
MOUNT NANSEN SITE

FISHERIES AND AQUATICS EXISTING CONDITIONS REPORT

PREPARED FOR:

GOVERNMENT OF YUKON
ASSESSMENT AND ABANDONED MINES
P.O. BOX 2703
WHITEHORSE, YUKON Y1A 2C6

PREPARED BY:



204-105 TITANIUM WAY
WHITEHORSE, YUKON
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EXECUTIVE SUMMARY

The Government of Yukon, Assessment and Abandoned Mines (AAM) is preparing for an assessment of proposed care and maintenance activities at the Mount Nansen Site, an abandoned gold and silver mine located approximately 45 km west of Carmacks, YT. Ecological Logistics & Research Ltd. (ELR) was retained by AAM to conduct fish and aquatic environment studies at the Mount Nansen Site in support of care and maintenance for the Site. AAM is anticipating this assessment by the Yukon Environmental and Socio-economic Assessment Board to be at the Designated Office level, although the studies programs had originally anticipated an assessment at the Executive Committee Level for the overall remediation of the Site.

As part of this project, ELR conducted fisheries and aquatic environment studies at the Mount Nansen Site during 2012, 2013, and 2014 to refine information on the fish-bearing status or usage by fish of project area watercourses, and describe fish habitat and characterize aquatic environment features in watercourses that are under direct influence of the Site. The objectives of the studies were:

- To investigate the fish-bearing status of Pony and Dome Creeks.
- To detail the characteristics of barriers to fish passage on Pony and Dome Creeks at late spring water levels.
- To collect information on fish presence, relative abundance and usage in Back and Victoria Creeks during the late spring and early/late summer periods.
- To collect information on fish usage, relative abundance, and distribution in deep pool habitat in Victoria Creek during the late summer period.
- To characterize fish habitat and to collect data on stream sediments, benthic macroinvertebrates and periphyton in Site watercourses.

Dome and Pony Creeks were assessed to characterize the current status of barriers to fish passage, and to confirm the fish-bearing status of each watercourse. Barriers were noted on both creeks, and no fish were captured, confirming the non-fish-bearing status of these watercourses.

Back Creek and Victoria Creek were assessed for fish on multiple occasions. A heavy sediment load in Back Creek was observed during one study event, but other events found low usage and poor habitat upstream, but higher quality habitat that was used by young of year Arctic Grayling near the outlet into Victoria Creek. Victoria Creek was found to have moderate habitat complexity, and was used consistently by Arctic Grayling, Slimy Sculpin, and Burbot. Despite apparently better quality habitat in the upper portion of the areas assessed, the frequency of fish capture was greater downstream of the Site. The study also identified that numerous large, deep pools are used extensively as later summer staging and feeding habitat.

An existing conditions aquatic environment assessment was completed in August of 2013, with some additional sampling during the summer of 2014. Sampling for stream sediment, periphyton, benthic macroinvertebrates was conducted, and an inventory of physical stream characteristics was completed at 12 sample sites. Results show that the majority of quality fish habitat is located in Victoria Creek, which provides a wider range of habitat features including deep pools, undercut stream banks, and overhanging woody debris.



Victoria Creek had the most diverse and species rich benthic and periphyton communities of the streams sampled, and the quality of habitat in Victoria Creek was consistent among the areas sampled, showing only minor differences between upstream and downstream sample sites. All sediments collected from Victoria Creek, including samples from the reference station, show elevated concentrations of arsenic in excess of Canadian Council of Ministers of the Environment (CCME) guidelines.

Back, Dome, and Pony Creeks had variable benthic macroinvertebrate and periphyton communities both amongst and within watercourses, but generally showed characteristics of watercourses affected by contamination. Contamination indicators included reduced species richness, lower indices of diversity or evenness, and prevalence of known contamination-tolerant species. Many sediment samples from these watercourses exceeded CCME guidelines for arsenic, zinc, cadmium, lead, copper, and silver. No definitive patterns were observed between upstream and downstream sampling stations, however the results for Dome and Pony Creeks suggest existing site influences are currently affecting aquatic resources within those streams.



CONTRIBUTING STAFF

This Mount Nansen Existing Conditions Study Program was conducted by Ecological Logistics & Research Ltd. (ELR). The following staff contributed to the success of this program:

Project Management	Chris Jastrebski
Field Program	Chris Jastrebski, Jesse Vigliotti, John Minder, Jonathan Lowey, Michelle McKay, Glenn Rudman
Data Entry and Analysis	Chris Jastrebski, Jesse Vigliotti, Aaron Nicholson, Jonathan Lowey
Authorship and Review	Chris Jastrebski, Aaron Nicholson, Glenn Wagner
Spatial Data Analysis and Mapping	Heidi Schindler, Chris Jastrebski

ACKNOWLEDGMENTS

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Chris Jastrebski, M. Sc., R.P.Bio.
Ecological Logistics & Research Ltd.
867.668.6386
chris@elr.ca



MOUNT NANSEN SITE, FISHERIES AND AQUATICS EXISTING CONDITIONS REPORT

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I. INTRODUCTION

Yukon Government, Assessment and Abandoned Mines (AAM) is preparing for an assessment of proposed care and maintenance activities at the Mount Nansen Site (the Site), an abandoned gold and silver mine located approximately 45 km (70 km by road) west of Carmacks, Yukon (herein referred to as the Site).

As part of the Site planning process, Ecological Logistics & Research Ltd. (ELR) was retained by AAM to conduct environmental studies to build upon previous existing conditions works conducted at the Mount Nansen Site and fill gaps in existing conditions data.

This report details fish, fish habitat, and aquatic environment studies conducted at the area between 2012 and 2014. These studies built on previous studies conducted at the Site (i.e., EDI 2007, EDI 2008, EDI 2009a, EDI 2009b, EDI 2009c), as well as on data gaps analyses prepared based on the most recent project proposal plan (CH2M HILL 2012).

Previous studies at the Mount Nansen Site suggested several watercourses had low usage by fish (Back Creek) or were non-fish-bearing (Dome and Pony Creeks; EDI 2007, EDI 2009a, 2009b). These studies on fish distribution were conducted in late summer and early fall when water levels are often reduced, and fish may have begun to move downstream from seasonally used areas to over-wintering areas. Additionally, a comprehensive set of recent data describing the aquatic environments in relation to the Site did not exist. Accordingly, additional studies were suggested to:

- Investigate the distribution of fish within the Site area during late spring/early summer, when fish species present in nearby systems are more likely to use upstream/headwater habitats.
- To record the current characteristics of barriers to upstream fish passage in Pony and Dome Creeks.
- To investigate the current characteristics of benthic macroinvertebrate, stream sediment, and periphyton communities in the study area, along with related stream habitat characteristics.

These studies were conducted with the intent of fulfilling existing conditions data requirements for fisheries as outlined in Section 4.1.11 of the YESAB *Proponent's Guide to Information Requirements for Executive Committee Project Proposal Submissions*, including to:

- Provide details on fish presence, abundance, and spatial/temporal distribution.
- Document critical and sensitive habitat, including relevant spawning, over-wintering, and migration periods and locations.
- Provide an account of existing conditions study methods, habitat surveys, and results of fieldwork.
- Provide a summary inventory of benthic invertebrates and periphyton existing conditions data for affected drainages including, where applicable, sample site descriptions, species abundance, spatial distribution, taxonomy, biomass, and chlorophyll contents.
- Provide information describing the geological and chemical characteristics of streambed sediments.



This report presents the following information: Section 2 describes the objectives and scope of the report; Section 3 describes the study area; Sections 4 and 5 contain the methods and results for the distribution, habitat use, and habitat assessment for fish in the study area; and Section 6 describes stream sediments, benthic macroinvertebrates, and periphyton in the study area. A summary discussion is presented in Section 7.

2. OBJECTIVES AND SCOPE

The objective of the fish and aquatics existing conditions study program was to refine information on the fish-bearing status, fish usage, and aquatic environment characteristics of Site area watercourses, specifically:

- To investigate the fish-bearing status of Pony and Dome Creeks.
- To detail the characteristics of barriers to fish passage on Pony and Dome Creeks at late spring water levels.
- To collect information on fish presence, relative abundance and usage in Back and Victoria Creeks during the late spring and early/late summer periods.
- To collect information on fish usage, relative abundance, and distribution in deep pool habitat in Victoria Creek during the late summer period.
- To characterize fish habitat and to collect data on stream sediments, benthic macroinvertebrates and periphyton in Site watercourses.

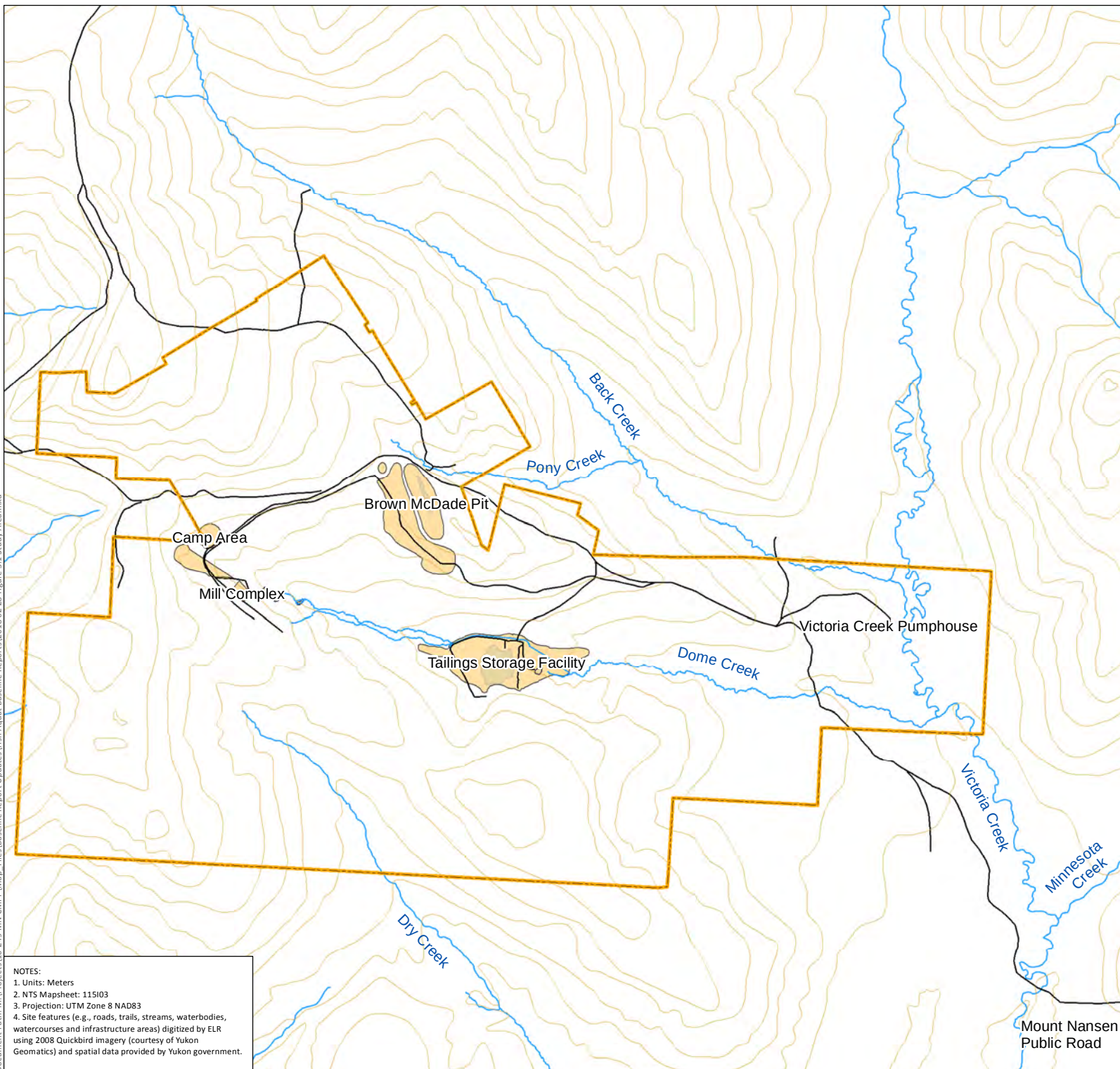
3. STUDY AREA

The fisheries and aquatics existing conditions study program was based on a study area delineated in relation to the Site (Figure 3.1). The study area included watercourses under the potential influence of the Site, as well as relevant reference sites. Sample sites were located on five streams of the Nisling River Drainage, including:

- Pony Creek which drains a portion of the OIC area downstream of the Brown-McDade Pit area into Back Creek.
- Back Creek, which originates north of the OIC area, is the receiving water for Pony Creek, and flows into Victoria Creek.
- Dome Creek, which originates within the OIC area, flows adjacent to the mill and bunkhouse, flows past the tailings pond area, accepts seepage water from the tailings area, and flows into Victoria Creek.
- Victoria Creek, which originates northeast of the OIC area, is the receiving water for Back Creek and Dome Creek, and flows into the Nisling River.



- Minnesota Creek, which flows into Victoria Creek from east of the study area, and feeds into Victoria Creek between Dome Creek and the access road.



Mount Nansen

Site

Fisheries and Aquatics
Existing Conditions Report



Client:



Legend

Base Layers

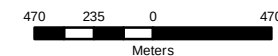
- Roads
- Watercourses
- Existing Site Infrastructure
- Waterbodies

Local Boundaries

- Order In Council Area



Scale: 1:30,000



February 1, 2018

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ELR Project: 16-249

Checked by: CJ

FIGURE 3.1

Fisheries and Aquatics
Study Area Overview

4. FISH DISTRIBUTION AND HABITAT USE

4.1 METHODS

ELR conducted fisheries studies within the study area during the late spring, mid-summer, and late summer, distributed across 2012 and 2013. Table 4.1 provides an overview of fisheries existing conditions field studies in 2012 and 2013.

Table 4.1: Summary of 2012 and 2013 Fisheries Existing Conditions Effort

Date	Watercourses Investigated	Purpose of Study
June 21-22, 2012	Dome Creek, Pony Creek Victoria Creek, Back Creek	Fish-bearing status Fish presence and distribution
July 24-25, 2012	Victoria Creek, Back Creek	Fish presence and distribution
August 23-30, 2013	Victoria Creek, Back Creek	Fish presence and distribution

All studies were conducted under the terms of scientific collection permits obtained from Fisheries and Oceans Canada (DFO); permit XR 171 2012, and permit XR 304 2013 (Appendix I).

4.1.1 Field Methods

ELR employed several field methods to capture fish or assess fish presence or habitat use during the study program. During all assessments, fish captured were identified, measured (fork or total length in millimeters), and released close to the capture site.

Backpack electrofishing was the primary technique used during the studies, employing a Smith Root LR-24 electrofisher. Electrofishing was conducted by two staff, an operator and netter, while moving upstream in each watercourse. Due to the size and variable nature of Victoria Creek, habitat-focused electrofishing was conducted where crews target riffles, the periphery of pools, margin habitats, back channels, and channel edges. When assessing smaller streams including Pony, Back, and Dome Creeks, the entire width of the stream was assessed while moving in an upstream direction.

Seine netting was employed by ELR in deep pool habitats of Victoria Creek where good fish holding or feeding habitat was suspected, and electrofishing was not possible. This effort was completed on a limited number of pools where seining could be safely conducted by field staff. Seine netting was conducted using a standard beach seine (15 m x 1.2 m; 5 mm mesh).

ELR also conducted visual assessments of deep pools in selected areas of Victoria Creek, where electrofishing or seining were not possible (i.e., too deep, or blocked by woody debris), to survey late summer habitat use within that watercourse. Visual assessments were conducted in an upstream sequence by two ELR staff working from shore equipped with dry suits and snorkel masks. Spaced at equal distance over the length of the pool, each observer immersed their head under water to enumerate fish species and numbers and assign life stages based on estimated lengths and previous electrofishing results from the creek. Observation times used to enumerate the fish community in deep pools ranged from 30 seconds to three minutes.

4.1.2 Effort Details

4.1.2.1 June 2012 Confirmation of Fish-Bearing Status – Dome and Pony Creeks

ELR assessed the entire connected length of Dome and Pony Creeks to provide a current confirmation of the non-fish-bearing status of these watercourses. As well, the current characteristics of barriers to fish passage were documented during late spring high water conditions. The entire length of each watercourse was walked, starting from their respective outflows into Victoria and Back Creeks. The location and characteristics of barriers along the length of each watercourse were recorded, as were general conditions within each watercourse. Each watercourse was electrofished from the outlet upstream to a significant next barrier to upstream fish passage, and representative photos of the watercourses and barriers were taken.

4.1.2.2 June/July 2012 Fish Presence and Usage – Victoria and Back Creeks

ELR assessed portions of Victoria Creek and Back Creek to provide information on fish presence during the late spring and early/late summer periods. This assessment employed a combination of backpack electrofishing and seine netting to inventory the fish species present, their life stages, and to provide an indication of habitats being used by fish. The areas assessed by ELR during this effort included Victoria Creek in the vicinity of the access road crossing and Back Creek, including its confluences with Victoria Creek and Pony Creek.

Seine netting also was conducted in deep pools within Victoria where good fish holding or feeding habitat was suspected, and backpack electrofishing was not possible.

4.1.2.3 August 2013 Fish Presence and Usage – Victoria and Back Creeks

ELR assessed portions of Victoria Creek and Back Creek to provide current information on fish presence during the late summer period. This assessment used a combination of backpack electrofishing and visual assessments to inventory fish species present and their life stages, and to provide an indication of the habitat being used. The areas assessed by ELR during this effort included Victoria Creek in the vicinity of the access road crossing and Back Creek, including upstream of its confluences with Victoria Creek and Pony Creek.

4.2 RESULTS

4.2.1 2012 Confirmation of Fish-Bearing Status – Dome and Pony Creeks

4.2.1.1 Dome Creek

Dome Creek was accessed at its outflow into Victoria Creek, and was assessed upstream approximately 845 m to the point of crossing at the Site access road (Figure 4.1). Only one potential barrier was noted, which occurs at the outflow of Dome Creek into Victoria Creek (Photo 1), a 45 cm cascade with a total pool depth of 58 cm where the channel of Dome Creek is supported by vegetation at the edge of an undercut bank of Victoria Creek. This cascade was determined to be a temporary barrier that could change in the future with stream erosion.

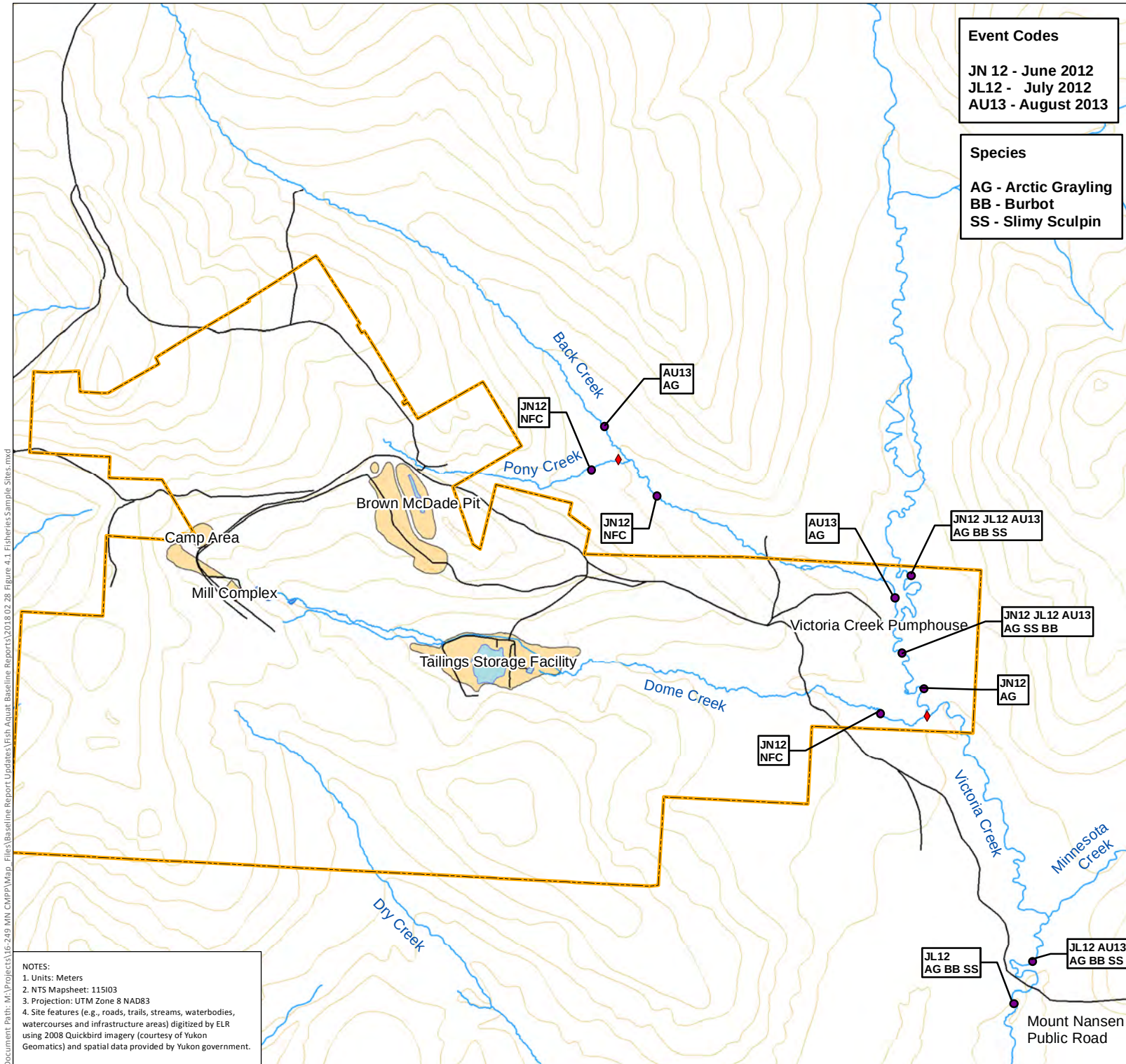
ELR electrofished the length of Dome Creek from Victoria Creek to the Site access road crossing (1,210 seconds effort). All areas of the creek within this length were fished, due to its small width. Electrofishing effort settings are summarized in Table 4.2, below.

Although suitable potential fish habitat was observed within Dome Creek (Section 5.1.2.2), the potential barrier observed at its outlet is currently still likely to prevent fish from entering from Victoria Creek, although there may be potential for adult Arctic Grayling to enter during high water conditions. The cascade was smaller than that described by EDI (2009b) (0.94 m in the previous study) and a proportionately deeper pool was present beneath the cascade, due to the higher water level in Victoria Creek. No fish were captured or observed in Dome Creek during the electrofishing assessment. The absence of Arctic Grayling likely is due to a combination of the barrier, elevated water metals concentrations, and high suspended solids concentrations due to metals precipitation. Water in lower Dome Creek has been observed as having concentrations of cyanide, aluminum, arsenic, cadmium, copper, iron, lead, manganese, silver, and zinc exceeding Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life (EDI 2013).

4.2.1.1.1 Pony Creek

Pony Creek was surveyed from its outflow into Back Creek upstream approximately 438 m to an area where a defined channel was no longer visible (Figure 4.1). Several barriers were observed within the creek, the largest of which was a stepped cascade at the outflow of Pony Creek into Back Creek. This cascade consisted of four adjacent drops measuring 28 cm, 51 cm, 58 cm, and 68 cm (upstream direction) having pools beneath measuring 17 cm, 32 cm, 56 cm, and 50 cm, respectively (Photos 2 and 3). Further upstream, two additional potential barriers were observed: a cascade with two adjacent drops measuring 18 and 28 cm (Photo 4); and a cascade with a drop of 46 cm (Photo 5). ELR electrofished the length of stream from Back Creek to the point the channel became undefined (327 seconds effort). All areas of the creek within this length were fished, due to the narrow width of the creek. Electrofishing settings used in Pony Creek are summarized in Table 4.2, below.

Although some suitable potential habitat was observed in Pony Creek (Section 5.1.2.3), the cascade barrier observed at its outlet likely prevents fish from entering from its confluence with Dome Creek. No fish were captured or observed in Pony Creek during the electrofishing assessment. Similar to Dome Creek, water in Pony Creek has been observed as having concentrations of cyanide, aluminum, arsenic, cadmium, copper, iron, and zinc exceeding CCME water quality guidelines for the protection of aquatic life (EDI 2013).



Mount Nansen

Site

Fisheries and Aquatics
Existing Conditions Report



Legend

- ♦ Barrier to Fish Passage
- Fisheries Sample Sites

Local Boundaries

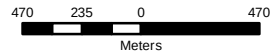
Order In Council Area

Base Layers

- Roads
- Watercourses
- Waterbodies
- Existing Site Infrastructure



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FIGURE 4.1

Fisheries Sampling Locations
and Capture Data

Table 4.2: Backpack Electrofisher Settings and Effort Summary for Dome, Pony, Back and Victoria Creeks in the Mount Nansen Study Area

Watercourse		Date	Effort (seconds)	Distance Fished (m)	Voltage (V)	Duty Cycle	Frequency (Hz)	Power (w)
June 2012 Assessment Efforts								
Dome Creek	From Victoria Creek to access road.	22/06/2012	1,210	845	250	14%	45	60-65
Pony Creek	From Back Creek to top of defined channel.	23/06/2012	327	438	350	14%	45	50-75
Victoria Creek	Downstream of confluence with Back Creek	21/06/2012	703	143	450	14%	45	30
	Upstream of confluence with Back Creek	21/06/2012	260	457	450	14%	45	30
	At confluence with Dome Creek	22/06/2012	131	148	450	14%	45	32
Back Creek	Below inflow of Pony Creek	23/06/2012	436	392	450	14%	45	52
July 2012 Assessment Efforts								
Victoria Creek	Victoria Creek – downstream of MN access road.	24/07/2012	1,322	514	450	14%	40	41-52
	Victoria Creek - upstream of MN access road.	25/07/2012	669	447	480	14%	40	45-52
	Victoria Creek – downstream of confluence with Back Creek	25/07/2012	715	450	480	14%	40	46-52
	Victoria Creek – upstream of confluence with Back Creek	25/07/2012	639	419	480	14%	40	46-52
August 2013 Assessment Efforts								
Back Creek	Lower Back Creek – from the confluence with Victoria Creek upstream	23/08/2013	807	210	350	14%	45	30-55
	Upper Back Creek – upstream of the confluence with Pony Creek	30/08/2013	1,052	321	400	14%	45	49-55
Victoria Creek	Victoria Creek – downstream of the confluence with Back Creek	23/08/2013	997	77	400	14%	45	57-63
	Victoria Creek – upstream of the access road crossing	23/08/2013	1,248	300	400	14%	45	55-60
	Victoria Creek – upstream of the confluence with Back Creek	23/06/2013	1,020	197	400	14%	45	26-37

4.2.2 June/July 2012 Fish Presence and Usage – Victoria and Back Creeks

4.2.2.1 June Fish Survey

ELR documented late spring fish communities in Victoria and Back Creeks from June 21 to 23, 2012. At this time, Back Creek had a high sediment load, likely originating from a placer mining operation at the upper reaches of that stream. ELR electrofished 392 m of targeted habitats in Back Creek during turbid conditions on June 23, however no fish were observed or captured (436 seconds effort). A summary of electrofishing settings used in Back Creek is provided in Table 4.2, above, with study areas shown in Figure 4.1.

ELR assessed Victoria Creek from June 21-23. At the time, water levels in Victoria Creek were very high, making fisheries assessment difficult (Photos 6 and 7). Seine netting or snorkel surveys were not possible under the high water conditions. ELR did attempt electrofishing, although fast currents resulted in conditions that were difficult and even unsafe in most areas. Three areas of Victoria Creek were assessed: 457 m upstream and 143 m downstream from the confluence with Back Creek; and 148 m downstream from the confluence with Dome Creek. A total electrofishing effort of 1,094 seconds was expended at this time over a length of 738 m of stream (703, 260, and 131 seconds, respectively), resulting in the capture of only one juvenile Burbot (280 mm) and one adult Arctic Grayling (292 mm). The fast currents and high water levels are thought to have influenced the ability to capture fish in Victoria Creek.

4.2.2.1.1 July Fish Survey

As a result of conditions encountered at Back and Victoria Creeks in June, ELR conducted further fisheries investigation at the Mount Nansen Site in mid-summer (July 24-25) to assess fish distribution in Victoria Creek. During this second site visit, water levels were lower compared with those observed in June. Although water levels were still not believed to be seasonally representative due to frequent rain events, ELR was able to more effectively assess Victoria Creek than in June.

During the July field visit, two main areas of Victoria Creek were assessed: the vicinity of the Mount Nansen access road crossing, as well as the vicinity of the confluence with Back Creek (Photos 8–10 and Figure 4.1). In total, 1,830 m of the Victoria Creek channel was assessed (3,345 seconds effort). A summary of electrofishing efforts is provided in Table 4.2, with effort areas shown in Figure 4.1. In addition to electrofishing, two seine net passes were made in a large pool located in Victoria Creek downstream of the access road area. The off-channel pool measured approximately 40 m², with a maximum depth of 1.2 m. Arctic Grayling, Burbot, and Slimy Sculpin were captured at both the access road crossing and Back Creek confluence. The catch rate of fish was found to differ between the two areas, higher in the vicinity of the access road, and lower in the Back Creek area. In lower Victoria Creek near the access road crossing, eight Arctic Grayling, five Slimy Sculpin, and one Burbot were captured (961 m, 1,991 seconds effort). Four additional Arctic Grayling and one Burbot were captured through seine netting. The size range of fish captured near the access road crossing was 140-350 mm for Arctic Grayling (fork length), 76-116 mm for Slimy Sculpin (total length), and 217 mm for Burbot (total length; both the same length, potentially the same individual; Table 4.3).

Table 4.3: Summary of Fisheries Captures During 2012 and 2013 Studies on Site Area Streams



Watercourse Areas	June 2012	July 2012	August 2013	Total per Area
Dome Creek – from Victoria Creek to access road.	NFC			NFC
Pony Creek – from Back Creek to top of defined channel.	NFC			NFC
Victoria Creek – upstream of confluence with Back Creek	NFC	- 1 Slimy Sculpin	- 4 Arctic Grayling - 3 Slimy Sculpin - 3 Burbot	- 4 Arctic Grayling - 3 Slimy Sculpin - 3 Burbot
Victoria Creek – downstream of confluence with Back Creek	- 1 Burbot	- 1 Arctic Grayling - 1 Burbot	- 3 Arctic Grayling - 2 Slimy Sculpin - 2 Burbot	- 4 Arctic Grayling - 2 Slimy Sculpin - 4 Burbot
Victoria Creek – at confluence with Dome Creek	- 1 Arctic Grayling			- 1 Arctic Grayling
Victoria Creek – downstream of public access road.		- 12 Arctic Grayling - 4 Slimy Sculpin - 2 Burbot		- 12 Arctic Grayling - 4 Slimy Sculpin - 2 Burbot
Victoria Creek – upstream of public access road.		- 1 Slimy Sculpin	- 12 Arctic Grayling - 2 Slimy Sculpin - 6 Burbot	- 12 Arctic Grayling - 2 Slimy Sculpin - 6 Burbot
Back Creek – upstream of inflow of Pony Creek			- 2 Arctic Grayling	- 2 Arctic Grayling
Back Creek – downstream of inflow of Pony Creek			- 41 Arctic Grayling	- 41 Arctic Grayling
Total Per Event	- 1 Burbot - 1 Arctic Grayling	- 13 Arctic Grayling - 6 Slimy Sculpin - 3 Burbot	- 62 Arctic Grayling - 7 Slimy Sculpin - 11 Burbot	- 76 Arctic Grayling - 13 Slimy Sculpin - 15 Burbot

Notes:

NFC indicates that fisheries effort took place, but that no fish were captured

Blank cells indicate that no fisheries effort took place

In upper Victoria Creek (Back Creek area), one Arctic Grayling (187 mm), one Slimy Sculpin (101 mm), and one Burbot (304 mm) were captured (869 m, 1,354 seconds effort; Table 4.2). A summary of captures is included in Appendix 2.

4.2.3 August 2013 Fish Presence and Habitat Usage – Victoria and Back Creeks

ELR documented late summer fish communities in Victoria and Back Creeks on August 23 and 30, 2013, focusing on main stream habitat and deep pool habitat, respectively.

Victoria Creek

Three areas of Victoria Creek were assessed on August 23: upstream and downstream of the confluence with Back Creek; and upstream of the access road crossing (574 m total, 3,265 seconds effort; Table 4.2). Three species of fish (i.e., Arctic Grayling, Burbot, and Slimy Sculpin) were captured in all three areas of Victoria Creek. In the area upstream and downstream of the Back Creek confluence, a total of seven Arctic Grayling (fork lengths ranging from 60-260 mm), five Slimy Sculpin (total lengths ranging from 86-133 mm), and five Burbot (total lengths ranging from 245-325 mm) were captured (274 m, 2,017 seconds effort) (Table 4.2). In Victoria Creek upstream of the access road crossing, 12 Arctic Grayling (fork length of 58-319 mm), two Slimy Sculpin (total length of 82 and 100 mm), and six Burbot (total length of 241-296 mm) were captured (300 m, 1,248 seconds effort). A summary of fish captures is included in Appendix 2.

Two areas of Victoria Creek containing extensive pool habitat (upstream of the confluence with Back Creek, and upstream from the access road crossing) were visually assessed for fish species, abundance, and life stages present on August 30, 2013 (Figure 4.1). High densities of Arctic Grayling were observed

in both areas. In the area upstream of the confluence with Back Creek (510 m section), 33 subadult/adult, two juvenile, and two young of year Arctic Grayling (37 total) and one Slimy Sculpin were observed (Table 4.4). Subadult or adult Arctic Grayling were present in 12 of the 18 pools surveyed, representing a 66% occupancy rate. Where subadult or adult Arctic Grayling were present, abundance ranged from 1 to 13 in an individual pool. In the area upstream of the access road crossing (669 m section), 46 subadult/adult, one juvenile, and one young of year Arctic Grayling (48 total) and two Slimy Sculpin were observed (Table 4.4). Subadult or adult Arctic Grayling were present in 11 of the 14 pools surveyed, representing a 79% occupancy rate. Where subadult or adult Arctic Grayling were present, abundance ranged from 1 to 11 in an individual pool.

Back Creek

ELR electrofished Back Creek upstream of its confluence with Victoria Creek on August 23. Forty-one young of year Arctic Grayling (fork lengths <70 mm) and one Slimy Sculpin were captured (210 m, 807 seconds effort) (Table 4.2). It is difficult to sample the channel in this section of Lower Back Creek because of heavy shrub cover along the banks and large amounts of woody debris in the channel, therefore only a fraction of the young of year Arctic Grayling observed were captured (we estimate that only 10-20% of those observed were captured). Accordingly, the density of young of year Arctic Grayling in this length of channel was extremely high. ELR also electrofished a segment of Back Creek upstream of the confluence with Pony Creek. Here, two sub-adult Arctic Grayling (fork lengths of 178 and 186 mm) were captured (321 m, 807 seconds effort). This reach of Back Creek has been altered by historic placer mining activities and has very little cover. Accordingly, it was possible to electrofish the entire stream width along this reach with high catch success rates.

Table 4.4: Summary of 2013 Victoria Creek Visual Pool Assessments

Effort	Upstream Sequential Pool Number	Fish Species			
		Arctic Grayling			Slimy Sculpin
		Young of Year	Juvenile	Subadult/ Adult	
Upper Victoria Creek, near confluence with Back Creek (510 m)	1			1	
	2				
	3			6	
	4				
	5				
	6			1	
	7			2	
	8			13	
	9		1	1	
	10				
	11			2	
	12			2	1
	13	1	1		
	14			1	
	15				
	16	1		1	
	17			1	
	18			2	
Lower Victoria Creek, upstream of access road crossing (669 m)	1				
	2			5	
	3			1	
	4			5	
	5			1	1
	6	1	1	6	
	7			1	
	8			2	
	9				
	10				
	11			1	
	12			3	
	13			10	
	14			11	1

Notes:

Arctic Grayling life stages were estimated based on underwater observations, based on prior electrofishing fork length data, where:

Young of Year = < 80 mm fork length

Juvenile = 80-200 mm fork length

Sub-adult/adult = >200 mm fork length

5. FISH HABITAT ASSESSMENT

ELR assessed the characteristics of aquatic habitat on each of the streams in the study area as part of the aquatic environment existing conditions study program. The purpose of assessing aquatic habitats was to describe the stream characteristics, and to characterize the distribution and value of stream habitat within the study area for fish and other aquatic resources.

