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Appendix 5.1.2.1C: Baseline Tatelkuz Lake Levels (Knight Piésold Ltd.)

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Appendix 5.1.2.3A: 2012 Site Investigation Report (Knight Piésold Ltd.)

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Appendix 5.1.2.6E: Blackwater Gold Project Effects Assessment of Davidson Creek Flow Augmentation on Homing of Salmonid Fish (AMEC E&I)

5.1.2 Aquatic Environment

This section provides a description of the baseline condition of the proposed Blackwater Gold Project (the Project) for the Aquatic Environment, which includes:

- Hydrology (**Section 5.1.2.1**);
- Surface Water and Sediment Quality (**Section 5.1.2.2**);
- Hydrogeology (**Section 5.1.2.3**);
- Groundwater Quality (**Section 5.1.2.4**);
- Wetlands (**Section 5.1.2.5**); and
- Fish and fish habitat (**Section 5.1.2.6**).

5.1.2.1 Hydrology

5.1.2.1.1 Introduction

The Project is located approximately 112 km southwest of Vanderhoof in central British Columbia (BC). The Project is located on the Nechako Plateau in the Nechako River watershed, which is part of the Fraser River drainage. This is an area of gently undulating highlands dissected by glacial and nival meltwater channels. The elevation of the study area ranges from approximately 1,000 (m) above sea level (masl) in the valley to 1,700 (m) on Mount Davidson. The deposit is located on the north slope of Mount Davidson, in the Davidson Creek Watershed (Knight Piésold Ltd. (Knight Piésold), 2013b).

The parameters presented in the hydrology baseline summary were used to assess monthly/annual flows, peak flows, low flows and lake levels under the Surface Water Flow Valued Component (VC) within Project watersheds for each phase of the Project (i.e., construction, operations, closure, and post-closure). The Surface Water Flow VC Local Study Area (LSA) and Regional Study Area (RSA) for the Project are presented in **Figure 5.1.2.1-1** and described in **Table 4.3-1** in **Section 4**. The LSA includes the following watersheds: Turtle Creek, Davidson Creek, Creek 661, Creek 705, and lower Chedakuz Creek (which contains Tatelkuz Lake) which are presented in **Figure 5.1.2.1-2**. These watersheds are either within or adjacent to the Project mine surface footprint (**Figure 5.1.2.1-3**). Hence, the Project has the potential to affect surface water flow in these watersheds and Tatelkuz Lake levels during construction, operation, closure, and post-closure. All Project mining components are on the surface and most of them are located in the Davidson Creek and Creek 661 watersheds. Drainage in the extreme upper extents of the Davidson Creek Watershed will be permanently directed to the Creek 705 Watershed. Water from Tatelkuz Lake in the Chedakuz Creek Watershed will be used to supplement mining operations, to provide Instream Flow Needs (IFN) in Davidson Creek, and to aid in the filling of the pit during closure.

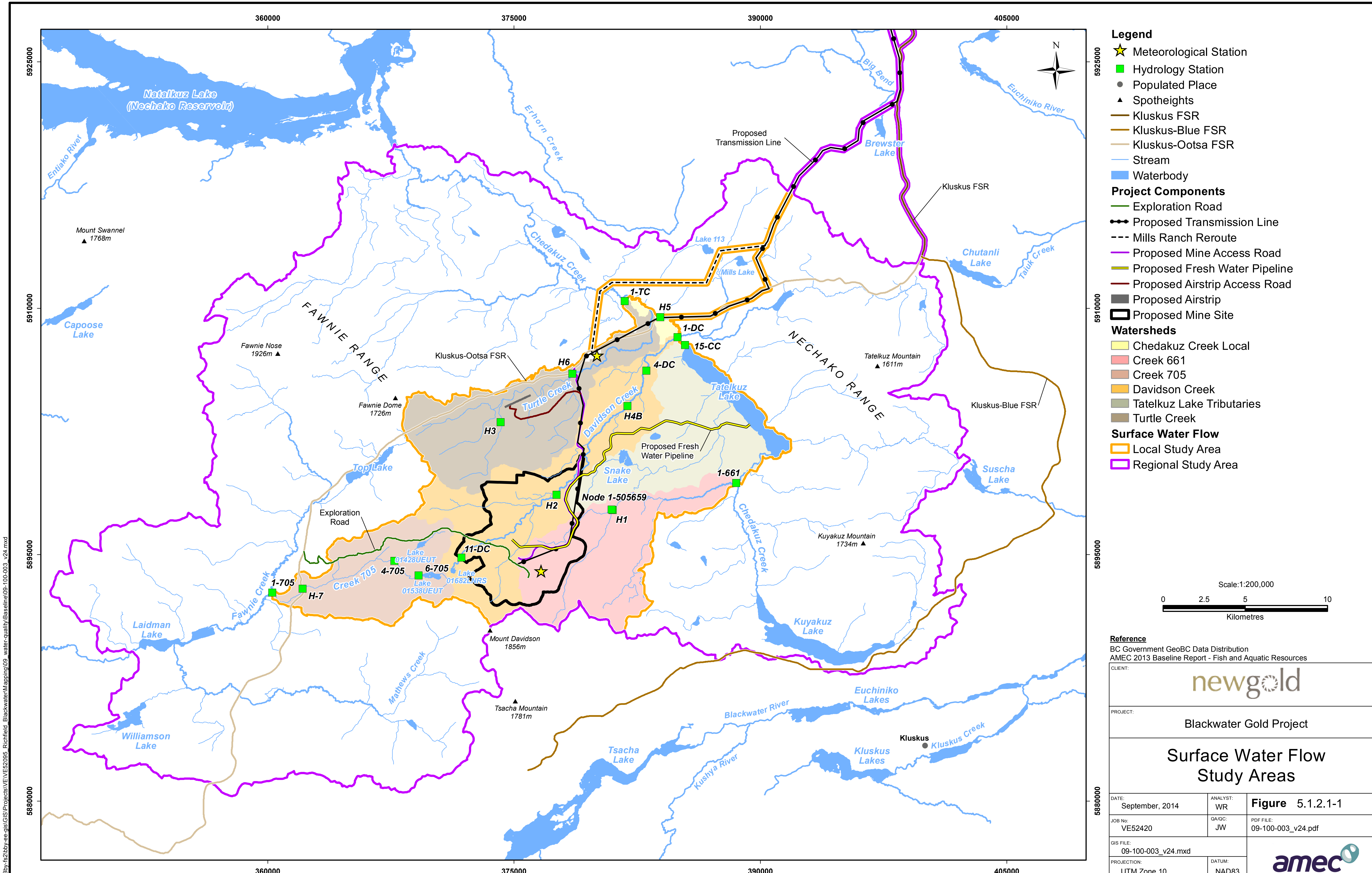
The Turtle Creek Watershed is a sub-watershed of the Chedakuz Creek Watershed. Turtle Creek drains into Chedakuz Creek, which then drains into Nechako Reservoir. The Turtle Creek Watershed is located north of the Project. No mining facilities are located within this watershed.

Nevertheless, the airstrip and limited portions of the proposed mine access road and transmission line will be located within the Turtle Creek Watershed. The mainstem of Turtle Creek has been identified as a key environmental location, given both the presence of rainbow trout and its contribution to Chedakuz Creek flows.

The Davidson Creek Watershed is a sub-watershed of the Chedakuz Creek Watershed. Davidson Creek drains into Chedakuz Creek, which then drains into Nechako Reservoir. The Davidson Creek Watershed contains most of the Project facilities, including the Tailings Storage Facility (TSF); open pit; waste rock dumps; low grade stockpile; supporting mine infrastructure; and other mine site water management features. Runoff from the extreme upper extents of the Davidson Creek Watershed will be permanently diverted to the Creek 705 Watershed due to the proposed TSF. Portions of the proposed mine access road and transmission line will be located within the Davidson Creek Watershed. The majority of Davidson Creek has been identified as a key environmental location, given the presence of kokanee (downstream of the Project) and rainbow trout and its contribution to Chedakuz Creek flows.

The Creek 661 Watershed is a sub-watershed of the Chedakuz Creek Watershed. Creek 661 drains into Chedakuz Creek, which then drains into Tatelkuz Lake. The majority of the Creek 661 Watershed is located east of the Project. Nevertheless, one of the Creek 661 tributaries is within the footprint of the mining facilities, including a portion of the open pit, the east dump, and both the construction and operations camps. Portions of the proposed mine access road and transmission line will be located within the Creek 661 Watershed. The majority of Creek 661 has been identified as a key environmental location, given both the presence of kokanee (downstream of the Project) and rainbow trout, and its contribution to Chedakuz Creek flows.

The Creek 705 Watershed is a sub-watershed of the Fawnie Creek Watershed. Creek 705 drains into Fawnie Creek, which eventually drains into the Nechako Reservoir via the Entiako River. The Creek 705 Watershed is located west of the Project mining facilities, and no mining facilities are located within this watershed. Nevertheless, a portion of the headwaters of the Davidson Creek Watershed will be permanently diverted to the Creek 705 Watershed, due to the proposed TSF within the Davidson Creek watershed. The majority of Creek 705 has been identified as a key environmental location, given both the presence of rainbow trout and its contribution to Fawnie Creek flows. In addition, two current surface water licenses (one is a drinking water source, and the other is a point of water diversion) are located on Matthews Creek, a tributary of Fawnie Creek.


Legend
Meteorological Station
Hydrology Station
Populated Place
Spotheights
Kluskus FSR
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Project Components
Exploration Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Surface Water Flow
Local Study Area
Regional Study Area
360000
375000
390000
405000
5925000
5910000
5895000
5880000
Natalkuz Lake
(Nechako Reservoir)
Entiako River
Erhorn Creek
Chedakuz Creek
Big Bend
Euchiniko River
Brewster Lake
Proposed Transmission Line
Kluskus FSR
Lake 113
Mills Lake
Chutanli Lake
Taiuk Creek
Mount Swannel 1768m
FAWNIE RANGE
NECHAKO RANGE
Capoose Lake
Fawnie Nose 1926m
Kluskus-Ootsa FSR
1-TC
H5
1-DC
15-CC
H6
4-DC
Tatelkuz Lake
Tatelkuz Mountain 1611m
Kluskus-Blue FSR
Fawnie Dome 1726m
Turtle Creek
Davidson Creek
H4B
H3
Proposed Fresh Water Pipeline
Top Lake
Snake Lake
1-661
Suscha Lake
Node 1-505659
H2
H1
Exploration Road
11-DC
Lake 01428UEUT
4-705
6-705
Lake 01682LNRS
Lake 01538UEUT
Creek 705
1-705
H-7
Fawnie Creek
Kuyakuz Mountain 1734m
Laidman Lake
Mount Davidson 1856m
Kuyakuz Lake
Mathews Creek
Tsacha Mountain 1781m
Euchiniko Lakes
Blackwater River
Williamson Lake
Tsacha Lake
Kushya River
Kluskus Lakes
Kluskus
Kluskus Creek
Scale:1:200,000
0 2.5 5 10
Kilometres
Reference
BC Government GeoBC Data Distribution
AMEC 2013 Baseline Report - Fish and Aquatic Resources
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Surface Water Flow
Study Areas
DATE: September, 2014
ANALYST: WR
Figure 5.1.2.1-1
JOB No: VE52420
QA/QC: JW
PDF FILE: 09-100-003_v24.pdf
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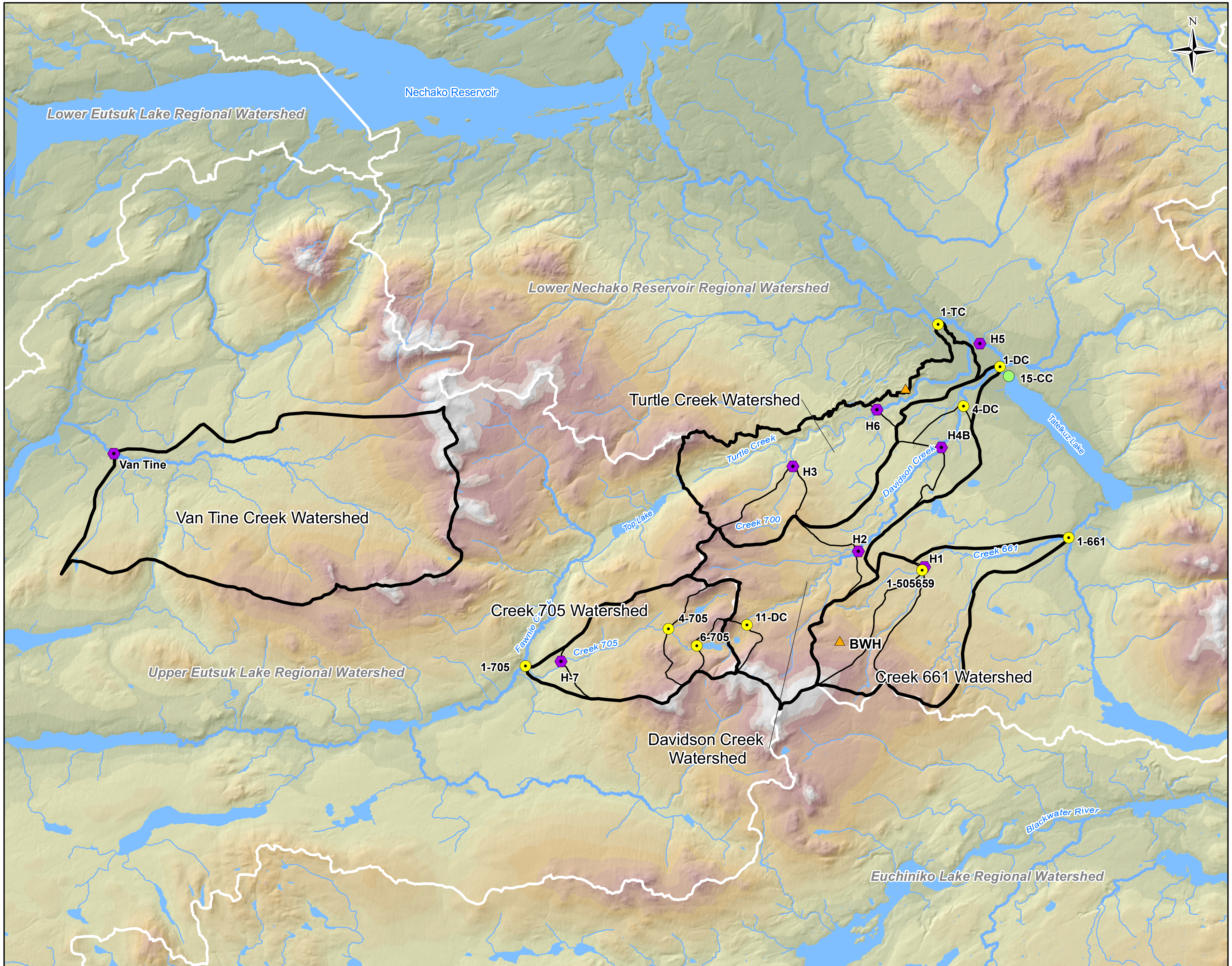
PROJECTION: UTM Zone 10
DATUM: NAD83
amec



Legend

- Climatology Station
- Hydrology Station/Watershed Model Node
- Node Not Included in Watershed Model
- Watershed Model Node
- River
- Lake
- Watershed Boundaries
- Sub-Watersheds (Used for Knight Piesold Watershed modeling)

ELEVATION BAND (M)

- < 915
- 915-1220
- 1220-1525
- 1525-1830
- > 1830

KEY MAP

0 2.5 5 10
Kilometres
Scale:1:200,000

Reference
Basemap: GeoBase DEM; Streams; Freshwater Atlas GeoBC; Hydrology stations and sub-watershed data from Knight Piésold 2013 Engineering Hydrometeorology Report (VA101-457/6-12, Revision 0) dated 04 November 2013 (Appendix 5.1.2.1B).

CLIENT: newgold

PROJECT: Blackwater Gold Project

Baseline Watershed Model Discretization

DATE: February, 2014	ANALYST: MY	Figure 5.1.2.1-2
JOB No: VE52277	QA/QC: AP	PDF FILE: 08-100-010_hydrometrix_monitoring_stations_v3.pdf
GIS FILE: 08-100-010_hydrometrix_monitoring_stations_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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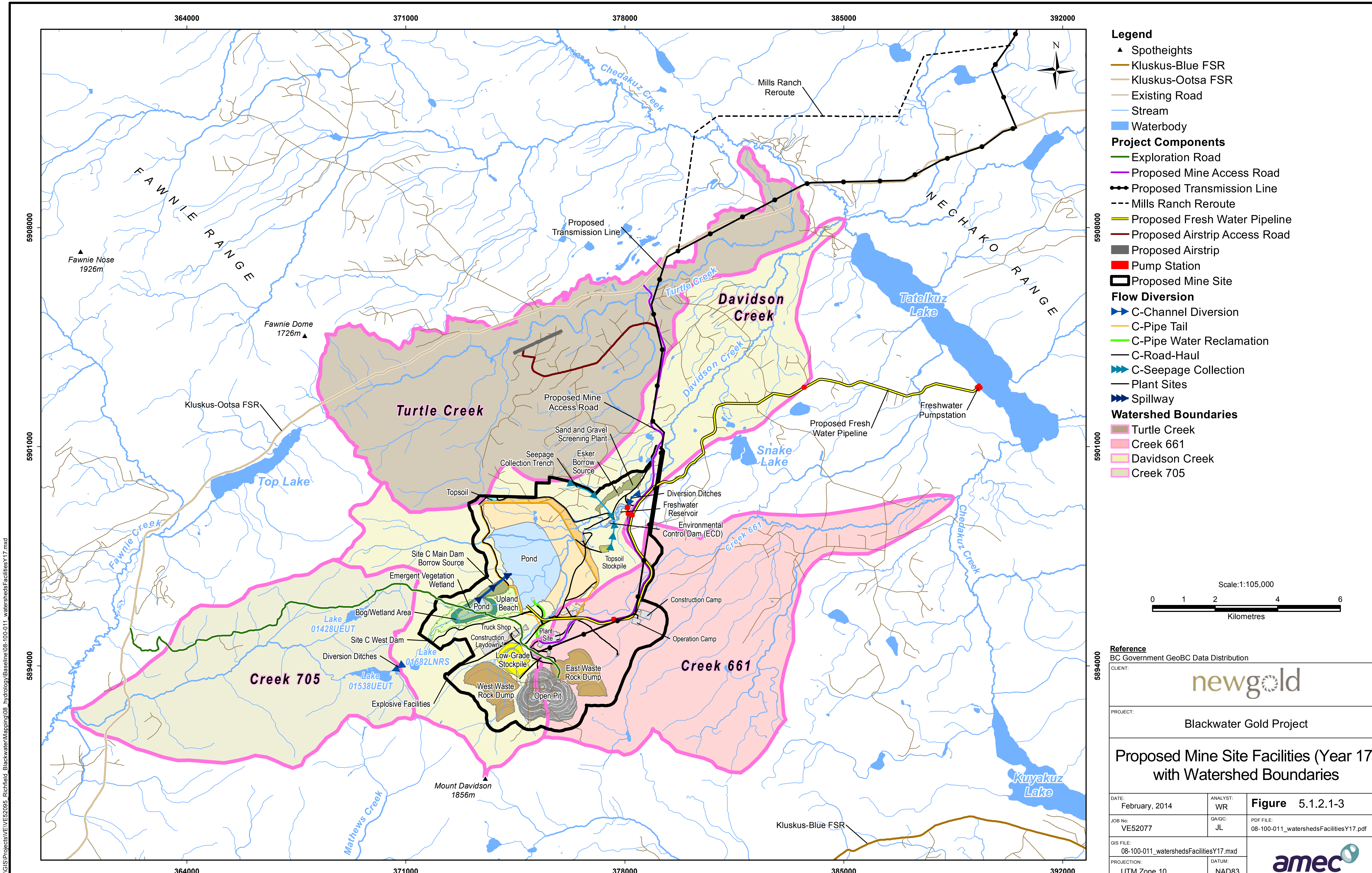

364000
371000
378000
385000
392000
5908000
5901000
5894000
Legend
Spotheights
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Existing Road
Stream
Waterbody
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Pump Station
Proposed Mine Site
Flow Diversion
C-Channel Diversion
C-Pipe Tail
C-Pipe Water Reclamation
C-Road-Haul
C-Seepage Collection
Plant Sites
Spillway
Watershed Boundaries
Turtle Creek
Creek 661
Davidson Creek
Creek 705
N
Scale:1:105,000
0 1 2 4 6
Kilometres
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Chedakuz Creek
Mills Ranch Reroute
Proposed Transmission Line
Turtle Creek
Davidson Creek
Tatelkuz Lake
Kluskus-Ootsa FSR
Proposed Mine Access Road
Sand and Gravel Screening Plant
Seepage Collection Trench
Esker Borrow Source
Topsoil
Diversion Ditches
Freshwater Reservoir
Environmental Control Dam (ECD)
Proposed Fresh Water Pipeline
Freshwater Pumpstation
Snake Lake
Top Lake
Fawnie Creek
Creek 661
Pond
Topsoil Stockpile
Site C Main Dam Borrow Source
Emergent Vegetation Wetland
Upland Beach
Bog/Wetland Area
Lake 01428UEUT
Truck Shop
Construction Laydown
Plant Site
Site C West Dam
Diversion Ditches
Lake 01682LNRS
Lake 01538UEUT
Low-Grade Stockpile
East Waste Rock Dump
West Waste Rock Dump
Open Pit
Explosive Facilities
Construction Camp
Operation Camp
Creek 705
Creek 661
Mathews Creek
Kuyakuz Lake
Kluskus-Blue FSR
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Proposed Mine Site Facilities (Year 17) with Watershed Boundaries
DATE: February, 2014
ANALYST: WR
Figure 5.1.2.1-3
JOB No: VE52077
QA/QC: JL
PDF FILE: 08-100-011_watershedsFacilitiesY17.pdf
GIS FILE: 08-100-011_watershedsFacilitiesY17.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
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The Chedakuz Creek Watershed contains the Turtle Creek, Davidson Creek, and Creek 661 Watersheds. Chedakuz Creek drains into Nechako Reservoir. The Chedakuz Creek Watershed encompasses both the Project and Tatelkuz Lake. Flows from the extreme upper extents of Davidson Creek will be cut off due to the construction of the TSF. Water from Tatelkuz Lake, in the Chedakuz Creek Watershed, will be used to supplement mining operations, to satisfy IFN in Davidson Creek, and to aid in the filling of the pit. The proposed mine access roads, transmission line, and airstrip will be located within the Chedakuz Creek Watershed. The mainstem of Chedakuz Creek, below Tatelkuz Lake, has been identified as a key environmental location, given the presence of kokanee (downstream of the Project) and rainbow trout.

In the spring of 2011, a field hydrology monitoring program was initiated for the proposed Project **Appendix 2.2A-2** in **Section 2.2** includes a detailed discussion of hydrometric stations used for the Project. The Application Information Requirements (AIR) indicates that 10 hydrometric stations would be used for rating curve development. The Application reports on H1 to H7; data collected from the Stations H8, H9 and H10 was not considered to characterize the baseline setting for the following reasons (Knight Piésold, pers. comm. 2015):

- H8 is located at the outlet of Top Lake in the headwaters of Fawnie Creek and the Project is not expected to impact Top Lake (Note: The station was installed in May 2012 and decommissioned April 2014);
- H9 is located at the outlet of the Three Lakes complex in lower Davidson Creek and data from this station was not required to characterize the catchment as Davidson Creek characteristics are based on H2 (and H4B) (Note: Installed May 2012 and decommissioned October 2013); and
- H10 is located in upper Davidson Creek and data from this station was not required to characterize the catchment because Davidson Creek characteristics are based on H2 (and H4B) (Note: Installed May 2012 and still active).

Hydrology data were collected seasonally and covered the period from the spring of 2011 through the winter of 2013 for the baseline. A climate-monitoring program was initiated for the Project with the installation of a climate station in July of 2011. A second climate station was installed in July of 2012. Available climate data were collected at these weather stations during 2011 and 2012 for the baseline (Knight Piésold, 2013a).

Section 5.1.2.1 summarizes the hydrology baseline for the Project; this includes surface water flow baseline information as well as the climate baseline information pertinent to the hydrology baseline. This section also summarizes Tatelkuz Lake level baseline information for the Project. Unless otherwise noted, all hydrology, climate and Tatelkuz Lake level baseline information was obtained from and provided by Knight Piésold. Detailed surface water flow, climate, and Tatelkuz Lake level baseline information from Knight Piésold is provided in **Appendix 5.1.1.1A**, **Appendix 5.1.2.1B,** and **Appendix 5.1.2.1C**.

This section only pertains to surface water flow, climate and Tatelkuz Lake level baseline information. Other sections under Aquatic Environment contain baseline information on surface water and sediment quality, fish and fish habitat, groundwater quantity and quality, and wetlands. The Project has the potential, with its water diversion, water management, and withdrawal activities to affect natural streams, drainage areas, and surface water flows (monthly and annual flows, peak flows, and low flows) within these watersheds and to affect Tatelkuz Lake levels during the construction, operations, closure, and post-closure phases. In addition, the alteration of surface water flows and Tatelkuz Lake levels has the potential to affect other Project VCs, such as surface water and sediment quality, fish and fish habitat, groundwater quantity and quality, and wetlands which are discussed under Aquatic Environment Effects Assessments including any applicable mitigation measures. Note that the Nechako Reservoir at the mouth of Chedakuz Creek is 42 km stream thalweg distance downstream from the proposed Project. No analysis of the entire watershed of Chedakuz Creek was conducted as no effects of the proposed Project are expected this distance downstream.

5.1.2.1.2 Methods

This section summarizes the information sources and methods for data analysis used to prepare the surface water flow, climate, and Tatelkuz Lake levels baseline data for the Project. Detailed baseline information sources, methods and data analysis for the Project are provided in **Appendix 5.1.1.1A, Appendix 5.1.2.1B**, and **Appendix 5.1.2.1C**.

5.1.2.1.2.1 Information Sources

5.1.2.1.2.1.1 Surface Water Flow

Hydrological data were collected within the Project area from the spring of 2011 through the winter of 2013. Data collection continued beyond 2013 for future work and permitting. **Figure 5.1.2.1-2** shows the location of the hydrometric stations. If necessary, hydrometric stations were removed during the winter months to avoid ice damage, although periodic winter flow measurements were obtained manually (Knight Piésold, 2013a). Data collection activities were undertaken according to the guidelines given in the Manual of British Columbia Hydrometric Standards (BC Ministry of the Environment (BC MOE), 2009). The hydrological program included the following:

- Establishing continuous water level recorders;
- Measuring stream discharges;
- Downloading continuous water level recorders and checking data at gauged streams;
- Establishing rating curves; and
- Determining the flow hydrographs.

Hydrological data were collected at the following seven hydrometric stations within the Project area:

- H1 (also Water Quality Node 5): Creek 661, a tributary of Chedakuz Creek, located at approximately the mid-point of the watershed;
- H2 (also Water Quality Node 10): Davidson Creek, a tributary of Chedakuz Creek, located in the upper extents of the Davidson Creek Watershed and immediately downstream of the proposed Project mine site;

- H3 (also Water Quality Node 11): Creek 700, a tributary of Turtle Creek;
- H4B (also Water Quality Node 26): Davidson Creek, a tributary of Chedakuz Creek, located in the lower extents of the Davidson Creek Watershed at a bridge crossing;
- H5 (also Water Quality Node 9): Chedakuz Creek, at a road crossing below its confluence with Davidson Creek and downstream of Tatelkuz Lake;
- H6: Turtle Creek, a tributary of Chedakuz Creek, located at a bridge crossing (Knight Piésold, 2012); and
- H7: Creek 705, a tributary of Fawnie Creek, located in the lower extents of the Creek 705 Watershed at the Kluskus-Ootsa Forest Service Road Bridge.

Table 5.1.2.1-1 summarizes the geographical information for the Project hydrometric stations.

Table 5.1.2.1-1: Project Hydrometric Stations

Station Name	Location	Drainage Area (km^2)	Elevation (m)	Start Year
H1	Creek 661	8.9	1,190	March 2011
H2	Davidson Creek	47.2	1,216	March 2011
H3	Creek 700	9.0	1,165	March 2011
H4B	Davidson Creek	61.0	1,053	November 2012
H5	Chedakuz Creek	593.0	934	March 2011
H6	Turtle Creek	55.0	1,029	March 2012
H7	Creek 705	41.0	1,128	April 2012

Source: Knight Piésold, 2013a (**Appendix 5.1.1.1A**)
Note: km^2 = square kilometre; m = metre

Regional hydrometric data are available from Water Survey of Canada (WSC). **Figure 5.1.2.1-4** shows the location of the hydrometric stations. **Table 5.1.2.1-2** includes a summary of regional hydrometric stations.

Table 5.1.2.1-2: Regional Hydrometric Stations

Station Name	ID#	Period of Record
Van Tine Creek near the Mouth	08JA014	1974-2006
Dean River below Tanswanket Creek	08FC003	1959-2012
Laventie Creek near the Mouth	08JA015	1976-2010
Whitesail Middle Creek near Tahtsa Reach	08JW029	1997-2010
North Beach Creek above Allin Creek	08JB013	1998-2010

Source: Knight Piésold, 2013a (**Appendix 5.1.1.1A**)

Site and regional climate and hydrometric data were used to estimate the following baseline flows for the Project:

- Average monthly and annual flows (referred to as mean monthly and annual flows in the AIR);
- Wet and dry monthly and annual flows for recurrence intervals of 5, 10, 20, and 50 years;
- Instantaneous peak flows for some hydrometric stations for recurrence intervals of 2, 5, 10, 20, 50, 100 and 200 years (referred to as peak flood events in the AIR; see **Section 2.2.3.4.6, Table 2.2.3-28** for discussion of rainfall storm/peak flood events); and
- Seven-day duration low flows for recurrence intervals of 10-year (7Q10, referred to as 10-year seven-day low flow in the AIR) and 20-year (7Q20).

The Knight Piésold 2013 Hydrometereology Report (**Appendix 5.1.1.1A)** provides summary statistics based on 40 years of simulated daily flows for baseline conditions at selected locations.

5.1.2.1.2.1.2 Climate

Climate data were collected at two weather stations on the Project site (**Figure 5.1.2.1-5**) during 2011 and 2012. The climate monitoring program was initiated for the Project in July 2011 with the installation of a climate station called Blackwater Low at an elevation of 1,050 masl. An additional station called Blackwater High was installed in July 2012 at an elevation of 1,470 masl (Knight Piésold, 2013a).

Regional climate data are available for weather stations operated in the area of the Project by Environment Canada (EC) or BC Forestry (**Figure 5.1.2.1-4**). **Table 5.1.2.1-3** includes a summary of regional weather stations.

Table 5.1.2.1-3: Regional Weather Stations

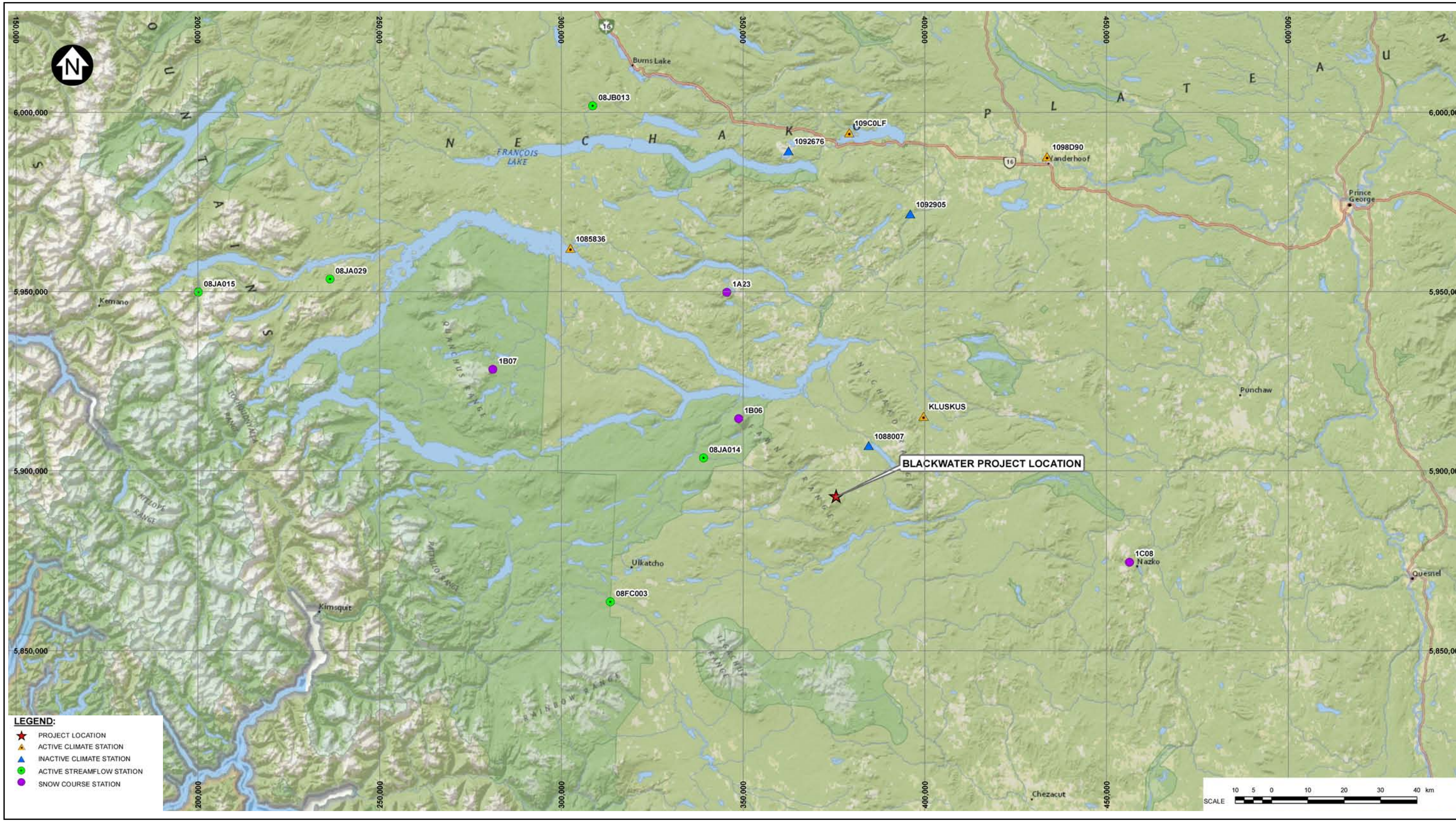
Station Name	ID#	Period of Record
Fraser Lake North Shore	109C0LF	1969–2007
Vanderhoof	1098D90	1980–2012
Tatelkuz Lake	1088007	1970–1977
Endako Mine	1092676	1973–1982
Fort Fraser 13S	1092905	1970–1993
Ootsa	1085835	1956–2012
Kluskus	n/a	1991–2012

Note: All stations are operated by Environment Canada except for Kluskus, which is operated by BC Forestry.
n/a = not applicable

Three snow course surveys were operated in 2012 near the Project (**Figure 5.1.2.1-5**). Regional snow course survey data are also available near the Project (**Figure 5.1.2.1-4**). These regional data were used in conjunction with site data to develop baseline climate estimates for precipitation, evapotranspiration, sublimation, and snowmelt for the Project.

5.1.2.1.2.1.3 Tatelkuz Lake Levels

A long-term synthetic discharge series was developed for Tatelkuz Lake by scaling available data from a nearby on-site hydrometric station (H5), which is located downstream of Tatelkuz Lake. A short period of record for lake levels in Tatelkuz Lake is available from the data collected by Avison Management Services and Knight Piésold from a water level logger. The datalogger was installed on 16 October 2012, removed on 10 December 2012 for the winter, and re-installed on 6 May 2013. AMEC carried out a bathymetric survey on Tatelkuz Lake (including cross-sections at the outlet) in the summer of 2013, which were used to relate the lake level changes to the area and volume of Tatelkuz Lake (Knight Piésold, 2013c).



Notes:
Figure from Knight Piésold 2013 Engineering Hydrometeorology Report (VA101-457/6-12, Revision 0) dated 04 November 2013 (Appendix 5.1.2.1B).

CLIENT:	newgold
	AMEC Environment & Infrastructure 4445 Lougheed, Suite 600, Burnaby, B.C., V5C 0E4 Tel. 604-294-3811 Fax 604-294-4664
DWN BY:	MY
CHK'D BY:	JK
DATUM:	N/A
PROJECTION:	N/A
SCALE:	N/A
PROJECT	Blackwater Gold Project
TITLE	Regional Streamflow and Climate Stations
DATE:	January 2014
PROJECT NO:	VE52277
REV. NO.:	A
FIGURE No.	5.1.2.1-4

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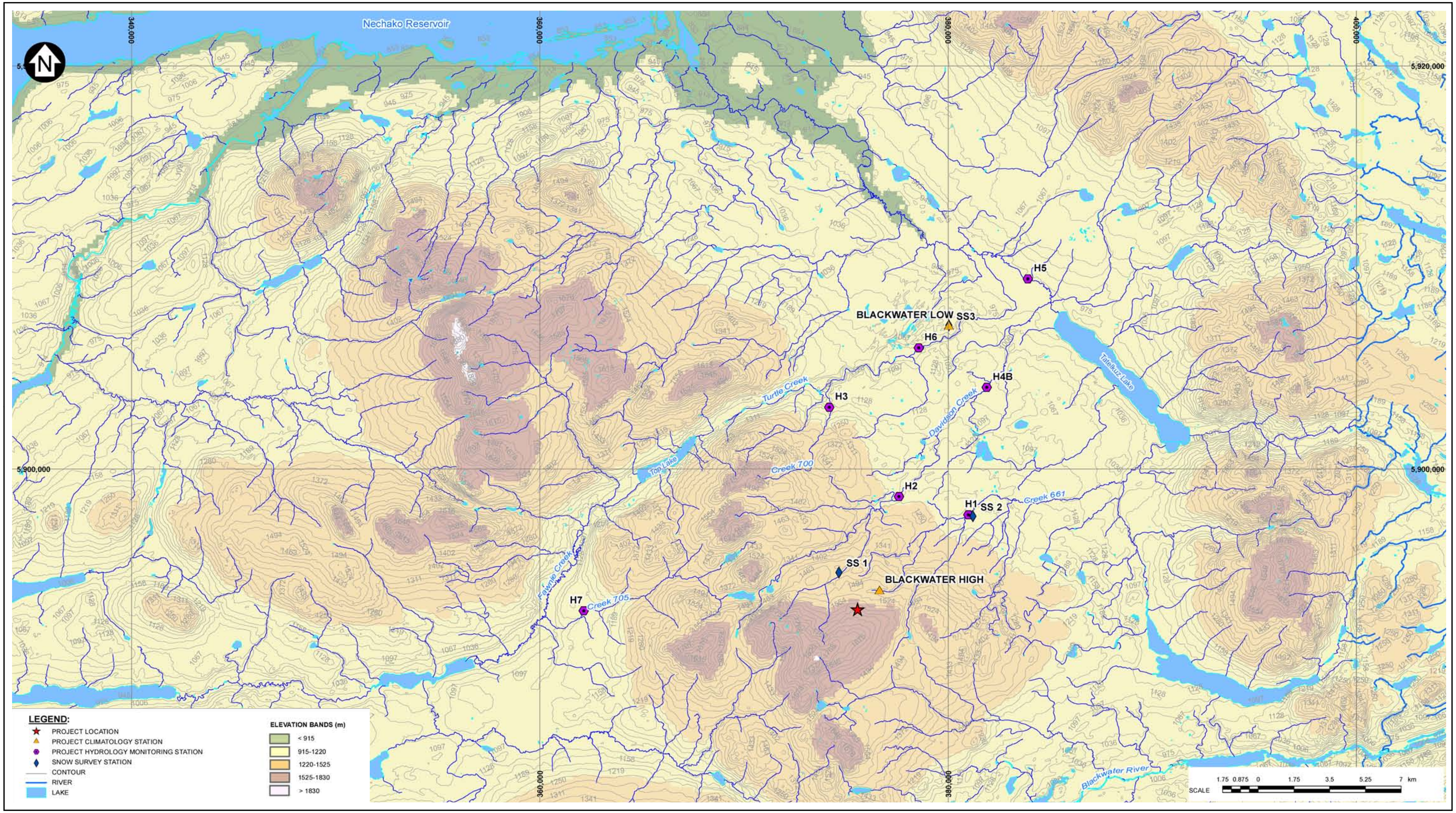

Notes:

Figure from Knight Piésold 2013 Engineering Hydrometeorology Report (VA101-457/6-12, Revision 0) dated 04 November 2013 (Appendix 5.1.2.1B).

CLIENT: newgold

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amec

DWN BY:	MY
CHK'D BY:	JK
DATUM:	N/A
PROJECTION:	N/A
SCALE:	N/A

PROJECT: Blackwater Gold Project

TITLE: Project Monitoring Stations

DATE:	January 2014
PROJECT NO:	VE52277
REV. NO.:	A
FIGURE No.	5.1.2.1-5

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5.1.2.1.2.2 Methods for Data Analysis

5.1.2.1.2.2.1 Surface Water Flow

Hydrological data were collected at seven hydrometric stations within the Project area as previously discussed in **Section 5.1.2.1.2.1.1**. The data were reviewed and preliminary rating curves and streamflow records were developed for all of these stations. The records for three of these stations (H1, H2, and H5) were used in the development of long-term synthetic flow series for the Project using concurrent data from WSC regional hydrometric station Dean River below Tanswanket Creek (ID# 08FC003). Frequency paired regression analyses and winter discharge analyses resulted in a 40-year synthetic daily flow series for H1, H2, and H5. These data were used to estimate long-term unit runoff for the Project (Knight Piésold, 2013b).

A spreadsheet watershed model with a monthly time step was developed to simulate the Project long-term baseline surface water flows, groundwater flows, and their interaction. The watershed model was used to estimate baseline average surface water flows within the Turtle Creek, Davidson Creek, Creek 661, and Creek 705 watersheds. The watershed model simulates flows for the period from 1984 to 2012. The first seven years of the modelling period had limited historical climate data and therefore used average monthly precipitation values to develop snowpack and establish storage within the groundwater and surface water reservoirs. Basic model parameters were calibrated using regional climate and streamflow data for the period of 1991 to 2012, and then site-specific calibration was completed using long-term synthesized site climate values and long-term synthesized flows for gauging stations H1 and H2. The Chedakuz Creek Watershed was not included in the spreadsheet watershed model. Instead, the long-term synthetic baseline stream flow series developed for Node H5 was prorated to Node 15-CC on the basis of drainage area (Knight Piésold, 2013b).

In addition to the Project hydrometric stations, various water quality monitoring nodes and locations of interest to fisheries were included in the watershed nodes within the watershed model. The following watershed model nodes (WMN) were deemed important to identifying the effects of the Project on surface water flows in the Turtle Creek, Davidson Creek, Creek 661, and Creek 705 watersheds (**Figure 5.1.2.1-2**):

- WMN H3 (also site hydrometric station H3 and Water Quality Node 11): Creek 700, a headwater tributary of Turtle Creek, located in the upper extents of the Turtle Creek Watershed;
- WMN H6 (also site hydrometric station H6): Turtle Creek, a tributary of Chedakuz Creek, located at the approximate mid-point of the Turtle Creek Watershed;
- WMN 1-TC (also Water Quality Node 26): Turtle Creek, a tributary of Chedakuz Creek, upstream of its confluence with Chedakuz Creek;
- WMN 11-DC: Headwaters of Davidson Creek, adjacent to the Project tailings storage facility (TSF) saddle dam and the limit of the Davidson Creek Watershed to be redirected to the Creek 705 Watershed by the Project;

- WMN H2 (also site hydrometric station H2 and Water Quality Node 10): Davidson Creek, a tributary of Chedakuz Creek, located in the upper extents of the Davidson Creek Watershed and immediately downstream of the Project mine site. This node was used for watershed model calibration (Knight Piésold, 2013b);
- WMN H4B (also site hydrometric station H4B and Water Quality Node 26): Davidson Creek, a tributary of Chedakuz Creek, located in the lower extents of the Davidson Creek Watershed at a bridge crossing;
- WMN 4-DC: Davidson Creek, a tributary of Chedakuz Creek, located at the approximate upper extents of Kokanee spawning;
- WMN 1-DC (also Water Quality Node 7): Davidson Creek, a tributary of Chedakuz Creek, upstream of its confluence with Chedakuz Creek;
- WMN H1 (also site hydrometric station H1 and Water Quality Node 5): Creek 661, a tributary of Chedakuz Creek, located at approximately the mid-point of the entire watershed. This node was used for watershed model calibration (Knight Piésold, 2013b);
- WMN 1-505659: A tributary of Creek 661, the drainage area to this node may be impacted by the Project mine site in the headwaters of the Creek 661 Watershed;
- WMN 1-661: Creek 661, a tributary of Chedakuz Creek, upstream of its confluence with Chedakuz Creek;
- WMN 6-705 (also Water Quality Node 16): Creek 705, a tributary of Fawnie Creek, downstream of Lake 01538UEUT;
- WMN 4-705: Creek 705, a tributary of Fawnie Creek, located downstream of all lakes in the upper extents of the Creek 705 Watershed;
- WMN H7 (also site hydrometric station H7): Creek 705, a tributary of Fawnie Creek, located in the lower extents of the Creek 705 Watershed at the Kluskus-Ootsa Forest Service Road bridge;
- WMN 1-705: Creek 705, a tributary of Fawnie Creek, upstream of its confluence with Fawnie Creek; and
- Van Tine: Regional WSC hydrometric station (ID# 08JA014) used for watershed model calibration (Knight Piésold, 2013b).

The following watershed nodes (WN) were deemed essential for identifying the effects of the Project on surface water flows in the Chedakuz Creek watershed but were not included in the spreadsheet watershed model as previously discussed (**Figure 5.1.2.1-2**):

- WMN 15-CC (also Water Quality Node 8): Chedakuz Creek, at the outlet of Tatelkuz Lake; and
- WMN H5 (also site hydrometric station H5 and Water Quality Node 9): Chedakuz Creek, at a road crossing below its confluence with Davidson Creek and downstream of Tatelkuz Lake.

The following hydrological events were determined using statistical methods external to the watershed model: 1:10 dry and wet years; 1:20 dry and wet years; 1:50 dry and wet years; and 7Q10 and 7Q20 low flows. Instantaneous peak flows were estimated for the Project using a combination of the Project and regional information (Knight Piésold, 2013b).

5.1.2.1.2.2.2 Climate

Using site and regional precipitation data, annual precipitation for the Project was estimated. Extreme 24-hour precipitation values for the Project were estimated using the Rainfall Frequency Atlas frequency factor approach. In addition, wet and dry year precipitation values were estimated based on a normally distributed probability of occurrence. No evaporation data were collected at the Project or at regional weather stations operated by EC near the Project. Therefore, annual potential and actual evapotranspiration values for the Project were estimated using common engineering practices. Due to limited snow course survey information for the Project, the snowmelt pattern for the Project was estimated using regional snow course survey data. Sublimation was estimated for the Project using values consistent with those reported in literature. Mean monthly temperature values were estimated based on a long-term synthetic monthly data series developed for the Project (Knight Piésold, 2013a).

5.1.2.1.2.2.3 Tatelkuz Lake Levels

Baseline outflows from Tatelkuz Lake were estimated by scaling a long-term synthetic discharge series based on drainage area from WN H5. These data, in conjunction with available lake level data, were used to estimate a relationship between discharge and lake levels. To fully understand the potential for changes in Tatelkuz Lake levels, annual estimated lake level fluctuations were related to the area and volume of the lake using the bathymetric survey (Knight Piésold, 2013c).

5.1.2.1.3 Results/Discussion

This section summarizes the surface water flow, climate, and Tatelkuz Lake levels baseline data for the Project. For more detailed baseline information refer to **Appendix 5.1.1.1A**, **Appendix 5.1.2.1B** and **Appendix 5.1.2.1C.**

5.1.2.1.3.1 Surface Water Flow

Regional data were used in conjunction with site data to estimate baseline hydrological parameters for the Project. Preliminary rating curves and streamflow records were developed for the seven Project hydrometric stations (Appendix A in **Appendix 5.1.1.1A**). The 40-year synthetic daily flow series estimated for Project hydrometric stations H1, H2, and H5 are summarized as monthly discharges in Table 3.4 and annual hydrographs on Figure 3.21 and Figure 3.22 (**Appendix 5.1.1.1A**). The long-term mean annual unit runoff for the Project area was estimated to be 6.1 litres per second per square kilometre (L/s/km^2), which equates to a watershed average runoff of 198 millimetres (mm). The effective annual runoff coefficient for the natural drainage areas in the Project was estimated to be 0.31 (Knight Piésold, 2013a).

Appendix 5.1.2.1A, Table 1, shows a summary of the baseline average and wet and dry monthly mean surface water flows estimated for the Project. **Appendix 5.1.1.1A, Appendix 5.1.2.1A** and **Appendix 5.1.2.1B** document detailed surface water flow baseline site and regional data for the Project. These surface water flows were used to assess the key hydrological parameters of monthly/annual flows, peak flows, and low flows within Project watersheds for each phase of the Project (i.e., construction, operations, closure, and post-closure).

Table 5.1.2.1-4 summarizes the instantaneous peak flows estimated for the Project hydrometric stations. These values were estimated using graphs by Obedkoff (1999) and ratios based on flood frequency analysis provided in **Appendix 5.1.1.1A**. Knight Piésold notes that using this method may considerably overestimate the instantaneous peak flows for the Project until more definitive site information is available (Knight Piésold, 2013a). From an engineering design standpoint, the estimated peak flows are deemed conservative.

Table 5.1.2.1-4: Estimated Instantaneous Peak Flows for the Project

Station Name	Area (km2)	Instantaneous Peak Flows (m3/s)						
		Return Period (Years)						
		2	5	10	20	50	100	200
Index Flood Frequency Factor		***0.47***	***0.76***	***1.00***	***1.26***	***1.65***	***1.99***	***2.40***
H1	8.9	1.2	1.9	2.5	3.1	4.1	4.9	5.9
H2	47.2	4	7	9	11	15	18	22
H3	9.0	1.2	1.9	2.5	3.2	4.2	5.0	6.0
H4B	61.0	5.4	8.8	11.6	14.6	19.1	23.1	27.8
H5	593	31	50	66	83	108	131	158
H6	55.0	5.0	8.2	10.7	13.5	17.7	21.3	25.7
H7	41.0	3.9	6.2	8.2	10.3	13.5	16.3	19.7

Source: Knight Piésold, 2013a (H1, H2, and H5 from Knight Piésold, **Appendix 5.1.1.1A**)
Remaining data estimated by AMEC.
Note: km^2 = square kilometre; m^3/s = cubic metres per second

Appendix 5.1.2.1A, Table 2, shows a summary of the baseline 7Q10 and 7Q20 low flows estimated for the Project.

5.1.2.1.3.2 Climate

Regional and site data were used to estimate baseline climate parameters for the Project. Only those climate parameters pertaining to surface water flow such as precipitation, evapotranspiration, sublimation, snowmelt, and temperature are summarized herein. **Appendix 5.1.1.1A** contains detailed climate baseline site and regional data for the Project from Knight Piésold. These climate parameters were used for watershed and water balance models and hydrological design criteria for the Project.

Mean annual precipitation of 636 mm was estimated for the Project. Based on regional precipitation distribution patterns, it is expected that the Project area would experience consistent precipitation throughout the year with April being the driest month and November, December, and

January being the wettest months (Knight Piésold, 2013a). **Table 5.1.2.1-5** summarizes the average precipitation, rainfall, and snow water equivalent estimated for the Project.

Table 5.1.2.1-5: Estimated Average Precipitation, Rainfall, and Snow Water Equivalent for the Project

Parameter	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation	mm	73	45	39	20	50	66	52	51	47	47	74	72	636
Precipitation Distribution	%	12	7	6	3	8	10	8	8	7	7	12	11	100
Rainfall	mm	0	0	0	13	50	66	52	51	47	31	0	0	310
Rainfall Distribution	%	0	0	0	65	100	100	100	100	100	65	0	0	49
Snow Water Equivalent	mm	73	45	39	7	0	0	0	0	0	16	74	72	326
Snow Water Equivalent Distribution	%	100	100	100	35	0	0	0	0	0	35	100	100	51

Source: Knight Piésold, 2013a (**Appendix 5.1.1.1A**).
Note: mm = millimetre; % = percent

Table 5.1.2.1-6 summarizes the 24-hour extreme precipitation estimated for the Project.

Table 5.1.2.1-6: Estimated 24-hour Extreme Precipitation for the Project

Return Period (Years)	24-hour Extreme Event (mm)
2	37
5	44
10	50
15	53
20	55
25	56
50	61
100	66
200	71
500	78
1000	82
PMP	195

Source: Knight Piésold, 2013a (**Appendix 5.1.1.1A**)
Note: mm = millimetre; PMP = Probable Maximum Precipitation

Table 5.1.2.1-7 summarizes the wet and dry annual precipitation estimated for the Project.

Table 5.1.2.1-7: Estimated Wet and Dry Annual Precipitation for the Project

Return Period (Years)	Precipitation (mm)
1:200 year wet	794
1:100 year wet	779
1:50 year wet	762
1:20 year wet	737
1:10 year wet	715
Mean Annual	636
1:10 year dry	557
1:20 year dry	535
1:50 year dry	510
1:100 year dry	493
1:200 year dry	478

Source: Knight Piésold, 2013a (**Appendix 5.1.1.1A**)
Note: mm = millimetre

Annual potential evapotranspiration of 445 mm was estimated for the Project. Annual actual evapotranspiration varies across the study area based on vegetative cover and ranges between 267 mm and 356 mm (Knight Piésold, 2013a). **Table 5.1.2.1-8** summarizes the estimated potential evapotranspiration for the Project. The potential evapotranspiration is defined as the amount of evapotranspiration that would occur given an infinite supply of water from a crop surface, and these values are believed to be reasonably representative of lake evaporation conditions.

Table 5.1.2.1-8: Estimated Potential Evapotranspiration for the Project

Parameter	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Potential Evapotranspiration	mm	0	0	0	20	66	93	104	91	54	13	0	0	445
Potential Evapotranspiration Distribution	%	0	0	0	4	15	21	23	20	12	3	0	0	100

Source: Knight Piésold, 2013a (**Appendix 5.1.1.1A**)
Note: mm = millimetre; % = percent

Sublimation was estimated for the Project to be 100 mm for the winter season (assumed to be distributed fairly evenly from November through March). While the snowmelt for the Project was estimated to be 21% in April, 53% in May, and 26% in June (Knight Piésold, 2013a).

Annual mean temperature was estimated to be 2.0°C for the Project. The minimum monthly mean temperature was estimated to be -7.7°C and is expected in January. The maximum monthly mean temperature was estimated to be 12.5°C and is expected in July (Knight Piésold, 2013a).

5.1.2.1.3.3 Tatelkuz Lake Levels

Knight Piésold used measured lake levels and outlet discharges to estimate Tatelkuz Lake levels for a 40-year period; the average lake level was determined to be approximately 927.60 masl. Long-term analysis suggests that Tatelkuz Lake levels are the lowest in April and August and highest during freshet with occasional higher levels following summer or fall rain events. For 80% of the time, lake level changes are expected to be small and within 0.3 m. The maximum fluctuation between historic minimum and maximum lake levels is approximately 2.0 m (Knight Piésold, 2013c). For lake levels, refer to Figure 3 and Figure 4 in **Appendix 5.1.2.1C**.

At the time of the bathymetric survey, the water level in Tatelkuz Lake was estimated to be 927.60 masl and the point of zero flow at the lake outlet was estimated to be 926.48 masl. The difference in lake volume between these two lake levels was determined to be approximately 11 million cubic metres (Mm^3) or approximately 5.6% of the total lake volume. The water depth at the lake outlet at the time of the bathymetric survey was estimated to be 1.12 m and the outflow to Chedakuz Creek to be about 7.1 m^3/s (Knight Piésold, 2013c). Detailed Tatelkuz Lake levels baseline data for the Project are included in **Appendix 5.1.2.1C**. These results were used for assessing the effects on Tatelkuz Lake levels resulting from each phase of the Project (i.e., construction, operations, closure, and post-closure).

5.1.2.1.4 Conclusions

The hydrological parameters estimated in the surface water flow baseline were used to assess monthly/annual flows, peak flows, and low flows within Project watersheds for each phase of the Project (i.e., construction, operations, closure, and post-closure). The climate parameters estimated in the climate baseline were used for water balance and watershed models and as hydrological design criteria for the Project. In addition, the results of the Tatelkuz Lake level baseline were used to assess the effects on Tatelkuz Lake water levels resulting from each phase of the Project.

5.1.2.2 Surface Water and Sediment Quality

This subsection presents the methods and results for baseline characterization for surface water and sediment quality. The rationale for including surface water quality and sediment quality as selected VCs is presented in **Section 5.3.1** of the Application.

5.1.2.2.1 Surface Water

AMEC collected water on a monthly basis at 16 stream sites (weekly at freshets in 2011, 2012, and 2013). However, the number of sites varied from 2011 through 2013 with sites added as the Project description evolved. Lakes in the Project area were sampled on a quarterly basis when it was safe to do so. During freeze-up and breakup, sampling was not possible. Summary results are presented in the following tables. The complete Surface Water Quality Baseline is presented in **Appendix 5.1.2.2A**. **Figure 5.1.2.2-1** shows the water quality LSA, RSA and monitoring sites in relation to the Project.

5.1.2.2.1.1 QA/QC

Field collection methods followed BC MOE guidelines (BC MOE 2012) including blind field duplicates, travel and field blanks. Recommended holding times were observed. Laboratory procedures followed BC MOE guidelines for analytical laboratories (BC MOE 2009) including lab duplicates; a CALA laboratory was employed for analyses.

5.1.2.2.1.2 Study Areas

The surface water quality LSA includes the entire watersheds of Davidson Creek, Creek 661, Turtle Creek, and Creek 705; tributaries flowing in to the south side of Tatelkuz Lake; Chedakuz Creek from confluence with Creek 661 to Tatelkuz Lake; Chedakuz Creek from Tatelkuz Lake to confluence with Turtle Creek. The surface water quality RSA included Laidman and Williamson lakes. A tributary to the Blackwater River that drains an area south of the proposed Project site but in a separate watershed and the Blackwater River downstream of the proposed Project were also sampled in 2012 at the request of BC MOE but are outside of the RSA.

The transmission line creek crossings were surveyed from fish population and habitat perspectives; no water quality monitoring was conducted as with best management practices (BMPs) no effects on streams are expected. However, construction monitoring of water quality will be required upstream and downstream of major crossings.

Surface water quality baseline sampling began early in recognition that it would be an identified valued component since aquatic organisms are dependent on water quality. Good water quality is also of interest to people from a health perspective (drinking and/or fish as a food source).

5.1.2.2.1.2.1 Local Study Area

5.1.2.2.1.2.1.1 Chedakuz Creek

Chedakuz Creek is a third order stream that originates above Kuyakuz Lake and flows generally northwest, emptying into the Nechako Reservoir. Chedakuz Creek is situated along the northern flanks of the Fawnie Range within the greater Nechako Plateau, and drains into the Nechako Reservoir. The watershed is characterized by predominantly lodgepole pine forests interspersed with natural meadows (BC Ministry of Forests (BC MOF), 1997). Upper Chedakuz Creek is approximately 15 km long and flows into Kuyakuz Lake. Middle Chedakuz Creek is approximately 12 km long and runs from Kuyakuz Lake into Tatelkuz Lake. Below Tatelkuz Lake, the Chedakuz Creek flows northwest for a distance of approximately 53 km.

5.1.2.2.1.2.1.2 Davidson Creek and Tributaries

Davidson Creek is a third order stream draining the Blackwater property, flowing northeast, and emptying into Chedakuz Creek just north of Tatelkuz Lake. The Davidson Creek drainage area is 77 square kilometres (km^2).

5.1.2.2.1.2.1.3 Turtle Creek and Tributaries

Turtle Creek is a third order stream north of Davidson Creek. It originates east of Top Lake, the headwaters of Fawnie Creek. At least two of its tributaries originate close to areas that could be affected by mining. Turtle Creek enters Chedakuz Creek downstream approximately 2 km from Davidson Creek in an ill-defined wetland area.

5.1.2.2.1.2.1.4 Fawnie Creek and Tributaries

Fawnie Creek is located approximately 10 km northwest of the Blackwater deposit. The creek flows southwest to join the Entiako River, which flows into Nechako Reservoir. One of Fawnie Creek's major tributaries from the south originates close to the Project and could be indirectly affected by the mine.

The Nechako Reservoir drains into the Nechako River, which joins the Fraser River at Prince George.

5.1.2.2.1.2.1.5 Creek 661

Creek 661 is an unnamed tributary of Chedakuz Creek that joins Chedakuz upstream of Tatelkuz Lake. Creek 661 drains the Blackwater deposit and flows in a northeasterly direction toward Tatelkuz Lake. It is a third-order stream with two of its branches originating east of the Project mine site.

5.1.2.2.1.2.1.6 Creek 700, Turtle Creek Tributary

Creek 700 flows into Reach 5 of Turtle Creek. Reach 1 of Creek 700 is a short, low gradient reach located within wetland complex in the lower valley of Turtle Creek. Average stream gradient increases to 3.3% in Reach 2 and is dominated by gravel and cobble substrates. Channel confinement and average gradient increases to 5.4% in Reach 3 for 1,200 m. The average stream gradient drops to 0.9% in Reach 4 of Creek 700 and becomes influenced by drainage from a large wetland complex along the east bank margin. Reach 5 and 6 are governed by steeper stream gradients.

5.1.2.2.1.2.1.7 Creek 705 and Tributaries

Creek 705 is a third order stream flowing down slope on the western side of Mt. Davidson to Fawnie Creek, approximately 8 km downstream of Top Lake. The watershed area of Creek 705 is 45 km^2 and ranges in elevation from approximately 1,500 masl upstream of Lake 01538UEUT to 1,000 masl near the confluence with Fawnie Creek.

Creek 705 contains a moderate-sized lake (Lake 01538UEUT) near the headwaters of the southern drainage. Creek 705 receives runoff from a number of small tributaries in the middle to upper watershed. The main northern basin in the upper part of the watershed is drained by Creek 606013 through a headwater lake (Lake 01428UEUT).

5.1.2.2.1.2.1.8 Kuyakuz Lake

Kuyakuz Lake is located approximately 20 km southeast of the Project. The lake has a surface area of 820 hectares (ha), a volume of 63 million cubic metres (Mm^3) and a mean depth of 7.7 m. The lake provides spawning and overwintering habitat for fish, including rainbow trout and a number of forage fish.

5.1.2.2.1.2.1.9 Tatelkuz Lake

Tatelkuz Lake is the second largest lake near the headwaters of Chedakuz Creek. It has a surface area of 927 ha and a volume of 188 Mm^3. The mean lake depth is 20 m.

Tatelkuz Lake is characterized by exposed cobble and sandy beaches, and by a forested shoreline. Tatelkuz Lake has six inlets and one outlet. Based on the lake survey, two inlets and the outlet were reported to have spawning potential. Numerous fish were observed, including rainbow fry and juveniles within the lake outlet. Fish inhabiting the lake include kokanee, rainbow trout, and several forage fish species.

5.1.2.2.1.2.1.10 Snake Lake

Snake Lake is located approximately 10 km northeast of the centre of the Project. The outlet stream feeds into Davidson Creek about half way along its length. The lake is slightly more than 10 m deep at its deepest point. A limnological survey of the lake is pending.

5.1.2.2.1.2.1.11 Lake 1682

Lake 1682 is the headwater lake of Davidson Creek. It has one circular basin with the deepest portion of the lake located in the centre. The basin has shallow slopes creating a large littoral area. There are two small islands in the lake, both of which are well vegetated. The lake does not have any inlets, but it has one outlet to Davidson Creek exiting at the north end of the lake.

5.1.2.2.1.2.1.12 Lake 1538

Lake 1538 is a moderate-sized lake near the headwaters of the southern drainage. It has two distinct basins that are orientated in an east to west direction. The smaller, western basin is less than 9 m deep and has a large littoral area at the western end near the lake outlet. There is also one inlet tributary, classified as a non-continuous drainage (NCD) that enters the western basin. The eastern basin of Lake 1538 is deeper and larger than the western basin. There are two inlet tributaries flowing into the lake at its eastern end; one was classified as S4 and the other classified as NCD. The steepest gradients in Lake 1538 are located in the eastern basin on the north and south shorelines.

5.1.2.2.1.2.1.13 Lake 1428

Lake 1428 is a headwater lake of Stream 705. It has one large main basin with a small, shallow bay branching off at the northeastern end of the lake. The lake is longer than it is wide, and is oriented along a northeast/southwest axis. The main basin is deepest near the middle and has steep gradients along the northern shoreline. The southeastern end of the lake is shallow with depths less than 4 m. The small bay is very shallow (<2 m) and extends into a large wetland area. The lake has no islands and has a single inlet tributary and a single outlet. The inlet tributary flows in from the northeast and the outlet discharges to Creek 705 to the southwest. Lake 1428 has a maximum depth of 7.6 m, an average depth of 3.09 m, and a relative depth of 1.64 m.

5.1.2.2.1.2.2 Regional Study Area

The RSA for surface water quality was made coincident with the aquatics study area and included, in addition to the LSA, all streams draining into Fawnie and Turtle Creeks as well as Laidman and Williamson lakes. There are lodges on the two lakes and concerns were expressed about proposed Project effects. Thus the lakes were considered with respect to fish and fish habitat. No water quality monitoring was conducted in the RSA. However, the two sites on the Blackwater River system are discussed in the baseline report.

5.1.2.2.1.2.3 Methods

Water quality samples were collected monthly from 13 sites on streams that could be affected by Project development or could act as controls for operations monitoring in 2011. The number of monthly sample sites was increased to 15 in 2012. **Figure 5.1.2.2-1** shows the sites. On the recommendation of the BC MOE in Prince George, two additional sites were added in December 2011 on the Blackwater River and a major tributary south of the Project, which will be sampled quarterly. In 2013 the Blackwater River and tributary sites were dropped after consultation with BC MOE. Quarterly sampling of selected lakes also commenced in 2012.

All stream samples were collected as single grab replicates from each monitoring site in sample bottles provided by the laboratory doing the analysis and labelled. Sample collection followed standardized protocols (BC MOE, 2011[1]). Samples were collected mid-stream; however, samples were collected from the stream bank when the safety of field personnel was a concern due to increased stream flow.

5.1.2.2.1.2.4 Weekly Sampling at Freshet

Weekly samples were collected at freshet high flow periods in May and June. The purpose was to determine variation within the months at periods likely to reflect maximum differences due to freshet conditions. Samples were collected over a consecutive five-week period. Samples were collected in the same manner as noted above.

WQ1 to 14 were sampled weekly during freshet in 2011, 2012, and 2013 as follows:

- 24 May to 13 June in 2011;
- 14 May to 18 June in 2012; and

[1] Updated 2012 to a final version

- 13 May to 17 June in 2013.

5.1.2.2.1.2.5 Laboratory Methods

Water (and sediment) samples were analyzed by AMEC's Edmonton laboratory which is Canadian Analytical Laboratories Association accredited. Laboratory methods followed BC MOE (2009).

5.1.2.2.1.3 Results

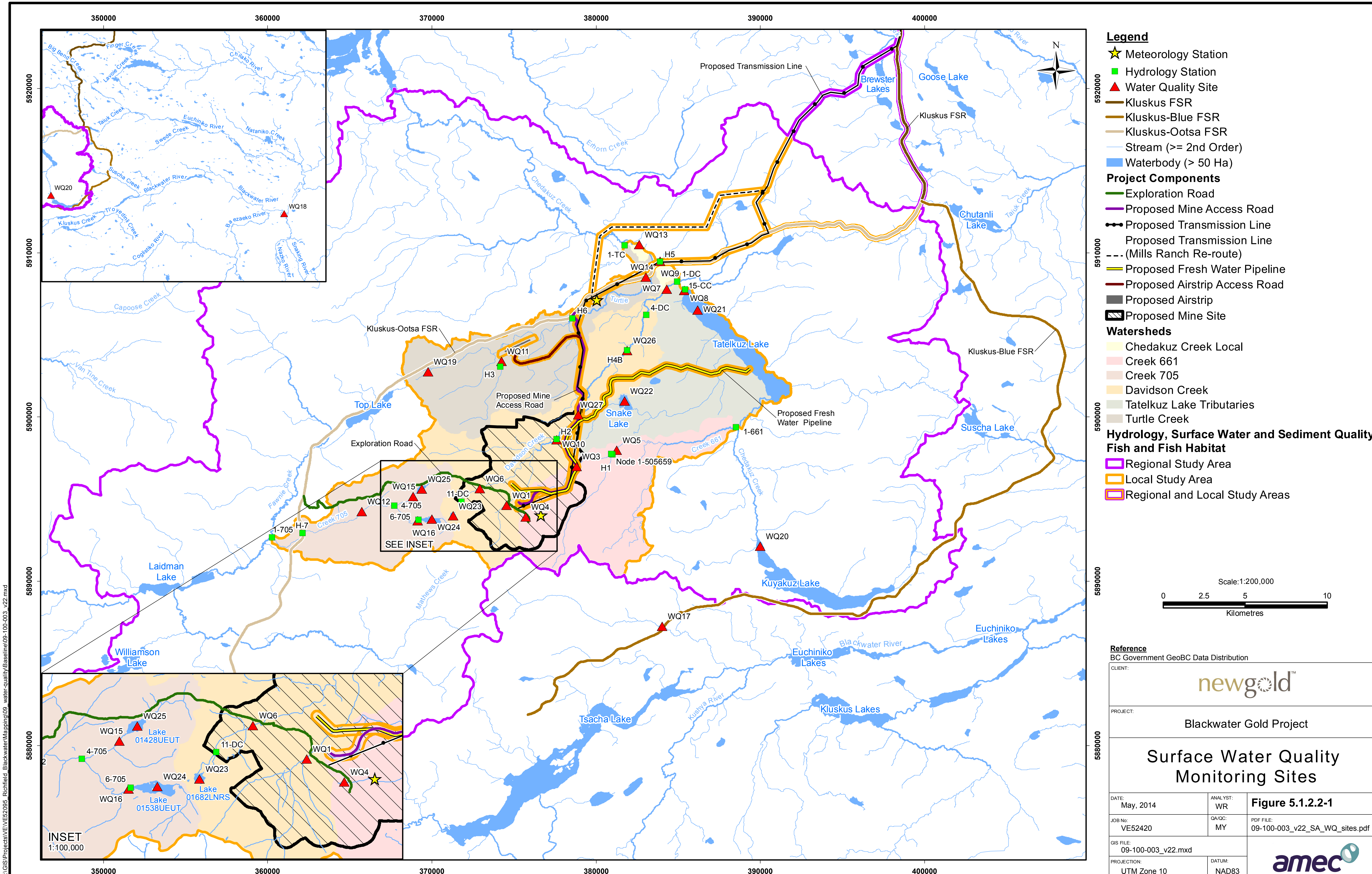
The water quality baseline in **Appendix 5.1.2.2A** discusses major parameters (possibly affected by mining operations) and minor parameters (of potential interest because a guideline exists for the parameter).

Table 5.1.2.2-1 provides mean water quality for streams (including the weekly freshet samples) for the parameters analyzed. Exceedances of the BC FWG (2006a, 2006b, 2008, 2009, and 2012), and exceedances of the CCME guidelines (2007) are indicated as follows: the 30-day and maximum grab guidelines exceedances are shown as red bold in red-shaded cells, and red bold, respectively. CCME short-term and long-term guidelines are red underlined and red bold italics, respectively.

Site water has circumneutral pH and low hardness; alkalinities are also low, consistent with low hardness and conductivity. For general parameters, only WQ18 on Blackwater River had exceedances based on mean values: CCME fluoride (0.13 mg/L versus CCME short-term guide of 0.12 mg/L). WQ18 will not be affected by the Project.

Table 5.1.2.2-2 lists the 95th percentile results for April 2011 to June 2013. The 30-day and maximum grab guidelines are shaded red bold, and red bold, respectively. CCME short-term and long-term guidelines are red underlined and red bold italics, respectively.

Mean metals concentrations are all low, and typically one to several orders of magnitude below their respective guidelines; exceedances of guidelines are listed in **Table 5.1.2.2-3**. **Table 5.1.2.2-4** lists the counts of guideline exceedances.



Legend
Meteorology Station
Hydrology Station
Water Quality Site
Kluskus FSR
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream (>= 2nd Order)
Waterbody (> 50 Ha)
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Transmission Line (Mills Ranch Re-route)
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Hydrology, Surface Water and Sediment Quality, Fish and Fish Habitat
Regional Study Area
Local Study Area
Regional and Local Study Areas
Scale:1:200,000
0 2.5 5 10
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Surface Water Quality Monitoring Sites
DATE: May, 2014
ANALYST: WR
Figure 5.1.2.2-1
JOB No: VE52420
QA/QC: MY
PDF FILE: 09-100-003_v22_SA_WQ_sites.pdf
GIS FILE: 09-100-003_v22.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
Proposed Transmission Line
Kluskus FSR
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Proposed Mine Access Road
Exploration Road
Proposed Fresh Water Pipeline
Brewster Lakes
Goose Lake
Chutani Lake
Tatelkuz Lake
Snake Lake
Top Lake
Suscha Lake
Kuyakuz Lake
Laidman Lake
Williamson Lake
Euchiniko Lakes
Kluskus Lakes
Tsacha Lake
WQ1 WQ3 WQ4 WQ5 WQ6 WQ7 WQ8 WQ9 WQ10 WQ11 WQ12 WQ13 WQ14 WQ15 WQ16 WQ17 WQ19 WQ20 WQ21 WQ22 WQ23 WQ24 WQ25 WQ26 WQ27
H1 H2 H3 H4B H5 H6 H-7 1-TC 1-DC 15-CC 4-DC 11-DC 4-705 6-705 1-705 1-661
Node 1-505659
SEE INSET
INSET
1:100,000
Lake 01428UEUT
Lake 01538UEUT
Lake 01682LNRS
WQ18

Table 5.1.2.2-1: Mean Stream Surface Water Quality Summary for the Project

Parameters	Unit	WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MoE Guideline		CCME	
		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	30-day	Maximum	Long Term	*Short Term*
Physical Tests																								
pH at 25°C	pH	6.64	7.57	7.09	7.15	7.2	7.57	7.91	7.84	7.42	7.36	7.29	7.83	7.8	7.32	7.31	7.43	7.95	8.04	7.55	6.5-9.0			6.5-9.0
Conductivity at 25°C	µS/cm	22.9	77.2	53.9	41.1	40.4	80	145.8	130.1	63.7	66.3	43.5	127	142.6	54.4	46	70.2	150	199.3	78.6				
T-Dissolved Solids at 180°C	mg/L	42.9	64	52.4	52.6	39.8	65.3	97.7	83.7	51.6	68.9	45.4	84.6	109	65	50.7	45.2	96.8	124	64.4				
Total Suspended Solids at 105°C	mg/L	1.8	3	3.8	2.9	1.6	10.8	6	4.7	2.3	<2	<2	5.4	2.2	2.1	6.2	<2	<2	<2	3.1				
Turbidity	NTU	2.63	1.83	3	1.34	1.5	4.43	3.63	2.21	1.58	1.58	1.57	2.26	1.52	1.55	2.79	0.62	***10.06***	0.8	1.44	8			8
T-Hardness as $CaCO_3$	mg/L	7.2	33.6	20.7	17.2	15.9	38.1	70.1	61.8	27.5	31.3	18.9	58.9	85.6	25.4	20.1	29.2	64.5	100.2	37.1				
Dissolved Anions																								
Total Alkalinity as $CaCO_3$	mg/L	5.9	38.6	13.8	17.7	16.9	38.7	75.4	63.7	30	31.2	20.4	62.4	71.5	23.3	21.6	31.8	76.6	98.7	38.8				
Fluoride-D	mg/L	0.03	0.06	0.05	0.05	0.04	0.05	0.07	0.07	0.05	0.05	0.04	0.07	0.07	0.04	0.03	0.05	*0.13*	0.06	0.05		0.4-1.33[c]		0.12
Sulphate-D	mg/L	1.3	1.5	7.5	0.9	1.5	2.1	4	3.9	2	1.4	1.2	3.7	2.9	1.4	1.4	2.8	1.7	3	2.2	115-270[c]			
Chloride-D	mg/L	0.5	0.4	0.9	0.3	0.4	0.4	0.5	0.5	0.3	0.4	0.3	0.8	0.6	0.3	0.3	0.3	0.8	1.2	0.3	150		120	640
Nutrients																								
Ammonia - Nitrogen	mg/L	<0.02	<0.02	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.424-2.08[1]	2.91-28.7[1]		0.42-189.97[1]
Nitrate-N-D	mg/L	0.01	0.021	0.013	0.023	0.015	0.018	0.034	0.03	0.021	0.022	0.018	0.02	0.017	0.028	0.029	0.046	0.066	0.179	0.03	3	31.3	13	550
Nitrite-N-D	mg/L	0.002	0.002	<0.003	<0.003	<0.003	<0.003	0.002	0.002	<0.003	<0.003	0.002	0.002	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.02	0.06		0.06
Total Kjeldahl Nitrogen (TKN)	mg/L	0.22	0.18	0.38	0.19	0.14	0.17	0.27	0.23	0.16	0.19	0.18	0.23	0.2	0.2	0.24	0.21	0.55	<0.08	0.11				
Phosphorous-Ortho-	mg/L	0.006	0.018	0.006	<0.003	0.006	0.007	0.008	0.006	0.007	0.005	<0.003	0.008	0.007			<0.003	<0.003	<0.003					
Phosphorous (Total-Dissolved)	mg/L	0.01	0.03	<0.02	<0.02	<0.02	0.4	0.01	0.01	0.01	0.01	<0.02	0.01	0.01	0.01	0.01	<0.01	0.04	<0.01	0.01				
Organic Parameters																								
Carbon (Total Organic)	mg/L	11.2	7.2	10.5	11.5	7.5	8.1	9.7	9.3	7.6	14.9	8.6	10.5	10.3	9.3	6.1	6.6	9.6	7.9	6.5				
Carbon (Dissolved Organic)	mg/L	10.4	6.9	10.5	11	7.3	8.1	9.1	8.9	7.4	14.5	8.6	9.4	10.2	8.9	6	6.5	9.4	7.1	6.4				
Total Metals																								
Aluminum-T	mg/L	*0.302*	*0.113*	*0.261*	*0.185*	*0.139*	*0.224*	0.027	0.071	*0.164*	*0.35*	*0.134*	0.076	0.06	0.059	*0.103*	0.063	*0.223*	<0.002	*0.109*				0.1[2]
Antimony-T	mg/L	0.00005	0.00006	0.00016	<5e-05	0.00005	0.00004	<5e-05	0.00004	<5e-05	<5e-05	<5e-05	0.00004	<5e-05	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	0.00004		0.02		
Arsenic-T	mg/L	0.0005	0.0008	0.0018	0.0004	0.0006	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.0005	0.0003	0.0003	0.0005	0.0004	0.0006	0.0004	0.0007	0.005			0.005
Barium-T	mg/L	0.00387	0.00503	0.00382	0.00406	0.00577	0.00874	0.00658	0.00761	0.00672	0.00838	0.00652	0.01034	0.01438	0.00885	0.00515	0.00633	0.01274	0.00903	0.00763	1	5		
Beryllium-T	mg/L	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04		0.0053		
Boron-T	mg/L	0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	0.002	0	<0.001	<0.001	0.001	0.001	0.003	1.2		1.5	29
Cadmium-T	mg/L	***0.000018***	<1.5e-05	***0.000116***	<1.5e-05	<1.5e-05	***0.000016***	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	0.000014	<1.5e-05	<1.5e-05	***0.000024***	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	0.000010–0.000033[3]		0.000017–0.00016[3]	0.00014–0.0021[3]
Calcium-T	mg/L	2.3	9.9	6.7	4.8	5.1	11	20.8	18.5	8.5	9.7	6.1	17.8	26.4	8.3	6.3	8.2	13.6	32.8	11.2				
Chromium-T	mg/L	0.0002	0.0008	<3e-04	0.0002	<3e-04	0.0004	<5e-04	<5e-04	0.0002	0.0003	<5e-04	<5e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04		0.001-0.0089[3]		0.001-0.0089[3]
Cobalt-T	mg/L	0.00006	0.00005	0.00006	0.00006	0.00003	0.0001	0.00003	0.00005	0.00003	0.00005	0.00004	0.00005	0.00004	0.00002	0.00003	0.00004	0.00037	<2e-05	0.00003	0.004	0.11		
Copper-T	mg/L	0.0008	0.0005	0.0006	0.0004	0.0003	0.0014	0.0005	0.0004	0.0003	0.001	0.0004	0.0004	0.0009	0.0003	0.0002	0.0005	0.0013	<1e-04	0.0004	0.002-0.004[3]	0.00267-0.0114[3][c]		0.002-0.0024[3]
Iron-T	mg/L	0.2255	0.164	0.1879	0.1655	0.1372	*0.3082*	0.0689	0.1804	0.1237	0.1661	0.2194	0.217	*0.3526*	0.1292	0.1936	0.0801	*0.8952*	0.0213	0.094		1		0.3
Lead-T	mg/L	0.00006	0.00006	0.00028	0.00004	0.00006	0.00012	<5e-05	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	0.00016	<5e-05	<5e-05	<5e-05	0.00005	0.0036-0.0065[c]	0.003-0.081[c]		0.001-0.0032[c]
Lithium-T	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.87		
Magnesium-T	mg/L	0.5	2.32	1.11	1.36	0.86	3.07	4.82	4.16	1.68	1.9	1.02	4.01	5.48	1.27	1.19	2.34	8.23	4.32	2.35				
Manganese-T	mg/L	0.012094	0.009346	0.026335	0.017403	0.008651	0.025601	0.023165	0.025236	0.006504	0.003713	0.016478	0.030234	0.029154	0.023624	0.034923	0.008892	0.082472	0.001563	0.007634	0.64-1.05[3]	0.62-1.64[3]		
Mercury-T	mg/L	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	0.000006	<8e-06	<8e-06	<8e-06	<5e-06	<5e-06	<8e-06	<8e-06	<5e-06	<5e-06	0.00002	0.0001		0.000026
Molybdenum-T	mg/L	0.00014	0.00055	0.00009	0.00014	0.00038	0.00049	0.00054	0.00057	0.00047	0.00015	0.00043	0.00054	0.00067	0.00059	0.00077	0.00187	0.00071	0.00069	0.00055	1	2		0.073
Nickel-T	mg/L	0.00027	0.00032	0.00032	0.00021	0.00023	0.00037	0.00026	0.00026	0.00018	0.00023	0.00012	0.00028	0.00041	0.00008	0.00008	0.00016	0.00154	<5e-05	0.00016		0.025-0.065[3]		0.025-0.096[3]
Phosphorous-T	mg/L	0.01	0.04	0.01	<0.02	0.01	0.14	0.02	0.01	0.01	0.01	0.01	0.01	0.02	<0.02	0.02	<0.02	0.09	<0.02	0.01				
Potassium-T	mg/L	<0.5	0.5	0.6	<0.5	<0.5	0.8	0.9	0.8	<0.5	0.4	<0.5	0.8	0.9	<0.5	<0.5	<0.5	2.5	0.6	0.5				

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MoE Guideline		CCME	
Parameters	**Unit**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**30-day**	Maximum	Long Term	*Short Term*
Selenium-T	mg/L	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	0.002			0.001
Silicon-T	mg/L	4.78	7.24	5.04	4.87	4.99	5.7	4.24	4.71	5.47	5.75	3.66	4.75	7.76	2.3	1.74	6.05	12.34	6.26	4.85				
Silver-T	mg/L	<5e-05	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	0.00005-0.0015 (3)	0.0001-0.003 (3)		0.0001
Sodium-T	mg/L	1.7	3	2.4	2.1	2	5.5	3.6	3.2	2.4	2.3	1.8	3.2	4.4	1.9	1.9	3.1	5.9	2.8	2.8				
Strontium-T	mg/L	0.020501	0.063794	0.038599	0.032395	0.038406	0.067805	0.098591	0.092993	0.058072	0.059378	0.047007	0.090094	0.129325	0.073019	0.043222	0.051156	0.063088	0.122367	0.067018				
Thallium-T	mg/L	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05		0.0003		0.0008
Tin-T	mg/L	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04				
Titanium-T	mg/L	0.0048	0.0028	0.0049	0.0027	0.0021	0.0066	0.0011	0.0026	0.0026	0.0044	0.0025	0.0027	0.0016	0.0009	0.0019	0.0006	0.0166	<2e-04	0.0019				
Uranium-T	mg/L	0.00015	0.00017	0.00005	0.00007	0.00017	0.00019	0.00009	0.00011	0.0002	0.00018	0.00018	0.00011	0.00012	0.00015	0.00037	0.0001	0.00013	0.00135	0.0002		0.3	0.015	0.033
Vanadium-T	mg/L	0.00026	0.00127	0.00017	0.00026	0.00011	0.00061	0.00015	0.0003	0.00022	0.00038	0.00014	0.0003	0.00021	<1e-04	0.00007	0.00012	0.00242	0.00063	<1e-04		0.006-0.01		
Zinc-T	mg/L	0.0043	0.0026	***0.0445***	0.0027	0.003	**0.0095**	0.0022	0.0016	0.0025	0.002	0.0022	0.0045	0.004	0.0021	0.0032	0.0018	***0.0311***	0.0017	0.0021	0.0075-0.015 (3)	0.033-0.0407 (3) c		0.03
Dissolved Metals																								
Aluminum-D	mg/L	**0.223**	**0.063**	**0.133**	**0.145**	**0.092**	**0.078**	0.005	0.02	**0.105**	**0.27**	**0.083**	0.025	0.016	0.044	0.023	0.049	0.012	0.003	**0.081**	0.05 (2)	0.1 (2)		
Antimony-D	mg/L	0.00003	0.00005	0.00014	0.00005	0.00005	0.00007	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00029	0.00005	0.00004	0.00005	0.00006	0.00005	0.00005				
Arsenic-D	mg/L	0.0004	0.0008	0.0013	0.0003	0.0005	0.0004	0.0005	0.0005	0.0004	0.0001	0.0002	0.0005	0.0002	0.0003	0.0004	0.0004	0.0004	0.0004	0.0006				
Barium-D	mg/L	0.00307	0.0043	0.00263	0.00365	0.00519	0.00665	0.00598	0.00694	0.00603	0.00765	0.00586	0.00714	0.01266	0.0083	0.00397	0.00632	0.00544	0.00892	0.00715				
Beryllium-D	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001				
Boron-D	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0	0	0.001	0.001	0.001	0.002				
Cadmium-D	mg/L	0.000012	0.000016	0.000075	0.000017	0.000016	0.000009	0.000015	0.000017	0.000015	0.000017	0.000016	0.000022	0.000017	0.000015	0.000018	0.000015	0.000108	0.000015	0.000015				
Calcium-D	mg/L	2.2	9.7	6.5	4.7	5	10.9	20.3	17.9	8.3	9.4	5.9	17.2	25.5	8.1	6.1	8	13	32.7	10.9				
Chromium-D	mg/L	0.0002	0.0006	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003				
Cobalt-D	mg/L	0.00003	0.00002	0.00002	0.00003	0.00002	0.00004	0.00001	0.00003	0.00002	0.00004	0.00002	0.00003	0.00003	0.00002	0.00001	0.00003	0.00003	0.00002	0.00002				
Copper-D	mg/L	0.0003	0.0003	0.0005	0.0004	0.0003	0.0013	0.0003	0.0003	0.0003	0.001	0.0003	0.0003	0.0008	0.0003	0.0002	0.0004	0.0008	0.0001	0.0004				
Iron-D	mg/L	0.1352	0.0796	0.0791	0.1115	0.0755	0.1047	0.0298	0.0911	0.0687	0.1188	0.1382	0.1043	0.1842	0.0902	0.066	0.0564	0.1234	0.0132	0.055		0.35		
Lead-D	mg/L	0.00007	0.00005	0.00005	0.00005	0.00006	0.00008	0.00005	0.00005	0.00006	0.00006	0.00005	0.00005	0.00008	0.00005	0.00008	0.00005	0.00005	0.00005	0.00005				
Lithium-D	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001				
Magnesium-D	mg/L	0.5	2.28	1.07	1.33	0.84	2.48	4.69	4.04	1.64	1.87	1	3.88	5.31	1.24	1.17	2.25	7.81	4.28	2.32				
Manganese-D	mg/L	0.00761	0.0042	0.00887	0.00412	0.00439	0.01352	0.00848	0.01747	0.00224	0.00164	0.00709	0.02168	0.01557	0.01142	0.01658	0.00817	0.00412	0.0012	0.00288				
Mercury-D	mg/L	0.000007	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006	0.000007	0.000007	0.000006	0.000006	0.000006	0.000005	0.000005	0.000006	0.000006	0.000005	0.000005				
Molybdenum-D	mg/L	0.00011	0.00048	0.00007	0.00012	0.00034	0.00043	0.00049	0.00051	0.00043	0.00014	0.00038	0.00049	0.0006	0.00052	0.00065	0.00164	0.00065	0.00066	0.00051				
Nickel-D	mg/L	0.00025	0.00029	0.00027	0.00018	0.0002	0.00043	0.00021	0.00023	0.00016	0.0002	0.00009	0.00023	0.00035	0.00007	0.00005	0.00014	0.00059	0.00005	0.00015				
Phosphorous-D	mg/L	0.01	0.03	0.01	0.01	0.01	0.41	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.01				
Potassium-D	mg/L	0.5	0.5	0.5	0.5	0.5	1.4	0.8	0.8	0.5	0.4	0.5	0.7	0.7	0.5	0.5	0.5	2.4	0.6	0.5				
Selenium-D	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0006	0.0006	0.0006	0.0003				
Silicon-D	mg/L	4.52	6.93	4.71	4.62	4.75	5.31	4	4.47	5.18	5.46	3.4	4.48	7.06	2.11	1.52	5.92	11.02	6.15	4.61				
Silver-D	mg/L	0.00005	0.00005	0.00003	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005				
Sodium-D	mg/L	1.6	2.9	2.2	2	1.9	5.4	3.4	3.2	2.3	2.3	1.7	3	3.6	1.8	1.9	3	5.7	2.8	2.6				
Strontium-D	mg/L	0.019419	0.061451	0.036204	0.03112	0.036829	0.063888	0.096156	0.089771	0.056016	0.057454	0.045274	0.087093	0.125312	0.069673	0.039949	0.049712	0.058884	0.119467	0.064182				
Thallium-D	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005				
Tin-D	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001				
Titanium-D	mg/L	0.0023	0.0012	0.0015	0.0014	0.0012	0.001	0.0002	0.0005	0.0012	0.0032	0.0012	0.0005	0.0006	0.0006	0.0004	0.0004	0.0008	0.0002	0.0011				
Uranium-D	mg/L	0.00014	0.00014	0.00005	0.00006	0.00015	0.00016	0.00008	0.0001	0.00018	0.00016	0.00016	0.0001	0.00011	0.00014	0.00022	0.00008	0.00011	0.00029	0.00019				
Vanadium-D	mg/L	0.00015	0.00104	0.00006	0.00017	0.00006	0.00024	0.00011	0.00018	0.00014	0.00027	0.00008	0.00018	0.00009	0.00005	0.00005	0.00012	0.00115	0.00064	0.00005				
D-Hardness as $CaCO_3$	mg/L	7.7	34	20.8	18.3	15.5	38.4	68.8	61	27.6	32.4	18.8	61	72.3	24.8	19.8	29.2	64.5	100.2	62				
Cyanide																								
Cyanide (Total)	mg/L	0.006	0.0056	0.0055	0.0059	0.0055	0.0056	0.005	0.0055	0.0058	0.0065	0.0057	0.0055	0.0054	0.005	0.005	0.005	0.005	0.005	0.005				
Cyanide (WAD)	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01		0.005

