Indian and Northern Affairs Canada
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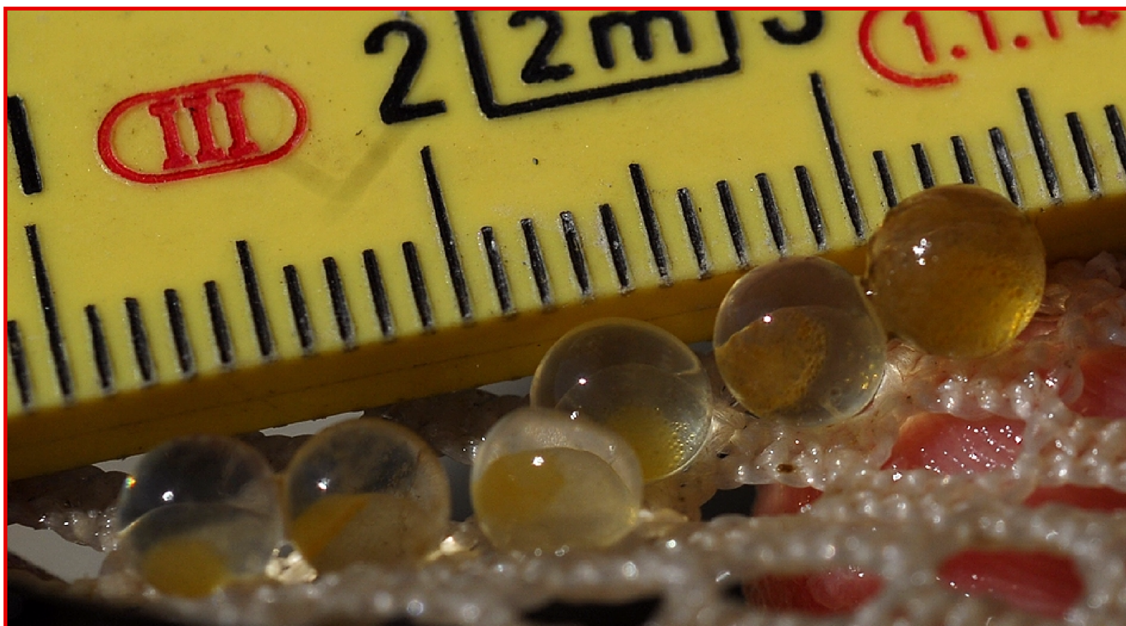
Baker Creek Results of Fish Monitoring in Reach 4, Spring 2007



Final Report April 2008

Department of Indian and Northern Affairs Canada

Golder Associates

07-1328-0021

FINAL REPORT

BAKER CREEK, RESULTS OF FISH MONITORING IN REACH 4, SPRING 2007

Submitted to:
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April 2008 **07-1328-0021**

ACKNOWLEDGEMENTS

This study was funded by Indian and Northern Affairs Canada, Giant Mine Reclamation Program. We wish to thank Bill Mitchell (INAC Project Manager) for his tireless efforts in providing logistical support and advice during the 2007 Baker Creek project. Alex Glowach (INAC Project Specialist) was instrumental in the daily work undertaken in Reach 4 and at the culvert crossing. He was a key member of our sampling crew and his first-hand knowledge of the stream and fish fauna proved invaluable. We wish to thank NHC for their expertise and efforts in physically restoring Baker Creek to productive fish habitat. The encouragement, editorial reviews and technical writing skills provided by Hilary Machtans are gratefully acknowledged. Information, and insight, provided by Dr. Tom G. Northcote (Professor Emeritus, University of British Columbia) contributed greatly to the successful outcome of the Spring 2007 Baker Creek study. Ernest Watson (Habitat Biologist, Department of Fisheries and Oceans Canada) showed interest in all aspects of our study and was quick to provide any assistance or advice when requested. His willingness to share his in-depth knowledge of Arctic grayling life history was much appreciated.

ACRONYMS & DEFINITIONS

°C	Degrees Celsius
µS/cm	Micro siemens per second
cm	Centimetres
DFO	Fisheries and Oceans Canada
FA	Fisheries Authorization
GRMP	Giant Mine Remediation Program
INAC	Indian and Northern Affairs Canada
km	Kilometres
m	Metres
m^3/s	Cubic meters per second
Mesolarva	Phase of larval development characterized by presence of forming fins, reduced or absent yolk sac
mg/L	Milligrams per litre
NHC	Northwest Hydraulic Consultants
Protolarva	Phase of larval development, post-hatching, characterized by absence of fin spines and rays and prominent yolk sac
YOY	Young-of the-year

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1 INTRODUCTION

1.1 BACKGROUND

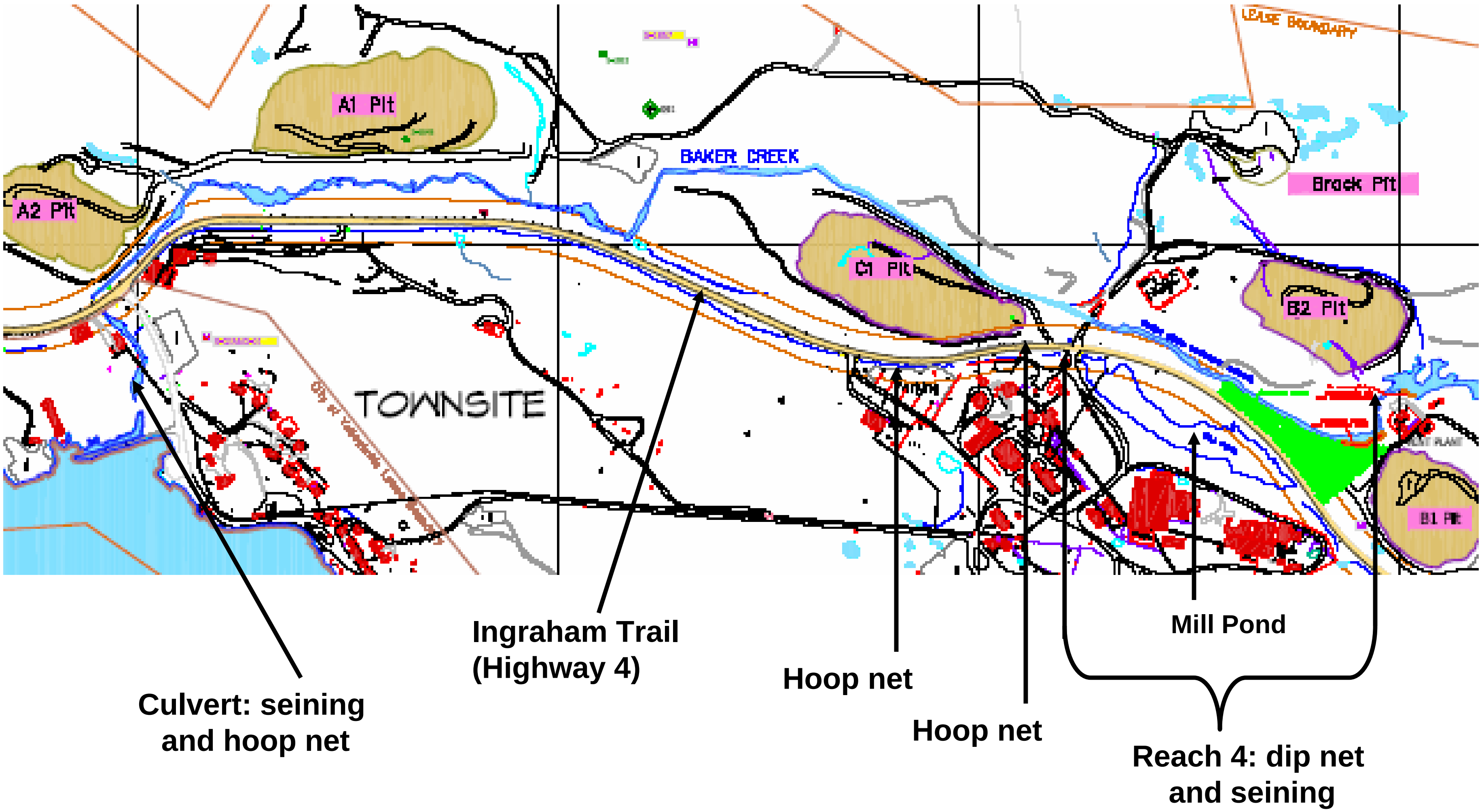
Baker Creek originates from a network of small lakes northeast of the city of Yellowknife and flows south into Yellowknife Bay on Great Slave Lake (Figure 1). The lower reaches of Baker Creek originally flowed through the mill ponds of the Giant Mine site on the east side of the Ingraham Trail, Highway 4 (Figure 1). The Mill Pond and runoff from adjacent areas are contaminated from historical mining activities. Historical contamination has affected sediment and water quality in Baker Creek. Water quality in the stream is also affected by treated effluent from the Giant Mine, which is discharged seasonally (July-Sept) into lower Baker Creek.

In summer 2006, 600 meters (m) of Baker Creek known as 'Reach 4' were realigned to the west side of Ingraham Trail. The primary objectives of the Reach 4 realignment were to isolate the contaminated Mill Pond from Baker Creek, thereby eliminating a source of ongoing contamination and preventing seepage loss from Baker Creek into areas of the mine itself (the C1 Pit). Secondary objectives of the realignment were to provide a stable flood conveyance channel, maintain or improve fish passage, and provide spawning and rearing habitat for native fish species.

Authorization for Work and Undertaking Affecting Fish Habitat (YK-06-0063) (Authorization) for the harmful alteration, disruption or destruction HADD of fish habitat resulting from the realignment of Baker Creek was issued by Fisheries and Oceans Canada (DFO) pursuant to Section 35(2) of the Fisheries Act in 2006. The Authorization required Indian and Northern Affairs Canada (INAC), the agency responsible for reclamation activities at Giant Mine, to reconstruct a reach of Baker Creek to provide suitable spawning, rearing and overwintering habitat for Arctic grayling (*Thymallus arcticus*) as compensation for habitat losses incurred from the realignment. INAC contracted Northwest Hydraulic Consultants (NHC) to design the new reach under the direction of SRK Consulting.

1.2 CONSTRUCTION SUMMARY

In the fall of 2006, seven riffles were constructed in the new Baker Creek channel. Five riffles were constructed (50 m intervals) in the upstream portion of Reach 4 (Figure 2), and two wider riffles were constructed 80 m and 160 m downstream of the fifth riffle (Figure 2). The surface complexity (bed material)



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Sampling Location of Baker Creek NT Spring 2007		
DRAWN: PV	APPROVED: JO	DATE: 05 November, 2007
PROJECT: 07-1328-0021		FIGURE: 1

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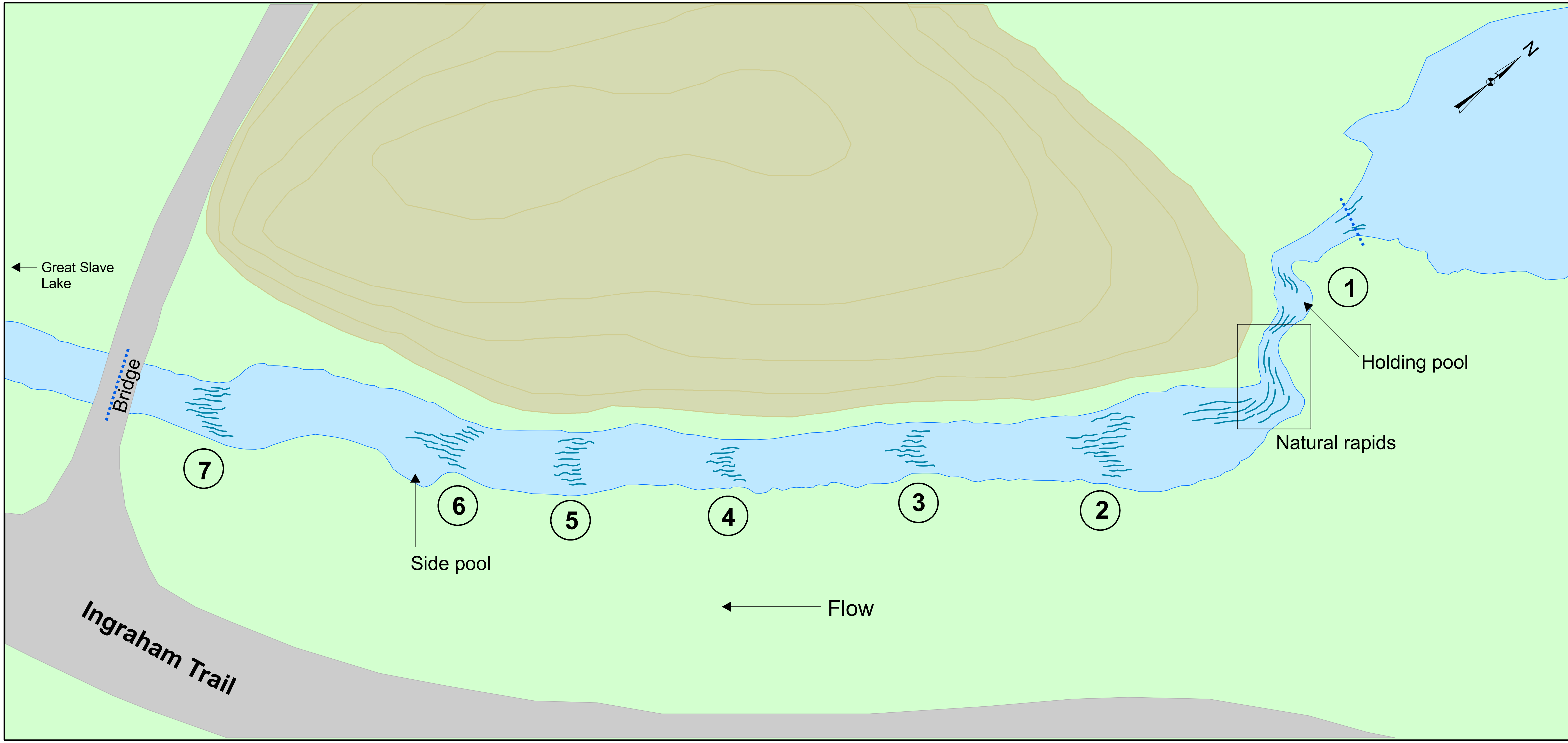

LEGEND

- Riffle Number
- Riffle
- Limit of Reach 4
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI

NOT TO SCALE

PROJECT

BAKER CREEK REACH 4 FISH SURVEY

TITLE

CONSTRUCTED HABITAT IN REACH 4

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007	**FIGURE: 2**	
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		

and slope of the downstream face of the riffles were designed to allow upstream fish passage over a wide range of flows.

Below each riffle, flow velocities declined and pools were excavated to provide lower flow velocities and holding habitat for young of year (YOY) and adult migrant fish. The pools varied in depth from 0.2 m to 1.4 m. Two to three large boulders were placed in groups within each pool to provide cover and a velocity break for fish. Glides or pool tailouts were constructed as low gradient transitions from the depths of a pool to the next riffle. Small (50 mm diameter) gravel was placed to provide suitable spawning habitat for species such as Arctic grayling. Boulders (≥500 mm diameter and larger) were also placed intermittently within the pools and glides of the channel to provide resting and feeding cover.

A large holding pool was constructed in the upstream portion of Reach 4, adjacent to the old pump house (Figure 2). The streambed, immediately downstream of a waterfall (the former weir located in the upper portion of Reach 4) was excavated to create a large, deep (approximately 1-1.5 m) plunge pool. The pool effectively reduces water velocity of the falls prior to entering the main stretch of Reach 4. The plunge pool was designed to provide a resting area and shelter for spawning fish following migration, and habitat for juveniles. The weir and waterfall that likely formed a barrier to further upstream migration were subsequently removed and replaced by a riffle.

To achieve the design objectives, the instream works in Reach 4 of Baker Creek would have to provide unobstructed passage for fish from Yellowknife Bay to the spawning sites in Baker Creek, suitable spawning habitat, and egg viability, and food availability.

In addition to work on Reach 4 of Baker Creek, at the request of DFO, INAC made modifications to the stream at the culvert crossing situated near the mouth (Figure 1). The culvert is 3 m in diameter, 25 m long with a 3 m cut-out on the upstream and downstream ends. The downstream end of the culvert was about 0.5 m above the water surface and was likely to impede fish access to Baker Creek (including Reach 4) at moderate to high flows. INAC contracted NHC to undertake minor channel modifications immediately downstream of the culvert outlet to improve fish access. Rock was placed on the stream bed in fall 2006 to raise the water level such that the culvert overhang was reduced to <0.1 m thereby facilitating fish passage through the culvert. This work was not required under the Fisheries Authorization but was carried out at the request of Bill Mitchell from INAC to ensure fish could access Reach 4.

1.2.1 Fish Monitoring Plan

The Section 5.0 of Authorization stipulated that once construction was complete, INAC was to develop a Monitoring Plan for the fish habitat compensation works:

5.0 Conditions that relate to the monitoring of the proponent plan, the mitigation and the compensation, the "Monitoring Plan."

5.1 INAC will undertake a Monitoring Program and will report to DFO on an annual basis for 2 years post-construction or by April 30, 2007, whether works were conducted within the schedule of the proponent plan and whether the mitigation measures outlined in the proponent plan and this authorization where followed, by:

5.1.1. Providing dated photographs of the works and completed project.

5.1.2. Providing dated photographs of the sediment control works and details of how they functioned to prevent sediment entry into the watercourse.

5.1.3. Providing details on any contingency measures that were followed in the event that mitigation measures did not function as described in the plan or this authorization.

5.2 INAC shall provide a Monitoring Plan for the fish habitat compensation works by January 15, 2007 for DFO review and approval.

5.2.1. The Monitoring Plan will be developed with the intent of demonstrating that the fish habitat compensation works were implemented and are functioning as intended.

5.2.2 The monitoring program shall be implemented as approved by DFO in each of three years beginning in spring 2007.

5.2.3. INAC will report to DFO the results of the Monitoring Plan on an annual basis for 3 years post construction by January 1, 2008.

5.2.4. INAC will provide a description of the contingency measures that were followed if, during the Monitoring Program, it was determined that the compensatory habitat was not functioning as intended.

INAC and NHC submitted a Monitoring Plan in January 2007. Golder Associates Ltd. was then contracted by DFO and INAC to design and implement the fish monitoring component of the Monitoring Plan. This report presents the findings of the 2007 fish monitoring program on Baker Creek.

1.3 OBJECTIVES

The objectives of the fish monitoring plan were as follows:

- Quantify the number of adult Arctic grayling, northern pike and suckers spawning in Reach 4 of Baker Creek;
- Describe spawning habitat for all species in Reach 4 of Baker Creek;
- Provide evidence of successful spawning by conducting egg surveys and observing and capturing YOY of species spawning in Baker Creek; and
- Observe and describe habitat use by YOY in Baker Creek prior to outmigration.

2 METHODS

2.1 FISH SAMPLING SITES AND CHRONOLOGY

Fish surveys at Baker Creek commenced on May 25, 2007 and continued until June 27, 2007 (Table 1). During this period, the stream was visited almost daily over the survey period to determine fish presence/absence and habitat use. Sampling was undertaken in Reach 4 and in the lower section of Baker Creek downstream of the Highway 4 culvert (Figure 1). Sampling included capture and observations of migrating adults, eggs, larvae, as well as measurements/observations of habitat conditions at sites occupied by the various life stages. Details of sampling dates and times are presented in Appendix I. Appendix II contains information on the life history of fish in Baker Creek and Appendix III contains a journal-style documentation of sampling and stream observations.

Table 1 Summary of Fish Sampling Effort in Baker Creek

Dates	Sampling Method	Target Life Stage	Location
Almost daily from May 25 to June 27 (See Appendix III for daily details)	Visual Observation	All	Pool downstream of Hwy 4 culvert Throughout Reach 4
May 26, 27, 28, 29, 30, June 1, 3	Seine	Adults and Larvae	Pool downstream of Hwy 4 culvert Throughout Reach 4
May 25, 26, 29, 30	Hoop Net	Adults	Rapids downstream of Reach 4 100 m downstream of Reach 4 Lowermost section of Baker Creek
May 26,27, 30, 31, June 5 and 10	Dip Net	Eggs and Larvae	Reach 4
June 10, 12, 20, 27, 29	Snorkelling	Adults and Larvae	Plunge pool Throughout Reach 4
June 6,10,12, 20	Underwater Camera	Adults and Larvae	Throughout Reach 4

2.2 ADULT/SPAWNING FISH SAMPLING AND HABITAT DESCRIPTION

2.2.1 Sampling Methods

Sampling for upstream migrating adults was carried out downstream of the Highway 4 culvert (Figure 1). In early May 2007, the stream channel in the culvert was iced-over; it was assumed that fish could not pass through the structure and access the upper reaches of Baker Creek. Therefore, sampling for migrating adults was carried out in an ice-free pool downstream of the culvert. To confirm that fish had not successfully moved through the ice-laden culvert, or may have accessed the stream from other areas of the Baker Creek watershed, attempts were made to capture spawning fish in Reach 4.

