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## **APPENDICES**

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**Appendix A1**

**Fisheries and Aquatics Technical  
Baseline Report**

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## Grassy Mountain Coal Project

### Fisheries and Aquatics Technical Baseline Report

**December 2016**

*Prepared for:*

**Benga Mining Limited**  
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# GRASSY MOUNTAIN COAL PROJECT: FISHERIES AND AQUATICS TECHNICAL BASELINE REPORT

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**DECEMBER 2016**

MEMS7779  
VERSION 3

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## LIST OF ACRONYMS

<b>ACA</b>	Alberta Conservation Association
<b>ADV</b>	Acoustic doppler velocimeter
<b>AEP</b>	Alberta Environment and Parks
<b>AER</b>	Alberta Energy Regulator
<b>AESRD</b>	Alberta Environment and Sustainable Resource Development
<b>BKTR</b>	Brook trout
<b>CEAA</b>	Canadian Environmental Assessment Agency
<b>CHPP</b>	Coal handling and preparation plant
<b>D</b>	Simpson's diversity index
<b>DFO</b>	Fisheries and Oceans Canada
<b>E</b>	Ephemeroptera
<b>EA</b>	Environmental Assessment
<b>EIA</b>	Environmental Impact Assessment
<b>EPEA</b>	Environmental Protection and Enhancement Act
<b>EPT</b>	Ephemeroptera, Plecoptera, and Trichoptera
<b>FHAP</b>	Fish Habitat Assessment Procedure
<b>FRL</b>	Fisheries Research Licence
<b>FWMIS</b>	Fish and Wildlife Management Information System
<b>GSDD</b>	Growth season degree day
<b>LSA</b>	Local study area
<b>LWD</b>	Large woody debris
<b>PAG</b>	Potential acid generating rocks
<b>RNTR</b>	Rainbow trout
<b>RSA</b>	Regional study area
<b>S</b>	Evenness
<b>SAR</b>	Species at Risk
<b>SARA</b>	Species at Risk Act
<b>SIR</b>	Supplemental information request
<b>VC</b>	Valued components
<b>VIE</b>	Visible implant elastomer
<b>WSCT</b>	Westslope cutthroat trout
<b>YOY</b>	Young of the year

## ACKNOWLEDGEMENTS

This report was prepared for Benga Mining Limited by Hatfield Consultants. Cory Bettles (M.Sc., R.P.Bio. FP-C) managed the 2016 data collection and report compilation for the Project. This report was written by Sarah Thomasen (M.Sc., R.P.Bio), Meghan Isaacs (M.Sc.), Peter Corbett (R.P.Bio.) and Rhia Mackenzie of Mirkwood Consultants and reviewed by Cory Bettles and Martin Davies (M.Sc., R.P.Bio.). Fieldwork was conducted by Sarah Quesnelle (M.Sc.), Cory Bettles, Jennifer Carter (M.R.M.), Meghan Isaacs, Alex Bourassa-Young (B.Sc.), Jocelyn Beniuk (B.Sc., P.Bio.), Fortune Ogbobo (Ph.D., R.P.Bio.), Sarah Thomasen, Peter Corbett and Rhia Mackenzie (Mirkwood Consultants).

## EXECUTIVE SUMMARY

Benga Mining Limited, a wholly owned subsidiary of Riversdale Resources Limited, is proposing to develop the Grassy Mountain Coal Project. This report characterizes the aquatic environment in Gold Creek and Blairmore Creek watersheds, in order to:

- Characterize fisheries and aquatic resources that could potentially be affected by the Project;
- Provide baseline information necessary to support the completion of an aquatic effects assessment for the Project *Environmental Impact Assessment (EIA)*; and
- Facilitate the design of any required mitigation, offsetting (i.e., compensation), and/or adaptive monitoring programs.

These objectives were met primarily through the execution of multiple field-based sampling programs from 2014 to 2016. Specifically, sampling was completed to describe: habitat quantity, quality and use in potentially affected areas, potential fish distribution both spatially and temporally, and to characterize lower trophic dynamics (i.e., macroinvertebrate). The level of detail for habitat assessment ranged from biophysical habitat surveys to detailed macrohabitat and mesohabitat characterization. Fish sampling was guided by standard protocol and designed to meet requirements of the Fisheries Research Licences (FRL 16-2611, 14-2724) and *Species at Risk Act (SARA)* Permit (16-PCAA-00026). Less invasive methods, such as snorkeling, were given preference over methods that have a higher potential to cause harm to fish, such as electrofishing, angling, and/or minnow trapping. Field-based surveys were driven primarily by seasonality and life history characteristics (i.e., spawning, overwintering, and rearing).

Results indicate that the habitat in Gold and Blairmore creeks is fairly similar. Both watercourses are dominated by coarse substrate with fast-flowing pool-riffle, riffle and riffle-run-pool habitat units (>80% by area). Stream temperatures in Gold Creek tended to be cooler (5.4°C) than Blairmore Creek (8.0 °C), on average. The coldest average stream temperatures were observed at Caudron Creek (4.3°C), a tributary to Gold Creek. WSCT is the only native species that has been detected within the LSA. Non-native RNTR, RNTR x WSCT, and BKTR are present in Gold Creek and Blairmore Creek, with the presence of barriers largely determining their distribution. Estimated fish density varied, with the upper reaches of both Gold and Blairmore creeks containing high density of smaller-sized fish, while the lower reaches contained lower densities comprised of larger fish. Results from the mark-recapture survey estimated total sub-adult/adult fish populations in Gold and Blairmore creeks at 1,625 and 3,210, respectively. Levels of the 34 metals tested in collected fish tissues were all low, and mercury levels were below federal consumption guidelines. Density of macroinvertebrates ranged from 3,892 individuals/m<sup>2</sup> in the LSA to 14,302 individuals/m<sup>2</sup> in the RSA. Diversity and evenness were fairly high across all sites and community composition at all sites representing good water quality.

## DISTRIBUTION LIST

The following individuals/firms have received this document:

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Mike Bartlett	Millennium EMS Solutions			✓	✓

## AMENDMENT RECORD

This report has been issued and amended as follows:

Issue	Description	Date	Approved by
1	Fisheries and Aquatics Technical Baseline Report – Draft Version	20161214	
2	Fisheries and Aquatics Technical Baseline Report – Final Version	20161229	
3	Fisheries and Aquatics Technical Baseline Report – Revised Version	20170126	<Original signed by>
			Martin Davies Project Director
			Cory Bettles Project Manager

# 1.0 INTRODUCTION

## 1.1 OVERVIEW

Benga Mining Limited (Benga), a wholly owned subsidiary of Riversdale Resources Limited (Riversdale), is proposing to develop the Grassy Mountain Coal Project (the Project) along the eastern edge of the Rocky Mountain foothills approximately 200 km south of Calgary, Alberta in the municipality of Crowsnest Pass (Figure 1.1). This area is part of Northern Continental Divide Ecoregion<sup>1</sup> and the Rocky Mountains Front Range Physiographic Region<sup>2</sup>. The Project is situated in the watersheds of Blairmore Creek (50 km<sup>2</sup>) and Gold Creek (63 km<sup>2</sup>), major drainages in the Crowsnest River watershed. Combined together, Blairmore and Gold creeks represent approximately 11% of the watershed area of the Crowsnest River. Both systems are part of the Oldman River watershed, which flows into the Saskatchewan River, ultimately discharging into Lake Winnipeg.

The Project will involve a surface steelmaking coal mine, a coal handling and preparation plant (CHPP) with associated infrastructure, an overland conveyor system, which will parallel an existing high grade access corridor and connect to a rail load-out facility, and a new section of rail track (Figure 1.2). The Project will encompass approximately 1,500 hectares (ha), roughly 14% of Blairmore Creek and Gold Creek watersheds combined and about 2% of the total area of the Crowsnest River watershed.

The Project triggers a federal *Canadian Environmental Assessment* under the *Canadian Environmental Assessment Act* (2012) as the designated Project involves the construction, operation, decommissioning and abandonment of a new coal mine with a coal production capacity of 3,000 tonnes/day or more. The Project also triggers a provincial *Alberta Environmental Impact Assessment* under the *Environmental Protection and Enhancement Act* (EPEA) as the designated Project will produce more than 45,000 tonnes/year.

The information described in this baseline report has been generated based on the data requirements outlined in the Project's Terms of Reference as well as supplemental information requests (SIR) received from provincial and federal regulators. Based on the review of the *Grassy Mountain Project Aquatic Resources Baseline and Effects* report submitted in November 2015 (Hatfield 2015), the Alberta Energy Regulator (AER), Canadian Environmental Assessment Agency (CEAA) and Fisheries and Oceans Canada (DFO) requested supplemental information in January and March 2016.

The regional and local study areas (RSA and LSA) for assessment of fish and fish habitat, water quality, and hydrology are congruent and encompass areas where Project activities have the potential to impact aquatic habitat or fish populations and communities (Figure 1.1, Figure 1.2). The Blairmore Creek watershed is relatively steep, with an average slope of 22% and elevations ranging between 2,300 and 1,300 metres above sea level (m.a.s.l.). The watershed is forested with the exception of historic mining in the upper reaches, cattle rangelands and the town of Blairmore, Alberta in the lower reaches. Gold Creek has similar characteristics with an average slope of 19% and elevations ranging from 2,500 to 1,300 m.a.s.l. in the region. This watershed is heavily forested, with a large portion of private and residential ownership.

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<sup>1</sup> <http://www.ecozones.ca/english/zone/MontaneCordillera/ecoregions.html>

<sup>2</sup> Pettapiece (1986), cited in [http://www.ag.gov.ab.ca/publications/MAP/PDF/MAP\\_550.pdf](http://www.ag.gov.ab.ca/publications/MAP/PDF/MAP_550.pdf)

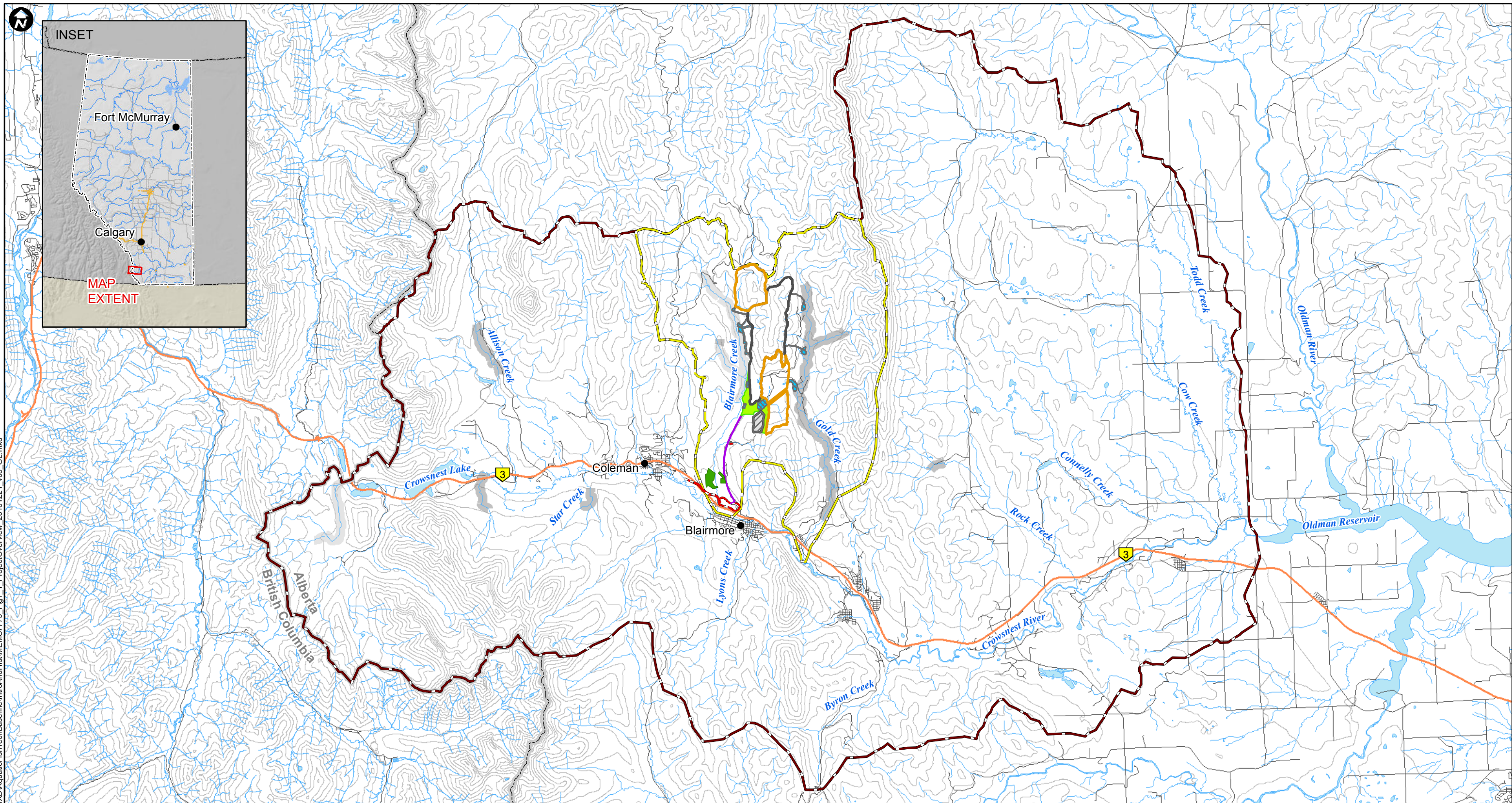
Agriculture is common in the region and livestock grazing occurs over much of the private and crown lands adjacent to the Project.

Fisheries and aquatics baseline information has been compiled from multiple sources. Sources include historical information (Section 2.0) and data/information collected from multiple baseline field investigations completed between summer 2014 and fall 2016 (Section 3.0 and 4.0, Table 1.1). A sampling program for drift invertebrates was completed in 2016 and is provided in Appendix A1.

**Table 1.1 Summary of fisheries and aquatic resource baseline studies completed within the LSA for the Project, 2014 to 2016.**

Study	2014	2015	2016
<b>Fish Habitat</b>			
Biophysical habitat assessment	√	√	-
Macrohabitat reach break delineation	-	-	√
Mesohabitat assessment & characterization	-	-	√
Stream temperature monitoring	-	-	√
Winter flow conditions	-	√	-
Barrier assessment	√	√	√
<b>Fish Biology</b>			
Sub-adult/Adult population assessment	-	-	√
Juvenile recruitment	-	-	√
Overwintering surveys	-	-	√
Spawning surveys	-	-	√
Tributary use	√	√	√
Genetic analysis (Blairmore Creek only)	-	√	-
<b>Lower Trophic Dynamics</b>			
Benthic macroinvertebrate surveys	√	-	-
Drift macroinvertebrate surveys	-	-	√
In situ water quality	√	√	√
Fish tissue residue	-	-	√
Periphyton surveys	√	-	√

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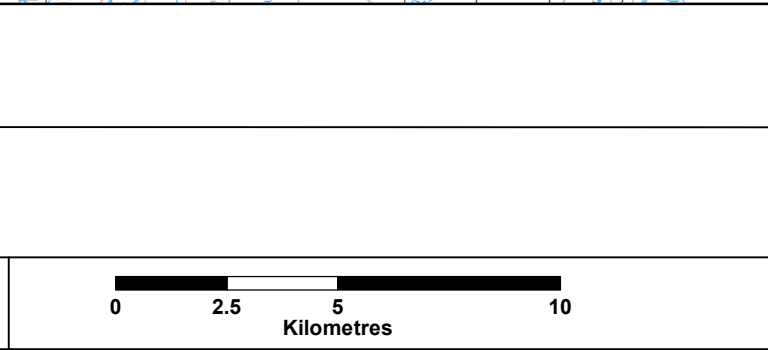


LEGEND		
Identified Westslope Cutthroat Trout Critical Habitat	Watercourse	Ponds and Ditches
Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation	Waterbody	Construction Camp
Primary Highway	Local Study Area	Covered Conveyor, Access Road and Powerline ROW
Road	Regional Study Area	Coal Handling Processing Plant and Infrastructure
100m Contour	Ultimate Pit Extent	Proposed Golf Course Area
	Ultimate Rock Disposal Area Extent	Railway Loop
	Topsoil Storage	

**PROJECT**  
**RIVERSDALE RESOURCES** **GRASSY MOUNTAIN COAL PROJECT**

**TITLE**  
**OVERVIEW OF PROJECT LOCATION**

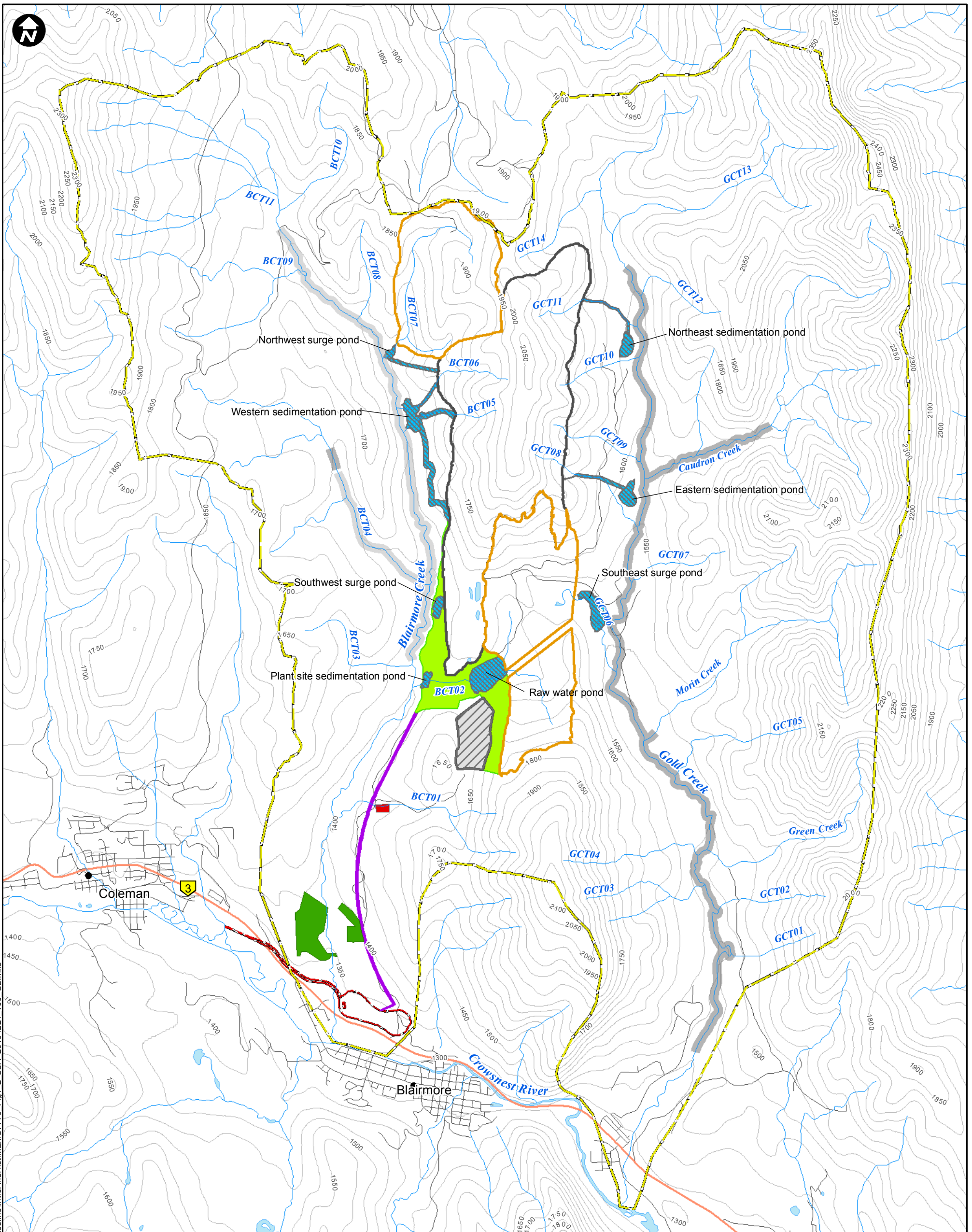
**NOTES**  
 Data Sources: Government of Canada, Government of Alberta  
 Datum/Projection: UTM NAD 83 Zone 11



**Hatfield CONSULTANTS**

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 CHECKED BY: CB  
 DATE: December 21, 2016

**FIGURE**  
**1.1**



**LEGEND**

- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study Area
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area
- Railway Loop

**PROJECT**

**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**FISHERIES AND AQUATICS LOCAL STUDY AREA**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

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DATE: December 21, 2016

**FIGURE**

**1.2**



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## 1.2 PURPOSE

The purpose of the *Fisheries and Aquatics Technical Baseline Report* is to characterize the aquatic environment in Gold Creek and Blairmore Creek watersheds. The specific objectives of the baseline study are to:

- Characterize fisheries and aquatic resources that could potentially be affected by the Project;
- Provide baseline information necessary to support the completion of an aquatic effects assessment for the Project *Environmental Impact Assessment (EIA)* ; and
- Facilitate the design of any required mitigation, offsetting (i.e., compensation), and/or adaptive monitoring programs.

These objectives were met primarily through the execution of multiple field-based sampling programs. Specifically, sampling was completed to describe: habitat quantity, quality and use in potentially affected areas, potential fish distribution both spatially and temporally, and to characterize lower trophic dynamics (i.e., macroinvertebrate). This information was used to facilitate the completion of an EIA for Aquatic Resources and the identification of local and regional mitigation actions to support responsible resource development in the Crowsnest River watershed. The data presented in this report describe existing conditions prior to the proposed mine development. In addition to this report, *the Instream Flow Needs Assessment Report* (Hatfield 2016a) and *Fluvial Geomorphology Assessment of Blairmore Creek and Gold Creek* (SNC-Lavalin 2016) have been prepared to characterize other aspects of the aquatic ecology within the LSA.

## 1.3 CANDIDATE VALUED COMPONENTS

Valued components (VCs) represent “components of the natural and human environments that are considered by the proponent, public, Aboriginal groups, scientists and other technical specialists, and government agencies involved the assessment process to have scientific, ecological, economic, social, cultural, archeological, historical, or other importance” (BC EAO 2013). Identification of VCs for an EA help to concentrate the assessment on the issues that matter most, resulting in a comprehensive yet efficient, accessible, and focused assessment.

Candidate valued components are potential VCs that are evaluated, in part, using baseline data, to determine whether they should be carried forward as VCs for the Project’s EA. If multiple candidate VCs are similarly affected by the Project and addressing both would result in redundancy, only one is carried forward to the EA to avoid redundancy in the analysis (BC EAO 2013).

A preliminary list of candidate VCs ([Table 1.2](#)) was identified for the Project in consultation with regulators, fisheries professionals experienced with Gold Creek and Blairmore Creek watersheds, interested public and Treaty 7 First Nations feedback. The baseline information presented in this report considers fisheries and aquatic resources broadly; however, it focuses primarily on one particular VC: westslope cutthroat trout (*Oncorhynchus clarkii lewisi*; WSCT).

WSCT are the primary fish VC because of their provincial and federal status in the local study area (LSA). They are also the only native fish species within the LSA to be potentially affected through potential direct

habitat loss and/or alteration (i.e., changes in stream flow). The Aquatic Health VC was included to consider potential water quality-related effects throughout the life of the mine and includes other fish species (non-native brook trout [*Salvelinus fontinalis*; BKTR], rainbow trout [*Oncorhynchus mykiss*; RNTR]) and lower trophic organisms. Given the conservation sensitivities surrounding WSCT, non-native BKTR and RNTR are used as a surrogate to evaluate potential water quality-related effects to all fish in the LSA. Evaluation of potential effects on the Aquatic Health VC is addressed predominantly through the *Surface Water Quality Environmental Assessment Report* (Hatfield 2016b), with the exception of fish tissue residue, which is included in [Section 3.1.6](#) of this report.

**Table 1.2 Summary of candidate valued components for fisheries and aquatic resources.**

Valued Component	Recovered in FWMIS database	Traditional use <sup>3</sup>	Captured in baseline field studies	Status of special concern <sup>4</sup>
<b>Fish</b>				
Westslope cutthroat trout	√	√	√	√
<b>Aquatic Health</b>				
Brook trout (surrogate for other fish species)	√	√	√	
Rainbow trout (surrogate for other fish species)	√	√	√	
Benthic macroinvertebrates	√	√	√	
Periphyton	√	√	√	
Aquatic sediment	√	√	√	

## 1.4 STUDY AREA

The fisheries and aquatics discipline used the aquatic RSA ([Figure 1.1](#)) and LSA ([Figure 1.2](#)) for the baseline study. The aquatic RSA is comprised of the entire Crowsnest River watershed so that the cumulative effects of all activities within the watershed can be evaluated at a regional level. The aquatic LSA was selected based on the Project footprint, boundaries of local watersheds and the spatial extent of potential immediate direct and indirect effects of the Project on hydrogeology, surface water hydrology, water quality, and fish/aquatic resources. The LSA was also defined as the conservative downstream limit of potential fish and fish habitat that may be influenced by the Project with a focus on the critical habitat defined in the WSCT federal and provincial Recovery Plans (Alberta Westslope Cutthroat Trout Recovery Team 2013, DFO 2014) assigned to Gold Creek and Blairmore Creek.

<sup>3</sup> Information gathered during traditional knowledge and traditional land use surveys with members of Treaty 7 First Nations conducted as part of Project preparation (Kanai Nation 2015, Piikani Nation 2015, Tsuut'ina Nation 2015, Siksika Nation 2015) suggest no particular fish species are more important for traditional uses than others and therefore all fish species found in the LSA are denoted as traditional use species.

<sup>4</sup> from [http://www.registrelep-sararegistry.gc.ca/species/schedules\\_e.cfm?id=1](http://www.registrelep-sararegistry.gc.ca/species/schedules_e.cfm?id=1), [http://www.cosewic.gc.ca/eng/sct3/index\\_e.cfm#3](http://www.cosewic.gc.ca/eng/sct3/index_e.cfm#3), and <http://aep.alberta.ca/fish-wildlife/species-at-risk/documents/SpeciesAssessed-Endangered-Jul18-2014.pdf>

## 2.0 HISTORICAL FISHERIES AND AQUATICS INFORMATION

The following summarizes publicly available information describing fish and fish habitat within the LSA (Figure 2.1). Pertinent historical information has been generated from the following resources:

- The Fish and Wildlife Management Information System (FWMIS), accessed through an information request to Alberta Environment and Sustainable Resource Development (AESRD) and provided by AESRD (now referred to as Alberta Environment and Parks [AEP]) in the form of a data report (AESRD 2013a) that included information on barriers to fish passage;
- Information contained in the Recovery Plan prepared for the WSCT (Alberta Westslope Cutthroat Trout Recovery Team 2013, DFO 2014);
- Published reports from the Alberta Conservation Association (ACA) as well as available scientific literature; and
- Information gathered during surveys of traditional knowledge and traditional land use with members of the Treaty 7 First Nations conducted as part of Project preparation (Kanai Nation 2015, Piikani Nation 2015, Tsuut'ina Nation 2015, Siksika Nation 2015).

Publicly available fisheries inventory and/or habitat assessment information for Gold Creek and Blairmore Creek watersheds is relatively limited. Sparse information was available through the FWMIS (i.e., fish presence/absence, species distribution) and peer-reviewed publications or technical reports (i.e., interspecific hybridization, Yau and Taylor 2014; population estimates, Blackburn 2011). To date, only limited anecdotal information was found with respect to fish habitat assessments, and no information was identified specific to seasonal fish movement or reproduction dynamics specific to either watershed.

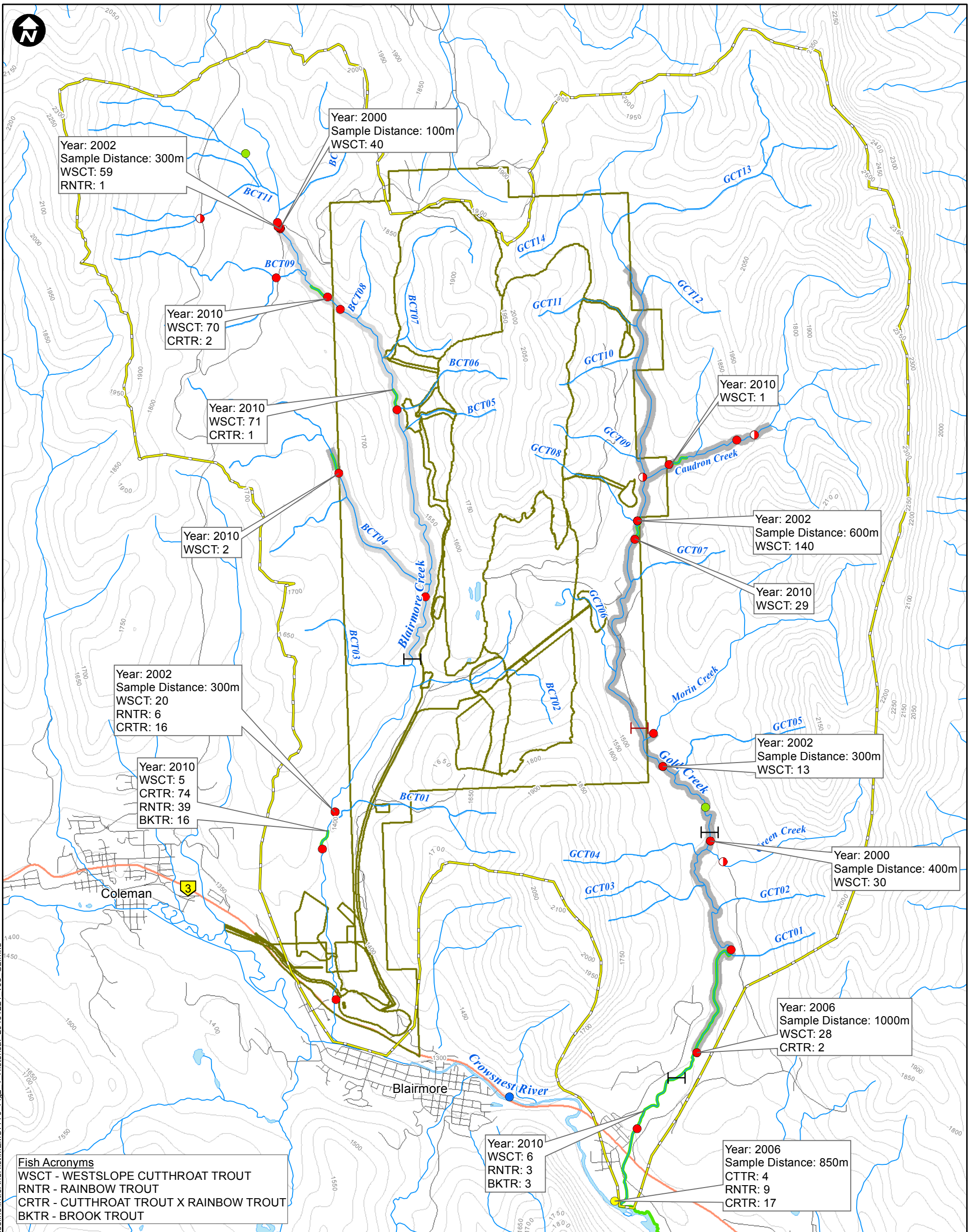
WSCT, RNTR, WSCT x RNTR hybrids, and BKTR have been reported in Gold Creek. The FWMIS does not distinguish between cutthroat trout (*Oncorhynchus clarkii*) and WSCT. However given the distribution of WSCT, cutthroat trout records in the FWMIS have been treated as WSCT. The majority of fish captured upstream of the most southern barrier (i.e., old water supply dam) were BKTR; however the location of their capture is unknown (AESRD 2013a). The source of these non-native fish has been traced to deliberate stocking and is not a result of the barrier on Gold Creek being passable to fish.

Gold Creek and Blairmore Creek are mapped Class B watercourses under the *Water Act* Code of Practice, which means they contain habitat important to the continued viability of a species and are considered sensitive to any type of activity. All tributaries of both Gold Creek and Blairmore Creek are also considered Class B habitat for a distance of 2 km upstream from their confluence with the mainstems and Class C habitat beyond that. Class C watercourses contain habitat of moderate sensitivity, which could potentially be damaged by unconfined or unrestricted activities within the waterbody.

WSCT have been documented in two main tributaries to Gold Creek, both of which drain into Gold Creek from the east: Caudron Creek and Morin Creek (Figure 2.1). An assessment conducted in 2002 (AESRD 2013a) characterized Morin Creek as having high fisheries potential, with moderate spawning substrate, high value rearing habitat, and moderate overwintering habitat quality. The extent of Morin Creek surveyed

is unknown. Surveys of Caudron Creek in 2002 and 2010 characterized the creek as primarily riffle habitat with sparse pools. Substrate comprised equal proportions of cobble and gravel, sub-dominated by boulder and fines. The precise extent of Caudron Creek surveyed is unknown. Blackburn (2011) estimated the WSCT population abundance in upper Gold Creek to be between 65 and 271 individuals. The federal Recovery Plan designates portions of Morin and Caudron creeks as critical habitat for WSCT (DFO 2014). A fish inventory was also completed in Green Creek, but no fish were detected during the survey.

As with Gold Creek, WSCT, RNTR and BKTR have been recovered in Blairmore Creek. Blackburn (2011) compiled historical sampling records for Blairmore Creek and completed population estimates of WSCT for both upper and lower Blairmore Creek. The population of upper Blairmore Creek WSCT was estimated to be between 121 and 277 individuals, while the lower Blairmore Creek population was estimated between 201 and 310. No publically available information could be found regarding previously conducted fish habitat assessments or spawning surveys.



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**LEGEND**

- Barrier to Fish Passage
- Barrier to Fish Passage - Seasonal
- Fisheries Inventory Program
- Historical Benthic Survey
- 2009 Crowsnest River Preliminary Tote-barge Electrofishing
- FWMIS Historical Survey (no fish caught)
- FWMIS Historical Survey (fish caught)
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation
- 2010 Crowsnest River tributary sample sites
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study
- Project Footprint

**PROJECT**



**TITLE**

**SUMMARY OF HISTORICAL FISHERIES AND AQUATICS BASELINE INFORMATION IN THE LOCAL STUDY AREA**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
 Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

DRAWN BY: SS / EDITED BY: GL

CHECKED BY: CB

DATE: December 21, 2016

**FIGURE**

**2.1**



## 3.0 METHODS

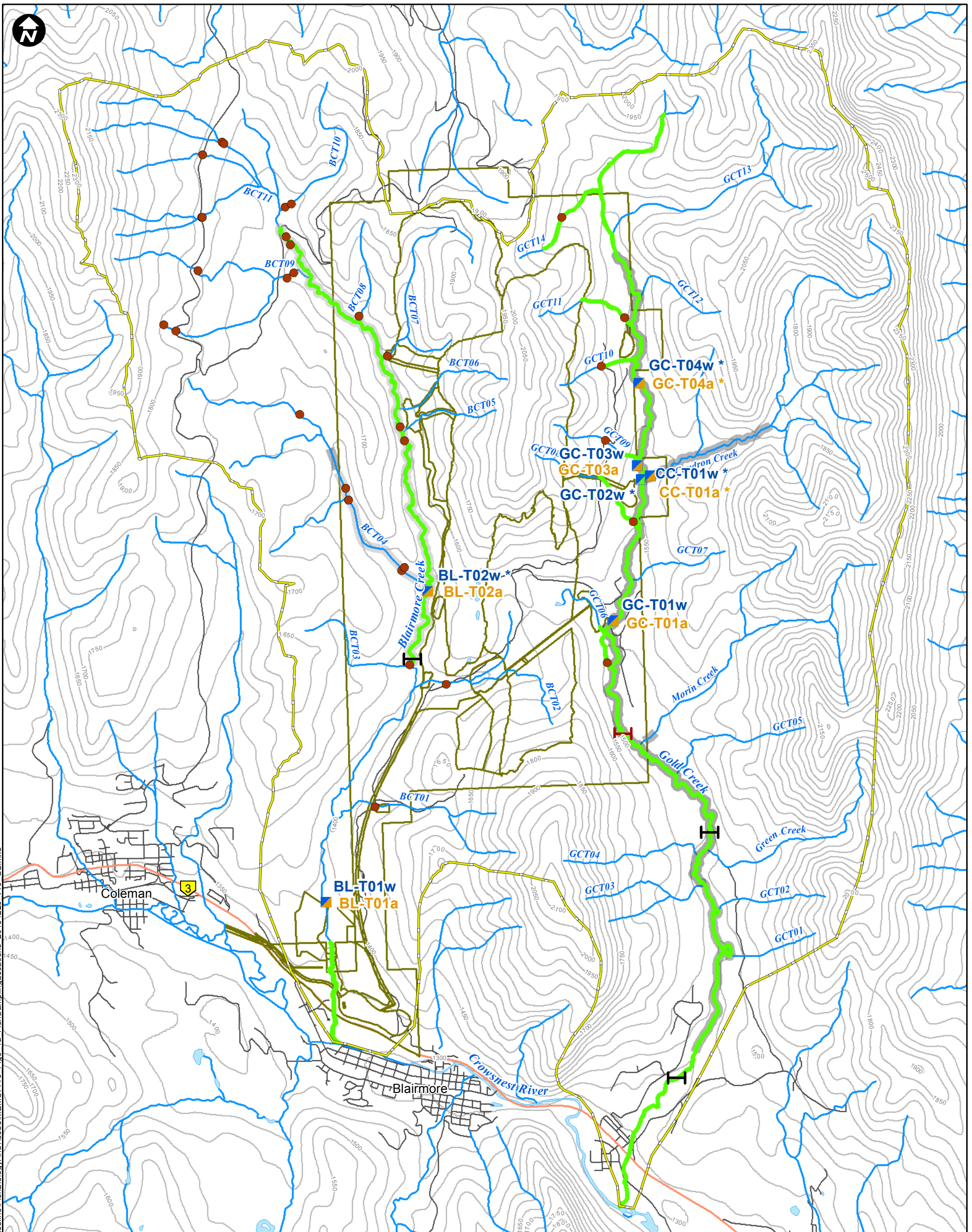
Field sampling programs were implemented for the Project from 2014 to 2016 to supplement the existing historical data within the LSA. These programs were designed to:

- Characterize fish habitat;
- Confirm fish presence and absence throughout the LSA;
- Describe fish distribution in terms of space and time;
- Characterize the fish community and understand fish species and life stages present;
- Enumerate fish populations using an abundance indicator (i.e., density);
- Understand life-history timing, with particular emphasis on seasonal habitat use;
- Establish baseline fish tissue conditions; and
- Characterize lower trophic dynamics.

An overview of the locations sampled is provided in [Figure 3.1](#). The 2016 field sampling program was based on the regulator-approved *Fisheries and Aquatic Resources Work Plan* (Hatfield 2016c).

### 3.1 FISHERIES RESOURCES

Fisheries resources include fish habitat, fish community, and fish population. Sampling occurred from 2014 to 2016 using several methods described below. The level of detail for habitat assessment ranged from biophysical habitat surveys to detailed macrohabitat and mesohabitat characterization. Fish sampling was guided by standard protocols (e.g., AESRD 2013b) and designed to meet requirements of the Fisheries Research Licences (FRL 16-2611, 14-2724) and *Species at Risk Act* (SARA) Permit (16-PCAA-00026). Less invasive methods, such as snorkeling, were given preference over methods that have a higher potential to cause harm to fish, such as electrofishing, angling, and/or minnow trapping. Field-based surveys were driven primarily by seasonality and life history characteristics (i.e., spawning, overwintering, and rearing). The sampling duration and timing of fisheries resources field sampling is summarized in [Figure 3.2](#).



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**LEGEND**

- |  |   |  |                   |
|--|---|--|-------------------|
|  | Barrier to Fish Passage   |  | Primary Highway   |
|  | Barrier to Fish Passage - Seasonal  |  | Road              |
|  | Biophysical Habitat Survey  |  | 50 m Contour      |
|  | Water Temperature Station   |  | Watercourse       |
|  | Air Temperature Station   |  | Waterbody         |
|  | Fish Habitat Assessment   |  | Local Study Area  |
|  | Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure) |  | Project Footprint |
|  | Near Pure WSCT (95% to 99% pure)  |  |                   |
|  | Provincial Conservation Designation   |  |                   |

Note: \* indicates station is active.

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**OVERVIEW OF SAMPLING LOCATIONS FOR A) FISH HABITAT**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

DRAWN BY: SS / EDITED BY: GL

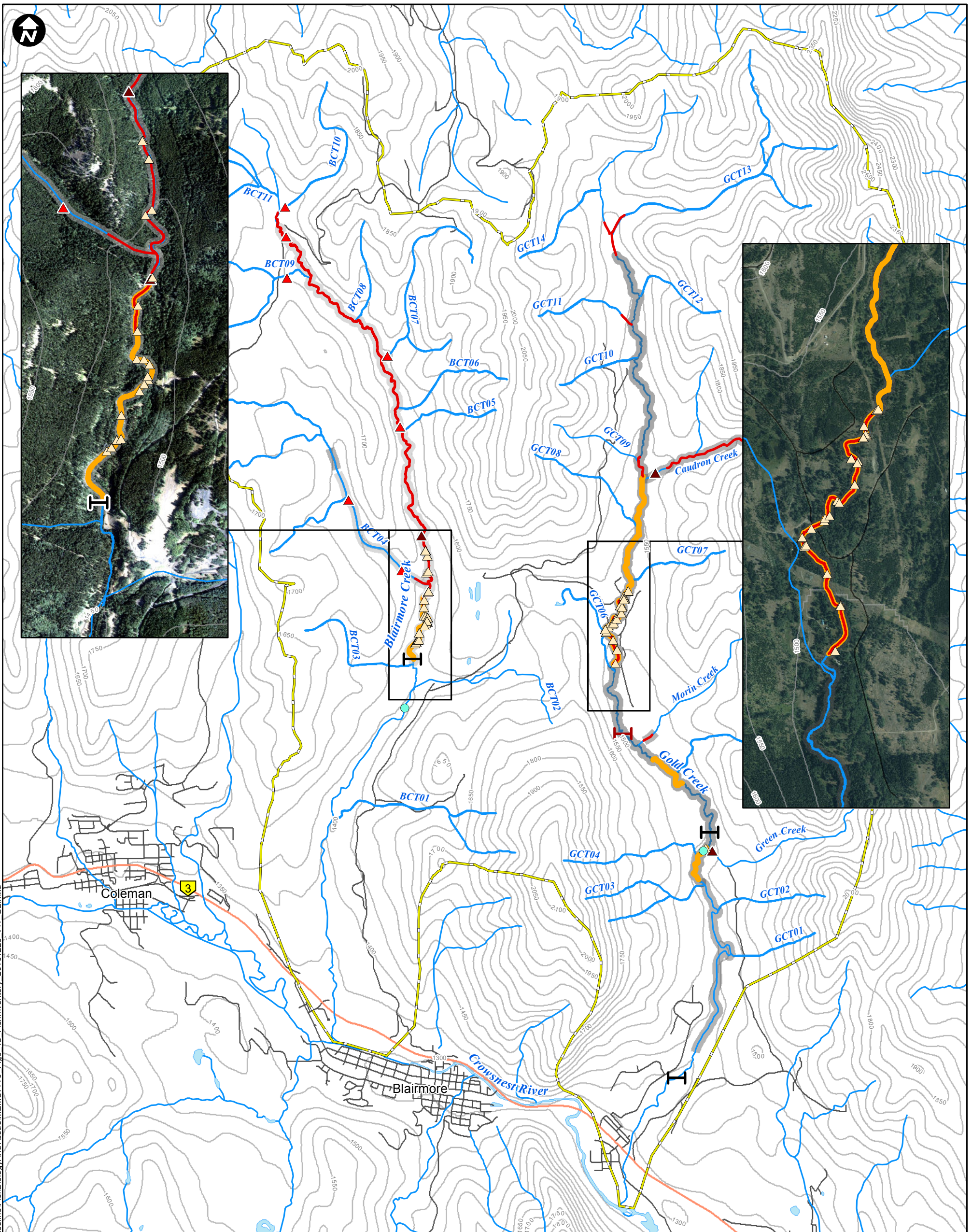
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DATE: December 23, 2016

**FIGURE**

**3.1a**





**LEGEND**

- Fish Tissue Survey
- ⊥ Barrier to Fish Passage
- ⊥ Barrier to Fish Passage - Seasonal
- Survey Type**
- ▲ Angling (mark-recapture)
- ▲ Electrofishing
- ▲ Snorkel
- Electrofishing
- Snorkel
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study Area

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**Hatfield**  
CONSULTANTS

**TITLE**

**OVERVIEW OF SAMPLING LOCATIONS FOR B) FISH SURVEYS**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, Aerial Photos, 0.25 m resolution, Tarin Resource Services Ltd.  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

DRAWN BY: SS / EDITED BY: GL

CHECKED BY: CB

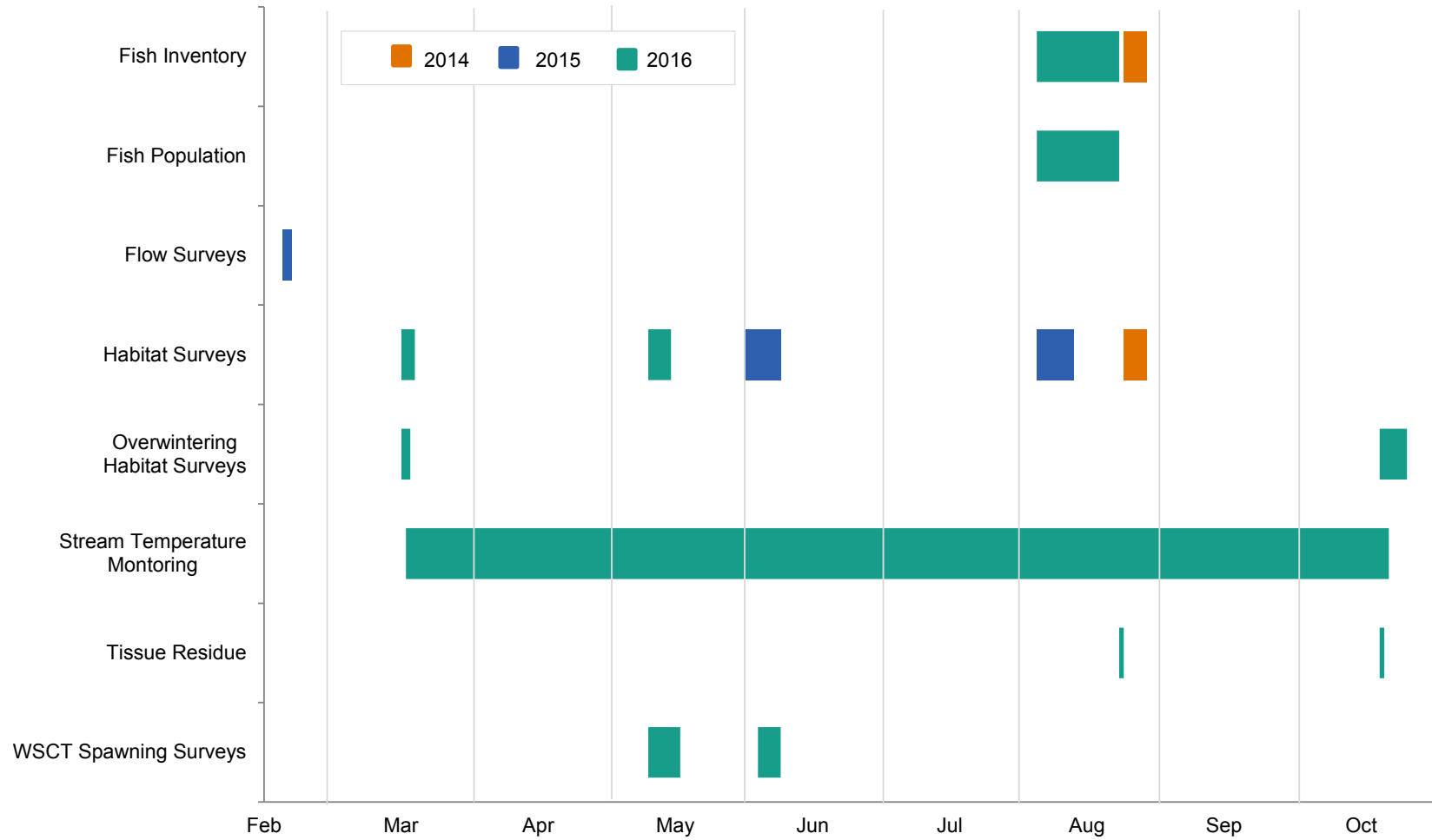
DATE: December 23, 2016

**FIGURE**

**3.1b**



**Figure 3.2 Overview of the duration and timing of fisheries resources field sampling from 2014 to 2016.**



### 3.1.1 Fish Habitat

Fish habitat assessments were completed from 2014 to 2016 to describe the quality, composition, and distribution of fish habitats throughout the mainstem and tributaries of Gold Creek and Blairmore Creek (Figure 3.1a). Biophysical habitat inventory surveys were completed in 2014 and 2015. In 2016, assessments were organized at different spatial scales to facilitate analysis: macrohabitat (reach scale), mesohabitat (hydraulic unit scale), and microhabitat (site-specific scale). The macrohabitat and mesohabitat scale are characterized in this report. Microhabitat data are captured in the Instream Flow Needs Assessment Report (Hatfield 2016a). Fish habitat surveys followed a modified version of British Columbia's *Fish Habitat Assessment Procedures* ([FHAP], Johnston and Slaney 1996) as described in Lewis et al. (2004), specifically aimed at water withdrawal/alteration projects.

The main objectives of the habitat assessments were to:

1. Describe fish habitat potentially affected by the Project;
2. Quantify habitat unit composition at the reach level delineating units into pool, run, riffle, and cascade habitats expressed in linear distance of channel occupied by the mesohabitat unit; and
3. Collect habitat data contributing instream flow needs assessment to predict changes in habitat quality and quantity with alterations in stream flow.

Stream temperature monitoring was initiated in 2014 and augmented in 2016 to characterize the baseline stream temperature conditions within the LSA. The following sections describe the methodology for the fish habitat assessment program.

#### 3.1.1.1 Biophysical Habitat

A series of habitat inventory surveys were completed from August 2014 to August 2015 to characterize the biophysical fish habitat in Gold Creek and Blairmore Creek watersheds (Table 3.1, Figure 3.1a). The mainstem and tributaries of Gold Creek and Blairmore Creek were targeted.

Surveys were conducted at two sites on mainstem Blairmore Creek and 17 sites on tributaries to Blairmore Creek (Figure 3.1a). The target length was 300m or 40 times the wetted width, following the conditions in the Fisheries Research Licence (FRL 14-2724). Substrate composition, overhead and instream cover, channel morphology, wetted and channel width, and maximum depth were documented. Photographs of each site were taken and the GPS coordinates of any potential barriers were recorded.

Habitat inventory surveys on Gold Creek and three Blairmore Creek tributaries likely to be impacted by the project (BCT05, BCT06 and BCT07) followed the methods outlined in Alberta Transportation's Fish Habitat Manual (Alberta Transportation 2009) with the objective of characterizing and mapping key biophysical features. Channel measurements were collected at periodic intervals based on the size of the watercourse and frequency of habitat change. Measurements included channel and wetted width, depth at 25%, 50% and 75% of wetted width, average velocity across the channel, maximum depth of all pools, slope of the channel, location and height of identified (candidate) barriers to fish passage, substrate, and cover. Photos were taken where channel measurements were made and any areas of disturbance were noted.

**Table 3.1 Summary of biophysical inventory surveys in Gold and Blairmore Creek watersheds, 2014 and 2015.**

Date	Description of field program
August 2014	<ul style="list-style-type: none"> <li>▪ Biophysical habitat inventory surveys at two sites on mainstem Blairmore Creek and 17 sites on the tributaries</li> </ul>
February 2015	<ul style="list-style-type: none"> <li>▪ Assessment of winter flow conditions at one location on five of the six tributaries of Gold Creek within the Project footprint.<sup>1</sup></li> </ul>
June 2015	<ul style="list-style-type: none"> <li>▪ Biophysical habitat inventory surveys of the lower reaches of six Gold Creek tributaries, starting at their confluence to Gold Creek.<sup>2</sup></li> <li>▪ Habitat reconnaissance surveys of three Blairmore Creek tributaries (revisited sites from August 2014)</li> </ul>
August 2015	<ul style="list-style-type: none"> <li>▪ Biophysical habitat inventory surveys of Gold Creek from the downstream delineation of critical habitat for westslope cutthroat trout to the upper reaches of Gold Creek, upstream of the Project footprint</li> </ul>

<sup>1</sup> One of the six tributaries (GCT14) could not be accessed in February 2015 due to deep snow.

<sup>2</sup> The length of watercourses covered by the aquatic habitat surveys of these tributaries in June 2015 was constrained by steep terrain and access limitations.

### 3.1.1.2 Fish Habitat Assessment

Detailed fish habitat assessments were conducted during 2016 to characterize the habitat for two different scales: macrohabitat (reach scale) and mesohabitat (hydraulic unit scale). Barriers were also assessed and documented during these surveys.

#### **Macrohabitat**

Macrohabitat reach breaks were delineated in Gold Creek and Blairmore Creek mainstems based on the criteria described in Lewis et al. (2004) classifying reaches as “a homogeneous section of stream channel, characterized by uniform discharge, gradient, channel morphology, channel confinement, and streambed and bank materials.” Detailed habitat assessments completed in May and October of 2016 identified reach breaks as:

1. Changes in stream gradient;
2. Changes in discharge, often where a significant tributary enters the mainstem; or
3. Identified barriers to fish movement.

Field data was supplemented by GIS topographic data to calculate the gradient and lengths of the various reaches. Although data collection procedures and survey design mirrored FHAP guidelines, deviations were necessary to address the objectives of this study (e.g., reaches were delineated on the basis of the location of proposed infrastructure and natural barriers).

## **Mesohabitat**

Mesohabitats are medium-sized stream features defined by stream hydraulic characteristics. Reaches are stratified into mesohabitats (pools, runs, riffles, cascades, etc.) so that the composition of each reach can be defined and expressed in area (m<sup>2</sup>) of channel occupied by each mesohabitat type. Mesohabitat was classified using the FHAP Level 1 methods. This level of survey was used to identify current habitat conditions in the LSA as outlined in Lewis et al. (2004) however, select departures were necessary to focus on the objectives of this study. They included:

1. A focus on impacts related to the proposed mine rather than impacts related to forest harvesting and/or opportunities for restoration;
2. The exclusion of the overview assessment, initial planning exercise, and Level 2 FHAP, which were deemed unnecessary for the purpose of this study;
3. The omission of discharge measurements as described in Lewis et al. (2004), given an instream flow needs assessment was completed as part of this study; and
4. A focus on limitations to fish production rather than forestry impacts, including a detailed assessment of spawning and overwintering habitat throughout the surveyed sections.

The study design consisted of sampling the majority of habitat units within the potentially affected sections of each watercourse. Quantitative data were measured rather than estimated wherever possible; however, estimates were made for pool depths greater than 1.5 m, dominant and subdominant bed materials, percent cover, and canopy closure. All field data were collected by a two-person crew and recorded onto FHAP site cards (1996 Edition).

Habitat units were classified as pools, runs, riffles, steps and cascades. Lewis et al. (2004) recommend using only pools, glide, riffle, cascade and “other”; however, we included run and step habitat types to better characterize habitat units in this system. Units were additionally classified by location within the stream as primary, secondary, and tertiary. Primary habitat units comprise more than 50% of the wetted width. Secondary units occur in minor channels that are isolated from the main channel by a vegetated island with perennial plants greater than 1 m in height. Tertiary units are significant, identifiable habitat units within the main stream channel that occupy less than 50% of the wetted width (e.g., are nested within primary units) and are typically small pools. We included this additional habitat classification given the shift in habitat units above and below the Caudron Creek/Gold Creek confluence.

The habitat unit composition of each reach was determined based on the proportion of wetted area occupied by each habitat type over the total wetted area of the reach. The habitat unit composition of each reach was determined based on the proportion of wetted area occupied by each habitat type over the total wetted area of the reach.

### **3.1.1.3 Barriers**

A barrier is any natural or man-made structure that restricts the upstream or downstream movement of fish. Fish passage may be limited by large drops, high water velocities, and low water depths. Many anthropogenic structures in streams, such as culverts and weirs, can create barriers to fish passage.

Barriers can prevent fish from migrating to critical habitats required to complete their lifecycles. However, barriers can also serve an additional purpose of preventing the migration of non-native fish species into critical habitat. Hybridization with RNTR and competition from BKTR are potential threats to WSCT (Alberta Westslope Cutthroat Trout Recovery Team, 2013); therefore, the presence of some barriers in the LSA can create a refuge for pure-strain WSCT. To determine the extent of barriers and their role in potentially shaping fish populations and communities in the LSA, it is important to understand the species present and their history in the area.

There is no single recognized assessment methodology available to identify barriers to fish passage. We adopted methodology for assessing falls and chutes (cascades) provided in Reiser et al. (2006), with supplementary information provided in Parker (2000). This methodology uses ground surveys to examine whether fish are capable of ascending a given barrier (jumping or swimming). Ground surveys for potential barriers to fish passage were surveyed from 2014 to 2016 during biophysical and habitat surveys for the Project.

Where applicable, potential barriers or obstructions to fish migration (e.g., falls, chutes, cascade and woody debris jams) were documented in detail. The height of each obstruction was measured and a judgment on whether fish could overcome the barrier was made by an experienced biologist. The height (m), length (m), and depth (m) of plunge pools were estimated.

The assessment of a fish's ability to successfully pass a barrier depends on the nature of the barrier (e.g., falls, chute, man-made) and the particular fish species' swimming ability, jumping ability, and individual size. For a fish to be able to successfully ascend a falls or culvert barrier it must be capable of leaping from the plunge pool to the top of the falls or culvert and then be able to swim upstream. For a fish to be able to ascend a chute or a cascade, it must be capable of either swimming up the chute and/or leaping over the barrier.

The swimming capabilities of cutthroat trout, RNTR, and BKTR are summarized in [Table 3.2](#). The assessment of fish passage at a falls was determined by comparing the maximum jump height to the length and height required for a fish to jump over a falls. Although no swimming speeds specific to WSCT exist, we estimated that cutthroat trout and rainbow trout have similar jumping and burst swimming capabilities. Sustained swimming speed is the swimming velocity that can be maintained indefinitely, prolonged swimming speed can be maintained for up to 200 minutes through difficult areas, and burst swimming speed are used for escape and feeding for up to 165 seconds. In addition to the species' maximum jump height, the ability to jump a vertical obstacle is also related to the depth of water from which a fish can leap. A pool depth of at least 1.25 times the height of the obstacle provides for ideal leaping conditions (Slaney and Zaldokas 1997).

**Table 3.2 Typical swimming capabilities and maximum jump heights for fish in the LSA.**

	Life stage	Maximum swimming speed (m/s)			Max. jumping height (m)	Source
		Sustained	Prolonged	Burst		
Brook Trout	Adult	-	0.9	-	-	Petersen 1974
	Adult	0.9	1.8	4.3	1.5	Slaney & Zaldokas 1997
Cutthroat Trout and Rainbow Trout	Juvenile (12.5 cm)	0.4	0.7	1.1	0.6	Slaney & Zaldokas 1997
	Juvenile (5 cm)	0.1	0.3	0.4	0.3	Slaney & Zaldokas 1997

### 3.1.1.4 Stream Temperature

Temperature plays a vital role in the presence/absence, life-histories and spatial distribution of stream organisms (Hauer and Lamberti 2006, Magnuson et al. 1979). Annual fluctuations in stream temperatures are important to critical life history variables such as reproduction as well as general movement throughout the habitat, as they provide an environmental cue for activities such as spawning and emergence of aquatic insects (Hasnain 2012, Hauer and Lamberti 2006, Jakober et al. 1998). Fish move throughout waterbodies, in response to changes in temperature: as water temperature declines in the fall, juveniles move downstream seeking out deep pool habitat and other protected areas to overwinter (Jakober et al. 1998).

Many streams experience diel temperature flux and range in daily temperature of more than 5°C is very common, however the high latent heat of water can cause stream temperatures to vary much more narrowly on a daily basis than air temperatures (Hauer and Lamberti 2006). Factors such as groundwater input and riparian shading can have a large influence on stream temperature (Hauer and Lamberti 2006, Leach et al. 2012) leading to high variation in stream temperatures between habitats only a few metres apart (Hauer and Lamberti 2006, Kalb 2013).

Stream temperature data was collected in 2014 from two hydrometric stations in Blairmore Creek and one location on Gold Creek. These data were further supplemented with the installation of multiple continuous temperature data loggers (Onset Computer Corporation, Cape Cod, Massachusetts: Hobo Model UA-002-66) on March 21 and 22, 2016. These data loggers were installed at two sites on Blairmore Creek and five sites on Gold Creek (Figure 3.1) following the *Standard Operating Procedures for Continuous Temperature Monitoring of Freshwater Rivers and Streams* (Ward 2011). The loggers were calibrated within the manufacturer’s stated accuracy using an ice water bath at 0°C. They measured temperature ranging from 0°C to 50°C with an accuracy of ± 0.53°C at 15-minute intervals.

Two data loggers were installed at each station: one was installed in the watercourse (Photo 3.1) and a second logger was installed in a nearby tree (Photo 3.2). Each logger was housed in white PVC pipe. Stream temperature loggers were deployed as close as possible to the active part of the stream to ensure representative temperatures (based on flow volume) were recorded throughout the entire deployment period. Deployment depth was approximately 10-15 centimetres (cm) above the stream bottom, to minimize any chance of recording groundwater inflow while minimizing risk of exposure to air during low-flow periods.

Ideal deployment locations typically were at the upstream outside edge or downstream inside edge of bends within the watercourse, or in the thalweg of run habitat, avoiding eddies or pools. To decrease exposure to conditions that may seasonally bias temperatures, site locations avoided areas immediately downstream of tributaries, and obvious hillside groundwater seeps.



**Photo 3.1** Typical installation of a water temperature logger. Hobo temperature logger is inside the white PVC pipe and attached to green rebar. Sledge hammer is for scale. Photo taken at Gold Creek Site 4 (GC-T04w) on March 21, 2016.



**Photo 3.2 Typical installation of the air temperature loggers. Hobo temperature logger is inside the white PVC pipe, which is wired to the tree. Photo taken at Gold Creek Site 4 (GC-T04a) on March 21, 2016.**

Data from the installed temperature loggers were downloaded between October 19 to 21, 2016. Loggers were redeployed at one location on Blairmore Creek, Gold Creek and Caudron Creek, respectively (Figure 3.1a) to continue monitoring temperature in both watersheds. Three loggers were disrupted during the field program and the following abnormalities were observed:

- Gold Creek Site 1 water temperature logger (GC-T01w) was retrieved on Oct 22, 2016 approximately 20-m downstream from the original sampling site, in the middle of the channel;
- Gold Creek Site 4 water temperature logger (GC-T04w) stopped recording for a 10-day period during July 2016;
- Blairmore Creek Site 2 air temperature logger (BC-T02a) was found to have a software malfunction that prevented the download of data.

To ensure equal comparison, the study period used for results interpretation was selected to represent the maximum period that all loggers were deployed concurrently.

### **3.1.2 Fish Inventory**

Fish inventory surveys were performed from 2014 to 2016 to confirm fish presence, distribution and habitat use within the study area. Surveys employed a suite of widely accepted standard protocols, including a combination of active capture methods (i.e., electrofishing) as well as direct visual observation (i.e., snorkel surveys). The goal of these surveys was to characterize fish species composition, distribution and abundance.

Given the federal WSCT Habitat Protection Order covering the majority of Gold Creek, we adopted an approach that limited electrofishing use to reduce stress on WSCT. Identified stream segments were only sampled using electrofishing when the following conditions were met: conductivity  $>10 \mu\text{Scm}^{-1}$ ; temperature  $>6^{\circ}\text{C}$ ; and water visibility  $>25 \text{ cm}$  at time of sampling. Inventory sampling using electrofishing occurred once WSCT yearlings (YOY) had fully emerged from the gravel in early August. We focused on juvenile habitat use, but also targeted select mesohabitat to understand habitat use by varying life stages.

Following the survey method described in AESRD (2013b), we conducted all electrofishing surveys using single pass backpack electrofishing (Model Smith-Root LR24) as per Fisheries Research Licenses (FRL) 16-2611, 14-2724 and SARA Permit 16-PCAA-00026. The target length of each survey was 300 linear meters or 40 times the wetted width as per AESRD protocol. All captured fish were retained in live-wells, measured, and returned to the stream close to the capture location. The fish were identified to species, weighed with a digital Ohaus scale ( $\pm 0.01 \text{ g}$ ) and measured for fork length using a fish measuring board ( $\pm 1 \text{ mm}$ ). Fish identified as WSCT were selected for genetic sampling (as per the requirements of the FRL) in support of the provincial WSCT Recovery Plan (Alberta Westslope Cutthroat Trout Recovery Team 2013). Caudal fin clips were stored in labeled 2 mL Cryo-vials filled with 95% ethanol. Genetic material was collected from 342 fish and submitted to AEP in 2014 and 2016.

Where habitat conditions permitted, snorkel surveys were conducted throughout Gold Creek and Blairmore Creek mainstems and tributaries, following the methodology described by O'Neal (2007). In reaches where depths were greater than 20 cm a snorkeler swam in an upstream direction against the current counting the fish as they swam by to avoid double counting. The snorkeler swam in a zigzag pattern across the margins of the stream, paying particular attention to potential hiding places, such as large boulders or woody debris. All the fish observed were tallied and assigned a fork length class at 10 cm intervals. Data were recorded by a stream bank assistant, who also monitored the swimmer's safety.

### 3.1.2.1 Fish-Bearing Status

Information collected during all fish and fish habitat surveys throughout the LSA was used to confirm fish presence and distribution throughout Gold and Blairmore Creek and their tributaries. Results from biophysical and habitat assessments ([Section 3.1.1](#)) guided fish inventory sampling, by identifying habitats that could potentially be used by fish through the identification of barriers and key habitat features. Surveys for fish population ([Section 3.1.3](#)) also provided information on fish presence and species occurrence.

Surveys targeting select tributaries in Gold Creek and Blairmore Creek were completed in August 2016 ([Figure 3.2](#)), with the objective of documenting fish presence, distribution, and habitat use (where fish were present). Select tributaries to Gold Creek (GCT13, GCT10, Caudron Creek, Morin Creek, and Green Creek) and Blairmore Creek (BCT04, BCT02) were sampled via electrofishing using an opportunistic sampling approach. Field crews sampled select mesohabitat where fish were most likely to be present. Captured fish were enumerated (i.e.,  $<5$ ,  $5-20$ ,  $>20$ ) and released at their respective locations. UTM coordinates and habitat type was recorded. In situ water quality measurements including temperature, conductivity, dissolved oxygen, and pH were collected from each sample location using hand-held meters and Winkler DO kits. Equipment was calibrated daily to ensure accurate measurements were collected.

Snorkel surveys were conducted, where appropriate (i.e., Caudron Creek), when electroshocking was deemed inefficient. The number of fish observed and stream survey length were recorded, from which a fish density (fish/m<sup>2</sup>) was calculated.