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MoE Guideline		CCME	
Parameters	**Unit**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**30-day**	Maximum	Long Term	*Short Term*
Cyanate	mg/L	0.28	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				0.2				
Thiocyanate (SCN)	mg/L	0.42	0.42	0.4	0.44	0.42	0.49	0.44	0.46	0.42	0.55	0.49	0.44	0.46	0.5	0.5				0.5				
Blackwater – Field Parameters																								
Conductivity (EC)	µS/cm	14.5	56.3	39.5	31.3	28.3	65.5	121.4	105.5	49.1	47.8	31.9	107.8	118.5	34.8	31.8	52.2	98.8	120	53.8				
DO Saturation %	%	94.9	97.2	87.5	91.6	96.5	96.5	90.1	96.3	97.7	95.6	91.4	98.7	89.9	84.8	78.5	107.2	113.1	80.7	110.1				
pH	pH	6.6	7.7	7	7.3	7.3	7.7	7.9	7.9	7.4	7.4	7.4	7.8	7.7	7.6	7.6	7.6	7.8	8.6	7.6	6.5-9.0			6.5-9.0
Temperature	°C	3.11	2.64	4.16	4.51	3.6	3.74	7.9	6.69	2.82	3.84	4.54	7.05	6.56	5.14	5.12	1.63	3.31	4.89	3.35		18		

Note: (1) pH and temperature dependent. Assume pH ranges from 6.7 to 8.25, and temperature from 0°C to 19°C. (2) pH dependent. (3) Hardness dependent
red font = exceeds 30 day guideline; **red & bold =** exceeds maximum guideline

Table 5.1.2.2-2: 95^{th} Percentile Surface Water Quality Summary

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MOE Guideline		CCME	
Parameters	**Unit**	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	95^{th} %ile	30-day	Maximum	Long Term	*Short Term*
Physical Tests																								
pH at 25°C BC-D	pH	7.02	7.87	7.46	7.56	7.49	7.9	8.12	8.1	7.93	8	7.58	8.04	8.11	7.43	7.47	7.75	8.15	8.19	7.88	6.5-9.0			6.5-9.0
Conductivity at 25°C	µS/cm	34.2	106.3	90.6	71.8	59	131	162.4	155	111	152	58.4	158.3	209.5	80.3	52	91.2	171.8	205.5	129				
T-Dissolved Solids at 180°C	mg/L	72.8	96.6	78.6	90.2	66.8	101.2	126.4	112.4	76.4	101.6	78.4	130.8	178	150.4	125.6	64.4	103.2	145.6	88				
Total Suspended Solids at105°C	mg/L	5	10.4	17	8.1	3	38.3	20.4	11	7.1	<2	<2	10	5.5	3.7	25	<2	<2	<2	6.5				
Turbidity	NTU	6.06	3.53	***12.99***	3.07	3.47	***14.8***	***9.43***	3.86	4.12	3.4	3.31	4.31	3	2.47	***9.8***	0.94	***35.86***	0.89	2.9	8			8
T-Hardness as $CaCO_3$	mg/L	10	49.3	34.5	31.7	25.3	66.6	82.6	78.1	53.4	72.9	25.3	75.4	111.5	36.7	24.1	38.8	73.3	109.5	64.8				
Dissolved Anions																								
Total Alkalinity as $CaCO_3$	mg/L	11	57.9	26.6	35.7	30	66.1	82.2	80	58	81.8	30.6	79.3	101	30	27	41.6	89.4	100.9	69				
Fluoride-D	mg/L	0.05	0.08	0.08	0.07	0.06	0.07	0.1	0.09	0.07	0.07	0.06	0.09	0.1	0.06	0.04	0.06	*0.15*	0.07	0.08		0.4-1.38[c]		0.12
Sulphate-D	mg/L	2.8	2.2	17.2	1.8	2.5	3.4	4.9	4.8	3.7	3.1	2	4.8	4.8	2.6	2	4.2	2.4	3.8	3.8	115-270[c]			
Chloride-D	mg/L	1.3	0.7	2	1.1	1.3	1	1.4	0.9	0.9	1.4	0.8	1.2	1.3	0.5	0.3	0.3	2	1.6	0.4	150		120	640
Nutrients																								
Ammonia – Nitrogen	mg/L	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.424-2.08[a]	2.91-28.7[a]		0.42-189.97[a]
Nitrate-N-D	mg/L	0.035	0.061	0.037	0.084	0.035	0.058	0.089	0.085	0.047	0.069	0.044	0.068	0.061	0.072	0.065	0.09	0.14	0.299	0.05	3	31.3	13	550
Nitrite-N-D	mg/L	0.008	0.008	<0.003	<0.003	<0.003	<0.003	0.009	0.01	<0.003	<0.003	0.009	0.01	0.011	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.02	0.06		0.06
Total Kjeldahl Nitrogen (TKN)	mg/L	0.61	0.42	0.79	0.42	0.31	0.46	0.58	0.58	0.38	0.52	0.51	0.57	0.5	0.39	0.66	0.59	1.42	<0.08	0.16				
Phosphorous-Ortho-DLL	mg/L	0.019	0.039	0.032	<0.003	0.032	0.043	0.018	0.012	0.047	0.038	<0.003	0.016	0.021			<0.003	<0.003	<0.003					
Phosphorous (Total-Dissolved) LL	mg/L	0.02	0.05	<0.02	<0.02	<0.02	0.02	0.02	0.02	0.02	0.02	<0.02	0.02	0.02	0.02	0.03	<0.01	0.05	<0.01	0.02				
Organic Parameters																								
Carbon (Total Organic)	mg/L	21.7	15.4	16.3	17.6	14.1	15.5	21	16.7	15.3	25.3	13.5	18.2	17.6	13.6	10.1	11.5	16.2	17.7	12.3				
Carbon (Dissolved Organic)	mg/L	20.6	14	17.9	15.4	14.3	15.5	15.7	14.9	13.8	22.5	12.8	14.2	18.5	11.5	9.8	11.3	16.2	15.8	12.2				
Total Metals																								
Aluminum-T	mg/L	*0.55*	*0.258*	*0.801*	*0.332*	*0.366*	*0.784*	0.094	*0.186*	*0.428*	*0.761*	*0.294*	*0.173*	*0.136*	0.1	*0.408*	*0.18*	*0.816*	<0.002	*0.313*				0.1[b]
Antimony-T	mg/L	0.00013	0.00008	0.00026	<5e-05	0.00007	0.00006	<5e-05	0.00005	<5e-05	<5e-05	<5e-05	0.00006	<5e-05	<5e-05	0.00009	<5e-05	<5e-05	<5e-05	0.00006		0.02		
Arsenic-T	mg/L	0.0008	0.0012	0.0035	0.0005	0.0008	0.0008	0.0006	0.0007	0.0006	0.0002	0.0003	0.0006	0.0008	0.0008	0.0011	0.0006	0.0012	0.0005	0.0021	0.005			0.005
Barium-T	mg/L	0.00777	0.00743	0.0085	0.00662	0.00948	0.01384	0.00895	0.00917	0.00849	0.01261	0.01044	0.01057	0.02226	0.01148	0.00875	0.00767	0.03483	0.00923	0.01514	1	5		
Beryllium-T	mg/L	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04		0.0053		
Boron-T	mg/L	0.004	0.003	0.002	0.004	<0.001	0.002	0.004	0.002	0.001	0.003	<0.001	0.003	0.003	0.002	<0.001	<0.001	0.002	0.002	0.013	1.2		1.5	29
Cadmium-T	mg/L	***0.000056***	<1.5e-05	***0.00022***	***0.00003***	***0.000031***	***0.000059***	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	***0.000039***	<1.5e-05	<1.5e-05	***0.000085***	<1.5e-05	<1.5e-05	<1.5e-05	<1.5e-05	0.0000046-0.000036[c]			0.0000046-0.000036[c]
Calcium-T	mg/L	3.2	14.6	11.1	8.7	7.8	19.1	24.2	23	16	22	7.9	22.9	32.6	11.7	7.4	10.8	15.9	35	19.2				
Chromium-T	mg/L	0.0004	*0.0012*	<3e-04	0.0005	<3e-04	0.001	<5e-04	<5e-04	0.0004	0.0005	<5e-04	<5e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04	<3e-04		0.001-0.0089		0.001-0.0089
Cobalt-T	mg/L	0.00009	0.0001	0.00023	0.00013	0.00007	0.00033	0.00007	0.00008	0.00008	0.00011	0.00011	0.00008	0.00016	0.00004	0.00012	0.00006	0.00138	<2e-05	0.00007	0.004	0.11		
Copper-T	mg/L	0.002	0.001	0.0015	0.0007	0.0007	0.0014	0.0013	0.0007	0.0007	*0.0027*	0.0007	0.0013	0.0017	0.0008	0.0007	0.0007	***0.0045***	<1e-04	0.0008	0.002-0.0045[c]	0.0029-0.0125[c]		0.002-0.0026[c]
Iron-T	mg/L	*0.4074*	*0.3202*	*0.6645*	*0.3544*	*0.368*	*0.8029*	0.2024	0.294	0.277	*0.3758*	*0.5373*	*0.3331*	*1.091*	0.211	*0.639*	0.0956	*3.0183*	0.0238	0.229		1		0.3
Lead-T	mg/L	0.00029	0.00023	0.00097	0.00014	0.00021	0.00044	<5e-05	<5e-05	0.00015	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	0.00036	<5e-05	<5e-05	<5e-05	0.00008	0.0035-0.00696[c]	0.0043-0.0938[c]		0.001-0.0036[c]
Lithium-T	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.87		
Magnesium-T	mg/L	0.73	3.35	1.97	2.53	1.36	4.25	5.54	5.15	3.21	4.39	1.36	5.21	7.5	2.14	1.4	3.11	9.66	4.83	4.08				
Manganese-T	mg/L	0.02266	0.02717	0.094015	0.027965	0.0227	0.058547	0.080442	0.042755	0.0155	0.009176	0.036785	0.057277	0.0923	0.040745	0.103	0.013168	0.3007	0.002152	0.01475	0.653-1.128[c]	0.661-1.851[c]		
Mercury-T	mg/L	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	<8e-06	0.000017	<8e-06	<8e-06	<8e-06	<5e-06	<5e-06	<8e-06	<8e-06	<5e-06	<5e-06	0.00002	0.0001		0.000026
Molybdenum-T	mg/L	0.00034	0.00088	0.0002	0.00028	0.00056	0.00084	0.00063	0.00067	0.00092	0.00037	0.00064	0.00069	0.00072	0.00069	0.00108	0.0025	0.00078	0.00074	0.00089	1	2		0.073
Nickel-T	mg/L	0.00052	0.00088	0.00049	0.00035	0.00046	0.00114	0.00045	0.00045	0.00042	0.0004	0.00029	0.00044	0.00105	0.00021	0.00033	0.00025	0.00469	<5e-05	0.00027		0.025-0.065[c]		0.025-0.104[c]
Phosphorous-T	mg/L	0.03	0.05	0.03	<0.02	0.02	0.04	0.05	0.04	0.02	0.02	0.02	0.02	0.03	<0.02	0.06	<0.02	0.24	<0.02	0.02				
Potassium-T	mg/L	<0.5	0.7	0.9	<0.5	<0.5	1.1	1	0.9	<0.5	0.7	<0.5	1	1.8	<0.5	<0.5	<0.5	3.6	0.7	0.7				
Selenium-T	mg/L	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	<6e-04	0.002			0.001

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MOE Guideline		CCME	
Parameters	**Unit**	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	**30-day**	Maximum	Long Term	*Short Term*
Silicon-T	mg/L	6.71	9.53	6.57	6.38	6.16	7.1	5.62	5.85	6.97	7.01	4.33	6	8.7	3.38	2.32	6.97	15.96	6.84	6.83				
Silver-T	mg/L	<5e-05	<5e-05	***0.00013***	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	0.00005-0.0015[c]	0.0001-0.003[c]		0.0001
Sodium-T	mg/L	2.5	4.1	4.5	3.1	2.8	4.2	4.1	4	3.7	3.9	2.3	4	5.4	2.4	2.3	3.8	7.5	3	4.1				
Strontium-T	mg/L	0.02912	0.0873	0.062296	0.05669	0.053763	0.1102	0.10915	0.113	0.098358	0.12292	0.064415	0.111205	0.1512	0.085663	0.054115	0.063944	0.073732	0.1239	0.108				
Thallium-T	mg/L	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05	<5e-05		0.0003		0.0008
Tin-T	mg/L	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04	<1e-04				
Titanium-T	mg/L	0.0105	0.0068	0.0226	0.0069	0.0062	0.0249	0.0043	0.0064	0.0066	0.0108	0.0064	0.0061	0.0048	0.0019	0.0079	0.0012	0.0621	<2e-04	0.0057				
Uranium-T	mg/L	0.0002	0.00026	0.00014	0.00012	0.00027	0.00029	0.0001	0.00014	0.0003	0.00031	0.00024	0.00014	0.00028	0.00019	0.00094	0.00015	0.0002	0.00318	0.00028		0.3	0.015	0.033
Vanadium-T	mg/L	0.00052	0.002	0.00063	0.00051	0.0004	0.00187	0.00041	0.0007	0.0004	0.00078	0.00036	0.0006	0.00035	<1e-04	0.00026	0.0002	0.00582	0.0008	<1e-04		0.006-0.01		
Zinc-T	mg/L	**0.0094**	**0.0095**	***0.0701***	0.0046	0.0072	**0.0245**	0.0061	0.0039	0.0063	0.0056	0.0042	**0.0219**	0.0138	0.0041	0.0072	0.0033	***0.118***	0.0024	0.0034	0.0075-0.0236[c]	0.033-0.0491[c]		0.03
Dissolved Metals																								
Aluminum-D	mg/L	**0.345**	**0.173**	**0.235**	**0.251**	**0.202**	**0.197**	0.012	**0.056**	**0.256**	**0.492**	**0.168**	0.05	**0.053**	**0.088**	**0.063**	**0.128**	0.034	0.006	**0.227**	0.05[b]	0.1[b]		
Antimony-D	mg/L	0.00009	0.00008	0.00024	0.00005	0.00006	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00008	0.00005	0.00007	0.00005	0.00005				
Arsenic-D	mg/L	0.0008	0.0012	0.0019	0.0004	0.0007	0.0005	0.0005	0.0006	0.0005	0.0001	0.0002	0.0006	0.0004	0.0007	0.0007	0.0006	0.0005	0.0005	0.0021				
Barium-D	mg/L	0.00506	0.00535	0.00361	0.00562	0.00685	0.00916	0.00736	0.00814	0.00772	0.01254	0.00828	0.00895	0.01455	0.01099	0.00816	0.00747	0.00703	0.00948	0.01514				
Beryllium-D	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001				
Boron-D	mg/L	0.004	0.003	0.002	0.002	0.001	0.002	0.003	0.002	0.001	0.002	0.001	0.002	0.003	0.002	0.001	0.001	0.002	0.001	0.013				
Cadmium-D	mg/L	0.000032	0.000015	0.000214	0.000025	0.000021	0.000022	0.000015	0.000024	0.000015	0.000019	0.000015	0.000026	0.000028	0.000015	0.000037	0.000015	0.000388	0.000015	0.000015				
Calcium-D	mg/L	3	14.2	10.6	8.6	7.8	19.7	24.2	23	16	22	7.9	22.2	32.4	11.4	7.4	10.6	14.8	35	19.2				
Chromium-D	mg/L	0.0004	0.0009	0.0003	0.0005	0.0003	0.0004	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0005	0.0003	0.0003				
Cobalt-D	mg/L	0.00005	0.00006	0.00003	0.00005	0.00004	0.00008	0.00003	0.00004	0.00004	0.00006	0.00004	0.00004	0.00004	0.00002	0.00003	0.00004	0.00006	0.00002	0.00003				
Copper-D	mg/L	0.0007	0.0008	0.001	0.0007	0.0006	0.0009	0.0006	0.0007	0.0007	0.0025	0.0006	0.0006	0.0008	0.0008	0.0004	0.0006	0.0029	0.0001	0.0008				
Iron-D	mg/L	0.2148	0.1687	0.1499	0.1769	0.1147	0.1511	0.0568	0.1697	0.1287	0.2112	0.2736	0.1825	0.3115	0.1366	0.143	0.0766	0.1564	0.0158	0.116		0.35		
Lead-D	mg/L	0.00015	0.00005	0.00019	0.00006	0.00006	0.00009	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00026	0.00005	0.00017	0.00005	0.00005	0.00005	0.00005				
Lithium-D	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001				
Magnesium-D	mg/L	0.71	3.35	1.93	2.53	1.36	4.25	5.54	5.15	3.12	4.39	1.36	4.84	7.49	2.04	1.38	3.04	9.12	4.83	4.06				
Manganese-D	mg/L	0.01478	0.00763	0.02849	0.00817	0.00766	0.02454	0.02298	0.03642	0.00346	0.00336	0.01492	0.04627	0.06685	0.02009	0.0553	0.01284	0.00719	0.00155	0.00392				
Mercury-D	mg/L	0.000011	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.00001	0.000013	0.000008	0.000008	0.000008	0.000005	0.000005	0.000008	0.000008	0.000005	0.000005				
Molybdenum-D	mg/L	0.0003	0.00083	0.00018	0.00027	0.00055	0.00077	0.00059	0.00062	0.00084	0.00035	0.0006	0.00063	0.00068	0.00068	0.00084	0.00213	0.00076	0.00074	0.00089				
Nickel-D	mg/L	0.00042	0.00075	0.0004	0.00028	0.00038	0.0005	0.00028	0.00033	0.00031	0.00029	0.00014	0.00033	0.00036	0.00015	0.00008	0.00024	0.00107	0.00005	0.00027				
Phosphorous-D	mg/L	0.02	0.05	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.05	0.01	0.01				
Potassium-D	mg/L	0.5	0.6	0.9	0.5	0.5	0.8	1	0.9	0.5	0.6	0.5	1	1.4	0.6	0.5	0.5	3.5	0.7	0.7				
Selenium-D	mg/L	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006				
Silicon-D	mg/L	6.62	9.52	5.95	6.34	6.16	6.67	5.27	5.43	6.74	6.83	4	5.62	8.63	2.99	1.96	6.65	13.18	6.84	6.83				
Silver-D	mg/L	0.00005	0.00005	0.00012	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005				
Sodium-D	mg/L	2.5	4.1	4.5	3.1	2.8	4.2	4.1	3.9	3.7	3.9	2.3	3.7	5.4	2.4	2.3	3.7	7.4	3	4.1				
Strontium-D	mg/L	0.026704	0.0873	0.055005	0.054925	0.053309	0.106855	0.10955	0.11	0.098147	0.12348	0.064415	0.110505	0.14995	0.082408	0.05103	0.061948	0.063676	0.12344	0.107				
Thallium-D	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005				
Tin-D	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001				
Titanium-D	mg/L	0.0049	0.0037	0.0035	0.0027	0.0026	0.0025	0.0004	0.0012	0.0033	0.006	0.0027	0.001	0.0012	0.0012	0.001	0.0009	0.0019	0.0002	0.0029				
Uranium-D	mg/L	0.00018	0.0002	0.00005	0.00008	0.00022	0.00028	0.0001	0.00013	0.00029	0.0003	0.00022	0.00012	0.00025	0.00017	0.00028	0.0001	0.00013	0.00034	0.00027				
Vanadium-D	mg/L	0.00031	0.00159	0.00014	0.00034	0.00017	0.00051	0.00025	0.00037	0.00031	0.00056	0.00024	0.00035	0.00024	0.00005	0.00005	0.0002	0.00141	0.00083	0.00005				
Zinc-D	mg/L	0.009	0.0089	0.0534	0.0041	0.0045	0.0153	0.0049	0.0039	0.005	0.0056	0.0054	0.0044	0.0123	0.0037	0.0059	0.0033	0.0958	0.0024	0.0029				
D-Hardness as $CaCO_3$	mg/L	10	46.9	35.8	31.8	23	61.8	80	74.6	46.1	69	25.9	76.2	102.8	27.4	21.9	38.8	73.3	109.5	62				
Cyanide																								
Cyanide (Total)	mg/L	0.014	0.01	0.0097	0.0115	0.009	0.0104	0.0052	0.0083	0.0106	0.0164	0.0098	0.0083	0.0079	0.005	0.005	0.005	0.005	0.005	0.005				
Cyanide (WAD)	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01		0.005

		WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	WQ26	BC MOE Guideline		CCME	
Parameters	**Unit**	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	95th %ile	**30-day**	Maximum	Long Term	*Short Term*
Cyanate	mg/L	0.35	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				0.2				
Thiocyanate (SCN)	mg/L	0.6	0.5	0.54	0.64	0.5	0.7	0.5	0.59	0.5	1.08	0.69	0.58	0.64	0.5	0.5				0.5				
Blackwater – Field Parameters																								
Conductivity (EC)	µS/cm	24.7	109.7	67.9	76.5	52	133.2	185.1	160	110.2	126	50.5	162.9	220.5	53.3	49.8	94.5	150.9	130.8	119.9				
DO Saturation %	%	101.7	107.2	96.1	104.1	104.4	107.6	116.6	110.3	114.2	108.7	104.5	107.7	105.1	106.4	100.2	175	152.9	88.5	178.4				
pH	pH	7.9	8.7	8.3	8.3	8.3	8.8	8.8	8.5	8.1	8.3	9	9	8.5	***9.3***	***9.5***	8.7	8	***9.8***	8.5	6.5-9.0			6.5-9.0
Temperature	°C	9.34	6.62	9.38	10.02	9.94	10.58	17.18	15.17	8.74	9.28	11.94	14.64	13.36	12.15	12.4	5.51	11.39	8.3	7.02		18		

Note: red font = exceeds 30 day guideline; **red & bold** = exceeds maximum guideline

Table 5.1.2.2-3: Stream Mean Concentration Exceedances

Site	Parameters Exceeded			
	BC FWG 30-day	**BC FWG Max.**	**CCME Long Term**	**CCME Short Term**
WQ1, WQ3, WQ4, WQ5, WQ6, WQ7, WQ10, WQ11, WQ12, WQ16, WQ18, WQ26			Al-t	
WQ1, WQ4, WQ5, WQ6, WQ7, WQ16	Cd-t[(1)]			
WQ18		Cr-t		
WQ7, WQ14, WQ18			Fe-t	
WQ4	Ag-t	Zn-t		
WQ7, WQ18		Zn-t		
WQ1, WQ4, WQ5, WQ10, WQ11, WQ26		Al-d		
WQ3, WQ6, WQ7, WQ12	Al-d			

Note: d = dissolved, t = total, Al = aluminum, Cd = cadmium, Cr = chromium, Fe = iron, Ag = silver, Zn = zinc.
The cadmium guidelines used were BC MOE, 2006 working guideline and CCME draft 2012.
[(1)] The BC (2006) soft water guideline is below MDL of 0.015 µg/L at 0.01 µg/L, thus all sites <MDL could be above the BC guideline.

Parameters with provincial or federal guidelines are discussed in detail in the baseline water quality report (**Appendix 5.1.2.2A**).

In general the 95th percentile exceedance pattern followed that of the means. Total copper was added to the list of exceeded guidelines at WQ11 (tributary of Turtle Creek) and WQ18 (Blackwater River). Total iron was added to the list of BCFWG exceedances (WQ14 – mouth of Turtle Creek and WQ18).

Mean results for lakes are presented in **Table 5.1.2.2-5**, and were generated by combining epilimnion, metalimnion, and hypolimnion profile samples. There were few exceedances of BC FWG: total cadmium at WQ21, WQ24, and WQ25, and dissolved iron at WQ23, WQ24, and WQ25. CCME guideline for total iron was exceeded at WQ23 and WQ24.

Complete results are attached in the water quality baseline report data appendix. Quality control for field and laboratory followed BC MOE protocols (2012b) and are discussed in the baseline report

Table 5.1.2.2-4: Exceedance Count for Provincial and Federal Protection of Aquatic Life Guidelines

Stn	Parameter	BC FWG-30d	BC FWG-max	CCME Long Term	CCME Short Term
WQ1	Al-t			29 of 29 (100%)	
WQ1	Cd-t	11 of 29 (38%)			
WQ1	Al-d	28 of 29 (97%)	27 of 29 (93%)		
WQ3	Al-t			22 of 38 (58%)	
WQ3	Al-d	18 of 38 (47%)			
WQ4	Al-t			23 of 28 (82%)	
WQ4	Cd-t	26 of 28 (93%)			
WQ4	Fe-t			4 of 28 (14%)	
WQ4	Ag-t			7 of 28 (25%)	
WQ4	Zn-t	27 of 28 (96%)	22 of 28 (79%)	22 of 28 (79%)	
WQ4	Al-d	22 of 28 (79%	17 of 28 (61%)		
WQ5	Al-t			19 of 30 (63%)	
WQ5	Cd-t	5 of 30 (73%)			
WQ5	Al-d		25 of 30 (83%)	19 of 30 (63%)	
WQ6	Al-t			19 of 34 (56%)	
WQ6	Cd-t	6 of 34 (18%)			
WQ6	Al-d	14 of 34 (41%)			
WQ7	Al-t			20 of 38 (53%)	
WQ7	Cd-t	8 of 38 (21%)			
WQ7	Fe-t			10 of 38 (26%)	
WQ7	Zn-t	7 of 38 (18%)	6 of 38 (16)	6 of 38 (16)	
WQ7	Al-d	19 of 38 (50%)			
WQ10	Al-t			21 of 39 (54%)	
WQ10	Al-d	20 of 39 (51%)	18 of 39 (46%)		
WQ11	Al-t			25 of 33 (76%)	
WQ11	Al-d	29 of 33 (88%)	24 of 33 (73%)		
WQ12	Al-t			22 of 38 (58%)	
WQ12	Al-d	22 of 38 (58%)			
WQ14	Fe-t			11 of 31 (35%)	
WQ16	Al-t			4 of 14 (29%)	
WQ16	Cd-t	4 of 14 (29%)			
WQ18	Al-t			1 of 5 (20%)	
WQ18	Cr-t	1 of 5 (20%)			
WQ18	Fe-t		1 of 5 (20%)	1 of 5 (20%)	
WQ18	Zn-t	1 of 5 (20%)	1 of 5 (20%)		
WQ26	Al-t			5 of 11 (45%)	
WQ26	Al-d	5 of 11 (45%)	4 of 11 (36%)		

.

Table 5.1.2.2-5: Lake Water Quality Summary Means

Parameter	Unit	WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	BC FWG		CCME	
								30-day	Max.	Long Term	Short Term
pH at 25°	pH	7.95	7.91	7.65	7.47	7.5	7.47	6.5-9.0			
Conductivity at 25°C	µS/cm	158.7	147.1	99.5	61	53.2	52.5				
T-Dissolved Solids at 180°C	mg/L	104.4	102.2	73.3	31.7	22.9	23.3				
Total Suspended Solids at 105°C	mg/L	6	2.4	2.3	2.9	2.2	2	5	+10%		
Turbidity	NTU	18.37	1.17	2.53	2.41	4.42	1.07	8 above bg	+10%		
Hardness as $CaCO_3$	mg/L	74	69.7	43.8	24.2	22.4	24.8				
Alkalinity as $CaCO_3$	mg/L	84.7	75.8	50.8	26.8	31.7	24.6				
Fluoride-D	mg/L	0.09	0.08	0.08	0.05	0.04	0.04	a	a	0.120	
Sulphate-D	mg/L	2	3.7	0.8	1.9	1.4	1.6	b			
Chloride-D(1)	mg/L	0.6	0.4	0.5	0.4	0.4	0.3	150		120	640
Ammonia - Nitrogen	mg/L	0.07	0.02	0.02	0.11	0.08	0.02	c		c	
Nitrate-N-D(2)	mg/L	0.03	0.047	0.095	0.036	0.04	0.04	3		3	
Nitrite-N-D	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.02		0.06	
Total Kjeldahl Nitrogen (TKN)	mg/L	0.5	0.21	0.44	0.18	0.15	0.18				
Phosphorous-Ortho(3)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003				
Phosphorous (Total-Dissolved)	mg/L	0.02	0.02	0.01	0.07	0.03	0.01				
Carbon (Total Organic)(4)	mg/L	13	11.7	17.9	5	5.8	8.8	±20%			
Carbon (Dissolved Organic)(5)	mg/L	12.3	11.4	16	4.5	5.6	8.6				
Aluminum-T(6)	mg/L	0.032	0.01	0.014	0.008	0.015	0.02			0.1	
Antimony-T(7)	mg/L	<0.00005	<0.00005	0.00006	0.00006	0.00006	<0.00005	0.02			
Arsenic-T	mg/L	0.0003	0.0004	0.0003	0.0026	0.0018	<0.0002	0.005		0.005	
Barium-T(8)	mg/L	0.01033	0.00602	0.00764	0.00401	0.00435	0.00891				
Beryllium-T(9)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Boron-T	mg/L	0.002	0.003	0.002	<0.001	<0.001	<0.001			1.5	29
Cadmium-T	mg/L	0.000012	**0.000024**	0.00002	0.000017	**0.000024**	**0.000032**		d (µg/L)	e (µg/L)	f (µg/L)
Calcium-T(10)	mg/L	21.6	21.1	12.8	7.7	7.2	8.4				

Parameter	Unit	WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	BC FWG		CCME	
								30-day	Max.	Long Term	Short Term
Chromium-T[(11)]	mg/L	0.0003	<0.0002	0.0003	<0.0002	0.0003	0.0003	g		h	
Cobalt-T	mg/L	0.00003	<0.00002	<0.00002	0.00004	0.00004	<0.00002	0.004	0.110		
Copper-T[(12)]	mg/L	0.0006	0.0006	0.0004	<0.0001	0.0002	0.0002	i (µg/L)	j (µg/L)	k	
Iron-T[(13)]	mg/L	0.1251	0.0226	0.1784	0.7836	0.9066	0.0579		1	0.3	
Lead-T[(14)]	mg/L	0.00143	0.00079	0.00073	0.00006	0.00006	0.00006	l (µg/L)	m (µg/L)	n	
Lithium-T	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.870		
Magnesium-T[(15)]	mg/L	5.85	4.81	3.41	1.34	1.3	1.16				
Manganese-T[(16)]	mg/L	0.115303	0.011469	0.044585	0.111516	0.255154	0.026627	o (µg/L)	p (µg/L)		
Mercury-T[(17)]	mg/L	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.00002	0.0001		
Molybdenum-T	mg/L	0.00078	0.00056	0.00031	0.00081	0.00126	0.00066		1	0.073	
Nickel-T[(18)]	mg/L	0.00028	0.00025	0.00016	0.00012	<0.00005	0.00008	q		q	
Phosphorous-T	mg/L	0.04	0.02	0.02	0.07	0.04	0.02	5	15		
Potassium-T	mg/L	0.9	0.8	1.1	0.5	0.5	0.5				
Selenium-T	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	0.002		0.001	
Silicon-T	mg/L	7.55	4.61	5.21	4.79	1.86	2				
Silver-T	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	r		0.00001	
Sodium-T	mg/L	3.5	3.6	3.2	2.4	1.9	1.8				
Strontium-T	mg/L	0.110778	0.101189	0.0718	0.05105	0.047625	0.080883				
Thallium-T	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005		0.0003	0.00008	
Tin-T	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Titanium-T	mg/L	0.0017	<0.0002	0.0003	<0.0002	<0.0002	<0.0002				
Uranium-T	mg/L	<0.00005	0.00009	<0.00005	0.00013	0.00032	0.00013		0.300	0.015	0.033
Vanadium-T	mg/L	<0.0001	<0.0001	<0.0001	0.00008	0.00008	0.00007	0.006			
Zinc-T	mg/L	0.0048	0.0058	0.0055	0.0021	0.0023	0.0026	s (µg/L)	t (µg/L)	0.030	
T-Hardness as $CaCO_3$	mg/L	74.2	68.8	43.5	22.1	18.2	21.7				
Aluminum-D	mg/L	<0.002	0.003	0.01	0.004	0.008	0.014	0.05	0.1		
Antimony-D	mg/L	<0.00005	<0.00005	0.00006	0.00006	0.00006	<0.00005				
Arsenic-D	mg/L	0.0003	0.0004	0.0003	0.0026	0.0017	0.0002				

Parameter	Unit	WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	BC FWG		CCME	
								30-day	Max.	Long Term	Short Term
Barium-D	mg/L	0.00872	0.00555	0.00686	0.0037	0.00388	0.00779				
Beryllium-D	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Boron-D	mg/L	0.003	0.003	<0.001	<0.001	<0.001	<0.001				
Cadmium-D	mg/L	<0.000015	<0.000015	<0.000015	<0.000015	<0.000015	<0.000015				
Calcium-D(19)	mg/L	20.1	20	12.1	7.5	6.8	8				
Chromium-D(20)	mg/L	0.0003	<0.0002	0.0003	<0.0002	0.0003	0.0003				
Cobalt-D	mg/L	<0.00002	<0.00002	<0.00002	0.00003	0.00004	<0.00002				
Copper-D	mg/L	<0.0001	0.0003	0.0002	<0.0001	0.0002	0.0002				
Iron-D	mg/L	0.048	0.0104	0.1174	0.7383	0.8172	0.0389		0.350		
Lead-D	mg/L	0.00012	0.00031	0.00044	<0.00005	<0.00005	<0.00005				
Lithium-D	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				
Magnesium-D	mg/L	5.66	4.64	3.29	1.31	1.27	1.12				
Manganese-D	mg/L	0.08753	0.00055	0.03829	0.10352	0.25306	0.02244				
Mercury-D	mg/L	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005				
Molybdenum-D	mg/L	0.00075	0.00055	0.0003	0.00078	0.00117	0.00065				
Nickel-D	mg/L	0.00012	0.00017	0.00009	<0.00005	<0.00005	0.00006				
Phosphorous-D	mg/L	0.02	0.02	<0.01	0.06	0.04	0.01				
Potassium-D	mg/L	0.9	0.8	1.1	<0.5	<0.5	<0.5				
Selenium-D	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006				
Silicon-D	mg/L	7.35	4.52	5.08	4.67	1.83	1.98				
Silver-D	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005				
Sodium-D	mg/L	3.4	3.5	3.2	2.4	1.9	1.7				
Strontium-D	mg/L	0.1028	0.096611	0.067217	0.049433	0.044375	0.073183				
Thallium-D	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005				
Tin-D	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				
Titanium-D	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002				
Uranium-D	mg/L	0.00005	0.00009	<0.00005	0.00013	0.00029	0.00012				
Vanadium-D	mg/L	0.00013	0.0001	0.00008	<0.00005	<0.00005	<0.00005				
Zinc-D	mg/L	0.0037	0.0051	0.0055	0.0021	0.0023	0.0025				

Parameter	Unit	WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	BC FWG		CCME	
								30-day	Max.	Long Term	Short Term
D-Hardness as $CaCO_3$	mg/L	68.1	64.8	40.2	21	16.8	19.6				
Cyanide (Total)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cyanide (WAD)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		0.005	0.005	0.010

Note:
a 0.4 mg/L hardness <10 mg/L [-51.73+92.57 x log{hardness}]x0.01 hardness >10 mg/L
b 115-410 mg/L Hardness=0-250 mg/L
c pH/Temp dependent Refer to Fig. 4.2-1
d 10e(0.86[log{hardness}]-3.2)
e 10e(0.83[log{hardness}]-1.71)
f 10e(1.01[log{hardness}]-2.46)
g 0.001 mg/L Cr6+ 0.0089 mg/L Cr3+
h 0.001 mg/L CR6+
i 0.002 hardness <50 mg/L 0.04 x [mean hardness] hardness >50 mg/L
j (0.094[hardness]) +2
k 0.002-0.006 mg/L hardness 0->180 mg/L
l 3.31+e(1.273 ln[mean hardness]-4.704)
m 3(1.273 ln[mean hardness]-1.460)
n 0.001-0.007 mg/L hardness 0->180 mg/L
o (0.00044 x hardness)+0.605
p (0.1102 x hardness)+0.54
q 0.025-0.150 mg/L hardness 0->180 mg/L
r 0.00005 mg/L hardness <100 mg/L 0.0015 mg/L hardness >100 mg/L
s 7.5 hardness <90 mg/L 7.5 + 0.75 x (hardness -90)
t 33 hardness <90 mg/L hardness >90 mg/L 33+0.75 x (hardness -90) hardness >90 mg/L

red font = exceeds 30 day guideline; **red & bold** = exceeds maximum guideline

5.1.2.2.1.4 Kluskus-Ootsa FSR, Transmission Line and Transmission Line Temporary Access

Water quality sampling for laboratory analytical testing was not conducted along the Kluskus-Ootsa FSR, transmission line, or the transmission line temporary or existing access right-of-ways (ROWs). The only potential issue for these areas (aside from accidental spills) would be erosion of upland sediment into water bodies at crossings during construction activities. Streams will be monitored during construction upstream and downstream of disturbance areas which is the only information pertinent to project effects. A general survey of the ROWs for fish suitability and navigability was conducted in 2013. As part of the survey, field measurements and observations about water clarity were conducted as it links to the potential effects of erosion of sediments. Field measurements were taken with electronic meters of some parameters of water quality in streams along the transmission line as part of the survey of fish and fish habitat, as described in **Section 5.1.2.6.1.3** (Fish Habitat VC Indicators). This survey included water quality variables such as temperature, conductivity, pH, the concentration of dissolved oxygen (DO), and transparency (as measured by Secchi depth). Results are presented in **Appendix 5.1.2.6B**, Annex 5.8-1.

5.1.2.2.2 Sediment Quality

Sediment quality was monitored in 2011, 2012, and 2013 for area streams. Since water quality monitoring sites were changed over the period, sediment sampling sites were also changed to mirror water quality site changes. In 2013, lake sediment samples were also collected; **Table 5.1.2.2-6** lists the sites and dates sampled.

Table 5.1.2.2-6: Sediment Sampling Program

Site	Type	2011	2012	2013
WQ1	Stream	X	X	
WQ3	Stream	X	X	
WQ4	Stream	X	X	
WQ5	Stream	X	X	
WQ6	Stream	X	X	
WQ7	Stream	X	X	
WQ8	Stream	X	X	
WQ9	Stream	X	X	
WQ10	Stream	X	X	
WQ11	Stream	X	X	
WQ12	Stream	X	X	
WQ13	Stream	X	X	
WQ14	Stream	X(1)	X(1)	
WQ15	Stream			X
WQ16	Stream			X
WQ17	Stream		X	
WQ18	Stream		X	
WQ19	Stream		X	
WQ21	Lake			X(1)
WQ22	Lake			X

Site	Type	2011	2012	2013
WQ23	Lake			X
WQ24	Lake			X
WQ25	Lake			X

Note: (1) Site where five replicates were collected

As per BC MOE (2012) guidelines, one sample was collected per station, plus five replicates at one station for each year. Laboratory splits were analyzed for every third sample. Exceedances of CCME Interim Sediment Quality Guidelines (ISQG) and Probable Effects Level (PEL) guidelines, and BC MOE Lowest Effects Level (LEL) and Severe Effects Level (SEL) guidelines occurred, and are listed in **Table 5.1.2.2-7**. Arsenic, iron, and manganese were exceeded most frequently (eight, five, and eight exceedances, respectively). Results are not atypical for streams, particularly in mineralized areas where sediment guidelines are often naturally exceeded. Healthy aquatic populations exist in all area streams and thus exceedances of guidelines do not indicate naturally occurring impairment of aquatic ecosystems. Sediment guidelines are often not a useful indicator of bioavailability and metals exposure for aquatic organisms.

Table 5.1.2.2-7: Exceedances of CCME and BC MOE Sediment Guidelines in Project Area Streams

Parameter	CCME ISQG	CCME PEL	BC MOE Lowest Effects Level	BC MOE Severe Effects Level
Arsenic	WQ1, WQ5, WQ10, WQ13, WQ17	WQ4, WQ6, WQ14	WQ1, WQ5, WQ10, WQ13, WQ17	WQ4, WQ6, WQ14
Cadmium	WQ2	WQ4	WQ2	WQ4
Chromium	WQ18, WQ19		WQ18, WQ19	
Copper	WQ15, WQ19		WQ15, WQ19	
Iron	WQ4, WQ13, WQ17, WQ18	WQ14	WQ4, WQ13, WQ17, WQ18	WQ14
Manganese			WQ5, WQ7, WQ10, WQ11, WQ17	WQ4, WQ13, WQ14
Mercury	WQ4		WQ4	
Nickel			WQ4, WQ7, WQ18, WQ19	
Silver				WQ4
Zinc	WQ1, WQ14	WQ4	WQ1, WQ14	WQ4

For stations where sampling occurred in 2011 and 2012, there was a fairly good correspondence between years for metals. For WQ14 where five replicates were collected in both 2011 and 2014, mercury had the highest inter-replicate variability, although recorded concentrations were low 0.02 µg/g to 0.04 µg/g. Zinc was next most variable (97 µg/g to 150 µg/g). **Table 5.1.2.2-8** lists mean results (individual results are for sites with only one sample).

Table 5.1.2.2-8: Blackwater Stream Sediment Summary

Station																					CCME		BC MOE Working Guidelines for Sediments	
Number																								
Analytical Parameter	Unit	MDL	WQ1 Mean 2	WQ3 Mean 4	WQ4 Mean 4	WQ5 Mean 2	WQ6 Mean 3	WQ7 Mean 4	WQ8 Mean 2	WQ9 Mean 2	WQ10 Mean 2	WQ11 Mean 2	WQ12 Mean 4	WQ13 Mean 2	WQ14 Mean 11	WQ15 1	WQ16 1	WQ17 1	WQ18 1	WQ19 1	ISQG (mg/kg)	PEL (mg/kg)	LEL based on SLC (mg/kg)	SEL based on SLC (mg/kg)
General Parameters																								
Moisture	%	0.5	58	66	13	32	88	28	10	54	42	50	65	50	13	65.2	41.9	26	35	34				
pH (1:1 H_2O) BC	pH unit	0.01	6.99	5.97	5.52	5.6	5.27	6.61	6.17	5.7	6.57	6.66	5.41	5.57	7.01	5.37	6.02	6.35	7.28	7.28				
Metals*																								
Aluminum	µg/g (ppm)	1	15,200	9,215	29,600	15,400	14,633	10,775	7,565	9,760	13,200	21,100	12,000	13,425	17,133	9,040	13,300	10,200	14,500	13,100				
Antimony	µg/g (ppm)	0.1	0.9	0.5	3.2	0.5	0.7	0.5	0.3	0.4	0.3	0.2	0.3	0.3	0.15	1.5	< 0.5	0.5	0.4	0.5				
Arsenic	µg/g (ppm)	0.05	16.2	5.8	**23.5**	7.3	**19.4**	5.4	2.3	3.4	9.5	5.3	4.4	12.9	**19.1**	5.4	1.9	11.2	3.99	4.53	5.9	**17**	5.9	**17**
Barium	µg/g (ppm)	0.1	112	81.1	243	104.6	135.3	95.6	56.7	83.3	121	163	109	168	258	161	123	92.5	119	58.9				
Beryllium	µg/g (ppm)	0.1	1	0.475	1.77	0.55	0.8	0.425	0.2	0.3	0.55	0.85	0.425	0.5	0.8	1	1.3	0.4	0.3	0.4				
Bismuth	µg/g (ppm)	0.1	0.1	< 0.1	0.2	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1			0.6	< 0.1	< 0.1				
Boron	µg/g (ppm)	0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.9			< 0.5	0.6	2.1				
Cadmium	µg/g (ppm)	0.01	1	0.3	**9.6**	0.3	0.6	0.2	0.1	0.1	0.2	0.3	0.1	0.3	0.5	0.6	0.3	0.3	0.2	0.4	0.6	**3.5**	0.6	**3.5**
Calcium	µg/g (ppm)	5	3,410	5,535	7,213	4,210	3,823	4,995	7,620	4,860	4,250	6,290	4,285	8,820	10,437	7,630	5,380	4,390	4,690	17,900				
Chromium	µg/g (ppm)	0.05	13.2	26.3	21.2	17.1	12.5	23.1	14.6	18.3	16.4	16.5	16.7	22.2	30	9.4	11.3	20.7	51.6	67.3	37.3	**90**	37.3	**90**
Cobalt	µg/g (ppm)	0.05	3.7	3.77	14.8	5.66	4.46	7.3	3.2	5.5	5.19	6.2	5.37	6.4	6.8	3.2	3	7.9	12.7	10.5				
Copper	µg/g (ppm)	0.01	10.5	9.6	25.8	12.9	12.1	12.8	14.4	11.4	9.3	18.2	11.4	24.7	36.8	37.3	20.8	25.6	15	61.8	35.7	**197**	35.7	**197**
Iron	µg/g (ppm)	5	11,800	9,733	31,267	15,600	16,400	18,875	8,875	15,250	17,950	19,900	16,900	34,450	**47,050**	10,900	7,300	23,600	28,700	18,800			21200	**43766**
Lead	µg/g (ppm)	0.1	10.9	11.2	48.4	10.9	17	7.9	4.5	6	9.8	7.4	6.9	6.1	6.1	19.4	13.7	8.9	3.9	7.2	35	**91.3**	35	**91.3**
Magnesium	µg/g (ppm)	1	1,700	1,600	2,150	2,655	2,063	3,678	2,660	3,090	2,265	2,750	2,590	3,450	3,725	1,230	1,800	2,900	6,110	7,620				
Manganese	µg/g (ppm)	0.1	212	400	**5,370**	544	430	462	195	250	494	743	339	**1,208**	**1,590**	1,090	95.4	596	454	364			460	**1100**
Mercury	µg/g (ppm)	0.02	0.11	0.07	0.23	0.06	0.15	0.04	< 0.02	0.03	0.06	0.065	0.048	0.045	0.043	0.22	0.13	0.02	0.06	0.06	0.17	**0.486**	0.17	**0.486**
Molybdenum	µg/g (ppm)	0.1	2.7	0.8	5.7	0.7	1.3	0.7	1.2	0.5	1.3	1.2	0.8	1.1	1.2	3.6	1.7	2.1	0.6	0.6				
Nickel	µg/g (ppm)	0.1	8.5	7.2	20.5	11	11.9	18.3	11.3	13.5	9.3	11	11	21.2	29.8	2.8	7.1	11.1	45.3	16.7			16	**75**
Phosphorus	µg/g (ppm)	5	812	661	1160	671	739	647	801	633	701	799	718	997	1,102	745	438	662	663	1,060				
Potassium	µg/g (ppm)	1	459	346	786	439	522	458	473	421	420	566	388	709	944	452	515	675	427	412				
Selenium	µg/g (ppm)	0.01	0.41	0.96	0.66	0.3	0.61	0.33	0.35	0.31	0.36	0.42	0.3	0.59	0.76	0.6	< 0.5	0.21	0.24	3.69			5	**5**
Silver	µg/g (ppm)	0.05	0.37	0.15	**3.62**	0.27	0.44	0.13	0.06	0.08	0.17	0.17	0.1	0.14	0.21	0.3	0.2	0.13	0.09	0.18			0.5	**0.5**
Sodium	µg/g)ppm)	1	94	109	105	141	87	199	269	212	124	130	159	187	177	116	113	249	336	364				
Strontium	µg/g (ppm)	0.1	35.7	46.8	63.5	36.7	43.1	41.8	52.6	36.9	36.6	55.2	34.2	63.7	80.2	74.2	42.3	36.2	37.9	70.3				
Thallium	µg/g (ppm)	0.05	0.4	0.1	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	< 0.5	< 0.5	0.1	< 0.05	0.1				
Tin	µg/g (ppm)	0.1	0.6	1.5	1.2	0.6	0.4	0.6	0.9	0.3	0.4	1	0.4	0.6	0.7	7.6	1.4	1.1	0.5	7.8				
Titanium	µg/g (ppm)	0.5	171	336	201	424	79	704	635	681	318	187	492	403	230	239	137	1,220	1,650	1,400				
Vanadium	µg/g (ppm)	0.05	38.6	28.7	53.2	30.9	26.7	42.8	24.2	34.9	34.2	35.5	33.8	45	56.5	18.4	13.5	55.6	65.9	53				
Zinc	µg/g (ppm)	0.5	125	50.4	**2913**	95.4	98.2	66.4	32.9	51	75.3	57.6	51.1	78.4	127.7	119	42.2	112	74	98	123	**315**	123	**315**
Organics																								
Inorganic Carbon	%	0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.16	<0.10	<0.10	<0.10	<0.10				
Total Organic Carbon	%	0.1	4.09	2.48	7.32	1.33	3.93	0.51	1.95	0.99	0.48	3.84	1.94	0.95	7.24	9.53	2.397	0.66	0.44	3.1				
$CaCO_3$ Equivalent	%	0.1	<0.80	<0.80	<0.80	<0.80	0.075	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	0.832	1.34	<0.80	<0.80	<0.80	<0.80				
Total Carbon by Combustion	%	0.1	4.1	2.5	7.3	1.3	3.9	0.5	1.9	1	0.5	3.8	2	1	7.3	9.7	3.0	0.7	0.4	3.1				
Particle Size																								
% Gravel (>2 mm)	%	0.1	0.1	0.1	<0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	5.07	7.71	<0.10	<0.10	<0.10				
% Sand (2.00 mm to 1.00 mm)	%	0.1	5.8	6.6	2.7	23	8.5	6.4	15.2	7.7	15.1	26	7.1	10.7	6.4	4.21	14.1	10	1.1	19.8				
% Sand (1.00 mm to 0.50 mm)	%	0.1	14.3	16.6	12	26	14.9	16.6	23.4	12.6	26.2	22.8	17.5	18.5	12.4	5.3	17.8	35.4	16.7	30.6				
% Sand (0.50 mm to 0.25 mm)	%	0.1	23.7	16.1	11.7	17.1	10.8	18.4	28.4	26.8	27.5	14.1	17.6	27.1	6.6	13.3	19.7	24.5	22.1	21				
% Sand (0.25 mm to 0.125 mm)	%	0.1	19.4	27.8	11.4	13.7	22.3	33.4	20.2	26.5	17.9	7.1	25.5	23.5	9.9	23.8	11.9	16.8	37.5	12.3				
% Sand (0.125 mm to 0.063 mm)	%	0.1	11.4	10	3.7	7.6	10.8	8.7	5.1	10.3	5.1	5.3	9.7	8.5	5.7	8.41	5.38	5.2	8.1	3.7				
% Silt (0.063 mm to 0.0312 mm)	%	0.1	13.5	10.7	19.6	4.5	14.8	7.6	2.5	8.7	3.3	7.9	10.1	4.9	24.3	17.5	8.1	2.8	3.9	4.7				
% Silt (0.0312 mm to 0.004 mm)	%	0.1	9.2	10	26.3	2.4	14.9	7.1	1.4	5.2	2.4	4.7	10.2	3.8	28.8	19	10.4	3.5	5.1	5.4				
% Clay (<4 µm)	%	0.1	5.15	2.09	12.6	0.9	3.1	1.9	0.9	2	1.7	1.3	2.4	2.9	5.9	3.42	5.03	1.9	5.6	2.4				

Note: red font = above ISQG/LEL; **red & bold** = above PEL/SEL

AMEC collected lake sediments in 2013 in response to the observation that increases in suspended sediments in hypolimnion (lake bottom) water samples often increased metals concentrations in the water samples. The Project will not directly affect lake sediments, except potentially some surface runoff from the West Dam to Lake 1428, but background information on lake sediment levels may be useful in interpreting water quality results.

Table 5.1.2.2-9 provides summary results for lake sediments; the complete results are provided in the Water Quality Baseline included in **Appendix, 5.1.2.2A**. Only one replicate sample was measured for particle size.

There were few guideline exceedances, all of which were for both ISQG and LEL:

- WQ22 Cu, Pb, Hg;
- WQ23 Hg;
- WQ24 Hg; and
- WQ25 Hg, Zn.

Mercury in lake-bottom sediments was slightly above guidelines in all lakes except Tatelkuz. The relatively low concentrations of sediment metals does not correlate with the observed elevation in hypolimnion water samples with increased sediment.

Table 5.1.2.2-9: Lake Sediment Mean Concentrations

Station Number								CCME		BC MOE Working Guidelines for Sediments	
Analytical Parameter	**Unit**	**MDL**	**WQ21 Mean 5**	**WQ22 Mean 2**	**WQ23 1**	**WQ24 1**	**WQ25 1**	**ISQG (mg/kg)**	**PEL (mg/kg)**	**LEL based on SLC (mg/kg)**	**SEL based on SLC (mg/kg)**
General Parameters											
Moisture	%	0.5	27.2	93.4	90	89.3	88.1				
pH (1:1 H2O) BC	pH units	0.01	6.30	5.90	5.72	5.52	5.84				
Metals*											
Aluminum	µg/g (ppm)	1	8,212	5,500	9,610	12,400	8,970				
Antimony	µg/g (ppm)	0.1	<0.5	0.7	3.1	1.4	0.6				
Arsenic	µg/g (ppm)	0.05	4.84	4.35	13.6	18	4.1	5.9	**17**	5.9	**17**
Barium	µg/g (ppm)	0.1	74.2	59	80	83	96				
Beryllium	µg/g (ppm)	0.1	0.22	0.2	0.9	1.1	0.7				
Bismuth	µg/g (ppm)	0.1									
Boron	µg/g (ppm)	0.5									
Cadmium	µg/g (ppm)	0.01	0.1	0.4	0.4	0.6	0.4	0.6	**3.5**	0.6	**3.5**
Calcium	µg/g (ppm)	5	4,050	10,300	3,970	3,450	3,510				
Chromium	µg/g (ppm)	0.05	26.66	22.9	18.3	14.3	9.2	37.3	**90**	37.3	**90**
Cobalt	µg/g (ppm)	0.05	5.32	3.2	2.7	3	2.7				
Copper	µg/g (ppm)	0.01	28.74	46.9	20	28.2	17.5	35.7	**197**	35.7	**197**
Iron	µg/g (ppm)	5	13,460	8,025	7,100	9,630	6,730			21200	**43,766**
Lead	µg/g (ppm)	0.1	18.72	44.55	16.4	23	18.1	35	**91.3**	35	**91.3**
Magnesium	µg/g (ppm)	1	3,628	2,815	1,220	1,350	764				
Manganese	µg/g (ppm)	0.1	264	262	158	254	464			460	**1,100**
Mercury	µg/g (ppm)	0.02	0.08	0.455	0.38	0.36	0.29	0.17	**0.486**	0.17	**0.486**
Molybdenum	µg/g (ppm)	0.1	1.24	2.5	4.8	7.3	3.5				
Nickel	µg/g (ppm)	0.1	15.5	15.1	6.3	7.3	5.7			16	**75**
Phosphorus	µg/g (ppm)	5	720.2	603.5	615	733	962				
Potassium	µg/g (ppm)	1	533	483.5	529	492	347				
Selenium	µg/g (ppm)	0.01	0.8	1.1	0.9	0.8	<0.5			5	**5**

Station Number								CCME		BC MOE Working Guidelines for Sediments	
Analytical Parameter	**Unit**	**MDL**	**WQ21 Mean 5**	**WQ22 Mean 2**	**WQ23 1**	**WQ24 1**	**WQ25 1**	**ISQG (mg/kg)**	**PEL (mg/kg)**	**LEL based on SLC (mg/kg)**	**SEL based on SLC (mg/kg)**
Silver	µg/g (ppm)	0.05	0.1	0.2	0.3	0.3	0.2			0.5	**0.5**
Sodium	µg/g)ppm)	1	249	791	125	102	79.6				
Strontium	µg/g (ppm)	0.1	30.1	59.8	36.4	35	44.8				
Thallium	µg/g (ppm)	0.05	<0.5	<0.5	< 0.5	<0.5	<0.5				
Tin	µg/g (ppm)	0.1	15.5	44.2	4.6	3.4	19				
Titanium	µg/g (ppm)	0.5	839	205	198	157	97.4				
Vanadium	µg/g (ppm)	0.05	33.24	26.5	21.5	26	16.4				
Zinc	µg/g (ppm)	0.5	58	101	77	94	140	123	**315**	123	**315**
Organics											
Inorganic Carbon	%	0.1	<0.10	<0.10	<0.10	<0.10	<0.10				
Total Organic Carbon	%	0.1	0.53	27.3	12.7	11.1	10.4				
$CaCO_3$ Equivalent	%	0.1	<0.80	<0.80	<0.80	<0.80	<0.80				
Total Carbon by Combustion	%	0.1	0.5	27.3	12.7	11.1	10.4				
Particle Size											
% Gravel (>2 mm)	%	0.1	12	<0.10	<0.10	<0.10	<0.10				
% Sand (2.00 mm to 1.00 mm)	%	0.1	11.9	<0.10	<0.10	<0.10	<0.10				
% Sand (1.00 mm to 0.50 mm)	%	0.1	15.8	0.19	<0.10	<0.10	<0.10				
% Sand (0.50 mm to 0.25 mm)	%	0.1	32.9	0.29	0.12	<0.10	<0.10				
% Sand (0.25 mm to 0.125 mm)	%	0.1	14.3	0.91	0.47	<0.10	<0.10				
% Sand (0.125 mm to 0.063 mm)	%	0.1	7.19	2.76	1.64	0.39	<0.10				
% Silt (0.063 mm to 0.0312 mm)	%	0.1	3.59	39.4	31.7	23.1	27.8				
% Silt (0.0312 mm to 0.004 mm)	%	0.1	2.22	47.5	50.6	56	51.3				
% Clay (<4 µm)	%	0.1	0.13	8.87	15.4	20.3	20.8				

Note: red font = above ISQG/LEL; **red & bold** = above PEL/SEL

5.1.2.3 Hydrogeology

This section presents a summary of the methods used and results for the characterization of baseline groundwater quantity in the LSA and the RSA. The LSA has been determined as a buffer area of approximately 1 km around the proposed mine footprint, and the RSA has been selected as the area encompassing and coinciding with the regional watersheds potentially connected with the mine activities (**Figure 5.1.2.3-1**). Baseline characterization consists of the review of available data, laboratory test results, and on-site field investigations. These test pit, drilling and laboratory test results, and other on-site field investigation data are presented in detail in the Knight Piésold 2012 Site Investigation Report (presented in **Appendix 5.1.2.3A**). The review of available data included:

- Current groundwater use in the area;
- Published geology and hydrogeology reports;
- Geological maps, watershed maps, and aerial photography (e.g., Watershed Modelling Report, **Appendix 5.1.2.1B**);
- Geological conditions based on drill hole and test pit data (e.g., Geotechnical Characterization Report, **Appendix 2.2A-4**);
- Climate and hydrometeorology and stream flow data (e.g., 2013 Hydrometeorology Report, **Appendix 5.1.1.1A**); and
- Results of laboratory permeability testing of samples obtained from site investigations.

On-site hydrogeology field investigations included:

- Installation of groundwater monitoring wells and water flow and quality sampling;
- Determination of groundwater levels and seasonal variation; and
- Completion of field hydrogeologic testing.

5.1.2.3.1 Geographic Setting

A general description of the geographic setting, landforms, topography, soil types, geomorphologic conditions, drainage, and climate, is provided in **Section 2.2** of this Application. The general geomorphology in the Project area is described as an area of moderate relief on the Interior Plateau east of the Coast Mountains, having an interior BC climate pattern. The mean annual temperature is 2.0 degrees Celsius, and the regional windspeed is 2.4 m/s. The mean annual precipitation is an estimated 636 mm.

Surface soils date to the last period of ice sheet glaciations in BC, termed the 'Fraser Glaciation'. The Cordilleran ice sheet covered this part of the Interior Plateau from about 20,000 years ago until 12,000 years ago and reached elevations of about 2,500 masl. Local ice flow at the mine site at the peak of glaciations was toward the northeast and is recorded by drumlins, rock drumlins, and other streamlined glacial landforms.

Deglaciation commenced about 15,000 years ago to 16,000 years ago and proceeded by frontal retreat to the west or southwest, back toward the Coast Mountains, and progressive lowering of the ice sheet surface by downwasting. The pattern of ice-marginal and subglacial meltwater channels indicates that high areas in the vicinity of the proposed mine site became ice free before low areas. Late during deglaciation, glacier ice appears to have stagnated in the valley of Davidson Creek, producing ice stagnation landforms such has kettles and kames. Large amounts of glacial meltwater were channeled along Davidson Creek and other valleys in the area, producing eskers and ablation till.

Terrain mapping indicates the surficial geology at the site of the proposed mine facility comprises a blanket of glacial till, ranging from gravelly silt with some cobbles and boulders to silty sand and gravel with some cobbles and boulders. Broad deposits of glaciofluvial soils exist along main drainage lines. These soils can be interpreted to be ice contact kame deposits. An area of north-trending sinous ridges can be found in the east part of the study area, as indicated as eskers. Surface veneer of colluviums is present on the steepest slopes in the west part of the proposed Project area on the moderate, incised slopes, adjacent to the main watercourses. Organic soils, comprising spongy fibrous peat, are found in the mine footprint area. Fluvial deposits are present in the vicinity of the main watercourses. Bedrock exposure is limited to the upland south and west parts of the proposed Project site. Relatively few landslides were identified in the area; they are mainly debris slides and rock fall. The terrain stability classification indicates the majority of the area to be stable.

5.1.2.3.2 MODFLOW

The MODFLOW report prepared by Knight Piésold presents the following (**Appendix 5.3.5A**):

- General description of the geographic setting, landforms, topography, drainage, climate, soil types, and geomorphologic conditions;
- General description of geologic setting, type and nature of geologic materials, vertical and lateral extent of geologic units, stratigraphy, and structural features;
- Locations and descriptions of hydrogeologic units, areal extent and thickness, and properties (hydraulic conductivity, etc.);
- Assessment of groundwater use, including amount and source(s) of groundwater recharge and discharge, quantity of groundwater storage, current amount of groundwater extraction, and potential amount available for future groundwater extraction;
- Description of local and regional groundwater levels, flow regime, and rates of movement;
- Evaluation of surface water/groundwater quantity interaction; and
- Evaluation of groundwater level data and hydraulic testing data.

Using the results of the field investigations and pertinent literature, conceptual flow models were prepared considering the following inputs:

- The watershed model was prepared to simulate monthly stream flows in the areas of the proposed mine. The model used climate records, streamflow records, and the conceptual groundwater model to develop monthly streamflows over a period of record. The model includes groundwater recharge, groundwater storage, and groundwater discharge. The watershed model also includes an evaluation of the precipitation, snow melt, evapotranspiration, infiltration, and runoff conditions; and
- A numerical 3-D groundwater flow model (MODFLOW) was used to simulate baseline groundwater flow conditions. The numerical model includes the assumptions developed as part of the conceptual model and the parameters and outputs of the watershed model and is calibrated to on-site measurements.

Due to the remote location of the proposed mine site, current groundwater extraction near the Project is negligible. The closest off-site wells (Kluskus well and TTM Resources well) are registered on the provincial WELLS database (BC MOE, 2013). One of these off-site wells reportedly supplies the Kluskus First Nation village at Kluskus Lake and the other is reportedly owned by a forest company. Both off-site wells are located more than 20 km from the Project.

Baseline investigation conceptual model preparation included review of provincial, regional, and local information sources to support the baseline assessment specific to the Project. Technical guidance for the design of the hydrogeology program and data collection methods took BC MOE (2012) guidelines into consideration, along with direction provided by provincial and federal agency staff.

Knight Piésold investigated site hydrogeology by drilling boreholes, installing monitoring wells and vibrating wire piezometers (VWP), and conducting well development and hydraulic tests in the Project's groundwater quantity and groundwater quality study areas. Baseline hydrogeology data were obtained from drilling information, in-situ hydraulic conductivity testing (packer testing and response testing), laboratory testing of samples and recorded groundwater levels at monitoring wells, standpipe piezometers, and VWP.

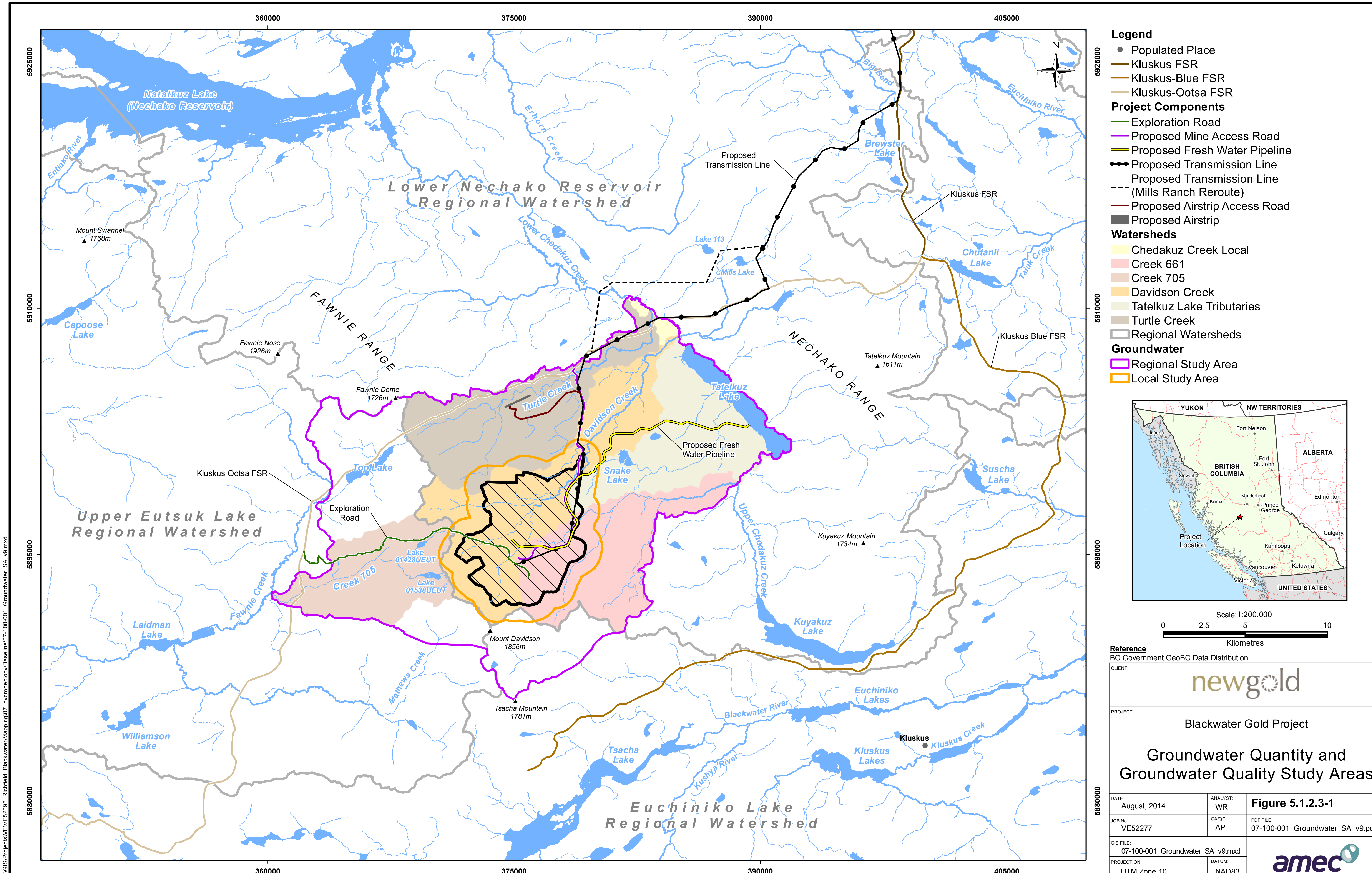
The groundwater monitoring well sites installed for groundwater quantity and quality assessments were strategically located both up-gradient and down-gradient of the proposed mine pit and infrastructure in order to provide site-wide spatial coverage. The 13 monitoring well pairs were installed between 21 March and 30 April 2012. All wells were developed and the water levels measured. Subsequently, the wells were response-tested and transducers were installed in all monitoring wells except eight that were found to be dry. The water levels of the 18 producing wells have been measured since the spring of 2012.

Two pumping tests were conducted in the open pit area: One test was conducted in an area of higher permeability bedrock within the deposit; the second was conducted in lower permeability bedrock south of the proposed open pit footprint. Two pumping wells and 12 observation wells with multipoint VWPs were installed to support the pumping test program. Artesian conditions were encountered within exploration drill holes near the northern edge of the deposit, with one hole flowing at 250 US gpm (0.0158 m^3/s).

Based on the drilling information and literature, the geology in the area has been simplified into eight hydrostratigraphic units:

- Fluvial and glaciofluvial channel deposits;
- Glaciofluvial kame deposits;
- Glacial till deposits;
- Glaciolacustrine and lacustrine deposits;
- Completely weathered bedrock (in situ and reworked regolith);
- Weathered bedrock;
- Higher permeability bedrock in the deposit area; and
- Competent bedrock.

Hydraulic conductivities for each hydrostratigraphic unit, based on in situ hydraulic conductivity testing, are provided in **Table 5.1.2.3-1**. Packer tests reported as “no take” have been presented as $1x10^{-9}$ m/s, and response tests with results below the measurable testing limit are presented as $1x10^{-8}$ m/s. Further details on each hydrostratigraphic unit follow below.



Legend
Populated Place
Kluskus FSR
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Proposed Transmission Line
Proposed Transmission Line (Mills Ranch Reroute)
Proposed Airstrip Access Road
Proposed Airstrip
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Regional Watersheds
Groundwater
Regional Study Area
Local Study Area
Natalkuz Lake (Nechako Reservoir)
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
FAWNIE RANGE
NECHAKO RANGE
Proposed Transmission Line
Kluskus FSR
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Exploration Road
Proposed Fresh Water Pipeline
Mount Swannel 1768m
Fawnie Nose 1926m
Fawnie Dome 1726m
Tatelkuz Mountain 1611m
Kuyakuz Mountain 1734m
Mount Davidson 1856m
Tsacha Mountain 1781m
Entiako River
Erhorn Creek
Lower Chedakuz Creek
Upper Chedakuz Creek
Big Bend
Euchiniko River
Brewster Lake
Lake 113
Mills Lake
Chutanli Lake
Taiuk Creek
Capoose Lake
Turtle Creek
Davidson Creek
Tatelkuz Lake
Top Lake
Snake Lake
Suscha Lake
Creek 705
Lake 01428UEUT
Lake 01538UEUT
Fawnie Creek
Laidman Lake
Kuyakuz Lake
Mathews Creek
Euchiniko Lakes
Blackwater River
Williamson Lake
Tsacha Lake
Kushya River
Kluskus Lakes
Kluskus
Kluskus Creek
360000
375000
390000
405000
5925000
5910000
5895000
5880000
N
YUKON
NW TERRITORIES
BRITISH COLUMBIA
ALBERTA
UNITED STATES
Fort Nelson
Fort St. John
Stewart
Vanderhoof
Prince George
Kitimat
Edmonton
Calgary
Kamloops
Kelowna
Vancouver
Victoria
Project Location
Scale:1:200,000
0 2.5 5 10
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Groundwater Quantity and Groundwater Quality Study Areas
DATE: August, 2014
ANALYST: WR
Figure 5.1.2.3-1
JOB No: VE52277
QA/QC: AP
PDF FILE: 07-100-001_Groundwater_SA_v9.pdf
GIS FILE: 07-100-001_Groundwater_SA_v9.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\07_hydrogeology\Baseline\07-100-001_Groundwater_SA_v9.mxd

Table 5.1.2.3-1: In Situ Hydraulic Conductivity Test Results

		Response Tests (No.)	Packer Tests (No.)	Airlift Tests (No.)	Minimum (m/s)	Maximum (m/s)	Log Mean (m/s)	Pumping Test (m/s)
Overburden	Glaciofluvial – Channel	1	-	-	9E-05	9E-05	-	-
	Glaciofluvial – Kame	6	-	-	1E-08	1E-03	4E-05	-
	Till	13	-	-	5E-08	7E-04	3E-06	-
	Lacustrine	1	-	-	1E-08	1E-08	-	-
Bedrock	***Weathered Bedrock (Geotechnical Investigations)[(1)]***							
	Completely Weathered	0	-	-	-	-	-	-
	Highly Weathered	3	-	-	2E-08	8E-08	4E-08	-
	Moderately Weathered	7	10	-	1E-09	2E-05	7E-08	-
	Slightly Weathered	4	65	-	1E-09	4E-06	7E-08	-
	Higher Permeability Bedrock Zone in the Deposit Area							
	Geomechanical Investigations[(2)]	-	129	-	5E-09	6E-05	8E-07	5E-06
	Hydrogeologic Investigation[(3)]	-	-	30	3E-08	2E-05	9E-07	
	Lower Permeability Bedrock Zone in the Deposit Area							
	Geomechanical Investigations[(2)]	-	45	-	1E-09	4E-06	8E-08	1E-07
	Hydrogeologic Investigation[(3)]		-	31	4E-08	8E-06	3E-07	

Note: [(1)] Blackwater 2012 geotechnical site investigation report (Knight Piésold, 2013c) and 2013 geotechnical site investigation report (Knight Piésold, 2013e).
[(2)] Feasibility open pit slope design report (Knight Piésold, 2013c).
[(3)] Open pit water management report (Knight Piésold, 2013h).
m/s = metres per second; No. = Number

Fluvial and glaciofluvial channel deposits: Channel deposits include esker deposits as well as glacial fluvial meltwater deposits and more recent fluvial channel deposits. This material is characterized by sands and gravels with little fines. One response test was conducted in a monitoring well installed in surficial material mapped as channel deposits. The hydraulic conductivity value estimated from the test of $9x10^{-5}$ m/s is within the lower range for loose granular deposits.

Glaciofluvial kame deposits: Kame deposits are mapped at the surface over much of the Davidson Creek valley and in the headwater tributaries feeding Creek 661. Kame deposits consist of silty and well-graded sand and gravel units. The geometric mean hydraulic conductivity of six response tests conducted in monitoring wells and piezometers screened in kame deposits is $4x10^{-5}$ m/s.

Glacial till deposits: Lodgement till covers much of the surface in the project area and has been encountered during site investigations at over 50 m thick. Ablation till has only been mapped within a few isolated locations at higher elevations and adjacent to Davidson Creek valley. The geometric mean hydraulic conductivity of 13 response tests conducted in monitoring wells and piezometers screened in till material is $3x10^{-6}$ m/s, which is at the upper limit of the expected range of hydraulic conductivity values for till material of $1x10^{-12}$ m/s to $1x10^{-6}$ m/s. Tests conducted in wells and piezometers screened in the till layer likely provide hydraulic conductivity values that are biased high, since monitoring well and piezometer installations tend to target more permeable, water-bearing zones. Laboratory testing of 108 till samples collected from drill holes and test pits for particle size analysis typically reported 25% to 45% fines (5th to 95th percentile distribution), with distributions of 5% to 50% gravel, 20% to 70% sand, 10% to 50% silt, and 0% to 17% clay. Results of laboratory permeability testing of till samples reported permeability ranges of 10^{-11} m/s to 10^{-7} m/s for 27 constant head tests and 10^{-8}m/s to 10^{-6} m/s for seven falling head tests. A hydraulic conductivity estimate, using the mean grain size distribution of the tests and the Kozeny-Carman equation, was $4x10^{-8}$ m/s, which falls within the range of laboratory tested values. A hydraulic conductivity value of $1x10^{-7}$ m/s has been adopted as a representative value for a till deposit, based on laboratory testing of the till material and grain size distributions.

Glaciolacustrine and lacustrine deposits: Glaciolacustrine sediments consist of thinly-bedded sandy silt, gravelly silt, and silt. Glaciolacustrine sediments are present beneath the upper till layer in the Davidson Creek valley. Recent lacustrine deposits are present at the surface beneath a few isolated lakes, such as Tatelkuz Lake. One response test was conducted in sediments identified as lacustrine (MW12-06D), which resulted in a hydraulic conductivity estimate of $<1x10^{-8}$ m/s. Laboratory testing of 40 glaciolacustrine samples collected from drill holes and test pits for particle size analysis typically reported 60% to 95% fines (5th to 95th percentile distribution) within the samples.

Bedrock: Within the MODFLOW model, bedrock is assumed to be a homogeneous unit, even though several types of bedrock are present at the study site. This approach is considered sufficient for the purpose of this hydrogeology assessment, considering the regional scale of the MODFLOW model.

For the separate TSF study a SEEP/W model was constructed which does separate the bedrock into several units since this model is constructed at the local TSF scale. Bedrock at the Project site is divided into units according to weathering and intactness, as follows:

- *Completely weathered bedrock:* Completely weathered bedrock (in situ regolith and reworked regolith) consists of a silt and clay matrix with abundant weathered bedrock clasts. This unit is inferred to be present only in the Davidson Creek valley. Laboratory testing of 32 in situ and reworked regolith samples collected from drill holes for particle size analysis reported 20% to 85% fines (5th to 95th percentile distribution within the samples). No in situ hydraulic conductivity tests were conducted exclusively within this unit; completion zones of monitoring wells screened in the completely weathered bedrock unit also spanned the contact with the overlying sand and gravel unit. The completely weathered bedrock unit is expected to be a low permeability unit, with a representative hydraulic conductivity of approximately 1x10-8 m/s;
- *Weathered bedrock:* The profile of weathering within the bedrock was distinguished based on characteristics of rock fracture spacing, intactness, and discolouration noted on drill core. The weathering profile grades with depth from highly weathered, to moderately weathered, to slightly weathered. Results only included tests conducted a distance from the deposit area, so that the hydraulic conductivity statistics were not influenced by tests conducted within higher permeability bedrock found in the deposit area (see discussion below). The maximum depth of tests conducted in weathered bedrock was generally less than 60 m below the top of the bedrock surface, although testing in one drill hole extended to a depth of 90 m below the top of the bedrock. The geometric mean hydraulic

conductivity increases slightly as weathering in the bedrock decreases from 4x10-8 m/s to 7x10-8 m/s. This increase in hydraulic conductivity is attributed to a decrease in clay infill within the weathered spaces. Only response tests could be conducted in the highly weathered bedrock zone, since difficulty seating the packer prohibited packer testing within the zone. The lower portion of the weathered bedrock is considered to be a more permeable pathway, and a hydraulic conductivity of 1x10-7 m/s is considered representative for this zone;

- *Higher permeability bedrock zone in the deposit area:* Results of in situ hydraulic conductivity testing and pumping tests indicate that bedrock within the central portion of the deposit area has a higher permeability than the surrounding bedrock due to faulting. The extent of this area is estimated and is closely, but not exactly, related to the “broken zone” in the Feasibility Open Pit Slope Design Report. A bulk hydraulic conductivity of 5x10-6 m/s was estimated for this higher permeability bedrock zone based on the results of a pumping test. The area of the higher permeability bedrock is inferred to be approximately 1 km wide and to extend to depths of 500 m below the bedrock surface. The higher permeability bedrock zone is mainly associated with the ore zone, is located within the limits of the proposed open pit, and will be excavated during mining operations; and
- *Competent bedrock:* Competent bedrock is present everywhere beneath the weathered bedrock. Hydraulic conductivity tests were conducted within deeper bedrock in the deposit area as part of open pit site investigation. The geometric mean hydraulic conductivity of 45 packer tests conducted in drill holes surrounding the open pit is $8x10^{-8}$ m/s. A bulk hydraulic conductivity of $1x10^{-7}$ m/s was estimated for the lower permeability bedrock zone surrounding the deposit, based on the results of a pumping test. Given the proximity of the packer and pumping tests to the higher permeability bedrock associated with the deposit, these test results for deeper bedrock are expected to be higher than elsewhere across the Project site. Drill holes for the geotechnical site investigations were advanced to depth until two consecutive packer tests yielded an estimated hydraulic conductivity value on the order of 10^{-7} m/s or less. As a result, tests from these site investigations are generally not considered to be part of the intact bedrock unit. Hydraulic conductivity in the competent bedrock is assumed to decrease with depth. A bulk hydraulic conductivity of $2x10^{-8}$ m/s is considered to be a representative value for the upper portion of the competent bedrock zone.

Groundwater in the Project area flows from recharge zones located in topographic highs (like Mount Davidson) to the vicinity of the proposed open pit, towards discharge zones located in the Davidson Creek, Turtle Creek, Creek 661, and Creek 705 valleys. Groundwater discharges into these creeks as baseflow, providing the majority of surface water flow in the winter and early spring months. At the local scale, geologic structures (faults and fractures) are expected to influence groundwater flow pathways and hydraulic gradients within the bedrock units. The main flow pathways in bedrock are through the highly fractured zones of rock. The upper 10 m to 20 m of bedrock is inferred to be highly fractured throughout the region and is expected to yield higher groundwater flow values than the underlying, more competent bedrock. A large zone of fractured bedrock, nearly circular in plan view, extends almost 500 m from the bedrock surface on the southeastern slope of Mount Davidson. This fractured rock, termed the broken zone, will be excavated by the planned open pit mine.

Based on these observations, a watershed and a MODFLOW groundwater model were constructed. The objectives of the modelling were to improve the understanding of the site hydrologic parameters and the hydrogeologic setting surrounding the Project area and to assess potential effects of the planned mine development and operations on surface water and groundwater quantity conditions in the Project area.

The watershed model was set up using catchment areas. The watershed model included estimates of precipitation, evapotranspiration, and sublimation that were used to determine the net water available for groundwater recharge and surface water runoff within the modelled area. The division of available water between groundwater and recharge and runoff was determined by calibrating the model to available streamflow records with values measured between 1991 and 2012. The calibration took into consideration characteristics of the streamflow response during both wet periods and low-flow conditions, which allowed for the estimation of streamflow, groundwater flow, and the groundwater component of streamflow (baseflow) leaving a catchment.

For the watershed modelling approach, a month-to-month water balance technique was selected to evaluate surface water and groundwater flows in the Project area. The following main characteristics and assumptions describe the watershed model:

- The watershed model was developed in spreadsheet format, which provided a simple and transparent technique that allowed for input and output flexibility;
- The watershed model was a semi-distributed, lumped parameter model, and the study area was divided into 16 sub-catchments within which groundwater and surface flows were modelled;
- The model was semi-distributed to allow for spatial variability of climate due to differences in elevation within each sub-catchment;
- Adjacent sub-catchments were linked together to allow surface and groundwater flows to be routed to downstream sub-catchments;
- The model was simulated with a monthly time step;
- The watershed model includes all aspects of the hydrologic cycle, including precipitation; snow accumulation; sublimation; rainfall and snowmelt; groundwater recharge, storage, and discharge; surface water detention in small ponds and wetlands; and inflows from upstream sub-catchments; and
- Long-term monthly precipitation data and temperature values for the Project area were estimated based on regional climate data.

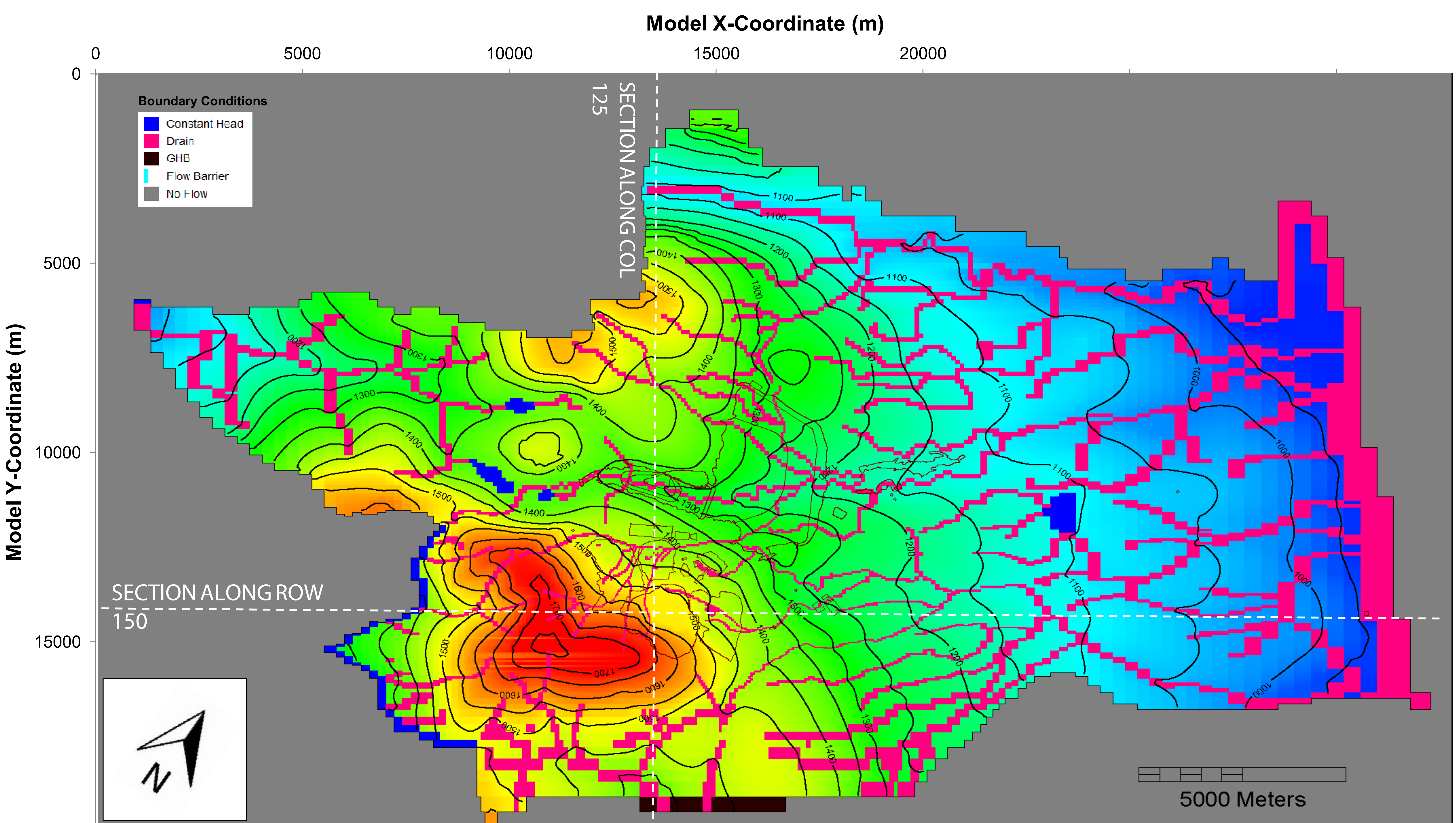
For the watershed model calibration, groundwater and surface water recharge and discharge parameters were adjusted to obtain a match between the monthly simulated and measured (or synthetic) streamflow records. The fit between modelled and observed streamflows was optimized to provide a good match between monthly mean streamflows, long-term mean monthly streamflows, cumulative mass balances, and flow distributions.

The numerical MODFLOW model was calibrated to baseflow targets with values derived from watershed modelling conducted for the Project representing average annual baseflows. Average annual baseflows are estimated with the watershed model using long-term synthetic streamflow records. Estimated baseflows at the outlets of Davidson Creek and Turtle Creek in the MODFLOW model are less than 5% different than baseflows estimated using the watershed model. MODFLOW-predicted baseflows within Creek 705 vary by over 40% from the watershed model estimates. There were limited surface water flow and groundwater head data available in Creek 705 with which to calibrate the watershed model; therefore, Creek 705 baseflow estimates have higher uncertainty than those for Davidson Creek and Creek 661, which are potentially more affected by the Project.

The baseline MODFLOW model results are presented in **Figure 5.1.2.3-2**.

The results from the MODFLOW baseline model calibration simulation were compared to head targets and local stream flow measurements. The head target results were measured VWP data and measured head data from monitoring wells. These measurements were considered generally representative of average annual conditions. The variation in simulated versus measured hydraulic heads in the model is generally less than 10 m, except for in the deposit area. This larger discrepancy was observed to be due to extensive faulting in the future pit area. The intention of the model calibration was not to reproduce the hydraulic head variation at all observation points within the deposit area, but to represent the hydrogeologic conditions over the modeled area.

