2011 Fisheries and Aquatic Investigation

Clowhom River Sustainable Energy Project

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ECL ENVIRONMENTAL SOLUTIONS

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DEFINITIONS AND ACRONYMS

"The Project"	The Clowhom River Sustainable Energy Project
"The Project/Study Area"	The Project/Study Area boundary encompasses the area above the headpond of the Upper Clowhom River hydroelectric generating station, including Phantom Lake and several reaches of the Clowhom River extending above the lake.
"Blue Listed Species"	Includes any indigenous species or subspecies considered to be vulnerable in British Columbia.

BC	British Columbia
BCEAA	*British Columbia Environmental Assessment Act*
BEC	Biogeoclimatic Ecosystem Classification
CABIN	Canadian Aquatic Biomonitoring Network
CC	Consultative Committee
CCT	Coastal Cutthroat Trout
CT	Cutthroat Trout
CEAA	*Canadian Environmental Assessment Act*
CPUE	Catch Per Unit Effort
CRSEP	Clowhom River Sustainable Energy Project
CV	Coefficient of Variation
CWH	Coastal Western Hemlock
DFO	Federal Department of Fisheries and Oceans
ECL	ECL Environmental Solutions Inc.
EA	Environmental Assessment
EM	Environmental Monitor
EMP	Environmental Management Plan
EMS	Environmental Management System
EF	Electrofishing
FDIS	Field Data Information System
FISS	Fisheries Information Summary System
FL	Fork Length
GN	Gill Net
GPS	Global Positioning System
HADD	Harmful Alteration, Disruption, or Destruction (of fish habitat)
IFR	Instream Flow Requirements
ILMB	Integrated Land Management Bureau
IUP	Investigative Use Permit
LWD	Large Woody Debris
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations

MOE	Ministry of Environment
MH	Mountain Hemlock
MT	Minnow Trap
MW	One Megawatt = 1 Million Watts
RB	Rainbow Trout
RISC	Resources Information Standards Committee (formerly RIC)
RMA	Riparian Management Area
SARA	Federal Species at Risk Act
UCRHPP	Upper Clowhom River Hydroelectric Power Plant
UTM	Universal Transverse Mercator
VEC	Valued Ecosystem Component

WAYPOINT DATA

- Previous Investigations
  - PGL 2007
  - PGL 2008
  - PGL 2009
- ECL – October 19th, 2011
  - Reach and Habitat Information
  - Gill Net Locations
  - Minnow Trap Locations
  - Electrofishing Locations
- ECL – October 20th, 2011
  - Reach and Habitat Information
  - Minnow Trap Locations
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Each link opens a *.kmz file in Google Earth®. To download a free version of the Google Earth® software interface, go to www.earth.google.com.

1.0 INTRODUCTION

ECL Environmental Solutions (ECL) completed a baseline inventory of fish and fish habitat in the uppermost region of the Clowhom watershed in the South Coast Region of the Province of British Columbia. For complete site information refer to the Watershed Overview Map (Appendix 1) of this report. Fish collection and fish habitat characterization in this inventory includes aquatic habitats in the stream system in the vicinity of the proposed 15 MW small hydro development referred to as the Clowhom River Sustainable Energy Project (CRSEP; the Project).

This report has been prepared by ECL for the Proponent. It is an examination of the baseline conditions of the aquatic ecosystems within which the Project is located. This examination is a necessary step in determining whether the Project has any potential to cause harmful alteration, disruption, or destruction (HADD) of fish habitat as defined under the federal *Fisheries Act.* It is also a requirement for determining the extent to which an instream flow assessment must be completed in order to identify and set sufficient instream flow requirements (IFRs) for fish within and downstream of the proposed diversion reaches. The 2011 Fisheries and Aquatic Investigation will provide aquatic baseline characteristics of fish and fish habitat based on provincial standards and guidelines (i.e. RISC 2001). The assessment includes both stream and lake components.

1.1 Phantom Lake

Phantom Lake (WBID: 00216JERV) is a hanging lake near the headwaters of the Clowhom drainage. The lake sits in a post-glacial geomorphic recess above an outlet forming Phantom Falls. The multi-stepped falls has a total drop of 250m to 300m, although the exact height of the falls isn't known. Greenfield (2009) suggested the tallest drop to be about 100 meters. In either case the falls are an obvious barrier to fish passage. The secondary north outlet north and the main outlet eventually meet at the base of the rock face. Both outlet falls are barriers to fish movement upstream. There are no roads into Phantom Lake and its elevation and remoteness make it inaccessible, except to float planes, helicopters, and hikers (Figure 1.1).

Records for Phantom Lake have reported the presence of wild indigenous cutthroat trout (CT; FISS 2011), a blue-listed under Provincial designation (CDC 2011). The Habitat Wizard Lakes Report for Phantom Lake likewise lists CT as present (MOE 2011), presumably from the same data source (i.e., January 1995). Recent observations of fish species in the lake have documented rainbow trout RB to be present, but not CT (PGL 2008, 2009) and there are no records of historic stocking activity for Phantom Lake (MOE 2011). Interestingly, a report from Winslow (1927) issued a recommendation to stock a nearby second "Phantom" Lake (now called Browning) located 30km directly southeast along Highway 99 and flowing into Howe Sound near Brittania Beach. The species recommended was rainbow trout (Winslow 1927) and there is an extensive stocking record dating back to 1928 (MOE 2011).

Figure 1.1 Aerial view of the south end of Phantom Lake, the main outlet and Phantom Falls (left) and the secondary outlet to the North (right).

There are reaches of the Clowhom River that flow into Phantom Lake on the north end forming a delta (Figure 1.2). There are two primary channels that merge upstream of the delta. This section of the Clowhom River likely supports spawning habitat for the lake's trout populations.

Figure 1.2 View of the north end of Phantom Lake and the delta formed by inputs from the Clowhom River above.

1.2 CLOWHOM RIVER

The Clowhom River (WSC 900-178900) is a fourth order stream flowing west into the Salmon Inlet from its origin at Mount Jimmy Jimmy of the Tantalus Range in the South Coast Mountains of the Province of British Columbia. The Salmon Inlet is part of a remote fjord system that branches south off the larger Jervis Inlet, then east off Sechelt Inlet. The mouth of the Clowhom River system contains a hydroelectric dam located at the outlet of Lower Clowhom Lake approximately 30 km northeast of the community of Sechelt on the Sunshine Coast of British Columbia (see Figure 1.3).

The river system below Phantom Lake has historically been subject to extensive development activity directed at both terrestrial and aquatic resources. Based on an aerial examination, the primary resource development activities include forestry (logging) and hydroelectric power generation (both storage dam and run-of-river). Resource roads extend up the drainage from the BC Hydro dam at Lower Clowhom Lake built in 1958 (BC Hydro 2005) to the Lower Clowhom and Upper Clowhom run-of-river projects owned and operated by Hydromax Energy Ltd. A resource road continues up the drainage to the intake and headpond of UCPHPP, directly below the Project.

Fisheries resources in the Clowhom River have been influenced by the hydroelectric developments. Initial impoundment of Clowhom Lake above the Clowhom Dam required implementation of a water use plan (WUP) to monitor and evaluate effects to fish and wildlife (BC Hydro 2005). Prior to the construction of the dam, notable resource ecologists at UBC provided the Province with information on the status of the Clowhom system and its fisheries, which included Kamloops (i.e., rainbow) trout (RB) *Oncorhynchus mykiss* and [coastal] cutthroat trout (CCT) *O. clarki* (Smith and Larkin 1950; Northcote *et al.* 1950). The Habitat Wizard Streams Report from the Ministry of Environment (MOE 2011) lists a presence of the following species in the Clowhom River:

- Chum salmon - *Oncorhynchus keta*
- Coastal cutthroat trout - *O. clarki clarki*
- Rainbow trout and steelhead - *O. mykiss*
- Dolly Varden char - *Salvelinus malma*
- Prickly sculpin - *Cottus asper*
- Sculpin - *Cottus spp.*

Chum salmon and steelhead observations have only occurred below the dam, presumably in spawning habitats for anadromous salmonid species. The Streams Report also does not contain any stocking information for the river (MOE 2011), although it is plausible that rainbow trout, which had previously been identified as Kamloops trout for this system (Smith and Larkin 1950; Northcote *et al.* 1950) may have been stocked in the lake prior to the dam's construction. Withler (1956) noted the significance of only cutthroat trout habitat in his evaluation of the Clowhom Dam's potential to affect spawning in the littoral and stream sections of the lake.

There are recorded observations of Dolly Varden char DV and RB in the upper portion of the Clowhom River (MOE 2011). Based on aerial observation of the pre-existing reach between the lake and inlet, DV is presumed to be non-anadromous, unless this reach had originally permitted passage of anadromous species prior to the dam construction (Figure 1.3). An uncertainty identified by the Consultative Committee (CC) for the Clowhom Lake WUP monitoring program postulated that sockeye salmon *Oncorhynchus nerka* previously spawned in the lake and was important as a nutrient input to lake productivity (Bruce 2003; BC Hydro 2005). Rainbow trout has been observed throughout the Clowhom

River including the uppermost reaches in the Project Area (PGL 2007, 2008, and 2009). Dolly Varden has not been observed above the UCRHPP.

Figure 1.3 Aerial view of the Clowhom River reach section between the Salmon Inlet below and Clowhom Lake above the dam.

2.0 METHODS

The collection of fisheries data in the Project Area took place on October 19th to 25th, 2011. For this report, the methodology has been largely discussed in two spatial units: Phantom Lake and Clowhom River.

The scope of this investigation considered lake sampling for fish in Phantom Lake, which includes the Clowhom River flowing into the lake above the delta on the north end. The delta's main channel PL1 has a primary side tributary PL2A. Below the lake outlets are lower sections of the Clowhom River, one channel at the main outlet CR4 and a secondary channel at the north outlet CR4A. Both outlets are located at the south end of the lake above Phantom Falls. The gear types employed for fish sampling in the Phantom Lake component consisted of gill nets (GN) set in the lake and minnow traps (MT) set in the lake's littoral zone, outlet channels, and the upper reaches above the delta. Finally, ECL also sampled for fish in the upper reaches above the delta using a Smith-Root® LR24 backpack electrofisher (EF). Stream habitats above the delta have been assumed as important to the lake's fish production in terms of spawning and rearing habitat.

Sampling in the Clowhom River included EF passes in the reaches below Phantom Falls and above the UCRHPP intake and headpond. For this initial investigation, ECL did not sample aquatic habitats adjacent to the diversion reaches, including Q Creek and the UCRHPP headpond; only the diversion reaches were of interest.

2.1 PHANTOM LAKE FISH SAMPLING

Lake sampling commenced on October 19 and ECL set one 50-m long gill net near the outlets on the south end (Site GN1) and a second gill net at the north end of the lake near the delta (Site GN2; Figure 2.1). Click here to view the GN waypoints in Google Earth®. ECL used a Hummingbird® depth sounder to explore the lake with a motorized zodiac and determine optimal locations for gill net placement based on the densities observed by the depth sounder. Nine large collapsible minnow traps were positioned in five locations of the littoral zone around the delta on the north end of the lake (Sites MT5-MT8 and MT12; see Table 1). ECL baited the traps with oatmeal infused with anise seed oil, known to be an effective attractant (Wilkinson 2009).

Figure 2.1 Location of gill net (Site GN2) set in Phantom Lake at the north end near the delta

On October 19, ECL placed and additional nine traps in three locations of this reach (Sites MT9-MT11), three of which were the larger collapsible type and six more minnow traps (i.e., Gee traps). The collapsible traps are selective for small and large fish (>70mm FL) and the Gee traps are selective for juvenile fish only (<150mm FL; see Figure 2.2). The confluence of the principal side tributary formed Reach Break 1. Click here to view all locations of MT placement on October 19th, 2011 in Google Earth®.