### 3.1.2.2 Size (Age) Structure

Fry (young-of-year; YOY), juvenile (parr), sub-adult, and adult life stages were assigned to all fish captured during all 2016 active sampling programs in Gold and Blairmore creeks. Age class was inferred from spikes in the length-frequency distribution. This less invasive method was chosen instead of aging with otoliths, given the sensitivities around sacrificing pure-strain WSCT. Fish assigned as fry are individuals in their first year (0+). The term juvenile is commonly used to discuss fish from one year of age to the age of maturity, which can vary. For the sake of this study, we used the term juvenile to assign one year-old fish (1+). Fish identified as two years and older (2+) were classified as sub-adults and adults. While understanding that fish two years and older can represent a mixture of mature and immature fish (i.e., adults and sub-adults), it is expected that they will require similar habitat based on their size and not their state of maturity.

### 3.1.3 Overwintering Habitat Survey

Overwintering surveys have presented many challenges to biologists, especially in the region of this project where winter temperatures and snowfall keep streams frozen and covered in deep snow throughout the winter months (Lotic Environmental 2015). These conditions make streambank observations or electrofishing ineffective. To address these limitations we chose to complete our surveys at the latest possible date to ensure stream ice had begun to break away and sufficient open water available (March 20 and 21, 2016) and the earliest possible date prior to ice up and snow accumulations (October 20 to 23, 2016) following the assumption that water temperatures and stream flows would be sufficiently reduced to induce movement of fish into winter habitats (Jakober et al. 1998). We employed snorkel survey methods (Section 3.1.2) in order to improve fish observations and collect quantifiable data with respect to fish density, size distribution and location, and overall overwinter habitat abundance and quality in both Blairmore Creek and Gold Creek mainstems. For overwintering habitat with high fish densities (i.e., pools), repeat surveys were conducted to confirm accuracy of fish counts.

### 3.1.4 WSCT Spawner Survey

Spring surveys were completed on all sections of Gold Creek and Blairmore Creek suspected of being fish-bearing based on historical fish presence/distribution information. Surveys were completed during two periods in 2016 (May 13 to 17 and June 6 to 11) to target the descending limb of the hydrograph when WSCT are known to spawn (Magee et al. 1996). Spawning surveys can prove challenging due to timing fluctuation of the spawning event between streams and between years within the same stream based on the variation of environmental conditions. Difficulties are compounded by the potential short duration of the event and in turbid streams, redds can be covered with sediment shortly after spawning.

Streambank observations can be inaccurate, especially for WSCT, as they will often spawn in areas under cover, including deep undercut banks and large woody debris (LWD). Therefore, snorkel surveys (Section 3.1.2) were conducted within each macrohabitat reach to determine location, timing and elevational extent of WSCT spawning. Preferred spawning habitats were also characterized. Number of fish in spawning condition as well as numbers of paired fish were recorded. Survey lengths were recorded so that spawning

densities could be calculated and critical spawning areas identified. Redds were not counted, given the challenges associated with identifying them with any confidence.

A mature WSCT was an individual displaying morphological and colour characteristics associated with spawning WSCT (e.g., intense colouration, rose-tinted belly). Two mature adults together and over top of spawning gravels were classified as a pair. Reach selection was based on access or availability of suitable habitat. Reaches were excluded in some cases due to poor spawning habitat, low fish densities, or was outside of the designated federal critical habitat or provincial conservation designation for WSCT.

### **3.1.5 Fish Population**

Two methods were employed to calculate population estimates of WSCT in both Gold Creek and Blairmore Creek: relative abundance (using snorkel surveys) and a mark and recapture program (using electrofishing and angling). A blended approach for mark and recapture was undertaken to address the limitations of both techniques in certain habitat types. Both Gold Creek and Blairmore Creek are of a size that pool habitat is often too deep to effectively sample by electrofishing while the riffle habitat was too shallow and fish size too small to angle. Relative abundance using snorkel surveys was employed as a less invasive option for population monitoring and to compare with the mark and recapture results. Given suitable watershed conditions, snorkel counts have been proven to be a reliable and efficient means of obtaining indices or relative abundance for WSCT throughout their range including the East Kootenay's (e.g., Baxter 2004, 2005, 2006a, 2006b, Baxter and Hagen 2003). It is possible that snorkel and electrofishing counts will be underestimates of true abundance as individuals are routinely missed due to impacts of visibility, fish behaviour and stream channel complexity.

#### **3.1.5.1 Relative Abundance**

Relative abundance was assessed using snorkel surveys from August 9 to 17, 2016 in the lower reaches of Blairmore Creek and Gold Creek. A snorkeler swam in an upstream direction, tallying fish as they swam by. In areas with high counts, the snorkeler revisited the site to ensure accuracy. Using a Garmin GPS, the boundaries of each sample site were recorded so that stream length could be measured to calculate fish densities (fish/100 m<sup>2</sup>). Additional detail on snorkel survey methodology is included in [Section 3.1.2](#).

#### **3.1.5.2 Sub-Adult/Adult Mark and Recapture**

A mark-recapture assessment was completed from August 6 to 23, 2016 using a combination of angling and electrofishing sampling techniques and snorkeling as the recapture (recovery) method. In the lower reaches of both mainstem watercourses, angling (using dry fly, barbless hook) was used in the deeper pools and electrofishing was used in the shallower run and riffle habitats. In the upper reaches, only electrofishing was used given unsuitable water depths for snorkeling. Additional detail on electrofishing methodology is included in [Section 3.1.2](#).

The sub-adult and adult WSCT population (> 15 cm fork length) was targeted above known migration barriers. Once fish were captured using either angling or electrofishing, they were marked by clipping the caudal fin. During the initial phase of the sampling program, visible implant elastomer (VIE) marking was employed, however it was determined that the VIE was ineffective (i.e., too small to observe) during snorkeling thus this marking method was discontinued from further use.

All marked fish were released within the mesohabitat unit in which they were captured. Approximately three to five days post-marking, the same sections of watercourse was surveyed using snorkel surveys where surveyor(s) recorded the number of fish marked and those fish with no marks.

Given the low number of recaptured fish, an adjusted population estimator called the Chapman estimator (Chapman 1954) was used, as follows:

$$N = \frac{(M + 1)(T + 1)}{(R + 1)} - 1$$

where        N = Total Population  
                  M = Number marked initially  
                  T = Total number in 2<sup>nd</sup> sample  
                  R = Number marked during recapture

The boundaries of each sample site were recorded so that stream length could be measured to calculate fish densities (Section 3.1.5.3).

### 3.1.5.3 Density Estimates

Fish density was determined by dividing the total number of fish observed through snorkel surveys (Section 3.1.5.1 Relative Abundance) or captured through angling and electrofishing (for Mark and Recapture, Section 3.1.5.2) by the survey stream length (fish/100 m<sup>2</sup>). The survey stream length was calculated using ArcGIS, based on the coordinates taken from a Garmin GPS during field surveys.

### 3.1.5.4 Juvenile Recruitment

The objective of the WSCT juvenile recruitment assessment was to collect information on fry and juvenile presence and distribution in key mesohabitats (i.e., pool, riffle, run), as well as determine density estimates of fry (0+) and juveniles (1+). Sampling occurred at six to ten reaches on the mainstems of Gold Creek and Blairmore Creek from August 20 to 23, 2016. Nested within each location, there were three sites encompassing pool, riffle, run and/or side-channel habitats; each segment length was 300 m or 40 times the wetted width as per AESRD (2013b). Each site was electrofished from downstream to upstream end in an “S” pattern. Juvenile or young-of-year (YOY) fish (<15 cm fork length) were kept alive in a bucket until the entire site was fished. Fish were then measured (fork length and weight) and returned to their respective habitat.

Fork length data were used to evaluate juvenile recruitment. Each fish was assigned an age class according to the results of the age class by fork length determination (see Section 3.1.2.2). To calculate the proportion of fish in each age class, the number of fish captured in each age class was divided by the total number of fish captured (Cook et al. 2010). Young and Guenther-Gloss (2004) suggest that fish in each age class must constitute at least 5% of the total population to indicate successful recruitment.

Juvenile recruitment was also evaluated in combination with baseline stream temperature data (Section 3.1.5.4). Growth Season Degree Day (GSDD) was calculated using Coleman and Fausch (2007) growth threshold (4°C) for cutthroat trout in high elevation mountainous streams. GSDD is calculated using the

mean daily temperatures over the growing season. The growing season for WSCT in small high elevation mountain streams is defined as beginning when the daily mean temperature exceeds and remains over that threshold (4°C) and ending when the daily mean temperature drops and remains below the threshold. All Celsius degree days above the threshold are added to equal GSDD.

### 3.1.5.5 Fish Condition

The condition of an individual fish can be estimated by using a ratio between fork length and weight. When the condition of each individual fish is combined with all fish sampled, the measure reflects overall population health. These two parameters (fork length and weight) were collected during all fish capture surveys (i.e., angling, electrofishing). Two methods of determining fish condition were used: the Fulton Condition Factor (Lagler 1956) and Relative Weight (Wege and Anderson 1978). Anderson and Neumann (1996) suggest that condition can be a useful surrogate to predict fecundity, reproduction, growth, mortality rates and a measure of environmental condition. Accepting this, condition can be a useful monitoring tool to measure effects on a fish population.

#### *Fulton Condition Factor (K)*

Based on Barnham and Baxter (1998) the Fulton Condition Factor (K) for an individual fish was calculated using the following equation:

$$K = \frac{W}{FL^3} \times 100$$

where K= Condition Factor

W= Weight (g)

FL = Fork Length (cm)

The Fulton Condition Factor ranges from 0.8 to 1.6, representing conditions ranging from “very poor” to “excellent”, as shown in [Table 3.3](#).

**Table 3.3 Fulton Condition Factor (K) assignment to fish condition.**

Fulton condition factor (K)	Condition
0.8	Very Poor
1.0	Poor
1.2	Fair
1.4	Good
1.6	Excellent

### Relative Weight ( $W_r$ )

The Relative Weight ( $W_r$ ) of an individual fish was calculated using the following equation, which compares observed weights of fish against published data for a given species:

$$W_r = W_a/W_s \times 100$$

where  $W_r$  = Relative weight

$W_a$  = Actual weight

$W_s$  = Standard weight

The standard weight curves for inland cutthroat trout were developed by Kruse and Hubert (1997) and described by the following equation:

$$\log_{10} W_s = -5.189 + 3.099 \log_{10}(TL)$$

where  $TL$  = Total Fish Length

To convert fork length to total length, the following equation was used:

$$TL = (FL + 1.850)/0.977$$

The results for the individual fish were then combined as an expression of population health. Each method was analyzed independently. The relative weight value can be attributed to fish condition as shown in (Table 3.4, Blackwell et al. 2000).

**Table 3.4 Relative Weight ( $W_r$ ) assignment to fish condition.**

Relative weight ( $W_r$ )	Condition
80+	Very Poor
90+	Poor
100+	Fair
110+	Good
120+	Excellent

### 3.1.6 Tissue Residue

The surficial geology of the Project includes potentially acid generating rocks (PAG), which can have potential effects on fish through the acidification of downstream habitats as the rock is exposed to weathering and water. This is a common issue near gold and metal mines. Tissues can absorb metal or organic contaminants discharged by operational or post-closure mines. Contaminants may be taken up directly from the water column via facilitated diffusion (e.g., inorganic metals) or they can be taken up via dietary sources, stored in fat and proteins, and biomagnified up the food chain.

The quantification of tissue contaminant levels provides reference for future contaminant accumulation in aquatic organisms. Establishing a fish tissue baseline is important to characterize any potential historical

mining-related effects on water-quality such as fish tainting and/or chronic/acute health effects. Significant change from baseline concentrations may trigger additional impact assessment and/or the implementation of contingency mitigation measures that are developed as part of the mine review process.

Given the sensitivities around WSCT and the low species diversity within the LSA, non-native trout were used as the target sentinel species to describe baseline metal concentrations in fish tissues. On August 17, 2016 BKTR fish tissue samples were collected from lower Green Creek off of Gold Creek (Figure 3.1b) via backpack electrofishing for a maximum of eight samples (n = 8). On October 20, 2016 BKTR, RNTR and/or RNTRxWSCT hybrids tissue samples were collected at locations downstream of the falls on Blairmore Creek (Figure 3.1b) via minnow traps for a maximum of eight samples (n = 8). All fish were identified to species (where possible), enumerated, weighed (g) and measured (fork length, cm). Fin clips were collected from all fish captured and those suspected as RNTR and WSCT (hybrids) were submitted to AESRD.

Fish specimens were frozen as soon as possible and shipped whole to an accredited analytical laboratory for analysis. Standards for tissue assessment followed the *British Columbia Water and Air Baseline Monitoring Guidance Document* (BC MOE 2016), using the eight specimens (replicates) collected from each watercourse to describe statistically both within-site and between-site variability. One of the replicates collected at each site was split to assess sampler and laboratory quality assurance/quality control.

## 3.2 AQUATIC RESOURCES

Aquatic resources include the lower trophic levels (i.e., invertebrates, periphyton), water and sediment quality. The lower trophic dynamics of Gold Creek and Blairmore Creek were characterized in 2014 and 2016 and are described in this report (Sections 3.2, 4.2, Appendix A1). The benthic invertebrate and periphyton program was executed in 2014 and a drift invertebrate program was implemented in 2016. Findings from the drift invertebrate program are reported on in detail in Appendix A1. Periphyton chemistry, water and sediment quality data have also been collected and are characterized and assessed in the *Surface Water Quality Assessment Report* (Hatfield 2016b).

### 3.2.1 Macroinvertebrates

#### 3.2.1.1 Benthic Macroinvertebrates

An assessment of benthic macroinvertebrates was conducted at four locations in the LSA and two locations in the RSA on October 8 and 9, 2014 (Figure 3.3). Three to five sub-samples of benthic macroinvertebrates were collected at each site following sampling methods outlined by Gibbons et al. (1993) and Environment Canada (2002) using a Neil-Hess cylinder (area = 0.086 m<sup>2</sup>, mesh = 250 µm). The Neil-Hess cylinder was placed mid riffle in a substrate of gravel to cobble and moderate to high flow velocity, ensuring the water was not overtopping the cylinder (<60 cm depth) and the net was trailing downstream. Substrate within the cylinder was disturbed with a trowel for three minutes. Any invertebrates attached to the cylinder were washed into the net. The sample was transferred to a 1-L plastic jar using a squirt bottle filled with creek water and preserved to a final concentration of 5% to 10% buffered formalin.

Samples were sorted and identified to the lowest practical level by Kilgour and Associates in Ottawa, Ontario. For samples that were deemed to be larger than average, a subsampling technique was used to reduce the amount of sorting time. Subsampling was completed by first rinsing the samples of formalin

used in the initial preservation process in a 180 µm sieve. Samples were then weighed and half of the weight of the sample was removed from the sieve for sorting and the other half was placed back into the 200 mL sample container and preserved with 70% Methanol. Specimens were identified to species level, where practical.

A number of invertebrate community metrics were used as indicators of aquatic quality: taxa richness, Simpson’s index of diversity, density, evenness, and proportion of the invertebrate population represented by mayflies (ephemeroptera), stoneflies (plecoptera) and caddisflies (trichoptera) (%EPT), ephemeroptera (%E), and chironomidae (% chironomidae) collected from each sample site. The importance of each metric and how it responds to disturbance is described in [Table 3.5](#).

**Table 3.5 Summary metrics used as bioassessment indicators of disturbance in streams (based on Environment Canada 2012) and Frenette (2008).**

<b>Metric</b>	<b>Description</b>	<b>Disturbance response</b>
Taxa richness	The total number of taxa identified to the family level. A higher number of taxa indicate a greater ability to adapt to changes.	Variable. Decreases in richness generally indicate increases in disturbance, as only tolerant taxa are able to survive
Simpson’s Diversity Index (D)	A quantitative measure that incorporates the number of species and their relative abundances within a sample. Diverse and even communities are better suited to adapt to change and are indicators of good water quality. Values range from 0 (indicating low community complexity) to 1 (indicating high community complexity).	Decrease
Total density	The total abundance of all benthic invertebrate organisms present in the sample, adjusted to the area sampled	Variable
Evenness	Measure of the relative abundance of different species contributing to the richness. A community dominated by one or two species is considered less diverse than one in which several species have a similar abundance.	Decrease
% Ephemeroptera, Plecoptera and Trichoptera (%EPT)	The proportion of individuals in the ephemeroptera, plecoptera, and trichoptera orders. These orders are often found in clean, cool waters and are sensitive to habitat changes. They are indicators of good water quality.	Decrease
% Ephemeroptera (%E)	The proportion of individuals in the ephemeroptera order has been found to be a useful indicator of the downstream effects of coal mining (Frenette 2008, Pond et al. 2008)	Decrease
% Chironomidae	The proportion of individuals in the chironomidae family. Species in this family tend to be tolerant of disturbances and are therefore indicators of poor water quality.	Increase

Simpson's diversity index (D) was calculated using taxa at the genus or species level using the following equation (Krebs 1985):

$$D = 1 - \sum (p_i)^2$$

where  $p_i$  is the proportion that taxon  $i$  contributes to the total number of invertebrates in a sample. Evenness (S) was also calculated as a measure of diversity that incorporates abundance and is standardized against the "maximum possible" diversity (defined as a community with equal numbers of all taxa present), where:

$$\text{Evenness} = \frac{D}{D_{\max}}$$

$$D_{\max} = 1 - \left( \frac{1}{S} \right)$$

### 3.2.1.2 Drift Invertebrates

Three sites on each Blairmore Creek and Gold Creek within the LSA were selected for sampling across two seasons in June and September 2016 (Figure 3.3). Sampling sites were arranged from near the headwaters, downstream to two sites located upstream and downstream of key tributaries entering the main channels. At each sample site, areas with velocities of 0.2 to 0.4 m/s (at 60% depth) were identified for setting nets using an Acoustic Doppler Velocimeter with top-set rod (ADV; SonTek FlowTracker Handheld; accuracy = 1% of measured velocity). At each sampling site (transect), 250- $\mu$ m-mesh nets measuring 0.31 m width by 0.31 m height with a 1.0 m tapered length were anchored into the channel using 10-mm rebar, ensuring tops of nets were above the water surface. Up to five nets were deployed simultaneously across the wetted width of the channel. Given Blairmore Creek and Gold Creek are small watercourses (i.e., <5.0 m wetted width), the number of replicate nets deployed at each site equaled the number of nets that fit across the wetted width of the channel.

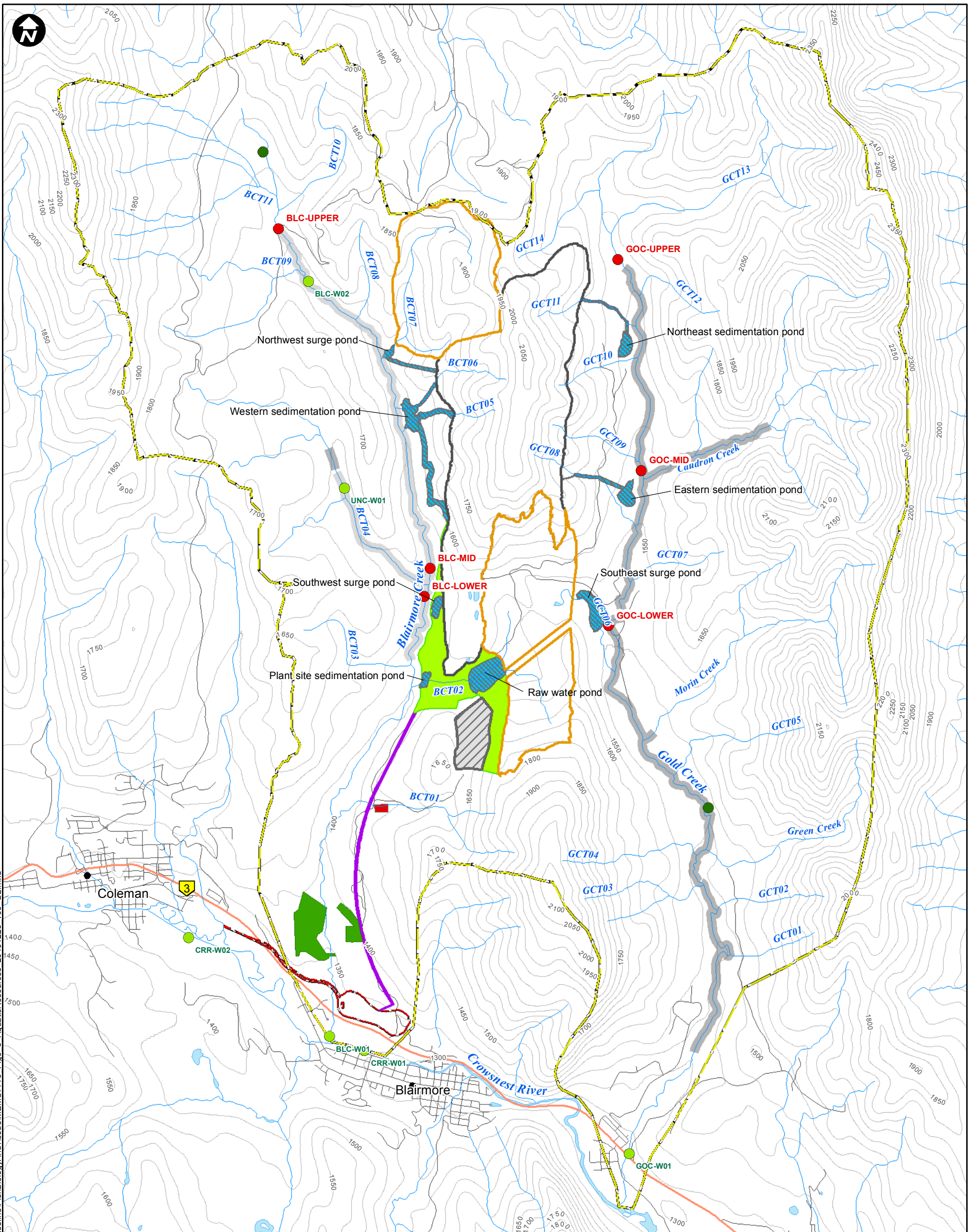
From each net, all contents adhered to the interior mesh was washed downward from the exterior with creek water. Contents from each net were transferred to a 250- $\mu$ m mesh sieve. Any remaining contents on the nets were washed in the mesh sieve using a squirt bottle filled with creek water. Contents were transferred into 500-mL plastic jars with leakproof, screw-top lids and preserved on site with a 10% formalin solution.

Samples were submitted to Jack Zloty, Ph.D. in Summerland, BC for processing, and processed following standard protocols based on Environment Canada (2002) and Gibbons et al. (1993). Drift invertebrate indices examined included density (no./m<sup>3</sup>), biomass (g/m<sup>3</sup>), taxonomic structure, diversity, and evenness of the assemblages.

Additional detail on the drift invertebrate methodology is provided in [Appendix A1](#).

### 3.2.2 Periphyton

Periphyton biomass sampling occurred on October 8 and 9, 2014 at the same sites as benthic invertebrate sampling (Figure 3.3). Three undisturbed rocks with surficial exposure in proximity to the benthic sample were selected. A plastic template with a 2 cm-by 2cm, square cutout was placed on the top of the rock and periphyton and other materials were scraped from within the 4 cm<sup>2</sup> area. These scrapings were transferred to a 5-cm diameter filter. The scraping from all three rocks were added to the same filter and folded into aluminum foil. The sample was placed in a plastic bag and frozen as soon as possible. The samples were shipped to ALS Laboratories (Calgary, Alberta) to conduct the chlorophyll *a* analyses.



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**LEGEND**

- Benthic Survey (Ree 2014)
- Benthic and Periphyton Survey 2014
- Invertebrate Sampling Location
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT Population (95% to 99% pure)
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study Area
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area

**PROJECT**

**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**LOCATION OF AQUATIC RESOURCES SAMPLING FOR THE PROJECT**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779  
DRAWN BY: SS / EDITED BY: GL  
CHECKED BY: CB  
DATE: December 23, 2016

**FIGURE 3.3**



## 4.0 RESULTS

### 4.1 FISHERIES RESOURCES

#### 4.1.1 Fish Habitat

##### 4.1.1.1 Biophysical Inventory

###### *Gold Creek*

Biophysical habitat in Gold Creek was assessed on June 3 to 10 and August 6 to 12, 2015 from the downstream delineation of critical habitat for WSCT to the headwaters, upstream of the Project footprint and the limits of the WSCT critical habitat (Figure 3.1a). Findings from the biophysical habitat surveys were mapped and are provided with photos in Appendix A2. Some key features to note for Gold Creek include:

- The substrate of Gold Creek mainstem is dominated by cobble associated with very sparse gravel patches and boulders. Only a small proportion of the substrate of Gold Creek is comprised of embedded silts and fines, with the exception of the middle reaches of the creek, which contain varying amounts of coal sediments and fines, likely either: (i) from coal outcroppings; or (ii) coal fines and sediments generated from legacy mining activities in the watershed and deposited in Gold Creek;
- Groundwater inputs were documented along both the east and west slopes of Gold Creek that supply groundwater to the mainstem at various locations;
- Two permanent barriers and one seasonal barrier were identified on Gold Creek mainstem. Both permanent barriers are located in lower Gold Creek (Figure 3.1a). The seasonal barrier was located upstream of Morin Creek (Figure 3.1a). Other waterfalls and chutes occur throughout Gold Creek mainstem but do not appear to be barriers to fish movement; and
- A number of segments within Gold Creek display evidence of anthropogenic disturbance: legacy mine outputs (e.g., coal deposits to Gold Creek), rangeland activities (e.g., grazing pastures, cattle crossings), recreational land use (e.g., ATV vehicle ford crossings, bridges, and fence crossings), and private land use.

Six of tributaries of Gold Creek were assessed during June 2015, near their confluence with Gold Creek (GCT06, GCT08, GCT09, GCT10, GCT11, and GCT14). With the exception of GCT06, all of these tributaries have steep gradients in their upper reaches often exceeding 20%, which is not conducive to good aquatic habitat. GCT06 has lower gradients throughout its length. The morphology of these tributaries is riffle or run in lower sections, transitioning to run or cascade in upper sections associated with increasing gradient. Relatively few reaches in these tributaries have pools, but many of the pools that do exist are plunge pools at the bottom of waterfalls. The morphology of GCT06 is an exception, and consists primarily of run and riffle throughout its length. The substrate of GCT06 and GCT08 is comprised primarily of fines and gravel, while the substrate of the other four tributaries is generally coarser, consisting of cobble and boulder, with some gravel.

A winter flow assessment in February 2015 detected limited flow in three of the five tributaries that could be surveyed, suggesting that groundwater baseflow may be an important source of flow during the winter. One of the tributaries (GCT14) could not be accessed due to deep snow.

### **Blairmore Creek**

Biophysical habitat in Blairmore Creek was obtained from field surveys conducted in August 2014, June 2015 and August 2015. Detailed results are included in [Appendix A3](#). Some key features to note for Blairmore Creek include:

- Blairmore Creek is comprised primarily of cobble and gravel substrates with bedrock chutes located in the lower reaches;
- There is evidence of groundwater seeps along Blairmore Creek that likely supply groundwater to the mainstem at various locations;
- There are a set of waterfalls on the Blairmore Creek mainstem immediately upstream of tributary BCT03. The lowermost waterfall is likely a seasonal barrier to upstream fish migration while the uppermost waterfall was deemed a permanent barrier to upstream fish migration ([Figure 3.1a](#));
- Additional waterfalls and chutes occur throughout Blairmore Creek mainstem, which do not appear to be barriers to upstream migration of fish in Blairmore Creek; and
- Blairmore Creek is frequently confined by steep valley walls, with limited anthropogenic disturbances in the middle portion of the drainage. Oil and gas and forestry activities occur in some of the upstream tributaries (above BCT10), but disturbance along the portion of the creek adjacent to the Project (from BCT10 to BCT01) is limited to recreational use as indicated by several fords across Blairmore Creek.

During June 2015, habitat assessments were completed on four of the tributaries to Blairmore Creek (BCT02, BCT05, BCT06 and BCT07). The lower sections of the tributaries were characterized as having a riffle run morphology transitioning to run cascade morphology in the upper reaches. All of these tributaries have steep gradients in their upper reaches, frequently exceeding 20%. Relatively few reaches in these tributaries have pools associated with them, and many of the pools that do exist are plunge pools at the bottom of waterfalls. The substrate of these watercourses is cobble and large gravel that would not provide suitable spawning habitat for trout species. The upper reaches of BCT07 contain several additional waterfalls and a habitat survey found no areas of substrate that would be suitable for spawning fish.

BCT07 is known to flow all year and had areas of open water in February 2015. BCT06 contained minimal surface flow that went subsurface during August 2014 surveys, but water was flowing in June 2015. BCT05 flows onto an ATV trail, before it enters Blairmore Creek. Both BCT05 and BCT06 would likely only be connected to Blairmore Creek during periods of high water.

#### 4.1.1.2 Habitat Assessment

##### Macrohabitat

Gold Creek was delineated into nine reaches (Figure 4.1) ranging from 437 m (Reach 3) to 3,183 m (Reach 7, Table 4.1) in length. Reaches 1 and 2 extend beyond the designated critical habitat for WSCT and the vicinity of the Project footprint; these were not surveyed to the same level of detail as the upper reaches and are not shown on Figure 4.1. These reaches were also assessed during the fluvial geomorphology surveys (SNC-Lavalin 2016). Average wetted width observed during the May 2016 surveys gradually increased from the headwaters (4.2 m, Reach 9, Table 4.1) to the most downstream reach (10.8 m, Reach 3, Table 4.1). Average bankfull width observed during the August 2015 surveys was 6.3 m, ranging from 1.3 m at a site in Reach 3 to 15.8 m at a site in Reach 7. The two shortest reaches in Gold Creek are the steepest (Reach 3, 3.3% gradient; Reach 5, 2.9% gradient), with the remaining reaches ranging from 0.5 to 0.9% gradient (Table 4.1).

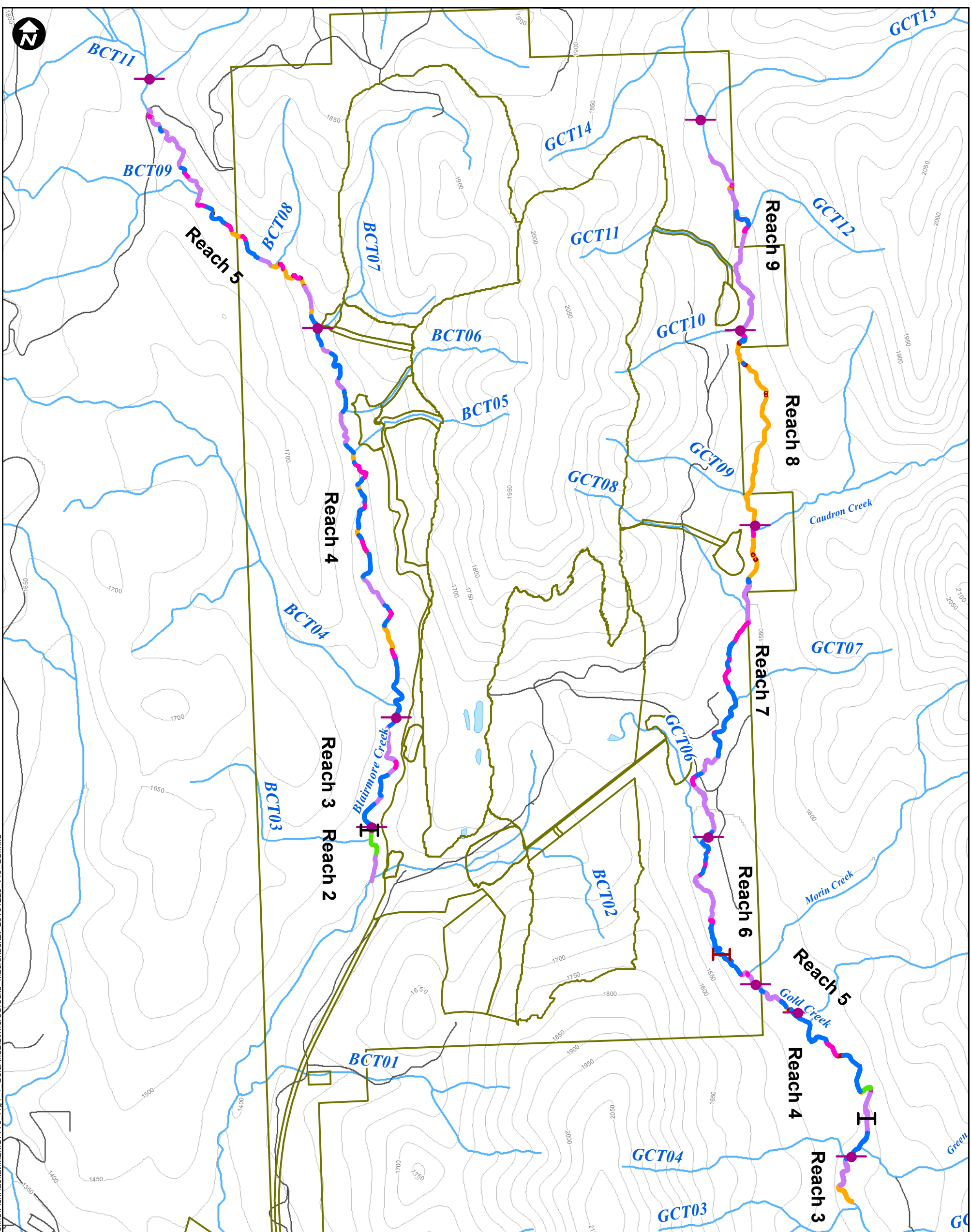
Blairmore Creek was delineated into five reaches (Figure 3.1) ranging from 399 m (Reach 2) to 3,942 m (Reach 4, Table 4.1) in length. Reach 1 extends beyond the provincial conservation designation for WSCT and the Project footprint, and was not surveyed to the same level of detail as the upper reaches or presented on Figure 4.1. The most downstream reach is the narrowest and the steepest (Reach 2, Figure 3.1) and the reach immediately upstream is the widest (Reach 3, Figure 3.1). The gradient in the upper reaches (Reach 4 and 5) is less steep, compared to the lower reaches (Figure 3.1).

**Table 4.1 Macrohabitat reach characterization in Gold Creek and Blairmore Creek.**

Watercourse	Reach	Length (m)	Average wetted width <sup>1</sup> (m)	% Gradient	
Gold Creek	3	437	10.8	3.3	
	4	1,820	7.5	0.8	
	5	502	7.8	2.9	
	6	1,683	5.7	0.9	
	7	3,183	6.4	0.5	
	8	1,906	5.6	0.8	
	9	2,130	4.2	0.8	
	Blairmore Creek	2	399	1.1	3.6
		3	1,167	4.9	1.3
4		3,942	4.6	0.4	
5		3,230	3.0	0.5	

1. Based on surveys during May 2016.

Note: Location of reaches is shown in Figure 4.1.



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**LEGEND**

- Macrohabitat Reach Break
  - Barrier to Fish Passage
  - Barrier to Fish Passage - Seasonal
  - Road
  - 50 m Contour
  - Watercourse
  - Waterbody
  - Project Footprint
- 
- Mesohabitat Unit Type**
  - Riffle Run Pool (tertiary)
  - Pool
  - Pool Riffle (tertiary)
  - Riffle
  - Run
  - Step Pool (tertiary)

**PROJECT**



**TITLE**

**GOLD CREEK AND BLAIRMORE CREEK MACROHABITAT REACH DELINEATION**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779  
DRAWN BY: SS / EDITED BY: GL  
CHECKED BY: CB  
DATE: December 23, 2016



**FIGURE**  
**4.1**

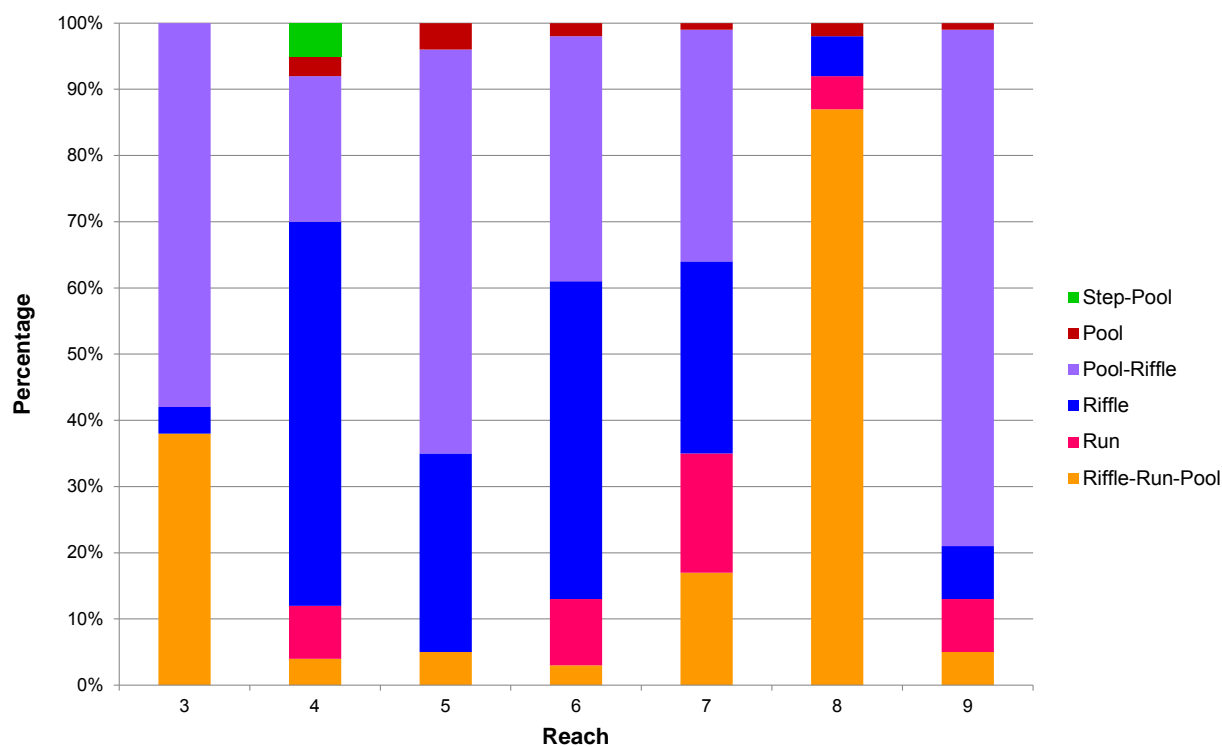
## Mesohabitat

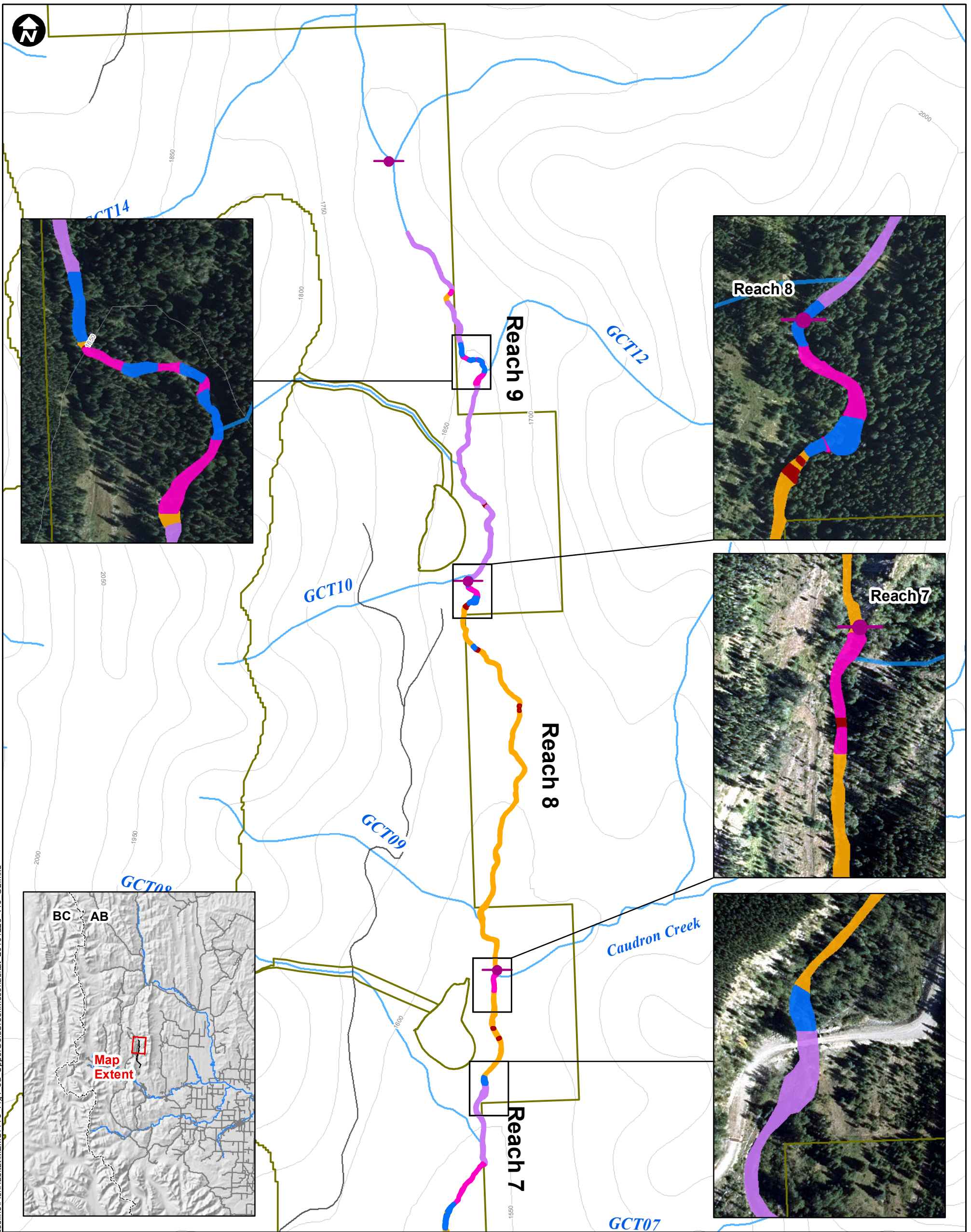
A total 20.4 km of potential fish habitat was assessed and mapped in Gold Creek and Blairmore Creek between March and May of 2016. The mesohabitat units indentified by the FHAP were digitized and are presented for Gold Creek (Figure 4.3a and b) and Blairmore Creek (Figure 4.5a and b). The entire surveyed area consisted of 247 mesohabitat units with a total wetted area of 107,241 m<sup>2</sup>. The average wetted width was 6.86 m on Gold Creek and 3.4 m on Blairmore Creek.

### Gold Creek

The percentage of each habitat type within the seven reaches on Gold Creek is illustrated in Figure 4.2. Pool-riffle is the most common morphology occurring in all reaches except for Reach 8 (Figure 4.2), but the majority of pools that were included in the pool-riffle characterization were of tertiary class (i.e., less than 50% of the wetted width). Reach 3 is comprised mostly of pool-riffle (58%) and riffle-run-pool (38%), with a small portion (4%) of riffle. Reach 4 is the most hydraulically diverse reach, comprised mostly of riffles (58%), and pool-riffles (22%) with a small proportion riffle-run-pool, run, pool and step-pool (<10% each). Reaches 5 to 7 are fairly similar to each other, containing mostly riffles (29% to 48%) and pool-riffles (35% to 61%). Reach 8 is fairly different from the other six reaches, as most of the area is comprised of riffle-run-pool morphology (87%). Reach 9 is dominated by pool-riffle (78%) with smaller components of riffle-run, run, riffle and pools (< 10% each). The location of the habitat units through Gold Creek are shown in Figure 4.3a and b.

**Figure 4.2 Percentage of mesohabitat types in Gold Creek for Reaches 3 through 9.**





**LEGEND**

- Macrohabitat Reach Break
  - Road
  - 50 m Contour
  - Watercourse
  - Project Footprint
- Mesohabitat Unit Type**
- Riffle Run Pool (tertiary)
  - Pool
  - Pool Riffle (tertiary)
  - Riffle
  - Run

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**MESOHABITAT CHARACTERIZATION ON A) UPPER GOLD CREEK**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, Aerial Photos, 0.25 m resolution, Tarin Resource Services Ltd.  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

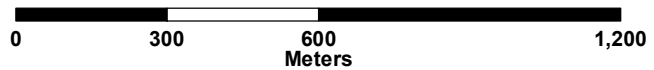
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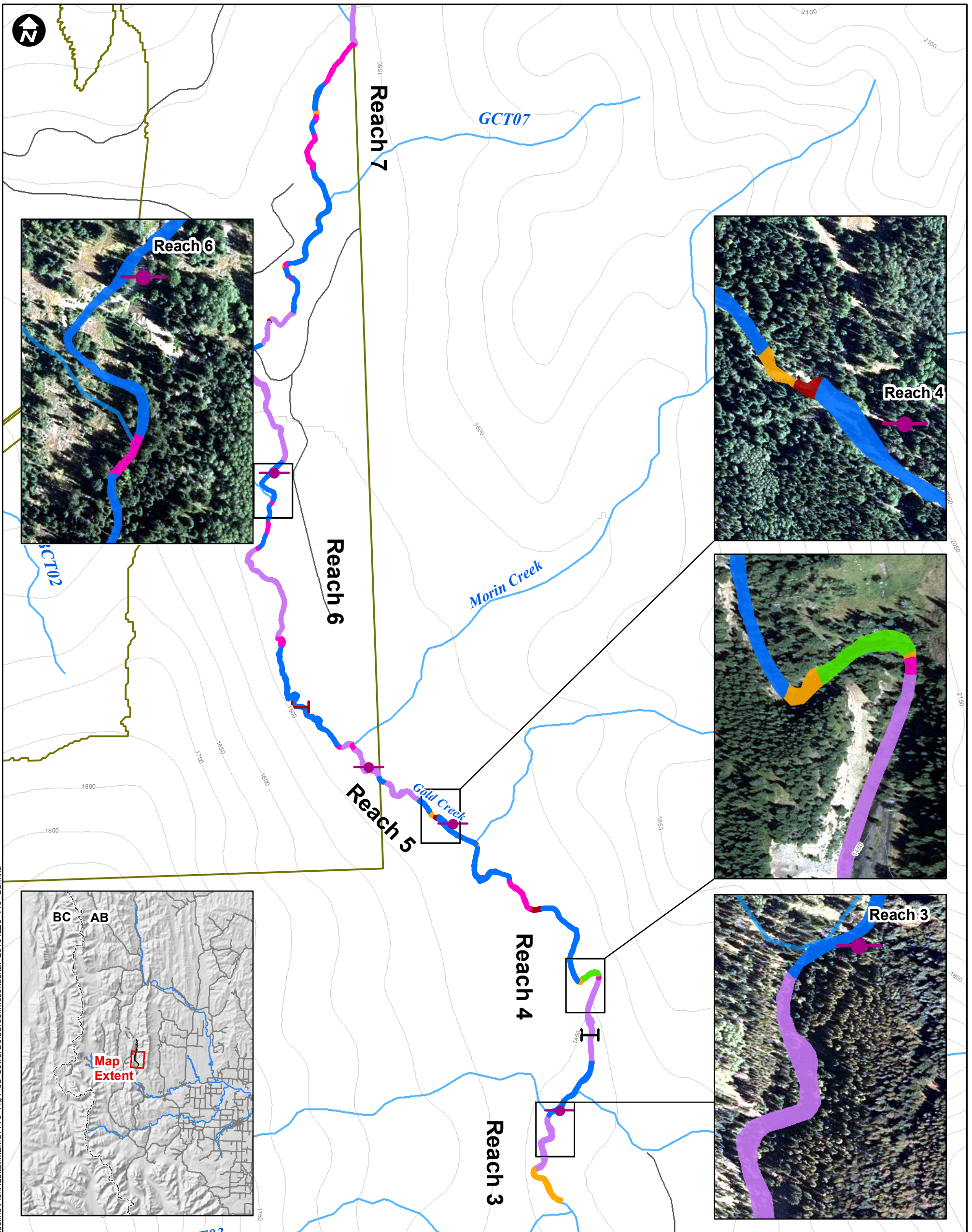
CHECKED BY: CB

DATE: December 23, 2016

FIGURE

**4.3a**





Document Path: K:\Data\Project\MES779A\_MXD\AquaticFishTechBaseline\FishHabitat\MES779A\_Fig4\_3b\_LowerGoldCreekMesohabitat\_20161223\_v10\_GI.mxd

**LEGEND**

- Macrohabitat Reach Break
  - Barrier to Fish Passage
  - Barrier to Fish Passage - Seasonal
  - Road
  - 50 m Contour
  - Watercourse
  - Waterbody
  - Project Footprint
- 
- Mesohabitat Unit Type**
  - Riffle Run Pool (tertiary)
  - Pool
  - Pool Riffle (tertiary)
  - Riffle
  - Run
  - Step Pool (tertiary)

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**MESOHABITAT CHARACTERIZATION ON B) LOWER GOLD CREEK**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, Aerial Photos, 0.25 m resolution, Tarin Resource Services Ltd.  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

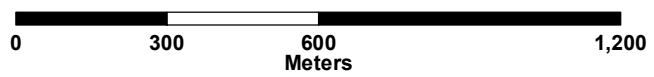
DRAWN BY: SS / EDITED BY: GL

CHECKED BY: CB

DATE: December 23, 2016

FIGURE

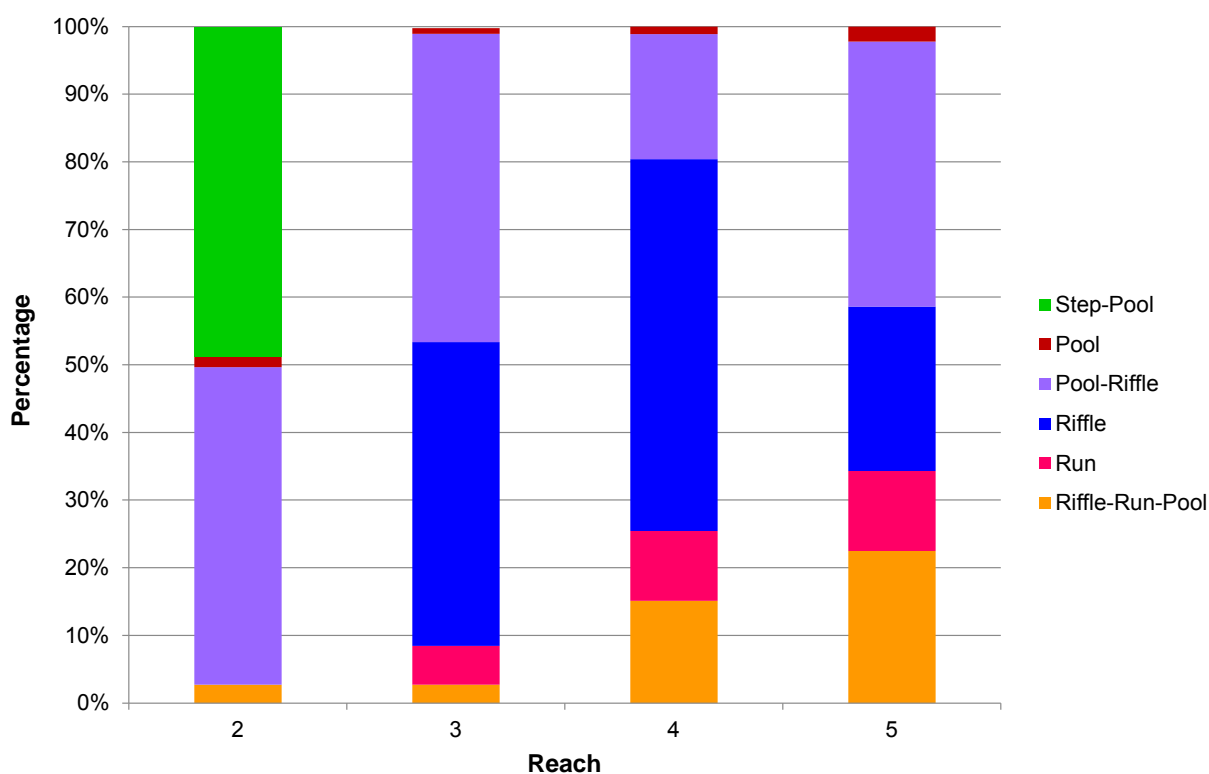
**4.3b**

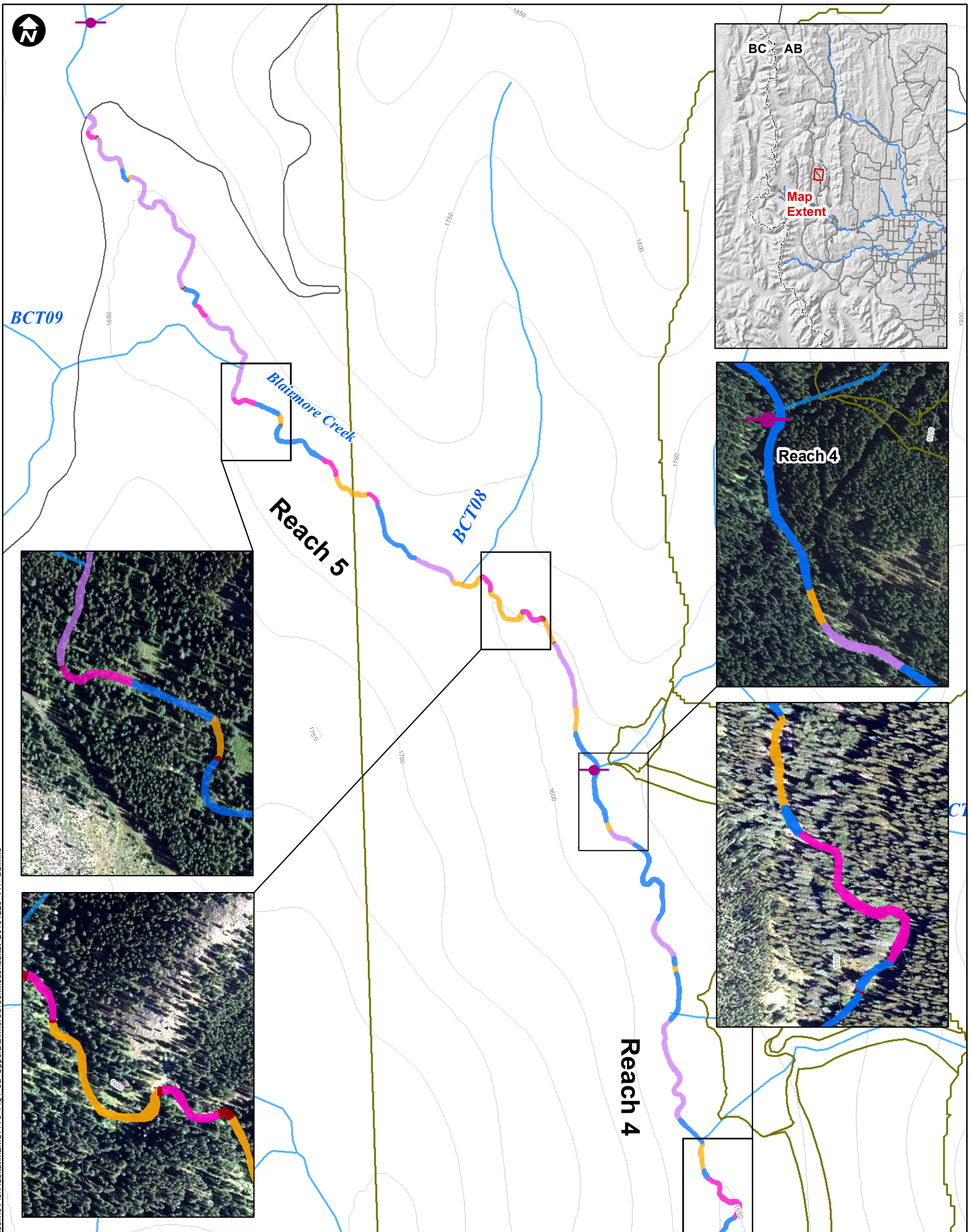


## Blairmore Creek

The percentage of each habitat type within the four reaches of Blairmore Creek is illustrated in Figure 4.4. Reach 2 differed from the other three reaches, with half of the area comprised of step-pool morphology (49%), and the remainder pool-riffle morphology (47%) with only small segments of pools and runs (< 3% each, Figure 4.4). Reaches 3, 4 and 5 are dominated by riffles (24% to 55%) and pool-riffle units (18% to 46%, Figure 4.4). The upper reaches have a higher proportion of riffle-run-pool (15% to 22%) compared to the lower reaches. Pools represent less than 2% of all area in each reach (Figure 4.4). The location of the habitat units through Blairmore Creek are shown in Figure 4.5a and b.

**Figure 4.4 Percentage of mesohabitat types by area in Reaches 2 to 5 of Blairmore Creek.**





**LEGEND**

- Macrohabitat Reach Break
  - Road
  - 50 m Contour
  - Watercourse
  - Project Footprint
- Habitat Unit Type**
- Riffle Run Pool (tertiary)
  - Pool
  - Pool Riffle (tertiary)
  - Riffle
  - Run

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**Hatfield**  
CONSULTANTS

**TITLE**

**MESOHA BITAT CHARACTERIZATION ON A) UPPER BLAIRMORE CREEK**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, Aerial Photos, 0.25 m resolution, Tarin Resource Services Ltd.  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

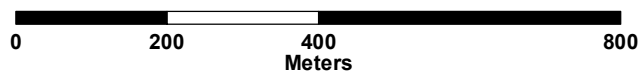
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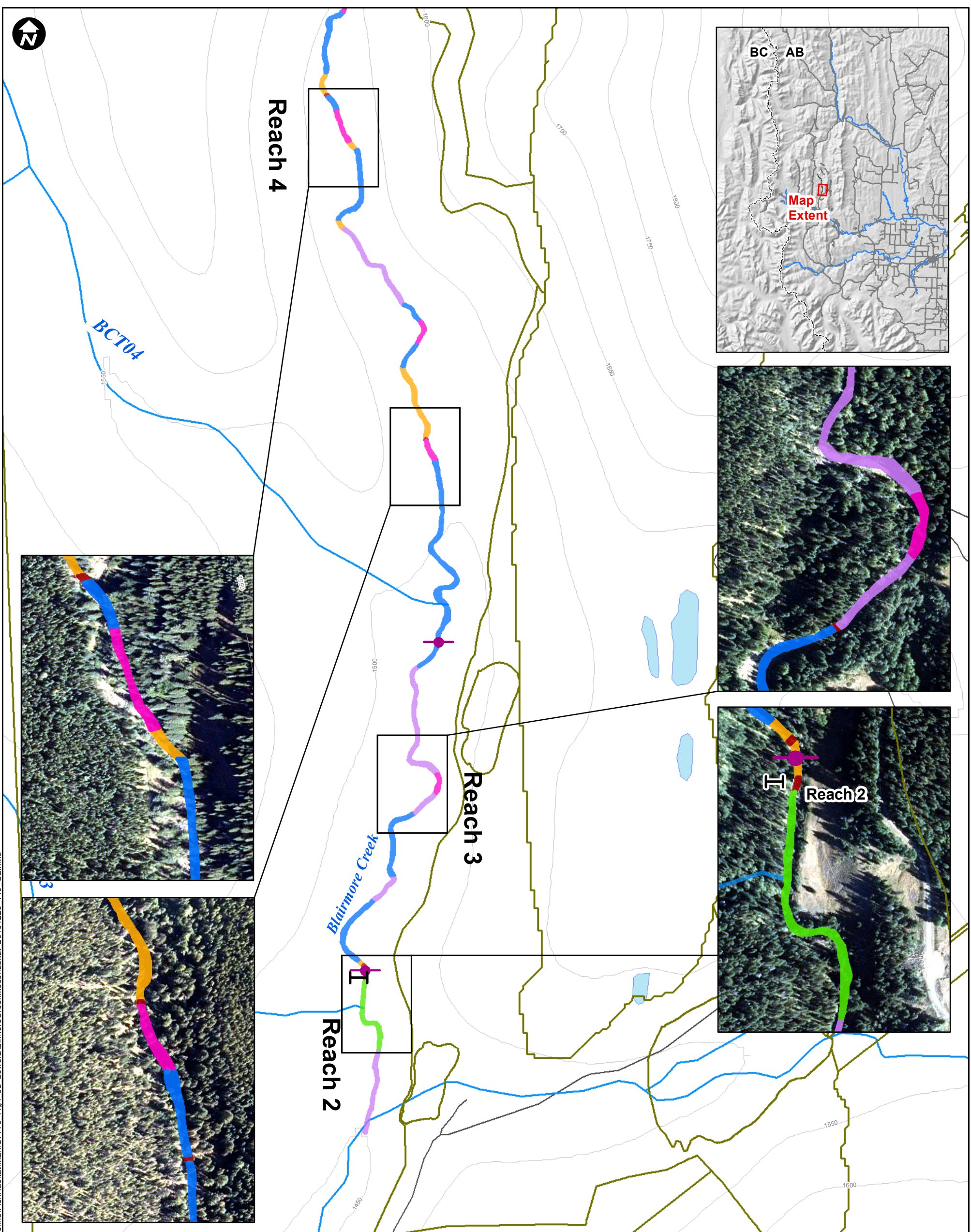
DATE: December 23, 2016

**FIGURE**

**4.5a**



Document Path: K:\Data\Project\MEMS7779A\_MXD\AquaticFishTechBaseline\FishHabitat\MES7779\_Fig4\_5b\_LowerBlairmoreCreekMesohabitat\_20161223\_v10\_GI.mxd



**LEGEND**

- Macrohabitat Reach Break
  - Barrier to Fish Passage
  - Road
  - 50 m Contour
  - Waterbody
  - Project Footprint
- Mesohabitat Unit Type**
- Riffle Run Pool (tertiary)
  - Pool
  - Pool Riffle (tertiary)
  - Riffle
  - Run
  - Step Pool (tertiary)

**PROJECT**

**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



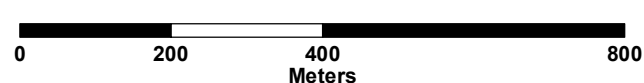
**TITLE**

**MESOHABITAT CHARACTERIZATION ON B) LOWER BLAIRMORE CREEK**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, Aerial Photos, 0.25 m resolution, Tarin Resource Services Ltd.  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779  
DRAWN BY: SS / EDITED BY: GL  
CHECKED BY: CB  
DATE: December 23, 2016



**FIGURE**  
**4.5b**

### 4.1.1.3 Barriers

The 2014 to 2016 fish and fish habitat surveys identified obstructions to fish movement throughout the LSA (Figure 4.1). There are two permanent barriers and one seasonal barrier on the mainstem of Gold Creek and one permanent barrier on the mainstem of Blairmore Creek in addition to barriers on several tributaries.

#### **Gold Creek**

The first permanent barrier located on Gold Creek mainstem was identified approximately 1 km above the Gold Creek Crowsnest River confluence and creates the break between Reach 1 and 2 (Figure 4.1). This old water supply dam marks the downstream extent of critical habitat on Gold Creek for WSCT designated in the Recovery Plan (Photo 4.1). The second permanent barrier is a waterfall/chute approximately 6 to 7 m high creating the break between Reach 2 and 3 (Figure 4.1). Both barriers obstruct upstream movement to all fish. A seasonal barrier was identified in Reach 6 (Figure 4.1). Reach 6 is a highly braided section; based on field observations and hydrological surveys between May and October 2016, substantial surface flows are lost sub-surface and during low flow events, the mainstem goes completely sub-surface for approximately 50 to 60 m before re-surfacing downstream (Photo 4.3).



**Photo 4.1** Looking downstream past the old water supply dam on Gold Creek that defines the downstream end of WSCT critical habitat designated in the Recovery Plan.



**Photo 4.2 Looking upstream at falls on Gold Creek that is a permanent barrier to fish movement between Reaches 2 and 3.**



**Photo 4.3 Looking downstream at subsurface flows in Reach 6 on Gold Creek that are a seasonal barrier to fish movement.**

Six tributaries to Gold Creek have an identified barrier that permanently obstructs upstream fish migration. Two tributaries were found to have no surface flow connectivity with Gold Creek mainstem (GCT06 and GCT08) while others contained impassable waterfalls near the confluence with Gold Creek (GCT09, GCT10, GCT11, and GCT14) and provided poor habitat above those obstructions. Photos of these barriers are included in [Appendix A4](#).

### ***Blairmore Creek***

There are a set of waterfalls on the Blairmore Creek mainstem immediately upstream of tributary BCT03 at the break between Reaches 2 and 3. The lowermost waterfall is believed to be seasonal and is passable under certain flow conditions (Photo 4.4). The uppermost barrier (Photo 4.5) has historically been classified as a seasonal barrier, given the presence of hybrid fish recovered upstream from the falls (Coombs, personal communication, 2013). Upon further evaluation of this obstruction in 2016, it is believed that the

barrier is a permanent obstacle preventing upstream migration of any fish species considering the water velocity at crest, vertical drop (~1.75 m in June 2016), the angle and length of the chute for fish to overcome, and the swimming performance of RBTR, BKTR, and WSCT (Table 3.2).



**Photo 4.4** Waterfall/cascade creating a seasonal barrier to upstream fish migration in Blairmore Creek.



**Photo 4.5** Primary falls/chute barrier located on Blairmore Creek upstream of tributary BCT03. This obstruction is believed to prevent permanent upstream fish migration.

Four tributaries of Blairmore Creek have a barrier to upstream migration of fish either in the form of a steep slope (BCT05 and BCT06) or a waterfall (BCT07 and BCT02). All of these barriers occur relatively close to the confluence of these tributaries with Blairmore Creek. They have steep gradients in their upper reaches often exceeding 20%, which provides poor fish habitat. The upper reaches of BCT07 contain several additional waterfalls and a 2015 habitat survey found no areas of substrate that would be suitable for spawning fish. Photos of these barriers are included in [Appendix A4](#).

#### 4.1.1.4 Stream Temperature

WSCT are found in streams with cooler temperatures than other trout species (DFO 2014). Several researchers (e.g., Fausch 1989, Rasmussen et al. 2012, Yau and Taylor 2014) have found evidence to suggest that WSCT have a selective advantage over non-native salmonids (e.g., rainbow trout) in headwater areas because they function better in colder environments. Their preferred temperature range is 9 to 12°C (Alberta Westslope Cutthroat Trout Recovery Team 2013) and they are rarely found in waters exceeding 22°C (Behnke and Zarn 1976). More recent work by Bear et al. (2007) found the upper incipient lethal temperature of WSCT is 19.6°C, and a maximum daily temperature between 13°C and 15°C ensures suitable thermal temperature for WSCT, with optimum growth occurring at 13.6°C.

The daily stream temperature on both Gold Creek and Blairmore Creek ranged from 4.3°C to 8.4°C during the study period ([Table 4.2](#)). The minimum detected temperature at three of the four sites monitored on Gold Creek (GC-T01w, GC-T03w, and GC-T04w), and both of the sites on Blairmore Creek (BL-T01w, BL-T02w) was less than 1°C during March 2016. The maximum temperature was higher in Blairmore Creek, compared to Gold Creek. The maximum temperature exceeded 15°C on 43 days at Blairmore Creek Site 1 and 17 days at Blairmore Creek Site 2. Bear et al. (2007) found that 15°C is the upper range at which optimum growth for WSCT occurs. Generally, stream temperatures in Gold Creek appeared to provide conditions more suitable for WSCT. Efforts were taken to ensure the selected sites were representative of the overall conditions in both watercourses; however fish are mobile organisms that move in response to microhabitat temperature fluctuations.