Results from the watershed and MODFLOW models are further discussed in **Section 5.3.5**.



Notes:
The contour lines shown above are of model simulated water table elevation (masl).

Proposed Mine facility outlines are shown for spatial reference only and are not simulated in the baseline model.

Figure based on Knight Piesold drawing January 2014

Water Table Contours (masl)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900

CLIENT: newgold	DWN BY: AA	PROJECT: Blackwater Gold Project	DATE: January 2014
	CHK'D BY: MY		PROJECT NO: VE52277
AMEC Environment & Infrastructure, 4445 Lougheed, Suite 600, Burnaby, B.C., V5C 0E4, Tel. 604-294-3811 Fax 604-294-4664 — amec	DATUM: N/A	TITLE: **Baseline Model Observed vs. Simulated Hydraulic Head**	REV. NO.: A
	PROJECTION: N/A		FIGURE No. 5.1.2.3-2
	SCALE: N/A		

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\06_vegetation\EIA\reclam_2030.ai

5.1.2.4 Groundwater Quality

This groundwater quality baseline assessment's main objective is to document chemical quality information using monitoring wells installed within the proposed mine site footprint. Therefore, the baseline characterization was focused on LSA and to a lesser extent on the RSA as presented in **Figure 5.1.2.4-1**. The LSA has been determined as a buffer area of approximately one kilometer around the proposed mine footprint, and the RSA has been selected as the area encompassing and coinciding with the regional watersheds potentially connected with the mine activities. The baseline program entails 13 sets of monitoring wells (deep and shallow) installed in 2012 (**Figure 5.1.2.4-2**). Wells were strategically placed to provide observations both up-gradient of the proposed mine site, and down-gradient to capture potential groundwater impacts. Ongoing quarterly sampling started in May 2012, with five monitoring rounds completed to date. Knight Piésold 2013 baseline report included in **Appendix 5.1.2.4A** provides the complete groundwater quality baseline program report, including well installation, well sampling, and groundwater quality results. **Appendix 5.1.2.4B** also presents these data, and in addition groundwater sampling and analysis results obtained from the same wells by AMEC E&I in 2013 and 2014.

The scope of the baseline groundwater chemical quality assessment work was to:

- Install groundwater monitoring wells within and near the proposed mine-site footprint;
- Monitor groundwater conditions during five quarterly groundwater monitoring rounds using the monitoring wells;
- Review of methods for geological interpretation, well design and well installation;
- Confirmation of sampling protocols for the list of elements analyzed;
- Review the groundwater monitoring chemical analysis results obtained from other sources;
- Collation of groundwater quality sampling results;
- Interpretation and analysis of groundwater quality using applicable standards and criteria; and
- Prepare this baseline report documenting the activities and their results.

The objectives of the baseline groundwater chemical quality assessment were to:

- Characterize baseline groundwater chemical quality within the predicted area of impact for the proposed mine development and operations;
- Assess groundwater chemical quality to assist with the design of Project facilities and monitoring programs; and
- Identify groundwater chemical quality information to assist with baseline and effects assessments for the hydrogeology discipline and other disciplines, such as aquatic and fish resources, and wetland habitats.

The baseline assessment monitoring program was designed using mine plans available at March 2013, and complies with guidance from the BC MOE document, Water and Air Baseline Monitoring

Guidance Document for Mine Proponents and Operators (BC MOE, 2012), which mandates that groundwater chemical quality should be monitored quarterly for a minimum of one year to assess baseline conditions, including the potential for groundwater chemistry to vary seasonally.

For Quality Assurance/Quality Control (QA/QC), blank samples were created concurrent with groundwater sampling. Field blanks monitor potential sampling bias, and were created by transferring blank samples, provided by ALS laboratories, from their original bottle to a new, empty sampling bottle. Travel blanks monitor sample and sample-bottle cross-contamination during transport to and from the field. ALS also provided the travel blanks, which were transported to the site and returned to the laboratory along with groundwater samples. Duplicate samples were created to assess variation due to sample heterogeneity or errors in laboratory sample-preparation or analytical procedures.

Table 5.1.2.4-1 shows a summary of groundwater chemistry, which follows BC MOE (2006a, 2006b, 2008, 2009, and 2012) water quality guidelines (BC FWG).

Based on the groundwater baseline chemical quality analyses completed, the following key findings are noted:

- Analyte concentrations above detection limits were found in three field-blank samples. This suggests either that the groundwater sampling procedures, or the laboratory sample preparation or analysis procedures, have biased some results. Thus, significance of measured analyte concentrations near the analytical detection limits should be interpreted with caution;
- Presence of elevated measured total suspended solids (TSS) and turbidity concentrations were identified in some groundwater samples. The presence of these elevated TSS and/or turbidity in relation to metals concentrations may result in metals containing soil or rock particles or colloids being analyzed along with the sampled groundwater. The significance of measured total metals concentrations in such samples should therefore be interpreted with caution. In any case, the primary measure of groundwater quality is dissolved metals and elevated TSS and turbidity would not affect these values. Dissolved metal values will continue to be used to assess groundwater quality with total metals used as a QC check (i.e., dissolved metal results should always be less than total metal results); and
- Except for measured concentrations of aluminum, arsenic, iron, and manganese in some analyzed groundwater samples, measured substance concentrations in the groundwater baseline samples are less than the Approved and Working Drinking Water Quality Guidelines (AWWQG). Additional monitoring of groundwater chemical quality is required to determine if the range in measured concentrations of these metals reflects that of actual baseline groundwater conditions.

In summary, it can be stated that most analyses showed typical groundwater quality, with no anomalies indicative of groundwater contamination. High turbidity values in some wells indicated that more purging of wells is required. Except for measured concentration of aluminum, arsenic, iron, and manganese, the measured substance concentrations in the groundwater baseline samples meet the applicable drinking water guidelines. However, the values measured slightly above the guidelines are not deemed to be indicators of a trend.

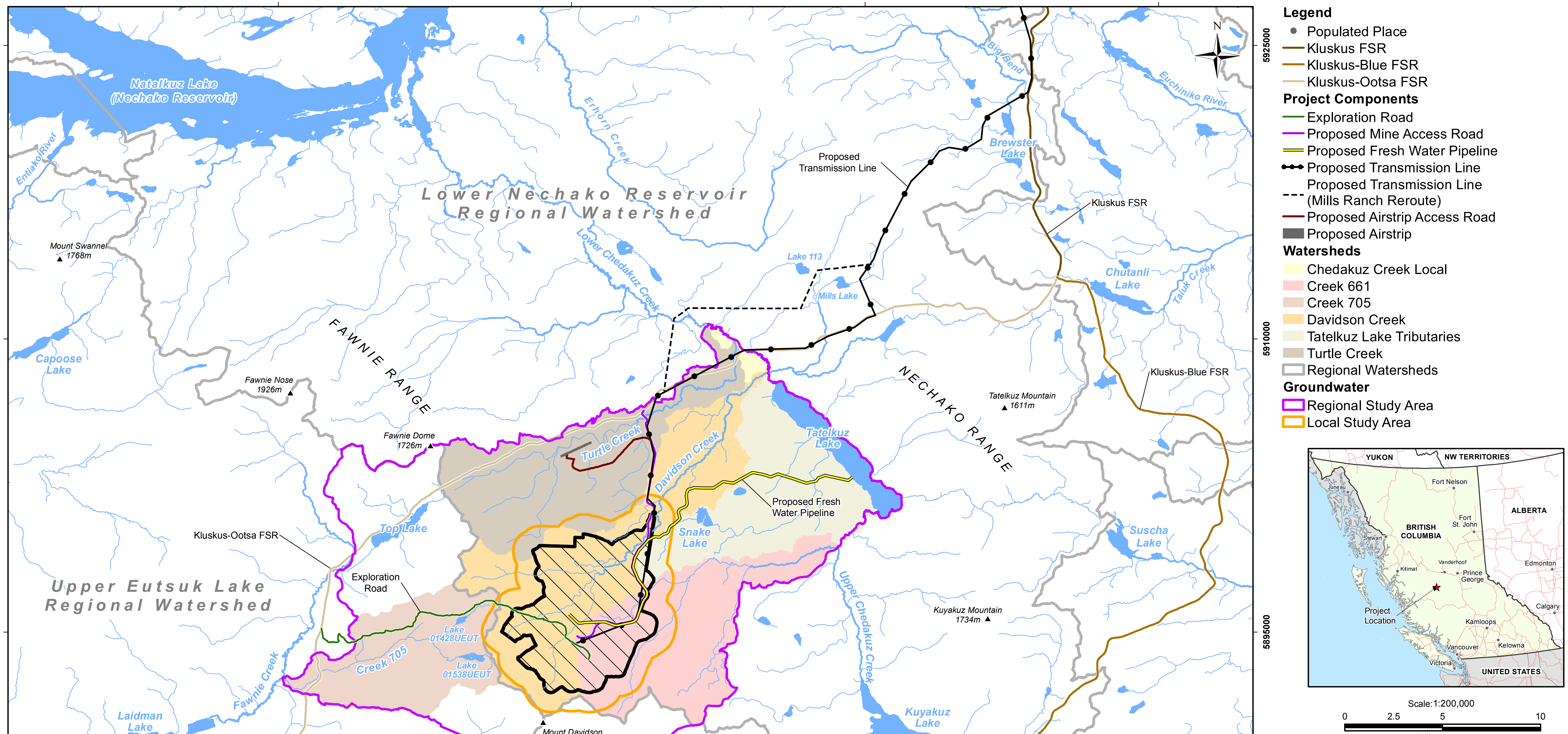
Table 5.1.2.4-1: Summary of Average Groundwater Chemistry

	Unit	Bedrock Average	Overburden Average
In Situ Parameters			
Conductivity	µS/cm	236	132
Oxygen Dissolved	%	42	62
Oxygen Dissolved		5.2	7.3
pH		7.8	7.6
Redox Potential	mV	-23	-52
Salinity	ppt	0.127	0.084
Specific Conductivity	µS/cm	227	138
Temperature	°C	8.0	6.8
Total Dissolved Solids	mg/L	211	113
Turbidity NTU	NTU	48	17
Physical Tests			
Alkalinity (Total as $CaCO_3$)	mg/L	100	73
Bicarbonate Alkalinity	mg/L	100	73
Carbonate Alkalinity	mg/L	2	2
Color TCU	TCU	5.1	5.1
Conductivity	µS/cm	232	140
Hardness as $CaCO_3$ (Dissolved)	mg/L	92	41
Hydroxide Alkalinity	mg/L	1.7	1.7
pH		8.1	7.9
Total Dissolved Solids	mg/L	150	60
Total Suspended Solids	mg/L	76	28
Turbidity NTU	NTU	30	14
Dissolved Anions			
Bromide (Dissolved)	mg/L	0.061	0.050
Chloride (Dissolved)	mg/L	0.977	0.517
Fluoride (Dissolved)	mg/L	0.113	0.097
Sulphate (Dissolved)	mg/L	23.998	2.911
Thiocyanate (Dissolved)	mg/L	0.423	0.429
Nutrients			
Ammonia (Total)	mg/L	0.024	0.126
Nitrate (as N)	mg/L	0.028	0.036
Nitrite (as N)	mg/L	0.001	0.001
Nitrogen (Dissolved)	mg/L	0.340	0.244
Nitrogen (Total)	mg/L	0.151	0.145
Nitrogen Kjeldahl (Total)	mg/L	0.141	0.127
Phosphate (Total)	mg/L	0.057	0.062

	Unit	Bedrock Average	Overburden Average
Phosphorus Dissolved	mg/L	0.063	0.064
Phosphorus Total	mg/L	0.152	0.108
Cyanide			
Cyanide (Free)[(1)]	mg/L	0.005	0.005
Cyanide (Total)[(1)]	mg/L	0.005	0.005
Cyanide (WAD)[(1)]	mg/L	0.005	0.005
Thiocyante (SCN)[(1)]	mg/L	0.500	0.500
Cyanate	mg/L	0.215	0.283
Dissolved Metals			
Aluminum (Dissolved)	mg/L	0.068	0.036
Antimony (Dissolved)	mg/L	0.0003	0.0002
Arsenic (Dissolved)	mg/L	0.005	0.003
Barium (Dissolved)	mg/L	0.037	0.021
Beryllium (Dissolved)	mg/L	0.0004	0.0005
Bismuth (Dissolved)	mg/L	0.000	0.000
Boron (Dissolved)	mg/L	0.016	0.018
Cadmium (Dissolved)	mg/L	0.0001	0.0001
Calcium (Dissolved)	mg/L	25	18
Chromium (Dissolved)	mg/L	0.001	0.001
Cobalt (Dissolved)	mg/L	0.000	0.001
Copper (Dissolved)	mg/L	0.001	0.001
Iron (Dissolved)	mg/L	0.302	0.492
Lead (Dissolved)	mg/L	0.0002	0.0002
Lithium (Dissolved)	mg/L	0.008	0.005
Magnesium (Dissolved)	mg/L	7.1	3.9
Manganese (Dissolved)	mg/L	0.223	0.632
Mercury (Dissolved)	mg/L	0.00018	0.00001
Molybdenum (Dissolved)	mg/L	0.005	0.004
Nickel (Dissolved)	mg/L	0.002	0.002
Phosphorus (Metal) Dissolved	mg/L	0.160	2.842
Potassium (Dissolved)	mg/L	1.037	0.689
Selenium (Dissolved)	mg/L	0.0004	0.0002
Silicon (Dissolved)	mg/L	7.2	7.0
Silver (Dissolved)	mg/L	0.00002	0.00001
Sodium (Dissolved)	mg/L	13.8	5.1
Strontium (Dissolved)	mg/L	0.787	0.129
Thallium (Dissolved)	mg/L	0.00003	0.00003
Tin (Dissolved)	mg/L	0.0002	0.0002
Titanium (Dissolved)	mg/L	0.013	0.014
Uranium (Dissolved)	mg/L	0.001	0.000
Vanadium (Dissolved)	mg/L	0.003	0.004
Zinc (Dissolved)	mg/L	0.005	0.005

	Unit	Bedrock Average	Overburden Average
Organics			
Carbon Organic (Dissolved)	mg/L	4.2	4.1
Carbon Organic (Total)	mg/L	2.2	2.2
Nitrogen Organic (Dissolved)	mg/L	0.303	0.233
Nitrogen Organic (Total)	mg/L	0.117	0.107
Sulphur (S)-Dissolved	mg/L	7	1
Sulphur (S)-Total	mg/L	7	1

Note: (1) Cyanide analysis returned as below detection limit, the detection limit values have been posted in this table.



Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Groundwater Quantity and Groundwater Quality Study Areas

DATE: August, 2014	ANALYST: WR	Figure 5.1.2.4-1
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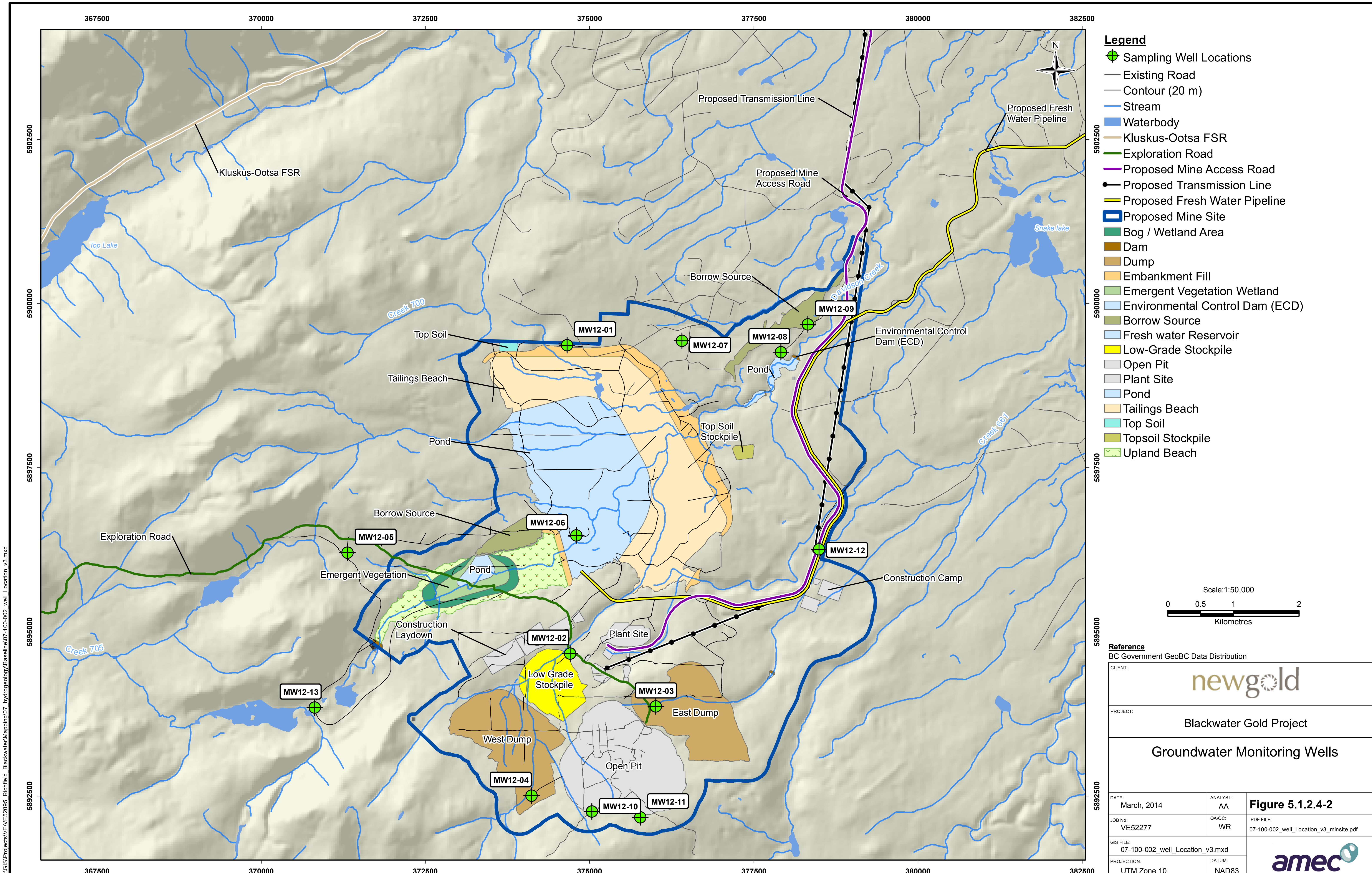

Legend
Sampling Well Locations
Existing Road
Contour (20 m)
Stream
Waterbody
Kluskus-Ootsa FSR
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Fresh Water Pipeline
Proposed Mine Site
Bog / Wetland Area
Dam
Dump
Embankment Fill
Emergent Vegetation Wetland
Environmental Control Dam (ECD)
Borrow Source
Fresh water Reservoir
Low-Grade Stockpile
Open Pit
Plant Site
Pond
Tailings Beach
Top Soil
Topsoil Stockpile
Upland Beach
367500
370000
372500
375000
377500
380000
382500
5902500
5900000
5897500
5895000
5892500
Kluskus-Ootsa FSR
Top Lake
Creek 700
Creek 705
Proposed Transmission Line
Proposed Fresh Water Pipeline
Proposed Mine Access Road
Snake lake
Davidson Creek
Borrow Source
Environmental Control Dam (ECD)
Creek 661
Top Soil
Tailings Beach
Pond
Top Soil Stockpile
Borrow Source
Exploration Road
Emergent Vegetation
Construction Laydown
Construction Camp
Plant Site
Low Grade Stockpile
East Dump
West Dump
Open Pit
MW12-01
MW12-02
MW12-03
MW12-04
MW12-05
MW12-06
MW12-07
MW12-08
MW12-09
MW12-10
MW12-11
MW12-12
MW12-13
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Kilometres
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newgold
PROJECT:
Blackwater Gold Project
Groundwater Monitoring Wells
DATE: March, 2014
ANALYST: AA
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5.1.2.5 Wetlands

5.1.2.5.1 Baseline Summary

The Wetlands Baseline Report (AMEC, 2013) (**Appendix 5.1.2.5A**) documents the methods and results of field and desktop reviews completed from 2011 to 2013. The wetlands baseline program was designed to document and describe the distribution, size, composition, and primary wetland functions within and adjacent to the Project area.

5.1.2.5.1.1 Study Areas and Project Components

The Project is located on the North Central Interior Plateau, approximately 110 km south of Vanderhoof, near the geographical centre of BC. For wetland delineation, classification, and functional value assessments, wetlands were separated into two primary components: the mine site and the linear features. The mine site has a LSA and RSA based on watershed drainage basins (**Figure 5.1.2.5-1**). The corridors for the water pipeline, mine access road, and airstrip and access road are located within the mine site LSA, and do not have a separate LSA for each. The transmission line extends north from the mine site, and includes the Mills Ranch and Stellako re-routes. The transmission line LSA applies outside of the mine-associated LSA. Each study area is mutually exclusive and further defined in **Table 5.1.2.5-1**.

Table 5.1.2.5-1: Description of Wetland Study Areas

Study Area	Description
Linear Components	Transmission Line Corridor (140 km long, 140 m wide), including Mills Ranch (15 km long) and Stellako (8 km long) re-routes
	Transmission Line LSA (includes 100 m on either side of corridor and applies outside the mine site LSA)
	Mine Access Road Corridor (15 km long, 20 m wide)
	Water Pipeline Corridor (20 km long, 110 m wide)
	Airstrip (2 km long, 200 m wide) including associated access road (10 m wide)
Mine Site	Encompasses all mine site related facilities (approx. 300 m buffer)
Local Study Area (LSA)	Surrounds the mine site and includes: Entire watersheds of Davidson Creek, Creek 661, Turtle Creek, and Creek 705. Tributaries flowing in to the south side of Tatelkuz Lake. Chedakuz Creek from confluence with Creek 661 to Tatelkuz Lake. Chedakuz Creek from Tatelkuz Lake to confluence with Turtle Creek
Regional Study Area (RSA)	Surrounds LSA: Includes entire watershed of Chedakuz Creek not included in the LSA. Includes entire watershed of Laidman Lake not included in the LSA. The RSA also includes 500 m on either side of the transmission line corridor extending north of the LSA watershed boundaries

5.1.2.5.2 Methodology Overview

5.1.2.5.2.1 Wetland Classification

Wetland ecosystems were mapped in accordance with Terrestrial Ecosystem Mapping (TEM) protocols (RIC, 1998). TEM is the stratification of a landscape into map units according to a combination of ecological features, primarily climate, physiography, surficial material, bedrock geology, soil, and vegetation. The hierarchical approach combines ecosections (Demarchi, 1996), biogeoclimatic (BGC) units (zones, subzones, and variants), and ecosystem units. An ecosystem unit combines site series or site associations, site modifiers (denotes site conditions), and structural stages. This is a multi-phase process and includes desktop pre-typing, field sampling, and final mapping. Further details are provided in the Wetlands Baseline Report (**Appendix 5.1.2.5A**).

All data collections followed the Field Manual for Describing Terrestrial Ecosystems 2nd Edition (BC MOFR and BC MOE, 2010) by establishing 400 square metre (m^2) plots in areas of relatively uniform vegetation, topography, soils, and hydrology to evaluate site and plant community patterns.

5.1.2.5.2.2 Wetland Functional Assessments

Wetland functional assessments were conducted within the LSA in conjunction with wetland classification field sampling. Baseline data were collected using both desktop review and field techniques for three primary wetland functions: hydrological, biochemical, and ecological/habitat functions. The functional components selected and associated protocols for data collections were developed using two Environment Canada Wetland Assessment Documents: Wetland Ecological Functions Assessment: An Overview of Approaches *(*Hanson et al., 2008) and Wetland Environmental Assessment Guideline (Milko, 1998).

The wetland hydrological functional assessment involves classifying wetlands based on hydrogeomorphic (HGM) units using topographic position and hydrologic source (Smith et al., 1995, BC MOFR and BC MOE, 2010). Wetland HGM units were then used to characterize wetland hydrological functions. Wetland HGM units are described using a hierarchical scheme based on systems and element groups. Six HGM systems are recognized in BC: upland, palustrine, lacustrine, fluvial, estuary, and marine. These systems describe the influence of major water source(s) and hydrological processes, similar to the wetland forms in the Canadian Wetland Classification System (Warner and Rubec, 1997). The element group depicts the patterns of waterflow related to the general water sources, hydrodynamics, and connectivity in the landscape. Hydrological functional assessments using HGM units involved in-situ surveys and GIS analyses by qualified wetland ecologists and hydrologists.

The biochemical functional assessment quantifies the water quality status and elemental composition of surface water associated with wetland resources. Biochemical water quality data were collected as per BC MOE standards (BC MOE, 2012). Surface water grab samples were collected and analyzed for routine physical parameters, major ions, nutrients, total and dissolved metals, and organic carbon. During sampling, in-situ field measurements (e.g., pH, conductivity, dissolved oxygen, and temperature) were also measured in different areas throughout the wetlands.

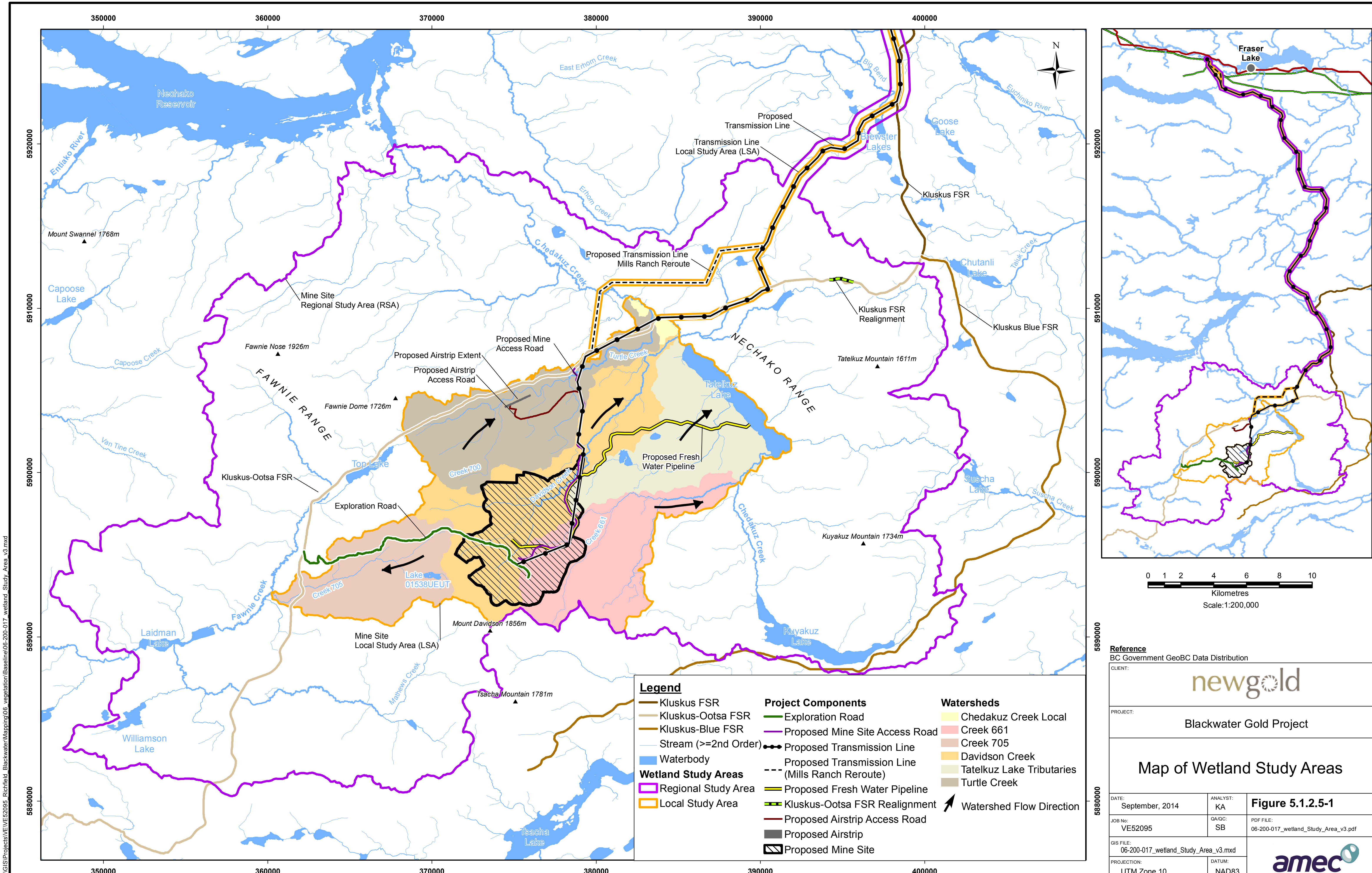
The ecological functional assessment quantifies the extent, structure, and complexity of the sampled wetlands. Wetland ecosystems were identified and inventoried as per provincial TEM standards (BC MOFR and BC MOE, 2010). Once mapped and classified, the area of wetland ecosystems was calculated using ArcMAP 10.0 (ESRI Redlands, CA). Wetland class, area, and distribution were then described and summarized.

The habitat assessments document wetland species and ecosystems at risk, and describe wetland habitat potential (e.g., vegetation and wildlife), biological diversity, and productivity. Habitat was described using the following techniques:

- Classified wetland ecosystems were compared against a database of Red- and Blue-listed ecological communities (BC CDC, 2012), and listed wetland communities were then revisited to confirm the classification;
- Rare plant surveys were conducted in select wetlands throughout the various study areas;
- Wildlife species potentially occurring in specific wetland habitats (e.g., amphibians, migrating birds, ungulates, etc.) were identified; and
- Biodiversity metrics, such as species richness and Shannon's Diversity Index, were calculated using full floristic information for select wetland plots.

5.1.2.5.2.2.1 Sampling Effort

Field surveys to classify and assess wetland resources were conducted from July to August 2011, July to September 2012, and July to August 2013. Survey intensity varied based on wetland study area so that biochemical and water quality data were largely collected in and around, as well as upstream and downstream of, the mine site. Other data collection surveys (e.g., TEM, hydrological, and ecological/habitat) were completed throughout the wetland study area to meet functional assessment needs.


350000
360000
370000
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5910000
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5890000
5880000
Nechako Reservoir
Entiako River
East Ernom Creek
Ernom Creek
Big Bend
Euchiniko River
Goose Lake
Brewster Lakes
Proposed Transmission Line
Transmission Line Local Study Area (LSA)
Kluskus FSR
Mount Swannel 1768m
Chedakuz Creek
Proposed Transmission Line Mills Ranch Reroute
Chutanli Lake
Tatuk Creek
Capoose Lake
Mine Site Regional Study Area (RSA)
Kluskus FSR Realignment
Kluskus Blue FSR
Fawnie Nose 1926m
Capoose Creek
Proposed Mine Access Road
Proposed Airstrip Extent
Proposed Airstrip Access Road
Turtle Creek
NECHAKO RANGE
Tatelkuz Mountain 1611m
FAWNIE RANGE
Fawnie Dome 1726m
Tatelkuz Lake
Van Tine Creek
Top Lake
Creek 700
Proposed Fresh Water Pipeline
Kluskus-Ootsa FSR
Davidson Creek
Suscha Lake
Suscha Creek
Exploration Road
Creek 661
Chedakuz Creek
Kuyakuz Mountain 1734m
Lake 01538UEUT
Creek 705
Fawnie Creek
Mount Davidson 1856m
Laidman Lake
Mine Site Local Study Area (LSA)
Kuyakuz Lake
Mathews Creek
Tsacha Mountain 1781m
Williamson Lake
Tsacha Lake
Legend
Kluskus FSR
Kluskus-Ootsa FSR
Kluskus-Blue FSR
Stream (>=2nd Order)
Waterbody
Wetland Study Areas
Regional Study Area
Local Study Area
Project Components
Exploration Road
Proposed Mine Site Access Road
Proposed Transmission Line
Proposed Transmission Line (Mills Ranch Reroute)
Proposed Fresh Water Pipeline
Kluskus-Ootsa FSR Realignment
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Watershed Flow Direction
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Fraser Lake
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newgold
PROJECT:
Blackwater Gold Project
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ANALYST: KA
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5.1.2.5.3 Results Overview

5.1.2.5.3.1 Wetland Distribution

Two-hundred and ten (210) wetland-related field surveys were completed between summer 2011 and summer 2013 in the wetland study areas. Within the proposed mine site, approximately 575 ha (13% by area) were classified as wetlands (**Table 5.1.2.5-2**). Swamp wetlands are the most common wetland class identified in the mine site (9.5%, 421 ha). Provincially Blue-listed wetland ecosystems occupy approximately 39 ha (0.9%) of the mine site. One Red-listed and several Blue-listed wetland ecosystems occur within the mine site LSA and RSA. Mapped wetland resources comprise approximately 3,122 ha (12%) of the mine site LSA and 5,846 ha (5%) of the mine site RSA.

Wetlands comprise approximately 6 ha (6%) of the access road corridor, 11 ha (8%) of the water pipeline corridor, and 2 ha (4%) of the airstrip linear feature. Bogs and swamps are the most prevalent wetland classes identified within these linear features.

The proposed transmission line has multiple reroute options; wetland areas provided in **Table 5.1.2.5-3** include the Mills Ranch and Stellako re-routes. Wetlands found within the transmission line corridor comprise approximately 144 ha or 7% of the total area. Bogs and swamps are the most prevalent wetland classes identified along the transmission line.

Table 5.1.2.5-2: Wetland Classes and Distribution in Mine Site, LSA, and RSA

Wetland Class	Code	Mine Site		LSA		RSA	
		(ha)	(%)	(ha)	(%)	(ha)	(%)
Wet Bog	Wb	101.40	2.29	947.79	3.64	-	-
Fen Wetland	Wf	39.34	0.89	612.66	2.35	-	-
Marsh Wetland	Wm	2.77	0.06	50.52	0.19	-	-
Swamp Wetland	Ws	421.25	9.54	1,452.54	5.58	-	-
Shallow-water	Ww	8.19	0.18	58.17	0.22	-	-
Pond	PD	2.16	0.05	-	-		
TRIM/TEM Wetland	WL	-	-	-	-	5,846.42	4.98
Total Wetland Area		**575.15**	**13.03**	**3,121.68**	**11.98**	**5,846.42**	**4.98**

Note: ha = hectare; % = percent of total area; LSA = Local Study Area; RSA = Regional Study Area

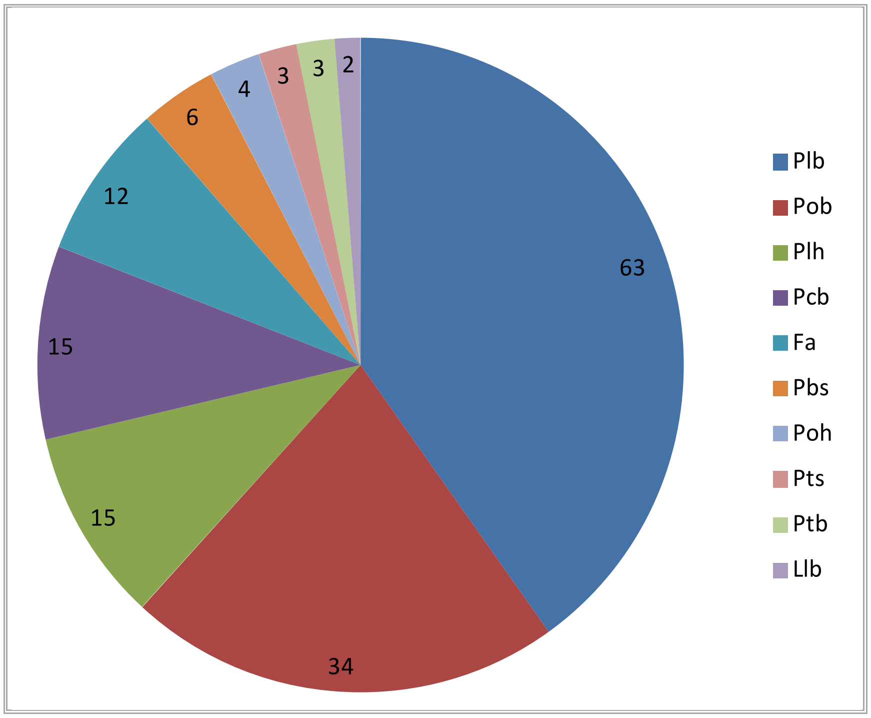
Table 5.1.2.5-3: Area of Wetland Classes in Linear Features Study Areas

Wetland Class	Code	Transmission Line				Mine Access Road		Water Pipeline Route		Airstrip and Airstrip Road	
		Corridor		LSA		Corridor		Corridor		Corridor	
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Bog	Wb	27.08	1.30	31.92	1.13	1.66	1.60	1.64	1.20	1.07	2.10
Fen	Wf	15.91	0.80	17.68	0.62	0.51	0.50	1.08	0.80	-	-
Marsh	Wm	2.97	0.10	6.68	0.24	0.11	0.10	0.05	<0.01	-	-
Swamp	Ws	97.15	4.70	151.00	5.34	4.00	3.90	8.14	5.90	0.88	1.70
Shallow-water	Ww	0.60	<0.01	3.21	0.11	-	-	-		-	-
TRIM Wetland	WL	-	-	-	-	-	-	-		-	-
Total Wetland Area		**143.70**	**6.90**	**210.49**	**7.44**	**6.28**	**6.10**	**11.03**	**8.00**	**1.95**	**3.86**
Total Area of Linear Component		**2,074.41**	**-**	**2,828.76**	**-**	**103.15**	**-**	**138.59**	**-**	**50.51**	**-**

Note: BGC = biogeoclimatic. Areas Calculated in UTM projection, Zone 10, NAD 83. Percents are % of total for that linear feature. The transmission line corridor and LSA includes the Mills Ranch and the Stellako re-routes.

5.1.2.5.3.2 Hydrological Function

Data on wetland hydrological functions were collected for 157 wetlands in and around, as well as upslope and downslope of, the mine site. Fifty percent (50%) of wetlands classified by HGM unit occur in palustrine, linked basins (63) or linked hollows (15). These wetlands include the largest sites; they typically occupy flat areas that are part of historical or small lake / flood plain bottoms, and likely have little ground-water input. Linked basins and linked hollows receive water from uplands and inflow from streams, and excess water flows through an outflow. This indicates that wetlands play an important role in surface water storage, flow moderation, and erosion control in the wetland study area (**Figure 5.1.2.5-2**).



Note: P = Palustrine, F = Fluvial, L = Lacustrine, lb = linked basin, ob = overflow basin, cb = closed basin, lh = linked hollow, a = alluvial, bs = blanket slope, oh = overflow hollow, tb = terminal basin, ts = toe slope

Figure 5.1.2.5-2: Distribution of Hydrogeomorphic Classes for 157 Select Wetlands in and around the Mine Site Study Area

5.1.2.5.4 Biochemical Function

Wetland biochemical function was described using water quality parameters related to nutrient, chemical, and metal concentrations found in the surface water of sampled wetlands. Overall, baseline water quality results suggest normal conditions for sampled wetlands. Indicators such as low pH, high nutrients (nitrogen and phosphorus), and moderate levels of organic carbon at sampled wetlands were within the natural range of variation for wetland ecosystems in BC (BC MOE, 2006, 2008). For example, average pH in sampled wetlands was lowest in bog wetlands, which typically have a lower pH relative to swamps and marshes due to the release of organic acids from peat (Mitsch and Gosselink, 2007; MacKenzie and Moran, 2004).

Freshwater aquatic guideline exceedances were detected for total and dissolved metals in all years for some parameters tested, particularly total cadmium, total iron, total zinc, dissolved aluminum, and dissolved iron (**Table 5.1.2.5-4**). These results indicate that naturally elevated metal concentrations occur in some sampled wetlands.

Table 5.1.2.5-4: Number of Elemental Chemistry Exceedances by Wetland Type

	Mine Site		Local Study Area			
	Fen	**Marsh**	**Fen**	**Marsh**	**Swamp**	**Bog**
	n=4	**n=1**	**n=21**	**n=6**	**n=5**	**n=7**
Total Arsenic	-	-	1	-	1	-
Total Barium	-	-	1	-	-	-
Total Cadmium	3	-	9	1	-	2
Total Chromium	-	-	2	-	1	-
Total Cobalt	-	-	1	-	1	-
Total Copper	-	-	4	-	-	-
Total Iron	-	-	3	-	2	-
Total Magnesium	-	-	2	-	1	-
Total Mercury	-	-	2	-	-	-
Total Zinc	-	-	3	-	-	-
Dissolved Aluminum	4	-	9	-	1	1
Dissolved Iron	-	-	1	-	-	-

Note: *Five sites are wetland complexes and therefore more than one wetland class may be associated with a single water quality sample site. The wetland complexes are: Wl15 = fen/swamp; WL19, Wl28 and B13027A = fen/bog and B13031B = swamp/bog.

A high level of biochemical functions are performed by wetlands in the mine site due to the high proportion of swamp wetlands and bogs. Both swamps and bogs export nutrients and organic carbon to streams, which supports the aquatic food chain. Seasonally fluctuating water tables in swamps enable frequent interactions between water and root-bacteria assemblages that provide the opportunity for biogeochemical cycling to improve water quality. Swamps and bogs also function to sequester and store carbon. Bogs generally perform this function better than swamps, as bogs accumulate peat and woody biomass over time, whereas swamps' seasonally fluctuating water tables allow for biomass and soil decomposition (Mitsch and Gosselink, 2007; Hanson et al., 2008).

5.1.2.5.5 Ecological Function

Wetland ecological function involves the role of wetlands in relation to their surroundings and their ability to support a variety of plant and animal species and communities. Twenty-one (21) distinct wetland ecosystems were classified within the wetlands study area. Ten of these wetland ecosystems are designated as Endangered or Threatened (Red-listed), or of Special Concern (Blue-listed) (BC MOE, 2012) (**Table 5.1.2.5-5**). Four Blue-listed wetland ecosystem types occupy 39 ha (0.9%) of the mine site. Red-listed wetlands cover approximately 6.19 ha at three separate sites east of the mine site in the LSA.

Table 5.1.2.5-5: Confirmed At-Risk Wetland Ecosystems in the Wetland Study Area

Site Association Label	Scientific Name	Common Name	BC CDC List	Project Component
Wb01	*Picea mariana – Gaultheria hispidula – Sphagnum*	Black spruce – Creeping-snowberry – Peat-moss	Blue	LSA, RSA
Wb10	*Pinus contorta – Carex pauciflora – Sphagnum spp.*	Lodgepole pine – Few-flowered sedge – Peat-moss	Blue	MS, LSA
Wb11	*Picea mariana – Menyanthes trifoliata – Sphagnum*	Black spruce – Buckbean – Peat-moss	Blue	LSA
Wb13	*Carex limosa – Menyanthes trifoliata – Sphagnum spp.*	Shore sedge – Buckbean – Peat-moss	Blue	LSA
Wf02	*Betula nana – Carex aquatilis*	Scrub birch – Water sedge	Blue	MS, LSA
Wf05	*Carex lasiocarpa – Drepanocladus aduncus*	Slender sedge – Common hook-moss	Blue	LSA
Wf08	*Carex limosa – Menyanthes trifoliata – Drepanocladus*	Shore sedge – Buckbean – Hook-moss	Blue	MS
Wf10	*Trichophorum alpinum – Scorpidium revolvens*	Hudson Bay clubrush – Red hook-moss	Red	LSA
Wf11	*Trichophorum cespitosum – Campylium stellatum*	Tufted clubrush – Star moss	Blue	MS, LSA
Wf13	*Eriophorum angustifolium – Carex limosa*	Narrow-leaved cotton-grass – Shore sedge	Blue	LSA

Note: Site Association Label: Bog Wetland Class (Wb), Fen Wetland Class (Wf); RSA was not fully classified to Site Association level. MS = mine site; LSA = Local Study Area; RSA = Regional Study Area.

Swamp wetlands (Ws) are the most common wetlands in the mine site and Spruce - Horsetail swamps (Ws07) show the highest plant species diversity. A total of 318 plant species were identified during the wetland field surveys, four of which are Blue-listed in BC: swollen beaked sedge *(Carex rostrata*), small-flowered lousewort *(Pedicularis parviflora ssp. parviflora*), meesia moss *(Meesia longiseta*), and sickleleaf tomentypnum moss (*Tomentypnum falcifolium*). One population of sickleleaf *Tomentypnum* moss was observed within the mine site boundaries (**Figure** 5.1.2.5-3).

Table 5.1.2.5-6 includes a list of at-risk plant species found in the Project area. The Red-listed Hudson Bay clubrush – red hook-moss wetland site association (Wf10) was observed in the mine site LSA and RSA, but not within the proposed mine site.

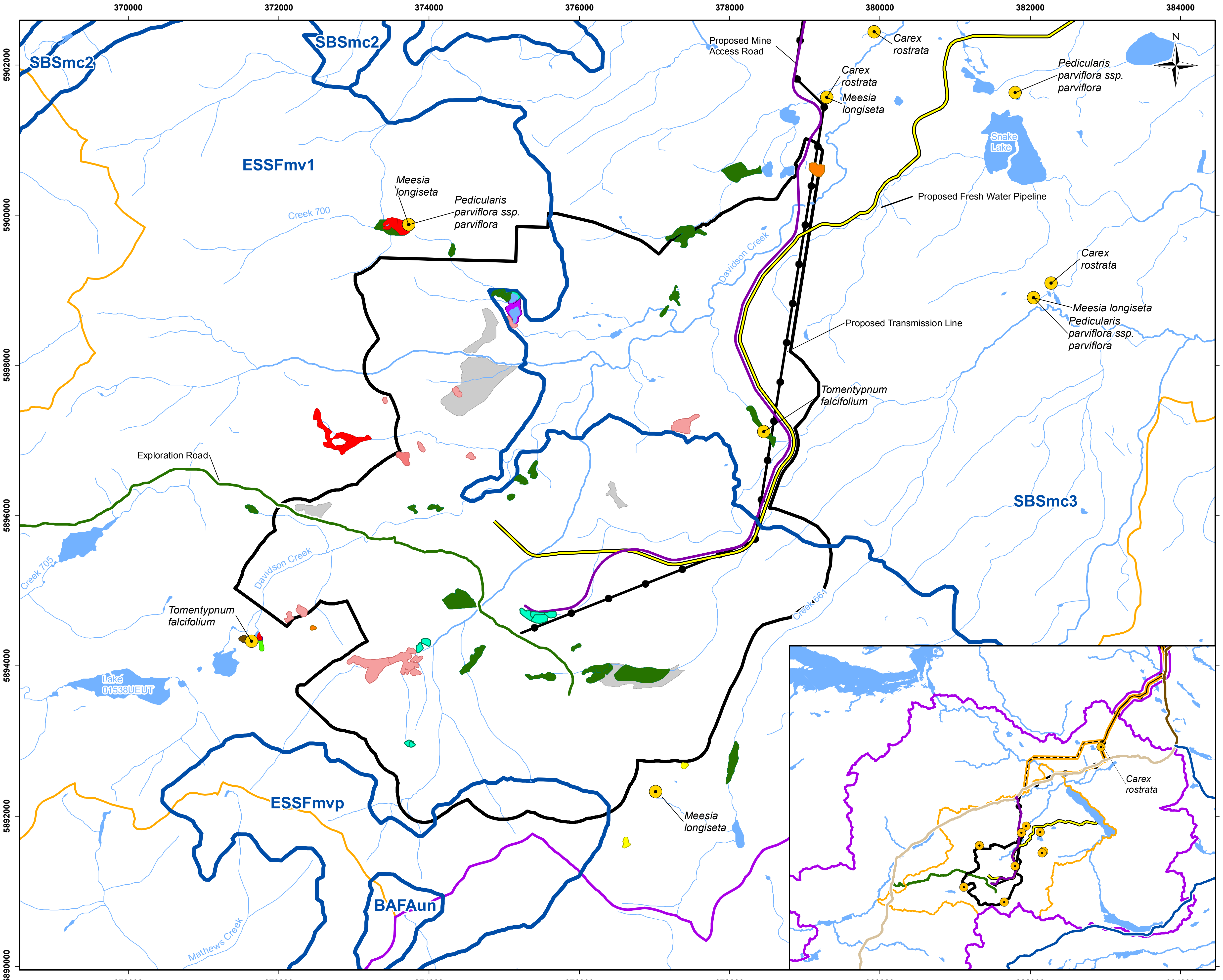
Table 5.1.2.5-6: At-Risk Wetland Plant Species Found in the Blackwater Project Area

Common Name	Scientific Name	BC CDC	*SARA*	Project Component
Meesia moss	*Meesia longiseta*	Blue	Not listed	LSA; Access Road; RSA
Sickleleaf tomentypnum moss	*Tomentypnum falcifolium*	Blue	Not listed	Mine Site; LSA
Small-flowered lousewort	*Pedicularis parviflora subsp. Parviflora*	Blue	Not listed	LSA; RSA
Swollen beaked sedge	*Carex rostrata*	Blue	Not listed	Access Road; LSA; RSA

5.1.2.5.6 Habitat Function

Wetland habitat function relates to the ability of a wetland ecosystem to support wildlife. A minimum of 132 wildlife species potentially occurring in northern BC depend on wetlands for a portion of their lifecycle, including four amphibians, 64 birds, 10 mammals, 54 ordonates, and seven lepidopterans. Of these, 16 are provincial species at risk and seven are *SARA*-listed, including western toad (*Anaxyrus boreas*), yellow rail (*Coturnicops noveboracensis*), long-billed curlew (*Numenius americanus*), short-eared owl (*Asio flammeus*), olive-sided flycatcher (*Contopus cooperi*), rusty blackbird (*Euphagus carolinus*), and caribou (*Rangifer tarandus).* Western toad, olive-sided flycatcher, rusty blackbird, and caribou were detected within the mine site or LSA. A comprehensive list of wildlife species potentially occurring versus detected in the wetland study area is provided in the Wetlands Baseline Report (**Appendix 5.1.2.5A**).

Wildlife habitat functionality values and ranks were developed for a representative sample of wetlands. Selected wetlands were evaluated for their suitability for up to 12 species and/or life stages of wildlife, including amphibians, birds, and mammals. With the exception of seven wetlands that are ranked high and one ranked low, 48 wetlands are ranked as moderate for wetland habitat function. Wetlands that are ranked high generally have high habitat value for multiple wildlife species. Marshes have the highest number of potentially occurring wildlife species, followed by open shallow-water, bogs, swamps, and fens; however, few marshes were observed. In general, fewer wildlife species occur at higher elevation wetlands in the mine site than lower elevation wetlands.



Legend

- Blue Listed Plant Population
- Stream
- Waterbody

Project Components

- Exploration Road
- Proposed Transmission Line
- Proposed Mine Access Road
- Proposed Fresh Water Pipeline
- Proposed Mine Site

Biogeoclimatic Zone

- BAFAun
- ESSFmv1
- ESSFmvp
- SBSmc2
- SBSmc3

Wetland Information

- Listed Wetlands < 20%

Red Listed Wetlands

- Wf10 - Hudson Bay clubrush - Red hook-moss

Blue Listed Wetlands

- Wb09 - Black spruce – Common horsetail – Peat-moss
- Wb11 - Black spruce – Buckbean – Peat-moss
- Wf13 - Narrow-leaved cotton-grass – Shore sedge
- Wb10 - Pine – Few-flowered sedge - Peat-moss Bog
- Wf02 - Scrub birch - Water sedge Fen
- Wf08 - Shore sedge - Buckbean - Hook-moss Fen
- Wf11 - Tufted clubrush - Star-moss Fen
- Wb13 - Shore sedge - Buckbean - Peatmoss

Wetland Study Areas

- Regional Study Area
- Local Study Area

Note

Blue and Red listed wetlands are only displayed where they occupy 20% or more of the TEM Mapped polygon.

Reference

BC Government GeoBC Data Distribution

CLIENT:	newgold
PROJECT:	Blackwater Gold Project
	Verified At-Risk Plant Species and Wetland Ecosystems in the Vicinity of the Mine Site
DATE: May, 2014	ANALYST: KA
	Figure 5.1.2.5-3
JOB No: VE52277	QA/QC: SB
PDF FILE:	06-200-010_wetland_at_risk_species_v5.pdf
GIS FILE:	06-200-010_wetland_at_risk_species_v5.mxd
PROJECTION: UTM Zone 10	DATUM: NAD83
	amec

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Approximately 69% (396 ha) of the wetlands mapped in the mine site are classified as Ws08 (Swamp Wetland–Subalpine fir–Horsetail–Glow moss) and Ws07 (Swamp Wetland–Spruce–Horsetail) (274 ha and 122 ha, respectively). Swamp wetlands provide highly variable levels of habitat functions, which is consistent with the moderate wetland habitat functionality values of the sampled wetlands listed above. Surveyed bogs, which potentially provide a high level of habitat functions (Hanson et al., 2008), also only had moderate functionality values due to the lack of species detections during the surveys. Bogs, fens, and marshes potentially function to provide valuable wildlife habitat, and occur at approximately 25% (101 ha, 39 ha, and 2.8 ha, respectively) of all mapped wetlands.

There were 41 migratory bird species observed in the wetlands study area that are expected to use wetlands for part of their lifecycle (breeding, moulting, feeding, etc.). Twenty-three (23) water bird species were detected including one species of conservation concern, the Blue-listed great blue heron (*Ardea herodias*). Seven of the detected water bird species are priority species for the local Bird Conservation Region 10 (Environment Canada, 2013). The four most frequently detected species include Wilson's snipe (*Gallinago gallinago*), greater yellowlegs (*Tringa melanoleuca*), bufflehead (*Bucephala albeola*), and common loon (*Gavia immer*). Many of the wetlands across the study area were found to have greater yellowlegs or Wilson's snipe; bufflehead or common Loon were present on most waterbodies. Wilson's snipe and greater yellowlegs were identified within the mine site. Additional information regarding migratory and water bird species and habitat in the study area is provided in the Wildlife and Wildlife Habitat Baseline Report for the Project (**Appendix 5.1.3.4A**).

5.1.2.6 Fish and Fish Habitat

5.1.2.6.1 Introduction

This section summarizes studies of fish and fish habitat that were conducted in streams and lakes of the Blackwater Aquatics LSA and RSA. The focus of this summary is on studies conducted for the Proponent in 2011, 2012, and 2013. Historical studies of fish and fish habitat that were conducted in the RSA from 1977 to 2006 by the BC MOE and forestry companies were reviewed for the purposes of defining data gaps and developing the study designs for 2011, 2012, and 2013. Historical data were also added to some of the data collected in 2011, 2012 and 2013, particularly summer inventories of stream fish and fish habitat.

Detailed methods and results of the studies of 2011, 2012, and 2013 are shown in the Blackwater Gold Project: Fish and Aquatic Resources 2011-2012 Baseline Report (**Appendix 5.1.2.6A**) and the Blackwater Gold Project: Fish and Aquatic Resources 2013 Baseline Report (**Appendix 5.1.2.6B**).

An additional three appendices describe technical studies that were conducted to support environmental assessment of fish and fish habitat: the Blackwater Gold Project Fisheries Mitigation and Offsetting Plan (FMOP) (**Appendix 5.1.2.6C**), the Blackwater Gold Project Instream Flow Study (IFS) (**Appendix 5.1.2.6D**), and the Blackwater Gold Project: Effects Assessment of Davidson Creek Flow Augmentation on Homing of Salmonid Fish (**Appendix 5.1.2.6E**).

This section contains three major subsections: Introduction, Methods (**Section 5.1.2.6.2**) and Results and Discussion (**Section 5.1.2.6.3**). This subsection includes summaries of study area (**Section 5.1.2.6.1.1**); study objectives (**Section 5.1.2.6.1.2**); fish habitat VC indicators (**Section 5.1.2.6.1.3**); and fish VC indicators (**Section 5.1.2.6.1.4**).

Methods includes a review of historical data (**Section 5.1.2.6.2.1**); design of field surveys (**Section 5.1.2.6.2.2**); summary of guidelines, standards and protocols (**Section 5.1.2.6.2.3**); components of field surveys (**Section 5.1.2.6.2.4**); and analysis and interpretation of data (**Section 5.1.2.6.2.5**).

Results and Discussion includes a summary of baseline information collected on fish habitat (**Section 5.1.2.6.3.1**) and on fish (**Section 5.1.2.6.3.2**).

5.1.2.6.1.1 Study Area

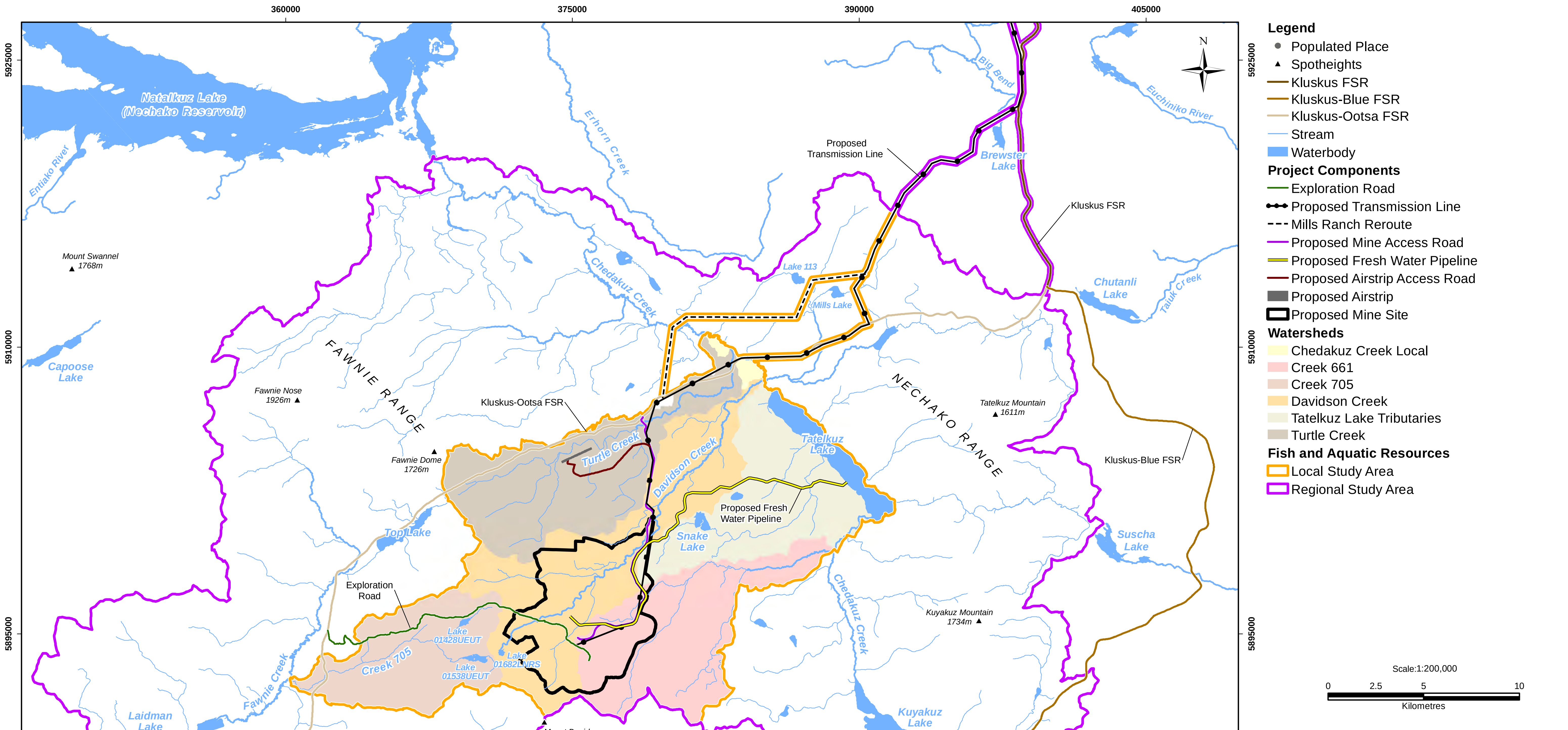
Baseline studies of fish and fish habitat focused on the aquatics LSA, which surrounds the proposed mine site (**Figure 5.1.2.6-1**). Detailed descriptions of the LSA are shown in Section 2.0 of **Appendix 5.1.2.6A** and Section 2.0 of **Appendix 5.1.2.6B**. The LSA contains five watersheds (**Table 5.1.2.6-1**).

Davidson Creek Watershed was the location of the greatest survey intensity because most Project infrastructure will be built in the upper half of that watershed. Davidson Creek flows from Mount Davidson north-east to lower Chedakuz Creek. The watershed has a surface area of approximately 86 km^2. Elevations range from 1,700 masl at the summit of Mount Davidson to 950 masl at the confluence with Chedakuz Creek. Davidson Creek originates from a small headwater lake (Lake 01682LNRS) located near the drainage divide between the Chedakuz and Fawnie Creek watersheds. Davidson Creek is fed by two main tributaries in the upper watershed: Creek 688328 and Creek 704454.

Table 5.1.2.6-1: Main Drainages of the Aquatics LSA

Gazetted Name	Local Name	BC Freshwater Atlas Code	Tributary of
n/a	Turtle Creek	100-567134-610692-480511	Chedakuz Creek
n/a	Creek 700	100-567134-610692-480511-645840	Turtle Creek
Davidson Creek	Davidson Creek	100-567134-610692-522527	Chedakuz Creek
n/a	Tatelkuz Lake Tributaries	100-567134-610692-579340	Tatelkuz Lake
n/a	Creek 661	100-567134-610692-671007	Chedakuz Creek
n/a	Creek 705	100-567134-641477-543682-598692	Fawnie Creek

Note: n/a = not applicable



Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish and Aquatic Resources Study Areas

DATE: March, 2014	ANALYST: WR	Figure 5.1.2.6-1
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-002_v13_aquatic_EA.pdf
GIS FILE: 10-100-002_v13_aquatic_EA.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Turtle Creek is north of Davidson Creek and roughly parallel to it. It also flows to lower Chedakuz Creek. The Project airstrip and airstrip access road will be built in Turtle Creek. Turtle Creek Watershed has an area of 60 km^2, and ranges in elevation from approximately 1,270 masl at its headwaters to 940 masl at the confluence with lower Chedakuz Creek, approximately 3 km downstream of the outlet of Tatelkuz Lake. Turtle Creek is fed by one main tributary – Creek 700.

Creek 661 is south of Davidson Creek. It flows north-east into middle Chedakuz Creek upstream of Tatelkuz Lake. Small portions of headwater streams of Creek 661 will be diverted into the mine site. Creek 661 Watershed has an area of 67.4 km^2, and the creek is approximately 21 km in length. Elevations range from 1,550 masl in the headwaters to 980 masl at the confluence with middle Chedakuz Creek. Creek 505659 is a tributary stream that flows into Creek 661.

Tatelkuz Lake Tributaries Watershed lies between Davidson Creek and Creek 661 watersheds. A water pipeline from Tatelkuz Lake to the mine site will traverse this watershed. The Tatelkuz Lake Tributaries Watershed includes low-gradient tributaries flowing into the west side of Tatelkuz Lake. Creek 579340, Creek 549629, and portions of middle Chedakuz Creek are included in this watershed.

Creek 705 Watershed drains the south-west side of Mount Davidson into Fawnie Creek. This watershed will receive water diverted from Lake 01682LNRS, the headwater lake of Davidson Creek, but will otherwise not be affected by Project activities. The watershed area of Creek 705 is 45 km^2. Elevations range from approximately 1,500 masl upstream of Lake 01538UEUT to 1,000 masl near the confluence of Creek 705 with Fawnie Creek. Creek 705 receives run-off from a number of small tributaries in the middle to upper watershed. It has two headwater lakes: Lake 01538UEUT (into which Lake 01682LNRS will be diverted) near the headwaters of the southern drainage, and Lake 01428UEUT near the headwaters of the northern drainage. Water from Lake 01428UEUT flows into the mainstem of Creek 705 through Creek 606013.

The Chedakuz Creek Watershed includes lower Chedakuz Creek (directly downstream of Tatelkuz Lake). It has habitat typical of a medium-sized river.

(There are two small catchments, called Chedakuz Creek Local Watersheds, located on the western bank of lower Chedakuz Creek. These are not true watersheds because they contain no streams, but they were created by defining the boundary of the LSA as the eastern bank of lower Chedakuz Creek.)

The LSA contains one large, valley-bottom lake – Tatelkuz Lake – and four smaller headwater lakes: Lake 01682LNRS in the Davidson Creek Watershed; lakes 01538UEUT and 01428UEUT in the Creek 705 Watershed; and Snake Lake in the Tatelkuz Lake Tributaries Watershed (**Figure** 5.1.2.6-1).

The RSA encompasses the whole of the Chedakuz Creek Watershed and part of the Fawnie Creek Watershed (**Figure 5.1.2.6-1**). It includes Kuyakuz Lake and Tatelkuz Lake, and all tributaries to that creek, lower Chedakuz Creek downstream to its confluence with Natalkuz Lake (which is part of the Nechako Reservoir), and upper Fawnie Creek Watershed, including Top Lake, Laidman Lake, Williamson Lake, and Mathews Creek.

The Project infrastructure includes a 133 km-long, 230-kilovolt (kV) transmission line that will run from BC Hydro's Glenannon Substation near Fraser Lake to the mine site (**Figure 5.1.2.6-2**). It also includes a 194-km long access road that follows a network of Forest Service Roads (FSRs) originating at the community of Engen, approximately 20 km west of Vanderhoof. Streams crossed by both corridors were surveyed for fish and fish habitat in 2012 and 2013. Two shorter corridors include a water pipeline that will run from the southwest end of Tatelkuz Lake to the mine site, and an airstrip access road. Streams crossed by both of those corridors were surveyed for fish and fish habitat in 2013 (**Figure 5.1.2.6-1**).

5.1.2.6.1.2 Objectives

The overall objectives of the studies on fish and fish habitat in 2011, 2012 and 2013 were to:

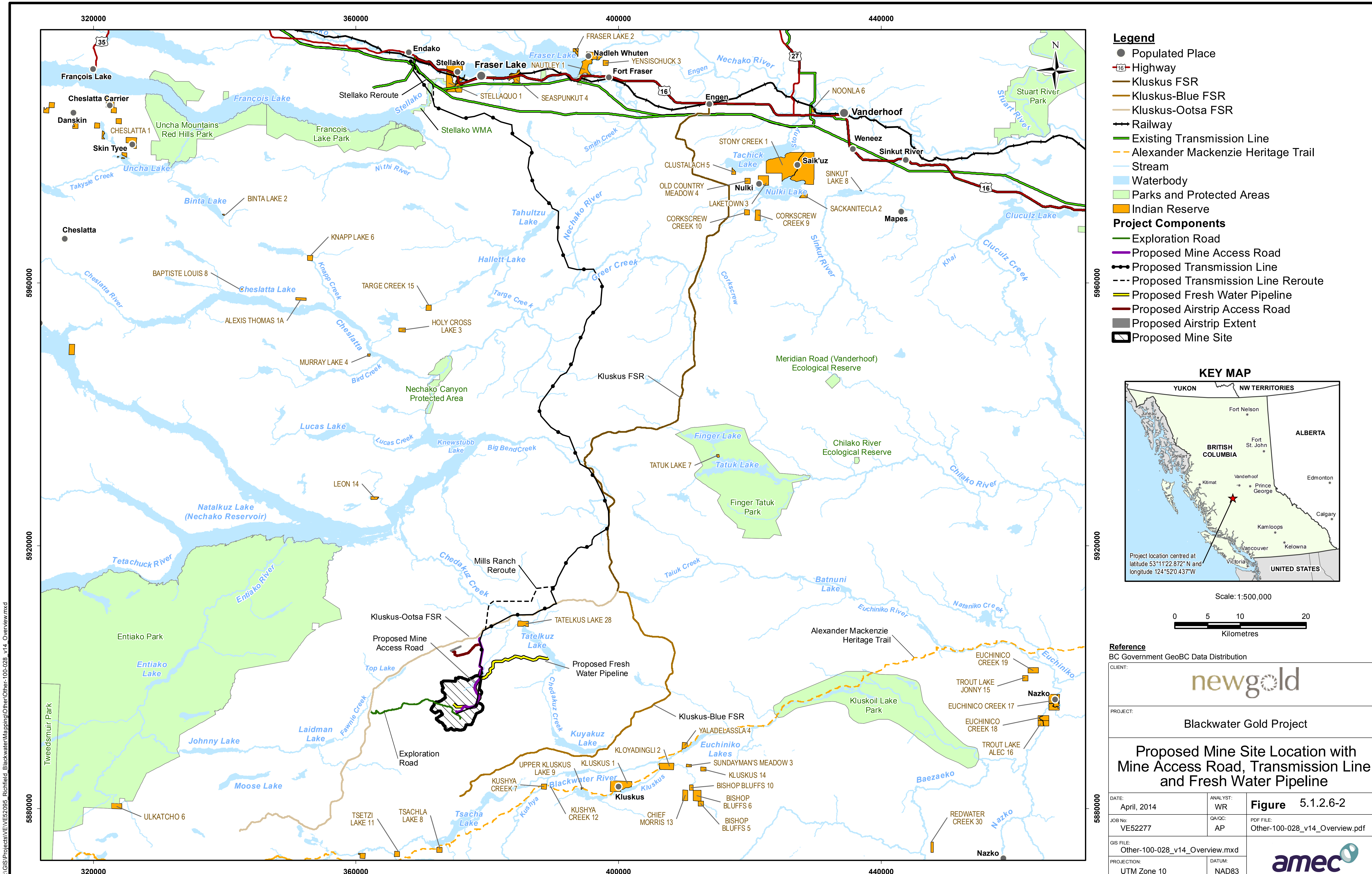
- Characterize fish and fish habitat in streams and lakes potentially affected by the Project to identify potential interactions and opportunities for mitigation, and to support an application for an Environmental Assessment Certificate;
- Provide baseline data that will support future environmental effects monitoring programs; and
- Quantify fish habitat (and its quality or productive capacity) potentially affected by the Project to support development of a Fisheries Mitigation and Offsetting Plan.

5.1.2.6.1.3 Fish Habitat VC Indicators

The six indicators of the fish habitat VC are the following:

- Surface water flow;
- Surface water quality (including water temperature) and sediment quality;
- Groundwater flow;
- Groundwater quality;
- Ecological health; and
- Riparian habitat.

Other sections of this EA summarize baseline information on surface water flow (**Section 5.1.2.1**), surface water quality and sediment quality (**Section 5.1.2.2**), groundwater flow (**Section 5.1.2.3**), groundwater quality (**Section 5.1.2.4**), and wetlands (**Section 5.1.2.5**).


Legend
Populated Place
Highway
Kluskus FSR
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Railway
Existing Transmission Line
Alexander Mackenzie Heritage Trail
Stream
Waterbody
Parks and Protected Areas
Indian Reserve
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Transmission Line Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip Extent
Proposed Mine Site
KEY MAP
YUKON
NW TERRITORIES
Fort Nelson
ALBERTA
BRITISH COLUMBIA
Fort St. John
Vanderhoof
Prince George
Edmonton
Kitimat
Calgary
Kamloops
Kelowna
Vancouver
Victoria
UNITED STATES
Project location centred at latitude 53°11'22.872" N and longitude 124°520.437"W
Scale: 1:500,000
0 5 10 20
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Proposed Mine Site Location with Mine Access Road, Transmission Line, and Fresh Water Pipeline
DATE: April, 2014
ANALYST: WR
Figure 5.1.2.6-2
JOB No: VE52277
QA/QC: AP
PDF FILE: Other-100-028_v14_Overview.pdf
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PROJECTION: UTM Zone 10
DATUM: NAD83
amec
320000
360000
400000
440000
5960000
5920000
5880000
Endako
Stellako
Fraser Lake
Nadleh Whuten
Fort Fraser
François Lake
Cheslatta Carrier
Danskin
Skin Tyee
Cheslatta
Stellako Reroute
Stellako WMA
Uncha Mountains Red Hills Park
Francois Lake Park
Engen
Vanderhoof
Weneez
Sinkut River
Saik'uz
Nulki
Mapes
Stuart River Park
Kluskus FSR
Meridian Road (Vanderhoof) Ecological Reserve
Nechako Canyon Protected Area
Finger Tatuk Park
Chilako River Ecological Reserve
Natalkuz Lake (Nechako Reservoir)
Mills Ranch Reroute
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Exploration Road
Kluskus-Blue FSR
Entiako Park
Tweedsmuir Park
Alexander Mackenzie Heritage Trail
Kluskoil Lake Park
Nazko
Kluskus
Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\Other\Other-100-028_v14_Overview.mxd

Ecological health of fish habitat was broadly defined to include the location, quantity, and quality of stream and lake habitat that supports the five life stages of fish: migration, spawning, overwintering, rearing, and feeding. Fish habitat includes measurements of size and shape. In streams, those include variables such as gradient, width, depth, flow, substrate composition, the presence or absence of barriers to fish migration, and the characteristics of riparian habitat. In lakes it includes variables such as water surface elevation, surface area, volume, depth, perimeter, and substrate composition of the littoral zone.

Fish habitat in both streams and lakes also includes water quality variables such as temperature, conductivity, pH, the concentration of dissolved oxygen (DO), and transparency (as measured by Secchi depth). It includes the prey of fish and the food base of that prey. In streams, that includes the biomass, density and taxonomic composition of periphyton and benthic macroinvertebrates (BMI). In lakes that includes the biomass, density and taxonomic composition of phytoplankton, zooplankton, and BMI.

Open-water wetlands were classified as fish habitat if they were directly connected to fish-bearing streams or if they were indirectly connected via non-fish-bearing channels. Wetlands that were not classified as open-water and consisted mainly of wet soil were not classified as fish habitat. **Appendix 5.1.2.5A** provides detailed baseline information on wetlands in the aquatics LSA and RSA and **Section 5.1.2.5** summarizes that data.

Spatial distribution and surface areas of riparian habitat in the mine site are described in the Ecosystem Composition VC assessment (**Section 5.4.5**). However, the areas of riparian habitat described in that section included areas surrounding both fish-bearing and non-fish-bearing habitat such as non-open water wetlands. **Section 5.1.2.6.3.1.1** describes the area and characteristics of riparian habitat surrounding fish-bearing watercourses. Fish habitat surveys reported in **Appendix 5.1.2.6A** and **Appendix 5.1.2.6B** recorded components of riparian habitat that are directly relevant to stream fish habitat such as the presence and absence of large woody debris and percent canopy closure. The Fisheries Mitigation and Offsetting Plan (FMOP; **Appendix 5.1.2.6C**) incorporated riparian habitat into the habitat offsetting budget by including a Habitat Suitability Index (HSI) for “food and nutrients” – the primary contributions to fish of riparian habitat. Annex C of **Appendix 5.1.2.6C** explains how food and nutrient HSI values were assigned to fish habitat. A summary is shown in the Riparian Habitat part of **Section 5.1.2.6.3.1.1**.

5.1.2.6.1.4 Fish VC Indicators

The two indicator species for the fish VC are kokanee (*Oncorhynchus nerka*), the landlocked life history variant of sockeye salmon, and rainbow trout (*Oncorhynchus mykiss*). They were selected because they are the two most numerous fish species in the aquatics LSA and RSA, they are both food fish that are components of recreational and Aboriginal fisheries, and they both use stream and lake habitat (although at different times of the year). Equally important, they have sufficiently different diets, habitat preferences, and seasonal life history timing that any potential effect of Project activities on fish and fish habitat in streams and lakes of the LSA and RSA will inevitably affect one or both species.

Kokanee are the most numerous fish in Tatelkuz Lake (the only kokanee residence lake in the LSA), and they are temporarily the single most numerous fish in the LSA when they emerge from Tatelkuz Lake to spawn in streams in mid- to late summer. **Section 5.1.2.6.3.2.4** summarizes the ecology of kokanee in the aquatics LSA.

Rainbow trout is the second most numerous fish species in Tatelkuz Lake, and the predominant fish species in three of the four headwater lakes of the LSA. (Lake chub, *Couesius plumbeus*, is the only fish species present in Snake Lake.) Except during the kokanee spawning migration, rainbow trout are the predominant fish species in streams of the LSA and RSA. Adult rainbow trout emerge from their residence lakes in spring to spawn in streams and then return to lakes, but juvenile rainbow trout remain in streams for up to 3 years before migrating to residence lakes to adopt an adult life style. **Section 5.1.2.6.3.2.5** summarizes the ecology of rainbow trout in the aquatics LSA. Selection of two of the twelve fish species present in the LSA as fish VC indicators does not mean that information on the other ten species is not important. Fish species richness in each stream and lake of the LSA and RSA is summarized in this section because it increases directly with increasing habitat diversity, which is usually positively correlated with waterbody size (Griffiths, 1997). The conservation status of each fish species is also an indicator of ecological health because the presence and relative abundance of vulnerable, threatened, or endangered species is an indicator of habitat diversity.

Rainbow trout, kokanee and at least five other species (longnose sucker, white sucker, largescale sucker, mountain whitefish and burbot) are components of recreational and/or Aboriginal fisheries. **Sections 5.1.2.6.3.2.6** to **Section 5.1.2.6.3.2.15** summarize the ecology of the other ten fish species in the aquatics LSA, beginning with the five species that are components of recreational or Aboriginal fisheries.

5.1.2.6.2 Methods

5.1.2.6.2.1 Review of Historical Data

Section 3.1 of **Appendix 5.1.2.6A** described a detailed review of historical data on fish and fish habitat in the LSA and RSA collected from 1977 to 2010. Primary sources of historical data included the following:

- Fish and fish habitat reconnaissance surveys completed by BC MOE on Tatelkuz Lake (Walsh and Hale, 1977), Kuyakuz Lake (Burns, 1977), Laidman Lake (Coombes, 1985a), and Top Lake (Coombes, 1985b);
- Fish distribution reports, and lake, stream, and stocking reports from the BC Fisheries Inventory Summary System (FISS) (BC FISS, 2012), EcoCat, FishWizard, and HabitatWizard databases (BC MOE, 2013a);
- Reconnaissance 1:20,000 fish and fish habitat inventory data for the Creek 705 Watershed (Golder Associates Ltd. (Golder), 1998);

- Fish and fish habitat inventory data obtained from CanFor Forest Products Ltd. (DWB Forestry Services Ltd. (DWB), 2001, 2002, 2008; Ecofor Consultants Ltd. (Ecofor), 2004; Triton Environmental Consultants Ltd. (Triton), 2006);
- Stream and lake inventories of fish and fish habitat reported by contractors for the Chu Molybdenum Project in the drainage of Chedakuz Creek northeast of the Blackwater LSA (Avison, 2010a, 2010b, 2010c, 2010d); and
- BMI data from historical sampling sites within the study areas available through the Canadian Aquatic Biomonitoring Network (CABIN) (CABIN, 2011, 2012).

Secondary sources included the following:

- Provincial 1:20,000 Freshwater Atlas stream and waterbody data layer issued by the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO) (BC MFLNRO, 2011);
- Light Detection and Ranging (LiDAR) imagery and ortho-photographs;
- Species summary and status reports from the BC Conservation Data Center (BC CDC) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC);
- Vanderhoof Land and Resource Management Plan prepared by the British Columbia Integrated Land Management Bureau (BC ILMB) (BC ILMB, 1997); and
- Vanderhoof Sustainable Forest Management Plan (BC ILMB, 2010).

5.1.2.6.2.2 Design of Field Surveys

Early in 2011, historical data on fish and fish habitat was reviewed, and a data gap analysis was conducted (Sections 3.1 and 3.2 of **Appendix 5.1.2.6A**). Reconnaissance overflights of the LSA and RSA were conducted. A baseline study plan was developed to fill those data gaps in 2011 and 2012 (Section 3.3 of **Appendix 5.1.2.6A**).

The study plan focused on the fish and fish habitat of streams and headwater lakes of the LSA, particularly of Davidson Creek Watershed, which will be most affected by Project activities. The plan included surveys of fish and fish habitat in the LSA during the summers of 2011 and 2012, and an overwintering survey of fish habitat in March 2012. It also included a regional survey of kokanee spawner distribution and abundance in the RSA, and surveys of fish and fish habitat at stream crossings of the transmission line and access road alignments. This study plan was discussed with representatives from BC MOE, BC MFLNRO, and Fisheries and Oceans Canada (DFO).

As the design of the Project progressed during those 2 years, it became clear that Tatelkuz Lake was the only waterbody in the LSA large enough to provide the volumes of water required for the mine processing plant and for flow augmentation of Davidson Creek – the major mitigation measure for Project effects on fish and fish habitat in Davidson Creek. In addition, baseline studies in 2011 and 2012 showed that Tatelkuz Lake is the major overwintering and residence lake for rainbow trout and kokanee that spawn in streams of the eastern half of the LSA (i.e., those that are tributary to Chedakuz Creek). Therefore, to assess the potential effects of water extraction on Tatelkuz Lake and its outlet, lower Chedakuz Creek, and to complete the description of rainbow trout and kokanee habitat in the LSA, the baseline study program was revised to include a survey of the aquatic ecosystem of Tatelkuz Lake and lower Chedakuz Creek. This study plan was described in a work plan that was distributed to regulatory agencies. This study was conducted in spring and summer of 2013. Section 3.0 of **Appendix 5.1.2.6B** describes the scope of that study.

The alignments of the transmission line, the access road, the water pipeline from Tatelkuz Lake to the mine site, and the airstrip access road were all finalized in 2013. This meant that the baseline study plan was revised further to include surveys of fish and fish habitat at stream crossings of all four alignments. In addition, finalization of the Fisheries Mitigation and Offsetting Plan required additional studies on stream fish and fish habitat in Creek 705 of the LSA, and finalization of the Instream Flow Study required additional studies on water velocities and depths of Davidson Creek, Creek 661, Creek 705 and lower Chedakuz Creek. These surveys were completed in the summer of 2013 (Section 3.0 of **Appendix 5.1.2.6B**).

Finally, the 2013 baseline study program included a second consecutive year of surveying overwintering fish habitat (in March 2013), a third consecutive year of monitoring stream water temperatures, and a third consecutive year of surveying kokanee spawner distribution and abundance in streams of the LSA (Section 3.0 of **Appendix 5.1.2.6B**).

5.1.2.6.2.3 Guidelines, Standards and Protocols

Designs of field surveys of fish and fish habitat in 2011, 2012 and 2013 were based on the data gap analysis of early 2011, on the preliminary Project Description (New Gold, 2012), on reconnaissance overflights of the LSA and RSA, and on the following guidelines, standards and protocols:

- BC MOE's Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MOE, 2012a);
- Environment Canada's (EC) 2010 Metal Mining EEM Technical Guidance Document (EC, 2011);
- Standards and procedures for inventories of fish and fish habitat established by the BC Resources Information Standards Committee (RISC) (RISC, 1997, 1999a, 1999b, 2000, 2001, 2008, 2009a, 2009b);
- Standards and procedures for reconnaissance-level fish and aquatic field inventories established by the BC Ministry of Forests (BC MOF) (BC MOF, 1995, 1998);
- Other standards and procedures for fish and aquatic field inventories developed by the BC government (Johnston and Slaney, 1996; Clark, 2003; Beatty et al., 2006);
- Standard methods for hydroacoustic surveys of fish in lakes (Thorne, 1983; Brandt, 1996; Simmonds and MacLennan, 2005), with special measures to ensure thorough coverage of the upper water column (Johnston, 1981; Yule, 2000; Beauchamp et al., 2009);

- CABIN protocols for field surveys of streams (EC, 2010), and for laboratory methods of processing BMI (McDermott et al., 2010);
- Procedures for lake BMI sampling established by the Ontario Benthos Biomonitoring Network (OBBN) (Jones et al., 2004); and
- Procedures for classification and quantification of fish habitat in lakes (Bradbury et al., 2001).

All fish sampling was carried out under the terms and conditions of permits issued by the BC MOE and of licenses issued by the DFO.