ECL then conducted electrofishing surveys on the reaches above Phantom Lake on October 19, 2011. This included sampling in Reach PL1 above the lake (Site EF PL1) as well as two more sites upstream (Figure 2.3). In the side tributary, ECL conducted electrofishing in the first reach (Reach PL2A) above the tributary confluence (Site EF PL2A) and further up in the main channel in Reach PL3 above the second reach break (Site EF PL3). ECL did not electrofish in the second reach of this channel where traps had been previously set and were soaking. Click here to view the electrofishing locations for October 19, 2011 in Google Earth®. All site and waypoint data are available for the Phantom Lake Spatial Unit collected on October 19, 2011.

On October 20, 2011 ECL examined the outlets on the south end of Phantom Lake. The larger outlet spills over the rock face and forms Phantom Falls. There is a series of debris jams and cascade pools in a short reach directly below the Lake (Reach CR4). ECL placed three Gee traps in this site (Site MT1), but did not collect site information as the reach is less than 100m in length and too short to characterize using acceptable standards (i.e., RISC 2001). The smaller, north outlet contained a longer, more defined reach above its barrier falls. ECL set seven traps in three sites on this reach. Site MT2 contained two traps, one large trap and one Gee trap, in the location directly above the falls of the north outlet (Reach CR4A). ECL placed five traps (three large traps and two Gee traps) in two additional sites (Sites MT3 and MT4) of this reach directly below the north outlet of the lake.

For a complete list of electrofishing, gill net, and trap site locations as well the total EF effort expended and net/trap soak times, refer to Table 2.1.

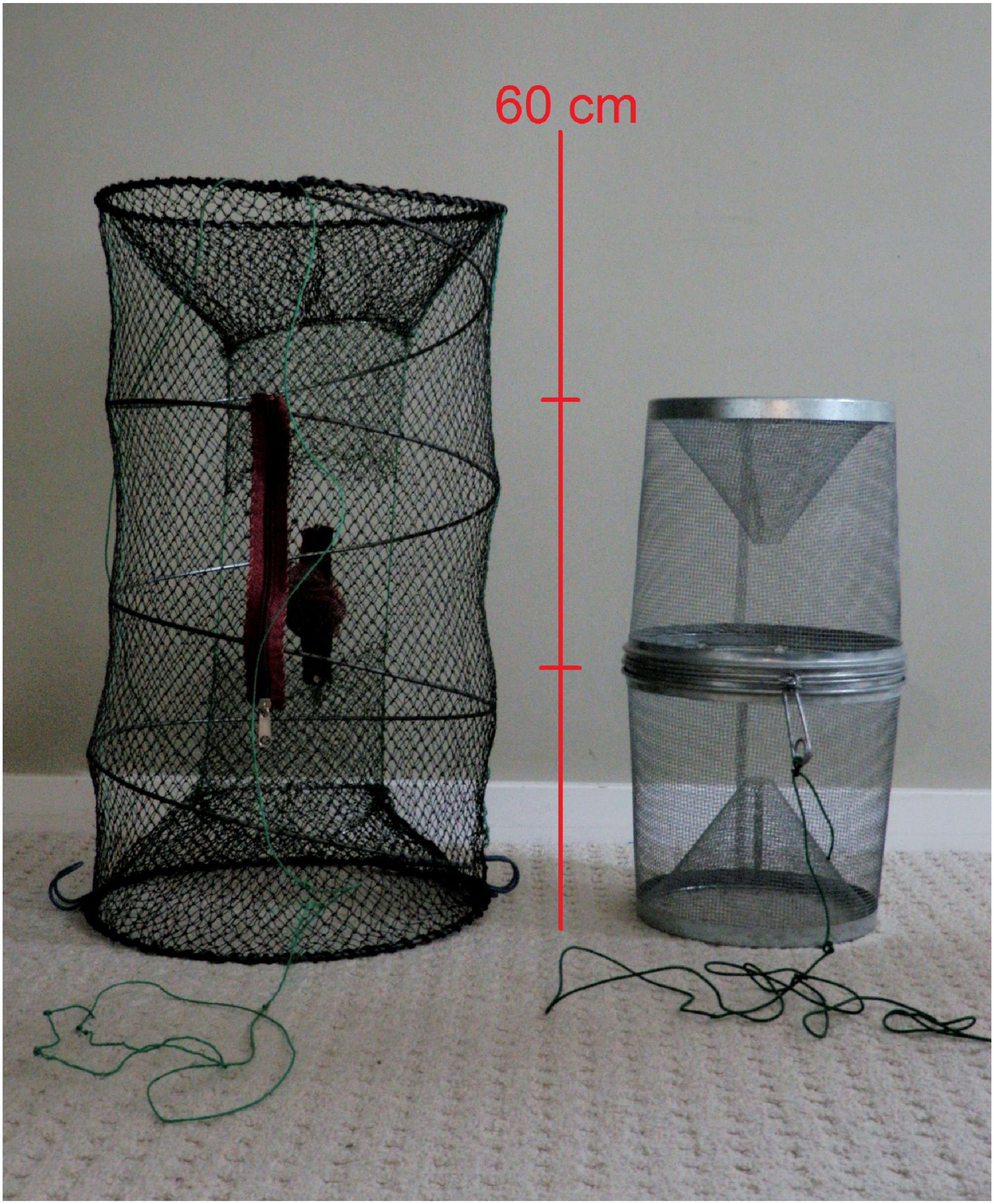


Figure 2.2 Two types of traps used in the 2011 CRSEP Fisheries and Aquatic Investigation.

Figure 2.3 ECL crew members electrofishing in the side tributary PL2A of the Clowhom River above Phantom Lake.

Table 2.1 Summary of all fish sampling methodology for the Phantom Lake spatial component of the 2011 CSREP Fisheries and Aquatic Investigation.

Site	Location (UTM)	Reach	Method	Unit/#	Soak Time/Effort
GN1	10U 465054 5521820	Lake delta	GN	50-m gang/1	23h
GN2A	10U 464196 5523738	Lake delta	GN	50-m gang/1	6h
GN2B	10U 464196 5523738	Lake delta	GN	50-m gang/1	23h
			Total Effort	**3**	**52h**
MT1	10U 465303 5521475	CR4	MT	Gee trap/**3**	120h
MT2	10U 465067 5522026	CR4A	MT	large trap & 2 Gee traps/3	118h
MT3	10U 465109 5521975	CR4A	MT	large trap & 1 Gee trap/2	118h
MT4	10U 465169 5521910	CR4A	MT	large trap & 1 Gee trap/2	118h
MT5	10U 464506 5523381	Lake delta	MT	large trap/1	138h
MT6	10U 464476 5523371	Lake delta	MT	large traps/2	138h
MT7	10U 464379 5523409	Lake delta	MT	large trap/1	138h
MT8	10U 464352 5523392	Lake delta	MT	large trap/1	138h
MT9	10U 464534 5523442	PL2	MT	large trap & 2 Gee traps/3	29h

Site	Location (UTM)	Reach	Method	Unit/#	Soak Time/Effort
MT10	10U 464439 5523508	PL2	MT	large trap & 2 Gee traps/3	29h
MT11	10U 464468 5523553	PL2	MT	large trap & 2 Gee traps/3	29h
MT12	10U 464608 5523223	Lake delta	MT	large traps/3	29h
			Total Effort	**24**	**1752h**
EF PL1	10U 464559 552334	PL1	EF	Smith-Root LR24 & dipnet/1	486s
EF PL2A	10U 464534 5533533	PL2A	EF	Smith-Root LR24 & dipnet/1	620s
EF PL3	10U 464468 5523659	PL3	EF	Smith-Root LR24 & dipnet/1	600s
			Total Effort	**3**	**1706s**

2.2 Clowhom River Fish Sampling

The section of stream above the headpond of the UCRHPP is relatively short in length (<750m). The first reach entering the headpond (CR1) contains a primary channel with a secondary braid as well as several off channel habitats. The confluence of Q Creek forms a reach break that separates the lower reach from an upper reach heading into a steep canyon up to Phantom Falls (CR2). ECL sampled in three locations of these two reaches in Clowhom River, including a site in the canyon (Site EF CR2) and two below Q Creek, one in the primary channel (Site EF CR1-3) and one in the secondary braid (Site EF CR1-1). Clowhom River sampling did not include Q Creek in this investigation, which is the primary input to the diversion for this Project.

Fish sampling for the Clowhom River component consisted of electrofishing in open sites. ECL did not set minnow traps in the section of the Project because electrofishing activity in the stream sections above Phantom Lake successfully managed to detect fish using this gear type. Although PGL (2007) had previously reported that low conductivity in the Clowhom River (<10 µS) precluded fish detection using an electrofisher, this was not the case for our investigation. Consequently fish sampling consisted of a single pass in open sites with relatively high voltages (700 - 900V) to offset the low conductivity observed. A summary of the electrofishing activities in the Clowhom River component has been provided in Table 2.2. See also the Google Earth® links of the lake outlet MT sites in the Phantom Lake Spatial Unit, electrofishing sites in the Clowhom River below Phantom Falls, and all other site and waypoint data for October 20, 2011.

Table 2.2 Summary of all fish sampling methodology for the Clowhom River spatial component of the 2011 CSREP Fisheries and Aquatic Investigation.

Site	Location (UTM)	Reach	Method	Unit	Effort
EF CR1-2	10U 466167 5521874	CR1-1	EF	Smith-Root LR24 & dipnet	375s
EF CR1-3	10U 466297 5521808	CR1-1	EF	Smith-Root LR24 & dipnet	523s
EF CR2	10U 465869 5521671	CR2	EF	Smith-Root LR24 & dipnet	876s

2.3 DATA ANALYSIS

Analysis of the aquatic ecosystem in the Project Area has been based on existing data from various sources (Northcote *et al.* 1950; Larkin and Smith 1950; PGL 2007) as well as the field data collected for this assessment. A qualitative evaluation of the Project Area has been based on the following subsets of data collection in this study:

- Phantom Lake general habitat description; and
- Clowhom River reach information (RISC 2000; 2001).

A quantitative analysis of the aquatic ecosystem in the Project Area has been based on the following subsets of data that ECL collected for each spatial component of the investigation:

- Total catch;
- Total catch-per-unit-effort (CPUE); and
- Morphometric analysis of RB and CCT in the Clowhom drainage.

Total catch has been analysed in terms of the different gear types used in each spatial component (i.e., GN, MT, and EF). As an index of abundance, ECL calculated the CPUE for each gear type. Gear-specific The CPUE values assume a constant catchability coefficient *q* across comparison sites for this assessment.

The catch data from Northcote *et al.* (1950) have been used in a morphometric analysis of the larger Clowhom system. The RB and CCT historical catch data came from Clowhom Lake prior to the dam construction and consequent impoundment of the lake. Because a subset of this catch also includes the age of the fish captured, it allowed ECL to assess growth rates using the von Bertalanffy growth model:

(1)
$$L_a = L_\infty\left(1 - e^{-K(a-a_o)}\right)$$

where L_a is the predicted average fork length of fish of age *a*. Two of the growth parameters were estimated using a non-linear numerical search procedure, where L_∞ is the asymptotic fork length, *K* is the metabolic coefficient, and a_o is the theoretical age at which fork length is zero (Hilborn and Walters 1992). ECL fit a growth curve for the Clowhom Lake RB data from Northcote *et al.* (1950) using the maximum likelihood approach, where three parameters were estimated (L_∞, K, *CV*). The coefficient of variation *CV* is used to determine the age-specific standard deviation σ_a in the set of the observed lengths L_i, i = 1 to n for each age class:

(2)
$$\sigma_a = CV \cdot L_a$$

The negative log likelihood of the data is given by:

(3)
$$L\left(L_i \mid age_i, L_\infty, a_o, K, CV\right) = n\ln(\sigma_a) + \sum_{i=1}^{n} \frac{(L_i - L_a)^2}{2\sigma_a{}^2}$$

Historic catch data from Clowhom Lake have been included in the baseline assessment in order to examine the distinct fish population units of Clowhom drainage. Clowhom Lake data serve as a useful baseline to compare morphometric attributes such as length to weight relationships between data sources in the Clowhom system. ECL assessed the length to weight relationship for Clowhom Lake RB and CCT based on the historic data (Northcote *et al.* 1950) and compared the applicable relationship with the data collected from Phantom Lakes and the Clowhom River between the Upper and Lower Clowhom River Hydroelectric Power Plants (LCRHPP; PGL 2007). The data from stream sections below Phantom Falls and above the lake collected in this assessment. The length weight relationship is useful in assessing growth rates among species and habitats such as lakes and rivers throughout the Clowhom system. It is a simple power function denoted as:

(4)
$$Wt = aFL^b$$

Where *t*he weight of a fish *Wt* varies as a function of its length *FL* according the parameters *a* and *b*. The relationship is useful means of predicting stock biomass from length data (Hilborn and Walters 1992). ECL compared the length weight relationship between CCT and RB data in Clowhom Lake (Northcote *et al.* 1950) and also compared Clowhom Lake RB with species data from PGL (2007) as well as Phantom Lake data from this investigation. ECL analysed these comparisons usin the log-transformed data for equation (4), which reduces to a linear function:

(5)
$$\log(Wt) = \log(a) + b\log(FL)$$

where the parameter *a* represents the intercept and *b* is the slope of the functional relationship.