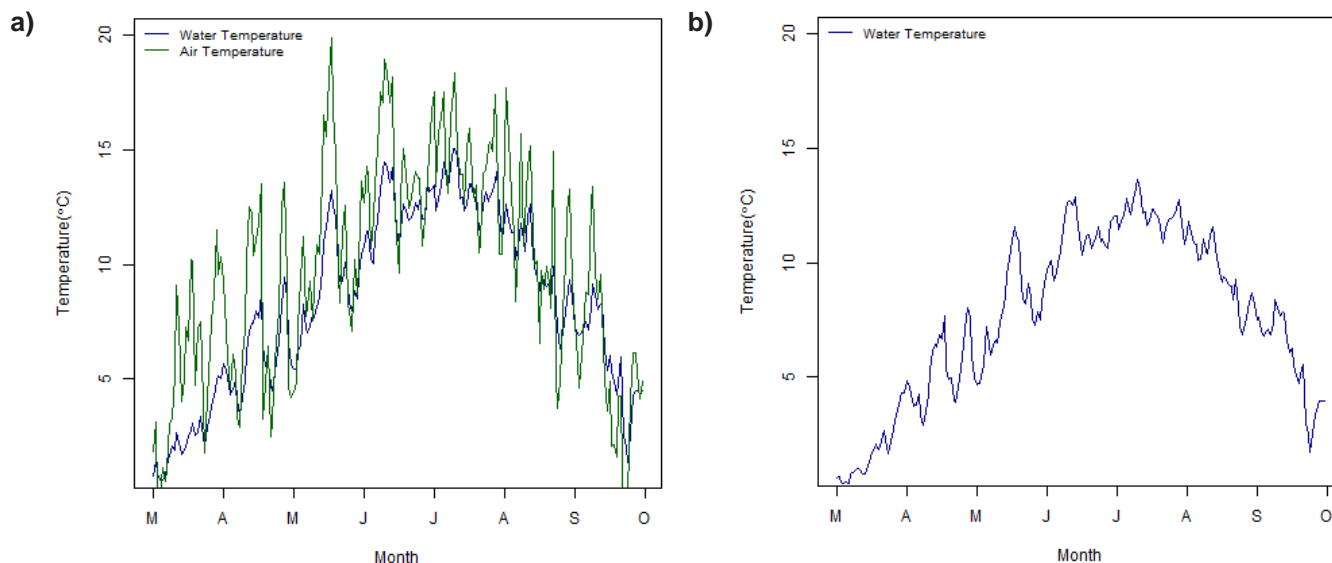
**Table 4.2 General summary of stream temperatures at seven locations in the LSA collected from March 23 to October 18, 2016.**

Site	Site code	Mean of daily temperature ± 95% CI (°C)	Minimum temperature (°C)	Maximum temperature (°C)	Days above 15°C
Gold Creek Site 1	GC-T01w	5.6 ± 0.2	0.8	12.4	0
Gold Creek Site 2	GC-T02w	4.6 ± 0.1	1.7	8.1	0
Gold Creek Site 3	GC-T03w	6.3 ± 0.4	0.0	13.8	0
Gold Creek Site 4 <sup>1</sup>	GC-T04w	5.2 ± 0.3	0.3	10.8	0
Caudron Creek Site 1	CC-T01w	4.3 ± 0.1	2.2	7.0	0
Blairmore Creek Site 1	BL-T01w	8.4 ± 0.5	0.0	18.5	43
Blairmore Creek Site 2	BL-T02w	7.6 ± 0.5	0.0	16.6	17

1. Missing data from July 14 to 23, 2016

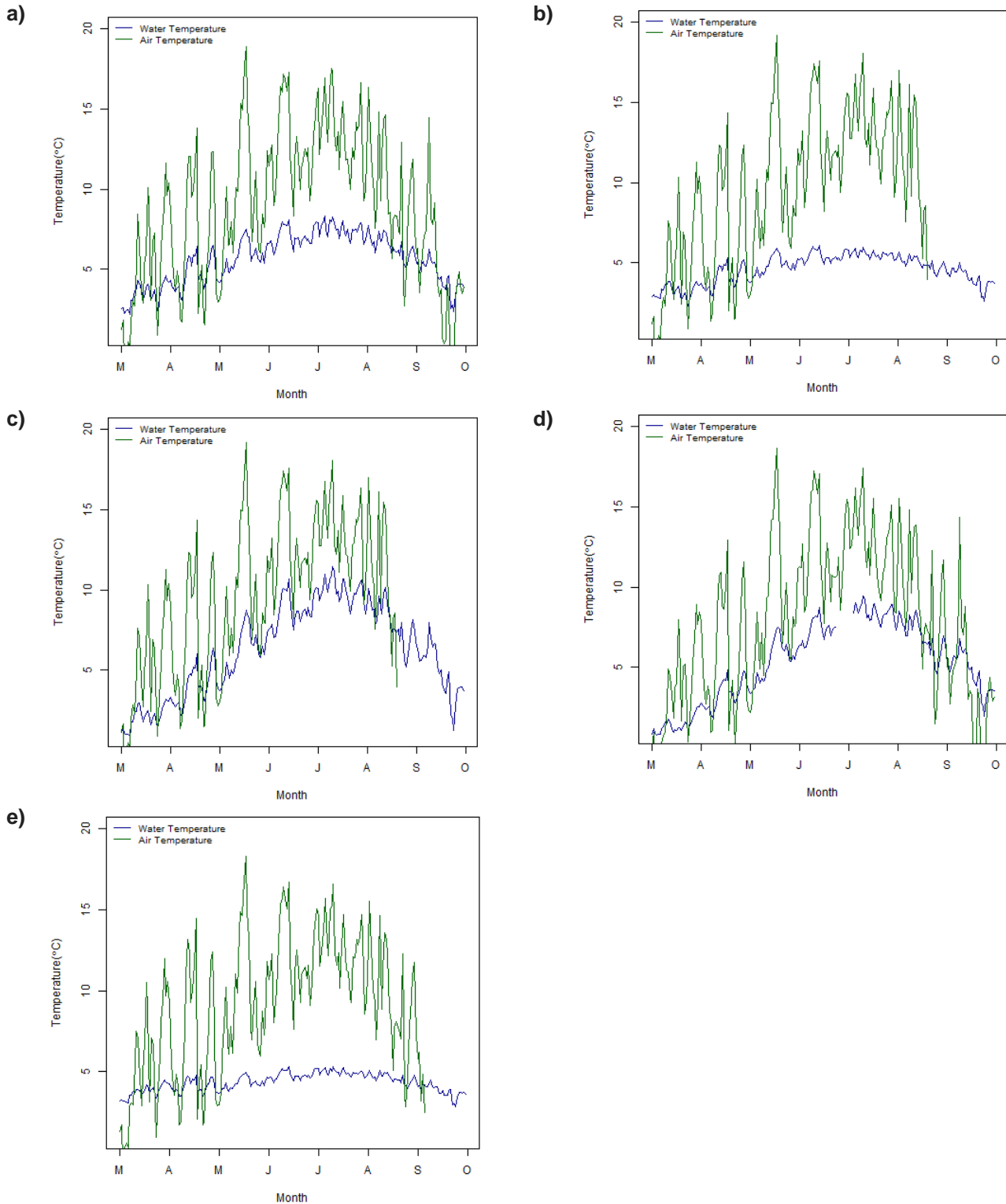
A more detailed description of the temperature profile of Blairmore Creek Site 1 (Figure 4.6a) and Blairmore Creek Site 2 (Figure 4.6b) illustrates the seasonal trends in temperature. The water and air temperature followed the expected increase during the summer months, which have more daylight hours, providing an increase in heating from solar radiation.

**Figure 4.6 Daily mean air and water temperatures calculated from 15-minute temperature readings at: a) Blairmore Creek Site 1 (BC-T01); and b) Blairmore Creek Site 2 (BC-T02). Blue line = water temperature, green line = air temperature.**



Temperature profiles for the temperature stations in Gold Creek watershed are provided in Figure 4.7. Caudron Creek, an important tributary to the Gold Creek mainstem, had the coolest water temperatures (daily mean 6.3°C Table 4.2, Figure 4.7e) of all of the sites and displayed minimal fluctuations over the study period, suggesting that groundwater is likely an important water supply. Gold Creek Site 3 (Figure 4.7c) is located immediately above the Caudron Creek/Gold Creek confluence and has a mean daily temperature of 6.3°C (Table 4.2), whereas Gold Creek Site 2 (Figure 4.7b), which is located immediately below the confluence of Caudron and Gold Creek, has a cooler mean daily temperature of 4.6°C (Table 4.2). This change in water temperature occurs over a distance of less than 100 m and is likely due to the inflow of cooler water from Caudron Creek. Thus, Caudron Creek appears to have a pronounced influence on the stream temperature of Gold Creek.

**Figure 4.7** Daily mean air and water temperatures calculated from 15 minute temperature readings at: a) Gold Creek Site 1 (GC-T01); b) Gold Creek Site 2 (GC-T02); c) Gold Creek Site 3 (GC-T03); d) Gold Creek Site 4 (GC-T04); and e) Caudron Creek Site 1 (CC-T01), Blue line = water temperature, green line = air temperature.



## 4.1.2 Fish Inventory

### 4.1.2.1 Fish Bearing Status

The community composition and distribution of fish throughout the LSA was characterized based on historical information (Section 2.0) and fish surveys completed from 2014 to 2016 (further described in Sections 4.1.2 and 4.1.5). The fish communities of Blairmore Creek and Gold Creek within the LSA are simple, with WSCT being the only native fish species that has been historically documented and observed during our field programs.

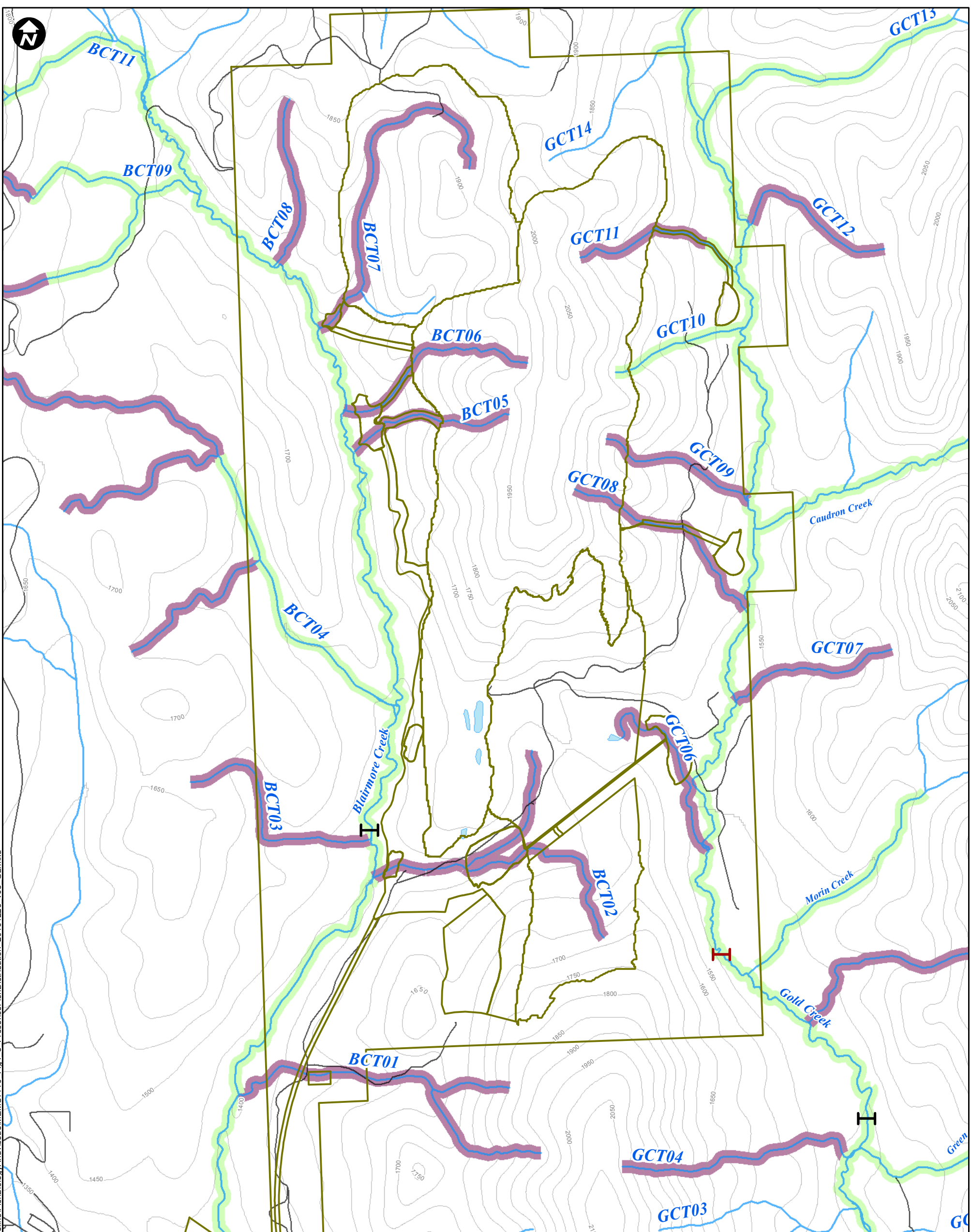
Distribution of fish throughout the LSA is largely driven by the presence of barriers, which prevent fish from expanding their range upstream. The presence of certain key barriers create a refuge for pure-strain WSCT, given they prevent non-native species from extending their range upstream. A visual representation of the distribution of fish throughout the LSA is provided in Figure 4.8.

#### *Gold Creek*

WSCT, RNTR, WSCT x RNTR hybrids, and BKTR have been reported in Gold Creek. Non-native BKTR and have been detected in Gold Creek below the identified permanent barrier on the mainstem north of Green Creek (Figure 4.8). Pure-strain WSCT occur throughout Gold Creek.

#### *Blairmore Creek*

Nonnative RNTR, BKTR, and WSCTxRNTR hybrids have been detected in Blairmore Creek primarily in the lowermost reaches below the identified barriers (falls). WSCTxRNTR hybrids have also been detected in upper Blairmore Creek above the uppermost barrier; hybrid fish recently captured in upper Blairmore Creek (2014) are backcrossed hybrids, suggesting that no new hybridization events between pure RNTR and WSCT (F<sub>1</sub> hybrids) have occurred recently. Therefore the presence of hybrid trout in Upper Blairmore may be the result of undocumented stocking/placement of RNTR and not the result of upstream migration.



**LEGEND**

- Barrier to Fish Passage
- Barrier to Fish Passage - Seasonal
- Fish Bearing
- Non-fish Bearing
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Project Footprint

**PROJECT**

**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**FISH DISTRIBUTION THROUGHOUT THE LOCAL STUDY AREA**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779  
DRAWN BY: SS / EDITED BY: GL  
CHECKED BY: CB  
DATE: December 23, 2016



**FIGURE**  
**4.8**

## 4.1.2.2 Tributary Assessments

### 2014 Fish Surveys

Fish sampling was conducted on seven Blairmore Creek tributaries (BCT04, BCT07, BCT08, BCT09, BCT10, BCT13 and BCT14) in August 2014, capturing fish at all sites except for two (BCT08 and BCT14). All 107 fish captured were identified as WSCT in the field and ranged in fork length from 2.6 cm to 20.3 cm with an average fork length of 12 cm (Table 4.3). Detailed results from the fish surveys are included in Appendix A5. Fork lengths (average and range) were comparable between Blairmore Creek and its tributaries; however the largest fish were captured in the mainstem. The smaller tributaries further away from mainstem Blairmore Creek (sites BCT09a and BCT04b) had smaller average and maximum size of fish; these sites also contained young of the year (YOY) sized fish (2 to 4 cm). The Recovery Plan designates a portion of BCT04 as critical habitat for WSCT (Figure 1.2).

**Table 4.3 Details of fish captured in tributaries of Blairmore Creek during August 2014 surveys.**

Site <sup>1</sup>	WSCT Captured	Average fork length (cm)	Size range (cm)	Total effort (seconds)	CPUE (No. fish/100 sec)
BCT14	0	-	-	464	0.00
BCT13	1	16.1	16.1	394	0.25
BCT10	23	10.1	6.3-16.8	252	9.13
BCT09a	25	11.6	2.6-17.6	485	5.15
BCT04b	24	11.7	2.6-17.5	622	3.86
BCT04a	34	13.8	9.8-20.3	419	8.11
BCT08	0	-	-	121	0.00
<b>TOTAL</b>	<b>107</b>		<b>2.6-20.3</b>	<b>2757</b>	<b>3.88</b>

Genetic samples (n = 170) were collected from captured fish and provided to AEP in support of their WSCT mapping program. The majority of the sampled fish (n = 132) were identified as pure-strain (100%) WSCT. The remaining 38 fish were identified as backcross hybrids comprised genetically of WSCT and non-native rainbow trout. No new hybridization events (production of F<sub>1</sub> hybrids) between pure strain WSCT and rainbow trout were evident based on the data.

### 2016 Fish Surveys

Surveys of the Gold Creek tributaries captured relatively few fish, ranging from zero WSCT in Caudron Creek to 11 WSCT in GCT13 (Table 4.4). Although no fish were captured in Caudron Creek using electrofishing, August snorkel surveys observed one sub-adult and six adults (Table 4.4). Density of fish was also low, ranging from 0.09 fish/m<sup>2</sup> in Morin Creek to 1.83 fish/m<sup>2</sup> in GCT13. Electrofishing surveys captured BKTR in Green Creek, many of which were YOY (suggesting recent spawning) and juveniles. These findings suggest that Green Creek is a potential source of BKTR in the lower reaches of Gold Creek.

Tributaries assessed in Blairmore Creek support higher densities of WSCT than tributaries of Gold Creek (Table 4.4). Catch ranged from 17 WSCT in BCT07 to 85 WSCT in BCT07. BCT07, a relatively large

tributary that creates the reach break between Reaches 4 and 5 (Figure 4.1), was not sampled in the 2016 field sampling season due to access issues. Fish captured within tributaries of Blairmore Creek were all juveniles or sub-adults size class.

**Table 4.4 Fish assessments in tributaries of Gold Creek and Blairmore Creek, August 2016.**

Watershed	Tributary	Method	Total WSCT	Survey length (m)	Fish/m <sup>2</sup>
Gold Creek	Green	Electrofishing	1	300	0.17
	Morin	Electrofishing	1	567	0.09
	Caudron	Electrofishing	0	300	0.00
	Caudron	Snorkeling	7	450	0.78
	GCT02	Electrofishing	5	190	1.32
	GCT 13	Electrofishing	11	300	1.83
	GCT10	Electrofishing	5	188	1.33
Blairmore Creek	BCT04	Electrofishing	85	300	14.17
	BCT07 <sup>1</sup>	Electrofishing	17	80	10.63

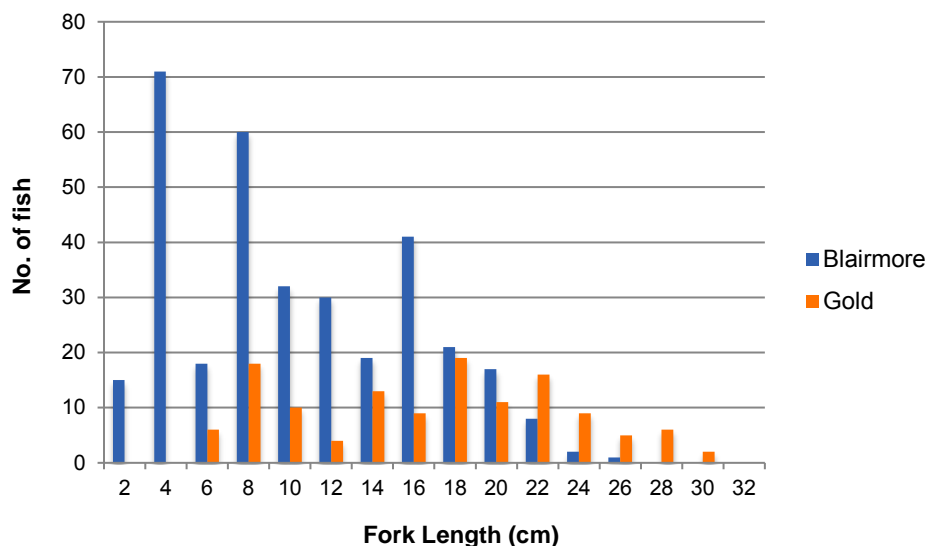
1. Survey occurred on August 27, 2014.

#### 4.1.2.3 Age Class by Fork Length

During the 2016 field sampling season, 463 WSCT were actively captured (i.e., angling and electrofishing) in the Gold and Blairmore Creek watershed (Gold Creek n = 128, Blairmore Creek n = 335, Figure 4.9). Using the combined catch data for Gold and Blairmore Creek, age class was estimated based on fork length (Table 4.5), using the assumption that as fish age, they grow larger. Blairmore Creek was sampled using the same timing and techniques as Gold Creek, to ensure no sampling bias occurred.

The fork length of WSCT in Blairmore Creek ranged from 2 to 26 cm, with most of the fish captured measuring less than 16 cm (Table 4.5). Surveys in Gold Creek captured WSCT which were larger, ranging from fork length of 6 to 30 cm (Table 4.5). The smaller size classes were not captured in Gold Creek, and were not observed during any snorkel surveys. This missing cohort could be attributed to a number of environmental variables, such as lower-than-normal flows or changes in freshet.

**Figure 4.9 Fork length (cm) distribution for Blairmore Creek and Gold Creek, August 2016. (Blairmore Creek N = 335, Gold Creek N = 128).**



Based on fork-length distribution (Figure 4.13), fry were classified between 2 and 6 cm, juveniles classified between 6 to 12 cm, and sub-adult/adults greater than 12 cm (Table 4.5). Thus, the fry age class (YOY) is the missing cohort from Gold Creek in 2016.

**Table 4.5 Age class designation based on fork length (cm) distribution for Gold Creek and Blairmore Creek, August, 2016. YOY = young of the year.**

Fork length (cm)	Age class	Life stage
2-6	YOY	Fry
6-12	1+	Juvenile
12-20	2+	Subadult/adult
20-26	3+	Subadult/adult
> 26	4+	Subadult/adult

### 4.1.3 Overwintering Habitat Survey

During the March surveys, a large portion of Gold Creek and all of Blairmore Creek were still frozen. One ice-free pool was detected in the lower reaches of Gold Creek and contained 32 fish ranging from < 20 cm to 40+ cm fork length (Pool A, Table 4.6). Additional open areas were surveyed, however no fish were observed.

Similar to other high-elevation WSCT populations (Jakober et al. 1998), fish in Blairmore Creek and Gold Creek had commenced their migration into overwintering habitat by October. Suitable quality pool habitat is defined by water depth consistently at least 1 m deep. Fish appear to utilize deep pool habitat associated with slower water velocities in both creeks, where multiple size classes congregated in large numbers

(Table 4.6). Habitat that had no deep pools but pocket water, riffles and cascades were used less (Pool G, III, V; Table 4.6) and by smaller sized fish. Primary deep pool habitat was extremely limited through the mainstems of both Gold Creek and Blairmore Creek, with only four suitable pools occupied by adult fish in Blairmore Creek (Pool I, II, III, IV; Table 4.6) and Gold Creek (Pool A, B, D and F; Table 4.6), respectively. All pools being used by fish were at least 0.7 m deep and 10 m long. The location of the pools is shown in Figure 4.10.

While many of the habitat units contain small pools (tertiary, < 50% of wetted width) which support fish, deep pools (primary, > 50% of wetted width) are deficient in this system. Bonneau and Scarnecchia (1998) suggest decreases in pool habitat could be harmful for cutthroat trout during overwintering. Fish may continue to migrate as winter approaches, with fish moving from small to deep pool habitats (Jakober et al. 1998). Therefore, all overwintering habitat use may not have been observed.

**Table 4.6 Fish observed at each overwintering pool in Gold Creek and Blairmore Creek, March and October 2016. YOY = young of the year**

Watercourse	Month	Reach	Pool	YOY	<20	20+	30+	40+	Total	Total adults
Gold	October	7	A	0	5	9	10	3	27	22
	March	7	A	0	6	15	10	1	32	26
	October	7	B	0	10	5	9	2	26	16
	October	7	C	0	4	1	0	0	5	1
	October	7	D	0	6	5	11	1	23	17
	October	7	E	0	2	0	0	0	2	0
	October	7	F	0	60	10	40	0	110	50
	October	8	G	0	2	3	0	0	5	3
Blairmore	October	3	I	0	1	2	0	0	3	2
	October	3	II <sup>1</sup>	21	40	40	48	2	151	90
	October	4	III	22	19	4	0	0	45	4
	October	4	IV <sup>2</sup>	41	29	41	3	0	114	44
	October	5	V <sup>3</sup>	6	9	0	0	0	15	0

1. Pool II no defined pools, habitat dominated by tertiary pool/pocket water (300 m sampled).
2. Pool IV no defined pools, habitat dominated by tertiary pool/ pocket water (400 m sampled).
3. Pool V no defined pools, habitat dominated by tertiary pool/pocket water (200 m sampled).



Document Path: K:\Data\Project\MEMS7779A\_MXD\AquaticFishTechBaseline\FishBiologyAndHabitat\_20161223\_v05\_GI.mxd  
 Fig4\_10\_OverwinteringHabitat\_20161223\_v05\_GI.mxd

**LEGEND**

- Overwintering Pool
- ⊥ Barrier to Fish Passage
- ⊥ Barrier to Fish Passage - Seasonal
- Identified Westslope Cutthroat Critical Habitat (greater than 99% pure)
- Near Pure WSCT Population (95% to 99% pure)
- Primary Highway
- Watercourse
- Waterbody

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**Hatfield**  
CONSULTANTS

**TITLE**

**OVERWINTERING HABITAT IN THE LOCAL STUDY AREA**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, ESRI Basemap  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

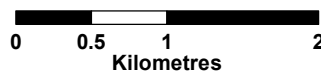
DRAWN BY: SS / EDITED BY: GL

CHECKED BY: CB

DATE: December 23, 2016

FIGURE

**4.10**



#### 4.1.4 WSCT Spawner Survey

All mature fish in Blairmore Creek and Gold Creek were observed in pool habitat, with pairs found predominantly over gravels with good cover (e.g., undercut banks, logs, boulders). Spawning was not geographically concentrated, but rather spread throughout reaches and based on habitat availability (Figure 4.11). Larger fish were observed spawning earlier in both systems. The early survey window (May) had more mature fish (30+ cm fork length class) than in the later survey window where more mature fish in the 20+ fork length class were observed (Table 4.7). Stream discharge was slightly higher in the earlier survey window (Hatfield 2016a) and may explain the size differential observed across the survey windows, given larger fish can generally handle higher flows.

Low numbers of fish were observed in the lower reaches of Gold Creek except in Reach 2 (Table 4.7; Reach 2 shown in Figure 4.1). In the headwater spawning survey area of Gold Creek (June 2016), the field crew observed, photographed and video documented five mature (>20 cm) WSCT displaying spawning behaviour (Photo 4.6).



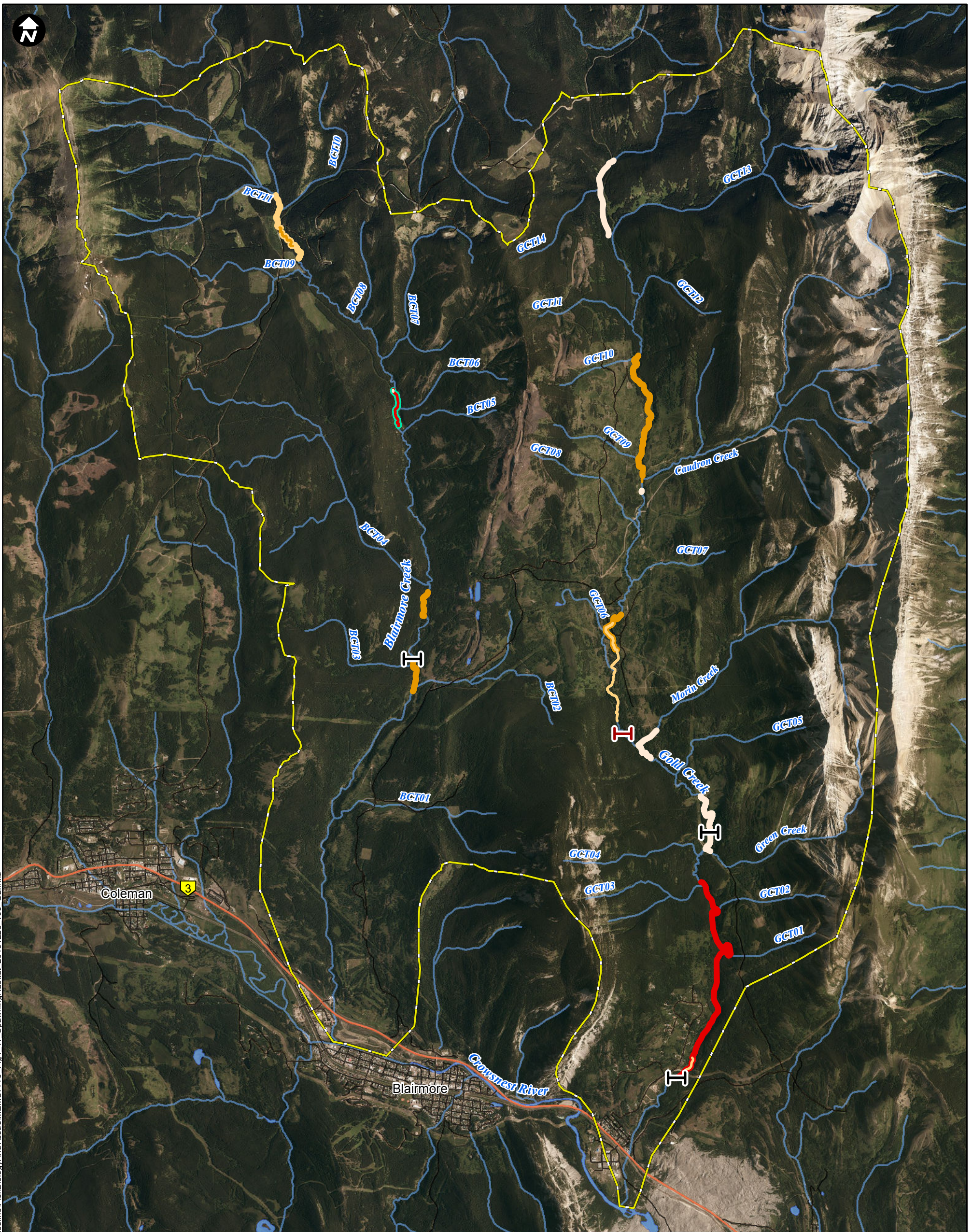
**Photo 4.6 WSCT observed spawning in the headwaters of Gold Creek in June 2016.**

The WSCT spawning window likely varies between years based on the timing of spring freshet, and associated increase in water temperatures. Based on the data collected by the temperature loggers (see Section 3.1.1) mean water temperature was 4.7°C during the May 2016 spawning survey and 7.8°C during the June 2016 spawning survey. During the first survey period in May, water temperature had yet to reach the general associated WSCT spawning temperature of 5 to 8°C (Coleman and Fausch 2007). Location of spawning likely also varies between years as pool habitat in these small, high gradient streams is very dynamic in nature.

**Table 4.7 Spawning surveys in Gold Creek and Blairmore Creek, May and June 2016.**













Watercourse	Month	Reach	Total WSCT	Total adults	Total mature	Total pairs	Survey length (m)	Total mature /m <sup>2</sup>
Gold Creek	May	2	41	28	26	1	3,579	0.07
		4	1	0	0	0	970	0.00
		5	1	0	0	0	522	0.00
		6	20	7	3	0	1710	0.03
		7	49	19	18	0	727	0.39
		8	45	17	17	5	562	3.78
	June	8	63	17	15	4	1975	0.95
		9	48	0	0	0	1126	0.00
Blairmore Creek	May	3	75	14	12	1	402.25	0.61
		4	105	29	29	9	577	1.09
		5	75	14	14	4	493	0.95
	June	2	313	65	12	2	506	2.16
		3	21	4	0	0	NA <sup>1</sup>	NA <sup>1</sup>
		4	214	40	22	1	611	0.78
		5	193	8	5	0	1117	0.15

1. Survey site was a single pool, therefore survey length is not applicable (NA).



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**LEGEND**

-  Barrier to Fish Passage
-  Barrier to Fish Passage - Seasonal
- Distribution of Mature WSCT**
-  0
-  1 - 10
-  11 - 20
-  21 - 30
-  31 - 40
-  Primary Highway
-  Road
-  Watercourse
-  Waterbody
-  Local Study Area

Note: Thinner Mature WSCT distribution lines are shown in overlapping areas.

**PROJECT**



**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**Hatfield**  
CONSULTANTS

**TITLE**

**SPAWNING HABITAT IN THE LOCAL STUDY AREA**

**NOTES**

Data Sources: Government of Canada, Government of Alberta, ESRI Basemap  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

DRAWN BY: SS / EDITED BY: GL

CHECKED BY: CB

DATE: December 23, 2016

**FIGURE**

**4.11**



## 4.1.5 Fish Population

### 4.1.5.1 Density Estimates

#### *Gold Creek Fish Density*

In Gold Creek, fish densities were much less in the lower reaches (Reaches 3 to 6, [Figure 4.1](#)) relative to the upper reaches (Reaches 7 to 8, [Table 4.8](#)). Reach 6 is a highly braided section with highly reduced stream flows and was therefore not sampled.

BKTR were found in Reaches 3 and 4 ([Table 4.8](#), reaches shown in [Figure 4.1](#)) as well as in Green Creek (see [Section 4.1.2.2](#)), which flows into Gold Creek at the reach break between Reaches 3 and 4 (see [Figure 4.1](#) for location). In Green Creek, YOY were captured and are likely a primary source of BKTR in lower Gold Creek.

**Table 4.8** Relative abundance of WSCT and BKTR based on snorkel surveys on Gold Creek, August 2016. Fork length class is broken down into 10 cm intervals. YOY=young of the year.

Species	Reach	YOY	Fork length (cm)				Total	Total adults	Survey length (m)	Adults /m <sup>2</sup>
			10+	20+	30+	40+				
WSCT	3	0	0	3	4	0	7	7	436	0.15
	4	0	0	0	1	0	1	1	380	0.04
	5	0	1	3	1	0	5	4	267	0.19
	7	0	157	208	97	6	467	310	2,874	1.69
	8	0	3	19	0	0	22	19	300	1.13
BKTR	3	0	0	11	2	0	13	13	436	0.28
	4	0	0	0	5	0	5	5	380	0.18

Using a blend of methods (i.e., angling, electrofishing) to ensure all habitat types were sampled during the mark and recapture surveys, the density of fish (total fish per square metre) was calculated and summarized in [Table 4.9](#). Any fish 13 cm fork length or larger were classified as sub-adult and adult ([Section 4.1.2.3](#)) and were used to calculate total fish using the Chapman estimator.

**Table 4.9 Fish density determined through mark and recapture surveys on Gold Creek, August 2016. Total fish was calculated using the Chapman Estimator where; M= total marked fish captured, T= total fish captured 2<sup>nd</sup> pass, R=total marked fish captured 2<sup>nd</sup> pass.**

Reach	Method	M	T	R	Total fish	Survey length (m)	Fish/m <sup>2</sup>
7	Angling	25	19	2	172	1,374	1.96
7	Electrofishing	10	3	1	21	1,374	0.24
8	Electrofishing	17	4	2	29	300	1.73
9	Electrofishing	23	16	1	203	368	13.13

In the upper reach of Gold Creek (Reach 9, [Figure 4.1](#)) fish density was highest ([Table 4.9](#)) and dominated by fish of smaller fork lengths. The lower reaches supported fewer fish; however, these fish were on average larger. Comparing the results of relative abundance through snorkel surveys and the mark and recapture, it is evident that many of the larger fish (>30 cm) were not captured by angling or electrofishing. This cohort is very valuable to sustain smaller populations because the larger fish, in particular the females, are more fecund than their smaller mature cohorts (Down et al. 1997).

### **Blairmore Creek Fish Density**

Fish density based on snorkel surveys was higher in the upper reach of Blairmore Creek compared to the lower reach, and was dominated by smaller fish ([Table 4.10](#)). Fish density based on mark and recapture surveys was much higher in Reach 5 of Blairmore Creek compared to the lower reaches, and was dominated by smaller fish ([Table 4.11](#)).

**Table 4.10 Relative abundance of WSCT using snorkel surveys on Blairmore Creek, August 2016.**

Reach	YOY	Fork length (cm)				Total	Total adults	Survey length (m)	Adults/m <sup>2</sup>
		<20	20+	30+	40+				
3	178	148	109	25	4	464	138	1167	2.41
4	136	183	121	17	1	458	139	897	3.37

Fish density based on mark and recapture surveys was much higher in Reach 5 of Blairmore Creek compared to the lower reaches, and was dominated by smaller fish (Table 4.11).

**Table 4.11 Fish density determined using mark and recapture surveys on Blairmore Creek, August 2016. Total fish was calculated using the Chapman Estimator where; M= total marked fish captured, T= total fish captured 2<sup>nd</sup> pass, R=total marked fish captured 2<sup>nd</sup> pass.**

Reach	Method	M	T	R	Total fish	Survey length (m)	Fish/m <sup>2</sup>
3	Angling	22	8	1	103	1167	1.80
3	Electrofishing	12	27	7	45	1167	0.79
4	Electrofishing	6	8	3	15	300	1.09
5	Electrofishing	44	46	8	234	300	26.00

### **Total Fish (Gold Creek and Blairmore Creek)**

To estimate the total number of fish (sub-adult and adult) in upper Gold Creek and Blairmore Creek, the mark and recapture fish densities (fish/m<sup>2</sup>) calculated from the sample sites was applied to the total reach length (Table 4.12). The lower reaches are not included because the fish density was too low to complete a mark and recapture survey (Table 4.8 and Table 4.10).

**Table 4.12 Total number of fish (sub-adults and adults) in upper Gold Creek and Blairmore Creek based on mark recapture surveys, August 2016.**

Watercourse	Reach	Reach length (m)	Method	Density (fish/m <sup>2</sup> )	Total Fish
Gold Creek	7	2,874	Angling	1.95	359
	7	2,874	Electrofishing	0.23	43
	8	1,704	Electrofishing	1.72	164
	9	1,922	Electrofishing	13.12	1059
				<b>Total</b>	<b>1,625</b>
Blairmore Creek	3	1,167	Angling	1.80	103
	3	1,167	Electrofishing	0.77	44
	4	3,942	Angling	1.911	347
	4	3,942	Electrofishing	1.09	197
	5	3,230	Electrofishing	26.00	2,519
				<b>Total</b>	<b>3,210</b>

1. Fish density for Reach 3 (Angling) was used as a surrogate for Reach 4 (Angling)

### 4.1.5.2 Juvenile Recruitment

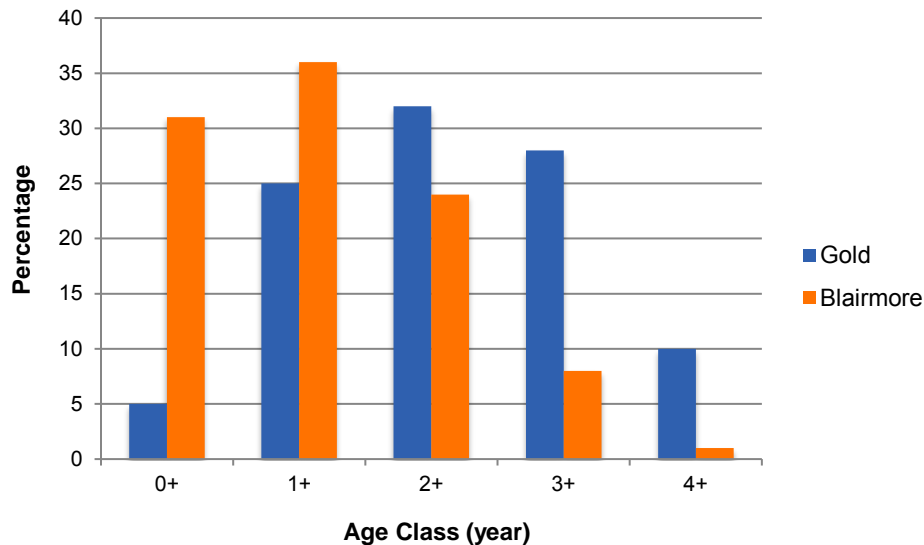
The total number of individuals captured by age class for both Blairmore Creek and Gold Creek is presented in [Table 4.13](#).

**Table 4.13** The number of individuals in the WSCT population in each age class for Gold Creek (n = 128) and Blairmore Creek (n = 335).

	Fry 0+	Juvenile 1+	Sub-adult 2+	Adult 3+	Adult 4+
Blairmore	104	122	81	27	1
Gold	6	32	41	36	13

Derived from [Table 4.13](#), the percentage of individuals in each age class is presented in [Figure 4.14](#).

**Figure 4.12** The percentage of individual WSCT within the population in Gold Creek and Blairmore Creek by age class.



Young and Guenther-Gloss (2004) suggest that fish in each age class must constitute at least 5% of the total population to indicate successful recruitment. Based on this assumption, recruitment in Gold Creek from the fry (0+) stage to the juvenile (1+) stage (based on 2016 data) would be unsuccessful and likely not sustain this cohort over time. Such population bottlenecks, especially in small, isolated headwater WSCT populations, increase these populations' vulnerability (Cook et al. 2010, Taylor et al. 2003).

Coleman and Fausch (2007) suggest that cold summer temperatures ( $\leq 4^{\circ}\text{C}$ ) limit recruitment of age class 0+ cutthroat trout in high elevation streams. Calculations for the Growth Season Degree Days (GSDD) at each temperature station throughout Gold Creek and Blairmore Creek are summarized in [Table 4.14](#). The stations are shown in [Figure 3.1](#). Stream temperature data were obtained from results found in Section [4.1.1.4](#).

**Table 4.14 Growth Season Degree Days (GSDD) for various reaches throughout Gold Creek and Blairmore Creek, March to October 2016.**

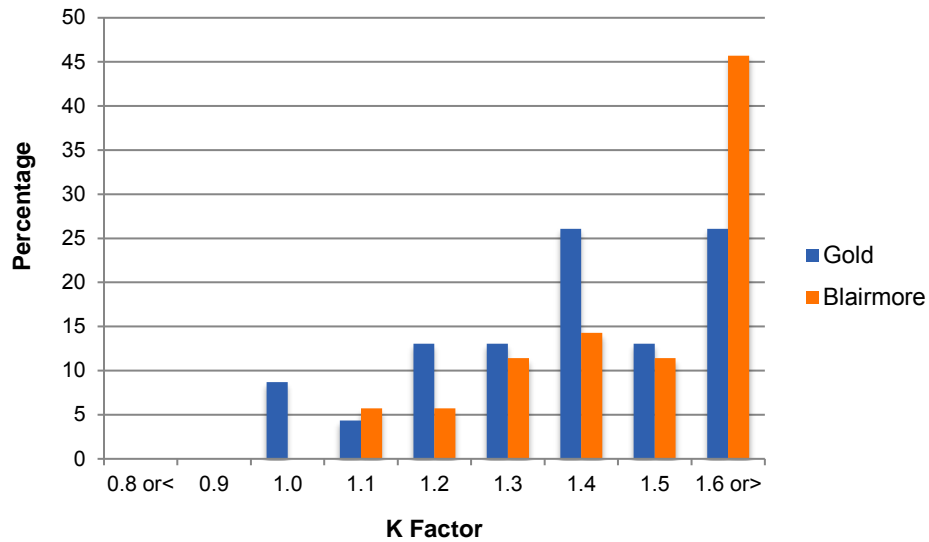
<b>Watercourse</b>	<b>Station</b>	<b>GSDD</b>	<b>Relative to recruitment threshold (Fausch and Coleman 2007)</b>
Gold Creek	GC-T03w	1,081	Above
	GC-T02w	755	Below
	GC-T04w	861	Below
	GC-T01w	988	Above
Caudron Creek	CC-T01w	570	Below
Blairmore Creek	BL-T02w	1,484	Above
	BL-T01w	1,675	Above

Coleman and Fausch (2007) suggest that less than 800 GSDD is the threshold limiting juvenile recruitment, because this effects both survival and growth of eggs through YOY and ultimately affects juvenile survival. It is possible that the cold waters of Caudron Creek may influence recruitment in Reach 7 and Caudron Creek, since the number of GSDD is less 800 (Table 4.14). This influence can be seen further downstream at Station GC-T04w, where the GSDD increases to 861 (Table 4.14), which is near the reported threshold (800), suggested by Coleman and Fausch (2007).

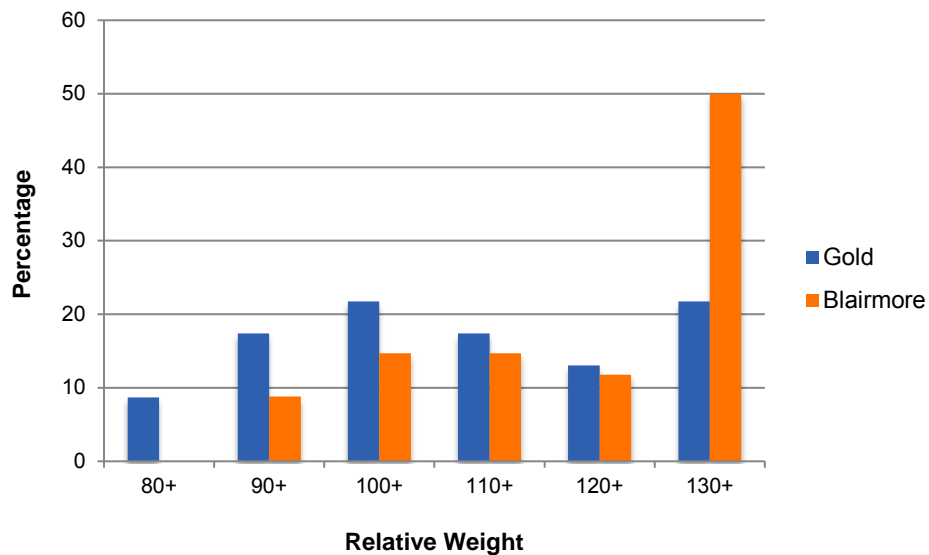
#### **4.1.5.3 Condition**

The fork length to weight ratio of individual WSCT was used to determine the condition of the populations in Blairmore and Gold Creek using the K Factor and Wr. Anderson and Neumann (1996) suggest that condition can be a useful surrogate to predict fecundity, reproduction, growth, mortality rates and a measure of environmental condition.

**Figure 4.13** The percentage of the population of WSCT in Gold Creek and Blairmore Creek by K Factor as a measure of fish condition.



**Figure 4.14** The percentage of the WSCT population in Gold Creek and Blairmore Creek by Relative Weight (Wr).



Individual WSCT within Blairmore Creek are considered to be in better condition than Gold Creek WSCT although, both stocks have a high percentage of individuals showing good or excellent condition. Fulton K for fish in good or excellent condition for Gold and Blairmore Creek populations is 65% and 71%, respectively. The Relative Weight for fish in good or excellent condition for Gold and Blairmore Creek populations is 52% and 77%, respectively.

#### 4.1.6 Tissue Residue

A summary of metal concentrations in trout collected from Gold Creek and Blairmore Creek are presented in [Table 4.15](#). Concentrations in individual fish are shown in [Appendix A6](#).

Concentrations of boron, lithium, and tellurium, were below detection limit in all trout collected from Gold Creek; concentrations of antimony, beryllium, bismuth, and zirconium were also below detection in over half of samples collected. All observed mercury concentrations were below the concentration (0.5 mg/kg) permitted in fish and fish products specified by the *Canadian Food Inspection Agency* (CFIA 2014) and below the maximum level in specified foods sold in Canada (Health Canada 2016).

Concentrations of boron, lithium, tellurium, and zirconium were below detection limit in all trout collected from Blairmore Creek; concentrations of beryllium and bismuth were also below detection in over half of samples collected. All observed mercury concentrations were below the concentration (0.5 mg/kg) permitted in fish and fish products specified by the *Canadian Food Inspection Agency* (CFIA 2014) and below subsistence (0.2 mg/kg) and general consumer (0.5 mg/kg) consumption advisory levels of Health Canada (2016).

**Table 4.15 Concentrations of metals in trout collected from Gold Creek and Blairmore Creek, August and October 2016.**

Parameters	Units	Detection Limit	Gold Creek (n=8a)				Blairmore Creek (n=8b)			
			Mean	SE	Min	Max	Mean	SE	Min	Max
% Moisture	%	0.50	71.5	0.285	70.5	73.2	77.4	0.239	76.2	78.4
<b>Total Metals</b>										
Aluminum (Al)-Total	mg/kg wwt	0.40	14.4	5.52	0.980	41.2	17.5	2.87	10.3	34.2
Antimony (Sb)-Total	mg/kg wwt	0.0020	0.0021	0.00005	<0.002	0.0023	0.004	0.001	<0.002	0.007
Arsenic (As)-Total	mg/kg wwt	0.0040	0.107	0.007	0.073	0.137	0.086	0.015	0.044	0.147
Barium (Ba)-Total	mg/kg wwt	0.010	0.707	0.128	0.298	1.490	1.409	0.084	1.160	1.870
Beryllium (Be)-Total	mg/kg wwt	0.0020	0.002	0.000	<0.002	0.005	0.002	0.00001	<0.002	0.002
Bismuth (Bi)-Total	mg/kg wwt	0.0020	0.002	0.000	<0.002	0.003	0.002	0.00040	<0.002	0.005
Boron (B)-Total	mg/kg wwt	0.20	0.200	0.000	<0.2	<0.2	<0.2	0	<0.2	<0.2
Cadmium (Cd)-Total	mg/kg wwt	0.0010	0.089	0.024	0.027	0.246	0.037	0.004	0.023	0.062
Calcium (Ca)-Total	mg/kg wwt	4.0	7120	682	3460	9390	5295	293	4280	6680
Cesium (Cs)-Total	mg/kg wwt	0.0010	0.003	0.001	0.001	0.006	0.005	0.000	0.003	0.007
Chromium (Cr)-Total	mg/kg wwt	0.010	0.024	0.007	<0.01	0.062	0.308	0.044	0.121	0.464
Cobalt (Co)-Total	mg/kg wwt	0.0040	0.092	0.013	0.058	0.175	0.254	0.029	0.125	0.369
Copper (Cu)-Total	mg/kg wwt	0.010	0.711	0.034	0.588	0.872	0.631	0.051	0.495	0.906
Iron (Fe)-Total	mg/kg wwt	0.60	23.7	5.37	12.2	58.7	37.525	4.821	21.300	63.700
Lead (Pb)-Total	mg/kg wwt	0.0040	0.017	0.005	0.005	0.040	0.016	0.002	0.009	0.030
Lithium (Li)-Total	mg/kg wwt	0.10	<0.1	0	<0.1	<0.1	<0.1	0	<0.1	<0.1
Magnesium (Mg)-Total	mg/kg wwt	0.40	315	21.7	226	425	279	5.72	253	304
Manganese (Mn)-Total	mg/kg wwt	0.010	0.928	0.167	0.368	2.000	3.23	0.371	2.05	4.83
Mercury (Hg)-Total	mg/kg wwt	0.0010	0.005	0.002	0.003	0.016	0.017	0.002	0.013	0.025
Molybdenum (Mo)-Total	mg/kg wwt	0.0040	0.013	0.002	0.009	0.026	0.051	0.006	0.026	0.078
Nickel (Ni)-Total	mg/kg wwt	0.010	0.052	0.014	0.021	0.142	0.290	0.035	0.153	0.444
Phosphorus (P)-Total	mg/kg wwt	2.0	5973	398	3900	7160	4371	163	3900	5230
Potassium (K)-Total	mg/kg wwt	4.0	3460	72	3060	3720	2968	83	2620	3240
Rubidium (Rb)-Total	mg/kg wwt	0.010	1.640	0.129	0.906	2.110	0.792	0.019	0.702	0.871
Selenium (Se)-Total	mg/kg wwt	0.010	1.923	0.136	1.540	2.780	1.235	0.049	1.060	1.460
Sodium (Na)-Total	mg/kg wwt	4.0	808	11.4	755	837	848	20.1	760	918
Strontium (Sr)-Total	mg/kg wwt	0.010	16.3	1.48	9.17	22.7	6.72	0.422	5.11	8.89
Tellurium (Te)-Total	mg/kg wwt	0.0040	<0.004	0	<0.004	<0.004	<0.004	0	<0.004	<0.004
Thallium (Tl)-Total	mg/kg wwt	0.00040	0.049	0.009	0.014	0.102	0.005	0.000	0.004	0.006
Tin (Sn)-Total	mg/kg wwt	0.020	0.038	0.006	<0.02	0.072	0.066	0.005	0.047	0.095
Uranium (U)-Total	mg/kg wwt	0.00040	0.003	0.001	0.001	0.007	0.002	0.000	0.001	0.003
Vanadium (V)-Total	mg/kg wwt	0.020	0.060	0.017	<0.02	0.132	0.055	0.009	0.023	0.105
Zinc (Zn)-Total	mg/kg wwt	0.10	33.2	1.81	23.4	39.5	22.0	0.872	19.6	26.9
Zirconium (Zr)-Total	mg/kg wwt	0.040	0.044	0.004	<0.04	0.075	<0.04	0	<0.04	<0.04

wwt = wet weight; n = number of samples; SE = standard error

a = BKTR; b = BKTR, RNTR and RNTRxWSCT

## 4.2 AQUATIC RESOURCES

### 4.2.1 Macroinvertebrates

#### 4.2.1.1 Benthic Macroinvertebrates

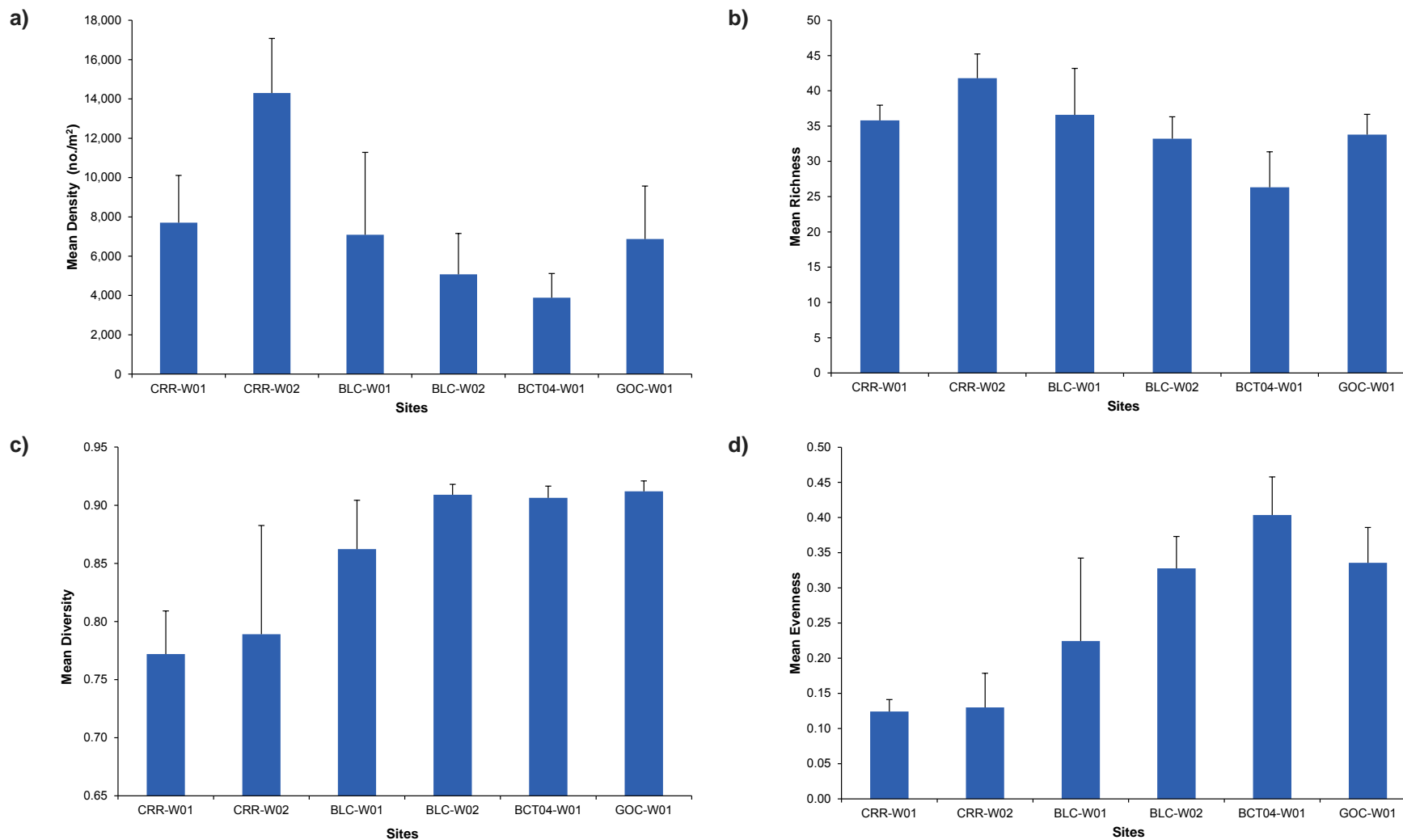
##### *Local Study Area (LSA)*

Density and taxa richness in the LSA was highest at Blairmore Creek Site 1 (BLC-W01) and the lowest at BCT04 (BCT04-W01; [Figure 4.15a](#) and [b](#)). Total mean density of benthic invertebrates in the LSA ranged from 3,892 individuals/m<sup>2</sup> at BCT04 (BCT04-W01) to 7,086 individuals/m<sup>2</sup> at the downstream location on Blairmore Creek (BLC-W01; [Figure 4.15a](#)). Mean taxa richness ranged from 26 at BCT04 (BCT04-W01) to 37 at Blairmore Creek Site 1 (BLC-W01). Benthic invertebrate communities at the Gold Creek location (GOC-W01) had a density of 6,874 individuals/m<sup>2</sup> ([Figure 4.15a](#)). Both diversity and evenness values were similar at all sites. Diversity values ranged from 0.86 to 0.91 and evenness values ranged from 0.24 to 0.28, indicating relatively diverse communities ([Figure 4.15c](#) and [d](#)).

Percent EPT were similar across all sites, ranging from 66% at the upstream site on Blairmore Creek (BLC-W02) to 76% on Gold Creek (GOC-W01) and BCT04 (BCT04-W01; [Table 4.16](#)). Similarly EPT taxa richness showed little variation across the sites, ranging from 17 at the upstream site on Blairmore Creek (BLC-W02) and BCT04 (BCT04-W01) to 21 at the Gold Creek location (GOC-W01; [Table 4.16](#)). The proportion of ephemeroptera (%E) was highest at Gold Creek (GOC-W01 39%; [Table 4.16](#)) compared to the sites on Blairmore Creek which ranged from 28% at Blairmore Creek Site 1 (BLC-W01) to 31% at BCT04 (BCT04-W01; [Table 4.16](#)). The proportion of chironomidae showed the most variation across the sites, ranging from around 9% at Gold Creek (GOC-W01) and BCT04 (BCT04-W01) to 25% at Blairmore Creek Site 2 (BLC-W02; [Table 4.16](#)). The presence and proportions of these taxa suggest that these watercourses are cool-water systems with good water quality.

Additional baseline information was completed by Ree (2014) that focused on spatial and temporal variation of benthic macroinvertebrate communities in Gold Creek and Blairmore Creek. Findings suggest that macroinvertebrate abundance in lower elevations does not significantly differ among the watercourses, and that availability is likely suitable in higher-elevation reaches.

**Figure 4.15 Summary of benthic invertebrate community: a) Mean density b) Mean taxa richness c) Mean diversity d) Mean evenness. Note: Error bar represents standard deviation.**



**Table 4.16 Summary of indicator taxa from the 2014 benthic invertebrate sampling.**

	LSA				RSA	
	BLC-W01	BLC-W02	BCT04-W01	GOC-W01	CRR-W01	CRR-W02
EPT Proportion (%)	75	66	76	76	70	53
EPT Taxa Richness	18	17	17	21	20	22
E Proportion (%)	28	31	30	39	52	43
Chironomidae Proportion (%)	16	25	8.9	9.0	23	38

### **Regional Study Area (RSA)**

Benthic invertebrate samples were also collected from two locations on the Crowsnest River: downstream of the Blairmore Creek confluence (CRR-W01) and upstream of the confluence (CRR-W02, [Figure 3.3](#)). Density and taxa richness is higher at the upstream site compared to the downstream site ([Figure 4.15a and b](#)). There were nearly twice as many benthic invertebrates at the upstream Crowsnest River site (14,302 individuals/m<sup>2</sup>) relative to the downstream location (7,706 individuals/m<sup>2</sup>). Both diversity and evenness values were fairly similar at the Crowsnest River sites, and were lower than the Blairmore and Gold Creek sites ([Figure 4.15c and d](#)). The proportion of EPT taxa was lower at the upstream site (CRR-W02 53%) than at the downstream site (CRR-W01 70%, [Table 4.16](#)), however the EPT taxa richness was slightly higher at the upstream site (CRR-W02). There was a higher proportion of E and a lower proportion of chironomidae at CRR-W01, compared to CRR-W02 ([Table 4.16](#)). Overall, these results suggest that the downstream site on the Crowsnest River (CRR-W01) is higher quality than the upstream site (CRR-W02). Raw benthic invertebrate data is included in [Appendix A7](#).

#### **4.2.1.2 Drift Invertebrates**

Overall, Blairmore and Gold creeks were similar across all indices examined. June was more productive for drift invertebrates in comparison to September. In most cases, density and diversity were higher in June samples, whereas biomass was consistently highest in June. Evenness was relatively low across all sites reflecting the presence of large and dominant taxonomic groups. Inputs of terrestrial invertebrates contributed a large proportion (up to 44.1%) to the drift assemblages. Three additional taxa including baetidae (mayflies), orthocladiinae (midges) and ostracoda (crustaceans) were consistently dominant across sites and season. Percent (%) EPT was high across all sites suggesting cool streams with good water quality. Overall, the presence of drift invertebrate density, biomass, and taxa suggests that Blairmore and Gold creeks provides a primary foraging resource for WSCT and, under current baseline conditions, greatly contributes to overall stream productivity. A more detailed report of the drift invertebrate sampling is provided in [Appendix A1](#).

## 4.2.2 Periphyton

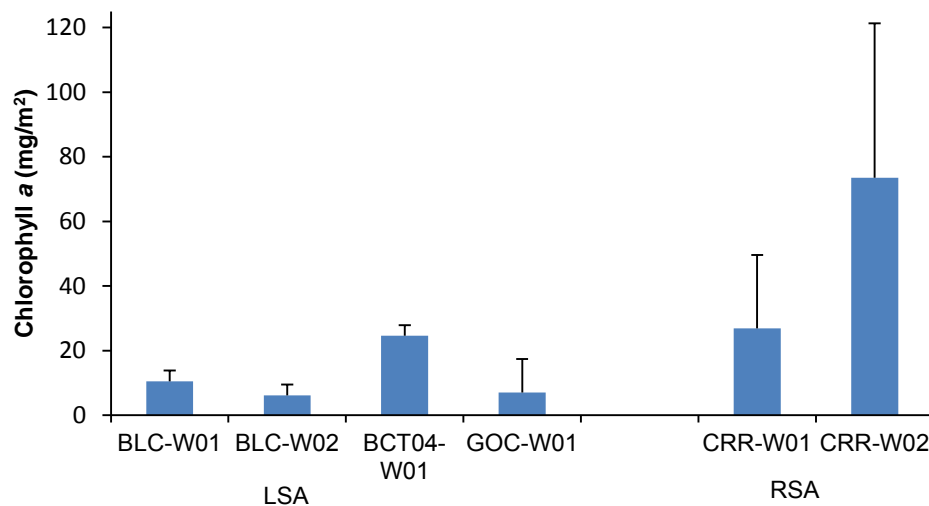
### Local Study Area

Levels of periphyton chlorophyll *a* in the LSA ranged from 6.1 mg/m<sup>2</sup> to 24.6 mg/m<sup>2</sup> with lowest levels measured at the upstream location on Blairmore Creek (BLC-W02) and highest levels at BCT04 (BCT04-W01), respectively (Figure 4.16). Chlorophyll *a* levels were 7.05 mg/m<sup>2</sup> and 10.5 mg/m<sup>2</sup> at the sampling location on Gold Creek (GOC-W01) and the upstream sampling location on Blairmore Creek (BLC-W01), respectively. Water quality conditions (Hatfield 2015) indicate higher levels of phosphorous in BCT04 (BCT04-W01) than elsewhere in the LSA, suggesting the higher periphyton growth at that location may be a result of higher nutrient concentrations. A combination of small substrate particle size, increased forest cover and lower nutrient levels are the likely result of decreased biomass at the Blairmore upstream and Gold Creek locations.

### Regional Study Area

At 73.5 mg/m<sup>2</sup>, chlorophyll *a* concentrations measured at the Crowsnest River upstream location (CRR-W02) were higher than at all other measured locations (Figure 4.16). This site is located on a larger, faster moving channel with larger substrate (i.e., boulders) which, compared to gravel and cobble in smaller streams provide greater surface area for establishment and growth of periphyton. Increased nutrient availability from human settlements may also contribute to increased periphyton abundance biomass in the Crowsnest River; nutrient concentrations measured in the RSA have been generally higher than in the LSA (Hatfield 2015).

**Figure 4.16 Chlorophyll *a* concentrations colonized on substrates in the LSA and the RSA, October 2014.**



## 5.0 SUMMARY OF FINDINGS

### 5.1 FISH HABITAT

The biophysical habitat in Gold and Blairmore creeks is fairly similar. Both watercourses are dominated by coarse substrate (mostly cobble with some gravel and boulders) and have tributaries with a steep gradient (>20%). There are bedrock chutes in the lower reach of Blairmore Creek, one of which creates a permanent barrier to the upstream migration of fish. Gold Creek has two permanent barriers and one seasonal barrier to upstream fish migration. Based on habitat assessment surveys, Gold Creek was delineated into nine reaches, ranging from 437 to 3,183 m long, 4.2 to 10.8 m wide, with a gradient of 0.5% to 3.3%. Blairmore Creek was delineated into five reaches, ranging from 399 to 3,942 m long, 1.1 to 4.9 m wide, with a gradient of 0.4% to 3.6%. At the mesohabitat level, both Gold and Blairmore creeks are also fairly similar, being dominated by fast-flowing habitats. By area, Gold Creek is dominated by pool-riffle (36%), riffle (30%), and riffle-run-pool (14%), and Blairmore Creek is dominated by riffle (42%), pool-riffle (30%), and riffle-run-pool (14%). Stream temperatures in Gold Creek tended to be cooler (5.4°C) than Blairmore Creek (8.0 °C), on average. The coldest average stream temperatures were observed at Caudron Creek (4.3°C), a tributary to Gold Creek.

