the terraces (high bench). Instream vegetation consisted of sedge, willow, and sphagnum moss. Photos 20-23 depict the habitat characteristics at Station FS5.

4.3.6 FS6 –Tributary C

Tributary C, a tributary to the Hess River, drains the MacTung Project area on the Yukon side of the study area. Tributary C flows northwest into Tributary A which flows into the Hess River. The Hess River lies on the western slope of Macmillan Pass on the Yukon side of the project study area.

Station FS6 is located downstream of WQ1. At Station FS6, Tributary C had a narrow wetted width of 7.0 m and a channel width of 11.4 m. The channel substrates were predominantly composed of boulders with some cobbles and gravels. The water surface was 20% pool, 30% run and 50% riffle, with water depths about 20 cm in the riffles and 40 cm in the pools. Cover for fish habitat amounted to approximately 10% and consisted of deep pools, boulders, undercut banks, and overstream vegetation. At Station FS6, rapids, a steep gradient, and small falls observed downstream could be an obstruction to fish passage.

Riparian vegetation was predominantly willow and sedge with sub alpine fir (*Abies lasiocarpa*) in higher areas, with a sedge and forb (*Mertensia paniculata*, *Senecio triangularis*) or sphagnum moss understory. Photos 24-26 depict the habitat characteristics at Station FS6.

4.3.7 FS7 –Tributary A

Tributary A, a tributary to the Hess River, drains the MacTung Project area on the Yukon side of the study area. Tributary C flows northwest into Tributary A which flows into the Hess River.

Station FS7 on Tributary A is located upstream of its confluence with the Hess River. At FS7, Tributary A had a narrow wetted width of 7.2 m and a channel width of 14.8 m. The substrates of the channel consisted of small and large cobbles, gravels and fines. The water surface was 30% pool, 50% run and 20% riffle, with water depths about 35 cm in the riffles and 75 cm in the pools. Cover for fish habitat amounted to approximately 40% and consisted of deep pools, undercut banks, and large organic debris. Conditions at Station FS7 appeared to provide ideal fish habitat. Backwater areas around Station FS7 provide what appears to be good fish rearing habitat.

Riparian vegetation was predominantly willow and sedge with sub alpine fir in higher areas with a sedge and forb or sphagnum moss understory. Photos 27-30 depict the habitat characteristics present at Station FS7.

4.3.8 FS8 – Upper Hess River

The Hess River lies on the western slope of Macmillan Pass on the Yukon side of the project study area. The Hess River flows southwest.

Station FS8 is located upstream of the confluence with Tributary A. At FS8, the Hess River had an estimated wetted width of 14 m and a channel width of 15 m (water was too deep and fast-flowing to wade across). The substrates of the channel consisted of small and large cobbles, boulders and gravels. The water surface was 40% run and 60% rapids. The water depths could not be determined. Cover for fish habitat amounted to approximately 10% and consisted of boulders and overstream vegetation. Conditions at FS8 appeared to provide good fish habitat. However, the wide stream and water flows provided little cover.

Riparian vegetation was predominantly willow and sedge with sub alpine fir in higher areas and a sedge and forb or sphagnum moss understory. Photos 31-33 depict the habitat characteristics at Station FS8.

4.3.9 FS9 – Lower Hess River

Station FS9 is located on the Hess River downstream of the confluence with Tributary A. This reach of the Hess is braided over a large area.

At Station FS9, the Hess River had a wetted width of 9.4 m and a channel width of 19.8 m. The substrates of the channel consisted of small and large cobbles, boulders and gravels. The water surface was 30% pool, 20% run and 50% riffle. The water depths were 35 cm in the riffle area and 70 cm in the run area. Cover for fish habitat amounted to approximately 40%, and consisted of deep pools and undercut banks. Conditions at FS9 appeared to provide good fish habitat. Numerous side channels also provide good fish rearing habitat.

Riparian vegetation was predominantly willow and sedge with sub alpine fir in higher areas and a sedge and forb or sphagnum moss understory. Photos 34-37 depict the habitat characteristics at Station FS9.

4.4 PHYSICAL WATER QUALITY

Physical water quality parameters were measured at all fisheries stations (FS1-FS9) between August 4 and August 8, 2006. Water quality parameters recorded included water temperature, dissolved oxygen, specific conductivity, and pH. Physical water quality parameters measured are summarized in the following section and presented in Table 1. The sample locations are shown in Figure 2.