Seine nets (15 m long x 2 m wide; 10 mm mesh; 1 m collection bag of 5 mm mesh) and hoop nets (2 m lead and 2 m panel wings, 2 cm mesh) were used. Electrofishing, angling and gill nets were not employed to reduce the risk of harming spawning fish. Sampling for adults in Reach 4 was discontinued in late May because of high water velocities (i.e., adult Arctic grayling able to swim out of the pursed seine before it could be completely closed). However, visual observations of adult fish in Reach 4 continued throughout the survey.

Seine nets were used from May 26 to June 3, 2007, in the pool downstream of the culvert. Methods of setting and deploying nets remained consistent among sampling events. Sampling events with the seine net began at the upstream end of the culvert pool and consisted of hauling the seine net downstream and across the channel. The sampled area included almost the entire area (7 m x 20 m) of swift and slack water habitat in the pool. The area sampled averaged 20 m in length and covered an area 7 m wide (140 m²).

Hoop nets were set at three locations to capture migrating spawners (Figure 1). The first hoop net was set May 25 in the rapids downstream of Reach 4 at stream kilometre 1.2. Several hours later, the hoop net was relocated to a narrow channel site (km 1.7) 100 m downstream of the end of Reach 4 where the net was deployed overnight. On May 29, the hoop net was set overnight near the mouth of Baker Creek to capture out-migrating fish. A follow-up, day-time set was carried out on May 30. Hoop net use was discontinued after May 30 due to concerns about unnecessary fish mortality (i.e., fish became entangled in the net and drowned).

All captured fish were removed from the seine with a dip net, or manually removed from the hoop nets. Fork length (cm) was recorded for all individuals.

Scales were removed and used as the primary, non-lethal method for age determination. Scales were removed from an area above the lateral line, below the dorsal fin. Otoliths and fin rays were taken on mortalities for validation. Lake whitefish were not measured to reduce handling time and minimize stress. When mortality occurred, scales, pelvic fin rays and otoliths were removed as a means of validating aging techniques. Fin rays were excised at the junction with the latero-ventral body surface. Age structures were submitted to John Tost of North Shore Environmental Services for analysis.

All fish with the exception of lake whitefish were tagged (2 cm Floy Tag) below the base of the dorsal fin. Lake whitefish were not tagged, due to their sensitivity to handling. If a fish was a recapture, the Floy tag number of the fish was recorded. Capture and handling mortalities were minimal; they included seven fish captured in the hoop net on May 30 and one lake chub captured in a seine haul (Appendix I).

An underwater video camera (Seaviewer 'Sea-Drop 650') was used to confirm species of fish, and the habitat in which fish were located. On June 6, 2007, the camera was submerged throughout a side pool in Reach 4 and along the slack water along the opposite bank (Figure 2). On June 10, June 12, and June 20, a diver conducted video observations/filming of adults and young fish upstream of Riffle 2 and 3.

2.2.2 Habitat Description

Fish habitat measurements commenced once adult Arctic grayling were observed in upper Reach 4 on May 26, 2007. Eight transects were setup to document the physical parameters of various habitat types in relation to fish use (Figure 3). The intersected transects representative habitats located in the upper section of the reach; the following parameters were recorded:

- activities of fish in vicinity transect (spawning, holding, feeding);
- habitat type (pool, glide, riffle);
- water velocity (measured with a Marsh McBirney meter; 1 m intervals; 2 cm above stream substrate); and
- water depth.

2.3 EGG SAMPLING AND HABITAT DESCRIPTION

Eggs were sampled by kick-netting, which involved wading in the stream, gently disturbing the gravel substrate, and capturing drifting eggs in a dip net positioned

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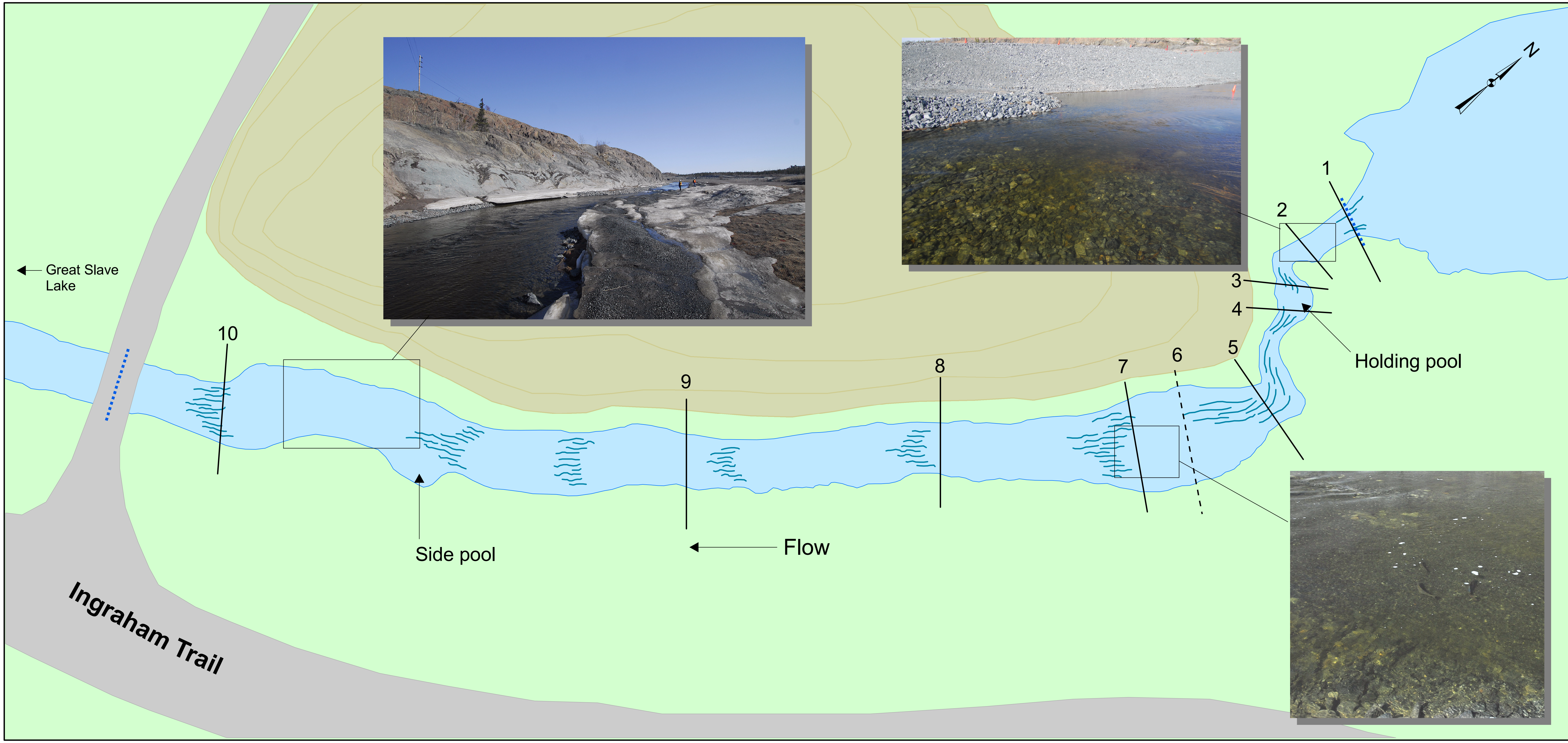


LEGEND

- Riffle
- Limit of Reach 4
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI.

NOT TO SCALE

PROJECT

BAKER CREEK REACH 4 FISH SURVEY

TITLE

LOCATION OF TRANSECT FOR FISH HABITAT

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007		
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		

FIGURE: 3

immediately downstream. Eggs were measured (mm) and were photographed using a Nikon D-200 digital camera with a Nikkor 55 mm micro lens. Following enumeration, measurement and species identification, eggs were returned the original collection sites. Photographs were reviewed by Golder Associates Ltd. personnel, and an independent expert, Martin Hochleithner (Aquatech Ltd.) to identify the eggs according to fish species and stage of development.

The locations of egg deposition sites were mapped, geo-referenced and photographed. The following habitat measurements were recorded at the egg deposition sites (which included a 1 m² area around the site):

- water velocity (measured with a Marsh McBirney meter; bottom, middle and surface of the water column);
- substrate type (fines, gravel, cobble, boulder);
- substrate size (diameter of 30 randomly selected rocks; to the nearest mm);
- substrate composition (percentage of each type of substrate);
- observations of sediment depositions; and
- water depth (cm).

2.4 LARVAE/YOY SAMPLING AND HABITAT DESCRIPTION

Three methods were used to capture and observe larval and young-of-the-year fish in Baker Creek: visual and underwater video camera observations (underwater/snorkel and surface), seine net, and dip net. Non-intrusive capture methods were employed to minimize damage and subsequent mortality of fish.

Young-of-the-year (YOY) or larval fish were first observed in early June. Immediately following emergence, larvae were too small to be captured with available dip nets (5 mm mesh); however, they were readily observed in the stream. Dip netting proved successful when larvae attained lengths of 20-40 mm.

A small seine net (10 m long by 1.5 m deep, 2 mm Delta knotless mesh) was used on June 5 and June 10 transects to capture larval fish. Larval fish (protolarvae and mesolarvae stage) were enumerated, photographed, and measured (mm). To identify species and developmental stage, photographs were reviewed by Golder Associates Ltd. personnel, and an independent expert. An underwater video camera was used on June 6 to document larval behaviour and habitat use.

Snorkelling was done on four occasions (June 10, 12, 20, 27) during the period that larval fish were observed in Reach 4. During each sampling event, a diver would enter the large pool at the upstream end of Reach 4 (Figure 1 and Figure 2) and survey the entire reach before exiting at the clearspan bridge located near the south end of Reach 4. Visual observations and video recording was used to document the relative densities and distribution of larval fish in various habitats.

The habitats occupied by larvae were described by measuring water depth (cm), water velocity (m^3/sec), and substrate type; the locations were mapped. Because larvae were located in close proximity to each other, habitat use was recorded for groups of larvae. A group was considered to be two or more individuals occupying a shared location (within 2-4 body lengths of each other) with uniform habitat characteristics. Habitat data was collected for both the protolarval and mesolarval stages of development.

2.5 SUPPORTING ENVIRONMENTAL VARIABLES

Spot measurements of water temperature (°C) were taken with a thermometer during the period May 25 to June 5. A temperature data logger was installed upstream of Riffle 5 on June 5 and retrieved on September 6. This device recorded water temperature on an hourly basis, providing 24 readings per day. After the data was downloaded, mean temperature per day was calculated.

Stream discharge data was provided by Environment Canada (Station #07SB013). Discharge (m^3/s) was calculated from a water level-data logger installed at the outlet of Lower Martin Lake. The data provided are preliminary and include January through June, 2007.

A range of water quality parameters were measured in the field with a YSI water quality meter including temperature (°C), dissolved oxygen (DO) concentration (mg/L), DO percent saturation (%), pH and conductivity (µS/cm). Measurements were taken near the peak of the spring freshet (June 5), and in mid-summer (July 20) when treated effluent from the Giant Mine was released into the stream. The measurements were taken near the bottom in water 0.26 m deep, in the mid-section of Reach 4 downstream of Riffle 5.

Water quality samples for laboratory analyses were collected on June 5 and August 8. On both occasions, a water sample from Reach 4, a field blank, and a travel blank were submitted. The samples were analyzed by ALS Laboratory Group in Yellowknife. Analytical parameters included physical parameters, anions and nutrients, cyanides, total metals, dissolved metals, and radiological parameters. The methods and detection limits for parameters were consistent with the Standard Operating Procedures for the Giant Mine (INAC 2006). The results were compared to data collected from Baker Creek in 2006. The 2006 data collection was part of the regular mine monitoring program in Baker Creek; sampling was carried out upstream of the effluent discharge (Station SNP 43-11), and in areas where effluent was present in the stream (Station 'Exposure Area').

2.6 DATA ANALYSIS

Catch-Per-Unit-Effort (CPUE) for adults was calculated for each gear type, and for each location (culvert or Reach 4). The Unit of Effort for hoop nets was hours of fishing; for seines it was number of hauls. Because the sampled area for individual seine net hauls was approximately equal, the CPUE was reported as number of fish captured per haul.

Length-frequency and age-frequency histograms were constructed for the most abundant fish captured. Data was compared with results from previous investigations to determine if growth rates of Baker Creek fish were typical of the region.

3 RESULTS

A total of 116 fish were captured in Baker Creek during the 2007 study; 113 were recorded downstream of the culvert and three were recorded in Reach 4 (Table 2 and Table 3; Figure 4). In addition, six fish that had been tagged were recaptured. Numerous ninespine stickleback were captured downstream of the culvert 4, but the total catch was not quantified because sampling was focussed on large-bodied fish. Appendix I contains the length, age, sex data for each fish captured.

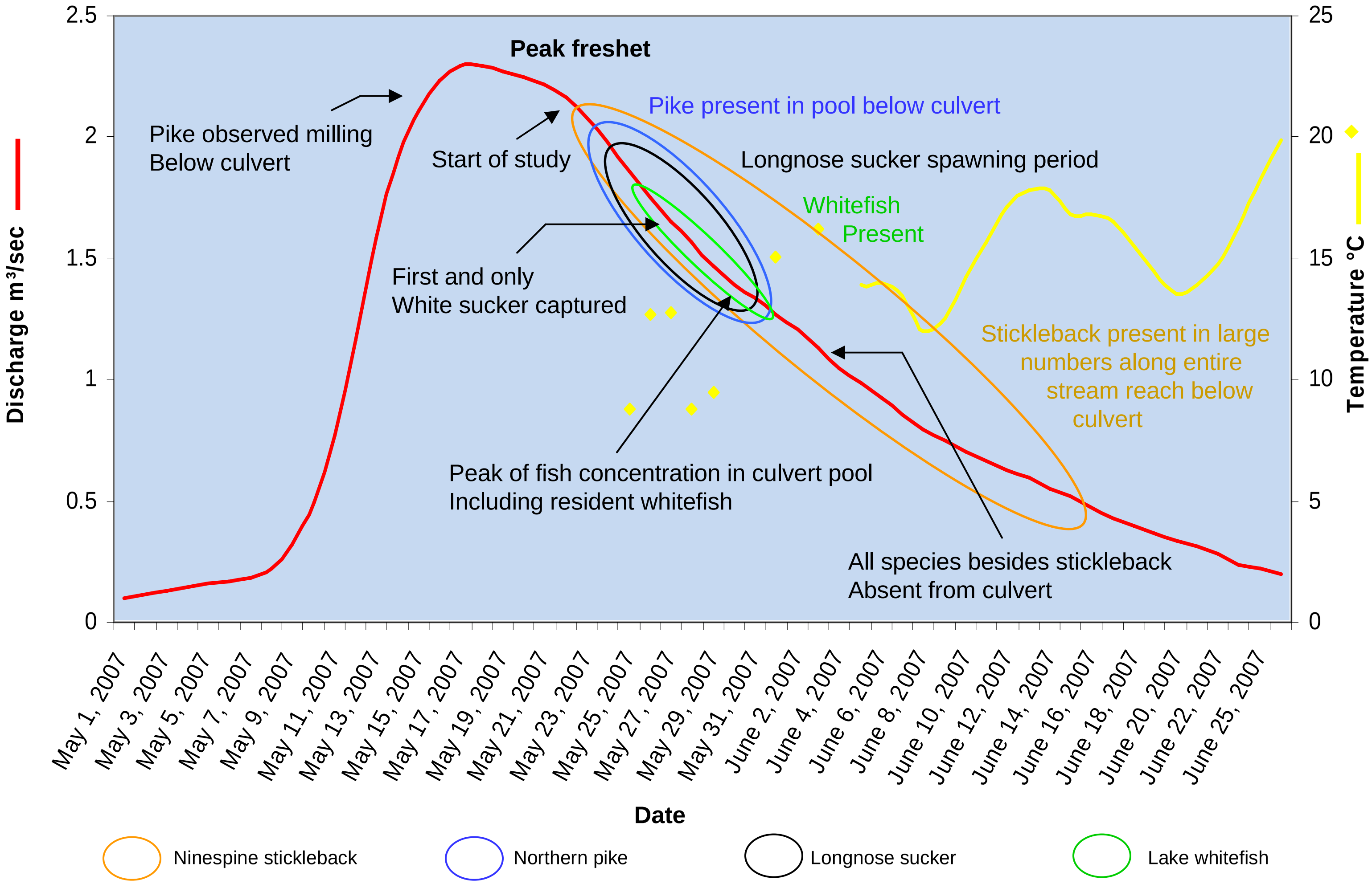
Table 2 Catch-Per-Unit-Effort (CPUE) for Seine Nets in Baker Creek, Spring 2007

Location and Sampling Dates	Effort (# of hauls)	Species	# of Fish Captured	CPUE (#fish/haul)
Downstream of Culvert (May 26-30; June 1-3)	13	Longnose sucker	44	3.38
		Northern pike	36	2.76
		White sucker	3	0.23
		Lake whitefish	18	1.38
		Lake chub	1	0.08
		Ninespine stickleback	>1000 (too numerous to estimate)	Not determined
Total	**13**	**All species**	**102**	**7.76**

Note: Each seine haul covered an area of approximately 140 m², therefore the unit of effort is one haul.

Table 3 Catch-Per-Unit-Effort for Hoop Nets in Baker Creek, Spring 2007

Location and Sampling Dates	Effort (# hours)	Species	# of Fish Captured	CPUE (#fish/hours)
Downstream of Culvert (May 29, 30)	17	Northern pike	8	0.47
		Lake whitefish	3	0.18
Total (downstream of culvert)			**11**	**0.65**
Reach 4 (May 25, 26, 28)	27	Northern pike	3	0.11
Total (hoop nets)			**14**	**0.32**



Discharge Data Source: Environment Canada discharge data-Lower Martin Lake
Temperature Points: Daily temperature readings at midday
Temperature Line Data: Collected using a temperature logger at half hour intervals and averaged for the day.

Golder Associates	
Fish Species Present in Baker Creek Culvert Area, Spring 2007	
DRAWN: PV	APPROVED: JO	DATE: 05 November, 2007
PROJECT: 07-1328-0021		FIGURE: 4

Six species of fish were documented (captured and/or observed) in Reach 4 including: northern pike, white sucker, longnose sucker, Arctic grayling, trout-perch, and lake whitefish (Figure 4 and Figure 5). Ninespine stickleback, lake chub and spottail shiners were observed downstream of the culvert and the mouth of Baker Creek near Yellowknife Bay but were not considered part of this survey (i.e., likely not a species migrating into Reach 4 in spring) Of the large-bodied species, longnose suckers and northern pike were the most abundant (Table 2).

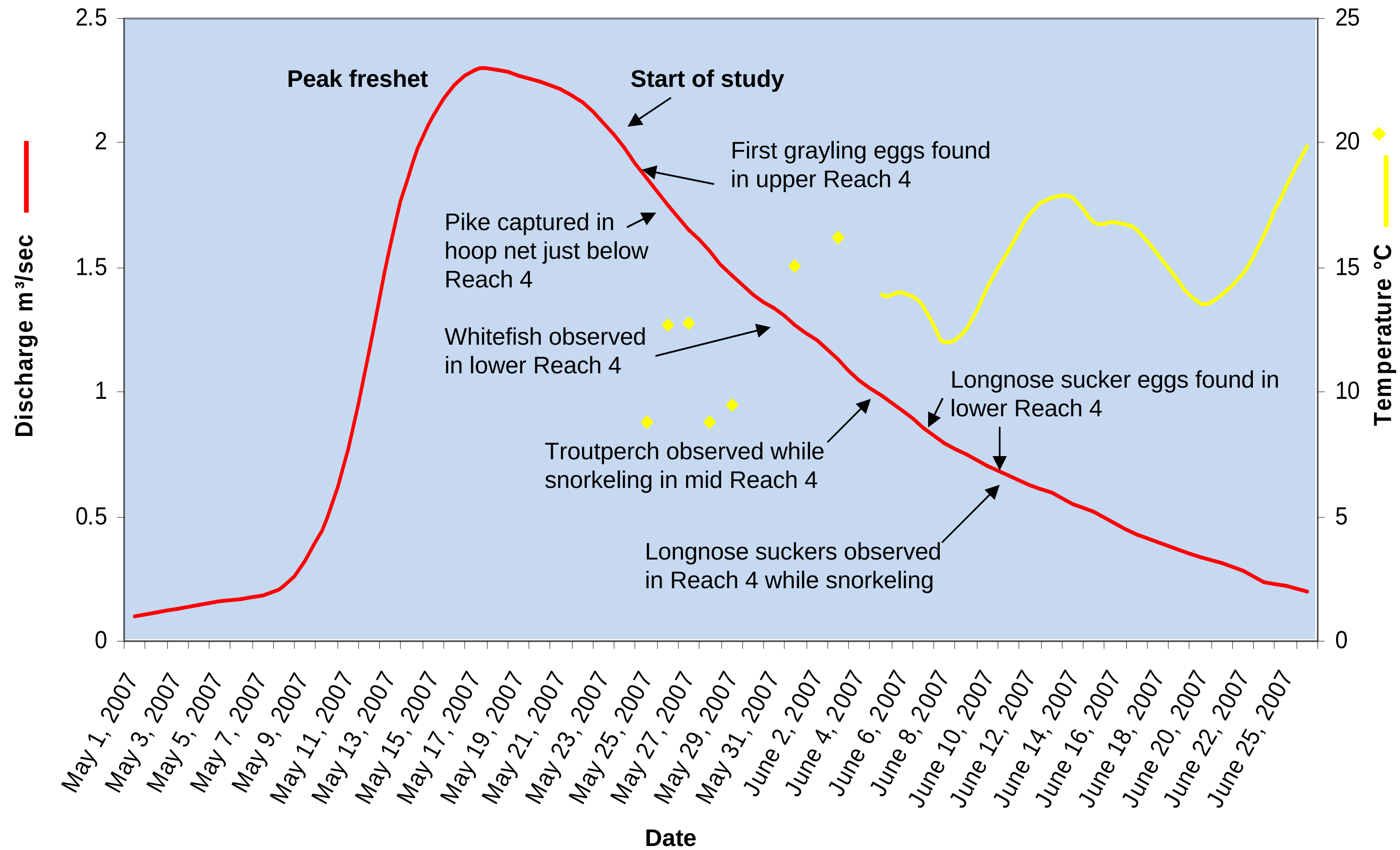
Seine nets were the most effective method of capturing fish near the culvert. Capture methods in Reach 4 were not successful due to high water velocities.

