Emergency Reduction of Lake Manitoba & Lake St. Martin Water Levels

Aquatic Environment Monitoring - Fall 2011

REPORT

Prepared for Manitoba Infrastructure and Transportation · August 2013
By North/South Consultants Inc. · 83 Scurfield Blvd. · Winnipeg, MB · R3Y 1G4

EMERGENCY REDUCTION OF LAKE MANITOBA AND LAKE ST. MARTIN WATER LEVELS

Aquatic Environment Monitoring
Fall 2011

August 2013

Prepared for
Manitoba Infrastructure and Transportation

By:

North/South Consultants Inc.
Aquatic Environment Specialists

83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca

Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

EXECUTIVE SUMMARY

Due to widespread record flooding throughout southern Manitoba in 2011, water levels in Lake Manitoba and Lake St. Martin staged several feet higher than desirable, resulting in significant damage to hundreds of properties, restricted road access to several communities, and the long-term evacuation of four First Nations communities. If no action was taken, it was expected that high water levels and associated negative impacts would persist into 2012.

The Province of Manitoba (the Province) retained KGS Group and AECOM to investigate options to provide an emergency reduction of water levels in the two lakes. Water flows out of Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then through the Dauphin River to Lake Winnipeg (Figure 1-1). However, drainage through the Dauphin River to Lake Winnipeg was not sufficient to rapidly reduce the flood stage water levels on Lake Manitoba and Lake St. Martin. After reviewing numerous strategies, it was recommended that an emergency channel (Reach 1 Emergency Outlet Channel) be constructed to reduce the hydraulic flow restrictions out of Lake St. Martin to Lake Winnipeg (KGS and AECOM 2011). By improving the outflow capacity, the Fairford River Water Control Structure (FRWCS) could be operated at maximum capacity, thereby lowering water levels on Lake Manitoba, throughout winter 2011/12 without increasing flooding issues on Lake St. Martin.

The requirement to assess and monitor environmental effects associated with construction and operation of Reach 1 was recognized in the early stages of Project development. Monitoring initiated in 2011 will be ongoing into future years and will generate information required to assess the effects of operation of the Reach 1 Outlet Emergency Channel. The following summarizes results of initial monitoring activities, conducted during fall 2011.

Water Quality Monitoring

Water quality monitoring was conducted during fall 2011 to provide additional baseline information prior to operation of Reach 1, document changes in water quality during construction and operation of Reach 1, and to help determine the spatial extent over which changes to water quality may have occurred. Water quality data were collected from upstream of Lake Manitoba and throughout Lake St. Martin, the Reach 1 Emergency Outlet Channel System, and Sturgeon Bay prior to and during operation of Reach 1. Water quality data collections consisted of several components, each with discrete objectives. Water quality monitoring consisted of the following programs:

- Regional Water Quality Monitoring Program (RWQMP);
- Construction Environmental Monitoring Program (CEMP); and,
- *In situ* and TSS Monitoring in Sturgeon Bay.

RWQMP

During the conduct of the RWQMP, water quality information was collected from all major waterbodies and waterways within the study area that were affected by flooding and encompassed the major inputs to the north basin of Lake Manitoba (i.e., Waterhen River and at the Lake Manitoba Narrows) downstream to and including Sturgeon Bay on Lake Winnipeg. The objectives of the program were to:

- provide baseline water quality information to assist with operational and post-project monitoring
- to provide information from locations where water quality data were lacking;
- supplement data sets at sites within the study area where Manitoba Conservation and Water Stewardship, Water Quality Management Branch (MCWS) conducts water quality monitoring; and,
- evaluate spatial differences in water quality within the study area.

An assessment of effect(s) of the construction and operation of Reach 1 on the water quality of the study area has not been undertaken for this report. A brief assessment will be included with the presentation of the results from the fall 2012 monitoring program with a thorough assessment including historical and project-related water quality data to follow.

RWQMP results indicate that water quality within the study area can be generally described as moderately nutrient-rich, low to moderately turbid, slightly alkaline, hard to very hard, and well-oxygenated.

The water quality of Buffalo Creek differed from the other waterbodies sampled. Buffalo Creek had lower turbidity/TSS, lower conductivity and total dissolved solids (TDS), lower chlorophyll a, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area.

Both Lake St. Martin and Sturgeon Bay were isothermal in fall 2011. Other in situ variables, including DO, turbidity, pH, and specific conductance, were relatively consistent across depth in both lakes. Molar ratios of N:P indicated that all of the sampled waterbodies were phosphorus limited in fall 2011. Total phosphorus exceeded the MWQSOG guidelines at Lake Manitoba Narrows and several sites in Sturgeon Bay, but all other routine water quality variables for which there are MWQSOG and CCME guidelines, including DO, pH, ammonia, nitrate and nitrite were within PAL objectives and guidelines at all locations.

The water quality of Sturgeon Bay was also influenced by the Dauphin River such that sites closest to the river mouth exhibited water quality similar to upstream sites, including: higher alkalinity, conductivity, TDS, nitrogen and carbon concentrations and lower turbidity/TSS, colour, phosphorus and chlorophyll a.

Concentrations of major ions and metals were generally lower in Buffalo Creek, compared to other waterbodies in the study area. Conversely, mercury and methyl mercury concentrations were higher, and were consistently detected, at sites in Buffalo Creek than at other sites sampled. Additionally, concentrations of the major ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) and hardness were higher at the sites closest to the Dauphin River outflow (LKW2 and 3) than at the other sites sampled in Sturgeon Bay, reflecting the higher concentration of these substances at upstream waterbodies in the region relative to Lake Winnipeg. Conversely, the Dauphin River contained lower concentrations of total aluminum, copper, iron, manganese, titanium, and uranium than sites in Sturgeon Bay most distant from the Dauphin River mouth.

Aluminum, chloride, fluoride, iron, and selenium all exceeded PAL guidelines or objectives on at least one occasion within the study area. All other metals and major ions were within MWQSOGs and CCME guidelines for PAL.

Of the 58 pesticides analysed for, only glyphosate was detected in the study area during fall 2011 and it did not exceed the federal and provincial guidelines for PAL.

CEMP

CEMP was conducted from September 2 to November 25, 2011. Additionally, following the opening of Reach 1 (November 1, 2011), water quality was monitored in the reach from November 1 to 25, 2011. The objective was to describe baseline water quality parameters and to monitor potential changes to water quality in Buffalo Creek and the lower Dauphin River during construction and early operation of Reach 1.

Construction EMP monitoring indicated that TSS concentrations had returned to near baseline conditions by the end of November following an initial increase measured during the opening of Reach 1 in early November (AECOM 2012). Immediately following the opening of Reach 1, the TSS concentrations exceeded CCME guidelines within Buffalo Creek and the Dauphin River immediately downstream of the creek, but fell below limits within two weeks.

Based on the data collected by AECOM (2012) there were no indications that the construction of Reach 1 or its initial operation resulted in changes to nutrient concentrations downstream. However, the mercury concentrations measured in two samples collected from the Dauphin River, one upstream and one downstream of Buffalo Creek, on October 14, 2011 exceeded the CCME guideline for PAL. There was no evidence of hydrocarbon contamination due to construction activities, as petroleum hydrocarbons were not detected during the monitoring program.

In situ and TSS Monitoring

In situ and TSS monitoring were conducted in Sturgeon Bay from September 30 to October 21, 2011. Objectives were to:

- collect baseline water quality information in Sturgeon Bay and the Dauphin River;
- help delineate the spatial extent over which suspended sediment inputs may be distributed in Sturgeon Bay and the Dauphin River; and,
- develop a reliable turbidity/TSS relationship for analysis of turbidity data.

In general, water quality near the surface was similar to that near the bottom at sites sampled in Sturgeon Bay. Turbidity was variable throughout Sturgeon Bay; however, since the measurements were collected on multiple days over a three week period, the ability to make spatial comparisons is limited to within transect comparisons. There was some evidence of higher turbidity at sites closer to shore along several of the Sturgeon Bay transects. There was no difference in pH or DO from nearshore to offshore in Sturgeon Bay, and pH and DO were similar throughout the area sampled. Sturgeon Bay was well-oxygenated and all DO measurements exceeded the MWQSOGs objectives and the CCME guidelines for PAL. All pH measurements were within the MWQSOGs and CCME guidelines for PAL.

In the Dauphin River, in situ water quality was similar upstream and downstream of Buffalo Creek. Likewise, no difference in water quality was observed across transects. A small number of laboratory samples were used to establish a TSS/turbidity relationship for Sturgeon Bay. Additional samples will subsequently be used to strengthen the relationship.

Sediment Inputs to Sturgeon Bay

Sediment inputs to Sturgeon Bay were monitored during fall 2011 to determine baseline sediment quality, characterize substrates in the lower Dauphin River and in Sturgeon Bay and measure the Dauphin River sediment contributions into Sturgeon Bay. A sedimentation study was also initiated during fall 2011 and will continue into future years. The objectives of the programs were to:

- Determine the type and amount of sediment deposited into Sturgeon Bay during operation of Reach 1;
- Determine the bed load contribution of the Dauphin River into Sturgeon Bay, before operation, and the Dauphin River and Buffalo Creek, during operation of Reach 1;
- Collect sediment grab samples in the Dauphin River and Sturgeon Bay for particle grain size and organic content analysis to assess changes in substrate due to sedimentation. This information will also be used to validate substrate data collected through sonar during habitat mapping studies; and,
- Collect sediment samples from the Dauphin River and Sturgeon Bay to document baseline sediment quality and assess Project-related impacts.

Bed Load and Suspended Sediments

Bed load samples and in situ water quality were collected on October 16, 22 and November 6 at three sites in the Dauphin River. High water velocity in Buffalo Creek precluded collection of bed load samples from within the creek and, consequently, the program objectives could not be met. All samples from the Dauphin River were archived.

Laboratory analyses of water samples collected prior to and following the onset of Reach 1 operation indicated an increase in Buffalo Creek and the Dauphin River downstream of Buffalo Creek after Reach 1 became operational. These data will support results from other water quality sampling programs (see Section 3.0).

Sedimentation Rate

Thirty sediment traps were deployed in Sturgeon Bay on October 19, 2011 to determine the type and amount of sediment being deposited in the area. The traps remained deployed until summer 2012 and results from the program were to be provided in subsequent reports.

Substrate Classification

Substrate sampling was conducted at Sturgeon Bay from September 30-October 1 and October 20-21 along 12 transects and at three offshore extensive zone sites. Sediment quality samples were archived for future metals analysis. Carbon and particle size analysis results indicated that nearshore sites in Sturgeon Bay were typically sand and gravel while offshore sites were characterized as clay. Total organic carbon ranged from 0.2-3.91% with the relative proportion increasing with distance offshore.

Habitat and Fisheries Survey of the Buffalo Creek Watershed

Project design was that the Buffalo Creek watershed would be the initial receiving environment for flow diverted through Reach 1. A lack of information pertaining to the watershed was identified during a preliminary screening process conducted prior to operation of Reach 1 and it was determined that a basic understanding of fish resources and use of aquatic habitat within the Buffalo Creek watershed would be required to assist in assessing the effects of Reach 1 operation. Consequently, a series of investigations were conducted to collect information describing aquatic resources within the Buffalo Creek watershed. The investigations included:

- conducting a Construction Environmental Monitoring Program (CEMP) to document water quality conditions in Lake St. Martin at the entrance to Reach 1, along Buffalo Creek, and in the Dauphin River upstream and downstream of the Buffalo Creek confluence during construction and initial operation of Reach 1;
- a brief field program conducted from 15-17 August, 2011, to collect *in situ* water quality information, describe aquatic habitat, and identify fish presence/absence and distribution throughout the Buffalo Creek watershed; and,
- a desk top exercise to quantify the type and amount of aquatic habitat occurring within the Buffalo Creek watershed.

Water Quality

Water quality information specific to the Buffalo Creek watershed was collected through the CEMP program and a brief field investigation that provided information specific to Big Buffalo Lake.

As part of the CEMP, water quality was monitored in Lake St. Martin, Buffalo Creek, and in the Dauphin River from September 2 until 01 November, when Reach 1 became operational. Sampling included the collection of in situ water quality data, as well as samples for laboratory analysis. Following the onset of operation, water quality monitoring continued throughout the system until 25 November, 2011. Prior to 01 November, monitoring was conducted approximately twice a month. After Reach 1 was opened, sampling frequency increased to twice a week. Prior to operation of Reach 1, the water quality of Buffalo Creek differed from Lake St. Martin, the Dauphin River or Sturgeon Bay. Buffalo Creek had lower turbidity/TSS, lower conductivity and total dissolved solids (TDS), lower chlorophyll a, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area.

In situ water quality measurements were taken at four sites in Big Buffalo Lake on 17 August, 2011. Results indicated that the lake was not thermally stratified, was relatively well-oxygenated, and near-neutral. Turbidity was less than 7 NTU and Secchi disk depth ranged from 1.2-2.2 m. In situ measurements at the mouth of Buffalo Creek indicated that water at the creek mouth was slightly more turbid, acidic, less oxygenated, and warmer than measured at Big Buffalo Lake.

Aquatic Habitat

Prior to operation of Reach 1, aquatic habitat in Big Buffalo Lake and Buffalo Creek were characterized and quantified to describe pre-Project conditions. The habitat assessment was completed using information collected during a brief field program conducted in August 2011 and by interpreting habitat characteristics from aerial orthometric imagery and geo-referenced digital photographs to classify and quantify aquatic habitat within the watershed.

Big Buffalo Lake is a small lake (surface area of 55 ha) from which Buffalo Creek originates. Maximum water depth was 2.2 m and substrate was comprised of a deep layer of loosely compacted organic sediments. Aquatic vegetation occurred throughout much of the lake, although was considerably less dense in the central portion compared to nearshore areas. Lake shorelines were composed largely of shrub wetlands comprised of cattails and bulrushes, as well floating bog in some areas. Few areas surrounding the lake support trees.

Buffalo Creek originates at Buffalo Lake and flows for approximately 17 km to its confluence with the Dauphin River. For approximately the first 4 km downstream of Big Buffalo Lake, the creek flows through a sparsely treed wetland/bog complex and is characterized by a narrow channel (< 5 m wide) that becomes indeterminate in some locations. Upon leaving the wetland/bog complex, the creek enters an area of higher gradient and develops a meandering pattern where riffle/run/pool sequences flow over local deposits of cobble, gravel, and sand. Beaver dams were common.

A total of 901,981.9 m^2 (or 90.2 ha) of habitat in the Buffalo Creek watershed was classified from digital imagery. Six different habitat types were identified. The majority of habitat in the watershed was identified as peat pool habitat. This habitat type occurred exclusively in the upper reaches of the watershed within the confines of the wetland/bog complex, and included Big Buffalo Lake. Most of Buffalo Creek downstream of the wetland/bog complex was comprised of the run habitat (15% of available habitat within the watershed. Pool and riffle habitat accounted for about 6% of total available habitat within the watershed, and beaver dams and pools each comprised less than 1% of the total available habitat.

Fish Presence and Abundance

At least ten species of fish were captured in the Buffalo Creek watershed. Some small dace and sculpin could not be identified to species and the catch may include more than one species of each. Species diversity was greater in Buffalo Creek than in Big Buffalo Lake, and there was little overlap in community composition between the upstream and downstream reaches of the creek.

The fish community within Big Buffalo Lake was sampled using experimental gill nets. The catch totalled 315 fish representing four species. Yellow Perch was the most abundant species, comprising 86.7% of the total catch. The remainder of the catch included Northern Pike (6.3%), Golden Shiner (3.8%), and White Sucker (3.2%). Northern Pike and White Suckers captured within the lake were all juvenile fish. The absence of adults suggests that these species do not fulfill all of their life history requirements within the lake. In contrast, adult, juvenile and young-of-the-year Yellow Perch were captured in the lake. In particular, large numbers of young perch were captured, suggesting that the lake supports a resident population. The extent to which Golden Shiner use the is not known, although large numbers of small fish not susceptible to capture in the gill nets were observed. It is possible that these were young-of-the-year Golden Shiner.

Back pack electrofishing was conducted at 12 sites along Buffalo Creek to document fish presence and abundance. Fishing focussed on two general areas within the creek. The first originated where the creek exited the wetland/bog complex and extended downstream for approximately 1 km. The second originated at the creek's confluence with the Dauphin River and extended upstream for approximately 2 km.

More than 250 fish representing four species were observed or captured at the upstream reach. The majority of the fish were Central Mudminnows and dace species, some of which were identified as Pearl Dace, but most of which were unidentified. A small number of juvenile White Sucker were also captured.

Considerably fewer fish were captured in the downstream reach. Twenty individuals representing five species were captured. Species occurring in the downstream reach were different than that observed in the upstream reach. Northern Pike, Longnose Dace, Slimy Sculpin, Yellow Perch, and Logperch were observed in the downstream reach but not the upstream reach. Central mudminnows and dace species other than Longnose Dace were abundant in the upstream reach but were not observed in the downstream reach. This difference may be due to different habitat conditions between the two areas, or due to proximity to the Dauphin River.

Habitat Mapping in Dauphin River and Sturgeon Bay

It was thought that operation of Reach 1 could result in substrate changes in Sturgeon Bay due to increased sediment inputs. The intent of habitat mapping studies was to document pre-operation habitat conditions in Sturgeon Bay and the Dauphin River and provide a baseline to help assess post-project changes. Specific study objectives include:

- collect habitat information (water depth and substrate type) where data do not exist;
- determine baseline depth and substrate types in shallow water areas of Sturgeon Bay and in the Dauphin River mouth and surrounding area understood by local knowledge to be potential Walleye and Lake Whitefish spawning habitat;
- To identify potential Walleye and Lake Whitefish spawning habitat in the Dauphin River and in Sturgeon Bay; and,
- To characterize deep water substrate types in offshore areas of Sturgeon Bay.

A suite of methods were proposed to compile habitat information within the Dauphin River and Sturgeon Bay. These included the collection of bathymetric and substrate data in the Dauphin River and Sturgeon Bay using sonar technology, collection of substrate samples in Sturgeon Bay and slow water velocity areas of the Dauphin River to help validate interpretation of the sonar data, and the conduct of rebar drags in fast water velocity areas of the Dauphin River to help validate interpretation of the sonar data. Collected information was used to produce maps of aquatic habitat.

Bathymetric and substrate classification field activities along the Dauphin River were conducted between 11 and 17 October, 2011. Inclement weather (high wind conditions) throughout fall 2011 prevented access to Sturgeon Bay and, consequently, only limited sampling occurred in Sturgeon Bay during fall 2011. Sonar data could not be collected from Sturgeon Bay, but a series of substrate samples were collected.

Dauphin River

Substrate conditions were mapped for 2,114,121.7 m2 of riverbed habitat in the lower Dauphin River. Cobble/boulder and gravel/sand were most abundant, each comprising almost 28% of the area mapped. Gravel/cobble and bedrock were the next most common types.

Habitat conditions in the lower Dauphin River suitable to support spawning for many species of fish, including Lake Whitefish and Walleye, were documented during fall 2011. Fall fisheries conducted during late fall 2011 documented spawning by Lake Whitefish in the lower Dauphin River in the vicinity of the Buffalo Creek/Dauphin River confluence (Section 7.2). Ongoing fisheries studies at Dauphin River have continued to document use of habitat in the lower Dauphin River by fish.

Sturgeon Bay

Substrate samples were collected at 48 sites within Sturgeon Bay. Visual assessments were conducted for each location where grabs were obtained or, if a grab could not be obtained due to size or compaction of substrate (i.e., cobble, boulder etc.), substrate characteristics were assessed by probing the bottom with a steel pole or dragging the ponar across the bottom. An indication of substrate conditions was derived from this program, and suggested that substrate conditions suitable to support spawning (gravels, cobbles and, to a lesser extent, boulders) by Lake Whitefish, Walleye, and other species occurred at numerous locations in nearshore areas of Sturgeon Bay, including to the east and west of Willow Point.

Fall Fisheries Surveys in Dauphin River and Sturgeon Bay

Fisheries surveys were conducted in the Dauphin River and Sturgeon Bay during fall 2011 to provide information to supplement pre-existing aquatic environment information, and provide contemporary pre-project information to assist in determining project-related effects. Specific study objectives included:

- identification of fall fish utilization in the Dauphin River, between the confluence with Buffalo Creek and Sturgeon Bay;

- identification of Lake Whitefish spawning areas in the Dauphin River, between the confluence with Buffalo Creek and Sturgeon Bay;
- determination of fall fish utilization of nearshore habitat in Sturgeon Bay during late fall (emphasis on fall spawning fish, particularly Lake Whitefish); and,
- collection of information on fall Lake Whitefish movements into the Dauphin River prior to operation of Reach 1.

Water Temperature

Water temperature loggers were deployed on 19 October. Water temperature in the Dauphin River and Sturgeon Bay were between 6 and 7°C when the loggers were deployed and decreased to 0-1°C by mid-November.

Fish Utilization

Nine species of fish were captured, most of which occurred contiguously in the Dauphin River and Sturgeon Bay. Four standard experimental gillnet gangs in Sturgeon Bay captured 333 fish, comprising all nine species. Cisco, White Sucker, Northern Pike, and Lake Whitefish were the most abundant species. Species diversity and abundance were highest at two nets set near the mouth of the Dauphin River. Most captured Lake Whitefish were adults in pre-spawn condition, including those fish captured near Willow Point.

Twenty-seven boat electrofishing runs were conducted in the Dauphin River, the lower-most reach of Buffalo Creek, and Sturgeon Bay in the vicinity of the Dauphin River over three sampling sessions during fall 2011. A total of 765 fish, comprising seven fish species, were captured during the electrofishing surveys with Lake Whitefish accounting for almost 94% of the catch. Most Lake Whitefish were captured in the Dauphin River in velocity refugia, including the downstream lee of shoals, small islands and at the confluence with Buffalo Creek. Male and female Lake Whitefish in early pre-spawn condition were captured at the onset of sampling in mid-October and, by November 5, most were in late pre-spawn condition.

Lake Whitefish Spawning Activity

Twenty egg mats were deployed in the mouth of Buffalo Creek and in the Dauphin River during fall 2011. Ten of these mats were successfully retrieved and sampled, producing a catch of 5,961 Lake Whitefish eggs. Most eggs were captured at three sites in the Dauphin River immediately upstream of the confluence with Buffalo Creek. The eggs were first captured on mats sampled on 04 November when large numbers of ripe females were observed during electrofishing surveys of the same area and egg abundance peaked on mats sampled on 15 November. The bulk of Lake Whitefish spawning in this reach of the Dauphin River during fall 2011 is suspected to have occurred during the first two weeks of November.

Debris Monitoring

Debris levels were obtained from four experimental gill nets set in Sturgeon Bay from 14 – 21 October. Three nets contained low levels of debris and the fourth contained none. Debris consisted primarily of aquatic and terrestrial vegetation.

Mercury Concentration in fish Tissue

The bioaccumulation of mercury in fish tissue was studied in Sturgeon Bay during fall 2011 due to the potential for flooding of watercourses as a result of Reach 1 operation increasing the loading of mercury and organic carbon into project waterbodies. The objectives of the mercury study were to:

- Document baseline mercury concentrations in commercially important fish species in Sturgeon Bay, prior to operation of Reach 1; and,
- Monitor mercury concentrations in fish tissue during project operation and evaluate potential increases relative to baseline conditions.

A total of 33 Lake Whitefish, 45 Northern Pike, and 18 Walleye captured during fall gillnetting surveys were analysed for age. Northern Pike sampled for mercury had a mean length almost identical to the standard length of 550 mm, whereas Lake Whitefish were on average larger and Walleye were on average smaller than the standard length for those species. Pike, Walleye, and Whitefish for which mercury analyses were conducted had mean ages of 5.4, 3.9 years, and 7.6, respectively.

Mercury concentrations in fish from Sturgeon Bay were generally low and similar to those recently documented for other areas of Lake Winnipeg. Concentrations, even in the largest fish, were typically lower than the Health Canada standard for commercial marketing of freshwater fish in Canada and most were lower than the now unofficial “safe consumption limit” for people eating “large quantities of fish”.

Local Knowledge

Biological information collected during a community consultation meeting in Gypsumville, 06 October, 2011 identified several spawning locations and fish movements in the study area. Lake Whitefish and Walleye spawning locations were identified east and west of Willow Point in Sturgeon Bay. Lake Whitefish move from Sturgeon Bay to Lake St. Martin via the Dauphin River during late August to freeze up. Spawning occurs by Lake Whitefish occurs at several locations in Lake St. Martin. Post-spawning downstream movements have been noted from November to December, although some Lake Whitefish remain in Lake St. Martin overwinter. In Lake St. Martin, Lake Whitefish spawning has been identified at The Narrows and Walleye, Carp, sucker, and Northern Pike spawning have been observed in various tributaries of the lake. Several fish harvest locations have been identified throughout the study area for Lake Whitefish, Walleye, Carp, and Yellow Perch.

TABLE OF CONTENTS

Page

Page

Page

Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

Page

Page

Page

LIST OF APPENDICES

Page

1.0 INTRODUCTION

Due to widespread record flooding throughout southern Manitoba in 2011, water levels in Lake Manitoba and Lake St. Martin staged several feet higher than desirable, resulting in significant damage to hundreds of properties, restricted road access to several communities, and the long-term evacuation of four First Nations communities.

The Province of Manitoba (the Province) retained KGS Group and AECOM to investigate options to provide an emergency reduction of water levels in the two lakes. Water flows out of Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then through the Dauphin River to Lake Winnipeg (Figure 1-1). However, drainage through the Dauphin River to Lake Winnipeg was not sufficient to rapidly reduce the flood stage water levels on Lake Manitoba and Lake St. Martin. After reviewing numerous strategies, it was recommended that an emergency channel (Reach 1 Emergency Outlet Channel) be constructed to reduce the hydraulic flow restrictions out of Lake St. Martin to Lake Winnipeg (KGS and AECOM 2011). By improving the outflow capacity, the Fairford River Water Control Structure (FRWCS) could be operated at maximum capacity, thereby lowering water levels on Lake Manitoba, throughout winter 2011/12 without increasing flooding issues on Lake St. Martin.

The proposed Reach 1 Emergency Outlet Channel (hereafter called Reach 1) included the excavation of a channel from Lake St. Martin to Big Buffalo Lake, a small lake located about 7 km northeast of Lake St. Martin (Figure 1-2). From Big Buffalo Lake, water would flow down Buffalo Creek and enter the Dauphin River about 4 km upstream of Sturgeon Bay on Lake Winnipeg. Construction of Reach 1 was initiated in late summer 2011 and water began flowing down the channel by 01 November 2011.

The requirement to assess and monitor environmental effects associated with construction and operation of Reach 1 was recognized in the early stages of Project development. KGS Group retained North/South Consultants Inc. to assist them with aquatic aspects of the environmental assessment and monitoring for the Project. Prior to completion of Reach 1, North/South Consultants Inc. produced an environmental scoping document that described, based on available information, the existing aquatic environmental conditions of waterbodies that might be affected by the Project, identified potential impacts that could result from construction and operation of the Project, and identified information needs to enhance the ability to mitigate and assess Project-related effects (North/South Consultants Inc. 2011a). As part of the screening process, a work plan was developed that detailed a suite of aquatic data collections to address identified information needs (North/South Consultants Inc. 2011b; Appendix 1-1). This report provides methods and results from aquatic investigations conducted during fall 2011.

Data collections will be ongoing throughout the operational and post-operational phase of Reach 1. Ultimately, the data presented in this report and collected subsequently will be used to produce an environmental effects assessment of the Project.

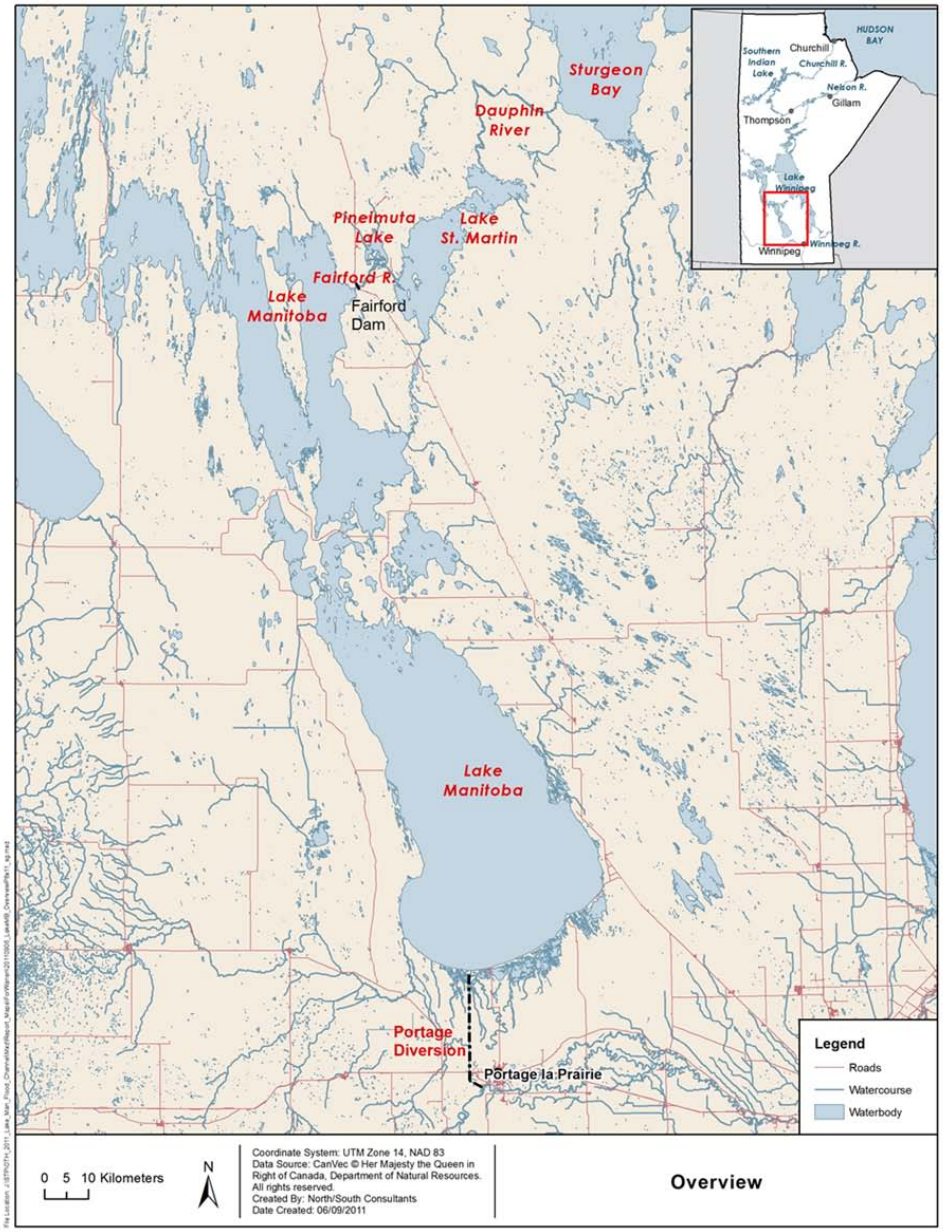

Figure 1-1. The location of major waterbodies and waterways affected by flooding in southern Manitoba during spring 2011.

Figure 1-2. Location of the Reach 1 Emergency Outlet Channel and Reach 3 Emergency Channel and the Buffalo Creek Drainage System in relation to Lake St. Martin, the Dauphin River and Sturgeon Bay.

2.0 STUDY AREA AND PROJECT DESCRIPTION

2.1 STUDY AREA

Construction and operation of Reach 1 and operation of the Fairford River Water Control Structure (FRWCS) at full capacity through the winter of 2011/2012 had the potential to affect aquatic environments in upstream waterbodies such as Lake Manitoba, the Fairford River, and Pineimuta Lake. However, the greatest potential impacts are expected on waterbodies in the vicinity and downstream of Reach 1, including Lake St. Martin, the Dauphin River, the Buffalo Creek Drainage System, and the Sturgeon Bay area of Lake Winnipeg (Figure 1-2). The emphasis of aquatic studies is on the area from Lake St. Martin downstream to Lake Winnipeg. Collectively, these waterways will be referred to as the "study area" throughout the remainder of this document.

The main water inflows into Lake Manitoba are from the Whitemud River, the Waterhen River (including Lake Winnipegosis and Dauphin Lake), and the Portage Diversion, which routes excess flows from the Assiniboine River into the south end of Lake Manitoba (Figure 1-1). Water flows out of Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then through the Dauphin River to Lake Winnipeg.

Big Buffalo Lake is a small lake (0.55 km2) located in a large wetland approximately 7 km north east of Lake St. Martin. The lake drains into Buffalo Creek, a small creek that discharges into the Dauphin River approximately 4 km upstream of Lake Winnipeg. Collectively, this area is referred to as the Buffalo Creek Drainage System. Prior to the construction and operation of Reach 1, the Buffalo Creek Drainage System did not receive water from the Lake Manitoba/Lake St. Martin watershed.

Construction of the Fairford Dam in 1961 allowed for the regulation of Lake Manitoba levels and in 1984 the Fairford Fishway was incorporated to provide passage of fish between Lake St. Martin, the Dauphin and Fairford rivers and Lake Manitoba. Dam design did not take into account impacts on downstream waterbodies and consequently, the Fairford River, Pineimuta Lake, Lake St. Martin, and the Dauphin River are subject to flooding during periods of high water levels in Lake Manitoba and levels lower than natural during low level periods. Following a study conducted by the Lake Manitoba Regulation Review Advisory Committee, it was decided that Lake Manitoba would be allowed to fluctuate closer to its pre-regulation state in order to sustain aquatic habitat along the lake shore (MWS 2010). However, downstream waterbodies continue to be impacted in extremely high water level years. Following construction of the Portage Diversion in 1970, water levels on Lake Manitoba rose higher than what was originally projected before the Fairford Dam was constructed. Consequently, its operation compounded the negative effects to downstream habitat that were produced by the Fairford Dam.

Additional descriptions of the biophysical environments and flow regulation on Lake Manitoba, Fairford River, Pineimuta Lake, Lake St. Martin, Dauphin River and Sturgeon Bay are provided in North/South Consultants Inc. (2011a).

2.2 PROJECT DESCRIPTION

The emergency reduction of Lake Manitoba and Lake St. Martin water levels includes the following project components:

2.2.1 Reach 1 Emergency Outlet Channel

The Reach 1 Emergency Outlet Channel is approximately 6 km in length, extending from Lake St. Martin to the bog area approximately 1.5 km south of Big Buffalo Lake to improve drainage from Lake St. Martin. The Reach 1 inlet is situated along the northeast shore of the north basin of Lake St. Martin. After flooding the bog area around Big Buffalo and Little Buffalo lakes, the drainage water will eventually flow into and follow Buffalo Creek for 14 km and discharge into the Dauphin River 3.8 km upstream of Sturgeon Bay. Buffalo Creek flows through a wide valley with relatively flat valley wall slopes. Buffalo Creek was not excavated to expand its capacity; therefore, the drainage water is expected overflow the natural banks of the creek in some areas.

In order to construct Reach 1, an access road, flanked by ditching to drain water from the peat, was constructed along each side of the channel. The area between the access road/ditches was cleared of trees and organic material prior to excavation.

The inlet of Reach 1 was constructed by widening and raising the invert to create a sill near the edge of the north basin of Lake St. Martin that water flows over into Reach 1. The sill was originally designed to be 120 m in length and have a bottom width of 60 m and 3:1 side slopes to convey the desired flow of 142 m3/s at a water level of 244.1 m. The invert of the inlet sill was designed to be at 243.1 m above sea level which is 0.3 m above the lower end of the desirable water level range for the lake at approximately the existing shoreline elevation. The original estimated flow upon initial operation of Reach 1 was approximately 255 m3/s based on Lake St. Martin water levels at an elevation substantially higher than 244.1 m.

2.2.2 Reach 3 Emergency Outlet Channel

As the Project developed, computer modeling of potential water levels at the mouth of the Dauphin River indicated that there was a substantial risk of major flooding of the Dauphin River communities in the spring of 2012 due to ice jam formations and unprecedented flows. It was determined that the construction of a Reach 3 Emergency Channel would divert flows away from the Dauphin River prior to the spring break up and, in combination with the dikes being constructed along the banks of the Dauphin River, substantially reduce the risk of flooding for the Dauphin River communities.

Five versions (3A to 3E) of the Reach 3 Emergency Channel were initially examined. Reach 3E was determined to be the most feasible option and is referred to simply as Reach 3 throughout the remainder of this report. The excavated Reach 3 would be terminated at an outlet approximately 3 km short of Lake Winnipeg as the slope of the natural ground surface increases fairly significantly at this point. The outlet and a length of approximately 300 m of Reach 3 leading up to the outlet would be overlaid with a riprap blanket to minimize erosion as the water exits the excavated channel. From the outlet of Reach 3 the water would flow along the ground and through the natural ground cover before entering Lake Winnipeg. It was anticipated that the flow would initially be shallow and widespread over land west of Willow Point. It was expected that Reach 3 would only operate for a short period of time to effectively remove the threat of flooding during the freshet. However, an exceptionally mild winter allowed sufficient drainage from Lake Manitoba and Lake St. Martin to reduce water levels to a point where risk of ice jamming and flooding at Dauphin River became negligible. Consequently, Reach 3 was not operated and field investigations related to fish movements into Reach 3 were therefore not conducted.

3.0 WATER QUALITY

Changes in flow regimes (rate and seasonality of flow), flooding along the diversion route, and erosion and mobilization of sediments due to construction and operation of Reach 1 and enhanced flow in Buffalo Creek may result in potential temporary impacts to water quality in water bodies from Lake Manitoba downstream to Sturgeon Bay. A suite of water quality data collections were conducted to provide additional baseline information prior to operation of Reach 1, document changes in water quality during construction and operation of Reach 1, and to help determine the spatial extent over which changes to water quality may occur. The data collections were organized into the following programs:

- A Regional Water Quality Monitoring Program (RWQMP);
- An Environmental Monitoring Program (EMP) conducted during construction of Reach 1 (this component of the water quality sampling programs was conducted by AECOM and KGS Group); and,
- A water quality monitoring program based on in situ measurements and focussed on Sturgeon Bay.

The objectives, methods, and results of fall 2011 monitoring for each program are presented in the following sections. It should be noted that, in some cases, spatial or temporal overlaps in sampling requirements occurred between the RWQMP and the EMP. When this occurred, sampling efforts between the programs were coordinated to minimize sample replication and maximize sampling efficiency. Results were then shared between the two programs.

3.1 REGIONAL WATER QUALITY MONITORING

During the conduct of the RWQMP, water quality information was collected from all major waterbodies and waterways within the study area that were affected by flooding and encompassed the major inputs to the north basin of Lake Manitoba (i.e., Waterhen River and at the Lake Manitoba Narrows) downstream to and including Sturgeon Bay on Lake Winnipeg. The objectives were to provide baseline water quality information to assist with operational and post-project monitoring, to provide information from locations where water quality data were lacking, to supplement data sets at sites within the study area where Manitoba Conservation and Water Stewardship, Water Quality Management Section (MCWS) has conducted long term water quality monitoring, and to evaluate spatial differences in water quality within the study area. Monitoring in fall 2011 was comprised of a single sampling event that included *in situ* water quality measurements and the collection of water samples for laboratory analysis. Detailed methods and results from the fall 2011 sampling event are provided below.

3.1.1 Methods

3.1.1.1 Sampling Sites

Water quality samples and *in situ* measurements were collected at 13 sites throughout area, including the following:

- Waterhen River - one site at the bridge on PTH # 328 (MWS site MB05LHS002);
- Lake Manitoba - one site at Lake Manitoba Narrows (MWS site MB05LKS009);
- Fairford River - one site at or near the PTH # 6 bridge (MWS site MB05LMS001);
- Lake St. Martin - one site in the north basin;
- Dauphin River - two sites, including one site at or near the existing MWS site (MWS Site MB05LMS003), and one site at or near the outflow from Lake St. Martin; and,
- Sturgeon Bay - seven sites, including one at or near the existing MWS site (MWS Site MB05SES012).

Additionally, seven sites were sampled in conjunction with the construction EMP program, including:

- Lake St. Martin - one site near the Reach 1 inlet;
- Buffalo Creek - three sites along the creek; and,
- Dauphin River - three sites; including one upstream of the confluence of Buffalo Creek, one immediately downstream of the confluence of Buffalo Creek, and one site in the mouth of the Dauphin River and upstream of Sturgeon Bay.

Sampling for the RWQMP and one of the sampling sessions for the EMP was conducted concurrently. On that occasion, effort was made to ensure that sampling methods and water quality parameters sampled for were the same at all sites; on other sampling dates, the construction EMP included different parameters than the RWQMP. A list of all sampling sites and locations are provided in Table 3-1 and illustrated in Figure 3-1.

3.1.1.2 Water Quality Parameters

Water quality parameters included in the RWQMP were identified based on the potential linkages between the Project and water quality, including potential effects on TSS (and related variables), effects related to diversion, and potential effects of flooding and/or diversion on water quality (i.e., nutrients, dissolved oxygen, pH and metals), and/or variables that provide supporting information for interpretation of other data. Ultratrace mercury and methylmercury were included to facilitate comparison to the newly revised Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs; MWS 2011) and because both may be affected by flooding. A complete list of water quality parameters selected for laboratory analysis and *in situ* measurements are provided in Table 3-2.

Additionally, samples for the analysis of pesticides and *E. coli* were collected from selected sites. These parameters were included based on consultation with Manitoba Conservation and Water Stewardship, Water Management Section. A full list of pesticide parameters is provided in Table 3-3; this list is consistent with those measured by MCWS in their current water quality monitoring programs in southern/central Manitoba.

3.1.1.3 Field Methods

Sampling sites were accessed by truck, boat, or helicopter depending on site accessibility. Water quality sampling was conducted at the Waterhen River, Lake Manitoba Narrows, the Fairford River and Sturgeon Bay on October 28, 2011, and Lake St. Martin, Buffalo Creek and the Dauphin River on October

29, 2011. Insufficient sample volume was collected for pesticide analysis on October 28 and 29; therefore, additional samples were collected from the Fairford and Dauphin rivers on November 6 to supplement pesticide samples collected on October 28 and 29. A list of samples collected during water quality studies is provided in Appendix 3-1.

In situ measurements of water quality parameters were collected at all sampling sites using a Horiba® W22-XD water quality meter. Parameters included pH, specific conductance, dissolved oxygen (DO), turbidity, and water temperature. At river sites and those accessed from shore *in situ* parameters were measured at approximately 0.3 m below the water surface. At lake sites, *in situ* measurements were recorded both near the surface and at approximately 0.3 m above the lake bottom. Water depth at each site was measured with a handheld depth sounder and sample locations were recorded using a handheld Garmin GPS receiver. Sampling date and time were noted for each sampling site.

At each sampling site, grab samples were collected from approximately 0.3 m below the water surface into clean sample bottles supplied by ALS Laboratories. If thermal stratification was evident (based on *in situ* temperature measurements) at lake sampling sites, the sampling protocol included the collection water samples from approximately 0.3 m above the sediments using a Kemmerer sampler. However, as thermal stratification was not observed, the collection of bottom samples did not occur. Where necessary, samples were preserved according to instructions provided by the analytical laboratory. After collection, samples were placed in a cooler and kept cool using ice packs until submission (within 48 hours) to ALS Laboratories in Winnipeg, MB (a Canadian Association for Laboratory Accreditations, Inc. (CALA) accredited laboratory) for analysis.

3.1.1.4 Quality Assurance and Quality Control (QA/QC)

Standard QA/QC measures were followed during sample collection (e.g., use of latex gloves, standard labelling practices, meter calibration, etc.). Additionally, QA/QC samples were collected, including a field blank, a trip blank, and replicate samples.

Field Blanks

Field blanks are intended to provide information on sample contamination from atmospheric exposure and sample handling techniques (i.e., cleanliness of sampling equipment, carry-over contamination from site to site), as well as potential laboratory contamination and/or error (British Columbia Ministry of Environment, Lands, and Parks (BCMELP) 1998). Field blanks were prepared by filling sample bottles with deionized water (both provided by the analytical laboratory) in the field and submitting the blanks along with the environmental samples.

Trip Blanks

Trip blanks are used for evaluating the potential for sample contamination that may occur from the container or preservatives through transport and storage of the sample, as well as laboratory precision (BCMELP 1998). Trip blanks were prepared in the laboratory by filling sample bottles with deionized water. Trip blanks were transported to the field sampling sites, but remained sealed, and were then submitted to the analytical laboratory in conjunction with environmental samples for analysis.

Replicate Samples

Replicate samples were collected at randomly selected sites to provide a measure of variability of environmental conditions and the overall precision associated with field methods and laboratory analyses. One triplicate and one duplicate sample were collected.

QA/QC Assessment

All water quality data were examined qualitatively for potential outliers and/or transcription or analytical errors. Where one replicate sample differed notably from the others, the measurement was flagged as “suspect”.

QA/QC samples were assessed according to standard criteria to evaluate precision and identify potential sample contamination issues (BCMELP 1998). Percent relative standard deviation (PRSD) was calculated for triplicate samples as follows:

PRSD (%) = standard deviation of the triplicate values / mean of the triplicate values x 100

The relative percent mean difference (RPMD) was calculated for duplicate samples as follows:

RPMD (%) = | (value 1 – value 2) / ((value 1 + value 2) / 2) | x 100

Precision of replicate samples was evaluated using the “rule of thumb” criteria for precision of 18% for triplicate samples and 25% for duplicate samples (BCMELP 1998). Where one or more of the replicate values were less than five times the analytical detection limit (DL), an analysis of precision was not undertaken, in accordance with guidance provided in BCMELP (1998).

Field and trip blank results were also evaluated for evidence of sample contamination. Values for any parameter that exceeded five times the DL were considered to be indicative of sample contamination and/or laboratory error.

3.1.1.5 Comparison to Water Quality Objectives and Guidelines

Results were compared to the MWQSOGs (MWS 2011) for the protection of aquatic life (PAL) as well as the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of freshwater aquatic life (CCME 1999; updated to 2012). Many of the MWQSOGs for PAL are identical to the CCME PAL guidelines for parameters measured; however, there are CCME guidelines for some parameters which lack a provincial guideline/objective and others for which the CCME guideline is different from the provincial one; typically the CCME guideline is more stringent than the MWQSOGs for those guidelines that differ.

Drinking water quality objectives and guidelines are intended to be applied to treated or finished water as it emerges from the tap and “are not intended to be applied directly to source waters” (CCME 1999, updated to 2012). However, comparison of water quality in the study area to drinking water quality objectives and guidelines is included to provide context. The MWQSOGs indicate that “all surface waters…are susceptible to uncontrolled microbiological contamination... [and] it is therefore assumed that all raw surface water supplies will be disinfected as the minimum level of treatment prior to consumption” (MWS 2011). Furthermore, it is indicated that the MWQSOGs “apply to finished drinking water, but can be extrapolated to provide protection to raw drinking water sources.”

In general, water quality objectives and guidelines are more stringent for the protection of aquatic life and wildlife, relative to those established to protect various human usages (e.g., drinking water). A summary of relevant water quality objectives and guidelines is presented in Appendix 3-2.

3.1.2 Results

3.1.2.1 Routine Variables and Limnology

Results of the fall 2011 RWQMP for routine water quality parameters are presented in Tables 3-4 and 3-5, and Figures 3-2 and 3-3. Laboratory certificates of analysis are provided in Appendix 3-3.

Based on the results of the RWQMP conducted in fall, 2011, water quality of the study area can be generally described as moderately nutrient-rich, low to moderately turbid, slightly alkaline, hard to very hard, and well-oxygenated. Not unexpectedly, both Lake St. Martin and Sturgeon Bay were isothermal in fall 2011. Other *in situ* variables, including DO, turbidity, pH, and specific conductance, were relatively consistent across depth in both lakes.

Total phosphorus (TP) concentrations in the study area were, with the exception of Buffalo Creek, composed primarily of particulate forms. Conversely, at the two upstream sites in Buffalo Creek (BC1 and BC2), TP was composed primarily of dissolved forms. The majority of total nitrogen (TN) was present in organic form at all sites, with ammonia generally comprising a greater amount of dissolved inorganic nitrogen (DIN) than nitrate/nitrite except at the two upstream sites on Buffalo Creek where the reverse was true. On the basis of TN:TP molar ratios, all waterbodies sampled were phosphorus limited in fall 2011.

The water quality of Buffalo Creek differed from the other waterbodies sampled. Buffalo Creek had lower turbidity/TSS, lower conductivity and total dissolved solids (TDS), lower chlorophyll *a*, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area.

The water quality of Sturgeon Bay was influenced by the Dauphin River; sites closest to the mouth (i.e., LKW2 and 3) exhibited higher alkalinity, higher conductivity and TDS, higher concentrations of DIN and TN, dissolved and total organic carbon; and, lower turbidity/TSS and colour, and concentrations of TP and chlorophyll *a* than other sites sampled in Sturgeon Bay.

TP exceeded the MWQSOGs narrative guideline for phosphorus for lakes (i.e., 0.025 mg/L) at Lake Manitoba Narrows, and in Sturgeon Bay at all but the two sites closest to the Dauphin River mouth (i.e. LKW2 and 3). Additionally, the TP concentration at the downstream end of Buffalo Creek (BC3) exceeded the narrative guideline for streams (0.050 mg/L) in one of the replicate samples collected; however, the results for this sample are considered suspect (see page 14). The TP concentration measured in the other sample collected at BC3 was well below the guideline. All other routine water quality variables for which there are MWQSOGs and CCME guidelines, including dissolved oxygen, pH, ammonia, nitrate and nitrite were within PAL objectives and guidelines in fall 2011.

Colour exceeded the MWQSOGs aesthetic objective for drinking water (≤15 TCU) at all three sites in Buffalo Creek. The MWQSOGs aesthetic objective for drinking water for TDS (500 mg/L) was exceeded at the Waterhen River, Lake Manitoba Narrows, the Fairford River, Lake St. Martin, the Dauphin River, and in Sturgeon Bay at the two sites closest to the Dauphin River mouth (i.e., LKW2 and 3). Additionally, laboratory measured pH at Lake Manitoba Narrows and the Fairford River was above the range for the aesthetic objective for drinking water (6.5-8.5). All other routine water quality variables for which there are MWQSOGs for drinking water, including nitrate, nitrite, and nitrate/nitrite were within allowable limits. As discussed in Appendix 3-2, an assessment of the maximum acceptable concentration for drinking water for turbidity was not conducted.

3.1.2.2 Metals and Major Ions

Metal and major ion concentrations measured in the study area in fall 2011 are presented in Table 3-6. A number of metals (total and dissolved forms) were not detected at any site, including: beryllium; bismuth; nickel; silver; tellurium; thallium; tin; tungsten; and, zinc.