4.4.1 FS1 – Dale Creek

Physical water quality parameters at Station FS1 were measured on August 4, 2006. Water temperature was 7.4°C, dissolved oxygen values were 10.15 mg/L and 84.5%, (specific) conductivity was 143.9 µS/cm, and pH was 7.13.

4.4.2 FS2 – Cirque Creek

Water quality parameters at Station FS2 were measured on August 4, 2006. Water temperature was 10.1°C, dissolved oxygen values were 9.16 mg/L and 81.2%, (specific) conductivity was 111.3 µS/cm, and pH was 7.11.

4.4.3 FS3 – Lower Tsichu River

Water quality parameters at Station FS3 were measured on August 5, 2006. Water temperature was 6.4°C, dissolved oxygen values were 10.34 mg/L and 84.0%, (specific) conductivity was 176.2 µS/cm, and pH was 6.31.

4.4.4 FS4 – Upper Tsichu River

Water quality parameters at Station FS4 were measured on August 5, 2006. Water temperature was 9.3°C, dissolved oxygen values were 9.21 mg/L and 80.1%, (specific) conductivity was 264.6 µS/cm, and pH was 4.65.

4.4.5 FS5 – Lower Dale Creek

Water quality parameters at Station FS5 were measured on August 5, 2006. Water temperature was 11.9°C, dissolved oxygen values were 7.95 mg/L and 74.5%, (specific) conductivity was 135.8 µS/cm, and pH was 7.03.

4.4.6 FS6 –Tributary C

Water quality parameters at Station FS6 were measured on August 6, 2006. Water temperature was 5.2°C, dissolved oxygen values were 10.63 mg/L and 83.7%, (specific) conductivity was 311.0 µS/cm, and pH was 7.13.

4.4.7 FS7 –Tributary A

Water quality parameters at Station FS7 were measured on August 6, 2006. Water temperature was 6.4°C, dissolved oxygen values were 10.07 mg/L and 80.2%, (specific) conductivity was 279.2 µS/cm, and pH was 6.77.

4.4.8 FS8 – Upper Hess River

Water quality parameters at Station FS8 were measured on August 6, 2006. Water temperature was 10.0°C, dissolved oxygen values were 9.04 mg/L and 80.0%, (specific) conductivity was 85.3 µS/cm, and pH was 6.99.

4.4.9 FS9 – Lower Hess River

Water quality parameters at Station FS9 were measured on August 7, 2006. Water temperature was 6.9°C, dissolved oxygen values were 10.27 mg/L and 84.6%, (specific) conductivity was 139.2 µS/cm, and pH was 6.99.

5.0 DISCUSSION

Fish sampling by electrofishing resulted in no fish captures and only a few observations of fish presence during the 2006 field program. Based on previous fisheries work on the NWT side of the project area, (AMAX 1983), Dale Creek and the Tsichu River were expected to support populations of Arctic grayling, Dolly Varden, mountain whitefish, slimy sculpins and burbot. It is not fully understood why no fish were captured with intensive fishing efforts. Aerial surveys further downstream in the area indicated no sign of impassable barriers to fish movements. The areas should be resurveyed to re-confirm these data. Slimy sculpins were observed in the Hess River, but not in Tributary A. The Hess River sculpins were not captured because of the safety considerations of electrofishing with a two-person crew in a deep, fast flowing river. It is recommended that these stations be resurveyed for a second season in 2007 to corroborate or alter the interim understanding of current fish utilization of the streams sampled.

Stream benthic invertebrate sampling data produced a wide range of abundance, density, richness and diversity between stations, and in some cases, between replicated samples. Diptera was the only group represented at all stations. There appear to be some differences between species composition in the two drainage areas surveyed as illustrated in Figures 3a and 3b. At stations FS1 to FS5 on the eastern slope of MacMillan Pass in the Northwest Territories, Diptera, Copepoda, Plecoptera, and Hydracarina dominated the benthic communities. At stations FS6 to FS9 on the western side of MacMillan Pass in Yukon Territory, Diptera, Ephemeroptera, and Plecopetra dominated the benthic communities. At most stations, abundance was considered low.

Stream habitat values were generally rated high. Station FS4 was given a habitat value of poor due to a naturally low pH reading of 4.65 and the presence of metal precipitates from natural sources. Station FS2 (Cirque Creek) and Station FS6 (Tributary C) were given values of average due to their steep gradients and resulting flows. All other stations were considered to provide potentially good habitat.