Quantitative data analyses in this investigation consider the fish distribution and abundance in the Project Area in the context of the existing land and water use activities that have cumulatively influenced the Clowhom River ecosystem up to its current state. This information is critical to identify potential impacts posed by the Project and develop an effective environmental management plan (EMP). Further to the results and discussion, management directives have been outlined in Section 5 of this report.

3.0 RESULTS

3.1 QUALITATIVE EVALUATION

3.1.1 General Habitat Description

3.1.1.1 Phantom Lake

Phantom Lake is approximately 3km in length in the NNW-SSW direction by approximately 550m wide in its widest point directly above the delta on the east side of the lake. The delta extends into the lake and reduces the width to approximately 35m at the delta tip. Directly south of the delta the lake widens again to a maximum of approximately 500m, but continually tapers narrow towards the outlet at the south end, where it is less than 150m wide. The lake sits in an upper basin that extends south as a raised promontory with a depression that collects precipitation and runoff. The lake has a relatively short ridge line around the south perimeter. Phantom Lake is located in the Coastal Western Hemlock (CWH) biogeoclimatic ecosystem classification (BEC) subzone, while parts of the northern tip of the lake extend into the higher elevation Mountain Hemlock (MH) BEC subzone.

The hanging lake is contained within a raised basin off the south buttress of Mount Jimmy Jimmy. There are relatively few inputs. A chute at the northern tip of the lake appears to be the second largest input apart from the Clowhom River. Other minor inputs include the steeper avalanche chutes that extend to the shore line on the northeast and east sides of the lake. The primary influence to Phantom Lake comes from the Clowhom River headwater reaches above the delta.

<u>Clowhom River Delta</u>

The reconnaissance survey of the perimeter of the delta allowed ECL to determine the presence of a single channel flowing into the lake and capable of supporting fish production. The substrate along the perimeter is mostly fine sediment with some sand and cobble deposits. The littoral zone contains a mixture of reeds *Equisetum hymale* and numerous sedges *Carex spp.* (Figure 3.1). Above the littoral zone there is a slightly raised bench (1-2m) that holds several shallow pools lined with bryophytes, sedges, herbs, and shrubs (Figure 3.2). Dominant bryophytes include haircap moss *Polytrichium spp.* and peat moss *Sphagnum spp.* Herb species include rein orchid *Platanthera spp.* and willowherb *Epilobium spp.* and shrubs include several species of willow *Salix spp.,* blueberry *Vaccinium spp., and* rose *Rosa spp.*, well as hardhack *Spirea douglasi.*

On the delta the terrain changes from an open meadowscape to a dense shrubland with numerous fens and small ponds occupied by amphibian tadpole larvae (Figure 3.3). The delta becomes forested with large conifers amidst a dense understory of shrubs. The substrate becomes much coarser in texture as the elevation increases. The main channel of the Clowhom River is located in this upper part of the delta. It cuts across the delta from the uppermost drainage basin to the north of the lake and enters the lake through a single channel on the south side of the delta. Several smaller, insignificant inflows were evident on other parts of the delta. These minor inflows probably represent pre-existing stream channels, but are no longer directly connected to the main channel of the Clowhom River.

Figure 3.1 A view of the littoral zone along the fingers of the delta extending out onto Phantom Lake.

Figure 3.2 An example of several shallow ponds located in the raised, dense shrublands of the delta on Phantom Lake.

Figure 3.3 Tadpole larva of an unidentified amphibian species located in a pond on the Phantom Lake delta.

Phantom Lake Outlet

There are two outlets that drain the lake on the south end. The main outlet is located at the very southern tip of the lake and spills over a large steep embankment that lines the southeast side of the lake (recall Figure 1.1). This outlet constitutes the main channel of the Clowhom River. The secondary north outlet is a side channel located approximately 700m north of the main outlet along the east shore of the lake. It flows diagonally along the embankment and merges with the main outlet below the uppermost cascades of Phantom Falls. Both outlets are characterized by LWD jams above short bedrock cascades that form obstructions to the reaches below (Figure 3.4).

Figure 3.4 View of the cascades and LWD jams on the short reach directly above Phantom Falls (Reach CR4) at the main outlet of the lake.

3.1.2 Clowhom River Reach Description

Reach descriptions have been included for the Project Area on the Clowhom system between the UCRHPP headpond (Figure 3.5) and the stream habitat extending above Phantom Lake. Descriptions are based primarily on the information contained in the site cards (RISC 2001).

Figure 3.5 View of the Hydromax Energy UCRHPP intake and headpond.

3.1.2.1 Reach CR1

Reach CR1 is the first reach above the UCRHPP headpond. It consists of a primary channel (CR1-3) and several braids including a secondary channel (CR1-1) that forms a continuous stream in a clearly defined streambed directly opposite the primary channel in the basin (Figure 3.6). In between the two outer braids are several more abandoned channels as well as a series of smaller indistinct channels that flow through the forest and spill into CR1-1. Braid CR1-2 crosses the plain from CR1-3 into CR1-1.

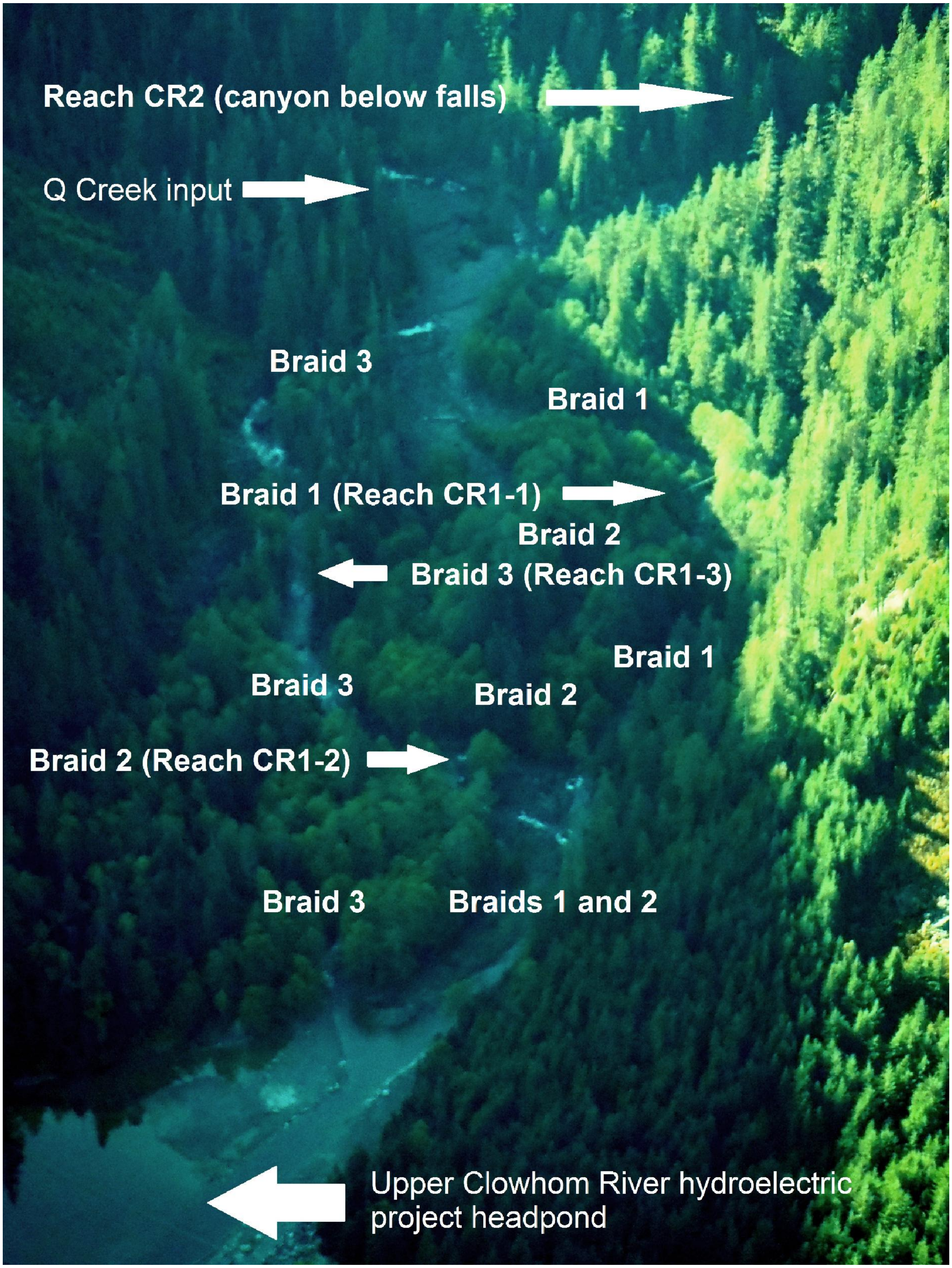


Figure 3.6 Reach CR1 of the Clowhom River above the headpond and below the confluence of Q Creek.

Inconspicuous channels have been classified as part of CR1-2, the central braid in Figure 3.6. ECL only detected fish in the primary channel (CR1-3) of this reach.

Reach CR1 is occasionally confined with some bedrock and consists predominately of large rounded cobble substrate. Evidence of active lateral shifting is based on the observation of several abandoned channels and exposed bars with raised LWD deposits. Subsurface flows in reach CR1-3 render several off-channel habitats isolated within dry intermittent channels. No fish were observed in these isolated habitats. Overall the reach consists of a narrow outwash plain (2-5% gradient) at the base of the bedrock canyon with a surficial braided stream complex that reworks the original deposits. The reach is partly coupled and there is evidence of mass wasting in CR1-1 where a debris slide has entered the channel. The plain is forested with a mix of deciduous and coniferous trees. Functional LWD jams form pools beneath and constitute primary fish habitat, especially in CR1-1. Boulders and undercuts in CR1-3 as well as dense crown closure over the inconspicuous channels of CR1-2 also provide ample cover for fish. Overall the reach has limited spawning habitat and good rearing habitat.

3.1.2.2 Reach CR2

Reach CR2 extends above Q Creek’s confluence in the steep bedrock canyon at the base of Phantom Falls. It is characterized by a single channel with step pool morphology composed of numerous cascades and plunge pools. The height of individual cascades increases with distance upstream towards the reach break to the highest cascades located at the base of the falls (Figure 3.7). The reach consists of coarse textured substrate (i.e., boulders and large cobble) with regular pooling as suitable holding areas for fish. Boulders and pools comprise the dominant forms of cover. Pools consist of small to large cobbles with some upwelling, but not well-suited for spawning. Rearing habitat is moderate to good given an ample amount of cover.

