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Freshwater Component Study for Commercial Nickel Processing Plant Long Harbour, NL

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1.0 INTRODUCTION

Voisey's Bay Nickel Company (VBNC) is planning to build a commercial nickel processing plant in Long Harbour, Newfoundland and Labrador. VBNC constructed a hydrometallurgical demonstration plant at Argentia that began operations in late 2005. The demonstration plant is gathering data that will be used to determine whether this technology is technically and economically feasible. In the event that it proves unfeasible, VBNC will construct and operate a conventional nickel refinery (matte plant) at the same location in Long Harbour.

Regardless of which processing technology will be deployed, there will be residues produced as a by-product of the refining process, and these residues require appropriate handling and disposal. Residue disposal options might include placement underwater. VBNC has identified the potential site for sub-aqueous residual disposal as Sandy Pond, near the proposed Long Harbour plant site. Using a pond for residue disposal would require approval under the federal *Fisheries Act*.

The proposed site and process will also require a water source. Extraction of water from the surrounding watersheds may also result in the harmful alteration, disruption and destruction of fish habitat (HADD) however the overall degree depends on many factors such as the habitat quality potentially affected and the volume and rate of water extraction required.

In addition to providing the information required as part of the HADD determination process, the **freshwater resources** of the Project have been identified as requiring a Component Study by the Assessment Committee. Component studies are required to gather baseline information to assist the proponent in predicting impacts to VECs, to assist the Assessment Committee and the Minister in determining significance of impacts and to describe baseline conditions for any required Environmental Effects Monitoring (EEM) programs. This report therefore not only provides the results of the 2006 freshwater baseline data collection program conducted to support the HADD determination of the proposed Long Harbour plant site location, it is also submitted as the Freshwater Resources Component Study. As such, it includes relevant historical information and freshwater data collected from the Project area during programs completed in 1997, 1998, 2002, 2005 and 2006.

Groundwater sampling and laboratory analyses were also conducted in 2006 to assess the chemical characteristics of the groundwater regime of the Study Area. The collection of baseline groundwater chemistry data is important since it is this data that will be used in the future to assess the presence or absence of affects to groundwater after the commencement of Project activities (construction and operations).

2.0 OBJECTIVES

The freshwater resources component study adds data to VBNC's regional baseline information on the freshwater environment and addresses information requirements related to habitat characterization suitable for quantification in the context of DFO HADD requirements, as well as aquatic habitat characterization in compliance with EA Guidelines. The specific work scopes were as follows:

1. Determine baseline surface water quality in selected watersheds;
2. Determine baseline sediment, benthic invertebrate and fish (metal body burden) quality in selected watersheds;
3. Determine baseline groundwater water quality in selected watersheds; and
4. Determine baseline habitat classification and quantification of ponds and streams potentially within the Project footprint to fulfill DFO's information requirements for quantifying the HADD of fish habitat potentially resulting from the Project.

2.1. Study Team

Core study team members for this project have been conducting freshwater and groundwater surveys and habitat classification for many years in Newfoundland and Labrador. Key team members are outlined below.

Mr. James McCarthy, M.Sc. is a Project Manager and Associate Biologist with the St. John's office who has over 15 years experience in fisheries research and environmental assessment. Mr. McCarthy has acted as senior biologist and assessor for numerous projects throughout Newfoundland and Labrador and North America. Mr. McCarthy acted as senior technical biologist and project manager for this work scope. Mr. McCarthy also acted as field data manager when conducting field surveys.

Mr. Eugene M. Lee, M.Sc. is a Senior Environmental/Aquatic Biologist with AMEC Earth and Environmental Ltd., St. John's. He has 21 years experience as a consulting biologist. Mr. Lee acted as field team lead for the sampling program. He also acted as back up to Mr. McCarthy and provided review of all material for content and Quality Assurance/Quality Control (QA/QC) and report writing.

Mr. James Millard, M.Sc., P.Geo. is a geologist / hydro geologist with 18 years combined mining and environmental consulting experience. Mr. Millard was acted as Senior Project Hydro geologist, providing technical guidance and management, data interpretation and report writing services.

Mr. Calvin Miles, P. Geo. has been involved in the field of geotechnical engineering since 1974 and has accumulated an extensive and diverse base of knowledge in soil and rock properties, foundation investigation, slope stability assessment, rock bolt design and hydro geological investigation. Mr. Miles was the groundwater/hydrogeology Project Manager, coordinating all of the field activities and providing technical guidance and QA/QC for the project.

Mr. Peter Lund, B.Sc. P.Geo., CESA is a Senior Associate Hydro geologist who has been a practicing environmental consultant since 1980. Mr. Lund provided Senior Project Review for the groundwater/hydrogeology portion of this project.

Mr. Roderick Mercer, B.Sc., P.Geo. is a senior geologist with 18 years experience in the design, implementation and reporting of geoscientific evaluations of various projects, including quarry and mine developments, highway construction projects, industrial developments, representative sampling and testing of aggregate and mineral resources. Mr. Mercer acted as Senior Geologist, responsible for geological mapping.

Mr. Kevin Penney, P.Eng. has 10 years experience in the earth and environmental fields. He has been involved in a wide range of projects related to geotechnical and environmental engineering ranging in complexity from general residential to heavy civil construction. Mr. Penney was responsible for drill supervision, soil and core logger and monitoring well installation / testing.

Mr. Andrew Peach, B.Sc. is a biologist with over nine years of direct field experience related to the scope of work for this project. Mr. Peach conducted field data collection and acted as field data manager. Mr. Peach also conducted data analysis for this program.

Ms. Suzanne Gouveia, B. Env. Studies (Honours) is an Environmental Scientist with the St. John's office. Ms. Gouveia has over six years of direct field experience related to the scope of work for this project. Ms. Gouveia conducted field data collection and analysis for this program.

Ms. Kelly Curtis is a certified Engineering Technologist with AMEC, St. John's with over nine years experience. Ms. Curtis provided support in the areas of drill supervision, monitoring well installation, well development and hydro geological testing.

Mr. Craig Taylor is a CSA certified Geo-Environmental Technologist with AMEC, St. John's. Mr. Taylor has over four years experience and provided support in the areas of drill supervision, monitoring well installation, well development, hydro geological testing and sampling.

Mr. Ben Hammond, **Mr. Mike Bannister** and **Mr. Jesse K. Noel** are Environmental Technicians with at least two years experience in data collection and field surveys. All were field team members for various tasks associated with the program.

Local field technicians (**Mr. Raymond King, Mr. Mike Singleton, Mr. Kevin Brothers, Mr. Gerald Brothers and Mr. Dave Keating**) were used where appropriate to complete the field sampling program. In particular, **Mr. Raymond King** provided valuable assistance and information such as access points to remote ponds and local general information regarding the ponds and their use. Local technicians also provided local contacts for assistance in access and gear deployment.

3.0 METHODS

Regardless of field measurement or analysis technique, all tasks incorporated the following in their completion.

3.1. Quality Assurance

Standard Operating Procedures (SOPs) developed by AMEC Earth & Environmental for conducting studies were implemented during the current program. These included:

- Water, Sediment, Fish and Macro-invertebrate Sampling
- Monitoring Well Installation, Hydro geological testing and Groundwater Sampling
- Electrofishing
- Bathymetry
- Fyke net and minnow trap use
- Stream Surveys
- Field Data Management and transfer

SOPs serve as established plans and procedures for conducting a series of tasks ensuring that the work is completed to an acceptable standard and in a prescribed manner. The SOPs used by AMEC are on file. SOPs were reviewed in the field by all team members to ensure consistency of sample collection. In addition, as part of each team's Job-Safety Assessment (JSA) was a list of contact numbers for senior biologists and a call-in procedure to ensure that each day's data collection was consistent and accurate. This was referred to if any confusion arose in the field.

In addition to SOPs, QA/QC forms were completed and tracked for all data transfer from field to digital form and any aspect of the project where data validation was deemed necessary. These forms are an integral part of AMEC's QA/QC for data entry.

3.2. Health and Safety

Safety, health and environment (SHE) is an important part of every participant's overall job performance. Although AMEC has made great efforts in reducing the accident and injury rate, the goal is to have zero accidents and injuries. Obtaining this goal requires developing and maintaining an effective safety, health and environment (SHE) management system and a safety culture among all employees. Managers continue to make safety their number one priority by promoting programs that are effective in identifying and reducing hazards in the workplace, providing ongoing training and making safety the primary consideration in all operations. As part of this program, field operations require job health and safety assessments (JSA) to be completed prior to remote activities. JSA documents are working documents that are brought to the work site and reviewed by all participants. Any outstanding issues are identified, documented and addressed as they arise. JSA reports are kept on file upon completion of the program.

3.3. Data Collection

The field data manager was responsible for ensuring that SOPs were followed during the collection of data and also for the daily transcription of field data onto data forms for subsequent computer data entry. For data requiring laboratory analysis, chain of custody forms were completed including documentation of preservation and storage methods. At least weekly, all data transcribed to data forms was reviewed by the data manager and cross referenced with field note books. Any discrepancies were noted on field data forms and a review of procedure was conducted.

3.4. Technical Reporting

Technical quality assurance extending from field data collection to data review and reporting was provided by field supervisors and senior scientists. Their role included reviewing the data entered for computer analysis and all subsequent reports for accuracy. A Data Validation, QA/QC Form was completed each time data was transferred (eg. from field data forms to digital spreadsheets). These forms suggest QA procedures and when filled out, outline what QA reviews and corrective actions, if required, were completed on the data.

3.5. Nomenclature

The naming of streams, ponds and landmarks was standardized for field teams and reporting by utilizing a protocol for naming similar to that used in previous reports (*see* JWEL 2003). Each pond and stream has been labeled by a unique identification number. For example, all ponds have been numbered and are represented by the code P##. Similarly, any stream sample locations have been identified using the codes S##. Ponds and streams labeled and sampled in past programs retained their label designation to allow direct comparison of results. However, in order to provide context for readers and reviewers, names of streams or ponds as found on 1:50,000 topographic maps were also used, such as Rattling Brook Big Pond and Sandy Pond. If locations were not named on maps, then local names were used.

All streams surveyed for habitat classification (i.e. not a point sample location) were named using the standard tributary structure outlined in Scruton *et al.* (1992). All names are provided in the appropriate sections of the report.

3.6. Geo-referencing

All sample locations were geo-referenced using handheld Global Positioning Systems (GPS) (Lowrance models). The position of each set was recorded on an internal SD chip and also recorded in field notebooks. All field positions were gathered using WGS84 datum unless sample locations from previous reports were used. In these circumstances, the original datum was used and is clearly shown. Where greater accuracy was required (i.e. during bathymetric surveys), Differential Global Positioning Systems (DGPS) were used. These systems used one of two methods to correct for position accuracy; integration of Canadian Coast Guard differential correction data or by integration of OMNIstar differential correction data. Tests on both systems prior to deployment indicated accuracies of 1m or less.

4.0 GROUNDWATER SAMPLING

Monitoring wells were established up-gradient and down-gradient of proposed Project infrastructure as well as within the footprint of candidate Project infrastructure. Monitoring Well locations are shown in Figures 4-1 (candidate Plant Site Area), Figure 4-2 (candidate Residue Storage Area), Figure 4-3 (candidate Residue Disposal Pond) and Figure 4-4 (Lower Tier 1 Area – former ERCO site) in Appendix B. Detailed methodology and results for the Groundwater Characterization Study were provided in a technical report finalized in May 2007 (AMEC 2007).

4.1. Schedule

Groundwater samples were collected during mid-summer (July 28 and 29, 2006) and late summer (September 18 and 19, 2006) to preliminarily assess the affect of seasonal variation on groundwater quality. Additional sampling was also completed between June 4-6, 2007.

4.2. Well Establishment and Sampling

All groundwater well site establishment and sampling were conducted in accordance to SOPs that are based on currently accepted standards of environmental industry practice. In preparation for sampling, and prior to the installation of monitoring wells, open boreholes were pumped with a submersible pump to remove drilling fluids and solids, immediately after drilling. Groundwater monitoring wells were developed initially in early July prior to the first sampling event utilizing the manual Waterra™ inertial pumping system. Subsequent to receiving the results of the first sampling round, it was determined that turbidity levels in many wells were elevated and that further well development was required. This was accomplished during early to mid-September by means of the same Waterra system, however with the use of an electrical inertial pump which provided for more effective well development. The turbidity results for the September round of sampling were generally lower than that of July which was indicative of effective well development.

Prior to sampling, each well was purged of three to five well volumes by means of a dedicated Waterra™ pumping system installed in each well. All samples were collected in bottles provided by the laboratory with appropriate preservative added where required and stored in coolers with ice packs and shipped to the laboratory within holding times specified by the laboratory. The schedule of laboratory parameters analyzed is presented in Table 4-1. Samples for metals analyses from monitoring wells were field filtered using a 0.45 um filter prior to preservation.

Table 4.1 List of Groundwater Analytical Parameters, 2006 and 2007.

	Units	RDL
General Chemistry		
Alkalinity (Total as CaCO3)	mg/L	1
Chloride (Cl)	mg/L	1
Colour	TCU	5
Hardness (CaCO3)	mg/L	1
Nitrate (N)	mg/L	0.06
Nitrite (N)	mg/L	0.06
Nitrite + Nitrate	mg/L	0.06
Nitrogen (Ammonia Nitrogen)	mg/L	0.05
Total Organic Carbon (C)	mg/L	0.5
Orthophosphate (P)	mg/L	0.3
pH	pH	N/A
Silica (SiO2)	mg/L	0.1
Sulphate (SO4)	mg/L	2
Turbidity	NTU	0.1
Conductivity	uS/cm	1
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	1
Calculated TDS	mg/L	1
Carb. Alkalinity (calc. as CaCO3)	mg/L	1
Dissolved Calcium (Ca)	mg/L	20
Dissolved Magnesium (Mg)	mg/L	11
Dissolved Potassium (K)	mg/L	1
Dissolved Sodium (Na)	mg/L	5
Arsenic (As)	ug/L	0.6
Boron (B)	ug/L	100
Phosphorus (P)	ug/L	100
Selenium (Se)	ug/L	1
Sulphur (S)	ug/L	3700

RDL – Reportable Detection Limit
Elemental phosphorus, free cyanide, and fluoride were added to the list for Lower Tier 1 Area monitoring wells.

	Units	RDL
Metals		
Aluminum (Al)	ug/L	5
Antimony (Sb)	ug/L	0.4
Barium (Ba)	ug/L	0.4
Beryllium (Be)	ug/L	0.5
Bismuth (Bi)	ug/L	2
Cadmium (Cd)	ug/L	0.017
Chromium (Cr)	ug/L	1
Cobalt (Co)	ug/L	1
Copper (Cu)	ug/L	2
Iron (Fe)	ug/L	100
Lead (Pb)	ug/L	1
Lithium (Li)	ug/L	1
Manganese (Mn)	ug/L	4
Molybdenum (Mo)	ug/L	4
Nickel (Ni)	ug/L	3
Silver (Ag)	ug/L	0.1
Strontium (Sr)	ug/L	2
Thallium (Tl)	ug/L	0.8
Tin (Sn)	ug/L	20
Titanium (Ti)	ug/L	3
Uranium (U)	ug/L	0.15
Vanadium (V)	ug/L	2
Zinc (Zn)	ug/L	2

5.0 SURFACE WATER, SEDIMENT AND BIOTA SAMPLING

In order to ensure consistent and comparable results over sample years, the current sampling program for surface water, sediment, benthic invertebrates and fish body burden followed collection and analysis methodologies as described in the 2002 sampling program (JWEL 2003). Additional details or modifications for specific tasks are outlined in the appropriate sections below.

The work comprised a set of clearly defined tasks which were carried out in accordance with the scope of work provided in the Request for Proposal by VBNC. Sample locations are provided in the table below (Table 5-1) and in Figure 5-1. The original control location (Pond P10 and Stream S24) was selected during 1992 sampling to resent a site that would not be impacted by any activity in the Project area and hence would provide good control for such long-term phenomena as airborne deposition. Given the long sampling timeline, it was felt that the location should be continued so as to provide ongoing monitoring results. Give the distance from the proposed site, additional control ponds have been selected closer to Long Harbour in subsequent sampling programs (eg. Ponds P9, P11, P18, P19, P20 and P21 and associated streams).

5.1. Schedule

Sampling was conducted on three occasions between March and August 2006 to investigate seasonal trends:

- March 2006 Winter/Ice cover conditions
- May-June 2006 Spring freshet flows prior to any thermocline formation in the ponds
- July-August 2006 Mid-summer low flows when metals may be more detectable and, where possible, pond thermoclines have formed.

In general, each visit consisted of various necessary tasks which are outlined below. The timing of each task is also detailed below. Tables 5-2 and 5-3 present the sampling collection schedule for the study ponds and streams respectively.

5.2. Surface Water Quality

Water quality sampling was conducted at the identified stream and pond sample locations for parameters identified in the 2002 sampling program during all site visits. Parameters analyzed are outlined in Table 5-4 below. All samples were analyzed by a CAEAL certified lab. Standard field duplicates of 10% of all samples were collected and sent to the lab for QA/QC. In addition, the lab results also identify all in-lab QA/QC measures (blanks and calibrations) as part of standard reporting (see Appendix B).

5.2.1. Ponds

Each sample location consisted of water collection at the near-surface, mid-depth and near-bottom. All samples were collected at the deepest known point within the pond. Each sample was collected using a Niskin water sampler and depth sounder. Once the sample location was determined, the sampler was set and lowered to the required depth. The depth sounder was used to verify sample depth during sampling at mid- and near-bottom collections. The sample was collected and decanted into appropriate bottles for shipment to the lab. All samples were stored in coolers and sent to the lab for analysis as soon as possible.

Table 5.1 Sample locations for 2006 freshwater study, Long Harbour.

Ponds		Streams	
Location	**Coordinates (UTM NAD 27)**	**Location**	**Coordinates (UTM NAD 27)**
Pond P8 (Rattling Brook Big Pond)	N5253327 E22 289308	Stream S19 (Outflow of Rattling Brook)	N5253403 E22 288844
Pond P9 (Ship Harbour Big Pond)	N5249381 E22 290982	Stream S3 (Ship Harbour Brook downstream of confluence with stream draining Rocky Pond)	N5247427 E22 283308
Pond P10 (St. Josephs Pond)	N5219509 E22 308215	Stream S24 (Outflow St. Joseph's Pond)	N5219180 E22 308170
Pond P11 (Rocky Pond)	N5245341 E22 285461	Stream S14 (Outflow of Rocky Pond)	N5245805 E22 286190
Pond P14 (Sam Howe's Pond)	N5252820 E22 288074	Stream S20 (Outflow of Rattling Brook at Long Harbour)	N5255602 E22 287536
Pond P15 (Sandy Pond)	N5256058 E22 289886	Stream S26 (Outflow of Sandy Pond)	N5256649 E22 290373
Pond P17 (First Pond, Bottom Brook)	N5259008 E22 292287	Stream S28 (Outflow of First Pond)	N5258632 E22 291569
Pond P18 (Lower Maturin Pond)	N5256978 E22 286955	Stream S40 (Outflow of Lower Maturin Pond)	N5256676 E22 286639
Pond P19 (Upper Maturin Pond)	N5258206 E22 288550	Stream S41 (Outflow Upper Maturin Pond)	N5257725 E22 288279
Pond P20 (Norman's Pond)	N5262020 E22 295140	Stream S35 (Outflow of Norman's Pond)	N5261540 E22 294860
Pond P21 (Bruce's Pond)	N5263875 E22 296043	Stream S36 (Outflow of Bruce's Pond)	N5264113 E22 296614
Pond P22 (Unnamed Pond 1)	N5254761 E22 287142	Stream S29 (Outflow of Unnamed Pond 1)	N5254630 E22 287027
Pond P23 (Unnamed Pond 2)	N5254431 E22 287148	Stream S30 (Outflow of Unnamed Pond 2)	N5254415 E22 287342
Pond P24 (Unnamed Pond 3)	N5253941 E22 287581	Stream S32 (Outflow of Unnamed Pond 3)	N5254024 E22 287618
Pond P25 (Unnamed Pond 4)	N5253866 E22 287765	Stream S31 (Outflow of Unnamed Pond 4)	N5253879 E22 287638
Pond P26 (Unnamed Pond 6)	N5256600 E22 289870	Stream S45 (Outflow of Unnamed Pond 6)	N5256480 E22 289909
Pond P27 (Unnamed Pond 5)	N5256338 E22 289615	Stream S46 (Outflow of Unnamed Pond 5) (no outflow on map – estimated)	N5256267 E22 289723
Pond P28 (Little Sandy Pond)	N5255368 E22 289760	Stream S43 (Outflow of Little Sandy Pond)	N5255171 E22 289813
Pond P29 (Unnamed Pond 7)	N5254518 E22 289146	Stream S44 (Outflow Unnamed Pond 7)	N5254364 E22 289208
Pond P30 (Forgotten Pond)	N5253653 E22 288275	Stream S42 (pipeline route)	N5254479 E22 288592
		Stream S25 (Outflow of Bottom Brook)	N5257916 E22 289943
		Stream S47 (pipeline route)	N5254697 E22 288651
		Stream S33 (sub-aerial disposal site)	N5253378 E22 284939

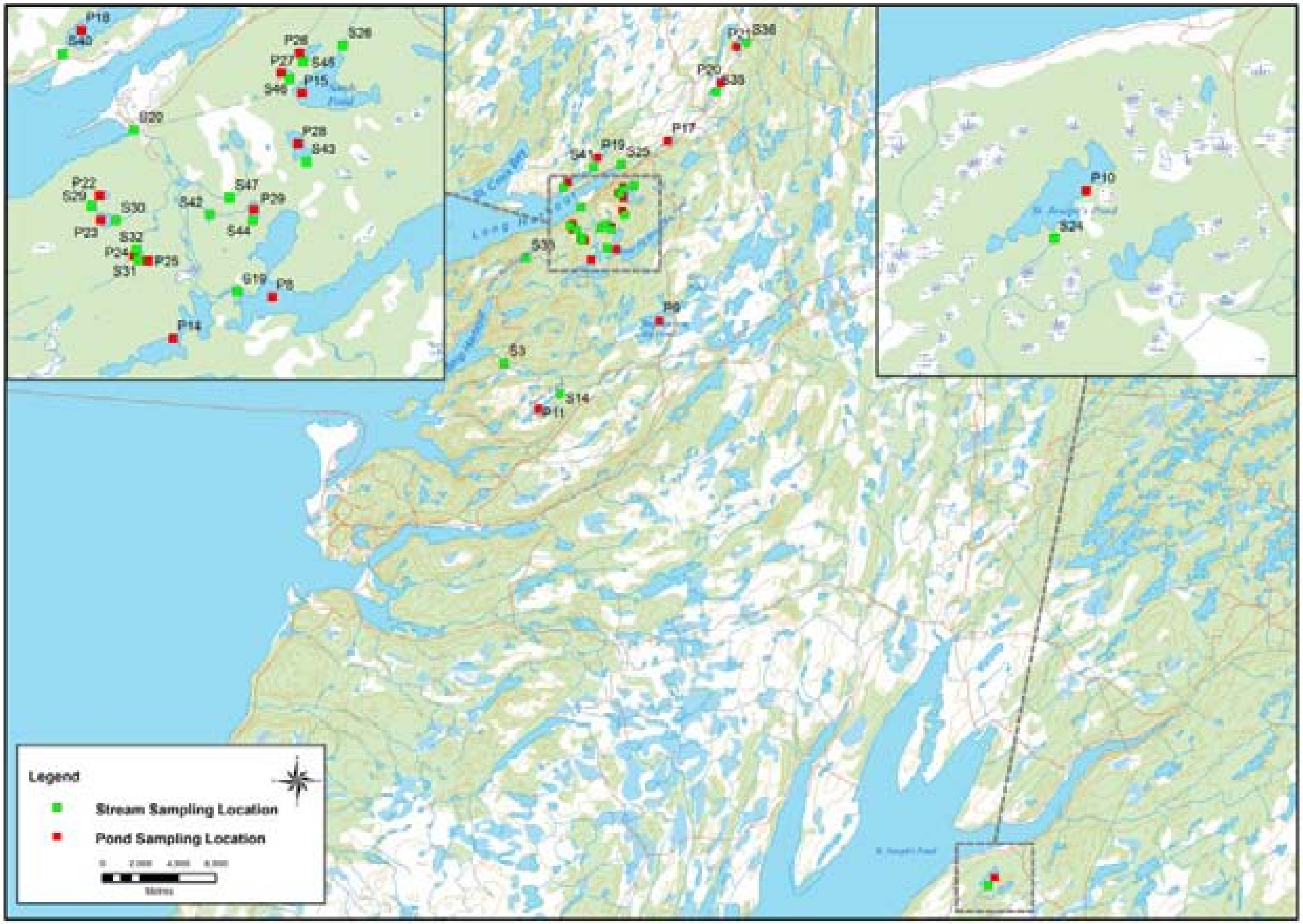

Figure 5.1 Study area, Long Harbour.

In addition to water samples, an in-situ water profile was also recorded at each sample location. A Hydro lab (model Surveyor 4a) mini-sonde probe was used to gather a profile of water temperature, pH, conductivity and dissolved oxygen at one metre intervals between the surface and near-bottom.

Water clarity was also recorded using a Secchi disc. The disc was lowered in the water column using a calibrated line on the shaded side of the boat. The distance when the disc disappeared from sight as it descended was recorded as well as the distance when the disc re-appeared as it ascended. The mean of these values represents the Secchi Disc depth.

Table 5.2 Sampling schedule summary for ponds, 2006.

Site ID	Site Name	March	May-June				July-August
		Water	Water	Sediment	Macro-invertebrates	Fish	Water
P8	Rattling Brook Big Pond	●	●	●	●	●	●
P9	Ship Harbour Brook Big Pond	●	●	●	●	●	●
P10	St. Josephs Pond	●	●	●	●	●	●
P11	Rocky Pond	●	●	●	●	●	●
P14	Sam Howe’s Pond	●	●	●	●	●	●
P15	Sandy Pond	●	●	●	●	●	●
P17	First Pond, Bottom Brook	●	●	●	●	●	●
P18	Lower Maturin Pond	●	●	●	●	●	●
P19	Upper Maturin Pond	●	●	●	●	●	●
P20	Norman’s Pond, Bottom Brook	●	●	●	●	●	●
P21	Bruce’s Pond	●	●	●	●	●	●
P22	Unnamed Pond 1 (Proposed Plant Site)	●	●	●	●	●	●
P23	Unnamed Pond 2 (Proposed Plant Site)	●	●	●	●	●	●
*P24	Unnamed Pond 3 (Proposed Plant Site)		●	●	●	●	●
*P25	Unnamed Pond 4 (Proposed Plant Site)		●	●	●	●	●
*P26	Unnamed Pond 6 (near Sandy Pond)		●	●	●	●	●
*P27	Unnamed Pond 5 (near Sandy Pond)		●	●	●	●	●
*P28	Unnamed Pond 8 (Proposed pipeline route)		●	●	●	●	●
*P29	Unnamed Pond 7 (Proposed pipeline route)		●	●	●	●	●

*Note: A water sample was not collected in March 2006, as these locations were not identified as being within the project footprint until after March 2006.

Table 5.3 2006 sampling schedule summary for streams.

Site ID	Site Name	March	May-June	July-August
		Water	Water	Water
S19	P8 - Rattling Brook Big Pond outflow	•	•	•
S3	P3 - Ship Harbour Brook outflow	•	•	•
S24	P10 - St. Josephs Pond outflow	•	•	•
S14	P11 - Rocky Pond outflow	•	•	•
S20	P14 – Sam Howe’s outflow	•	•	•
S26	P15 - Sandy Pond outflow	•	•	•
S25	Bottom Brook outflow	•	•	•
S40	P18 - Lower Maturin Pond outflow	•	•	•
S41	P19 - Upper Maturin Pond outflow	•	•	•
S35	P20 - Norman’s Pond outflow	•	•	•
S36	P21 - Bruce’s Pond outflow	•	•	•
S29	P22 - Unnamed Pond 1 outflow	•	•	•
S30	P23 - Unnamed Pond 2 outflow	•	•	•
*S32	P24 - Unnamed Pond 3 outflow		•	•
*S31	P25 - Unnamed Pond 4 outflow		•	•
*S43	P26 - Unnamed Pond 6 outflow		•	•
*S46	P27 - Unnamed Pond 5 outflow		•	•
*S45	P28 - Unnamed Pond 8 outflow		•	•
*S44	P29 - Unnamed Pond 7 outflow		•	•
*S42	Stream (near Proposed Pipeline route)		•	
*S47	Stream (near Proposed Pipeline route)		•	•
*S33	Stream near Proposed sub-aerial disposal site		•	•
*S28	P17 - First Pond outflow		•	•

*Note: A water sample was not collected in March 2006, as these locations were not identified as being within the project footprint until after March 2006.

Table 5.4 Analytical requirements for freshwater water quality, 2006.

Parameter	Method of Analysis	MDL	Parameter	Method of Analysis	MDL
Potassium	ICP-OES	0.02mg/l	Aluminum	ICP-MS	1ug/l
Calcium	ICP-OES	500ug/l	Antimony	ICP-MS	1ug/l
Magnesium	ICP-OES	0.02mg/l	Arsenic	ICP-MS	1ug/l
Alkalinity ($CaCO_3$)	Colourimetric	5000ug/l	Barium	ICP-MS	0.5ug/l
Sodium	ICP-OES	500ug/l	Beryllium	ICP-MS	0.1ug/l
Sulfate	Colourimetric	100ug/l	Bismuth	ICP-MS	0.5ug/l
Chloride	Colourimetric	100ug/l	Boron	ICP-MS	2ug/l
Reactive Silica	Colourirnetric		Cadmium	ICP-MS	0.015ug/l
Nitrite (as N)	Colourimetric	50ug/l	Chromium	ICP—MS	1ug/l
Nitrate (as N)	Colourimetric	50ug/l	Cobalt	ICP-MS	1ug/l
Total Phosphorous	Colourimetric	10ug/l	Copper	ICP-MS	1ug/l
Ammonia (as N)	Colourimetric	0.01mg/l	Iron	ICP-MS	1ug/l
Colour	Colourimetric	5 TCU	Lead	ICP-MS	1ug/l
Turbidity	Nephelometer	0.1 NTU	Manganese	ICP-MS	1ug/l
Specific Conductance	Electrode	5 uS/cm	Mercury	CVAAS	0.1ug/l
pH	Electrode	-	Molybdenum	ICP-MS	2ug/l
Dissolved Organic Carbon	UV-ox	0.5mg/l	Nickel	ICP-MS	1ug/l
Hardness (as $CaCO_3$)	Calculated	0.3mg/l	Selenium	ICP-MS	1ug/l
Bicarbonate	Calculated	6mg/l	Silver	ICP-MS	0.1ug/l
Carbonate	Calculated	3mg/l	Strontium	ICP-MS	1ug/l
TDS Calculated	Calculated	10,000ug/l	Thallium	ICP-MS	0.5ug/l
Cation Sum	Calculated	- meg/l	Tin	ICP-MS	2ug/l
Anion Sum	Calculated	- meq/l	Titanium	ICP-MS	2ug/l
Ion Balance	Calculated	- %	Uranium	ICP-MS	1ug/l
Total Suspended Solids	Gravimetric	2000ug/l	Vanadium	ICP-MS	2ug/l
			Zinc	ICP-MS	1ug/l

ICP-OES - Inductively Coupled Plasma/Optical Emission Spectrometer
ICP-MS - Inductively Coupled Plasma/Mass Spectrometer
CVAAS - Cold Vapour Atomic Absorption Spectrometer
UV–ox – Measurement by Ultraviolet light, promoted by persulphate oxidation

5.2.2. Streams

Stream sample locations were sampled at least 50m downstream from the associated pond. Only near-surface water samples were collected. All samples were stored in coolers and sent to the lab for analysis as soon as possible.

In addition to water samples, standard stream transect measurements were also conducted at each location (see Scruton *et al*. 1991 and Sooley *et al.* 1998 for a more detailed summary of methods). The stream total and wetted width were measured at each location using a standard measuring tape. Measurements of water depth and mean water column velocity (i.e. the water velocity at 0.6 the water column depth) were conducted at 1/4, 1/2 and 3/4 the steam wetted width. Water depth was recorded using a metre stick and mean water velocity was measured using a Global Flow Probe (model FP101 ±0.01m/s) velocity meter or estimated by measuring the travel time of a hockey ball to float a distance of 5m as outlined in Sooley *et al*. (1998). The Hydrolab (model Surveyor 4a) mini-sonde probe was used to gather water temperature, pH, conductivity and dissolved oxygen data at each sample location. The substrate composition of each location was also recorded as the percentage of each substrate classification as outlined in Sooley *et al.* (1999).

5.3. Sediment Sampling

Sediment sampling was also conducted at the deepest known point of each pond using a Ponar grab (model 1725-F10). The Ponar was equipped with 500µm top screens which assisted in reducing the loss of macro invertebrates residing on the surface substrates prior to recovery of the grab. The grab was brought to the surface and the appropriate depth horizons extracted from the sampler using stainless steel instruments. As in past sampling, sediment analysis was conducted during one site visit only (May-June). Parameters analyzed are provided in Table 5-5. Duplicate samples of the 0-5cm and the 5-10cm depth horizons of each pond were collected so that historic and recent deposition could be recorded.

5.4. Benthic Invertebrates

Benthic macro invertebrates have been shown to be good indicators of habitat health (Reice and Wohlenberg 1993) and are typically involved in long-term Environmental Effects Monitoring (EEM) Programs. Benthic sampling was conducted at all Pond sites using methodologies similar to those in 2002 (JWEL 2003). Sampling for benthic invertebrates was conducted during the May-June site visit. A total of three samples were collected from each pond. Each sample was collected at moderate depth, from similar depositional substrate, along the shoreline at random locations using a Ponar grab (model 1725-F10) with a total collection area of 152mm x 152mm and a sample volume of 2.4 litres. The Ponar was equipped with 500µm top screens which assisted in reducing the loss of macro invertebrates residing on the surface substrates prior to recovery of the grab. Each sample was field cleaned using an 80µm sieve and stored in bottles with preservative (90% ethanol). Samples were taken to the lab and cleaned with all invertebrates placed in a clean vial under 70% ethanol.

Each sample had all organisms identified to the lowest possible level (typically to Family) and enumerated. Due to the relatively low numbers of organisms, no splitting of the samples was conducted and no sub-sampling was conducted. Baseline diversity was conducted using standard methods with calculations of richness (total number of families), Shannon-Weiner Diversity Indices (H) and an estimation of Species Evenness (D). A brief description of each is provided in Sub-section 5.4.1.

Table 5.5 Analytical requirements for freshwater sediment, 2006.

Parameter	Method of Analysis	MDL (mg/kg dry wt)
Aluminum	Nitric peroxide digest; ICP-MS	5m
Antimony	Nitric peroxide digest; ICP-MS	0.5
Arsenic	Nitric peroxide digest; ICP-MS	0.1
Barium	Nitric peroxide digest; ICP-MS	0.5
Beryllium	Nitric peroxide digest; ICP-MS	0.2
Boron	Nitric peroxide digest; ICP-MS	1
Cadmium	Nitric peroxide digest; ICP-MS	0.5
Chromium	Nitric peroxide digest; ICP-MS	1
Cobalt	Nitric peroxide digest; ICP-MS	1
Copper	Nitric peroxide digest; ICP-MS	1
Iron	Nitric peroxide digest; ICP-MS	5
Lead	Nitric peroxide digest; ICP-MS	5
Lithium	Nitric peroxide digest; ICP-MS	5
Manganese	Nitric peroxide digest; ICP-MS	1
Mercury	Acid Digestion; CVAAS	0.01
Molybdenum	Nitric peroxide digest; ICP-MS	2
Nickel	Nitric peroxide digest; ICP-MS	5
Selenium	Nitric peroxide digest; ICP-MS	0.1
Silver	Nitric peroxide digest; ICP-MS	0.25
Strontium	Nitric peroxide digest; ICP-MS	2
Sulphate	COBAS	100
Thallium	Nitric peroxide digest; ICP-MS	2.1
Uranium	Nitric peroxide digest; ICP-MS	0.5
Vanadium	Nitric peroxide digest; ICP-MS	5
Zinc	Nitric peroxide digest; ICP-MS	2
TIC	Induction Furnace	500
TOC	Induction Furnace	500
PSA	Gravimetric (Pipette for silt, clay)	%

MDL Estimated Laboratory Method Detection Limit
TIC - Total Inorganic Carbon
TOC - Total Organic Carbon
PSA - Particle Size Analysis
ICP-MS - Inductively Coupled Plasma/Mass Spectrometer
CVAAS - Cold Vapour Atomic Absorption Spectrometer
COBAS - Automated Centrifugal Colourimetric Analysis

5.4.1. Invertebrate Diversity Estimates

The mathematics of *information theory* is used to make calculations about groups of organisms and their *first-order diversity*, H_1, and *divergence from equiprobability*, D_1. For example, if there are *n* possible categories in a data set and their proportions are $p_i,.....,p_n$, then the measure of diversity, for this system is defined to be

$$H_1 = \sum_{i=1}^{n} p_i \log_2 p_i$$

Since $\log_2 0$ is not defined, if $p_i = 0$ the conventional adoption is the expression $p_i \log_2 p_i = 0$. In a data set with n categories, $H_{1max}(n)$ is the maximum possible value of H_1.

The divergence from equiprobability is defined to be:

$$D_1 = H_{max} - H_1 = \log_2 n - H_1$$

A low D_1 value means H_1 is close to H_{1max}, that is, the system is nearly in a state of equiprobability; there is a high degree of diversity present. Conversely, a high D_1 value means that H_1 is small relative to H_{1max}, that is, the system has diverged substantially from equiprobability and is not very diverse. For example, for an H_1 of 1.5 and an H_{1max} of 2.0, the D_1 value would be 0.5. In this case 0.5 is a substantial divergence, since it represents 25% of H_{1max}.

5.5. Fish Body Burden

Ponds within the study area had brook trout (*Salvelinus fontinalis*) analyzed for whole body burden (stomachs removed) of metals under DFO permit number NL-467-06-Amendment 1. Parameters analyzed are outlined in Table 5-6. Portable fyke nets and angling were used for fish collection. These gear types allowed select fish size ranges to be captured and all fish not required for analysis to be released alive. Sampling was conducted during May-June. Each fish collected was measured (fork length), weighed (grams), had scales collected for subsequent aging and stomachs only removed prior to being frozen in labeled, individual sample bags for shipment to a CAEAL certified lab. Where possible, a total of ten fish were collected from each pond.

Table 5.6 Analytical requirements for freshwater fish tissue analysis, 2006.

Parameter	Method of Analysis	MDL (mg/kg dry wt)
Aluminum	ICP-MS	2.5
Antimony	ICP-MS	0.5
Arsenic	ICP-MS	0.5
Barium	ICP-MS	1.5
Beryllium	ICP-MS	1.5
Boron	ICP-MS	1.5
Cadmium	ICP-MS	0.08
Chromium	ICP-MS	0.5
Cobalt	ICP-MS	0.2
Copper	ICP-MS	0.5
Iron	ICP-MS	5
Lead	ICP-MS	0.18
Manganese	ICP-MS	0.5
Mercury	Acid Digestion; CVAAS	0.002
Molybdenum	ICP-MS	0.5
Nickel	ICP-MS	0.5
Selenium	ICP-MS	0.5
Silver	ICP-MS	0.12
Strontium	ICP—MS	1.5
Thallium	TCP-MS	0.02
Tin	ICP-MS	0.5
Uranium	ICP-MS	0.02
Vanadium	ICPMS	0.5
Zinc	ICP-MS	0.5

MDL Estimated Laboratory Method Detection Limit
TIC - Total Inorganic Carbon
TOC - Total Organic Carbon
PSA - Particle Size Analysis
ICP-MS - Inductively Coupled Plasma/Mass Spectrometer
CVAAS - Cold Vapour Atomic Absorption Spectrometer
COBAS - Automated Centrifugal Colourimetric Analysis

6.0 Fish Species within the Proposed Project Area

Fish species recorded in the proposed Project area include brook trout (*Salvelinus fontinalis*), Arctic charr (*Salvelinus alpinus*), rainbow smelt (*Osmerus mordax*) and American eel (*Anguilla rostrata*). Recent DFO documents summarize the general biology of each species for use in habitat quantification (*see* Bradbury et al. 1999 and Grant and Lee 2004). Each is listed below with a brief life history description from the above documents.