Based on habitat values and previous studies (AMAX 1982) fish presence was expected at stations FS1, FS3, FS5, FS7, FS8 and FS9. During the 2006 survey, fish presence could only be confirmed at stations FS8 and FS9. Due to the low ph measured at Station FS4, no fish were expected to be found at this station. In addition, fish were not expected to be present at stations FS3 and FS7 due to the steep gradients and high water velocities that characterize these locations.

Physical water quality was generally good at all stations. Station FS4 exhibited a low pH value of 4.65, and stations FS4, FS6, and FS7 exhibited higher conductivity values than the other stations. Dissolved oxygen levels were high at all stations. The lowest recorded level of dissolved oxygen was 7.95 mg/L at station FS5 in upper Dale Creek.

6.0 CLOSURE

EBA is pleased to present NATCL with this 2006 Fisheries and Aquatic Resources report for the MacTung Project. The survey objective was to document fish and benthic species and habitat characteristics within the study area for future regulatory submissions leading to MacTung Project approvals and implementation. We are confident that the data and associated information obtained will assist in supporting this objective.

Respectfully submitted,
EBA Engineering Consultants Ltd.

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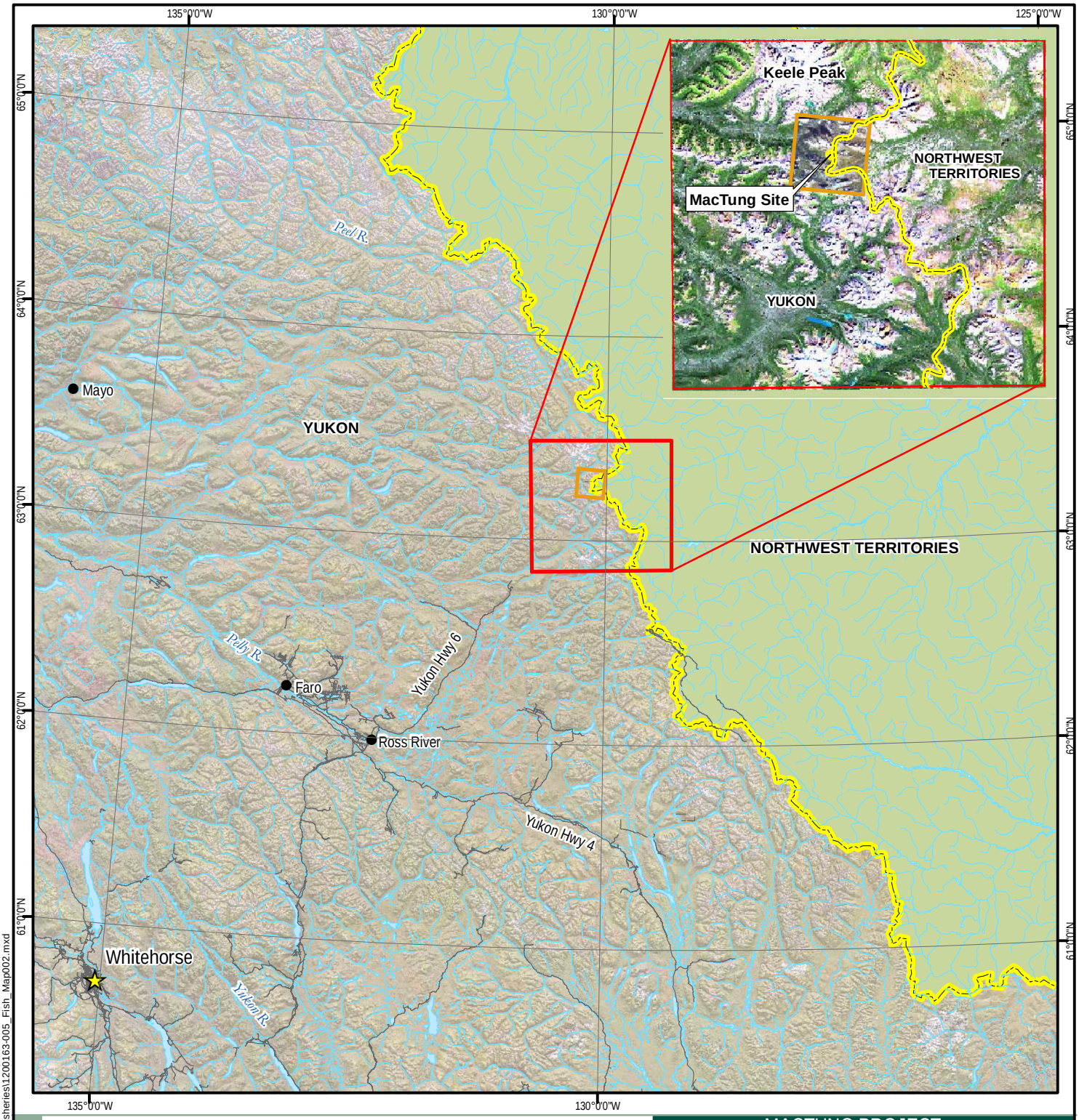
FIGURES