5.1.1 Methods

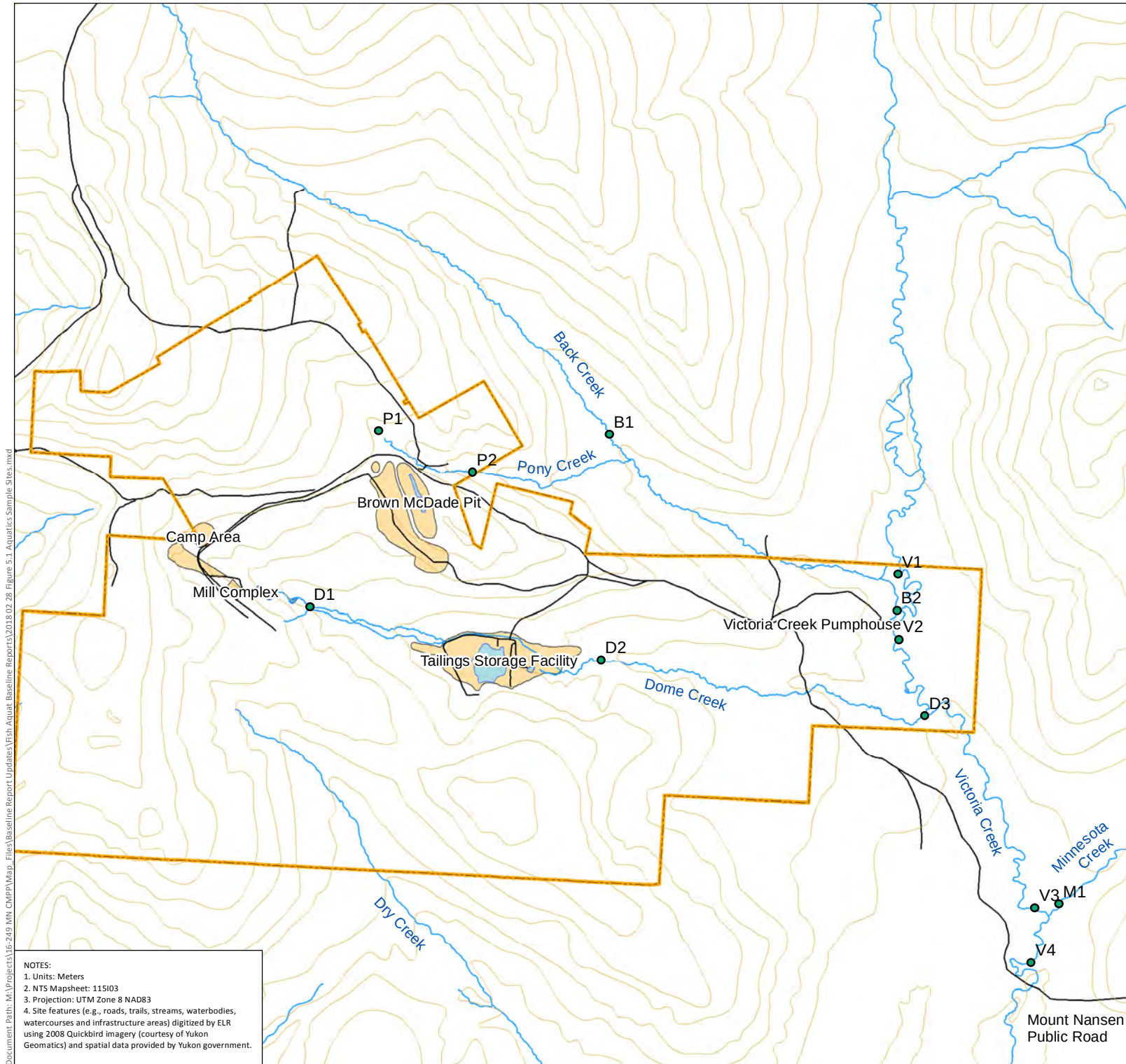
Site Selection

ELR established 12 fish habitat / aquatic environment assessment sites on Victoria, Dome, Back, Pony, and Minnesota Creeks, at which to assess fish habitat characteristics. Where possible, sites were selected to either align with sites used in previous or historic studies at the Site (to allow data comparisons over time), and/or to align with water quality monitoring stations (to allow discussion of potential water quality influences). A description of the study sites is provided in Table 5.1 and shown in Figure 5.1. Back, Victoria, and Minnesota Creeks were assessed between August 21 and 22, 2013. Dome and Pony Creeks were assessed from August 28-29, 2013.

Table 5.1: Description of Aquatic Habitat and Aquatic Environment Sample Sites

Watercourse	Site	Site Description
Victoria Creek	V1	Victoria Creek reference site, located approximately 700 m upstream of Back Creek confluence. Placer-affected reference site.
	V2	Victoria Creek downstream of Back Creek confluence and upstream of Dome Creek confluence. Sample site located approximately 150 m downstream of Back Creek confluence.
	V3	Victoria Creek, downstream of Dome Creek confluence, and upstream of Minnesota Creek confluence. Sample site located approximately 100 m upstream of Minnesota Creek confluence.
	V4	Victoria Creek receiving water site, located downstream of Minnesota Creek confluence, and approximately 450 m upstream of the access road crossing.
Dome Creek	D1	Upper Dome Creek, located approximately 300 m downstream from the mill area.
	D2	Middle Dome Creek, located approximately 260 m downstream of the junction of diverted Dome Creek channel with the original channel.
	D3	Lower Dome Creek, located approximately 50 m upstream from the confluence with Victoria Creek.
Back Creek	B1	Upper Back Creek, located approximately 200 m upstream of the Pony Creek confluence. Placer-affected reference site.
	B2	Lower Back Creek, located approximately 100 m upstream from the confluence with Victoria Creek.
Pony Creek	D1	Upper Pony Creek, located approximately 450 m upstream from the seep outlet from the Adit of the Brown McDade Pit.
	D2	Lower Pony Creek, located approximately 170 m downstream from the seep outlet from the Adit of the Brown McDade Pit.
Minnesota Creek	M1	Minnesota Creek, located approximately 100 m upstream from the confluence with Victoria Creek. Used for comparison with previous data from this site, not as a reference for the other sites.

ELR conducted habitat assessments according to the *Reconnaissance (1:20,000) Fish and Fish Habitat Assessment Inventory: Standards and Procedures* (RIC 2001). At each sampling station, a representative area of the stream was established by walking along the channel in the survey area (i.e., a segment of channel that was representative of the stream in the reach including the study site). Habitat features were assessed along a length of channel ranging from 100 m to 125 m (dependent on channel width). The following habitat data were assessed and recorded:



Mount Nansen

Site

Fisheries and Aquatics
Existing Conditions Report



Client:



Legend

● Habitat Sampling Locations

Local Boundaries

Order In Council Area

Base Layers

— Roads

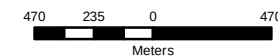
Watercourses

Waterbodies

Existing Site Infrastructure



Scale: 1:30,000



February 9, 2018

Drawn by: CJ

ELR Project: 16-249

Checked by: CJ

FIGURE 5.1

Fish Habitat and Aquatic
Environment Sampling Locations

- Physical stream channel characteristics
 - Bankfull width measured at the elevation of the regular high water mark on each streambank;
 - Wetted width measured between the streambanks at water surface level at the time of the site visit;
 - Bankfull depth measured from deepest part of channel to line bisecting the bankfull mark of each streambank;
 - Residual pool depth measured the difference between the maximum pool depth and the outlet crest depth;
 - Channel gradient measured the slope of the channel bed.

Mean values were calculated from several individual cross sectional measurements in order to give an indication of normal stream values and variability.

- Stream morphology characteristics (e.g., riffle, run, and pool).
- Stream substrate composition and characteristics, including dominant and subdominant substrates
 - D95 - diameter of bed material particles that are larger than 95% of the materials in the stream channel;
 - D - diameter of the largest particle on the channel bed that will be moved at channel forming flow levels.
- Bank slope and characteristics, riparian vegetation characteristics, and percent crown closure.
- Instream cover composition and abundance.
- Large-scale channel reach characteristics (disturbances, confinement, stream pattern, etc.).

Basic *in-situ* water quality attributes also were collected using a YSI Quattro Professional Plus Field Meter and a Lamotte 2020e Turbidity Meter. Measured variables included dissolved oxygen (mg/L and percent saturation), conductivity ($\mu\text{S}/\text{cm}$), temperature ($^{\circ}\text{C}$), turbidity (NTU), and pH (pH units).

5.1.2 Results

A detailed summary of aquatic habitat inventory data is provided in Table 5.2. The characteristics of aquatic habitats are described in the following sections according to stream.

5.1.2.1 Victoria Creek

Victoria Creek is the primary receiving environment for the Site, receiving flows from all other watercourses studied. It flows from north to south along the eastern edge of the OIC, and flows into the Nisling River. The characteristics of Victoria Creek were relatively consistent among the four sites sampled, with wetted widths ranging from 2.5 to 6.6 m, and a cobble-based channel with moderate habitat complexities that forms frequent deep pools along its length. All areas of Victoria Creek surveyed were considered to provide good fish habitat.



Table 5.2: Summary of 2013 Fish Habitat Data for Victoria, Dome, Pony, and Back Creeks

Parameters	Back Creek		Pony Creek		Dome Creek		
	B1	B2	P1	P2	D1	D2	D3
	08/22/13	08/21/13	08/28/13	08/28/13	08/29/13	08/29/13	08/29/13
Stream Characteristic							
Residual Pool Depth (m) –Max./Min./Avg. (n)	0.18 / 0.04 / 0.09 (3)	0.2 / 0.14 / 0.16 (4)	0.28 / 0.12 / 0.19 (3)	0.29 / 0.13 / 0.2 (3)	0.67 / 0.13 / 0.28 (4)	0.37 / 0.09 / 0.21 (4)	0.62 / 0.19 / 0.33 (4)
Channel Width (m) - Max./Min./Avg. (n)	3.35 / 2.02 / 2.75 (6)	2.62 / 0.8 / 1.6 (6)	1.75 / 0.39 / 0.78 (6)	3.1 / 1.21 / 2.01 (6)	2.54 / 0.86 / 1.4 (6)	1.9 / 0.75 / 1.2 (6)	2.05 / 0.75 / 1.3 (6)
Wetted Width (m) - Max./Min./Avg. (n)	2.26 / 0.9 / 1.44 (6)	1.81 / 0.68 / 1.1 (6)	0.86 / 0.24 / 0.42 (6)	1.3 / 0.41 / 0.74 (6)	0.7 / 0.19 / 0.5 (6)	1.1 / 0.5 / 0.725 (6)	1.73 / 0.41 / 0.83 (6)
Mean Bankfull Depth (m) – Avg. (n)	0.43 (4)	0.43 (4)	0.31 (4)	0.24 (3)	0.39 (4)	0.36 (4)	0.41 (4)
Range of Stream Gradient – (%)	2.25 - 6	2.25 - 3	5 - 4	6 - 6.5	-	1.5 - 6	3.5 - -
Substrate Composition							
Dominant Substrate (D)	Cobbles	Gravel	Gravel	Cobbles	Fines	Cobbles	Fines
Subdominant Substrate (subD)	Gravels	Sand	Fines	Gravel	₂²	Fines	₂²
D95 (cm)	10	3.5	5	4.5	₂²	₂²	₂²
D (cm)	18	9	11	10	₂²	₂²	₂²
Stream Morphology							
General Morph. Characteristics¹	RP-C / Mostly Riffle	Riffle-Run	RP-G	RP-C	RP-F + Run	RP-C + Run	Riffle-Run
Water Quality							
Water Temperature (°C)	5.6	10.7	4.5	4.1	3.4	9.2	7.9
pH (pH units)	8.16	8.27	7.41	7.09	7.81	8.18	8.11
Conductivity (µscm⁻¹)	376.4	761	186.5	590	1,612	1,466	1,204
Dissolved Oxygen (mg/L)/(%Saturation)	10.82 / 98.2	8.16 / 96.7	9.63 / 87.7	8.25 / 73.4	10.82 / 94.8	8.21 / 88.2	10.14 / 97.6
Cover/Habitat Value							
Total Fish Habitat Cover (%)	3	41	65	75	90	50	47
Primary Fish Habitat Components (%)	Small woody debris (0) Large wood debris (0) Boulder (0) Undercut (<1) Deep pool (0) Overstream vegetation (3) Instream vegetation (0)	Small woody debris (2) Large wood debris (<1) Boulder (0) Undercut (3) Deep pool (0) Overstream vegetation (35) Instream vegetation (0)	Small woody debris (2) Large wood debris (2) Boulder (0) Undercut (1) Deep pool (0) Overstream vegetation (60) Instream vegetation (0)	Small woody debris (0) Large wood debris (0) Boulder (0) Undercut (5) Deep pool (0) Overstream vegetation (70) Instream vegetation (0)	Small woody debris (0) Large wood debris (0) Boulder (0) Undercut (0) Deep pool (0) Overstream vegetation (90) Instream vegetation (0)	Small woody debris (0) Large wood debris (0) Boulder (0) Undercut (0) Deep pool Overstream vegetation (50) Instream vegetation (0)	Small woody debris (1) Large wood debris (1) Boulder (0) Undercut (0) Deep pool (0) Overstream vegetation (47) Instream vegetation (0)
Riparian Habitat Composition	Veg. Type - Grass/Shrub Stage – Initial/Shrub	Veg. Type - Grass/Shrub/Conifer Stage – Mature Forest	Veg. Type - Grass/Shrub Stage – Shrub/Mature Forest	Veg. Type - Grass/Shrub Stage – Shrub	Veg. Type - Shrub Stage – Shrub	Veg. Type - Shrub Stage – Shrub	Veg. Type - Grass/Shrub/Conifer Stage – Mature Forest
Crown Closure (%)	0-20%	71-90%	41-70%	21-40%	71-90%	21-40%	71-90%
Channel Characteristics	Islands - Irregular Bars - Side Coupling - Decoupling Confinement – Unconfined	Islands - None Bars - Side Coupling - Decoupling Confinement	Islands - None Bars - None Coupling - Decoupling Confinement - Unconfined	Islands - None Bars - None Coupling - Decoupling Confinement - Unconfined	Islands - None Bars - None Coupling - Decoupling Confinement - Unconfined	Islands - None Bars - Side Coupling - Decoupling Confinement - Unconfined	Islands - None Bars - None Coupling - Decoupling Confinement - Unconfined

¹ General Morph. Characteristics are described using RIC 2001, acronyms are as follows; RP=Riffle-Pool, C=Cascade, CP=Cascade Pool, SP=Step Pool, and LC=Large Channel.

² Stream substrate at sample sites D1 and D3 are composed entirely of fines; therefore no substrate measurements were possible.



Table 5.2: Summary of 2013 Fish Habitat Data for Victoria, Dome, Pony, and Back Creeks (Cont.)

Stream	Minnesota Creek	Victoria Creek			
Sample ID	MI	VI	V2	V3	V4
Sampling Date	08/22/13	08/22/13	08/21/13	08/22/13	08/22/13
Stream Characteristic					
Residual Pool Depth (m) –Max./Min./Avg. (n)	0.26 / 0.19 / 0.22 (3)	0.98 / 0.28 / 0.64 (3)	0.95 / 0.17 / 0.49 (3)	1.12 / 0.52 / 0.73 (3)	1.25 / 0.5 / 0.85 (4)
Channel Width (m) - Max./Min./Avg. (n)	5.42 / 1.82 / 3.13 (6)	5.72 / 3.91 / 4.95 (6)	9.3 / 4.6 / 6.5 (6)	9.14 / 5.17 / 6.45 (6)	9.7 / 4.75 / 6.5 (6)
Wetted Width (m) - Max./Min./Avg. (n)	3.14 / 1.43 / 2.28 (6)	4.3 / 2.81 / 3.6 (6)	6.19 / 2.51 / 4.04 (6)	6.58 / 3.61 / 5.02 (6)	5.22 / 3.8 / 4.65 (6)
Mean Bankfull Depth (m) – Avg. (n)	0.34 (3)	0.64 (4)	0.89 (4)	0.63 (3)	0.71 (4)
Range of Stream Gradient – (%)	2.5 - 3	3.5 - 0.5	2.5 - -	2 - 1.5	2 - 0.5
Substrate Composition					
Dominant Substrate (D)	Cobbles	Cobbles	Cobbles	Cobbles	Cobbles
Subdominant Substrate (subD)	Sand	Sand	Sand	Sand	Sand
D95 (cm)	10	13	10	10	7
D (cm)	16	21	21	17	14
Stream Morphology					
General Morph. Characteristics	RP-C	RP-C	RP-C	RP-C	RP-C
Water Quality					
Water Temperature (°C)	6.8	9.7	7.2	9.3	8.7
pH (pH units)	8.16	8.21	8.03	8.27	8.34
Conductivity (µscm ⁻¹)	91.8	224	225.1	281.2	260.2
Dissolved Oxygen (mg/L)/(%Saturation)	10.35 / 96.2	9.6 / 96.2	9.14 / 91	9.84 / 97	10.06 / 97.7
Cover/Habitat Value					
Total Fish Habitat Cover (%)	27	7	15	6	8
Primary Fish Habitat Components (%)	Small woody debris (1) Large wood debris (1) Boulder (0) Undercut (0) Deep pool (0) Overstream vegetation (25) Instream vegetation (0)	Small woody debris (1) Large wood debris (1) Boulder (0) Undercut (1) Deep pool (1) Overstream vegetation (3) Instream vegetation (0)	Small woody debris (0) Large wood debris (1) Boulder (0) Undercut (5) Deep pool (2) Overstream vegetation (7) Instream vegetation (0)	Small woody debris (0) Large wood debris (1) Boulder (0) Undercut (0) Deep pool (1) Overstream vegetation (4) Instream vegetation (0)	Small woody debris (0) Large wood debris (1) Boulder (0) Undercut (1) Deep pool (4) Overstream vegetation (2) Instream vegetation (0)
Riparian Habitat Composition	Veg. Type - Grass/Shrub/Conifer Stage – Mature Forest	Veg. Type - Grass/Shrub/Conifer Stage - Mature Forest	Veg. Type - Grass/Shrub/Conifer Stage - Mature Forest	Veg. Type - Grass/Shrub/Conifer Stage - Mature/Young Forest	Veg. Type - Grass/Shrub/Conifer Stage - Mature Forest
Crown Closure (%)	1-20%	1-20%	21-40%	1-20%	1-20%
Channel Characteristics	Islands - Occasional Bars - Side Coupling – Partially Coupled Confinement – Occasionally	Islands - None Bars – Side Coupling - Decoupled Confinement - Unconfined	Islands - None Bars - Side Coupling - Decoupled Confinement - Unconfined	Islands - Occasional Bars - Side/Mid Coupling - Decoupled Confinement - Unconfined	Islands - None Bars - Side Coupling - Decoupled Confinement - Unconfined

¹ General Morph. Characteristics are described using RIC 2001, acronyms are as follows; RP=Riffle-Pool, C=Cascade, CP=Cascade Pool, SP=Step Pool, and LC=Large Channel.

² Stream substrate at sample sites D1 and D3 are composed entirely of fines; therefore no substrate measurements were possible.

VI – Victoria Creek Reference

The Victoria Creek reference site (VI) was located upstream from the confluence with Back Creek, and therefore upstream of any influence from the Mount Nansen Site. The channel at site VI had mean channel and wetted widths of 4.95 m and 3.6 m, respectively. Mean residual pool depth was 0.64 m and mean bankfull depth was 0.64 m (Photo 11). The mean gradient of the stream in the area surveyed was 2%. Substrate at Site VI was dominated by cobble and sand, with D95 and D measured to be 13 cm and 21 cm, respectively. Total cover at VI was estimated to be 7%, consisting of overstream vegetation (3%), with small amounts of small woody debris (1%), large woody debris (1%), undercut banks (1%), and deep pools (1%). Crown closure varied between 1 and 20%, consisting primarily of grass, shrubs, and mature conifer forest. Water quality was found to be within a suitable range to support aquatic life and habitat. Dissolved Oxygen was 9.6 mg/L or 96.2% saturation; pH was slightly basic at 8.21, and water temperature 9.7°C.

V2 - Victoria Creek Downstream of Back Creek Confluence

Habitat inventoried at Site V2 was typical of that found on the Victoria Creek system, consisting of unconfined and decoupled in morphology. Victoria Creek downstream of Back Creek had mean channel and wetted widths of 6.5 m and 4.04 m, respectively (Photo 12). Mean residual pool depth was 0.49 m and mean bankfull depth was 0.89 m. The mean gradient of the stream in the area surveyed was 2.5%. Substrate at Victoria Creek downstream of Back Creek was dominated by cobble and sand, with D95 and D measured to be 10 cm and 21 cm, respectively. Total cover was estimated to be 15%, which was comprised of overstream vegetation (7%) and undercut banks (5%), with some large woody debris (1%), and deep pools (2%). Crown closure ranged from 21 to 40%, consisting of primarily grass, shrubs, and mature conifer forest.

V3 – Victoria Creek Downstream of Dome Creek Confluence

The channel of Victoria Creek downstream of the Back Creek confluence had mean channel and wetted widths of 6.45 m and 5.02 m, respectively (Photo 13). Mean residual pool depth was 0.73 m and mean bankfull depth was 0.63 m. The mean gradient of the stream in the area surveyed was 1.75%. Substrate at Victoria Creek upstream of the Minnesota Creek confluence was dominated by cobble and sand, with D95 and D measured to be 10 cm and 17 cm, respectively. Total cover at Site V3 was estimated to be 6%, which consisted of overstream vegetation (4%), with some large woody debris (1%), and deep pools (1%). Crown closure ranged from one to 20%, consisting of grass, shrubs, and young conifer forest. In-situ water quality variables at Site V3 were similar to those upstream, with the exception of a slight increase in conductivity (281.2 µs/cm).

V4 - Victoria Creek Downstream of Minnesota Creek

The Victoria Creek channel downstream of the Minnesota Creek confluence had mean channel and wetted widths of 6.5 m and 4.65 m, respectively (Photo 14). Mean residual pool depth was 0.85 m and mean bankfull depth was 0.71 m. The mean gradient of the stream in the area surveyed was 1.25%. Substrate was dominated by cobble and sand, with D95 and D measured to be 7 cm and 14 cm, respectively. Total cover at Site V4 was estimated to be 8%, which consisted of deep pools (4%), and overstream vegetation (2%), and with some large woody debris (1%), undercut banks (1%). Crown closure ranged from 1-20%, consisting of grass, shrubs, and mature conifer forest.

5.1.2.2 Dome Creek

Dome Creek was characterized as providing poor overall habitat conditions, with narrow channels and substrates dominated by fines. No fish habitat is currently provided by Dome Creek due to temporary barriers that currently exist at its outlet and poor water quality in the stream. The habitat quality for contribution to fish habitat downstream also is considered to be poor. All Dome Creek habitat inventories were completed on August 29, 2013. In-situ conductivity recorded from Dome Creek was the highest of all stations sampled during the 2013 study (max. of 1,612 μscm^{-1} at Site D1).

D1- Upper Dome Creek

Upper Dome Creek had a mean channel and wetted widths of 1.4 m and 0.5 m, respectively (Photo 15). Mean residual pool depth was 0.28 m and mean bankfull depth was 0.39 m. Gradient in the area of Site D1 could not be measured due to heavy vegetation cover, but was similar to that of lower Dome Creek (estimated at 2-4%). Substrate in upper Dome Creek was dominated by fines, with no larger substrate materials occurring. The assessed channel had a riffle-pool habitat distribution. Total cover at Site D1 was estimated to be 90%, comprised entirely of overstream vegetation. Accordingly, crown closure was measured to be between 71% and 90%, primarily composed of tall shrubs.

D2 – Middle Dome Creek

The channel at middle Dome Creek (below the Dome Creek diversion) had mean channel and wetted widths of 1.2 m and 0.725 m, respectively (Photo 16). Mean residual pool depth was 0.21 m and mean bankfull depth was 0.36 m. The mean gradient of the stream in the area surveyed was 3.75%. Substrate in middle Dome Creek was dominated by cobble and fines, and the assessed channel had a riffle-pool habitat distribution with isolated runs. Total cover at Site D2 was estimated to be 50%, comprised entirely of overstream vegetation. Crown closure was measured to be between 21% and 40%, consisting primarily of tall shrubs.

D3 – Lower Dome Creek

The channel in lower Dome Creek had a mean channel and wetted widths of 1.3 m and 0.83 m, respectively (Photo 17). Mean residual pool depth was 0.33 m and mean bankfull depth was 0.41 m. The mean gradient of the stream in the area surveyed was 3.5%. Substrate in lower Dome Creek was dominated by fines, and accordingly specific substrate size measurements were not possible. The assessed channel had a riffle/run habitat distribution. Total cover in the area of Site D3 was estimated at 47%, consisting entirely of overstream vegetation. Crown closure was measured at 71-90%, consisting primarily of grass, shrubs, and mature conifer forest.

5.1.2.3 Pony Creek

Pony Creek is a small watercourse that drains from an area north of the Brown McDade Pit to Back Creek. This stream ranges in width from 0.4 m to 1.3 m, with substrates dominated by gravel and cobble. Pony Creek has a moderate gradient, ranging from 4-6.5%. No fish habitat is provided by Pony Creek due to the barriers that currently exist at its outlet, but the habitat quality for contribution to fish habitat downstream is considered to be fair.

P1 - Upper Pony Creek

Upper Pony Creek was the narrowest stream inventoried during the 2013 assessment (Photo 18). In the area surveyed, Pony Creek had mean channel and wetted widths of 0.78 m and 0.42 m, respectively. Mean residual pool depth was 0.19 m and mean bankfull depth was 0.31 m. The mean gradient of the stream in the area surveyed was 4.5%. Substrate in upper Pony Creek was dominated by gravel and fines, with D95 and D measured to be 5 cm and 11 cm, respectively. The assessed channel had a riffle-pool habitat distribution. Total cover was estimated to be 65%, dominated by overstream vegetation (60%), small and large woody debris (2% each), and undercut banks (1%). Crown closure was measured at 41-70%, primarily grasses and tall shrubs.

P2 - Lower Pony Creek

Lower Pony Creek in the area surveyed had mean channel and wetted widths of 2.01 m and 0.74 m, respectively (Photo 19). Mean residual pool depth was 0.2 m and mean bankfull depth was 0.24 m. The mean gradient of the stream in the area surveyed was 6.25%. Substrate in lower Pony Creek was dominated by cobble and gravel, with D95 and D measured to be 4.5 cm and 10 cm, respectively. The assessed channel had a riffle-pool habitat distribution. Total cover was estimated to be 75%, dominated by overstream vegetation (70%), and undercut banks (5%). Crown closure was measured at 21-40%, primarily grasses and tall shrubs.

5.1.2.4 Back Creek

Back Creek originates north of the OIC area and flows to the southeast into Victoria Creek. This stream ranges in width from 0.7-2.3 m, with a gradient ranging from 2.25-6%. This stream has been heavily altered by both current and historical placer mining activities.

B1 - Upper Back Creek

Back Creek at Site B1 had mean channel and wetted widths of 2.75 m and 1.44 m, respectively (Photo 20). Mean residual pool depth was 0.09 m and mean bankfull depth was 0.43 m. The mean gradient of the stream in the area surveyed was 4.1%. Substrate in lower Pony Creek was dominated by cobble and gravel, with D95 and D measured to be 10 cm and 18 cm, respectively. The assessed channel had a mostly riffle habitat distribution. Total cover was estimated to be 3%, consisting of overstream vegetation (3%) and undercut banks (<1%). Crown closure was measured to be between 0% and 20%, consisting of grasses and tall shrubs. The overall fish habitat value in upper Back Creek was considered to be poor due to low cover availability and homogeneous habitat features.

B2 - Lower Back Creek

Back Creek at Site B1 had mean channel and wetted widths of 1.6 m and 1.1 m, respectively (Photo 21). Mean residual pool depth was 0.16 m and mean bankfull depth was 0.43 m. The mean gradient of the stream in the area surveyed was 2.6%. Substrate in lower Back Creek was dominated by gravel and sand, with D95 and D measured to be 3.5 cm and 9 cm, respectively. Total cover was estimated to be 41%, consisting of overstream vegetation (35%), small woody debris (2%), and large woody debris (<1%). Crown closure ranged from 71-90%, consisting of grass, shrubs, and mature conifer forest. *In-situ* water quality results revealed higher conductivity in lower Back Creek compared to upper Back Creek (376.4 to 761 μscm^{-1}). Other water quality variables were found to be similar. The overall fish habitat value in lower Back Creek was considered to be good due to high cover availability and heterogeneous habitat features.



5.1.2.5 Minnesota Creek

MI – Minnesota Creek

Minnesota Creek at Site MI had mean channel and wetted widths of 3.13 m and 2.28 m, respectively (Photo 22). Mean residual pool depth was 0.22 m and mean bankfull depth was 0.34 m. The mean gradient of the stream in the area surveyed was 2.8%. Substrate at of Minnesota Creek was dominated by cobble and sand, with D95 and D measured to be 10 cm and 16 cm, respectively. Total cover was estimated to be 27%, dominated by overstream vegetation (25%), and with some large and small woody debris (one % each). Crown closure was measured to range from 1-20%, consisting primarily of grass, shrubs, and mature conifer forest. The overall fish habitat value of Minnesota Creek was considered to be poor due to low visibility from the presence of fine sediment likely caused by metal precipitate, and poor habitat availability due to partly to embedded substrates.

6. AQUATIC ENVIRONMENT

ELR conducted an aquatic environment sampling program, including the collection of stream sediment, periphyton, and benthic macroinvertebrates at the same 12 sample sites as selected for fish habitat (as described in Section 5). These sites were selected to provide current, up-to-date data describing the current state of aquatic habitats in relation to the Mount Nansen Site infrastructure, and further to describe the current influences on those aquatic habitats.

As earlier shown in Table 5.1, four sampling locations were established on Victoria Creek; an upstream reference station (V1), and three subsequent stations positioned to characterize the influence of Back (V2), Dome (V3), and Minnesota Creeks (V4), respectively. The remaining eight stations were positioned to characterize upstream and downstream habitat conditions of Back (B1 and B2), Pony (P1 and P2), Dome (D1, D2, and D3), and Minnesota Creeks (M1). Aquatic environment sampling sites are shown on Figure 5.1.

The majority of sampling and assessment of aquatic habitat was completed during the periods of August 21–22 and August 28–30, 2013. Due to sample location and methodology constraints, primarily related to stream substrate characteristics, additional benthic invertebrate and periphyton samples were collected the following year on September 4, 2014. A change in methodology during the 2014 site visit (i.e., the use of kick-nets and artificial substrate) allowed for sampling of areas with fine sediment, but in turn limited the use of certain analytical metrics (Table 6.1). A summary of the sampling details are provided in Table 6.1, while the details of each sampling program are outlined in Sections 6.1 through 6.3.

Table 6.1: Summary of Aquatic Environment Sampling Efforts in the Mount Nansen Study Area

Stream	Back Creek		Pony Creek		Dome Creek			Minnesota Creek	Victoria Creek			
Sample ID	B1	B2	P1	P2	D1	D2	D3	M1	V1	V2	V3	V4
Benthic Invertebrates												
Density	✓	✓	✓	✓	-	✓	-	✓	✓	✓	✓	✓
Taxonomy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Periphyton												
Biomass	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Taxonomy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stream Sediment												
Sediment Metals	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Organic Content (LOI)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grain Size	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stream Habitat Assessment												
Inventory of Stream Habitat Characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

--Indicates no sample was collected.

6.1 STREAM SEDIMENT METALS AND GRAIN SIZE

6.1.1 Methods

6.1.1.1 Field Sampling

Stream sediment samples were collected during the 2013 aquatics existing conditions study program from all 12 sample sites (Figure 5.1). At each site, one sub-sample was collected from each of three depositional areas within the active main channel, for a total of three sub-samples. Each sub-sample was collected using a cleaned aluminum spade, by a collector wearing latex gloves. Sub-samples were placed directly into labelled 125 mL glass jars and kept refrigerated until being packed with ice in coolers for transport under chain of custody to Maxxam Analytics Ltd. in Burnaby, BC for analysis. Sampling stations located on Back Creek (B1 & B2) and Minnesota Creek (MN), as well as three Victoria Creek stations (V1, V2, & V3) were sampled during the August 21-22 sampling event. All remaining stations (P1, P2, D1, D2, D3 and V4) were sampled during the August 28-29 sampling event.

Due to natural variations in stream habitat characteristics, it was not possible to sample all aquatic environment components at all study sites.

6.1.1.2 Laboratory and Data Analysis

At the laboratory, samples were dried and screened using sieves at American Society for Testing and Materials (ASTM) mesh numbers 16, 30, 50, 100, 140, 200, 270, and 400. The percentage of total sample retained by the sieve was recorded as dry weight fractions. Following size fractioning, a sub-sample of sediments from the #100 sieve was analyzed by the lab for metals concentration using inductively coupled plasma mass spectrometry (ICPMS) analysis, as well as organics content using loss of ignition (LOI) at 550°C.

Results of the ICPMS analysis were compared to Canadian Council of Ministers of the Environment (CCME) *Canadian Sediment Quality Guidelines (CSQG) for the protection of Freshwater Aquatic Life* (CCME 2002). This document includes two sets of guidelines: the interim sediment quality guidelines (ISQG) and probable effect level (PEL). Both guidelines were used in this report to report the baseline conditions for each water quality variable measured. ISQGs were developed using standardized analytical protocols for total concentrations of chemicals in freshwater and marine surficial sediments (i.e., top 5 cm), and are intended to be used for evaluating the potential for biological effects. The PEL is the upper level of the association between the concentration of each chemical or metal measured in the sediment and any adverse biological effect observed. The PEL defines the level above which adverse effects are expected to occur frequently. For those metals where no CCME standard exists, sample results were compared to the working sediment quality guidelines for British Columbia (BCSQG; Nagpal et al. 2006), for those chemicals or metals for which they exist. BCSQG are also comprised of two sets of guidelines: the screening level concentration (SLC) which estimates the highest concentration (normalized to sediment organic carbon concentration) of a particular nonpolar organic contaminant in sediments that can be tolerated by approximately 95% of benthic infauna; and PEL (which use the same definition as above).

Results of the particle size distribution were assessed for consistency between replicate samples at a given site by calculating coefficient of variation (CV) between sample replicates for each sieve class. CV is defined as the standard deviation to the mean, and describes the extent of variability between replicate samples. CV values are dimensionless numbers that allow for comparison between data sets. CV was calculated using the following formula:

$$CV = \frac{\sigma}{\mu}$$

Where: σ is equal to the standard deviation, and μ is equal to the mean.

The relative composition of sediment according to size fractions also was compared amongst sites to provide an indication of the stream energy within each reach studied. Sediment size was described using the Wentworth scale (Allan 1995) that defines particle size classes in intervals that increase by the power of two. A description of categories in relation to ASTM mesh and mesh size is provided in Table 6.2.

Table 6.2: Comparison of Sieve Size, Grain Size & Wentworth Scale Classifications

Sieve Size	Particle Size	Wentworth Scale	Classification
Sieve - #16	>1.18mm	Very Coarse Sand (1-2)	Coarse and Very Coarse Sand
Sieve - #30	>0.60mm	Coarse Sand (0.5-1)	
Sieve - #50	>0.300 mm	Medium Sand (0.25-0.5)	Medium Sand
Sieve - #100	>0.15mm	Fine Sand (0.125-0.25)	Fine Sand
Sieve - #140	>0.106mm	Very Fine Sand (0.0625-0.125)	Very Fine Sand
Sieve - #200	>0.075mm	Very Fine Sand (0.0625-0.125)	
Sieve - #270	>0.053mm	Silt (<0.0625)	Silt
Sieve - #400	>0.038 mm	Silt (<0.0625)	
Sieve - Pan	<0.038 mm	Silt (<0.0625)	

6.1.2 Stream Sediment Results

6.1.2.1 Grain Size

The general pattern of distribution in grain sizes observed by ELR during the 2013 existing conditions aquatic habitat assessment varied considerably between each stream system sampled (Figure 6.1).

Variability in grain size among replicate samples within sites (as measured by CV) was greatest in samples from Back Creek, upper Pony Creek, and Victoria Creek (Figure 6.1; Table 6.3). No discernable pattern occurred between grain size and placer mining activity. The grain size of sediment from Dome and Minnesota Creeks was relatively consistent amongst replicate samples (i.e., having a CV <0.75).

Sediment collected from Victoria Creek was dominated by fine to coarse grain sand (Figure 6.1, Appendix 3). Sediments collected from the furthest upstream and downstream sample sites in Victoria Creek (V1 and V4) were composed of a greater percentage of coarse grain sand, whereas sediment collected from the middle reaches (V2 and V3) had a relatively higher component of fine grain sand to coarse silt.

Sediment collected from Dome Creek was comprised of a higher relative composition of fine sediments compared with other study area streams. This creek does experience metals precipitation, primarily iron. The upper and lower Dome Creek sampling stations (D1 and D3) were dominated by fine grain sand to silt. Sediment from middle Dome Creek (D2) was comprised of a higher relative composition of fine grain sand.

Sediment in Pony Creek was dominated by very coarse grain sediments. Silts also formed a major component of the sediment from both Pony Creek sites (14% to 38% of the total sample; Figure 6.1, Appendix 3).

Samples collected from Back Creek show a grain size distribution dominated by coarse to very fine grain sand. Samples showed no major variation between samples from upstream and downstream locations (Appendix 3).

Sediments collected from Minnesota Creek (MN) were dominated by medium to fine grain sand (Appendix 3).