6.1. Brook Trout

Brook trout are widely distributed throughout Newfoundland and Labrador and are thought to exist in all Newfoundland freshwater ecosystems where they have been reported to make extensive use of lake habitats. They can be either landlocked or anadromous, spending one or two months feeding at sea in relatively shallow water, close to their natal stream. There is also evidence to suggest that two forms of brook trout may coexist in some Newfoundland lakes; a primarily benthic feeding population that is relatively slow growing and short-lived and a larger-bodied, piscivorous population that is faster growing and longer-lived. Optimal riverine habitat is characterized as clear, cold spring-fed water with silt-free rocky substrate in riffle-run areas; well vegetated stream banks; an approximate 1:1 pool-riffle ratio with areas of slow, deep water; abundant instream cover; and relatively stable water flow, temperature regimes and stream banks.

Spawning in Newfoundland normally occurs between late September and early November in shallow, gravel-bottomed streams and occasionally in lakes. In lakes, spawning typically occurs at depths less than two metres. Although growth rates are variable in Newfoundland, brook trout usually mature at two to four years of age. Although they seldom live longer than five or six years of age, brook trout have been reported from several Newfoundland lakes up to eight years of age.

Brook trout often seek refuge among rocks, aquatic vegetation, woody debris, overhanging logs and undercut banks.

6.2. Arctic charr

The Arctic charr has the most northerly distribution of any freshwater fish and is distributed throughout Newfoundland and the entire Labrador coast and may be classified as either anadromous or resident freshwater populations. In Newfoundland, Arctic charr have been reported as being rather common and the dominant species in some lakes.

In Newfoundland, landlocked Arctic charr may spawn in streams or lakes from early October to mid-November. Preferred habitat is usually gravel/cobble substrate at depths of 1-5m which are sufficient to keep eggs safe from winter ice.

In Newfoundland lakes, Arctic charr (age 4+ to 9+) have been found predominantly in the pelagic zone during June and July, while occupying mainly benthic areas during other times of the year. Within lakes, some part of the adult population usually performs a seasonal movement from the benthic to the pelagic zone in response to improved food abundance during late summer in the form of high crustacean zooplankton density.

6.3. Rainbow Smelt

Rainbow smelt occur in both anadromous and landlocked forms. Landlocked populations may exist as either normal- or dwarf-sized forms and have been reported throughout many parts of insular Newfoundland. It has been assumed that both have similar habitat requirements.

On the Avalon Peninsula, landlocked rainbow smelt have been observed spawning in lakes before ice-out in early- to mid-April, while spawning in tributary streams does not occur until early to mid-May, after ice has moved out. During spawning, eggs are released indiscriminately over a wide variety of substrates including mud, clay, sand, gravel, cobble, rubble, boulders and aquatic vegetation at depths ranging from 0.1 to five metres deep. In Newfoundland, rainbow smelt mature at 1-2 years of age.

6.4. American eel

The American eel is distributed from the southern tip of Greenland, southward along the Atlantic coast and the Gulf of Mexico to the northern portion of the east coast of South America. They have been reported throughout Newfoundland and the south-eastern coast of Labrador as far north as Hamilton Inlet. The American eel is catadromous spending most of its life in freshwater and estuaries but migrating to sea to spawn. Eels typically begin their spawning migration in late summer and fall throughout much of eastern Canada, although migration from lakes that are far inland may begin earlier. Peak migratory activity often occurs in September-October during the last quarter of the moon and is enhanced by dark, stormy nights and rising water levels.

Eels spawn in the Sargasso Sea, with peak spawning occurring in mid-winter between January and March, but may extend as late as May or June. Although the depth at which spawning occurs is not known, evidence suggests that eels spawn in the upper few hundred metres of the water column. Adult eels presumably die after spawning.

During their freshwater phase of their life cycle, eels move into streams, rivers and muddy or silt-bottomed lakes, generally following the bank of the river in very shallow water. Eels can be very mobile and may gain access to ponds and lakes, which appear unavailable to them, by using very small watercourses or by moving overland through wet grass. Being nocturnal, they usually spend the day hiding under rocks and logs or buried in the mud. Investigations on diet composition of juvenile eels suggest that American eels rely heavily on benthic organisms and demersal fishes as food sources.

There are indications that a proportion of eels remain in brackish estuaries and do not enter freshwater at all. In Newfoundland, eels migrate to sea after spending twelve to thirteen years in freshwater.

Recent concern regarding population decreases in the Great Lakes has prompted COSEWIC to list the American eel as a Species of Concern in 2006 (COSEWIC 2006). This designation is defined as a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats. The reason for the designation has been indicators of the status of the total Canadian component of this species are not available. Indices of abundance in the Upper St. Lawrence River and Lake Ontario have declined by approximately 99% since the 1970s. The only other data series of comparable length (no long-term indices are available for Scotia/Fundy, Newfoundland and Labrador) are from the lower St. Lawrence River and Gulf of St. Lawrence, where four out of five time series declined. Because the eel is panmictic (i.e. all spawners form a single breeding unit), recruitment of eels to Canadian waters would be affected by the status of the species in the United States as well as Canada.

Prior to their declines, eels reared in Canada comprised a substantial portion of the breeding population of the species. The collapse of the Lake Ontario-Upper St. Lawrence component may have significantly affected total reproductive output, but time series of elver abundance, although relatively short, do not show evidence of an ongoing decline. Recent data suggest that declines may have ceased in some areas; however, numbers in Lake Ontario and the Upper St. Lawrence remain drastically lower than former levels, and the positive trends in some indicators for the Gulf of St. Lawrence are too short to provide strong evidence that this component is increasing. Possible causes of the observed decline include habitat alteration, dams, fishery harvest, oscillations in ocean conditions, acid rain and contaminants. The designation as a Species of Concern does not enact any additional conservation measures outside those within the *Fisheries Act*.

7.0 RIVERINE HABITAT CLASSIFICATION

Many features of facility design are still under development; however the following aspects are known and served to direct the habitat survey work. Pond P15 (Sandy Pond) is currently proposed as the site for any aqueous disposal of process residue from the hydrometallurgical plant. As such, the pond would become part of a closed system to settle the residue and recycle the water back to the plant for re-use and treatment. As a result, the outflow stream will no longer have water input from the pond. Pond P8 (Rattling Brook Big Pond) drainage basin would provide the water required for the Plant processing operations (either hydrometallurgical or matte refining). While the exact location of extraction is not yet finalized, the volume, timing and location of water withdrawal have the potential to create a HADD as does any potential disturbance or diversion of any portion of the stream. The Plant footprint and drainage control may also fall within the drainage area of four small water bodies (P22, P23, P24, and P25) and associated outflow streams (see Figure 5-1).

The methods used to classify and quantify the aquatic habitat was based on standardized methodologies such as Scruton *et al*. (1992), Sooley *et al*. (1998), Bradbury *et al*. (2001) and McCarthy *et al*. (2006). Riverine habitat classification involved an aerial survey of all fish habitat as well as ground surveying of habitats present within the identified streams using standard techniques (see Scruton *et al*. 1992 and Sooley *et al*. 1999). Figure 7-1 presents the stream sections surveyed and the naming of the sections. Each stream was sub-divided into habitat reaches based on visible and measured changes in habitat characteristics (eg. streambed slope, water velocity, stream width and/or water depth). Each stream reach was surveyed for numerous parameters such as channel width, wetted perimeter, mean water column velocity, mean water depth, streambed slope and substrate composition. Based on these measurements, each reach was classified into various habitat types.

Two habitat classification systems were used; the Beak (1980) and a new classification system soon to be implemented by DFO (McCarthy *et al.* 2006). The Beak habitat classification system uses a total of four habitat types based on salmonid life-cycle stages and habitat suitabilities (Table 7-1).

The proposed new classification system outlined in McCarthy *et al.* (2006) takes into account the suitability of the habitat for each species using the habitat by life-cycle stage (spawning, young-of-year, juvenile and adult). Habitat classes should be defined in an ecologically meaningful way (i.e. taking into account how fish utilize their habitat) that can be easily recognized by both field staff and habitat managers. Figure 7-2 provides an outline of the new habitat classification system, while Table 7-2 provides a description of each habitat type along with the range of parameter values associated with each.

The system is based on easily identifiable habitat characteristics that are not unlike many of the descriptive summaries provided in previous North American and Newfoundland and Labrador documents. It is comprised of a series of three levels, each providing progressively more detail about the habitat. This three-level hierarchical system provides the level of resolution needed for many habitat management purposes. Although the third level doesn't provide a further breakdown in habitat characterization, it does add significant information regarding site-specific species utilization of the Intermediate Level habitat types, which may be required for more detailed assessments.

Each habitat type has a discrete range of water velocities, substrate types, depths and gradients as possible which have been determined using the described biological 'preferences' outlined in Grant and Lee (2004). While not a defined habitat requirement, gradient is listed as a parameter which can be used in various levels of the system to distinguish between habitat types. It should be noted that not all habitat parameter descriptions are exclusive of all others (e.g., water depth); however, the combined parameters should offer a reasonable designation of most habitat types encountered.

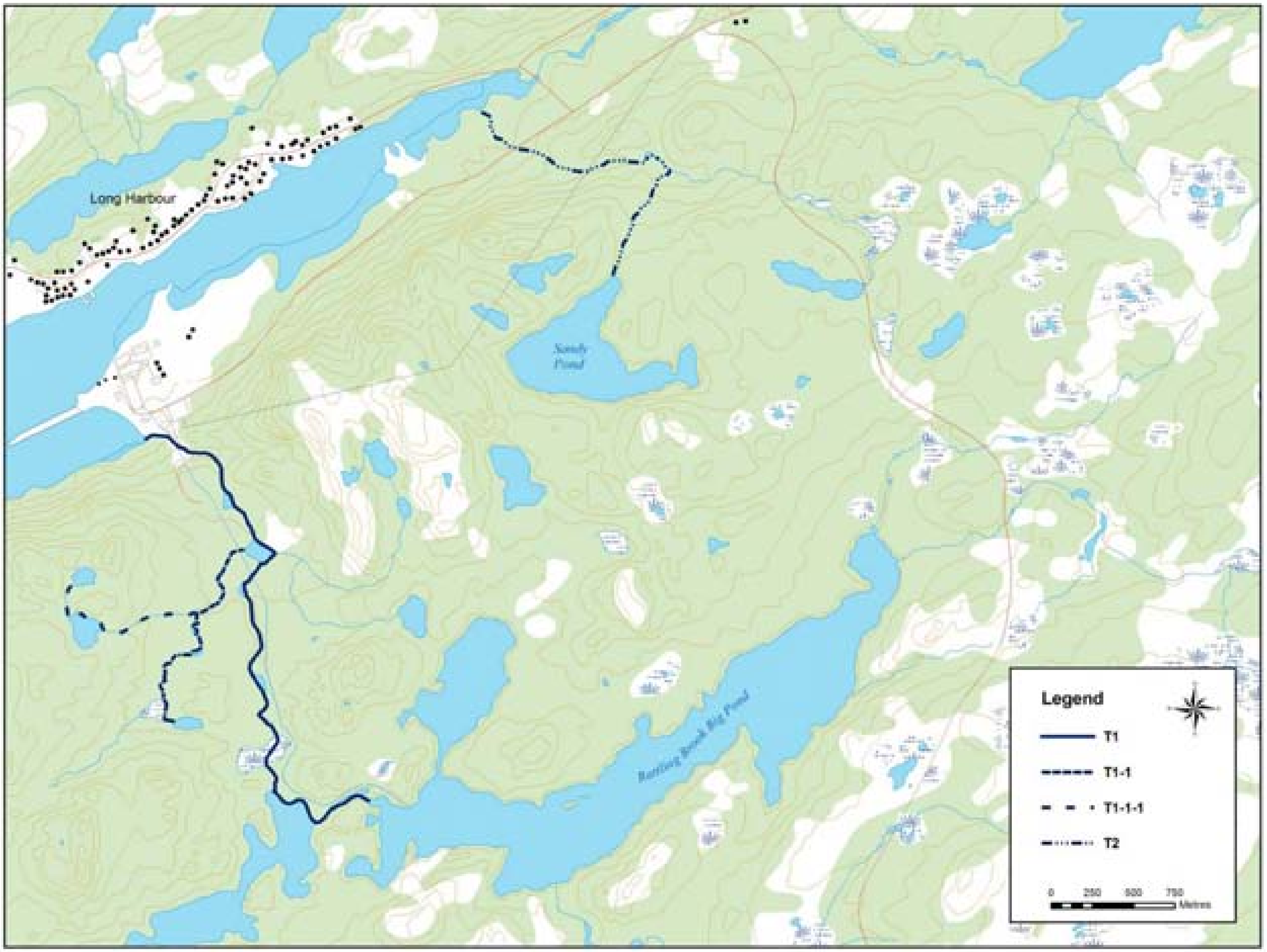

Figure 7.1 Stream habitat survey coverage and naming.

Table 7.1 Habitat classifications of Beak (1980).

Habitat Classification	Habitat Description
Type I	Good salmonid spawning and rearing habitat: often with some feeding pools for larger age classes: **flows:** moderate riffles; **current:** 0.1-0.3 m/s; **depth:** relatively shallow, 0.3-1.0 m; **substrate:** gravel to small cobble, some large rocks, boulders; **general habitat types:** primarily riffle, pool.
Type II	Good salmonid rearing habitat with limited spawning usually only in isolated gravel pockets, good feeding and holding areas for larger fish in deeper pools, pockets or backwater eddies: **flows:** heavier riffles to light rapids; **current:** 0.3-1.0 m/s; **depth:** variable from 0.3-1.5 m; **substrate:** Larger cobble/rubble size rock to boulders, bedrock, some gravel pockets between larger rocks; **general habitat types:** run, riffle, pocketwater, pool.
Type III	Poor rearing habitat with no spawning capabilities, used for migratory purposes: **flows:** very fast, turbulent, heavy rapids, chutes, small falls; **current:** 1.0 m/s or greater; **depth:** variable, 0.3-1.5 m; **substrate:** Large rock and boulders, bedrock; **general habitat types:** run, pocketwater, cascades.
Type IV	Poor juvenile salmonid rearing habitat with no spawning capability, provides shelter and feeding habitat for larger, older salmonid (especially brook trout): **flows:** sluggish; **current:** 0.15 m/s; **depth:** variable but often 1 m; **substrate:** Soft sediment or sand, occasionally large boulders or bedrock, aquatic macrophytes present in many locations; **general habitat types:** flat, pool, glide.

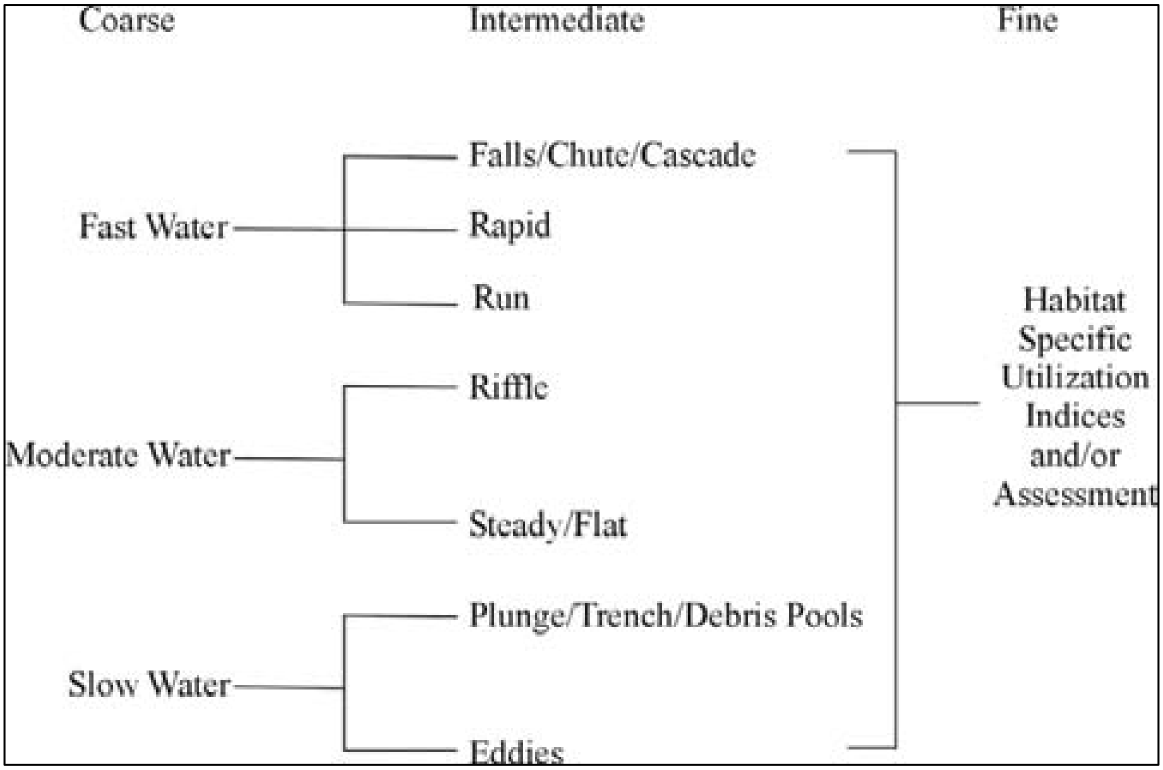

Figure 7.2 Outline of the proposed riverine habitat classification system from McCarthy *et al.* (2006).

Table 7.2 Descriptions of riverine habitat classifications in McCarthy *et al.* (2006).

Habitat Type	Habitat Parameter	Description
Fast Water	**Mean Water Velocity** **Stream Gradient**	**> 0.5m/s** **Generally > 4%.**
Rapid	General Description Mean Water Velocity Mean Water Depth Substrate Stream Gradient	Considerable white water[1] present. > 0.5 m/s < 0.6 m Usually dominated by boulder (Coarse[2]) and rubble (Medium[2]) with finer substrates (Medium and Fine[2]) possibly present in smaller amounts. Larger boulders typically break the surface. Generally 4-7%
Falls/ Chute/ Cascade	General Description Mean Water Velocity Mean Water Depth Substrate Stream Gradient	Mainly white water present. The dominating feature is a rapid change in stream gradient with most water free-falling over a vertical drop or series of drops. > 0.5 m/s Variable and will depend on degree of constriction of stream banks. Dominated by bedrock and/or large boulders (Coarse). > 7% and can be as high as 100%.
Run	General Description Mean Water Velocity Mean Water Depth Substrate Stream Gradient	Relatively swift flowing, laminar[3] and non-turbulent. > 0.5 m/s > 0.3 m Predominantly gravel, cobble and rubble (Medium) with some boulder (Coarse) and sand (Fine) in smaller amounts. Typically < 4% (exception to gradient rule of thumb)
Moderate Water	**Mean Water Velocity** **Stream Gradient**	**0.2-0.5m/s** **>1 and < 4%**
Riffle	General Description Mean Water Velocity Mean Water Depth Substrate Stream Gradient	Relatively shallow and characterized by a turbulent surface[4] with little or no white water. 0.2 – 0.5 m/s < 0.3 m Typically dominated by gravel and cobble (Medium) with some finer substrates present, such as sand (Fine). A small amount of larger substrates (Coarse) may be present, which may break the surface.[5] Generally >1 and < 4%
Steady/ Flat	General Description Mean Water Velocity Mean Water Depth Substrate Stream Gradient	Relatively slow-flowing, width is usually wider than stream average and generally has a flat bottom. 0.2 - 0.5 m/s >0.2 m Predominantly sand and finer substrates (Fine) with some gravel and cobble (Medium). > 1 and < 4%
Slow Water	**Mean Water Velocity** **Stream Gradient**	**Generally < 0.2m/s (some eddies can be up to 0.4m/s).** **< 1%.**
Plunge / Trench / Debris Pools	General Description Mean Water Velocity Mean Water Depth Substrate Stream Gradient	Generally caused by increased erosion near or around a larger, embedded object in the stream such as a rock or log or created by upstream water impoundment resulting from a complete, or near complete, channel blockage. These pool types may be classified as an entire reach (e.g., pools greater than 60% of the stream width) or as sub-divisions of a fast water habitat. < 0.2 m/s > 0.5 m depending on stream size (e.g., may be shallower in smaller systems). Highly variable (i.e., coarse, medium or fine substrates) Generally < 1%

Habitat Type	Habitat Parameter	Description
Eddy	General Description	Relatively small pools caused by a combination of damming and scour: however scour is the dominant forming action. Formation is due to a partial obstruction to stream flow from boulders, roots and/or logs. Partial blockage of flow creates erosion near obstruction. It is typically < 60% of the stream width and hence will be a sub-division of a faster-water habitat type (e.g., Run with 20% eddies).
	Mean Water Velocity	Typically < 0.4 m/s, but can be variable.
	Mean Water Depth	> 0.3 m. May vary depending on obstruction type, orientation, streambed and bank material and flows experienced.
	Substrate	Predominantly sand, silt and organics (Fine) with some gravels (Medium) in smaller amounts.
	Stream Gradient	Variable

[1] White water is present when hydraulic jumps are sufficient to entrain air bubbles which disturb the water surface and reduces visibility of objects in the water.
[2] Coarse, Medium and Fine substrate types are classified according to the Standard Methods Guide for the Classification/Quantification of Lacustrine Habitat in Newfoundland and Labrador (Bradbury *et al*. 2001).
[3] Laminar describes the surface of the water as smooth and glass-like with no reduced visibility of objects in the water.
[4] Turbulence is present if there are local patches of white water or if water movement disturbs a portion of the surface.
[5] Pocket water often constitutes an important component of riffles in Newfoundland and Labrador and is characterized by a predominance of larger substrates (e.g., boulders) breaking the surface. The result is a riffle with many eddies around the boulders.

7.1. Riverine Habitat Quantification

The quantification of potentially affected riverine habitat within the identified streams was completed using both classification systems. The quantification of habitat using the Beak classification is the total area of each habitat type.

Under the proposed system, an Intermediate Level Assessment would be used for both medium and high risk developments where a HADD of fish habitat is likely to occur. This level of assessment uses the typical species habitat preference ranges contained within Grant and Lee (2004) and the measured habitat parameter ranges to derive a more detailed habitat suitability estimate of each habitat type present.

To calculate final suitability values, both substrate and velocity ratings are taken into consideration. The preferred range of water velocity listed in Grant and Lee (2004) and the ranges measured within each habitat are compared to determine the proportion available to each species life-cycle stage. A similar exercise is also conducted using the preferred substrate ranges and the proportions estimated from each habitat type. In order to keep final suitability calculations similar to the Lacustrine Quantification Methodology (Bradbury *et al*. 1999), the mean of both values is used to derive a final suitability value unless an unsuitable rating (i.e., 0.00) is present for either. In this case, the habitat suitability would be 0.00. These calculations would be completed for all species and life stages present. As a precautionary approach, the highest suitability value of the four life stages would then be used as the species-specific utilization value for that habitat type in an attempt to ensure that any ‘critical’ habitat requirements that a species/life stage might have would be incorporated to the highest extent possible. Using the final habitat suitability values and the overall area of each habitat type, the total Habitat Equivalent Units (HEU) of each habitat type can be calculated for each species. The total HEU is the quantity of suitable habitat for each species within a watershed or specific stream reach.

7.2. Riverine Species Presence and Population Estimates

Population estimates were calculated using standard quantitative electrofishing methods (*see* Scruton and Gibson 1995). Fish species presence and relative utilization was also conducted in locations not suitable for quantitative sites using index electrofishing stations.

Quantitative sites of similar habitat type were isolated using standard barrier nets on both the upstream and downstream end of each site. Each site was fished using a Smith-Root electrofisher (model 15-D). The removal method was used to calculate population estimates using as least four sweeps in each station. Each fish captured was anaesthetized with clove oil (2ml of 10:1 ethanol:clove oil in 8L of water), identified, measured (fork length for salmonids, total length for eels) and weighed (grams). Representative habitat types were surveyed and population estimates established (with confidence limits) using Microfish 3.0 (Van Deventer and Platts 1989).

Index sites were electrofished without barrier nets in areas where barrier nets were not possible. Index sites were used to gather additional information regarding fish species presence. Each station was conducted within one habitat type over a fishing time of at least 300 seconds (Scruton and Gibson 1995). Each fish captured was placed in an aerated container with mild anesthetic (2ml of 10:1 ethanol:clove oil in 8L of water), identified, measured (fork length for salmonids, total length for eels) and weighed (grams). Captured fish were then allowed to recover in fresh water and then released downstream of the site.

A total of five quantitative sites and seven index sites were completed within Rattling Brook; two quantitative sites and two index sites were completed within Sandy Brook and two quantitative sites within the tributaries draining the ponds near the proposed Plant location (within the Rattling Brook watershed) were completed (Figure 7-3).

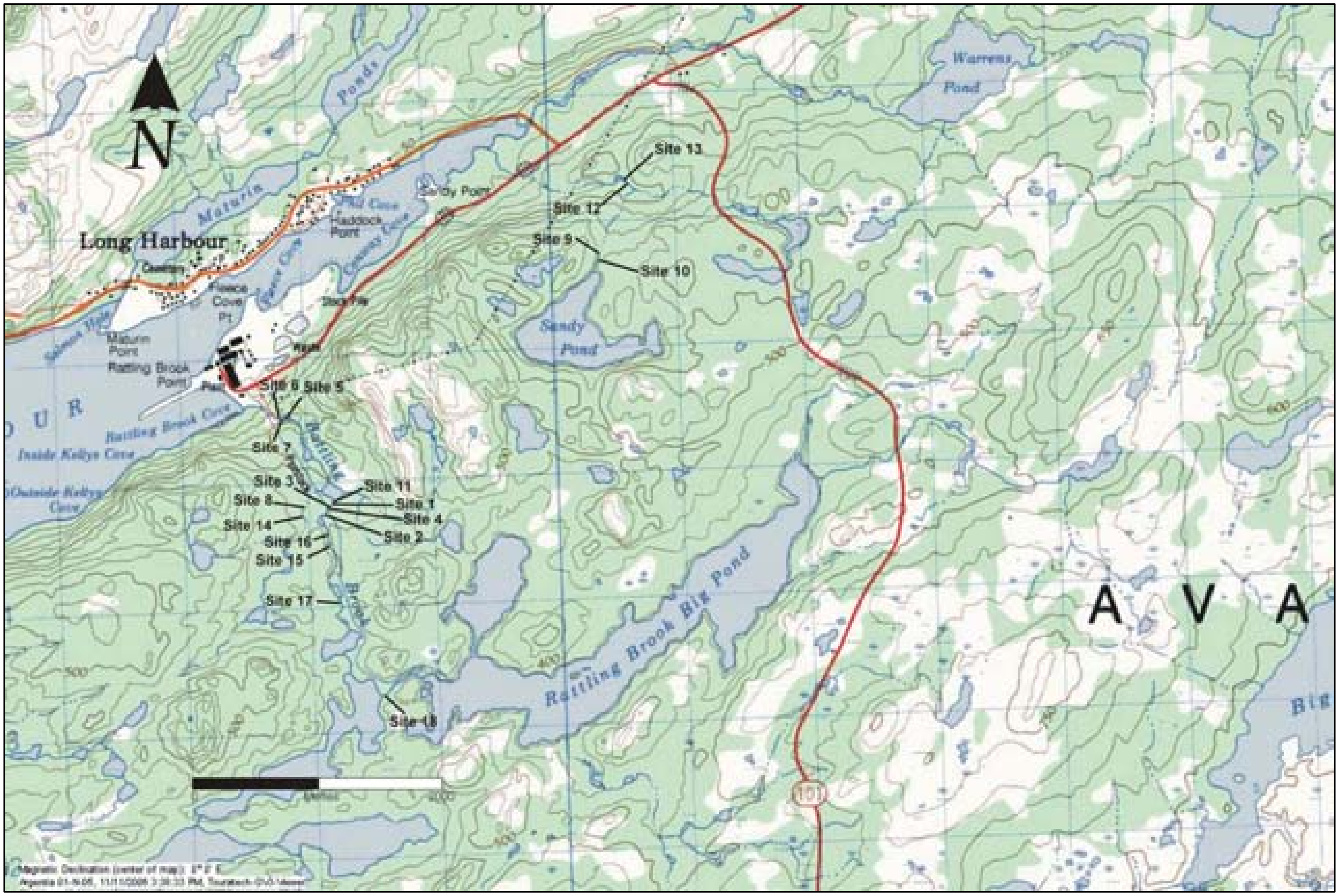

Figure 7.3 Electrofishing Site locations, Long Harbour, July 2006.

7.3. Riverine Spawning Utilization

Radio tagging was employed in order to establish which spawning areas are used by brook trout resident in Rattling Brook Big Pond. Twenty radio tags were implanted in mature brook trout (i.e. at least 180mm in length) in August so that their location during the spawning season could be determined without disturbance. Table 7-3 presents the radio tag frequencies and measurements of those implanted. Each fish was placed in an anesthetic bath of 3cc of clove oil:ethanol (1:10) mixed with eight litres of water until they achieved the appropriate level of anesthesia (*see* McKinley *et al*. 1992). A battery-powered aerator was also placed in the bath. A small incision was opened on the ventral side of the fish between the pelvic fins and anus where the tag was implanted. The antenna was pushed through the body wall on the left-hand side of the incision. The incision was then closed with two or three independent sutures. The fish was then allowed to recuperate from the anesthetic in an aerated cooler prior to release back into Rattling Brook Big Pond (P8). Each fish was checked to see if they were reactive prior to being released (caudal fin was gently touched to determine if they would swim away).

Table 7.3 Summary of radio tagged brook trout, Rattling Brook Big Pond, August 2006.

Capture Date	Tag Frequency	Code ID	Length (mm)	Weight (gm)
August 10	148.640	31	180	- -
August 10	148.640	32	200	- -
August 10	148.640	33	200	- -
August 10	148.640	34	180	- -
August 18	148.640	35	250	194.4
August 10	148.680	36	230	142.8
August 11	148.680	37	240	143.0
August 11	148.680	38	220	140.6
August 11	148.680	39	220	119.0
August 11	148.680	40	220	118.1
August 11	148.780	41	230	124.4
August 11	148.780	42	220	110.3
August 11	148.780	43	210	112.5
August 11	148.780	44	215	96.7
August 18	148.780	45	200	98.7
August 18	148.800	46	250	188.6
August 18	148.800	47	200	94.7
August 18	148.800	48	220	140.9
August 18	148.800	49	210	101.2
August 18	148.800	50	220	130.2

7.4. Stable Isotope Analysis

In order to determine whether individuals within Sandy Pond have migrated successfully to and from Long Harbour, samples were collected and analyzed for stable isotope analysis. Isotopes of carbon and nitrogen from the freshwater and marine environment contain distinct signatures and therefore ratio analysis against both signatures can assist in determining whether a sample of fish was anadromous (Jardine *et al*. 2003). Samples were collected based on the methodology provided by the University of New Brunswick under the direction of Mr. Timothy Jardine. In general, sub samples of the brook trout and rainbow smelt populations within Sandy Pond were collected along with a sub-sample of winter flounder (*Pseudopleuronectes americanus*) to represent the marine environment. The Stable Isotopes in Nature Laboratory (SINL), Department of Biology at the University of New Brunswick conducted the isotope analysis.

A total of twenty-eight rainbow smelt, eight brook trout and eighteen winter flounder were sampled. Table 7-4 outlines the samples collected. Each sample consisted of at least one gram of flesh, frozen and shipped for analysis.

Table 7.4 Stable isotope sample summary, Pond P15 (Sandy Pond), 2006.

Sample Species	Date of Capture	Location of Capture	Sample ID	Length (mm)	Weight (gm)
Rainbow Smelt	August 30	Sandy Pond	SM001	105	11
Rainbow Smelt	August 30	Sandy Pond	SM002	85	5.2
Rainbow Smelt	August 30	Sandy Pond	SM003	100	7.5
Rainbow Smelt	August 30	Sandy Pond	SM004	88	5.8
Rainbow Smelt	August 30	Sandy Pond	SM005	95	11.5
Rainbow Smelt	August 30	Sandy Pond	SM006	65	4.0
Rainbow Smelt	August 30	Sandy Pond	SM007	102	7.2
Rainbow Smelt	August 30	Sandy Pond	SM008	91	5.9
Rainbow Smelt	August 30	Sandy Pond	SM009	86	5.8
Rainbow Smelt	August 31	Sandy Pond	SM101	111	11.4
Rainbow Smelt	August 31	Sandy Pond	SM102	125	15
Rainbow Smelt	August 31	Sandy Pond	SM103	118	11.3
Rainbow Smelt	August 31	Sandy Pond	SM104	117	15.8
Rainbow Smelt	August 31	Sandy Pond	SM105	118	13.2
Rainbow Smelt	August 31	Sandy Pond	SM106	137	15.7
Rainbow Smelt	August 31	Sandy Pond	SM107	124	14.8
Rainbow Smelt	August 31	Sandy Pond	SM108	123	14.3
Rainbow Smelt	August 31	Sandy Pond	SM109	123	14.3
Rainbow Smelt	August 31	Sandy Pond	SM110	106	6.1
Rainbow Smelt	August 31	Sandy Pond	SM111	94	5.6

Sample Species	Date of Capture	Location of Capture	Sample ID	Length (mm)	Weight (gm)
Brook Trout	August 31	Sandy Pond	BT001	60	2.5
Brook Trout	August 31	Sandy Pond	BT002	125	22.7
Brook Trout	August 31	Sandy Pond	BT003	135	26.2
Brook Trout	August 31	Sandy Pond	BT004	122	18.0
Brook Trout	August 31	Sandy Pond	BT005	118	20.0
Brook Trout	August 31	Sandy Pond	BT006	76	4.5
Brook Trout	August 31	Sandy Pond	BT112	70	4.5
Brook Trout	August 31	Sandy Pond	BT113	69	3.9
Winter Flounder	September	Long Harbour	Ref-04	- -	- -
Winter Flounder	September	Long Harbour	Ref-10	- -	- -
Winter Flounder	September	Long Harbour	Ref-13	- -	- -
Winter Flounder	September	Long Harbour	Ref-7	- -	- -
Winter Flounder	September	Long Harbour	Ref-5	- -	- -
Winter Flounder	September	Long Harbour	Ref-18	- -	- -
Winter Flounder	September	Long Harbour	Ref-02	- -	- -
Winter Flounder	September	Long Harbour	Ref-03	- -	- -
Winter Flounder	September	Long Harbour	Ref-01	- -	- -
Winter Flounder	September	Long Harbour	Ref-11	- -	- -
Winter Flounder	September	Long Harbour	Ref-08	- -	- -
Winter Flounder	September	Long Harbour	Ref-14	- -	- -
Winter Flounder	September	Long Harbour	Ref-15	- -	- -
Winter Flounder	September	Long Harbour	Ref-12	- -	- -
Winter Flounder	September	Long Harbour	Ref-06	- -	- -
Winter Flounder	September	Long Harbour	Ref-17	- -	- -
Winter Flounder	September	Long Harbour	Ref-09	- -	- -
Winter Flounder	September	Long Harbour	Ref-10	- -	- -

7.5. Wetted Perimeter Assessment

The final location of water withdrawal from the Rattling Brook drainage basin has yet to be determined. Because there is a likelihood of water extraction which will, in turn affect stream hydrology, a wetted perimeter assessment was conducted in Rattling Brook.

The Wetted Perimeter Method (WPM) is a fixed flow hydraulic rating method based on the hydraulic relationship between flow (i.e. discharge) and wetted river perimeter at selected transect(s) (Stalnaker *et al*. 1994). Using the relationship, the flow corresponding to the wetted perimeter (wetted width of the stream transect), which is needed to minimally protect all habitats, can be estimated. Figure 7-4 presents a schematic of a wetted perimeter/flow relationship and indicates the point of inflection for that relationship. The point of inflection is taken as the flow below which dewatering would take place rapidly for the represented habitat. Field surveys should typically cover the range of natural flows. Where this is not achievable, Manning's equation can be applied to estimate extreme values. Manning's equation is given by

Velocity (m/s) = $R^{2/3} * S^{1/2} / n$ where

R = Hydraulic radius (Area / wetted perimeter) – *see* Figure 5-3
S = slope at transect
n = Manning's n.

The cross-sections, or transects, selected to determine the minimum flow for habitat protection is very important in this technique. The selected transects for assessment must stand as an index habitat for the rest of the river or river section being assessed (Stalnaker *et al*. 1994). Riffles are typically selected because cross sections in these areas exhibit sensitivity of width, depth and velocity to changes in flow. They are usually the shallowest habitat type found and as such, would indicate the critical water level needed to protect all habitats. Therefore, once a minimum level of flow is estimated for a riffle, it is assumed that other habitat areas, such as pools and runs, are also satisfactorily protected. Because the shape of the channel can influence the results of the analysis, transects are usually located in areas that are wide, shallow, and rectangular.

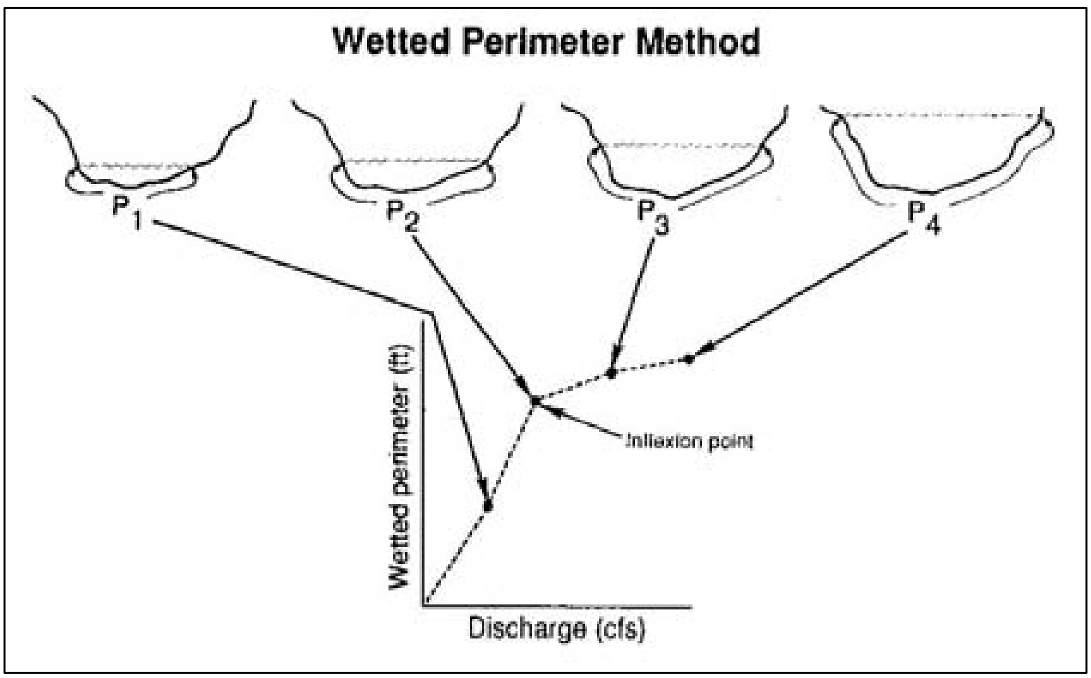

Figure 7.4 Example of wetted perimeter method to estimate instream flows (Nelson 1980).

The following assumptions apply to the WPM:

- the selected area is a suitable index of habitat for the rest of the river, i.e., if the minimum flow requirement is satisfied at the chosen critical location, it will be satisfied in other habitat types. The greater the number of transect locations, the higher the level of confidence in the minimum flow estimation;
- the point of inflection is a suitable surrogate for acceptable habitat, i.e., flow reductions below that point on the graph will result in loss of habitat quality; and
- all wetted area is equally important as habitat or to satisfy other biological criteria.

Discharge (i.e. flow) was calculated at all transects surveyed, however the discharge from Transect Two was taken as the typical due to the channel shape and stability of the transect. One discharge survey was completed at each transect with Manning's equation providing the remainder of the data.

All information from each transect survey was used to create AutoCAD drawings of the transect (Appendix A). Using Manning's equation, the discharge at various water levels was then simulated using the profile and data provided by the AutoCAD drawing. The maximum water depth at each transect was used as the marker for an estimate of the water level associated with each simulated discharge. For each transect location, the water level was modeled from the measured levels by decreasing in 0.05m increments until the streambed was practically dry and increasing in 0.10m increments until the water level reached the height of the streambed (*see* Appendix A).

The transect profiles at these various water depths were simulated to get parameters needed to estimate discharges using Manning's equation. The estimated velocity values derived from Manning's equation were used to calculate discharges at each simulated water level.

7.5.1. Transect Selection

Three transects were selected to represent critical/representative cross-sections within Rattling Brook (Figures 7-5 to 7-7). Details are presented in Appendix A and each is described in summary below.