LEGEND

- Provincial / Territorial Boundary
- Local Study Area
- Watercourse
- Waterbody
- Roads

N
W E
S

MACTUNG PROJECT
2006 ENVIRONMENTAL BASELINE STUDIES
FISHERIES AND AQUATIC RESOURCES

Project Area

PROJECTION	DATUM
UTM Zone 9	NAD83

0 12.5 25 50 75 100
Kilometres

EBA Engineering Consultants Ltd.

FILE NO.: 1200163-005_Fish_Map002

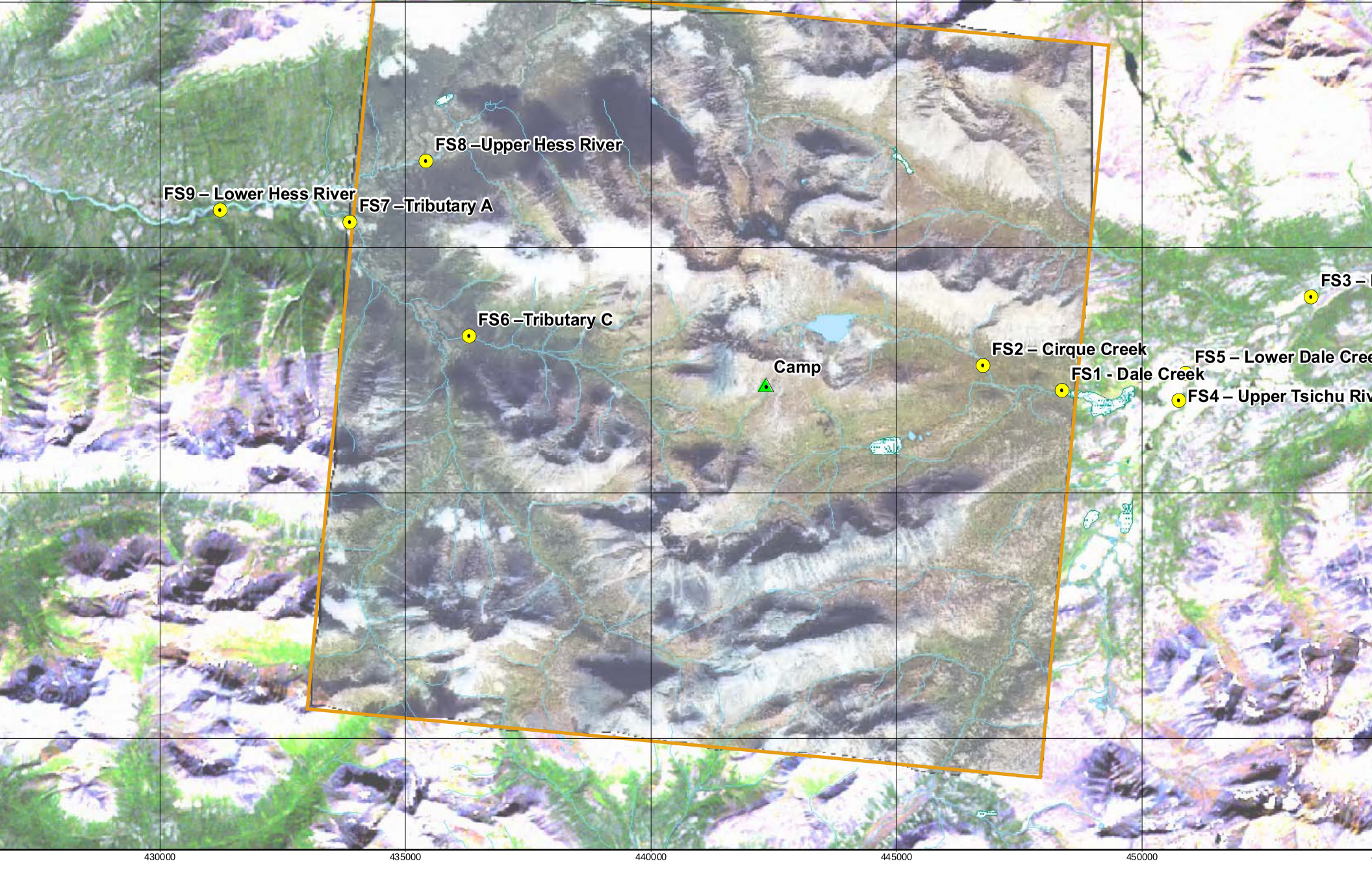
PROJECT NO.	DWN	CKD	REV
1200163.005	KMW	TA	1

