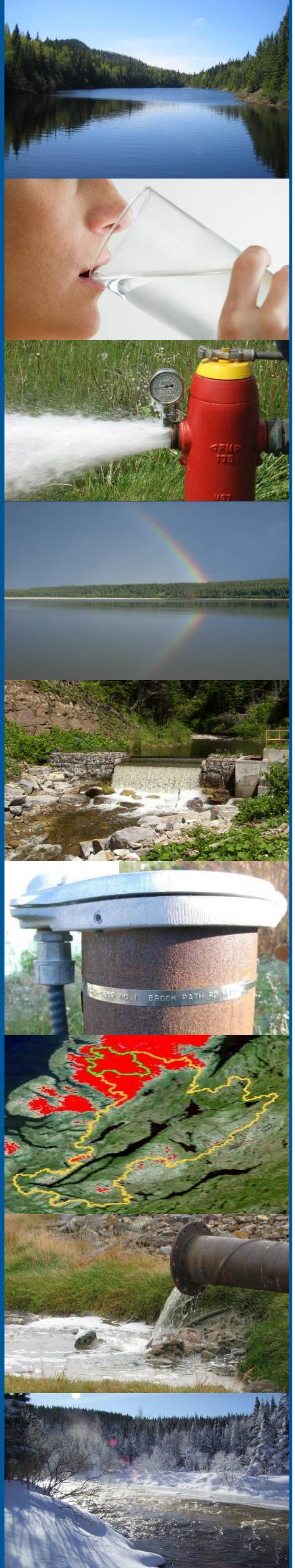

Intensive Survey of Bonne Bay Big Pond and Bonne Bay Little Pond

September 2014

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
St. John’s, NL, A1B 4J6 Canada

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Executive Summary

The intensive survey of Bonne Bay Big Pond and Bonne Bay Little Pond was carried out in the summer of 2009 under the mandate of the Canada – Newfoundland and Labrador Water Quality Monitoring Agreement.

The main objectives of the survey were to:

- Assess general water quality of Bonne Bay Little Pond and Bonne Bay Big Pond, and;
- Identify any existing and/or potential impacts from ongoing land use activity.

The survey was particularly interested in any potential impacts associated with the extensive cottage development around the eastern shores of Bonne Bay Big Pond and the northern shore of Bonne Bay Little Pond.

The results of the intensive survey of Bonne Bay Big Pond and Bonne Bay Little Pond show that in general, the water quality of both ponds is consistently healthy with all parameters within the recommended limits of the *Canadian Environmental Quality Guidelines: Water Quality Guidelines for the Protection of Aquatic Life* (CCME, 1999). Furthermore, the results indicate that water quality is relatively consistent throughout the two ponds and does not deteriorate from headwaters to the outlet at Lomond River.

Given that the water quality is good and consistent throughout the two ponds, it can be concluded that the existing cottage development and associated recreational and land use activity along extensive sections of both ponds are not having a noticeable deleterious impact on water quality.

It is noteworthy that some of the constituent polycyclic aromatic hydrocarbons (PAHs) were detected at levels slightly above the *Canadian Environmental Quality Guidelines for Sediment* (CCME, 1999) for freshwater aquatic life and/or the *Interim Sediment Quality Guidelines* (CCME, 1999). These exceedances indicate that it is likely that human activity in the watershed area and/or the surrounding region as a whole have had some long term cumulative impacts on this watershed area.

The results of the bacteriological water quality sampling and the benthic macroinvertebrates sample collected at Lomond River do not provide evidence of deleterious impacts from land use activity in the watershed area, however they do give an indication that there may be some low level impacts.

It appears that the existing level of cottage development and land use activity in general in the Lomond River watershed are not having a noticeable impact on the water quality of Bonne Bay Little Pond or Bonne Bay Big Pond. However, there is some indication that activity may be starting to have a cumulative impact over time, and if so it is likely that additional developments and land use activity above and beyond the current level could potentially begin to accelerate these impacts. Therefore it is recommended that some effort be made to determine the cottage carrying capacity of both these ponds in order to limit future developments to levels which are sustainable in the long term. It is also

recommended that this intensive survey be repeated after 10 years to determine if there is any change in the water and or sediment quality of the study area.

It is recommended that the trend analysis study carried out under the Canada-Newfoundland and Labrador Water Quality Monitoring Agreement in 2003 for a number of Newfoundland water quality monitoring sites, including Lomond River, be updated to include more recent data.

It is recommended that further repetitive benthic macroinvertebrate sampling at the two sites included in this study would allow comparisons between adjacent watersheds and determination of trends or changes over time at each of the locations.

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1.0 Introduction

The intensive survey of Bonne Bay Big Pond and Bonne Bay Little Pond was carried out in the summer of 2009 under the mandate of the Canada – Newfoundland and Labrador Water Quality Monitoring Agreement. Field work for the survey was completed during the week of July 20th to 24th, 2009 by staff of the Atlantic Water Quality Monitoring and Surveillance Division of the Science and Technology Branch of Environment Canada (EC-WQMS), and the Water Resources Management Division of the Newfoundland and Labrador Department of Environment and Conservation (NL ENVC).

1.1 Survey Objectives

The main objectives of the survey were to:

- Assess the general water quality of Bonne Bay Little Pond and Bonne Bay Big Pond, and;

- Identify any existing and/or potential impacts from ongoing land use activity.

The survey was particularly interested in any potential impacts associated with the extensive cottage development around the eastern shores of Bonne Bay Big Pond and the northern shore of Bonne Bay Little Pond. The general location of the study area is outlined in figure 1.

The survey was designed as a general investigation of the water quality of both ponds with an emphasis on the sections most heavily developed for recreational cottages. The survey included a comprehensive sampling program for water and sediments and also included a biota sampling component. The details of the study design and the various monitoring components will be outlined in the methodology section. A select region of both ponds was profiled using a georeferenced YSI water quality probe to identify general water quality characteristics throughout the system. A georeferenced depth survey was also carried out to enable the preparation of rough bathymetric maps of the two ponds.

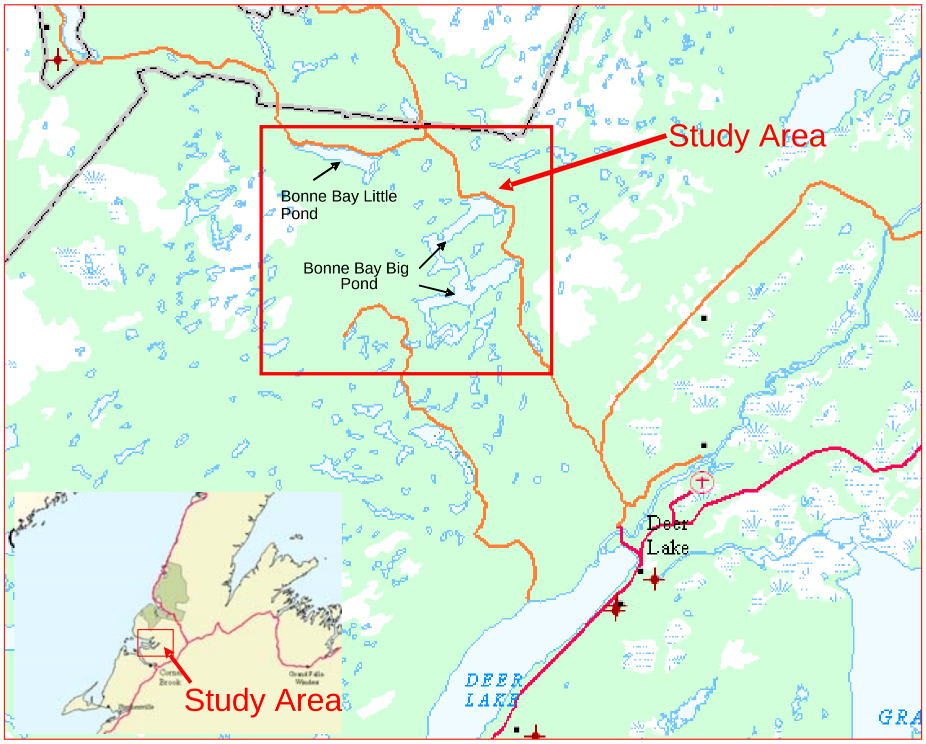

Figure 1: Location of the Study Area

1.2 Description of the Survey Area

1.2.1 Physical Characteristics of the Lomond River Watershed

Bonne Bay Big Pond and Bonne Bay Little Pond are located in the Lomond River watershed. While this survey is focused on the water quality of the two ponds it is also necessary to consider them in the context of the whole Lomond River watershed. There is a long established water quality monitoring station on Lomond River approximately 1.7 km downstream of Bonne Bay Little Pond. Figure 2 shows the watershed area upstream from this station.

According to the Provincial Land Use Atlas (Land Management Division, 2011) the Lomond River watershed has an area of approximately 266 km^2. Approximately 78% of the watershed is forested with an additional 4% covered by non-forest vegetation. Surface water covers about 10% of the watershed, while exposed bedrock accounts for approximately 3%, and wetlands a further 4%, with the remaining 1% of the land being unclassified.

The majority of the watershed (90%) is in the Western Newfoundland Forest Ecosystem, Corner Brook Subregion, with the remainder comprised of the Long Range Barrens ecosystem, Northern Long Range Subregion (Parks and Natural Areas, 2012). The headwaters of Lomond River drain heavily forested reaches of the Long Range Highlands into Bonne Bay Big Pond and Bonne Bay Little Pond. With the exception of some barrens located in the highlands of this watershed, the remaining hills are covered with an extensive boreal forest. The main indicator species found within the watershed are balsam fir and black spruce. Isolated pockets of mixed hardwood species including birch and maple occur throughout.

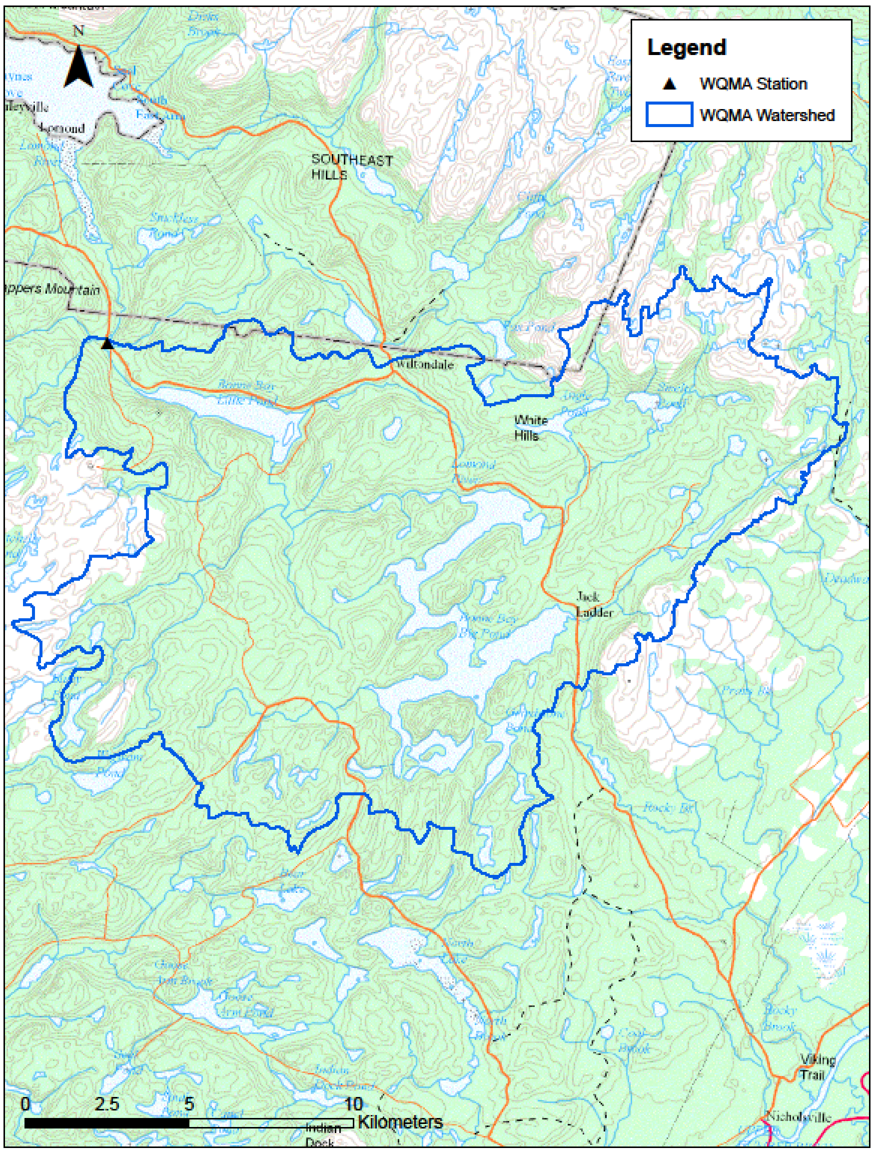

Figure 2: Lomond River Watershed

The bedrock geology is about 57% carbonate rocks (platformal limestone and dolostone), 20 % siliciclastic sediments and volcanics, 11 % siliclastic and mafic volcanic rocks with the remainder a mix of granitoid suites, granitoid gneiss and paragneiss (Land Management Division, 2011). The surficial geology is mostly drift and tills with a small amount of exposed bedrock, alluvium and glaciofluvial formations. There are both blanket (greater than 1.5m) and veneer (less than 1.5m) tills which consist of a mixture of grain sizes from clay to boulders which were deposited by glacial action.

The Lomond River is a scheduled salmon fishing river and there is a regulated recreational fishery on the section of the river from the outlet of Bonne Bay Little Pond downriver to salt water (Mullins et. al., 2001). Apart from Atlantic salmon, other fish present include sea trout, brook trout, assorted stickleback, rainbow smelt, and American eel (Parks and Natural Areas, 2012).

The prevalence of carbonate rocks in the study area has resulted in significant karst topography (Karolyi, 1978). Karst topography is a landscape shaped by the dissolution of a layer or layers of soluble bedrock, usually carbonate rock such as limestone or dolomite. Due to subterranean drainage there are usually numerous underground streams and springs. There are also a variety of distinctive karst surface features such as sinkholes and caves; however these may be obscured by glacial till or debris. The karst topography of the study area has been greatly influenced by glacial and glaciofluvial processes.

Within the study area there are numerous underground streams and springs and the influence of groundwater is most notable in the upper section of Bonne Bay Big Pond.

1.2.2 Water Quality of the Lomond River Watershed

There has been a regular ongoing water quality monitoring station at Lomond River since 1986. The results of this sampling for key parameters are outlined in table A1 in Appendix A. From this data it can be seen that this is basically pristine water with very few parameters exceeding any *Canadian Environmental Quality Guidelines: Water Quality Guidelines for the Protection of Aquatic Life* (CCME, 1999). The only identified exceedances were aluminum (total) and cadmium, which both had a number of samples with minor exceedances. However the mean values for both parameters were well below the recommended guidelines. It should be noted that due to natural background water quality, aluminum (total) and cadmium quite often exceed the guidelines in Newfoundland and Labrador.

The Lomond River data has an average specific conductance of 163.1 uS/cm^2 and an average pH of 7.84 which is typical of significant influence from groundwater. This influence from groundwater is also indicated by the clarity of this water with an average turbidity of only 0.38 NTU. Given the significant extent of karst topography in this watershed it is not surprising that groundwater plays a significant role.

A report on water quality trends in selected water bodies of Newfoundland and Labrador (Dawe, 2003) included an analysis of Lomond River water quality data from 1986 to 1999. The report identifies a number of trends in the water quality of Lomond River including deteriorating trends for color, turbidity, pH, DOC, nitrate/nitrite, nitrogen, silica, beryllium, cadmium and molybdenum and improving trends for sodium, potassium, chloride, barium, copper and mercury. The report attributes the trends to a combination of impacts from climate change causing increased precipitation as well as impacts from land use activities such as forestry and cottage development. However, there is no indication of the relative significance of any of these variables.

1.2.3 Physical Characteristics of Bonne Bay Little Pond

Bonne Bay Little Pond is surrounded by steep sided heavily wooded hills (figure 3) and is approximately 4.7 km long with width ranging from approximately 300 m to 900m (Figure 4). It is oriented in a west-north-west to east-south-east direction with the Lomond River flowing in on the east-south-east end and out on the west-south-west end. Apart from the Lomond River there are numerous smaller tributaries flowing into Bonne Bay Little Pond around its perimeter.

Figure 3: Bonne Bay Little Pond

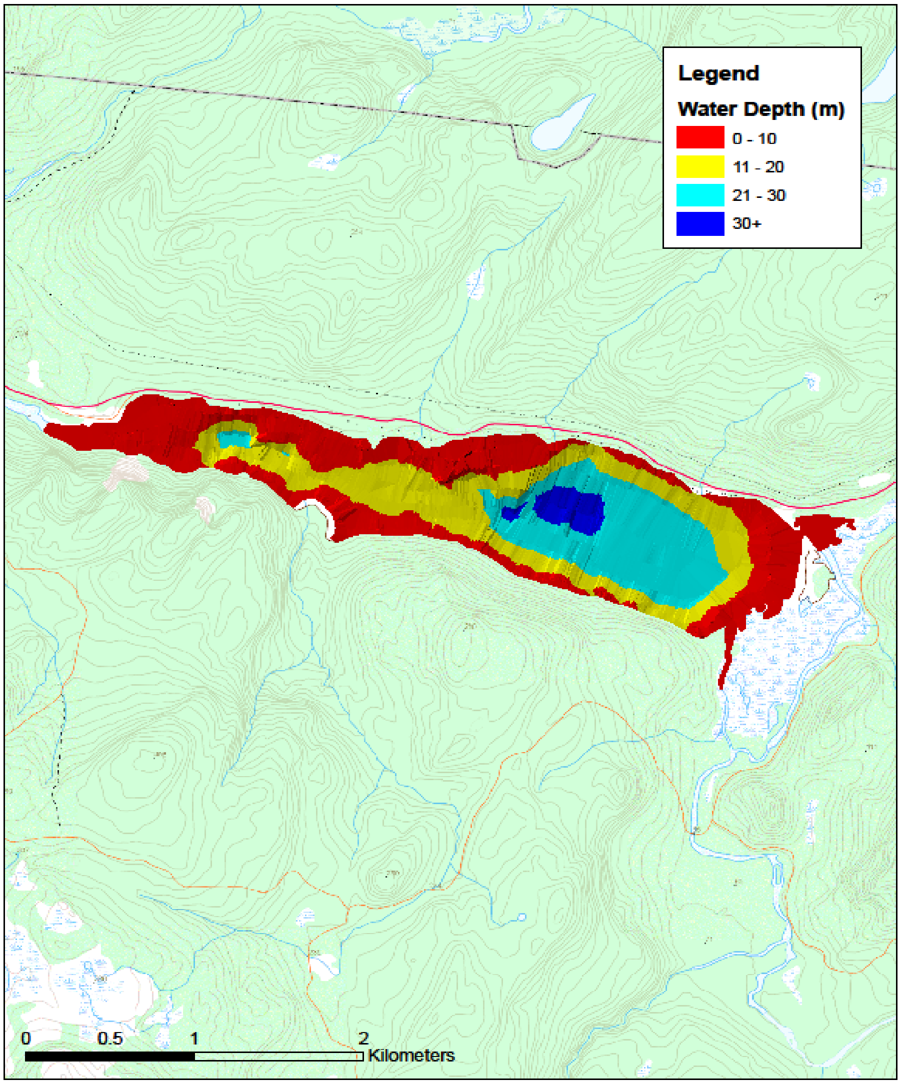

Figure 4: Approximate Bathymetry of Bonne Bay Little Pond

Figure 4 shows the result of an approximate bathymetric survey of Bonne Bay Little Pond carried out as part of this water quality survey. (*It should be noted that this is approximate bathymetric survey and should not be used for navigational purposes*). The bathymetric survey was carried out using a depth transponder and was intended to provide a general indication of the water depths throughout the pond. From figure 4 it can be seen that depths vary from a few meters along the shorelines to over 30 meters at the midpoint of the widest section of the pond.