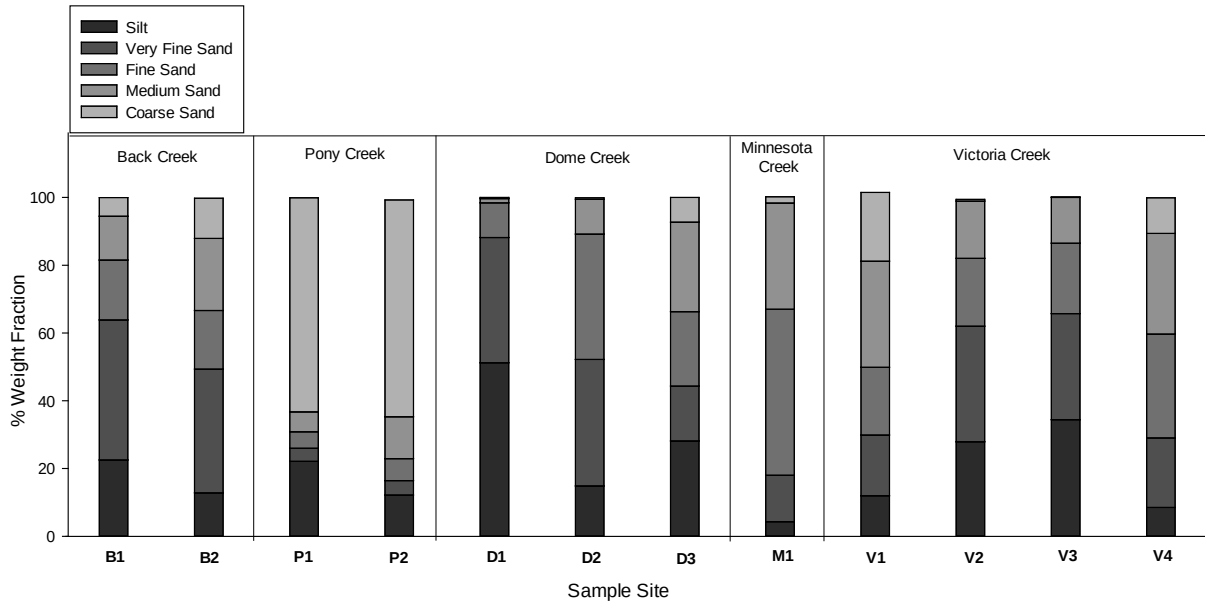


Figure 6.1: Sediment Grain Size Distribution of Samples Collected from Victoria, Dome, Back, and Pony Creeks in the Mount Nansen Study Area

Table 6.3: Summary of Coefficient of Variation (CV) Data from Mount Nansen Area Sediment

Stream	Back Creek		Pony Creek		Dome Creek			Minnesota Creek	Victoria Creek			
Sample ID	B1	B2	P1	P2	D1	D2	D3	M1	V1	V2	V3	V4
Sieve - #16 (>1.18mm)	0.60	1.24	0.49	0.24	0.29	0	0.82	0	1.14	0	0	1.5
Sieve - #30 (>0.60mm)	0.63	1.07	0.55	0.59	0.51	0.18	0.64	0.70	0.79	1.10	0.35	1.27
Sieve - #50 (>0.300 mm)	1.08	0.92	0.64	0.28	0.75	0.40	0.87	0.33	0.29	1.44	0.94	0.31
Sieve - #100(>0.15mm)	0.38	0.13	1.09	0.24	0.62	0.22	0.20	0.21	0.54	0.53	0.69	0.33
Sieve - #140 (>0.106mm)	0.34	0.60	1.08	0.38	0.38	0.26	0.45	0.27	0.47	0.43	0.19	0.36
Sieve - #200 (>0.075mm)	0.47	0.70	0.90	0.43	0.17	0.34	0.54	0.52	0.47	0.53	0.17	0.37
Sieve - #270 (>0.053mm)	0.46	0.79	0.90	0.39	0.19	0.11	0.67	0.62	0.46	0.64	0.42	0.43
Sieve - #400 (>0.038 mm)	0.56	0.90	0.64	0.13	0.26	0.46	0.41	0.68	0.42	0.91	0.80	0.54
Sieve – Pan (<0.038 mm)	0.29	0.44	0.76	0.20	0.45	0.25	0.75	0.60	0	0.71	0.92	1.01

Notes:

Shaded cells represent CV values >0.75

Shaded and bold cells represent CV values >1.0

6.1.2.2 Organic Content

Loss of Ignition (LOI) data describe the organic content of stream sediment sample. Results are shown in Figure 6.2 and are described in detail in Appendix 3. The proportion of organic content was relatively low in all replicate samples collected from the twelve sample sites. The lowest values recorded were from samples collected in Back and Minnesota Creeks, whereas higher organic contents were found in samples collected from Pony and Dome Creeks.

The organic content of sediment from Back Creek was relatively consistent throughout the system, ranging from 1.2% to 1.4% of the total sample weight. The organic content of sediment from Minnesota Creek was relatively consistent among replicate samples, ranging from 1.3% to 2.7% of the total sample weight. Sediments from Pony Creek had a higher relative proportion of organics at upper Pony Creek (P1), ranging from 6.0% to 10% of the total sample weight, when compared to lower Pony Creek (P2; ranging from 4.2% to 6.4%). Sediments from lower Dome Creek had the highest relative proportions of organics of all sites sampled, ranging from 16.9% to 24% of the total sample weight. In comparison the organic content of samples from upper and middle Dome Creek was lower, ranging from 4.4% to 6.9% and 1.8% to 6.9%, respectively. Organic content of samples collected from Victoria Creek were relatively consistent throughout the system, ranging between 1.7% and 3.5% of the total sample weight.

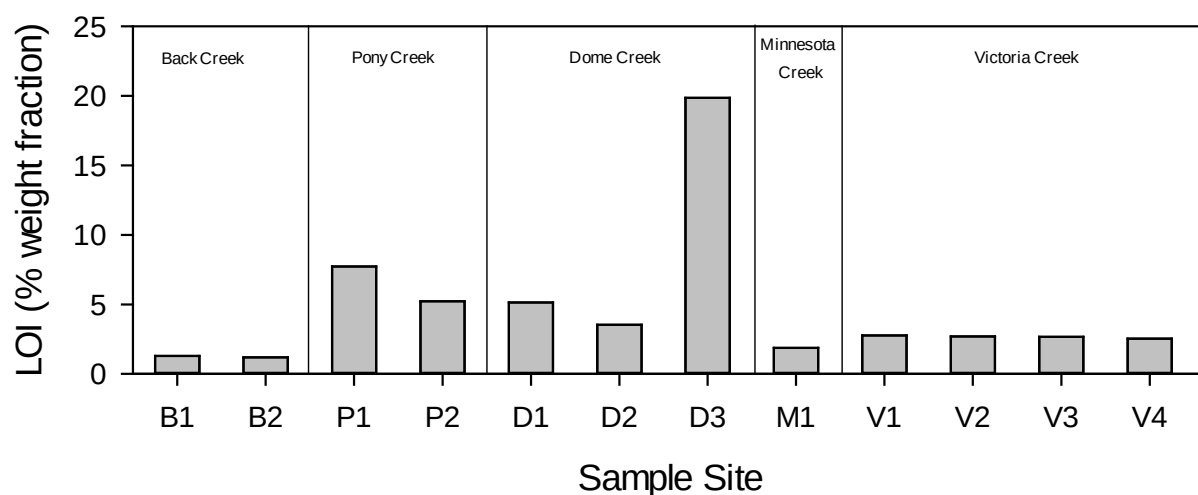


Figure 6.2: Mean Organic Content (Loss on Ignition) of Sediment from Victoria, Dome, Back, and Pony Creeks in 2013 in the Mount Nansen Study Area

6.1.2.3 Sediment Metals

Across all samples, sediment from sites within the study area were found to exceed BCSQG or CSQG for arsenic, zinc, cadmium, lead, copper, and silver at one or more sites. Exceedance of CCME-ISQG, CCME-PEL, or BCSQG for at least one metal occurred at each site sampled during the 2013 sampling program. Detailed results of stream sediment metals analysis, including comparisons with applicable guideline levels, are provided in Table 6.4. Guideline exceedances for each sample site, as well as a description of trends for each water course, are provided below.

6.1.2.3.1 Pony Creek

Upper Pony Creek (P1)

- Arsenic in sediment from upper Pony Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Cadmium in sediment from upper Pony Creek exceeded CCME-ISQG in all three replicate samples.
- Lead in sediment from upper Pony Creek exceeded CCME-ISQG in two of three replicate samples.
- Zinc in sediment from upper Pony Creek exceeded CCME-ISQG in one of three replicate samples.
- Iron in sediment from upper Pony Creek exceeded BCSQG-SLC in two of three replicate samples.
- Silver in sediment from upper Pony Creek exceeded BCSQG-PEL in one of three replicate samples.

Lower Pony Creek (LPC)

- Arsenic in sediment from lower Pony Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Cadmium in sediment from lower Pony Creek exceeded CCME- PEL and BCSQG-PEL in all three replicate samples.
- Lead in sediment from lower Pony Creek exceeded CCME- PEL and BCSQG-PEL in all three replicate samples.
- Zinc in sediment from lower Pony Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Copper in sediment from lower Pony Creek exceeded CCME-ISQG in all three replicate samples.
- Iron in sediment from lower Pony Creek exceeded BCSQG-SLC in all three replicate samples.
- Silver in sediment from lower Pony Creek exceeded BCSQG-PEL in all three replicate samples.

All sediment metals that exceeded BCSQG-SEL or CCME-ISQG at Pony Creek sample sites (i.e., arsenic, cadmium, copper, lead, silver, iron and zinc) were elevated in lower Pony Creek compared to upper Pony Creek. More than an order of magnitude increase in arsenic levels were observed between sediment from the upper Pony Creek and lower Pony Creek sample sites (values ranging from 26.3 to 90.8 mg/kg and values ranging from 661 to 803 mg/kg, respectively). Levels of zinc also increased downstream, with values ranging from 93.2 to 137 mg/kg in upper Pony Creek and values ranging from 380 to 1,060 mg/kg in lower Pony Creek. Concentrations of lead show a similar pattern, with values ranging from 30 to 70.1 mg/kg in upper Pony Creek and values ranging from 245 to 312 mg/kg in lower Pony Creek (Table 6.4).

Table 6.4: Detailed Stream Sediment Metals Analytical Data Including Comparisons with Applicable Aquatic Life Standards

Sample Location	Upper Back Creek			Lower Back Creek			Upper Pony Creek			Lower Pony Creek			BCSQG ¹		CCME ²	
Replicate Sample ID	B1-S1	B1-S2	B1-S3	B2-S1	B2-S2	B2-S3	P1-S1	P1-S2	P1-S3	P2-S1	P2-S2	P2-S3				
Sampling Date	08/22/13	08/22/13	08/22/13	08/21/13	08/21/13	08/21/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	SLC ³	PEL ⁴	ISQG ⁵	PEL ⁴
Total Metals by ICPMS (mg/kg)																
Aluminum	5,060	5,710	5,440	5,530	5,270	5,150	10,100	11,500	7,000	6,460	6,130	6,870	-	-	-	-
Antimony	0.72	0.94	0.68	0.54	0.56	0.51	4.03	4.87	5.14	92.7	68.1	72.8	-	-	-	-
Arsenic	10.8	15.1	11.2	8.73	8.28	8.80	32.0	90.8	26.3	791	803	661	-	17	5.9	17
Barium	83.6	102	82.7	73.4	69.3	79.7	115	211	117	199	142	122	-	-	-	-
Beryllium	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	0.68	<0.40	0.64	<0.40	<0.40	<0.40	-	-	-	-
Bismuth	0.15	0.28	0.20	0.14	0.12	0.19	0.15	0.46	0.18	5.60	6.42	4.86	-	-	-	-
Cadmium	0.315	0.435	0.391	0.253	0.255	0.276	1.30	1.50	1.66	18.3	9.77	5.45	-	3.5	0.6	3.5
Calcium	3,960	5,020	4,040	3,600	3,400	4,040	5,230	6,180	4,310	5,010	4,220	4,390	-	-	-	-
Chromium	11.6	16.3	12.0	9.4	8.7	10.9	4.0	13.2	3.6	8.9	8.9	10.7	-	90	37.3	90
Cobalt	3.34	4.18	3.49	3.15	3.04	3.19	5.49	7.48	4.98	10.6	8.15	4.87	-	-	-	-
Copper	5.59	7.70	6.19	5.47	5.31	5.20	9.63	16.7	9.23	136	107	127	-	197	35.7	197
Iron	12,200	18,000	12,300	9,880	9,210	11,900	27,300	21,900	20,800	29,900	32,400	30,500	21,200 ⁶	-	-	-
Lead	10.9	17.4	10.8	9.77	8.62	8.32	58.1	30.0	70.1	312	286	245	-	91	35	91.3
Lithium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.5	7.4	<5.0	<5.0	<5.0	5.4	-	-	-	-
Magnesium	2,050	2,240	2,170	2,250	2,190	2,090	3,200	2,980	2,200	2,220	2,040	2,240	-	-	-	-
Manganese	222	324	295	260	276	312	717	1,530	999	7,810	4,140	676	-	-	-	-
Mercury	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.068	<0.050	0.073	0.065	0.071	-	0.486	0.17	0.486
Molybdenum	0.38	0.53	0.37	0.29	0.23	0.29	0.31	0.52	0.44	1.13	0.79	0.48	-	-	-	-
Nickel	5.72	6.88	6.08	5.76	5.45	5.83	3.24	8.63	3.11	7.94	6.23	5.87	16 ⁶	-	-	-
Phosphorus	800	1,090	778	641	568	829	1,090	766	949	561	560	600	-	-	-	-
Potassium	467	542	513	524	509	470	666	642	432	679	614	578	-	-	-	-
Selenium	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	5	-	-
Silver	0.087	0.120	0.087	0.112	0.095	0.085	0.205	0.804	0.133	5.51	7.76	11.1	-	0.5 ⁷	-	-
Sodium	149	162	159	155	156	157	176	203	135	129	120	130	-	-	-	-
Strontium	19.1	23.3	21.7	21.5	20.0	21.4	34.1	50.0	25.5	66.6	51.7	44.2	-	-	-	-
Thallium	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.180	<0.050	0.216	0.191	0.154	-	-	-	-
Tin	0.25	0.28	0.24	0.22	0.22	0.25	0.56	0.45	1.13	0.44	0.48	0.45	-	-	-	-
Titanium	357	406	365	341	310	365	49.1	288	9.7	211	272	338	-	-	-	-
Uranium	0.840	0.849	0.533	0.409	0.363	0.441	0.392	1.57	0.337	0.888	0.829	0.785	-	-	-	-
Vanadium	32.2	48.9	30.6	22.3	20.1	31.1	54.9	35.9	32.9	26.4	27.2	29.4	-	-	-	-
Zinc	5,060	5,710	5,440	5,530	5,270	5,150	102	137	93.2	1,060	630	380	-	315	123	315
Zirconium	0.72	0.94	0.68	0.54	0.56	0.51	0.79	<0.50	<0.50	<0.50	<0.50	<0.50	-	-	-	-

Notes

¹Working Sediment Quality Guidelines for British Columbia (BCSQG), 2006.

²CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002.

³SLC = Screening Level Concentration

⁴ISQG = Interim Sediment Quality Guidelines

⁵PEL = Probable Effect Level

⁶Lowest effect level based on SLC

⁷Based on the Ontario Sediment Quality Guideline.

“-” Indicates no analysis conducted or no applicable standard available.

BOLD text indicates parameter exceeds CCME-ISQG

Shaded text indicates parameter exceeds CCME-PEL

ITALICS indicate parameter exceeds Working Sediment Quality Guidelines for British Columbia



Table 6.4: Detailed Stream Sediment Metals Analytical Data Including Comparisons with Applicable Aquatic Life Standards (Cont.)

Sample Location	Upper Dome Creek			Middle Dome Creek			Lower Dome Creek			Minnesota Creek			BCSQG ¹		CCME ²	
Replicate Sample ID	D1-S1	D1-S2	D1-S3	D2-S1	D2-S2	D2-S3	D3-S1	D3-S2	D3-S3	MI-S1	MI-S2	MI-S3				
Sampling Date	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/22/13	08/22/13	08/22/13	SLC ³	PEL ⁴	ISQG ⁵	PEL ⁴
Total Metals by ICPMS (mg/kg)																
Aluminum	6,530	6,720	8,050	11,800	6,570	6,130	9,970	8,700	10,000	5,060	5,530	6,280	-	-	-	-
Antimony	70.2	62.0	69.7	2.08	0.92	0.71	18.0	17.7	13.5	0.39	0.25	0.91	-	-	-	-
Arsenic	893	598	667	56.5	20.6	24.8	768	671	497	5.01	4.77	6.80	-	17	5.9	17
Barium	97.4	102	120	139	63.5	66.1	354	348	301	74.1	76.6	97.9	-	-	-	-
Beryllium	<0.40	<0.40	<0.40	0.58	<0.40	<0.40	0.40	<0.40	<0.40	<0.40	<0.40	<0.40	-	-	-	-
Bismuth	1.09	1.07	1.19	0.12	<0.10	<0.10	0.21	0.19	0.20	<0.10	<0.10	<0.10	-	-	-	-
Cadmium	8.19	6.90	10.7	0.807	0.296	0.250	2.42	2.04	1.97	0.103	0.103	0.178	-	3.5	0.6	3.5
Calcium	5,870	4,760	6,340	12,600	7,570	6,130	14,000	11,200	11,700	2,380	2,750	3,590	-	-	-	-
Chromium	10.1	9.7	12.2	23.3	13.3	12.0	21.5	18.4	20.9	8.6	9.5	21.5	-	90	37.3	90
Cobalt	4.14	4.17	4.95	8.36	4.45	3.93	12.6	12.1	10.8	3.27	3.50	5.36	-	-	-	-
Copper	32.2	26.1	34.8	20.3	7.97	6.63	41.5	36.9	36.3	5.31	5.54	7.82	-	197	35.7	197
Iron	28,000	16,700	22,000	25,400	14,300	13,000	64,000	55,600	47,600	9,170	9,960	26,600	21,200 ⁶	-	-	-
Lead	331	278	302	11.7	6.67	4.73	89.1	77.7	68.2	3.87	2.73	3.69	-	91	35	91.3
Lithium	5.2	5.5	6.8	11.0	5.8	<5.0	7.4	5.9	7.8	<5.0	<5.0	5.7	-	-	-	-
Magnesium	2,750	2,650	3,100	5,490	3,160	2,730	3,970	3,440	4,000	2,130	2,240	2,510	-	-	-	-
Manganese	681	596	589	437	409	158	11,500	10,400	11,000	166	202	282	-	-	-	-
Mercury	0.051	<0.050	0.060	<0.050	<0.050	<0.050	0.059	<0.050	<0.050	<0.050	<0.050	<0.050	-	0.486	0.17	0.486
Molybdenum	0.32	0.27	0.43	0.49	0.27	0.20	1.78	1.74	1.40	0.25	0.27	0.44	-	-	-	-
Nickel	6.28	6.55	7.90	16.3	8.68	7.58	17.1	16.4	16.1	6.21	6.68	9.33	16 ⁶	-	-	-
Phosphorus	634	507	602	620	563	509	712	763	632	356	402	541	-	-	-	-
Potassium	725	625	734	1,260	620	554	969	837	1,020	481	504	565	-	-	-	-
Selenium	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.69	0.56	0.61	<0.50	<0.50	<0.50	-	5	-	-
Silver	7.25	5.00	4.74	0.292	0.132	0.073	2.16	1.92	1.68	0.051	<0.050	0.058	-	0.5 ⁷	-	-
Sodium	138	149	155	275	190	160	235	210	224	123	144	139	-	-	-	-
Strontium	29.1	24.8	30.5	54.7	34.2	26.5	83.3	68.4	70.7	14.3	15.9	18.3	-	-	-	-
Thallium	0.268	0.247	0.329	0.168	0.067	<0.050	0.184	0.147	0.165	<0.050	<0.050	0.071	-	-	-	-
Tin	0.60	0.50	0.59	0.41	0.22	0.19	0.54	0.50	0.47	0.24	0.28	0.41	-	-	-	-
Titanium	338	359	408	785	463	413	428	421	451	287	327	468	-	-	-	-
Uranium	0.466	0.468	0.655	0.815	0.395	0.335	1.20	0.970	1.04	0.288	0.324	0.513	-	-	-	-
Vanadium	25.9	21.9	27.8	50.9	32.8	30.1	58.9	55.5	54.7	19.5	22.2	72.1	-	-	-	-
Zinc	782	720	1,090	107	53.6	45.3	256	245	200	24.0	25.2	38.1	-	315	123	315
Zirconium	0.90	0.85	0.98	1.80	1.50	1.41	1.16	0.85	1.27	0.88	0.85	0.76	-	-	-	-

Notes
¹Working Sediment Quality Guidelines for British Columbia (BCSQG), 2006.
²CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002.
³SLC = Screening Level Concentration
⁴ISQG = Interim Sediment Quality Guidelines
⁵PEL = Probable Effect Level
⁶Lowest effect level based on SLC
⁷Based on the Ontario Sediment Quality Guideline.
“-“ Indicates no analysis conducted or no applicable standard available.
BOLD text indicates parameter exceeds CCME-ISQG
Shaded text indicated parameter exceeds CCME-PEL
ITALICS indicate parameter exceeds Working Sediment Quality Guidelines for British Columbia



Table 6.4: Detailed Stream Sediment Metals Analytical Data Including Comparisons with Applicable Aquatic Life Standards (Cont.)

Sample Location	Victoria Creek - Reference			Victoria Creek – Downstream Back			Victoria Creek – Upstream Minnesota			Victoria Creek – Downstream MC			BCSQG ¹		CCME ²	
Replicate Sample ID	V1-S1	V1-S2	V1-S3	V2-S1	V2-S2	V2-S3	V3-S1	V3-S2	V3-S3	V4-S1	V4-S2	V4-S3				
Sampling Date	08/22/13	08/22/13	08/22/13	08/21/13	08/21/13	08/21/13	08/22/13	08/22/13	08/22/13	08/29/13	08/29/13	08/29/13	SLC ³	PEL ⁴	ISQG ⁵	PEL ⁴
Total Metals by ICPMS (mg/kg)																
Aluminum	8,100	6,460	7,740	8,240	7,180	6,090	7,120	7,970	7,240	7,500	7,100	6,140	-	-	-	-
Antimony	0.86	0.71	0.70	0.72	0.83	0.48	0.88	0.85	0.98	1.02	0.86	0.91	-	-	-	-
Arsenic	15.0	12.2	13.2	14.0	15.0	8.92	16.6	16.5	17.7	16.9	15.1	15.1	-	17	5.9	17
Barium	118	94.2	110	113	113	75.0	109	111	107	109	105	95.4	-	-	-	-
Beryllium	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	-	-	-	-
Bismuth	0.17	0.13	0.14	0.16	0.15	0.12	0.19	0.19	0.22	0.20	0.17	0.19	-	-	-	-
Cadmium	0.399	0.270	0.314	0.371	0.402	0.225	0.440	0.373	0.344	0.339	0.420	0.290	-	3.5	0.6	3.5
Calcium	4,130	3,230	3,640	4,290	3,730	3,420	4,040	3,700	3,700	3,990	3,850	3,330	-	-	-	-
Chromium	12.9	10.1	12.2	12.7	11.7	9.7	13.0	14.6	13.3	12.0	12.5	10.7	-	90	37.3	90
Cobalt	5.28	4.77	5.07	5.10	4.98	3.43	4.91	5.24	4.66	4.50	4.71	3.94	-	-	-	-
Copper	12.1	9.06	10.6	11.2	10.5	7.77	10.8	11.5	10.4	10.7	10.9	8.49	-	197	35.7	197
Iron	15,700	12,400	14,100	14,500	14,100	10,300	14,400	14,400	15,400	13,500	14,000	12,700	21,200 ⁶	-	-	-
Lead	13.2	10.5	13.0	12.8	14.0	8.79	14.9	13.7	16.7	14.5	13.0	13.9	-	91	35	91.3
Lithium	6.6	5.5	6.9	7.2	6.5	5.4	6.3	6.6	6.2	6.5	6.2	5.1	-	-	-	-
Magnesium	3,020	2,550	2,960	3,160	2,830	2,340	2,800	3,190	2,780	2,860	2,770	2,420	-	-	-	-
Manganese	276	253	236	274	296	165	327	292	409	286	273	259	-	-	-	-
Mercury	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-	0.486	0.17	0.486
Molybdenum	0.65	0.53	0.56	0.50	0.51	0.42	0.56	0.55	0.56	0.52	0.52	0.51	-	-	-	-
Nickel	7.70	6.39	7.42	8.19	7.48	6.11	7.66	8.43	7.83	7.69	7.36	6.25	16 ⁶	-	-	-
Phosphorus	735	639	635	559	581	663	745	549	662	581	632	607	-	-	-	-
Potassium	514	436	514	638	530	444	596	650	589	634	550	502	-	-	-	-
Selenium	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	5	-	-
Silver	0.181	0.106	0.183	0.173	0.148	0.088	0.166	0.150	0.157	0.158	0.147	0.133	-	0.5 ⁷	-	-
Sodium	143	139	147	167	159	150	150	172	156	164	148	143	-	-	-	-
Strontium	32.5	26.3	31.0	34.9	31.6	22.5	27.0	30.2	25.6	28.6	28.4	23.1	-	-	-	-
Thallium	0.065	0.052	0.065	0.072	0.064	<0.050	0.072	0.080	0.064	0.078	0.062	0.055	-	-	-	-
Tin	0.28	0.27	0.27	0.24	0.27	0.21	0.27	0.28	0.30	0.27	0.26	0.26	-	-	-	-
Titanium	393	326	384	406	373	315	396	417	425	389	371	335	-	-	-	-
Uranium	1.15	0.726	0.864	0.881	0.784	0.670	0.909	0.946	0.855	0.814	0.991	0.617	-	-	-	-
Vanadium	32.7	25.2	29.7	28.2	29.2	21.8	32.5	28.3	33.6	27.6	29.8	27.5	-	-	-	-
Zinc	59.7	46.9	58.3	55.7	52.6	37.9	54.3	58.8	57.7	55.8	53.7	46.4	-	315	123	315
Zirconium	0.95	1.12	1.11	1.12	1.13	1.20	1.12	1.18	1.29	1.03	1.03	1.10	-	-	-	-

Notes
¹Working Sediment Quality Guidelines for British Columbia (BCSQG), 2006.
²CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life, 2002.
³SLC = Screening Level Concentration
⁴ISQG = Interim Sediment Quality Guidelines
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⁷Based on the Ontario Sediment Quality Guideline.
“-” Indicates no analysis conducted or no applicable standard available.
BOLD test indicates parameter exceeds CCME-ISQG
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6.1.2.3.2 Dome Creek

Upper Dome Creek (D1)

- Arsenic in sediment from upper Dome Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Cadmium in sediment from upper Dome Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Lead in sediment from upper Dome Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Zinc in sediment from upper Dome Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Iron in sediment from upper Dome Creek exceeded BCSQG-SLC in two of three replicate samples.
- Silver in sediment from upper Dome Creek exceeded BCSQG-PEL in all three replicate samples.

Middle Dome Creek (D2)

- Arsenic in sediment from middle Dome Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Cadmium in sediment from middle Dome Creek exceeded CCME-ISQG in one of three replicate samples.
- Iron in sediment from upper Dome Creek exceeded BCSQG--SLC in one of three replicate samples.
- Nickel in sediment from upper Dome Creek exceeded BCSQG-SLC in one of three replicate samples.

Lower Dome Creek (D3)

- Arsenic in sediment from lower Dome Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.
- Cadmium in sediment from lower Dome Creek exceeded CCME-ISQG in all three replicate samples.
- Copper in sediment from lower Dome Creek exceeded CCME-ISQG in all three replicate samples.
- Lead in sediment from lower Dome Creek exceeded CCME-ISQG in all three replicate samples, and
- Zinc in sediment from lower Dome Creek exceeded CCME-ISQG in all three replicate samples.
- Silver in sediment from lower Dome Creek exceeded BCSQG-PEL in all three replicate samples.

- Iron in sediment from upper Dome Creek exceeded BCSQG-SLC in all three replicate samples.
- Nickel in sediment from upper Dome Creek exceeded BCSQG-SLC in all three replicate samples.

All sediment metals that exceeded CCME-ISQG or BCSQG-SEL in Dome Creek (i.e., arsenic, cadmium, copper, lead, silver, iron, nickel and zinc) had lower concentrations at middle Dome Creek compared to levels at both the upper and lower Dome Creek sample sites. Arsenic concentrations in sediment from middle Dome Creek range from 20.6 and 56.5 mg/kg. These values are lower than those at upper and lower Dome Creek sample sites (598 to 893 mg/kg and 497 to 768 mg/kg, respectively). Zinc concentrations in sediments from Dome Creek revealed a similar pattern, with lowest values in the middle site (45.3 to 107 mg/kg) compared to the upper (720 to 1,090 mg/kg) and lower (200 to 256 mg/kg) sites. The highest observed metal concentrations on Dome Creek typically were found in sediments from the upper Dome Creek sample site (Table 6.4).

6.1.2.3.3 Back Creek

Upper Back Creek (B1)

- Arsenic in sediment from upper Back Creek exceeded CCME-ISQG in all three replicate samples.
- Zinc in sediment from upper Back Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.

Lower Back Creek (B2)

- Arsenic in sediment from lower Back Creek exceeded CCME-ISQG in all three replicate samples.
- Zinc in sediment from lower Back Creek exceeded CCME-PEL and BCSQG-PEL in all three replicate samples.

All sediment metals that exceeded BCSQG-SLC/PEL or CCME-PEL/ISQG on Back Creek (i.e., arsenic and zinc) had lower average concentrations at lower Back Creek compared to upper Back Creek. Zinc concentrations in all sediments from Back Creek were very high, with values ranging from 5,060 to 5,710 mg/kg at upper Back Creek and 5,150 to 5,530 mg/kg at lower Back Creek, respectively. Arsenic levels in sediments from Back Creek also show a slight decrease at the downstream site, with values ranging from 10.8 to 15.1 mg/kg at upper Dome Creek and 8.28 to 8.8 mg/kg at lower Dome Creek.

6.1.2.3.4 Victoria Creek

Victoria Creek Reference (V1)

- Arsenic in sediment from Victoria Creek reference exceeded CCME-ISQG in all three replicate samples.

Victoria Creek Downstream of Back Creek (V2)

- Arsenic in sediment from Victoria Creek downstream of Back Creek exceeded CCME-ISQG in all three replicate samples.

Victoria Creek Downstream of Dome Creek (V3)

- Arsenic in sediment from Victoria Creek upstream of Minnesota Creek exceeded CCME-PEL and BCSQG-PEL in one of three replicate samples, and CCME-ISQG in the remaining two replicate samples.

Victoria Creek Downstream Minnesota Creek (V4)

- Arsenic in sediment from Victoria Creek downstream of Minnesota Creek exceeded CCME-ISQG in all three replicate samples.

Arsenic levels exceeded CCME-ISQG at all Victoria Creek sample sites, and exceeded CCME-PEL and BCSQG-PEL in one replicate at sample Site V3 (with a value of 17.7 mg/kg). Levels of arsenic in Victoria Creek sediment generally were consistent throughout the Victoria Creek sample sites, ranging from 8.92 to 17.7 mg/kg. No major increases of sediment metals were observed between the Victoria Creek upstream reference and the downstream sample sites (Table 6.4).

6.1.2.3.5 Minnesota Creek

Minnesota Creek (MN)

- Arsenic in sediment from Minnesota Creek exceeded CCME-ISQG in one of three replicate samples.

Arsenic concentrations of 8.6 mg/kg were observed in samples collected from Minnesota Creek. All other metal concentrations met BCSQG-SLC and CCME-ISQG. Samples collected from the Minnesota Creek station (MN) had the lowest metal concentrations observed during the 2013 sampling program (Table 6.4).

6.2 STREAM BENTHIC MACROINVERTEBRATE COMMUNITY

The abundance, diversity, and community composition of benthic macroinvertebrates can be used as an indicator of changing environmental conditions. Many types of benthic invertebrates are sensitive to pollutants such as metals and organic wastes. Therefore, these organisms can be used as a monitoring tool to help track changes in aquatic habitat quality over time. ELR conducted benthic macroinvertebrate sampling in study area streams to provide a current characterization of benthic communities in relation to the Site.

6.2.1 Methods

6.2.1.1 Field and Laboratory Methods

ELR conducted benthic macroinvertebrate sampling at 12 aquatic environment sampling sites over two years (Figure 5.1; Table 6.5). Benthic invertebrate samples were originally collected from Pony Creek (P1 and P2), Back Creek (B1 and B2), Victoria Creek (V1, V2, V3, and V4), Minnesota Creek (M1), and middle Dome Creek (D2) in August of 2013. During this sampling event, it was discovered that substrates in upper and lower Dome Creek were too fine to be sampled using a Hess sampler, which had been chosen for the program. As data from these sites was considered important, follow up sampling was completed in September of 2014 using a Kick Net. During this second event, samples were collected from upper and lower Dome Creek (D1 and D3), and repeat samples were collected from middle Dome Creek (D2) and

Victoria Creek (V1, V2, V3, and V4) to allow for future comparison between the two sampling techniques. A summary of benthic invertebrate samples collected within the study area is provided in Table 6.5.

Table 6.5: Summary of Benthic Invertebrate Sampling Efforts in the Mount Nansen Study Area

Location	Sample Site	Date Sampled	Methodology
Back Creek	B1	Aug.30, 2013	Hess Sampler
	B2	Aug.28, 2013	
Pony Creek	P1	Aug.28, 2013	Hess Sampler
	P2	Aug.28, 2013	
Dome Creek	D1	Sept.4, 2014	Kick-net
	D2	Aug.29, 2013	Hess Sampler
		Sept.4, 2014	Kick-net
	D3	Sept.4, 2014	Kick-net
Minnesota Creek	M1	Aug.29, 2013	Hess Sampler
Victoria Creek	V1	Aug.28, 2013	Hess Sampler
		Sept.4, 2014	Kick-net
	V2	Aug.28, 2013	Hess Sampler
		Sept.4, 2014	Kick-net
	V3	Aug.29, 2013	Hess Sampler
		Sept.4, 2014	Kick-net
	V4	Aug.29, 2013	Hess Sampler
		Sept.4, 2014	Kick-net

The Hess sampler used in 2013 had an area of 0.086 m² used 363 µm mesh. The Hess sampler was inserted into the substrate to a depth of approximately 10 cm, and the substrate was washed for five minutes using a gloved hand (RIC 1997). Three replicate samples were collected from riffle areas in each sampling site. Each replicate sample was collected from an area with similar flow, depth, and substrate characteristics, and was sampled moving in an upstream direction (each spaced a minimum of 2 m from the previous).

The kick net used during 2014 sampling was a standard Canadian Aquatic Biomonitoring Network (CABIN) kick net with a mesh size of 400 µm. Sampling was conducted using a traveling kick technique, over three minute sampling intervals.

All macroinvertebrate samples were collected in plastic containers and preserved on site in 10% buffered formalin. Samples were sent under chain of custody to Cordillera Consulting of Summerland, British Columbia for taxonomic identification and enumeration. The taxonomist rinsed and sorted all samples to retrieve invertebrates prior to enumeration and identification to the lowest possible taxonomic level.

6.2.1.2 Data Analysis

Invertebrate Density

Benthic invertebrate density was calculated to provide a measure of the total abundance of organisms in a standardized area of streambed. Because density is calculated based on the area sampled, it could only be calculated for 2013 samples collected using a Hess sampler (area is not measured for kick nets). Each 2013 Hess replicate sample encompassed an area of 0.086 m², from which a standardized density of organisms/m² of streambed was calculated. Mean densities also were calculated for each study site.

Species Richness & EPT Index

Species richness is a measure of the number of individual taxa (species) identified in each sample.

The EPT index is a measure of the species richness (number of taxa) of Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) combined in each sample. Previous studies have reported the EPT index as a reliable indicator of water quality (Plafkin et al. 1989). Heavy-metal concentration has been shown to be the most important predictor variable for this metric (Clements et al. 2000).

Species Diversity & Evenness

Simpson's Diversity Index is a measure of the probability that two entities taken at random from a dataset will represent the same type, thereby providing a measure of the level of diversity in a particular community. Simpson's Diversity Index values range from zero and one, with greater values representing more diverse communities. Species diversity takes into consideration species richness (i.e., total number of different species in a community) and evenness (i.e., variation of abundance in individuals per species in a community).

The Simpson's Diversity Index (D) was calculated for each benthic macroinvertebrate replicate sample using the following equation (Environment Canada 2012):

$$D = 1 - \sum_{i=1}^S (p_i)^2$$

Where:

p_i is the proportion of the total count for each taxon i , and S is the total number of taxa.

Simpson's Evenness is a measure of the relative abundance of different species that make up the sample. Simpson's Evenness Index also ranges between zero and one, with greater values representing communities with a more even distribution of species.

Simpson's Evenness Index (E) was calculated using the following equation (Environment Canada 2012):

$$E = 1 / \sum_{i=1}^S (p_i)^2 / S$$

Where:

p_i is the proportion of the total count for each taxon i , and S is the total number of taxa.

Functional Group Composition

Functional feeding group analysis is a trait-based approach to benthic invertebrate assessment. Invertebrates are categorized based on physiological and morphological adaptations to show community level responses to environmental disturbances typically related to food web dynamics. Functional group information has been derived from lists developed for the Pacific Northwest by Aquatic Biology Associates, Inc. (CAMLnet 2003), which in turn was derived from Merritt and Cummins (1996) and other primary reference texts. Functional group composition was categorized according to the following major functional groups: predators, collector-gatherers, collector-filterers, scrapers, shredders, and other

(which includes all other functional groups). Previous studies have shown heavy-metal concentrations have a negative effect on the abundance of all the major feeding groups, with the greatest negative response observed in scrapers and predators (Clements et al. 2000).

Community Composition

The composition of benthic macroinvertebrate communities is widely used as an indicator of water quality and stream ecosystem health (Rosenberg et al. 1993). Benthic organisms have specific requirements in terms of physical and chemical conditions, and typically show taxa-related responses to environmental change. The proportion of pollution tolerant (Diptera and Oligochaeta) and intolerant (Ephemeroptera, Plecoptera, Trichoptera) taxa in a community help to assess the level of impact associated with a stream environment.

6.2.2 Results

6.2.2.1 Abundance and Diversity

Individual results for benthic community diversity and abundance measures are summarized in Appendix 4. Raw benthic invertebrate community results are provided in Appendix 5. Mean values of key metrics including density, species richness, EPT index, Simpson's Diversity Index, and Simpson's evenness are provided for each sample site in Table 6.6.

It should be noted that any variation in sampling method (e.g., Hess sampler vs. kick-net) will affect data consistency, thereby making comparisons across sampling events more difficult. For example, kick-net sampling is typically more effective at obtaining a complete species inventory for a given site as a larger area of the stream is sampled (resulting in higher species richness and EPT index), whereas the Hess sampler produces a more quantifiable measure for site specific densities. This variation should be noted when viewing the results within this report.

