Fisheries and Aquatic Habitat Baseline Assessment

2016

Lake Manitoba Outlet Channel Route Options

Report Prepared by:

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Fisheries and Aquatic Habitat Assessment:

Lake Manitoba
Outlet Channel Routes Project

November 2016

Prepared for:

M. Forster Enterprises

for Submission to:

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November 30, 2016

Ms. Maureen Forster
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Dear Ms. Forster:

RE: Fisheries and Aquatic Assessment: Lake Manitoba Outlet Channel Routes Project

As requested, AAE Tech Services Inc. has completed a fisheries and aquatic habitat assessment of the Lake Manitoba and Lake St. Martin areas of concern in relation to Manitoba infrastructure's proposed diversion channel routes C and D. Fieldwork was conducted during the fall of 2015 and spring of 2016 at all intersections between the two proposed channel routes and present waterways, including two sites each on Lake Manitoba and Lake St. Martin, as well as along Birch Creek, Watchorn Creek, and Mercer Creek. Included herein are descriptions of methods and results of the analysis of habitat, water quality, fish distribution and composition, and benthic invertebrates. Recommendations in regards to channel route selection, additional work going forward, and mitigating adverse impacts to fish and aquatic habitat within these systems are also provided.

If you require additional information or have any questions regarding the attached report please feel free to contact myself at 204-997-3483 or via email at mlowdon@aaetechservices.ca

Sincerely,

Mark Lowdon
Fisheries Biologist
AAE Tech Services Inc.

EXECUTIVE SUMMARY

In response to the events and damage transpiring from the 2011 and 2014 Assiniboine River floods, a Lake Manitoba outlet channel was proposed to mitigate future flooding by accelerating the diversion of floodwater from Lake Manitoba into Lake St. Martin. After evaluation of several route options, two channel routes, Routes C and D, have been selected as the most suitable channel options to achieve this goal. Route C is an 11.6 km channel connecting Portage Bay on Lake Manitoba with a point on Lake St. Martin located approximately 4.5 km north of Hilbre. Route D is a 24.0 km channel connecting Watchorn Bay on Lake Manitoba to the outlet of Birch Creek on Lake St. Martin. As part of the final step in route selection, an assessment of numerous factors, including a systematic environmental review, are to be carried out. Little is known about the habitat to be affected by channel construction on either route and the resulting short and long term environmental impacts as a result of the project.

As part of this environmental baseline assessment, AAE Tech Services has completed a fisheries and aquatic habitat assessment of the localized and regional areas on Lake Manitoba and Lake St. Martin potentially impacted as a result of channel construction. The assessment encompassed all waterways intersecting both channel routes, including two sites on both Lake Manitoba and Lake St. Martin. Results of this assessment will be used to provide baseline data and identify concerns which will be considered in the selection and modification of Lake Manitoba Outlet Routes C or D and will enable future monitoring efforts at the affected sites.

Study sites were identified according to location. The two Lake Manitoba channel inlet sites are located approximately 2.0 km south of the outlet into the Fairford River (Route C) and within Watchorn Bay (Route D), referred to in this report as the Fairford and Watchorn Bay sites, respectively. The two Lake St. Martin outlet sites are located 1 km north of Harrison Creek (Route C) and at Birch Bay immediately north of Birch Creek (Route D), referred to in this report as the Harrison Bay and Birch Bay sites, respectively. Data collection was also completed on four tributaries linked to these sites: Birch Creek (Birch Bay site), Watchorn Creek (Watchorn Bay site), Mercer Creek (Watchorn Bay site), and Harrison Creek (Harrison Bay site).

Fieldwork was completed during the fall of 2015 and spring of 2016. Baseline data was collected to investigate five major environmental components:

1. Desktop review of potential protected species inhabiting the area,
2. Aquatic and riparian habitat assessment,
3. Baseline water quality measures,
4. Fish distribution and composition, and
5. Benthic invertebrate analysis.

Habitat assessment included a bathymetric survey, including an analysis of depth, substrate, and vegetation cover at each study site, and cross-sectional profiles of each tributary. Baseline water quality variables measures were collected, including temperature, dissolved oxygen, pH, conductivity, turbidity, and total suspended solids. Fish distribution and composition was assessed through boat and backpack electrofishing surveys, gill net sets, hoop netting, larval fish net tows, egg mat sampling, and kick net sampling. Fall fish sampling was performed using fewer, shorter set times to avoid disrupting the migratory patterns of Lake Whitefish, a commercially important fall-spawning species previously documented to be utilizing the lakes. Benthic macroinvertebrates were collected and identified as an indicator of water quality and ecosystem health. Results were tabulated, compiled, and are presented in this report for each study site.

Fairford Study Site – Lake Manitoba, Route C

The Fairford study site was characterized as having a gently sloping lake bottom reaching a maximum measured depth of 2.2 m approximately 650 m from shore. Substrate was predominantly coarse, including mixtures of gravel, sand and cobble. Vegetation cover was greatest at depths between 1 m and 1.5 m, though plant height was relatively low (<0.6 m) and biovolume was found to be relatively low across the site. Water quality measures were similar between fall and spring sampling periods, and characteristic of a healthy ecosystem. Dissolved oxygen levels remained above CCME minimum guideline values for the protection of aquatic life (CCME 1999), and turbidity and total suspended solids were relatively low.

A total of 226 fish representing 14 species were captured during spring and fall sampling at Fairford. Fall sampling found Northern Pike to be the most abundant species, with White Sucker and Lake Whitefish also present. Spring sampling identified a large fish community including predominantly Yellow Perch, Walleye, White Sucker, and Northern Pike. Fish larvae net tows yielded 63 larval fish representing two species, including Walleye and White Sucker. Egg mat (70 mats) and kick sampling efforts (25 m^2) yielded no eggs during either the spring or fall field season.

A total of 23 taxa from 10 orders of benthic macroinvertebrates were captured at Fairford. The most common orders were Ephemeroptera (Mayflies), Diptera (True Flies), Amphipoda, and Trichoptera (Caddisfly). Mean richness (number of taxa per sample) was determined to be 8.40, overall mean was 405 BMI/m^2, and Simpson's Diversity was 0.55.

Overall, habitat structure and water quality were characteristic of high quality aquatic habitat for fish species. Benthic invertebrate species identified further suggest high water quality at the Fairford study site. While egg mat surveys did not identify any eggs, fish in spawning condition were identified during both the fall and spring study period, and small numbers of fish larvae sampled in the spring suggest that some spawning may take place within the Fairford site. Fish species diversity was relatively high (14 species recorded).

Watchorn Bay Study Site – Lake Manitoba, Route D

The Watchorn Bay study site was characterized as having a very shallow sloping lake bottom reaching a maximum measured depth of 2.7 m approximately 750 m from shore. Substrate was predominantly sand to depths of 1.5 m. Vegetation cover was minimal, restricted to pockets of gravel/cobble substrate at depths greater than 2 m. Water quality measures were similar between fall and spring sampling periods, and characteristic of a healthy ecosystem. Dissolved oxygen levels remained above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Turbidity levels were highest at the Watchorn site, with total suspended solid measures higher than those at the Fairford site.

A total of 218 fish representing 12 species were captured during spring and fall sampling at Watchorn Bay. Fall sampling yielded predominantly Lake Whitefish, while spring sampling yielded predominantly Yellow Perch and White Sucker. Fish larvae net tows yielded 24 larval fish representing two species, including Walleye and White Sucker. Egg mat sampling (70 mats) yielded no eggs during either the spring or fall field season.

A total of 16 taxa from eight orders of benthic macroinvertebrates were collected in Watchorn Bay. The most common orders were Ephemeroptera, Diptera, Trombidiformes (Mites), and Amphipoda. Mean richness was determined to be 5.30, overall mean was 144 BMI/m^2, and Simpson's Diversity was 0.62.

Overall, habitat structure and water quality do not represent diverse aquatic habitat for fish species. With primarily sandy substrate, Watchorn Bay is characteristics of a shallow and windswept bay. The increased wave action and sediment movement found at this site resulted in egg mats becoming completely clogged and embedded in sediment; this is not conducive to productive spawning habitat as eggs would similarly be battered and covered in sediment.

Those creeks that drain into Watchorn Bay (Mercer Creek and Watchorn Creek), however, were determined to be valuable spawning sites, with White Sucker in spawning condition migrating upstream within both systems, and the presence of licensed commercial trap nets on both creeks confirmed these creeks as productive fish migration routes. This would suggest that Watchorn Bay may serve as an important part of the spawning migratory route in this area, supported by the collection of Lake Whitefish (fall) and White Sucker (spring) in spawning condition within the Watchorn Bay study site. Overall quality of habitat directly impacted by Route D channel construction was assessed as low.

Harrison Bay Study Site – Lake St. Martin, Route C

The Harrison Bay study site bathymetric survey depicted a gradually sloping lake bottom throughout most of Harrison Bay, reaching a maximum measured depth of 3.2 m approximately 750 m from shore.

Substrate was predominantly a gravel-sand mixture. Vegetation cover was dense at depths greater than 1.5 m, though plant height and total biovolume was extremely low. Water quality measures were only collected during the spring sampling season, and were characteristic of a productive ecosystem, with lower turbidity and increased total suspended solids. Dissolved oxygen levels remained above CCME minimum guideline values for the protection of aquatic life (CCME 1999), and turbidity and total suspended solids were relatively low.

A total of 271 fish representing sixteen species, were captured during fall and spring sampling at Harrison Bay. Fall sampling yielded predominantly Lake Whitefish, Yellow Perch and Northern Pike species. Spring sampling identified a diverse fish community (14 species), including large numbers of White Sucker. Fish larvae net tows yielded 5,844 larval fish representing two species including White Sucker and Walleye. Egg mat sampling (70 mats) yielded no eggs during either the spring or fall field season.

A total of 22 taxa from ten orders of benthic macroinvertebrates were collected in Harrison Bay. The most common orders were Ephemeroptera, Diptera, Amphipoda, and Trombidiformes. Mean richness was determined to be 8.50, overall mean was 195 BMI/m^2, and Simpson's Diversity was 0.72.

Riparian habitat was the most extensive and complex at the Harrison Bay site. Aquatic vegetation within the marsh is extremely dense and highly productive, draining directly into Lake St. Martin at the Route C site. This habitat is characteristic of spawning habitat for fish species such as Northern Pike and Yellow Perch. Overall, aquatic habitat quality at the Harrison Bay site was very high, with both the highest total number of species observed, and the highest total catch and CPUE of spring larval fish. The presence of both fish in spawning condition and fish larvae suggest Harrison bay site provides important spawning habitats for the fish communities within Lake St. Martin, though egg mat sampling was not able to identify specific spawning sites.

Birch Bay Study Site – Lake St. Martin, Route D

Results of the bathymetric survey demonstrated a gradually sloping lake bottom throughout most of Birch Bay, reaching a maximum measured depth of 3.7 m. Slopes were steepest along the west shoreline at the Route D channel site, following a relatively consistent slope to a depth of 3 m approximately 250 m from shore. Substrate was predominantly sand and gravel. Vegetation cover was sparse especially in the western portion of Birch Bay at the Route D channel site, with relatively low biovolume outside the mouth of Birch Creek. Where the creek enters the lake, habitat is heavily vegetated, with long grass and cattails extending north. This narrow band of marsh habitat will likely be utilized by Northern Pike, Yellow Perch or forage fish for spawning, nursery of refuge. It is however, less extensive than that observed at Harrison Creek. Water quality measures were comparable between fall and spring sampling, and depict similar trends to that observed at Harrison Creek to the north. Dissolved oxygen levels remained above CCME minimum guideline values for the protection of aquatic life (CCME 1999), and turbidity and total suspended solids were relatively low.

A total of 89 fish representing 8 species were captured during fall and spring sampling at Birch Bay; the lowest diversity in species captured of all study sites. Fall sampling yielded predominantly Lake Whitefish, and spring sampling yielded predominantly White Sucker, Northern Pike, and Common Carp. Fish larvae net tows yielded capture of 2,855 larval fish representing two species, including White Sucker and Walleye. Egg mat sampling (70 mats) yielded no eggs during either the spring or fall field seasons.

A total of 22 taxa from eleven orders of benthic macroinvertebrates were collected in Birch Bay. The most common orders were Diptera, Ephemeroptera, and Amphipoda. Mean richness was determined to be 9.25, overall mean was 409 BMI/m^2, and Simpson's Diversity was 0.57.

Similar to Harrison Bay to the north, Birch Bay was found to include productive, high quality aquatic habitat with substrate and water quality characteristics conducive to fish spawning and habitation. While egg mat sampling did not identify specific spawning sites with this area, high larval fish counts and the presence of fish in spawning condition suggest this area plays an active role in fish spawning migration. The capture of a significant number of spawning White Sucker on Birch Creek, as well as the presence of a licensed commercial trap net on this creek, support the importance of Birch Bay and the Birch Creek tributary to the productivity of this fishery. Draining primarily agricultural land to the south and west of Lake St. Martin, nutrient levels are expected to be high, and it's isolation from the main current of flow between the Fairford River inlet and Dauphin River outlet suggest this basin of Lake St. Martin likely serves as a nutrient sink, promoting more productive and complex habitat in both the Birch Bay and Harrison bay sites.

In summary, this baseline assessment found all four study sites to possess a healthy aquatic ecosystem with established fish communities.When examining the results of the benthic invertebrate study, combined with water quality measurements, in particular turbidity and TSS levels, it can be determined that the aquatic habitat within the Route C area of impact (Fairford and Harrison Bay) represents relatively higher quality fish and aquatic habitat. This is reflected in comparative CPUE of adult and larval fish, species diversity, and overall habitat characteristics between Route C and Route D sites, most notably between the Lake St. Martin sites.

Baseline results presented in this report are the product of a single seasonal cycle of the Lake Manitoba and Lake St. Martin aquatic ecosystem, and provide a snapshot of fish and aquatic habitat conditions within each study site. With the finalization of Channel Route selection, additional studies should be scheduled to place the results of this report within the context of natural variability of these aquatic systems. More baseline data on the complexity of the nutrient cycling within the lakes and the surrounding watershed would allow greater insight into the potential effects of the proposed channel on the fisheries and aquatic habitat, in particular on Lake St. Martin not just within the localized Route C / D outlet sites, but impacts to the entire Lake St. Martin fishery and aquatic ecosystem.

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LIST OF ABBREVIATIONS AND ACRONYMS

°C	Degrees Celsius
BMI	Benthic macroinvertebrates
cm	Centimetre
CPUE	Catch-per-unit-effort
km	Kilometre
L	Litre
m	Metre
µS	Micro-Siemens
mg	Milligram
mm	Millimetre
NTU	Nephelometric turbidity units
$\bar{x}$	Sample mean
n	Sample size
σ	Standard deviation
TSS	Total Suspended Solids

1.0 INTRODUCTION

In response to the events and damage transpiring from the 2011 and 2014 Assiniboine River floods, a Lake Manitoba outlet channel (LMOC) was proposed to mitigate future flooding by accelerating the diversion of floodwater from Lake Manitoba into Lake St. Martin. The proposed LMOC (the Project) would include not only the diversion channel itself, but construction of new bridge, a water control structure, and other supporting infrastructure such as a new transmission line. After evaluation of several route options, the Stage 1 and Stage 2 Conceptual Designs (KGS Group, 2014) identified two preferred options Routes C and D, as the most suitable locations for such a channel. However, the final step in selection between these routes involves further study of numerous factors, including a systematic environmental review. Little is currently known about the aquatic habitat and ecosystems to be affected by channel construction, or the resulting short and long term environmental effects.

AAE Tech Services Inc. (AAE) was tasked by M. Forster Enterprises, on behalf of Manitoba Infrastructure (MI) to complete the fisheries and aquatic habitat portion of the baseline assessment of Lake Manitoba and Lake St. Martin. The assessment encompassed all waterways intersecting both routes, including two sites on both Lake Manitoba and Lake St. Martin, as well as sites along four creeks located between them: Birch Bay Creek, Watchorn Creek, Mercer Creek, and Harrison Creek. Results of this baseline assessment will be used to identify risk associated with the construction of the Lake Manitoba Outlet Routes C or D, facilitate channel selection, and will enable future environmental assessment and monitoring efforts.

The introduction of this report presents a detailed outline of the effects of the Portage Diversion and Fairford River Water Control Structure (FRWCS) on Lake Manitoba and Lake St. Martin, past and current efforts being made to mitigate these effects, groups of people most impacted by the effects of flooding within this area, and a general project description. The remainder of the report presents the methods used for this assessment, the results obtained, a discussion of how the results relate to future channel construction, and how to minimize negative impacts to the aquatic environment.

1.1 EFFECTS OF THE PORTAGE DIVERSION AND FAIRFORD RIVER WATER CONTROL STRUCTURE

Since its completion in 1970, the Portage Diversion has played a key role in flood mitigation in Manitoba (Figure 1 top). As it directs excess water from the Assiniboine River into Lake Manitoba, the diversion has significantly increased the lake's inflow (Lake Manitoba Regulation Review Advisory Committee, 2003). The Fairford River Water Control Structure (FRWCS), which was constructed in 1961 to better control high and low water levels within Lake Manitoba, was demonstrated to be capable of managing this increased inflow for decades (Figure 1; KGS Group, 2014). In 2003, it was estimated that, during FRWCS operation, increased inflow from the Portage Diversion raised water levels by an average of approximately 6.6 cm in the years since its construction, which fell within the desirable range of water levels (Lake Manitoba Regulation Review and Advisory Committee, 2003).

The FRWCS nevertheless limits the volume of water capable of being discharged from Lake Manitoba. As a result, lake levels are more significantly impacted during periods of very high water, such as during the Assiniboine River flood of 2011, which was later determined to be greater than a 300-year event (Government of Manitoba, 2013; KGS Group, 2014). When combined with the already high lake levels and above average precipitation, lake levels on Lake Manitoba reportedly reached a record wind-eliminated peak of 817.05 feet (249.037 m), which was "more than 4.5 feet (1.4 m) higher than the top of the desirable range of water levels" (Government of Manitoba, 2013).

Figure 1. *Aerial photographs of the Portage Diversion (top) and Fairford River Water Control Structure (FRWCS, below). Pictures obtained from Government of Manitoba, 2013 and KGS Group, 2014, respectively.*

As the regulation of Lake Manitoba water levels increases, waterbodies downstream of the FRWCS experience an even greater level of variation. While the FRWCS functions to lower Lake Manitoba water levels during high water periods, it accordingly increases inflow into the downstream waterbodies. Prior to construction of the FRWCS, little analysis or concern was given to downstream effects of this increased inflow. Operation of the Portage Diversion only compounds this effect by further increasing inflow into Lake Manitoba (Government of Manitoba, 2013; Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).

Located approximately 12 km downstream of Lake Manitoba via the Fairford River and Pineimuta Lake, Lake St. Martin is susceptible to flooding due to its single outflow source (the Dauphin River) and the surrounding, relatively flat topography. During the Assiniboine River flood of 2011, these factors were compounded by the record volume of water entering Lake Manitoba via the Portage Diversion. The "FRWCS was operated to allow for maximum discharge out of Lake Manitoba" (Government of Manitoba, 2013). Water levels reportedly reached a maximum of 805.5 feet (245.516 m), approximately 4.5 feet (1.371 m) above the maximum desirable level of 801 feet (44.145 m) and 2.0 feet (0.6 m) higher than the previously recorded maximum level. The resulting flood forced the evacuation of people from 18 First Nation communities (Government of Manitoba, 2013). As of December 22, 2015, more than 1800 residents from the four neighbouring First Nation communities – Lake St. Martin, Little Saskatchewan, Dauphin River, and Pinaymootang – remained evacuated (AANDC, 2016).

1.2 FLOOD MITIGATION EFFORTS

The provincial government has taken steps to mitigate impacts of large floods, such as those experienced in 2011 and 2014, within Lake Manitoba and Lake St. Martin. One step taken was the construction of the Lake St. Martin emergency outlet channel in 2011, which served to lower lake levels within both lakes by draining them into Lake Winnipeg. The channel was closed in November 2012, but was re-opened in July 2014 following heavy rainfall which raised the level of both lakes above flood stage (KGS Group, 2014).

To further mitigate future flooding within this area, a Lake Manitoba outlet channel was proposed to drain Lake Manitoba directly into Lake St. Martin. Six channel routes were originally proposed and two, Routes C and D, were selected to be most suitable. Among the final steps in the selection of Route C or D is a systematic environmental review.

1.3 GROUPS UTILIZING LAKE MANITOBA AND LAKE ST. MARTIN

Neighbouring First Nations communities, permanent and seasonal residents, tourists, farmers, and recreational and commercial fishermen utilizing the lakes are among those potentially impacted by changes to lake levels within Lake Manitoba and/or Lake St. Martin. Fish within Lake Manitoba and Lake St. Martin are an important food source to the over 10,000 on-reserve inhabitants of the eight First Nations communities located on or very near the lakes (Government of Canada, 2016). Campgrounds, RV parks, fixed roof accommodations (e.g. hotels and fishing lodges), approximately 2000 cottages, and numerous tourist attractions including three provincial parks and numerous beaches, are located along Lake Manitoba's shoreline and could be flooded by rising water levels (Manitoba Association of Campgrounds & Parks, 2016). Figure 2 illustrates a population concentration map displaying the locations and relative populations of the residences in the neighbouring area.

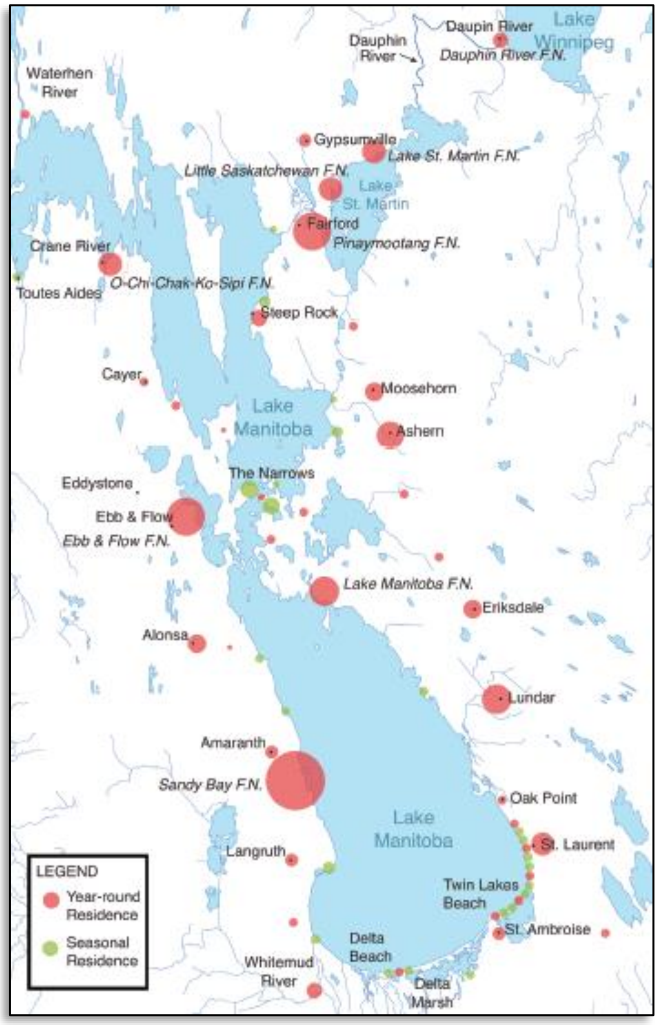
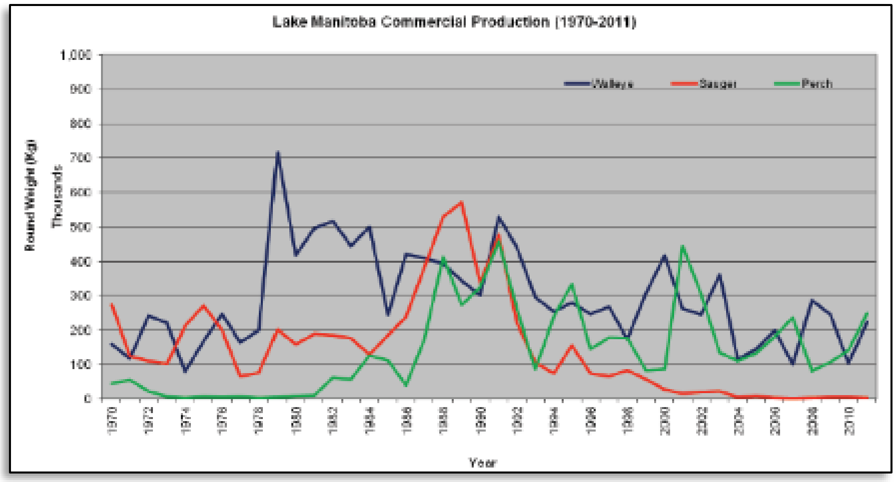


Figure 2. *Lake Manitoba and Lake St. Martin population concentration map. Image borrowed from the Lake Manitoba/Lake St. Martin Regulation Review Committee (2013).*

In addition to concerns faced by many permanent residents, livestock farmers occupying the land between the two lakes are primarily concerned about damage to their pastures and forage crops and increased soil salinity resulting from flooding. The effects of either may last for years post-flood and the costs and time commitment required for hay replacement are substantial (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).

One major aspect of the environmental review is concerned with the effect of channel construction on fish populations and habitat. The Lake Manitoba and Lake St. Martin fisheries provide income for First Nations, commercial fishermen, and their assistants. Of the 44 fish species found within Lake Manitoba and Lake St. Martin (Stewart and Watkinson, 2007), those most commonly captured include Walleye (*Sander vitreus*), Cisco (*Coregonus artedi*), Lake Whitefish (*Coregonus clupeaformis*), Northern Pike (*Esox lucius*), Yellow Perch (*Perca flavescens*), and White Sucker (mullet, *Catostomus commersonii*), although relative quantities differ between the lakes. Harvests within both lakes have fluctuated, but at reduced levels since the 1970's (Figure 3). The 362 commercial fishing licenses granted for Lake Manitoba in 2010 yielded an average income of only $4,114. However, the average total payouts per year for fish harvested from Lake Manitoba and Lake St. Martin were substantial at $1.9 million (1.1 million kilograms of fish) and $123,738 (118,459 kilograms of fish) respectively between the 1990/91 and 2011/2012 fishing seasons (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).



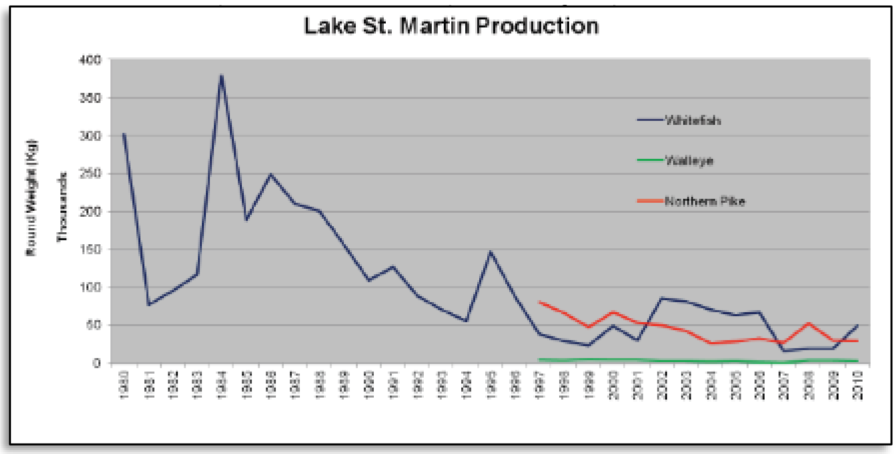


Figure 3. *Commercial fish production within Lake Manitoba (top) and Lake St. Martin (bottom). Images borrowed from the Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013.*

1.4 PROJECT DESCRIPTION

The focus of this study was to provide baseline environmental data describing the fisheries and aquatic habitat within regions to be affected by the construction of one of the proposed outlet channels routing excess floodwater from Lake Manitoba into Lake St. Martin, Routes C and D (Figure 4). Prior to this study, very little was known about the habitat to be affected both during and after channel construction..

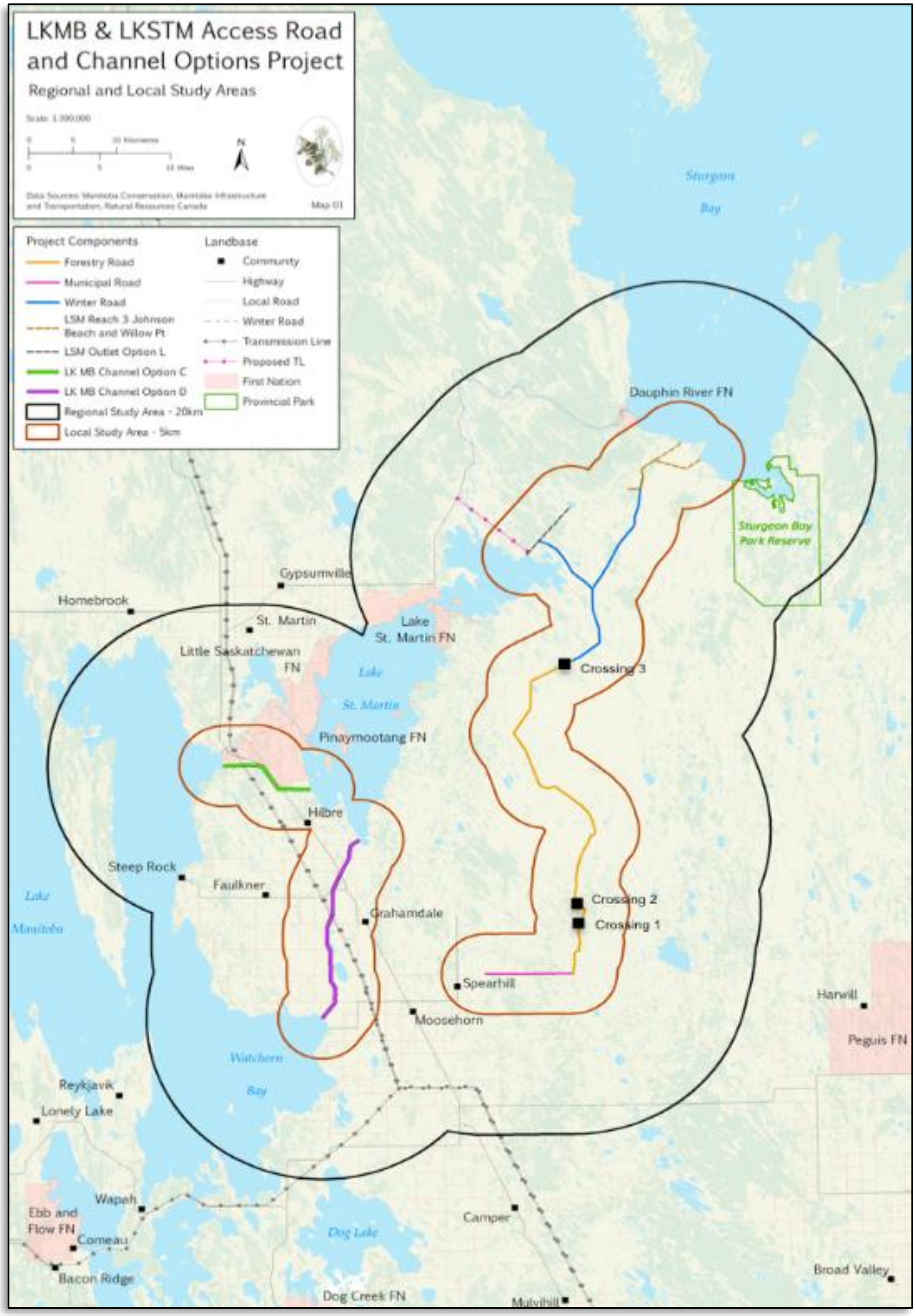


Figure 4. *Locations of the proposed channel Routes for the Lake Manitoba Outlet Channel Project. Channel Route C is indicated in green and Channel Route D is indicated in purple.*

Of the six preliminary routes proposed for a Lake Manitoba Outlet Channel (LMOC), Routes C and D were determined to be most favourable. The preliminary assessment used in the selection of these channels was based on the level of flood protection provided, economic aspects, and a preliminary understanding of the potential risks and concerns. Both of these routes propose channels connecting Lake Manitoba directly to Lake St. Martin (KGS Group, 2014).

Route C is an 11.6 km channel connecting Portage Bay on Lake Manitoba with a point on Lake St. Martin located approximately 4.5 km north of Hilbre. Route D is a 24.0 km channel connecting Watchorn Bay on Lake Manitoba to the outlet of Birch Creek on Lake St. Martin. Both routes are located on privately held land and crown leased land, and would require construction of a new control structure and bridge (KGS Group, 2014).

Channel construction may impact fish communities and, therefore, the commercial fisheries of Lake Manitoba and Lake St. Martin. However, because little was known about the habitat to be affected, further research was required to determine which channel route would yield fewer negative effects to fish populations. Some fish species are heavily dependent upon vegetation for spawning, feeding, and/or protection. Heavily-vegetated shoreline habitats such as wetlands, marshes and beaches are often complex, warm, and nutrient-rich and provide excellent fish habitat (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013). Preliminary assessment of the channel routes cited numerous ways in which this could potentially occur, including "alteration or loss of fish habitat, shoreline excavation, altered flow patterns, flooding and water quality changes" (KGS Group, 2014). Channel construction could negatively impact habitat within the lakes themselves as well as the network of channels and passages that fish depend upon for transport, breeding, and feeding.

2.0 SCOPE OF WORK

The primary objective of this component of the study was to provide environmental baseline data describing the fisheries and aquatic habitat within regions to be affected by the construction of one of the proposed outlet channels, Routes C or D. Work was to be completed during the fall of 2015 (Figure 5) and spring of 2016 (Figure 6). Baseline data included four major components, each of which included specific tasks:

1) HABITAT ASSESSMENT
    a. Perform fall and spring bathymetric surveys at the two proposed inlet sites for Routes C and D on Lake Manitoba, as well as the two proposed outlet sites on Lake St. Martin. Provide maps and written descriptions of water depth, substrate, and plant coverage and plant height for each site;
    b. Perform an aerial topographic survey to document riparian habitat at each proposed channel inlet and outlet site;

   c. Perform a ground-truth survey in conjunction with other field work to further document habitat at all sites throughout the duration of the study; and
   d. Perform cross-sectional profiles along all major creeks with outlets near the proposed Lake Manitoba inlets or Lake St. Martin outlets during the spring to document each creek's width, depth, substrate composition, and water velocity.

2) WATER QUALITY
   a. Conduct general water quality testing at all lake and creek sites to measure parameters including temperature, dissolved oxygen, pH, conductivity, and turbidity; and
   b. Set temperature loggers in Lake Manitoba and Lake St. Martin to record water temperature continuously throughout the duration of the study, as well as through the winter.
3) FISH DISTRIBUTION AND COMPOSITION
   a. Perform boat and backpack electrofishing, as determined by water depth, throughout each lake and creek site during the fall and spring to study overall fish presence;
   b. Perform gill netting at each lake site during the fall and spring to study the presence of medium- to large-bodied fish within each lake site;
   c. Perform hoop netting at each creek site during the spring to study the presence of medium- to large-bodied fish within each creek site;
   d. Perform zooplankton tows at each lake site post spring spawning to study the presence of larval fish within the lakes;
   e. Place and retrieve egg mats throughout each lake site during the fall and spring to document fish spawning within each lake site; and
   f. Perform kick net sampling throughout each lake site during the spring to further determine the presence of fish spawning within each lake site.
4) BENTHIC MACROINVERTEBRATES
   a. Collect and identify benthic macroinvertebrates (BMI) from each lake site to document species composition and diversity, and use this information to infer information about water quality and productivity.

See Figure 5 for a detailed summary of field sampling effort over the fall 2015 and spring 2016 seasons.

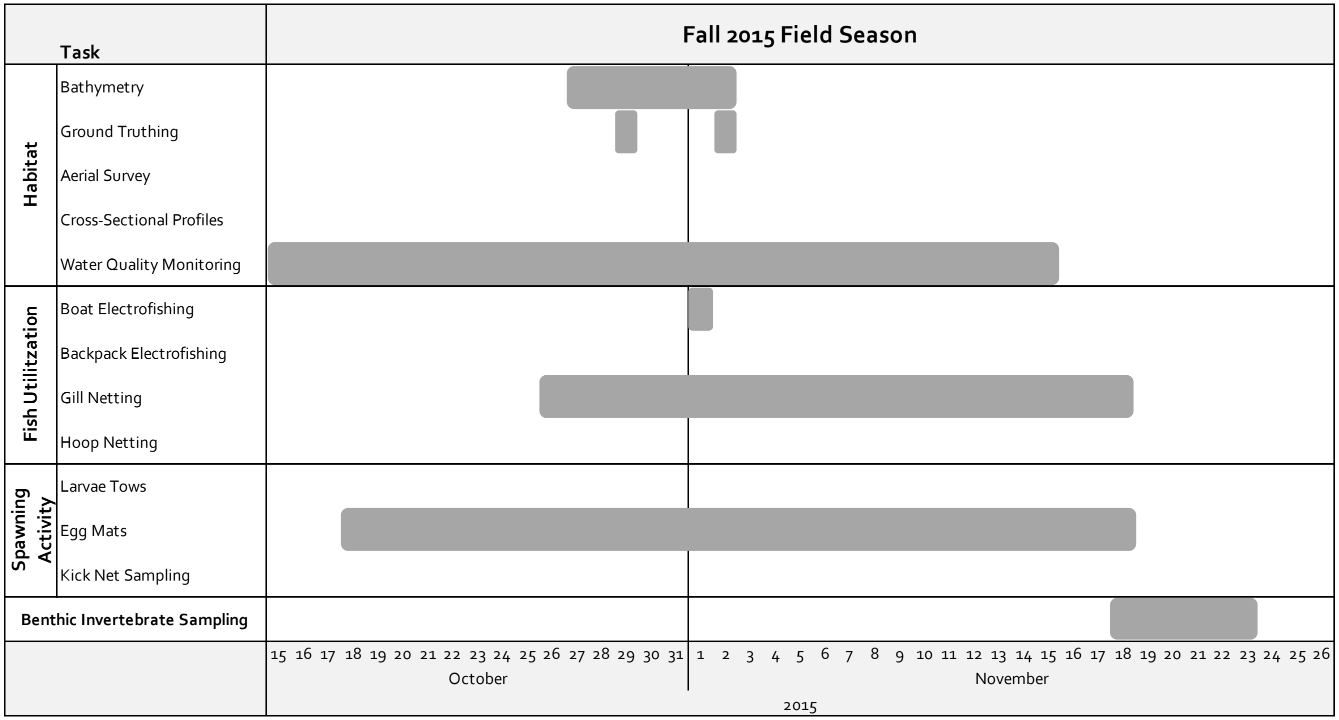


Figure 5. *Timetable of work completed during the fall, 2015 field season.*

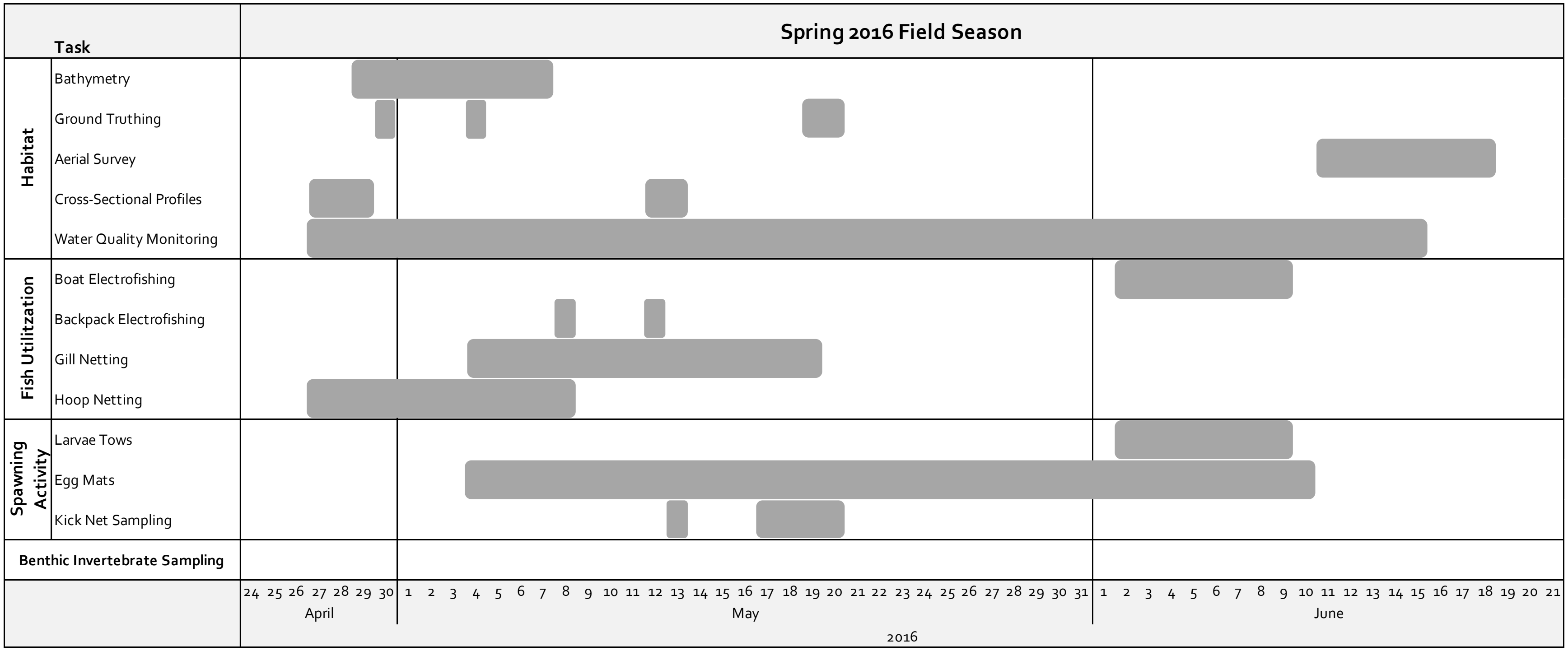


Figure 6. *Timetable of work completed during the spring, 2016 field season.*

3.0 STUDY AREA

The study area included aquatic and riparian habitat most likely to be impacted by construction of the two proposed channels, Routes C and D defined as the local study area (LSA). The two proposed inlet locations on Lake Manitoba and the two outlets on Lake St. Martin are the four lake sites facing the most direct impact of channel construction. The two Lake Manitoba channel inlet sites are located approximately 2.0 km south of the outlet into the Fairford River (Route C) and within Watchorn Bay (Route D), henceforth referred to as the Fairford and Watchorn Bay sites, respectively (Figure 7). The two Lake St. Martin outlet sites are located 1 km north of Harrison Creek and 4.5 km north of Hilbre, MB (Route C) and within Birch Bay at the southernmost extent of the Lake (Route D), hereafter referred to as the Harrison Bay and Birch Bay, respectively (Figure 7).

Channel construction may indirectly impact waterways neighbouring these sites, with the most critical effects being expected within tributaries in closest proximity to the disturbed lake sites. Of the four study areas, three include creek outlets. Two creeks, Mercer Creek and Watchorn Creek, drain into Watchorn Bay on Lake Manitoba, Birch Creek drains into Lake St. Martin at the Birch Bay site, and Harrison Creek drains into Lake St. Martin at the Harrison Bay site. Tributary assessments were completed for each of these creeks. Descriptions of each lake and its study sites are provided below.

3.1 LAKE MANITOBA

With a surface area of 4700 km^2, Lake Manitoba is Canada's thirteenth largest lake. The lake is 225 km in length from north to south and has approximately 915 km of shoreline. The lake is comprised of two basins, north and south, connected by a narrow passage located approximately halfway along the lake's length referred to as the Lake Manitoba Narrows. Average and maximum depths within the lake are approximately five and seven meters, respectively (Lake Manitoba Regulation Review Advisory Committee, 2013).

The most significant inflows into Lake Manitoba are the Portage Diversion, Waterhen River (fed by Lake Winnipegosis), and Whitemud River. Direct precipitation is also a significant contributor to water volume. Water flows out of Lake Manitoba via the Fairford River into Lake Pineimuta, which then flows through Lake St. Martin to the Dauphin River and Lake Winnipeg (Lake Manitoba Regulation Review Advisory Committee, 2003).

Four First Nation communities are located around Lake Manitoba with a combined on-reserve population of approximately 7,000. These communities, although outside of the Regional Study Area, (5 km radius surrounding proposed outlet channel) utilize the resource the lake offers, such as fishing. The Lake Manitoba First Nations include Lake Manitoba First Nation, O-Chi-Chak-Ko-Sipi (Crane River), Sandy Bay, and Ebb and Flow First Nation (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013;

AADNC, 2012). Approximately 2,000 seasonal cottages are located along the lake's shoreline (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).

Land use differs somewhat around the north and south basins. The landscape of the northern basin is largely in its natural state, with the exception of some mixed agriculture in the Swan River/Birch River area, isolated areas of cow/calf production, and forestry activity for an oriented strand board plant located in Minitonas. The landscape of the southern basin is primarily agricultural and varies east and west of the lake. Land to the east of the lake focusses primarily on livestock, forage and forage seed production, whereas land to the west focuses primarily on crop production and mixed farming with some livestock production closer to the lake's shorelines (Lake Manitoba Regulation Review Advisory Committee, 2003).

Forty-two fish species have distribution ranges extending into Lake Manitoba (Table 1). The only species with an elevated status under the Species at Risk Act (SARA) or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is Bigmouth Buffalo (*Ictiobus cyprinellus*), which is listed as Special Concern under COSEWIC. The species generating the greatest proportion of production by weight on Lake Manitoba include Walleye, Sauger, and Yellow Perch (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).

The LMOC study site for Route C (Fairford) is located approximately 2.0 km south of the Fairford River (51.566230, -98.730808). The site for LMOC Route D (Watchorn Bay) is located within Watchorn Bay approximately 10.3 km west of Moosehorn (51.282825, -98.569408). Also included in this assessment are Watchorn Creek and Mercer Creeks, two large creeks draining into Watchorn Bay. Watchorn Creek originates near Reed Lake approximately 10 km to the northeast, and Mercer Creek originates approximately 14 km to the north-northwest. Both creeks have been largely channelized, draining primarily agricultural land. However, within approximately 1.5 km of Lake Manitoba, Watchorn Creek reverts to a more sinuous, natural watercourse as it approaches Watchorn Provincial Park, with improved and more complex riparian habitat.

3.2 LAKE ST. MARTIN

Located approximately 12 km downstream of Lake Manitoba, Lake St. Martin has a surface area of approximately 345 km^2 and approximately 260 km of shoreline. The lake is comprised of two basins: a large south basin and a smaller north basin. Average depths for the large and small basins are approximately 4.1 m and 1.5 m, respectively (Lake Manitoba Regulation Review Advisory Committee, 2003).

Water flows east from Lake Manitoba into Lake St. Martin via the Fairford River and Pineimuta Lake. Water flows northeast out of Lake St. Martin into the Dauphin River and continues to Sturgeon Bay in Lake Winnipeg (Lake Manitoba Regulation Review Advisory Committee, 2003). An emergency outlet channel was constructed in 2011 to mitigate the effects of the FRWCS outflows. With the further increased outflows resulting from construction of a Lake Manitoba outlet channel, further construction is planned to increase the capacity of this channel (KGS Group, 2014).

Three First Nation communities are situated on Lake St. Martin, including Lake St. Martin First Nation, Pinaymootang (Fairford), and Little Saskatchewan. A fourth community, Dauphin River, is situated on Lake Winnipeg at the outlet of the Dauphin River. It is usually grouped together with the three Lake St. Martin communities because although it does not border Lake St. Martin, it receives the same additional inflow from Lake Manitoba via the FRWCS (AADNC, 2012; Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013). The combined on-reserve population of these four communities in 2012 was 3,588. Due to repeated flooding within the area, most land around Lake St. Martin, apart from the First Nation communities, has been purchased by the government and is now crown land (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).

Thirty-five fish species have distribution ranges which include Lake St. Martin (Table 1). The only species with an elevated SARA or COSEWIC status is Lake Sturgeon (*Acipenser fulvescens*), which is listed as Endangered under COSEWIC. The species generating the greatest proportion of production by weight on Lake St. Martin include Northern Pike, Lake Whitefish, White Sucker, and Carp (Lake Manitoba/Lake St. Martin Regulation Review Committee, 2013).

The Lake St. Martin study site for LMOC Route C (Harrison Bay) is located approximately 4.5 km north of Hilbre and 8.7 km SSE of Fairford (51.542583, -98.589734). The study site for LMOC Route D (Birch Bay) is located approximately 0.5 km north of the southernmost point of Lake St. Martin within Birch Bay (51.482235, -98.508041). Also included in this assessment is Birch Creek, which originates at Birch Lake (Goodison Lake) approximately 6.5 km southwest of Lake St. Martin, and Harrison Creek, which originates approximately 4.5 km west of the Harrison Bay study site. Both creeks drain primarily agricultural land, and are largely channelized in the upstream extents. However, unlike those creeks identified on Lake Manitoba, within 1 km of Lake St. Martin, both Birch and Harrison Creeks revert to more sinuous, natural watercourses with more developed and complex riparian habitat.