Reach CR2 is engorged within the canyon with pronounced bedrock faces and steep banks. Riparian vegetation is relatively sparse and is composed primarily of mosses, ferns, and mature conifers. The reach is coupled by extensive boulder deposits through which the stream flows. Reach CR2 has little to no functional LWD.

Figure 3.7 Uppermost cascades of Reach CR2 constitute the reach break in the canyon at the base of Phantom Falls.

3.1.2.3 Reach CR3

Reach CR3 is the series of step falls that extends from the upper cascades in Figure 3.7 to the two outlets of Phantom Lake. Phantom falls is the most pronounced barrier separating the lower fish populations above the UCRHPP headpond from the population in Phantom Lake and the short reaches in the lake outlets above the falls (Figure 3.8). ECL did not collect site card information for this reach.

3.1.2.4 Reach CR4

Reach CR4 is the short reach (<100m in length) at the top of Phantom Falls and extending to the south end of the lake (Figure 3.4). ECL set minnow traps in the deep pools below pronounced cascade, but did not complete a site card for Reach CR4 because of the length.

Fugure 3.8 Lower portion of series of chutes that comprise Phantom Falls, Reach CR3.

3.1.2.5 Reach CR4A

Reach CR4A constitutes the north outflow of Phantom Lake between the lake and the top of the gradient barrier that joins the main outlet to form Phantom Falls. The reach consists of moderately steep (4-10% gradient) step pool morphology with cascades and plunge pools (Figure 3.9). The stream is confined to engorged and flows as a single sinuous channel with several rock obstructions. Shrubs are the dominant riparian vegetation. Streambed and bank material is primarily coarse textured (boulder and bedrock) and pools are the primary fish habitat.

The reach has limited spawning capability, but the pools are large enough to serve as overwintering habitat. Fish in the reach are likely resident spawners or get flushed from the lake over the cascade through entrainment and are held in the pool refuges by velocity barriers and rock obstructions. Adult and juvenile rearing is rated as moderate to good, but the spawning habitat is poor.

Figure 3.9 Typical cascade pool habitat found in Reach CR4A of the north Clowhom River outlet.

3.1.2.6 Reach PL1

Reach PL1 is the first reach of the main inflow to Phantom Lake (Figure 3.10). It consists of a shallow, slow moving section that enters into the lake below the confluence of PL2 and a side tributary PL2A. ECL electrofished here, but did not complete a site card for the reach.

Figure 3.10 Reach PL1 above Phantom Lake.

3.1.2.7 Reach PL2A

Reach PL2A is the primary side tributary of the mainstem Clowhom River above Phantom Lake. The channel is characteristically distinct from the mainstem. It is higher gradient, poorly sorted, has more angular substrate, and dense crown closure. There is also a greater amount of instream vegetation (mosses and algae). ECL sampled Reach PL2A with the electrofisher up to a large piece of functional LWD at the top of the reach (Figure 3.11). Above this point the stream gradient increases forming step pool morphology. ECL did not collect site card information on this reach.

Figure 3.11 Function LWD forming a plunge pool at the uppermost section of Reach PL2A.

3.1.2.8 Reach PL2

Reach PL2 is a slower, with deeper water and a shallow gradient (1%) that forms an irregular meander in the forested habitat of the upper delta. The reach is characterized by riffle-pool morphology with regular deposits of gravels and finer sediments that form side and mid bars in open habitat. There is an abundance of clumped LWD that functions as the dominant cover at bends, thereby forming deep pools below where ECL set minnow traps (Figure 3.12). Streambed material is dominated by rounded cobbles and secondary gravel deposits. The stream banks are dominated by shrubs and consist of fine textured substrates forming undercuts ideal as rearing habitat and possibly for overwintering. Overall cover is low in Reach PL2 with trace amounts of overhanging vegetation and no instream vegetation or boulder cover. Gravel deposit could serve as suitable spawning habitat.

Figure 3.12 Functional LWD and pool habitat characteristic of Reach PL2.

3.1.2.9 Reach PL3

Reach PL3 is faster moving section of the Clowhom River mainstem above Phantom Lake. It is dominated by cobble and secondarily boulder substrate in a sinuous channel that has riffle-pool/riffle-run morphology with cobble side bars opposite undercuts with some overhanging vegetation alongside clumped distributions of functional LWD that form the dominant cover for fish (Figure 3.13). The reach is open with riparian vegetation dominated by shrubs and mixed mature forest. It has a gradient of 2-5% with some evidence of side inputs from minor tributaries flowing in from the east. ECL electrofished the Reach PL3 as the uppermost sample site for the Clowhom River. In terms of fish habitat, the reach possesses potential spawning habitat and minimal overwintering habitat due to a lack of deep pooling. Available cover allows for moderate rearing habitat, though the section is fairly homogenous with a mix of cobble, boulder and some fines. Fish were observed to cluster around the LWD structures and undercuts of the stream banks in this reach. Above the reach break the stream gradient increases markedly to form step pool in Reach PL4 (Figure 3.14).

Figure 3.13 Typical characteristics of Reach PL3 above Phantom Lake.

Figure 3.14 Higher gradient step pool morphology of Reach PL1-4. ECL did not sample this reach.

3.2 QUANTITATIVE ANALYSIS

3.2.1 Total Catch

For the 2011 CRSEP Fisheries and Aquatic Investigation, ECL successfully retained 46 fish, 25 of which were captured using net and trap gear (Table 3.1) and 21 that were caught with the electrofisher (Table 3.2); all fish have been classified as RB.

3.2.1.1 Phantom Lake

ECL retained a total of 8 fish in the two gill nets, four in each site. ECL retained these fish as voucher specimens. In the minnow traps, ECL captured a total of 17 fish, with eight in the traps set in the outlet reaches (two fish in CR4 and 6 fish in CR4A) and seven in the traps set in the littoral zone of the delta. Two fish were retained in minnow traps in the reaches above the lake PL2.

Table 3.1 Summary of the total catch and total effort expended using gill net and minnow trap gear types in the Phantom Lake spatial component.

Gear Type:	Gill Net (Phantom Lake)	Minnow Trap (Phantom Lake Spatial Unit)			
Locale:	South End	North End	Outlets	Littoral Zone	Upper Reaches
FL (mm)	316	219	118	270	80
	252	306	105	145	100
	250	73	125	260	
	256	57	160	210	
			90	220	
			175	150	
			135	210	
			175		
Total Catch:	**4**	**4**	**8**	**7**	**2**
Total Effort:	**23 hrs.**	**31 hrs.**	**1769 hrs.**	**1128 hrs.**	**1215 hrs.**

Fish captured in the littoral zone on October 25, 2011 all displayed varying degrees of evidence that they had previously interacted with the gill nets located in deeper waters prior to being caught in the traps (e.g. Figure 3.16). One fish had actually been found dead in the minnow trap and possessed severe marking and abrasion that indicated it had been previously trapped in the gill net.

Figure 3.16 Rainbow trout captured in a minnow trap that showed evidence of previous entanglement in a gill net based on the marks and abrasion on its dorsal side.

3.2.1.2 Clowhom River

ECL retained a total of 21 fish using the electrofisher (Table 3.2). Thirteen RB were retained In the Clowhom River reaches sampled below Phantom Falls. Reach CR1 had two sites, one of which was a side braid where ECL did not capture any fish (CR1-1). Four RB were retained in the main channel (Braid 3; CR1-3). ECL also captured 9 RB in Reach CR2, the canyon above the Q Creek confluence. The largest fish was retained as a voucher specimen and later examined to be a gravid female, even though it was captured in October (Figure 3.17). The specimen was also devoid of any stomach contents.

In the Clowhom River reaches above the lake, ECL captured a total of 8 fish. One RB was captured in Reach PL1 while two more were observed, but not captured. In Reach PL3, ECL captured four fish, all of which were RB. In the principal side tributary of the Clowhom River (Reach PL2A) flowing in from the east ridgeline, ECL captured total of 3 fish, all of which have been reported here as RB.

Table 3.2 Total catch and total effort expended using a Smith Root® LR-24 backpack electrofisher.

Gear Type:	Electrofisher	
Locale:	Below Falls	Above Lake
FL (mm)	52	108
	65	111
	70	140
	75	160
	85	168
	90	183
	95	185
	125	195
	125	
	145	
	170	
	170	
	175	
Total Catch:	**13**	**8**
Total Effort:	**1774 sec.**	**1706 sec.**

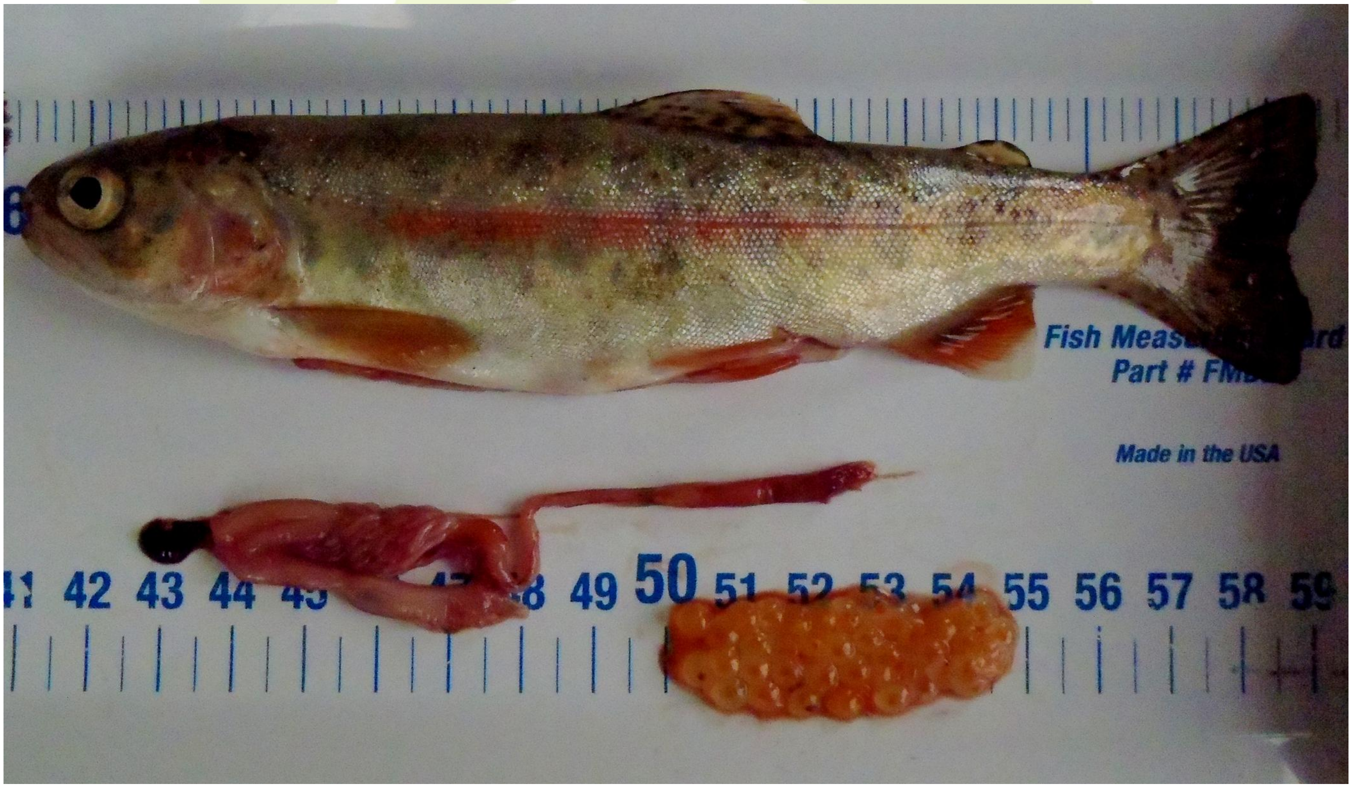


Figure 3.17 Voucher specimen of a gravid female RB captured in Reach CR2.

3.2.2 Total CPUE

Total CPUE has been presented as an index of fish abundance assuming constant catchability *q* across the different sites using the same gear type.