### 5.2 FISH INVENTORY

WSCT is the only native species that has been detected within the LSA. Non-native RNTR, RNTR x WSCT, and BKTR are present in Gold Creek and Blairmore Creek, with the presence of barriers largely determining their distribution. Five tributaries to Gold Creek (GCT13, GCT10, Caudron Creek, Morin Creek and Green Creek) and three tributaries to Blairmore Creek are fish-bearing (BCT11, BCT09, and BCT04). The 463 fish captured during the 2016 angling and electrofishing surveys ranged from 6 to 30 cm fork length in Gold Creek, and 2 to 26 cm fork length in Blairmore Creek. Overall fish captured in Gold Creek were larger and the YOY cohort was missing.

### 5.3 OVERWINTERING HABITAT SURVEY

The overwintering habitat in both Gold and Blairmore creeks is limited. Pools were at least 0.7 m deep and 10 m long. Four main pools were observed in each creek containing up to 110 WSCT in Gold Creek and 151 WSCT in Blairmore Creek.

### 5.4 WSCT SPAWNER SURVEY

Spawning was largely driven by available habitat. Larger fish (30+ cm) were observed spawning during the May survey, compared to the June survey (20+ cm) in both Gold and Blairmore creeks. Overall, the upper reaches of Gold Creek had more spawning WSCT compared to the lower reaches. Spawning in Blairmore Creek was spread throughout the reaches, with the highest count observed in Reach 4 on the mainstem between BCT06 and BCT05 (22 to 29 mature WSCT).

### 5.5 FISH POPULATION

Gold and Blairmore creeks have a higher density of smaller fish in their upper reaches, compared to their lower reaches which have lower density and larger fish. Density based on snorkel surveys in Gold Creek is

estimated at 0.04 to 1.69 fish/m<sup>2</sup> and the estimated density from the mark-recapture is higher, ranging from 0.24 to 13.13 fish/m<sup>2</sup>. Density based on snorkel surveys in Blairmore Creek is estimated at 2.41 to 3.37 fish/m<sup>2</sup>, and density from the mark-recapture ranges from 0.79 fish/m<sup>2</sup> to 26 fish/m<sup>2</sup>. Based on the mark-recapture, the estimated total fish in Gold Creek is about half (1,625 fish) that of Blairmore Creek (3,210 fish). Juvenile (YOY, 1+ year) recruitment in Gold Creek appears to be limited, which may be due to the colder water flowing in from Caudron Creek. Based on the Fulton K and Relative Weight condition factors, most of the fish (>50%) in both Gold and Blairmore creeks are in good to excellent condition.

## 5.6 TISSUE RESIDUE

The levels of all 34 metals tested were fairly low in all fish sampled in both Gold and Blairmore creeks. Seven metals were below detection limits in at least half of the samples from Gold Creek, and six metals were below detection limits in at least half of the samples from Blairmore Creek. Mercury levels were below the federal consumption guidelines (CFIA 2014, Health Canada 2016) in all samples.

## 5.7 MACROINVERTEBRATES

Based on the 2014 benthic invertebrate surveys, total density in the LSA (3,892 to 7086 individuals/m<sup>2</sup>) was lower than the total density in the RSA (7,706 to 14,302 individuals/m<sup>2</sup>). Diversity and evenness were fairly high across all sites. The proportion of EPT and E were also fairly high, while the proportion of chironimidae were low, which indicates good quality overall. These trends were also reflected in the 2016 drift invertebrate surveys. Periphyton was lower in the LSA (6.1 to 24.6 mg/m<sup>2</sup>), compared to the RSA (26.8 to 73.5 mg/m<sup>2</sup>).

## 6.0 REFERENCES

- [AESRD] Alberta Environment and Sustainable Resource Development (AESRD). 2013a. FWMIS Information for Crowsnest Pass.
- [AESRD] Alberta Environment and Sustainable Resource Development (AESRD). 2013b. Code of Practice for Watercourse Crossings. Accessed on 31 October 2016 at: <http://www.gp.alberta.ca/documents/codes/CROSSING.PDF>.
- Alberta Environment. 1990. Selected methods for the monitoring of benthic invertebrates in Alberta rivers. Edmonton (AB): Environmental Quality Monitoring Branch, Environmental Assessment Division, AENV. 41 pp.
- Alberta Transportation. 2009. Fish Habitat Manual: Guidelines and procedures for watercourse crossings in Alberta. Alberta, Canada, 163 pp.
- Alberta Westslope Trout Recovery Team. 2013. Alberta Westslope Cutthroat Trout Recovery Plan: 2012-2017. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 28. Edmonton, AB. 77 pp.
- Anderson RO, Neumann RM. 1996. Length, weight and associated structural indices. *In*: B.R. Murphy and D.W. Willis (editors). Fisheries Techniques 2nd edition. American Fisheries Society: Bethesda, Maryland.
- Barnham C, Baxter A. 1998. Condition factor K for salmonid fish. FN0005. State of Victoria, Australia.
- Baxter J. 2004. Westslope cutthroat trout studies in the upper Bull River: preliminary surveys conducted in fall 2003. BC Hydro, Environment & Social Issues, Castlegar, BC. 25 p. + 1 app
- Baxter J. 2005. Westslope cutthroat trout studies in the upper Bull River: second year surveys conducted in fall 2004. BC Hydro, Environment & Social Issues, Castlegar, BC. 15 p. +2 app.
- Baxter J. 2006a. Westslope cutthroat trout studies in the upper Bull River: third year surveys conducted in summer/fall 2005. BC Hydro, Environment & Social Issues, Castlegar, BC. 14 p. + app.
- Baxter J. 2006b. Westslope cutthroat trout studies in the upper Bull River: fourth year surveys conducted in summer/fall 2006. BC Hydro, Environment & Social Issues, Castlegar, BC. 11 p. + 2 app
- Baxter J, Hagen J. 2003. Population size, reproductive biology, and habitat use of Westslope cutthroat trout (*Oncorhynchus clarkii lewisii*) in the Wigwam River watershed. Report prepared for Tembec Industries Inc., Cranbrook, B.C. Report prepared by Baxter Environmental and J. Hagen and Associates, Nelson, B.C. 20 p. +7 app.
- [BC EAO] British Columbia Environmental Assessment Office. 2013. Guidelines for the selection of valued components and assessment of potential effects. Environmental Assessment Office, British Columbia, Canada. 45 pp

- [BC MOE] British Columbia Ministry of the Environment. 2016. British Columbia Water and Air Baseline Monitoring Guidance Document. Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators. Technical Guidance 6: Version 2.0., June 2016.
- Bear E, McMahon T, Zale A. 2007. Comparative thermal requirements of westslope cutthroat trout and rainbow trout: implications for species interactions and development of thermal protection standards. *Transactions of the American Fisheries Society* 136:1113-1121
- Behnke RD, M Zarn. 1976. Biology and management of threatened and endangered western trout. US Department of Agriculture, Forest Services General Technical Report RM-28. 45 pp
- Blackburn J. 2011. Crowsnest River drainage sport fish population assessment, 2010. Technical Report, T-2011-001, produced by the Alberta Conservation Association, Lethbridge, Alberta, Canada. 27 pp + App.
- Blackwell BG, Brown ML, Willis DW. 2000. Relative weight ( $W_r$ ) status and current use in fisheries assessment and management. *Revelations in Fish Science* 8(1): 1-44
- Bonneau JL, Scarnecchia DL. 1998. Seasonal and diel changes in habitat use by juvenile bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarkii*) in a mountain stream. *Canadian Journal of Zoology* 76(5): 783-790
- [CFIA] Canadian Food Inspection Agency [Internet]. 2014. Fish products standards and methods manual; [updated 2014 August; cited 2016 Nov 21]. Available from: <http://www.inspection.gc.ca/food/fish-and-seafood/manuals/standards-and-methods/eng/1348608971859/1348609209602>
- Chapman DG. 1945. The estimation of biological populations. *The Annals of Mathematical Statistics*. 25(1): 1-15
- Coleman MA, Fausch KD. 2007. Cold summer temperature regimes cause a recruitment bottleneck in age-0 Colorado River cutthroat trout reared in laboratory streams. *Transactions of the American Fisheries Society*, 136(3): 639-654.
- Cook N, Rahel FJ, Hubert WA. 2010. Persistence of Colorado River cutthroat trout populations in isolated headwater streams of Wyoming. *Transactions of the American Fisheries Society*, 139(5): 1500-1510.
- [DFO] Fisheries and Oceans Canada. 2014. Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada [Final]. Ottawa: Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada.
- Environment Canada. 2002. Revised Guidance for Sample Sorting and Subsampling Protocols for EEM Benthic Invertebrate Community Surveys. National EEM Office, Ottawa, ON, Canada.
- Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. National EEM Office, Ottawa, ON, Canada.

- Fausch KD. 1989. Do gradient and temperature affect distributions of, and interactions between, brook charr (*Salvelinus fontinalis*) and other resident salmonids in streams? *Physiology and Ecology Japan*, Special Volume 1:303–322.
- Frenette JL. 2008. An evaluation of benthic invertebrate communities as an indicator of stream ecosystem health below active coal mines in the Elk River watershed. [Thesis]. Royal Roads University. 23 pp.
- Gibbons WN, Munn MD, Paine MD, EVS Environmental Consultants. 1993. Guidelines for Monitoring Benthos in Freshwater Environments. Environment Canada. North Vancouver, BC.
- Hasnain S. 2012. Factors influencing ecological metrics of thermal response in North American freshwater fish. [MSc. Thesis].
- [Hatfield] Hatfield Consultants. 2015. Grassy Mountain Project Aquatic Resources Baseline and Effects Assessment Report. Prepared for Benga Mining Ltd.
- [Hatfield] Hatfield Consultants. 2016a. Grassy Mountain Coal Project: Instream Flow Needs Assessment Report. Prepared for Benga Mining Ltd.
- [Hatfield] Hatfield Consultants. 2016b. Grassy Mountain Coal Project: Surface Water Quality Assessment Report. Prepared for Benga Mining Ltd.
- [Hatfield] Hatfield Consultants. 2016c. Grassy Mountain Coal Project: 2016 Fisheries and Aquatic Resources Work Plan. Prepared for Benga Mining Ltd.
- Hauer FR, Lamberti GA (editors). 2006. *Methods in stream ecology*. 2nd ed. Academic Press, San Diego, California, USA
- Health Canada [Internet]. 2016. Health Canada's maximum levels for chemical contaminants in foods; [updated 2016 May 4; cited 2016 Nov 21]. Available from: <http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/contaminants-guidelines-directives-eng.php>
- Jakober M, McMahon T, Thurow R, Clancy C. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. *Transactions of the American Fisheries Society*. 127: 223-235
- Kalb B. 2013. A bioenergetic assessment of seasonal habitat selection and behavioural thermoregulation of rainbow trout (*Oncorhynchus mykiss*) in a southwestern headwater stream [Thesis]. [New Mexico]: New Mexico State University.
- Krebs CJ. 1985. *Ecology: The Experimental Analysis of Distribution and Abundance*. Third Edition. Harper and Row, New York. 800 pp.
- Kruse CG, Hubert WA. 1997 Proposed standard weight ( $W_r$ ) equations for inland cutthroat trout. *N.A. Journal Fish Man.*17:784-790
- Lagler KF. 1956. *Freshwater fish biology*. WC Brown Company: Dubuque, Iowa. 107 A. pp 131-135; 159-166

- Lotic Environmental. 2015. Elkview Operations Baldy Ridge Extension Project – Fish and Fish Habitat Baseline Assessment. Prepared for Teck Coal Ltd. 244 pp. + 25 appendices
- Leach JA, Moore RD, Hinch SG, Gomi T. 2012. Estimation of forest harvesting-induced stream temperature changes and bioenergetic consequences for cutthroat trout in a coastal stream in British Columbia, Canada. *Aquatic Sciences* 74: 427-441
- Lewis A, Hatfield T, Chilibeck B, Roberts C. 2004. Assessment Methods for Aquatic Habitat and Instream Flow Characteristics in Support of Applications to Dam, Divert, or Extract Water from Streams in British Columbia. Report prepared for Ministry of Water, Land, and Air Protection and Ministry of Sustainable Resources Management. 62 pp. plus appendices. Accessed on 21 September 2015 at [http://www.env.gov.bc.ca/wld/documents/bmp/assessment\\_methods\\_instreamflow\\_in\\_bc.pdf](http://www.env.gov.bc.ca/wld/documents/bmp/assessment_methods_instreamflow_in_bc.pdf).
- Magee JP, TE McMahon, RF Thurow. 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. *Transactions of the American Fisheries Society* 125(5): 768-779
- Magnuson J, Crowder L, Medvick P. 1979. Temperature as an ecological resource. *American Zoology* 19:331-343
- O’Neal J. 2007. Snorkel surveys. (pp 325-340) *In: Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations*. Johnson DH, BM Shrier, JS O’Neal, JA Knutzen, X Augerot, TA O’Neil, and TN Pearsons (Eds.) American Fisheries Society, Bethesda, Maryland
- Parker M. 2000. Fish Passage – Culvert inspection procedures. Ministry of Environment, Lands and Parks, Williams Lake, BC, Canada. 52 pp
- Piikani Nation. 2015. Public Report on Piikani Traditional Knowledge and Use of the Grassy Mountain Area. Report compiled by Kai Scott and Natasha Thorpe. 64 pp.
- Pond GJ, Passmore ME, Borsuk FA, Reynolds L, Rose CJ. 2008. Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus- level macroinvertebrate bioassessment tools. *Journal of the North American Benthological Society*. 27(3): 717-737.
- Rasmussen JB, Robinson MD, Hontela A, Heath D. 2012. Metabolic traits of westslope cutthroat trout, introduced rainbow trout and their hybrids in an ecotonal hybrid zone along an elevation gradient. *Biological Journal of the Linnean Society* 105: 56-72
- Ree M. 2014. Spatial and temporal variation of benthic macroinvertebrate communities in three Westslope Cutthroat Trout tributaries in the Rocky Mountains. Undergraduate Thesis. Concordia University College of Alberta. 27 pp.
- Reiser DW, Chi-Ming H, Beck S, Gagner M, Jeanes E. 2006. Defining flow windows for upstream passage of adult anadromous salmonids at cascades and falls. *Transactions of the American Fisheries Society* 135: 668-679.
- Slaney P, Zaldokas D (editors). 1997. Fish Habitat Rehabilitation Procedures. Ministry of Environment, Lands and Parks, Ministry of Forests. Vancouver, BC. 313 pp.

- SNC-Lavalin. 2016. Grassy Mountain Coal Project: fluvial geomorphology assessment of Blairmore Creek and Gold Creek. Prepared for Hatfield Consultants
- Taylor EB, Stamford MD, Baxter JS. 2003. Population subdivision in westslope cutthroat trout (*Oncorhynchus clarki lewisii*) at the northern periphery of its range: evolutionary inferences and conservation implications. *Molecular ecology*, 12(10), 2609-2622.
- Tsuut'ina Nation. 2015. Public Report on Tsuut'ina Traditional Knowledge and Use of the Grassy Mountain Area. Report compiled by Natasha Thorpe and Kai Scott. 53 pp.
- Ward W. 2011. Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams. Vol. 1. Washington Department of Ecology. Approved October 26, 2011.
- Wege GJ, Anderson RO. 1978. Relative weight (Wr): A new index of condition for largemouth bass. pp 79-91 *In*: Novinger GD, Dillard JG (Eds.). *New approaches to the management of small impoundments*. American Fisheries Society Symposium 4. Bethesda, Maryland.
- Yau MM, Taylor EB. 2014. Cold tolerance performance of westslope cutthroat trout (*Oncorhynchus clarkia lewisii*) and rainbow trout (*Oncorhynchus mykiss*) and its potential role in influencing interspecific hybridization. *Canadian Journal of Zoology* 92: 777-784
- Young MK, Guenther-Gloss P. M. 2004. Population Characteristics of Greenback Cutthroat Trout in Streams: Their Relation to Model Predictions and Recovery Criteria. *North American Journal of Fisheries Management*, 24(1): 184-197.

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## **APPENDICES**

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**Appendix A1**

**Drift Invertebrate Technical Baseline  
Report**

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## **Grassy Mountain Coal Project**

### **Drift Invertebrate Technical Baseline Report**

**December 2016**

*Prepared for:*

**Benga Mining Limited**  
Blairmore, Alberta

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# GRASSY MOUNTAIN COAL PROJECT: DRIFT INVERTEBRATE TECHNICAL BASELINE REPORT

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**DECEMBER 2016**

MEMS7779  
VERSION 2

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## EXECUTIVE SUMMARY

This report strengthens existing baseline knowledge of lower trophic (secondary producer) dynamics in the Blairmore Creek and Gold Creek mainstems, by characterizing and quantifying drift invertebrate assemblages. Findings from this study expand the existing invertebrate baseline data set, with specific consideration of potential flow-related effects of the Project on invertebrate productivity. Drift invertebrates play a fundamental role in stream productivity by providing a key foraging resource for trout species. Three sites on each Blairmore Creek and Gold Creek within the Project's local study area (LSA) were selected for sampling across two seasons in June and September. Sampling sites were arranged from near the headwaters, downstream to two sites located upstream and downstream of key tributaries entering the main channels. Drift invertebrate indices examined included density (no./m<sup>3</sup>), biomass (g/m<sup>3</sup>), taxonomic structure, diversity, and evenness of the assemblages. Results indicated that Blairmore and Gold creeks were similar across all indices examined. June was more productive for drift invertebrates in comparison to September. In most cases, density and diversity were higher in June samples, whereas biomass was consistently highest in June. Evenness was relatively low across all sites reflecting the presence of large and dominant taxonomic groups. Inputs of terrestrial invertebrates contributed a large proportion (up to 44.1%) to the drift assemblages. Three additional taxa including Baetidae (mayflies), Orthocladiinae (midges) and Ostracoda (crustaceans) were consistently dominant across sites and season. Percent (%) EPT and %E was high across all sites suggesting cool streams with good water quality. Overall, the presence of drift invertebrate density, biomass, and taxa suggests that Blairmore and Gold creeks provides a primary foraging resource for Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) and, under current baseline conditions, greatly contributes to overall stream productivity.

## DISTRIBUTION LIST

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## AMENDMENT RECORD

This report has been issued and amended as follows:

Issue	Description	Date	Approved by
1	First version of Draft Invertebrate Technical Baseline Report	20161130	
2	Final version of Invertebrate Technical Baseline Report	20161222	<Original signed by>

Martin Davies	Cory Bettles
Project Director	Project Manager

## ACKNOWLEDGEMENTS

This report was prepared for Benga Mining Limited by Hatfield Consultants. Cory Bettles (MSc, RPBio, FP-C) managed the 2016 to present field and reporting programs for the Project. This report was written by Sarah Quesnelle (MSc) and reviewed by Cory Bettles (MSc, RPBio, FP-C) and Martin Davies (MSc, RPBio). Fieldwork was conducted by Kerry Head (MSc, PBio), David Khan (PEng), and Sarah Quesnelle (MSc).

## 1.0 INTRODUCTION

### 1.1 BACKGROUND

Benga Mining Limited (Benga), a wholly owned subsidiary of Riversdale Resources Limited (Riversdale), is proposing to develop the Grassy Mountain Coal Project (the Project). The Project is to be located along the eastern edge of the Rocky Mountain foothills approximately 90 km southwest of Fort McLeod, Alberta, in the municipality of Crowsnest Pass (Figure 1.1). The Project is situated in the watersheds of Blairmore and Gold creeks, which are major drainages in the Crowsnest River watershed, itself a major drainage in the Oldman River system.

The information presented herein provides baseline data describing lower trophic dynamics specifically relevant to assessment of potential Project effects on creek flows. This report has been prepared as an appendix to the Fish and Aquatic Technical Baseline Report (Hatfield 2016a). Aquatic resource baseline information (e.g., benthic invertebrates and periphyton) collected in previous years specific to the Project are presented in the Fish and Aquatic Technical Baseline Report.

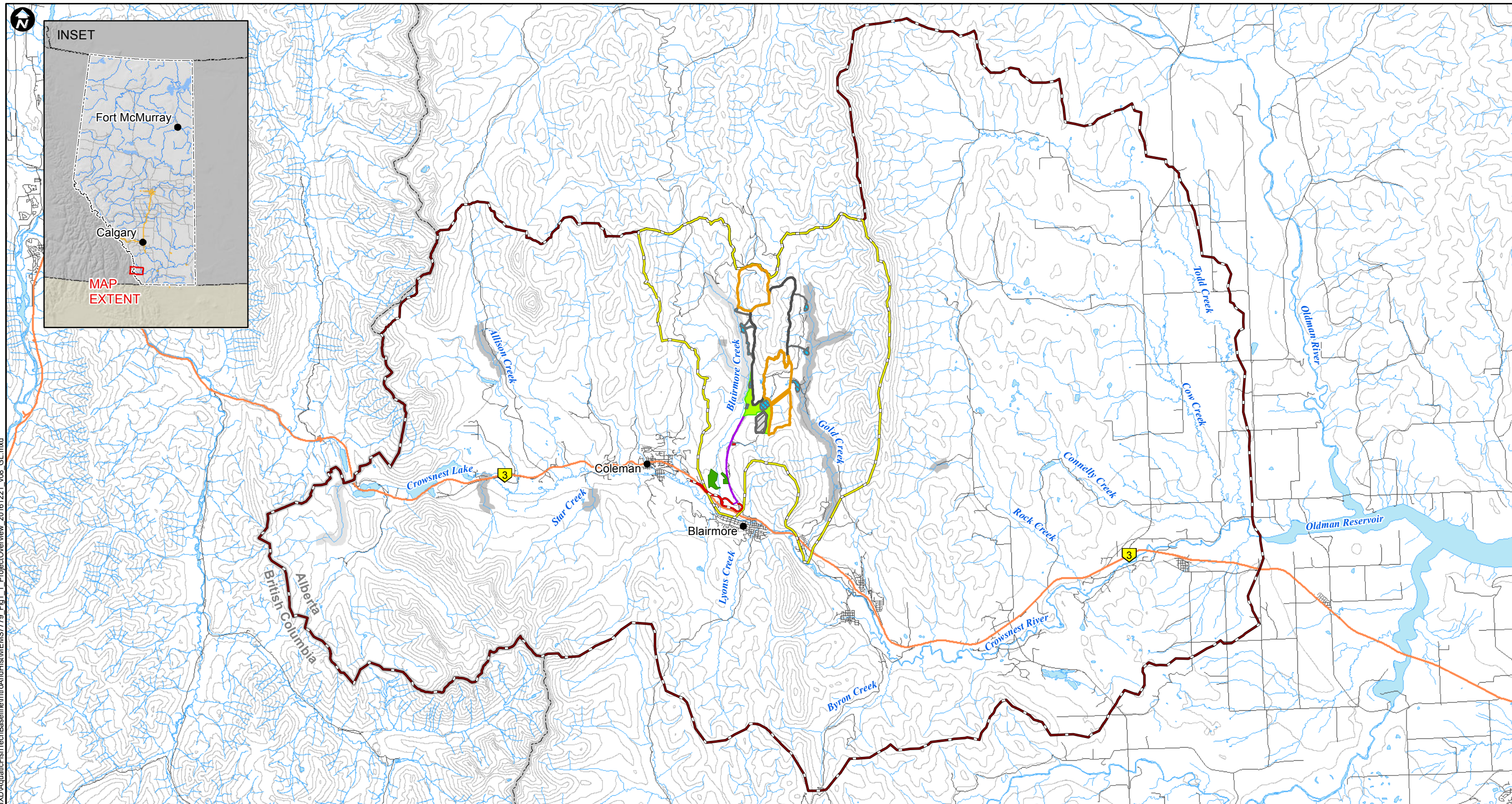
### 1.2 PURPOSE

This report strengthens existing baseline knowledge of lower trophic (secondary producer) dynamics in the Blairmore Creek and Gold Creek mainstems, by characterizing and quantifying drift invertebrate assemblages. Findings from this study expand the existing invertebrate baseline data set, with specific consideration of potential flow-related effects of the Project on invertebrate productivity.


Invertebrate drift describes the process of downstream movement of terrestrial and aquatic invertebrates suspended in the channel (Leung et al. 2009; Naman et al. 2016). Drift includes active and passive movement of invertebrates in the stream channel, moving in the water column either intentionally (e.g., feeding or escaping predation) or accidentally (e.g., when a benthic invertebrate loses contact with the substrate) (Dewson et al. 2007; Naman et al. 2016) and may include terrestrial invertebrates contributed by the riparian community. Invertebrate drift is widely recognized as a fundamental ecological process in lotic environments and can be a nearly exclusive food source for drift-foraging fish such as stream-resident trout (Elliot 1973; Wipfli and Gregovich 2002; Romaniszyn et al. 2006; Leung et al. 2009; Naman et al. 2016; Jenkins and Keeley 2010). The biomass and production (including growth) of cutthroat trout are strongly correlated to drift invertebrate density (Romaniszyn et al. 2006). The sustained productivity of fish stocks (populations), such as the Westslope Cutthroat Trout (WSCT; *Oncorhynchus clarkii lewisi*) inhabiting Blairmore and Gold creeks, is thereby the primary logic for inclusion of this baseline study.

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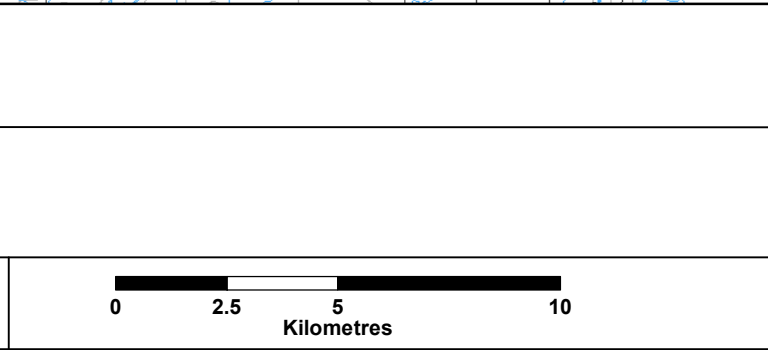



LEGEND		
Identified Westslope Cutthroat Trout Critical Habitat	Watercourse	Ponds and Ditches
Near Pure WSCT (95% to 99% pure) Provincial Conservation Designation	Waterbody	Construction Camp
Primary Highway	Local Study Area	Covered Conveyor, Access Road and Powerline ROW
Road	Regional Study Area	Coal Handling Processing Plant and Infrastructure
100m Contour	Ultimate Pit Extent	Proposed Golf Course Area
	Ultimate Rock Disposal Area Extent	Railway Loop
	Topsoil Storage	

**PROJECT**  
 **RIVERSDALE RESOURCES** **GRASSY MOUNTAIN COAL PROJECT**

**TITLE**  
**OVERVIEW OF PROJECT LOCATION**

**NOTES**  
 Data Sources: Government of Canada, Government of Alberta  
 Datum/Projection: UTM NAD 83 Zone 11



  
**Hatfield CONSULTANTS**

PROJECT: 7779  
 DRAWN BY: SS / EDITED BY: GL  
 CHECKED BY: CB  
 DATE: December 21, 2016

**FIGURE**  
**1.1**

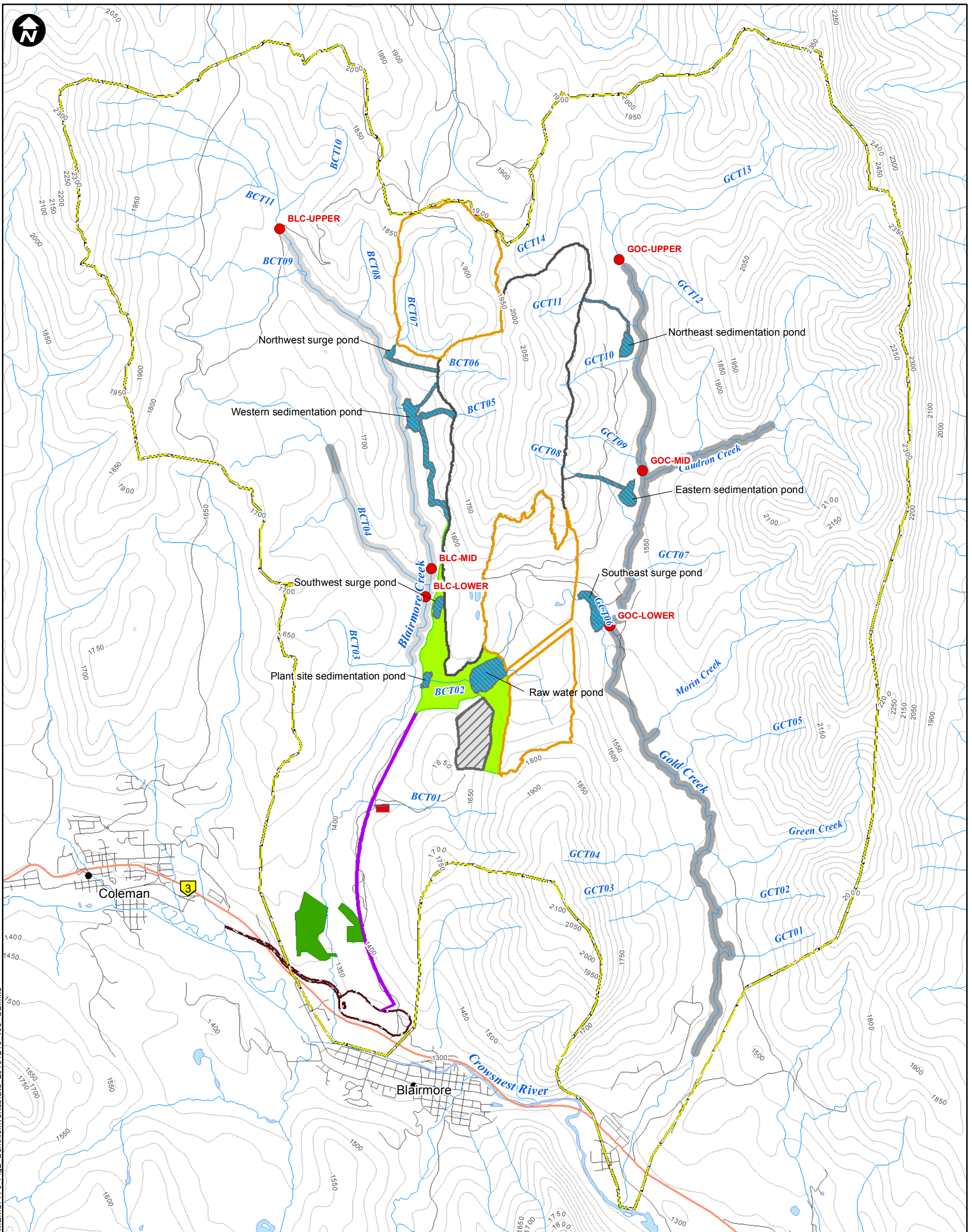
## 2.0 METHODS

### 2.1 SAMPLE COLLECTION

Drift invertebrate sampling locations, dates and duration appear in [Table 2.1](#). All sites were georeferenced in the field at the time of sampling with a handheld GPS unit and recorded on field datasheets. Site locations are illustrated in [Figure 2.1](#) within the LSA. Site names describe each site's location, with "BLC" and "GOC" abbreviations indicating Blairmore and Gold creeks, respectively.

Uppermost sites were located near the headwaters of each system and indicated by "UPPER" in site names. Lower sites were selected based on their location upstream and downstream of key tributaries to each Blairmore Creek and Gold Creek. On Blairmore Creek, the sample site located upstream of the major tributary known as "BCT04" is indicated by "MID" in the site name. On Gold Creek, the "MID" site is located upstream of Caudron Creek, an important tributary to Gold Creek. Site names including "LOWER" are located furthest downstream on both creeks, and downstream of the confluences with the tributaries described herein. Due to access and channel morphology, the "LOWER" site on Blairmore Creek is geographically closer in comparison to the "LOWER" Gold Creek site. More information about these tributaries can be found in the Fish and Aquatic Technical Baseline report (Section 2.0 in Hatfield 2016a).

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**LEGEND**

- Invertebrate Sampling Location
- Identified Westslope Cutthroat Trout Critical Habitat (greater than 99% pure)
- Near Pure WSCT Population (95% to 99% pure)
- Primary Highway
- Road
- 50 m Contour
- Watercourse
- Waterbody
- Local Study Area
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Ponds and Ditches
- Construction Camp
- Covered Conveyor, Access Road and Powerline ROW
- Coal Handling Processing Plant and Infrastructure
- Proposed Golf Course Area
- Railway Loop

**PROJECT**

**RIVERSDALE GRASSY MOUNTAIN COAL PROJECT**  
RESOURCES



**TITLE**

**DRIFT INVERTEBRATE SAMPLING LOCATIONS, JUNE AND SEPTEMBER 2016**

**NOTES**

Data Sources: Government of Canada, Government of Alberta  
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 7779

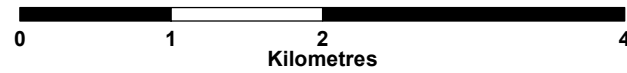
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DATE: December 16, 2016

**FIGURE**

**2.1**



**Table 2.1 Drift Invertebrate sampling site locations and timing for Blairmore Creek and Gold Creek.**

Site	Sample Date <sup>1</sup> (DD-MMM-YY)	UTM Coordinate		Start Time <sup>2</sup>	End Time <sup>3</sup>	Sampling Duration <sup>4</sup> (hr:min)
		Easting	Northing			
<b>Blairmore Creek</b>						
BLC-UPPER	29-Jun-16	682926	5509935	15:49	19:51	4:08
	15-Sep-16			07:35	11:36	4:01
BLC-MID	29-Jun-16	684938	5504980	08:23	12:34	4:11
	14-Sep-16			13:42	17:55	4:13
BLC-LOWER	29-Jun-16	684896	5504889	09:05	13:25	4:20
	14-Sep-16			14:05	18:00	3:55
<b>Gold Creek</b>						
GOC-UPPER	28-Jun-16	687564	5509517	16:09	20:08	3:59
	15-Sep-16			13:36	17:38	4:02
GOC-MID	28-Jun-16	687882	5506616	09:32	13:40	4:08
	14-Sep-16			09:50	12:17	3:57
GOC-LOWER	30-Jun-16	687431	5504492	07:24	11:30	4:06
	13-Sep-16			09:54	13:44	3:50

<sup>1</sup> Indicates both dates within summer (June) and fall (September) seasons of sampling.

<sup>2</sup> Indicates when the first net was set.

<sup>3</sup> Indicates when the last net was removed.

<sup>4</sup> Indicates the duration from when the first net was set and the last net removed.

At each sample site, areas with velocities of 0.2 to 0.4 m/s (at 60% depth) were identified for setting nets using an Acoustic Doppler Velocimeter with top-set rod (ADV; SonTek FlowTracker Handheld; accuracy = 1% of measured velocity). As outlined in Hatfield et al. (2007) and Ganshorn and Lewis (2011), nets set in this range are optimal for sampling drift invertebrates, given fish are not actively foraging and less filtered material can clog nets relative to higher flows. Depending on time of year and size of systems sampled, this range of velocities was not always present for sampling; sampling was most often conducted in lower velocities in June and always in September. The range of flows sampled was conducted across riffle habitat at each sample site.

At each sampling site (transect), 250-µm-mesh nets measuring 0.31 m width by 0.31 m height with a 1.0 m tapered length were anchored into the channel using 10-mm rebar, ensuring tops of nets were above the water surface. Up to five nets were deployed simultaneously across the wetted width of the channel. Given Blairmore Creek and Gold Creek are small watercourses (i.e., <5.0 m wetted width), the number of replicate nets deployed at each site equalled the number of nets that fit across the wetted width of the channel. Photos demonstrating net placement in the channel within sampling sites can be found in Appendix A1. Each net opening was placed facing upstream and perpendicular to the direction of flow, and spaced so that there was no obstruction to flows leading to each net. Whenever a net was set or removed, time was recorded as well as water temperature (°C) using a Hanna Combo pH/EC instrument.

Water depth (m) and velocity (m/s) at the center of each net mouth was measured using an ADV every 60 to 90 minutes. These frequent measurements of velocity accounted for any variation in volume of filtered water over the duration of the set. Nets were checked visually for clogging, with any organic material gently moved to the downstream end of the net to restore filtration efficiency. Care was taken not to disturb any upstream areas, including substrate and riparian vegetation, over the duration of sampling.

After four hours of sampling, final measurements of depth, velocity, and water temperature were taken and all nets were removed from the channel. Nets were placed on the streambank in a manner that organics and invertebrates captured in the net would remain submerged in site water. Rebar was left in place in the channel and a final, post-sampling depth and velocity measurement was performed with nets removed.

From each net, all contents adhered to the interior mesh was washed downward from the exterior with creek water. Contents from each net were transferred to a 250- $\mu$ m mesh sieve. Any remaining contents on the nets were washed in the mesh sieve using a squirt bottle filled with creek water. Contents were transferred into 500-mL plastic jars with leakproof, screw-top lids and preserved on site with a 10% formalin solution. Each sample jar was filled to a maximum of 50% with material and preserved. Remaining empty volume of sample jars were topped up with creek water to minimize movement and potential damage to specimens. Each jar was labelled three times (i.e., lid, side and with a waterproof interior label) with the site name, net number and date. Jar lids were then sealed with duct tape to prevent lids from shifting and double packed in re-sealable bags to isolate any leaks.

Additional site information also was measured at the start of each net sampling period, including air temperature and in-situ water quality data, i.e., pH, conductivity ( $\mu$ S), dissolved oxygen (mg/L). Habitat information including wetted and channel width, substrate composition, organic matter presence, and visual estimates of riparian overhang (%) and canopy closure (%) were recorded on field data sheets. Digital photographs of each site also were collected, in the sequence of upstream, downstream, right downstream bank and left downstream bank. All data and photographs are included in appendices.

## 2.2 LAB PROCESSING

Samples were submitted to Jack Zloty, Ph.D. in Summerland, BC for processing, and processed following standard protocols based on Environment Canada (2002) and Gibbons et al. (1993). Invertebrate samples were first washed through a 250- $\mu$ m sieve to remove preservative and any fine sediments remaining after field sieving. Organic material was separated from inorganic material using elutriation, and inorganic material was checked for any remaining shelled or cased invertebrates, which were removed and added to the organic material. Coarse fractions were sorted in their entirety. Fine fractions of samples containing large amounts of detritus or large numbers of organisms were subsampled using the device described by Wrona et al. (1982). All remaining material was preserved for random checks of sorting efficiency.

One replicate (or net) from each site was processed for taxonomy from both sample months. Invertebrates were identified to the levels recommended by Alberta Environment (1990) and Environment Canada (2010, 2012), typically Genus for most invertebrates. Damaged organisms and early-instar-stage insects were identified to the lowest level possible, generally to family. Terrestrial invertebrates were

grouped into one category and not identified further. Organisms that required detailed microscopic examination for identification (i.e., Chironomidae and Oligochaeta) were mounted on microscope slides using appropriate media. All rare or less commonly occurring taxa were mounted on microscope slides for identification.

Data were presented as the number of organisms per sample (organisms/sample) for individual taxa. Unlike taxonomy data, all replicates were processed for biomass. The biomass, in units of grams wet weight (g ww), for major taxonomic groups was estimated for each replicate and presented in the raw dataset. As part of the QC program, the re-sorting of benthic sample residues was conducted on 10% of the samples to determine the level of sorting efficiency.

## 2.3 DATA ANALYSIS

Density (number of individuals) and biomass (g wet weight) data were expressed in units of volume ( $m^3$ ) for the amount of water that was filtered through each net. Volume was calculated as per Ganshorn and Lewis (2011), by multiplying the average velocity measured at each net by the area sampled (average water depth recorded at set and removal by the width of the net opening) and by the duration of sampling. Simpson's diversity index (D) was calculated using taxa at the Family level (or Subfamily for Chironomidae) as the lowest level using the following formula:

$$D = 1 - \sum (p_i)^2$$

where  $p_i$  is the proportion that taxon  $i$  contributes to the total number of invertebrates in a sample.

Evenness (S) was also calculated as a measure of diversity that incorporates abundance and is standardized against the "maximum possible" diversity (defined as a community with equal numbers of all taxa present), where:

$$\text{Evenness} = \frac{D}{D_{\max}}$$

$$D_{\max} = 1 - \left( \frac{1}{S} \right)$$

The top five and top ten taxa (based on Family level or higher) comprising invertebrate drift was determined by the percent contribution of each taxa based on density. Terrestrial organisms were grouped together to determine the contribution of invertebrates from outside of the free-swimming and benthic community. The terrestrial group was not included when calculating diversity or evenness.

R Statistical Software (Version 3.4.4) was used to run a Bray-Curtis analysis as a measurement of dissimilarity between samples and sites on each Blairmore Creek and Gold Creek. The resulting output of the Bray-Curtis was then examined using a cluster analysis dendrogram. This method uses a hierarchical clustering linking group means, where the sample data is broken down into groups based on similarities. In this case, biomass data ( $g/m^3$ ) was used across transects (i.e., replicates), sites, and seasons to determine if the sample locations grouped based on the biomass of the drift invertebrates. Ward's hierarchical clustering (Ward 1963) using Euclidean distances was used in the cluster analysis. Values of

each variable were standardized to a mean of zero and divided by the standard deviation (ter Braak and Smilauer 2002) to account for the large differences in scale between taxa.

Additional indices evaluated as potential indicators of baseline water quality included the proportion of the invertebrate population represented by mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) (%EPT), Ephemeroptera (%E), and Chironomidae (%Chironomidae) collected from each sample site. These EPT taxa are widely recognized to be sensitive to habitat change and indicative of good water quality conditions. The use of %E alone has been found to be a useful indicator of downstream effects of coal mining (Frenette 2008; Pond et al. 2008). Chironomid taxa are known to be tolerant of disturbance.

## 3.0 RESULTS

### 3.1 BLAIRMORE CREEK

Drift invertebrate density and biomass in Blairmore Creek were higher in summer (June) than in fall, and increased with distance downstream, with peak density at BLC-LOWER in summer more than double that of the next highest density observed (Figure 3.1). Average within-site variability in biomass was somewhat higher in fall than in summer.

Examination of the taxa illustrated a relatively consistent and high Simpson's diversity index across sites from both seasons (Figure 3.1). Taxa evenness was relatively low across all sites and seasons indicating a few taxonomic groups generally dominated most samples. Evenness was generally lower in summer than in fall. Although the evenness of taxa is low, the high diversity index takes both taxa richness and abundance into account. The high diversity suggests that the Blairmore Creek invertebrate community is well distributed, and the channel is able to support the habitat requirements of a diverse a range of organisms.

Top taxa represented at each site (by proportion of total density) appear in Figure 3.2. In June, terrestrial invertebrates contributed a large proportion (26.3% to 44.1%) to the drift assemblage. The top five taxa were relatively consistent between sites and in addition to terrestrials, included Baetid mayflies, Orthoclad non-biting midges, ostracods (seed-shrimp), and Ephemerellid (spiny crawler) mayflies. The top five taxa contributed 77.0% to 82.7% of the total drift assemblage. The top ten taxa, which varied across sites, contributed 90.9% to 92.6% of the total drift in June. In September, drift also was dominated by terrestrial invertebrates (18.0% to 34.6%) and Baetids (20.9% to 36.0%). Other taxa that completed the top three contributors to density at different sites included ostracods and Orthoclad midges (although these midges were not among the top ten taxa at BLC-UPPER). The taxon with the third highest contribution to density at BLC-UPPER Spermichontid water mites. The remaining taxa in the top five (by percent contribution) were similar to that observed in summer, although within-site variability was higher in fall. Additional taxa completing the top five grouping included Spermichontids, Ephemerellid mayflies, and pupal-stage midges (Chironomidae). In total, the top five taxa comprised 77.4% to 90.9% of the drift assemblage in fall, and the top ten taxa represented over 90% of the observed drift assemblage density (Figure 3.2).

**Figure 3.1** Drift Invertebrate density (no./m<sup>3</sup>), mean biomass (± standard deviation), Simpson’s diversity index and evenness for June (summer) and September (fall) 2016 on Blairmore Creek and Gold Creek.

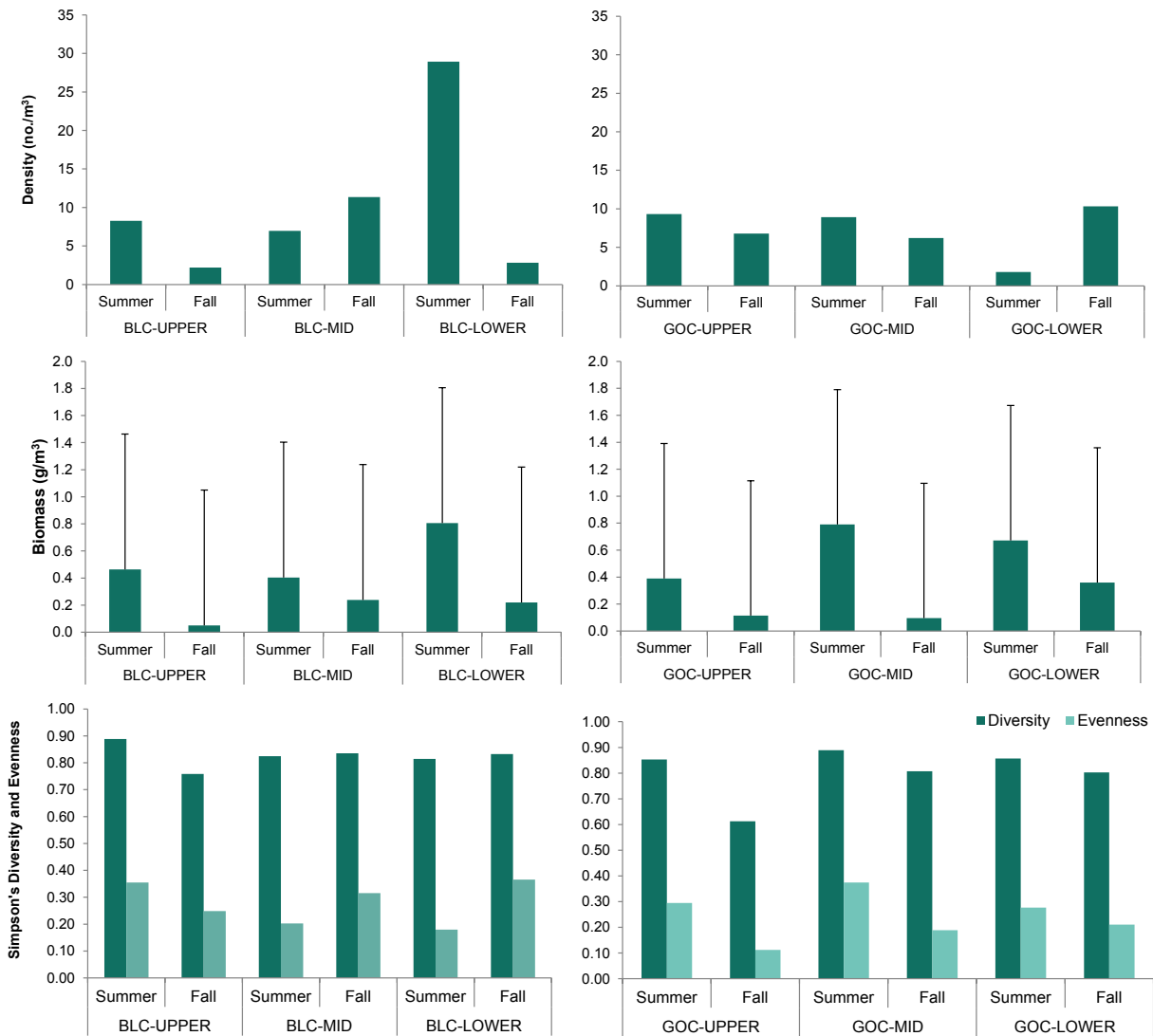
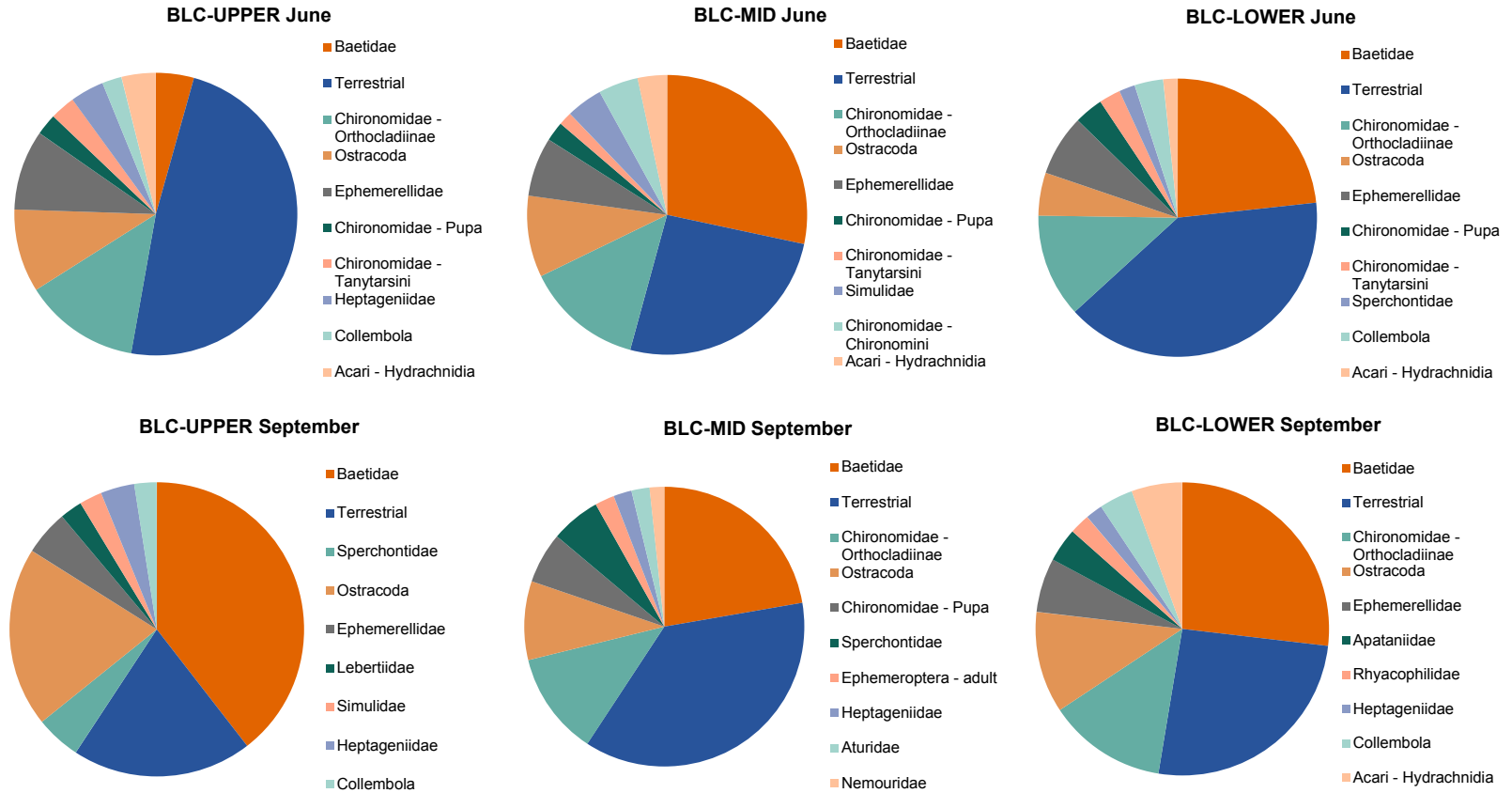
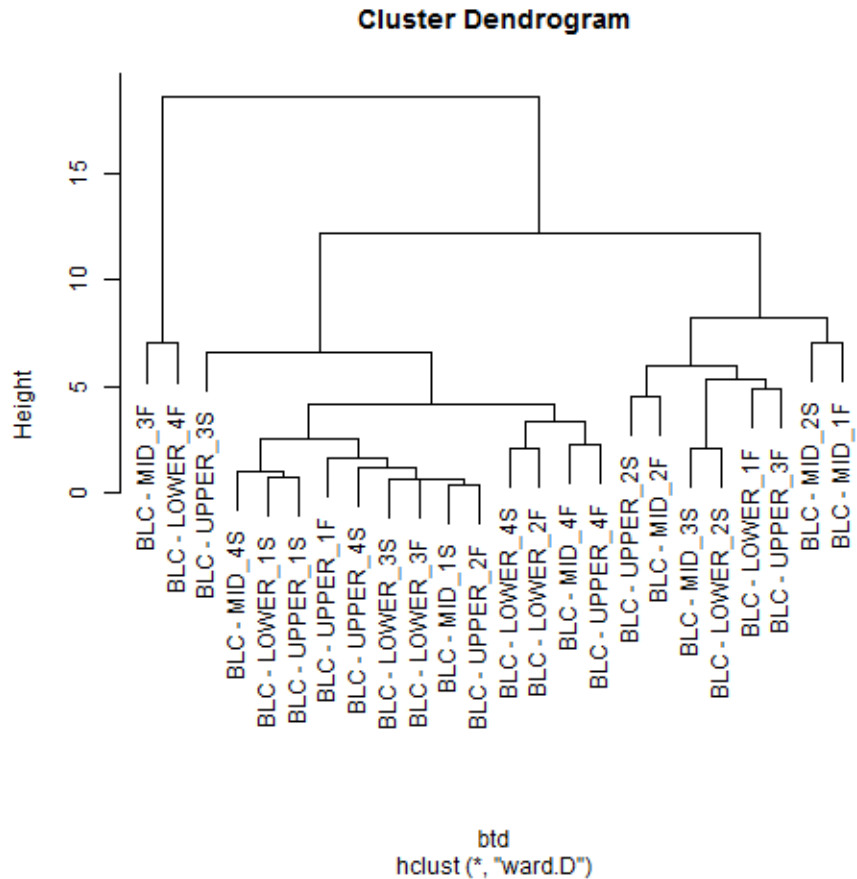


Figure 3.3 presents a dendrogram (cluster analysis) of community similarity based on Bray-Curtis index, with all sites and seasons included. The vertical axis of the dendrogram represents the distance (or dissimilarity) between sites. Drift communities in the Blairmore Creek mainstem were generally similar in composition among sites and between seasons. Greatest dissimilarity was observed in BLC-MID and BLC-LOWER communities in fall, which had higher within-site variability than other sites possibility resulting from tributary influence.

**Figure 3.2 Top ten taxa by percent (%) contribution to density in the Blairmore Creek drift invertebrate sampling sites, June and September, 2016.**



**Figure 3.3** Bray-Curtis cluster analysis results for Blairmore Creek, June and September 2016.



Note: Site name labels correspond to replicates and season. "S" indicates summer or June, as "F" indicates fall or September.

Table 3.1 outlines %EPT, %E and %Chironomidae proportions for Blairmore Creek. Consistent with the documented top ten taxa, EPT comprised the majority of drift, ranging from 21.0% to 50.6%. With the exception of BLC-MID, %EPT and %E was higher in September than in June. Chironomids were less common than EPT taxa, and more common in summer than fall. The presence and proportions of these taxa suggests that Blairmore Creek is a turbulent, cool-water system with good water quality.

**Table 3.1** Proportions of Ephemeroptera, Plecoptera and Trichoptera (%EPT), Ephemeroptera (%E), and Chironomidae (%Chironomidae) in the Blairmore Creek drift invertebrate sampling sites, June and September, 2016.

	BLC-UPPER		BLC-MID		BLC-LOWER	
Season	Summer	Fall	Summer	Fall	Summer	Fall
%EPT	21.0	50.6	34.8	28.1	31.1	40.4
%E	16.5	44.9	34.1	25.6	30.0	32.8
%Chironomidae	17.7	0.0	22.6	17.3	18.1	15.7

## 3.2 GOLD CREEK

Drift densities and biomass on Gold Creek was generally consistent across sampling sites and seasons, and typically higher in summer than in fall with the exception of the GOC-LOWER site in summer, where density was lower than at other sites in summer or fall (Figure 3.1). Density and biomass values in summer and fall in Gold Creek were similar to those in Blairmore Creek except at lower creek sites (i.e., GOC-LOWER and BLC-LOWER), where highest densities were observed in Blairmore Creek but lowest densities were observed in Gold Creek.

Simpson's diversity index was consistently high across sites and seasons, except at GOC-UPPER in fall (Figure 3.1). Simpson's diversity and evenness both were consistently higher in summer than in fall, indicating a greater distribution of taxa within samples during the summer.

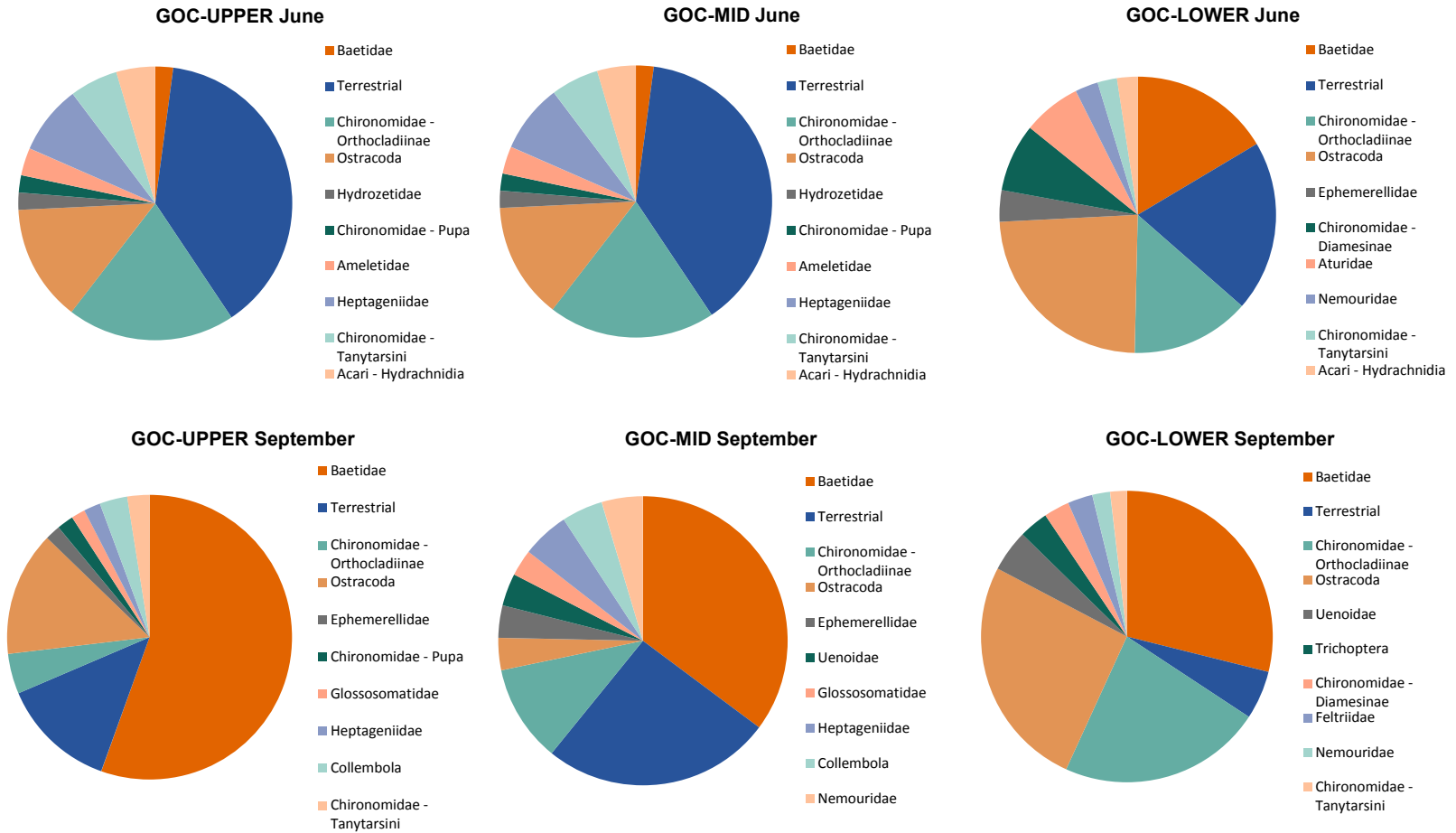
The top ten taxa by proportion of total site density at each site appear in Figure 3.4. Terrestrial invertebrates were large contributors to drift at all sites, ranging from 18.1% to 35.3% of the total assemblage. The top three taxa varied across sites, but generally consisted of ostracods, Baetid mayflies, Orthoclad midges, and Ephemerellid mayflies. Other taxa included in the top five included Heptageniid mayflies, non-biting midges of the groups Diamesinae and Tanytarsini (midges). Among sites and seasons, the top five taxa comprised 68.3% to 78.7% of the total density, while the top ten taxa comprised approximately 90% of total density. In GOC-MID, the top ten also included Hydrachnid water mites at tenth position (Figure 3.4).

In September, the terrestrial contribution to drift assemblages was much lower, ranging from 4.9% to 22.7% among sites. In contrast to June, Baetid mayflies was the dominant taxon at each site, contributing approximately one-quarter to one-half of the September drift at each site. The top three taxa were similar to June and included Baetids, ostracods and Orthoclad midges. Remaining taxa in the top five most abundant included Heptageniid mayflies, Collembola (springtails) and Uenoid caddisflies. The top five taxa made up 72.3 to 85.6% of the drift assemblage; the top ten taxa accounted for 88.6% to 94.7% of the total assemblage.

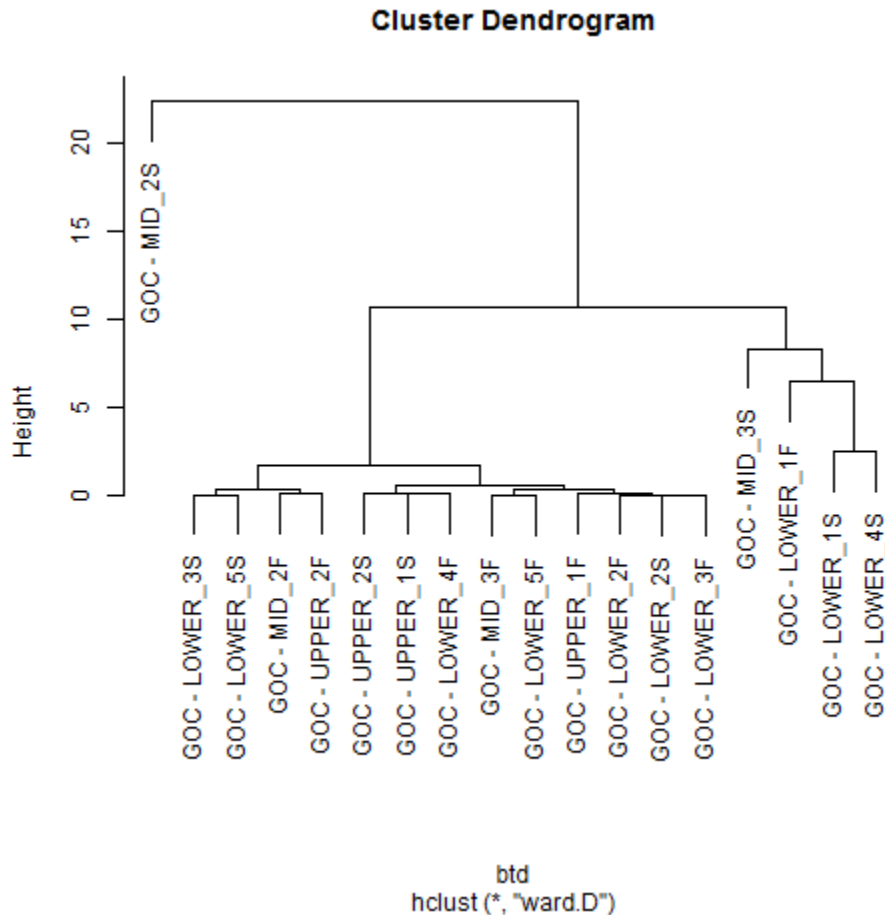
Generally, community composition among sites in Gold Creek and between sites was very similar, with communities from most sites and seasons clustering together (Figure 3.5). However, the community at GOC-MID in summer clustered separately from all other samples, as did a small cluster of samples from GLC-LOWER and GLC-MID collected mostly in summer (S). The presence of large terrestrials at some sites, particularly in summer, contributed to calculated dissimilarity of these sites.

The %EPT across Gold Creek sample sites ranged from 18.2% to 60.7% (Table 3.2). As indicated in the top ten taxa of September, Baetid mayflies dominated most sites in fall, and Chironomid midges were typically less abundant than EPT groups. As with Blairmore Creek, these values suggest that Gold Creek is a cool-water system with good water quality.

**Figure 3.4 Top ten taxa (by terrestrials and Family, or next possible resolution) by percent (%) contribution to density in the Gold Creek drift invertebrate sampling sites, June and September, 2016.**



**Figure 3.5** Bray-Curtis cluster analysis results for Gold Creek, June and September 2016.



Note: Site name labels correspond to replicates and season. "S" indicates summer or June, as "F" indicates fall or September.

**Table 3.2** Proportions of Ephemeroptera, Plecoptera and Trichoptera (%EPT), Ephemeroptera (%E), and Chironomidae (%Chironomidae) in the Gold Creek drift invertebrate sampling sites, June and September, 2016.

	GOC-UPPER		GOC-MID		GOC-LOWER	
Season	Summer	Fall	Summer	Fall	Summer	Fall
%EPT	18.2	60.7	50.5	53.9	25.5	39.2
%E	14.1	57.0	41.8	39.7	21.1	27.6
%Chironomidae	25.4	9.1	20.1	11.7	23.0	26.5

## 4.0 SUMMARY OF FINDINGS

Invertebrate drift was evaluated on Blairmore Creek and Gold Creek during the summer (June) and fall (September) seasons to characterize seasonal baseline conditions during the primary growing season of Westslope Cutthroat Trout. Baseline drift results suggest that Blairmore Creek and Gold Creek are similar in terms of drift invertebrate density (no./m<sup>3</sup>), biomass (g/m<sup>3</sup>), diversity, evenness, and taxonomic composition. Despite some variation among sites, results indicated that summer is a more productive season than the fall. Evenness was consistently low across all sites and decreased between seasons. This was reflected by the relatively consistent and dominant taxa groups comprising the drift invertebrate assemblage. In most cases, terrestrial invertebrates made up a considerable proportion of the drift in Blairmore and Gold creeks. Consistently among the top three taxa within both watercourses were Baetidae, Orthoclaadiinae (midges, Subfamily of Chironomidae), and Ostracoda. Additional dominant taxa such as those within the top five and top ten contributing groups (based on density) were more variable. A study by Ree (2014) included the examination of the benthic invertebrate community of Blairmore Creek and Gold Creek across summer and fall seasons and found no difference between density or biomass across seasons. When examining taxonomic groups, Ree (2014) observed similar dominant (mayfly) taxa as observed during this baseline study including Ephemerillidae, Baetidae and Heptageniidae.

Percent (%) EPT and %E were found to be high and %Chironomidae to be low in both Blairmore and Gold creeks suggesting both watercourses display good water quality and legacy coal mining effects (in either watershed) are not evident from the data. High proportions of Ephemeroptera will also allow for continued monitoring on both systems as %E has been identified as a useful metric to detect potential effects from coal mining (Frenette 2008; Pond et al. 2008).