5.1.2.6.2.4 Components of Field Surveys

The fish and fish habitat surveys of the LSA and RSA in 2011 and 2012 included 17 components (Sections 3.0 and 4.0 of **Appendix 5.1.2.6A** and **Table 5.1.2.6-2** and **Table 5.1.2.6-3**):

- Continuous measurement of stream water temperatures with data loggers at 11 sites in the LSA in 2011 and at 13 sites in 2012 (**Figure 5.1.2.6-3**);
- Sampling of periphyton communities at 14 stream sites in mid-summer 2011 and 2012 (**Figure 5.1.2.6-4**). Five replicate samples were taken at each sampled site for measurement of biomass (i.e., the concentration of chlorophyll *a*) and another five replicate samples were taken for measurement of taxonomic composition;
- Sampling of BMI communities at the same stream sites sampled for periphyton. Five replicate samples were taken at each site for analysis of taxonomic composition. One additional BMI sample was collected at each sampling site for measurement of BMI tissue metals concentrations because there was only one species of fish – rainbow trout – in streams for sampling tissue metals concentrations and the BC government requires two species (BC MOE, 2012);
- Bathymetry of headwater lakes of the LSA;
- Physical limnology of each of the four headwater lakes of the LSA in mid-summer, plus Tatelkuz and Kuyakuz lakes. That included vertical profiles of temperature, dissolved oxygen (DO), and conductivity plus measurement of transparency (i.e., Secchi depth);
- Sampling of phytoplankton, zooplankton, littoral BMI, and profundal BMI in each of three headwater lakes (all except Snake Lake) in mid-summer. As with streams, one additional littoral BMI sample was collected in each of the three lakes for measurement of BMI tissue metals concentrations;
- Surveys of littoral fish habitat in three of the four headwater lakes (all except Snake Lake);
- Surveys of stream fish habitat at 34 sites using Fish Habitat Assessment Procedure (FHAP) (Johnston and Slaney, 1996) (**Figure 5.1.2.6-5**). Continuous FHAP surveys were conducted for Davidson Creek within the proposed site of the Tailings Storage Facility

(TSF), and modified FHAP surveys were conducted for 250 m-long sections around fish sampling sites in other selected streams;

- Surveys of stream fish habitat at another 113 sites using the Reconnaissance 1:20,000 Fish and Fish Habitat (RISC, 2001) methodology (**Figure 5.1.2.6-6**). These sites were mainly smaller tributary streams within the proposed Project area and at stream crossings along the proposed access road and transmission line alignment;
- Spring rainbow trout spawning survey from 7 to 28 June 2011 with eight sets of paired hoop nets (upstream and downstream) installed in four watersheds of the LSA (three sites in Turtle Creek including one site in Creek 700; two sites each in Davidson Creek and Creek 661; and one site in Creek 705) (**Figure 5.1.2.6-7** to **Figure 5.1.2.6-10**). All fish that passed through the hoop nets were identified to species and their direction of travel, counted, measured for length and weight, and released live in the direction of travel. Before release, all rainbow trout were fin-clipped using a clip site that was unique to each hoop net site so as to identify the original capture locations of any recaptured trout. Some fin clips were subsequently used in a microsatellite DNA study of genetic relatedness;
- Summer stream inventories at 24 sites in July and August 2011 and at 54 sites in August to October 2012 using one-pass backpack electrofishing (using stop nets to isolate the electrofished site), minnow traps, and angling in five watersheds of the LSA (Turtle Creek, Davidson Creek, Creek 661, Creek 705, and Tatelkuz Lake Tributaries) (**Figure 5.1.2.6-7** to **Figure 5.1.2.6-11**). Most captured fish were identified to species, counted, measured for length and weight, and released live. Some rainbow trout were fin-clipped for DNA microsatellite analysis, and some were sacrificed for age structures (i.e., otoliths), stomach contents (i.e., diet), and tissue samples for metals analysis;
- Summer lake inventory of fish species and their relative abundance using provincial standards (Resource Inventory Committee (RIC), 2001) floating and sinking gillnets set for short periods to reduce mortality, in the four headwater lakes of the LSA (**Figure 5.1.2.6-7** to **Figure 5.1.2.6-11**). Sampling was conducted from 13 to 17 August 2011, from 8 to 19 September 2012, and from 17 to 18 October 2012, using gillnets, minnow traps, shoreline backpack electrofishing, and angling. Fish were processed in the same way as in the summer stream inventory program;

Table 5.1.2.6-2: Number of Sampling Sites, Fish and Fish Tissues, Blackwater Project LSA, 2011 and 2012

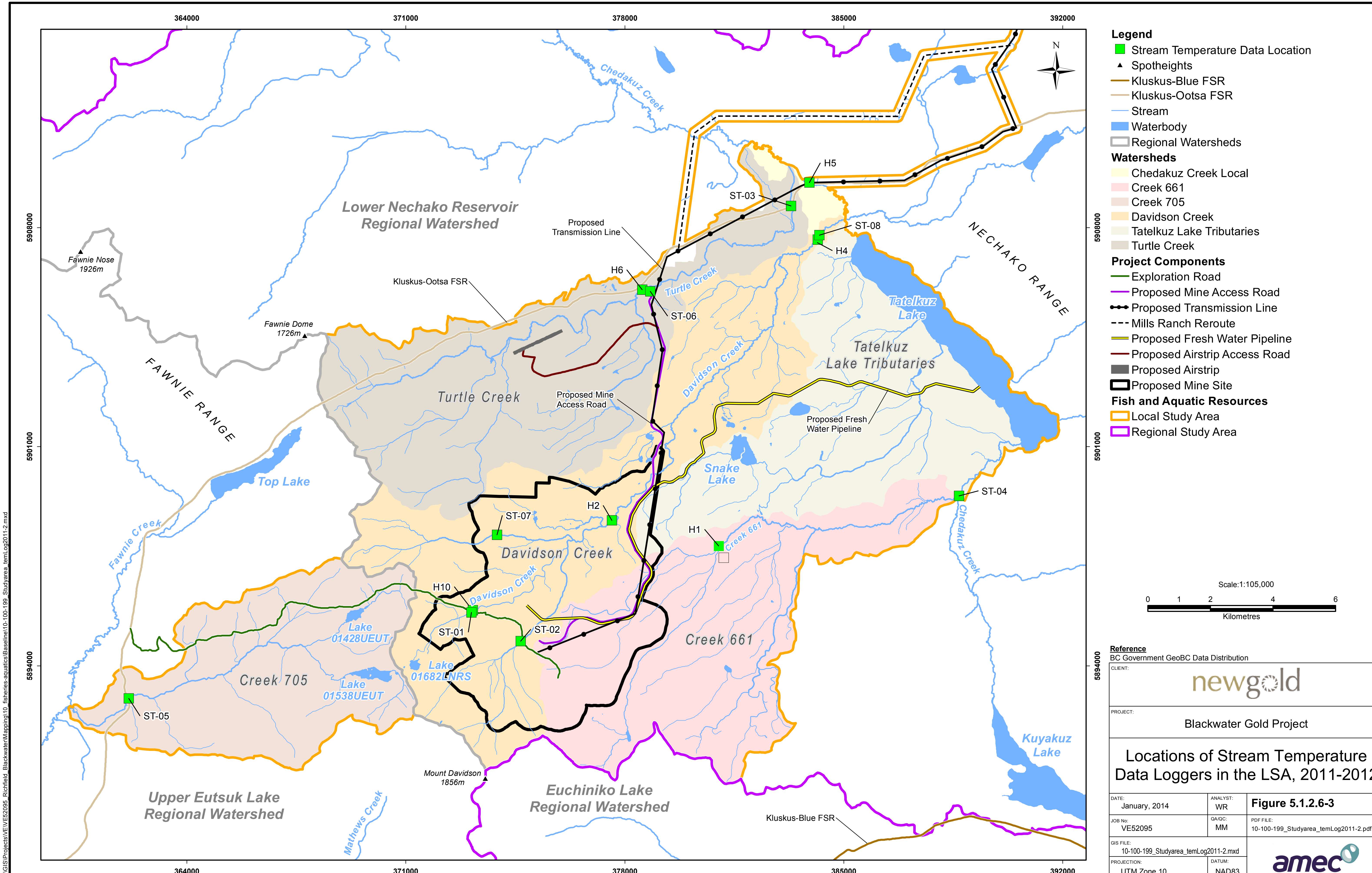
Field Component	Unit	Watershed					Total
		Davidson Creek	Turtle Creek	Creek 661	Creek 705	Tatelkuz Lake Tributaries	
Reconnaissance overflights	n/a	yes	yes	yes	yes	yes	yes
Overwintering stream and lake habitat	Sites	5	2	3	1	2	13
Stream temperature monitoring	Sites	6	3	2	1	1	13
Stream periphyton	Sites	5	2	2	2	1	12
Stream benthic macroinvertebrates	Sites	5	2	2	2	1	12
Bathymetry (headwater lakes)	Lake	1	0	0	2	0	3
Physical limnology (headwater lakes)	Sites	1	0	0	2	1	4
Phytoplankton (headwater lakes)	Sites	1	0	0	2	0	3
Zooplankton (headwater lakes)	Sites	1	0	0	2	0	3
Lake benthic macroinvertebrates (littoral)	Sites	1	0	0	2	1	3
Lake benthic macroinvertebrates (profundal)	Sites	1	0	0	2	2	3
	FHAP sites	22	5	5	0	2	34
Fish habitat (streams)	Recon. 1:20,000K sites	64	10	21	5	13	113
Fish littoral habitat (headwater lakes)	Sites	1	0	0	2	0	3
Spring rainbow trout spawning survey	Hoop nets	2	3	2	1	0	8
Summer fish inventory (streams)	Sites	33	9	16	4	8	70
Summer fish inventory (headwater lakes)	Sites	1	0	0	2	1	4
Summer-fall kokanee spawning survey	Sites	1	0	1	0	2	4
Fall mountain whitefish spawning survey	Sites	1	1	1	1	0	4
Rainbow trout diet (stomachs)	Fish	7	7	4	33	0	51
Rainbow trout tissue metals concentrations	Tissues	58	27	26	83	0	194
Fish microsatellite DNA sampling	Fish(1)	71	32	71	59	65	298

Note: (1)includes both rainbow trout and kokanee

Table 5.1.2.6-3: Number of Sampling Sites, Fish and Fish Tissues, Blackwater Project RSA, 2011 and 2012

Field Component	Unit	Watershed				Total
		Chedakuz Creek	Fawnie Creek	Blackwater River	Meadow Creek	
Reconnaissance overflights	n/a	yes	yes	yes	no	
Stream periphyton	Sites	0	1	1	0	2
Stream BMI	Sites	0	1	1	0	2
Fish habitat (streams)	Recon. 1:20,0000 sites	4	0	0	0	4
Physical limnology (lakes)	Lakes	1	0	0	0	1
Summer/fall regional kokanee spawner survey	Sites	18	0	0	0	18
Fish microsatellite DNA sampling	Fish(1)	68	33	0	30	131

Note: (1)includes both rainbow trout and kokanee



Legend
Stream Temperature Data Location
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Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
FAWNIE RANGE
NECHAKO RANGE
Turtle Creek
Davidson Creek
Creek 705
Creek 661
Tatelkuz Lake Tributaries
Tatelkuz Lake
Snake Lake
Top Lake
Kuyakuz Lake
Lake 01428UEUT
Lake 01682LNRS
Lake 01538UEUT
Chedakuz Creek
Fawnie Creek
Mathews Creek
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Kluskus-Ootsa FSR
Kluskus-Blue FSR
Proposed Transmission Line
Proposed Mine Access Road
Proposed Fresh Water Pipeline
ST-01
ST-02
ST-03
ST-04
ST-05
ST-06
ST-07
ST-08
H1
H2
H4
H5
H6
H10
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BC Government GeoBC Data Distribution
CLIENT: newgold
PROJECT: Blackwater Gold Project
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DATE: January, 2014
ANALYST: WR
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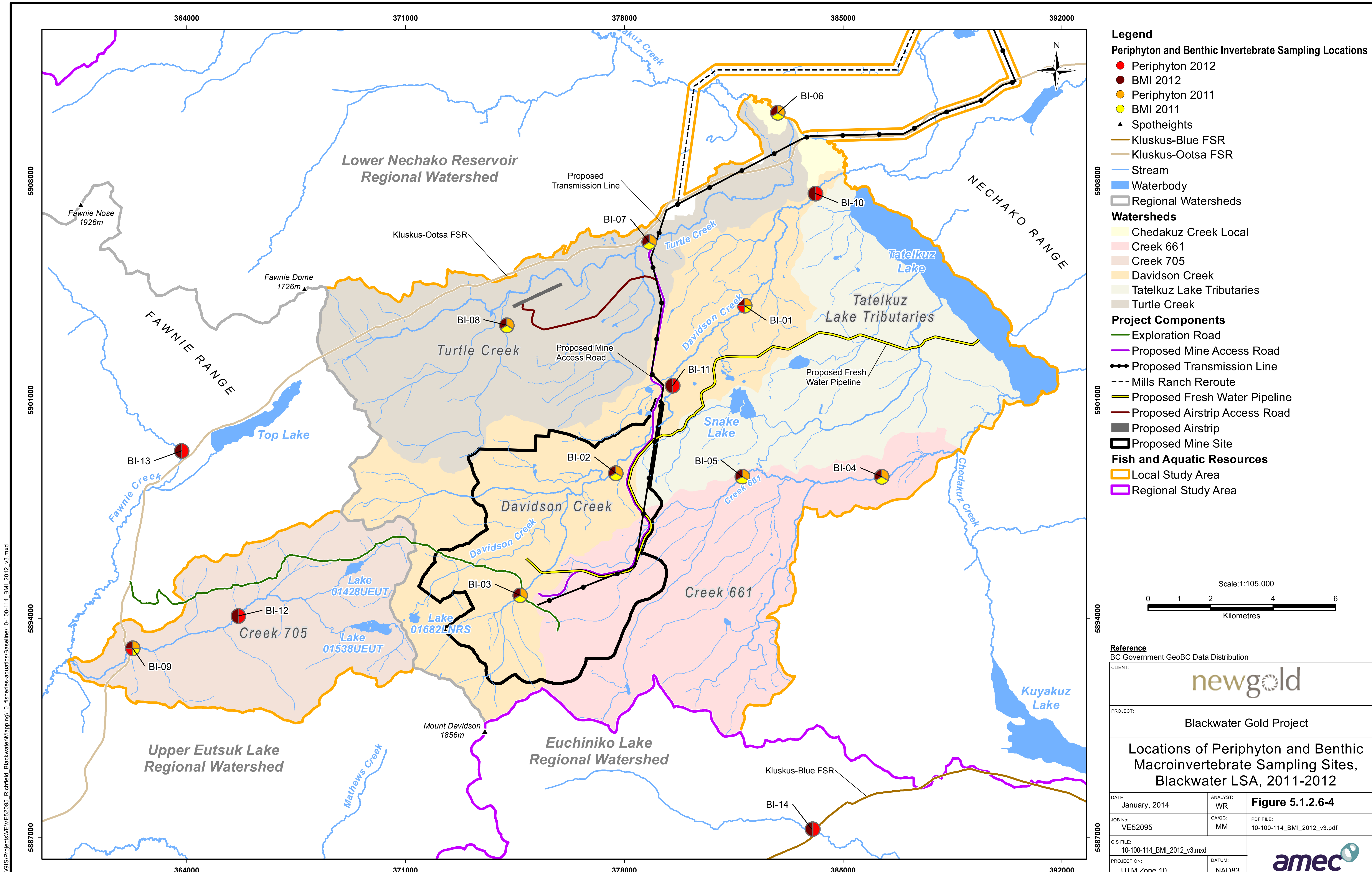
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Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Top Lake
Fawnie Creek
Turtle Creek
Davidson Creek
Creek 705
Creek 661
Tatelkuz Lake Tributaries
Tatelkuz Lake
Snake Lake
Kuyakuz Lake
Chedakuz Creek
Mathews Creek
Lake 01428UEUT
Lake 01538UEUT
Lake 01682LNRS
Proposed Transmission Line
Kluskus-Ootsa FSR
Kluskus-Blue FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
BI-01
BI-02
BI-03
BI-04
BI-05
BI-06
BI-07
BI-08
BI-09
BI-10
BI-11
BI-12
BI-13
BI-14
N
Legend
Periphyton and Benthic Invertebrate Sampling Locations
Periphyton 2012
BMI 2012
Periphyton 2011
BMI 2011
Spotheights
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
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PROJECT:
Blackwater Gold Project
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DATE: January, 2014
ANALYST: WR
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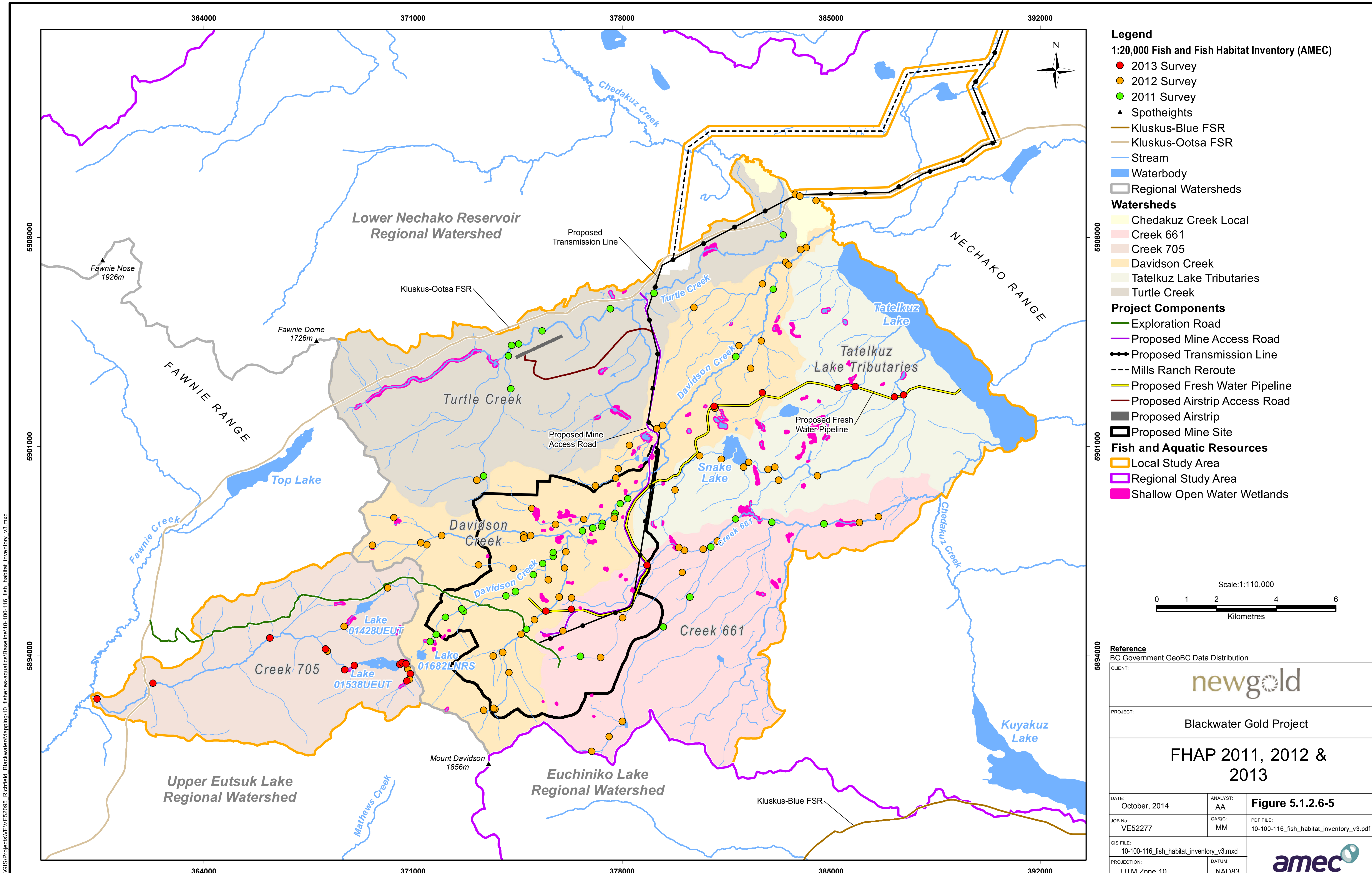
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2012 Survey
2011 Survey
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Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
Shallow Open Water Wetlands
Scale:1:110,000
0 1 2 4 6
Kilometres
364000
371000
378000
385000
392000
5908000
5901000
5894000
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Kluskus-Ootsa FSR
Kluskus-Blue FSR
Proposed Transmission Line
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Chedakuz Creek
Turtle Creek
Davidson Creek
Tatelkuz Lake
Tatelkuz Lake Tributaries
Snake Lake
Top Lake
Fawnie Creek
Creek 661
Creek 705
Lake 01428UEUT
Lake 01682LNRS
Lake 01538UEUT
Kuyakuz Lake
Mathews Creek
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
FHAP 2011, 2012 & 2013
DATE: October, 2014
ANALYST: AA
Figure 5.1.2.6-5
JOB No: VE52277
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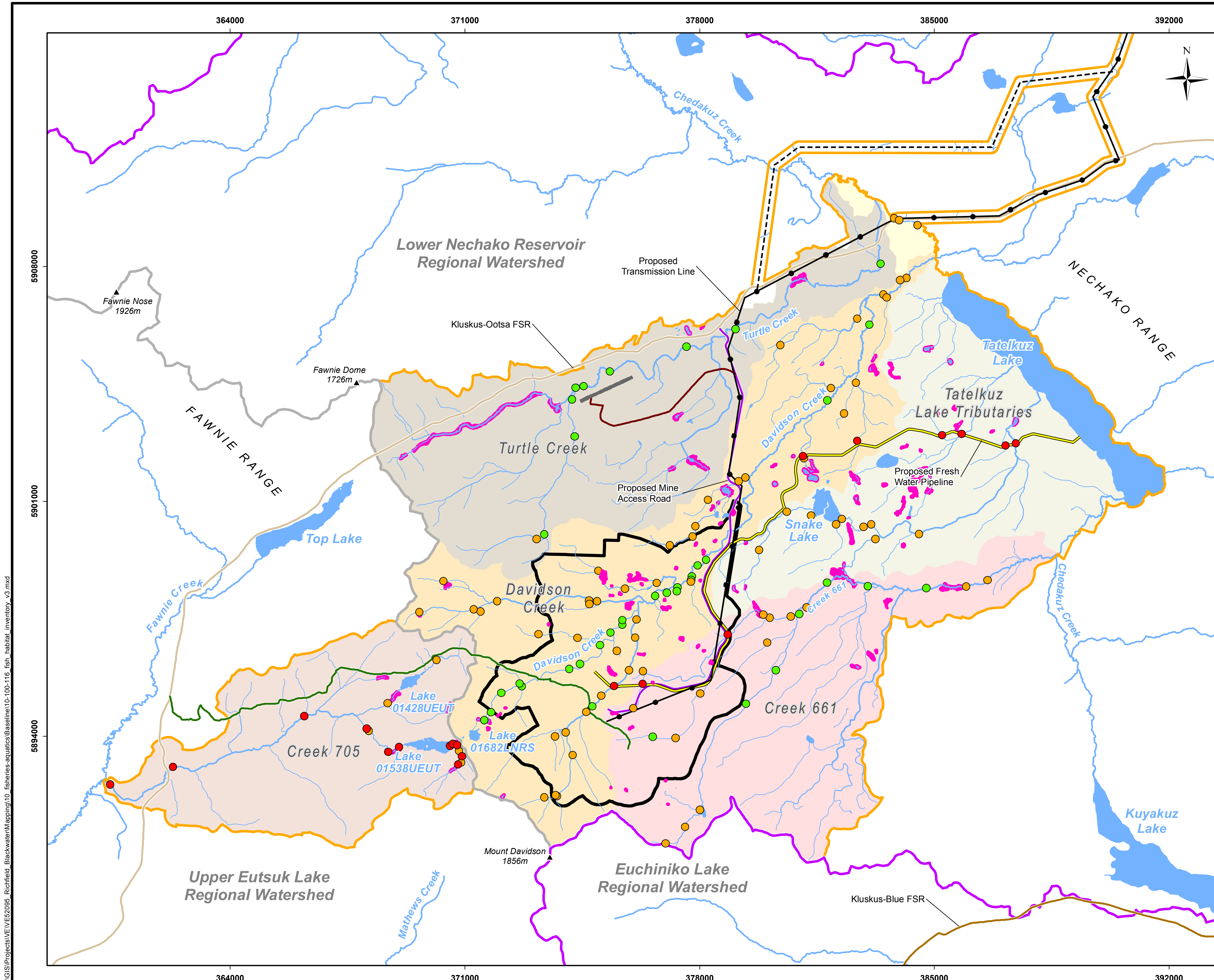

Legend

1:20,000 Fish and Fish Habitat Inventory (AMEC)
- 2013 Survey
- 2012 Survey
- 2011 Survey
- Spotheights
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream
- Waterbody
- Regional Watersheds

Watersheds
- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Project Components
- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Fish and Aquatic Resources
- Local Study Area
- Regional Study Area
- Shallow Open Water Wetlands

Scale:1:110,000

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Kilometres

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish Habitat Inventory 2011, 2012 & 2013

DATE: October, 2014	ANALYST: AA	**Figure 5.1.2.6-6**
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- Kokanee spawning survey in Davidson Creek and Creek 661 from 8 to 22 August 2011. Stream banks were walked and the number and location of kokanee spawners and redds were counted. Some kokanee were fin-clipped for DNA microsatellite analysis, and length and weight were measured;
- Regional-scale steambank survey of the number and location of kokanee spawners and their redds in lower, middle and upper Chedakuz Creek and all third-order tributaries of Chedakuz Creek (i.e., from the northwestern edge of the RSA near the Nechako Reservoir to the upstream reaches of the major inlet to Kuyakuz Lake) from 7 August to 9 October 2012 (**Figure 5.1.2.6-12**). Some kokanee spawners were fin-clipped for microsatellite DNA analysis of genetic relatedness. This survey included collection of fin clips from kokanee spawners in the Fawnie Creek Watershed and in the Meadow Creek Watershed of the Kootenays for use as outliers in the DNA analysis;
- Survey of overwintering fish habitat in streams and headwater lakes in March 2012 (**Figure 5.1.2.6-13**). The purpose was to determine the abundance and quality of available overwintering habitat and to assess whether overwintering habitat is limiting fish production;
- Survey in August and September 2012 of fish and fish habitat at stream sites that will be crossed by the Project transmission line and road access corridors using backpack electrofishing (using stop nets to isolate the electrofished site) and minnow traps. All captured fish were identified to species, counted, measured for length and weight, and released live; and
- Fall mountain whitefish spawning survey from 10 October to 20 November 2012 using hoop nets, one-pass backpack electrofishing (using stop nets to isolate the electrofished site), and seine nets at four of the eight sites used for rainbow trout hoop netting in spring 2011 (**Figure 5.1.2.6-7** to **Figure 5.1.2.6-10**). All fish that passed through the hoop nets were identified to species and direction of movement, counted, measured for length and weight, and released live in the direction of travel.

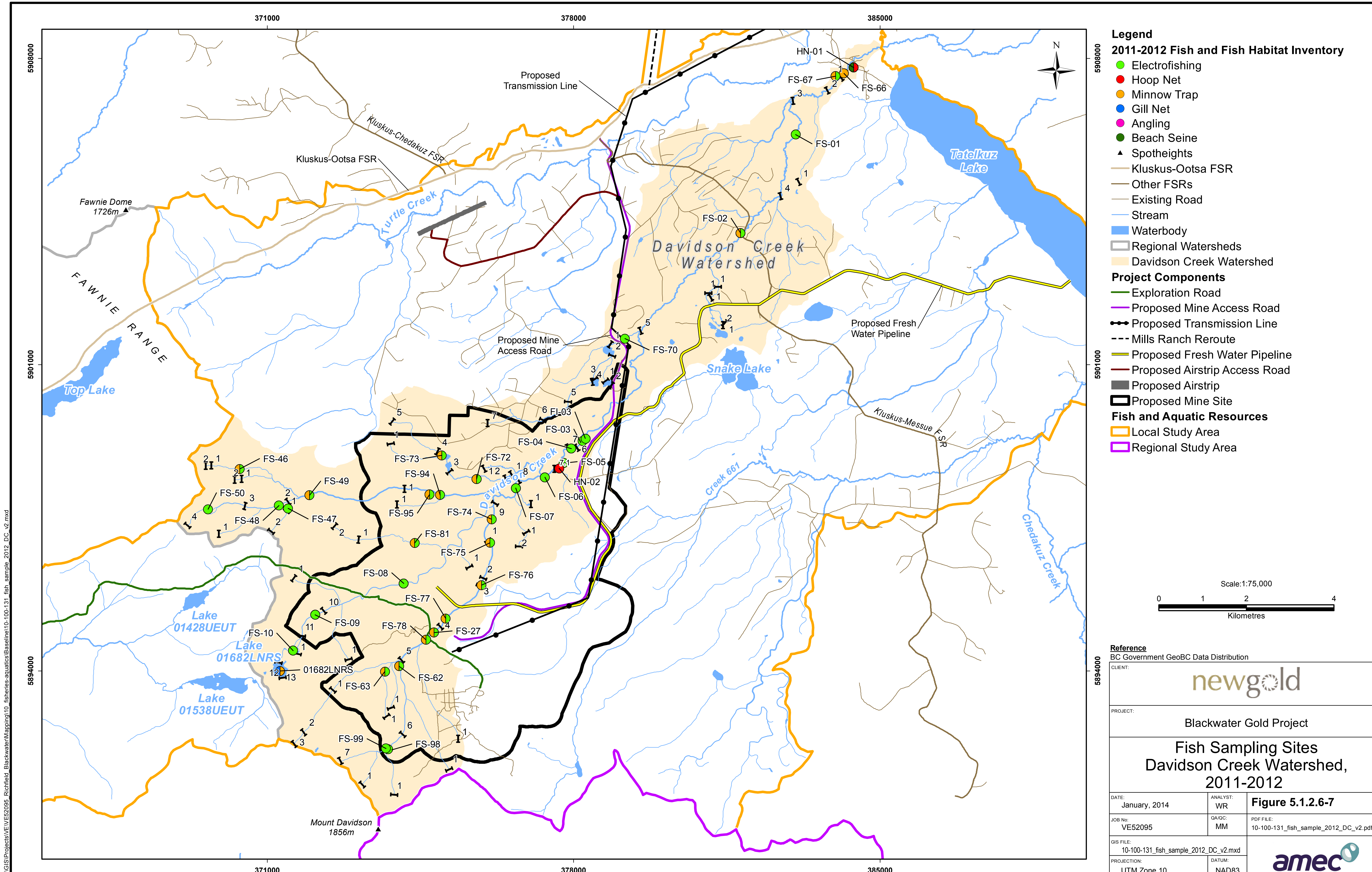
In 2013, five of those field components were repeated (Sections 3.0 and 4.0 of **Appendix 5.1.2.6B** and **Table 5.1.2.6-4**):

- Survey of overwintering fish habitat in 20 streams and 3 headwater lakes of the LSA from 12 to 17 March 2013 (**Figure 5.1.2.6-13**);
- Measurement of stream water temperatures at seven of the sites in the LSA monitored in 2011 and 2012 for part or all of the open-water season of 2013;
- Surveys of fish and fish habitat at stream crossings of the final alignments of the Project's transmission line (92 crossings) and the access road (9 crossings) using reconnaissance 1:20,000 methods (not shown in **Table 5.1.2.6-4**);
- Vertical profiles of temperature, DO and conductivity plus Secchi depth at one site in the northern third of Tatelkuz Lake in January, July (three times), and October; and
- Steambank survey of abundance and spatial distribution of kokanee spawners and redds in streams of the LSA.

Another 12 field components were new in 2013 (Sections 3.0 and 4.0 of **Appendix 5.1.2.6B** and **Table 5.1.2.6-4**):

- Bathymetric survey of Tatelkuz Lake in May and June;
- Hydroacoustic assessment of absolute fish numbers (including rainbow trout and kokanee) in Tatelkuz Lake from 9 to 12 July (followed by estimation of absolute number of rainbow trout in three headwater lakes by extrapolation from rainbow trout estimates in Tatelkuz Lake);
- Gillnet and minnow trap survey of the fish community of Tatelkuz Lake from 12 to 19 July to ground-truth the hydroacoustic survey and to describe the species richness and biological characteristics (i.e., length, weight, age, growth, sex, sexual maturation, and diet) of the fish community (**Figure 5.1.2.6-14**). Tissue metal concentrations were measured for rainbow trout and mountain whitefish;
- Littoral habitat survey of Tatelkuz Lake in late July;
- Survey of physical limnology and of the phytoplankton, zooplankton, and profundal BMI communities at two sites in Tatelkuz Lake in mid-August; and
- Survey of littoral BMI communities at 20 sites in the littoral zone of Tatelkuz Lake in mid-August;
- Electrofishing survey of fish community in lower Davidson Creek (to finish the survey begun in 2011) in early July. (Stop nets were used to isolate the electrofished site);
- Survey of fish and fish habitat in lower Chedakuz Creek using minnow traps, visual counts and FHAP;
- Survey of fish habitat in Creek 505659, a tributary of Creek 661, using FHAP (required due to revision of the mine design in 2013);
- Survey of fish and fish habitat in Creek 705 using electrofishing, (with stop nets) minnow traps, FHAP and reconnaissance 1:20,000 methods. This was required because flows in Creek 705 downstream of Lake 01538UEUT will increase once Lake 01682LNRS is diverted into Lake 01538UEUT during mine construction;
- Surveys of fish and fish habitat at nine stream crossings of the water pipeline from Tatelkuz Lake to the mine site, and three crossings of the airstrip access road, using electrofishing (with stop nets to isolate the electrofished site) and reconnaissance 1:20,000 methods; and
- Installation of instream flow transects in run, riffle and pool habitats in Davidson Creek, Creek 661, Creek 705, and lower Chedakuz Creek to measure relationships between stream discharge and depth, water velocity, and useable habitat area (**Figure 5.1.2.6-15** and **Appendix 5.1.2.6D**.

Standard QA/QC protocols were followed in processing samples and data.



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2011-2012 Fish and Fish Habitat Inventory
Electrofishing
Hoop Net
Minnow Trap
Gill Net
Angling
Beach Seine
Spotheights
Kluskus-Ootsa FSR
Other FSRs
Existing Road
Stream
Waterbody
Regional Watersheds
Davidson Creek Watershed
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
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Kilometres
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BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Fish Sampling Sites
Davidson Creek Watershed,
2011-2012
DATE: January, 2014
ANALYST: WR
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Davidson Creek Watershed
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Snake Lake
Top Lake
Lake 01428UEUT
Lake 01682LNRS
Lake 01538UEUT
Turtle Creek
Davidson Creek
Creek 661
Chedakuz Creek
Fawnie Dome 1726m
Mount Davidson 1856m
FAWNIE RANGE
Kluskus-Chedakuz FSR
Kluskus-Ootsa FSR
Kluskus-Messue FSR
Proposed Transmission Line
Proposed Mine Access Road
Proposed Fresh Water Pipeline
HN-01
HN-02
FS-01
FS-02
FS-03
FS-04
FS-05
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FS-09
FS-10
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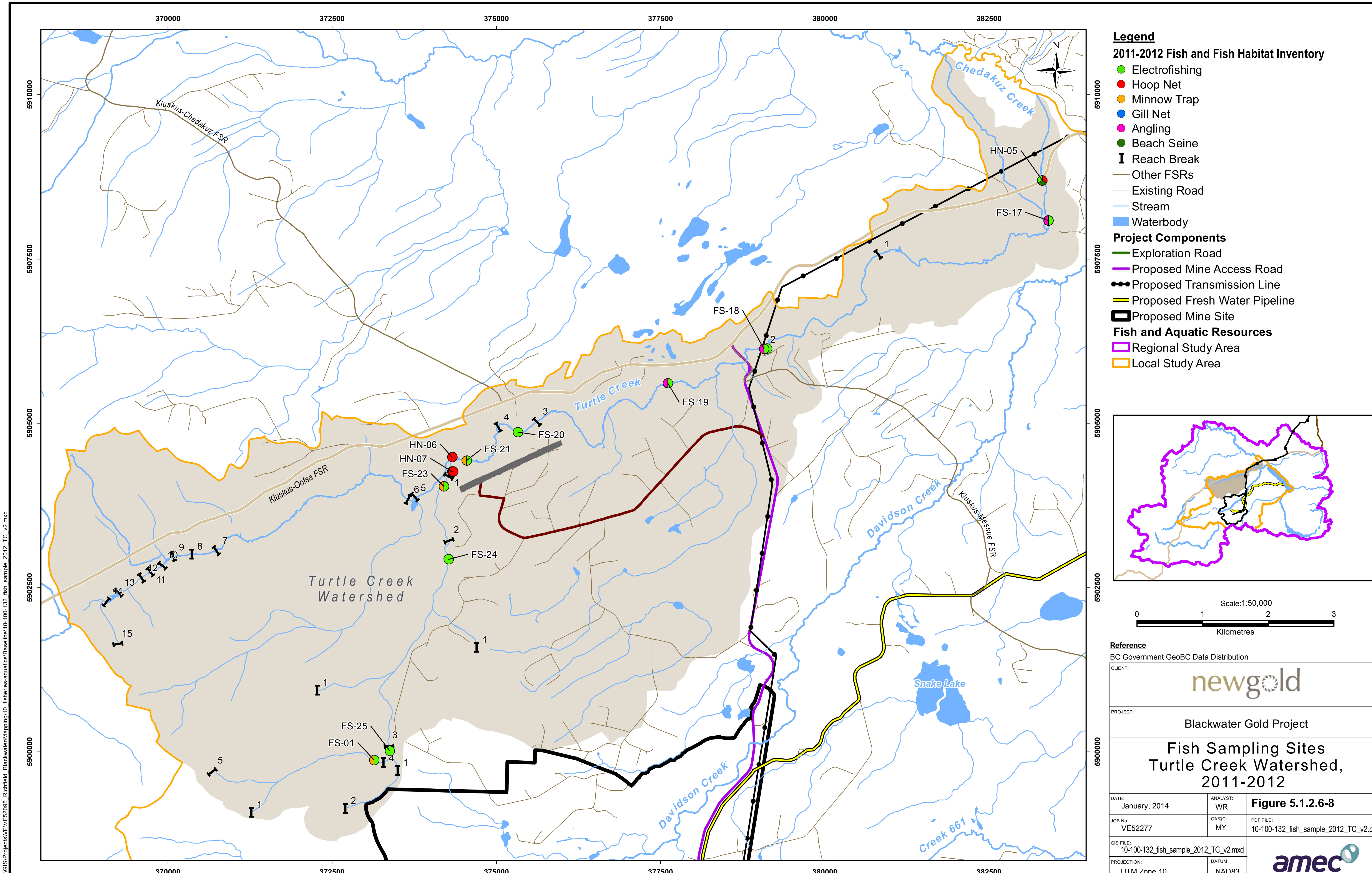
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Minnow Trap
Gill Net
Angling
Beach Seine
Reach Break
Other FSRs
Existing Road
Stream
Waterbody
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Fresh Water Pipeline
Proposed Mine Site
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Regional Study Area
Local Study Area
Scale:1:50,000
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2
3
Kilometres
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BC Government GeoBC Data Distribution
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newgold
PROJECT:
Blackwater Gold Project
Fish Sampling Sites
Turtle Creek Watershed,
2011-2012
DATE:
January, 2014
ANALYST:
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Chedakuz Creek
Kluskus-Chedakuz FSR
Kluskus-Ootsa FSR
Turtle Creek
Turtle Creek Watershed
Davidson Creek
Kluskus-Messue FSR
Snake Lake
Creek 661
HN-05
FS-17
FS-18
FS-19
FS-20
FS-21
HN-06
HN-07
FS-23
FS-24
FS-25
FS-01
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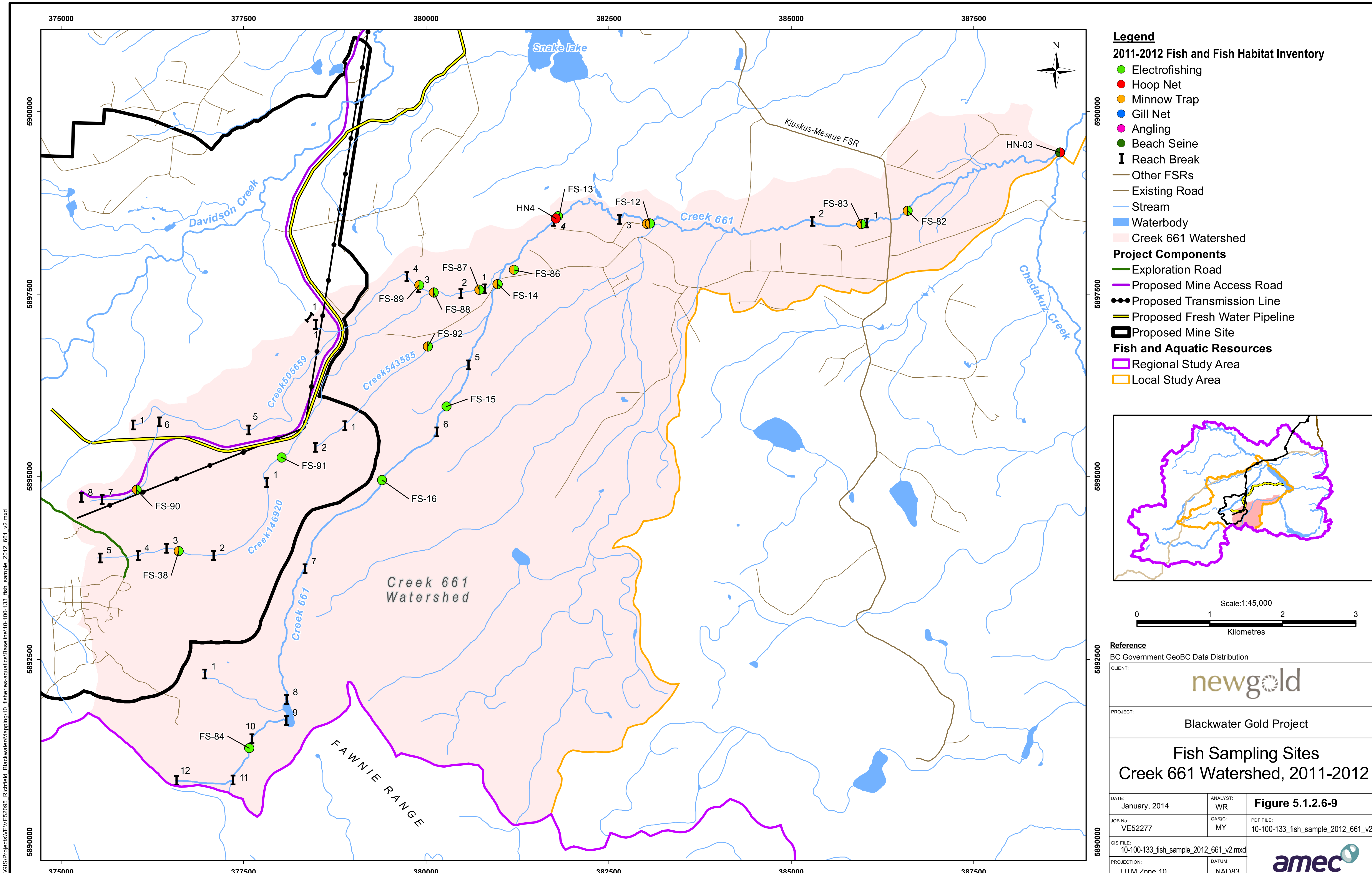

Legend
2011-2012 Fish and Fish Habitat Inventory
Electrofishing
Hoop Net
Minnow Trap
Gill Net
Angling
Beach Seine
Reach Break
Other FSRs
Existing Road
Stream
Waterbody
Creek 661 Watershed
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Fresh Water Pipeline
Proposed Mine Site
Fish and Aquatic Resources
Regional Study Area
Local Study Area
Scale:1:45,000
0 1 2 3
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Fish Sampling Sites
Creek 661 Watershed, 2011-2012
DATE: January, 2014
ANALYST: WR
Figure 5.1.2.6-9
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DATUM: NAD83
amec
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377500
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387500
5900000
5897500
5895000
5892500
5890000
Snake lake
Davidson Creek
Creek 661
Kluskus-Messue FSR
Chedakuz Creek
Creek505659
Creek543585
Creek146920
Creek 661 Watershed
FAWNIE RANGE
HN-03
HN4
FS-13
FS-12
FS-83
FS-82
FS-87
FS-86
FS-14
FS-89
FS-88
FS-92
FS-15
FS-91
FS-16
FS-90
FS-38
FS-84
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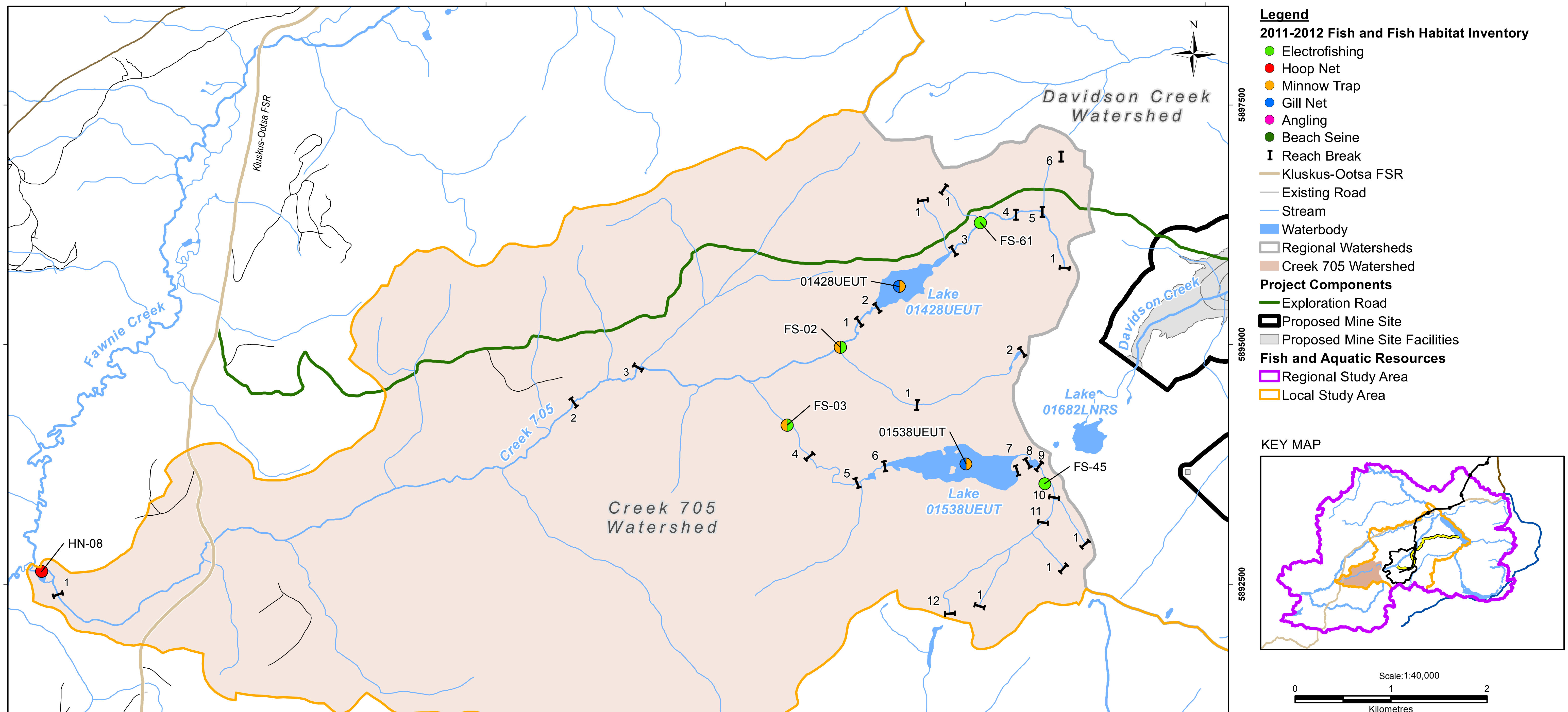

Reference
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CLIENT:
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PROJECT:
Blackwater Gold Project

Fish Sampling Sites
Creek 705 Watershed, 2011-2012

DATE: January, 2014	ANALYST: WR	Figure 5.1.2.6-10
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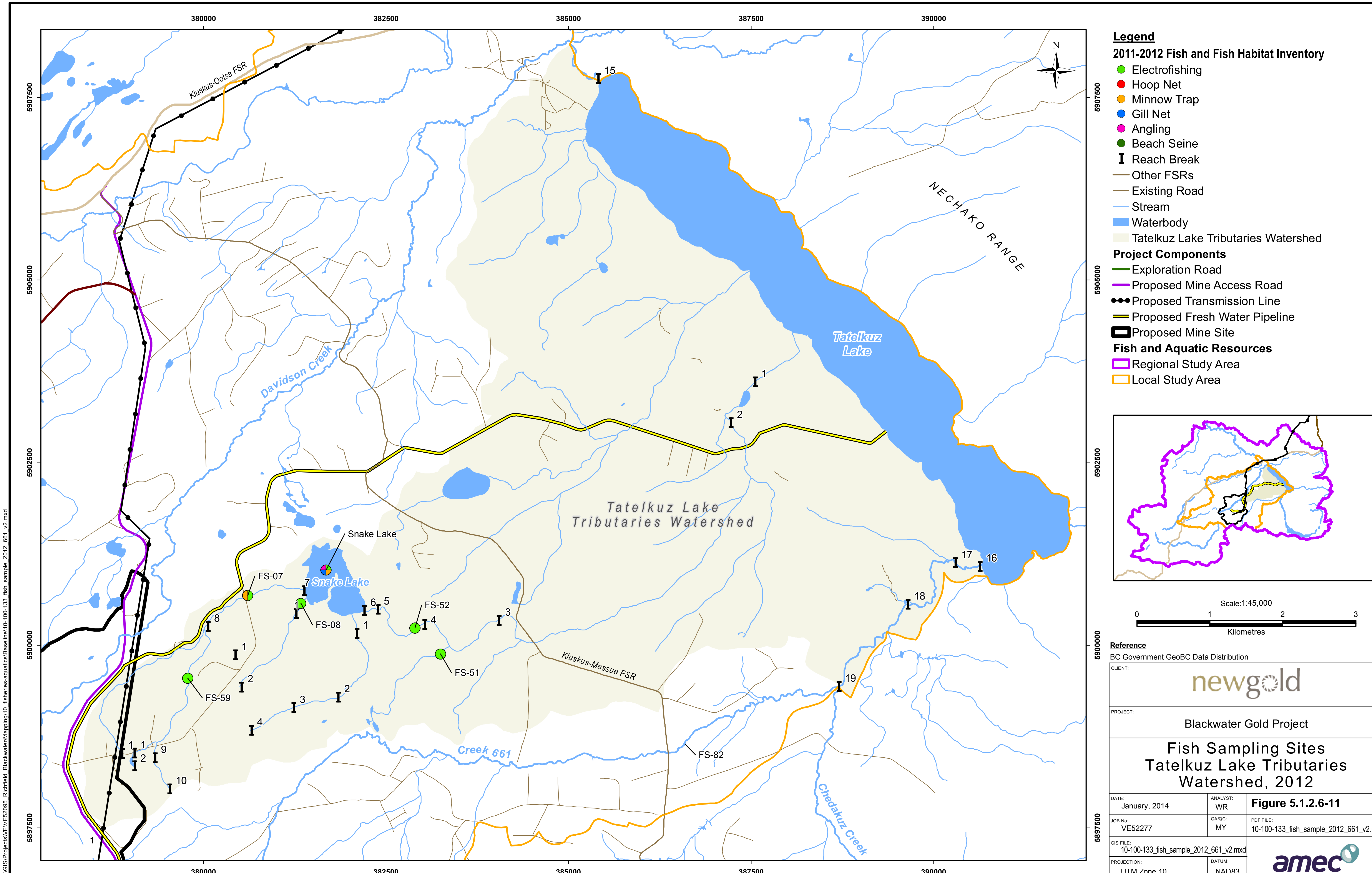

Legend
2011-2012 Fish and Fish Habitat Inventory
Electrofishing
Hoop Net
Minnow Trap
Gill Net
Angling
Beach Seine
Reach Break
Other FSRs
Existing Road
Stream
Waterbody
Tatelkuz Lake Tributaries Watershed
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Proposed Fresh Water Pipeline
Proposed Mine Site
Fish and Aquatic Resources
Regional Study Area
Local Study Area
Scale:1:45,000
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Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Fish Sampling Sites
Tatelkuz Lake Tributaries
Watershed, 2012
DATE: January, 2014
ANALYST: WR
Figure 5.1.2.6-11
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Kluskus-Messue FSR
NECHAKO RANGE
Tatelkuz Lake
Tatelkuz Lake Tributaries Watershed
Davidson Creek
Snake Lake
Creek 661
Chedakuz Creek
FS-07
FS-08
FS-52
FS-51
FS-59
FS-82
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382500
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387500
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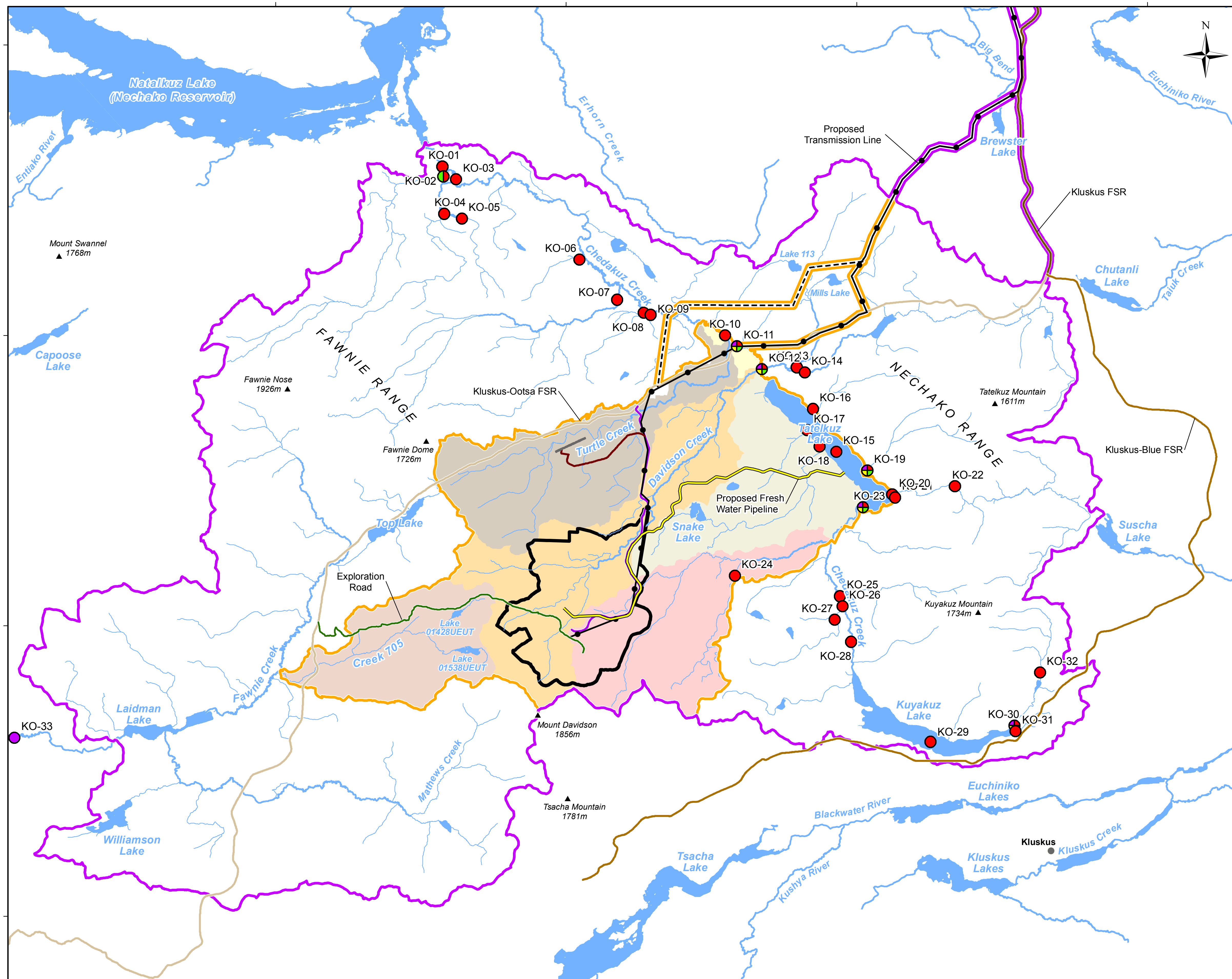

Legend

Kokanee Survey Sites
- KO Survey Conducted
- 1:20K Habitat Survey
- Kokanee Counts Completed
- DNA Collected
- Populated Place
- Spotheights
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream
- Waterbody

Project Components
- Exploration Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Mine Access Road
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Watersheds
- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Fish and Aquatic Resources
- Local Study Area
- Regional Study Area

Scale:1:200,000

0 2.5 5 10

Kilometres

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Kokanee Survey Sites
Regional Study Area, 2012

DATE: January, 2014	ANALYST: WR	Figure 5.1.2.6-12
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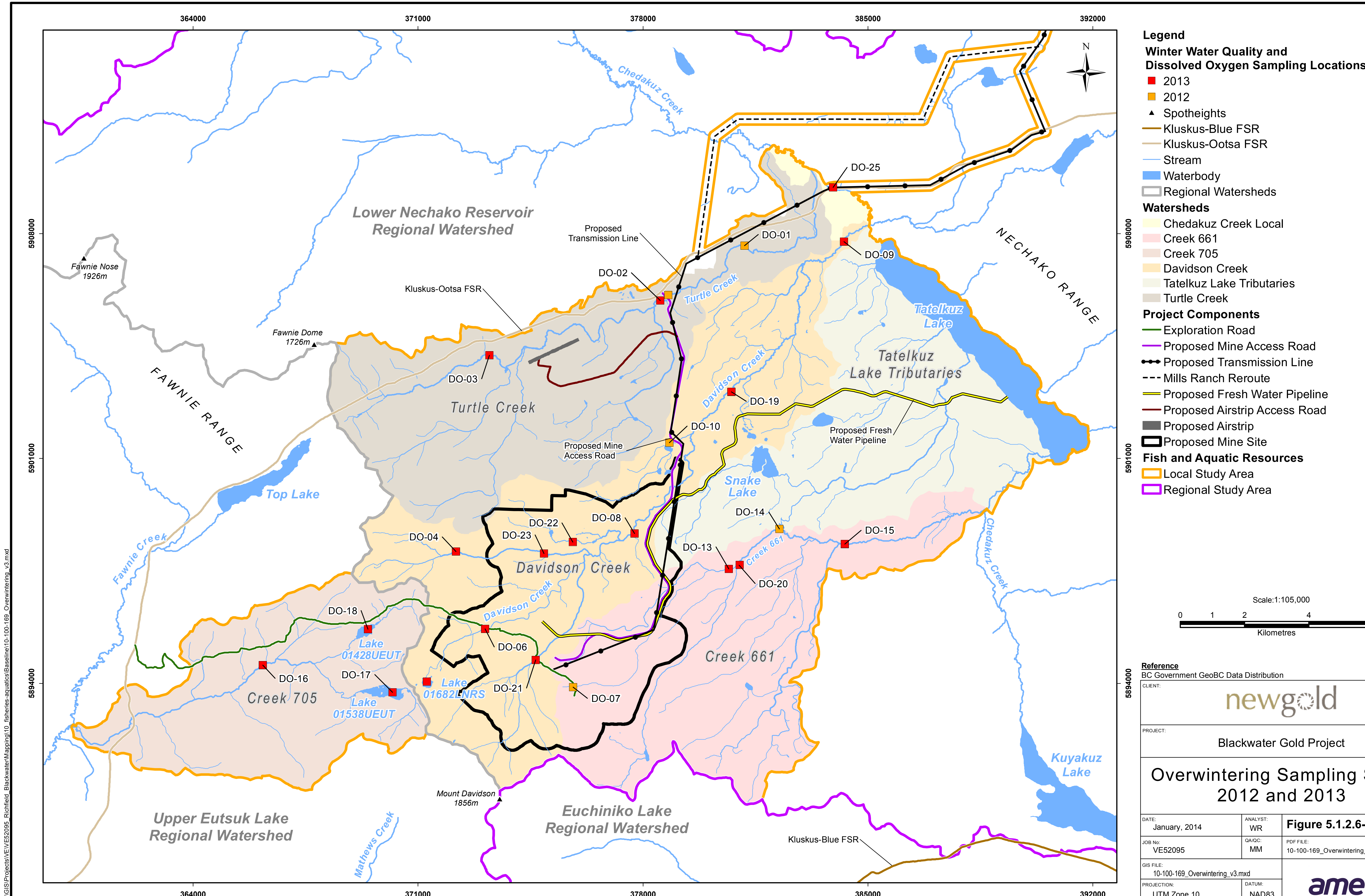

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Overwintering Sampling Sites, 2012 and 2013

DATE: January, 2014	ANALYST: WR	**Figure 5.1.2.6-13**
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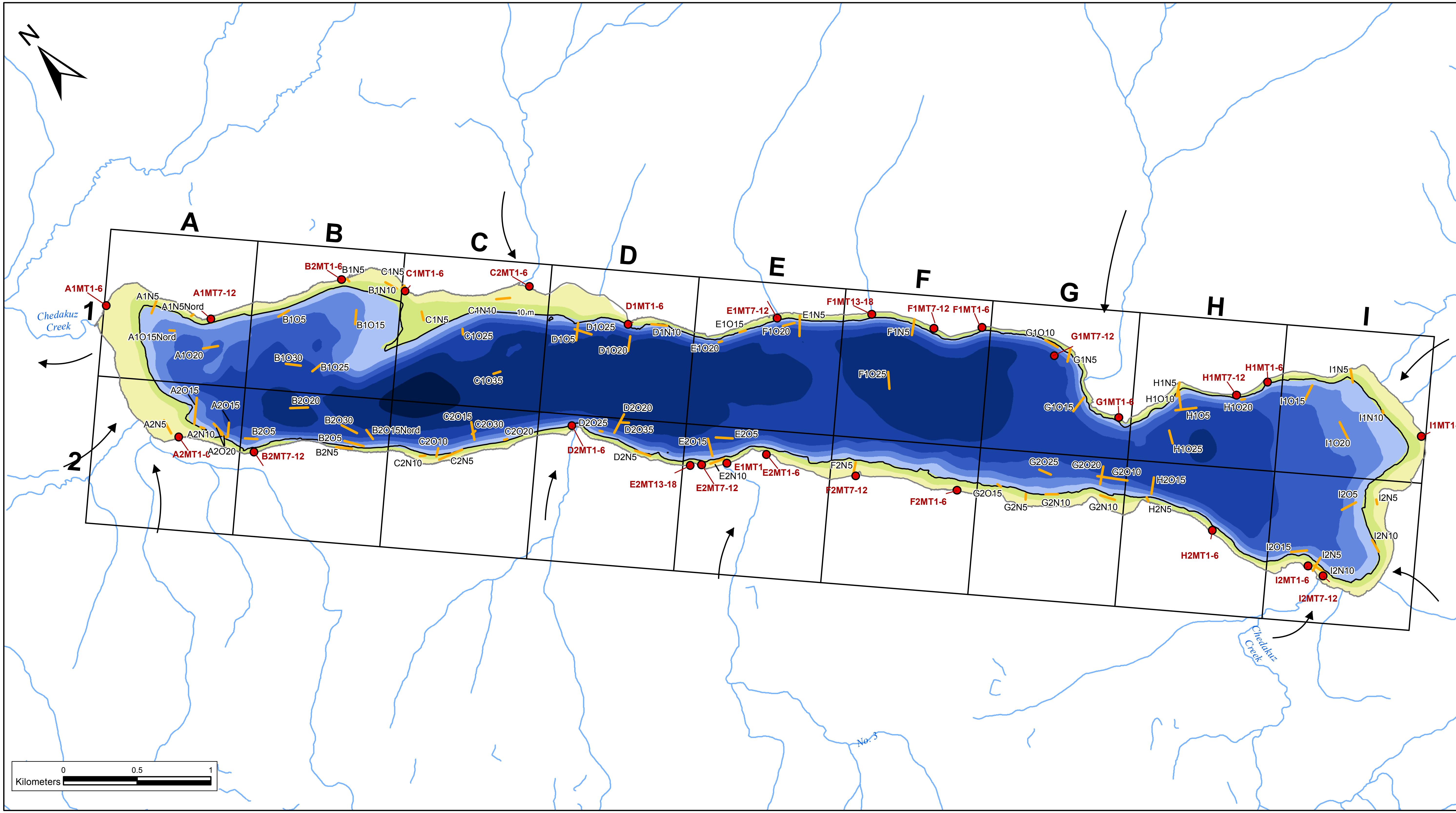
GIS FILE: 10-100-169_Overwintering_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Table 5.1.2.6-4: Number of Sampling Sites, Fish and Fish Tissues, Blackwater Project LSA, 2013

Field Component	Unit	Watershed							Total
		Davidson Creek	Turtle Creek	Creek 661	Creek 705	Tatelkuz Lake Tributaries	Chedakuz Creek	Tatelkuz Lake	
Overwintering stream and lake habitat	Sites	12	2	5	3	0	1	0	23
Stream temperature monitoring	Sites	4	2	1	0	0	0	0	7
Lake bathymetry	Lakes	0	0	0	0	0	0	1	1
Hydroacoustic estimate of fish number	Lakes	0	0	0	0	0	0	1	1
Lake fish community survey (gillnets)	Sites	0	0	0	0	0	0	78	78
Lake fish community survey (minnow trap groups)(1)	Sites	0	0	0	0	0	0	27	27
Physical limnology	Sites	0	0	0	0	0	0	2	2
Phytoplankton	Sites	0	0	0	0	0	0	2	3
Zooplankton	Sites	0	0	0	0	0	0	2	3
Lake BMI (littoral)	Sites	0	0	0	0	0	0	20	20
Lake BMI (profundal)	Sites	0	0	0	0	0	0	2	2
Fish habitat (lake)	Shoreline transects	0	0	0	0	0	0	21	21
Fish habitat (streams)	FHAP sites	0	0	1	9	0	1	0	11
	Recon. 1:20,000K sites	1	0	1	11	6	0	0	19
Summer fish inventory (streams)	Sites	3	0	0	11	0	12	0	25
Summer-fall kokanee spawning survey	Sites	4	0	3	0	0	8	0	15
Fish diet (stomachs)	Fish(2)	0	0	0	0	0	0	37	37
Fish tissue metals concentrations	Tissues(3)	0	0	0	0	0	0	79	79

Note: **(1)**Six traps per groups
(2)includes kokanee, rainbow trout, and mountain whitefish
(3)includes rainbow trout and mountain whitefish.



REFERENCE:
BC Government GeoBC Data Distribution

Legend

Fish Sample Sites (AMEC 2013)
- Minnow Trapping
- Gillnets
- Depth Contour - 10 m
- Streams and Rivers

Water Depth (m)
- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40

CLIENT
newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

amec

ANALYST: KA
QA: MM
DATUM: NAD83
PROJECTION: UTM Zone 10
SCALE: 1:25,000

PROJECT
Blackwater Gold Project

TITLE
Fish Sample Sites
Tatelkuz Lake, 2013

REV. NO: A
DATE: November, 2013
PROJECT NO: VE52277
FIGURE NO: 5.1.2.6-14

5.1.2.6.2.5 Analysis and Interpretation of Data

5.1.2.6.2.5.1 Guidance Documents

Field-collected data on fish and fish habitat were analyzed and interpreted using the following guidance documents (in addition to those documents listed in **Section 5.1.2.6.2.3**):

- Optimal and lethal DO concentrations for rainbow trout reported by Raleigh et al. (1984) and Ford et al. (1995), and the BC MOE DO criteria for buried fish embryos and alevins (BC MOE, 1997a);
- Optimum water temperature ranges for life history stages of rainbow trout and kokanee (BC MOE, 2001);
- British Columbia Approved Water Quality Guidelines (BC MOE, 2006);
- BC water quality criteria for nutrients and algae in streams (BC MOE, 2007);
- Draft BC ambient water quality guidelines for sulphate (BC MOE, 2012b);
- Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007, 2013);
- Statistical techniques for analyzing population data for aquatic plants and animals (Bray and Curtis, 1957; Cochran, 1977; Clarke and Green, 1988; Barbour et al., 1999; Krebs, 1989; Anderson, 2001; Clarke and Warwick, 2001; Kelly, 2001; Crawley, 2007; R Core Team, 2012);
- Protocols for analyzing BMI data within the CABIN format (Reynoldson et al., 1997, 2001; Bennett, 2001; Yeow et al., 2007);
- Criteria of healthy stream BMI communities (Hilsenhoff, 1987; Mandaville, 2002; Hargett et al., 2005; Feldman, 2006; de Zwart et al., 2006; Hubler, 2008);
- Standard methods for analyzing physical limnology of lakes (Parsons et al., 1984; Wetzel, 2001);
- Species conservation status reports for BMI and fish (BC CDC, 2013, 2014; COSEWIC, 2013);
- Traditional Knowledge (TK) and Traditional Land Use (TLU) information on fish and fish habitat in the LSA and RSA gathered from interviews with representatives of local First Nations (Interviews with Lhoosk'uz Dene Elders, 2013) and from archaeological investigations (New Gold, 2012);
- Reviews of fish life history and habitat use (Scott and Crossman, 1973; Burgner, 1991; Ford et al., 1995; Roberge et al., 2002; McPhail, 2007; Nowosad and Taylor, 2013);
- BC provincial “biostandards” developed for stream populations of rainbow trout surveyed before and after watershed habitat restoration (Keeley et al., 1996; Koning and Keeley, 1997);
- Hydroacoustic surveys of kokanee and rainbow trout population numbers in lakes of the Pacific Northwest (Stables and Thomas, 1992; Bussanich et al. 2005; Stark, 2006;

Maiolie et al., 2008; Schindler et al., 2009; Schoby et al., 2009; Stables and Perrin, 2010; Wahl et al., 2010);

- Standard methods for analyzing fish size, age and growth (Ricker, 1975);
- Statistical methods for analyzing tissue metal concentrations of BMI and fish (SAS, 2013);
- Toxicity to humans of total mercury, methyl-mercury, and selenium concentrations in fish tissues (CCME, 2000; Eisler, 2006; BC MOE, 2013b, 2013c; Health Canada, 2013);
- Review of mercury and selenium concentrations in rainbow trout tissues from sites in BC and Canada (Rieberger, 1992; DeForest, 2009; Depew et al., 2013);
- Protocol for derivation of fish tissue residue guidelines for the protection of wildlife consumers of aquatic biota established by the Canadian Council of Ministers of the Environment (CCME) (CCME, 1998);
- Standard methods for analyzing microsatellite DNA data of rainbow trout and kokanee (Weir and Cockerham, 1984; Pritchard et al., 2000; Raymond and Rousset, 2001; Redenbach and Taylor, 2003; Excoffier et al., 2006); and
- Review papers on genetic relatedness of rainbow trout populations in BC (Tamkee et al., 2010; Taylor et al., 2007) and kokanee populations in BC (Taylor and Gow, 2007).

This list does not include the many references used for taxonomic identification of periphyton, phytoplankton, zooplankton and BMI, or for analysis of metal concentrations in fish and BMI tissue samples.

5.1.2.6.2.5.2 Fisheries Mitigation and Offsetting Plan

AMEC conducted a study of the amount and quality of fish habitat that will be lost to Project activities and developed mitigation measures to avoid some of that lost habitat. An FMOP was developed to compensate for the rest of the lost fish habitat. **Appendix 5.1.2.6C** describes that study.

Some of the fish habitat calculations described in **Appendix 5.1.2.6C** are briefly described in this summary because they provide the most concise summary of fish habitat. Specifically, the total area (m^2) of fish habitat in streams was calculated for each watershed of the LSA based on fish habitat surveys conducted in 2011, 2012 and 2013, and historical fish surveys conducted from 1977 to 2010. Areas were calculated by multiplying the lengths and mean widths of each stream reach in each watershed of the LSA. All reaches of all streams were included. Those classified as “non-fish-bearing” still provide some habitat even if it is only in the form of the export of water, nutrients and drifting insect prey to downstream fish-bearing reaches.

Stream lengths were measured using GIS software, but mean reach widths were calculated from field surveys of fish habitat. FHAP data was used where available, which was generally in the mainstems of large streams in the Project area. Reconnaissance 1:20,000 habitat inventory data were used for tributary streams where FHAP data was unavailable. Historical data were used for tributary streams where no other information was available. Where no data was available for a stream, mean widths were calculated from all other tributaries in each watershed.

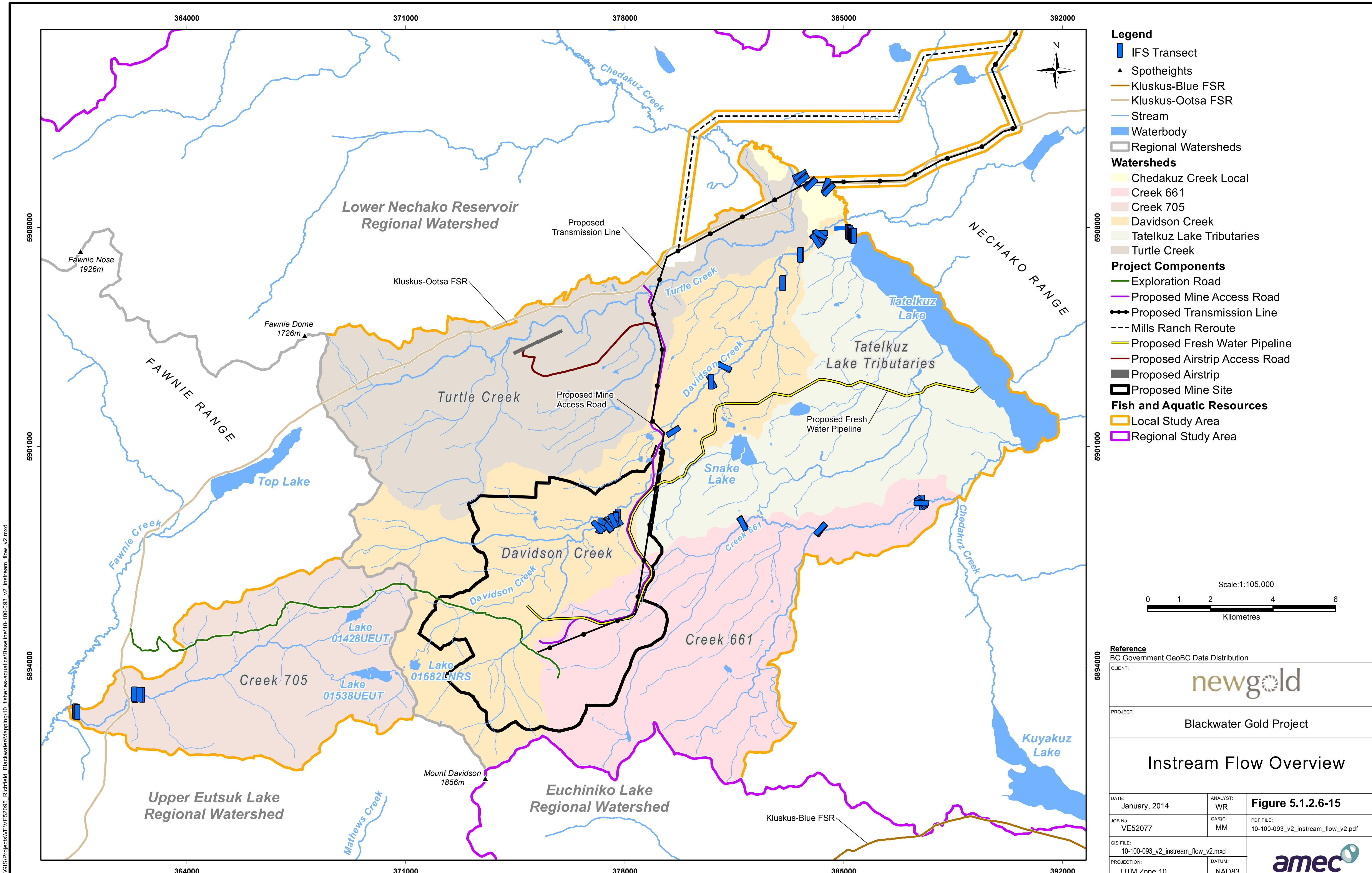
The total numbers of Habitat Units (HU) in each watershed of the LSA were calculated using the Habitat Evaluation Procedure (HEP). HU are the product of the area of fish habitat in a habitat unit and a Habitat Suitability Index (HSI) assigned to that habitat unit. An HSI is an index of habitat quality and has a value between 0 (unsuitable) and 1 (optimal). HSI for the HEP analysis in the FMOP were based on published literature and site-specific fish and fish habitat sampling. HSI development and validation is described in Annex C of the FMOP. The sampling of fish and fish habitat that was undertaken to support the HSI is summarised in this section. Surveys of fish habitat of the LSA were comprehensive, as shown in **Figure 5.1.2.6-5** and **Figure 5.1.2.6-6**, and included first-to third-order streams and small ponds and wetlands connected to stream habitat. Fish were sampled from streams using electrofishing (with blocking nets), minnow traps and angling, as appropriate.

To determine HSI, stream reaches were first divided into seven mesohabitat types that were defined for the Project: cascades, riffles, glides, pools, tributary streams, lakes, and other. Each of the seven habitat types was further sub-divided into classes to represent the range of microhabitat variability within each habitat type. HSI were assigned to all habitat categories for each life stage of rainbow trout and kokanee based on professional judgement using knowledge of the species life histories, descriptions in the habitat classification system, and knowledge of habitat use and fish densities gained from the baseline studies of 2011, 2012 and 2013.

In addition, fish habitat quality ranks of nil, low, medium and high were shown on a map of streams in the LSA. To determine those rankings, stream reaches were first divided into six habitat types: cascades, riffles, glides, pools, tributary streams, and other (**Table 5.1.2.6-5**). Each of the six habitat types was further sub-divided into habitat classes to represent the range of microhabitat variability within each habitat type. Each habitat class was assigned a quality rating of nil, low, medium and high, based on an average of habitat suitability scores for all life stages of rainbow trout and kokanee. Where habitat type proportions were known, based on FHAP data, habitat quality ratings were weighted by these proportions and averaged to produce a single habitat quality rating for each reach. Where habitat type proportions for a reach were not known (because only reconnaissance 1:20,000 habitat inventory or historical data were available), then reaches were assigned to the tributary habitat type. Habitat quality ratings for tributary reaches were based on stream order.

No *a priori* weighting was given to any particular habitat type or life stage of fish in the analyses shown in the FMOP. Spawning habitat was not given any more importance than rearing habitat, overwintering habitat, or foraging habitat. However, different habitats were rated differently for spawning, rearing, foraging, or overwintering based on their unique habitat characteristics and how suitable these characteristics were for different life stages of fish. These are objectively calculated from baseline data however, not subjectively weighted according to perceived limiting habitats.

The total area and number of HU in each lake of the LSA were calculated in a similar manner.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IFS Transect
Spotheights
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
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Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
364000
371000
378000
385000
392000
5908000
5901000
5894000
N
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
NECHAKO RANGE
FAWNIE RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Proposed Transmission Line
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Kluskus-Blue FSR
Chedakuz Creek
Turtle Creek
Davidson Creek
Tatelkuz Lake
Tatelkuz Lake Tributaries
Snake Lake
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5.1.2.6.2.5.3 Instream Flow Study

A study was conducted of instream flow needs of fish in the LSA in order to determine what flows are required to conserve fish habitat and fish populations in streams and lakes potentially affected by the Project. The study required collection of baseline data on water flow, velocity and depth at 103 transects in Davidson Creek, Creek 661, lower Chedakuz Creek and Creek 705 (**Figure 5.1.2.6-15**). **Appendix 5.1.2.6D** describes the methods and results of the IFS.

The IFS used hydrological data that was reported in **Section 5.3.2** (Hydrology VC). Because site-specific climate and stream flow data were only available for a baseline period of three years (2011 to 2013), regional data were used to generate a 40 year-long synthetic hydrological database for the years 1973 to 2013.

Habitat Suitability Curves (HSC) were used in the IFS to assess the effect of predicted flow changes in Davidson Creek, Creek 661, Creek 705 and Chedakuz Creek on rainbow trout and kokanee habitat. Those HSC indicate the suitability of different depths, water velocities and substrates for rainbow trout and kokanee spawning, juvenile rearing, and adult foraging. Standard BC HSC curves were obtained from BC MOE and used as starting points (Ron Ptolemy, BC MOE, personal communication). Those HSC were then validated or adjusted, where necessary, using site-specific field data. Section 3.3.1 of the IFS provides details of validation, including the number of data points used for validation.

As with the FMOP, no a priori weighting was given to any particular habitat type or life stage of fish in the analyses shown in the IFS.

5.1.2.6.2.5.4 Effects Assessment of Davidson Creek Flow Augmentation on Homing of Salmonid Fish

The major mitigation measure proposed for the Project is the augmentation of flows in the lower half of Davidson Creek with water pumped from the south-eastern end of Tatelkuz Lake. This mitigation will maintain flows in the lower half of Davidson Creek at levels that will be sufficient to conserve the populations of rainbow trout and kokanee that currently use spawning and rearing habitat in Davidson Creek.

Water will be pumped through an 8 km-long buried pipeline and temporarily stored in a reservoir located below the TSF before discharge into Davidson Creek. Since water from Tatelkuz Lake comes from a different sub-basin in the Chedakuz Creek Watershed than water that currently flows in Davidson Creek, and Tatelkuz Lake is a residence lake for the populations of rainbow trout and kokanee that spawn and rear in Davidson Creek, there is some concern that this mitigation measure may interfere with chemical imprinting of the two species of fish on spawning habitat in Davidson Creek and cause temporary or permanent loss of those two populations from Davidson Creek.

Appendix 5.1.2.6E assesses the potential effects of flow augmentation of Davidson Creek on homing of rainbow trout and kokanee spawners and describes an adaptive management plan to deal with the range of potential outcomes.

Table 5.1.2.6-5: Stream Habitat Quality Ranking

Habitat Type	Class	Definitions and Habitat Variables	Overall Habitat Quality(1)
Cascade	3	Steep, stepped riffles of bedrock or emergent cobbles/boulders, fast-flowing water, turbulent, shallow, gradients > 4%	L
Riffle	1	Turbulent, fast-flowing water, shallow, moderate gradient, spawning gravels extensive, dominate substrate are gravels, low cover and habitat complexity	H
	2	Turbulent, fast-flowing water, shallow, moderate gradient, pockets of spawning gravels, dominant substrates are cobbles or boulders, moderate cover and habitat complexity	H
	3	Turbulent, fast-flowing water, shallow, moderate gradient, no spawning gravels, dominant substrates are cobbles or boulders, high cover and habitat complexity	M
Glide	1	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, spawning gravels extensive, dominant substrate are gravels, low cover and habitat complexity	H
	2	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, pockets of spawning gravels, dominant substrates are cobbles or boulders, moderate cover and habitat complexity	H
	3	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, no spawning gravels, dominant substrates are cobbles or boulders, high cover and habitat complexity or areas of slow flowing, deep water with fine substrates	M
Pool	1	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, good pool depth (>0.50 m), abundant cover, high LWD and overhead cover	H
	2	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, moderate pool depth (0.30-0.50 m), moderate cover, moderate LWD and overhead cover	M
	3	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, low pool depth (<0.30 m), low cover, low LWD and overhead cover	L
Other	1	Off-channel habitat, >2 m deep, abundant cover, high LWD and overhead cover, substrate complexity	H
	2	Beaver dams, open water wetland complexes, shallow <2 m, low gradient, fine substrates, variable cover	L
Tributary Streams	1	2nd order headwater streams or tributaries , small 3rd order tributaries (lower valley), riffle-pool morphology , variable cover, juvenile rearing habitat only	L
	2	1st order headwater streams or tributaries, riffle-pool morphology, variable cover, juvenile rearing habitat only	L
	3	2nd or 1st order headwater streams or tributaries, small 3rd order tributaries (lower valley), large channel morphology, low gradient wetland habitats, intermittent channel features, fine substrates, juvenile rearing habitat only	L
	4	Ephemeral, headwater or tributary streams, NVC and NCD, non fish-bearing	N

Note: (1)H = High, M = Medium, L = Low, N = Nil

5.1.2.6.3 Results and Discussion

5.1.2.6.3.1 Fish Habitat

5.1.2.6.3.1.1 Streams

5.1.2.6.3.1.1.1 Baseline Monthly Flows

Table 5.3.2-1 of **Section 5.3.2** (Hydrology VC) shows baseline monthly and annual flows for each of the five streams of the LSA. Monthly and annual flows are shown for the mean condition, and for the 1:5, 1:10: 1:20 and 1:50 wet and dry years. These flows were based on the 40-year synthetic time series for 1970 to 2013. **Figure 5.3.2-1** shows the locations and code numbers for the hydrometric stations of the LSA.

Figure 5.1.2.6-16 shows mean monthly flows for the five watersheds of the LSA. Monthly flows for lower Chedakuz Creek were taken at the outlet of Tatelkuz Lake (station 15-CC). Monthly flows for the other four streams were taken from stations at the downstream end of each watershed: station 1-TC for Turtle Creek, station 1-DC for Davidson Creek, station 1-661 for Creek 662, and station 1-705 for Creek 705.

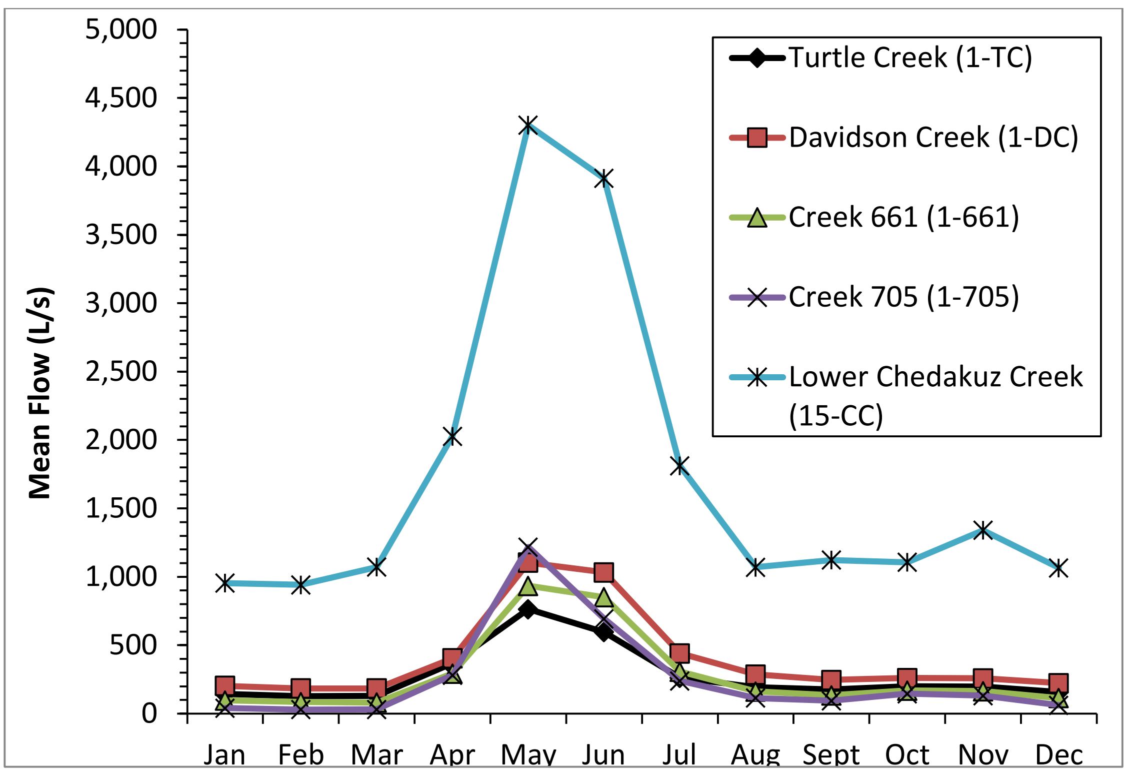


Figure 5.1.2.6-16: Mean Monthly Flows of the Five Streams of the LSA

Figure 5.1.2.6-16 shows that lower Chedakuz Creek has mean monthly flows that are approximately four times higher than the other four streams and that those four streams have similar monthly flows. For all five streams, highest flows are in May and lowest flows are in February or March.

Figure 5.1.2.6-17 shows that flows increase with downstream distance in Davidson Creek, as they do in all five streams. The lowest flows are found at station 11-DC in Reach 11, just downstream of headwater Lake 01682LNRS. Flows increase substantially at station H2 in Reach 8 due to tributary input. Flows continue to increase at station H4B in the upper part of Reach 4, station 4-DC in lower Reach 4, and station 1-DC in Reach 1 just upstream from the confluence with lower Chedakuz Creek.

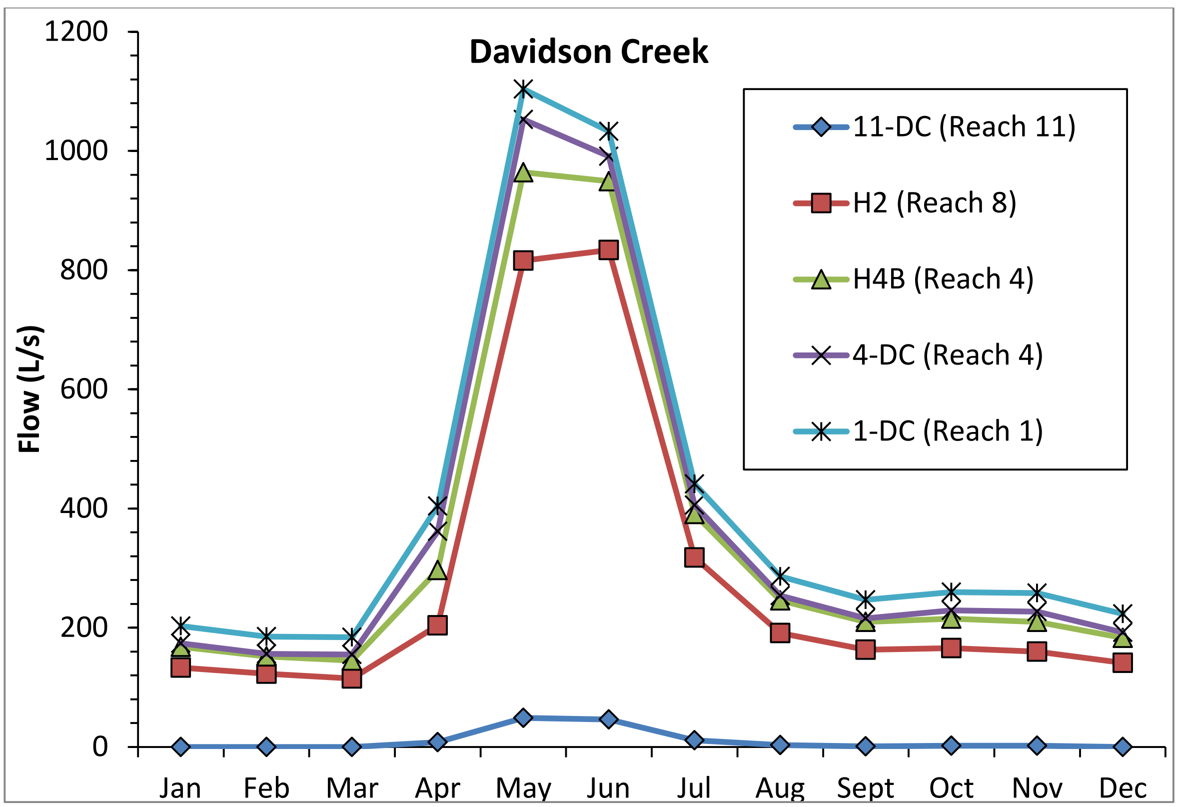


Figure 5.1.2.6-17: Mean Monthly Flows at Hydrometric Stations along Davidson Creek

Flows in Davidson Creek vary substantially under wet and dry conditions. **Figure 5.1.2.6-18** shows that peak flows at station 1-DC under 1:50 year conditions are more than twice as great as mean flows and that the month of peak flow shifts from May to June. Flows under 1:50 dry conditions are half of mean flows. These flows were based on the 40-year synthetic time series for 1970 to 2013 shown in **Table 5.3.2-1** of **Section 5.3.2** (Hydrology VC).

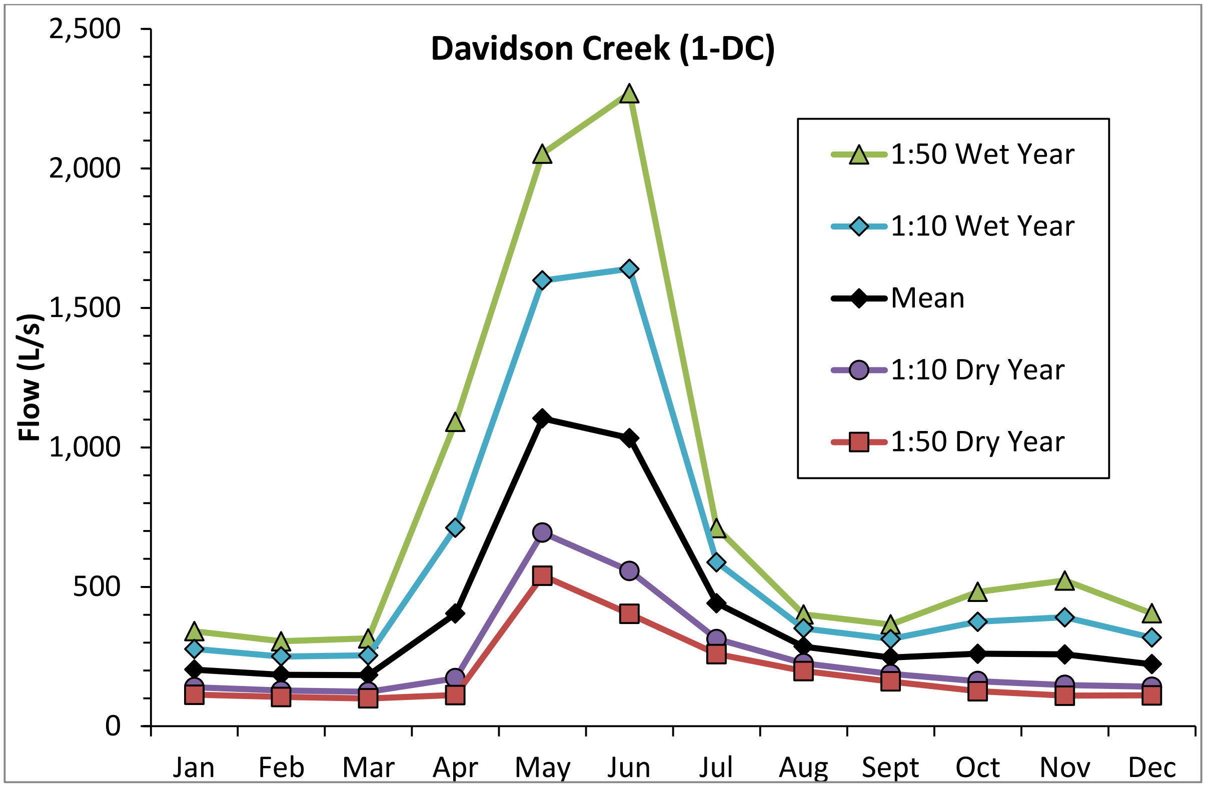


Figure 5.1.2.6-18: Mean Monthly Flows of Davidson Creek for Wet and Dry Years

5.1.2.6.3.1.1.2 Status of Baseline Years

The simplest way of determining the hydrometeorological status (i.e., dry, average or wet year) of the baseline years 2011, 2012 and 2013 was to use the peak modelled baseline discharge of Tatelkuz Lake into lower Chedakuz Creek over the years 1973 to 2013, as shown in Figure 5 of **Appendix 5.3.2C** (of the Hydrology VC). Baseline spring discharge ranged from a low of 1.9 m^3/s in 2004 to a maximum of 14.7 m^3/s in 1976 with a mean of 26.0 m^3/s (SE = 0.4) and a median of 3.7 m^3/s over all 41 years. Those 41 years were sorted by magnitude of peak discharge and then divided into dry, average and wet classes each containing 15 years. Wet years had discharges between 4.9 and 14.7 m^3/s, average years had discharges between 3.4 and 4.0 m^3/s, and dry years had discharges between 1.9 and 3.4 m^3/s. All three baseline years were classified as wet; 2011 had a peak discharge of 12.6 m^3/s (rank = 2), 2012 had a peak discharge of 5.7 m^3/s (rank = 10), and 2013 had a peak discharge of 7.4 m^3/s (rank = 4).