Transect One

Transect One is located just below the second bridge on Rattling Brook (22 288287E 5255047N WGS84). The location was identified as a potential spawning riffle during July stream surveys (Figure 7-5). The transect is a relatively wide riffle flowing over primarily cobble/gravel substrate. General characteristics of the transect are as follows:

Transect Length (m):	27.2
Transect Substrate:	70% cobble, 30% gravel
Transect Slope (m/m):	0.025/33.5
Transect shoreline description:	lhs bank 60^o up to 0.5m high rhs bank 30^o up to 0.5m high

Transect Two

Transect Two is located just upstream of Transect One in an area of steady habitat which appears to have been part of an excavation of the streambed (relatively straight and uniform with substrate material piled along the shore) (Figure 7-6). The substrate consists primarily of rubble and cobble. This location had relatively stable flows at the time of measurement and was considered the best location for estimating discharge (Q). General transect characteristics are as follows:

Transect Length (m):	8.5
Transect Substrate:	50% cobble, 50% rubble
Transect Slope (m/m):	0.03/50.0
Transect shoreline description:	lhs bank 60^o up to 0.5m high rhs bank 45^o up to 1.0m high

Figure 7.5 Transect One across potential spawning habitat.

Figure 7.6 Transect Two across steady habitat.

Transect Three

Transect Three is located within a riffle located below a small pond downstream of Pond P14 (Sam Howe's Pond) (22 288300E 5254157N WGS84) which has a relatively high proportion of gravels (Figure 7-7). The substrate across the transect consists primarily of rubble, cobble and gravel.

Transect Length (m):	7.7
Transect Substrate:	30% rubble, 40% cobble, 30% gravel
Transect Slope (m/m):	0.245/49.5
Transect shoreline description:	lhs bank 45^o up to 1.0m high rhs bank 60^o up to 1.0m high

Figure 7.7 Transect Three across riffle habitat.

7.6. Flow Duration Curve and Hydrograph Estimations

Estimated hydrographs and flow duration curves (FDC) are required for basins within the Rattling Brook basin and other adjacent basins. Drainage areas for each basin were delineated and measured using both 1:12,500 and 1:50,000 scale topographical mapping. Table 7-5 summarizes the drainage areas.

As part of the Pre-Feasibility studies, a detailed water supply model was set up for the Project (Rattling Brook basin) using Acres Reservoir Simulation Package (ARSP). ARSP uses a simplified network of channels, reservoirs, nodes (connecting points for channels) and structures to represent a water system. In general, the model takes daily inflows and uses the water to first satisfy environmental demands and Project water supply requirements, based on various physical and operational constraints. The portion of the inflow not used for these demands is either stored in Rattling Brook Big Pond or spilled to the downstream reach. The model was set up for both pre- and post-project conditions. The pre-project ARSP model (existing conditions) schematic is provided in Figure 7-8.

Table 7.5 Drainage areas used to estimate hydrographs and FDC.

Basin	Drainage Area (km^2)
Rattling Brook	
- Rattling Brook	37.0
- Sam Howe's Pond	32.9
- Rattling Brook Big Pond	23.0
- Tributary (at plant site)	2.0
- Rattling Brook Big Pond Tributary (total)	2.5
- Rattling Brook Big Pond Tributary (above road)	1.7
Sandy Pond	
- Total outflow Sandy Pond Area (above road)	3.5
- Sandy Pond (at confluence)	2.0
- Small Stream above Sandy Pond (at confluence)	1.3
- Sandy Pond	1.8
Little Rattling Brook	
- Little Rattling Brook (at Ship Harbour)	6.3

The input data required to set up the existing conditions model included representative daily hydrological inflow sequences and parameters to represent Rattling Brook Big Pond and Sam Howe's Pond storage and outflow characteristics. Since there are no hydrometric station data available within Rattling Brook or adjacent to the Rattling Brook basin, an estimate of inflows was required. There are three basic approaches that are typically used in developing a hydrological inflow sequence for a location that does not have a continuous record of flow data available for a long period of record. The choice depends on the type and quality of data available. The three basic approaches are as follows:

Approach 1: Use back-calculated inflows from recorded water level and flow data.

Approach 2: Use precipitation and temperature data, assuming that a relationship has been or can be developed between precipitation and runoff. The hydrological inflow sequence is then produced by simulating runoff for the required period from climate data.

Approach 3: Select a basin with suitable characteristics from the Environment Canada network of hydrometric stations and adjust the daily flows from a basin in the database to represent inflows to the basin of interest. Adjustment of flow data can be achieved from relationship of basin characteristics or correlation of flow data for a given period of overlapping flow data with the location of interest.

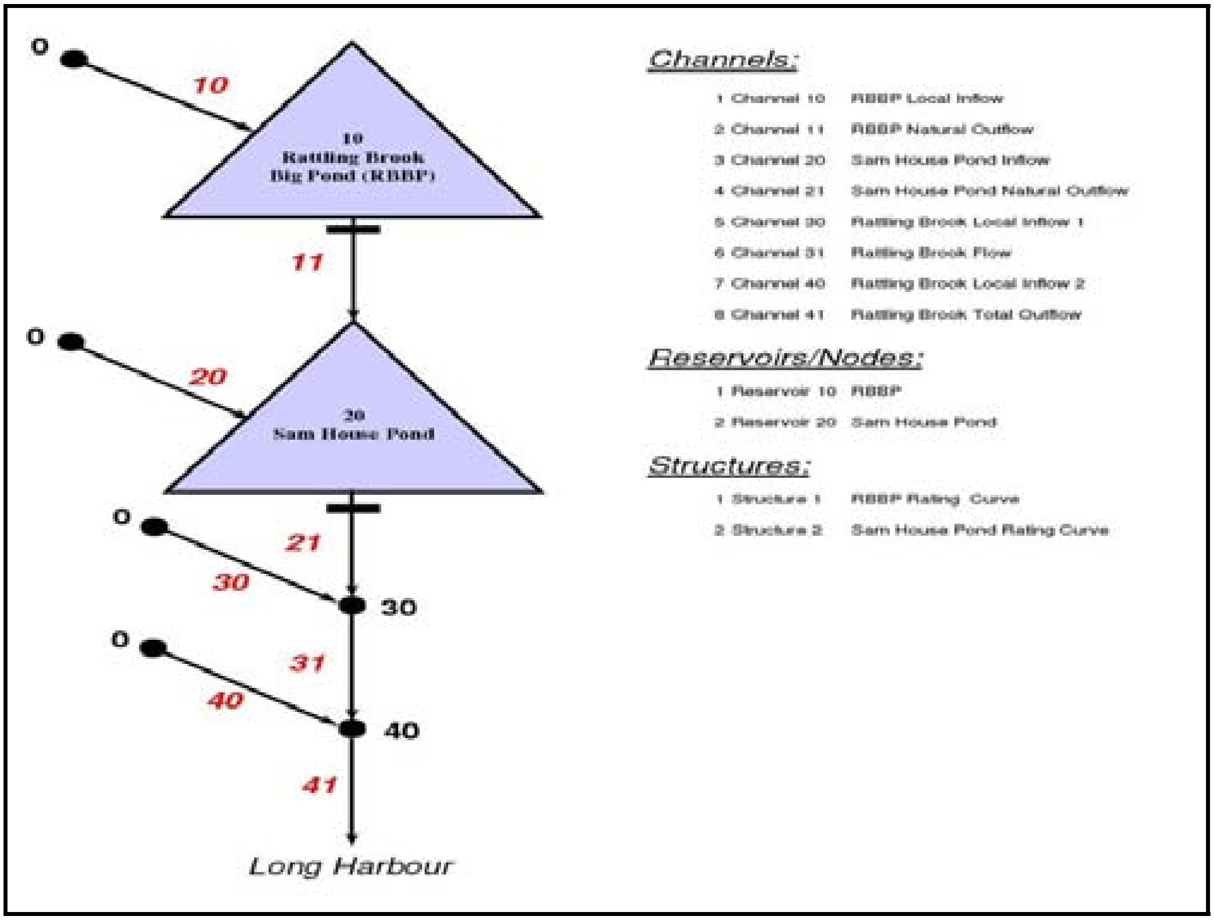

Figure 7.8 Rattling Brook Basin ARSP Model Schematic – Existing Conditions.

To develop a hydrological inflow sequence necessary for simulating the long term average flows for water supply, it is general practice to ensure that the sequence selected is sufficiently long in record to include typical dry periods in the basin. Based on the three approaches noted above for developing inflow sequences, it was decided that, due to the lack of recorded flows and the variation of temperature and precipitation in the basin, Approach 3 should be used. The benefit of using Approach 3 over the other approaches is that if a basin can be located that is easily adjusted to the location of interest, the quality and accuracy of the flow data is improved.

During the pre-feasibility stage, available long term flow data in the Project area collected by Environment Canada was reviewed. Based on that review, it was recommended that for reliable yield analysis related to water supply, the record from Come by Chance River near Goobies (02ZH002) is preferred. The Come by Chance record includes a dry sequence critical to the assessment of water supply locations. Other factors critical in the selection of this flow record for the water supply assessment follow:

- The basin is in the same hydrological region as Rattling Brook basin.
- Both basins have similar drainage areas.
- Both basins have similar mean annual runoffs.
- The flow record is both long and continuous (36 years).

As indicted in Figure 7-8, there are a number of local drainage basins within the overall Rattling Brook drainage basin that require hydrological inflow sequences for modeling. The 36-year daily record for the Come by Chance station was prorated to each local basin by the ratio of drainage areas. The drainage area for each local basin was divided by the drainage area of the Come by Chance basin (43.3 km^2), and this ratio was then multiplied by the daily flows recorded at Come by Chance station to provide an estimated hydrological inflow sequence for the Rattling Brook sub-basins. Typically with this type of analysis, the flows are further prorated based on the difference in mean annual runoff. This was not required for this study, since the Come by Chance station is in the same hydrological region as Rattling Brook and the long term mean annual runoff for Come by Chance is within the range of mean annual runoffs expected for the Rattling Brook basin.

Reservoir characteristics were required for both Rattling Brook Big Pond and Sam Howe’s Pond to define the storage – elevation and outflow relationships at these locations. Information used to define these input was based on available mapping and existing bathymetric surveys conducted for the area provided by VBNC and AMEC. For those basins not included in the model (Little Rattling Brook and Sandy Pond), the flow duration curves and hydrographs are direct prorations of drainage areas relative to the Rattling Brook basin.

8.0 LACUSTRINE CLASSIFICATION/QUANTIFICATION

Ten ponds were surveyed for lacustrine habitat classification/quantification; Pond P8 (Rattling Brook Big Pond), Pond P14 (Sam Howe’s Pond), Pond P15 (Sandy Pond), Pond P22 (Unnamed), Pond P23 (Unnamed), Pond P24 (Unnamed), Pond P25 (Unnamed), Pond P26 (Unnamed), Pond P27 (Unnamed) and Pond P30 (Unnamed). All pond surveys were completed during 2006 with the exception of Pond P14 (Sam Howe’s Pond) and Pond P30. These ponds were completed in May of 2007.

8.1. Bathymetry

Bathymetry of the identified ponds was completed as part of lacustrine habitat quantification. Bathymetry was conducted using digital sonar with DGPS (differential GPS) attached to a

Zodiac™ boat. The sonar was calibrated to collect a position and water depth every second. The data was digitally collected and mapped upon completion of the surveys using existing mapping of the study area and contour mapping software. The pond boundary was extracted from existing provincial 1:50,000 digital base maps of the area and was used as the boundary for all contour modeling. Bathymetric plots were generated using 3DField™ software, gridding the data using simple linear equations with grid intervals of 1m. All completed bathymetric contours were then exported to ARCGIS™ for analysis.

8.2. Habitat Quantification

The approach used for the quantification of lacustrine habitat was conducted as per the Standard Methods Guide for the Classification / Quantification of Lacustrine Habitat in Newfoundland and Labrador (Bradbury *et al*. 2001). The approach involved the completion of both littoral and profundal habitat mapping and sampling for species presence and habitat utilization. Secchi disc depth was used to discriminate between littoral and profundal habitat types. Substrate compositions were also estimated visually and with eckman grabs in deeper areas.

Fish presence was determined using fyke nets, minnow traps and angling (DFO permit number NL-467-06-Amendment 1). All fish species captured were considered indicative of that species utilizing the habitat for life processes. Fyke nets used were standard double-bag fyke nets with 4-5mm mesh size. These nets do not have wings as such but a single lead “wing” and traps on both ends. Smaller single-bag fyke nets were employed at some of the smaller ponds. These fyke nets are more typical in style and have 2m wings and consist of 3 and 5mm mesh sizes.

9.0 RESULTS

The results of all baseline data collected from 2006 and 2007 as well as previous data have been consolidated. The collected data will serve as a description of the existing baseline conditions and as a basis for anticipated EEM programs. Data from previous programs conducted by VBNC in 1997, 1998, 2002 and 2005 have been included where appropriate. For comparison purposes, summaries of the data have been categorized into the various watersheds near and around the Long Harbour Project area as follows:

- The **Rattling Brook Watershed** includes all waterbodies and streams sampled within the Rattling Brook drainage area;
- The **Sandy Pond Watershed** includes all waterbodies and streams sampled within the Sandy Pond drainage area;
- **Long Harbour Sample Area** includes all waterbodies outside the Rattling Brook and Sandy Pond Watersheds which drain into Long Harbour; and
- **Control Sample Area** includes all waterbodies which do not drain into Long Harbour.

These categories were used rather than direct comparisons between individual ponds as the ponds sampled changed between years as the project description and location became more defined. It should be noted that Pond P10 (St. Joseph's Pond) has been included in all sampling years as this location is outside the influence of any potential project activities and would most likely be considered the control site of any required EEM monitoring program.

9.1. Groundwater Quality

The regional major ion groundwater quality of the Avalon Peninsula was studied and documented by the Newfoundland and Labrador Department of Environment, Water Resources Division in 1984 (NLDOE 1984). Near surface groundwater of the Avalon Peninsula are very similar, being characterized by very low Total Dissolved Solids (TDS) (<25 mg/L), pH between 4 and 6.5 and average alkalinity/hardness of <10 mg/L. Chemistry of available dug wells show a chemistry with low TDS and pH values between 5 and 6. Three bedrock water quality groups were identified in the NLDOE (1984) report.

Group I Groundwater_– Calcium bicarbonate type waters with alkalinity/hardness >50 mg/L as $CaCO_3$ and pH values between 6.5 and 9. It is thought that this water originates from dissolution of calcite by carbonic acid from atmospheric precipitation and the soil zone.

Group II Groundwater – Sodium bicarbonate type waters with high pH (>8), high alkalinity, and low hardness. This chemistry may results from aluminosilicate weathering of albite (Na) plagioclase.

Group III Groundwater – Very soft, acidic (pH 4.0 – 5.5), low alkalinity, low TDS. The chemistry is similar to near surface groundwater chemistry (overburden wells). Likely receive local recharge from nearby overburden deposits.

The three bedrock water quality groups above indicate low solubility of parent rock materials with major ion chemistry involving some combination of calcium, magnesium, sodium and bicarbonate. Chloride and sulphate concentrations result mainly from airborne sea spray.

The most common chemical problem associated with water wells in the Avalon Peninsula is high manganese concentrations, often associated with high iron values. The elevated or depressed pH values are considered to be due to natural processes such as acidic rainfall and buffering capacity of the overburden and bedrock.

Based on a regional water quality surveys conducted by NLDOE (Government of Newfoundland and Labrador 2007), arsenic is commonly elevated in groundwater throughout the Avalon Peninsula due to the natural enrichment in till and bedrock. Batterson and Taylor (2003) conducted a regional till-sampling program across the central Avalon Peninsula. Samples were collected from the C- or BC-soil horizon, taken at shallow depths (0.5 m to 1.0 m depths) in test pits, quarries or road cuts. Sample spacing was approximately one sample per 1-4 km^2. The area sampled included the Project and surrounding areas. The results of metals analyses indicated that 7% of till samples exhibited concentrations of arsenic above 12 mg/kg (above the CCME soil quality guidelines for residential/parkland land use). The 2003 study also reported elevated concentrations of copper, lead, and iron associated with the Bull Arm Formation, as well as other locations across the Central Avalon Peninsula.

9.1.1. Project Groundwater Quality

The laboratory chemistry results for the July 31 and September 18-19, 2006 and June 4-6, 2007 sampling rounds are presented in Appendix B. Reported concentrations are compared with CCME FWAL and MAL Guidelines.

The major ion chemistry of the groundwater across the Study Area is quite similar. The groundwater can generally be classified as calcium bicarbonate type groundwater. Within the soil and upper bedrock layers, groundwater has a slightly acidic pH and a lower TDS as compared to groundwater samples from the deeper bedrock layer. With depth, there is a trend toward increasing calcium and bicarbonate, alkalinity, hardness and pH.

Piper plots of the major ion chemistry by area for the September 18-19 sampling event are presented in Appendix B. The September sampling event was chosen for presentation purposes because of the potential for the first sampling event to have been influenced by introduced drill waters and solids introduced during borehole drilling.

The Piper plots illustrate the geochemical evolution of the groundwater as it flows from soil and upper bedrock layers into the deeper bedrock layer. The relative concentrations of the groundwater plot roughly as a straight line suggesting water that is mixing from two different sources: young infiltrating rain water (soil and upper bedrock), and older, deeper bedrock groundwater.

The groundwater major ion chemistry from the soil and shallow bedrock layers is quite similar to results from an overburden water quality survey presented for the Avalon Peninsula by NLDOE (1984). The deeper bedrock groundwater chemistry of the of the Study Area most closely resemble Group 1 regional groundwater classification (NLDOE 1984) which are calcium bicarbonate type waters with appreciable hardness and alkalinity.

Elevated iron at levels above referenced guideline criteria is common in soil and upper bedrock layers, with decreasing to non-detectable concentrations in the deeper bedrock. Manganese is elevated in all layers. The iron is likely mobilized from the tills due to a low redox potential environment and low pH. This is a common condition in the Avalon Peninsula for overburden wells and has been documented by NLDOE (1984). Iron staining was commonly observed in the shallow bedrock at depths less than 24 metres.

Other metals that were elevated above referenced guideline criteria were arsenic, cadmium, copper, lead, and zinc. Table 9-1 details the number of metal guideline exceedances by area and parameter for the 2006 July and September and 2007 June sampling events. Aluminum was not included on this list because it is not unusual to see slightly elevated aluminum in groundwater, especially with lower pH values.

For the Lower Tier 1 Area (i.e. the former ERCO site) fluoride was detected in three monitoring wells between 0.3 and 2.2 mg/L. Free cyanide and elemental phosphorus were not detected.

Table 9.1 Number of Metal Guideline Exceedances by Area and Parameter.

Number of Metal Guideline Exceedances by Area and Parameter.

		Arsenic		**Cadmium**		**Copper**		**Iron**		**Lead**		**Zinc**	
CCME Criteria (ug/L)		**FWAL**	**MAL**	**FWAL**	**MAL**	**FWAL**	**MAL**	**FWAL**	**MAL**	**FWAL**	**MAL**	**FWAL**	**MAL**
	n	5	12.5	0.017[1]	0.12	2-4[1]	--	300	--	1-7[1]	--	30	--
Plant Site Area													
31-Jul-06	11	5	3	10	4	9	--	6	--	2	--	3	--
19-Sep-06	10	4	2	9	5	3	--	3	--	3	--	1	--
05-June-07	11	4	2	10	3	7	--	3	--	1	--	3	--
Residue Storage Area													
31-Jul-06	5	1	0	4	1	4	--	2	--	0	--	0	--
19-Sep-06	5	0	0	3	1	1	--	3	--	1	--	0	--
05-June-07	5	0	0	4	1	3	--	2	--	1	--	2	--
Residue Disposal Pond (Sandy Pond) Area													
31-Jul-06	11	0	0	11	2	7	--	4	--	0	--	0	--
19-Sep-06	11	0	0	10	3	7	--	5	--	1	--	0	--
05-June-07	7	0	0	6	0	4	--	4	--	0	--	2	
Lower Tier 1 Area													
31-Jul-06	2	0	0	0	0	1	--	1	--	0	--	0	--
19-Sep-06	3	0	0	2	1	1	--	0	--	0	--	0	--
05-June-07	3	0	0	1	0	1	--	1	--	0	--	0	--

CCME FWAL Canadian Council of Ministers of the Environment, protection of Freshwater Aquatic Life

CCME MAL Canadian Council of Ministers of the Environment, protection of Marine Aquatic Life

1 Parameter is hardness dependent
-- no guideline

n number of samples taken

9.2. Surface Water Quality

Water quality was collected during all three site visits in 2006. The surface water sampling program included ponds within the direct footprint of the proposed Project as well as many that would be considered control locations. Baseline water quality data has also been incorporated into an Ecological Risk Assessment (ERA) of the Project area. The baseline water quality will also be incorporated into any Environmental Effects Monitoring (EEM) programs required. While summaries are provided below, some of the comparisons between control and study ponds have been conducted with very few samples and very limited temporal data. The analysis was provided to give the reader/reviewer a general overview of the water quality in the area. Ongoing sampling required as part of any monitoring programs will increase the data and power of any statistical analysis.

Water quality parameters collected in 1997, 1998, 2002, 2005 and 2006 from ponds and streams near the Project area are provided in Appendix B. Appendix B also has figures showing past sampling sites as well as laboratory results of the 2006 program. Photographs of all 2006 sampling locations are provided in Appendix C.

Historic sampling has been conducted in ponds in the general Long Harbour area which indicate that pond water is typically high colour, low conductivity and very soft (O'Connell and Andrews 1987). Past sampling of ponds located to the north-east of the former plant (the direction of prevailing winds) indicated elevated levels of phosphate, calcium and fluoride which were assumed to be the result of airborne phosphate ore-dust from the phosphorus plant property (*see* O'Connell and Andrews 1987; Lake 1984). The effect to the pond's ecology at the time was an enrichment process (eutrophication) and an increase in the level of water hardness during the open water season.

1997

Pond water quality measurements were collected during site visits in February of 1997. Samples were taken from ponds within Rattling Brook (Pond P8) and the Control (Ponds P2, P3, P6, P9 and P10) Sample Area. The water quality of the Rattling Brook and Control areas were very similar with respect to most dissolved metals and minerals. There were high levels of aluminum found in both watersheds; with both the Rattling Brook and Control watersheds exceeding the CCME guidelines (CCME 2006) for the Protection of Freshwater Aquatic Life (FAL) (i.e. 207.5±6.3ug/L and 192.5±23.0ug/L respectively). There was no significant difference between mean manganese levels (17.5±0.9ug/L and 20.6±1.4ug/L for the Rattling Brook and Control watersheds respectively). Water hardness was significantly higher ($p<0.05$) in the Control area compared to Rattling Brook (14.0±1.43mg/L and 6.95±0.22mg/L respectively). This may be due, in part, to the significantly greater bicarbonate levels recorded in the Control area ($p<0.05$); showing a 57% higher level than that of Rattling Brook (7.0±0.8 and 3.0±0.0mg/L respectively). Further, pH within Rattling Brook was significantly ($p<0.05$) lower

(6.03±0.01 and 6.43±0.07 respectively). Finally, total dissolved solids were significantly higher ($p<0.05$) in the Control area (38,312±3100ug/L compared to 23,750±478ug/L).

1998

Pond water quality measurements were collected during site visits in April, May and December of 1998. Samples were taken from ponds within Rattling Brook (Pond P8) and the Control (Ponds P1, P2, P3, P4, P5, P6, P7, P9 and P10) Sample Area. The water quality of Rattling Brook and Control watersheds were very similar with respect to most dissolved metals and minerals. There were high levels of aluminum found in both watersheds; with both the Rattling Brook and Control watersheds exceeding the CCME guidelines (CCME 2006) for Protection of Freshwater Aquatic Life (i.e. 140.8+/-11.7 mg/L and 164.44+/-7.5 mg/L respectively). Aluminum levels were very high in some ponds within the Control watershed, particularly in Pond P1 where levels exceeded 400 mg/L. There was no significant difference between watersheds with respect to mean manganese levels (25.3+/-3.54 mg/L and 19.5+/-1.75 mg/L for the Rattling Brook and Control watersheds respectively).

2002

Water quality measurements were collected during site visits in October and November of 2002. Samples were taken from ponds within the Rattling Brook (Pond P8) and the Control (Ponds P6, P9, P10, and P11) Sample Area. The water quality of the Rattling Brook and Control watersheds were similar, having a pH of less than 7.00. Lower pH tends to cause elevated levels of metals; some above CCME guidelines (CCME 2006).

Manganese levels in both watersheds exceeded the CCME guidelines, with the Rattling Brook watershed having a significantly higher level ($P<0.001$) than the Control (17.0±6.1ug/L compared to 6.2±0.6ug/L in the Control). While not exceeding the CCME guidelines, aluminum levels were elevated in both watersheds; with Rattling Brook having a significantly greater concentration ($P=0.02$; 118±10.7ug/L and 80±7.0ug/L, respectively).

2005

Water quality measurements were collected from the Rattling Brook watershed (Ponds P8, P14 and Streams S19 and S20), the Sandy Pond watershed (Pond P15 and Stream S26), the Long Harbour sample area (Pond P17 and Stream S28) and the Control area (Ponds P6, P9, P10, P11, P12, P13, P16 and Streams S3, S14 and S24).

The Control Area (sampled in May-June, September, November and December) had a mean aluminum concentration above CCME guidelines (138.2+/-8.6ug/L). Some ponds exhibited iron levels above the CCME guideline of 300ug/L (particularly high in Pond P10 (506ug/L) and Pond P13 (373ug/L). The Long Harbour Areas showed similar results, with mean aluminum levels of 181.3±14.8ug/L and iron levels averaging 387.2±44.8ug/L (above CCME guidelines). Rattling Brook and Sandy Pond watersheds had similar profiles, both exceeding guidelines for aluminum (146.2±12.1ug/L and 155.9±9.1ug/L respectively) but with no samples that exceeded iron (mean concentrations of 125.2±11.5 and 193.9±39.7ug/L respectively). The Control Area had the hardest water (averaging 16.4+/-2.3mg/L), with all other areas averaging less than 10mg/L. All Areas were acidic, ranging from 5.28 in the Control (November) to 6.07 in the Long Harbour (September) sample areas.

2006

The water quality of the Rattling Brook and Sandy Brook watersheds was similar in 2006 to the other watersheds in the area including control locations. This includes being acidic with a pH of less than 7.00. With a lower pH come elevated levels of some metals; some above CCME Guidelines for the Protection of Freshwater Aquatic Life (CCME 2006).

In the Rattling Brook watershed, metals such as aluminum and cadmium showed relatively constant elevated levels while copper, iron, lead, arsenic and nickel showed occasional elevated levels particularly in summer and fall. It should be noted that occasional elevations in the above noted metals were reported from the surface and mid-depth waters of the smaller plateau ponds and their outflows near the proposed Project footprint (Ponds P22, P23 and Stream S30). Arsenic was noted above CCME Guidelines in the Rattling Brook watershed in Pond P28 (surface and mid-depth) and its outflow from the August 2006 sampling.

Similar to the nearby small plateau ponds in Rattling Brook, Little Rattling Brook also had low pH and elevated aluminum, cadmium and iron levels. The brook also had elevated mercury levels above CCME guidelines reported from the June 2006 sample.

There have been similar elevated levels of some metals identified in the Sandy Pond watershed above CCME Guidelines for the Protection of Aquatic Life (CCME 2006). In general, aluminum showed relatively constant elevated levels while cadmium, copper, iron, lead and mercury showed occasional elevated levels particularly in spring and summer. The occasional elevations noted above were generally recorded in the smaller plateau ponds within the watershed (Ponds P26 and P27). Mercury was elevated only in Ponds P26 and P27 in the June 2006 sampling.

Fluoride was also analyzed as part of the 2006 sampling program in all ponds. While there are no CCME guideline values for the Protection of Freshwater Aquatic Life, Jamieson (1975) states that fluoride in high levels (above 1.5mg/L) has been shown to adversely affect freshwater fish populations. Ellis (1946) reports levels of 1.5mg/L to also cause slower and poorer hatching of trout eggs. In addition, the Canadian Drinking Water Quality Guidelines identify an upper limit of 1.5mg/L (1,500ug/L) (CCME 2006). Fluoride analysis of water from all ponds and brooks in the 2006 program showed fluoride levels less than 0.2mg/L (AMEC 2007) indicating baseline levels and no likely residual effects from the former phosphorus plant.

9.2.1. Between Year Comparison

Both the Control sample area and the Rattling Brook watershed had pH values decline between the 1997 and 2006 sampling periods; going from 6.43 to 5.85 and 6.03 to 5.53 respectively. A trend in average aluminum concentration was also observed, with both the Rattling Brook watershed and Control sample area showing a sharp decline (from 207.5$\pm$6.3ug/L to 88.8$\pm$6.8ug/L and 192.5$\pm$23.0ug/L to 105.4$\pm$7.2ug/L). Sulfate levels in the Rattling Brook watershed (Pond P8 in particular) showed a 45% decline between 1997 and 2006, from an average of 3,000ug/L to 1670ug/L, respectively. This trend was also observed in the Control sample area, with the 2006 value being 76% less than 1997 levels (averaging 1357ug/L and 5650ug/L, respectively). While the only common pond sampled between these two years was Pond P9, it also showed a similar trend (declining 57% from 3,000ug/L to 1,282.5ug/L). Copper levels in both areas showed a marked decline as well, falling from an average of 2.5ug/L and 3.1ug/L in 1997 in the Rattling Brook (P8) and Control sample area respectively, to values less than 1.0ug/L in 2006.

9.3. Sediment Quality

Sediment samples were collected from all sites during the May 2006 site visit. Sediment quality parameters analyzed from all ponds and streams near the Project area in 1997, 1998, 2002, 2005 and 2006 are summarized in Appendix B. Appendix B also has laboratory results of the 2006 program. Photographs of all 2006 sampling locations are provided in Appendix C.

1997

Table 9-2 presents the 1997 mean values for each sample area as compared to CCME FAL Guidelines (CCME 2006). Sediment samples were collected in 1997 within the Control sample area and the Rattling Brook watershed. Each area exceeded the CCME guidelines for arsenic, cadmium, mercury and zinc. Rattling Brook had a significantly higher ($p<0.05$) arsenic concentration than the Control, being 2.5-times higher. It should be noted that even though Pond P6 in the Control area had copper concentrations greater than the CCME guideline, the area as a whole had copper concentrations below the guidelines. While there are no CCME guidelines for iron, it can be noted that Rattling Brook had significantly higher ($p<0.05$) concentrations than the Control.

1998

Sediment analysis in 1998 was conducted in May on the Control (Ponds P1, P2, P3, P4, P5, P6, P7, P9 and P10) and Rattling Brook (Pond P8) areas only. Table 9-3 presents the 1998 mean values for each sample area as compared to CCME FAL Guidelines (CCME 2006). Each Area exceeded the CCME limits for arsenic, cadmium, lead, mercury and zinc. Only two samples were taken from the Rattling

Brook watershed (Pond P8), limiting the strength of statistical comparisons with the Control Sample Area (with a total 9 ponds sampled). However, the Rattling Brook watershed showed very high samples of lead and mercury (72 mg/kg and 0.44 mg/kg respectively), each being over double the CCME limits and much higher than any of the Control samples.

Table 9.2 Summary comparison of 1997 sediment results.

Parameter	CCME Guideline (mg/kg)	Control Sample Area (mg/kg)	Rattling Brook Watershed (mg/kg)
Arsenic	5.9	7.79 ± 1.14	19.5 ± 0.50*
Cadmium	0.6	1.13 ± 0.18	1.15 ± 0.05
Lead	35.0	29.06 ± 3.65	29.0 ± 9.0
Mercury	0.17	0.29 ± 0.03	0.31 ± 0.05
Zinc	123	176.6 ± 24.1	145.0 ± 5.0

* Significantly higher than the Control

Table 9.3 Summary comparison of 1998 sediment results.

Parameter	CCME Guideline (mg/kg)	Control (mg/kg)	Rattling Brook (mg/kg)
Arsenic	5.9	8.39 ± 1.11	10.0 ± 1.0
Cadmium	0.6	1.09 ± 0.08	1.45 ± 0.05
Lead	35.0	35.29 ± 6.37	72.0 ± 0.05*
Mercury	0.17	0.21 ± 0.06	0.44 ± 0.01*
Zinc	123	149.9 ± 10.4	145.0 ± 5.0

* Significantly higher than the Control

2002

Sediment results from 2002 in the Rattling Brook watershed (Pond P8) and the Control sample area (Ponds P6, P9, P10 and P11) showed elevated levels of metals. Table 9-4 presents the mean values for each area as compared to CCME Guidelines for the Protection of Aquatic Life (CCME 2006). While arsenic, cadmium, lead, mercury and zinc levels all exceeded the CCME guidelines in both Rattling Brook and the control area; a significant difference was only seen with mercury. Mercury in the sediment of the Rattling Brook watershed was significantly higher than the Control ($p=0.0423$). Iron levels were also significantly higher in the Rattling Brook watershed ($p=0.0167$).

2005

Table 9-5 presents a summary of the 2005 sediment sampling results. Sediment samples from 2005 were taken from three areas (Pond P8 and P14 in Rattling Brook, Pond P17 in the Long Harbour sample area and Ponds P6, P9, P10, P11, P12, P13 and P14 in the Control sample area). All areas, on average, exceeded the CCME guidelines for arsenic, cadmium, lead, mercury and lead. The Control sample area had the highest levels of arsenic and zinc; with arsenic concentrations being approximately 2.5-times above the CCME guidelines. Cadmium levels in the Rattling Brook and Long Harbour areas were significantly higher ($p<0.05$) than the Control area, with all three exceeding the CCME guideline. While no area exceeded the CCME limits for copper, the Control area exhibited a significantly greater ($p<0.05$) concentration than the Rattling Brook or Long Harbour areas. Lead levels in the Long Harbour area were comparatively very high being over 2.5-times higher than the CCME guideline. However, the Long Harbour area exhibited comparatively low zinc concentrations compared to the Control and Rattling Brook areas and was the only one to be below the CCME guideline.

Table 9.4 Summary comparison of 2002 sediment results.

Parameter	CCME Guidelines (mg/kg)	Control Sample Area (mg/kg)	Rattling Brook Watershed (mg/kg)
Arsenic	5.9	14.0 ± 2.55	16 ± 2.0
Cadmium	0.6	0.99 ± 0.18	1.15 ± 0.05
Lead	35	21.68 ± 6.26	22 ± 3.0
Mercury	0.17	0.11 ± 0.02	0.23 ± 0.02*
Zinc	123	168.6 ± 10.8	120 ± 0

* Significantly higher than the Control

Table 9.5 Summary comparison of 2005 sediment results.

Parameter	CCME Guideline (mg/kg)	Control Sample Area (mg/kg)	Rattling Brook Watershed (mg/kg)	Long Harbour Sample Area (mg/kg)
Arsenic	5.9	15.16 ± 3.42	12.77 ± 3.19	12.95 ± 0.55
Cadmium	0.6	0.75 ± 0.07	1.17 ± 0.06*	1.25 ± 0.07*
Copper	35.7	27.77 ± 4.33	15.80 ± 1.75†	15.75 ± 0.75†
Lead	35	41.92 ± 3.64	44.70 ± 4.35	93.75 ± 1.49*
Mercury	0.17	0.23 ± 0.02	0.39 ± 0.04*	0.23 ± 0.01
Zinc	123	149.88 ± 5.58	141.80 ± 11.76	121.25 ± 1.49†

* Significantly higher than the Control
† Significantly lower than the Control

2006

The 2006 sediments results showed marked differences across the four sample areas. Table 9-6 presents a summary of the 2006 sediment sampling results. All watersheds, on average, exceeded the CCME limits for arsenic and cadmium, with the Control area having the highest concentration of both metals; representing concentrations approximately 3.9 and 2.8-times the CCME guidelines for these metals respectively. It should be noted that Pond P9 had very high levels of these metals which tended to increase the mean concentrations of the Control sample area. Lead levels exceeded CCME guidelines in all watersheds except Rattling Brook, being highest in Long Harbour. All areas, except for the Control, exceeded the mercury guideline, with Sandy Pond having the greatest mean concentration. Zinc levels were highest in the Control area, with the Long Harbour sample area also exceeding the zinc guideline. The Control sample area had a significantly lower ($p<0.05$) mean mercury concentration than the other sample areas.

Table 9.6 Summary comparison of 2006 sediment results.

Parameter	CCME Guideline (mg/kg)	Control Sample Area (mg/kg)	Rattling Brook Watershed (mg/kg)	Long Harbour Sample Area (mg/kg)	Sandy Pond Watershed (mg/kg)
Arsenic	5.9	22.75 ± 2.23	10.92 ± 2.74†	9.88 ± 2.49†	7.85 ± 0.54†
Cadmium	0.6	1.69 ± 0.23	1.03 ± 0.059†	1.53 ± 0.10	1.00 ± 0.11†
Lead	35	56.13 ± 9.3	27.5 ± 3.86†	62.16 ± 9.19*	41.33 ± 5.83
Mercury	0.17	0.16 ± 0.01	0.21 ± 0.01*	0.21 ± 0.01*	0.27 ± 0.02*
Zinc	123	188.88 ± 25.03	62.40 ± 9.41†	160.20 ± 8.14	80.67 ± 4.93†

* Significantly higher than the Control
† Significantly lower than the Control

9.3.1. Between Year Comparison

Direct comparison between results is difficult as the same ponds were not sampled throughout the entire dataset. However, general observations regarding the data and trends are noted. In the Control sample area there has been a significant increase in the average arsenic, lead and zinc levels found in sediment samples between 1997 and 2006. Arsenic has increased 2.9-times (7.79±1.14mg/kg to 22.75±2.23mg/kg), lead levels almost doubled (29.06±3.65mg/kg to 56.13±9.3mg/kg), and zinc levels increased by 7% (176.6±24.1 to 188.88±25.03mg/kg) over the nine years since the first samples were taken in 1997. These differences, however, may be attributed to the different ponds sampled between 1997 and 2006.

Rattling Brook appears to have been more stable over the four sampling years, only showing a marked difference in zinc and mercury levels. The 2006 mean zinc concentration decreased 2.4-times from its 1997 level (62.4±9.41mg/kg and 145.0±5.0mg/kg respectively), and mercury levels also decreased by approximately 33% (0.207±0.012mg/kg from 0.31±0.05mg/kg). This may also be due to the variation in ponds sampled between years, as the additional ponds sampled in 2006 (Ponds P24, P8 and P29) had lower average zinc levels than Pond P8 which was the only pond sampled in 1997 and 2002. If Pond P8 is compared alone, no significant decrease was found.

9.4. Benthic Invertebrates

Invertebrate sampling was conducted during 1997, 2005 and 2006 in the Control, Rattling Brook, Long Harbour and Sandy Pond watersheds. Appendix D presents the macro invertebrate results from each location. Table 9-7 presents a summary of species richness, Evenness and Shannon-Weiner diversity indices from each pond sampled.

An effective comparison between years, and sample areas is difficult due to the relatively small number of ponds sampled in any given year or area and the varying timing of the collections. For example, the 1997 samples were collected in February, while 2006 studies were completed in May. Despite these issues, generalizations can be used to describe the benthic invertebrates within the watersheds.

Ponds outside the Long Harbour area were sampled only in 1997 and 2006 and showed no significant variation between these years. Evenness and H_{max} showed little variation, except in Pond P10, which had a very uneven species distribution in 1997 owing to the limited quantity of individuals captured. Rattling Brook was the only watershed to be sampled during all three years, with the 2005 and 2006 results showing a greater Evenness and H_{max} due to the 4-6 fold increase in the number of individuals captured. Sandy Pond was only sampled in 2006 and had the greatest numbers of individuals captured from any sample location. The Long Harbour Sample Area was surveyed in 2005 and 2006 and showed limited variation between years

Not surprisingly, the more comprehensive sampling program in 2006 yielded the greatest variety of invertebrate groups found in any year with 19 separate Orders identified. Long Harbour was the only area where Hydrachnidia were found (Pond P17). Members of the Families Tricpotera, Diptera, Mollusca and Oligochaetae were found in all watersheds/sample areas. Onodontans and Crustacea were absent from any of the 1997 ponds, while no Hirundinea were found in 2005.

9.5. Fish Body Burden

Public concern regarding fluoride levels in the environment during the 1970s prompted DFO to examine fish flesh from samples collected in ponds downwind of the plant between Long Harbour and the Trans Canada Highway (Albright & Wilson 1992). The study was conducted circa 1982-83 (2-3 years after the installation of stack scrubbers at the phosphorus plant) and indicated no elevated levels of fluoride in any samples analyzed.

Brook trout were collected from ponds in 2006 and analyzed for metal body burden analysis. Body burden parameters analyzed from all ponds and streams near the Project area in 1997, 1998, 2002, 2005 and 2006 are summarized in Appendix B. Appendix B also has laboratory results of the 2006 program. Some ponds had very low numbers of fish and the full complement of samples was not collected from some ponds. The effort and results identify those ponds with low relative brook trout numbers.