Several abiotic and biotic factors including hydrology, riparian characteristics, as well as air and water temperature may influence drift (Elliot 1973; Romaniszyn et al. 2006; Dewson et al. 2007; Naman et al. 2016). Changes in these factors may be most commonly observed from “seasonal dynamics” (Naman et al. 2016). Several studies (e.g., Romaniszyn et al. 2006; Naman et al. 2016) have indicated that summer and fall peaks occur; however, drift abundance generally displays a decreasing trend from spring to fall, which the Gold Creek and Blairmore Creek systems tend to follow.

Seasonal changes in discharge can influence drift abundance by the amount substrate scouring (and thereby suspension of benthic organisms), the volume of water carrying invertebrates, and, the amount of aquatic or riparian habitat available by surface area (Romaniszyn et al. 2006). Summer and fall sampling in 2016 occurred during a low flow year (see the Instream Flow Needs Assessment Report; Hatfield 2016b), thus drift assemblage and abundance during more typical seasonal flow regimes may be higher than reported in the 2016 data.

Changes in stream flow has the potential to alter drift assemblages and thereby influence food availability for trout populations (Dewson et al. 2007). Factors such as changes in microhabitat characteristics that may alter diel activity and thereby drift patterns of invertebrates (Poff and Ward 1991) has presented mixed results. Predicted changes in stream flow in both Gold and Blairmore creeks resulting from the Project will evaluate potential effects on invertebrate drift as part of the Instream Flow Needs Assessment (Hatfield 2016b).

Results of the baseline conditions of Blairmore Creek and Gold Creek invertebrate drift share similar characteristics of other streams as supported by Romaniszyn et al. (2006), Ree (2014) and Naman et al. (2016). The presence of drift invertebrate density, biomass and taxonomic groups suggests that Blairmore and Gold creeks provides a primary foraging resource for local Westslope Cutthroat Trout populations. The presence of taxa such as chironomids, ephemeropterans, and ostracods, as well as terrestrial invertebrates are major components of Westslope Cutthroat Trout diet (Moore and Gregory 1988; Young et al. 1997; Romero et al. 2005; Romaniszyn et al. 2006; Ree 2014) and therefore are a key contributor in sustaining the current Westslope Cutthroat Trout stocks and overall aquatic productivity within each watercourse.

## 5.0 REFERENCES

- AENV (Alberta Environment). 1990. Selected Methods for the Monitoring of Benthic Invertebrates in Alberta Rivers. Environmental Quality Monitoring Branch, Environmental Assessment Division. Edmonton, AB.
- Dewson ZS, James ABW, Death RG. 2007. A review of the consequences of decreased for instream habitat and macroinvertebrates. *Journal of the North American Benthological Society*. 26(3):401-415.
- Elliot JM. 1973. The food of brown and rainbow trout (*Salmo trutta* and *S. gairdneri*) in relation to the abundance of drifting invertebrates in a mountain stream. *Oecologia*. 12:329-347.
- Environment Canada. 2002. Revised Guidance for Sample Sorting and Subsampling Protocols for EEM Benthic Invertebrate Community Surveys. National EEM Office, Ottawa, ON, Canada.
- Environment Canada. 2010. Pulp and Paper Environmental Effects Monitoring (EEM) Technical Guidance Document. National EEM Office, Ottawa, ON, Canada
- Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. National EEM Office, Ottawa, ON, Canada.
- Frenette JL. 2008. An evaluation of benthic invertebrate communities as an indicator of stream ecosystem health below active coal mines in the Elk River watershed. Master's Thesis. Royal Roads University. 23 pp.
- Ganshorn K, Lewis A. 2011. Upper Lillooet Hydro Project. Environmental Background – Fish Habitat. Report 4: Invertebrate Drift V.1. Consultant's report prepared by Ecofish Research Ltd.
- Gibbons WN, Munn MD, Paine MD, EVS Environmental Consultants. 1993. Guidelines for Monitoring Benthos in Freshwater Environments. Environment Canada. North Vancouver, BC.
- Hatfield T, Lewis AF, Babakaiff S. 2007. Guidelines for the collection and analysis of fish and fish habitat data for the purpose of assessing impacts from small hydropower projects in British Columbia. Prepared by Solander Ecological Research Ltd. And Ecofish Ltd. For the BC Ministry of Environment, Surrey BC.
- Hatfield Consultants. 2016a. Fish and Aquatic Resource Technical Baseline Report. Prepared for Benga Mining Ltd.
- Hatfield Consultants. 2016b. Grassy Mountain Instream Flow Needs Assessment Report. Prepared for Benga Mining Ltd.
- Jenkins AR, Keeley ER. 2010. Bioenergetic assessment of habitat quality for stream-dwelling cutthroat trout (*Oncorhynchus clarkii bouvieri*) with implications for climate change and nutrient supplementation. *Canadian Journal of Fisheries and Aquatic Sciences*. 67:371-385.
- Leung ES, Rosenfield JS, Bernhardt JR. 2009. Habitat effects on invertebrate drift in a small trout stream: implications for prey availability to drift-feeding fish. *Hydrobiologia*. 623:113-125.

- Moore KMS, Gregory SV. 1988. Summer habitat utilization and ecology of cutthroat try fry (*Salmo clarki*) in Cascade Mountain streams. *Canadian Journal of Fisheries and Aquatic Sciences*. 45:1921-1930.
- Naman SM, Rosenfield JS, Richardson JS. 2016. Causes and consequences of invertebrate drift in running waters: from individuals to populations and trophic fluxes. *Canadian Journal of Fisheries and Aquatic Sciences*. 73:1292-1305.
- Poff NL, Ward JV. 1991. Drift response of benthic invertebrates to experimental streamflow variation in a hydrologically stable stream. *Canadian Journal of Fisheries and Aquatic Sciences*. 48:1926-1936.
- Pond GJ, Passmore ME, Borsuk FA, Reynolds L, Rose CJ. 2008. Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus- level macroinvertebrate bioassessment tools. *Journal of the North American Benthological Society*. 27(3): 717-737.
- Ree M. 2014. Spatial and temporal variation of benthic macroinvertebrate communities in three Westslope Cutthroat Trout tributaries in the Rocky Mountains. Undergraduate Thesis. Concordia University College of Alberta. 27 pp.
- Romaniszyn ED, Hutchens JJ. Jr, Wallace JB. 2006. Aquatic and terrestrial invertebrate drift in southern Appalachian Mountain streams: implications for trout food resources. *Freshwater Biology*. 52:1-11.
- Romero N, Gresswell RE, Li JL. 2005. Changing patterns in coastal cutthroat trout (*Oncorhynchus clarki clarki*) diet and prey in a gradient of deciduous canopies. *Canadian Journal of Fisheries and Aquatic Science*. 62:1797-1807.
- Rosenfield JS, Boss S. 2001. Fitness consequences of habitat use for juvenile cutthroat trout: energetic costs and benefits in pools and riffles. *Canadian Journal of Fisheries and Aquatic Science*. 58:585-593.
- Ter Braak CJF, Smilauer P. 2002. CANOCO Reference manual and CanoDraw for Windows User's guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, New York. 500 pp.
- Ward JH Jr. 1963. Hierarchical Grouping to Optimize an Objective Function. *Journal of the American Statistical Association*, 58: 236–244.
- Wipfli MS, Gregovich DP. 2002. Export invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. *Freshwater Biology* 47:957–969.
- Wrona FJ, Culp JM, Davies RW. 1982. Macroinvertebrate Subsampling: a Simplified Apparatus and Approach. *Canadian Journal of Fisheries and Aquatic Science*. 39:1051-1054.
- Young MK, Rader RB, Belish TA. 1997. Influence of macroinvertebrate drift and light on the activity and movement of Colorado River cutthroat trout. *Transactions of the American Fisheries Society*. 126:428-437.

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## **APPENDICES**

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**Appendix A1**

**Invertebrate Drift Sample Site Photos**

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**Figure A1.1 Blairmore Creek drift invertebrate sampling site BLC-UPPER.**



**Looking upstream, September 2016**



**Looking downstream, September 2016**



**Right downstream bank, September 2016**



**Left downstream bank, September 2016**

**Figure A1.2 Blairmore Creek drift invertebrate sampling site BLC-MID.**



**Looking upstream, June 2016**



**Looking downstream, September 2016**



**Looking downstream to right downstream bank,  
June 2016**



**Left downstream bank, September 2016**

**Figure A1.3 Blairmore Creek drift invertebrate sampling site BLC-LOWER.**



**Looking upstream, September 2016**



**Looking downstream, September 2016**



**Right downstream bank, September 2016**



**Left downstream bank, September 2016**

**Figure A1.4 Gold Creek drift invertebrate sampling site GOC-UPPER.**



**Looking upstream, September 2016**



**Looking downstream, June 2016**



**Looking cross-channel to right downstream bank, June 2016**



**Left downstream bank, September 2016**

**Figure A1.5 Gold Creek drift invertebrate sampling site GOC-MID.**



**Looking upstream, September 2016**



**Looking downstream, September 2016**



**Right downstream bank, September 2016**



**Left downstream bank looking downstream,  
June 2016**

**Figure A1.6 Gold Creek drift invertebrate sampling site GOC-LOWER.**



**Looking upstream, September 2016**



**Looking downstream, June 2016**



**Right downstream bank, September 2016**



**Left downstream bank, September 2016**

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## **Appendix A2**

### **Invertebrate Drift Raw Data**

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**Table A2.1 Raw data collected at each sampling site as part of the drift invertebrate study on Blairmore Creek, June and Spetember 2016.**

Site	Date	Easting	Northing	Time Set	Time Pulled	Duration	Time Sampled	Net 1		Net 2		Net 3		Net 4		Net 5		Water Temperature (°C)	Conductivity (uS)	pH	Dissolved Oxygen (mg/L)	Bankfull Width	Wetted Width	Bank Height	Riparian Overhang	Canopy cover (%)				
								Flow	Depth	Flow	Depth	Flow	Depth	Flow	Depth	Flow	Depth													
BLC-UPPER	29-Jun-16	682905	5509929	15:49	19:57	4:08	15:56	0.451	0.110	0.341	0.120	0.334	0.130	0.573	0.160	0.470	0.160	12.0	223	8.30	8	6.4	3.7	0.55	0	0				
							16:55	0.281	0.110	0.302	0.120	0.180	0.130	0.617	0.160	0.380	0.160													
							17:56	0.418	0.110	0.354	0.120	0.111	0.130	0.681	0.160	0.406	0.160													
							19:02	0.317	0.110	0.390	0.120	0.388	0.130	0.581	0.160	0.363	0.160	10.9												
							19:44	0.180	0.110	0.352	0.120	0.339	0.130	0.585	0.160	0.469	0.160													
							19:57	0.189	0.110	0.325	0.120	0.236	0.130	0.615	0.160	0.369	0.160													
BLC-MID	29-Jun-16	684950	5505010	8:23	12:34	4:11	8:29	0.262	0.150	0.391	0.200	0.173	0.180	0.378	0.130	0.245	0.120	10.4	250	8.25	8.9	9.4	5	0.45	TR	0				
							10:03	0.314	0.150	0.382	0.200	0.235	0.180	0.538	0.130	0.185	0.120													
							11:23	0.346	0.150	0.405	0.200	0.285	0.180	0.398	0.130	0.217	0.120	13.3												
							12:28	0.227	0.150	0.228	0.200	0.108	0.180	0.331	0.130	0.226	0.120													
							12:39	0.131	0.150	0.362	0.200	0.158	0.180	0.380	0.130	0.362	0.120													
BLC-LOWER	29-Jun-16	684906	5504889	9:05	13:25	4:20	9:08	0.223	0.150	0.251	0.160	0.532	0.210	0.485	0.200	0.641	0.210	10.5	254	8.32	9.10	11.10	4.50	0.80	0.00	0.00				
							10:27	0.321	0.150	0.260	0.160	0.447	0.210	0.458	0.200	0.383	0.210													
							11:39	0.339	0.150	0.239	0.160	0.372	0.210	0.331	0.200	0.428	0.210	14.6												
							13:19	0.277	0.150	0.167	0.160	0.588	0.210	0.287	0.200	0.505	0.210													
BLC-UPPER	15-Sep-16	682926	5509935	7:35	11:36	4:01	7:35	0.100	0.090	0.100	0.090	0.100	0.050	0.100	0.080	-	-	5.3	248	8.46	8.2	2.2	4.6	1	0	0				
							8:47	0.100	0.090	0.100	0.090	0.100	0.070	0.100	0.080	-	-													
							10:10	0.100	0.090	0.100	0.090	0.100	0.050	0.100	0.080	-	-	8.4												
							11:35	0.100	0.090	0.100	0.090	0.100	0.050	0.100	0.050	-	-													
							11:37	0.200	0.090	0.100	0.090	0.100	0.050	0.100	0.090	-	-													
BLC-MID	14-Sep-16	684938	5504980	13:42	17:55	4:13	13:42	0.200	0.100	0.050	0.100	0.100	0.050	0.200	0.080	-	-	10.0	276	8.54	7.6	9.65	4	1.2	0	0				
							14:50	0.200	0.100	0.200	0.080	0.200	0.050	0.200	0.050	-	-													
							16:10	0.200	0.100	0.100	0.100	0.200	0.050	0.200	0.050	-	-	9.8												
							17:40	0.200	0.090	0.200	0.090	0.200	0.005	0.200	0.050	-	-													
							17:57	0.200	0.090	0.200	0.080	0.200	0.050	0.200	0.050	-	-													
BLC-LOWER	14-Sep-16	684896	5504899	14:05	18:00	3:55	14:05	0.100	0.100	0.200	0.170	0.200	0.150	0.100	0.110	-	-	9.9	276	8.54	7.6	12.1	4.6	1.1	0	0				
							15:00	0.100	0.100	0.200	0.140	0.200	0.110	0.100	0.110	-	-													
							16:14	0.100	0.100	0.100	0.150	0.100	0.120	0.100	0.100	-	-	9.8												
							17:57	0.100	0.100	0.100	0.120	0.200	0.100	0.100	0.100	-	-													
							18:05	0.100	0.100	0.200	0.100	0.200	0.150	0.100	0.100	-	-													

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**Appendix A2**

**Gold Creek Habitat Mapping**

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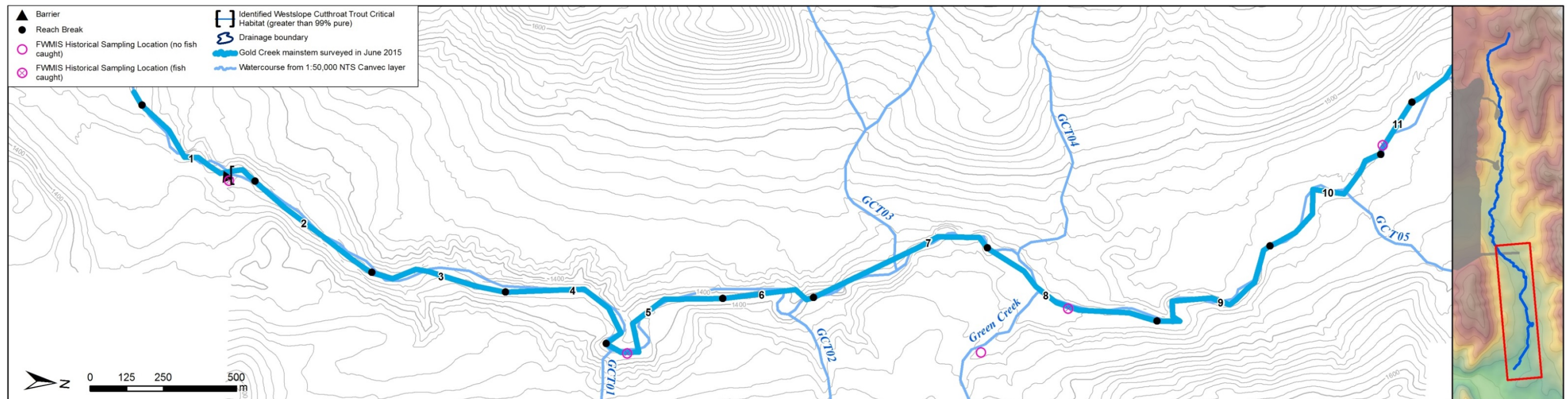
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**Table A2.1 Biophysical habitat survey results for Gold Creek, August 2015.**

REACH	1	2	3	4	5	6	7	8	9	10	11
<b>Easting</b>	688391	688616	688892	688919	689064	688876	688845	688625	688823	688534	688189
<b>Northing</b>	5498323	5498731	5499157	5499617	5499976	5500360	5500669	5501246	5501846	5502209	5502559
<b>Wetted width (m)</b>	1.1	1.0	1.1	1.0	1.1	1.8	1.3	1.2	0.7	0.8	7.5
<b>Channel width (m)</b>	10.7	6.0	7.0	7.2	7.1	5.9	7.0	7.6	7.4	7.8	15.0
<b>Reach length (m)</b>	560	508	475	535	555	327	661	656	616	579	209
<b>Habitat area (m<sup>2</sup>)</b>	622	488	499	556	600	578	872	788	409	463	1,566
<b>Average depth (m)</b>	0.04	0.10	0.06	0.05	0.07	0.12	0.05	0.07	0.02	0.03	0.53
<b>Substrate</b>	Cobble Gravel	Cobble Boulder	Boulder Cobble	Boulder Cobble	Cobble Boulder	Cobble Boulder	Cobble Boulder	Boulder Cobble	Cobble Gravel	Boulder Cobble	Cobble Gravel
<b>Slope (%)</b>	6.0	2.5	9.5	3.1	2.5	17.6	2.7	2.0	2.7	3.3	3.7
<b>Morphology</b>	Run Pool	Riffle Run Pool	Riffle Run Pool	Run Pool	Riffle Pool	Riffle	Riffle Pool	Run Pool	Riffle Run Pool	Riffle	Run
<b>Cover</b>	SWD OHV			OHV		UCB OHV	UCB	OHV UCB	UCB		
<b>Other habitat features</b>	Fish observed WF, plunge pool	Fish observed WF, plunge pools	Fish observed WF, plunge pools, chutes	Fish observed WF, plunge pools, chutes	Evidence of groundwater inputs to mainstem	WF	WF	Evidence of groundwater inputs to mainstem	Fish Observed	WF, plunge pools	Fish Observed WF
<b>Disturbances</b>	Coal sediments observed Pipeline crossing Evidence of cattle crossings		Potential coal seam on LDB	Coal sediments on floodplain Coarse coal sediments on gravel bars	Evidence of cattle crossing			Road/trail crossing Evidence of cattle crossing Extensive evidence of coal sediments	Extensive evidence of cattle crossing, coal sediments and deposits Evidence of ATV crossing Remains of old bridge	Evidence of cattle crossing ATV crossing	ATV trails along both banks

Notes: UTM's refer to the start of each reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.

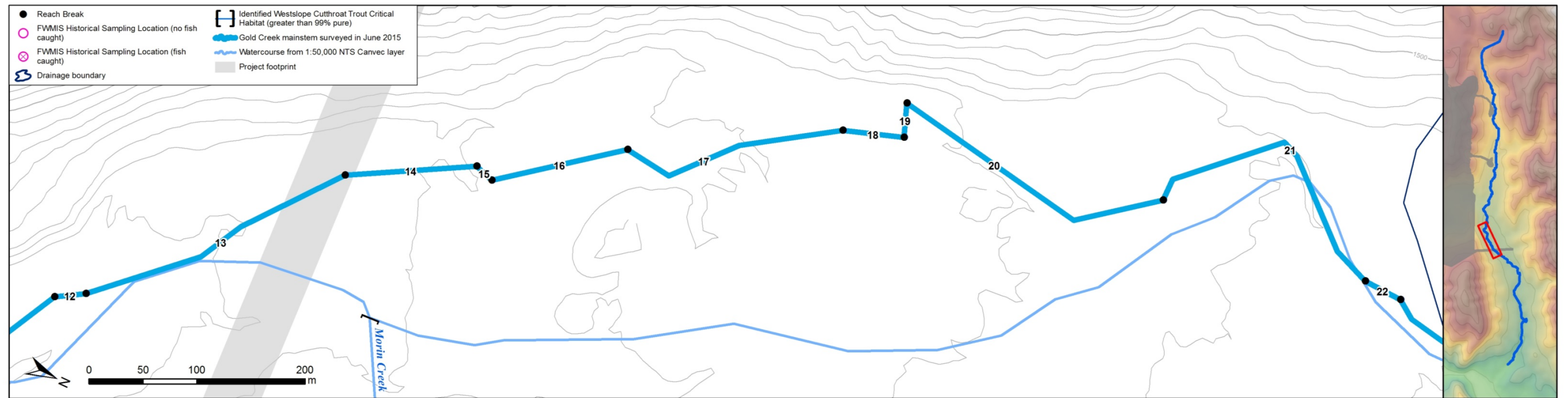


				
Reach 1, RDB-D/S, main barrier on Gold Creek	Reach 1, LDB-U/S	Reach 2, LDB-D/S	Reach 2, LDB-U/S	Reach 3, LDB-U/S
				
Reach 3, D/S from mid-channel	Reach 3, LDB-D/S	Reach 4, LDB-D/S	Reach 4, LDB-U/S	Reach 5, LDB-D/S
				
Reach 5, D/S from mid-channel	Reach 5, D/S from mid-channel	Reach 6, D/S from mid-channel	Reach 7, D/S from mid-channel	Reach 11, D/S from mid-channel

**Table A2.1 Biophysical habitat survey, August 2015, continued.**

REACH	12	13	14	15	16	17	18	19	20	21	22
<b>Easting</b>	688002	687987	687786	687727	687733	687654	687554	687536	687506	687487	687476
<b>Northing</b>	5502649	5502674	5502845	5502952	5502970	5503072	5503245	5503299	5503288	5503541	5503742
<b>Wetted width (m)</b>	4.2	0.9	3.0	8.2	1.4	0.7	3.3	3.9	2.6	0.7	3.6
<b>Channel width (m)</b>	10.5	9.5	4.7	9.4	5.5	2.4	3.7	5.1	8.3	3.4	3.7
<b>Reach length (m)</b>	29	266	122	19	129	213	57	32	274	281	37
<b>Habitat area (m<sup>2</sup>)</b>	122	239	360	156	174	156	190	125	705	188	132
<b>Average depth (m)</b>	0.50	0.22	0.92	0.66	0.55	0.30	0.53	0.87	0.54	0.29	0.50
<b>Substrate</b>	Cobble Boulder	Cobble Boulder	Cobble Gravel	Cobble Gravel	Cobble Gravel	Cobble Gravel	Cobble Gravel	Cobble Gravel	Cobble Fines	Cobble Gravel	Cobble Gravel
<b>Slope (%)</b>	1.9	1.8	3.3	0.2	2.4	1.2	3.1	0.1	1.3	1.8	2.5
<b>Morphology</b>	Run Riffle Pool	Riffle Run Pool	Run Pool	Run Pool	Run Riffle Pool	Run Pool	Run Pool	Run Pool	Run Pool	Run Pool	Run Pool
<b>Cover</b>	UCB		LWD		SWD					UCB	LWD
<b>Other habitat features</b>											
<b>Disturbances</b>		Coal sediments observed	Coal sediments observed	Coal sediments observed	Coal sediments observed	Coal sediments observed Coal/gravel pit approx. 50 m from watercourse	Coal sediments observed	Coal sediments observed	Coal sediments observed Evidence of cattle crossing	Coal sediments observed	Coal sediments observed

Notes: UTM's refer to the start of each reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.





Reach 12, LDB-D/S



Reach 13, LDB-U/S



Reach 13, D/S from mid-channel



Reach 14, LDB-D/S



Reach 15, LDB-D/S



Reach 16, CC



Reach 17, D/S from mid-channel



Reach 17, U/S from mid-channel



Reach 18, CC



Reach 19, RDB-U/S



Reach 20, RDB-D/S



Reach 20, RDB-U/S



Reach 21, RDB-D/S



Reach 21, U/S from mid-channel

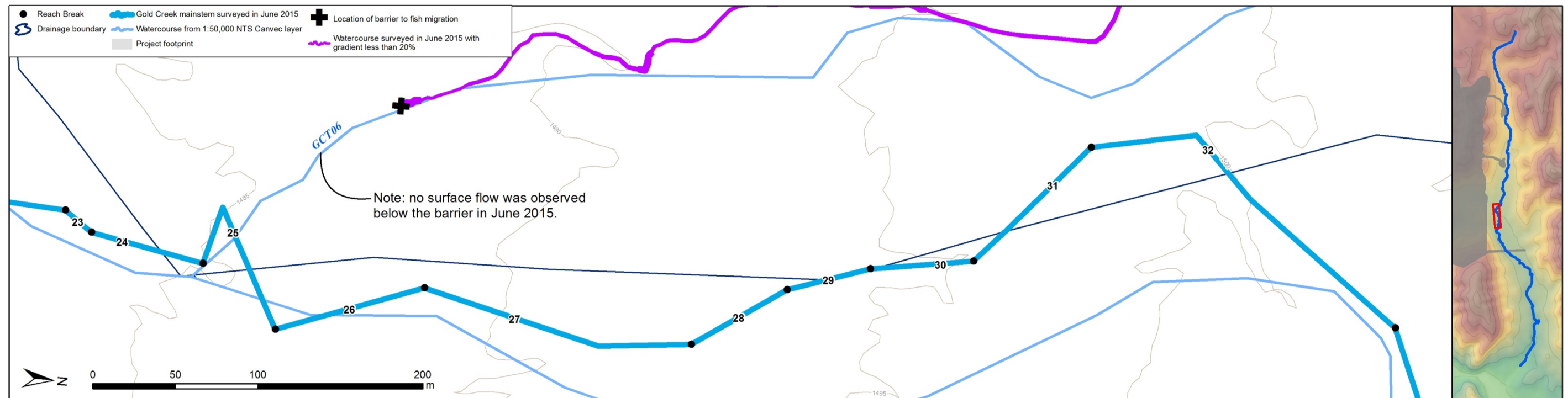


Reach 22, LDB-D/S

**Table A2.1 Biophysical habitat survey results for Gold Creek, August 2015, continued.**

REACH	23	24	25	26	27	28	29	30	31	32	33
<b>Easting</b>	687478	687490	687503	687539	687506	687526	687488	687471	687461	687386	687479
<b>Northing</b>	5503779	5503796	5503865	5503912	5504000	5504164	5504219	5504268	5504330	5504395	5504588
<b>Wetted width (m)</b>	3.0	3.8	4.3	5.0	3.7	4.0	2.4	3.5	1.3	1.4	3.3
<b>Channel width (m)</b>	3.6	5.7	9.1	3.2	9.2	4.7	5.1	7.4	5.8	5.1	4.5
<b>Reach length (m)</b>	21	70	117	94	167	67	52	63	99	232	102
<b>Habitat area (m<sup>2</sup>)</b>	61	268	502	470	619	264	122	220	132	322	337
<b>Average depth (m)</b>	0.76	0.49	0.23	0.28	0.19	0.61	0.70	0.57	0.47	0.24	0.45
<b>Substrate</b>	Cobble Gravel	Cobble Gravel	Fines Cobble	Cobble Gravel	Cobble Fines	Cobble Boulder	Cobble Boulder	Cobble Gravel	Cobble Fines	Cobble Gravel	Cobble Boulder
<b>Slope (%)</b>	2.7	1.8	0.7	2.9	2.0	1.6	2.9	0.9	2.5	2.3	1.4
<b>Morphology</b>	Riffle Run Pool	Riffle Pool	Run Pool	Riffle	Run Pool	Riffle Run Pool	Run Pool	Run Pool	N/A	Riffle Run Pool	Run Riffle
<b>Cover</b>			LWD			LWD	SWD		LWD SWD		
<b>Other habitat features</b>									Fish Observed		
<b>Disturbances</b>	Coal sediments observed	Coal sediments observed	Coal sediments observed Evidence of cattle crossing	Coal sediments observed	Coal sediments observed Shed located in riparian area of RDB	Coal sediments observed	Coal sediments observed	Coal sediments observed	Coal sediments observed	Coal sediments observed Camping area in riparian area of LDB Evidence of cattle and ATV crossing	Coal sediments observed

Notes: UTM's refer to the start of each reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.

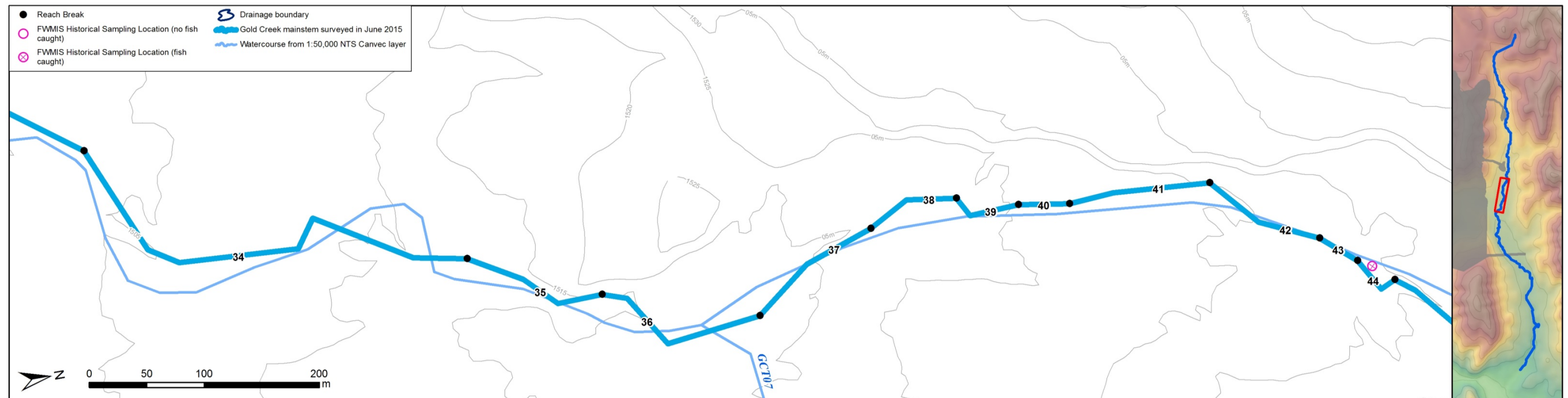

















				
Reach 23, D/S from mid-channel	Reach 23, D/S from mid-channel	Reach 24, U/S from mid-channel	Reach 25, D/S from mid-channel	Reach 26, RDB-D/S
				
Reach 27, D/S from mid-channel	Reach 27, LDB-D/S	Reach 28, RDB-D/S	Reach 30, D/S from mid-channel	Reach 31, D/S from mid-channel
				
Reach 32, LDB-D/S	Reach 32, D/S from mid-channel	Reach 32, LDB-D/S	Reach 32, D/S from mid-channel	Reach 33, LDB-U/S

**Table A2.1 Biophysical habitat survey, August 2015, continued.**

REACH	34	35	36	37	38	39	40	41	42	43	44
<b>Easting</b>	687479	687629	687680	687722	687664	687651	687666	687673	687676	687740	687765
<b>Northing</b>	5504588	5504900	5505010	5505142	5505250	5505328	5505380	5505424	5505547	5505633	5505662
<b>Wetted width (m)</b>	0.6	2.4	1.1	3.1	1.3	2.1	2.1	3.0	0.9	5.4	6.5
<b>Channel width (m)</b>	4.5	9.9	5.4	6.8	7.0	7.9	2.7	6.5	5.9	5.6	15.8
<b>Reach length (m)</b>	304	128	159	124	83	62	45	123	110	38	47
<b>Habitat area (m<sup>2</sup>)</b>	167	307	180	388	104	131	91	370	96	205	300
<b>Average depth (m)</b>	0.08	0.07	N/A	0.11	0.19	0.15	0.24	0.14	0.14	0.28	0.11
<b>Substrate</b>	Cobble Boulder	Boulder Gravel	Fines Gravel	Cobble Boulder	Boulder Cobble	Fines Gravel	Boulder Cobble	Gravel Boulder	Boulder Fines	Gravel Boulder	Cobble Gravel
<b>Slope (%)</b>	2.5	2.8	4.5	1.3	2.3	3.7	2.0	3.3	2.2	3.2	2.9
<b>Morphology</b>	Run Riffle Pool	Riffle Pool	Riffle Pool	Riffle	N/A	Riffle Pool	Riffle	N/A	Riffle	Riffle Run	Riffle
<b>Cover</b>		SWD			PL LWD UCB	SWD PL	UCB	UCB	UCB OHV	PL UCB	LWD PL OHV
<b>Other habitat features</b>	Fish Observed WF, plunge pool		Evidence of groundwater inputs to mainstem		Evidence of beaver activity					Fish Observed	
<b>Disturbances</b>	Coal sediments observed Evidence of cattle and ATV crossing	Coal sediments observed	Coal sediments observed Evidence of cattle crossing	Coal sediments observed Evidence of cattle crossing	Coal sediments observed	Coal sediments observed Evidence of cattle crossing	Coal sediments observed	Coal sediments observed Evidence of cattle crossing	Coal sediments observed	Coal sediments observed	

Notes: UTM's refer to the start of each reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.

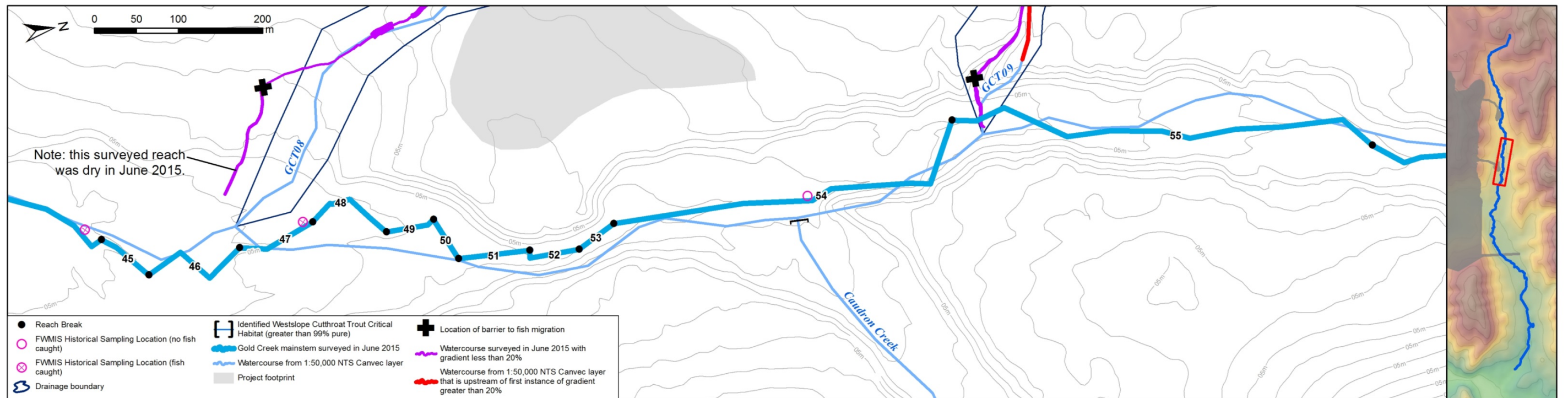

















				
Reach 34, RDB-U/S	Reach 34, RDB-D/S	Reach 35, RDB-D/S	Reach 36, CC	Reach 36, RDB-U/S
				
Reach 37, D/S from mid-channel	Reach 38, RDB-D/S	Reach 39, RDB-D/S	Reach 40, RDB-U/S	Reach 41, D/S from mid-channel, with coal sediments
				
Reach 42, D/S from mid-channel, with coal sediments	Reach 42, RDB-U/S, with coal sediments	Reach 43, U/S from mid-channel, with coal sediments	Reach 44, D/S from mid-channel	Reach 44, RDB-D/S

**Table A2.1 Biophysical habitat survey results for Gold Creek, August 2015, continued.**

REACH	45	46	47	48	49	50	51	52	53	54	55
<b>Easting</b>	687787	687838	687825	687810	687837	687832	687883	687888	687897	687874	687823
<b>Northing</b>	5505691	5505739	5505851	5505942	5506026	5506084	5506105	5506190	5506248	5506294	5506711
<b>Wetted width (m)</b>	2.5	1.9	3.0	1.5	2.8	10.7	5.1	2.4	3.4	0.5	0.3
<b>Channel width (m)</b>	4.7	6.1	6.2	9.5	6.3	12.2	5.2	5.7	4.1	5.1	4.4
<b>Reach length (m)</b>	70	143	96	113	59	55	85	68	51	462	526
<b>Habitat area (m<sup>2</sup>)</b>	176	276	287	167	163	590	434	160	175	243	158
<b>Average depth (m)</b>	0.16	0.06	0.14	0.05	0.10	0.21	0.49	0.16	0.50	0.04	0.01
<b>Substrate</b>	Boulder Gravel	Boulder Gravel	Boulder Cobble	Boulder Cobble	Boulder Cobble	Cobble Gravel	Gravel Fines	Fines Gravel	Boulder Cobble	Gravel	Boulder Cobble
<b>Slope (%)</b>	1.6	2.4	2.0	2.2	2.0	4.0	4.4	13.3	4.8	10.2	4.0
<b>Morphology</b>	Riffle Run	Riffle Pool	Riffle	Riffle Run	Riffle Run	Run		Riffle Run	Run	Run Riffle	Riffle Pool
<b>Cover</b>	OWV	UCB LWD	OWV	OWV UCB SWD	OWV PL	SWD	OWV	UCB	OWV	OWV	
<b>Other habitat features</b>	Evidence of groundwater inputs to mainstem Fish Observed	Fish Observed								WF, plunge pool Fish Observed	WF, plunge pool Fish Observed
<b>Disturbances</b>		Coal sediments observed	Coal sediments observed	Coal sediments observed Evidence of cattle crossing	Evidence of cattle crossing	Evidence of cattle crossing				Coal sediments observed Evidence of cattle crossing	Coal sediments observed Evidence of cattle crossing

Notes: UTM refer to the start of each reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.

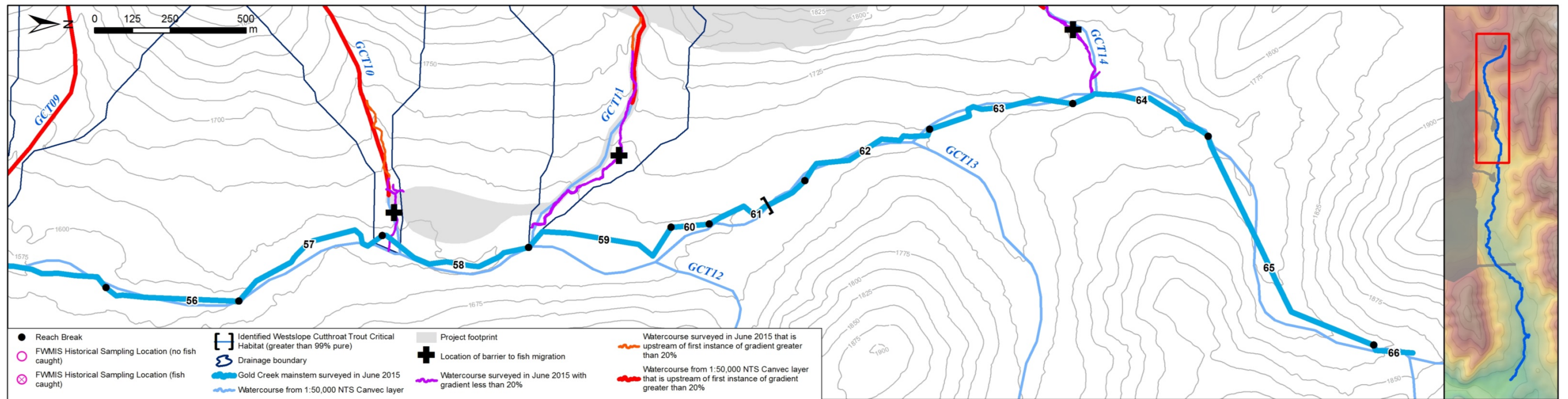



				
Reach 45, U/S from mid-channel	Reach 45, D/S from mid-channel	Reach 46, D/S from mid-channel	Reach 47, D/S from mid-channel	Reach 48, U/S from mid-channel
				
Reach 49, U/S from mid-channel	Reach 50, RDB-U/S	Reach 51, D/S from mid-channel	Reach 51, D/S from mid-channel	Reach 52, U/S from mid-channel
				
Reach 53, D/S from mid-channel	Reach 54, D/S from mid-channel	Reach 54, D/S from mid-channel	Reach 55, U/S from mid-channel	Reach 55, LDB-D/S

**Table A2.1 Biophysical habitat survey results for Gold Creek, August 2015, continued.**

REACH	56	57	58	59	60	61	62	63	64	65	66
<b>Easting</b>	687939	687984	687768	687807	687740	687729	687587	687417	687333	687441	688129
<b>Northing</b>	5507198	5507636	5508110	5508592	5509062	5509188	5509504	5509916	5510388	5510834	5511381
<b>Wetted width (m)</b>	0.7	0.3	0.3	0.8	4.5	0.7	0.3	0.4	0.1	0.5	0.4
<b>Channel width (m)</b>	3.8	9.0	4.2	4.2	4.5	N/A	3.9	3.1	4.2	2.7	1.3
<b>Reach length (m)</b>	448	597	528	562	126	377	486	515	499	933	141
<b>Habitat area (m<sup>2</sup>)</b>	325	167	167	472	569	269	157	200	56	504	61
<b>Average depth (m)</b>	0.03	0.15	0.04	0.04	0.53	N/A	0.03	0.03	0.01	0.16	0.02
<b>Substrate</b>	N/A	Cobble Gravel	Cobble Boulder	Cobble Gravel	Boulder Gravel	N/A	Boulder Cobble	Boulder Gravel	Cobble Gravel	Cobble Gravel	N/A
<b>Slope (%)</b>	3.0	2.4	2.1	2.2	3.1	3.0	3.3	4.5	6.5	8.7	18.0
<b>Morphology</b>	Run Pool	Run Pool	Run Pool	Run	Riffle Run Pool	Pool Run	Run Pool	Run Pool	Riffle Run Pool	Riffle	Riffle
<b>Cover</b>	UCB	UCB LWD						LWD UCB	LWD	WF	
<b>Other habitat features</b>		Fish Observed	Fish Observed	Fish Observed		Fish Observed	Fish Observed	Fish Observed	Fish Observed	Fish Observed	Much of reach is dry channel
<b>Disturbances</b>	Evidence of cattle crossing					Evidence of ATV crossing	Road Crossing with Culvert	Evidence of cattle crossing Evidence of ATV crossing	ATV trail running parallel to watercourse	Road Crossing with Culvert	

Notes: UTM's refer to the start of each reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.



				
Reach 56, U/S from mid-channel	Reach 56, D/S from mid-channel	Reach 57, U/S from mid-channel	Reach 57, LDB-D/S	Reach 58, RDB-U/S
				
Reach 59, D/S from mid-channel	Reach 60, D/S from mid-channel	Reach 61, U/S from mid-channel	Reach 61, U/S from mid-channel	Reach 62, D/S from mid-channel
				
Reach 62, RDB-U/S	Reach 63, D/S from mid-channel	Reach 64, LDB-U/S	Reach 65, LDB-D/S	Reach 66, CC

**Table A2.2 Biophysical habitat survey results for GCT06, June 2015.**

Reach No.	7	8	9	10	11	12	13	14	15	16	17
<b>Easting</b>	687398	687393	687381	687355	687363	687352	687316	687311	687312	687312	687322 687250
<b>Northing</b>	5503976	5503988	5504016	5504090	5504118	5504125	5504198	5504222	5504254	5504288	5504387 5504467
<b>Wetted width (m)</b>	3.5	0.75	1.2	1.65	3.1	1.2	0.7	0.9	2.3	1.4	1.85
<b>Channel width (m)</b>	3.5	0.75	1.2	1.65	3.1	1.2	0.7	0.9	2.3	1.4	1.85
<b>Reach length (m)</b>	12.8	31.4	91.1	29.3	15.7	87.5	24.9	31.9	35.0	100.0	113.5
<b>Habitat area (m<sup>2</sup>)</b>	44.7	23.6	109.3	48.3	48.7	105.0	17.4	28.7	80.5	139.9	210.0
<b>Average depth (m)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.13	0.24	0.13	0.11
<b>Substrate</b>	Fines	Fines, Cobble	Boulder, Fines	Fines, Gravel	Fines	Fines, Boulder	Fines, Boulder	Fines, Boulder	Gravel, Cobble	Boulder, Cobble	Fines, Gravel
<b>Slope (%)</b>	0.0	0.0	3.3	0.0	6.4	3.4	4.0	0.0	0.0	0.0	3.5
<b>Morphology</b>	Pool	Run	Riffle	Run	Run	Riffle	Riffle	Run	Run	Riffle	Run
<b>Cover</b>	SWD D	N	N	N	N	N	N	N	N	LWD SWD	LWD
<b>Other habitat features</b>	Start of subsurface flow										Potential LWD Barrier
<b>Disturbances</b>											ATV Bridge

Notes: UTM's refer to the start of each reach. Second UTM in final column represents end of the surveyed reach.

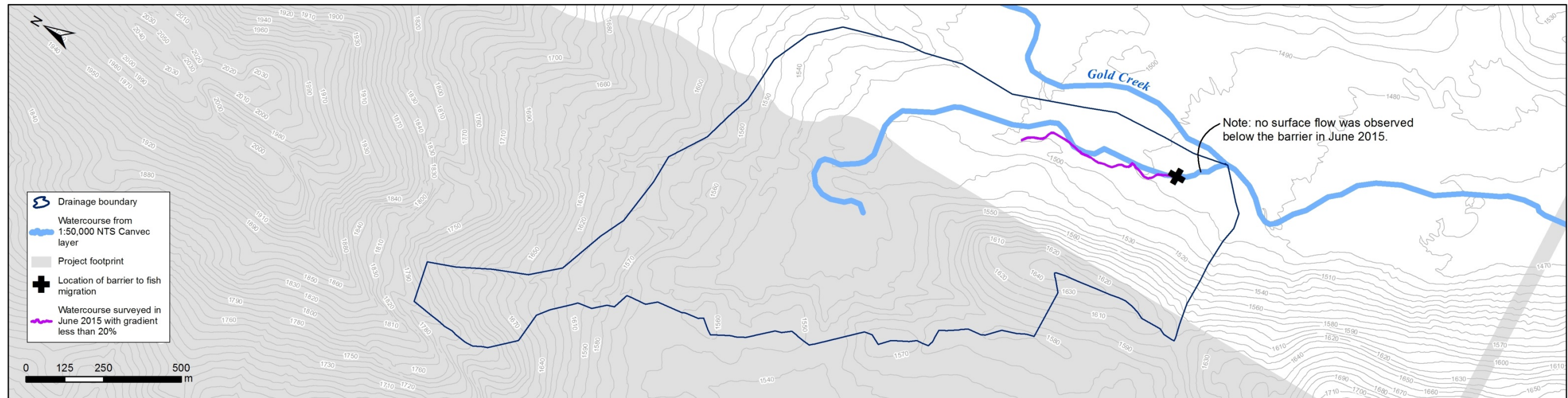
Substrate and cover information are presented in order of decreasing dominance.

N/A – not obtained; N – little or no cover present.

SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream

Gray-shaded reaches are reaches that will be removed by the Project footprint

The start of Reach 7 marks the location at which GCT06 was observed to subsurface, approximately 160 m from Gold Creek. Tributary GCT06 was not connected to Gold Creek via surface flows in June 2015. Reaches 1 to 6 that were surveyed in the drainage of tributary GCT06 represent a side channel of Gold Creek.



<p>Lower end of Reach 7, LDB-D/S, and start of subsurface flow approximately 160 m from Gold Creek.</p>	<p>Reach 7, LDB-U/S</p>	<p>Reach 8, LDB-U/S</p>	<p>Reach 9, LDB-U/S</p>	<p>Reach 10, LDB-U/S</p>
<p>Reach 11, RDB-U/S</p>	<p>Reach 12, RDB-U/S</p>	<p>Reach 14, RDB-U/S</p>	<p>Reach 15, LDB-U/S</p>	<p>Reach 17, LDB-U/S</p>
<p>Reach 17, RDB-U/S, LWD Barrier</p>	<p>Upstream of Reach 17, RDB-U/S, indicating stagnant water with little or no flow</p>			

**Table A2.3 Biophysical habitat survey results for GCT08, June 2015.**

REACH	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
<b>Easting</b>	687760	687643	687627	687616	687605	687597	687590	687576	687573	687566	687549	687536	687507	687488	687454	687449	687437	687427	687422	687420	687414	687384	687355	687314 687301
<b>Northing</b>	5505845	5505912	5505984	5506025	5506051	5506076	5506101	5506128	5506142	5506149	5506168	5506190	5506197	5506208	5506221	5506238	5506286	5506331	5506345	5506352	5506358	5506419	5506436	5506497 5506543
<b>Wetted width (m)</b>	0.65	0.37	0.45	0.65	0.85	0.75	0.95	0.7	0.9	0.95	0.85	0.65	0.65	0.85	0.4	1.25	0.4	1.15	0.7	0.65	1	1.5	0.55	0.55
<b>Channel width (m)</b>	1.5	0.55	0.45	1	7	0.75	4.35	2.3	0.9	0.95	0.85	1.5	0.65	0.85	0.4	1.25	0.4	1.15	1.3	1.8	1.5	1.5	0.55	0.55
<b>Reach length (m)</b>	140.6	74.8	43.9	28.4	26.7	26.1	31.4	14.5	10.5	25.9	25.4	34.1	23.0	38.3	17.8	49.4	46.5	15.5	6.9	9.3	70.9	34.2	74.4	67.6
<b>Habitat area (m<sup>2</sup>)</b>	210.9	41.1	19.8	28.4	186.9	19.6	136.6	33.4	9.5	24.6	21.6	51.2	15.0	32.6	7.1	61.8	18.6	17.8	9.0	16.7	106.4	51.3	40.9	37.2
<b>Average depth (m)</b>	0.03	0.13	0.06	0.04	0.13	0.05	0.04	0.06	0.03	0.16	0.04	0.05	0.04	0.15	0.13	0.06	0.08	0.06	0.05	0.05	0.28	0.03	0.06	0.04
<b>Substrate</b>	Fines Gravel	Cobble Sand	Cobble Sand	Gravel Sand	Gravel Sand	Gravel Sand	Gravel Sand	Gravel Sand	Sand Gravel	Sand Gravel	Gravel Sand	Gravel Sand	Gravel Boulder	Gravel Boulder	Gravel Boulder	Gravel Boulder	Boulder Gravel	Boulder Gravel	Gravel Boulder	Gravel Boulder	Gravel Sand	Cobble Gravel	Cobble Gravel	Gravel Sand
<b>Slope (%)</b>	7.8	5.3	11.4	7.0	3.7	11.5	6.4	0.0	9.6	3.9	7.9	17.6	8.7	23.5	5.6	8.1	10.7	0.0	29.0	21.4	7.1	8.8	16.1	3.0
<b>Morphology</b>	Run	Run	Run	Run	Cascade	Cascade	Cascade	Run	Run	Run	Run	Run	Run	Cascade	Riffle	Cascade	Cascade	Cascade	Cascade	Cascade	Cascade	Cascade	Cascade	Cascade
<b>Cover</b>	OHV	OHV	OWD OHV	OWD UCB LWD	N	N	OHV	N	OHV	N	UCB	OHV	N	OHV	OWD	OWD	N	UCB OWD	UCB OWD	N	OHV	N	OHV	N
<b>Other habitat features</b>	Start of subsurface flow immediately downstream of culvert	WF: 1.2 WF: 0.55 entrenched channel		WF:0.4 entrenched channel								entrenched channel		WF:0.7 Step pools	entrenched channel	WF:>1.0	Step pools	Step pools	entrenched channel		entrenched channel Step pools	Step pools	WF:0.85 Step pools	WF:0.65
<b>Disturbances</b>				Flood evidence	Flood evidence				Flood evidence	Cattle grazing											Flood evidence			Culvert

Notes: UTM's refer to the start of each reach. Second UTM in final column represents end of the surveyed reach.

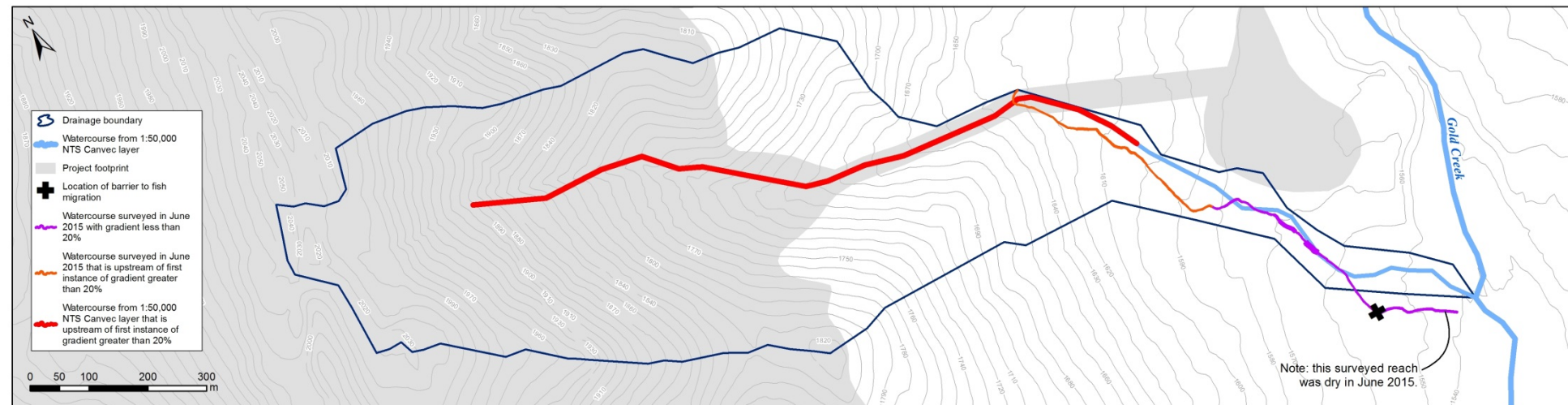
Substrate and cover information are presented in order of decreasing dominance.

N/A – not obtained; N – little or no cover present.

SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream

Gray-shaded reaches are reaches that will be removed by the Project footprint

The start of Reach 3 marks the location at which GCT08 was observed to subsurface, approximately 110 m from Gold Creek. Tributary GCT08 was not connected to Gold Creek via surface flows in June 2015. Reach 1 that was surveyed in the drainage of tributary GCT08 represents a culvert from channel of GCT08 that was not flowing in June 2015.

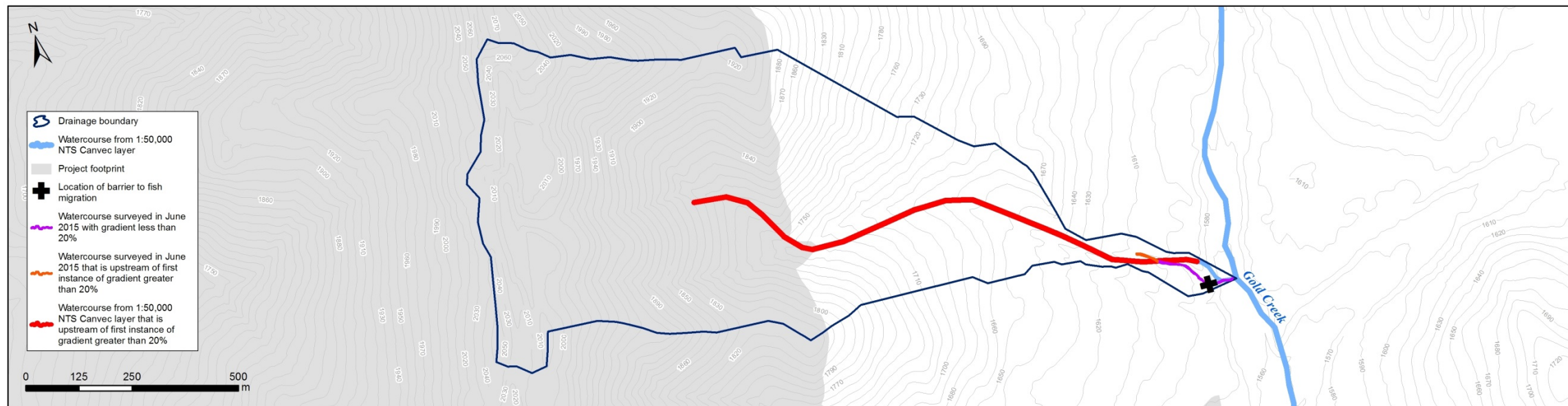












				
<p>Start of subsurface flow downstream of Reach 2 approximately 110 m from Gold Creek</p>	<p>Additional subsurface flow downstream of Reach 2. The channel eventually became completely dry before reaching Gold Creek</p>	<p>Reach 3 showing 1.2 m waterfall and entrenched channel</p>	<p>Reach 3 showing 0.55 m waterfall</p>	<p>Reach 4, LDB-U/S</p>
				
<p>Reach 6: LDB-U/S</p>	<p>Reach 8: RDB-U/S</p>	<p>Reach 12: LDB-D/S</p>	<p>Reach 15: LDB-D/S at top of waterfall</p>	<p>Reach 17: LDB-D/S</p>
				
<p>Reach 18, RDB-D/S</p>	<p>Reach 20, LDB-D/S</p>	<p>Reach 22, LDB-D/S, showing flood evidence</p>	<p>Reach 24, LDB-D/S</p>	<p>Culvert at upper end of Reach 25, RDB-D/S, marking end of surveyed portion of GCT08</p>

**Table A2.4 Biophysical habitat survey results for GCT09, June 2015.**

Reach No.	1	2	3	4
<b>Easting</b>	687837	687799	687761	687678 687544
<b>Northing</b>	5506746	5506745	5506768	5506831 5506878
<b>Wetted width (m)</b>	2.55	1.0	0.7	1.1
<b>Channel width (m)</b>	2.7	2.0	0.7	1.1
<b>Reach length (m)</b>	38.0	48.4	108.9	53.5
<b>Habitat area (m2)</b>	96.9	48.4	76.2	58.9
<b>Average depth (m)</b>	0.03	0.07	0.08	0.07
<b>Substrate</b>	Gravel Cobble	Boulder	Boulder	Cobble Boulder
<b>Slope (%)</b>	12.4	13.8	16.8	21.3
<b>Morphology</b>	Run Pool	Cascade	Cascade	Riffle
<b>Cover</b>	Pool	N	OWD LWD	OWD
<b>Other habitat features</b>	WF:0.2 WF:>1.0	WF:1.1 WF:0.65 WF:0.4	Chute	WF:>1.0
<b>Disturbances</b>				Old trail crossing coal fines observed throughout reach

Notes: UTM's refer to the start of each reach. Second UTM in final column represents end of the surveyed reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation;  
 UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream  
 Gray-shaded reaches are reaches that will be removed by the Project footprint



				
<p>Reach 1 - Confluence of CGT09 with Gold Creek</p>	<p>Reach 1, RDB-U/S with pool containing fish immediately below waterfall estimated at 0.4 m in height</p>	<p>Reach 1, RDB-U/S, waterfall estimated at 1.0 m in height</p>	<p>Reach 2, RDB-U/S</p>	<p>Reach 2, RDB-U/S</p>
				
<p>Chute in Reach 3, RDB-U/S</p>	<p>Chute in Reach 3, LDB-U/S</p>	<p>Reach 4, RDB-D/S</p>	<p>Reach 4, RDB-U/S, waterfall estimated at &gt;1.0 m in height</p>	<p>Coal sediments in Reach 4</p>

**Table A2.5 Biophysical habitat survey results for GCT10, June 2015.**

REACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
<b>Easting</b>	687818	687746	687720	687701	687678	687658	687641	687629	687622	687615	687594	687573	687548	687520	687499	687473	687433	687413	687370	687352	687329 687322	
<b>Northing</b>	5508130	5508152	5508159	5508154	5508150	5508153	5508154	5508154	5508180	5508128	5508128	5508133	5508117	5508118	5508118	5508113	5508108	5508094	5508087	5508074	5508060 5508058	
<b>Wetted width (m)</b>	0.83	0.75	1.2	1.1	1.55	1.05	0.85	1.9	1.55	1.1	0.9	1.15	0.85	1.25	1.0	1.2	0.6	1.3	0.6	3.0	2.4	
<b>Channel width (m)</b>	0.83	1.65	1.2	1.1	1.55	1.05	1.4	1.9	1.55	1.1	0.9	1.15	1.35	1.25	1.0	1.2	0.6	1.3	0.6	3.0	2.4	
<b>Reach length (m)</b>	78.2	27.4	19.9	24.7	20.6	17.2	20.5	35.7	55.4	20.9	21.7	31.0	31.2	20.6	27.8	41.6	27.8	53.5	23.4	27.5	7.2	
<b>Habitat area (m<sup>2</sup>)</b>	64.9	45.2	23.9	27.2	31.9	18.1	28.7	67.8	85.9	23.0	19.5	35.7	42.1	25.8	27.8	49.9	16.7	69.6	14.0	82.5	17.3	
<b>Average depth (m)</b>	0.13	0.09	0.11	0.09	0.10	0.06	0.06	0.13	0.04	0.11	0.09	0.13	0.05	0.05	0.15	0.16	0.13	0.19	0.08	0.07	0.16	
<b>Substrate</b>	Cobble Gravel	Cobble Boulder	Boulder	Boulder	Boulder Gravel	Boulder	Gravel Boulder	Gravel Boulder	Gravel Boulder	Cobble Gravel	Boulder Gravel	Boulder Cobble	Gravel Cobble	Cobble Gravel	Boulder	Cobble Boulder	Cobble Gravel	Boulder Gravel	Cobble Gravel	Cobble Gravel	Cobble Gravel	Cobble Gravel
<b>Slope (%)</b>	2.6	3.7	15.1	4.1	9.7	11.6	19.5	8.4	3.6	9.6	13.8	22.6	9.6	24.2	18.0	19.2	10.8	14.9	12.8	14.5	0.0	
<b>Morphology</b>	Riffle	Riffle Cascade	Riffle Cascade	Riffle Cascade	Riffle Cascade	Riffle Cascade Pool	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle
<b>Cover</b>	LWD OWD	OWD OHV	OHV	OWD	N	N	LWD	N	OWD	N	N	LWD OWD	OHV OWD	SWD OWD UCB	N	SWD	OHV	N	N	N	N	
<b>Other habitat features</b>	WF:1.02 WF:1.05	WF:1.2		WF		WF:0.57 WF:0.88	WF:0.7 WF:0.8						WF:>1.0	WF:0.71			WF:0.95					
<b>Disturbances</b>								Road Crossing													Hanging Culvert:>1.0	

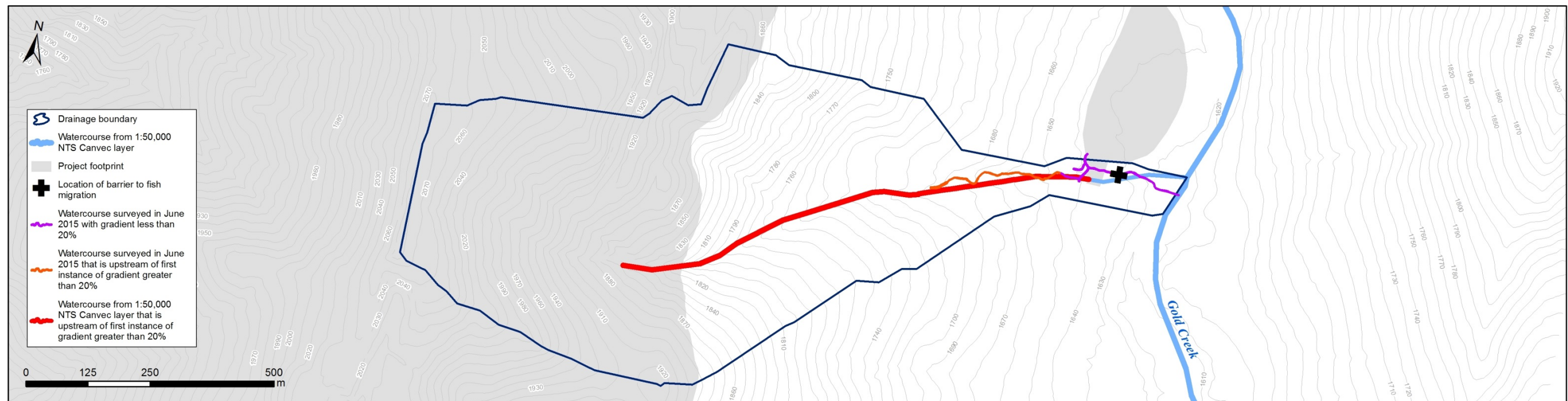
Notes: UTM's refer to the start of each reach. Second UTM in final column represents end of the surveyed reach.

Substrate and cover information are presented in order of decreasing dominance.