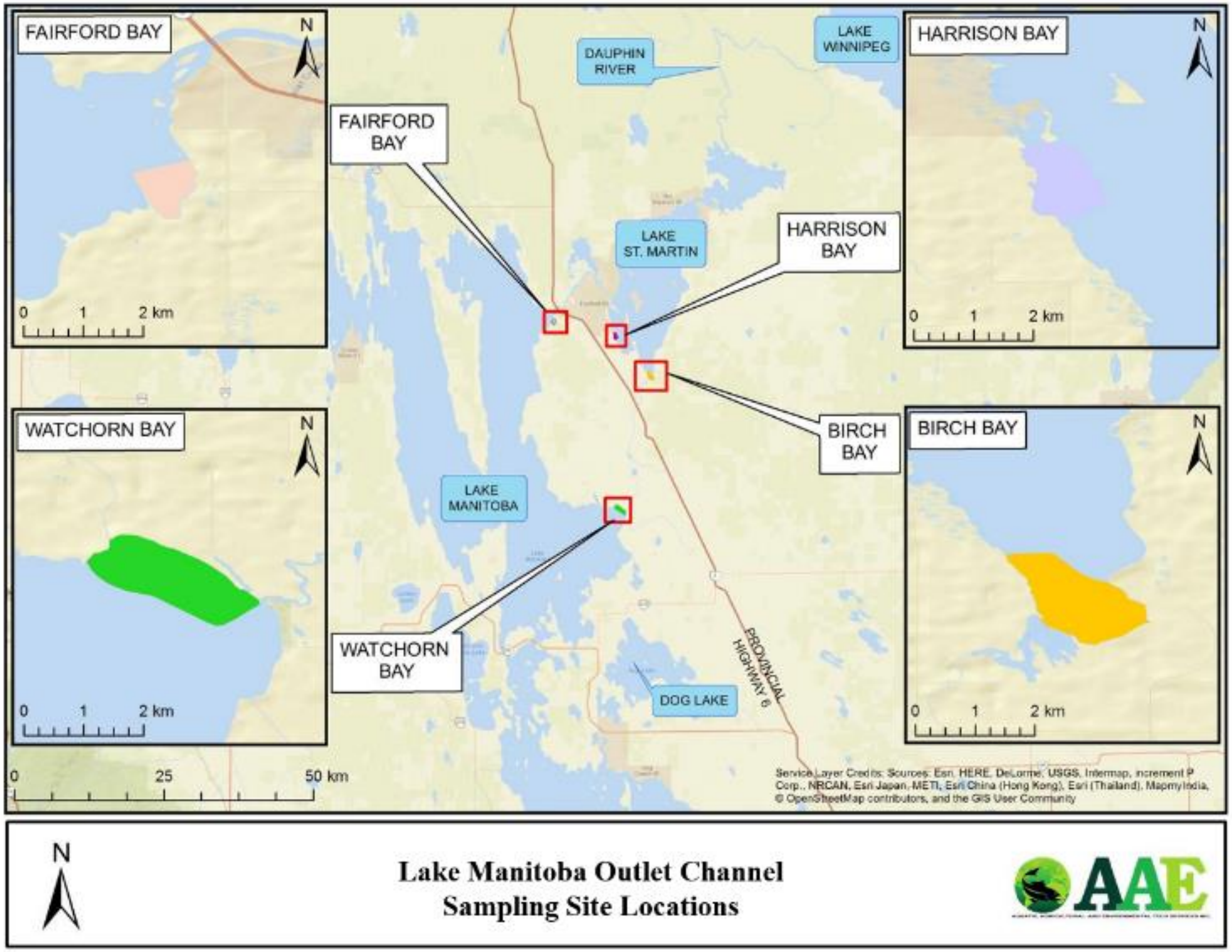


Figure 7. *Study area map, outlining 4 study sites to be impacted by Route C and D channel construction on Lake Manitoba and Lake St. Martin.*

Table 1. *List of fish species inhabiting Lake Manitoba and Lake St. Martin. List borrowed from Stewart and Watkinson, 2004.*

Common Name	Species	Family	SARA Status	COSEWIC Status	Breeding Season	Lake Manitoba	Lake St. Martin
Lake Sturgeon	*Acipenser fulvescens*	Acipenseridae	No Status	Endangered	Spring	No	Yes
Goldeye	*Hiodon alosoides*	Hiodontidae	Not Listed	Not Listed	Spring	Yes	Yes
Mooneye	*Hiodon tergisus*	Hiodontidae	Not Listed	Not Listed	Spring	Yes	No
Carp	*Cyprinus carpio*	Cyprinidae	Not Listed	Not Listed	Spring	Yes	No
Pearl Dace	*Margariscus margarita*	Cyprinidae	Not Listed	Not Listed	Spring	Yes	Yes
Golden Shiner	*Notemigonus crysoleucas*	Cyprinidae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Emerald Shiner	*Notropis atherinoides*	Cyprinidae	Not Listed	Not Listed	Summer	Yes	Yes
Blacknose Shiner	*Notropis heterolepis*	Cyprinidae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Spottail Shiner	*Notropis hudsonius*	Cyprinidae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Sand Shiner	*Notropis stramineus*	Cyprinidae	Not Listed	Not Listed	Spring to summer	Yes	No
Northern Redbelly Dace	*Phoxinus eos*	Cyprinidae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Finescale Dace	*Phoxinus neogaeus*	Cyprinidae	Not Listed	Not Listed	Spring	Yes	Yes
Fathead Minnow	*Pimephales promelas*	Cyprinidae	Not Listed	Not Listed	Spring	Yes	Yes
Longnose Dace	*Rhinichthys cataractae*	Cyprinidae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Creek Chub	*Semotilus atromaculatus*	Cyprinidae	Not Listed	Not Listed	Spring	Yes	No
Quillback	*Carpiodes cyprinus*	Catostomidae	Not Listed	Not Listed	Spring	Yes	Yes
White Sucker	*Catostomus commersonii*	Catostomidae	Not Listed	Not Listed	Spring	Yes	Yes
Bigmouth Buffalo	*Ictiobus cyprinellus*	Catostomidae	Special Concern	Non-Active	Spring	Yes	No
Silver Redhorse	*Moxostoma anisurum*	Catostomidae	Not Listed	Not Listed	Spring	Yes	Yes
Shorthead Redhorse	*Moxostoma macrolepidotum*	Catostomidae	Not Listed	Not Listed	Spring	Yes	Yes
Black Bullhead	*Ameiurus melas*	Ictaluridae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Brown Bullhead	*Ameiurus nebulosus*	Ictaluridae	Not Listed	Not Listed	Spring to summer	Yes	No
Channel Catfish	*Ictalurus punctatus*	Ictaluridae	Not Listed	Not Listed	Summer	Yes	No
Tadpole Madtom	*Noturus gyrinus*	Ictaluridae	Not Listed	Not Listed	Summer	Yes	No
Northern Pike	*Esox Lucius*	Esocidae	Not Listed	Not Listed	Spring	Yes	Yes
Muskellunge	*Esox masquinongy*	Esocidae	Not Listed	Not Listed	Spring	Yes	No
Central Mudminnow	*Umbra limi*	Umbridae	Not Listed	Not Listed	Spring	Yes	Yes
Cisco	*Coregonus artedi*	Salmonidae	Not Listed	Not Listed	Autumn	Yes	Yes
Lake Whitefish	*Coregonus clupeaformis*	Salmonidae	Not Listed	Not Listed	Autumn	Yes	Yes

Table 1. *Continued.*

Common Name	Species	Family	SARA Status	COSEWIC Status	Breeding Season	Lake St. Martin	Lake Manitoba
Rainbow Trout	*Oncorhynchus mykiss*	Salmonidae	Not Listed	Not Listed	Not Found	Yes	Yes
Troutperch	*Percopsis omiscomaycus*	Percopsidae	Not Listed	Not Listed	Spring	Yes	Yes
Burbot	*Lota lota*	Gadidae	Not Listed	Not Listed	Mid-winter	Yes	Yes
Brook Stickleback	*Culaea inconstans*	Gasterosteidae	Not Listed	Not Listed	Spring	Yes	Yes
Ninespine Stickleback	*Pungitius pungitius*	Gasterosteidae	Not Listed	Not Listed	Spring	Yes	Yes
Mottled Sculpin	*Cottus bairdii*	Cottidae	Not Listed	Not Listed	Spring	Yes	Yes
Rock Bass	*Ambloplites rupestris*	Centrarchidae	Not Listed	Not Listed	Spring	Yes	Yes
Iowa Darter	*Etheostoma exile*	Percidae	Not Listed	Not Listed	Spring to summer	Yes	Yes
Johnny Darter	*Etheostoma nigrum*	Percidae	Not Listed	Not Listed	Spring	Yes	Yes
Yellow Perch	*Perca flavescens*	Percidae	Not Listed	Not Listed	Spring	Yes	Yes
Logperch	*Percina caprodes*	Percidae	Not Listed	Not Listed	Spring	Yes	Yes
River Darter	*Percina shumardi*	Percidae	Not Listed	Not at Risk	Spring to summer	Yes	Yes
Sauger	*Sander canadensis*	Percidae	Not Listed	Not Listed	Spring	Yes	Yes
Walleye	*Sander vitreus*	Percidae	Not Listed	Not Listed	Spring	Yes	Yes
Freshwater Drum	*Aplodinotus grunniens*	Sciaenidae	Not Listed	Not Listed	Spring	Yes	Yes

4.0 METHODS

The fisheries assessment was performed over the course of two study periods. The fall study period, carried out October and November, 2015, included field work on Lake Manitoba and Lake St. Martin to document habitat, water quality, benthic invertebrate distribution and fish species composition during the fall spawning period with emphasis on Lake Whitefish spawning. The spring study period, carried out April to June, 2016, was completed at all four lake study sites as well as well as their associated tributaries, to coincide with the spring spawning season and provide seasonal comparisons between the spring and fall study periods.

4.1 DESKTOP REVIEW OF PROTECTED SPECIES

Prior to conducting field work, a desktop review was completed to establish an inventory of all fish species known to occur within the Lake Manitoba/Lake St. Martin system, and thus could potentially be found at the study sites, with special attention given to those species with elevated status under the Species at Risk Act (SARA) and/or Committee on the Status of Endangered Wildlife in Canada (COSEWIC). A list of species at risk was compiled using a combination of distribution data provided by Stewart and Watkinson (2004) and the Species at Risk Public Registry available online. Results of the desktop review are provided in Table 1.

4.2 HABITAT ASSESSMENT

Channel construction has the potential to impact fish habitat within neighbouring waterbodies by potentially disturbing natural spawning locations, altering migtation patterns, altering nutrient levels and food sources, altering flow pattern and potenially reducing the quality of fish habitat availabe for those fish inhabiting the area, . To provide baseline information regarding pre-construction fish and riparian habitat characteristics, a habitat assessment was conducted on Lake Manitoba, Lake St Martin, and along the four associated creeks, at their points of intersection with the channel routes and in the neighbouring riparian areas. Lake sites were assessed for benthic, shoreline, and riparian habitat using a combination of bathymetric survey, aerial survey, and ground-truthing methods. Creek sites were each assessed through a series of cross-sectional profiles establishing flow rates and substrate characteristics.

Data obtained through this assessment will be considered in final channel route selection, and will provide a baseline for future habitat monitoring at each site during and post-construction.

4.2.1 BATHYMETRIC SURVEY

4.2.1.1 Bathymetry

A BioSonics MX Echosounder with Visual Acquisition 6 software was used to collect bathymetric data from each lake site. The Echosounder collects bathymetric data including depth, substrate type, and metrics to assess vegetation and biomass at an accuracy of 1.7 cm +/- 0.2% of depth, at a ping rate of approximately 4.9 pings/sec, and with a depth range of up to 100 m.

A sonar transducer was mounted to the bow of a 16-foot boat and positioned at a calibrated depth below the water's surface. Data was collected along both longitudinal transects parallel to shore and cross-sectional transects perpendicular to shore at each of the four study sites. The exact position of the transducer was measured by an internal GPS and automatically coupled with bathymetric data. At points of intersection between transects, substrate was identified manually using either a benthic probe or grab sampler for ground-truthing, to ensure accurate identification of substrate types from the bathymetric data.

It was expected that bathymetric data could vary significantly between the two periods of fieldwork in regards to vegetation coverage and height. To document these changes across each study area, transects were completed at each of the four lake study sites during both the fall and spring study periods. Transects were spaced approximately 100 metres apart, with additional transects surveyed as required to better capture complex areas (e.g. sandbars, delta channels, etc.).

Due to the sensitivity of the Echosounder to interference and instability, there were some limitations to sampling, including:

- **Wind speed and direction**: Waves produced by steady or gusting wind were consistent limitations to sampling efficiency. Crosswinds limited sampling by rocking the boat, changing the angle of the transducer, and causing immediate loss of signal. Bathymetric surveys were not conducted when wind speeds exceeded 20 km/h.
- **Boat speed**: Maximum boat speed varied with wind conditions. In calm conditions, boat speed of up to 10 km/h was possible while maintaining data quality, while under moderately windy conditions speeds above 6.5 km/h frequently resulted in signal loss.
- **Vegetation**: While the MX Echosounder is usually capable of detecting both plant canopy and bottom depth/type simultaneously, very thick plant coverage sometimes prevented signals from adequately reaching or returning from the lake bottom, leading to a loss of bottom depth and substrate data. In most cases, however, post-processing corrections were able to compensate for this effect.

Data post-processing was completed using Visual Habitat software from BioSonics. Data from all transects was loaded into Visual Habitat and analyzed for bottom depth, plant canopy height, and plant coverage using the program's established algorithms. Each transect was then visually inspected to identify anomalies in bottom depth or plant identification, (e.g. gaps in lake bottom, surface wave anomalies detected as vegetation). All identified errors were corrected using the program's manual editing tool. Bottom type was analyzed using a Principal Component Analysis algorithm, with the number of clusters (substrate types) set manually and classified based on the number and types of substrates encountered during ground truth substrate sampling.

4.2.1.2 Substrate and Data Verification

After completion of the bathymetric surveys, substrate was manually sampled at a minimum of 20 points at each study site using a benthic probe or Petite Ponar grab sampler. Manual substrate sampling was completed at transect intersection points during surveys, with additional verification points sampled as required to cover the full range of observed substrate types based on a preliminary analysis of bottom type.

Boat-based bathymetric surveys are only possible in depths exceeding approximately 1 m. Thus, at each of the Lake Manitoba study sites (Fairford and Watchorn Bay), where nearshore water depths precluded boat-surveying of habitat within ~50 m of the shoreline, a Trimble RTK ground survey unit was used to measure lake bottom elevation within the shallow (<1 m) nearshore habitat. Survey points were taken along a line perpendicular to shore every 10 m to a depth of approximately 1.1 m to tie into boat-based bathymetric surveys and provide a seamless data set for accurate habitat analysis. Survey lines were spaced approximately 25 m apart along the extent of shoreline within the delineated study area. Substrate was also recorded by visual assessment and benthic probe at each survey point.

Prior to GIS analysis all bathymetric results were corrected for daily water elevation changes and depths were standardized using the Trimble GNSS survey equipment. Prior to data analysis, the shoreline for each study site was delineated using high-resolution satellite imagery to define a zero-depth contour.

4.2.1.3 Map Production

Maps of bathymetry, bottom type, plant biovolume, plant coverage, and plant height were produced for each lake site using ArcMap 10.1 software.

Bathymetric maps were produced according to the following procedure:

i. A Triangulated Irregular Network (TIN) model of the lake bottom was produced using the 3D Analyst toolset using raw bathymetric data (corrected for changes in water elevation over the study) and the zero-depth shoreline polygon;
ii. The TIN was converted to a raster image with a longest edge of 15000 pixels;
iii. The raster image was smoothed using the Focal Statistics tool in the Spatial Analyst toolset;
iv. The raster was clipped to exact lake dimensions using the Extract By Mask tool in Spatial Analyst;
v. Contours were added using 3D Analyst, set at 0.25 m intervals and using maximum measured water elevation as the base (zero-depth) contour;
vi. The underlying raster gradient was classified at equal intervals, with colour breaks set to match contour placement;

vii. Contours were labeled and maps were exported to .PNG files at 96 and 200 dpi resolution.

Submerged plant height and coverage were combined into a single measure of plant biovolume, using the following formula (obtained from Valley and Drake (2005)):

$$Biovolume\ (\%) = \left(\frac{Plant\ height(m)}{Depth(m)}\right) \times Plant\ coverage(\%)$$

This yielded the percent of the water column occupied by aquatic vegetation at the location of each ping. Plant biovolume maps were produced according to the following procedure:

i. Fall and spring datasets were analyzed separately;
ii. Biovolume (%) for each ping was calculated in Excel;
iii. Each dataset was imported to ArcMap and lake-wide biovolume in spring and fall were calculated using the Natural Neighbors interpolation tool in Spatial Analyst;
iv. Resulting rasters were smoothed with Focal Statistics and clipped to exact lake dimensions;
v. Statistics on maximum and average biovolume were obtained, using clipped but unsmoothed rasters;
vi. A consistent symbology was applied to spring and fall smoothed rasters. Maps were exported to .PNG files at 96 and 200dpi resolution.

Finally, maps of substrate were produced according to the following procedure:

i. Substrate data from June sampling was imported to ArcMap (September sampling was not included in the analysis, as the change in plant coverage would have resulted in invalid substrate comparisons during the Principal Components Analysis in Visual Habitat);
ii. Substrate type between transects was estimated using the Create Thiessen Polygons tool in the Analysis toolset;
iii. The resulting polygons were converted to a raster image using the Conversion toolset, and clipped to lake dimensions with Spatial Analyst;
iv. Grab sampling results were overlaid onto the maps to verify consistency between the two;
v. Map size was decreased by lowering raster resolution using the Aggregate tool in Spatial Analyst. The resulting raster was converted to labeled points;
vi. Finalized maps were exported to .PNG files at 96 and 200 dpi resolution.

Maps depicting bathymetry, bottom type, plant biovolume, plant coverage, and plant height at each site are provided in Section 5.0 (Results).

4.2.2 SHORELINE AND RIPARIAN HABITAT AERIAL TOPOGRAPHIC SURVEY

4.2.2.1 Aerial Survey

Aerial surveys were performed in the fall to avoid the presence of snow- or ice-covered areas, which would reduce accuracy of the data set. Aerial surveys of the shoreline and riparian habitat at each site were surveyed to develop orthomosaic images of each study site for habitat qualification. Four to eight black and white targets measuring 1 m^2 were placed throughout each study site to be used as ground control points. Trimble RX-8 RTK 4 survey equipment was used to survey locations and elevations at each target center (Figure 8). Using eMotion 2 software, a custom flight plan was developed in advance for each site and adapted on the day of the survey to account for variables such as wind speed and direction, ceiling height, and precipitation. Taken at an altitude of 80 m to 90 m above ground level, photos had 70% to 80% overlay to produce a high-quality orthomosaic image of each site.

The UAV (Unmanned Aerial Vehicle; eBee drone by senseFly) was launched by hand and flew autonomously following the predetermined flight plan (Figure 8). A technician operated the control station, continuously monitoring drone performance and flight status, and applying corrective actions if complications arose. In addition, one to two observers were on site to maintain continuous visual contact with the drone during its flight.

There were a number of limitations to conducting UAV aerial surveying, including:

- **Wind speed:** Surveys at each site were performed under low wind conditions, as UAV flight is not recommended at wind speeds exceeding 10 m/s (36 km/h). Flights were aborted if wind gusts rose above 12 m/s (43 km/h).
- **Precipitation:** UAV flights were not conducted under rainy conditions.
- **Time of Day:** UAV surveys were restricted to daylight hours to preserve image quality and survey accuracy. Flights were not performed within two hours of sunset or sunrise.

Figure 8. *Trimble RX-8 RTK 4 survey equipment (top) and a UAV (eBee drone) launch.*

4.2.2.2 Data Processing

Data was pre-processed to verify data quality and ensure full coverage. When necessary, additional flights were performed to correct any quality issues and ensure full site coverage. A 2D orthomosaic and 3D site model were produced for each site in GeoTIFF format using Pix4D software.

4.2.2.3 Data Analysis

High resolution GeoTIFF files were uploaded to Google Earth Pro software (Google Inc. 2015) for analysis. For each study site, shoreline structure and composition were examined, as well as adjacent riparian habitat, including structure and vegetation cover, and surrounding land use (e.g. agricultural). Assessment focused on shoreline and riparian habitat within the proposed channel right of way at each site (KGS Group 2015a, KGS Group 2015b).

4.2.3 CHANNEL MORPHOLOGY

Cross-sectional profiles were measured along Harrison, Birch, Watchorn and Mercer Creeks to assess habitat characteristics within each creek during the spring of 2016. Trimble R*X*-8 RTK 4 survey equipment was used along each transect to document elevation changes and describe channel morphology. Transects were carried out along lines perpendicular to the left bank. Elevations were measured along each transect from the upper riparian zone of the left bank to the upper riparian zone of the right bank. Vegetation, substrate and water velocity were documented along each transect and photographs were taken to better document riparian conditions. Velocities were measured at 40% (0.4 x depth) of the water column at 0.5 m intervals along each transect line using a Swoffer™ (Model 2100) velocity meter.

4.2.4 WATER QUALITY ASSESSMENT

Channel construction has the potential to affect water quality, in particular as it relates to local habitat conditions and aquatic species health and productivity. Increased organic matter accumulation or altering parameters such as pH, dissolved oxygen, or water temperature can result in both short- and long-term impacts to the aquatic ecosystem, such as fish spawning success. Preliminary analysis of the channel routes by KGS (2014) assessed the risk of water quality changes, including "increases in organic matter, changes in dissolved oxygen, pH levels and methylmercury resulting from channel construction as a moderate ("medium") risk". Results of water quality analysis will allow for monitoring during and after Lake Manitoba outlet channel construction.

4.2.4.1 WATER QUALITY

Water quality parameters were selected to provide baseline measurements where impacts may be present during channel construction and operation (pH, Total Suspended Solids, Turbidity), or which are considered in evaluating fish and aquatic habitat (Conductivity, Dissolved Oxygen).

In-situ water quality parameters were measured on the lake sites (~0.5 m depth) and creek sites (~0.3 m depth) using a hand-held YSI multi meter (model 556) and LaMotte 2020e/I turbidity meter to measure dissolved oxygen (DO, mg/L), pH, conductivity (µS/cm), turbidity (NTU), and water temperature (°C). A handheld GPS unit was used to record geographic locations of each sampling site.

At each study site, three 500 ml water samples were collected at increasing levels of turbidity. Laboratory analysis of these samples (ALS Environmental) provided assessment of Total Suspended Solids (TSS, mg/L). TSS measurements presented are interpolated from Turbidity samples collected in the field.

4.2.4.2 WATER TEMPERATURE

Water temperature loggers (Hobo® Water Temp Pro) were used to provide year-round water temperature data of Lake St. Martin, Lake Manitoba, and the associated creeks to be assessed. A logger was placed in each lake at the beginning of the fall, 2015 field season at a depth of approximately 1.3 m, and set to record water temperature hourly for the duration of the project. Loggers were removed at the completion of the spring field season in June, 2016. Failure of the Lake St. Martin temperature logger occurred approximately one week after installation, thus only partial temperature data is available for the Lake St. Martin sites.

4.3 FISH DISTRIBUTION AND COMPOSITION

To evaluate fish utilization at all sites along waterbodies potentially impacted by channel construction, field sampling was carried out over two field seasons: Fall 2015 and Spring 2016. The field seasons were designed to ensure assessment of habitat use and community structure of both fall-spawning (e.g. Lake Whitefish, Cisco) and spring-spawning (e.g. Walleye, White Sucker) species within Lake Manitoba and Lake St Martin. Boat electrofishing and experimental gill nets were used to capture fish within Lake Manitoba and Lake St. Martin. Hoop (fyke) nets were set to capture fish within the associated creeks. Egg mats, kick net sampling and larval net tows were utilized to assess egg deposition and spawning activity within the lacustrine habitat which may be impacted by channel construction.

All sampling protocols implemented for this study, including sampling methods for adult and juvenile fish, larval fish, and egg deposition, were designed to assess species composition, community structure, and habitat use within the predicted areas of impact on Lake Manitoba and Lake St. Martin while taking every effort to mitigate direct impacts to these fish communities, especially during the fall and spring spawning windows where sampling of sensitive species and habitats can have significant impacts. All fish sampling was performed in a manner to reduce stress on those fish captured and to prevent fish mortality. This can include reducing gill net soak times when field investigators find catch-per-unit-effort (CPUE) is high and the net processing time is prolonged, or halting electrofishing in instances where large schools of fish are observed and not all fish can be collected, to limit extended exposure to electrical current especially for small-bodied or spawning fish.

4.3.1 FIELD METHODS

Fish collection and processing was completed in the fall of 2015 under Manitoba Conservation and Water Stewardship Scientific Collection Permit #50-15, and in the spring of 2016 under Manitoba Conservation and Water Stewardship Scientific Collection Permit #09-16. Representative photographs of all species collected during this study are presented in Appendix C.

4.3.1.1 BOAT ELECTROFISHING

Boat electrofishing was conducted using a Smith-Root 2.5 GPP electrofisher system with two boom umbrella arrays mounted to the bow of a 4.8 m dual hull aluminum boat. Boat electrofishing was performed to document small- and large-bodied fish species present throughout the four lake sites during fall and spring spawning periods. Boat electrofishing allows thorough sampling of shallower, more vegetated habitat where gill netting is hindered. Survey transects were selected to include a range of depths and habitat types. Boat electrofishing was carried out at the Harrison Bay study area during the fall, 2015 spawning window to evaluate habitat use of spawning species including Lake Whitefish and Cisco. Safe work practices and procedures for boat electrofishing limit the weather conditions in which electrofishing may be carried out. Due to adverse weather conditions in the fall of 2015, electrofishing at the remaining study sites was not conducted.

During the spring, 2016 field season, boat electrofishing was conducted at all four study sites, to document fish species structure and habitat use during the spring spawning migration.

Fish were captured and stored in a live well for a short period (<30 minutes) before processing and release at the completion of each transect. Sampling effort (# of seconds electrofisher was engaged) and electrofishing settings (Voltage, Frequency, Pulse rate) were recorded for each survey transect.

4.3.1.2 BACKPACK ELECTROFISHING

Backpack electrofishing was conducted in the spring, 2016 field season within all Lake Manitoba and Lakes St. Martin tributaries (Watchorn Creek, Mercer Creek, Birch Creek, Harrison Creek) using a Smith-Root LR 24 backpack electrofisher. Surveys were completed moving in an upstream direction, sampling from shoreline to shoreline, with all captured fish immediately transferred to an insulated holding container. Captured fish were processed at the completion of each sampling reach. Fish were identified to species, enumerated, and measured for fork length before being released downstream of the sampling reach.

4.3.1.3 EXPERIMENTAL GILL NETTING

Gill netting was conducted to assess fish species composition and level of spawning activity taking place at each study site. Gill nets were set at each site during the fall and spring study periods to facilitate seasonal comparison of fish species and abundance. Non-lethal sampling protocols were implemented, with net soak times limited to one hour to reduce stress on those fish captured and to reduce the potential for fish mortality. Gill nets were set perpendicular to the shore in water depths ranging from 0.8 to 2.2 m. Experimental gill net gangs stretched a total of 137.2 m long, consisting of 22.9 m long x 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.

4.3.1.4 HOOP NETTING

Hoop (fyke) nets were set to capture fish within Birch Creek, Watchorn Creek, Mercer Creek and Harrison Creek during the spring study period. Hoop nets were set to assess upstream fish migration in each creek system during the spring spawning window. Hoop nets were set facing downstream at sampling sites within each creek system. Each hoop net was 1.2 m in diameter and constructed of 1.85 cm^2 nylon mesh. Two 4.5 m wings were attached to the opening of each net to direct fish into the traps. Hoop nets were set and monitored for between two and twelve hours at each site, depending on the number of fish captured.

4.3.2 BIOLOGICAL SAMPLING

Fish captured were identified to species, enumerated by sampling site and date, and measured for fork length ($\pm$ 1 mm), and round weight ($\pm$ 25 g, gill netting only). Individuals were also examined for sex and state of maturity (if captured during species' spawning window) by applying pressure to the abdomen in order to extrude gametes (sperm/eggs). Fish were classified as Male (M), Female (F) or Juvenile (J), and as Pre-spawn (N), Ripe (R), or Spent (S). All fish were kept in live wells for no more than 30 minutes, and released immediately after processing. In instances where CPUE was high and holding times would exceed this threshold, round weight data was collected for a sub-sample of 30 individuals of each species to reduce holding times and minimize stress to fish.

4.3.3 DATA ANALYSIS

Fish collection results were analyzed to assess seasonal fish species composition for each study site. Catch-per-unit-effort (CPUE) was calculated for total catch per sampling set (gill net set, hoop net set, or boat electrofishing transect (per 60 seconds sampling effort)).

Fork length (mm) was calculated for all fish captured during the study. Round weight (g) and condition factor (K) were calculated for fish captured during gill net sampling at each lake study site. Condition factor (K) was calculated using the following formula:

$$K = \text{Round Weight (kg)}^2 / \text{Fork Length (mm)}^3$$

Length-frequency distribution was plotted for all fish species captured at each site, where n ≥ 15. Fork lengths were categorized into 25 mm intervals (e.g. 100 – 124 mm) for most fish species; Northern Pike were categorized into 50 mm intervals, Yellow Perch were categorized into 10 mm intervals, and small-bodied fish species (e.g. Spottail Shiner) were categorized into 5 mm intervals.

4.4 SPAWNING ACTIVITY

4.4.1 EGG MATS

A total of 280 egg mats were set at each lake site during the fall and spring study periods. Each egg mat consisted of a 0.08 m^2 (0.4 x 0.2 m) cement block covered with a furnace filter material and were similar to those used in previous Lake St. Martin and Lake Winnipeg diversion channel studies (North/South Consultants Inc. 2014). The filter fibers provide a rough surface layer for trapping deposited eggs. Egg mats were placed within areas where spawning was expected to occur. Location, water depth, and substrate type were recorded at each sampling site. Substrate type was classified using a modified Wentworth approach where sand was classified as < 2.0 mm diameter, gravel ranged from 2.0 to 75 mm; cobble ranged from 76 to 255 mm; and boulder was > 256 mm (Wentworth, 1922).

4.4.1.1 FIELD METHODS

Seven clusters of 5 egg mats were set at each lake study site, with 140 egg mats set in the fall and 140 egg mats set in the spring, for a total of 280 egg mat sets in the two field seasons. Mats were set for 22 to 39 days, beginning approximately 5 days before the expected spawning window (Table 2). Egg mat sampling was completed at the conclusion of each spawning season, as determined by the spawning condition of fish captured in gill nets.

Table 2. *Egg mat set and retrieval dates for fall 2015 and spring 2016 field seasons.*

	Fall 2015			Spring 2016		
Site	**Date Set**	**Date Pulled**	**Set Length (Days)**	**Date Set**	**Date Pulled**	**Set Length (Days)**
Fairford	October 20	November 18	22	May 5	June 10	39
Watchorn Bay	October 20	November 18	29	May 4	June 9	39
Harrison Bay	October 18	November 17	30	May 8	June 10	36
Birch Bay	October 18	November 17	30	May 6	June 10	38

4.4.2 KICK SAMPLING

Kick sampling was performed to better ascertain fish spawning locations within each lake site and augment egg mat sampling to assess spawning activity at each study site. Sampling was conducted at a total of 49 sites. At each site, kick sampling was performed by wading and disturbing the substrate within a 1 m^2 area for 45 seconds and capturing all suspended fish eggs using a dip net (mesh size of 0.250 mm). Sampling was conducted over all available substrate types (i.e. gravel, cobble, boulder, silt, sand, and vegetation), though emphasis was placed on those substrates known to be favourable spawning habitat. GPS coordinates, sampling date and time, and substrate composition were recorded for each sample collected.

Kick samples were filtered and examined for the presence of eggs on-site to limit sample handling and sample degradation. Captured eggs were retained in fresh water in a glass sample vial, labelled according to date and sample site, and transported to the lab for processing and identification. Eggs were identified to family and photographed under 20x magnification.

4.4.3 FISH LARVAE SAMPLING

Net tow surveys were completed to assess the presence of larval fish at each of the Lake Manitoba and Lake St. Martin study sites. Once eggs begin to hatch following the spring spawning period, emerging larval fish are non-mobile, drifting passively by current, wave action and wind at or near the surface of the water. Sampling of larval fish provides additional insight into spawning activity at each study site, including spawning success within the area and the presence of larvae emerging from nearby creek systems.

Three four-minute net tows were completed along the surface of the water at each study site using a 1 m diameter zooplankton net 1.5 m in length with a mesh size of 500 μm. A GO Environmental propeller flow meter attached to the cod end recorded water flow through the net to standardize CPUE.

Methods used for larval sampling were adapted from Mason and Phillips (1986) for use with a zooplankton sampling net. The net was situated approximately 1.5 metres off the bow on the starboard side of the boat. The position allowed for control of the net orientation and depth, and eliminated any effect of the boat (e.g. wake) on sampling effort. Date and time, survey start and end waypoints, environmental conditions (weather, water temperature, start and end water depth), and flow meter counts were recorded for each transect. Surveys were carried out for 4 minutes at a speed of approximately 7-10 km/h. The net was retrieved after each completed transect and captured larvae were fixed in 10 % formalin. After one week, preserved fry were soaked in water for 24 hours to remove formalin from tissues; following a second 24-hour rinse, fry were transferred into 70% ethanol for preservation.

In the laboratory, samples remained in ethanol until identified. Fry were viewed under 10X magnification and identified to the lowest possible taxonomic level. Samples were retained and archived in 70% ethanol. Representative photographs of collected larvae samples are presented in Appendix C. Once identified and enumerated, mean catches per transect were calculated. For each transect, the volume of water sampled was calculated using the value indicated on the flow meter multiplied by the GO meter's established correction factor to establish survey distance, then multiplied by the catch area of the 1 m diameter net.

4.5 BENTHIC INVERTEBRATES

4.5.1 FIELD SAMPLING METHODS

Benthic macroinvertebrates (BMI) were collected during the fall 2015 field season at each of the Lake Manitoba and Lake St. Martin study sites as invertebrates are an important food source for both juvenile and adult commercial, recreational and Aboriginal (CRA) fish species . Invertebrate sampling was conducted in the late fall season when water temperatures had decreased, after most species have mated and immatures have had the chance to develop over the summer in preparation for overwintering (Rosenberg *et al.* 1997). Sampling was performed using a 500 µm mesh kick net in near-shore habitat (depth < 1.0 m). The kick and sweep method was used to cover 1 m^2 over a period of 2 minutes. Ten samples were collected from each site and stored in individual bags. The bags were frozen in the field and taken back to the laboratory for identification.

4.5.2 IDENTIFICATION AND ANALYSIS

In the laboratory, samples were thawed at room temperature over several hours and sorted the same day. Under 10X magnification, all BMI were removed from the debris in the sample, placed into vials, and preserved in 95% ethanol. For QA/QC purposes, 20% of the samples were re-examined by a biologist to ensure 95% efficiency. If more than 5% of the BMI were still in the debris after the initial picking, all samples that were picked that day were redone. All preserved BMI were identified to family, or lowest practical taxa, under magnification (up to 40X). This protocol was the same protocol required by Environment Canada for Environmental Effects Monitoring studies. Three measures of diversity were calculated for each site, including:

- Mean richness: average number of taxa per sample;
- Density: average number of organisms per square metre; and
- Simpson's Diversity Index: measures 'evenness' of a community from 0 to 1, where greater values indicate greater diversity and calculated as:

$SDI = 1 - \sum_{I} (n_i/n)^2$, where n_i is the number of individuals of taxon

Representative photos of all invertebrate families identified are provided in Appendix D.

5.0 RESULTS

Data collected during this assessment were tabulated and analyzed by individual Lake Manitoba inlet and Lake St. Martin outlet study sites for the proposed LMOC Routes C and D. Bathymetry, aquatic and riparian habitat characteristics, water quality, fish species distribution and spawning activity, and benthic invertebrate communities were analyzed and assessed at each site. Tributary assessments were also completed for four creeks identified as potentially impacted by construction activity: Watchorn Creek and Mercer Creek (Lake Manitoba – Watchorn Bay study site); Harrison Creek (Lake St. Martin – Harrison Bay study site); and Birch Creek (Lake St. Martin – Birch Bay study site). Channel morphology, water quality, and fish species composition were assessed for each tributary.

Results are compiled and presented below by study site:

- 5.1 Fairford Study Site, Lake Manitoba
- 5.2 Watchorn Bay Study Site, Lake Manitoba
    - 5.2.6 Watchorn Creek Tributary Assessment
    - 5.2.7 Mercer Creek Tributary Assessment
- 5.3 Harrison Bay Study Site, Lake St. Martin
    - 5.3.6 Harrison Creek Tributary Assessment
- 5.4 Birch Bay Study Site, Lake St. Martin
    - 5.4.6 Birch Creek Tributary Assessment

Summary sheets of all results compiled for each study site are presented in Appendix E.

5.1 ROUTE C – LAKE MANITOBA, FAIRFORD STUDY SITE

5.1.1 HABITAT ASSESSMENT

Aquatic and riparian habitat was assessed at the Fairford study site, by completing a full bathymetric, substrate and aquatic vegetation profile, as well as an aerial photographic survey of shoreline and riparian habitat.

5.1.1.1 Bathymetry

Bathymetric analysis enabled close examination of the lake bottom characteristics at Fairford (Figure 9). The lake bottom at the Route C inlet had an average slope of 0.004, with a steeper sloping shoreline (slope = 0.008) to a depth of approximately 1 m, and then leveling out (slope = 0.0027) to the extent of the survey approximately 650 m from shore, at a maximum depth of 2.2 m.

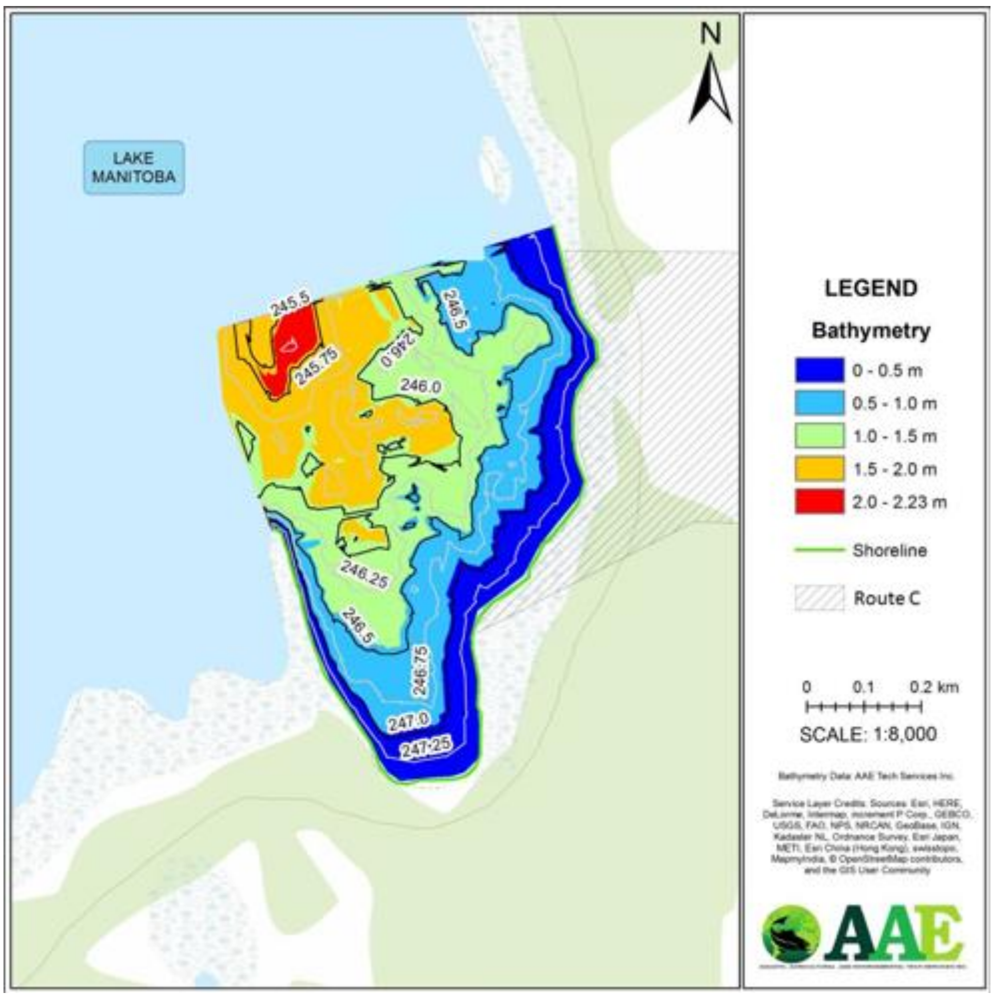


Figure 9. *Bathymetric map of the Fairford study area on Lake Manitoba.*

5.1.1.2 Substrate

Sonar analysis of substrate identified three distinct substrate types (Figure 10). Substrate within approximately 200 m of the shoreline (at depths less than 1 m) was composed primarily of gravel (<80%) with some sand and cobbles. Boulder gardens were also common in this nearshore habitat. Between 200m and 400 m from shore (depths 1.0 m - 1.5 m), the substrate consists primarily of a 50% gravel, 50% sand mix. Beyond 400 m (depths > 1.5 m), substrate consists primarily of sand (>80%) with some gravel.

Substrate compaction at the Fairford site limited the effectiveness of petite Ponar efforts during substrate ground truthing. As such, a telescopic metal probe was used to prod a 1 m^2 area of substrate at each of the 36 ground truthing sites.

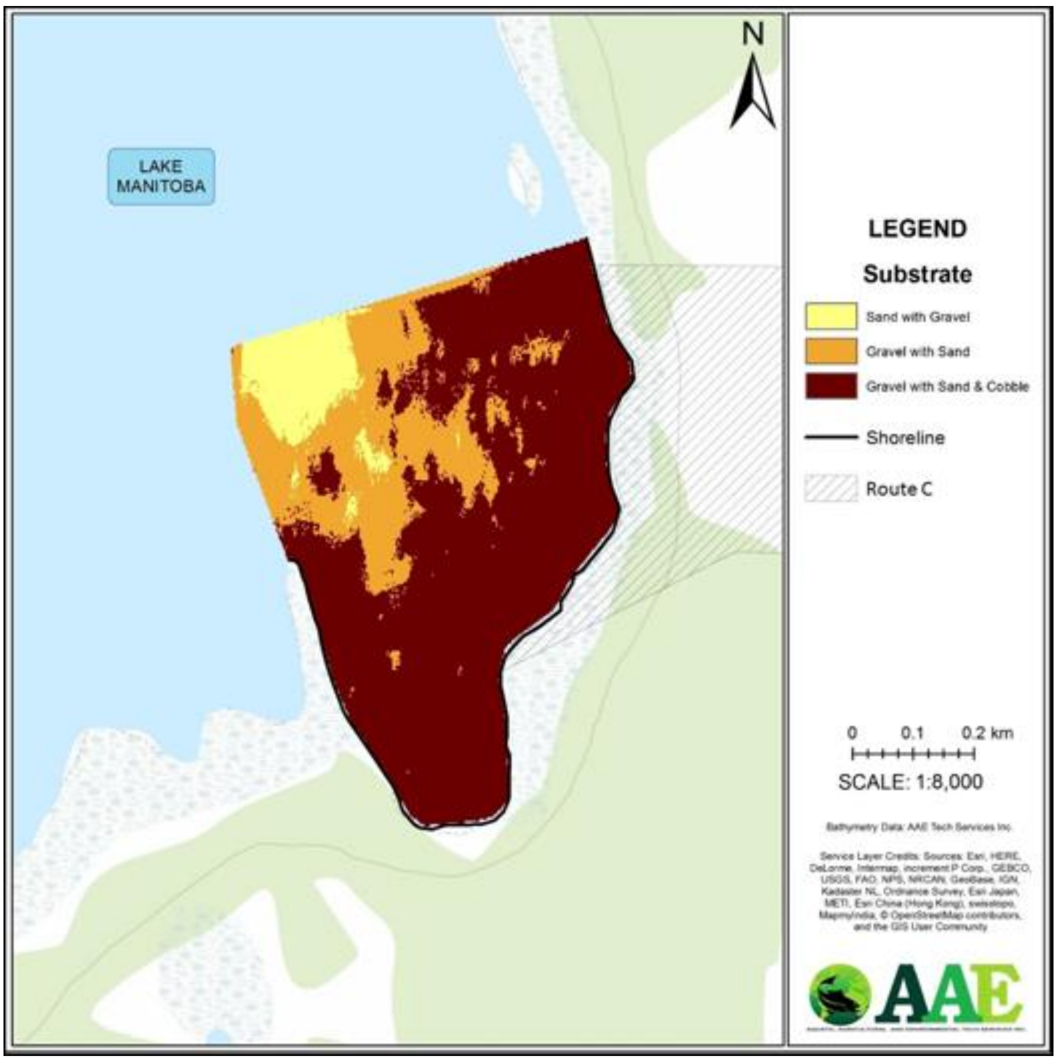


Figure 10. *Substrate composition map of the Fairford study area on Lake Manitoba.*

5.1.1.3 Aquatic Vegetation

Aquatic vegetation cover (Figure 11) was abundant (60% - 100% cover over >50% area) at depths between 0.5 m and 1.5 m; however, plant height (Figure 12) rarely exceeds 0.6 m. Plant bed biovolume (Figure 13) was relatively low (0% - 15%) across most of the study area, particularly at depths <1 m (100m - 150 m from the shoreline). Plant bed biovolume was greatest (up to 60%) at the northern extent of the study area, within 75 m of the shoreline at the Route C inlet site.

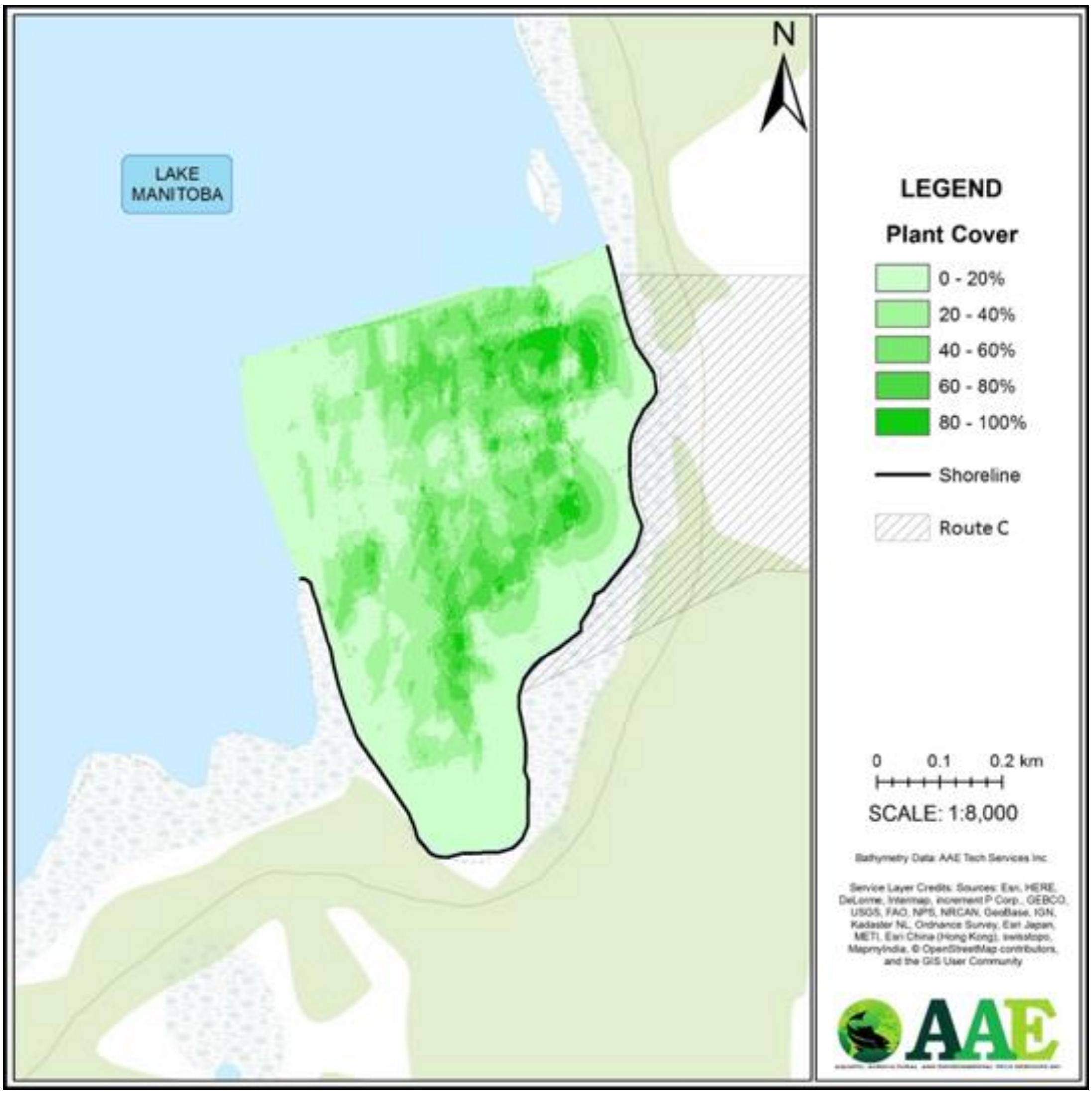


Figure 11. *Plant Cover (% area) map of the Fairford study area on Lake Manitoba.*

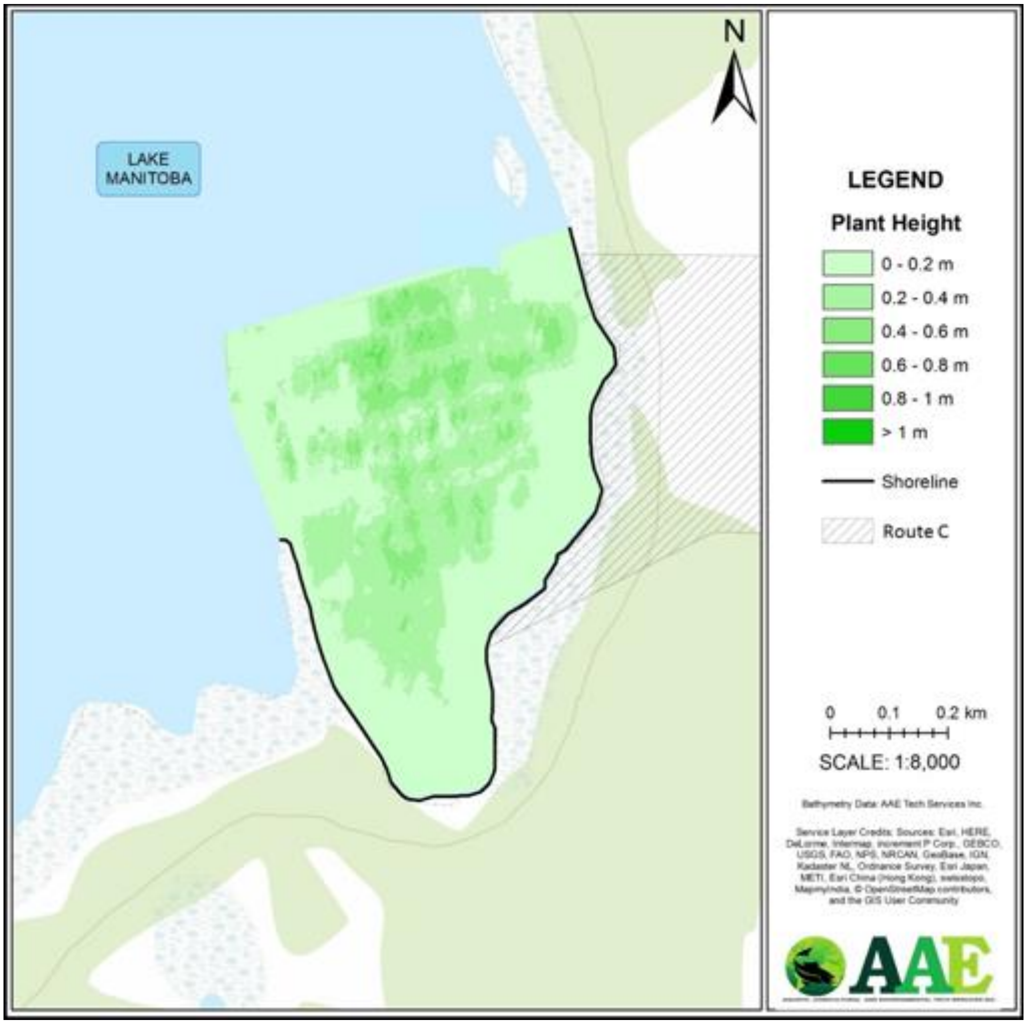


Figure 12. *Plant Height map of the Fairford study area on Lake Manitoba.*

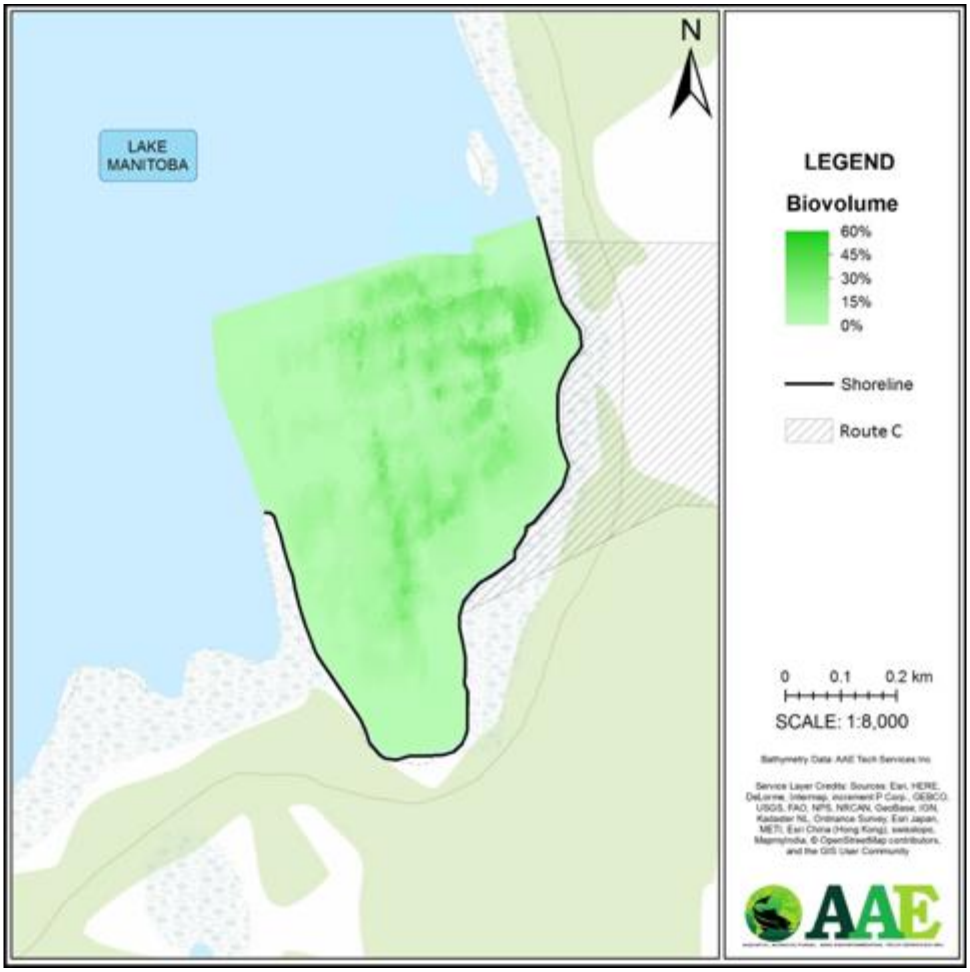


Figure 13. *Total Biovolume (% water column) map of the Fairford study area on Lake Manitoba.*

5.1.1.4 Shoreline and Riparian Habitat

Aerial photographic surveys of the Fairford study site revealed relatively simple shoreline and riparian habitat characteristics (Figures 14 – 16).