5.1.2.6.3.1.1.3 General Morphology

Fish habitat surveys of the LSA from 2011 to 2013 (Section 5.8 of **Appendix 5.1.2.6A** and Sections 5.4 to 5.8 of **Appendix 5.1.2.6B**) showed a system typical of the central BC interior – steep, sub-alpine headwater tributaries of poor quality habitat draining to lower gradient reaches of higher quality habitat that flow into valley-bottom streams (e.g., Chedakuz and Fawnie creeks) that are the inlets or outlets of large, overwintering lakes (e.g., Tatelkuz Lake).

Overall, streams within the LSA have a mean gradient of 1.53%, a mean bankfull width of 5.09 m, and a mean bankfull depth of 0.56 m (**Table 5.1.2.6-6**). Stream habitat is dominated by glides (40.8%) and riffles (38.6%) with pools making up only 16.4% of all surveyed sites.

Table 5.1.2.6-6: Habitat Parameters for All Streams Surveyed in the LSA, 2011-2013

Variable		*Mean*	*SE*	*n*	*Min*	*Max*
Bankfull Width (m)		5.09	0.25	495	0.35	57.0
Wetted Width (m)		4.49	0.23	506	0.20	57.0
Bankfull Depth (m)		0.56	0.01	496	0.14	1.53
Wetted Depth (m)		0.33	0.01	506	0.04	1.69
Residual Pool Depth (m)		0.48	0.02	218	0.10	1.65
Gradient (%)		1.53	0.08	673	0.00	15.0
Habitat (% Composition)	Riffle	38.6	-	-	-	-
	Glide	40.8	-	-	-	-
	Pool	16.4	-	-	-	-
	Other	4.2	-	-	-	-

Note: SE = standard error, n = sample size, min = minimum, max = maximum.

5.1.2.6.3.1.1.4 Habitat Quantity and Quality

Habitat quantities and qualities shown in this section were calculated using the same techniques used to calculate the habitat budget shown in the FMOP (**Appendix 5.1.2.6C**).

5.1.2.6.3.1.1.4.1 Davidson Creek

Lower Davidson Creek (i.e., Reaches 1 to 4) is characterized by riffle-pool morphology, which, combined with abundant suitably-sized gravels, provides good spawning habitat for kokanee and rainbow trout. Stable banks, deep pools, and good channel and hydraulic habitat complexity from large woody debris provide high-quality rearing habitat for juvenile rainbow trout.

Middle Davidson Creek (Reaches 5 to 8) is characterized by riffle and glide habitat, with fewer pools than are present in the lower section of the creek. Substrates are characterized by a mixture of cobbles and boulders, with spawning gravels present in more isolated pockets.

The upper reaches of Davidson Creek (Reaches 9 to 12) are dominated by glides and runs, rather than by pools and riffles, as in the lower reaches of Davidson Creek. As a result, habitat complexity and suitability of spawning and juvenile rearing habitat is lower than in the lower reaches of Davidson Creek.

Davidson Creek Watershed contains a total of 104,371 m of stream length (**Table 5.1.2.6-7**). This is 27.1% of the total stream length in the LSA, and it is the single longest length of stream of the six watersheds in the LSA (if one includes lower Chedakuz Creek as a separate watershed).

Table 5.1.2.6-7: Fish Habitat Area in Streams and Ponds of Watersheds of the LSA

Watershed	Stream Length (m)	Fish Habitat Area Streams (m^2)	Fish Habitat Area Ponds (m^2)	Fish Habitat Area Total (m^2)	Pond/Stream Area Ratio
Davidson Creek	104,371	230,665	237,333	467,998	1.03
Turtle Creek	82,693	156,376	149,532	305,908	0.96
Creek 661	85,352	125,817	95,595	221,412	0.76
Creek 705	44,805	119,134	25,474	144,608	0.21
Tatelkuz Lake Tributaries	62,750	90,996	317,800	408,796	3.49
Lower Chedakuz Creek[(1)]	4,485	55,458	0	55,458	0.00
Total	**384,456**	**778,446**	**825,734**	**1,604,180**	

Note: Stream and pond habitat only (no lakes included).
(1) Reach 15 only (from outlet of Tatelkuz Lake to Kluskus FSR bridge).

Multiplying the length of each stream reach by its mean width, as measured by FHAP and reconnaissance 1:20,000 surveys, provides a total of 230,665 m^2 of stream fish habitat (**Table 5.1.2.6-7**). Similar calculations showed there is an additional 237,333 m^2 of fish habitat in ponds (including shallow open-water wetlands), side-channels and other waterbodies (except lakes) within streams or connected to them. The amount of pond habitat is 3% greater than the amount of stream habitat (i.e., a pond/stream area ratio of 1.03) (**Table 5.1.2.6-7**). The total amount of stream and pond fish habitat in the Davidson Creek Watershed is 467,998 m^2. This is 29.2% of the total area of fish habitat in the LSA – the largest area of fish habitat provided by a single watershed.

Multiplying the area of each mesohabitat unit within a reach by appropriate HSI for each of five life stages of rainbow trout (spawning and egg incubation, fry summer rearing, juvenile summer rearing, adult summer foraging, and overwintering), for one life stage of kokanee (spawning and egg incubation), and for food and nutrients (which includes the ecological services of the riparian zone), gives a total number of habitat units (HU, where 1 HU is one unit of excellent quality habitat) for the Davidson Creek Watershed of 574,364 (**Table 5.1.2.6-8**). This is 30.8% of the total number of stream and pond HU in the LSA, and it is the single largest number of stream and pond HU provided by a single watershed.

Table 5.1.2.6-8: Fish Habitat Units in Streams and Ponds of Watersheds of the LSA

Watershed	RB Spawning and Egg Incubation (HU)	RB Fry Summer Rearing (HU)	RB Juvenile Summer Rearing (HU)	RB Adult Summer Foraging (HU)	RB Overwintering (HU)	KO Spawning and Egg Incubation (HU)	Food and Nutrient Production (HU)	Total (HU)
Davidson Creek	42,594	127,171	124,493	0	91,523	5,017	183,565	574,364
Turtle Creek	7,987	58,440	101,672	0	54,791	0	103,146	326,036
Creek 661	20,927	43,532	69,479	0	37,286	17,221	72,777	261,221
Creek 705	17,721	41,437	42,749	0	26,403	0	64,021	192,333
Tatelkuz Lake Tributaries	0	79,450	110,351	0	79,450	0	102,199	371,450
Lower Chedakuz Creek(1)	38,950	15,027	10,556	0	8,220	40,112	25,345	138,210
Total	128,179	365,057	459,300	0	297,673	62,350	551,054	1,863,613

Note: Stream and pond habitat only (no lakes).
(1)Reach 15 only (from outlet of Tatelkuz Lake to Kluskus FSR bridge).

The single largest contributor to the total number of stream and pond HU of Davidson Creek is the food and nutrients HSI (32.0%) (**Table 5.1.2.6-8**), followed by rainbow trout fry summer rearing (22.1%), rainbow trout juvenile summer rearing (21.7%), rainbow trout overwintering (15.9%), rainbow trout spawning and egg incubation (7.4%), and kokanee spawning and egg incubation (0.9%).

Habitat quality is ranked as high for most of mainstem of Davidson Creek, with a few short reaches of medium quality habitat in the upper section (**Figure 5.1.2.6-19**). Habitat quality is ranked as low for all tributaries, including small ponds on the tributaries, except for some short tributaries and tributary reaches with non-visible channels that were classified as nil quality.

5.1.2.6.3.1.1.4.2 Turtle Creek

The lower to middle reaches of Turtle Creek are dominated by low-gradient pools and glides, with occasional riffles. As a result, multiple shallow ponds and wetlands have formed, particularly in the lower half of the watershed. Fine substrates are the dominant bed materials. Spawning gravels are present only in isolated pockets throughout Turtle Creek and spawning habitat quality is generally poor. Good cover is provided by overhanging vegetation, deep pools, and patches of large and small woody debris. Good to fair juvenile rearing habitat is present in Turtle Creek.

Turtle Creek Watershed contains a total of 82,693 m of stream length (**Table 5.1.2.6-7**). This is 21.5% of the total stream length in the LSA, and it is the third longest length of stream of the six watersheds in the LSA. Multiplying the length of each reach by its mean width provides a total of 156,376 m^2 of stream fish habitat. There is an additional 149,532 m^2 of pond fish habitat, for a total of 305,948 m^2 of stream and pond fish habitat. (The amount of pond habitat is only 4% less than the amount of stream habitat.) This is 19.1% of the total area of fish habitat in the LSA, and it is the third largest area of fish habitat provided by a single watershed.

Multiplying the area of each habitat unit by appropriate HSI gives a total number of HU of 326,036 (**Table 5.1.2.6-8**). This is 17.5% of the total number of HU in the LSA, and it is the third largest number of HU provided by a single watershed.

As with Davidson Creek, the single largest contributor to the total number of HU of Turtle Creek is the food and nutrients HSI (31.6%). This was followed by rainbow trout juvenile summer rearing (31.2%), rainbow trout fry summer rearing (17.9%), rainbow trout overwintering (16.8%), and rainbow trout spawning and egg incubation (2.4%). There is no kokanee spawning and egg incubation in Turtle Creek.

Habitat quality is ranked as medium for most of the mainstem of Turtle Creek with a high quality habitat in the middle of the mainstem and at the upstream end (**Figure 5.1.2.6-19**). Habitat quality is ranked as low for all tributaries with the exception of a few short reaches with non-visible channels that were ranked as nil quality.

5.1.2.6.3.1.1.4.3 Creek 661

Creek 661 exhibits similar physical habitat conditions to those found in Davidson Creek, albeit on a smaller scale, and with more wetlands and beaver impoundments in its middle to upper reaches. Lower Creek 661, above the confluence with Chedakuz Creek, is laterally stable, with riffle-pool morphology, and good habitat complexity and diversity. High quality spawning gravels in the lower reaches of Creek 661 (Reaches 1 to 3) provide good spawning habitat for both kokanee and rainbow trout.

Creek 661 Watershed contains a total of 85,352 m of stream length (**Table 5.1.2.6-7**). This is 22.2% of the total stream length in the LSA, and it is the second longest length of stream of the six watersheds in the LSA. Multiplying the length of each reach by its mean width provides a total of 125,817 m^2 of stream fish habitat. There is an additional 95,959 m^2 of pond fish habitat, for a total of 221,412 m^2 of stream and pond fish habitat (i.e., a pond/stream ratio of 0.76). This is 13.8% of the total area of stream and pond fish habitat in the LSA, and it is the fourth largest area of stream and pond fish habitat provided by a single watershed.

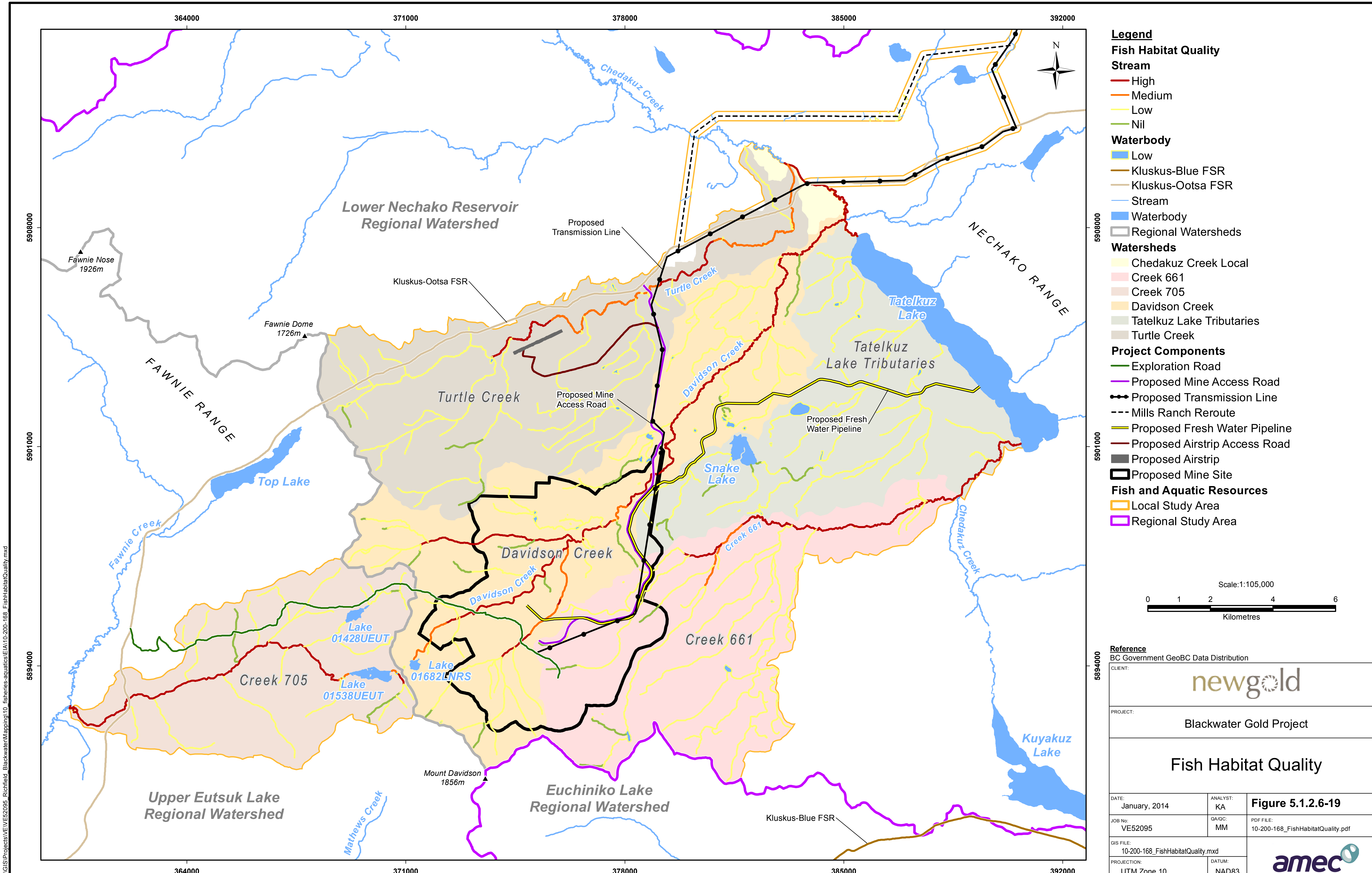
Multiplying the area of each habitat unit by appropriate HSI gives a total number of stream and pond HU in Creek 661 of 261,221 (**Table 5.1.2.6-8**). This is 14.0% of the total number of stream and pond HU in the LSA, and it is the fourth largest number of HU provided by a single watershed.

As with Davidson Creek and Turtle Creek, the single largest contributor to the total number of HU of Creek 661 is the food and nutrients HSI (27.9%). This was followed by rainbow trout juvenile summer rearing (26.6%), rainbow trout fry summer rearing (16.7%), rainbow trout overwintering (14.3%), rainbow trout spawning and egg incubation (8.0%), and kokanee spawning and egg incubation (6.6%).

Habitat quality is ranked as high for almost the entire length of the mainstem of Creek 661, except for two small sections of the headwaters (**Figure 5.1.2.6-19**). Habitat quality is ranked as low for all tributaries with the exception of a few short reaches with non-visible channels that were ranked as nil quality.

5.1.2.6.3.1.1.4.4 Creek 705

Good quality rainbow trout rearing habitat is present throughout the lower to middle reaches of Creek 705, where good cover is provided by deep pools, overhanging vegetation, and hydraulic habitat complexity. Spawning habitat in the lower reaches of Creek 705 is good, particularly in Reach 1 near the confluence with Fawnie Creek. Spawning habitat quality is more variable in the upper watershed, ranging from good to poor depending on the availability of suitably sized gravel substrates. However, there are areas of habitat with suitable spawning gravels at the outlets of both headwater lakes, and this habitat is assumed to be used by lake-resident adults.



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Creek 705 Watershed contains a total of 44,805 m of stream length (**Table 5.1.2.6-7**). This is 11.7% of the total stream length in the LSA, and it is the fifth longest length of stream of a single watershed. Multiplying the length of each habitat unit by its mean width provides a total of 119,134 m^2 of stream fish habitat. There is an additional 25,474 m^2 of stream fish habitat (i.e., a pond/stream ratio of 0.21) for a total of 144,608 m^2 of stream and pond fish habitat. This is 9.0% of the total area of stream and pond fish habitat in the LSA and it is the fifth largest area provided by a single watershed.

Multiplying the area of each habitat unit by appropriate HSI gives a total number of stream and pond HU of 192,333 in Creek 705 (**Table 5.1.2.6-8**). This is 10.3% of the total number of HU in the LSA, and it is the fifth largest number of HU provided by a single watershed. One reason for this relatively low ranking, despite the apparently high quality of stream habitat, is the low amount of pond habitat area and HU.

As with Davidson Creek, Turtle Creek and Creek 661, the single largest contributor to the total number of HU of Creek 705 is the food and nutrients (HSI) (33.3%) (**Table 5.1.2.6-8**). This was followed by rainbow trout juvenile summer rearing (22.2%), rainbow trout fry summer rearing (21.5%), rainbow trout overwintering (13.7%), and rainbow trout spawning and egg incubation (9.2%). There is no kokanee spawning and egg incubation in Creek 705.

Habitat quality is ranked as high for the entire length of the mainstem (**Figure 5.1.2.6-19**). Habitat quality is ranked as low for all tributaries with the exception of a few short reaches with non-visible channels that were ranked as nil quality.

5.1.2.6.3.1.1.4.5 Tatelkuz Lake Tributaries

Streams in the Tatelkuz Lake Tributary Watershed are narrow and shallow. Mean bankfull width for these streams is 1.20 m and mean wetted width is 1.04 m. Mean bankfull depth is 0.29 m. Mean gradients in these streams range from 0.0 to 7.5 %. Bed materials are dominated by fine sediments, with occasional cobbles.

Habitat quality ratings for streams in the Tatelkuz Lake Tributary Watershed indicate that these streams have the capacity to support limited rearing habitat. Spawning habitat is absent in all surveyed reaches, except reach 1.2 of Creek 579340, which is rated as poor for spawning. Overwintering habitat is rated as nil or poor and rearing habitat ratings range from poor to good. Four stream reaches rated as No Visible Channel (NVC) create barriers to migration in Creek 579340 near Snake Lake.

Tatelkuz Lake Tributaries Watershed contains a total of 62,750 m of stream length (**Table 5.1.2.6-7**). This is 16.3% of the total stream length in the LSA, and it is the fourth longest length of stream in the LSA. Multiplying the length of each reach by its mean width provides a total of 90,996 m^2 of stream fish habitat. There is an additional 317,800 m^2 of pond fish habitat (i.e., a pond/stream ratio of 3.49 – the highest ratio of all six watersheds), for a total of 408,796 m^2 of stream and pond fish habitat. This is 25.5% of the total area of stream and pond fish habitat in the LSA and it is the second largest area of stream and pond fish habitat provided by a single watershed.

Multiplying the area of each habitat unit by appropriate HSI gives a total number of HU in this watershed of 371,405 (**Table 5.1.2.6-6**). This is 19.9% of the total number of stream and pond HU in the LSA and it is the second largest number of HU provided by a single watershed.

Unlike the other watersheds, the single largest contributor to the total number of stream and pond HU is rainbow trout juvenile summer rearing (29.7%), followed by food and nutrients (27.5%), rainbow trout fry summer rearing (21.4%), and rainbow trout overwintering (21.4%). There is no habitat for rainbow trout spawning and egg incubation or kokanee spawning and egg incubation.

Habitat quality is ranked as high for almost the entire length of the mainstem, except for two small sections of the headwaters (**Figure 5.1.2.6-19**). Habitat quality is ranked as low for all tributaries with the exception of a few short reaches with non-visible channels that were ranked as nil quality.

5.1.2.6.3.1.1.4.6 Lower Chedakuz Creek

Reach 15 of lower Chedakuz Creek (directly downstream of Tatelkuz Lake) has habitat typical of a medium-sized river. Mean gradients range from 0% to 1%, and the average bankfull width is approximately 14 m. Abundant gravels provide good quality spawning habitat for rainbow trout and kokanee in lower Chedakuz Creek. Deep pools and instream vegetation provide good cover and rearing opportunities for juvenile trout.

Reach 15 is 4,485 m long (**Table 5.1.2.6-7**). This is 1.2% of the total stream length in the LSA, and it is the sixth longest stream length in the LSA. Multiplying the length of the reach by its mean width provides a total of 55,458 m^2 of stream fish habitat. There is no additional pond fish habitat (i.e., a pond/stream ratio of zero – the lowest ratio of all six watersheds). This is 3.5% of the total area of stream and pond fish habitat in the LSA and it is the sixth largest area of stream and pond fish habitat provided by a single watershed.

Multiplying the area of each habitat unit by appropriate HSI gives a total number of HU in this watershed of 138,210 (**Table 5.1.2.6-8**). This is 7.4% of the total number of stream and pond HU in the LSA and it is the sixth largest number of HU provided by a single watershed.

Unlike the other watersheds, the single largest contributor to the total number of stream and pond HU is kokanee spawning and egg incubation (29.0%), followed by rainbow trout spawning and egg incubation (28.2%), food and nutrients (18.3%), rainbow trout fry summer rearing (10.9%), rainbow trout juvenile summer rearing (7.6%), and rainbow trout overwintering (5.9%) (**Table 5.1.2.6-8**).

Habitat quality in Reach 15 of lower Chedakuz Creek is ranked as high for the entire mainstem (**Figure 5.1.2.6-19**).

5.1.2.6.3.1.1.4.7 Overwintering Habitat

A total of 33 stream sites were visited in March 2012 and March 2013 (**Table 5.1.2.6-9**; Section 5.8 of **Appendix 5.1.2.6A** and Section 5.1 of **Appendix 5.1.2.6B**). Overwintering habitat quality ranged from none to good in both years, but the frequency distribution varied between years. In March 2013, the highest percentage (45%) was classified as fair and the lowest percentage (15%)

was classified as none. In March 2012, the highest percentage was none (31%) and the other three categories were lower (23%).

Table 5.1.2.6-9: Quality of Overwintering Habitat in Streams, Blackwater LSA, March 2012 and March 2013

Watershed	Year	Number of Stream Sites				
		Good	**Fair**	**Poor**	**None**	**Total**
Davidson Creek	2012	2	2	1	0	5
	2013	0	6	3	2	11
Turtle Creek	2012	0	0	1	1	2
	2013	2	0	0	0	2
Creek 661	2012	1	0	0	2	3
	2013	1	3	0	1	5
Creek 705	2012	0	1	0	0	1
	2013	0	0	1	0	1
Tatelkuz Lake Tributaries	2012	0	0	1	1	2
	2013	0	0	0	0	0
Lower Chedakuz Creek	2012	0	0	0	0	0
	2013	1	0	0	0	1
Total	**2012**	**3**	**3**	**3**	**4**	**13**
	2013	**4**	**9**	**4**	**3**	**20**

Eight sites were visited in both years. There was no change in overwintering habitat quality for two of the eight sites (DO-06 and DO-13), but habitat quality decreased from March 2012 to March 2013 for three sites (DO-08, DO-09 and DO-16) and increased for three sites (DO-02, DO-04 and DO-10).

These results show that there is a range of overwintering habitat quality in streams of the Blackwater LSA, but that it varies between years. Hence, the quantity of overwintering habitat of sufficient quality to support fish (i.e., fair and good) may limit fish production in the LSA, but its effect varies between years.

5.1.2.6.3.1.1.4.8 Disturbance

No blasting or other type of major disturbance to aquatic habitat is currently being conducted in the aquatic LSA or RSA.

5.1.2.6.3.1.1.5 Wetlands

Section 5.1.2.5 of this Application describes a survey of wetlands in the aquatics LSA. The only class of wetland that can support fish is “shallow open-water wetland”. The BC Ministry of Forests (BC MOF) defines this class as having water depths between 0.5 and 2.0 m at midsummer and a plant cover usually less than 10%. In the Blackwater LSA that plant cover consisted mainly of species of the families *Utriculatia (*bladderworts*), Potamogeton* (pondweed) and *Nuphar* (water lily).

The pond habitat areas shown in **Table 5.1.2.6-7** include areas of shallow open-water wetlands.

Figure 5.1.2.6-5 and **Figure 5.1.2.6-6** show the location of shallow open-water wetlands within the LSA in relation to locations of the FHAP and 1:20,000 Reconnaissance fish habitat survey sites, respectively. A total of 66.4 ha of shallow open-water wetlands were identified in the LSA (**Table 5.1.2.6-10**), of which 15.5 ha (or 23%) were not connected to any stream that supported rainbow trout, 5.8 ha (or 9%) were directly connected to confirmed rainbow trout stream habitat, and 45.0 ha (or 68%) were connected to unconfirmed rainbow trout stream habitat.

Table 5.1.2.6-10: Surface Area of Shallow Open-Water Wetlands in the Aquatics LSA in Relation to Rainbow Trout Stream Habitat

Watershed	Connected to Known Rainbow Trout Habitat	Connected to Unconfirmed Rainbow Trout Habitat	Not Connected to Rainbow Trout Habitat	Total
		Area (ha)		
Creek 661	3.2	1.0	3.0	7.3
Creek 705	1.7	2.5	0.0	4.1
Davidson Creek	0.3	13.8	6.6	20.8
Tatelkuz Lake Trib	0.0	11.9	5.5	17.4
Turtle Creek	0.7	15.7	0.4	16.8
Total	5.8	45.0	15.5	66.4
		Percent of Watershed Total		
Creek 661	44	14	41	100
Creek 705	40	60	0	100
Davidson Creek	1	67	32	100
Tatelkuz Lake Trib	0	69	31	100
Turtle Creek	4	94	3	100
Total	9	68	23	100

"Confirmed" in this context means that the stream was surveyed for fish and fish habitat and that rainbow trout were captured. "Unconfirmed" means that the stream was surveyed for fish and fish habitat (because it was connected to other fish-bearing reaches and contained fish habitat) but no rainbow trout were captured. In most cases, the status of unconfirmed was due to the low density of juvenile rainbow trout in streams of the LSA compared to BC provincial "biostandards" (Keeley et al., 1996; Koning and Keeley, 1997). As described in **Section 5.1.2.6.3.2.5**, over 70% of the 78 values of electrofishing CPUE measured in streams of the LSA in 2011 and 2012 were below 1.0 fish/100 s. Hence, both confirmed and unconfirmed streams are considered to be fish-bearing and to contain fish habitat and both types were sampled for fish and fish habitat.

Most shallow open-water wetlands are located in headwaters regions of watersheds, and most unconfirmed rainbow trout stream habitat is also located in headwaters. Hence, most connections were between shallow open-water wetlands and unconfirmed rainbow trout stream habitat.

Those wetlands that are connected to confirmed or unconfirmed fish habitat provide mainly rearing habitat for juvenile rainbow trout during summer months. They also provide food and nutrients to downstream habitat that directly supports fish. They do not provide overwintering habitat because they are shallow and so freeze to the bottom during winter. Nor do they provide spawning habitat because their substrates consist mainly of fines.

Comparison of the locations of shallow open-water wetlands with the locations of fish habitat survey sites in **Figure 5.1.2.6-5** and **Figure 5.1.2.6-6** show that some of those wetlands that were directly connected to stream habitat were directly surveyed. Others were not surveyed as a consequence of the sub-sampling that had to be adopted to cover the long stream distances of the LSA. Information on the location, frequency of occurrence, and mean area of those wetlands that were surveyed was used to calculate the total areas of pond fish habitat for each watershed that are shown in **Table 5.1.2.6-7** and in relevant parts of the FMOP.

5.1.2.6.3.1.1.6 Riparian Habitat

Riparian zones are vegetated corridors along the borders of streams, lakes, and wetlands. Riparian vegetation stabilizes stream banks and provides shade (which cools streams in summer). Riparian zones also export to streams coarse woody debris (which is used as cover by fish), terrestrial insects that fall on the stream surface (and are prey for fish), and nutrients from leaf litter. These functions have high value for fish and fish habitat. For example, as shown in **Table 5.1.2.6-8**, the food and nutrient HSI contributes a total of 551,053 HU or 29.6% of the total number of stream habitat HU in the aquatics LSA. That is the single largest contribution of all seven types of HSI to the total number of HU in the LSA. The food and nutrient HSI is the dominant contributor of HU for Davidson Creek Watershed, Turtle Creek Watershed, Creek 661 Watershed and Creek 7095 Watershed. It is the second greatest contributor for the Tatelkuz Lake Tributaries Watershed and the third greatest contributor for the lower Chedakuz Creek Watershed.

As with all HSI, the food and nutrient HSI was applied to every reach of every stream in the LSA because there is a riparian zone bordering all streams. Annex C of **Appendix 5.1.2.6C** describes how the numerical values of the food and nutrient HSI were chosen for stream habitat types. In summary, riffles (class 2 and class 3 – see **Table 5.1.2.6-5** for definitions of stream habitat classes) were assigned food and nutrient HSI values of 1.0 because aquatic invertebrates are most abundant and diverse in riffle areas due to their turbulent flows, rubble substrate and moderate to high cover, including cover provided by riparian vegetation, such as canopy cover, coarse woody debris, and overhanging vegetation. Class 1 riffles were assigned food and nutrient HSI values of 0.75 because riffle habitats with smaller substrates are more prone to bed load transport and because cover, including cover from riparian vegetation, is lower than in classes 2 and 3. Glides (class 2 and 3) were also assigned food and nutrient HSI values of 0.75 for the same reasons – cobble/boulder substrates and moderate to high cover. Class 1 glides were assigned a food and nutrient HSI of 0.5 because of lower cover than class 2 and 3 glides. Cascades were also assigned a food and nutrient HSI of 0.5. All remaining habitat classes (pools, small tributaries and "other") were assigned a food and nutrient HSI of 0.25.

Table 5.4.5-19 of the Ecosystem Composition VC (**Section 5.4.5**) shows there is a baseline area of 679 ha of riparian habitat within the mine site. However, that number includes riparian habitat bordering ponds and wetlands that are not connected to stream habitat and which do not support fish. This section provides estimates of riparian habitat area only for fish-bearing watercourses within the aquatic LSA and within the mine site. That includes both confirmed and unconfirmed fish-bearing streams – connectivity with the drainage system was the only criterion for inclusion.

Riparian areas for fish-bearing watercourses in the LSA were identified by applying a 30 m-wide buffer to all streams and potentially fish-bearing lakes or ponds from the TRIM dataset, as shown in **Figure 5.1.2.6-20**. The width of the riparian zone was defined as 30 m because the functions provided by riparian zones to watercourses are generally found within one tree height of a stream – the assumed mean tree height within the LSA. This is the same definition used in **Section 5.4.5**. This is a conservative assumption because not all stream banks in the LSA support a 30 m-wide strip of trees or shrubs.

The total riparian area for fish-bearing watercourses in the LSA is 2,520.2 ha of which 2,343.2 (or 93%) is associated with streams and 177.0 ha (or 7%) is associated with lakes, ponds and wetlands (**Table 5.1.2.6-11**). Those riparian zones were further sub-divided into biogeoclimatic zones (BGC).

Table 5.1.2.6-12 shows that a total of 362.5 ha of fish-bearing riparian habitat is present in the mine site of which 351.2 ha (or 97%) borders streams and 11.3 ha (or 3%) borders wetlands and ponds. That is 53% of the total area of riparian habitat on the mine site that was identified by **Table 5.4.5-19**.

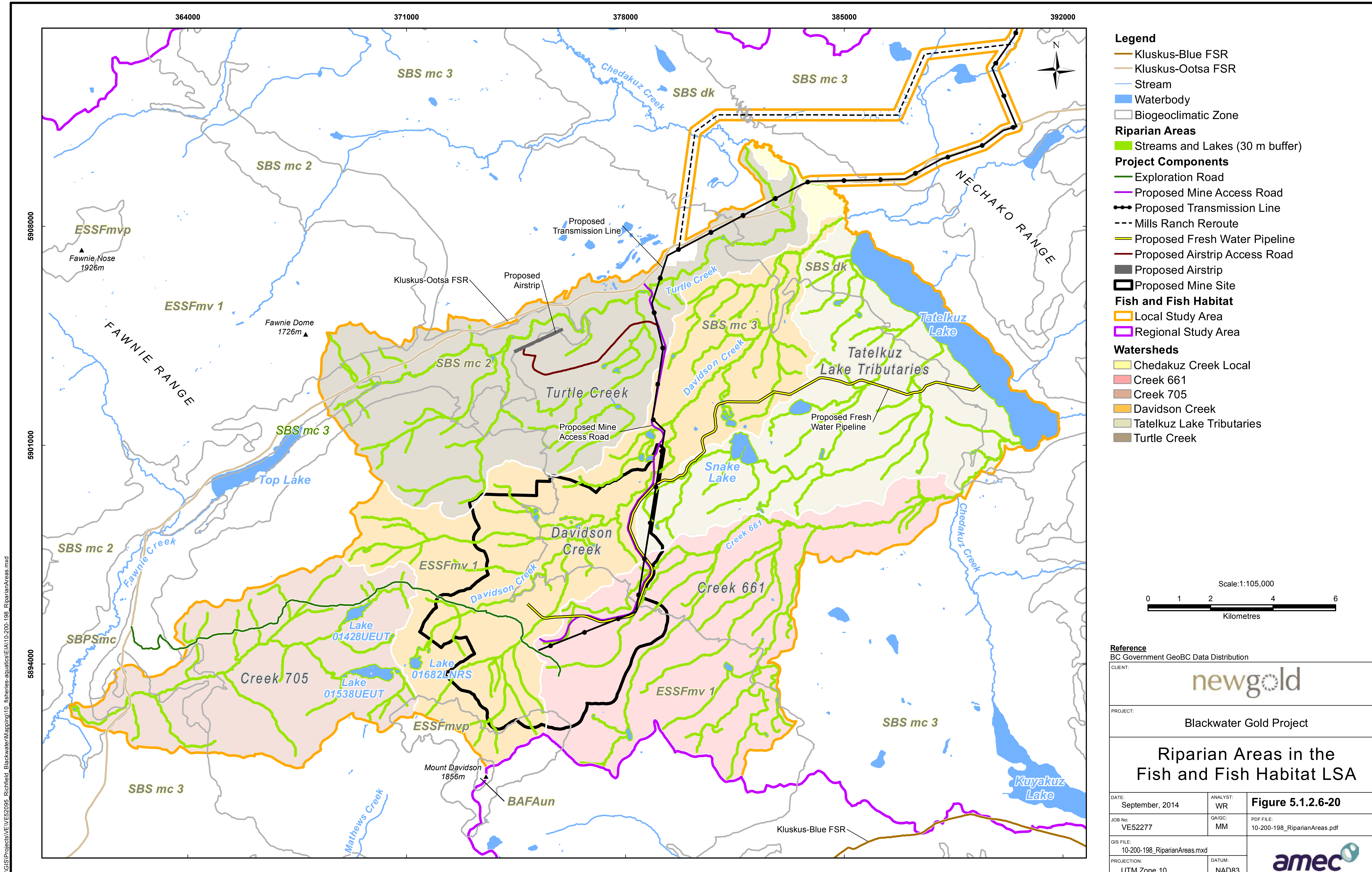

364000
371000
378000
385000
392000
5908000
5901000
5894000
Legend
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Biogeoclimatic Zone
Riparian Areas
Streams and Lakes (30 m buffer)
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Fish Habitat
Local Study Area
Regional Study Area
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
N
SBS mc 3
SBS dk
SBS mc 2
ESSFmvp
ESSFmv 1
SBPSmc
BAFAun
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
FAWNIE RANGE
NECHAKO RANGE
Chedakuz Creek
Turtle Creek
Davidson Creek
Creek 661
Fawnie Creek
Mathews Creek
Top Lake
Tatelkuz Lake
Snake Lake
Kuyakuz Lake
Lake 01428UEUT
Lake 01682LNRS
Lake 01538UEUT
Turtle Creek
Davidson Creek
Creek 661
Creek 705
Tatelkuz Lake Tributaries
Proposed Transmission Line
Proposed Airstrip
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Kluskus-Blue FSR
Scale:1:105,000
0 1 2 4 6
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Riparian Areas in the Fish and Fish Habitat LSA
DATE: September, 2014
ANALYST: WR
Figure 5.1.2.6-20
JOB No: VE52277
QA/QC: MM
PDF FILE: 10-200-198_RiparianAreas.pdf
GIS FILE: 10-200-198_RiparianAreas.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\EIA\10-200-198_RiparianAreas.mxd

Table 5.1.2.6-11: Riparian Areas of Fish-Bearing Streams and Lakes within the Aquatics LSA Derived from GIS Mapping

BGC Zone	Watershed						Total (ha)
	Davidson Creek (ha)	Turtle Creek (ha)	Creek 661 (ha)	Creek 705 (ha)	Tatelkuz Lake Tributaries (ha)	Chedakuz Creek Local (ha)	
Streams							
ESSFmv1	255.4	99.3	222.3	213.8	-	-	790.8
ESSFmv1p	20.0	-	-	0.6	-	-	20.6
SBSdk	46.2	48.3	-	-	82.8	18.6	195.9
SBSmc2	-	117.4	-	20.4	-	-	137.8
SBSmc3	337.2	201.4	298.1	34.4	313.1	-	1,184.2
SBPSmc	-	-	-	13.9	-	-	13.9
Streams Total	658.8	466.4	520.4	283.1	395.9	18.6	2,343.2
Lakes and Ponds							
ESSFmv1	7.5	1.2	8.8	24.6	-	-	42.1
ESSFmv1p	0.4	-	-	-	-	-	0.4
SBSdk	-	1.0	-	-	30.4	-	31.4
SBSmc2	-	12.0	-	-	-	-	12.0
SBSmc3	33.9	18.4	2.8	-	35.0	-	90.1
SBPSmc	-	-	-	1.0	-	-	1.0
Lakes and Ponds Total	41.8	32.6	11.6	25.6	65.4	-	177.0
Overall Total	**700.6**	**499.0**	**532.0**	**308.7**	**461.3**	**18.6**	**2,520.2**

Notes: BCG = biogeoclimatic zones: ESSFmv1 = Nechako Very Cold Engelmann Spruce Subalpine Fir variant; ESSFmv1p = Nechako Very Cold Engelmann Spruce-Subalpine Fir Parkland Variant; SBSdk = Dry Cool Sub-Boreal Spruce Subzone, SBSmc2 = Babine Moist Cold Sub-Boreal Spruce Variant, SBSmc3 = Kluskus Moist Cold Sub-Boreal Spruce Variant, SBPSmc = Moist Cold Sub-Boreal Pine – Spruce Subzone.

Table 5.1.2.6-12: Riparian Areas of Streams and Lakes in the Mine Site Footprint

BGC Zone	Watershed			Total (ha)
	Davidson Creek (ha)	Creek 661 (ha)	Tatelkuz Lake Tributaries (ha)	
Streams				
ESSFmv1	161.6	58.4	-	220.0
ESSFmv1p	2.6	-	-	2.6
SBSmc3	106.2	14.1	8.3	128.6
Stream Total	270.4	72.5	8.3	351.2
Lakes and Ponds				
ESSFmv1	0.3	-	-	0.3
ESSFmv1p	0.4	-	-	0.4
SBSmc3	10.6	-	-	10.6
Lakes and Ponds Total	11.3	0	0	11.3
Overall Total	**281.7**	**72.5**	**8.3**	**362.5**

Data collected using the Reconnaissance 1:20,000 Fish and Fish Habitat inventories of streams of the aquatics LSA Inventory protocol was used to further characterize riparian habitat within the LSA. The seven variables were the following:

- Percent crown closure (i.e. canopy cover);
- Percent instream cover;
- Overhanging vegetation cover (classes: dominant, subdominant, trace and none);
- Small woody debris cover (classes: dominant, subdominant, trace and none);
- Large woody debris cover (classes: dominant, subdominant, trace and none);
- Percent type of riparian vegetation (classes: mixed wood, coniferous, deciduous, shrub, grass, wetland); and
- Riparian vegetation stage (classes: mature forest, young forest, shrub, initial and other).

Figure 5.1.2.6-21 shows that the most common percent range of crown closure was 1 to 20% for five of the six watersheds. The most common crown closure rating for the Tatelkuz Lake Tributaries Watershed was 0%, likely due to the high relative abundance of wetlands and scarcity of forested areas in this watershed.

Total percent of instream cover for fish was rated as greater than 20% at the majority of sites in each watershed. Sources of instream cover include overhanging vegetation, large woody debris and small woody debris. Generally, overhanging vegetation was rated as the dominant or subdominant component of overall cover. Large and small woody debris were typically rated as subdominant or trace contributors to total cover.

Coniferous forests were the most abundant vegetation type in riparian habitat of all watersheds. Shrubby vegetation was the next most common type in five of the six watersheds. Mature forest was the most common succession stage, followed by the shrub stage.

5.1.2.6.3.1.1.7 Water Temperature

Continuous monitoring of stream water temperatures in the LSA for 2011 to 2013 showed five patterns (Section 5.1 of **Appendix 5.1.2.6A** and Section 5.2 of **Appendix 5.1.2.6B**):

- The expected dome-shaped variation with season. Mean daily temperatures rose from near 0°C in early April to a maximum of between 11.2°C and 20.8°C in mid-July and early August and then fell to near 0°C in early October;
- A gradient of decreasing temperature with increasing elevation;
- Warmer summer temperatures in 2013 and 2012 than in 2011;
- Colder temperatures in Davidson Creek than in other watersheds of the LSA; and
- Warmer temperatures in lower Chedakuz Creek than in other streams of the LSA.

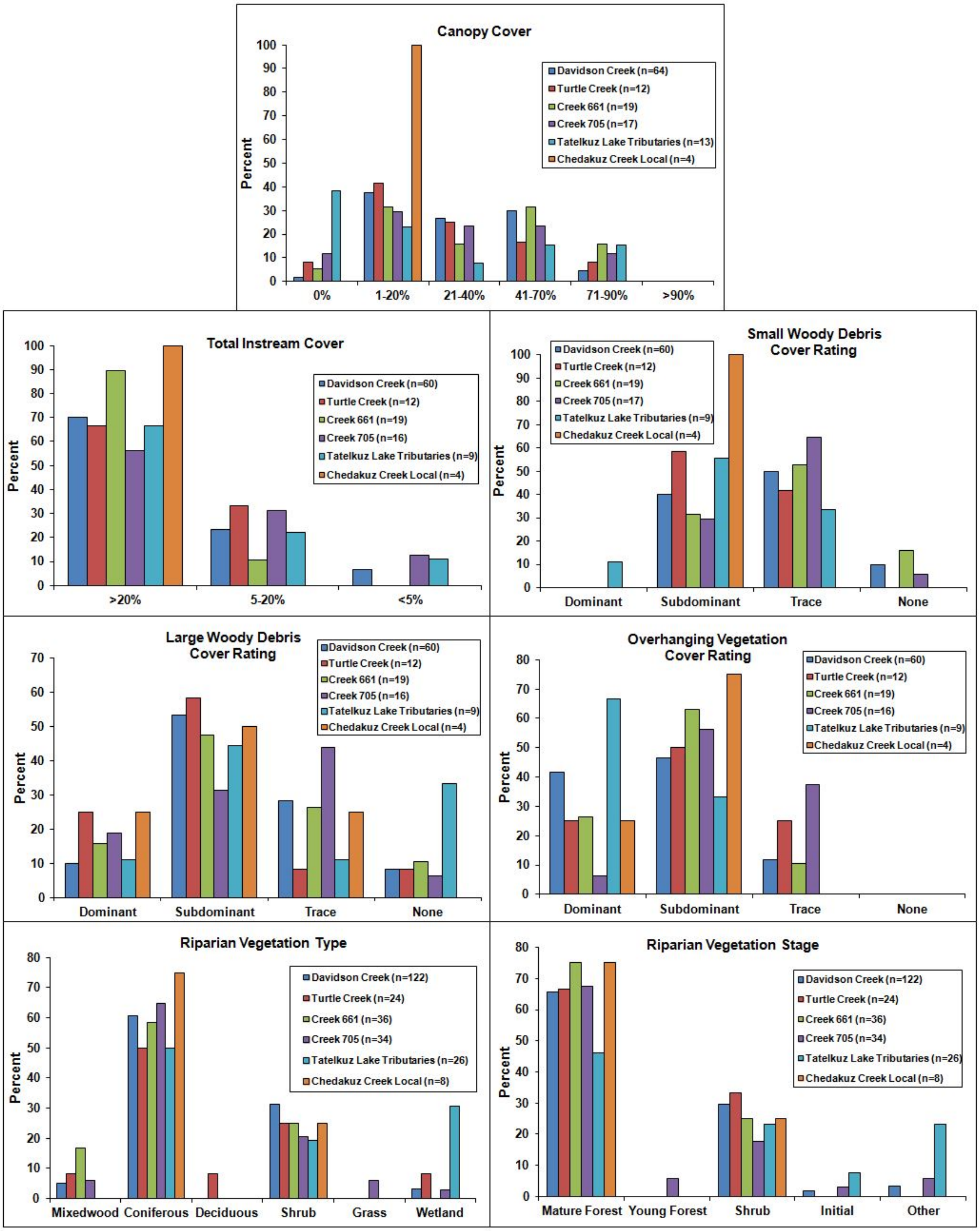


Figure 5.1.2.6-21: Characteristics of Riparian Areas in the Fish and Fish Habitat LSA

These patterns are shown in a plot of mean monthly water temperatures for data collected in 2011 and 2012 – the two years when the maximum number of temperature data loggers were installed (11 in 2011, 13 in 2012, but only 7 in 2013) (**Figure 5.1.2.6-22**).

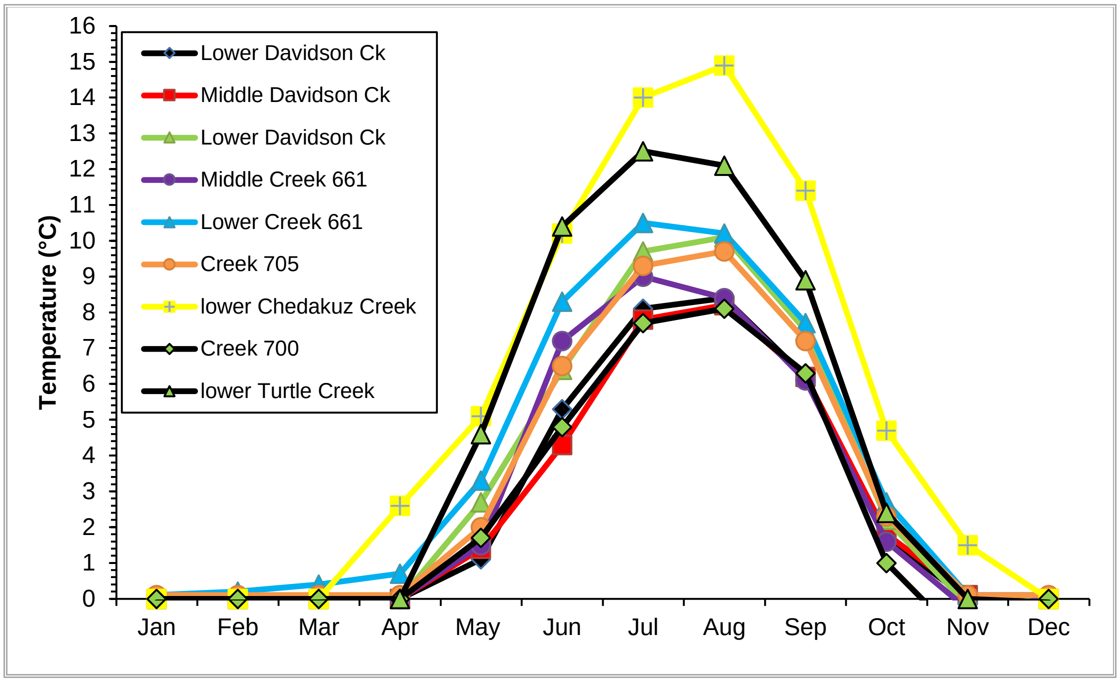


Figure 5.1.2.6-22: Mean Monthly Stream Temperature in Watersheds of the LSA, 2011 – 2012

Differences among years are shown by comparing mean daily temperatures among the three sections of Davidson Creek from April to October in 2011, 2012 and 2013 (**Figure 5.1.2.6-23** to **Figure 5.1.2.6-25**).

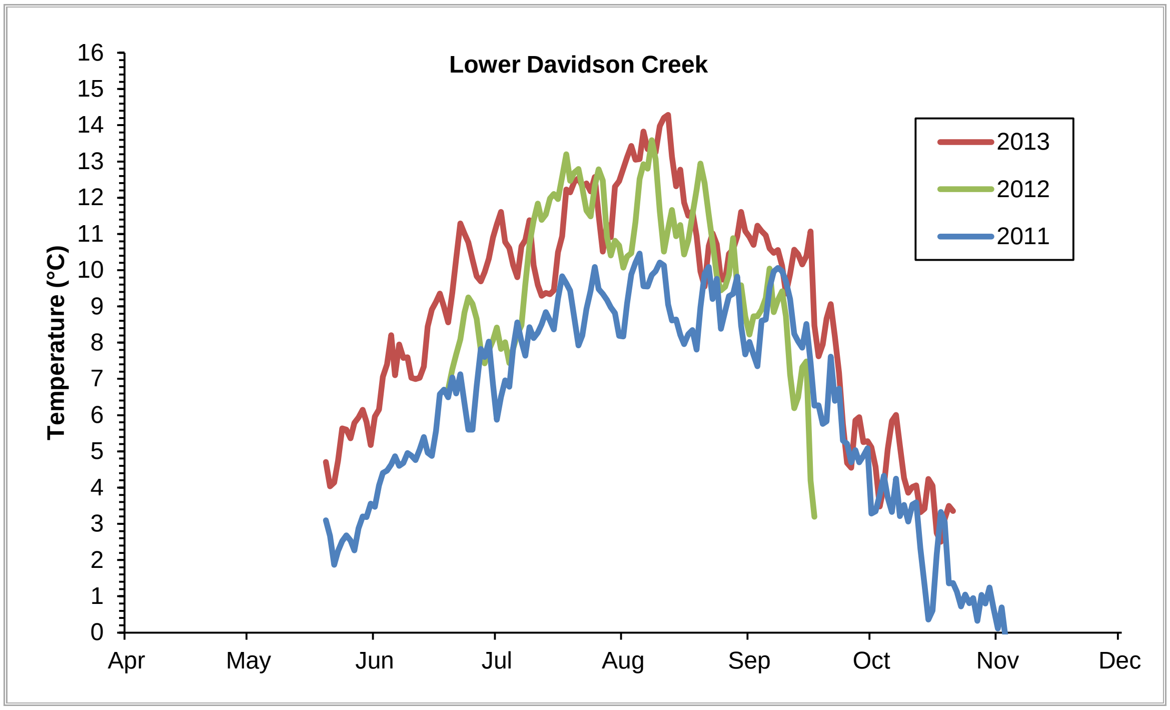


Figure 5.1.2.6-23: Mean Daily Stream Temperature in Lower Davidson Creek (Site H4), 2011 – 2013

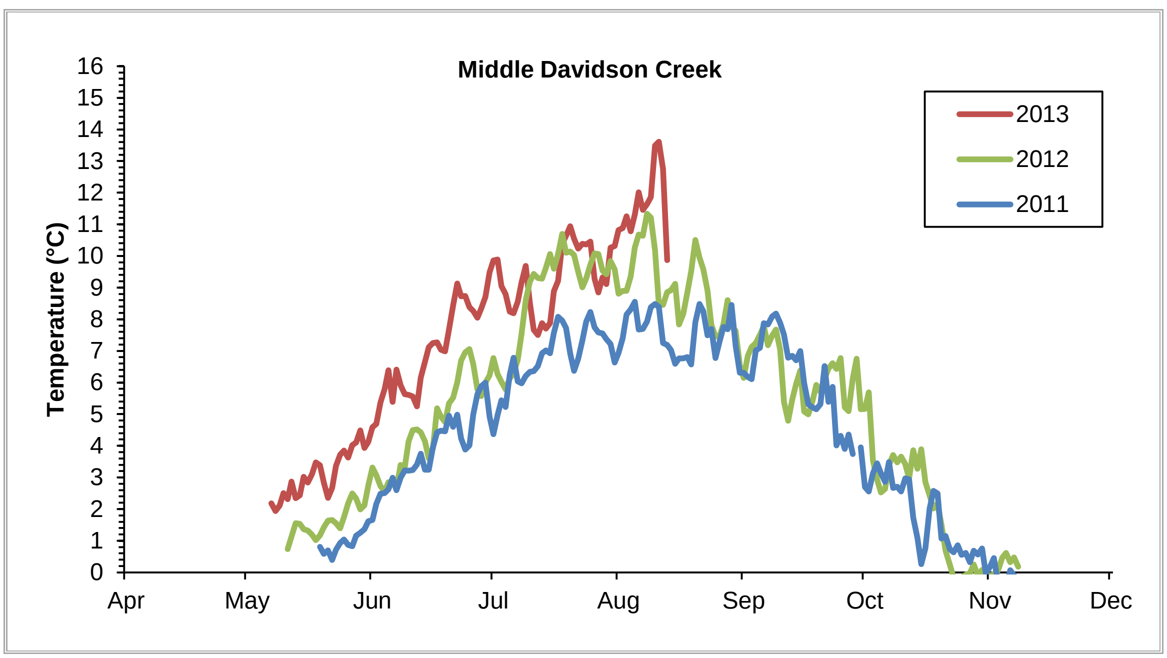


Figure 5.1.2.6-24: Mean Daily Stream Temperature in Middle Davidson Creek (Site H2), 2011 – 2013

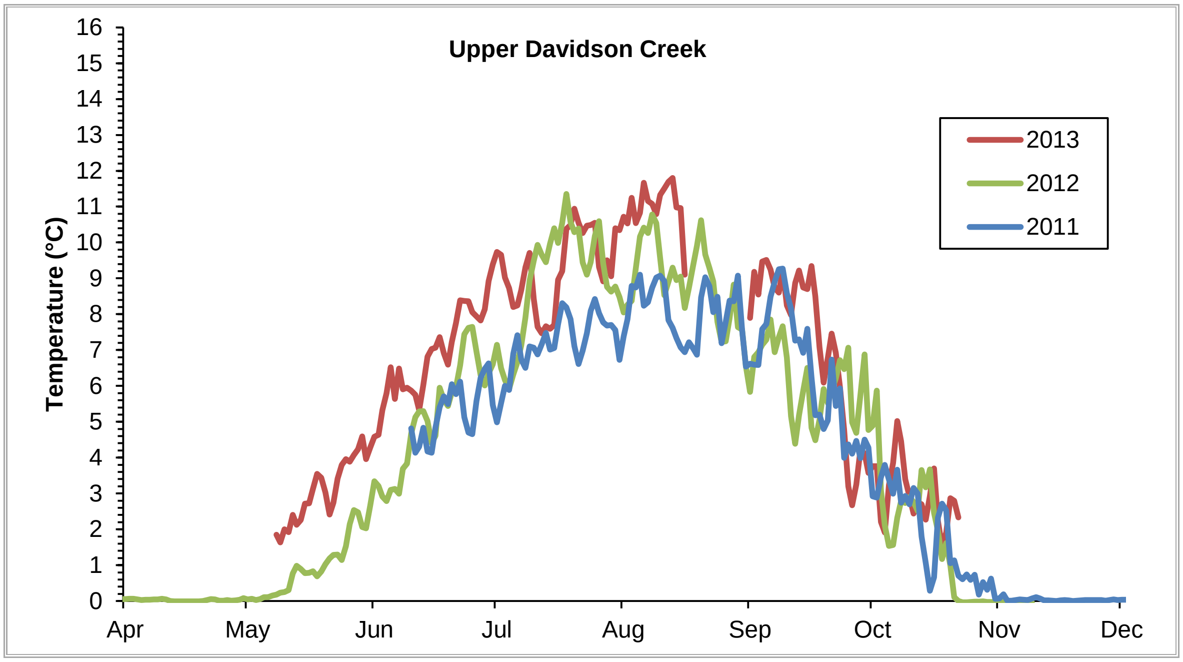


Figure 5.1.2.6-25: Mean Daily Stream Temperature in Upper Davidson Creek (Site H10), 2011 – 2013

Stream temperatures in most watersheds of the LSA generally fall below the BC MOE optimal temperature ranges for most life history stages of rainbow trout (**Figure 5.1.2.6-26**). However, they fall within the range for most life history stages of kokanee (with the exception of incubation from November to May) (**Figure 5.1.2.6-27**). Hence, water temperatures in the LSA are more suitable for production of kokanee than they are for production of rainbow trout.

In general, low temperatures rather than high temperatures limit aquatic biological processes in the LSA. Low water temperatures are one reason why the rainbow trout population of Davidson Creek has lower productivity than other rainbow trout populations of the LSA. For example, Davidson Creek had the lowest mean catch-per-unit-effort (CPUE) of adult rainbow trout spawners sampled in the spring 2011 hoop net survey.

Low water temperatures also explain why mean length of juvenile rainbow trout of the Davidson Creek population (131 mm, SE = 4) and the Davidson Headwaters population (125 mm, SE = 8) are lower than mean lengths for other populations in the LSA including Creek 661 (150 mm, SE = 5), Turtle Creek (151 mm, SE = 2), Creek 705 Headwaters North (153 mm, SE = 10), and Creek 705 Headwaters South (153 mm, SE = 13).

Low water temperatures also explain why the kokanee spawning run in lower Davidson Creek is the earliest of all kokanee spawning runs in the Blackwater LSA. Kokanee spawn in the lower four reaches of Davidson Creek a month earlier than kokanee that spawn in lower Chedakuz Creek.

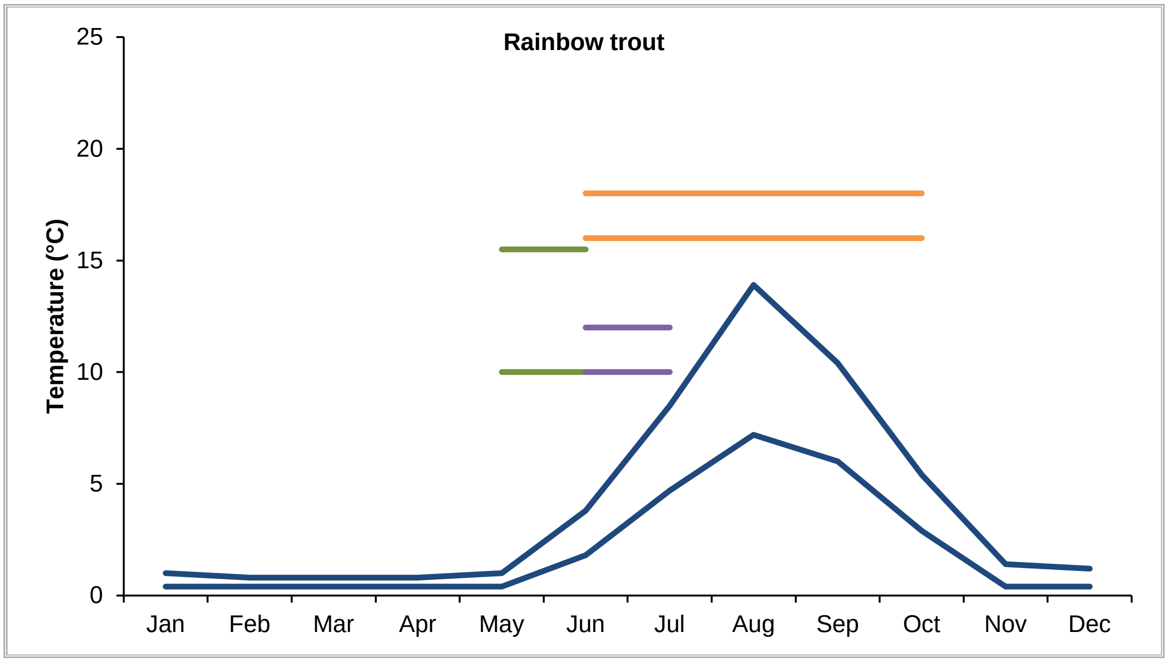


Figure 5.1.2.6-26: Water Temperature Envelope of Lower and Middle Davidson Creek (blue) Compared to BC Guidelines for Rainbow Trout Spawning (Green), Incubation (Purple), and Rearing (Orange)

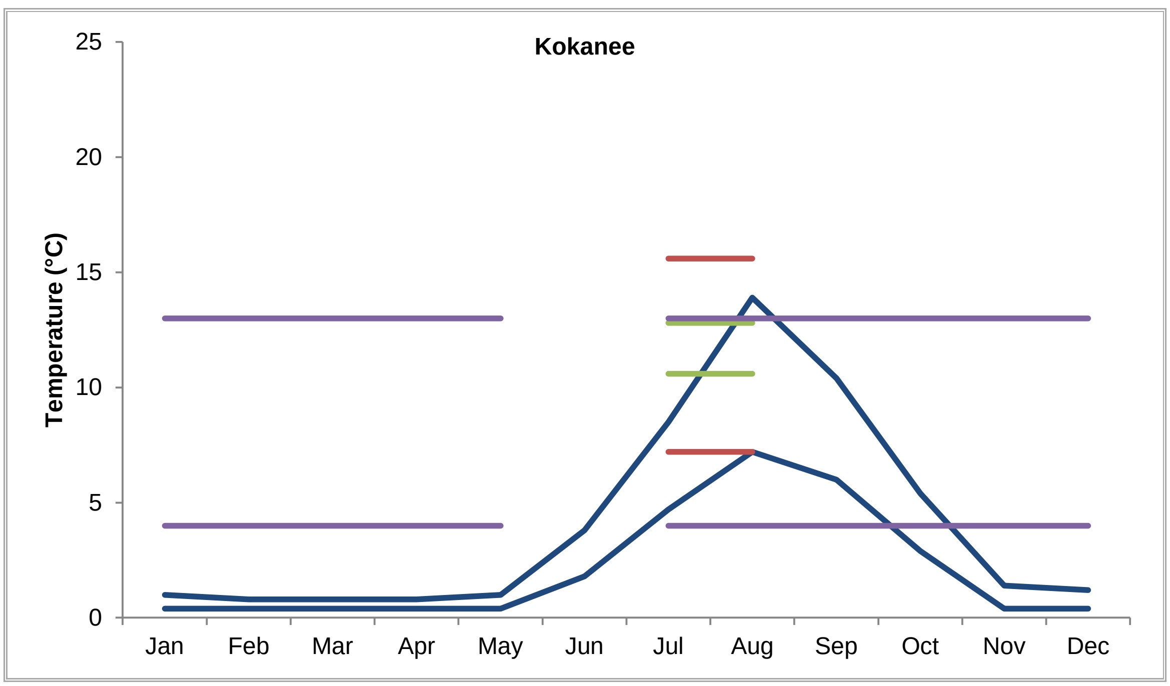


Figure 5.1.2.6-27: Observed Water Temperature Envelope of Lower and Middle Davidson Creek (blue) Compared to BC Guidelines for Kokanee Migration (red), Spawning (green), and Incubation (purple)

5.1.2.6.3.1.1.8 Periphyton Community

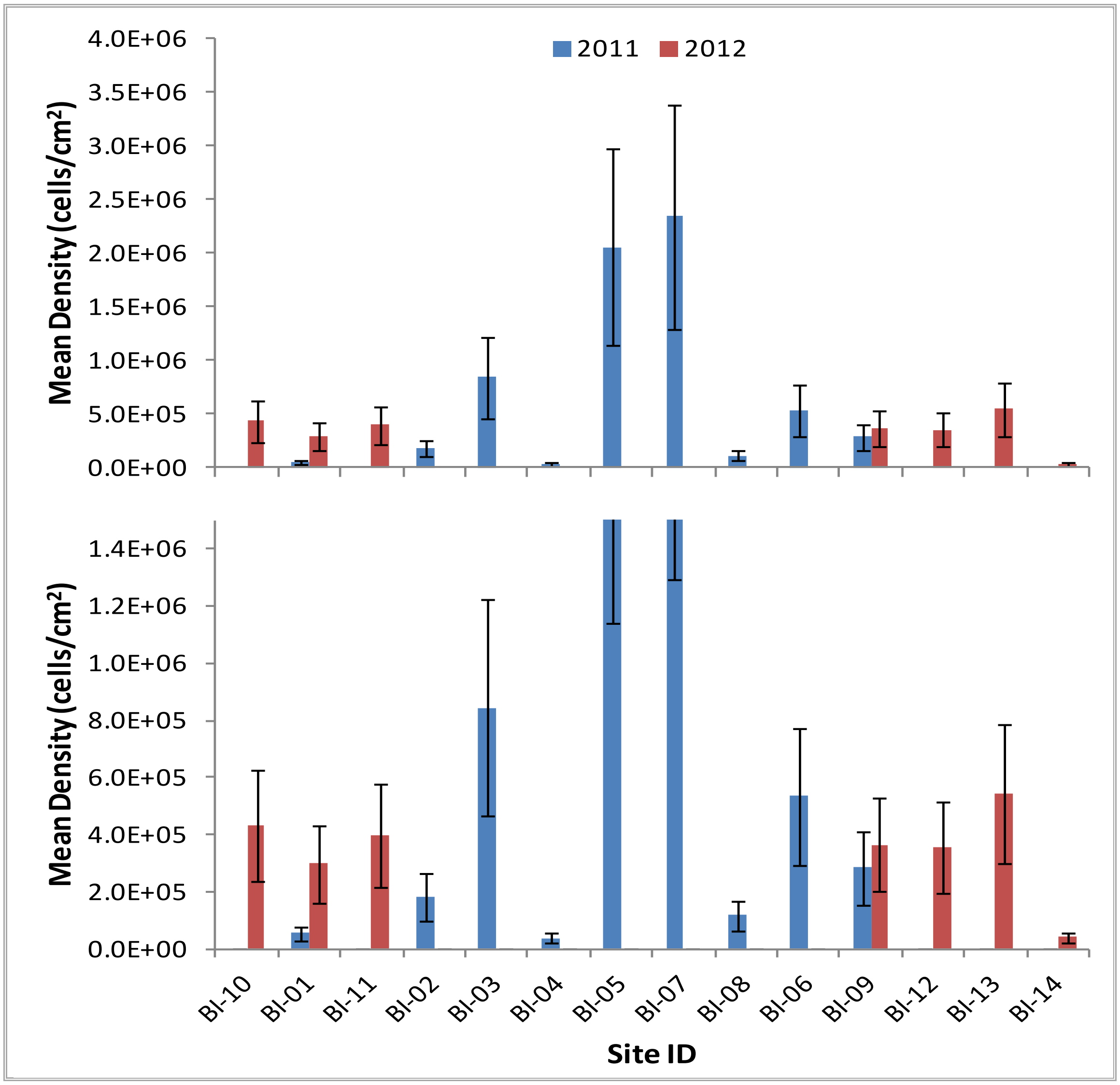
Periphyton is a complex mix of algae, bacteria, and protozoans attached as a biofilm to submerged surfaces. It is the primary photosynthetic community in streams, and an important food source for BMI. One hundred and sixty samples of periphyton (80 for biomass and 80 for taxonomic analysis) were collected from stream sampling sites of the LSA and RSA in 2011 and 2012.

Periphyton density showed substantial among-site variation (**Figure 5.1.2.6-28**; Section 5.2 of **Appendix 5.1.2.6A**). (The names of the sites are listed in **Table 5.1.2.6-13**.) Mean density was lowest in upper Davidson Creek, lower Creek 661 and Creek 700, and highest in Turtle Creek, upper Creek 661, and Creek 704. Spatial distribution of periphyton biomass was similar to the distribution of periphyton density, with the exception of site BI-06 (the lower Chedakuz Creek site). Mean biomass at this site (6.18 µg/cm^3) approached the BC guidelines for the protection of aquatic life in streams (10 µg/cm^3), indicating that this site was nutrient enriched, perhaps from local agricultural run-off.

Most periphyton communities were dominated by diatoms and cyanobacteria in both 2011 and 2012. Diatoms were predominant at 10 of 14 sites sampled and cyanobacteria were predominant at the other four sites. Relatively high proportions of cyanobacteria in streams are generally associated with high nutrient concentrations.

Motile diatom species – species in the genera *Nitzschia*, *Navicula*, *Gyrosigma*, and *Surirella* – which serve as indicators of siltation, were present in the periphyton samples collected from the LSA. However, on average, motile diatoms comprised less the 50% of the total diatoms at all stream sampling sites in 2011, which does not indicate a high degree of siltation from past land use activities (e.g. logging) at these stream sampling sites. For the two sites sampled in both years, motile diatom species made up greater proportions of the periphyton community in 2012 than in 2011, indicating greater siltation in 2012 than in 2011.

Taxa richness (S) at the 14 stream sites sampled in 2011 and 2012 ranged from a low of 8 genera in the Blackwater River Tributary (BI-14) to a high of 18 genera in upper Creek 705 (BI-12) with a mean over all 16 values of 14 genera (SE = 1) (**Table 5.1.2.6-13**). Taxa richness at the two sites sampled in both years did not show any clear trends between years, decreasing from 16 to 12 genera at site BI-01 (lower Davidson Creek) and increasing from 11 to 17 genera at site BI-09 (lower Creek 705).



Note: cm^2 = square centimetres; ID = identification; error bars are SE of the mean

Figure 5.1.2.6-28: Mean Periphyton Density at Stream Sites, LSA and RSA, 2011 and 2012

Table 5.1.2.6-13: Taxa Richness, Diversity, and Evenness Metrics for Periphyton Communities at Stream Sites, 2011 and 2012

Stream	Baseline Map Site ID	Taxa Richness (S)		Shannon-Weaver Index (H')		Pielou's Evenness (J)	
		2011	2012	2011	2012	2011	2012
Davidson Creek near the Mouth	BI-10	-	16	-	1.8	-	0.38
Lower Davidson Creek	BI-01	16	12	2.0	1.5	0.49	0.45
Mid Davidson Creek	BI-11	-	17	-	1.8	-	0.39
Upper Davidson Creek	BI-02	14	-	1.6	-	0.40	-
Creek 704454	BI-03	16	-	2.0	-	0.47	-
Lower Creek 661	BI-04	10	-	1.5	-	0.44	-
Upper Creek 661	BI-05	13	-	1.3	-	0.32	-
Turtle Creek	BI-07	13	-	1.3	-	0.30	-
Creek 700	BI-08	12	-	1.8	-	0.51	-
Lower Chedakuz Creek	BI-06	14	-	2.1	-	0.62	-
Lower Creek 705	BI-09	11	17	1.7	2.0	0.56	0.45
Upper Creek 705	BI-12	-	18	-	2.1	-	0.47
Fawnie Creek Tributary	BI-13	-	17	-	2.0	-	0.45
Blackwater River Tributary	BI-14	-	8	-	1.2	-	0.57

Note: Dashes indicate no data available.

Diversity (i.e., *H'*) ranged from a low of 1.3 in Turtle Creek (BI-07) and upper Creek 661 (BI-05) to a high of 2.1 in lower Chedakuz Creek (BI-12) and upper Creek 705 with a mean over all 16 values of 1.7 (SE = 0.1) (**Table 5.1.2.6-13**). H' at the two sites sampled in both years did not show any clear trends between years, decreasing from 2.0 to 1.5 at site BI-01 (lower Davidson Creek) and increasing from 1.7 to 2.0 at site BI-09 (lower Creek 705).

5.1.2.6.3.1.1.9 Stream Benthic Macroinvertebrate Community

Benthic macroinvertebrates (BMI) are a diverse group of animals living on or in the substrates of streams, wetlands, and lakes. They include protozoans, flatworms, nematodes, aquatic worms, crustaceans (i.e., ostracods, isopods, and amphipods), molluscs (i.e., snails and clams), and larvae of aquatic insects (i.e., mayflies, dragonflies, and blackflies). Many BMI feed on periphyton and are prey for fish, thereby providing a link between primary production and fish.

One hundred and fifteen BMI samples were collected with kick nets from late August to early September in 2011 and 2012 at the same stream sites and dates as were periphyton.

5.1.2.6.3.1.1.9.1 Community Organization

BMI communities in streams of the LSA and RSA clustered into five significantly different groups (**Table 5.1.2.6-14**), based on multivariate analysis of their taxonomic composition. Sites within groups did not differ statistically distinct from other group members, but groups of sites are statistically distinct. Of the five groups, only two represented multiple sites (Group A and B), and over half of all sites are found in Group A (8 of 14).

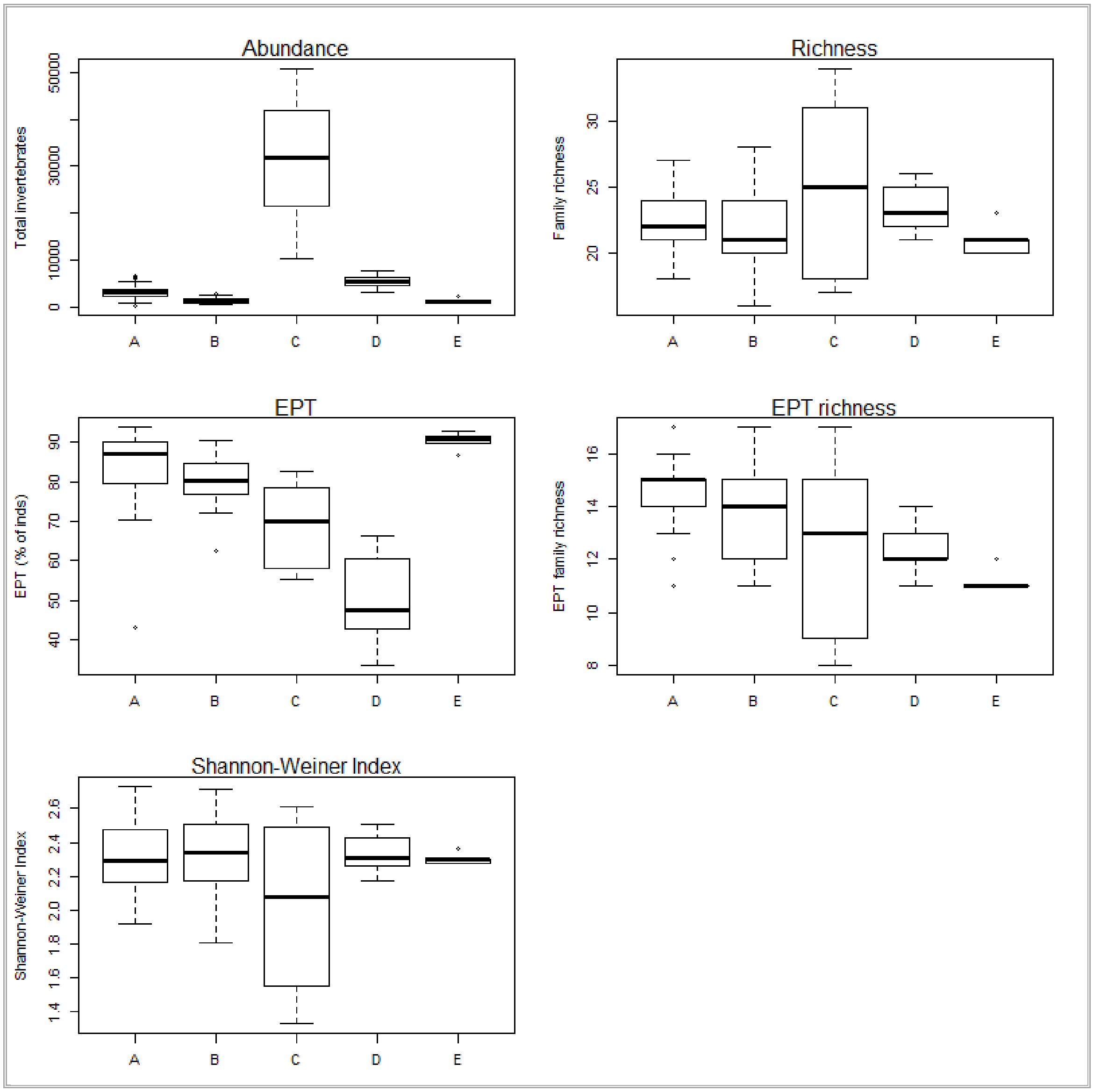
Table 5.1.2.6-14: Habitat Characteristics Associated with Stream BMI Groups

BMI Grouping (Sites)	Site Characteristics
A (BI-01, BI-02, BI-04, BI-05, BI-09, BI-11, BI-13, BI-14)	Moderate altitude, larger substrate, fast flows, medium conductivity and mix of stream orders (2-4)
B (BI-03, BI-08, BI-12)	High altitude, small streams, with larger substrate, low conductivity and slow flow
C (BI-06)	Large, low altitude stream, with low canopy coverage, high conductivity and periphyton
D (BI-07)	Mid-altitude, highest conductivity, high periphyton and small substrate
E (BI-10)	Moderate velocity, width, conductivity, low altitude and small substrate

The subset of site habitat variables that were best correlated with the variation observed in BMI communities included altitude, stream width, the amount of periphyton, and the importance of silt as a substrate (**Table 5.1.2.6-14**). These four variables are well aligned with the habitat characterizations of the five significant BMI groupings observed in the LSA and RSA (Spearman correlation coefficient score = 0.82).

There were also clear differences among the five groups in their mean indices of abundance and diversity (**Figure 5.1.2.6-29**). For example, Group A had the highest mean number of EPT and the highest EPT species richness, and Group C had the highest density and species richness but the lowest Shannon-Weiner index of diversity.

Comparison of the BMI communities in the LSA and RSA with two candidate CABIN reference models – Fraser Model (2005) and Skeena Model (2010) – showed that they resembled most closely the Skeena model rather than the Fraser model (**Figure 5.1.2.6-30**). Using the Skeena model as a reference condition, all but one sampling site were classified as in good condition (**Figure 5.1.2.6-31**). The exception was site BI-06 in lower Chedakuz Creek that had also been shown to have unusually high periphyton densities due to potential nutrient enrichment from local ranching activity.



Note: Solid horizontal bar is mean, box is 25% to 75% percentile, and dotted vertical line is range

Figure 5.1.2.6-29: Metric Comparisons of Project Benthic Invertebrate Site Groupings (A – E)

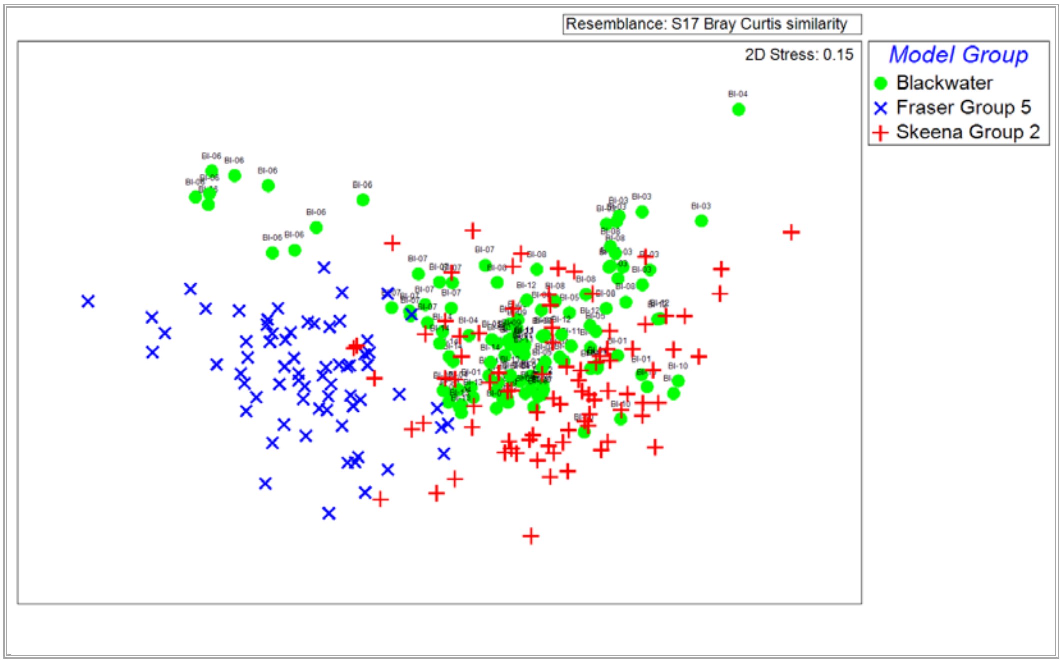


Figure 5.1.2.6-30: An MDS Ordination Comparing Project BMI Communities to those of the Skeena and Fraser Reference Condition Models

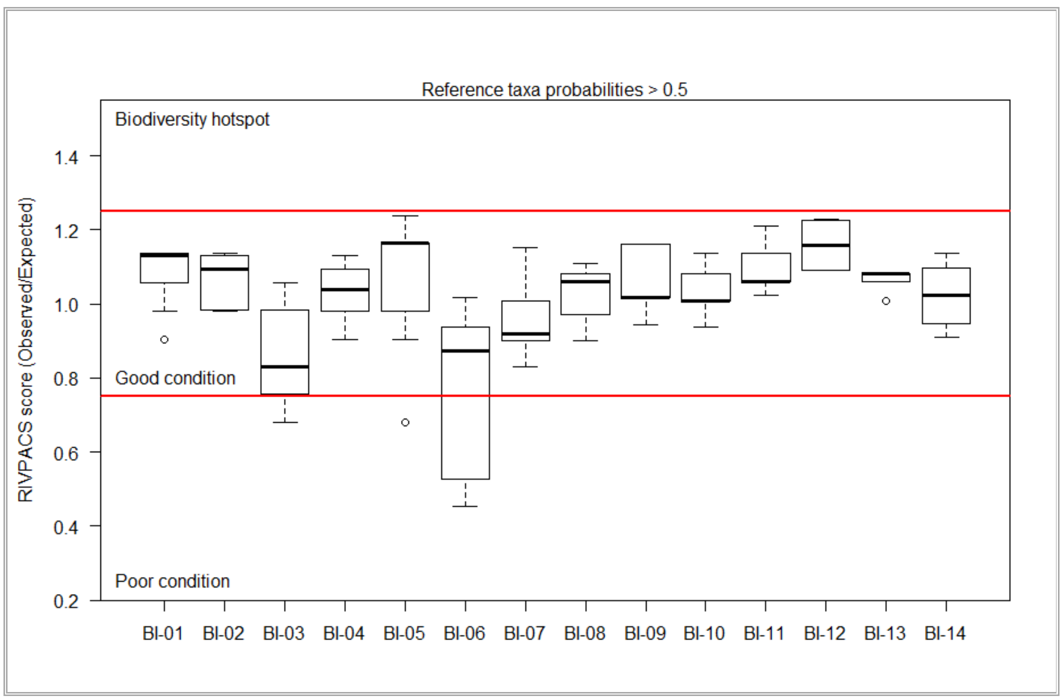


Figure 5.1.2.6-31: RIVPACS Analysis of BMI Communities using the Skeena 2010 Reference Model

5.1.2.6.3.1.1.9.2 Metal Concentrations

A total of 17 BMI samples were analyzed for concentrations of 41 total metals: samples of stream BMI from 14 sites and three samples of littoral BMI from the three headwater lakes.

Table 5.1.2.6-15 shows the mean metal concentrations of BMI sampled from streams and lakes in the LSA. Stream values are pooled from all sampling sites. The data were pooled and subjected to principal component analysis (PCA) to identify the major trends in the data. PCA extracted three principal components that explained a total of 75% of the total variance.

The first component, PC1, explained 47% of the variance and was a "size" component – an index of the concentration of heavy metals in BMI tissue. (Note that the term "heavy metals" is conventionally used to describe a loosely defined subset of elements that exhibit metallic properties. The term does not indicate toxicity because all heavy metals, with the exception of mercury, are micro-nutrients that are essential for life and hence are found naturally in all fish tissue.)

There was no substantial variation in PC1 among watersheds and among BMI taxonomic groups (A to E). Since BMI are fixed to the substrate, this indicates that the concentrations of metals in water and sediment to which BMI communities are exposed may not be substantially different among the watersheds of the LSA. The lack of difference in PC1 scores among the five taxonomic groups indicates that concentrations of metals in BMI tissue are not influenced by differences in the physical characteristics of habitat that drives taxonomic composition.

However, lake samples had much lower PC1 scores than stream samples, indicating much lower metal concentrations. This was mainly due to the difference in type of organisms that were sampled. The lake samples were "scuds" – large-bodied crustaceans of the families Gammaridae and Hyallela – but stream BMI samples were dominated by small-bodied aquatic insects.

The second component, PC2, explained 19% of the variance and was significantly and positively correlated with 20 metals, of which arsenic had the highest correlation. PC2 scores showed no clear spatial trends nor did they show any trends with taxonomic group.

The third component, PC3, explained 9% of the variance and was most highly negatively correlated with potassium. PC3 scores decreased in a downstream direction in Davidson Creek, Turtle, Creek, and Creek 705, and, to a lesser extent, in Creek 661. Since PC3 was interpreted as the absence of potassium, these trends indicate trends of increasing potassium with downstream distance.

In summary, stream BMI tissue samples had higher metal concentrations than lake BMI tissue samples, and there was a trend of increasing potassium concentration with downstream distance in BMI tissue samples.

Table 5.1.2.6-15: Mean Metal Concentrations in Lake and Stream BMI

Metals	Unit	Streams	Lake 01428UEUT	Lake 01538UEUT	Lake 01682LNRS
Aluminum	mg/kg wwt	165.9	9.94	8.37	4.58
Antimony	mg/kg wwt	0.0051	0.0025	0.0063	0.0034
Arsenic	mg/kg wwt	0.271	0.2150	0.6128	0.1610
Barium	mg/kg wwt	4.25	31.200	8.416	4.950
Beryllium	mg/kg wwt	0.0129	<0.0020	0.0060	<0.0020
Bismuth	mg/kg wwt	0.0026	<0.0020	0.0010	<0.0020
Boron	mg/kg wwt	0.48	<0.20	0.10	<0.20
Cadmium	mg/kg wwt	0.0906	0.0189	0.0360	0.0110
Calcium	mg/kg wwt	2249	25,100	21,900	13,200
Cesium	mg/kg wwt	0.0220	0.0207	0.0673	0.0494
Chromium	mg/kg wwt	0.269	0.431	0.136	0.109
Cobalt	mg/kg wwt	0.1415	0.0147	0.0179	0.0056
Copper	mg/kg wwt	4.05	6.45	4.25	4.69
Gallium	mg/kg wwt	0.0412	<0.0040	0.0020	<0.0040
Iron	mg/kg wwt	311.8	34.50	246.54	14.50
Lead	mg/kg wwt	0.1356	0.0439	0.0658	0.0227
Lithium	mg/kg wwt	0.085	<0.020	0.010	<0.020
Magnesium	mg/kg wwt	237	324	354	234
Manganese	mg/kg wwt	78.3	13.8000	36.5160	3.4400
Mercury	mg/kg wwt	0.0105	<0.015	0.010	<0.0050
Methyl Mercury	mg/kg wwt	0.0079	0.0036	0.0024	0.0052
Molybdenum	mg/kg wwt	0.1437	0.1580	0.1663	0.0457
Nickel (Ni)	mg/kg wwt	0.209	0.238	0.029	0.036
Phosphorus	mg/kg wwt	1120	2,170	1,958	1,400
Potassium	mg/kg wwt	969	970	1,166	570
Rhenium	mg/kg wwt	0.001	<0.0020	0.0010	<0.0020
Rubidium	mg/kg wwt	0.506	1.280	1.128	0.574
Selenium	mg/kg wwt	0.184	0.081	0.050	0.054
Silver	mg/kg wwt	0.0298	0.1560	0.0497	0.0752
Sodium	mg/kg wwt	483	780	1,002	450
Strontium	mg/kg wwt	5.34	138.000	51.980	33.600
Tellurium	mg/kg wwt	0.002	<0.0040	0.0020	<0.0040
Thallium	mg/kg wwt	0.00298	0.00660	0.00323	0.00284
Thorium	mg/kg wwt	0.0295	<0.0020	0.0036	<0.0020
Tin	mg/kg wwt	0.0683	2.1400	0.3132	0.7280
Titanium	mg/kg wwt	7.52	0.330	0.265	0.144
Uranium	mg/kg wwt	0.0640	0.02920	0.07152	0.01850
Vanadium	mg/kg wwt	0.502	0.0342	0.0607	0.0176
Yttrium	mg/kg wwt	0.2138	0.0301	0.0645	0.0176
Zinc	mg/kg wwt	37.5	8.67	5.83	4.21
Zirconium	mg/kg wwt	0.164	<0.040	0.026	<0.040

5.1.2.6.3.1.2 Lakes

5.1.2.6.3.1.2.1 Bathymetry

The LSA contains one large, valley-bottom lake – Tatelkuz Lake – and four smaller headwater lakes: Lake 01682LNRS in the Davidson Creek Watershed; lakes 01538UEUT and 01428UEUT in the Creek 705 Watershed; and Snake Lake in the Tatelkuz Lake Tributaries Watershed (**Figure** 5.1.2.6-1 and **Table 5.1.2.6-16**).