3.1 ADULT FISH (CAPTURED AND OBSERVED)

Arctic Grayling

Adult grayling were not captured during the study. Attempts to intercept migrating adults below the culvert were not successful; sampling in the vicinity of the highway culvert was not initiated early enough in the spring to intercept the spawning run. This was partly due to not receiving the License to Fish for Scientific Purposes required to collect fish until late May. Arctic grayling were seemingly able to navigate through crevices in the ice-jam in the culvert and access Reach 4 prior to our arrival. Arctic grayling were observed in Reach 4 on May 25 through May 27 (Figure 6 and Figure 7); they were photographed while spawning in the lower portion of glides and above riffles. Based on velocity transect data collected on May 25, adult grayling were occupying swift moving portions of the stream where bottom velocities ranged from 0.3 to 0.4 m/sec (Appendix I, Table I-10).

While much of the spawning probably occurred prior to the commencement of the survey, some activity was observed on May 26 (Figure 6; see daily journal photograph for May 27, Appendix III). Also, a large male exhibited territorial aggression on May 27. This individual displayed his dorsal fin next to female causing smaller, subordinate males to keep their distance. The large male, who spent much of his time chasing smaller males, generally returned to the area referred to as egg collection Site 4 (Section 3.2, Table 4). Transect data collected on May 26 above Riffle 2 (Appendix I, Table I-9) provided insight into the habitat characteristics of adult holding sites during spawning activity. Adult grayling occupied areas with velocities ranging from 0.12 to 0.52 m/sec (mean 0.34 m/sec), depths ranged from 0.2 to 0.4 m, and gravel and gravel/cobble substrate (Table 4; Appendix I, Table I-10). Stream temperatures were approximately 8.8°C to 12.8°C when adults were observed.



Discharge Data Source: Environment Canada discharge data-Lower Martin Lake
Temperature Points: Daily temperature readings at midday
Temperature Line Data: Collected using a temperature logger at half hour intervals and averaged for the day.

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General Fish Habitat Observations in Reach 4 of Baker Creek, 2007

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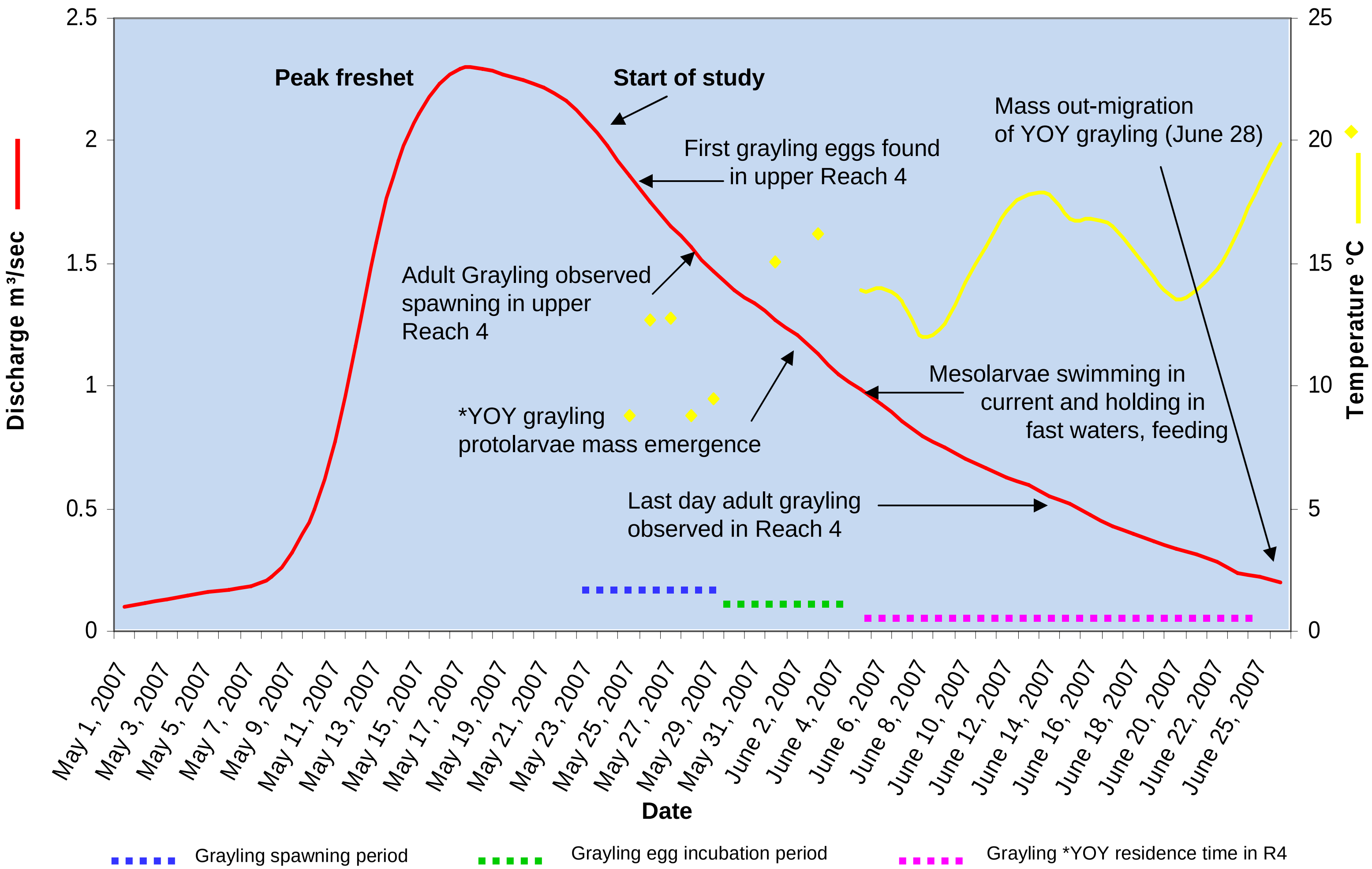
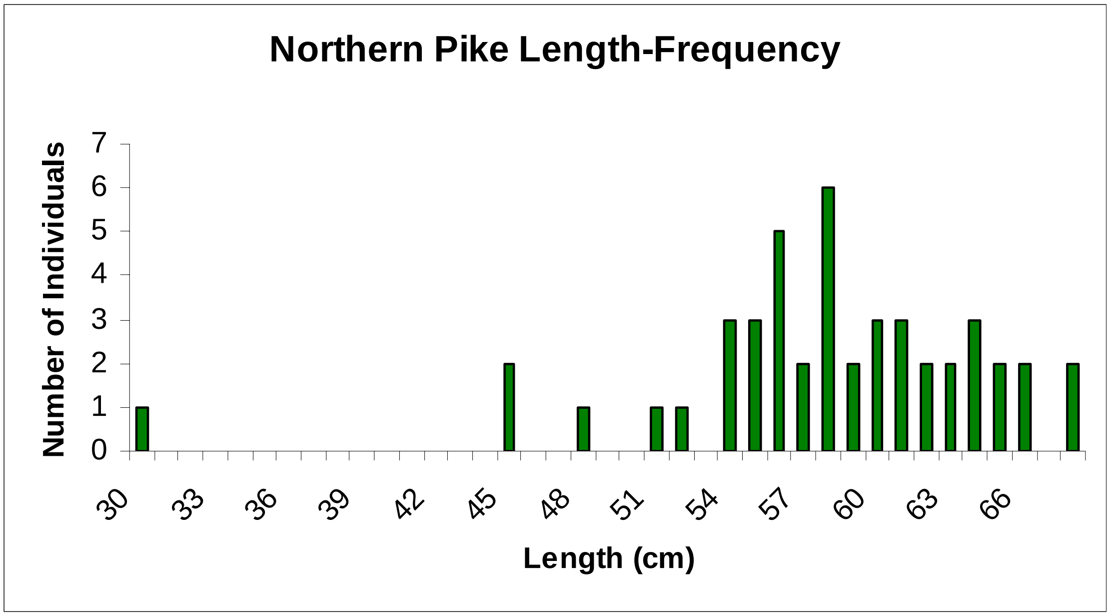
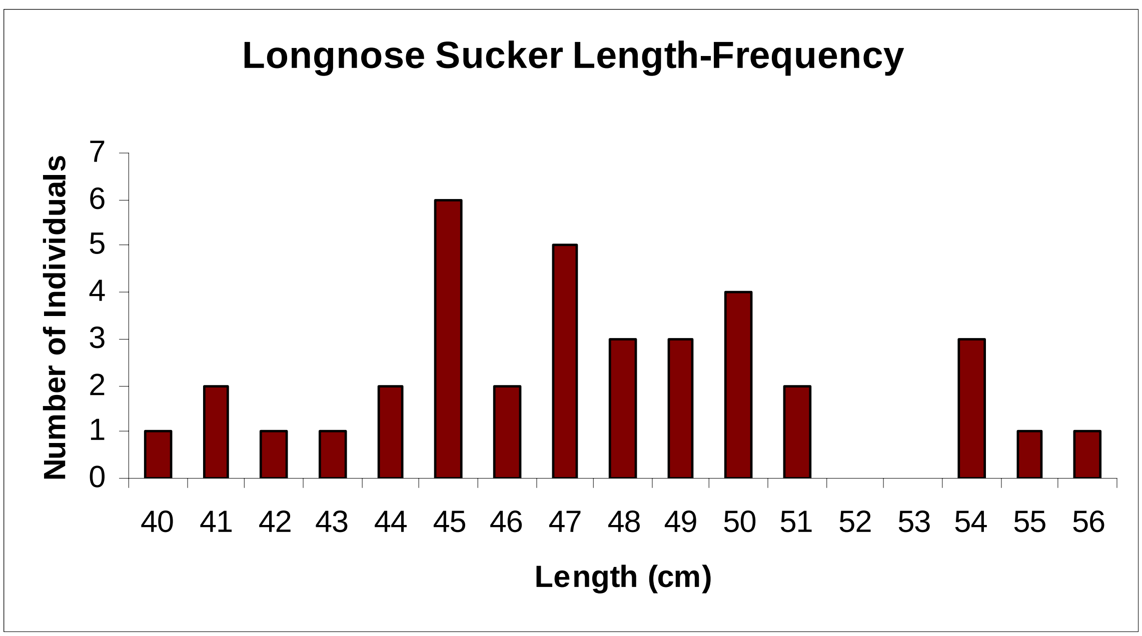
PROJECT: 07-1328-0021		FIGURE: 5



Discharge Data Source: Environment Canada discharge data-Lower Martin Lake
Temperature Points: Daily temperature readings at midday
Temperature Line Data: Collected using a temperature logger at half hour intervals and averaged for the day.

Arctic Grayling Life Stages in Relation to Temp and Discharge in Reach 4, Spring 2007		
DRAWN: PV	APPROVED: JO	DATE: 05 November, 2007
PROJECT: 07-1328-0021		FIGURE: 6





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Length Frequency Relationship of Three Species of Fish in Baker Creek, Spring 2007

DRAWN: PV	APPROVED: JO	DATE: 05 November, 2007
PROJECT: 03-1321-023		Figure: 7

Longnose Sucker

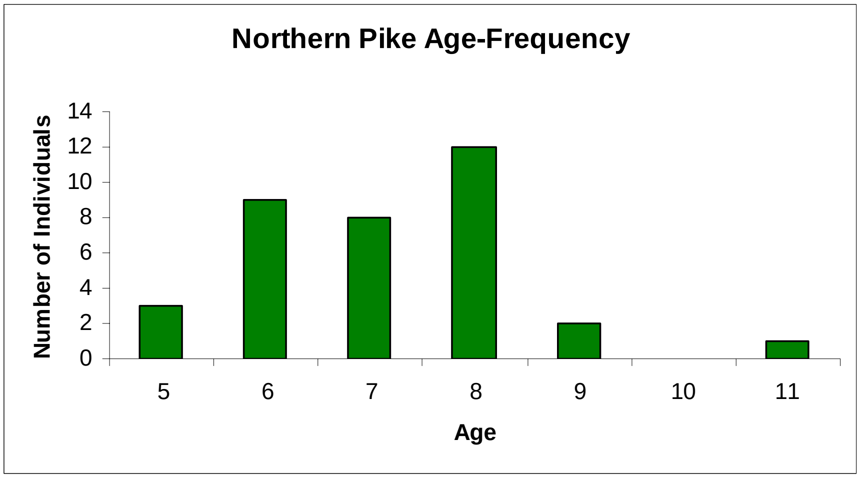
Longnose suckers were abundant downstream of the culvert in Baker Creek (Table 2 and Table 3). Adult longnose suckers began entering Baker Creek when water temperatures reached 6°C. Ripe "running" individuals were captured on May 30 when water temperatures reached 9°C. Peak spawning activity occurred on May 30 and June 1; numerous ripe "running" specimens were captured during this period. Females in spawning condition had a green-bronze dorsal surface. A distinct dark band was conspicuous along the flanks of the body. Males in spawning condition were similar in appearance but coloration was more pronounced. The dorsum was dark brown to black with a dark red or pink lateral band along the dorsolateral surface. Nuptial tubercles were visible along the rays of the anal and caudal fins. Sex of spawning longnose suckers could usually be determined by external morphology and confirmed by release of eggs or milt when handled.

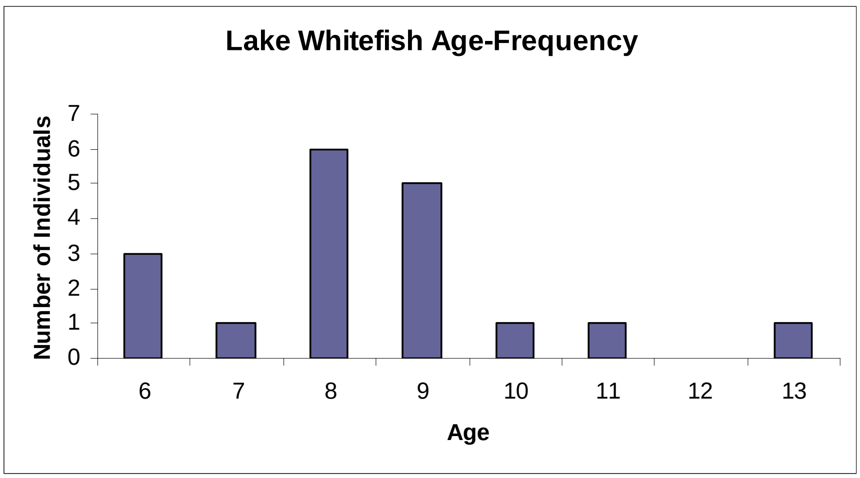
The average length of spawning adults captured in Baker Creek was 475 mm and the average age was 11 years (Figure 7 and Figure 8; see Appendix I for raw data). The length to age correlation for longnose suckers from Baker Creek is similar to the relationship developed for this species in Great Slave Lake (Rawson 1951). Age determination based on scales can under represent the true age of longnose suckers. However, because the age compared well with historical data for Great Slave Lake (Harris 1962, Rawson 1951) and the scales were intact and readable (i.e., seasonal annuli were well-represented), the age data is considered valid.

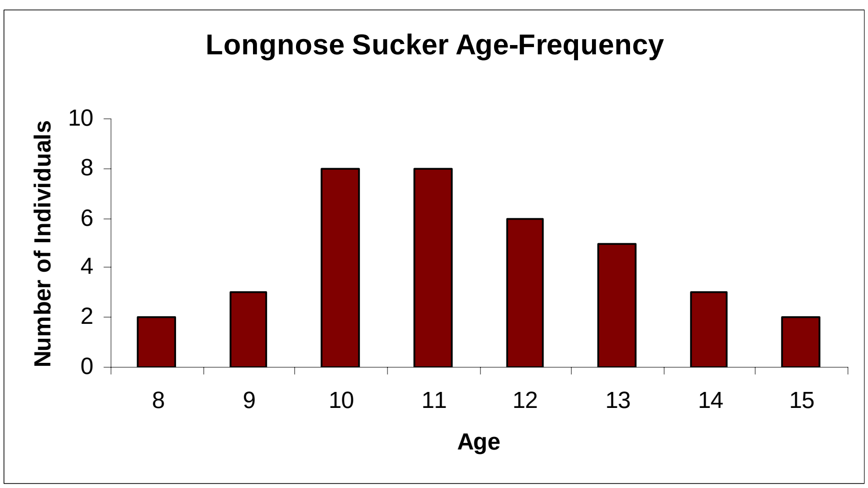
Spawning longnose suckers were primarily encountered downstream of the culvert on Baker Creek (Figure 9). However, a portion of the spawning run extended into Reach 4. The pre-spawn and spawning behaviour of 13 individuals was observed during the study (see June 2, Appendix III). Most of the activity was restricted to Riffle 7 and the glide upstream of Riffle 7. On June 10, six longnose suckers were observed in the area of Riffle 6.

White Sucker

Only three white suckers were captured (<3% of the catch) in Baker Creek during the 2007 spring survey (Table 2); these fish were caught downstream of the culvert. Also, two individuals were observed in Reach 4 below the 5th riffle; they were swimming with a school of spawning longnose suckers. The average length of the sampled white suckers was 49.3 cm, and the average age was 10 (Figure 7 and Figure 8; see Appendix I for raw data). The age determination of white suckers from scales can under represent the true age. For all sampled individuals; the scales were intact and the seasonal annuli were evident, as such, the age data is considered valid.