Comparison of fish body burden with CCME guidelines shows that all samples (from all years) had mercury levels below the CCME guideline of 0.33mg/kg. The only exception being one sample from 2005 (BT 085 from Pond P8) had a mercury value above the CCME limit (0.38mg/kg).

Table 9.7 Summary of species Richness (S), Shannon-Weiner (H) and Evenness (E) diversity indices.

Sample ID	Watershed[1]	Number of Species (Richness - S)	Number of Individuals (n)	Shannon-Weiner (H)	H_{max}	Evenness (E) %
1997						
Pond P2	Control	4	10	1.357	2	67.8
Pond P6	Control	11	65	2.544	3.46	73.5
Pond P9	Control	6	24	1.817	2.585	70.3
Pond P10	Control	5	7	2.236	2.322	9.3
2005						
Pond P8	RBBP	4	44	1.655	2.000	82.7
Pond P14	RBBP	10	64	2.765	3.322	83.2
Pond P19	Long Hbr	7	56	2.135	2.807	76.0
Pond P22	Long Hbr	5	31	1.930	2.322	83.1
2006						
Pond P8	RBBP	1	6	0.000	0.000	- -
Pond P9	Control	6	41	1.936	2.585	74.9
Pond P10	Control	6	64	1.592	2.585	61.6
Pond P11	Control	5	32	1.782	2.322	76.8
Pond P14	RBBP	6	59	2.070	2.585	80.1
Pond P15	Sandy Pnd	5	250	1.532	2.322	66.0
Pond P17	Long Hbr	9	30	2.278	3.170	71.9
Pond P18	Long Hbr	8	86	1.409	3.000	47.0
Pond P19	Long Hbr	8	79	2.067	3.000	68.9
Pond P20	Long Hbr	10	72	2.676	3.322	80.6
Pond P21	Long Hbr	6	30	2.061	2.585	79.7
Pond P22	Long Hbr	5	70	1.863	2.322	80.2
Pond P23	Long Hbr	8	207	2.208	3.000	73.6
Pond P24	Long Hbr	7	169	1.812	2.807	64.5
Pond P25	Long Hbr	5	166	1.486	2.322	64.0
Pond P26	Long Hbr	9	201	1.541	3.170	48.6
Pond P27	Long Hbr	5	70	1.246	2.322	53.7

[1] RBBP – Rattling Brook watershed, Long Hbr – Long Harbour sample area, Sandy Pnd – Sandy Pond watershed, Control – Control sample area.

9.6. Riverine Habitat Classification/Quantification

9.6.1. Tributary T1 (Rattling Brook)

The main stem of Rattling Brook (Tributary T1) is a total length of 3,176m with the watershed extending inland approximately 6.5km from the southern shore of Long Harbour. It drains a total area of 38km^2, with the majority of this coming from Rattling Brook Big Pond (23.5km^2). Its outflow is very near the existing Long Harbour Industrial Park and wharf. This watershed contains many large and small ponds with a large network of tributaries; most identified as intermittent in nature. Detailed habitat measurements are presented in Appendix E. Photos of the stream reaches are presented in Appendix F. Appendix G presents a map of the Project area with detailed map of pond names and locations near the Project area.

The stream is relatively small with a series of very steep rapids at its mouth which makes it inaccessible to searun salmonids, although American eels were captured just above the existing concrete weir approximately 400m upstream. In addition to the falls and cascades below the weir, a second set of steep falls and rapids approximately 200m upstream of the weir are also impassible to upstream migration. In fact, no eels were captured above this point. The substrate composition of the stream is primarily of cobble and larger, up to and including bedrock and indications of past channelization for water management as part of previous activities in the area are evident. Gravels and smaller substrates are found in relatively low quantities typically located in isolated patches behind larger boulders. Despite limited gravels throughout the system, there have been several areas identified (eg. the downstream end of Reach 20, the upstream end of Reach 23 and the braided side channels of Reach 37) with very high quantities of gravels. These locations were also recorded as areas of brook trout spawning activity in September.

Table 9-8 presents a summary of habitat characteristics as well as the habitat classification in both the Beak and proposed new Riverine Classifications. The Beak habitat classification quantifies the river as a total of 20.50 units of Type I (spawning), 313.73 units of Type II (rearing), 39.07 units of Type III and 225.58 units of Type IV (pool) habitat. The new Classification System identifies a total of 265.60 units of Riffle, 176.15 units of Pool/small pond, 17.25 units of Rapid, 86.62 units of Steady, 14.95 units of Cascade, 26.24 units of Falls, and 12.06 units of Run habitat types.

The natural hydrology of the system has been established from past records as well as from new water-level stations installed in the main stem of Rattling Brook in the fall of 2006. Figure 9-1 presents the hydrographs for a typical, dry and wet year for Rattling Brook while Figure 9-2 presents the flow duration curve.

Table 9.8 Summary habitat information and habitat classifications, Tributary T1 (Rattling Brook Big Pond Outflow).

Reach #	Length (m)	Mean Wet Width (m)	Area[2] (Units)	Mean Slope (%)	Mean Depth (m)	Mean Velocity (m/s)	Substrate (% coverage)[1]							Classification	
							Be	B	R	C	G	S	D	Beak	New
1	6.7	10.9	0.73	1.05	0.28	0.540	0	60	15	20	5	0	0	II	Riffle
2	22.6	18.0	4.07	2.91	0.44	0.844	95	5	0	0	0	0	0	III	Cascade
3	18.1	11.1	2.01	0.74	0.50	0.512	40	25	15	10	10	0	0	II	Run
4	18.0	12.0	2.16	4.10	0.12	2.226	100	0	0	0	0	0	0	III	Falls
5	16.0	8.0	1.28	0.84	1.55	0.118	40	30	15	10	5	0	0	IV	Pool
6	283.0	8.0	22.64	60.63	0.22	>2.00	100	0	0	0	0	0	0	III	Falls
7	42.9	7.9	3.39	3.70	0.23	0.810	50	25	10	10	5	0	0	III	Cascade
8	36.0	24.0	8.64	0.42	2.00	0.000	5	15	10	20	10	5	35	IV	Pool
9	15.0	1.8	0.27	- -	0.13	0.079	0	10	40	35	15	0	0	II	Riffle
10	28.7	17.9	5.14	0.06	0.28	0.188	10	20	40	25	5	0	0	II	Riffle
11	21.6	10.0	2.16	14.57	0.29	0.626	100	0	0	0	0	0	0	III	Cascade
12	30.7	13.0	3.99	0.05	0.59	0.075	10	25	30	15	5	0	15	IV	Steady
13	63.0	21.2	6.66	>2.47	0.36	0.783	0	70	15	10	5	0	0	II	Rapid
14	32.0	13.0	4.16	0.35	1.09	0.362	60	20	10	5	5	0	0	IV	Pool
15	24.0	2.0	0.48	20.30	0.20	1.216	100	0	0	0	0	0	0	III	Falls
16	60.0	8.9	5.34	2.93	0.68	0.246	0	80	10	10	0	0	0	II	Cascade
17	199.0	7.2	14.33	2.93	0.37	0.421	0	80	10	10	0	0	0	II	Riffle
18	277.1	38.7	107.79	1.33	0.23	0.243	0	70	17	10	3	0	0	II	Riffle
19	146.0	40.0	58.40	0.01	0.67	0.000	0	20	0	0	0	0	80	IV	Pool
20	14.0	19.1	2.67	- -	0.53	0.277	0	10	30	30	30	0	0	I	Riffle
21	33.3	7.0	2.35	0.15	0.63	0.300	0	15	40	35	10	0	0	I	Steady
22	60.0	63.5	3.81	1.52	0.29	0.550	0	15	40	30	15	0	0	II	Run
23	36.0	8.0	2.88	0.53	0.46	0.263	0	10	40	30	20	0	0	I	Steady
24	85.7	8.6	7.37	3.26	0.40	0.928	0	60	30	8	2	0	0	II	Rapid
25	12.7	7.0	0.88	0.30	0.37	0.372	0	30	40	15	15	0	0	II	Steady
26	35.2	26.0	9.15	0.04	1.33	0.000	0	30	25	20	0	15	10	IV	Pool
27	90.6	22.0	19.93	2.15	0.28	0.251	0	65	20	15	0	0	0	II	Riffle
28	154.0	12.0	18.48	0.44	0.49	0.281	0	60	30	10	0	0	0	II	Steady
29	13.0	9.0	1.17	23.01	0.63	0.677	0	60	30	10	0	0	0	III	Rapids

Reach #	Length (m)	Mean Wet Width (m)	Area[2] (Units)	Mean Slope (%)	Mean Depth (m)	Mean Velocity (m/s)	Substrate (% coverage)[1]							Classification	
							Be	B	R	C	G	S	D	Beak	New
30	8.0	12.0	0.96	25.00	- -	- -	100	0	0	0	0	0	0	III	Falls
31	279.9	18.9	57.26	1.76	0.34	0.334	0	55	33	9	3	0	0	II	Riffle
32	118.0	54.0	63.72	<0.05	>1.00	0.000	20	0	0	0	0	0	80	IV	Pool
33	186.7	7.3	14.33	0.68	0.37	0.327	0	8	47	37	8	0	0	II	Riffle
34	116.2	7.8	9.12	0.09	0.51	0.268	0	5	50	30	15	0	0	I	Steady
35															Pond
36	18.6	11.0	2.05	3.82	0.31	0.301	0	70	20	5	5	0	0	III	Rapid
37	102.6	12.0	8.80	0.61	0.31	0.347	0	45	35	5	15	0	0	II	Riffle
38	29.0	12.0	3.48	0.05	1.50	0.00	0	20	50	10	20	0	0	I	Steady
39															Pond P14
40	84.4	7.4	6.25	3.36	0.28	0.420	0	90	10	0	0	0	0	II	Run
41	86.1	36.0	31.00	0.08	0.26	0.395	0	65	25	10	0	0	0	II	Riffle
42	70.0	44.0	30.80	0.02	2.00	0.000	0	10	0	0	0	0	90	IV	Pool
43	142.0	32.0	45.44	0.22	0.25	0.182	0	70	20	10	0	0	0	IV	Steady
44	42.0	8.0	3.36	1.36	0.44	0.648	0	100	0	0	0	0	0	II	Riffle
Total	**3,176.95**		**598.88**												

[1] Be-Bedrock, B-Boulder, R-Rubble, C-Cobble, G-Gravel, S-Sand, D-Muck/Detritus
[2] Area calculations are based on calculations from all transects within a reach and not on mean wet width presented above.

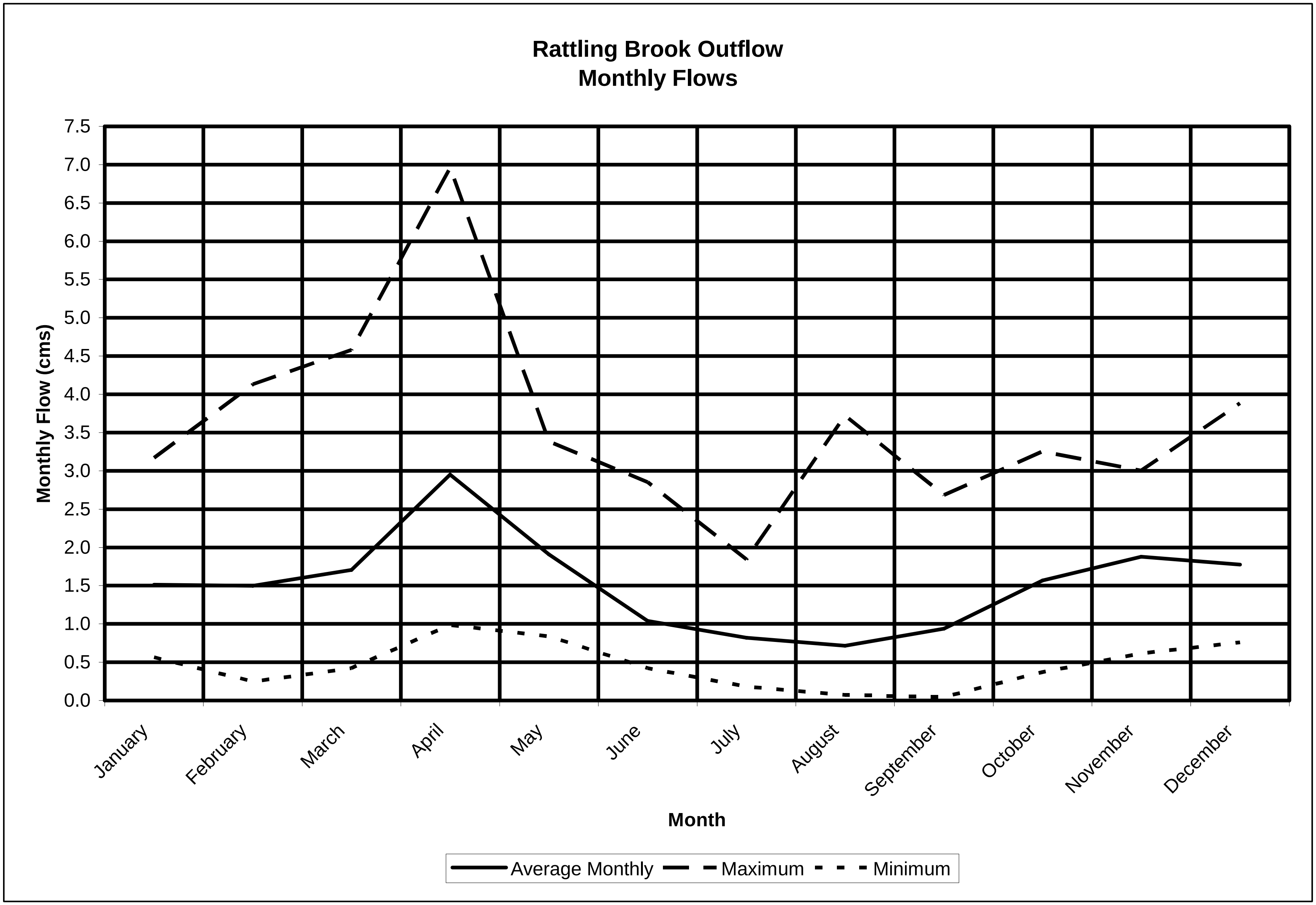

Figure 9.1 Hydrographs (typical, wet and dry year), Rattling Brook outflow.

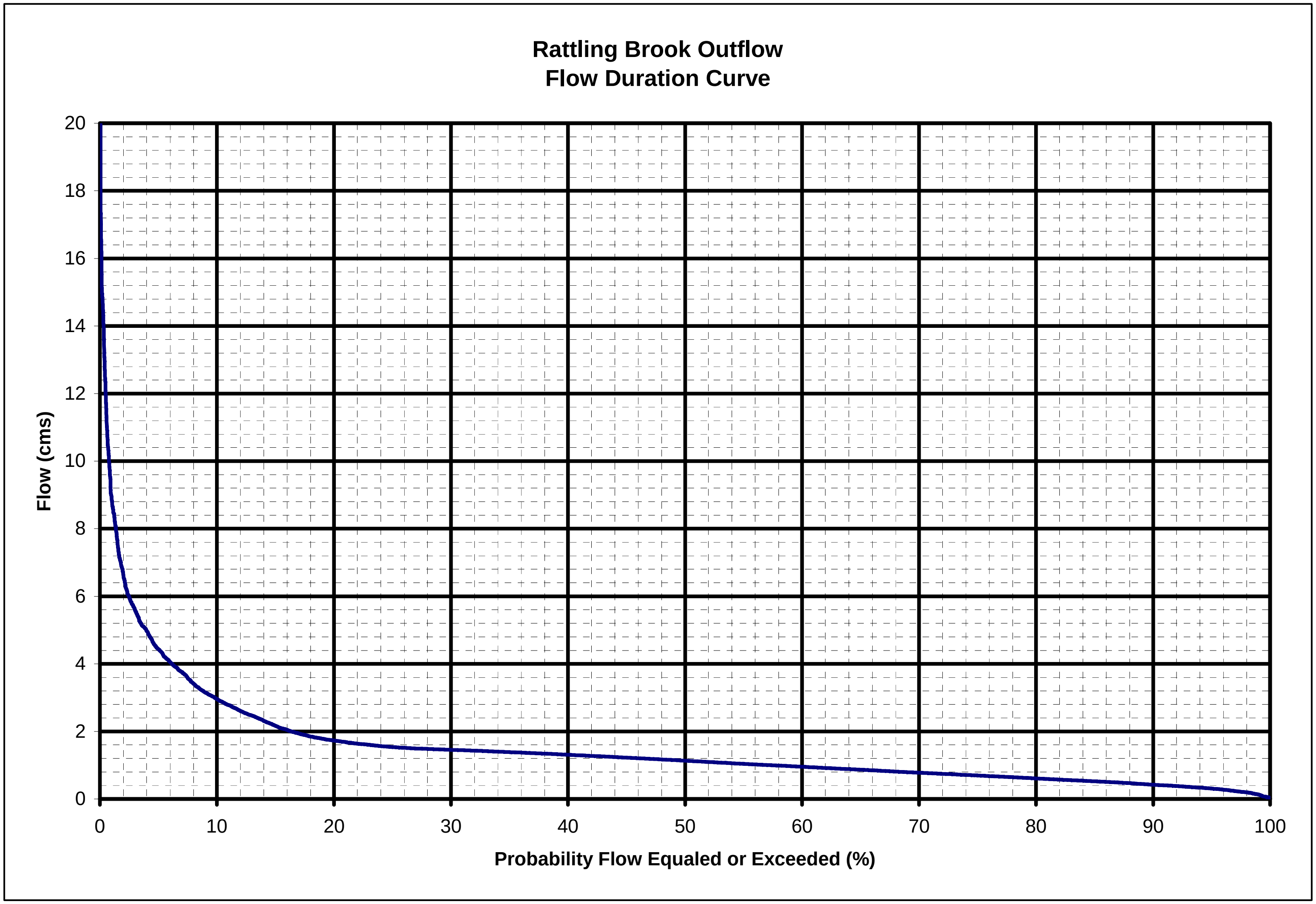

Figure 9.2 Flow duration curve, Rattling Brook outflow.

The stream has been subject to past channelization and damming as part of the former Electrical Reduction Company (ERCO) operations. The decommissioned water extraction infrastructure associated with the ERCO phosphorus plant still remains in the watershed and includes:

- a wooden-creosote water pipeline between Rattling Brook Big Pond and the Long Harbour Industrial Park;
- a concrete weir in the brook approximately 400m upstream from the mouth; and
- a rock-fill dyke on the outflow of Sam Howe's Pond (Pond P14).

The pipeline is still in place but does not present a major alteration of aquatic habitat and does not pose a barrier to migration. The concrete weir is approximately 4.5m high with a vertical downstream face (Figure 9-3). The weir would be a complete obstruction to fish passage; however the right-hand side has eroded such that there is a small side channel around the weir. At certain flows, this side channel may provide passage. The rock-fill dyke was constructed to keep water levels high for extraction by the phosphorus plant (Figure 9-4). The dyke is approximately 2m high with a downstream slope estimated at 60^{o}. The dyke is still in place but leaks, and during low to moderate flows water exits the pond through the dyke itself with no clear channel for fish movement (i.e. the top of the dyke is dry). During high flows, the water crests the dyke and flows over its downstream face. This dyke is considered an obstruction to fish passage.

Stream channelizations have also occurred in at least two locations in the main stem. The first is just downstream of the current upper bridge crossing (i.e. Reaches 20-23). The stream has had large boulders removed and placed along the left-hand shore (Figure 9-5). The habitat in this area is more uniform than most other locations but gravels from the road and bridge have accumulated behind the downstream left-hand bridge abutment and at the downstream end of Reach 20, providing some of the more suitable spawning habitat in the area at moderate flows. While the area was not surveyed during high flows, it is anticipated that the upper reaches near the bridge would have relatively high water velocities with the removal of these larger substrates.

The second channelized section is located at the outflow of a small pool/pond (Reach 35). The channelized section (Reaches 33 and 34) is approximately 360m long and is more uniform than most other locations however unlike the channelized area below the bridge, there are no gravel additions and hence substrates are primarily cobble and rubble (Figure 9-6). At the time of the survey, water velocities as high as 0.75m/s were recorded.

Fish Species Present

Fish species recorded in the Rattling Brook watershed during 2005-2006 investigations include brook trout, Arctic charr and American eel (AMEC 2007). This current species composition is supported by past reports (eg. Albright and Wilson 1992).

Figure 9.3 Concrete weir near the mouth of Rattling Brook, June 22, 2006.

Figure 9.4 Rock-fill dyke at the outflow of Sam Howe's Pond (P14) during high flow, January 8, 2007.

Figure 9.5 Rattling Brook Reach 21 showing channelized habitat, June 22, 2006. Large boulders were removed and placed just beyond the left-hand bank.

Figure 9.6 Rattling Brook Reach 34 showing channelized habitat, June 22, 2006. Large boulders were removed and placed just beyond the left-hand bank.

The 1992 Environmental Impact Statement for the Long Harbour decommissioning of the Phosphorus Plant (Albright and Wilson 1992) indicates that the main fish species in the surrounding watersheds is brook trout. Atlantic salmon (*Salmo salar*), though reported to occasionally occur in the lower sections of the larger brooks in the Long Harbour area, are not considered to utilize the watersheds near the Project area to any degree; none are scheduled salmon rivers and there are no reports of ouananiche (landlocked salmon) in the ponds. Occasional Arctic charr have been previously taken from Rattling Brook Big Pond (Albright and Wilson 1992). These were determined by DFO to be a resident landlocked form (Albright and Wilson 1992).

As stated previously, brook trout are the primary fish species utilizing the Rattling Brook watershed. They were found in most ponds and electrofishing stations within the watershed in 2006. Due to the natural barriers at the mouth of the brook and the rock-fill dyke at the outflow of Sam Howe's Pond (Pond P14), the species is resident and not anadromous.

American eels were captured in low numbers in electrofishing stations below the second series of falls on the main stem (i.e. below Reach 14). A total of three eels were captured which indicates that they can traverse the initial falls but cannot get farther upstream. No eels were captured in any pond or stream section upstream of Reach 14.

A single Arctic charr was captured in Rattling Brook Big Pond during the 2006 investigations.

Habitat Quantification

Habitat quantification has been completed using both the Beak and the habitat classification system outlined in McCarthy *et al*. (2006). The Beak quantification is the tally of all four habitat-types.

The McCarthy *et al*. (2006) system applies species habitat suitability indices to available habitat so that Habitat Equivalent Units (HEU) can be calculated. Species captured from each respective stream are included in habitat quantification. Both brook trout (*Salvelinus fontinalis*) and American eel (*Anguilla rostrata*) were captured in portions of Rattling Brook, however only brook trout were captured above the obstructions at Reach 14. This was therefore the only species used for quantification of Rattling Brook and sub-tributaries upstream of this reach.

It should be noted that Grant and Lee (2004) does not provide velocity preferences for American eels for use in habitat quantification. In order to remain conservative, only substrate preference values were used (i.e. habitat equivalent values were not reduced/adjusted due to unsuitable velocity values). Table 9-9 presents a summary of each species life-cycle stage habitat suitability values. Table 9-10 summarizes the species suitability for each reach of Rattling Brook (i.e. highest life-cycle stage value) as well as the calculations of the habitat equivalent units (HEU). American eel juveniles give an HEU of 23.19 units for the first 14 reaches (brook trout give an HEU of 31.37 units). Brook trout give an overall HEU value of 375.71 units for the entire main stem of Rattling Brook.

Table 9.9 Summary habitat suitability information for each species, Tributary T1. Bolded values are those brought forward for HEU calculations.

Reach #	Habitat	Brook Trout				American Eel[1]
		Spawning	Young-of-Year	Juvenile	Adult	Juvenile
1	Riffle	0.46	0.67	**1.00**	0.67	**0.78**
2	Cascade	0.00	0.19	**0.53**	0.51	**0.05**
3	Run	0.43	0.47	**0.80**	0.77	**0.47**
4	Falls	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
5	Pool	0.58	0.80	0.80	**0.94**	**0.48**
6	Falls	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
7	Cascade	0.24	0.00	**0.75**	0.59	**0.38**
8	Pool	**0.00**	**0.00**	**0.00**	**0.00**	**0.70**
9	Riffle	0.42	**0.67**	**0.67**	**0.67**	**0.60**
10	Riffle	0.65	0.95	0.95	**0.99**	**0.63**
11	Cascade	0.00	0.00	0.00	**0.50**	**0.00**
12	Steady	0.46	0.71	**0.78**	0.77	**0.73**
13	Rapid	0.41	0.67	**0.92**	0.67	**0.88**
14	Pool	0.22	0.37	0.37	**0.57**	**0.33**
15	Falls	**0.00**	**0.00**	**0.00**	**0.00**	- -
16	Cascade	0.55	0.83	**1.00**	0.83	- -
17	Riffle	0.55	0.67	**1.00**	0.83	- -
18	Riffle	0.57	0.89	**1.00**	0.89	- -
19	Pool	**0.00**	**0.00**	**0.00**	**0.00**	- -
20	Riffle	0.80	**1.00**	**1.00**	**1.00**	- -
21	Steady	0.73	0.83	**1.00**	0.83	- -
22	Run	0.64	0.75	**1.00**	0.75	- -
23	Steady	0.75	**1.00**	**1.00**	**1.00**	- -
24	Rapid	0.22	0.67	**1.00**	0.67	- -
25	Steady	0.65	0.83	**1.00**	0.83	- -
26	Pool	**0.00**	**0.00**	**0.00**	**0.00**	- -
27	Riffle	0.41	**0.83**	**0.83**	**0.83**	- -
28	Steady	0.55	**1.00**	**1.00**	**1.00**	- -
29	Rapids	0.38	0.67	**1.00**	0.67	- -
30	Falls	**0.00**	**0.00**	**0.00**	**0.00**	- -
31	Riffle	0.54	0.81	**1.00**	0.92	- -
32	Pool	**0.00**	**0.00**	**0.00**	**0.00**	- -
33	Riffle	0.64	0.71	**0.92**	0.79	- -
34	Steady	0.73	**1.00**	**1.00**	**1.00**	- -
35	Pond	- -	- -	- -	- -	- -
36	Rapid	0.55	0.83	**1.00**	**1.00**	- -
37	Riffle	0.52	0.67	**0.92**	0.83	- -

Reach #	Habitat	Brook Trout				American Eel[1]
		Spawning	Young-of-Year	Juvenile	Adult	Juvenile
38	Steady	**0.00**	**0.00**	**0.00**	**0.00**	- -
39	Pond P14	- -	- -	- -	- -	- -
40	Run	0.00	0.00	**0.83**	0.00	- -
41	Riffle	0.55	0.67	**1.00**	0.83	- -
42	Pool	**0.00**	**0.00**	**0.00**	**0.00**	- -
43	Steady	0.38	**0.83**	**0.83**	**0.83**	- -
44	Riffle	0.00	0.83	**1.00**	0.83	- -

[1] American eel values are based on substrate preference criteria only. Eels were only utilizing habitat below complete obstructions (Reaches 1-14).

Table 9.10 Summary habitat suitability information and habitat equivalent units, Tributary T1.

Reach #[1]	Units ($100m^2$)	Brook Trout		American Eel	
		Habitat Suitability	HEU	Habitat Suitability	HEU
1	0.73	1.00	0.73	0.78	0.56
2	4.07	0.53	2.16	0.05	0.20
3	2.01	0.80	1.61	0.47	0.94
4	2.16	0.00	0.00	0.00	0.00
5	1.28	0.94	1.20	0.48	0.61
6	22.64	0.00	0.00	0.00	0.00
7	3.39	0.75	2.54	0.38	1.29
8	8.64	0.00	0.00	0.70	6.05
9	0.27	0.67	0.18	0.60	0.16
10	5.14	0.99	5.09	0.63	3.24
11	2.16	0.50	1.08	0.00	0.00
12	3.99	0.78	3.11	0.73	2.91
13	6.66	0.92	6.13	0.88	5.86
14	4.16	0.53	2.20	0.33	1.37
15	0.48	0.00	0.00	- -	- -
16	5.34	1.00	5.34	- -	- -
17	14.33	1.00	14.33	- -	- -
18	107.79	1.00	107.79	- -	- -
19	58.40	0.00	0.00	- -	- -
20	2.67	1.00	2.67	- -	- -
21	2.35	1.00	2.35	- -	- -
22	3.81	1.00	3.81	- -	- -
23	2.88	1.00	2.88	- -	- -
24	7.37	1.00	7.37	- -	- -
25	0.88	1.00	0.88	- -	- -
26	9.15	0.00	0.00	- -	- -
27	19.93	0.83	16.54	- -	- -
28	18.48	1.00	18.48	- -	- -
29	1.17	1.00	1.17	- -	- -
30	0.96	0.00	0.00	- -	- -
31	57.26	1.00	57.26	- -	- -
32	63.72	0.00	0.00	- -	- -
33	14.33	0.92	13.19	- -	- -
34	9.12	1.00	9.12	- -	- -
35	- -	- -	- -	- -	- -
36	2.05	1.00	2.05	- -	- -
37	8.80	0.92	8.09	- -	- -
38	3.48	0.00	0.00	- -	- -
39	- -	- -	- -	- -	- -
40	6.25	0.83	5.18	- -	- -
41	31.00	1.00	30.10	- -	- -

Reach #[1]	Units ($100m^2$)	Brook Trout		American Eel	
		Habitat Suitability	HEU	Habitat Suitability	HEU
42	30.80	0.00	0.00	- -	- -
43	45.44	0.83	37.72	- -	- -
44	3.36	1.00	3.36	- -	- -
Total	**598.89**		**375.71**		**23.19**

[1] Reaches are numbered progressing upstream.

9.6.2. Tributary T1-1

Tributary T1-1 is a sub-tributary of T1 (Rattling Brook) and flows from two headwater ponds (Ponds P24 and P25) to the west of Rattling Brook. It has a total drainage area of $2.1km^2$ and extends inland to the west from the main stem of Rattling Brook approximately 1.8km. The stream is a total of 1,552m in length and joins the main stem of Rattling Brook at Reach 17. The entire stream was surveyed on the ground using both the Beak and the new Riverine Classification systems. Table 9-11 shows a summary of habitat characteristics for each identified river reach. Detailed habitat measurements are presented in Appendix E. Photos of the stream are presented in Appendix F.

The stream is a small tributary of Rattling Brook which drains two small headwater ponds (*see* Figure 7-1). The tributary is shown as intermittent on 1:50,000 topographic mapping however the stream surveys were conducted after several days of steady rain and therefore the flows and wetted widths would be considered near summer full or bankfull flows. The stream has very heavy riparian vegetation with excessive large woody debris throughout the upper reaches. The slope of the tributary tends to increase upstream toward the ponds. At the time of the surveys, there were no barriers to migration. The substrate composition is primarily of rubble and boulders with some bedrock. Gravels are noticeably absent in the tributary (except for a single reach at the downstream end of the tributary) and may be an indication of the nature of the natural bed material of the area or of relatively low flows. It should be noted that the tributary begins with a culvert that crosses the access road to Rattling Brook Big Pond. It has a diameter of approximately 1.1m with no evidence of excess erosion due to extreme flows. Only brook trout were captured in this stream.

The natural hydrology of the system has been pro-rated from past records as well as from a new water-level station installed in the main stem of Rattling Brook in the fall of 2006. Figure 9-7 presents the hydrographs for a typical, dry and wet year for the tributary while Figure 9-8 presents the flow duration curve.

Table 9-10 presents a summary of habitat characteristics as well as the habitat classification in both the Beak and McCarthy *et al.* (2006) Riverine Classification.

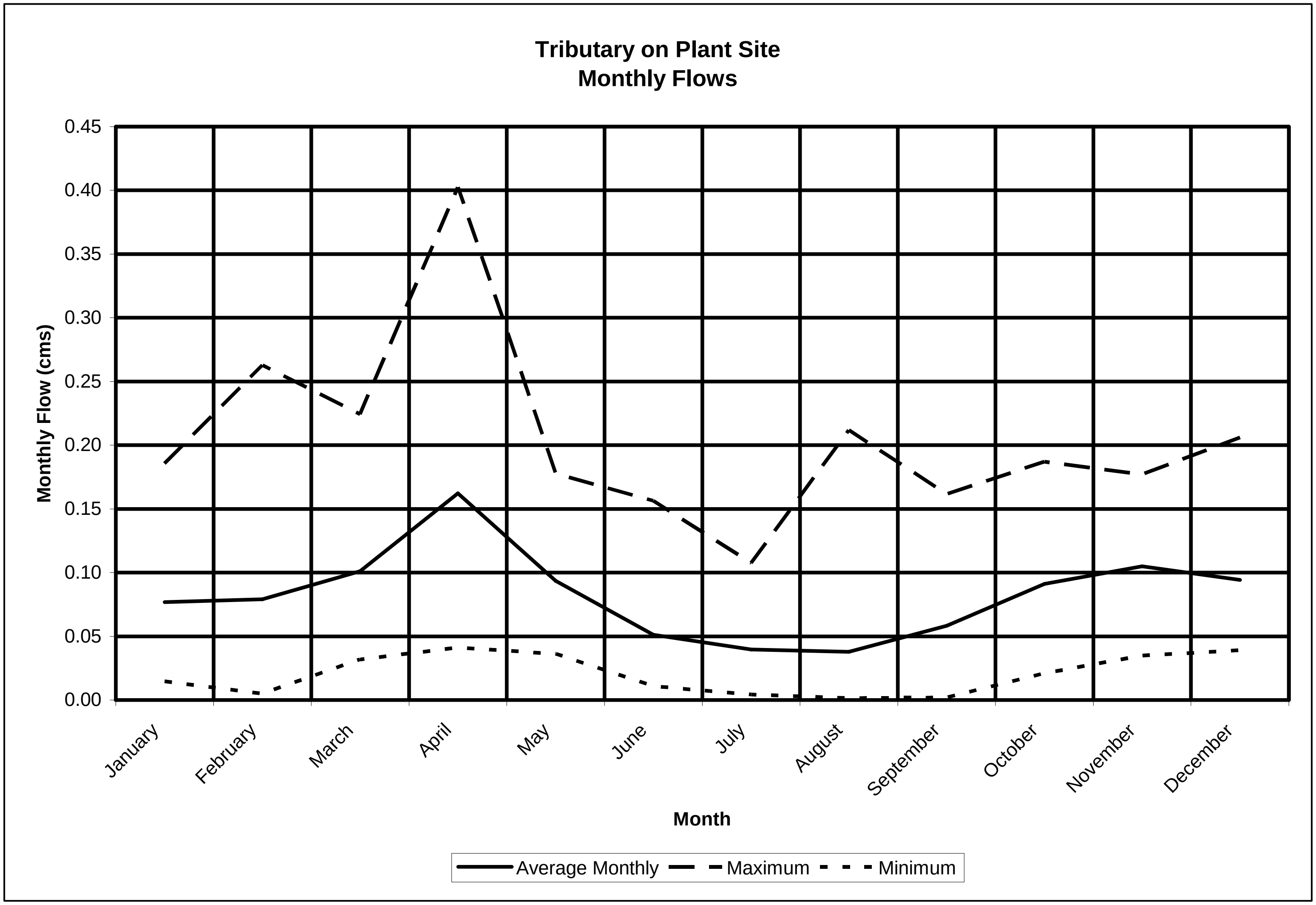

Figure 9.7 Hydrographs (typical, wet and dry year), Tributary T1-1 outflow.

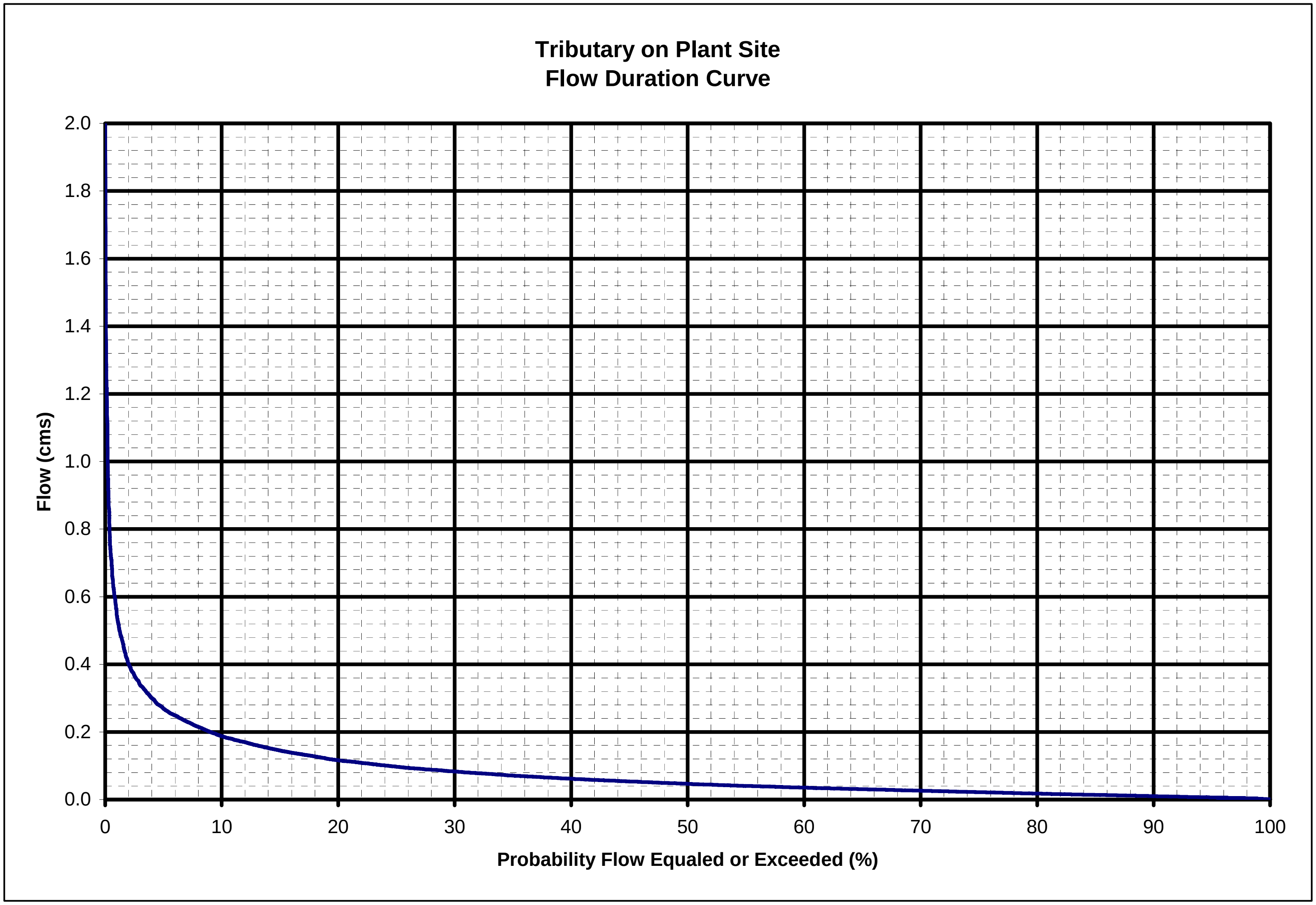

Figure 9.8 Flow duration curve, T1-1 outflow.

Table 9.11 Summary habitat information and habitat classifications, Tributary T1-1.