Table 5.1.2.6-16: Elevation and Bathymetry of Lakes of the LSA

Lake	Elevation (m)	Total Area (m^2)	Littoral Area (m^2)	Volume (m^3)	Maximum Depth (m)	Mean Depth (m)	Surface-Volume Ratio (m^{-1})	Perimeter (m)
01682LNRS	1,345	91,881	57,419	509,173	16.3	5.5	0.18	1,667
01538UEUT	1,346	357,375	187,504	1,946,905	11.2	5.5	0.18	4,304
01428UEUT	1,354	169,304	164,676	522,815	7.6	3.1	0.32	2,508
Snake	1,102	519,832	481,832	1,652,000	11.6	3.2	0.31	4,502
Tatelkuz	928	9,100,000	1,010,000	196,000,000	33.7	21.4	0.05	25,000

Note: m = metre; littoral area is area where depth < 6m.

Lake 01682LNRS is the headwater lake of Davidson Creek. It is the smallest of the headwater lakes, with one circular basin. However, its maximum depth, 16.3 m, is the deepest of the four headwater lakes. It is deep enough to stratify thermally in summer. It has shallow basin slopes that create a large littoral area relative to its total surface area (62% of total area).

Lake 01538UEUT is the southernmost headwater lake of the Creek 705 Watershed. It is the largest of the four headwater lakes. The lake has two distinct basins, both oriented in an east-west direction. The smaller, western basin is less than 9 m deep and has a large littoral area near the lake outlet. The eastern basin of Lake 15 is deeper and larger than the western basin. This lake is too shallow to stratify and is well-mixed throughout the year. Littoral area is 52% of total area.

Lake 01428UEUT is the northernmost headwater lake of the Creek 705 Watershed. It is the shallowest of the four headwater lakes and littoral area makes up 97% of total area. This lake has one large main basin, with a small, shallow bay at the north-eastern end. The main basin is deepest near the middle with steep gradients along the north shore. This lake is well-mixed throughout the year.

Snake Lake is intermediate in elevation between Tatelkuz Lake and the other three headwater lakes. It has the second largest area of the four headwater lakes, and has the second greatest maximum depth. It has one circular basin partly intersected by a long, snake-like moraine (hence the name). This gives it the longest perimeter of the four headwater lakes. The shallow slopes of that perimeter mean that its littoral zone makes up 93% of total area.

Tatelkuz Lake is at a lower elevation and is much bigger and deeper than the four headwater lakes (**Table 5.1.2.6-16**). For example, maximum depth of Tatelkuz Lake (33.7 m) is twice the maximum depth of Lake 01682LNRS (16.3 m), three times the maximum depth of Lake 01538UEUT (11.2 m), and over four times the maximum depth of Lake 01428UEUT (7.6 m). Tatelkuz Lake is deep enough to stratify in summer. Tatelkuz Lake is a narrow, elliptical, steep-sided lake compared to the shallow, lens-shaped headwater lakes. Littoral area is only 11% of total area, and the ratio of surface area to volume (0.05 m^{-1}) is one-third that of Lakes 16 and 15 (0.18 m^{-1}) and one-sixth that of Lake 14 (0.32 m^{-1}).

5.1.2.6.3.1.2.2 Elevation of Tatelkuz Lake

Table 5.3.2-30 of **Section 5.3.2** (Hydrology VC) shows seasonal and annual mean water surface elevations of Tatelkuz Lake. Elevations were measured on a monthly basis during 2011, 2012 and 2013. Those measurements were calibrated to discharges from the outlet of Tatelkuz Lake. That elevation-discharge relationship was used to estimate Tatelkuz Lake elevations for a 40-year period (1973 to 2013) using historical discharges from Tatelkuz Lake that were estimated from the synthetic time-series of watershed flows.

Mean annual lake elevation was estimated to be approximately 927.60 masl. Mean monthly elevations are lowest in January and February (926.9 masl), and highest in May (927.4 masl) – a mean seasonal difference of 0.5 m (**Figure 5.1.2.6-32**). Over the 40 year time period, monthly elevations fluctuated by as little as 0.2 masl in February to as much as 1.3 masl in May. The fluctuation about the annual mean was 1.5 m. The maximum fluctuation between minimum and maximum annual lake levels was approximately 2.0 m.

5.1.2.6.3.1.2.3 Physical Limnology

This section summarizes the results presented in Section 5.9 of **Appendix 5.1.2.6A** and Section 5.11 of **Appendix 5.1.2.6B**.

Table 5.1.2.6-17 summarizes the results of vertical profiles of temperature, DO, and conductivity and measurements of Secchi depth in five lakes of the LSA and one lake of the RSA (Kuyakuz Lake).

A more intensive survey of the physical limnology of Tatelkuz Lake was conducted in 2013. Vertical profiles showed that the lake was fully mixed as of 28 January 2013, but had developed thermal stratification by 8 July 2013 and maintained it to at least 7 October 2013 (**Table 5.1.2.6-18** and **Figure 5.1.2.6-33**).

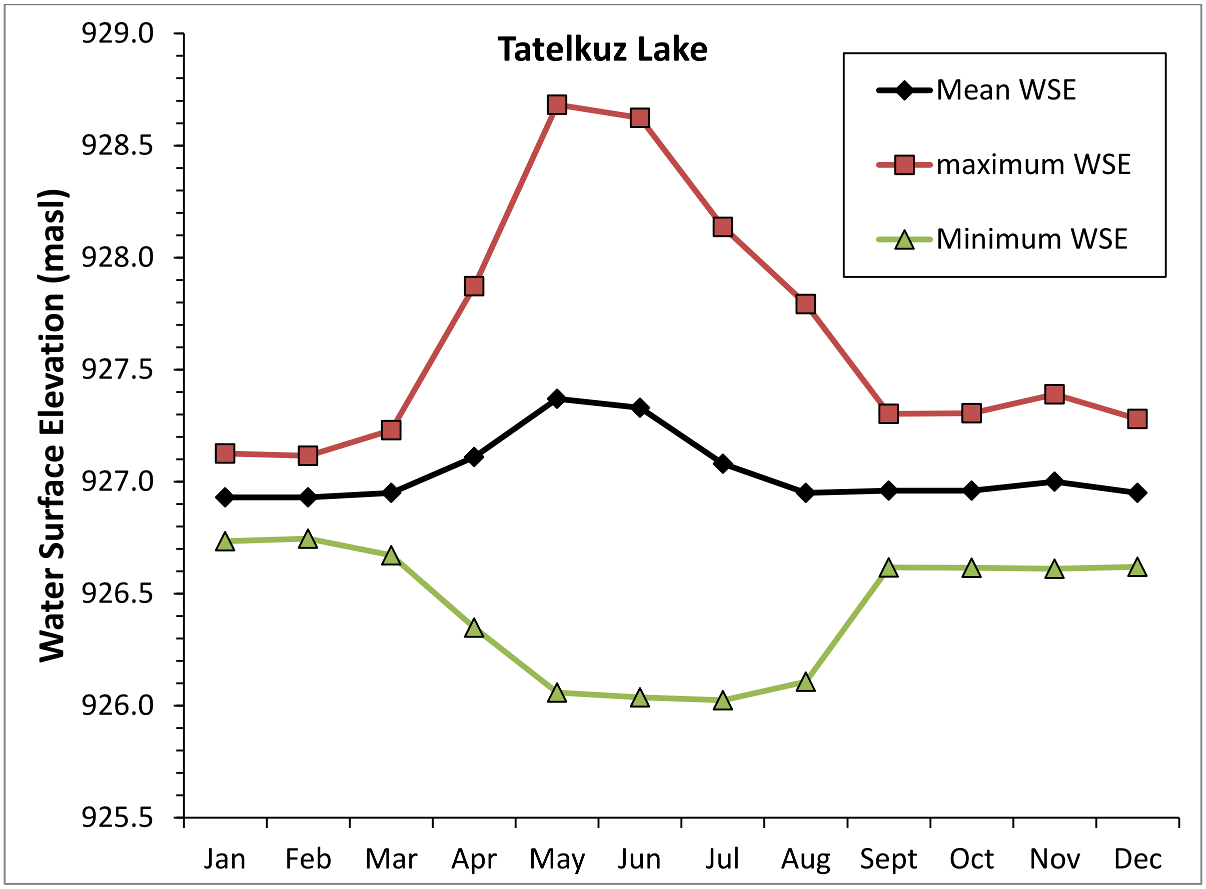


Figure 5.1.2.6-32: Mean Water Surface Elevation of Tatelkuz Lake

Table 5.1.2.6-17: Limnology Parameters Measured in Six Lakes, August 2011 and September 2012

Lake	Date	Temp. Range (°C)	DO Range (mg/L)	Specific Conductivity Range (µS/cm)	pH Range	Secchi Depth (m)	1% Euphotic Depth (m)	Thermo Cline Depth (m)
Lake 1682LNRS	14-Aug-11	4.5 – 14.5	0.1 - 9.5	42 – 67	6.8 – 7.7	5.5	14.9	3.0 – 6.0
	26-Jun-12	4.3 – 13.2	0.2 - 10.1	-	-	-	-	3.0 – 6.0
	11-Sep-12	5.0 – 12.1	0.1 - 10.2	-	-	-	-	5.0 – 7.0
	19-Sep-12	4.8 – 12.1	0 - 9.3	48 – 69	-	5.7	15.4	6.0 – 8.0
Lake 01538UEUT	12-Aug-11	10.7 – 15.8	3.6 - 9.0	41 – 43	7.1 – 8.0	4.0	10.8	4.0 – 6.0
	26-Jun-12	9.7 – 12.4	8.1 - 9.3	-	-	-	-	4.0 – 7.0
	10-Sep-12	13.5 – 13.7	8.2 - 8.6	34 – 35	-	5.7	15.4	-
	11-Sep-12	11.9 – 12.1	6.9 - 9.1	-	-	-	-	-
Lake 01428UEUT	16-Aug-11	12 – 12.6	0 - 9.2	32 – 44	7.2 – 8.0	4.0	10.8	-
	08-Sep-12	12.4 – 14.0	7.5 - 8.6	48	-	3.0	8.1	3.0 – 4.0
	11-Sep-12	10.3 – 10.8	3.2 - 9.5	-	-	-	-	-
Tatelkuz Lake	25-Jun-12	7.0 – 14.2	8.8 - 10.4	-	-	-	-	4.0 – 6.0
	10-Sep-12	5.8 – 14.8	1.2 - 9.2	-	-	-	-	9.0 – 12.0
Kuyakuz Lake	25-Jun-12	12.7 – 14.1	8.9 - 9.5	-	-	-	-	-
	10-Sep-12	14.8 – 15.1	0.7 - 7.9	-	-	-	-	-
Snake Lake	26-Jun-12	8.9 – 15.1	0.2 - 8.3	-	-	-	-	3.0 – 4.0
	11-Sep-12	11.8 – 12.5	0.4 - 7.7	-	-	-	-	-

Note: °C = degrees Celsius; DO = dissolved oxygen; µS/cm = microSiemens per centimetre; m = metre; mg/L = milligram per litre; '-' = not sampled/calculated; % = percent.

Table 5.1.2.6-18: Physical Limnology Parameters Measured in Tatelkuz Lake, 2013

Date	Temp. Range (°C)	DO Range (mg/L)	Specific Conductivity Range (µS/cm)	pH Range	Secchi Depth (m)	1% Euphotic Depth ($Z_{1\%}$, m)	Thermo Cline Depth (m)
28 Jan	1.2 – 3.4	0.1 – 8.9	-	-	-	-	N/A
8 Jul	4.8 – 18.8	0.7 – 9.0	-	-	-	-	2.0 – 11.0
17 Jul	4.8 – 17.2	6.5 – 9.0	139 – 152	6.9 – 8.0	3.75	10.1	3.0 – 12.0
23 Jul	5.1 – 19.0	0.3 – 9.4	138 – 162	7.0 – 8.2	3.75	10.1	4.0 – 9.0
15 Aug	5.2 – 20.7	4.5 – 9.1	150 – 212	7.3 – 8.8	3.70	10.0	3.5 – 13.0
16 Aug	5.1 – 20.4	4.0 – 9.2	150 – 209	7.4 – 8.9	3.70	10.0	3.0 – 14.5
7 Oct	5.5 – 10.7	1.6 – 12.3	-	-	-	-	8.0 – 13.0

Note: °C = degrees Celsius; DO = dissolved oxygen; µS/cm = microSiemens per centimetre; m = metre; mg/L = milligram per litre; '-' = not sampled/calculated; % = percent; N/A = not applicable. Thermocline not present during winter.

Vertical profiles taken at northern and southern sites in both July and August showed few differences, indicating strong horizontal mixing.

Secchi depths in Tatelkuz Lake ranged from 3.70 to 3.75 m in July and August 2013, showing little differences between the northern and southern halves of the lake (**Table 5.1.2.6-18**). The maximum depth for photosynthetic production (i.e., $Z_{1\%}$) ranged from 10.0 to 10.1 m. Since mean depth of the lake is 21.4 m, photosynthesis only occurs in the upper half of the lake.

The physical limnology of Tatelkuz Lake differs from that of the three headwater lakes due to differences among lakes in size, shape, elevation, volume of inflows, and position within the hydrological system. Tatelkuz Lake is deep enough to stratify in summer, but only Lake 01682LNRS is deep enough to stratify (**Figure 5.1.2.6-34**). The other two headwater lakes (01428UEUT and 01538UEUT) are well mixed throughout summer.

Stratification meant that bottom temperatures of Tatelkuz Lake in 2013 were similar to those of Lake 01682LNRS in 2012, but lower than those of the other two headwater lakes.

Summer surface temperatures of Tatelkuz Lake were notably warmer than all three headwater lakes. This was due mainly to the lower elevation of Tatelkuz Lake (928 m) compared to the three headwater lakes (1,345 to 1,354 m). This phenomenon was first observed in streams of the LSA during 2011, 2012 and 2013 – water temperatures during all seasons decrease with increasing elevation.

DO concentrations in Tatelkuz Lake never fall below 4 mg/L, but those in Lake 01682LNRS fall to zero during summer (**Figure 5.1.2.6-34**). Lakes 01538UEUT and 01428UEUT were well mixed with DO concentrations approximately 8.0 mg/L and constant with depth.

One of the most striking differences between Tatelkuz Lake and the three headwater lakes is the much higher conductivity in Tatelkuz Lake (**Figure 5.1.2.6-34**). In 2013, conductivity ranged from 93 to 212 µS/cm in Tatelkuz Lake, which was three to five times higher than the ranges measured in the headwater lakes in August and September 2012 (34 to 43 µS/cm for Lake 01538UEUT, 32 to 48 for Lake 01428UEUT, and 42 to 69 µS/cm for Lake 01682LNRS). The reason is that the three headwater lakes are at the head of watersheds and receive relatively little inflows per unit volume, while Tatelkuz Lake receives inflows from numerous watersheds of the Chedakuz Creek Valley. Essentially, all of the TSS and dissolved minerals from the upper and middle Chedakuz Valley eventually flow into Tatelkuz Lake. Another reason may be differences among headwater and valley-bottom lakes in mineral composition of soils and geology. A third explanation may be nutrient input from the cattle ranch at the head of Tatelkuz Lake.

Higher conductivity typically implies higher rates of biological production. This was partially confirmed by Secchi depth, which was slightly deeper in Tatelkuz Lake (3.7 m) than in Lake 01428UEUT (3.0 m), but it was exceeded by both lakes 01538UEUT (5.7 m) and 01682LNRS (5.7 m).

All three headwater lakes have 1% euphotic zone depths that are greater than maximum lake depth (**Table 5.1.2.6-17**). That means photosynthesis occurs throughout the entire volumes of those lakes. In contrast, the 1% euphotic zone depth in Tatelkuz Lake ranged from 10.0 to 10.1 m. Since mean depth of the lake is 21.4 m, photosynthesis only occurs in the upper half of the lake.

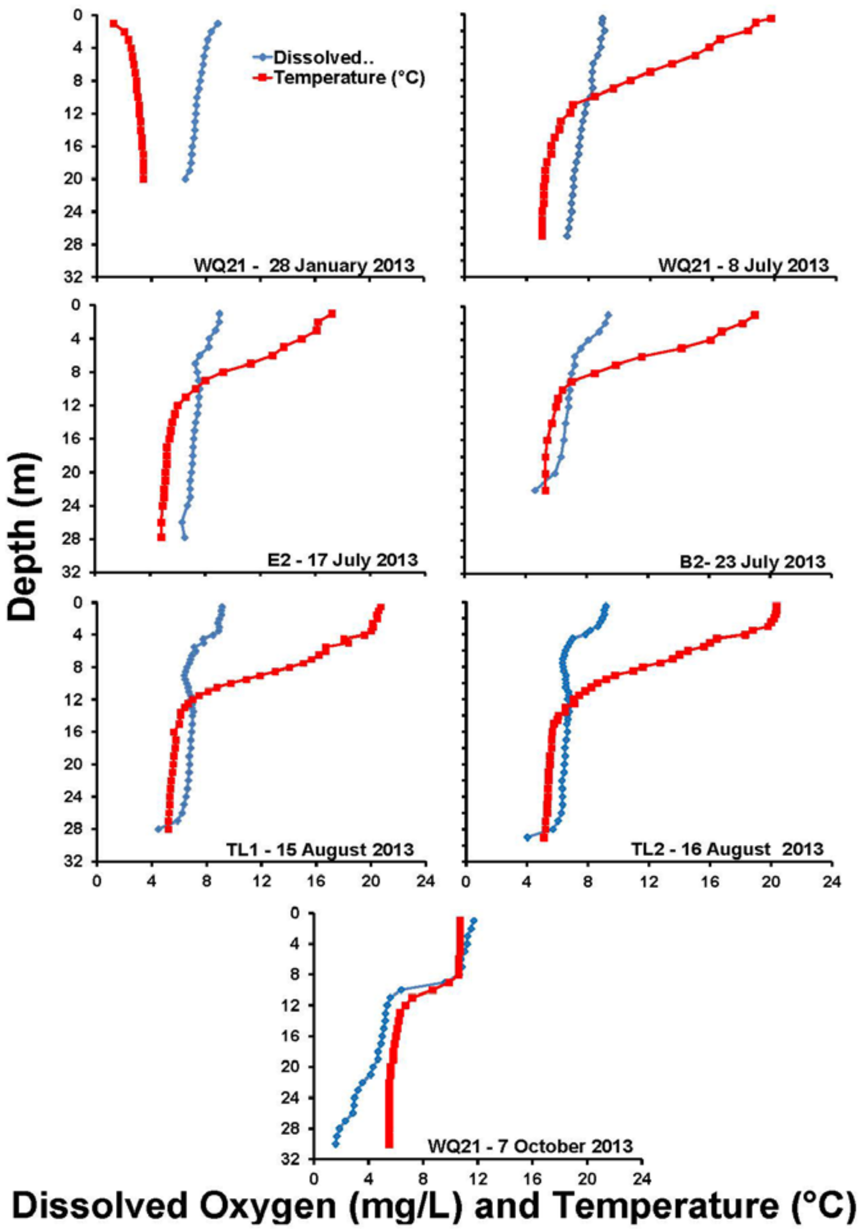


Figure 5.1.2.6-33: Vertical Profiles of Temperature and DO Concentrations, Tatelkuz Lake, 2013

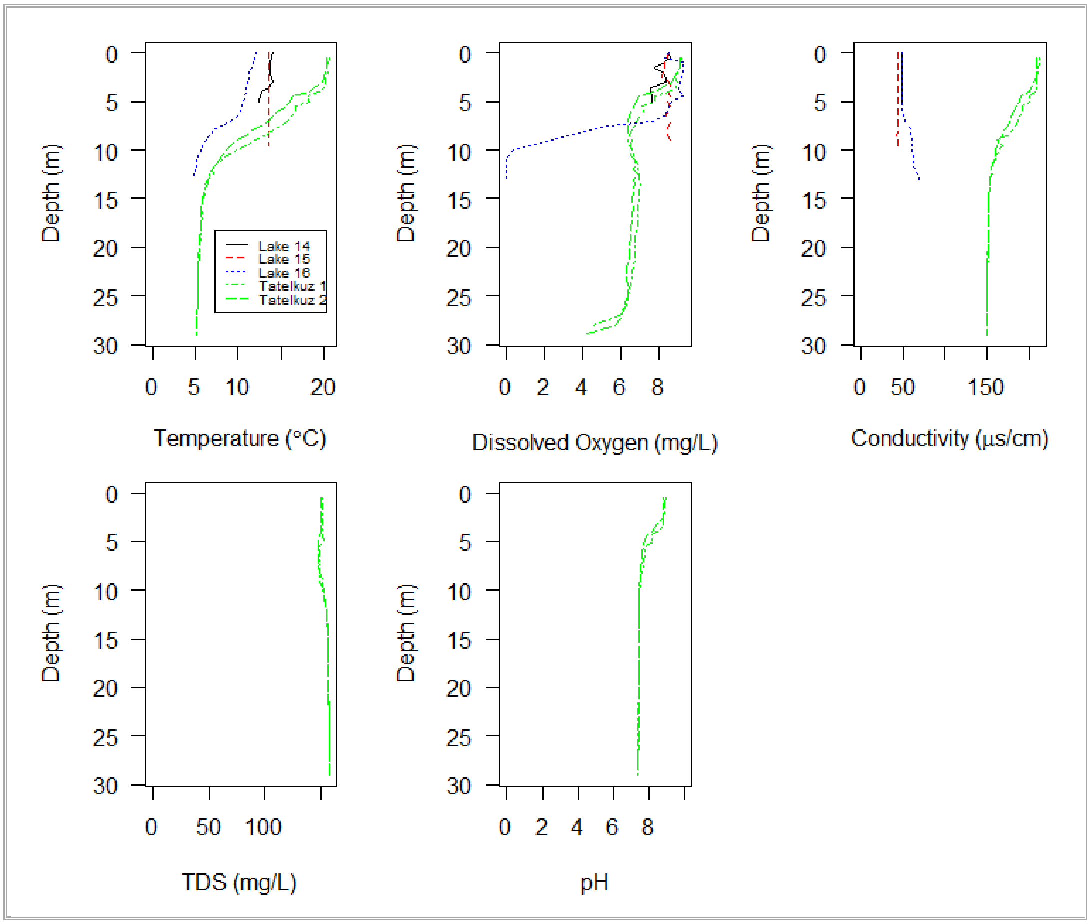


Figure 5.1.2.6-34: Mid-Summer Vertical Profiles of Temperature, Dissolved Oxygen, Specific Conductivity (upper panels), Total Dissolved Solids, and pH (lower panels) of Tatelkuz Lake and Three Headwater Lakes

5.1.2.6.3.1.2.4 Habitat Quality

This section summarizes the results presented in Section 5.9 of **Appendix 5.1.2.6A** and Section 5.10 of **Appendix 5.1.2.6B**.

5.1.2.6.3.1.2.4.1 Littoral Habitat

As shown in **Table 5.1.2.6-16**, littoral area makes up a much smaller proportion of surface area in Tatelkuz Lake than in the four headwater lakes. Littoral habitat area is only 11% of total area in Tatelkuz Lake compared to 52% in Lake 01538UEUT, 62% in Lake 01682LNRS, 93% in Snake Lake, and 97% in Lake 01428UEUT.

For all four lakes, the littoral habitat zone was divided into discrete habitat units based on the type of dominant and subdominant substrate. For example, a unit dominated by gravel (G) with fines (F) as sub-dominant would be labelled Gf, where the dominant type is shown in upper case and the sub-dominant type is shown in lower case. Nine habitat units were defined, including some with more than one sub-dominant substrate (e.g., Gbf or Gravel-boulder/fines) (**Table 5.1.2.6-19**).

Table 5.1.2.6-19: Littoral Habitat Classes and Area

Littoral Habitat Classes[(2)]	Lake 01682LNRS		Lake 01538UEUT		Lake 01428UEUT		Tatelkuz Lake[(1)]	
	Area (m^2)	Area (%)	Area (m^2)	Area (%)	Area (m^2)	Area (%)	Area (m^2)	Area (%)
Gf	0	0	20,438	10.9	0	0	135,258	16.1
Gc	0	0	0	0	0	0	48,764	5.8
Gbf	4,249	7.4	132,003	70.4	0	0	0	0
Cg	0	0	0	0	0	0	261,131	31.0
Cb	0	0	0	0	0	0	16,211	1.9
Cbf	6,029	10.5	19,125	10.2	76,410	46.4	0	0
Cbg	43,007	74.9	15,938	8.5	76,739	46.6	0	0
Bc	0	0	0	0	0	0	7,893	0.9
Fg	4,134	7.2	0	0	11,527	7.0	372,896	44.3
Sum	57,419	100	187,504	100	164,676	100	842,153	100

Note: [(1)]Littoral habitat classes were assessed to a depth of 4.0 m for Tatelkuz Lake and 6.0 m for the headwater lakes due to greater transparency of headwater lakes.
[(2)]Dominant: B = boulder, C = cobble, F = fines, G = gravel; sub-dominant: b = boulder, c = cobble, f = fines, g = gravel.

Each of the lakes showed a different distribution of littoral habitat types. Littoral habitat in Lake 01682LNRS is mainly comprised of cobble-boulder/gravel substrate. The remainder consists of cobble-boulder/fines (11%), gravel-boulder/fines (7%), and fines-gravel (7%) substrates.

Lake 01538UEUT habitat is mainly gravel-boulder/fines (71%), with gravel-fines (11%), cobble-boulder/fines (10%), and cobble-boulder/gravel (8.5%) also present.

Approximately half of the Lake 01428UEUT littoral zone substrates are cobble-boulder/gravel (47%) and the other half is cobble-boulder/fines (46%), with fines-gravel also present (7%).

Three habitat classes dominate the littoral zone of Tatelkuz Lake. In order of relative abundance, these are: fines-gravel substrates (36% of total littoral area <4 m deep), cobble-gravel substrates (31%) and gravel-fines (14%). These habitat types are distributed in a distinct manner. The littoral zone of Tatelkuz Lake along the eastern and western shorelines is narrow (<25 m) and steep (>10%) and comprised of large substrates (i.e., cobble and boulders). Sand/silt/gravel beaches are located at the northwest and southeast ends where the littoral zone is wide (>150 m) and has a gradual gradient (<3%) (**Figure 5.1.2.6-35**).

In general, substrates in Tatelkuz Lake change from coarse to fine with increasing depth and distance from shore. This is particularly true along the longer and steeper east and west shorelines.

5.1.2.6.3.1.2.4.2 Profundal Habitat

The headwater lakes are generally shallow with low gradient banks and profundal habitats comprise less than half of their total areas. In contrast, Tatelkuz Lake is a steep-sided lake in which 89% of its total area is profundal habitat. In all four lakes, profundal habitat is assumed to consist of fine silt with occasional rock outcrops, and to have low habitat quality for fish.

5.1.2.6.3.1.2.4.3 Total Habitat Units

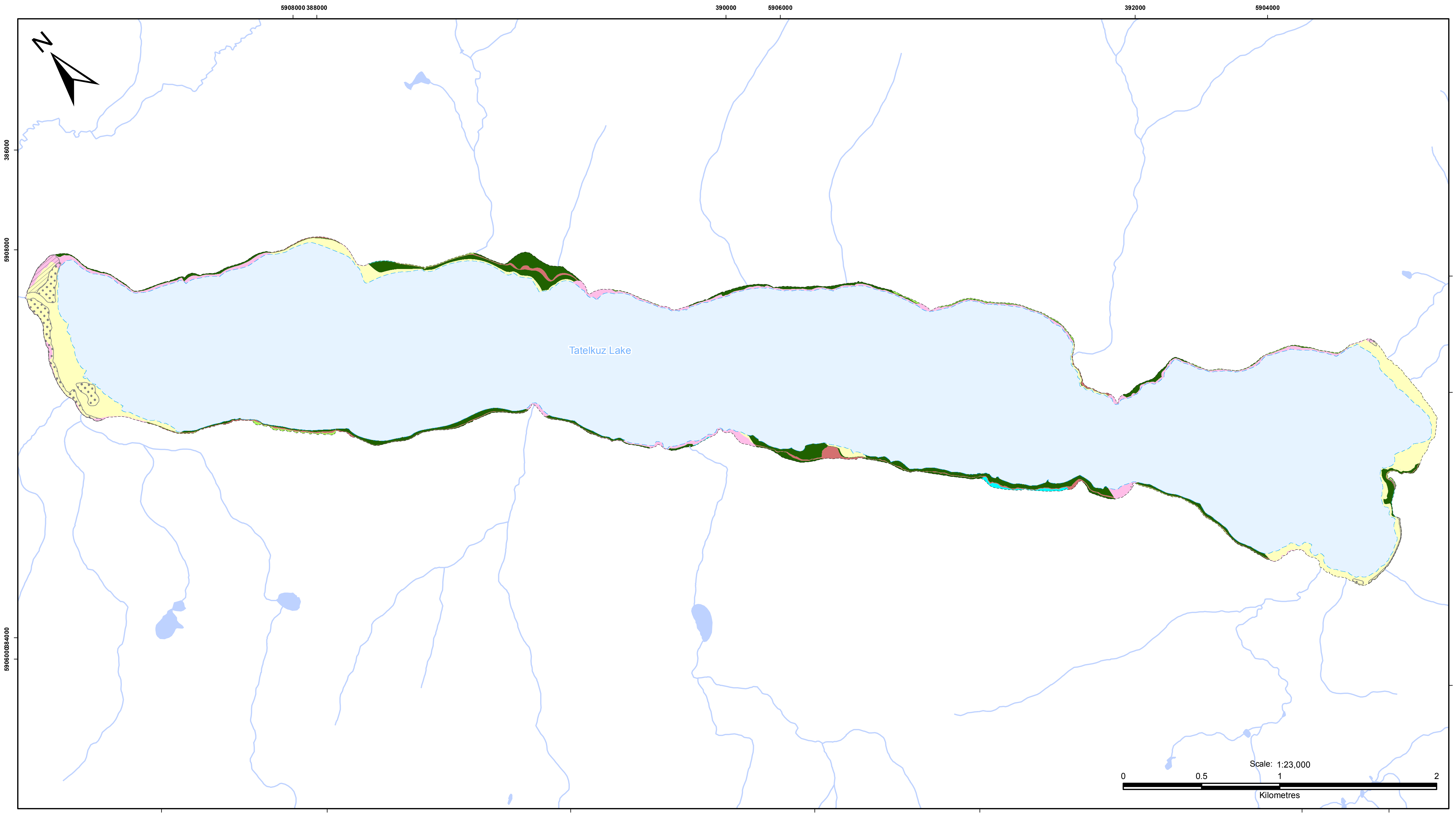
Fish habitat units were calculated for four of the five lakes in the LSA using rainbow trout and kokanee as the two indicator fish species. Although Tatelkuz Lake supports an additional eight fish species, none use habitat in the two streams that will be most affected by Project activities: Davidson Creek and Creek 661. Snake Lake was excluded from the list of lakes because it does not support either rainbow trout or kokanee. The total number of lake HU for those four lakes is 48,061,870 (**Table 5.1.2.6-20**).

Table 5.1.2.6-20: Fish Habitat Units in Lakes of the LSA

Lake	RB Juvenile Summer Rearing (HU)	RB Adult Summer Foraging (HU)	RB Overwintering (HU)	KO Juvenile Summer Rearing (HU)	KO Adult Summer Foraging (HU)	KO Overwintering (HU)	Food and Nutrient Production (HU)	Total (HU)
Tatelkuz	4,861,498	6,737,073	9,034,151	8,386,285	8,386,285	8,386,285	575,663	46,367,241
01538UEUT	229,693	250,051	340,769	0	0	0	175,644	996,157
01428UEUT	125,837	106,051	148,379	0	0	0	82,826	463,093
01682LNRS	60,278	59,273	82,238	0	0	0	33,593	235,380
Total	**5,277,305**	**7,152,448**	**9,605,537**	**8,386,285**	**8,386,285**	**8,386,285**	**867,726**	**48,061,870**

Note: RB = rainbow trout, KO = kokanee, HU = habitat units. No RB or KO spawning/egg incubation or RB fry summer rearing habitat.

Tatelkuz Lake provides the overwhelming majority of those HU (96.5%) because it is much larger than the three headwater lakes and because it supports both rainbow trout and kokanee. (Kokanee are not present in the headwater lakes.) Even if the comparison among lakes was restricted to rainbow trout (i.e., a total HU of 22,905,015), Tatelkuz Lake would make up 92.6% of all lake HU in the LSA and the three headwater lakes would provide only 4.3% (01538UEUT), 2.0% (01428UEUT), and 1.0% (01682LNRS).



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Substrates : ***Boulder dominant (B)***

Boulder dominant, cobble sub-dominant (Bc)

Cobble dominant (C)

Cobble dominant, boulder sub-dominant (Cb)

Cobble dominant, gravel sub-dominant (Cg)

Fines dominant (F)

Fines dominant, gravel sub-dominant (Fg)

Gravel dominant (G)

Gravel dominant, cobble sub-dominant (Gc)

Gravel dominant, fines sub-dominant (Gf)

Vegetation

Emergent

Submergent

Source: Shoreline Habitat Classification conducted July 2013.

Maximum lake elevation (927.6masl)

Bathymetry contour - 4.0m (923.5masl)

CLIENT

newgold

AMEC Environment and Infrastructure

4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

amec

ANALYST:	WR
QA:	MY
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:23,000

PROJECT

Blackwater Gold Project

TITLE

Tatelkuz Lake Littoral Habitat

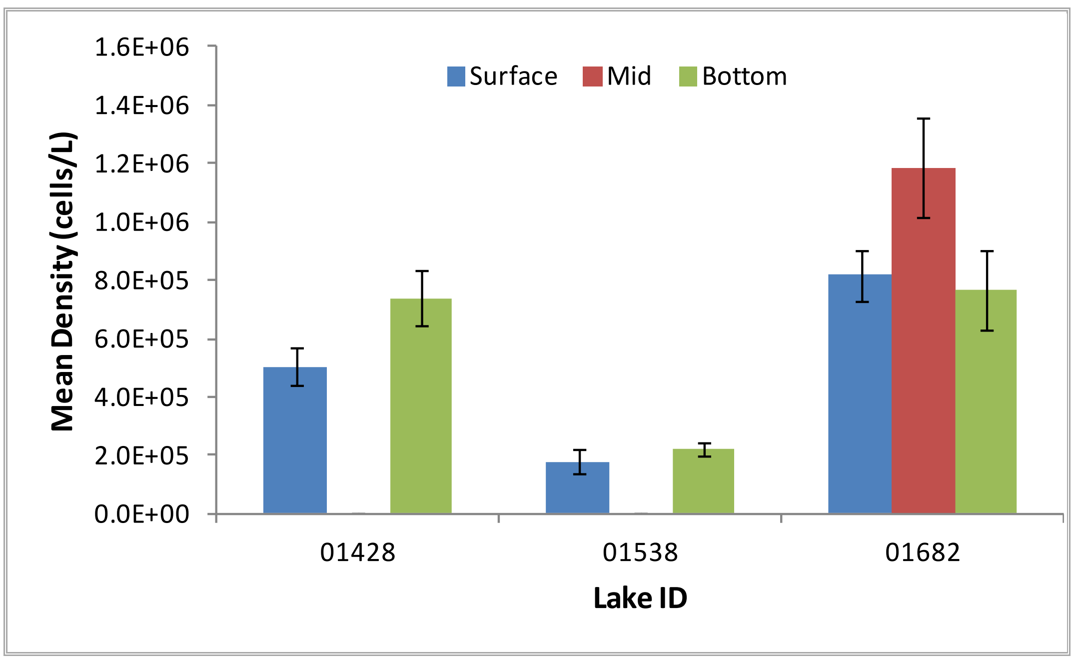
REV. NO:	A
DATE:	November, 2013
PROJECT NO:	VE52277
FIGURE NO:	5.1.2.6-35

5.1.2.6.3.1.2.5 Phytoplankton Community

This section summarizes the results presented in Section 5.4 of **Appendix 5.1.2.6A** and Section 5.11.2 of **Appendix 5.1.2.6B**.

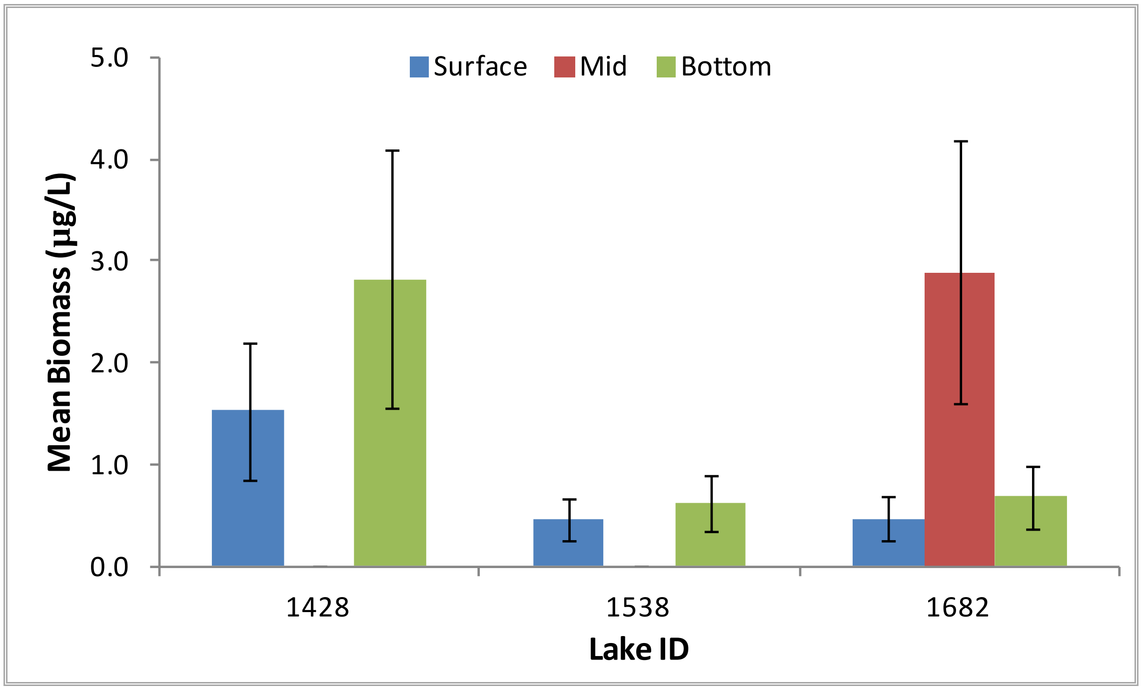
For the headwater lakes, mean phytoplankton cell density and biomass were highest in Lake 01682LNRS and lowest in Lake 01538UEUT (**Figure 5.1.2.6-36** and **Figure 5.1.2.6-37**). With one exception, mean densities and biomasses were similar among depths in each lake. The exception was the mid-depth samples taken from below the thermocline of Lake 01682LNRS. Those had higher density and biomass than surface and bottom samples, indicating that nutrients were concentrated immediately below the summer thermocline resulting in elevated phytoplankton density and biomass.

Chrysophytes (i.e., golden algae and diatoms) were the predominant major taxa in Lakes 01538UEUT and 01428UEUT and in the surface and deep samples from Lake 01682LNRS. However, Cryptophytes were the predominant major taxa below the thermocline of Lake 01682LNRS. *Cryptomonas marssonii* was the single most abundant species of algae within all samples. Green algae (Chlorophyta) were present in all lakes, but never made up more than 29% of total community density. Blue-green algae and dinoflagellates typically dominate the algal community in poor water quality environments. The relative paucity of these taxa from the samples collected in 2012 indicates that the headwater lakes have good water quality.



Note: Mid = sample taken at bottom of thermocline; L = litres; ID = identification; error bars are SE of the mean

Figure 5.1.2.6-36: Phytoplankton Density at Headwater Lake Sites, 2012

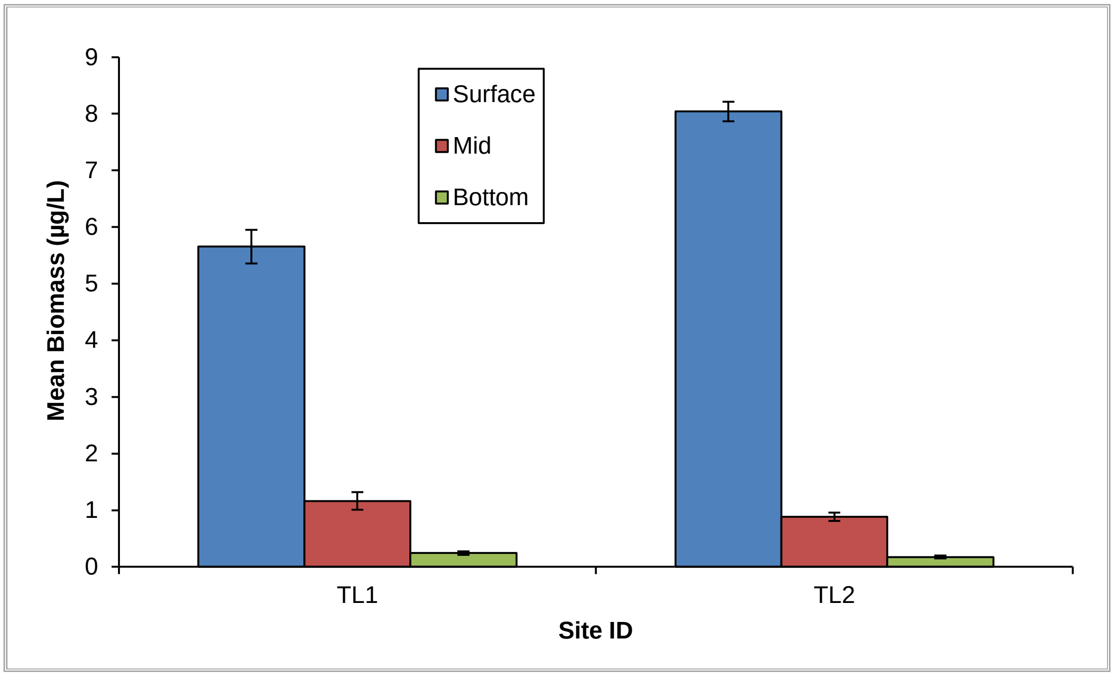


Note: Mid = sample taken at bottom of thermocline; mg/L = milligram per Litre; ID = identification; error bars are SE of the mean

Figure 5.1.2.6-37: Phytoplankton Biomass at Headwater Lake Sites, 2012

Unlike the headwater lakes, mean phytoplankton biomass in Tatelkuz Lake was highest in the epilimnion (i.e., at a depth of 1 m) where light intensity was greatest, and decreased with increasing depth (**Figure 5.1.2.6-38**). Mean biomass was several times lower just below the thermocline at mid-depths of 13 and 15 m, and several times lower again at a bottom depth of 27 m. (Mean density of phytoplankton (expressed as cells/L) showed a similar pattern with site and depth as phytoplankton biomass.) This pattern is the result of the decrease in light intensity with depth – a factor that was less important in the shallower headwater lakes than in Tatelkuz Lake.

In Tatelkuz Lake, a total of 114 phytoplankton taxa were present. Green algae (Chlorophyceae) was the most diverse group (51 taxa), followed by blue-green algae (Cyanophyceae; 25 taxa) and the diatoms (21 taxa). In general, surface waters of Tatelkuz Lake were numerically dominated by blue-green algae and Cryptophyte flagellates (each representing 38% by abundance). *Rhodomonas minuta* was the most abundant species within the epilimnion. Below the thermocline, the diatom *Cyclotella bodanica* was typically the most abundant species of algae. Chrysophytes (i.e., golden algae and diatoms) were the predominant major taxa throughout the entire water column. Chlorophyta (i.e., green algae) is a preferred food for zooplankton, but only represented up to 19.2% of total community density. Grazing by zooplankton may have contributed to its relatively low abundance.

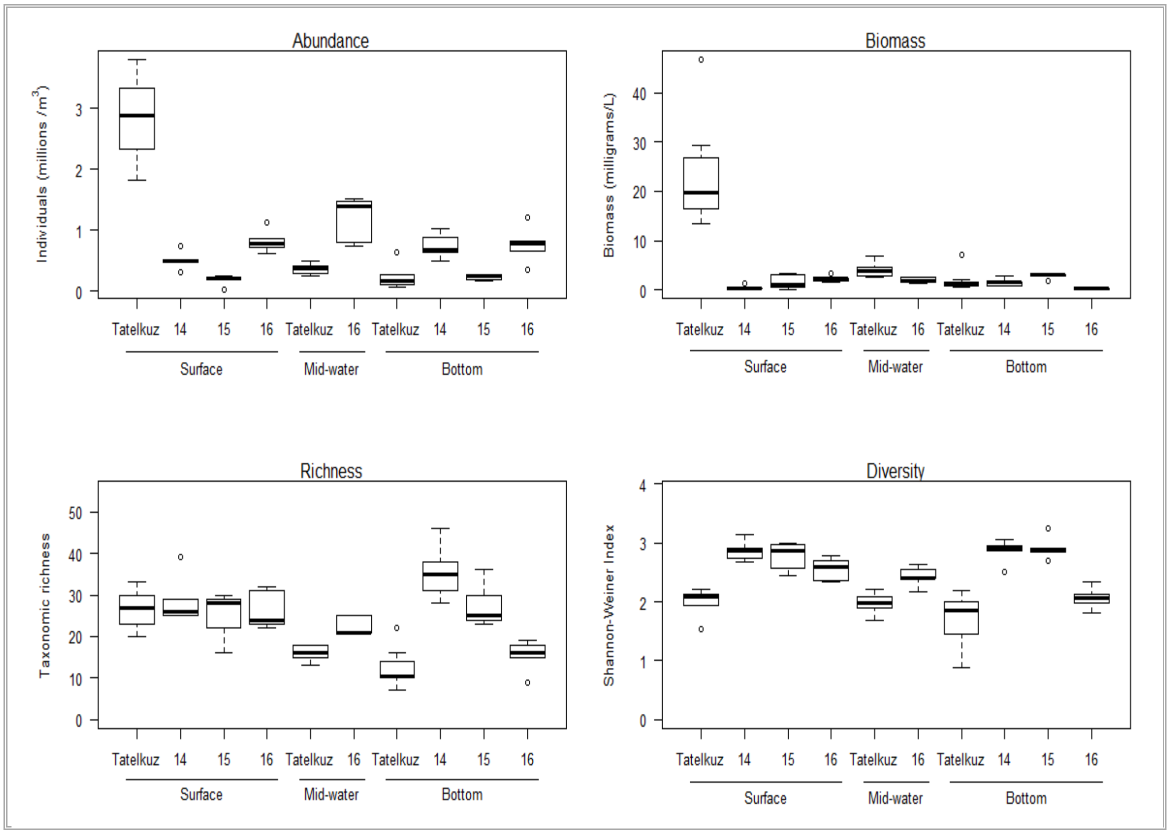


Note: Mid = sample taken at bottom of thermocline; µg/L = microgram per litre; ID = identification; error bars are SE of the mean

Figure 5.1.2.6-38: Phytoplankton Biomass, Tatelkuz Lake, August 2013

Clustering analysis indicated that, with the exception of two replicate outliers, Tatelkuz Lake phytoplankton communities at all depths show significant divergence in taxonomic composition from those of the headwater lakes of the LSA. Within the headwater lake group, each lake's communities differ significantly from the others. For lakes 01428UEUT and 01538UEUT, which lack thermal stratification, both bottom and surface samples group together. For Lake 01682LNRS, each depth class (surface, mid-water and bottom) is distinct, although surface samples are more closely related to those of lakes 01428UEUT and 01538UEUT. Similarly, Tatelkuz Lake depth classes also show significant divergence but like Lake 01682LNRS, mid-water samples are most closely related to bottom samples from the same lake.

The major difference in phytoplankton communities among lakes was the significantly higher density (or abundance) and biomass in surface waters of Tatelkuz Lake than the headwater lakes (**Figure 5.1.2.6-39** and **Table 5.1.2.6-21**). This was due mainly to greater nutrient concentrations in Tatelkuz Lake than in headwater lakes.



Note: box = mid-quartiles; error bars = 1.5X interquartile data; bolded lines within each box = median value.

Figure 5.1.2.6-39: Metrics of Phytoplankton Communities of Tatelkuz Lake and Headwater Lakes

The greater depth of Tatelkuz Lake, and hence the significant reduction in light intensity and phytoplankton density and biomass with depth, also played a role. While biomass below the thermocline remained significantly elevated in Tatelkuz Lake, density of phytoplankton was significantly lower than in Lake 01682LNRS – the only headwater lake that had hypolimnetic habitat. Like density, chlorophyll *a* was significantly elevated above the thermocline in Tatelkuz Lake, but was significantly less than Lake 01682LNRS's below the thermocline. The decline in density and biomass with increasing depth was greater in Tatelkuz Lake where light penetration in the hypolimnion was reduced due to its deeper depth and reduced water clarity.

Physical limnology contributed to determining how phytoplankton communities segregated according to location in the water column when the lake was stratified. Plankton communities in lakes that were not stratified (i.e., lakes 01428UEUT and 01538UEUT) were similar throughout the waterbody, indicating no barriers to mixing. In contrast, stratified lakes (Tatelkuz Lake and Lake 01682LNRS) showed differences in community structure through the water column, with mid-water samples (collected below the thermocline) being most similar to bottom samples. Phytoplankton density and biomass were reduced in the bottom samples relative to surface waters. This decline in density and biomass was greater in Tatelkuz Lake where light penetration in the hypolimnion was reduced due to its increased depth and reduced water clarity.

In summary, phytoplankton communities in lakes of the LSA reflect different nutrient levels and the incidence of thermal stratification. Elevated levels of chlorophyll a, greater phytoplankton abundance and biomass, lower taxonomic diversity, and elevated presence of blue-green algae in Tatelkuz Lake indicate a mesotrophic status for Tatelkuz Lake versus an oligotrophic status for headwater lakes.

Table 5.1.2.6-21: Summary Statistics of Phytoplankton Metrics of Tatelkuz Lake and Headwater Lakes

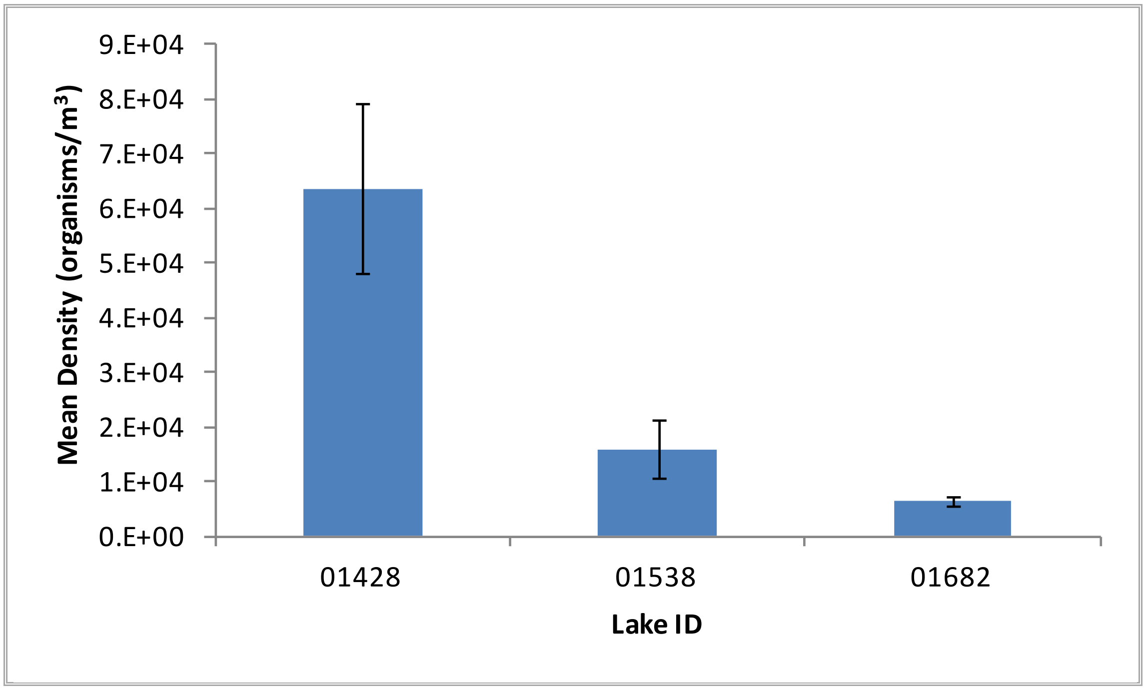
Habitat	Metric	Tatelkuz		Headwater Lakes(1)		t (d.f. = 33,1)	P(2)
		Mean	Range	Mean	Range		
Above Thermocline	Density (number/m³)	2,854,887	1,815,935-3,792,325	500,987	24,495-1,132,812	96.08	<0.001
	Biomass (µg/L)	23,099	13,517-46,681	1,485	148-3,241	-11.08	<0.001
	Taxa Richness	27	20-33	27	16-39	0.79	0.435
	Diversity (Shannon-Weiner Index)	2.03	1.54-2.22	2.73	2.34-3.15	9.20	<0.001
	Chlorophyll a (µg/L)	6.85	4.82-8.45	0.82	0.29-2.11	-13.87	<0.001
Below Thermocline	Density (number/m³)	288,404	65,625-634,481	728,354	163,355-1,516,921	-6.94	<0.001
	Biomass (µg/L)	2,912	480-7,197	1,682	95-3,399	2.50	0.019
	Taxa Richness	14	7-22	25	9-46	-3.12	0.004
	Diversity (Shannon-Weiner Index)	1.84	0.89-2.20	2.57	1.82-3.25	-3.14	0.004
	Chlorophyll a (µg/L)	0.62	0.12-1.59	1.75	0.35-3.94	-3.65	0.001

Note: (1) = includes Lakes 01428UEUT, 01538UEUT, and 01682LNRS for above thermocline but only Lake 01682LNRS for below thermocline; (2) = bolded values are significant at P<0.05.

5.1.2.6.3.1.2.6 Zooplankton Community

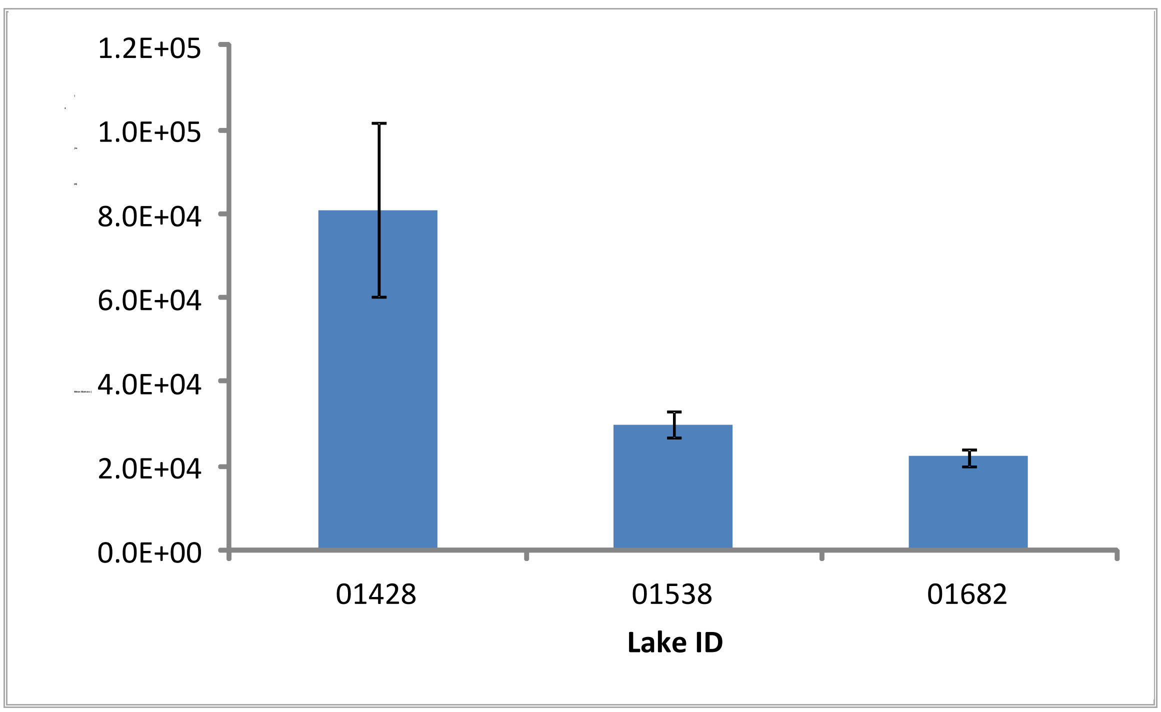
This section summarizes the results presented in Section 5.5 of **Appendix 5.1.2.6A** and Section 5.11.3 of **Appendix 5.1.2.6B**.

In headwater lakes, mean zooplankton density and biomass were highest in Lake 01428UEUT and lowest in Lake 01682LNRS (**Figure 5.1.2.6-40** and **Figure 5.1.2.6-41**). Lake 01428UEUT is the shallowest headwater lake, with the highest percent littoral habitat and the lowest Secchi depth. This suggests that zooplankton abundance in the headwater lakes is driven by morphometry, with shallow, turbid lakes producing the densest populations of zooplankton. Deep, clear lakes with lower percent littoral zone produce less dense populations.



Note: m^3 = cubic metre; ID = identification; error bars are SE of the mean

Figure 5.1.2.6-40: Zooplankton Density from Headwater Lakes, 2012

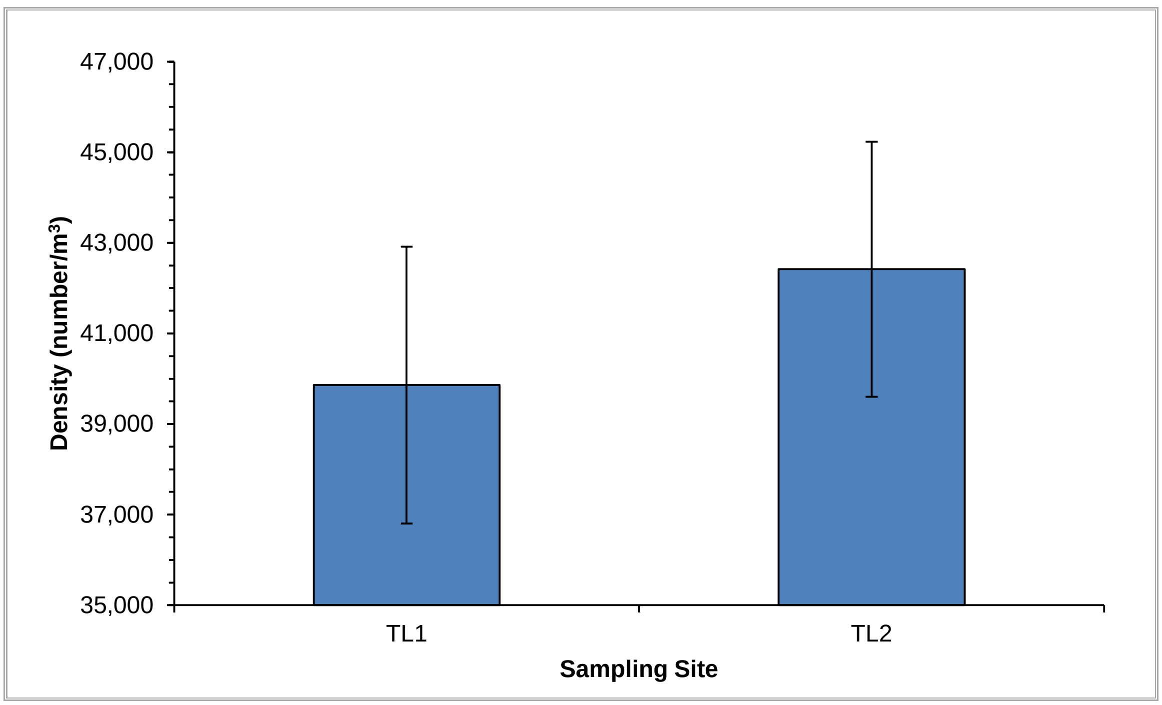


Note: $\mu g/m^3$ = microgram per cubic metre; ID = identification; error bars are SE of the mean

Figure 5.1.2.6-41: Zooplankton Biomass from Headwater Lakes, 2012

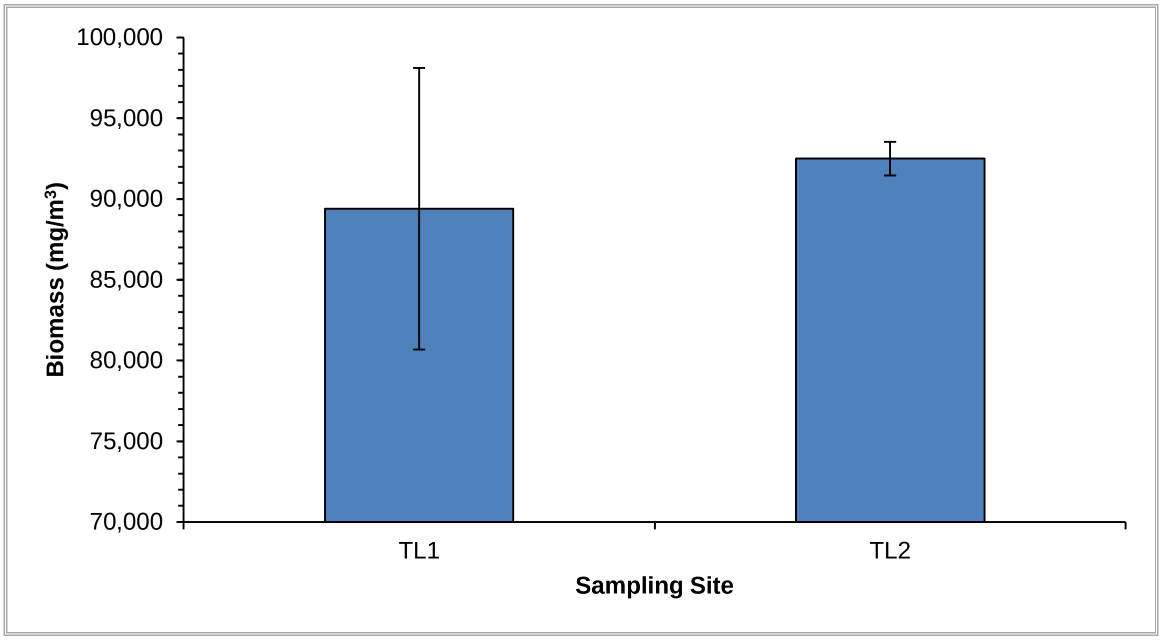
Rotifers were the predominant zooplankton taxon by density in all three headwater lakes. Copepods were the second most common taxon, being predominant in Lake 01682LNRS and second-ranked in Lake 01428UEUT, and third-ranked in Lake 01538UEUT. Ciliophors were the third most common group, being second ranked in Lake 01538UEUT. Cladocerans were the least common taxon in the headwater lakes, only making up between 1% and 9% of the communities by density. Zooplankton species richness ranged from 9 to 16 taxa and mean richness was similar among lakes. Mean diversity index was highest for Lake 01682LNRS and lowest for Lake 01428UEUT – the opposite trend for density and biomass.

Mean zooplankton density and biomass were similar between the northern and southern sampling sites of Tatelkuz Lake (**Figure 5.1.2.6-42** and **Figure 5.1.2.6-43**). This supports the idea of strong horizontal mixing within the lake.



Note: m^3 = cubic metre; Error bars are SE of the mean

Figure 5.1.2.6-42: Mean Zooplankton Density, Tatelkuz Lake, August 2013



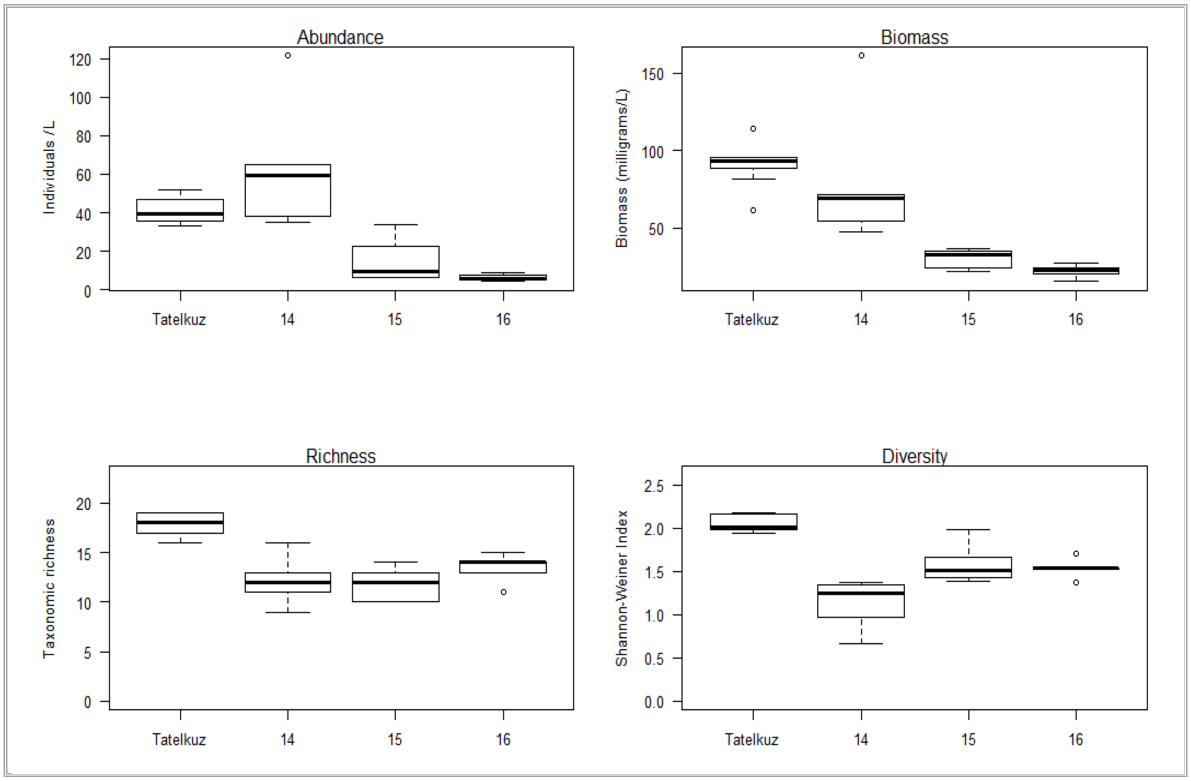
Note: µg/m^3 = microgram per cubic metre; Error bars are SE of the mean

Figure 5.1.2.6-43: Mean Zooplankton Biomass, Tatelkuz Lake, August 2013

Copepods were the predominant zooplankton taxon by density within Tatelkuz Lake. The dominant copepod at both sample locations in Tatelkuz Lake was cyclopoid nauplii. Rotifers were the second most common taxon. The dominant rotifer species at both sample sites was *Kellicotia longispina*. Ciliophors and cladocerans were not highly represented within the Tatelkuz Lake zooplankton population. Ciliophors and cladocerans were not highly represented within the Tatelkuz Lake zooplankton population. Zooplankton species richness (S) was similar at both sampling sites within Tatelkuz Lake, ranging between 16 and 19 taxa.

Zooplankton communities showed very strong differentiation by lake (**Figure 5.1.2.6-44** and **Table 5.1.2.6-22**). Tatelkuz Lake had greater biomass (but not density), taxa richness and diversity than headwater lakes.

Lakes 01428UEUT and 01538UEUT were characterized by a very high proportion of rotifers (88% and 74% respectively) and very low proportions of cladocerans and copepods. In contrast, taxa were much more evenly distributed across Tatelkuz Lake and Lake 01682LNRS samples. This was the main reason why mean density was higher in Lake 01428UEUT than in any other lake.



Note: box = mid-quartiles; error bars = 1.5X interquartile data; bolded lines within each box = median value.

Figure 5.1.2.6-44: Metrics of Zooplankton Communities of Tatelkuz Lake and Headwater Lakes

Table 5.1.2.6-22: Summary Statistics of Zooplankton Communities of Tatelkuz Lake and Headwater Lakes

Metric	Tatelkuz Lake		Headwater Lakes(1)		t (d.f. = 23,3)	Pb
	Mean	**Range**	**Mean**	**Range**		
Abundance (number/m^3)	41,137.7	33,101.3 - 51,780.5	28,695.2	4,477.0 - 121,358.8	-1.185	0.248
Biomass (µg/L)	90,944.8	61,394.4 - 113,990.0	44,338.2	15,472.0 - 161,281.7	-3.826	<0.001
Taxa Richness	18	16-19	12	9-16	-7.704	<0.001
Diversity (Shannon-Weiner Index)	2.05	1.94-2.18	1.41	0.66-1.98	-6.313	<0.001

Note: (1) = includes Lakes 14, 15 and 16 for above thermocline but only Lake 01682LNRS for below thermocline; b = bolded values are significant at P<0.05.

Interestingly, measures of taxonomic richness and diversity were significantly elevated in the zooplankton community of Tatelkuz Lake. These results are inconsistent with nutrient-enriched lakes, but perhaps reflect the habitat diversity of Tatelkuz Lake, which provides habitat (e.g., temperature, productivity etc.) for taxa of different environmental tolerances. Lake 01682LNRS's relatively high richness and diversity, despite its low biomass and abundance, supports this idea.

5.1.2.6.3.1.2.7 Lake Benthic Macroinvertebrate (BMI) Community

This section summarizes the results presented in Sections 5.6 and 5.7 of **Appendix 5.1.2.6A** and Section 5.11.4 of **Appendix 5.1.2.6B**.

5.1.2.6.3.1.2.7.1 Conservation Status

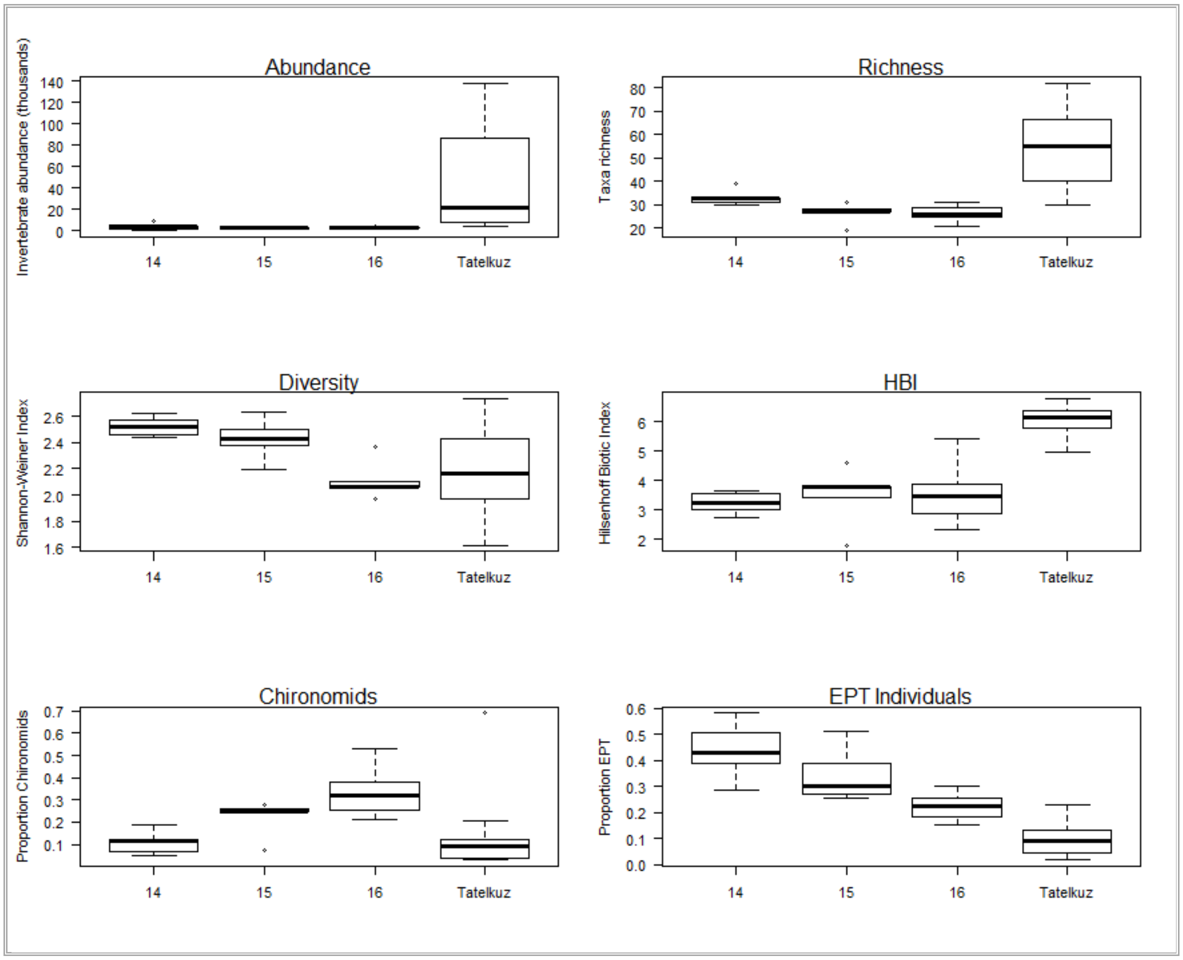
Only one species of lake-dwelling BMI was identified as a blue-listed species. The Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet, was observed in a single sample of littoral zone BMI collected from Lake 01682LNRS with a kick-net in August 2012 (**Appendix 5.1.2.6A**). It was a rare species in that sample, representing only 0.3% of the number of organisms (i.e., 17 individuals were counted within the 5,301 benthic invertebrates in the sample).

The Rocky Mountain Capshell is recognized as a species of Special Concern by the BC CDC (BC CDC, 2014). It has a Provincial S3 conservation status (i.e., blue-listed) and a Global status of G3 (BC CDC, 2014). COSEWIC classifies it as "Not at Risk". It was assigned to the Provincial blue-list because it is the only species of the Family Acroloxidae found in North America, and in BC it is found only in the east-central region (Klinkenberg, 2012). Its habitat is high-altitude oligotrophic and mesotrophic lakes and ponds. It is found in rocky, exposed portions of lakes and ponds in shallow water on the underside of rocks and vegetation on wave-swept shores. Populations are not endangered, but their habitat type is limited.

The Rocky Mountain Capshell may be present in other alpine lakes in the LSA that share similar habitat characteristics as Lake 01682LNRS. The other two alpine lakes are Lake 01428UEUT and Lake 01538UEUT in the Creek 705 Watershed. Both of those lakes were sampled for benthic *invertebrates* in summer of 2012, but no specimens of the Rocky Mountain Capshell were found. That may indicate that they are absent or that they are present, but rare.

5.1.2.6.3.1.2.7.2 Littoral Zone

The BMI communities of Tatelkuz Lake are distinct from those sampled in the headwater lakes (**Figure 5.1.2.6-45** and **Table 5.1.2.6-23**). Abundance, taxa richness, and the Hilsenhoff Biotic Index (HBI) index are greater, but species diversity and the numbers of chironomids and EPT are lower. These differences likely arise from a combination of the nutrient-enriched condition and the unique morphology and habitat heterogeneity of Tatelkuz Lake relative to the smaller lakes.



Note: box = mid-quartiles; error bars = 1.5X interquartile data; bolded lines within each box = median value.

Figure 5.1.2.6-45: Metrics of Littoral BMI Communities of Tatelkuz Lake and Three Headwater Lakes

Table 5.1.2.6-23: Summary Statistics of Littoral BMI, Tatelkuz Lake, and Headwater Lakes

Habitat	Metric	Tatelkuz		Headwater Lakes[1]		F (d.f. = 33,1)	P[2]
		Mean	Range	Mean	Range		
Littoral	Abundance	45,712	3,584-137,695	3,162	240-9,360	13.6	<0.001
	Taxa Richness	54	30-82	29	19-39	37.1	<0.001
	Diversity (Shannon-Weiner Index)	2.2	1.6-2.7	2.35	1.97-2.64	3.16	0.085
	HBI	6.06	4.6-6.8	3.43	1.79-5.39	129.9	<0.001
	Percent Chironomids	0.1	0.03-0.7	0.22	0.047-0.53	4.66	0.032
	Percent EPT	0.1	0.02-0.2	0.34	0.15-0.58	53.41	<0.001

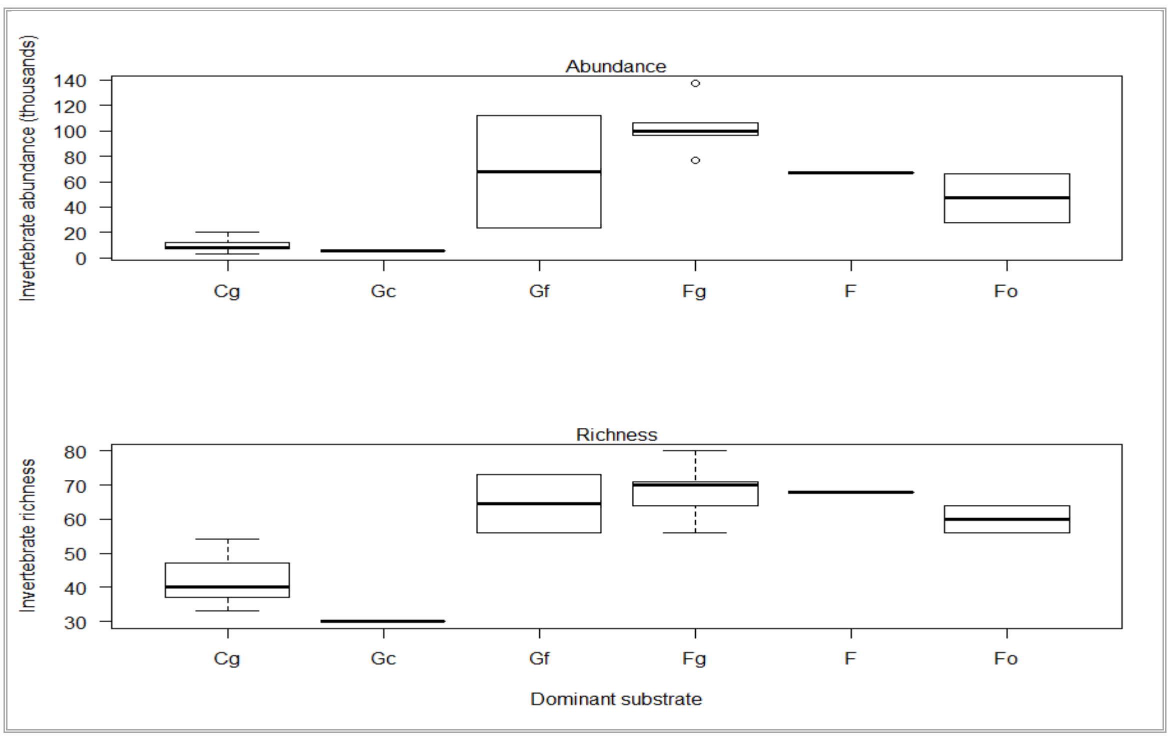
Note: [1] Includes Lakes 01428UEUT, 01538UEUT, and 01682LNRS; [2]bolded values significant at α = 0.05.

The nutrient-enriched nature of Tatelkuz Lake is evident from its water chemistry (e.g., conductivity is three to four times higher) and its elevated phytoplankton and zooplankton biomasses compared to headwater lakes. The majority of metric results associated with the lake BMI communities of Tatelkuz Lake align well with expectations for nutrient-enriched lakes.

Some metrics however did not correspond to expectations of nutrient enrichment. The proportions of chironomids (considered pollution tolerant taxa) were found to be of marginally lower abundance in Tatelkuz Lake, while taxonomic richness was significantly elevated in Tatelkuz Lake. No differences in Shannon-Weiner diversity were observed between the two groups of lakes.

Within Tatelkuz Lake littoral BMI communities, the community structure reflects the habitat heterogeneity of the lake (**Figure 5.1.2.6-46**). There is a more rich and abundant BMI community in the fine habitats (Fine/Gravel, Fine and Fine/Organic) than in the coarse habitats (Cobble/Gravel, Gravel/Cobble and Gravel/Fine). Abundance on fine substrates was 4.3 times greater while richness was 1.4 times greater.

Despite the influence of substrate type on abundance and richness, coarse substrates in Tatelkuz Lake still had levels (19,670 individuals and 45 taxa per sample) that exceeded mean levels of the three headwater lakes.



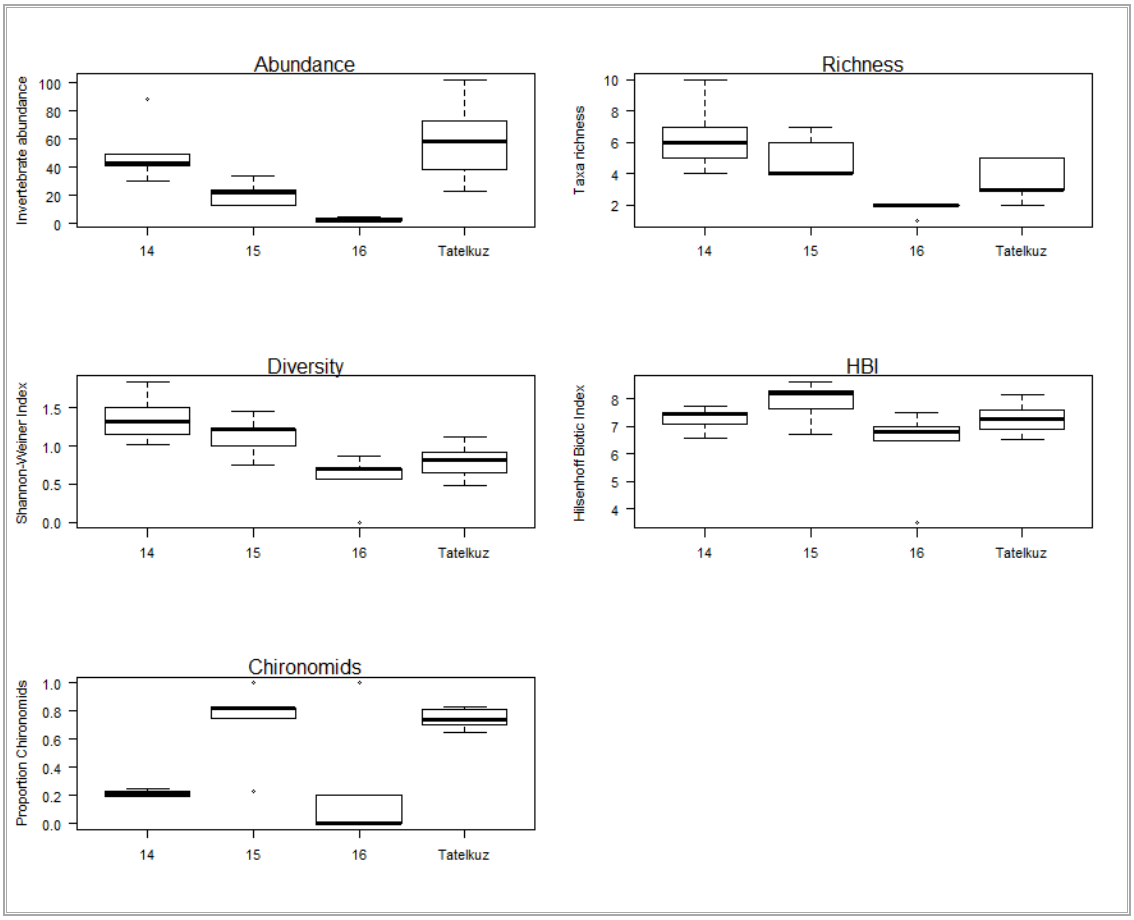
Note: box = mid-quartile; error bars = 1.5 X interquartile range; bolded lines = median value; Substrates: uppercase = dominant; lower case = subdominant; c = cobble; g = gravel; F = fine; o = organic.

Figure 5.1.2.6-46: Littoral BMI Community Abundance and Taxa Richness in Relation to Substrate Type, Tatelkuz Lake, August 2013

5.1.2.6.3.1.2.7.3 Profundal Zone

The profundal BMI community of Tatelkuz Lake was significantly different than those collected from the headwater lakes (**Figure 5.1.2.6-47** and **Table 5.1.2.6-24**). It had higher density and higher percent chironomids. However, unlike littoral communities, profundal samples showed no additional structure within Tatelkuz Lake. Almost half of the observed dissimilarity arose from the greater abundance of two dominant taxa (*Chironomus* sp. midges and Tubificid worms) in Tatelkuz Lake relative to the headwater lakes.

These results suggest that environmental factors associated with profundal habitats (e.g., low DO) overshadow the influences of nutrient enrichment in Tatelkuz Lake.



Note: box = mid-quartile; error bars = 1.5X interquartile range; bolded lines = median value.

Figure 5.1.2.6-47: Metrics of Profundal BMI Communities of Tatelkuz Lake and Headwater Lakes

Table 5.1.2.6-24: Summary Statistics of BMI Metrics for Profundal Areas of Tatelkuz and Headwater Lakes

Habitat	Metric	Tatelkuz		Headwater Lakes[1]		F (d.f. = 23,1)	P[2]
		Mean	Range	Mean	Range		
Profundal	Abundance	59	23-102	25	2-88	12.11	**<0.002**
	Taxa Richness	3	2-5	4	1-10	1.41	0.247
	Diversity (Shannon-Weiner Index)	0.80	0.48-1.12	1.02	0.00-1.85	2.18	0.153
	HBI	7.31	6.52-8.16	7.15	3.50-8.65	0.17	0.687
	Percent Chironomids	0.75	0.65-0.83	0.39	0.00-1.00	8.96	**0.006**

Note: HBI = Hilsenhoff Biotic Index; d.f. = degrees of freedom;
(1) includes Lakes 01428UEUT, 01538UEUT, and 01682LNRS;
(2) Bolded values significant at α = 0.05.

5.1.2.6.3.2 Fish

5.1.2.6.3.2.1 Commercial, Recreational and Aboriginal Fisheries

5.1.2.6.3.2.1.1 LSA and RSA of Mine Site

There are no commercial fisheries within the aquatics LSA or the RSA. There are recreational fisheries for rainbow trout, as shown, for example, by the presence of a fishing resort at the northern end of Tatelkuz Lake. The fishing resort provides a boat, canoes and kayaks for visitors to use on Tatelkuz Lake. Access to Tatelkuz Lake is limited because there is no public road or boat launch. Vehicle access to the lake is either via a boat along Chedakuz Creek or through Indian Reserve (IR) #28 and the Tatelkuz Lake Ranch/Resort. Representatives of First Nations groups have noted that boating supports fishing activity in these areas (Interviews with Lhoosk'uz Dene Elders, 2013). However, the magnitude and intensity of those recreational fisheries are not known because there have been no creel surveys in the RSA. In a May 2013 Open House, a community member noted the south-east side of Tatelkuz Lake is used for recreational purposes such as camping and fishing.

5.1.2.6.3.2.1.1.1 Lhoosk'uz Dene Nation

There are Aboriginal fisheries in the LSA; IR #28 is located at the northern end of Tatelkuz Lake. The reserve is currently occupied by one family with four members of the Lhoosk'uz Dene Nation. Fishing remains an important food source for this family who estimates that approximately three to four meals per week consist of fresh or dried fish. In an interview with residents of IR #28 on 4 July 2013, it was reported that they harvest rainbow trout, suckers, and kokanee in Tatelkuz Lake, Davidson Creek, and lower and middle Chedakuz Creek (Interviews with Lhoosk'uz Dene Elders, 2013). They usually fish in the spring when rainbow trout and suckers migrate from their residence lakes into spawning streams. Rainbow trout and suckers are also fished in the "Twin Lakes" (Lake 113 and Mills Lake) located within the north-east corner of the RSA.

The Lhoosk'uz people use a range of fishing techniques. For example, moose heart is used as bait for larger rainbow trout (Indigenous Work Force, 2013). Fishing instruments are made by wrapping fishing line around plastic bottles or soup cans and attaching a hook and sinker. This technique is used instead of fishing poles that often break (**Section 7.2.7**).

There have been historical Aboriginal fisheries in the RSA, as evidenced by the numerous archaeological sites distributed along the shorelines of Tatelkuz and Kuyakuz lakes (New Gold, 2012). Kuyakuz Lake remains an important fishing spot for Lhoosk'uz Dene Nation.

Little to no information on fish habitat was gathered during background research or interviews with First Nation representatives. However, the family residing at IR #28 described fish spawning areas. The elder described Davidson Creek as an area where kokanee spawn and the areas near lower Chedakuz Creek where suckers spawn.

5.1.2.6.3.2.1.1.2 Ulkatcho First Nation

The Ulkatcho Traditional Land Use Study (TLUS) (summarized in **Section 7.2.7** of this Application) indicates that fishing continues in many areas throughout the Ulkatcho FN Traditional Territory. The TLUS identified Kuyakuz Lake, Moose Lake, and Johnny Lake as areas of intensive use within the RSA. Species fished within the RSA and LSA include suckers, burbot, and trout. Steelhead was also identified as a food fish, but this species is not present in the RSA. It is, however, present in the Blackwater River, which is the main focus of Ulkatcho FN harvest activities.

5.1.2.6.3.2.1.1.3 Saik'uz First Nation

During interviews, representatives noted that members of the Saik'uz FN fish throughout the region, and that fishing is an important traditional practice and dietary source. Members appear to have an intimate understanding of different fish species and where they can be found. This knowledge is used when deciding what, when, and where to fish. This knowledge is shared and taught to the community's youth.