The shoreline extends 30 m from the water's edge, and was composed of a compacted gravel – cobble-sand substrate, similar to the substrate documented in the bathymetric survey at depths up to 1 m. Cobble and boulder fields were visible within the shallow nearshore habitat (Figure 16), and become more prevalent (> 50%) at the shoreline.

The nearshore riparian habitat was open with compacted gravel – cobble substrate and sparse vegetation cover, extending 40 – 105 m from the shoreline. Beyond this, the upper riparian habitat consisted of a shelterbelt of deciduous trees parallel to the shoreline and approximately 80 m in width. Land use beyond this was agricultural, and included a rural residence and land used for livestock grazing.

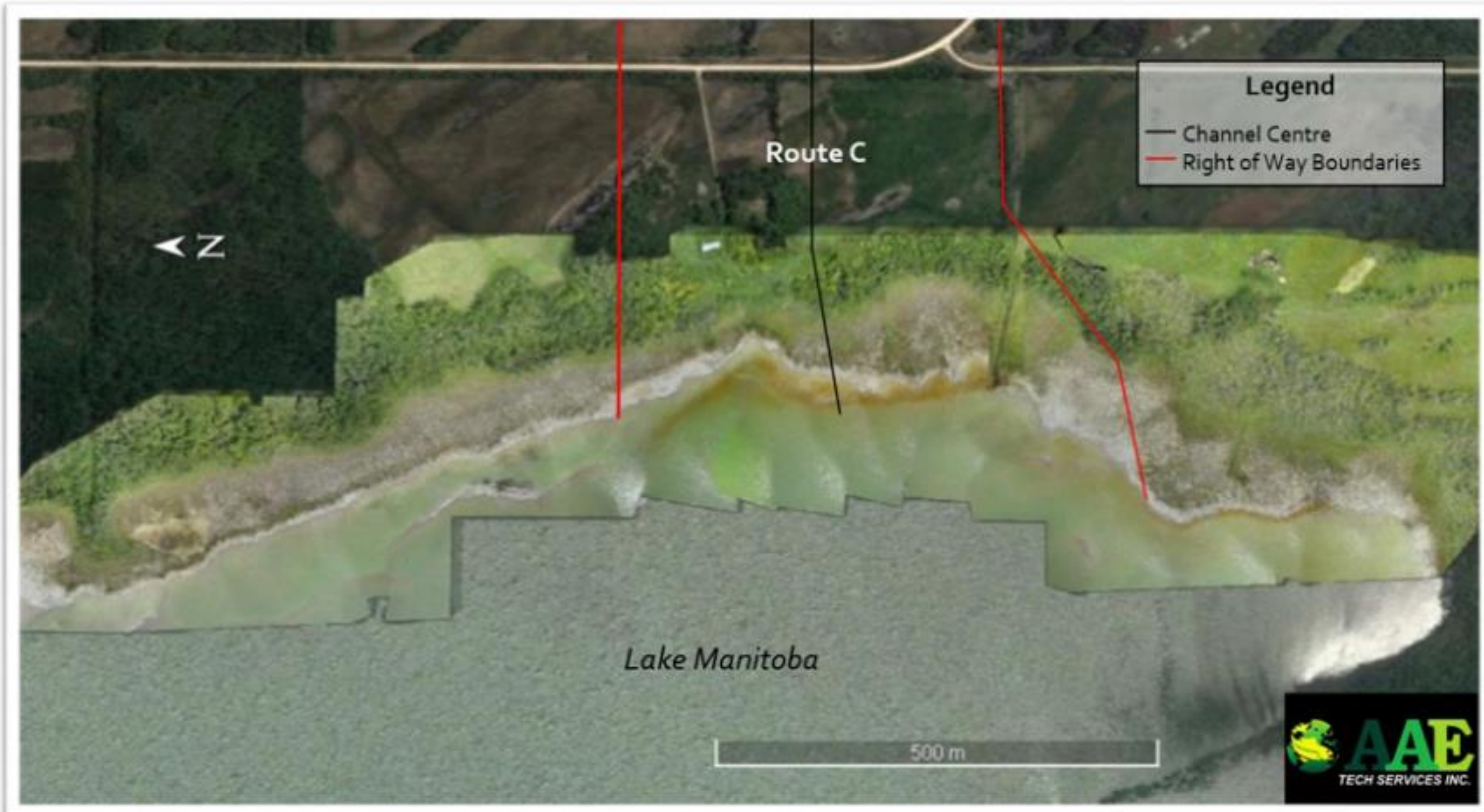


Figure 14. *Aerial photo orthomosaic of the Fairford study site for Route C, focusing on shoreline and riparian habitat.*

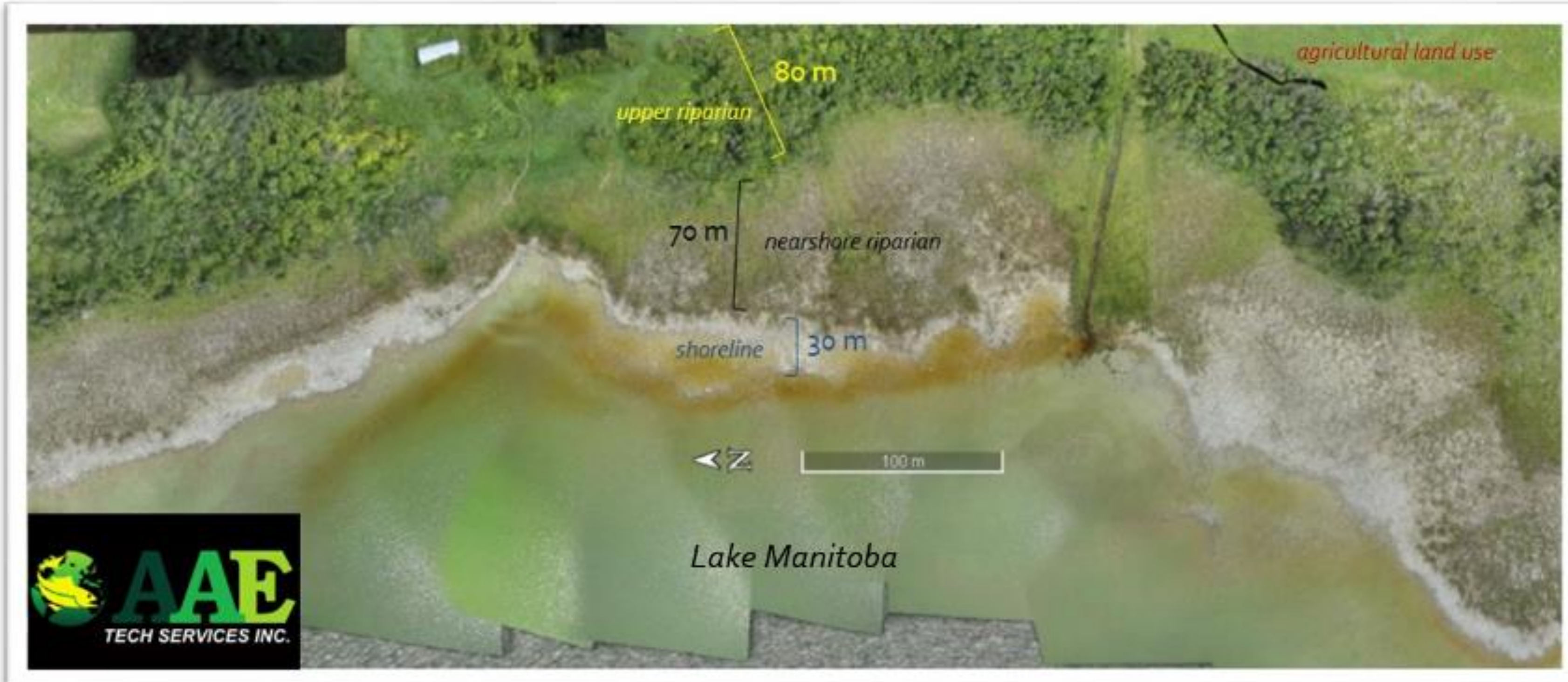


Figure 15. *Aerial photo orthomosaic of the Fairford study site for Route C, depicting extent of shoreline and riparian habitat. Centred on proposed Route C inlet site.*

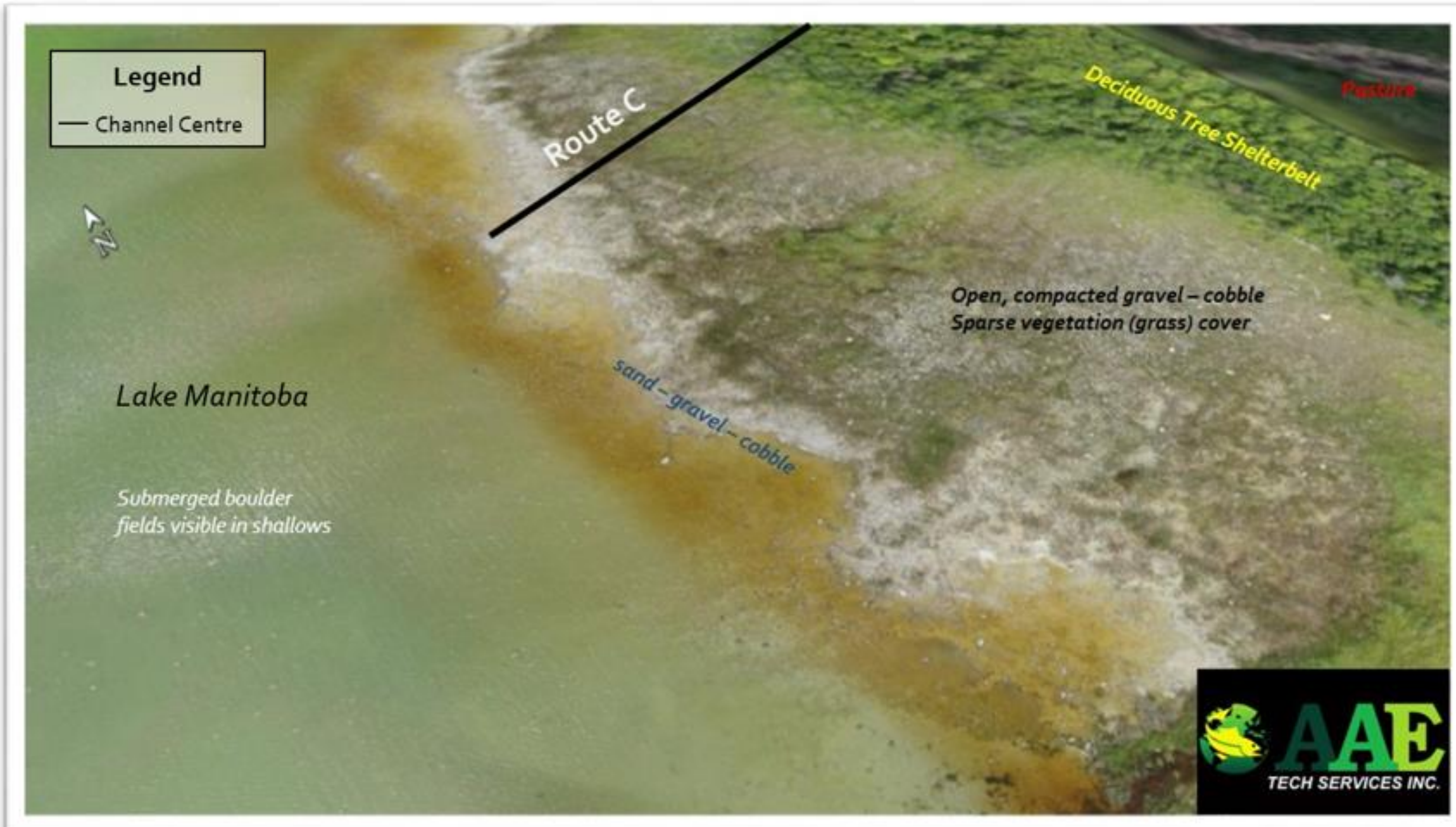


Figure 16. *Aerial photo orthomosaic of the Fairford study site for Route C, depicting shoreline and riparian habitat cover and composition. Oblique view from the southwest, centred on proposed Route C inlet site.*

5.1.2 WATER QUALITY

Mean water temperature for Lake Manitoba during the fall study period (October – November, 2015) was 6.33°C (Table 3), with temperatures declining steadily from 8.92°C on October 04, 2015 until ice-up on November 19, 2015, then remained near freezing (range: 0.079°C – 0.742°C) until April, 2016 (Figure 33). Temperatures began to rise after April 27, 2016 in conjunction with ice breakup. Mean water temperature over the spring study period (April – June) on Lake Manitoba was 14.58°C (range: 0.467°C – 24.05°C) (Table 3).

Remaining water quality parameters were relatively similar between the fall, 2015 and spring, 2016 field seasons (Table 3). Mean dissolved oxygen at the Fairford site was 10.18 mg/L during the fall study period, and 8.85 mg/L (8.10 – 9.55 mg/L) during the spring study period; DO values were consistently above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity, total suspended solids (TSS), pH and Conductivity values were assessed for the Fairford site based on mean measurements taken using *in-situ* readings between October 16, 2015 and November 14, 2015 (Fall study period) and April 27, 2016 and June 3, 2016 (Spring study period), and are presented in Table 3.

Table 3. *Mean Water quality measurements, Fairford.*

	Sampling Season		
Water Quality Parameter	**Fall 2015**	**Spring 2016**	**CCME Minimum Guideline Value**
Temperature*	6.33*	14.58*	Variable
Dissolved Oxygen (mg/L)	10.18	8.85	Variable: 5.5 – 9.5
pH	7.09	7.30	6.5 – 9.0
Conductivity (µS/cm)	1160	902	No Data
Turbidity (NTU)	2.41	3.02	Variable
TSS (mg/L)	10.948	12.326	No Data

5.1.3 FISH DISTRIBUTION AND COMPOSITION

Fish and invertebrate sampling was carried out at the Fairford study site over a 34-day fall sampling period in October and November, 2015, and a 45-day spring sampling period from April through June, 2016. Fish community composition was assessed using gill net and boat electrofishing surveys, egg mat sets (5 traps per cluster), larval fish tows, and kick net benthic sampling (Figure 17). A total of 226 fish representing fourteen species were captured. No species of concern were identified at this site.

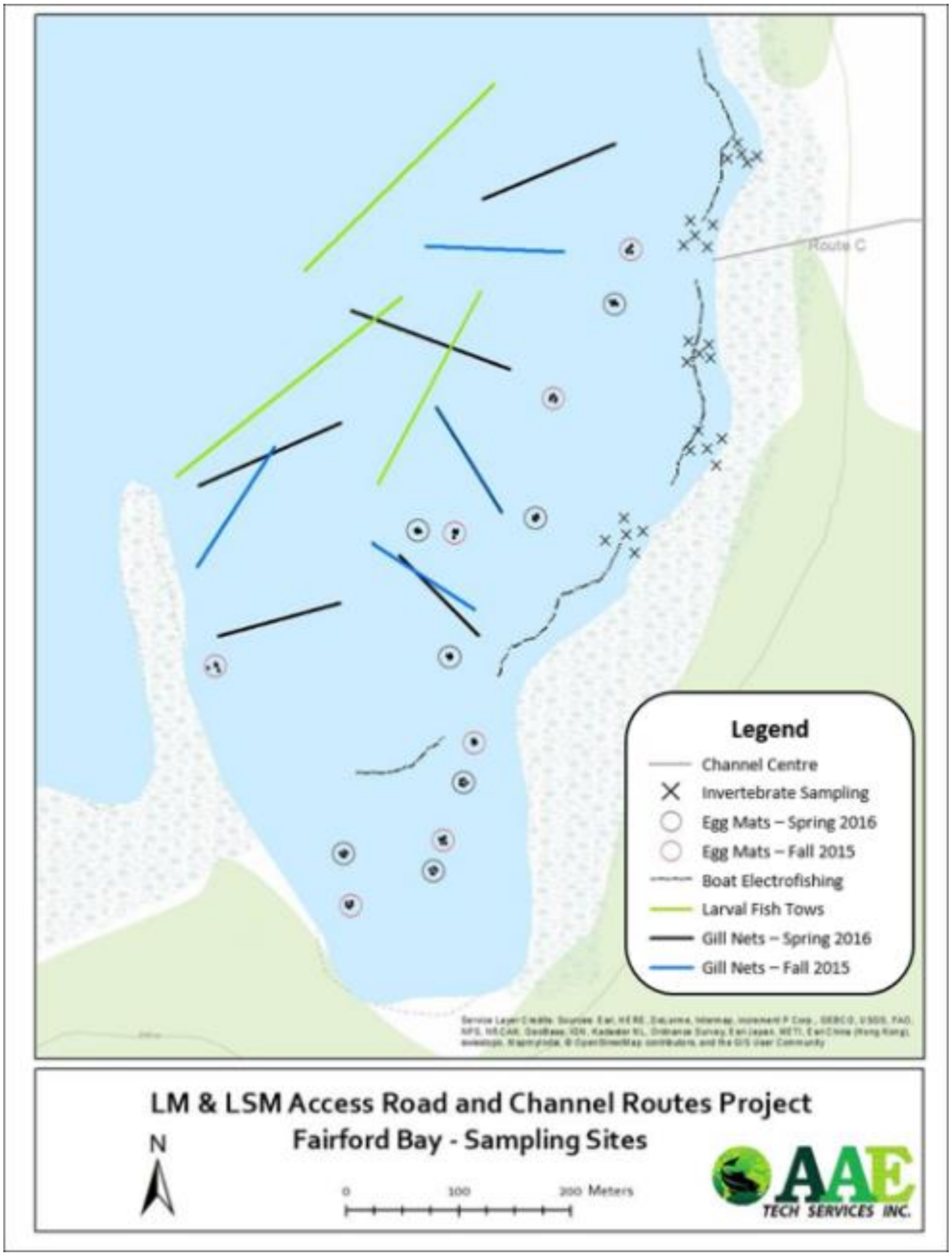


Figure 17. *Fish and invertebrate sampling locations at the Fairford study site.*

5.1.3.1 Boat Electrofishing

A total of 111 fish representing eleven species were successfully captured during spring boat electrofishing at Fairford (Figure 18 and Table 4). The CPUE was 2.022 fish/minute with a total fishing effort of 3,293 seconds. Yellow Perch (*Perca flavescens*) was the most abundant species captured, accounting for 56.8% of the total catch. Additional species captured include Walleye (*Sander vitreus*, 17.1%), Spottail Shiner (*Notropis hudsonius*, 9.9%), White Sucker (*Catostomus commersonii*, 4.5%), Emerald Shiner (*Notropis atherinoides*, 3.6%), Freshwater Drum (*Aplodinotus grunniens*, 2.7%), Northern Pike (*Esox lucius*, 1.8%), Common Carp (*Cyprinus carpio*, 0.9%), Fathead Minnow (*Pimephales promelas*, 0.9%), Johnny Darter (*Etheostoma nigrum*, 0.9%), and Logperch (*Percina caprodes*, 0.9%). Fork length measurements (mean and range) for each species captured are provided in Table 4.

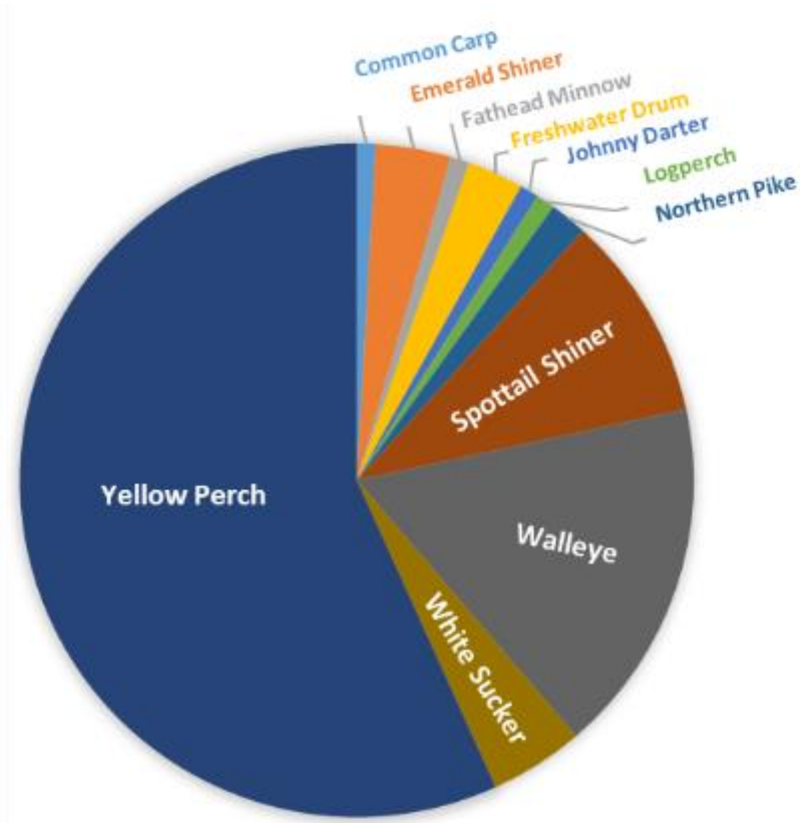


Figure 18. *Relative species abundance for fish captured during spring boat electrofishing at Fairford.*

Table 4. *Boat electrofishing results, Fairford.*

Site	Species	#	Fork Length (mm)		Effort (sec)
			Mean	Range	
Fairford	Common Carp	1	630	630	3293
	Emerald Shiner	4	47	45-50	
	Fathead Minnow	1	44	44	
	Freshwater Drum	3	427	402-453	
	Johnny Darter	1	46	46	
	Logperch	1	64	64	
	Northern Pike	2	458	413-502	
	Spottail Shiner	11	56	38-87	
	Walleye	19	296	143-529	
	White Sucker	5	415	389-444	
	Yellow Perch	63	87	59-186	
	Total	**111**			
				CPUE (#/min)	**2.022**

5.1.3.2 Gill Netting

A total of 115 fish representing six species were successfully captured during fall and spring gill netting at Fairford (Figure 19 and Table 5).

During fall sampling, 23 fish representing three species were captured over a total set time of 122 minutes (CPUE = 7.8 fish/100 m/hour). Northern Pike was the most abundant species captured, accounting for 52.2% of the total catch. White Sucker was the second most abundant species captured, accounting for 30.4% of the total catch. Lake Whitefish accounted for the remaining 17.4% of the total catch. Round weight data was not collected during fall gill net sampling at Fairford, thus condition factor (K) analysis is not available for this period.

During spring sampling, 92 fish representing five species were captured over a total set time of 350 minutes (CPUE = 12.78 fish/100 m/hour). White Sucker was the most abundant species captured, accounting for 80.4% of the total catch. Northern Pike was the second most abundant species captured, accounting for 14.1% of the total catch. The remainder of species captured included Shorthead Redhorse (*Moxostoma* macrolepidotum, 2.2%), Walleye (2.2%), and Quillback (*Carpiodes cyprinus*, 1.1%). Mean size and condition factor (K) for each species is presented in Table 5.

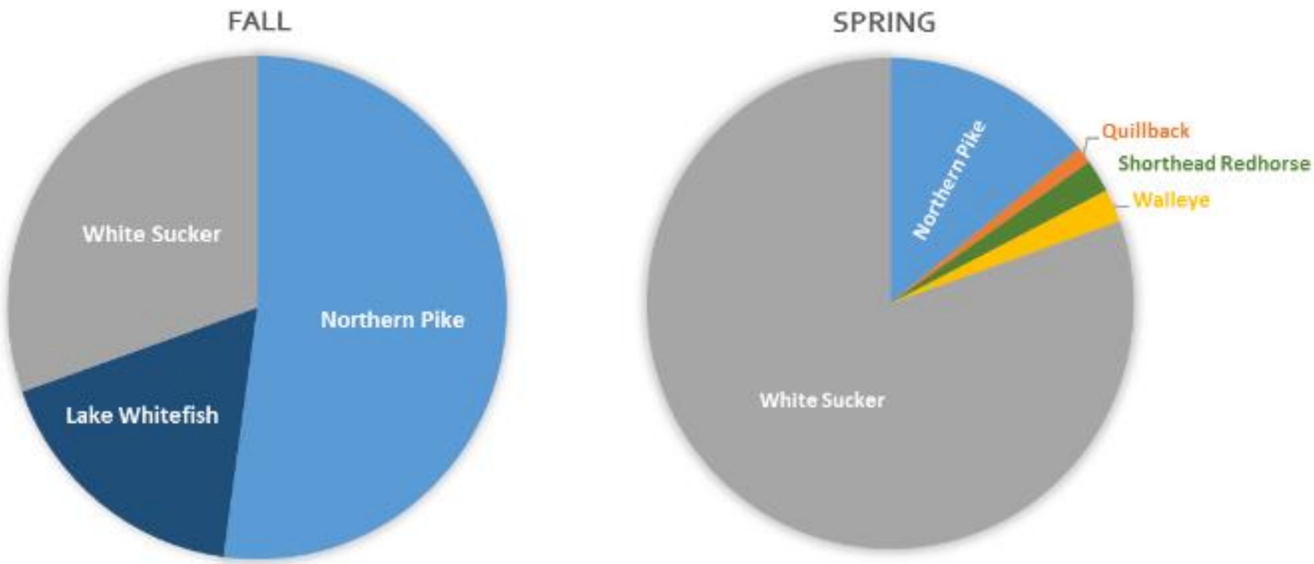


Figure 19. *Relative species abundance for fish captured during fall (left) and spring (right) gill netting at Fairford.*

Table 5. *Gill netting results for Fairford, including mean size and condition factor (K).*

Site	Season	Species	#	Fork Length (mm)		Round Weight (g)		Mean Condition Factor (K)
				Mean	Range	Mean	Range	
Fairford	Fall	Northern Pike	12	666	479-981	-	-	-
		Lake Whitefish	4	399	392-410	-	-	-
		White Sucker	7	394	374-435	-	-	-
		Total	**23**					
	Mean CPUE (#/100 m/hour)		7.80					
	Spring	Northern Pike	13	462	379-573	728.9	400-1200	0.745
		Quillback	1	349	-	800.0	-	1.882
		Shorthead Redhorse	2	378	329-426	687.5	500-875	1.268
		Walleye	2	447	441-452	850.0	850-850	0.956
		White Sucker	74	407	326-594	981.8	600-1925	1.536
		Total	**92**					
	Mean CPUE (#/100 m/hour)		12.78					

5.1.3.3 Length Frequency Distribution Analysis

Fish collection data for the Fairford study site were combined across all sampling methods and field seasons, and frequency distribution plots were generated for all fish species where sample size (n) was equal to or greater than 15 fish. Plots depict both fall, 2015 and spring, 2016 sample sets. A total sample size necessary to conduct a distribution analysis was achieved for four species captured at Fairford, including Northern Pike (n = 27), White Sucker (n = 86), Walleye (n = 21), and Yellow Perch (n = 63).

Northern Pike mean fork length was 552.4 mm, however the majority of individuals fell into the 400 – 449 mm and 500 – 549 mm classes (Figure 20). Fork lengths were noticeably higher during the fall 2015 sampling period (max. 950 – 999 mm) compared to the following spring (max. 550 – 599 mm). Maximum observed fork length, sampled in the fall, was 981 mm.

White Sucker mean fork length was 406.4 mm with a relatively symmetrical distribution, the majority falling in the 375 – 399 mm and 400 – 424 mm classes, with one outlier to the right (Figure 21). Trends were similar in both the fall, 2015 and spring, 2016 sampling periods, though all larger fish (FL > 450 mm) were captured in the spring, with a maximum observed fork length of 594 mm.

Walleye mean fork length was 310.4 mm with a relatively symmetrical distribution; the majority falling in the 275 – 299 mm and 300 – 324 mm classes (Figure 22). All Walleye were captured during the spring field season, with length-frequency distribution depicting a mature spawning population with fork lengths between 225 – 374 mm. Maximum observed fork length was 529 mm.

Yellow Perch mean fork length was 87 mm with the majority falling in the 60 – 69 mm size class, as well as a second smaller peak in the 90 – 99 mm size class (Figure 23). All Yellow Perch were captured during the spring field season. Maximum observed fork length was 186 mm.

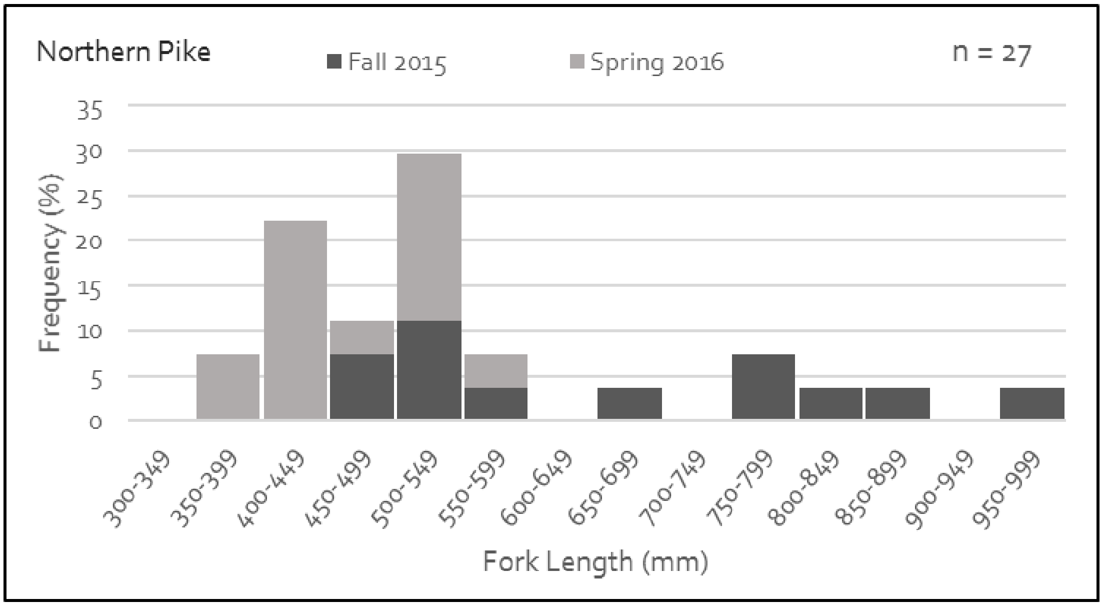


Figure 20. *Length-frequency distribution for Northern Pike, Fairford.*

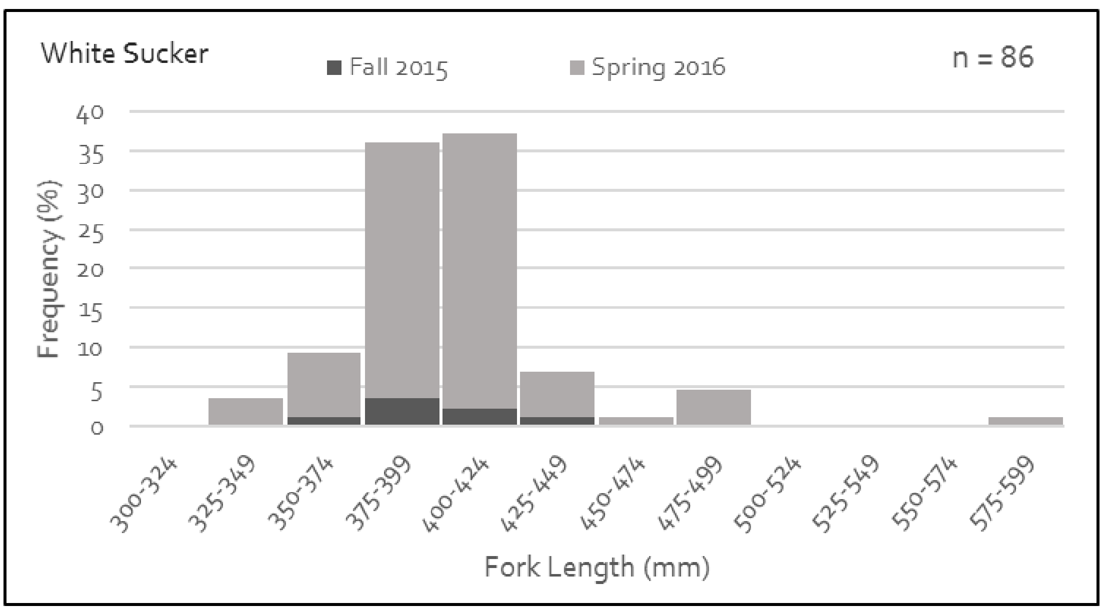


Figure 21. *Length-frequency distribution for White Sucker, Fairford.*

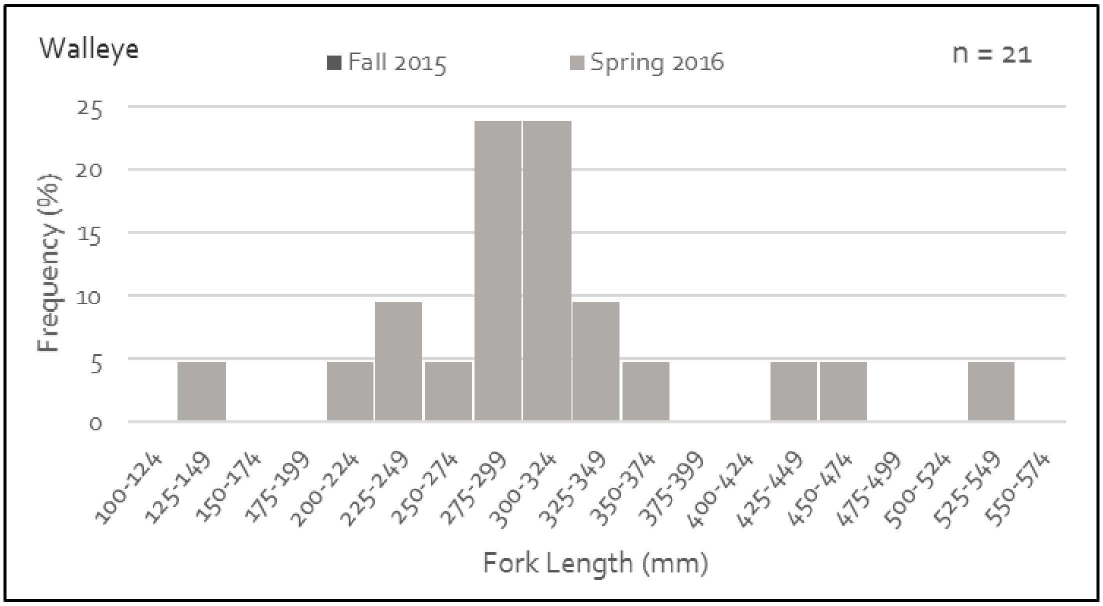


Figure 22. *Length-frequency distribution for Walleye, Fairford.*

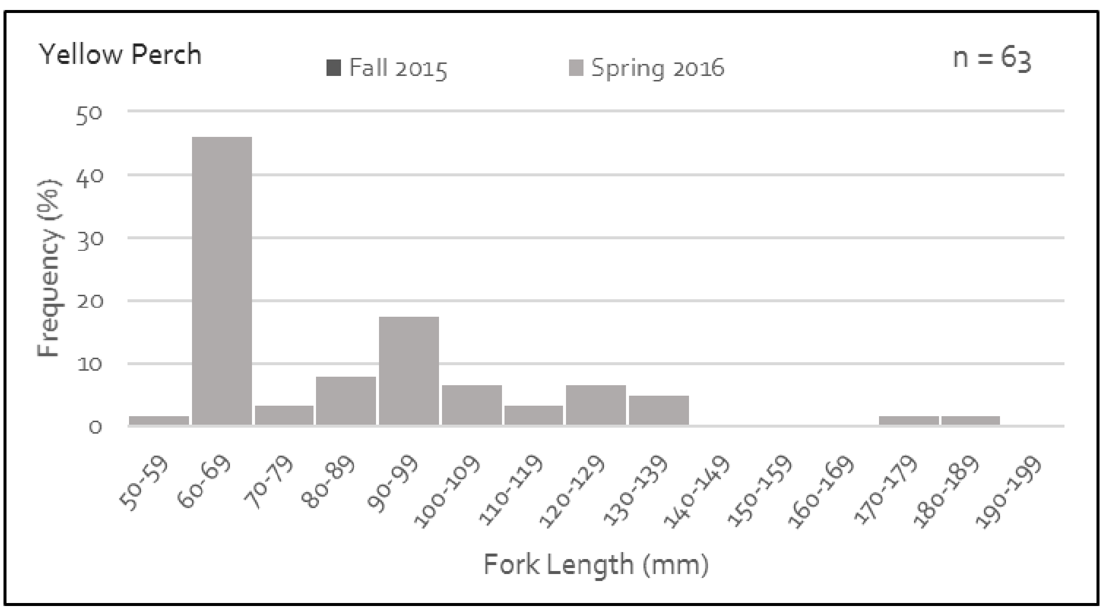


Figure 23. *Length-frequency distribution for Yellow Perch, Fairford.*

5.1.4 FISH SPAWNING ACTIVITY

Adult fish in spawning condition were observed within the Fairford study area during both the fall (Lake Whitefish) and spring (Northern Pike, Walleye, White Sucker) field seasons. However, egg mat and kick sampling efforts yielded no eggs during either the spring or fall season. Larval sampling completed following the spring spawning window identified Walleye and White Sucker larvae within the Fairford study area.

5.1.4.1 Adult Fish Spawning Condition

Fall 2015 gill net sampling was completed to coincide with the Lake Whitefish spawning window, and assess the presence of spawning adult fish within this study area. A total of four Lake Whitefish (three male, one female) were captured during fall gill netting efforts and were found to be in spawning condition (Table 6).

Spring 2016 gill net sampling was completed to coincide with the spring spawning window; Walleye, Northern Pike, and White Sucker were expected to be in or approaching their spawning run. A total of 12 Northern Pike, 2 Walleye and 73 White Sucker were in spawning condition (Table 5).

Table 6. *Sex and spawning condition observations during gill net sampling, Fairford.*

Site	Season	Species	#	Sex				Maturity			
				Male	Female	Juvenile	Undeter-mined	Pre-spawn	Ripe and Running	Spent	Undeter-mined
Fairford	Fall	Northern Pike	12	0	0	0	12	0	0	0	12
		Lake Whitefish	4	3	1	0	0	0	4	0	0
		White Sucker	7	0	0	0	7	0	0	0	7
		Total	**23**	**3**	**1**	**0**	**19**	**0**	**4**	**0**	**19**
	Spring	Northern Pike	13	4	2	0	7	0	6	6	1
		Quillback	1	0	0	0	1	0	0	0	1
		Shorthead Redhorse	2	0	1	0	1	1	1	0	0
		Walleye	2	1	0	0	1	0	1	1	0
		White Sucker	74	41	32	0	1	0	63	10	1
		Total	**92**	**46**	**35**	**0**	**11**	**1**	**71**	**17**	**3**

5.1.4.2 *Larval Sampling*

A total of 59 larval fish representing two species were captured during three four-minute net tows at the Fairford study site. The most abundant species captured was Walleye, which accounted for 96.6% of larval fish captured (Table 7). The remaining catch was identified as White Sucker (n=2). Incidental by-catch during larval net tows included four Emerald Shiner.

Table 7. *Results of larval fish net tow sampling for Fairford.*

Site	Species	#	Total Volume (L)	Mean CPUE (# of fish/L)
Fairford	Walleye	57	578.388	0.099
	White Sucker	2		0.003

5.1.4.3 *Egg Mats*

No eggs were captured from the 70 egg mats placed at Fairford during both the fall and spring field seasons. Egg mat placement sites favored coarse gravel substrate, boulder gardens, and sand/gravel substrate, as these represent ideal spawning habitat for most Commercial, Recreational and Aboriginal (CRA) targeted fish species, including those identified during fall sampling (e.g. Lake Whitefish) and spring sampling efforts (e.g. Walleye, White Sucker).

5.1.4.4 *Kick Sampling*

A total of 25 m^2 of near-shore habitat was sampled using kick sampling. No eggs were captured during kick sampling at Fairford. Most habitat sampled had a substrate composed of 70% gravel, 20% cobble, 10% sand.

5.1.5 BENTHIC INVERTEBRATES

A total of 23 taxa from 10 orders of benthic macroinvertebrates (BMI) were captured at Fairford (Table 8 and Figure 24). Four orders dominated this site, with the most common being Ephemeroptera (Mayfly) (mean ($\bar{x}$) = 270.55/m^2), consisting of the family Leptophlebiidae ($\bar{x}$ = 239.30/m^2), Caenidae ($\bar{x}$ = 23.55/m^2), Ephemeridae ($\bar{x}$ = 7.50/m^2), and Heptageniidae ($\bar{x}$ = 0.20/m^2). The second most common order was Diptera (True Flies) ($\bar{x}$ = 78.00/m^2), which consisted largely of the family Chironomidae ($\bar{x}$ = 73.70/m^2) and, to a lesser extent, Empididae ($\bar{x}$ = 2.75/m^2), Ceratopogonidae ($\bar{x}$ = 1.50/m^2) and Tabanidae ($\bar{x}$ = 0.05/m^2). The third most common order was Amphipoda (Scuds) ($\bar{x}$ = 21.60/m^2), which consisted almost entirely of the family Dogielinotidae ($\bar{x}$ = 21.25/m^2), with a small number of Gammaridae

($\bar{x}$ = 0.35/m^2). The fourth most common order was Trichoptera (Caddisfly) ($\bar{x}$ = 20.65/m^2), consisting predominantly of the family Hydropsychidae ($\bar{x}$ = 17.40/m^2), as well as the families Polycentropodidae ($\bar{x}$ = 2.75/m^2), Hydroptilidae ($\bar{x}$ = 0.25/m^2), Helicopsychidae ($\bar{x}$ = 0.15/m^2), Leptoceridae ($\bar{x}$ = 0.05/m^2), and Limnephilidae ($\bar{x}$ = 0.05/m^2). The remaining six orders represented a combined total mean of 13.85/m^2, and included Trombidiformes (Mites) ($\bar{x}$ = 8.35; family Hydrachnidiae), Coleoptera (beetles) ($\bar{x}$ = 5.30/m^2; families Elmidae ($\bar{x}$ = 5.20/m^2), Dyticidae (water beetles) ($\bar{x}$ = 0.10/m^2)), Hirudinea (leeches) ($\bar{x}$ = 0.05/m^2; not classified to family), Leptidoptera (butterflies/moths) ($\bar{x}$ = 0.05/m^2, family Pyralidae), Nematoda (roundworms) ($\bar{x}$ = 0.05/m^2, not classified to family), and Odonata (dragonfly) ($\bar{x}$ = 0.05/m^2, family Coenarionidae).

The mean richness (number of taxa per sample) was determined to be 8.40 (standard deviation (σ) = 2.95), the overall mean for the site (number of individuals per m^2) was 405 BMI/m^2 (σ = 505.99), and Simpson's Diversity Index (number of species and abundance of each species) was 0.55 (Table 9)

Table 8. *Mean benthic invertebrates captured per square meter at Fairford during two minutes of kick sampling.*

Order	Family	Genus	Species	Mean (per m²)
Ephemeroptera	Leptophlebiidae	spp.	spp.	239.30
	Caenidae	spp.	spp.	23.55
	Ephemeridae	spp.	spp.	7.50
	Heptageniidae	spp.	spp.	0.20
	Total			270.55
Diptera	Chironomidae	spp.	spp.	73.70
	Empididae	spp.	spp.	2.75
	Ceratopogonidae	spp.	spp.	1.50
	Tabanidae	spp.	spp.	0.05
	Total			78.00
Amphipoda	Dogielinotidae	*Hyalella*	*azteca*	21.25
	Gammaridae	spp.	spp.	0.35
	Total			21.60
Trichoptera	Hydropsychidae	spp.	spp.	17.40
	Polycentropodidae	spp.	spp.	2.75
	Hydroptilidae	spp.	spp.	0.25
	Helicopsychidae	*Helicopsyche*	spp.	0.15
	Leptoceridae	spp.	spp.	0.05
	Limnephilidae	spp.	spp.	0.05
	Total			20.65
Trombidiformes	Hydrochnidiae	spp.	spp.	8.35
	Total			8.35
Coleoptera	Elmidae	spp.	spp.	5.20
	Dytiscidae	spp.	spp.	0.10
	Total			5.30
Hirudinea	Total			0.05
Leptidoptera	Pyralidae	spp.	spp.	0.05
	Total			0.05
Nematoda	Total			0.05
Odonata	Coenarionidae	spp.	spp.	0.05
	Total			0.05

Table 9. *Number of families, diversity, richness, and Simpson's Diversity for benthic invertebrates, Fairford.*

	Diversity		Richness		Simpson's Diversity	
Number of Families	**Mean**	**σ**	**Mean**	**σ**	**Mean**	**σ**
23	405	506	8.4	2.95	0.55	0.15

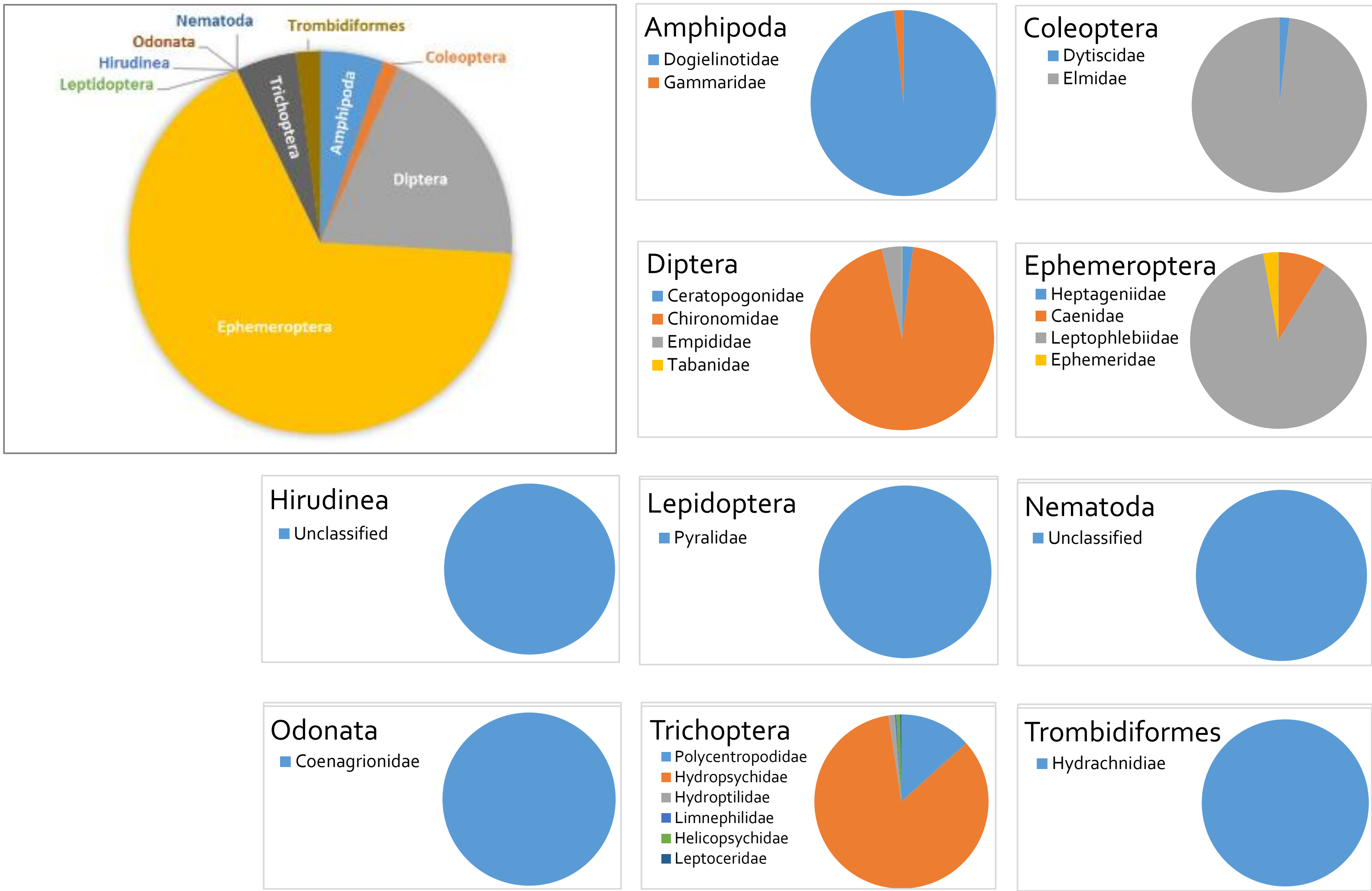


Figure 24. *Relative benthic invertebrate counts by Order (black box) and Family (grey boxes) at Fairford.*

5.2 ROUTE D – LAKE MANITOBA, WATCHORN BAY STUDY SITE

5.2.1 HABITAT ASSESSMENT

Aquatic and riparian habitat was assessed at the Watchorn Bay study site by completing a full bathymetric, substrate and aquatic vegetation profile, as well as an aerial photographic survey of shoreline and riparian habitat.

5.2.1.1 Bathymetry

Bathymetric analysis of the Watchorn Bay study site (Figure 25) revealed a relatively uniform slope across the entire study area. Lake bottom at the Route D inlet has an average slope of 0.0059. Steeper shoreline exists to the northwest of the Route D inlet site (slope = 0.022) to a depth of 1 m, before leveling out to average. Maximum depth within the surveyed area is 2.7 m, at approximately 750 m from shore.