Additionally, several metals were not detected in dissolved form at any site, including: cesium; cobalt; lead; thorium; and, zirconium. Aluminum (total), arsenic, barium, calcium, chloride, fluoride, lithium, magnesium, manganese, potassium, rubidium, silicon, sodium, strontium, sulphate, titanium, and vanadium were consistently detected; the remaining metals and major ions were detected in some samples.

Concentrations of major ions and metals were generally lower in Buffalo Creek, compared to other waterbodies in the study area. Conversely, mercury and methyl mercury concentrations were higher, and were consistently detected, at sites in Buffalo Creek than at other sites sampled.

Additionally, concentrations of the major ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) and hardness were higher at the sites closest to the Dauphin River outflow (LKW2 and 3) than at the other sites sampled in Sturgeon Bay, reflecting the higher concentration of these substances at upstream waterbodies in the region relative to Lake Winnipeg. Conversely, the Dauphin River contained lower concentrations of total aluminum, copper, iron, manganese, titanium, and uranium than sites in Sturgeon Bay most distant from the Dauphin River mouth.

Aluminum exceeded the MWQSOGs and CCME guideline for PAL (0.1 mg/L) at all but one site (LKW2) in Sturgeon Bay, and at one site in Buffalo Creek (BC3), but remained within guidelines in all other waterbodies sampled. Similarly, iron concentrations were above the MWQSOGs and CCME guideline for PAL (0.3 mg/L) at most sites in Sturgeon Bay (LKW1, LKW4 to 7). At most sites chloride concentrations exceeded the CCME long-term guideline for PAL (120 mg/L), including: the Waterhen River; Lake Manitoba Narrows; the Fairford River; Lake St. Martin; all sites on the Dauphin River; and, two sites in Sturgeon Bay (LKW2 and LKW3). Chloride concentrations in Buffalo Creek were consistently below the guideline. Chloride concentrations were well below the CCME short-term guideline for PAL (640 mg/L) at all sites. Fluoride concentrations exceeded the CCME guideline for PAL at the same locations as chloride. In addition, one sample collected at the mouth of the Dauphin River (DR1.1) was above the MWQSOGs and CCME guideline for PAL for selenium and the sample collected in Sturgeon bay nearest the Dauphin River (LK3) was at the PAL guideline; however, the analytical detection limit for selenium (0.001 mg/L) is equal to the guideline and these exceedances should be viewed with caution. All other metals and major ions for which there are MWQSOGs or CCME guidelines for PAL were within objectives and guidelines at each of the sampling sites in fall 2011.

Iron concentrations exceeded the MWQSOGs aesthetic objective for drinking water (0.3 mg/L) at most sites in Sturgeon Bay (LKW1, LKW4 to 7). All other metals and major ions for were within the existing MWQSOGs for drinking water.

3.1.2.3 Pesticides

Pesticides were only measured at selected sites, including: the Fairford River (FR1), Dauphin River (DR1 and DR3) and Sturgeon Bay (LKW7). The results of this analysis are presented in Table 3-7. Glyphosate was detected at all sites sampled on October 28 and 29; all other pesticides, for which sufficient sample was collected to conduct the analysis, were below analytical detection limits on these dates. Pesticides were consistently below the analytical detection limits in samples collected from the Fairford and Dauphin rivers on November 6, after Reach 1 was in operation. Glyphosate concentrations did not exceed the MWQSOGs or CCME guideline for PAL, or the MWQSOGs for drinking water in any samples collected in fall 2011.

3.1.2.4 QA/QC

Field and Trip Blanks

Field and trip blank results indicate high precision and no sample contamination. Measurements for all parameters (metals, dissolved metals and routine parameters) were below the threshold of five times the detection limit (Appendix 3-4).

Replicate Samples

PRSD and RPMD were not derived for several parameters due to low concentrations (i.e., concentrations less than five times the DL). In general, the results indicate good agreement between samples and acceptable levels of precision. The RPMD exceeded threshold values (25% RPMD) for three parameters including: total aluminum (36%); total titanium (26%); and dissolved organic carbon (28%; Appendix 3-4). The PRSD exceeded threshold values (18% PRSD) for two parameters including: dissolved aluminum (41%) and phaeophytin *a* (30%). Additionally, although an RPMD value was not derived, TP and TPP concentrations measured in the duplicate samples collected at BC3 were quite different (e.g., TP = 0.116 mg/L and 0.011 mg/L), and based on values for other parameters measured (e.g., TSS, TKN, and total metals) the TP and TPP results for Replicate 1 are considered suspect.

3.2 CEMP

During construction of Reach 1, water quality was also monitored at sites along the diversion route and at its points of entry (i.e., Lake St. Martin) and exit (i.e., Dauphin River). A detailed report of this sampling program including sites sampled, parameters measured, methods used, and a discussion of the results are presented in AECOM (2012; Appendix 3-5). A brief summary of this program is provided below.

3.2.1 Summary of Methods

As part of the CEMP, water quality was monitored in Lake St. Martin, Buffalo Creek, and in the Dauphin River from September 2 to November 25, 2011. Additionally, following the opening of Reach 1 (November 1, 2011), water quality was monitored in the reach from November 1 to 25, 2011. During Reach 1 construction, monitoring was conducted approximately twice a month. After Reach 1 was opened, sampling frequency increased to twice a week. Water quality parameters measured included: *in situ* measurements of turbidity, DO, pH, conductivity, and temperature; and laboratory analysis of water samples for TSS, nutrients (TP, dissolved P, ammonia, and TN), mercury, and petroleum hydrocarbons (benzene, toluene, ethylbenzene and xylene [BTEX]; and, hydrocarbons F1-F4).

3.2.2 Summary of Results

3.2.2.1 Total Suspended Solids

TSS concentrations increased downstream of Reach 1 after it was opened on November 1, with peak TSS concentrations occurring on November 4. Following Reach 1 operation, TSS concentrations exceeded CCME guidelines within Buffalo Creek and the Dauphin River immediately downstream of the creek; TSS fell below CCME limits at all sites within two weeks of Reach 1 opening. Following the excavation of the remaining material from the south shore road, a second peak in TSS was observed within Reach 1 on November 17 and at downstream sites a few days later. TSS concentrations remained within CCME guidelines in Buffalo Creek and the Dauphin River during this second peak. TSS concentrations had not returned to baseline at the end of the monitoring period and AECOM (2012) recommended that monitoring continue.

3.2.2.2 Nutrients

AECOM (2012) concluded that ammonia concentrations exceeded CCME guidelines at several sites and times during the monitoring program. The CCME guideline for ammonia is dependent upon the specific temperature and pH of the water in question. In their assessment of the CCME guideline for ammonia, AECOM (2012) took a conservative approach and applied the most stringent value calculated for the sampling program to all sampling locations and dates. A reassessment of the results using sample specific guidelines (i.e., calculated based on the temperature and pH measured *in situ* at the time and location the sample was collected) indicated that all ammonia-N results were well below the CCME guidelines for PAL. Nitrate and nitrite were consistently below the CCME guidelines for PAL at all sites and times sampled. There are no CCME guidelines for PAL for other nutrients measured. Based on the data collected by AECOM (2012) there were no indications that the construction of Reach 1or its initial operation resulted in changes to nutrient concentrations downstream.

3.2.2.3 Mercury

The analytical detection limit applied to the majority of the samples collected for the analysis of mercury was typically higher than the CCME guideline for PAL (26 ng/L); as a result, a proper assessment of this guideline could not be conducted. However, the mercury concentrations measured in two samples collected from the Dauphin River, one upstream and one downstream of Buffalo Creek, on October 14, 2011 exceeded the CCME guideline for PAL.

3.2.2.4 Petroleum Hydrocarbons

There was no evidence of hydrocarbon contamination due to construction activities, as petroleum hydrocarbons were not detected during the monitoring program.

3.3 *In Situ* WATER QUALITY MONITORING

In addition to the RWQMP and the Construction EMP, an intensive *in situ* water quality monitoring program was conducted in Sturgeon Bay, and on the Dauphin River. The intent of the sampling was to gather spatial information on the water quality of Sturgeon Bay, and in particular to define the area of influence of the Dauphin River; as well as to determine what if any spatial differences exist in the water quality of the Dauphin River in relation to Buffalo Creek.

3.3.1 Methods

In Sturgeon Bay, eight transects were established extending approximately four kilometres out from shore (Figure 3-4); seven were located along the southwest shore (T-1 to -6 and T-11) and one was located on the southeast shore just north of Poplar Point (T-9). Five sites were located along each transect, as follows: nearshore (i.e., approximately 50-100 m from shore); and, 0.5 km, 1 km, 2 km, and 4 km from the nearshore site. Additionally, three sites were located in the offshore extensive zone (EZ-1 to -3). The Sturgeon Bay *in situ* water quality sites correspond to the substrate classification sites presented in Section 3.6.

In the Dauphin River, three transects were established across the channel width. Transects were located upstream from Buffalo Creek, immediately downstream from Buffalo Creek and at the Dauphin River mouth (Figure 3-4). Three sampling sites were located along each transect at approximately 25%, 50% and 75% of the wetted width.

In situ measurements were collected at all sampling sites using a Horiba® W22-XD water quality meter. Parameters measured included: pH, specific conductance, DO, turbidity, and temperature. In Sturgeon Bay, *in situ* measurements were recorded both near the surface (i.e., approximately 0.3 m) and at approximately 0.3 m above the lake bottom. At Dauphin River sites, measurements were recorded only near the surface due to high velocities. Water depth at each site was measured with a handheld depth sounder and sample locations were recorded using a handheld Garmin GPS receiver. Sampling date and time were noted for each sampling site. All sites were accessed by boat.

3.3.2 Results

Due to adverse weather, *in situ* sampling was completed over a three week period from September 30 to October 21, 2011. Results of the *In situ* water quality monitoring program are presented in Table 3-8. As a result of the extended time period over which the data were collected, the ability to make spatial comparisons is limited to data collected on the same day.

3.3.2.1 Sturgeon Bay

In general, water quality near the surface was similar to that near the bottom at sites sampled in Sturgeon Bay (Table 3.8). Turbidity (Figure 3-5), DO, and pH were consistent between surface and bottom at all sites, and with the exception of Transects 1 and 2, this was also true for specific conductance (Figure 3-6)Figure . Along Transect 1, specific conductance near the surface was increasingly lower relative to the bottom starting at approximately 1 km offshore, this trend extended out to 4 km offshore. Specific conductance was also lower near the surface than near the bottom at the most offshore site along Transect 2.

Turbidity was variable throughout Sturgeon Bay; however, since the measurements were collected on multiple days over a three week period, the ability to make spatial comparisons is limited to within transect comparisons. Turbidity was generally consistent along Transects 2, 3 and 9 (Figure 3-5). At Transects 4 and 11, turbidity was higher nearshore than offshore. There was also some indication of this trend of higher turbidity closer to shore at Transects 1 and 6, though the differences were smaller. Turbidity was consistent between sites in the offshore extensive zone.

The ability to make absolute comparisons of specific conductance is limited to measurements collected on the same day; however, specific conductance is typically a variable that is relatively consistent with time and can be useful in determining the extent of the mixing zone between two water masses. Measureable changes in specific conductance were observed due to inflows from the Dauphin River (Figure 3-6). At the majority of transects, there was a slight decrease in specific conductance at the offshore sites (Figure 3-6). Overall, specific conductance was higher along transects located closer to the Dauphin River mouth (i.e., T-2, T-3, T-4 and T-5) than along transects located in the southern area of the bay (i.e., T-1, T-11, T-9). Transect 6, which was located along the northern edge of the river plume, showed an increase in specific conductance from nearshore to 1 km offshore, followed by a decrease in specific conductance to 4 km offshore. Based on specific conductance measurements, the mixing zone of the Dauphin River in Sturgeon Bay extended offshore at least five kilometers and down the south shore of the bay as far as Willow Point.

There was no difference in pH or DO from nearshore to offshore in Sturgeon Bay, and pH and DO were similar throughout the area sampled. Sturgeon Bay was well-oxygenated and all DO measurements exceeded the MWQSOGs objectives and the CCME guidelines for PAL. All pH measurements were within the MWQSOGs and CCME guidelines for PAL.

3.3.2.2 Dauphin River

In the Dauphin River, *in situ* water quality was similar upstream and downstream of Buffalo Creek (Table 3-8). Likewise, no difference in water quality was observed across transects.

3.4 SUMMARY

RWQMP

During the conduct of the RWQMP, water quality information was collected from all major waterbodies and waterways within the study area that were affected by flooding and encompassed the major inputs to the north basin of Lake Manitoba (i.e., Waterhen River and at the Lake Manitoba Narrows) downstream to and including Sturgeon Bay on Lake Winnipeg. The objectives of the program were to:

- provide baseline water quality information to assist with operational and post-project monitoring
- to provide information from locations where water quality data were lacking;
- supplement data sets at sites within the study area where Manitoba Conservation and Water Stewardship, Water Quality Management Branch (MCWS) conducts water quality monitoring; and,
- evaluate spatial differences in water quality within the study area.

RWQMP results indicate that water quality within the study area can be generally described as moderately nutrient-rich, low to moderately turbid, slightly alkaline, hard to very hard, and well-oxygenated.

The water quality of Buffalo Creek differed from the other waterbodies sampled. Buffalo Creek had lower turbidity/TSS, lower conductivity and total dissolved solids (TDS), lower chlorophyll a, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area.

Both Lake St. Martin and Sturgeon Bay were isothermal in fall 2011. Other in situ variables, including DO, turbidity, pH, and specific conductance, were relatively consistent across depth in both lakes. Molar ratios of N:P indicated that all of the sampled waterbodies were phosphorus limited in fall 2011. Total phosphorus exceeded the MWQSOG guidelines at Lake Manitoba Narrows and several sites in Sturgeon Bay, but all other routine water quality variables for which there are MWQSOG and CCME guidelines, including DO, pH, ammonia, nitrate and nitrite were within PAL objectives and guidelines at all locations.

The water quality of Sturgeon Bay was also influenced by the Dauphin River such that sites closest to the river mouth exhibited water quality similar to upstream sites, including: higher alkalinity, conductivity, TDS, nitrogen and carbon concentrations and lower turbidity/TSS, colour, phosphorus and chlorophyll a.

Concentrations of major ions and metals were generally lower in Buffalo Creek, compared to other waterbodies in the study area. Conversely, mercury and methyl mercury concentrations were higher, and were consistently detected, at sites in Buffalo Creek than at other sites sampled. Additionally, concentrations of the major ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) and hardness were higher at the sites closest to the Dauphin River outflow (LKW2 and 3) than at the other sites sampled in Sturgeon Bay, reflecting the higher concentration of these substances at upstream waterbodies in the region relative to Lake Winnipeg. Conversely, the Dauphin River contained lower concentrations of total aluminum, copper, iron, manganese, titanium, and uranium than sites in Sturgeon Bay most distant from the Dauphin River mouth.

Aluminum, chloride, fluoride, iron, and selenium all exceeded PAL guidelines or objectives on at least one occasion within the study area. All other metals and major ions were within MWQSOGs and CCME guidelines for PAL.

Of the 58 pesticides analysed for, only glyphosate was detected in the study area during fall 2011 and it did not exceed the federal and provincial guidelines for PAL.

Construction EMP Monitoring

Construction EMP monitoring was conducted from September 2 to November 25, 2011. Additionally, following the opening of Reach 1 (November 1, 2011), water quality was monitored in the reach from November 1 to 25, 2011. The objective was to describe baseline water quality parameters and to monitor potential changes to water quality in Buffalo Creek and the lower Dauphin River during construction and early operation of Reach 1.

Construction EMP monitoring indicated that TSS concentrations had returned to near baseline conditions by the end of November following an initial increase measured during the opening of Reach 1 in early November (AECOM 2012). Immediately following the opening of Reach 1, the TSS concentrations exceeded CCME guidelines within Buffalo Creek and the Dauphin River immediately downstream of the creek, but fell below limits within two weeks.

Based on the data collected by AECOM (2012) there were no indications that the construction of Reach 1 or its initial operation resulted in changes to nutrient concentrations downstream. However, the mercury concentrations measured in two samples collected from the Dauphin River, one upstream and one downstream of Buffalo Creek, on October 14, 2011 exceeded the CCME guideline for PAL. There was no evidence of hydrocarbon contamination due to construction activities, as petroleum hydrocarbons were not detected during the monitoring program.

In situ and TSS Monitoring

In situ and TSS monitoring were conducted in Sturgeon Bay from September 30 to October 21, 2011. Objectives were to:

- collect baseline water quality information in Sturgeon Bay and the Dauphin River;
- help delineate the spatial extent over which suspended sediment inputs may be distributed in Sturgeon Bay and the Dauphin River; and,
- develop a reliable turbidity/TSS relationship for analysis of turbidity data.

In general, water quality near the surface was similar to that near the bottom at sites sampled in Sturgeon Bay. Turbidity was variable throughout Sturgeon Bay; however, since the measurements were collected on multiple days over a three week period, the ability to make spatial comparisons is limited to within transect comparisons. There was some evidence of higher turbidity at sites closer to shore along several of the Sturgeon Bay transects. There was no difference in pH or DO from nearshore to offshore in Sturgeon Bay, and pH and DO were similar throughout the area sampled. Sturgeon Bay was well-oxygenated and all DO measurements exceeded the MWQSOGs objectives and the CCME guidelines for PAL. All pH measurements were within the MWQSOGs and CCME guidelines for PAL.

In the Dauphin River, in situ water quality was similar upstream and downstream of Buffalo Creek. Likewise, no difference in water quality was observed across transects.

Table 3-1. Location of sites sampled as part of the RWQMP conducted during fall 2011.

Waterbody	Location Description	Site ID	MWS Site	Location [1]	
				Easting	Northing
Waterhen River	at PTH #328	WHR1	MB05LHS002	462204	5742368
Lake Manitoba	at Lake Manitoba Narrows	NARR1	MB05LKS009	515348	5658969
Fairford River	near PTH #6	FR1	MB05LMS001	518838	5715229
Lake St. Martin	North basin	LSM1	-	550136	5736730
	Near the inlet to Reach 1	LSM2[2]	-	552303	5738143
Buffalo Creek [2]		BC1	-	562544	5745653
		BC2	-	564247	5747173
		BC3	-	562318	5454770
Dauphin River	River inlet at Lake St. Martin	DR1.1	-	547332	5741774
	Between Gypsumville and Anama Bay	DR1.3	MB05LMS003	546106	5757242
		DR1[2]	-	561896	5754959
		DR3[2]	-	562432	5754831
	River mouth at Lake Winnipeg	DR02[2]	-	564025	5756392
Sturgeon Bay		LKW1	-	578400	5750390
		LKW2	-	571480	5754215
		LKW3	-	569032	5759095
		LKW4	-	566327	5765369
		LKW5	-	577144	5758612
		LKW6	-	573290	5762611
		LKW7	MB05SES012	574055	5771081

1 - UTM coordinates; Datum NAD 83, Zone 14U

2 - Sample collected as part of the construction EMP program. LSM2 is known as site LM01 in the 2011 EMP program (AECOM 2012).

Table 3-2. Water quality parameters measured as part of the RWQMP conducted during fall, 2011.

Routine Parameters	Metals and Major Ions
Alkalinity	Metals (Total and Dissolved)
Dissolved Organic Carbon	Antimony (Sb)
Total Inorganic Carbon	Arsenic (As)
Total Organic Carbon	Barium (Ba)
Colour, True	Beryllium (Be)
Conductivity (at 25°C)	Bismuth (Bi)
Hardness (Calculated from metals)	Boron (B)
Total Kjeldahl Nitrogen	Cadmium (Cd)
Ammonia-N	Calcium (Ca)
Nitrate+Nitrite- N	Cesium (Cs)
Nitrite-N	Chromium (Cr)
Nitrate-N	Chloride (dissolved)
Phosphorus, Total	Cobalt (Co)
Phosphorus, Total Dissolved	Copper (Cu)
Phosphorus Total Particulate (Calculated)	Fluoride (dissolved)
pH	Iron (Fe)
Total Dissolved Solids	Lead (Pb)
Total Suspended Solids	Lithium (Li)
Turbidity	Magnesium (Mg)
	Manganese (Mn)
In Situ Parameters	Molybdenum (Mo)
pH	Mercury (Hg)
Temperature	Nickel (Ni)
Dissolved oxygen	Potassium (K)
Turbidity	Rubidium (Rb)
Specific Conductance	Selenium (Se)
	Silicon (Si)
	Silver (Ag)
	Sodium (Na)
	Strontium (Sr)
	Tellurium (Te)
	Sulphate (dissolved)
	Thallium (Tl)
	Thorium (Th)
	Tin (Sn)
	Titanium (Ti)
	Tungsten (W)
	Uranium (U)
	Vanadium (V)
	Zinc (Zn)
	Zirconium (Zr)
	Methylmercury

Table 3-3. Pesticide parameters analyzed from selected sites as part of the RWQMP conducted during fall, 2011.

Parameter	
2,4,6-Tribromophenol	Eptam
2,4-D	Ethalfluralin
2,4-DB	Fenoxaprop
2,4-Dichlorophenylacetic Acid	g-chlordane
2,4-DP	Glyphosate
2-Fluorobiphenyl	Imazamethabenz-methyl
2-Fluorobiphenyl	Lindane
a-chlordane	Malathion
Alachlor	MCPA
alpha-BHC	Mecoprop
Atrazine	Methoxychlor
Atrazine Desethyl	Methyl Parathion
Azinphos-methyl	Metribuzin
Benomyl	Metsulfuron-methyl
beta-BHC	Parathion
Bromacil	Pentachlorophenol
Bromoxynil	Picloram
Carbofuran	Propachlor
Carboxin	Propanil
Chlorothalonil	Propoxur
Chlorpyrifos	Quizalofop
Cyanazine	Sethoxydim
d14-Terphenyl	Simazine
d14-Terphenyl	Terbufos
delta-BHC	Thifensulfuron-methyl
Deltamethrin	Tralkoxydim
Diazinon	Triallate
Dicamba	Tribenuron-methyl
Diclofop-methyl	Triclopyr
Dimethoate	Trifluralin
Dinoseb	Trifluralin
Diuron	

Table 3-4. *In situ* water quality measurements recorded as part of the RWQMP conducted in fall 2011.

Sample Location	Location ID	Sample Date	Water Depth (m)	Measurement Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	Turbidity (NTU)	pH
Waterhen	WHR1	28-Oct-11	-	0.3	4.4	11.87	1290	20.4	7.75
Lake Manitoba Narrows	NARR1	28-Oct-11	-	0.3	4.7	10.76	1290	39.0	7.88
Fairford River	FR1	28-Oct-11	-	0.3	5.5	11.46	1310	70.4	8.04
Lake St. Martin	LSM1	29-Oct-11	3.6	0.3	5.2	11.98	1360	17.3	8.18
		29-Oct-11	-	3.3	5.2	11.97	1360	17.8	8.18
	LSM2	29-Oct-11	-	0.3	4.6	13.09	1190	4.82	8.49
Dauphin River	DR1.1	29-Oct-11	3.1	0.3	5.1	12.08	136.0	18.9	8.18
				2.8	5.0	11.90	136.0	19.4	8.18
		6-Nov-11	-	0.3	3.8	12.17	130.0	23.0	8.18
	DR1.3	29-Oct-11	-	0.3	4.7	11.32	1370	18.5	8.07
	DR1	29-Oct-11	-	0.3	4.8	14.10	1200	5.86	8.38
	DR3	29-Oct-11	-	0.3	4.6	10.81	1140	5.49	8.32
	DR02	29-Oct-11	3.0	0.3	4.7	11.84	1370	31.5	8.16
		6-Nov-11	-	0.3	3.5	11.66	1300	18.4	8.05
Sturgeon Bay	LKW1	28-Oct-11	4.7	0.3	5.3	12.32	418	88.1	8.14
				4.4	5.3	12.36	417	93.2	8.14
	LKW2	28-Oct-11	4.4	0.3	4.9	12.12	1340	23.0	8.11
				4.1	4.9	12.90	1340	26.4	8.12
	LKW3	28-Oct-11	7.1	0.3	5.1	11.60	1300	25.1	8.06
				6.8	5.1	11.67	1300	25.9	8.07
	LKW4	28-Oct-11	7.8	0.3	5.5	12.02	702	37.2	7.87
				7.5	5.5	11.97	705	36.3	8.02

Table 3-4. (continued).

Sample Location	Location ID	Sample Date	Water Depth (m)	Measurement Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	Turbidity (NTU)	pH
Sturgeon Bay	LKW5	28-Oct-11	8.4	0.3	5.6	11.89	558	56.2	8.05
				8.0	5.1	11.83	700	58.3	7.00
	LKW6	28-Oct-11	9.1	0.3	5.5	11.78	734	37.0	8.11
				8.8	5.4	11.60	749	40.1	8.09
	LKW7	28-Oct-11	6.7	0.3	5.9	11.96	555	47.4	8.01
				6.4	5.8	11.93	559	50.0	8.03
Buffalo Creek	BC1	29-Oct-11	-	0.3	3.5	11.96	186	0.79	7.42
	BC2	29-Oct-11	-	0.3	3.1	11.56	194	2.96	7.84
	BC3	29-Oct-11	-	0.3	2.6	11.99	254	5.93	7.77

Table 3-5. Laboratory results for routine water quality parameters analyzed as part of the RWQMP conducted in fall 2011.

Sample Location	Location ID	Sample Date	Lab pH	Alkalinity			
				as Bicarbonate (HCO_3^-) (mg/L)	as $CaCO_3$ (mg/L)	as Carbonate (CO_3^{2-}) (mg/L)	as Hydroxide (OH^-) (mg/L)
Analytical Detection Limits			*0.10*	*2.0*	*1.0*	*0.60*	*0.40*
Waterhen River	WHR1	28-Oct-11	8.29	217	178	<0.60	<0.40
Lake Manitoba Narrows	NARR1	28-Oct-11	8.54	246	218	8.97	<0.40
Fairford River	FR1	28-Oct-11	8.51	225	199	7.33	<0.40
Lake St. Martin	LSM1	29-Oct-11	8.47	230	201	6.42	<0.40
	LSM2	29-Oct-11	8.46	234	204	6.22	<0.40
Dauphin River	DR1.1	29-Oct-11	8.46	232	202	5.96	<0.40
	DR1.3	29-Oct-11	8.40	236	203	4.38	<0.40
	DR1	29-Oct-11	8.46	233	203	6.15	<0.40
	DR3	29-Oct-11	8.43	231	200	5.17	<0.40
	DR02	29-Oct-11	8.40	236	203	4.32	<0.40
Sturgeon Bay	LKW1	28-Oct-11	8.37	136	117	2.42	<0.40
	LKW2	28-Oct-11	8.42	232	200	4.45	<0.40
	LKW3	28-Oct-11	8.39	228	195	3.73	<0.40
	LKW4	28-Oct-11	8.38	173	148	2.88	<0.40
	LKW5	28-Oct-11	8.36	154	132	2.29	<0.40
	LKW6	28-Oct-11	8.38	177	151	2.99	<0.40
	LKW7	28-Oct-11	8.35	152	129	2.16	<0.40
Buffalo Creek	BC1	29-Oct-11	8.12	151	124	<0.60	<0.40
	BC2	29-Oct-11	8.19	152	124	<0.60	<0.40
	BC3	29-Oct-11	8.19	160	131.5	<0.60	<0.40

Table 3-5. (continued).

Sample Location	Location ID	Sample Date	Nitrogen					Phosphorus		
			Dissolved Ammonia (mg/L N)	Nitrate/ nitrite (mg/L N)	Nitrate-N (mg/L N)	Nitrite-N (mg/L N)	TKN (mg/L N)	Total (mg/L P)	Dissolved (mg/L P)	Total Particulate (mg/L P)
Analytical Detection Limits			*0.010*	*0.0051*	*0.0050*	*0.0010*	*0.20*	*0.010*	*0.0020/0.010*	*0.010/0.014*
Waterhen River	WHR1	28-Oct-11	0.016	0.0054	0.0054	<0.0010	0.83	0.014	<0.0020	0.012
Lake Manitoba	NARR-1	28-Oct-11	0.017	<0.0051	<0.0050	<0.0010	1.13	0.028	0.0049	0.023
Fairford River	FR1	28-Oct-11	0.023	<0.0051	<0.0050	<0.0010	1.31	0.029	0.0039	0.025
Lake St. Martin	LSM1	29-Oct-11	0.052	0.0139	0.0122	0.0017	1.14	0.013	<0.0020	0.012
	LSM2	29-Oct-11	0.044	0.0086	0.0086	<0.0010	1.11	0.016	<0.010	<0.014
Dauphin River	DR1.1	29-Oct-11	0.060	0.0272	0.0251	0.0021	1.06	0.013	0.003	0.01
	DR1.3	29-Oct-11	0.069	0.0152	0.0130	0.0022	1.10	0.014	<0.0020	0.012
	DR1	29-Oct-11	0.069	0.0174	0.0148	0.0026	1.09	0.017	<0.010	<0.014
	DR3	29-Oct-11	0.068	0.0168	0.0146	0.0022	1.08	0.017	<0.010	<0.014
	DR02	29-Oct-11	0.067	0.0166	0.0141	0.0025	1.11	0.018	<0.0020	0.017
Sturgeon Bay	LKW1	28-Oct-11	<0.010	<0.0051	<0.0050	<0.0010	0.68	0.043	0.0156	0.027
	LKW2	28-Oct-11	0.035	0.0177	0.0164	0.0013	1.07	0.018	0.0037	0.014
	LKW3	28-Oct-11	0.033	0.0173	0.0161	0.0012	1.05	0.022	0.0021	0.020
	LKW4	28-Oct-11	0.012	0.0063	0.0063	<0.0010	0.76	0.031	0.0047	0.027
	LKW5	28-Oct-11	<0.010	<0.0051	0.0050	<0.0010	0.62	0.029	0.0122	0.016
	LKW6	28-Oct-11	0.013	0.0119	0.0116	<0.0010	0.79	0.029	0.0039	0.025
	LKW7	28-Oct-11	<0.010	0.0230	0.0230	<0.0010	0.72	0.036	0.0140	0.022
Buffalo Creek	BC1	29-Oct-11	<0.010	0.0308	0.0308	<0.0010	0.81	0.024	0.020	<0.014
	BC2	29-Oct-11	<0.010	0.0063	0.0063	<0.0010	0.80	0.025	0.022	<0.014
	BC3	29-Oct-11	<0.010	<0.0051	<0.0050	<0.0010	0.76	0.064	0.016	0.051

Table 3-5. (continued).

Sample Location	Location ID	Sample Date	Carbon			Conductivity (µmhos/cm)	TDS (mg/L)
			Total Inorganic (mg/L)	Total Organic (mg/L)	Dissolved Organic (mg/L)		
Analytical Detection Limits			*1.0*	*1.0*	*1.0*	*20*	*5.0*
Waterhen River	WHR1	28-Oct-11	39.3	12.5	12.6	1040	646
Lake Manitoba	LMBNARR1	28-Oct-11	47.6	13.4	13.2	1030	696
Fairford River	FR1	28-Oct-11	43.3	14.9	13.4	1060	676
Lake St. Martin	LSM1	29-Oct-11	45.0	13.5	12.0	1080	652
	LSM2	29-Oct-11	30.2	14.8	13.7	1060	704
Dauphin River	DR1.1	29-Oct-11	45.8	14.0	12.8	1080	692
	DR1.3	29-Oct-11	46.5	14.3	12.5	1090	676
	DR1	29-Oct-11	37.5	13.3	13.0	1060	704
	DR3	29-Oct-11	32.3	13.9	13.0	1030	726
	DR02	29-Oct-11	46.5	14.6	13.8	1090	656
Sturgeon Bay	LKW1	28-Oct-11	25.7	8.9	8.4	410	230
	LKW2	28-Oct-11	45.4	14.5	12.7	1070	658
	LKW3	28-Oct-11	44.5	13.8	12.0	1040	614
	LKW4	28-Oct-11	33.2	10.8	9.8	678	380
	LKW5	28-Oct-11	29.9	9.7	8.7	546	310
	LKW6	28-Oct-11	34.0	10.6	9.9	706	398
	LKW7	28-Oct-11	28.9	9.3	8.5	540	286
Buffalo Creek	BC1	29-Oct-11	22.3	20.7	20.8	217	164
	BC2	29-Oct-11	23.5	19.1	16.9	217	166
	BC3	29-Oct-11	21.3	19.6	17.3	237	177

Table 3-5. (continued).

Sample Location	Location ID	Sample Date	Water Clarity			Algal Pigments	
			TSS (mg/L)	Turbidity (NTU)	True Colour (CU)	Chlorophyll *a* (µg/L)	Phaeophyton a (µg/L)
Analytical Detection Limits			*2.0*	*0.10*	*5.0*	*0.10*	*0.10*
Waterhen River	WHR1	28-Oct-11	2.4	2.5	6.4	3.37	1.42
Lake Manitoba	NARR1	28-Oct-11	13.2	8.8	7.4	9.16	2.37
Fairford River	FR1	28-Oct-11	26.4	21.0	7.4	11.4	1.95
Lake St. Martin	LSM1	29-Oct-11	4.0	3.8	6.9	6.85	1.83
	LSM2	29-Oct-11	5.8	3.3	8.4	6.98	1.92
Dauphin River	DR1.1	29-Oct-11	2.9	3.9	8.1	7.93	1.38
	DR1.3	29-Oct-11	2.8	3.4	10.8	6.97	1.62
	DR1	29-Oct-11	8.0	4.7	8.5	5.83	1.79
	DR3	29-Oct-11	7.5	4.5	10.4	5.98	1.80
	DR02	29-Oct-11	7.6	5.1	6.4	5.75	2.04
Sturgeon Bay	LKW1	28-Oct-11	24.0	30.0	9.5	14.7	2.61
	LKW2	28-Oct-11	7.2	5.6	9.0	7.33	1.95
	LKW3	28-Oct-11	6.8	6.6	9.5	7.04	1.60
	LKW4	28-Oct-11	10.4	14.1	11.8	13.3	1.90
	LKW5	28-Oct-11	8.8	16.5	10.5	11.0	1.32
	LKW6	28-Oct-11	10.7	14.9	11.1	8.62	1.75
	LKW7	28-Oct-11	8.8	19.3	12.5	10.6	1.48
Buffalo Creek	BC1	29-Oct-11	<2.0	0.7	52.3	0.51	0.57
	BC2	29-Oct-11	<2.0	0.9	51.5	0.37	0.61
	BC3	29-Oct-11	4.2	4.8	53.2	0.52	0.77

Table 3-6. Concentrations of metals and major ions measured as part of the RWQMP conducted in fall 2011. Units are mg/L unless otherwise indicated.

Sample Location	Location ID	Sample Date	Hardness as $CaCO_3$	Aluminum		Antimony		Arsenic	
				Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.30*	*0.0020*	*0.0050*	*0.00020*	*0.00020*	*0.00020*	*0.00020*
Waterhen River	WHR1	28-Oct-11	260	<0.0020	0.0124	<0.00020	<0.00020	0.00187	0.00207
Lake Manitoba	NARR1	28-Oct-11	296	0.0023	0.0528	0.00020	0.00021	0.00383	0.0037
Fairford River	FR1	28-Oct-11	323	<0.0020	0.0651	<0.00020	<0.00020	0.00283	0.00289
Lake St. Martin	LSM1	29-Oct-11	341	<0.0020	0.0388	<0.00020	<0.00020	0.00296	0.00275
	LSM2	29-Oct-11	328	0.0041	0.0346	<0.00020	<0.00020	0.00269	0.00260
Dauphin River	DR1.1	29-Oct-11	319	<0.0020	0.0355	<0.00020	<0.00020	0.00312	0.00262
	DR1.3	29-Oct-11	308	<0.0020	0.0291	<0.00020	<0.00020	0.00287	0.00274
	DR1	29-Oct-11	358	0.0039	0.0621	<0.00020	<0.00020	0.00293	0.00251
	DR3	29-Oct-11	337	0.0036	0.0369	<0.00020	<0.00020	0.00273	0.00243
	DR02	29-Oct-11	332	<0.0020	0.0773	<0.00020	<0.00020	0.00328	0.00271
Sturgeon Bay	LKW1	28-Oct-11	163	0.117	1.1000	<0.00020	<0.00020	0.00163	0.00173
	LKW2	28-Oct-11	300	0.0023	0.0949	<0.00020	<0.00020	0.00275	0.00255
	LKW3	28-Oct-11	324	0.0029	0.1690	<0.00020	<0.00020	0.00286	0.00254
	LKW4	28-Oct-11	218	0.0629	0.5190	<0.00020	<0.00020	0.00212	0.00205
	LKW5	28-Oct-11	193	0.101	0.7100	<0.00020	<0.00020	0.00191	0.00191
	LKW6	28-Oct-11	230	0.0578	0.5150	<0.00020	<0.00020	0.00246	0.00210
	LKW7	28-Oct-11	185	0.172	0.9030	<0.00020	<0.00020	0.00209	0.00194
Buffalo Creek	BC1	29-Oct-11	166	0.0052	0.0307	<0.00020	<0.00020	0.00048	0.00045
	BC2	29-Oct-11	166	0.0043	0.0550	<0.00020	<0.00020	0.00050	0.00048
	BC3	29-Oct-11	159	0.0103	0.2185	<0.00020	<0.00020	0.00059	0.00055

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Barium		Beryllium		Bismuth	
			Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.00020*	*0.00020*	*0.00020*	*0.00020*	*0.00020*	*0.00020*
Waterhen River	WHR1	28-Oct-11	0.0366	0.0387	<0.00020	<0.00020	<0.00020	<0.00020
Lake Manitoba	NARR1	28-Oct-11	0.0635	0.0690	<0.00020	<0.00020	<0.00020	<0.00020
Fairford River	FR1	28-Oct-11	0.0491	0.0539	<0.00020	<0.00020	<0.00020	<0.00020
Lake St. Martin	LSM1	29-Oct-11	0.0498	0.0535	<0.00020	<0.00020	<0.00020	<0.00020
	LSM2	29-Oct-11	0.0482	0.0508	<0.00020	<0.00020	<0.00020	<0.00020
Dauphin River	DR1.1	29-Oct-11	0.0495	0.0499	<0.00020	<0.00020	<0.00020	<0.00020
	DR1.3	29-Oct-11	0.0495	0.0538	<0.00020	<0.00020	<0.00020	<0.00020
	DR1	29-Oct-11	0.0483	0.0506	<0.00020	<0.00020	<0.00020	<0.00020
	DR3	29-Oct-11	0.0472	0.0486	<0.00020	<0.00020	<0.00020	<0.00020
	DR02	29-Oct-11	0.0497	0.0530	<0.00020	<0.00020	<0.00020	<0.00020
Sturgeon Bay	LKW1	28-Oct-11	0.0317	0.0406	<0.00020	<0.00020	<0.00020	<0.00020
	LKW2	28-Oct-11	0.0493	0.0510	<0.00020	<0.00020	<0.00020	<0.00020
	LKW3	28-Oct-11	0.0478	0.0501	<0.00020	<0.00020	<0.00020	<0.00020
	LKW4	28-Oct-11	0.0397	0.0430	<0.00020	<0.00020	<0.00020	<0.00020
	LKW5	28-Oct-11	0.0355	0.0428	<0.00020	<0.00020	<0.00020	<0.00020
	LKW6	28-Oct-11	0.0397	0.0452	<0.00020	<0.00020	<0.00020	<0.00020
	LKW7	28-Oct-11	0.0374	0.0412	<0.00020	<0.00020	<0.00020	<0.00020
Buffalo Creek	BC1	29-Oct-11	0.00734	0.00780	<0.00020	<0.00020	<0.00020	<0.00020
	BC2	29-Oct-11	0.00751	0.00804	<0.00020	<0.00020	<0.00020	<0.00020
	BC3	29-Oct-11	0.00922	0.01032	<0.00020	<0.00020	<0.00020	<0.00020

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Boron		Cadmium		Calcium	
			Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.010*	*0.010*	*0.000010*	*0.000010*	*0.050*	*0.10*
Waterhen River	WHR1	28-Oct-11	0.086	0.076	<0.000010	<0.000010	51.2	49.8
Lake Manitoba	NARR1	28-Oct-11	0.098	0.113	<0.000010	0.000012	47.6	47.2
Fairford River	FR1	28-Oct-11	0.115	0.096	<0.000010	0.000010	44.2	48.0
Lake St. Martin	LSM1	29-Oct-11	0.119	0.106	<0.000010	0.000049	44.7	54.8
	LSM2	29-Oct-11	0.089	0.096	0.000016	<0.000010	46.0	53.7
Dauphin River	DR1.1	29-Oct-11	0.107	0.112	<0.000010	<0.000010	46.0	45.6
	DR1.3	29-Oct-11	0.098	0.114	<0.000010	<0.000010	47.6	45.1
	DR1	29-Oct-11	0.125	0.117	0.000013	<0.000010	46.4	54.3
	DR3	29-Oct-11	0.122	0.113	<0.000010	<0.000010	46.5	52.1
	DR02	29-Oct-11	0.097	0.113	<0.000010	<0.000010	45.4	54.7
Sturgeon Bay	LKW1	28-Oct-11	0.045	0.034	<0.000010	0.000011	30.9	34.6
	LKW2	28-Oct-11	0.099	0.103	<0.000010	0.000010	48.5	44.0
	LKW3	28-Oct-11	0.098	0.113	<0.000010	0.000010	47.2	54.2
	LKW4	28-Oct-11	0.070	0.061	<0.000010	<0.000010	36.7	39.4
	LKW5	28-Oct-11	0.052	0.048	<0.000010	0.000012	32.5	38.1
	LKW6	28-Oct-11	0.073	0.063	<0.000010	<0.000010	36.1	42.0
	LKW7	28-Oct-11	0.055	0.046	<0.000010	0.000010	33.0	35.9
Buffalo Creek	BC1	29-Oct-11	<0.010	<0.010	<0.000010	<0.000010	22.9	27.2
	BC2	29-Oct-11	<0.010	<0.010	<0.000010	<0.000010	23.3	27.1
	BC3	29-Oct-11	0.014	<0.010	<0.000010	<0.000010	25.9	28.8

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Cesium		Chloride	Chromium		Cobalt	
			Dissolved	Total	Dissolved	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.00010*	*0.00010*	*0.20*	*0.0020*	*0.0010*	*0.00020*	*0.00020*
Waterhen River	WHR1	28-Oct-11	<0.00010	<0.00010	216	<0.0020	<0.0010	<0.00020	<0.00020
Lake Manitoba	NARR1	28-Oct-11	<0.00010	<0.00010	154	<0.0020	<0.0010	<0.00020	<0.00020
Fairford River	FR1	28-Oct-11	<0.00010	<0.00010	197	<0.0020	<0.0010	<0.00020	<0.00020
Lake St. Martin	LSM1	29-Oct-11	<0.00010	<0.00010	205	<0.0020	<0.0010	<0.00020	<0.00020
	LSM2	29-Oct-11	<0.00010	<0.00010	209	<0.0020	<0.0010	<0.00020	<0.00020
Dauphin River	DR1.1	29-Oct-11	<0.00010	<0.00010	204	<0.0020	<0.0010	<0.00020	<0.00020
	DR1.3	29-Oct-11	<0.00010	<0.00010	205	<0.0020	<0.0010	<0.00020	<0.00020
	DR1	29-Oct-11	<0.00010	<0.00010	206	<0.0020	<0.0010	<0.00020	<0.00020
	DR3	29-Oct-11	<0.00010	<0.00010	198	<0.0020	<0.0010	<0.00020	<0.00020
	DR02	29-Oct-11	<0.00010	<0.00010	205	0.0020	<0.0010	<0.00020	<0.00020
Sturgeon Bay	LKW1	28-Oct-11	<0.00010	0.00010	41.3	<0.0020	0.0015	<0.00020	0.00041
	LKW2	28-Oct-11	<0.00010	<0.00010	201	<0.0020	<0.0010	<0.00020	<0.00020
	LKW3	28-Oct-11	<0.00010	<0.00010	194	<0.0020	<0.0010	<0.00020	<0.00020
	LKW4	28-Oct-11	<0.00010	<0.00010	104	<0.0020	<0.0010	<0.00020	<0.00020
	LKW5	28-Oct-11	<0.00010	<0.00010	72.6	<0.0020	<0.0010	<0.00020	0.00025
	LKW6	28-Oct-11	<0.00010	<0.00010	110	0.0022	<0.0010	<0.00020	<0.00020
	LKW7	28-Oct-11	<0.00010	<0.00010	72.3	<0.0020	<0.0010	<0.00020	0.00029
Buffalo Creek	BC1	29-Oct-11	<0.00010	<0.00010	4.07	<0.0020	<0.0010	<0.00020	<0.00020
	BC2	29-Oct-11	<0.00010	<0.00010	4.00	<0.0020	<0.0010	<0.00020	<0.00020
	BC3	29-Oct-11	<0.00010	<0.00010	6.11	<0.0020	<0.0010	<0.00020	<0.00020

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Copper		Fluoride	Iron		Lead	
			Dissolved	Total	Dissolved	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.00020*	*0.00020*	*0.020*	*0.010/0.10*	*0.010/0.10*	*0.000090*	*0.000090*
Waterhen River	WHR1	28-Oct-11	0.00054	0.00041	0.138	<0.010	0.026	<0.000090	<0.000090
Lake Manitoba	NARR1	28-Oct-11	0.00077	0.00071	0.166	<0.010	0.11	<0.000090	0.00018
Fairford River	FR1	28-Oct-11	0.00063	0.00063	0.154	<0.010	0.13	<0.000090	0.000295
Lake St. Martin	LSM1	29-Oct-11	0.00055	0.00050	0.159	<0.010	0.040	<0.000090	0.000288
	LSM2	29-Oct-11	0.00048	0.00051	0.160	<0.10	<0.10	<0.000090	0.000095
Dauphin River	DR1.1	29-Oct-11	0.00067	0.00054	0.160	<0.010	0.045	<0.000090	0.000114
	DR1.3	29-Oct-11	0.00057	0.00046	0.156	<0.010	0.024	<0.000090	0.000095
	DR1	29-Oct-11	0.00054	0.00054	0.153	<0.10	0.12	<0.000090	0.000099
	DR3	29-Oct-11	0.00062	0.00051	0.158	<0.10	<0.10	<0.000090	0.000107
	DR02	29-Oct-11	0.00066	0.00050	0.153	<0.010	0.12	<0.000090	0.000108
Sturgeon Bay	LKW1	28-Oct-11	0.00136	0.00221	0.100	0.010	0.84	<0.000090	0.000416
	LKW2	28-Oct-11	0.00064	0.00055	0.158	<0.010	0.13	<0.000090	0.000174
	LKW3	28-Oct-11	0.00067	0.00065	0.152	<0.010	0.18	<0.000090	0.000137
	LKW4	28-Oct-11	0.00112	0.00137	0.119	<0.010	0.34	<0.000090	0.000210
	LKW5	28-Oct-11	0.00132	0.00176	0.109	0.013	0.47	<0.000090	0.000241
	LKW6	28-Oct-11	0.00112	0.00138	0.121	<0.010	0.34	<0.000090	0.000212
	LKW7	28-Oct-11	0.00154	0.00185	0.105	0.021	0.54	<0.000090	0.000267
Buffalo Creek	BC1	29-Oct-11	<0.00020	<0.00020	0.060	<0.10	<0.10	<0.000090	<0.000090
	BC2	29-Oct-11	<0.00020	0.00021	0.061	<0.10	<0.10	<0.000090	<0.000090
	BC3	29-Oct-11	0.00028	0.000365	0.069	<0.10	0.15	<0.000090	<0.000090

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Lithium		Magnesium		Manganese	
			Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.0020*	*0.0020*	*0.010*	*0.010*	*0.00010*	*0.00030*
Waterhen River	WHR1	28-Oct-11	0.0265	0.0289	26.0	32.9	0.00038	0.00707
Lake Manitoba	NARR1	28-Oct-11	0.0495	0.0510	45.8	43.3	0.00036	0.00764
Fairford River	FR1	28-Oct-11	0.0361	0.0385	37.7	49.3	0.00019	0.01110
Lake St. Martin	LSM1	29-Oct-11	0.0361	0.0411	41.7	49.5	0.00018	0.00491
	LSM2	29-Oct-11	0.0363	0.0371	40.2	47.1	0.00036	0.00540
Dauphin River	DR1.1	29-Oct-11	0.0383	0.0353	43.1	49.7	0.00020	0.00526
	DR1.3	29-Oct-11	0.0386	0.0413	45.0	47.5	0.00030	0.00569
	DR1	29-Oct-11	0.0387	0.0379	41.1	54.0	0.00120	0.00666
	DR3	29-Oct-11	0.0371	0.0355	41.5	50.4	0.00132	0.00648
	DR02	29-Oct-11	0.0363	0.0386	42.0	47.4	0.00033	0.00682
Sturgeon Bay	LKW1	28-Oct-11	0.0141	0.0134	18.8	18.6	0.00047	0.01740
	LKW2	28-Oct-11	0.0382	0.0358	47.7	46.2	0.00026	0.00684
	LKW3	28-Oct-11	0.0375	0.0341	44.3	45.7	0.00022	0.00743
	LKW4	28-Oct-11	0.0218	0.0224	27.6	29.0	0.00045	0.00894
	LKW5	28-Oct-11	0.0170	0.0173	21.2	23.8	0.00047	0.00985
	LKW6	28-Oct-11	0.0219	0.0233	26.3	30.4	0.00034	0.00823
	LKW7	28-Oct-11	0.0162	0.0175	21.7	23.3	0.00066	0.00925
Buffalo Creek	BC1	29-Oct-11	0.0081	0.0059	16.6	23.9	0.00432	0.00574
	BC2	29-Oct-11	0.0071	0.0059	17.3	23.9	0.00318	0.00491
	BC3	29-Oct-11	0.0072	0.0064	17.7	22.5	0.00695	0.01080

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Mercury (ng/L)		Methyl Mercury (ng/L)		Molybdenum	
			Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*1.0*	*1.0*	*0.050*	*0.050*	*0.00010*	*0.00020*
Waterhen River	WHR1	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00189	0.00206
Lake Manitoba	NARR1	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00255	0.00272
Fairford River	FR1	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00216	0.00226
Lake St. Martin	LSM1	29-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00226	0.00242
	LSM2	29-Oct-11	<1.0	1.5	<0.050	<0.050	0.00219	0.00229
Dauphin River	DR1.1	29-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00224	0.00230
	DR1.3	29-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00219	0.00247
	DR1	29-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00217	0.00219
	DR3	29-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00207	0.00211
	DR02	29-Oct-11	<1.0	1.1	<0.050	<0.050	0.00220	0.00240
Sturgeon Bay	LKW1	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00086	0.00088
	LKW2	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00221	0.00207
	LKW3	28-Oct-11	<1.0	1.1	<0.050	<0.050	0.00203	0.00207
	LKW4	28-Oct-11	<1.0	1.1	<0.050	<0.050	0.00135	0.00130
	LKW5	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00105	0.00110
	LKW6	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00137	0.00143
	LKW7	28-Oct-11	<1.0	<1.0	<0.050	<0.050	0.00106	0.00105
Buffalo Creek	BC1	29-Oct-11	1.6	1.9	0.050	0.057	<0.00010	<0.00020
	BC2	29-Oct-11	1.3	1.6	<0.050	0.056	<0.00010	<0.00020
	BC3	29-Oct-11	1.7	2.1	0.052	0.067	<0.00010	<0.00020