1.2.4 Physical Characteristics of Bonne Bay Big Pond

Bonne Bay Big Pond is a highly irregularly shaped pond made up of numerous bays and irregular shaped lobes. It ranges in a north-south direction for approximately 9 km and east-west for approximately 6 km. From figure 5 it can be seen that the pond is surrounded by heavily wooded rolling hills.

Figure 6 shows an approximate bathymetric survey of Bonne Bay Big Pond carried out as part of this study. (*It should be noted that this is an approximate bathymetric survey and should not be used for navigational purposes*). The survey was carried out using a depth transponder and was intended to provide a general indication of the water depths throughout the pond. From the map, it can be seen that depths vary considerably throughout the pond and are generally deepest at the midpoint of the widest section. The deepest section measured is in the general area of sample site BBBP 11 (figure 9) where depths of up to approximately 62 meters were measured.

Figure 5: Bonne Bay Big Pond

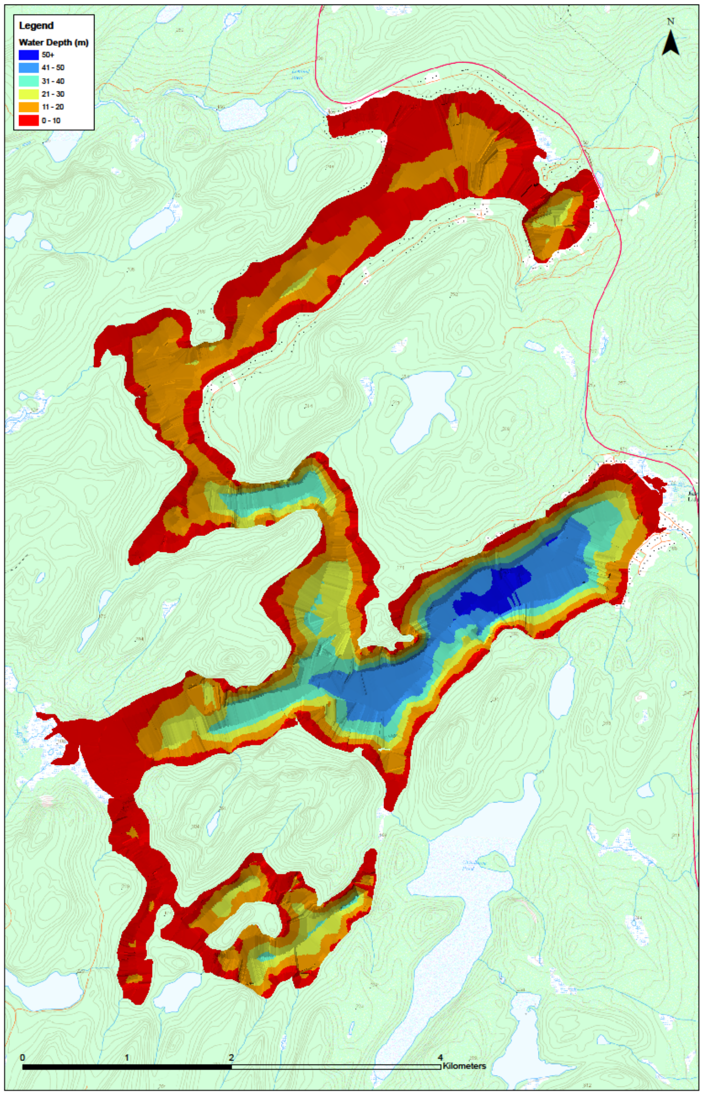

Figure 6: Approximate Bathymetry of Bonne Bay Big Pond

1.2.5 Land Use in the Study Area

There is a wide range of land use activity in the Lomond River watershed. Most notably there are linear developments, forest management activities, extensive cottage developments, commercial activities and recreational activities (Land Management Division, 2011).

In terms of linear developments, there are both paved provincial highways and gravel forest resource roads in the Lomond River watershed area, as well as a variety of power and communication utility transmission lines. There are approximately 24.2 km of paved highway and 23.5 km of unpaved public roads in this watershed, as well as approximately 59.4 km of resource roads and 50.9 km of trails and forest extraction roads.

Over the past 25 years there has been significant forest access road construction and the commercial harvesting of approximately 13.5 km^2 of forested area inside the Lomond River watershed area. In addition, there has been approximately 36 km^2 of pre-commercial thinning. It should be noted that there is a significant level of domestic cutting in the area for firewood and saw logs and that there is one small scale commercial sawmill operating in the Wiltondale area. From 2002 to 2009 there were significant infestations of both Hemlock Looper and Balsam Fir Sawfly in this watershed area. During this time the Newfoundland Forest Service carried out a series of summertime spray programs using a variety of biological pesticides including B.t.K., NeabNVP, and Abietiv.

There are seven quarries located in the watershed area and a history of prospecting and mineral exploration. All quarries are located near highways and are/were used for aggregate material during road construction Mineral exploration has included nickel-cobalt-copper exploration off the eastern shore of Bonne Bay Big Pond and in areas along the southern edge of the watershed.

Figure 7: Cottage Development at Bonne Bay Big Pond

Cottage development in the watershed area is concentrated along the northern shore of Bonne Bay Little Pond and along the eastern shores of Bonne Bay Big Pond. There are approximately 520 cottages in the Lomond River watershed (Land Management Division, 2011). Figure 7 shows an area of significant cottage development along the eastern side of Bonne Bay Big Pond. Most of the cottages are used sporadically throughout the year with heavier use during the late spring to early fall period. However, there is a growing trend towards year round use with cottages becoming permanent residences. It is estimated that five to ten percent of the cottages in this area have become year round residences.

There are several commercial establishments including two gas stations/convenience stores, a tourist lodge, and two cottage rental locations within the watershed. Finally, there is a wide variety of consumptive and non-consumptive recreational activity in the area including; boating, snowmobiling, use of ATVs, fishing, hunting, trapping, berry picking, hiking, swimming, cross country skiing, canoeing, kayaking, biking, and a variety of other outdoor recreational activities.

2.0 Methodology

This survey was designed to provide a snapshot of water quality throughout the two study ponds by completing an intensive survey over a relatively short timeframe. All field work was completed over a five day period from July 20 to 24, 2009. Field work was completed using two teams which consisted of three person crews in two 16 foot aluminum boats. Field work included collection of water quality, sediment and biota samples, as well as use of a georeferenced YSI water quality probe to collect surface water quality data throughout the two ponds and also at regular depth intervals at a number of the sampling sites. A survey of water depth was also carried out throughout the two ponds in order to complete an approximate bathometric map of each pond.

The sampling program included general water chemistry and bacteriological samples at 11 sampling sites. At eight of the sites water quality depth profiles were measured with a YSI water quality probe to evaluate changes with depth and the characteristics of the thermocline. For several of the depth profile sites samples were collected both above and below the thermocline, which is the layer of water in the lake where water temperature decreases most significantly with depth. The sampling program also included sediment samples at several locations. A QA/QC component was built into the sampling program and included the collection of a triplicate and blank water quality sample and a duplicate sediment sample.

The study objectives included a biotic sampling component, however while attempts were made to acquire fish for tissue samples, there were insufficient fish captured to be able to carry out analysis. One benthic invertebrate sample was collected in 2009 from the study watershed as part of the Canadian Aquatic Biomonoitoring Network (CABIN) program. This sample was collected from Line Brook which is a tributary to Bonne Bay Little Pond. In 2008 a CABIN sample was collected from Lomond River and a review of the results for this sample will also be included.

2.1 Sample Locations

Eleven sampling sites were identified for water chemistry with four of these sites also including sediment sampling. Sampling locations are indicated in figures 8 and 9 and outlined in table 1. From figure 8 it can be seen that there were four sampling sites for Bonne Bay Little Pond and from figure 9 it can be seen that there were seven sampling sites for Bonne Bay Big Pond. Sampling locations were selected both to provide background water quality in relatively undeveloped sections of the ponds as well as potentially impacted sites near the heaviest concentrations of cottage development. Table 1 outlines the rationale for selecting each site and table 2 has information on the types of sampling carried out at each site.

Table 1: Sediment and/or Water Quality Sampling Locations

Sample ID	Lat.	Long.	Location Description	Rationale for Sample Location
LBBP1	49.402	57.78	Lomond River above Rte. 431 Bridge	Existing long term water quality station
LBBP2	49.38798	57.69833	Middle of Bonne Bay Little Pond 1.5 km upstream from outlet	Indicates water quality leaving Bonne Bay Little Pond
LBBP3	49.37803	57.65927	Middle of Bonne Bay Little Pond 600 m from eastern end	Indicates water quality in upper end of pond
LBBP4	49.38295	57.65211	Lomond River as it enters Bonne Bay Little Pond	Indicates water quality of Lomond River before it enters the pond
BBBP5	49.36116	57.57645	N side of Cove 300 m upstream of outlet to Lomond River	Indicates water quality leaving Bonne Bay Big Pond
BBBP6	49.36077	57.56193	Middle of N arm of Bonne Bay Big Pond 300 m from shore	Indicates water quality in close proximity to shore with many cottages
BBBP7	49.33155	57.59643	Mid section of the main body of Bonne Bay Big Pond	Site is just upstream of all cottage development in the northern arm
BBBP8	49.3285	57.5414	Middle E arm of Bonne Bay Big Pond 200 m from shore	There is a concentration of cottages in the E arm
BBBP9	49.30723	57.6048	Middle SW arm of Bonne Bay Big Pond 550m from SW shore	This area is away from cottages but frequented by boats
BBBP10	49.28995	57.58465	Middle of the S section of Bonne Bay Big Pond 140 m SE of the island	This is a relatively undeveloped section of the pond
BBBP11	49.31948	57.55678	Middle E arm of Bonne Bay Big Pond 1.75 km from shore	Site is just outside the concentration of cottages in the E arm

Table 2: Details of Sampling Program Components

Sample ID	Surface Water Quality	Sample at Depth	Depth Profile	Sediment Sample	Blank Sample
LBBP1	Yes				
LBBP2	Yes		Yes	Yes	
LBBP3	Yes		Yes		
LBBP4	Yes				
BBBP5	Yes			Yes	
BBBP6	Yes	Yes	Yes		
BBBP7	Yes		Yes		
BBBP8	Yes	Yes	Yes	Yes (Duplicate)	
BBBP9	Yes (Triplicate)		Yes		Yes
BBBP10	Yes	Yes	Yes	Yes	
BBBP11	Yes	Yes	Yes		

2.2 Sampling Program and Collection Procedures

The sampling program included a variety of sampling and water quality measurement techniques at the 11 specific sampling sites and throughout the study watershed. General water chemistry and bacteriological samples were collected at all 11 of the designated sampling sites. In addition, four of the water quality sampling sites were selected for sediment sampling. The sampling program also included a biota sampling component, a continuous survey of surface water quality through the lower section of the study area using a GPS referenced YSI multi-parameter probe, and the measurement of water depth throughout the two study ponds.

At select sites, water samples were collected at a depth below the thermocline in order to assess changes of water quality with depth. Changes in water quality with depth were also recorded using the YSI water quality probe to evaluate changes with depth and the characteristics of the thermocline.

The sampling program included a QA/QC component which included a triplicate and blank sample samples for water quality and a duplicate sample for sediments.

All water, sediment and biota sampling was completed using procedures outlined in the following manual:

- Protocols manual for Water Quality Sampling in Canada, Canadian Council of Ministers of the Environment, 2009

A brief discussion of the specific procedures and equipment used for each component of the sampling program is included in the following sections.

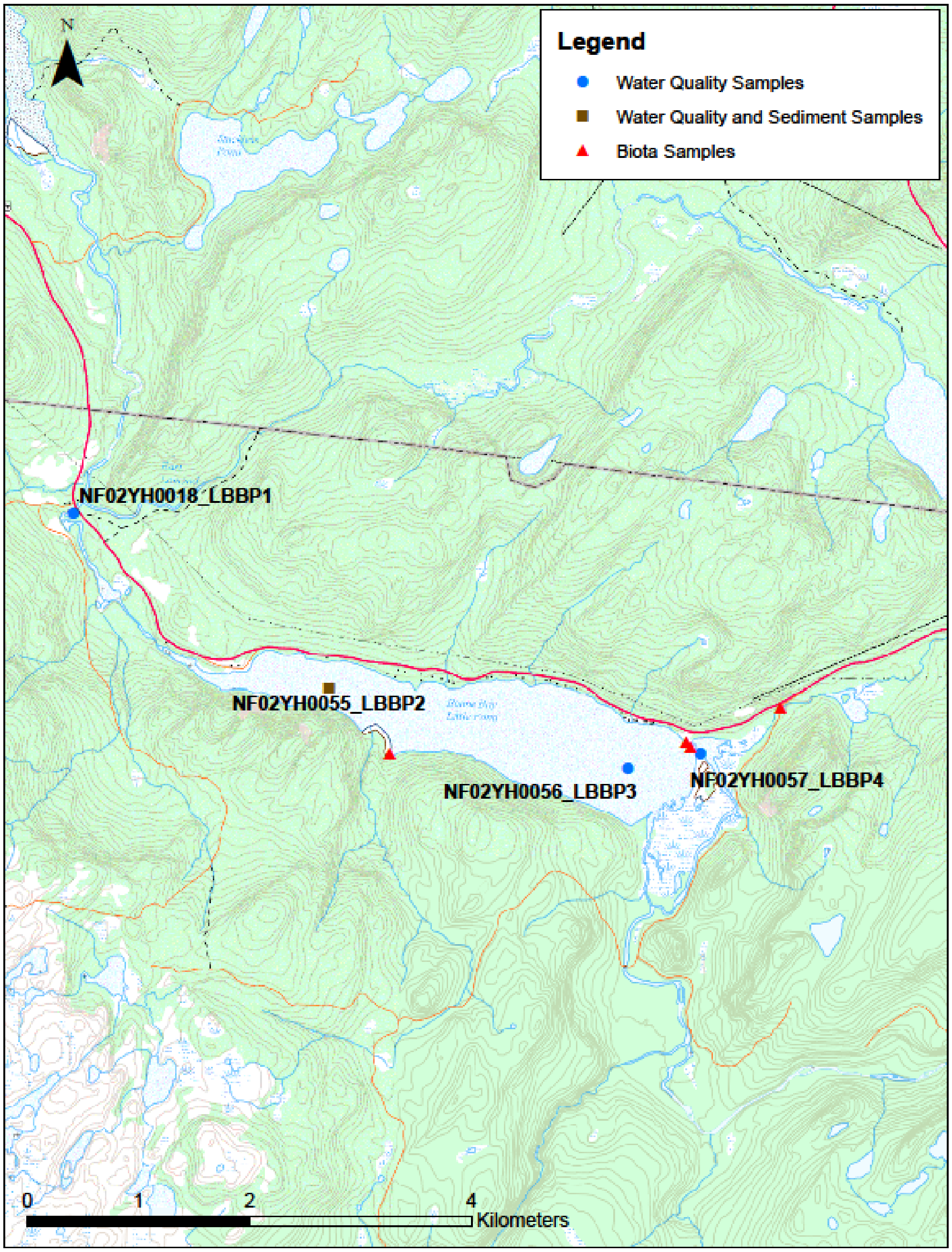

Figure 8: Sample Locations in Bonne Bay Little Pond

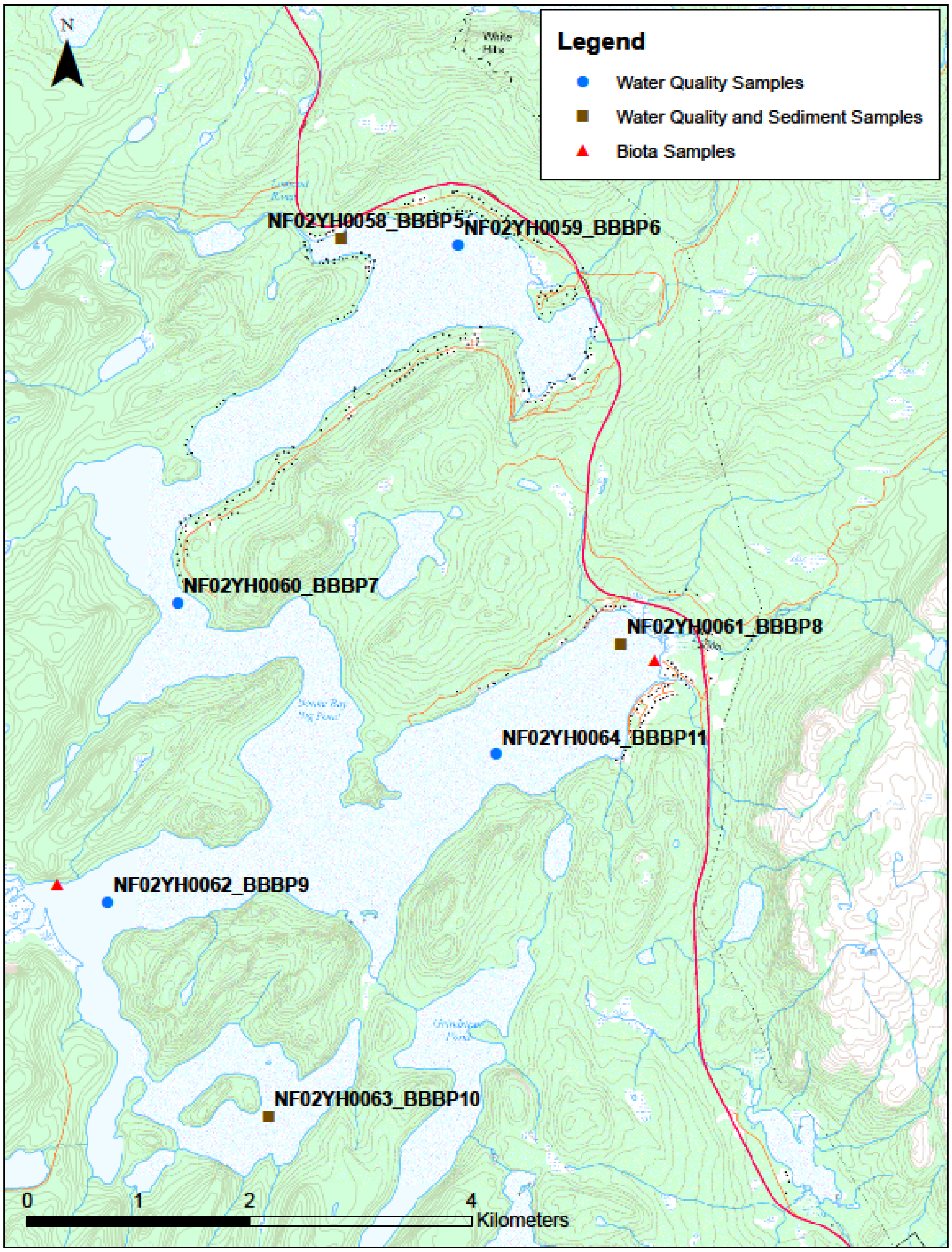

Figure 9: Sample Locations in Bonne Bay Big Pond

2.2.1 Water Sampling

The Water sampling program consisted of three distinct components which are outlined in the subsections below.