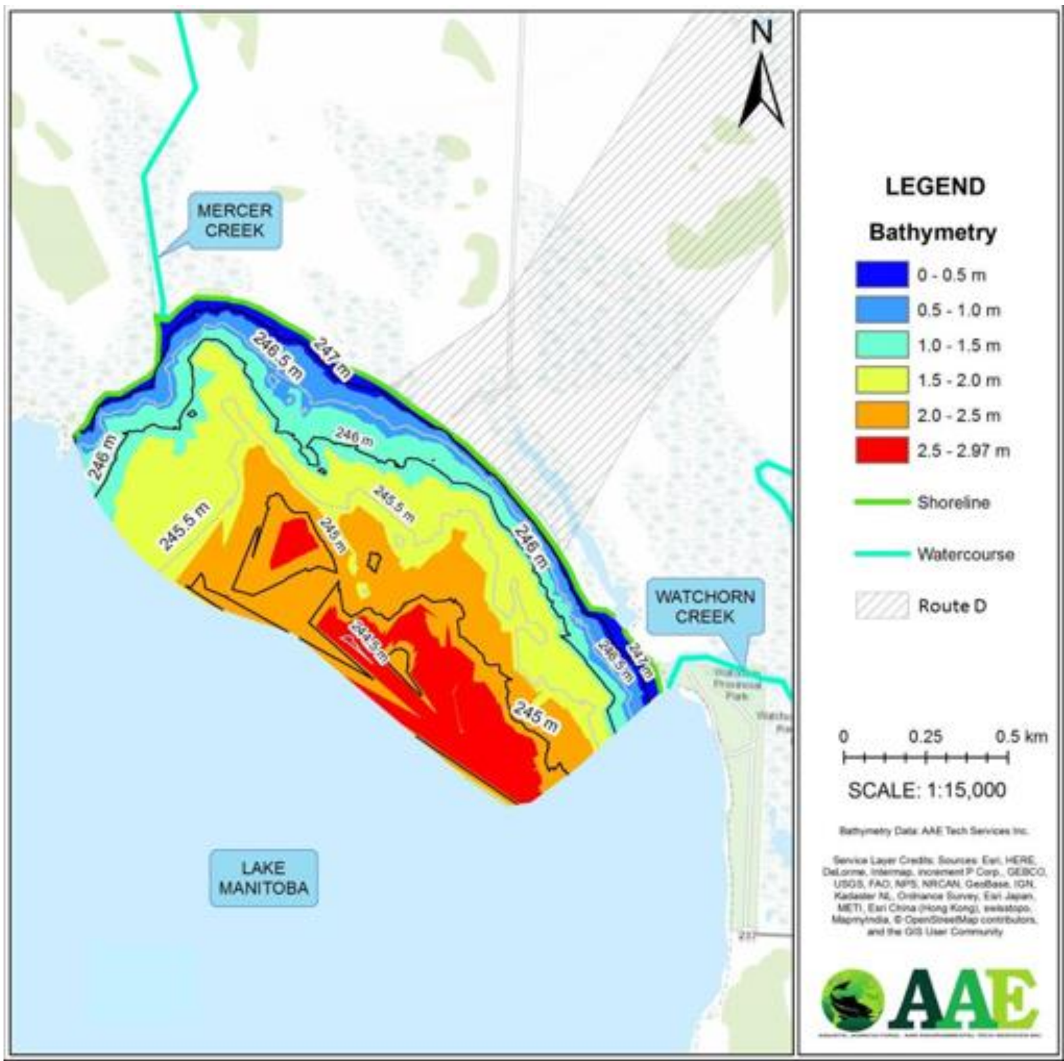


Figure 25. *Bathymetric map of the Watchorn Bay study area on Lake Manitoba.*

5.2.1.2 Substrate

Sonar analysis of substrate (Figure 26) identified three distinct substrate types, with a fourth type observed along the shoreline. Substrate immediately offshore (0.5 m > 1.5 m depth) was predominantly (>90%) sand, with scattered boulders across the study area. At depths exceeding 1.5 m, substrate consisted of a finer gravel – sand – silt mixture (50% - 30% - 20% respectively). Pockets of substrate consisting of coarser sand and gravel (50% - 50%) were also identified, at depths greater than 2.0 m. Boulders and boulder fields were also observed across the study area at all depths, occurring in localized clusters within all substrate types.

Ground truthing was accomplished using a telescopic metal probe to assess bottom compaction, texture and grain class of a 1 m^2 area of substrate at 38 ground truthing sites. Substrate along the shoreline and within approximately 1 m of the water's edge (depth < 0.4 m), consisted primarily (> 80%) of gravel and cobble material. The source of this material is likely a berm that runs parallel to the shore (5 – 10 m inland) along the extent of the study area for flood and weather protection of adjacent agricultural land.

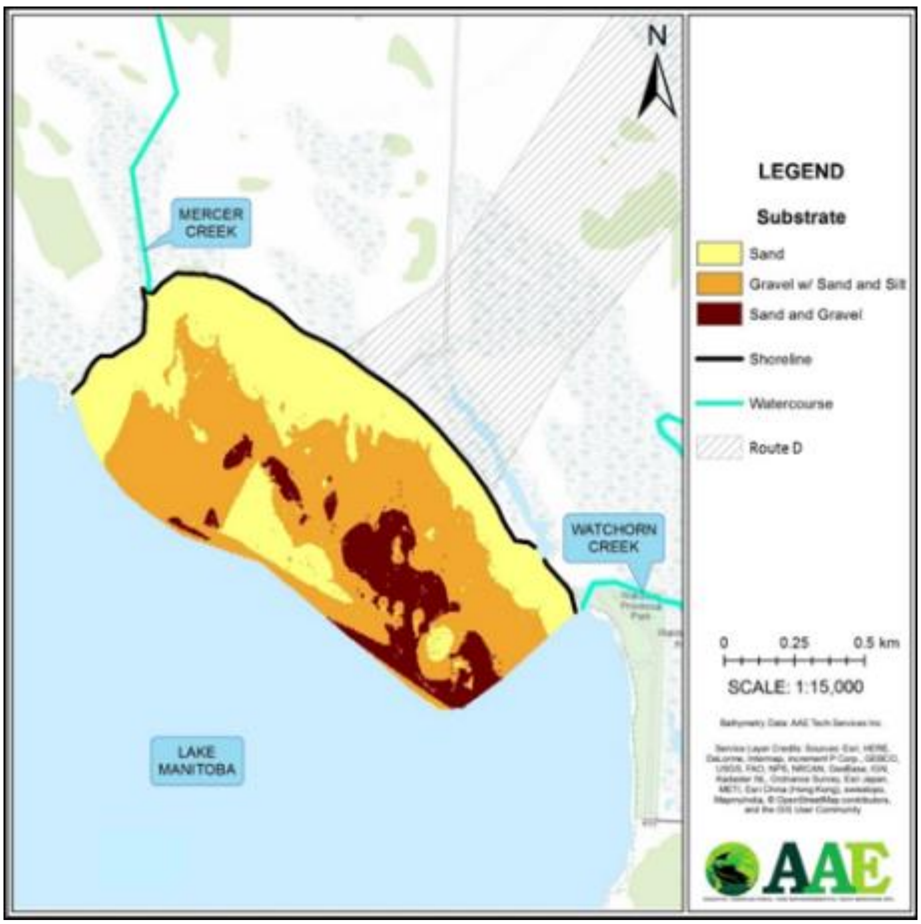


Figure 26. *Substrate composition map of the Watchorn Bay study area on Lake Manitoba.*

5.2.1.3 Aquatic Vegetation

Aquatic vegetation cover (Figure 27) was sparse (0% - 20% cover over >90% area) across much of the study area. Plant cover (Figure 28) occurred almost exclusively at depths exceeding 2.0 m, in one localized and isolated area, with plant height (Figure 29) reaching above 1 m in one instance. Additional plant cover was observed in localized areas near the Watchorn Creek and Mercer Creek inlets, though plant height at these locations did not exceed 0.4 m. Plant bed biovolume was low (<10%) across most of the study area. Areas with increased plant cover had higher corresponding biovolume, reaching ~60% in some areas where depths exceed 2.0 m, as well as the Mercer Creek inlet.

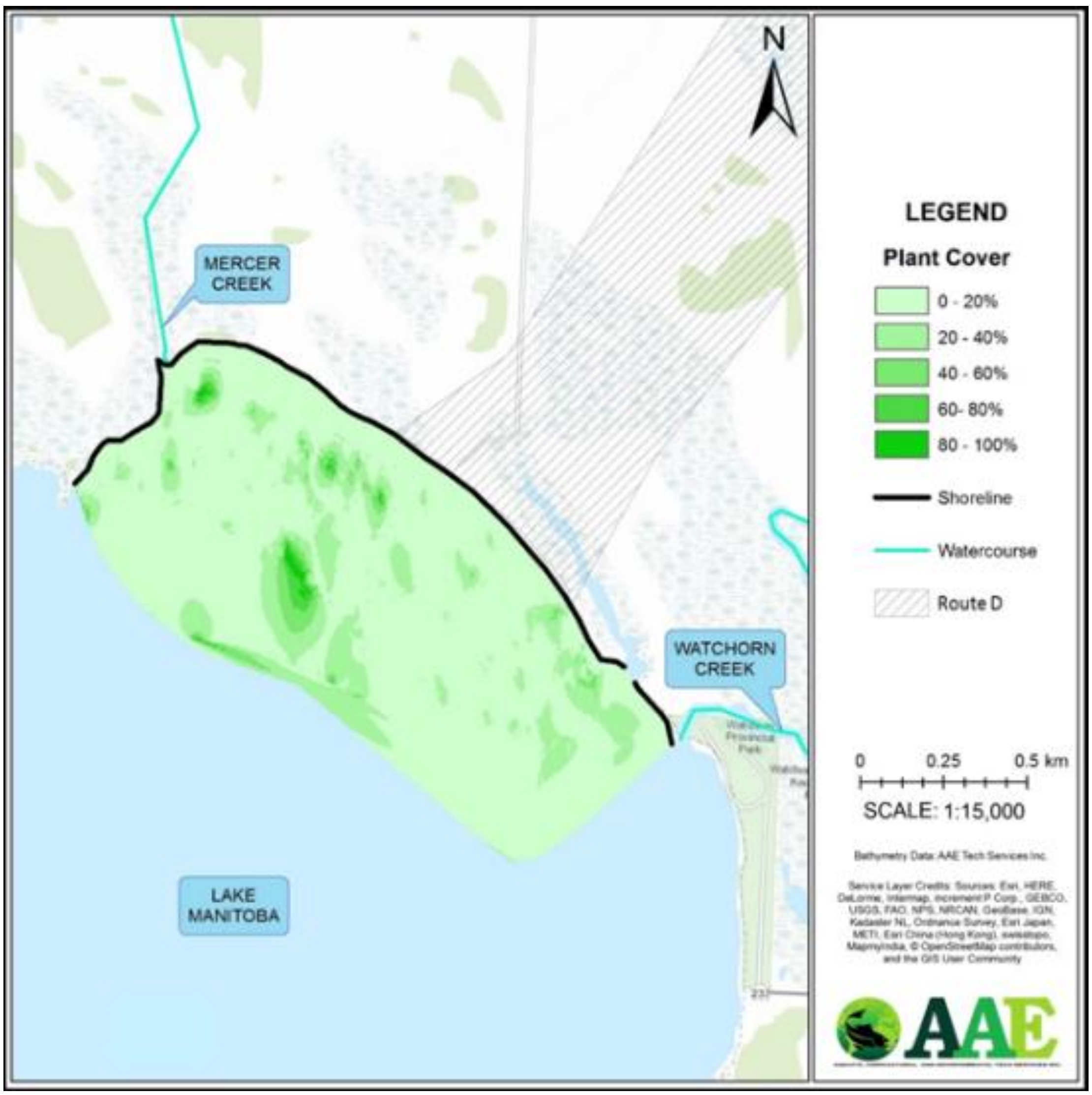


Figure 27. *Plant Cover (% area) map of the Watchorn Bay study area on Lake Manitoba.*

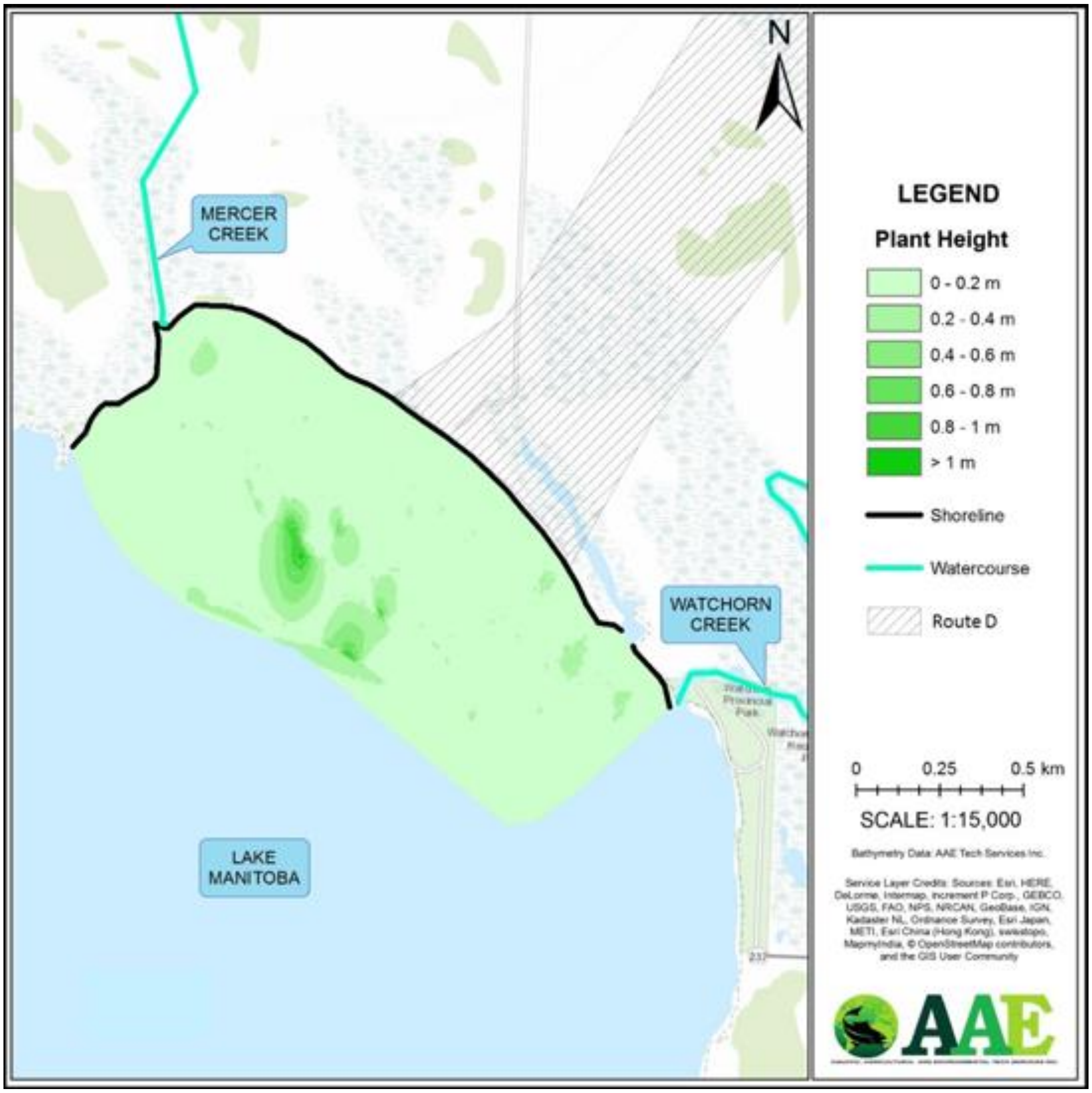


Figure 28*. Plant Height map of the Watchorn Bay study area on Lake Manitoba*.

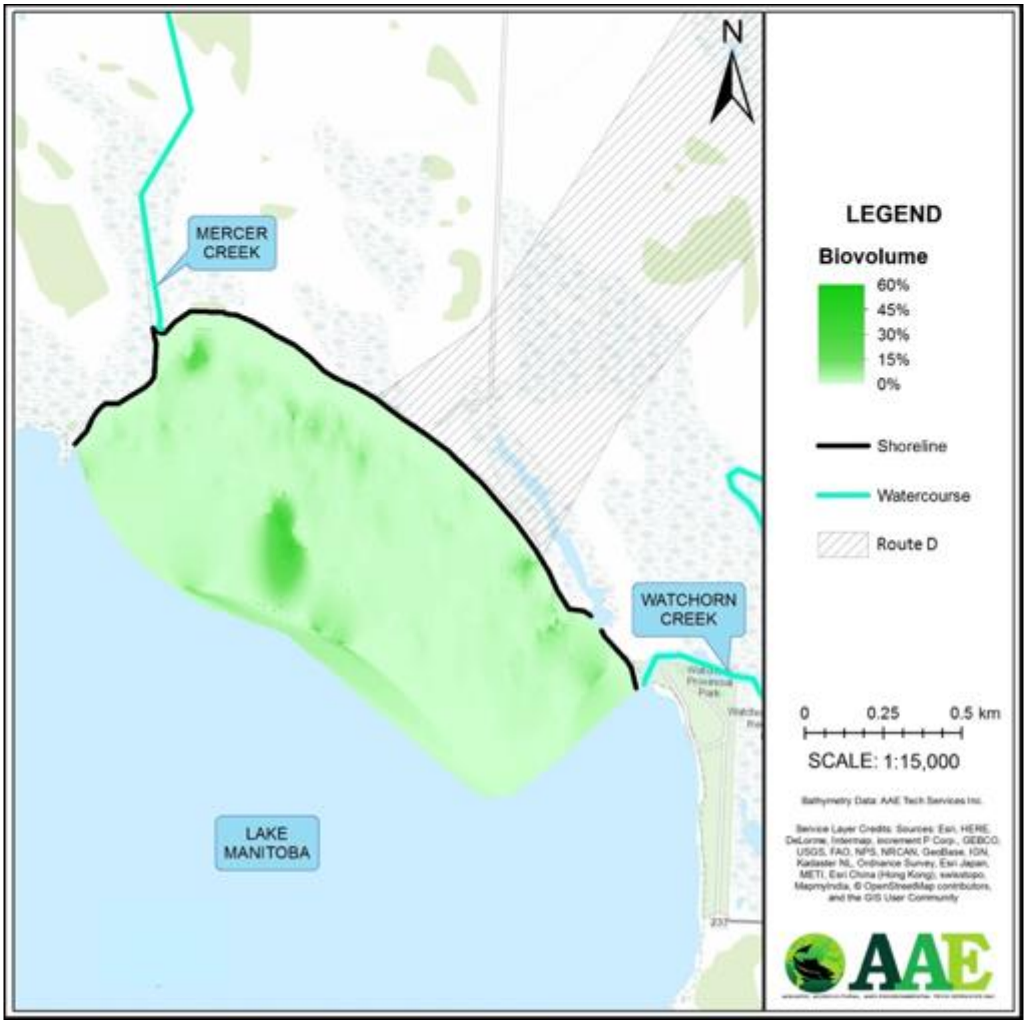


Figure 29. *Total Biovolume (% water column) map of the Watchorn Bay study area on Lake Manitoba.*

5.2.1.4 Shoreline and Riparian Habitat

Aerial photographic surveys of the Watchorn study site revealed a narrow shoreline and riparian habitat (Figures 30 – 32).

The shoreline habitat extends 8 m back from the water's edge, and is composed of a compacted gravel – cobble – sand substrate. Boulders are visible within the sandy shallow nearshore habitat (Figure 32), in particular within the western extent of the study area and towards Mercer Creek.

A gravel-cobble berm with a height of approximately 1.5 m and a width of 15 m runs parallel to the shoreline, and is situated ~5 – 10 m back from the water's edge. Dense vegetation cover is present along the extent of this berm, including a mixture of long grasses, low shrubs and deciduous trees. Beyond the berm, land has been developed for agricultural use, including a farm yard immediately west of the Route D right of way, and land used for livestock grazing. Habitat within and to the east of the Route D right of way includes a small shallow inlet adjacent to Watchorn Creek, which is linked to the agricultural drainage system along the access road to the north. This area is characteristic of floodplain habitat, with long grass and cattail vegetation coverage extending 135 m back from the berm. Land use beyond this is agricultural (livestock grazing) with areas of standing water that are characteristic of repeated flooding and wet lowland conditions.

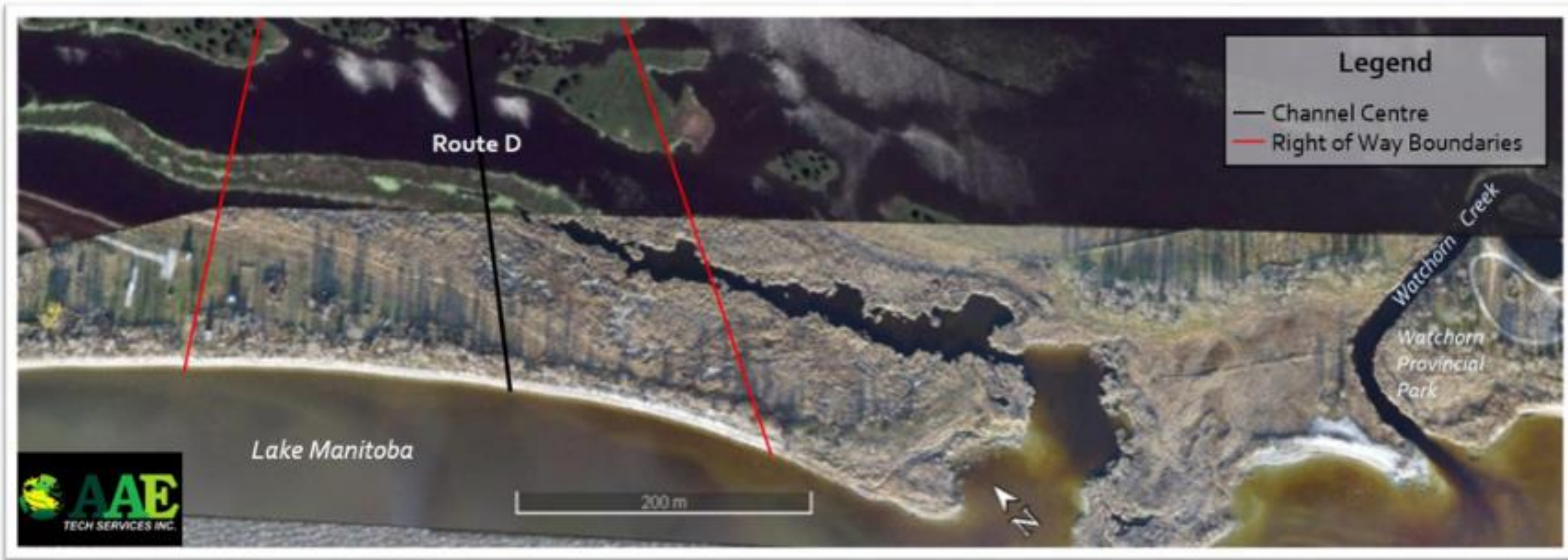


Figure 30. *Aerial photo orthomosaic of the Watchorn Bay study site for Route D, focusing on shoreline and riparian habitat.*

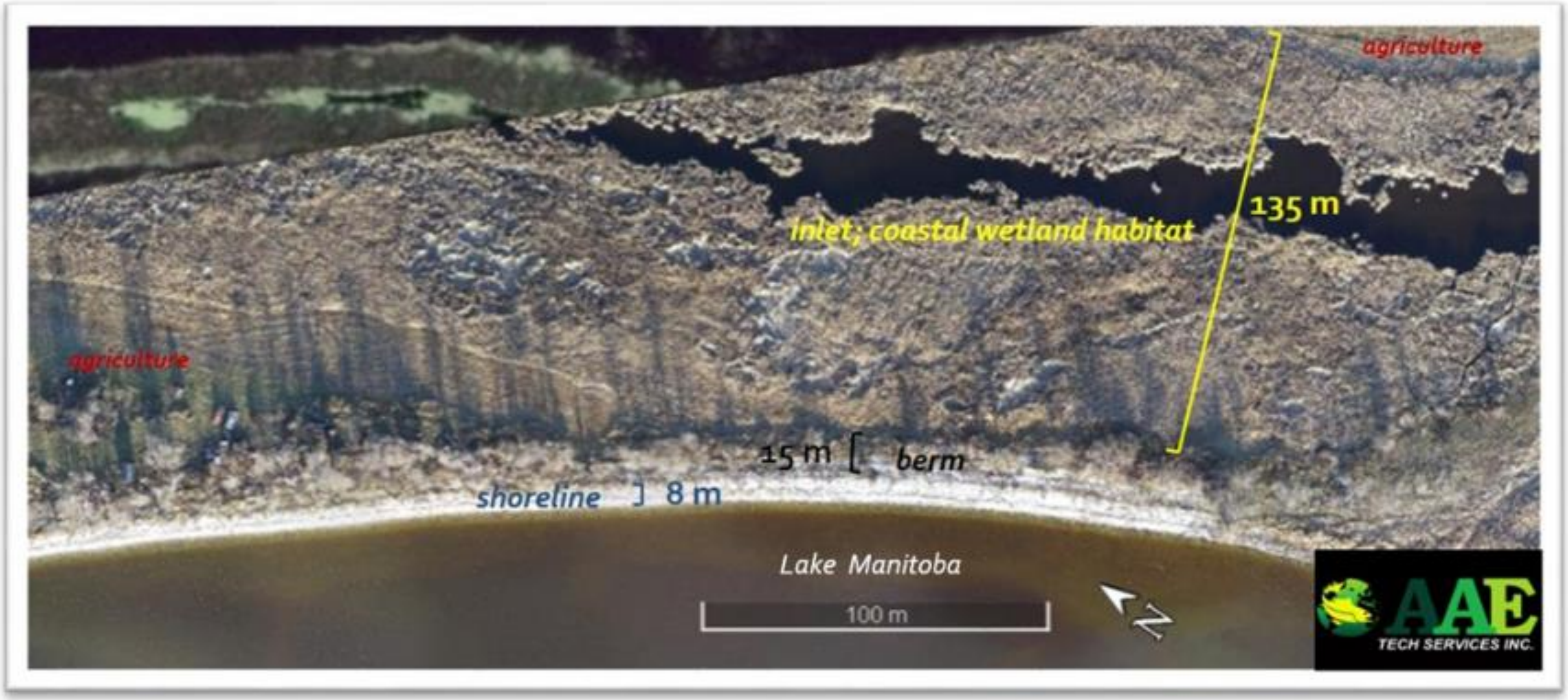


Figure 31. *Aerial photo orthomosaic of the Watchorn Bay study site for Route D, depicting extent of shoreline and riparian habitat. Centred on the Route D inlet site.*

Figure 32. *Aerial photo orthomosaic of the Watchorn Bay study site for Route D, depicting shoreline and riparian habitat cover and composition. Oblique view from the west, centred on Route D inlet site.*

5.2.2 WATER QUALITY

The mean water temperature for Lake Manitoba during the fall study period (October – November, 2015) was 6.33°C (Table 3). Temperature declined steadily from 8.92°C on October 04, 2015 until ice-up on November 19, 2015, then remained near freezing (range: 0.079°C – 0.742°C) until April, 2016 (Figure 33). Temperatures began to rise after April 27, 2016 in conjunction with ice breakup. The mean water temperature over the spring study period (April – June) on Lake Manitoba was 14.58°C (range: 0.467°C – 24.05°C, Table 3).

Remaining water quality parameters were relatively similar between the fall, 2015 and spring, 2016 field seasons (Table 10). Mean dissolved oxygen at the Watchorn Bay site was 12.30 mg/L during the fall study period, and 8.79 mg/L (8.10 – 9.55 mg/L) during the spring study period; DO values were consistently above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity, total suspended solids (TSS), pH and Conductivity values were assessed for the Watchorn Bay site based on mean measurements taken using *in-situ* readings between October 15, 2015 and November 12, 2015 (Fall study period) and April 29, 2016 and June 3, 2016 (Spring study period), and are presented in Table 10.

Table 10. *Mean water quality values, Watchorn Bay.*

	Sampling Season		
WQ Parameter	**Fall 2015**	**Spring 2016**	**CCME Minimum Guideline Value**
Temperature*	6.33*	14.58*	Variable
Dissolved Oxygen (mg/L)	12.30	8.79	Variable: 5.5 – 9.5
pH	6.84	6.60	6.5 – 9.0
Conductivity (µS/cm)	823	877	No Data
Turbidity (NTU)	3.91	4.05	Variable
TSS (mg/L)	14.336	14.65	No Data

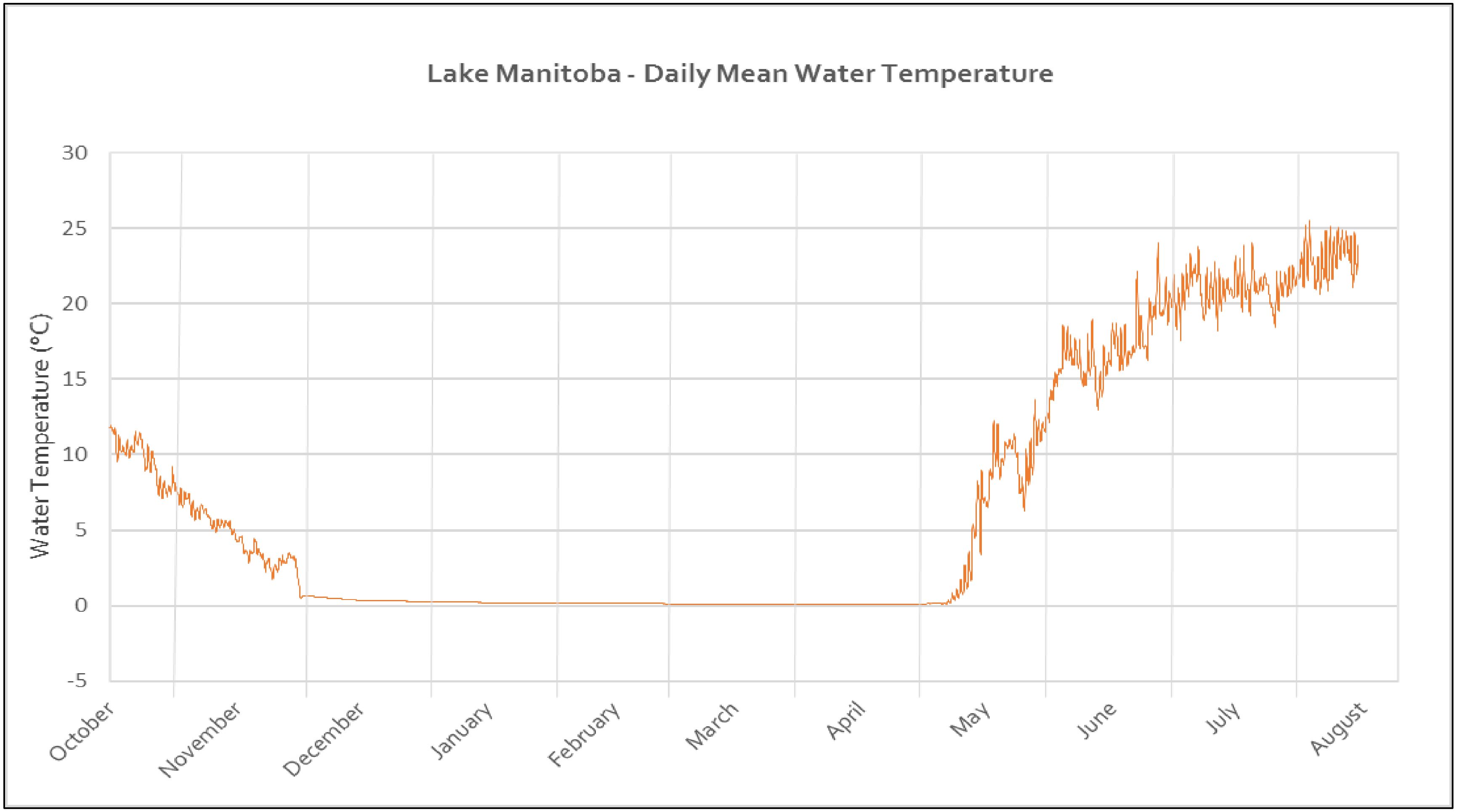


Figure 33. *Lake Manitoba hourly water temperature measurements, May 2015 – July 2016.*

5.2.3 FISH DISTRIBUTION AND COMPOSITION

Fish and invertebrate sampling was carried out at the Watchorn Bay study site over a 34-day fall sampling period in October and November, 2015, and a 45-day spring sampling period from April through June, 2016. Fish community composition was assessed using gill net and boat electrofishing surveys, egg mats, larval fish tows, and kick net benthic sampling (Figure 34). A total of 218 fish representing twelve species were captured. No species of concern were identified at this site.

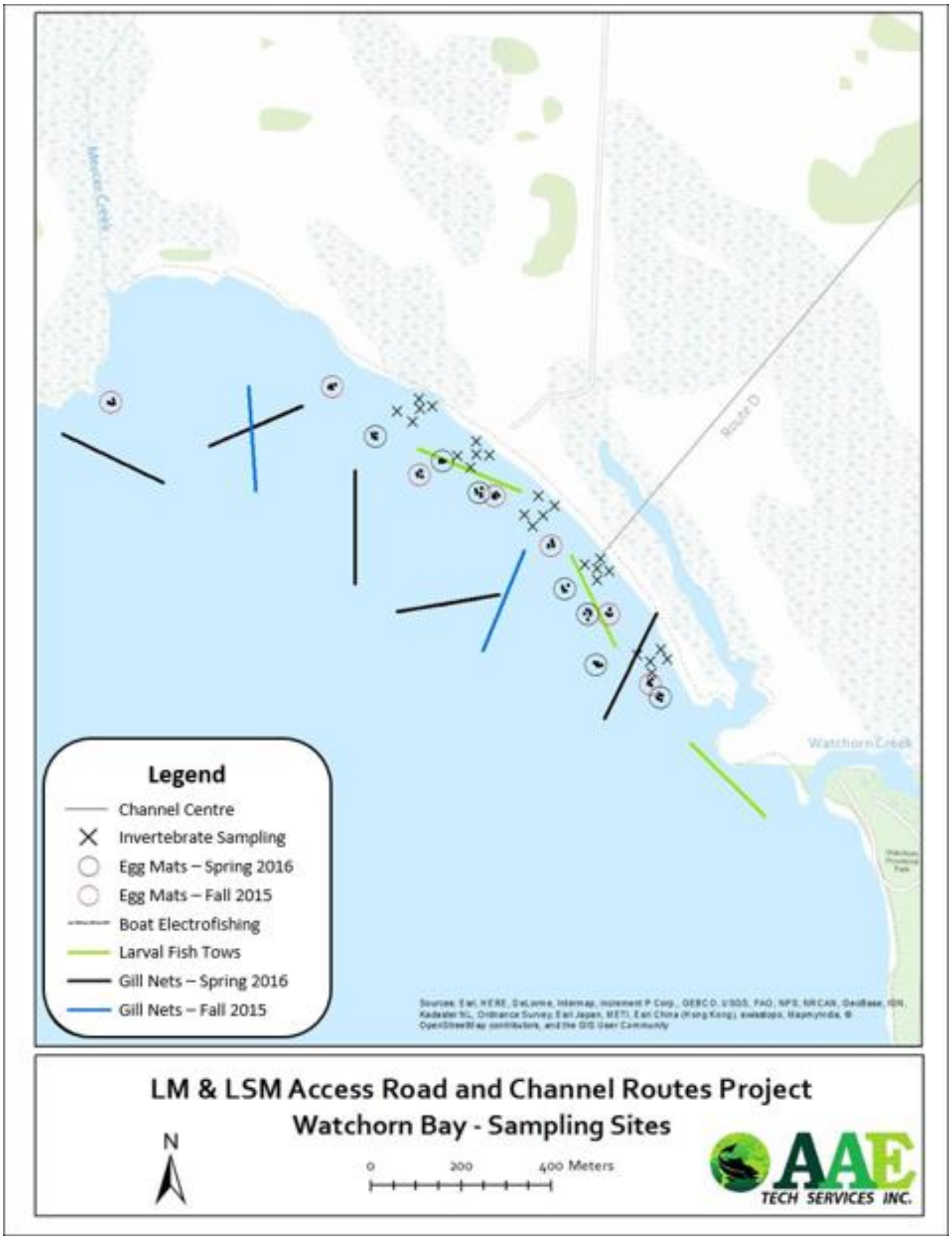


Figure 34.*Fish and invertebrate sampling locations at the Watchorn Bay study site.*

5.2.3.1 Boat Electrofishing

A total of 80 fish representing eight species were successfully captured during spring boat electrofishing at Watchorn Bay (Figure **35** and Table **11**). CPUE was 2.366 fish/minute with a total fishing effort of 2029 seconds. Yellow Perch was the most abundant species captured, accounting for 48.8% of the total catch. Other species captured included Spottail Shiner (23.8%), Common Carp (12.5%), Fathead Minnow (5.0%), Logperch (3.8%), Northern Pike (3.8%), Johnny Darter (1.2%) and Troutperch (*Percopsis omiscomaycus*, 1.2%).

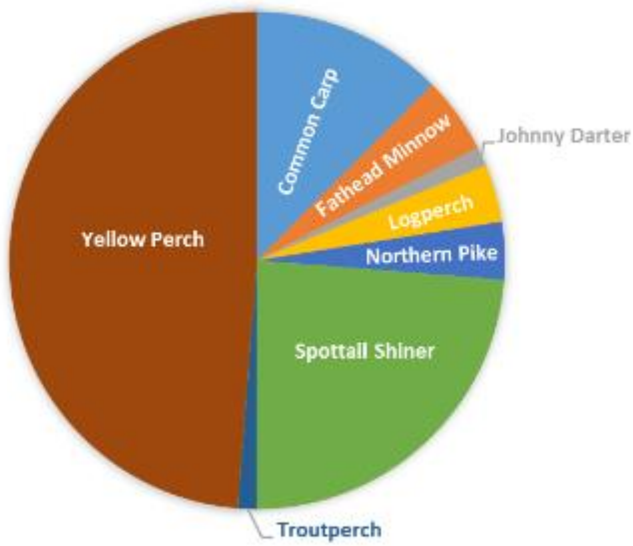


Figure 35. *Relative species abundance for fish captured during spring boat electrofishing at Watchorn Bay.*

Table 11. *Boat electrofishing results for Watchorn Bay.*

Site	Species	#	Fork Length (mm)		Effort (sec)
			Mean	Range	
Watchorn Bay	Common Carp	10	612	529-683	2029
	Fathead Minnow	4	53	43-57	
	Johnny Darter	1	42	42	
	Logperch	3	61	89	
	Northern Pike	3	379	61-548	
	Spottail Shiner	19	59	41-98	
	Troutperch	1	79	79	
	Yellow Perch	39	74	59-129	
	Total	**80**			
				CPUE (#/min)	**2.366**

5.2.3.2 Gill Netting

A total of 138 fish representing six species were successfully captured during fall and spring gill netting efforts at the Watchorn Bay study site (Figure 36 and Table 12).

During fall sampling, 25 fish representing three species were captured over a total set time of 60 minutes. (CPUE = 18.24 fish/100 m/hour) Lake Whitefish was the most abundant species captured, accounting for 92.0% of the total catch. Northern Pike (4.0%) and White Sucker (4.0%), were also captured.

During spring sampling, 113 fish representing five species were captured over a total set time of 355 minutes (CPUE = 13.56 fish/100 m/hour) White Sucker was the most abundant species accounting for 87.6% of the total catch. Additional species captured included Northern Pike (7.1%), Walleye (2.7%), Common Carp (1.8%), and Freshwater Drum (0.9%).

Mean size and condition factor (K) for each species sampled in both the fall and spring sampling periods is presented in Table 12.

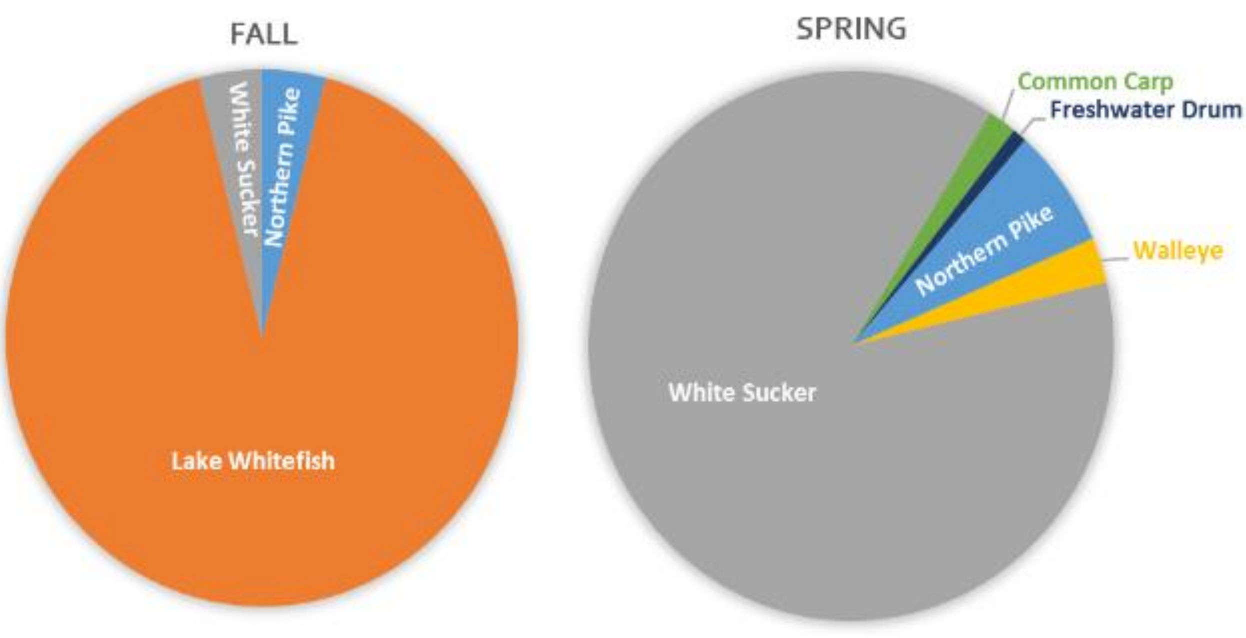


Figure 36. *Relative species abundance for fish captured during fall (left) and spring (right) gill netting at Watchorn Bay.*

Table 12. *Gill netting results for Watchorn Bay, including mean size and condition factor (K).*

Site	Season	Species	#	Fork Length (mm)		Round Weight (g)		Mean Condition Factor (K)
				Mean	Range	Mean	Range	
Watchorn Bay	Fall	Northern Pike	1	534	-	765.4	-	0.503
		Lake Whitefish	23	393	358 - 434	832.1	595.3-1105.6	1.395
		White Sucker	1	415	-	963.9	-	1.349
		Total	**25**					
	Mean CPUE (#/100 m/hour)		18.24					
	Spring	Common Carp	2	685	651-719	6125.0	5250-7000	1.893
		Freshwater Drum	1	475	-	-	-	-
		Northern Pike	8	469	311-543	812.5	450-1200	0.537
		Walleye	3	495	443-551	1275.0	950-1600	1.025
		White Sucker	99	399	319-486	957.1	400-2150	1.452
		Total	**113**					
	Mean CPUE (#/100 m/hour)		13.56					

5.2.3.3 Length Frequency Distribution Analysis

Fish collection data for the Watchorn study site were combined across all sampling methods and field seasons, and frequency distribution plots were generated for all fish species where sample size (n) was equal to or greater than 15 fish. Plots depict both fall, 2015 and spring, 2016 sample sets. The total sample size necessary for distribution analysis was achieved for four species captured at Watchorn, including White Sucker (n = 101), Yellow Perch (n = 39), Spottail Shiner (n = 19), and Lake Whitefish (n = 23).

White Sucker mean fork length was 399.16 mm with a relatively symmetrical distribution; the majority falling in the 375 – 399 mm and 400 – 424 mm classes (Figure 37). Only a single White Sucker was collected in the fall sampling period, with the remainder captured in the spring. Maximum observed fork length, sampled in the spring, was 486 mm.

Yellow Perch mean fork length was 74.0 mm with a distribution skewed to the left; the majority falling in the 60 – 69 mm class (Figure 38). All samples at the Watchorn Bay study site were captured in the spring, with a maximum observed fork length of 129 mm.

Spottail Shiner mean fork length was 59.0 mm with a bimodal distribution skewed to the left. Peak fork lengths fell into the 40 – 44 mm class, and a lesser peak in the 75-79 mm class (Figure 39). All Spottail Shiners were captured during the spring field season, with a maximum observed fork length of 98 mm.

Lake Whitefish mean fork length was 393 mm with a near-symmetrical distribution; the majority falling in the 375 – 399 mm class (Figure 40). All Lake Whitefish were captured during the fall field season, with length-frequency distribution depicting a mature spawning population with fork lengths of 350 – 449 mm. Maximum observed fork length was 186 mm.

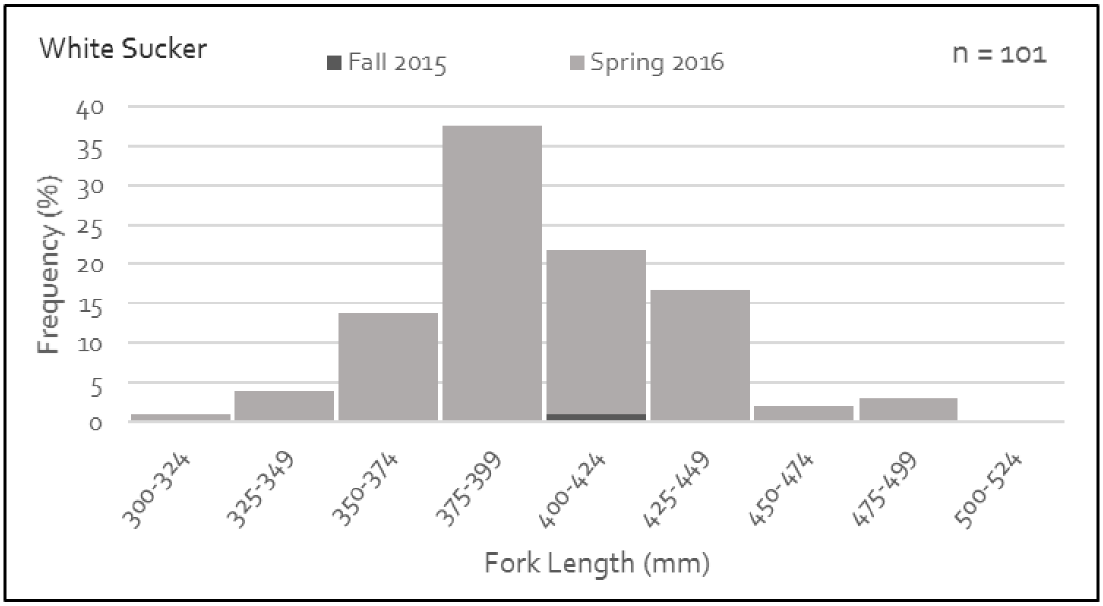


Figure 37. *Length-frequency distribution for White Sucker, Watchorn Bay.*

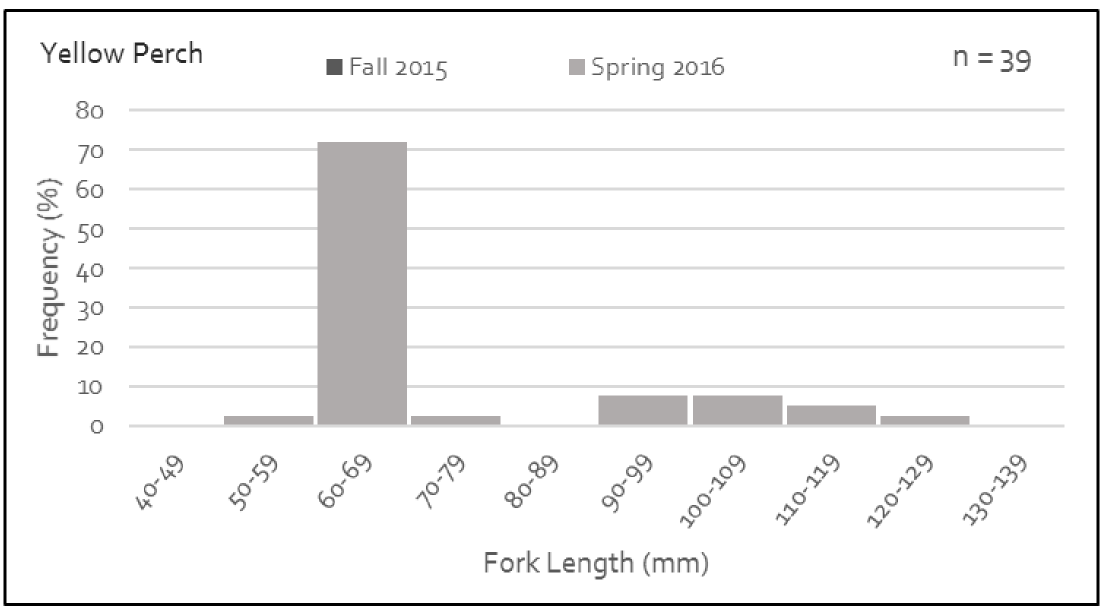


Figure 38. *Length-frequency distribution for Yellow Perch, Watchorn Bay.*

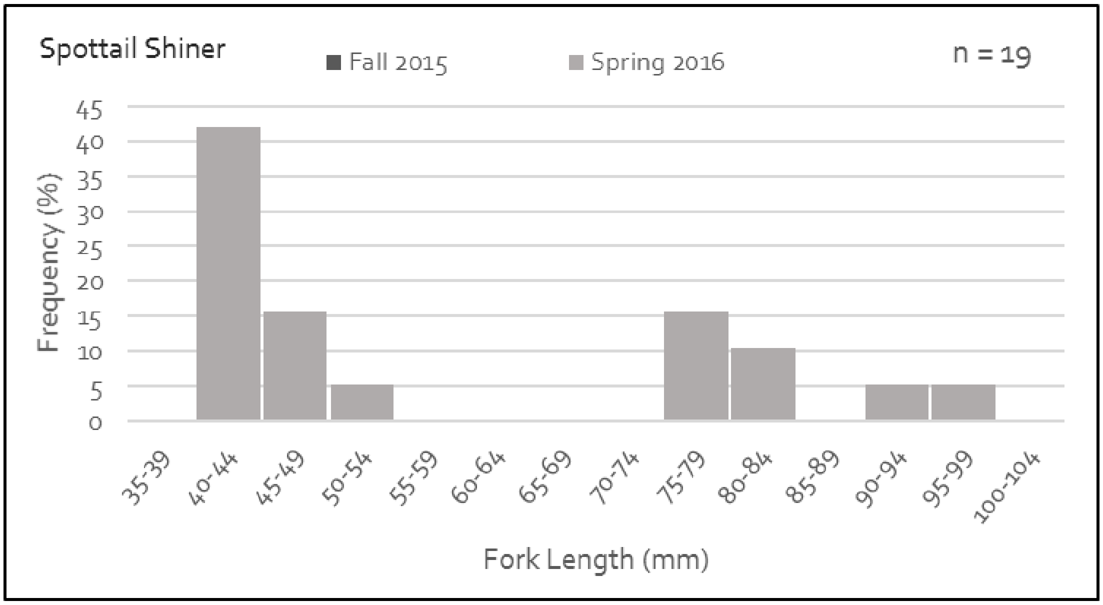


Figure 39. *Length-frequency distribution for Spottail Shiner, Watchorn Bay.*

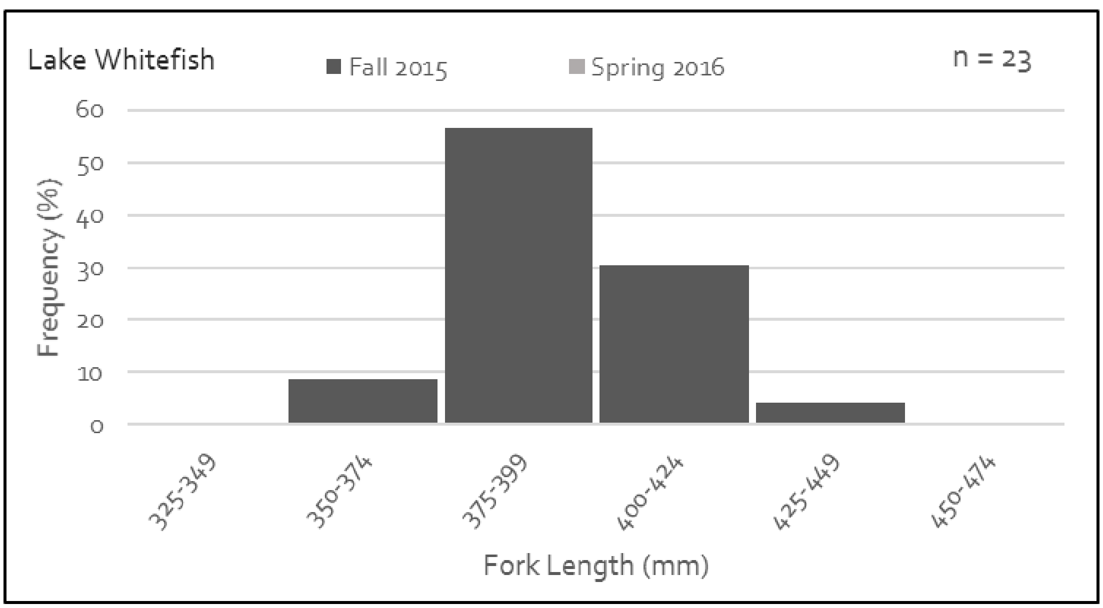


Figure 40. *Length-frequency distribution for Lake Whitefish, Watchorn Bay.*

5.2.4 FISH SPAWNING ACTIVITY

Adult fish in spawning condition were observed within the Watchorn Bay study area during both the fall (Lake Whitefish) and spring (Northern Pike, Walleye, White Sucker) field seasons. Egg mat and kick sampling efforts identified no eggs during the fall field season. Kick sampling efforts during the spring field season yielded 1 egg of the Percidae family, and 1 egg of the Catostomidae family. Larval sampling completed following the spring spawning window identified Walleye and White Sucker larvae present within the Watchorn Bay study area.