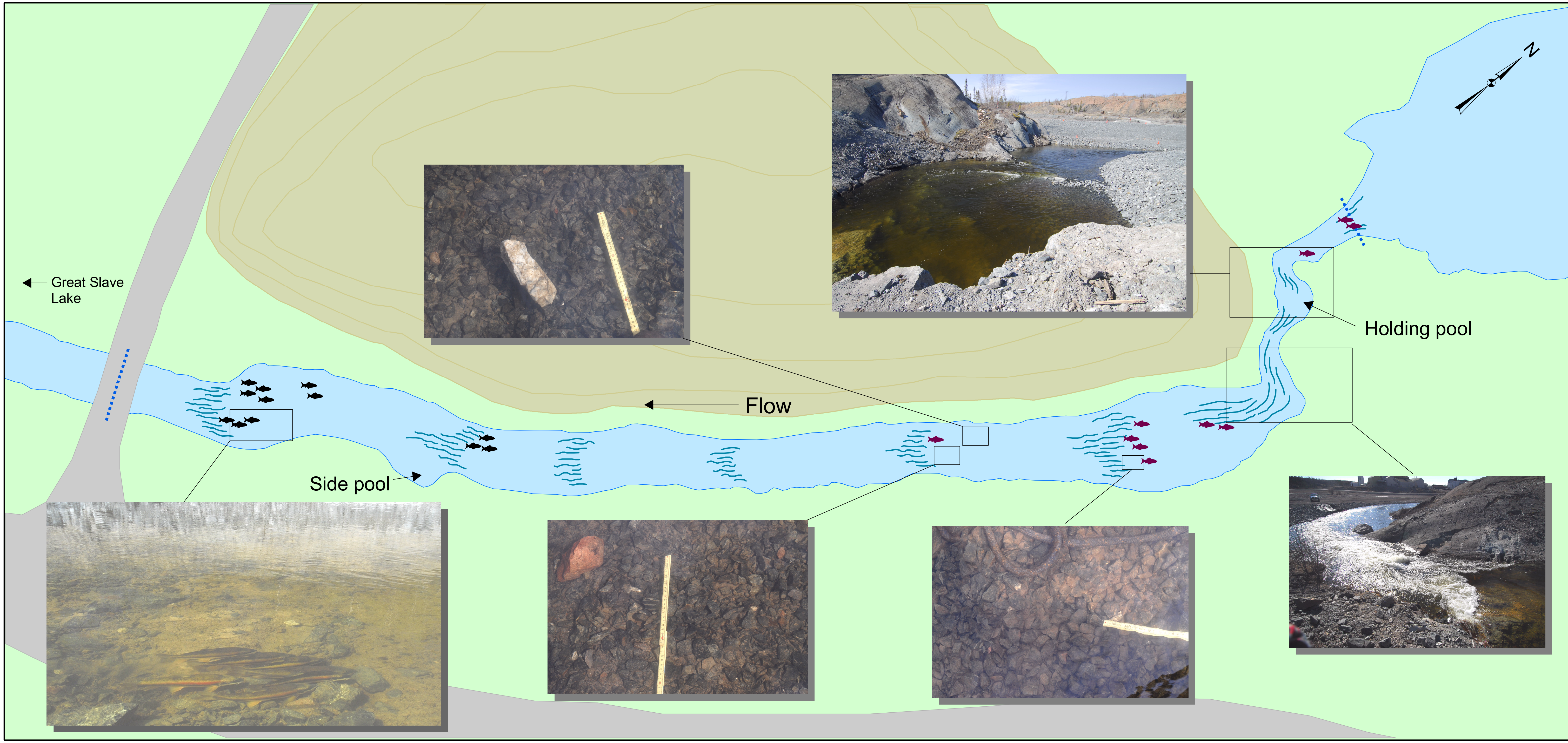




Golder Associates

Age Frequency Relationship of Three Species of Fish in Baker Creek, Spring 2007

DRAWN: PV	APPROVED: JO	DATE: 05 November, 2007
PROJECT: 07-1328-0021		Figure: 8



LEGEND

- Arctic Grayling
- Longnose Sucker
- Riffle
- Limit of Reach 4
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI. NOTE: LAKE WHITEFISH AND NORTHERN PIKE NOT SHOWN BECAUSE THEY WERE NOT SPAWNING IN REACH 4.

NOT TO SCALE

PROJECT

BAKER CREEK REACH 4 FISH SURVEY

TITLE

DISTRIBUTION OF SPAWNING ARCTIC GRAYLING AND LONGNOSE SUCKERS

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007	**FIGURE: 9**	
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		

Northern Pike

A total of 44 northern pike were captured downstream of the culvert (Table 2 and Table 3). Only three northern pike were captured in Reach 4 (Table I-4 in Appendix I).

The average length of captured northern pike was 57.8 cm, and the average age was 7.1 years (Figure 7 and Figure 8; see Appendix I for raw data). The length-to-age correlation for northern pike matched that of nearby northern populations (Miller and Kennedy 1948). Unlike the longnose suckers, the northern pike sample from Baker Creek did not represent the full range of adult age classes. Individuals over 11 years of age were not captured in Baker Creek, whereas other northern stocks commonly reach 15 to 26 years of age (Scott and Crossman 1973, Kennedy 1948). Age of pike as determined by scales, otoliths and fins rays compared well to the published literature; as such, the age data is considered valid.

Lake Whitefish

Twenty-one lake whitefish were captured in the pool below the culvert between May 27 and June 1, 2007 (Table 2). Length of lake whitefish was not recorded due to their sensitivity to being handled but mean age was approximately 8.4 years (Appendix I). According to age-of-maturity data for Great Slave Lake (Bond and Turnbull 1973) approximately 40% of whitefish mature at 8 years of age. It seems likely that Baker Creek provides feeding habitat for a mix of sub-adult and young adult lake whitefish. Two adult lake whitefish were observed with longnose suckers in Reach 4 on June 2, 2007.

Ninespine Stickleback

In early spring (May 26-June 15), large concentrations of ninespine sticklebacks were seen along the banks of Baker Creek, downstream of the culvert. In previous surveys of Baker Creek, sticklebacks were observed near Reach 4 (Golder Associates 2001, Dillon 1998) but they were not observed in Reach 4 in 2007.

Trout Perch

On June 12, one trout perch was observed while snorkelling downstream of Riffle 5. Areas upstream and downstream of Reach 4 may offer more suitable habitat for this species.

3.2 EGGS (RECORDED AND OBSERVED)

Egg deposition sites were widely distributed in Reach 4. Of the 15 sites located, thirteen were Arctic grayling egg deposition sites and two were longnose sucker sites. Egg deposition sites were located exclusively within glides or pool tailouts situated upstream of the various riffles (Figure 10).

Arctic grayling eggs were first located on May 26 in a shallow, swift run above the first riffle in Reach 4 (Figure 6). The eggs were 4 mm in diameter (see Figure 10), and were in mid stages of cleavage. Numerous blastomeres were visible and fertilization would have taken place less than 24 hours previous. On May 27 and May 31, more eggs were discovered at various sites within Reach 4. These eggs contained embryos in various stages of development. The eyes and yolk-sac of all embryos were well developed.

Arctic grayling eggs were located within the gravel interstices and within 1 to 2 cm of the surface. Egg sites were characterized by relatively uniform water depth and velocity (Table 4); the substrate was comprised of gravel of varying sizes (Table 4). Groups of 6 to 20+ eggs were examined to photograph and identify the eggs to species. Eggs sites contained hundreds of eggs; the densities were not quantified so as not to disturb the eggs.

On June 5, longnose sucker eggs were located in the lower portion of Reach 4, upstream of Riffle 7 (Figure 10). The eggs appeared to be viable and recently fertilized; cell division was apparent. Because only a few eggs (6) were collected, the depth of deposition could not be determined. Only one longnose sucker egg was found upstream of Riffle 6; it appeared viable.

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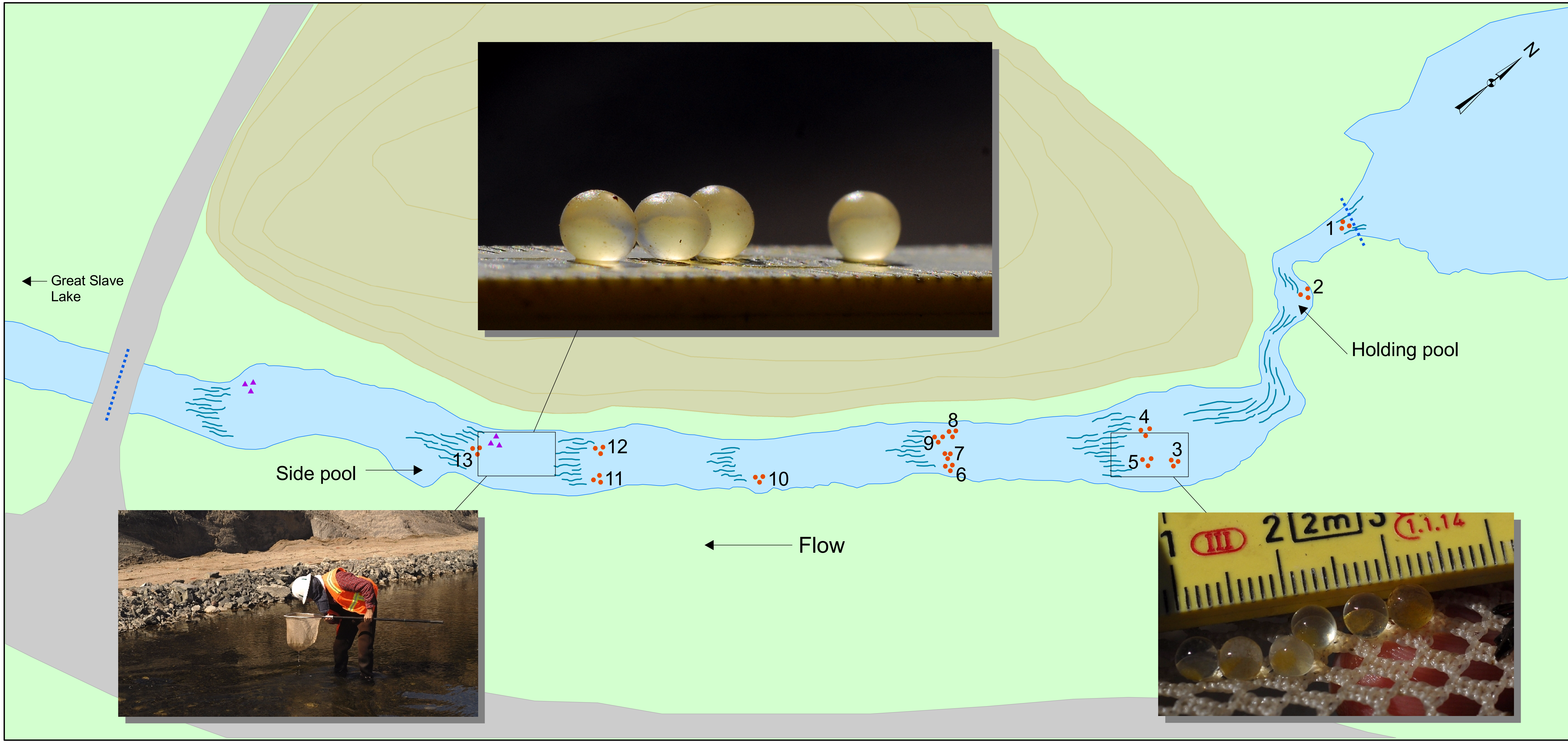

LEGEND

- Arctic Grayling Egg Site
- Longnose Sucker Egg Site
- Riffle
- Limit of Reach 4
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI.

NOT TO SCALE

PROJECT

BAKER CREEK REACH 4 FISH SURVEY

TITLE

EGG SITES IDENTIFIED FOR ARCTIC GRAYLING AND LONGNOSE SUCKERS

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007	FIGURE: 10	
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		

Table 4 Habitat Characteristics at Arctic Grayling Egg Collection Sites in Reach 4 of Baker Creek, Spring 2007

Site	Location	Depth (cm)	Depth Range (cm) of (1 m^2 area)	Velocity (m/s) (Surface)	Velocity (m/s) (Mid-Column)	Velocity (m/s) (Near Substrate)	Mean Substrate Size (mm)[1]	Substrate Composition %
1	Riffle 1 (upstream end)	38	36-51	1.00	0.91	0.31	43.0 (large gravel)	50% large gravel 40% small gravel 10% fine
2	Riffle 1 (upstream from pool)	49	45-55	0.97	0.86	0.31	61.0 (large gravel)	60% large gravel 40% medium gravel
3	Natural Rapids (between Riffle 1 and 2)	56	55-61	0.98	1.12	0.49	24.1 (medium gravel)	10% large gravel 90% medium gravel
4	Natural Rapids (between Riffle 1 and 2)	42	34-53	1.33	1.43	0.27	42.4 (large gravel)	40% medium gravel 60% large gravel
5	Natural Rapids (between Riffle 1 and 2)	33	29-33	0.96	0.77	0.37	53.9 (large gravel)	10% small cobble 90% large gravel
6	Riffle 3	32	29-32	1.42	1.34	0.80	29.6 (medium gravel)	40% large gravel 60% medium gravel
7	Riffle 3	31	30-36	1.44	0.66	0.96	28.6 (medium gravel)	100% medium gravel
8	Riffle 3	35	34-35	1.16	1.19	1.05	27.6 (medium gravel)	100% medium gravel
9	Riffle 3	26	26-34	1.45	0.8	1.31	17.3 (medium gravel)	5% large gravel 85% medium gravel 5% small gravel 5% fine
10	Riffle 4	34	32-36	1.79	1.72	0.89	24.3 (medium gravel)	10% large gravel 70% medium gravel 20% small gravel
11	Riffle 5	40	37-42	1.18	1.09	0.78	37.5 (large gravel)	20% small cobble 70% large gravel 5% med gravel 5% sml grav
12	Riffle 6	39	39-41	1.31	1.62	0.7	17.2 (medium grave)l	50% medium gravel 20% small gravel 30% fine
13	Riffle 7	33	27-36	1.12	0.80	0.72	18.5 (medium gravel)	50% medium gravel 40% small gravel 10% fine
Mean and Standard Deviation		38 ± 8	-	1.24 ± 0.25	1.01 ± 0.34	0.69 ± 0.32	32.7 ± 14.0	
Range		26-56	-	0.96-1.79	0.66-1.72	0.27-1.31	17.2 - 61	

1 Average of measurements of 30 individual substrate particles in 1 m^2 area around egg site.
m/s – meters per second; m^2 – meters squared, m – meters, mm – millimetres.

3.3 LARVAL/YOY FISH (CAPTURED AND OBSERVED)

Arctic grayling larvae were observed on June 5 and June 6. Based on the state of development, the date of emergence was approximately June 5, 2007. The larvae were at the stage termed ‘protolarvae’ meaning free embryos. They were observed in large numbers in a small side pool upstream of Riffle 4 and along the opposite bank and were associated with slack water (Figure 11). The recently-hatched fish were holding throughout the water column, and were actively swimming using whirlingtail movements. The yolk sac was still prominent and the heavy black pigmentation (chromatophore distribution) on the head, dorsum and ventrum (associated with Arctic grayling YOY) could be seen (Figure 11). At this stage, no fin folds were visible. Larvae did not seem to associate with any particular type of substrate.

On June 5, a seine haul was conducted to assess the abundance, and examine the developmental stage of larval fish. Approximately 200 larval Arctic grayling were captured, visually assessed and then released. The larvae, which were approximately 14 mm in length, were located in low velocity areas (ranging from zero to 0.24 m/sec).

June 9 and 10 marked the transition phase between protolarvae and mesolarvae for most YOY grayling. Many individuals were observed along the slow-moving margins throughout Reach 4. At this stage, the swim bladder was functional, and YOY grayling were observed swimming actively and feeding exogenously throughout the water column, in areas of low velocity (Figure 12).

On June 10, approximately 50 larval fish were captured in one seine haul; they were released following a visual assessment. The larvae were approximately 18 to 20 mm in length, and were found in high concentrations in low velocity areas, ranging from 0.10 m/sec to 0.15 m/sec (Appendix I, Table I-9). Once large numbers of YOY grayling appeared in the stream, use of the seine net was discontinued (i.e., to prevent harming or disturbing the fish). Periodic snorkelling was undertaken thereafter to monitor developmental progress (Table 1).

On June 27, 2007, eight Arctic grayling were captured by dip net; these individuals were, measured and photographed. They were captured in velocities ranging from 0.35 to 0.68 m/sec (Appendix I, Table I-9). Based on their morphology it was confirmed that the Arctic grayling were in an advanced stage of development; all fins and fin rays were fully formed. The convex outer margin of the dorsal fin was evident (Figure 13) and ten to 12 distinct parr marks were visible along the body. The juvenile fish were 32-38 mm in length and preferred

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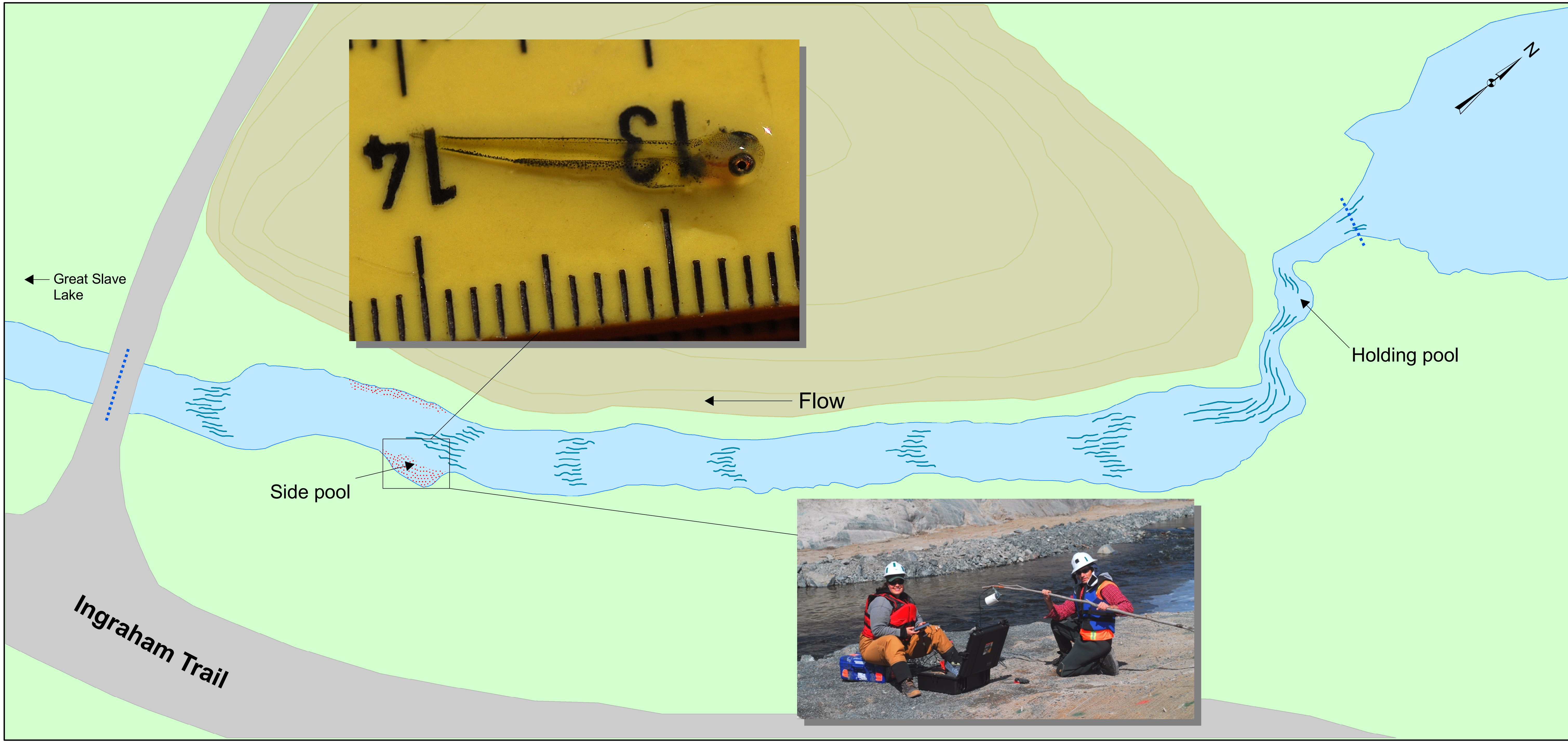


LEGEND

- Riffle
- Limit of Reach 4
- Protolarvae
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI.

NOT TO SCALE

PROJECT

BAKER CREEK REACH 4 FISH SURVEY

TITLE

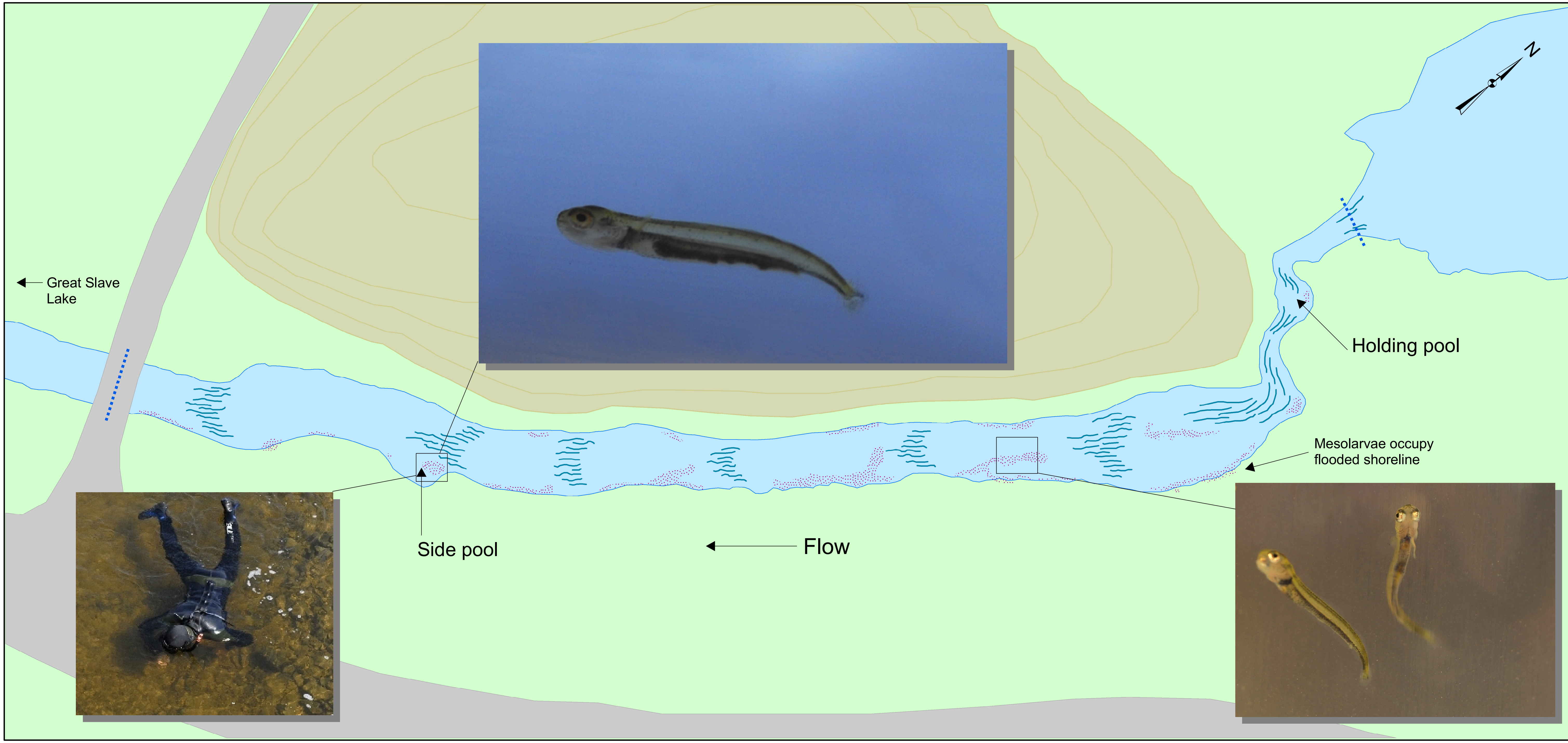
LOCATION OF PROTOLARVAE AFTER EMERGENCE

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007		
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		

FIGURE: 11

Project: N:\Active\GIS\2007\07-1321-0021 Baker Creek\mxd\For INAC Report\Reach4Survey_Fig12.mxd



LEGEND

- Riffle
- Limit of Reach 4
- Mesolarvae
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI.