3.2.2.1 Phantom Lake

Total CPUE for the gill nets set in Phantom Lake was calculated to be 0.15 fish per net per hour; however; this result is not equal between gill nets. On the south end of Phantom Lake, GN1 was only set for a total of 23 hours whereas GN2 on the north end was set for a total of 31 hours; both nets caught the same number of fish (Table 3.1). The CPUE for each gill net is displayed in Figure 3.18.

Total CPUE for the minnow traps set in the various locations of the Phantom Lake spatial component was calculated at 0.0041 fish per trap per hour. For the minnow traps set in Reaches CR4 and CR4A of the Phantom Lake outlets, CPUE was calculated as 0.0045 fish per trap per hour. The CPUE for traps set in the littoral zone was 0.0062. The CPUE for the traps set in Reach PL2 above the lake was calculated to be 0.0016 fish per trap per hour. The CPUE for each locale is displayed along with the trap efficiency in Figure 3.20. Trap efficiency assesses the catch in terms of the number of traps that caught fish as a percentage of the total number of traps set in each locale.

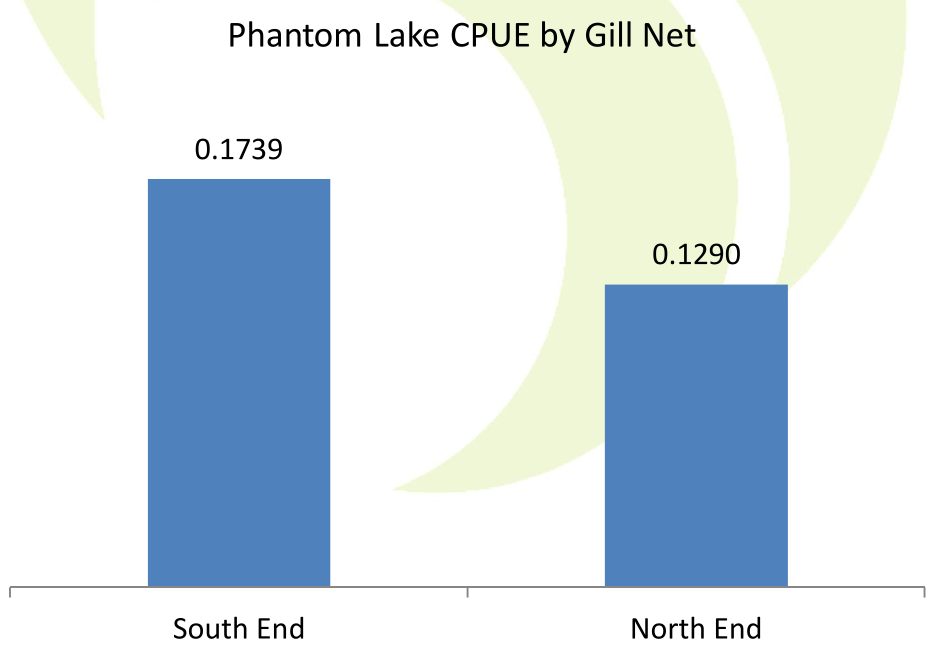
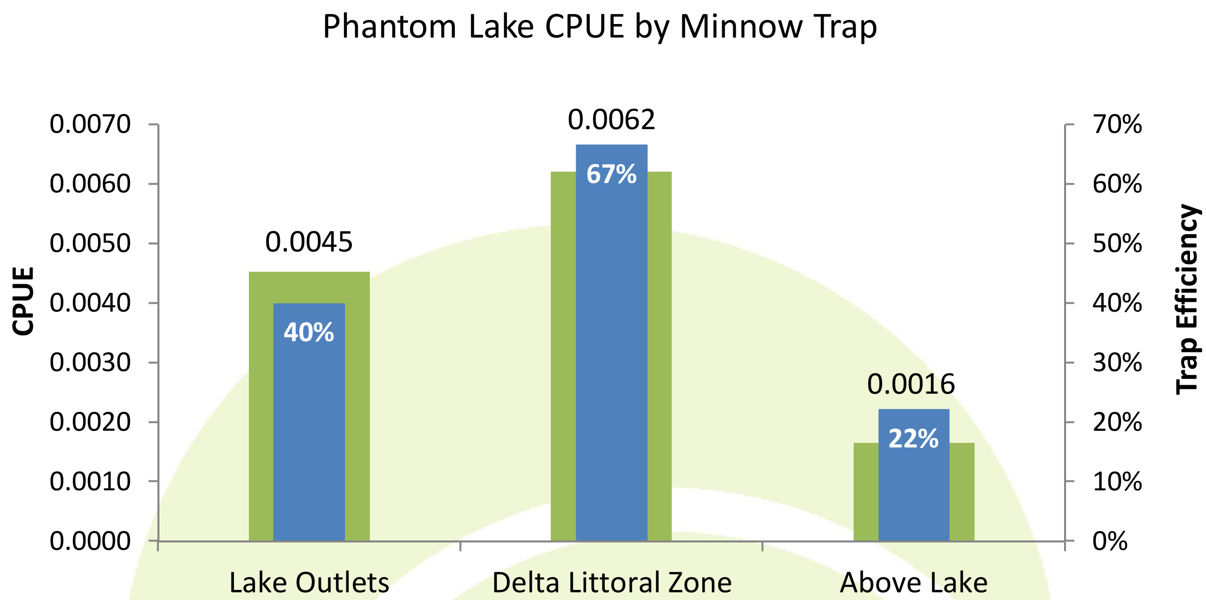


Figure 3.18 CPUE for each gill net set in Phantom Lake.



Figuure 3.20 CPUE and trap efficiency for minnow traps set in each locale of the Phantom Lake spatial component.

3.2.2.2 Clowhom River

Total CPUE for the electrofishing component of the 2011 CRSEP Fisheries and Aquatic Investigation was calculated to be 0.0066 fish per EF second. In the reaches of the Clowhom River spatial component, CPUE was 0.0073 fish per EF second below the falls and CPUE for upper reaches above the lake in the Phantom Lake spatial component was 0.0047 fish per EF second (Figure 3.21). Reach-wise CPUE is displayed in Figure 3.22

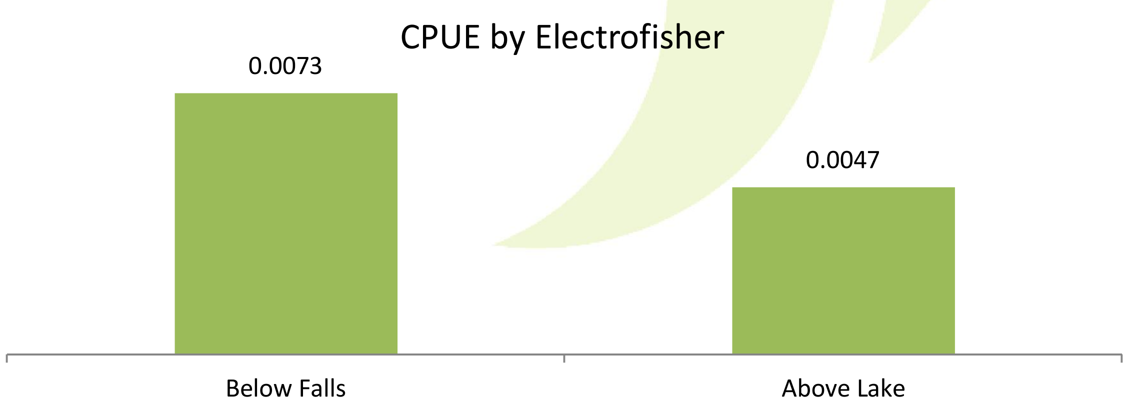


Figure 3.21 CPUE for reaches of the Clowhom River below the falls (left) and above the lake (right).

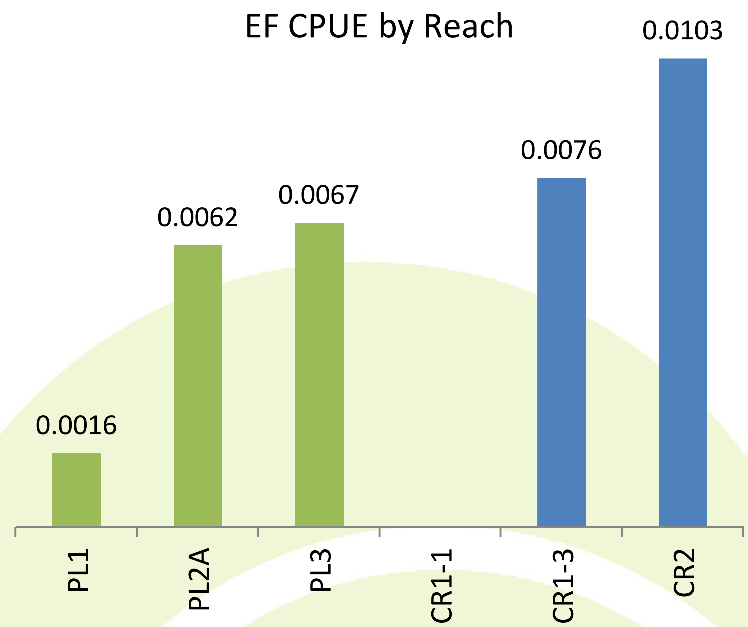


Figure 3.22 CPUE for each reach in the Clowhom River above (green) and below (blue) Phantom Lake. No fish were captured in Reach CR1-1.

3.3 Morphometric Analysis

Historic data of RB age and length from Clowhom Lake (Northcote *et al.* 1950) were used to construct a growth model (Figure 3.23). The parameter L_∞ was estimated to be 317mm, also the length of the largest fish in the subset of fish of known age (Northcote *et al.* 1950), applied here as a constraint. The parameter K was estimated to be 0.8, and the coefficient of variation *CV* was estimated at 0.10.

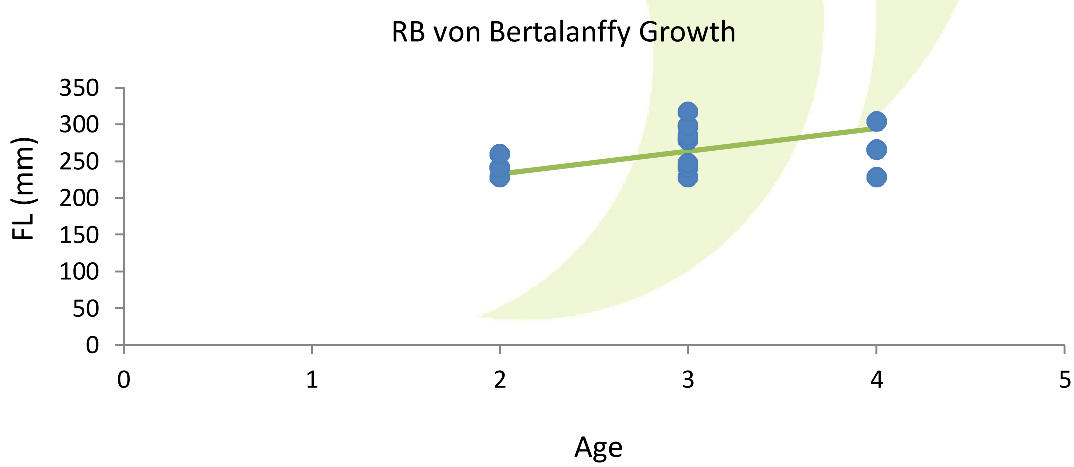


Figure 3.23 Plot of the fork length and age data from Northcote *et al.* (1950) for Clowhom lake, fit to the von Bertalanffy growth equation.

Length weight relationships of the historical data (Northcote *et al.* 1950; PGL 2007) comparing previous lake and stream fish with Phantom Lake vouchers specimens are depicted in Figure 3.23. Log-transformed linear regressions for these corresponding data are displayed in Figure 3.24 with the functional relationship included. All regressions are statistically significant (α=0.05).