5.2.4.1 Adult Fish Spawning Condition

Fall 2015 gill net sampling was completed to coincide with the Lake Whitefish spawning window, and assess the presence of spawning adult fish within this study area. A total of 11 Lake Whitefish (9 male, 2 female) were captured during fall gill netting efforts and found to be in spawning condition (Table 13).

Spring 2016 gill net sampling was completed to coincide with the spring spawning window; Walleye, Northern Pike, and White Sucker were expected to be in or approaching their spawning run. A total of one Northern Pike, one Walleye and 99 White Sucker were captured and found to be in spawning condition (Table 13).

Table 13. Sex and *spawning condition observations during gill net sampling, Watchorn Bay.*

Site	Season	Species	#	Sex				Maturity			
				Male	Female	Juvenile	Undeter-mined	Pre-spawn	Ripe and Running	Spent	Undeter-mined
Watchorn Bay	Fall	Northern Pike	1	0	0	0	1	0	0	0	1
		Lake Whitefish	23	9	2	0	12	0	11	0	12
		White Sucker	1	0	0	0	1	0	0	0	1
		Total	**25**	**9**	**2**	**0**	**14**	**0**	**11**	**0**	**14**
	Spring	Common Carp	2	0	0	0	2	0	0	0	2
		Northern Pike	1	2	2	0	4	0	4	4	0
		Freshwater Drum	8	0	0	0	1	0	0	0	1
		Walleye	3	0	1	0	2	0	1	0	2
		White Sucker	99	40	59	0	0	0	95	4	0
		Total	**113**	**42**	**62**	**0**	**9**	**0**	**100**	**8**	**5**

5.2.4.2 Larval Sampling

A total of 23 larval fish representing two species were captured during three four-minute tows at Watchorn Bay (Table 14). The most abundant species captured was Walleye, which accounted for 91.7% of the total larval fish captured ($\bar{x}$ = 7.3). A single White Sucker was also caught(4.2%, $\bar{x}$ = 0.3).

Table 14. *Results of larval fish net tow sampling for Watchorn Bay.*

Site	Species	#	Total Volume (L)	Mean CPUE (# of fish/L)
Watchorn Bay	Walleye	22	482.304	0.046
	White Sucker	1		0.002

5.2.4.3 Egg Mats

No eggs were discovered on the 70 egg mats placed at Watchorn Bay during the fall or spring field seasons. Substrate was relatively uniform across the study site, consisting of predominantly sand with some small pockets of gravel and scattered boulders. At every check interval, all egg mats were retrieved completely clogged with sediment (Figure 41). The shallow waters of Watchorn Bay are exposed to strong westerly winds crossing Lake Manitoba, and the resulting wave action at this site likely caused this sedimentation issue.

Figure 41. *Egg mat retrieved from Watchorn Bay study site; all mats at this site were retrieved clogged with sand.*

5.2.4.4 Kick Sampling

Kick net sampling of 25 m^2 of shallow benthos along the Watchorn Bay site shoreline yielded a total of 2 eggs, including one identified as Catostomidae and one identified as Percidae (Figure 42). Considering the results of egg mat sampling, and the frequent wave action and sediment movement experienced at this site, it is likely that the eggs collected during kick sampling were incidental, and not the result of direct spawning within the study site.

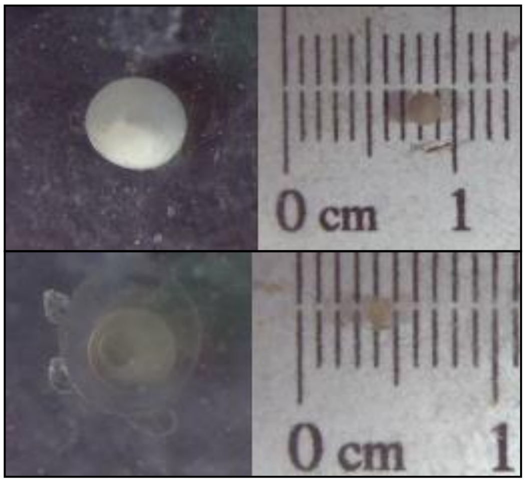


Figure 42. *Catostomidae egg (upper), and Percidae egg (lower), collected during kick sampling at the Watchorn Bay site.*

5.2.5 BENTHIC INVERTEBRATES

A total of 16 taxa from eight orders of benthic macroinvertebrates (BMI) were collected in Watchorn Bay (Table 15, Figure 43). The most common order was Ephemeroptera (Mayfly) ($\bar{x}$ = 55.50/m^2), consisting of the families Caenidae ($\bar{x}$ = 50.80/m^2), Leptophlebiidae ($\bar{x}$ = 4.55/m^2), Ephemeridae ($\bar{x}$ = 0.10/m^2), and Heptageniidae ($\bar{x}$ = 0.05/m^2). The second most common order was Diptera (True fly) ($\bar{x}$ = 36.75/m^2), including the families Chironomidae ($\bar{x}$ = 33.50/m^2), Empididae ($\bar{x}$ = 2.00/m^2) and Ceratopogonidae ($\bar{x}$ = 1.25/m^2). The third most common order was Trombidiformes (Mites), family Hydrochnidiae ($\bar{x}$ = 26.70/m^2),. The fourth most common order was Amphipoda (Scuds), family Dogielinotidae ($\bar{x}$ = 21.90/m^2). The remaining four orders comprised a combined total mean of 2.90/m^2, including Nematoda (Round worms) ($\bar{x}$ = 2.25/m^2, not classified to family), Trichoptera (Caddisfly) ($\bar{x}$ = 0.50/m^2); families Limnephilidae ($\bar{x}$ = 0.25/m^2), Leptoceridae ($\bar{x}$ = 0.15/m^2), Hydroptilidae ($\bar{x}$ = 0.05/m^2) and Polycentropodidae ($\bar{x}$ = 0.05/m^2), Coleoptera (Beetles) ($\bar{x}$ = 0.10/$m^{2)}$; family Dyticidae, and Hemiptera (True bugs) ($\bar{x}$ = 0.05/$m^{2)}$, family Corixidae.

The mean richness (number of taxa per sample) was determined to be 5.30 (σ = 2.56), the overall mean for the site (number of individuals per m^2) was 144 BMI/m^2 (σ = 198.91), and Simpson's Diversity Index (number of species and abundance of species) was 0.62 (Table 16).

Table 15. *Mean benthic invertebrates captured per square meter at Watchorn Bay during two minutes of kick sampling.*

Order	Family	Genus	Species	Mean (per m²)
Ephemeroptera	Caenidae	spp.	spp.	50.80
	Leptophlebiidae	spp.	spp.	4.55
	Ephemeridae	spp.	spp.	0.10
	Heptageniidae	spp.	spp.	0.05
	Total			55.50
Diptera	Chironomidae	spp.	spp.	33.50
	Empididae	spp.	spp.	2.00
	Ceratopogonidae	spp.	spp.	1.25
	Total			36.75
Trombidiformes	Hydrochnidiae	spp.	spp.	26.70
	Total			26.70
Amphipoda	Dogielinotidae	*Hyalella*	*azteca*	21.90
	Total			21.90
Nematoda	Total			2.25
Trichoptera	Limnephilidae	spp.	spp.	0.25
	Leptoceridae	spp.	spp.	0.15
	Hydroptilidae	spp.	spp.	0.05
	Polycentropodidae	spp.	spp.	0.05
	Total			0.50
Coleoptera	Dytiscidae	spp.	spp.	0.10
	Total			0.10
Hemiptera	Corixidae	spp.	spp.	0.05
	Total			0.05

Table 16. *Number of families, diversity, richness, and Simpson's Diversity for benthic invertebrates captured at Watchorn Bay.*

	Diversity		Richness		Simpson's Diversity	
Number of Families	Mean	σ	Mean	σ	Mean	σ
16	144	199	5.3	2.56	0.62	0.11

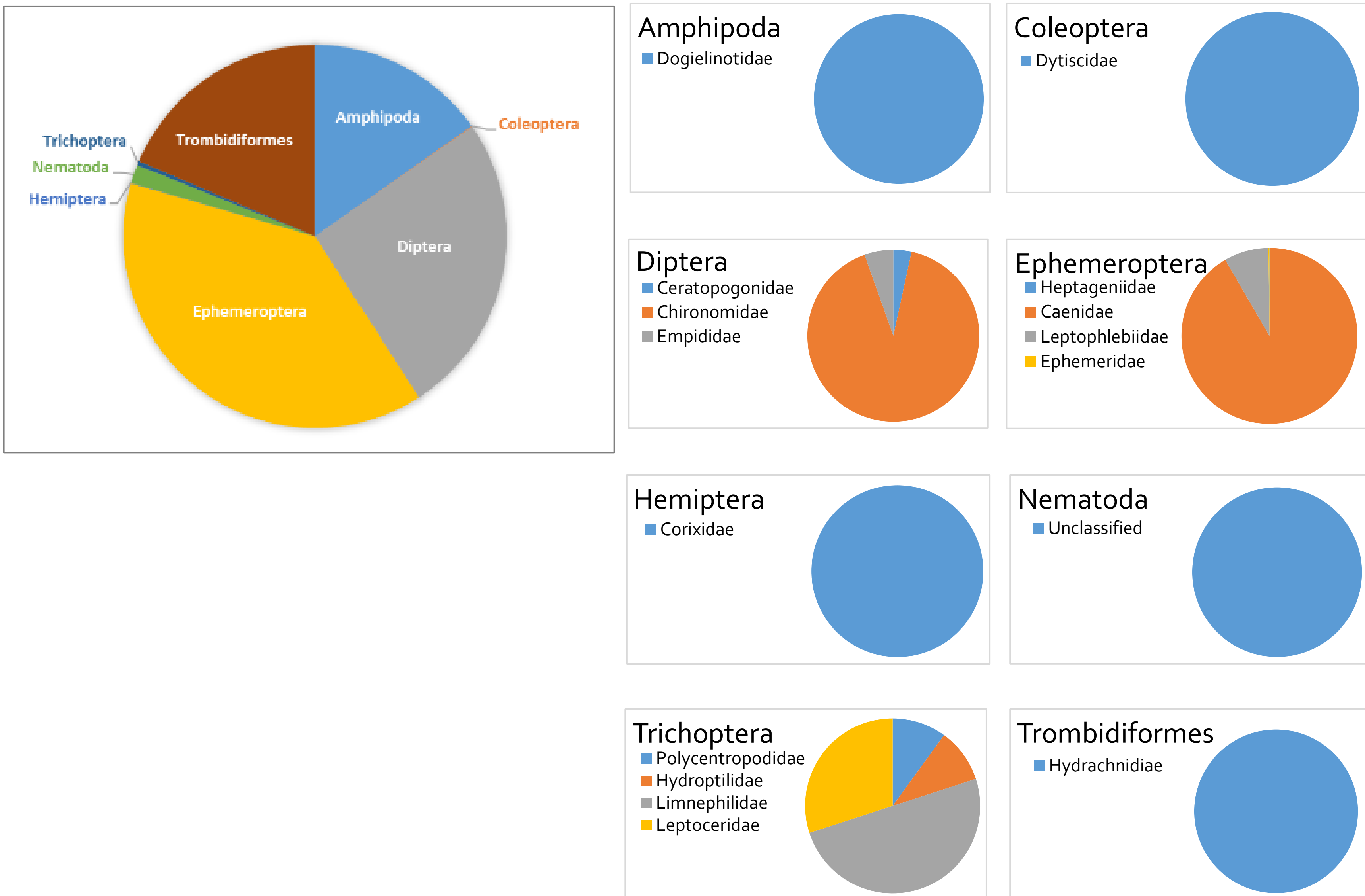


Figure 43. *Relative benthic invertebrate counts by Order (black box) and Family (grey boxes) at Watchorn Bay.*

5.2.6 WATCHORN CREEK TRIBUTARY ASSESSMENT

A baseline tributary assessment was completed on Watchorn Creek as part of the spring field season in April and May of 2016. Hoop nets were used to assess fish migration within the system, water quality readings were recorded, and channel cross-sectional profiles were developed from measures of water velocity, depth, substrate composition, and adjacent riparian habitat (Figure 44).

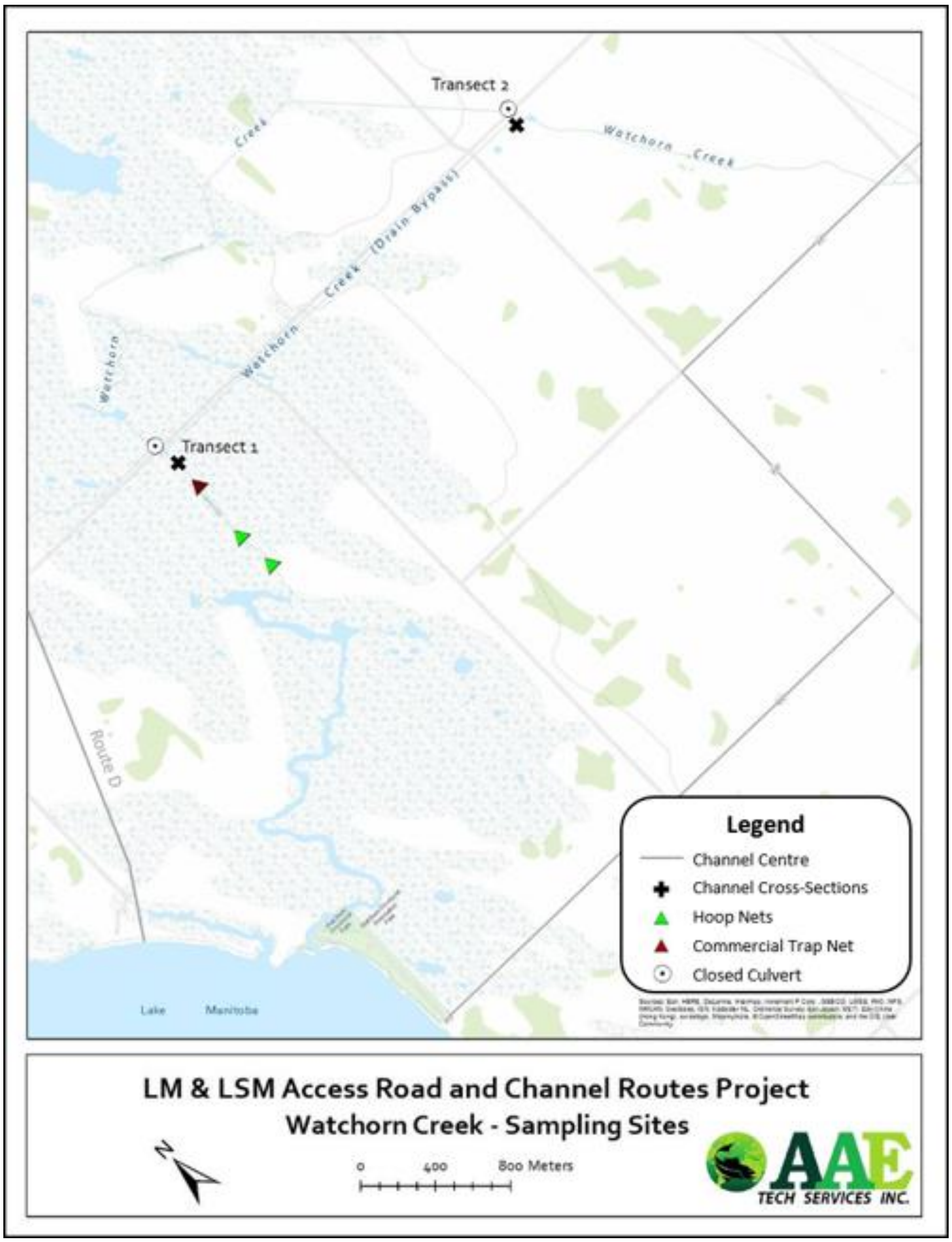


Figure 44. *Spring, 2016 sampling locations on Watchorn Creek.*

5.2.6.1 CHANNEL MORPHOLOGY

Watchorn Creek flows into Lake Manitoba at the eastern extent of the Watchorn Bay study area, draining predominantly agricultural land from the north and east. The watercourse at its lowest extent (to ~4800 m upstream of Lake Manitoba) is characteristic of a natural meandering creek. Riparian habitat (Appendix A) is predominantly narrow with simple vegetation (mixed grasses, cattails) characteristic of a floodplain. Adjacent land use is almost exclusively agricultural (livestock grazing), with standing water and fallow conditions noted in most low-lying areas. Watchorn Creek also passes through Watchorn Provincial Park immediately upstream of Lake Manitoba.

Two culvert crossings were identified along Watchorn Creek, crossing the same unnamed gravel road at 4800 m and again at 8800 m upstream of Lake Manitoba. At each of these crossings, culverts have been closed, acting as a water control system and isolating the 4000-m reach of Watchorn Creek to the north of this road. A drainage channel follows the south side of the gravel road 2.6 km east-west linking these two crossing sites and diverting flow. At the time of study, these culverts were closed (Figure 45), with flow diverted through the bypass drain, therefore this isolated 4000 m reach was excluded from the assessment. It should be noted that flow characteristics, water quality, and fish migration may vary with the opening and closing of this water control system.

Two cross-sectional profiles were completed (Figure 44) to assess water depth, velocity and aquatic habitat within the Watchorn Creek system (Appendix B-1 and B-2). Creek width ranged from 8.0 m to 11.3 m, with a mean thalweg depth of 0.73 m (0.49 – 0.97 m). Depth profiles depict a W-shaped channel, with a steeper left bank and shallow sloping right bank at both cross-section sites. Peak water velocity ranged from 0.00 m/s (no measurable flow) at Transect 1, to 0.14 m/s at Transect 1.

Transect 1 was located downstream of the bypass drain. The habitat at this transect included simple grasses and dead trees directly adjacent to pasture land, with little riparian habitat present. Substrate composition was a uniform clay (70% > 90%) with some silt (< 10%). Mean water velocity was 0.0875 m/s, peaking at 0.14 m/s at 2.4 m from the left bank. Creek width at this site was 11.3 m, with a max depth of 0.97 m at the centre of the channel.

Transect 2, located at the upstream extent of the bypass drain, was representative of a channelized drainage ditch. Riparian habitat at this site was predominantly simple grasses and cattails. The substrate composition was primarily silt (30% > 70%), with some sand and gravel substrates, and a sand-gravel-cobble mixture along the left bank. No measurable flow was present at Transect 2. Creek width at this site was 6.8 m, with a max depth of 0.49 m at the centre of the channel.

Figure 45. *Facing upstream; Closed culverts at the downstream road crossing. The bypass drain enters from the right (east).*

5.2.6.2 WATER QUALITY

Mean water temperature for Watchorn Creek during the spring study period (April – June) was 14.64°C (range: 11.47°C – 17.80°C) (Table 17).

Mean dissolved oxygen on Watchorn Creek was 8.345 mg/L (7.80 – 8.89 mg/L) during the spring study period; DO values were consistently above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity (NTU), pH and Conductivity values were assessed for Watchorn Creek based on mean measurements taken using *in-situ* readings between April 30, 2016 and June 7, 2016, and are presented in Table 17.

Table 17. *Mean water quality values, Watchorn Creek.*

Water Quality Parameter	Spring 2016	CCME Minimum Guideline Value
Temperature	14.64	Variable
Dissolved Oxygen (mg/L)	8.345	Variable: 5.5 – 9.5
pH	6.75	6.5 – 9.0
Conductivity (µS/cm)	389	No Data
Turbidity (NTU)	1.11	Variable

5.2.6.3 FISH DISTRIBUTION AND COMPOSITION

A licensed commercial trap net was identified in the Watchorn Creek study reach (Figures 45 and 46). White Sucker (n = ~50 – 70) and Walleye (n = 2) were observed within the trap, and conversations with the trap owner indicated that White Sucker was the target species, with all other species (Walleye and Northern Pike reported) released back to the creek unharmed.

Figure 46. *Licensed commercial trap net identified on Watchorn Creek.*

5.2.6.3.1 Hoop Nets

Hoop nets were installed at two locations along Watchorn Creek (Figure 44) to identify those fish species migrating upstream, and to assess creek habitat use during the spring field season. A total of 132 minutes of fishing effort identified 1 White Sucker migrating upstream (Table 18). It should be noted that hoop net sampling sites were located upstream of the commercial trap net identified on the creek (Section 5.5.3), which may have impacted sampling efficacy resulting in lower than expected catch numbers recorded on this creek.

Table 18. *Hoop net sampling results, Watchorn Creek.*

Site	Species	#	Fork Length (mm)		Total Effort (min)
			Mean	Range	
Watchorn Creek	White Sucker	1	414	-	132
	Total	**1**			
		Mean CPUE (#/min)			0.008

5.2.7 MERCER CREEK TRIBUTARY ASSESSMENT

A baseline tributary assessment was completed on Mercer Creek as part of the spring field season in April and May of 2016. Hoop nets were used to assess fish migration within the system, water quality readings were recorded, and channel cross-sectional profiles were developed from measures of water velocity, depth, substrate composition, and adjacent riparian habitat (Figure 47).

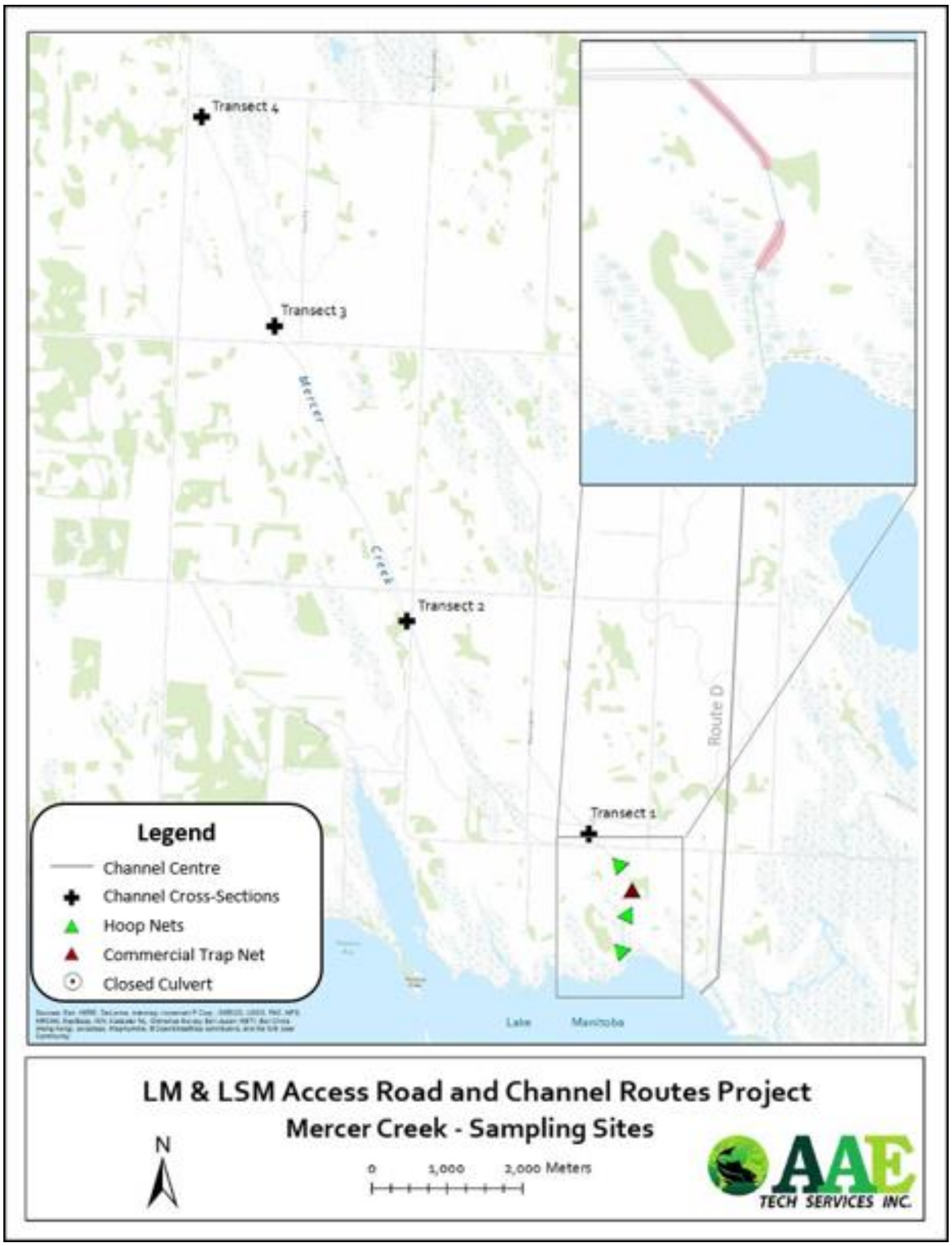


Figure 47. *Spring, 2016 sampling locations on Mercer Creek.*

5.2.7.1 CHANNEL MORPHOLOGY

Mercer Creek flows into Lake Manitoba at the western extent of the Watchorn Bay study area, draining predominantly agricultural land from the north. The Mercer Creek watercourse has been straightened and channelized along it's entire extent. Riparian habitat (Appendix A) is predominantly narrow with simple vegetation cover (mixed grasses, cattails). Adjacent land use was almost exclusively agricultural (livestock grazing).

Four cross-sectional profiles were completed (Figure 47) to assess water depth, velocity and aquatic habitat within the Mercer Creek system (Appendix B-3, B-4, B-5 and B-6). Creek width ranged from 5.2 to 7.6 m, with a mean thalweg depth of 0.36 m (0.31 – 0.44 m). Depth profiles depict a shallow W-shaped channel. Peak water velocity ranged from 0.02 m/s at Transect 4, to 0.36 m/s at Transect 1.

Transect 1 was located within the downstream extent of Mercer Creek, 1.6 km upstream of Lake Manitoba. Riparian habitat at this site was predominantly simple grasses and sedges, and the extent of the channel was composed of a uniform silt substrate (100%). Aquatic vegetation at this site covered approximately 80% of the channel bottom. Surveyors noted > 30 White Sucker in spawning condition migrating upstream. Mean velocity at this site was 0.0.093 m/s, peaking at 0.36 m/s at 5.2 m from the left bank. Creek width at this site was 7.6 m, with a max depth of 0.4 m to the right of channel centre.

Transect 2 was located 5.8 km upstream of Lake Manitoba. Riparian habitat included tall grasses and willow along both banks. Substrate composition was a uniform silt (90% - 100%) along the entire cross-section, with some gravel (10%) observed at the centre of the channel. Surveyors noted White Sucker fish species in spawning condition within this reach of the creek. Mean velocity was 0.0.061 m/s, peaking at 0.16 m/s at 2.0 and 3.1 m from the left bank. Creek width at this site was 5.2 m, with a max depth of 0.39 m to the right of channel centre.

Transect 3 was located 10.1 km upstream of Lake Manitoba. Riparian habitat at this site included predominantly tall grass with some shrubs along both banks. Channel substrate was a uniform silt (100%) along the entire channel cross-section. Surveyors noted ~15 White Sucker in spawning condition within this reach of the creek. Mean velocity was 0.025 m/s, peaking at 0.08 m/s at 3.1 m from the left bank. Creek width at this site was 6.1 m, with a max depth of 0.31 m at the centre of the channel.

Transect 4, located at the upstream extent of Mercer Creek 13.4 km upstream of Lake Manitoba, included very little riparian habitat, with pasture land extending to the observed high water level. Substrate composition was a uniform silt (100%) along the entire surveyed cross-section. Surveyors noted ~10 White Sucker in spawning condition migrating within this reach of the creek. Mean velocity was 0.006 m/s, peaking at 0.02 m/s at 4.1 m from the left bank. Creek width at this site was 6.1 m, with a max depth of 0.31 m at the centre of the channel.

5.2.7.2 WATER QUALITY

Water temperature for Mercer Creek during the spring habitat assessment (April, 2016) was 9.48°C (Table 19).

Dissolved oxygen on Mercer Creek was 8.67 mg/L on April 28, 2016; DO was above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity (NTU), pH and conductivity values were assessed for Mercer Creek based on measurements taken using *in-situ* readings on April 28, 2016, and are presented in Table 19.

Table 19. *Water quality values, Mercer Creek.*

Water Quality Parameter	Spring 2016	CCME Minimum Guideline Value
Temperature	9.48	Variable
Dissolved Oxygen (mg/L)	8.67	Variable: 5.5 – 9.5
pH	7.0	6.5 – 9.0
Conductivity (µS/cm)	352	No Data
Turbidity (NTU)	1.19	Variable

5.2.7.3 FISH DISTRIBUTION AND COMPOSITION

A licensed commercial trap net was identified in the Mercer Creek study reach (Figure 47). White Sucker (n = ~30) and Walleye (n = 2) were observed within the trap, and conversations with the trap owner indicated that White Sucker was the target species, with all other species (Walleye and Northern Pike reported) released back to the creek unharmed.

5.2.7.3.1 Hoop Nets

Hoop nets were installed at three locations along Mercer Creek (Figure 47) to identify fish species migrating upstream, and assess creek habitat use during the spring field season. A total of 681 minutes of fishing effort identified three fish species migrating upstream within the Mercer Creek system (Table 20). Most fish captured were identified as White Sucker (n = 60). Yellow Perch (n = 1) and Spottail Shiner (n = 7) were also captured.

Table 20. *Hoop net sampling results, Mercer Creek.*

Site	Species	#	Fork Length (mm)		Total Effort (min)
			Mean	Range	
Mercer Creek	Spottail Shiner	7	81	64-89	648
	White Sucker	60	395	351-466	
	Yellow Perch	1	87	-	
	Total	**68**			
		Mean CPUE (#/min)			0.191

5.2.7.3.2 Backpack Electrofishing

Preliminary depth and habitat assessment of the creek study sites identified Mercer Creek as a candidate for backpack electrofishing sampling (depths < 1.0 m, dense aquatic vegetation). Electrofishing was completed at two sampling reaches (Figure 47). A total of 187 fish representing six species were captured (Table 21, Figure 48). CPUE was 10.457 fish/minute with a total effort of 1073 seconds. The most abundant species collected was Fathead Minnow accounting for 28.9% of the total catch. Spottail Shiner (28.3%), Yellow Perch (25.7%), Emerald Shiner (12.3%), Iowa Darter (*Etheostoma exile*, 2.7%) and White Sucker (2.1%) were also recorded.

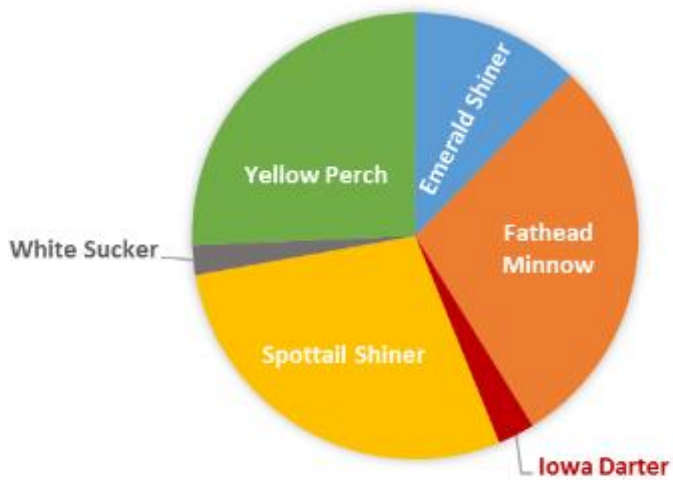


Figure 48. *Relative species abundance for fish captured during backpack electrofishing on Mercer Creek.*

Table 21. *Backpack electrofishing data for Mercer Creek.*

		Fork Length (mm)		
Species	**#**	**Average**	**Range**	**Effort (sec)**
Emerald Shiner	23	34	20 - 50	1073
Fathead Minnow	54	33	28 - 48	
Iowa Darter	5	33	31 - 36	
Spottail Shiner	53	43	19 - 93	
White Sucker	4	394	376 - 420	
Yellow Perch	48	56	46 - 64	
Total	187		CPUE (#/min)	10.457

5.3 ROUTE C – LAKE ST. MARTIN, HARRISON BAY STUDY SITE

5.3.1 HABITAT ASSESSMENT

Aquatic and riparian habitat was assessed for the Harrison Bay study site by completing a full bathymetric, substrate and aquatic vegetation profile, as well as an aerial photographic survey of shoreline and riparian habitat.

The Harrison Bay study site included extensive riparian marsh habitat, extending approximately 500 – 700 metres back from the outer shoreline (see Section 5.3.1.4). This marsh habitat drains directly into Lake St. Martin at the proposed LMOC Route C outlet site, making this habitat directly available to fish and aquatic species within Lake St. Martin. Sampling efforts, including bathymetric and substrate analysis, and fish and invertebrate sampling, were restricted to open water habitat for this assessment. Aerial surveys of the study site provided insight into the extent and density of this marsh habitat. Aerial survey assessment of this area was included as part of the riparian habitat assessment presented in Section 5.3.1.4.

5.3.1.1 Bathymetry

Bathymetric analysis of the Harrison Bay study area at the Route C outlet revealed a relatively uniform slope (Figure 49). The lake bed at this site has an average slope of 0.006, with a steeper sloping shoreline (slope = 0.033) to a depth of approximately 1 m. Beyond this, the substrate levels off (slope = 0.005) to the extent of the survey approximately 550 m from shore. Maximum depth of the survey area was 3.25 m. Bathymetric surveys were hindered at the Harrison Bay site by extensive marsh vegetation, extending approximately 500 – 700 metres back from the shoreline at the edge of open water (see Section 5.3.1.4). This area was classified as marsh riparian habitat. Depths within this area are not well know, but cursory investigations suggest average depth will not exceed 1 m across most of the area.

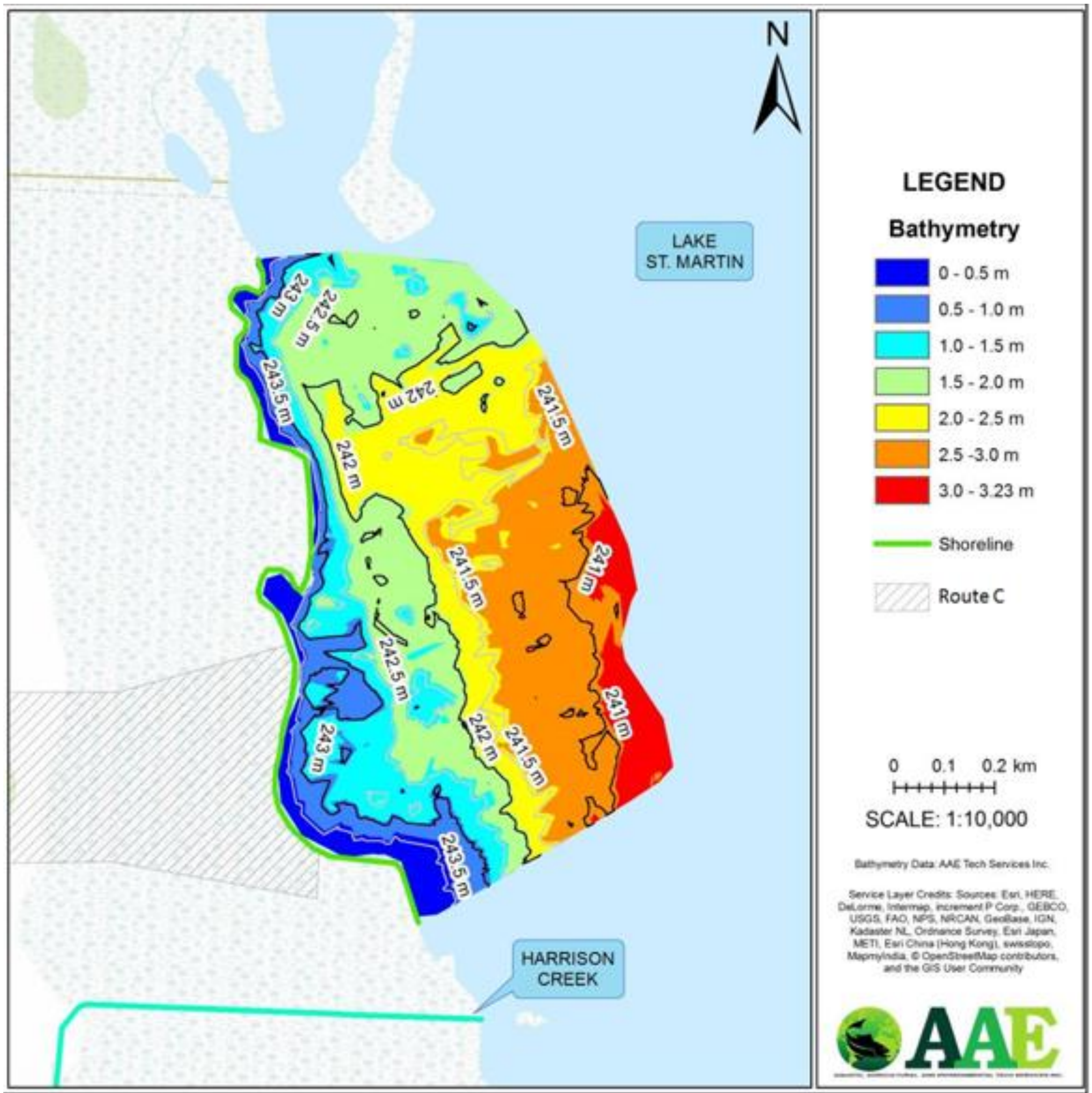


Figure 49. *Bathymetric map of the Harrison Bay study area on Lake St. Martin.*

5.3.1.2 Substrate

Sonar analysis of substrate (Figure 50) identified three distinct substrate types. Substrate along the shoreline to depths of ~1.5 m was found to be predominantly sand (> 80%) with some gravel. At depths exceeding 1.5 m, substrate includes a combination of sand (> 80%) and gravel, and a more evenly mixed sand – gravel (50% - 50%) bottom cover. In the southern half of the study area, and directly off-shore of the proposed LMOC Route C outlet site, a bar of coarse gravel (70%) and cobble (30%) substrate was identified at depths between 2.5 m and 3.0 m. Gravel and cobble shoreline was common to the north of the study area, with occasional boulders observed in the nearshore habitat (depths < 1.2 m).

Ground truthing was conducted at 66 sites using a telescopic metal probe to assess bottom compaction, texture and grain size of a 1 m^2 area of substrate.

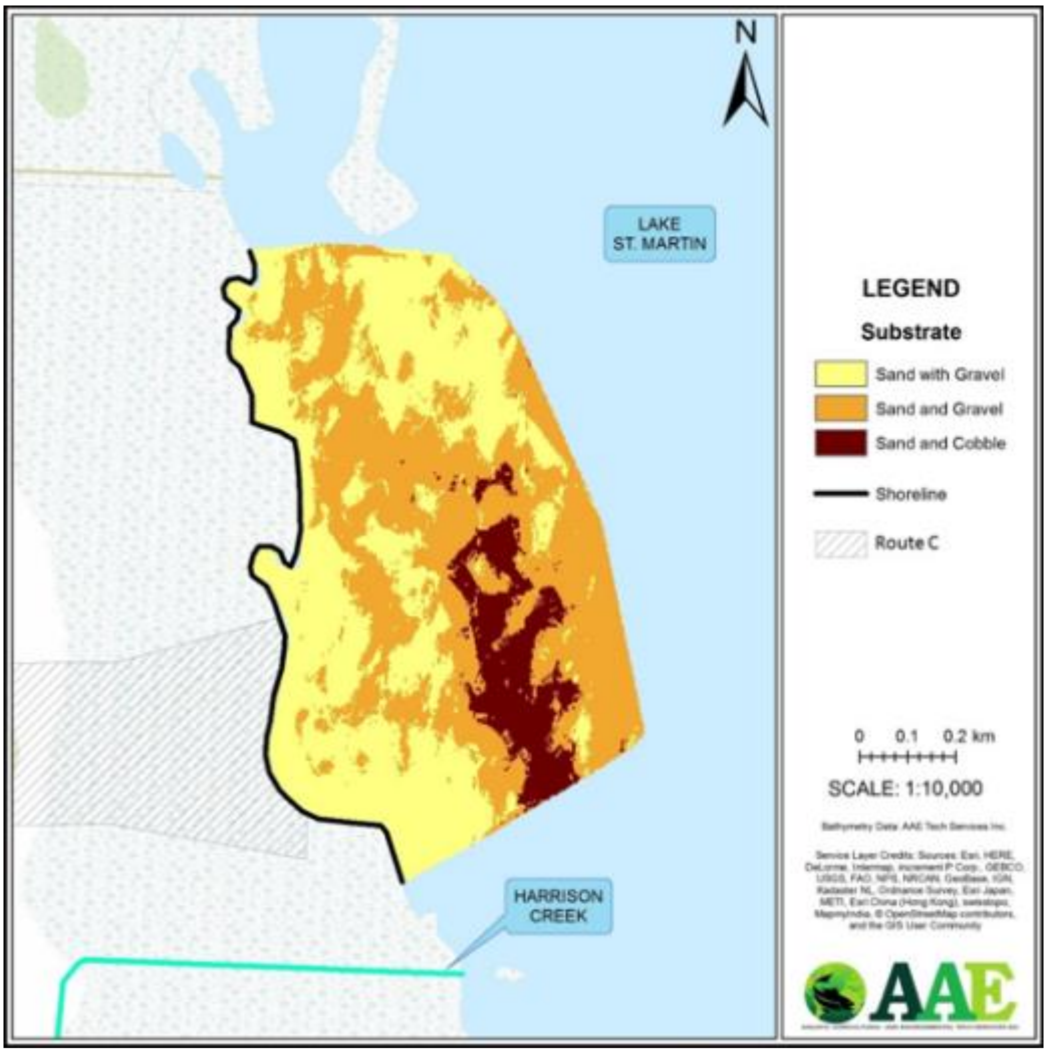


Figure 50. *Substrate composition map of the Harrison Bay study area on Lake St. Martin.*

5.3.1.3 Aquatic Vegetation

Within the open-water study area, aquatic vegetation cover was low (0% - 40% cover) over habitat < 1.5 m deep (Figure 51). Plant height (Figure 52) at this depth was similarly low (0.00 m – 0.2 m). At depths > 1.5 m plant cover increased, especially in the northern half of the study area where the majority of the area consisted of 80% - 100% plant cover. Corresponding plant height was relatively low for this area (0.2 m – 0.6 m), as well as over the remaining study area (0.0 m – 0.4 m). Total biovolume (Figure 53) was also low across most of the study area (0.0% - 15.0%), with only slightly higher values at the northern extent of the study area (25% - 40%) at depths > 1.5 m.

Aquatic vegetation within the adjacent marsh was extremely dense (> 70%), including submerged vegetation and reed and cattail cover that rose to upwards of 1 m above the surface.

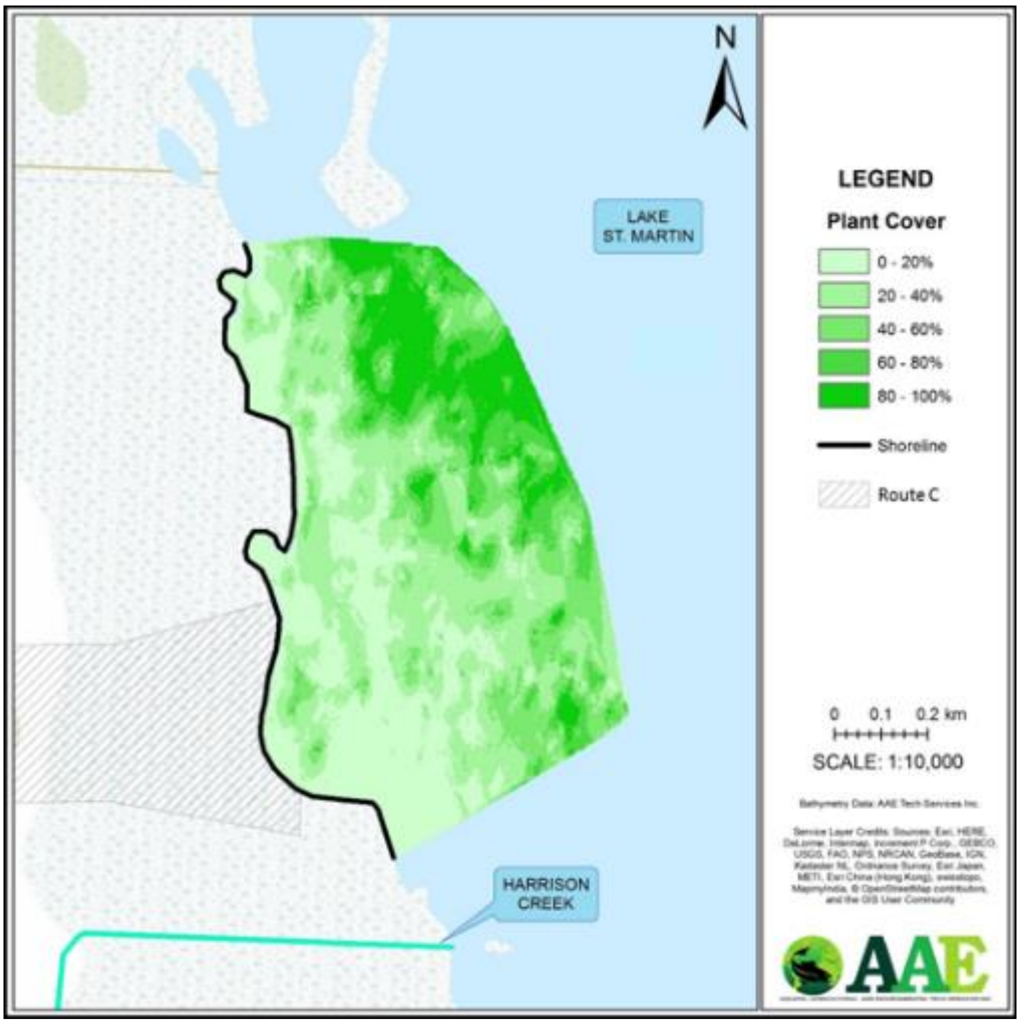


Figure 51. *Plant Cover (% area) map of the Harrison Bay study area on Lake St. Martin.*

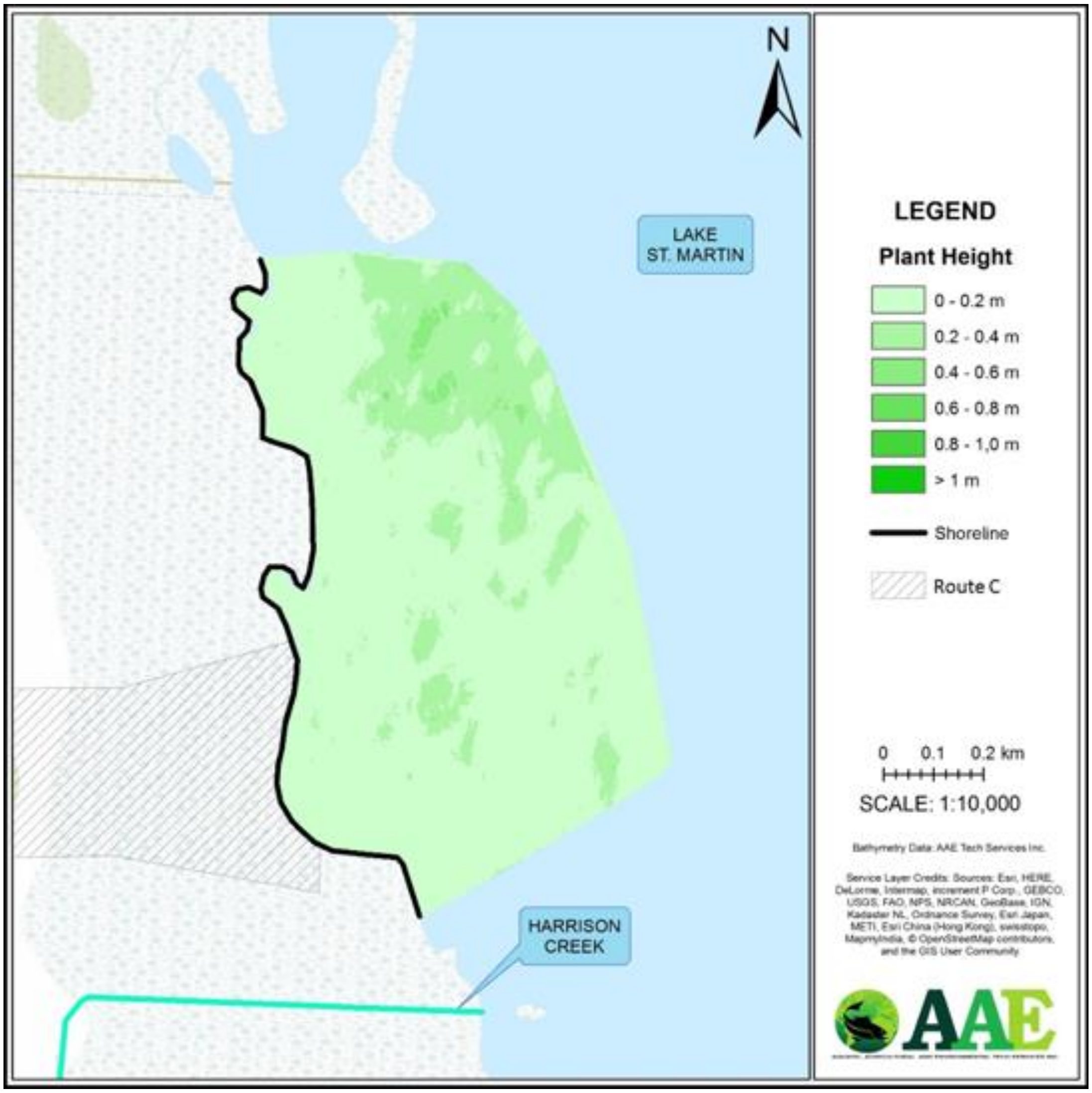


Figure 52. *Plant Height map of the Harrison Bay study area on Lake St. Martin.*

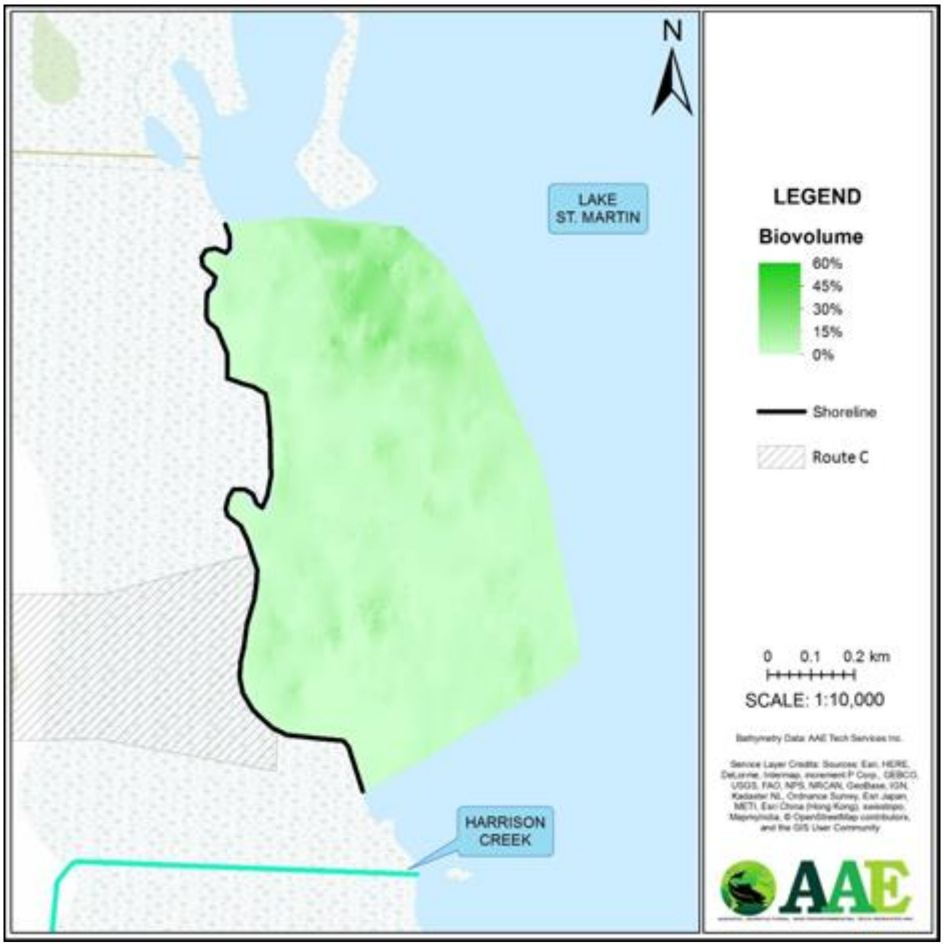


Figure 53. *Total Biovolume (% water column) map of the Harrison Bay study area on Lake St. Martin.*

5.3.1.4 Shoreline and Riparian Habitat

Aerial photographic surveys of the Harrison Bay study site revealed a relatively simple shoreline (exposed, sparse long grass vegetation cover). Beyond the shoreline, riparian habitat was characterized as extensive and densely vegetated marsh (Figures 54 – 56).