Reach #	Length (m)	Mean Wet Width (m)	Area[2] (Units)	Mean Slope (%)	Mean Depth (m)	Mean Velocity (m/s)	Substrate (% coverage)[1]							Classification	
							Be	B	R	C	G	S	D	Beak	New
1	9.7	1.1	0.11	- -	0.78	0.360	0	0	0	0	0	0	0	III	Culvert
2	14.0	2.0	0.28	- -	0.29	0.117	0	40	40	0	20	0	0	I	Riffle
3	12.9	1.8	0.22	- -	0.26	0.058	0	20	10	0	0	0	70	II	Steady
4	159.6	2.5	4.02	- -	0.32	0.205	0	35	46.7	18.3	0	0	0	II	Riffle
5	24.5	4.6	1.13	0.12	0.53	0.004	0	80	0	20	0	0	0	IV	Steady
6	220.0	1.5	3.19	2.60	0.26	0.329	0	70	30	0	0	0	0	II	Riffle
7	3.7	3.0	0.11	0.14	0.34	0.072	0	0	100	0	0	0	0	IV	Pool
8	426.9	3.0	12.78	2.24	0.25	0.180	0	80	10	10	0	0	0	II	Riffle
9	96.5	0.63	7.81	0.15	0.34	0.114	0	35	65	0	0	0	0	IV	Steady
10	56.0	28.0	15.68	0.63	>1.0	0.000	0	0	0	0	0	0	100	IV	Pool
11	64.2	3.9	3.27	1.32	0.31	0.203	0	75	25	0	0	0	0	II	Riffle
12	69.0	20.0	13.80	0.00	>1.00	0.00	0	0	0	0	0	0	100	IV	Pool
13	21.1	2.6	0.55	0.36	0.46	0.102	0	90	10	0	0	0	0	II	Riffle
14	120.0	3.5	4.11	3.80	0.23	0.262	40	55	5	0	0	0	0	III	Cascade
15	46.6	3.1	1.42	- -	0.15	0.107	0	0	80	20	0	0	0	IV	Steady
16	33.5	2.1	0.70	3.07	0.28	0.184	35	30	35	0	0	0	0	II	Riffle
17	41.0	4.7	1.93	- -	0.54	0.019	0	50	50	0	0	0	0	IV	Steady
18	60.0	10.0	6.00	0.00	0.80	0.000	0	0	0	0	0	0	100	IV	Pool
19	76.0	2.7	2.00	0.40	0.35	0.062	20	35	45	0	0	0	0	IV	Steady
Total	**1,552.2**		**79.11**												

[1] Be-Bedrock, B-Boulder, R-Rubble, C-Cobble, G-Gravel, S-Sand, D-Muck/Detritus
[2] Area calculations are based on calculations from all transects within a reach and not on mean wet width presented above.

The Beak habitat classification quantifies the river as a total of 0.28 units of Type I (spawning), 24.74 units of Type II (rearing), 4.22 units of Type III (migratory) and 49.87 units of Type IV (pool) habitat (excluding Ponds P24 and P25). The new Classification System identifies a total of 24.79 units of Riffle, 35.59 units of Pool, 14.51 units of Steady and 4.11 units of Cascade habitat types. There are also 0.11 units of culvert at the mouth of the tributary.

Riverine habitat surveys are typically conducted during mid-summer low flows; however heavy rains prior to the surveys caused flows of $0.15m^3/s$; approximately three-times higher than the average mean monthly flow for June ($0.05m^3/s$) at the time of the survey. As a result, the habitat units in the brook are considered conservative. An assessment of the relative overestimation of habitat area was conducted on several of the stream reach transects in order to determine whether an adjustment of the habitat units was warranted. Due to the relatively steep shorelines of the habitat, even a reduction in flow to $0.05m^3/s$ only altered the habitat areas by less than five percent (i.e. the water levels dropped but overall wetted width did not). It should be noted however, that a reduction in flow to the June mean monthly value can decrease mean water levels by up to 0.1m. This may affect the suitability of certain habitat types (eg. reach 15) however since all suitabilities are based on those parameters measured in the field, no adjustments to habitat areas has been applied.

Habitat Quantification

Habitat quantification has been completed using both the Beak and the new Habitat Classification system. The Beak quantification is the tally of all four habitat-types.

Species captured from each respective stream are included in the proposed habitat quantification. Brook trout was the only species captured in Tributary T1-1 and therefore this species was included in the quantification. The juvenile and adult life-cycle stages accounted for all the brook trout utilization values, indicating that the stream has relatively low utilization as spawning habitat and is more suitable for use as rearing habitat. Table 9-12 presents a summary of brook trout life-cycle stage habitat suitability values and the calculated habitat equivalent units (HEU). Brook trout suitabilities give a total HEU of 41.52 units.

9.6.3. Tributary T1-1-1

Tributary T1-1-1 is a sub-tributary of T1-1 and flows from another two headwater ponds (Ponds P22 and P23) directly west of Tributary T1-1 (*see* Figure 7-1). The stream is a total of 731m in length. The entire stream was surveyed on the ground using both the Beak and the McCarthy *et al.* (2006) Riverine Classification systems. Table 9-13 shows a summary of habitat characteristics for each identified river reach. Detailed habitat measurements are presented in Appendix E. Photos of the stream are presented in Appendix F.

Table 9.12 Summary habitat suitability information for each species, Tributary T1-1. Bolded values are those brought forward for HEU calculations.

Reach #[1]	Habitat	Brook Trout				HEU
		Spawning	0.06	**Juvenile**	**Adult**	
1	Culvert	0.00	0.23	0.00	**0.59**	0.06
2	Riffle	0.43	0.22	**0.83**	**0.83**	0.23
3	Steady	0.62	3.86	**1.00**	0.77	0.22
4	Riffle	0.55	0.76	**0.96**	0.96	3.86
5	Steady	0.27	3.19	**0.67**	0.67	0.76
6	Riffle	0.00	0.09	**1.00**	0.88	3.19
7	Pool	0.00	12.78	**0.83**	0.83	0.09
8	Riffle	0.54	7.34	**1.00**	1.00	12.78
9	Steady	0.00	0.00	**0.94**	0.94	7.34
10	Pool	**0.00**	3.27	**0.00**	**0.00**	0.00
11	Riffle	0.00	0.00	**1.00**	**1.00**	3.27
12	Pool	**0.00**	0.46	**0.00**	**0.00**	0.00
13	Riffle	0.00	4.11	**0.83**	0.83	0.46
14	Cascade	0.53	1.42	**1.00**	0.92	4.11
15	Steady	0.60	0.66	**1.00**	**1.00**	1.42
16	Riffle	0.00	1.31	0.83	**0.94**	0.66
17	Steady	0.00	0.00	**0.67**	**0.67**	1.31
18	Pool	0.00	1.76	**0.00**	**0.00**	0.00
19	Steady	0.00	**41.52**	0.82	**0.88**	1.76
Total						**41.52**

[1] Reaches are numbered progressing upstream.

Like T1-1, Tributary T1-1-1 is also shown as intermittent on 1:50,000 topographic mapping however stream surveys were conducted after several days of steady rain and therefore the flows and wetted widths would be considered near summer full or bankfull flows. The stream has very heavy riparian vegetation with excessive large woody debris throughout the upper reaches. A steep section of the stream occurs approximately 300m upstream. Only brook trout were seen in this stream. Since this stream was not electrofished but brook trout were captured in Tributary T1-1, they were used in the calculation of Habitat Equivalent Units (HEU). The substrate composition is primarily of rubble and boulders with some bedrock. Like T1-1, gravels are noticeably absent in the tributary (except for pockets in a single reach near the steeper section of Reach 16).

Table 9-13 presents a summary of habitat characteristics as well as the habitat classification in both the Beak and McCarthy *et al.* (2006) Riverine Classification.

Table 9.13 Summary habitat information and habitat classifications, Tributary T1-1-1.

Reach #	Length (m)	Mean Wet Width (m)	Area[2] (Units)	Mean Slope (%)	Mean Depth (m)	Mean Velocity (m/s)	Substrate (% coverage)[1]							Classification	
							Be	B	R	C	G	S	D	Beak	New
1	60.0	1.0	0.60	0.25	0.26	0.013	0	0	0	0	0	0	100	IV	Steady
2	38.9	1.0	0.39	0.18	0.18	0.131	0	25	75	0	0	0	0	II	Riffle
3	77.0	1.3	0.96	14.88	0.13	0.225	0	95	5	0	0	0	0	III	Cascade
4	6.4	1.4	0.09	- -	0.29	0.141	80	20	0	0	0	0	0	II	Steady
5	124.6	1.4	1.68	2.95	0.24	0.075	20	5	75	0	0	0	0	II	Riffle
6	173.4	1.8	3.04	9.06	0.13	0.651	8.3	21.7	53.4	13.3	3.3	0	0	III	Cascade
7	60.0	2.7	1.62	3.05	0.15	0.193	0	0	80	20	0	0	0	II	Riffle
8	106.5	2.7	2.86	3.21	0.25	0.041	40	47.5	12.5	0	0	0	0	IV	Pool
9	85.0	2.8	2.56	0.14	0.28	0.059	35	45	20	0	0	0	0	IV	Steady
Total	**731.8**		**13.81**												

[1] Be-Bedrock, B-Boulder, R-Rubble, C-Cobble, G-Gravel, S-Sand, D-Muck/Detritus
[2] Area calculations are based on calculations from all transects within a reach and not on mean wet width presented above.

The Beak habitat classification quantifies the stream as a total of 3.77 units of Type II (rearing), 4.00 units of Type III (migratory) and 6.03 units of Type IV (pool) habitat. The new Classification System identifies a total of 3.68 units of Riffle, 2.86 units of Pool, 3.25 units of Steady and 4.00 units of Cascade habitat types. Flows at the time of the survey were estimated at $0.15 m^3/s$, approximately three-times higher than the average mean monthly flow for June therefore the habitat units in the brook are considered conservative. However, as discussed in *Section 9.6.2* above, no adjustments to habitat areas has been applied.

Habitat Quantification

Habitat quantification has also been completed using both the Beak and the McCarthy *et al*. (2006) Habitat Classification system. The Beak quantification is the tally of all four habitat-types.

Species captured from each respective stream are included in the proposed habitat quantification. Brook trout were the only species captured in the nearby tributary (T1-1) and therefore these species were included in the quantification. The adult life-cycle stage accounted for the majority of all the brook trout utilization values, indicating that the stream has relatively low utilization as spawning habitat and is more suitable for use as rearing habitat. Table 9-14 presents a summary of each species life-cycle stage habitat suitability values and the calculated habitat equivalent units (HEU). Brook trout suitabilities give a total HEU of 11.75 units.

Table 9.14 Summary habitat suitability information for each species, Tributary T1-1-1. Bolded values are those brought forward for HEU calculations.

Reach #[1]	Habitat	Brook Trout				HEU
		Spawning	Young-of-Year	Juvenile	Adult	
1	Steady	0.50	0.00	**0.83**	0.50	0.50
2	Riffle	0.00	**1.00**	**1.00**	**1.00**	0.39
3	Cascade	0.53	0.92	**1.00**	0.92	0.96
4	Steady	0.00	0.60	0.60	**0.87**	0.08
5	Riffle	0.00	0.82	0.82	**0.88**	1.48
6	Cascade	0.53	0.90	0.90	**0.92**	2.80
7	Riffle	0.60	**1.00**	**1.00**	**1.00**	1.62
8	Pool	0.00	0.47	0.47	**0.60**	1.72
9	Steady	0.00	0.74	0.74	**0.86**	2.20
Total						**11.75**

[1] Reaches are numbered progressing upstream.

9.6.4. Tributary T2 (Sandy Brook)

Tributary T2 (Sandy Brook) is located just east of Rattling Brook and also drains to the south side of Long Harbour (*see* Figure 7-1). This watershed extends inland approximately 3.0km and contains one large waterbody; Sandy Pond (Pond P15) as well as two smaller ponds (Ponds P26 and P27). The drainage area of Sandy Brook is approximately $4.8km^2$ with approximately half of the drainage coming from the outflow of Sandy pond ($2.3km^2$). The stream is a total of 2,361m in length. The shoreline of Sandy Pond was traversed and no other inflow tributaries were identified. The stream is shown as intermittent on 1:50,000 topographic mapping however surveys were conducted after several days of steady rain and therefore the flows and wetted widths would be considered near summer full or bankfull flows.

The entire stream was surveyed on the ground using both the Beak and the McCarthy *et al*. (2006) Riverine Classification systems. Table 9-15 shows a summary of habitat characteristics for each identified stream reach. Detailed habitat measurements are presented in Appendix E. Photos of the stream are presented in Appendix F. The stream has very heavy riparian vegetation with large woody debris throughout the upper reaches. In fact, the large woody debris hindered slope measurements in mid-to-upper reaches. The stream has a total of two sections that were totally dry during the surveys. The flows appeared to go underground for a total of almost 500m in length (308m and 188m reaches). The stream also has at least five cascade sections which may be obstructions under most flows. One of the cascades is located upstream of the dry reaches. Brook trout and American eel were captured in this stream. The substrate composition is primarily of boulders and rubble throughout with some gravels and sand in the lower reaches of the stream. Species within the watershed are brook trout, rainbow smelt (*Osmerus mordax*) and American eel.

The natural hydrology of Sandy Brook has been established based on past records of nearby gauging stations (*see* Section 7.6). The data has been pro-rated for the Sandy Brook drainage basin. Figure 9-9 presents the hydrographs for a typical, dry and wet year. Figure 9-10 presents the flow duration curve. There is a small sub-tributary that drains from the East into Reach 21 of the main stem of Sandy Brook approximately 1.5km upstream from Long Harbour. This small sub-tributary is intermittent with no clear stream boundary as it connects to Sandy Brook. The pro-rated hydrology of the brook is presented below (Figure 9-11) which shows its low flows.

Despite its low flows, it is estimated to provide one-third the mean annual flow to Sandy Brook below its confluence. This tributary of Sandy Brook is not within the proposed footprint of the Project.

Riverine habitat surveys are typically conducted during mid-summer low flows; however heavy rains prior to the surveys caused flows of $0.23m^3/s$; approximately 2.5-times higher than the average mean monthly flow for June ($0.09m^3/s$) at the time of the survey. It should be noted that the low flows for Sandy Brook have been noted at $0.01m^3/s$ (Figure 9-10).

Table 9.15 Summary habitat information and habitat classifications, Tributary T2 (Stream S26).

Reach #	Length (m)	Mean Wet Width (m)	Area[2] (Units)	Mean Slope (%)	Mean Depth (m)	Mean Velocity (m/s)	Substrate (% coverage)[1]							Classification	
							Be	B	R	C	G	S	D	Beak	New
1	420.0	2.8	11.91	3.08	0.20	0.542	10.7	11.8	40.7	30.4	6.4	0	0	II	Riffle
2	60.0	4.7	2.79	8.71	0.17	0.678	0	10	25	40	25	0	0	III	Cascade
3	28.2	7.7	2.17	0.16	0.35	0.087	0	0	0	30	10	60	0	IV	Pool
4	60.0	2.9	1.71	4.58	0.20	1.084	5	5	50	40	0	0	0	III	Cascade
5	120.0	5.5	6.60	9.36	0.36	0.488	0	42.5	12.5	30	15	0	0	III	Cascade
6	60.0	3.8	2.25	2.84	0.17	0.293	10	15	15	35	25	0	0	II	Riffle
7	60.0	10.1	6.06	8.29	0.38	0.352	50	15	5	20	10	0	0	III	Cascade
8	60.0	3.6	2.16	3.04	0.21	0.576	0	5	5	30	60	0	0	II	Riffle
9	10.3	4.5	0.46	2.55	0.30	0.195	0	10	20	50	20	0	0	II	Steady
10	60.0	4.3	2.58	3.21	0.22	0.489	0	25	25	20	30	0	0	II	Riffle
11	60.0	2.5	1.50	3.73	0.21	0.875	0	45	10	35	10	0	0	III	Rapid
12	55.2	6.9	3.81	0.21	0.28	0.113	20	30	30	20	0	0	0	IV	Steady
13	25.5	4.8	1.26	0.13	0.30	0.027	0	60	0	5	0	20	15	IV	Pool
14	11.6	3.2	0.37	4.62	0.42	0.084	0	60	15	5	0	20	0	III	Cascade
15	23.0	3.4	7.9	0.18	0.29	0.103	0	60	15	5	0	20	0	II	Steady
16	48.9	4.4	1.88	4.18	0.33	0.135	10	65	15	0	0	10	0	III	Cascade
17	26.0	12.1	3.15	- -	0.15	0.209	10	65	15	0	0	10	0	IV	Steady
18	41.1	3.6	1.47	2.44	0.17	0.212	0	70	15	5	0.5	9.5	0	II	Riffle
19	10.0	3.0	0.30	- -	0.15	0.103	0	0	40	30	10	20	0	II	Steady
20	160.0	3.4	5.44	- -	0.21	0.300	0	100	0	0	0	0	0	III	Riffle
21	135.0	9.8	13.19	- -	0.39	0.000	0	45	25	15	5	10	0	IV	Pool
22	92.0	6.3	6.34	- -	0.59	0.037	0	53.3	0	0	0	6.7	40	IV	Steady
23	16.8	2.8	0.53	1.49	0.12	0.062	0	56.3	7.7	15	1	0	20	- -	- -
24	309.0	Dry	- -	53.17	- -	- -	0	100	0	0	0	0	0	- -	Dry
25	16.9	1.5	0.25	0.83	0.22	0.053	0	40	50	0	0	0	10	III	Riffle
26	188.0	Dry	- -	- -	- -	- -	0	100		0	0	0	0	- -	Dry
27	67.1	5.6	3.76	1.43	0.08	- -	0	65	30	5	0	0	0	- -	- -

Reach #	Length (m)	Mean Wet Width (m)	Area[2] (Units)	Mean Slope (%)	Mean Depth (m)	Mean Velocity (m/s)	Substrate (% coverage)[1]							Classification	
							Be	B	R	C	G	S	D	Beak	New
28	19.9	3.8	0.80	0.26	0.28	0.074	0	65	30	5	0	0	0	II	Steady
29	13.0	1.7	0.21	- -	0.11	0.287	0	80	15	5	0	0	0	II	Riffle
30	76.5	2.2	1.57	5.33	0.23	0.146	12.5	62.5	13.7	1.3	0	0	10	III	Cascade
31	27.8	3.15	1.10	3.60	0.22	0.205	20	40	20	0	0	0	20	II	Run
Total	**2,361.7**		**86.43**												

[1] Be-Bedrock, B-Boulder, R-Rubble, C-Cobble, G-Gravel, S-Sand, D-Muck/Detritus

[2] Area calculations are based on calculations from all transects within a reach and not on mean wet width presented above.

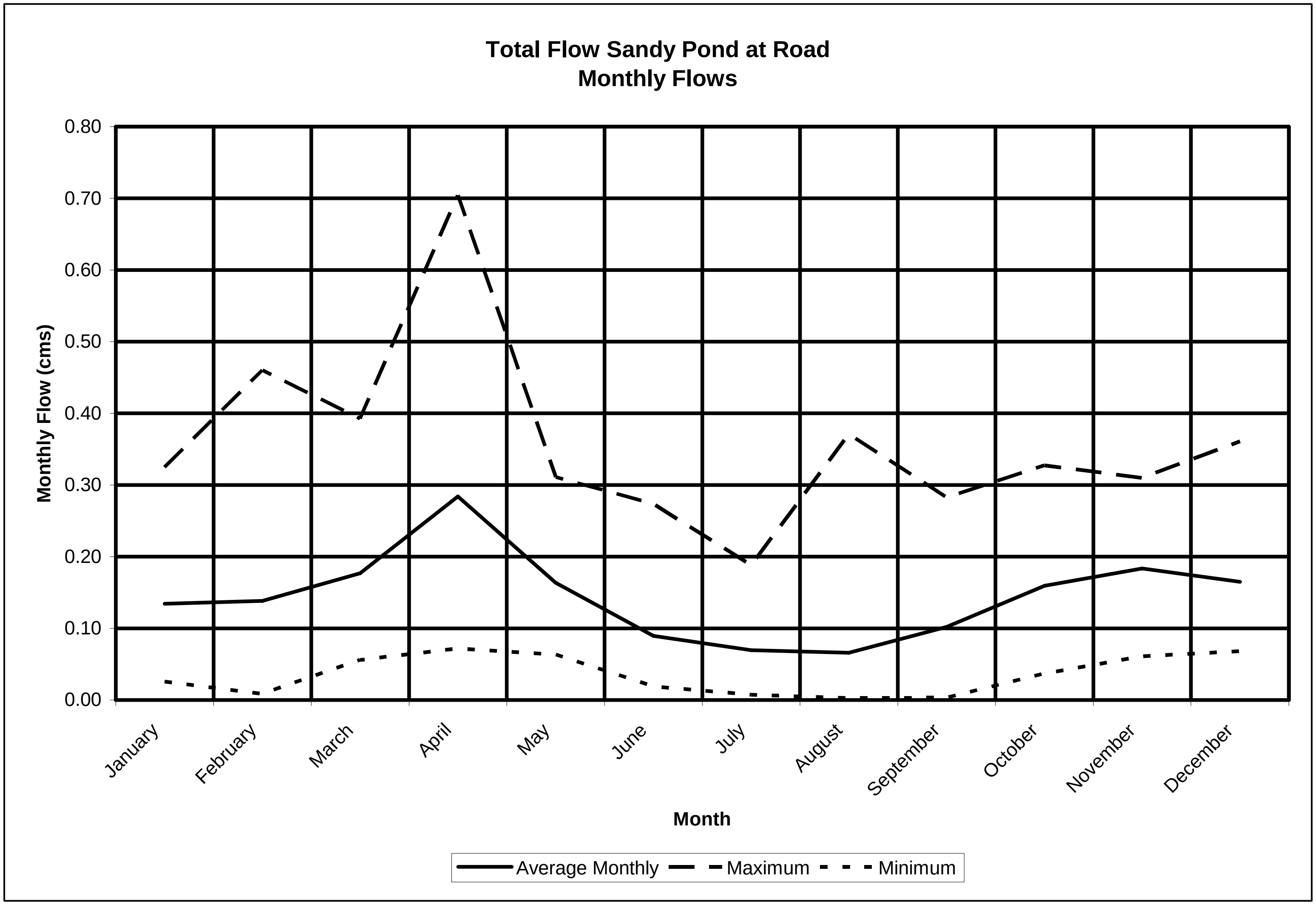

Figure 9.9 Hydrographs (typical, wet and dry year), Sandy Brook outflow.

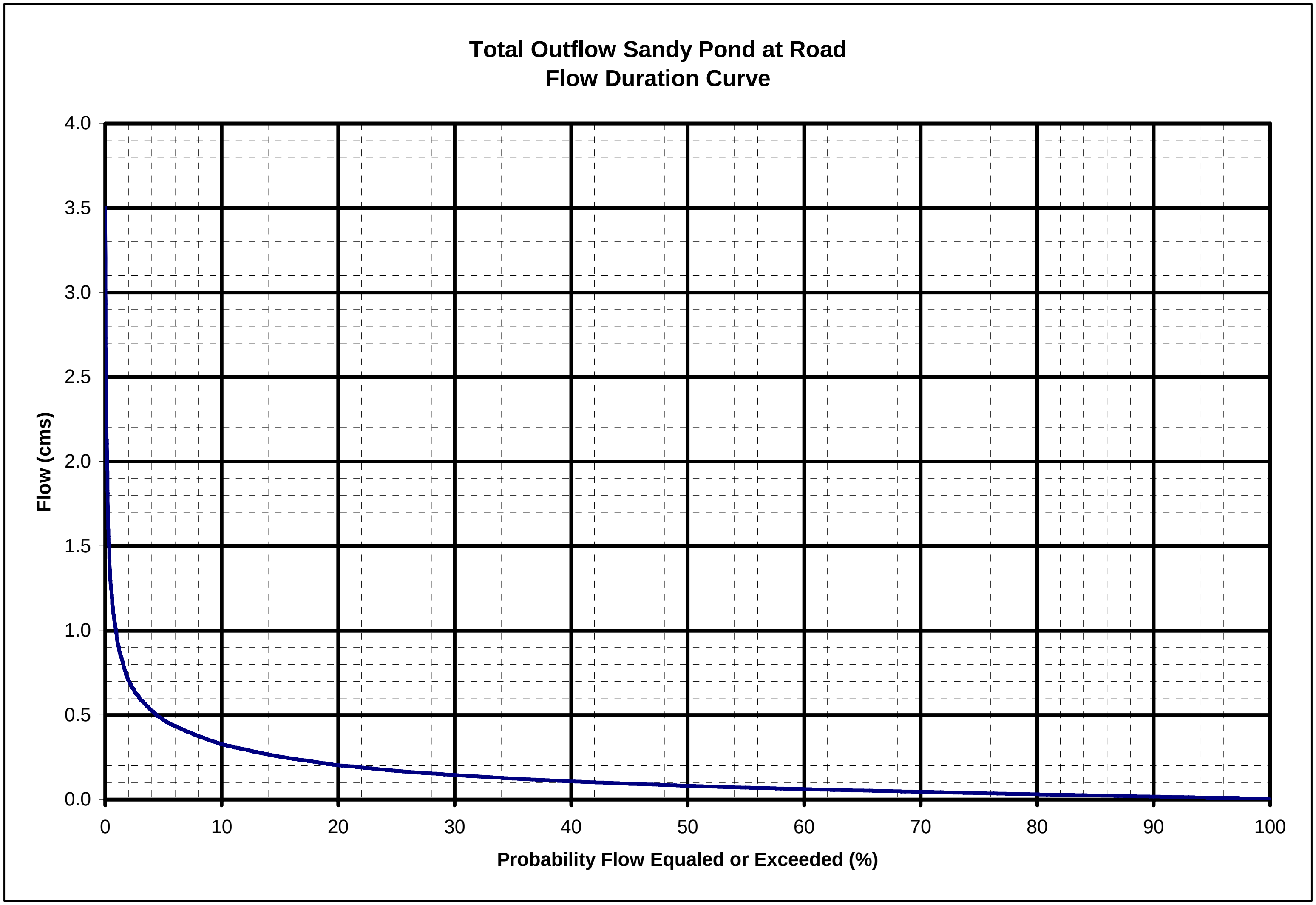

Figure 9.10 Flow duration curve, Sandy Brook outflow.

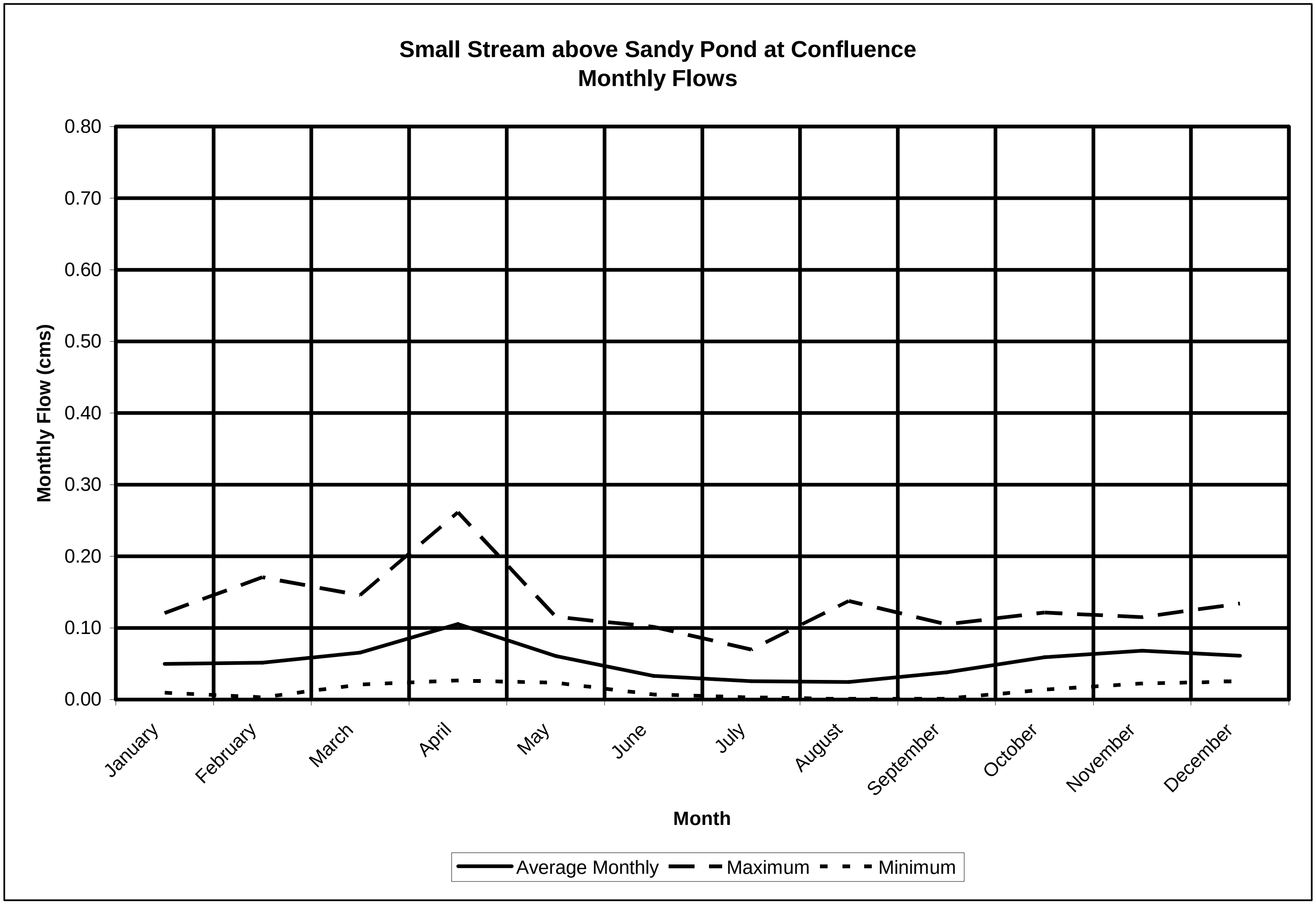

Figure 9.11 Hydrographs (typical, wet and dry year), Sandy Brook tributary.

As a result, the habitat units measured in the brook are considered conservative (i.e. overestimated). An assessment of the relative overestimation of habitat area was conducted on several of the stream reach transects which were considered typical of the stream shape (Transects Four and Six) in order to determine whether an adjustment of the habitat units could be warranted. Assessment was conducted using a similar modelling exercise as that outlined in Section 6.5. Due to the relative slope of the shorelines, a reduction in flow to approximately $0.09m^3/s$ would reduce the wetted width of the transects by 30%. It should be noted that the reduction in flow to the June mean monthly value would also decrease mean water levels between 0.05 and 0.1m. This reduced wetted width was used to conservatively reduce the habitat area calculations by 30% overall. It was not used to reduce or adjust the suitability of the habitats.

Table 9-15 presents a summary of habitat characteristics measured as well as the habitat classification in both the Beak and new Riverine Classification. The Beak habitat classification quantifies the river as a total of 22.94 units (**adjusted to 18.55**) of Type II (rearing), 28.18 units (**adjusted to 19.73**) of Type III (migratory) and 26.5 units (**adjusted to 18.55**) of Type IV (pool) habitat. The new Classification System identifies a total of 26.28 units (**adjusted to 18.40**) of Riffle, 16.63 units (**adjusted to 11.64**) of Pool, 1.50 units (**adjusted to 1.05**) of Rapid, 15.65 units (**adjusted to 10.96**) of Steady, 20.98 units (**adjusted to 14.69**) of Cascade and 1.10 units (**adjusted to 0.77**) of Run habitat types. There was also 4.28 (**adjusted to 3.00**) units of habitat that were unclassified (Reaches 24 and 27) with trace quantities of water flowing through large substrate just upstream and downstream of where flows moved underground.

Habitat Quantification

Habitat quantification has also been completed using both the Beak and the new Habitat Classification system. The Beak quantification is the tally of all similar habitat-type units.

Species captured from each respective stream are included in the proposed habitat quantification. Both brook trout and American eel were captured in Stream S26 therefore these species were included in the quantification. The juvenile and adult life-cycle stages accounted for all brook trout utilization values. Only American eel juveniles are used for riverine utilization value calculations. Table 9-16 presents a summary of each species life-cycle stage habitat suitability values. Table 9-17 presents the calculated habitat equivalent units (HEU) for each species. Brook trout gives the greatest total HEU with 66.54 units (**adjusted to 46.58**). American eel give a total HEU of 61.20 units (**adjusted to 42.84**).

Table 9.16 Summary habitat suitability information for each species, Tributary T2. Bolded values are those brought forward for HEU calculations.

Reach #[3]	Habitat	Brook Trout				American Eel[1]
		Spawning	Young-of-Year	Juvenile	Adult	Juvenile
1	Riffle	0.61	0.71	**0.95**	0.74	**0.57**
2	Cascade	0.83	0.00	**1.00**	0.00	**0.52**
3	Pool	**0.83**	0.63	**0.83**	0.73	**0.47**
4	Cascade	0.37	0.00	**0.98**	0.0	**0.55**
5	Cascade	0.64	0.75	**1.00**	0.75	**0.65**
6	Riffle	0.80	0.95	0.95	**0.99**	**0.47**
7	Cascade	0.65	0.58	**0.75**	**0.75**	**0.27**
8	Riffle	0.78	0.83	**1.00**	0.83	**0.50**
9	Steady	0.85	**1.00**	**1.00**	**1.00**	**0.43**
10	Riffle	0.75	0.67	**1.00**	0.83	**0.70**
11	Rapid	0.56	0.67	**1.00**	0.67	**0.62**
12	Steady	0.60	0.90	0.90	**0.97**	**0.60**
13	Pool	0.32	0.53	**0.67**	0.58	**0.88**
14	Cascade	0.63	**1.00**	**1.00**	**1.00**	**0.88**
15	Steady	0.46	**0.83**	**0.83**	**0.83**	**0.88**
16	Cascade	0.47	0.83	0.87	**0.88**	**0.87**
17	Steady	0.55	0.92	0.95	**0.97**	**0.87**
18	Riffle	0.35	0.67	**0.80**	0.69	**0.92**
19	Steady	0.80	0.94	**1.00**	0.97	**0.60**
20	Riffle	0.00	**1.00**	**1.00**	**1.00**	**1.00**
21	Pool	**0.00**	**0.00**	**0.00**	**0.00**	**0.80**
22	Steady	0.16	0.34	**0.75**	0.41	**0.98**
23	- -	0.28	0.57	**0.67**	0.60	**0.85**
24	Dry	- -	- -	- -	- -	- -
25	Riffle	0.52	0.95	**1.00**	0.97	**1.00**
26	Dry	- -	- -	- -	- -	- -
27	- -	0.05[2]	**1.00**	**1.00**	**1.00**	**0.95**
28	Steady	0.30	**0.78**	**0.78**	**0.78**	**0.95**
29	Riffle	0.53	0.83	**1.00**	**1.00**	**0.95**
30	Cascade	0.43	0.69	**0.84**	0.75	**0.86**
31	Run	0.41	0.55	**0.78**	0.65	**0.80**

[1] American eel values are based on substrate preference criteria only.
[2] Shaded brook trout cell values are based on only substrate preference criteria.
[3] Reaches are numbered progressing upstream.

Table 9.17 Summary habitat suitability information and habitat equivalent units, Tributary T2.

Reach #	Units ($100m^2$)	Brook Trout		American Eel		Classification	
		Overall Habitat Suitability	HEU	Overall Habitat Suitability	HEU	Beak	New
1	11.91	0.95	11.31	0.57	6.79	II	Riffle
2	2.79	1.00	2.79	0.52	1.45	III	Cascade
3	2.17	0.83	1.80	0.47	1.02	IV	Pool
4	1.71	0.98	1.67	0.55	0.94	III	Cascade
5	6.60	1.00	6.60	0.65	4.29	III	Cascade
6	2.25	0.99	2.23	0.47	1.06	II	Riffle
7	6.06	0.75	4.55	0.27	1.64	III	Cascade
8	2.16	1.00	2.16	0.50	1.08	II	Riffle
9	0.46	1.00	0.46	0.43	0.20	II	Steady
10	2.58	0.83	2.14	0.70	1.81	II	Riffle
11	1.50	1.00	1.50	0.62	0.93	III	Rapid
12	3.81	0.97	3.70	0.60	2.29	IV	Steady
13	1.26	0.67	0.84	0.88	1.11	IV	Pool
14	0.37	1.00	0.37	0.88	0.33	III	Cascade
15	0.78	0.83	0.65	0.88	0.69	II	Steady
16	1.88	0.88	1.65	0.87	1.64	III	Cascade
17	3.15	0.97	3.06	0.87	2.74	IV	Steady
18	1.47	0.80	1.18	0.92	1.35	II	Riffle
19	0.30	1.00	0.30	0.60	0.18	II	Steady
20	5.44	1.00	5.44	1.00	5.44	III	Riffle
21	13.19	0.00	0.00	0.80	10.55	IV	Pool
22	6.34	0.75	4.76	0.98	6.21	IV	Steady
23	0.53	0.67	0.36	0.85	0.45	- -	- -
24	- -	- -	- -	- -	- -	- -	Dry
25	0.25	1.00	0.25	1.00	0.25	III	Riffle
26	- -	- -	- -	- -	- -	- -	Dry
27	3.76	1.00	3.76	0.95	3.57	- -	- -
28	0.80	0.78	0.62	0.95	0.76	II	Steady
29	0.21	1.00	0.21	0.95	0.20	II	Riffle
30	1.57	0.84	1.32	0.86	1.35	III	Cascade
31	1.10	0.78	0.86	0.80	0.88	II	Run
Total	**86.43**		**66.54**		**61.20**		

9.6.5. Tributary T3 (Little Rattling Brook)

Little Rattling Brook (T3) is located to the west of Rattling Brook and drains to Ship Harbour (Figure 5-1). This small watershed (approximately 8.55km^2) is identified as intermittent near the proposed processing plant site. If the Matte processing plant becomes the preferred option, a dry residue storage area may be within one of the small headwater drainages (total drainage estimated at 0.73km^2).

Field surveys in 2005-6 were limited to water quality sampling. Past DFO surveys indicate the brook is approximately 1.6km in length and has a complete obstruction approximately 500m upstream from Ship Harbour (Porter *et al.* 1974). Therefore anadromous species would not be present. The pro-rated hydrology of the brook presented below (Figure 9-12) shows its intermittent nature in summer low flow periods. Unless a Matte processing facility is selected, this watershed would not be affected by the proposed processing facilities. If any portion of the Project has the potential to impact the aquatic environment in this area, an assessment (i.e. habitat classification/quantification) will be completed.

9.7. Productivity Estimate

Table 9-18 presents the mean standing stock estimates of all species from the representative electrofishing stations in the Project area. Appendix G presents all completed electrofishing survey sheets. While all fish captured were measured, a sub-sample of each species was weighed and a length-weight regression established to determine total biomass within each habitat. Figures 9-13 to 9-15 present the length-weight relationship for those brook trout captured in each of the three streams; T1 (S20 - Rattling Brook), T1-1 (S30 – Beaver Brook) and T2 (S26 - Sandy Brook) respectively. A statistical comparison of the length-weight regressions (i.e. comparison of the log-log 95% CI of the regression slopes) indicates that the length-weight relationships in all three brooks are not significantly different.

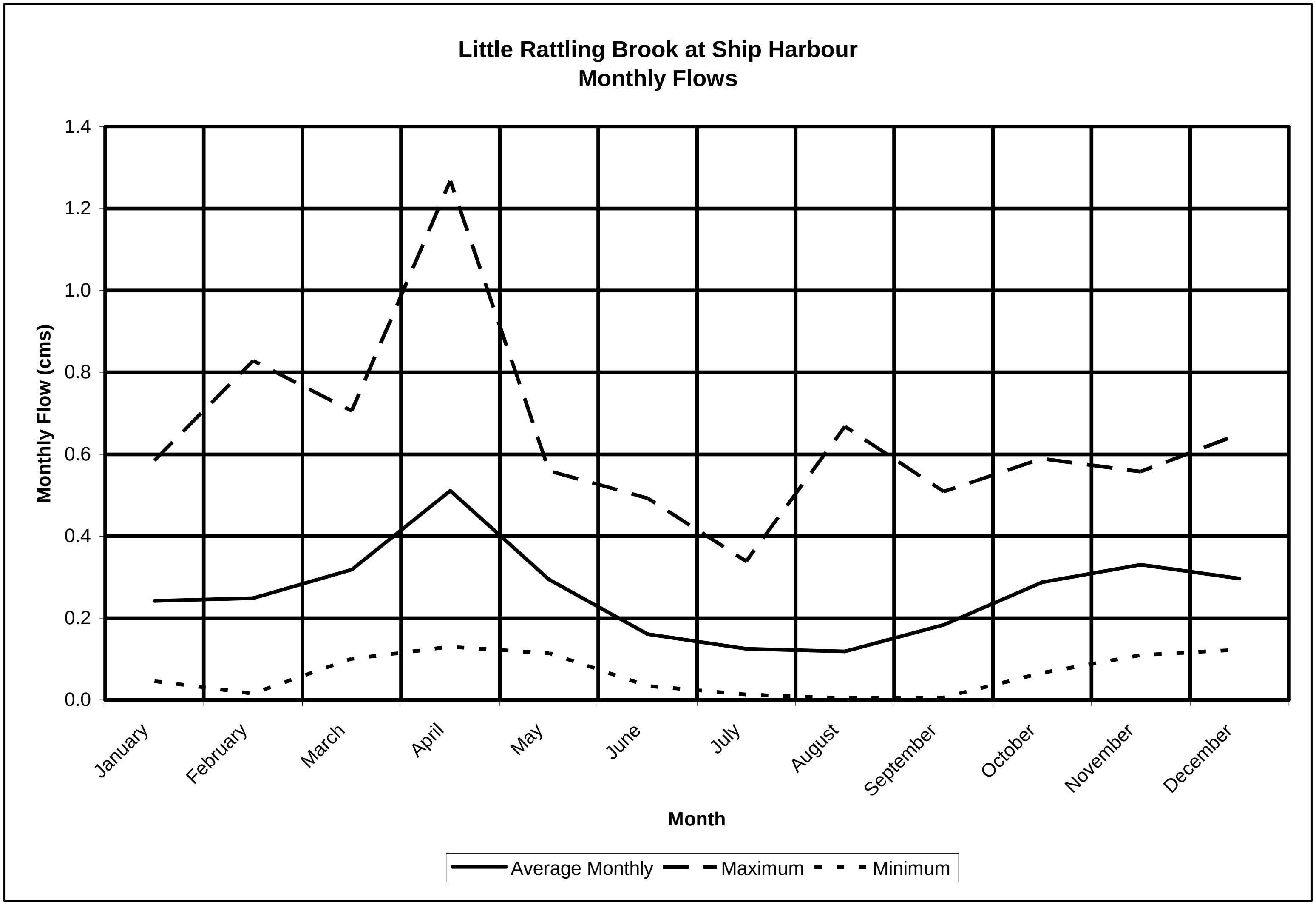

Figure 9.12 Hydrographs (typical, wet and dry year), Little Rattling Brook outflow.