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Nickel		Potassium		Rubidium	
			Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.0010*	*0.0020*	*0.020*	*0.020*	*0.00020*	*0.00020*
Waterhen River	WHR1	28-Oct-11	<0.0010	<0.0020	7.51	9.40	0.00347	0.00393
Lake Manitoba	NARR1	28-Oct-11	<0.0010	<0.0020	12.2	12.9	0.00358	0.00372
Fairford River	FR1	28-Oct-11	<0.0010	<0.0020	10.2	10.4	0.00335	0.00411
Lake St. Martin	LSM1	29-Oct-11	<0.0010	<0.0020	10.2	10.8	0.00361	0.00409
	LSM2	29-Oct-11	<0.0010	<0.0020	10.4	10.5	0.00359	0.00406
Dauphin River	DR1.1	29-Oct-11	<0.0010	<0.0020	10.8	11.0	0.00357	0.00385
	DR1.3	29-Oct-11	<0.0010	<0.0020	9.94	10.9	0.00361	0.00412
	DR1	29-Oct-11	<0.0010	<0.0020	10.6	10.5	0.00354	0.00391
	DR3	29-Oct-11	<0.0010	<0.0020	10.3	10.0	0.00352	0.00377
	DR02	29-Oct-11	<0.0010	<0.0020	10.4	10.6	0.00362	0.00417
Sturgeon Bay	LKW1	28-Oct-11	<0.0010	<0.0020	3.63	4.29	0.00148	0.00355
	LKW2	28-Oct-11	<0.0010	<0.0020	10.9	9.80	0.00364	0.00384
	LKW3	28-Oct-11	<0.0010	<0.0020	10.3	9.65	0.00346	0.00391
	LKW4	28-Oct-11	<0.0010	<0.0020	6.24	6.96	0.00227	0.00317
	LKW5	28-Oct-11	<0.0010	<0.0020	4.69	5.71	0.00180	0.00301
	LKW6	28-Oct-11	<0.0010	<0.0020	6.32	7.74	0.00229	0.00330
	LKW7	28-Oct-11	<0.0010	<0.0020	4.92	5.57	0.00199	0.00324
Buffalo Creek	BC1	29-Oct-11	<0.0010	<0.0020	0.91	1.10	0.00164	0.00177
	BC2	29-Oct-11	<0.0010	<0.0020	0.98	0.994	0.00164	0.00177
	BC3	29-Oct-11	<0.0010	<0.0020	1.18	1.37	0.00146	0.00187

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Selenium		Silicon		Silver		Sodium	
			Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.001*	*0.0010*	*0.05*	*0.050*	*0.0001*	*0.00010*	*0.020*	*0.030*
Waterhen River	WHR1	28-Oct-11	<0.0010	<0.0010	4.28	4.29	<0.00010	<0.00010	122	135
Lake Manitoba	NARR1	28-Oct-11	<0.0010	<0.0010	4.81	3.49	<0.00010	<0.00010	105	110
Fairford River	FR1	28-Oct-11	<0.0010	<0.0010	3.56	4.63	<0.00010	<0.00010	121	125
Lake St. Martin	LSM1	29-Oct-11	<0.0010	<0.0010	5.01	4.93	<0.00010	<0.00010	132	132
	LSM2	29-Oct-11	<0.0010	<0.0010	5.01	4.75	<0.00010	<0.00010	138	131
Dauphin River	DR1.1	29-Oct-11	<0.0010	<0.0010	5.17	4.99	<0.00010	<0.00010	134	135
	DR1.3	29-Oct-11	<0.0010	<0.0010	5.02	4.70	<0.00010	<0.00010	131	136
	DR1	29-Oct-11	<0.0010	<0.0010	5.00	5.59	<0.00010	<0.00010	140	147
	DR3	29-Oct-11	<0.0010	0.0011	4.93	5.80	<0.00010	<0.00010	135	144
	DR02	29-Oct-11	<0.0010	<0.0010	5.00	4.73	<0.00010	<0.00010	135	132
Sturgeon Bay	LKW1	28-Oct-11	<0.0010	<0.0010	1.14	2.77	<0.00010	<0.00010	29.5	30.5
	LKW2	28-Oct-11	<0.0010	<0.0010	4.80	4.53	<0.00010	<0.00010	122	130
	LKW3	28-Oct-11	<0.0010	0.0010	5.03	4.87	<0.00010	<0.00010	122	128
	LKW4	28-Oct-11	<0.0010	<0.0010	2.88	3.29	<0.00010	<0.00010	68.1	70.1
	LKW5	28-Oct-11	<0.0010	<0.0010	2.27	3.23	<0.00010	<0.00010	46.8	51.8
	LKW6	28-Oct-11	<0.0010	<0.0010	3.09	3.51	<0.00010	<0.00010	74.3	74.5
	LKW7	28-Oct-11	<0.0010	<0.0010	3.22	4.05	<0.00010	<0.00010	51.2	51.3
Buffalo Creek	BC1	29-Oct-11	<0.0010	<0.0010	7.33	7.72	<0.00010	<0.00010	3.53	5.67
	BC2	29-Oct-11	<0.0010	<0.0010	7.32	7.66	<0.00010	<0.00010	3.62	4.57
	BC3	29-Oct-11	<0.0010	<0.0010	6.67	6.74	<0.00010	<0.00010	6.02	7.59

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Strontium		Sulphate	Tellurium		Thallium	
			Dissolved	Total	Dissolved	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.00010*	*0.00010*	*0.50*	*0.00020*	*0.00020*	*0.00010*	*0.00010*
Waterhen River	WHR1	28-Oct-11	0.274	0.291	59.2	<0.00020	<0.00020	<0.00010	<0.00010
Lake Manitoba	NARR1	28-Oct-11	0.307	0.325	138	<0.00020	<0.00020	<0.00010	<0.00010
Fairford River	FR1	28-Oct-11	0.292	0.318	93.5	<0.00020	<0.00020	<0.00010	<0.00010
Lake St. Martin	LSM1	29-Oct-11	0.302	0.315	93.9	<0.00020	<0.00020	<0.00010	<0.00010
	LSM2	29-Oct-11	0.289	0.301	91.9	<0.00020	<0.00020	<0.00010	<0.00010
Dauphin River	DR1.1	29-Oct-11	0.300	0.301	94.2	<0.00020	<0.00020	<0.00010	<0.00010
	DR1.3	29-Oct-11	0.304	0.323	93.7	<0.00020	<0.00020	<0.00010	<0.00010
	DR1	29-Oct-11	0.293	0.300	93.9	<0.00020	<0.00020	<0.00010	<0.00010
	DR3	29-Oct-11	0.283	0.287	90.6	<0.00020	<0.00020	<0.00010	<0.00010
	DR02	29-Oct-11	0.302	0.315	93.5	<0.00020	<0.00020	<0.00010	<0.00010
Sturgeon Bay	LKW1	28-Oct-11	0.143	0.141	38.2	<0.00020	<0.00020	<0.00010	<0.00010
	LKW2	28-Oct-11	0.300	0.283	90.5	<0.00020	<0.00020	<0.00010	<0.00010
	LKW3	28-Oct-11	0.290	0.285	87.5	<0.00020	<0.00020	<0.00010	<0.00010
	LKW4	28-Oct-11	0.204	0.190	57.6	<0.00020	<0.00020	<0.00010	<0.00010
	LKW5	28-Oct-11	0.167	0.174	47.6	<0.00020	<0.00020	<0.00010	<0.00010
	LKW6	28-Oct-11	0.206	0.213	59.7	<0.00020	<0.00020	<0.00010	<0.00010
	LKW7	28-Oct-11	0.171	0.163	46.3	<0.00020	<0.00020	<0.00010	<0.00010
Buffalo Creek	BC1	29-Oct-11	0.0332	0.0323	1.44	<0.00020	<0.00020	<0.00010	<0.00010
	BC2	29-Oct-11	0.0336	0.0322	1.42	<0.00020	<0.00020	<0.00010	<0.00010
	BC3	29-Oct-11	0.0438	0.0418	4.95	<0.00020	<0.00020	<0.00010	<0.00010

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Thorium		Tin		Titanium		Tungsten	
			Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.00010*	*0.00010*	*0.00020*	*0.00020*	*0.00020*	*0.00020*	*0.00020*	*0.0010*
Waterhen River	WHR1	28-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	<0.00020	0.00034	<0.00020	<0.0010
Lake Manitoba	NARR1	28-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00063	0.00140	<0.00020	<0.0010
Fairford River	FR1	28-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00032	0.00204	<0.00020	<0.0010
Lake St. Martin	LSM1	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00054	0.00098	<0.00020	<0.0010
	LSM2	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00034	0.00085	<0.00020	<0.0010
Dauphin River	DR1.1	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00041	0.00117	<0.00020	<0.0010
	DR1.3	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00048	0.00089	<0.00020	<0.0010
	DR1	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00046	0.00413	<0.00020	<0.0010
	DR3	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00037	0.00142	<0.00020	<0.0010
	DR02	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00064	0.00248	<0.00020	<0.0010
Sturgeon Bay	LKW1	28-Oct-11	<0.00010	0.00028	<0.00020	<0.00020	0.00221	0.04030	<0.00020	<0.0010
	LKW2	28-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00038	0.00360	<0.00020	<0.0010
	LKW3	28-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00042	0.00619	<0.00020	<0.0010
	LKW4	28-Oct-11	<0.00010	0.00013	<0.00020	<0.00020	0.00147	0.01780	<0.00020	<0.0010
	LKW5	28-Oct-11	<0.00010	0.00018	<0.00020	<0.00020	0.00207	0.02410	<0.00020	<0.0010
	LKW6	28-Oct-11	<0.00010	0.00012	<0.00020	<0.00020	0.00139	0.01707	<0.00020	<0.0010
	LKW7	28-Oct-11	<0.00010	0.00020	<0.00020	<0.00020	0.00369	0.02730	<0.00020	<0.0010
Buffalo Creek	BC1	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	<0.00020	0.00098	<0.00020	<0.0010
	BC2	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00021	0.00168	<0.00020	<0.0010
	BC3	29-Oct-11	<0.00010	<0.00010	<0.00020	<0.00020	0.00057	0.00735	<0.00020	<0.0010

Table 3-6. (continued).

Sample Location	Location ID	Sample Date	Uranium		Vanadium		Zinc		Zirconium	
			Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Analytical Detection Limits			*0.00010*	*0.00010*	*0.00020*	*0.00020*	*0.0020*	*0.0050*	*0.00040*	*0.00040*
Waterhen River	WHR1	28-Oct-11	0.00136	0.00145	0.00110	0.00092	<0.0020	<0.0050	<0.00040	<0.00040
Lake Manitoba	NARR1	28-Oct-11	0.00235	0.00231	0.00265	0.00251	0.0089	<0.0050	<0.00040	<0.00040
Fairford River	FR1	28-Oct-11	0.00164	0.00168	0.00164	0.00181	<0.0020	<0.0050	<0.00040	<0.00040
Lake St. Martin	LSM1	29-Oct-11	0.00169	0.00177	0.00220	0.00270	<0.0020	<0.0050	<0.00040	<0.00040
	LSM2	29-Oct-11	0.00157	0.00166	0.00165	0.00135	<0.0020	<0.0050	<0.00040	<0.00040
Dauphin River	DR1.1	29-Oct-11	0.00166	0.00174	0.00200	0.00250	<0.0020	<0.0050	<0.00040	<0.00040
	DR1.3	29-Oct-11	0.00167	0.00179	0.00210	0.00240	<0.0020	<0.0050	<0.00040	<0.00040
	DR1	29-Oct-11	0.00162	0.00170	0.00202	0.00260	<0.0020	<0.0050	<0.00040	<0.00040
	DR3	29-Oct-11	0.00158	0.00163	0.00165	0.00134	<0.0020	<0.0050	<0.00040	<0.00040
	DR02	29-Oct-11	0.00167	0.00178	0.00220	0.00260	<0.0020	<0.0050	<0.00040	<0.00040
Sturgeon Bay	LKW1	28-Oct-11	0.00078	0.00084	0.00134	0.00282	<0.0020	<0.0050	<0.00040	0.00063
	LKW2	28-Oct-11	0.00163	0.00160	0.00176	0.00154	<0.0020	<0.0050	<0.00040	<0.00040
	LKW3	28-Oct-11	0.00154	0.00156	0.00190	0.00230	<0.0020	<0.0050	<0.00040	<0.00040
	LKW4	28-Oct-11	0.00110	0.00109	0.00169	0.00197	<0.0020	<0.0050	<0.00040	<0.00040
	LKW5	28-Oct-11	0.00091	0.00100	0.00147	0.00228	<0.0020	<0.0050	<0.00040	0.00043
	LKW6	28-Oct-11	0.00110	0.00119	0.00170	0.00233	<0.0020	<0.0050	<0.00040	<0.00040
	LKW7	28-Oct-11	0.00094	0.00098	0.00172	0.00263	<0.0020	<0.0050	<0.00040	0.00043
Buffalo Creek	BC1	29-Oct-11	<0.00010	<0.00010	0.00028	0.00023	<0.0020	<0.0050	<0.00040	<0.00040
	BC2	29-Oct-11	<0.00010	<0.00010	0.00040	0.00025	<0.0020	<0.0050	<0.00040	<0.00040
	BC3	29-Oct-11	<0.00010	<0.00010	0.00040	0.00058	<0.0020	<0.0050	<0.00040	<0.00040

Table 3-7. Concentrations of pesticides measured at selected sites as part of the RWQMP conducted in fall 2011.

Location	Location ID	Sample Date	Bromacil (µg/L)	Glyphosate and AMPA		Carboxin (µg/L)	Diuron (µg/L)	Eptam (µg/L)	Fenoxaprop (µg/L)	Imazamethabenz-methyl (µg/L)
				AMPA (µg/L)	Glyphosate (µg/L)					
Analytical Detection Limit			*0.10*	*0.20*	*0.20*	*0.10*	*0.018*	*0.20*	*0.10*	*0.010*
Fairford River	FR1	28-Oct-11	-	<0.20	0.45	<0.10	<0.018	<0.20	<0.10	<0.020
		06-Nov-11	<0.10	<0.20	<0.20	<0.10	<0.018	<0.20	<0.10	<0.010
Dauphin River	DR1.1	29-Oct-11	-	<0.20	0.42	<0.10	<0.018	<0.20	<0.10	<0.010
		06-Nov-11	<0.10	<0.20	<0.20	<0.10	<0.018	<0.20	<0.10	<0.010
	DR02	29-Oct-11	-	<0.20	0.39	<0.10	<0.018	<0.20	<0.10	<0.010
		06-Nov-11	<0.10	<0.20	<0.20	<0.10	<0.018	<0.20	<0.10	<0.010
Sturgeon Bay	LKW7	29-Oct-11	-	<0.20	0.23	<0.10	<0.018	<0.20	<0.10	<0.010

Table 3-7. (continued).

Location	Location ID	Sample Date	Metsulfuron-methyl (µg/L)	Propachlor (µg/L)	Propanil (µg/L)	Propoxur (µg/L)	Quizalofop (µg/L)	Sethoxydim (µg/L)	Thifensulfuron-methyl (µg/L)
Analytical Detection Limit			*0.010*	*0.20*	*0.20*	*0.20*	*0.10*	*0.10*	*0.010*
Fairford River	FR1	28-Oct-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010
		06-Nov-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010
Dauphin River	DR1.1	29-Oct-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010
		06-Nov-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010
	DR02	29-Oct-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010
		06-Nov-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010
Sturgeon Bay	LKW7	29-Oct-11	<0.010	<0.20	<0.20	<0.20	<0.10	<0.10	<0.010

Table 3-7. (continued).

Location	Location ID	Sample Date	Tralkoxydim (µg/L)	Chlorothalonil (µg/L)	Triclopyr (µg/L)	Benomyl (µg/L)	Deltamethrin (µg/L)	Tribenuron-methyl (µg/L)	Ethalfluralin (µg/L)
Analytical Detection Limit			*0.10*	*0.060*	*0.050*	*0.10*	*0.040*	*0.010*	*0.020*
Fairford River	FR1	28-Oct-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020
		06-Nov-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020
Dauphin River	DR1.1	29-Oct-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020
		06-Nov-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020
	DR02	29-Oct-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020
		06-Nov-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020
Sturgeon Bay	LKW7	29-Oct-11	<0.10	<0.060	<0.050	<0.10	<0.040	<0.010	<0.020

Table 3-7. (continued).

Location	Location ID	Sample Date	Trifluralin (µg/L)	Alachlor (µg/L)	Atrazine (µg/L)	Atrazine Desethyl (µg/L)	Azinphos-methyl (µg/L)	Carbofuran (µg/L)	Chlorpyrifos (µg/L)	Cyanazine (µg/L)
Analytical Detection Limit			*0.030*	*0.10*	*0.10*	*0.10*	*0.10*	*0.20*	*0.020*	*0.10*
Fairford River	FR1	28-Oct-11	<0.030	-	-	-	-	-	-	-
		06-Nov-11	<0.030	<0.10	<0.10	<0.10	<0.10	<0.20	<0.020	<0.10
Dauphin River	DR1.1	29-Oct-11	<0.030	-	-	-	-	-	-	-
		06-Nov-11	<0.030	<0.10	<0.10	<0.10	<0.10	<0.20	<0.020	<0.10
	DR02	29-Oct-11	<0.030	-	-	-	-	-	-	-
		06-Nov-11	<0.030	<0.10	<0.10	<0.10	<0.10	<0.20	<0.020	<0.10
Sturgeon Bay	LKW7	29-Oct-11	<0.030	-	-	-	-	-	-	-

Table 3-7. (continued).

Location	Location ID	Sample Date	Diazinon (µg/L)	Diclofop-methyl (µg/L)	Dimethoate (µg/L)	Malathion (µg/L)	Methyl Parathion (µg/L)	Metribuzin (µg/L)	Parathion (µg/L)	Simazine (µg/L)
Analytical Detection Limit			*0.030*	*0.10*	*0.10*	*0.10*	*0.10*	*0.20*	*0.10*	*0.10*
Fairford River	FR1	28-Oct-11	-	-	-	-	-	-	-	-
		06-Nov-11	<0.030	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
Dauphin River	DR1.1	29-Oct-11	-	-	-	-	-	-	-	-
		06-Nov-11	<0.030	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
	DR02	29-Oct-11	-	-	-	-	-	-	-	-
		06-Nov-11	<0.030	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
Sturgeon Bay	LKW7	29-Oct-11	-	-	-	-	-	-	-	-

Table 3-7. (continued).

Location	Location ID	Sample Date	Terbufos (µg/L)	Triallate (µg/L)	Trifluralin (µg/L)	Organochlorine Pesticides				
						alpha-BHC (µg/L)	beta-BHC (µg/L)	delta-BHC (µg/L)	a-chlordane (µg/L)	g-chlordane (µg/L)
Analytical Detection Limit			*0.10*	*0.10*	*0.030*	*0.10*	*0.10*	*0.10*	*0.010*	*0.010*
Fairford River	FR1	28-Oct-11	-	-	-	-	-	-	-	-
		06-Nov-11	<0.10	<0.10	<0.030	<0.10	<0.10	<0.10	<0.010	<0.010
Dauphin River	DR1.1	29-Oct-11	-	-	-	-	-	-	-	-
		06-Nov-11	<0.10	<0.10	<0.030	<0.10	<0.10	<0.10	<0.010	<0.010
	DR02	29-Oct-11	-	-	-	-	-	-	-	-
		06-Nov-11	<0.10	<0.10	<0.030	<0.10	<0.10	<0.10	<0.010	<0.010
Sturgeon Bay	LKW7	29-Oct-11	-	-	-	-	-	-	-	-

Table 3-7. (continued).

Location	Location ID	Sample Date	Organochlorine Pesticides		Pentachlorophenol (µg/L)	Phenoxy Acid Herbicides			
			Lindane (µg/L)	Methoxychlor (µg/L)		2,4-D (µg/L)	2,4-DB (µg/L)	2,4-DP (µg/L)	Bromoxynil (µg/L)
Analytical Detection Limit			*0.10*	*0.010*	*0.020*	*0.050*	*0.050*	*0.050*	*0.020*
Fairford River	FR1	28-Oct-11	-	-	-	-	-	-	-
		06-Nov-11	<0.10	<0.010	<0.020	<0.050	<0.050	<0.050	<0.020
Dauphin River	DR1.1	29-Oct-11	-	-	-	-	-	-	-
		06-Nov-11	<0.10	<0.010	<0.020	<0.050	<0.050	<0.050	<0.020
	DR02	29-Oct-11	-	-	-	-	-	-	-
		06-Nov-11	<0.10	<0.010	<0.020	<0.050	<0.050	<0.050	<0.020
Sturgeon Bay	LKW7	29-Oct-11	-	-	-	-	-	-	-

Table 3-7. (continued).

Location	Location ID	Sample Date	Phenoxy Acid Herbicides			Mecoprop (µg/L)	Picloram (µg/L)
			Dicamba (µg/L)	Dinoseb (µg/L)	MCPA (µg/L)		
Analytical Detection Limit			*0.0060*	*0.050*	*0.025*	*0.050*	*0.20*
Fairford River	FR1	28-Oct-11	-	-	-	-	-
		06-Nov-11	<0.0060	<0.050	<0.025	<0.050	<0.20
Dauphin River	DR1.1	29-Oct-11	-	-	-	-	-
		06-Nov-11	<0.0060	<0.050	<0.025	<0.050	<0.20
	DR02	29-Oct-11	-	-	-	-	-
		06-Nov-11	<0.0060	<0.050	<0.025	<0.050	<0.20
Sturgeon Bay	LKW7	29-Oct-11	-	-	-	-	-

Table 3-8. *In situ* water quality results measured along transects in Sturgeon Bay and the Dauphin River, fall 2011. Data for Sturgeon Bay are ordered from nearshore to offshore within each transect, and Dauphin River sites are listed from left to right bank when facing upstream. See Figure 3-4 for more detail.

Transect Location	Site ID	Sample Date	Depth (m)		Temperature (^{o}C)	Dissolved Oxygen		Sp. Cond (µS/cm)	Turbidity (NTU)	pH
			Total	Measurement		(mg/L)	(% Saturation)			
Sturgeon Bay	T1-5	12-Oct-11	0.9	0.3	11.9	10.36	97.3	1280	37.6	8.13
				0.7	11.9	10.33	97.0	1280	34.6	8.15
	T1-4	12-Oct-11	4.0	0.3	12.1	10.36	97.7	1290	26.1	8.17
				3.0	12.1	10.32	97.3	1290	24.1	8.19
	T1-3	12-Oct-11	4.5	0.3	12.1	10.41	98.2	1170	17.3	8.15
				3.5	12.1	10.31	97.2	1220	18.8	8.19
	T1-2	12-Oct-11	6.1	0.3	12.2	10.19	96.3	1140	17.5	8.17
				5.1	12.1	10.01	94.4	1200	17.1	8.18
	T1-1	12-Oct-11	6.8	0.3	12.1	10.10	95.3	1040	21.4	8.16
				5.8	12.0	9.00	84.7	1220	30.6	8.14
	T2-5	2-Oct-11	2.0	0.3	12.3	10.16	96.2	1460	39.2	8.24
				1.3	12.3	10.13	95.9	1460	38.1	8.25
	T2-4	2-Oct-11	4.5	0.3	12.4	9.91	94.0	1490	27.4	8.24
				4.0	12.4	9.92	94.1	1490	26.3	8.25
	T2-3	2-Oct-11	6.0	0.3	12.3	10.04	95.1	1410	31.4	8.22
				5.5	12.3	9.90	93.7	1410	32.0	8.24
	T2-2	2-Oct-11	6.9	0.3	12.4	10.03	95.2	1440	28.5	8.18
				6.4	12.3	9.92	93.9	1440	29.1	8.19
	T2-1	2-Oct-11	7.3	0.3	12.4	9.92	94.1	1360	37.3	8.12
				6.6	12.4	9.77	92.7	1410	31.1	8.12
	T3-5	1-Oct-11	1.1	0.3	12.3	10.23	96.9	1510	26.6	8.25
				1.0	12.3	10.19	96.5	1510	27.7	8.25
	T3-4	1-Oct-11	3.4	0.3	12.0	10.02	94.3	1520	28.4	8.24
				3.1	12.0	9.94	93.6	1520	26.8	8.24
	T3-3	1-Oct-11	5.0	0.3	12.2	10.06	95.1	1520	28.4	8.22
				4.0	12.1	9.90	93.4	1520	29.6	8.21
	T3-2	1-Oct-11	5.2	0.3	12.4	9.66	91.7	1510	25.1	8.13
				4.7	12.3	9.56	90.5	1510	26.1	8.13
	T3-1	1-Oct-11	7.1	0.3	12.5	9.96	94.7	1450	43.8	8.00
				6.5	12.4	9.73	92.3	1450	32.7	8.01

Table 3-8. (continued).

Transect Location	Site ID	Sample Date	Depth (m)		Temperature (°C)	Dissolved Oxygen		Sp. Cond (µS/cm)	Turbidity (NTU)	pH
			Total	Measurement		(mg/L)	(% Saturation)			
Sturgeon Bay	T4-5	30-Sep-11	1.1	0.3	12.7	10.13	96.7	1480	75.6	8.25
				0.7	12.7	10.13	96.7	1480	78.9	8.26
	T4-4	30-Sep-11	2.7	0.3	12.6	9.86	93.9	1500	44.1	8.22
				2.2	12.5	9.79	93.1	1500	48.4	8.22
	T4-3	30-Sep-11	3.7	0.3	13.1	9.78	94.1	1490	24.8	8.18
				3.2	13.1	9.76	93.9	1490	28.7	8.19
	T4-2	30-Sep-11	5.2	0.3	12.9	9.13	87.5	1510	24.0	8.10
				4.7	12.9	9.02	86.5	1510	22.1	8.10
	T4-1	30-Sep-11	6.1	0.3	13.1	9.31	89.6	1420	31.3	8.05
				5.7	13.1	9.20	88.5	1420	30.9	8.08
	T5-5	1-Oct-11	1.2	0.3	13.4	10.35	100.2	1510	33.2	8.22
				1.0	13.4	10.33	100.0	1510	31.6	8.22
	T5-4	1-Oct-11	2.5	0.3	13.0	10.16	97.6	1510	35.6	8.21
				1.8	13.0	10.06	96.6	1510	34.7	8.21
	T5-3	1-Oct-11	3.8	0.3	12.9	9.96	95.5	1470	39.6	8.19
				3.1	12.8	9.84	94.1	1480	36.6	8.18
	T5-2	1-Oct-11	6.7	0.3	12.8	9.78	93.6	1440	46.3	8.14
				6.0	12.2	9.63	91.0	1500	48.2	8.14
	T5-1	1-Oct-11	7.0	0.3	12.8	9.84	94.1	1510	35.1	8.20
				6.5	12.7	9.69	92.5	1510	38.9	8.17
	T6-5	30-Sep-11	1.7	0.3	11.7	9.52	89.1	1060	43.4	8.02
				1.2	11.7	9.44	88.3	1060	63.7	8.03
	T6-4	30-Sep-11	4.1	0.3	12.3	9.25	87.6	1130	41.7	8.01
				3.5	12.3	9.16	86.7	1130	50.2	8.04
	T6-3	30-Sep-11	6.6	0.3	13.3	8.96	86.6	1470	31.9	8.03
				6.0	13.3	8.76	84.7	1480	31.4	7.97
	T6-2	30-Sep-11	6.8	0.3	12.9	9.27	88.9	1310	33.8	8.03
				6.5	12.9	9.20	88.2	1320	33.4	8.06
	T6-1	30-Sep-11	7.4	0.3	12.7	9.20	87.8	1240	40.3	8.00
				7.0	12.7	8.02	76.6	1240	39.8	8.02
	T9-5	12-Oct-11	1.6	0.3	12.2	10.20	96.4	1260	19.0	8.25
				1.2	12.2	10.19	96.3	1260	19.2	8.25

Table 3-8. (continued).

Transect Location	Site ID	Sample Date	Depth (m)		Temperature (°C)	Dissolved Oxygen		Sp. Cond (µS/cm)	Turbidity (NTU)	pH
			Total	Measurement		(mg/L)	(% Saturation)			
Sturgeon Bay	T9-4	12-Oct-11	4.5	0.3	12.1	10.31	97.2	1240	15.6	8.27
				3.5	12.1	10.31	97.2	1240	16.8	8.27
	T9-3	12-Oct-11	4.9	0.3	12.1	10.09	95.2	1230	16.9	8.24
				3.9	12.1	10.07	95.0	1230	17.7	8.24
	T9-2	12-Oct-11	6.3	0.3	12.2	10.16	96.0	1220	17.0	8.21
				5.3	12.2	10.16	96.0	1220	17.5	8.22
	T9-1	12-Oct-11	6.8	0.3	12.2	9.81	92.7	1040	23.6	8.17
				5.8	12.2	9.61	90.8	1060	26.0	8.16
	T11-5	21-Oct-11	1.5	0.3	4.8	12.78	103.9	1190	129.0	7.80
				1.2	4.6	12.70	102.9	1160	121.0	7.93
	T11-4	21-Oct-11	2.0	0.3	6.0	12.25	102.1	1220	35.1	7.97
				1.7	5.9	12.27	102.1	1220	34.2	7.98
	T11-3	21-Oct-11	3.7	0.3	6.0	12.32	102.7	1200	39.1	7.95
				3.4	5.9	12.32	102.5	1220	44.1	7.98
	T11-2	21-Oct-11	6.0	0.3	5.9	12.08	100.5	1110	50.4	7.86
				5.7	5.9	12.14	101.0	1110	55.4	7.91
Extensive Zone (offshore)										
	EZ-1	1-Oct-11	8.5	0.3	13.0	10.21	98.1	1220	37.6	8.22
				8.0	12.5	9.90	94.1	1220	40.4	8.19
	EZ-2	1-Oct-11	8.2	0.3	13.2	10.32	99.5	1210	35.4	8.23
				7.6	12.5	9.96	94.7	1190	37.6	8.19
	EZ-3	1-Oct-11	7.6	0.3	13.4	10.59	102.5	1140	37.3	8.25
				7.3	12.2	9.83	92.9	1200	42.2	8.19
Dauphin River										
Upstream from Buffalo Cr.	DR-T1-1	30-Sep-11	3.1	0.3	13.1	9.10	87.6	1560	18.8	8.12
	DR-T1-2	30-Sep-11	2.5	0.3	13.1	8.94	86.0	1560	20.9	8.10
	DR-T1-3	30-Sep-11	2.3	0.3	13.1	9.14	88.0	1560	20.4	8.10
Downstream from Buffalo Cr.	DR-T2-1	30-Sep-11	1.7	0.3	13.2	9.17	88.4	1550	19.0	8.11
	DR-T2-2	30-Sep-11	1.4	0.3	13.1	8.94	86.0	1540	17.7	8.10
	DR-T2-3	30-Sep-11	2.1	0.3	13.1	9.12	87.8	1550	18.9	8.09
Mouth	DR-T3-1	30-Sep-11	3.4	0.3	13.2	9.05	87.3	1560	18.8	8.08
	DR-T3-2	30-Sep-11	3.4	0.3	13.2	9.01	86.9	1540	19.7	8.08
	DR-T3-3	30-Sep-11	3.9	0.3	13.2	9.18	88.5	1500	19.2	8.07

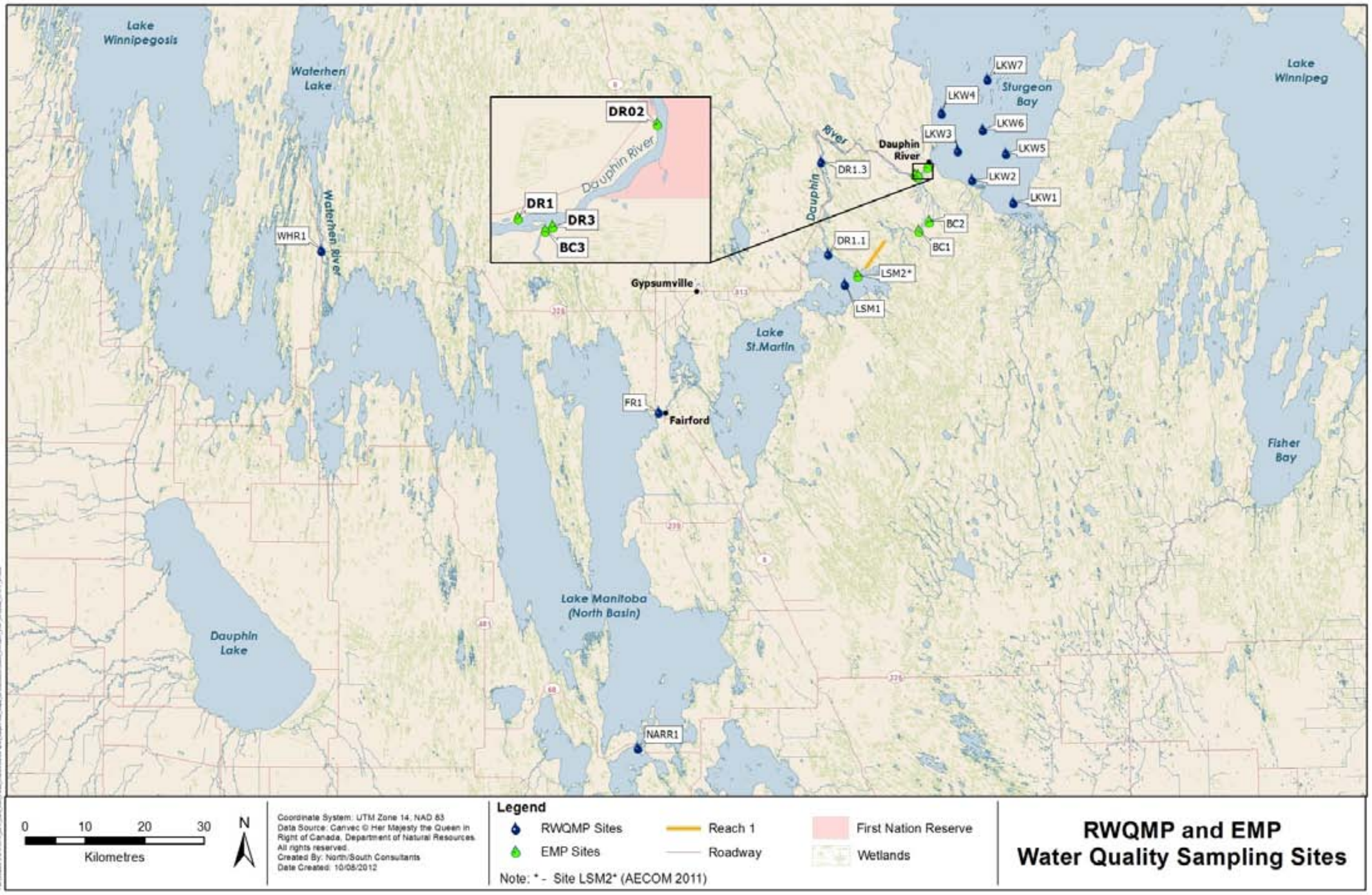

Figure 3-1. Location of sites sampled as part of the RWQMP and EMP conducted during fall 2011.

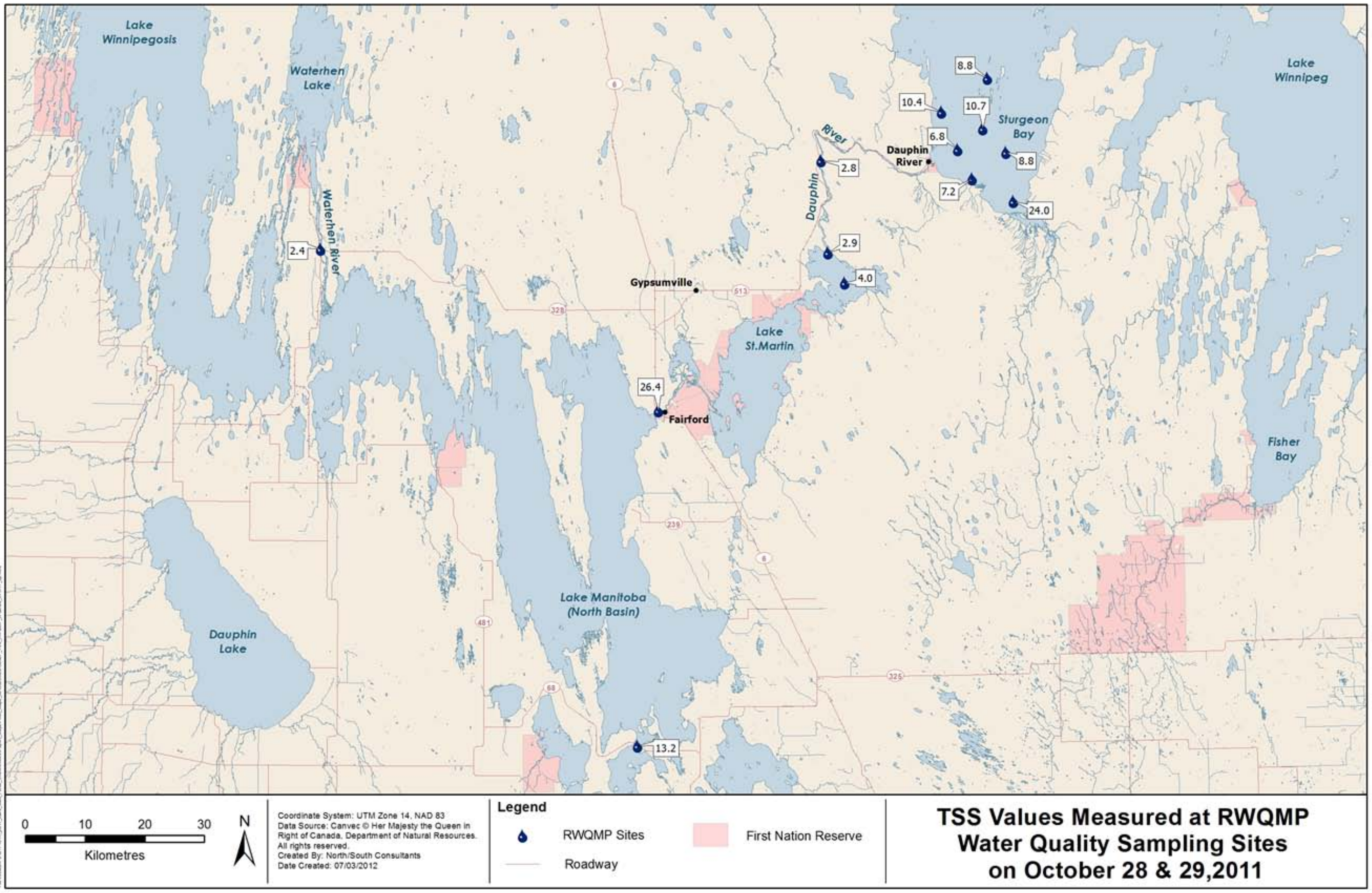

Figure 3-2. Total suspended solids (TSS) values measured at RWQMP sites on 28-29 October, 2011.

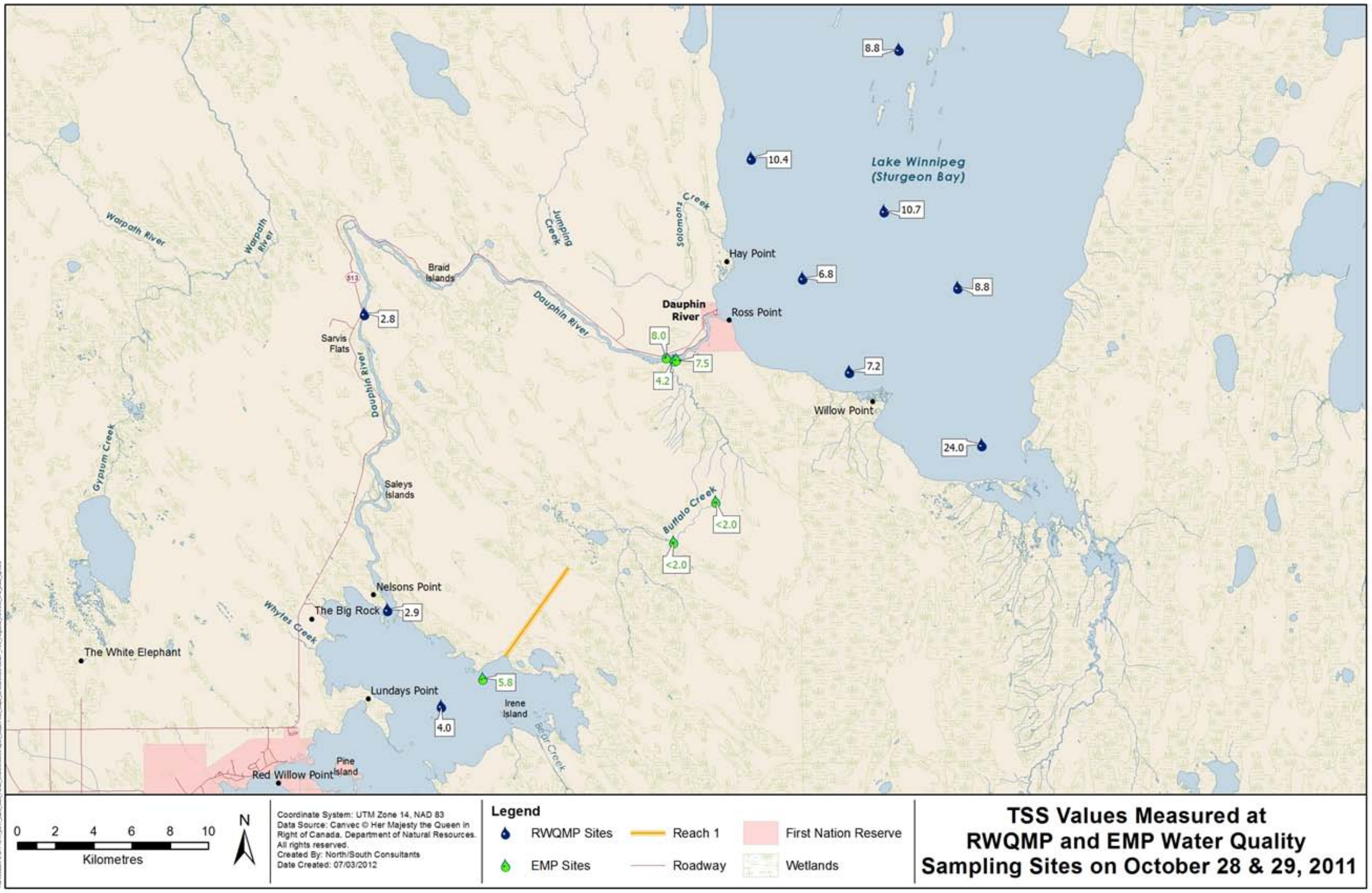

Figure 3-3. Total suspended solids (TSS) values measured at RWQMP and EMP sites on 28-29 October, 2011.

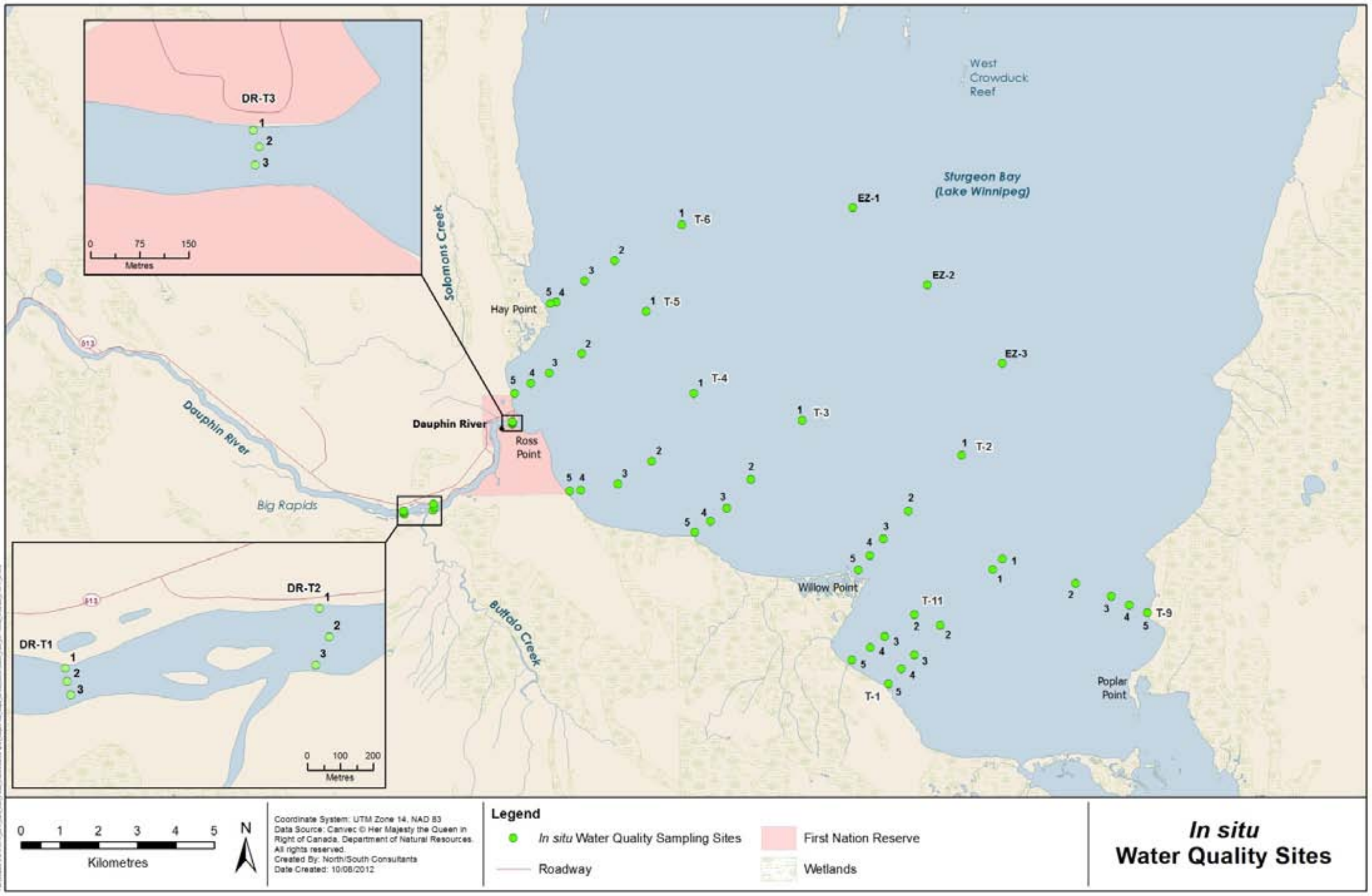

Figure 3-4. Location of sites where *in situ* water quality measurements were recorded during fall 2011.

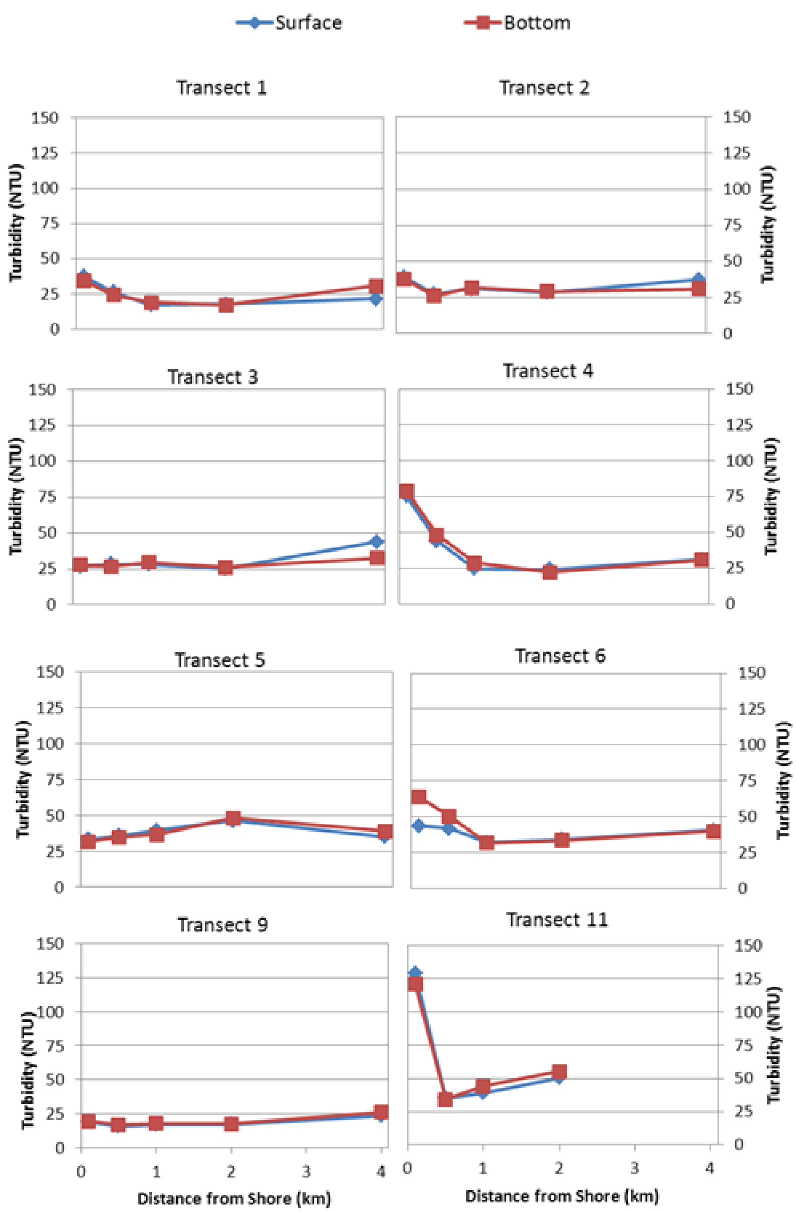

Figure 3-5. *In situ* turbidity measured along transects extending out from shore in Sturgeon Bay, fall 2011.