Density

The mean density of benthic macroinvertebrates across all sites and watercourses sampled ranged from 643 organisms/m² at sample site V3, to 14,826 organisms/m² at upper Pony Creek (P1; Table 6.6). This does not include samples collected in upper and lower Dome Creek (D1 and D3), where samples were only collected using a kick-net.

Victoria Creek benthic macroinvertebrate densities were highest at the upstream reference site (V1; mean density of 2,097 organisms/m²) and downstream of the Minnesota Creek confluence (V4; mean density of 2,287 organisms/m²). Lower densities were observed at sample sites downstream of the Dome Creek confluence (V3; mean of 643 organisms/m²) and, to a lesser extent, downstream of the Back Creek confluence (V2; mean of 1,461 organisms/m²).

Back Creek benthic macroinvertebrate densities varied significantly between sites. The mean benthic invertebrate density at lower Back Creek (B2) was 1,969 organisms/m². In comparison, the mean density at upper Back Creek (B1) was more than double this value, at 4,461 organisms/m².

Pony Creek benthic macroinvertebrate densities also were significantly different between upstream and downstream sample sites. The mean density at lower Pony Creek (P2) was 3,267 organisms/m², and the mean density at upper Pony Creek (P1) was 4.5 times higher, at 14,826 organisms/m² (Table 6.6).

Table 6.6: Summary of Mean Density, Species Richness, Simpson's Diversity, and Simpson's Evenness of Benthic Macroinvertebrate Samples Collected from the Mount Nansen Site in 2013 and 2014.

Sample Site ID	Sample Date	Invertebrate Density (#/m ²) ¹	Invertebrate Indices ²			
			Species Richness (No. species)	EPT Index (No. species)	Simpson's Diversity	Simpson's Evenness
V1	Aug.29, 2013	2,097	20	8	0.82	0.34
	Sept.4, 2014	-	32	15	0.84	0.20
V2	Aug.29, 2013	1,461	22	10	0.89	0.45
	Sept.4, 2014	-	33	17	0.82	0.17
V3	Aug.29, 2013	643	17	9	0.91	0.71
	Sept.4, 2014	-	29	15	0.79	0.16
V4	Aug.29, 2013	2,287	21	9	0.80	0.26
	Sept.4, 2014	-	32	17	0.87	0.24
D1	Sept.4, 2014	-	30	6	0.88	0.28
D2	Aug.28, 2013	1,760	18	1	0.75	0.23
	Sept.4, 2014	-	38	8	0.88	0.22
D3	Sept.4, 2014	-	14	5	0.17	0.09
B1	Aug.30, 2013	4,461	16	5	0.63	0.18
B2	Aug.29, 2013	1,969	15	5	0.68	0.21
P1	Aug.28, 2013	14,826	22	3	0.85	0.34
P2	Aug.28, 2013	3,267	20	4	0.68	0.16
MI	Aug.29, 2013	872	15	2	0.85	0.44

¹ Invertebrate density is only calculated for samples collected using a Hess sampler.

² For samples collected in 2013, indices presented are a mean value calculated from three replicates at each site. For samples collected in 2014, values are calculated from a single sample.

Species Richness

Species richness varied slightly among sample sites, with mean values ranging from 14 species (observed at lower Dome Creek; D3) to 38 species (observed at middle Dome Creek; D2). Samples collected in 2014 on Dome Creek produced the largest contrast between upstream and downstream sample locations (Table 6.6). In all other sampled streams, species richness was similar between upstream and downstream sites. In Victoria Creek, only the site below the Dome Creek confluence (V3) varied in species richness (17-29 species compared to 20-32 species; Table 6.6).

Samples collected using a kick-net methodology consistently produced a higher species richness values than those collected using the Hess sampler (Table 6.6).

EPT Index

Compared to species richness, EPT values demonstrated moderate variability amongst sites (Table 6.6). EPT index values were consistent and high at sampling sites located on Victoria Creek, ranging from 8 to 17 species. The next highest EPT value was from middle Dome Creek in 2014 (Kick net sample at D2; 8 species). Interestingly, the lowest EPT value observed was also at middle Dome Creek but in 2013 (Hess sampler at D2; 1 species). EPT index values from Pony Creek were similar between upstream and downstream sample sites, with a mean value of 3 species observed at upper Pony Creek and 4 species observed at lower Pony Creek. EPT index values from Minnesota Creek were also quite low, with a mean value of only 2 species.

Species Diversity

Species diversity was also found to be highest in Victoria Creek, upper and middle Dome Creek, upper Pony Creek, and Minnesota Creek (Table 6.6).

Simpson's diversity values calculated from Victoria Creek samples were consistently high in data collected using both techniques, ranging from 0.79-0.91. Both the highest (0.91) and lowest (0.79) species diversity values on Victoria Creek were reported at sample site V3.

Simpson's diversity values were generally lower for Back Creek, as well as for lower Pony Creek, and lower Dome Creek. In contrast, Simpson's diversity was relatively high in upper Pony Creek (P1) and upper and middle Dome Creek (D1 and D2) (Table 6.6). The lowest diversity value reported in the study was from lower Dome Creek, with a Simpson's diversity value of only 0.17 (suggesting a very simple community). Species diversity of samples collected from Minnesota Creek was higher than the majority of the other small streams (mean value of 0.85).

Species Evenness

Species evenness varied considerably between sample sites, with values ranging from a low of 0.09 at lower Dome Creek to a high of 0.71 (V3 in 2013). Species evenness in Victoria Creek was lowest downstream of the Back Creek confluence (V2; 0.17) and downstream of the Dome Creek confluence (V3 in 2014; 0.16). Similar to species diversity values, both the highest (0.71) and lowest (0.16) species evenness values observed on Victoria Creek were from sample site V3 (again likely related to the difference in collection methods).

Species evenness values for Back Creek were similarly low for both upstream and downstream sites (B1 and B2; 0.18 and 0.21). In Pony Creek, species evenness was higher at the upstream site (P1, 0.34) compared to the downstream site (P2, 0.16). The lowest evenness value reported in the study was from lower Dome Creek, with a Simpson's diversity value of only 0.09.

6.2.2.2 Community Composition Measures

Detailed benthic community and functional group composition data are provided in Appendix 4. General distribution of functional feeding groups and taxa are shown in Figure 6.2.

Functional Group Composition

Scrapers

Scrapers were only found in Victoria Creek and in upper Back Creek. Amongst the Victoria Creek sites, scrapers were most abundant at sites V2 and V3 in 2013 (mean value of 4% and 12.4% of the sample, respectively), as well as at Site V1 in both 2013 and 2014 (1.73% and 1.93%, respectively).

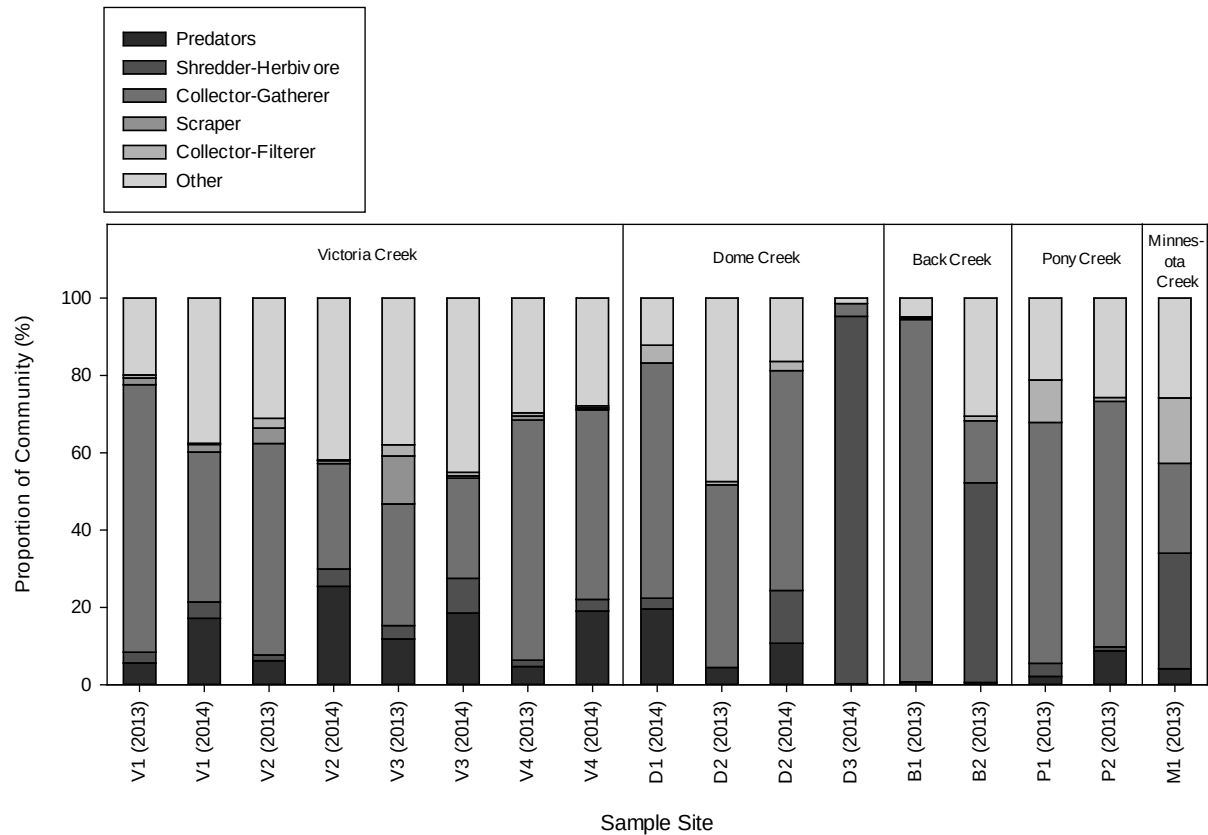


Figure 6.2: Relative Proportion of Functional Feeding Groups in Benthic Macroinvertebrate Sample Data from the Mount Nansen Study Area.

Predators

Predators occurred at all sample sites and from nearly all samples, being absent from only one replicate in lower Back Creek (B2). The proportion of predators ranged between 0.28% (D3) and 25.4% (V2 in 2014).

Amongst the Victoria Creek sites, the proportion of predators was found to be extremely varied, with consistently higher proportions observed from 2014 data (related to a change in sampling methods). Predators were found to represent a larger proportion at Site V2 (25.4%), but displayed no obvious pattern amongst the other Victoria Creek sites.

Predators were relatively least abundant in Back Creek, where they comprised only 0.6% and 0.8% at Sites B2 and B1, respectively. Predators represented a larger percentage of the community in lower Pony Creek (8.74%) compared to upper Pony Creek (2.12%).

The proportion of predators in Dome Creek was significantly reduced between upstream (19.5%; D1) and downstream (0.29%; D3) sample sites.

Shredder-Herbivores

The proportion of shredder-herbivores varied greatly amongst sample sites, with this group being absent from all replicate samples collected from middle Dome Creek and upper Back Creek (Figure 6.2).

Shredder-herbivores were identified in relatively low proportions in all samples from Victoria Creek, ranging from 1.47% (V2) and 8.97% (V3). In Back Creek, shredder-herbivores were absent in samples collected from upper Back Creek, but comprised 51.7% of the lower Back Creek sample. Similarly, in Dome Creek, the proportion of shredder-herbivores changed from 2.75% at the upstream sample site (D1) to 94.97% at the downstream site (D4).

In Pony Creek, the proportion of shredder-herbivores was similar between upper and lower sites, 3.4% and 1.08% of samples at Sites P1 and P2, respectively.

Shredder-herbivores comprised 29.8% of the sample from Minnesota Creek (M1).

Collector-Gatherers

Collector-gatherers were generally the most abundant functional feeding group identified, and the most abundant at nearly all sites sampled. The proportion of collector-filterers ranged from 3.2% (D3) to 93.6% (B2).

Amongst the Victoria Creek sites, collector-gatherers were proportionally most abundant at the upstream reference site (V1; 69.2%) and downstream of the Minnesota Creek confluence (V4; 62.1%). Collector-gatherers were least frequent proportionally downstream of the Back Creek confluence (V3; 25.9%).

Proportions of collector-gatherers in Back Creek were significantly higher upstream at Site B1 (93.6%) than those found downstream at Site B2 (16%). Similarly, proportions of collector-gatherers in Dome Creek were higher at the upper (D1, 60.8%) and mid (D2, 52%) sites compared to the lower site (D3, 3.2%). Proportions of collector-gatherers on Pony Creek were relatively consistent between upstream and downstream sample sites, with mean proportions of 62.32% and 63.45% at Sites P1 and P2, respectively.

Collector-Filterers

Collector-filterers were relatively uncommon in samples from the Site, but were present in nearly all samples except those at site D3. The mean proportion of collector-filterers ranged from 0% (D3) to 16.9% (M1).

In Victoria Creek, collector-filterers were least common in samples from the reference site at V1 (0.8%) and downstream of V4 (0.9%). Relatively higher proportions were found at V2 (2.5%) and V3 (2.9%).

Proportion of collector-filterers in Back Creek were similar between upstream (0.5%) and downstream (1.2%) sites.

The proportion of collector-filterers in Pony Creek were higher at the upper (11.0%) compared to the lower (1.0%) site. Similarly, proportions of collector-filterers in Dome Creek were higher at the upper (4.5%) compared to the mid (1.59%) and lower (0%) sites.

Taxonomic Composition

Detailed taxonomic data are provided in Appendix 4, while the mean distribution of key pollution tolerant and intolerant taxa are shown in Table 6.7 and described in the following section.

Pollution Tolerant Taxa (Diptera and Oligochaeta)

Pollution tolerant taxa such as macroinvertebrates belonging to the orders Diptera (true flies) and Oligochaeta (aquatic worms) were found in almost all samples, with Oligochaetes absent from only one location (D1; Table 6.7).

Amongst the Victoria Creek sites, benthic macroinvertebrates belonging to the order Diptera ranged between 23.27% and 67.63%, respectively. The proportion of dipterans in Victoria Creek was highest at Site V4 downstream of the Minnesota Creek confluence, but was comparable to the upstream reference site (V1) at most other locations (Table 6.7). The proportion of Oligochaetes in Victoria Creek ranged between 1.49% (V3) and 34.61% (V1) and demonstrated a decreasing trend from upstream to downstream sites, with the exception of an elevated proportion in lower Victoria Creek during 2014 (V4; 18.19%).

The abundance of dipterans was highly elevated in upper and middle Dome Creek (D1 and D2). These taxa represented between 77.13% and 91.6% of these samples, respectively. Dipterans were less abundant in lower Dome Creek, representing only 3.16% of the sample. Oligochaetes also represent only a small proportion of Dome Creek samples, with proportions ranging between 0% (D1) and 3.78% (D2).

The proportion of dipterans in samples from Back Creek was much lower at the lower site (B2, 87.9%) compared to the upper site (B1, 15.9%). In contrast, the relative proportion of oligochaetes at upper and lower Back Creek samples were similar (8.5% and 9.1%, respectively).

In Pony Creek, dipterans were a major contributor to the total number of taxa, representing 78.1% and 94.8% at Sites P1 and P2, respectively. Oligochaetes represented a small percentage of taxa at both sites (7.3 and 0.8%, respectively).

The proportion of pollution tolerant taxa in samples from Minnesota Creek was intermediate to other streams studied, with dipterans comprising 53.2% of samples and oligochaetes comprising 14.9% of benthic organisms.

Pollution Intolerant Taxa (Baetidae, Odonata, Ephemeroptera, Plecoptera, and Trichoptera)

Pollution intolerant taxa such as benthic invertebrates belonging to the orders Baetidae (small mayflies), Odonata (dragon flies and damselflies), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), were found in larger proportions in samples collected from Victoria Creek when compared to those collected from the smaller tributaries (Dome, Back, Pony, and Minnesota Creeks; Table 6.7).

Amongst the Victoria Creek sites, benthic macroinvertebrates belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera, were present in all samples, and were represented in varying proportions throughout the system. In all Victoria Creek samples, Ephemeroptera and Plecoptera were the most frequently occurring pollution intolerant taxa, with Trichoptera, Baetidae, and Odonata occurring less frequently.

The proportion of species belonging to the order Ephemeroptera in Victoria Creek was found to range between 2.83% (V4) and 47.14% (V3), respectively. Plecopterans also comprised between 12.17% (V4) and 27.34% (V2) of the benthic community Victoria Creek samples. Trichoptera were found in all Victoria Creek samples but less frequently, representing between 0.74% and 4.52%. Baetids were present in some of the Victoria Creek samples, but contributed only a small proportion and were not consistently present throughout the system. In addition, lower Victoria Creek (V4) was the only site at which species from the Order Odonata were observed (2.8% of the sample).



At the majority of the remaining sample locations (Dome, Back, Pony, and Minnesota Creeks), pollution intolerant invertebrates comprised only small proportions of the community, but with several exceptions (Table 6.7). Plecoptera were highly abundant at two locations: in lower Back Creek (B2; 71.13%) and in lower Dome Creek (D3; 94.98%).

Table 6.7: Summary of Mean Taxonomic Composition of Benthic Pollution Tolerant and Intolerant Macroinvertebrate Taxa Collected from the Mount Nansen Site in 2013 and 2014.

Sample Site ID	Sample Location	Taxonomic Composition Measures						
		Pollution Tolerant Taxa		Pollution Intolerant Taxa				
		% Diptera	% Oligochaeta	% Ephemeroptera	% Plecoptera	% Trichoptera	% Baetidae	% Odonata
V1	Aug.29, 2013	43.19	34.61	6.21	14.68	1.20	0.53	-
	Sept.4, 2014	32.94	10.64	34.23	17.10	4.52	1.94	-
V2	Aug.29, 2013	48.88	20.00	22.65	25.77	0.74	5.86	-
	Sept.4, 2014	24.04	5.81	39.70	27.34	2.88	3.49	-
V3	Aug.29, 2013	32.70	15.98	12.02	17.17	2.06	-	-
	Sept.4, 2014	23.27	1.49	47.14	26.26	1.49	5.37	-
V4	Aug.29, 2013	67.63	15.44	2.83	12.17	1.28	-	2.84
	Sept.4, 2014	35.01	18.19	26.48	18.73	0.27	4.96	-
D1	Sept.4, 2014	87.46	-	0.92	2.75	1.22	0.31	-
D2	Aug.28, 2013	91.57	3.71	-	1.54	-	-	-
	Sept.4, 2014	77.13	3.78	1.47	14.86	0.90	1.47	-
D3	Sept.4, 2014	3.16	1.15	0.57	94.98	0.14	-	-
B1	Aug.30, 2013	87.91	8.52	10.93	1.88	0.27	1.16	-
B2	Aug.29, 2013	15.94	9.10	3.39	71.13	0.30	0.66	-
P1	Aug.28, 2013	78.11	7.32	0.10	13.81	0.12	-	-
P2	Aug.28, 2013	94.80	0.80	0.49	1.78	0.49	0.34	-
M1	Aug.29, 2013	53.20	14.88	-	1.13	1.13	-	-

Notes:

Mean indices for 2013 data are calculated from three replicate samples at each site.

6.2.2.3 *Benthic Invertebrate Summary*

In summary, the benthic macroinvertebrate samples collected from Victoria Creek tended to have more abundant and diverse benthic communities compared with the smaller tributary streams. The benthic community composition at the three downstream sites on Victoria Creek (sites V2, V3, and V4) were similar in most cases to the uppermost (reference) condition at Site VI.

Benthic invertebrate samples collected from Back, Pony, and Dome Creeks exhibited characteristics that could suggest simpler or more impaired stream environments. Samples collected from these watercourses typically had high percentages of pollution tolerant taxa (e.g., Diptera), lower EPT index values, and reduced proportions of heavy-metal sensitive feeding groups (scrapers and predators).

Comparisons of data from upstream and downstream sampling stations on both Back and Pony Creeks do not show consistent trends. The benthic macroinvertebrate community in samples collected at upper Back Creek had higher proportions of pollution tolerant organisms, but were similar to lower Back Creek when comparing other community measures. Samples collected from upper Pony Creek demonstrated higher species diversity, while those collected in lower Pony Creek demonstrated an increase in metal-sensitive feeding groups. The proportion of pollution tolerant organisms was relatively consistent between upper and lower Pony Creek sites.

Results from Dome Creek demonstrated some conflicting trends in results. Upper and middle sites in Dome Creek (D1 and D2) were comprised of more pollution-tolerant taxa, had higher diversity, and high species richness compared to the lower site (D3). The community of lower Dome Creek (D1) was dominated by relatively few taxon, including stoneflies (Plecoptera) of the family Nemouridae that comprised nearly 95% of the sample. This difference can also be viewed in the distribution of functional feeding groups, which suggests differences in available habitat between stream sites (Figure 6.2). These data suggest that lower Dome Creek may be influenced by processed occurring downstream of the tailings storage facility, although cannot be determined precisely whether it may be due to chemical, physical, or biological processes.

6.3 STREAM PERIPHYTON

Periphyton is an important food source for invertebrates and fish, and often is used as an indicator of primary productivity and water quality. Periphyton is comprised of benthic algae, bacteria, fungi, microinvertebrates and detritus that grow attached to substrate, such as rocks and larger plants, in the aquatic ecosystem.

Periphyton biomass was estimated at aquatic environment sample sites using photosynthetic pigment concentrations (i.e., chlorophyll *a*, chlorophyll *b*, and phaeophytin *a*). Chlorophyll *a* is found in all oxygen-evolving photosynthetic organisms and is used as a standard measure of periphytic biomass (Biggs and Kilroy 2000). Chlorophyll *b* is found in the green algae (euglenophytes) and other minor groups (Wetzel 2001). Although different taxonomic groups contain distinct assemblages of pigments, chlorophyll *a* is found in the majority of periphytic algae including cyanobacteria and is, therefore, the most useful pigment in estimating total periphyton biomass (Biggs and Kilroy 2000, Wetzel 2001). Many factors may influence periphyton community composition, including light and temperature dynamics, inorganic and organic nutrient availability, and predation by benthic invertebrates and other organisms (Wetzel 2001).

6.3.1 Methods

6.3.1.1 Field Sample Collection and Analysis

Periphyton communities were characterized in each of the five streams sampled during the study program over two years (2013 and 2014). Periphyton samples were originally collected from Pony Creek (P1 and P2), Back Creek (B1 and B2), Victoria Creek (V1, V2, V3, and V4), Minnesota Creek (M1), and middle Dome Creek (D2) in August of 2013. During this sampling event, it was discovered that the substrate of upper and lower Dome Creek consisted nearly entirely of fines and lacked suitable substrates for in-situ sampling (e.g., cobbles or boulders) from which to sample periphyton. As data from these sites was considered important, follow up sampling was completed during the summer of 2014 using artificial substrates. During this second effort, artificial substrates were established and sampled in upper and lower Dome Creek (D1 and D3), and repeat samples were collected from middle Dome Creek (D2) and Victoria Creek (V1, V2, V3, and V4) to allow for future comparison between the two sampling techniques.

For sites sampled in 2013, three separate rocks were retrieved randomly from riffle habitat (at least 1 m apart from each other). Two standard size circles (5.5 cm diameter) were etched into the surface of each rock, following which the periphyton was scraped from within the circles using a knife and small brush, and washed into two separate containers. One of the samples was wrapped in aluminum foil and kept dark and chilled for productivity analysis (Maxxam Analytics in Burnaby BC). Productivity analyses included chlorophyll *a*, *b*, and phaeophytin *a*. The other sample was preserved with Lugol's solution for taxonomic analysis (Fraser Environmental Services, Surrey, BC). Taxonomic analyses included cell enumeration and identification (to the lowest level possible).

For sites sampled in 2014, artificial substrates were used due to a lack of suitable natural substrates. Artificial substrate sampling is a useful methodology for measuring biomass production rates where the natural substrates cannot be sampled (Biggs and Kilroy 2000). For this sampling, five plates of artificial substrate (ceramic tile bonded to a clay brick for weight) were installed at each sample location (Biggs and Kilroy 2000) to provide a smooth surface on which periphyton could colonize. Each plate was installed into the streambed to be flush with the existing stream substrate, and further positioned to reduce stream turbulence. Plates were placed in similar type habitat at each location, targeting the tail end of riffle areas where there would be consistent flow and sufficient water to ensure the plates would stay submerged at lower water conditions. The plates were then sampled following a seven week colonization period. At

that time, each plate was retrieved, and a standard size area (5.5 × 11.0 cm) was etched into the surface of three of the five installed plates, following which the periphyton was scraped from within the area using a knife and small brush, and washed into two separate containers. The sampled plates were selected based on field condition (i.e., plate was not found covered in substrate, and upright in its original position) and colonization potential (plates appeared to have been submerged throughout the colonization period). Consistent with methods used in 2013, one of the samples was wrapped in aluminum foil and kept dark and chilled for productivity analysis (Maxxam Analytics in Burnaby BC). The other sample was preserved with Lugol's solution for taxonomic analysis (Fraser Environmental Services, Surrey, BC).

6.3.1.2 Data Analysis

Cell Density and Primary Productivity

Periphyton cell densities were calculated to provide a measure of the total abundance of periphyton on a standardized area of stream substrate. For sites sampled in 2013, each sample encompassed an area of 0.0085 m², whereas 2014 samples encompassed an area of 0.00238 m². A standardized density unit of cells/cm² of substrate was calculated for each site.

Standardized figures of periphyton productivity were calculated from chlorophyll *a* data, where chlorophyll densities were calculated in terms of mg/m² of stream/artificial substrate.

Community Diversity and Evenness

The community diversity of periphyton at each site was calculated using Simpson's Diversity Index (Environment Canada 2012):

$$D = 1 / \sum_{i=1}^S (p_i)^2$$

Where:

p_i is the proportion of the total average cell density (cells/cm²) for each taxon i , and S is the total number of taxa.

Simpson's Evenness is a measure of relative abundance of the different species that make up a particular sample. Simpson's Evenness Index also ranges between zero and one, with greater values representing communities with a more even distribution of species.

Simpson's Evenness Index (E) was calculated as (Environment Canada, 2012):

$$E = 1 / \sum_{i=1}^S (p_i)^2 / S$$

Where:

p_i is the proportion of the total average cell density (cells/cm²) for each taxon i , and S is the total number of taxa.

6.3.2 Results

Detailed biomass, community indicator, and major taxonomic composition data for periphyton samples is provided in Table 6.8. A summary of the predominant taxa in periphyton samples (representing 1% or greater of each sample by cell count) is provided in Table 6.9. These results are described according to each indicator in the following sections. Raw taxonomic and primary productivity data are presented in Appendices 6 and 7.

6.3.2.1 Cell Density and Primary Productivity

The cell density of periphyton samples collected from the study area watercourses ranged from 3,074 cells/cm² in lower Pony Creek (P2) to 1,306,636 cells/cm² in Victoria Creek downstream of the Back Creek confluence (V2; Figure 6.3).

Periphyton abundance in Victoria Creek was on average lowest at the upstream reference site (V1) and on average highest downstream of the Back Creek confluence (V2), although the average density at downstream of the Dome Creek confluence (V3) were nearly as high. In general, the Victoria Creek sites yielded some of the highest periphyton cell counts found within the study. Samples collected in 2014, using artificial substrate, consistently yielded lower counts than those collected from in-situ substrate except for the case of Site V1 (Figure 6.3; Table 6.8).

In the majority of the small creek systems (Back, Pony, and Dome Creeks), periphyton cell densities were lower at downstream sites compared to upstream sites (Figure 6.3). Periphyton cell densities from lower Pony Creek (P2) were the lowest observed during the study (3,074 cells/cm²), with significantly higher densities reported upstream (P1; 692,092 cells/cm²). Samples from Back Creek demonstrated a similar pattern, with higher counts upstream at B1 (1,251,538 cells/m²) compared to the downstream B2 sample site (553,148 cells/m²). Cell density in Dome Creek also displayed a similar pattern, however with low counts both at upper (D1) and lower (D3) sites. Minnesota Creek had a low cell density in relation other sites within the study (188,792 cells/cm²).

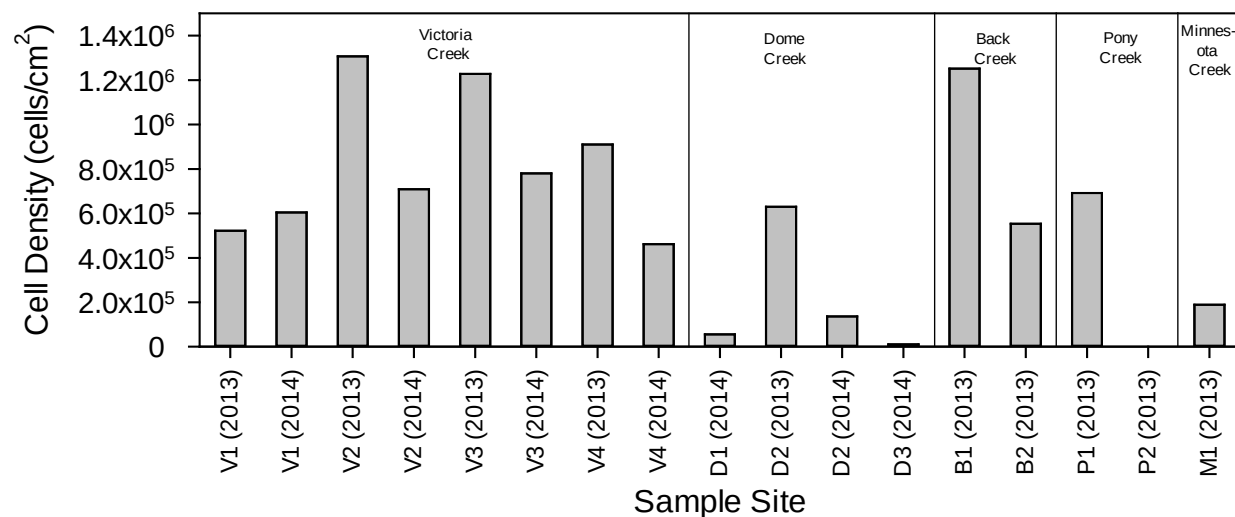


Figure 6.3: Periphyton Cell Density in the Mount Nansen Study Area



Table 6.8: Summary of Biomass, Community Index, and Taxonomic Composition of Periphyton Samples from the Mount Nansen Site

Watercourse	Back Creek		Pony Creek		Dome Creek				Minnesota Creek	Victoria Creek							
Sample Site	B1	B2	P1	P2	D1	D2		D3	M1	V1		V2		V3		V4	
Date Sampled	08/22/13	08/22/13	08/28/13	08/28/13	09/04/14	08/29/13	09/04/14	09/04/14	08/22/13	08/22/13	09/04/14	08/22/13	09/04/14	08/22/13	09/04/14	08/22/13	09/04/14
Primary Productivity																	
Chlorophyll a (mg/m²)	1.27	0.77	0.92	4.71	1.68	6.70	5.79	<0.3	0.58	2.58	4.21	3.32	9.40	0.94	3.90	1.26	2.71
Chlorophyll b (mg/m²)	<0.004	<0.002	0.14	0.26	<0.30	0.15	<0.90	<0.30	<0.002	<0.002	<0.60	<0.002	<1.50	<0.002	<0.60	<0.003	<0.60
Phaeophytin A (mg/m²)	<0.04	<0.07	0.31	0.50	<0.30	<0.01	<0.90	<0.30	<0.07	<0.09	0.98	<0.09	<1.50	<0.07	<0.60	<0.03	<0.60
Abundance & Taxonomic Indicators																	
Abundance (cells/cm²)	1,251,538	553,148	692,092	3,074	55,765	629,492	136,034	11,026	188,792	522,183	604,213	1,306,636	708,964	1,227,788	780,454	910,241	461,923
Taxon Richness	39	38	54	23	34	28	29	40	36	47	65	54	60	46	65	58	60
Simpson's Diversity	0.12	0.12	0.54	0.88	0.52	0.74	0.80	0.75	0.17	0.73	0.82	0.68	0.91	0.45	0.79	0.37	0.82
Simpson's Evenness	0.04	0.04	0.06	0.42	0.08	0.17	0.20	0.12	0.05	0.10	0.10	0.08	0.22	0.06	0.09	0.04	0.11
Taxonomic Composition (%) ¹																	
Bacillariophyceae	0.46	1.50	3.25	44.74	30.37	30.92	99.12	74.37	0.98	9.90	81.01	8.09	81.11	0.99	87.63	1.25	83.15
Chlorophyta	-	-	0.13	-	67.63	0.14	-	0.25	0.08	0.01	2.07	0.05	0.03	-	0.13	0.01	0.20
Chrysophyta	0.40	0.09	0.39	2.63	0.02	-	0.77	0.73	0.05	0.44	0.96	0.15	11.70	0.01	0.58	0.01	0.20
Cryptophyta	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanophyta	99.14	98.40	91.09	50.88	1.79	68.92	0.11	24.59	92.70	89.57	15.96	90.44	7.15	98.93	11.63	98.66	16.46
Euglenophyta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrrophyta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhodophyta	-	0.01	5.13	1.75	0.18	0.01	-	0.06	6.18	0.07	0.01	1.28	-	0.06	0.02	0.07	-

Notes:
¹ Phylum which represent less than 0.01% of the total taxonomic composition are not reported in the table



Table 6.9: Major Taxonomic Composition of Periphyton Samples Collected at Streams in the Mount Nansen Study Area

Watercourse		Back Creek		Pony Creek		Dome Creek				Minnesota Creek	Victoria Creek							
		B1	B2	P1	P2	D1	D2		D3	M1	V1		V2		V3		V4	
Sample Site		08/22/13	08/22/13	08/28/13	08/28/13	09/04/14	08/29/13	09/04/14	09/04/14	08/22/13	08/22/13	09/04/14	08/22/13	09/04/14	08/22/13	09/04/14	08/22/13	09/04/14
Taxon (% of Total Abundance)																		
Bacillariophyceae (diatoms)	<i>Achnanthes minutissima</i>	-	1.0	-	7.0	14.66	24.0	35.0	41.6	-	1.0	9.5	1.0	6.6	-	24.5	-	21.6
	<i>Achnanthidium microcephalum</i>	-	-	-	-	-	-	1.9	19.8	-	-	35.5	-	9.5	-	36.1	-	32.3
	<i>Ceratoneis arcus</i>	-	-	-	2.0	-	-	-	-	-	2.0	-	1.0	-	-	-	-	-
	<i>Cymbella</i> cf. ¹ <i>cymbiformis</i>	-	-	-	-	-	-	2.4	-	-	-	-	-	-	-	-	-	-
	<i>Diatoma moniliformis</i>	-	-	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-	-
	<i>Diatoma tenuis</i>	-	-	-	-	-	1.0	5.2	-	-	5.0	12.0	4.0	13.9	1.0	7.2	1.0	7.4
	<i>Encyonema minutum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0
	<i>Achnanthes petersenii</i>	-	-	-	4.0	-	1.0	-	-	-	-	-	-	-	-	-	-	-
	<i>Fragilaria vaucheriae</i>	-	-	-	4.0	2.8	1.0	6.1	-	-	-	-	1.0	1.0	-	-	-	-
	<i>Fragilaria</i> spp.	-	-	-	-	1.81	-	5.8	2.2	-	-	-	-	-	-	-	-	-
	<i>Gomphonema angustatum</i> /parvulum	-	-	-	-	-	-	14.8	-	-	-	4.1	-	11.7	-	2.9	-	3.3
	<i>Gomphonema</i> cf. ¹ <i>olivaceoides</i>	-	-	-	-	-	-	-	-	-	-	1.9	-	10.4	-	2.1	-	1.6
	<i>Hannaea arcus</i>	-	-	-	-	-	-	-	-	-	-	8.3	-	14.0	-	3.2	-	2.6
	<i>Rossithidium petersenii</i>	-	-	-	-	-	-	2.8	1.5	-	-	-	-	-	-	-	-	-
	<i>Rossithidium</i> spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1
	<i>Synedra</i> cf. ¹ <i>famelica</i>	-	-	-	-	8.52	-	20.2	4.2	-	-	3.1	-	8.7	-	5.3	-	8.6
	<i>Synedra ulna</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-
	<i>Deformed Diatoms</i>	-	-	-	-	-	-	-	-	-	-	-	-	2.1	-	-	-	-
Chlorophyta (green algae)	<i>Geminella</i> sp.	-		-	-	67.0	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Ulothrix</i> spp.	-		-	-	-	-	-	-	-	1.2	-	-	-	-	-	-	-
Chrysophyta (golden-brown algae)	<i>UID Chrysophyta palmella stage</i> ²	-		-	-	-	-	-	-	-	-	-	8.4	-	-	-	-	-
	<i>UID Chrysophyta flagellate</i> ²	-		-	-	-	-	-	-	-	-	-	2.3	-	-	-	-	-
Cyanophyta (blue-green algae)	<i>Chamaesiphon</i> spp.	94.0	94.0	27.0	11.0	-	1.0	-	3.8	-	29.0	1.8	38	1.7	68.0	-	77.0	8.1
	<i>Clastidium setigerum</i>	-	-	1.0	1.0	-	-	-	18.0	91.0	-	13.6	-	3.8	2.0	10.4	1.0	7.8
	<i>Homoeothrix janthina</i>	5.0	4.0	62.0	27.0	-	38.0	-	-	-	36.0	-	40.0	-	28.0	-	19.0	-
	<i>Homoeothrix</i> spp.	-	-	-	8.0	-	23.0	-	-	-	-	-	5.0	1.5	-	-	-	-
	<i>Oscillatoria</i> sp. A	-	-	-	-	-	-	-	-	-	22.0	-	6.0	-	-	-	1.0	-
	<i>Pseudanabaena</i> spp.	-	-	1.0	4.0	-	7.0	-	-	1.0	1.0	-	-	-	-	-	-	-

Notes:
Table includes only taxa that comprise minimum of 1% of the total taxonomic composition of a particular sample.
“-” indicates either no species were identified in the sample, or the species represents less than 1% of the sample.
¹ Conferim. Cells were close together and therefore only possible identification for species
² Unidentified species.