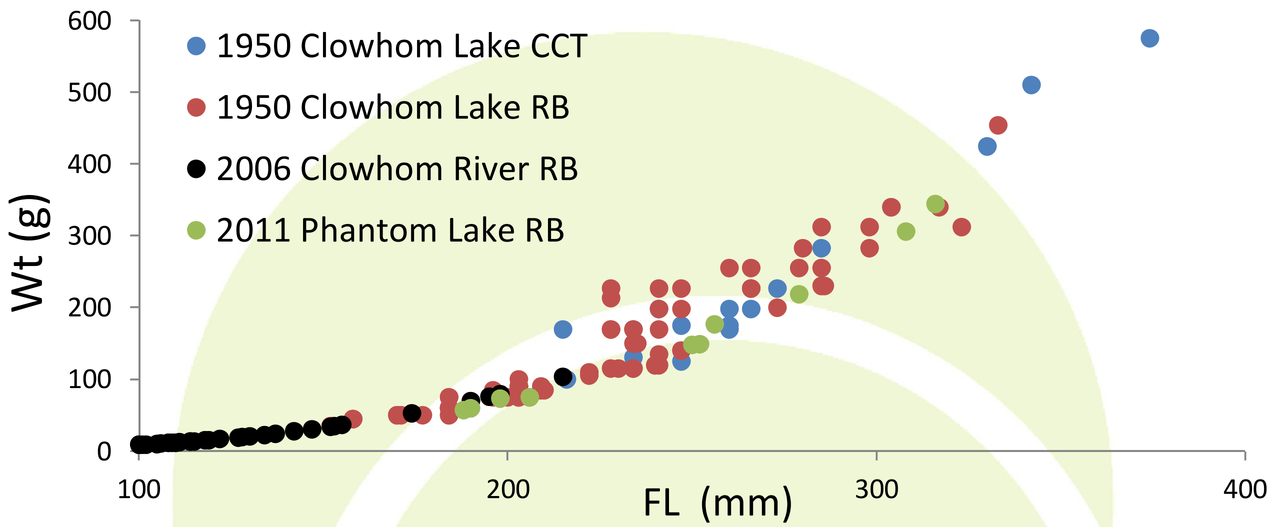


Figure 3.23 Length (FL) weight (Wt) relationship between Clowhom LakeCCT (blue) and RB (red) based on historical data from Northcote *et al.* (1950) compared to Phantom Lake RB (green).

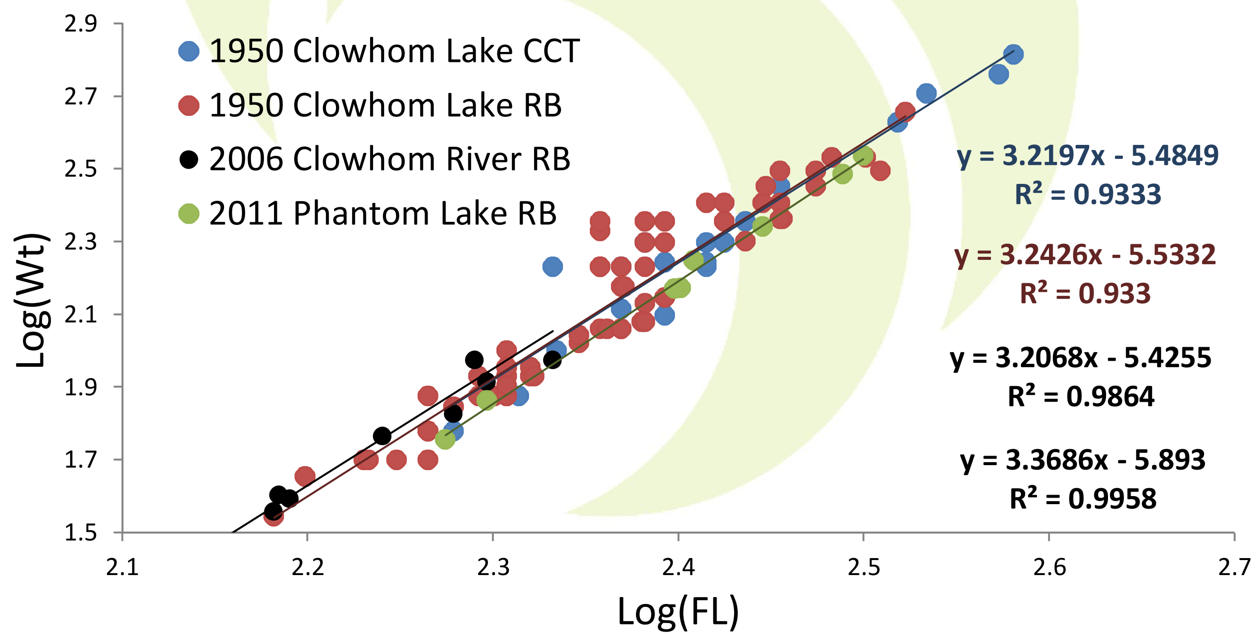


Figure 3.24 Log-transformed regressions between Clowhom Lake RB (red), Clowhom Lake CCT (blue), and 2011 Phantom Lake RB voucher specimens (green).

The length weight relationship in the voucher specimens from Phantom Lake has been further assessed in comparison to the two voucher specimens taken from the Clowhom River: one RB in the canyon Reach CR2 below Phantom Falls and the single RB voucher collected in the stream system above the lake (Reach PL3; Figure 3.25).

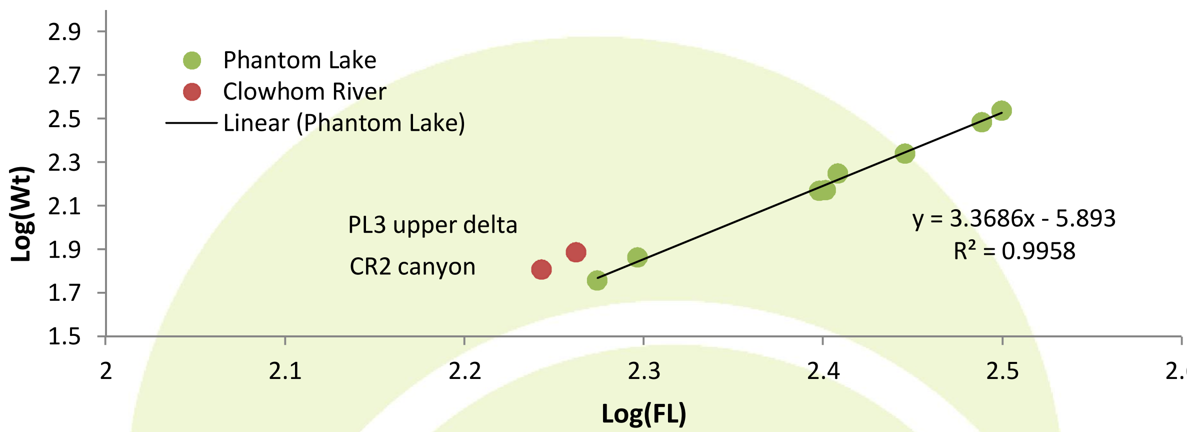


Figure 3.25 Comparison of the length weight relationship in the voucher specimens collected in Phantom Lake (blue) with the two specimens taken from the Clowhom River (red).

Finally, a comparison of RB growth rates in lake and stream habitats in the Project Area has included the historical data from Clowhom Lake. A subsample of specimens of similar length has been taken from Phantom Lake as well as the historic data set from Clowhom Lake (Northcote *et al.* 1950) and compared to these stream vouchers in terms of the length to weight ratio. The length/weight ratio for each source has been displayed in Figure 3.26.

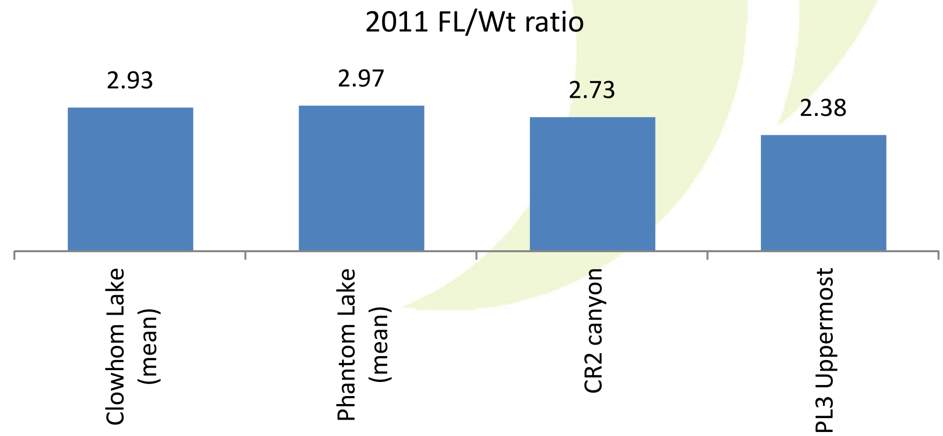


Figure 3.26 Comparison of length/weight ratios for RB of similar length in Clowhom Lake (n=2; Northcote *et al.* 1950) and Phantom Lake (n=2) to the Clowhom River voucher specimens (n=1).

4.0 DISCUSSION

4.1 FISH DISTRIBUTION AND ABUNDANCE

4.1.1 Phantom Lake

All fish retained in the 2011 CRSEP Fisheries and Aquatic Investigation were rainbow trout (RB). The perceived absence of CCT in Phantom Lake is confounding, despite an historical documentation of its presence in the lake in 1995 (FISS 2011). Rainbow trout has not been previously documented in Phantom Lake according to provincial government databases; however, this study and recent investigations by PGL (2008, 2009) have found *only RB* in the lake and the reaches upstream of the delta and below the outlets. ECL was unable to find any records of historic stocking of Phantom Lake with rainbow trout, although numerous lower elevation lakes in the region have been stocked for some time (e.g., Winlow 1927). The inference then, is that if CCT occupies Phantom Lake, the population is sympatric with RB.

Sympatric lake populations of CCT and RB display interactive segregation, whereby RB has been observed to occupy surface and midwater prey and CCT occupies the littoral zones and exhibits piscivory on smaller species, such as sculpin and stickleback (Nilsson and Northcote 1981). In Phantom Lake, ECL set gill nets in the lake and traps in the littoral zone in an attempt to maximize the number of limnetic fish species captured. If Phantom Lake holds sympatric populations of RB and CCT, ECL expected that CCT would be detected in the traps set in the littoral zone. Only RB was observed and the traps in the littoral zone had both the highest capture efficiency and CPUE among locales (Figure 3.18). This indicates it to be an effective sampling method for Phantom Lake, but also suggests that CCT is not present in the lake.

The results indicate that overall the abundance of fish in Phantom Lake is low. The most compelling result of the combination of capture methods used for lake sampling is the observation of trap caught fish that had previously been snagged in the gill nets set in the lake. ECL deliberately set nets in areas of higher fish density using a depth sounder. Each gill net had only been set for a maximum of 31 hours while the minnow traps soaked for five days after the gill nets had been removed. All the fish examined in the minnow traps showed signs (i.e., scale abrasion and constrictions) of being previously marked by passing through the gill net (Figure 3.15 and 4.1), including one mortality that was found in the trap with obvious and severe constrictions behind the eyes and around the gills. These constrictions could not have resulted from an attempt to escape the minnow trap because it has a much smaller mesh size.

The methodological approach actually serves as an informal mark-recapture experiment. Although it is not known how many RB in the lake passed through the gill nets (i.e., the total number of marked fish) prior to ending up in traps, there is no reason to expect these fish would be more likely to swim into baited traps in the littoral zone over the five days of soaking, compared to 'unmarked fish'. The likelihood of only 'marked' fish ending up in the traps over unmarked fish is very low. This implies that overall there are actually few RB in the lake that fish do not occupy the littoral zone exclusively; fish are quite mobile between lake habitats.