Shoreline habitat extends 12 m from the water's edge, and is composed of a compacted gravel / sand substrate with scattered cobble and boulder throughout. Within the northern section of Harrison Bay, at the proposed LMOC Route C outlet site, a gap in the shoreline has created an inlet into to the adjacent marsh habitat, providing direct connectivity between Lake St. Martin and the adjacent marsh. Vegetation cover at this inlet includes submerged and emergent vegetation (mixed grasses, reeds, cattails) > 1 m above the water's surface. This highly productive and densely vegetated habitat is characteristic of spawning habitat for fish species such as Northern Pike and Yellow Perch.

The wetland habitat extends 420 m inland, with dense (> 70% coverage) emergent vegetation cover. Observed water depths in this area were < 1.0 m within ~50 m of the Lake St. Martin shoreline. Land use beyond this area was agricultural, including a rural residence to the south and land used for livestock grazing.

Figure 54. *Aerial photo orthomosaic of the Harrison Bay study site for Route C, focusing on shoreline and riparian habitat.*

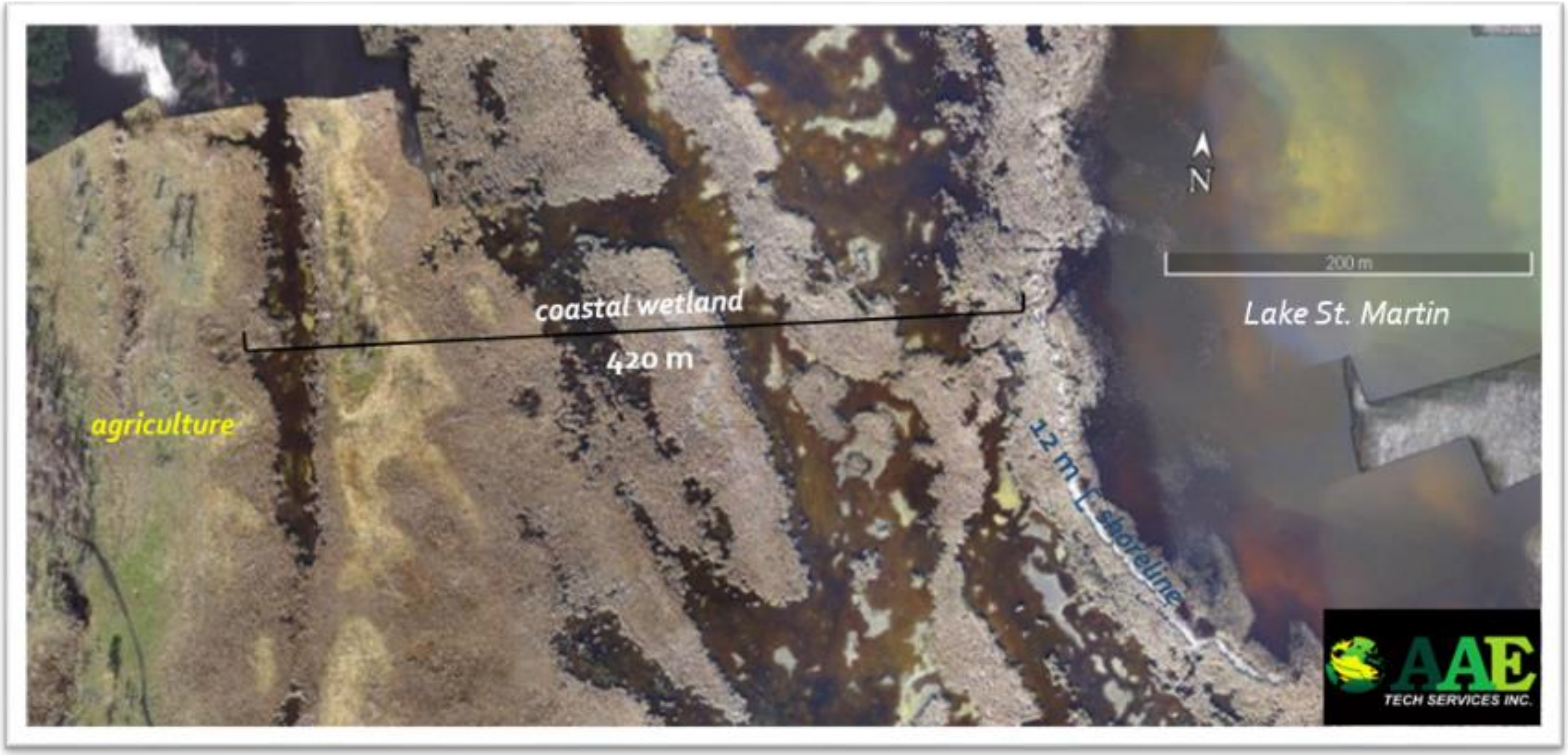


Figure 55. *Aerial photo orthomosaic of the Harrison Bay study site for Route C, depicting extent of shoreline and riparian habitat. Centred on Route C inlet site.*

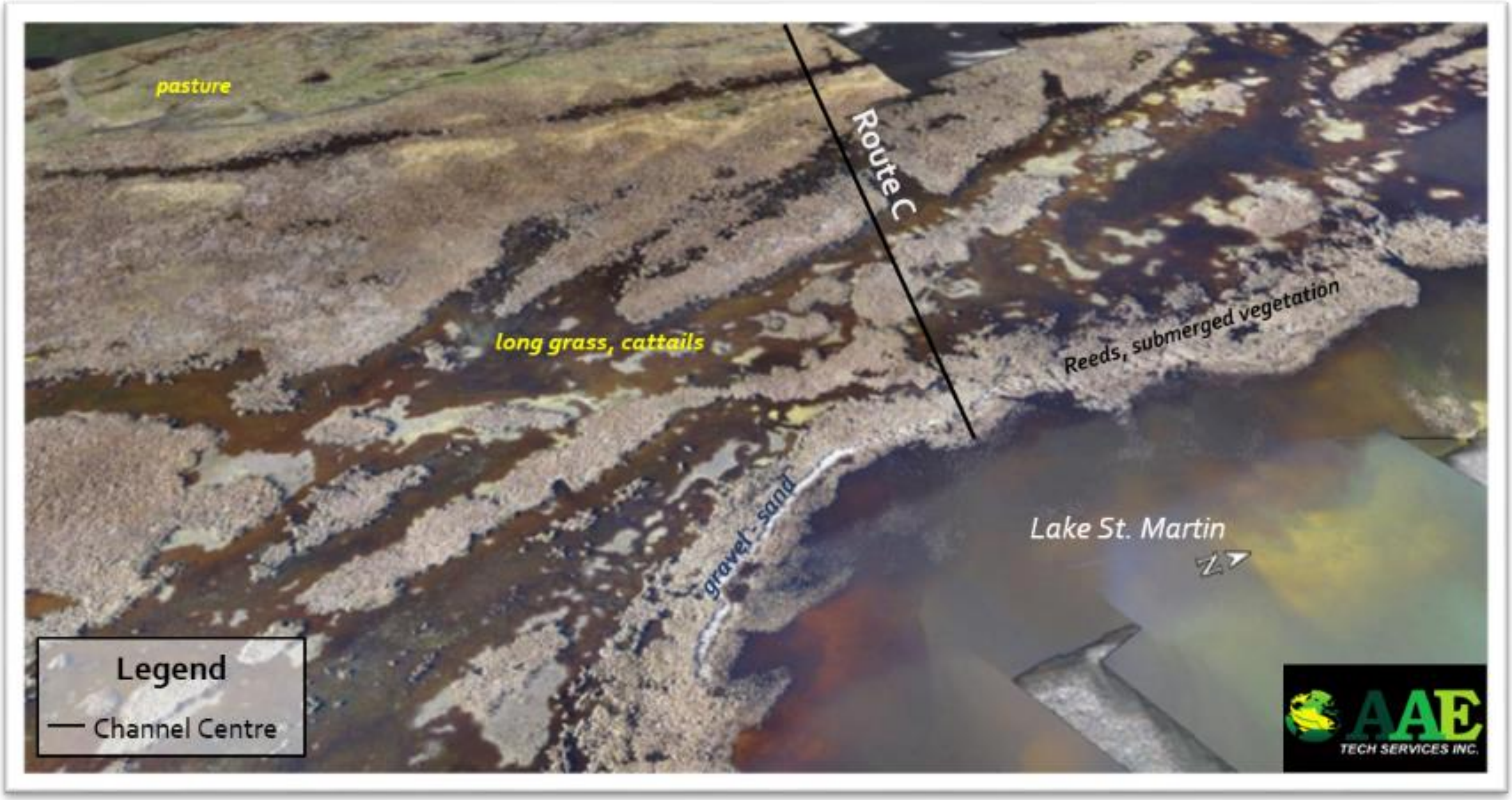


Figure 56. *Aerial photo orthomosaic of the Harrison Bay study site for Route C, depicting shoreline and riparian habitat cover and composition. Oblique view from the east, centred on Route C inlet site.*

5.3.2 WATER QUALITY

Failure of the temperature logger installed at Lake St. Martin resulted in only partial water temperature data for the fall, 2015 field season (Figure 81). Mean temperature values were derived from *in-situ* measurements. Water quality measurements for the Harrison Bay study site were not available for the fall, 2015 field season; mean water quality values are presented for the spring, 2016 field season only.

Mean water temperature for Lake St. Martin at Harrison Bay during the spring study period (April – June) was 17.98°C (range: 13.40°C – 22.55°C) (Table 22).

Mean dissolved oxygen at the Harrison Bay site was 11.61 mg/L (10.62 – 12.60 mg/L) during the spring study period; DO values were consistently above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity, total suspended solids (TSS), pH and conductivity values were assessed for the Harrison Bay site based on mean measurements taken using *in-situ* readings between April 30, 2016 and June 7, 2016 (Table 22).

Table 22. *Mean water quality values, Harrison Bay.*

	Sampling Season		
WQ Parameter	**Fall 2015**	**Spring 2016**	**CCME Minimum Guideline Value**
Temperature	-	13.40	Variable
Dissolved Oxygen (mg/L)	-	11.61	Variable: 5.5 – 9.5
pH	-	6.43	6.5 – 9.0
Conductivity (µS/cm)	-	393	No Data
Turbidity (NTU)	-	2.49	Variable
TSS (mg/L)	-	15.470	No Data

5.3.3 FISH DISTRIBUTION AND COMPOSITION

Fish and invertebrate sampling was carried out at the Harrison Bay study site over a 34-day fall sampling period in October and November, 2015, and a 45-day spring sampling period from April through June, 2016. Fish community composition was assessed using gill net and boat electrofishing surveys, egg mats, larval fish tows, and kick net benthic sampling (Figure 57). A total of 271 fish representing sixteen species were captured. No species of concern were identified at this site.

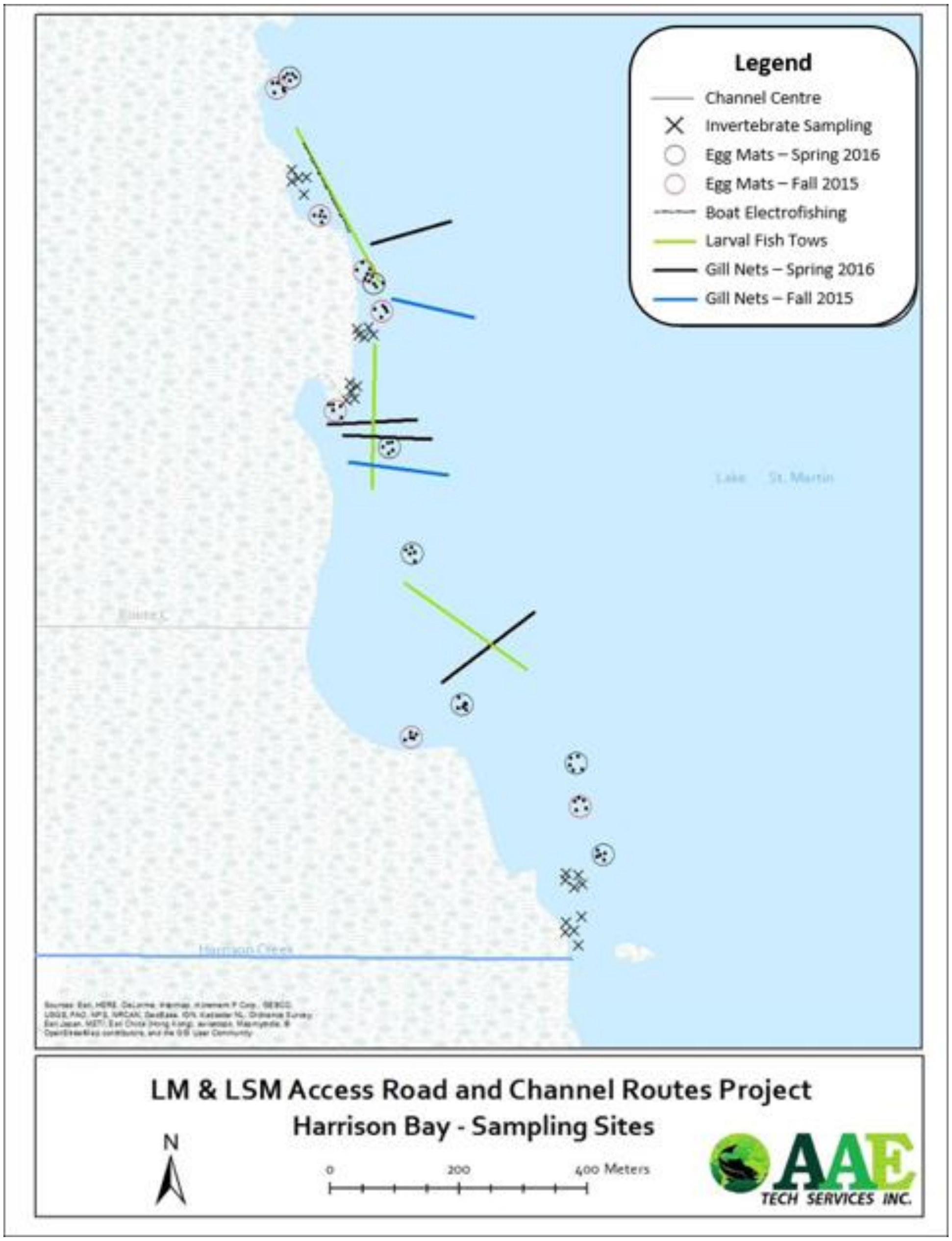


***Figure 57**. Harrison Bay study area, fish and invertebrate sampling locations.*

5.3.3.1 Boat Electrofishing

A total of 125 fish representing eleven species were captured during fall and spring boat electrofishing surveys in Harrison Bay (Figure 58 and Table 23).

During fall sampling, 39 fish were captured representing five species. CPUE was 0.999 fish/minute with a total electrofishing effort of 2343 seconds. Northern Pike was the most abundant species captured, accounting for 39.5% of the total catch. Additional species captured include Yellow Perch (34.2%), White Sucker (15.8%), Spottail Shiner (7.9%), and Emerald Shiner (2.6%).

Spring sampling resulted in the capture of 95 fish representing eight species. CPUE was 1.468 fish/minute with a total fishing effort of 3882 seconds. Yellow Perch was the most abundant species captured, accounting for 31.6% of the total catch. Remaining catch included Blacknose Shiner (*Notropis heterolepis*, 21.1%), Northern Pike (9.5%), Fathead Minnow (8.4%), Troutperch (8.4%), Mottled Sculpin (*Cottus bairdii*, 5.3%), Common Carp (4.2%), and Golden Shiner (*Notropis crysoleucas*, 2.1%).

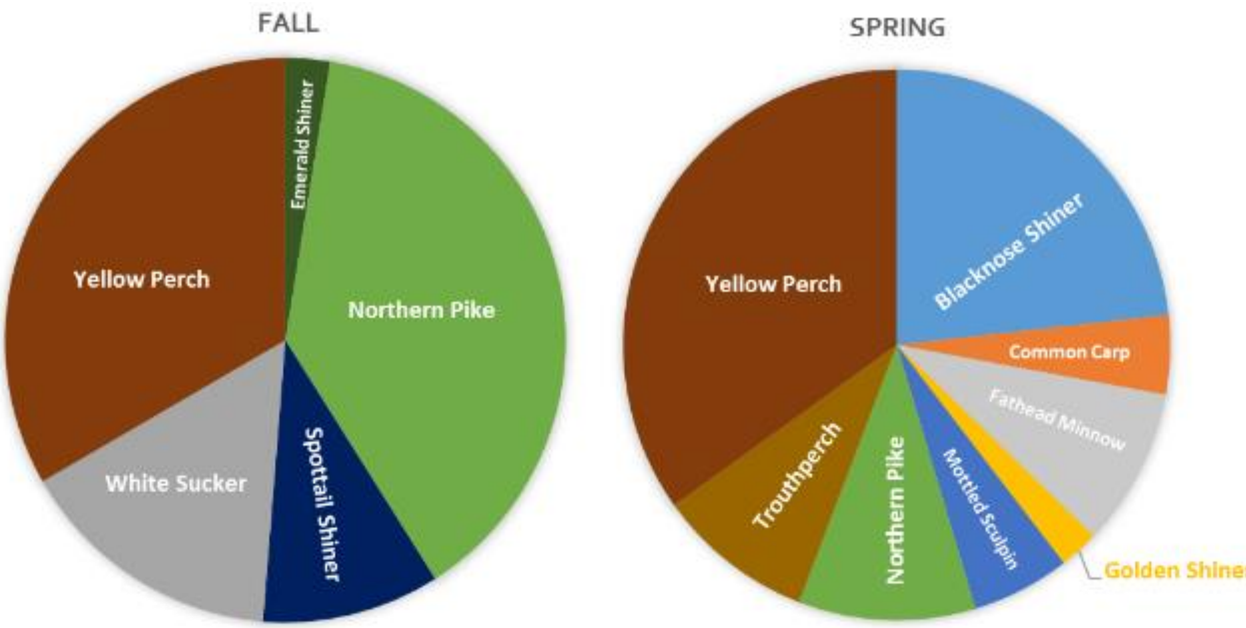


Figure 58. *Relative species abundance for fish captured during fall (left) and spring (right) boat electrofishing at Harrison Bay.*

Table 23. *Boat electrofishing results for Harrison Bay.*

Site	Season	Species	#	Fork Length (mm) Mean	Fork Length (mm) Range	Effort (sec)
Harrison Bay	Fall	Emerald Shiner	1	68	68	2343
		Northern Pike	15	521	305-684	
		Spottail Shiner	4	80	71-90	
		White Sucker	6	383	306-480	
		Yellow Perch	13	96	48-138	
		Total	**39**			
					CPUE (#/min)	**0.999**
	Spring	Blacknose Shiner	20	48	42-57	3882
		Common Carp	4	652	610-700	
		Fathead Minnow	8	49	44-62	
		Golden Shiner	2	58	57-58	
		Mottled Sculpin	5	64	54-71	
		Northern Pike	9	447	199-655	
		Troutperch	8	56	49-63	
		Yellow Perch	30	79	54-146	
		Total	**86**			
					CPUE (#/min)	**1.329**

5.3.3.2 Gill Netting

A total of 146 fish representing seven species were captured during fall and spring gill netting at Harrison Bay (Figure 59 and Table **24**).

During fall sampling, 11 fish representing three species were captured over a total set time of 45 minutes (CPUE = 12.42 fish/100 m/hour). Lake Whitefish was the most abundant species captured, accounting for 72.7% of the total catch. Northern Pike (18.2%) and White Sucker (9.1%), were also captured.

During spring sampling, 135 fish representing six species were captured over a total set time of 366 minutes (CPUE = 16.44 fish/100 m/hour). White Sucker was the most abundant species captured, accounting for 43.7% of the total catch. Shorthead Redhorse (26.7%), Northern Pike (18.5%), Walleye (5.2%), Freshwater Drum (4.4%), and Black Bullhead (1.5%) were also captured.

Mean size and condition factor (K) for each species sampled in both fall and spring sampling periods is presented in Table 24.

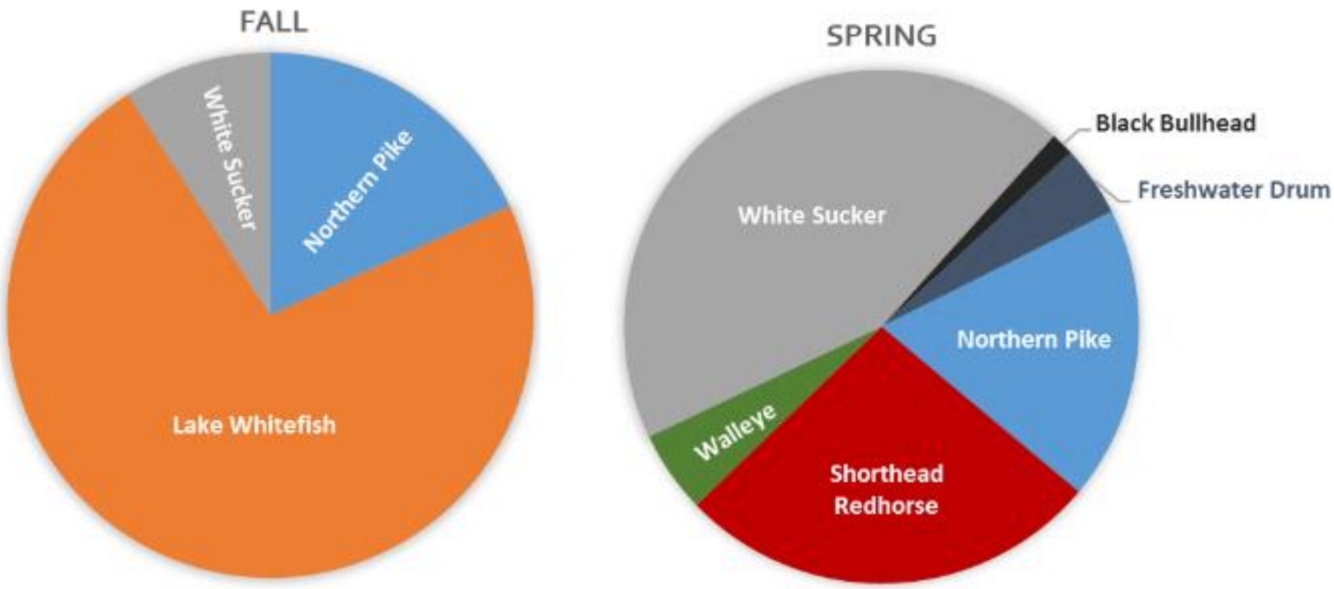


Figure 59. *Relative species abundance for fish captured during fall (left) and spring (right) gill netting at Harrison Bay.*

Table 24. *Gill netting results for Harrison Bay, including mean size and condition factor (K).*

Site	Season	Species	#	Fork Length (mm)		Round Weight (g)		Mean Condition Factor (K)
				Mean	Range	Mean	Range	
Harrison Bay	Fall	Northern Pike	2	838	828 - 847	5358.1	5244.7-5471.5	0.912
		Lake Whitefish	8	398	364 - 433	755.4	680.4-1048.9	1.026
		White Sucker	1	321	-	481.9	-	1.457
		Total	**11**					
	Mean CPUE (#/100 m/hour)		12.42					
	Spring	Black Bullhead	2	315	291-338	452.5	380-525	1.451
		Freshwater Drum	6	437	345-504	1691.7	1150-2200	2.088
		Northern Pike	25	543	387-990	1095.8	70-6400	0.609
		Shorthead Redhorse	36	378	220-489	671.7	50-1725	1.220
		Walleye	7	458	310-575	1128.6	300-2050	1.015
		White Sucker	59	419	348-485	945.8	400-2325	1.262
		Total	**135**					
	Mean CPUE (#/100 m/min)		16.44					

5.3.3.3 Length Frequency Distribution Analysis

Fish collection data for the Harrison Bay study site were combined across all sampling methods and field seasons, and frequency distribution plots were generated for all fish species where sample size (n) was equal to or greater than 15 fish. Plots depict both fall, 2015 and spring, 2016 sample sets. The total sample size necessary for distribution analysis was achieved for five species captured at Harrison Bay, including Northern Pike (n = 51), White Sucker (n = 66), Blacknose Shiner (n = 51), Shorthead Redhorse (n = 36), and Yellow Perch (n = 43).

Northern Pike mean fork length was 531.2 mm with a relatively symmetrical distribution, and a modal length class of 500 – 549 mm class. (Figure 60). Distribution was similar between fall, 2015 and spring, 2016 results. Maximum observed fork length, sampled in the spring, was 990 mm.

White Sucker mean fork length was 414.2 mm with the majority falling in the 375 – 399 mm, 400 – 424, and 425 - 449 mm classes (Figure 61). Lengths were smaller during the fall, 2015 sampling period, though sample size was relatively small. Spring, 2016 sampling yielded the majority of larger fish, likely attributable to a higher proportion of adults. The length-frequency distribution depicted a mature spawning population with most fork lengths between 375 mm and 474 mm, and a maximum observed fork length of 485 mm.

Blacknose Shiner mean fork length was 48.0 mm with a symmetrical distribution, the majority falling in the 45 – 49 mm class (Figure 62). All Blacknose Shiner were captured during the spring sampling period. Maximum observed fork length was 57 mm.

Shorthead Redhorse mean fork length was 378.0 mm with the majority falling in the 350 – 374 mm and 400 – 424 mm classes (Figure 63). All Shorthead Redhorse were captured during the spring sampling period. The length-frequency distribution depicted a mature population as the modal fork length class was 325 – 449 mm. The maximum observed fork length was 489 mm.

Yellow Perch mean fork length was 84.1 mm with a length-frequency distribution skewed to the left; and a modal length class of 90 – 99 mm class, with a second smaller peak in the 50 – 59 mm and 60 – 64 mm classes (Figure 64). Distribution was similar between fall, 2015 and spring, 2016 results. Maximum observed fork length was 146 mm, sampled in the spring.

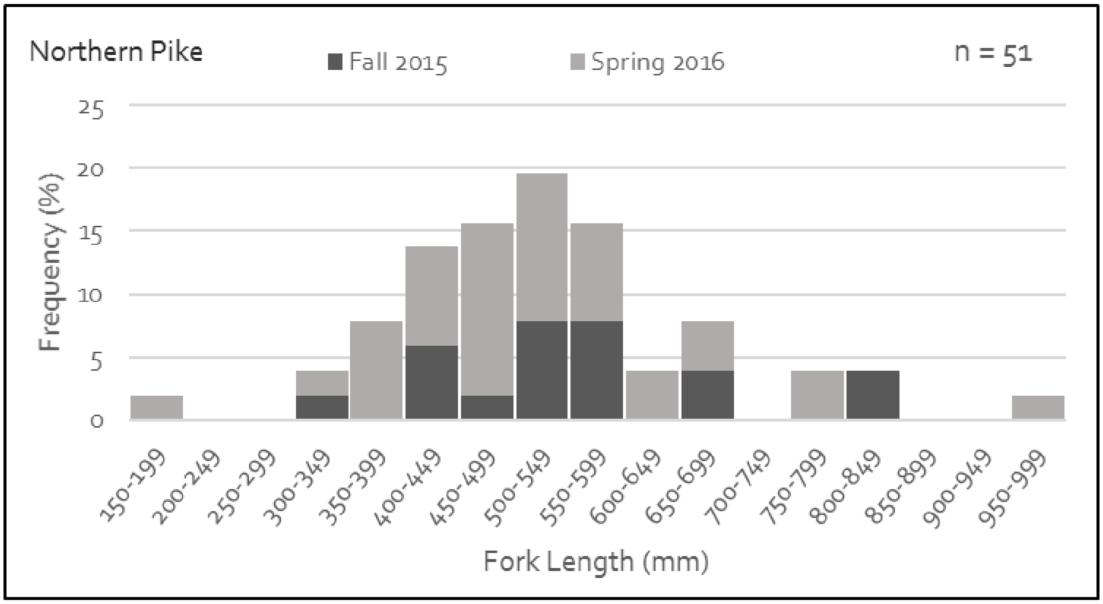


Figure 60. *Length-frequency distribution for Northern Pike, Harrison Bay.*

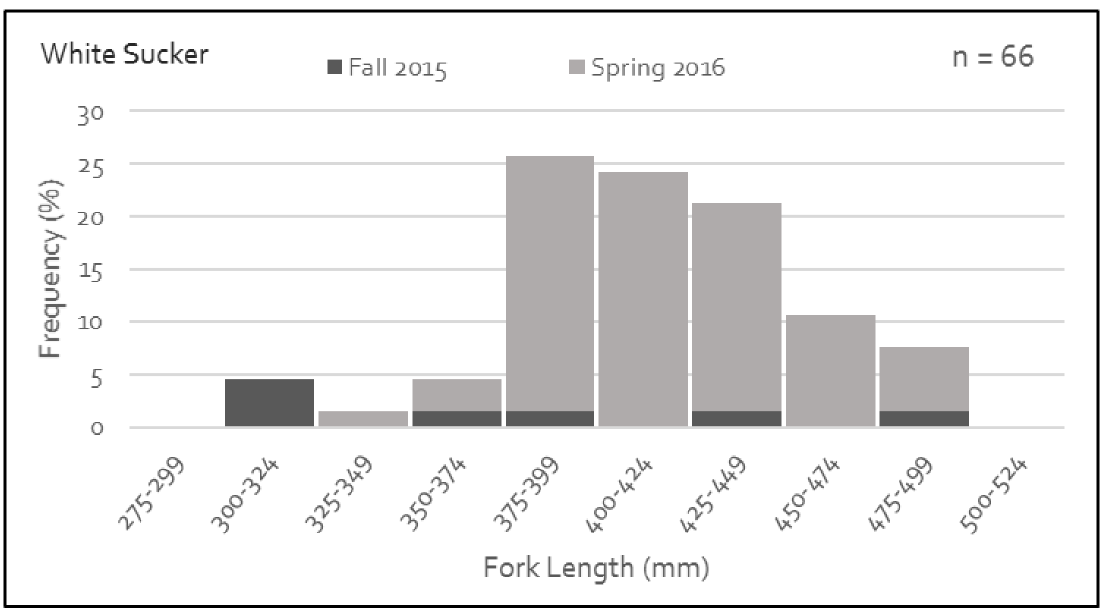


Figure 61. *Length-frequency distribution for White Sucker, Harrison Bay.*

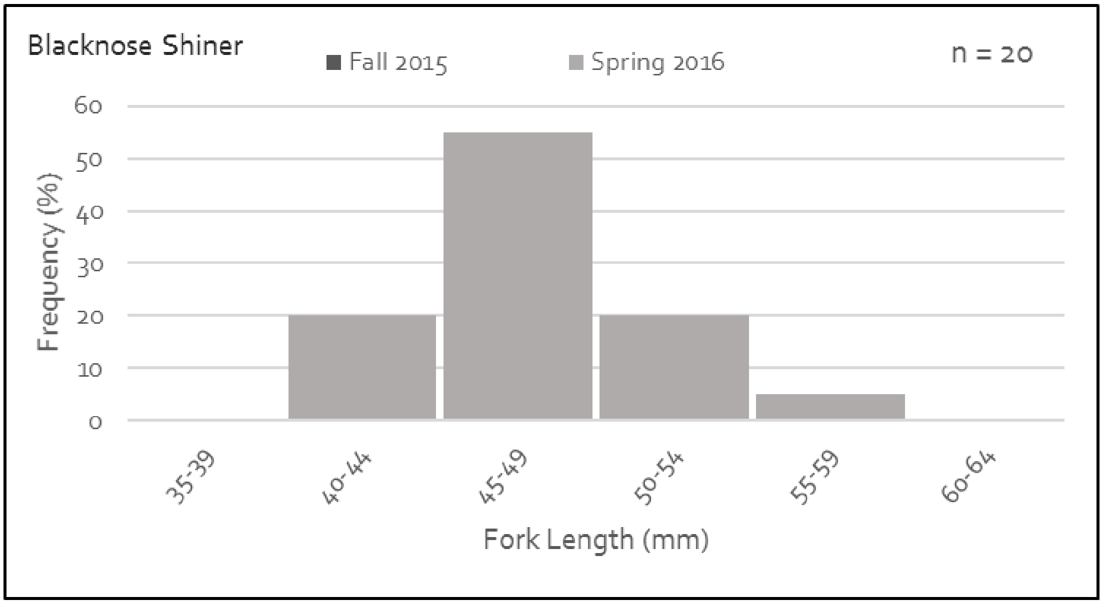


Figure 62. *Length-frequency distribution for Blacknose Shiner, Harrison Bay.*

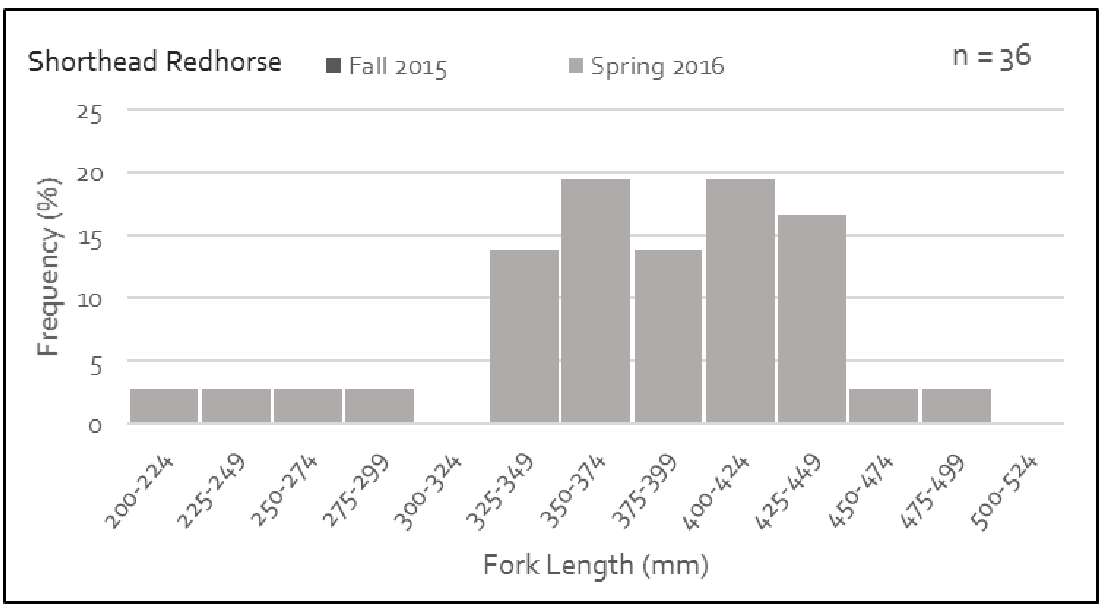


Figure 63. *Length-frequency distribution for Shorthead Redhorse, Harrison Bay.*

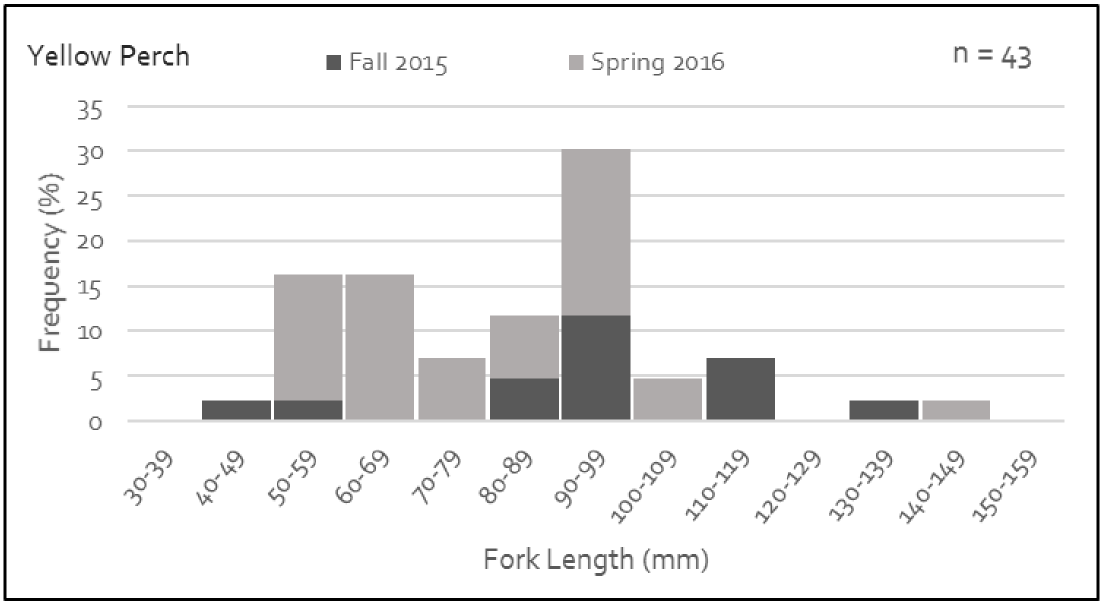


Figure 64. *Length-frequency distribution for Yellow Perch, Harrison Bay.*

5.3.4 FISH SPAWNING ACTIVITY

Adult fish in spawning condition were captured in the Harrison Bay study area during both the fall (Lake Whitefish) and spring (Northern Pike, Walleye, White Sucker, Shorthead Redhorse) sampling periods. Egg mat and kick sampling efforts, however, yielded no eggs during either the spring or fall season. Larval sampling conducted following the estimated spring spawning window produced Walleye and White Sucker larvae.

5.3.4.1 Adult Fish Spawning Condition

Fall 2015 gill net sampling was conducted during the estimated Lake Whitefish spawning window. A total of eight Lake Whitefish were captured of which one male and two female were found to be in spawning condition (Table 25).

Spring 2016 gill net sampling was completed to coincide with the spring spawning windows of species such as Walleye, Northern Pike, and White Sucker. A total of 17 Northern Pike, 4 Walleye, 57 White Sucker and 8 Shorthead Redhorse were in spawning condition (Table 25).

Table 25. *Sex and spawning condition observations during gill net sampling, Harrison Bay.*

Site	Season	Species	#	Sex				Maturity			
				Male	Female	Juvenile	Undeter-mined	Pre-spawn	Ripe and Running	Spent	Undeter-mined
Harrison Bay	Fall	Northern Pike	2	0	0	0	2	0	0	0	2
		Lake Whitefish	8	1	2	0	5	0	3	0	5
		White Sucker	1	0	-	0	1	0	0	0	1
		Total	**11**	**1**	**2**	**0**	**8**	**0**	**3**	**0**	**8**
	Spring	Black Bullhead	2	0	0	0	2	0	0	0	2
		Freshwater Drum	6	0	0	0	6	0	0	0	6
		Northern Pike	25	8	9	0	8	0	17	8	0
		Shorthead Redhorse	36	6	2	3	25	25	8	0	0
		Walleye	7	2	2	0	3	0	4	3	0
		White Sucker	59	29	28	0	2	0	57	0	2
		Total	**135**	**45**	**41**	**3**	**46**	**25**	**86**	**11**	**10**

5.3.4.2 *Larval Sampling*

A total of 5844 larval fish were captured during three four-minute net tows conducted within the Harrison Bay study site. White Sucker accounted for 95.4% of the catch (n = 5577; Table 26). Walleye (n=267) were also captured.

Table 26. *Results of larval fish sampling for Harrison Bay*

Site	Species	#	Total Volume (L)	Mean CPUE (# of fish/L)
Harrison Bay	Walleye	267	534.114	0.500
	White Sucker	5577		10.442

5.3.4.3 *Egg Mats*

No eggs were captured in egg mats set in Harrison Bay during either the fall or spring study periods.

5.3.4.4 Kick Sampling

A total of 15 m^2 of near-shore habitat was sampled. No eggs were captured during kick sampling at Harrison Bay. The majority of habitat sampled was classified as 60% sand, 40% gravel.

5.3.5 BENTHIC INVERTEBRATES

A total of 22 taxa from 10 orders of benthic macroinvertebrates (BMI) were identified in samples collected in Harrison Bay (**Table 27**, Figure 65). The most common order captured was Ephemeroptera (Mayfly) ($\bar{x}$ = 74.75/m^2), including the family Leptophlebiidae ($\bar{x}$) = 52.45/m^2), Caenidae ($\bar{x}$ = 21.70/m^2), Ephemeridae ($\bar{x}$ = 0.30m^2), and Heptageniidae ($\bar{x}$ = 0.30/m^2). The second most common order was Diptera (True fly) ($\bar{x}$ = 56.80/m^2), including the families Chironomidae ($\bar{x}$ = 55.75/m^2), Ceratopogonidae ($\bar{x}$ = 0.95/m^2) and Empididae ($\bar{x}$ = 0.10/m^2). The third most common order was Amphipoda ($\bar{x}$ = 36.50/m^2), including the families Dogielinotidae ($\bar{x}$ = 33.40/m^2) and Gammaridae ($\bar{x}$ = 3.10/m^2). The fourth most common order was Trombidiformes (Mites) ($\bar{x}$ = 21.25), family Hydrachnidiae. The remaining six orders comprised a combined total mean of 4.95/m^2, including Odonata (Dragon fly) ($\bar{x}$ = 1.95/m^2, family Coenarionidae), Trichoptera (Caddisfly) ($\bar{x}$ = 1.60/$m^{2;}$) families Polycentropodidae ($\bar{x}$ = 1.20/m^2), Hydroptilidae ($\bar{x}$ = 0.20/m^2), and Limnephilidae ($\bar{x}$ = 0.20/m^2), Nematoda (Round worm) ($\bar{x}$ = 0.70/m^2, not classified to family), Hemiptera (True bug) ($\bar{x}$ = 0.45/m^2; family Corixidae), Coleoptera (Butterfly/moth) [($\bar{x}$ = 0.20/m^2; families Dyticidae ($\bar{x}$ = 0.10/m^2) and Elmidae ($\bar{x}$ = 0.10/m^2)], and Megaloptera ($\bar{x}$ = 0.05/m^2; family Sialidae).

The mean richness (number of taxa per sample) was determined to be 8.50 (σ = 2.12). The overall mean for the site (number of individuals per m^2) was 195 BMI/m^2 (σ = 132.49), and Simpson's Diversity Index (measuring both number of species and relative abundance of each species) was 0.72 (Table 28).

Table 27. *Mean benthic invertebrates captured per square meter at Harrison Bay during two minutes of kick sampling.*

Order	Family	Genus	Species	Mean (per m²)
Ephemeroptera	Leptophlebiidae	spp.	spp.	52.45
	Caenidae	spp.	spp.	21.70
	Ephemeridae	spp.	spp.	0.30
	Heptageniidae	spp.	spp.	0.30
	Total			74.75
Diptera	Chironomidae	spp.	spp.	55.75
	Ceratopogonidae	spp.	spp.	0.95
	Empididae	spp.	spp.	0.10
	Total			56.80
Amphipoda	Dogielinotidae	*Hyalella*	*azteca*	33.40
	Gammaridae	spp.	spp.	3.10
	Total			36.50
Trombidiformes	Hydrochnidiae	spp.	spp.	21.25
	Total			21.25
Odonata	Coenarionidae	spp.	spp.	1.95
	Total			1.95
Trichoptera	Polycentropodidae	spp.	spp.	1.20
	Hydroptilidae	spp.	spp.	0.20
	Limnephilidae	spp.	spp.	0.20
	Total			1.60
Nematoda	Total			0.70
Hemiptera	Corixidae	spp.	spp.	0.45
	Total			0.45
Coleoptera	Dytiscidae	spp.	spp.	0.10
	Hydrophilidae	spp.	spp.	0.10
	Total			0.20
Megaloptera	Sialidae	spp.	spp.	0.05
	Total			0.05

Table 28. *Number of families, diversity, richness, and Simpson's Diversity for benthic invertebrates captured at Harrison Bay. σ = standard deviation.*

	Diversity		Richness		Simpson's Diversity	
Number of Families	**Mean**	**σ**	**Mean**	**σ**	**Mean**	**σ**
19	194	132	8.5	2.12	0.72	0.09

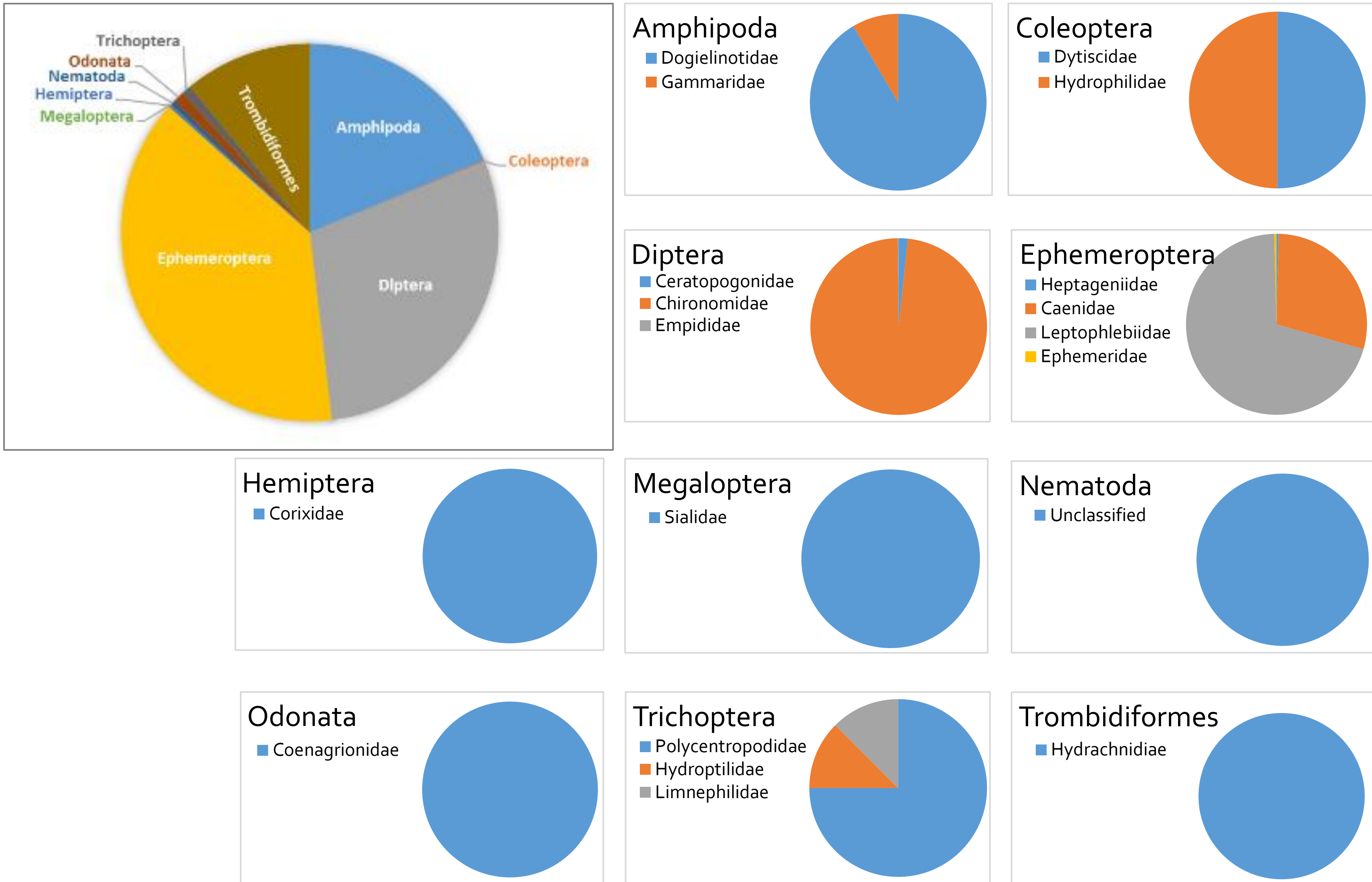


Figure 65. *Relative benthic invertebrate counts by Order (black box) and Family (grey boxes) at Harrison Bay.*

5.3.6 HARRISON CREEK TRIBUTARY ASSESSMENT

A baseline tributary assessment was completed on Harrison Creek during the spring field season in April and May of 2016. Hoop nets were used to assess fish migration within the system, water quality readings were recorded, and channel cross-sectional profiles were developed using measures of water velocity, depth, substrate composition, and adjacent riparian habitat (Figure 66).