Chlorophyll *a*

Chlorophyll *a* concentrations in periphyton samples ranged from below detection ($<0.3 \text{ mg/m}^2$) in lower Dome Creek (D3) to 9.4 mg/m^2 in Victoria Creek downstream of the Dome Creek confluence (V3; Figure 6.4; Table 6.8). No other definitive patterns in periphyton productivity were apparent amongst the study area watercourses.

In Dome Creek, Chlorophyll *a* concentrations were highest both sampling years in middle Dome Creek (6.7 and 5.79 mg/m^2 in 2013 and 2014 downstream of the tailings facility; D2), and lowest in lower Dome Creek (0.30 mg/m^2 in 2014; Figure 6.4).

Samples collected from Victoria Creek in 2014 (using artificial substrate) yielded higher chlorophyll *a* concentrations than those collected from in-situ substrate, while those collected similarly from middle Dome Creek (D2) were lower but comparable (Figure 6.4; Table 6.8).

Chlorophyll *a* concentrations upstream in Back Creek were 39% lower than the downstream site (1.27 mg/m^2 at B1 compared to 0.77 mg/m^2 at B2). Chlorophyll *a* concentrations in Pony Creek showed the opposite trend, where concentrations at the lower site were five times higher than the downstream site (0.92 mg/m^2 at P1 compared to 4.71 mg/m^2 at P2; Figure 6.4; Table 6.8).

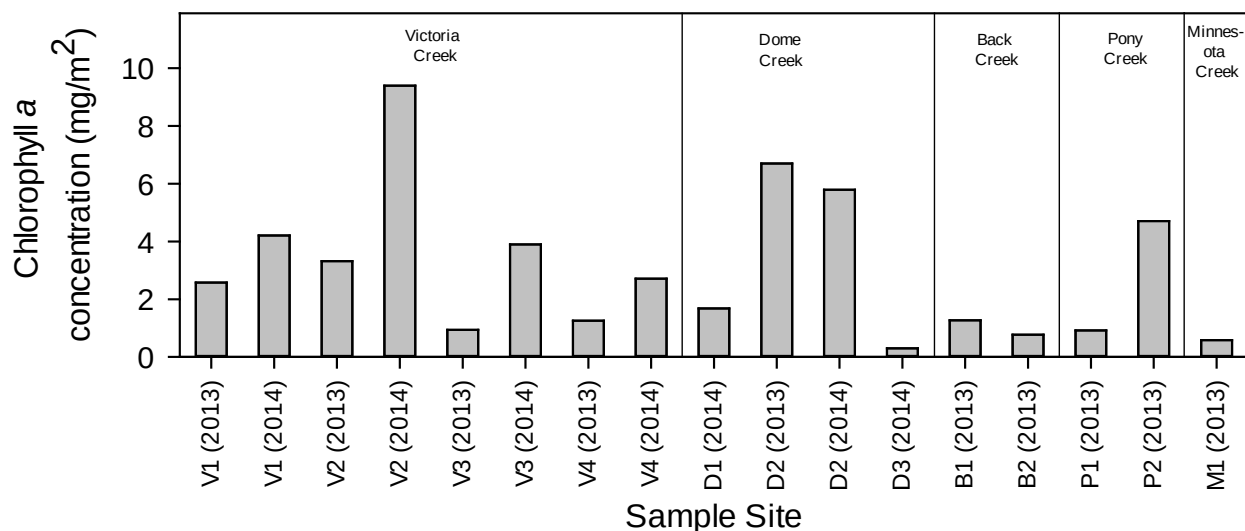


Figure 6.4: Periphyton Chlorophyll *a* Concentrations in the Mount Nansen Study Area

Chlorophyll *b* and Phaeophytin *a*

Chlorophyll *b* concentrations were below detection limits in the majority of samples collected, having only been detected at stations D2, P1, and P2. This pigment generally is present in green algae, and the study taxonomic results showed that green algae comprised only a small proportion of the total species abundance (<1% in all samples; Appendix 6). Concentrations of phaeophytin *a* also were below detectable limits in most samples; having only been detected in the samples from Pony Creek (P1 and P2) and the Victoria Creek reference site (V1).

Taxonomic Richness

Total taxonomic richness varied in periphyton samples, from 23 (P2) to 65 (V1 and V3) species per site. The highest taxonomic richness was observed in Victoria Creek, with 65 species identified at the upstream reference site (V1) and downstream of the Dome Creek confluence (V3), as well as 60 species identified at sites V2 and V4 (Figure 6.5 and Table 6.8; all from 2014 samples). The lowest taxonomic richness (24 species) was observed at lower Pony Creek.

A relatively low taxonomic richness was observed on Dome Creek (between 28 and 40 species), with the lower site having the greatest richness (D3). No major shift in species richness was observed between upper (B1; 39 species) and lower (B2; 38 species) Back Creek. A reduction in taxonomic richness was observed between upper (P1) and lower (P2) Pony Creek sites (54 species and 23 species, respectively). Overall, no consistent pattern was observed between upstream and downstream sites in any watercourse.

In all cases, the artificial substrates sampled in 2014 yielded higher taxonomic richness compared to 2013 in-situ samples.

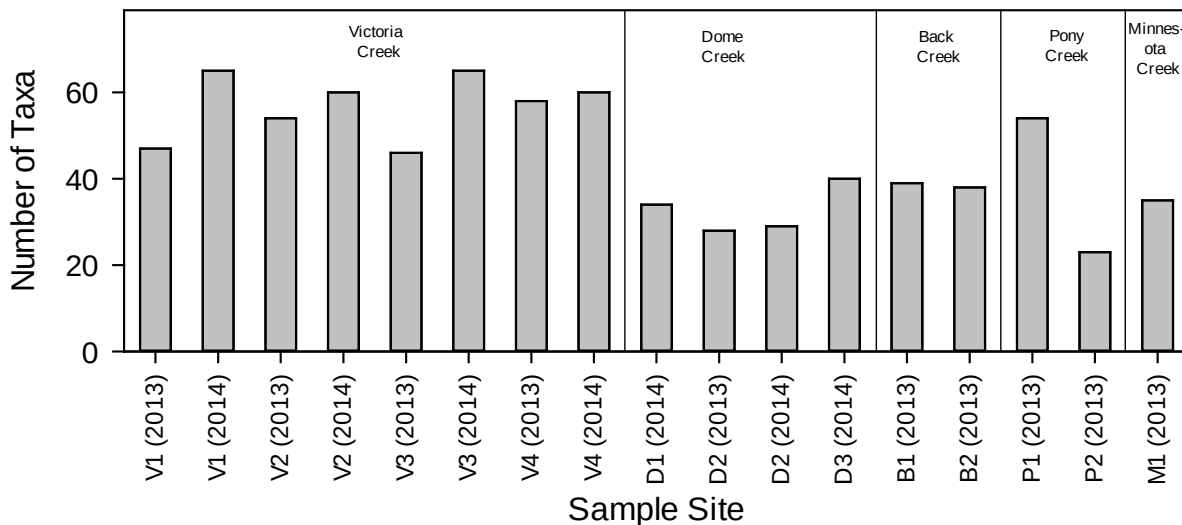


Figure 6.5: Periphyton Taxonomic Richness in the Mount Nansen Study Area

Simpson's Diversity

Species diversity (as indicated by Simpson's Diversity Index) varied considerably among sites, with the greatest index values calculated for samples collected at stations V2 (0.91), P2 (0.88), V1 (0.82), and V4 (0.82) (Figure 6.6; Table 6.8). At each of these sites, a notable shift in taxonomic composition was observed, with periphyton communities typically showing a reduction in relative abundance of blue-green algae (Cyanophyta) and increase of diatom (Bacillariophyceae) abundance.

Species diversity was lowest in Back Creek, having a value of 0.12 at both upper and lower sites. In these samples, blue-green algae (Cyanophyta) comprised between 98 and 99 percent of the species identified in each sample. Species diversity in Pony Creek was moderate and demonstrated an increase from the upstream site (P1) to the downstream site (P2) (0.54 and 0.88, respectively).

Species diversity in Minnesota Creek (M1) was amongst the lowest observed, at 0.17.

In all cases, the artificial substrates sampled in 2014 yielded higher Simpson's diversity figures compared to 2013 in-situ samples. The artificial substrate used during 2014 sampling tended to be more efficient at promoting colonization of diatom (Bacillariophyceae) communities, which is believed to have resulted in increased diversity within these samples (Figure 6.6; Table 6.8).

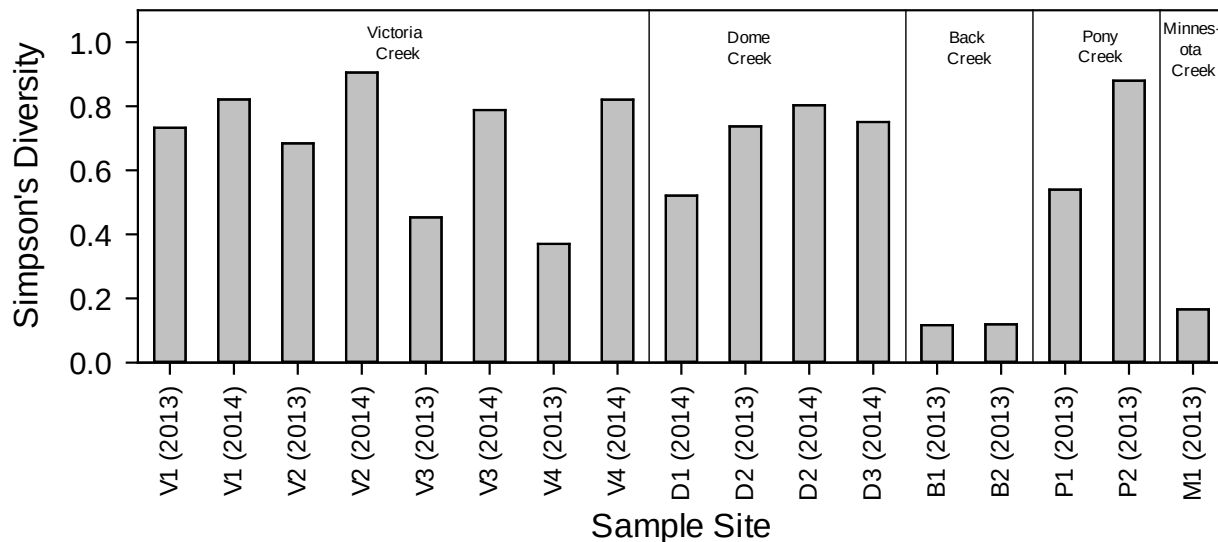


Figure 6.6: Simpson's Diversity Values for Periphyton Sampled in the Mount Nansen Study Area

Simpson's Evenness

Species evenness was low in all samples collected, ranging from 0.04 in Back Creek (B1 and B2) to 0.42 in lower Pony Creek (P2). Although species richness ranged between 23 (P2) and 65 (V1 and V3) species per site, the majority of these species were represented in relatively low densities, with several key species being highly abundant. Periphyton communities within the study tended to be either blue-green algae (Cyanophyta) or diatom (Bacillariophyceae) dominant, with the latter representing a slightly more diverse and even distribution of species.

Accordingly, sites that had an increased relative abundance of diatom species (e.g., P2, D2, and V1) had the highest values for species evenness (Figure 6.7; Table 6.8).

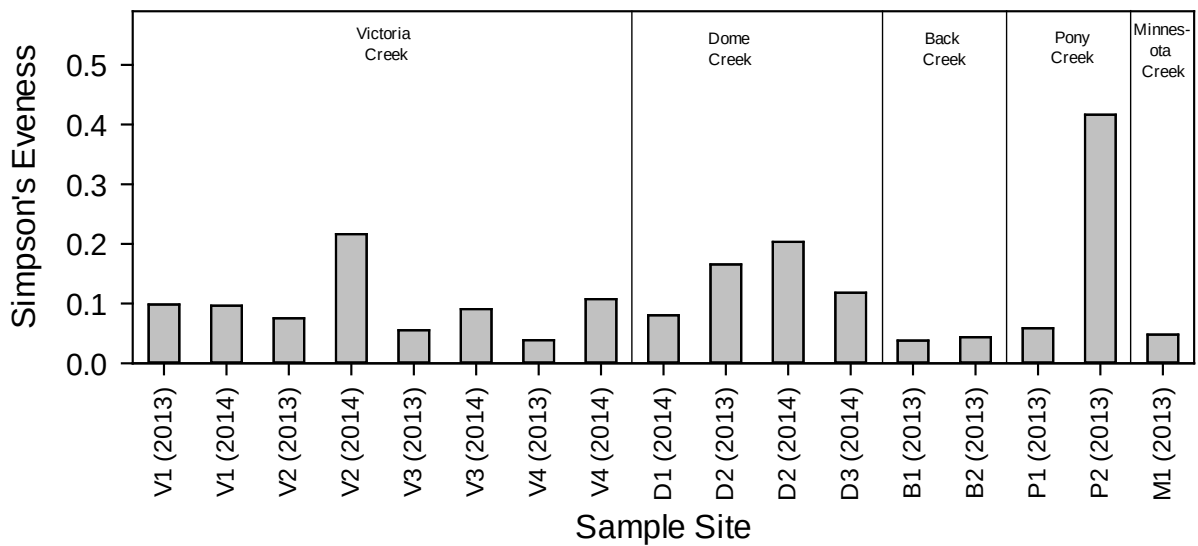


Figure 6.7: Simpson's Evenness Values for Periphyton Samples in the Mount Nansen Study Area

Community Indicators

Species belonging to the phylum cyanophyta (blue-green algae) dominated periphyton communities in the majority of samples collected in 2013, whereas samples collected in 2014 were predominantly comprised of species belonging to the phylum bacillariophyceae (diatoms). This is believed to be reflective of the change in sampling method as opposed to any actual shift in community assemblage.

Cyanophytes were identified in all samples and were the most ubiquitous phylum within 2014, with abundance ranging from 50.88% at station P2 to 99.14% at station B1. In contrast, the prevalence of cyanophytes in 2014 samples ranged from 0.11% at station D2 to 16.46% at station V4.

Diatoms (members of phylum bacillariophyceae) were the second most common periphyton group, and demonstrated an opposite shift to Cyanophytes (abundant in 2014 samples, but not in 2013 samples). Their abundance ranged from between 0.46% (at B1) to 83.15% (at V4) of the total species abundance in 2013 samples, and between 81.01% (at V1) and 92.2% (at D2) in 2014 samples (Table 6.8).

Blue Green Algae

Of the blue-green algae observed, two species dominated the samples collected; *Chamaesiphon* spp. and *Homoeothrix janthina* (Table 6.9).

In samples collected from Back Creek, *Chamaesiphon* spp. dominated both upstream (B1) and downstream (B2) sample sites, comprising 94% of the total taxonomic composition at both locations. Periphyton species *Homoeothrix janthina* was the sub-dominant species on the Back Creek system, comprising only 4% and 5% of the total taxonomic composition (Table 6.9).

Samples collected from Pony Creek demonstrated a reversed dominant/sub-dominant structure compared to Back Creek, although proportions were more evenly balanced. Upper Pony Creek (P1) was dominated by *Homoeothrix janthina* (62%) and sub-dominated *Chamaesiphon* spp. (27%). Although reduced in relative proportion, lower Pony Creek (P2) had a similar taxonomic composition, with *Homoeothrix janthina* as the dominant (27%) and *Chamaesiphon* spp. sub-dominant taxa (11%).

Samples collected from the Victoria Creek system also showed *Chamaesiphon* spp. and *Homoeothrix janthina* as the dominant/sub-dominant taxa for 2013 samples, however samples collected in 2014 show a greater dominance of diatom communities. Upstream and downstream sample sites had similar compositions of these species (Table 6.9).

Periphyton samples collected from Minnesota Creek showed a notably different taxonomic composition compared to the other sample sites because a different species was dominant. Here, the blue-green algae species *Clastidium setigerum* comprised 91% of the total taxonomic composition. This species is recognized as being an indicator of metal pollution. The reason for the presence of this species in Minnesota Creek is not known as all small streams sampled as part of this study show at least some elevated levels of metals (EDI, 2013).

Diatoms

Although in some samples diatom communities contributed only a small proportion to the total periphyton biomass, their relative abundance may still be useful in determining current environmental influences. The relative abundance of specific diatom taxa has been used as a bioindicator of heavy metal pollution (Yoshiaki et al. 2004). Specifically, the presence of *Achnanthes minutissima* has been correlated with concentrations of heavy metals, including copper, zinc, lead, and cadmium. *A. minutissima* was

identified in the majority of periphyton samples collected, and represented a substantial proportion of communities found in Dome Creek (Table 6.9).

The relative abundance of *A. minutissima* was highest in middle and in lower Dome Creek (D2 and D3), ranging between 24% and 41.6% of the total taxonomic composition, respectively. *A. minutissima* was also identified in all Victoria Creek sites, and was observed at slightly greater proportions at downstream sample locations (Table 6.9).

7. DISCUSSION

The presence of potential barriers to upstream fish movement and poor water quality conditions (also evidenced by benthic invertebrate and periphyton results) corroborate the lack of fish observations or captures in both Dome and Pony Creeks. These results, along with several other studies performed at different times of year that found no fish present (EDI 2007, EDI 2009a, EDI 2009c), support the current non-fish-bearing designation for these two watercourses. Dome Creek and Pony Creek currently do not provide direct fish habitat and are unlikely to do so regardless of the observed potential barriers in each system. In Dome Creek, the high level of suspended solids due to metals precipitation likely limits available rearing, summer feeding, and spawning habitats due to lack of pools and gravels. Other effects of reduced water quality included reduced oxygen content at some stations, and benthic macroinvertebrate and periphyton communities that appeared to be affected by stream conditions, which can have an effect on food availability. As well, both creeks are relatively small (e.g., Dome Creek channel width ranges from 0.30 to 1.4 m; Pony Creek channel width ranges from 0.40 to 1.3 m) and have been shown to freeze to the bottom during winter (EDI 2009a), thus eliminating overwintering habitat for fish. While it may be possible for fish to migrate past the potential barriers on either creek during spring freshet, the combination of poor habitat availability and poor water quality are likely the major determining factors for fish not using the creeks.

The fisheries and aquatic habitat assessment in Back Creek provided important information regarding the ongoing influence of placer mining, and also provided information suggesting that this stream is not frequently used by fish. No physical barriers were observed that would limit fish distribution in Back Creek. However, it appears the influence of current and historic extensive placer mining in Back Creek continues to affect habitat quality in all areas, but more noticeably in upstream areas. The streambed appears to be unstable and is undergoing rapid movement and riparian vegetation, which helps to stabilize a watercourse, is largely lacking. Despite these factors, Back Creek does provide important rearing habitat, at least occasionally.

The assessment of Victoria Creek provided additional information describing fish usage of this watercourse. The upstream portions of Victoria Creek (with respect to the OIC area) do not appear to be used heavily by fish despite the presence of suitable habitat (e.g., pools, deep runs, large woody debris features, and well developed riparian vegetation cover). The presence of both adult, juvenile, and young of year Arctic Grayling in Victoria Creek suggests this stream provides good quality feeding habitat during late summer, and that spawning is likely in upper reaches of Victoria Creek or its tributaries (beyond the study area), or in lower mainstem reaches.

Results from the fish habitat assessment show the majority of quality habitat is located on the Victoria Creek system. Victoria Creek is a more dynamic system compared to its four smaller tributaries (Back, Dome, Pony, and Minnesota), and offers a wider range of habitat features including deep pools, undercut stream banks, and large woody debris. These types of features provide excellent feeding and staging habitat for fish and other aquatic life. Benthic sampling shows that Victoria Creek also has the most diverse and species rich benthic communities found within the Project area, with moderate to high densities. The quality of habitat on Victoria is generally consistent throughout the extent of the sampled reach, showing only minor differences between upstream and downstream sampling locations. The most apparent differences were observed below the Minnesota Creek confluence, with benthic communities exhibiting characteristics of a more impacted stream environment. All sediments collected from Victoria Creek, including samples from the reference site, show elevated concentrations of arsenic in excess of CCME-ISQG guidelines. However, sediment metals were elevated for at least one metal in all sites studied.



Elevated concentrations of metals in sediment and water quality (EDI 2013) are expected to affect benthic and periphyton community compositions across all sites.

The fish habitat assessment conducted on Back, Dome, and Pony creeks show that channel width, substrate size, and overgrown vegetation were only some of the factors affecting lack of habitat availability. Sediment metal results show BCSQG or CCME quality guideline exceedances of many metals, including arsenic, zinc, cadmium, lead, copper, and silver. Benthic invertebrate samples collected from Back, Pony, and Dome Creeks exhibit characteristics of impacted stream environments, including high percentages of pollution tolerant taxa (e.g., dipterans), low EPT index values, and reduced proportions of heavy-metal sensitive feeding groups (scrappers and predators). Stream periphyton samples were also indicative of the current influence of metals within these streams, as evidenced by a simpler community structure and the presence of a metals tolerant species (*Achnanthes minutissima*).

8. LIMITATIONS AND DISCLAIMER

This report has been prepared for the Yukon government, Assessment and Abandoned Mines (YG-AAM), for application to the management of the Mount Nansen Site. The contents of this report have been prepared for the sole use of YG-AAM and its agents, for application to the aforementioned project. ELR is not responsible for the report contents or for any information within the report when the report is used or relied upon by any Party other than YG-AAM. The data and analysis are primarily based on field data collected by ELR between 2012 and 2014 on site, but also on previous unconfirmed data collected by other parties and provided to ELR for use in the current program.

This report has been prepared according to current professional standards, and using the information available as of the date of issue.

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PHOTOGRAPHS



Photo 1: View of the 45 cm cascade located at the outflow of Dome Creek to Victoria Creek. Photo taken June 20, 2012.



Photo 2: View of the series of cascades located at the outflow of Pony Creek into Back Creek. Photo taken June 23, 2012.



Photo 3: Alternate view of the series of cascades located at the outflow of Pony Creek into Back Creek. Photo taken June 23, 2012.



Photo 4: View of the 5th cascade identified on Pony Creek (18 and 28 cm drops). Photo taken June 23, 2012.



Photo 5: View of the sixth cascade identified on Pony Creek (46 cm). Photo taken June 23, 2012.



Photo 6: Representative photo of conditions in Victoria Creek in June of 2012. Photo taken June 21, 2012.



Photo 7: Representative photo of conditions in Victoria Creek in June of 2012. Photo taken June 21, 2012.



Photo 8: Representative photo of conditions in Victoria Creek in July of 2012. Photo taken July 24, 2012.



Photo 9: Representative photo of conditions in Victoria Creek in July of 2012. Photo taken July 24, 2012.



Photo 10: Representative photo of conditions in Victoria Creek in July of 2012. Photo also shows the main channel pool where several adult Arctic grayling were captured using a seine net. Photo taken July 24, 2012.



Photo 11: Representative photo of conditions of Victoria Creek in in August of 2013. Photo taken August 22,2013, Downstream view from sample site V1.



Photo 12: Representative photo of conditions of Victoria Creek in in August of 2012. Photo taken July 25,2012, Downstream view from sample site V2.



Photo 13: Representative photo of conditions of Victoria Creek in in August of 2013. Photo taken August 22,2013, Upstream view from sample site V3.



Photo 14: Representative photo of conditions of Victoria Creek in in August of 2013. Photo taken August 22,2013, Upstream view from sample site V4.



Photo 15: Representative photo of conditions of Dome Creek in in August of 2013. Photo taken August 29, 2013. Upstream view from sample site D1.



Photo 16: Representative photo of conditions of Dome Creek in in August of 2013. Photo taken August 29, 2013. Downstream view from sample site D2.



Photo 17: Representative photo of conditions of Dome Creek in in August of 2013. Photo taken August 29, 2013. Downstream view from sample site D3.



Photo 18: Representative photo of conditions of Pony Creek in in August of 2013. Photo taken August 28, 2013. Upstream view from sample site P1.



Photo 19: Representative photo of conditions of Pony Creek in August of 2013. Photo taken August 28, 2013. Upstream view from sample site P2.



Photo 20: Representative photo of conditions of Back Creek in August of 2013. Photo taken August 22, 2013. Upstream view from sample site B1.



Photo 21: Representative photo of conditions of Back Creek in in August of 2013. Photo taken August 21, 2013. Upstream view from sample site B2.



Photo 22: Representative photo of conditions of Minnesota Creek in in August of 2013. Photo taken August 22, 2013. Downstream view from sample site M1.



APPENDIX I – SCIENTIFIC COLLECTION PERMITS XR171-2012 AND XR304-2013



Valid From: 18-Jun-2012

Expiry Date: 31-Oct-2012

This licence and/or permit is issued under the authority of SECTION 52 OF THE FISHERY (GENERAL) REGULATIONS.

This licence and/or permit authorizes the person(s) listed below, subject to the following terms and conditions, to collect the species and quantity of fish identified below for: Scientific purposes. Non-compliance with any condition of this licence and/or permit may result in the cancellation of this licence and/or permit.

Licence/Permit Activity Description:

To sample fish with the intent to capture information on distribution, abundance, and habitat use. Information will be used for a fisheries baseline study being conducted within the watercourses near the Mount Nansen site.

Licence Holder:

FIN: 126381

Ecological Logistics & Research Ltd.

Contact Number: 867-668-6386

Fax Number: 867-668-6385

31 Thompson Road
Whitehorse YT Y1A 0C4

Contact Party:

FIN: 125636

Jastrebski, Chris

Contact Number: 867-335-1932

Fax Number: 867-668-6385

Individuals or groups assisting with the authorized activity:

Other assistant still TBD, all names to be included in notice provided prior to commencing sampling, as per "Terms and Conditions" of this licence.

FIN: 129315

John Minder

Contact Number: 867-668-6386

Species, Quantity of Fish, Area(s) and Gear:

Species: Unknown Species

Gear: Electroshocker
Rod And Reel
Seine, Beach
Trap, Gee/Minnow

Licence Area: Yukon/Transboundary
Watershed: 843 1403 902
Victoria Creek (as far downstream as 3 km downstream of the Mt. Nansen Road Crossing)
Dome Creek
Back Creek
Pony Creek

To be Retained: 0

Units: Individual Pieces

Additional Descriptions: **Gear :** When using bait, all bait must be from the drainage basin where the sampling is to occur or must be suitably preserved to remove all risk of the transmission of pathogens.

All gear left unattended must be clearly labelled XR 171 2012



Reporting Requirements:

XR 171 2012 Summary Report

Due Date 31-Dec-12

See "Terms and Conditions" of this licence for detailed requirements.

Terms and Conditions:

This licence authorizes collections to be made by the licensee and employees, volunteers and students of the licensee provided that all persons, other than minors who are engaged in activities under the authority of this licence, are carrying suitable photo identification to be produced upon request of a Fishery Officer or Guardian.

This license is subject to immediate termination upon written or verbal notice from a representative of the Yukon Government- Department of Environment, or of Fisheries and Oceans Canada.

Samplers: It is the responsibility of the license holder to ensure that samplers are experienced and competent in the fish collection methods authorized in this license.

Electrofishing: Is not permitted in the vicinity of spawning fish or their redds. A trained and certified electrofisher operator must be a part of the electrofishing crew.

Notice: Prior to commencing sampling, notice is to be given to:

- Fisheries and Oceans Canada, Yukon/Transboundary Rivers Area - Tel: (867) 393-6722 Fax (867) 393-6738 or Email: YTLicence@dfo-mpo.gc.ca
- Oliver Barker, YTG Fisheries - Email: fisheries@gov.yk.ca
- Appropriate First Nation governments.

The notice is to include following information:

- i. The Collection License number,
- ii. The watercourse or water body on which, and the location where the sampling is to take place,
- iii. The dates on which sampling will occur
- iv. The names of all assistants which will be engaged in the sampling.

- Note: Notice is also to be given to the Government of Yukon Conservation Officer responsible for any area where sampling is to take place at least 24 hours prior to the start of sampling.

Aquatic Invasive Species

To prevent the introduction of aquatic invasive species there are a few simple things that can be considered: a) Before leaving an area: Drain water from boat, trailer and gear, remove all plant parts and mud and b) Before entering another water body: Wash all your gear including waders with soapy water. For Further Information:

<http://www.pac.dfo-mpo.gc.ca/publications/docs/invasives-envahissantes-eng.htm>,

<http://www.dfo-mpo.gc.ca/science/enviro/ais-eae/plan/plan-eng.htm>

Disposition of fish: Any fish captured and retained under the authority of this license are not to enter any commercial markets or establishments. Any fish collected and retained, or incidental mortalities associated with non-lethal sampling, are not to be utilized for human consumption or personal use purposes unless authorized by Fisheries & Oceans Canada.

Release of fish: All live fish must be released unharmed into the water body or course from which they originated and as near as possible to the location from which they were captured. Exception to this is where fish are retained for identification or forensic purposes.



Transport or transplant of live fish and/or eggs/milt: Live fish and/or eggs (spawn) cannot be transported without prior written approval of the transplant committee or transplanted without a licence granted pursuant to Section 56 of the Fishery (General) Regulations.

Need to carry and produce permit: A copy of this license must be in the immediate possession of the samplers during sampling, and must be produced upon the request of any representative designated as a Fishery Officer or Fishery Guardian pursuant to the Fisheries Act (Canada).

Report: A report must be submitted after completion of sampling, preferably in electronic form by email. The report may be in the form of photocopied data sheets or field notes, or as the final report for the project, and must include the following:

- a. The Collection License number
- b. The location(s) of the sampling with GPS coordinates, and a map or detailed described if GPS coordinates were not possible;
- c. Names of all individuals engaged in sampling;
- d. The dates on which the sampling occurred;
- e. The number of fish sampled, by species;
- f. Any mortalities

A summary report is to be submitted by December 31, 2012 to:

Area Licensing Manager
Fisheries and Oceans Canada
100-419 Range Rd
Whitehorse Yukon
Y1A 3V1
Email: YTLicence@dfo-mpo.gc.ca

126381

FIN

Licence Holder - Print Name

Signature

Date

JUN 17 2012

Issued by: Denis D'Amours, A/Area Director, Yukon Transboundary Rivers Area
Fisheries and Oceans Canada

Date

Licence Printed: 18 June 2012



Valid From: 10-Aug-2013

Expiry Date: 31-Oct-2013

This licence and/or permit is issued under the authority of SECTION 52 OF THE FISHERY (GENERAL) REGULATIONS.

This licence and/or permit authorizes the person(s) listed below, subject to the following terms and conditions, to collect the species and quantity of fish identified below for: Scientific purposes. Non-compliance with any condition of this licence and/or permit may result in the cancellation of this licence and/or permit.

Licence/Permit Activity Description:

To sample fish for distribution, abundance. Information will be used for a fisheries baseline study being conducted within the watercourses near the Mount Nansen site.

Period of Activity:

Initial sampling: August 10-20; Additional sampling: Early September or October

Licence Holder:

FIN: 126381
31 Thompson Road
Whitehorse YT Y1A 0C4

Ecological Logistics & Research Ltd.

Contact Number: 867-668-6386
Fax Number: 867-668-6385

Contact Party:

FIN: 125636 Jastrebski, Chris

Contact Number: 867-335-1932
Fax Number: 867-668-6385

Individuals or groups assisting with the authorized activity:

Other assistant still TBD, all names to be included in notice provided prior to commencing sampling, as per "Terms and Conditions" of this licence.

FIN: 131525 Jonathan Lowey
FIN: 125637 Dave Desmarais

Contact Number: 867-668-6386
Contact Number: 867-668-3068

Species, Quantity of Fish, Area(s) and Gear:

Species: Unknown Species
Gear: Electroshocker
Seine, Beach
Trap, Gee/Minnow

Licence Area: Yukon/Transboundary; Watershed: 843; Victoria Creek (as far downstream as 3 km downstream of the Mt. Nansen Road Crossing); Back Creek

To be Retained: 0

Units: Individual Pieces

Additional Descriptions: **Gear :** When using bait, all bait must be from the drainage basin where the sampling is to occur or must be suitably preserved to remove all risk of the transmission of pathogens.

All gear left unattended must be clearly labelled XR 304 2013



Reporting Requirements:

XR 304 2013 Summary Data Report

Due Date 31-Dec-13

See "Terms and Conditions" of this licence for detailed requirements.

Terms and Conditions:

This licence authorizes collections to be made by the licensee and employees, volunteers and students of the licensee provided that all persons, other than minors who are engaged in activities under the authority of this licence, are carrying suitable photo identification to be produced upon request of a Fishery Officer or Guardian.

This license is subject to immediate termination upon written or verbal notice from a representative of the Yukon Government- Department of Environment, or of Fisheries and Oceans Canada.

Samplers: It is the responsibility of the license holder to ensure that samplers are experienced and competent in the fish collection methods authorized in this license.

Electrofishing: Is not permitted in the vicinity of spawning fish or their redds. A trained and certified electrofisher operator must be a part of the electrofishing crew.

Notice: Prior to commencing sampling, notice is to be given to:

- Fisheries and Oceans Canada, Yukon/Transboundary Rivers Area - Tel: (867) 393-6722 Fax (867) 393-6738 or Email: YTLicence@dfo-mpo.gc.ca
- Oliver Barker, YTG Fisheries - Email: fisheries@gov.yk.ca
- Appropriate First Nation Government in whose Traditional Territory the activity is taking place.

The notice is to include following information:

- i. The Collection License number,
- ii. The watercourse or water body on which, and the location where the sampling is to take place,
- iii. The dates on which sampling will occur
- iv. The names of all assistants which will be engaged in the sampling.

- Note: Notice is also to be given to the Government of Yukon Conservation Officer responsible for any area where sampling is to take place at least 24 hours prior to the start of sampling.

Aquatic Invasive Species

To prevent the introduction of aquatic invasive species there are a few simple things that can be considered: a) Before leaving an area: Drain water from boat, trailer and gear, remove all plant parts and mud and b) Before entering another water body: Wash all your gear including waders with soapy water. For Further Information:

<http://www.pac.dfo-mpo.gc.ca/publications/docs/invasives-envahissantes-eng.htm>,

<http://www.dfo-mpo.gc.ca/science/enviro/ais-eae/plan/plan-eng.htm>

Disposition of fish: Any fish captured and retained under the authority of this license are not to enter any commercial markets or establishments. Any fish collected and retained, or incidental mortalities associated with non-lethal sampling, are not to be utilized for human consumption or personal use purposes unless authorized by Fisheries & Oceans Canada.

Release of fish: All live fish must be released unharmed into the water body or course from which they originated and as near as possible to the location from which they were captured. Exception to this is where fish are retained for identification or forensic purposes.

Transport or transplant of live fish and/or eggs/milt: Live fish and/or eggs (spawn) cannot be transported without



prior written approval of the transplant committee or transplanted without a licence granted pursuant to Section 56 of the Fishery (General) Regulations.

Need to carry and produce permit: A copy of this license must be in the immediate possession of the samplers during sampling, and must be produced upon the request of any representative designated as a Fishery Officer or Fishery Guardian pursuant to the Fisheries Act (Canada).