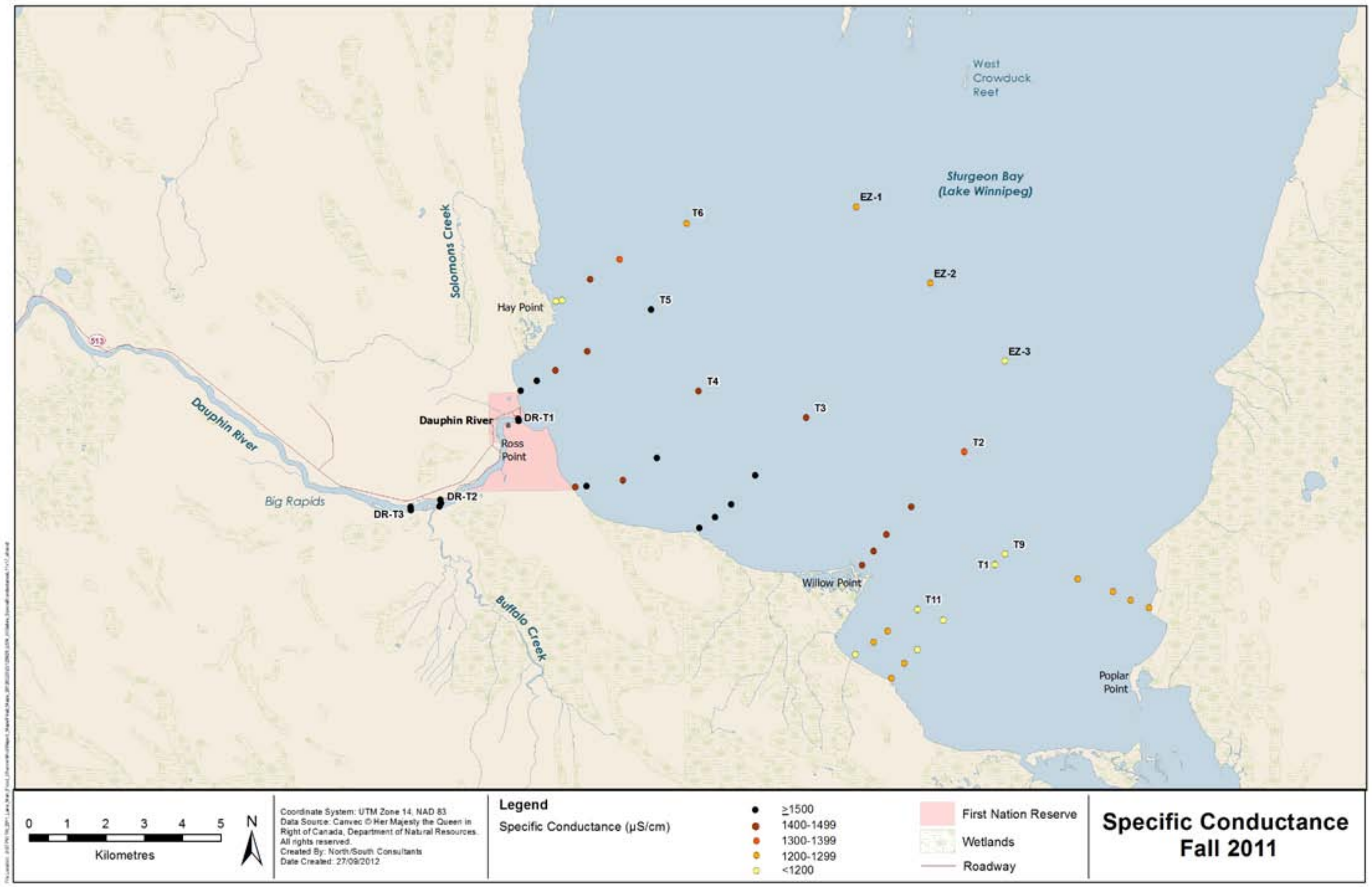

Figure 3-6. Map of specific conductance values measured near the surface in the Dauphin River and Sturgeon Bay, fall 2011.

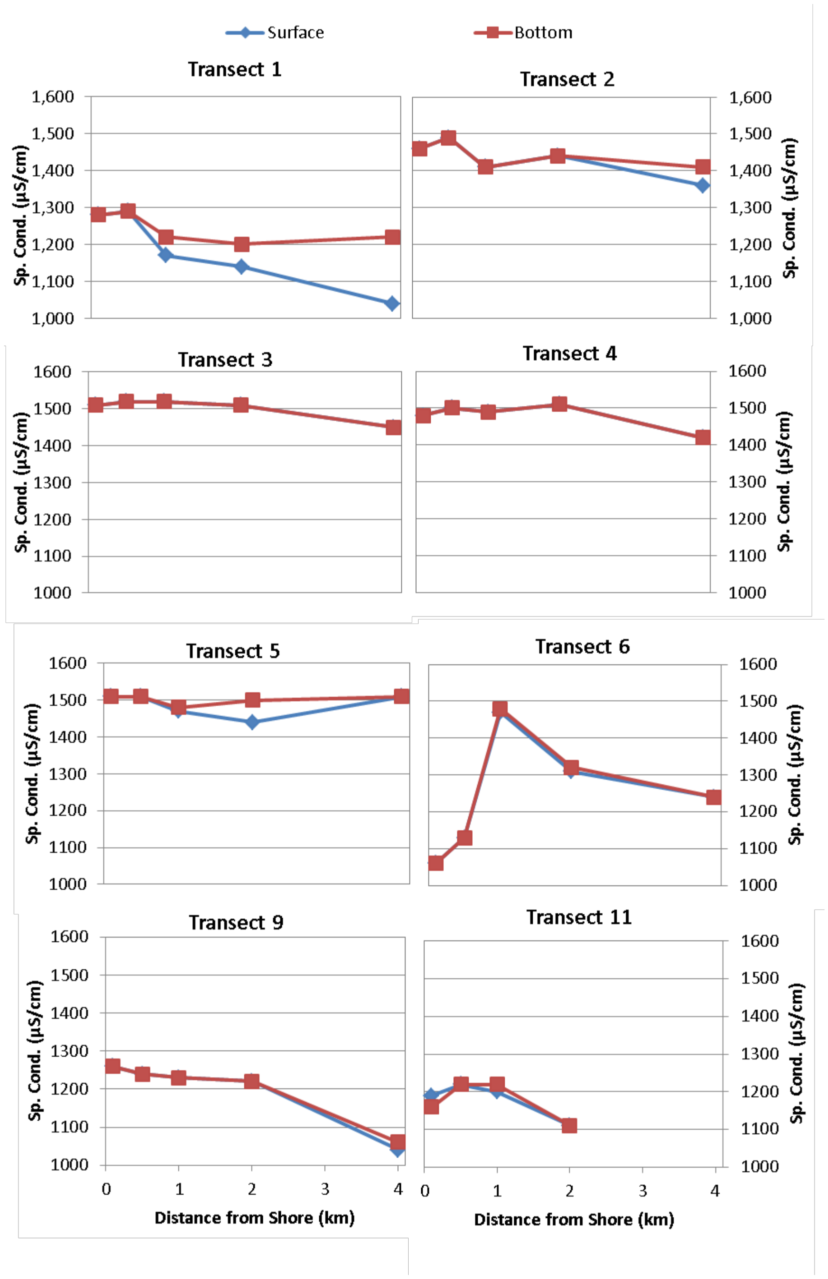

Figure 3-7. *In situ* specific conductance measured along transects extending out from shore in Sturgeon Bay, fall 2011.

4.0 SEDIMENT INPUTS TO STURGEON BAY

It was anticipated that high flow along the Dauphin River and through the diversion route will result in an increase in bed load and suspended organic materials and sediments inputs to Sturgeon Bay. The intent of bed load and suspended sediment studies is to provide information to assess the extent to which increased sedimentation may affect habitat within Sturgeon Bay. Specific study objectives include:

- Determining the type and amount of sediment deposited into Sturgeon Bay during operation of Reach 1;
- Determining the bed load contribution of the Dauphin River into Sturgeon Bay, before operation, and the Dauphin River and Buffalo Creek, during operation of Reach 1;
- Collecting sediment grab samples in the Dauphin River and Sturgeon Bay for particle grain size and organic content analysis to assess changes in substrate due to sedimentation. This information will also be used to validate substrate data collected through sonar during habitat mapping studies; and,
- Collecting sediment samples from the Dauphin River and Sturgeon Bay to document baseline sediment quality and assess Project-related impacts.

Fall 2011 investigations focussed on determining baseline sediment quality, characterizing substrates in the lower Dauphin River and in Sturgeon Bay and measuring the Dauphin River bed load contributions into Sturgeon Bay. Additionally, a sedimentation study (sediment traps) was initiated in Sturgeon Bay in fall 2011 and will be ongoing throughout 2012.

4.1 BED LOAD AND SUSPENDED SEDIMENTS

4.1.1 Methods

Bed load samples were collected on October 16, 22 and November 6 at three sites in the Dauphin River (Figure 4-1). The sample sites were located:

- Approximately 1 km upstream from Buffalo Creek to determine the Dauphin River bed load; and
- 0.6 km and 0.9 km downstream from Buffalo Creek to determine the combined bed load from the Dauphin River and the diversion route.

Bed load samples were collected using a US BL-84 cable-suspended bed load sampler. The sampler consisted of a steel and aluminum frame with a 76 x 76 mm square opening and attached 46 cm long, 250 µm mesh bag. Three replicate samples were collected at each sample site. For each replicate, the sampler was lowered to the river bottom with the opening oriented into the current. The sampler was left for five or ten minutes to capture particles as they were transported along the streambed. Once retrieved the mesh bag was emptied directly into individually labelled 500 mL plastic sample jars. The samples were kept cool and transported to the North/South Consultants Laboratory in Winnipeg.

To supplement bed load sampling, *in situ* water quality was measured and laboratory water quality samples were collected at each bed load sample site (October 22 and November 6), the Buffalo Creek outflow and the Dauphin River mouth (November 6). *In situ* pH, specific conductance, DO, turbidity and temperature were measured at the water surface (approx. 0.30 m depth) using a Horiba® W22-XD water quality meter. Grab samples were collected approximately 0.30 m below the water surface in sample bottles provided by ALS Laboratories. Water samples were kept cool and transported to ALS Laboratories in Winnipeg where they were analysed for turbidity and TSS.

Water depth at each site was measured with a handheld depth sounder and sample locations were recorded using a handheld Garmin GPS receiver.

4.1.2 Results

Prior to the onset of Reach 1 operation, bed load sampling was conducted in the Dauphin River upstream and downstream of the confluence of Buffalo Creek. Following the onset of operation of Reach 1, the intent was to repeat the sampling in the Dauphin River and add another site within Buffalo Creek in order to determine the bed load being contributed to the Dauphin River by diversion flows down Buffalo Creek. However, high water velocity precluded the collection of bed load samples from within the creek once Reach 1 was operational. Consequently, the program objectives could not be met, and the program could not be completed. All bed load samples collected in the Dauphin River were archived (Appendix 3-2).

In situ water quality measurements and laboratory analyses of water quality samples collected at bed load sampling sites are presented in Table 4-1. Total suspended solids measured in the Dauphin River prior to operation of Reach 1 were similar at all locations and ranged from 5-6 mg/L. Similarly, AECOM (2012; Appendix 3-5) reported that TSS at the Buffalo Creek mouth ranged from <5.0-6.0 mg/L in September and October 2011 (six samples collected approximately every 1-2 weeks). Samples collected after Reach 1 became operational indicated that TSS in the Dauphin River was higher downstream of Buffalo Creek (8-17 mg/L) compared to upstream of the creek (< 5mg/L). Additional examination of TSS changes in the Dauphin River and Buffalo Creek associated with Reach 1 operation are provided in Section 3.0 and Appendix 3-5.

4.2 SEDIMENTATION RATE

4.2.1 Methods

Thirty sediment traps were deployed in Sturgeon Bay on October 19, 2011 to determine the type and amount of sediment being deposited in the area. Twenty-seven sediment traps were set along six transects extending from the southwest shore to a distance 6-12 kilometres offshore (Figure 4-2). Three additional single sediment trap sites were established in off shore areas.

Sediment traps consisted of three 0.50 m long plastic pipes with a 5.0 cm outer diameter, clamped together with cable ties (Figure 4-3). The bottom of each pipe was sealed. Foam was attached along the length of the trap to keep the pipes upright in the water column. To anchor the trap, the bottom of the pipes was connected by a short rope (approx. 0.30 m) to a cinder block.

Water depth at each site was measured with a handheld depth sounder and sample locations were recorded using a handheld Garmin GPS receiver.

4.2.2 Results

Sediment traps remain deployed in Sturgeon Bay and were retrieved and sampled in summer 2012. Results are provided in a subsequent report.

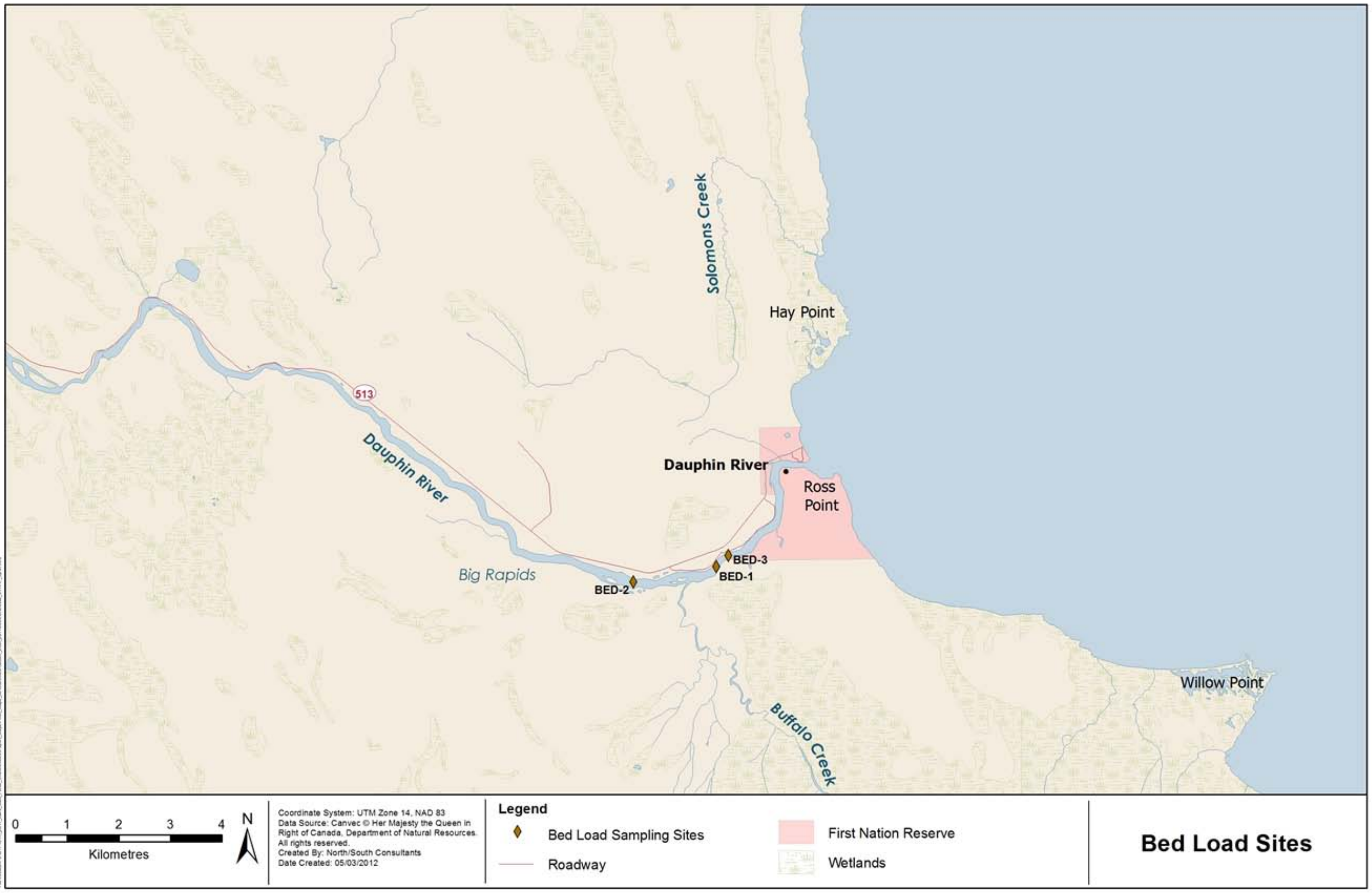

Figure 4-1. Location of sites in the Dauphin River where bed load samples were collected during fall 2011.

Table 4-1. In situ water quality and laboratory TSS results at bed load sampling sites.

Site	Date	Sample Time	*In Situ*						Laboratory	
			Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (mS/m)	Conductivity [1] (µS/cm)	Turbidity (NTU)	pH	TSS (mg/L)	Turbidity [2] (NTU)
BED-1	22-Oct-11	11:35	6.3	-	133	855	-	7.84	5.0	4.2
	06-Nov-11	10:05	3.5	11.44	130	766	41.6	8.08	<5.0	4.2
BED-2	22-Oct-11	11:59	6.2	-	134	859	-	7.96	5.0	5.0
	06-Nov-11	9:06	3.5	12.27	135	796	31.7	8.10	8.0	3.7
BED-3	22-Oct-11	10:25	6.4	-	133	857	35.6	7.73	6.0	4.9
	06-Nov-11	11:12	3.5	11.71	131	772	42.9	8.00	16.0	11.1

1 - Conductivity = Specific Conductance * (1 + 0.0191*(water temperature -25°C))

2 - Laboratory samples exceeded hold time for turbidity analysis

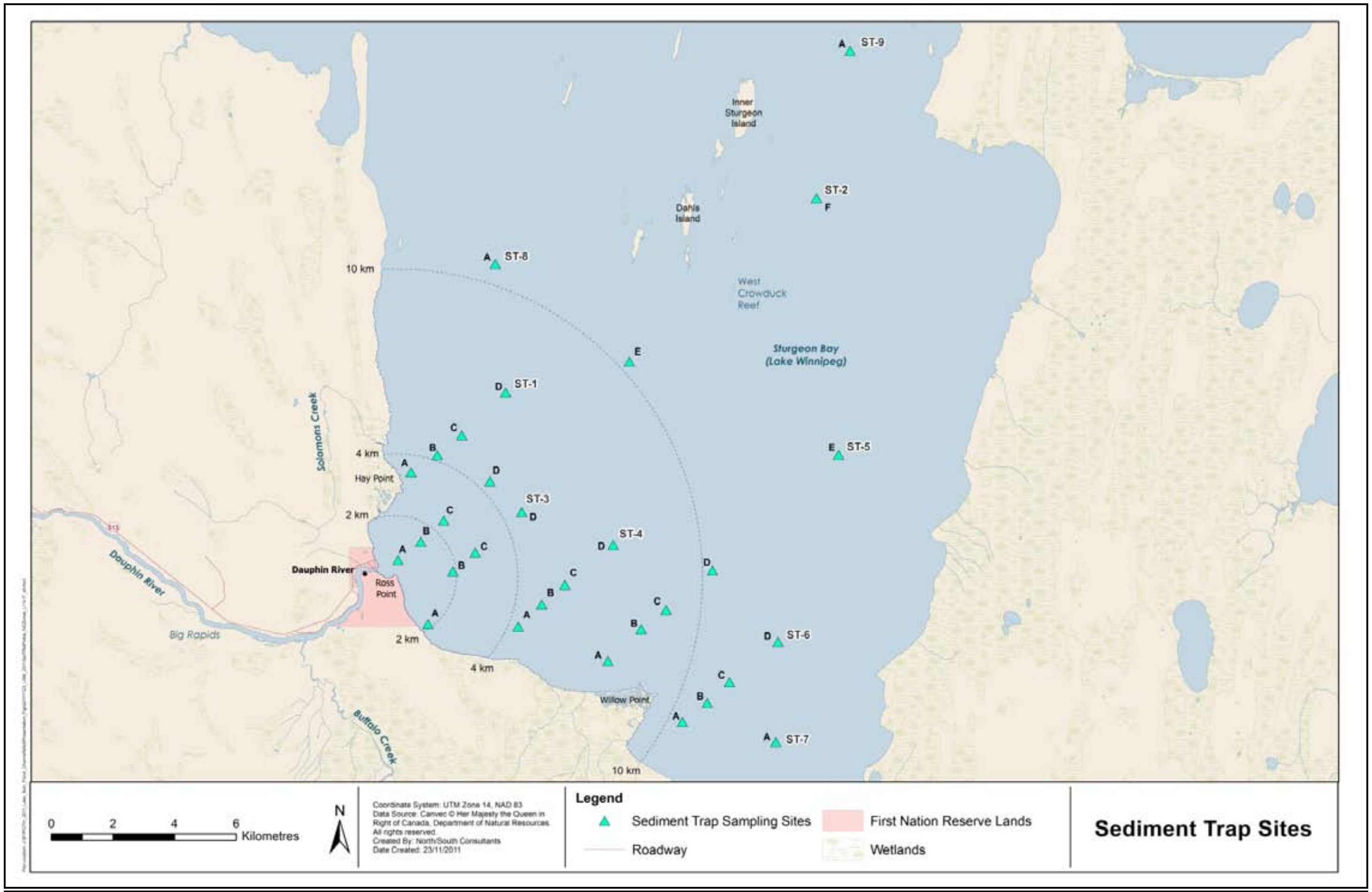

Figure 4-2. Location of sediment trap sites in Sturgeon Bay, fall 2011.

Figure 4-3. Example of sediment trap deployed in Sturgeon Bay.

4.3 SUBSTRATE CLASSIFICATION

4.3.1 Methods

Substrate sampling was conducted at Sturgeon Bay from September 30-October 1 and October 20-21. Twelve transects were established extending 3-4 km from the southwest (eight transects) and southeast shores (one transect) (Figure 4-4). Sediment sampling was conducted at four or five sites along each transect. Three additional sites were located in the offshore extensive zone.

Bottom substrates were sampled using a large (229 x 229 mm sample area) or petite ponar (152 mm x 152 mm). At each site, ponar penetration depth and relative proportion (%) of each substrate type within the sample was visually estimated and recorded. Substrate types were classified as: clay; silt; sand; gravel; small cobble; large cobble; boulder; and organics. Where substrate compaction (e.g., hard clay) or type (e.g., boulder, cobble) precluded ponar sample collection, substrate composition was estimated by probing with a 2.5 m steel pole.

Where ponar grabs were successful (34 sites), sediment quality samples were collected in individually labelled sample jars (metals) and/or clean polyethylene bags (total carbon [TOC] and particle size analysis). TOC and particle size samples were transported to ALS Laboratories in Winnipeg for analysis. The metals samples were transported to the North/South Consultants laboratory in Winnipeg and archived for future analysis.

Sediment core samples were also collected at five ponar grab sites (EZ-2, T3-1, T5-2, T5-1 and T2-1; Figure 4-4). Bottom substrates were collected using an Ekman Grab Sampler. A sub-sample of bottom substrates was collected directly from the Ekman Grab Sampler using a five centimeter (outer diameter) core tube (0.002 m^2 surface area). The core tube was pressed through the center of the grab sample penetrating its entire depth. Each end of the core tube was capped and stored upright in a cool storage container. The samples were transported to the North/South Consultants laboratory in Winnipeg, and archived for future analysis. Samples were handled and stored in such a way to avoid agitation.

At most sites, *in situ* water quality was measured with a using a Horiba® W22-XD water quality meter. *In situ* measurements were conducted in conjunction with *in situ* water quality sampling. Methods, parameters and results are discussed in Section 3.3.

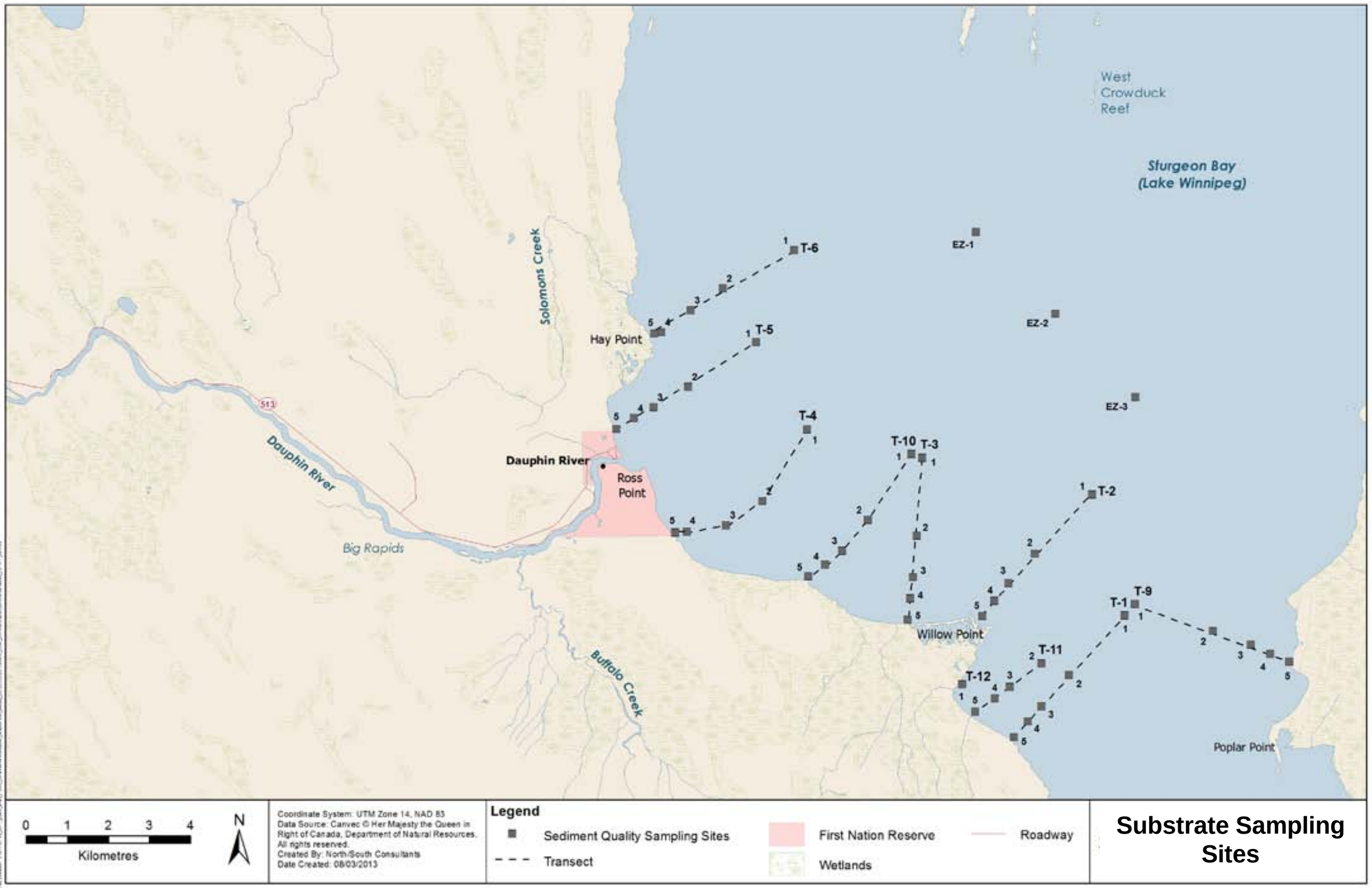

Figure 4-4. Location of substrate classification sites in Sturgeon Bay, fall 2011.

4.3.2 Results

Sediment quality samples have been archived and stored for future metals analysis. Carbon and particle size analysis results for sediment samples collected in Sturgeon Bay are presented in Table 4-2. Field estimates of substrate composition are presented in Table 4-3. Photographs of substrate samples are provided in Appendix 4-1.

Nearshore sites in Sturgeon Bay were typically sand and gravel; however rocky substrates (boulder, boulder/cobble) were dominant at nearshore sites near Hay Point and north of Poplar Point. Offshore sites were characterized as clay. Total organic carbon ranged from 0.2-3.91%. The relative proportion of organic carbon increased with distance offshore.

Within the Intensive Zone (within 2 km of the Dauphin River mouth), TOC was ranged from 0.2-0.75 %. Substrates were typically sand, gravel and/or cobble.

Table 4-2. Total carbon and particle size analysis results for sediment samples collected from Sturgeon Bay, fall 2011.

Transect	Sample ID	Sample Date	Total Carbon (%) Inorganic	Organic	$CaCO_3$ Equivalent	by combustion	Particle Size (%) Sand (2.0mm-0.05mm)	Silt (0.05mm-2µm)	Clay (<2µm)	Texture
Analytical Detection Limit			*0.10*	*0.10*	*0.80*	*0.1*	*0.10*	*0.10*	*0.10*	
1	T1-1	12-Oct-11	4.81	2.89	40.1	7.7	38.1	49	12.8	Silt loam / Loam
	T1-2	12-Oct-11	5.08	2.54	42.4	7.6	36.7	50.9	12.4	Silt loam
	T1-4	12-Oct-11	4.43	0.49	36.9	4.9	20.2	28.1	51.7	Clay
2	T2-1	2-Oct-11	2.31	3.68	19.2	6	3.21	39	57.8	Silty clay / Clay
	T2-2	2-Oct-11	3.02	3.79	25.1	6.8	5.68	44.7	49.6	Silty clay
	T2-3	2-Oct-11	4.21	1.07	35.1	5.3	63.9	28.5	7.65	Sandy loam
	T2-4	2-Oct-11	7.96	0.51	66.4	8.5	86.7	7.34	5.96	Loamy sand
3	T3-1	1-Oct-11	2.85	3.52	23.8	6.4	1.1	45.3	53.6	Silty clay
	T3-2	1-Oct-11	11.8	0.35	98	12.1	-	-	-	-
4	T4-1	30-Sep-11	3.33	3.91	27.8	7.2	2.95	53.3	43.7	Silty clay
	T4-2	30-Sep-11	4.71	1.24	39.3	6	64.4	25.1	10.5	Sandy loam
	T4-3	30-Sep-11	4.98	0.65	41.5	5.6	92	5.77	2.21	Sand
5	T5-1	1-Oct-11	2.31	3.72	19.2	6	0.48	31.9	67.6	Clay
	T5-2	1-Oct-11	3.54	2.55	29.5	6.1	36.3	39.3	24.4	Loam
	T5-3	1-Oct-11	7.64	0.75	63.7	8.4	80	10.3	9.71	Loamy sand
	T5-4	1-Oct-11	2.59	0.54	21.6	3.1	96.8	2.33	0.89	Sand
	T5-5	1-Oct-11	0.94	0.2	7.85	1.1	98.6	0.43	0.93	Sand
6	T6-1	30-Sep-11	2.04	3.48	17	5.5	0.8	38	61.2	Clay
	T6-2	30-Sep-11	1.98	3.74	16.5	5.7	0.51	37.9	61.6	Clay
	T6-3	30-Sep-11	2.1	3.89	17.5	6	0.43	38.4	61.2	Clay
	T6-4	30-Sep-11	5.84	0.57	48.7	6.4	87.5	9.39	3.1	Sand

Table 4-2. (continued).

Transect	Sample ID	Sample Date	Total Carbon (%)				Particle Size (%)			Texture
			Inorganic	Organic	$CaCO_3$ Equivalent	by combustion	Sand (2.0mm-0.05mm)	Silt (0.05mm-2µm)	Clay (<2µm)	
Analytical Detection Limit			*0.10*	*0.10*	*0.80*	*0.1*	*0.10*	*0.10*	*0.10*	
9	T9-1	12-Oct-11	4.4	2.87	36.7	7.3	27.3	48.9	23.8	Silt loam / Loam
	T9-2	12-Oct-11	3.08	0.73	25.7	3.8	9.09	65.3	25.6	Silt loam
	T9-5	12-Oct-11	0.9	0.35	7.51	1.3	99.7	0.22	<0.10	Sand
10	T10-1	19-Oct-11	3.97	3.12	33.1	7.1	4.34	58.9	36.7	Silty clay loam
	T10-4	19-Oct-11	4.09	0.49	34.1	4.6	55.2	11.3	33.5	Sandy clay loam
	T10-5	19-Oct-11	1.66	0.22	13.8	1.9	99.1	0.46	0.41	Sand
11	T11-2	19-Oct-11	4.57	2.43	38.1	7	24.2	56.4	19.4	Silt loam
	T11-3	19-Oct-11	4.75	0.86	39.6	5.6	78	11.1	11	Sandy loam
	T11-5	19-Oct-11	4.62	0.59	38.5	5.2	60	23.8	16.2	Sandy loam
12	T12-1	19-Oct-11	2.39	0.79	19.9	3.2	69.9	19.6	10.5	Sandy loam
Extensive Zone (offshore)	EZ-1	1-Oct-11	1.31	2.87	10.9	4.2	0.87	28.6	70.5	Clay
	EZ-2	1-Oct-11	1.27	3.02	10.6	4.3	2.48	30.4	67.1	Clay
	EZ-3	1-Oct-11	1.35	3.32	11.2	4.7	0.85	31.7	67.4	Clay

Table 4-3. Field estimates of substrate composition (%) at sediment sampling sites in Sturgeon Bay, fall 2011.

Transect	Site ID	Sample Date	Water Depth (m)	Penetration Depth (m)	Composition (%)								Sample collected				Comments
					Clay	Silt	Sand	Gravel	Small cobble	Large cobble	Boulder	Organics	PSA	Metals	Benthics	Core	
1	T1-1	12-Oct-11	6.8	0.06	70	30	0	0	0	0	0	0	Y	Y	Y	-	medium compaction, brown clay with black silt throughout
	T1-2	12-Oct-11	6.1	0.06	70	30	0	0	0	0	0	0	Y	Y	Y	-	medium compaction, brown clay with black silt throughout
	T1-3	12-Oct-11	4.5	0.01	25	0	5	0	70	0	0	0	-	-	-	-	insufficient material for metals or PSA (substrate too compact)
	T1-4	12-Oct-11	4.0	0.01	90	0	10	0	0	0	0	0	Y	-	-	-	insufficient sample for metals- substrate too compact
	T1-5	12-Oct-11	0.9	n/a	0	0	0	5	15	0	80	0	-	-	-	-	No grabs possible; substrate probed with metal pole
2	T2-1	2-Oct-11	7.3	0.08	98	2	0	0	0	0	0	0	Y	Y	Y	Y	consolidated, very soft
	T2-2	2-Oct-11	6.9	0.08	98	2	0	0	0	0	0	0	Y	Y	Y	-	consolidated, very soft
	T2-3	2-Oct-11	6.0	0.05	90	0	10	0	0	0	0	0	Y	Y	Y	-	un-consolidated, medium compaction
	T2-4	2-Oct-11	4.5	0.01	0	0	90	10	0	0	0	0	Y	-	-	-	insufficient sample for metals- substrate too compact
	T2-5	2-Oct-11	2.0	n/a	~0	0	5	25	70	0	0	0	-	-	-	-	No grabs possible ;substrate probed with metal pole; hard clay found beneath rock
3	T3-1	1-Oct-11	7.1	0.08	98	2	0	0	0	0	0	0	Y	Y	Y	Y	consolidated, soft
	T3-2	1-Oct-11	5.2	n/a	0	0	0	1	99	0	0	0	Y	-	-	-	insufficient sample for metals - ponar picking up cobble only
	T3-3	1-Oct-11	5.0	n/a	0	0	0	5	90	5	0	0	-	-	-	-	Ponar picking up cobble/gravel only
	T3-4	1-Oct-11	3.4	n/a	0	0	0	99	1	0	0	0	-	-	-	-	Ponar picking up cobble/gravel only
	T3-5	1-Oct-11	1.1	n/a	2	0	3	94	1	0	0	0	-	-	-	-	Ponar picking up cobble/gravel only

Table 4-3. (continued).

Transect	Site ID	Sample Date	Water Depth (m)	Penetration Depth (m)	Composition (%)								Sample collected				Comments
					Clay	Silt	Sand	Gravel	Small cobble	Large cobble	Boulder	Organics	PSA	Metals	Benthics	Core	
4	T4-1	30-Sep-11	6.1	0.08	95	5	0	0	0	0	0	0	Y	Y	Y	-	consolidated, soft
	T4-2	30-Sep-11	5.2	0.04	90	0	5	5	0	0	0	0	Y	Y	Y	-	consolidated, medium compaction
	T4-3	30-Sep-11	3.7	0.04	0	0	35	60	5	0	0	0	Y	-	-	-	insufficient sample for metals- substrate too compact
	T4-4	30-Sep-11	2.7	n/a	~0	0	15	20	65	0	0	0	-	-	-	-	No grabs possible, substrate probed with metal pole; clay found beneath rock substrates
	T4-5	30-Sep-11	1.1	n/a	0	0	0	5	95	0	0	0	-	-	-	-	No grabs possible; substrate probed with metal pole; clay found beneath rock substrates
5	T5-1	1-Oct-11	7.0	0.08	98	2	0	0	0	0	0	0	Y	Y	Y	Y	consolidated, soft
	T5-2	1-Oct-11	6.7	0.08	80	3	17	0	0	0	0	0	Y	Y	Y	Y	consolidated, soft; layers of silt over clay over sand
	T5-3	1-Oct-11	3.8	0.02	0	40	40	20	0	0	0	0	Y	-	-	-	insufficient sample for metals- substrate too compact
	T5-4	1-Oct-11	2.5	0.06	30	5	60	0	0	0	0	5	Y	Y	Y	-	medium compaction
	T5-5	1-Oct-11	1.2	0.06	1	1	98	0	0	0	0	0	Y	Y	Y	-	medium compaction
6	T6-1	30-Sep-11	7.4	0.08	100	0	0	0	0	0	0	0	Y	Y	Y	-	consolidated, soft
	T6-2	30-Sep-11	6.8	0.08	98	2	0	0	0	0	0	0	Y	Y	Y	-	consolidated, soft
	T6-3	30-Sep-11	6.6	0.08	98	2	0	0	0	0	0	0	Y	Y	Y	-	consolidated, soft
	T6-4	30-Sep-11	4.1	0.02	0	0	10	90	~0	0	0	0	Y	Y	-	-	
	T6-5	30-Sep-11	1.7	n/a	~0	0	0	10	10	30	50	0	-	-	-	-	No grabs possible; substrate probed with metal pole; clay found beneath rock substrates

Table 4-3. (continued).

Transect	Site ID	Sample Date	Water Depth (m)	Penetration Depth (m)	Composition (%)								Sample collected				Comments
					Clay	Silt	Sand	Gravel	Small cobble	Large cobble	Boulder	Organics	PSA	Metals	Benthics	Core	
9	T9-1	12-Oct-11	6.8	0.10	90	10	0	0	0	0	0	0	Y	Y	Y	-	medium compaction; clay is gray with brown silt throughout
	T9-2	12-Oct-11	6.3	0.03	95	0	5	0	0	0	0	0	Y	-	-	-	substrate too compact to collect sufficient sample
	T9-3	12-Oct-11	4.9	0.02	20	0	5	15	60	0	0	0	-	-	-	-	substrate too compact to collect sufficient sample
	T9-4	12-Oct-11	4.5	0.02	50	0	10	20	20	0	0	0	-	-	-	-	substrate too compact to collect sufficient sample
	T9-5	12-Oct-11	1.6	0.06	0	0	100	0	0	0	0	0	Y	Y	Y	-	medium compaction
10	T10-1	19-Oct-11	7.0	n/a	100	0	0	0	0	0	0	0	Y	Y	Y	-	soft/smooth clay
	T10-2	19-Oct-11	4.8	n/a	0	0	10	20	40	30	0	0	-	-	-	-	hard bottom; no grabs
	T10-3	19-Oct-11	4.7	n/a	0	0	0	20	60	20	0	0	-	-	-	-	hard bottom; no grabs
	T10-4	19-Oct-11	3.8	n/a	0	0	80	20	0	0	0	0	Y	-	-	-	hard sand/gravel bottom
	T10-5	19-Oct-11	1.5	n/a	0	0	90	10	0	0	0	0	Y	Y	-	-	Hard sand/gravel bottom, large ponar
11	T11-2	21-Oct-11	6.0	n/a	95	5	0	0	0	0	0	0	Y	Y	Y	-	soft clay with a thin layer of fine silt on top
	T11-3	21-Oct-11	3.7	n/a	0	0	50	30	20	0	0	0	Y	N	-	-	underlying clay covered with sand/gravel/cobble
	T11-4	21-Oct-11	2.0	n/a	0	0	0	30	60	10	0	0	N	N	-	-	Substrate too compact; probed with metal pole
	T11-5	21-Oct-11	1.5	n/a	70	0	25	5	0	0	0	0	Y	Y	-	-	
12	T12-1	21-Oct-11	1.3	n/a	0	0	90	0	0	0	0	10	Y	Y	-	-	1-2 cm layer of coarse brown sand over darker, finer sand and organics

Table 4-3. (continued).

Transect	Site ID	Sample Date	Water Depth (m)	Penetration Depth (m)	Composition (%)								Sample collected				Comments
					Clay	Silt	Sand	Gravel	Small cobble	Large cobble	Boulder	Organics	PSA	Metals	Benthics	Core	
Extensive Zone (offshore)																	
	EZ-1	1-Oct-11	8.5	0.10	95	5	0	0	0	0	0	0	Y	Y	Y	-	consolidated, very soft
	EZ-2	1-Oct-11	8.2	0.10	95	5	0	0	0	0	0	0	Y	Y	-	Y	consolidated, very soft
	EZ-3	1-Oct-11	7.6	0.10	95	5	0	0	0	0	0	0	Y	Y	-	-	consolidated, very soft

4.4 SUMMARY

Bed Load and Suspended Sediments

Bed load samples and *in situ* water quality were collected on October 16, 22 and November 6 at three sites in the Dauphin River. High water velocity in Buffalo Creek precluded collection of bed load samples from within the creek and, consequently, the program objectives could not be met. All samples from the Dauphin River were archived.

Laboratory analyses of water samples collected prior to and following the onset of Reach 1 operation indicated an increase in Buffalo Creek and the Dauphin River downstream of Buffalo Creek after Reach 1 became operational. These data will support results from other water quality sampling programs (see Section 3.0).

Sedimentation Rate

Thirty sediment traps were deployed in Sturgeon Bay on October 19, 2011 to determine the type and amount of sediment being deposited in the area. The traps remained deployed until summer 2012 and results from the program were to be provided in subsequent reports.

Substrate Classification

Substrate sampling was conducted at Sturgeon Bay from September 30-October 1 and October 20-21 along 12 transects and at three offshore extensive zone sites. Sediment quality samples were archived for future metals analysis. Carbon and particle size analysis results indicated that nearshore sites in Sturgeon Bay were typically sand and gravel while offshore sites were characterized as clay. Total organic carbon ranged from 0.2-3.91% with the relative proportion increasing with distance offshore.

5.0 FISHERIES AND HABITAT SURVEY OF THE BUFFALO CREEK WATERSHED

Project design was that the Buffalo Creek watershed would be the initial receiving environment for flow diverted through Reach 1 (see Figure 1-2). A lack of information pertaining to the watershed was identified during a preliminary screening process conducted prior to operation of Reach 1 (North/South Consultants Inc. 2011a) and it was determined that a basic understanding of fish resources and use of aquatic habitat within the Buffalo Creek watershed would be required to assist in assessing the effects of Reach 1 operation. Consequently, a series of investigations were conducted to collect information describing aquatic resources within the Buffalo Creek watershed. The investigations included:

- conducting a Construction Environmental Monitoring Program (CEMP) to document water quality conditions in Lake St. Martin at the entrance to Reach 1, along Buffalo Creek, and in the Dauphin River upstream and downstream of the Buffalo Creek confluence during construction and initial operation of Reach 1;
- a brief field program conducted from 15-17 August, 2011, to collect *in situ* water quality information, describe aquatic habitat, and identify fish presence/absence and distribution throughout the Buffalo Creek watershed; and,
- a desk top exercise to quantify the type and amount of aquatic habitat occurring within the Buffalo Creek watershed.

The following sections provide the methods and results of the various investigations.

5.1 WATER QUALITY

Water quality information specific to the Buffalo Creek watershed was collected during the CEMP and during a brief field program conducted in Buffalo Creek watershed during August 2011.

5.1.1 CEMP

The CEMP was conducted to document water quality conditions in Lake St. Martin at the entrance to Reach 1, along Buffalo Creek, and in the Dauphin River upstream and downstream of the Buffalo Creek confluence during construction and initial operation of Reach 1. A detailed report of this sampling program including sites sampled, parameters measured, methods used, and a discussion of the results are presented in AECOM (2012; Appendix 3-5). A brief summary of methods and results pertinent to the Buffalo Creek watershed is provided below.

5.1.1.1 Summary of Methods

As part of the CEMP, water quality was monitored in Lake St. Martin, Buffalo Creek, and in the Dauphin River from September 2 until 01 November, when Reach 1 became operational. Sampling included the collection of *in situ* water quality data, as well as samples for laboratory analysis. Following the onset of operation, water quality monitoring continued throughout the system until 25 November, 2011. Prior to 01 November, monitoring was conducted approximately twice a month. After Reach 1 was opened, sampling frequency increased to twice a week. Water quality parameters measured included: *in situ* measurements of turbidity, DO, pH, conductivity, and temperature; and laboratory analysis of water samples for TSS, nutrients (TP, dissolved P, ammonia, and TN), mercury, and petroleum hydrocarbons (benzene, toluene, ethylbenzene and xylene [BTEX]; and, hydrocarbons F1-F4).

5.1.1.2 Summary of Results

Total Suspended Solids and Turbidity

TSS concentration measured at sites along Buffalo Creek prior to operation of Reach 1 was low, remaining at or below the laboratory analytical detection limit of 5.0 mg/L at all sites on most sampling occasions. Similarly, turbidity at most sites and on most occasions was low (< 4 NTUs), except at the downstream most location (BC03), where turbidity was consistently higher, ranging from 6-13 NTUs.

Shortly after Reach 1 became operational, TSS concentrations in Buffalo Creek exceeded the Canadian Council of Ministers of the Environment (CCME) guidelines, but fell below the CCME limits at all sites within two weeks of Reach 1 opening. Following the excavation of the remaining material from the south shore road, a second peak in TSS was observed within Reach 1 on November 17 and at downstream sites a few days later. TSS concentrations remained within CCME guidelines in Buffalo Creek during this second peak. TSS concentrations had not returned to baseline at the end of the monitoring period and AECOM (2012) recommended that monitoring continue.

Nutrients and Routine Variables

Based on the results of the CEMP sampling and the RWQMP sampling (see Section 3.1 in this report), conducted in fall, 2011, water quality in Buffalo Creek prior to operation of Reach 1 could generally have been described as moderately nutrient-rich, low to moderately turbid, slightly alkaline, hard to very hard, and well-oxygenated.

Total phosphorus (TP) concentrations in Buffalo Creek, composed primarily of dissolved forms. The majority of total nitrogen (TN) was present in organic form at all sites, with nitrate/nitrite generally comprising a greater amount of dissolved inorganic nitrogen (DIN) than ammonia. On the basis of TN:TP molar ratios, Buffalo Creek was considered to be phosphorus limited in fall 2011.

The TP concentration at the downstream end of Buffalo Creek (BC3) exceeded the Manitoba Water Quality Standards, Objectives, and Guidelines (MSWQSOGs; MWS 2011) narrative guideline for streams (0.050 mg/L) in one of the replicate samples collected; however, the results for this sample were considered suspect (see Section 3.1.2.4). The TP concentration measured in the other sample collected at BC3 was well below the guideline. All other routine water quality variables for which there are MWQSOGs and CCME guidelines, including dissolved oxygen, pH, ammonia, nitrate and nitrite were within PAL objectives and guidelines.

Colour exceeded the MWQSOGs aesthetic objective for drinking water (≤15 TCU) at all three sites in Buffalo Creek sampled during the RWQMP.

Mercury

The analytical detection limit applied to the majority of the samples collected for the analysis of mercury was typically higher than the CCME guideline for PAL (26 ng/L); as a result, a proper assessment of this guideline could not be conducted.

Summary

Prior to operation of Reach 1, the water quality of Buffalo Creek differed from Lake St. Martin, the Dauphin River or Sturgeon Bay (see Section 3.1 for descriptions of Lake St. Martin, Dauphin River, and Sturgeon Bay water quality descriptions). Buffalo Creek had lower turbidity/TSS, lower conductivity and total dissolved solids (TDS), lower chlorophyll *a*, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area.

5.1.2 *In situ* Field Measurements

In situ measurements of water quality parameters were taken in Big Buffalo Lake and at one location in Buffalo Creek during August 2011.

5.1.2.1 Methods

In situ water quality measurements were collected using a Horiba® W-22XD water quality meter. The following parameters were measured:

- dissolved oxygen (DO; mg/L);
- temperature (°C);
- specific conductance (mS/m);
- pH; and,
- turbidity (NTUs).

Depth profiles (every 0.5 m) of *in situ* parameters were measured at lake sites and a single surface measurement was taken from the bank at the creek site. In addition, Secchi disk depth was measured at each site in Big Buffalo Lake. Secchi disk depth is defined as the average of two depth readings:

1) the depth at which a circular black and white disk 30 cm in diameter can no longer be seen when lowered into the water column; and,
2) the depth at which the disk becomes visible again, when raised.

Location of each sampling site was recorded with a Garmin GPSMap 76S global positioning system.

The unit of measure for specific conductance (mS/m) was converted to µS/cm by multiplying the field measurements by 10. Conductivity was then calculated using the following formula:

$$\text{Conductivity} = \text{Specific Conductance } (\mu S/cm) * (1 + 0.0191*(\text{water temperature } -25^{o}C))$$

5.1.2.2 Results

In situ water quality measurements were taken at four sites in Big Buffalo Lake on 17 August, 2011 (Figure 5-1). Water depth at the sampling locations ranged from 1.2-2.1 m deep (Table 5-1).

In situ measurements collected from four sites in Big Buffalo Lake indicated that the lake was not thermally stratified, was relatively well-oxygenated, and near-neutral. Turbidity was less than 7 NTU and Secchi disk depth ranged from 1.2-2.2 m. For comparison, Secchi disk depths measured in Sturgeon Bay from 2008 to 2010 (open-water season) ranged from 0.3-1.7 m (MWS unpublished data).

Surface water quality was measured at the mouth of Buffalo Creek immediately upstream of its confluence with the Dauphin River. Sampling location and results are presented in Table 5-1. *In situ* measurements at the creek mouth indicated that water at the creek mouth was slightly more turbid, acidic, less oxygenated, and warmer than measured at Big Buffalo Lake. Also, parameter values measured at this location in August varied slightly from comparable measurements collected along Buffalo Creek and in the Dauphin River during fall 2011 (prior to operation of Reach 1; AECOM 2012; see Appendix 3-5).