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Gray-shaded reaches are reaches that will be removed by the Project footprint

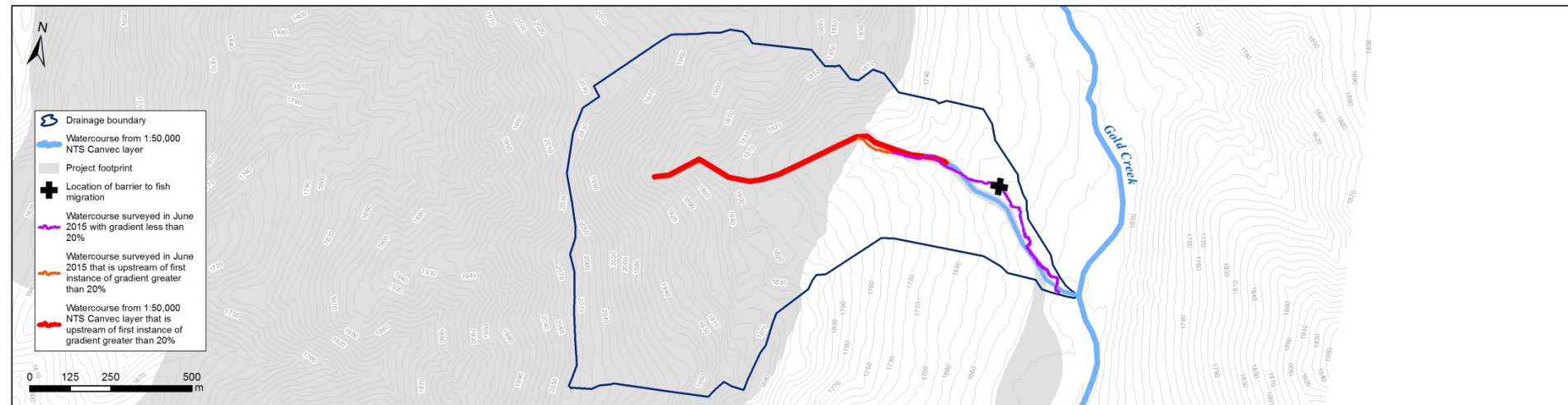






				
Confluence of GCT10 with Gold Creek	Reach 1, RDB-D/S from waterfall estimated at 1.05 m in height	Reach 2, RDB-D/S	Reach 3, RDB-D/S	Reach 4, RDB-D/S
				
Reach 6, RDB-D/S from waterfall estimated at 0.88 m in height	Reach 8, RDB-D/S	Reach 10, LDB-D/S	Reach 13, RDB-U/S	Reach 14, LDB-U/S
				
Reach 16, LDB-U/S	Reach 18, RDB-D/S	Reach 19, LDB-D/S	Reach 20, RDB-D/S	Reach 21, LDB-D/S

**Table A2.6 Biophysical habitat survey results for GCT11, June 2015.**

REACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
<b>Easting</b>	687741	687727	687727	687699	687681	687636	687626	687625	687619	687600	687592	687582	687574	687551	687528	687502	687462	687388	687320	687256	687184	687155	687109 687727
<b>Northing</b>	5508603	5508613	5508645	5508654	5508668	5508705	5508716	5508742	5508750	5508770	5508789	5508812	5508838	5508839	5508870	5508892	5508894	5508906	5508928	5508938	5508936	5508936	5508936 5508613
<b>Wetted width (m)</b>	1.4	1.1	1.3	1.1	1.2	0.7	1.95	1.2	1.45	0.65	1.65	1.0	1.05	1.95	N/A	N/A	N/A	N/A	N/A	0.9	N/A	N/A	1.7
<b>Channel width (m)</b>	8.3	1.1	1.3	1.1	1.2	0.7	1.95	1.2	1.45	0.65	1.65	1.0	1.05	1.95	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.7
<b>Reach length (m)</b>	18.2	32.8	31.6	23.5	59.2	14.9	31.5	10.2	30.4	20.1	24.9	28.0	22.8	39.9	36.9	45.7	77.0	72.2	71.8	72.7	29.6	45.6	69.1
<b>Habitat area (m<sup>2</sup>)</b>	25.4	36.1	41.1	25.9	71.1	10.4	61.5	12.3	44.1	13.1	41.2	28.0	23.9	77.9	N/A	N/A	N/A	N/A	N/A	65.4	N/A	N/A	117.5
<b>Average depth (m)</b>	0.07	0.17	0.19	0.10	0.14	0.13	0.12	0.13	0.19	0.18	0.30	0.11	0.12	0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.11
<b>Substrate</b>	Gravel Cobble	Gravel Cobble	Gravel Cobble	Boulder Gravel	Boulder Gravel	Gravel Sand	Boulder Gravel	Boulder Gravel	Gravel	Boulder Bedrock	Gravel Cobble	Gravel Boulder	Boulder	Gravel Boulder	Gravel Boulder	Cobble Boulder	Boulder Bedrock	Boulder Bedrock	Boulder Gravel	Boulder Gravel	Boulder Gravel	Boulder Gravel	Boulder
<b>Slope (%)</b>	0.0	5	4	4	5	0.0	5	4	5	14	9	12	12	8	14	8	20	18	18	14	18	22	20
<b>Morphology</b>	Riffle Run	Riffle Run	Cascade Pool	Cascade Riffle	Riffle Pool	Riffle Pool	Riffle Pool	Riffle Pool	Cascade Riffle Pool	Cascade Riffle	Cascade Riffle	Cascade Riffle Pool	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle	Cascade Riffle
<b>Cover</b>	LWD	LWD OWD UCB	P UCB	OWD	OWD OHV P UCB	N	OWD LWD	SWD UCB	UCB OWD	LWD	UCB	N	N	N	N	N	N	N	N	N	N	N	N
<b>Other habitat features</b>	WF:0.3	Entrenched Channel WF:0.63	Pool:0.5 Pool:0.45		Fish Observed WF:0.61	WF:0.45		Multiple waterfalls				WF:0.69 Pool:0.48			WF:>1.0	WF:>1.0			WF:>1.0		WF:0.9 Groundwater Seep	WF:>1.0	
<b>Disturbances</b>								Remains of old bridge	Culvert														

Notes: UTM's refer to the start of each reach. Second UTM in final column represents end of the surveyed reach.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream  
 Gray-shaded reaches are reaches that will be removed by the Project footprint

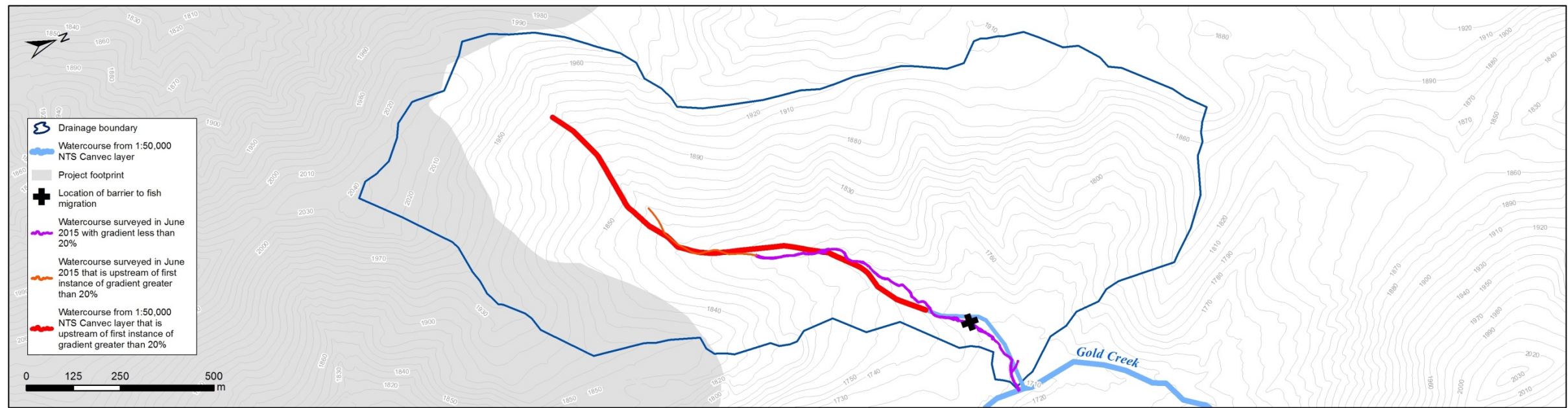

















				
Reach 1: Confluence of CGCT11 with Gold Creek	Reach 2, RDB-U/S, with waterfall estimated at 0.63 m in height	Reach 2, LDB-U/S	Reach 4, RDB-U/S	Reach 6, RDB-D/S
				
Reach 8, RDB-U/S, with remains of old bridge	Reach 9, RDB-U/S, with culvert	Reach 11, LDB-D/S	Reach 12, RDB-U/S	Reach 15, RDB-D/S
				
Reach 17, LDB-D/S	Reach 19, LDB-D/S	Reach 20, RDB-U/S	Reach 21, RDB-U/S, waterfall with estimated height of 0.9 m	Reach 23, LDB-U/S

**Table A2.7 Biophysical habitat survey results for GCT14, June 2015.**

REACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
<b>Easting</b>	687302	687253	687250	687232	687200	687177	687151	687128	687112	687087	686989	687003	687048	687060	687073	687082	686969	686945	686930	686896	686770	686753	686559	686725 686559
<b>Northing</b>	5510452	5510448	5510448	5510454	5510450	5510444	5510435	5510422	5510407	5510391	5510281	5510299	5510324	5510348	5510365	5510385	5510269	5510263	5510246	5510212	5510054	5509990	5509705	5509917 5509705
<b>Wetted width (m)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Channel width (m)</b>	3.2	1.85	0.86	2.5	1.55	2.2	2.65	1.85	1.75	1.85	2.9	1.95	6.9	2.82	3.05	3.2	1.25	1.55	2.36	N/A	N/A	N/A	N/A	N/A
<b>Reach length (m)</b>	49.7	22.2	36.7	38.1	23.4	28.4	26.8	23.9	30.2	7.1	23.6	25.3	53.9	27.2	22.0	22.2	26.2	24.9	49.4	222.8	67.6	79.3	52.0	292.1
<b>Habitat area (m<sup>2</sup>)</b>	159.1	41.1	31.6	95.2	36.3	62.6	70.9	44.3	52.8	13.1	68.4	49.3	371.7	76.7	67.2	71.2	32.7	38.5	116.6	N/A	N/A	N/A	N/A	N/A
<b>Average depth (m)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25	0.27	0.19	0.25	0.24	0.20	0.20	0.19	0.25	0.27	0.32	0.17	N/A	N/A	N/A	N/A	N/A
<b>Substrate</b>	Gravel	Gravel	Gravel	Bedrock Gravel	Cobble Gravel	Boulder Cobble	Gravel Cobble	Cobble	Boulder	Cobble	Cobble Gravel	Boulder Cobble	Cobble	Boulder Gravel	Cobble	Boulder	Boulder Gravel	Boulder	Gravel Boulder	Gravel	Boulder Gravel	Cobble Gravel	Cobble Gravel	Cobble Gravel
<b>Slope (%)</b>	8	6	5	6	6	4	6	10	14	10	14	12	10	8	10	8	11	16	19	4	11	14	25	30
<b>Morphology</b>	Riffle Cascade	Riffle Cascade	Riffle Cascade	Cascade Riffle Pool	Cascade Riffle Pool	Cascade Riffle	Cascade Riffle	Cascade Riffle Pool	Cascade Riffle	Cascade	Cascade	Cascade	Riffle	Riffle	Cascade	Cascade	Cascade	Cascade	Cascade	Riffle Pool	Riffle Cascade	Riffle Cascade Pool	Riffle Cascade	Riffle Cascade
<b>Cover</b>	N	LWD	N	Pool	LWD OWD Pool	N	LWD	Pool	N	N	N	N	N	LWD	N	N	N	N	N	Pool	N	Pool	N	N
<b>Other habitat features</b>	Chute			Pool:0.52		GW Seep					WF:1.6	WF:0.8						WF:0.7		WF:0.8	Pool:0.5	GW Seep		
<b>Disturbances</b>																								

Notes: UTM's refer to the start of each reach. Second UTM in final column represents end of the surveyed watercourse.  
 Substrate and cover information are presented in order of decreasing dominance.  
 N/A – not obtained; N – little or no cover present.  
 SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris; OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m; Pool:xx – Pool with depth of xx m; RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream; GW – groundwater  
 Gray-shaded reaches are reaches that will be removed by the Project footprint



				
Reach 1, RDB-U/S, immediately upstream of confluence of GCT14 with Gold Creek	Reach 4, RDB-U/S	Reach 6, RDB-U/S	Reach 8, LDB-U/S	Reach 11, LDB-U/S, waterfall with height estimated at 1.6 m
				
Reach 13, RDB-U/S	Reach 13, RDB-U/S	Reach 16, RDB-U/S	Reach 18, RDB-U/S	Reach 18, RDB-U/S
				
Reach 20, LDB-D/S	Reach 21, RDB-U/S	Reach 21, RDB-U/S	Reach 23, Groundwater seep	Reach 24, RDB-U/S

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**Appendix A3**

**Blairmore Creek Habitat Data**

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## A3.0 BLAIRMORE CREEK HABITAT DATA

Figure A3.1 Summary of biophysical habitat at BC01, August 2014.


Referencing Information	
Site Code:	<b>BC01</b>
Date Assessed:	August 27, 2014
Time Assessed:	14:10
UTM (NAD83):	11U 684541E 5507209N
Access:	UTV
In situ Water Quality	
Temperature (°C):	13.2
Dissolved Oxygen (mg/L):	9.2
pH:	8.35
Conductivity (µS/cm):	252
Physical Description	
Maximum depth (m):	0.7
Wetted Width (m):	3.25
Rooted Width (m):	10.00
Reach Length (m):	290
<b>Substrate</b>	
Dominant Substrate:	cobble
Subdominant substrate:	bedrock
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Riffle-run.
Pattern:	Irregular meandering.
Islands/Bars	Cobble bars and exposed cobble.
Notes	
<p>Channel shows evidence of redirection via flood event (likely from 2013). Large log jam was within the reach examined. Banks are unstable and eroding throughout. Alluvial deposits present on top of banks. ATV trail crosses creek at the downstream end of the reach and there is evidence of cattle crossing as well.</p> <p>The reach examined did not contain any gravel suitable for spawning. Some pools were present, but maximum depth was 0.7 m. Unstable banks were present throughout the study reach.</p>	



View looking upstream, Aug 2014.




View looking downstream, Aug 2014.




Unstable banks are common within this study reach, Aug 2014.

**Figure A3.2 Summary of biophysical habitat at BC02, August 2014.**


Referencing Information	
Site Code:	<b>BC02</b>
Date Assessed:	August 26, 2014
Time Assessed:	09:21
UTM (NAD83):	11U 682981E 5509810N
Access:	UTV
In situ Water Quality	
Temperature (°C):	7.0
Dissolved Oxygen (mg/L):	9.4
pH:	8.29
Conductivity (µS/cm):	248
Physical Description	
Maximum depth (m):	0.5
Wetted Width (m):	2.0
Rooted Width (m):	2.3
Reach Length (m):	300
<b>Substrate</b>	
Dominant Substrate:	cobble
Subdominant substrate:	sand/fines
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Run with riffles and small pools.
Pattern:	Irregular meandering.
Islands/Bars	Some exposed bars along margins.
Notes	
<p>Flood signs include debris piles and deposits within the riparian area, but no bank erosion was evident.</p> <p>Habitat consisting of runs, riffles and pools with abundant instream and overhead cover. No suitable spawning substrate within study section, but excellent rearing and potential overwintering habitat was present.</p> <p>Log jams across creek may create temporary low flow barriers.</p>	



View looking upstream, Aug 2014.




View looking downstream, Aug 2014.





Log jam creating potential low flow barrier, Aug 2014.

**Figure A3.3 Summary of biophysical habitat at BCT01, August 2014.**


Referencing Information	
Site Code:	<b>BCT01</b>
Date Assessed:	August 29, 2014
Time Assessed:	14:10
UTM (NAD83):	11U 684213E 5502010N
Access:	Road
Notes	
<p>The entire valley of the existing channel has been filled in with waste rock from Grassy Mountain Road to the confluence with Blairmore Creek.</p> <p>Infilling apparently took place in the mid 1980's.</p> <p>Water could be heard flowing in the culvert underneath Grassy Mountain Road.</p> <p>No direct fish habitat potential. Flows contribute to the water level in Blairmore Creek but would not provide habitat at any point of the year.</p>	
	
<p><b>View looking downstream from Grassy Mountain Road, Aug 2014.</b></p>	

**Figure A3.4 Summary of biophysical habitat at BCT02, August 2014.**

Referencing Information	
Site Code:	<b>BCT02</b>
Date Assessed:	August 29, 2014
Time Assessed:	09:20
UTM (NAD83):	11U 6851893E 5503691N
Access:	Road/hike
Notes	
<p>Numerous barriers including bedrock waterfalls and log jams occur between the mouth of the creek and Grassy Mountain Road.</p> <p>The first barrier is located approximately 30 m from the confluence with Blairmore Creek and is a 0.8 m high falls over bedrock.</p> <p>Creek receives drainage from old underground mines leading to extensive iron staining.</p> <p>Barrier near mouth would prevent fish from reaching upper portions of tributary. Benthic invertebrate drift may provide a food source for fish and flows contribute to the water level in Blairmore Creek.</p>	
	
<p><b>Iron staining from discharge from existing underground mine works, Aug 2014.</b></p>	
	
<p><b>Waterfall located approximately 30 m from confluence with Blairmore Creek, Aug 2014.</b></p>	

**Figure A4.5 Summary of biophysical habitat at BCT03, August 2014.**

Referencing Information	
Site Code:	<b>BCT03</b>
Date Assessed:	August 29, 2014
Time Assessed:	09:20
UTM (NAD83):	11U 684694E 5503910N
Access:	Road/hike
Notes	
<p>Small, first order tributary with waterfall over bedrock at confluence with Blairmore Creek.</p> <p>Defined channel upstream of waterfall would provide opportunity for invertebrates to colonize and provide potential food source for Blairmore Creek.</p> <p>Barrier near mouth would prevent fish from reaching upper portions of tributary. No direct fish habitat.</p> <p>Benthic invertebrate drift may provide food source for fish and flows contribute to the water level in Blairmore Creek.</p>	



**Waterfall at confluence with Blairmore Creek, Aug 2014.**

**Figure A3.6 Summary of biophysical habitat at BCT04a, August 2014.**

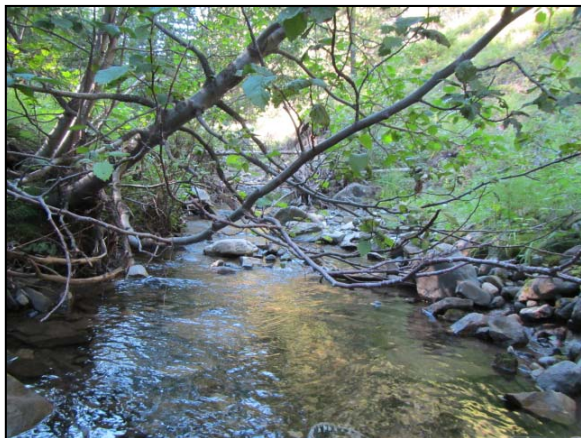
Referencing Information	
Site Code:	<b>BCT04a</b>
Date Assessed:	August 26, 2014
Time Assessed:	12:28
UTM (NAD83):	11U 684579E 5505248N
Access:	UTV
In situ Water Quality	
Temperature (°C):	9.8
Dissolved Oxygen (mg/L):	9.2
pH:	8.44
Conductivity (µS/cm):	356
Physical Description	
Maximum depth (m):	0.5
Wetted Width (m):	1.50
Rooted Width (m):	1.75
Reach Length (m):	312
<b>Substrate</b>	
Dominant Substrate:	cobble
Subdominant substrate:	fine
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Run with riffles and small pools. Some steeper cascades.
Pattern:	Straight.
Islands/Bars	Some exposed bars along margins.
Notes	
<p>Predominantly run habitat with riffles and pools. Exposed bedrock substrate creates cascades that would not be a barrier to fish passage. Creek is within a steep valley and is confined to valley walls throughout most of the section examined.</p> <p>Habitat consists of runs, riffles and pools with abundant instream and overhead cover. No suitable spawning substrate within study section, but excellent rearing and potential overwintering habitat was present.</p> <p>Valley walls were unstable and slumping was observed resulting in fine material entering the creek.</p>	



Looking upstream at cascade over bedrock, Aug 2014.



View looking downstream showing unstable bank on left side, Aug 2014.



Typical habitat in BCT04a, Aug 2014.

**Figure A3.7 Summary of biophysical habitat at BCT04b, August 2014.**

Referencing Information	
Site Code:	<b>BCT04b</b>
Date Assessed:	August 28, 2014
Time Assessed:	12:05
UTM (NAD83):	11U 684579E 5506212N
Access:	UTV
In situ Water Quality	
Temperature (°C):	10.5
Dissolved Oxygen (mg/L):	9.8
pH:	8.55
Conductivity (µS/cm):	358
Physical Description	
Maximum depth (m):	0.5
Wetted Width (m):	1.75
Rooted Width (m):	3.50
Reach Length (m):	290
<b>Substrate</b>	
Dominant Substrate:	bedrock
Subdominant substrate:	cobble
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	√
Large Woody Debris:	√
Detritus:	-
Substrate:	√
Undercut Banks:	√
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Shallow runs over bedrock with riffles and cascades. Small pools at base of cascades.
Pattern:	Straight.
Islands/Bars	None.
Notes	
<p>Predominantly run habitat with bedrock substrate throughout. Cobble and small gravel on top of bedrock. Shallow pools at base of cascades. Downstream of site was a steeply sloped bedrock chute that would be a barrier at high flow.</p> <p>Small patches of gravel may be suitable for spawning. Extensive instream and overhead cover would be excellent rearing habitat for all stages. Shallow pools at base of some cascades would provide overwintering habitat assuming flows were present all winter.</p>	



**Pool below cascade, Aug 2014.**




**View looking upstream from upper end of reach, Aug 2014.**



**View looking downstream from upper end of reach sampled, Aug 2014.**

**Figure A3.8 Summary of biophysical habitat at BCT04c, August 2014.**

Referencing Information	
Site Code:	<b>BCT04c</b>
Date Assessed:	August 28, 2014
Time Assessed:	14:44
UTM (NAD83):	11U 683222E 5507459N
Access:	Road
Notes	
<p>Site BCT04c is situated on one of the two upstream channels of this tributary to Blairmore Creek. A small pool exists at the trail crossing location. Upstream of the ATV trail, the channel is poorly defined in places with extensive vegetation cover. Channel downstream of crossing is also poorly defined and flows through terrestrial vegetation.</p> <p>Water was flowing, but there was insufficient depth for fish capture at the time of assessment.</p> <p>No direct fish habitat potential, but flows contribute to sites further downstream where fish were captured.</p>	



**Channel downstream of ATV trail flows through terrestrial vegetation, Aug 2014.**

**Figure A3.9 Summary of biophysical habitat at BCT05, August 2014 and June 2015.**

Referencing Information		
Site Code:	<b>BCT05</b>	
Date Assessed:	Aug 27, 2014	Jun 1, 2015
Time Assessed:	14:10	16:30
UTM (NAD83):	11U 684541E 5507209N	
Access:	UTV	
In situ Water Quality		
Parameter	Aug 2014	Jun 2015
Temperature (°C):	N/A	8.12
Dissolved Oxygen (mg/L):	N/A	11.55
pH:	N/A	7.48
Conductivity (µS/cm):	N/A	107
Physical Description		
	Aug 2014	June 2015
Maximum depth (m):	N/A	0.15
Wetted Width (m):	N/A	1.67
Rooted Width (m):	N/A	2.47
Reach Length (m):	150	145
<b>Substrate</b>		
Dominant Substrate:	gravel	
Subdominant substrate:	sand	
<b>Instream cover (presence/ absence)</b>		
Small Woody Debris:	✓	
Large Woody Debris:	✓	
Detritus:	-	
Substrate:	-	
Undercut Banks:	-	
Instream vegetation:	-	
<b>Overhead cover</b>		
Aquatic Vegetation:	None (flooded terrestrial vegetation)	
Riparian Vegetation:	Mixed wood forest, shrubs	
Notes		
<p>Creek flows along an ATV trail in spots which has created a very shallow run habitat along the trail itself. Water was flowing during both assessments. The creek flows along the top of the bank of Blairmore Creek and empties into Blairmore over a 0.5 m high drop which would be a barrier to fish passage unless Blairmore Creek is in flood stage.</p> <p>Upstream of the ATV trail, the creek flows overland through multiple shallow channels with poorly defined bed and banks and evidence of cattle use. Slope at this section was 22% and there was insufficient depth for fish passage even in the spring.</p> <p>There is limited potential for rearing habitat in the lowermost 100 m of this creek, but it would be limited to times when Blairmore Creek was at bankfull stage.</p>		



**Confluence of GCT05 with Blairmore Creek, June 2015.**






**View looking upstream towards the ATV trail, June 2015.**



**View looking downstream from the ATV trail, Aug 2014.**

**Figure A3.10 Summary of biophysical habitat at BCT06, August 2014 and June 2015.**

Referencing Information	
Site Code:	<b>BCT06</b>
Date Assessed:	Aug 27, 2014    Jun 1, 2015
Time Assessed:	13:15                    17:10
UTM (NAD83):	11U 684563E 5507445N
Access:	UTV
Notes	
<p>Creek had flowing water in both August 2014 and June 2015 visits. Channel downstream of ATV trail is poorly defined in some places and flow was subsurface near the confluence with Blairmore Creek in August.</p> <p>Creek flows over banks of Blairmore Creek resulting in a 0.75 m high barrier at the confluence. Additional barrier is present immediately upstream of the ATV trail crossing.</p> <p>Given the low summer flows, it is unlikely that any invertebrates would be able to develop within this creek.</p> <p>This creek contributes flow to Blairmore Creek, but does not provide any direct fish habitat.</p>	
 <p><b>Confluence of GCT06 with Blairmore Creek, June 2015.</b></p>	
 <p><b>Waterfall immediately upstream of ATV trail, June 2015.</b></p>	
 <p><b>View looking upstream from confluence with Blairmore Creek showing area of subsurface flow, Aug 2014.</b></p>	

**Figure A3.11 Summary of biophysical habitat at BCT07, August 2014, February and June 2015.**

Referencing Information			
Site Code:	<b>BCT07</b>		
Date Assessed:	Aug 2014	Feb 2015	Jun 2015
Time Assessed:	12:00	15:12	18:56
UTM (NAD83):	11U 684371E 5508212N		
Access:	UTV/hike		
In situ Water Quality			
Parameter	Aug 2014	Feb 2015	Jun 2015
Temperature (°C):	9.7	0.2	8.4
Dissolved Oxygen (mg/L):	9.8	9.8	10.49
pH:	8.43	8.65	7.66
Conductivity (µS/cm):	173	149	79
Physical Description			
	Aug, 2014	Jun, 2015	
Maximum depth (m):	0.7	0.8	
Wetted Width (m):	1.10	1.1	
Rooted Width (m):	1.75	1.2	
Reach Length (m):	160	110	
<b>Substrate</b>			
Dominant Substrate:	bedrock		
Subdominant substrate:	gravel		
<b>Instream cover (presence/ absence)</b>			
Small Woody Debris:	✓		
Large Woody Debris:	✓		
Detritus:	-		
Substrate:	✓		
Undercut Banks:	✓		
Instream vegetation:	-		
<b>Overhead cover</b>			
Aquatic Vegetation:	None		
Riparian Vegetation:	Shrubs and mixed forest		
Channel Morphology			
Morphology:	Shallow runs over bedrock with riffles and cascades. Small pools at base of cascades.		
Pattern:	Straight.		
Islands/Bars	None.		
Notes			
<p>Predominantly riffle habitat with bedrock substrate throughout. Cobble and boulder on top of bedrock. Shallow pools at base of cascades. Waterfall located approximately 75 m from confluence with Blairmore Creek.</p> <p>Upstream of waterfall habitat was a series of riffles with cobble on bedrock. No spawning gravel was observed. Slope of channel was 12% with two additional impassable waterfalls (see barriers section). Creek was flowing in the winter.</p>			



Typical habitat in section below falls, June 2015.



View looking downstream from the first waterfall, Aug 2014.



View looking upstream at typical habitat upstream of waterfall, June 2015.

**Figure A3.12 Summary of biophysical habitat at BCT08, August 2014.**

Referencing Information	
Site Code:	<b>BCT08</b>
Date Assessed:	August 27, 2014
Time Assessed:	11:35
UTM (NAD83):	11U 684020E 5508709N
Access:	UTV
In situ Water Quality	
Temperature (°C):	9.0
Dissolved Oxygen (mg/L):	9.8
pH:	8.22
Conductivity (µS/cm):	239
Physical Description	
Maximum depth (m):	0.20
Wetted Width (m):	0.5
Rooted Width (m):	1.50
Reach Length (m):	92
<b>Substrate</b>	
Dominant Substrate:	cobble
Subdominant substrate:	gravel
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Shallow riffles with small falls and pools.
Pattern:	Straight.
Islands/Bars	None.
Notes	
<p>Water was flowing, but was very shallow at the time of assessment. Narrow creek with instream and overhead cover that would be suitable for rearing. Gravel patches suitable for spawning were present and may be usable in higher flows.</p> <p>Multiple steps and subsurface flow create low flow barriers. No permanent barrier noted within area examined. Extensive overhead cover provides shading for creek. Shallow pools would provide rearing habitat.</p>	



**View looking downstream, Aug 2014.**



**Low flow barrier with pool, Aug 2014.**

**Figure A3.13 Summary of biophysical habitat at BCT09a, August 2014.**

Referencing Information	
Site Code:	<b>BCT09a</b>
Date Assessed:	August 26, 2014
Time Assessed:	17:53
UTM (NAD83):	11U 683006E 5509253N
Access:	UTV
In situ Water Quality	
Temperature (°C):	15.7
Dissolved Oxygen (mg/L):	11.0
pH:	8.52
Conductivity (µS/cm):	267
Physical Description	
Maximum depth (m):	0.80
Wetted Width (m):	0.5
Rooted Width (m):	2.0
Reach Length (m):	250
<b>Substrate</b>	
Dominant Substrate:	cobble
Subdominant substrate:	finer
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Shallow run with riffles.
Pattern:	Straight.
Islands/Bars	None.
Notes	
<p>Temperature at this site was considerably higher than at other locations likely due to a pond upstream of the road.</p> <p>Extensive overhead cover throughout the reach assessed.</p> <p>Wide pool downstream of culvert, but creek narrowed considerably once outside of the road right of way.</p> <p>Substrate was predominantly small gravel with some embedded fine material, but overall suitable spawning substrate for trout.</p>	





**View looking downstream, Aug 2014.**



**Perched culvert under Devon Road, Aug 2014.**

**Figure A3.14 Summary of biophysical habitat at BCT09b, August 2014.**

Referencing Information	
Site Code:	<b>BCT09b</b>
Date Assessed:	August 29, 2014
Time Assessed:	08:20
UTM (NAD83):	11U 681761E 5509331N
Access:	Road
Notes	
<p>Defined channel with a channel width of 0.5 m. Culvert under Forestry Trunk Road is not perched, but shallow depth and steep slope would prevent upstream migration of fish.</p> <p>Creek downstream of the Forestry Trunk Road would provide potential rearing habitat for fish during higher flows, but access is limited by a perched culvert at the Devon Road (site BCT09a).</p>	
	
<p><b>Channel downstream of Forestry Trunk Road, Aug 2014.</b></p>	
	
<p><b>Culvert under Forestry Trunk Road is too steep for fish passage, Aug 2014.</b></p>	



**Figure A3.15 Summary of biophysical habitat at BCT09c, August 2014.**

Referencing Information	
Site Code:	<b>BCT09c</b>
Date Assessed:	August 29, 2014
Time Assessed:	08:05
UTM (NAD83):	11U 681482E 5508527N
Access:	Road

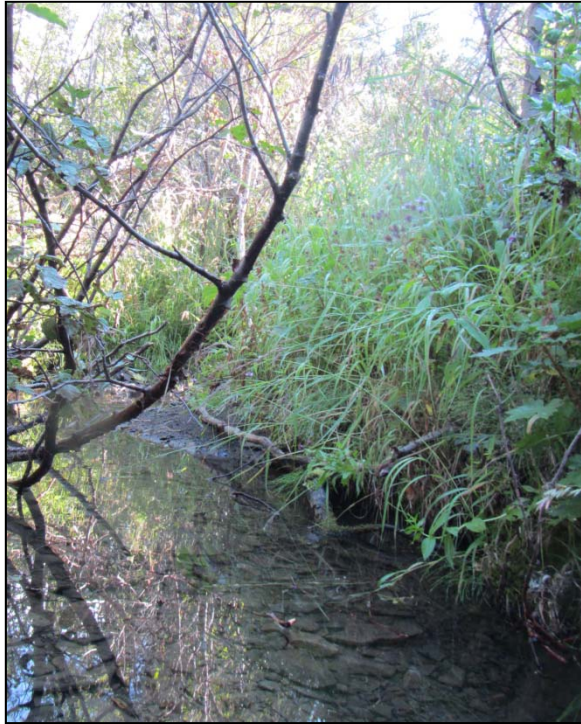
Notes
<p>Narrow, incised defined channel with a channel width of 0.2m. Culvert under Forestry Trunk Road is not perched, but shallow depth and steep slope would prevent upstream migration of fish.</p> <p>Insufficient wetted area for fish to use this channel.</p> <p>Contributes flows to downstream.</p>

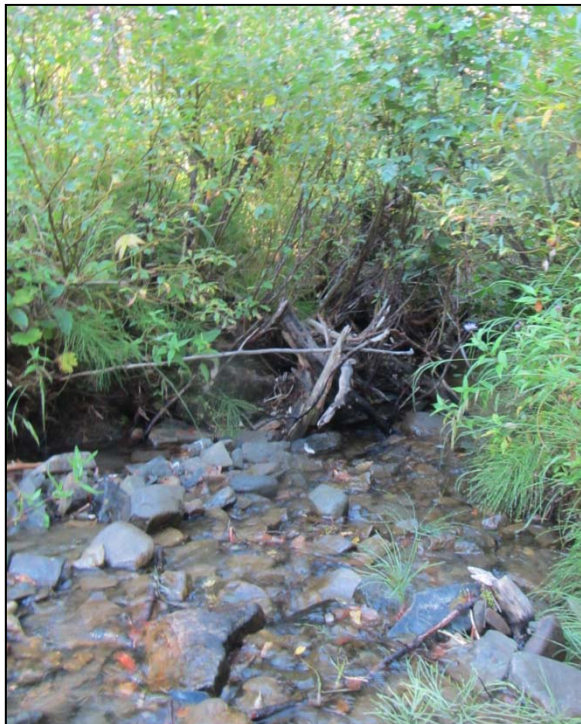

<p><b>Channel downstream of Forestry Trunk Road, Aug 2014.</b></p>

<p><b>Culvert under Forestry Trunk Road is partially buried, but is too steep for fish passage, Aug 2014.</b></p>

**Figure A3.16 Summary of biophysical habitat at BCT10, August 2014.**

Referencing Information	
Site Code:	<b>BCT10</b>
Date Assessed:	August 27, 2014
Time Assessed:	9:53
UTM (NAD83):	11U 682994E 5510178N
Access:	UTV
In situ Water Quality	
Temperature (°C):	8.0
Dissolved Oxygen (mg/L):	9.8
pH:	8.52
Conductivity (µS/cm):	167
Physical Description	
Maximum depth (m):	0.3
Wetted Width (m):	1.1
Rooted Width (m):	2.0
Reach Length (m):	230
<b>Substrate</b>	
Dominant Substrate:	Gravel
Subdominant substrate:	Cobble
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Run-riffle habitat.
Pattern:	Straight.
Islands/Bars	None.
Notes	
<p>Evidence of cattle use in the area, including crossing of the stream. Good overhead cover provides shading to the stream. Areas of gravel with suitable size for spawning fish. Runs with undercut banks provide good rearing habitat for all life stages. Overwintering would be limited by the lack of depth in the pools, but is possible if water flow was maintained.</p>	





**Typical habitat at site BCT10, Aug 2014.**



**View downstream at site BCT10, Aug 2014.**

**Figure A3.17 Summary of biophysical habitat at BCT12, August 2014.**

Referencing Information	
Site Code:	<b>BCT12</b>
Date Assessed:	August 29, 2014
Time Assessed:	08:30
UTM (NAD83):	11U 681853E 5510942N
Access:	Road
Notes	
<p>Defined channel downstream of the Forestry Trunk Road appears to have been filled with boulders. No access to be able to observe culvert, but channel slope is estimated at 30% and would be a barrier to fish passage at this location. Boulders are only near highway and the channel becomes more defined further downstream but remains steep.</p> <p>There was sufficient flow to provide at least rearing habitat farther downstream once the channel becomes less steep. Otherwise, creek provides flow for Blairmore Creek downstream.</p>	
 <p><b>Channel downstream of Forestry Trunk Road, Aug 2014.</b></p>  <p><b>Culvert under Forestry Trunk Road is too steep for fish passage, Aug 2014.</b></p>	

**Figure A3.18 Summary of biophysical habitat at BCT13, August 2014.**

Referencing Information			
Site Code:	<b>BCT13</b>		
Date Assessed:	August 25, 2014		
Time Assessed:	15:53		
UTM (NAD83):	11U 681838E 5510087N		
Access:	UTV		
In situ Water Quality			
Temperature (°C):	7.6		
Dissolved Oxygen (mg/L):	8.8		
pH:	8.41		
Conductivity (µS/cm):	268		
Physical Description			
Maximum depth (m):	0.3		
Wetted Width (m):	1.5		
Rooted Width (m):	2.5		
Reach Length (m):	100		
<b>Substrate</b>			
Dominant Substrate:	cobble		
Subdominant substrate:	boulder		
<b>Instream cover (presence/ absence)</b>			
Small Woody Debris:	✓		
Large Woody Debris:	✓		
Detritus:	-		
Substrate:	✓		
Undercut Banks:	✓		
Instream vegetation:	-		
<b>Overhead cover</b>			
Aquatic Vegetation:	None		
Riparian Vegetation:	Mixed forest, grasses, shrubs		
Channel Morphology			
Morphology:	Riffles with step pools.		
Pattern:	Straight.		
Islands/Bars	None.		
Notes			
Higher gradient stream with large substrate and fast water. Some areas of slow water provide velocity refuge.			
Small (0.2-0.4 m high) waterfalls were found within the study reach. Culvert under the road would be a barrier to fish passage. Iron staining along banks indicates potential groundwater input.			
Fish Capture Summary			
CTTR Captured	1	CPUE (#fish/100 sec)	0.25
Fork Length (mm)	161.0	Wetted Width	1.5
Size Range (mm)	161	Length	100
Total Effort (seconds)	394	Area	150
		Density (fish/100 m <sup>2</sup> )	0.67



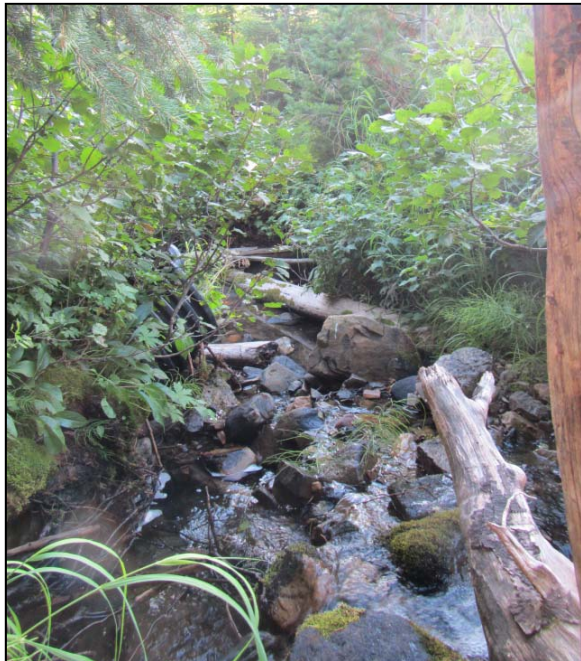
**View looking upstream, Aug 2014.**



**Small waterfall on BCT13. Unlikely a barrier to fish passage, Aug 2014.**

**Figure A3.19 Summary of biophysical habitat at BCT14, August 2014.**

Referencing Information	
Site Code:	<b>BCT14</b>
Date Assessed:	August 25, 2014
Time Assessed:	17:50
UTM (NAD83):	11U 682118E 5511115N
Access:	UTV
In situ Water Quality	
Temperature (°C):	8.3
Dissolved Oxygen (mg/L):	9.0
pH:	8.32
Conductivity (µS/cm):	222
Physical Description	
Maximum depth (m):	0.35
Wetted Width (m):	1.1
Rooted Width (m):	1.8
Reach Length (m):	300
<b>Substrate</b>	
Dominant Substrate:	Bedrock
Subdominant substrate:	gravel
<b>Instream cover (presence/ absence)</b>	
Small Woody Debris:	✓
Large Woody Debris:	✓
Detritus:	-
Substrate:	✓
Undercut Banks:	✓
Instream vegetation:	-
<b>Overhead cover</b>	
Aquatic Vegetation:	None
Riparian Vegetation:	Mixed forest, grasses, shrubs
Channel Morphology	
Morphology:	Riffles with step pools.
Pattern:	Straight.
Islands/Bars	None.
Notes	
<p>Extensive overhead cover from terrestrial vegetation. Some areas of gravel with suitable size for spawning.</p> <p>Impassable barrier located within this reach. Electrofishing was conducted upstream and downstream. No fish captured upstream of the barrier. Additional barrier in the form of a perched culvert underneath access road.</p>	



Typical habitat downstream of waterfall, Aug 2014.



2.0 m high waterfall. Permanent barrier to fish passage, Aug 2014.

**Figure A3.20 Summary of biophysical habitat survey at BCT05, June 2015.**

<b>REACH</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Easting</b>	684635	684633	684647	684634	684634
<b>Northing</b>	5507041	5507045	5507084	5507131	5507205
<b>Wetted width (m)</b>	1.7	0.78	2.35	multiple channel	1.1
<b>Channel width (m)</b>	2.4	0.81	2.7	>10 m	7.1
<b>Reach length (m)</b>	25.4	60.7	58.7	77	25
<b>Habitat area (m<sup>2</sup>)</b>	61	49.17	158.5	N/A	
<b>Average depth (m)</b>	0.07	0.09	0.053	0.05	0.05
<b>Substrate</b>	Gravel	Gravel Sand	Gravel Cobble	Boulder Cobble	Boulder
<b>Slope (%)</b>	<5	<5	<2	22	25
<b>Morphology</b>	Riffle	Riffle	Riffle	Riffle	Step pools
<b>Cover</b>	SWD	SWD	SWD OHV	None	OHV SWD
<b>Other habitat features</b>	0.5 m fall over bank of Blairmore Creek at mouth	0.6 m high falls	None	Braided channel over steep slope flowing into ATV trail	Shallow step pools over boulders and bedrock
<b>Disturbances</b>	None	None	Flows partially or fully along an existing ATV trail	ATV trail	None

Notes: UTM's refer to the start of each reach.

Substrate and cover information are presented in order of decreasing dominance.

N/A – not obtained; N – little or no cover present.

SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris;

OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m;

RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.



Reach 1, Confluence of BCT05 with Blairmore Creek



Reach 1, looking U/S from Blairmore Creek



Reach 2, Small barrier at start of reach



Reach 2, looking U/S



Reach 3, U/S along ATV trail



Reach 4, undefined channel in lower portion of reach



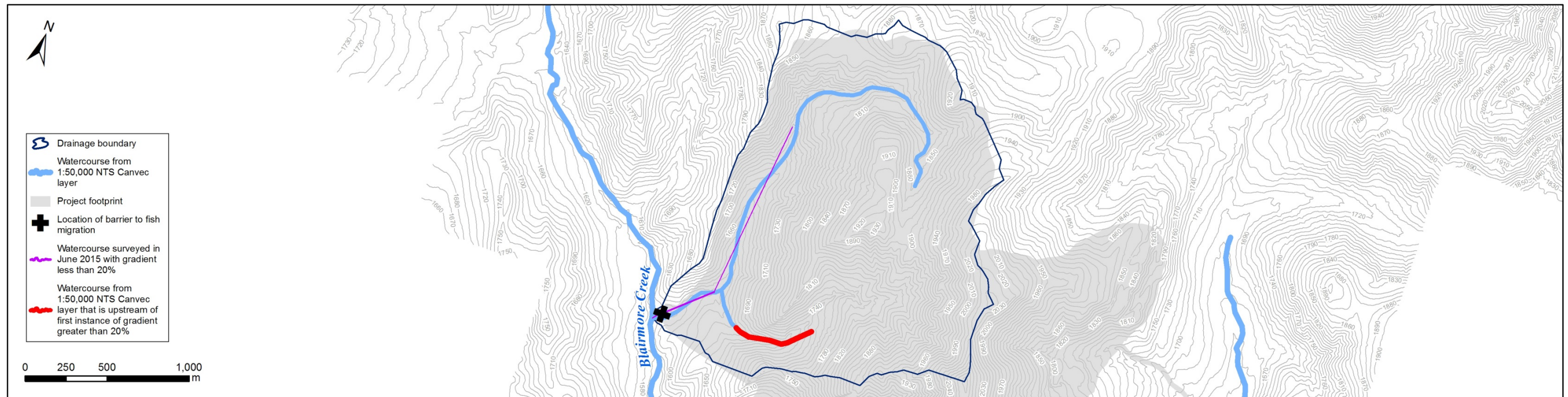
Reach 4, shallow cobble channel along 22% slope



Reach 5, looking upstream from start of reach



Reach 5, looking upstream from end of assessed portion of tributary



**Figure A3.21 Summary of biophysical habitat survey at BCT06, June 2015.**

REACH	1	2	3
<b>Easting</b>	684524	684562	684571
<b>Northing</b>	5507467	5507456	5507458
<b>Wetted width (m)</b>	1.1	1.6	varies
<b>Channel width (m)</b>	1.2	1.6	varies
<b>Reach length (m)</b>	40	10	N/A
<b>Habitat area (m<sup>2</sup>)</b>	48	16	N/A
<b>Average depth (m)</b>	0.2	0.05	varies
<b>Substrate</b>	Cobble Gravel	Cobble Gravel	Cobble
<b>Slope (%)</b>	21	5	-
<b>Morphology</b>	Riffle	Riffle	Riffle
<b>Cover</b>	SWD	None	SWD OHV
<b>Other habitat features</b>	0.75 m fall over bank of Blairmore Creek at mouth	Small pool at upstream side of trail crossing	1.2 m high waterfall upstream from ATV trail marks the start of this reach and the end of assessments. Creek became narrow and steep upstream
<b>Disturbances</b>	None	ATV trail	None

Notes: UTM's refer to the start of each reach.

Substrate and cover information are presented in order of decreasing dominance.

N/A – not obtained; N – little or no cover present.

SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris;

OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m;

RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.



Reach 1, Confluence of BCT06 with Blairmore Creek. June 2015

Reach 1, looking U/S from Blairmore Creek. June 2015

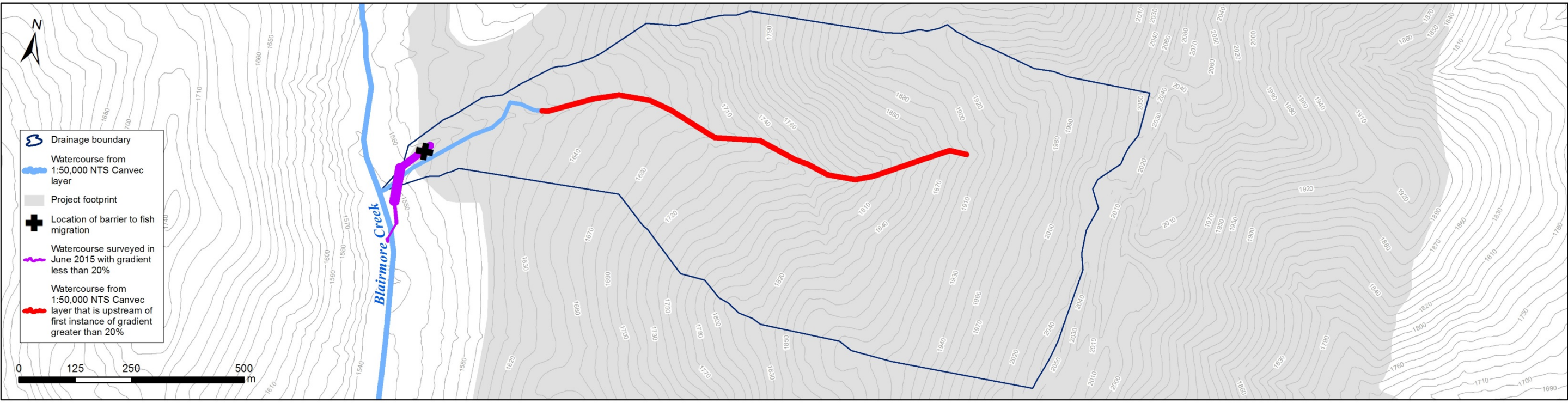
Reach 1, steep section just downstream from ATV trail crossing. June 2015

Reach 1, steep section just downstream from ATV trail. August 2014

Reach 2, U/S along ATV trail



Reach 3, waterfall at start of reach just upstream of the ATV trail



**Figure A3.22 Summary of biophysical habitat survey at BCT07, June 2015.**

REACH	1	2	3	4
<b>Easting</b>	684312	684348	684372	684611
<b>Northing</b>	5508161	5508206	5508220	5508438
<b>Wetted width (m)</b>	1.4	0.8	1.5	1.2
<b>Channel width (m)</b>	1.55	0.8	3.1	1.2
<b>Reach length (m)</b>	75.1	35	350	1170
<b>Habitat area (m<sup>2</sup>)</b>	116	30.4	1085	1404
<b>Average depth (m)</b>	0.2	0.05	0.2	0.1
<b>Substrate</b>	Boulder	Bedrock	Boulder Cobble	Boulder Cobble
<b>Slope (%)</b>	12	Vertical in places	7	12
<b>Morphology</b>	Riffle	Falls/chutes	Riffle	Riffle with falls/chutes
<b>Cover</b>	Trace SWD	None	SWD OHV	SWD OHV
<b>Other habitat features</b>	Creek was flowing in February 2015	Series of chutes over bedrock. Total elevation change is 5 m. Downstream chute has a drop of 2.5 m with a measured velocity of 4.5 m/s.	1.2 m high waterfall upstream from ATV trail marks the start of this reach and the end of assessments. Creek became narrow and steep upstream	Small waterfalls (<1m height) are present along the reach. Upstream of Reach 4, the tributary was very steep with multiple waterfalls and chutes
<b>Disturbances</b>	Unstable banks upstream from mouth	None	None	Mine tailings adjacent to the channel upstream of the end of Reach 4.

Notes: UTM's refer to the start of each reach.

Substrate and cover information are presented in order of decreasing dominance.

N/A – not obtained; N – little or no cover present.

SWD – Small Woody Debris; P – Pool; LWD – Large Woody Debris; OWD – Overhanging Woody Debris;

OHV – Overhanging Vegetation; UCB – Undercut Banks; WF:xx – waterfall with height of xx m;

RDB – Right Downstream Bank; LDB – Left Downstream Bank; U/S – upstream; D/S – downstream.



Reach 1, looking upstream from the confluence of BCT07 with Blairmore Creek



Reach 1, habitat just downstream of the falls



Reach 2, lowermost chute



Reach 2, uppermost chute with flow rod for scale



Reach 3, typical habitat upstream of falls



Reach 3, view of typical habitat upstream of falls looking downstream



Reach 3, small falls are present upstream of the main falls



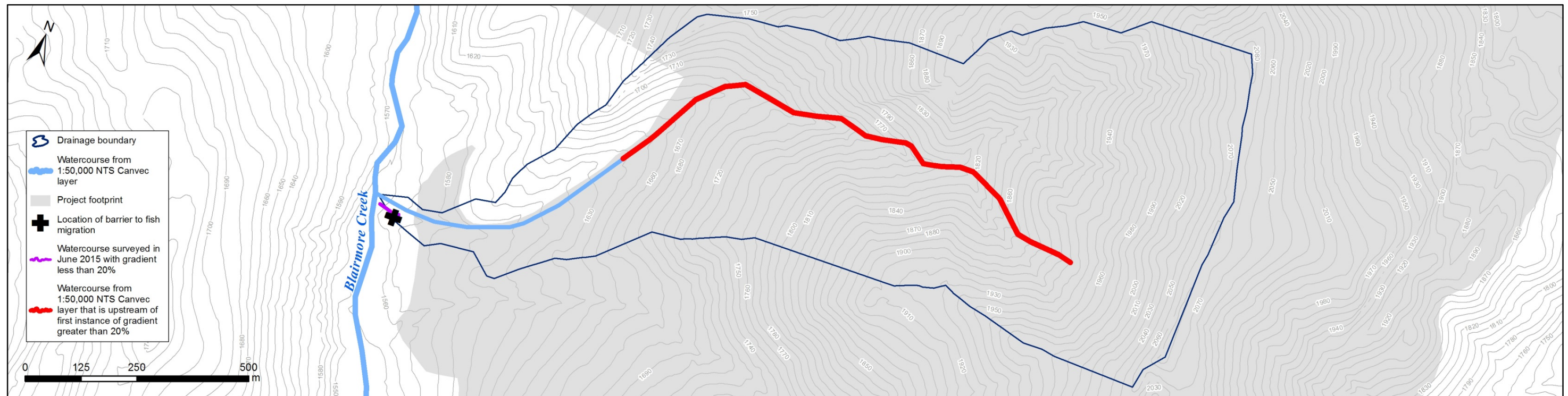
Reach 4, habitat consists almost entirely of riffles with a boulder-cobble substrate



Reach 4, small waterfall within reach



Reach 4. Upstream end of reach is a steep channel through old coal spoil with multiple chutes



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**Appendix A4**

**Photos of Tributary Barriers**

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**GCT06**

687355 E  
5503970 N

GCT06 originates at a small pond upstream of a road crossing and goes subsurface approximately 80 m before Gold Creek. No defined channel could be located between the last part of the wetted channel and Gold Creek.



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**GCT08**

687772 E  
5505780 N

The main channel of GCT08 flowed subsurface in sections, and the last open water was observed approximately 30 m from Gold Creek. No defined connection to Gold Creek could be found.



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**GCT09**

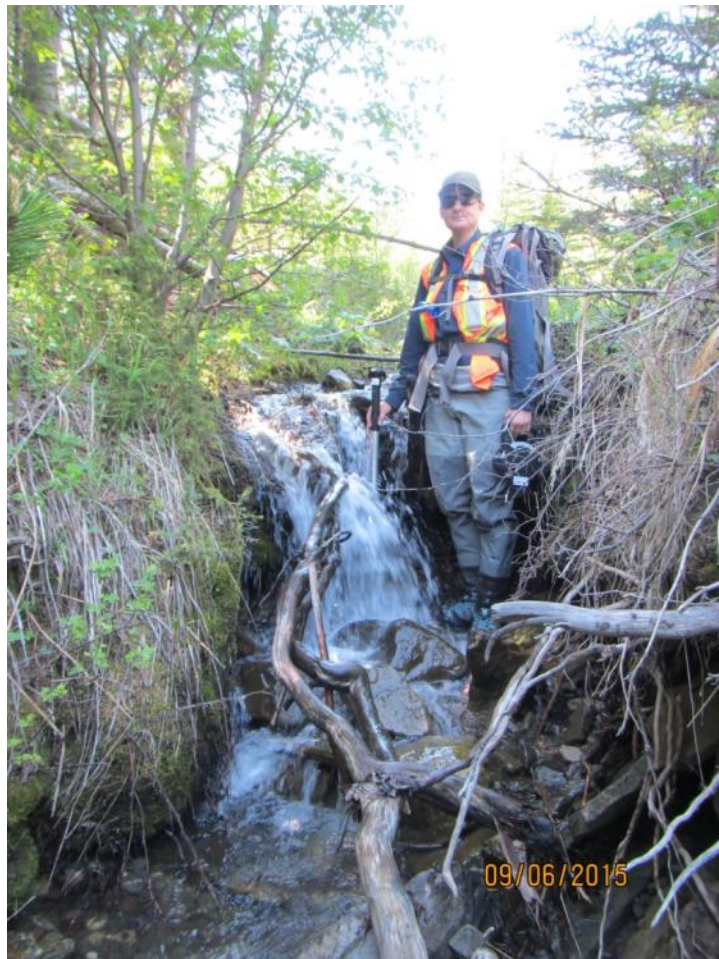
687779 E  
5506747 N

There are two waterfalls, each over 1 m high, located approximately 45 m from confluence of GCT09 and Gold Creek. These are both assessed as a barrier to fish passage due to their height and the shallow depth of the pool at the base of each waterfall.

**GCT10**

687691 E  
5508156 N

There are four waterfalls within 75 m of the mouth. The most upstream of the four was over 1.2 m high with no plunge pool and are assessed as a barrier to fish passage.



**GCT11**

687500 E  
5508883 N

The first natural barrier to fish passage occurs approximately 440 m from the confluence with Gold Creek. A 1.2 m high waterfall over bedrock is assessed as being impassable to westslope cutthroat trout.



**GCT14**

687081 E  
5510394 N

The first barrier to fish passage occurred 250 m from the confluence with Gold Creek. This was a 1.63 m high vertical waterfall that is assessed as a permanent barrier to upstream fish migration.



---

**BCT02**

685189 E  
5503691 N

The first barrier on the tributary is located approximately 30 m from the confluence with Blairmore Creek and is a 0.8 m high falls over bedrock. Barrier near mouth is assessed as preventing fish from reaching upper portions of tributary.



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**BCT03**

684694 E  
5503910N

Waterfall over bedrock at confluence with Blairmore Creek. Barrier near mouth may prevent fish from reaching upper portions of tributary.



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**BCT04b**

683950 E  
5506031 N



**BCT05**

684681 E  
5507251 N

The creek flows along the top of the bank of Blairmore Creek and empties into Blairmore over a 0.5 m high drop which would be a barrier to fish passage unless Blairmore Creek is in flood stage.



---

**BCT06**

684563 E  
5507448 N

Channel downstream of ATV trail is poorly-defined in some places and flow was subsurface near the confluence with Blairmore Creek in August. Creek flows over banks of Blairmore Creek resulting in a 0.75 m high barrier at the confluence. Additional barrier is present immediately upstream of the ATV trail crossing.



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**BCT07**

684361 E  
5508203 N

Falls/chute over bedrock. Electrofishing was conducted upstream and no fish were captured and falls assessed as a permanent barrier to fish migration.



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**BCT14**

682196 E  
5511066 N



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**Appendix A5**  
**Fish Survey Data**

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## LIST OF FIGURES

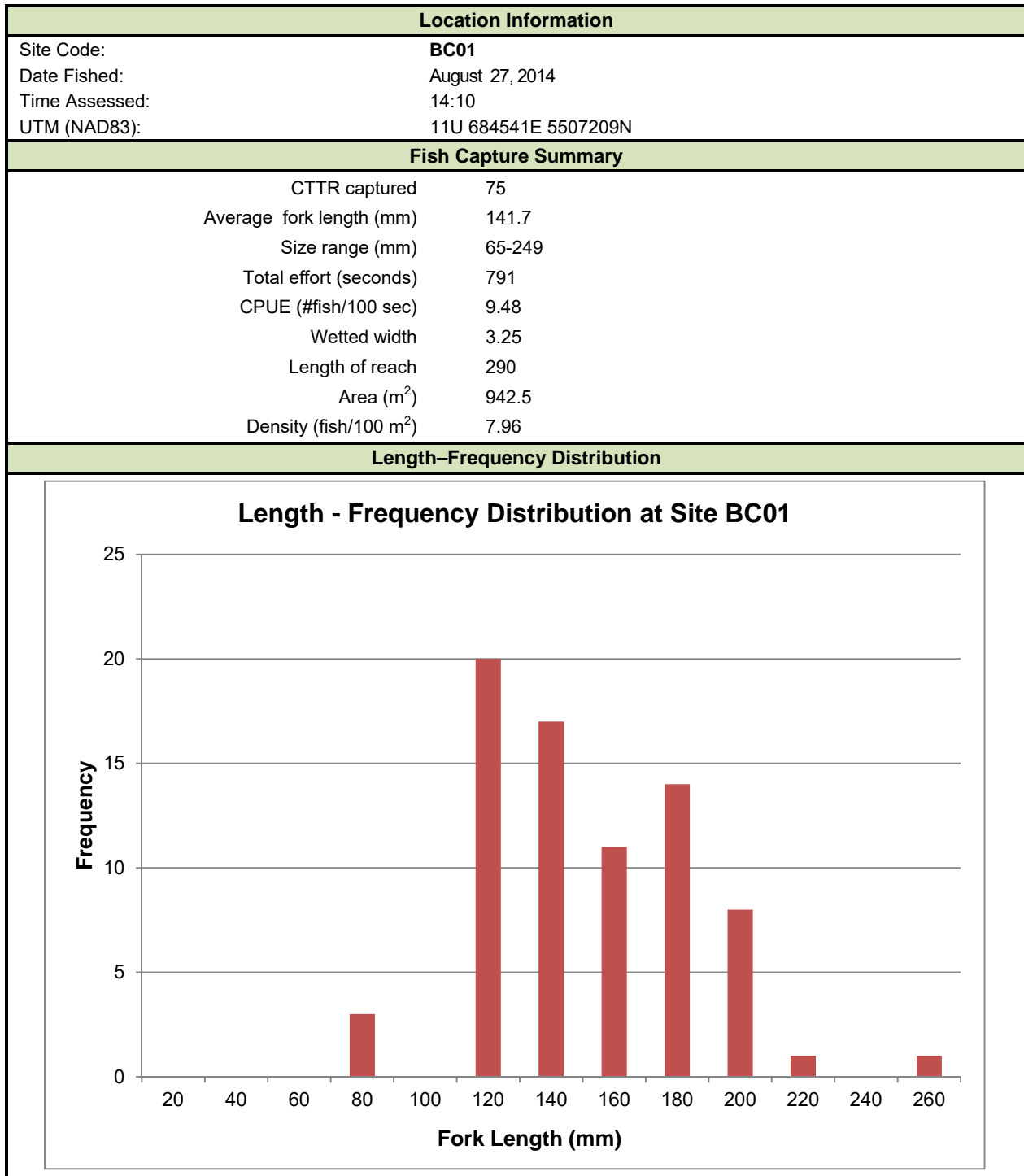
Figure A5.1	Fish capture information for sampling location BC01, August 2014.....	5-1
Figure A5.2	Fish capture information for sampling location BC02, August 2014.....	5-2
Figure A5.3	Fish capture information for sampling location BCT04a, August 2014.....	5-3
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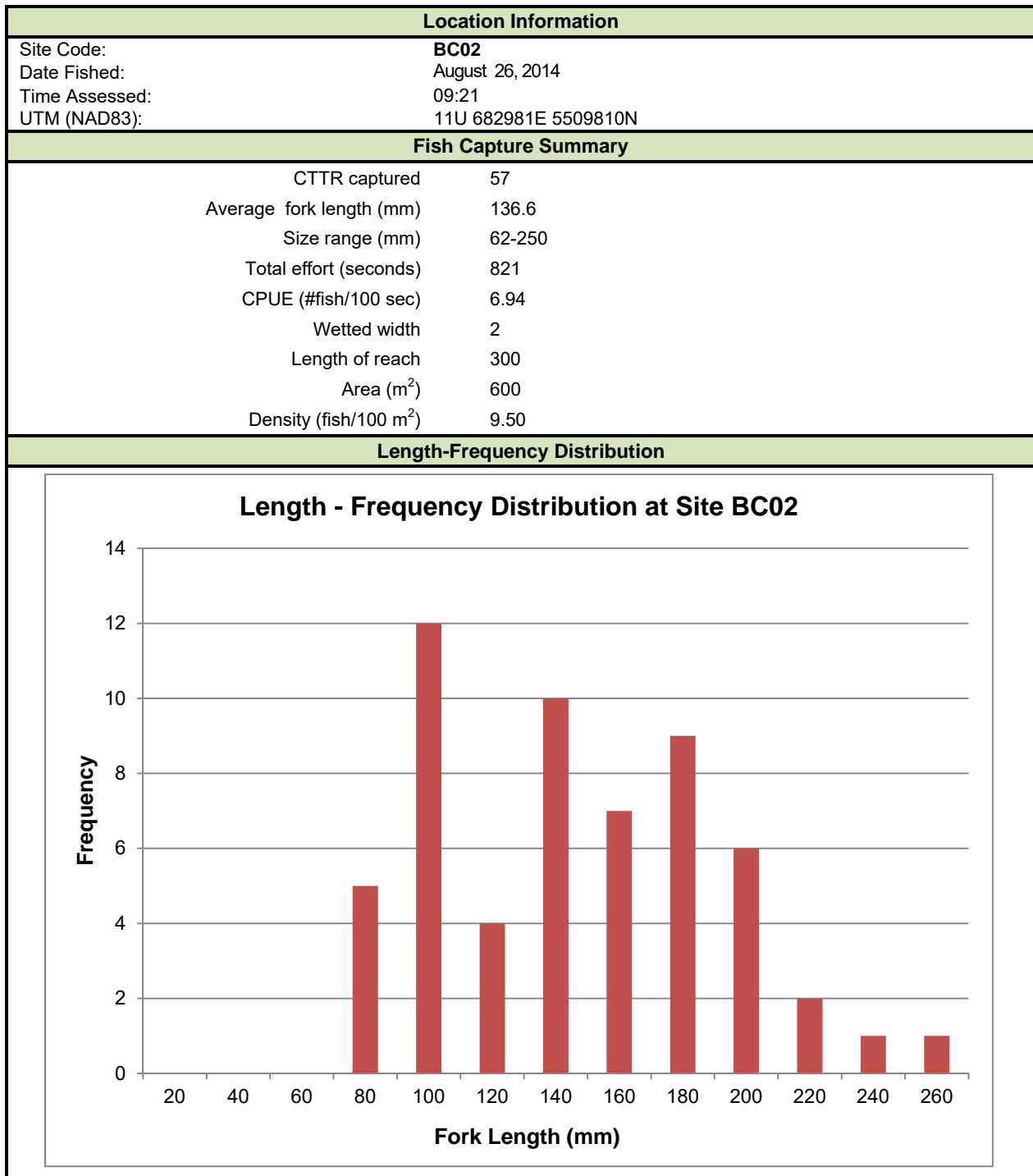
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## A5.0 FISH SURVEY DATA – BLAIRMORE CREEK AND TRIBUTARIES

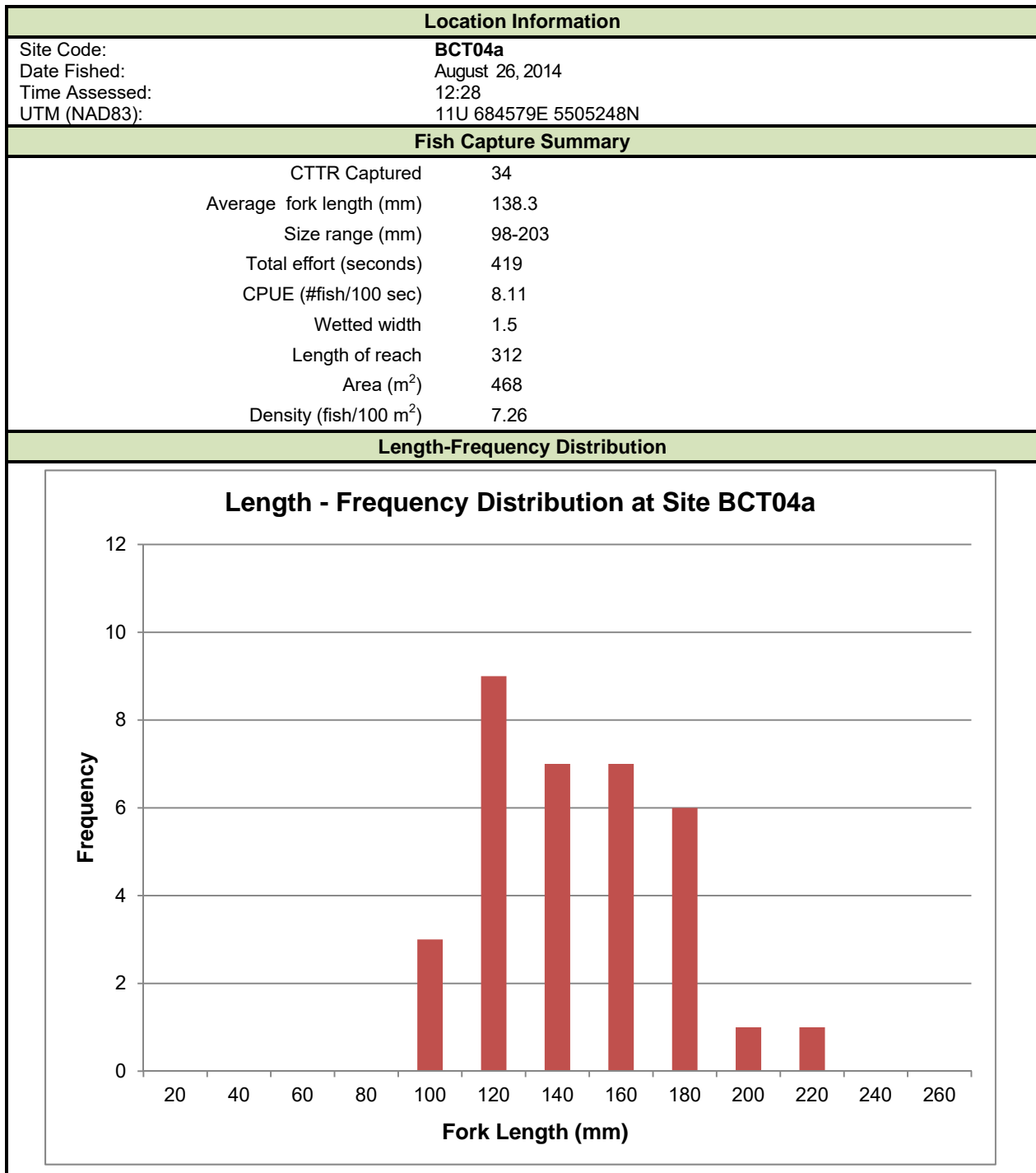
Figure A5.1 Fish capture information for sampling location BC01, August 2014.