Report: A report must be submitted after completion of sampling, in electronic spreadsheet form as provided by email with permit. If no sampling takes place a nil report is required. The report must be in the form of the spreadsheet provided but is not limited to and may also include photocopied data sheets or field notes, or the final report for the project, and must include the following:

- a. The Collection License number
- b. The location(s) of the sampling with GPS coordinates, and a map or detailed described if GPS coordinates were not possible;
- c. Names of all individuals engaged in sampling;
- d. The dates on which the sampling occurred;
- e. The number of fish sampled, by species;
- f. Any mortalities

A summary report is to be submitted by December 31, 2013 to:

Area Licensing Manager
Fisheries and Oceans Canada
100-419 Range Rd
Whitehorse Yukon
Y1A 3V1
Email: YTLicence@dfo-mpo.gc.ca

126381

FIN	Licence Holder - Print Name	Signature	Date
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Licence Issued: 06 August 2013

Licence Printed: 06 August 2013
Licence Issued By: LOUISE NAYLOR



APPENDIX 2 – SUMMARY OF 2012 AND 2013 FISH CAPTURE DATA

Location	Date	Gear Type ¹	Species ²	Fork Length (mm)	Total Length (mm)	Release Status
Victoria Creek DS of confluence with Back Creek	June 21 2012	EF	BB		280	Released Alive
Victoria Creek at confluence with Dome Creek	June 22 2012	EF	AG	292		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	AG	184		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	AG	335		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	AG	303		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	AG	152		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	AG	173		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	SS	108		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	SS	76		Released Alive
Victoria Creek, DS of site access road.	July 24 2012	EF	SS	92		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	EF	SS	116		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	EF	AG	184		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	EF	AG	140		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	EF	AG	166		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	EF	BB		217	Released Alive
Victoria Creek, US of site access road.	July 25 2012	EF	SS	91		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	SN	BB		217	Released Alive
Victoria Creek, DS of site access road.	July 25 2012	SN	AG	262		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	SN	AG	191		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	SN	AG	308		Released Alive
Victoria Creek, DS of site access road.	July 25 2012	SN	AG	350		Released Alive
Victoria Creek DS of confluence with Back Creek	July 25 2012	EF	BB		304	Released Alive
Victoria Creek DS of confluence with Back Creek	July 25 2012	EF	AG	187		Released Alive
Victoria Creek US of confluence with Back Creek	July 25 2012	EF	SS	101		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	57		Mortality
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	56		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	67		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	55		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	65		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	68		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	62		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	58		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	65		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	63		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	61		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	58		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	56		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	59		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	61		Released Alive



**Mount Nansen Site Fisheries and Aquatics Existing
Conditions Report**

February, 2018

Location	Date	Gear Type¹	Species²	Fork Length (mm)	Total Length (mm)	Release Status
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	66		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	66		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	56		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	62		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	61		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	56		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	62		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	67		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	66		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	64		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	65		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	65		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	65		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	58		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	59		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	56		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	59		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	61		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	62		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	51		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	58		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	65		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	66		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	56		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	55		Released Alive
Lower Back Creek, US of confluence with Victoria Creek	August 23 2013	EF	AG	63		Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	AG	222		Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	SS		102	Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	SS		87	Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	AG	260		Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	BB		325	Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	SS		101	Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	AG	238		Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	BB		285	Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	BB		261	Released Alive
Victoria Creek, US of confluence with Back Creek	August 23 2013	EF	AG	60		Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	AG	223		Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	AG	231		Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	SS		133	Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	BB		372	Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	BB		245	Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	AG	210		Released Alive
Victoria Creek, DS of confluence with Back Creek	August 23 2013	EF	SS		86	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	BB		250	Released Alive



Mount Nansen Site Fisheries and Aquatics Existing
Conditions Report

February, 2018

Location	Date	Gear Type ¹	Species ²	Fork Length (mm)	Total Length (mm)	Release Status
Victoria Creek, US of site access road	August 23 2013	EF	AG	197		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	239		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	313		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	258		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	BB		256	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	BB		245	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	SS		82	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	262		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	316		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	181		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	58		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	318		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	203		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	79		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	BB		241	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	SS		100	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	AG	319		Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	BB		287	Released Alive
Victoria Creek, US of site access road	August 23 2013	EF	BB		296	Released Alive
Back Creek, US of confluence with Pony Creek	August 30 2013	EF	AG	178		Released Alive
Back Creek, US of confluence with Pony Creek	August 30 2013	EF	AG	186		Released Alive

Notes:

¹ Gear codes: EF = Backpack electrofisher, SN = Seine net

² Species Codes: AG = Arctic Grayling; SS = Slimy Sculpin; BB = Burbot



APPENDIX 3 – SUMMARY STREAM SEDIMENT PHYSICAL CHARACTERISTICS FROM MOUNT NANSEN SITE STREAMS



Appendix 3: 2013 Results of Sediment Grain Size, Organic Content, and Moisture Content from Mount Nansen Site

Sample Location	Upper Back Creek			Lower Back Creek			Upper Dome Creek			Middle Dome Creek			Lower Dome Creek			Minnesota Creek		
Replicate Sample ID	B1-S1	B1-S2	B1-S3	B2-S1	B2-S2	B2-S3	D1-S1	D1-S2	D1-S3	D2-S1	DC-S2	D2-S3	D3-S1	D3-S2	D3-S3	M1-S1	M1-S2	M1-S3
Sampling Date	08/22/13	08/22/13	08/22/13	08/21/13	08/21/13	08/21/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/29/13	08/22/13	08/22/13	08/22/13
Organics (% weight fraction)																		
Loss on Ignition	1.2	1.3	1.4	1.2	1.2	1.2	4.4	4.1	6.9	6.9	1.9	1.8	24.0	18.7	16.9	1.3	1.6	2.7
Grain Size Distribution (% weight fraction)																		
Sieve - #16 (>1.18mm)	<0.20	0.92	0.83	<0.20	0.52	3.1	<0.20	0.32	<0.20	<0.20	<0.20	<0.20	3.9	0.59	1.7	<0.20	<0.20	<0.20
Sieve - #30 (>0.60mm)	1.8	8.0	5.0	<0.20	9.0	23	0.45	<0.20	0.20	0.39	0.37	0.51	3.5	3.1	9.1	2.0	0.49	3.1
Sieve - #50 (>0.300 mm)	4.1	29	5.7	0.76	23	40	2.3	0.80	0.61	11	5.8	14	7.2	20	52	40	20	34
Sieve - #100(>0.15mm)	12	25	16	16	20	16	17	9.2	4.5	45	29	37	17	24	25	48	60	39
Sieve - #140 (>0.106mm)	22	11	21	29	17	7.6	25	16	12	16	27	20	13	11	4.7	7.1	12	12
Sieve - #200 (>0.075mm)	32	11	27	32	18	5.9	23	18	17	11	22	16	9.1	8.3	2.5	1.8	3.0	5.2
Sieve - #270 (>0.053mm)	17	6.5	11	14	6.7	2.1	11	11	15	6.7	8.2	7.0	5.6	4.0	0.97	0.51	0.62	1.5
Sieve - #400 (>0.038 mm)	4.6	1.7	2.1	3.1	1.2	0.37	4.4	5.7	7.5	2.5	1.5	1.0	1.6	0.88	<0.20	<0.20	0.25	0.71
Sieve - Pan (<0.038 mm)	6.7	7.0	11	4.6	4.6	1.8	16	39	44	7.3	6.1	4.3	39	28	4.3	0.97	3.9	4.5
Moisture Content (% weight fraction)																		
Moisture	22	17	24	27	18	17	48	49	57	47	24	20	59	49	18	21	20	24

Notes: ¹Duplicate exceeded acceptance criteria due to sample non homogeneity. Reanalysis yielded similar results.

Sample Location	Victoria Creek - Reference			Victoria Creek – Downstream Back			Victoria Creek – Upstream Minnesota			Victoria Creek – Downstream Minnesota			Upper Pony Creek			Lower Pony Creek		
Replicate Sample ID	V1-S1	V1-S2	V1-S3	V2-S1	V2-S2	V2-S3	V3-S1	V3-S2	V3-S3	V4-S1	V4-S2	V4-S3	PI-S1	PI-S2	PI-S3	P2-S1	P2-S2	P2-S3
Sampling Date	08/22/13	08/22/13	08/22/13	08/21/13	08/21/13	08/21/13	08/22/13	08/22/13	08/22/13	08/29/13	08/29/13	08/29/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13
Organics (% weight fraction)																		
Loss on Ignition	3.2	2.3	2.8	3.5	2.9	1.7	2.7	2.8	2.5	2.7	3.1	1.8	7.2	10.0	6.0	6.4	4.2	5.1
Grain Size Distribution (% weight fraction)																		
Sieve - #16 (>1.18mm)	<0.20	0.82	3.3	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.34	<0.20	5.5	30	49	82	32	52	47
Sieve - #30 (>0.60mm)	1.7	28	27	0.22	1.3	<0.20	0.35	<0.20	<0.20	4.2	0.57	21	15	9.0	4.5	34	11	16
Sieve - #50 (>0.300 mm)	22	32	40	3.5	45	2.2	14	26	0.54	34	19	36	9.0	7.0	1.7	16	9.0	12
Sieve - #100(>0.15mm)	32	17	11	19	31	10	31	27	4.3	35	38	19	4.6	9.4	0.59	4.7	7.2	7.6
Sieve - #140 (>0.106mm)	12	7.7	4.4	20	7.6	16	16	13	11	13	14	6.6	1.3	4.6	0.29	1.3	2.7	2.9
Sieve - #200 (>0.075mm)	15	8.6	6.0	24	7.8	27	18	15	21	8.8	13	6.2	0.97	4.0	0.39	1.0	2.4	2.5
Sieve - #270 (>0.053mm)	11	7.4	4.1	14	4.3	21	9.6	8.9	18	2.9	6.1	3.2	0.86	2.3	0.29	0.57	1.0	1.3 ¹
Sieve - #400 (>0.038 mm)	3.5	2.2	1.5	3.9	1.0	9.7	2.3	2.8	9.1	0.69	1.8	0.84	0.54	1.1	0.29	0.34	0.27	0.34
Sieve – Pan (<0.038 mm)	3.1	<0.20	3.1	14	1.8	14	8.8	7.7	36	0.80	7.1	2.1	38	13	10	10	14	10
Moisture Content (% weight fraction)																		
Moisture	26	21	22	29	27	31	30	31	36	19	22	15	23	39	14	22	22	17

Notes: ¹Duplicate exceeded acceptance criteria due to sample non homogeneity. Reanalysis yielded similar results.



APPENDIX 4 – SUMMARY OF BENTHIC MACROINVERTEBRATE COMMUNITY DATA FROM MOUNT NANSEN SITE STREAMS



Appendix 4 – Analysis Results for 2013 Benthic Macroinvertebrate Samples from the Mount Nansen Site, including Abundance/Diversity Measures, Taxonomic Composition, and Functional Group Composition

Stream Section	Upper Back Creek			Lower Back Creek			Upper Pony Creek			Lower Pony Creek			Middle Dome Creek		
Replicate Sample ID	B1-S1	B1-S2	B1-S3	B2-S1	B2-S2	B2-S3	P1-S1	P1-S2	P1-S3	P2-S1	P2-S2	P2-S3	D2-S1	D2-S2	D2-S3
Sampling Date	08/30/13	08/30/13	08/30/13	08/29/13	08/29/13	08/29/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13
Abundance/Diversity Measures															
Sample Calculated Abundance	397	446	308	246	110	152	2,023	1127	675	254	291	298	155	120	179
Density ¹ (organisms/m²)	4,783	5,373	3,711	2,964	1,325	1,831	24,373	13,578	8,133	3,060	3,506	3,590	1,867	1,446	2,157
Species Richness (# spp.)	16	20	11	22	17	11	21	15	26	26	18	17	19	17	17
EPT Index (# spp.)	5	6	3	6	6	4	3	2	4	5	4	3	1	1	1
Simpson's Diversity Index	0.61	0.64	0.64	0.65	0.70	0.71	0.83	0.86	0.86	0.68	0.68	0.69	0.76	0.76	0.74
Simpson's Evenness Index	0.16	0.14	0.26	0.13	0.19	0.31	0.29	0.47	0.27	0.12	0.17	0.19	0.22	0.24	0.22
Community Composition															
% Diptera (True Flies)	90.68%	87.67%	85.39%	18.29%	16.36%	13.16%	78.45%	85.36%	70.52%	92.91%	94.50%	96.98%	94.19%	88.33%	92.18%
% Ephemeroptera (Mayflies)	3.25%	3.64%	3.29%	0.76%	2.02%	0.97%	-	-	0.30%	0.79%	0.34%	0.34%	-	-	-
% Plecoptera (Stoneflies)	68.70%	73.64%	71.05%	1.76%	2.91%	0.97%	6.57%	10.12%	24.74%	1.57%	3.44%	0.34%	1.29%	1.67%	1.68%
% Trichoptera (Caddisflies)	-	0.91%	-	0.25%	0.22%	0.32%	0.35%	-	-	0.79%	0.34%	0.34%	-	-	-
% Oligochaeta (Aquatic Worms)	6.05%	7.17%	12.34%	9.35%	5.45%	12.50%	13.49%	4.61%	3.85%	0.39%	0.34%	1.68%	1.94%	5.83%	3.35%
% Baetidae (Mayflies)	0.50%	2.02%	0.97%	0.41%	0.91%	-	-	-	-	-	0.34%	0.34%	-	-	-
% Chironomidae (Midges)	89.92%	85.20%	84.42%	11.38%	8.18%	9.87%	74.15%	82.61%	66.96%	68.90%	62.89%	68.46%	84.52%	84.17%	84.92%
% Odonata (Dragonflies & Damselflies)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Functional Group Composition ²															
% Predators	0.25%	1.79%	0.32%	1.63%	0.91%	-	4.65%	0.53%	1.19%	12.20%	10.31%	3.69%	6.45%	5.83%	1.12%
% Shredder-Herbivores	-	-	-	57.72%	50.00%	47.37%	2.62%	3.64%	5.78%	0.79%	1.37%		-	-	-
% Collector-Gatherers	94.21%	91.26%	95.45%	17.07%	11.82%	19.08%	65.99%	76.22%	44.74%	70.08%	62.54%	57.72%	25.81%	48.33%	70.39%
% Scrapers	0.25%	-	0.32%	-	-	-	-	-	-	-	-	-	-	-	-
% Collector-Filterers	0.25%	0.45%	0.65%	0.41%	1.82%	1.32%	18.14%		3.85%		1.03%	1.01%	17.42%	2.50%	6.15%
% Other ³	5.04%	6.50%	3.26%	23.17%	35.45%	32.23%	8.60%	19.61%	44.44%	16.93%	24.75%	37.58%	50.32%	43.34%	22.34%

Notes:
¹ Each replicate sample collected invertebrates from an area of 0.086 m².
²Functional group information has been derived from CAMLnet 2003, which in turn was derived from Merritt and Cummins (1996).
³%Other' category includes parasites, piercer herbivore, omnivore, and xylophages (wood eater).
“-” Indicates no organisms identified in the sample.



Appendix 4 – Analysis Results for 2013 Benthic Macroinvertebrate Samples from the Mount Nansen Site, including Abundance/Diversity Measures, Taxonomic Composition, and Functional Group Composition (Continued)

Stream Section	Minnesota Creek			Victoria Creek - Reference			Victoria Creek – Downstream Back			Victoria Creek – Upstream Minnesota			Victoria Creek – Downstream MC		
Replicate Sample ID	MI-S1	MI-S2	MI-S3	VI-S1	VI-S2	VI-S3	V2-S1	V2-S2	V2-S3	V3-S1	V3-S2	V3-S3	V4-S1	V4-S2	V4-S3
Sampling Date	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/28/13	08/29/13	08/29/13	08/29/13	08/28/13	08/28/13	08/28/13	08/29/13	08/29/13	08/29/13
Abundance/Diversity Measures															
Sample Calculated Abundance	104	51	70	89	134	318	68	119	190	83	44	39	99	155	336
Density ¹ (organisms/m²)	1,253	614	843	1,072	1,614	3,831	819	1,434	2,289	1,000	530	470	1,193	1,867	4,048
Species Richness (# spp.)	14	16	15	18	17	25	19	24	22	21	16	16	15	19	29
EPT Index (# spp.)	1	3	3	7	6	10	8	10	12	10	8	8	4	9	13
Simpson's Diversity Index	0.81	0.87	0.86	0.86	0.88	0.71	0.89	0.92	0.87	0.93	0.88	0.93	0.82	0.81	0.76
Simpson's Evenness Index	0.38	0.48	0.47	0.39	0.50	0.14	0.50	0.50	0.34	0.71	0.51	0.91	0.37	0.28	0.14
Community Composition															
% Diptera (True Flies)	46.15%	70.59%	42.86%	34.83%	60.45%	34.28%	52.94%	39.50%	54.21%	39.76%	25.00%	33.33%	87.88%	32.26%	82.74%
% Ephemeroptera (Mayflies)				10.11%	2.24%	6.29%	19.28%	20.45%	28.21%	8.82%	6.72%	20.53%	1.01%	4.52%	2.98%
% Plecoptera (Stoneflies)	29.81%	21.57%	32.86%	11.24%	24.63%	8.18%	24.10%	25.00%	28.21%	10.29%	28.57%	12.63%	5.05%	21.94%	9.52%
% Trichoptera (Caddisflies)		1.96%	1.43%		2.99%	0.63%	3.61%		2.56%		1.68%	0.53%	1.01%	1.94%	0.89%
% Oligochaeta (Aquatic Worms)	20.19%	5.88%	18.57%	43.82%	9.70%	50.31%	26.47%	23.53%	10.00%	13.25%	29.55%	5.13%	4.04%	38.71%	3.57%
% Baetidae (Mayflies)	-	-	-	-	0.75%	0.31%	2.94%	2.52%	12.11%	-	-	-	-	-	-
% Chironomidae (Midges)	16.35%	47.06%	18.57%	30.34%	58.21%	27.04%	41.18%	31.93%	52.63%	31.33%	15.91%	17.95%	83.84%	23.87%	80.36%
% Odonata (Dragonflies & Damselflies)	-	-	-	-	-	-	-	-	-	-	-	-	1.01%	4.52%	2.98%
Functional Group Composition ²															
% Predators	4.81%	1.96%	5.71%	4.49%	4.48%	7.86%	8.82%	5.04%	4.74%	13.25%	6.82%	15.38%	3.03%	9.03%	2.08%
% Shredder-Herbivores	29.81%	-	-	-	5.22%	0.31%	1.47%	-	-	2.41%	4.55%	-	-	2.58%	0.60%
% Collector-Gatherers	23.08%	19.61%	27.14%	71.91%	61.19%	74.53%	60.29%	51.26%	52.63%	34.94%	36.36%	23.08%	67.68%	52.90%	65.77%
% Scrapers	-	-	-	3.37%	1.49%	0.31%	2.94%	1.68%	7.37%	3.61%	18.18%	15.38%	2.02%	0.65%	0.60%
% Collector-Filterers	21.15%	19.61%	10.00%	1.12%	0.75%	0.63%	-	2.52%	-	3.61%	2.27%	-	1.01%	0.65%	0.89%
% Other ³	21.15%	58.82%	57.15%	19.11%	26.87%	16.36%	26.48%	39.50%	35.26%	42.18%	31.82%	46.16%	26.26%	34.19%	30.06%

Notes:
¹ Each replicate sample collected invertebrates from an area of 0.086 m².
²Functional group information has been derived from CAMLnet 2003, which in turn was derived from Merritt and Cummins (1996).
³%Other³ category includes parasites, piercer herbivore, omnivore, and xylophages (wood eater).
“-“ Indicates no organisms identified in the sample.



Appendix 4 – Analysis Results for 2014 Benthic Macroinvertebrate Samples from the Mount Nansen Site, including Abundance/Diversity Measures, Taxonomic Composition, and Functional Group Composition

Stream Section	Dome Creek			Victoria Creek			
	D1	D2	D3	V1	V2	V3	V4
	Sampling Date						
Abundance/Diversity Measures							
Sample Abundance ¹	654	1,561	13,940	3,871	2,151	5,586	4,030
Density ¹ (organisms/m ²)							
Species Richness (# spp.)	30	38	14	32	33	29	32
EPT Index (# spp.)	6	8	5	15	17	15	17
Simpson's Diversity Index	0.12	0.12	0.83	0.16	0.18	0.21	0.13
Simpson's Evenness Index	0.28	0.22	0.09	0.20	0.17	0.16	0.24
Community Composition							
% Diptera (True Flies)	87.46%	77.13%	3.16%	32.94%	24.04%	23.27%	35.01%
% Ephemeroptera (Mayflies)	0.92%	1.47%	0.57%	34.23%	39.70%	47.14%	26.48%
% Plecoptera (Stoneflies)	2.75%	14.86%	94.98%	17.10%	27.34%	26.26%	18.73%
% Trichoptera (Caddisflies)	1.22%	0.90%	0.14%	4.52%	2.88%	1.49%	0.27%
% Oligochaeta (Aquatic Worms)		3.78%	1.15%	10.64%	5.81%	1.49%	18.19%
% Baetidae (Mayflies)	0.31%	1.47%		1.94%	3.49%	5.37%	4.96%
% Chironomidae (Midges)	70.34%	65.79%	2.73%	27.77%	18.97%	19.39%	29.50%
% Odonata (Dragonflies & Damselflies)							
Functional Group Composition ²							
% Predators	19.57%	10.70%	0.29%	17.15%	25.43%	18.51%	19.01%
% Shredder-Herbivores	2.75%	13.65%	94.98%	4.21%	4.46%	8.97%	3.03%
% Collector-Gatherers	60.86%	56.89%	3.30%	38.83%	27.29%	25.96%	49.06%
% Scrapers				1.94%	0.79%	0.59%	0.55%
% Collector-Filterers	4.59%	2.37%		0.34%	0.19%	0.90%	0.55%
% Other ³	16.82%	18.77%	1.43%	37.87%	42.03%	45.97%	28.36%

Notes:
¹ Abundance is the result of the three-minute travelling kick sample.
²Functional group information has been derived from CAMLnet 2003, which in turn was derived from Merritt and Cummins (1996).
³%Other³ category includes parasites, piercer herbivore, omnivore, and xylophages (wood eater), or unclassified.
“-“ Indicates no organisms identified in the sample.



APPENDIX 5 – RAW BENTHIC MACROINVERTEBRATE TAXONOMIC DATA

Site:	UPC	UPC	UPC	LPC	LPC	LPC	LBC	LBC	LBC	UBC	UBC	UBC	VC-REF	VC-REF	VC-REF	VC-UMC	VC-UMC	VC-UMC	VC-DBC	VC-DBC	VC-DBC	VC-R	VC-R	VC-R	MDC	MDC	MDC	MC	MC	MC
Sample:	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CC#:	CC140847	CC140848	CC140849	CC140850	CC140851	CC140852	CC140853	CC140854	CC140855	CC140856	CC140857	CC140858	CC140859	CC140860	CC140861	CC140862	CC140863	CC140864	CC140865	CC140866	CC140867	CC140868	CC140869	CC140870	CC140871	CC140872	CC140873	CC140874	CC140875	CC140876
EMS:																														
Sieve Size:	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
SubSample %:	15	29	46	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Phylum: Arthropoda	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Subphylum: Hexapoda	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Insecta	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Ephemeroptera	0		0	2	0		4		0		0		0		0		0		0		0		0		0		0		0	
Family: Ameletidae	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Ameletus</u>	0		0		0		0		0		0		1		7		0		0		0		0		0		0		0	
Family: Baetidae	0		0		0		0		0		9	3	0		1		0		0		23		0		0		0		0	
<u>Baetis bicaudatus</u>	0		0		0		1		0	2	0	3	0		0		0		2	3	0		0		0		0		0	
<u>Baetis sp.</u>	0		0		1	1	0	1	0	0	0	0	0	1	0		0		0		0		0		0		0		0	
Family: Ephemerellidae	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Drunella doddsii</u>	0		0		0		0		0		0		0		0	1	0		0		0		0		0		0		0	
<u>Ephemerella dorothea</u>	0		0		0		0		0		0		0		0		0		0		0		1		0		0		0	
Family: Heptageniidae	0		1		0		3	3	5	0	0	0	5		11	12	1	5	2	3	2		6	7	0		0		0	
<u>Cinygmula sp.</u>	0		0		0		0		0		0		2	2	1		2	4	0	1	4		0	1	0		0		0	
<u>Epeorus deceptivus</u>	0		0		0		0		0	1	0	0	1	2	0		6	2	2	1	10	1	1	1	0		0		0	
<u>Rhithrogena sp.</u>	0		0		0		0		0		0		0		0	3	0	2	0	1	0		0		0		0		0	
Order: Plecoptera	0	21	48	1	6	1	0	1	1	4	6	0	6		0	5	1	2	2	5	6	0	12	0		3		0		1
Family: Capniidae	0		0		0		2	1	0	1	0		0		3		1	1	1	3	1		1	3	0		0		2	
Family: Chloroperlidae	0		0		0		0		0	0	0		0		0		0		0		1		0		0		0		0	
<u>Suwallia sp.</u>	0		0		0		0		0	0	0		0	4	7	4	0		2		1		5	1	0		0		0	
Family: Nemouridae	12		11	1	0		25	25	35	5	7	3	0		1		0		0	21	9		0	4	0		0		9	22
<u>Nemoura</u>	0	12	18	2	4		142	55	72	0	0	0	0		0		0		0		0		0	2	0		0	31	0	
<u>Ostrocerca sp.</u>	8		0		0		0		0	0	0	0	0		0		0		0		0		0		0		0		0	
<u>Zapada oregonensis group</u>	0		0		0		0		0	0	0	0	7	1	2	2		1		0		3		0		0		0		0
Family: Perlodidae	0		0		0		0		0	2	1		3	22	14	7	6	6	4	4	4	4	24	8	2	2	0		0	
<u>Megarcys sp.</u>	0		0		0		0		0	0	0		1		0		0	2	1		0		1	2	0		0		0	
<u>Skwala sp.</u>	0		0		0		0		0	0	0		0		0	2	1		1		2	1	0		0		0		0	
Order: Trichoptera	0		0		0		0		0	0	0		0		0		0		0		0		0		0		0		0	
Family: Apataniidae	0		0		0		0		0	0	0		0		0		0		0		0		0		0		0		0	
<u>Apatania sp.</u>	0		0		0		0		0	0	0		0		0		0		0		0	1	0		0		0		0	
Family: Brachycentridae	0		0		0		0		0	0	0		0		0		0		0		0		0		0		0		0	
<u>Brachycentrus sp.</u>	0		0		0		0		0	0	0		0		0		0		0		0		1	1	0		0		0	
Family: Glossosomatidae	0		0		0		0		0	0	0		0		0		0		0		0		0		0		0		0	
<u>Anagapetus sp.</u>	0		0		0		0		0	0	0	1	0		0		0		0		0		0		0		0		0	
Family: Hydropsychidae	0		0		0		0		0	0	0		0		0		0		0		0		0		0		0		0	
<u>Hydropsyche sp.</u>	0		0		1		0		0	0	0		0		0		0		0		0		0		0		0		0	
Family: Limnephilidae	1		0	2	0	1	0		0	0	0		0		0	1	0	1	0		0		0		0		0		1	1
<u>Ecclisomyia sp.</u>	0		0		0		0	1	0	1	1		0	4	2	2	0		0	2	1		2	2	0		0		0	
Order: Coleoptera	0		0		0		0		0	0	0		0		0		0</													

	Site:	UPC	UPC	UPC	LPC	LPC	LPC	LBC	LBC	LBC	UBC	UBC	UBC	VC-REF	VC-REF	VC-REF	VC-UMC	VC-UMC	VC-UMC	VC-DBC	VC-DBC	VC-DBC	VC-R	VC-R	VC-R	MDC	MDC	MDC	MC	MC	MC
	Sample:	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	CC#:	CC140847	CC140848	CC140849	CC140850	CC140851	CC140852	CC140853	CC140854	CC140855	CC140856	CC140857	CC140858	CC140859	CC140860	CC140861	CC140862	CC140863	CC140864	CC140865	CC140866	CC140867	CC140868	CC140869	CC140870	CC140871	CC140872	CC140873	CC140874	CC140875	CC140876
	EMS:																														
	Sieve Size:	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
	SubSample %:	15	29	46	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
<u>Paqastia sp.</u>		0		0		0		0		0				2	14	1	4	2	5	2	1	14	32	5	19	0	1	0		0	
<u>Pseudodiamesa sp.</u>		0	2	0	1	0		0		0	2	0		0		0		0		0		0		0		0		0		0	
Subfamily: Orthoclaadiinae		0		0		0	1	0		0		0		0		0		0		0		0		0		0		0	1	0	
<u>Diplocladius cultriger</u>		0		0		0		0		0		0		0		0		0		0		0		0		15	36	83	1	1	
<u>Eukiefferiella sp.</u>		13	35	70		3	37	10	3	5	9	4	4	2	9	15	7	4		7	8	19	20	15	60	69	46	30	13	14	7
<u>Hydrobaenus sp.</u>		34	70	21	9	5		1		0		0		0		0		0		0		0		0	3	1		0		0	
<u>Krenosmittia sp.</u>		10		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Limnophyes sp.</u>		0		0	9	3	6	3	1	0		1		0		0		1	1	1	1	0		0	2	0	7	21		0	
<u>Lopescladius sp.</u>		0		3		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Metriocnemus sp.</u>		0		0		0		0		0		0		0		0		0		0		0		0		0		1		0	
<u>Orthocladius complex</u>		6		0		0		0		0		0		17	32	58	7	0		9	15	11	11	4	22	5		12	1	1	
<u>Parakiefferiella sp.</u>		0	28	6		0		0		0		0		0		0		0		0		0		0		0		0		0	1
<u>Thienemanniella</u>		0		0		0		0		0		0		0		0		0		0		0		0		0		0	1		
Subfamily: Podonominae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Trichotanypus sp.</u>		0	18	12	2	0		0	1	0		0		0		0		0		0		0		0		0		0		1	
Subfamily: Tanypodinae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Tribe: Pentaneurini		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Thienemannimyia group</u>		0	1	0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Tribe: Procladiini		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Procladius sp.</u>		0		1	2	0		0		0		0		0		0		0		0		0		0		0	1	0		0	
Family: Empididae		0		0	1	0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Chelifera sp.</u>		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Chelifera/ Metachela</u>		7	1	1		0		2	1	0	1	4	1	1	2	8	2	1	4	3	4	1	1	8	3	0		0	1	0	1
Family: Muscidae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Limnophora sp.</u>		1		0	1	2	1	0		0		0		0		0		0		0		1		0		0		0		0	
Family: Psychodidae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Pericoma/Telmatoscopus sp.</u>		0		0		0		0		0		0		0		1	1	0		0	1	0		0		2		0		0	
Family: Simuliidae		0		4	4	5	7	2	2	0		1		0		0		0		4		1	1	0	1	0		0	7	2	6
<u>Prosimulium sp.</u>		0		1		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Simulium sp.</u>		0		0		2	3	1	2	2	1	1	2	0		0		1		0	2	0	1	1	1	0		9	22	8	7
Family: Tipulidae		0		0		0		0		0		0		0		0		0	1	0		0		0		0		0		0	2
<u>Dicranota sp.</u>		2		1	21	24	9	1		0		3		2		1	2	1		0		0	1	0	1	5		1	1	1	1
<u>Tipula sp.</u>		0		0		0		6	3	3		1		1	1	4	1	1	1	1	1	0		4	2	1		1	1	1	
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Hemiptera		0		0	1	0		0		0		0		0		0		0		0		0		0		1		0		0	
Order: Lepidoptera		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Family: Crambidae		0		0		0		0		0		0		0		0		0		0		0		1		0		0		0	
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Subphylum: Crustacea		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Malacostraca		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Amphipoda		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Family: Hyalellidae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Hyalella sp.</u>		1		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Subphylum: Chelicerata		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Arachnida		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Trombidiformes		0		0		0	1	0		0		0		0		0		0		0		0		0		2		0	2	0	
Family: Hygrobatidae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Hygrobates sp.</u>		0		0		0		1		0		0		0		0		0		0		0		0		0		0		0	
Family: Sperchontidae		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
<u>Sperchon sp.</u>		0		1		0		0		0		0		0		1		0		0		2		0		0		0	1	0	2
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Sarcoptiformes		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Family: Hydrozetidae		1		0	2	3		0		0		0		0		0		0		0		0		0		0	1	0		0	
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Phylum: Mollusca		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Bivalvia		0		0		0		0		0		0		0		0		0		0		0		0		0		5		0	
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Phylum: Annelida		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Subphylum: Clitellata		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Oligochaeta		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Lumbriculida		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Family: Lumbriculidae		8	6	2		0	3	20	6	17	22	23	33	24	11	159	11	13	2	18	14										

	Site:	UPC	UPC	UPC	LPC	LPC	LPC	LBC	LBC	LBC	UBC	UBC	UBC	VC-REF	VC-REF	VC-REF	VC-UMC	VC-UMC	VC-UMC	VC-DBC	VC-DBC	VC-DBC	VC-R	VC-R	VC-R	MDC	MDC	MDC	MC	MC	MC
	Sample:	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	CC#:	CC140847	CC140848	CC140849	CC140850	CC140851	CC140852	CC140853	CC140854	CC140855	CC140856	CC140857	CC140858	CC140859	CC140860	CC140861	CC140862	CC140863	CC140864	CC140865	CC140866	CC140867	CC140868	CC140869	CC140870	CC140871	CC140872	CC140873	CC140874	CC140875	CC140876
	Sieve Size:	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
	SubSample %:	15	29	46	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Family: Enchytraeidae <i>Enchytraeus</i> Family: Naididae <i>Pristina sp.</i> Family: Tubificidae Subfamily: Tubificinae immatu		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
		32	1	2	1	1	2	1				0		0		0		0		0		0		0		2	1	2		0	
		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
		0		0		0		2		0		0		0	1	0		0		0		0		0		0		0		0	
		1		2		0		0		0		1	4	15	1	0		0		0		0	14	0		5	1	6	2		1
Totals:		302	327	311	251	291	298	246	110	152	397	446	308	89	134	318	83	44	38	67	119	190	99	155	336	155	120	179	104	51	69

Taxa present but not included:

<i>Terrestrials</i>	1	1	0	8	0	4	0	2	7	20	0		2		0		1	2	7		3	3	0		8	8	0		0	3
	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Phylum: Arthropoda	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Entognatha	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Collembola	0		2		0		0		0	1		1		0		0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Subphylum: Crustacea	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Ostracoda	2		0		0		0		0		0		0		0		0		0		0		0		7	5	0		0	
Class: Branchiopoda	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Order: Cladocera	1	2	0		0		0		0		0		0		0		0		0		0		0		0		0		0	
	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Copepoda	0	4	0	1	0	1	1		1		0		0		0		0		0		0		0		0		1		0	
	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Phylum: Nemata	30	4	0	2	0	4	3		0		1		0	1	1	1	0	2	4		0	1	0	1	1	3	1		0	9
Phylum: Platyhelminthes	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
Class: Turbellaria	0		0		0		0		0		0		0		0		0		0		0		0		0		0	20	39	19
Totals:	34	11	2	11	0	9	4	2	8	21	1	1	2	1	1	1	1	4	11	0	3	4	0	1	16	16	2	20	39	31

Site:	D	D	D	V	V	V	V
Sample:	1	2	3	1	2	3	4
CC#:	CC152230	CC152231	CC152232	CC152233	CC152234	CC152235	CC152236
EMS:							
Sieve Size:	400	400	400	400	400	400	400
SubSample %:	50	22	5	8	24	6	9
Phylum: Arthropoda	0	0	0	0	0	0	0
Subphylum: Hexapoda	0	0	0	0	0	0	0
Class: Insecta	0	0	0	0	0	0	0
Order: Ephemeroptera	0	0	4	0	0	0	0
Family: Ameletidae	0	0	0	0	0	0	0
<i>Ameletus</i>	0	0	0	1	3	1	0
Family: Baetidae	0	4	0	2	2	6	1
<i>Acentrella sp.</i>	0	0	0	4	8	1	6
<i>Baetis</i>	1	1	0	0	7	11	7
<i>Baetis tricaudatus group</i>	0	0	0	0	1	0	4
Family: Ephemerellidae	0	0	0	0	0	0	1
<i>Ephemerella</i>	0	0	0	2	1	1	4
Family: Heptageniidae	2	0	0	95	180	136	71
<i>Cinygmula sp.</i>	0	0	0	2	3	2	2
	0	0	0	0	0	0	0
Order: Plecoptera	0	4	0	0	0	0	0
Family: Capniidae	0	0	0	1	2	1	2
Family: Chloroperlidae	0	0	0	1	7	0	2
<i>Suwallia</i>	0	0	0	0	3	0	3
Family: Nemouridae	8	37	633	4	4	7	1
<i>Nemoura</i>	1	10	26	0	0	0	0
<i>Ostrocerca sp.</i>	0	0	3	0	0	0	0
<i>Zapada oregonensis group</i>	0	0	0	7	18	22	10
Family: Perlodidae	0	0	0	33	93	54	47
<i>Skwala</i>	0	0	0	7	14	3	2
Family: Taeniopterygidae	0	0	0	0	0	1	0
<i>Taenionema</i>	0	0	0	0	0	0	1
	0	0	0	0	0	0	0
Order: Trichoptera	0	0	0	0	0	0	0
Family: Apataniidae	0	0	0	0	0	0	0
<i>Apatania</i>	0	0	0	2	0	0	0
Family: Brachycentridae	0	0	0	0	0	0	0
<i>Brachycentrus americanus</i>	0	0	0	0	0	0	1
Family: Glossosomatidae	0	0	0	0	0	0	0
<i>Glossosoma</i>	0	0	0	2	1	0	0
Family: Hydroptilidae	0	0	0	0	0	0	0
<i>Hydroptila</i>	0	1	0	0	0	0	0
Family: Leptoceridae	0	0	0	0	0	0	0
<i>Oecetis</i>	0	1	0	0	0	0	0
Family: Limnephilidae	3	1	1	0	0	2	0
<i>Ecclisomyia sp.</i>	0	0	0	10	14	3	0
Family: Polycentropodidae	1	0	0	0	0	0	0
	0	0	0	0	0	0	0
Order: Diptera	18	0	1	0	0	0	0
Family: Ceratopogonidae	0	0	0	0	0	0	0
<i>Culicoides</i>	30	10	1	0	0	0	0
<i>Probezzia</i>	0	0	0	0	1	0	0
Family: Chironomidae	12	23	2	5	3	4	9
Subfamily: Chironominae	0	0	0	0	0	0	0
Tribe: Chironomini	0	0	0	0	0	0	0
<i>Chironomus</i>	0	4	0	0	0	0	0
<i>Endochironomus sp.</i>	4	1	0	0	0	0	0
Tribe: Tanytarsini	0	0	0	0	0	0	0
<i>Micropsectra</i>	1	17	3	9	6	15	9
<i>Rheotanytarsus</i>	0	1	0	0	0	0	0
<i>Sublettea sp.</i>	15	6	0	1	0	0	0
Subfamily: Diamesinae	0	0	0	0	0	0	0
Tribe: Diamesini	0	0	0	0	0	0	0