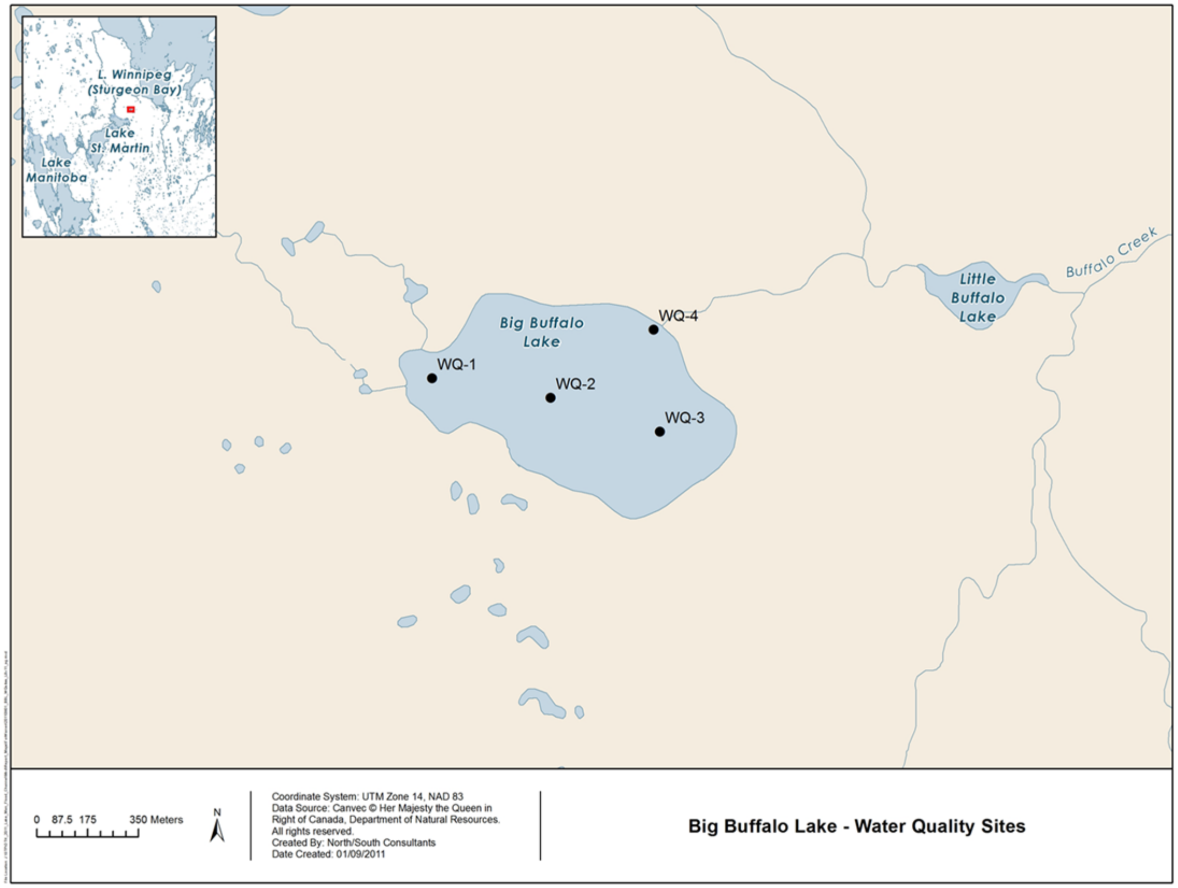

Figure 5-1. Location of water quality sampling sites on Big Buffalo Lake, 17 August, 2011.

Table 5-1. *In situ* water quality data measured in Big Buffalo Lake and Buffalo Creek during August, 2011 [1].

Site	Coordinates [2]		Depth (m)			Temperature (°C)	Dissolved Oxygen		Specific conductance (µS/cm)	Conductivity (µS/cm)	Turbidity (NTU)	pH
	Easting	Northing	Total	Measurement	Secchi		(mg/L)	(% Saturation)				
Big Buffalo Lake												
WQ-1	557773	5745614	1.2	0.3	1.2	19.5	8.0	88.3	180	161.1	4.7	7.49
				1		19.5	8.1	88.7	180	161.1	5.2	7.50
WQ-2	558182	5745547	2.2	0.3	2.2	19.7	8.0	88.6	180	161.8	4.2	7.40
				1		19.6	8.1	89.3	180	161.4	4.0	7.44
				1.5		19.6	8.2	90.0	179	160.5	4.9	7.48
				2		19.7	8.3	91.1	179	160.9	4.7	7.52
WQ-3	558559	5745430	2.1	0.3	2.1	19.8	8.2	90.8	179	161.2	6.2	7.47
				1		19.6	8.3	91.1	179	160.5	4.6	7.52
				1.5		19.6	8.3	91.6	179	160.5	4.6	7.53
				2		19.6	8.3	91.3	179	160.5	3.5	7.49
WQ-4	558537	5745782	1.2	0.3	1.2	18.8	8.3	90.2	178	156.9	3.7	7.29
				1		18.8	8.3	90.2	178	156.9	4.5	7.28
		Minimum	*1.2*	*0.3*	*1.2*	*18.8*	*8.0*	*88.3*	*178*	*156.9*	*3.5*	*7.28*
		Maximum	*2.2*	*2*	*2.2*	*19.8*	*8.3*	*91.6*	*180*	*162.1*	*6.2*	*7.53*
Buffalo Creek												
T-7	562243	5754664	> 1.0	surface	-	19.7	6.9	77.2	283	254.4	17.8	6.88

1 - all field measurements taken on17 August, 2011.
2 - water quality sampling sites are illustrated in Figures 5-1 and 5-2.

5.2 AQUATIC HABITAT

Prior to operation of Reach 1, aquatic habitat in Big Buffalo Lake and Buffalo Creek were characterized and quantified to describe pre-Project conditions. The habitat assessment was completed using information collected during a brief field program conducted in August 2011 and by interpreting habitat characteristics from aerial orthometric imagery and geo-referenced digital photographs to classify and quantify aquatic habitat within the watershed. Habitat information collected during the field program was used to help validate interpretations from the digital imagery.

5.2.1 Methods

5.2.1.1 Field Program

Big Buffalo Lake

Aquatic habitat occurring in Big Buffalo Lake was characterized by collecting depth measurements and describing substrate compaction and size characteristics at a series of locations across the lake. Location of sampling sites was recorded using a Garmin GPSMap 76S GPS receiver.

Substrate compaction was a qualitative assessment of the firmness of the substrate. Two compaction categories, hard or soft, where used. Substrate size classification was based on Wentworth (1922), and included the following size categories:

- Boulder > 256 mm
- Cobble 64-256 mm
- Gravel (aggregate) 2-64 mm
- Sand (aggregate) 62.5 µm – 2 mm
- Silt 3.9-62.5 µm
- Clay < 3.9 µm

Lake area was determined from orthometric aerial imagery (see Section 5.2.1.2).

Buffalo Creek

Habitat information was collected from a series of locations within Buffalo Creek. Location of sampling sites was recorded using a Garmin GPSMap 76S GPS receiver. At each location, the following habitat parameters were measured, categorized, or described:

- Habitat category (riffle, pool, run; after Bisson et al. 1982);
- Wetted width (m);
- Water depth at 5 locations across the creek (m);
- Substrate composition;
- Substrate compaction; and,

- Presence/absence and type of instream vegetation.

Substrate compaction was a qualitative assessment of the firmness of the substrate. Two compaction categories, hard or soft, where used. Substrate size classification was based on Wentworth (1922), and included the following size categories:

- Boulder > 256 mm
- Cobble 64-256 mm
- Gravel (aggregate) 2-64 mm
- Sand (aggregate) 62.5 µm – 2 mm
- Silt 3.9-62.5 µm
- Clay < 3.9 µm

At each location, other habitat attributes of interest such as the occurrence of beaver dams were noted.

5.2.1.2 Habitat Classification and Quantification

Aquatic habitat classification and quantification in the Buffalo Creek watershed was conducted through visual assessment from two data sources:

1) A high resolution (30 cm pixel) mosaic assembled from orthometric imagery of the Buffalo Creek watershed and Reach 1 alignment collected during July 2011; and,
2) A series (n = 262) geo-referenced digital photographs taken on 16 August 2011. Photographic coverage extended from the creek mouth at the Dauphin River upstream to and including Big Buffalo Lake.

Habitat information collected during the field program was used to help validate imagery interpretations.

Habitat classification and quantification was completed in three main steps. These included the following:

1) Aquatic habitat type delineation;
2) Aquatic habitat boundary extraction; and,
3) Habitat quantification.

<u>Habitat Type Delineation</u>

The high resolution orthometric mosaic was examined in ArcGIS to delineate polygons of discrete aquatic habitat types within the watershed. Six habitat types were delineated (all adapted from Bisson et al. 1982, with the exception of Peat Pool), including:

1) Riffle - Characterized by moderate to high gradients and ,stream velocities ; moderate to high and turbulence; and the presence of hard and fine to coarse substrates such as gravel, pebble and cobbles and below average depths;

2) Pool - Characterized by relatively low gradients with substratum of fine materials (i.e., silt or sand); below average water velocities and turbulence and above average depth;
3) Run - Characterized by moderate gradients with substrata consisting of small gravel and/or cobble; average depth and velocities with controlled channel boundaries; low turbulence and absence of any stream obstructions;
4) Beaver Pool - Characterized by water impounded upstream from a complete or nearly complete channel obstruction typical of beaver dams. Pool locations reflect the present (photo date) location of beaver dams which can shift from year to year.
5) Beaver Dam - Characterized as a full or partial obstruction of a stream consisting of woody debris and mud; and,
6) Peat Pool - Characterized by low to stagnant velocities, organic substrates, and the absence/paucity of defined channel boundaries.

Habitat polygons were stored in a centroid file, and the boundary of each polygon was manually digitized in ArcGIS to generate a mosaic of habitat polygons representing the distribution of various habitat types within the watershed. The geo-referenced digital photographs and field data were used to help validate the assignment of habitat type to each polygon.

<u>Aquatic Habitat Boundary Extraction</u>

In order to quantify the composition of aquatic habitat, stream channel boundaries needed to be derived and combined with the habitat polygons to calculate areas of each type listed above.

Aquatic habitat boundaries were derived from the high resolution orthometric aerial imagery. The first step included a multivariate, unsupervised spectral classification of the blue green and red visible bands of the orthometric mosaic, completed using ArcGIS software. This classification approach allows the user to specify the number of clustered spectral classes into which the image should be segmented. After the image has been classified, the user can then interpret the classes and assign them to a land cover type. In this case, a general classification of land and water was all that was required to delineate the land and water boundary. Once the imagery was reclassified into land and water cover types, it was converted from a raster to a vector GIS format. A smoothing algorithm (polynomial approximation with exponential kernel; PAEK) was used to remove the relic grid pattern remaining in the vector shoreline data set.

In areas where shadows were confused with the open water class, a manual interpretation of the shoreline was required, which involves ‘heads up’ digitization of the creek banks using ArcGIS software. After the digitization was completed the polylines representing the shorelines where converted to polygons.

Habitat Quantification

Habitat quantification was conducted by combining the habitat polygon mosaic, the centroid file and the aquatic habitat boundary file to produce a final polygon mosaic. The areas for each habitat type were then summed and tabulated.

5.2.2 Results

5.2.2.1 Field Program

Aquatic habitat information was collected in the Buffalo Creek watershed during a short field program conducted 15-17 August 2011. Data collections focussed on Big Buffalo Lake, the largest lake in the watershed, and in two general areas along Buffalo Creek.

Big Buffalo Lake

Big Buffalo Lake is a small lake (surface area of 55 ha) from which Buffalo Creek originates. During the field program, maximum measured water depth was 2.2 m (Figure 5-2) and substrate was comprised of a deep layer of loosely compacted organic sediments. Aquatic vegetation (primarily *Potamogeton* sp.) occurred throughout much of the lake, although was considerably less dense in the central portion compared to nearshore areas. Lake shorelines were composed largely of shrub wetlands (Figure 5-3) comprised of cattails and bulrushes, as well floating bog in some areas. Few areas surrounding the lake support trees (Figure 5-4). Lake inflow is comprised of local run off from surrounding wetlands. Outflow is through Buffalo Creek (Figure 1-2).

Buffalo Creek

Buffalo Creek originates at Buffalo Lake and flows for approximately 17 km to its confluence with the Dauphin River. For approximately the first 4 km downstream of Big Buffalo Lake, the creek flows through a sparsely treed wetland/bog complex and is characterized by a narrow channel (< 5 m wide) that becomes indeterminate in some locations (Figures 1-2 and 5-5). Topography in the area is very flat.

Upon leaving the wetland/bog complex, the creek enters an area of better-drained soils, and develops a meandering pattern where riffle/run/pool sequences flow over local deposits of cobble, gravel, and sand (Figure 5-6). Gradient increases along this portion of the creek and beaver dams were common. The lower-most kilometer or so of the creek was characterized by a well-defined channel.

During the conduct of the field program, habitat information was collected at two general reaches along the creek. The first originated where the creek exited the wetland/bog complex and extended downstream for approximately 1 km (Figure 5-7). The second originated at the creek's confluence with the Dauphin River and extended upstream for approximately 2 km. Habitat information was collected at six sites at the upstream-most reach and from six locations in the downstream area (Table 5-2; Figure 5-7).

At the upstream reach, where Buffalo Creek leaves the bog complex, the wetted width of the creek ranged from 7.1-12.2 m and water depth ranged 0.1-> 1 m deep, depending upon habitat type (Table 5-2). Substrate compaction was generally hard, but a layer of loose compacted organic material occurred on top of underlying hard compacted substrate in peripheral areas where velocity was reduced, as well as upstream of beaver dams and in pool areas. Substrate type varied between organic materials, clays and sands to larger materials such as gravel, cobble and boulder (Table 5-2). Instream vegetation was sparse in this area, and consisted of inundated grasses and sedges grasses growing along the periphery of the stream.

The portion of creek surveyed near the creek mouth at the Dauphin River was characterized by low flow, caused largely by backwater effects due to high water level on the Dauphin River. Substrate materials were comprised of highly compacted sands, gravels, cobbles and boulders in the central portion of the channel (Table 5-2). Hard compacted clay was predominant in peripheral areas of the channel (Table 5-2). Little instream vegetation was observed at most sampling sites within this reach, although bank vegetation such as grasses and shrubs were inundated due to high water level caused by backwater effects from the Dauphin River. Large and dense beds of lily pads were observed upstream of a large beaver dam at the upstream-most portion of this reach.

5.2.2.2 Habitat Classification and Quantification

It should be noted that several beaver dams occurring along Buffalo Creek were removed prior to conduct of the field program. However, on only two transects at two locations were field measurements of habitat parameters collected where a beaver dam was recently removed. The orthometric imagery used to conduct the habitat classification and quantification was collected prior to removal of the beaver dams, so field measurements collected from the areas where beaver dams were removed were not used to help interpret the orthometric imagery.

A total of 901,981.9 m^2 (or 90.2 ha) of habitat in the Buffalo Creek watershed was classified into six different habitat types (Table 5-3). The majority of habitat in the watershed was identified as peat pool habitat. This habitat type occurred exclusively in the upper reaches of the watershed within the confines of the wetland/bog complex, and included Big Buffalo Lake and Little Buffalo Lake (Figure 5-8). Most of Buffalo Creek downstream of the wetland/bog complex was comprised of the run habitat (15% of available habitat within the watershed; Table 5-3 and Figure 5-8). Pool and riffle habitat accounted for about 6% of total available habitat within the watershed, and beaver dams and pools each comprised less than 1% of the total available habitat (Table 5-3). Twenty-one beaver dams, partial or complete obstructions of the creek, were identified from the aerial imagery.

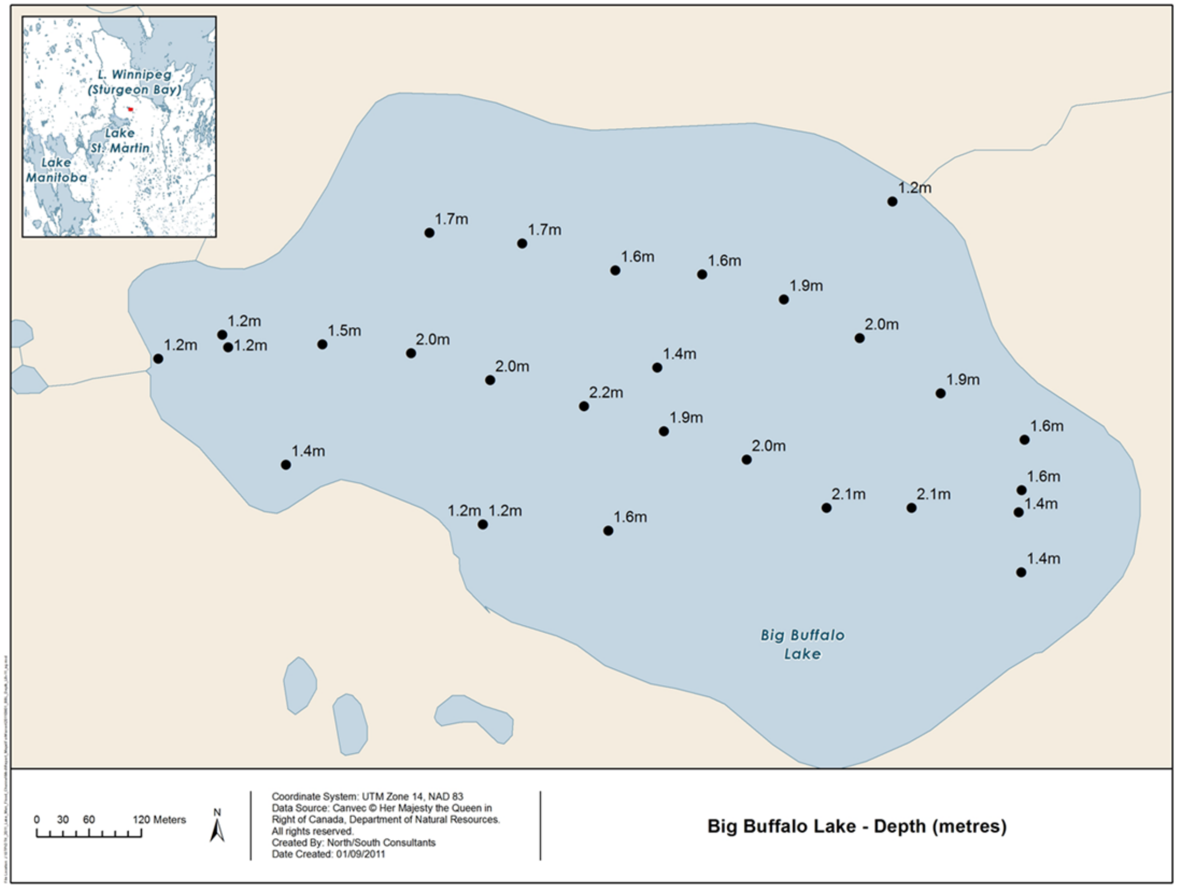

Figure 5-2. Point depth measurements in Big Buffalo Lake, 17 August, 2011.

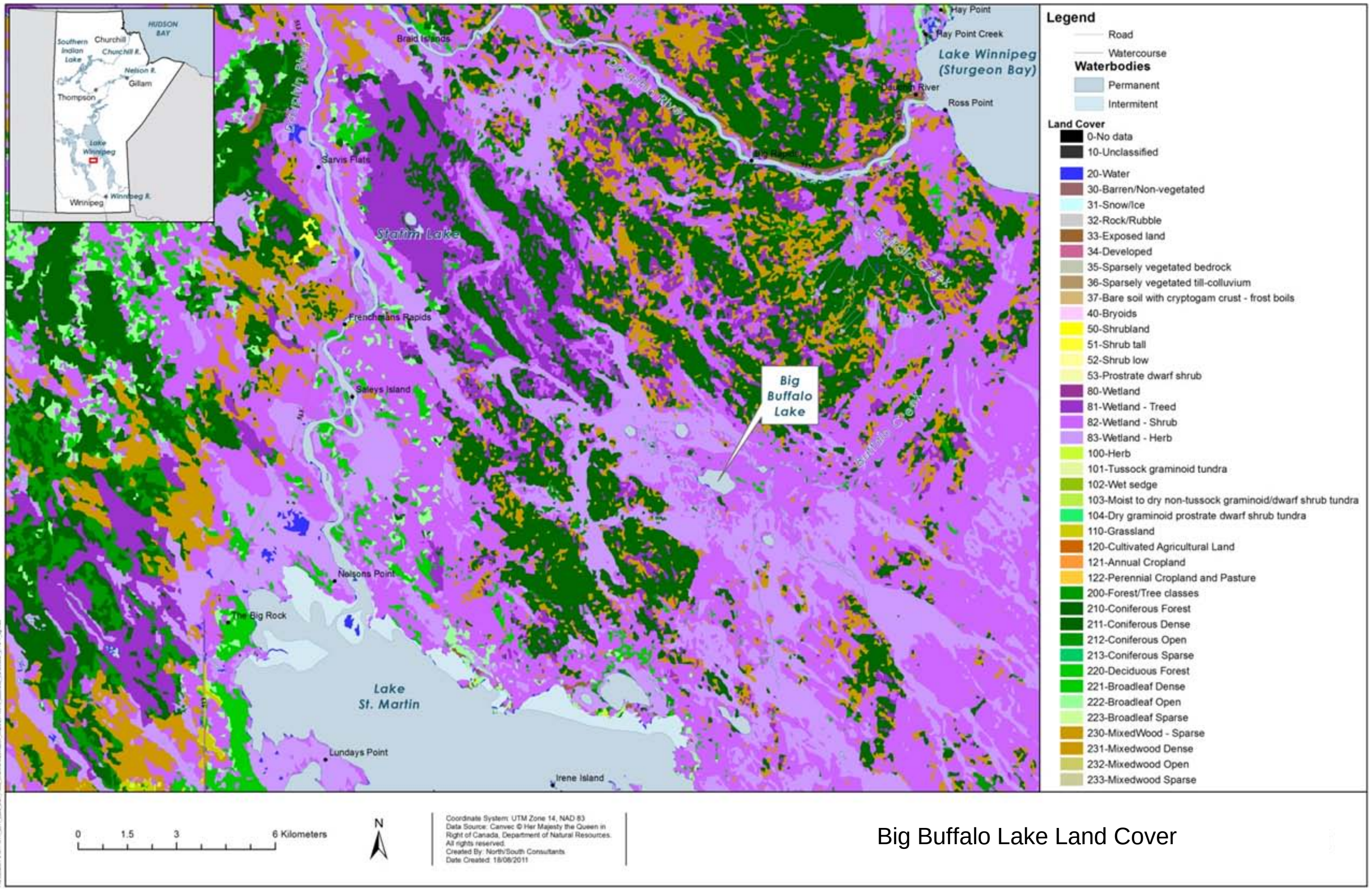

Figure 5-3. Land cover surrounding Big Buffalo Lake. Data from GeoBase (2000; www.geobase.ca)

Figure 5-4. Big Buffalo Lake and associated shoreline, August, 2011.

Figure 5-5. Buffalo Creek downstream of Big Buffalo Lake, illustrating wetland/bog complex through which the creek flows.

Figure 5-6. Buffalo Creek showing riffle/pool/run sequences and meandering pattern, August, 2011.

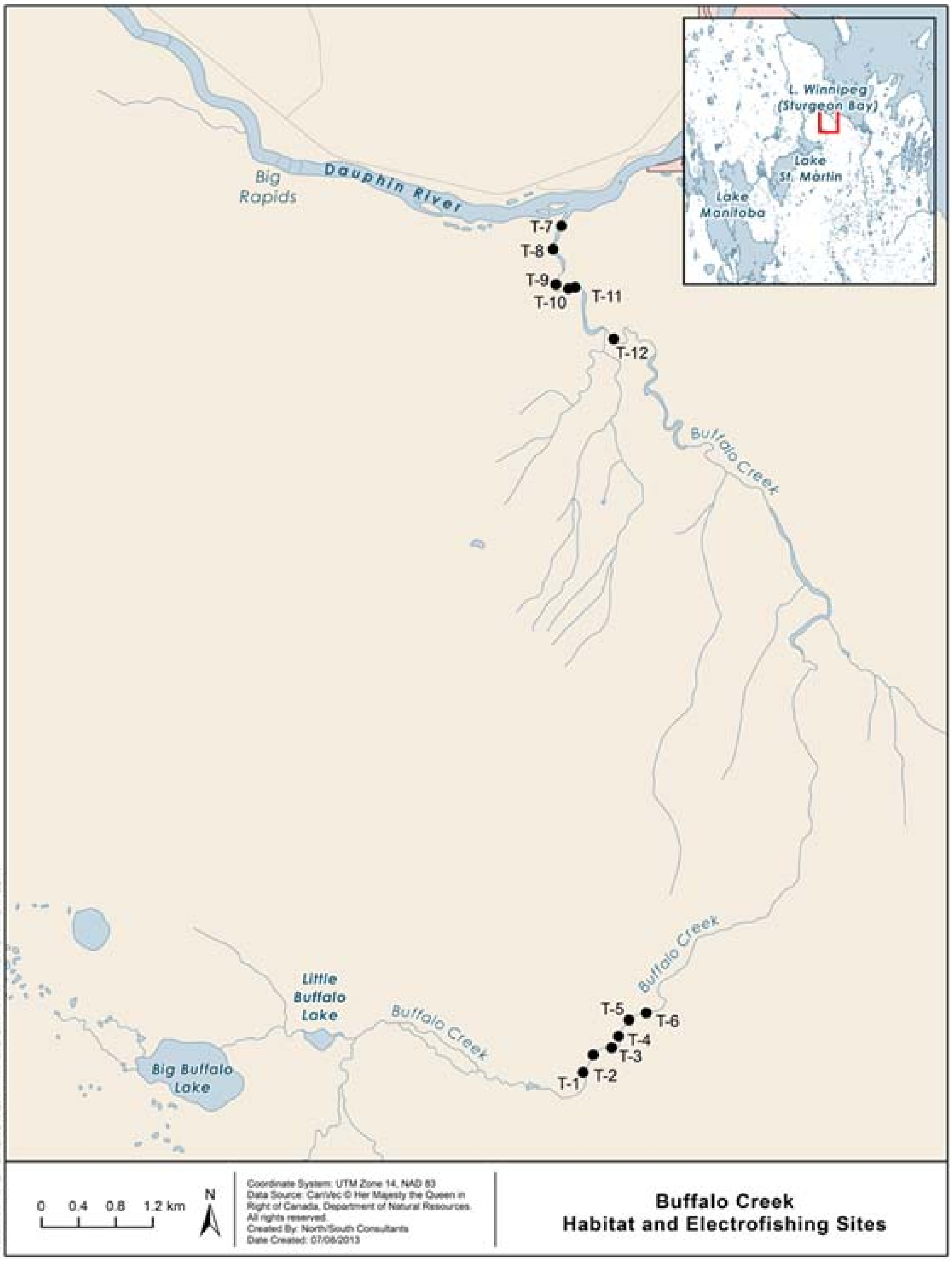

Figure 5-7. Location of habitat sampling and back pack electrofishing sites along Buffalo Creek.

Table 5-2. Habitat information recorded at locations along Buffalo Creek during August, 2011.

Site	Date	Location [1]		Type	Wetted Width (m)	Water Depth (m)	Substrate [2]	Compaction	Instream Vegetation	Comments
		Easting	Northing							
T-1	15-Aug	562476	5745548	run (pool)	7.2	0.1-0.2	sand and gravel, some cobble	Loose, non-compacted organic debris overlying hard compacted substrate	grasses, sedges	recently drained beaver dam
T-2	15-Aug	562585	5745737	run (pool)	7.1	0.2-0.3	clay	Hard	grasses, sedges	recently drained beaver dam
T-3	15-Aug	562784	5745814	pool	7.5	> 1.0	clay	Hard	grasses, sedges	upstream of existing beaver dam
T-4	15-Aug	562858	5745938	riffle/pool	12.2	0.-0.3	cobble/boulder in riffle gravel/boulder overlain by organic debris in pool	riffle - hard pool - loose non-compacted organic debris overlying hard compacted substrate	none	downstream of newly constructed beaver dam
T-5	15-Aug	562969	5746115	run (pool)	8.1	0.2-0.3	cobble, gravel , and sand; scattered boulders overlain by organic debris	loose non-compacted organic debris overlying hard compacted substrate	none	recently drained beaver dam
T-6	15-Aug	563155	5746191	riffle/run	8.5	0.1-0.3	cobble, boulder	hard compaction		
T-7	17-Aug	562243	5754664	backwater	22	> 1.5	gravel cobble boulders	hard compaction	grasses, sedges	water ponding influence from Dauphin River
T-8	17-Aug	562153	5754413	backwater	10	1.2	clay along stream edges, gravel and boulder in middle	Hard	grasses, sedges	water ponding influence from Dauphin River
T-9	17-Aug	562185	5754034	backwater	12	0.3-0.7	sand and gravel, some boulders	Hard	None	water ponding influence from Dauphin River
T-10	17-Aug	562319	5753988	riffle/run	11	0.3-0.5	sand, gravel, some cobble and boulder	Hard	None	low flow
T-11	17-Aug	562391	5754002	riffle	7	0.1-0.3	cobble/boulder	Hard	None	low flow
T-12	17-Aug	562806	5753448	pool	29	< 1.0	clay and organic debris	Hard	Dense beds of lily pads	upstream of existing beaver dam

1 - UTM coordinates; Datum NAD 83, Zone 14U; locations illustrated on Figure 5-3

2 - Substrate size classification based on Wentworth (1922); described in Section 5.2.1.1

Table 5-3. Stream habitat classification in Buffalo Creek, August 2011.

Habitat Type	Area (m^2)	Area (ha)	Proportion (%)
Beaver Dams	1,588.0	0.16	0.2
Beaver Pools	7,626.4	0.76	0.8
Riffle	20,610.7	2.06	2.3
Run	133,706.6	13.37	14.8
Pool	37,323.2	3.73	4.1
Peat Pool	701,127.0	70.11	77.7
Grand Total	901,981.9	90.20	100.00

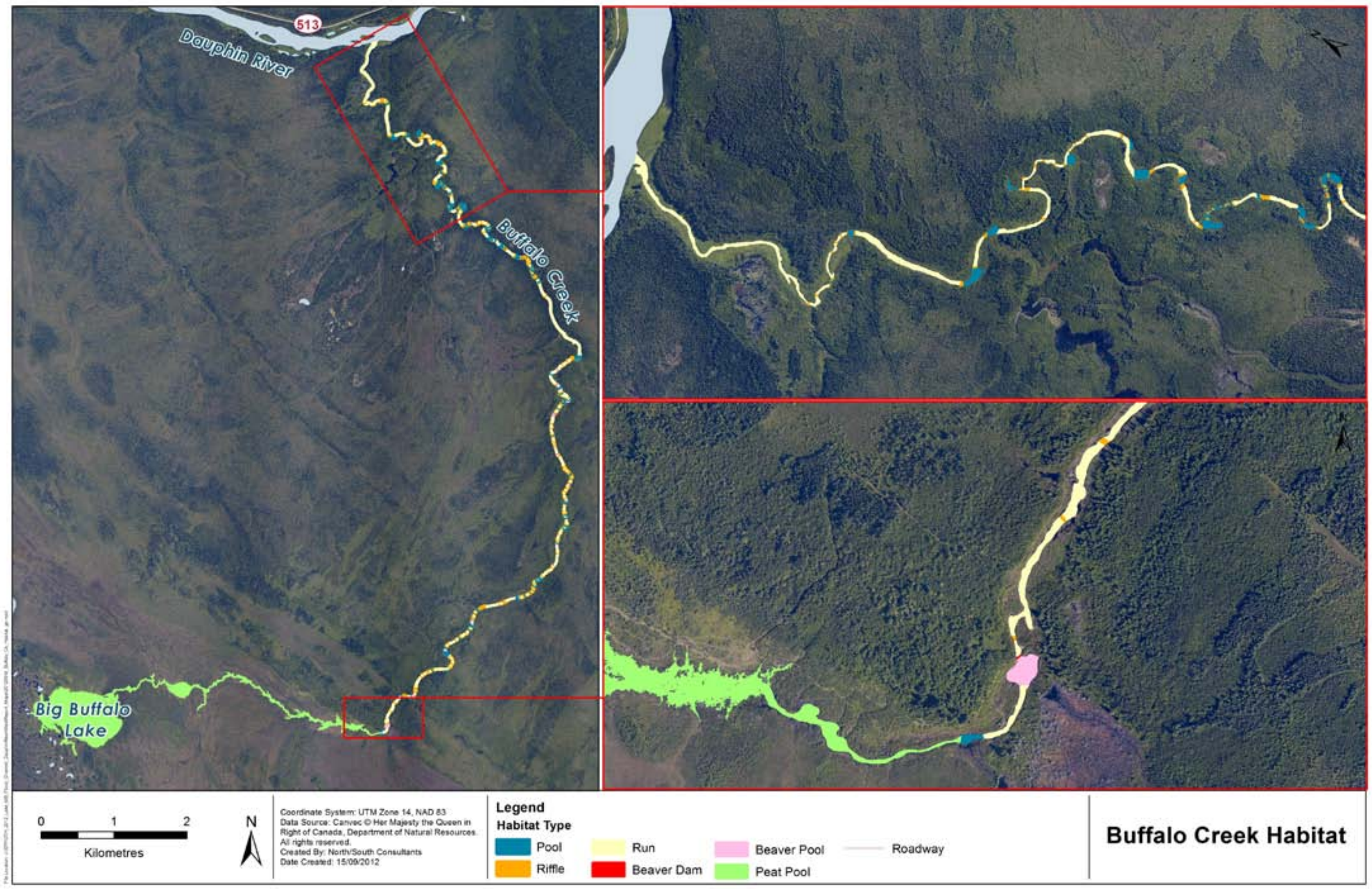

Figure 5-8. Habitat types in the Buffalo Creek watershed, August 2011.

5.3 FISH PRESENCE AND DISTRIBUTION

Information to describe the presence, abundance, and species composition of fish occurring throughout the Buffalo Creek watershed was collected during August 2011, prior to operation of Reach 1.

5.3.1 Methods

5.3.1.1 Big Buffalo Lake

Experimental and small mesh gillnet gangs were used to sample fish in Big Buffalo Lake. Each experimental gillnet gang consisted of three 22.9 m long by 1.8 m deep panels of either 38, 51, and 76 mm stretched twisted nylon mesh or 95, 108, and 127 mm stretched mesh. Small mesh gangs were 30 m long and consisted of three 10 m long by 1.8 m deep panels of 16, 20, and 25 mm twisted nylon stretched mesh.

Net set and retrieval dates and times were recorded for each gang. Net set locations were recorded with a handheld Garmin GPSmap 76S GPS receiver. Water depth (± 0.1 m) was measured at each end of the net with a hand-held SM-5 (Speedtech Instruments) depth sounder, and surface water temperature was recorded with a handheld thermometer (±0.5 °C).

All fish captured were enumerated by species and sampling location. Each fish (mortalities and live released fish) was measured for fork length (± 1 mm) and round weight (± 25 g). All live fish were released following sampling. The gonads of fish that died while in the gill nets were examined internally to determine spawning status. The following sexual maturity codes were used:

Females (F)

2 - maturing to spawn (pre-spawn)
3 - ripe (immediate pre-spawn)
4 - spend (post-spawn)

Males (M)

7 - maturing to spawn (pre-spawn)
8 - ripe (immediate pre-spawn)
9 - spend (post-spawn)

5.3.1.2 Buffalo Creek

A Smith-Root model LR-24 back pack electrofisher was used to sample for fish along Buffalo Creek. Electrofishing was conducted at numerous sites within two general reaches along the creek.

At each sampling site, single passes were conducted with the electrofisher to document presence of fish. Immobilized fish were captured using a hand-held dip net held in a water-filled bucket on shore. At the conclusion of the electrofishing pass, all captured fish were identified to species, enumerated, and released back into the creek. In many instances, large numbers of individuals of the same fish species would be observed in a very small location. Rather than capture all of them, a subsample would be captured to confirm species identification and the total number observed would be estimated.

The duration of electrofishing effort was recorded for each sampling site, the location of each site was recorded with a handheld Garmin GPSmap 76S GPS receiver, and aquatic habitat characteristics were noted (see Section 5.2).

5.3.1.3 Data Analyses

Gillnetting and electrofishing catches were tabulated by species and capture location. Catch-per-unit-effort (CPUE) was calculated for the overall catch and for each species, by site. For gill nets, CPUE was calculated as the number of fish caught per 100 m of net per 24 hours of sampling. Total CPUE was calculated by averaging all net set CPUE values.

Mean fork length (mm) was calculated for each species from the gillnetting catch. Length-frequency distributions were plotted for each species where more than 15 fish were captured and measured. Length intervals of 10 mm were used for smaller-bodied species (e.g., Yellow Perch; 80-89 mm). A 25 mm interval was used for larger-bodied species (e.g., Northern Pike).

5.3.2 Results

At least ten species of fish were captured in the Buffalo Creek watershed (Table 5-4). Some small dace and sculpin could not be identified to species and the catch may include more than one species of each. Species diversity was greater in Buffalo Creek than in Big Buffalo Lake, and there was little overlap in community composition between the upstream and downstream reaches of the creek.

5.3.2.1 Big Buffalo Lake

Six experimental gillnet gangs and one standard small mesh gillnet gang were set in Big Buffalo Lake during fall 2011 (Table 5-5; Figure 5-9). All nets were set in water depths less than 2 m. Water temperature was approximately 19°C at the time of sampling (Table 5-1). Four of the experimental gangs and the small mesh net were set for 20-23 hours. Two additional experimental gangs were set for approximately 5 hours (Table 5-5).

The catch totalled 315 fish representing four species (Table 5-6). Yellow Perch was the most abundant species, comprising 86.7% of the total catch (n = 273). The remainder of the catch included Northern Pike (n = 20; 6.3%), Golden Shiner (n = 12; 3.8%), and White Sucker (n = 10; 3.2%). Species diversity and abundance was greatest in the smaller mesh nets. The two experimental gangs consisting of three smaller mesh panels (38, 51, and 76 mm) captured 68 fish while the four experimental gangs consisting of larger mesh sizes (95, 108, and 127 mm) captured only a single Northern Pike. The CPUE ranged from 0.0 fish/100 m gang/24 hours in nets GN-1, 2, and 5 to 926.1 fish/100 m/24 hours in the small mesh net (Table 5-7).

Species Accounts

The following sections present size and condition information for selected fish species captured.

Golden Shiner

Golden Shiners (n = 12) were captured exclusively in the small mesh net set in Big Buffalo Lake (Table 5-6). Catch-per-unit-effort was 45.2 fish/100m/24hrs (Table 5-7). Mean length of captured Golden Shiner was 77 mm (Table 5-8).

Northern Pike

Northern Pike was the second most abundant species (n = 20) captured in gill nets set in Big Buffalo Lake (Table 5-6). Mean CPUE for Northern Pike was 5.2 fish/100m/24hrs in the experimental gangs and was and 15.1 fish/100m/24hrs for the small mesh gang (Table 5-7). The Northern Pike catch was comprised larger juvenile fish, ranging in size from 243-486 mm in fork length (Table 5-8). Mean fork length was 359 mm and the modal fork length interval was 425-449 mm (Figure 5-10).

White Sucker

White Sucker were the least abundant species (n = 10) in the gillnetting catch (Table 5-6). Mean CPUE for Northern Pike was 5.2 fish/100m/24hrs in the experimental gangs and was and 15.1 fish/100m/24hrs for the small mesh gang (Table 5-7). The White Sucker catch was comprised of juvenile fish with a size range of 121-209 mm and a mean fork length of 165 mm (Table 5-8).

Yellow Perch

Yellow Perch were, by far, the most abundant species captured in Big Buffalo Lake (Table 5-6). Mean CPUE for Yellow Perch was 132.9 fish/100m/24hrs (Table 5-7). The Yellow Perch catch was a mixture of juveniles and adults, ranging in size from 50-245 mm with a mean fork length of 86 mm (Table 5-8). The modal length interval was 60-69 mm (Figure 5-11). More than 80% of the Perch captured were 50-89 mm in length.

Table 5-4. Distribution of fish species captured in the Buffalo Creek watershed.

Species	Scientific Name	Big Buffalo Lake	Buffalo Creek	
			Upstream Reach [1]	Downstream Reach [1]
Central Mudminnow	*Umbra limi*	-	✓	-
Dace [2]	*Phoxinus* sp.	✓	✓	-
Golden Shiner	*Notemigonus chrysoleucas*	✓	-	-
Logperch	*Percina caprodes*	-	✓	✓
Longnose Dace	*Rhinichthys cataractae*	-	-	✓
Northern Pike	*Esox lucius*	✓	-	✓
Sculpin [3]	*Cottus* sp.	-	-	✓
Brook Stickleback	*Culaea inconstans*	-	-	-
Stickleback [4]		-	✓	-
White Sucker	*Catostomus commersonii*	✓	✓	-
Yellow Perch	*Perca flavescens*	✓	-	✓

1 - sampling locations illustrated in Figure 5-7; Upstream Reach includes sites T1 to T6, Downstream Reach includes sites T7 to T12

2 - all young-of-the-year fish; one of or perhaps both of Finescale Dace (*Phoxinus neogaeus*) or Northern Redbelly Dace (*Phoxinus eos*)

3 - one of or perhaps both of Mottled Sculpin (*Cottus bairdi*) or Slimy Sculpin (*Cottus cognatus*)

4 - dead and partially decomposed specimen found; either Brook Stickleback or Ninespine Stickleback (*Pungitius pungitius*)

Table 5-5. Location and set information for gill nets set in Big Buffalo Lake during August, 2011.

Site [1]	Start UTM [2]		End UTM [2]		Water Depth (m)	Set Date	Set Time	Pull Date	Pull Time	Duration (hrs)	Mesh Sizes [3]
	Easting	Northing	Easting	Northing							
GN-1	558685	5745356	558682	5745424	1.4	15-Aug	13:40	16-Aug	10:00	20.3	2
GN-2	558210	5745403	558214	5745489	1.6	15-Aug	13:50	16-Aug	10:15	20.4	2
GN-3	557839	5745479	557837	5745571	1.4	15-Aug	14:10	16-Aug	10:30	20.3	1
GN-4	558266	5745591	558242	5745673	1.4	15-Aug	14:45	16-Aug	13:20	22.6	1
GN-5	558689	5745508	558685	5745450	1.6	16-Aug	10:10	16-Aug	15:30	5.3	2
GN-6	557692	5745601	557766	5745628	1.2	16-Aug	10:20	16-Aug	15:35	5.3	2
SM-1	558066	5745411	558024	5745459	1.2	15-Aug	14:00	16-Aug	11:15	21.2	3

1 - Net locations are illustrated in Figure 5-9.

2 - NAD83 datum, Zone 14U

3 - 1: standard experimental net gang; three panels; one each of 38, 51, and 76 mm stretched mesh;
2: standard experimental net gang; three panels; one each of 95, 108, and 127 mm stretched mesh; and,
3: Swedish-style small mesh net; three panels; one each of 16, 20, and 25 mm stretched mesh

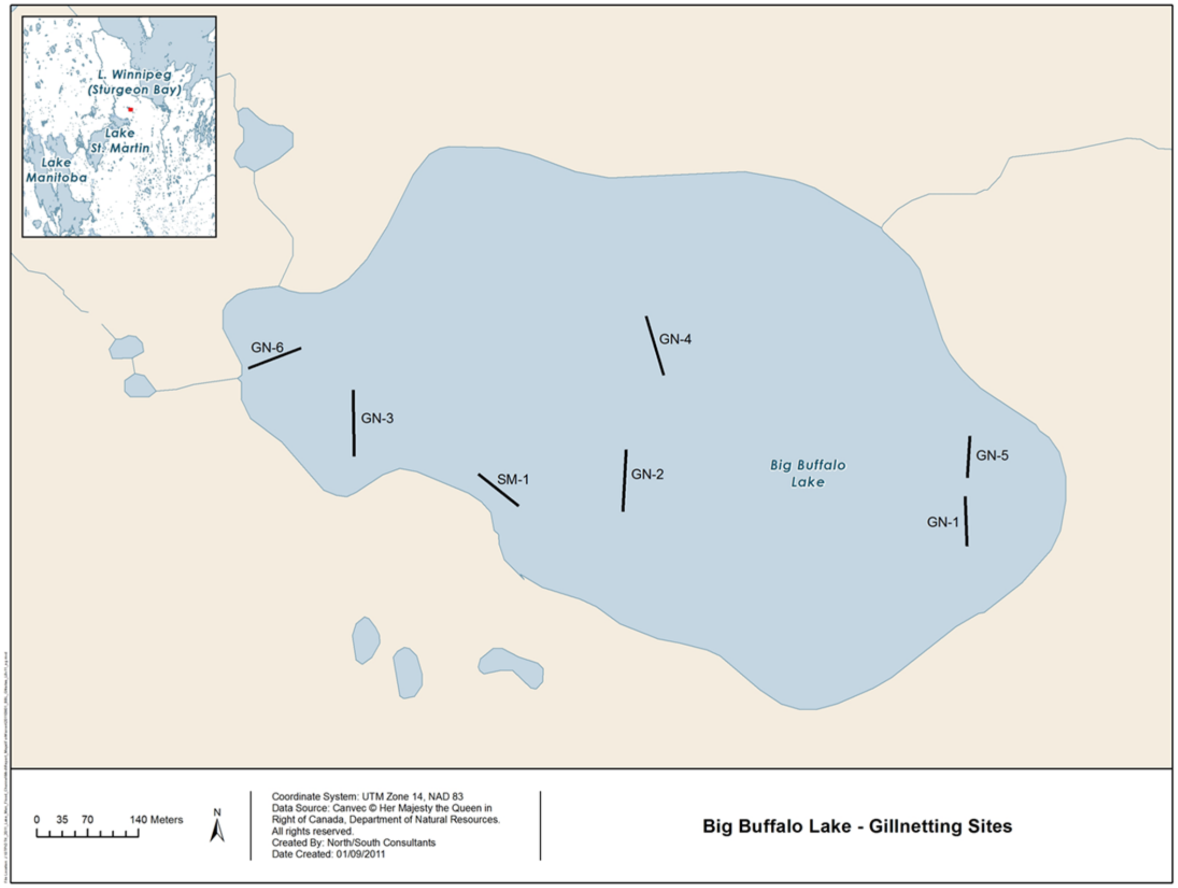

Figure 5-9. Location of gillnetting sites on Big Buffalo Lake, August, 2011.

Table 5-6. Summary of the gillnetting catch from Big Buffalo Lake by net location, August 2011.

Site [1]	Species				All Species
	Golden Shiner	Northern Pike	White Sucker	Yellow Perch	
Experimental Gangs					
GN-1	0	0	0	0	0
GN-2	0	0	0	0	0
GN-3	0	6	2	24	32
GN-4	0	9	5	22	36
GN-5	0	0	0	0	0
GN-6	0	1	0	0	1
Small Mesh Gang					
SM-1	12	4	3	227	246
Total	12	20	10	273	315
Frequency (%) [2]	3.8	6.3	3.2	86.7	100.0

1 - Net locations are illustrated on Figure 5-9.

2 - Frequency of occurrence calculated as a percentage of the total catch

Table 5-7. Catch-per-unit-effort (#fish /100 m/24 hrs) for each fish species captured in gill nets set in Big Buffalo Lake, August 2011.

Site	Duration (hrs)	Species				Total
		Golden Shiner	Northern Pike	White Sucker	Yellow Perch	
Experimental Gangs						
GN-1	20.33	0.0	0.0	0.0	0.0	0.0
GN-2	20.42	0.0	0.0	0.0	0.0	0.0
GN-3	20.33	0.0	10.3	3.4	41.3	55.1
GN-4	22.58	0.0	14.0	7.8	34.1	55.8
GN-5	5.33	0.0	0.0	0.0	0.0	0.0
GN-6	5.25	00	6.7	0.0	0.0	6.7
	Average	0.0	5.2	1.9	12.6	19.6
	SD [1]	0.0	6.1	3.2	19.6	27.9
Small Mesh Gang						
SM-1	21.3	45.2	15.1	11.3	854.6	926.1

1 - SD = standard deviation

Table 5-8. Fork length (mm) for fish species captured in gill nets set in Big Buffalo Lake, August 2011.

Species	n [1]	Length (mm)		
		Average	SD [2]	Range
Golden Shiner	12	77	8	67-92
Northern Pike	20	359	85	243-486
White Sucker	10	165	22	121-209
Yellow Perch	273	86	48	50-245

1 - n = the number of fish measured; may not equal the total number captured

2 - SD = standard deviation

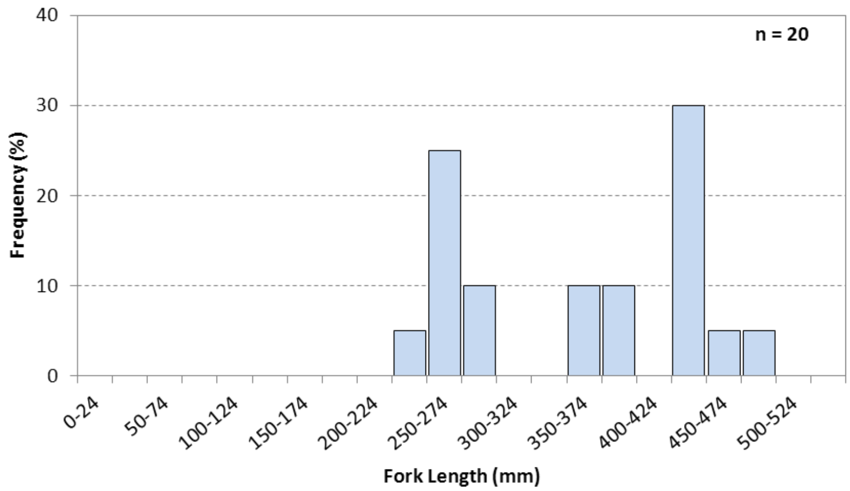

Figure 5-10. Length-frequency distribution for Northern Pike captured in gill nets set in Big Buffalo Lake, August 2011.

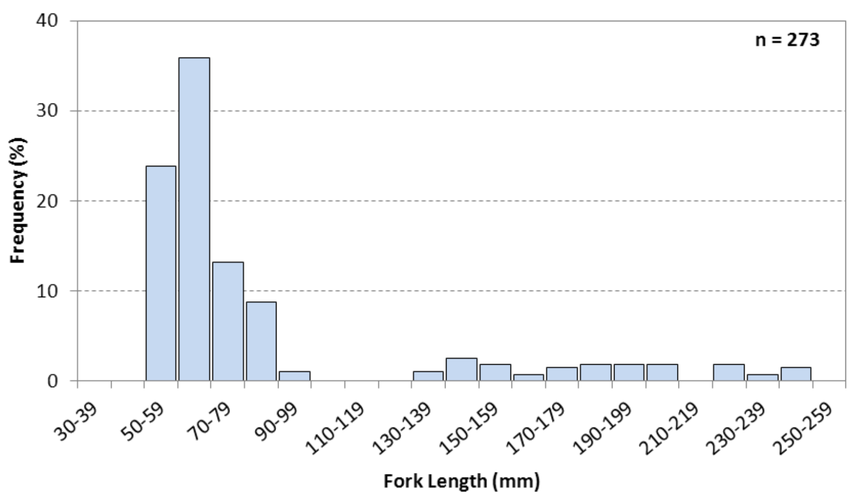

Figure 5-11. Length-frequency distribution for Yellow Perch captured in gill nets set in Big Buffalo Lake, August 2011.