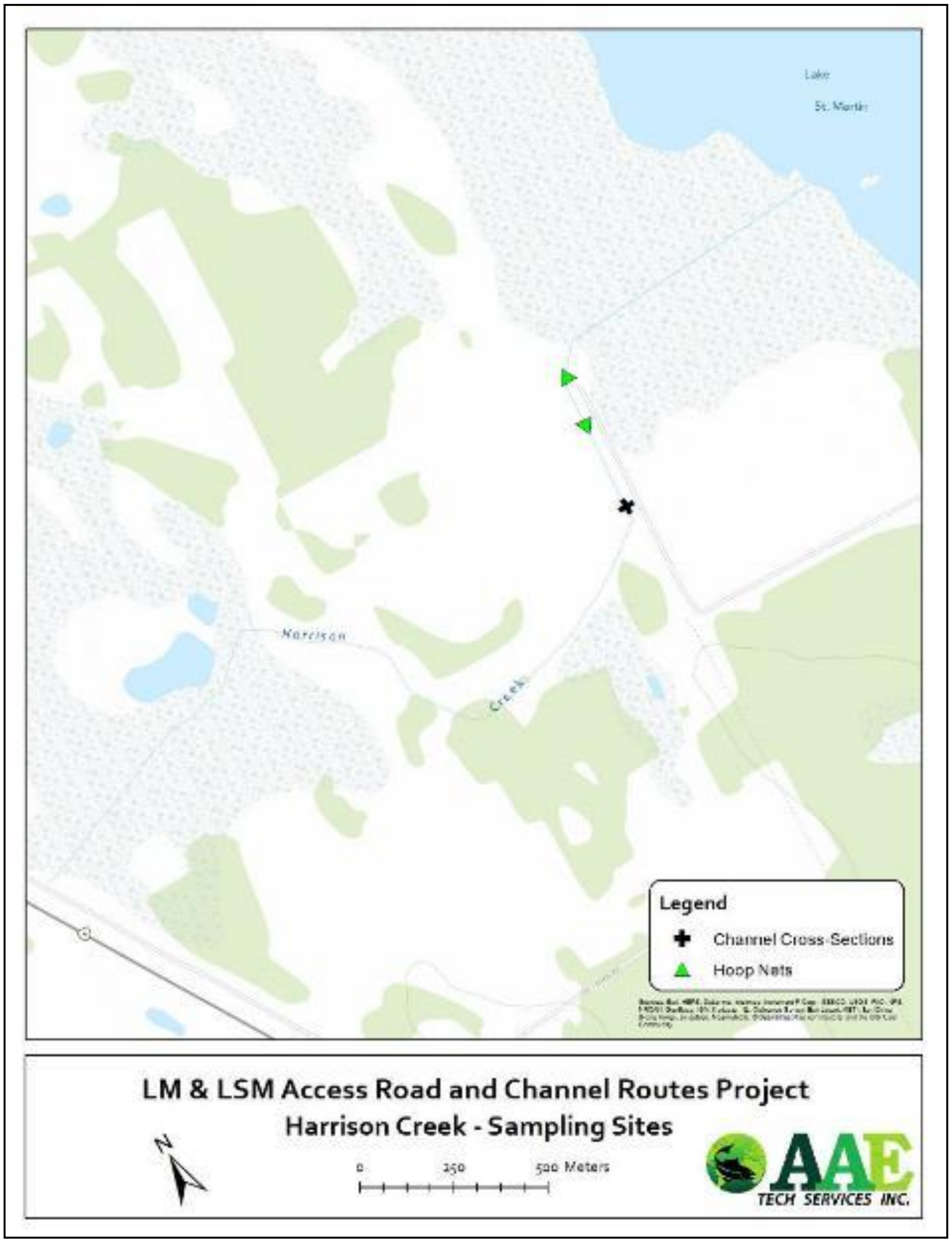


Figure 66 *Spring, 2016 sampling locations on Harrison Creek.*

5.3.6.1 CHANNEL MORPHOLOGY

Harrison Creek drains into Lake St. Martin approximately 380 m southeast of the proposed LMOC Route C outlet site. Harrison Creek drains predominantly agricultural land to the west. Much of the watercourse has been straightened and channelized, extending upstream 3.7 km to the west where it is spanned by MB Provincial Highway #6. At this point it continues both north and south as drainage ditches. Riparian habitat (Appendix A) is predominantly narrow and simple (mixed grasses, cattails, occasional willow), with adjacent land use almost exclusively agricultural (livestock grazing). Harrison Creek also passes through approximately 800 metres of dense marsh habitat as it flows into Lake St. Martin. This habitat extends north beyond the proposed LMOC Route C site.

One cross-sectional profile of Harrison Creek was studied (Figure 66), at a location approximately 200 m upstream of the marsh area (Appendix B-7). Creek width was 7.4 m, with a maximum water depth of 1.41 m. Mean water velocity was 0.67 m/s, peaking at 0.97 m/s at the channel centre. A depth profile of this site is characteristic of a steep-sided U-shaped agricultural drain. At the time of assessment, water levels were at approximately 0.4 m above the natural high water level of the creek.

Substrate consisted of sand (50%) and gravel (50%) at the centre of the channel, transitioning to sand (50%) and clay (50%) toward the right bank. The left bank was composed of clay (100%).

5.3.6.2 WATER QUALITY

Water quality measurements were not collected for Harrison Creek.

5.3.6.3 FISH DISTRIBUTION AND COMPOSITION

During spring, 2016 fish sampling was conducted on Harrison Creek. Although Northern Pike were not captured, it was noted from conversations with land owners that "large numbers of Northern Pike" were observed migrating upstream the week prior to the sampling survey.

5.3.6.3.1 Hoop Net

During the spring, 2016 field season, hoop nets were installed at two locations along Harrison Creek (Figure 66) oriented to capture upstream-migrating fish. One White Sucker was captured over 367 minutes of fishing effort (Table 29).

Table 29. *Hoop net sampling results, Harrison Creek.*

Site	Species	#	Fork Length (mm)		Total Effort (min)
			Mean	Range	
Harrison Creek	White Sucker	1	439	-	367
	Total	**1**			
		Mean CPUE (#/hour)			0.14

5.4 ROUTE D – LAKE ST. MARTIN, BIRCH BAY STUDY SITE

5.4.1 HABITAT ASSESSMENT

Aquatic and riparian habitat was assessed at the Birch Bay study site, including a full bathymetric, substrate and aquatic vegetation profile, as well as an aerial photographic survey of shoreline and riparian habitat.

5.4.1.1 Bathymetry

Bathymetric analysis of the Birch Bay study area at the proposed LMOC Route D outlet revealed a relatively uniform slope characteristics within the bay (Figure 67). The lake bed at this site has an average slope of 0.0035. Bathymetry directly adjacent to the proposed LMOC Route D outlet site, however, was much steeper, with an average slope of 0.012 from the water's edge to depths of 3 m. Beyond 3 m, lake bottom leveled off (slope = 0.0017) to a maximum depth of 3.71 m. Birch Creek drains into Birch Bay immediately south of the proposed LMOC Route D outlet site, through a large, heavily vegetated marsh / floodplain (see Section 5.4.1.4). Depths within this area are not well know, but cursory investigations suggest average depth will not exceed 1 m across most of the area outside of the main creek channel. This marsh habitat was considered as part of the creek system, and sampling efforts, including bathymetric and substrate analysis were restricted to open water habitat at this site. A prominent reef was also observed extending from the south across the mouth of Birch Creek, rising to a depth of < 1.0 m.

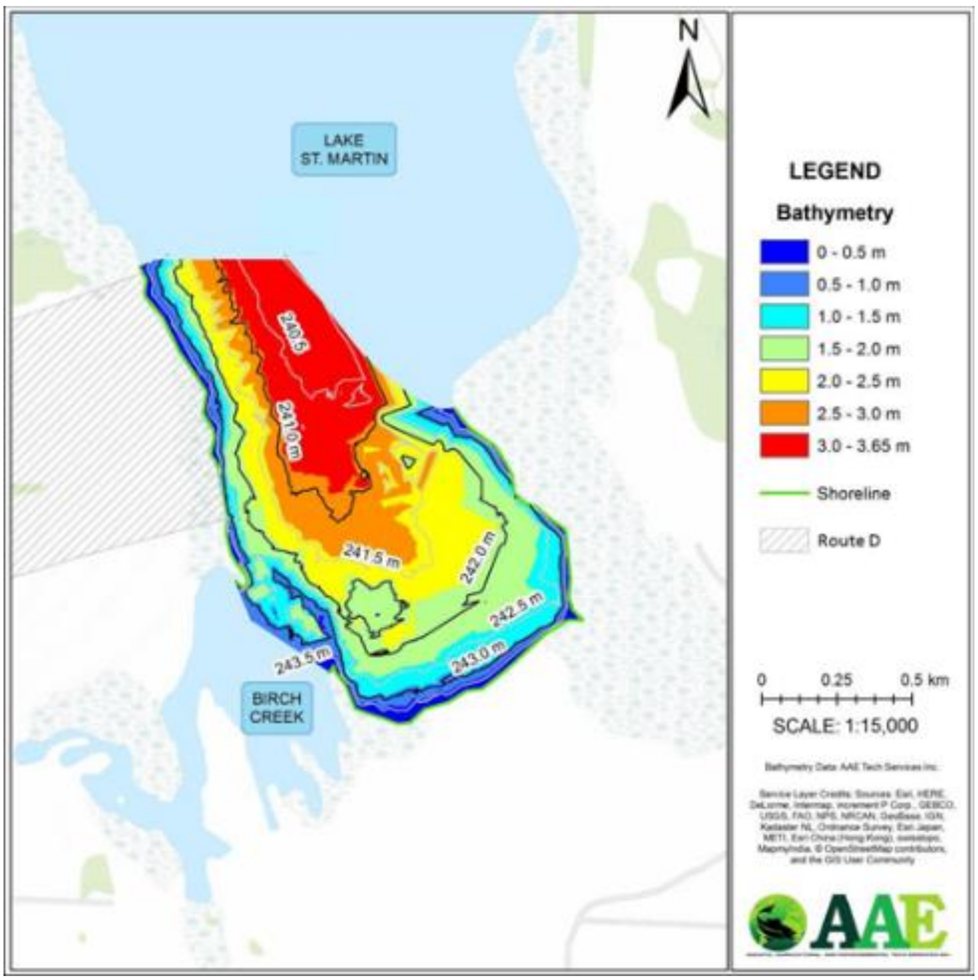


Figure 67. *Bathymetric map of the Birch Bay study area on Lake St. Martin.*

5.4.1.2 Substrate

Sonar analysis of substrate identified three distinct substrate types (Figure 68). Substrate along the shoreline to depths of ~2.5 m was extremely uniform, and found to be a gravel – sand mixture (70% - 30% respectively). At depths exceeding 2.5 m, substrate transitions to a sand substrate (> 90%). Small areas of gravel substrate (>90%) were also observed at depths > 3.0 m. Gravel and cobble shoreline was common along the extent of the study area, with occasional boulders observed in the nearshore habitat (depths < 1.0 m), including the reef that crosses the mouth of Birch Creek.

Ground truthing was accomplished using a telescopic metal probe to assess bottom compaction, texture and grain size of a 1 m^2 area of substrate at each of 53 ground truthing sites.

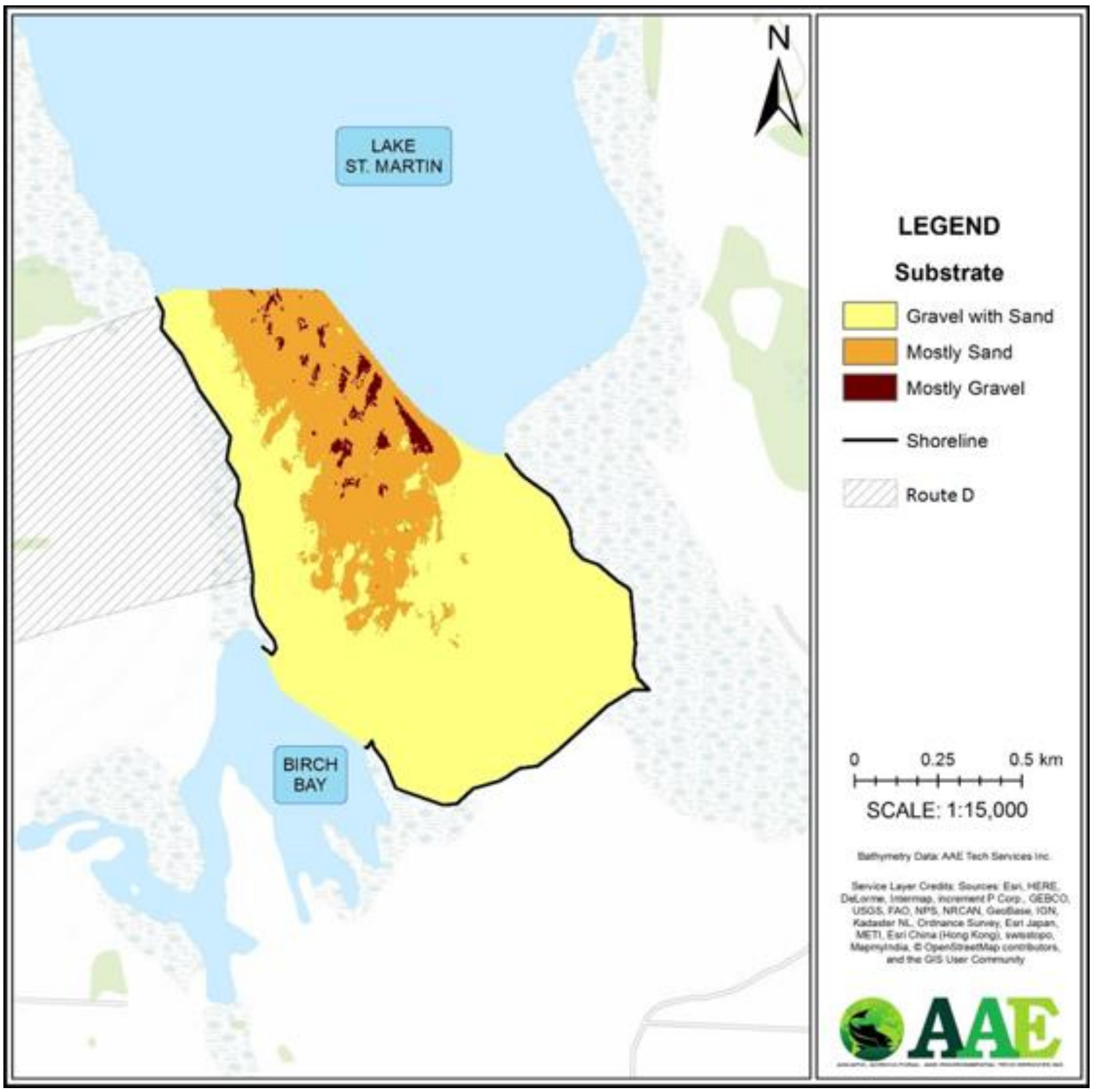


Figure 68. *Substrate composition map of the Birch Bay study area on Lake St. Martin.*

5.4.1.3 Aquatic Vegetation

Aquatic vegetation cover (Figure 69) was present almost exclusively at depths < 2.0 m, and was highest (60% - 100%) in shallower areas along the west and east shores of Birch Bay. Corresponding plant height (Figure 70) was low over much of the study area (0.0 – 0.2 m), with instances of slightly higher (0.2 m – 0.4 m) plant height along the eastern shoreline, and across the mouth of Birch Creek.

Plant biovolume (Figure 71) was similarly highest (20% - 45%) along the eastern shoreline, and across the mouth of Birch Creek, with little plant biovolume measured at depths > 3.0 m.

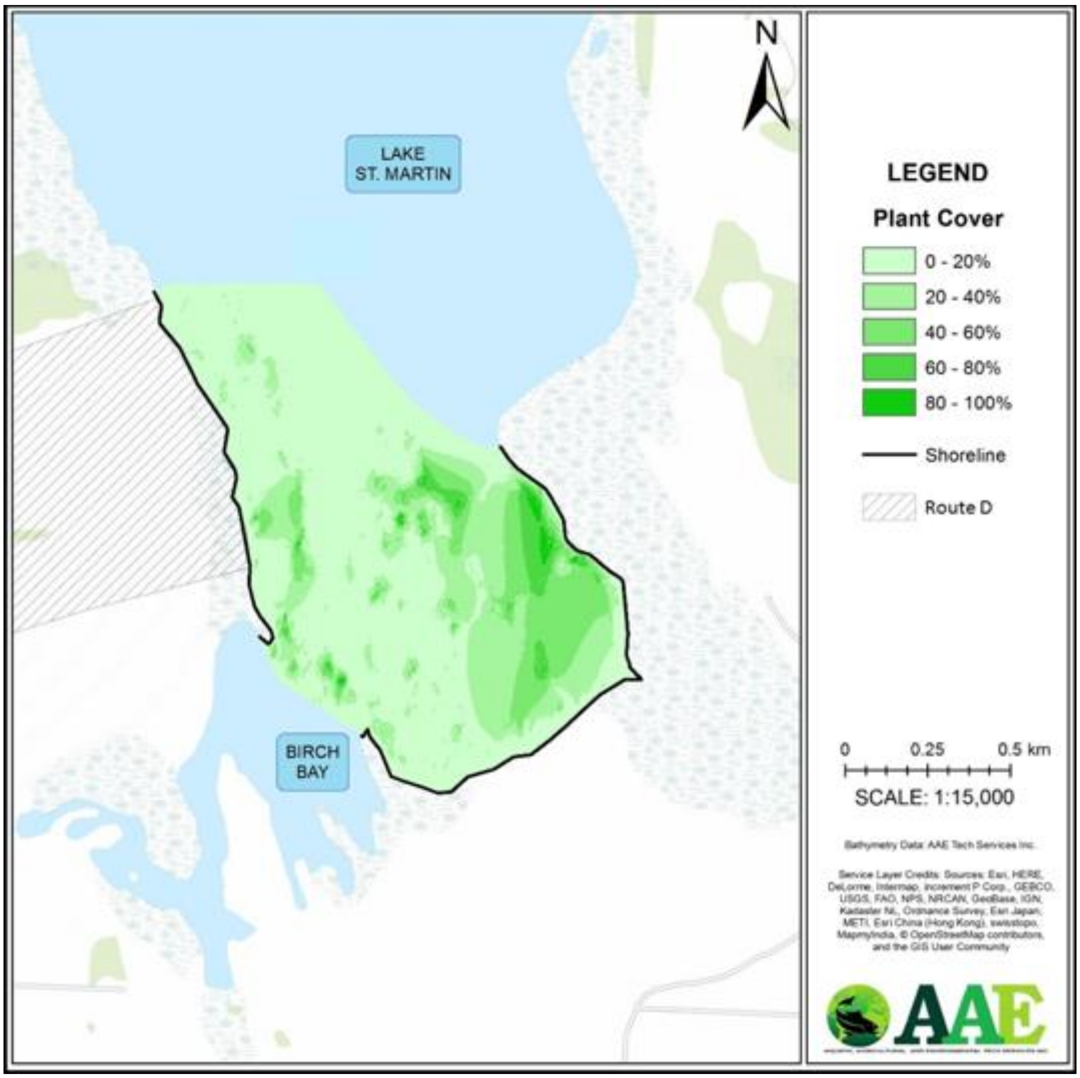


Figure 69. *Plant Cover (% area) map of the Birch Bay study area on Lake St. Martin.*

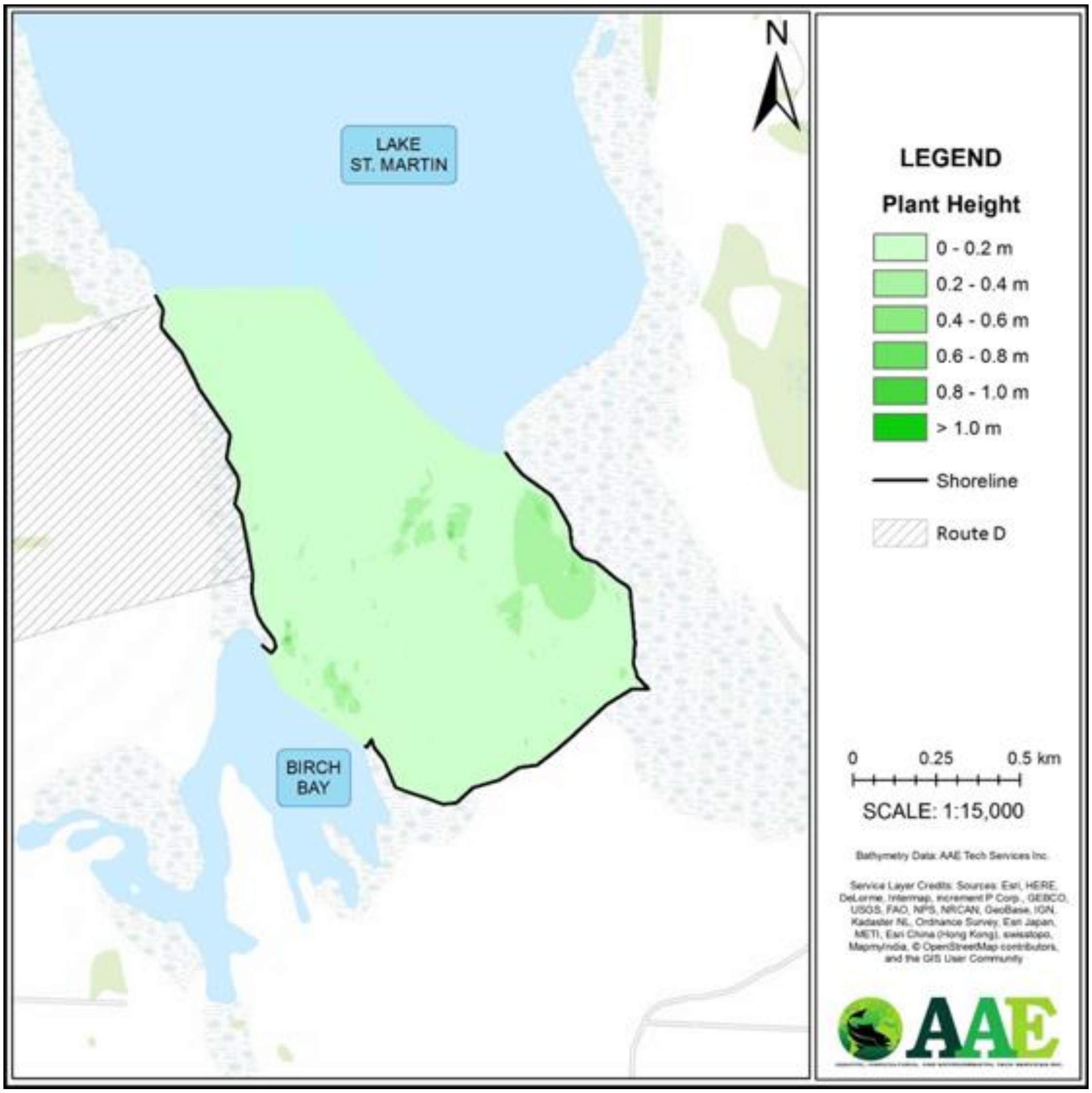


Figure 70. *Plant Height map of the Birch Bay study area on Lake St. Martin.*

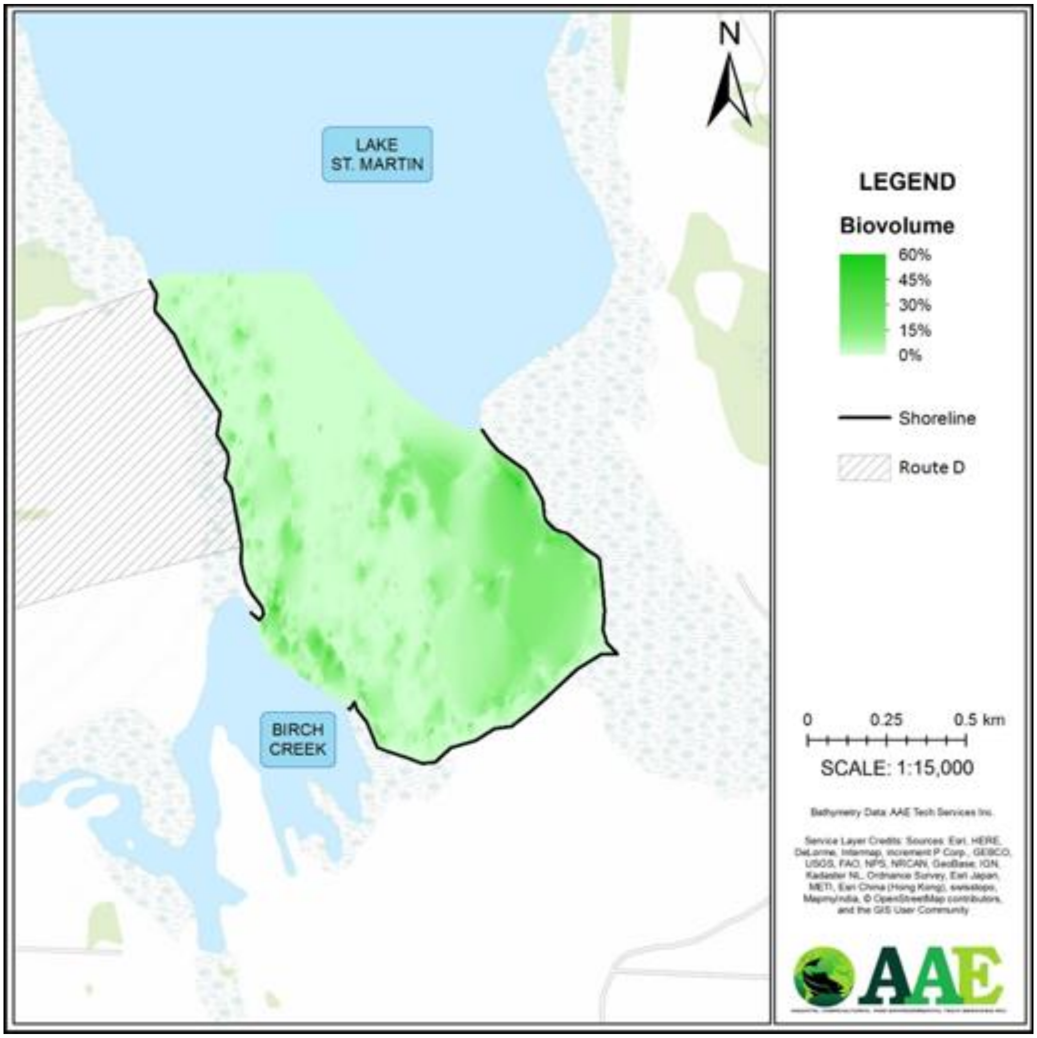


Figure 71. *Total Biovolume (% water column) map of the Birch Bay study area on Lake St. Martin.*

5.4.1.4 Shoreline Habitat

Aerial photographic surveys of the Birch Bay study site revealed a relatively narrow shoreline and riparian habitat (Figures 72 – 74).

Shoreline habitat extends 10 m from the water's edge, composed of a compacted gravel – cobble substrate with scattered boulders. Submerged boulder fields were visible within the shallow nearshore habitat (Figure 74), particularly within 20 m of the shoreline.

Wetland habitat extends between 62 m and 127 m back from the shoreline within the proposed LMOC Route D right of way, and was characteristic of a flood plain / wetland habitat with long grass and cattail vegetation cover and areas of standing water, particularly to the south extending to Birch Creek. Riparian habitat narrows to < 12 m to the north of the proposed Route D right of way. Land use beyond this area was agricultural, including seed crops and harvested hay land.

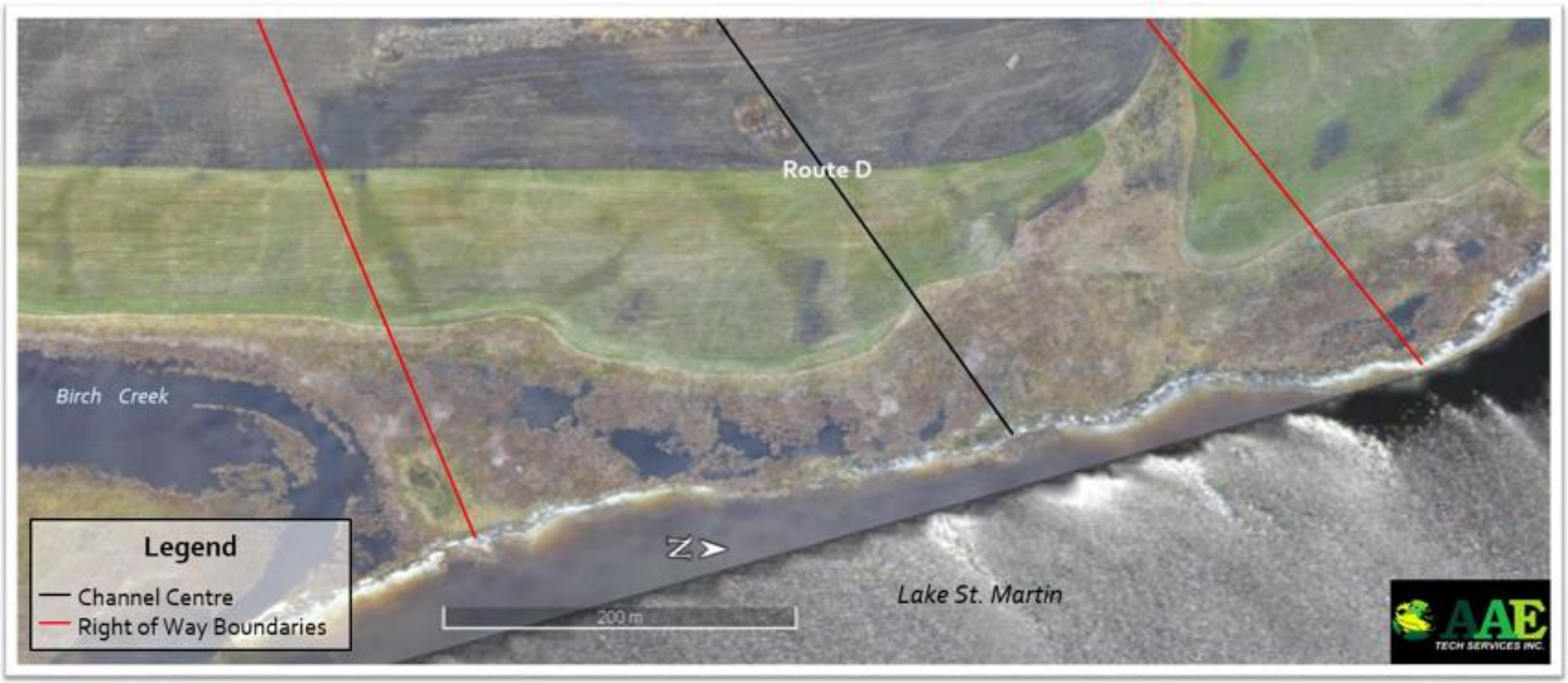


Figure 72. *Aerial photo orthomosaic of the Birch Bay study site for the proposed LMOC Route D, focusing on shoreline and riparian habitat.*

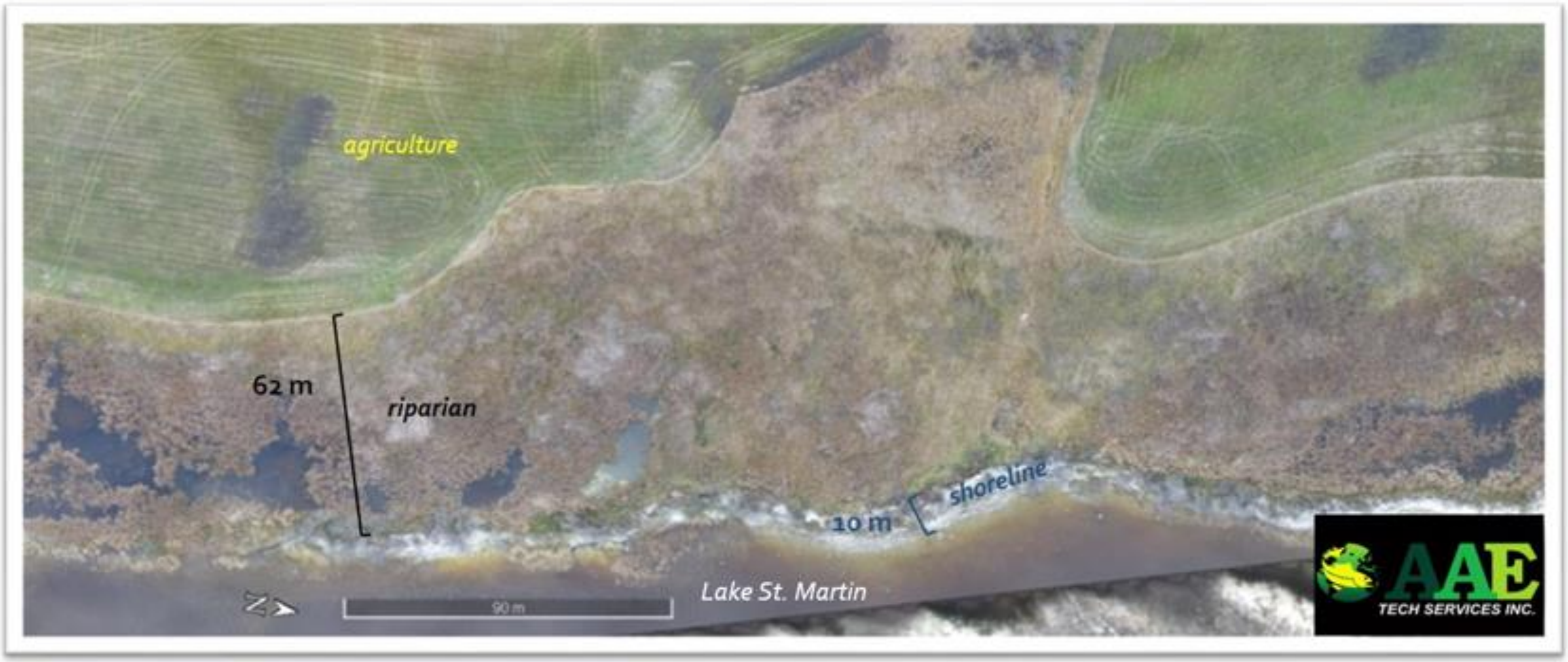


Figure 73. *Aerial photo orthomosaic of the Birch Bay study site for propsoed LMOC Route D, depicting extent of shoreline and riparian habitat. Centred on proposed channel inlet site.*

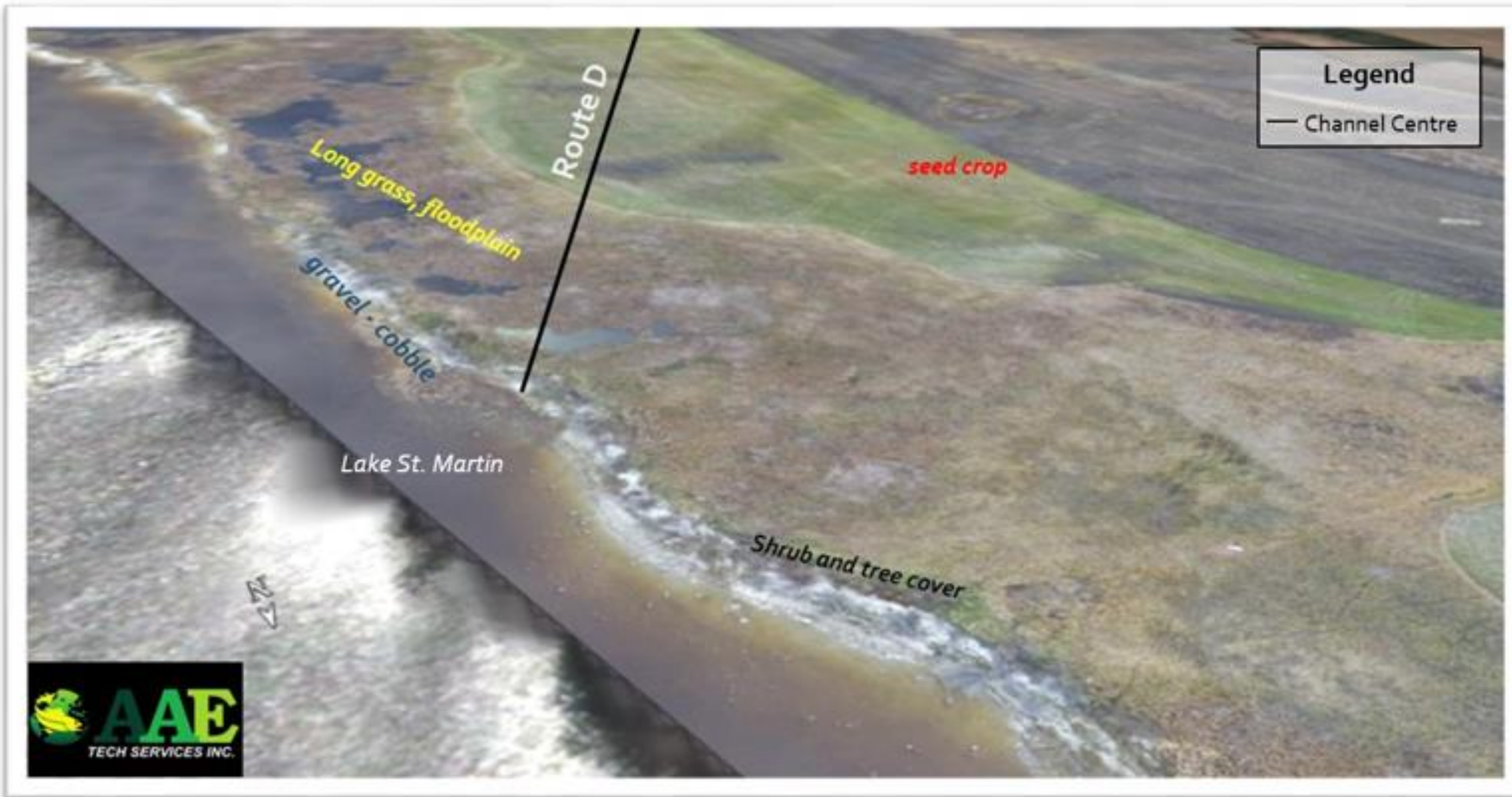


Figure 74. *Aerial photo orthomosaic of the Birch Bay study site for proposed LMOC Route D, depicting shoreline and riparian habitat cover and composition. Oblique view from the northeast, centred on proposed channel inlet site.*

5.4.2 WATER QUALITY

Failure of the temperature logger installed at Lake St. Martin resulted in only partial water temperature data for the fall, 2015 field season (Figure 81). Mean temperature values were instead derived from *in-situ* measurements collected along with remaining water quality parameters.

Mean water temperature of Lake St. Martin at the Birch Bay study site during the fall study period (October – November, 2015) was 5.52°C (range: 0.29°C – 10.75°C, Table 21). Mean water temperature over the spring study period (April – June) at Birch Bay was 16.95°C (range: 12.52°C – 21.98°C, Table 21).

Remaining water quality parameters were relatively similar between fall, 2015 and spring, 2016 field seasons (Table 30). Mean dissolved oxygen at the Birch Bay site was 10.57 mg/L (8.10 – 9.55 mg/L) during the fall study period, and 10.63 mg/L (9.70 – 12.28 mg/L) during the spring study period; DO values were consistently above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity, total suspended solids (TSS), pH and Conductivity values were assessed for the Birch Bay site based on mean measurements taken using *in-situ* readings between October 18, 2015 and November 13, 2015 (Fall study period), and May 01, 2016 and June 01, 2016 (Spring study period), and are presented in Table 30.

Table 30. *Mean water quality values, Birch Bay.*

	Sampling Season		
WQ Parameter	**Fall 2015**	**Spring 2016**	**CCME Minimum Guideline Value**
Temperature	5.52	16.95	Variable
Dissolved Oxygen (mg/L)	10.57	10.63	Variable: 5.5 – 9.5
pH	6.88	6.72	6.5 – 9.0
Conductivity (µS/cm)	683	494.7	No Data
Turbidity (NTU)	3.20	3.68	Variable
TSS (mg/L)	16.486	17.172	No Data

5.4.3 FISH DISTRIBUTION AND COMPOSITION

Fish and invertebrate sampling was carried out at the Birch Bay study site over a 34-day fall sampling period in October – November, 2015, and a 45-day spring sampling period in April – June, 2016. Fish community composition was assessed using gill net and boat electrofishing surveys, egg mat sets, larval fish tows, and kick net benthic sampling (Figure 75). A total of 89 fish representing eight species were captured. No species of concern were identified at this site.

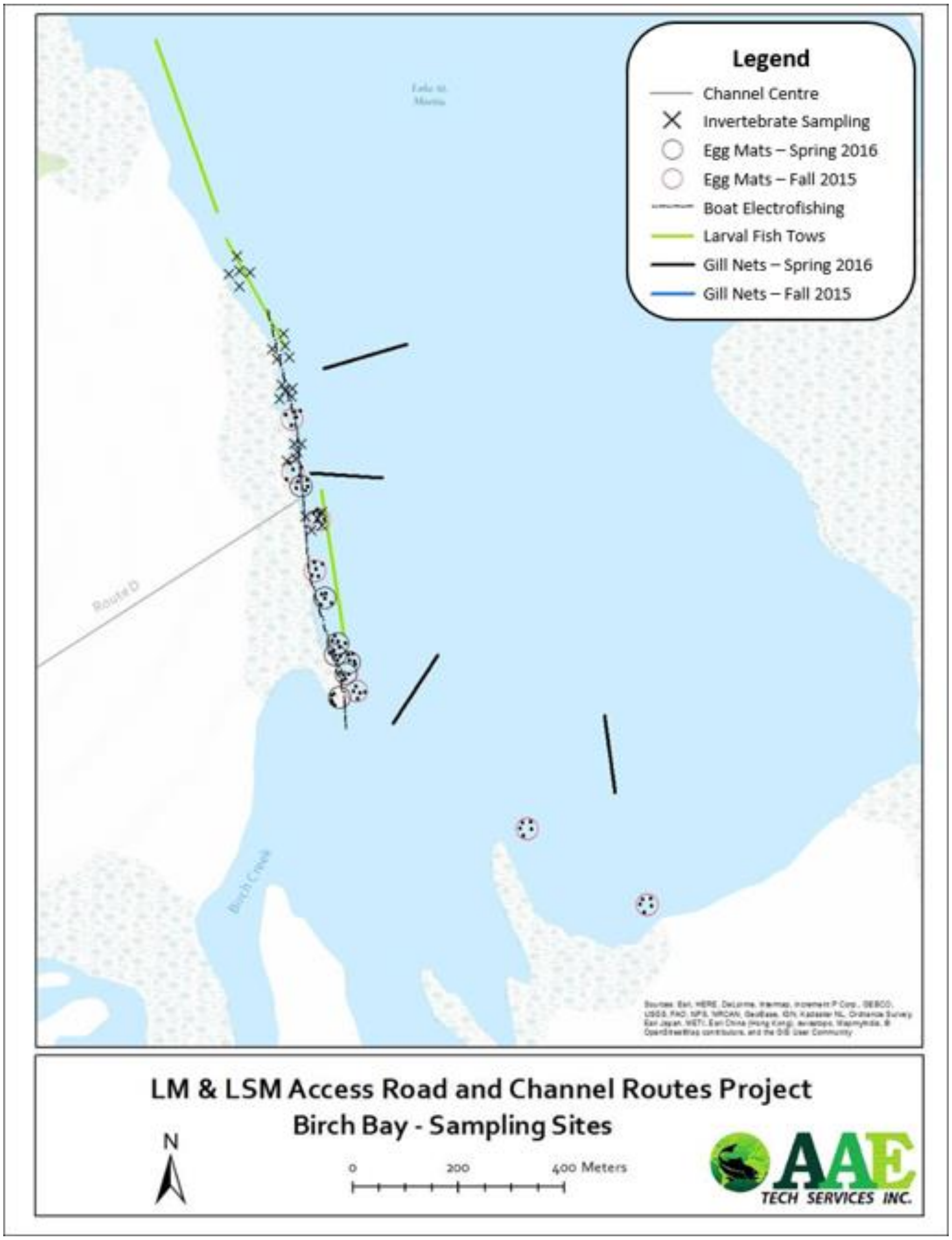


Figure 75. *Birch Bay study area, fish and invertebrate sampling locations.*

5.4.3.1 Boat Electrofishing

A total of 19 fish representing three species were successfully captured during spring boat electrofishing at Birch Bay (Figure 76, Table 31). With a total fishing effort of 1,934 seconds, CPUE was 0.589 fish/minute. Common Carp was the most abundant species captured, accounting for 57.9% of the total catch. Yellow Perch (31.6%) and Northern Pike (10.5%) were also captured.

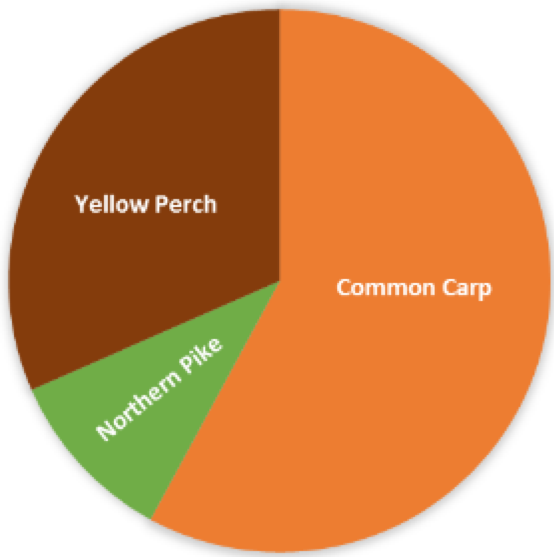


Figure 76. *Relative species abundance for fish captured during spring boat electrofishing at Birch Bay.*

Table 31. *Boat electrofishing results for Birch Bay.*

Site	Species	#	Fork Length (mm)		Effort (sec)
			Mean	Range	
Birch Bay	Common Carp	11	659	572-751	1934
	Northern Pike	2	762	678-846	
	Yellow Perch	6	70	54-95	
	Total	**19**			
				CPUE (#/min)	**0.589**

5.4.3.2 Gill Netting

A total of 70 fish representing seven species were successfully captured during fall and spring gill netting at Birch Bay (Figure 77 and Table 32).

During fall sampling, 4 fish representing three species were captured over a total set time of 60 minutes. (CPUE = 13.86 fish/100 m/hour). Lake Whitefish was the most abundant species captured, which accounted for 57.9% of the total catch. White Sucker (21.1%), Cisco (15.8%), and Northern Pike (5.2%) were also present.

During spring sampling, 51 fish representing seven species were captured over a total set time of 126 minutes (CPUE = 18.30 fish/100 m/hour). Northern Pike was the most abundant species captured, accounting for 37.3% of the total catch. White Sucker (27.5%), Shorthead Redhorse (19.6%), Cisco (7.8%), Yellow Perch (3.9%), and Lake Whitefish (2.0%) were also present.

Mean size and condition factor (K) for each species sampled in both fall and spring sampling periods is presented in Table 32.

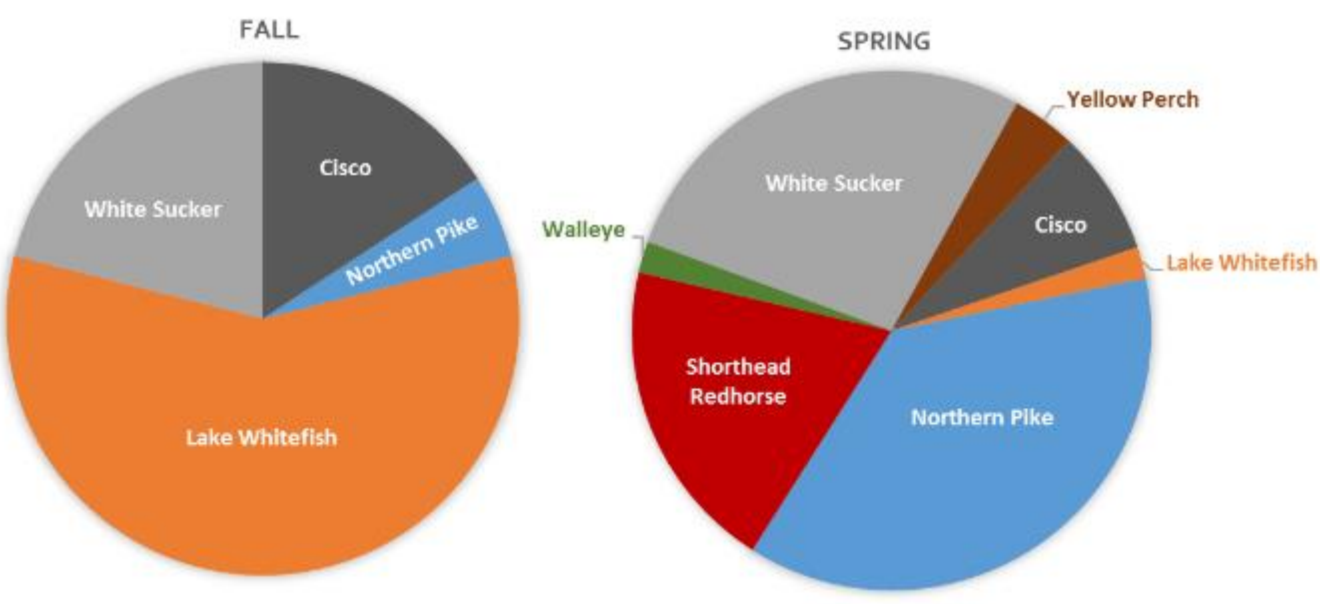


Figure 77. *Relative species abundance for fish captured during fall (left) and spring (right) gill netting at Birch Bay.*

***Table 32.** Gill netting results for Birch Bay, including mean size and condition factor (K).*

Site	Season	Species	#	Fork Length (mm)		Round Weight (g)		Mean Condition Factor (K)
				Mean	Range	Mean	Range	
Birch Bay	Fall	Cisco	3	179	173 - 186	56.7	28.3-85	0.843
		Northern Pike	1	529	-	963.9	-	0.651
		Lake Whitefish	11	396	361 - 445	842.7	538.6-1247.4	1.333
		White Sucker	4	426	385 - 462	893.7	907.2-1389.1	0.843
		Total	**19**					
	Mean CPUE (#/100 m/hour)		13.86					
	Spring	Cisco	4	186	179-203	68.8	50-75	0.983
		Lake Whitefish	1	389	-	825.0	-	1.402
		Northern Pike	19	488	345-792	868.2	300-1950	0.711
		Shorthead Redhorse	10	383	338-442	810.0	350-1450	1.412
		Walleye	1	348	-	325.0	-	0.771
		White Sucker	14	417	350-567	1068.3	300-2050	1.538
		Yellow Perch	2	163	161-165	25.0	20-30	0.574
		Total	**51**					
	Mean CPUE (#/100 m/hour)		18.3					

5.4.3.3 Length Frequency Distribution Analysis

Fish collection data for the Birch Bay study site were combined across all sampling methods and field seasons, and frequency distribution plots were generated for all fish species where sample size (n) was equal to or greater than 15 fish. Plots depict both fall, 2015 and spring, 2016 sample sets. The total sample size necessary for distribution analysis was achieved for two species captured at Birch Bay, including Northern Pike (n = 22) and White Sucker (n = 18).

Northern Pike mean fork length was 514.8 mm with the majority falling in the 400 – 449 mm class. (Figure 78). All but one Northern Pike was captured during the spring, 2016 study period. Maximum observed fork length, sampled in the spring, was 846 mm.

White Sucker mean fork length was 419.0 mm with the majority falling in the 350 – 374 mm classes and a second slightly lower peak in the 450 – 474 mm class (Figure 79). Spring, 2016 sampling yielded most fish (n = 14), with length-frequency distribution depicting a mature spawning population with most fork lengths between 350 – 499 mm, with a maximum observed fork length of 567 mm, observed in the spring.