2.2.2 Grab Samples

Grab samples were collected at a depth of approximately 0.3 meters below the surface. Lab-certified bottles were pre-labeled and immersed in the water to collect the sample. Sample number, date and time were recorded on the bottle. The boat was pointed upwind and the water sample was taken from the bow of the boat to prevent contamination from the boat and motor. Samples were immediately placed in coolers on ice and kept at 4°C during the storage and transportation phases. Field measurements using a YSI multi-probe were taken at each sampling site and parameters measured included water temperature, pH, conductivity, dissolved oxygen, turbidity, chlorophyll, blue green algae, and depth.

All water chemistry analysis was carried out at Environment Canada's Atlantic Laboratory for Environmental Testing (ALET) in Moncton and included the parameters outlined in table 3.

Bacteria grab sampling was completed by submerging the bottle to a depth of 0.3 meters. Samples were immediately placed in a cooler with ice and were transported to the lab in Corner Brook within a few hours after collection. Samples were analyzed for total and fecal coliform (*E.Coli*).

Table 3: Water Quality Parameters Included in Grab Sample Analysis

Physical, Major ions, Nutrients		
pH	calcium (diss)	nitrate (diss)
conductivity	magnesium (diss)	nitrite (diss)
TOC	potassium (diss)	total nitrogen
Color	sodium(diss)	total phosphorus
turbidity(NTU)	chloride (diss)	sulphate (diss)
alkalinity (tot & gran)		
Total Metals		
aluminum	tin	titanium
nickel	uranium	antimony
cadmium	iron	mercury
vanadium	arsenic	chromium
lead	selenium	zinc
barium	cobalt	molybdenum
silver	beryllium	copper
manganese	strontium	thallium

2.2.3 Samples at Depth

Within lakes and ponds water quality can vary significantly with depth and at various periods throughout the year water can become stratified into distinct layers. This stratification is largely due to the temperature gradient. In summer there tends to be a warm layer (epilimnion) on top of a colder layer (hypolimnion). Between these two layers there is a zone called the thermocline where temperature changes more rapidly with depth than it does in the layers above or below. The depth of the thermocline can vary throughout a lake and can change over the course of the seasons.

For this study, eight of the water quality monitoring sites were selected for depth profiling using the YSI water quality sonde. The sonde was lowered into the water and water quality data were collected at regular intervals of approximately 1 to 1.5 meters. The main objective of this profiling was to determine the depth of the thermocline and any significant changes in water quality above and below the thermocline.


Figure 10: Kemmerer Sampler

In addition to profiling the water quality at regular depth intervals with the YSI multi-parameter probe, four sites were selected for collecting samples below the thermocline. The samples at depth were collected to show any differences in water quality above and below the thermocline. Samples below the thermocline were collected using a Kemmerer sampler similar to the one shown in figure 10. In this case a stainless steel version of the Kemmerer sampler was used. If one was available, it would have been more appropriate to use a Teflon version to avoid any trace metal contamination of the sample.

A Kemmerer water sampler is a device that makes it possible to obtain a sample of water from a pond, river or lake at a specified depth down in the water column. The sampler is essentially a metal tube with stoppers on each end that can be held open when the sampler is lowered by a line to a desired depth. These same stoppers can then be triggered to close the ends of the tube when a metal cylinder called a messenger is dropped down the line holding the Kemmerer sampler. After the stoppers close the ends of the tube, the sampler is retrieved with the desired sample of water being uncontaminated by water from other depths. Once the sampler is retrieved the sample water inside is transferred to an appropriate sample bottle for storage and transportation to the laboratory for analysis.

2.2.4 Continuous Samples

Figure 11: GPS Enabled Multi-parameter Probe Deployed from Side of Boat

Field measurements were taken using a freshly calibrated multi-parameter YSI 6000MS sonde connected to a Garmin Rhino 530 GPS unit. The sensors on the sonde were situated at a depth of approximately 0.3 m at the side of the boat near the front to minimize influence from the boat and motor. This set-up was capable of logging in-situ temperature, dissolved oxygen, specific conductance, pH, turbidity, chlorophyll, and blue green algae (BGA), while obtaining the GPS coordinates at each measurement location. This set-up enabled logging of field parameters at 5 second intervals while the boat was moving. The logged data was plotted on a map to assess spatial variability in the parameters. A photo of the deployed sonde is shown in figure 11.

The initial plan was to complete a field survey of both ponds, however time constraints in the field restricted data collection to the lower section of the study area.

2.2.5 Sediment Sampling

Sediment samples were taken using a mini Ponar sampler similar to the one shown in figure 12. This sampler is lowered over the side of the boat suspended on a rope until it reaches the bottom. The Ponar grab consists of a pair of weighted, tapered jaws which are held open by a catch bar. It is triggered upon impact with the sediment and the tension on the catch bar is reduced allowing the jaws to close. The upper portion of the jaws is covered with a mesh screen which allows water to flow freely during descent, consequently reducing the shock wave that precedes the sampler. Upon recovery, the mesh can be removed to allow access to the sediment for sub-sampling purposes. The Ponar grab is suitable for collecting fine-grained to coarse material.

Figure 12: Mini Ponar Sampler

Depth of the sample was obtained using a depth sounder and recorded in a field book. Due to the unconsolidated nature of the sediments, it was not necessary to prepare the sample on a tray. Instead, the top layer of silty sediment was placed in a lab-certified container using a new, clean pair of nitrile gloves. The sediment samples were placed inside a cooler with ice until they could be frozen and shipped to the laboratory using an overnight courier. The mini Ponar sampler was rinsed in the pond several times in between each sampling location to minimize carry over of sediments from previous sampling sites. The nature of the sediments described above was such that carry-over was not a major issue because the sediments did not stick to the sampler.

Four sites were selected for sediment sampling: LBBP2, BBBP5, BBBP8 and BBBP10. The sample at BBBP8 was a duplicate sample for quality assurance/quality control purposes. Two of these sites (BBBP8 & BBBP10) were selected to be well upstream of the main cottage development areas and were selected as reference sites. The other two sites (LBBP2 and BBBP5) are located in the general area of cottage development and were selected as potentially impacted sites. Sediment analysis included the following parameters: extractable non-residual metals, total mercury, and PAHs.

2.2.6 Biota Sampling

The intention of the biota sampling component was to catch fish (trout and/or small salmon) at several locations, both in the vicinity of cottages and away from them, and to have fish tissue samples analyzed for a variety of parameters. Attempts were made to catch fish using fyke nets and fishing rods in the vicinity of several of the fyke nets. While some small fish were captured and submitted for analysis, the lab determined that sample size was too small and insufficient for analysis.

Fyke nets were deployed at five locations which are described in table 4 and shown in figure 13. Fyke nets are bag-shaped nets which are held open by hoops and have a leader to direct fish towards the opening in the bag. The fyke net deployed at site FYKE1 is shown in figure 14.

Table 4: Fyke Net Locations

Site	Latitude	Longitude
FYKE1	49.382619 N	-57.690722 W
FYKE2	49.383381 N	-57.653369 W
FYKE3	49.383789 N	-57.653889 W
FYKE4	49.327128 N	-57.537161 W
FYKE5	49.308611 N	-57.611031 W

In addition to the fish sampling program, the study included collection of an aquatic benthic macroinvertebrate sample from a tributary to Bonne Bay Little Pond. This sample was collected in September of 2009 as part of a larger province wide sampling program carried out for the Canadian Aquatic Biomonitoring Network (CABIN). The CABIN program involves the collection of benthic macroinvertebrate samples from streams and rivers to allow the determination of a population profile which is used to assess ecosystem health. The sample was collected from Line Brook at a location indicated in figure 15. In 2008 a CABIN sample was collected from Lomond River at the same site as the WQMA sampling station show in figure 2. Results from both these CABIN samples will be discussed in section 3.6.1.

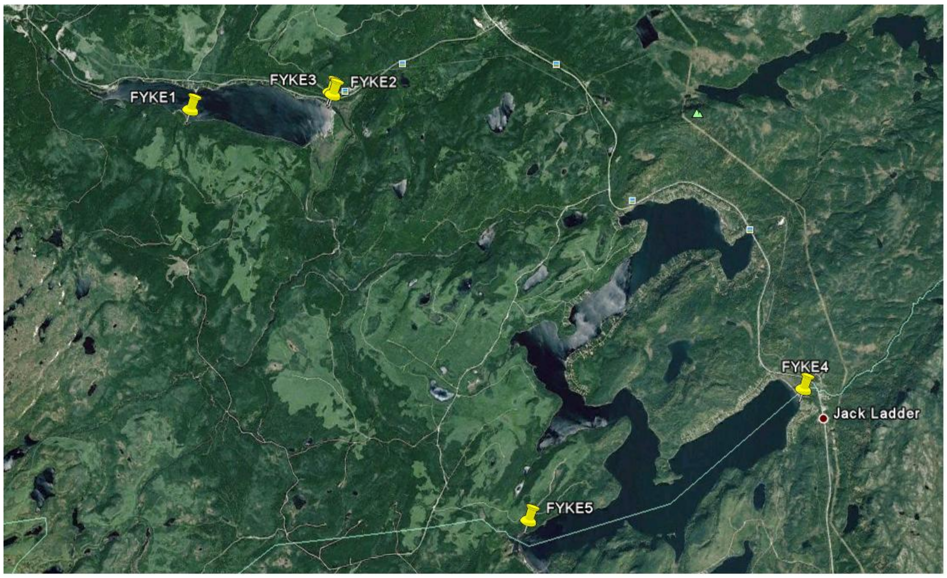

Figure 13: Locations of Fyke Nets

Figure 14: Fyke Net Deployed at Bonne Bay Little Pond

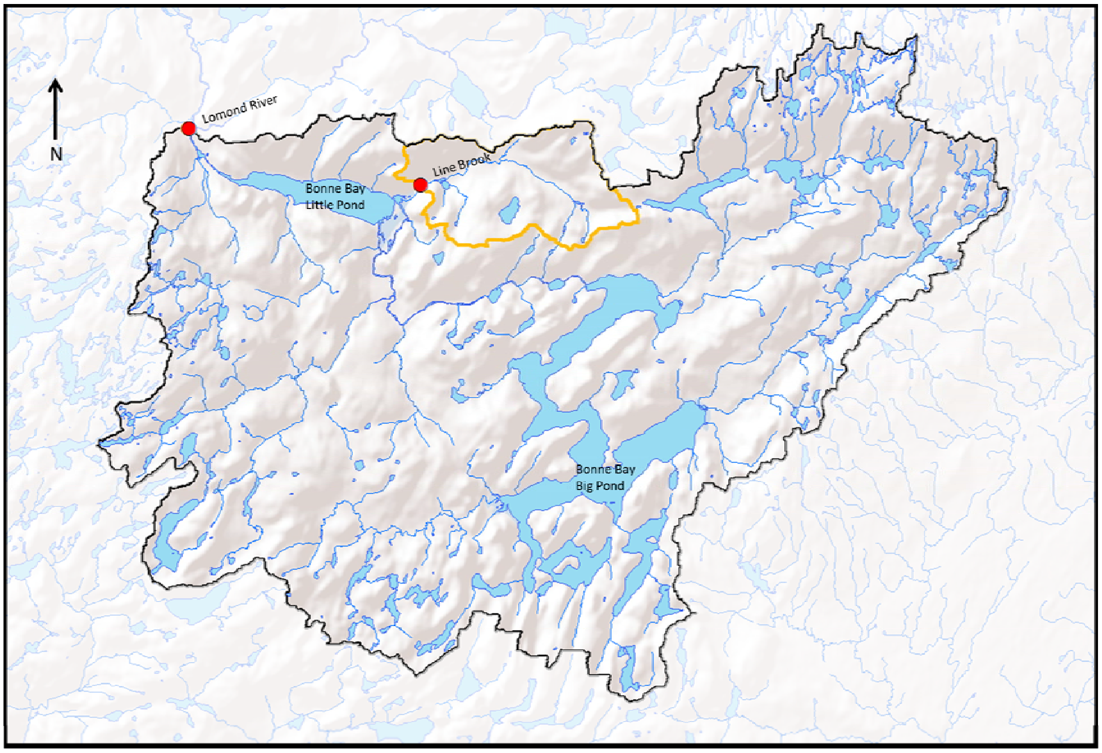

Figure 15: Location of Aquatic Benthic Macroinvertebrate Samples

2.3 Lake Depth Survey

A survey of water depth was completed for both Bonne Bay Little Pond and Bonne Bay Big Pond using a GeoXT (GPS) with a Sonarmite depth sounder. The depth sounder was mounted on one of the aluminum boats and automatic georeferenced readings were logged every few seconds while the boat traveled transects across all sections of the two ponds. A total of approximately 30,000 depth measurements were taken from both ponds allowing for the preparation of approximate bathometric maps of both lakes. Results of the depth survey were previously presented in figures 3 and 6.

2.4 Laboratory Analysis

At the end of the field program all water quality and sediment samples, with the exception of the bacteriological samples, were transported by the Environment Canada staff to the laboratory for analysis. All analyses were conducted by Environment Canada's Atlantic Laboratory for Environmental Testing (ALET) in Moncton, New Brunswick. This laboratory is accredited by the Canadian Association for Laboratory Accreditation (CALA, www.cala.ca) which assures that the data are produced according to the highest standards of quality.

Bacteriological samples were transported by staff of the Department of Environment and Conservation to Corner Brook to be analyzed by the Newfoundland and Labrador Public Health Laboratory located there.

Water samples were analyzed for general environmental chemistry, metals and bacteriology, in order to assess water quality and provide an indicator of any impacts of land use activity in the study area. Sediment samples were analyzed for metals and polyaromatic hydrocarbons (PAHs). Fish tissue samples were of insufficient size for proper analysis and therefore none was completed. Table 5 provides a summary of the analyses completed for this study.

Table 5: Sample Analysis Summary

Sample Matrix	Number of Samples	Sample Analyses Conducted
Water - inorganic and organic	15	• Major Ions • Nutrients • Physicals • Metals (including Mercury)
Water – bacteriology	11	• Total and Fecal Coliforms *(Escherichia coli)*
Sediment	4	• Metals (including Mercury) • PAHs

2.5 Quality Assurance and Quality Control (QA/QC)

Quality assurance and quality control (QA/QC) samples were collected to assess the bias and representivity of the samples collected during this study. In this study, three types of quality control samples were collected: field blank, triplicate samples, and duplicate samples. The data was also screened for outliers and anomalous results using basic data validation techniques (e.g. ion balances, etc.).

Detailed information for each type of QA/QC sample is provided below and a discussion of the QA/QC sample results is included in section 3.

2.5.1 Field Blank

A field blank is used to assess if any contamination was introduced during the sample collection, sample transportation, and/or sample analysis processes. A field blank was prepared on July 22, 2009 using laboratory supplied distilled water. The field blank was prepared while in the boat using the same procedure and equipment as the regular water quality samples. The laboratory supplied water was poured into the water quality sample bottles, labeled with the date and time, and kept with the other samples until reception at the laboratory.

2.5.2 Triplicate Samples

Triplicate samples are used to assess the variability introduced during the sample collection and analysis processes. In this study, a triplicate sample was collected on July 22, 2009 at station NF02YH0062 (Bonne Bay Big Pond Site 9) for the water matrix.

2.5.3 Duplicate Samples

Duplicate samples are used to assess the variability introduced during the sample collection and analysis processes. In this study, a duplicate sample was collected on August 22, 2008 at station NF02YH0061 (Bonne Bay Big Pond Site 8) for the sediment matrix.

3.0 Results

3.1 Study Period Details

All sampling and field work for this intensive survey were carried out from July 20th to 24th, 2009. Weather conditions were sunny and warm with relatively light winds and no precipitation. Daytime highs reached 24.5°C and nighttime lows reached 6°C. There were light rains for several days prior to the field work but no discernable water quality impacts associated with it. There was some boating and general activity associated with the recreational cottage activity in the area but there were no observed impacts on water quality noted during the week of the field work.

3.2 Water Sampling Results

3.2.1 General Water Chemistry

Before discussing the data results it is important to note both that this is a very limited data set involving only a single set of samples, and that the water quality parameters analyzed can display considerable natural spatial and temporal variability. A single set of samples all collected within a short time span offers limited data for statistical analysis. Water quality is very dynamic and there are significant natural variations over space and time both in the short and long term. Water quality can vary significantly with the seasons and in relation to major wind and precipitation events. The data in this study provides a single snapshot of water quality conditions during typical summer conditions. As such, they provide a benchmark of conditions that can be compared to any future water quality work.

In all cases except for bacteriological results, data from this study were compared to the *Canadian Environmental Quality Guidelines: Water Quality Guidelines for the Protection of Aquatic Life* (CCME, 1999). Bacteriological results were compared to the *Health Canada Guidelines for Canadian Recreational Water Quality* (Health Canada, 2012).

All water sampling results are presented in tabular form in table A2 in Appendix A. The Canadian Environmental Quality Guidelines for Aquatic Life are included in the table for all parameters which have a specific guideline.

Some general observations are:

- Water quality is very comparable throughout the system and all parameters are within the limits recommended by the *Canadian Environmental Quality Guidelines: Water Quality Guidelines for the Protection of Aquatic Life*

- Specific conductivity was found to be higher in the upper section of Bonne Bay Big Pond indicating a greater prevalence of groundwater in this area. This is confirmed by higher calcium levels at BBBP #10

- There does not appear to be any significant variability, or evidence of water quality impact, for nutrients (nitrogen, phosphorus, & potassium) throughout the study area.

3.2.2 YSI Grab Sample Results

At the time of collecting grab samples, field parameters were measured in situ with a YSI 6000MS and results are provided in table 6 below. As with the grab sample results, the in situ measurements are all very comparable with the exception of BBBP 10 which clearly shows more influence by groundwater than the other sites.

A review of the YSI grab sample data in table 6 shows that water quality was very consistent at all of the sites with only site BBBP10 showing some distinctive characteristics which may be attributable to a greater influence from groundwater.

Temperature varied little over the sites, particularly considering sampling took place over three days and the depth of these readings ranged from 0.266 to 2.069 m. Temperature ranged from a minimum of 16.5°C to a maximum of 19.1°C with a mean of 17.85°C. Specific conductivity was very consistent and ranged from a minimum of 0.152 mS/cm to a maximum of 0.225 mS/cm with a mean of 0.167 mS/cm. At 0.225 mS/cm site BBBP10 has a noticeably higher specific conductivity than all the other sites. This higher specific conductivity at BBBP10 is a good indicator of a greater influence from groundwater at this site. TDS readings are calculated based on specific conductivity and are therefore tightly grouped around a mean of 0.108 g/L. pH was very consistent ranging from 8.17 to 8.41 with an average of 8.22. Site BBBP10 had the highest pH at 8.41, which is also an indication of a greater influence from groundwater. Turbidity values were all negative and slightly below zero which is actually a zero reading. Oxygen levels indicate very healthy water with percent saturation ranging from 96.4% to 101.6% with an average of 99.7%, and dissolved oxygen concentrations ranging from 9.04 mg/l to 9.91 mg/l with an average of 9.42 mg/l. The blue green algae readings are all relatively low and well within the expected background range for a healthy freshwater ecosystem. Negative values are a function of the sensors variability. Chlorophyll readings are tightly grouped ranging from 0.2 µg/L to 1.6 µg /L with an average of 0.74 µg/L.