Table 9.18 Summary of standing stock and biomass estimates for electrofishing stations, Long Harbour, July 2006.

Station (habitat type)	Area (m^2)	Species	Pop. Est./Unit (N/unit)	95% Confidence Limits (N/unit)		Biomass/area estimate (gm/unit)
				Lower[1]	Upper[2]	
Stn 1 Rattling Brook (Reach T1#21 Steady)	94.5	Brook Trout Am. Eel	48.68 0	40.21 - -	63.93 - -	847.0 0.0
Stn 3 Rattling Brook (Reach T1#22 Run)	103.5	Brook Trout Am. Eel	55.07 0	30.92 - -	113.43 - -	633.3 0.0
Stn 4 Rattling Brook (Reach T1#23 Steady)	115.5	Brook Trout Am. Eel	47.62 0	39.44 - -	63.26 - -	295.2 0.0
Stn 6 Rattling Brook (Reach T1#10 Riffle)	110.2	Brook Trout Am. Eel	9.98 2[3]	9.98 - -	10.40 - -	178.6 163.2
Stn 11 Rattling Brook (Reach T1#21 Steady)	150.6	Brook Trout Am. Eel	24.57 0	20.58 - -	32.74 - -	412.8 0.0
Stn 2 Rattling Brook (Reach T1#23-24Rapids/Pool)	Index	Brook Trout Am. Eel	29[3] 0	- - - -	- - - -	- - - -
Stn 5 Rattling Brook (Reach T1#12 Steady)	Index	Brook Trout Am. Eel	0 1[3]	- - - -	- - - -	- - - -
Stn 7 Rattling Brook (Reach T1#14 Pool)	Index	Brook Trout Am. Eel	0 3[3]	- - - -	- - - -	- - - -
Stn 15 Rattling Brook (Reach T1#33 Riffle)	Index	Brook Trout Am. Eel	5[3] 0	- - - -	- - - -	- - - -
Stn 16 Rattling Brook (Reach T1#33 Riffle)	Index	Brook Trout Am. Eel	25[3] 0	- - - -	- - - -	- - - -
Stn 17 Rattling Brook (Reach T1#37 Riffle)	Index	Brook Trout Am. Eel	48[3] 0	- - - -	- - - -	- - - -
Stn 18 Rattling Brook (Reach T1#40 Run)	Index	Brook Trout Am. Eel	29[3] 0	- - - -	- - - -	- - - -
Stn 8 Beaver Brook (Reach T1-1#6 Riffle)	78.4	Brook Trout Am. Eel	15.31 0	15.31 - -	15.51 - -	352.1 0.0
Stn 14 Beaver Brook (Reach T1-1#7 Steady)	74.8	Brook Trout Am. Eel	34.76 0	33.42 - -	39.60 - -	684.8 0.0
Stn 9 Sandy Brook (Reach T2#27 Riffle)	84.5	Brook Trout Am. Eel	124.23 0	120.68 - -	130.16 - -	2,062.2 0.0
Stn 10 Sandy Brook (Reach T2#28-29 Steady/Riffle)	156.2	Brook Trout Am. Eel	53.14 1[3]	51.22 - -	56.51 - -	441.1 33.8
Stn 12 Sandy Brook (Reach T2#22 Steady)	Index	Brook Trout Am. Eel	15[3] 0	- - - -	- - - -	- - - -
Stn 13 Sandy Brook (Reach T2#22 Steady)	Index	Brook Trout Am. Eel	5[3] 0	- - - -	- - - -	- - - -

[1] Lower Confidence Limit (LCL). The lower confidence limit is equal to the number of fish actually caught/unit.
[2] Upper Confidence Limit (UCL).
[3] Number based on those captured (sample too small to calculate estimate or was an Index site).

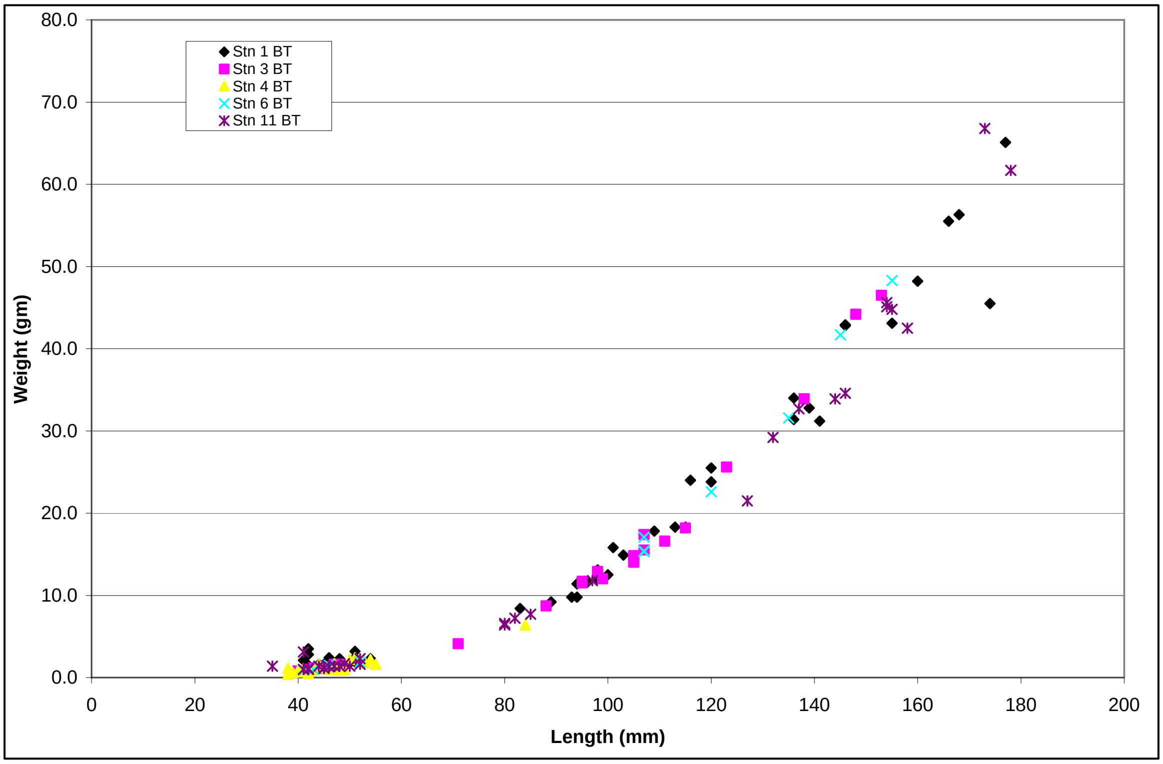

Figure 9.13 Length-weight relationship, brook trout, T1 (Rattling Brook), 2006.

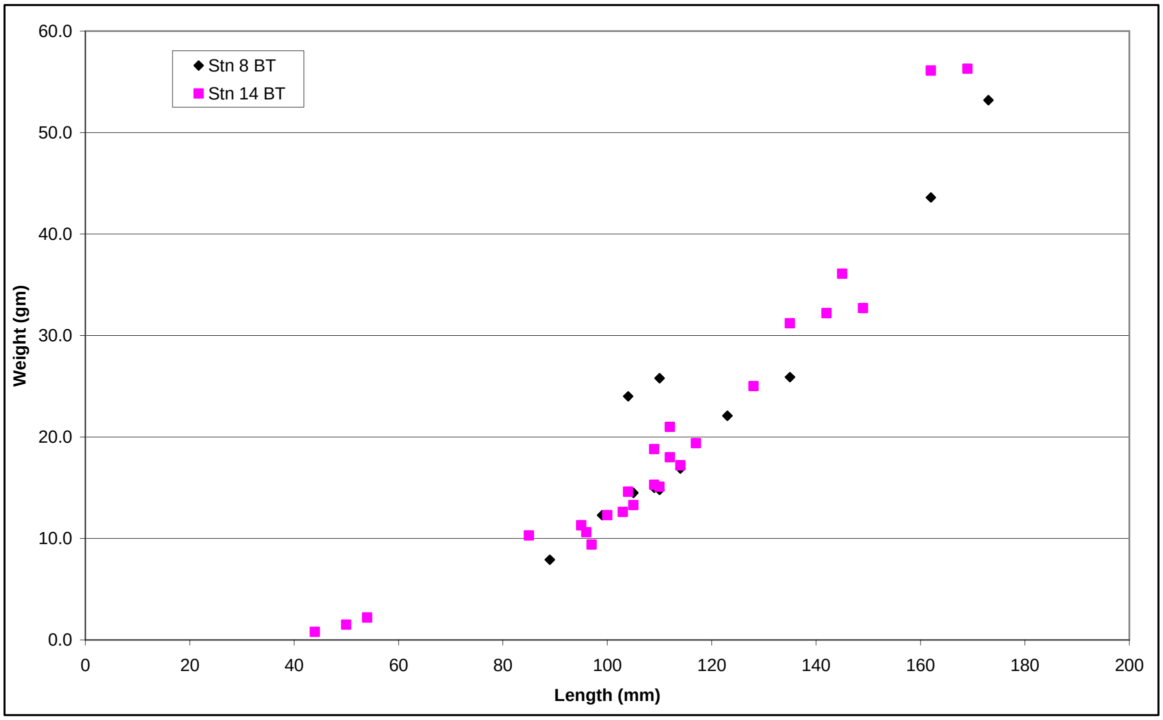

Figure 9.14 Length-weight relationship, brook trout, T1-1 (Beaver Brook), 2006.

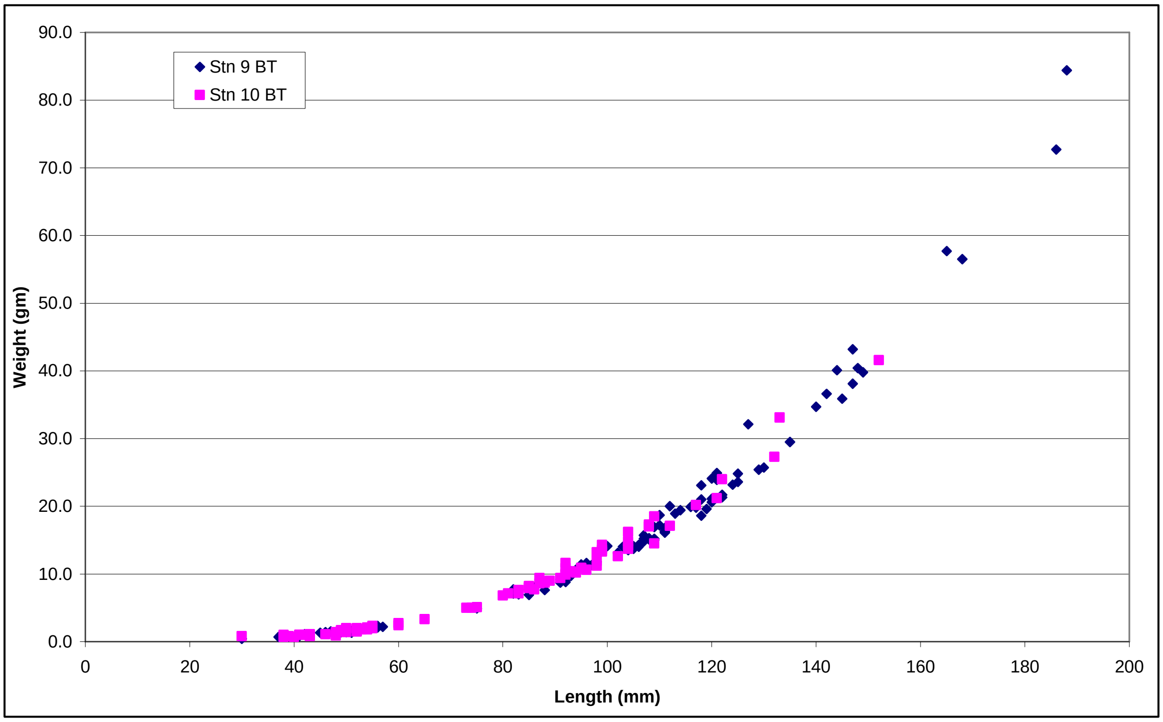

Figure 9.15 Length-weight relationship, brook trout, T2 (Sandy Pond outflow), 2006.

9.8. Riverine Spawning Utilization

Tracking of radio tagged individuals was initiated when spawning behaviors were observed in Rattling Brook (i.e. pairing, aggression, redd digging and/or holding positions over gravels). These behaviors were recorded on the week of September 18, 2006. Large numbers of brook trout were observed over the gravel substrates at the lower end of Reach 20 (Riffle) below the second bridge on Rattling Brook as well as at Reach 36 (Riffle) at the inflow to a small pond on September 24, 2006. Each location had an estimate of 60 and 15 brook trout respectively. The entire length of Rattling Brook, as well as most of the sub-tributaries, was surveyed by ground with a radio receiver. Tracking did not detect any tags within any section of Rattling Brook. The only tag detected (code 47) was in Rattling Brook Big Pond approximately 300m off the boat launch. Aerial surveys were conducted on September 28. During this survey, the entire drainage basin was surveyed. The helicopter traveled over all inflow and outflow tributaries at a speed of less than 25km/hr at a height of less than 60m elevation. A total of eight radio tags were detected. Of these, none were detected within any section of the outflow of Rattling Brook Big Pond. Two tags (codes 35 and 43) were recorded in the inflow tributaries of Rattling Brook Big Pond and six tags (codes 39, 50, 46, 48, 49 and 47) were recorded within Rattling Brook Big Pond itself (code 49 was in the pond but near the mouth of an inflow tributary). Of those in the pond, four were detected near shore and two were detected in the centre of the pond.

The tags near shore were in areas with identified gravels and hence may be an indication of nearshore spawning. Due to the depth of the pond and the inability of the radio receiver to detect radio signals from tags greater than 20m in depth, it is reasonable to assume that the two radio tags identified in the middle of Rattling Brook Big Pond were within the upper 20m of the water column.

9.9. Stable Isotope Analysis

Table 9-20 presents the results of stable isotope analysis. A comparison of the marine signature provided from winter flounder samples and those of brook trout and rainbow smelt of Sandy Pond indicate that all fish analyzed from Sandy Pond are resident and non-anadromous.

9.10. Wetted Perimeter Assessment

The level of detail required (i.e. Wetted Perimeter) was derived from a review provided by Gosse *et a.l* (2002) called "*A Common Approach to Understanding and Addressing Instream Flow Needs in Newfoundland and Labrador*" which outlines the level of assessment required for water extractions based on various parameters and characteristics of the Project and fish in the area. Based on the project complexity, resource value and impact level on flow, Standard Setting of Fixed Flow analysis (i.e. Tennant or Wetted Perimeter) was suggested as an appropriate level of detail. In this respect, the more detailed of the two methods was completed (i.e. Wetted Perimeter). The WPM results are presented in Appendix A. Table 9-19 presents the point of inflection for each transect and the corresponding discharge value. While the measured cross section of each transect would be valid for all flows, the points of inflection are based on simulated flows at various water levels using only one field data survey. Therefore a cautionary approach should be employed when determining an appropriate point of inflection.

As stated previously, transects were selected to represent habitat types that would represent habitat most likely affected by water extraction first, i.e. relatively wide, shallow habitat with a high proportion of gravels. The combined results of the three transects indicates that a minimum flow of 0.30-0.35m^3/s would satisfy the transect areas selected.

Table 9.19 Summary of transect points of inflection and related discharges.

Transect #	Estimated Discharge at Point of Inflection (m^3/s)	Estimated Wetted Perimeter (m) at Point of Inflection	Wetted Perimeter (m) at Time of Survey
1 (Riffle)	0.128	18.5	25.5
2 (Run)	0.070	4.5	7.8
3 (Riffle)	0.313	5.4	7.9

Table 9.20 Stable Isotope Results, Sandy Pond, 2006.

ID#	Species	SINLAB ID	Date	Line	Amount	CO2 Ampl	N2 Ampl	d13C	d15N	%C	%N	C/N
001	Rainbow Smelt	JMC 044	13-Dec-06	20	0.221	2.508	2.732	-26.96	8.91	48.04	13.99	3.43
001	Rainbow Smelt	JMC 044 R	13-Dec-06	32	0.220	2.584	2.896	-27.27	8.96	49.53	14.87	3.33
002	Rainbow Smelt	JMC 045	13-Dec-06	21	0.206	1.946	2.198	-27.71	8.40	40.12	12.15	3.30
003	Rainbow Smelt	JMC 046	13-Dec-06	22	0.219	2.649	2.686	-27.94	8.31	51.18	13.93	3.67
101	Rainbow Smelt	JMC 047	13-Dec-06	23	0.213	2.487	2.796	-27.16	9.08	49.32	14.88	3.32
102	Rainbow Smelt	JMC 048	13-Dec-06	24	0.188	2.104	2.432	-26.75	8.37	47.37	14.69	3.22
103	Rainbow Smelt	JMC 049	13-Dec-06	25	0.209	2.400	2.694	-27.34	8.71	48.52	14.63	3.32
104	Rainbow Smelt	JMC 050	13-Dec-06	26	0.210	2.528	2.824	-27.56	8.85	50.72	15.20	3.34
105	Rainbow Smelt	JMC 051	13-Dec-06	27	0.211	2.426	2.763	-26.71	8.82	48.50	14.83	3.27
106	Rainbow Smelt	JMC 052	13-Dec-06	28	0.204	2.506	2.755	-27.86	9.31	51.83	15.31	3.38
107	Rainbow Smelt	JMC 053	13-Dec-06	29	0.192	2.287	2.642	-27.46	8.24	50.24	15.55	3.23
108	Rainbow Smelt	JMC 054	13-Dec-06	30	0.205	2.435	2.807	-27.27	8.64	50.04	15.47	3.23
109	Rainbow Smelt	JMC 055	13-Dec-06	31	0.214	2.495	2.878	-27.31	8.60	49.01	15.13	3.24
110	Rainbow Smelt	JMC 056	13-Dec-06	38	0.227	2.654	2.917	-27.39	8.87	49.24	14.53	3.39
110	Rainbow Smelt	JMC 056 R	13-Dec-06	52	0.217	2.645	2.905	-27.42	8.92	51.41	15.12	3.40
111	Rainbow Smelt	JMC 057	13-Dec-06	39	0.198	2.429	2.665	-27.77	8.65	51.80	15.28	3.39
112	Brook Trout	JMC 058	13-Dec-06	40	0.233	2.754	3.045	-25.63	7.18	49.68	14.70	3.38
113	Brook Trout	JMC 059	13-Dec-06	41	0.199	2.371	2.345	-26.29	7.04	50.35	13.39	3.76
004	Rainbow Smelt	JMC 060	13-Dec-06	42	0.194	2.350	2.583	-28.19	7.77	51.19	15.09	3.39
005	Rainbow Smelt	JMC 061	13-Dec-06	43	0.206	2.508	2.720	-27.57	9.07	51.60	15.03	3.43
006	Rainbow Smelt	JMC 062	13-Dec-06	44	0.233	2.877	2.768	-28.91	8.27	52.13	13.44	3.88
007	Rainbow Smelt	JMC 063	13-Dec-06	45	0.196	2.272	2.654	-27.62	8.49	48.95	15.28	3.20
009	Rainbow Smelt	JMC 064	13-Dec-06	46	0.215	2.749	3.145	-27.95	8.05	53.96	16.54	3.26
BT001	Brook Trout	JMC 065	13-Dec-06	47	0.189	2.021	2.055	-26.72	6.94	45.26	12.35	3.66
BT002	Brook Trout	JMC 066	13-Dec-06	48	0.199	1.646	1.720	-25.66	8.28	35.12	9.84	3.57
BT003	Brook Trout	JMC 067	13-Dec-06	49	0.195	2.216	2.385	-25.84	8.59	48.10	13.92	3.46
BT004	Brook Trout	JMC 068	13-Dec-06	50	0.211	2.088	2.230	-24.81	8.90	41.86	11.96	3.50
BT005	Brook Trout	JMC 069	13-Dec-06	51	0.226	2.322	2.459	-25.50	9.51	43.39	12.33	3.52
BT006	Brook Trout	JMC 070	13-Dec-06	57	0.222	2.461	2.842	-25.04	7.88	46.76	14.48	3.23
BT006	Brook Trout	JMC 070 R	13-Dec-06	74	0.187	2.137	2.456	-24.89	8.01	48.35	14.88	3.25
BT091	Brook Trout	JMC 071	13-Dec-06	58	0.213	2.345	2.729	-25.85	11.04	46.49	14.48	3.21
Ref-01	Winter Flounder	JMC 072	13-Dec-06	59	0.206	2.425	2.513	-18.97	14.32	49.64	13.75	3.61
Ref-02	Winter Flounder	JMC 073	13-Dec-06	60	0.207	2.240	2.388	-18.82	15.42	45.67	13.05	3.50
Ref-03	Winter Flounder	JMC 074	13-Dec-06	61	0.216	2.471	2.709	-17.93	14.84	48.26	14.18	3.40
Ref-04	Winter Flounder	JMC 075	13-Dec-06	62	0.215	2.350	2.598	-18.26	15.08	46.13	13.69	3.37
Ref-05	Winter Flounder	JMC 076	13-Dec-06	63	0.205	2.472	2.644	-18.49	14.70	50.88	14.60	3.48
Ref-06	Winter Flounder	JMC 077	13-Dec-06	64	0.180	2.202	1.870	-19.76	14.66	51.73	11.79	4.39
Ref-07	Winter Flounder	JMC 078	13-Dec-06	65	0.215	2.644	2.390	-19.87	15.27	51.73	12.53	4.13
Ref-08	Winter Flounder	JMC 079	13-Dec-06	66	0.214	2.308	2.216	-19.45	14.71	45.56	11.74	3.88
Ref-09	Winter Flounder	JMC 080	13-Dec-06	67	0.204	2.583	1.975	-20.77	14.96	53.34	10.94	4.88
Ref-10	Winter Flounder	JMC 081	13-Dec-06	68	0.244	2.981	1.223	-22.76	14.33	51.43	5.67	9.06
Ref-11	Winter Flounder	JMC 082	13-Dec-06	69	0.190	1.994	2.047	-19.21	13.47	44.43	12.20	3.64
Ref-12	Winter Flounder	JMC 083	13-Dec-06	70	0.193	2.402	1.804	-20.29	14.61	52.59	10.60	4.96
Ref-13	Winter Flounder	JMC 084	13-Dec-06	71	0.206	3.085	1.420	-22.71	15.33	63.09	7.80	8.09
Ref-14	Winter Flounder	JMC 085	13-Dec-06	72	0.195	2.349	1.465	-21.58	15.30	50.82	8.50	5.98
Ref-15	Winter Flounder	JMC 086	13-Dec-06	73	0.228	3.144	1.882	-21.33	14.59	57.95	9.31	6.23
Ref-16	Winter Flounder	JMC 087	13-Dec-06	75	0.230	2.592	2.415	-19.74	14.68	47.49	11.83	4.01
Ref-17	Winter Flounder	JMC 088	13-Dec-06	76	0.221	2.872	2.048	-20.86	15.00	54.73	10.46	5.23
Ref-18	Winter Flounder	JMC 089	13-Dec-06	77	0.220	2.978	2.277	-20.48	14.74	57.03	11.71	4.87

9.11. Lacustrine Habitat Classification/Quantification

The lacustrine habitat classification and quantification of ponds within and near the potential Project area are described below.

9.11.1. Pond P8 – Rattling Brook Big Pond

Fish Species Present

A total of 2 fyke nets (12 net-nights) and 48 hours of angling were deployed/completed throughout the pond over a period of six days. Brook trout and Arctic charr (*Salvelinus alpinus*) were captured. Brook trout captured ranged from 80-260mm in length while only one Arctic charr was captured (160mm in length).

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 3.6m. The maximum depth measured in Pond P8 was 36m. Pond P8 comprises 189.29ha; of which 83.10ha is littoral and 106.19ha is profundal. Figure 9-16 presents the bathymetric contours of Pond P8 as modeled from the data. Figure 9-17 presents the Littoral and Profundal areas of Pond P8.

Substrate Composition

Substrate composition of both the littoral and profundal zones were conducted and used in the DFO spreadsheet to calculate aerial extents and habitat equivalent units. These calculations are provided later in this section. The pond has a shoreline comprising a majority of boulder, bedrock and rubble with the deeper zones comprised of muck (organics and detritus). The overall composition of each substrate type (m^2) is outlined below:

	Littoral	Profundal
o Bedrock	17,470.63	
o Boulder	302,691.76	
o Rubble	51,708.33	
o Cobble	27,650.55	
o Gravel	4,604.69	
o Sand		
o Muck/Detritus (organic)	396,378.32	1,061,868
o **Total**	**800,504.28**	**1,061,868.00**

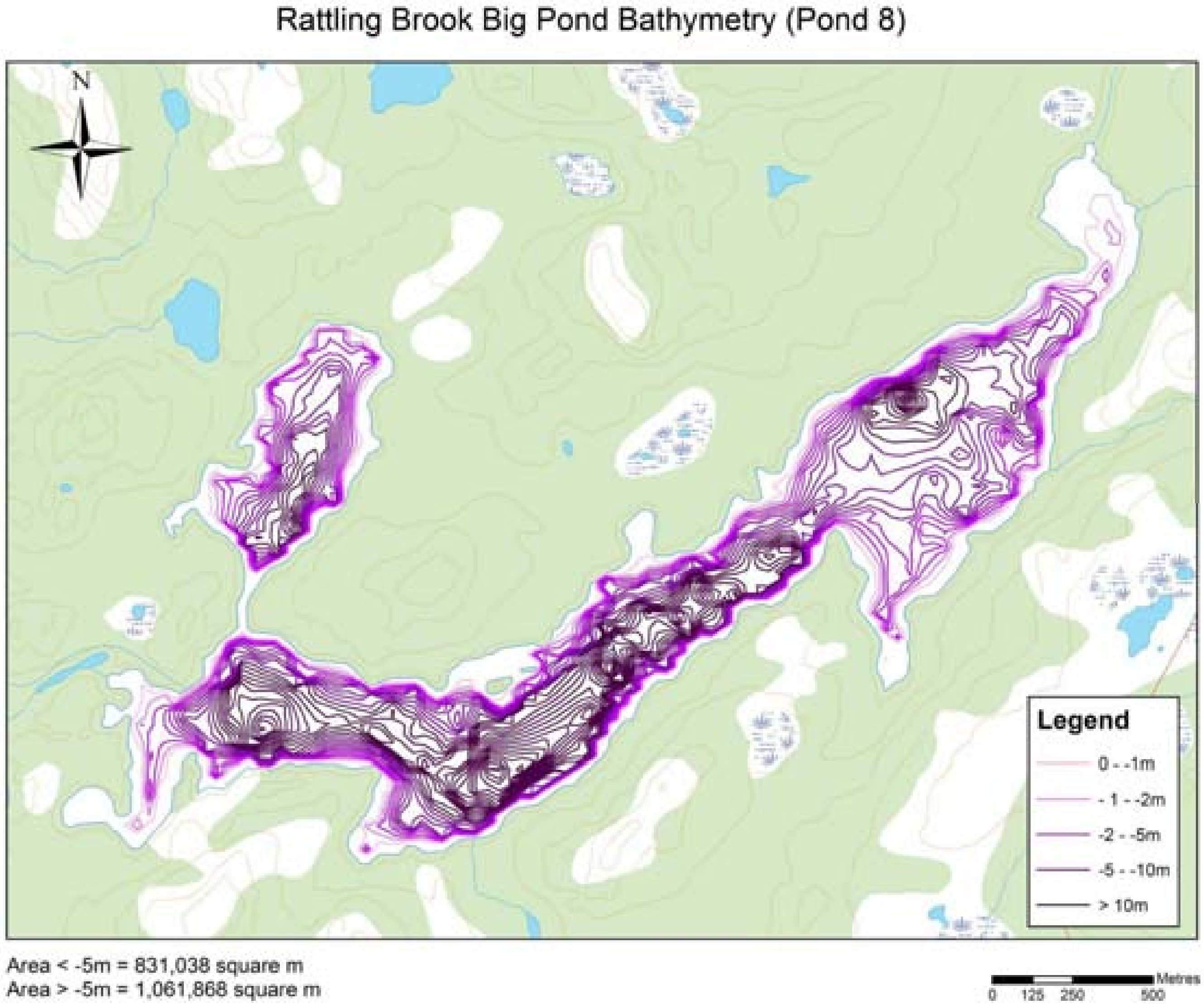

Figure 9.16 Pond P8 Bathymetric contours, August 16, 2006.

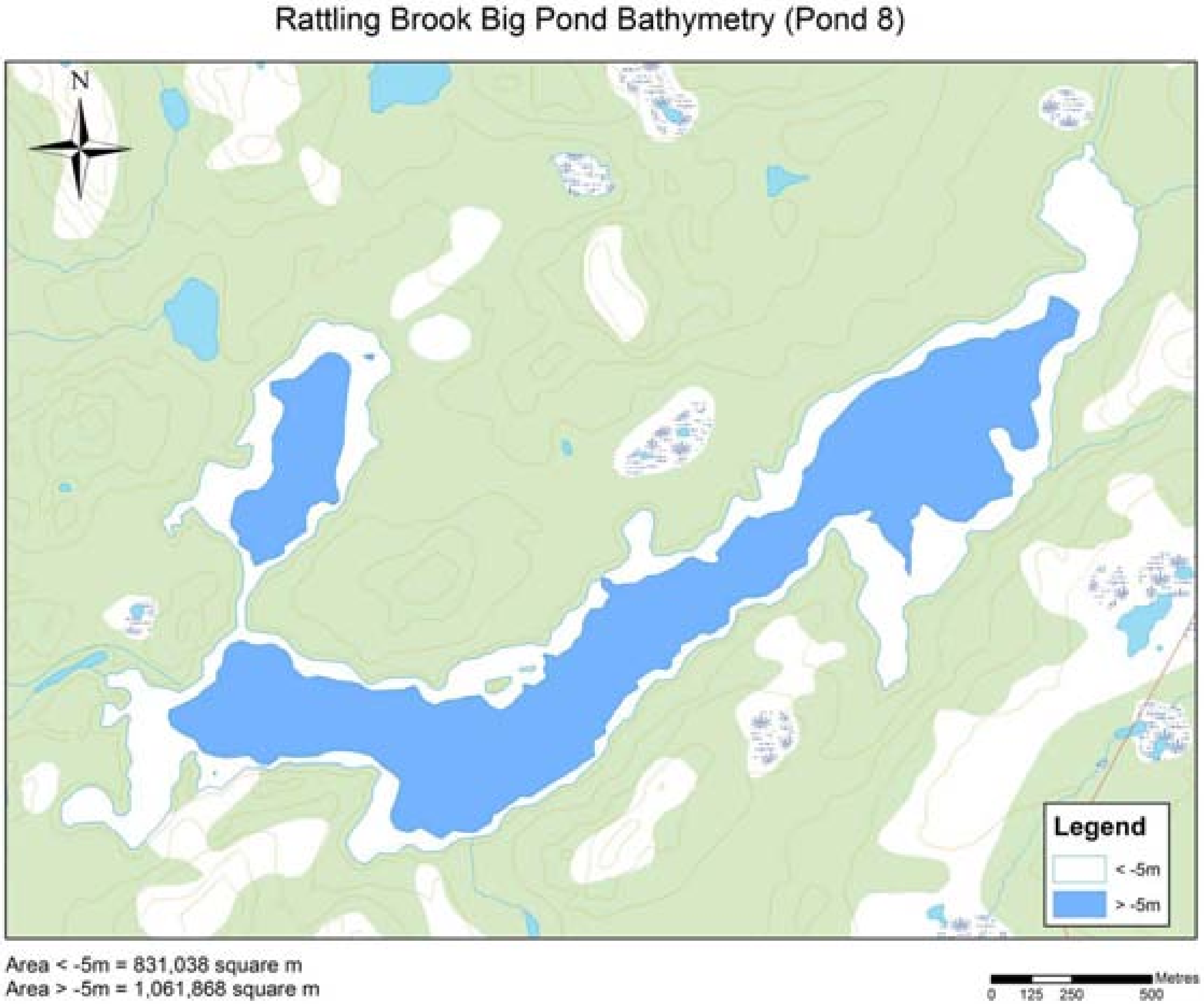

Figure 9.17 Pond P8 Littoral and Profundal zones, August 16, 2006.

The pond has emergent vegetation present/visible, primarily in the east end of the pond and near the outflow. Estimated coverage of the littoral zone was 30,537.63m^2. Table 9-21 presents the calculated area of each habitat type in Pond P8.

Table 9.21 The calculated total area of each habitat type within Pond P8.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**106.19**
Lc - Littoral Zone - Coarse	32.02
Lm - Littoral Zone - Medium	8.40
Lf - Littoral Zone – Fine, no aquatic vegetation	39.64
Lf – Littoral Zone – Fine, with aquatic vegetation	3.05
Sub Total, Littoral Zone	**83.10**
Total Habitat	**189.29**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-22 presents an overview of the habitat information used to determine habitat areas. Table 9-23 shows the habitat suitabilities of each habitat type for the species present; brook trout and Arctic charr.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-24 presents the results for both brook trout and resident Arctic charr.

Table 9.22 Summary of Pond P8 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P8 (Rattling Brook Big Pond)

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m: Path 1			IF Lake Depth is greater than 10 m: Path 2	
A Enter Depth of Littoral Zone:	0	OR	A-1 Enter mean depth of Non-Littoral Zone:	13
B Enter Mean Depth of Lake:	0		B-1 Enter depth of Benthic Zone:	2

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	17,470.63	Rubble:	51,708.33	Sand:	0.00
	Boulder:	302,691.76	Cobble:	27,650.55	Silt:	0.00
			Gravel:	4,604.69	Muck:	396,378.32
					Clay:	0.00
	SubTotals:	320,162		83,964		396,378

Littoral Zone (Vegetation)						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	30,537.63
					Clay:	0.00
	SubTotals:	0		0		30,538

Non-Littoral Zone						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	1,061,868.00
					Clay:	0.00
	SubTotals:	0		0		1,061,868

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	320,162
Littoral Medium/No vegetation	83,964
Littoral Fine/No vegetation	396,378
subtotal Littoral/No vegetation	**800,504**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	30,538
Subtotal Littoral/Vegetation	**30,538**
Subtotal Littoral	**831,042**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	1,061,868
Subtotal nonlittoral	**1,061,868**
Total Available Habitat	**1,892,910**

Table 9.23 Habitat suitabilities for all species, Pond P8.

STEP 4 Rattling Brook Big Pond

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
1	Arctic Char (Freshwater Resident Dwarf)	Spawning	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.00
		YOY	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.57
		Adult	0.00	0.67	0.00	NA	NA	0.00	NA	NA	0.85
2	Brook Trout (freshwater resident)	Spawning	0.00	0.72	0.56	NA	NA	0.56	NA	NA	0.03
		YOY	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.28
		Adult	0.00	0.67	0.00	NA	NA	0.00	NA	NA	0.28

Table 9.24 Habitat equivalent units for all species, Pond P8.

STEP 5

Species	Littoral Zone						Non-Littoral Zone		
	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
Arctic Char (Freshwater Resident Dwarf)	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Brook Trout (Freshwater Resident)	0.50	1.00	0.56	0.00	0.00	0.56	0.00	0.00	0.28

Species	Littoral Zone						Non-Littoral Zone			TOTAL
	Coarse/No Vegetation 320162	Medium/No Vegetation 83964	Fine/No Vegetation 396378	Coarse/Vegetation 0	Medium/Vegetation 0	Fine/Vegetation 30538	Coarse/Pelagic 0	Medium/Pelagic 0	Fine/Pelagic 1061868	
Arctic Char (Freshwater Resident Dwarf)	0	56,256	0	0	0	0	0	0	902,588	958,844
Brook Trout (Freshwater Resident)	160,081	83,964	221,972	0	0	17,101	0	0	297,323	780,441

Pond P14 – Sam Howe's Pond

Fish Species Present

Since this pond was surveyed in May of 2007, no fyke netting was conducted. While no sampling was conducted within Sam Howe's Pond, there were a total of seven quantitative electrofishing sites and seven index electrofishing sites completed with Rattling Brook to determine the species within the system. In addition, a total of seven ponds within the watershed were sampled using multiple techniques including fyke nets, angling and baited minnow traps to determine the species utilizing the watershed. The results indicate that brook trout are the dominant species in the watershed. Since Sam Howe's Pond is outside the project footprint and we have substantial sampling of the habitat within Rattling Brook watershed to indicate that brook trout is the dominant species throughout the system, it is a reasonable assumption to quantify the pond using brook trout. In addition, a total of two hours of angling were completed throughout the pond in 2006 for body burden sampling. A total of 16 brook trout were captured ranging in size from 143-183mm in length.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 2.6m. The maximum depth measured in Pond P14 was 12.3m. Pond P14 comprises 38.08ha; of which 8.89ha is littoral and 29.19ha is profundal. Figure 9-18 presents the bathymetric contours of Pond P14 as modeled from the data. Figure 9-19 presents the Littoral and Profundal areas of Pond P14.

Substrate Composition

Substrate composition of both the littoral and profundal zones were conducted and used in the DFO spreadsheet to calculate aerial extents and habitat equivalent units. These calculations are provided later in this section. The pond has a shoreline comprising a majority of boulder and rubble with the deeper zones comprised of muck (organics and detritus). The overall composition of each substrate type (m^2) is outlined below:

	Littoral	**Profundal**
o Bedrock		
o Boulder	97,198.70	
o Rubble	71,220.67	
o Cobble	40,864.32	
o Gravel	12,551.18	
o Sand		
o Muck/Detritus (organic)	70,053.13	88,929.00
o **Total**	**291,888.00**	**88,929.00**

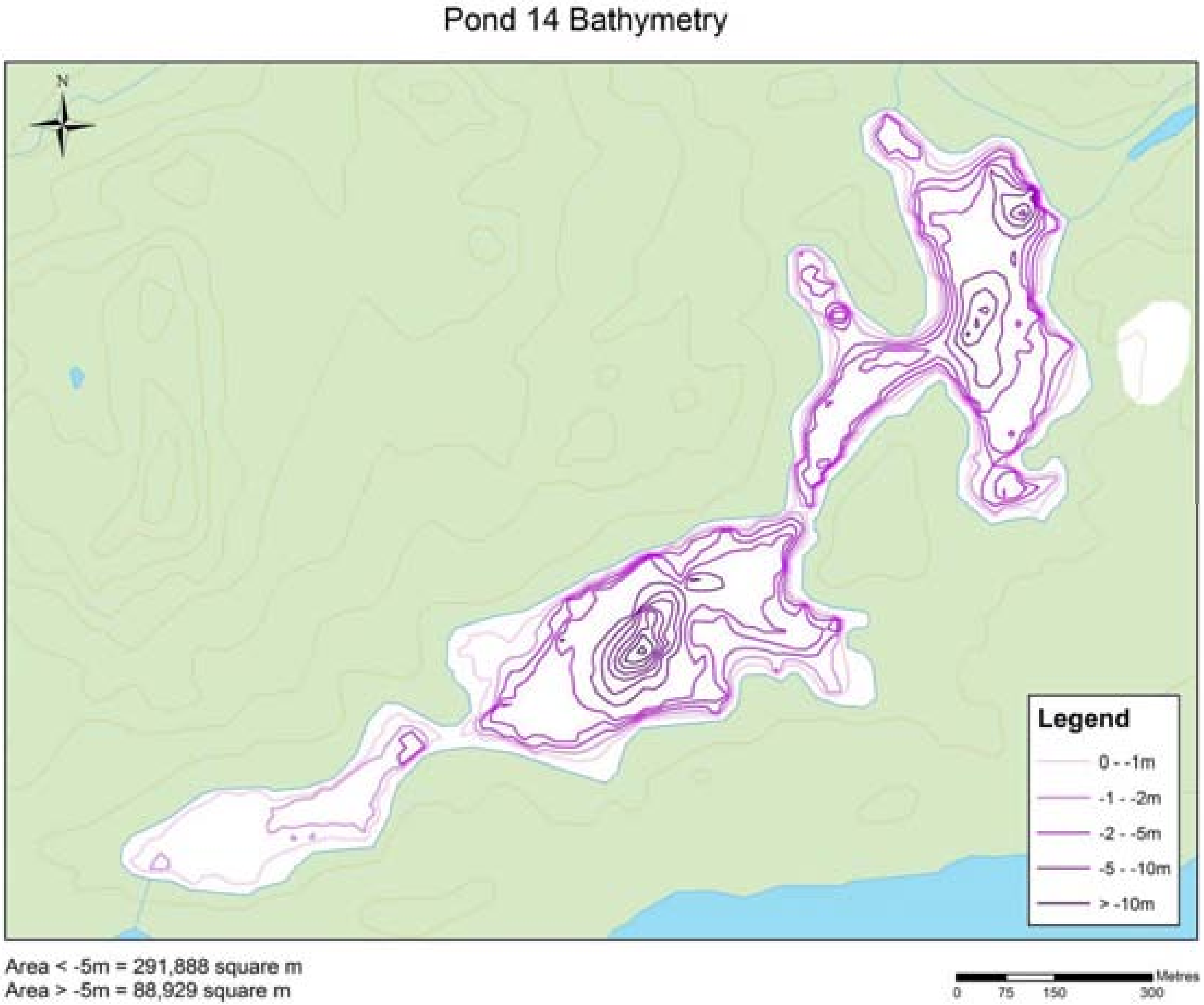

Figure 9.18 Pond P14 Bathymetric contours, May 9, 2007.