NOT TO SCALE

PROJECT

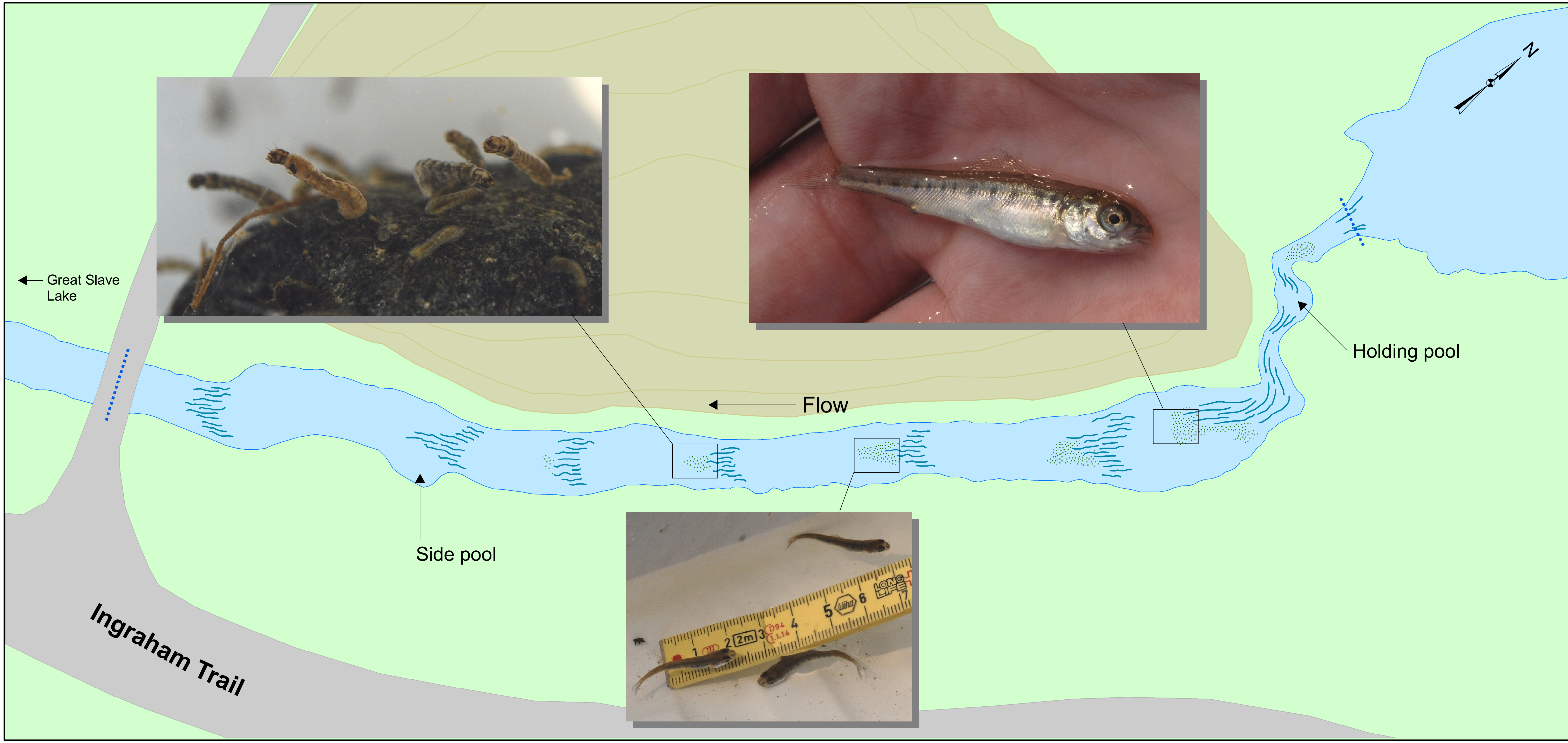
BAKER CREEK REACH 4 FISH SURVEY

TITLE

DISTRIBUTION OF ARCTIC GRAYLING MESOLARVAE

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007	**FIGURE: 12**	
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		



LEGEND

- Riffle
- Limit of Reach 4
- Late Mesolarvae/Juvenile
- Baker Creek
- Hill
- Road

REFERENCE

SCHEMATIC DRAWING BASED ON GIANT MINE DRAWING BY P. VECSEI.

NOT TO SCALE

PROJECT

BAKER CREEK REACH 4 FISH SURVEY

TITLE

DISTRIBUTION OF JUVENILES

Golder Associates
Yellowknife, Northwest Territories

PROJECT No. 07-1328-0021			NOT TO SCALE	REV. 0
DESIGN	PV	30 Oct. 2007		
GIS	LC	29 Apr. 2008		
CHECK	PV	29 Apr. 2008		
REVIEW	JO	12 Nov. 2007		

FIGURE: 13

to hold in shallow riffles and runs and were no longer seen along the low velocity stream margins (Figure 13).

Mesolarvae and YOY appeared to feed on pond-derived micro-crustacea in the drift. The majority of these invertebrates were zooplankton but other drift forage were also present. Macro-invertebrates were also observed in Baker Creek, particularly Ephemeropteran (mayfly) nymphs and small-sized adults from the Family Baetidae (Figure 13, Appendix III); it is possible that some of these invertebrates were eaten by grayling. In late June, blackfly larvae (Order Diptera – Family Simuliidae) were seen clinging to almost all rock substrate in the fast flowing portions of Baker Creek. While snorkelling, many of these larvae were dislodged from the rocks and were actively preyed upon by YOY Arctic grayling.

On June 29, Reach 4 was snorkelled. No fish were observed in Reach 4 during the June 29 snorkelling survey. Outmigration of YOY Arctic grayling had occurred on June 28.

Adult longnose suckers were last seen in Reach 4 on June 12. Larval longnose suckers were not observed in Baker Creek. The eggs appeared viable when observed earlier in the spring, and it likely the larvae migrated out of the stream at night immediately after hatching, which is a common life history pattern for the species (Appendix III).

3.4 SUPPORTING ENVIRONMENTAL VARIABLES

Water temperature in Baker Creek was variable throughout the spring (Figure 5; Appendix I, Table I-11). The logger recorded temperatures ranging from 9°C in spring to > 20°C during the summer. A range of water quality measurements were recorded in the field (Table 5).

Table 5 Water Quality (Field Measurements) Reach 4, Spring 2007

Water Quality Parameter	June 5
DO (mg/L)	9.35
Conductivity (µS/cm)	79
pH	7.27
Turbidity (NTU)*	1.25
Temperature (°C)	13.95
Salinity	0.05
Depth (m)	0.26

No field measurements are available for June 20 due to meter malfunction.

Note: DO = dissolved oxygen, mg/L = milligrams per litre, µS/cm = microSiemens per centimetre, °C = degrees Celsius, m = metre, NTU = Nephelometric Turbidity Units, n/a. = not available.

Mean daily discharge in the stream varied from <0.1 m^3/s in early April, peaked at 2.29 m^3/s in mid-May and returned to 0.2 m^3/s near the end of June, 2007 (Figure 6; Appendix I, Table I-1). It is assumed that the discharge at the outlet of Martin Lake is similar to the discharge in Reach 4 of Baker Creek but this has not been confirmed. The range of spring flows and the date of peak freshet (mid-May) is similar to the historical flow statistics for the stream (www.wsc.ec.gc.ca/staflo/index) – Baker Creek outlet data January 1983 to December 2006. The peak daily discharge in 2007 was 2.29 m^3/s and this is slightly higher than the historical mean daily discharge for the stream (approximately 1.8 m^3/s) but well below the maximum discharge recorded for the stream (>8 m^3/s).

Water quality in Reach 4 in early June 2007 (Appendix I, Table I-8) was similar to that reported in 2006 (INAC 2007) for the upper reaches of Baker Creek unaffected by effluent discharge. Neither the total dissolved solids nor total suspended solids were elevated relative to 2006. Sediment was observed in pools, which is expected in depositional habitat; a small amount of sediment also was noted in faster flowing areas. However, water quality and clarity were generally high throughout the study period indicating that runoff from construction activities did not contribute a significant amount of suspended sediment to the system.

With a few exceptions, water quality in July 2007 (following discharge of treated effluent) was similar to that determined in 2006 (INAC 2007). Some parameters, such as arsenic, were elevated in 2007 relative to previous years. Because fish had migrated out of Reach 4 prior to the release of treated effluent into Baker Creek, the impact on fish resources in Reach 4 was considered to be negligible. The impact of treated effluent on fish downstream of Reach 4 is being investigated in separate studies (Golder Associates 2006).

4 DISCUSSION

During the Spring 2007 study, longnose sucker, white sucker, northern pike and lake chub were captured downstream of the culvert and longnose sucker, Arctic grayling, trout perch and northern pike were observed and/or captured in Reach 4 of Baker Creek.

4.1 ARCTIC GRAYLING

Adult Arctic grayling were not captured downstream of the culvert, or on the spawning grounds in Reach 4. However, adults were observed on the spawning grounds during bank and snorkelling surveys. The timing of the onset of the study likely contributed to the low capture success downstream of the highway culvert (i.e., the bulk of the run had probably migrated upstream prior to the seining events). The water temperatures were already fairly high in relation to when Arctic grayling normally move upstream (Northcote 1993, Murrow 1980). Due to the build-up of ice inside the culvert, it was assumed that Arctic grayling could not migrate upstream between May 18 and May 25. While there was flow under the ice accumulation, it appeared that current velocities were too high to allow fish passage. When measured on May 27, velocities in the culvert ranged from 0.8 m/sec on the bottom, to 2.5 m/sec at mid depth, and 2.7 m/sec at the surface. Apparently, some grayling did succeed in circumventing these obstacles since they were already present in Reach 4 on May 25 and had largely completed spawning. Because water clarity was reduced in Baker Creek during peak freshet, it was difficult to determine whether grayling were actually present in Reach 4 when the study began.

Spawning was successful in Reach 4, and widespread with eggs recovered above riffles at 13 sites. Egg-hatching was successful based on the number of protolarvae. YOY Arctic grayling exhibit strong natal site fidelity for the first few weeks of life so their presence along the entire Reach 4 confirms successful use of area by larvae as nursery habitat. YOY outmigrated after rearing/feeding in the stream for the early part of the summer.

Arctic grayling population size is controlled by the use a series of different habitats over their life cycle ranging sequentially from spawning habitat, YOY feeding habitat, juvenile and adult wintering habitats, to juvenile and adult feeding habitats. The mechanisms responsible for the sudden outmigration of all YOY grayling likely consist of temperature along with the ontogenetic shift or developmental stage. By the time grayling outmigrated in late June, they were fully formed and functional juveniles with increasing food requirements. It is possible that food items preferred by juveniles are not abundant in Baker Creek.

Spatial distribution of Arctic grayling is a function of habitat availability, access, migration patterns and instream thermal and flow conditions. Optimal habitat conditions increase carrying capacity; however, unimpeded spatial and temporal access to these habitats is essential for Arctic grayling propagation and survival.

4.2 LONGNOSE SUCKER

Our 2007 study determined that longnose suckers make extensive use of the lower portion of Baker Creek for spawning. A small portion of the run also made its way into Reach 4, where spawning was observed. During spring 2007, the highway culvert could have represented a velocity barrier (2.76 m/sec just above the corrugated steel bottom on May 30) to most suckers.

While 44 longnose suckers were caught downstream of the culvert and tagged, only four were recaptured. The recaptured fish were recorded downstream of the culvert. Several tagged individuals were observed amongst a group of spawning longnose suckers in Reach 4, confirming that at least a portion of the spawners had originated from downstream, and had successfully negotiated the culvert.

4.3 WHITE SUCKER

White suckers were captured in small numbers in Baker Creek downstream of the highway culvert. Habitat conditions in Baker Creek may not be suitable for white sucker spawning; alternatively, this species may not be well-represented in Yellowknife Bay.

4.4 NORTHERN PIKE

Northern pike are thought to spawn in the Baker Creek delta. This area provides flooded shallows with abundant aquatic vegetation. The presence of post-spawn adult pike below the Ingraham Trail culvert following spawning could indicate use of this habitat for foraging, particularly due to the abundance of sticklebacks in the area. Pike were also observed (and captured) upstream of the culvert. While Reach 4 does not offer suitable habitat for pike, much of the watershed downstream and upstream of the reconstructed area offers prime pike habitat. The individuals recorded were likely transients, moving from one zone to another.

4.5 NINESPINE STICKLEBACK

This high concentration of ninespine sticklebacks could in turn, account for the numerous pike holding in the vicinity of the culvert throughout our sampling period. The abundance of ninespine stickleback below the culvert in spring of 2007 was considered unusual by local residents. The concentration of sticklebacks along the rapids was of particular interest since much of the suitable spawning habitat is located downstream from the culvert area.

4.6 LAKE WHITEFISH

The Lake whitefish is a fall spawner (See Appendix I, 1.6). The presence of so many adults below the culvert is likely an indication of the abundance of prey items typically consumed by lake whitefish. The duration of lake whitefish presence below the culvert was limited to the period between May 27 and June 3 and their departure was likely dictated by increasing water temperatures and decreasing flow rates.

4.7 SPOTTAIL SHINER

The lack of spottail shiners in Reach 4 can be explained by their limited swimming capability and the culvert acting as a barrier to any upstream movement. However, the small lakes throughout the Baker Creek watershed are thought to contain minnows, and spottail shiners could eventually take up residence throughout Reach 4. However, the lack of submerged aquatic vegetation is likely a limiting factor for spottail shiner in Reach 4.

4.8 TEMPERATURES AND WATER QUALITY

Instream temperatures are determined by air temperature, photoperiod, riparian health, channel morphology and streamflow. In the course of YOY residents in Baker Creek, at no time did daily maximum temperatures exceed 21.6°C. While the steady rise in temperature was a concern at the time, a gradual cooling down period followed, and temperatures never reached the lethal range documented for grayling or longnose suckers. The lethal known limit for juvenile grayling is 24.5°C (La Perriere and Carlson 1973). However, at temperatures above 22.5°C, juveniles can be stressed and growth rates are negatively affected (Sandrine et al. 2006). Adult grayling become physiologically stressed when water temperatures reach 17.2°C (Wojcik 1955, 1954). This may in part explain the relatively rapid outmigration of post-spawners as Baker Creek reached 17.0°C on June 11. In late June or July, Baker Creek stream flow is supplemented with treated mine drainage water. Discharge can often be doubled with these supplemental flows however, in 2007, this occurred well after all grayling and longnose suckers had outmigrated.

Throughout the Arctic grayling's distribution, streams that are affected by human development suffer from water level fluctuations, erosion and high temperatures. Grayling populations in lower elevation streams are more likely to be at risk. However, Baker Creek proved to be relatively stable (hydrologically and thermally) during the period when adult and YOY where present but lower discharge during freshet and warmer temperatures could adversely affect future spawners and cohorts alike. Larger streams and rivers benefit from greater "compartment diversity" where resident fish exploit a variety of habitats by seeking refuge in neighbouring compartments when others are affected by disturbances or unfavourable conditions (Sandrine et al. 2006). Due to the small spatial scale of Baker Creek, there is less compartment diversity and unless conditions remain suitable in Reach 4, there is no likely thermal refuge other than outmigration. The rapid development of grayling is an ontogenetic adaptation to early life history in ephemeral streams that often become inhospitable habitat. However, if a cohort is forced to outmigrate early, predation may take an increased toll and decrease annual survival. Based on the 2007 data, the Baker Creek Arctic grayling population is not temperature limited. In fact, the temperature range and food availability are likely responsible for the rapid growth prior to outmigration.

4.9 EGG SITES

Fish are most vulnerable in their early life history stages, often experiencing high mortality. Predation and poor environmental conditions are the leading causes of mortality in eggs. These factors can occur in combination or independently. Predation can be a source of mortality for eggs laid in substrate (Pepin 1991, McGurk 1986) however, while egg predation does occur for demersal spawners, it is likely to have less effect than environmental factors (Duarte and Alcaraz 1992). Temperature has a direct influence on both the developmental rate and mortality of eggs (Pepin 1991), and is a source of mortality for most demersal (bottom) spawners (Duarte and Alcaraz 1992). Excessive fine sediment build-up is a potential problem in any small stream and bank stability should be (and has been) made a priority throughout Reach 4.

Spawning over gravel and having the eggs sink into the intergravel spaces is likely a grayling adaptation which optimizes survival for gravel substrate spawners. The eggs remain anchored by being slightly adhesive. The intergravel period ensures protection against possible predation and also from fluctuating water levels. The losses experienced by eggs during incubation are usually due to crowding and environmental conditions (Northcote 1993). All the eggs we dislodged from the egg sites were viable and crowding of egg sites was not a limiting factor for Arctic grayling spawning in Baker Creek in spring of 2007.

Rather than trying to quantify egg production which would have disturbed or killed many viable eggs, our objective was to locate spawning sites based on the presence of fish eggs. Our approach involved minimal substrate disturbance and eggs were always placed back on the substrate where they were found.

4.10 YOY

Upon hatching, YOY remain in the gravel for 3-4 days prior to emergence from the substrate (Kratt and Smith 1977). The high mortality experienced in this early life history stage of fishes is termed the “critical period”. This typically occurs during the transition from endogenous to exogenous feeding (Vladimirov 1975). Li and Mathias (1987) found that environmental conditions, such as temperature and food availability, would mediate mortality during the critical period and this is likely what happened in Baker Creek in 2007. Between June 5 and June 9, the maximum daily recorded temperature was 14.7°C and 14.2°C respectively. The combination of suitable temperature, well within the species’ tolerance range, along with an abundance of zooplankton and insect larvae ensured high survival of YOY. The timing of the transition to exogenous feeding coincided with the short period of productivity of such a sub-arctic stream and proved critical for the survival and growth for the 2007 cohort.

Habitat: The components of fish habitat can be divided into categories such as food, flow, access, cover, substrate, temperature, dissolved oxygen and water clarity. Currently, there are few fish habitat enhancement projects that have been properly documented (Smokoroski et al. 1998). The Jones et al. (2003) study on Arctic grayling habitat enhancement in a diversion channel at a diamond mine is one of the only projects undertaken in the NWT. Habitat enhancement projects should be monitored and results published so that habitat managers can draw from collective experiences for future effective habitat enhancement or restoration endeavours (Minns et al. 1996, Jones et al. 2003).

The number of gravel riffle runs in Baker Creek is directly correlated to fish habitat availability. Gravel substrate is directly linked to spawning success of Arctic grayling and longnose suckers (Ward 1951). Recently hatched Arctic grayling remain 3 to 4 days in the gravel substrate prior to emergence (Kratt and Smith 1977). Habitat that may indirectly affect fish would be the riparian vegetation along the stream bank which may play a role in regulating water temperature or increasing the number of insects used for food by some fish species (Cott and Moore 2003). The absence of vegetation and cover may be another reason that overall species richness is low in Reach 4, but this is probably a temporary artifact of the recent relocation of the stream channel.