Table 6: Grab Sample YSI Results

Site	Date	Temp °C	SpCond mS/cm	pH	Turb. NTU	ODO%	ODO Conc mg/L	Depth m	BGA cells/mL	Chlorophyll µg/L	TDS g/L
Lomond	07/21/09	18.05	0.168	8.18	-0.2*	101.1	9.56	0.578	-314	0.7	0.109
LBBP2	07/21/09	17.82	0.167	8.17	-0.1	97.8	9.29	1.084	144	0.9	0.109
LBBP3	07/21/09	18.45	0.168	8.17	-0.2	96.4	9.04	0.931	227	0.9	0.109
LBBP4	07/21/09	16.55	0.166	8.18	-0.2	101.6	9.91	0.973	151	0.8	0.108
BBBP5	07/22/09	19.03	0.152	8.2	-0.3	99.6	9.23	1.012	148	0.6	0.099
BBBP6	07/22/09	19.1	0.152	8.2	-0.3	99.8	9.23	1.041	3	0.4	0.099
BBBP7	07/22/09	18.68	0.158	8.22	-0.3	98.9	9.23	1.028	240	0.2	0.102
BBBP8	07/23/09	16.5	0.159	8.24	-0.3	98.8	9.65	1.056	266	1.6	0.103
BBBP9	07/22/09	16.7	0.160	8.21	-0.3	99.5	9.68	0.266	154	0.7	0.104
BBBP10	07/22/09	18.64	0.225	8.41	-0.3	99.8	9.32	0.358	50	0.7	0.146
BBBP11	07/23/09	16.8	0.159	8.2	-0.3	97.6	9.47	2.069	174	0.6	0.103
	Min	16.5	0.152	8.17	-0.3	96.4	9.04	0.266	-314	0.2	0.099
	Max	19.1	0.225	8.41	-0.1	101.6	9.91	2.069	266	1.6	0.146
	Mean	17.85	0.167	8.22	-0.25	99.17	9.42	0.95	113	0.74	0.108

* note: negative values are a function of calibration for low level readings and are effectively 0.0 NTU

3.2.3 Bacteriological Water Quality

Water samples for total and fecal coliform (*E. coli*) analysis were collected on July 21 & 22, 2009 and all results are presented in table 7 below. Bacteriological water quality falls under the mandate of Health Canada in terms of the public health risks associated with recreational activity in freshwater. Total and faecal Coliform levels are used as indicators of general bacteriological and faecal contamination as well as the risk of contamination by more serious microbial contaminants significant to human health.

Table 7: Bacteriological Water Quality Results

Site #	**Total Coliform** (coliform/100 ml)	**Faecal Coliform*** (*E. coli*/100 mL)
LBBP1(Lomond R.)	>80	10
LBBP2	>80	11
LBBP3	>80	18
LBBP4	>80	27
BBBP5	50	5
BBBP6	7	4
BBBP7	11	0
BBBP8	11	1
BBBP9	29	3
BBBP10	2	0

* The current guideline (Health Canada, 2012) for recreational water quality for Faecal Coliform is a geometric mean concentration (minimum of five samples) of ≤ 200 *E. coli*/100 mL with a single-sample maximum concentration of ≤ 400 *E. coli*/100 mL

All total and faecal coliform results are within the normal background range for surface water in Newfoundland and Labrador during the summer season and there is no indication of deleterious impacts from any land use activity. However, it should be clearly noted that a more comprehensive sampling program over an extended period would be required to fully assess the bacteriological water quality of this area and conclusively determine if there are any impacts related to land use activity. It is of interest to note that samples LBBP1 through BBBP4, which were all collected in Bonne Bay Little Pond, all have total coliform and faecal coliform levels that are slightly elevated above the samples collected further upstream in Bonne Bay Big Pond. Without a more comprehensive sampling program over a longer time frame it is difficult to draw any significant conclusions from this; however it may be an indication of impacts from upstream land use activity.

3.2.4 Depth Profile Results

Depth profiles were carried out using the YSI probe at eight of the sample sites and all results are presented in tabular form in Appendix B. Table 8 below summarizes the depth profiles data for temperature collected at each site. Figure 16 shows a graph of the depth versus temperature for all sites.

From figure 16 it can be seen that all sites, with the exception of BBBP9, which is perhaps too shallow, exhibit a fairly well defined thermocline. The deeper sites tend to show a more sharply defined thermocline than the shallower sites. From table 8 it can be seen that the thermocline has similar characteristics throughout the lake with typical depths somewhere in the six to ten meter range and very similar temperature regimes.

Table 8: Overview of Depth Profile Data

Site #	Approximate Depth(m)	# of Temp Readings	Temp Range (°C)	Thermocline Depth (m)	Thermocline Temp Range (°C)
LBBP2	18.3	18	9.07 – 16.33	4 – 6.5	11 - 15.5
LBBP3	23.4	25	6.91 – 18.54	8.5 - 10	10.5 - 18
BBBP6	11.3	13	9.75 – 18.16	7 - 8	13 - 17
BBBP7	11.8	13	8.21 – 18.46	7 - 9	11 - 14
BBBP8	22	22	6.09 – 18.35	6 - 9	9.5 – 16.5
BBBP9	9.5	10	11.52 – 16.7	8 – 9*	11.5 – 15.5
BBBP10	21.5	22	5.6 – 18.64	6 - 8	11 - 18
BBBP11	52	26	5.3 – 16.8	6 - 10	8.5 - 16

* The temp appears to drop at a faster rate over the last 1.5 meters however the site is not deep enough to have a clearly defined thermocline

The thermocline not only impacts temperature characteristics throughout the water column but also has an impact on other parameters, most notably those which are temperature dependant. While it is not practical to present the results of the depth profiles for all parameters for all sites, graphs for pH and oxygen for two typical sites are presented as these two parameters were most consistently affected by changes with depth.

For all the depth profiling sites both oxygen and pH consistently vary with depth and the corresponding temperature gradient. Figure 17 shows a graph for depth versus pH for sample site BBBP11. It appears that pH is directly proportional to temperature and decreases with depth in a manner very similar to temperature. Oxygen is inversely proportional to temperature and increases with depth as can be seen in figure 18, which shows depth versus oxygen for site BBBP8.

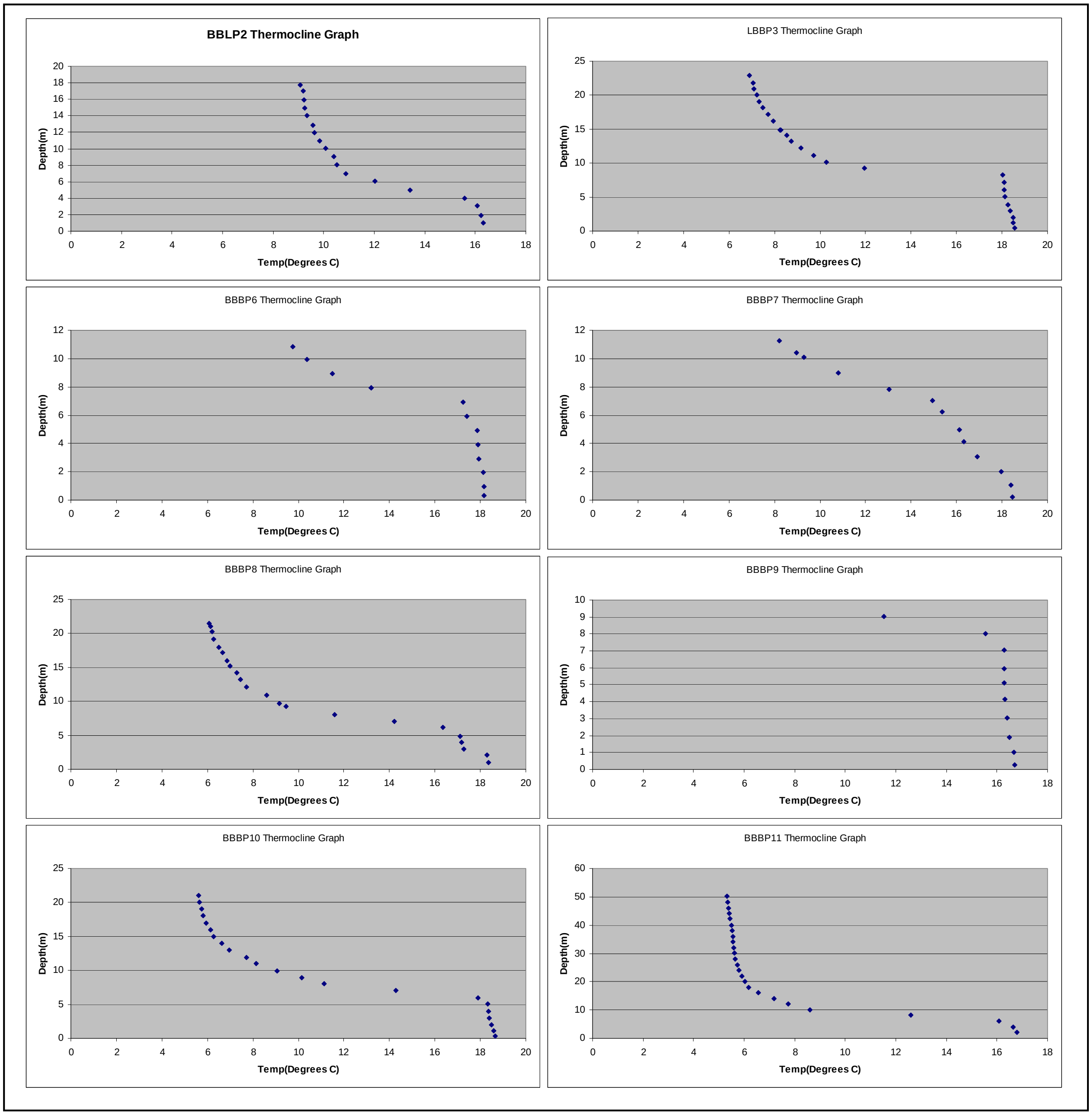

Figure 16: Thermocline Graphs for 8 Depth Profile Sites

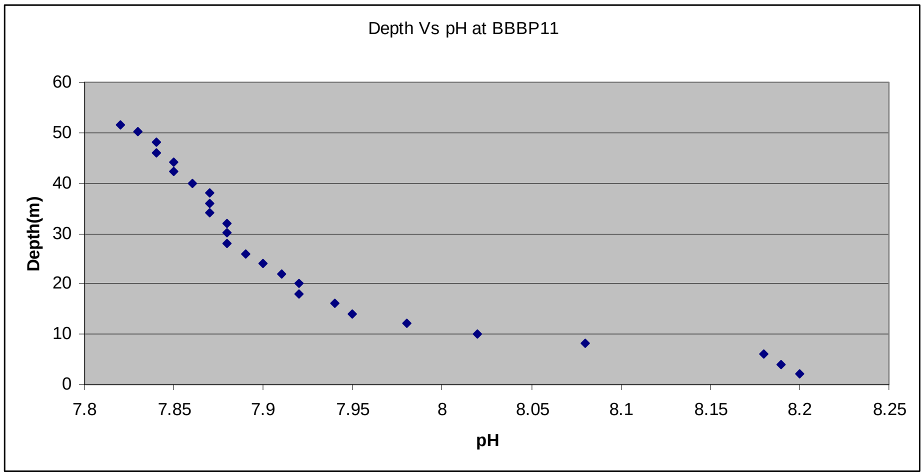

Figure 17: Depth(m) Vs pH for Site BBBP 11

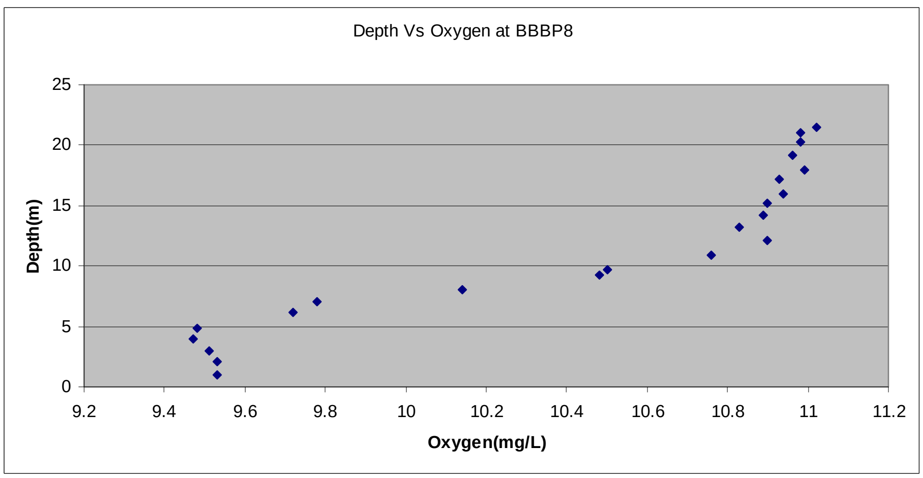

Figure 18: Depth(m) Vs Oxygen(mg/L) for Site BBBP8

3.2.5 Continuous Water Quality Sampling Results

The results of the continuous water quality sampling using a GPS enabled multi-parameter YSI 6000MS sonde indicated that water quality was very consistent throughout Bonne Bay Little Pond and the portion of Bonne Bay Big Pond which was covered. For all of the measured parameters including; temperature, dissolved oxygen, specific conductance, pH, turbidity, chlorophyll, and blue green algae, the water quality was very comparable throughout the two areas surveyed and there where no obvious patterns detected that indicate impacts from land use activity in the watershed.

While there were no obvious patterns or variability detected, there were some subtle changes in water quality for selected parameters. For example, figure 19 shows the results for specific conductance (mS/cm) for all of Bonne Bay Little Pond and the lower section of Bonne Bay Big Pond which was included in the continuous monitoring. From the results it appears that the specific conductance in Bonne Bay Little Pond is slightly higher than in Bonne Bay Big Pond. This may be due to a slightly higher influence from groundwater affecting Bonne Bay Little Pond than Bonne Bay Big Pond.

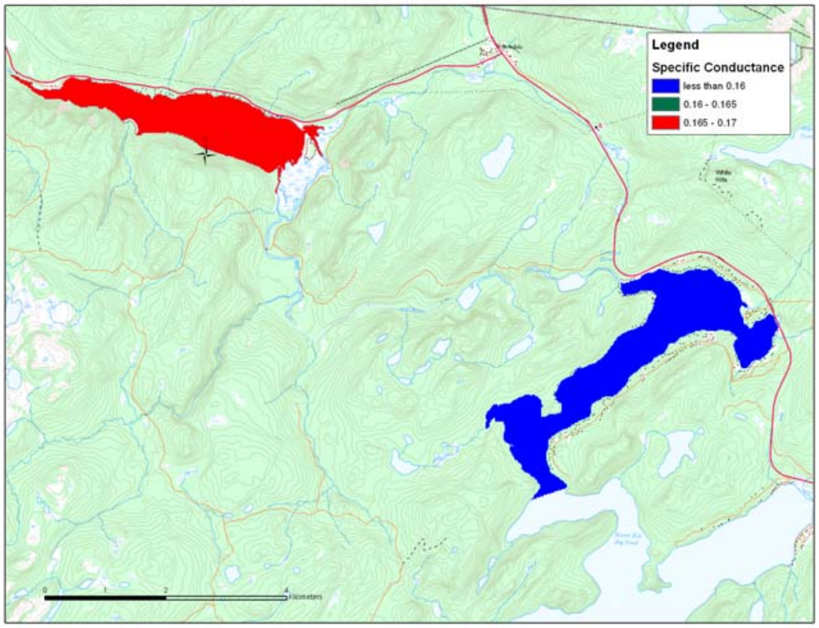

Figure 19: Continuous Water Sampling Results for Specific Conductance (mS/cm)

Figure 20 shows the results for pH for all of Bonne Bay Little Pond and the lower section of Bonne Bay Big Pond. It can be seen that there are only relatively subtle changes in pH throughout the area covered and pH levels appear to be quite consistent between the two ponds. There are some areas where pH varies slightly throughout the two ponds. For example in the most easterly cove of Bonne Bay Big Pond pH appears to be slightly higher than the surrounding area. This is most likely due to localized influence from surface or underground stream/s draining into this cove.

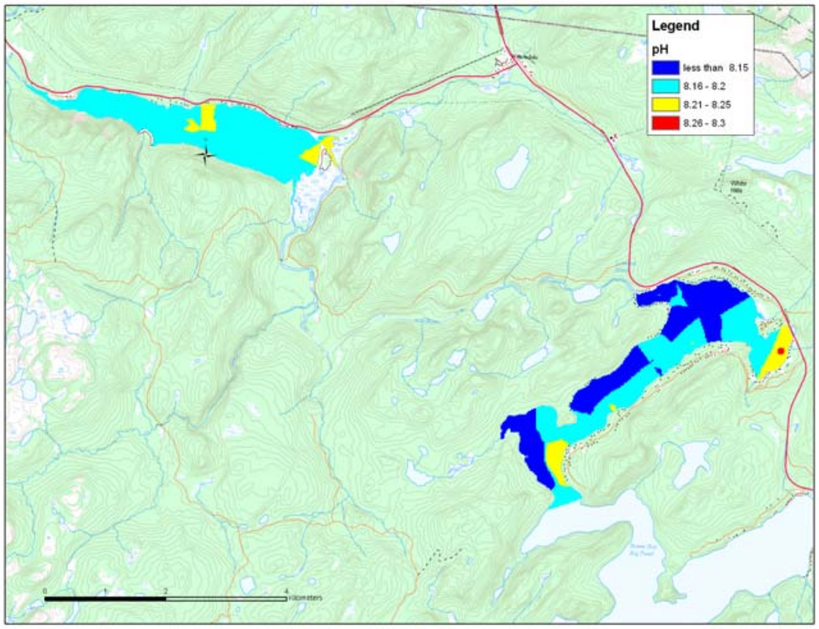

Figure 20: Continuous Water Sampling Results for pH

3.3 Sediment Sampling Results

Analysis of the sediment samples was carried out at Environment Canada's Atlantic Laboratory for Environmental Testing (ALET) in Moncton, New Brunswick. In all cases sample results were compared to the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Sample results are provided in tables A3 and A4 in Appendix A.

3.3.1 Metals/Mercury

Results of the metals/mercury analysis for the sediment samples are included in table A3 of Appendix A. Results for the metals/mercury analysis for all four sites sampled were below the CCME Sediment Quality Guidelines for the Protection of Freshwater Aquatic life. The sample results for all four sites and between the duplicate samples collected at BBBP8 were all in the same general range indicating that sediment quality is consistent throughout the two ponds.

3.3.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are a diverse class of organic compounds which have two or more fused aromatic (benzene) rings and are classified into one of two subgroups based on low or high molecular weight (CCME. 1999). PAHs are known to have the potential to cause adverse biological effects and are of significant concern in environmental monitoring. In aquatic ecosystems PAHs tend to concentrate in sediments where they can be a concern to the health of aquatic organisms. PAHs are most common in atmospheric emissions and can come from natural sources such as forest fires and volcanic explosions, or anthropogenic sources such as industrial emissions, the burning of fossil fuels, the incineration of wastes and asphalt run-off, particularly from coal tar sealants.

Results of the PAH analysis for the sediment samples are included in table A4 in Appendix A. Of the 16 PAH parameters tested in the sediment samples, six have provisional guidelines, six have Interim Sediment Quality Guideline/Probable Effects Level guidelines, and four have no currently associated guidelines. There were a number of exceedances of the Interim Soil Quality Guideline for a variety of the parameters. It should be noted that the Interim Soil Quality Guideline is significantly lower than the Probable Effects Level Guideline.

Test results which exceed a guideline are bolded in table 4A. There were exceedances of six parameters at site LBBP2, three parameters at BBBP8 and one parameter at the duplicate sample for BBBP8 and BBBP10. In all cases the exceedances were only slightly over the Interim Soil Quality Guideline and were all well below the Probable Effects Level Guidelines. The results for PAHs at all the sites were typical of background levels of PAHs found in freshwater sediments in other areas of Canada (CCME. 1999).