OFFICE: EBA-VANC
DATE: March 13, 2007

Figure 1

NOTES Landsat TM imagery Earthsat acquired Sept,17, 1995
Bands 432 enhanced

Q:\Vancouver\GIS\0201_YUKON\1200163_MacTung\Maps\005_Aquatic-Fisheries\1200163-005_Fish_Map002.mxd


FS8 –Upper Hess River
FS9 – Lower Hess River
FS7 –Tributary A
FS6 –Tributary C
Camp
FS2 – Cirque Creek
FS1 - Dale Creek
FS5 – Lower Dale Cree
FS4 – Upper Tsichu Riv
FS3 –
430000
435000
440000
445000
450000

PHOTOGRAPHS

Photo 1
MacTung Camp on MacMillian Pass

Photo 2
Fish sampling conducted by Electrofishing

Photo 3
Benthic invertebrate sampling

Photo 4
Fisheries equipment airlifted to sampling stations

Photo 5
Station FS1 downstream

Photo 6
Station FS1 looking upstream

Photo 7
Typical substrates at station FS1

Photo 8
Cirque Lake, headwaters to Cirque Creek

Photo 9
Station FS2 looking downstream

Photo 10
Station FS2 looking upstream

Photo 11
Typical substrates at station FS2

Photo 12
Aerial view of station FS3. Channel is braided and meandering

Photo 13
Station FS3 looking downstream

Photo 14
Station FS3 looking upstream

Photo 15
Typical substrates at station FS3

Photo 16
Aerial view of station FS4, upper Tsichu River

Photo 17
Sidechannels at station FS4

Photo 18
Station FS4 looking downstream

Photo 19
Typical substrates at station FS4

Photo 20
Confluence of Dale Creek and Tsichu River

Photo 21
Station FS5 looking upstream

Photo 22
Small falls near station FS5

Photo 23
Typical substrates at Station FS5

Photo 24
Station FS6 looking downstream

Photo 25
Station FS6 looking upstream

Photo 26
Typical substrates at station FS6

Photo 27
Aerial view of station FS7

Photo 28
Station FS7 looking downstream

Photo 29
Station FS7 looking upstream

Photo 30
Confluence of Hess River and Tributary A looking downstream

Photo 31
Station FS8, the Hess River looking upstream

Photo 32
Fast deep flow at station FS8

Photo 33
Typical substrates at station FS8

Photo 34
Braided channels at station FS9 on the Hess River

Photo 35
Station FS9 looking upstream

Photo 36
Beaver dam on side channel at station FS9

Photo 37
Typical substrates at station FS9

APPENDIX

APPENDIX A BENTHIC INVERTEBRATE COMMUNITY SURVEY RAW DATA

				FS-1			FS-2			FS-3			FS-4			FS-5			FS-6			FS-7			FS-8			FS-9		
				Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
ORDER,CLASS	**FAMILY**	***GENERA***	**STAGE**																											
EPHEMEROPTERA	**HEPTAGENIIDAE**	***EPEORUS***	L																					1	1					
EPHEMEROPTERA	**HEPTAGENIIDAE**	***RHITHROGENA***	L		1													1	10	9				2			1			
EPHEMEROPTERA	**HEPTAGENIIDAE**	***CINYGMULA***	L															20	15	8			1	1		5				
EPHEMEROPTERA	**HEPTAGENIIDAE**	***Heptageniidae-1st instars***	L																						3					
EPHEMEROPTERA	**EPHEMERELLIDAE**	***DRUNELLA doddsi***	L																					3	4	4		1		
EPHEMEROPTERA	**EPHEMERELLIDAE**	***DRUNELLA COLORADENSIS***	L																					1	1	1				
EPHEMEROPTERA	**BAETIDAE**	***BAETIS***	L																1											
EPHEMEROPTERA	**BAETIDAE**	***ACENTRELLA***	L																					3	4	6				
EPHEMEROPTERA	**AMELETIDAE**	***AMELETUS***	L															2	2	3			1							
PLECOPTERA	**CHLOROPERLIDAE**	***SWELTZA group***	L						1																					
PLECOPTERA	**CHLOROPERLIDAE**	***SUWALLIA***	L							1															2	8				