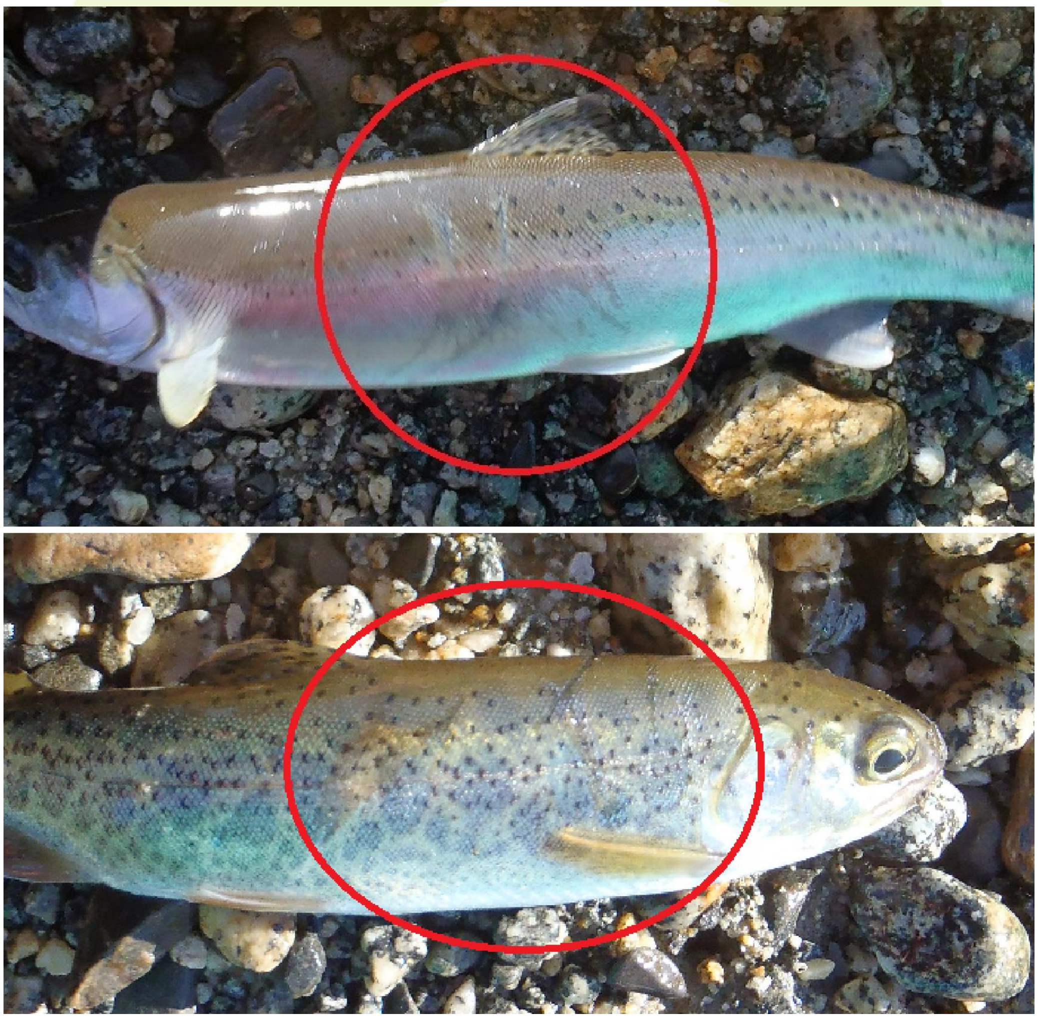


Figure 4.1 Fish caught in minnow traps after five day of soaking show evidence of previous interaction with gill nets.

4.1.2 Clowhom River

Fish captures in the Clowhom River also consisted solely of RB, both above and below Phantom Lake. The successful capture of a single fry and several age-1 RB indicates that the reaches above the UCRHPP have capable of supporting an isolated population. Reach CR1 is the most likely area where spawning takes place and the main channel (Braid 3, or CR1-3) appears to be the most suitable habitat; this is also where the lone fry had been captured.

Based on the amount of EF seconds expended in the reaches below the falls, the canyon reach CR2 actually had the highest CPUE of all reaches in the study, both above and below the lake. This is unexpected given the perceived lack of suitable habitat in CR2. No fry were caught here, but ECL caught six age 1 fish, which would not have been able to migrate upstream above the cascades into the reach. Recruitment is either a result of successful RB spawning events in the limited pockets of habitat in CR2. Plunge pools and residual pool habitat with cobble substrate and upwelling (Figure 4.2) may also serve as overwintering habitat, depending on the extent to which these coastal stream freeze up in winter. Alternatively it results from upstream spawning events and consequent entrainment over the falls into the reach. A voucher specimen collected from CR2 was observed to be sexually mature at 175mm FL; it was both gravid and had under-developed eggs when examined later (Figure3.16). Because of the timing of the survey (October), this indicates that the fish did not spawn during the normal spring spawning season and was still carrying the eggs. The stomach the fish was also empty.

In comparison to below the falls, the reaches above Phantom Lake had lower CPUE compared to below the falls. The slow moving reach at the inflow (PL1) had the lowest CPUE, but the upper sites had a CPUE comparable to CR1-3. In both cases, fish densities increased with movement upstream, which may be a result of actual higher densities or just improved catchability in narrow and restricted channels. Reach PL1 is a wider, slow-moving reach where fish can easily escape the electrofisher and ECL biologists observed two fish that escaped catch in this reach.

In comparing CPUE across sites, it seems that the assumption of equally catchability q may be inappropriate. CR2 had the highest CPUE and CR1-1 had no fish whatsoever, implying that CR2 fish are more “catchable” on average, whereas the reverse is true for CR1-1. Possible explanations for this include the cascade-pool/step pool morphology of CR2, which forces fish into pools with reduced cover thereby making them more vulnerable to capture. Conversely, CR1-1 was that last reach to be sampled with the electrofisher. Fish may have been unresponsive at this point because the battery had been exhausted on the electrofisher in combination with the observed low conductivity levels (<5 µS). Alternatively, the section electrofished was devoid of fish altogether because it did not possess ample holding habitat or cover. In any case, electrofishing results show that the Upper Clowhom River has low fish densities overall and all fish observed are RB, but one fish did exhibit mild CCT characteristics.

Figure 4.2 Typical plunge pool and upwelling in residual pool habitat in Reach CR2.

ECL biologists captured one fish in the tributary reach of the mainstem Clowhom River above Phantom Lake (Reach PL2A) that appeared to potentially be a result of RB introgression with CCT. It was the only fish in the study to express a mild degree of the characteristic reddish-orange ventral markings of CCT (Figure 4.3). ECL did not retain this fish as a voucher, but the observation is an indication of possible CCT presence in upper system above Phantom Falls. Evidence seems to indicate that RB has not been stocked in Phantom Lake and is naturally sympatric with CCT. Although this is the first evidence of any possibility of CCT in the system apart from the observation noted in FISS (2011), the fish expressed only mild evidence of introgression, if any at all. Docker *et al.* (2003) have noted that natural sympatric populations of RB and CCT do exhibit some degree of introgression, although it is significantly reduced compared to that of populations where RB has been introduced through a stocking program.

Figure 4.3 Mild phenotypic expression of possible CCT ventral marking on a RB specimen caught in Reach PL2A above Phantom Lake.

Minnow trapping efforts in the stream also revealed low densities that corroborate with electrofishing efforts. As with the electrofishing, both the CPUE and trap efficiency for the reach above the delta was the lowest in the study area compared trapping effort in the lake's littoral zone and Reaches CR4 and CR4A below the outlets (Figure 3.18). A reasonable explanation for the observed low densities in the upper reaches is based on the timing of the investigation (October). Rainbow trout spawn in the spring and the lake population would be most likely to use this habitat during this time, then retreat to the lake following spawning; however, ECL still expected higher densities of age 0 and age 1 fish in rearing habitats.

The observed fish density in Reaches CR4 and CR4A, below several rock obstructions and velocity barriers, was unexpected and presents evidence for isolated population units. Such distinct population units may be self-sustaining as a result of limited spawning and overwintering habitat in these reaches combined with entrainment of fish from the lake population upstream. It is not clear from this investigation whether these distinct population units are self-sustaining based solely on the availability of habitat for all life stages or if they require inputs from the lake. All fish retained in minnow traps were RB.

4.2 Growth and Productivity

For the proposed Project, ECL has determined there are at least two distinct population units, one in Phantom Lake and one in the Clowhom River below the falls and above the UCRHPP intake. Evidence suggests that small reaches directly adjacent to the falls, both above and below, may also contain isolated 'satellite' populations, although it has not been confirmed at this stage. ECL did not sample the UCRHPP headpond for this investigation; however, the fish population in Phantom Lake has been directly comparable to previous data, including Clowhom Lake (Northcote *et al.* 1950) and the Upper Clowhom River below UCRHPP. Unfortunately, previous data collected for the Project Area (PGL 2008, 2009) are incomplete and unusable. The examination of this limited number of voucher specimens does give some indication of growth and productivity of RB populations above below Phantom Falls.

Northcote *et al.* (1950) provided the necessary length and age data for determining growth rates in Clowhom Lake using a relatively simple and well known model. Parameter estimates for the von Bertalanffy growth model indicate adult RB in Clowhom Lake to be relatively small in length (L_∞ = 317mm); however, the data constitute a small sample size with limited ages (2-4 only) given length. For adult fish, L_∞ denotes of the maximum expected length of the largest fish in a population, based on the sample data. When the model was statistically fit to the historical data, ECL applied the usual constraint that L_∞ could not be less than the largest fish in this sample (317 mm FL, age 3). Consequently, the best fit estimated L_∞ at 317mm, although a larger fish existed in the overall sample (age unknown) that was actually 333mm. This is a clear biased and underestimated L_∞ that is not enough information to confidently assess growth rates in Clowhom Lake RB.

4.2.1 Phantom Lake RB

Although the von Bertalanffy growth model was not informative in assessing growth rates, information about growth and productivity can still be gained from the length weight relationship. The historical length weight parameters between Clowhom Lake RB and CCT were coincidental even though CCT grew to be larger in size overall compared to RB. This is clear evidence of sympatry for these species according to Nilsson and Northcote (1981). Clowhom Lake and Phantom Lake have perceived differences in terms of the length weight relationship. Adult fish in Phantom Lake RB have significantly lower body mass than Clowhom Lake RB at any given fork length. This essentially means that overall RB biomass of Phantom Lake given a number of fish of a particular fork length is significantly lower than the same number of fish (CCT or RB) given the same fork length in Clowhom Lake. It is a fairly clear indication that Phantom Lake is less productive and with limited capacity to support RB. It begs the question of whether CCT currently occupy, or have ever occupied the lake.

Evidence suggests the RB population is stable and has a low carrying capacity. The shift in the length weight relationship for Phantom Lake RB accompanied by lower length/weight ratios shows a limited capability to support fish. Food in the late fall consists almost entirely of winged insects (Figure 4.4). There is evidence of starved lake fish of the same length as stream fish, but slender in shape (see Figure 4.5). Of course forested stream habitats above the lake provide biomass inputs alongside an observed healthy benthos. Upper Clowhom above the lake has great fish habitat, but appears low in abundance, as shown in the results for both EF and MT methods. The lake fish have limited resources and there seems to be dominance by relatively few large fish. It is interesting that the first fish caught in this investigation was also the largest fish in the sample. It was the only fish to be gill-netted in a single eight hour set (Figure 4.4). ECL examined its stomach contents. Large flying ants and smaller black flies dominate (Figure 4.4).

Obvious morphometric differences are evident between the rainbow trout caught from Phantom Lake compared to the streams. A disparity is ostensible in the log-transformed length weight relationship for Phantom Lake voucher specimens compared to the stream sections above and below Phantom Lake (Figure 3.23). This is further depicted in the body mass to length ratio for historic Clowhom Lake

Northcote *et al.* 1950) and existing Phantom Lake RB compared to stream fish of the same fork length (Figure 3.25). Stream fish of the same fork length appeared morphologically robust (Figure 4.5).