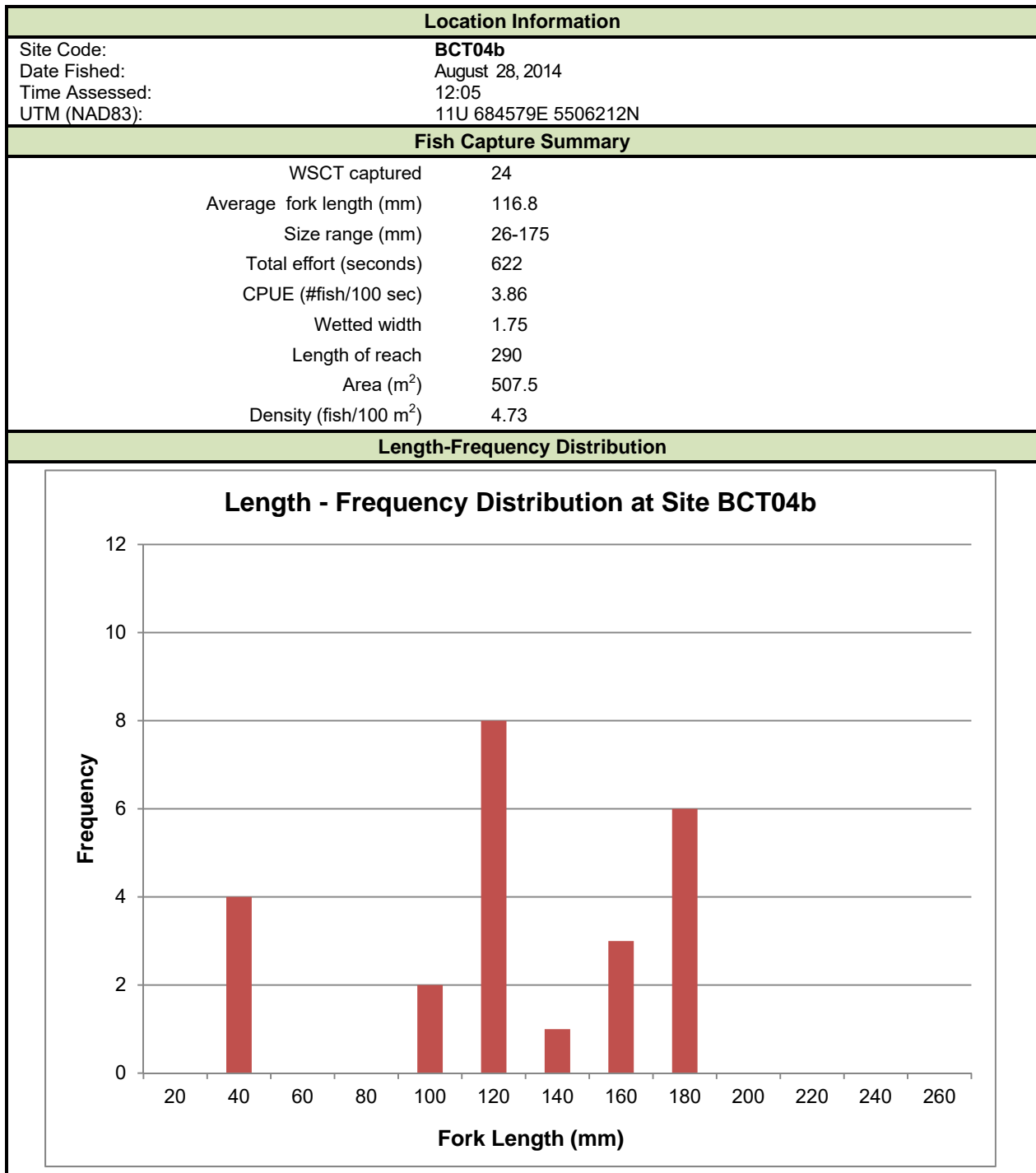
**Figure A5.2 Fish capture information for sampling location BC02, August 2014.**



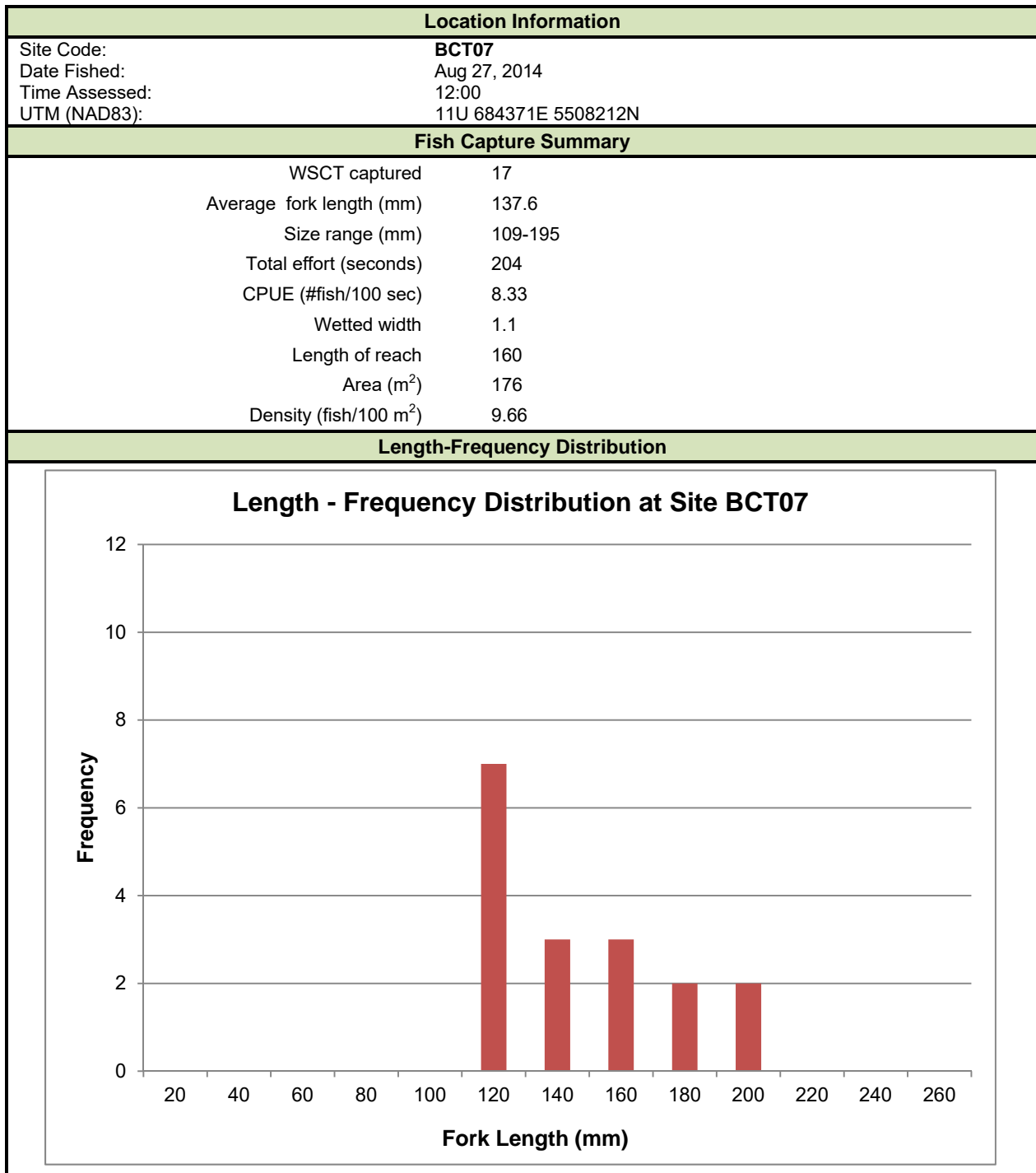
**Figure A5.3 Fish capture information for sampling location BCT04a, August 2014.**



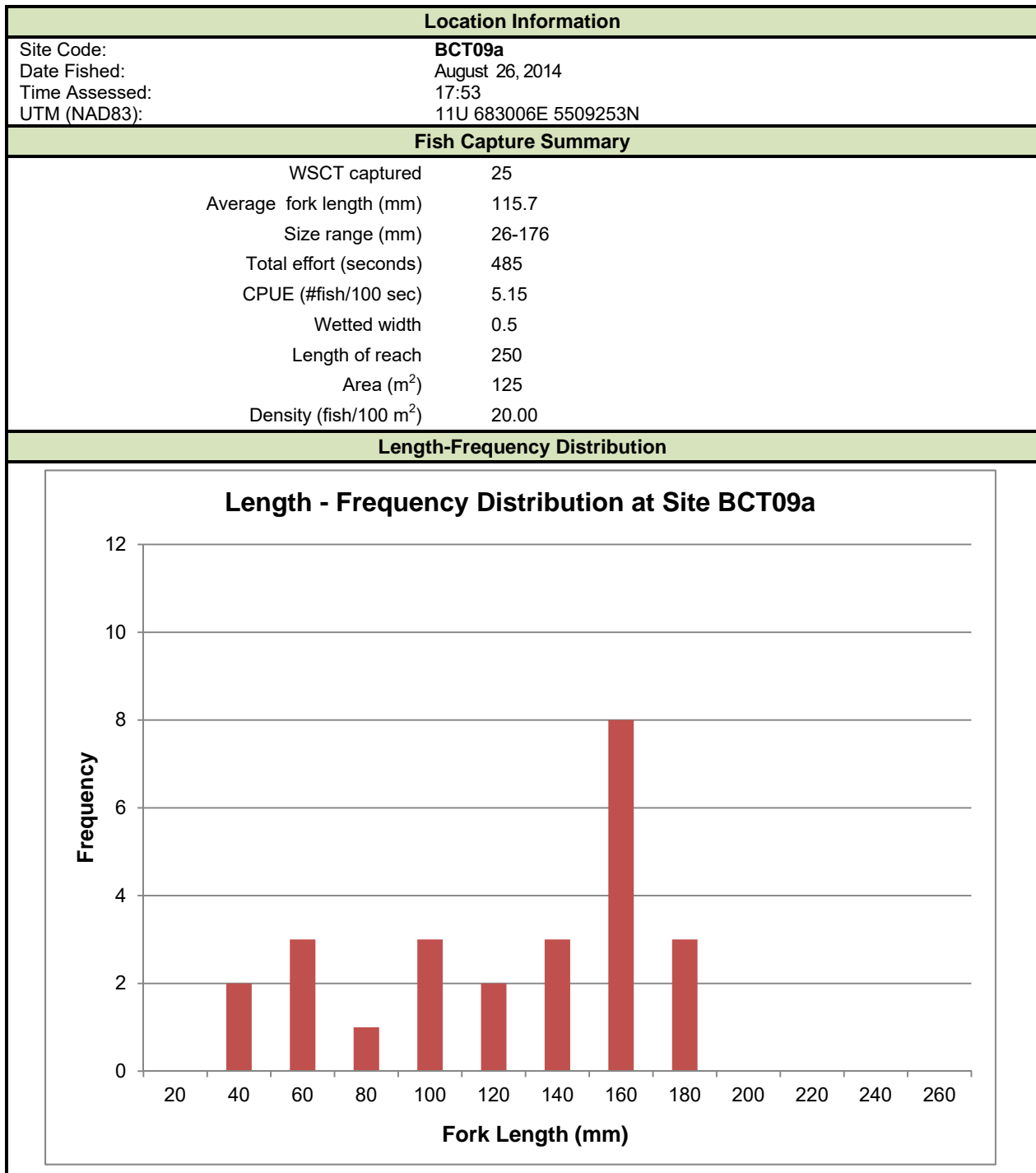
**Figure A5.4 Fish capture information for sampling location BCT04b, August 2014.**



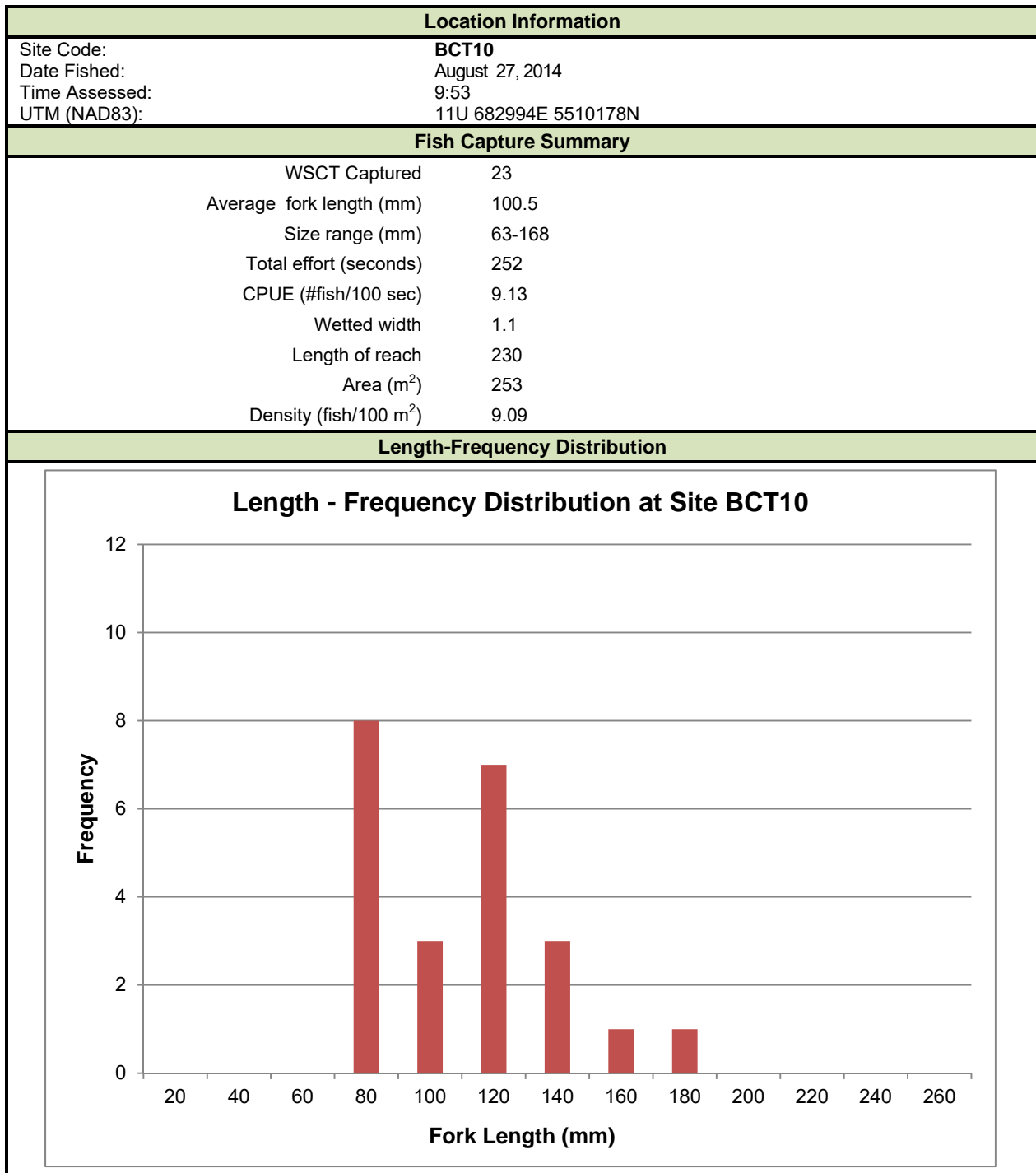
**Figure A5.5 Fish capture information for sampling location BCT07, August 2014.**



**Figure A5.6 Fish capture information for sampling location BCT09a, August 2014.**



**Figure A5.7 Fish capture information for sampling location BCT10, August 2014.**



**Table A5.1 Fish observed during snorkel surveys, August 2016.**

Date	Waterbody	Reach	YOY	>20	20+	30+	40+	Total	Notes, W=scar fish, H=possible hybrid
13-Aug-16	Gold	7	-	24	78	46	4	152	Reach X (blended mark/recap area) Braids-picnic table
13-Aug-16	Gold	7	-	11	19	2	-	32	Reach X(X) picnic table to trib below bridge
14-Aug-16	Gold	8	-	3	19	-	-	22	Reach Y (EL mark/recap area) above Caudron
14-Aug-16	Gold	7	-	99	87	41	1	218	Reach X(X) Bridge to Caudron
19-Aug-16	Gold	7	-	23	24	8	1	65	Reach X(X) trib below bridge to bridge
18-Aug-16	Gold	3	-	-	3	4	-	7	Barrier to Green CT count
18-Aug-16	Gold	3	-	-	11	2	-	13	Barrier to Green EB count
18-Aug-16	Gold	6	-	-	-	1	-	1	Green u/s towards Morin CT count
18-Aug-16	Gold	6	-	-	-	5	-	5	Green u/s towards Morin EB count
19-Aug-16	Gold	6,5	-	1	3	1	-	5	above and below falls total 900m (1 CT +20=H)
9-Aug-16	Caudron	-	-	2	2	2	1	7	Verifying Caudron presence/absence
16-Aug-16	Blairmore	3	15	12	15	-	-	42	Barrier falls to end of mark/recap area
16-Aug-16	Blairmore	3	163	136	94	25	4	422	Reach F (blended mark/recap area) (4 <20 H, 10 +20 H, 1 +30 H, 5 +20 W)
17-Aug-16	Blairmore	4	37	39	23	4	1	106	Reach E (blended mark/recap area) (1 +20 W)
17-Aug-16	Blairmore	4	99	144	98	13	-	354	Reach E(X) after E u/s end @ 0684848 5505726

**Table A5.2 Fish captured during electrofishing surveys from August 9 to 18, 2016.**

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Blairmore Creek	682988	5509844	682884	5510055		1	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	145	41.8
Blairmore Creek	682988	5509844	682884	5510055		2	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	163	58.2
Blairmore Creek	682988	5509844	682884	5510055		3	16-Aug-2016	RNTR	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	142	36.1
Blairmore Creek	682988	5509844	682884	5510055		4	16-Aug-2016	WSCT			82	7.8
Blairmore Creek	682988	5509844	682884	5510055		5	16-Aug-2016	WSCT			94	8.8
Blairmore Creek	682988	5509844	682884	5510055		6	16-Aug-2016	WSCT			108	14.4
Blairmore Creek	682988	5509844	682884	5510055		7	16-Aug-2016	WSCT			81	6.4
Blairmore Creek	682988	5509844	682884	5510055		8	16-Aug-2016	WSCT			70	3.6
Blairmore Creek	682988	5509844	682884	5510055		9	16-Aug-2016	WSCT			82	6.1
Blairmore Creek	682988	5509844	682884	5510055		10	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	181	88.6
Blairmore Creek	682988	5509844	682884	5510055		11	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	159	46.1
Blairmore Creek	682988	5509844	682884	5510055		12	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	167	50.7
Blairmore Creek	682988	5509844	682884	5510055		13	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	175	63.9
Blairmore Creek	682988	5509844	682884	5510055		14	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	170	64.7
Blairmore Creek	682988	5509844	682884	5510055		15	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	195	80.8
Blairmore Creek	682988	5509844	682884	5510055		16	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics; shortened operculum	160	45.8
Blairmore Creek	682988	5509844	682884	5510055		17	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	175	59.2
Blairmore Creek	682988	5509844	682884	5510055		18	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	171	58.8
Blairmore Creek	682988	5509844	682884	5510055		19	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	134	26
Blairmore Creek	682988	5509844	682884	5510055		20	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	133	27.5
Blairmore Creek	682988	5509844	682884	5510055		21	16-Aug-2016	WSCT		Shortened operculum	86	4.6
Blairmore Creek	682988	5509844	682884	5510055		22	16-Aug-2016	WSCT			87	7.7
Blairmore Creek	682988	5509844	682884	5510055		23	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	150	41.7
Blairmore Creek	682988	5509844	682884	5510055		24	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	185	43.5
Blairmore Creek	682988	5509844	682884	5510055		25	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	161	57
Blairmore Creek	682988	5509844	682884	5510055		26	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	188	70.7
Blairmore Creek	682988	5509844	682884	5510055		27	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	220	112
Blairmore Creek	682988	5509844	682884	5510055		28	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	180	70.3
Blairmore Creek	682988	5509844	682884	5510055		29	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	168	60
Blairmore Creek	682988	5509844	682884	5510055		30	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	188	69.1
Blairmore Creek	682988	5509844	682884	5510055		31	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	174	50.6
Blairmore Creek	682988	5509844	682884	5510055		32	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	165	54.9
Blairmore Creek	682988	5509844	682884	5510055		33	16-Aug-2016	WSCT			131	22.7
Blairmore Creek	682988	5509844	682884	5510055		34	16-Aug-2016	WSCT			134	25.8
Blairmore Creek	682988	5509844	682884	5510055		35	16-Aug-2016	WSCT			126	20.7
Blairmore Creek	682988	5509844	682884	5510055		36	16-Aug-2016	WSCT			110	14.1
Blairmore Creek	682988	5509844	682884	5510055		37	16-Aug-2016	WSCT			164	3.8
Blairmore Creek	682988	5509844	682884	5510055		38	16-Aug-2016	WSCT			100	9.9
Blairmore Creek	682988	5509844	682884	5510055		39	16-Aug-2016	WSCT			87	8.1
Blairmore Creek	682988	5509844	682884	5510055		40	16-Aug-2016	WSCT			51	3.7
Blairmore Creek	682988	5509844	682884	5510055		41	16-Aug-2016	WSCT			131	26.1
Blairmore Creek	682988	5509844	682884	5510055		42	16-Aug-2016	WSCT			112	17.3
Blairmore Creek	682988	5509844	682884	5510055		43	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	177	57.7
Blairmore Creek	682988	5509844	682884	5510055		44	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	185	64.9
Blairmore Creek	682988	5509844	682884	5510055		45	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	175	65.5
Blairmore Creek	682988	5509844	682884	5510055		46	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	167	52.2
Blairmore Creek	682988	5509844	682884	5510055		47	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	171	52.1
Blairmore Creek	682988	5509844	682884	5510055		48	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	206	86.4
Blairmore Creek	682988	5509844	682884	5510055		49	16-Aug-2016	RNTR x WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics; strong RNTR features	197	80.3

**Table A5.2 (Cont'd.)**

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Blairmore Creek	682988	5509844	682884	5510055		50	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	147	38.9
Blairmore Creek	682988	5509844	682884	5510055		51	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	160	45.4
Blairmore Creek	682988	5509844	682884	5510055		52	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	155	39.8
Blairmore Creek	682988	5509844	682884	5510055		53	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	RECAPTURE - clipped already	164	39.9
Blairmore Creek	682988	5509844	682884	5510055		54	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	150	39
Blairmore Creek	682988	5509844	682884	5510055		55	16-Aug-2016	WSCT			134	6.2
Blairmore Creek	682988	5509844	682884	5510055		56	16-Aug-2016	WSCT			131	23.1
Blairmore Creek	682988	5509844	682884	5510055		57	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	152	39.7
Blairmore Creek	682988	5509844	682884	5510055		58	16-Aug-2016	WSCT			140	31.2
Blairmore Creek	682988	5509844	682884	5510055		59	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	155	42.6
Blairmore Creek	682988	5509844	682884	5510055		60	16-Aug-2016	RNTR	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	144	37.2
Blairmore Creek	682988	5509844	682884	5510055		61	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	153	36.3
Blairmore Creek	682988	5509844	682884	5510055		62	16-Aug-2016	WSCT			135	25.5
Blairmore Creek	682988	5509844	682884	5510055		63	16-Aug-2016	WSCT			125	23.5
Blairmore Creek	682988	5509844	682884	5510055		64	16-Aug-2016	WSCT			95	9.5
Blairmore Creek	682988	5509844	682884	5510055		65	16-Aug-2016	WSCT			100	7.2
Blairmore Creek	682988	5509844	682884	5510055		66	16-Aug-2016	WSCT			104	13.1
Blairmore Creek	682988	5509844	682884	5510055		67	16-Aug-2016	WSCT			65	2.6
Blairmore Creek	682988	5509844	682884	5510055		68	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	165	50.4
Blairmore Creek	682988	5509844	682884	5510055		69	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	177	72
Blairmore Creek	682988	5509844	682884	5510055		70	16-Aug-2016	WSCT			75	4.7
Blairmore Creek	682988	5509844	682884	5510055		71	16-Aug-2016	WSCT			70	3.1
Blairmore Creek	682988	5509844	682884	5510055		72	16-Aug-2016	WSCT			93	6.8
Blairmore Creek	682988	5509844	682884	5510055		73	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	165	46.6
Blairmore Creek	682988	5509844	682884	5510055		74	16-Aug-2016	WSCT			195	96.7
Blairmore Creek	682988	5509844	682884	5510055		75	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	172	56.7
Blairmore Creek	682988	5509844	682884	5510055		76	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	RECAPTURE - clipped already	131	27.1
Blairmore Creek	682988	5509844	682884	5510055		77	16-Aug-2016	WSCT			83	6.4
Blairmore Creek	682988	5509844	682884	5510055		78	16-Aug-2016	WSCT			95	8.7
Blairmore Creek	682988	5509844	682884	5510055		79	16-Aug-2016	WSCT			82	6
Blairmore Creek	682988	5509844	682884	5510055		1	18-Aug-2016	RNTR	Fin Clip-Lower Lobe Caudal -CCL	Recapture	140	
Blairmore Creek	682988	5509844	682884	5510055		2	18-Aug-2016	WSCT			144	
Blairmore Creek	682988	5509844	682884	5510055		3	18-Aug-2016	WSCT			155	
Blairmore Creek	682988	5509844	682884	5510055		4	18-Aug-2016	WSCT			180	
Blairmore Creek	682988	5509844	682884	5510055		5	18-Aug-2016	WSCT			229	
Blairmore Creek	682988	5509844	682884	5510055		6	18-Aug-2016	WSCT			130	
Blairmore Creek	682988	5509844	682884	5510055		7	18-Aug-2016	WSCT			170	
Blairmore Creek	682988	5509844	682884	5510055		8	18-Aug-2016	WSCT			140	
Blairmore Creek	682988	5509844	682884	5510055		9	18-Aug-2016	RNTR x WSCT			160	
Blairmore Creek	682988	5509844	682884	5510055		10	18-Aug-2016	WSCT			135	
Blairmore Creek	682988	5509844	682884	5510055		11	18-Aug-2016	WSCT			140	
Blairmore Creek	682988	5509844	682884	5510055		12	18-Aug-2016	WSCT			201	
Blairmore Creek	682988	5509844	682884	5510055		13	18-Aug-2016	WSCT			147	
Blairmore Creek	682988	5509844	682884	5510055		14	18-Aug-2016	WSCT			162	
Blairmore Creek	682988	5509844	682884	5510055		15	18-Aug-2016	WSCT			151	
Blairmore Creek	682988	5509844	682884	5510055		16	18-Aug-2016	WSCT			170	
Blairmore Creek	682988	5509844	682884	5510055		17	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	180	
Blairmore Creek	682988	5509844	682884	5510055		18	18-Aug-2016	WSCT			190	
Blairmore Creek	682988	5509844	682884	5510055		19	18-Aug-2016	WSCT			176	

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Blairmore Creek	682988	5509844	682884	5510055		20	18-Aug-2016	WSCT			156	
Blairmore Creek	682988	5509844	682884	5510055		21	18-Aug-2016	WSCT			170	
Blairmore Creek	682988	5509844	682884	5510055		22	18-Aug-2016	WSCT			154	
Blairmore Creek	682988	5509844	682884	5510055		23	18-Aug-2016	WSCT			199	
Blairmore Creek	682988	5509844	682884	5510055		24	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	189	
Blairmore Creek	682988	5509844	682884	5510055		25	18-Aug-2016	WSCT			203	
Blairmore Creek	682988	5509844	682884	5510055		26	18-Aug-2016	WSCT			150	
Blairmore Creek	682988	5509844	682884	5510055		27	18-Aug-2016	WSCT			153	
Blairmore Creek	682988	5509844	682884	5510055		28	18-Aug-2016	WSCT			156	
Blairmore Creek	682988	5509844	682884	5510055		29	18-Aug-2016	WSCT			214	
Blairmore Creek	682988	5509844	682884	5510055		30	18-Aug-2016	WSCT			179	
Blairmore Creek	682988	5509844	682884	5510055		31	18-Aug-2016	WSCT			150	
Blairmore Creek	682988	5509844	682884	5510055		32	18-Aug-2016	WSCT			135	
Blairmore Creek	682988	5509844	682884	5510055		33	18-Aug-2016	WSCT			175	
Blairmore Creek	682988	5509844	682884	5510055		34	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	164	
Blairmore Creek	682988	5509844	682884	5510055		35	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	216	
Blairmore Creek	682988	5509844	682884	5510055		36	18-Aug-2016	WSCT			150	
Blairmore Creek	682988	5509844	682884	5510055		37	18-Aug-2016	WSCT			143	
Blairmore Creek	682988	5509844	682884	5510055		38	18-Aug-2016	WSCT			135	
Blairmore Creek	682988	5509844	682884	5510055		39	18-Aug-2016	WSCT			155	
Blairmore Creek	682988	5509844	682884	5510055		40	18-Aug-2016	WSCT			225	
Blairmore Creek	682988	5509844	682884	5510055		41	18-Aug-2016	WSCT			146	
Blairmore Creek	682988	5509844	682884	5510055		42	18-Aug-2016	WSCT			180	
Blairmore Creek	682988	5509844	682884	5510055		43	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	157	
Blairmore Creek	682988	5509844	682884	5510055		44	18-Aug-2016	WSCT			215	
Blairmore Creek	682988	5509844	682884	5510055		45	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	168	
Blairmore Creek	682988	5509844	682884	5510055		46	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	195	
Gold Creek	687884	5506540	687838	5506805		1	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	180	75.8
Gold Creek	687884	5506540	687838	5506805		2	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	216	117.3
Gold Creek	687884	5506540	687838	5506805		3	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	190	75.8
Gold Creek	687884	5506540	687838	5506805		4	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	205	116.7
Gold Creek	687884	5506540	687838	5506805		5	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	215	103.1
Gold Creek	687884	5506540	687838	5506805		6	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	196	99.4
Gold Creek	687884	5506540	687838	5506805		7	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	197	94.3
Gold Creek	687884	5506540	687838	5506805		8	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	195	85.3
Gold Creek	687884	5506540	687838	5506805		9	17-Aug-2016	WSCT			124	22.7
Gold Creek	687884	5506540	687838	5506805		10	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	157	49.4
Gold Creek	687884	5506540	687838	5506805		11	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	160	45
Gold Creek	687884	5506540	687838	5506805		12	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	160	39.2
Gold Creek	687884	5506540	687838	5506805		13	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	148	34.8
Gold Creek	687884	5506540	687838	5506805		14	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	150	35
Gold Creek	687884	5506540	687838	5506805		15	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	152	36.6
Gold Creek	687884	5506540	687838	5506805		16	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	135	25.1
Gold Creek	687884	5506540	687838	5506805		17	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	123	24.5
Gold Creek	687884	5506540	687838	5506805		18	17-Aug-2016	WSCT			72	4.2
Gold Creek	687884	5506540	687838	5506805		19	17-Aug-2016	WSCT			80	6.5
Gold Creek	687884	5506540	687838	5506805		20	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	88	7.2
Gold Creek	687884	5506540	687838	5506805		1	18-Aug-2016	WSCT			205	
Gold Creek	687884	5506540	687838	5506805		2	18-Aug-2016	WSCT			194	

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Gold Creek	687884	5506540	687838	5506805		3	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	197	
Gold Creek	687884	5506540	687838	5506805		4	18-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	177	
Blairmore Creek	684888	5504968	684948	5505257		1	14-Aug-2016	WSCT			38	0.2
Blairmore Creek	684888	5504968	684948	5505257		2	14-Aug-2016	WSCT			44	0.8
Blairmore Creek	684888	5504968	684948	5505257		3	14-Aug-2016	WSCT			84	6.9
Blairmore Creek	684888	5504968	684948	5505257		4	14-Aug-2016	WSCT			49	0.8
Blairmore Creek	684888	5504968	684948	5505257		5	14-Aug-2016	WSCT			31	0.5
Blairmore Creek	684888	5504968	684948	5505257		6	14-Aug-2016	WSCT			39	0.8
Blairmore Creek	684888	5504968	684948	5505257		7	14-Aug-2016	WSCT			52	0.6
Blairmore Creek	684888	5504968	684948	5505257		8	14-Aug-2016	WSCT			95	10.7
Blairmore Creek	684888	5504968	684948	5505257		9	14-Aug-2016	WSCT			31	0.6
Blairmore Creek	684888	5504968	684948	5505257		10	14-Aug-2016	WSCT			87	7.5
Blairmore Creek	684888	5504968	684948	5505257		11	14-Aug-2016	WSCT		shortened operculum	88	7.9
Blairmore Creek	684888	5504968	684948	5505257		12	14-Aug-2016	WSCT			84	3.9
Blairmore Creek	684888	5504968	684948	5505257		13	14-Aug-2016	RNTR x WSCT			99	9.4
Blairmore Creek	684888	5504968	684948	5505257		14	14-Aug-2016	WSCT			99	11
Blairmore Creek	684888	5504968	684948	5505257		15	14-Aug-2016	WSCT			44	1.4
Blairmore Creek	684888	5504968	684948	5505257		16	14-Aug-2016	WSCT			89	7.4
Blairmore Creek	684888	5504968	684948	5505257		17	14-Aug-2016	WSCT			64	1.5
Blairmore Creek	684888	5504968	684948	5505257		18	14-Aug-2016	WSCT			91	9.4
Blairmore Creek	684888	5504968	684948	5505257		19	14-Aug-2016	WSCT			54	9.1
Blairmore Creek	684888	5504968	684948	5505257		20	14-Aug-2016	WSCT			72	5.5
Blairmore Creek	684888	5504968	684948	5505257		21	14-Aug-2016	WSCT			75	5
Blairmore Creek	684888	5504968	684948	5505257		22	14-Aug-2016	WSCT			51	1.2
Blairmore Creek	684888	5504968	684948	5505257		23	14-Aug-2016	RNTR x WSCT			53	1.9
Blairmore Creek	684888	5504968	684948	5505257		24	14-Aug-2016	WSCT			48	1.1
Blairmore Creek	684888	5504968	684948	5505257		25	14-Aug-2016	WSCT			86	6
Blairmore Creek	684888	5504968	684948	5505257		26	14-Aug-2016	RNTR x WSCT			95	18.4
Blairmore Creek	684888	5504968	684948	5505257		27	14-Aug-2016	WSCT			47	1.2
Blairmore Creek	684888	5504968	684948	5505257		28	14-Aug-2016	WSCT			45	1.5
Blairmore Creek	684888	5504968	684948	5505257		29	14-Aug-2016	RNTR x WSCT		shortened operculum	50	1.1
Blairmore Creek	684888	5504968	684948	5505257		30	14-Aug-2016	WSCT			80	3.9
Blairmore Creek	684888	5504968	684948	5505257		31	14-Aug-2016	WSCT			124	15.2
Blairmore Creek	684888	5504968	684948	5505257		32	14-Aug-2016	WSCT			46	0.6
Blairmore Creek	684888	5504968	684948	5505257		33	14-Aug-2016	WSCT			50	1.6
Blairmore Creek	684888	5504968	684948	5505257		34	14-Aug-2016	WSCT			48	1.2
Blairmore Creek	684888	5504968	684948	5505257		35	14-Aug-2016	WSCT			120	18.4
Blairmore Creek	684888	5504968	684948	5505257		36	14-Aug-2016	RNTR x WSCT			54	0.6
Blairmore Creek	684888	5504968	684948	5505257		37	14-Aug-2016	WSCT			77	4.5
Blairmore Creek	684888	5504968	684948	5505257		38	14-Aug-2016	WSCT			125	13.5
Blairmore Creek	684888	5504968	684948	5505257		39	14-Aug-2016	WSCT			137	21.2
Blairmore Creek	684888	5504968	684948	5505257		40	14-Aug-2016	WSCT			120	17.5
Blairmore Creek	684888	5504968	684948	5505257		41	14-Aug-2016	WSCT			135	23.6
Blairmore Creek	684888	5504968	684948	5505257		42	14-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Clipped for marking	180	56.7
Blairmore Creek	684888	5504968	684948	5505257		43	14-Aug-2016	WSCT			109	22.3
Blairmore Creek	684888	5504968	684948	5505257		44	14-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Clipped for marking	155	45.3
Blairmore Creek	684888	5504968	684948	5505257		45	14-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Clipped for marking	185	75.3
Blairmore Creek	684888	5504968	684948	5505257		46	14-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Clipped for marking	163	53.6
Blairmore Creek	684888	5504968	684948	5505257		47	14-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Clipped for marking	200	117.9

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Blairmore Creek	684888	5504968	684948	5505257		48	14-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Clipped for marking	202	89
Blairmore Creek	684888	5504968	684948	5505257		1	16-Aug-2016	WSCT			165	
Blairmore Creek	684888	5504968	684948	5505257		2	16-Aug-2016	WSCT			182	
Blairmore Creek	684888	5504968	684948	5505257		3	16-Aug-2016	WSCT			173	
Blairmore Creek	684888	5504968	684948	5505257		4	16-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Recapture	205	
Blairmore Creek	684888	5504968	684948	5505257		5	16-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Recapture	154	
Blairmore Creek	684888	5504968	684948	5505257		6	16-Aug-2016	WSCT	Fin Clip-Upper Lobe Caudal -CCU	Recapture	204	
Blairmore Creek	684888	5504968	684948	5505257		7	16-Aug-2016	WSCT			172	
Blairmore Creek	684888	5504968	684948	5505257		8	16-Aug-2016	WSCT			139	
Gold Creek	687507	5503960	687533	5504298		1	11-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	215	108.5
Gold Creek	687507	5503960	687533	5504298		2	11-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	197	92.8
Gold Creek	687507	5503960	687533	5504298		3	11-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	250	157.6
Gold Creek	687507	5503960	687533	5504298		4	11-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	165	56.2
Gold Creek	687507	5503960	687533	5504298		5	11-Aug-2016	WSCT			84	7.3
Gold Creek	687507	5503960	687533	5504298		6	11-Aug-2016	WSCT			74	4.1
Gold Creek	687507	5503960	687533	5504298		7	11-Aug-2016	WSCT			67	3.3
Gold Creek	687477	5504232	687670	5504961		1	12-Aug-2016	WSCT			68	3.4
Gold Creek	687477	5504232	687670	5504961		2	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	124	123.6
Gold Creek	687477	5504232	687670	5504961		3	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	195	96.3
Gold Creek	687514	5504006	687676	5504960		1	15-Aug-2016	WSCT			230	
Gold Creek	687514	5504006	687676	5504960		2	15-Aug-2016	WSCT		Recapture	230	
Gold Creek	687514	5504006	687676	5504960		3	15-Aug-2016	WSCT			180	
Gold Creek	687566	5509507	687449	5509806		1	14-Aug-2016	RNTR x WSCT			98	10.5
Gold Creek	687566	5509507	687449	5509806		2	14-Aug-2016	WSCT			89	8.1
Gold Creek	687566	5509507	687449	5509806		3	14-Aug-2016	WSCT			98	11.7
Gold Creek	687566	5509507	687449	5509806		4	14-Aug-2016	WSCT			95	9.1
Gold Creek	687566	5509507	687449	5509806		5	14-Aug-2016	WSCT			93	8.7
Gold Creek	687566	5509507	687449	5509806		6	14-Aug-2016	WSCT			98	11.6
Gold Creek	687566	5509507	687449	5509806		7	14-Aug-2016	WSCT			95	8.6
Gold Creek	687566	5509507	687449	5509806		8	14-Aug-2016	WSCT			109	12.6
Gold Creek	687566	5509507	687449	5509806		9	14-Aug-2016	WSCT			90	8.4
Gold Creek	687566	5509507	687449	5509806		10	14-Aug-2016	WSCT			91	8.5
Gold Creek	687566	5509507	687449	5509806		11	14-Aug-2016	WSCT			100	11.2
Gold Creek	687566	5509507	687449	5509806		12	14-Aug-2016	WSCT			100	11.8
Gold Creek	687566	5509507	687449	5509806		13	14-Aug-2016	WSCT			95	9.5
Gold Creek	687566	5509507	687449	5509806		14	14-Aug-2016	WSCT			100	11.1
Gold Creek	687566	5509507	687449	5509806		15	14-Aug-2016	WSCT			96	5.6
Gold Creek	687566	5509507	687449	5509806		16	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	180	59.5
Gold Creek	687566	5509507	687449	5509806		17	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	150	32.6
Gold Creek	687566	5509507	687449	5509806		18	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	183	74.4
Gold Creek	687566	5509507	687449	5509806		19	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	172	57.5
Gold Creek	687566	5509507	687449	5509806		20	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	190	80.8
Gold Creek	687566	5509507	687449	5509806		21	14-Aug-2016	WSCT			97	10.2
Gold Creek	687566	5509507	687449	5509806		22	14-Aug-2016	WSCT			99	9.5
Gold Creek	687566	5509507	687449	5509806		23	14-Aug-2016	WSCT			150	33.1
Gold Creek	687566	5509507	687449	5509806		24	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	155	23.4
Gold Creek	687566	5509507	687449	5509806		25	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	151	28.5
Gold Creek	687566	5509507	687449	5509806		26	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	193	74.6
Gold Creek	687566	5509507	687449	5509806		27	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	180	70.8

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Gold Creek	687566	5509507	687449	5509806		28	14-Aug-2016	WSCT			105	12.6
Gold Creek	687566	5509507	687449	5509806		29	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	176	66.2
Gold Creek	687566	5509507	687449	5509806		30	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	180	66.1
Gold Creek	687566	5509507	687449	5509806		31	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	183	77.5
Gold Creek	687566	5509507	687449	5509806		32	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	187	80.1
Gold Creek	687566	5509507	687449	5509806		33	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	139	39
Gold Creek	687566	5509507	687449	5509806		34	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	159	48.8
Gold Creek	687566	5509507	687449	5509806		35	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	163	49.8
Gold Creek	687566	5509507	687449	5509806		36	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	172	61.6
Gold Creek	687566	5509507	687449	5509806		37	14-Aug-2016	WSCT			100	10
Gold Creek	687566	5509507	687449	5509806		38	14-Aug-2016	WSCT			110	4.7
Gold Creek	687566	5509507	687449	5509806		39	14-Aug-2016	WSCT			99	9.8
Gold Creek	687566	5509507	687449	5509806		40	14-Aug-2016	WSCT			99	9.5
Gold Creek	687566	5509507	687449	5509806		41	14-Aug-2016	WSCT			6	2.1
Gold Creek	687566	5509507	687449	5509806		42	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	191	86.7
Gold Creek	687566	5509507	687449	5509806		43	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	143	34.2
Gold Creek	687566	5509507	687449	5509806		44	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	195	95.4
Gold Creek	687566	5509507	687449	5509806		45	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	152	38.7
Gold Creek	687566	5509507	687449	5509806		46	14-Aug-2016	WSCT			99	10.4
Gold Creek	687566	5509507	687449	5509806		47	14-Aug-2016	WSCT			105	11.6
Gold Creek	687566	5509507	687449	5509806		48	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	146	40.9
Gold Creek	687566	5509507	687449	5509806		49	14-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	151	35.6
Gold Creek	687566	5509507	687449	5509806		50	14-Aug-2016	WSCT			94	8.2
Gold Creek	687566	5509507	687449	5509806		51	14-Aug-2016	WSCT			55	2.8
Gold Creek	687566	5509507	687449	5509806		1	17-Aug-2016	WSCT			136	
Gold Creek	687566	5509507	687449	5509806		2	17-Aug-2016	WSCT			155	
Gold Creek	687566	5509507	687449	5509806		3	17-Aug-2016	WSCT			225	
Gold Creek	687566	5509507	687449	5509806		4	17-Aug-2016	WSCT			175	
Gold Creek	687566	5509507	687449	5509806		5	17-Aug-2016	WSCT			134	
Gold Creek	687566	5509507	687449	5509806		6	17-Aug-2016	WSCT			220	
Gold Creek	687566	5509507	687449	5509806		7	17-Aug-2016	WSCT			163	
Gold Creek	687566	5509507	687449	5509806		8	17-Aug-2016	WSCT			153	
Gold Creek	687566	5509507	687449	5509806		9	17-Aug-2016	WSCT			170	
Gold Creek	687566	5509507	687449	5509806		10	17-Aug-2016	WSCT			130	
Gold Creek	687566	5509507	687449	5509806		11	17-Aug-2016	WSCT			177	
Gold Creek	687566	5509507	687449	5509806		12	17-Aug-2016	WSCT			225	
Gold Creek	687566	5509507	687449	5509806		13	17-Aug-2016	WSCT			143	
Gold Creek	687566	5509507	687449	5509806		14	17-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	171	
Gold Creek	687566	5509507	687449	5509806		15	17-Aug-2016	WSCT			160	
Gold Creek	687566	5509507	687449	5509806		16	17-Aug-2016	WSCT			180	
Blairmore Creek	684717	5504081	684940	5504940		1	12-Aug-2016	WSCT			39	0.6
Blairmore Creek	684717	5504081	684940	5504940		2	12-Aug-2016	WSCT			42	0.7
Blairmore Creek	684717	5504081	684940	5504940		3	12-Aug-2016	WSCT			45	0.3
Blairmore Creek	684717	5504081	684940	5504940		4	12-Aug-2016	WSCT			38	0.5
Blairmore Creek	684717	5504081	684940	5504940		5	12-Aug-2016	WSCT			35	0.5
Blairmore Creek	684717	5504081	684940	5504940		6	12-Aug-2016	WSCT			45	0.8
Blairmore Creek	684717	5504081	684940	5504940		7	12-Aug-2016	WSCT			45	1.1
Blairmore Creek	684717	5504081	684940	5504940		8	12-Aug-2016	WSCT			98	8.8
Blairmore Creek	684717	5504081	684940	5504940		9	12-Aug-2016	WSCT			105	12.6

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species Code	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	UTM/TTM Easting	UTM/TTM Northing	UTM/TTM Easting	UTM/TTM Northing								
Blairmore Creek	684717	5504081	684940	5504940		10	12-Aug-2016	WSCT			45	0.7
Blairmore Creek	684717	5504081	684940	5504940		11	12-Aug-2016	WSCT			53	1.2
Blairmore Creek	684717	5504081	684940	5504940		12	12-Aug-2016	WSCT			110	3.6
Blairmore Creek	684717	5504081	684940	5504940		13	12-Aug-2016	WSCT			82	6.9
Blairmore Creek	684717	5504081	684940	5504940		14	12-Aug-2016	WSCT			53	1.3
Blairmore Creek	684717	5504081	684940	5504940		15	12-Aug-2016	WSCT			85	6.4
Blairmore Creek	684717	5504081	684940	5504940		16	12-Aug-2016	WSCT			99	10.3
Blairmore Creek	684717	5504081	684940	5504940		17	12-Aug-2016	WSCT			43	0.4
Blairmore Creek	684717	5504081	684940	5504940		18	12-Aug-2016	WSCT			114	14.9
Blairmore Creek	684717	5504081	684940	5504940		19	12-Aug-2016	WSCT			103	13.6
Blairmore Creek	684717	5504081	684940	5504940		20	12-Aug-2016	WSCT			99	10.7
Blairmore Creek	684717	5504081	684940	5504940		21	12-Aug-2016	WSCT			89	7.1
Blairmore Creek	684717	5504081	684940	5504940		22	12-Aug-2016	WSCT			96	10.5
Blairmore Creek	684717	5504081	684940	5504940		23	12-Aug-2016	WSCT			100	11.5
Blairmore Creek	684717	5504081	684940	5504940		24	12-Aug-2016	WSCT			40	0.6
Blairmore Creek	684717	5504081	684940	5504940		25	12-Aug-2016	WSCT			100	12.1
Blairmore Creek	684717	5504081	684940	5504940		26	12-Aug-2016	WSCT			99	10.7
Blairmore Creek	684717	5504081	684940	5504940		27	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	162	53.5
Blairmore Creek	684717	5504081	684940	5504940		28	12-Aug-2016	WSCT			132	26.9
Blairmore Creek	684717	5504081	684940	5504940		29	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	151	37.2
Blairmore Creek	684717	5504081	684940	5504940		30	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	170	56.3
Blairmore Creek	684717	5504081	684940	5504940		31	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	150	44.3
Blairmore Creek	684717	5504081	684940	5504940		32	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	204	104.2
Blairmore Creek	684717	5504081	684940	5504940		33	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	192	54
Blairmore Creek	684717	5504081	684940	5504940		34	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	184	70.3
Blairmore Creek	684717	5504081	684940	5504940		35	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	173	64.3
Blairmore Creek	684717	5504081	684940	5504940		36	12-Aug-2016	WSCT			136	27.5
Blairmore Creek	684717	5504081	684940	5504940		37	12-Aug-2016	WSCT			123	24.3
Blairmore Creek	684717	5504081	684940	5504940		38	12-Aug-2016	WSCT			42	1.1
Blairmore Creek	684717	5504081	684940	5504940		39	12-Aug-2016	WSCT			120	20.3
Blairmore Creek	684717	5504081	684940	5504940		40	12-Aug-2016	WSCT			47	1.3
Blairmore Creek	684717	5504081	684940	5504940		41	12-Aug-2016	WSCT			44	0.8
Blairmore Creek	684717	5504081	684940	5504940		42	12-Aug-2016	WSCT			44	0.8
Blairmore Creek	684717	5504081	684940	5504940		43	12-Aug-2016	WSCT			44	0.9
Blairmore Creek	684717	5504081	684940	5504940		44	12-Aug-2016	WSCT			42	0.7
Blairmore Creek	684717	5504081	684940	5504940		45	12-Aug-2016	WSCT			52	1.5
Blairmore Creek	684717	5504081	684940	5504940		46	12-Aug-2016	WSCT			83	17.7
Blairmore Creek	684717	5504081	684940	5504940		47	12-Aug-2016	WSCT			49	1.6
Blairmore Creek	684717	5504081	684940	5504940		48	12-Aug-2016	WSCT			45	0.6
Blairmore Creek	684717	5504081	684940	5504940		49	12-Aug-2016	WSCT			47	1.3
Blairmore Creek	684717	5504081	684940	5504940		50	12-Aug-2016	WSCT			42	0.6
Blairmore Creek	684717	5504081	684940	5504940		51	12-Aug-2016	WSCT			35	0.4
Blairmore Creek	684717	5504081	684940	5504940		52	12-Aug-2016	WSCT			52	1.9
Blairmore Creek	684717	5504081	684940	5504940		53	12-Aug-2016	WSCT			43	0.8
Blairmore Creek	684717	5504081	684940	5504940		54	12-Aug-2016	WSCT			44	0.8
Blairmore Creek	684717	5504081	684940	5504940		55	12-Aug-2016	WSCT			45	0.9
Blairmore Creek	684717	5504081	684940	5504940		56	12-Aug-2016	WSCT			45	1
Blairmore Creek	684717	5504081	684940	5504940		57	12-Aug-2016	WSCT			39	0.6
Blairmore Creek	684717	5504081	684940	5504940		58	12-Aug-2016	WSCT			49	3.6

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species Code	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	UTM/TTM Easting	UTM/TTM Northing	UTM/TTM Easting	UTM/TTM Northing								
Blairmore Creek	684717	5504081	684940	5504940		59	12-Aug-2016	WSCT			45	2.3
Blairmore Creek	684717	5504081	684940	5504940		60	12-Aug-2016	WSCT			39	0.7
Blairmore Creek	684717	5504081	684940	5504940		61	12-Aug-2016	WSCT			40	0.9
Blairmore Creek	684717	5504081	684940	5504940		62	12-Aug-2016	WSCT			42	0.9
Blairmore Creek	684717	5504081	684940	5504940		63	12-Aug-2016	WSCT			37	0.5
Blairmore Creek	684717	5504081	684940	5504940		64	12-Aug-2016	WSCT			89	6.6
Blairmore Creek	684717	5504081	684940	5504940		65	12-Aug-2016	WSCT			96	8.7
Blairmore Creek	684717	5504081	684940	5504940		66	12-Aug-2016	WSCT			100	13.3
Blairmore Creek	684717	5504081	684940	5504940		67	12-Aug-2016	WSCT			47	0.9
Blairmore Creek	684717	5504081	684940	5504940		68	12-Aug-2016	WSCT			135	23.4
Blairmore Creek	684717	5504081	684940	5504940		69	12-Aug-2016	WSCT			100	13.4
Blairmore Creek	684717	5504081	684940	5504940		70	12-Aug-2016	WSCT			89	6.5
Blairmore Creek	684717	5504081	684940	5504940		71	12-Aug-2016	WSCT			124	20.1
Blairmore Creek	684717	5504081	684940	5504940		72	12-Aug-2016	WSCT			66	3.2
Blairmore Creek	684717	5504081	684940	5504940		73	12-Aug-2016	WSCT			44	1.1
Blairmore Creek	684717	5504081	684940	5504940		74	12-Aug-2016	WSCT			137	26.6
Blairmore Creek	684717	5504081	684940	5504940		75	12-Aug-2016	WSCT			116	19.6
Blairmore Creek	684717	5504081	684940	5504940		76	12-Aug-2016	WSCT			100	10.8
Blairmore Creek	684717	5504081	684940	5504940		77	12-Aug-2016	WSCT			106	13.2
Blairmore Creek	684717	5504081	684940	5504940		78	12-Aug-2016	WSCT			112	14.3
Blairmore Creek	684717	5504081	684940	5504940		79	12-Aug-2016	WSCT			41	0.6
Blairmore Creek	684717	5504081	684940	5504940		80	12-Aug-2016	WSCT			91	6.6
Blairmore Creek	684717	5504081	684940	5504940		81	12-Aug-2016	WSCT			136	29.2
Blairmore Creek	684717	5504081	684940	5504940		82	12-Aug-2016	WSCT			136	23.6
Blairmore Creek	684717	5504081	684940	5504940		83	12-Aug-2016	WSCT			121	18.4
Blairmore Creek	684717	5504081	684940	5504940		84	12-Aug-2016	WSCT			74	5
Blairmore Creek	684717	5504081	684940	5504940		85	12-Aug-2016	WSCT			48	1.1
Blairmore Creek	684717	5504081	684940	5504940		86	12-Aug-2016	WSCT			51	0.6
Blairmore Creek	684717	5504081	684940	5504940		87	12-Aug-2016	WSCT			100	10
Blairmore Creek	684717	5504081	684940	5504940		88	12-Aug-2016	WSCT			46	5.2
Blairmore Creek	684717	5504081	684940	5504940		89	12-Aug-2016	WSCT			121	18.2
Blairmore Creek	684717	5504081	684940	5504940		90	12-Aug-2016	WSCT			49	1.2
Blairmore Creek	684717	5504081	684940	5504940		91	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	195	97.5
Blairmore Creek	684717	5504081	684940	5504940		92	12-Aug-2016	WSCT			40	0.7
Blairmore Creek	684717	5504081	684940	5504940		93	12-Aug-2016	WSCT			41	0.9
Blairmore Creek	684717	5504081	684940	5504940		94	12-Aug-2016	WSCT			31	0.4
Blairmore Creek	684717	5504081	684940	5504940		95	12-Aug-2016	WSCT			34	0.4
Blairmore Creek	684717	5504081	684940	5504940		96	12-Aug-2016	WSCT			49	0.9
Blairmore Creek	684717	5504081	684940	5504940		97	12-Aug-2016	WSCT			100	10.9
Blairmore Creek	684717	5504081	684940	5504940		98	12-Aug-2016	WSCT			105	13.4
Blairmore Creek	684717	5504081	684940	5504940		99	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	195	101.3
Blairmore Creek	684717	5504081	684940	5504940		100	12-Aug-2016	WSCT			90	7.8
Blairmore Creek	684717	5504081	684940	5504940		101	12-Aug-2016	WSCT			80	4.9
Blairmore Creek	684717	5504081	684940	5504940		102	12-Aug-2016	WSCT			85	5.9
Blairmore Creek	684717	5504081	684940	5504940		103	12-Aug-2016	WSCT			99	10.2
Blairmore Creek	684717	5504081	684940	5504940		104	12-Aug-2016	WSCT			124	18.6
Blairmore Creek	684717	5504081	684940	5504940		105	12-Aug-2016	WSCT			35	0.6
Blairmore Creek	684717	5504081	684940	5504940		106	12-Aug-2016	WSCT			80	6.1
Blairmore Creek	684717	5504081	684940	5504940		107	12-Aug-2016	WSCT			80	5.4

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species Code	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	UTM/TTM Easting	UTM/TTM Northing	UTM/TTM Easting	UTM/TTM Northing								
Blairmore Creek	684717	5504081	684940	5504940		108	12-Aug-2016	WSCT			130	20.8
Blairmore Creek	684717	5504081	684940	5504940		109	12-Aug-2016	WSCT			124	20.9
Blairmore Creek	684717	5504081	684940	5504940		110	12-Aug-2016	WSCT			90	6.9
Blairmore Creek	684717	5504081	684940	5504940		111	12-Aug-2016	WSCT			101	12.1
Blairmore Creek	684717	5504081	684940	5504940		112	12-Aug-2016	WSCT			34	0.4
Blairmore Creek	684717	5504081	684940	5504940		113	12-Aug-2016	WSCT			70	4.6
Blairmore Creek	684717	5504081	684940	5504940		114	12-Aug-2016	WSCT			34	0.6
Blairmore Creek	684717	5504081	684940	5504940		115	12-Aug-2016	WSCT			82	5.8
Blairmore Creek	684717	5504081	684940	5504940		116	12-Aug-2016	WSCT			110	14.9
Blairmore Creek	684717	5504081	684940	5504940		117	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	190	76.1
Blairmore Creek	684717	5504081	684940	5504940		118	12-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Clipped for genetics	215	124.4
Blairmore Creek	684717	5504081	684940	5504940		119	13-Aug-2016	WSCT			79	5.1
Blairmore Creek	684717	5504081	684940	5504940		120	13-Aug-2016	WSCT			85	5.9
Blairmore Creek	684717	5504081	684940	5504940		121	13-Aug-2016	WSCT			32	0.5
Blairmore Creek	684717	5504081	684940	5504940		122	13-Aug-2016	WSCT			40	0.8
Blairmore Creek	684717	5504081	684940	5504940		123	13-Aug-2016	WSCT			49	1.2
Blairmore Creek	684717	5504081	684940	5504940		124	13-Aug-2016	WSCT			32	0.5
Blairmore Creek	684717	5504081	684940	5504940		125	13-Aug-2016	WSCT			69	3.8
Blairmore Creek	684717	5504081	684940	5504940		126	13-Aug-2016	WSCT			84	6.4
Blairmore Creek	684717	5504081	684940	5504940		127	13-Aug-2016	WSCT			35	0.6
Blairmore Creek	684717	5504081	684940	5504940		128	13-Aug-2016	WSCT			32	0.6
Blairmore Creek	684717	5504081	684940	5504940		129	13-Aug-2016	WSCT			123	20.7
Blairmore Creek	684717	5504081	684940	5504940		130	13-Aug-2016	WSCT			94	6.6
Blairmore Creek	684717	5504081	684940	5504940		131	13-Aug-2016	WSCT			165	48.5
Blairmore Creek	684717	5504081	684940	5504940		132	13-Aug-2016	WSCT			185	66.7
Blairmore Creek	684717	5504081	684940	5504940		133	13-Aug-2016	WSCT			166	53.3
Blairmore Creek	684717	5504081	684940	5504940		134	13-Aug-2016	WSCT			125	33.5
Blairmore Creek	684717	5504081	684940	5504940		135	13-Aug-2016	WSCT			115	24.7
Blairmore Creek	684717	5504081	684940	5504940		136	13-Aug-2016	WSCT			165	49.3
Blairmore Creek	684717	5504081	684940	5504940		137	13-Aug-2016	WSCT			220	105.1
Blairmore Creek	684717	5504081	684940	5504940		138	13-Aug-2016	WSCT			140	31
Blairmore Creek	684717	5504081	684940	5504940		139	13-Aug-2016	WSCT			99	10.4
Blairmore Creek	684717	5504081	684940	5504940		140	13-Aug-2016	WSCT			85	6.4
Blairmore Creek	684717	5504081	684940	5504940		141	13-Aug-2016	WSCT			25	0.3
Blairmore Creek	684717	5504081	684940	5504940		142	13-Aug-2016	WSCT			39	0.5
Blairmore Creek	684717	5504081	684940	5504940		143	13-Aug-2016	WSCT			89	8
Blairmore Creek	684717	5504081	684940	5504940		144	13-Aug-2016	WSCT			95	10.7
Blairmore Creek	684717	5504081	684940	5504940		145	13-Aug-2016	WSCT			35	0.5
Blairmore Creek	684717	5504081	684940	5504940		146	13-Aug-2016	WSCT			79	5.2
Blairmore Creek	684717	5504081	684940	5504940		147	13-Aug-2016	WSCT			46	0.6
Blairmore Creek	684717	5504081	684940	5504940		148	13-Aug-2016	WSCT			47	1
Blairmore Creek	684717	5504081	684940	5504940		149	13-Aug-2016	WSCT			73	4.7
Blairmore Creek	684717	5504081	684940	5504940		150	13-Aug-2016	WSCT			84	5.7
Blairmore Creek	684717	5504081	684940	5504940		151	13-Aug-2016	WSCT			87	7.2
Blairmore Creek	684717	5504081	684940	5504940		152	13-Aug-2016	WSCT			92	7.9
Blairmore Creek	684717	5504081	684940	5504940		153	13-Aug-2016	WSCT			84	5.4
Blairmore Creek	684717	5504081	684940	5504940		154	13-Aug-2016	WSCT			89	8.4
Blairmore Creek	684717	5504081	684940	5504940		155	13-Aug-2016	WSCT			120	16.1
Blairmore Creek	684717	5504081	684940	5504940		156	13-Aug-2016	WSCT			79	5.4

Table A5.2 (Cont'd.)