5.3.2.2 Buffalo Creek

Back pack electrofishing was conducted at 12 sites along Buffalo Creek during mid-August, 2011 (Table 5-9; Figure 5-7). Fishing effort ranged from 87 to 644 seconds per site (Table 5-9). In many instances, large numbers of individuals of a given species were observed. When this occurred, the number of fish observed was estimated but most were not captured. Only a small subsample was captured to confirm species identity.

Fishing focussed on two general areas within the creek. The first originated where the creek exited the wetland/bog complex and extended downstream for approximately 1 km (Figure 5-7). The second originated at the creek's confluence with the Dauphin River and extended upstream for approximately 2 km (Figure 5-7).

More than 250 fish representing four species were observed or captured at the upstream reach (Table 5-9). The majority of the fish were Central Mudminnows (>140 fish) and dace (>120 fish), some of which were identified as Pearl Dace, but most of which were unidentified to species (Table 5-9). A small number of juvenile White Sucker (n = 11; Table 5-9) were also captured. Captured White Suckers ranged in length from 20-150 mm (Table 5-9).

Considerably fewer fish were captured in the downstream reach. Twenty individuals representing five species were captured (Table 5-9). Species occurring in the downstream reach were different than that observed in the upstream reach. Northern Pike, Longnose Dace, Slimy Sculpin, Yellow Perch, and Logperch were observed in the downstream reach but not the upstream reach. Central mudminnows and dace species other than Longnose Dace were abundant in the upstream reach but were not observed in the downstream reach (Table 5-9). This difference may be due to different habitat conditions between the two areas, or due to proximity to the Dauphin River.

Table 5- 9. Results of back pack electrofishing conducted along Buffalo Creek during August, 2011.

Site	Date	Location [1]		Fishing Effort (seconds)	Species										Numbers Observed
		Easting	Northing		Brook Stickleback	Central Mudminnow	Dace	Logperch	Longnose Dace	Northern Pike	Pearl Dace	Slimy Sculpin	White Sucker	Yellow Perch	
Upstream Reach															
1	15-Aug	562476	5745548	305	-	> 20	> 50	-	-	-	-	-	-	-	> 70
2	15-Aug	562585	5745737	366	-	> 20	> 50	-	-	-	-	-	4 (70, 80, 100, 150)	-	> 74
3	15-Aug	562784	5745814	177	-	> 20	-	-	-	-	> 20	-	-	-	> 40
4	15-Aug	562858	5745938	269	1	> 50	-	-	-	-	1	-	4 (20, 40, 40, 120)	-	> 52
5	15-Aug	562969	5746115	400	-	> 20	-	1	-	-	-	-	-	-	> 21
6	15-Aug	563155	5746191	644	1	> 50	-	-	-	-	-	-	3 (30, 40, 80)	-	> 74
Downstream Reach															
7	17-Aug	562243	5754664	87	-	-	-	-	-	-	-	-	-	-	0
8	17-Aug	562153	5754413	NF	-	-	-	-	-	-	-	-	-	-	
9	17-Aug	562185	5754034	284	-	-	-	-	-	-	-	-	-	1 (110)	1
10	17-Aug	562319	5753988	451	-	-	-	3	-	1 (220)	-	-	-	-	4
11	17-Aug	562391	5754002	394	-	-	-	2	4	3 (100, 100, 120)	-	9	-	-	15
12	17-Aug	562806	5753448	183	-	-	-	-	-	-	-	-	-	-	0

1 - Sampling locations are illustrated on Figure 5-7

5.4 SUMMARY

Water Quality

Water quality information specific to the Buffalo Creek watershed was collected through the CEMP program and a brief field investigation that provided information specific to Big Buffalo Lake.

As part of the CEMP, water quality was monitored in Lake St. Martin, Buffalo Creek, and in the Dauphin River from September 2 until 01 November, when Reach 1 became operational. Sampling included the collection of in situ water quality data, as well as samples for laboratory analysis. Following the onset of operation, water quality monitoring continued throughout the system until 25 November, 2011. Prior to 01 November, monitoring was conducted approximately twice a month. After Reach 1 was opened, sampling frequency increased to twice a week. Prior to operation of Reach 1, the water quality of Buffalo Creek differed from Lake St. Martin, the Dauphin River or Sturgeon Bay. Buffalo Creek had lower turbidity/TSS, lower conductivity and total dissolved solids (TDS), lower chlorophyll a, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area.

In situ water quality measurements were taken at four sites in Big Buffalo Lake on 17 August, 2011. Results indicated that the lake was not thermally stratified, was relatively well-oxygenated, and near-neutral. Turbidity was less than 7 NTU and Secchi disk depth ranged from 1.2-2.2 m. In situ measurements at the mouth of Buffalo Creek indicated that water at the creek mouth was slightly more turbid, acidic, less oxygenated, and warmer than measured at Big Buffalo Lake.

Aquatic Habitat

Prior to operation of Reach 1, aquatic habitat in Big Buffalo Lake and Buffalo Creek were characterized and quantified to describe pre-Project conditions. The habitat assessment was completed using information collected during a brief field program conducted in August 2011 and by interpreting habitat characteristics from aerial orthometric imagery and geo-referenced digital photographs to classify and quantify aquatic habitat within the watershed.

Big Buffalo Lake is a small lake (surface area of 55 ha) from which Buffalo Creek originates. Maximum water depth was 2.2 m and substrate was comprised of a deep layer of loosely compacted organic sediments. Aquatic vegetation occurred throughout much of the lake, although was considerably less dense in the central portion compared to nearshore areas. Lake shorelines were composed largely of shrub wetlands comprised of cattails and bulrushes, as well floating bog in some areas. Few areas surrounding the lake support trees.

Buffalo Creek originates at Buffalo Lake and flows for approximately 17 km to its confluence with the Dauphin River. For approximately the first 4 km downstream of Big Buffalo Lake, the creek flows through a sparsely treed wetland/bog complex and is characterized by a narrow channel (< 5 m wide) that becomes indeterminate in some locations. Upon leaving the wetland/bog complex, the creek enters an area of higher gradient and develops a meandering pattern where riffle/run/pool sequences flow over local deposits of cobble, gravel, and sand. Beaver dams were common.

A total of 901,981.9 m^2 (or 90.2 ha) of habitat in the Buffalo Creek watershed was classified from digital imagery. Six different habitat types were identified. The majority of habitat in the watershed was identified as peat pool habitat. This habitat type occurred exclusively in the upper reaches of the watershed within the confines of the wetland/bog complex, and included Big Buffalo Lake. Most of Buffalo Creek downstream of the wetland/bog complex was comprised of the run habitat (15% of available habitat within the watershed. Pool and riffle habitat accounted for about 6% of total available habitat within the watershed, and beaver dams and pools each comprised less than 1% of the total available habitat.

Fish Presence and Abundance

At least ten species of fish were captured in the Buffalo Creek watershed. Some small dace and sculpin could not be identified to species and the catch may include more than one species of each. Species diversity was greater in Buffalo Creek than in Big Buffalo Lake, and there was little overlap in community composition between the upstream and downstream reaches of the creek.

The fish community within Big Buffalo Lake was sampled using experimental gill nets. The catch totalled 315 fish representing four species. Yellow Perch was the most abundant species, comprising 86.7% of the total catch. The remainder of the catch included Northern Pike (6.3%), Golden Shiner (3.8%), and White Sucker (3.2%). Northern Pike and White Suckers captured within the lake were all juvenile fish. The absence of adults suggests that these species do not fulfill all of their life history requirements within the lake. In contrast, adult, juvenile and young-of-the-year Yellow Perch were captured in the lake. In particular, large numbers of young perch were captured, suggesting that the lake supports a resident population. The extent to which Golden Shiner use the is not known, although large numbers of small fish not susceptible to capture in the gill nets were observed. It is possible that these were young-of-the-year Golden Shiner.

Back pack electrofishing was conducted at 12 sites along Buffalo Creek to document fish presence and abundance. Fishing focussed on two general areas within the creek. The first originated where the creek exited the wetland/bog complex and extended downstream for approximately 1 km. The second originated at the creek's confluence with the Dauphin River and extended upstream for approximately 2 km.

More than 250 fish representing four species were observed or captured at the upstream reach. The majority of the fish were Central Mudminnows and dace species, some of which were identified as Pearl Dace, but most of which were unidentified. A small number of juvenile White Sucker were also captured.

Considerably fewer fish were captured in the downstream reach. Twenty individuals representing five species were captured. Species occurring in the downstream reach were different than that observed in the upstream reach. Northern Pike, Longnose Dace, Slimy Sculpin, Yellow Perch, and Logperch were observed in the downstream reach but not the upstream reach. Central mudminnows and dace species other than Longnose Dace were abundant in the upstream reach but were not observed in the downstream reach. This difference may be due to different habitat conditions between the two areas, or due to proximity to the Dauphin River.

6.0 HABITAT MAPPING IN DAUPHIN RIVER AND STURGEON BAY

It was thought that operation of Reach 1 could result in substrate changes in Sturgeon Bay due to increased sediment inputs. The intent of habitat mapping studies was to document pre-operation habitat conditions in Sturgeon Bay and the Dauphin River and provide a baseline to help assess post-project changes. Specific study objectives include:

- collect habitat information (water depth and substrate type) where data do not exist;
- determine baseline depth and substrate types in shallow water areas of Sturgeon Bay and in the Dauphin River mouth and surrounding area understood by local knowledge to be potential Walleye and Lake Whitefish spawning habitat;
- To identify potential Walleye and Lake Whitefish spawning habitat in the Dauphin River and in Sturgeon Bay; and,
- To characterize deep water substrate types in offshore areas of Sturgeon Bay.

6.1 METHODS

It was proposed that a suite of methods be used to compile habitat information within the Dauphin River and Sturgeon Bay. These included the following:

- Collection of bathymetric and substrate data in the Dauphin River and Sturgeon Bay using sonar technology;
- Collection of substrate samples in Sturgeon Bay and slow water velocity areas of the Dauphin River to help validate interpretation of the sonar data; and,
- Conduct of rebar drags in fast water velocity areas of the Dauphin River to help validate interpretation of the sonar data.

6.1.1 Data Collection

6.1.1.1 Survey Areas

The survey area within the lower Dauphin River extended from approximately 750 m upstream of the confluence of the Dauphin River and Buffalo Creek downstream and approximately 1 km into Sturgeon Bay (Figure 6-1). The riverine survey consisted of longitudinal shoreline and centre channel transects followed by a zig-zag, bank-to-bank, transect pattern (Figure 6-1).

The Sturgeon Bay portion of the survey was to consist of a series of transects oriented perpendicular to the shoreline and extending from shore to approximately 5 km offshore. Transects were to be spaced approximately 250m apart and were to cover the area extending along the Sturgeon Bay shoreline from approximately 3 km north of the Dauphin River mouth to south and east of Willow Point.

6.1.1.2 Sonar Data Collection

Bathymetric and bottom-typing surveys throughout the area were conducted from a 22 foot boat operated at ~5 to 10 km/h. Depth, positional data, and bottom-type data were acquired concurrently using a Quester Tangent Corporation (QTC) Series 5.5 scientific-grade 50 kHz echosounder paired with a Trimble Pro-XRS real-time differential global positioning system (DGPS). The echosounder's transducer was positioned 0.61 m below the surface of the water adjacent to the hull in the middle of the boat. The DGPS receiver National Marine Electronics Association (NMEA) GGA output coordinates, and time stamps were logged to a notebook computer along with the QTC sonar depth and bottom-type data at one second intervals, using QTC's QTRT acquisition software.

6.1.1.3 Substrate Validation

Substrate samples were collected from Sturgeon Bay and low water velocity areas of the lower Dauphin River to provide information used to validate the interpretation of the sonar data. Substrate samples were collected using a petit ponar grab (152 mm x 152 mm mouth opening). At each site, ponar penetration depth and relative proportion (%) of each substrate type within the sample was visually estimated and recorded. Substrate size classification was based on Wentworth (1922), and included the following size categories:

- Boulder > 256 mm
- Cobble 64-256 mm
- Gravel (aggregate) 2-64 mm
- Sand (aggregate) 62.5 µm – 2 mm
- Silt 3.9-62.5 µm
- Clay < 3.9 µm

In areas where high water velocity precluded the use of the ponar grab, validation of bottom substrates and structure in the riverine study reach was conducted through a series of rebar drags (Figure 6-1). Steel rebar was attached on one end with a rope and dragged along the river bed. The vibration and movement of the rebar on the river bed provides some indication of the substrate material. Soft, fine substrate areas have very little vibration and jump, whereas complicated and hard bottoms have increased levels of vibration and jump. For each rebar drag transect, aggregate size was estimated and noted (aided by visual assessment where possible).

6.1.1.4 Digital Photography

GPS-linked digital photography was used to document shoreline conditions and to aid in the development of the substrate map. GPS-linked digital photography allows each image taken to be imprinted with geographic coordinates so that they can be mapped and displayed accordingly post-survey. The locations of the acquired GPS-linked digital photography are illustrated in Figure 6-2.

6.1.2 Data Analysis and Mapping

6.1.2.1 Bathymetry

The sonar depth and GPS records were merged and exported to an ASCII comma separated values format using QTC Impact software. The depth and position data were then imported into Microsoft Excel for additional processing, including correction for transducer depth. A geographic vector shoreline file was provided by KGS Group for use in mapping and bathymetric analysis. The corrected sonar depths were combined with vertices extracted from the shoreline polyline file, which had been assigned zero depth values using ArcGIS 10 software. The merged shapefile was imported into Surfer® 9 (Golden Software) and a Kriging spherical variogram model interpolation was used to produce a 5 m pixel resolution depth grid. The raster grid was imported back into ArcGIS 10 for vector contouring at 0.5 metre intervals and final cartographic presentation for the report.

6.1.2.2 Substrate

The QTC acoustic data were exported from QTC Impact and imported to and analyzed with the statistical package SPSS. A multivariate principal components analysis (PCA) was used to reduce the 166 acoustic waveform variables related to bed roughness and hardness down to 5 principal component variables representing over 90 % of the variability within the data set. An unsupervised classification K-means clustering approach was used to produce 5 discrete acoustic classes, representing 5 different substrate types. The classified acoustic tracks were imported into ArcGIS 10 to identify the acoustic classes that co-occurred with the bottom-type validation classes. In addition the GPS-linked digital shoreline photographs were used to validate the acoustic bottom-type classes and increase mapping resolution in the near-shore zone. Substrate classes were digitized as polygons from the classified acoustic tracks, and a final substrate data set was mapped and class areas calculated in ArcGIS 10.

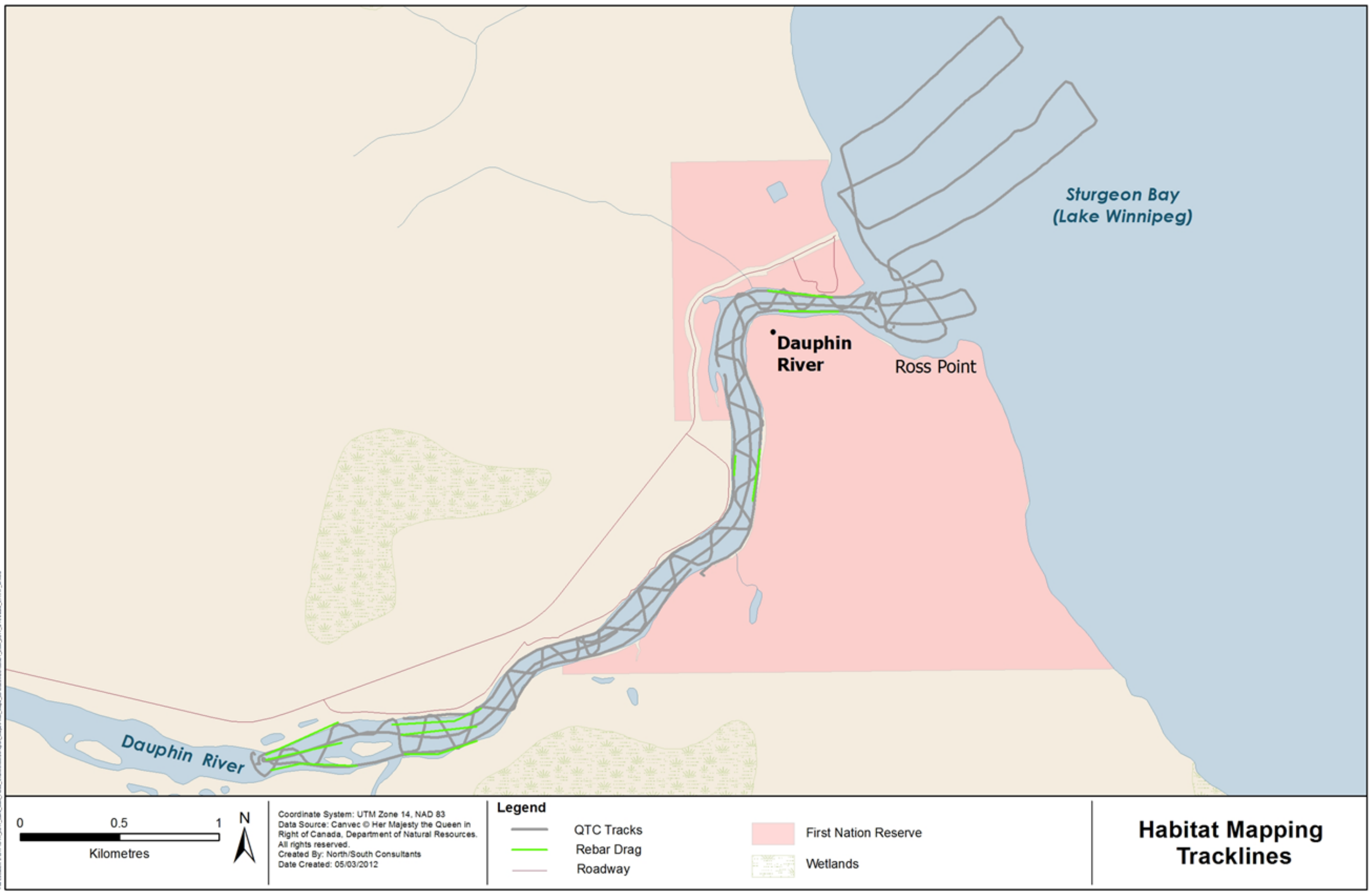

Figure 6-1. Survey track lines (QTC tracks) and substrate validation transects (Rebar Drag) conducted along the Dauphin River during fall 2011.

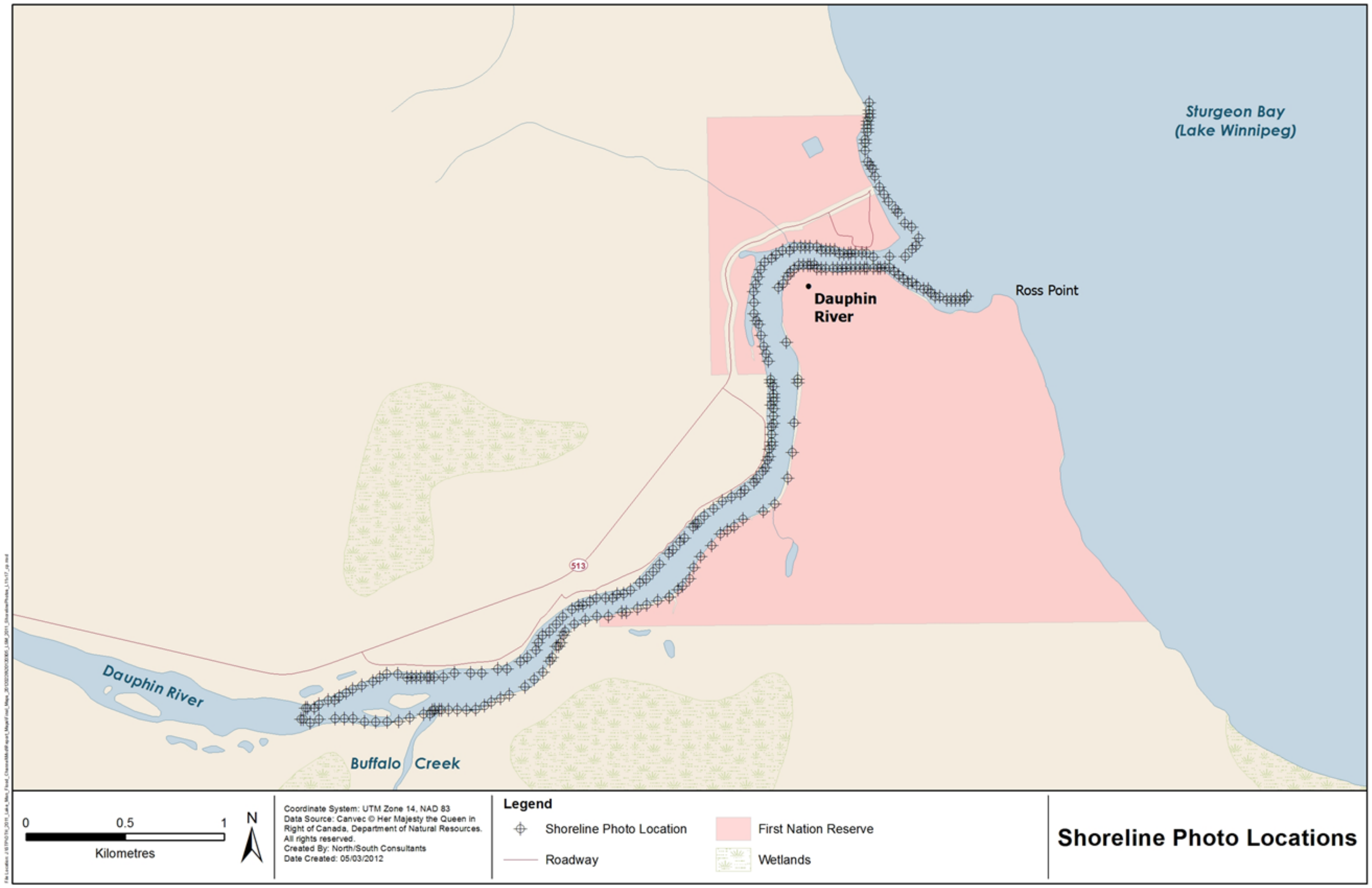

Figure 6-2. Locations where geo-referenced digital photographs were collected along the lower Dauphin River during fall 2011.

6.2 RESULTS

Bathymetric and substrate classification field activities along the Dauphin River were conducted between 11 and 17 October, 2011. Inclement weather (high wind conditions) throughout fall 2011 prevented access to Sturgeon Bay and, consequently, only limited sampling occurred in Sturgeon Bay during fall 2011. Sonar data could not be collected, but a series of substrate samples were collected during from Sturgeon Bay. These data presented in Section 4.3.

6.2.1 Dauphin River

A total of 6,568 bathymetric soundings were collected during the October survey. Detailed bathymetry of the lower reaches of the Dauphin River and portions of Sturgeon Bay are illustrated in Figure 6-3. Within the surveyed area, the shallowest depths (0-2 m) were generally located in the vicinity of the confluence with Buffalo Creek and along portions of the south shore. Depths were typically higher along the north shore and increased to 4-5 m towards the mouth of the river.

Substrate conditions were mapped for 2,114,121.7 m^2 of riverbed habitat in the lower Dauphin River (Table 6-1). Cobble/boulder and gravel/sand were most abundant, each comprising almost 28% of the area mapped. Gravel/cobble and bedrock were the next most common types.

Figure 6-4 shows examples of the GPS-linked digital photographs that were used to document shoreline habitat and assist with development of a substrate map. The distribution of substrate types in the lower reaches of the Dauphin River is illustrated in Figure 6-5. In the vicinity of the Buffalo Creek confluence, bedrock-limestone shelves occurred, with patches of sand and cobble/boulder upstream of the creek mouth. Downstream of the confluence, predominantly gravel/cobble substrate occurs until approximately 1 km upstream of Sturgeon Bay. The remainder of river substrate downstream to Sturgeon Bay consists largely of gravel/sand (Figure 6-5).

Habitat conditions in the lower Dauphin River suitable to support spawning for many species of fish, including Lake Whitefish and Walleye, were documented during fall 2011. Fall fisheries conducted during late fall 2011 documented spawning by Lake Whitefish in the lower Dauphin River in the vicinity of the Buffalo Creek/Dauphin River confluence (Section 7.2). Ongoing fisheries studies at Dauphin River have continued to document use of habitat in the lower Dauphin River by fish.

6.2.2 Sturgeon Bay

Inclement weather (winds) through late September and October severely hampered the ability to conduct boat-based work in Sturgeon Bay and, consequently, the Quester Tangent substrate and depth data collection program could not be completed.

However, substrate samples were collected at 48 sites within Sturgeon Bay (see Section 4.3). Visual assessments were conducted for each location where grabs were obtained or, if a grab could not be obtained due to size or compaction of substrate (i.e., cobble, boulder etc.), substrate characteristics were assessed by probing the bottom with a steel pole or dragging the ponar across the bottom. Figure 6.6 illustrates locations where substrate composition was assessed.

An indication of habitat conditions was be derived from the substrate classification program. Sites highlighted in red indicate those locations where substrate (gravels, cobbles and, to a lesser extent, boulders) was suitable to support spawning by Lake Whitefish, Walleye, and other species.

Table 6-1. Habitat types in the lower Dauphin River, fall 2011 [1].

Habitat Type	Area (m^2)	Area (ha)	Proportion (%)
Bedrock - Limestone	243,189.3	24.32	11.5
Cobble/Boulder	588,959.0	58.90	27.9
Compacted Gravel	152,641.7	15.26	7.2
Gravel/Cobble	418,922.9	41.89	19.8
Gravel/Sand	585,047.4	58.50	27.7
Sand	125,361.4	12.54	5.9
Grand Total	2,114,121.7	211.41	100.0

1 - area sampled illustrated in Figures 6-1, 6-3, and 6-5

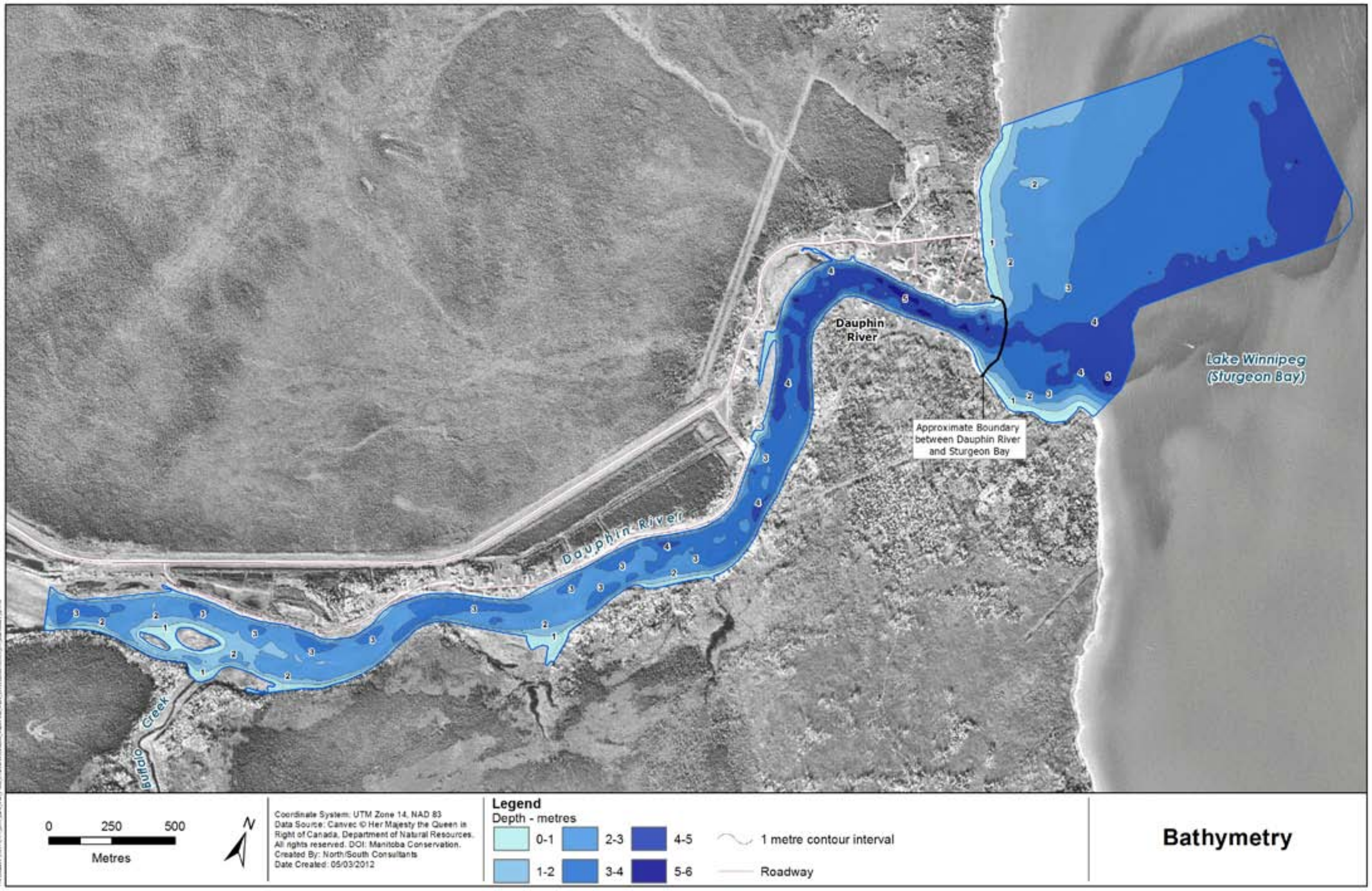

Figure 6-3. Bathymetric map of the lower reaches of the Dauphin River and portions of Sturgeon Bay.

Figure 6-4. Limestone bedrock outcrop overlain by till materials in areas along the Dauphin River (top) and cobble/boulder shoreline extending into the water along the Dauphin River near Sturgeon Bay (bottom).

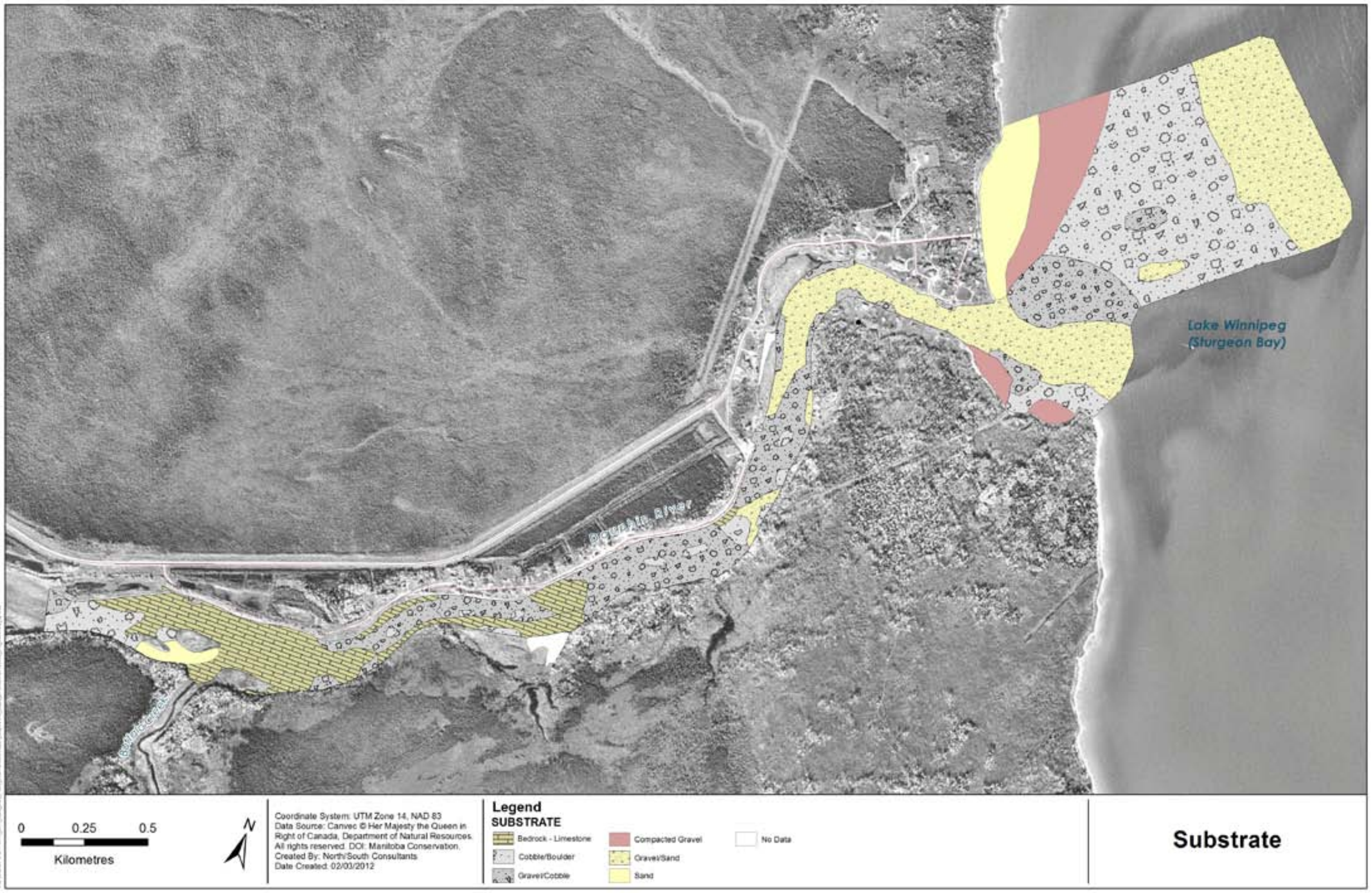

Figure 6-5. Substrate composition map of the lower reaches of the Dauphin River and portions of Sturgeon Bay.

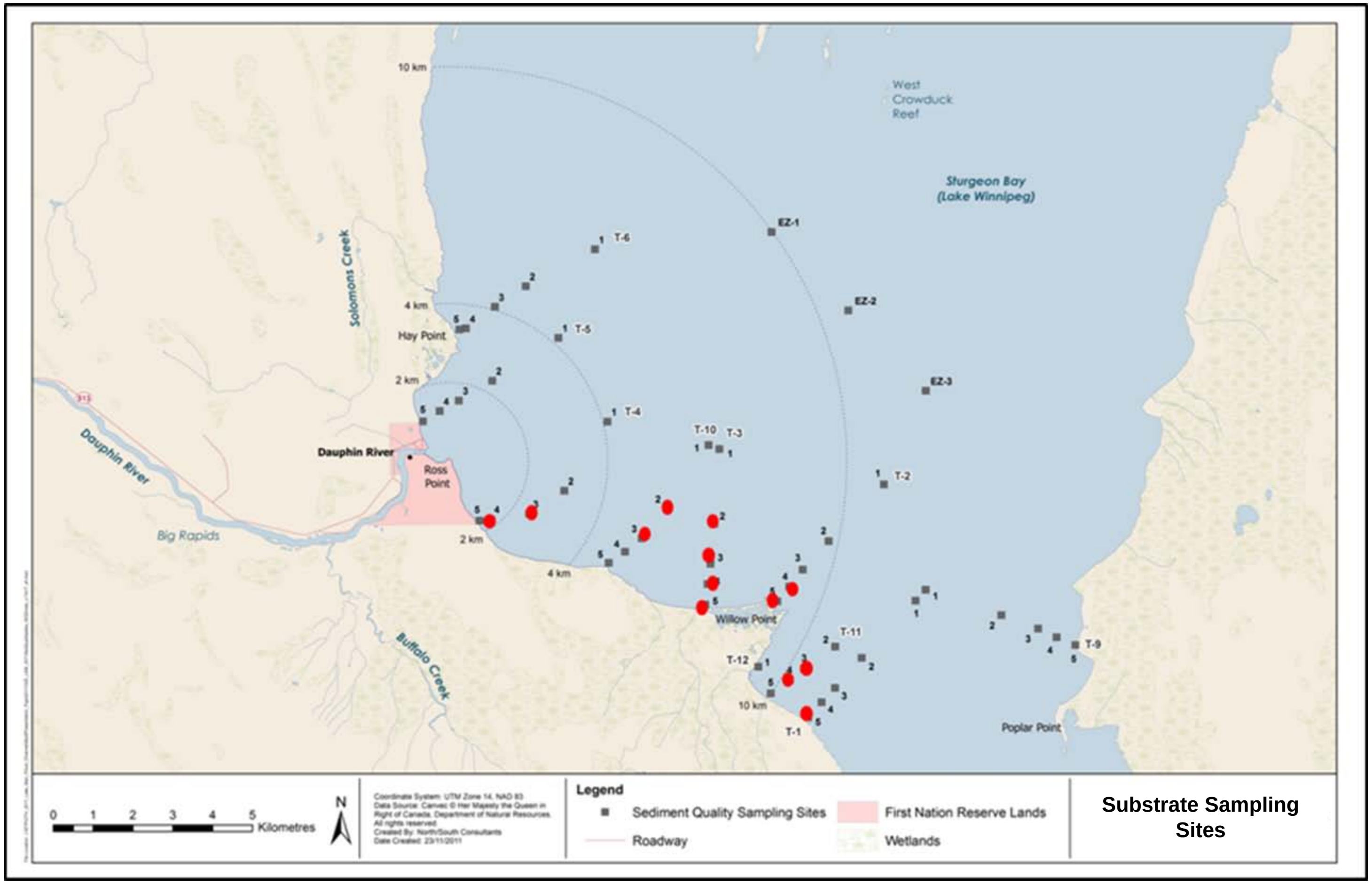

Figure 6-6. Sites where sediment samples were collected to determine sediment composition. Locations highlighted in red indicate sites where substrate type was most suitable to support Lake Whitefish and Walleye spawning (i.e., gravels and larger substrates).

6.3 SUMMARY

A suite of methods were proposed to compile habitat information within the Dauphin River and Sturgeon Bay. These included the collection of bathymetric and substrate data in the Dauphin River and Sturgeon Bay using sonar technology, collection of substrate samples in Sturgeon Bay and slow water velocity areas of the Dauphin River to help validate interpretation of the sonar data, and the conduct of rebar drags in fast water velocity areas of the Dauphin River to help validate interpretation of the sonar data. Collected information was used to produce maps of aquatic habitat.

Bathymetric and substrate classification field activities along the Dauphin River were conducted between 11 and 17 October, 2011. Inclement weather (high wind conditions) throughout fall 2011 prevented access to Sturgeon Bay and, consequently, only limited sampling occurred in Sturgeon Bay during fall 2011. Sonar data could not be collected from Sturgeon Bay, but a series of substrate samples were collected.

Dauphin River

Substrate conditions were mapped for 2,114,121.7 m^2 of riverbed habitat in the lower Dauphin River. Cobble/boulder and gravel/sand were most abundant, each comprising almost 28% of the area mapped. Gravel/cobble and bedrock were the next most common types.

Habitat conditions in the lower Dauphin River suitable to support spawning for many species of fish, including Lake Whitefish and Walleye, were documented during fall 2011. Fall fisheries conducted during late fall 2011 documented spawning by Lake Whitefish in the lower Dauphin River in the vicinity of the Buffalo Creek/Dauphin River confluence (Section 7.2). Ongoing fisheries studies at Dauphin River have continued to document use of habitat in the lower Dauphin River by fish.

Sturgeon Bay

Substrate samples were collected at 48 sites within Sturgeon Bay. Visual assessments were conducted for each location where grabs were obtained or, if a grab could not be obtained due to size or compaction of substrate (i.e., cobble, boulder etc.), substrate characteristics were assessed by probing the bottom with a steel pole or dragging the ponar across the bottom. An indication of substrate conditions was derived from this program, and suggested that substrate conditions suitable to support spawning (gravels, cobbles and, to a lesser extent, boulders) by Lake Whitefish, Walleye, and other species occurred at numerous locations in nearshore areas of Sturgeon Bay, including to the east and west of Willow Point.

7.0 FALL FISHERIES SURVEYS IN DAUPHIN RIVER AND STURGEON BAY

Habitat changes and altered flow regimes may impact fish distribution, community structure and habitat use in areas affected by the Project. Fall fisheries investigations focussed on the lower Dauphin River and nearshore areas of Sturgeon Bay. The intent was to provide information to supplement pre-existing aquatic environment information, and provide contemporary pre-project information to assist in determining project-related effects. Specific study objectives included:

- identification of fall fish utilization in the Dauphin River, between the confluence with Buffalo Creek and Sturgeon Bay;
- identification of Lake Whitefish spawning areas in the Dauphin River, between the confluence with Buffalo Creek and Sturgeon Bay;
- determination of fall fish utilization of nearshore habitat in Sturgeon Bay during late fall (emphasis on Lake Whitefish); and,
- collection of information on fall Lake Whitefish movements into the Dauphin River prior to operation of Reach 1.

7.1 METHODS

The timing and extent to which fish used nearshore areas of Sturgeon Bay and the Dauphin River were documented during a series of sampling campaigns conducted during fall 2011. Fish activities of interest, such as Lake Whitefish movement into the Dauphin River or the timing of Lake Whitefish spawning, can occur over a broad period of time, can occur abruptly, or, as is the case for spawning movements and spawning, occur sequentially. Conducting field activities in a series of field campaigns provided a better opportunity to capture the occurrence and timing of fish activities.

7.1.1 Water Temperature

Water temperature is an important factor that affects the timing of fish activities such as large-scale movements or spawning. Water temperature data was collected from a series of locations throughout the study area to support fisheries and engineering investigations.

Water temperature data was collected using HOBO V2 water temperature loggers (Onset Computer Corporation) programed to record water temperature on an hourly basis. A total of 8 water temperature loggers were deployed at the beginning of field fisheries investigations. Two moorings, each with three loggers recording temperature at different water depths, were deployed in Sturgeon Bay. Two loggers were deployed in the Dauphin River; one at a location downstream of the confluence of Buffalo Creek and one upstream of the confluence of Buffalo Creek. Logger locations and deployment information are provided in Table 7-1 and illustrated in Figure 7-3.

Table 7-1. Location and deployment information for water temperature loggers deployed in Sturgeon bay and the Dauphin River during fall, 2011.

Location	Logger ID	Date Deployed	Date Downloaded	Site Description	Water Depth (m)	Location [1, 2]	
						Easting	Northing
Sturgeon Bay (Mooring 1) [3]	DR-1	19-Oct-11	15-Nov-11	north of the Dauphin River mouth	0.9	565545	5758393
	DR-2	19-Oct-11	15-Nov-11		1.8		
	DR-3	19-Oct-11	15-Nov-11		2.7		
Sturgeon Bay (Mooring 2) [3]	DR-4	19-Oct-11	15-Nov-11	south of the Dauphin River mouth	0.9	566165	5756385
	DR-5	19-Oct-11	15-Nov-11		1.8		
	DR-6	19-Oct-11	15-Nov-11		2.7		
Dauphin River [4]	DR-7	19-Oct-11	29-Nov-11	downstream of Buffalo Creek	0.5	563634	5755782
Buffalo Creek [4]	DR-8	19-Oct-11	04-Nov-11	mouth of Buffalo Creek	0.5	562245	5754720

1 - UTM coordinates; Datum NAD 83, Zone 14U
2 - logger locations illustrated on Figure 7-1
3 - data downloaded and logger left in place to support on-going engineering studies
4 - logger removed

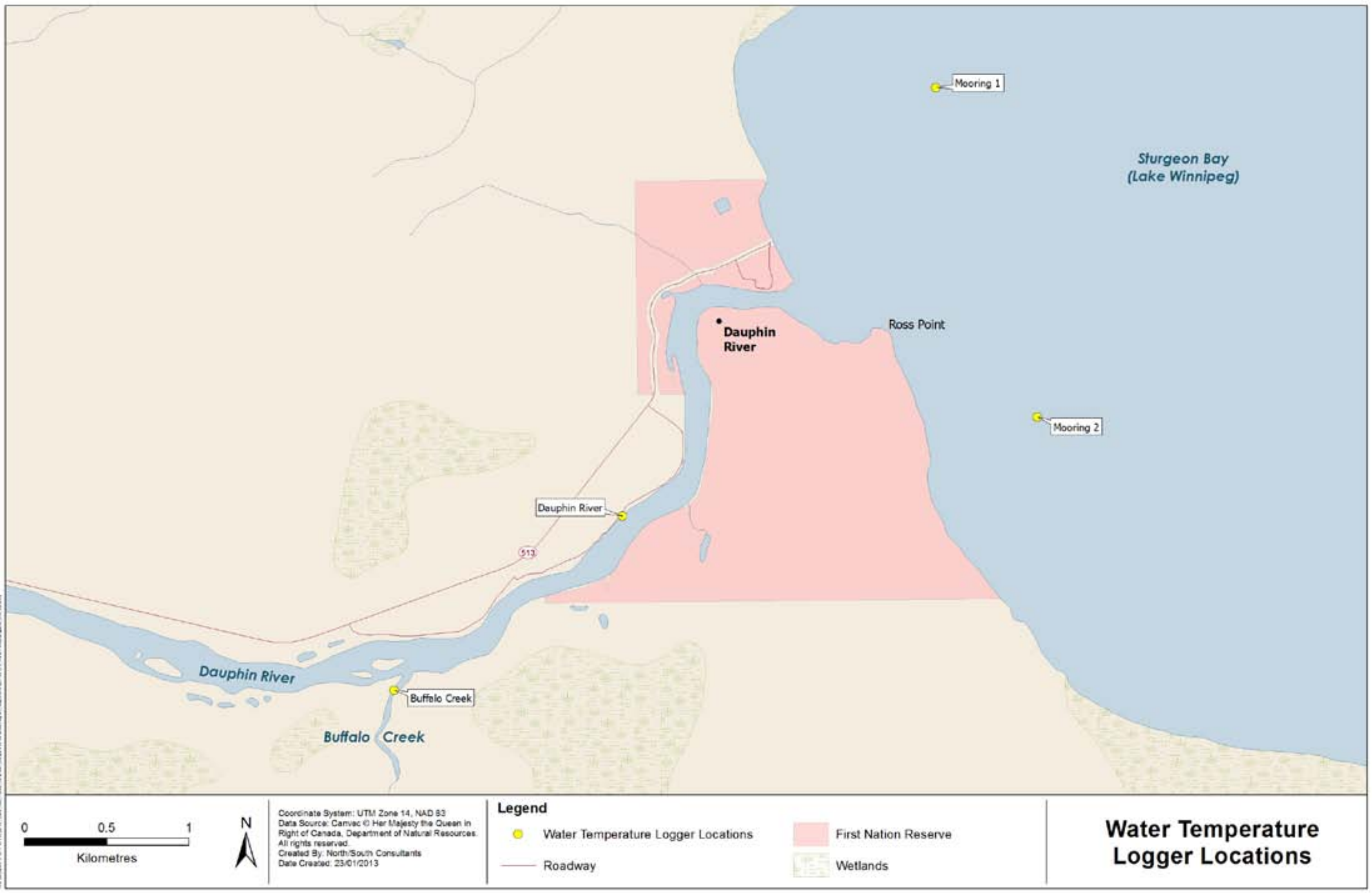

Figure 7-1. The location of water temperature loggers deployed in Sturgeon Bay and the Dauphin River during fall, 2011.

7.1.2 Fish Utilization

Two fish capture techniques were used to sample fish in the Dauphin River and Sturgeon Bay during fall 2011. The technique used varied based on sampling location. In general, standard experimental gillnet gangs were used to sample for fish in Sturgeon Bay and boat-based electrofishing was used to sample fish in the Dauphin River. Field and data analysis methods are discussed in the following sections.

7.1.2.1 Experimental Gillnetting

Standard index gillnet gangs were 137.2 m long and consisted of 22.9 m long by 1.8 m deep panels of 1.5, 2.0, and 3.0 inch stretched twisted nylon mesh and 3.75, 4.25, and 5.0 inch stretched twisted monofilament mesh. In general, nets sets were to be of short duration (<3 hours) to minimize fish mortality.

Set data and time, as well as net retrieval date and time, were recorded for each net set. Net set locations were recorded with a handheld Garmin Etrex® GPS receiver. Water depth (± 0.1 m) was measured at each end of the net with a hand-held SM-5 (Speedtech Instruments®) depth sounder, and surface water temperature was recorded with a handheld thermometer (±0.5 °C).

7.1.2.2 Boat Electrofishing

Boat electrofishing was conducted in Sturgeon Bay, Dauphin River and Buffalo Creek and targeted fall spawning migrations of Lake Whitefish). Fish were captured using a Smith-Root GPP 5.0 electrofisher with dual boom Smith-Root UAA-6 Umbrella anodes (0.91 m diameter), mounted two meters apart. Two crew members, positioned at the bow of the boat on the port and starboard side, captured fish as they swam toward the anodes. Fish were placed in live holds until they could be processed.

Numerous electrofishing runs were conducted during each sampling period. Effort was made to sample in various habitat types. The following information was collected for each electrofishing run:

- Date and time of day;
- GPS data - starting and end waypoint, as well a track log of the path followed by the electrofishing boat;
- Fishing effort (number of seconds the electrofisher operated);
- Electrofisher settings (volts, amperage, pulse width and frequency); and,
- A species-specific count of fish observed but not captured.

7.1.2.3 Biological Sampling

All fish captured were enumerated by species and location (gill net site or electrofishing run). Each fish was measured for fork length (± 1 mm) and round weight (±25 g using a pan balance). All lake whitefish were examined for sex and maturity by gamete extrusion. The following sexual maturity codes were used:

Females (F)	**Males (M)**
2 - maturing to spawn (pre-spawn)	7 - maturing to spawn (pre-spawn)
3 - ripe	8 - ripe
4 - spend (post-spawn)	9 - spend (post-spawn)

Lake Whitefish captured by during electrofishing runs were marked with individually numbered plastic Floy® FD-94 T-bar anchor tags. Floy® tags were inserted between the basal pterygiophores of the dorsal fin using a Dennison® Mark II tagging gun. All live fish were released at the original point of capture following sampling.

7.1.2.4 Data Analysis

Gillnetting and electrofishing catches were tabulated by species and capture location. Catch-per-unit-effort (CPUE) was calculated for the overall catch and for each species, by site. For gill nets, CPUE was calculated as the number of fish caught per 100 m of net per 24 hours. Total CPUE was calculated by averaging all net set CPUE values. CPUE for electrofishing catches were calculated as the number of fish caught per minute of electrofishing.

Mean fork length (mm), weight (g) and condition factor (K) were calculated for each species. Condition factor was calculated for fish where fork length and round weight were measured, using the following formula (after Fulton 1911, in Ricker 1975):

$$K = W \times 10^5/L^3$$

Where: W = round weight (g); and
L = fork length (mm)

Length-frequency distributions were plotted for each species where more than 15 fish were captured. Length intervals of 25 mm were used for most species (e.g., 225-249 mm). A 50 mm interval was used for Northern Pike.