It is interesting to note that the area with most of the PAH exceedances was site LBBP2 which is near the outlet of Bonne Bay Little Pond to Lomond River. This site is the furthest downstream of all of the cottage development and recreational activity and in the area most likely to be impacted by upstream activities. In addition, the site with the second most PAH exceedances was site BBBP8 which is in a cove with a concentration of cottages. The fact that exceedances were mostly found in areas more likely to be impacted by land use activity gives an indication that the land use activities in the watershed could potentially be having a long term cumulative impact. However, all the exceedances were relatively low and it is impossible to differentiate any impacts from local land use activity from those caused by larger scale atmospheric deposition from sources further away in the province or even from sources outside the province

3. 4 Biota Sampling Results

As outlined in section 2.2.6, efforts to collect fish samples for tissue analysis were not successful as an insufficient number of smaller fish were captured and the lab was unable to perform proper analysis.

3.4.1 Canadian Aquatic Biomonitoring Network (CABIN) Results

The Canadian Aquatic Biomonitoring Network (CABIN) is a national program coordinated by Environment Canada which samples benthic macroinvertebrates in rivers and streams to assess the water quality and overall health of freshwater ecosystems in Canada. Benthic macroinvertebrates are useful bioindicators of water quality as they are sedentary, generally abundant, diverse, a key part of the food chain, and long lived, thus reflecting possible cumulative pollution impacts.

Although no benthic macroinvertebrate samples were taken directly from Bonne Bay Big Pond or Bonne Bay Little Pond, a stream draining into Bonne Bay Little Pond was sampled in 2009 and the Lomond River was sampled at LBBP1 in 2008. These samples in the immediate area of the study provide some indication of the community assemblages in the area. However, these single samples offer only a "snapshot-in-time" view of the populations and further repetitive monitoring would be required to determine trends or changes over time at each of the locations.

The Lomond River site (NF02YH0018) is 1.7 km downstream from Bonne Bay Little Pond (figure 2) and was sampled using CABIN techniques in September 2008. This 5th order stream was sampled 30m upstream of the bridge on Route 431. The substrate is dominated by cobble, with lesser amounts of pebble and gravel.

The tributary to Bonne Bay Little Pond (NF02YH0065), also known as Line Brook, was sampled in September 2009. It is not connected to Bonne Bay Big Pond and thus is free of any influence from its watershed upstream of Bonne Bay Little Pond. Line Brook is a 3rd order stream which originates at Jacks Pond near Route 430. The stream meanders through valleys, following routes 430 and 431 and enters Bonne Bay Little Pond 1km downstream from the benthic sampling site. Sampling occurred upstream of an old forest access bridge off route 431. The substrate is dominated by cobble, with lesser amounts of pebble and boulder.

Metric results of the analysis of the benthic macroinvertebrates found at Lomond River and Line Brook are presented in table 9 below.

The benthic macroinvertebrate sample of the community assemblage at Lomond River contained 1750 individuals from 16 taxa. The community was dominated by chironomids (50%), with a lesser population of EPT (Ephemeroptera, Plecoptera, Tricoptera) individuals (37%). The dominant taxa found in the sample make up over 50% of the community. The Shannon-Wiener estimate of community diversity for Lomond River is 1.75. The Line Brook community contained 851 individuals from 24 taxa. The community was dominated by EPT species (82%), with a lesser population of chironomids (4%). The dominant taxa at this site accounts for 22% of the community, which has a Shannon-Wiener community diversity value of 2.47.

Table 9: Selected community metrics of benthic macroinvertebrates collected as part of the Canadian Aquatic Biomonitoring Network (CABIN)

Metric	NF02YH0018 (Sep 30 2008)	NF02YH0065 (Sep 23 2009)
	Lomond River	Trib to Little Bonne Bay Pond
% Chironomidae	50.85714286	4.215720747
% Diptera + Non-insects	56.57142857	13.85148627
% Ephemeroptera	31.14285714	46.08859063
% EPT Individuals	37.71428571	82.23358019
% of 2 dominant taxa	65.71428571	41.87404486
% of 5 dominant taxa	84.57142857	67.47855738
% of dominant taxa	50.85714286	22.59428988
% Plecoptera	1.714285714	4.81847025
% Tricoptera	4.857142857	31.32651931
Chironomidae taxa (genus level only)	1	1
Coleoptera taxa	1	1
Diptera taxa	3	3
Ephemeroptera taxa	4	4
EPT Individuals (Sum)	660	699.890008
EPT taxa (no)	11	14
No. EPT individuals/Chironomids+EPT Individuals	0.425806452	0.951234762
Odonata taxa	1	1
Pielou's Evenness	0.631978092	0.77941143
Plecoptera taxa	2	3
Shannon-Wiener Diversity	1.752215331	2.47701148
Simpson's Diversity	0.702726531	0.872787313
Simpson's Evenness	0.210244123	0.327535466
Total Abundance	1750	851.1000085
Total No. of Taxa	16	24
Trichoptera taxa	5	7

The dominance at the Line Brook site by EPT individuals with fewer chironomids and greater taxonomic diversity indicate that this site is relatively pristine and not influenced by many inputs that could cause negative effects on the benthic macroinvertebrate community. The dominance at the Lomond River site by chironomids with a low number of EPT individuals and low taxonomic diversity indicate that this site may be impacted to some degree by upstream activities.

It is important to note that as these are individual samples, comparisons between the two populations would be inaccurate and unwise. Replicate samples are required to establish natural variability before conclusions can be drawn from such metrics; otherwise they are merely descriptions of the community at a single point in time.

3. 5 QA/QC Samples

The QA/QC program included three components, a blank water sample, a triplicate water sample and a duplicate sediment sample. Overall, the QA/QC samples and data validation indicated that the study results were of good quality. The specific results of each QA/QC component will be discussed briefly below.

The analytical results from the field blank sample (table A1, Appendix A) collected at BBBP9D shows that the concentrations in this sample are extremely low with results for almost all of the parameters below the detection limit and the remaining parameters showing trace levels. These results clearly show that the collection, shipping, and analysis did not introduce appreciable levels of contamination in the samples from this study.

Table 10: % Relative Standard Deviation for Triplicate Sample

Parameter	BBBP9A	BBBP9B	BBBP9C	Mean	SDev	%RSD
ALKALINITY GRAN MG/L	69.81	67.8	70.4	69.34	1.36	1.97
ALKALINITY TOTAL MG/L	71.7	71.3	72	71.67	0.35	0.49
ALUMINUM EXTRACTABLE μg/L	18	20	19	19	1	**5.3**
ARSENIC, EXTRACTABLE μg/L	0.1	0.1	0.1	0.1	0	0
BARIUM EXTRACTABLE μg/L	9	10	10	9.67	0.58	**5.97**
CALCIUM EXTRACTABLE MG/L	22.53	22.69	22.71	22.643	0.099	0.436
CARBON TOTAL ORGANIC MG/L	3.3	3.4	3.2	3.3	0.1	3.0
CHLORIDE, DISSOLVED MG/L	5.4	5.42	5.41	5.41	0.01	0.18
COLOUR APPARENT REL UNITS	12	13	218	81	118.65	**146.48**
COPPER EXTRACTABLE μg/L	0.3	0.4	0.4	0.37	0.06	**15.75**
MAGNESIUM EXTRACTABLE MG/L	4.73	4.79	4.79	4.77	0.035	0.726
MERCURY NG/L	1	0.8		0.9	0.1	**15.7**
NITROGEN TOTAL MG/L	0.12	0.14	0.16	0.14	0.02	**14.29**
NITROGEN,DISSOLVED NITRATE MG/L	0.04	0.04	0.04	0.04	0	0
PH UNITS	8.27	8.23	8.32	8.27	0.05	0.55
PHOSPHOROUS TOTAL MG/L	0.002	0.002	0.004	0.0027	0.0012	**43.3013**
POTASSIUM EXTRACT/UNFILT MG/L	0.3	0.2	0.2	0.23	0.06	**24.74**
SODIUM EXTRACT/UNFILT MG/L	3.3	3.36	3.38	3.347	0.042	1.244
SPECIFIC CONDUCTANCE μS/CM	160.3	159.8	160.3	160.13	0.29	0.18
STRONTIUM EXTRACTABLE μg/L	43	44	44	43.67	0.58	1.32
SULPHATE, DISSOLVED MG/L	2.06	2.1	2.1	2.087	0.023	1.107
TITANIUM EXTRACTABLE μg/L	0.1	0.1	0.2	0.13	0.06	**43.30**
TURBIDITY NTU	0.2	0.2	0.2	0.2	0	0
URANIUM EXTRACTABLE μg/L	0.1	0.1	0.1	0.1	0	0

For the water quality triplicate sample collected at BBBP9, BBBP9A, BBBP9B, & BBBP9C precision was evaluated as an expression of percent relative standard deviation by dividing the standard deviation of the analytical result by the mean and then multiplying by 100. Ideally the percent relative standard deviation (%RSD) should be close to 0%. However, when sample results are close to the detection limit it is quite common for %RSD to be higher.

Table 10 shows the results for the triplicate sample for all results above the detection limit with the mean, standard deviation and %RSD. All cases where the %RSD is above 5% are highlighted in bold. It should be noted that many of the results are only slightly above the detection limit and therefore variability between results is higher. It should also be noted that it appears that sample BBBPC has an unusually high color reading which is most likely the result of lab error as none of the other parameters show elevated sample results for this sample.

For duplicate samples precision can be expressed as a relative percent difference (RPD) according to the following equation: RPD = (A – B)/((A + B)/2) x 100.

For the duplicate sediment sample RPD Values are shown in table 11 for all values above detection limit. All RPD values which exceeded 5% are highlighted in bold. The highest relative percent difference RPD between the primary and the duplicate sediment sample result was 43.8 for the manganese analysis. It should be noted that many of the results are only slightly above the detection limit and therefore variability between results is higher.

Table 11: Relative % Difference For Duplicate Sediment Sample

Parameter	BBBP#8	BBBP#8	RPD
HG-TL/SED MG/KG	0.11	0.1	**9.52**
ALUMINUM IN SEDIMENT UG/G	18477	18195	1.5
ARSENIC IN SEDIMENT UG/G	18	22	**20**
BARIUM IN SEDIMENT UG/G	269.7	271.6	0.70
BERYLLIUM IN SEDIMENT UG/G	0.6	0.5	**18.18**
CADMIUM IN SEDIMENT UG/G	2	2	0
CHROMIUM IN SEDIMENT UG/G	28.8	27.7	3.89
COBALT IN SEDIMENT UG/G	17.1	17.2	0.58
COPPER IN SEDIMENT UG/G	21.9	21.32	2.684
IRON IN SEDIMENT UG/G	33741	37898	**11.6**
LEAD IN SEDIMENT UG/G	32	32	0
MANGANESE IN SEDIMENT UG/G	5390	8413	**43.8**
MOLYBDENUM IN SEDIMENT UG/G	0.5	0.5	0
NICKEL IN SEDIMENT UG/G	36.99	35.14	**5.130**
STRONTIUM IN SEDIMENT UG/G	22.88	22	3.9
TITANIUM IN SEDIMENT UG/G	330	287	**13.9**
VANADIUM IN SEDIMENT UG/G	40.2	38.2	**5.10**
ZINC IN SEDIMENT UG/G	133.2	132.6	0.45
% MOISTURE	66	66.5	0.75

4.0 Conclusions

1) The results of the intensive survey of Bonne Bay Big Pond and Bonne Bay Little Pond show that, in general, the water quality of both ponds is consistently very good with all parameters within the recommended limits of the *Canadian Environmental Quality Guidelines: Water Quality Guidelines for the Protection of Aquatic Life*. Furthermore the results indicate that water quality is relatively

consistent throughout the two ponds and does not deteriorate from headwaters to the outlet at Lomond River.

2) Given that the water quality is good and consistent through the two ponds it can be concluded that the existing cottage development and associated recreational and land use activity along significant sections of both ponds are not having a deleterious impact on water quality.

3) The presence of some of the constitute PAHs at levels slightly above the Canadian Environmental Quality Guidelines for Sediment for Aquatic Life and/or the Interim Sediment Quality Guideline is noteworthy. These exceedances indicate that it is likely that human activity in the watershed area and/or the surrounding region as a whole have had some long term cumulative impacts on this watershed area.

4) The results of the bacteriological water quality sampling and the benthic macroinvertebrate sample collected at Lomond river do not provide compelling evidence of deleterious impacts from land use impacts in the watershed area, however they do give an indication that there may be some low level impacts.

5.0 Recommendations

1) It appears that the existing level of cottage development and land use activity in general in the Lomond River Watershed are not having a noticeable impact on the water quality of Bonne Bay Little Pond or Bonne Bay Big Pond. However, there is some indication that activity may be starting to have a cumulative impact over time, and if so it is likely that additional developments and land use activity above and beyond the current level could potentially begin to accelerate these impacts. **Therefore, it is recommended that an updated review of the cottage carrying capacity of both these ponds, and the Lomond River watershed in general, be carried out to ensure future developments are at levels which are sustainable in the long term.**

2) While at present there does not appear to be any noticeable impacts on water quality associated with the existing cottage developments and land use activity in the study area, there is no guarantee that the situation will not change in the future. **Therefore, it is recommended that this intensive survey be repeated after 10 years to determine if there is any change in the water and or sediment quality of the study area.**

3) **It is recommended that the trend analysis study carried out under the Canada-Newfoundland and Labrador Water Quality monitoring Agreement in 2003 for a number of Newfoundland water quality monitoring sites, including Lomond River, be updated to include more recent data.**

4) **It is recommended that further repetitive benthic macroinvertebrate sampling at the two sites included in this study would allow comparisons between adjacent watersheds and determination of trends or changes over time at each of the locations.**

6.0 References

CCME (Canadian Council of Ministers of the Environment), 1999, Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment, Winnipeg Further information on these guidelines can be found at: http://ceqg-rcqe.ccme.ca/ .

Dawe, P., 2003, Water Quality Trends in Selected Water Bodies of Newfoundland and Labrador, Canada-Newfoundland Water Quality Monitoring Agreement, Water Resources Management Division, Department of Environment, St. John's, NL

Karolyi, M.S., 1978, Karst development in Ordovician carbonates: Western Platform of Newfoundland, Open Dissertations and Thesis, McMaster University

Land Management Division, Dept. of Environment and Conservation, 2011, Provincial Land Use Atlas

Mullins et. al., 2001, Status of the Atlantic Salmon (*Salmo salar L.*) Stocks of Lomond River, Torrent river and Western Arm brook, Newfoundland, 2000, Canadian Science Advisory Secretariat, Research Document 2001/039

Parks and Natural Areas, Dept. of Environment and Conservation, 2012, mapping and fact sheets on the ecoregions of NL available at http://www.env.gov.nl.ca/env/parks/maps/ecoregions_nf_lab.pdf

Health Canada, 2012, Guidelines for Canadian recreational Water Quality, Third Edition, Cat.: H129-15/2012E, ISBN: 978-1-100-20892-3, Further information on these guidelines can be found at: http://www.hc-sc.gc.ca/index-eng.php

Prepared by the Federal-Provincial-Territorial Working Group on Recreational Water Quality of the Federal-Provincial-Territorial Committee on Health and the Environment

Appendix A

Table A-1 - General Water Quality – Lomond River(1992-2009)

Parameter	Units	Count	Minimum	Maximum	Median	CCME Guideline *
Arsenic	mg/L	106	<0.0001	0.0007	0.0001	5.0 ug/l
Alkalinity	mg/L as CaCO3	158	4.4	84.7	71.0	
Aluminum(total)	mg/L	153	0.018	0.101	0.0338	5-100 ug/l **
Barium	mg/L	156	0.0067	0.0117	0.0087	
Iron	mg/L	154	0.0123	0.0869	0.0351	300 ug/l
Calcium	mg/L	136	9.22	25.2	21.3	
Carbon(DOC)	mg/L	157	2	18	3.6	
Cadmium	mg/L	134	<0.0001	0.0002	0.0001	0.17 ug/l***
Chloride	mg/L	154	1.84	8.66	5.77	640 mg/l
Chromium	mg/L	154	0.000047	0.0026	0.00038	
Cobalt	mg/L	154	0.000009	0.0004	0.0001	
Color	Rel. Units	122	<5	167	16.4	
Copper	mg/L	154	0.00018	0.0055	0.00066	0.002
Lead	mg/L	154	0.000005	0.0016	0.00029	
Lithium	mg/L	151	0.0001	0.0015	0.0003	
Magnesium	mg/L	158	1.49	6.33	5.50	
Manganese	mg/L	154	0.0015	0.0081	0.0033	
Mercury(total)	ug/L	105	<0.005	0.01	0.006	
Molybdenum	mg/L	154	0.000096	0.0006	0.00013	0.073
Nickle	mg/L	137	0.00011	0.00078	0.00029	0.0025
Sulphate	mg/L	136	2.03	3.8	2.73	
Strontium	mg/L	152	0.0295	0.0465	0.0381	
Nitrate(Dissolved)	mg/L as N	109	0.011	0.17	0.074	
Nitrogen(Dissolved)	mg/L	101	0.086	0.242	0.158	
Oxygen(Dissolved)	mg/L	136	7.5	15.41	11.84	
Total Phosphorus	mg/L	158	0.0003	0.0162	0.0031	
Potassium(Dissolved)	mg/L	119	0.19	0.4	0.28	
Sodium(Dissolved)	mg/L	119	2.74	4.8	3.41	
Specific Conductance	µS/cm	158	35.3	187	163.1	
Temperature	Degrees C	140	-0.05	22.4	7.8	
Turbidity	NTU	142	0.01	10	0.38	
pH	pH units	158	6.75	8.31	7.84	6.5-9.0