Although salmon fishing has slowed down quite a bit due to poor salmon returns and regulatory limitations, it was communicated that sockeye salmon are a species of importance to the SFN (SFN Chief and Council representatives, pers. comm.; SFN Elders, pers. comm.). The Nechako River, which is crossed by the Project's proposed transmission line, is a popular river to catch spring and other types of salmon, while kokanee are fished in a variety of lakes. Some ice fishing occurs during the winter (**Section 7.2.7**). Trout is the major species, and there are other types that are consumed as well.

5.1.2.6.3.2.1.1.4 Nazko First Nation

NFN members actively fish within their Traditional Territory, and members identified that kokanee is a sustenance resource. It is not currently known if the NFN fish in the lakes, rivers, or streams in the RSA and LSA.

5.1.2.6.3.2.1.2 LSA of the Transmission Line

5.1.2.6.3.2.1.2.1 Skin Tyee Nation

The Traditional Territory of the Skin Tyee Nation runs along the Project's transmission line. Fish are important to the culture and sustenance of the STN, and members use the Morice River and its tributaries for fishing (Enbridge, 2010). (The Morice River basin is not within the RSA or LSA.) STN representatives noted that spring salmon are often caught with nets, and that trout fishing is done with rods or nets. At Uncha Lake (not within the RSA or LSA), nets are also used to catch char (STN representatives pers. comm.). When fish are caught, they are typically preserved by drying, canning, or smoking.

5.1.2.6.3.2.1.2.2 Nadleh Whut'en First Nation

The main traditional activity of the Nadleh Whut'en people continues to be fishing. Fish are a primary traditional food staple for the Carrier people and this harvesting helps to sustain them over the winter (PTP ASEP Training Society, 2010; Hudson, 1983; Cranny, 1986).

Sockeye salmon are the primary fish collected by the Carrier people has been sockeye salmon (Hudson, 1983). These fish are captured in large rivers such as the Nechako and Stellako rivers, both of which will be crossed by the transmission line. Depending on the availability of sockeye (either due to seasonal or spawning cycles), other fish would supplement their intake. This included char, whitefish, kokanee, mountain whitefish, burbot and rainbow trout. These fish species are caught in streams, rivers and lakes, some of which may be crossed by the transmission line.

5.1.2.6.3.2.1.2.3 Stellat'en First Nation

More than half of the population of 400 Stellat'en, which means "people of Stella," live in Stellako, located on the western shore of Nadleh Bun (Fraser Lake). Fraser Lake and the nearby Stellako River are major sockeye salmon spawning and rearing waterbodies. The Project transmission line will cross the Stellako River. As with the Nadleh Whut'en people, sockeye salmon are the primary fish collected by the Stellat'en people.

5.1.2.6.3.2.2 Fish Species Richness

A total of 12 fish species were captured in streams and lakes of the LSA in 2011, 2012 and 2013 (**Table 5.1.2.6-25**). This list includes all of the fish species captured at stream crossings of the transmission line, access road, water pipeline, and airstrip access road. It also includes all fish species identified in historical reports and in interviews with Lhoosk'uz Dene elders.

Table 5.1.2.6-25: Fish Species Captured in the LSA

Common Name	Scientific Name	BC Fish Species Code
Kokanee	*Oncorhynchus nerka*	KO
Rainbow trout	*Oncorhynchus mykiss*	RB
Mountain whitefish	*Prosopium williamsoni*	MW
Northern pikeminnow	*Ptycheilus oregonensis*	NSC
Longnose sucker	*Catostomus catostomus*	LSU
Largescale sucker	*Catostomus macrocheilus*	CSU
Burbot	*Lota lota*	BB
Brassy minnow	*Hybognathus hankinsoni*	BMC
Lake chub	*Couesius plumbeus*	LKC
Slimy sculpin	*Cottus cognatus*	CCG
Longnose dace	*Rhinichthyes cataractae*	LNC
White sucker	*Catostomus commersonii*	WSU

Coombes (1985b) reported that one additional fish species – prickly sculpin (*Cottus asper* – BC fish code CAS) was present in Laidman Lake. Prickly sculpin are not reported to be present in any other waterbody in the RSA.

Table 5.1.2.6-25 also includes the fish species that were captured at stream crossings of the transmission line LSA and the access road LSA, but it does not include the other fish species that are known from historical reports to be present in those streams.

Fish species richness ranges from 1 to 5 species in streams and from 1 to 10 species in lakes (**Table 5.1.2.6-26**). As expected, fish species richness increases with increased size of waterbody in both streams and lakes (Griffiths, 1997). Among streams, Chedakuz Creek has the greatest species richness followed by Creek 705. Turtle Creek has the lowest species richness. Among lakes, Tatelkuz Lake has the greatest species richness, followed by Kuyakuz and Laidman lakes. Snake Lake and Lake 01682LNRS each support only one fish species. Rainbow trout is the most common species, being present in every waterbody except Snake Lake. Longnose sucker is the second most common species, followed by mountain whitefish and kokanee. The remaining nine species are each present in one to three waterbodiesAs expected, fish species richness increases with increased size of waterbody in both streams and lakes (Griffiths, 1997). Among streams, Chedakuz Creek has the greatest species richness followed by Creek 705. Turtle Creek has the lowest species richness. Among lakes, Tatelkuz Lake has the greatest species richness, followed by Kuyakuz and Laidman lakes. Snake Lake and Lake 01682LNRS each support only one fish species.

Rainbow trout is the most common species, being present in every waterbody except Snake Lake. Longnose sucker is the second most common species, followed by mountain whitefish and kokanee. The remaining nine species are each present in one to three waterbodies.

5.1.2.6.3.2.3 Conservation Status

There are no *Species at Risk Act* (*SARA*)-listed fish species present in the LSA or in the RSA.

Only one of the 12 fish species present in the LSA has any kind of conservation classification. The BC CDC (2013) classifies the Pacific group of brassy minnow (into which the brassy minnow of Tatelkuz Lake fall) as sensitive or vulnerable (i.e., a blue-listed species with a rank of S2S3) because its distribution in BC is disjunct, with isolated populations in the lower Fraser Valley and in the Nechako Lowlands near Vanderhoof and Prince George (McPhail, 2007; Nowosad and Taylor, 2013). Species of plants and animals with disjunct distributions typically have higher risk of local extirpation than species with continuous distributions. Blue-listed taxa are at risk, but are not extirpated, endangered or threatened.

Brassy minnow is not assigned a rank by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC, 2013).

The global ranking for brassy minnow is G5TNR where G5 = demonstrably widespread, abundant and secure (BC CDC, 2013). This is because brassy minnow is widespread and has a contiguous distribution throughout the central United States and south-eastern Canada. Brassy minnow was not selected as an indicator species for the Fish Valued Component of the EA.

Brassy minnow is present in other water bodies in the RSA. A total of 10 brassy minnow were found in Reaches 4 and 5 of Mathews Creek during a fish inventory that was conducted as part of the search for potential offsetting fish habitat (Annex I in **Appendix 5.1.2.6C**). Those two reaches were classified as low-gradient, sinuous meadow habitat. They both contained pools, runs, in-stream vegetation and were broken up by numerous beaver dams. Banks of both reaches were trampled by cattle.

Small numbers of brassy minnow were captured by electrofishing and minnow traps at stream crossings of the transmission line in 2012 (**Appendix 5.1.2.6A**), and in minnow traps in shallow water areas of Tatelkuz Lake in 2013 (**Appendix 5.1.2.6B**).

Brassy minnow may be present in other water bodies of the RSA that have not yet been surveyed or which have been surveyed but not with a focus on the low-gradient, shallow, weedy habitat that brassy minnow prefer. In the Chedakuz Creek Watershed, brassy minnow may be present at some places in the littoral zone of Kuyakuz Lake. In the Fawnie Creek Watershed, they may be present in the littoral zones of Laidman and Top lakes and in some reaches of Fawnie Creek.

Table 5.1.2.6-26: Fish Species Present in the LSA and RSA

Stream/Lake	RB	LSU	MW	KO	CSU	NSC	BB	CCG	LKC	BMC	WSU	LNC	CAS	Total
Local Study Area														
Davison Creek	X	-	X	X	-	-	-	-	-	-	-	-	-	3
Turtle Creek	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Creek 661	X	-	-	X	-	-	-	-	-	-	-	-	-	2
Creek 705	X	X	X	-	-	-	X	-	-	-	-	-	-	4
Chedakuz Creek	X	X	-	X	-	-	-	X	-	-	-	X	-	5
Lake 01682LNRS	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Lake 01538UEUT	X	X	-	-	-	-	-	-	-	-	-	-	-	2
Lake 01428UEUT	X	X	-	-	-	-	-	-	-	-	-	-	-	2
Snake Lake	-	-	-	-	-	-	-	-	X	-	-	-	-	1
Tatelkuz Lake	X	X	X	X	X	X	X	X	-	X	X	-	-	10
Sub-Total	9	5	3	4	1	1	2	2	1	1	1	1	0	
Regional Study Area														
Fawnie Creek	X	-	-	X	-	-	-	-	-	-	-	-	-	2
Kuyakuz Lake[(1)]	X	X	X	X	X	-	-	-	X	-	-	-	-	6
Laidman Lake[(2)]	X	X	X	-	X	X	-	-	-	-	-	-	X	6
Top Lake[(3)]	X	X	X	-	-	-	-	-	-	-	-	-	-	3
Sub-Total	4	3	3	2	2	1	0	0	1	0	0	0	1	
Total	**13**	**8**	**6**	**6**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	

Note: [(1)]Burns (1977); [(2)]Coombes (1985b); [(3)]Coombes (1985a).

A population of white sturgeon (*Acipenser transmontanus*) is present in the Nechako River. That river is outside the aquatic RSA of this Project, but it will be crossed by the transmission line. The Nechako white sturgeon population was red-listed by the province in 2010 (BC CDC, 2013). Its conservation status is S1 or "critically imperilled" due to long-term reproductive failure that began in the 1960s after the river was dammed for purposes of hydroelectric power production. In 2003, COSEWIC classified the Nechako sturgeon as "endangered" (COSEWIC, 2003; Ptolemy and Vennesland, 2003).

In March 2014, Environment Canada, Parks Canada and DFO, released the final *Recovery Strategy for White Sturgeon in Canada* to the SARA Public Registry (http://www.registrelep-sararegistry.gc.ca). This planning document identifies what needs to be done to arrest or reverse the decline of white sturgeon. It sets goals and objectives and identifies the main areas of activities to be undertaken. DFO is now preparing an Action Plan for the Nechako population of white sturgeon. It will contain specific recovery measures to support conservation of the species.

The only other blue-listed aquatic species is the Rocky Mountain Capshell (*Acroloxus coloradensis*), a type of freshwater limpet, that was observed in a single sample of littoral zone BMI collected from Lake 01682LNRS with a kick-net in August 2012 (**Appendix 5.1.2.6A**). The Rocky Mountain Capshell is recognized as a species of Special Concern by the BC CDC (BC

CDC, 2014). It has a Provincial S3 conservation status (i.e., blue-listed) and a Global status of G3 (BC CDC, 2014). COSEWIC classifies it as "Not at Risk". It was assigned to the Provincial blue-list because it is the only species of the Family Acroloxidae found in North America, and in BC it is found only in the east-central region (Klinkenberg, 2012). Its habitat is high-altitude oligotrophic and mesotrophic lakes and ponds. It is found in rocky, exposed portions of lakes and ponds in shallow water on the underside of rocks and vegetation on wave-swept shores. Populations are not endangered, but their habitat type is limited.

5.1.2.6.3.2.4 Kokanee

5.1.2.6.3.2.4.1 General Life History

Kokanee spend most of their lives in lakes where they feed on zooplankton and small fish in the shallow pelagic zone (McPhail, 2007). In late summer and fall, when water temperatures drop below 12°C (Ford et al., 1995; McPhail, 2007), adult kokanee migrate from their residence lakes to tributary streams to spawn (Scott and Crossman, 1973) (**Table 5.1.2.6-27**). In some BC systems (e.g., Okanagan Lake) kokanee spawn in inshore areas of lakes where upwelling or subsurface flows exist (McPhail, 2007). Kokanee lake spawning was not observed in Tatelkuz Lake, and has not been reported from Kuyakuz Lake. TK has not reported kokanee lake spawning in either lakes. On the spawning grounds, females establish territories and dig nests (or redds) into which they deposit their eggs. After fertilization of eggs by a male, the female covers the nest with gravel. Adults die within several weeks of spawning and their carcasses drift downstream or are buried under sediment or are scavenged by birds and bears. Embryos incubate in gravel over winter. Fry emerge in the spring after ice break-up and quickly migrate to their residence lake. They remain there, feeding and growing, until they reach the size and age of sexual maturation.

Table 5.1.2.6-27: Life history Periodicity Chart for Fish Species of the LSA and RSA, 2011-2013

Species	Life Stage – Activity	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Kokanee	Adult migration/spawning															■	■	■	■						
	Embryo incubation	■	■	■	■	■	■	■	■									■	■	■	■	■	■	■	■
	Juvenile migration							■	■	■	■														
	Juvenile rearing											■	■	■	■	■	■	■	■	■	■				
	Juvenile overwintering	■	■	■	■	■	■															■	■	■	■
	Adult rearing							■	■	■	■	■	■	■	■										
	Adult overwintering	■	■	■	■	■	■													■	■	■	■	■	■
Rainbow trout	Adult migration/spawning										■	■	■												
	Embryo incubation											■	■	■	■										
	Juvenile migration (lake dwelling)													■	■	■	■	■	■						
	Juvenile rearing													■	■	■	■	■	■	■	■	■	■		
	Juvenile overwintering	■	■	■	■	■	■	■	■													■	■	■	■
	Adult rearing									■	■	■	■	■	■	■	■	■							
	Adult overwintering	■	■	■	■	■	■	■	■										■	■	■	■	■	■	■
Mountain whitefish	Adult spawning																			■	■	■	■	■	■
	Embryo incubation	■	■	■	■	■	■	■	■																
	Juvenile migration									■	■	■	■	■	■	■	■	■	■						
	Juvenile rearing								■	■	■	■	■	■	■	■	■	■	■						
	Juvenile overwintering	■	■	■	■	■	■	■												■	■	■	■	■	■
	Adult rearing									■	■	■	■	■	■	■	■	■	■						
	Adult migration		■	■				■	■									■	■	■	■				
	Adult overwintering			■	■	■	■																		
Burbot	Adult migration/spawning		■	■	■																				
	Embryo incubation							■	■	■	■														
	Juvenile rearing							■	■	■	■	■	■	■	■	■	■	■	■						
	Adult rearing							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Brassy minnow	Adult spawning										■	■	■	■	■										
	Embryo incubation										■	■	■	■	■										
	Juvenile rearing											■	■	■	■	■	■	■	■	■	■				
	Juvenile overwintering	■	■	■	■	■	■	■	■	■												■	■	■	■
	Adult rearing															■	■	■	■	■	■				
	Adult overwintering	■	■	■	■	■	■	■	■	■												■	■	■	■

Species	Life Stage – Activity	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Northern pikeminnow	Adult spawning										■	■	■	■	■										
	Embryo incubation										■	■	■	■	■	■									
	Juvenile rearing											■	■	■	■	■	■	■	■						
	Juvenile overwintering	■	■	■	■	■	■													■	■	■	■	■	■
	Adult rearing							■	■	■	■	■	■	■	■	■	■	■	■						
	Adult overwintering	■	■	■	■	■	■													■	■	■	■	■	■
Lake chub	Adult spawning										■	■	■												
	Embryo incubation											■	■												
	Juvenile rearing														■	■	■	■	■	■	■	■			
	Juvenile/adult migration									■	■										■	■			
	Juvenile/adult overwintering	■	■	■	■	■	■	■	■													■	■	■	■
Slimy sculpin	Adult migration/spawning						■	■	■	■															
	Embryo incubation						■	■	■	■	■														
	Juvenile rearing							■	■	■	■	■	■	■	■	■	■								
	Adult rearing						■	■	■	■	■	■	■	■	■	■	■								
Largescale sucker	Adult spawning								■	■	■	■	■												
	Embryo incubation								■	■	■	■	■	■											
	Juvenile migration										■	■	■	■	■										
	Juvenile rearing											■	■	■	■	■	■								
	Juvenile overwintering	■	■	■	■	■	■	■	■									■	■	■	■	■	■	■	■
	Adult rearing									■	■	■	■	■	■	■	■								
	Adult overwintering	■	■	■	■	■	■	■	■									■	■	■	■	■	■	■	■
Longnose sucker	Adult migration/spawning										■	■	■												
	Embryo incubation												■	■											
	Juvenile migration															■	■	■	■	■	■				
	Juvenile rearing														■	■	■	■	■	■	■				
	Juvenile overwintering										■	■	■	■	■	■	■	■	■	■	■				
	Adult rearing	■	■	■	■	■	■	■	■	■												■	■	■	■
	Adult overwintering								■	■										■	■				
Longnose dace	Adult spawning									■	■	■	■												
	Embryo incubation									■	■	■	■												
	Juvenile rearing											■	■	■	■	■	■	■	■						
	Adult rearing/overwintering	■	■	■	■	■	■	■	■											■	■	■	■	■	■

Species	Life Stage – Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
White sucker	Adult migration/spawning					blue	blue						
	Embryo incubation					red	red	red					
	Juvenile migration						green	green	green				
	Juvenile rearing						green	green	green	green			
	Juvenile overwintering	green	green	green	green					green	green	green	green
	Adult rearing					blue	blue	blue	blue				
	Adult overwintering	blue	blue	blue	blue					blue	blue	blue	blue

Note: Red bars represents embryo stages, blue bars represents adult stages, and green bars represents juvenile stages

5.1.2.6.3.2.4.2 Spatial Distribution of Kokanee by Life Stage

Figure 5.1.2.6-48 shows the spatial distribution of kokanee migration, spawning and incubation habitat within the LSA, based on stream surveys of fish and fish habitat conducted from 2011 to 2013 and known kokanee habitat preferences. **Figure 5.1.2.6-49** shows the spatial distribution of kokanee rearing, foraging, and overwintering habitat in Tatelkuz Lake – the only kokanee residence lake in the LSA. It also shows the potential distribution of spawning habitat should kokanee ever be found to spawn on lake beaches. Kokanee beach spawning has never been recorded in Tatelkuz Lake. **Table 5.1.2.6-28** shows the total amount of available stream habitat for kokanee by life stage for each watershed in the LSA.

Table 5.1.2.6-28: Total Estimated Available Kokanee Spawning Habitat in Streams in the LSA

Stream Name	Spawning and Egg Incubation (m^2)	Migration Routes (m^2)
Davidson Creek	10,862	33,754
Creek 661	17,741	33,322
Lower Chedakuz Creek	109,339	140,973
Middle Chedakuz Creek[1]	31,026	31,026

Note: 1: RIC card data only available
m^2 = meters squared

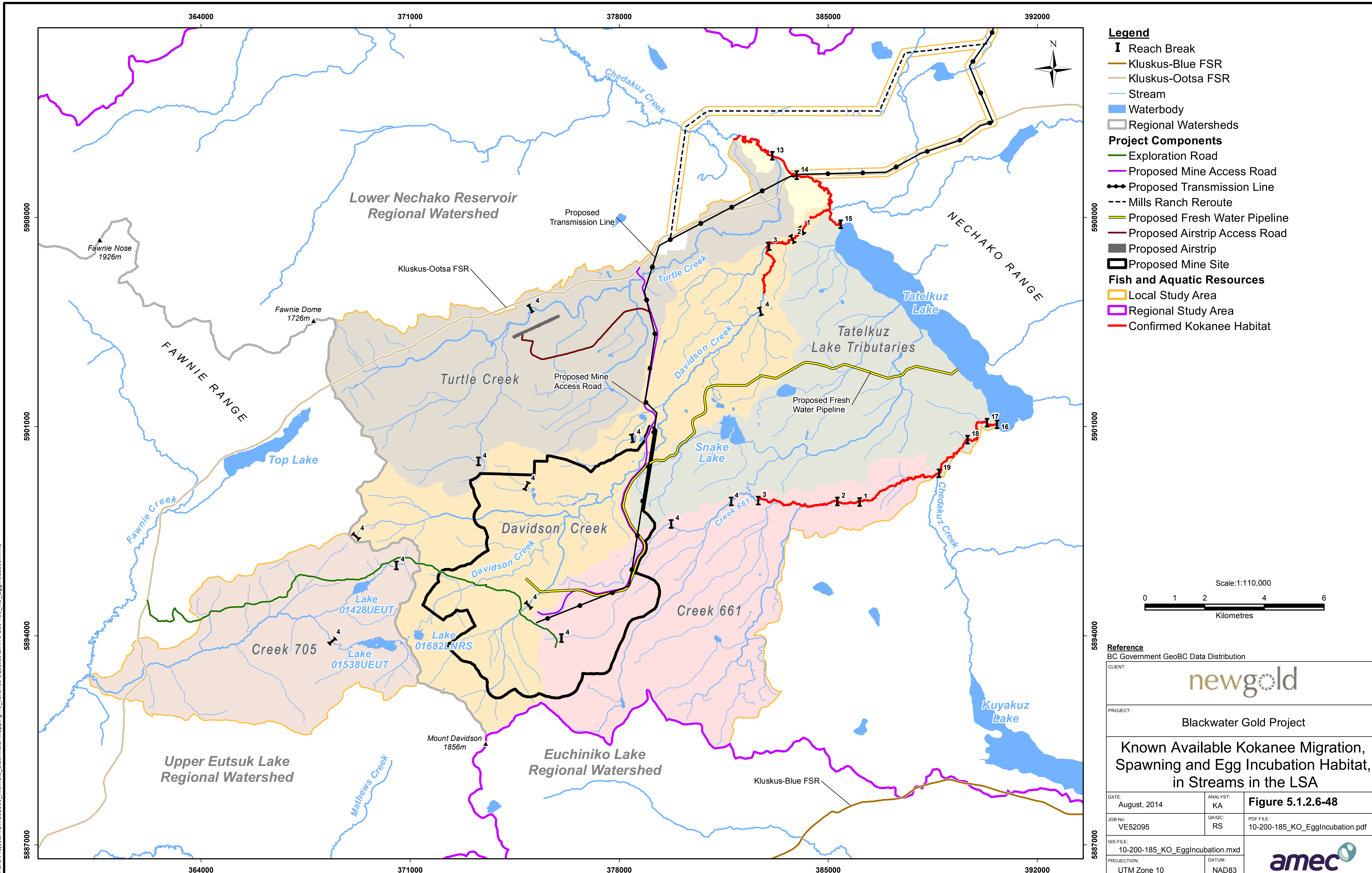
5.1.2.6.3.2.4.3 Number and Location of Populations

Tatelkuz and Kuyakuz lakes are the two residence lakes for kokanee in the LSA and RSA, respectively. Kokanee are not present in the four headwater lakes of the LSA.

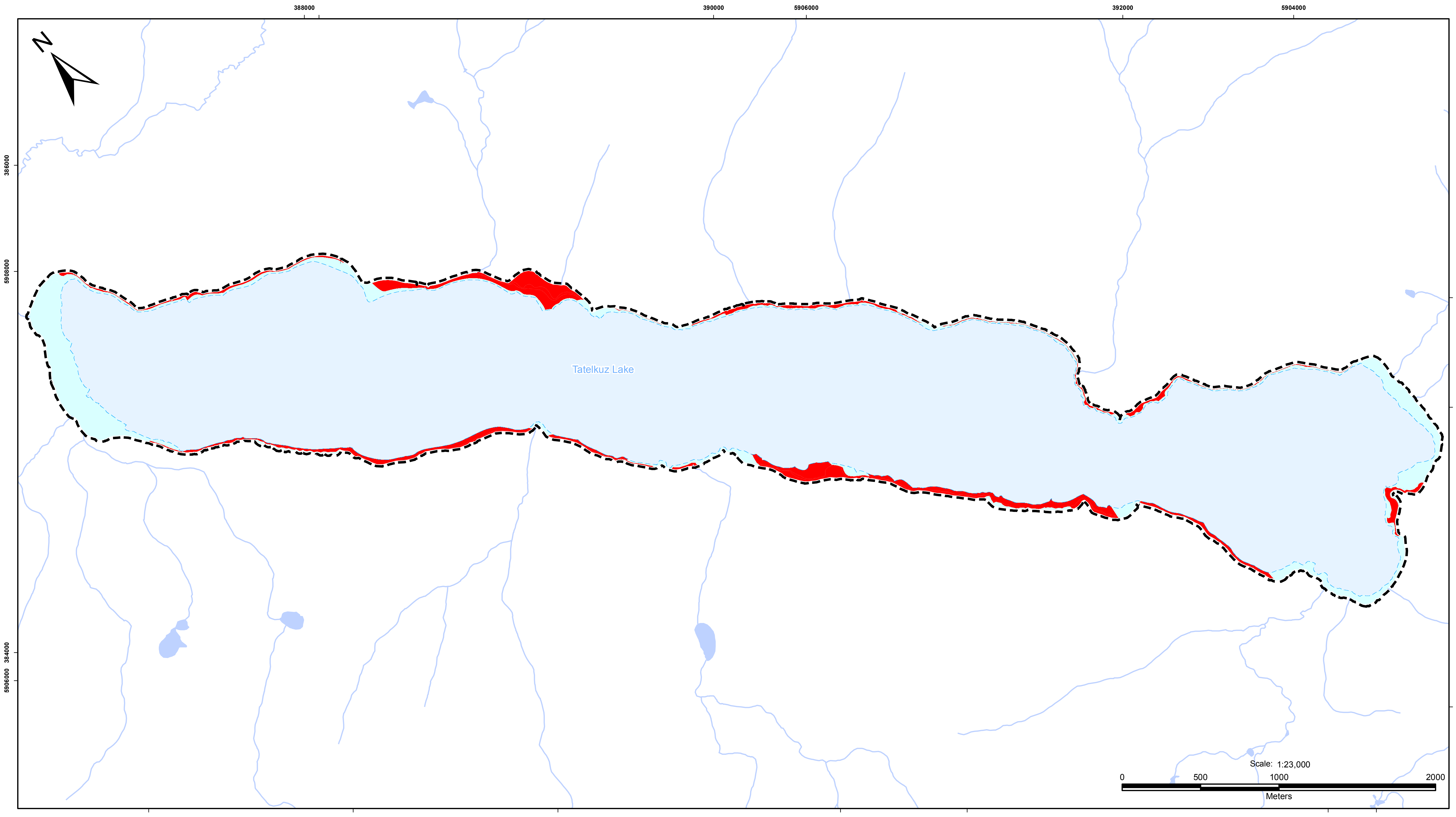
Microsatellite DNA analysis of kokanee tissue samples collected in 2012 from spawners in the LSA, RSA, and Meadow Creek, a tributary of Kootenay Lake, showed four broad groupings (**Figure 5.1.2.6-50**; Section 5.1.3.7 and Annex 5.10-12 of **Appendix 5.1.2.6A**):

- Davidson Creek, Creek 661, and middle Chedakuz Creek between Tatelkuz Lake and the confluence of Creek 661;
- lower Chedakuz Creek, Creek 522107 (a tributary to lower Chedakuz Creek), and Fawnie Creek;
- Chedakuz Creek upstream of Kuyakuz Lake; and
- Kootenay Lake.

- Removing the outlying Kootenay Lake group showed the three groups of the LSA and RSA more clearly (**Figure 5.1.2.6-51**).



Legend
Reach Break
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
Confirmed Kokanee Habitat
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
Turtle Creek
Davidson Creek
Creek 705
Creek 661
Tatelkuz Lake Tributaries
Tatelkuz Lake
Snake Lake
Top Lake
Kuyakuz Lake
Lake 01428UEUT
Lake 01538UEUT
Lake 01682LNRS
Fawnie Creek
Chedakuz Creek
Mathews Creek
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Proposed Transmission Line
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Kluskus-Blue FSR
364000
371000
378000
385000
392000
5908000
5901000
5894000
5887000
Scale:1:110,000
0 1 2 4 6
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Known Available Kokanee Migration, Spawning and Egg Incubation Habitat, in Streams in the LSA
DATE: August, 2014
ANALYST: KA
Figure 5.1.2.6-48
JOB No: VE52095
QA/QC: RS
PDF FILE: 10-200-185_KO_EggIncubation.pdf
GIS FILE: 10-200-185_KO_EggIncubation.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\EIA\10-200-185_KO_EggIncubation.mxd



Legend

- Waterbody
- Tatelkuz Lake Littoral Zone (to 6 m depth)
- Stream

Kokanee Habitat

- Kokanee Rearing, Feeding, and Overwintering Habitat in Tatelkuz Lake = 9 100 000 m^2 (entire lake)
- Potential Kokanee Spawning Habitat in Tatelkuz Lake = 309 895 m^2

Source: Shoreline Habitat Classification conducted July 2013.

- Maximum lake elevation (927.6masl)
- Bathymetry contour - 4.0m (923.5masl)

CLIENT: newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

amec

ANALYST:	KA
QA:	MY
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:23,000

PROJECT: Blackwater Gold Project

TITLE: Kokanee Rearing, Foraging, Overwintering and Potential Spawning HabitatTatelkuz Lake

REV. NO:	A
DATE:	August, 2014
PROJECT NO:	VE52277
FIGURE NO:	5.1.2.6-49

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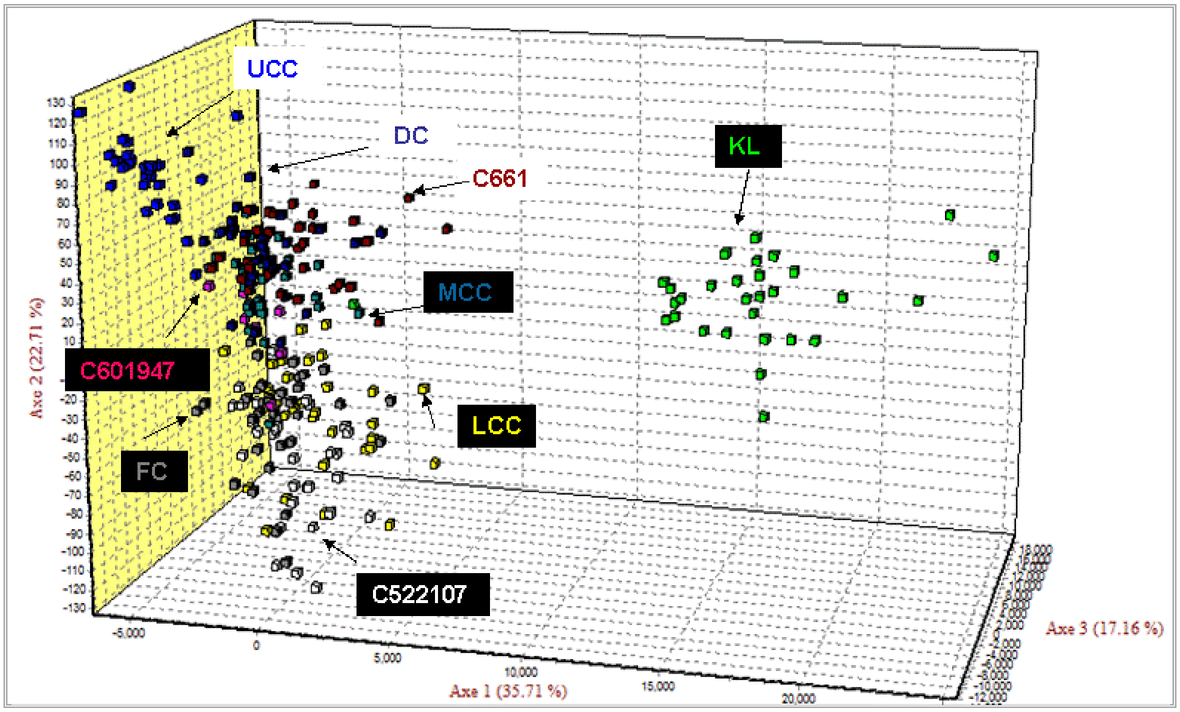
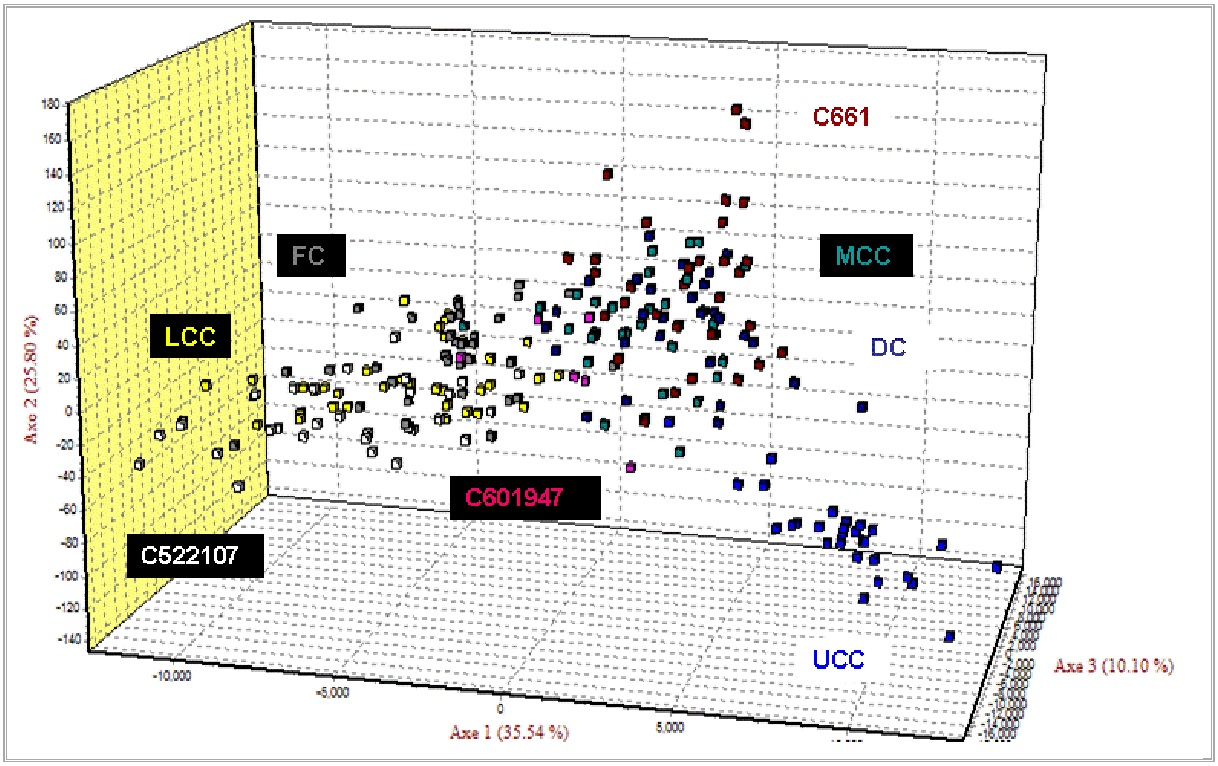


Note: C661 = Creek 661; DC = Davidson Creek; FC = Fawnie Creek; KL = Kootenay Lake; LCC = lower Chedakuz Creek; MCC = middle Chedakuz Creek; UCC = upper Chedakuz Creek.

Figure 5.1.2.6-50: Factorial Correspondence Analysis Depicting Relative Similarity among Samples of Kokanee Sampled from Tatelkuz Lake/Chedakuz Creek (Fraser River System) and Kootenay Lake (Columbia River) Drainages

This indicates the presence of three populations of kokanee in the RSA: one of which lives Kuyakuz Lake and spawns in its tributaries, and two of which live in Tatelkuz Lake and spawn in its tributaries. Most of the samples were demonstrably genetically distinct from one another, particularly upper Chedakuz Creek, and are probably largely demographically independent from one another, although some movement likely does occur occasionally between localities that are currently interconnected. (This may explain the inclusion of Fawnie Creek samples in the second group.)

The presence of three distinct kokanee populations in the RSA is supported by two other lines of evidence. The first is earlier timing of kokanee spawning in Davidson Creek (August 1 to 15) than in lower Chedakuz Creek (September 7 to 21). Those differences in spawn timing are driven by lower water temperatures in Davidson Creek than in lower Chedakuz Creek in July and August. The second is the presence of larger kokanee spawners in upper Chedakuz Creek (mean length = 283 mm, mean weight = 280 g, and mean condition = 1.22) than in downstream locations tributary to Tatelkuz Lake (mean length = 209 mm, mean weight = 280 g, and mean condition = 1.05).



Note: C661 = Creek 661; DC = Davidson Creek; FC = Fawnie Creek; KL = Kootenay Lake; LCC = lower Chedakuz Creek; MCC = middle Chedakuz Creek; UCC = upper Chedakuz Creek.

Figure 5.1.2.6-51: Factorial Correspondence Analysis Depicting Relative Similarity among Samples of Kokanee Sampled from Tatelkuz Lake/Chedakuz Creek Drainages

5.1.2.6.3.2.4.4 Total Number in Tatelkuz Lake

The hydroacoustic study of Tatelkuz Lake in early July 2013, calibrated by the gillnet survey of the fish community of mid-July 2013, estimated a total of 606,274 kokanee in Tatelkuz Lake (**Table 5.1.2.6-29**; Section 5.14 of **Appendix 5.1.2.6B**). That was 78.2% of all of fish counted in the lake. Tatelkuz Lake is essentially a kokanee lake. The 95% confidence limits of that total number of kokanee range from 503,207 to 709,340 or ±17% of the total number.

The relatively high abundance of kokanee in the lake is due to their preference for relatively shallow (5 to 15 m deep) offshore habitat, which is the single largest type of habitat by volume in Tatelkuz Lake.

When multiplied by the mean weight of kokanee (90 g) measured during the Tatelkuz Lake fish community survey, the total number of kokanee is equivalent to a total biomass of 54,565 kg (95% CL = 45,289 to 63,841) and a biomass density of 60.8 kg/ha (95% CL = 50.5 to 71.1).

Table 5.1.2.6-29: Number and Density of Fish in Tatelkuz Lake, July 2013, from Hydroacoustic Survey

Species	Number				Density (number/ha)		
	Estimate	Lower 95% CL	Upper 95% CL	Percent of Total	Estimate	Lower 95% CL	Upper 95% CL
Kokanee	606,274	503,207	709,340	78.2	676	561	791
Rainbow trout	117,068	97,167	136,970	15.1	131	108	153
Mountain whitefish	26,360	21,879	30,841	3.4	29	24	34
Longnose sucker	13,955	11,583	16,328	1.8	16	13	18
Northern pikeminnow	11,629	9,652	13,606	1.5	13	11	15
Total	**775,286**	**643,487**	**907,085**	**100.0**	**864**	**717**	**1,011**

Note: CL = confidence limit; ha = hectare.
Density calculated from lake surface area of 897 ha at time of hydroacoustic survey.
Total number of fish estimated in the lake does not include benthic fish species (slimy sculpin, brassy minnow, burbot, largescale sucker, and white sucker) that were undetectable with acoustics and that were not caught in large numbers in gillnets.

The estimate of kokanee number is credible for several reasons. First, the precision of the total abundance estimate was high (±17% of the total) compared to a typical range of ±15 to 40%. This was due to a fairly uniform night-time spatial distribution of fish. Second, the whole-lake fish density estimates of 864 total fish/ha (all species combined) and 676 kokanee/ha are comparable with densities reported for other water bodies of western Canada and the US. In Stave Reservoir of southwestern BC, the total fish density for nearshore and offshore zones combined was 137 to 527 fish/ha and kokanee density was 135 to 513 fish/ha from 2005 to 2009 (Stables and Perrin, 2010). In both zones of Coquitlam Reservoir of southwestern BC, total fish and kokanee densities were 538 and 214 fish/ha, respectively (Bussanich et al. 2005). Pelagic surveys of kokanee in western reservoirs (where no nearshore sampling was conducted and other species were not listed) have reported densities of 576 kokanee/ha in Dworshak Reservoir (Idaho) in 2005 (Stark, 2006), 307 to 670 kokanee/ha in Lake Pend Oreille (Idaho) for 2006-2008 (Maiolie et al., 2008; Schoby et al., 2009; Wahl et al., 2010), and 156 to 901 kokanee/ha in Kootenay Reservoir of south-eastern BC from 1985 to 2006 including years of fertilization (Schindler et al., 2009).

Annex 5.14-1 of **Appendix 5.1.2.6B** provides more detail about the methods and results of the hydroacoustic survey.

5.1.2.6.3.2.4.5 Spawning Timing

Kokanee spawners from Tatelkuz Lake were observed in spawning creeks of the LSA from mid-July to late September – a 10 week-long period (**Table 5.1.2.6-30**).

Table 5.1.2.6-30: Kokanee Spawn Timing, LSA, 2011-2013

Stream	July		August				September			
	17-23	24-31	1-8	9-16	17-23	24-31	1-7	8-15	16-22	23-31
Davidson Creek										
Creek 661										
Lower Chedakuz Creek										
Middle Chedakuz Creek										

Note: Bold borders indicate probable peak spawning period.

Kokanee first enter Davidson Creek in mid-July, which is at least 2 weeks earlier than any of the other four streams. They have the longest spawning period – 6 weeks. Peak spawning is between 8 and 12 August. Kokanee enter Creek 661 and middle Chedakuz Creek in early August and leave in early September. Peak spawning in both streams is in the second and third week of August. Kokanee enter lower Chedakuz Creek in early September – 6 weeks later than Davidson Creek – and peak spawning is in mid-September.

These differences in kokanee spawn timing among stream are largely due to differences in water temperature on the spawning grounds. The earliest spawning occurs in the coldest stream – lower Davidson Creek (**Figure 5.1.2.6-52**) – and the latest spawning occurs in the warmest stream – lower Chedakuz Creek (**Figure 5.1.2.6-53**). The differences in spawning timing between the Davidson Creek population and the lower Chedakuz Creek populations are so large – over 1 month – that there is little likelihood of overlap of spawners. In lower Creek 661, optimal water temperatures for kokanee spawning occurred in July and August 2012, but not in 2011 when temperatures were below the optima (**Figure 5.1.2.6-54**).

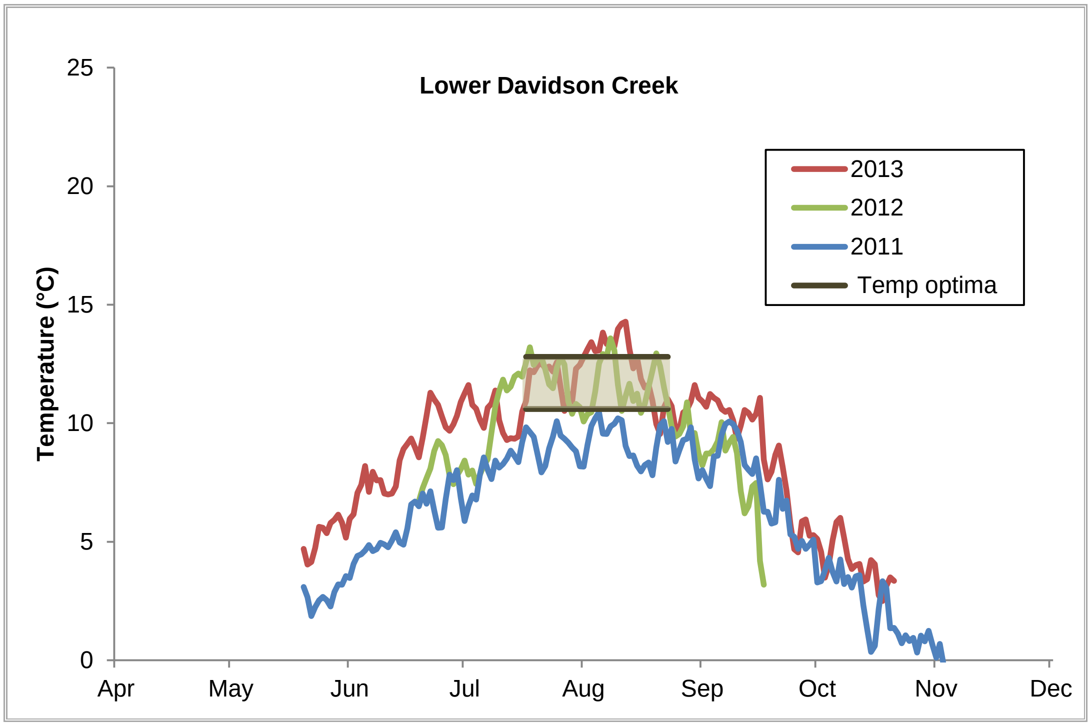


Figure 5.1.2.6-52: Mean Daily Water Temperature in Lower Davidson Creek Compared to BC Guidelines for Kokanee Spawning (black), 2011-2013

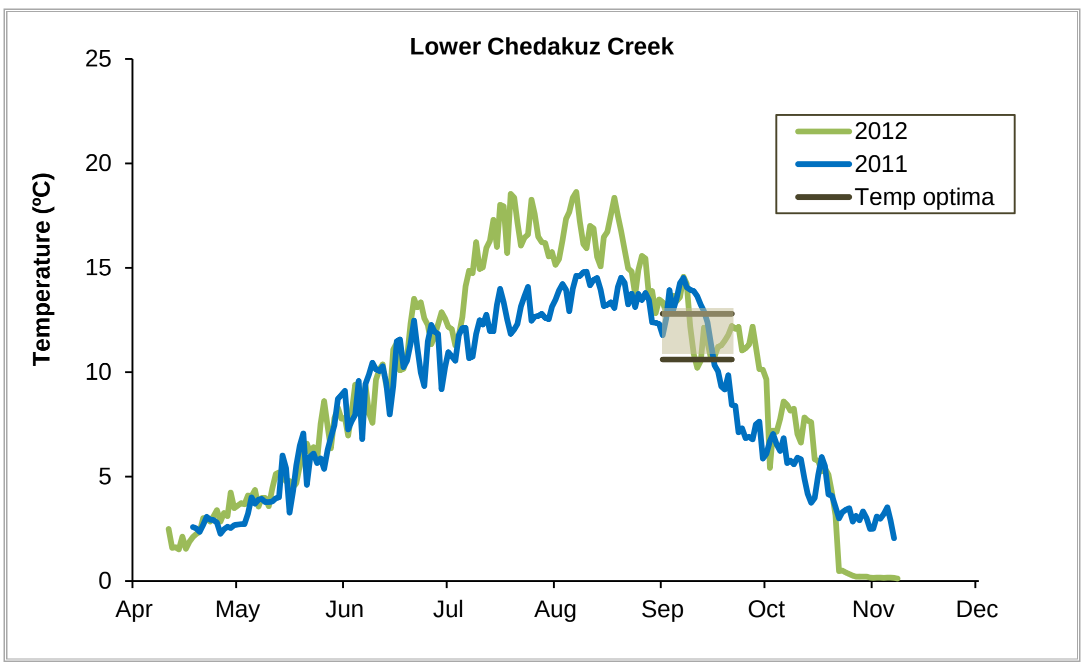


Figure 5.1.2.6-53: Mean Daily Water Temperatures in Lower Chedakuz Creek Compared to BC Guidelines for Kokanee Spawning (black), 2011-2012

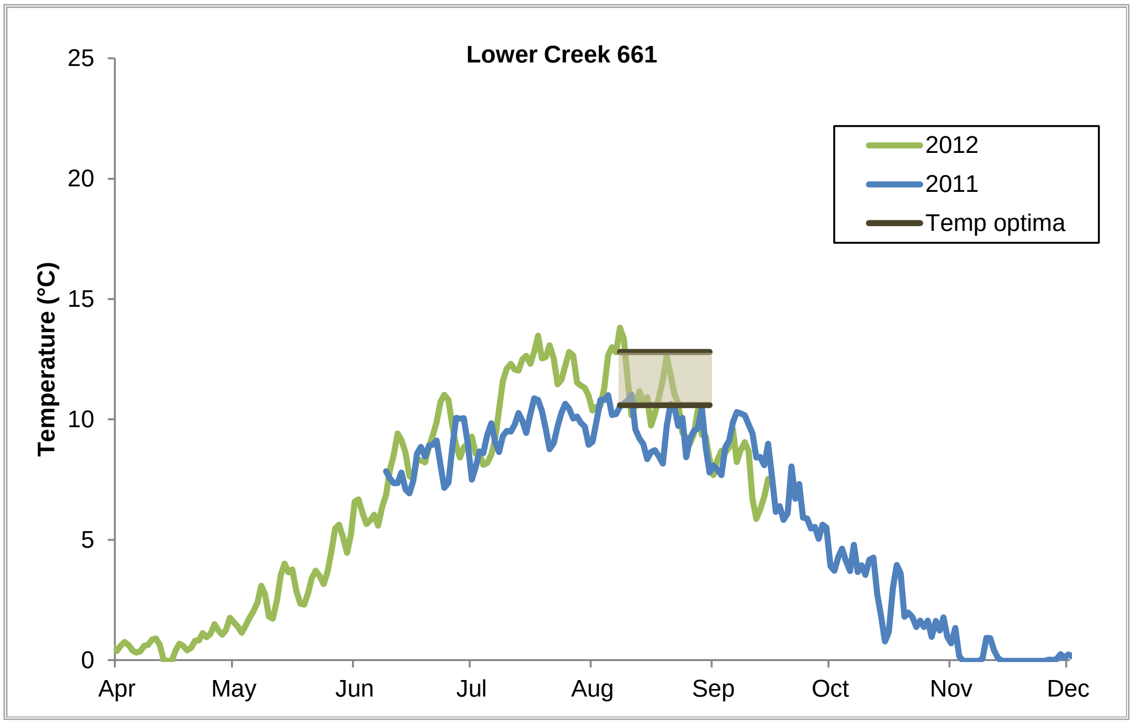


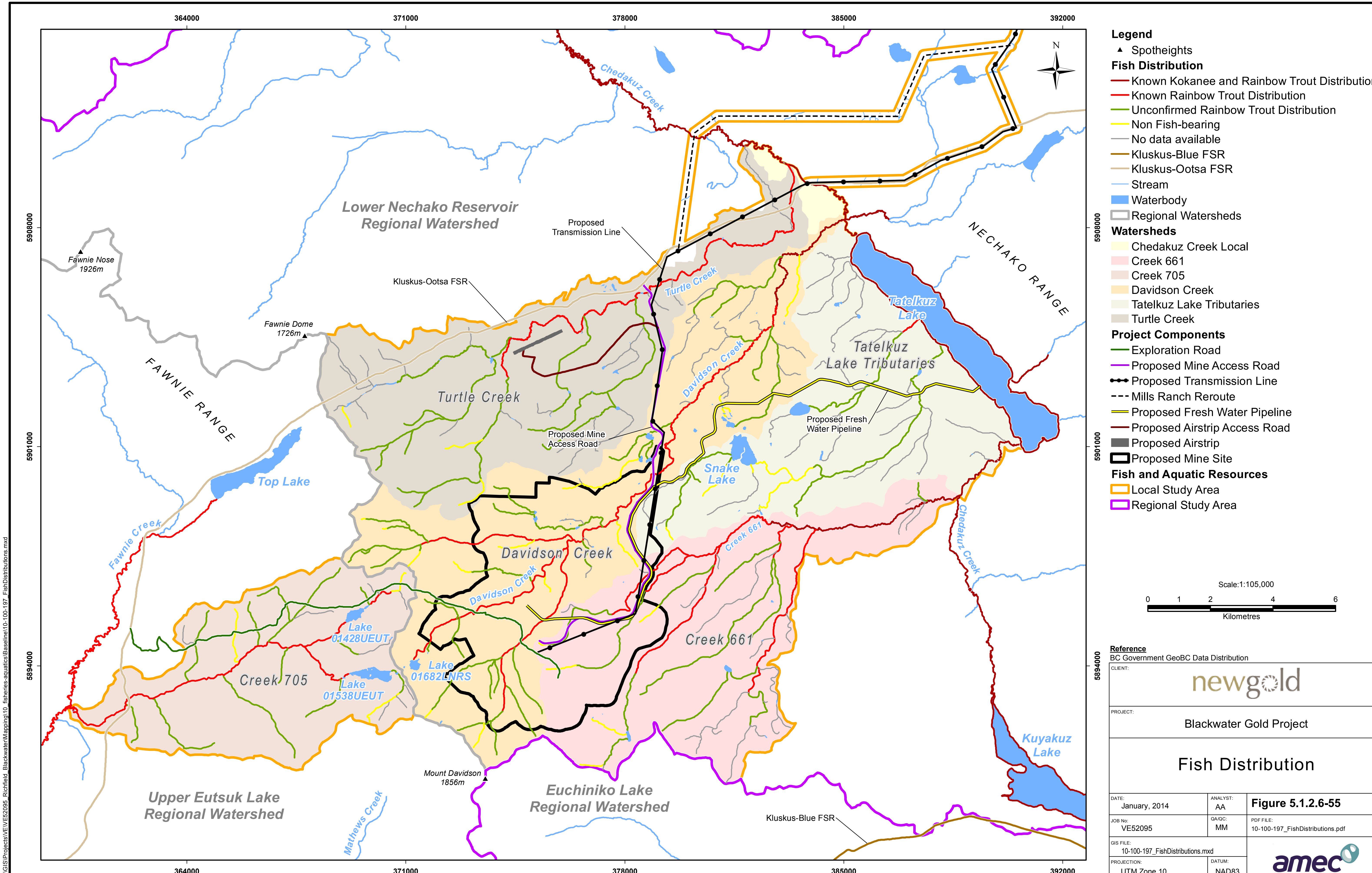
Figure 5.1.2.6-54: Mean Daily Water Temperature in Lower Creek 661 Compared to BC Guidelines for Kokanee Spawning (black), 2011-2012

5.1.2.6.3.2.4.6 Spatial Distribution of Spawners in Streams

Kokanee from Tatelkuz Lake spawn in three major creeks (Chedakuz Creek, Creek 661 and Davidson Creek) and in a number of smaller creeks in the LSA (**Figure 5.1.2.6-55**). Surveys in 2011, 2012 and 2013 focused on the major creeks. Some of the minor creeks (tributaries to Tatelkuz Lake and middle and lower Chedakuz Creek) were surveyed as part of the regional-scale kokanee spawner survey conducted in the summer of 2012.

Over the three survey years, the highest linear densities (1.05-1.97 fish/m) of kokanee spawners were observed in Reaches 17 and 20 in middle Chedakuz Creek (Section 5.15 of **Appendix 5.1.2.6B**). Reaches 17 to 19 lie between Tatelkuz Lake and the confluence of Creek 661, and Reach 20 extends approximately 3 km upstream of that confluence. Few kokanee spawners were observed in middle Chedakuz Creek and its tributaries in Reaches 21 to 26, indicating that kokanee spawners from Kuyakuz Lake prefer to migrate upstream into tributaries of Kuyakuz Lake, particularly its main tributary upper Chedakuz Creek, rather than downstream into middle Chedakuz Creek.

Mean linear density in Creek 661 was highest in Reach 1 (1.43 fish/m), just upstream of the confluence with middle Chedakuz Creek, and decreased with increasing upstream distance to 0.55 fish/m in Reach 2 and 0.05 fish/m in Reach 3.


Legend
Spotheights
Fish Distribution
Known Kokanee and Rainbow Trout Distribution
Known Rainbow Trout Distribution
Unconfirmed Rainbow Trout Distribution
Non Fish-bearing
No data available
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
364000
371000
378000
385000
392000
5908000
5901000
5894000
N
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Chedakuz Creek
Turtle Creek
Davidson Creek
Creek 661
Creek 705
Tatelkuz Lake Tributaries
Tatelkuz Lake
Snake Lake
Top Lake
Fawnie Creek
Mathews Creek
Kuyakuz Lake
Lake 01428UEUT
Lake 01538UEUT
Lake 01682LNRS
Proposed Transmission Line
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Kluskus-Blue FSR
Scale:1:105,000
0 1 2 4 6
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Fish Distribution
DATE: January, 2014
ANALYST: AA
Figure 5.1.2.6-55
JOB No: VE52095
QA/QC: MM
PDF FILE: 10-100-197_FishDistributions.pdf
GIS FILE: 10-100-197_FishDistributions.mxd
PROJECTION: UTM Zone 10
DATUM: NAD83
amec
Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-197_FishDistributions.mxd

A similar pattern of decreasing density with upstream distance was observed in Lower Chedakuz Creek and Davidson Creek. Density in Lower Chedakuz Creek was highest in Reach 15 (0.71 fish/m) immediately downstream of Tatelkuz Lake and decreased to 0.22 fish/m in Reach 14 and 0.02 fish/m in Reach 13. Density in Davidson Creek increased from 1.27 fish/m in Reach 1 to 1.84 fish/m in Reach 2 and then decreased to 0.99 fish/m in Reach 3 and 0.03 fish/m in Reach 4.

In summary, kokanee of the LSA prefer to travel upstream to spawn, most likely because it allows their fry to migrate downstream to a residence lake with the current rather than against it. In the case of lower Chedakuz Creek, most kokanee spawn close to the outlet of Tatelkuz Lake to reduce the distance their fry must migrate upstream to reach the lake.

5.1.2.6.3.2.4.7 Number of Spawners

When kokanee spawners migrate out of Tatelkuz Lake to spawn in streams, they are temporarily the single most abundant fish species in streams. A combination of focused kokanee spawner surveys in Davidson Creek and Creek 661 in 2011 and 2012 plus a regional-scale kokanee spawner survey of the RSA in 2012 resulted in a total kokanee spawner count of 23,964 for the RSA. That was 86% of all fish counted in streams and lakes during surveys conducted in 2011 and 2012 (Section 5.10 of **Appendix 5.1.2.6A**).

The most accurate estimate of the number of kokanee that spawn in the LSA each year was calculated by combining all spawner density data from the three survey years and then extrapolating those density estimates across the length of all reaches known to support kokanee spawning (**Table 5.1.2.6-31**; Section 5.15.6 of **Appendix 5.1.2.6B**). A total of 24,988 kokanee spawners was calculated, of which middle Chedakuz Creek between Tatelkuz Lake and the confluence of Creek 661 contributed 9.805 (or 39.2% or the total), followed by Creek 661 (5,893 or 23.6%), lower Chedakuz Creek (5,343 or 21.4%), and Davidson Creek (3,947 or 15.8%).

That estimate of total spawner number is 4.1% of the total number of kokanee counted in Tatelkuz Lake in July 2013 (**Table 5.1.2.6-29**). That implies that, on average, 95.9% of the kokanee in Tatelkuz Lake are sexually immature.

Table 5.1.2.6-31: Estimated Number of Kokanee Spawners in the LSA, 2011-2013

Stream	Reach	Reach Length (m)	2011			2012			2013			Years Combined				
			Linear Density (No./m)	Estimated Number of KO	Percentage of Total KO (%)	Linear Density (No./m)	Estimated Number of KO	Percentage of Total KO (%)	Linear Density (No./m)	Estimated Number of KO	Percentage of Total KO (%)	Mean Linear Density (No./m)	SE	n	Estimated Number of KO	Percentage of Total KO (%)
Davidson Creek	1	1,373.9	1.22	1,676	13.1	0.26	358	2.3	1.27	1,741	8.9	0.92	0.33	3	1,258	5.0
	2	498.5	0.94	470	3.7	0.69	346	2.2	1.84	916	4.7	1.16	0.35	3	577	2.3
	3	1,184.3	1.81	2,149	16.9	0.32	382	2.4	0.99	1,176	6.0	1.04	0.43	3	1,236	4.9
	4	2,112.2	1.16	2,444	19.2	0.06	124	0.8	0.03	60	0.3	0.41	0.37	3	876	3.5
	Total	5,168.9		6,738	52.9		1,209	7.6		3,894	19.9				3,947	15.8
Creek 661	1	3,483.8	1.10	3,824	30.0	1.33	4,644	29.4	1.43	4,988	25.5	1.29	0.10	3	4,485	17.9
	2	824.9	0.77	635	5.0	–	–	–	0.55	450	2.3	0.66	0.11	2	543	2.2
	3	3,043.0	0.51	1,548	12.1	–	–	–	0.06	183	0.9	0.28	0.22	2	865	3.5
	Total	7,351.7		6,007	47.1		4,644	29.4		5,621	28.7				5,893	23.6
Lower Chedakuz Creek	13	8,698.4	–	–	–	–	–	–	0.02	217	1.1	0.02	–	1	217	0.9
	14	1,133.8	–	–	–	–	–	–	0.22	251	1.3	0.22	–	1	251	1.0
	15	3,612.8	–	–	–	1.99	7,191	45.5	0.71	2,558	13.1	1.35	0.64	2	4,874	19.5
	Total	13,445.0					7,191	45.5		3,026	15.5				5,343	21.4
Middle Chedakuz Creek	17-18	1833.7	–	–	–	1.51	2,762	17.5	–	–	–	1.51	–	1	2,762	11.1
	19	1734.4	–	–	–	–	–	–	1.97	3,413	17.4	1.97	–	1	3,413	13.7
	20	3488.9	–	–	–	–	–	–	1.04	3,630	18.5	1.04	–	1	3,630	14.5
	Total	7,057.0					2,762	17.5		7,043	36.0				9,805	39.2
Total		33,022.6		12,745	100.0		15,805	100.0		19,584	100.0				24,988	100.0

Note: No./m = number of fish per metre; No. = number; KO = kokanee; % = percent; m = metre; n = sample number; SE = standard error; dash indicates reach was not sampled

5.1.2.6.3.2.4.8 Number of Spawners per Redd

A linear regression of kokanee spawner number on redd number for the combined data of 2011 to 2013 was highly significantly (P<0.001) and explained 78% of the variance in spawner number (**Figure 5.1.2.6-56**). The intercept was 430 spawners, which was significantly (P<0.001) different from zero. This was the result of counting spawners in sections where no redds were observed, most likely because spawners were counted while migrating to upstream spawning grounds. The regression slope was 5.0 spawners/redd, indicating that the production of each kokanee redd requires an average of five spawners.

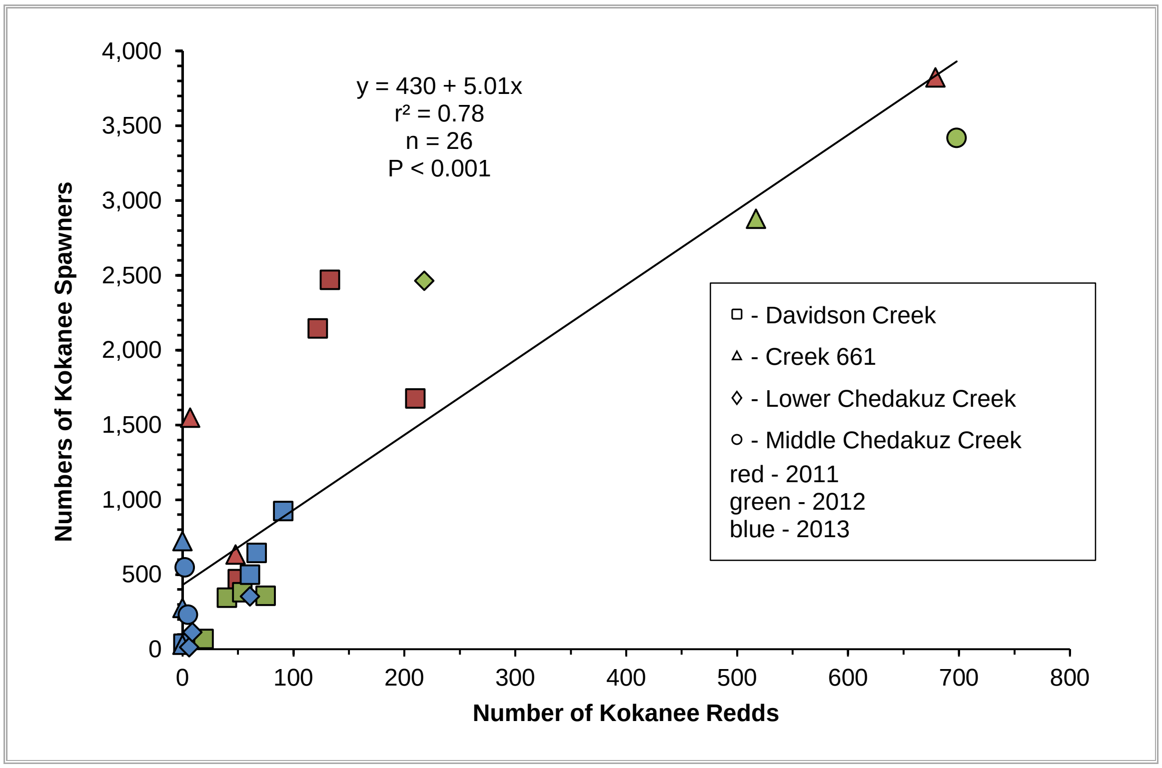


Figure 5.1.2.6-56: Linear Regression of Number of Kokanee Spawners on Number of Kokanee Redds in the LSA, 2011-2013

There are several reasons why the number of spawners was not identical to the number of redds (i.e., a regression slope of 1.0). The first is that not all kokanee that arrive on the spawning grounds survive to mate and dig redds because they die from parasites and disease during in-stream migration, or are eaten by wildlife such as eagles and bears during their migration or soon after they arrive on the spawning grounds. The second reason is that competition among spawners for limited spawning habitat may result in sub-dominant spawners being forced into marginal habitat where spawning is less successful (Burgner, 1991). The third reason is redd superpositioning – the digging up of older redds by more recent arrivals on the spawning grounds. All of these factors operate in salmonid fish populations.

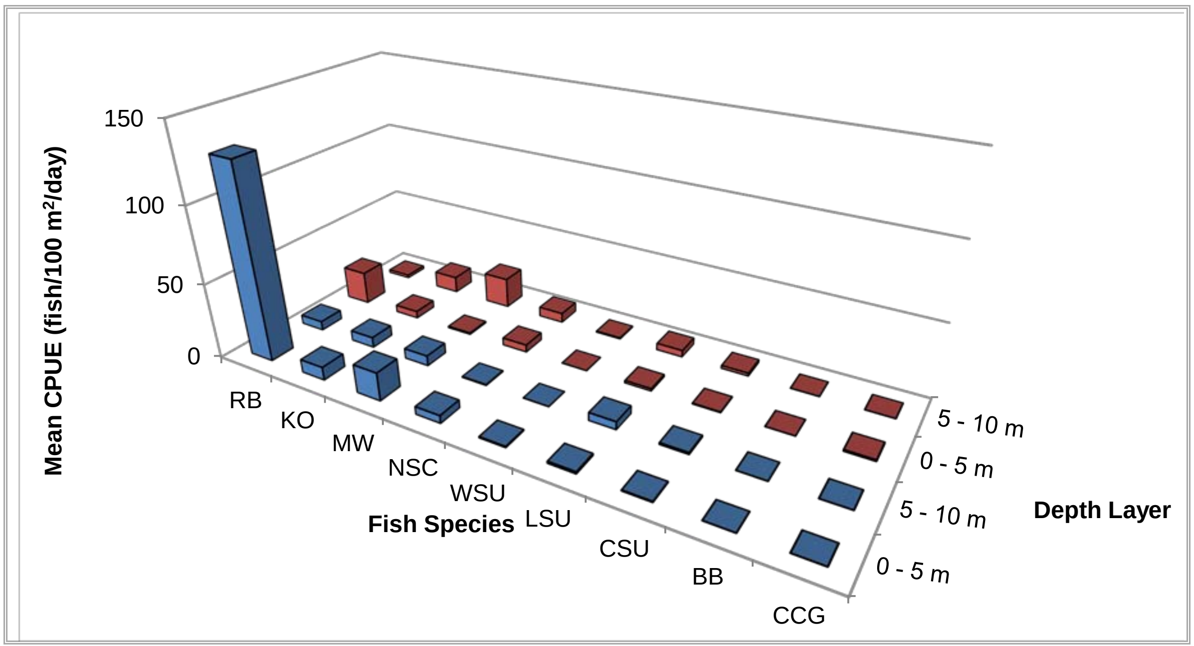
5.1.2.6.3.2.4.9 Habitat Characteristics of Redds

Habitat type (glide, riffle and pool) was assigned to each of the 2,093 kokanee redds counted in the three survey years. In each of the four streams, redds were found predominantly in glides, followed by riffles and pools. Pooled over all four streams, 66.5% were found in glide habitat, 26.4% in riffle habitat and 7.1% in pool habitat.

Redd depth was measured only in the 2011 and 2012 surveys. In each of the four streams, the majority of redds were found in 0.21 to 0.40 m depth range. Pooled over all four streams, 58.2% of the 2,451 redds for which depth was measured were at a depth of 0.21 to 0.40 m, followed by 30.2% at a depth of 0.00 to 0.19 m, and 7.0% at a depth of 0.41 to 0.60 m. Nineteen redds or 0.8% of the total were reported to be at depths greater than 1.0 m.

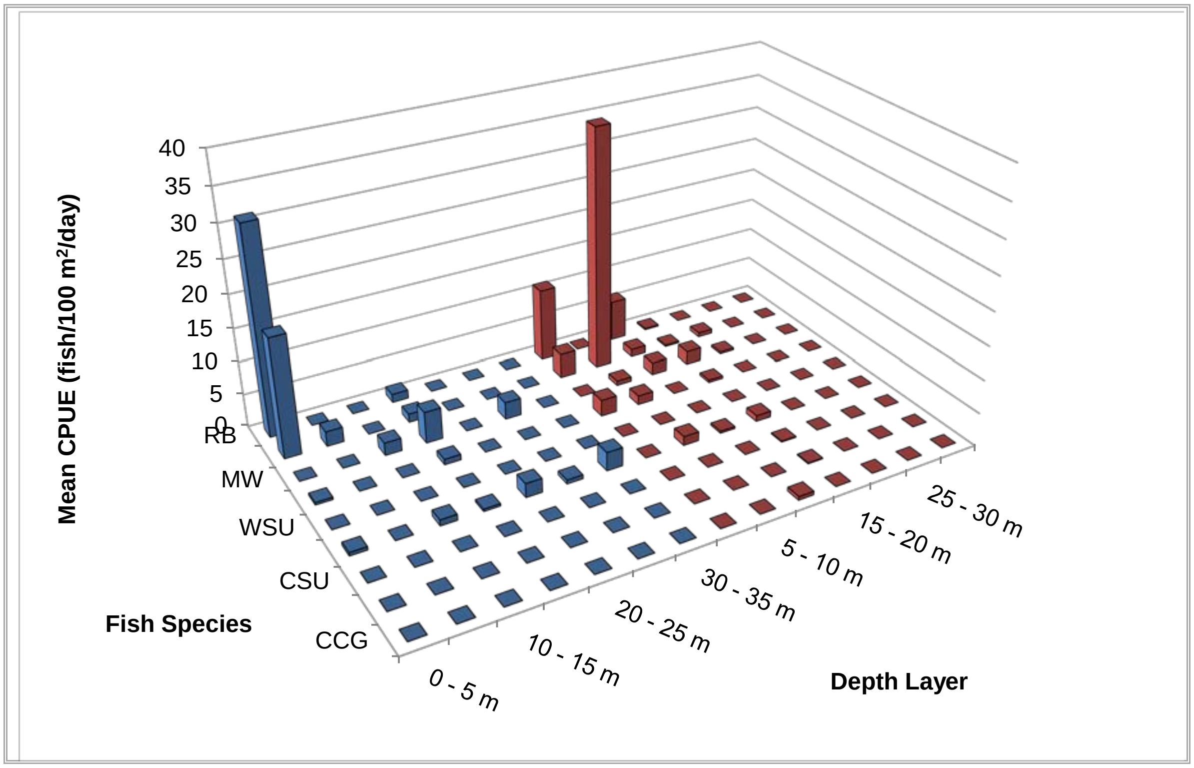
5.1.2.6.3.2.4.10 Spatial Distribution in Tatelkuz Lake

In Tatelkuz Lake in July 2013, kokanee were more abundant offshore than nearshore during day and night (Section 5.12 of **Appendix 5.1.2.6B**) (**Figure 5.1.2.6-57** and **Figure 5.1.2.6-58**). (Offshore is defined as habitat with depth greater than 10 m.) In offshore areas they were most abundant in the 0 to 5 m depth layer during the day and shifted slightly deeper, mainly to the 5 to 10 m layer, at night. Kokanee were the main species present in the midwater pelagic zone of Tatelkuz Lake.



Note: CPUE = Catch-Per-Unit-Effort; m^2 = square metres; RB = rainbow trout; MW = mountain whitefish; KO = kokanee; NSC = northern pikeminnow;
LSU = longnose sucker; CSU = largescale sucker; CCG = slimy sculpin; BB = burbot

Figure 5.1.2.6-57: Mean Gillnetting CPUE by Fish Species, Nearshore Habitat, and Depth, Day (blue) and Night (red), Tatelkuz Lake, July 2013



Note: CPUE = Catch-Per-Unit-Effort; m^2 = metres squared; RB = rainbow trout; MW = mountain whitefish; KO = kokanee; NSC = northern pikeminnow; LSU = longnose sucker; CSU = largescale sucker; CCG = slimy sculpin; BB = burbot

Figure 5.1.2.6-58: Mean Gillnetting CPUE by Fish Species, Offshore Habitat, and Depth, Day (blue) and Night (red), Tatelkuz Lake, July 2013

5.1.2.6.3.2.4.11 Size, Age and Growth

Mean length, weight and condition of kokanee spawners sampled from tributaries of Kuyakuz Lake in August and September 2012 were substantially higher than for kokanee spawners sampled from tributaries of Tatelkuz Lake (**Table 5.1.2.6-32**).

Mean length of kokanee sampled from Tatelkuz Lake in July 2013 was 191 mm, mean weight was 90 g, and mean condition was 1.21 (**Table 5.1.2.6-33**). Six species were longer than kokanee, and only rainbow trout (184 mm), brassy minnow (68 mm), and slimy sculpin (57 mm) were shorter.

Mean condition factor of kokanee fell within the range of 1.10 to 1.45 calculated for the other ten species. These differences among species largely reflect differences in body shape. Burbot have low condition because they are a slender, eel-like species, but suckers have high condition because they are compact, barrel-shaped species. Kokanee have the typical torpedo shape of a pelagic fish that places them in the middle of the range of body shapes.

Both kokanee and rainbow trout both had the lowest mean ages (3 years) of the six species for which ages were determined. Their narrow age ranges – 1 to 5 years for kokanee and 1 to 6 years for rainbow trout – indicate high mortality rates compared with mountain whitefish (2 to 14 years) and northern pikeminnow (8 to 14 years).

Von Bertalanffy growth models were successfully fit to length-age data for rainbow trout, kokanee, and mountain whitefish of Tatelkuz Lake – the three species for which sufficient age data had been collected to allow growth modelling (**Figure 5.1.2.6-59**). Both kokanee and rainbow trout showed faster initial growth than mountain whitefish, but mountain whitefish reached a greater asymptotic length due to a longer lifespan. Kokanee had a shorter length (32 mm) at age 0 years than rainbow trout (64 mm) because kokanee fry migrate immediately to Tatelkuz Lake after emergence but rainbow trout juveniles rear in streams for up to 2 years before migrating to Tatelkuz Lake.

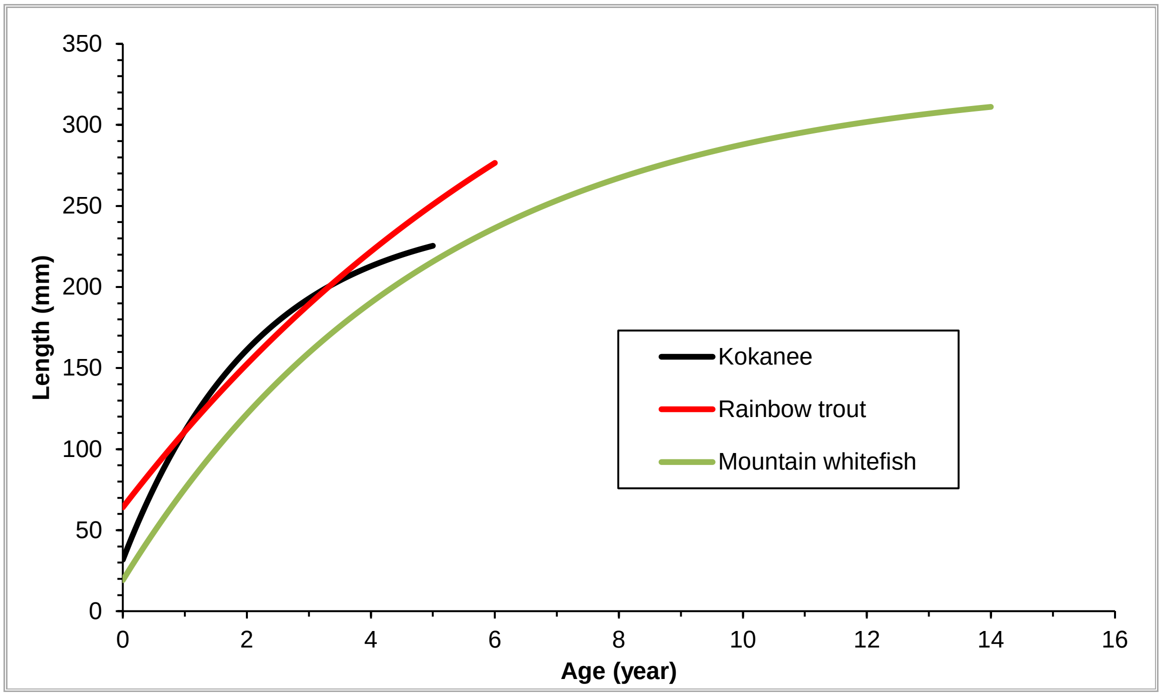


Figure 5.1.2.6-59: Growth of Kokanee, Rainbow Trout, and Mountain Whitefish, Tatelkuz Lake, July 2013

Table 5.1.2.6-32: Mean Length, Weight, and Condition Factor of Kokanee, Blackwater Study Area, 2012

Population	Sampling Time	Fork Length (mm)				Weight (g)				Condition Factor			
	2012	n	Mean	SE	Range	n	Mean	SE	Range	n	Mean	SE	Range
Tatelkuz Lake Tributaries	Aug, Sept	163	209	1	173 - 263	163	97	2	50 - 197	163	1.05	0.01	0.75 - 1.43
Kuyakuz Lake Tributaries	Sept	30	283	3	236 - 332	30	280	11	157 - 442	30	1.22	0.02	0.97 - 1.45

Note: mm = millimetre; g = gram; n = sample size; SE = standard error.

Table 5.1.2.6-33: Mean Length, Weight, Condition Factor, and Age of Fish Species, Tatelkuz Lake, July 2013

Species	Fork Length (mm)				Weight (g)				Condition Factor				Age (year)			
	n	Mean	SE	Range	n	Mean	SE	Range	n	Mean	SE	Range	n	Mean	SE	Range
Brassy minnow	31	68	2	43 - 94	-	-	-	-	-	-	-	-	-	-	-	-
Burbot	1	323	-	323 - 323	1	195	-	195 - 195	1	0.58	-	0.58 - 0.58	1	5	-	5 - 5
Kokanee	222	191	2	107 - 231	210	90	3	13 - 207	210	1.21	0.01	0.66 - 2.59	58	3	0.1	1 - 5
Largescale sucker	9	364	35	110 - 455	7	662	126	15 - 1000	7	1.35	0.05	1.13 - 1.53	-	-	-	-
Longnose sucker	53	272	16	63 - 470	28	446	52	5.8 - 1175	28	1.26	0.02	1.02 - 1.41	3	6	0.9	4 - 7
Mountain whitefish	161	210	5	115 - 347	150	137	9	15 - 408	150	1.10	0.01	0.71 - 1.39	97	6	0.3	2 - 14
Northern pikeminnow	86	249	12	62 - 495	62	339	48	18.6 - 1550	62	1.16	0.01	0.89 - 1.40	4	11	1.3	8 - 14
Rainbow trout	625	184	2	75 - 463	581	89	3	4 - 438	581	1.13	0.01	0.75 – 1.42	153	3	0.1	1 – 6
Slimy sculpin	60	57	2	35 - 103	-	-	-	-	-	-	-	-	-	-	-	-
White sucker	3	370	10	352 - 387	3	739	65	625 - 850	3	1.45	0.01	1.43 - 1.47	-	-	-	-

Note: mm = millimetre; g = gram; n = sample size; SE = standard error.

5.1.2.6.3.2.4.12 Sex Ratio and Sexual Maturation

Sex ratios were calculated for only four of the ten species (kokanee, rainbow trout, mountain whitefish, and northern pikeminnow) captured in Tatelkuz Lake in July 2013 (**Table 5.1.2.6-34**) because there were insufficient data for the other five species. Sex ratios ranged from 0.4 for kokanee to 2.5 for rainbow trout. This wide variation in sex ratio was due to the relatively small sample sizes compared to those typically needed for an accurate estimate of this ratio.

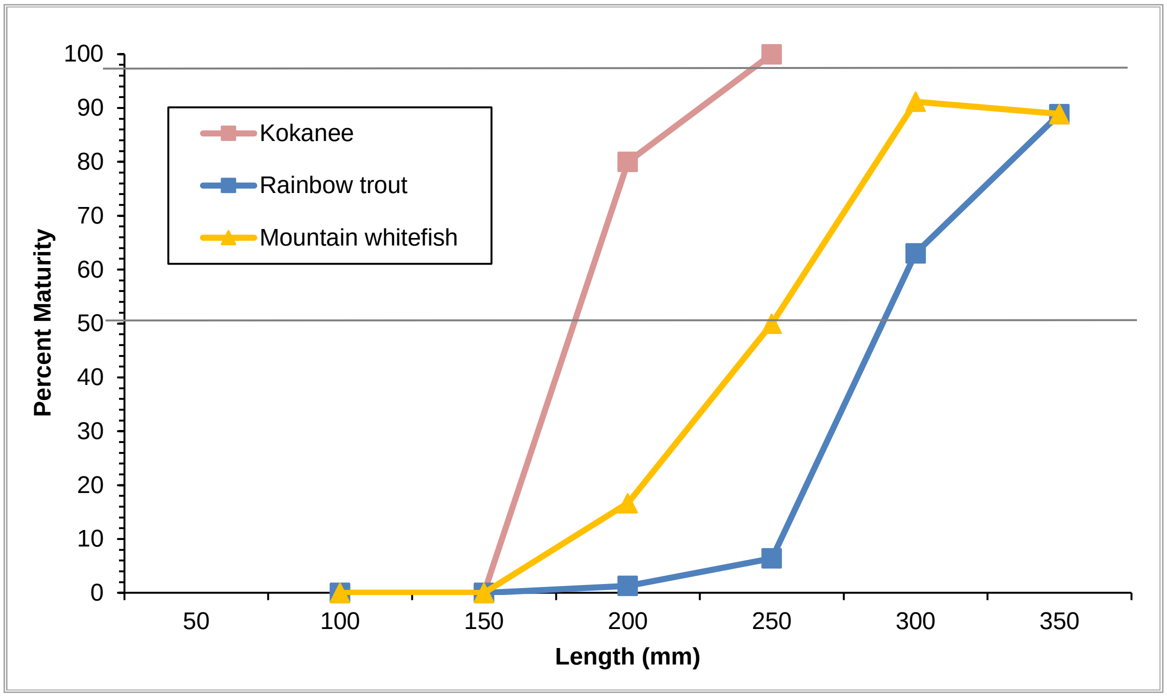
Table 5.1.2.6-34: Sex Ratio of Fish Species, Tatelkuz Lake, July 2013

Population	Number Female	Number Male	Total Number Male and Female	Sex Ratio
burbot	1	0	1	-
kokanee	30	68	98	0.4
longnose sucker	1	0	1	-
mountain whitefish	48	25	78	1.9
northern pikeminnow	1	2	3	0.5
rainbow trout	66	26	92	2.5
Total	**147**	**121**	**273**	**1.2**

Note: Sex ratio = (number of females)/(number of males); dash indicates no data available.

Lengths at 50% maturity for kokanee, mountain whitefish, and rainbow trout were approximately 180, 250, and 290 mm, respectively (**Figure 5.1.2.6-60**). No fish were mature at lengths below 150 mm. Kokanee has an approximate mean length at 95% maturity of 240 mm. Lengths at 95% maturity could not be determined for rainbow trout and mountain whitefish due to small sample sizes.

Gonad weights were measured only for kokanee, rainbow trout, and mountain whitefish. No ripe fish were identified, and only one spent male rainbow trout was identified. Of the 84 kokanee autopsied, 80 (or 95%) were classified as mature and four (or 5%) were classified as immature. None were classified as spent. This is the pattern expected of a species preparing to spawn later in the summer, which they did from late July to September 2013.



Note: mm = millimetre

Figure 5.1.2.6-60: Percent Maturity at Length of Kokanee, Rainbow Trout, and Mountain Whitefish, Tatelkuz Lake, July 2013

5.1.2.6.3.2.4.13 Diet

Of the 12 kokanee stomachs sampled from Tatelkuz Lake in July 2013, seven contained prey items and five were empty. Amphipods were the most abundant prey, followed by Diptera (true flies, Trichoptera (caddisflies), and Ephemoptera (mayflies) larva. While amphipods were the most abundant of all prey items found in kokanee stomachs, they were only found in a single individual.

All of the 12 rainbow trout stomachs sampled from Tatelkuz Lake in July 2013 contained prey items. The most abundant prey was chironomid larva, followed by beetles (Coleoptera), and amphipods.

All of the 13 mountain whitefish stomachs contained prey items. Dipterans comprised the majority of identifiable prey items, almost exclusively chironomid larvae. These were followed by caddisflies and beetles.

In summary, there was a clear separation of diet among the three fish species: kokanee consumed pelagic prey, mainly amphipods; rainbow trout consumed a mixture of benthic and pelagic prey; and mountain whitefish consumed BMI, mainly chironomid larvae.

5.1.2.6.3.2.5 Rainbow Trout

5.1.2.6.3.2.5.1 General Life History

Rainbow trout belong to the Family Salmonidae. Unlike other members of the *Oncorhynchus* genus, rainbow trout can spawn multiple times in a lifetime instead of spawning once and dying. All rainbow trout in the LSA and RSA spend their entire lives in fresh water – there are no anadromous populations.

Rainbow trout are spring spawners. Once water temperature rises above 4°C (McPhail, 2007), adults migrate from overwintering lakes or rivers to tributary streams. After spawning they return to their lakes or rivers of residence (Scott and Crossman, 1973). In Tatelkuz Lake, rainbow trout begin migrating to spawning grounds in early June and finish spawning by the end of June.

Embryos incubate in gravel for several weeks and fry emerge to rear in stream habitat. Juveniles spend their first summer in streams – and sometimes stay as long as 1 or 2 years if there is available habitat – and then migrate to their overwintering lake. There, they rear and forage until becoming sexually mature adults, typically within 3 to 5 years.

Rainbow trout in streams feed primarily on BMI, drifting aquatic insects and terrestrial insects that fall on the water surface. Once in lakes, they will also feed on zooplankton and other fish, if those prey are available.

5.1.2.6.3.2.5.2 Spatial Distribution of Rainbow Trout by Life Stage

Figure 5.1.2.6-61 shows the spatial distribution of rainbow trout migration, spawning, incubation and juvenile rearing habitat within the LSA, based on stream surveys of fish and fish habitat conducted from 2011 to 2013 and known habitat preferences of rainbow trout. **Figure 5.1.2.6-62** shows the spatial distribution of rainbow trout overwintering habitat. **Table 5.1.2.6-35** shows the total amount of available stream habitat for rainbow trout by life stage for each watershed in the LSA.

Table 5.1.2.6-35: Total Rainbow Trout Habitat Areas in Streams of the LSA

Watershed	Migration (m^2)	Spawning and Egg Incubation (m^2)	Fry Summer Rearing (m^2)	Juvenile Summer Rearing (m^2)	Overwintering (m^2)
Davidson Creek	81,000	51,968	127,758	33,058	23,841
Chedakuz Creek Local	120,457	109,339	114,803	42,560	4,270
Creek 661	61,739	50,108	58,617	39,522	12,370
Creek 705	56,262	29,055	65,888	26,712	15,916
Turtle Creek	48,796	41,418	51,866	7,378	6,930
Tatelkuz Lake Tributaries[1]	35,508	35,508	35,508	35,508	0

Note: [1] Numbers are similar because they are based on RIC data.
m^2 = meter squared

Figure 5.1.2.6-63 shows the total area of rainbow trout habitat in the four lakes that support rainbow trout in the LSA and **Table 5.1.2.6-36** shows the total amount of available lake habitat for rainbow trout for the LSA.