Site:	D	D	D	V	V	V	V
Sample:	1	2	3	1	2	3	4
CC#:	CC152230	CC152231	CC152232	CC152233	CC152234	CC152235	CC152236
EMS:							
Sieve Size:	400	400	400	400	400	400	400
SubSample %:	50	22	5	8	24	6	9
<i>Diamesa</i>	0	1	0	0	0	0	0
<i>Paqastia</i>	0	0	0	62	75	36	69
<i>Pseudodiamesa sp.</i>	6	6	0	0	0	0	0
Subfamily: Orthocladiinae	0	0	0	0	0	0	0
<i>Brillia sp.</i>	0	0	0	2	1	1	0
<i>Cricotopus</i>	3	1	0	0	0	0	0
<i>Diplocladius cultriger</i>	75	23	0	1	0	0	2
<i>Eukiefferiella</i>	3	24	2	1	5	3	11
<i>Hydrobaenus</i>	4	0	0	0	0	0	0
<i>Limnophyes sp.</i>	10	15	11	0	0	0	0
<i>Lopescladius sp.</i>	0	0	0	0	1	0	0
<i>Metriocnemus sp.</i>	22	2	0	0	0	0	0
<i>Orthocladius (Euorthocladius)</i>	0	0	0	2	0	0	0
<i>Orthocladius sp.</i>	68	100	1	2	6	6	5
<i>Tvetenia</i>	0	0	0	1	1	0	2
Subfamily: Podonominae	0	0	0	0	0	0	0
<i>Paraboreochlus sp.</i>	1	0	0	0	0	0	0
<i>Trichotanypus sp.</i>	2	0	0	0	0	0	0
Subfamily: Tanypodinae	0	0	0	0	0	0	0
Tribe: Pentaneuriini	0	0	0	0	0	0	0
<i>Thienemannimyia group</i>	0	1	0	0	0	0	0
Tribe: Procladiini	0	0	0	0	0	0	0
<i>Procladius</i>	4	1	0	0	0	0	0
Family: Empididae	0	0	0	0	0	1	0
<i>Chelifera/ Metachela</i>	1	1	0	8	9	2	11
Family: Psychodidae	0	0	0	0	0	0	0
<i>Pericoma/Telmatoscopus sp.</i>	1	6	0	1	0	5	3
Family: Simuliidae	0	0	0	0	1	0	2
<i>Simulium</i>	0	1	0	0	0	3	0
Family: Tipulidae	2	0	0	0	0	0	0
<i>Dicranota</i>	4	16	1	4	10	1	1
<i>Hexatoma sp.</i>	0	1	0	0	0	0	0
<i>Ormosia sp.</i>	0	1	0	0	0	0	0
<i>Tipula</i>	0	3	0	3	5	1	3
	0	0	0	0	0	0	0
Order: Hemiptera	0	0	0	0	0	0	0
Family: Corixidae	0	0	0	0	0	0	0
<i>Callicorixa alaskensis</i>	0	1	0	0	0	0	0
	0	0	0	0	0	0	0
Subphylum: Chelicerata	0	0	0	0	0	0	0
Class: Arachnida	4	0	0	0	0	0	0
Order: Trombidiformes	0	0	0	0	0	0	0
Family: Lebertiidae	0	0	0	0	0	0	0
<i>Lebertia</i>	0	0	0	0	1	0	0
Family: Sperchontidae	0	0	0	0	0	0	0
<i>Sperchon</i>	0	0	0	1	0	0	0
	0	0	0	0	0	0	0
Order: Oribatei	0	0	0	0	0	0	0
Family: Halacaridae	0	1	0	0	0	0	0
Family: Oribatidae	0	0	0	0	0	0	0
<i>Oribatida</i>	20	3	0	0	0	1	5
	0	0	0	0	0	0	0
Phylum: Mollusca	0	0	0	0	0	0	0
Class: Gastropoda	0	0	0	0	0	0	0
Order: Basommatophora	0	0	0	0	0	0	0
Family: Planorbidae	0	0	0	0	0	0	0
<i>Promenetus sp.</i>	1	0	0	0	0	0	0
	0	0	0	0	0	0	0

Site:	D	D	D	V	V	V	V
Sample:	1	2	3	1	2	3	4
CC#:	CC152230	CC152231	CC152232	CC152233	CC152234	CC152235	CC152236
EMS:							
Sieve Size:	400	400	400	400	400	400	400
SubSample %:	50	22	5	8	24	6	9
Phylum: Annelida	0	0	0	0	0	0	0
Subphylum: Clitellata	0	0	0	0	0	0	0
Class: Oligochaeta	0	0	0	0	0	0	0
Order: Lumbriculida	0	0	0	0	0	0	0
Family: Lumbriculidae	0	1	0	3	2	0	2
	0	0	0	0	0	0	0
Order: Tubificida	0	0	0	0	0	0	0
Family: Enchytraeidae	0	10	8	30	28	5	64
Family: Naididae	0	2	0	0	0	0	0
Totals:	327	342	697	309	516	335	363

Taxa present but not included:

Phylum: Arthropoda	0	0	0	0	0	0	0
Subphylum: Crustacea	0	0	0	0	0	0	0
Class: Ostracoda	0	50	30	0	0	0	0
Class: Copepoda	0	5	5	0	0	0	0
	0	0	0	0	0	0	0
Phylum: Nemata	0	0	0	0	0	0	1
Totals:	0	55	35	0	0	0	1



APPENDIX 6 – RAW PERIPHYTON TAXONOMIC IDENTIFICATION DATA



APPENDIX 7 – ANALYTICAL LABORATORY REPORT ON PERIPHYTON PRIMARY PRODUCTIVITY DATA

Your Project #: 12-127.TA07.AE
 Site Location: MOUNT NANSEN REMEDIATION PROJECT - MT. NANSEN
 MINE SITE
 Your C.O.C. #: 08377597

Attention: Chris Jastrebski
 Ecological Logistics & Research Ltd
 #204 - 105 Titanium Way
 Whitehorse, YT
 CANADA Y1A 0E7

Report Date: 2013/09/10

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B378708
Received: 2013/09/03, 14:07

Sample Matrix: Water
 # Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chlorophyll B (water)(sin)	3	N/A	2013/09/10	BBY6SOP-00002	SM-10200 H
Chlorophyll A (water)(sin)	3	2013/09/10	2013/09/10	BBY6SOP-00002	SM-10200 H
Phaeophytin A (water)(sin)	3	N/A	2013/09/10	BBY6SOP-00002	SM-10200H

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ken Pomeroy, Project Manager
 Email: KPomeroy@maxxam.ca
 Phone# (604) 638-5020

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1



Maxxam Job #: B378708
Report Date: 2013/09/10

Ecological Logistics & Research Ltd
Client Project #: 12-127.TA07.AE
Site Location: MOUNT NANSEN REMEDIATION PROJECT - MT. NANSEN
MINE SITE

Sampler Initials: JL

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HJ8657		HJ8658	HJ8659		
Sampling Date		2013/08/29 11:45		2013/08/28 16:00	2013/08/28 14:00		
COC#		08377597		08377597	08377597		
	UNITS	MDC	RDL	LPC	UPC	RDL	QC Batch
Misc. Inorganics							
Phaeophytin A	ug/L	<10	10	85.4	53.0	5.0	7157000
Parameter							
Chlorophyll a	ug/L	813	10	800	156	5.0	7156536
Chlorophyll b	ug/L	17.7	0.50	44.0	24.2	0.50	7156994

RDL = Reportable Detection Limit

Maxxam Job #: B378708
Report Date: 2013/09/10

Ecological Logistics & Research Ltd
Client Project #: 12-127.TA07.AE
Site Location: MOUNT NANSEN REMEDIATION PROJECT - MT. NANSEN
MINE SITE
Sampler Initials: JL

QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Spiked Blank		Method Blank	
			% Recovery	QC Limits	Value	UNITS
7156536	Chlorophyll a	2013/09/10	99	80 - 120	<0.50	ug/L
7156994	Chlorophyll b	2013/09/10			<0.50	ug/L
7157000	Phaeophytin A	2013/09/10			<0.50	ug/L

N/A = Not Applicable

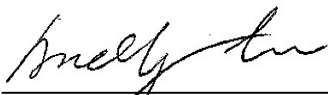
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Validation Signature Page

Maxxam Job #: B378708

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

A handwritten signature in black ink, appearing to read "Andy Lu", is written over a horizontal line.

Andy Lu, Data Validation Coordinator

=====
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Your Project #: 12-127.TA07.AE
 Site Location: MOUNNT NANSEN REMEDIATION PROJECT MT. NANSEN
 MINE SITE
 Your C.O.C. #: 08377401

Attention: Chris Jastrebski
 Ecological Logistics & Research Ltd
 #204 - 105 Titanium Way
 Whitehorse, YT
 CANADA Y1A 0E7

Report Date: 2013/09/04

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B376265
Received: 2013/08/27, 10:40

Sample Matrix: Water
 # Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chlorophyll B (water)(sin)	7	N/A	2013/09/04	BBY6SOP-00002	SM-10200 H
Chlorophyll A (water)(sin)	7	2013/09/04	2013/09/04	BBY6SOP-00002	SM-10200 H
Phaeophytin A (water)(sin)	7	N/A	2013/09/04	BBY6SOP-00002	SM-10200H

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ken Pomeroy, Project Manager
 Email: KPomeroy@maxxam.ca
 Phone# (604) 638-5020

=====

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Total cover pages: 1

Maxxam Job #: B376265
Report Date: 2013/09/04

Ecological Logistics & Research Ltd
Client Project #: 12-127.TA07.AE
Site Location: MOUNNT NANSEN REMEDIATION PROJECT MT. NANSEN MINE
SITE
Sampler Initials: JL

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HI1987		HI1988	HI1989		HI1990		HI1991	HI1992	HI1993		
Sampling Date		2013/08/22 11:00		2013/08/22 09:00	2013/08/21 15:30		2013/08/22 17:00		2013/08/22 14:00	2013/08/22 15:00	2013/08/21 17:00		
COC#		08377401		08377401	08377401		08377401		08377401	08377401	08377401		
	UNITS	BC-U/S	RDL	VC-REF	VC-DBC	RDL	VC-R	RDL	VC-UMC	MN	LBC	RDL	QC Batch
Misc. Inorganics													
Phaeophytin A	ug/L	<5.0	5.0	<20	<20	20	<5.0	5.0	<20	<20	<20	20	7141152
Parameter													
Chlorophyll a	ug/L	180	5.0	549	706	20	214	5.0	266	165	219	20	7141137
Chlorophyll b	ug/L	<0.50	0.50	<0.50	<0.50	0.50	<0.50	0.50	<0.50	<0.50	<0.50	0.50	7141192

Maxxam Job #: B376265
Report Date: 2013/09/04

Ecological Logistics & Research Ltd
Client Project #: 12-127.TA07.AE
Site Location: MOUNNT NANSEN REMEDIATION PROJECT MT. NANSEN MINE
SITE
Sampler Initials: JL

QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Spiked Blank		Method Blank	
			% Recovery	QC Limits	Value	UNITS
7141137	Chlorophyll a	2013/09/04	96	80 - 120	<0.50	ug/L
7141152	Phaeophytin A	2013/09/04			<0.50	ug/L
7141192	Chlorophyll b	2013/09/04			<0.50	ug/L

N/A = Not Applicable

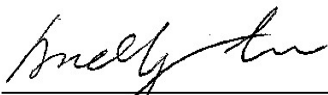
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Validation Signature Page

Maxxam Job #: B376265

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

A handwritten signature in black ink, appearing to read "Andy Lu", is written over a horizontal line.

Andy Lu, Data Validation Coordinator

=====
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APPENDIX 8 – ANALYTICAL LABORATORY REPORT ON STREAM SEDIMENT PHYSICAL CHARACTERISTIC AND METAL ANALYSIS

Your Project #: 12-127/TA07.AE
 Site Location: 204-105 TITANIUM WAY
 Your C.O.C. #: 08377847, 08377848, 08377849

Attention: Chris Jastrebski
 Ecological Logistics & Research Ltd
 #204 - 105 Titanium Way
 Whitehorse, YT
 CANADA Y1A 0E7

Report Date: 2013/09/15

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B379491
Received: 2013/09/05, 08:40

Sample Matrix: Soil
 # Samples Received: 36

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	36	2013/09/10	2013/09/10	BBY7SOP-00004	BCMOE-SALM
Loss on Ignition, Org. & Inorg. Residue (2)	19	N/A	2013/09/10	BBY6SOP-00040	Carter SSMA 44.3
Loss on Ignition, Org. & Inorg. Residue (2)	17	N/A	2013/09/11	BBY6SOP-00040	Carter SSMA 44.3
Moisture (1)	36	N/A	2013/09/12	AB SOP-00002	CCME PHC-CWS
Particle Size by Sieve (Special) (1,3)	12	2013/09/11	2013/09/12	AB SOP-00022	SSMA 55.4
Particle Size by Sieve (Special) (1,3)	4	2013/09/12	2013/09/12	AB SOP-00022	SSMA 55.4
Particle Size by Sieve (Special) (1,3)	9	2013/09/12	2013/09/13	AB SOP-00022	SSMA 55.4
Particle Size by Sieve (Special) (1,3)	11	2013/09/13	2013/09/13	AB SOP-00022	SSMA 55.4
Particle Size by Sieve (Grain Size) (1)	16	N/A	2013/09/12	AB SOP-00022	SSMA 55.4
Particle Size by Sieve (Grain Size) (1)	20	N/A	2013/09/13	AB SOP-00022	SSMA 55.4

* Results relate only to the items tested.

- (1) This test was performed by Maxxam Calgary Environmental
 (2) Loss on Ignition was reported on a dry weight basis.
 (3) Result indicates % of sample retained on the sieve.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ken Pomeroy, Project Manager
 Email: KPomeroy@maxxam.ca
 Phone# (604) 638-5020

=====

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Total cover pages: 1

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		HK2996	HK2997		HK2998	HK2999	HK3000		HK3001		HK3002		
Sampling Date		2013/08/21 17:00	2013/08/21 17:00		2013/08/21 17:00	2013/08/21 15:30	2013/08/21 15:30		2013/08/21 15:30		2013/08/29 16:00		
COC#		08377847	08377847		08377847	08377847	08377847		08377847		08377847		
	UNITS	LBC-S1	LBC-S2	QC Batch	LBC-S3	VC-DBC-S1	VC-DBC-S2	QC Batch	VC-DBC-S3	QC Batch	LDC-S1	RDL	QC Batch
Physical Properties													
Grain Size	N/A	COARSE	COARSE	7151757	COARSE	COARSE	COARSE	7151757	COARSE	7151757	COARSE	N/A	7151757
Loss on Ignition	%	1.2	1.2	7156219	1.2	3.5	2.9	7156219	1.7	7156219	24.0	1.0	7156219
Sieve - #16 (>1.18mm)	%	<0.20	0.52	7160259	3.1	<0.20	<0.20	7161878	<0.20	7161878	3.9	0.20	7160259
Sieve - #30 (>0.60mm)	%	<0.20	9.0	7160259	23	0.22	1.3	7161878	<0.20	7161878	3.5	0.20	7160259
Sieve - #50 (>0.300 mm)	%	0.76	23	7160259	40	3.5	45	7161878	2.2	7161878	7.2	0.20	7160259
Sieve - #100(>0.15mm)	%	16	20	7160259	16	19	31	7161878	10	7161878	17	0.20	7160259
Sieve - #140 (>0.106mm)	%	29	17	7160259	7.6	20	7.6	7161878	16	7161878	13	0.20	7160259
Sieve - #200 (>0.075mm)	%	32	18	7160259	5.9	24	7.8	7161878	27	7161878	9.1	0.20	7160259
Sieve - #270 (>0.053mm)	%	14	6.7	7160259	2.1	14	4.3	7161878	21	7161878	5.6	0.20	7160259
Sieve - #400 (>0.038 mm)	%	3.1	1.2	7160259	0.37	3.9	1.0	7161878	9.7	7161878	1.6	0.20	7160259
Sieve - Pan	%	4.6	4.6	7160259	1.8	14	1.8	7161878	14	7161878	39	0.20	7160259
Moisture	%	27	18	7162975	17	29	27	7162911	31	7162975	59	0.30	7162975

Maxxam ID		HK3003		HK3004		HK3005		HK3006		HK3007	HK3007		
Sampling Date		2013/08/29 16:00		2013/08/29 16:00		2013/08/29 17:00		2013/08/29 17:00		2013/08/29 17:00	2013/08/29 17:00		
COC#		08377847		08377847		08377847		08377847		08377847	08377847		
	UNITS	LDC-S2	QC Batch	LDC-S3	QC Batch	VC-R-S1	QC Batch	VC-R-S2	QC Batch	VC-R-S3	VC-R-S3 Lab-Dup	RDL	QC Batch
Physical Properties													
Grain Size	N/A	COARSE	7151757	COARSE	7151757	COARSE	7151757	COARSE	7151757	COARSE		N/A	7151757
Loss on Ignition	%	18.7	7156219	16.9	7156219	2.7	7156219	3.1	7156219	1.8		1.0	7156219
Sieve - #16 (>1.18mm)	%	0.59	7160259	1.7	7161878	0.34	7160259	<0.20	7161878	5.5		0.20	7160259
Sieve - #30 (>0.60mm)	%	3.1	7160259	9.1	7161878	4.2	7160259	0.57	7161878	21		0.20	7160259
Sieve - #50 (>0.300 mm)	%	20	7160259	52	7161878	34	7160259	19	7161878	36		0.20	7160259
Sieve - #100(>0.15mm)	%	24	7160259	25	7161878	35	7160259	38	7161878	19		0.20	7160259
Sieve - #140 (>0.106mm)	%	11	7160259	4.7	7161878	13	7160259	14	7161878	6.6		0.20	7160259
Sieve - #200 (>0.075mm)	%	8.3	7160259	2.5	7161878	8.8	7160259	13	7161878	6.2		0.20	7160259
Sieve - #270 (>0.053mm)	%	4.0	7160259	0.97	7161878	2.9	7160259	6.1	7161878	3.2		0.20	7160259
Sieve - #400 (>0.038 mm)	%	0.88	7160259	<0.20	7161878	0.69	7160259	1.8	7161878	0.84		0.20	7160259
Sieve - Pan	%	28	7160259	4.3	7161878	0.80	7160259	7.1	7161878	2.1		0.20	7160259
Moisture	%	49	7162911	18	7162911	19	7162975	22	7162911	15	17	0.30	7162911

N/A = Not Applicable

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		HK3034		HK3035		HK3036		HK3037		HK3038		
Sampling Date		2013/08/22 15:00		2013/08/22 15:00		2013/08/22 15:00		2013/08/22 14:00		2013/08/22 14:00		
COC#		08377848		08377848		08377848		08377848		08377848		
	UNITS	MN-S1	QC Batch	MN-S2	QC Batch	MN-S3	QC Batch	VC-UMC-S1	QC Batch	VC-UMC-S2	RDL	QC Batch
Physical Properties												
Grain Size	N/A	COARSE	7151757	COARSE	7151757	COARSE	7151757	COARSE	7151757	COARSE	N/A	7151757
Loss on Ignition	%	1.3	7156219	1.6	7156219	2.7	7156219	2.7	7156219	2.8	1.0	7156219
Sieve - #16 (>1.18mm)	%	<0.20	7161878	<0.20	7160259	<0.20	7161878	<0.20	7160259	<0.20	0.20	7161878
Sieve - #30 (>0.60mm)	%	2.0	7161878	0.49	7160259	3.1	7161878	0.35	7160259	<0.20	0.20	7161878
Sieve - #50 (>0.300 mm)	%	40	7161878	20	7160259	34	7161878	14	7160259	26	0.20	7161878
Sieve - #100(>0.15mm)	%	48	7161878	60	7160259	39	7161878	31	7160259	27	0.20	7161878
Sieve - #140 (>0.106mm)	%	7.1	7161878	12	7160259	12	7161878	16	7160259	13	0.20	7161878
Sieve - #200 (>0.075mm)	%	1.8	7161878	3.0	7160259	5.2	7161878	18	7160259	15	0.20	7161878
Sieve - #270 (>0.053mm)	%	0.51	7161878	0.62	7160259	1.5	7161878	9.6	7160259	8.9	0.20	7161878
Sieve - #400 (>0.038 mm)	%	<0.20	7161878	0.25	7160259	0.71	7161878	2.3	7160259	2.8	0.20	7161878
Sieve - Pan	%	0.97	7161878	3.9	7160259	4.5	7161878	8.8	7160259	7.7	0.20	7161878
Moisture	%	21	7162911	20	7162975	24	7162911	30	7162975	31	0.30	7162911

Maxxam ID		HK3039	HK3039		HK3040	HK3040		HK3041	HK3041		HK3042		
Sampling Date		2013/08/22 14:00	2013/08/22 14:00		2013/08/22 11:00	2013/08/22 11:00		2013/08/22 11:00	2013/08/22 11:00		2013/08/22 11:00		
COC#		08377848	08377848		08377848	08377848		08377848	08377848		08377848		
	UNITS	VC-UMC-S3	VC-UMC-S3 Lab-Dup	QC Batch	BC-US-S1	BC-US-S1 Lab-Dup	QC Batch	BC-US-S2	BC-US-S2 Lab-Dup	QC Batch	BC-US-S3	RDL	QC Batch
Physical Properties													
Grain Size	N/A	FINE		7151757	COARSE		7151757	COARSE		7151757	COARSE	N/A	7151757
Loss on Ignition	%	2.5		7156219	1.2	1.1	7156219	1.3	1.3	7160169	1.4	1.0	7160169
Sieve - #16 (>1.18mm)	%	<0.20	<0.20	7161878	<0.20		7161878	0.92		7160259	0.83	0.20	7161878
Sieve - #30 (>0.60mm)	%	<0.20	<0.20	7161878	1.8		7161878	8.0		7160259	5.0	0.20	7161878
Sieve - #50 (>0.300 mm)	%	0.54	0.53	7161878	4.1		7161878	29		7160259	5.7	0.20	7161878
Sieve - #100(>0.15mm)	%	4.3	5.4	7161878	12		7161878	25		7160259	16	0.20	7161878
Sieve - #140 (>0.106mm)	%	11	13	7161878	22		7161878	11		7160259	21	0.20	7161878
Sieve - #200 (>0.075mm)	%	21	27	7161878	32		7161878	11		7160259	27	0.20	7161878
Sieve - #270 (>0.053mm)	%	18	18	7161878	17		7161878	6.5		7160259	11	0.20	7161878
Sieve - #400 (>0.038 mm)	%	9.1	7.2	7161878	4.6		7161878	1.7		7160259	2.1	0.20	7161878
Sieve - Pan	%	36	29	7161878	6.7		7161878	7.0		7160259	11	0.20	7161878
Moisture	%	36		7162975	22		7162911	17		7162911	24	0.30	7162911

N/A = Not Applicable

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		HK3043		HK3044		HK3045		HK3056		HK3057	HK3058		
Sampling Date		2013/08/22 09:00		2013/08/22 09:00		2013/08/22 09:00		2013/08/29 12:00		2013/08/29 12:00	2013/08/29 12:00		
COC#		08377848		08377848		08377848		08377849		08377849	08377849		
	UNITS	VC-REF-S1	QC Batch	VC-REF-S2	QC Batch	VC-REF-S3	QC Batch	MDC-S1	QC Batch	MDC-S2	MDC-S3	RDL	QC Batch
Physical Properties													
Grain Size	N/A	COARSE	7151757	COARSE	7151757	COARSE	7151757	COARSE	7151757	COARSE	COARSE	N/A	7151757
Loss on Ignition	%	3.2	7160169	2.3	7160169	2.8	7160169	6.9	7160169	1.9	1.8	1.0	7160169
Sieve - #16 (>1.18mm)	%	<0.20	7161878	0.82	7160259	3.3	7161878	<0.20	7161878	<0.20	<0.20	0.20	7160259
Sieve - #30 (>0.60mm)	%	1.7	7161878	28	7160259	27	7161878	0.39	7161878	0.37	0.51	0.20	7160259
Sieve - #50 (>0.300 mm)	%	22	7161878	32	7160259	40	7161878	11	7161878	5.8	14	0.20	7160259
Sieve - #100(>0.15mm)	%	32	7161878	17	7160259	11	7161878	45	7161878	29	37	0.20	7160259
Sieve - #140 (>0.106mm)	%	12	7161878	7.7	7160259	4.4	7161878	16	7161878	27	20	0.20	7160259
Sieve - #200 (>0.075mm)	%	15	7161878	8.6	7160259	6.0	7161878	11	7161878	22	16	0.20	7160259
Sieve - #270 (>0.053mm)	%	11	7161878	7.4	7160259	4.1	7161878	6.7	7161878	8.2	7.0	0.20	7160259
Sieve - #400 (>0.038 mm)	%	3.5	7161878	2.2	7160259	1.5	7161878	2.5	7161878	1.5	1.0	0.20	7160259
Sieve - Pan	%	3.1	7161878	<0.20	7160259	3.1	7161878	7.3	7161878	6.1	4.3	0.20	7160259
Moisture	%	26	7162975	21	7162975	22	7162975	47	7162911	24	20	0.30	7162975

Maxxam ID		HK3059		HK3060	HK3061		HK3062	HK3062		HK3063		
Sampling Date		2013/08/29 10:00		2013/08/29 10:00	2013/08/29 10:00		2013/08/28 14:00	2013/08/28 14:00		2013/08/28 14:00		
COC#		08377849		08377849	08377849		08377849	08377849		08377849		
	UNITS	UDC-S1	QC Batch	UDC-S2	UDC-S3	QC Batch	UPC-S1	UPC-S1 Lab-Dup	QC Batch	UPC-S2	RDL	QC Batch
Physical Properties												
Grain Size	N/A	COARSE	7151757	FINE	FINE	7151757	COARSE		7151758	COARSE	N/A	7151758
Loss on Ignition	%	4.4	7160169	4.1	6.9	7160169	7.2		7160169	10.0	1.0	7160169
Sieve - #16 (>1.18mm)	%	<0.20	7160259	0.32	<0.20	7161878	30		7161878	49	0.20	7160259
Sieve - #30 (>0.60mm)	%	0.45	7160259	<0.20	0.20	7161878	15		7161878	9.0	0.20	7160259
Sieve - #50 (>0.300 mm)	%	2.3	7160259	0.80	0.61	7161878	9.0		7161878	7.0	0.20	7160259
Sieve - #100(>0.15mm)	%	17	7160259	9.2	4.5	7161878	4.6		7161878	9.4	0.20	7160259
Sieve - #140 (>0.106mm)	%	25	7160259	16	12	7161878	1.3		7161878	4.6	0.20	7160259
Sieve - #200 (>0.075mm)	%	23	7160259	18	17	7161878	0.97		7161878	4.0	0.20	7160259
Sieve - #270 (>0.053mm)	%	11	7160259	11	15	7161878	0.86		7161878	2.3	0.20	7160259
Sieve - #400 (>0.038 mm)	%	4.4	7160259	5.7	7.5	7161878	0.54		7161878	1.1	0.20	7160259
Sieve - Pan	%	16	7160259	39	44	7161878	38		7161878	13	0.20	7160259
Moisture	%	48	7162975	49	57	7162911	23	26	7162975	39	0.30	7162975

N/A = Not Applicable

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		HK3064		HK3065	HK3066		HK3067	HK3067		
Sampling Date		2013/08/28 14:00		2013/08/28 16:00	2013/08/28 16:00		2013/08/28 16:00	2013/08/28 16:00		
COC#		08377849		08377849	08377849		08377849	08377849		
	UNITS	UPC-S3	QC Batch	LPC-S1	LPC-S2	QC Batch	LPC-S3	LPC-S3 Lab-Dup	RDL	QC Batch
Physical Properties										
Grain Size	N/A	COARSE	7151758	COARSE	COARSE	7151758	COARSE		N/A	7151758
Loss on Ignition	%	6.0	7160169	6.4	4.2	7160169	5.1		1.0	7160169
Sieve - #16 (>1.18mm)	%	82	7160259	32	52	7161878	47	54	0.20	7160259
Sieve - #30 (>0.60mm)	%	4.5	7160259	34	11	7161878	16	15	0.20	7160259
Sieve - #50 (>0.300 mm)	%	1.7	7160259	16	9.0	7161878	12	11	0.20	7160259
Sieve - #100(>0.15mm)	%	0.59	7160259	4.7	7.2	7161878	7.6	6.1	0.20	7160259
Sieve - #140 (>0.106mm)	%	0.29	7160259	1.3	2.7	7161878	2.9	2.2	0.20	7160259
Sieve - #200 (>0.075mm)	%	0.39	7160259	1.0	2.4	7161878	2.5	1.9	0.20	7160259
Sieve - #270 (>0.053mm)	%	0.29	7160259	0.57	1.0	7161878	1.3 ⁽¹⁾	0.75	0.20	7160259
Sieve - #400 (>0.038 mm)	%	0.29	7160259	0.34	0.27	7161878	0.34	0.38	0.20	7160259
Sieve - Pan	%	10	7160259	10	14	7161878	10	8.5	0.20	7160259
Moisture	%	14	7162911	22	22	7162911	17		0.30	7162911

N/A = Not Applicable

RDL = Reportable Detection Limit

(1) - Duplicate exceeds acceptance criteria due to sample non homogeneity. Reanalysis yields similar results.

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		HK2996	HK2996	HK2997	HK2998		HK2999		HK3000		HK3001		
Sampling Date		2013/08/21 17:00	2013/08/21 17:00	2013/08/21 17:00	2013/08/21 17:00		2013/08/21 15:30		2013/08/21 15:30		2013/08/21 15:30		
COC#		08377847	08377847	08377847	08377847		08377847		08377847		08377847		
	UNITS	LBC-S1	LBC-S1 Lab-Dup	LBC-S2	LBC-S3	QC Batch	VC-DBC-S1	QC Batch	VC-DBC-S2	QC Batch	VC-DBC-S3	RDL	QC Batch
Total Metals by ICPMS													
Total Aluminum (Al)	mg/kg	5530	5290	5270	5150	7155324	8240	7155477	7180	7155324	6090	100	7155477
Total Antimony (Sb)	mg/kg	0.54	0.50	0.56	0.51	7155324	0.72	7155477	0.83	7155324	0.48	0.10	7155477
Total Arsenic (As)	mg/kg	8.73	8.86	8.28	8.80	7155324	14.0	7155477	15.0	7155324	8.92	0.50	7155477
Total Barium (Ba)	mg/kg	73.4	71.4	69.3	79.7	7155324	113	7155477	113	7155324	75.0	0.10	7155477
Total Beryllium (Be)	mg/kg	<0.40	<0.40	<0.40	<0.40	7155324	<0.40	7155477	<0.40	7155324	<0.40	0.40	7155477
Total Bismuth (Bi)	mg/kg	0.14	0.13	0.12	0.19	7155324	0.16	7155477	0.15	7155324	0.12	0.10	7155477
Total Cadmium (Cd)	mg/kg	0.253	0.278	0.255	0.276	7155324	0.371	7155477	0.402	7155324	0.225	0.050	7155477
Total Calcium (Ca)	mg/kg	3600	3720	3400	4040	7155324	4290	7155477	3730	7155324	3420	100	7155477
Total Chromium (Cr)	mg/kg	9.4	9.2	8.7	10.9	7155324	12.7	7155477	11.7	7155324	9.7	1.0	7155477
Total Cobalt (Co)	mg/kg	3.15	2.95	3.04	3.19	7155324	5.10	7155477	4.98	7155324	3.43	0.30	7155477
Total Copper (Cu)	mg/kg	5.47	5.36	5.31	5.20	7155324	11.2	7155477	10.5	7155324	7.77	0.50	7155477
Total Iron (Fe)	mg/kg	9880	9430	9210	11900	7155324	14500	7155477	14100	7155324	10300	100	7155477
Total Lead (Pb)	mg/kg	9.77	9.14	8.62	8.32	7155324	12.8	7155477	14.0	7155324	8.79	0.10	7155477
Total Lithium (Li)	mg/kg	<5.0	<5.0	<5.0	<5.0	7155324	7.2	7155477	6.5	7155324	5.4	5.0	7155477
Total Magnesium (Mg)	mg/kg	2250	2150	2190	2090	7155324	3160	7155477	2830	7155324	2340	100	7155477
Total Manganese (Mn)	mg/kg	260	245	276	312	7155324	274	7155477	296	7155324	165	0.20	7155477
Total Mercury (Hg)	mg/kg	<0.050	<0.050	<0.050	<0.050	7155324	<0.050	7155477	<0.050	7155324	<0.050	0.050	7155477
Total Molybdenum (Mo)	mg/kg	0.29	0.27	0.23	0.29	7155324	0.50	7155477	0.51	7155324	0.42	0.10	7155477
Total Nickel (Ni)	mg/kg	5.76	5.53	5.45	5.83	7155324	8.19	7155477	7.48	7155324	6.11	0.80	7155477
Total Phosphorus (P)	mg/kg	641	621	568	829	7155324	559	7155477	581	7155324	663	10	7155477
Total Potassium (K)	mg/kg	524	503	509	470	7155324	638	7155477	530	7155324	444	100	7155477
Total Selenium (Se)	mg/kg	<0.50	<0.50	<0.50	<0.50	7155324	<0.50	7155477	<0.50	7155324	<0.50	0.50	7155477
Total Silver (Ag)	mg/kg	0.112	0.122	0.095	0.085	7155324	0.173	7155477	0.148	7155324	0.088	0.050	7155477
Total Sodium (Na)	mg/kg	155	166	156	157	7155324	167	7155477	159	7155324	150	100	7155477
Total Strontium (Sr)	mg/kg	21.5	20.7	20.0	21.4	7155324	34.9	7155477	31.6	7155324	22.5	0.10	7155477
Total Thallium (Tl)	mg/kg	<0.050	<0.050	<0.050	<0.050	7155324	0.072	7155477	0.064	7155324	<0.050	0.050	7155477
Total Tin (Sn)	mg/kg	0.22	0.20	0.22	0.25	7155324	0.24	7155477	0.27	7155324	0.21	0.10	7155477
Total Titanium (Ti)	mg/kg	341	333	310	365	7155324	406	7155477	373	7155324	315	1.0	7155477
Total Uranium (U)	mg/kg	0.409	0.412	0.363	0.441	7155324	0.881	7155477	0.784	7155324	0.670	0.050	7155477
Total Vanadium (V)	mg/kg	22.3	21.8	20.1	31.1	7155324	28.2	7155477	29.2	7155324	21.8	2.0	7155477
Total Zinc (Zn)	mg/kg	32.3	31.8	30.3	30.2	7155324	55.7	7155477	52.6	7155324	37.9	1.0	7155477
Total Zirconium (Zr)	mg/kg	1.48	1.40	1.47	1.53	7155324	1.12	7155477	1.13	7155324	1.20	0.50	7155477

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		HK3001		HK3002		HK3003		HK3004		HK3005	HK3006		
Sampling Date		2013/08/21 15:30		2013/08/29 16:00		2013/08/29 16:00		2013/08/29 16:00		2013/08/29 17:00	2013/08/29 17:00		
COC#		08377847		08377847		08377847		08377847		08377847	08377847		
	UNITS	VC-DBC-S3 Lab-Dup	QC Batch	LDC-S1	QC Batch	LDC-S2	QC Batch	LDC-S3	QC Batch	VC-R-S1	VC-R-S2	RDL	QC Batch
Total Metals by ICPMS													
Total Aluminum (Al)	mg/kg	6290	7155477	9970	7155324	8700	7155477	10000	7155324	7500	7100	100	7155477
Total Antimony (Sb)	mg/kg	0.49	7155477	18.0	7155324	17.7	7155477	13.5	7155324	1.02	0.86	0.10	7155477
Total Arsenic (As)	mg/kg	8.63	7155477	768	7155324	671	7155477	497	7155324	16.9	15.1	0.50	7155477
Total Barium (Ba)	mg/kg	74.3	7155477	354	7155324	348	7155477	301	7155324	109	105	0.10	7155477
Total Beryllium (Be)	mg/kg	<0.40	7155477	0.40	7155324	<0.40	7155477	<0.40	7155324	<0.40	<0.40	0.40	7155477
Total Bismuth (Bi)	mg/kg	0.11	7155477	0.21	7155324	0.19	7155477	0.20	7155324	0.20	0.17	0.10	7155477
Total Cadmium (Cd)	mg/kg	0.251	7155477	2.42	7155324	2.04	7155477	1.97	7155324	0.339	0.420	0.050	7155477
Total Calcium (Ca)	mg/kg	3560	7155477	14000	7155324	11200	7155477	11700	7155324	3990	3850	100	7155477
Total Chromium (Cr)	mg/kg	9.3	7155477	21.5	7155324	18.4	7155477	20.9	7155324	12.0	12.5	1.0	7155477
Total Cobalt (Co)	mg/kg	3.45	7155477	12.6	7155324	12.1	7155477	10.8	7155324	4.50	4.71	0.30	7155477
Total Copper (Cu)	mg/kg	6.54	7155477	41.5	7155324	36.9	7155477	36.3	7155324	10.7	10.9	0.50	7155477
Total Iron (Fe)	mg/kg	10200	7155477	64000	7155324	55600	7155477	47600	7155324	13500	14000	100	7155477
Total Lead (Pb)	mg/kg	8.45	7155477	89.1	7155324	77.7	7155477	68.2	7155324	14.5	13.0	0.10	7155477
Total Lithium (Li)	mg/kg	5.2	7155477	7.4	7155324	5.9	7155477	7.8	7155324	6.5	6.2	5.0	7155477
Total Magnesium (Mg)	mg/kg	2360	7155477	3970	7155324	3440	7155477	4000	7155324	2860	2770	100	7155477
Total Manganese (Mn)	mg/kg	159	7155477	11500	7155324	10400	7155477	11000	7155324	286	273	0.20	7155477
Total Mercury (Hg)	mg/kg	<0.050	7155477	0.059	7155324	<0.050	7155477	<0.050	7155324	<0.050	<0.050	0.050	7155477
Total Molybdenum (Mo)	mg/kg	0.35	7155477	1.78	7155324	1.74	7155477	1.40	7155324	0.52	0.52	0.10	7155477
Total Nickel (Ni)	mg/kg	5.74	7155477	17.1	7155324	16.4	7155477	16.1	7155324	7.69	7.36	0.80	7155477
Total Phosphorus (P)	mg/kg	674	7155477	712	7155324	763	7155477	632	7155324	581	632	10	7155477
Total Potassium (K)	mg/kg	461	7155477	969	7155324	837	7155477	1020	7155324	634	550	100	7155477
Total Selenium (Se)	mg/kg	<0.50	7155477	0.69	7155324	0.56	7155477	0.61	7155324	<0.50	<0.50	0.50	7155477
Total Silver (Ag)	mg/kg	0.091	7155477	2.16	7155324	1.92	7155477	1.68	7155324	0.158	0.147	0.050	7155477
Total Sodium (Na)	mg/kg	151	7155477	235	7155324	210	7155477	224	7155324	164	148	100	7155477
Total Strontium (Sr)	mg/kg	23.2	7155477	83.3	7155324	68.4	7155477	70.7	7155324	28.6	28.4	0.10	7155477
Total Thallium (Tl)	mg/kg	<0.050	7155477	0.184	7155324	0.147	7155477	0.165	7155324	0.078	0.062	0.050	7155477
Total Tin (Sn)	mg/kg	0.20	7155477	0.54	7155324	0.50	7155477	0.47	7155324	0.27	0.26	0.10	7155477
Total Titanium (Ti)	mg/kg	334	7155477	428	7155324	421	7155477	451	7155324	389	371	1.0	7155477
Total Uranium (U)	mg/kg	0.675	7155477	1.20	7155324	0.970	7155477	1.04	7155324	0.814	0.991	0.050	7155477
Total Vanadium (V)	mg/kg	21.7	7155477	58.9	7155324	55.5	7155477	54.7	7155324	27.6	29.8	2.0	7155477
Total Zinc (Zn)	mg/kg	37.2	7155477	256	7155324	245	7155477	200	7155324	55.8	53.7	1.0	7155477
Total Zirconium (Zr)	mg/kg	1.20	7155477	1.16	7155324	0.85	7155477	1.27	7155324	1.03	1.03	0.50	7155477