Source: Envirodat, 2012

* CCME Guidelines for Freshwater Aquatic Life

** 5 ug/l if pH < 6.5 & 100 ug/l if pH ≥ 6.5

*** 100.86[log10(hardness)]-3.2 µg/L

Table A-2 Sample Sites - General Water Chemistry

Parameter	Lomond	LBBP#2	LBBP#3	LBBP#4	CCME Guideline* (ug/L)
ALKALINITY GRAN MG/L (10110)	74.68	73.46	73.45	74.58	
ALKALINITY TOTAL MG/L (10111)	76.3	75.5	75.1	76.2	
ALUMINUM EXTRACTABLE UG/L (T01129)	26	25	27	24	5-100[a]
ANTIMONY EXTRACTABLE UG/L (T108)	L0.1	L0.1	L0.1	L0.1	
ARSENIC, EXTRACTABLE UG/L (T109)	0.1	0.1	0.1	0.2	5.0
BARIUM EXTRACTABLE UG/L (T01130)	9	9	10	10	
BERYLLIUM EXTRACTABLE UG/L (T01131)	L1	L1	L1	L1	
BERYLLIUM EXTRACTABLE UG/L (T111)	L0.1	L0.1	L0.1	L0.1	
CADMIUM EXTRACTABLE UG/L (T113)	L0.1	L0.1	L0.1	L0.1	0.017[b]
CALCIUM EXTRACTABLE MG/L (100098)	22.7	22.48	22.61	23.11	
CARBON TOTAL ORGANIC MG/L (06010)	3.4	3.4	3.4	3.7	
CHLORIDE, DISSOLVED MG/L (17209)	6.07	5.85	5.97	5.2	
CHROMIUM EXTRACTABLE UG/L (T01133)	L2	L2	L2	L2	
CHROMIUM EXTRACTABLE UG/L (T114)	L0.4	L0.4	L0.4	L0.4	
COBALT EXTRACTABLE UG/L (T01134)	L5	L5	L5	L5	
COBALT EXTRACTABLE UG/L (T115)	L0.1	L0.1	L0.1	L0.1	
COLOUR APPARENT REL UNITS (T01173)	15	14	13	15	
COPPER EXTRACTABLE UG/L (T01135)	L2	L2	L2	L2	2.0[c]
COPPER EXTRACTABLE UG/L (T116)	0.4	0.5	0.5	0.4	2.0[c]
IRON EXTRACTABLE MG/L (100088)	L0.02	L0.02	0.02	0.04	300
LEAD EXTRACTABLE UG/L (T01136)	L20	L20	L20	L20	1[d]
LEAD EXTRACTABLE UG/L (T118)	L0.1	L0.1	0.2	L0.1	1[d]
MAGNESIUM EXTRACTABLE MG/L (100099)	5.63	5.55	5.58	5.53	
MANGANESE EXTRACTABLE UG/L (T01137)	4	4	4	11	
MERCURY NG/L (T01038)	0.8	1.1	1.3	1	0.026
MOLYBDENUM EXTRACTABLE UG/L (T01138)	L5	L5	L5	L5	73
MOLYBDENUM EXTRACTABLE UG/L (T121)	0.1	0.1	0.1	0.1	73
NICKEL EXTRACTABLE UG/L (T01139)	L6	L6	L6	L6	25[e]
NICKEL EXTRACTABLE UG/L (T122)	L0.1	L0.1	L0.1	L0.1	25[e]
NITROGEN TOTAL MG/L (T01045)	0.14	0.12	0.13	0.17	
NITROGEN,DISSOLVED NITRATE MG/L (07315)	0.04	0.04	0.03	0.03	
PH PH UNITS (10301)	8.31	8.29	8.32	8.33	6.5-9
PHOSPHOROUS TOTAL MG/L (T01042)	0.003	0.003	0.002	0.003	
POTASSIUM EXTRACTABLE/UNFILT. MG/L (100101)	0.3	0.3	0.3	0.3	
SELENIUM EXTRACTABLE UG/L (100913)	0.1	L0.1	0.3	L0.1	1.0
SILVER EXTRACTABLE UG/L (T01140)	L2	L2	L2	L2	0.1
SILVER EXTRACTABLE UG/L (T132)	L0.1	L0.1	L0.1	L0.1	0.1
SODIUM EXTRACTABLE/UNFILT. MG/L (100100)	3.74	3.7	3.71	3.36	
SPECIFIC CONDUCTANCE USIE/CM (02041)	169.8	168.4	169.2	167.4	
STRONTIUM EXTRACTABLE UG/L (T01141)	40	40	40	41	
SULPHATE, DISSOLVED MG/L (16309)	2.23	2.16	2.22	2.1	
THALLIUM EXTRACTABLE UG/L (100919)	L0.1	L0.1	L0.1	L0.1	0.8
TIN EXTRACTABLE UG/L (100916)	L0.1	L0.1	L0.1	L0.1	
TITANIUM EXTRACTABLE UG/L (T01142)	L1	L1	L1	L1	
TITANIUM EXTRACTABLE UG/L (T125)	0.2	0.2	0.2	0.2	
TURBIDITY NTU (02073)	0.2	0.3	0.3	0.2	
URANIUM EXTRACTABLE UG/L (100894)	0.1	0.1	0.1	0.1	15
VANADIUM EXTRACTABLE UG/L (T01143)	L4	L4	L4	L4	
VANADIUM EXTRACTABLE UG/L (T126)	L0.1	L0.1	L0.1	L0.1	
ZINC EXTRACTABLE UG/L (T01144)	L2	L2	L2	L2	30
ZINC EXTRACTABLE UG/L (T127)	L0.3	L0.3	L0.3	1	30

Table A-2 Sample Sites - General Water Chemistry

Parameter	BBBP5	BBBP6A	BBBP6B (At Depth)	BBBP7	BBBP8A	CCME Guideline*
ALKALINITY GRAN MG/L (10110)	65.33	65.58	64.65	70.31	69.37	
ALKALINITY TOTAL MG/L (10111)	67.2	67.6	66.3	72.1	71.2	
ALUMINUM EXTRACTABLE UG/L (T01129)	26	26	26	21	20	5-100[a]
ANTIMONY EXTRACTABLE UG/L (T108)	L0.1	L0.1	L0.1	L0.1	L0.1	
ARSENIC, EXTRACTABLE UG/L (T109)	0.2	0.1	0.1	0.1	L0.1	5.0
BARIUM EXTRACTABLE UG/L (T01130)	9	10	9	10	10	
BERYLLIUM EXTRACTABLE UG/L (T01131)	L1	L1	L1	L1	L1	
BERYLLIUM EXTRACTABLE UG/L (T111)	L0.1	L0.1	L0.1	L0.1	L0.1	
CADMIUM EXTRACTABLE UG/L (T113)	L0.1	L0.1	L0.1	L0.1	L0.1	0.017[b]
CALCIUM EXTRACTABLE MG/L (100098)	21.22	21.35	21.01	22.47	22.71	
CARBON TOTAL ORGANIC MG/L (06010)	3.3	3.4	3.5	3.3	3.3	
CHLORIDE, DISSOLVED MG/L (17209)	5.43	5.48	5.47	5.48	5.5	
CHROMIUM EXTRACTABLE UG/L (T01133)	L2	L2	L2	L2	L2	
CHROMIUM EXTRACTABLE UG/L (T114)	L0.4	L0.4	L0.4	L0.4	L0.4	
COBALT EXTRACTABLE UG/L (T01134)	L5	L5	L5	L5	L5	
COBALT EXTRACTABLE UG/L (T115)	L0.1	L0.1	L0.1	L0.1	L0.1	
COLOUR APPARENT REL UNITS (T01173)	12	13	14	12	11	
COPPER EXTRACTABLE UG/L (T01135)	L2	L2	L2	L2	L2	2.0[c]
COPPER EXTRACTABLE UG/L (T116)	0.4	0.4	0.4	0.4	0.4	2.0[c]
IRON EXTRACTABLE MG/L (100088)	L0.02	L0.02	0.02	L0.02	L0.02	300
LEAD EXTRACTABLE UG/L (T01136)	L20	L20	L20	L20	L20	1[d]
LEAD EXTRACTABLE UG/L (T118)	L0.1	L0.1	L0.1	L0.1	L0.1	1[d]
MAGNESIUM EXTRACTABLE MG/L (100099)	4.57	4.6	4.56	4.8	4.76	
MANGANESE EXTRACTABLE UG/L (T01137)	2	2	3	L2	L2	
MERCURY NG/L (T01038)	1	0.6	1.2	0.9	0.6	0.026
MOLYBDENUM EXTRACTABLE UG/L (T01138)	L5	L5	L5	L5	L5	73
MOLYBDENUM EXTRACTABLE UG/L (T121)	L0.1	0.3	0.2	0.2	0.1	73
NICKEL EXTRACTABLE UG/L (T01139)	L6	L6	L6	L6	L6	25[e]
NICKEL EXTRACTABLE UG/L (T122)	L0.1	L0.1	0.3	L0.1	L0.1	25[e]
NITROGEN TOTAL MG/L (T01045)	0.13	0.15	0.14	0.14	0.17	
NITROGEN,DISSOLVED NITRATE MG/L (07315)	0.04	0.04	0.06	0.04	0.04	
PH PH UNITS (10301)	8.26	8.22	8.27	8.27	8.24	6.5-9
PHOSPHOROUS TOTAL MG/L (T01042)	L0.002	0.003	0.003	0.004	0.004	
POTASSIUM EXTRACT/UNFILT MG/L (100101)	0.3	0.2	0.3	0.2	0.2	
SELENIUM EXTRACTABLE UG/L (100913)	L0.1	L0.1	L0.1	0.2	L0.1	1.0
SILVER EXTRACTABLE UG/L (T01140)	L2	L2	L2	L2	L2	0.1
SILVER EXTRACTABLE UG/L (T132)	L0.1	L0.1	L0.1	L0.1	L0.1	0.1
SODIUM EXTRACT/UNFILT MG/L (100100)	3.38	3.39	3.39	3.41	3.42	
SPECIFIC CONDUCTANCE USIE/CM (02041)	152.4	153.4	151.8	159	159.9	
STRONTIUM EXTRACTABLE UG/L (T01141)	41	42	41	44	45	
SULPHATE, DISSOLVED MG/L (16309)	2.05	2.09	2.07	2.11	2.1	
THALLIUM EXTRACTABLE UG/L (100919)	L0.1	L0.1	L0.1	L0.1	L0.1	0.8
TIN EXTRACTABLE UG/L (100916)	L0.1	L0.1	5.6 **	L0.1	L0.1	
TITANIUM EXTRACTABLE UG/L (T01142)	L1	L1	L1	L1	L1	
TITANIUM EXTRACTABLE UG/L (T125)	0.2	0.2	0.3	0.2	0.1	
TURBIDITY NTU (02073)	0.2	0.2	0.3	0.2	0.3	
URANIUM EXTRACTABLE UG/L (100894)	L0.1	0.1	0.1	0.1	0.1	15
VANADIUM EXTRACTABLE UG/L (T01143)	L4	L4	L4	L4	L4	
VANADIUM EXTRACTABLE UG/L (T126)	L0.1	L0.1	L0.1	L0.1	L0.1	
ZINC EXTRACTABLE UG/L (T01144)	L2	L2	L2	L2	L2	30
ZINC EXTRACTABLE UG/L (T127)	0.3	0.3	1.3	0.5	0.7	30

** Elevated Tin in the sample at depth may indicate contamination from the Kemmerer sampler

Table A-2 Sample Sites - General Water Chemistry

Parameter	BBBP8B (At depth)	BBBP9A (triplicate)	BBBP9B (triplicate)	BBBP9C (triplicate)	BBBP9D (Blank)	CCME Gdline*
ALKALINITY GRAN MG/L (10110)	69.74	69.81	67.8	70.4	0.02	
ALKALINITY TOTAL MG/L (10111)	71.3	71.7	71.3	72	L20	
ALUMINUM EXTRACTABLE UG/L (T01129)	18	18	20	19	L4	5-100[a]
ANTIMONY EXTRACTABLE UG/L (T108)	L0.1	L0.1	L0.1	L0.1	L0.1	
ARSENIC, EXTRACTABLE UG/L (T109)	L0.1	0.1	0.1	0.1	L0.1	5.0
BARIUM EXTRACTABLE UG/L (T01130)	9	9	10	10	L1	
BERYLLIUM EXTRACTABLE UG/L (T01131)	L1	L1	L1	L1	L1	
BERYLLIUM EXTRACTABLE UG/L (T111)	L0.1	L0.1	L0.1	L0.1	L0.1	
CADMIUM EXTRACTABLE UG/L (T113)	L0.1	L0.1	L0.1	L0.1	L0.1	0.017[b]
CALCIUM EXTRACTABLE MG/L (100098)	22.97	22.53	22.69	22.71	L0.01	
CARBON TOTAL ORGANIC MG/L (06010)	3.2	3.3	3.4	3.2	L0.2	
CHLORIDE, DISSOLVED MG/L (17209)	5.7	5.4	5.42	5.41	L0.1	
CHROMIUM EXTRACTABLE UG/L (T01133)	L2	L2	L2	L2	L2	
CHROMIUM EXTRACTABLE UG/L (T114)	L0.4	L0.4	L0.4	L0.4	L0.4	
COBALT EXTRACTABLE UG/L (T01134)	L5	L5	L5	L5	L5	
COBALT EXTRACTABLE UG/L (T115)	L0.1	L0.1	L0.1	L0.1	L0.1	
COLOUR APPARENT REL UNITS (T01173)	14	12	13	218	L5	
COPPER EXTRACTABLE UG/L (T01135)	L2	L2	L2	L2	L2	2.0[c]
COPPER EXTRACTABLE UG/L (T116)	0.4	0.3	0.4	0.4	L0.2	2.0[c]
IRON EXTRACTABLE MG/L (100088)	L0.02	L0.02	0.02	L0.02	L0.02	300
LEAD EXTRACTABLE UG/L (T01136)	L20	L20	L20	L20	L20	1[d]
LEAD EXTRACTABLE UG/L (T118)	L0.1	L0.1	L0.1	L0.1	L0.1	1[d]
MAGNESIUM EXTRACTABLE MG/L (100099)	4.82	4.73	4.79	4.79	L0.05	
MANGANESE EXTRACTABLE UG/L (T01137)	2	L2	L2	L2	L2	
MERCURY NG/L (T01038)		1	0.8			0.026
MOLYBDENUM EXTRACTABLE UG/L (T01138)	L5	L5	L5	L5	L5	73
MOLYBDENUM EXTRACTABLE UG/L (T121)	0.2	L0.1	0.1	L0.1	L0.1	73
NICKEL EXTRACTABLE UG/L (T01139)	L6	L6	L6	L6	L6	25[e]
NICKEL EXTRACTABLE UG/L (T122)	0.1	L0.1	L0.1	L0.1	L0.1	25[e]
NITROGEN TOTAL MG/L (T01045)	0.18	0.12	0.14	0.16	0.03	
NITROGEN,DISSOLVED NITRATE MG/L (07315)	0.09	0.04	0.04	0.04	L0.02	
PH PH UNITS (10301)	8.3	8.27	8.23	8.32	5.83	6.5-9
PHOSPHOROUS TOTAL MG/L (T01042)	0.003	0.002	0.002	0.004	0.002	
POTASSIUM EXTRACT/UNFILT MG/L (100101)	0.3	0.3	0.2	0.2	L0.1	
SELENIUM EXTRACTABLE UG/L (100913)	L0.1	L0.1	L0.1	L0.1	L0.1	1.0
SILVER EXTRACTABLE UG/L (T01140)	L2	L2	L2	L2	L2	0.1
SILVER EXTRACTABLE UG/L (T132)	L0.1	L0.1	L0.1	L0.1	L0.1	0.1
SODIUM EXTRACT/UNFILT MG/L (100100)	3.46	3.3	3.36	3.38	0.02	
SPECIFIC CONDUCTANCE USIE/CM (02041)	161.1	160.3	159.8	160.3	0.7	
STRONTIUM EXTRACTABLE UG/L (T01141)	45	43	44	44	L1	
SULPHATE, DISSOLVED MG/L (16309)	2.14	2.06	2.1	2.1	L0.1	
THALLIUM EXTRACTABLE UG/L (100919)	L0.1	L0.1	L0.1	L0.1	L0.1	0.8
TIN EXTRACTABLE UG/L (100916)	3.6	L0.1	L0.1	L0.1	L0.1	
TITANIUM EXTRACTABLE UG/L (T01142)	L1	L1	L1	L1	L1	
TITANIUM EXTRACTABLE UG/L (T125)	0.2	0.1	0.1	0.2	L0.1	
TURBIDITY NTU (02073)	0.2	0.2	0.2	0.2	0.1	
URANIUM EXTRACTABLE UG/L (100894)	L0.1	0.1	0.1	0.1	L0.1	15
VANADIUM EXTRACTABLE UG/L (T01143)	L4	L4	L4	L4	L4	
VANADIUM EXTRACTABLE UG/L (T126)	L0.1	L0.1	L0.1	L0.1	L0.1	
ZINC EXTRACTABLE UG/L (T01144)	L2	L2	L2	L2	L2	30
ZINC EXTRACTABLE UG/L (T127)	0.8	L0.3	L0.3	L0.3	L0.3	30

Table A-2 Sample Sites - General Water Chemistry

Parameter	BBBP10A	BBBP10B (At Depth)	BBBP11A	BBBP11B (At depth)	CCME Guideline*
ALKALINITY GRAN MG/L (10110)	107.2	106.2	69.98	69.73	
ALKALINITY TOTAL MG/L (10111)	109.3	107.8	71.5	71.7	
ALUMINUM EXTRACTABLE UG/L (T01129)	5	4	19	20	5-100[a]
ANTIMONY EXTRACTABLE UG/L (T108)	L0.1	L0.1	L0.1	L0.1	
ARSENIC, EXTRACTABLE UG/L (T109)	0.1	0.1	L0.1	0.1	5.0
BARIUM EXTRACTABLE UG/L (T01130)	8	10	10	9	
BERYLLIUM EXTRACTABLE UG/L (T01131)	L1	L1	L1	L1	
BERYLLIUM EXTRACTABLE UG/L (T111)	L0.1	L0.1	L0.1	L0.1	
CADMIUM EXTRACTABLE UG/L (T113)	L0.1	L0.1	L0.1	L0.1	0.017[b]
CALCIUM EXTRACTABLE MG/L (100098)	32.59	32.35	22.92	23.08	
CARBON TOTAL ORGANIC MG/L (06010)	2.1	2.2	3.3	3.2	
CHLORIDE, DISSOLVED MG/L (17209)	4.89	4.98	5.46	5.62	
CHROMIUM EXTRACTABLE UG/L (T01133)	L2	L2	L2	L2	
CHROMIUM EXTRACTABLE UG/L (T114)	L0.4	L0.4	L0.4	L0.4	
COBALT EXTRACTABLE UG/L (T01134)	L5	L5	L5	L5	
COBALT EXTRACTABLE UG/L (T115)	L0.1	L0.1	L0.1	L0.1	
COLOUR APPARENT REL UNITS (T01173)	L5	L5	13	14	
COPPER EXTRACTABLE UG/L (T01135)	L2	L2	L2	L2	2.0[c]
COPPER EXTRACTABLE UG/L (T116)	0.3	0.3	0.4	0.4	2.0[c]
IRON EXTRACTABLE MG/L (100088)	L0.02	L0.02	L0.02	L0.02	300
LEAD EXTRACTABLE UG/L (T01136)	L20	L20	L20	L20	1[d]
LEAD EXTRACTABLE UG/L (T118)	L0.1	L0.1	L0.1	L0.1	1[d]
MAGNESIUM EXTRACTABLE MG/L (100099)	7.96	8.07	4.82	4.82	
MANGANESE EXTRACTABLE UG/L (T01137)	L2	L2	L2	L2	
MERCURY NG/L (T01038)	0.4	1	0.7	0.7	0.026
MOLYBDENUM EXTRACTABLE UG/L (T01138)	L5	L5	L5	L5	73
MOLYBDENUM EXTRACTABLE UG/L (T121)	0.3	0.3	0.1	0.1	73
NICKEL EXTRACTABLE UG/L (T01139)	L6	L6	L6	L6	25[e]
NICKEL EXTRACTABLE UG/L (T122)	L0.1	L0.1	L0.1	L0.1	25[e]
NITROGEN TOTAL MG/L (T01045)	0.15	0.11	0.18	0.17	
NITROGEN,DISSOLVED NITRATE MG/L (07315)	0.04	0.06	0.04	0.08	
PH PH UNITS (10301)	8.47	8.42	8.31	8.32	6.5-9
PHOSPHOROUS TOTAL MG/L (T01042)	0.002	0.003	0.003	0.004	
POTASSIUM EXTRACTABLE/UNFILT MG/L (100101)	0.3	0.3	0.3	0.3	
SELENIUM EXTRACTABLE UG/L (100913)	0.1	L0.1	L0.1	L0.1	1.0
SILVER EXTRACTABLE UG/L (T01140)	L2	L2	L2	L2	0.1
SILVER EXTRACTABLE UG/L (T132)	L0.1	L0.1	L0.1	L0.1	0.1
SODIUM EXTRACTABLE/UNFILT MG/L (100100)	2.9	2.96	3.41	3.47	
SPECIFIC CONDUCTANCE USIE/CM (02041)	226	226	160.2	161.2	
STRONTIUM EXTRACTABLE UG/L (T01141)	49	49	45	45	
SULPHATE, DISSOLVED MG/L (16309)	2.48	2.56	2.08	2.11	
THALLIUM EXTRACTABLE UG/L (100919)	L0.1	L0.1	L0.1	L0.1	0.8
TIN EXTRACTABLE UG/L (100916)	L0.1	2.8	L0.1	2.6	
TITANIUM EXTRACTABLE UG/L (T01142)	L1	L1	L1	L1	
TITANIUM EXTRACTABLE UG/L (T125)	0.1	L0.1	0.2	0.2	
TURBIDITY NTU (02073)	0.2	0.2	0.2	0.1	
URANIUM EXTRACTABLE UG/L (100894)	0.2	0.3	0.1	0.1	15
VANADIUM EXTRACTABLE UG/L (T01143)	L4	L4	L4	L4	
VANADIUM EXTRACTABLE UG/L (T126)	L0.1	L0.1	L0.1	L0.1	
ZINC EXTRACTABLE UG/L (T01144)	L2	L2	L2	L2	30
ZINC EXTRACTABLE UG/L (T127)	L0.3	0.3	0.5	0.7	30