Food Supply: The presence of a stable food source is critical for the survival of YOY Arctic grayling. YOY primarily consume larger taxa, especially Chironomidae and Simuliidae. Even among these taxa, grayling tend to select larger individuals. As they grow, YOY Arctic grayling consume larger numbers of both large and small prey, particularly the larger invertebrates (Jones et al. 2003). Prior to outmigration, the grayling were 32-36 mm in length and their gape size would allow them to feed on insect larvae. The insects we captured and observed in Baker Creek (Ephemeroptera and Diptera) are among the most common insects in the Northwest Territories and their larval stages occur in flowing waters. Members of the Order Ephemeroptera are collectors that feed on detritus on the stream bottom.

4.11 SNORKELLING OBSERVATIONS

Snorkelling was not used as a means for quantifying fish densities but rather to identify the species diversity throughout Reach 4 and to qualify the emergence success of grayling YOY.

For Reach 4 of Baker Creek, it soon became apparent that snorkelling was a productive means of data gathering where environmental conditions such as low conductivity, fast water, etc., limited the effectiveness of other methods. Snorkelling was efficient for covering long stretches of a Baker Creek in shorter time periods. Water clarity, stream size and the snorkler's identification skills determined the efficacy of snorkelling data.

Snorkelling was cost effective because of the small amount of equipment required and the number of fish observed. Also more area can be covered in a shorter time and there is no handling of the fish. It is relatively unbiased, although not purely accurate due to difficulty in counting fish within complex habitats. The in ability to detect fish (especially small ones), while likely in streams with dense cover and range of habitat complexity, was unlikely in Baker Creek due to the shallow open aspect of the streambed.

4.12 SUMMARY

Adult spawning fish and YOY require a combination of food, flow, access, cover, substrate, temperature, dissolved oxygen and water clarity unique to each species (Table 6). Often, as in the case of the longnose sucker and Arctic grayling, these parameters may overlap. Based on our 2007 data, Baker Creek offers a range of parameters that suits the requirements for both these species. Young-of-year grayling hatched in Reach 4 of Baker Creek further benefit from the unusual species composition throughout the stream. While adult northern pike are present in limited numbers, their prey size typically consists of larger fish (Scott and Crossman 1973). Predatory species that would normally predate heavily on YOY Arctic grayling (i.e., bull trout (*Salvelinus confluentus*), rainbow trout (*Oncorhynchus mykiss*) and Dolly Varden (*Salvelinus malma*)) are absent from the watershed (Scott and Crossman 1973, McPhail and Lindsey 1970).

Habitat loss and population decline for the Baker Creek grayling is difficult to assess because little historic documentation exists. Current information is more anecdotal than quantitative or qualitative. Arctic grayling and longnose suckers are known to have strong homing abilities leading to spawning site fidelity (Kristiansen and Diving 1996). This life history trait could be of great significance to their future successful management and enhancement in Baker Creek where habitat fragmentation, high water temperatures and low water levels may prove to be key population limiting factors for Baker Creek Arctic grayling.

Table 6 Summary of Life Stage and Habitat Characteristics for Fish in Reach 4

Life Stage	Habitat Characteristics			Substrate	Velocity	Figure
	Glide	Riffle	Pool			
Egg	✓			Eggs are deposited in intergravel of substrate measuring 2-5 cm	Egg sites are in areas with moderate bottom velocities (0.27-0.96 m/sec)	Figure 10
Emergence/ Protolarvae			✓	Upon emergence, YOY remain in intergravel for 2-4 days. Protolarvae are associated with silt but this may be an artifact of holding in areas of deposition	Protolarvae seek out slowest flows and prefer areas with virtually no current (0-0.2 m/sec)	Figure 11
Mesolarvae	✓		✓	This stage highly associated with gravel substrate and boulders	Mesolarvae prefer water velocities ranging from 0.10 to 0.15 m/sec	Figure 12
Juvenile		✓		Juveniles are restricted to flowing waters and appear to be feeding on prey items in the drift. Total avoidance of slack water	Below and in riffles where velocities range from 0.35-0.68 m/sec	Figure 13
Spawning Arctic grayling	✓			Spawners seek out areas with medium to large gravel with good intergravel space in which eggs can settle	Spawners prefer areas of moderate flow above riffles	Figure 9
Spawning Longnose suckers	✓			Spawners seek out areas with medium to large gravel with good intergravel space in which eggs can settle but substrate type can be more mixed than at grayling spawning sites	Spawners prefer areas of moderate flow above riffles or in pools with some flow	Figure 9

Based on our inability to capture adult Arctic grayling and the low number of recaptures among longnose suckers and northern pike, we were unable to generate any population estimates for annual spawners or residents in Baker Creek. The study of fish population dynamics in Baker Creek faces considerable experimental difficulties both logistical and theoretical. Future investigations may require the use of weirs installed during periods of low discharge or using experimental Nordic gillnets at the mouth of Baker creek.

Spawning habitat was documented based on observation of spawning adults and the sampling of numerous egg sites. We were able to generate a summary of data qualifying the habitats that proved successful for adult Arctic grayling and longnose sucker reproduction. Based on our baseline data, Baker Creek has a combination of discharge, velocity, temperature and substrate suitable for spawning and early life history.

Conservation measures must address factors limiting grayling habitat, including stream flow dynamics, riparian and channel health and fish passage. In the future, Baker Creek, with intact riparian areas, healthy channel morphology and unimpeded access should have a high abundance of both Arctic grayling and possibly longnose suckers. As shown by the recent remediation of Baker Creek, habitat management can be the best instrument for successful fish restoration and conservation.

5 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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6 REFERENCES

Armstrong, R.H. 1986. A review of the Arctic grayling studies in Alaska, 1952-1982. Biol. Paper Univ. Alaska No. 23:3-17.

Bardonnet, A. and P. Gaudin 1991. Influence of daily variations of light and temperature on the emergence rhythm of grayling fry (Thymallus thymallus). Canadian Journal of Fisheries and Aquatic Science 48, 1176-1180.

Beauchamp, D.A. 1990. Movements, habitat use, and spawning strategies of Arctic grayling in a subalpine lake tributary. Northwest Sci. 64:195-207.

Bond, W.A. and T.D. Turnbull. 1973. Fishery Investigations at Great Slave Lake, Northwest Territories 1972. Technical Report Series No. CEN/T-73-7. Resource Management Branch, Central Region. 78 pp.

Brannon, E.L. 1987. Mechanisms stabilizing salmonid fry emergence timing. In Sockeye salmon (Oncorhynchus nerka) population biology and future management. Edited by H.D. Smith, L. Margolis and C.C. Wood. Can. Spec. Publ. Fish.Aquat. Sci. No. 96. pp. 120-124.

Carl, L.M., D. Walty and D.M. Rimmer. 1992. Demography of spawning grayling (Thymallus arcticus) in the Beaverlodge River, Alberta. Volume 1: 243-244.

Casselman, J.M. 1996. Age, growth, and environmental requirements of pike. Pages 69-101 in J.F. Craig, editor, Pike: biology and exploitation. Chapman and Hall, London.

Chapman, C.A. and W.C. Mackay. 1984. Direct observation of habitat utilization by northern pike. Copeia 1984: 255-258.

Clark, C.F. 1950. Observations on the early life history of the northern pike, Esox lucius L., in Houghton Lake, Michigan. Trans. Am. Fish. Soc. 71:149-164.

Cott, P.A. and J.P. Moore. 2003. Working Near Water: Considerations for Fish and Fish Habitat. Reference and Workshop Manual. Northwest Territories. Department of Fisheries and Oceans-Western Arctic Area. Inuvik, Northwest Territories.

De Bruyn, M., and P. McCart. 1974. Life history of the grayling (Thymallus arcticus) in Beaufort Sea drainages in the Yukon Territory. In P.J. McCart [ed.] Arctic Gas Biological Report Series, Vol. 15, Chapter 2, 41p.

Dillon Consulting Limited (Dillon). 1998. Baker Creek Fish Habitat and Rehabilitation Study for Abandonment and Restoration Planning. Prepared for Royal Oak Mines Inc.

Duarte, C.M., and Alcaraz, M. 1989. To produce many small or few large eggs: a size-independent reproductive tactic of fish. Oecologia 80: 401-404.

Engel, L. 1973. Inventory and cataloging of Kenai Peninsula, Cook Inlet, and Prince William Sound drainages and fish stocks. Alaska Dept. Fish and Game, Ann. Rep. of Prog. 1972-1973, Proj. F-9-5, 14:25p.

Fabricius, E. and K.J. Gustafson. 1963. Some new observations on the spawning behavior of the pike, Esox lucius L. Fish Bd. Sweden, Inst. Freshwater Res. Drottningholm, 39:23-54.

Falk, M.R., M.M. Roberge, D.V. Gillman, and G. Low. 1982. The Arctic grayling, Thymallus arcticus (Pallas), in Providence Creek, Northwest Territories, 1976-79. Can. Man. Rep. Fish. Aquat. Sci. 1665: 27p.

Franklin, D.R., and L.L. Smith. 1963. Early life history of northern pike, Esox lucius, with special reference to the factors influencing the numeral strength of year classes. Transactions of American Fishery Society, 92: 91-110.

Golder Associates. 2001. Final Abandonment and Restoration Plan Prepared for Indian and Northern Affairs Canada by Miramar Giant Mine Ltd. Yellowknife NT. Submitted to Miramar Giant Mine, September 2001.

Golder Associates. 2006. Environmental Effects Monitoring Phase 2 Study Design. Prepared for Indian and Northern Affairs Canada. by Golder Associates Ltd., Yellowknife, NT. 75 p. + appendices.

Hammar, J. 1989. Freshwater ecosystems of polar regions: vulnerable resources. Ambio 18: 6-22.

Harris, R.D.H. 1962. Growth and reproduction of the longnose sucker, Catostomus catostomus (Forster), in Great Slave Lake. J. Fish. Res. Board Can. 19: 113-126.

Healey, M.C. 1979. Detritus and juvenile salmon production in the Nanaimo estuary: I. Production and feeding rates of juvenile chum salmon (Oncorhynchus keta). J. Fish. Res. Board Can. 36: 488-496.

Indian and Northern Affairs Canada. 2006. Standard Operating Procedures for Effluent and Water Quality monitoring in Accordance with The Metal Mining Effluent Regulations (MMER), Environmental Effects Monitoring (EEM), and Mackenzie Valley Land and Water Board Water License N1L2-0043. Prepared for Deton' Cho Nuna Joint Venture, Indian and Northern Affairs Canada by Golder Associates Ltd., Yellowknife, NT. 54 p.

Indian and Northern Affairs Canada. 2007. 2006 Annual Report for Giant Mine: Environmental Effects Monitoring and Metal Mining Effluent Results. Prepared for Deton' Cho Nuna Joint Venture, Indian and Northern Affairs Canada by Ron Connell and Golder Associates Ltd., Yellowknife, NT. 11p. + appendices (181 p).

Jones, N.E. and W.M. Tonn. 2004. Enhancing productive capacity in the Canadian arctic: assessing the effectiveness of instream habitat structures in habitat compensation. Transactions of the American Fisheries Society 133:1356-1365.

Jones, N.E. and W.M. Tonn. 2004. Resource selection functions for age-0 Arctic grayling (Thymallus arcticus) and their application to stream habitat compensation. Canadian Journal of Fisheries and Aquatic Sciences 61:1736-1746.

Jones, N.E., W.M. Tonn and G.J. Scrimgeour. 2003. Selective foraging of age-0 arctic grayling in lake-outlet streams of the Northwest Territories, Canada. Environmental Biology of Fishes 67:169-178.

Kratt, L.F. and J.F. Smith. 1977. A post-hatching sub-gravel stage in the life history of the Arctic grayling, Thymallus arcticus. Transactions of the American Fisheries Society 106: 241-243.

Kristiansen, H. and K.B. D¿ving. (1996). The migration of spawning stocks of grayling, Thymallus thymallus, in Lake Mj¿sa, Norway. Environmental Biology of Fishes 47: 43-50.

LaPerriere, J.D. and R.F. Carlson. 1973. Thermal tolerances of interior Alaskan Arctic grayling, Thymallus arcticus. Institute of Water Resources Report IWR-46. University of Alaska, Fairbanks. 36 pp.

Li, S., and J.A. Mathias 1987. The critical period of high mortality of larvae fish - A discussion based on current research. Chin. J. Oceanol. Limnol. 5: 80-97.

Magee, J., E. Rens, P. Lamothe. 2006. Arctic Grayling Recovery Program: Fluvial Arctic Grayling Monitoring Report 2005, Big Hole River and Reintroduction Efforts. Montana Department of Fish, Wildlife and Parks Dillon, Montana. 54 pp.

McGurk, M.D. 1986. Natural mortality of marine pelagic fish eggs and larvae: role of spatial patchiness. Mar. Ecol. Prog. Ser. 34: 227-242.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska, Fisheries Research Board of Canada. Bulletin 173: 125-128.

Miller, R.R., and Kennedy, W.A. 1948. Pike (Esox lucius) from four northern Canadian lakes. J. Fish. Res. Board Can. 7: 190–199.

Minns C.K., J. R.M. Kelso, and R.G. Randall. 1996. Detecting the response of fish to habitat alterations in freshwater ecosystems. Can. J. Fish. Aquat. Sci. 53: 403–414.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Company, Anchorage, Alaska. 248 pp.

Northcote, T.G. 1993. A review of management and enhancement options for the Arctic grayling (Thymallus arcticus) with special reference to the Williston Reservoir watershed in British Columbia. B.C. Ministry of Environment, Lands and Parks, Fisheries Branch, Fisheries Management Report No. 101, 69 pages.

Pepin, P. 1991. Effect of temperature and size on development, mortality, and survival rates of the pelagic early life history stages of marine fish. Can. J. Fish. Aquat. Sci. 48: 503-518.

Petrosky, B.R., and J.J. Magnuson. 1973. Behavioral responses of northern pike, yellow perch and bluegill to oxygen concentrations under simulated winterkill conditions. Copeia, 1:124 – 132.

Rawson, D.S. 1951. Studies of the fish of Great Slave Lake. J. Fish. Res. Bd. Can. 8(4): 207-240.

Roach, S.M. 1998. Site fidelity, dispersal, and movement of radio implanted northern pike in Minto Lakes, 1995-1997. Alaska Department of Fish and Game, Division of Sport Fish. Fishery Manuscript No. 98-1, Anchorage. 44 pp.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. 1973. Bulletin 184. Fisheries Research Board of Canada, Ottawa. 966 pp.

Snyder, D.E., and R.T. Muth. 2004. Catostomid fish larvae and early juveniles of the Upper Colorado River Basin–morphological descriptions, comparisons, and computer-interactive key. Colorado Division of Wildlife Technical Publication 42.

Stewart, R.J., R.E. McLenehan, J.D. Morgan, and W.R. Olmsted. 1982. Ecological studies of Arctic grayling (Thymallus arcticus), Dolly Varden char (Salvelinus malma), and mountain whitefish (Prosopium williamsoni) in the Liard River drainage, B.C. E.V.S. Consultants Ltd. for Westcoast Transmission Company Ltd. and Foothills Pipe Lines (North B.C.) Ltd., 99p.

Stuart, K.M., and G.R. Chislett. 1979. Aspects of the life history of Arctic grayling in the Sukunka drainage. Prov. B.C., Fish. Br., Prince George, Internal Rep., 111p.

Tack, S.L. 1971. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. Fish and Game, Ann. Rep. of Prog. 1970-1971, Proj. F-9-3, 12:35 p.

Vladimirov, V.I. 1975. Critical periods in the development of fishes. J. Ichthyol. 15: 851-868.

Ward, J.C. 1951. Breeding biology of the Arctic grayling in the southern Athabasca drainage. M.A. Thesis, University of Alberta, Edmonton, Canada.

Wojcik, F. 1954. Spawning habits of grayling in interior Alaska. U.S. Fish Wildl. Serv. and Alaska Game Comm., Quarterly Prog. Rep., Proj. F-l-R-4, 4(1):3p.

Wojcik, F. 1955. Life history and management of the grayling in interior Alaska. M.Sc. Thesis, University of Alaska, Fairbanks. 54 pp.

APPENDIX I

RAW DATA TABLES

Table I-1 Mean Discharge of Baker Creek, Preliminary Results

Date	Mean Calculated Discharge (m^3/s)
10/05/2007	0.497
11/05/2007	0.775
12/05/2007	1.16
13/05/2007	1.58
14/05/2007	1.92
15/05/2007	2.11
16/05/2007	2.23
17/05/2007	2.29
18/05/2007	2.29
19/05/2007	2.27
20/05/2007	2.25
21/05/2007	2.22
22/05/2007	2.16
23/05/2007	2.08
24/05/2007	1.98
25/05/2007	1.86
26/05/2007	1.75
27/05/2007	1.65
28/05/2007	1.57
29/05/2007	1.47
30/05/2007	1.39
31/05/2007	1.34
01/06/2007	1.27
02/06/2007	1.21
03/06/2007	1.13
04/06/2007	1.05
05/06/2007	0.986
06/06/2007	0.927
07/06/2007	0.855
08/06/2007	0.792
09/06/2007	0.748
10/06/2007	0.702
11/06/2007	0.662
12/06/2007	0.627
13/06/2007	0.6
14/06/2007	0.552
15/06/2007	0.519
16/06/2007	0.474
17/06/2007	0.427
18/06/2007	0.398
19/06/2007	0.368
20/06/2007	0.339

Table I-1 Mean Discharge of Baker Creek, Preliminary Results (continued)

Date	Mean Calculated Discharge (m^3/s)
21/06/2007	0.311
22/06/2007	0.282
24/06/2007	0.239
25/06/2007	0.219
26/06/2007	0.202
29/05/2007	1.47
30/05/2007	1.39
31/05/2007	1.34
01/06/2007	1.27
02/06/2007	1.21
03/06/2007	1.13
04/06/2007	1.05
05/06/2007	0.986
06/06/2007	0.927

m^3/s – cubic meters per second.

Source: Environment Canada, Station 07SB013, Outlet of Lower Martin Lake. Preliminary analysis only. Final data forthcoming in 2008.