Figure 4.4 The largest fish captured in Phantom Lake and the only fish to be retained in a single 8-hour set with a 50-m long gill net. Stomach contents consists largely of winged insects.

Figure 4.5 Morphological differences between RB vouchers specimens from Phantom Lake (left) Clowhom River above the lake (centre) and Clowhom River in the canyon reach below the falls (right).

The lack of stomach contents in smaller lake fish suggests hierarchical dominance in feeding among a limited number of mature RB in the lake. The presence of roe in the voucher specimen from Reach CR2 indicates that the isolated system above the UCPHPP also has clear resource limitations.

5.0 MANAGEMENT

Effective management of the Clowhom system above the UCRHPP headpond should include continual monitoring of these distinct RB populations over a period of time to determine if they are viable under the proposed resource development activities. ECL recommends a rigorous, non-lethal, and cost-effective means of conducting a credible population study of Phantom Lake RB. A key management question includes a better determination of the status of RB in the reaches above the delta as well as the isolated pockets in the outlet reaches. Regular monitoring of fish density should accompany any seasonal instream flow management regime. It is the only way to credibly determine the fate of each population and ensure stability. This goal would satisfy the federal requirement of “no net loss” using population size as a measurable criterion.

ECL also recommends non-lethal testing of fish to determine whether any genetic evidence exists for CCT introgression with RB populations. The two main ways to determine this are a tissue analysis and deep water fish sampling in Phantom Lake. Any presence of CCT alleles in the RB genome can indicate whether CCT historically occupied the lake. ECL also recommends deep water lake sampling to more closely examine for the presence of a suppressed CCT population, which may occupy lower levels of the lake as potential habitat beneath RB. This would be a result of differences in feeding and growth that have led to interactive segregation of sympatric populations (Nilsson and Northcote 1981). Use of minnow traps baited with anise seed essence is an effective fish attractant for cutthroat trout (Wilkinson 2009) and can effectively examine shallow versus deep fish presence.

5.1 CUMULATIVE EFFECTS MONITORING

The lake, headpond, and outlet reaches can be effectively and non-lethally sampled. Population monitoring is quite possible using fairly simple estimation procedures. This should be included as part of Hydromax’s operational monitoring strategy for the headpond. Collaborative management is an ideal means to address cumulative effects and manage the impact. Phantom Lake construction and operational monitoring plans must proceed with the Proponent in direct consultation with Hydromax for proper environmental management.

Intensively developed regions like the Clowhom watershed have long since defined it as a resource-based ecosystem. A dynamic systems approach, such as adaptive management (Walters 1986; Holling 1978), is well-suited to the uppermost Clowhom aquatic ecosystem. Hydromax’s UCRHPP headpond is an anthropogenic barrier below Phantom Falls and clearly bounds the system. Hydromax has created this isolated upper mountain system, comparable in terms of fish habitat values to the lake. It presents a powerful collaborative scheme and is an index for monitoring stable population parameters, such as abundance *N* and growth rate *k* between distinct populations and jointly managed by ARE and Hydromax.

A smaller, satellite system like the headpond is easily monitored as a measurable gauge, against which the lake population is compared. It is effective because it is informative and represents a quantitative means to satisfy Fisheries and Oceans Canada's "no net loss" policy on fish habitat (i.e., HADD). Population monitoring is the key to adaptive management of the uppermost Clowhom aquatic ecosystem. This can ultimately lead to RB population stabilization under suitable instream flow requirements and effectively mitigated over time.

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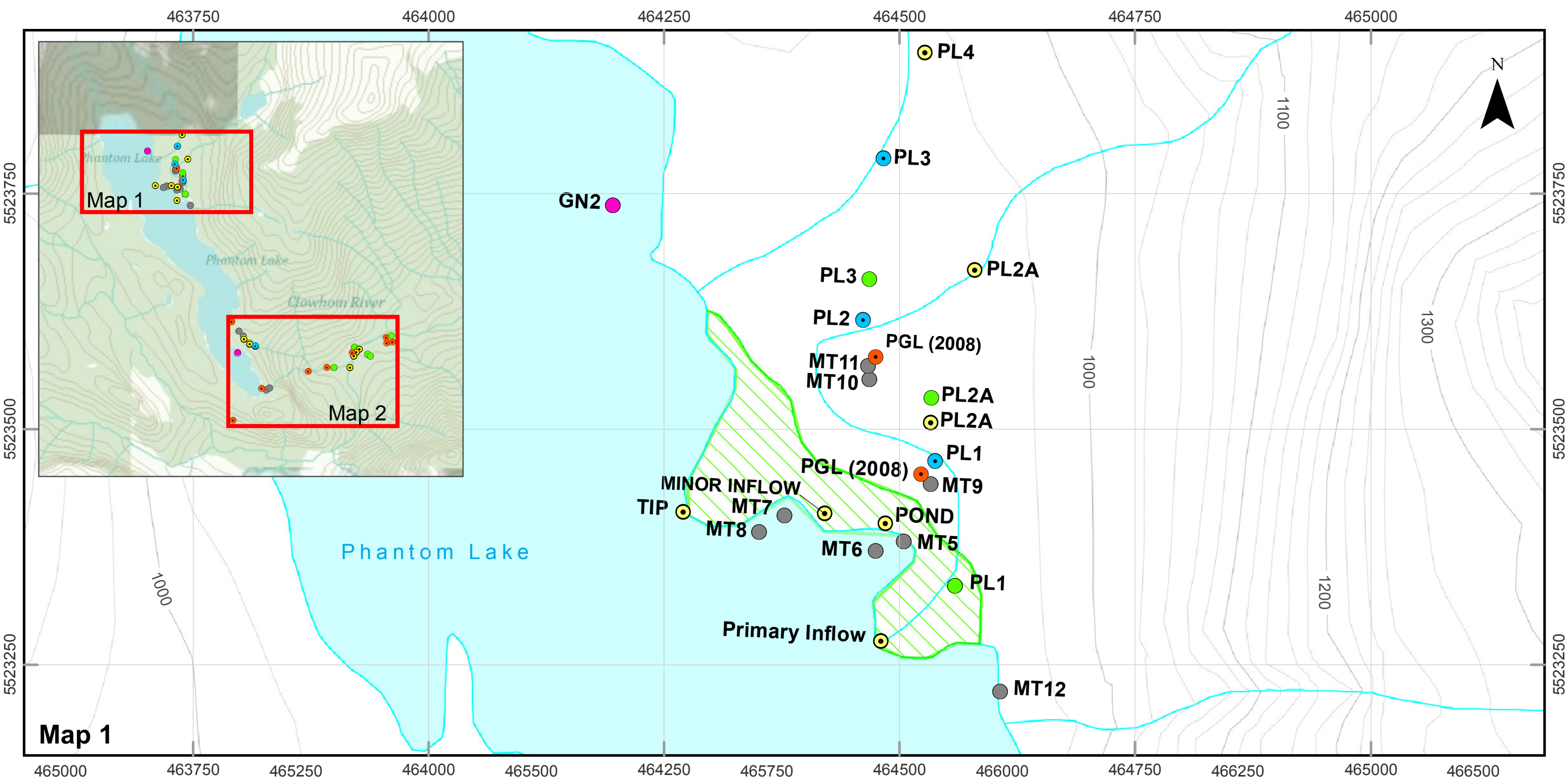
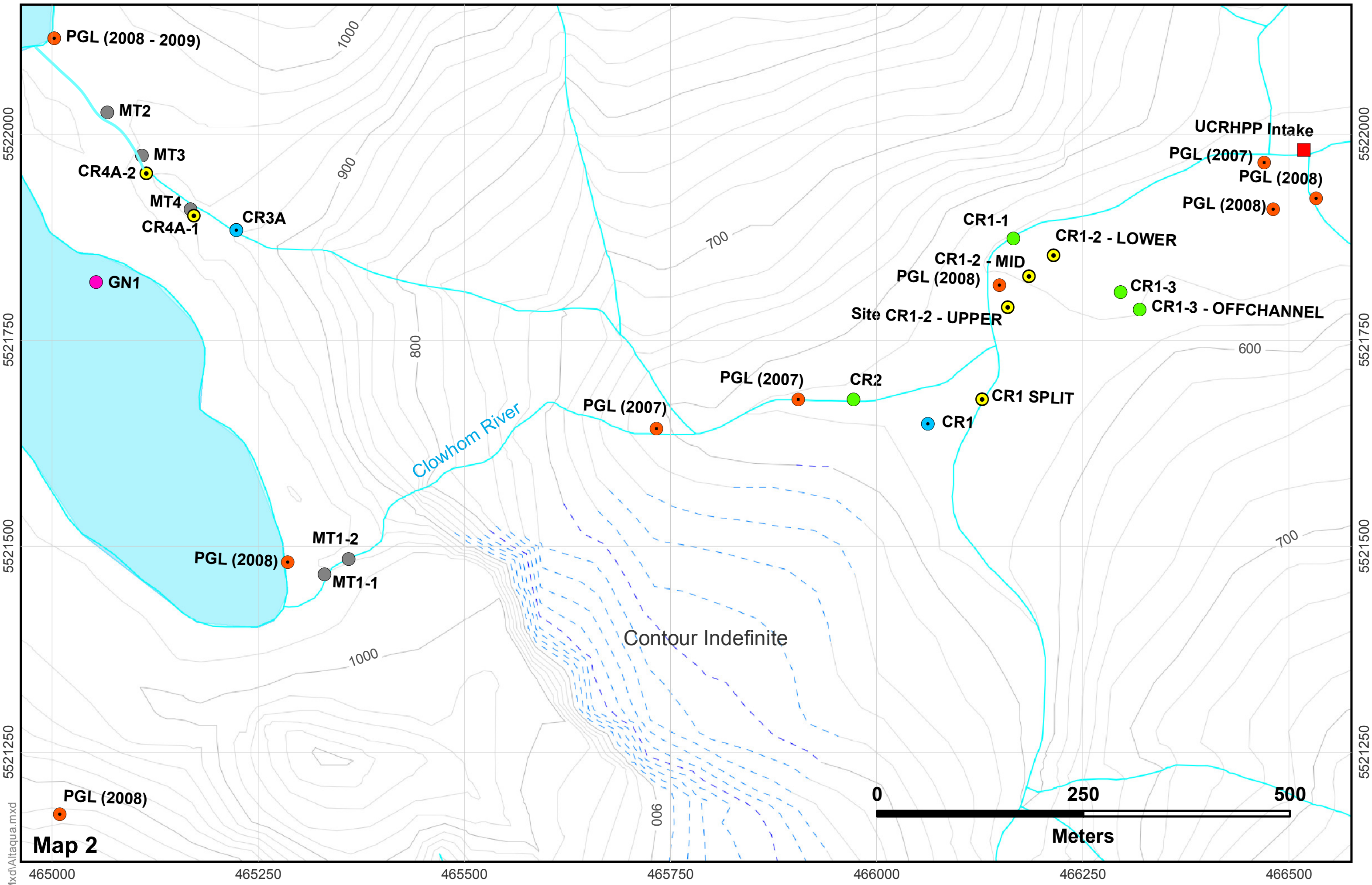
APPENDIX 1

WATERSHED OVERVIEW MAP





Path: C:\GIS\ECL_Projects\Hartley Bay\Mxd\Altaqua.mxd

LEGEND

- Electrofishing Locations
- Gill Net Location
- Intake
- Minnow Trap Locations
- Previous RB Detections
- Reach Break
- Reach and General Habitat Information
- Wetland

Please note: the Clowhom River watercourse has shifted since this overlay was created.

Coordinate System: NAD 1983 UTM Zone 10N

PROJECT
Clowhom River Sustainable Energy Project

TITLE
2011 Fisheries and Aquatic Investigation

ECL ENVIRONMENTAL SOLUTIONS
Vancouver, BC Office

GIS	KF	13 Dec 11
REVIEW	KF	13 Dec 11
CHECK	CW	13 Dec 11

SCALE 1:8,000
SCALE AS SHOWN
REV. 2

Appendix 3