* CCME Canadian Environmental Quality Guidelines for freshwater Aquatic Life

a Aluminum guideline is = 5 ug/L if pH < 6.5 & = 100 ug/L if pH ≥ 6.5

b value at a hardness of 48.5 mg/L or use equation $10^{0.86[\log10(\text{hardness})]-3.2}$ μg/L

c Minimum of 2.0 with an equation of $e^{0.8545[\ln(\underline{\text{hardness}})]-1.465}$ * 0.2 μg/L

d minimum of 1.0 with an equation of $e^{1.273[\ln(\underline{\text{hardness}})]-4.705}$ μg/L

e minimum of 25 with an equation $e^{0.76[\ln(\underline{\text{hardness}})]+1.06}$ μg/L

Table A-3 Metals Results for Sediment Samples

Parameter	LBBP#2	BBBP#5	BBBP#8	BBBP#8	BBBP#10	CCME Guidelines* ug/kg
HG-TL/SED MG/KG	0.2	0.04	0.11	0.1	0.19	170/486
ALUMINUM IN SEDIMENT UG/G	22187	15111	18477	18195	18530	
ANTIMONY IN SEDIMENT UG/G	<5	<5	<5	<5	<5	
ARSENIC IN SEDIMENT UG/G	33	4	18	22	9	5900/17000[a]
BARIUM IN SEDIMENT UG/G	592.6	110.6	269.7	271.6	191.2	
BERYLLIUM IN SEDIMENT UG/G	1	0.5	0.6	0.5	1	
CADMIUM IN SEDIMENT UG/G	3	1	2	2	3	600/3500
CHROMIUM IN SEDIMENT UG/G	36	20.7	28.8	27.7	41.7	37300/90000
COBALT IN SEDIMENT UG/G	24.3	10.6	17.1	17.2	11.6	
COPPER IN SEDIMENT UG/G	33.85	15.46	21.9	21.32	25.89	35700/197000
IRON IN SEDIMENT UG/G	49683	18500	33741	37898	24146	
LEAD IN SEDIMENT UG/G	71	17	32	32	53	35000/91300
MANGANESE IN SEDIMENT UG/G	15722	212.3	5390	8413	982.5	
MOLYBDENUM IN SEDIMENT UG/G	1.1	0.6	0.5	0.5	1.1	
NICKEL IN SEDIMENT UG/G	45.62	23.93	36.99	35.14	42.57	
SELENIUM IN SEDIMENT UG/G	6	<5	<5	<5	<5	
SILVER IN SEDIMENT UG/G	<0.25	<0.25	<0.25	<0.25	<0.25	
STRONTIUM IN SEDIMENT UG/G	30.3	21.49	22.88	22	46.81	
THALLIUM IN SEDIMENT UG/G	<2.5	<2.5	<2.5	<2.5	<2.5	
TIN IN SEDIMENT UG/G	<3.0	<3.0	<3.0	<3.0	<3.0	
TITANIUM IN SEDIMENT UG/G	402.6	411.2	330	287	357	
VANADIUM IN SEDIMENT UG/G	45.3	27.6	40.2	38.2	41.3	
ZINC IN SEDIMENT UG/G	218.7	166.3	133.2	132.6	155.9	123000/315000
% MOISTURE	68.4	65.5	66	66.5	79.4	

* CCME Canadian Environmental Quality Guidelines for Sediment - freshwater Aquatic Life. Where two guidelines are shown they are for ISQG/PEL (Interim Soil Quality Guideline/Probable Effects Level)

Table A-4 PAH Results for Sediment Samples

Parameter	LBBP#2	BBBP#5	BBBP#8	BBBP#8	BBBP#10	CCME Guidelines* ug/kg
NAPHTALENE ng/g	<5	<5	<5	<5	<5	34.6/391**
ACENAPHTHYLENE ng/g	9	<5	6	<5	<5	5.87/128**
ACENAPHTHENE ng/g	<5	<5	<5	<5	<5	6.7188.9**
FLUORENE ng/g	<5	<5	<5	<5	<5	21.2/144**
PHENANTHRENE ng/g	36	<5	12	9	8	41.9/515
ANTHRACENE ng/g	13	10	7	6	8	46.9/245**
FLUORANTHENE ng/g	101	20	52	42	38	111/2355
PYRENE ng/g	70	11	31	24	21	53/875
BENZ(A)ANTHRACENE ng/g	44	14	23	19	20	31.7/385
CHRYSENE ng/g	70	12	41	34	39	57.1/862
BENZO(B)FLUORANTHENE ng/g	97	15	77	60	80	
BENZO(K)FLUORANTHENE ng/g	68	16	50	40	55	
BENZO(A)PYRENE ng/g	55	14	32	28	31	31.9/782
INDE0(1,2,3-C,D)PYRENE ng/g	69	10	58	39	72	
DIBENZ(A,H)ANTHRACENE ng/g	13	<5	11	8	14	6.22/135**
BENZO(G,H,I)PERYLENE ng/g	56	8	48	33	56	

* CCME Canadian Environmental Quality Guidelines for Sediment - freshwater Aquatic Life. Where two guidelines are shown they are for ISQG/PEL (Interim Soil Quality Guideline/Probable Effects Level)
** Provisional Guideline

Table A-5 Bacteriological Water Quality

Site #	Total Coliform	Fecal Coliform
BBLP#1(Lomond R.)	>80	10
BBLP#2	>80	11
BBLP#3	>80	18
BBLP#4	>80	27
BBBP#5	50	5
BBBP#6	7	4
BBBP#7	11	0
BBBP#8	11	1
BBBP#9	29	3
BBBP#10	2	0

Appendix B

Table B-1: Site 2 Depth Profile Data

Site#2_LBBP2_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	psi
07/20/09 17:41	16.33	0.163	0.106	0.973	7.4	-52	-0.1	0.8	0.2	334	0.2	94	9.21	14.67
07/20/09 17:42	16.24	0.163	0.106	1.863	7.52	-58.7	-0.1	1.1	0.3	98	0	94.2	9.25	14.67
07/20/09 17:43	16.09	0.163	0.106	3.075	7.55	-60.3	-0.1	1	0.3	73	0	93.7	9.23	14.67
07/20/09 17:44	15.59	0.162	0.105	4.015	7.6	-63	-0.1	1	0.2	325	0.2	93	9.25	14.67
07/20/09 17:45	13.42	0.157	0.102	4.941	7.58	-61.8	-0.2	1	0.2	241	0.1	90	9.39	14.67
07/20/09 17:46	12.04	0.154	0.1	6.06	7.55	-60.1	-0.2	1.5	0.4	210	0.1	88.5	9.53	14.67
07/20/09 17:47	10.88	0.152	0.099	7.01	7.53	-58.6	-0.2	1.1	0.3	130	0.1	87.3	9.66	14.67
07/20/09 17:48	10.53	0.152	0.099	8.042	7.52	-58.2	-0.2	1.2	0.3	151	0.1	87.3	9.73	14.67
07/20/09 17:49	10.39	0.152	0.099	9.022	7.52	-58.3	-0.2	1.2	0.3	321	0.2	87.1	9.74	14.67
07/20/09 17:50	10.07	0.152	0.099	10.088	7.52	-58.2	-0.2	1.2	0.3	153	0.1	86.8	9.78	14.67
07/20/09 17:51	9.83	0.152	0.099	10.947	7.53	-58.5	-0.2	0.9	0.2	226	0.1	86.4	9.79	14.67
07/20/09 17:52	9.65	0.152	0.099	11.925	7.53	-58.4	-0.2	0.9	0.2	226	0.1	86.6	9.85	14.67
07/20/09 17:53	9.59	0.152	0.099	12.894	7.53	-58.7	-0.2	0.9	0.2	252	0.1	85.9	9.78	14.67
07/20/09 17:54	9.35	0.152	0.099	14.025	7.54	-58.9	-0.2	1.1	0.3	256	0.1	85.4	9.78	14.67
07/20/09 17:55	9.26	0.152	0.099	14.91	7.54	-59.2	-0.1	1.1	0.3	399	0.2	85.3	9.8	14.67
07/20/09 17:56	9.21	0.152	0.099	15.969	7.54	-59.3	-0.1	1.3	0.3	254	0.1	85.5	9.83	14.67
07/20/09 17:57	9.19	0.152	0.099	17.031	7.55	-59.4	-0.1	1.3	0.3	254	0.1	85.5	9.84	14.67
07/20/09 17:59	9.07	0.188	0.122	17.75	7.57	-60.7	0.6	0.2	0	422	0.2	85.5	9.86	14.67

Table B-2: Site 3 Depth Profile Data

Site#3_LBBP3_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	Psi
07/20/09 18:26	18.54	0.168	0.109	0.448	8.1	-92	613.6	0.7	0.2	276	0.1	99.3	9.3	14.67
07/20/09 18:28	18.5	0.168	0.109	1.237	8.13	-93.4	0.1	1	0.2	318	0.2	99.2	9.3	14.67
07/20/09 18:28	18.5	0.168	0.109	1.97	8.13	-93.4	0	1.3	0.3	249	0.1	99.1	9.29	14.67
07/20/09 18:29	18.37	0.168	0.109	2.921	8.13	-93.5	0.1	1	0.2	251	0.1	98.8	9.27	14.68
07/20/09 18:30	18.27	0.168	0.109	3.874	8.13	-93.5	0	1.4	0.3	223	0.1	98.2	9.25	14.67
07/20/09 18:31	18.12	0.168	0.109	5.028	8.13	-93.4	0.1	0.9	0.2	160	0.1	97.6	9.21	14.68
07/20/09 18:31	18.11	0.168	0.109	6.096	8.12	-93.2	0	1.3	0.3	160	0.1	97.5	9.21	14.67
07/20/09 18:32	18.09	0.168	0.109	7.196	8.13	-93.4	0	1.3	0.3	160	0.1	97.5	9.21	14.68
07/20/09 18:32	18.03	0.168	0.109	8.285	8.12	-93.3	0	1.3	0.3	160	0.1	97.6	9.23	14.68
07/20/09 18:33	11.94	0.153	0.099	9.287	7.95	-82.4	-0.2	1.3	0.3	275	0.1	88.2	9.51	14.67
07/20/09 18:35	10.28	0.151	0.098	10.146	7.87	-77.4	-0.2	0.8	0.2	193	0.1	86.9	9.74	14.67
07/20/09 18:36	9.72	0.152	0.099	11.107	7.83	-74.9	-0.1	1.3	0.3	305	0.1	86.3	9.8	14.67
07/20/09 18:37	9.15	0.151	0.098	12.22	7.81	-73.7	-0.2	0.9	0.2	321	0.2	85.5	9.84	14.67
07/20/09 18:38	8.73	0.151	0.098	13.257	7.8	-73.2	-0.2	0.8	0.2	697	0.3	85.5	9.94	14.67
07/20/09 18:38	8.53	0.151	0.098	14.055	7.8	-73.2	-0.2	0.9	0.2	365	0.2	86.5	10.12	14.67
07/20/09 18:39	8.26	0.151	0.098	14.904	7.79	-72.9	-0.1	1.4	0.3	286	0.1	86.2	10.14	14.67
07/20/09 18:39	8.23	0.151	0.098	14.918	7.79	-72.9	-0.2	1	0.2	196	0.1	86.2	10.15	14.67
07/20/09 18:40	7.96	0.152	0.099	16.136	7.79	-72.6	-0.1	1.3	0.3	439	0.2	86.4	10.24	14.68
07/20/09 18:40	7.73	0.153	0.099	17.16	7.78	-72.2	-0.1	1.1	0.3	353	0.2	85.8	10.23	14.67
07/20/09 18:41	7.49	0.153	0.099	18.139	7.77	-71.7	-0.1	0.9	0.2	324	0.2	85.3	10.23	14.68
07/20/09 18:42	7.33	0.153	0.1	19.024	7.76	-71.1	-0.1	0.9	0.2	324	0.2	85.5	10.29	14.67
07/20/09 18:42	7.22	0.154	0.1	20.013	7.76	-70.7	-0.1	0.9	0.2	324	0.2	85.6	10.33	14.67
07/20/09 18:43	7.11	0.155	0.101	20.931	7.75	-70.4	-0.1	1.1	0.3	524	0.3	83.9	10.15	14.67
07/20/09 18:43	7.06	0.156	0.101	21.851	7.75	-70.2	-0.1	1.4	0.3	344	0.2	83.7	10.14	14.67
07/20/09 18:43	6.91	0.157	0.102	22.931	7.73	-69.5	-0.1	1	0.3	285	0.1	82	9.98	14.67

Table B-3: Site 6 Depth Profile Data

Site#6_BBBP6_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	Psi
07/21/09 18:18	18.16	0.152	0.099	0.311	8.18	-96.4	-0.2	0.8	0.2	177	0.1	99.1	9.34	14.57
07/21/09 18:19	18.15	0.152	0.099	0.943	8.19	-96.8	-0.2	0.2	0.1	151	0.1	99.1	9.34	14.57
07/21/09 18:20	18.13	0.152	0.099	1.953	8.19	-97.1	-0.2	0.7	0.2	85	0	99	9.35	14.57
07/21/09 18:20	17.93	0.151	0.098	2.914	8.19	-97.1	-0.2	1	0.3	145	0.1	98.7	9.35	14.58
07/21/09 18:21	17.89	0.151	0.098	3.902	8.19	-96.9	-0.2	1	0.2	261	0.1	98.4	9.33	14.57
07/21/09 18:21	17.88	0.151	0.098	4.901	8.18	-96.4	-0.2	1.2	0.3	172	0.1	98.3	9.32	14.57
07/21/09 18:22	17.4	0.148	0.096	5.944	8.17	-95.5	-0.2	1.2	0.3	172	0.1	98.9	9.47	14.57
07/21/09 18:23	17.23	0.148	0.097	6.94	8.16	-95.1	-0.1	1.3	0.3	210	0.1	96.1	9.24	14.57
07/21/09 18:24	13.2	0.145	0.095	7.926	8.03	-87	-0.2	1.3	0.3	258	0.1	90.4	9.48	14.58
07/21/09 18:24	13.21	0.146	0.095	7.93	8.03	-86.8	-0.2	1.5	0.3	288	0.1	90.5	9.48	14.57
07/21/09 18:25	11.5	0.15	0.098	8.959	7.96	-82.6	-0.2	1.3	0.3	321	0.2	88.3	9.62	14.57
07/21/09 18:26	10.39	0.151	0.098	9.937	7.92	-80.1	-0.3	1.3	0.3	170	0.1	86.5	9.67	14.57
07/21/09 18:27	9.75	0.151	0.098	10.831	7.89	-78.3	-0.3	1.3	0.3	170	0.1	87.2	9.9	14.58

Table B-4: Site 7 Depth Profile Data

Site#7_BBBP7_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	Psi
07/21/09 16:09	18.46	0.156	0.102	0.19	8.25	-100.3	-0.3	0.6	0.2	188	0.1	98.4	9.23	14.57
07/21/09 16:09	18.38	0.156	0.102	1.072	8.24	-99.7	-0.3	0.4	0.1	135	0.1	98	9.2	14.57
07/21/09 16:10	17.96	0.157	0.102	2.03	8.23	-99.4	-0.3	0.8	0.2	108	0.1	97.4	9.23	14.57
07/21/09 16:11	16.92	0.158	0.103	3.055	8.22	-98.5	-0.3	1.4	0.3	175	0.1	96	9.29	14.57
07/21/09 16:12	16.31	0.158	0.103	4.104	8.2	-97.1	-0.3	1.1	0.3	162	0.1	95.4	9.35	14.58
07/21/09 16:13	16.13	0.158	0.103	4.983	8.18	-96.2	-0.3	1.1	0.3	162	0.1	95.6	9.41	14.57
07/21/09 16:13	15.36	0.158	0.103	6.217	8.17	-95.1	-0.3	0.3	0.1	270	0.1	94.2	9.42	14.58
07/21/09 16:22	14.95	0.158	0.103	7.006	8.15	-94.3	-0.2	1.3	0.3	199	0.1	94.1	9.49	14.58
07/21/09 16:23	13.04	0.156	0.101	7.845	8.1	-90.7	-0.3	1	0.2	209	0.1	92	9.68	14.58
07/21/09 16:24	10.81	0.155	0.101	8.981	8.05	-87.5	-0.3	0.8	0.2	220	0.1	89.1	9.86	14.58
07/21/09 16:25	9.28	0.156	0.102	10.114	8.02	-85.5	-0.4	1.1	0.3	204	0.1	87.8	10.08	14.58
07/21/09 16:26	8.96	0.156	0.102	10.389	7.99	-83.8	-0.3	1	0.2	261	0.1	88.2	10.2	14.58
07/21/09 16:27	8.21	0.157	0.102	11.271	7.97	-82.5	-0.3	1	0.2	261	0.1	89	10.49	14.58