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Blairmore Creek	684717	5504081	684940	5504940		157	13-Aug-2016	WSCT			56	1.5
Blairmore Creek	684717	5504081	684940	5504940		158	13-Aug-2016	WSCT			69	3.5
Blairmore Creek	684717	5504081	684940	5504940		159	13-Aug-2016	RNTR x WSCT		shortened operculum	99	8.3
Blairmore Creek	684717	5504081	684940	5504940		160	13-Aug-2016	WSCT			91	8.3
Blairmore Creek	684717	5504081	684940	5504940		161	13-Aug-2016	WSCT			105	12.7
Blairmore Creek	684717	5504081	684940	5504940		162	13-Aug-2016	WSCT			71	4.2
Blairmore Creek	684717	5504081	684940	5504940		163	13-Aug-2016	RNTR x WSCT			88	7.2
Blairmore Creek	684717	5504081	684940	5504940		164	13-Aug-2016	WSCT			43	0.8
Blairmore Creek	684717	5504081	684940	5504940		165	13-Aug-2016	WSCT			42	0.8
Blairmore Creek	684717	5504081	684940	5504940		166	13-Aug-2016	WSCT			190	90.1
Blairmore Creek	684717	5504081	684940	5504940		167	13-Aug-2016	WSCT			131	21.9
Blairmore Creek	684717	5504081	684940	5504940		168	13-Aug-2016	WSCT			142	50.7
Blairmore Creek	684717	5504081	684940	5504940		169	13-Aug-2016	WSCT			135	23.6
Blairmore Creek	684717	5504081	684940	5504940		170	13-Aug-2016	WSCT			130	26.3
Blairmore Creek	684717	5504081	684940	5504940		171	13-Aug-2016	WSCT			175	56.4
Blairmore Creek	684717	5504081	684940	5504940		172	13-Aug-2016	WSCT			165	40.8
Blairmore Creek	684717	5504081	684940	5504940		1	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	174	
Blairmore Creek	684717	5504081	684940	5504940		2	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	195	
Blairmore Creek	684717	5504081	684940	5504940		3	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	151	
Blairmore Creek	684717	5504081	684940	5504940		4	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	154	
Blairmore Creek	684717	5504081	684940	5504940		5	16-Aug-2016	WSCT			197	
Blairmore Creek	684717	5504081	684940	5504940		6	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	166	
Blairmore Creek	684717	5504081	684940	5504940		7	16-Aug-2016	WSCT			163	
Blairmore Creek	684717	5504081	684940	5504940		8	16-Aug-2016	WSCT			230	
Blairmore Creek	684717	5504081	684940	5504940		9	16-Aug-2016	WSCT			192	
Blairmore Creek	684717	5504081	684940	5504940		10	16-Aug-2016	WSCT			220	
Blairmore Creek	684717	5504081	684940	5504940		11	16-Aug-2016	WSCT			200	
Blairmore Creek	684717	5504081	684940	5504940		12	16-Aug-2016	WSCT			183	
Blairmore Creek	684717	5504081	684940	5504940		13	16-Aug-2016	WSCT			250	
Blairmore Creek	684717	5504081	684940	5504940		14	16-Aug-2016	WSCT			229	
Blairmore Creek	684717	5504081	684940	5504940		15	16-Aug-2016	WSCT			195	
Blairmore Creek	684717	5504081	684940	5504940		16	16-Aug-2016	WSCT			176	
Blairmore Creek	684717	5504081	684940	5504940		17	16-Aug-2016	WSCT			200	
Blairmore Creek	684717	5504081	684940	5504940		18	16-Aug-2016	WSCT			195	
Blairmore Creek	684717	5504081	684940	5504940		19	16-Aug-2016	WSCT			173	
Blairmore Creek	684717	5504081	684940	5504940		20	16-Aug-2016	WSCT			220	
Blairmore Creek	684717	5504081	684940	5504940		21	16-Aug-2016	WSCT			155	
Blairmore Creek	684717	5504081	684940	5504940		22	16-Aug-2016	WSCT			187	
Blairmore Creek	684717	5504081	684940	5504940		23	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	193	
Blairmore Creek	684717	5504081	684940	5504940		24	16-Aug-2016	WSCT	Fin Clip-Lower Lobe Caudal -CCL	Recapture	220	
Blairmore Creek	684717	5504081	684940	5504940		25	16-Aug-2016	WSCT			185	
Blairmore Creek	684717	5504081	684940	5504940		26	16-Aug-2016	WSCT			200	
Blairmore Creek	684717	5504081	684940	5504940		27	16-Aug-2016	WSCT			215	
Green Creek	688703	5501370	688817	5501410		1	17-Aug-2016	BKTR		Sacrificed for tissue samples	126	25
Green Creek	688703	5501370	688817	5501410		2	17-Aug-2016	BKTR		Sacrificed for tissue samples	115	16.5
Green Creek	688703	5501370	688817	5501410		3	17-Aug-2016	BKTR		Sacrificed for tissue samples	107	14.5
Green Creek	688703	5501370	688817	5501410		4	17-Aug-2016	BKTR		Sacrificed for tissue samples	115	18.6
Green Creek	688703	5501370	688817	5501410		5	17-Aug-2016	BKTR		Sacrificed for tissue samples	115	18.7
Green Creek	688703	5501370	688817	5501410		6	17-Aug-2016	BKTR		Sacrificed for tissue samples	169	25.6

**Table A5.2 (Cont'd.)**

Waterbody	Start Point		End Point		Observed Count	Sample #	Date	Species Code	Marking	Individual Sample Comments	Fork Length (mm)	Weight (g)
	Easting	Northing	Easting	Northing								
Green Creek	688703	5501370	688817	5501410		7	17-Aug-2016	BKTR		Sacrificed for tissue samples	105	18.5
Green Creek	688703	5501370	688817	5501410		8	17-Aug-2016	BKTR		Sacrificed for tissue samples	133	29.8
Green Creek	688703	5501370	688817	5501410		9	17-Aug-2016	WSCT		Observed		
Morin Creek	687912	5502878	688040	5502923	1	1	10-Aug-2016	WSCT		Observed		
GCT13	687461	5509894	687643	5510093	11	1	11-Aug-2016	WSCT		Observed		
Gold Creek	687455	5509910	687387	5510022	17	1	11-Aug-2016	WSCT		Observed		
BCT04	684924	5504965	684755	5505125	85	1	13-Aug-2016	WSCT		Observed		
Blairmore Creek	684930	5504894	682856	5510139	225	1	13-Aug-2016	WSCT		Observed		
GCT10	687727	5508615	687604	5508758	5	1	17-Aug-2016	WSCT		Observed in pools with cover		
Caudron Creek	688213	5506656	689452	5507142			9-Aug-2016			No fish captured		

**Table A5.3 Overwintering survey observations by snorkelling, Mar. 21 and Oct. 20 to 23, 2016.**

Reach	Waterbody	Date	Pool Code	Easting	Northing	YOY	<20	20+	30+	40+	Total	Notes
3	Blairmore	10/22/2016	I	684743	5504070	-	1	2	-	-	3	Low water levels, u/s barrier pool
3	Blairmore	10/22/2016	II	684776	5504262	21	40	40	48	2	151	Slow, deep, bedrock pool
4	Blairmore	10/23/2016	III	684930	5504917	22	19	4	-	-	45	All fish seen in pockets from Ford to Bone, * pool
4	Blairmore	10/23/2016	IV	684910	5505504	40	30	41	3	-	114	Bone pool
5	Blairmore	10/22/2016	V	684908	5505510	6	9	-	-	-	15	Pocket pools, ** pool
4	Gold	10/20/2016	-	688193	5502564	-	-	-	-	-	0	Below waterfall, 0 fish as in summer, deep slow overwintering pool, Faery pool
3	Gold	10/21/2016	-	688601	5501078	-	-	-	-	-	0	Slow, deep, Pool 1
3	Gold	10/21/2016	-	688586	5501121	-	-	-	-	-	0	Slow, deep, Pool 2
3	Gold	10/21/2016	-	688616	5501232	-	-	-	-	-	0	Slow, deep, Pool 3
3	Gold	10/21/2016	-	688642	5501239	-	-	-	-	-	0	Slow, deep, Pool 4
7	Gold	03/21/2016	A	687388	5504402	-	6	15	10	1	32	Cory's pool
7	Gold	10/20/2016	A	687388	5504402	-	5	9	10	3	27	Slow velocity, Cory's pool
7	Gold	10/22/2016	A	687388	5504402	-	6	9	10	3	28	Revisit for fish movement, Cory's pool
7	Gold	10/20/2016	B	687625	5504849	-	10	5	9	2	26	Slow velocity, Picnic pool
7	Gold	10/20/2016	C	687682	5504970	-	4	1	-	-	5	Faster velocity, Bedrock 1 pool
7	Gold	10/20/2016	D	687682	5504016	-	6	5	11	1	23	Slow velocity, Bedrock 2 pool
7	Gold	10/20/2016	E	687827	5506062	-	2	-	-	-	2	Slow velocity, lower water levels, Bridge pool
7	Gold	10/20/2016	F	687869	5506458	-	60	10	40	-	110	Slow velocity, 95 fish pool
8	Gold	10/22/2016	G	687977	5507622	-	2	3	-	-	5	Pocket pools, * pool

**Table A5.4 Spawning surveys by snorkelling throughout Gold Creek and Blairmore Creek from May 13 to 17 and June 6 to 11, 2016.**

Waterbody	Reach	Reach Description	Date	Easting	Northing	Total Count	Adults	Mature Adults	Pairs	Cover	Sp. Habitat	Picture	Notes
Gold	2	weir-green	13-May-16	688361	5498264	-	-	-	-	n	y	n	
Gold	2	weir-green	13-May-16	688545	5498457	-	-	-	-	n	y	y	
Gold	2	weir-green	13-May-16	688588	5498571	15	15	15	-	n	y	y	all coloured, staging, none paired
Gold	2	weir-green	13-May-16	688580	5498632	-	-	-	-	n	n	y	gravel deposit on slab rock
Gold	2	weir-green	13-May-16	688603	5498645	-	-	-	-	n	y	y	deep pool w/waterfall
Gold	2	weir-green	13-May-16	688684	5498855	-	-	-	-	n	y	n	
Gold	2	weir-green	13-May-16	688903	5499198	1	1	1	-	n	y	y	sm pool
Gold	2	weir-green	13-May-16	688903	5499234	-	-	-	-	n	y	y	excellent hab
Gold	2	weir-green	13-May-16	688877	5499303	-	-	-	-	n	y	y	excellent hab
Gold	2	weir-green	13-May-16	688855	5499333	1	-	-	-	n	n	n	juv in little pocket
Gold	2	weir-green	13-May-16	688852	5499353	1	1	1	-	n	y	y	deep sm pocket
Gold	2	weir-green	13-May-16	688882	5499432	20	8	6	-	n	y	y	big school in 1.5 deep pool below falls, otter scat beside pool
Gold	2	weir-green	13-May-16	688882	5499479	1	1	1	-	n	y	n	in pool under second falls
Gold	2	weir-green	13-May-16	688895	5499518	-	-	-	-	n	y	y	
Gold	2	weir-green	13-May-16	688893	5499508	2	2	2	1	y	y	y	250m of deep channel hab, pair of sp. In undercut bank w/ gravels
Gold	2	weir-green	13-May-16	688924	5499896	-	-	-	-	n	n	n	beginning of canyon, deeply incised
Gold	2	weir-green	13-May-16	689066	5500010	-	-	-	-	n	n	n	back down after canyon (s feature)
Gold	2	weir-green	13-May-16	688981	5500062	-	-	-	-	n	y	n	
Gold	2	weir-green	13-May-16	688921	5500074	-	-	-	-	n	y	n	excellent hab
Gold	2	weir-green	13-May-16	688890	5500180	-	-	-	-	n	y	n	
Gold	2	weir-green	13-May-16	688800	5500774	-	-	-	-	n	y	n	excellent hab
Gold	2	weir-green	13-May-16	688733	5500949	-	-	-	-	n	y	n	excellent hab
Gold	2	weir-green	13-May-16	688669	5500974	-	-	-	-	n	y	n	possible fish barrier, 6m waterfalls, big pool
Gold	8	caudron	14-May-16	688056	5506582	-	-	-	-	n	n	n	park @ caudron, walkt to confluence and up on gold
Gold	8	caudron	14-May-16	687868	5506955	5	4	4	-	n	y	y	
Gold	8	caudron	14-May-16	687848	5506829	1	1	1	-	n	n	n	
Gold	8	caudron	14-May-16	687841	5506814	1	-	-	-	n	n	n	
Gold	8	caudron	14-May-16	687815	5506779	1	1	1	-	n	n	n	
Gold	8	caudron	14-May-16	687814	5506779	-	-	-	-	n	y	n	
Gold	8	caudron	14-May-16	687817	5506764	4	1	1	-	n	n	n	
Gold	8	caudron	14-May-16	687826	5506740	8	2	2	1	y	y	y	paired under lg overhanging rock on gravels
Gold	8	caudron	14-May-16	687885	5506650	7	4	4	2	y	y	y	paired under lg overhanging rock on gravels
Gold	8	caudron	14-May-16	687870	5506570	13	2	2	1	y	y	n	paired under lg overhanging rock on gravels
Gold	8	caudron	14-May-16	687872	5506558	-	-	-	-	n	n	n	gravel deposit on slab rock
Gold	8	caudron	14-May-16	687863	5506346	-	-	-	-	n	n	n	below caudron on gold
Gold	8	caudron	14-May-16	687874	5506379	-	-	-	-	n	y	n	deep pool, slab
Gold	8	caudron	14-May-16	687867	5506405	-	-	-	-	n	y	n	deep pool, slab
Gold	8	caudron	14-May-16	687865	5506461	5	2	2	1	n	y	n	
Gold	8	caudron	14-May-16	688005	5506550	-	-	-	-	n	n	n	on caudron, no hab, steep gradient
Gold	7	mid reach	14-May-16	687528	5504167	7	1	-	-	n	n	n	below bridge and hydrolines
Gold	7	mid reach	14-May-16	687481	5504212	-	-	-	-	n	y	n	
Gold	7	mid reach	14-May-16	687470	5504273	5	1	1	-	n	n	n	
Gold	7	mid reach	14-May-16	687463	5504305	-	-	-	-	n	y	n	
Gold	7	mid reach	14-May-16	687461	5504329	10	4	4	-	n	y	n	
Gold	7	mid reach	14-May-16	687387	5504398	13	12	12	-	n	y	y	foot bridge pool (cory's) undercut root bank, no gravels
Gold	7	mid reach	14-May-16	687452	5504498	2	-	-	-	n	n	n	
Gold	7	mid reach	14-May-16	687474	5504576	3	-	-	-	n	n	n	
Gold	7	mid reach	14-May-16	687484	5504600	3	-	-	-	n	y	n	
Gold	7	mid reach	14-May-16	687513	5504597	4	1	1	-	n	n	n	
Gold	7	mid reach	14-May-16	687541	5504597	2	-	-	-	n	n	n	
Gold	7	mid reach	14-May-16	687586	5504651	-	-	-	-	n	n	n	terminus, potentail sp. Offset, 40 m glide, build spillover to cap gravels

Table A5.4 (Cont'd.)

Waterbody	Reach	Reach Description	Date	Easting	Northing	Total Count	Adults	Mature Adults	Pairs	Cover	Sp. Habitat	Picture	Notes
Gold	6	morin	14-May-16	688090	5503077	-	-	-	-	n	y	n	upstream of morin on Gold
Gold	6	morin	14-May-16	687910	5502970	1	-	-	-	n	n	n	sick juv
Gold	5	morin	14-May-16	687924	5502739	-	-	-	-	n	n	n	many channels, heavy periphyton, confluence with gold
Gold	5	morin	14-May-16	687985	5502673	-	-	-	-	n	n	n	no sp habitat for at least 500m d/s on gold
Blairmore	5	upper reach	15-May-16	682951	5509985	-	-	-	-	n	n	n	parked at devon rd by bridge
Blairmore	5	upper reach	15-May-16	682934	5509865	20	1	1	-	n	n	y	2 lrg pools
Blairmore	5	upper reach	15-May-16	683024	5509779	16	4	4	-	n	y	n	
Blairmore	5	upper reach	15-May-16	683308	5509323	2	2	1	-	y	y	y	vis less than 1 mLWD cover
Blairmore	5	upper reach	15-May-16	683297	5509357	7	-	-	-	n	y	n	
Blairmore	5	upper reach	15-May-16	683289	5509375	2	-	-	-	n	n	n	
Blairmore	5	upper reach	15-May-16	683274	5509361	-	-	-	-	n	y	y	
Blairmore	5	upper reach	15-May-16	683257	5509359	12	2	1	-	n	y	y	deep pool excellent sp. Gravel
Blairmore	5	upper reach	15-May-16	683239	5509383	6	2	2	-	n	y	y	
Blairmore	5	upper reach	15-May-16	683165	5509499	2	2	2	1	y	y	y	pair of spawners in undersut bank w/gravels and test redds
Blairmore	5	upper reach	15-May-16	683168	5509535	2	-	-	-	n	y	y	excellent hab
Blairmore	5	upper reach	15-May-16	683146	5509644	2	-	-	-	n	y	n	excellent hab
Blairmore	5	upper reach	15-May-16	683125	5509685	4	1	1	-	n	y	y	1 adult spawner on gravel
Blairmore	5	upper reach	15-May-16	683088	5509687	-	-	-	-	n	y	n	
Gold		morin/gold	15-May-16	687377	5504516	-	-	-	-	n	n	n	up near Gold bridge heading to conf w/ morin going above and below on Gold
Gold	6	morin/gold	15-May-16	688002	5502647	-	-	-	-	n	y	y	lrg pool LWD, upstream on Gold
Gold	6	morin/gold	15-May-16	687820	5502855	16	6	2	-	n	y	y	
Gold	6	morin/gold	15-May-16	687750	5502872	-	-	-	-	n	y	n	
Gold	6	morin/gold	15-May-16	687734	5502950	-	-	-	-	n	y	n	
Gold	6	morin/gold	15-May-16	687734	5503002	-	-	-	-	n	n	y	beginning of channalized hab/heavy periphyton, beside coal dep. 300 m
Gold	6	morin/gold	15-May-16	687658	5503065	4	1	1	-	n	y	y	man made pool beside coal deposit
Gold	6	morin/gold	15-May-16	687611	5503193	-	-	-	-	n	n	n	Gold braids, dries up in some sections, little flow, no hab
Blairmore	4	mid reach	16-May-16	684531	5507228	6	2	1	-	n	y	n	start of riprap, ***2 possible hybrid**** 4 pools
Blairmore	4	mid reach	16-May-16	684531	5507250	-	-	-	-	n	y	n	end of riprap
Blairmore	4	mid reach	16-May-16	684527	5507262	8	2	2	1	n	y	n	2 pools
Blairmore	4	mid reach	16-May-16	684515	5507279	7	3	1	-	n	y	n	2 pools
Blairmore	4	mid reach	16-May-16	684519	5507316	17	5	5	2	Y	y	y	some smaller w/colour too, pairs on gravel under LWD
Blairmore	4	mid reach	16-May-16	684496	5507372	13	1	10	-	n	y	n	
Blairmore	4	mid reach	16-May-16	684490	5507421	22	5	5	2	Y	y	y	possible redd, underwater photos w/Sarah's cam
Blairmore	4	mid reach	16-May-16	684487	5507440	8	2	2	1	n	y	n	
Blairmore	4	mid reach	16-May-16	684496	5507465	4	4	4	2	n	y	n	
Blairmore	4	mid reach	16-May-16	684519	5507484	5	-	-	-	n	y	n	
Blairmore	4	mid reach	16-May-16	684519	5507568	11	3	3	1	n	y	n	
Blairmore	4	mid reach	16-May-16	684509	5507611	-	-	-	-	n	n	y	sluffing road bank, possible offsetting
Blairmore	4	mid reach	16-May-16	684458	5507720	4	2	2	-	n	Y	n	
Blairmore	3	bct04	16-May-16	684888	5504623	9	-	-	-	n	Y	n	d/s of bct04 on Blairmore ****2 possible hybrid****
Blairmore	3	bct04	16-May-16	684887	5504686	12	2	2	-	n	Y	n	2 pools
Blairmore	3	bct04	16-May-16	684884	5504715	14	1	1	-	n	Y	n	
Blairmore	3	bct04	16-May-16	684887	5504733	7	2	2	1	n	Y	n	
Blairmore	3	bct04	16-May-16	684875	5504744	2	-	-	-	n	y	n	
Blairmore	3	bct04	16-May-16	684873	5504851	31	9	9	3	y	y	n	excellent hab
Blairmore	3	bct04	16-May-16	684937	5504954	-	-	-	-	n	n	n	terminus @ ford, bct04 sm incised ltd hab, low flow
Gold	4	green	17-May-16	688831	5501407	-	-	-	-	n	n	n	park at green/gold conf, upstream on gold
Gold	4	green	17-May-16	688808	5501560	-	-	-	-	n	y	n	
Gold	4	green	17-May-16	688803	5501642	-	-	-	-	n	y	n	
Gold	4	green	17-May-16	688811	5501668	-	-	-	-	n	y	n	excellent hab

Table A5.4 (Cont'd.)

Waterbody	Reach	Reach Description	Date	Easting	Northing	Total Count	Adults	Mature Adults	Pairs	Cover	Sp. Habitat	Picture	Notes
Gold	4	green	17-May-16	688792	5501759	-	-	-	-	n	y	n	
Gold	4	green	17-May-16	688810	5501817	-	-	-	-	n	y	y	great sp. Hab, void of complexity, lrg coal deposit for 300 m
Gold	4	green	17-May-16	688834	5501905	-	-	-	-	n	y	n	
Gold	4	green	17-May-16	688788	5501904	-	-	-	-	n	y	n	more complexity, great hab for 120 m
Gold	4	green	17-May-16	688766	5501898	1	-	-	-	n	y	n	
Gold	4	green	17-May-16	688733	5502098	-	-	-	-	n	y	n	excellent hab
Gold	4	green	17-May-16	688686	5502151	-	-	-	-	n	n	n	terminus u/s walk back d/s to truck
Gold		morin/gold	17-May-16	687727	5502918	-	-	-	-	n	n	n	Confluence of Morin and Gold
Gold	6	morin/gold	17-May-16	687626	5502013	-	-	-	-	n	n	n	100m up/s Gold loses water volume ltd hab
Gold		weir-green	17-May-16	688464	5498444	3	1	1	-	n	n	n	
Gold	2	weir-green	17-May-16	688545	5498457	2	1	1	-	n	y	n	revisit, no fish last time
Gold	2	weir-green	17-May-16	688588	5498571	-	-	-	-	n	y	n	revisit, no fish this time (had 15CT)
Blairmore	5	upper reach	6-Jun-16	683164	5509521	-	-	-	-	n	y	y	begin at pool, revisit, no fish
Blairmore	5	upper reach	6-Jun-16	683179	5509536	7	2	2	-	y	y	n	colour fading
Blairmore	5	upper reach	6-Jun-16	683180	5509553	1	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683197	5509610	1	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683155	5509635	1	-	-	-	y	n	n	
Blairmore	5	upper reach	6-Jun-16	683141	5509657	2	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683140	5509675	5	1	-	-	n	n	n	two pools
Blairmore	5	upper reach	6-Jun-16	683121	5509693	2	-	-	-	n	N	n	pool slightly u/s
Blairmore	5	upper reach	6-Jun-16	683118	5509699	-	-	-	-	n	y	n	pool, no fish
Blairmore	5	upper reach	6-Jun-16	683107	5509703	-	-	-	-	n	n	y	nice pool, no fish
Blairmore	5	upper reach	6-Jun-16	683099	5509710	6	1	-	-	n	y	n	
Blairmore	5	upper reach	6-Jun-16	683091	5509693	2	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683072	5509686	2	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683061	5509698	7	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683056	5509716	8	1	1	-	n	n	n	s/a
Blairmore	5	upper reach	6-Jun-16	683055	5509727	5	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683064	5509740	4	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	683065	5509747	6	-	-	-	n	N	n	3 juv lrger in upper pool, two pools
Blairmore	5	upper reach	6-Jun-16	683030	5509774	8	-	-	-	n	y	n	lrg pool, last time lots of fish
Blairmore	5	upper reach	6-Jun-16	683011	5509770	7	-	-	-	n	n	n	
Blairmore	5	upper reach	6-Jun-16	682991	5509820	2	-	-	-	n	y	n	
Blairmore	5	upper reach	6-Jun-16	682974	5509828	2	-	-	-	y	y	n	undcut bank w/pool
Blairmore	5	upper reach	6-Jun-16	682931	5509875	2	-	-	-	n	y	n	at least 2 fish, lots of gravel, not wanting disturbance
Blairmore	5	upper reach-above bridge	6-Jun-16	682905	5509949	11	1	1	-	n	y	n	pool above bridge
Blairmore	5	upper reach-above bridge	6-Jun-16	682907	5509959	4	-	-	-	n	y	y	
Blairmore	5	upper reach-above bridge	6-Jun-16	682892	5509992	13	1	1	-	n	n	y	
Blairmore	5	upper reach-above bridge	6-Jun-16	682883	5510018	8	-	-	-	n	n	n	
Blairmore	5	upper reach-above bridge	6-Jun-16	682881	5510044	16	-	-	-	y	y	y	gasline restoration site, two pools, overhang wood structure w/12 CT
Blairmore	5	upper reach-above bridge	6-Jun-16	682887	5510089	2	-	-	-	n	n	n	
Blairmore	5	upper reach-above bridge	6-Jun-16	682911	5510110	3	-	-	-	n	y	n	
Blairmore	5	upper reach-above bridge	6-Jun-16	682900	5510128	6	-	-	-	n	y	y	
Blairmore	5	upper reach-above bridge	6-Jun-16	682889	5510144	9	-	-	-	n	y	y	v. deep pool
Blairmore	5	upper reach-above bridge	6-Jun-16	682898	5510158	17	1	-	-	n	n	n	colour fading, CT over 3 small pools
Blairmore	5	upper reach-above bridge	6-Jun-16	682922	5510181	9	-	-	-	n	n	y	at conf. w/ sm steep trib
Blairmore	5	upper reach-above bridge	6-Jun-16	682903	5510192	6	-	-	-	n	y	n	
Blairmore	5	upper reach-above bridge	6-Jun-16	682907	5510210	9	-	-	-	n	n	n	1 possible wctrb?
Blairmore	5	upper reach-above bridge	6-Jun-16	682839	5510388	-	-	-	-	n	n	n	terminus
Gold	8	caudron	7-Jun-16	687881	5506542	2	-	-	-	n	n	n	heading u/s of caudron

Table A5.4 (Cont'd.)

Waterbody	Reach	Reach Description	Date	Easting	Northing	Total Count	Adults	Mature Adults	Pairs	Cover	Sp. Habitat	Picture	Notes
Gold	8	caudron	7-Jun-16	687874	5506554	11	2	2	-	n	n	n	colour fading
Gold	8	caudron	7-Jun-16	687874	5506578	4	2	2	-	n	n	n	colour fading
Gold	8	caudron	7-Jun-16	687878	5506631	7	3	2	1	y	y	n	3 redds
Gold	8	caudron	7-Jun-16	687821	5506738	4	2	2	1	y	y	n	1 redd, pair on gravel, undcut rock (saw pair 1st trip)
Gold	8	caudron	7-Jun-16	687992	5506761	8	4	4	2	n	n	n	2 pair, m CT w/ kype
Gold	8	caudron	7-Jun-16	687819	5506776	1	-	-	-	n	y	n	2 redds or test redds
Gold	8	caudron	7-Jun-16	687858	5506828	5	-	-	-	n	n	n	
Gold	8	caudron	7-Jun-16	687867	5506877	4	-	-	-	n	n	n	
Gold	8	caudron	7-Jun-16	687875	5506923	4	1	1	-	n	n	n	
Gold	8	caudron	7-Jun-16	687874	5506954	3	1	1	-	n	y	n	1 redd
Gold	8	caudron	7-Jun-16	687894	5506990	4	2	1	-	n	n	n	
Gold	8	caudron	7-Jun-16	687900	5507071	3	-	-	-	n	y	n	
Gold	8	caudron	7-Jun-16	687913	5507156	3	-	-	-	n	n	n	
Gold	8	caudron	7-Jun-16	687825	5508179	-	-	-	-	n	n	n	terminus
Gold	7	mid reach	7-Jun-16	687392	5504399	13	7	3	-	n	y	n	revisit cory's pool
Blairmore	4	mid reach	8-Jun-16	684535	5507224	14	7	4	-	n	n	n	beginning of riprap stretch
Blairmore	4	mid reach	8-Jun-16	684531	5507256	12	3	3	-	n	n	n	colour fading, end of riprap
Blairmore	4	mid reach	8-Jun-16	684526	5507265	4	-	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684516	5507262	18	2	2	1	y	y	n	
Blairmore	4	mid reach	8-Jun-16	684520	5507280	9	3	-	-	n	y	n	colour fading
Blairmore	4	mid reach	8-Jun-16	684525	5507293	23	4	2	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684524	5507329	3	-	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684500	5507346	2	-	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684498	5507353	5	-	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684493	5507352	3	1	1	-	n	y	n	colour fading
Blairmore	4	mid reach	8-Jun-16	684492	5507372	15	-	-	-	n	y	n	
Blairmore	4	mid reach	8-Jun-16	684483	5507418	9	-	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684487	5507420	14	-	-	-	n	y	n	2 possible wctxrb ?
Blairmore	4	mid reach	8-Jun-16	684483	5507440	6	-	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684488	5507467	10	1	-	-	n	y	n	
Blairmore	4	mid reach	8-Jun-16	684480	5507452	8	5	5	-	n	y	n	colour fading
Blairmore	4	mid reach	8-Jun-16	684491	5507464	10	1	-	-	n	n	n	started to note juv/s/a (residents) w/colour
Blairmore	4	mid reach	8-Jun-16	684512	5507494	13	3	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684524	5507583	6	-	-	-	n	y	n	
Blairmore	4	mid reach	8-Jun-16	684509	5507606	4	1	1	-	n	n	n	colour fading
Blairmore	4	mid reach	8-Jun-16	684510	5507641	8	5	-	-	n	n	n	
Blairmore	4	mid reach	8-Jun-16	684452	5507734	18	4	4	-	n	n	n	
Blairmore	2	lower	8-Jun-16	684728	5503594	-	-	-	-	n	n	n	begin at lower Blairmore near BCT02
Blairmore	2	lower	8-Jun-16	684746	5503656	35	10	2	-	n	y	n	bedrock pool, 2 possible wctxrb
Blairmore	2	lower	8-Jun-16	684756	5503686	17	5	2	1	n	y	y	
Blairmore	2	lower	8-Jun-16	684772	5503707	10	2	-	-	n	y	n	
Blairmore	2	lower	8-Jun-16	684779	5503758	21	13	2	-	n	n	y	2 w/injury/white mold
Blairmore	2	lower	8-Jun-16	684786	5503777	23	1	-	-	n	n	y	1 brook trout, pool by possible barrier
Blairmore	2	lower	8-Jun-16	684766	5503799	38	7	-	-	n	n	y	1 w/mold
Blairmore	2	lower	8-Jun-16	684785	5503823	13	2	-	-	n	n	n	
Blairmore	2	lower	8-Jun-16	684783	5503849	24	3	-	-	n	n	y	
Blairmore	2	lower	8-Jun-16	684778	5503884	3	2	1	-	n	n	n	colour fading
Blairmore	2	lower	8-Jun-16	684763	5503909	23	5	-	-	n	n	n	
Blairmore	2	lower	8-Jun-16	684751	5503909	20	6	2	-	n	n	n	change of habitat more, boulder/cobble
Blairmore	2	lower	8-Jun-16	684732	5503928	26	9	3	1	n	n	n	

Table A5.4 (Cont'd.)

Waterbody	Reach	Reach Description	Date	Easting	Northing	Total Count	Adults	Mature Adults	Pairs	Cover	Sp. Habitat	Picture	Notes
Blairmore	2	lower	8-Jun-16	684745	5504039	60	-	-	-	n	n	n	barrier/water fall w/ lrg deep pool, CT est.
Gold	9	headwaters	9-Jun-16	687470	5510873	-	-	-	-	n	n	n	headwaters at culvert, head d/s then u/s to bridge
Gold	9	headwaters	9-Jun-16	687666	5509371	1	-	-	-	n	n	n	3 sm. Pockets, cascade/run, cobble hab
Gold	9	headwaters	9-Jun-16	687653	5509390	2	-	-	-	n	n	n	sm pockets
Gold	9	headwaters	9-Jun-16	687646	5509405	4	-	-	-	n	n	n	
Gold	9	headwaters	9-Jun-16	687646	5509405	3	-	-	-	y	y	n	pool 5 m u/s, LWD, only actual pool
Gold	9	headwaters	9-Jun-16	687638	5509442	-	-	-	-	n	y	n	
Gold	9	headwaters	9-Jun-16	687635	5509452	3	-	-	-	n	y	n	2 sm pockets
Gold	9	headwaters	9-Jun-16	687630	5509470	2	-	-	-	y	y	n	lrg pocket/sm pool
Gold	9	headwaters	9-Jun-16	687619	5509475	3	-	-	-	n	y	y	sm pockets *hydro transect cand*
Gold	9	headwaters	9-Jun-16	687598	5509505	6	-	-	-	n	n	y	video here, 3 male 1 female, 2 jacks (residents - will be in other sheet)
Gold	9	headwaters	9-Jun-16	687547	5509522	4	-	-	-	n	n	n	
Gold	9	headwaters	9-Jun-16	687533	5509534	2	-	-	-	n	y	y	didn't want to disturb gravels **
Gold	9	headwaters	9-Jun-16	687521	5509552	-	-	-	-	y	y	n	
Gold	9	headwaters	9-Jun-16	687518	5509584	2	-	-	-	n	y	Y	**
Gold	9	headwaters	9-Jun-16	687518	5509602	2	-	-	-	n	y	Y	**
Gold	9	headwaters	9-Jun-16	687512	5509655	2	-	-	-	n	y	n	**
Gold	9	headwaters	9-Jun-16	687481	5509723	3	-	-	-	n	y	Y	**
Gold	9	headwaters	9-Jun-16	687453	5509770	2	-	-	-	n	y	n	
Gold	9	headwaters	9-Jun-16	687453	5509806	2	-	-	-	y	y	y	offset pot. Open up pool
Gold	9	headwaters	9-Jun-16	687446	5509817	5	-	-	-	n	y	y	** , glide
Gold	9	headwaters	9-Jun-16	687471	5509884	2	-	-	-	n	n	n	u/s on steep trib, fish bearing no sp. Hab.
Blairmore	1	golf course	9-Jun-16			-	-	-	-	n	n	n	3 juv. Brook trout
Gold	7	Caudron	10-Jun-16	687867	5506322	-	-	-	-	n	n	n	start d/s
Gold	7	Caudron	10-Jun-16	687862	5506347	18	3	-	-	n	n	n	
Gold	7	rainbow	10-Jun-16	687834	5506072	2	-	-	-	n	n	n	at bridge above Rainbow farm
Gold	7	mid reach	10-Jun-16	687394	5504399	7	-	-	-	n	n	n	Cory's pool
Blairmore	4	mid reach	11-Jun-16	684467	5507700	5	-	-	-	n	n	n	at ford near end of stretch
Blairmore	4	mid reach	11-Jun-16	684467	5507719	12	-	-	-	n	n	n	see other sheet
Blairmore	3	BCT04	11-Jun-16	684870	5504853	21	4	-	-	n	y	n	below BCT04 in pool

**Table A5.5 WSCT captured by angling during the mark phase for the mark recapture study August 7 to 12, 2016.**

Date	Waterbody	Easting	Northing	Reach	Fish ID	Fork length (mm)	Mark/Recap	Notes
6-Aug-16	Gold	688744	5501452	3	GLD(U)001	215	M	
7-Aug-16	Gold	687380	5504406	7	GLD(X)001	295	M	
7-Aug-16	Gold	687380	5504406	7	GLD(X)002	316	M	
7-Aug-16	Gold	687380	5504406	7	GLD(X)003	280	M	
7-Aug-16	Gold	687507	5503979	7	GLD(X)004	243	M	
7-Aug-16	Gold	687528	5504167	7	GLD(X)005	245	M	
8-Aug-16	Gold	687462	5504512	7	GLD(X)006	275	M	
8-Aug-16	Gold	687462	5504512	7	GLD(X)007	235	M	
8-Aug-16	Gold	687462	5504512	7	GLD(X)008	280	M	
8-Aug-16	Gold	687514	5504595	7	GLD(X)009	220	M	
8-Aug-16	Gold	687601	5504758	7	GLD(X)010	285	M	
8-Aug-16	Gold	687572	5504768	7	GLD(X)011	275	M	
8-Aug-16	Gold	687572	5504768	7	GLD(X)012	225	M	
8-Aug-16	Gold	687675	5504966	7	GLD(X)013	275	M	
8-Aug-16	Gold	687675	5504966	7	GLD(X)014	235	M	
8-Aug-16	Gold	687675	5504966	7	GLD(X)015	225	M	
8-Aug-16	Gold	687675	5504966	7	GLD(X)016	223	M	
9-Aug-16	Gold	687675	5504966	7	GLD(X)017	245	M	
9-Aug-16	Gold	687637	5504863	7	GLD(X)018	235	M	
9-Aug-16	Gold	687637	5504863	7	GLD(X)019	225	M	
12-Aug-16	Gold	684908	5505525	7	GLD(X)026	255	M	
12-Aug-16	Gold	684908	5505525	7	GLD(X)027	198	M	
12-Aug-16	Gold	687369	5504442	7	GLD(X)028	235	M	
12-Aug-16	Gold	687369	5504442	7	GLD(X)029	245	M	
12-Aug-16	Gold	687680	5504967	7	GLD(X)030	270	M	
11-Aug-16	Blairmore	684884	5504742	3	BL(F)001	225	M	scar fish
11-Aug-16	Blairmore	684881	5504628	3	BL(F)002	218	M	
11-Aug-16	Blairmore	684910	5504626	3	BL(F)003	175	M	
11-Aug-16	Blairmore	684933	5504605	3	BL(F)004	185	M	
11-Aug-16	Blairmore	684933	5504605	3	BL(F)005	225	M	
11-Aug-16	Blairmore	684933	5504605	3	BL(F)006	183	M	
11-Aug-16	Blairmore	684928	5504542	3	BL(F)007	240	M	
11-Aug-16	Blairmore	684928	5504542	3	BL(F)008	220	M	
11-Aug-16	Blairmore	684928	5504542	3	BL(F)009	205	M	
11-Aug-16	Blairmore	684910	5504528	3	BL(F)010	215	M	
11-Aug-16	Blairmore	684912	5504523	3	BL(F)011	125	M	
11-Aug-16	Blairmore	684777	5504264	3	BL(F)012	195	M	
11-Aug-16	Blairmore	684777	5504264	3	BL(F)013	130	M	
11-Aug-16	Blairmore	684777	5504264	3	BL(F)014	123	M	

**Table A5.5 (Cont'd.)**

Date	Waterbody	Easting	Northing	Reach	Fish ID	Fork length (mm)	Mark/Recap	Notes
11-Aug-16	Blairmore	684758	5504249	3	BL(F)015	195	M	
11-Aug-16	Blairmore	684777	5504264	3	BL(F)016	128	M	
11-Aug-16	Blairmore	684777	5504264	3	BL(F)017	155	M	
11-Aug-16	Blairmore	684798	5504295	3	BL(F)018	225	M	
11-Aug-16	Blairmore	684798	5504295	3	BL(F)019	205	M	
11-Aug-16	Blairmore	684798	5504295	3	BL(F)020	145	M	
11-Aug-16	Blairmore	684798	5504295	3	BL(F)021	215	M	
11-Aug-16	Blairmore	684816	5504300	3	BL(F)022	220	M	
12-Aug-16	Blairmore	684946	5504963	4	BL (E)001	145	M	
12-Aug-16	Blairmore	684946	5504963	4	BL (E)002	175	M	
12-Aug-16	Blairmore	684946	5504963	4	BL (E)003	115	M	
12-Aug-16	Blairmore	684916	5505218	4	BL (E)004	183	M	
12-Aug-16	Blairmore	684943	5505241	4	BL (E)005	213	M	
12-Aug-16	Blairmore	684931	5505449	4	BL (E)006	185	M	
12-Aug-16	Blairmore	684931	5505449	4	BL (E)007	113	M	
12-Aug-16	Blairmore	684904	5505524	4	BL (E)008	175	M	
12-Aug-16	Blairmore	684904	5505524	4	BL (E)009	155	M	
12-Aug-16	Blairmore	684904	5505524	4	BL (E)010	210	M	Hybrid?
12-Aug-16	Blairmore	684904	5505524	4	BL (E)011	230	M	
12-Aug-16	Blairmore	684904	5505524	4	BL (E)012	165	M	
12-Aug-16	Blairmore	684904	5505524	4	BL (E)013	205	M	
12-Aug-16	Blairmore	684904	5505524	4	BL (E)014	105	M	

**Table A5.6 WSCT captured by angling during the recapture phase for the mark recapture study August 15 and 16, 2016.**

Date	Waterbody	Easting	Northing	Fork Length (mm)	Mark (Y or N)	Notes
15-Aug-16	Gold	687528	5504163	228	N	
15-Aug-16	Gold	687474	5504295	215	N	
15-Aug-16	Gold	687387	5504412	268	N	
15-Aug-16	Gold	687409	5504480	215	N	
15-Aug-16	Gold	687465	5504523	205	N	
15-Aug-16	Gold	687483	5504534	235	N	
15-Aug-16	Gold	687523	5504587	268	N	
15-Aug-16	Gold	687587	5504662	235	N	
15-Aug-16	Gold	687587	5504662	258	N	
15-Aug-16	Gold	687597	5504749	215	N	
15-Aug-16	Gold	687624	5504902	195	N	
15-Aug-16	Gold	687683	5504972	173	N	
15-Aug-16	Gold	687631	5504867	190	N	
16-Aug-16	Gold	687622	5504855	238	N	
16-Aug-16	Gold	687622	5504855	310	N	
16-Aug-16	Gold	687622	5504855	235	N	
16-Aug-16	Gold	687622	5504855	235	Y	
16-Aug-16	Gold	687370	5504445	245	N	
16-Aug-16	Gold	687370	5504445	295	Y	****snorkle recap*** hook scar fish
16-Aug-16	Blairmore	684886	5504847	185	N	Hybrid
16-Aug-16	Blairmore	684925	5504556	215	N	
16-Aug-16	Blairmore	684925	5504556	178	N	Hybrid
16-Aug-16	Blairmore	684925	5504556	255	Y	Hybrid
16-Aug-16	Blairmore	684925	5504556	175	N	
16-Aug-16	Blairmore	684892	5504495	263	N	
16-Aug-16	Blairmore	684818	5504396	165	N	
16-Aug-16	Blairmore	684818	5504396	195	N	

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**Appendix A6**

**Fish Tissue Results by Individual**

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**Table A6.1 Concentration of metals in fish tissue samples collected from Gold Creek, August 2016.**

Measurement Parameters	Units	Sample ID	BKTR 01	BKTR 02	BKTR 03	BKTR 04	BKTR 05	BKTR 06	BKTR 07	BKTR 08
		Date Samples	17-Aug-16	17-Aug-16	17-Aug-16	17-Aug-16	17-Aug-16	17-Aug-16	17-Aug-16	17-Aug-16
Detection Limit										
% Moisture	%	0.50	71.3	71.6	71.2	72.1	70.5	73.2	71.2	71.2
<b>Total Metals</b>										
Aluminum (Al)-Total	mg/kg wwt	0.40	5.61	7.31	0.98	4.94	17.0	2.50	41.2	35.5
Antimony (Sb)-Total	mg/kg wwt	0.0020	<0.0020	0.0023	0.0023	0.0022	<0.0020	<0.0020	<0.0020	<0.0020
Arsenic (As)-Total	mg/kg wwt	0.0040	0.0734	0.137	0.111	0.114	0.103	0.0885	0.105	0.123
Barium (Ba)-Total	mg/kg wwt	0.010	0.561	0.592	0.479	0.562	0.848	0.298	0.827	1.49
Beryllium (Be)-Total	mg/kg wwt	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0048	0.0022
Bismuth (Bi)-Total	mg/kg wwt	0.0020	0.0025	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Boron (B)-Total	mg/kg wwt	0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)-Total	mg/kg wwt	0.0010	0.0488	0.0754	0.0499	0.0269	0.0560	0.101	0.109	0.246
Calcium (Ca)-Total	mg/kg wwt	4.0	6850	7130	9390	7260	7920	3460	5670	9280
Cesium (Cs)-Total	mg/kg wwt	0.0010	0.0015	0.0017	0.0012	0.0015	0.0027	0.0010	0.0064	0.0057
Chromium (Cr)-Total	mg/kg wwt	0.010	<0.010	0.014	<0.010	0.010	0.033	<0.010	0.039	0.062
Cobalt (Co)-Total	mg/kg wwt	0.0040	0.0920	0.0618	0.0885	0.0581	0.0943	0.0850	0.0799	0.175
Copper (Cu)-Total	mg/kg wwt	0.010	0.726	0.588	0.705	0.610	0.702	0.872	0.669	0.816
Iron (Fe)-Total	mg/kg wwt	0.60	17.0	17.9	12.2	15.6	25.7	14.4	28.4	58.7
Lead (Pb)-Total	mg/kg wwt	0.0040	0.0084	0.0086	0.0052	0.0106	0.0170	0.0045	0.0383	0.0397
Lithium (Li)-Total	mg/kg wwt	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg)-Total	mg/kg wwt	0.40	281	307	289	344	366	226	282	425
Manganese (Mn)-Total	mg/kg wwt	0.010	0.926	0.755	0.737	0.820	0.985	0.368	0.829	2.00
Mercury (Hg)-Total	mg/kg wwt	0.0010	0.0034	0.0040	0.0036	0.0036	0.0037	0.0042	0.0045	0.0160
Molybdenum (Mo)-Total	mg/kg wwt	0.0040	0.0105	0.0118	0.0085	0.0109	0.0129	0.0095	0.0115	0.0263
Nickel (Ni)-Total	mg/kg wwt	0.010	0.030	0.030	0.021	0.025	0.070	0.039	0.059	0.142
Phosphorus (P)-Total	mg/kg wwt	2.0	5760	5900	7090	6130	7160	3900	4960	6880
Potassium (K)-Total	mg/kg wwt	4.0	3360	3480	3520	3670	3720	3460	3410	3060
Rubidium (Rb)-Total	mg/kg wwt	0.010	1.56	2.02	2.11	1.64	1.71	1.50	1.67	0.906
Selenium (Se)-Total	mg/kg wwt	0.010	1.54	1.84	1.72	1.84	1.72	1.80	2.14	2.78
Sodium (Na)-Total	mg/kg wwt	4.0	837	811	835	814	834	819	762	755
Strontium (Sr)-Total	mg/kg wwt	0.010	16.8	17.6	22.7	17.1	19.5	9.17	14.9	12.3
Tellurium (Te)-Total	mg/kg wwt	0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Thallium (Tl)-Total	mg/kg wwt	0.00040	0.0482	0.0479	0.102	0.0376	0.0635	0.0399	0.0403	0.0135
Tin (Sn)-Total	mg/kg wwt	0.020	0.033	0.050	0.044	0.072	0.023	0.026	0.036	<0.020
Uranium (U)-Total	mg/kg wwt	0.00040	0.00135	0.00139	0.00066	0.00139	0.00507	0.00106	0.00399	0.00658
Vanadium (V)-Total	mg/kg wwt	0.020	0.025	0.028	<0.020	0.030	0.132	<0.020	0.122	0.100
Zinc (Zn)-Total	mg/kg wwt	0.10	30.7	35.9	37.5	23.4	35.4	29.8	33.0	39.5
Zirconium (Zr)-Total	mg/kg wwt	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.075	<0.040

wwt = wet weight

**Table A6.2 Concentration of metals in fish tissue samples collected from Blairmore Creek, October 2016.**

Measurement Parameters	Units	Detection Limit	BL03 - 102016	BL04 - 102016	BL05 - 102016	BL06 - 102016	BL07 - 102016	BL08 - 102016	BL09 - 102016	BL10 - 102016	SPLIT SAMPLE
% Moisture	%	0.50	78.4	77.5	77.7	78.0	76.9	77.2	77.5	76.2	79.0
<b>Total Metals</b>											
Aluminum (Al)-Total	mg/kg ww	0.40	13.3	11.8	20.7	10.3	12.7	23.2	34.2	13.8	14.6
Antimony (Sb)-Total	mg/kg ww	0.0020	0.0073	0.0034	0.0056	<0.0020	0.0032	0.0031	<0.0020	0.0021	<0.0020
Arsenic (As)-Total	mg/kg ww	0.0040	0.0514	0.0710	0.0444	0.141	0.0443	0.122	0.0640	0.147	0.122
Barium (Ba)-Total	mg/kg ww	0.010	1.23	1.16	1.52	1.57	1.38	1.33	1.87	1.21	1.28
Beryllium (Be)-Total	mg/kg ww	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0021	<0.0020	<0.0020
Bismuth (Bi)-Total	mg/kg ww	0.0020	0.0052	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Boron (B)-Total	mg/kg ww	0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)-Total	mg/kg ww	0.0010	0.0619	0.0388	0.0233	0.0340	0.0243	0.0455	0.0301	0.0358	0.0307
Calcium (Ca)-Total	mg/kg ww	4.0	5000	6680	5250	5730	6140	4620	4660	4280	6070
Cesium (Cs)-Total	mg/kg ww	0.0010	0.0043	0.0031	0.0059	0.0031	0.0036	0.0052	0.0065	0.0045	0.0041
Chromium (Cr)-Total	mg/kg ww	0.010	0.225	0.121	0.464	0.199	0.246	0.417	0.406	0.385	0.383
Cobalt (Co)-Total	mg/kg ww	0.0040	0.125	0.279	0.201	0.292	0.181	0.252	0.369	0.336	0.332
Copper (Cu)-Total	mg/kg ww	0.010	0.603	0.495	0.525	0.689	0.497	0.574	0.761	0.906	0.707
Iron (Fe)-Total	mg/kg ww	0.60	31.5	21.3	41.4	26.8	30.7	49.2	63.7	35.6	34.9
Lead (Pb)-Total	mg/kg ww	0.0040	0.0149	0.0123	0.0166	0.0092	0.0112	0.0178	0.0295	0.0142	0.0136
Lithium (Li)-Total	mg/kg ww	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg)-Total	mg/kg ww	0.40	261	291	253	285	304	282	275	279	319
Manganese (Mn)-Total	mg/kg ww	0.010	2.05	2.25	4.42	3.03	3.70	4.83	3.36	2.19	2.40
Mercury (Hg)-Total	mg/kg ww	0.0010	0.0250	0.0162	0.0135	0.0131	0.0154	0.0211	0.0130	0.0156	0.0164
Molybdenum (Mo)-Total	mg/kg ww	0.0040	0.0429	0.0262	0.0778	0.0398	0.0391	0.0660	0.0612	0.0577	0.0580
Nickel (Ni)-Total	mg/kg ww	0.010	0.238	0.153	0.444	0.197	0.242	0.357	0.370	0.315	0.290
Phosphorus (P)-Total	mg/kg ww	2.0	4000	4700	3900	4610	5230	4430	3950	4150	5450
Potassium (K)-Total	mg/kg ww	4.0	2780	2710	2620	3090	3110	3240	3000	3190	3440
Rubidium (Rb)-Total	mg/kg ww	0.010	0.702	0.871	0.807	0.758	0.766	0.787	0.787	0.854	0.825
Selenium (Se)-Total	mg/kg ww	0.010	1.27	1.46	1.36	1.08	1.30	1.06	1.17	1.18	1.14
Sodium (Na)-Total	mg/kg ww	4.0	841	760	805	910	894	851	803	918	967
Strontium (Sr)-Total	mg/kg ww	0.010	5.88	7.73	5.79	8.89	6.70	5.11	7.01	6.64	8.81
Tellurium (Te)-Total	mg/kg ww	0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Thallium (Tl)-Total	mg/kg ww	0.00040	0.00545	0.00468	0.00490	0.00554	0.00441	0.00385	0.00483	0.00489	0.00535
Tin (Sn)-Total	mg/kg ww	0.020	0.095	0.061	0.069	0.063	0.063	0.055	0.074	0.047	0.056
Uranium (U)-Total	mg/kg ww	0.00040	0.00185	0.00114	0.00246	0.00148	0.00180	0.00249	0.00285	0.00231	0.00138
Vanadium (V)-Total	mg/kg ww	0.020	0.034	0.023	0.060	0.046	0.039	0.066	0.105	0.069	0.068
Zinc (Zn)-Total	mg/kg ww	0.10	26.9	20.8	20.8	21.3	20.2	22.0	19.6	24.5	20.7
Zirconium (Zr)-Total	mg/kg ww	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040

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**Appendix A7**

**Benthic Invertebrate Raw Data**

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**Table A7.1 Benthic Invertebrate Raw Data 2014**

Phylum	Class	Order	Family	Area Station Replicate Genus and/or species	CRR		CRR					BLC					BLC					GOC					BCT04						
					W01	W01	W01	W01	W01	W02	W02	W02	W02	W02	W01	W01	W01	W01	W01	W02	W02	W02	W02	W02	W01	W01	W01	W01	W01	W01	W01	W01	W01
					1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	3	4	5	
					1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	3	4	5	
Annelida	Clitellata	OLIGOCHAETA	ENCHYTRAEIDAE	ENCHYTRAEIDAE	12	26	22	10	102	0	0	4	38	11	3	3	1	0	0	0	0	6	1	0	0	0	0	0	0	0			
Annelida	Clitellata	OLIGOCHAETA	LUMBRICIDAE	LUMBRICIDAE (juveniles)	3	1	0	0	2	0	0	2	4	3	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
Annelida	Clitellata	OLIGOCHAETA	LUMBRICIDAE	<i>Eiseniella tetraedra</i>	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Annelida	Clitellata	OLIGOCHAETA	LUMBRICULIDAE	LUMBRICULIDAE	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				
Annelida	Clitellata	OLIGOCHAETA	LUMBRICULIDAE	<i>Rhynchelmis</i>	0	0	0	0	0	0	0	0	0	7	0	13	0	1	0	0	0	0	0	0	32	28	62	36	86	0	0		
Annelida	Clitellata	OLIGOCHAETA	NAIDIDAE	NAIDIDAE	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			
Annelida	Clitellata	OLIGOCHAETA	NAIDIDAE	<i>Nais spp.</i>	3	0	0	2	2	56	30	38	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Annelida	Clitellata	OLIGOCHAETA	TUBIFICIDAE	TUBIFICIDAE	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		
Annelida	Clitellata	OLIGOCHAETA	TUBIFICIDAE	Immature With Hairs	0	0	0	0	0	2	0	8	0	3	2	1	0	0	0	11	4	2	0	0	0	0	0	0	0	0	0		
Arthropoda	Arachnida	ACARINA	ATURIDAE	ATURIDAE	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		
Arthropoda	Arachnida	ACARINA	ATURIDAE	<i>Aturus</i>	0	0	4	2	2	2	0	2	2	3	0	2	1	1	0	0	1	12	2	2	0	0	0	0	0	0	0		
Arthropoda	Arachnida	ACARINA	HYDRYPHANTIDAE	HYDRYPHANTIDAE:	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		
Arthropoda	Arachnida	ACARINA	HYDRYPHANTIDAE	<i>Protzia</i>	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	Arachnida	ACARINA	HYDRYPHANTIDAE	<i>Wandesia</i>	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	1	0		
Arthropoda	Arachnida	ACARINA	LEBERTIIDAE	LEBERTIIDAE:	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		
Arthropoda	Arachnida	ACARINA	LEBERTIIDAE	<i>Lebertia</i>	4	1	4	0	0	5	6	12	0	6	0	6	8	9	4	0	0	0	0	0	6	0	2	4	2	0	0		
Arthropoda	Arachnida	ACARINA	PIONIDAE	PIONIDAE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0		
Arthropoda	Arachnida	ACARINA	TORRENTICOLIDAE	TORRENTICOLIDAE	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		
Arthropoda	Arachnida	ACARINA	TORRENTICOLIDAE	<i>Testudacarus</i>	0	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	COLEOPTERA	DYTISCIDAE	DYTISCIDAE	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		
Arthropoda	INSECTA	COLEOPTERA	DYTISCIDAE	<i>Liodessus</i>	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	COLEOPTERA	ELMIDAE	ELMIDAE	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		
Arthropoda	INSECTA	COLEOPTERA	ELMIDAE	<i>Narpus concolor</i>	0	0	0	0	0	0	0	4	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	COLEOPTERA	ELMIDAE	<i>Optioservus</i>	5	5	8	6	6	19	54	58	18	66	21	18	45	15	21	22	49	24	22	30	6	0	6	14	15	62	66	31	
Arthropoda	INSECTA	COLLEMBOLA	SMINTHURIDAE	COLLEMBOLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	COLLEMBOLA	SMINTHURIDAE	SMINTHURIDAE	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		
Arthropoda	INSECTA	COLLEMBOLA	SMINTHURIDAE	<i>Sminthurides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CERATOPOGONIDAE	CERATOPOGONIDAE	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		
Arthropoda	INSECTA	DIPTERA	CERATOPOGONIDAE	<i>Bezzia/Palpomya</i>	0	0	0	0	0	0	0	0	0	0	4	2	0	1	4	0	0	0	2	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	CHIRONOMIDAE:CHIRONOMINAE	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		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	<i>Microtendipes</i>	0	0	0	0	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	<i>Micropsectra</i>	0	0	0	0	2	6	20	34	2	18	4	6	6	4	3	0	39	6	8	24	2	1	2	2	6	4	1	3	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	<i>Polypedilum</i>	19	97	122	76	136	3	22	20	40	8	46	31	46	7	0	0	10	0	0	2	4	0	2	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	<i>Rheotanytarsus</i>	4	0	14	0	34	19	58	64	4	26	9	9	16	6	0	6	130	18	4	94	2	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	<i>Stempellina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16	0	0	10	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:CHIRONOMINAE	<i>Sublettea/Tanytarsus</i>	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:DIAMESINAE	CHIRONOMIDAE:DIAMESINAE	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		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:DIAMESINAE	<i>Diamesa</i>	0	9	6	24	4	161	96	88	52	413	7	11	5	2	1	0	0	0	2	0	24	4	12	38	1	0	3	1	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:DIAMESINAE	<i>Pagastia</i>	0	0	0	0	0	0	2	2	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:DIAMESINAE	<i>Potthastia longimana</i>	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIROOMIDAE:ORTHOCLADIINAE	CHIROOMIDAE:ORTHOCLADIINAE	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	
Arthropoda	INSECTA	DIPTERA	CHIROOMIDAE:ORTHOCLADIINAE	<i>Corynoneura</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	1	2	0	0	0	8	0	0	0	1		
Arthropoda	INSECTA	DIPTERA	CHIROOMIDAE:ORTHOCLADIINAE	<i>Cricotopus</i>	0	0	0	0	0	114	96	220	16	281	5	12	28	32	16	1	0	6	4	4	20	4	0	8	0	8	7	4	
Arthropoda	INSECTA	DIPTERA	CHIROOMIDAE:ORTHOCLADIINAE	<i>Eukiefferiella</i>	18	19	28	68	54	9	20	54	60	211	4	0	0	0	0	0	0	0	0	0	0	0	0	0	16	12	10		
Arthropoda	INSECTA	DIPTERA	CHIROOMIDAE:ORTHOCLADIINAE	<i>Heterotrissocladus</i>	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIROOMIDAE:ORTHOCLADIINAE	<i>Paraphaenocladus</i>	2	4	6</																										

Table A7.1 (Cont'd.)

Phylum	Class	Order	Family	Area Station Replicate Genus and/or species	CRR		CRR				BLC				BLC				GOC					BCT04										
					W01	W01	W01	W01	W01	W02	W02	W02	W02	W02	W01	W01	W01	W01	W01	W02	W02	W02	W02	W02	W01	W01	W01	W01	W01	W01	W01			
					1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	3	4	5		
					1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	3	4	5		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	CHIRONOMIDAE:PRODONOMINAE:	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					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Boreochlus</i>	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	34	0	0	0	0	0	0	0					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	CHIRONOMIDAE:TANYPODINAE:	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					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Ablabesmyia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	2	0	4	0	0	0	0	0	0					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Conchapelopia/Helopelopia</i>	1	1	6	4	0	3	4	10	0	0	7	7	22	10	6	1	0	0	0	0	0	0	0	0	0					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	DOLICHOPODIDAE:	0	11	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	EMPIDIDAE:	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					
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Chelifera/Metachela</i>	0	0	0	0	0	0	0	0	0	0	3	1	3	3	4	0	0	0	0	0	6	0	2	0	1	0	1	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Hemerodromia</i>	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Oreogeton</i>	0	0	0	4	4	8	6	14	0	5	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	PELECORHYNCHIDAE:	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	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Glutops</i>	0	3	0	0	2	0	0	0	0	0	2	1	1	1	0	0	0	0	0	2	0	4	8	1	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	PSYCHODIDAE:	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	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Pericoma</i>	0	0	0	0	0	0	2	0	0	0	2	4	7	2	2	1	29	12	18	10	16	7	14	16	8	0	0	1	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	SIMULIIDAE:	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	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Simulium</i>	0	1	2	6	0	0	0	0	8	2	6	2	0	0	0	0	0	0	2	1	4	0	1	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	TIPULIDAE:	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	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Antocha</i>	0	1	22	10	10	46	38	66	20	58	5	1	4	2	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Dicranota</i>	1	2	0	0	0	0	0	0	0	1	1	0	0	1	0	1	8	2	1	4	0	0	2	0	0	2	0	1	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Hexatoma</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Pseudolimnophila</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	DIPTERA	CHIRONOMIDAE:PRODONOMINAE	<i>Tipula</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	EPHEMEROPTERA	AMELETIDAE	AMELETIDAE	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	
Arthropoda	INSECTA	EPHEMEROPTERA	AMELETIDAE	<i>Ameletus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	3	2	2	0	0	8	0	0	0	5	0		
Arthropoda	INSECTA	EPHEMEROPTERA	BAETIDAE	BAETIDAE:(early instars)	196	246	422	340	366	296	678	384	868	183	285	139	153	54	13	54	119	48	77	90	78	24	18	104	24	36	53	38		
Arthropoda	INSECTA	EPHEMEROPTERA	BAETIDAE	<i>Acentrella</i>	1	0	2	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	EPHEMEROPTERA	BAETIDAE	<i>Baetis</i>	2	2	2	2	2	3	4	6	10	4	3	2	5	0	0	1	0	0	0	4	1	0	0	3	0	0	0	0		
Arthropoda	INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	EPHEMERELLIDAE:(early instars)	6	4	12	6	14	14	22	30	30	29	7	37	14	1	3	6	0	0	0	50	28	50	80	38	36	48	33	0		
Arthropoda	INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	<i>Caudatella</i>	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	8	0	0	0	0	0		
Arthropoda	INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	<i>Drunella doddsi</i>	3	2	2	2	2	0	0	0	10	1	1	2	1	0	0	0	0	0	0	2	13	18	20	10	0	0	0	0		
Arthropoda	INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	<i>Drunella grandis ingens</i>	0	0	2	2	0	2	0	0	4	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	<i>Ephemerella</i>	0	1	0	2	2	0	0	0	2	0	0	0	9	4	3	9	32	6	10	18	0	0	0	0	0	0	8	1	0	
Arthropoda	INSECTA	EPHEMEROPTERA	EPHEMERELLIDAE	<i>Seratella</i>	0	0	0	0	0	8	14	66	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthropoda	INSECTA	EPHEMEROPTERA	HEPTAGENIIDAE	HEPTAGENIIDAE:(early instars)	24	17	8	46	48	15	24	42	8	5	86	46	79	15	9	7	1	2	12	0	26	0	0	0	0	6	35	33	0	
Arthropoda	INSECTA	EPHEMEROPTERA	HEPTAGENIIDAE	<i>Epeorus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	8	0	8	0	0	0	0		
Arthropoda	INSECTA	EPHEMEROPTERA	HEPTAGENIIDAE	<i>Heptagenia</i>	0	0	0	0	0	1	0	2	8	0	3	19	14	2	2	2	25	0	14	52	32	46	90	202	88	14	13	22	0	
Arthropoda	INSECTA	EPHEMEROPTERA	HEPTAGENIIDAE	<i>Rhithrogenia</i>	13	1	0	18	2	1	2	0	6	2	18	1	0	0	0	1	0	1	0	12	17	58	56	40	0	1	0	0	0	
Arthropoda	INSECTA	EPHEMEROPTERA	LEPTOPHLEBIIDAE	LEPTOPHLEBIIDAE:(early instars)	0	0	0	2	2	1	2	2	0	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	EPHEMEROPTERA	LEPTOPHLEBIIDAE	<i>Paraleptophlebia</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	9	80	4	17	62	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	PLECOPTERA	CAPNIIDAE	CAPNIIDAE:(early instars)	6	7	2	0	4	0	0	2	2	2	45	20	3	8	29	38	32	44	14	2	2	2	2	4	32	79	46	0	0	
Arthropoda	INSECTA	PLECOPTERA	CAPNIIDAE	<i>Isocapnia</i>	0	0	0	0	0	2	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	PLECOPTERA	CHLOROPERLIDAE	CHLOROPERLIDAE:(early instars)	5	3	2	2	6	0	0	12	0	0	4	4	0	5	3	14	59	88	53	68	16	10	22	10	39	10	61	20	0	
Arthropoda	INSECTA	PLECOPTERA	CHLOROPERLIDAE	<i>Alloperla</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	4	20	12	7	4	2	19	24	24	8	8	22	8	0	
Arthropoda	INSECTA	PLECOPTERA	CHLOROPERLIDAE	<i>Hastaperla bevis</i>	10	9	2	8	0	1	26	44	32	13	18	32	70	0	2	0	7	0	1	0	0	0	0	0	0	0	1	0	0	
Arthropoda	INSECTA	PLECOPTERA	LEUCTRIDAE	LEUCTRIDAE:(early instars)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	4	0	1	0	0	0	0	0	0	0	0	0	
Arthropoda	INSECTA	PLECOPTERA	LEUCTRIDAE	<i>Paraleuctra</i>	6	6	0	0	2	0	0	4	8	1	13	8	5	1	5	0	1	20	0	0	0	2	10	4	16	0	5	7	0	
Arthropoda	INSECTA	PLECOPTERA	NEMOURIDAE	NEMOURIDAE:(early instars)	17	0	24	26	38	5	10	4	6	1	161	277	325	124	25	3	1	8	25	2	114	64	10	196	43	20	33	15	0	
Arthropoda	INSECTA	PLECOPTERA	NEMOURIDAE	<i>Malenka</i>	9	0	4	14	10	1	0	0	12	7	49	48	55	0	0	0	9	28	24	2	10	5	0	8	2	0	0	0	0	

Table A7.1 (Cont'd.)

Phylum	Class	Order	Family	Area Station Replicate Genus and/or species	CRR					CRR					BLC					BLC					GOC					BCT04				
					W01	W01	W01	W01	W01	W02	W02	W02	W02	W02	W01	W01	W01	W01	W01	W02	W02	W02	W02	W02	W01	W01	W01	W01	W01	W01	W01	W01	W01	W01
					1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
					1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Arthropoda	INSECTA	PLECOPTERA	NEMOURIDAE	<i>Zapada haysi</i>	0	0	0	0	0	2	0	0	2	5	0	0	0	0	0	1	1	0	0	4	18	18	6	30	5	0	5	6		
Arthropoda	INSECTA	PLECOPTERA	PELTOPERLIDAE	PELTOPERLIDAE	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		
Arthropoda	INSECTA	PLECOPTERA	PELTOPERLIDAE	<i>Yoraperla</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	14	8	8	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	PLECOPTERA	PERLIDAE	PERLIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0		
Arthropoda	INSECTA	PLECOPTERA	PERLIDAE	<i>Acroneuria abnormis</i>	0	0	0	0	0	0	0	0	0	0	1	3	17	1	0	0	1	8	2	0	0	1	0	6	1	0	7	0		
Arthropoda	INSECTA	PLECOPTERA	PERLIDAE	<i>Calineuria californica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		
Arthropoda	INSECTA	PLECOPTERA	PERLIDAE	<i>Hesperoperla pacifica</i>	0	0	2	4	10	6	28	22	12	30	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	PLECOPTERA	PERLODIDAE	PERLODIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	18	0	0	2	2		
Arthropoda	INSECTA	PLECOPTERA	PERLODIDAE	<i>Isoperla</i>	5	3	8	10	6	5	8	6	14	14	7	10	25	1	2	2	7	0	3	14	4	1	2	0	0	2	0	0		
Arthropoda	INSECTA	PLECOPTERA	PERLODIDAE	<i>Megarcys</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	6	0	2	3	0		
Arthropoda	INSECTA	PLECOPTERA	TAENIOPTERYGIDAE	TAENIOPTERYGIDAE	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		
Arthropoda	INSECTA	PLECOPTERA	TAENIOPTERYGIDAE	<i>Taenionema</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	28	98	12	97	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	BRACHYCENTRIDAE	<i>Brachycentrus</i>	7	1	16	16	2	3	10	6	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	BRACHYCENTRIDAE	<i>Micrasema</i>	1	13	4	8	2	32	14	52	8	22	6	31	46	24	7	0	0	0	0	0	0	0	0	2	0	4	1	6		
Arthropoda	INSECTA	TRICHOPTERA	GLOSSOSOMATIDAE	GLOSSOSOMATIDAE	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		
Arthropoda	INSECTA	TRICHOPTERA	GLOSSOSOMATIDAE	<i>Glossosoma</i>	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	3		
Arthropoda	INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	HYDROPSYCHIDAE	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		
Arthropoda	INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	<i>Arctopsyche grandis</i>	17	5	32	66	30	0	2	4	138	5	38	7	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	<i>Hydropsyche</i>	7	2	8	4	6	1	0	0	20	2	14	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	HYDROPSYCHIDAE	<i>Parapsyche elsis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	14	5	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	HYDROPTILIDAE	HYDROPTILIDAE	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		
Arthropoda	INSECTA	TRICHOPTERA	HYDROPTILIDAE	<i>Hydroptila</i>	0	0	0	0	0	6	2	12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMATIDAE	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		
Arthropoda	INSECTA	TRICHOPTERA	LEPIDOSTOMATIDAE	<i>Lepidostoma</i>	13	11	24	6	4	13	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0		
Arthropoda	INSECTA	TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILIDAE	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		
Arthropoda	INSECTA	TRICHOPTERA	RHYACOPHILIDAE	<i>Rhyacophila</i>	8	8	18	12	6	7	0	4	6	9	3	3	2	0	1	3	5	4	3	2	10	7	6	12	6	10	10	7		
Arthropoda	INSECTA	TRICHOPTERA	UEONIDAE	UEONIDAE	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		
Arthropoda	INSECTA	TRICHOPTERA	UEONIDAE	<i>Neothremma</i>	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		
NEMATODA	-	NEMATODA	-	<b>NEMATODA</b>	0	1	4	2	4	0	10	12	20	5	1	1	3	0	1	0	1	4	1	4	4	2	0	22	1	0	1	0		
PLATYHELMINTHES	-	-	-	<b>PLATYHELMINTHES</b>	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		
PLATYHELMITURBELLAN	THES	TRICLADIDA	PLANARIIDAE	PLANARIIDAE	1	3	0	0	0	1	0	2	10	3	0	0	1	0	0	17	9	8	22	12	36	36	26	44	22	2	2	1		
TOTAL TAXA					33	37	34	37	38	41	37	44	41	46	47	38	36	31	31	32	37	30	36	31	36	32	30	37	34	21	31	27		
TOTAL NUMBERS					430	530	846	828	950	887	1326	1432	1526	1481	925	810	1064	338	159	221	741	434	404	562	564	401	568	1066	598	286	493	307		