7.1.3 Spawning Activity

Egg mats have frequently been used to collect fish eggs in order to determine spawning habitat preferences and delineate spawning locations (La Haye et al. 2003; Manny et al. 2007; MacDougall and MacDonell 2009; Thompson 2009). Egg mats are set in or immediately downstream of areas where spawning is thought to occur and, as eggs settle onto the substrate or are stirred up from the river bottom, they readily adhere to the filter material of the egg mat (Figure 7-1). Egg mats used in this study were comparable to those used in lake sturgeon and and walleye spawning investigations at other locations (MacDougal and MacDonell 2009; Manny et al. 2007; Thompson 2009).

Egg mats consisted of 39 x 19 x 9 cm cinder blocks wrapped with air filter material (i.e., latex-coated horse hair or fiberglass; Figure 7-2). The filter material was held in place against the cinder block with sideline. Eggs mats were deployed by attaching a float and line to the cinder block and lowering the egg mat to the river or lake bottom. Date, time, and UTM coordinates were recorded for every egg mat that was set. Egg mats were set in the mouth of Buffalo Creek and in the Dauphin River to identify Lake Whitefish spawning areas. Sites located in the Dauphin River were generally located near the mouth of Buffalo Creek and approximately 900 m downstream from Buffalo Creek. Sample locations were based on substrate, and water depth and velocity.

During retrieval, each air filter was removed and placed in an individually labelled bag. Samples were transported to the North/South Consultants laboratory in Winnipeg where they were examined for fish eggs. Lake Whitefish eggs were enumerated and placed into individually labeled sample containers and preserved in 10% formalin.

Figure 7-2. Lake Whitefish eggs collected on an egg mat set in the Dauphin River during fall, 2011.

Figure 7-3. An egg mat ready for deployment.

7.1.4 Debris Monitoring

The possibility that increases in flow through the bog/wetland complex surrounding Big Buffalo Lake and down Buffalo Creek could result in erosion and transport of large amounts of debris (organic and mineral materials, scoured peat bog, and terrestrial vegetation such as trees, etc.) that would ultimately be introduced into Sturgeon Bay was recognized prior to operation of Reach 1. Commercial fishers working Sturgeon Bay expressed concern that increased debris could negatively affect the commercial fishery by causing the destruction of fishing nets, increased effort to keep nets clean and fishing efficiently, and possibly by reducing fish stocks in Sturgeon Bay due to damage/alteration of spawning areas through increased sedimentation. The occurrence of debris in experimental gill nets set in Sturgeon Bay was recorded during fall 2011 to help address this concern.

Monitoring programs to document debris in gillnet gangs have previously been conducted in Manitoba. From 1993 to 1997, Manitoba Hydro, the Province of Manitoba, and the Norway House Fisherman's Cooperative conducted a monitoring program to document the effects that debris may have had on the commercial fishery in Playgreen Lake (Graveline and Horne 1998). The methods used in that study were followed for this program.

The quantity and type of debris were evaluated for each net set. The amount of debris in each gang was categorized based on the percentage of the gang area (surface area of mesh) fouled by debris. Categories for debris quantity were as follows:

- None (no debris in gang; nets were clean);
- Low (< 5% of gang area covered by debris);
- Medium (5-15% of gang area covered by debris);
- High (16-25% of gang area covered by debris); and,
- Very High (> 25% of gang area covered by debris).

The type of debris was then categorized as a percentage of the total amount of debris in the gang. By this method, the sum of the relative percentage of all debris types present always equalled 100%, regardless of the debris level. For example, if a gang contained only one stick, sticks would constitute 100% of the debris in the gang. Categories for debris composition were as follows:

- Terrestrial vegetation (trees, shrubs, grass, etc.);
- Terrestrial moss (muskeg);
- Sticks (driftwood or logs);
- Aquatic vegetation (weeds);
- Algae;
- Silt/mud; and,
- Other (rocks, shells, etc.).

The amount and type of debris that occurred in each gang was tabulated.

7.2 RESULTS

7.2.1 Water Temperature

Water temperature loggers were deployed on 19 October and data were either downloaded or the logger retrieved during November (Table 7-1). Continuous hourly water temperature recordings were obtained from all loggers during the period that they were deployed.

Data from loggers deployed in the Dauphin River, Buffalo Creek, and the surface logger at Mooring 1 (logger ID DR-1; Table 7-1) were plotted to illustrate water temperature conditions while fall 2011 fisheries monitoring programs were conducted. Logger DR-1 was considered to be representative of water temperature conditions in Sturgeon Bay; data from remaining loggers are presented elsewhere.

Water temperature in the Dauphin River and Sturgeon Bay were between 6 and $7^{O}C$ when the loggers were deployed on 19 October (Figure 7-4). Temperature remained fairly consistent between the two locations throughout the fall, rarely having more than $1^{o}C$ difference between the areas. Water temperature steadily decreased to $1^{o}C$ by 15 November in Sturgeon Bay and reached $0^{o}C$ in the Dauphin River by 16 November (Figure 7-4). Daily fluctuations in water temperature were observed at both locations, reflecting changes in air temperature throughout each day (Figure 7-4).

The temperature logger deployed in Buffalo Creek remained in place until 04 November, about three days after flow in the creek increased dramatically due to the onset of Reach 1 operation. High flows in the creek moved the logger downstream and onto the Dauphin River shore after 04 November and, consequently, temperatures recorded did not reflect those occurring in Buffalo Creek (i.e., because the logger was on shore, air temperature, rather than water temperature, was recorded).

Water temperature in Buffalo Creek was about 5°C on 19 October, at least one degree less than temperatures recorded in the Dauphin River or Sturgeon Bay. Larger daily fluctuations in temperature were also observed in Buffalo Creek compared to the Dauphin River and Sturgeon Bay (Figure 7-4). This is likely because the shallow waters in the Buffalo creek watershed would be more susceptible to changes in air temperature compared to the much larger volumes of water occurring in the Dauphin River and Sturgeon Bay.

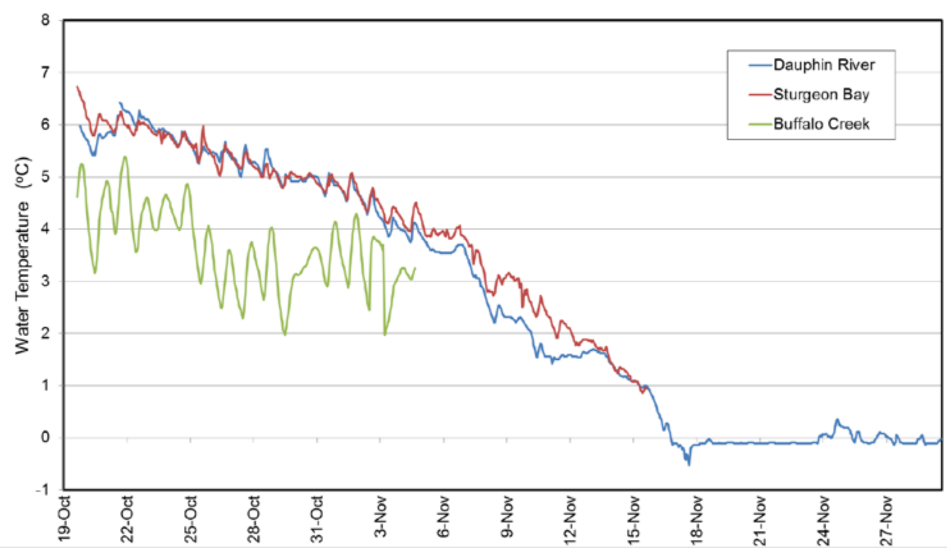

Figure 7-4. Daily water temperature in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

7.2.2 Fish Utilization

Information describing fish use of the lower-most portions of Buffalo Creek, the Dauphin River and Sturgeon Bay began in late September and continued into mid-November during 2011. Nine species of fish were captured, most of which occurred contiguously in the Dauphin River and Sturgeon Bay (Table 7.2). A detailed presentation of results is provided in the following sections.

Table 7-2. List of fish species captured in Sturgeon Bay, Dauphin River and Buffalo Creek during fall, 2011.

Common Name	Scientific Name	Sturgeon Bay GN [1]	Sturgeon Bay EF [2]	Dauphin River EF [2]	Buffalo Creek EF [2]
Burbot	*Lota lota*	✓	-	-	-
Cisco	*Coregonus artedi*	✓	-	✓	-
Freshwater Drum	*Aplodinotus grunniens*	✓	-	✓	-
Lake Whitefish	*Coregonus clupeaformis*	✓	✓	✓	✓
Northern Pike	*Esox lucius*	✓	-	✓	✓
Shorthead Redhorse	*Moxostoma macrolepidotum*	✓	-	-	-
Walleye	*Sander vitreus*	✓	-	✓	-
White Sucker	*Catostomus commersonii*	✓	✓	✓	✓
Yellow Perch	*Perca flavescens*	✓	-	✓	✓

1 - experimental gillnet gang
2 - boat-based electrofishing

7.2.2.1 Experimental Gillnetting

Fisheries work on Sturgeon Bay was limited during fall 2011 by high wind conditions that persisted through October and early November. Four standard experimental gillnet gangs were set in Sturgeon Bay between 14 to 21 October (Table 7-3). Two gillnet gangs were set in the vicinity of Willow Point and two gangs were set near the mouth of the Dauphin River (Figure 7-5). Gang set durations ranged from two to 23 hours (Table 7-3).

A total of 333 fish, comprising nine fish species, were captured (Table 7-4). Lake Whitefish comprised 10.2% of the catch, and were captured at all sampling locations. Other species captured, in decreasing order of abundance, included Cisco (36.3%), White Sucker (22.8%), Northern Pike (13.5%), Yellow Perch (8.1%), Walleye (5.7%), Shorthead Redhorse (2.7%), Freshwater Drum (0.3%, and Burbot (0.3%). Species-specific mean catch-per-unit-effort is provided in Table 7-5.

Table 7-3. Location, water depth, water temperature, and set duration for experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

Site	Location [1, 2]		Water Depth (m)	Water Temperature (°C)	Set Date	Set Time	Pull Date	Pull Time	Duration (hrs)
	Easting	Northing							
GN-01	565363	5758049	3.4-3.7	9.0	14-Oct-11	14:44	15-Oct-11	9:30	18.8
GN-02	565477	5758742	-	-	15-Oct-11	10:20	16-Oct-11	9:37	23.3
GN-03	572052	5753631	3.3-3.7	4.0	19-Oct-11	15:10	20-Oct-11	9:17	18.1
GN-04	573143	5751611	1.5-2.0	5.0	21-Oct-11	10:10	21-Oct-11	12:15	2.1

1 - UTM coordinates; NAD 83, Zone 14U
2 - locations illustrated on Figure 7-5

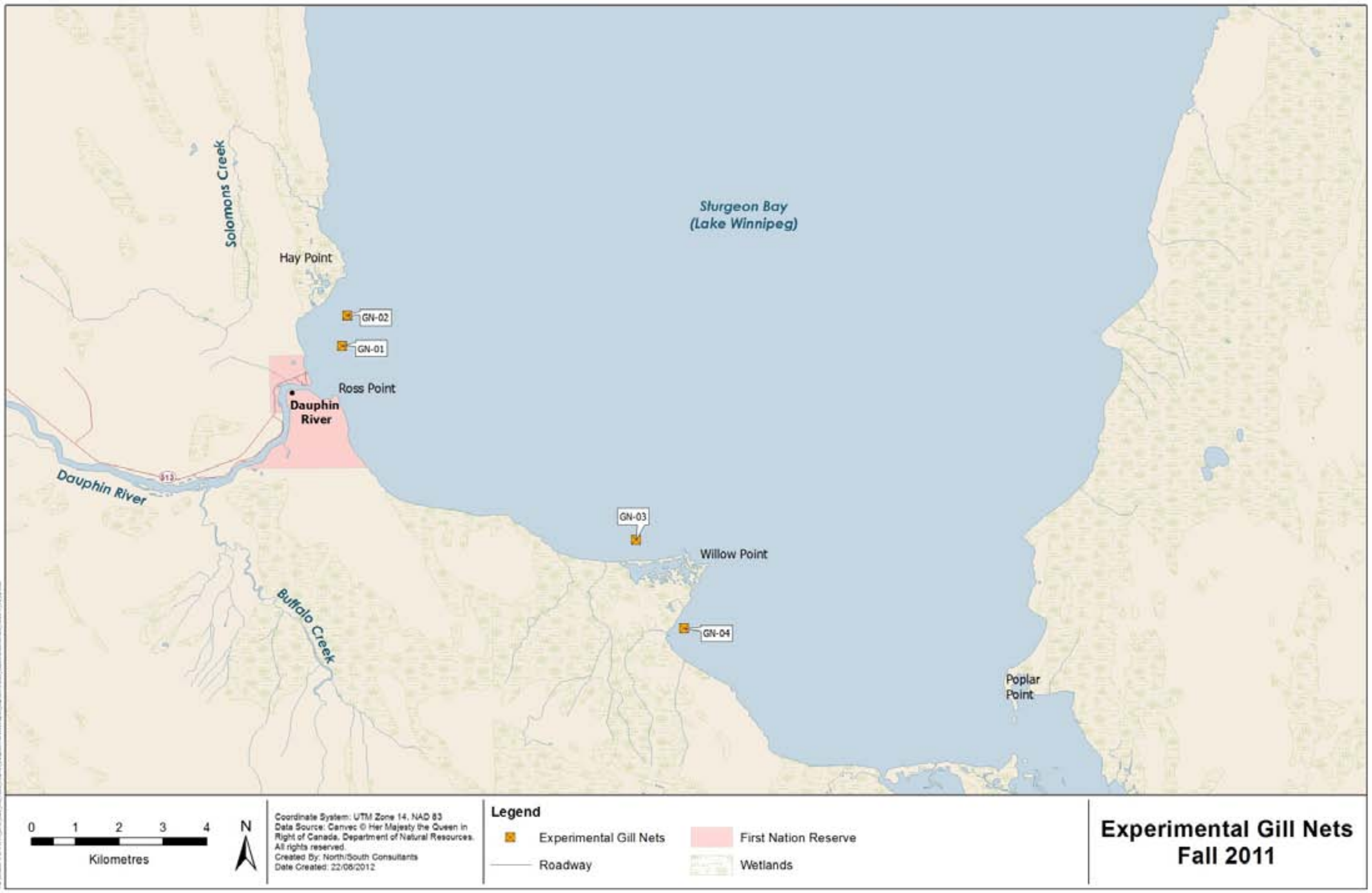

Figure 7-5. Locations where experimental gillnet gangs were set in Sturgeon Bay during fall, 2011.

Table 7-4. Number (n) and relative abundance (%) of each fish species captured in standard index gill nets set in Sturgeon Bay during fall, 2011.

Site		Species									Total
		Burbot	Cisco	Freshwater Drum	Lake Whitefish	Northern Pike	Shorthead Redhorse	Walleye	White Sucker	Yellow Perch	
GN-01	n	1	62	1	20	12	5	16	17	19	153
	%	0.7	40.5	0.7	13.1	7.8	3.3	10.5	11.1	12.4	45.9
GN-02	n	-	17	-	6	27	2	3	31	4	90
	%	-	18.9	-	6.7	30.0	2.2	3.3	34.4	4.4	27.0
GN-03	n	-	35	-	2	4	2	-	26	3	72
	%	-	48.6	-	2.8	5.6	2.8	-	36.1	4.2	21.6
GN-04	n	-	7	-	6	2	-	-	2	1	18
	%	-	38.9	-	33.3	11.1	-	-	11.1	5.6	5.4
Overall	n	1	121	1	34	45	9	19	76	27	333
	%	0.3	36.3	0.3	10.2	13.5	2.7	5.7	22.8	8.1	100.0

Table 7-5. Species- and gillnet gang-specific catch-per-unit-effort (CPUE) for fish species captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

Site	Species-specific CPUE (#fish/100m/24hrs)									Total
	Burbot	Cisco	Freshwater Drum	Lake Whitefish	Northern Pike	Shorthead Redhorse	Walleye	White Sucker	Yellow Perch	
GN-01	0.9	57.8	0.9	18.6	11.2	4.7	14.9	15.9	17.7	142.7
GN-02	0.0	12.8	0.0	4.5	20.3	1.5	2.3	23.3	3.0	67.6
GN-03	0.0	33.8	0.0	1.9	3.9	1.9	0.0	25.1	2.9	69.5
GN-04	0.0	58.8	0.0	50.4	16.8	0.0	0.0	16.8	8.4	151.2
Mean CPUE [1]	0.3	34.8	0.3	8.4	11.8	2.7	5.7	21.4	7.9	93.3
SD [2]	0.5	22.5	0.5	9.0	8.2	1.7	8.0	4.9	8.5	42.8

1 - GN-04 not included in the calculation of mean CPUE because the gang was set for only a short period of time (~2 hrs), whereas the remaining gangs were set for longer periods of time (>18 hrs)

2 - SD = standard deviation

Species diversity and abundance were highest at GN-01 (nine species; 153 fish) and GN-02 (seven species; 90 fish), both located near the mouth of the Dauphin River. The proportion of Lake Whitefish captured in gangs set in close proximity to the Dauphin River mouth was higher than those set near Willow Point (see Figure 7-5). Most Lake Whitefish captured were adult fish in a pre-spawn condition, including those fish captured near Willow Point.

Species Accounts

The following sections present size and condition information for selected fish species captured. Discussion is not provided for species where fewer than 10 individuals were captured.

Cisco

Cisco (n = 121) was the most abundant species captured in Sturgeon Bay. Individuals were captured at all four gillnet sites (Table 7-4). Mean Cisco CPUE (34.8 fish/100m/24hrs) was more than twice that of any other species (Table 7-5). Most Cisco captured were smaller, juvenile fish. Mean length of captured Cisco was 214 mm (Table 7-6) and the modal fork length interval was 175-199 mm (Figure 7-6). Few adult fish in a pre-spawning condition were captured.

Lake Whitefish

Lake Whitefish (n = 34) were captured at all gillnet sites in Sturgeon Bay (Table 7-4). Mean CPUE was 8.4 fish/100m/24hrs) (Table 7-5). The Lake Whitefish catch was comprised mostly of large, adult fish. Mean length was 386 mm (Table 7-6) and the modal fork length interval 375-399 mm (Figure 7-7). Pre-spawn male and female fish were identified at sites located at the mouth of the Dauphin River (GN-01 and GN-02; Figure 7-5), but not at gangs set near Willow Point.

Northern Pike

Northern Pike were the third most abundant species in the fall gillnetting catch. Forty-five Pike were captured at all locations (Table 7-4), but were most abundant in the catch from a gang set to the north of the Dauphin River (GN-02; Table 7-4; Figure 7-5). Mean CPUE for Northern Pike was 11.8 fish/100m/24hrs (Table 7-5). The Northern Pike catch was comprised mostly of larger adult fish, ranging in size from 550-650 mm in fork length. Mean fork length was 551 mm (Table 7-6) and the modal fork length interval was 600-649 mm, although a relatively high proportion of fish 500-549 mm were also captured (Figure 7-8).

Walleye

Walleye comprised only a small portion (5.7%) of the gillnetting catch (Table 7-4) and were only captured in gangs set near the mouth of the Dauphin River (GN-01 and GN-02; Figure 7-5). Mean CPUE was 5.7 fish/100m/24hrs (Table 7-5). Captured Walleye had a mean length of 350 mm (Table 7-6). The size distribution of Walleye in the fall gill netting catch is illustrated in Figure 7-9.

White Sucker

White Sucker were the second most frequently occurring species in the gillnetting catch, and were captured at all locations fished (Table 7-4; Figure 7.5). Seventy-six individuals were captured, comprising 22.8% of the total catch (Table 7-4). Mean CPUE was 21.4 fish/100m/24hrs (Table 7-5). The White Sucker catch was comprised of large, adult fish. All individuals were larger than 355 mm in fork length (Table 7-6), mean fork length was 416 mm (Table 7-6), and the modal length interval was 425-449 mm for the length-frequency distribution for the catch (Figure 7-10).

Yellow Perch

Yellow Perch were captured at all locations fished (Table 7-4; Figure 7.5). A total of 27 individuals were captured, comprising 8.1% of the total catch (Table 7-4). Mean CPUE for Yellow Perch was 7.9 fish/100m/24hrs (Table 7-5). Yellow Perch ranged in size from 134-261 mm in fork length, had a mean fork length of 164 mm (Table 7-6), and a modal length interval of 125-149 mm (Figure 7-10). More than 90% of the Perch captured were 125-199 mm in length (Figure 7-11).

Table 7-6. Mean size and relative condition factor (K) for species captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

Species	Length [1] (mm)				Weight (g)				K			
	N [2]	Mean	SD [3]	Range	n	Mean	SD	Range	n	Mean	SD	Range
Burbot	1	745	-	-	1	1800	-	-	1	0.44	-	-
Cisco	121	214	39.1	154-347	9	211	69.7	150-350	9	2.03	0.22	1.80-2.50
Freshwater Drum	1	342	-	-	1	500	-	-	1	1.25	-	-
Lake Whitefish	34	386	64.8	141-456	32	954	232	400-1500	32	1.48	0.18	1.16-2.00
Northern Pike	45	551	129	210-818	43	1573	912	75-4450	43	0.77	0.09	0.38-0.90
Shorthead Redhorse	9	392	29.2	342-425	6	1025	309	650-1350	6	1.66	0.09	1.52-1.76
Walleye	19	350	122	164-486	16	822	553	50-1600	16	1.21	0.17	0.75-1.46
White Sucker	76	416	28.5	355-480	69	1233	269	700-2100	69	1.69	0.20	1.28-2.23
Yellow Perch	27	164	28.8	134-261	-	-	-	-	-	-	-	-

1 - total length for Burbot and fork length for all other species.
2 - n = number of fish measured; may not equal number captured.
3 - SD = standard deviation.

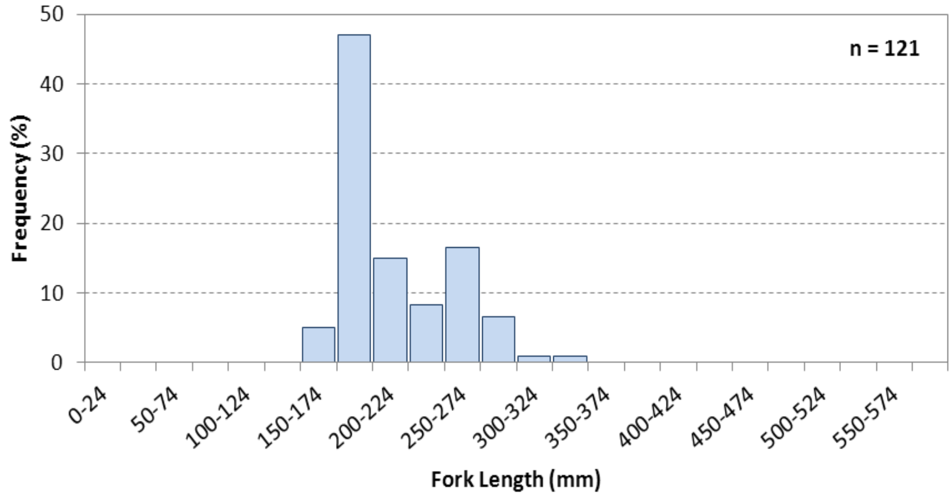

Figure 7-6. Length-frequency distribution for Cisco captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

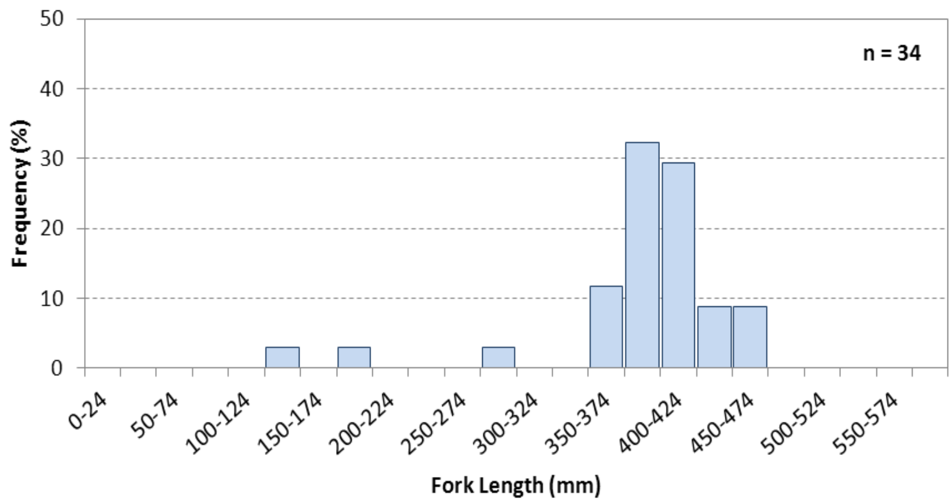

Figure 7-7. Length-frequency distribution for Lake Whitefish captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

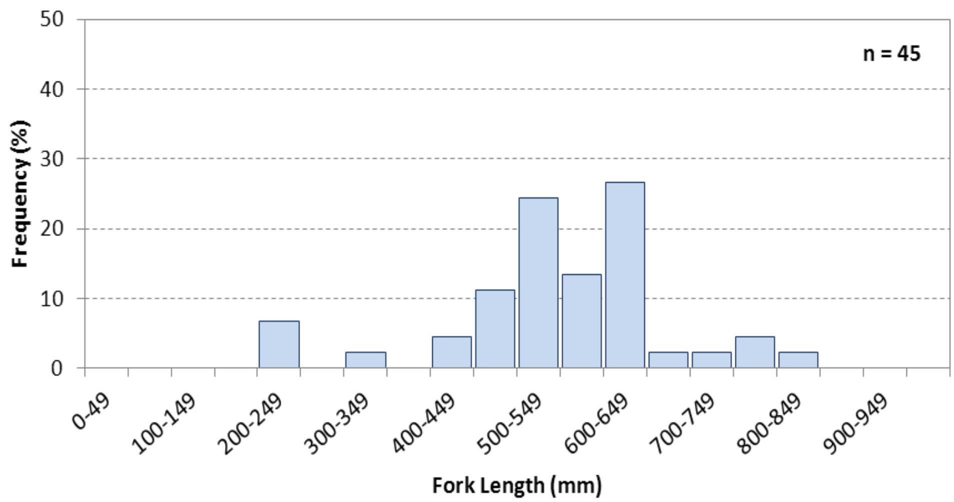

Figure 7-8. Length-frequency distribution for Northern Pike captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

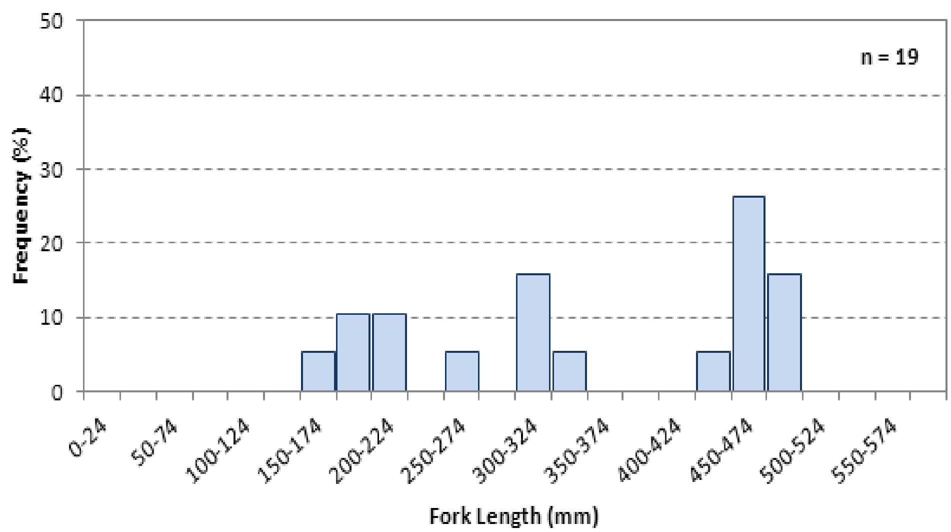

Figure 7-9. Length-frequency distribution for Walleye captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

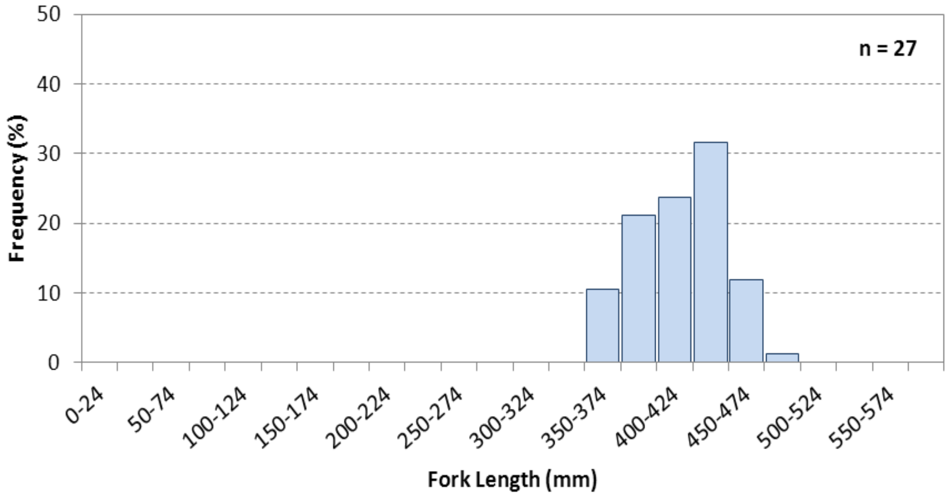

Figure 7-10. Length-frequency distribution for White Sucker captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

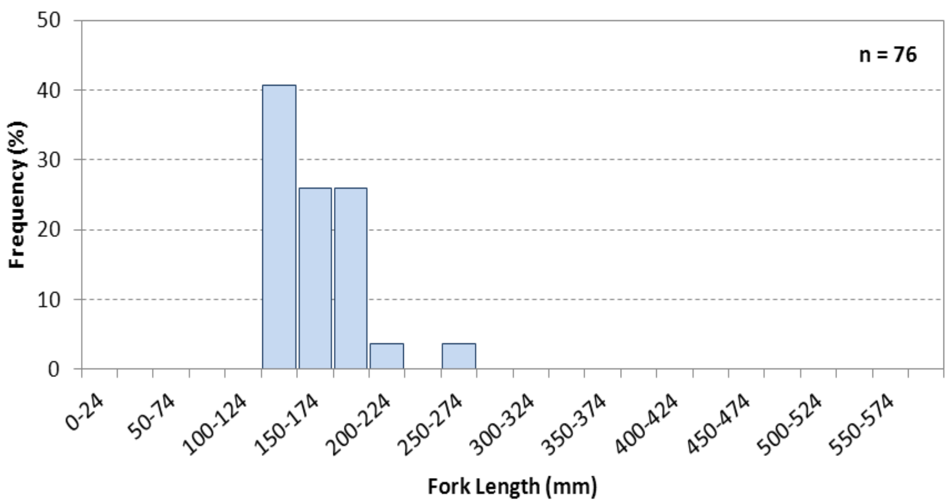

Figure 7-11. Length-frequency distribution for Yellow Perch captured in experimental gillnet gangs set in Sturgeon Bay during fall, 2011.

7.2.2.2 Boat Electrofishing

Boat electrofishing was conducted in the Dauphin River, the lower-most reach of Buffalo Creek, and Sturgeon Bay in the vicinity of the Dauphin River during three sampling sessions during fall 2011. Most effort was spent electrofishing in the Dauphin River (Table 7-7). Inclement weather restricted access to Sturgeon Bay through most of the fall, and the lower reaches of Buffalo Creek became in accessible once flow down Reach 1 began on 01 November.

Twenty-seven electrofishing runs were conducted from 14-15 October, 20-21 October, and on 05 November. Locations and fishing effort for each electrofishing run are described in Table 7-7 and illustrated in Figure 7-12.

A total of 765 fish, comprising seven fish species, were captured during the electrofishing surveys (Table 7-8). Lake Whitefish were the most abundant fish captured, accounting 93.5% (n = 715) of the total fall overall electrofishing catch (Table 7-8). Small numbers of Cisco (n = 26) and White Sucker (n = 16) were captured, while Freshwater Drum, Northern Pike, Yellow Perch and Walleye were only captured incidentally.

Species diversity and abundance were greatest in the Dauphin River catch with Lake Whitefish, Cisco, and White Sucker the dominant species. Lake Whitefish and White Sucker were the only species captured in Sturgeon Bay. In Buffalo Creek, Lake Whitefish, Northern Pike, White Sucker, and Yellow Perch were all captured in similar, relatively small numbers. Lake Whitefish were captured at all but one (EF-18 in the Dauphin River) electrofishing site (Table 7-8). The two most upstream sites in the Dauphin River (EF-18 and EF-19) and a site along the right side of an island produced the fewest Lake Whitefish despite an increased level of effort relative to most sites (Table 7-9), suggesting limited fall use of these areas by the species. Most Lake Whitefish were captured in velocity refugia, including the downstream lee of shoals, small islands and at the confluence with Buffalo Creek.

Lake Whitefish CPUE in the Dauphin River (20.3 fish/min) was several times higher than in Buffalo Creek (1.03) or Sturgeon Bay (1.84) (Table 7-10). Generally, CPUE in the Dauphin River was highest at sites in the vicinity of the confluence with Buffalo Creek (e.g., EF-1, EF-10-14, EF-16-17) or downstream of the confluence (e.g., EF-3). Large aggregations of Lake Whitefish were observed upstream of the confluence (as much as 9 km upstream), but typically at lower CPUE with increasing distance from Buffalo Creek. In addition, Lake Whitefish CPUE was highest during the first sampling period (14-15 Oct). Average CPUE at Dauphin River sites near the confluence with Buffalo Creek decreased from 102.5 fish/min during the earliest period to 51.6 fish/min from 20-21 October and 25.6 fish/min on 5 November (Table 7-10). In Sturgeon Bay, most Lake Whitefish were captured at the site nearest the outflow from the Dauphin River.

Table 7-7. Location, fishing effort, and electrofisher settings for boat electrofishing runs conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

Electrofishing Run	Date	Start Location [1, 2]		End Location [3]		Fishing Effort (secs)	Electrofisher Settings		
		Easting	Northing	Easting	Northing		Voltage	Amps	Pulses per Second
Dauphin River									
EF-1	14-Oct	562252	5754833	-	-	33	300	8	30
EF-2	14-Oct	563875	5755855	564070	5756255	110	300	8	30
EF-3	14-Oct	564010	5756555	563999	5756622	33	300	8	30
EF-8	14-Oct	559825	5755194	560137	5755146	78	300	8	30
EF-9	14-Oct	560411	5755142	560691	5755080	78	300	8	30
EF-10 [4]	14-Oct	562315	5754827	-	-	51	300	8	30
EF-11 [4]	15-Oct	562319	5754782	-	-	38	300	8	30
EF-12 [4]	15-Oct	562274	5754729	-	-	44	300	8	30
EF-13 [4]	15-Oct	562327	5754816	-	-	8	300	8	30
Sturgeon Bay									
EF-4	14-Oct	564603	5757147	564813	5757156	93	300	8	30
EF-5	14-Oct	564699	5757312	564778	5757666	528	300	8	30
EF-6	14-Oct	564541	5757742	565022	5758148	683	300	8	30
Buffalo Creek									
EF-7	14-Oct	562229	5754137	562194	5754512	408	1000	3	30
Dauphin River									
EF-14	20-Oct	-	-	-	-	25	300	8	30
EF-15	20-Oct	562211	5754971	562276	5754970	194	300	8	30
EF-16	20-Oct	562423	5755015	562750	5755075	32	300	8	30
EF-17	20-Oct	562249	5754830	-	-	32	300	8	30
EF-18	21-Oct	554293	5759061	554401	5759017	144	300	8	30
EF-19	21-Oct	554766	5758877	555061	5758778	186	300	8	30
EF-20	21-Oct	555693	5758508	555542	5758645	178	300	8	30
EF-21	21-Oct	556346	5757999	556467	5757969	103	300	8	30
Dauphin River									
EF-22	05-Nov	555241	5758844	555539	5758644	92	300	8	30
EF-23	05-Nov	555682	5758523	555777	5758424	131	300	8	30
EF-24	05-Nov	562088	5754794	-	-	73	300	8	30
EF-25	05-Nov	562116	5754799	562211	5754813	70	300	8	30
EF-26	05-Nov	562451	5754848	562728	5754882	182	300	8	30
EF-27	05-Nov	562575	5754816	562696	5754881	82	300	8	30

1 - UTM coordinates; NAD 83 Zone 14U

2 - location of electrofishing runs illustrated in Figure 7-12

3 - fish abundance and capture was so high at some locations that the boat did not move; consequently, no end location or track was recorded

4 - electrofishing run conducted in an area of very low water velocity in the mouth of Buffalo Creek

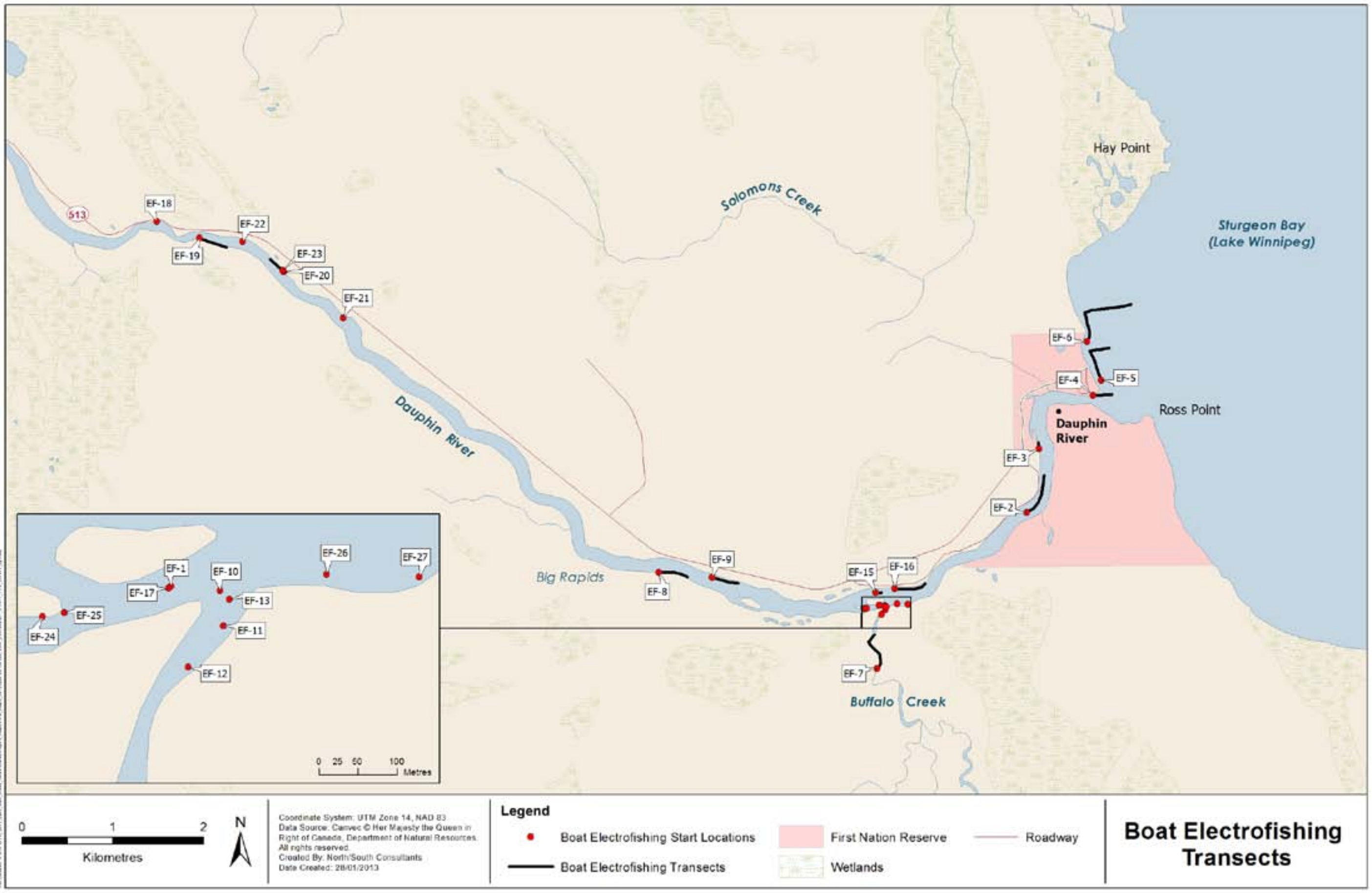

Figure 7-12. Location of boat electrofishing runs in conducted in eth Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

Table 7-8. Number (n) and relative abundance (%) of fish species captured during boat electrofishing runs conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

Species	Location						Overall	
	Dauphin River		Buffalo Creek		Sturgeon Bay			
	n	%	n	%	n	%	n	%
Cisco	26	3.6	-	-	-	-	26	3.4
Freshwater Drum	3	0.4	-	-	-	-	3	0.4
Lake Whitefish	675	94	2	29	38	95	715	93.5
Northern Pike	1	0.1	1	14	-	-	2	0.3
Walleye	1	0.1	-	-	-	-	1	0.1
White Sucker	12	1.7	2	29	2	5	16	2.1
Yellow Perch	0	0	2	29	-	-	2	0.3
Total	718	100	7	100	40	100	765	100

Table 7-9. Number of fish captured, by site, during boat electrofishing surveys conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

Run	Date	Species: Cisco	Freshwater Drum	Lake Whitefish	Northern Pike	Walleye	White Sucker	Yellow Perch	Overall
Sampling Period 1									
Dauphin River									
EF-1	14-Oct	-	-	25	-	-	-	-	25
EF-2	14-Oct	4	-	29	-	-	1	-	34
EF-3	14-Oct	-	-	34	-	-	-	-	34
EF-8	14-Oct	1	3	21	-	-	-	-	25
EF-9	14-Oct	4	-	33	-	-	3	-	40
EF-10	14-Oct	-	-	23	-	-	-	-	23
EF-11	15-Oct	-	-	36	-	-	1	-	37
EF-12	15-Oct	-	-	39	-	-	-	-	39
EF-13	15-Oct	-	-	44	-	-	-	-	44
	Total	*9*	*3*	*284*	*0*	*0*	*5*	*0*	*301*
Sturgeon Bay									
EF-4	14-Oct	-	-	27	-	-	-	-	27
EF-5	14-Oct	-	-	4	-	-	2	-	6
EF-6	14-Oct	-	-	7	-	-	-	-	7
	Total	*0*	*0*	*38*	*0*	*0*	*2*	*0*	*40*
Buffalo Creek									
EF-7	14-Oct	-	-	2	1	-	2	2	7
	Total	*0*	*0*	*2*	*1*	*0*	*2*	*2*	*7*
Sampling Period 2									
Dauphin River									
EF-14	20-Oct	1	-	28	-	-	-	-	29
EF-15	20-Oct	4	-	1	-	1	-	-	6
EF-16	20-Oct	1	-	25	-	-	1	-	27
EF-17	20-Oct	1	-	49	-	-	-	-	50
EF-18	21-Oct	-	-	-	-	-	1	-	1
EF-19	21-Oct	-	-	2	-	-	-	-	2
EF-20	21-Oct	-	-	33	1	-	1	-	35
EF-21	21-Oct	-	-	19	-	-	2	-	21
	Total	*7*	*0*	*157*	*1*	*1*	*5*	*0*	*171*
Sampling Period 3									
Dauphin River									
EF-22	05-Nov	-	-	44	-	-	-	-	44
EF-23	05-Nov	-	-	45	-	-	1	-	46
EF-24	05-Nov	1	-	39	-	-	-	-	40
EF-25	05-Nov	2	-	39	-	-	-	-	41
EF-26	05-Nov	3	-	30	-	-	-	-	33
EF-27	05-Nov	4	-	37	-	-	1	-	42
	Total	10	0	234	0	0	2	0	246
All Sampling Periods		26	3	675	1	1	12	0	718

Table 7-10. Catch-per-unit-effort (CPUE; # fish/60 seconds of fishing effort) by site and fish species for boat electrofishing surveys conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

Run	Date	Species							Overall
		Cisco	Freshwater Drum	Lake Whitefish	Northern Pike	Walleye	White Sucker	Yellow Perch	
Sampling Period 1									
Dauphin River									
EF-1	14-Oct	-	-	45.5	-	-	-	-	45.5
EF-2	14-Oct	2.2	-	15.8	-	-	0.5	-	18.5
EF-3	14-Oct	-	-	61.8	-	-	-	-	61.8
EF-8	14-Oct	0.8	2.3	16.2	-	-	-	-	19.2
EF-9	14-Oct	3.1	-	25.4	-	-	2.3	-	30.8
EF-10	14-Oct	-	-	27.1	-	-	-	-	27.1
EF-11	15-Oct	-	-	56.8	-	-	1.6	-	58.4
EF-12	15-Oct	-	-	53.2	-	-	-	-	53.2
EF-13	15-Oct	-	-	330.0	-	-	-	-	330.0
	Total	1.1	0.4	36.0	0.0	0.0	0.6	0.0	38.2
Sturgeon Bay									
EF-4	14-Oct	-	-	17.4	-	-	-	-	17.4
EF-5	14-Oct	-	-	0.5	-	-	0.2	-	0.7
EF-6	14-Oct	-	-	0.6	-	-	-	-	0.6
	Total	0	0.0	1.7	0.0	0.0	0.1	0.0	1.8
Buffalo Creek									
EF-7	14-Oct	-	-	0.3	0.1	-	0.3	0.3	1.0
	Total	0	0	0.3	0.1	0	0.3	0.3	1.0
Sampling Period 2									
Dauphin River									
EF-14	20-Oct	2.4	-	67.2	-	-	-	-	69.6
EF-15	20-Oct	1.2	-	0.3	-	0.3	-	-	1.9
EF-16	20-Oct	1.9	-	46.9	-	-	1.9	-	50.6
EF-17	20-Oct	1.9	-	91.9	-	-	-	-	93.8
EF-18	21-Oct	-	-	-	-	-	0.4	-	0.4
EF-19	21-Oct	-	-	0.6	-	-	-	-	0.6
EF-20	21-Oct	-	-	11.1	0.3	-	0.3	-	11.8
EF-21	21-Oct	-	-	11.1	-	-	1.2	-	12.2
	Total	0.5	0.0	10.5	0.1	0.1	0.3	0.0	11.5
Sampling Period 3									
Dauphin River									
EF-22	05-Nov	-	-	28.7	-	-	-	-	28.7
EF-23	05-Nov	-	-	20.6	-	-	0.5	-	21.1
EF-24	05-Nov	0.8	-	32.1	-	-	-	-	32.9
EF-25	05-Nov	1.7	-	33.4	-	-	-	-	35.1
EF-26	05-Nov	1	-	9.9	-	-	-	-	10.9
EF-27	05-Nov	2.9	-	27.1	-	-	0.7	-	30.7
	Total	1.0	0.0	22.3	0.0	0.0	0.2	0.0	23.4

Male and female Lake Whitefish in pre-spawn condition were captured at the onset of sampling in mid-October (October 14-15). Ripe males were identified the following week (October 20-21), comprising 62% of males captured during the time period. By November 5, almost all captured males were on the verge of spawning (95%). Ripe females were not abundant until November 5 (53% of females captured). The abundance of Lake Whitefish during the early sampling period in pre-spawn condition suggest these fish were possibly staging in velocity refugia prior to spawning in nearby habitat. Floy tags were applied to 691 Lake Whitefish (Appendix 7-1).

The following sections discuss the overall catch for each species where the number of fish captured was greater than ten. A summary of length, weight, condition factor and CPUE for all captured species are presented in Table 7-11.

Cisco

Cisco (n = 26) was the second most abundant species captured during fall electrofishing surveys, all of which were captured in the Dauphin River (Table 7-8). Relatively equal numbers of Cisco were captured during each sampling period in the Dauphin River (Table 7-9) with CPUE values ranging from 0.5 fish/minute during the October 20-21 survey to 1.1 fish/minute on the October 14-15 survey (Table 7-10). Mean length, weight and condition factor for Cisco were 250 mm, 339 g and 2.02, respectively (Table 7-11). The modal fork length interval of captured Cisco was 250-274 mm (Figure 7-13).

Lake Whitefish

Lake Whitefish (n = 715) was, by far, the most abundant species captured during fall electrofishing surveys, accounting for almost 94% of the total catch (Table 7-8). Most of these fish were captured in the Dauphin River, but small numbers were also captured in Buffalo Creek and Sturgeon Bay (Table 7-9). Peak catch and CPUE of Lake Whitefish in the Dauphin River occurred during the October 14-15 period while the fewest were captured in the October 20-21 period despite almost double the effort (Tables 7-9 and 7-10). Mean length, weight and condition factor for Lake Whitefish were 404 mm, 989 g and 1.49, respectively (Table 7-11). The modal fork length interval of captured Lake Whitefish was 400-424 mm with more than 75% of the catch in the 375-424 mm range (Figure 7-14).

White Sucker

White Sucker (n = 16) was the third most abundant species captured during fall electrofishing surveys (Table 7-8). Twelve were captured in the Dauphin River, primarily during the first two sampling periods, and two each were captured in Buffalo Creek and Sturgeon Bay (Table 7-9). The CPUE for White Sucker ranged from 0.2-0.6 fish/minute (Table 7-10). Mean length, weight and condition factor for White Sucker were 368 mm, 1086 g and 1.69, respectively (Table 7-11). The modal fork length interval of captured White Sucker was 400-424 mm (Figure 7-15).

Table 7-11. Fork length (mm), weight and condition factor (K) for species captured during electrofishing surveys conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

Species	Length (mm)				Weight				K			
	n[1]	Mean	SD[2]	Range	n	Mean	SD	Range	n	Mean	SD	Range
Cisco	26	250	32.8	176-312	21	339	126	100-600	21	2.02	0.38	1.11-2.75
Freshwater Drum	3	567	20.9	543-581	3	2867	153	2700-3000	3	1.58	0.10	1.51-1.69
Lake Whitefish	715	404	26.6	113-511	714	989	208	550-1900	714	1.49	0.17	0.74-2.12
Northern Pike	2	227	61.5	183-270	-	-	-	-	-	-	-	-
Walleye	1	500	-	-	1	1500	-	-	1	1.20	-	-
White Sucker	16	368	80.8	163-435	14	1086	302	200-1350	14	1.69	0.26	0.86-1.97
Yellow Perch	2	104	3.54	101-106	-	-	-	-	-	-	-	-

1 - n = number of fish measured; may not equal number captured.
2 - SD = standard deviation.