Table B-5: Site 8 Depth Profile Data

Site#8_BBBP8_Depth Profile														
DateTime	**Temp**	**SpCond**	**TDS**	**Depth**	**pH**	**pHmV**	**Turb.**	**Chlorophyll**	**Chlorophyll**	**BGA PC Conc**	**BGA PC**	**ODO%**	**ODO Conc**	**BP**
M/D/Y	**°C**	**mS/cm**	**g/L**	**M**		**mV**	**NTU**	**ug/L**	**RFU**	**cells/mL**	**RFU**	**%**	**mg/L**	**Psi**
7/22/2009 7:38	18.35	0.159	0.103	1.041	8.28	-101.9	-0.2	0.9	0.2	227	0.1	101.4	9.53	14.56
7/22/200917:38	18.29	0.158	0.103	2.042	8.25	-100.4	-0.3	0.7	0.2	257	0.1	101.3	9.53	14.56
7/22/200917:39	17.29	0.158	0.102	3.01	8.24	-99.4	-0.2	1.3	0.3	241	0.1	99	9.51	14.56
7/22/200917:40	17.17	0.158	0.103	3.969	8.21	-98.2	-0.2	0.8	0.2	261	0.1	98.4	9.47	14.56
7/22/2009 7:41	17.12	0.159	0.103	4.815	8.21	-97.9	-0.3	1	0.2	270	0.1	98.3	9.48	14.56
7/22/200917:42	16.36	0.159	0.103	6.165	8.18	-96.2	-0.3	1	0.2	270	0.1	99.3	9.72	14.56
7/22/200917:43	14.23	0.159	0.103	7.076	8.1	-90.8	-0.3	1.1	0.3	149	0.1	95.4	9.78	14.56
7/22/200917:44	11.6	0.158	0.103	8.085	8.02	-86.2	-0.3	1.5	0.4	305	0.1	93.2	10.14	14.56
7/22/200917:45	9.46	0.158	0.103	9.247	7.96	-82.5	-0.3	1	0.2	228	0.1	91.7	10.48	14.56
7/22/200917:46	9.16	0.158	0.103	9.732	7.94	-80.9	-0.3	1.1	0.3	272	0.1	91.2	10.5	14.56
7/22/200917:50	8.62	0.158	0.103	10.917	7.91	-79.5	-0.3	0.8	0.2	105	0.1	92.3	10.76	14.56
7/22/200917:51	7.72	0.158	0.103	12.103	7.92	-79.6	-0.3	0.5	0.1	114	0.1	91.4	10.9	14.56
7/22/200917:52	7.45	0.158	0.103	13.238	7.9	-78.7	-0.3	0.9	0.2	297	0.1	90.3	10.83	14.55
7/22/200917:53	7.29	0.158	0.103	14.183	7.9	-78.6	-0.3	0.6	0.1	288	0.1	90.4	10.89	14.56
7/22/200917:53	6.98	0.159	0.103	15.151	7.9	-78.6	-0.3	0.5	0.1	209	0.1	89.8	10.9	14.55
7/22/200917:54	6.86	0.159	0.103	15.942	7.9	-78.5	-0.3	0.4	0.1	122	0.1	89.8	10.94	14.55
7/22/200917:55	6.68	0.159	0.103	17.209	7.9	-78.4	-0.3	0.7	0.2	213	0.1	89.4	10.93	14.55
7/22/200917:57	6.49	0.159	0.103	17.944	7.89	-78	-0.3	0.6	0.2	163	0.1	89.4	10.99	14.56
7/22/200917:58	6.28	0.159	0.103	19.209	7.89	-77.7	-0.3	0.9	0.2	391	0.2	88.7	10.96	14.55
7/22/200917:58	6.21	0.159	0.103	20.272	7.88	-77.5	-0.3	0.7	0.2	250	0.1	88.7	10.98	14.55
7/22/200918:00	6.14	0.159	0.103	21.035	7.88	-77.5	-0.3	0.9	0.2	321	0.2	88.6	10.98	14.55
7/22/200918:00	6.09	0.159	0.103	21.499	7.88	-77.5	-0.2	1.4	0.3	202	0.1	88.7	11.02	14.55

Table B-6: Site 9 Depth Profile Data

Site#3_LBBP3_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	Psi
7/22/2009 9:41	16.7	0.16	0.104	0.266	8.21	-97.7	-0.3	0.7	0.2	154	0.1	99.5	9.68	14.59
7/22/2009 9:44	16.66	0.16	0.104	1.009	8.2	-97	-0.4	1.1	0.3	-169	-0.1	99.4	9.67	14.59
7/22/2009 9:45	16.48	0.16	0.104	1.915	8.2	-97	-0.3	1.7	0.4	246	0.1	98.8	9.65	14.59
7/22/2009 9:46	16.4	0.16	0.104	3.039	8.19	-96.8	-0.3	0.7	0.2	172	0.1	98.5	9.63	14.59
7/22/2009 9:47	16.33	0.161	0.105	4.124	8.18	-96.3	-0.2	1	0.2	235	0.1	98.3	9.63	14.59
7/22/2009 9:48	16.3	0.162	0.105	5.096	8.19	-96.7	-0.3	1.1	0.3	211	0.1	98.4	9.65	14.6
7/22/2009 9:49	16.3	0.162	0.105	5.963	8.19	-96.5	-0.3	0.9	0.2	249	0.1	98.2	9.63	14.6
7/22/2009 9:50	16.28	0.161	0.105	7.066	8.19	-96.4	-0.3	0.9	0.2	249	0.1	98.2	9.63	14.59
7/22/2009 9:51	15.56	0.162	0.105	8.024	8.17	-95.3	-0.2	1.2	0.3	279	0.1	96.4	9.6	14.59
7/22/2009 9:52	11.52	0.159	0.103	9.018	8.09	-90	-0.3	0.5	0.1	281	0.1	91.6	9.97	14.59

Table B-7: Site 10 Depth Profile Data

Site#10_LBBP10_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	Psi
7/22/200910:30	18.64	0.225	0.146	0.358	8.41	-109.6	-0.3	0.7	0.2	50	0	99.8	9.32	14.61
7/22/200910:31	18.59	0.225	0.146	1.051	8.41	-109.8	-0.4	-0.2	-0.1	133	0.1	99.8	9.33	14.61
7/22/200910:32	18.5	0.225	0.146	1.974	8.41	-109.8	-0.4	0.3	0.1	58	0	99.5	9.32	14.61
7/22/200910:33	18.38	0.225	0.146	3.028	8.41	-109.7	-0.4	-0.1	0	25	0	99.3	9.32	14.61
7/22/200910:34	18.36	0.225	0.146	3.964	8.42	-109.9	-0.3	0.7	0.2	57	0	99.1	9.31	14.61
7/22/200910:35	18.33	0.225	0.146	5.042	8.42	-110	-0.3	0.7	0.2	57	0	99.1	9.32	14.61
7/22/200910:36	17.89	0.225	0.146	5.965	8.41	-109.4	-0.3	0.4	0.1	507	0.2	99.1	9.4	14.61
7/22/200910:37	14.29	0.224	0.146	7.028	8.34	-104.6	-0.3	0.1	0	182	0.1	109.8	11.24	14.61
7/22/200910:39	11.12	0.223	0.145	8.042	8.31	-102	-0.4	0.2	0.1	224	0.1	104.9	11.53	14.61
7/22/200910:40	10.14	0.222	0.144	8.967	8.3	-101.3	-0.3	0.4	0.1	293	0.1	103.7	11.66	14.61
7/22/200910:41	9.06	0.223	0.145	9.928	8.29	-100.4	-0.3	0.8	0.2	102	0	101.7	11.73	14.61
7/22/200910:42	8.16	0.222	0.145	11.008	8.29	-100	-0.3	0.7	0.2	289	0.1	100.1	11.81	14.61
7/22/200910:44	7.73	0.223	0.145	11.917	8.27	-99	-0.3	0.7	0.2	135	0.1	98.3	11.71	14.61
7/22/200910:44	6.97	0.223	0.145	13.038	8.24	-96.9	-0.3	0.8	0.2	173	0.1	98.3	11.93	14.61
7/22/200910:46	6.64	0.223	0.145	13.972	8.2	-94.9	-0.2	1	0.2	481	0.2	92.9	11.38	14.61
7/22/200910:47	6.27	0.224	0.146	14.977	8.17	-93.1	-0.2	0.5	0.1	366	0.2	91.5	11.3	14.61
7/22/200910:48	6.14	0.224	0.145	15.986	8.15	-92.2	-0.2	0.8	0.2	425	0.2	90.1	11.17	14.6
7/22/200910:49	5.95	0.224	0.146	17.011	8.13	-90.8	-0.2	0.9	0.2	439	0.2	88.6	11.03	14.61
7/22/200910:50	5.82	0.224	0.146	18.011	8.11	-90	-0.2	0.9	0.2	439	0.2	88.7	11.08	14.6
7/22/200910:50	5.74	0.225	0.146	19.022	8.1	-89.1	-0.2	0.9	0.2	400	0.2	86.6	10.84	14.6
7/22/200910:51	5.64	0.225	0.146	20.035	8.08	-87.9	-0.2	1.2	0.3	449	0.2	84.7	10.63	14.6
7/22/200910:52	5.6	0.225	0.146	20.998	8.05	-86.7	-0.2	0.8	0.2	550	0.3	83.4	10.49	14.6

Table B-8: Site 11 Depth Profile Data

Site#10_LBBP10_Depth Profile														
DateTime	Temp	SpCond	TDS	Depth	pH	pHmV	Turb.	Chlorophyll	Chlorophyll	BGA PC Conc	BGA PC	ODO%	ODO Conc	BP
M/D/Y	°C	mS/cm	g/L	M		mV	NTU	ug/L	RFU	cells/mL	RFU	%	mg/L	Psi
7/23/200912:15	16.8	0.159	0.103	2.069	8.2	-97.5	-0.3	0.6	0.1	174	0.1	97.6	9.47	14.55
7/23/200912:15	16.64	0.158	0.102	4.07	8.19	-96.6	-0.2	1.4	0.3	308	0.1	97	9.44	14.55
7/23/200912:16	16.09	0.158	0.103	5.963	8.18	-95.8	-0.2	1.2	0.3	358	0.2	96.2	9.47	14.55
7/23/200912:17	12.6	0.158	0.103	8.083	8.08	-89.3	-0.3	1.4	0.3	292	0.1	93.3	9.91	14.55
7/23/200912:18	8.6	0.158	0.103	10.08	8.02	-85.2	-0.3	1.2	0.3	167	0.1	89.4	10.43	14.55
7/23/200912:19	7.75	0.158	0.103	12.06	7.98	-82.9	-0.3	1.2	0.3	167	0.1	90.4	10.77	14.55
7/23/200912:19	7.17	0.158	0.103	14.014	7.95	-81.3	-0.3	1.2	0.3	167	0.1	91.1	11	14.55
7/23/200912:20	6.57	0.159	0.103	16.035	7.94	-80.6	-0.3	0.8	0.2	117	0.1	88.1	10.81	14.55
7/23/200912:21	6.17	0.159	0.103	17.994	7.92	-79.7	-0.3	0.9	0.2	221	0.1	87.5	10.84	14.55
7/23/200912:22	6.02	0.159	0.104	20.027	7.92	-79.2	-0.3	1	0.2	244	0.1	87.4	10.87	14.55
7/23/200912:22	5.92	0.159	0.104	22.045	7.91	-79	-0.3	0.6	0.1	177	0.1	87.5	10.91	14.55
7/23/200912:23	5.8	0.16	0.104	24.092	7.9	-78.2	-0.3	0.8	0.2	207	0.1	86.9	10.87	14.55
7/23/200912:24	5.72	0.16	0.104	26.013	7.89	-78	-0.3	0.8	0.2	207	0.1	87	10.9	14.55
7/23/200912:24	5.65	0.159	0.104	28.075	7.88	-77.5	-0.3	0.8	0.2	207	0.1	87.1	10.93	14.55
7/23/200912:25	5.62	0.16	0.104	30.012	7.88	-77.2	-0.2	0.8	0.2	353	0.2	86.5	10.86	14.55
7/23/200912:26	5.59	0.16	0.104	32.086	7.88	-76.9	-0.3	1	0.2	168	0.1	86.4	10.87	14.55
7/23/200912:26	5.57	0.16	0.104	34.146	7.87	-76.8	-0.3	0.4	0.1	184	0.1	86.1	10.83	14.55
7/23/200912:27	5.55	0.16	0.104	36.072	7.87	-76.5	-0.3	1.2	0.3	220	0.1	85.8	10.8	14.55
7/23/200912:28	5.52	0.16	0.104	37.996	7.87	-76.5	-0.3	1	0.2	240	0.1	85.7	10.8	14.55
7/23/200912:28	5.49	0.16	0.104	39.991	7.86	-76.2	-0.3	0.3	0.1	172	0.1	85.6	10.79	14.54
7/23/200912:29	5.44	0.16	0.104	42.162	7.85	-75.7	-0.3	0.3	0.1	172	0.1	85.7	10.81	14.55
7/23/200912:29	5.42	0.16	0.104	44.086	7.85	-75.4	-0.3	0.3	0.1	172	0.1	85.7	10.82	14.55
7/23/200912:29	5.39	0.16	0.104	46.094	7.84	-75.2	-0.3	1.4	0.3	213	0.1	84.7	10.7	14.55
7/23/200912:30	5.35	0.16	0.104	48.056	7.84	-74.9	-0.3	1.1	0.3	200	0.1	84.3	10.66	14.55
7/23/200912:31	5.33	0.16	0.104	50.137	7.83	-74.6	-0.2	0.7	0.2	222	0.1	83.7	10.59	14.54

Appendix C

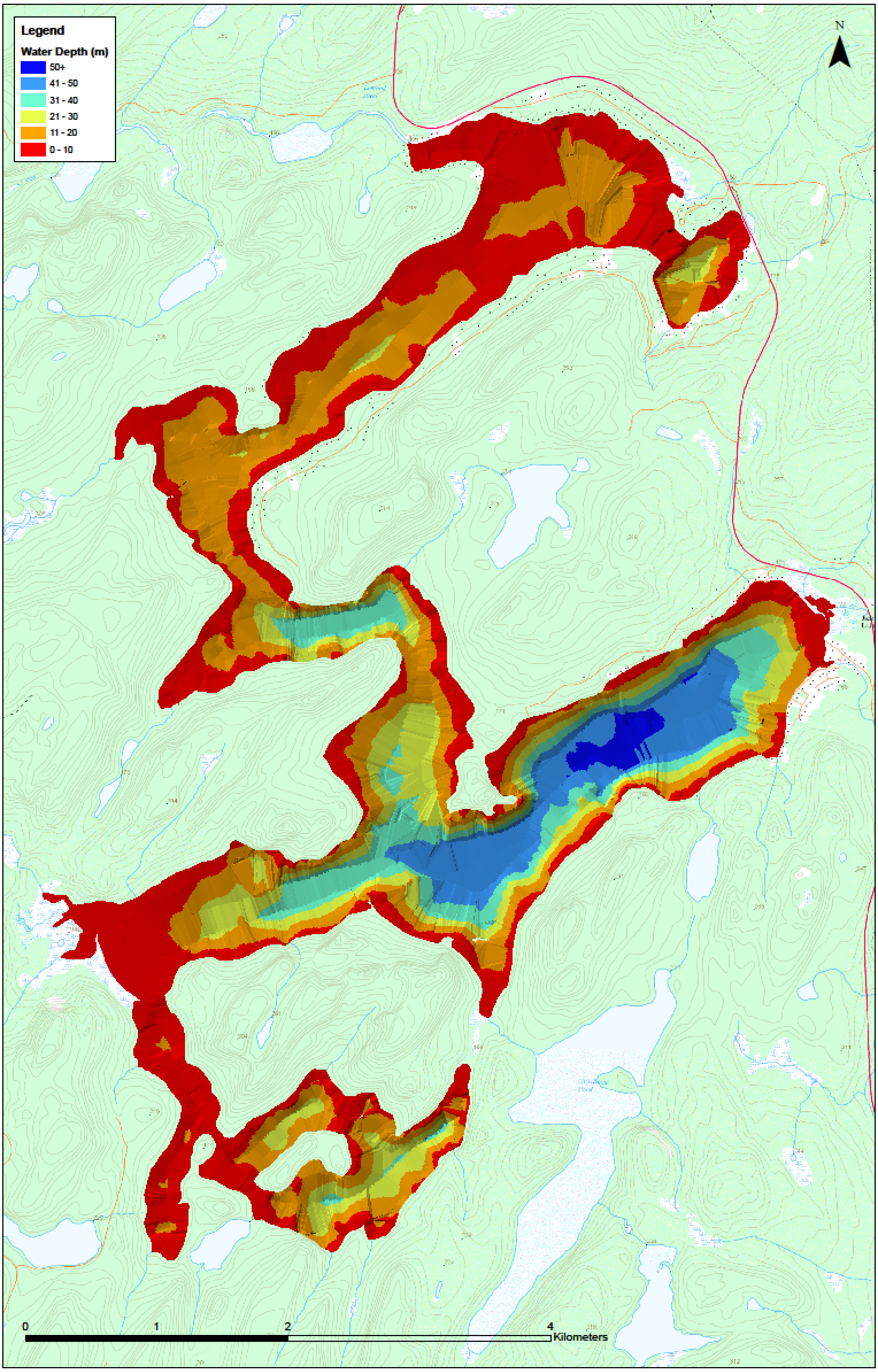

Figure 1: Rough Bathymetric Map of Bonne Bay Big Pond

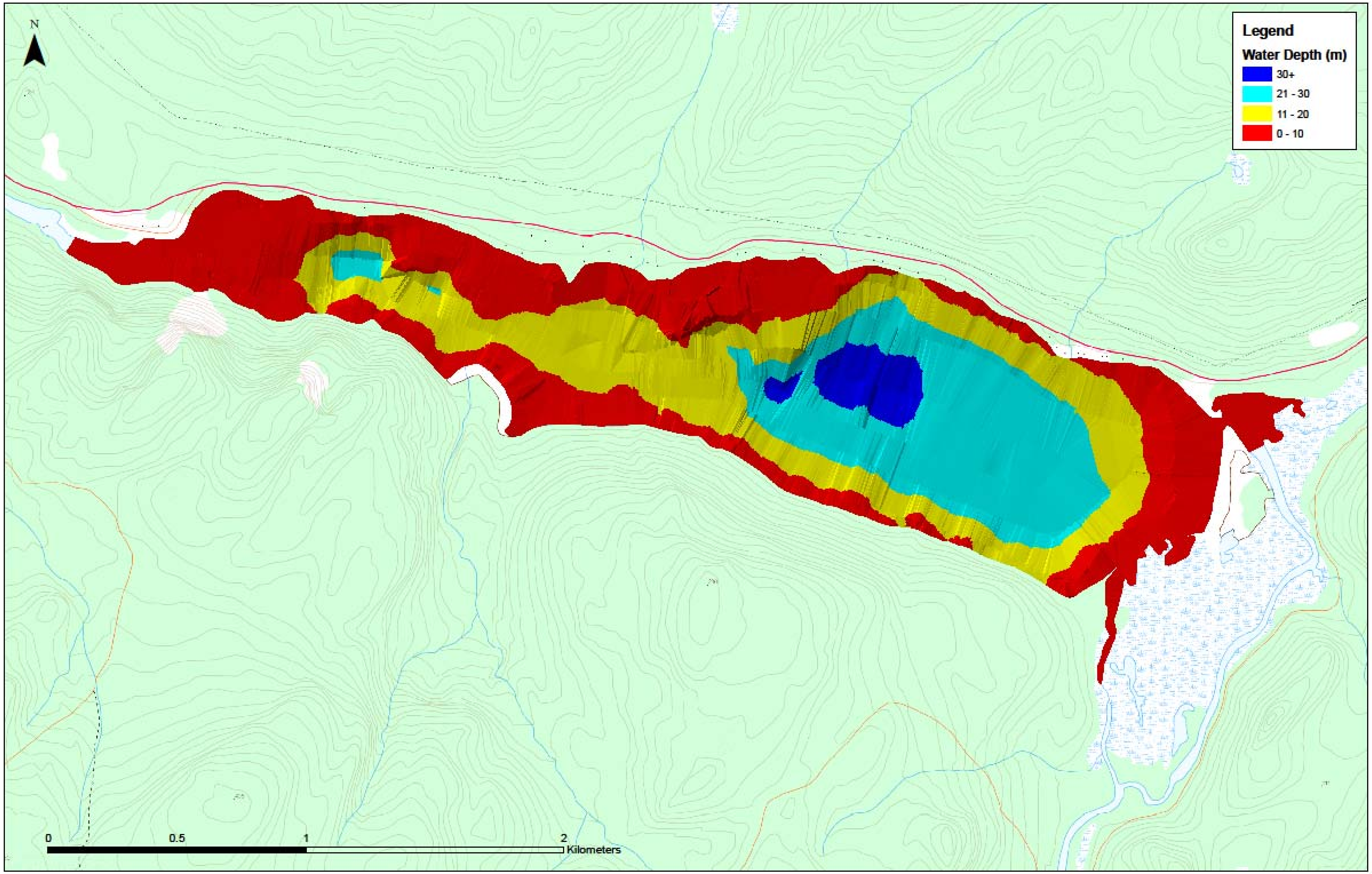

Figure 2: Rough Bathymetric Map of Bonne Bay Little Pond