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		HK3007		HK3034		HK3035		HK3036	HK3037		HK3038		
Sampling Date		2013/08/29 17:00		2013/08/22 15:00		2013/08/22 15:00		2013/08/22 15:00	2013/08/22 14:00		2013/08/22 14:00		
COC#		08377847		08377848		08377848		08377848	08377848		08377848		
	UNITS	VC-R-S3	QC Batch	MN-S1	QC Batch	MN-S2	QC Batch	MN-S3	VC-UMC-S1	QC Batch	VC-UMC-S2	RDL	QC Batch
Total Metals by ICPMS													
Total Aluminum (Al)	mg/kg	6140	7155477	5060	7155324	5530	7155477	6280	7120	7155324	7970	100	7155477
Total Antimony (Sb)	mg/kg	0.91	7155477	0.39	7155324	0.25	7155477	0.91	0.88	7155324	0.85	0.10	7155477
Total Arsenic (As)	mg/kg	15.1	7155477	5.01	7155324	4.77	7155477	6.80	16.6	7155324	16.5	0.50	7155477
Total Barium (Ba)	mg/kg	95.4	7155477	74.1	7155324	76.6	7155477	97.9	109	7155324	111	0.10	7155477
Total Beryllium (Be)	mg/kg	<0.40	7155477	<0.40	7155324	<0.40	7155477	<0.40	<0.40	7155324	<0.40	0.40	7155477
Total Bismuth (Bi)	mg/kg	0.19	7155477	<0.10	7155324	<0.10	7155477	<0.10	0.19	7155324	0.19	0.10	7155477
Total Cadmium (Cd)	mg/kg	0.290	7155477	0.103	7155324	0.103	7155477	0.178	0.440	7155324	0.373	0.050	7155477
Total Calcium (Ca)	mg/kg	3330	7155477	2380	7155324	2750	7155477	3590	4040	7155324	3700	100	7155477
Total Chromium (Cr)	mg/kg	10.7	7155477	8.6	7155324	9.5	7155477	21.5	13.0	7155324	14.6	1.0	7155477
Total Cobalt (Co)	mg/kg	3.94	7155477	3.27	7155324	3.50	7155477	5.36	4.91	7155324	5.24	0.30	7155477
Total Copper (Cu)	mg/kg	8.49	7155477	5.31	7155324	5.54	7155477	7.82	10.8	7155324	11.5	0.50	7155477
Total Iron (Fe)	mg/kg	12700	7155477	9170	7155324	9960	7155477	26600	14400	7155324	14400	100	7155477
Total Lead (Pb)	mg/kg	13.9	7155477	3.87	7155324	2.73	7155477	3.69	14.9	7155324	13.7	0.10	7155477
Total Lithium (Li)	mg/kg	5.1	7155477	<5.0	7155324	<5.0	7155477	5.7	6.3	7155324	6.6	5.0	7155477
Total Magnesium (Mg)	mg/kg	2420	7155477	2130	7155324	2240	7155477	2510	2800	7155324	3190	100	7155477
Total Manganese (Mn)	mg/kg	259	7155477	166	7155324	202	7155477	282	327	7155324	292	0.20	7155477
Total Mercury (Hg)	mg/kg	<0.050	7155477	<0.050	7155324	<0.050	7155477	<0.050	<0.050	7155324	<0.050	0.050	7155477
Total Molybdenum (Mo)	mg/kg	0.51	7155477	0.25	7155324	0.27	7155477	0.44	0.56	7155324	0.55	0.10	7155477
Total Nickel (Ni)	mg/kg	6.25	7155477	6.21	7155324	6.68	7155477	9.33	7.66	7155324	8.43	0.80	7155477
Total Phosphorus (P)	mg/kg	607	7155477	356	7155324	402	7155477	541	745	7155324	549	10	7155477
Total Potassium (K)	mg/kg	502	7155477	481	7155324	504	7155477	565	596	7155324	650	100	7155477
Total Selenium (Se)	mg/kg	<0.50	7155477	<0.50	7155324	<0.50	7155477	<0.50	<0.50	7155324	<0.50	0.50	7155477
Total Silver (Ag)	mg/kg	0.133	7155477	0.051	7155324	<0.050	7155477	0.058	0.166	7155324	0.150	0.050	7155477
Total Sodium (Na)	mg/kg	143	7155477	123	7155324	144	7155477	139	150	7155324	172	100	7155477
Total Strontium (Sr)	mg/kg	23.1	7155477	14.3	7155324	15.9	7155477	18.3	27.0	7155324	30.2	0.10	7155477
Total Thallium (Tl)	mg/kg	0.055	7155477	<0.050	7155324	<0.050	7155477	0.071	0.072	7155324	0.080	0.050	7155477
Total Tin (Sn)	mg/kg	0.26	7155477	0.24	7155324	0.28	7155477	0.41	0.27	7155324	0.28	0.10	7155477
Total Titanium (Ti)	mg/kg	335	7155477	287	7155324	327	7155477	468	396	7155324	417	1.0	7155477
Total Uranium (U)	mg/kg	0.617	7155477	0.288	7155324	0.324	7155477	0.513	0.909	7155324	0.946	0.050	7155477
Total Vanadium (V)	mg/kg	27.5	7155477	19.5	7155324	22.2	7155477	72.1	32.5	7155324	28.3	2.0	7155477
Total Zinc (Zn)	mg/kg	46.4	7155477	24.0	7155324	25.2	7155477	38.1	54.3	7155324	58.8	1.0	7155477
Total Zirconium (Zr)	mg/kg	1.10	7155477	0.88	7155324	0.85	7155477	0.76	1.12	7155324	1.18	0.50	7155477

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		HK3039		HK3040		HK3041		HK3042		HK3043		
Sampling Date		2013/08/22 14:00		2013/08/22 11:00		2013/08/22 11:00		2013/08/22 11:00		2013/08/22 09:00		
COC#		08377848		08377848		08377848		08377848		08377848		
	UNITS	VC-UMC-S3	QC Batch	BC-US-S1	QC Batch	BC-US-S2	QC Batch	BC-US-S3	QC Batch	VC-REF-S1	RDL	QC Batch
Total Metals by ICPMS												
Total Aluminum (Al)	mg/kg	7240	7155477	5060	7155324	5710	7155477	5440	7155324	8100	100	7155477
Total Antimony (Sb)	mg/kg	0.98	7155477	0.72	7155324	0.94	7155477	0.68	7155324	0.86	0.10	7155477
Total Arsenic (As)	mg/kg	17.7	7155477	10.8	7155324	15.1	7155477	11.2	7155324	15.0	0.50	7155477
Total Barium (Ba)	mg/kg	107	7155477	83.6	7155324	102	7155477	82.7	7155324	118	0.10	7155477
Total Beryllium (Be)	mg/kg	<0.40	7155477	<0.40	7155324	<0.40	7155477	<0.40	7155324	<0.40	0.40	7155477
Total Bismuth (Bi)	mg/kg	0.22	7155477	0.15	7155324	0.28	7155477	0.20	7155324	0.17	0.10	7155477
Total Cadmium (Cd)	mg/kg	0.344	7155477	0.315	7155324	0.435	7155477	0.391	7155324	0.399	0.050	7155477
Total Calcium (Ca)	mg/kg	3700	7155477	3960	7155324	5020	7155477	4040	7155324	4130	100	7155477
Total Chromium (Cr)	mg/kg	13.3	7155477	11.6	7155324	16.3	7155477	12.0	7155324	12.9	1.0	7155477
Total Cobalt (Co)	mg/kg	4.66	7155477	3.34	7155324	4.18	7155477	3.49	7155324	5.28	0.30	7155477
Total Copper (Cu)	mg/kg	10.4	7155477	5.59	7155324	7.70	7155477	6.19	7155324	12.1	0.50	7155477
Total Iron (Fe)	mg/kg	15400	7155477	12200	7155324	18000	7155477	12300	7155324	15700	100	7155477
Total Lead (Pb)	mg/kg	16.7	7155477	10.9	7155324	17.4	7155477	10.8	7155324	13.2	0.10	7155477
Total Lithium (Li)	mg/kg	6.2	7155477	<5.0	7155324	<5.0	7155477	<5.0	7155324	6.6	5.0	7155477
Total Magnesium (Mg)	mg/kg	2780	7155477	2050	7155324	2240	7155477	2170	7155324	3020	100	7155477
Total Manganese (Mn)	mg/kg	409	7155477	222	7155324	324	7155477	295	7155324	276	0.20	7155477
Total Mercury (Hg)	mg/kg	<0.050	7155477	<0.050	7155324	<0.050	7155477	<0.050	7155324	<0.050	0.050	7155477
Total Molybdenum (Mo)	mg/kg	0.56	7155477	0.38	7155324	0.53	7155477	0.37	7155324	0.65	0.10	7155477
Total Nickel (Ni)	mg/kg	7.83	7155477	5.72	7155324	6.88	7155477	6.08	7155324	7.70	0.80	7155477
Total Phosphorus (P)	mg/kg	662	7155477	800	7155324	1090	7155477	778	7155324	735	10	7155477
Total Potassium (K)	mg/kg	589	7155477	467	7155324	542	7155477	513	7155324	514	100	7155477
Total Selenium (Se)	mg/kg	<0.50	7155477	<0.50	7155324	<0.50	7155477	<0.50	7155324	<0.50	0.50	7155477
Total Silver (Ag)	mg/kg	0.157	7155477	0.087	7155324	0.120	7155477	0.087	7155324	0.181	0.050	7155477
Total Sodium (Na)	mg/kg	156	7155477	149	7155324	162	7155477	159	7155324	143	100	7155477
Total Strontium (Sr)	mg/kg	25.6	7155477	19.1	7155324	23.3	7155477	21.7	7155324	32.5	0.10	7155477
Total Thallium (Tl)	mg/kg	0.064	7155477	<0.050	7155324	<0.050	7155477	<0.050	7155324	0.065	0.050	7155477
Total Tin (Sn)	mg/kg	0.30	7155477	0.25	7155324	0.28	7155477	0.24	7155324	0.28	0.10	7155477
Total Titanium (Ti)	mg/kg	425	7155477	357	7155324	406	7155477	365	7155324	393	1.0	7155477
Total Uranium (U)	mg/kg	0.855	7155477	0.840	7155324	0.849	7155477	0.533	7155324	1.15	0.050	7155477
Total Vanadium (V)	mg/kg	33.6	7155477	32.2	7155324	48.9	7155477	30.6	7155324	32.7	2.0	7155477
Total Zinc (Zn)	mg/kg	57.7	7155477	33.7	7155324	43.5	7155477	36.6	7155324	59.7	1.0	7155477
Total Zirconium (Zr)	mg/kg	1.29	7155477	1.64	7155324	2.01	7155477	1.64	7155324	0.95	0.50	7155477

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		HK3044		HK3045	HK3056		HK3057	HK3058	HK3059	HK3060	HK3061		
Sampling Date		2013/08/22 09:00		2013/08/22 09:00	2013/08/29 12:00		2013/08/29 12:00	2013/08/29 12:00	2013/08/29 10:00	2013/08/29 10:00	2013/08/29 10:00		
COC#		08377848		08377848	08377849		08377849	08377849	08377849	08377849	08377849		
	UNITS	VC-REF-S2	QC Batch	VC-REF-S3	MDC-S1	QC Batch	MDC-S2	MDC-S3	UDC-S1	UDC-S2	UDC-S3	RDL	QC Batch
Total Metals by ICPMS													
Total Aluminum (Al)	mg/kg	6460	7155324	7740	11800	7155477	6570	6130	6530	6720	8050	100	7155324
Total Antimony (Sb)	mg/kg	0.71	7155324	0.70	2.08	7155477	0.92	0.71	70.2	62.0	69.7	0.10	7155324
Total Arsenic (As)	mg/kg	12.2	7155324	13.2	56.5	7155477	20.6	24.8	893	598	667	0.50	7155324
Total Barium (Ba)	mg/kg	94.2	7155324	110	139	7155477	63.5	66.1	97.4	102	120	0.10	7155324
Total Beryllium (Be)	mg/kg	<0.40	7155324	<0.40	0.58	7155477	<0.40	<0.40	<0.40	<0.40	<0.40	0.40	7155324
Total Bismuth (Bi)	mg/kg	0.13	7155324	0.14	0.12	7155477	<0.10	<0.10	1.09	1.07	1.19	0.10	7155324
Total Cadmium (Cd)	mg/kg	0.270	7155324	0.314	0.807	7155477	0.296	0.250	8.19	6.90	10.7	0.050	7155324
Total Calcium (Ca)	mg/kg	3230	7155324	3640	12600	7155477	7570	6130	5870	4760	6340	100	7155324
Total Chromium (Cr)	mg/kg	10.1	7155324	12.2	23.3	7155477	13.3	12.0	10.1	9.7	12.2	1.0	7155324
Total Cobalt (Co)	mg/kg	4.77	7155324	5.07	8.36	7155477	4.45	3.93	4.14	4.17	4.95	0.30	7155324
Total Copper (Cu)	mg/kg	9.06	7155324	10.6	20.3	7155477	7.97	6.63	32.2	26.1	34.8	0.50	7155324
Total Iron (Fe)	mg/kg	12400	7155324	14100	25400	7155477	14300	13000	28000	16700	22000	100	7155324
Total Lead (Pb)	mg/kg	10.5	7155324	13.0	11.7	7155477	6.67	4.73	331	278	302	0.10	7155324
Total Lithium (Li)	mg/kg	5.5	7155324	6.9	11.0	7155477	5.8	<5.0	5.2	5.5	6.8	5.0	7155324
Total Magnesium (Mg)	mg/kg	2550	7155324	2960	5490	7155477	3160	2730	2750	2650	3100	100	7155324
Total Manganese (Mn)	mg/kg	253	7155324	236	437	7155477	409	158	681	596	589	0.20	7155324
Total Mercury (Hg)	mg/kg	<0.050	7155324	<0.050	<0.050	7155477	<0.050	<0.050	0.051	<0.050	0.060	0.050	7155324
Total Molybdenum (Mo)	mg/kg	0.53	7155324	0.56	0.49	7155477	0.27	0.20	0.32	0.27	0.43	0.10	7155324
Total Nickel (Ni)	mg/kg	6.39	7155324	7.42	16.3	7155477	8.68	7.58	6.28	6.55	7.90	0.80	7155324
Total Phosphorus (P)	mg/kg	639	7155324	635	620	7155477	563	509	634	507	602	10	7155324
Total Potassium (K)	mg/kg	436	7155324	514	1260	7155477	620	554	725	625	734	100	7155324
Total Selenium (Se)	mg/kg	<0.50	7155324	<0.50	<0.50	7155477	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7155324
Total Silver (Ag)	mg/kg	0.106	7155324	0.183	0.292	7155477	0.132	0.073	7.25	5.00	4.74	0.050	7155324
Total Sodium (Na)	mg/kg	139	7155324	147	275	7155477	190	160	138	149	155	100	7155324
Total Strontium (Sr)	mg/kg	26.3	7155324	31.0	54.7	7155477	34.2	26.5	29.1	24.8	30.5	0.10	7155324
Total Thallium (Tl)	mg/kg	0.052	7155324	0.065	0.168	7155477	0.067	<0.050	0.268	0.247	0.329	0.050	7155324
Total Tin (Sn)	mg/kg	0.27	7155324	0.27	0.41	7155477	0.22	0.19	0.60	0.50	0.59	0.10	7155324
Total Titanium (Ti)	mg/kg	326	7155324	384	785	7155477	463	413	338	359	408	1.0	7155324
Total Uranium (U)	mg/kg	0.726	7155324	0.864	0.815	7155477	0.395	0.335	0.466	0.468	0.655	0.050	7155324
Total Vanadium (V)	mg/kg	25.2	7155324	29.7	50.9	7155477	32.8	30.1	25.9	21.9	27.8	2.0	7155324
Total Zinc (Zn)	mg/kg	46.9	7155324	58.3	107	7155477	53.6	45.3	782	720	1090	1.0	7155324
Total Zirconium (Zr)	mg/kg	1.12	7155324	1.11	1.80	7155477	1.50	1.41	0.90	0.85	0.98	0.50	7155324

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		HK3062	HK3063	HK3064		HK3065	HK3066	HK3067		
Sampling Date		2013/08/28 14:00	2013/08/28 14:00	2013/08/28 14:00		2013/08/28 16:00	2013/08/28 16:00	2013/08/28 16:00		
COC#		08377849	08377849	08377849		08377849	08377849	08377849		
	UNITS	UPC-S1	UPC-S2	UPC-S3	QC Batch	LPC-S1	LPC-S2	LPC-S3	RDL	QC Batch
Total Metals by ICPMS										
Total Aluminum (Al)	mg/kg	10100	11500	7000	7155477	6460	6130	6870	100	7155324
Total Antimony (Sb)	mg/kg	4.03	4.87	5.14	7155477	92.7	68.1	72.8	0.10	7155324
Total Arsenic (As)	mg/kg	32.0	90.8	26.3	7155477	791	803	661	0.50	7155324
Total Barium (Ba)	mg/kg	115	211	117	7155477	199	142	122	0.10	7155324
Total Beryllium (Be)	mg/kg	0.68	<0.40	0.64	7155477	<0.40	<0.40	<0.40	0.40	7155324
Total Bismuth (Bi)	mg/kg	0.15	0.46	0.18	7155477	5.60	6.42	4.86	0.10	7155324
Total Cadmium (Cd)	mg/kg	1.30	1.50	1.66	7155477	18.3	9.77	5.45	0.050	7155324
Total Calcium (Ca)	mg/kg	5230	6180	4310	7155477	5010	4220	4390	100	7155324
Total Chromium (Cr)	mg/kg	4.0	13.2	3.6	7155477	8.9	8.9	10.7	1.0	7155324
Total Cobalt (Co)	mg/kg	5.49	7.48	4.98	7155477	10.6	8.15	4.87	0.30	7155324
Total Copper (Cu)	mg/kg	9.63	16.7	9.23	7155477	136	107	127	0.50	7155324
Total Iron (Fe)	mg/kg	27300	21900	20800	7155477	29900	32400	30500	100	7155324
Total Lead (Pb)	mg/kg	58.1	30.0	70.1	7155477	312	286	245	0.10	7155324
Total Lithium (Li)	mg/kg	5.5	7.4	<5.0	7155477	<5.0	<5.0	5.4	5.0	7155324
Total Magnesium (Mg)	mg/kg	3200	2980	2200	7155477	2220	2040	2240	100	7155324
Total Manganese (Mn)	mg/kg	717	1530	999	7155477	7810	4140	676	0.20	7155324
Total Mercury (Hg)	mg/kg	<0.050	0.068	<0.050	7155477	0.073	0.065	0.071	0.050	7155324
Total Molybdenum (Mo)	mg/kg	0.31	0.52	0.44	7155477	1.13	0.79	0.48	0.10	7155324
Total Nickel (Ni)	mg/kg	3.24	8.63	3.11	7155477	7.94	6.23	5.87	0.80	7155324
Total Phosphorus (P)	mg/kg	1090	766	949	7155477	561	560	600	10	7155324
Total Potassium (K)	mg/kg	666	642	432	7155477	679	614	578	100	7155324
Total Selenium (Se)	mg/kg	<0.50	<0.50	<0.50	7155477	<0.50	<0.50	<0.50	0.50	7155324
Total Silver (Ag)	mg/kg	0.205	0.804	0.133	7155477	5.51	7.76	11.1	0.050	7155324
Total Sodium (Na)	mg/kg	176	203	135	7155477	129	120	130	100	7155324
Total Strontium (Sr)	mg/kg	34.1	50.0	25.5	7155477	66.6	51.7	44.2	0.10	7155324
Total Thallium (Tl)	mg/kg	<0.050	0.180	<0.050	7155477	0.216	0.191	0.154	0.050	7155324
Total Tin (Sn)	mg/kg	0.56	0.45	1.13	7155477	0.44	0.48	0.45	0.10	7155324
Total Titanium (Ti)	mg/kg	49.1	288	9.7	7155477	211	272	338	1.0	7155324
Total Uranium (U)	mg/kg	0.392	1.57	0.337	7155477	0.888	0.829	0.785	0.050	7155324
Total Vanadium (V)	mg/kg	54.9	35.9	32.9	7155477	26.4	27.2	29.4	2.0	7155324
Total Zinc (Zn)	mg/kg	102	137	93.2	7155477	1060	630	380	1.0	7155324
Total Zirconium (Zr)	mg/kg	0.79	<0.50	<0.50	7155477	<0.50	<0.50	<0.50	0.50	7155324

RDL = Reportable Detection Limit

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7155324	Total Antimony (Sb)	2013/09/10	91	75 - 125	99	75 - 125	<0.10	mg/kg	NC	30	104	70 - 130
7155324	Total Arsenic (As)	2013/09/10	93	75 - 125	96	75 - 125	<0.50	mg/kg	1.4	30	100	70 - 130
7155324	Total Barium (Ba)	2013/09/10	NC	75 - 125	102	75 - 125	<0.10	mg/kg	2.7	35	107	70 - 130
7155324	Total Beryllium (Be)	2013/09/10	95	75 - 125	101	75 - 125	<0.40	mg/kg	NC	30		
7155324	Total Cadmium (Cd)	2013/09/10	94	75 - 125	99	75 - 125	<0.050	mg/kg	9.5	30	107	70 - 130
7155324	Total Chromium (Cr)	2013/09/10	99	75 - 125	101	75 - 125	<1.0	mg/kg	2.5	30	107	70 - 130
7155324	Total Cobalt (Co)	2013/09/10	101	75 - 125	102	75 - 125	<0.30	mg/kg	6.5	30	100	70 - 130
7155324	Total Copper (Cu)	2013/09/10	97	75 - 125	105	75 - 125	<0.50	mg/kg	2.0	30	96	70 - 130
7155324	Total Lead (Pb)	2013/09/10	99	75 - 125	106	75 - 125	<0.10	mg/kg	6.7	35	104	70 - 130
7155324	Total Lithium (Li)	2013/09/10	93	75 - 125	101	75 - 125	<5.0	mg/kg	NC	30		
7155324	Total Manganese (Mn)	2013/09/10	NC	75 - 125	101	75 - 125	<0.20	mg/kg	5.8	30	106	70 - 130
7155324	Total Mercury (Hg)	2013/09/10	96	75 - 125	102	75 - 125	<0.050	mg/kg	NC	35	105	70 - 130
7155324	Total Molybdenum (Mo)	2013/09/10	99	75 - 125	102	75 - 125	<0.10	mg/kg	NC	35	111	70 - 130
7155324	Total Nickel (Ni)	2013/09/10	95	75 - 125	102	75 - 125	<0.80	mg/kg	4.1	30	96	70 - 130
7155324	Total Selenium (Se)	2013/09/10	93	75 - 125	97	75 - 125	<0.50	mg/kg	NC	30		
7155324	Total Silver (Ag)	2013/09/10	97	75 - 125	98	75 - 125	<0.050	mg/kg	NC	35		
7155324	Total Strontium (Sr)	2013/09/10	93	75 - 125	98	75 - 125	<0.10	mg/kg	3.7	35	104	70 - 130
7155324	Total Thallium (Tl)	2013/09/10	98	75 - 125	102	75 - 125	<0.050	mg/kg	NC	30	96	70 - 130
7155324	Total Tin (Sn)	2013/09/10	92	75 - 125	99	75 - 125	<0.10	mg/kg	NC	35		
7155324	Total Titanium (Ti)	2013/09/10	NC	75 - 125	98	75 - 125	<1.0	mg/kg	2.5	35	109	70 - 130
7155324	Total Uranium (U)	2013/09/10	97	75 - 125	103	75 - 125	<0.050	mg/kg	0.7	30	102	70 - 130
7155324	Total Vanadium (V)	2013/09/10	97	75 - 125	101	75 - 125	<2.0	mg/kg	2.6	30	107	70 - 130
7155324	Total Zinc (Zn)	2013/09/10	NC	75 - 125	102	75 - 125	<1.0	mg/kg	1.7	30	92	70 - 130
7155324	Total Aluminum (Al)	2013/09/10					<100	mg/kg	4.4	35	112	70 - 130
7155324	Total Calcium (Ca)	2013/09/10					<100	mg/kg	3.5	30	104	70 - 130
7155324	Total Iron (Fe)	2013/09/10					<100	mg/kg	4.6	30	105	70 - 130
7155324	Total Magnesium (Mg)	2013/09/10					<100	mg/kg	4.4	30	92	70 - 130
7155324	Total Phosphorus (P)	2013/09/10					<10	mg/kg	3.2	30	86	70 - 130
7155324	Total Bismuth (Bi)	2013/09/10					<0.10	mg/kg	NC	30		
7155324	Total Potassium (K)	2013/09/10					<100	mg/kg	4.2	35		
7155324	Total Sodium (Na)	2013/09/10					<100	mg/kg	NC	35		
7155324	Total Zirconium (Zr)	2013/09/10					<0.50	mg/kg	NC	30		
7155477	Total Antimony (Sb)	2013/09/10	99	75 - 125	99	75 - 125	<0.10	mg/kg	NC	30	96	70 - 130
7155477	Total Arsenic (As)	2013/09/10	94	75 - 125	94	75 - 125	<0.50	mg/kg	3.4	30	92	70 - 130
7155477	Total Barium (Ba)	2013/09/10	NC	75 - 125	99	75 - 125	<0.10	mg/kg	0.9	35	103	70 - 130
7155477	Total Beryllium (Be)	2013/09/10	101	75 - 125	98	75 - 125	<0.40	mg/kg	NC	30		
7155477	Total Cadmium (Cd)	2013/09/10	97	75 - 125	98	75 - 125	<0.050	mg/kg	NC	30	103	70 - 130
7155477	Total Chromium (Cr)	2013/09/10	97	75 - 125	97	75 - 125	<1.0	mg/kg	4.7	30	100	70 - 130
7155477	Total Cobalt (Co)	2013/09/10	98	75 - 125	100	75 - 125	<0.30	mg/kg	0.6	30	92	70 - 130
7155477	Total Copper (Cu)	2013/09/10	95	75 - 125	100	75 - 125	<0.50	mg/kg	17.2	30	91	70 - 130

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7155477	Total Lead (Pb)	2013/09/10	99	75 - 125	102	75 - 125	<0.10	mg/kg	3.9	35	98	70 - 130
7155477	Total Lithium (Li)	2013/09/10	98	75 - 125	95	75 - 125	<5.0	mg/kg	NC	30		
7155477	Total Manganese (Mn)	2013/09/10	NC	75 - 125	99	75 - 125	0.24, RDL=0.20	mg/kg	3.5	30	100	70 - 130
7155477	Total Mercury (Hg)	2013/09/10	99	75 - 125	100	75 - 125	<0.050	mg/kg	NC	35	92	70 - 130
7155477	Total Molybdenum (Mo)	2013/09/10	100	75 - 125	100	75 - 125	<0.10	mg/kg	NC	35	104	70 - 130
7155477	Total Nickel (Ni)	2013/09/10	97	75 - 125	99	75 - 125	<0.80	mg/kg	6.2	30	93	70 - 130
7155477	Total Selenium (Se)	2013/09/10	97	75 - 125	95	75 - 125	<0.50	mg/kg	NC	30		
7155477	Total Silver (Ag)	2013/09/10	99	75 - 125	97	75 - 125	<0.050	mg/kg	NC	35		
7155477	Total Strontium (Sr)	2013/09/10	99	75 - 125	96	75 - 125	<0.10	mg/kg	3.3	35	102	70 - 130
7155477	Total Thallium (Tl)	2013/09/10	98	75 - 125	101	75 - 125	<0.050	mg/kg	NC	30	93	70 - 130
7155477	Total Tin (Sn)	2013/09/10	96	75 - 125	99	75 - 125	<0.10	mg/kg	NC	35		
7155477	Total Titanium (Ti)	2013/09/10	NC	75 - 125	96	75 - 125	1.1, RDL=1.0	mg/kg	5.8	35	101	70 - 130
7155477	Total Uranium (U)	2013/09/10	97	75 - 125	98	75 - 125	<0.050	mg/kg	0.7	30	94	70 - 130
7155477	Total Vanadium (V)	2013/09/10	96	75 - 125	96	75 - 125	<2.0	mg/kg	0.5	30	100	70 - 130
7155477	Total Zinc (Zn)	2013/09/10	NC	75 - 125	99	75 - 125	<1.0	mg/kg	2.0	30	89	70 - 130
7155477	Total Aluminum (Al)	2013/09/10					<100	mg/kg	3.1	35	107	70 - 130
7155477	Total Calcium (Ca)	2013/09/10					<100	mg/kg	4.0	30	97	70 - 130
7155477	Total Iron (Fe)	2013/09/10					<100	mg/kg	0.9	30	98	70 - 130
7155477	Total Magnesium (Mg)	2013/09/10					<100	mg/kg	0.9	30	85	70 - 130
7155477	Total Phosphorus (P)	2013/09/10					<10	mg/kg	1.6	30	83	70 - 130
7155477	Total Bismuth (Bi)	2013/09/10					<0.10	mg/kg	NC	30		
7155477	Total Potassium (K)	2013/09/10					<100	mg/kg	NC	35		
7155477	Total Sodium (Na)	2013/09/10					<100	mg/kg	NC	35		
7155477	Total Zirconium (Zr)	2013/09/10					<0.50	mg/kg	NC	30		
7156219	Loss on Ignition	2013/09/10					<1.0	%	NC	35		
7160169	Loss on Ignition	2013/09/11					<1.0	%	NC	35		
7160259	Sieve - #200 (>0.075mm)	2013/09/12							28.6	35	98	86 - 114
7160259	Sieve - Pan	2013/09/12							18.5	35	101	94 - 106
7160259	Sieve - #16 (>1.18mm)	2013/09/12							14.0	35		
7160259	Sieve - #30 (>0.60mm)	2013/09/12							6.4	35		
7160259	Sieve - #50 (>0.300 mm)	2013/09/12							8.6	35		
7160259	Sieve - #100(>0.15mm)	2013/09/12							20.9	35		
7160259	Sieve - #140 (>0.106mm)	2013/09/12							30.1	35		
7160259	Sieve - #270 (>0.053mm)	2013/09/12							NC	35		
7160259	Sieve - #400 (>0.038 mm)	2013/09/12							NC	35		
7161878	Sieve - #200 (>0.075mm)	2013/09/13							26.2	35	102	86 - 114
7161878	Sieve - Pan	2013/09/13							21.8	35	99	94 - 106
7161878	Sieve - #16 (>1.18mm)	2013/09/13							NC	35		
7161878	Sieve - #30 (>0.60mm)	2013/09/13							NC	35		
7161878	Sieve - #50 (>0.300 mm)	2013/09/13							NC	35		

Maxxam Job #: B379491
Report Date: 2013/09/15

Ecological Logistics & Research Ltd
Client Project #: 12-127/TA07.AE
Site Location: 204-105 TITANIUM WAY

QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7161878	Sieve - #100(>0.15mm)	2013/09/13							21.8	35		
7161878	Sieve - #140 (>0.106mm)	2013/09/13							16.1	35		
7161878	Sieve - #270 (>0.053mm)	2013/09/13							1.3	35		
7161878	Sieve - #400 (>0.038 mm)	2013/09/13							23.5	35		
7162911	Moisture	2013/09/12					<0.30	%	10.9	20		
7162975	Moisture	2013/09/12					<0.30	%	14.3	20		

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

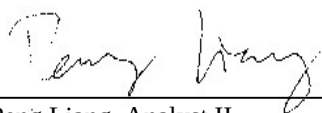
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

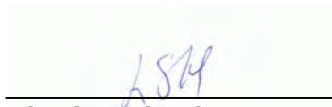
Validation Signature Page

Maxxam Job #: B379491

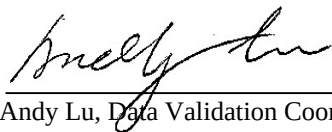
The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Peng Liang, Analyst II



Luba Shymushovska, Senior Analyst, Organic Department



Andy Lu, Data Validation Coordinator

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: [REDACTED]

COC #: [REDACTED]

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Page: 2 of 3

Invoice To: Require Report? Yes ☒ No ☐

Company Name: Ecological Logistics & Research Ltd.
Contact Name: Chris Jastrebski
Address: 204-105 Titanium Way, Whitehorse YT
PC: Y1A 0E7
Phone / Fax#: Ph: 867.668.6386 Fax: 867.668.6385
E-mail: jonathan@elr.ca and chris@elr.ca

Company Name: Ecological Logistics & Research Ltd.
Contact Name: Chris Jastrebski
Address: 204-105 Titanium Way, Whitehorse YT
PC: Y1A 0E7
Phone / Fax#: Ph: 867.668.6386 Fax: 867.668.6385
E-mail: jonathan@elr.ca and chris@elr.ca

PO #:
Quotation #:
Project #: 12-127/TA07.AE
Proj. Name:
Location: 204-105 Titanium Way
Sampled by: Jonathan Lowey, Chris Jastrebski

REGULATORY REQUIREMENTS: SERVICE REQUESTED:

- ☐ CSR ☒ Regular Turn Around Time (TAT)
(5 days for most tests)
☐ CCME ☐ RUSH (Please contact the lab)
☐ BC Water Quality ☐ 1 Day ☐ 2 Day ☐ 3 Day
☐ Other ☐ DRINKING WATER Date Required: _____

SPECIAL INSTRUCTIONS:

Return Cooler ☐ Ship Sample Bottles (please specify) ☐

ANALYSIS REQUESTED

☐ CCME	(5 days for most tests)
☐ BC Water Quality	☐ RUSH (Please contact the lab)
☐ Other _____	☐ 1 Day ☐ 2 Day ☐ 3 Day
☐ DRINKING WATER	Date Required: _____

SPECIAL INSTRUCTIONS:

Return Cooler ☐ Ship Sample Bottles (please specify) ☐

Sample Identification	Lab Identification	Sample Type	Date/Time(24hr) Sampled	BTEX/VPH	MTBE	VOC/VPH	TEH	PAH	CCME-PHC (Fractions 1-4 Plus BTEX)	CCME-PHC (Fractions 2-4)	CCME-PHC (Fraction 1 Plus BTEX)	PCB	Phenols by 4AAP	Phenols by GC/MS	MOG	SMOG	Field Filtered?	Dissolved Metals (DM)	Field Acidified?	Total Metals Field Acidified?	Nitrate	Nitrite	Ammonia	Chloride	Fluoride	Sulphate	Total Suspended Solids (TSS)	pH	Conductivity	Alkalinity	BOD	COD	Coliform: Total & E.coli	Fecal	TKN	Grain Size	LOI (Loss on Ignition)	ICP Metals	HOLD	Number of Containers	YES	NO	YES	NO		
1 MN-S1 HK3034		Soil	13/08/22 15:00																																		X	X	X			2				
2 MN-S2 HK3035		Soil	13/08/22 15:00																																		X	X	X			2				
3 MN-S3 HK3036		Soil	13/08/22 15:00																																		X	X	X			2				
4 VC-UMC-S1 HK3037		Soil	13/08/22 14:00																																		X	X	X			2				
5 VC-UMC-S2 HK3038		Soil	13/08/22 14:00																																		X	X	X			2				
6 VC-UMC-S3 HK3039		Soil	13/08/22 14:00																																		X	X	X			2				
7 BC-US-S1 HK3040		Soil	13/08/22 11:00																																		X	X	X			2				
8 BC-US-S2 HK3041		Soil	13/08/22 11:00																																		X	X	X			2				
9 BC-US-S2 HK3042		Soil	13/08/22 11:00																																		X	X	X			2				
10 VC-REF-S1 HK3043		Soil	13/08/22 09:00																																		X	X	X			2				
11 VC-REF-S2 HK3045		Soil	13/08/22 09:00																																		X	X	X			2				
12 VC-REF-S3 HK3046		Soil	13/08/22 09:00																																		X	X	X			2				

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Samples are from a Drinking Water Source

Does source supply multiple households?



8379491

Print name and sign			Print name and sign			Laboratory Use Only					
*Relinquished By:	Date (yy/mm/dd):	Time (24 hr):	Received by:	Date (yy/mm/dd):	Time (24 hr):	Time Sensitive ☐	Temperature on Receipt (°C)	Custody Seal	Yes	No	
J Lowey	2013/09/04	10:00	<i>[Signature]</i>	2013/09/05	08:40		A) 5 B) 6 C) 7	Present?	NA	☐	☐
					VL		Just sampled & rec'd on ice	Intact?	☐	☐	☐

IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORDS. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