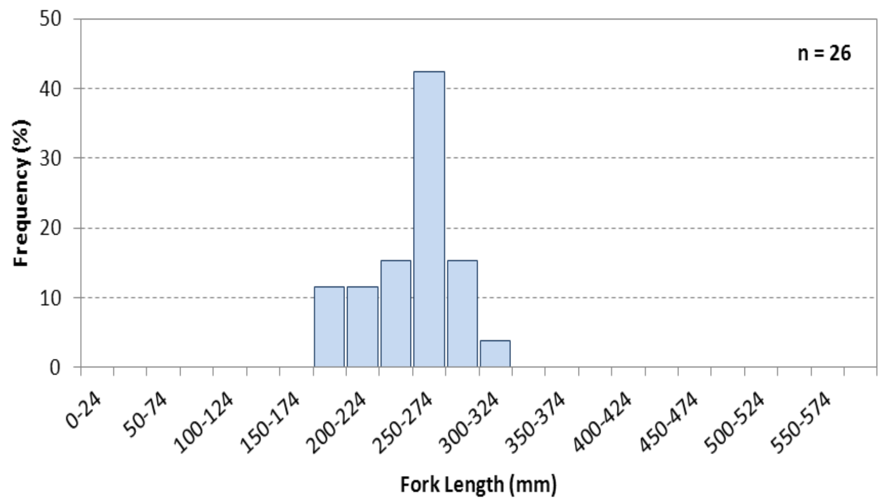

Figure 7-13. Length-frequency distribution for Cisco captured during boat electrofishing surveys conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

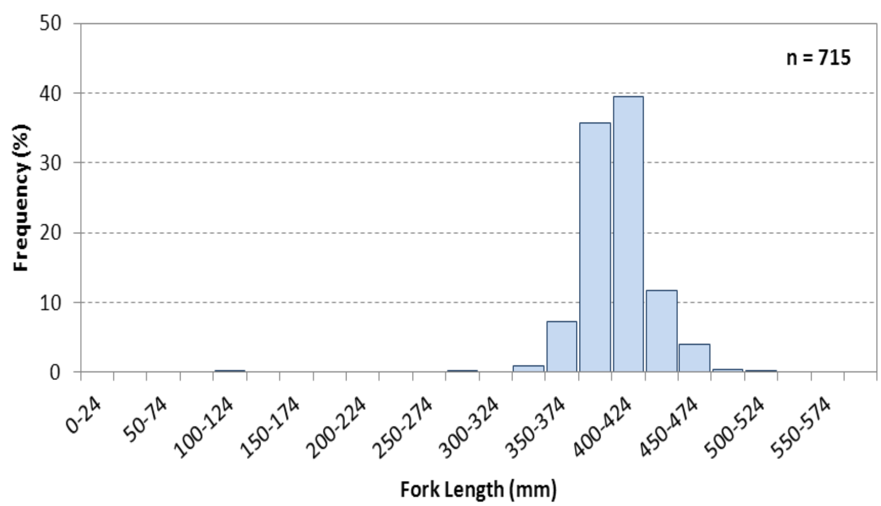

Figure 7-14. Length-frequency distribution for Lake Whitefish captured during boat electrofishing surveys conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

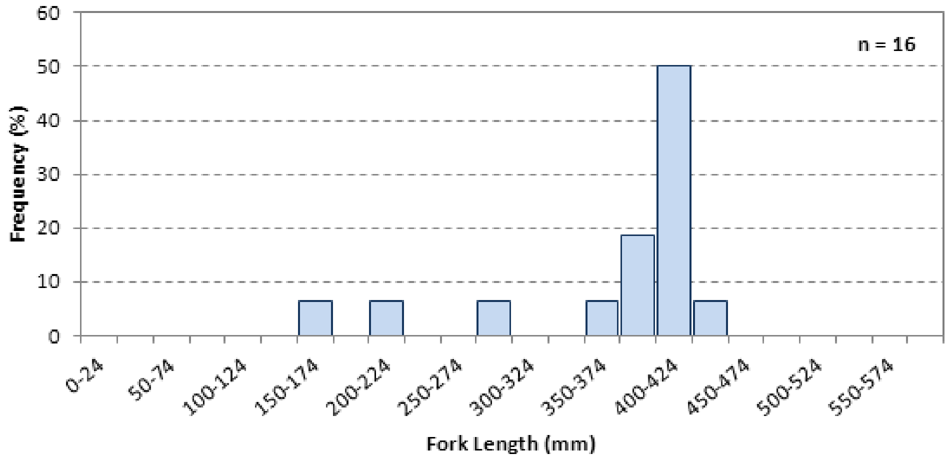

Figure 7-15. Length-frequency distribution for White Sucker captured during boat electrofishing surveys conducted in the Dauphin River, Sturgeon Bay, and Buffalo Creek during fall, 2011.

7.2.3 Spawning Activity

Twenty egg mats were deployed in the mouth of Buffalo Creek and in the Dauphin River (Table 7-11). Twelve mats were set October 29 - November 4 and eight mats November 5-15, 2011.

Ten egg mats were retrieved during the egg mat survey, nine of which captured 5,961 Lake Whitefish eggs. The remaining ten mats were not recovered (i.e. lost due to high flows). Eggs were detected in all sampling areas including 900 m downstream from Buffalo Creek and in and near the mouth of Buffalo Creek. Most eggs (n = 4,651) were captured at three sites in the Dauphin River just upstream from Buffalo Creek. One of these sites captured 3,729 eggs.

Females on the verge of spawning were first captured in abundance (53% of captured females) in the vicinity of Buffalo Creek on 05 November when almost all the captured males were also ripe and ready to spawn. Lake Whitefish eggs were captured on mats retrieved on 04 November, confirming that spawning had commenced in late October-early November in the vicinity of Buffalo Creek. Furthermore, egg abundance was much higher on mats retrieved on 15 November than on those retrieved earlier, suggesting that the bulk of spawning in the areas likely occurred during the first two weeks of November.

The much higher CPUE and more widely distributed aggregations of Lake Whitefish in pre-spawn condition during mid-October compared with results from early November when spawning was just beginning in the vicinity of Buffalo Creek may indicate that at least a portion of the captured Lake Whitefish were staging in the area before moving further upstream in the Dauphin River and into Lake St. Martin to spawn at other locations.

Table 7-12. Number of Lake Whitefish eggs captured on egg mats set in the Dauphin River and in the mouth of Buffalo Creek during fall, 2011.

Site ID	Location	Location [1]		Set Date	Pull Date	No. LKWH Eggs [2]
		Easting	Northing			
EM-1	Dauphin River	562983	5755318	29-Oct-11	04-Nov-11	30
EM-2	Dauphin River	562978	5755298	29-Oct-11	04-Nov-11	-
EM-3	Dauphin River	562988	5755345	29-Oct-11	04-Nov-11	-
EM-4	Dauphin River	562965	5755296	29-Oct-11	04-Nov-11	-
EM-5	Mouth of Buffalo Creek	562251	5754726	29-Oct-11	04-Nov-11	-
EM-6	Mouth of Buffalo Creek	562313	5754789	29-Oct-11	04-Nov-11	28
EM-7	Mouth of Buffalo Creek	562249	5754729	29-Oct-11	04-Nov-11	-
EM-8	Mouth of Buffalo Creek	562314	5754788	29-Oct-11	04-Nov-11	-
EM-9	Mouth of Buffalo Creek	562295	5754838	29-Oct-11	04-Nov-11	-
EM-10	Mouth of Buffalo Creek	562330	5754900	29-Oct-11	04-Nov-11	230
EM-11	Mouth of Buffalo Creek	562302	5754847	29-Oct-11	04-Nov-11	-
EM-12	Mouth of Buffalo Creek	562306	5754883	29-Oct-11	04-Nov-11	-
EM-13	Dauphin River	562299	5754904	05-Nov-11	15-Nov-11	740
EM-14	Upstream of Buffalo Creek	562107	5754835	05-Nov-11	15-Nov-11	62
EM-15	Upstream of Buffalo Creek	562128	5754778	05-Nov-11	15-Nov-11	860
EM-16	Upstream of Buffalo Creek	562204	5754763	05-Nov-11	15-Nov-11	3729
EM-17	Mouth of Buffalo Creek	562312	5754819	05-Nov-11	15-Nov-11	-
EM-18	Dauphin River	562224	5754922	05-Nov-11	15-Nov-11	242
EM-19	Downstream of Buffalo Creek	562424	5754849	05-Nov-11	15-Nov-11	0
EM-20	Downstream of Buffalo Creek	562716	5754879	05-Nov-11	15-Nov-11	40

1 - UTM coordinates; Zone 14U

2 - "-" indicates that the egg mat was not recovered from that site

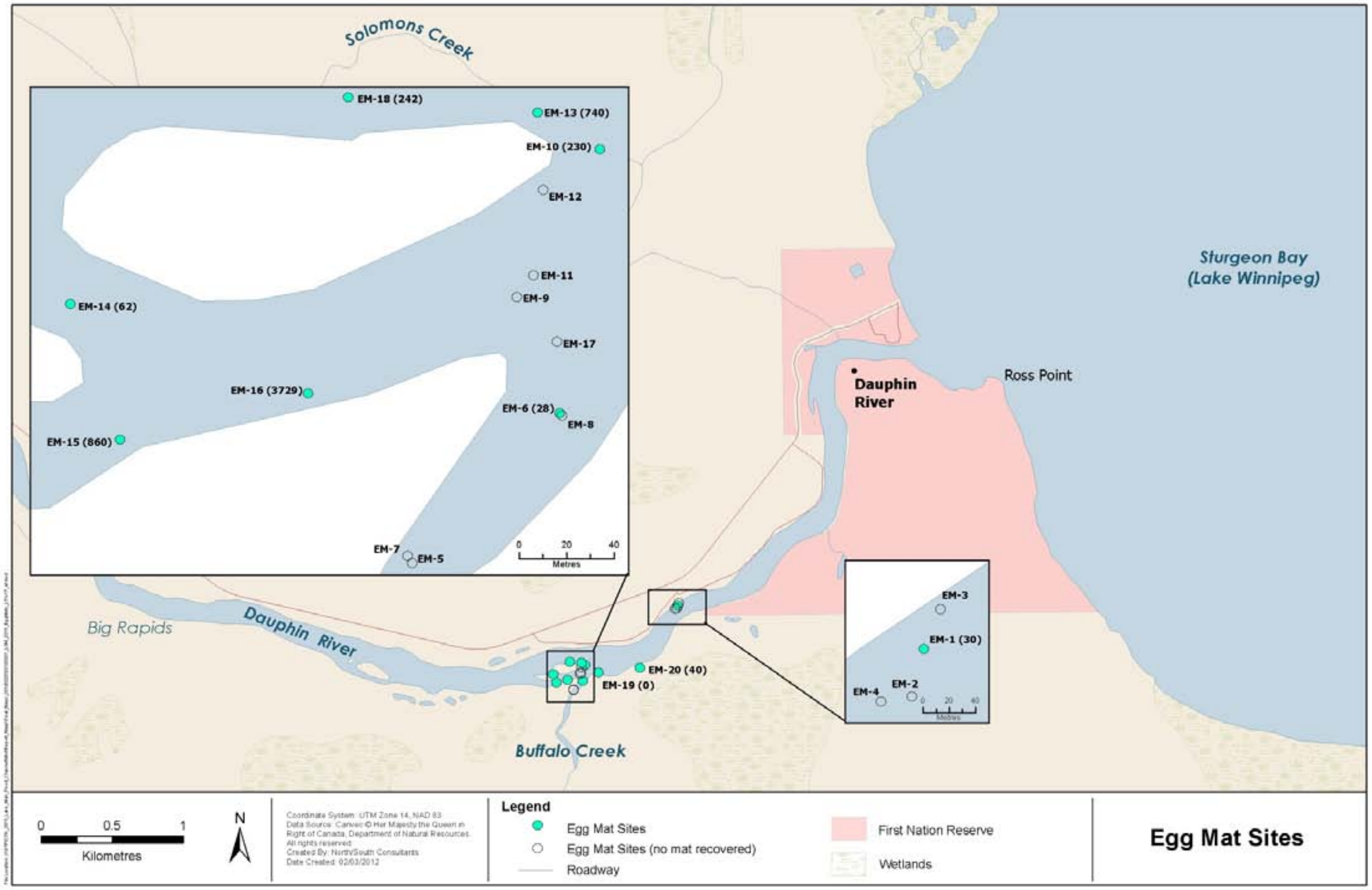

Figure 7-16. Location of egg mats set in the Dauphin River and Buffalo Creek during fall, 2011.

7.2.4 Debris Monitoring

Debris levels were obtained from four experimental gill nets set in Sturgeon Bay from 14 – 21 October, 2011 (Figure 7-5). Basic set information for the four gill nets is summarized in Table 7-3.

Three of the four experimental gill nets set in Sturgeon Bay in the fall of 2011 were long-duration (overnight) sets and one, the net set south of Willow Point, was short-duration. Of the three long-duration sets, two contained low levels of debris and one contained no debris (Table 7-13). Debris composition in the two nets consisted of 85% aquatic vegetation (weeds), followed by 10% terrestrial vegetation (grass) and 5% other (clam shells) (Table 7-13; Figure 7-17). The short-duration set contained a low level of debris that consisted of 50% grass and 50% weeds (Table 7-13).

Table 7-13. Net-specific debris level and composition in experimental gill nets set in Sturgeon Bay during fall, 2011.

Site	Set Duration (hrs)	Debris Level [1]	Debris Type (% of total debris per net)							Comments
			Terrestrial Vegetation	Terrestrial Moss	Sticks	Aquatic Vegetation	Algae	Silt/Mud	Other	
GN-01	18.8	Low	-	-	-	90%	-	-	10%	clam shells
GN-02	23.3	Low	20%	-	-	80%	-	-	-	-
GN-03	18.1	None	-	-	-	-	-	-	-	-
GN-04	2.1	Low	50%	-	50%	-	-	-	-	-

1 - debris level categories defined in Section 7.1.4

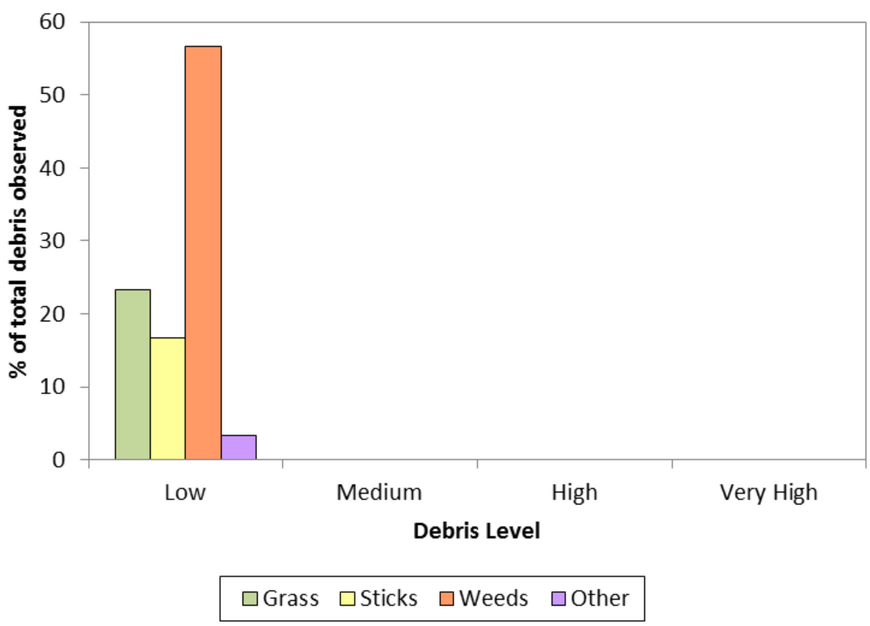

Figure 7-17. Relative composition of debris observed in three experimental gill nets set in Sturgeon Bay during fall, 2011. Note that one of four nets for which debris information was recorded had no debris in it.

7.3 SUMMARY

Water Temperature

Water temperature loggers were deployed on 19 October. Water temperature in the Dauphin River and Sturgeon Bay were between 6 and 7OC when the loggers were deployed and decreased to 0-1°C by mid-November.

Fish Utilization

Nine species of fish were captured, most of which occurred contiguously in the Dauphin River and Sturgeon Bay. Four standard experimental gillnet gangs in Sturgeon Bay captured 333 fish, comprising all nine species. Cisco, White Sucker, Northern Pike, and Lake Whitefish were the most abundant species. Species diversity and abundance were highest at two nets set near the mouth of the Dauphin River. Most Lake Whitefish captured were adult fish in a pre-spawn condition, including those fish captured near Willow Point.

Twenty-seven boat electrofishing runs were conducted in the Dauphin River, the lower-most reach of Buffalo Creek, and Sturgeon Bay in the vicinity of the Dauphin River during three sampling sessions during fall 2011. A total of 765 fish, comprising seven fish species, were captured during the electrofishing surveys with Lake Whitefish accounting for almost 94% of the catch. Most Lake Whitefish were captured in the Dauphin River in velocity refugia, including the downstream lee of shoals, small islands and at the confluence with Buffalo Creek. Male and female Lake Whitefish in early pre-spawn condition were captured at the onset of sampling in mid-October and, by November 5, most were in late pre-spawn condition.

Spawning Activity

Twenty egg mats were deployed in the mouth of Buffalo Creek and in the Dauphin River during fall 2011. Ten of these mats were successfully retrieved and sampled, producing a catch of 5,961 Lake Whitefish eggs. Most eggs were captured at three sites in the Dauphin River immediately upstream of the confluence with Buffalo Creek. The eggs were first captured on mats sampled on 04 November when large numbers of ripe females were observed during electrofishing surveys of the same area and egg abundance peaked on mats sampled on 15 November. The bulk of Lake Whitefish spawning in this reach of the Dauphin River during fall 2011 is thought to have occurred during the first two weeks of November.

Debris Monitoring

Debris levels were obtained from four experimental gill nets set in Sturgeon Bay from 14 – 21 October. Three nets contained low levels of debris and the fourth contained none. Debris consisted primarily of aquatic and terrestrial vegetation.

8.0 MERCURY CONCENTRATION IN FISH TISSUE

Operation of Reach 1 and consequent flooding of watercourses along the diversion route may result in increased loading of mercury and organic carbon (i.e., a food source for mercury methylating bacteria) to the aquatic environment and subsequent increased bioaccumulation of methylmercury in aquatic biota. The objectives of the mercury study were to:

- Document baseline mercury concentrations in commercially important fish species in Sturgeon Bay, prior to operation of Reach 1; and
- Monitor mercury concentrations in fish tissue during project operation and evaluate potential increases relative to baseline conditions.

To obtain baseline mercury concentrations in fish from Sturgeon Bay, muscle tissue samples were collected from Lake Whitefish, Northern Pike, and Walleye. These species are commonly selected in mercury monitoring programs because of their importance to commercial and domestic fisheries in Manitoba, because Pike and Walleye have relatively high mercury levels due to their position as top predators in the aquatic food chain, and because mercury concentrations for these species have historically been (Jansen and Strange 2007a) and currently are (CAMPP 2013) monitored in Manitoba ().

8.1 METHODS

8.1.1 Sample Selection and Processing

Fish for mercury analysis were collected during fish community sampling. An effort was made to collect 50 fish each of Lake Whitefish, Northern Pike, and Walleye. The individuals chosen for mercury analysis of these three species were to represent a broad size range and, as much as possible, provide an equal representation of size classes. Nets were set for various durations ranging from approximately 2-23 hours. Upon capture, large-bodied fish were measured for fork length (±1 mm) and total weight. Weight was recorded to ±50 g on an AccuWeight SM 410 (Yamato Scale Co., Ltd.) electronic pan balance. Fish were also examined internally to determine sex and maturity, and bony structures were removed for age analysis: otoliths were dissected from Lake Whitefish, dorsal spines were taken from Walleye, and cleithra were collected from Northern Pike. A portion of axial muscle weighing approximately 10-50 g was removed from each fish anterior to the caudal (tail) fin for mercury analysis. The muscle with skin attached was covered with cling-wrap, placed in a mercury-free Whirl-Pac bag with internal and external labeling, and stored on ice until it could be frozen.

8.1.2 Laboratory Analysis

Frozen muscle samples were shipped to ALS Laboratories (Winnipeg, MB) and analyzed for total mercury using an adaptation of US EPA Method 200.3 "Sample Procedures for Spectrochemical Determination of Total Recoverable Elements in Biological Tissues". Skin-off muscle samples were homogenized in a blender and sub-sampled (if necessary) prior to hot-block digestion with nitric and hydrochloric acids, in combination with repeated additions of hydrogen peroxide. Mercury quantification was by atomic fluorescence spectrophotometry, using a PS Analytical (Deerfield Beach, Florida) "Millenium Merlin" analyzer. The analytical detection limit (DL) of this method was 0.01 ppm for a sample weight of ≥ 2 g. Samples of three different standard (certified) reference materials (SRMs) were analyzed with each sample run:

- apple leaves (National Institute of Standards & Technology, NIST; https://www-s.nist.gov/srmors/view_cert.cfm?srm=1515; last accessed 10 June, 2011);
- lobster hepatopancreas (Tort-2; National Research Council Canada, NRC; http://www.nrc-cnrc.gc.ca/obj/inms-ienm/doc/crm-mrc/eng/TORT-2_e.pdf, last accessed 10 June, 2011; and,
- fish protein (DORM-3, NRC; http://www.nrc-cnrc.gc.ca/obj/inms-ienm/doc/crm-mrc/eng/DORM-3_e.pdf, last accessed 10 June, 2011.

In addition, several duplicate analyses of the same sample were run for quality control purposes.

Dried ageing structures of fish were prepared and analyzed using a variety of techniques (Mackay et al. 1990). Fin rays or spines were coated in epoxy and sectioned with a Struers microtome saw. Sections were then fixed on glass slides with Cytoseal 280 and fish ages were determined by examining the slides with a Wild M3 dissecting microscope. Otoliths were slightly polished on a whetstone, immersed in synthetic wintergreen oil, and viewed with a dissecting microscope. Cleithra were cleaned and examined under reflected light.

It should be noted that more than 90% of the total mercury in large-bodied boreal freshwater fish is in the form of methylmercury (Lockhart et al. 1972; Bloom 1992; Johnston et al. 2001). Total mercury was measured in the laboratory but is considered to be indicative of methylmercury because of the high proportion of total mercury that methylmercury comprises.

8.1.3 Data Analysis

Because fish accumulate mercury over their life time, so that older and, normally, larger individuals have higher levels than younger, smaller fish, mean mercury concentrations have been standardized to facilitate comparisons between samples of fish from the same location or between samples of fish from different waterbodies over time (Jansen and Strange 2007a). The standard lengths for Lake Whitefish, Northern Pike, and Walleye are 350, 550, and 400 mm, respectively.

In addition to arithmetic means, standardized mean mercury concentrations were calculated from unique regression equations for each species based on the analysis of logarithmic transformations of muscle mercury concentration and fork lengths using the following relationship:

$$\text{Log10}[Hg] = a + b\,(\text{Log10}L)$$

Where: [Hg] = muscle mercury concentration (µg/g);

L = fork length (mm);

a = Y-intercept (constant); and,

b = slope of the regression line (coefficient).

To present data in more familiar units, all standardized means and their confidence limits were retransformed to arithmetic values.

8.2 RESULTS

8.2.1 Mean Size and Age

A total of 33 Lake Whitefish, 45 Northern Pike, and 18 Walleye captured during fall gillnetting surveys were analysed for age. Northern Pike sampled for mercury had a mean length almost identical to the standard length of 550 mm, whereas Lake Whitefish were on average larger and Walleye were on average smaller than the standard length for those species (Table 8-1). Pike, Walleye, and Whitefish for which mercury analyses were conducted had mean ages of 5.4, 3.9 years, and 7.6, respectively (Table 8-1). Age-specific mean size and condition factor for each species are provided in Tables 8-2 to 8-4.

Size and condition factor at age for each species are presented in Tables 8-2 to 8-4, Appendix 8-1 includes biological variables for individual fish.

8.2.2 Mercury

The sample target size of 50 fish was nearly obtained for Northern Pike; Lake Whitefish and, particularly Walleye, had sample sizes that were considerably lower than the desired target.

Quality Control/Quality Assurance

Standard/certified reference materials (SRM) analyzed by ALS Laboratories during each fish muscle sample run had mean mercury concentrations that differed from the mean certified value by 3.8% on average (range 0-11%). The mean difference in mercury concentrations between duplicate analyses of the same sample was 5.7% with a range of 0.6 to 16.0% (see Appendix 8-1).

Mercury Concentration

Mean arithmetic and length standardized mercury concentrations of all three fish species were similar, reflecting the fact that mean lengths were close to the standard length for the species and/or that the length distribution of sampled fish within a species was reasonably balanced (i.e., similar numbers of smaller and larger fish were sampled). Only standardized means will be discussed further.

Mercury concentrations in fish from Sturgeon Bay were generally low. Pike and Walleye had mean concentrations of 0.17 ppm and 0.20 ppm (Table 8-5), respectively. Both were substantially below the Health Canada standard for commercial marketing of freshwater fish in Canada (Health Canada 2007) and were below the 0.2 ppm guideline originally instituted as a “safe consumption limit” for people eating “large quantities of fish” (Wheatley 1979). Although no longer officially recognized, the 0.2 ppm guideline is still considered for domestic consumption by Health Canada today (Ross Wilson, Wilson Scientific Consulting, Vancouver, Canada, pers. comm., January 2012). Even the largest (770-820 mm Pike; 440-480 mm Walleye) and oldest (7-8 year Pike; 5-6 year Walleye) fish had muscle concentrations of less than 0.4 ppm mercury. The mean mercury concentration in sampled Lake Whitefish was 0.04

ppm (Table 8-5), substantially lower than than Walleye and Northern Pike. Only one of the largest (456 mm) and oldest (15 years) Lake Whitefish sampled exceeded a mercury concentration of 0.10 ppm.

Mercury concentrations in all three species from the Sturgeon Bay area of Lake Winnipeg are generally similar to those recently documented for other areas of the lake. Results from the Province of Manitoba/Manitoba Hydro's Coordinated Aquatic Monitoring Pilot Program (CAMP) for 2010 show standardized mean mercury concentrations of Lake Whitefish (0.01 ppm), Walleye (0.11 ppm), and Northern Pike (0.22 ppm, arithmetic mean) from Mossy Bay to be the lowest or among the lowest of the 24 Manitoba waterbodies surveyed that year (CAMP 2013). Although the concentrations obtained for Walleye and Whitefish from Sturgeon Bay are significantly higher than those of their conspecifics from Mossy Bay, they are still in the lower third of concentrations of the representative samples of Manitoba lakes and rivers analyzed for fish mercury under CAMP.

Mean weights and condition factors of all three species (Tables 8-1 to 8-3) were similar to those for fish sampled for mercury analysis from other waterbodies in Manitoba (CAMPP 2013).

Table 8- 1. Mean (± standard error, SE) fork length, round weight, condition (K), and age of Northern Pike, Walleye, and Lake Whitefish sampled for mercury from Lake Winnipeg, Sturgeon Bay in 2011.

Species	n	Length (mm)	Weight (g)	K	Age (years)
Northern Pike	45[1]	550.8 ± 19.2	1573.5 ± 139.0	0.77 ± 0.01	5.4 ± 0.3
Walleye	18[2]	359.6 ± 27.8	822.6 ± 137.9	1.22 ± 0.04	3.9 ± 0.4
Lake Whitefish	33[3]	391.6 ± 9.8	953.9 ± 41.0	1.48 ± 0.03	7.6 ± 0.6

1 - n = 43 for weight and K
2 - n = 16 for weight and K
3 - n = 32 for weight and K

Table 8-2. Fork length, weight and condition factor (K), by age class, for Lake Whitefish captured in experimental gill nets set in Sturgeon Bay, fall 2011.

Age	Fork Length (mm)				Weight (g)				K			
	n[1]	Mean	SD[2]	Range	n	Mean	SD	Range	n	Mean	SD	Range
1	0	-	-	-	0	-	-	-	0	-	-	-
2	1	141	-	-	0	-	-	-	0	-	-	-
3	0	-	-	-	0	-	-	-	0	-	-	-
4	1	396	-	-	1	1000	-	-	1	1.61	-	-
5	1	375	-	-	1	900	-	-	1	1.71	-	-
6	13	381	37	280-421	13	813	209	400-1100	13	1.45	0.17	1.22-1.82
7	10	402	16	370-429	10	955	164	700-1200	10	1.46	0.12	1.33-1.68
8	0	-	-	-	0	-	-	-	0	-	-	-
9	1	408	-	-	1	1150	-	-	1	1.69	-	-
10	0	-	-	-	0	-	-	-	0	-	-	-
11	1	438	-	-	1	1100	-	-	1	1.31	-	-
12	0	-	-	-	0	-	-	-	0	-	-	-
13	1	440	-	-	1	1100	-	-	1	1.29	-	-
14	0	-	-	-	0	-	-	-	0	-	-	-
15	4	438	34	386-456	4	1288	193	1100-1500	4	1.56	0.34	1.16-2.00
Total	33	392	56	141-456	32	954	232	400-1500	32	1.48	0.18	1.16-2.00

1 - n = number of fish sampled; may not equal total number captured
2 - SD = standard deviation

Table 8-3. Fork length, weight and condition factor (K), by age class, for Northern Pike captured in experimental gill nets set in Sturgeon Bay, fall 2011.

Age	Fork Length (mm)				Weight (g)				K			
	n[1]	Mean	SD[2]	Range	n	Mean	SD	Range	n	Mean	SD	Range
1	2	221	15	210-231	0	-	-	-	0	-	-	-
2	1	235	-	-	1	75	-	-	1	0.58	-	-
3	1	340	-	-	1	150	-	-	1	0.38	-	-
4	10	494	51	423-568	10	960	278	600-1400	10	0.78	0.06	0.69-0.90
5	11	538	36	476-610	11	1205	251	900-1700	11	0.77	0.05	0.67-0.83
6	9	598	43	524-640	9	1706	385	1100-2200	9	0.79	0.07	0.66-0.87
7	7	651	62	572-771	7	2275	802	1475-3950	7	0.80	0.03	0.77-0.86
8	2	808	14	798-818	2	4175	389	3900-4450	2	0.79	0.03	0.77-0.81
9	0	-	-	-	0	-	-	-	0	-	-	-
10	1	634	-	-	1	2250	-	-	1	0.88	-	-
11	0	-	-	-	0	-	-	-	0	-	-	-
12	1	720	-	-	1	2700	-	-	1	0.72	-	-
13	0	-	-	-	0	-	-	-	0	-	-	-
14	0	-	-	-	0	-	-	-	0	-	-	-
15	0	-	-	-	0	-	-	-	0	-	-	-
Total	45	551	129	210-818	43	1573	912	75-4450	43	0.77	0.09	0.38-0.90

1 - n = number of fish sampled; may not equal total number captured
2 - SD = standard deviation

Table 8-4. Fork length, weight and condition factor (K), by age class, for Walleye captured in experimental gill nets set in Sturgeon Bay, fall 2011.

Age	Fork Length (mm)				Weight (g)				K			
	n[1]	Mean	SD[2]	Range	n	Mean	SD	Range	n	Mean	SD	Range
1	0	-	-	-	0	-	-	-	0	-	-	-
2	5	220	64	164-328	4	200	204	50-500	4	1.27	0.19	1.08-1.45
3	4	296	31	251-322	3	300	50	250-350	3	1.01	0.24	0.75-1.22
4	1	438	-	-	1	1000	-	-	1	1.19	-	-
5	4	467	14	455-486	4	1300	147	1150-1500	4	1.27	0.04	1.22-1.31
6	4	471	9	458-479	4	1313	193	1200-1600	4	1.26	0.15	1.12-1.46
7	0	-	-	-	0	-	-	-	0	-	-	-
8	0	-	-	-	0	-	-	-	0	-	-	-
9	0	-	-	-	0	-	-	-	0	-	-	-
10	0	-	-	-	0	-	-	-	0	-	-	-
11	0	-	-	-	0	-	-	-	0	-	-	-
12	0	-	-	-	0	-	-	-	0	-	-	-
13	0	-	-	-	0	-	-	-	0	-	-	-
14	0	-	-	-	0	-	-	-	0	-	-	-
15	0	-	-	-	0	-	-	-	0	-	-	-
Total	18	460	137	164-486	16	822	553	50-1600	16	1.21	0.17	0.75-1.46

1 - n = number of fish sampled; may not equal total number captured

2 - SD = standard deviation

Table 8-5. Mean arithmetic (± standard error, SE) and standardized (95% confidence limits, C.L.) mercury concentrations (ppm) for Northern Pike, Walleye, and Lake Whitefish from Lake Winnipeg, Sturgeon Bay in 2011.

Species	n	Arithmetic	SE	Standard	95% C.L.
Northern Pike	45	0.170	0.011	0.170	0.146 - 0.196
Walleye	18	0.200	0.016	0.188	0.130 - 0.273
Lake Whitefish	33	0.039	0.003	0.039	0.029 - 0.053

.

Table 8-5. Mean (± standard error, SE) fork length, round weight, condition (K), and age of Northern Pike, Walleye, and Lake Whitefish sampled for mercury from Lake Winnipeg, Sturgeon Bay in 2011.

Species	n	Length (mm)	Weight (g)	K	Age (years)
Northern Pike	45[1]	550.8 ± 19.2	1573.5 ± 139.0	0.77 ± 0.01	5.4 ± 0.3
Walleye	18[2]	359.6 ± 27.8	822.6 ± 137.9	1.22 ± 0.04	3.9 ± 0.4
Lake Whitefish	33[3]	391.6 ± 9.8	953.9 ± 41.0	1.48 ± 0.03	7.6 ± 0.6

1 - n=43 for weight and K

2 - n=16 for weight and K

3 - n=32 for weight and K

8.3 SUMMARY

The bioaccumulation of mercury in fish tissue was studied in Sturgeon Bay during fall 2011 due to the potential for flooding of watercourses as a result of Reach 1 operation increasing the loading of mercury and organic carbon into project waterbodies.

A total of 33 Lake Whitefish, 45 Northern Pike, and 18 Walleye captured during fall gillnetting surveys were analysed for age. Northern Pike sampled for mercury had a mean length almost identical to the standard length of 550 mm, whereas Lake Whitefish were on average larger and Walleye were on average smaller than the standard length for those species. Pike, Walleye, and Whitefish for which mercury analyses were conducted had mean ages of 5.4, 3.9 years, and 7.6, respectively.

Mercury concentrations in fish from Sturgeon Bay were generally low and similar to those recently documented for other areas of Lake Winnipeg. Concentrations, even in the largest fish, were typically lower than the Health Canada standard for commercial marketing of freshwater fish in Canada and most were lower than the now unofficial “safe consumption limit” for people eating “large quantities of fish”.

9.0 LOCAL KNOWLEDGE

At the onset of the Project, it was recognized that knowledge collected from local people (commercial fishers and First Nations) could considerable information about the existing aquatic environment, and would be of value in assessing and possibly mitigating project-related impacts.

9.1 METHODS

Information relating to biology and harvesting activities was collected from a series of meetings held as part of the community consultation process undertaken by Manitoba Infrastructure and Transportation, Aboriginal Affairs and Northern Development Canada, and Manitoba Aboriginal and Northern Affairs. While emphasis of the meetings was to present the Project, Project updates, and pre-Project assessments of possible Project-related environmental effects on local waterbodies to the communities, some discussion regarding fish and fishing activities did occur.

Meetings included the following:

- The Project description (including construction plans), a preliminary assessment of potential effects due to operation of Reach 1, the aquatic studies workplan, and an update on ongoing aquatic study results were presented to commercial fishermen (meeting at Gypsumville; 06 October 2011);

- The Project description (including construction update and plans), a preliminary assessment of potential effects due to operation of Reach 1, the aquatic studies workplan, and an update on ongoing aquatic study results were presented to Pinaymootang First Nation council (meeting at Fairford; 11 October 2011);

- The Project description (including construction update and plans), a preliminary assessment of potential effects due to operation of Reach 1, the aquatic studies workplan, and an update on ongoing aquatic study results were presented to Pinaymootang First Nation community members (meeting at Fairford; 03 November, 2011);

- The Project description (including construction update and plans), a preliminary assessment of potential effects due to operation of Reach 1, the aquatic studies workplan, and an update on ongoing aquatic study results were presented to Dauphin River First Nation community members (meeting at Winnipeg; 12 December, 2011); and,

- The Project description (including construction update and plans), a preliminary assessment of potential effects due to operation of Reach 1, the aquatic studies workplan, and an update on ongoing aquatic study results were presented to Dauphin River First Nation community members (meeting at Dauphin River; 11 January, 2012).

Local knowledge was generally collected on an opportunistic basis; formal questionnaires were not developed. Instead, information was often obtained during discussions regarding some aspect of the Project. The intent was to conduct a mapping session following each meeting, where participants would be encouraged to record known areas of importance or interest. Emphasis was placed on identifying important areas as they related to fish biology or fish harvest (domestic or commercial fishing), but other information was collected as well.

9.2 RESULTS

Most local knowledge was collected during the meeting held in Gypsumville on 06 October. This was the only meeting where there was an opportunity to sit down following the meeting to discuss areas of interest with meeting participants. At meetings other than on 06 October, most attendees left immediately afterwards.

Information pertaining to fish biology and fish harvest activities is illustrated in Figures 9-1 and 9-2. Other biological information collected at the 06 October meeting is presented in the meeting notes, contained in Appendix 9-1.

Comment [WB1]: Add to this?

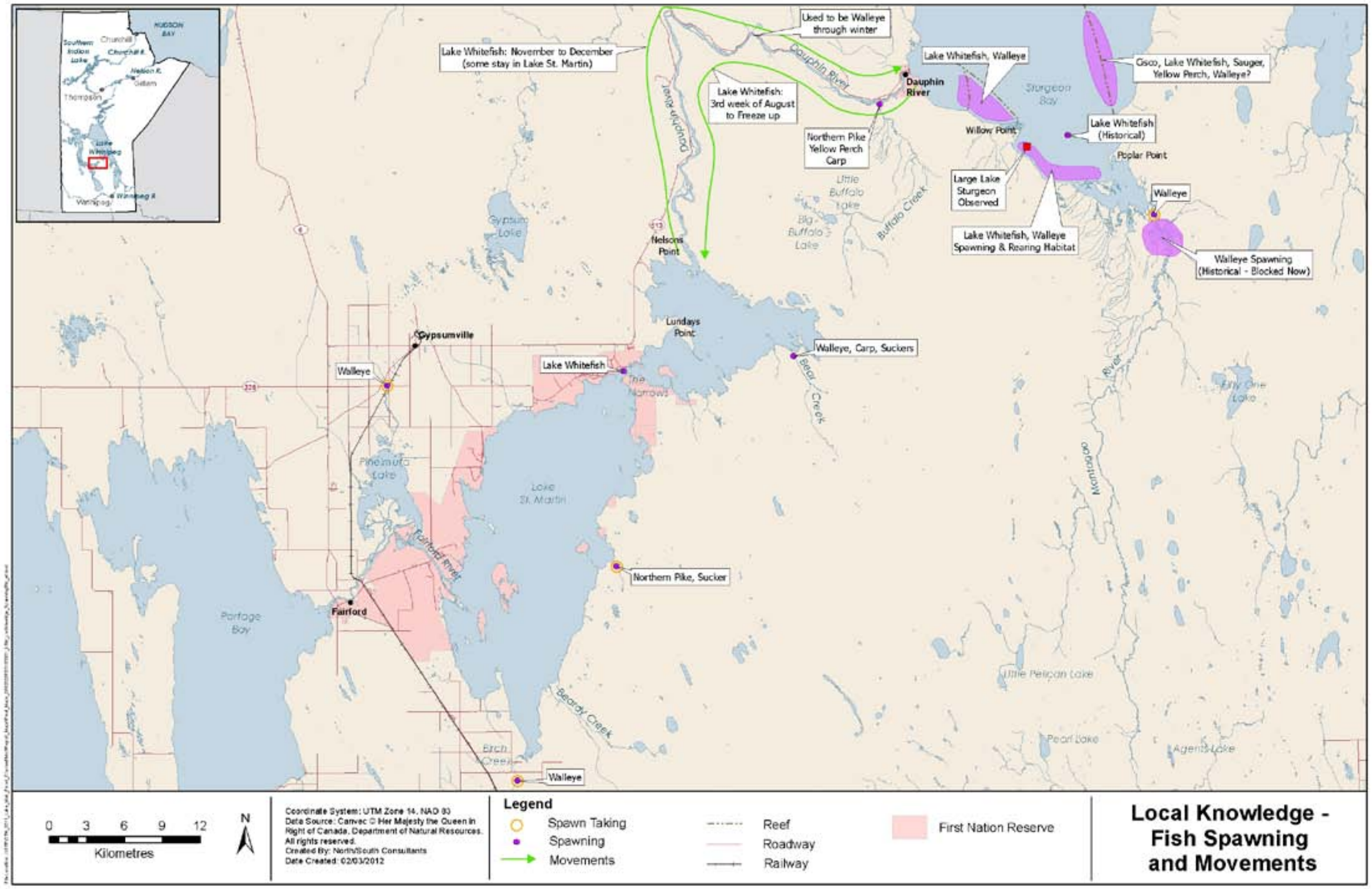

Figure 9- 1. Biological information collected during a community consultation meeting in Gypsumville, 06 October, 2011.

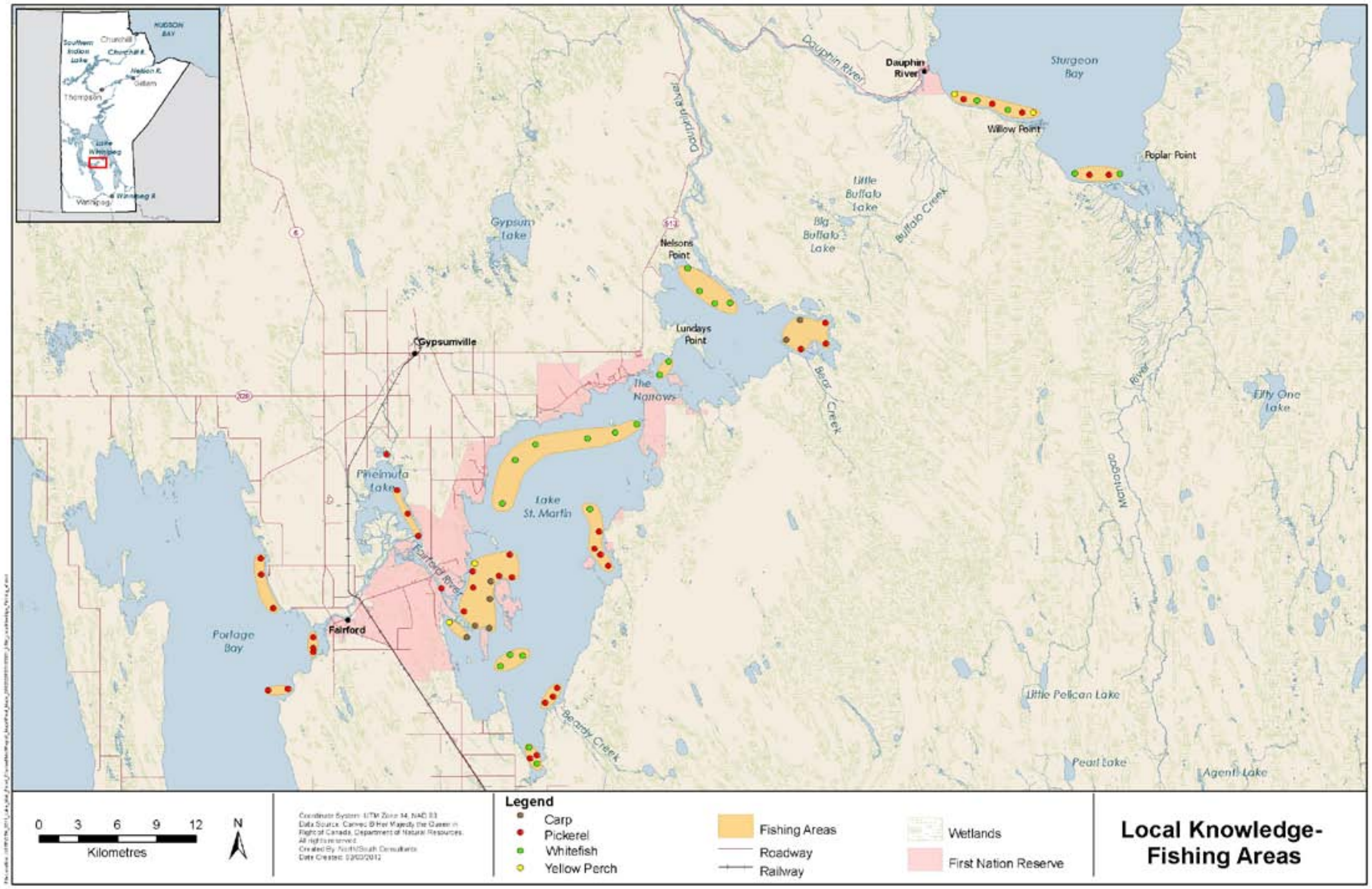

Figure 9- 2. Fish harvest locations collected during a community consultation meeting in Gypsumville, 06 October, 2011.

10.0 REFERENCES

AECOM. 2012. Lake St. Martin Emergency Outlet Channel Environmental Monitoring Final Report. A memorandum from AECOM to Manitoba Infrastructure and Transportation. February 12, 2012.

Bisson, P. A., J. L. Nielsen, R. A. Palmason, and L. E. Grove. 1982. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. Pages 62-73 in N. B. Armantrout, editor. Acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Western Division, Bethesda, Maryland.

Bloom, N. S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Can. J. Fish. Aquat. Sci. 49:1010-1017.

British Columbia Ministry of Environment, Lands, and Parks (BCMELP). 1998. Guidelines for interpreting water quality data. Version 1, May 1998. Prepared for the Land Use Task Force Resource Inventory Committee.

CAMPP (Coordinated Aquatic Monitoring Pilot Program). 2013. Three Year Summary Report. Report prepared for the Manitoba/Manitoba Hydro CAMP MOU Working Group by North/South Consultants.

Canadian Council of Ministers of the Environment (CCME). 1999 (Updated to 2012). Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg.

Graveline, P.G., and B.D. Horne. 1998. Norway House Commercial Fishery Debris Monitoring Program – Five Year Summary Report. 1993-1997. A report prepared for Manitoba Hydro, The Province of Manitoba, and the Norway House Commercial Fishermen’s Cooperative by North/South Consultants Inc. ix + 48 p.

Health Canada. 2007. Human health risk assessment of mercury in fish and health benefits of fish consumption. Health Canada: Bureau of Chemical Safety, Food Directorate, Health Products and Food Branch, Ottawa, Ont., 69 pp.

Jansen, W. and N.E. Strange. 2007a. Mercury in fish in northern Manitoba reservoirs: results from 2005 sampling and a summary of monitoring data from 1975-2005. Report by North/South Consultants Inc., Winnipeg, MB for Manitoba Hydro, 102 pp.

Jansen, W. and N.E. Strange. 2007b. Mercury concentrations in fish from the Keeyask project study area for 1999-2005. Report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, 152 pp.

Johnston, T.A., R.A. Bodaly, M.A. Latif, R.J.P. Fudge, and N.E. Strange. 2001. Intra- and interpopulation variability in maternal transfer of mercury to eggs of walleye (*Stizostedion vitreum*). Aquatic Toxicology 52: 73-85

KGS and AECOM. 2011. Analysis of options for emergency reduction of Lake Manitoba and Lake St. Martin levels. Manitoba Infrastructure and Transportation. 15 p.

La Haye, Michel, S. Desloges, C. Cote, J. Deer, S. Philips Jr., B. Giroux, S. Clermont, and P. Dumont. 2003. Location of lake sturgeon (Acipenser fulvescens) spawning grounds in the upper part of the Lachine rapids (St. Lawrence River). Study carried out on behalf of the Societe de la faune et des parcs du Quebec, Dirrection d l'amenagement de la faune de Montreal, de Laval et de la Monteregie, Longuieuil. Technical Report 16-15E. ix + 43 p.

Lockhart, W. L., J. F. Uthe, A. R. Kenney, and P. M. Mehrle. 1972. Methylmercury in northern pike (*Esox lucius*): distribution, elimination, and some biochemical characteristics of contaminated fish. J. Fish. Res. Board. Can. 29:1519 1523.

Manny, B.A., G.W. Kennedy, J.D. Allen, and J.R.P. French III. 2007. First evidence of egg deposition by walleye in the Detroit River. Journal of Great Lakes Research **33**: 512-513.

Mackay, W.C., G.R. Ash, and H.J. Norris (eds.). 1990. Fish ageing methods for Alberta. R.L. & L. Environmental Services Ltd., Edmonton, AB. 113 p.

McDougall, C. A. and D.S. MacDonell. 2009. Results of Lake Sturgeon Studies in the Slave Falls Reservoir and Pointe du Bois Forebay - 2008. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, Manitoba. 255 pp. #5811.08-04.

Manitoba Water Stewardship (MWS). 2010. Fairford Dam Operation. http://www.gov.mb.ca/waterstewardship/floodinfo/forecast_centre/reservoirs_dams/general_dam_inform_operation_targets/fairford_dam.pdf. Accessed August 10, 2011.

Manitoba Water Stewardship (MWS). 2011. Manitoba Water Quality Standards, Objectives, and Guidelines. Manitoba Water Stewardship Report 2011-01. July 4, 2011. 68 pp.

North/South Consultants Inc. 2011a. Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels – Existing Aquatic Environment, Potential Impacts, and Work Plan. A draft report prepared for Manitoba Infrastructure and Transportation by North/South Consultants Inc. (23 September 2011). xiv + 87 p.

North/South Consultants Inc. 2011b. Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels - Baseline Data Collection and Monitoring Plan for DFO. A draft monitoring plan prepared for Manitoba Infrastructure and Transportation by North/South Consultants Inc. (23 September 2011). iv + 20 p.

North/South Consultants Inc. 2012. Manitoba/Manitoba Hydro Coordinated Aquatic Monitoring Pilot Program (CAMPP): Three Year (2008-2010) Review. A draft report prepared for Manitoba and Manitoba Hydro by North/South Consultants Inc. xiii + 2425 p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Can. Bull. Fish. Aquat. Sci. 191. 382 p.

Schetagne R. and R. Verdon. 1999. Mercury in fish of natural lakes of Québec. In: "Mercury in the Biochemical Cycle", Lucotte, M., Schetagne, R., Thérien, N., Langlois, C., and Trembley, A., eds., Springer, Berlin, p. 115-130.

Thompson, A.L. 2009. Walleye habitat use, spawning behavior, and egg deposition in Sandusky Bay, Lake Erie. Master's thesis. Ohio State University, Columbus.

Wheatley, B. 1979. Methylmercury in Canada; exposure of Indian and Inuit residents to methylmercury in the Canadian environment. Health and Welfare Canada, Medical Service Branch, Ottawa, ON. 200 pp.