Pond 14 Bathymetry

Figure 9.19 Pond P14 Littoral and Profundal zones, May 9, 2007.

The pond did not have evidence of emergent vegetation present/visible. Table 9-25 presents the calculated area of each habitat type in Pond P14.

Table 9.25 The calculated total area of each habitat type within Pond P14.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**8.89**
Lc - Littoral Zone - Coarse	9.72
Lm - Littoral Zone - Medium	12.46
Lf - Littoral Zone – Fine, no aquatic vegetation	7.01
Lf – Littoral Zone – Fine, with aquatic vegetation	0.00
Sub Total, Littoral Zone	**29.19**
Total Habitat	**38.08**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of muck/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-26 presents an overview of the habitat information used to determine habitat areas. Table 9-27 shows the habitat suitabilities of each habitat type for the species present; brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-28 presents the results for brook trout.

Table 9.26 Summary of Pond P14 habitat values used to calculate aerial extents.

Enter Lake name: Pond P14

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:		OR	IF Lake Depth is greater than 10 m:	
Path 1			Path 2	
A Enter Depth of Littoral Zone:	5		A-1 Enter mean depth of Non-Littoral Zone:	
B Enter Mean Depth of Lake:	4		B-1 Enter depth of Benthic Zone:	

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	71,220.67	Sand:	0.00
	Boulder:	97,198.70	Cobble:	40,864.32	Silt:	0.00
			Gravel:	12,551.18	Muck:	70,053.12
					Clay:	0.00
	SubTotals:	97,199		124,636		70,053

Littoral Zone (Vegetation)						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Non-Littoral Zone						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	88,929.00
					Clay:	0.00
	SubTotals:	0		0		88,929

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	97,199
Littoral Medium/No vegetation	124,636
Littoral Fine/No vegetation	70,053
subtotal Littoral/No vegetation	**291,888**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	0
Subtotal Littoral/Vegetation	**0**
Subtotal Littoral	**291,888**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	88,929
Subtotal nonlittoral	**88,929**
Total Available Habitat	**380,817**

Table 9.27 Habitat suitabilities for all species, Pond P14.

STEP 4 Sam Howe's Pond

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
1	Brook Trout (freshwater resident)	Spawning	0.00	0.72	0.56	NA	NA	NA	NA	NA	0.11
		YOY	1.00	1.00	0.00	NA	NA	NA	NA	NA	0.00
		Juvenile	1.00	1.00	0.00	NA	NA	NA	NA	NA	0.11
		Adult	0.00	0.67	0.00	NA	NA	NA	NA	NA	0.11

Table 9.28 Habitat equivalent units for all species, Pond P14.

STEP 5

Species	Littoral Zone						Non-Littoral Zone		
	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
Brook Trout	1.00	1.00	0.56	0.00	0.00	0.00	0.00	0.00	0.11

Species	Littoral Zone						Non-Littoral Zone			
	Coarse/No Vegetation 97199	Medium/No Vegetation 124636	Fine/No Vegetation 70053	Coarse/Vegetation 0	Medium/Vegetation 0	Fine/Vegetation 0	Coarse/Pelagic 0	Medium/Pelagic 0	Fine/Pelagic 88929	TOTAL
Brook Trout	97,199	124,636	39,230	0	0	0	0	0	9,782	270,847

9.11.2. Pond P15 – Sandy Pond

Fish Species Present

A total of one fyke net, two charr traps and 2.5 hours of angling were deployed/completed throughout the pond over a period of four days. This effort is the equivalence of three fyke net-nights and six charr trap net-nights. Brook trout, American eel and rainbow smelt (*Osmerus mordax*) were captured within Pond P15. Brook trout captured ranged from 80-320mm in length, American eel ranged in length from 690-910mm. Rainbow smelt ranged from 88-126mm in length.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 2.9m. The maximum depth measured in Pond P15 was 16.5m. Pond P15 (Sandy Pond) comprises 37.83ha; of which 13.91ha is littoral and 23.92ha is profundal. Figure 8-18 presents the bathymetric contours of Pond P15 as modeled from the data. Figure 8-19 presents the Littoral and Profundal areas of Pond P15.

Substrate Composition

Substrate composition of both the littoral and profundal zones were conducted and used in the DFO spreadsheet to calculate aerial extents and habitat equivalent units. These calculations are provided later in this section. The pond has a shoreline comprising of mainly boulders and rubble with the majority of the deeper zones comprised of muck (organics and detritus). The overall composition of each substrate type (m^2) is outlined below:

	Littoral	**Profundal**
o Bedrock	9,443.82	
o Boulder	24,063.84	
o Rubble	12,389.85	
o Cobble	6,084.79	
o Gravel	550.66	
o Sand	330.40	
o Muck/Detritus (organic)	86,285.64	239,196.00
o **Total**	**139,149.60**	**239,196.00**

The pond has emergent vegetation present/visible (included in Muck/Detritus above), primarily in the small, semi-isolated east end of the pond. Estimated coverage of the littoral zone was $2,202.64m^2$. Table 9-29 presents the calculated area of each habitat type in Pond P15.

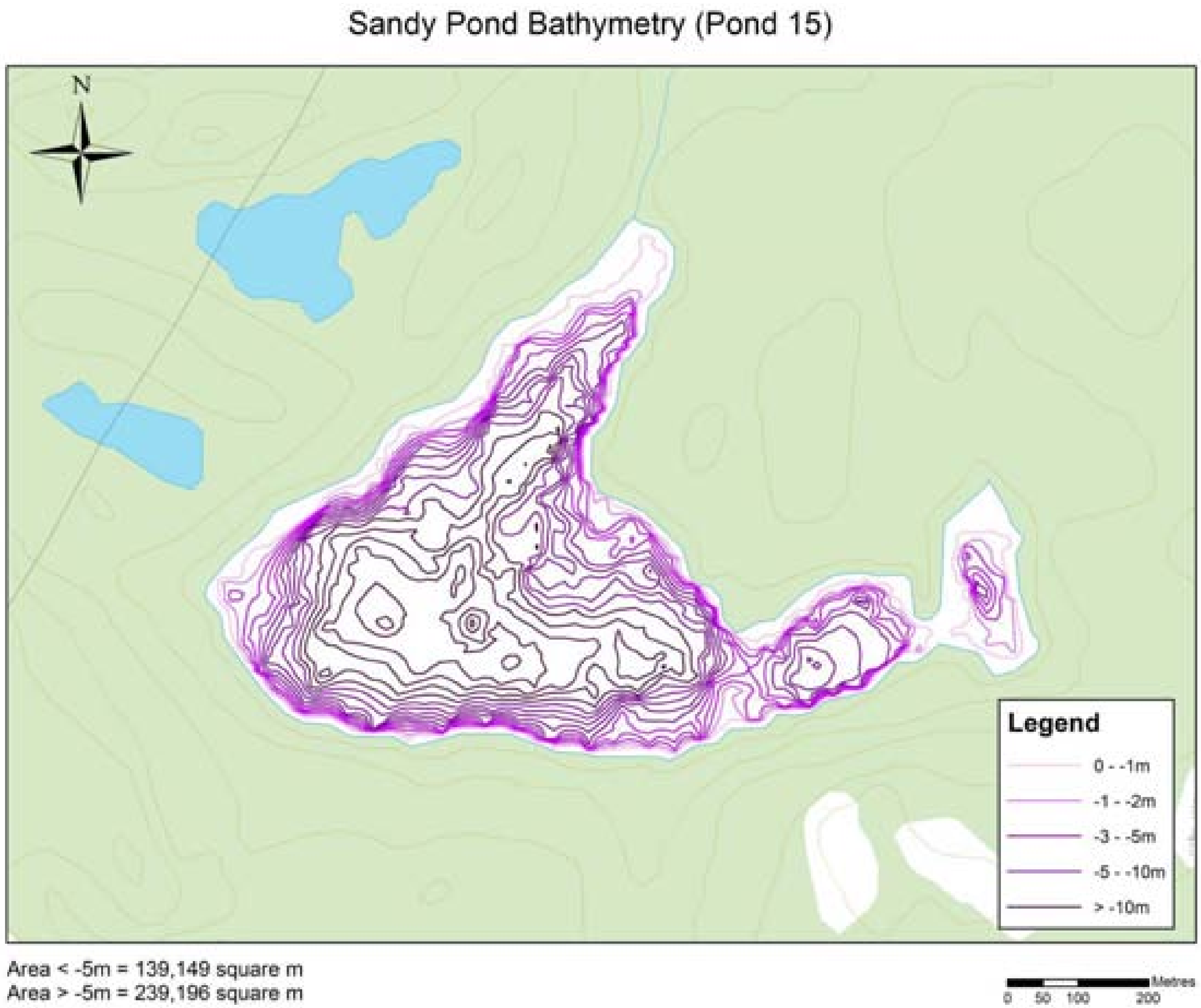

Figure 9.20 Pond P15 Bathymetric contours, August 17, 2006.

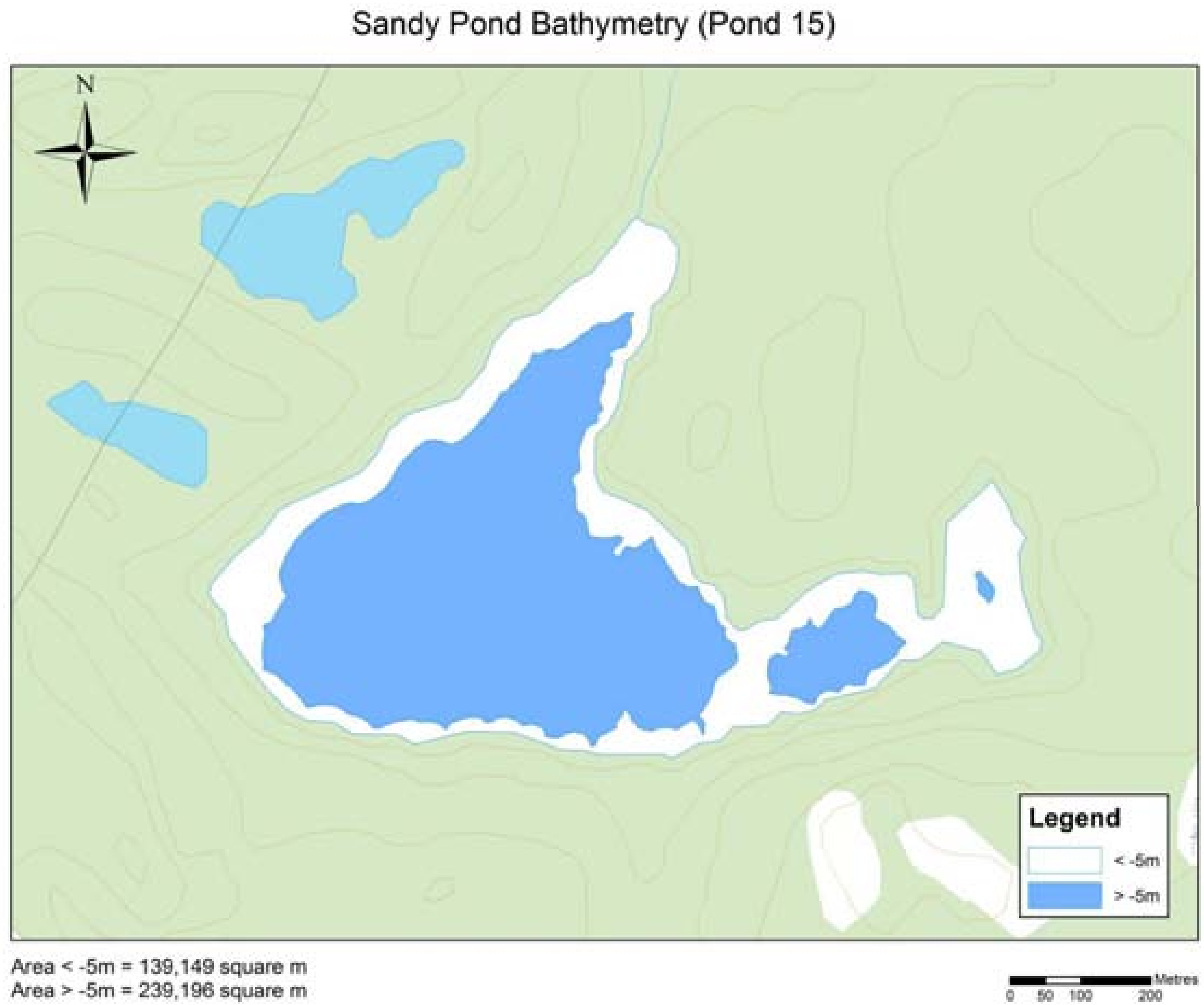

Figure 9.21 Pond P15 Littoral and Profundal zones, August 17, 2006.

Table 9.29 The calculated total area of each habitat type within Pond P15 (Sandy Pond).

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**23.92**
Lc - Littoral Zone - Coarse	3.35
Lm - Littoral Zone - Medium	1.90
Lf - Littoral Zone – Fine, no aquatic vegetation	8.44
Lf – Littoral Zone – Fine, with aquatic vegetation	0.22
Sub Total, Littoral Zone	**13.91**
Total Habitat	**37.83**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-30 presents an overview of the habitat information used to determine habitat areas. Table 9-31 shows the habitat suitabilities of each habitat type for the species present; brook trout, American eel and rainbow smelt.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-32 presents the results for each species present.

Table 9.30 Summary of Pond P15 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P15 (Sandy Pond)

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			**IF Lake Depth is greater than 10 m:**	
Path 1		**OR**	**Path 2**	
A Enter Depth of Littoral Zone:	5		**A-1 Enter mean depth of Non-Littoral Zone:**	0
B Enter Mean Depth of Lake:	8		**B-1 Enter depth of Benthic Zone:**	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	**9,443.82**	Rubble:	**12,389.85**	Sand:	**330.40**
	Boulder:	**24,063.84**	Cobble:	**6,084.79**	Silt:	**0.00**
			Gravel:	**550.66**	Muck:	**0.00**
					Clay:	**84,083.00**
	SubTotals:	33,508		19,025		84,413

Littoral Zone (Vegetation)						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	**0.00**	Rubble:	**0.00**	Sand:	**0.00**
	Boulder:	**0.00**	Cobble:	**0.00**	Silt:	**0.00**
			Gravel:	**0.00**	Muck:	**0.00**
					Clay:	**2,202.64**
	SubTotals:	0		0		2,203

Non-Littoral Zone						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	**0.00**	Rubble:	**0.00**	Sand:	**0.00**
	Boulder:	**0.00**	Cobble:	**0.00**	Silt:	**0.00**
			Gravel:	**0.00**	Muck:	**0.00**
					Clay:	**239,196.00**
	SubTotals:	0		0		239,196

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	**Bottom Surface area (m^2)**
Littoral Coarse/No vegetation	33,508
Littoral Medium/No vegetation	19,025
Littoral Fine/No vegetation	84,413
subtotal Littoral/No vegetation	**136,946**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	2,203
Subtotal Littoral/Vegetation	**2,203**
Subtotal Littoral	**139,149**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	239,196
Subtotal nonlittoral	**239,196**
Total Available Habitat	**378,345**

Table 9.31 Habitat suitabilities for all species, Pond P15.

STEP 4 Sandy Pond

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
1	American Eel	Spawning	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.00
		YOY	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	0.50	0.33	0.50	NA	NA	0.78	NA	NA	0.33
		Adult	0.50	0.33	1.00	NA	NA	1.00	NA	NA	0.33
2	Brook Trout (freshwater resident)	Spawning	0.00	0.72	0.64	NA	NA	0.56	NA	NA	0.11
		YOY	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.11
		Adult	0.00	0.67	0.34	NA	NA	0.00	NA	NA	0.11
3	Rainbow Smelt (Freshwater Resident)	Spawning	0.50	1.00	1.00	NA	NA	1.00	NA	NA	0.33
		YOY	0.50	0.67	0.00	NA	NA	0.00	NA	NA	0.33
		Juvenile	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.33
		Adult	0.00	0.00	0.00	NA	NA	0.00	NA	NA	0.33

Table 9.32 Habitat equivalent units for all species, Pond P15.

Step 5

Species	Littoral Zone						Non-Littoral Zone		
	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
American eel	0.50	0.33	1.00	0.00	0.00	1.00	0.00	0.00	0.33
Brook Trout (Freshwater Resident)	0.50	1.00	0.64	0.00	0.00	0.56	0.00	0.00	0.11
Rainbow Smelt (Freshwater Resident)	0.50	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.33

Species	Littoral Zone						Non-Littoral Zone			TOTAL
	Coarse/No Vegetation 33508	Medium/No Vegetation 19025	Fine/No Vegetation 84413	Coarse/Vegetation 0	Medium/Vegetation 0	Fine/Vegetation 2203	Coarse/Pelagic 0	Medium/Pelagic 0	Fine/Pelagic 239196	
American eel	16,754	6,278	84,413	0	0	2,203	0	0	78,935	188,583
Brook Trout (Freshwater Resident)	16,754	19,025	54,024	0	0	1,234	0	0	26,312	117,349
Brook Trout (Freshwater Resident)	16,754	19,025	84,413	0	0	2,203	0	0	78,935	201,330

9.11.3. Pond P22

Fish Species Present

A total of four fyke nets, three minnow/charr traps and two hours of angling were deployed/completed throughout the pond over a period of three days. This effort is the equivalence of eight fyke net-nights, six minnow traps net-nights. Brook trout (three in total) were the only species captured within Pond P22. Brook trout captured ranged from 238-240mm in length.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 0.9m which was the maximum depth measured in the pond. Pond P22 therefore is comprised entirely of littoral habitat; 1.18ha.

Substrate Composition

The pond has a substrate comprising a majority of muck (organics and detritus) with high gravel, cobble and boulders along the shoreline. The overall composition of each substrate type (m^2) is outlined below:

	Littoral	Profundal
o Bedrock		
o Boulder	1,456.69	
o Rubble	911.91	
o Cobble	1,515.90	
o Gravel	2,167.27	
o Sand	260.55	
o Muck/Detritus (organic)	5,530.68	
Total	**11,843.00**	

The pond has emergent vegetation everywhere muck/detritus was present (included in Muck/Detritus above). Estimated coverage of the littoral zone was 5,530.68m^2. Table 9-33 presents the calculated area of each habitat type in Pond P22.

Table 9.33 The calculated total area of each habitat type within Pond P22.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.00**
Lc - Littoral Zone - Coarse	0.14
Lm - Littoral Zone - Medium	0.46
Lf - Littoral Zone – Fine, no aquatic vegetation	0.03
Lf – Littoral Zone – Fine, with aquatic vegetation	0.55
Sub Total, Littoral Zone	**1.18**
Total Habitat	**1.18**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-34 presents an overview of the habitat information used to determine habitat areas. Table 9-35 shows the habitat suitabilities of each habitat type for brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-36 presents the results.

Table 9.34 Summary of Pond P22 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P22

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			IF Lake Depth is greater than 10 m:	
Path 1		OR	Path 2	
A Enter Depth of Littoral Zone:	1		A-1 Enter mean depth of Non-Littoral Zone:	0
B Enter Mean Depth of Lake:	1		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	911.91	Sand:	260.55
	Boulder:	1,456.69	Cobble:	1,515.90	Silt:	0.00
			Gravel:	2,167.27	Muck:	0.00
					Clay:	0.00
	SubTotals:	1,457		4,595		261

Littoral Zone (Vegetation)						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	5,530.68
					Clay:	0.00
	SubTotals:	0		0		5,531

Non-Littoral Zone						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	1,457
Littoral Medium/No vegetation	4,595
Littoral Fine/No vegetation	261
subtotal Littoral/No vegetation	**6,312**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	5,531
Subtotal Littoral/Vegetation	**5,531**
Subtotal Littoral	**11,843**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	**11,843**

Table 9.35 Habitat suitabilities for all species, Pond P22.

STEP 4 Pond 22

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
1	Brook Trout (freshwater resident)	Spawning	0.00	0.84	0.84	NA	NA	0.67	NA	NA	NA
		YOY	1.00	1.00	0.00	NA	NA	0.00	NA	NA	NA
		Juvenile	1.00	1.00	0.00	NA	NA	0.00	NA	NA	NA
		Adult	0.00	0.67	0.67	NA	NA	0.00	NA	NA	NA

Table 9.36 Habitat equivalent units for all species, Pond P22.

Step 5

Species	Littoral Zone						Non-Littoral Zone		
	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
Brook Trout	1.00	1.00	0.84	0.00	0.00	0.67	0.00	0.00	0.00

Species	Littoral Zone						Non-Littoral Zone			
	Coarse/No Vegetation 1457	Medium/No Vegetation 4595	Fine/No Vegetation 261	Coarse/Vegetation 0	Medium/Vegetation 0	Fine/Vegetation 5531	Coarse/Pelagic 0	Medium/Pelagic 0	Fine/Pelagic 0	TOTAL
Brook Trout	1,457	4,595	219	0	0	3,706	0	0	0	9,977

9.11.4. Pond P23

Fish Species Present

A total of four fyke nets and three minnow traps were deployed throughout the pond for a period of three days. This effort is the equivalence of eight fyke net-nights, six minnow traps net-nights. Brook trout (twelve in total) were the only species captured within Pond P23. Brook trout captured ranged from 149-228mm in length.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 1.05m. The maximum depth measured in Pond P23 was 3.4m. Pond P23 comprises 2.85ha of which 2.48ha is littoral and 0.37ha is profundal habitat. Figure 9-22 presents the bathymetric contours of P23 as modeled from the data. Figure 9-23 presents the Littoral and Profundal areas of Pond P23.

Substrate Composition

The pond has a littoral zone comprising a majority of muck (organics and detritus) with some larger substrates around the shoreline. Most of the profundal zone is comprised of muck (organics and detritus). The overall composition of each substrate type (m^2) is outlined below:

	Littoral	Profundal
o Bedrock	247.66	
o Boulder	8,420.44	
o Rubble	3,467.24	
o Cobble	2,724.26	
o Gravel	2,228.94	
o Sand		
o Muck/Detritus (organic)	7,677.46	3,712.00
o **Total**	**24,766.00**	**3,712.00**

The pond has emergent vegetation present/visible (included in Muck/Detritus above) throughout the small pond. Estimated coverage of the littoral zone was 5,944.00m^2. Table 9-37 presents the calculated area of each habitat type in Pond P23.

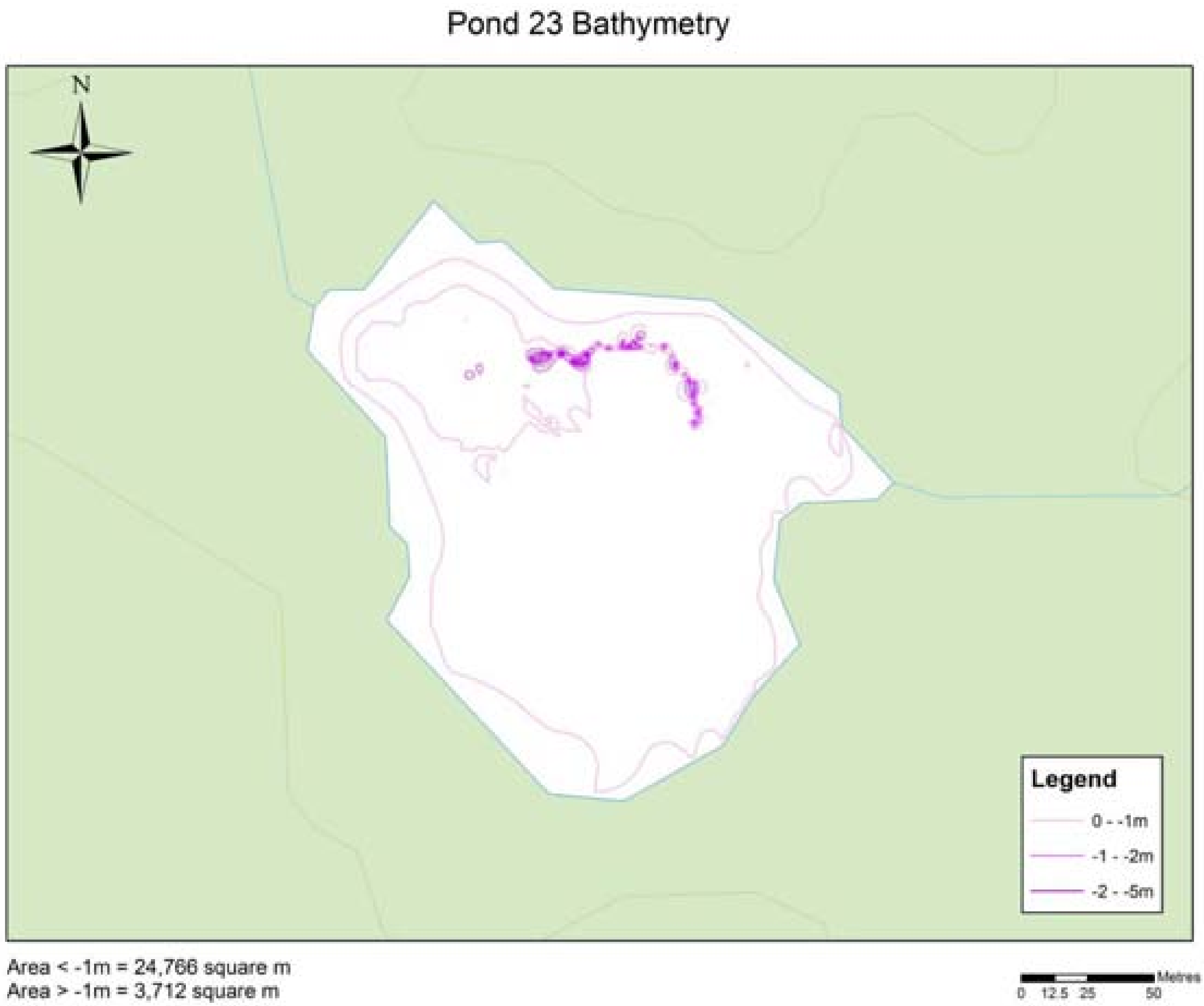

Figure 9.22 Pond P23 Bathymetric contours, July 22, 2006.

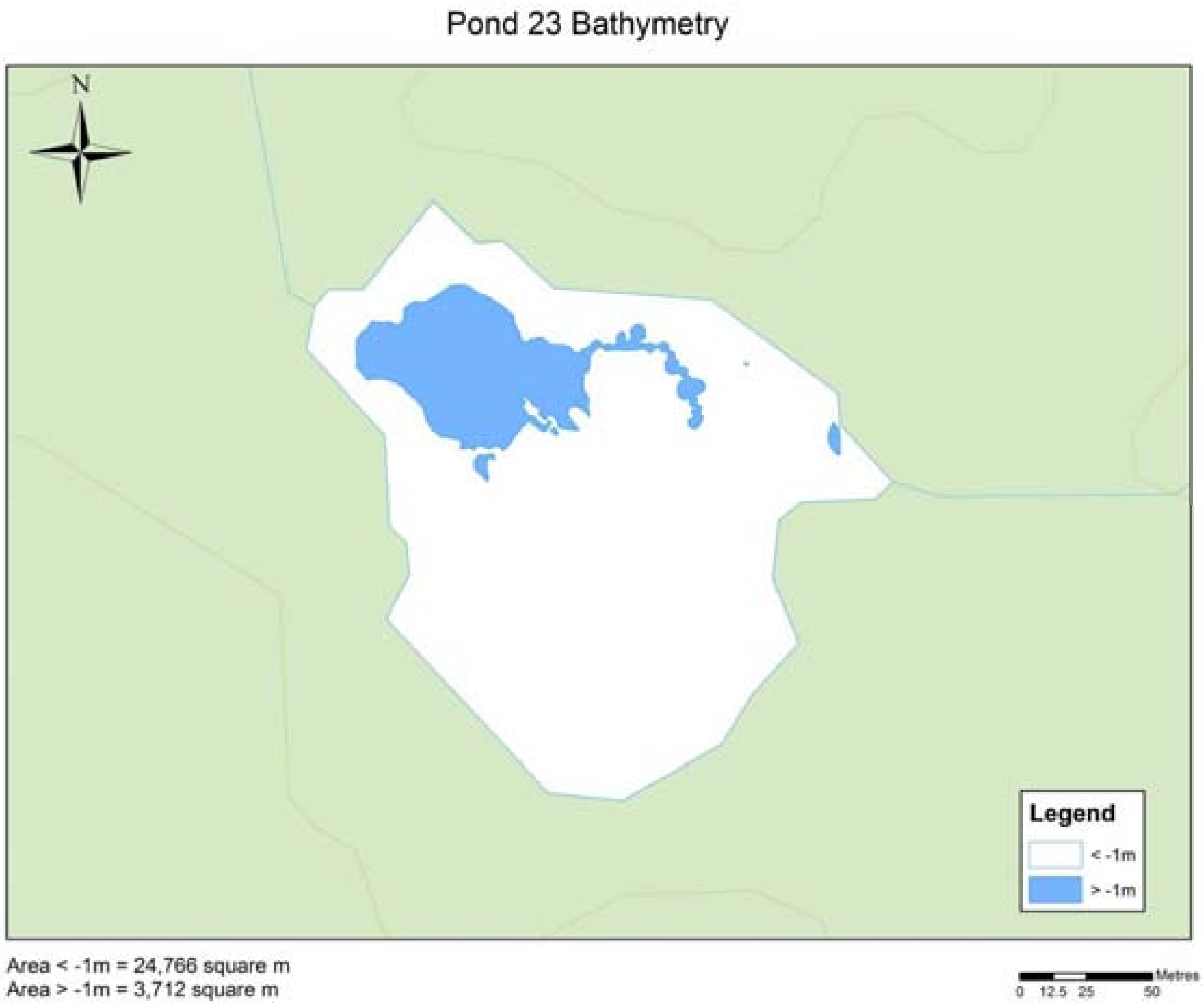

Figure 9.23 Pond P23 Littoral and Profundal zones, July 22, 2006.

Table 9.37 The calculated total area of each habitat type within Pond P23.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.37**
Lc - Littoral Zone - Coarse	0.87
Lm - Littoral Zone - Medium	0.84
Lf - Littoral Zone – Fine, no aquatic vegetation	0.17
Lf – Littoral Zone – Fine, with aquatic vegetation	0.60
Sub Total, Littoral Zone	**2.48**
Total Habitat	**2.85**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-38 presents an overview of the habitat information used to determine habitat areas. Table 9-39 shows the habitat suitabilities of each habitat type for brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-40 presents the results for each species.

Table 9.38 Summary of Pond P23 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P23

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			IF Lake Depth is greater than 10 m:	
Path 1		OR	Path 2	
A Enter Depth of Littoral Zone:	1		A-1 Enter mean depth of Non-Littoral Zone:	0
B Enter Mean Depth of Lake:	1		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:		
Mean depth of Non-Littoral Zone:		*(Reduced Value)*
Depth of the Benthic Zone:		*(Reduced Value)*
Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	247.66	Rubble:	3,467.24	Sand:	0.00
	Boulder:	8,420.44	Cobble:	2,724.26	Silt:	0.00
			Gravel:	2,228.94	Muck:	1,733.62
					Clay:	0.00
	SubTotals:	8,668		8,420		1,734

Littoral Zone (Vegetation)						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	5,943.84
					Clay:	0.00
	SubTotals:	0		0		5,944

Non-Littoral Zone						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	3,712.00
					Clay:	0.00
	SubTotals:	0		0		3,712

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	8,668
Littoral Medium/No vegetation	8,420
Littoral Fine/No vegetation	1,734
subtotal Littoral/No vegetation	**18,822**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	5,944
Subtotal Littoral/Vegetation	**5,944**
Subtotal Littoral	**24,766**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	3,712
Subtotal nonlittoral	**3,712**
Total Available Habitat	**28,478**

Table 9.39 Habitat suitabilities for all species, Pond P23.

STEP 4 Pond 23

	Species	Life Stage	Littoral Zone						Non-Littoral Zone		
			Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
1	Brook Trout (freshwater resident)	Spawning	0.00	0.84	0.67	NA	NA	0.67	NA	NA	0.33
		YOY	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.11
		Adult	0.00	0.67	0.00	NA	NA	0.00	NA	NA	0.11

Table 9.40 Habitat equivalent units for Pond P23.

Step 5

Species	Littoral Zone						Non-Littoral Zone		
	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
Brook Trout	0.50	1.00	0.67	0.00	0.00	0.67	0.00	0.00	0.33

Species	Littoral Zone						Non-Littoral Zone			
	Coarse/No Vegetation 8668	Medium/No Vegetation 8420	Fine/No Vegetation 1734	Coarse/Vegetation 0	Medium/Vegetation 0	Fine/Vegetation 5944	Coarse/Pelagic 0	Medium/Pelagic 0	Fine/Pelagic 3712	TOTAL
Brook Trout	4,334	8,420	1,162	0	0	3,982	0	0	1,225	19,123

Pond P24

Fish Species Present

A total of four fyke nets and two minnow/charr traps were deployed throughout the pond for a period of three days. This effort is the equivalence of seven fyke net-nights and four minnow trap net-nights. Brook trout (total of thirty-one) were the only species captured within Pond P24. Brook trout captured ranged between 81-220mm in length.

Habitat Quantification

Light penetration was determined to be to the bottom of Pond P24 (1.0m). Pond P24 is therefore comprised entirely of littoral habitat; 1.34ha.

Substrate Composition

The pond has a substrate comprising a majority of muck (organics and detritus) with higher portions of boulders along the shoreline. The overall composition of each substrate type (m^2) is outlined below:

	Littoral	Profundal
o Bedrock	133.98	
o Boulder	803.88	
o Rubble	133.98	
o Cobble	133.98	
o Gravel	133.98	
o Sand		
o Muck/Detritus (organic)	12,058.20	
Total	**13,398.00**	

The pond has emergent vegetation everywhere muck/detritus was present (included in Muck/Detritus above). Estimated coverage of the littoral zone was 12,058.20m^2. Table 9-41 presents the calculated area of each habitat type in pond P24.

Table 9.41 The calculated total area of each habitat type within P24.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.00**
Lc - Littoral Zone - Coarse	0.09
Lm - Littoral Zone - Medium	0.04
Lf - Littoral Zone – Fine, no aquatic vegetation	0.00
Lf – Littoral Zone – Fine, with aquatic vegetation	1.21
Sub Total, Littoral Zone	**1.34**
Total Habitat	**1.34**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-42 presents an overview of the habitat information used to determine habitat areas. Table 9-43 shows the habitat suitabilities of each habitat type for the species present; brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-44 presents the results.

Table 9.42 Summary of Pond P24 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P24

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			IF Lake Depth is greater than 10 m:	
Path 1		OR	Path 2	
A Enter Depth of Littoral Zone:	1		A-1 Enter mean depth of Non-Littoral Zone:	0
B Enter Mean Depth of Lake:	1		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	133.98	Rubble:	133.98	Sand:	0.00
	Boulder:	803.88	Cobble:	133.98	Silt:	0.00
			Gravel:	133.98	Muck:	0.00
					Clay:	0.00
	SubTotals:	938		402		0

Littoral Zone (Vegetation)						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	12,058.20
					Clay:	0.00
	SubTotals:	0		0		12,058

Non-Littoral Zone						
Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	938
Littoral Medium/No vegetation	402
Littoral Fine/No vegetation	0
subtotal Littoral/No vegetation	**1,340**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	12,058
Subtotal Littoral/Vegetation	**12,058**
Subtotal Littoral	**13,398**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	**13,398**

Table 9.43 Habitat suitabilities for all species, Pond P24.

STEP 4 Pond 24

			Littoral Zone						Non-Littoral Zone		
	Species	Life Stage	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
		Spawning	0.00	0.84	NA	NA	NA	0.67	NA	NA	NA
		YOY	0.50	1.00	NA	NA	NA	0.00	NA	NA	NA
	Brook Trout	Juvenile	0.50	1.00	NA	NA	NA	0.00	NA	NA	NA
1	(freshwater resident)	Adult	0.00	0.67	NA	NA	NA	0.00	NA	NA	NA

Table 9.44 Habitat equivalent units for all species, Pond P24.

Step 5

	Littoral Zone						Non-Littoral Zone		
Species	Coarse/No Vegetation	Medium/No Vegetation	Fine/No Vegetation	Coarse/Vegetation	Medium/Vegetation	Fine/Vegetation	Coarse/Pelagic	Medium/Pelagic	Fine/Pelagic
Brook Trout	0.50	1.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00

	Littoral Zone						Non-Littoral Zone			
Species	Coarse/No Vegetation 938	Medium/No Vegetation 402	Fine/No Vegetation 0	Coarse/Vegetation 0	Medium/Vegetation 0	Fine/Vegetation 12058	Coarse/Pelagic 0	Medium/Pelagic 0	Fine/Pelagic 0	TOTAL
Brook Trout	469	402	0	0	0	8,079	0	0	0	8,950

Pond P25

Fish Species Presence

A total of five fyke nets, three minnow traps and 13 hours of angling were deployed/completed throughout the pond over a period of three days. This effort is the equivalence of nine fyke net-nights and five minnow traps net-nights. Brook trout (total of thirteen) were the only species captured within Pond P25. Brook trout captured ranged from 165-227mm in length.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 3.35m. The maximum depth measured in Pond P25 was 4.41m. P25 comprises 1.07ha of which all is within the designated littoral zone. Figure 9-24 presents the bathymetric contours of P25 as modeled from the data.

Substrate Composition

Substrate composition of the littoral zone was conducted and used in the DFO spreadsheet to calculate aerial extents and habitat equivalent units. These calculations are provided later in this section. The pond has a littoral zone comprising a majority of muck (organics and detritus) with some larger boulders around the shoreline. The overall composition of each substrate type (m^2) is outlined below:

	Littoral	**Profundal**
o Bedrock		
o Boulder	2,255.55	
o Rubble	103.35	
o Cobble	119.25	
o Gravel	71.55	
o Sand		
o Muck/Detritus (organic)	8,160.70	
Total	**10,710.40**	

The pond has emergent vegetation present/visible (included in Muck/Detritus above) throughout the small pond. Estimated coverage of the littoral zone was 2,697.70m^2. Table 9-45 presents the calculated area of each habitat type in Pond P25.