PLECOPTERA	**CHLOROPERLIDAE**	***ALLOPERLA/HAPLOPERLA***	L	9	9	14	1		2							7	3		7	25	9					3		1	5		
PLECOPTERA	**CHLOROPERLIDAE**	***PARAPERLA***	L									1						1												
PLECOPTERA	**PERLODIDAE**	***SKWALA***	L																1											
PLECOPTERA	**NEMOURIDAE**	***ZAPADA***	L	1														19	3	1					1					
PLECOPTERA	**CAPNIIDAE**		L																					1	3	7				1
PLECOPTERA	**TAENIOPTERIGIDAE**	***TAENIONEMA***	L															5												
TRICHOPTERA	**GLOSSOSOMATIDAE**	***GLOSSOSOMA***	L																					9	6	5				
TRICHOPTERA	**LIMNEPHILIDAE**	***ECCLISOMYIA***	L													1														
TRICHOPTERA	**LIMNEPHILIDAE**	***CRYPTOCHIA***	L						1																					
TRICHOPTERA		***unident. Trichoptera pupae***	PU													1														
TRICHOPTERA	***RHYACOPHILIDAE***	***RHYACOPHILA***	PU																											
ODONATA	**GOMPHIDAE**	***OPHIOGOMPHUS***	L																											
ODONATA	**AESHNIDAE**	***AESHNA***	L																											
DIPTERA	**UID**		A								3		1		2															
DIPTERA	**SIMULIIDAE**	***PROSIMULIUM***	L	1																				1						
DIPTERA	**SIMULIIDAE**	***SIMULIUM***	L																											1
DIPTERA	**SIMULIIDAE**	***SIMULIIDAE pupae***	PU													3										1		1		
DIPTERA	**EMPIDIDAE**	***WIEDEMANNIA***	L	1														1												
DIPTERA	**TIPULIDAE**	***DICRANOTA***	L													6	5													
DIPTERA	**TIPULIDAE**	***LIMNOPHILA***	L														2													
DIPTERA	**TIPULIDAE**	***MOLOPHILUS***	L														1													
DIPTERA	**EPHYDRIDAE**		L									1																		
DIPTERA	**Deuterophlebiidae**	**Deuterophlebia**	LAR																1											
DIPTERA	**Deuterophlebiidae**	**Deuterophlebia**	PU																							1				
DIPTERA	**CHIRONOMIDAE**	***Diamesa***	L	4	5	1	3	15	68	2					1	3			5				1							
DIPTERA	**CHIRONOMIDAE**	***Pagastia***	L													5	2													
DIPTERA	**CHIRONOMIDAE**	***Cricotopus/Orthocladius***	L	1	1	1	1		4						2	144	75	9						3	2	21				
DIPTERA	**CHIRONOMIDAE**	***Tanytarsus***	L				2									1		1				1								
DIPTERA	**CHIRONOMIDAE**	***Corynoneura***	L														1													
DIPTERA	**CHIRONOMIDAE**		PU	3	1							1				32	13	5				1	1							
DIPTERA	**CHIRONOMIDAE**		AD/EM							1	1																			
COLLEMBOLA	**ISOTOMURIDAE**					1																								
COLEOPTERA	**ELMIDAE**	**juvenile ELMID larvae**	L																								1			
"HYDRACARINA"	**LEBERTIIDAE**	***Lebertia***								1		1					1											1		
"HYDRACARINA"	**SPERCHONIDAE**	***SPERCHON***				1										2			1					1	1					
"HYDRACARINA"	**"HYDRACARINA"-ju**	***"HYDRACARINA"-juvenile***			1																									
HAPLOTAXIDA	**NAIDIDAE**																							3			1		1	
LUMBRICULIDA	**LUMBRICULIDAE 1**	***RHYNCHELMIS***																5		1				7						
LUMBRICULIDA	**LUMBRICULIDAE2**	***(LUMBRICULUS like)***																						5	6	10				
ORIBATEI								1																						
Copepoda	**Harpacticoida**									1																				
Copepoda	**Cyclopoida**				5	9	3		480	2		2	1																	
TOTAL # IND/SAMPLE (Abundace)				20	23	27	10	16	556	8	4	6	2	0	5	205	103	16	60	64	31	2	1	3	41	37	69	4	8	3

L = LARVAL stage
PU = PUPAE stage
AD = ADULT stage

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