Table I-2 Lake Whitefish Capture Data

Date	Length (cm)	Tag #	Mature	Sex	Age	Age Structure	Live Release	Method	Site
27/05/2007	34.5	dead	yes	n/a	7	ot/fr/sc	no	seine net	culvert
30/05/2007	38	-	yes	n/a	8	scales	yes	seine net	culvert
30/05/2007	40	-	yes	n/a	10	scales	yes	seine net	culvert
30/05/2007	42	-	yes	n/a	11	scales	yes	seine net	culvert
30/05/2007	36	-	yes	n/a	6	scales	yes	seine net	culvert
30/05/2007	39	-	yes	n/a	6	scales	yes	seine net	culvert
30/05/2007	34	-	yes	n/a	8	scales	yes	seine net	culvert
30/05/2007	40	-	yes	n/a	9	scales	yes	seine net	culvert
30/05/2007	35	-	yes	n/a	8	scales	yes	seine net	culvert
30/05/2007	34	dead	yes	n/a	6	ot/sc	no	seine net	culvert
30/05/2007	39.5	dead	yes	n/a	9	ot/sc	no	seine net	culvert
30/05/2007	41	-	yes	n/a	-	scales	yes	seine net	culvert
01/06/2007	38	-	yes	n/a	-	scales	yes	seine net	culvert
01/06/2007	39	-	yes	n/a	-	scales	yes	seine net	culvert
01/06/2007	35	-	yes	n/a	9	scales	yes	seine net	culvert
01/06/2007	39	-	yes	n/a	13	scales	yes	seine net	culvert
01/06/2007	35	-	yes	n/a	8	scales	yes	seine net	culvert
01/06/2007	33	-	yes	n/a	9	scales	yes	seine net	culvert
01/06/2007	-	-	yes	n/a	8	scales	yes	seine net	culvert
01/06/2007	-	-	yes	n/a	-	scales	yes	seine net	culvert
01/06/2007	41	-	yes	n/a	9	scales	yes	seine net	culvert
03/06/2007	34.5	dead	yes	n/a	8	ot/fr/sc	no	seine net	culvert

Table I-3 Longnose Sucker Capture Data

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
26/05/2007	51	111	yes	n/a	12	scales	yes	seine net	culvert
26/05/2007	45	102	yes	n/a	11	scales	yes	seine net	culvert
26/05/2007	48	104	yes	n/a	9	scales	yes	seine net	culvert
26/05/2007	43	105	yes	n/a	9	scales	yes	seine net	culvert
27/05/2007	49	201	yes	female	12	scales	yes	seine net	culvert
27/05/2007	40	212	yes	female	13	scales	yes	seine net	culvert
27/05/2007	50	211	yes	female	14	scales	yes	seine net	culvert
27/05/2007	45	210	yes	male	10	scales	yes	seine net	culvert
27/05/2007	50	205	yes	male	10	scales	yes	hoop net	culvert
27/05/2007	51	202	yes	female	10	scales	yes	seine net	culvert
30/05/2007	50	139	yes	female	13	scales	yes	seine net	culvert
30/05/2007	45.5	129	yes	n/a	13	scales	yes	seine net	culvert
30/05/2007	47	130	yes	n/a	-	scales	yes	seine net	culvert
30/05/2007	41	131	yes	male	-	scales	yes	seine net	culvert
30/05/2007	48	134	yes	male	11	scales	yes	seine net	culvert
30/05/2007	47	135	yes	female	12	scales	yes	seine net	culvert
30/05/2007	46	136	yes	male	11	scales	yes	seine net	culvert
30/05/2007	42	137	yes	male	8	scales	yes	seine net	culvert
30/05/2007	50	141	yes	female	10	scales	yes	hoop net	culvert
30/05/2007	47	142	yes	male	11	scales	yes	seine net	culvert
30/05/2007	54	143	yes	female	-	scales	yes	seine net	culvert
30/05/2007	53.5	144	yes	female	>12	scales	yes	seine net	culvert
01/06/2007	54.5	145	yes	female	-	scales	yes	seine net	culvert
01/06/2007	41	146	yes	female	9	scales	yes	seine net	culvert
01/06/2007	54	147	yes	female	14	scales	yes	seine net	culvert
01/06/2007	45	148	yes	male	12	scales	yes	seine net	culvert
01/06/2007	44	150	yes	male	11	scales	yes	seine net	culvert
01/06/2007	44	51	yes	male	10	scales	yes	seine net	culvert
01/06/2007	49	52	yes	male	13	scales	yes	seine net	culvert

Table I-3 Longnose Sucker Capture Data (continued)

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
01/06/2007	56	54	yes	male	>10	scales	yes	seine net	culvert
01/06/2007	48	55	yes	male	12	scales	yes	seine net	culvert
01/06/2007	45	57	yes	male	8	scales	yes	seine net	culvert
01/06/2007	47	59	yes	male	14	scales	yes	seine net	culvert
01/06/2007	45	60	yes	male	-	scales	yes	seine net	culvert
01/06/2007	48.5	61	yes	female	15	scales	yes	seine net	culvert
01/06/2007	47	62	yes	male	11	scales	yes	seine net	culvert
01/06/2007	45	63	yes	male	10	scales	yes	seine net	culvert
01/06/2007	recap	62	yes	-	11	scales	yes	seine net	culvert
01/06/2007	recap	146	yes	-		scales	yes	seine net	culvert
01/06/2007	recap	61	yes	-	15	scales	yes	seine net	culvert
01/06/2007	-	65	yes	male	10	scales	yes	seine net	culvert
01/06/2007	-	66	yes	male	11	scales	yes	seine net	culvert
01/06/2007	recap	145	yes	-	13	scales	yes	seine net	culvert
01/06/2007	-		yes	male	-	scales	yes	hoop net	culvert

Table I-4 Northern Pike Capture Data

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
26/05/2007	63.5	103	yes	n/a	8	scales	yes	seine net	culvert
26/05/2007	54	108	yes	n/a	8	scales	yes	seine net	culvert
26/05/2007	66	109	yes	n/a	8	scales	yes	seine net	culvert
26/05/2007	55	110	yes	n/a	6	scales	yes	seine net	culvert
26/05/2007	59	112	yes	n/a	7	no	yes	seine net	culvert
26/05/2007	57	117	yes	n/a	6	scales	yes	seine net	culvert
26/05/2007	61	118	yes	n/a	6	scales	yes	seine net	culvert
26/05/2007	65	121	yes	n/a	7	scales	yes	seine net	culvert

Table I-4 Northern Pike Capture Data (continued)

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
26/05/2007	48	123	yes	n/a	6	no	yes	seine net	culvert
26/05/2007	66	124	yes	n/a	-	scales	yes	seine net	culvert
26/05/2007	56	225	yes	n/a	7	scales	yes	seine net	culvert
26/05/2007	53.5	224	yes	n/a	6	no	yes	seine net	culvert
26/05/2007	51	223	yes	n/a	7	no	yes	seine net	culvert
26/05/2007	59.7	101	yes	n/a	-	no	yes	hoop net	Reach 4
27/05/2007	30	none	no	n/a	-	scales	yes	seine net	culvert
27/05/2007	58	219	yes	n/a	-	scales	yes	seine net	culvert
27/05/2007	58	217	yes	n/a	7	scales	yes	seine net	culvert
27/05/2007	58	216	yes	n/a	-	scales	yes	seine net	culvert
27/05/2007	60	214	yes	n/a	8	scales	yes	seine net	culvert
27/05/2007	65	213	yes	n/a	8	scales	yes	seine net	culvert
27/05/2007	68	209	yes	n/a	8	scales	yes	seine net	culvert
27/05/2007	45	208	yes	n/a	6	scales	yes	seine net	culvert
27/05/2007	68	207	yes	n/a	7	scales	yes	seine net	culvert
27/05/2007	45	204	yes	n/a	5	scales	yes	seine net	culvert
27/05/2007	62	203	yes	n/a	8	scales	yes	seine net	culvert
27/05/2007	56	221	yes	n/a	8	scales	yes	seine net	culvert
27/05/2007	55	218	yes	n/a	8	scales	yes	seine net	culvert
27/05/2007	58	215	yes	n/a	8	scales	yes	seine net	culvert
28/05/2007	55	207	yes	n/a	-	scales	yes	seine net	culvert
28/05/2007	52	247	yes	n/a	-	scales	yes	seine net	culvert
28/05/2007	54	248	yes	n/a	5	scales	yes	seine net	culvert
28/05/2007	63.5	250	yes	n/a	7	scales	yes	hoop net	Reach 4
28/05/2007	61	249	yes	n/a	-	scales	yes	hoop net	Reach 4
29/05/2007	61	246	yes	n/a	6	scales	yes	seine net	culvert
30/05/2007	56	242	yes	n/a	-		yes	hoop net	culvert
30/05/2007	61.5	dead 1	yes	female	9	ot/fr/sc	no	hoop net	culvert
30/05/2007	57	126	yes	n/a	5	scales	yes	hoop net	culvert

Table I-4 Northern Pike Capture Data (continued)

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
30/05/2007	64	127	yes	n/a	8	scales	yes	hoop net	culvert
30/05/2007	63	128	yes	n/a	6	scales	yes	hoop net	culvert
30/05/2007	56	dead 2	yes	male	11	ot/fr/sc	no	hoop net	culvert
30/05/2007	58.5	dead 3	yes	female re	9	ot/fr/sc	no	hoop net	culvert
30/05/2007	57.5	dead 4	yes	female	8	ot/fr/sc	no	hoop net	culvert
01/06/2007	56	53	yes	n/a	-	scales	yes	seine net	culvert
01/06/2007	recap	112	yes	n/a	-	scales	yes	seine net	culvert
01/06/2007	60	escaped	yes	n/a	-	no	yes	seine net	culvert
01/06/2007	57.5	64	yes		7	scales	yes	seine net	culvert
01/06/2007	-	69	yes	n/a	-	scales	yes	seine net	culvert
03/06/2007	63	72	yes	n/a	6	scales	yes	seine net	culvert

Table I-5 White Sucker Capture Data

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
29/05/2007	52	244	yes	female	11	scales	yes	seine net	culvert
30/05/2007	45	138	yes	female	9	scales	yes	seine net	culvert
01/06/2007	51	68	yes	female	-	scales	yes	seine net	culvert

Table I-6 Lake Chub Capture Data

Date	Length (cm)	Tag	Mature	Sex	Age	Age Structure	Live Release	Method	Site
01/06/2007	5.3	-	yes	n/a	-	-	no	seine net	culvert

Table I-7 Measured Substrate Size (mm) at Each Egg Site in Reach 4

Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
28	60	45	40	40	48	25	40	10	28	50	24	28
31	63	36	20	41	21	30	22	25	22	170	16	18
30	48	40	34	40	25	22	42	20	33	130	60	30
32	40	30	20	40	23	24	60	31	50	170	48	20
44	44	27	31	35	30	22	30	40	10	80	50	22
18	42	30	30	46	22	22	28	30	30	60	80	22
41	46	91	30	14	10	21	28	21	18	60	46	40
25	50	49	21	48	8	33	28	25	35	170	22	20
29	45	30	42	33	11	18	20	25	25	50	16	20
29	48	32	40	0.8	19	13	32	33	39	40	29	14
18	26	40	30	28	20	11	18	20	44	40	31	12
20	28	39	12	20	39	21	20	20	31	55	28	11
40	31	40	12	33	10	20	14	16	12	43	16	13
39	28	50	19	22	5	11	15	6	54	51	20	16
31	22	29	19	10	7	10	12	10	20	98	21	13
20	20	30	38	0.8	15	10	9	12	30	140	21	15
30	15	41	28	20	9	9	10	14	14	42	30	11
25	38	40	27	12	16	31	20	14	11	30	58	11
12	30	99	20	20	17	18	22	10	41	32	19	10
21	31	130	21	20	13	10	11	16	25	20	52	11
22	31	35	20	10	30	8	11	15	38	62	32	10
20	88	40	30	36	20	8	30	11	20	21	29	18
22	40	40	17	18	25	16	30	8	44	22	30	13
10	30	20	50	40	8	10	24	11	30	22	39	10
8	40	30	40	44	12	12	33	8	21	12	62	40
10	48	20	40	30	13	14	30	6	26	16	13	22
18	41	24	38	20	10	44	10	10	15	42	10	32
30	40	16	40	39	10	3.8	11	28	21	10	10	12
10	31	22	21	25	8	2.7	40	22	26	10	20	27
10	30	18	28	30	15	33	30	-	25	53	10	32

mm = millimetres.

Table I-8 Results of Water Quality Samples Taken in Reach 4, 2007

Sample ID	Reach 4 Sample 1	Field Blank	Travel Blank	Detection Limits	Reach 4 Sample 2	Field Blank	Travel Blank	Detection Limits	Units
Date Sampled	05-JUN-07	05-JUN-07	05-JUN-07		08-AUG-07	08-AUG-07	08-AUG-07		
Time Sampled	15:07	15:07	15:07		14:45	00:00	00:00		
ALS Sample ID	L514008-1	L514008-2	L514008-3		L539674-1	L539674-2	L539674-3		
Matrix	Water	Water	Water		Water	Water	Water		
Physical Tests									
Hardness (as CaCO3)	45.9	<0.50	<0.50	0.5	388	<0.50	<0.50	0.5	mg/L
Conductivity	94.4	<2.0	<2.0	2	848	<2.0	<2.0	2	µS/cm
pH	7.48	5.79	5.66	0.01	7.94	5.53	5.52	0.01	pH
Total Dissolved Solids	78.0	<1.2	<1.2	10	653	<1.2	<1.2	1.2	mg/L
Total Suspended Solids	1.5	<1.0	<1.0	1	1.6	<1.0	<1.0	1	mg/L
Turbidity	1.25	<0.10	<0.10	0.1	1.80	<0.10	<0.10	0.1	NTU
Anions and Nutrients									
Ammonia as N	0.0135	<0.0050	<0.0050	0.005	0.0165	<0.0050	<0.0050	0.005	mg/L
Acidity (as CaCO3)	4.6	1.6	1.6	1	1.7	1.1	1.1	1	mg/L
Alkalinity, Total (as CaCO3)	39.6	<1.0	<1.0	1	66.3	<1.0	<1.0	1	mg/L
Alkalinity, Carbonate (as CaCO3)	<1.0	<1.0	<1.0	1	-	-	-	-	mg/L
Alkalinity, Hydroxide (as CaCO3)	<1.0	<1.0	<1.0	1	-	-	-	-	mg/L
Alkalinity, Total (as CaCO3)	39.6	<1.0	<1.0	1	-	-	-	-	mg/L
Chloride (Cl)	3.12	<0.50	<0.50	1	61.6	<0.50	<0.50	0.5	mg/L
Fluoride (F)	0.070	<0.020	<0.020	0.5	0.105	<0.020	<0.020	0.02	mg/L
Sulfate (SO4)	5.18	<0.50	<0.50	0.02	274	<0.50	<0.50	0.5	mg/L
Sulphide as S	<0.020	<0.020	<0.020	0.5	<0.020	<0.020	<0.020	0.02	mg/L
Nitrate and Nitrite as N	-	-	-	0.02	0.513	<0.0050	<0.0050	0.005	mg/L
Total Kjeldahl Nitrogen	0.626	<0.050	<0.050	0.05	0.877	<0.050	<0.050	0.05	mg/L
Total Dissolved Phosphate As P	0.0061	<0.0020	<0.0020	0.002	0.0129	<0.0020	<0.0020	0.002	mg/L
Total Phosphate as P	0.0150	<0.0020	<0.0020	0.002	0.0182	<0.0020	<0.0020	0.002	mg/L
Cyanides									
Cyanide, Total	0.0083	<0.0050	<0.0050	0.005	0.0100	<0.0050	<0.0050	0.005	mg/L

Table I-8 Results of Water Quality Samples Taken in Reach 4, 2007 (continued)

Sample ID	Reach 4 Sample 1	Field Blank	Travel Blank	Detection Limits	Reach 4 Sample 2	Field Blank	Travel Blank	Detection Limits	Units
Total Metals									
Aluminum (Al)-Total	0.0329	<0.0010	<0.0010	0.001	0.0221	<0.0010	<0.0010	0.002	mg/L
Antimony (Sb)-Total	0.00341	<0.00010	<0.00010	0.0001	0.0731	<0.00010	<0.00010	0.0002	mg/L
Arsenic (As)-Total	0.0558	<0.00010	<0.00010	0.0001	0.253	<0.00010	<0.00010	0.0002	mg/L
Barium (Ba)-Total	<0.010	<0.010	<0.010	0.01	0.029	<0.010	<0.010	0.01	mg/L
Beryllium (Be)-Total	<0.0050	<0.0050	<0.0050	0.005	<0.0050	<0.0050	<0.0050	0.005	mg/L
Bismuth (Bi)-Total	<0.20	<0.20	<0.20	0.2	<0.20	<0.20	<0.20	0.2	mg/L
Boron (B)-Total	<0.10	<0.10	<0.10	0.1	<0.10	<0.10	<0.10	0.1	mg/L
Cadmium (Cd)-Total	<0.000050	<0.000050	<0.000050	0.00005	<0.00010	<0.000050	<0.000050	0.0001	mg/L
Calcium (Ca)-Total	12.7	<0.050	<0.050	0.05	118	<0.050	<0.050	0.05	mg/L
Chromium (Cr)-Total	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	0.01	mg/L
Cobalt (Co)-Total	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	0.01	mg/L
Copper (Cu)-Total	0.00361	<0.00010	<0.00010	0.0001	0.0129	<0.00010	<0.00010	0.0002	mg/L
Iron (Fe)-Total	0.093	<0.010	<0.010	0.01	0.075	<0.010	<0.010	0.01	mg/L
Lead (Pb)-Total	0.000170	<0.000050	<0.000050	0.00005	0.00015	<0.000050	<0.000050	0.0001	mg/L
Lithium (Li)-Total	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	0.01	mg/L
Magnesium (Mg)-Total	4.07	<0.10	<0.10	0.1	24.8	<0.10	<0.10	0.1	mg/L
Manganese (Mn)-Total	0.0203	<0.0050	<0.0050	0.005	0.0095	<0.0050	<0.0050	0.005	mg/L
Mercury (Hg)-Total	<0.00020	<0.00020	<0.00020	0.0002	<0.00020	<0.00020	<0.00020	0.0002	mg/L
Molybdenum (Mo)-Total	0.000471	<0.000050	<0.000050	0.00005	0.00390	<0.000050	<0.000050	0.0001	mg/L
Nickel (Ni)-Total	0.00075	<0.00050	<0.00050	0.0005	0.0083	<0.00050	<0.00050	0.001	mg/L
Phosphorus (P)-Total	<0.30	<0.30	<0.30	0.3	<0.30	<0.30	<0.30	0.3	mg/L
Potassium (K)-Total	<2.0	<2.0	<2.0	2	3.7	<2.0	<2.0	2	mg/L
Selenium (Se)-Total	<0.0010	<0.0010	<0.0010	0.001	<0.0020	<0.0010	<0.0010	0.002	mg/L
Silicon (Si)-Total	0.253	<0.050	<0.050	0.05	0.568	<0.050	<0.050	0.05	mg/L
Silver (Ag)-Total	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	0.01	mg/L
Sodium (Na)-Total	4.3	<2.0	<2.0	2	32.3	<2.0	<2.0	2	mg/L
Strontium (Sr)-Total	0.0479	<0.0050	<0.0050	0.005	0.734	<0.0050	<0.0050	0.005	mg/L
Thallium (Tl)-Total	<0.20	<0.20	<0.20	0.2	<0.20	<0.20	<0.20	0.2	mg/L

Table I-8 Results of Water Quality Samples Taken in Reach 4, 2007 (continued)

Sample ID	Reach 4 Sample 1	Field Blank	Travel Blank	Detection Limits	Reach 4 Sample 2	Field Blank	Travel Blank	Detection Limits	Units
Tin (Sn)-Total	<0.030	<0.030	<0.030	0.03	<0.030	<0.030	<0.030	0.03	mg/L
Titanium (Ti)-Total	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	0.01	mg/L
Uranium (U)-Total	0.000209	<0.000010	<0.000010	0.00001	0.000811	<0.000010	<0.000010	0.00002	mg/L
Vanadium (V)-Total	<0.030	<0.030	<0.030	0.03	<0.030	<0.030	<0.030	0.03	mg/L
Zinc (Zn)-Total	<0.0040	<0.0040	<0.0040	0.004	0.0045	<0.0040	<0.0040	0.004	mg/L
Dissolved Metals									
Aluminum (Al)-Dissolved	<0.0090	-	-	0.009	<0.0070	-	-	0.007	mg/L
Antimony (Sb)-Dissolved	0.00331	-	-	0.0001	0.0731	-	-	0.0002	mg/L
Arsenic (As)-Dissolved	0.0494	-	-	0.0001	0.237	-	-	0.0002	mg/L
Barium (Ba)-Dissolved	<0.010	-	-	0.01	0.028	-	-	0.01	mg/L
Beryllium (Be)-Dissolved	<0.0050	-	-	0.005	<0.0050	-	-	0.005	mg/L
Bismuth (Bi)-Dissolved	<0.20	-	-	0.2	<0.20	-	-	0.2	mg/L
Boron (B)-Dissolved	<0.10	-	-	0.1	<0.10	-	-	0.1	mg/L
Cadmium (Cd)-Dissolved	<0.000050	-	-	0.00005	<0.00010	-	-	0.0001	mg/L
Calcium (Ca)-Dissolved	12.2	-	-	0.05	115	-	-	0.05	mg/L
Chromium (Cr)-Dissolved	<0.010	-	-	0.01	<0.010	-	-	0.01	mg/L
Cobalt (Co)-Dissolved	<0.010	-	-	0.01	<0.010	-	-	0.01	mg/L
Copper (Cu)-Dissolved	0.00304	-	-	0.0001	0.0115	-	-	0.0002	mg/L
Iron (Fe)-Dissolved	0.01	-	-	0.01	0.01	-	-	0.01	mg/L
Lead (Pb)-Dissolved	<0.000050	-	-	0.00005	<0.00010	-	-	0.0001	mg/L
Lithium (Li)-Dissolved	<0.010	-	-	0.01	<0.010	-	-	0.01	mg/L
Magnesium (Mg)-Dissolved	3.77	-	-	0.1	24.4	-	-	0.1	mg/L
Manganese (Mn)-Dissolved	<0.0050	-	-	0.005	<0.0050	-	-	0.005	mg/L
Mercury (Hg)-Dissolved	<0.00020	-	-	0.0002	<0.00020	-	-	0.0002	mg/L
Molybdenum (Mo)-Dissolved	0.000456	-	-	0.00005	0.00388	-	-	0.0001	mg/L
Nickel (Ni)-Dissolved	0.00079	-	-	0.0005	0.0081	-	-	0.001	mg/L
Phosphorus (P)-Dissolved	<0.30	-	-	0.3	<0.30	-	-	0.3	mg/L
Potassium (K)-Dissolved	<2.0	-	-	2	3.7	-	-	2	mg/L
Selenium (Se)-Dissolved	<0.0010	-	-	0.001	<0.0020	-	-	0.002	mg/L

Table I-8 Results of Water Quality Samples Taken in Reach 4, 2007 (continued)

Sample ID	Reach 4 Sample 1	Field Blank	Travel Blank	Detection Limits	Reach 4 Sample 2	Field Blank	Travel Blank	Detection Limits	Units
Silicon (Si)-Dissolved	0.143	-	-	0.05	0.503	-	-	0.05	mg/L
Silver (Ag)-Dissolved	<0.010	-	-	0.01	<0.010	-	-	0.01	mg/L
Sodium (Na)-Dissolved	2.9	-	-	2	32.0	-	-	2	mg/L
Strontium (Sr)-Dissolved	0.0453	-	-	0.005	0.725	-	-	0.005	mg/L
Thallium (Tl)-Dissolved	<0.20	-	-	0.2	<0.20	-	-	0.2	mg/L
Tin (Sn)-Dissolved	<0.030	-	-	0.03	<0.030	-	-	0.03	mg/L
Titanium (Ti)-Dissolved	<0.010	-	-	0.01	<0.010	-	-	0.01	mg/L
Uranium (U)-Dissolved	0.000200	-	-	0.00001	0.000829	-	-	0.00002	mg/L
Vanadium (V)-Dissolved	<0.030	-	-	0.03	<0.030	-	-	0.03	mg/L
Zinc (Zn)-Dissolved	<0.004	-	-	0.004	0.004	-	-	0.004	mg/L
Aggregate Organics									
Oil and Grease	<1.0	<5.0	<5.0	1	-	<1.0	<1.0	-	mg/L
Organic Parameters									
Dissolved Organic Carbon	13.5	<0.50	<0.50	0.5	11.5	-	<0.50	0.5	mg/L
Total Organic Carbon	14.1	<0.50	<0.50	0.5	12.8	<0.50	<0.50	0.5	mg/L
Radiological Parameters									
Radium-226	<0.005	0.007	<0.005	0.005	<0.005	<0.005	<0.005	0.005	Bq/L

Table I-9 Habitat Measurements along Transect 5 Where Adult Arctic Grayling Were Seen in Reach 4

Site	Velocity (m/s)	Substrate	Depth (cm)
RUB 1	0.12	gravel	40
2	0.22	gravel	32
3	0.26	gravel	36
4	0.38	gravel	43
5	0.35	gravel	38
6	0.52	gravel + cobble	44
7	0.62	gravel + cobble	38
8	0.38	gravel + cobble	26
LUB 9	0.20	gravel + cobble	20

Measurements taken at 1 meter intervals from RUB – right upstream bank.
LUB – left upstream bank.