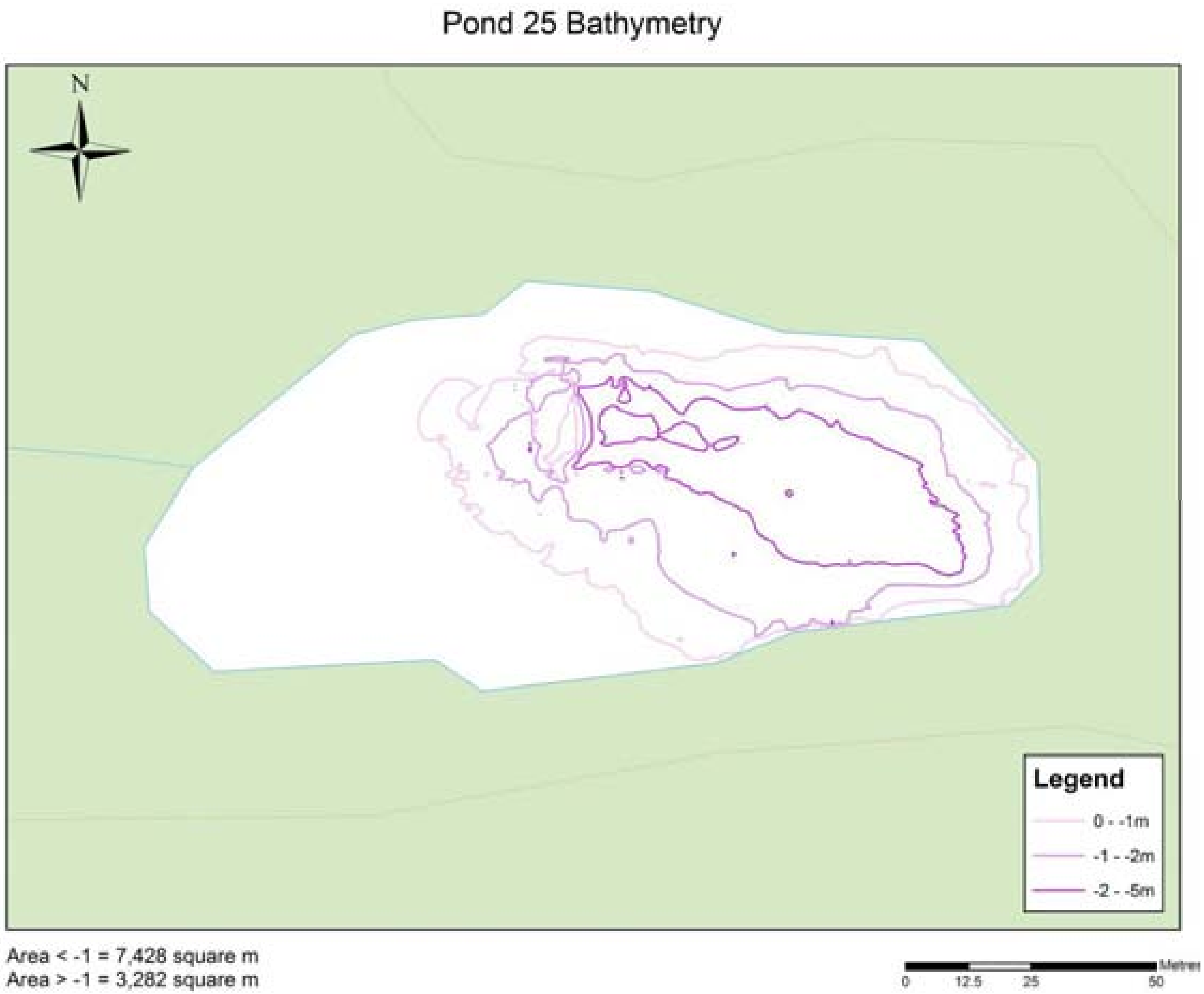

Figure 9.24 Pond P25 Bathymetric contours, July 12, 2006.

Table 9.45 The calculated total area of each habitat type within Pond P25.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.00**
Lc - Littoral Zone - Coarse	0.22
Lm - Littoral Zone - Medium	0.03
Lf - Littoral Zone – Fine, no aquatic vegetation	0.55
Lf – Littoral Zone – Fine, with aquatic vegetation	0.27
Sub Total, Littoral Zone	**1.07**
Total Habitat	**1.07**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-46 presents an overview of the habitat information used to determine habitat areas. Table 9-47 shows the habitat suitabilities of each habitat type for the species present; brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-48 presents the results.

Table 9.46 Summary of Pond P25 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P25

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			IF Lake Depth is greater than 10 m:	
Path 1		OR	Path 2	
A Enter Depth of Littoral Zone:	5		A-1 Enter mean depth of Non-Littoral Zone:	0
B Enter Mean Depth of Lake:	2		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	103.35	Sand:	0.00
	Boulder:	2,255.15	Cobble:	119.25	Silt:	0.00
			Gravel:	71.55	Muck:	5,463.00
					Clay:	0.00
	SubTotals:	2,255		294		5,463

Littoral Zone (Vegetation)						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	2,697.70
					Clay:	0.00
	SubTotals:	0		0		2,698

Non-Littoral Zone						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	2,255
Littoral Medium/No vegetation	294
Littoral Fine/No vegetation	5,463
subtotal Littoral/No vegetation	**8,012**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	2,698
Subtotal Littoral/Vegetation	**2,698**
Subtotal Littoral	**10,710**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	**10,710**

Table 9.47 Habitat suitabilities for all species, Pond P25.

STEP 4 Pond 25

	Species	Life Stage	Littoral Zone Coarse/No Vegetation	Littoral Zone Medium/No Vegetation	Littoral Zone Fine/No Vegetation	Littoral Zone Coarse/Vegetation	Littoral Zone Medium/Vegetation	Littoral Zone Fine/Vegetation	Non-Littoral Zone Coarse/Pelagic	Non-Littoral Zone Medium/Pelagic	Non-Littoral Zone Fine/Pelagic
1	Brook Trout (freshwater resident)	Spawning	0.00	0.72	0.56	NA	NA	0.56	NA	NA	NA
		YOY	1.00	1.00	0.00	NA	NA	0.00	NA	NA	NA
		Juvenile	1.00	1.00	0.00	NA	NA	0.00	NA	NA	NA
		Adult	0.00	0.67	0.00	NA	NA	0.00	NA	NA	NA

Table 9.48 Habitat equivalent units for all species, Pond P25.

Step 5

Species	Littoral Zone Coarse/No Vegetation	Littoral Zone Medium/No Vegetation	Littoral Zone Fine/No Vegetation	Littoral Zone Coarse/Vegetation	Littoral Zone Medium/Vegetation	Littoral Zone Fine/Vegetation	Non-Littoral Zone Coarse/Pelagic	Non-Littoral Zone Medium/Pelagic	Non-Littoral Zone Fine/Pelagic
Brook Trout	1.00	1.00	0.56	0.00	0.00	0.56	0.00	0.00	0.00

Species	Littoral Zone Coarse/No Vegetation 2255	Littoral Zone Medium/No Vegetation 294	Littoral Zone Fine/No Vegetation 5463	Littoral Zone Coarse/Vegetation 0	Littoral Zone Medium/Vegetation 0	Littoral Zone Fine/Vegetation 2698	Non-Littoral Zone Coarse/Pelagic 0	Non-Littoral Zone Medium/Pelagic 0	Non-Littoral Zone Fine/Pelagic 0	TOTAL
Brook Trout	2,255	294	3,059	0	0	1,511	0	0	0	7,119

9.11.5. Pond P26

Fish Species Present

A total of eight fyke nets and six minnow/charr traps were deployed throughout the pond for a period of two days. This effort is the equivalence of eight fyke net-nights, six minnow traps net-nights. No fish were captured.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 2.90m. The maximum depth measured in Pond P26 was 4.32m. Pond P26 comprises 4.10ha of which all is within the designated littoral zone. Figure 9-25 presents the bathymetric contours of Pond P26 as modeled from the data.

Substrate Composition

The pond has a shoreline comprised of a majority of boulders, rubble, cobble and bedrock. Gravels are also present as well as muck/organics. The overall composition of each substrate type (m^2) is outlined below:

	Littoral	Profundal
o Bedrock	2,496.89	
o Boulder	6,128.73	
o Rubble	4,766.79	
o Cobble	4,539.80	
o Gravel	1,588.93	
o Sand		
o Muck/Detritus (organic)	21,388.86	
Total	**40,910.00**	

The pond has emergent vegetation present/visible (included in Muck/Detritus above) along the two sides of the small point on the south-east side of the pond. Estimated coverage of the littoral zone is 1,588.93m^2. Table 9-49 presents the calculated area of each habitat type in Pond P26.

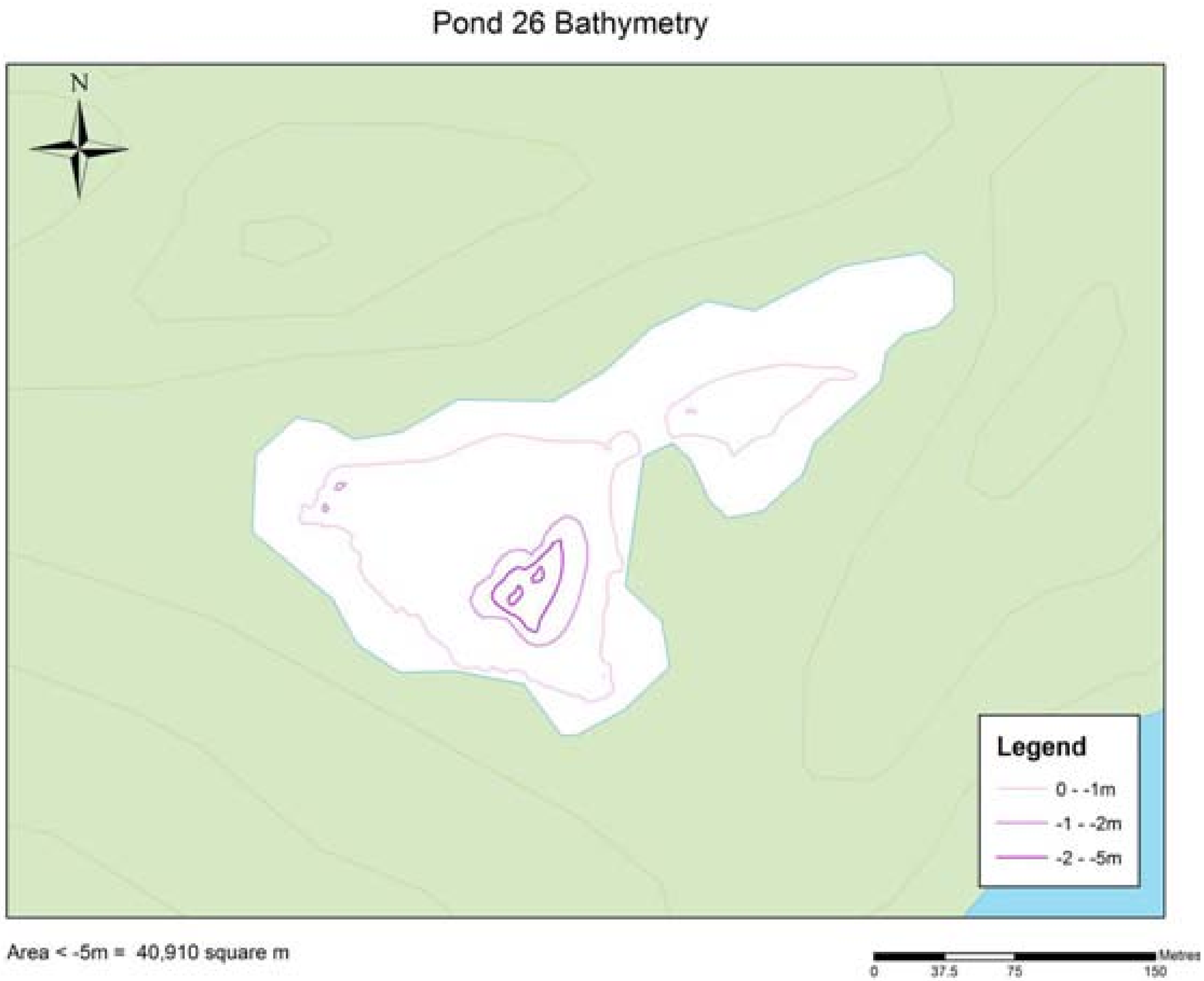

Figure 9.25 Pond P26 Bathymetric contours, July 2, 2006.

Table 9.49 The calculated total area of each habitat type within Pond P26.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.00**
Lc - Littoral Zone - Coarse	0.87
Lm - Littoral Zone - Medium	1.09
Lf - Littoral Zone – Fine, no aquatic vegetation	1.98
Lf – Littoral Zone – Fine, with aquatic vegetation	0.16
Sub Total, Littoral Zone	**4.10**
Total Habitat	**4.10**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

With no fish utilizing Pond 26, it is not considered fish habitat.

9.11.6. Pond P27

Fish Species Presence

A total of six fyke nets, six minnow/charr traps and five hours of angling were deployed/completed throughout the pond for a period of four days. This effort is the equivalence of eighteen fyke net-nights, eighteen minnow traps net-nights. Brook trout (total of two) were the only species captured within Pond P24 and are considered to be the main species utilizing the pond. Brook trout captured ranged 390-410mm in length.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 1.35m. the maximum depth measured in Pond P27 was 7.48m. Pond P27 comprises 1.62ha of which 1.08ha is littoral and 0.54ha is profundal habitat. Figure 9-26 presents the bathymetric contours of P27 as modeled from the data. Figure 9-27 presents the Littoral and Profundal areas of Pond P27.

Substrate Composition

Substrate composition of both the littoral and profundal zones were conducted and used in the DFO spreadsheet to calculate aerial extents and habitat equivalent units. The pond has a shoreline comprising a majority of boulders and cobble with some rubble, cobble, gravel and organics. The deeper portion of the littoral zone (1-2m) is composed primarily of organics and detritus. The majority of the profundal zone is comprised of muck (organics and detritus). The overall composition of each substrate type (m^2) is outlined below:

	Littoral	Profundal
o Bedrock	1,088.36	
o Boulder	3,677.44	
o Rubble	696.28	
o Cobble	959.92	
o Gravel	148.72	
o Sand		
o Muck/Detritus (organic)	4,222.28	5,421.00
o **Total**	**10,793.00**	**5,421.00**

The pond has limited emergent vegetation present/visible (included in Muck/Detritus above) throughout the small pond. Estimated coverage of the littoral zone was 114.92m^2. Table 9-50 presents the calculated area of each habitat type in Pond P27.

Pond 27 Bathymetry

Area < -2m = 10,793 square m
Area > -2m = 5,421 square m

Figure 9.26 Pond P27 Bathymetric contours, June 30, 2006.

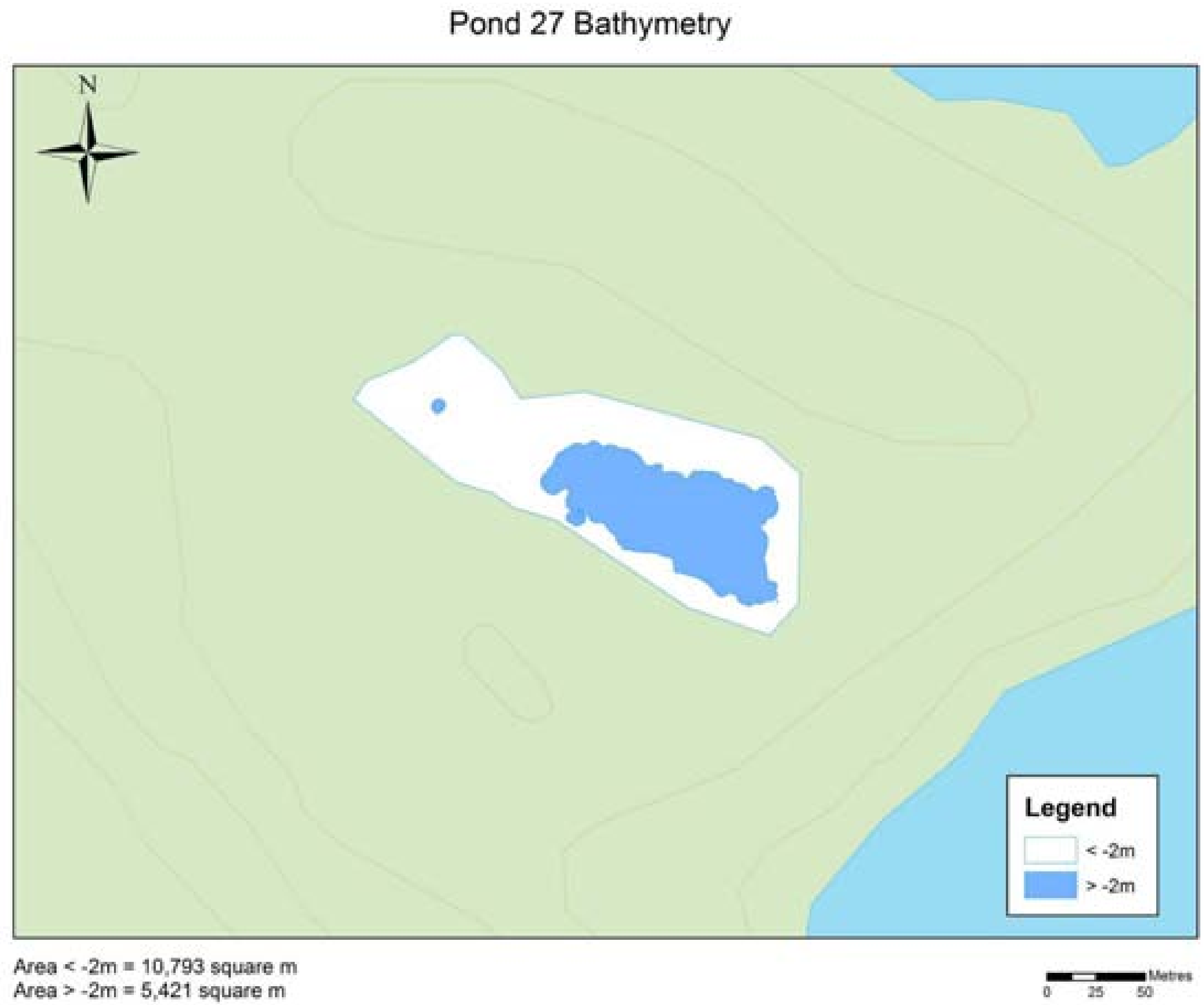

Figure 9.27 Pond P27 Littoral and Profundal zones, June 30, 2006.

Table 9.50 The calculated total area of each habitat type within Pond P27.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.54**
Lc - Littoral Zone - Coarse	0.48
Lm - Littoral Zone - Medium	0.18
Lf - Littoral Zone – Fine, no aquatic vegetation	0.41
Lf – Littoral Zone – Fine, with aquatic vegetation	0.01
Sub Total, Littoral Zone	**1.08**
Total Habitat	**1.62**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel);
Littoral Fine (comprising a majority of sand and organics/detritus); and
Profundal (comprising a majority of organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-51 presents an overview of the habitat information used to determine habitat areas. Table 9-52 shows the habitat suitabilities of each habitat type for brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-53 presents the results.

Table 9.51 Summary of Pond P27 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated automatically

Enter Lake name: P27

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m: Path 1		OR	IF Lake Depth is greater than 10 m: Path 2	
A Enter Depth of Littoral Zone:	2		A-1 Enter mean depth of Non-Littoral Zone:	0
B Enter Mean Depth of Lake:	2		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:			
	Mean depth of Non-Littoral Zone:		*(Reduced Value)*
	Depth of the Benthic Zone:		*(Reduced Value)*
	Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	1,088.36	Rubble:	696.28	Sand:	0.00
	Boulder:	3,677.44	Cobble:	959.92	Silt:	0.00
			Gravel:	148.72	Muck:	4,107.36
					Clay:	0.00
	SubTotals:	4,766		1,805		4,107

Littoral Zone (Vegetation)						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	114.92
					Clay:	0.00
	SubTotals:	0		0		115

Non-Littoral Zone						
Substrate:	**Coarse**	m^2	**Medium**	m^2	**Fine**	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	5,421.00
					Clay:	0.00
	SubTotals:	0		0		5,421

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	4,766
Littoral Medium/No vegetation	1,805
Littoral Fine/No vegetation	4,107
subtotal Littoral/No vegetation	**10,678**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	115
Subtotal Littoral/Vegetation	**115**
Subtotal Littoral	**10,793**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	5,421
Subtotal nonlittoral	**5,421**
Total Available Habitat	**16,214**

Table 9.52 Habitat suitabilities for all species, Pond P27.

STEP 4 Pond 27

	Species	Life Stage	Littoral Zone: Coarse/No Vegetation	Littoral Zone: Medium/No Vegetation	Littoral Zone: Fine/No Vegetation	Littoral Zone: Coarse/Vegetation	Littoral Zone: Medium/Vegetation	Littoral Zone: Fine/Vegetation	Non-Littoral Zone: Coarse/Pelagic	Non-Littoral Zone: Medium/Pelagic	Non-Littoral Zone: Fine/Pelagic
1	Brook Trout (freshwater resident)	Spawning	0.00	0.84	0.67	NA	NA	0.67	NA	NA	0.22
		YOY	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.00
		Juvenile	0.50	1.00	0.00	NA	NA	0.00	NA	NA	0.11
		Adult	0.00	0.67	0.00	NA	NA	0.00	NA	NA	0.11

Table 9.53 Habitat equivalent units for all species, Pond P27.

Step 5

Species	Littoral Zone: Coarse/No Vegetation	Littoral Zone: Medium/No Vegetation	Littoral Zone: Fine/No Vegetation	Littoral Zone: Coarse/Vegetation	Littoral Zone: Medium/Vegetation	Littoral Zone: Fine/Vegetation	Non-Littoral Zone: Coarse/Pelagic	Non-Littoral Zone: Medium/Pelagic	Non-Littoral Zone: Fine/Pelagic
Brook Trout	0.50	1.00	0.67	0.00	0.00	0.67	0.00	0.00	0.22

Species	Littoral Zone: Coarse/No Vegetation 4766	Littoral Zone: Medium/No Vegetation 1805	Littoral Zone: Fine/No Vegetation 4107	Littoral Zone: Coarse/Vegetation 0	Littoral Zone: Medium/Vegetation 0	Littoral Zone: Fine/Vegetation 115	Non-Littoral Zone: Coarse/Pelagic 0	Non-Littoral Zone: Medium/Pelagic 0	Non-Littoral Zone: Fine/Pelagic 5421	TOTAL
Brook Trout	2,383	1,805	2,752	0	0	77	0	0	1,193	8,209

Pond P30 – Forgotten Pond

Fish Species Present

This small bog pond was considered a pool in the Rattling Brook stream surveys conducted in 2006 but was later quantified as a pond in May 2007. While no fish species presence data was collected for the pond, it has been assumed that the fish species present in Rattling Brook would also be present here, i.e. brook trout. A total of seven quantitative electrofishing sites and seven index electrofishing sites were completed within Rattling Brook to determine the species within the system. In addition, a total of seven ponds within the watershed were sampled using multiple techniques including fyke nets, angling and baited minnow traps to determine the species utilizing the watershed. The results indicate that brook trout are the dominant species in the watershed.

Habitat Quantification

Secchi depth was averaged over 2 samples and determined to be 2.65m. The maximum depth measured in Pond P30 was 3.9m. Pond P30 comprises 4.22ha; of which all is littoral habitat. Figure 9-28 presents the bathymetric contours of Pond P30 as modeled from the data.

Substrate Composition

Substrate composition of the littoral zone was conducted and used in the DFO spreadsheet to calculate aerial extents and habitat equivalent units. These calculations are provided later in this section. The pond has a shoreline comprising a majority of boulder with some rubble and cobble with the deeper zones comprised of muck (organics and detritus). The deepest portion of the pond is a small pocket located near the inflow. This area had a quantity of gravels. The overall composition of each substrate type (m^2) is outlined below:

	Littoral	**Profundal**
o Bedrock		
o Boulder	4,562.59	
o Rubble	2,319.96	
o Cobble	1,237.31	
o Gravel	3,866.60	
o Sand		
o Muck/Detritus (organic)	30,198.15	
o **Total**	**42,184.61**	

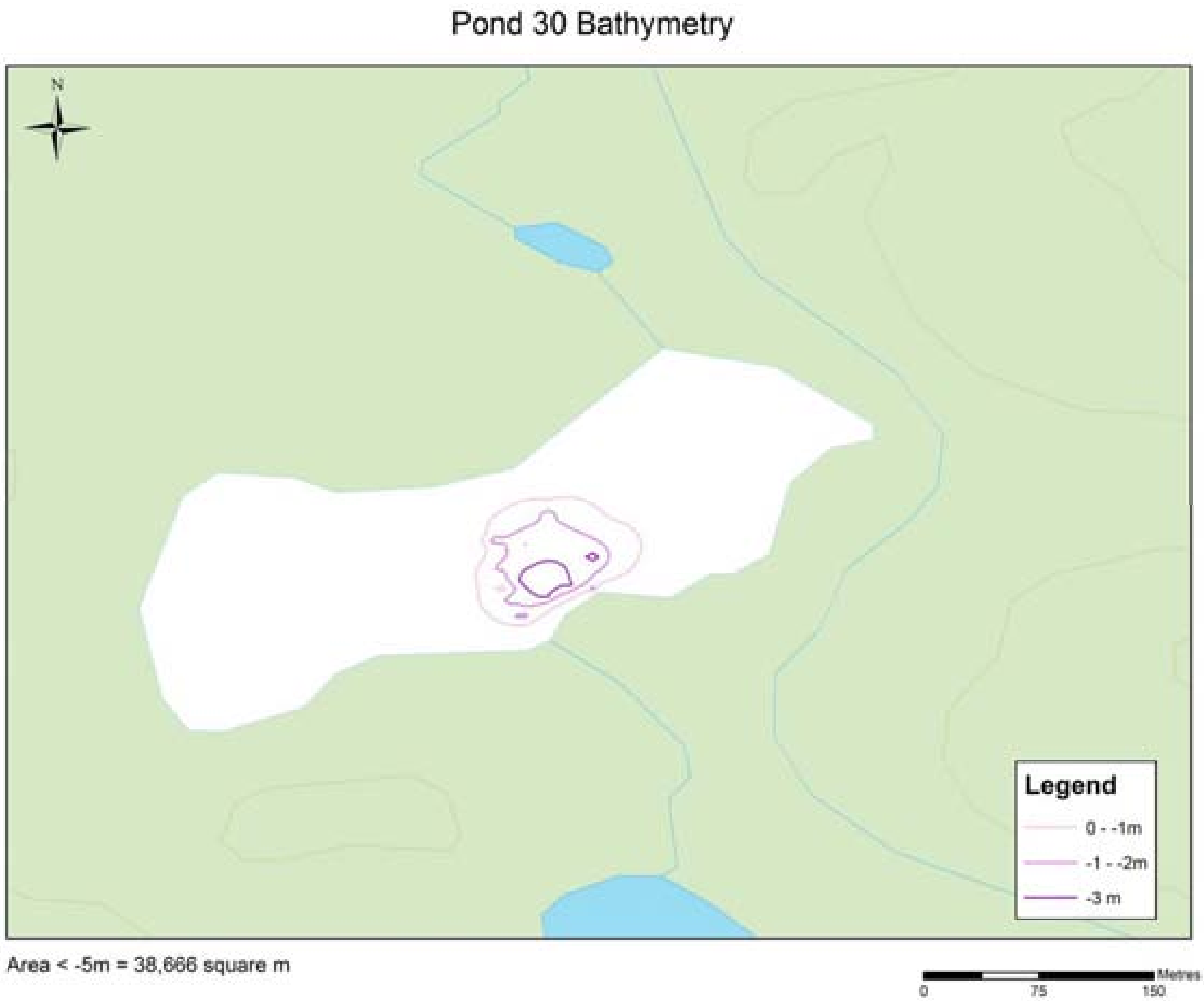

Figure 9.28 Pond P30 Bathymetric contours, May 8, 2007.

The pond has emergent vegetation present/visible throughout, primarily in all areas were muck/organics are present. Estimated coverage of the littoral zone was 30,198.15m^2. Table 9-54 presents the calculated area of each habitat type in Pond P30.

Table 9.54 The calculated total area of each habitat type within Pond P30.

HABITAT TYPE	AREA (hectares)
P - Profundal Zone	**0.00**
Lc - Littoral Zone - Coarse	0.46
Lm - Littoral Zone - Medium	0.74
Lf - Littoral Zone – Fine, no aquatic vegetation	0.00
Lf – Littoral Zone – Fine, with aquatic vegetation	3.02
Sub Total, Littoral Zone	**4.22**
Total Habitat	**4.22**

Littoral Coarse (comprising a majority of bedrock, boulder);
Littoral Medium (comprising a majority of rubble, cobble and gravel); and
Littoral Fine (comprising a majority of sand and organics/detritus).

Habitat Suitabilities

The DFO spreadsheet for calculating lacustrine habitat suitabilities and habitat equivalent units was used with the field habitat and species presence data collected. Table 9-55 presents an overview of the habitat information used to determine habitat areas. Table 9-56 shows the habitat suitabilities of each habitat type for the species (assumed) present; brook trout.

Habitat Equivalent Units

DFO spreadsheet calculations were used to determine final habitat equivalent units of each habitat type present. Table 9-57 presents the results.

Table 9.55 Summary of Pond P30 habitat values used to calculate aerial extents.

Step 1

Note: Only enter the values in the cells shaded blue, the subtotals, totals and ratios will be calculated autor

Enter Lake name: P30

Part 1 Entering Lake depth(s):

IF Lake Depth is less than or equal to 10 m:			IF Lake Depth is greater than 10 m:	
Path 1		OR	Path 2	
A Enter Depth of Littoral Zone:	5		A-1 Enter mean depth of Non-Littoral Zone:	0
B Enter Mean Depth of Lake:	2		B-1 Enter depth of Benthic Zone:	0

Path 2 (Continued…)

IF Lake Depth is greater than 10 m:

Mean depth of Non-Littoral Zone:		*(Reduced Value)*
Depth of the Benthic Zone:		*(Reduced Value)*
Benthic Pelagic ratio:		

Part 2 Enter the values for the estimated bottom surface area:

Littoral Zone (No vegetation):

Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	2,319.96	Sand:	0.00
	Boulder:	4,562.59	Cobble:	1,237.31	Silt:	0.00
			Gravel:	3,866.60	Muck:	0.00
					Clay:	0.00
	SubTotals:	4,563		7,424		0

Littoral Zone (Vegetation)

Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	30,198.15
					Clay:	0.00
	SubTotals:	0		0		30,198

Non-Littoral Zone

Substrate:	Coarse	m^2	Medium	m^2	Fine	m^2
	Bedrock:	0.00	Rubble:	0.00	Sand:	0.00
	Boulder:	0.00	Cobble:	0.00	Silt:	0.00
			Gravel:	0.00	Muck:	0.00
					Clay:	0.00
	SubTotals:	0		0		0

Part 3 Summary Table for Bottom Surface Area Totals:

Habitat Types	Bottom Surface area (m^2)
Littoral Coarse/No vegetation	4,563
Littoral Medium/No vegetation	7,424
Littoral Fine/No vegetation	0
subtotal Littoral/No vegetation	**11,986**
Littoral Coarse/Vegetation	0
Littoral Medium/Vegetation	0
Littoral Fine/Vegetation	30,198
Subtotal Littoral/Vegetation	**30,198**
Subtotal Littoral	**42,185**
Non-littoral Coarse/Pelagic	0
Non-littoral Medium/Pelagic	0
Non-littoral Fine/Pelagic	0
Subtotal nonlittoral	**0**
Total Available Habitat	**42,185**

Table 9.56 Habitat suitabilities for all species, Pond P30.

STEP 4 Pond 30

	Species	Life Stage	Littoral Zone: Coarse/No Vegetation	Littoral Zone: Medium/No Vegetation	Littoral Zone: Fine/No Vegetation	Littoral Zone: Coarse/Vegetation	Littoral Zone: Medium/Vegetation	Littoral Zone: Fine/Vegetation	Non-Littoral Zone: Coarse/Pelagic	Non-Littoral Zone: Medium/Pelagic	Non-Littoral Zone: Fine/Pelagic
1	Brook Trout (freshwater resident)	Spawning	0.00	0.72	NA	NA	NA	0.56	NA	NA	NA
		YOY	1.00	1.00	NA	NA	NA	0.00	NA	NA	NA
		Juvenile	1.00	1.00	NA	NA	NA	0.00	NA	NA	NA
		Adult	0.00	0.67	NA	NA	NA	0.00	NA	NA	NA

Table 9.57 Habitat equivalent units for all species, Pond P30.

Step 5

Species	Littoral Zone: Coarse/No Vegetation	Littoral Zone: Medium/No Vegetation	Littoral Zone: Fine/No Vegetation	Littoral Zone: Coarse/Vegetation	Littoral Zone: Medium/Vegetation	Littoral Zone: Fine/Vegetation	Non-Littoral Zone: Coarse/Pelagic	Non-Littoral Zone: Medium/Pelagic	Non-Littoral Zone: Fine/Pelagic
Brook Trout	1.00	1.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00

Species	Littoral Zone: Coarse/No Vegetation 4563	Littoral Zone: Medium/No Vegetation 7424	Littoral Zone: Fine/No Vegetation 0	Littoral Zone: Coarse/Vegetation 0	Littoral Zone: Medium/Vegetation 0	Littoral Zone: Fine/Vegetation 30198	Non-Littoral Zone: Coarse/Pelagic 0	Non-Littoral Zone: Medium/Pelagic 0	Non-Littoral Zone: Fine/Pelagic 0	TOTAL
Brook Trout	4,563	7,424	0	0	0	16,911	0	0	0	28,898

10.0 Past Resource Use

The Rattling Brook watershed was used in the past as a freshwater source for the former phosphorus plant owned and operated by ERCO between 1968 and 1989. While exact volumes used by the plant are not readily available, several sources have identified the total water requirements for the plant. For example, the main effluents discharged into Long Harbour during operation included:

- "phossy water" which consisted of sea water used to condense the phosphorus;
- water from the pelletizing plant; and
- water from the dryers (Lake 1987).

According to Idler (1969), the total effluent flows from these processes above were estimated at 8,000USGPM (i.e. 0.505m^3/s). A report on the Industrial Waste Control of the Phosphorus Plant (ERCO 1967) indicated the total effluent from the boiler house was 7,000USGPM (i.e. 0.442m^3/s). As a conservative estimate, the boiler room has been used to represent a reasonable water extraction rate. Figure 2.7 therefore shows the estimated results of this rate of water extraction on the natural hydrograph of Rattling Brook. This extraction of water would have reduced the total fish and fish habitat within the watershed by restricting the amounts of suitable riverine habitat for most of the year, particularly summer and mid-winter.

A minimum flow requirement estimate was conducted on the main stem of Rattling Brook using the Wetted-Perimeter Method (WPM). The results indicated that a maintained minimum flow of 0.30-0.35m^3/s would provide adequate protection of the aquatic habitat. This flow is higher than those currently experienced during low flow years in February and the typical low summer flow periods of July to September. As shown in Figure 9-1, during low flow years (i.e. minimum flows) no flow would have been present during mid-February to mid-March and from mid-June to mid-October. The WPM minimum flow recommendation would also keep flows above those estimated to have occurred during average monthly flows in Rattling Brook for the month of August during the ERCO extractions.

The Sandy Pond watershed is undeveloped and no cabins or roads exist as a result of past resource use. The former phosphorus plant was not within the Sandy Brook drainage area.

11.0 Present Resource Use

The Rattling Brook watershed is not pristine as researchers recorded five cabins on Sam Howe's Pond, three on Rattling Brook Big Pond and one on Forgotten Pond. The decommissioned water extraction infrastructure associated with the ERCO phosphorus plant still remains in the watershed which includes a water pipeline between Rattling Brook Big Pond and the Long Harbour Industrial Park, a concrete weir in the main stem of the brook approximately 400m upstream from the mouth and a rock-fill dyke on the outflow of Sam Howe's Pond (P14) (*see* Section 8.5.1 above for general descriptions).

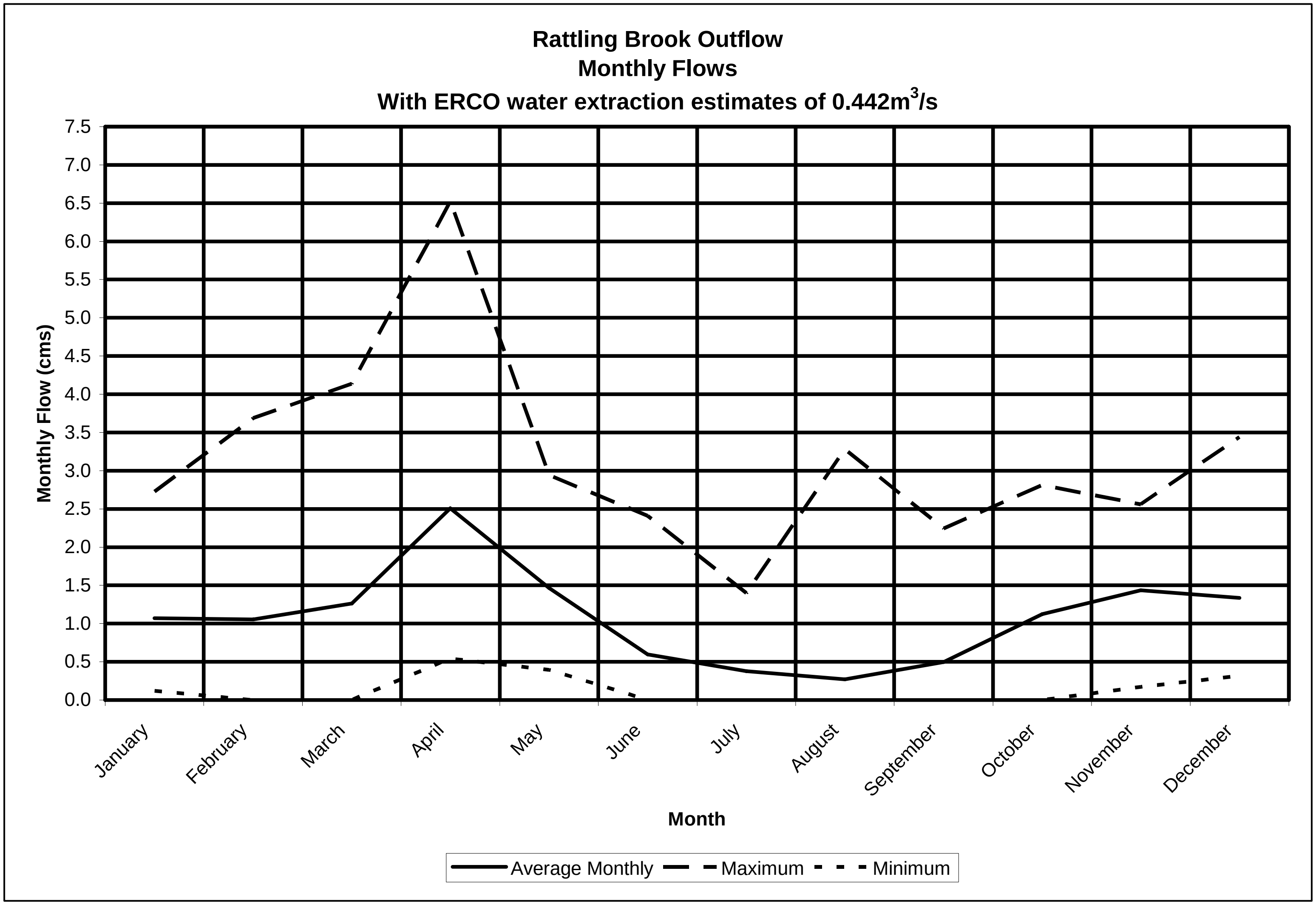

Figure 11.1 Hydrograph of Rattling Brook with estimated water extraction for the former phosphorus plant.

The maintenance and access road originally constructed by ERCO still provides access to the watershed from the Long Harbour Industrial Park. This is used extensively by local residents, cabin owners, hunters and anglers to access the area. As many as four boats were stored by anglers and hunters at Rattling Brook Big Pond where the road ends during 2006 surveys.

The federal Department of Fisheries and Oceans issues licenses for commercial American eel fishing in the province. Licensing data indicates that no traps were registered for any streams in the Long Harbour area since 2001 (i.e. 2001-2005 licensing period). DFO did indicate that both Rattling Brook in Placentia and Fox Harbour were identified as trap locations in the licensing period 1994-1999. (Mr. Jeff Venoit, DFO, Personal Communication).

Sandy Pond is a local destination for brook trout fishing as discussions with local residents and anglers indicate that fish can be larger than those typically found in the surrounding ponds. As noted by DFO, this is most likely due to the rainbow smelt as a food source (Albright and Wilson 1992). There is an existing trail from Highway 101 to Sandy Pond which is used by anglers to access the pond. Indications are that most anglers fish the pond during the winter season as it is easier to access. Information from locals indicates that even though the fish may be larger, they are not preferred eating as their flesh is pale and of poor quality and taste (most likely due to rainbow smelt as a major food source).

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Mr. Jeff Venoit, Department of Fisheries and Oceans, St. John's, NL.