Table 5.1.2.6-36: Total Rainbow Trout Habitat Area in Lakes of the LSA

Lake Name	Littoral Area (m^2)	Total Surface Area (m^2)
Lake 01682LNRS	57,419	91,881
Lake 01538UEUT	187,504	357,375
Lake 01428UEUT	164,676	164,676
Tatelkuz lake	842,154	9,100,000

Note: m^2 = meters squared

5.1.2.6.3.2.5.3 Number and Location of Populations

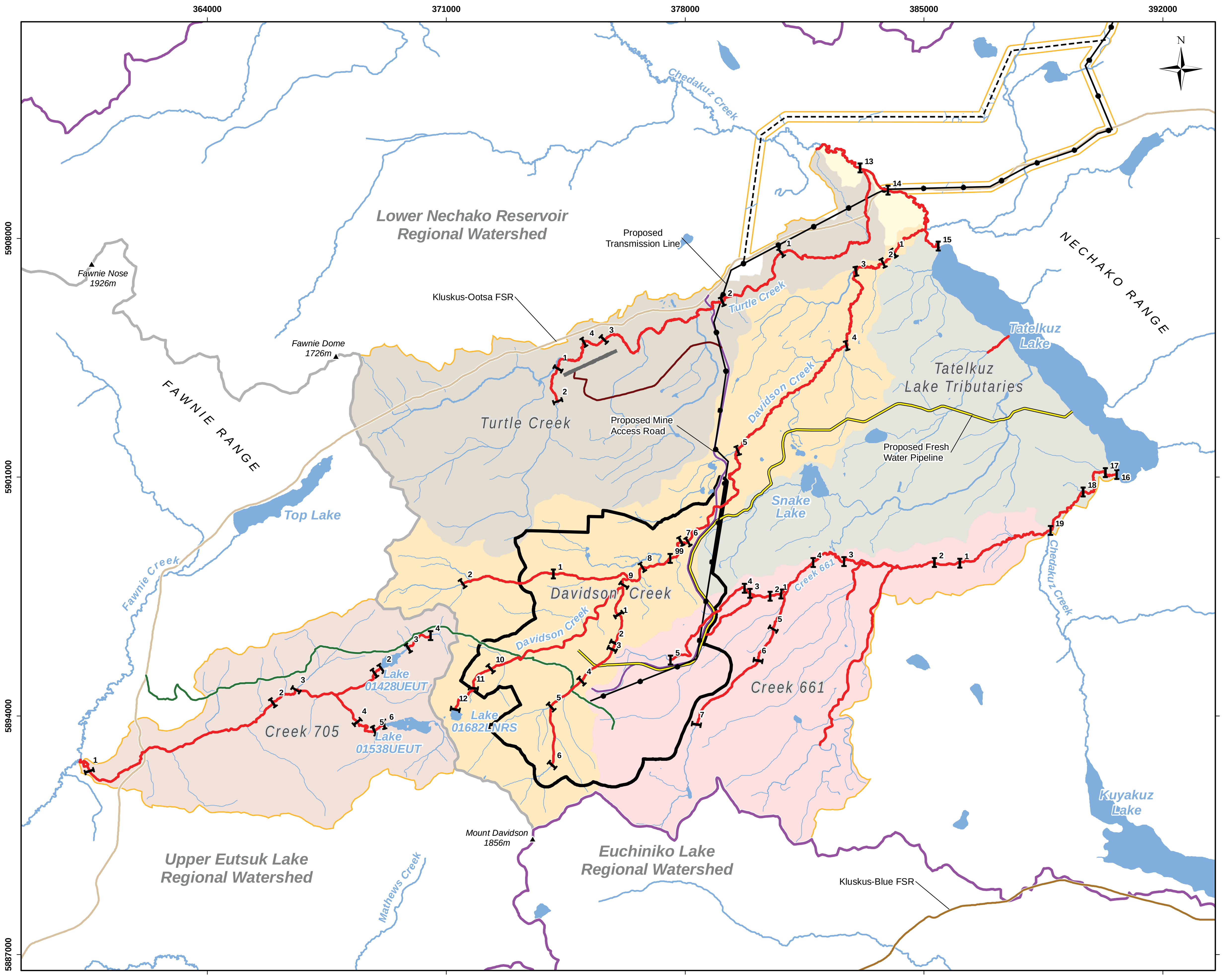
All rainbow trout populations in the LSA are assumed to be lake-resident because with few exceptions the rainbow trout captured in streams in the summers of 2011, 2012 and 2013 were juveniles between the ages of 0 and 3 years. Adult rainbow trout were found only in streams during the spring spawning period or in lakes. Also, lakes are the only waterbodies that provide the large volume of under-ice habitat that is required to support adult rainbow trout during the winter.

Microsatellite DNA analysis of 170 samples of rainbow trout tissue sampled from streams and headwater lakes in 2011 and 2012 showed four broad groupings corresponding to four watersheds: Davidson Creek, Creek 705, Turtle Creek, and Creek 661 (**Figure 5.1.2.6-64**; Section 5.10.3.7 and Annex 5.10-1 of **Appendix 5.1.2.6A**).

Approximately 7% of the total variation in allele frequencies was attributable to differences between the Chedakuz Creek and Fawnie Creek Watersheds, 5% to localities within watersheds, and 88% to variation within localities. Most of the samples were demonstrably genetically distinct from one another and are probably largely demographically independent from one another, although some movement likely does occur occasionally between localities that are currently interconnected.

The proportion of the total variation in microsatellite allele frequencies of rainbow trout in the LSA and RSA that is attributable to differences among populations is consistent with previous results reported for rainbow trout in BC and Alberta once differences in the geographic scale of coverage and physical connectivity are accounted for.

Based on these results, one population is assumed to spawn in each of the four watersheds of the LSA, except for those watersheds with headwater lakes, in which case one additional population is assumed to exist for each headwater lake. Hence, there are seven populations of rainbow trout in the LSA: two in Davidson Creek, one each in Turtle Creek and Creek 661, and three in Creek 705 (**Figure 5.1.2.6-65**).



Legend

- Reach Break
- Stream
- Waterbody
- Regional Watersheds
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Fish and Aquatic Resources

- Local Study Area
- Regional Study Area
- Confirmed Rainbow Trout Habitat

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Rainbow Trout Migration, Migration Spawning, Egg Incubation, Fry Rearing, and Juvenile Rearing Habitat in Streams in the LSA

DATE: August, 2014	ANALYST: KA	Figure 5.1.2.6-61
JOB No: VE52095	QA/QC: RS	PDF FILE: 10-200-184_RB_EggIncubation.pdf
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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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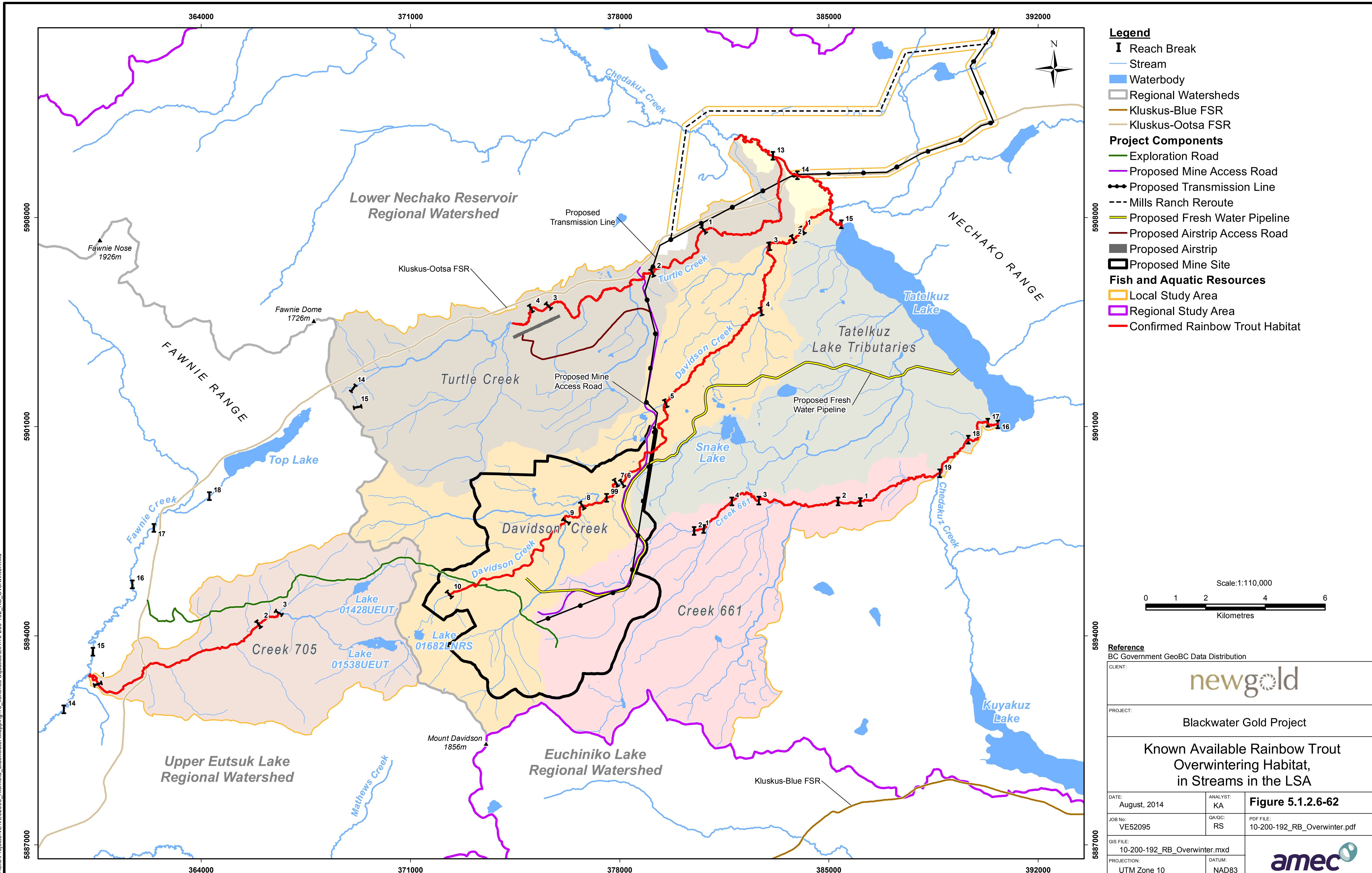
Legend
Reach Break
Stream
Waterbody
Regional Watersheds
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
Confirmed Rainbow Trout Habitat
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
Tatelkuz Lake Tributaries
Turtle Creek
Davidson Creek
Creek 705
Creek 661
Tatelkuz Lake
Snake Lake
Top Lake
Kuyakuz Lake
Lake 01428UEUT
Lake 01682LNRS
Lake 01538UEUT
Fawnie Creek
Chedakuz Creek
Mathews Creek
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Proposed Transmission Line
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Kluskus-Blue FSR
364000
371000
378000
385000
392000
5908000
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5894000
5887000
Scale:1:110,000
0 1 2 4 6
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Known Available Rainbow Trout Overwintering Habitat, in Streams in the LSA
DATE: August, 2014
ANALYST: KA
Figure 5.1.2.6-62
JOB No: VE52095
QA/QC: RS
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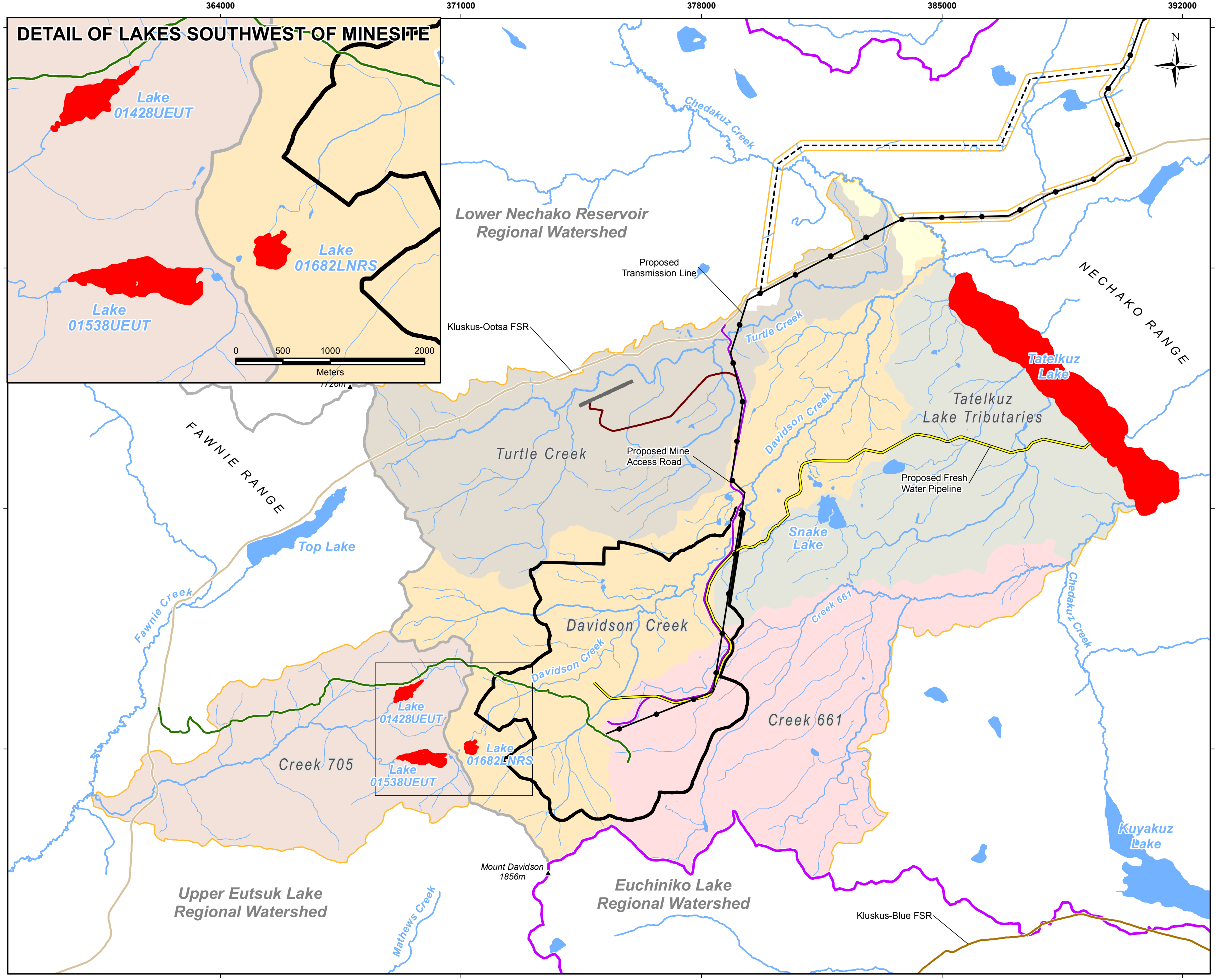

Legend

- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream
- Waterbody
- Regional Watersheds

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Fish and Aquatic Resources

- Local Study Area
- Regional Study Area
- Confirmed Rainbow Trout Habitat

Watersheds

- Chedakuz Creek Local
- Creek 661
- Creek 705
- Davidson Creek
- Tatelkuz Lake Tributaries
- Turtle Creek

Rainbow Trout Rearing, Feeding, and Overwintering Habitat

	Area (m^2)
Tatelkuz Lake	9 100 000
Lake 01428UEUT	170 840
Lake 01538UEUT	352 087
Lake 01682LNRS	90 084

Scale:1:110,000

0 1 2 4 6
Kilometres

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Known Available Rearing, Foraging and Overwintering Lake Rainbow Trout Habitat in the LSA

DATE: August, 2014 | ANALYST: KA | **Figure 5.1.2.6-63**

JOB No: VE52095 | QA/QC: RS | PDF FILE: 10-200-186_RB_Lake.pdf

GIS FILE: 10-200-186_RB_Lake.mxd

PROJECTION: UTM Zone 10 | DATUM: NAD83

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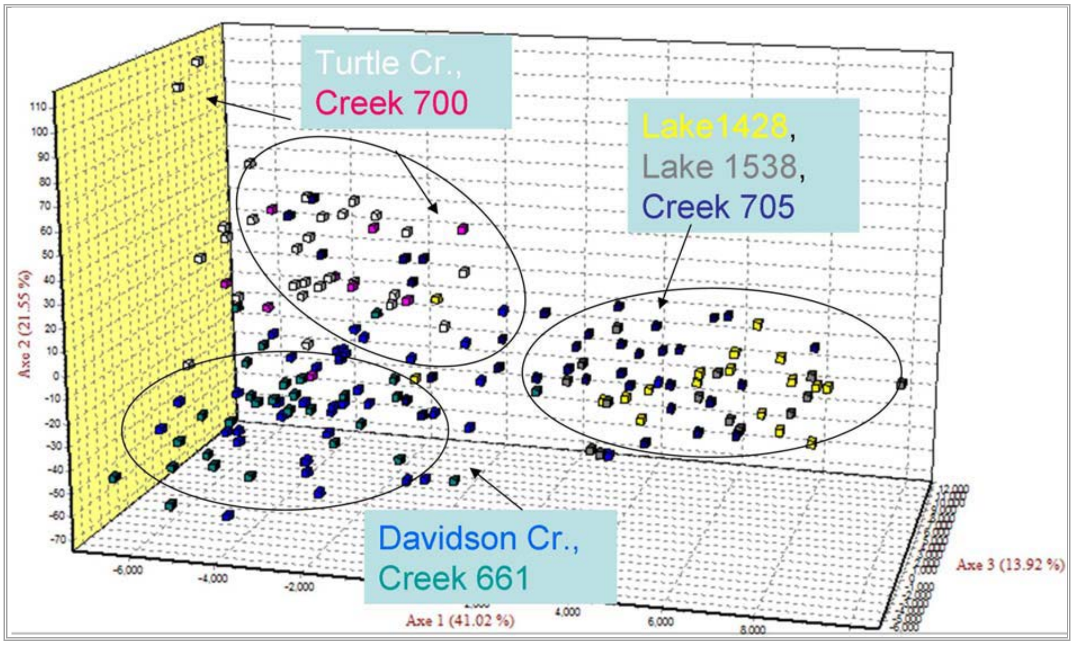


Figure 5.1.2.6-64: Factorial Correspondence Analysis Depicting Relative Similarity among Samples of Rainbow Trout, LSA and RSA, 2011

5.1.2.6.3.2.5.3.1 Davidson Creek Population

In Davidson Creek, rainbow trout were divided into two populations, Davidson Creek and Davidson Headwaters. This division was based on the following information:

- Unrestricted access to lower and middle Davidson Creek by rainbow trout that overwinter in Tatelkuz Lake (i.e., no known barriers to fish passage), allowing spring migration of spawners from the lake to the creek;
- Observation through hoop net catches of upstream migration of rainbow trout spawners from lower Chedakuz Creek into lower Davidson Creek in early June 2011, followed by their downstream migration back to Chedakuz Creek later in June;
- Presence of headwater Lake 01628LNRS that is known from gillnet surveys in 2011 and 2012 to hold adult rainbow trout;
- Presence of a partial barrier to upstream fish passage at the lower end of Reach 11 of upper Davidson Creek;
- Predominance of early downstream rainbow trout migrants observed in hoop nets in upper Davidson Creek in June 2011, which is a pattern not seen in any of the other seven hoop nets in the other three watersheds of the LSA, and which indicates downstream dispersal of spawners and juveniles from headwater Lake 01628LNRS to middle Davidson Creek;

- Relatively high summer densities of juveniles at the outlet of headwater Lake 01682LNRS, indicating spawning at that location;
- Predominance of small, juvenile rainbow trout in Davidson Creek during summer, and the absence of large, adult stream residents; and
- Slower growth of rainbow trout sampled from Lake 01682LNRS than from fish sampled in lower and middle Davidson Creek, indicating two separate populations.

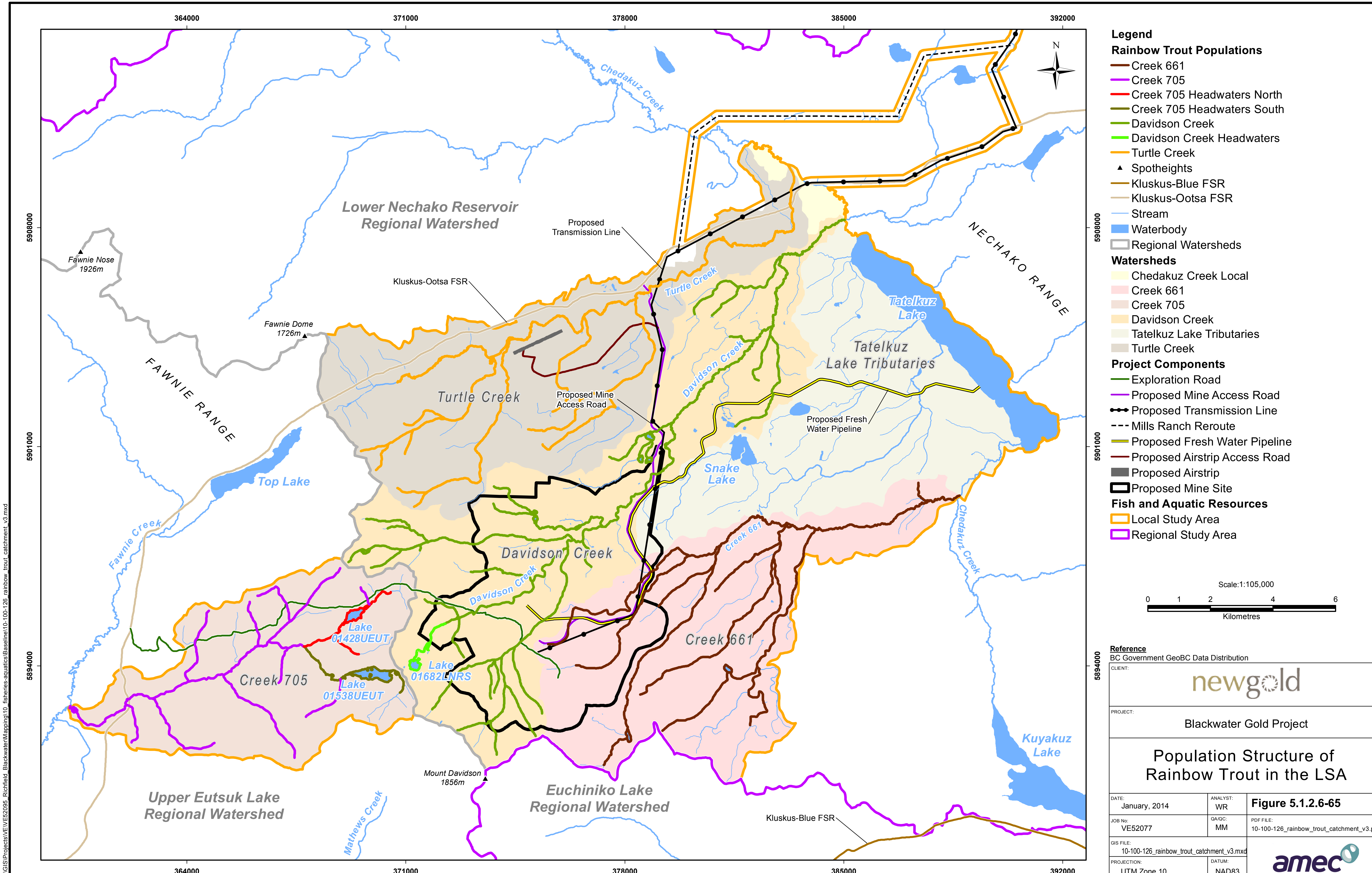
The Davidson Creek population is assumed to account for the majority of trout that use the watershed.

In spring, spawners migrate out of Tatelkuz Lake into lower Chedakuz Creek and then swim up into the lower and middle reaches of Davidson Creek (Reaches 1 to 10 and tributaries) to spawn. This upstream migration was observed using hoop nets installed in lower Davidson Creek in June 2011.

Spawners are unlikely to migrate further upstream into Reaches 11 and 12 of Davidson Creek because of the presence of a steep cascade in lower Reach 11 that acts as a partial barrier to upstream fish passage. It does not likely prevent downstream passage of fish from above the cascade.

After spawning, adults are assumed to return to Tatelkuz Lake. This downstream migration out of Davidson Creek was observed in hoop nets installed in lower Davidson Creek in June 2011.

Fry and juveniles rear in middle and lower Davidson Creek and their tributaries for at least one summer and perhaps one or two more before eventually migrating downstream into Chedakuz Creek and Tatelkuz Lake.



Legend
Rainbow Trout Populations
Creek 661
Creek 705
Creek 705 Headwaters North
Creek 705 Headwaters South
Davidson Creek
Davidson Creek Headwaters
Turtle Creek
Spotheights
Kluskus-Blue FSR
Kluskus-Ootsa FSR
Stream
Waterbody
Regional Watersheds
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Project Components
Exploration Road
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Regional Study Area
Scale:1:105,000
0 1 2 4 6
Kilometres
Reference
BC Government GeoBC Data Distribution
364000
371000
378000
385000
392000
5908000
5901000
5894000
N
Lower Nechako Reservoir Regional Watershed
Upper Eutsuk Lake Regional Watershed
Euchiniko Lake Regional Watershed
FAWNIE RANGE
NECHAKO RANGE
Fawnie Nose 1926m
Fawnie Dome 1726m
Mount Davidson 1856m
Top Lake
Tatelkuz Lake
Snake Lake
Kuyakuz Lake
Chedakuz Creek
Fawnie Creek
Mathews Creek
Turtle Creek
Davidson Creek
Creek 661
Creek 705
Tatelkuz Lake Tributaries
Lake 01428UEUT
Lake 01538UEUT
Lake 01682LNRS
Proposed Transmission Line
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Kluskus-Blue FSR
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Population Structure of Rainbow Trout in the LSA
DATE: January, 2014
ANALYST: WR
Figure 5.1.2.6-65
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QA/QC: MM
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DATUM: NAD83
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5.1.2.6.3.2.5.3.2 Davidson Creek Headwater Population

The Davidson Headwater population of rainbow trout occupies much less area than the Davidson Creek population because its ambit is restricted to Reaches 11 and 12 and headwater Lake 01682LNRS. Adults overwinter in the lake, and in spring they migrate through the single lake outlet and spawn in Reaches 11 and 12 of Davidson Creek and then return to the lake. High densities of juvenile rainbow trout observed in the outlet of Lake 01682LNRS in 2011 supports the existence of a separate population of rainbow trout that spawns downstream of the lake in these two reaches.

The presence of the steep cascade in Reach 11 probably deters most members of this population from descending further downstream. However, there is almost certainly some downstream dispersal of adults and juveniles over the cascades. A predominance of early downstream migrants in hoop net catches in Reach 8 of Davidson Creek in June 2011 supports this idea. This was the only hoop net site where downstream migrants were earlier than upstream migrants were. Most of the migrants probably do not return to their natal habitat, but seek overwintering habitat in Chedakuz Creek and Tatelkuz Lake.

Juveniles of the Davidson Headwater population rear in Reaches 11 and 12 for at least one summer before eventually migrating upstream into Lake 01682LNRS. The extent to which juveniles use habitat in Reaches 11 and 12 for overwintering is uncertain. These reaches were observed to be covered by ice in March of 2012 and 2013. Overwintering habitat quality was rated as fair in Reach 11 and poor in Reach 12.

5.1.2.6.3.2.5.3.3 Turtle Creek Population

Turtle Creek Watershed is not lake-headed nor is it known to have barriers to fish passage. Therefore, a single population of rainbow trout that migrates to and from Tatelkuz Lake is assumed to use this watershed for spawning and rearing. The predominance of juvenile rainbow trout in this creek during the summer supports this idea. If there was a stream-resident population of significant size, then those adults would have been caught in the summer inventories.

In spring, adults migrate out of Tatelkuz Lake into lower Chedakuz Creek and then upstream into Turtle Creek, as well as into Creek 700, a major tributary that flows into Reach 5 of Turtle Creek. This upstream migration was observed at hoop nets installed in lower Turtle Creek and in Creek 700.

After spawning, adults return to Tatelkuz Lake, while juveniles rear in Turtle Creek and Creek 700 for at least one summer and possibly one or two additional summers before eventually descending through lower Chedakuz Creek into Tatelkuz Lake to overwinter. The downstream migration was observed at hoop nets installed in lower Turtle Creek and in Creek 700.

5.1.2.6.3.2.5.3.4 Creek 661 Population

Creek 661 is headed by a shallow pond that is unlikely to provide overwintering habitat. It also has no barriers to upstream migration. Therefore, similar to Turtle Creek, it is assumed to support a single population of rainbow trout. The predominance of juvenile rainbow trout in this creek during summer, and the absence of large rainbow trout, supports the idea that lake-residency is the predominant life history type for this population.

Similar to the Davidson Creek and Turtle Creek populations, the Creek 661 population is assumed to overwinter in Tatelkuz Lake. Spawners migrate up middle Chedakuz Creek and then into Creek 661 to spawn in spring. This upstream migration was observed at hoop nets installed in lower Creek 661 in spring 2011.

After spawning, adults return to Tatelkuz Lake, while juveniles rear in Creek 661 and its tributaries for at least one summer and possibly one or two additional summers before eventually descending through middle Chedakuz Creek into Tatelkuz Lake to overwinter. The downstream migration was observed at hoop nets installed in lower Creek 661 in spring 2011.

5.1.2.6.3.2.5.3.5 Creek 705 Population

Creek 705 Watershed is assumed to support three separate populations of rainbow trout: 705 Headwater North, 705 Headwater South, and Creek 705. This division was made not because of genetic differences. Rather, the watershed contains two headwater lakes with resident trout, and provides spawning and rearing habitat for trout that ascend to the lower and middle reaches of Creek 705 from overwintering locations in Fawnie Creek.

The Creek 705 population is comprised of fish that overwinter in one or more undetermined locations in the Fawnie Creek Watershed downstream of Creek 705 – probably Top Lake or Laidman Lake. In spring, adults of this population migrate upstream or downstream through Fawnie Creek into Reaches 1 to 4 of Creek 705 where they spawn. These migrants were observed passing through hoop nets installed at the downstream end of Creek 705 in June 2011. These fish then return to Fawnie Creek or their residence lakes in the Fawnie Creek Watershed. Their downstream migration was also observed using through hoop nets installed at the downstream end of Creek 705 in June 2011.

Juveniles rear in the mainstem and tributaries of the lower and middle reaches of Creek 705 until they mature and migrate downstream into Fawnie Creek. The spatial extent of this population is arbitrarily set to be from the confluence of Creek 705 and Fawnie Creek upstream to the confluence of Creek 705 and Creek 606013.

5.1.2.6.3.2.5.3.6 Creek 705 Headwater North Population

The Creek 705 Headwater North population overwinters in Lake 01428UEUT. Water from that lake flows down Creek 606013 and into the middle of Reach 4 of Creek 705. In spring, adults are assumed to migrate out of Lake 01428UEUT to spawn in Creek 606013 and its tributaries. Adults are also assumed to migrate out of the major inlet to the lake and spawn there because juveniles were observed in both inlet and outlet reaches of Lake 01428UEUT in 2011, indicating that spawning occurred above and below the lake. These migrations were not observed because hoop nets were not installed in upper Creek 705 in spring.

Adults then return to the lake to forage in summer and overwinter. Juveniles remain in Creek 606013 and its tributaries to rear. For mapping purposes, the downstream extent of this population is set at the confluence of Creek 606013 and Creek 705.

5.1.2.6.3.2.5.3.7 Creek 705 Headwater South Population

The Creek 705 Headwater South population overwinters in Lake 01538UEUT. In spring, adults migrate out of its outlet to spawn in Reaches 4, 5 and 6 of Creek 705 (the lake is classified as Reach 7 of Creek 705) and its tributaries and then return to the lake. This migration was not observed because hoop nets were not installed in upper Creek 705 in spring.

Juveniles remain in the upper reaches of Creek 705 and its tributaries to rear. Juveniles were observed in the outlet reaches of Lake 01538UEUT in summer 2011, confirming their presence and utilization of upper Creek 705 for rearing. The downstream extent of this population is arbitrarily set at Reach 4 of Creek 705.

5.1.2.6.3.2.5.4 Total Number in Tatelkuz Lake

The hydroacoustic survey estimated 117,068 rainbow trout in Tatelkuz Lake in July 2013 (or 15.1% of the total number of fish in the lake. The 95% CL of that total number of rainbow trout were 97,167 to 136,970 or +/-17% of the total number. That was equivalent to a density of 131 trout/ha of lake surface area (95% CL = 108 to 153 fish/ha).

When multiplied by the mean weight of rainbow trout (89 g) measured during the Tatelkuz Lake fish community survey, the total number of rainbow trout was equivalent to a total biomass of 10,419 kg (95% CL = 8,648 to 12,190) and a biomass density of 11.6 kg/ha (95% CL = 9.6 to 13.6).

If all lakes in the LSA are assumed to have the same density of rainbow trout, then the density measured for Tatelkuz Lake can be used to estimate the absolute number of rainbow trout in the three headwater lakes (**Table 5.1.2.6-37**). These estimates range from 120 rainbow trout for Lake 01682LNRS to 4,682 rainbow trout for Lake 01538UEUT.

The null hypothesis of uniform density of rainbow trout in lakes of the LSA was tested and is discussed below.

Table 5.1.2.6-37: Predicted Number of Rainbow Trout Estimated from Lake Surface Area Assuming Uniform Density of 131 Fish/Ha

Lake	Surface Area (ha)	Predicted Number
01682LNRS	0.9	120
01428UEUT	16.9	2,218
01538UEUT	35.7	4,682

5.1.2.6.3.2.5.5 Relative Abundance in Lakes

Gillnet, minnow trap, and shoreline electrofishing surveys of the four headwater lakes in 2011 and 2012 showed that rainbow trout was the predominant species in lakes 01682LNRS, 01538UEUT and 01428UEUT, but that Snake Lake supported only lake chub.

Lake 01428UEUT had the highest mean rainbow trout gillnet CPUE of the three headwater lakes, followed by Lake 01538UEUT and Lake 01682LNRS (**Table 5.1.2.6-38**). Tatelkuz Lake had a mean rainbow trout gillnet CPUE that fell between that of Lake 01538UEUT and Lake 01428UEUT.

Table 5.1.2.6-38: Mean Gillnet CPUE in Lakes, 2011-2013

Lake	Gillnet CPUE (fish/100 m²/day)		
	mean	SE	N
01682LNRS	10.1	7.8	7
01538UEUT	25.0	8.4	6
Tatelkuz	31.1	7.4	78
01428UEUT	96.0	14.2	3

Note: SE = standard error

A one-way analysis of variance (ANOVA) using individual gillnet CPUE transformed with the ln(X + 1) function (to normalize the frequency distribution of CPUE and to include zero counts) showed that these means were significantly different from each other ($F_{3,93}$ = 3.26, P = 0.025), but only barely. (The minimum criterion of significance is P<0.05. Moderate significance is 0.001<P<0.010, and high significance is P<0.001.) One reason for the barely significant differences in mean gillnet CPUE among lakes was the high variances of the means caused by the large number of CPUE with zero values. For example, 42 of the 78 gillnet sets from Tatelkuz Lake (or 54%) contained no rainbow trout, and 5 of the 7 gillnets sets for Lake 01682LNRS (or 71%) contained no rainbow trout.

In summary, the available evidence does not strongly disprove the null hypothesis of uniform rainbow trout density in lakes of the LSA. Hence, the assumption of uniform density is a useful approximation.

5.1.2.6.3.2.5.6 Number of Spawners

A total of 2,023 fish were captured in hoop nets installed in Davidson Creek, Turtle Creek, Creek 661 and Creek 705 in June 2011, of which 1,997 (or 98.7%) were rainbow trout. Total hoop net CPUE of rainbow trout in June 2011 were highest in Creek 705, followed by Turtle Creek, Creek 661, and Davidson Creek (**Figure 5.1.2.6-66**).

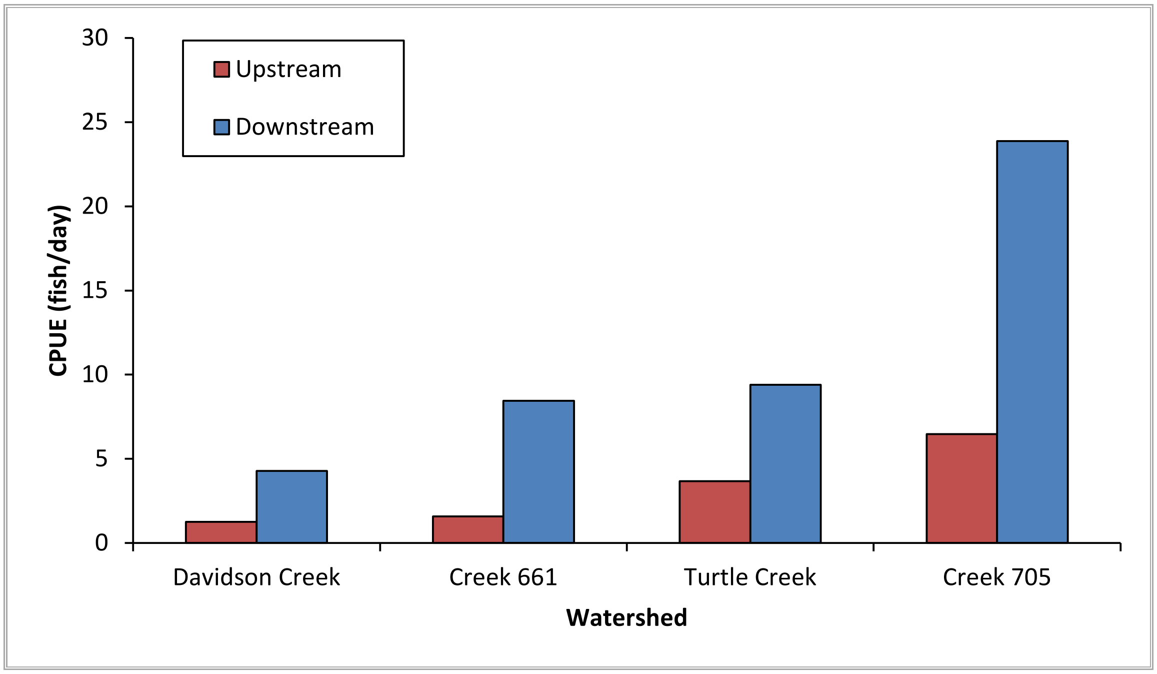

Figure 5.1.2.6-66: Hoop Net CPUE by Direction and Watershed for Rainbow Trout of the LSA, June 2011

In all four watersheds, total downstream catches of rainbow trout in hoop nets were higher than upstream catches because the nets could not be installed before the spawning migration began due to unusually high freshet flows in 2011. Although rainbow trout are reported in the scientific literature to begin their spawning migration at a water temperature of 5°C, those in the LSA and RSA were migrating at temperatures lower than 5°C, and may have begun their migrations while some streams were still covered in ice.

This means that total downstream hoop net CPUE is the least biased index of relative abundance of rainbow trout spawners in the four watersheds of the LSA. If one assumes that the number of spawners counted in a stream is proportional to the total number of rainbow trout in its residence lake that belong to that population, then total hoop net CPUE can be used to estimate the proportion of the rainbow trout in Tatelkuz Lake that belong to Davidson Creek, Creek 661, and Turtle Creek populations (**Table 5.1.2.6-39**).

These calculations indicate that the number of rainbow trout in Tatelkuz Lake that emerged from gravel in Davidson Creek is approximately 19% of the total number of rainbow trout in the lake.

The calculations shown in **Table 5.1.2.6-39** are admittedly simplistic because they assume a 1:1 correspondence between number of spawners and number of all other age classes in a population. The numbers shown in **Table 5.1.2.6-39** are probably overestimates of the contribution to the total number of rainbow trout in Tatelkuz Lake by each of the three streams because they do not take into account the contribution of rainbow trout that may spawn in lower and middle Chedakuz Creek and in the many small creeks that are tributary to Tatelkuz Lake.

Table 5.1.2.6-39: Number of Rainbow Trout in Tatelkuz Lake Belonging to Natal Stream Populations Estimated from Total Downstream Hoop Net CPUE of Rainbow Trout Spawners

Creek	Total Downstream CPUE	Percent	Number in Tatelkuz Lake
Davidson	4.3	19	22,778
661	8.4	38	44,496
Turtle	9.4	43	49,794
Total	22.1	100	117,068

5.1.2.6.3.2.5.7 Spawning Timing

Upstream migrants were observed earlier than downstream migrants at seven of the eight hoop nets (**Figure 5.1.2.6-67**). The exception was upper Davidson Creek. This supports the existence of a second population of rainbow trout that overwinters in Lake 01628LNRS and spawns in Reaches 10 and 11 and in lower reaches as well, although they would have to descend a cascade to enter middle Davidson Creek and probably would not be able to return to their overwintering lake after spawning, but continue downstream to Tatelkuz Lake.

Spawners were first counted on the spawning grounds on June 7 and were last counted on June 28 – a total period of 21 days (**Table 5.1.2.6-40**). Dates of 50% upstream counts ranged from June 11 to 25 with a mid-date of June 18, and dates of 50% downstream counts ranged from June 15 to 23 with a mid-date of June 19.

It took a mean of 6 days (n = 8, SE = 2 day) from the date of first appearance of spawners to the date of 50% counts (**Table 5.1.2.6-40**). This is assumed to be the approximate duration of the migration from the residence lake to the hoop nets.

The difference in dates at which 50% cumulative catches of rainbow trout occurred for the paired upstream and downstream hoop nets at each sampling site (**Table 5.1.2.6-40**) was defined as “spawning time.” It ranged from 3 to 10 days with a mean of 5 days (n = 8, SE = 1 day).

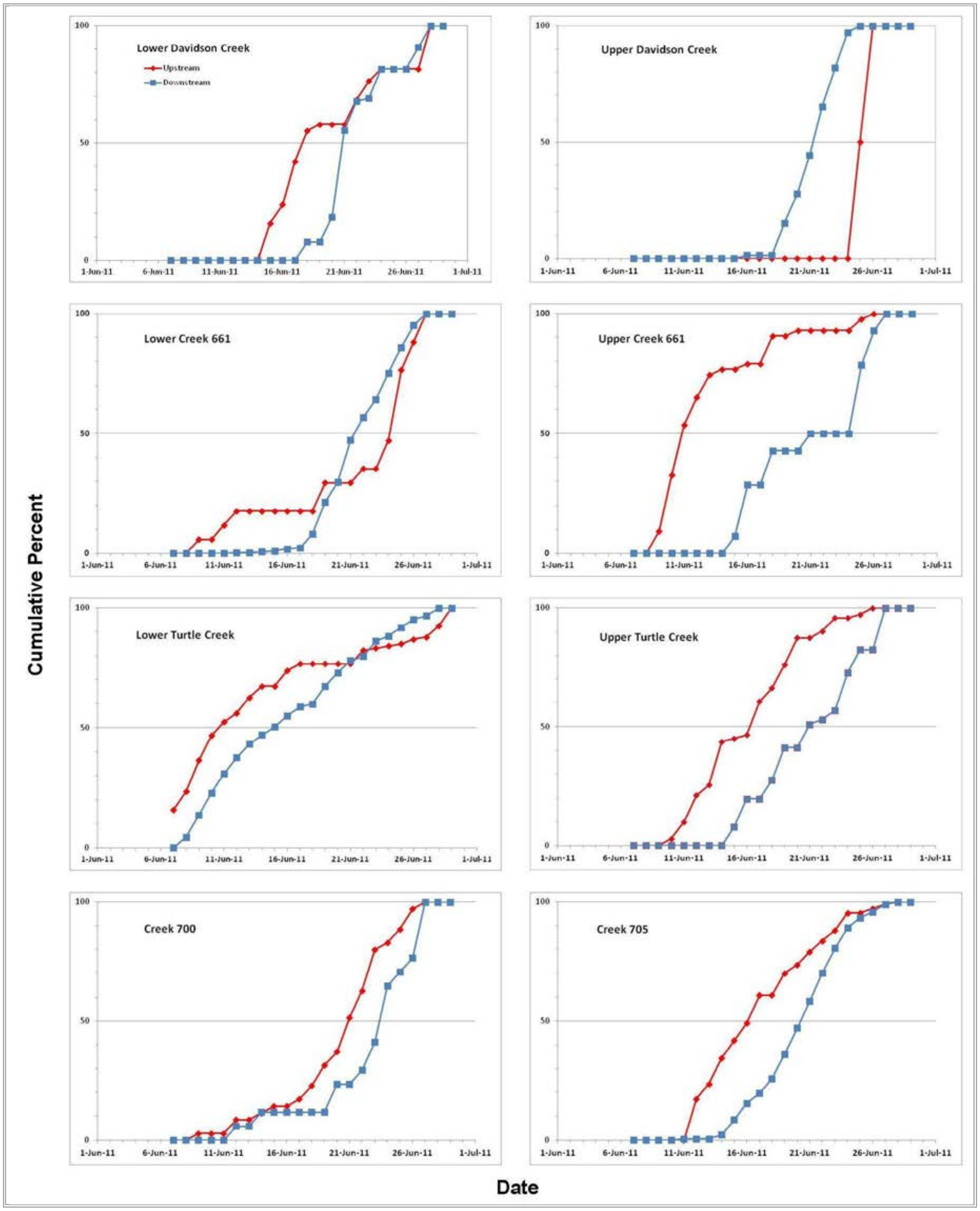

Figure 5.1.2.6-67: Cumulative Percent Catches of Rainbow Trout in Hoop Nets, June 2011

It took a mean of 7 days (n = 8, SE = 1 day) from the date of 50% downstream counts to the date of 100% downstream (**Table 5.1.2.6-40**). This is assumed to be the approximate duration of the migration from the hoop nets to the residence lake.

In summary, the spawning run lasted 18 days: 6 days to migrate to the spawning grounds, 5 days to spawn, and 7 days to return to the residence lakes.

5.1.2.6.3.2.5.8 Stream Spawning Fidelity

All rainbow trout that were captured and processed in hoop nets in the spring of 2011 were given a unique fin clip. A total of 152 clipped rainbow trout were recaptured in hoop nets late in June 2011, of which 92% were recaptured at the same site where they were originally clipped, only moving in the opposite direction. The other 8% were captured at different sites in the same watershed. These results indicate fidelity by rainbow trout to their spawning grounds and it supports the idea that each watershed in the LSA is used by at least one distinct population of rainbow trout.

5.1.2.6.3.2.5.9 Juvenile Abundance and Spatial Distribution

Except for Creek 705, which was surveyed for fish in the summer of 2013, inventories of rainbow trout juveniles in streams of the LSA were conducted in the summers of 2011 and 2012 (Section 5.10.2.4 of **Appendix 5.1.2.6A**). Electrofishing CPUE ranged from 0.0 to 7.2 fish/100 s, and electrofishing density ranged from 0.0 to 28.3 fish/100 m^2 (**Figure 5.1.2.6-68**). Over 70% of the 78 values of electrofishing CPUE were below 1.0 fish/100 s, and over 75% of fish densities were below 5.0 fish/100 m^2. Minnow trapping CPUE was also low. Over 75% of the 37 values of minnow trapping CPUE were below 1.0 fish/trap-hour (**Figure 5.1.2.6-69**).

This range of densities includes the BC provincial “biostandards” developed for stream populations of rainbow trout surveyed before and after watershed habitat restoration (Keeley et al., 1996; Koning and Keeley, 1997). The mean “before” density reported by Koning and Keeley (1997) was 3.6 fish/100 m^2 and the mean “after” density was 9.7 fish/100 m^2. Hence, the “before” biostandard is most applicable to rainbow trout in streams of the LSA. This further supports the idea that production of rainbow trout in streams and lakes of the LSA is limited by low water temperatures.

Table 5.1.2.6-40: Spawning Timing of Rainbow Trout, LSA, June 2011

Hoop Net Site	Upstream Hoop Net Catches			Upstream Migration	Downstream Hoop Net Catches			Spawning	Downstream Migration
	0%	50%	100%	Time (days)[1]	0%	50%	100%	Time (days)[2]	Time (days)[3]
Lower Davidson Creek	June 14	June 18	June 28	4	June 17	June 21	June 28	4	7
Upper Davidson Creek	June 24	June 25	June 26	1	June 15	June 21	June 25	4	4
Lower Creek 661	June 8	June 24	June 27	16	June 13	June 21	June 27	3	6
Upper Creek 661	June 8	June 11	June 26	3	June 14	June 21	June 27	10	6
Lower Turtle Creek	June 7	June 11	June 29	4	June 7	June 15	June 28	4	13
Upper Turtle Creek	June 9	June 16	June 26	7	June 14	June 21	June 27	4	6
Creek 700	June 8	June 21	June 27	13	June 11	June 23	June 27	2	4
Creek 705	June 11	June 13	June 28	2	June 13	June 20	June 28	7	8
Mean				6				5	7
SE				2				1	1

Note: [1]Difference between dates of 0% and 50% upstream counts.
[2]Difference between dates of 50% upstream and 50% downstream counts.
[3]Difference between dates of 0% and 50% downstream counts.

Pooling electrofishing CPUE of rainbow trout by population over both the 2011 and 2012 surveys showed that the Creek 705 Headwaters South population had the highest mean CPUE (**Table 5.1.2.6-41**), followed by the Creek 705 Headwaters South population, the Davidson Creek Headwaters population, and the Creek 661 population. The Tatelkuz Lake Tributaries Watershed (lower Chedakuz Creek) had the lowest CPUE.

The stream inventory data summarized in this section were used to search for relationships between rainbow trout electrofishing CPUE and mesohabitat types by pooling all data among watersheds and years. No clear linear or curvilinear relationships were observed between electrofishing CPUE and percent riffles, percent pools, and percent glides for each stream sampling site. Similar plots of rainbow trout density on mesohabitat types, and minnow trap CPUE and mesohabitat types also found no clear relationships with percent riffles, percent pools, and percent glides for each stream sampling site. The most likely reason for the absence of apparent habitat preferences by juvenile rainbow trout is that the low density of juvenile rainbow trout in streams of the LSA obscured any relationships that exist.

Table 5.1.2.6-41: Rainbow Trout Mean Electrofishing CPUE and Fish Density by Population or Watershed, 2011 and 2012

Population	Number Captured	Electrofishing Effort (s)	Mean CPUE (fish/100 s)	Area Sampled (m^2)	Mean Fish Density (No./100 m^2)
Davidson Creek	263	34,008	0.8	9,262	2.8
Davidson Creek Headwaters	101	5,230	1.9	854	11.8
Turtle Creek	28	7,527	0.4	3,310	0.8
Creek 661	160	14,366	1.1	4,278	3.7
Creek 705 Headwaters North	49	980	5.0	320	15.3
Creek 705 Headwaters South	23	1,053	2.2	300	7.7
Tatelkuz Lake Tributaries	4	2,792	0.1	2,578	0.2
Total or Mean	**628**	**65,956**	**1.0**	**20,902**	**3.0**
SE			**0.6**		**2.2**

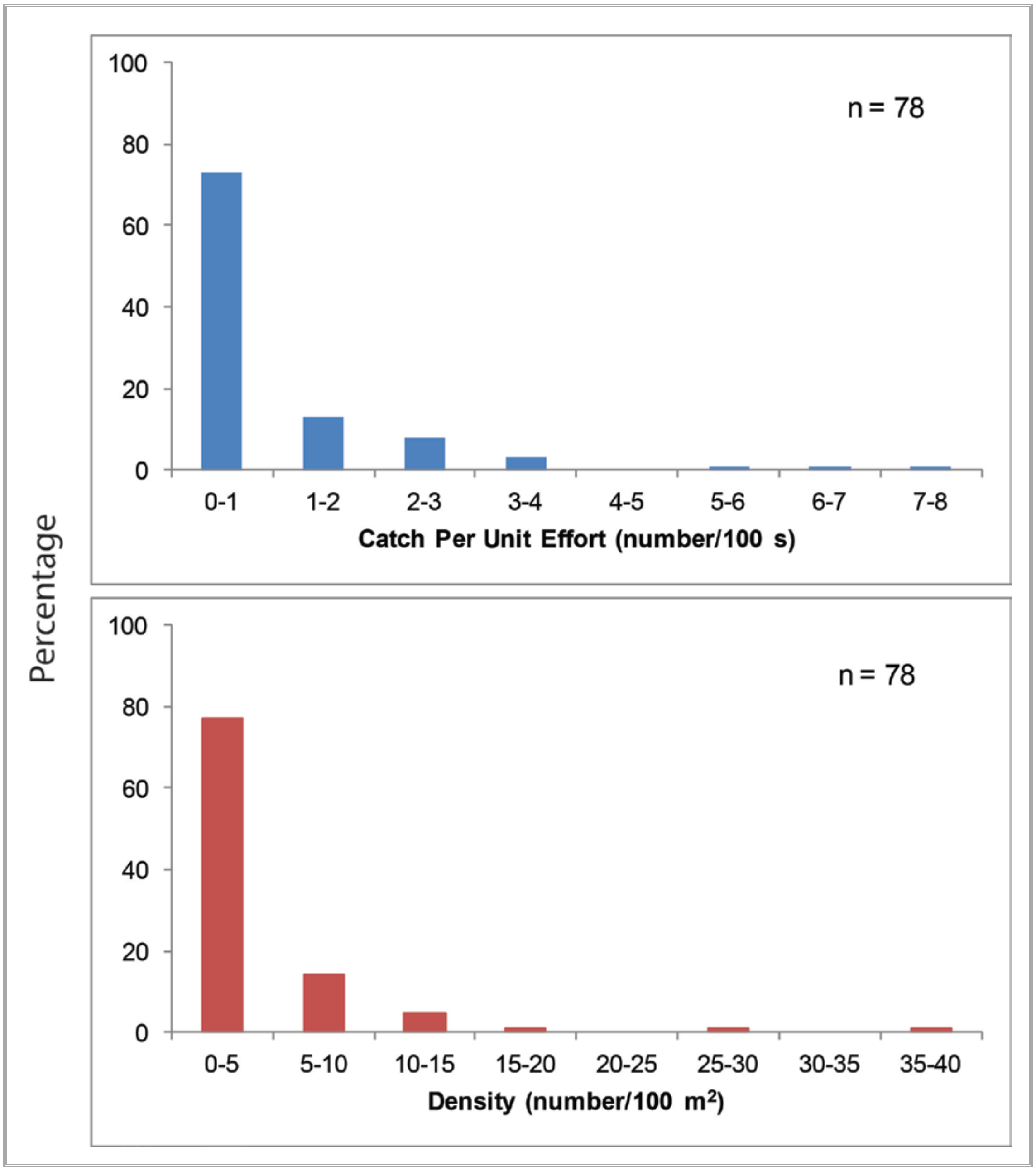

Figure 5.1.2.6-68: Frequency Distribution of Electrofishing CPUE and Density in the LSA, 2011 and 2012

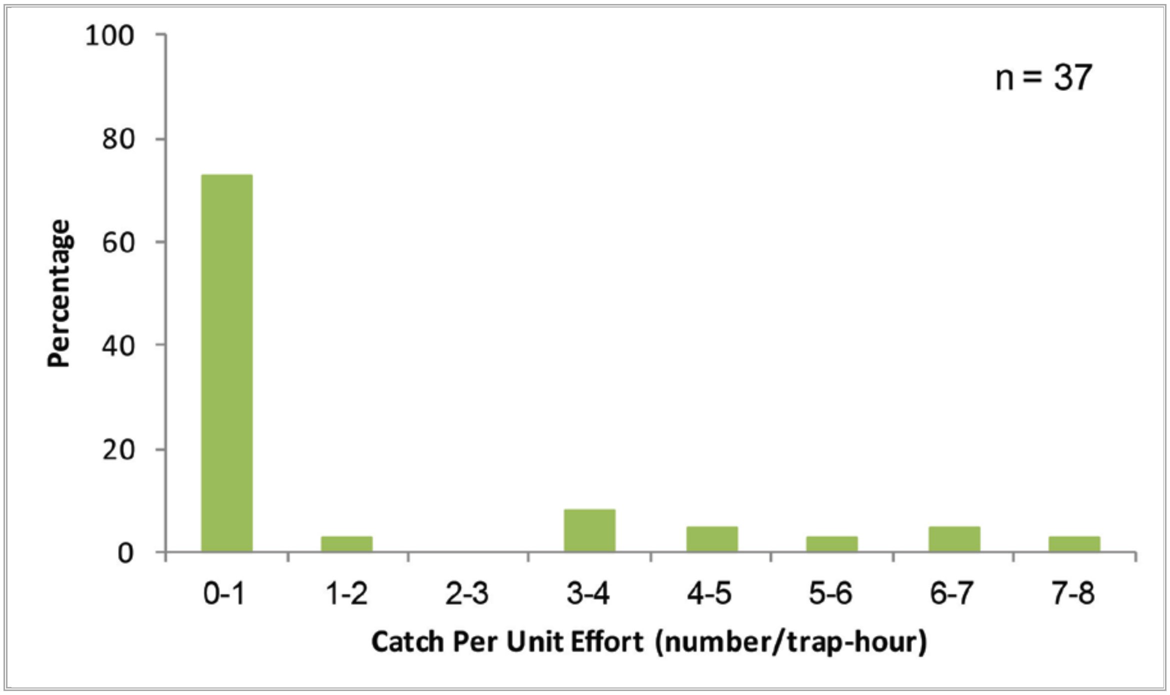

Figure 5.1.2.6-69: Frequency Distribution of Minnow Trap CPUE in the LSA, 2011 and 2012

5.1.2.6.3.2.5.10 Spatial Distribution in Tatelkuz Lake

The gillnet survey of the fish community of Tatelkuz Lake in July 2013 showed that rainbow trout, kokanee, and mountain whitefish were the most abundant species in both nearshore and offshore habitat during both day and night (**Figure 5.1.2.6-57** and **Figure 5.1.2.6-58**). During the day, rainbow trout were especially abundant in the nearshore zone and near the lake surface (0-5 m depth) in both habitats. At night, their nearshore abundance decreased and offshore they moved deeper in the water column.

5.1.2.6.3.2.5.11 Size, Age and Growth

Mean size and age of rainbow trout varied substantially among the seven populations in the LSA and Tatelkuz Lake (**Table 5.1.2.6-42**), but most of the variation was due to differences in gear selectivity and sampling time. For example, Creek 705 has the longest, heaviest, and oldest specimens, but the lowest mean condition of any of the four main watersheds. This was because most of those fish captured in that watershed were spawners captured in hoop nets in June 2011. The Davidson Creek Headwater population has the shortest mean length, but the highest mean condition, because most of those fish were juveniles captured by electrofishing in the summers of 2011 and 2012.

von Bertalanffy growth models were successfully fit to rainbow trout captured from each of the seven populations plus Tatelkuz Lake (**Figure 5.1.2.6-70**). Most growth curves grouped together with the exception of Tatelkuz Lake, which showed slower apparent growth than any of the seven populations. This is unlikely to reflect differences in environmental conditions because Tatelkuz Lake is warmer and has higher conductivity (which means higher nutrient concentrations) than tributary streams and headwater lakes and so rainbow trout from that lake would be expected to show faster growth and larger body size.

The most likely reason for this difference is related to the timing of sampling. Rainbow trout in Tatelkuz Lake in July 2013 had recently completed their spawning migration but rainbow trout in streams were sampled during their spawning migration and summer juvenile period. Some of the large spawners that were sampled in hoop nets installed in streams in spring 2011 may not have survived to return to Tatelkuz Lake due to predation during stream residency and the stress of spawning.

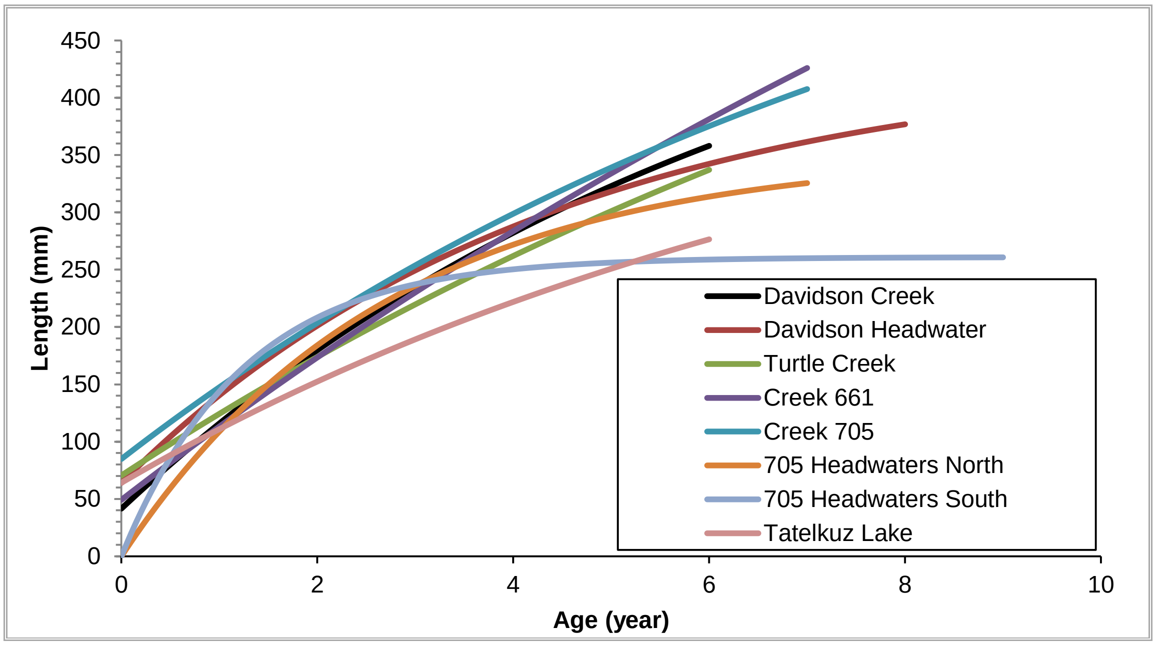

Figure 5.1.2.6-70: Growth in Length of Rainbow Trout Populations of the LSA, 2011-2013

Table 5.1.2.6-42: Mean Length, Weight, Condition Factor, and Age of Rainbow Trout, Blackwater Study Area, 2011-2013

	Sampling Time			Fork Length (mm)				Weight (g)				Condition Factor				Age (year)			
Population	**2011**	**2012**	**2013**	**n**	**Mean**	**SE**	**Range**	**n**	**Mean**	**SE**	**Range**	**n**	**Mean**	**SE**	**Range**	**n**	**Mean**	**SE**	**Range**
Davidson Creek	Jun, Aug	Aug, Oct	-	479	131	4	15 - 415	390	79	8	1 - 744	390	1.13	0.01	0.64 - 2.71	102	2	0.1	0 - 6
Davidson Headwaters	Aug	Aug, Sep	-	116	125	8	47 - 380	116	65	13	1 - 587	116	1.17	0.02	0.64 - 2.71	51	2	0.3	0 - 8
Turtle Creek	Jun, Aug	Aug – Nov	-	1,021	151	2	34 - 390	977	56	3	1 - 660	977	1.03	0.01	0.43 - 3.08	73	2	0.2	0 - 6
Creek 661	Jun, Aug	Aug, Oct	-	535	150	5	22 - 460	501	113	10	1 - 840	501	1.06	0.01	0.46 - 2.03	88	2	0.2	0 - 7
Creek 705	Jun	Oct	-	626	246	5	33 - 431	526	298	9	4 - 836	526	0.95	0.01	0.54 - 1.59	61	4	0.2	1 - 6
705 Headwaters North	Aug	Sep	-	115	153	10	28 - 380	102	104	14	1 - 295	102	1.11	0.02	0.45 - 1.94	27	4	0.3	1 - 7
705 Headwaters South	Aug	Sep	-	55	153	13	32 - 298	54	86	12	1 - 275	55	1.06	0.03	0.00 - 1.68	29	5	0.3	3 - 9
Tatelkuz Lake	-	-	Jul	625	184	2	75 - 463	581	89	3	4 - 438	581	1.13	0.01	0.75 – 1.42	153	3	0.1	1 - 6

Note: mm = millimetre; g = gram; n = sample size; SE = standard error; dashes indicates not applicable.

5.1.2.6.3.2.5.12 Sex Ratio and Sexual Maturation

Sex ratios for rainbow trout in streams and lakes of the LSA, as assessed from the hoop net survey of spring 2011, headwater lake surveys of 2011 and 2012, and summer stream inventories of 2011 and 2012, ranged from a low of 0.2 for the 705 Headwaters North population to a maximum of 5.0 for the Davidson Headwaters population (**Table 5.1.2.6-43**; Section 5.10.3.2 of **Appendix 5.1.2.6A**). The mean sex ratio for all populations combined was 0.7. The wide variation in sex ratio among populations is most likely a function of small sample sizes and the large number of fish that could not be assigned a sex due to their immaturity. In general, the larger the sample size, the closer the ratio approached the value of 1.0 expected for a stable population.

Table 5.1.2.6-43: Sex Ratio of Rainbow Trout, Blackwater Study Area, 2011-2012

Population	No. Females	No. Males	No. Immature	Total	Sex Ratio
Davidson Creek	38	74	233	345	0.5
Davidson Headwaters	5	1	79	85	5.0
Turtle Creek	83	191	518	788	0.4
Creek 661	55	83	290	428	0.7
Creek 705	124	101	290	515	1.2
705 Headwaters North	2	10	39	51	0.2
705 Headwaters South	11	11	8	30	1.0
Total	318	471	1,457	2,246	0.7

Note: No. = number of; sex ratio = number of females/number of males.

For those same rainbow trout sampled in 2011 and 2012, the length at 50% maturity of rainbow trout ranged from 100 to 300 mm among populations in the LSA, with a pooled estimate over all populations of 150 mm (**Figure 5.1.2.6-71**). No fish were mature at lengths below 100 mm. For all populations pooled, 95% of fish were mature at a length of 300 mm. On average, these fish were mature at shorter lengths than those sampled in Tatelkuz Lake in July 2013.

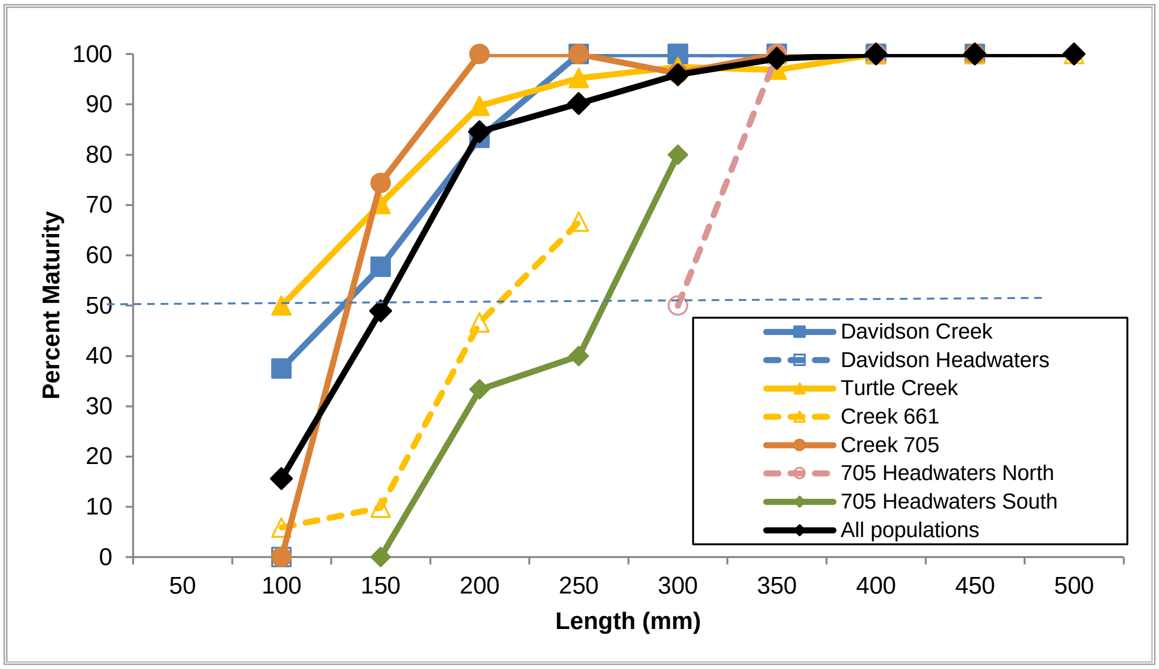

Figure 5.1.2.6-71: Plot of Percent Maturity on Length of Rainbow Trout, Blackwater Study Area, 2011 and 2012

5.1.2.6.3.2.5.13 Diet

The stomach contents of 50 rainbow trout from streams and lakes of the LSA were examined in 2011 and 2012 (Section 5.10.3.5 of **Appendix 5.1.2.6A** and Section 5.12.3.6 of **Appendix 5.1.2.6B**).

Dipterans dominated the diet of small trout captured in Creek 661 (<100 mm long) and Davidson Creek (<120 mm), and terrestrial insects were found only in the diet of larger fish from Turtle Creek (>180 mm), indicating that prey selection in stream-dwelling rainbow trout changes with body size. Davidson Creek trout had more prey items and more taxonomic diversity than did the Creek 661 trout. (However, this conclusion is based on low sample size – only four stomachs were sampled from Creek 661.)

For the headwater lake populations, there appears to be a clear relationship between rainbow trout diet and habitat availability. Daphnids were the most abundant prey item for trout from Lake 01538UEUT. (Daphnids are pelagic zooplankton that migrate vertically in the water column.) In contrast, benthic gammarids were the dominant prey item for trout from Lake 01428UEUT. The surface area of Lake 01538UEUT is 52% littoral and 48% pelagic, but the area of Lake 01428UEUT is 97% littoral and 3% pelagic. Feeding on zooplankton is common for rainbow trout when other forms of prey are not available.

These results support the idea that rainbow trout are opportunistic feeders, consuming the most common prey available from both benthic and pelagic habitat. These include aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, and other small fish. Their diet also shifts as they grow in size, and are better able to exploit multiple niches (Scott and Crossman 1973).

5.1.2.6.3.2.5.14 Tissue Metal Concentrations

In 2011 and 2012, rainbow trout were collected for tissue metals analysis from 20 sites in the LSA: Davidson Creek (7 sites), Turtle Creek (4 sites), Creek 661 (5 sites), Chedakuz Creek (1 site), and one site each in headwater lakes 01538UEUT, 01428UEUT, and 01682LNRS. A total of 103 rainbow trout were used for tissue sampling. As a general rule, 16 fish were collected from each watershed or lake: 8 in 2011 and 8 in 2012.

Metal concentrations were required from different parts of fish. Muscle and liver metal concentrations were required to evaluate human health because both parts of the fish are eaten by humans. Whole-body metal concentrations were also required for ecological risk assessment because piscivorous wildlife consume the whole body not just muscle or liver. A total of 219 tissue samples were analyzed in 2011 and 2012: 76 whole fish, 83 muscle and 59 liver.

From 17 to 19 July 2013, rainbow trout and mountain whitefish were collected for tissue metals analysis from Tatelkuz Lake. Mountain whitefish were chosen as a second species because they were abundant in gillnet catches, they were large-bodied fish that provided large tissue samples, they are the target of recreational and Aboriginal fisheries (at least historically), and they have different habitat preferences and prey than rainbow trout, indicating potentially different tissue metals profile. A total of 79 tissue samples were collected and submitted for laboratory analysis: 20 whole fish for rainbow trout and 19 whole fish for mountain whitefish; 10 muscle and 10 liver for rainbow trout; and 10 muscle and 10 liver for mountain whitefish.

Each of these 218 tissue samples was analyzed for percent moisture, concentrations of 41 total metals, and percent lipid content. Sub-sets of whole fish, liver, and muscle samples were also analyzed for methyl-mercury (MeHg) concentration. The metals analyzed and their method detection limits (MDL) were consistent with the requirements of the BC MOE (BC MOE, 2012).

5.1.2.6.3.2.5.14.1 Principal Component Analysis (PCA)

Because there were two species, three tissue types, and a large number of analytical variables, PCA was used to identify major trends in the fish tissue metals data set and remove redundancies in the data set (Section 5.13 of **Appendix 5.1.2.6B**).

The first three principle components extracted by PCA explained a cumulative total of 66.2% of the total variance of the data matrix. The first component, PC1, explained 35.8% of the total variance and was significantly ($P<0.001$) positively correlated with 22 heavy metals. It was interpreted as representing the concentration of heavy metals. (Note that the term “heavy metals” is conventionally used to describe a loosely defined subset of elements that exhibit metallic properties. The term does not indicate toxicity because all heavy metals, with the exception of mercury, are micro-nutrients that are essential for life and hence are found naturally in all fish tissue.)

The second component, PC2, explained 21.9% of the total variance and was significantly (P<0.001) positively correlated with structural metals such as calcium, aluminum, and manganese and significantly (P<0.001) negatively correlated with heavy metals such as mercury and copper that do not bind to structural tissues such as bones. PC2 was interpreted as the concentration of structural metals.

The third component, PC3, explained 8.4% of the total variance and was significantly (P<0.001) positively correlated with caesium and rubidium – two metals that have similar chemical and physical properties. PC3 was interpreted as representing a geological signature of part of the study area, i.e., location.

Plots of PC2 scores on PC1 scores for mountain whitefish and rainbow trout separated the three types of tissues without any overlap. Whole fish samples had high concentrations of heavy metals and structural metals, liver samples had high concentrations of heavy metals but low concentrations of structural metals, and muscle samples had low concentrations of heavy metals and intermediate concentrations of structural metals.

5.1.2.6.3.2.5.14.2 Mercury

Total mercury (Hg) was given a focused statistical analysis because it is one of the few metals that have no known biological function, and is potentially toxic to plants and animals. All tissue samples collected from mountain whitefish and rainbow trout in Tatelkuz Lake in July 2013 were analyzed for total mercury concentrations, and all concentrations were above the MDL.

Mean total mercury concentrations for both mountain whitefish and rainbow trout were highest in liver tissue and lowest in whole fish.

Only one of the 218 rainbow trout tissue samples collected in 2011 and 2012 exceeded Health Canada’s total mercury guideline for human consumption of 0.5 mg/kg wet weight (wwt) – a liver sample taken from a trout captured from Lake 01682LNRS. None of the rainbow trout and mountain whitefish tissue samples collected from Tatelkuz Lake in July 2013 exceeded Health Canada’s total mercury guideline.

5.1.2.6.3.2.5.14.3 Methyl-mercury

In 2011 and 2012, a total of 13 rainbow trout tissue samples (or 6% of the total) were analyzed for methyl-mercury concentrations. In 2013, another 19 tissue samples were analyzed for methyl-mercury concentrations: 9 rainbow trout and 10 mountain whitefish.

A linear regression of methyl-mercury concentration on total mercury concentration for rainbow trout tissues was highly significant (P<0.001) and explained 75% of the variation in methyl-mercury concentration. The intercept of the regression was not significantly different from zero, and the slope of the regression was 0.51, indicating that, on average, rainbow trout methyl-mercury concentration was 51% of total mercury concentration.

A linear regression of methyl-mercury concentration on total mercury concentration for mountain whitefish tissues was also highly significant ($P<0.001$) and explained 80% of the variation in methyl-mercury concentration. The intercept of the regression was not significantly ($P>0.05$) different from zero, and the slope of the regression was 0.32, indicating that, on average, mountain whitefish methyl-mercury concentration was 32% of total mercury concentration.

A site-specific methyl-mercury guideline of 0.062 mg/L was calculated by determining the species of fish-eating birds that resides or visits the Project area that has the highest potential consumption rate of fish. For the rainbow trout samples of 2011 and 2012, only two tissue samples from a single rainbow trout from Lake 01682LNRS would be classified as exceeding that guideline. For the fish samples collected from Tatelkuz Lake in July 2013, only one mountain whitefish sample exceeded the Blackwater site-specific methyl-mercury TRG of 0.062 mg/kg wwt – a liver from a 347 mm-long fish.

5.1.2.6.3.2.5.14.4 Selenium

Selenium (Se) was also the subject of focused analysis because it is an essential micronutrient for all animals, but it is toxic in high concentrations. Its primary toxic effect on fish is on egg and larval mortality. Adults transfer (or depurate) selenium from their muscles and organs to developing eggs and sperm. Elevated concentrations may cause deformities in embryos and larvae that lead to death.

For both rainbow trout and mountain whitefish sampled from Tatelkuz Lake in July 2013, mean total selenium concentration was highest for liver tissue and lowest for muscle tissue, with whole fish having an intermediate concentration. A different situation was found in the rainbow trout samples collected in 2011 and 2012 – the highest selenium concentrations were found in muscle and whole body samples of juvenile rainbow trout. Pooling all rainbow trout tissues for all three years showed highly significant ($P<0.001$) negative correlations of selenium concentration and body length for both muscle and whole body tissues but not for liver.

The most reasonable explanation for that observation is that it reflects the difference between selenium uptake from diet and selenium depuration into eggs and milt. Both processes are linked to changes in body size and habitat. Juvenile rainbow trout accumulate selenium in their livers and muscle as they feed and grow in streams. Sexually mature adults living in lakes also accumulate selenium in their tissues, but are able to transfer some of it from muscle tissue into eggs and milt – which are expelled during spawning. Hence, their total selenium concentrations in muscle and whole fish samples are lower than those of juvenile fish.

None of the rainbow trout and mountain whitefish tissue samples exceeded the lowest of the three selenium guidelines issued by the BC MOE and the BC Ministry of Health (i.e., 1.8 mg/kg wwt for 7 servings/week).

BC MOE established a draft total selenium whole fish guideline for protection of aquatic life of 1 mg/kg wwt. The guideline was exceeded by all 59 of the liver samples collected from lakes and streams in 2011 and 2012, but by none of the muscle samples. Eight whole rainbow trout collected from streams in 2011 and 2012 exceeded the guideline. That guideline was also exceeded by all of the rainbow trout liver samples collected from Tatelkuz Lake, but none of the muscle or whole fish samples.

5.1.2.6.3.2.6 Mountain Whitefish

Mountain whitefish was the third most common species captured in Tatelkuz Lake in 2013, comprising 12.8% of the total number of fish observed and captured from that lake. It was the sixth most common species captured in stream surveys in 2011 and 2012, comprising 0.1% of the total number of fish observed and captured.

Mountain whitefish is one of many species of whitefishes (Subfamily Coregoninae) in the northern hemisphere. It is a lake-resident fish that spawns in large tributary streams in late fall and early winter (Roberge et al., 2002) (**Table 5.1.2.6-27**). No nest is prepared. Instead, eggs are broadcast over gravel. Adults return to lakes immediately after spawning. Embryos develop in the gravel over winter and fry emerge in spring and immediately migrate to residence lakes. Their diet consists mainly of BMI.

In BC, mountain whitefish is a sport fish and historically a food fish. It is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

The mountain whitefish spawning survey of fall 2012 (described in **Appendix 5.1.2.6A**) was restricted to selected tributary streams. There was no survey of mountain whitefish spawning activity in Tatelkuz Lake because, although beach spawning in lakes is known for some BC populations of mountain whitefish (e.g., in Okanagan Lake), there is no historical record or TK information that indicates beach spawning by mountain whitefish in Tatelkuz Lake. There are gravel and cobble substrates in the littoral zone of Tatelkuz Lake, but the steep sides of the lake and its narrow littoral zone do not provide abundant spawning habitat.

The fall 2012 survey showed that mountain whitefish spawners were present in low numbers in lower Davidson Creek and in Creek 705. This indicates the existence of at least two populations in the aquatics LSA: one population that resides in Tatelkuz Lake and spawns in Chedakuz Creek and its tributaries and a second population that resides in one or more lakes in the Fawnie Creek Watershed and spawns in Fawnie Creek and its tributaries.

The large number of mountain whitefish residing in Tatelkuz Lake indicates that they require large amounts of spawning habitat. The low numbers of spawners captured in streams in fall 2012 indicates that either most spawners do not use small tributary streams to Chedakuz Creek. Therefore, it is likely that most mountain whitefish residing in Tatelkuz Lake spawn in Chedakuz Creek because it is the main inlet and outlet of the lake and is the largest stream in the immediate vicinity of the lake. Middle Chedakuz Creek is the most likely spawning location because newly-emerged fry would be washed downstream into Tatelkuz Lake. The use of Chedakuz Creek by mountain whitefish for spawning and embryo incubation has not yet been confirmed due to the difficulty in installing hoop nets in such a large stream, particularly at higher fall discharges.

5.1.2.6.3.2.7 Longnose Sucker

Longnose sucker was the sixth most common species captured in Tatelkuz Lake in July 2013, comprising 4.2% of the total number of fish captured or observed. It was the fourth most common species captured in stream surveys in 2011 and 2012, comprising 0.2% of total number of fish observed or captured.

It belongs to the sucker family (Family Catostomidae). It resides in both lakes and rivers and feeds exclusively on BMIs. Immediately after ice-out in spring, adult longnose suckers migrate to spawning sites in tributary streams (Roberge et al., 2002) (**Table 5.1.2.6-27**). Eggs are sticky and are deposited on the surface of gravel (Scott and Crossman, 1973). Adults quickly return to their residence area, whether lake or stream. Fry hatch several weeks later and migrate to their residence lake.

Longnose sucker is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

Tatelkuz and Kuyakuz lakes are probably the primary residence lakes for longnose sucker in the LSA and RSA. Burns (1977) reported them present in Kuyakuz Lake, and Walsh and Hale (1977) reported them present in Tatelkuz Lake. In 2012, they were captured in the two headwater lakes of Creek 705 (Lake 01538UEUT and Lake 01428UEUT), but not in Lake 01682LNRS, the headwater lake of Davidson Creek.

The population structure of longnose sucker in the LSA and RSA is not well understood because of low catches. A working hypothesis is the presence of at least four separate populations – one each for Tatelkuz Lake, Kuyakuz Lake, Lake 01538UEUT, and Lake 01428UEUT.

5.1.2.6.3.2.8 Largescale Sucker

Largescale sucker was the eighth most common species captured in Tatelkuz Lake in 2013, comprising 0.9% of the total number of fish captured or observed. It was not captured in stream surveys conducted in 2011 and 2012.

Largescale sucker is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

Largescale sucker belongs to the sucker family (Family Catostomidae). It resides in both lakes and slow-moving rivers. Adults feed primarily on BMI and periphyton, while juveniles feed on plankton. They spawn in the spring, after water temperatures reach a minimum of 8°C (**Table** 5.1.2.6-27). Spawning takes place over coarse gravel or cobble substrates. Spawning sites are typically located in shallow water areas of lakes or adjacent to riffles in rivers. No nest is created, although the substrate is cleaned and a shallow depression is created during egg release. Eggs are broadcast over the cleaned gravel and adhere to the gravel surface. Fry emerge between 7 and 20 days after fertilization, depending on temperature.

Tatelkuz and Kuyakuz lakes are the primary residence lakes for largescale sucker in the LSA and RSA (Burns, 1977). The population structure of largescale sucker in the LSA and RSA is not well understood because of low catches in 1977 and 2013.

5.1.2.6.3.2.9 White Sucker

White sucker was the ninth most common species captured in Tatelkuz Lake in 2013, comprising 0.2% of the total number of fish captured or observed. A single white sucker was captured in 2012 by minnow traps at a stream that will be crossed by the transmission line. That single fish comprises 0.004% of the total number of fish counted and captured in streams in 2011 and 2012.

White sucker belongs to the sucker family (Family Catostomidae). Like the longnose sucker, it resides in lakes and streams and migrates to tributaries in spring to spawn (Scott and Crossman, 1975) (**Table 5.1.2.6-27**). It feeds on BMI.

White sucker is reported as a species captured in Aboriginal fisheries in the aquatics LSA.

Its population structure in the LSA and RSA is not well understood because of low catches. One population exists in Tatelkuz Lake, and at least one other population exists in a watershed along the transmission line corridor.

5.1.2.6.3.2.10 Burbot

Burbot was the tenth most common species captured in Tatelkuz Lake in 2013, comprising 0.1% of the total number of fish captured. It was the seventh most common species captured in streams in 2011 and 2012, comprising 0.01% of the total number of fish observed and captured.

Burbot are the only freshwater member of the cod family (Family Gadidae). They are also one of only two species in the LSA and RSA that spawn in winter (January to March) (**Table 5.1.2.6-27**). The other winter-spawning species is mountain whitefish, which spawn in early winter. Burbot spawn mainly on lake shoals or in the outlets of lakes (Scott and Crossman, 1973). Embryos take 1 to 2 months to develop, depending on temperature (McPhail, 2007). Juveniles feed on algae and BMI. Adult burbot are predators of fish eggs and juveniles, as well as of BMI.

Burbot are targets of both recreational and Aboriginal fisheries in the aquatics LSA.

Burbot population structure in Tatelkuz Lake is not well understood because of low catches. One population exists in Tatelkuz Lake and at least one population exists in the Fawnie Creek Watershed, based on the capture of four burbot in June 2011 as they passed through hoop nets in lower Creek 705 and the capture of several burbot in lower Creek 705 in July 2013. Their capture during the rainbow trout spawning season in 2011 suggests they were intent on eating rainbow trout eggs.

5.1.2.6.3.2.11 Northern Pikeminnow

Northern pikeminnow was the fourth most common species captured in Tatelkuz Lake in July 2013, comprising 6.9% of the total number of fish captured and observed. Pikeminnow were not captured in streams in 2011 and 2012.

Northern pikeminnow is the largest native member of the minnow family (Family Cyprinidae) in British Columbia. Northern pikeminnow are mainly found in lakes and slow-moving rivers, with adults preferring deeper habitat than juveniles (Scott and Crossman, 1973). The diet of juvenile northern pikeminnow is dominated by insects and plankton while adults feed primarily on fish. This species is the dominant predator of the Tatelkuz Lake fish community.

Northern pikeminnow are not captured in recreational and Aboriginal fisheries in the aquatics LSA.

Northern pikeminnow spawn in spring when water temperature reaches the threshold temperature of 12°C (**Table 5.1.2.6-27**). Spawning typically takes place in shallow water over a gravel-dominated substrate. Spawning sites can be located along lake shores or on stream riffles immediately upstream of lakes. No nest is prepared. Eggs are broadcast over gravel and settle into interstices following fertilization. Fry emerge in approximately 6 days and migrate to shallow lake habitats to rear.

The population structure of northern pikeminnow in the LSA and RSA is not well understood because of low catches in 1977 and 2013. There is at least one population in Tatelkuz Lake. Northern pikeminnow of Tatelkuz Lake probably spawn in Chedakuz Creek or in Tatelkuz Lake itself because no northern pikeminnow were captured during the spring hoop net survey conducted in Davidson Creek, Creek 661 and Turtle Creek in 2011.

5.1.2.6.3.2.12 Lake Chub

Lake chub was the third most common fish species captured in 2011 and 2012, comprising 0.4% of total counts. It was the only species found in Snake Lake. It was caught in relatively large numbers during a gillnet and minnow trapping survey of Snake Lake in 2012. Lake chub were not found in Tatelkuz Lake.

Lake chub are small fish (mean length is usually less than 100 mm) and belong to the minnow family (Family Cyprinidae). The live mainly in lakes and are often the only species found in lakes with shallow depths and low DO concentrations (Scott and Crossman 1973).

Lake chub are too small in size to support recreational or Aboriginal fisheries.

Immediately after ice-out in spring, lake chub migrate to tributary streams to spawn (McPhail 2007) (**Table 5.1.2.6-27**). In the LSA and RSA, spawning would occur in May and June. However, lake spawning has also been reported (McPhail 2007). Embryos take only one week to complete development and emerge from their nests in June and July (McPhail 2007). Juveniles and adults feed mainly on the smaller members of the BMI community.

The population structure of lake chub in the LSA and RSA is not well understood because of low catches. One population exists in Snake Lake and another in Kuyakuz Lake (Burns, 1977). Avison (2010b, 2010c, 2010d) reported lake chub present in lakes of the Chu Molybdenum Project area in a watershed that drains via an unnamed creek into the eastern side of Chedakuz Creek downstream of Tatelkuz Lake. Ecofor (2004) reported lake chub in upper Matthews Creek, a tributary to Laidman Lake of the Fawnie Creek Watershed.

5.1.2.6.3.2.13 Slimy Sculpin

Slimy sculpin was the fifth most common species captured in Tatelkuz Lake in 2013, comprising 4.8% of the total number of fish captured and observed. All but two slimy sculpin were captured in minnow traps and they comprised the largest portion of the total minnow trap catch (58 of 114 or 51%). No slimy sculpin were captured in streams in 2011 and 2012.

Slimy sculpin members of the Family Cottidae. They are typically found along lake bottoms or in cool, rocky streams. Their diet generally consists of aquatic insect larvae and nymphs (Scott and Crossman, 1973). Slimy sculpin are prey for larger, predaceous fishes such as northern pikeminnow, rainbow trout, and burbot.

Slimy sculpin are too small in size to support recreational or Aboriginal fisheries.

Slimy sculpin spawning typically occurs in mid-March to early April, when water temperature reaches 4°C (**Table 5.1.2.6-27**). Males excavate and defend nest cavities beneath flat rocks in preparation for spawning. Females enter the nest and deposit their adhesive eggs on the ceiling of the nest. Males then guard the eggs until they hatch, usually for approximately one month. Larvae typically remain in the nest for 2 weeks after hatching.

The population structure of slimy sculpin in the LSA and RSA is not well understood because of low catches in 1977 and in 2013. There is at least one population in Tatelkuz Lake.

5.1.2.6.3.2.14 Brassy Minnow

Brassy minnow was the seventh most common species captured in 2013, comprising 2.5% of the total number of fish observed and captured in Tatelkuz Lake. They were the fifth most common species captured in streams in 2011 and 2012, comprising 0.1% of the total number of fish observed and captured.

Brassy minnow are small in body size and belong to the Family Cyprinidae. They are found mainly in small streams and wetlands where they feed on a wide assortment of plants and small invertebrates. Distribution in BC is disjunct, with isolated populations in the lower Fraser Valley and in the Nechako Lowlands near Vanderhoof and Prince George (McPhail 2007; Nowosad, 2013). For this reason, brassy minnow is classified by the BC CDC (2013) as “S2S3” (i.e., “Imperilled, Special concern, Vulnerable to extirpation or extinction”).

Brassy minnow are too small in size to support recreational or Aboriginal fisheries.

Spawning of brassy minnow begins in mid-June and continues to early August (McPhail 2007) (**Table 5.1.2.6-27**). Embryo development is rapid and fry emerge in less than 1 week.

The population structure of brassy minnow in the LSA and RSA is not well understood because of low catches. There is at least one population in Tatelkuz Lake.

5.1.2.6.3.2.15 Longnose Dace

A single longnose dace was captured by backpack electrofishers in lower Chedakuz Creek in 2011. It comprised 0.004% of all fish observed and captured in streams in 2011 and 2012.

Longnose dace are too small in size to support recreational or Aboriginal fisheries.

This species is a small fish (adults approximately 100 mm long) that belongs to the minnow family (Family Cyprinidae). It resides in lakes and streams and spawns in spring and early summer (**Table 5.1.2.6-27**). It feeds on benthic macroinvertebrates.

The population structure of longnose dace in the LSA and RSA is not well understood because of low catches. However, at least one population exists in lower Chedakuz Creek.