Table I-10 Bottom Water Velocity along Habitat Transects in Reach 4

	Transect Number									
	1	2	3	4	5	6	7	8	9	10
	0.65	0.5	0.43	0	0.91	0.42	0.59	0.52	1.2	0.4
	0.22	0.59	0.52	0.02	1.6	0.5	0.69	0.52	1.4	1.3
	0.34	0.69	0.62	0.02	3.4	too deep for further measurements	0.22	0.53	1	2.1
	0.44	0.34	0.65	0.01			0.12	0.48	0.3	2.2
	0.56	0.17	0.61	0.2			0.24	0.51		1.97
			0.41	0.23			0.2	0.48		
				0.17			0.2			
				0.42			0.15			
				0.57						
				0.66						
range	0.22-0.65	0.17-0.69	0.41-0.65	0.00-0.66	0.91-3.40	0.42-0.50	0.12-0.69	0.48-0.53	0.3-1.4	0.4-2.2
mean	0.44	0.46	0.54	0.23	1.97	0.46	0.3	0.51	0.98	1.59

Table I-11 Water Temperature – Data Logger

Date	Temperature(ºC)	
	mean	max
6/05/07	14.499	14.840
6/06/07	13.198	14.337
6/07/07	13.491	14.409
6/08/07	11.981	12.534
6/09/07	12.556	14.218
6/10/07	14.241	15.581
6/11/07	15.687	17.130
6/12/07	17.137	18.771
6/13/07	17.818	18.842
6/14/07	17.837	18.438
6/15/07	16.783	17.677
6/16/07	16.845	18.295
6/17/07	16.502	17.486
6/18/07	15.515	16.463
6/19/07	14.481	15.008
6/20/07	13.547	14.361
6/21/07	13.887	15.891
6/22/07	14.727	15.867
6/23/07	16.284	18.889
6/24/07	18.268	20.841
6/25/07	19.858	22.034
6/26/07	20.355	21.819
6/27/07	20.076	21.628
6/28/07	20.295	22.178
6/29/07	19.770	20.674
6/30/07	20.068	22.393
7/01/07	18.893	20.055
7/02/07	19.563	22.298
7/03/07	20.287	22.489
7/04/07	19.807	21.366
7/05/07	18.816	19.960
7/06/07	18.006	19.436
7/07/07	17.986	19.508
7/08/07	19.067	21.652
7/09/07	19.511	20.960
7/10/07	19.695	21.939
7/11/07	19.221	20.793
7/12/07	20.468	23.160
7/13/07	21.123	22.753
7/14/07	21.990	24.363
7/15/07	22.062	23.761

Table I-11 Water Temperature – Data Logger (continued)

Date	Temperature(ºC)	
	mean	max
7/16/07	22.465	24.557
7/17/07	22.611	25.355
7/18/07	21.522	23.376
7/19/07	21.622	23.160
7/20/07	22.597	24.291
7/21/07	19.900	21.509
7/22/07	20.024	22.681
7/23/07	21.369	23.930
7/24/07	21.166	23.400
7/25/07	18.808	20.365
7/26/07	18.722	20.817
7/27/07	18.141	19.175
7/28/07	18.832	21.366
7/29/07	19.606	21.843
7/30/07	20.069	22.298
7/31/07	19.320	20.388
8/01/07	18.773	20.627
8/02/07	19.700	21.390
8/03/07	20.117	22.130
8/04/07	20.353	21.748
8/05/07	19.370	21.437
8/06/07	18.277	18.889
8/07/07	17.190	18.010
8/08/07	15.123	17.058
8/09/07	18.913	20.269
8/10/07	19.919	20.817
8/11/07	19.430	20.198
8/12/07	20.183	20.555
8/13/07	20.573	21.485
8/14/07	20.940	21.533
8/15/07	21.378	22.441
8/16/07	22.371	23.761
8/17/07	21.397	21.939
8/18/07	21.337	22.154
8/19/07	21.799	22.345
8/20/07	23.010	24.750
8/21/07	22.489	24.460
8/22/07	20.148	20.936
8/23/07	20.355	21.342
8/24/07	20.607	21.390
8/25/07	20.410	20.865

Table I-11 Water Temperature – Data Logger (continued)

Date	Temperature(ºC)	
	mean	max
8/26/07	20.129	20.484
8/27/07	20.553	21.461
8/28/07	19.950	20.436
8/29/07	19.703	20.889
8/30/07	21.150	23.184
8/31/07	22.434	23.328
9/01/07	21.162	21.700
9/02/07	21.157	21.819
9/03/07	21.070	21.700
9/04/07	21.125	21.676
9/05/07	20.941	21.557
9/06/07	21.048	22.298

APPENDIX II

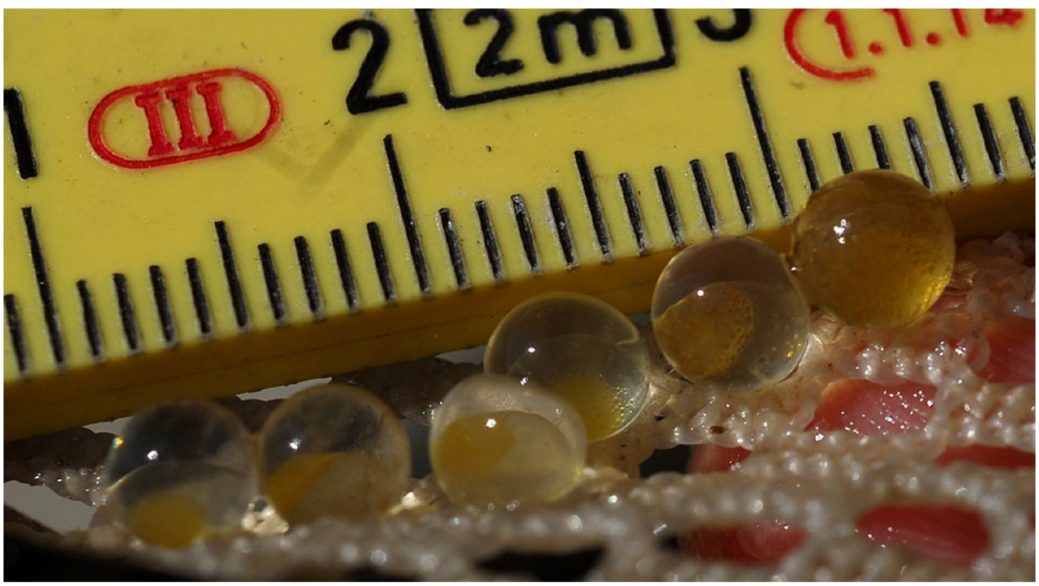
SUMMARY OF LIFE HISTORY OF FISH SEEN IN BAKER CREEK

May 18, 2007 Ice still blocking culvert but water is flowing underneath.
Water temperature 4.6°C and four pike observed in slack water in upper portion of pool directly below the culvert spillway. Ice and snow pack still present along shoreline.

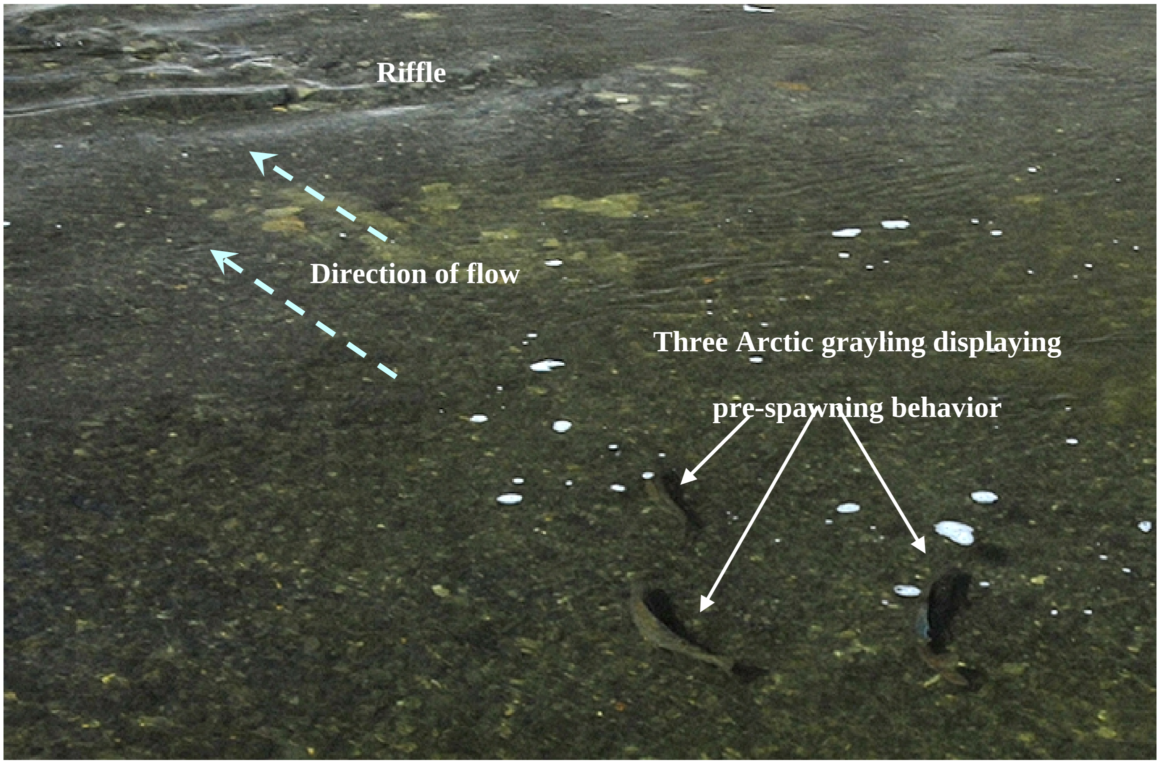
May 21, 2007 Six pike observed below culvert. Lots of ice still in culvert.

May 24, 2007 Preliminary survey undertaken of Reach 4 and lower portion of Baker Creek in order to determine sampling methods.

May 25, 2007 (Official start of project). Hoop net installed in rapids well below Reach 4. Later in the day, it is removed and installed in the gorge below the new bridge in Reach 4.



May 26, 2007 Hoop net set from previous day is pulled and has one pike. Seining at culvert captured many pike. Early stage of longnose sucker spawning run with several "unripe" specimens captured. Seining attempted for capturing adult spawning grayling but with no success. However, first grayling eggs were collected in the swift run above riffle 1. The eggs were photographed and all were viable eggs with cell division apparent.



May 27, 2007 Similar to preceding day with pike dominating the catch with more, early running longnose suckers. First lake whitefish captured. More grayling eggs found in Reach 4.

May 28, 2007 A few pike caught at culvert and among them was our first recapture. Hoop net upstream in Reach 4 captures two pike. Stickleback swarms present throughout entire section of Baker Creek below culvert.

May 29, 2007 Few fish caught at culvert but among them is first white sucker of the year. Hoop net installed in most furthest downstream section of Baker Creek, 100 m below culvert. Hoop net is positioned to capture fish leaving the system. Primarily targeting post spawn grayling.

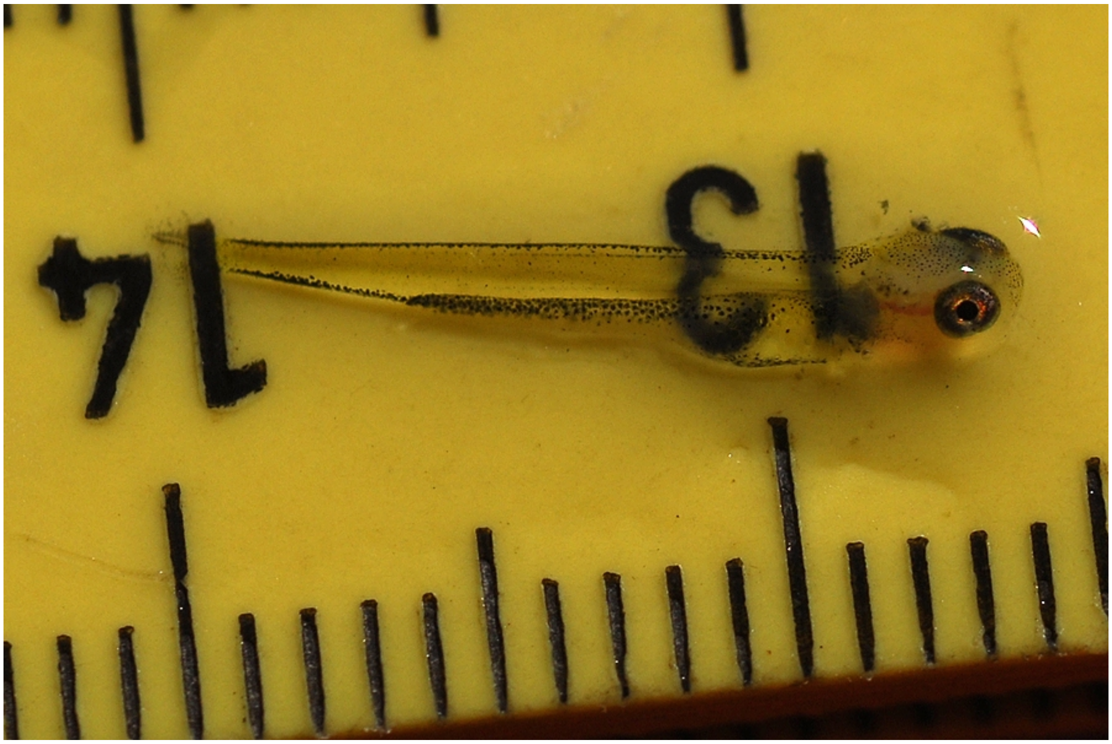
May 30, 2007 Hoop net captures pike and whitefish with first mortalities of the season. Different ageing structures taken to validate ageing methods. Many pike, whitefish and longnose suckers captured in pool below culvert. Longnose sucker spawning approaching peak with many "ripe and running" fish captured. More eggs found at various locations above every riffle in Reach 4.

May 31, 2007 All activity centered in Reach 4. More grayling eggs found with well developed embryos visible inside eggs. Every glide just upstream of a riffle seems to have egg sites. Photos taken of all egg sites with ruler on substrate.

June 1, 2007 First longnose suckers observed in lower Reach 4 in last riffle before bridge. Below culvert, longnose sucker spawning activity and abundance has peaked. Northern pike virtually gone from area but second recapture of this species occurs on this day. Four longnose sucker recaptures also take place on June 1. The only lake chub in the course of this study is captured. Several lake whitefish caught. Sticklebacks are everywhere with swarms right below culvert

June 2, 2007 Longnose sucker numbers peak in Reach 4 with spawning observed and photographed. Also, two whitefish were seen milling with suckers. A single white sucker seen holding with longnose suckers. All sucker observations restricted to pools above riffle 7 and 6. No seining below culvert.

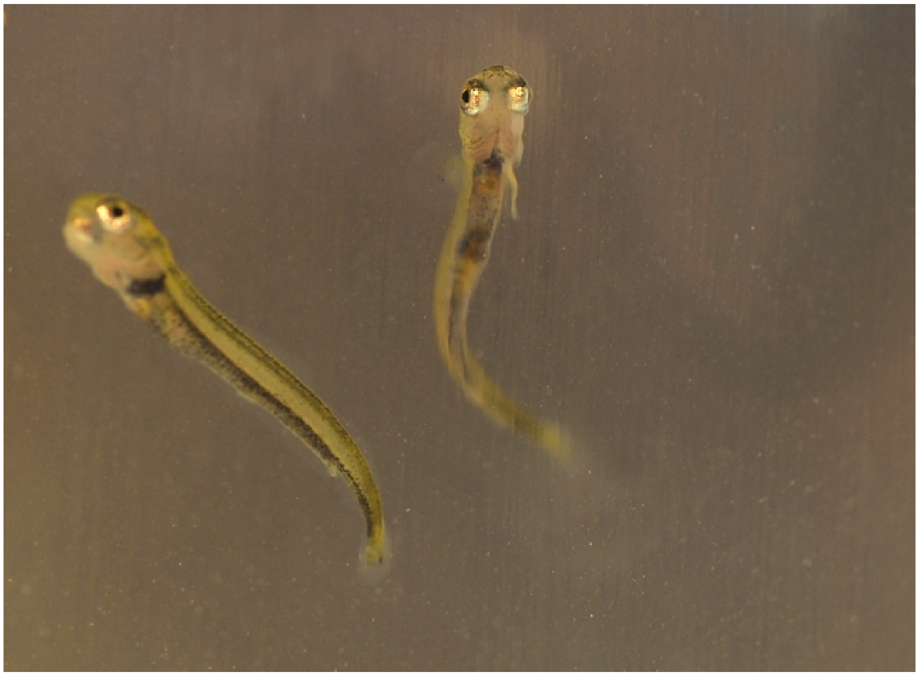
June 3, 2007 Baker Creek below culvert no longer full of fish. A single whitefish and pike are caught. Otherthan the continued presence of sticklebacks, these represent the last fish captures in the area.



June 5, 2007 Emergence of YOY grayling. Large numbers captured (by seining) in the side pool between riffle 6 and 7. Protolarvae photographed and measured. YSI used to take complete set of water quality parameters. First longnose sucker eggs found in lower Reach 4.

June 6, 2007 Underwater video taken by means of attaching video lens head to pole and lowered into are were Protolarvae were observed the previous day but where now filmed in their natural habitat. At this stage, YOY are scattered in the water column and do not seem associated to particular substrate type.

June 7, 2007 YOY grayling spreading out in terms of locations in Reach 4.



June 9, 2007 YOY grayling observed throughout entire length of Reach 4 but holding in slow shoreline waters.

June 10, 2007 Last suckers in Reach 4 observed while snorkelling in area under walk bridge. Longnose sucker eggs found in location where spawning was observed. Eggs were clearly eyed and viable. More seining done to capture a few mesolarvae grayling to document development. Dip net catches some aquatic insects.

June 12, 2007 Snorkelling done with underwater video probe. Lots of good footage taken showing mesolarval/juvenile transition stage and their use of habitat in Reach 4. Last day of seeing longnose suckers.

June 14, 2007 General survey of Reach 4 continued. Two adult grayling observed in large pool above riffle 2.

June 15, 2007 Observed 1 pike and 2 grayling in pool above riffle 2. Snorkelling revealed YOY grayling have now spread out through reach 4 and are holding in areas of slow current along shore but also in main channel. High concentrations drawn to boulders placed in midstream, particularly in pool above riffle 1.

June 20, 2007 Snorkelled and observed that YOY grayling are fully developed juveniles. They are now more attracted to fast flows and avoid slack water. Enormous numbers of black fly larvae observed on all rock substrate surfaces in areas of moving water. Other insect larvae also observed. Juvenile grayling gap size can accommodate black fly larvae but primary food source seems to be zooplankton in the drift.

June 27, 2007 Snorkelled and YOY grayling observed in mid-riffle runs. Several were captured using dip net and photographed to show advanced stage of development. Black fly larvae use of large gravel and cobble photographed.

June 29, 2007 Juvenile grayling have all outmigrated. Thorough search by snorkelling revealed not a single one left in Reach 4.