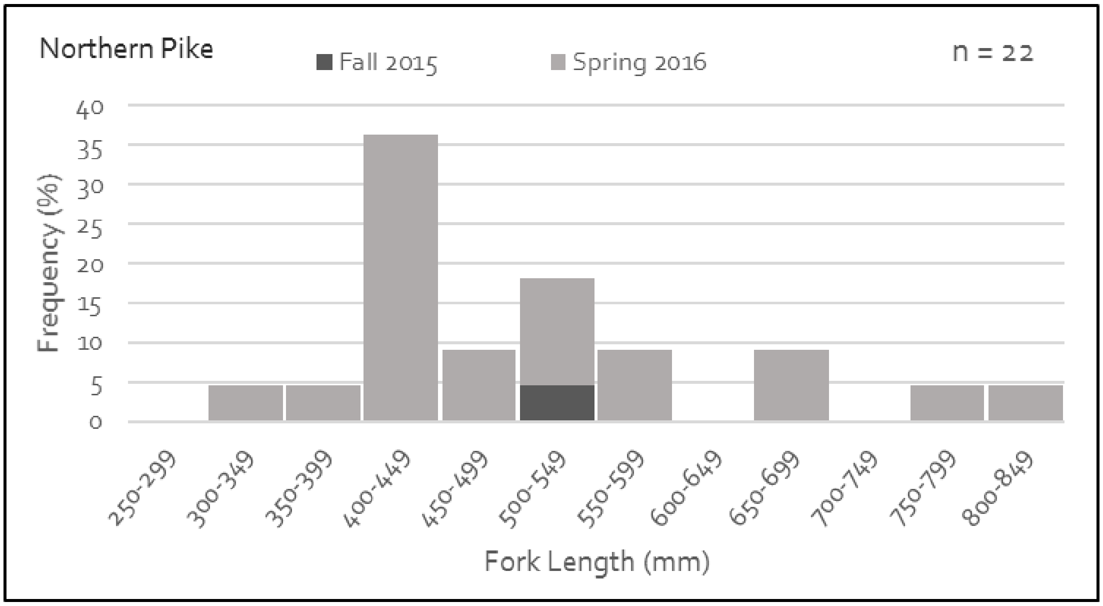


Figure 78. *Length-frequency distribution for Northern Pike, Birch Bay*

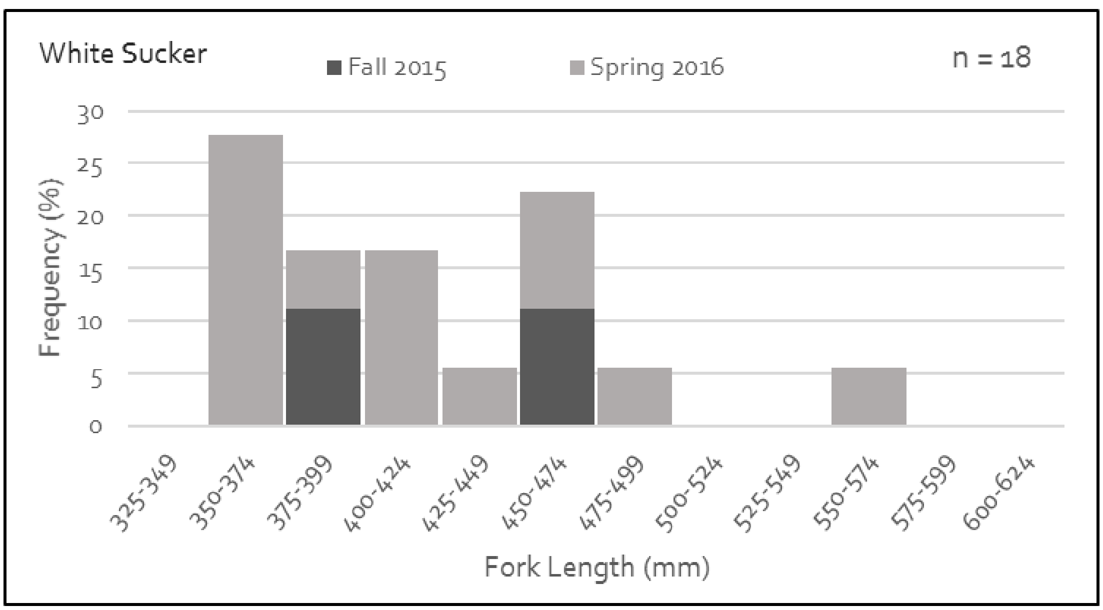


Figure 79. *Length-frequency distribution for White Sucker, Birch Bay*

5.4.4 FISH SPAWNING ACTIVITY

Adult fish in spawning condition were observed within the Birch Bay study area during both the fall (Lake Whitefish) and spring (Northern Pike, Walleye, White Sucker) field seasons. Egg mat and kick sampling efforts, however, yielded no eggs during either the spring or fall season. Larval sampling completed following the spring spawning window identified Walleye and White Sucker larvae present within the Birch Bay study area.

5.4.4.1 Adult Fish Spawning Condition

Fall 2015 gill net sampling was completed to coincide with the Lake Whitefish spawning window, and assess the presence of spawning adult fish within this study area. A total of 11 Lake Whitefish (8 male, 3 female) were captured during fall gill netting efforts and found to be in spawning condition (Table 33). Of these, 10 fish were described as ripe (still in the staging phase prior to the start of the spawning run), and 2 fish were found to be spent (eggs/milt have been deposited over spawning habitat).

Spring 2016 gill net sampling was completed to coincide with the spring spawning window; Walleye, Northern Pike, and White Sucker species were expected to be in or approaching their spawning run. A total of 12 Northern Pike, 1 Walleye, and 13 White Sucker were captured and found to be in spawning condition (Table 33). Of these, all (n = 26) were found to be ripe; milt/eggs are able to be observed through light pressure to the abdomen, though fish are still in the staging phase prior to the start of the spawning run, and are not actively releasing milt/eggs.

Table 33. *Sex and spawning condition observations during gill net sampling, Fairford.*

Site	Season	Species	#	Sex				Maturity			
				Male	Female	Juvenile	Undeter-mined	Pre-spawn	Ripe and Running	Spent	Undeter-mined
Birch Bay	Fall	Cisco	3	0	0	0	0	0	0	0	0
		Northern Pike	1	0	0	0	0	0	0	0	0
		Lake Whitefish	11	7	3	0	1	0	0	0	11
		White Sucker	4	0	0	0	0	0	0	0	0
		Total	**19**	**7**	**3**	**0**	**1**	**0**	**0**	**0**	**11**
	Spring	Cisco	4	0	0	0	4	0	0	0	4
		Lake Whitefish	1	0	0	0	1	0	0	0	1
		Northern Pike	19	7	5	0	7	0	0	0	19
		Shorthead Redhorse	10	0	0	0	10	0	0	0	10
		Walleye	1	0	0	0	1	0	0	0	1
		White Sucker	14	0	0	0	14	0	0	0	14
		Yellow Perch	2	0	0	0	2	0	0	0	2
		Total	**51**	**7**	**5**	**0**	**39**	**0**	**0**	**0**	**51**

5.4.4.2 Larval Sampling

A total of 2855 larval fish representing four species were captured during three four-minute net tows at the Birch Bay study site. The most abundant species captured was White Sucker, which accounted for 93.3% of larval fish captured (n = 2665, Table 24). The remaining catch was identified as Walleye (n=187).

Table 34. *Results of larval fish sampling for Birch Bay.*

Species	#	Total Volume (L)	Mean CPUE (# of fish/L)
Walleye	187	578.388	0.323
White Sucker	2665		4.608

5.4.4.3 Egg Mats

No eggs were present in the 70 egg mats placed at Birch Bay in either the fall or spring field season. Substrate consisted largely of sand – gravel substrates, with occasional boulders.

5.4.4.4 Kick Sampling

No eggs were captured in the 22 m² sampled along the nearshore shallow (< 1.2 m) habitat of the Birch Bay study site. Two types of substrate were targeted for sampling: sand with boulder, and 70% gravel – 30% sand substrates.

5.4.5 BENTHIC INVERTEBRATES

A total of 22 taxa from eleven orders of benthic macroinvertebrates (BMI) were collected in Birch Bay (Table 35 and Figure 80). The most common order captured was Diptera (True fly) ($\bar{x}$ = 158.40/m²), including the families Chironomidae ($\bar{x}$ = 157.25/m²), Ceratopogonidae ($\bar{x}$ = 0.90/m²) and Empididae ($\bar{x}$ = 0.25/m²). The second most common order was Ephemeroptera (Mayfly) ($\bar{x}$ = 124.65/m²), including the families Leptophlebiidae ($\bar{x}$ = 122.00/m²), Caenidae ($\bar{x}$ = 2.40/m²), Ephemeridae ($\bar{x}$ = 0.15/m²), and Heptageniidae ($\bar{x}$ = 0.10/m²). The third most common family was Amphipoda ($\bar{x}$ = 109.90/m²), families Dogielinotidae ($\bar{x}$ = 102.60/m²) and Gammaridae ($\bar{x}$ = 7.30/m²). The remaining eight orders comprised a combined total mean of 15.50/m², including Trombidiformes (Mites) ($\bar{x}$ = 5.75; family Hydrachnidiae), Hemiptera (True bugs) ($\bar{x}$ = 4.75; families Corixidae ($\bar{x}$ = 4.70) and Belostomatidae ($\bar{x}$ = 0.05)), Odonata (Dragon fly) ($\bar{x}$ = 2.45/m², family Coenarionidae), Trichoptera (Caddisfly) ($\bar{x}$ = 2.30/m²; families Polycentropodidae ($\bar{x}$ = 1.35/m²), Hydroptilidae ($\bar{x}$ = 0.0.60/m²), Leptoceridae ($\bar{x}$ = 0.20/m²), Limnephilidae ($\bar{x}$ = 0.0.10/m²) and Phryganeidae ($\bar{x}$ = 0.05/m²)), Hirudinea (Leeches) ($\bar{x}$ = 0.10/m²; not classified to family), Coleoptera (Beetles) ($\bar{x}$ = 0.05/m²; family Dyticidae), Megaloptera ($\bar{x}$ = 0.05/m²; family Sialidae), and Nematoda (Round worm) ($\bar{x}$ = 0.05/m², not classified to family).

The mean richness (number of taxa per sample) was determined to be 9.25 (σ = 2.1). The overall mean for the site (number of individuals per m²) was 409 BMI/m² (σ = 259.67), and Simpson's Diversity Index (measuring both number of species and relative abundance of each species) was 0.57 (Table 36).

Table 35. *Mean benthic invertebrates captured per square meter at Birch Bay during two minutes of kick sampling.*

Order	Family	Genus	Species	Mean (per m²)
Diptera	Chironomidae	spp.	spp.	157.25
	Ceratopogonidae	spp.	spp.	0.90
	Empididae	spp.	spp.	0.25
	Total			158.40
Ephemeroptera	Leptophlebiidae	spp.	spp.	122.00
	Caenidae	spp.	spp.	2.40
	Ephemeridae	spp.	spp.	0.15
	Heptageniidae	spp.	spp.	0.10
	Total			124.65
Amphipoda	Dogielinotidae	*Hyalella*	*azteca*	102.60
	Gammaridae	spp.	spp.	7.30
	Total			109.90
Trombidiformes	Hydrochnidiae	spp.	spp.	5.75
	Total			5.75
Hemiptera	Corixidae	spp.	spp.	4.70
	Belostomatidae	*Lethocerus*	spp.	0.05
	Total			4.75
Odonata	Coenarionidae	spp.	spp.	2.45
	Total			2.45
Trichoptera	Polycentropodidae	spp.	spp.	1.35
	Hydroptilidae	spp.	spp.	0.60
	Leptoceridae	spp.	spp.	0.20
	Limnephilidae	spp.	spp.	0.10
	Phryganeidae	spp.	spp.	0.05
	Total			2.30
Hirudinea	Total			0.10
Coleoptera	Dytiscidae	spp.	spp.	0.05
	Total			0.05
Megaloptera	Sialidae	*Sialis*	spp.	0.05
	Total			0.05
Nematoda	Total			0.05

Table 36. *Number of families, diversity, richness, and Simpson's Diversity for benthic invertebrates captured at Birch Bay. σ = standard deviation.*

	Diversity		Richness		Simpson's Diversity	
Number of Families	**Mean**	**σ**	**Mean**	**σ**	**Mean**	**σ**
22	408	260	9.25	2.17	0.57	0.13

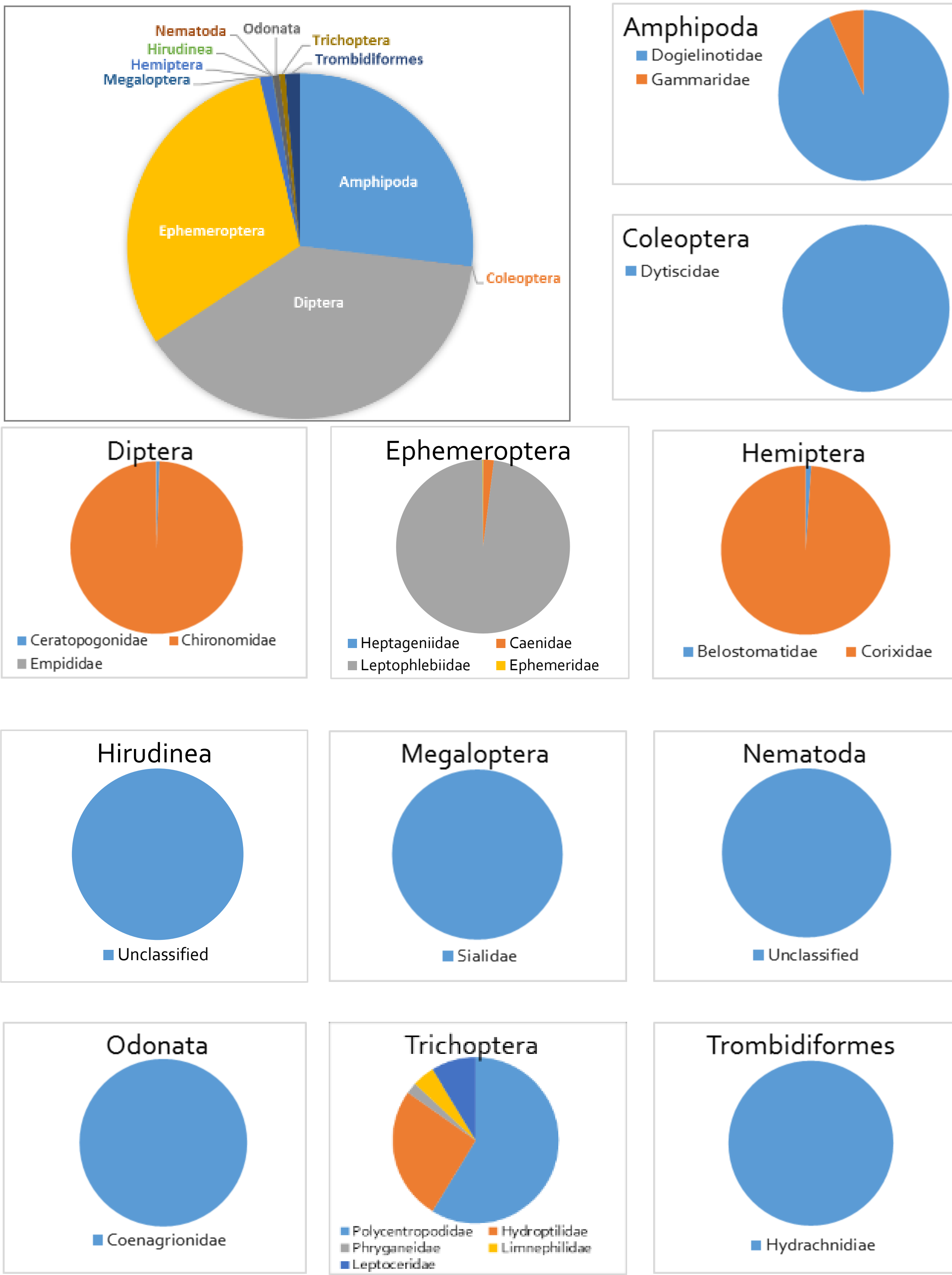


Figure 80. *Relative benthic invertebrate counts by Order (black box) and Family (grey boxes) at Birch Bay.*

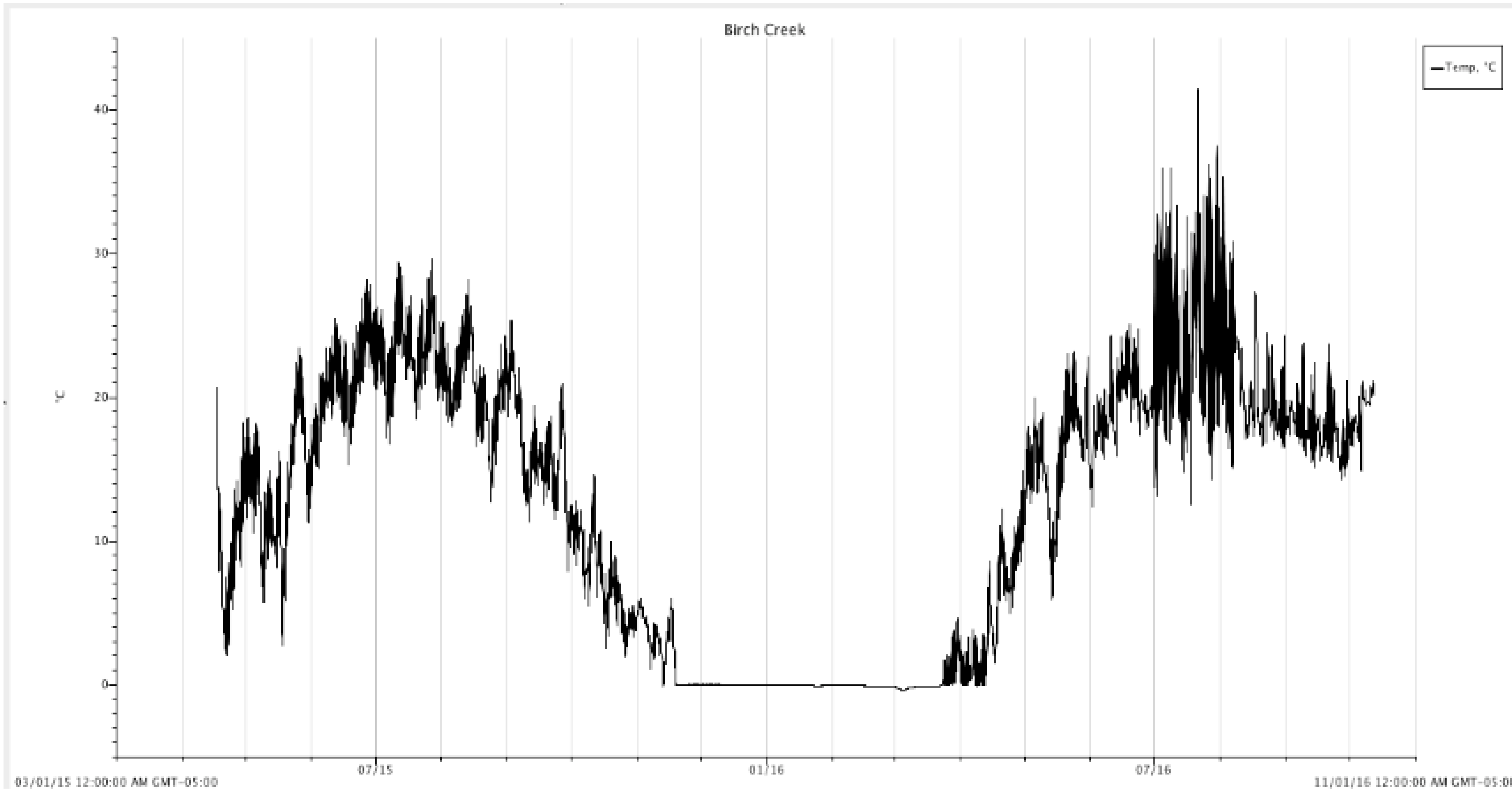


Figure 81. *Lake St. Martin / Birch Creek hourly water temperature measurements. May 2015 – July 2016.*

5.4.6 BIRCH CREEK TRIBUTARY ASSESSMENT

A baseline tributary assessment was completed on Birch Creek as part of the spring field season in April and May of 2016. Hoop nets were used to assess fish migration within the system, water quality readings were recorded, and channel cross-sectional profiles were developed using measures of water velocity, depth, substrate composition, and adjacent riparian habitat (Figure 82).

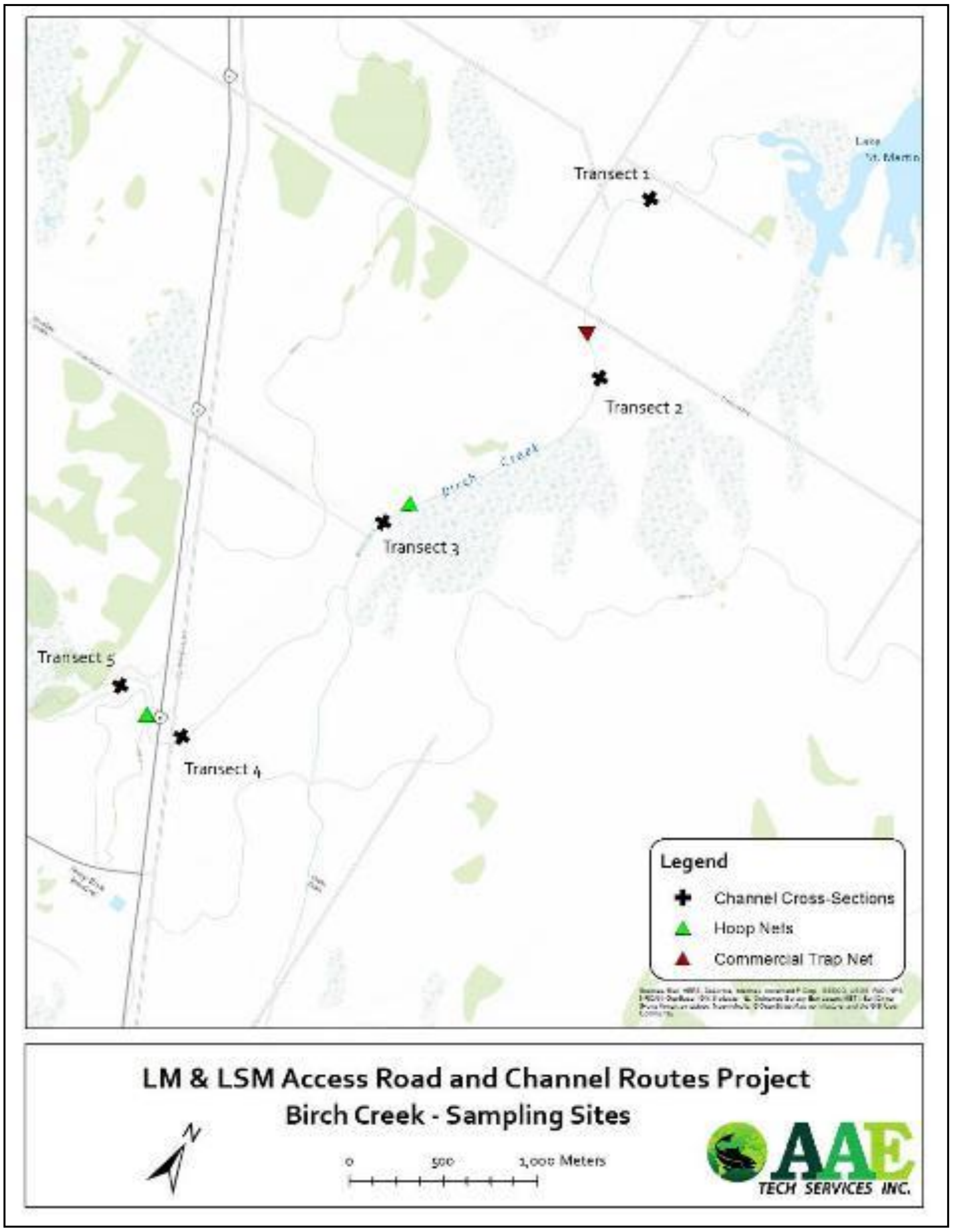


Figure 82. *Spring, 2016 sampling locations on Birch Creek.*

5.4.6.1 CHANNEL MORPHOLOGY

Birch Creek originates at Birch Lake (also known as Goodison Lake) and flows north approximately 7.4 km into Birch Bay on Lake St. Martin. Much of the watercourse has been straightened and channelized, apart from the lowest 1 km, where it passes through dense marsh habitat before entering Lake St. Martin. Riparian habitat (Appendix A) is predominantly narrow and simple (mixed grasses, cattails), with adjacent land use almost exclusively agricultural (livestock grazing).

Five cross-sectional profiles were completed (Figure 82) to assess the aquatic habitat within the system (Appendix B-8, B-9, B-10, B-11, and B-12). The average creek width was 9.5 m (range: 8.6 - 10.4 m), with an average maximum water depth of 0.95 m (range: 0.68 - 1.10 m). Depth profiles depict a consistent, U-shaped channel. Peak water velocity ranged between 0.54 and 0.80 m/s, and was always located near the center of the channel. Substrate was highly variable within and among the five cross-sections.

Transect 1 was located in the downstream reach of Birch Creek, 2.8 km upstream of Lake St. Martin. Habitat characteristics at this site were consistent with a U-shaped agricultural drainage channel. Riparian habitat was minimal, with agricultural land use (pasture) extending to the high-water level of the creek. Substrate composition was varied, with a predominantly gravel substrate (70 – 80%) along the left bank of the creek through the centre of the channel. Substrate transitioned to predominantly sand (70 – 90%) to the right of the channel centre, with a silt substrate (80 – 90%) along the right bank of the creek. Mean velocity was 0.425 m/s, peaking at 0.68 m/s at 3.2 m from the left bank. Creek width at this site was 9.6 m, with a max depth of 1.10 m to the right of channel centre.

Transect 2, located 4 km upstream of Lake St. Martin, was consistent with an agricultural drainage channel. Riparian habitat was minimal, with agricultural land use (pasture) extending to the high-water level of the creek. A predominantly clay substrate (70 – 100%) along the channel cross-section, with some gravel (10 – 30%) present, and sand and cobble (< 10%) observed on the left bank. Mean velocity was 0.528 m/s, peaking at 0.78 m/s at 3.6 m and 4.2 m from the left bank. Creek width at this site was 8.6 m, with a max depth of 0.98 m at the centre of the channel.

Transect 3 was located 5.4 m upstream of Lake St. Martin. Habitat characteristics at this site were consistent with an agricultural drainage channel. Riparian habitat was minimal, with agricultural land use (pasture) extending to the high-water level of the creek. Substrate at this site was complex; while predominantly clay (50 – 100%) across the entire channel, a mixture of gravel (10 – 30%) and boulder (0 – 30%) material was noted in the shallower outer edges of the channel, and substrate within the centre of the channel included a mixture of gravel (10 – 40 %), sand (20%), and cobble (10 – 20%) substrates. Mean velocity was 0.418 m/s, peaking at 0.80 m/s at 5.4 m from the left bank. Creek width at this site was 10.4 m, with a max depth of 0.92 m at the centre of the channel.

Transect 4, located 7.13 km upstream of Lake St. Martin, was consistent with an agricultural drainage channel. Riparian habitat was minimal, with agricultural land use (pasture) extending to the high-water level of the right bank, and within 2 m of the left bank. Tall grasses and willow were present within 2 m of the left bank. Substrate along the water edge of both banks was predominantly silt (100%). Substrate composition within the channel was found to be a mixture of silt, sand, gravel, and cobble materials, with primarily gravel (40 – 50%) and cobble (20 – 40%) substrate along the left and centre of the channel, and higher silt (50 – 60%) with sand (30 – 50%) composition along the right side of the channel. Mean velocity was 0.441 m/s, peaking at 0.72 m/s at 4.1 m from the left bank. Creek width at this site was 9.2 m, with a max depth of 0.68 m to the right of channel centre.

Transect 5 was located near the upstream extent of Birch Creek, 7.8 km upstream of Lake St. Martin and 1.2km downstream of Birch Lake. Habitat characteristics at this site were consistent with an agricultural drainage channel. Riparian habitat was minimal, with agricultural land use (pasture) extending to the high-water level of the creek. Substrate was found to be predominantly silt (50 – 100%) along the entire width of the channel. Gravel substrate (30%) was also observed along the left half of the channel, transitioning to sand (30%) and clay (10%) towards the right bank. Mean velocity was 0.287 m/s, peaking at 0.54 m/s at 4.1 m from the left bank. Creek width at this site was 9.4 m, with a max depth of 1.08 m at the centre of the channel.

5.4.6.2 WATER QUALITY

Water temperature for Birch Creek during the spring habitat assessment (April, 2016) was measured at 7.77°C (Table 37).

Dissolved oxygen on Birch Creek was 10.04 mg/L on April 27, 2016; DO was above CCME minimum guideline values for the protection of aquatic life (CCME 1999). Baseline turbidity (NTU), pH and Conductivity values were assessed for Mercer Creek based on measurements taken using *in-situ* readings between on April 28, 2016, and are presented in Table 37.

Table 37. *Water quality measurements made at Birch Creek.*

Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Turbidity (NTU)
7.77	10.04	7.5	358	4.94

5.4.6.3 FISH DISTRIBUTION AND COMPOSITION

A licensed commercial trap net was identified in the Birch Creek study reach (Figures 82 and 83). White Sucker (n = ~30) and Walleye (n = 2) were observed within the trap, and conversations with the trap owner indicated that White Sucker were the target species, with all other species (Walleye and Northern Pike reported) released back to the creek unharmed.

Figure 83. *Licensed commercial trap net identified on Birch Creek.*

5.4.6.3.1 Hoop Net

Hoop nets were installed at two locations along Birch Creek (Figure 82) to identify those fish species migrating upstream, and assess creek habitat use during the spring field season. Sampling of catch in the licensed commercial trap net at this site, with the permission of the trap owner, was also completed, with the results included in this assessment. A total of 648 minutes of fishing effort identified two fish species migrating upstream within the Birch Creek system (Table 38). Most fish captured were identified as White Sucker (n = 332). Northern Pike (n = 6) were also captured.

Table 38. *Hoop net sampling results, Birch Creek.*

Site	Species	#	Fork Length (mm)		Total Effort (min)
			Mean	Range	
Birch Creek	Northern Pike	6	374	250-452	270
	White Sucker	332	430	337-532	
	Total	**338**			
		Mean CPUE (#/min)			0.801

6.0 DISCUSSION

This report presents a detailed assessment of the aquatic ecosystems of the areas of Lake Manitoba and Lake St. Martin likely to be affected by the construction of one of the proposed outlet channels, Routes C and D, as outlined by Manitoba Infrastructure. The results herein are to facilitate project management decision making with route selection in order to ensure the project results in minimal impacts on the aquatic and terrestrial environments. Mitigation and prevention measures to be considered during site selection are provided herein.

6.1 HABITAT ASSESSMENT

One of the primary focuses of the 2015 and 2016 aquatic environmental baseline assessment was to document fish habitat around the proposed inlet and outlets of the Channel Routes C and D connecting Lake Manitoba to Lake St. Martin. Bathymetric surveys, aerial surveys, ground-truthing surveys were all performed to ensure the current habitat conditions were documented. The bathymetric surveys measured water depth, classified substrate type and determined the presence of submerged vegetation, cover and plant height. These parameters were used to define and characterize fish habitat at each site. The habitat assessment was also extended to include those creeks and tributaries flowing into, or near the project sites. Channel morphology, hydrology and descriptions of fish habitat (cover, substrate riparian zone) within the creeks were included in the overall assessment as the proposed routes may alter fish migration patterns, fish use of these tributaries, and/or alter the hydrology of these watercourses.

In addition to defining the habitat within the study areas based primarily on specific habitat characteristics, fish use was a key factor in determining the importance of the sites assessed. For example, if no fish were identified from a specific area, that area would be considered less favourable then one site teaming with spawning fish. Fish utilize various habitats for different phases in their life cycle, such as, for spawning, feeding, migration, or nursery habitat. As such, sampling for fish during this assessment was conducted over a range of conditions and seasons (spring/fall).

6.1.1 LAKE MANITOBA SITES

Fish habitat within Lake Manitoba and Lake St. Martin differs between lakes and sites with each site having unique habitat characteristics. On Lake Manitoba, Watchorn Bay is characterized as a shallow, windswept bay with sandy beaches extending out into the lake 200-300 m. Fish habitat was described as simple as limited vegetation growth and habitat cover was present within the bay, with the exception of a few boulder gardens situated at the northern extent of the study area. As most egg mats positioned within the bay to assess egg deposition were completely covered by sand and debris, it is unlikely that fish will utilize the habitat within Watchorn bay for spawning as their eggs too would likely become buried and/or destroyed during the incubation period. Alternatively, Watchorn Bay may serve as an important part of the spawning migratory route in this area, and likely acts as a staging area for spawning fish prior to moving into the creeks at the east and west bounds of the bay. Furthermore, Watchorn Bay may also provide a valuable feeding ground for fish. The two, third order streams flowing into Watchorn Bay near the proposed channel, Mercer Creek and Watchorn Creek, bring nutrients and a viable food source for Lake Manitoba fish. These highly productive streams also provide valuable spawning habitat for many Lake Manitoba fish species including Walleye, White Sucker and Northern Pike as these species were documented migrating upstream within both systems, and the presence of licensed commercial trap nets on both creeks confirmed these creeks as migratory passages for spawning. Alterations to this bay with the addition of an outlet channel could disrupt fish migration spawning routes.

The Fairford study site was similar to that of Watchorn Bay in terms of fish use, however, the habitats were quite different. The Fairford Bay site is better protected from wind and appears to provide additional cover and refuge habitat for fish. The coarser substrates found within this bay, consisting of a combination of sand, gravel, cobble and boulders, would likely provide valuable spawning habitat for commercial, recreational and aboriginal (CRA) targeted fish species. Aquatic vegetation cover was extensive at the Fairford site (60% - 100% cover over >50% area) in comparison to the Watchorn site, which had sparse vegetation cover (0% - 20% cover over >90% area), although plant height within the bay was limited to less than 0.60 m and would, therefore, not provide a significant amount of additional habitat or complexity for fish use.

6.1.2 LAKE ST. MARTIN SITES

The two Lake St. Martin sites where the outlet channels would enter include the Birch Bay site (Route D), located at the southern tip of the lake and the Harrison Bay site (Route C), located on the west of the lake approximately midway down the lake. Both of these sites share similar characteristics to the previously described sites on Lake Manitoba but also have characteristics that are quite different. The more northern site, Harrison Bay, was the most productive site in terms of fish (larval, juvenile, adults) and invertebrates captured. The shoreline and riparian habitat within this bay is surrounded by wetland habitats extending approximately 200-300 m inshore before transitioning to pasture land. Aquatic vegetation within the marsh along the shoreline is extremely dense, highly productive, and nutrient rich, and is characteristic of spawning habitat for fish species such as Northern Pike and Yellow Perch. This area is directly accessible to fish and aquatic species in Lake St. Martin. The aquatic vegetation cover decreased moving into the open water habitat off shore and away from the marsh. The substrates away from the marsh transitioned from a depositional area with silt substrates and organics to an area primarily covered by sand (70%) and gravel (30%). Like the Fairford site, this habitat can again be described as suitable spawning habitat for most CRA fish species captured.

The Birch Bay site (Route D) was similar to the Harrison bay site but not as extensive as that observed at the Harrison Bay site. The wetland habitat at the southern tip of Lake St. Martin extends from the mouth of Birch Creek and occupies a narrower strip of land along the shoreline. The bay is sheltered, rimmed by a rocky gravel-cobble shoreline and with a substrate composed of 70% sand and 30% gravel to depths up to 2.5 m, all of which could potentially support spawning activity. Common Carp in particular were observed spawning along the shoreline on June 2nd when boat electrofishing surveys were conducted. Many other adult fish were captured while in spawning condition during both fall and spring sampling. This suggests that habitat within this bay may serve as a staging area and corridor for spawning migration into Birch Creek or along the lakeshore. This finding is supported by the large number of spawning White Sucker captured during hoop net sampling or by visual observations on Birch Creek and it associated tributaries in the spring of 2016, and the identification of fish in spawning condition during both fall and spring gill netting in Birch Bay. Furthermore, as discussed above for the Watchorn Bay site, Birch Creek would provide nutrient rich waters to the southern tip of Lake St. Martin and would likely attract fish to this area as a feeding ground. Invertebrates were also plentiful in and around the Birch Creek outlet.

6.1.3 ROUTE D – BIRCH CREEK WATERSHED IMPLICATIONS

The proposed Route D channel, extending north and east into Lake St. Martin, would run parallel to the length of Birch Creek. The route would also pass adjacent to Birch Creek's headwaters, including Clear Lake and Birch (Goodison) Lake. As discussed, Birch Creek was found to be a productive system for spawning CRA fish species such as White Sucker, Walleye and Northern Pike. The current expected path of Route D would result in segmentation of the Birch Creek watershed, isolating approximately 26% of watershed drainage (Figure 84). The impacts that this reduction in watershed area may have on flow rates and aquatic habitat are not currently known, but could be significant, particularly during the spring and fall spawning windows when seasonal precipitation can vary. Further study is needed to investigate the effects the Route D channel may have on creek flow and spawning migration.

6.2 FISH COMMUNITIES AND BENTHIC INVERTEBRATES

Boat electrofishing, gill netting, and hoop nets were used to collect and assess fish communities at all study sites. As an interconnected system, both Lake Manitoba and Lake St. Martin were found to be productive, with comparable fish and invertebrate species identified within both lakes. Adult fish in spawning condition were observed at all four study sites during both the fall and spring field seasons. White Sucker were particularly productive, and are an important resource for commercial fisheries operations on these lakes, as noted by the licensed commercial trap nets installed at three of the assessed creeks in both the Lake Manitoba and Lake St. Martin systems. Walleye is the targeted fish species by Commercial Fishers in Lake Manitoba and Lake Whitefish is the primary fish targeted for in Lake St. Martin.

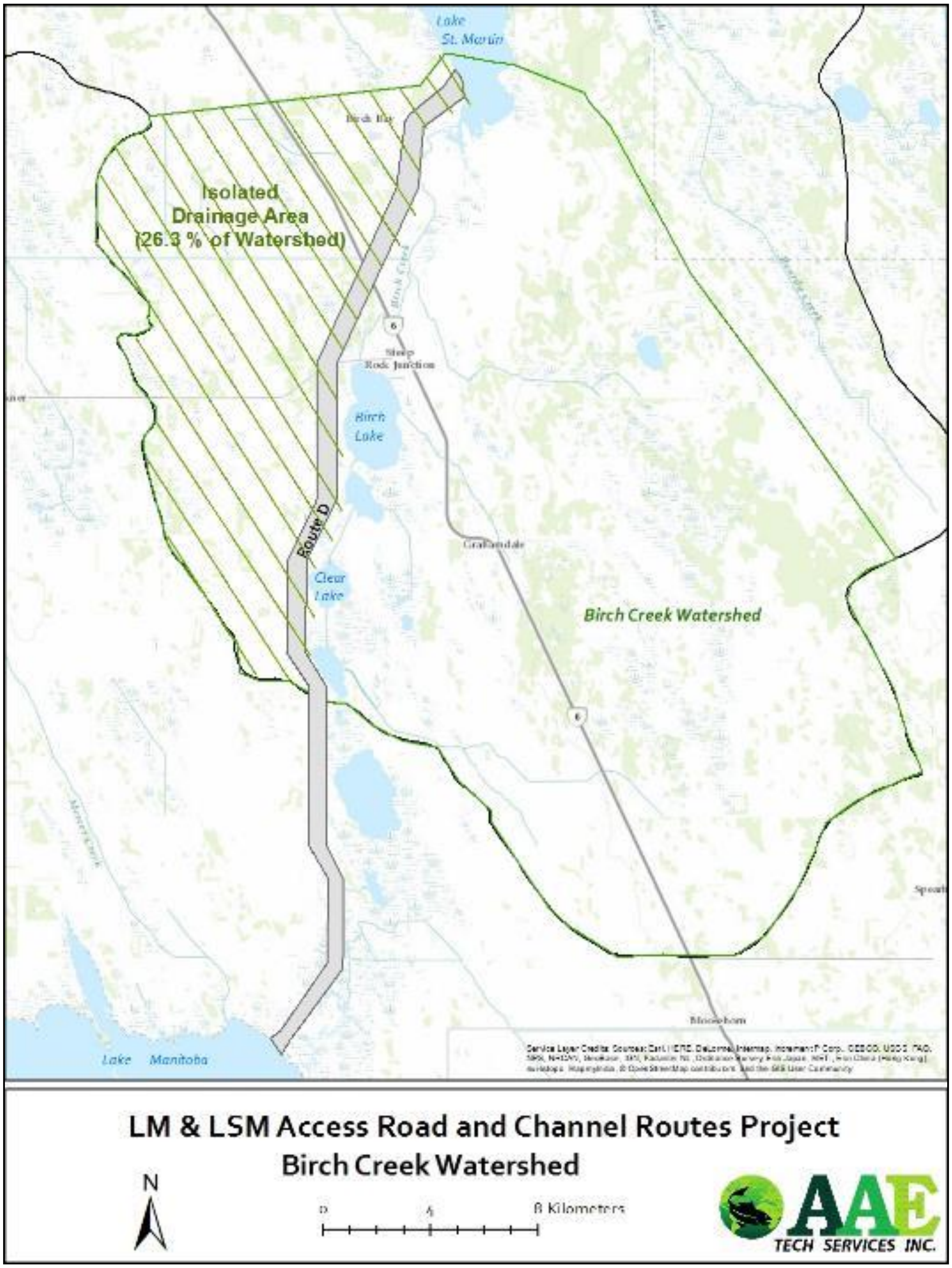


Figure 84. *Birch Creek watershed, depicting the proposed Route D channel path and potential area removed from Birch Creek catchment.*

6.2.1 FISH COMMUNITIES

A total of 444 fish were collected in Lake Manitoba, representing 15 species, with no species of concern collected (Figure 85). Fish productivity and diversity within Fairford Bay and Watchorn Bay were comparable, with 226 fish representing 14 species caught in Fairford Bay and 218 fish representing 12 species caught in Watchorn Bay. Similar findings between these bays were also found when sampling for larval fish while dragging the zooplankton net. A total of 23 larval fish were sampled in Watchorn bay while 53 larval fish were collected from the Fairford site. The small number of larval fish sampled further suggests that very little spawning occurs within these bays.

On Lake St. Martin, similar numbers of juvenile and adult fish (n = 360) were collected compared to Watchorn bay. Similar numbers of species were also (n = 17) identified to inhabit the bay, with no species of concern collected (Figure 85). Within Lake St. Martin, Harrison Bay had greater productivity and diversity than Birch Bay, with 271 fish collected representing 16 species, compared to the 89 fish representing 8 species collected in Birch Bay. However, significant differences were noted between the Lake Manitoba sites and the Lake St. Martin sites in terms of larval fish catch. Within Birch Bay Creek (Route D), a total of 2,852 larval fish (White Sucker and Walleye) were collected. In Harrison Bay (Route C), a total of 5,844 larval fish (White Sucker and Walleye) were collected. At this stage of development, larval fish are not motile, suggesting spawning is occurring within and around the Harrison Bay site, most likely within the adjacent marsh.

The four creeks that were assessed during this study (Watchorn Creek, Mercer Creek, Birch Creek, Harrison Creek) were found to be important fish migratory and spawning routes. For Watchorn and Mercer Creeks, both of which feed into Watchorn Bay, a combined total of approximately 80-100 White Sucker and four Walleye were observed in licensed commercial trap nets over a 24-hour period (1/3 of the creek was sampled by commercial fishing net). AAE's collection efforts yielded an additional 61 White Sucker, seven Spottail Shiner, and one Yellow Perch in the two creeks during the spring field season.

At Birch Creek, approximately 30 White Sucker, two Walleye and one Northern Pike were observed in licensed commercial trap nets near the mouth of the creek (trap covered approximate 1/3 of wetted creek width). AAE's collection efforts at Birch Creek yielded 332 White Sucker and six Northern Pike for the spring season (measured and released). Thousands of White Suckers and numerous Northern Pike were observed during their spring spawning migration near the Provincial Trunk Highway 6 (PTH6) on Birch Creek. These observations confirm that Birch Creek and its tributaries provide important spawning habitat for numerous fish species including White Sucker, Walleye and Northern Pike.

The much smaller Lake St. Martin tributary, Harrison Creek, which feeds into Harrison Bay is a spawning tributary for Northern Pike and White Sucker as reported by a local land owner. These results were confirmed as visual observations of these species were conducted during the fisheries assessment.

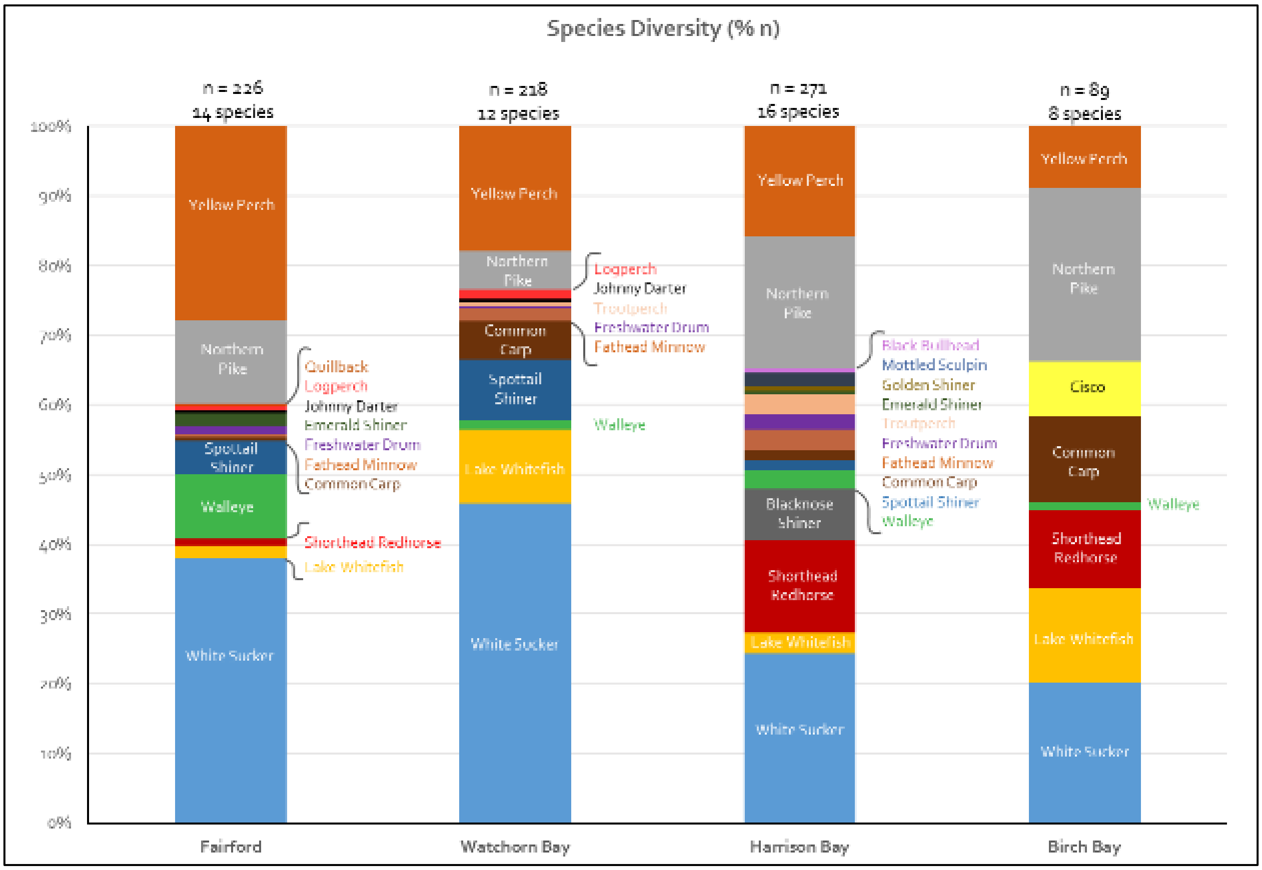


Figure 85. *Fish species composition at each site (%), where n is the total number of fish collected over all sampling methods.*

6.2.2 BENTHIC INVERTEBRATES

Several orders of benthic invertebrates are widely used as indicator species for evaluating water quality. At all four sites, two of these orders (*Ephemeroptera* and *Trichoptera*) were detected. A third indicator order (*Plecoptera*) was not detected at any sites, though its absence may be more related to the fact that samples were taken from lake environments rather than stream of river systems where they are commonly found. Together, these results suggest that water quality does not differ between sites, and is likely of high quality overall.

Additionally, a greater number of taxa within an invertebrate community are considered an indicator of a healthier ecosystem (British Columbia Ministry of Environment, 2007). A higher richness value indicates a greater number of taxa and/or a more even distribution of species within a site. Simpson's Diversity value is similar, but gives less weight to rare taxa, and indicates a relatively even distribution of individuals across taxa at that site.

Differences in invertebrate diversity were more pronounced between the two lakes than within them. By both measures, Lake St. Martin contains the more diverse benthic macroinvertebrate community. The species richness of Harrison Bay and Birch Bay combined was significantly higher than that of Fairford Bay and Watchorn Bay ($p = 0.001$). Similarly, Simpson's Diversity for the two Lake St. Martin sites was also higher than for the two Lake Manitoba sites ($p = 0.04$).

Within each lake, differences in invertebrate diversity were present but less clear. Between the two Lake Manitoba sites, Fairford Bay had significantly greater species richness ($p = 0.001$) than Watchorn Bay, while there was no significant difference in Simpson's Diversity ($p = 0.13$). Within Lake St. Martin, there was no significant difference in species richness between Harrison Bay and Birch Bay ($p = 0.28$), but Harrison Bay did have a higher Simpson's Diversity ($p = 0.0001$).

6.3 WATER QUALITY

Water quality measurements were similar between all four study sites, and indicative of a healthy overall ecosystem. Dissolved oxygen levels at all sites were consistently above CCME minimum guidelines for the protection of aquatic life (CCME 1999).

Mean turbidity and total suspended solids (TSS) measurements were notably higher at the Watchorn site during both field seasons. This result is likely due to the high exposure to strong westerly winds, combined with a shallow bathymetric profile and a predominantly sandy substrate. These characteristics are not conducive to fish spawning habitat, as evidenced by egg mat sampling results which found mats to be embedded in sediment and clogged with sand.

The south basin of Lake St. Martin, which includes both the Harrison bay and Birch Bay sites, is nutrient rich and likely does not fully mix with the north basin of the lake or the Fairford River connected to the north basin. Birch Creek carries water from agricultural lands into Birch Bay, creating this nutrient sink. Further study is needed to determine the impact Route C and Route D would have on the nutrient loading of Birch Bay and the nutrient cycling within the lakes.

For this study, AAE was contracted to collect basic measures of water quality: temperature, dissolved oxygen, pH, conductivity, turbidity, and total suspended solids (TSS). AAE did not collect data on chlorophyll-a concentrations, nutrient levels, or heavy metal contamination in the water as this information was collected during previous studied in the area (North/South, 2014). Additional studies that include more indicators of water quality could, however, build upon this baseline data to show the natural variability within the water system could more accurately indicate potential impacts from the proposed channels.

6.3.1 POTENTIAL IMPACTS TO LAKE ST. MARTIN FLOW DYNAMICS AND NUTRIENT LEVELS IN THE SOUTH BASIN.

The Fairford River which at present is the only outflow point for Lake Manitoba, drains into the south basin of Lake St. Martin near the midpoint of the lake, approximately 9 km north of the Harrison Bay study site. Flow into Lake St. Martin is guided by a series of islands and peninsulas, which serve to direct current northward and subsequently isolate approximately one third of the south basin, including the Harrison Bay and Birch Bay study sites. Flow within Lake St. Martin is directed to the northeast, into the north basin of the lake, eventually draining into the Dauphin River and out to Lake Winnipeg (Figure 86). The south basin of Lake St. Martin, and in particular that area south of the Fairford River, including both the Harrison Bay and Birch Bay sites, appears to be a productive system, with very little mixing occurring with the rest of the lake. With predominantly agricultural land to the south and west, those smaller secondary tributaries including Harrison Creek and Birch Creek are expected to act as a nutrient source for this system, creating a nutrient sink within this part of the south basin. Both Channel Routes C and D would increase discharge into the south basin by 5000 – 7500 cubic feet per second (KGS 2014), which will alter flow dynamics within the south basin (Figure 86). This increased flow at either study site could have a significant impact on present nutrient levels, impacting productivity and aquatic habitat quality. Further study is needed to determine the impact Route C and Route D would have on the hydrology and nutrient levels of the south basin, including potential impacts to fish and aquatic ecosystem health and stability.

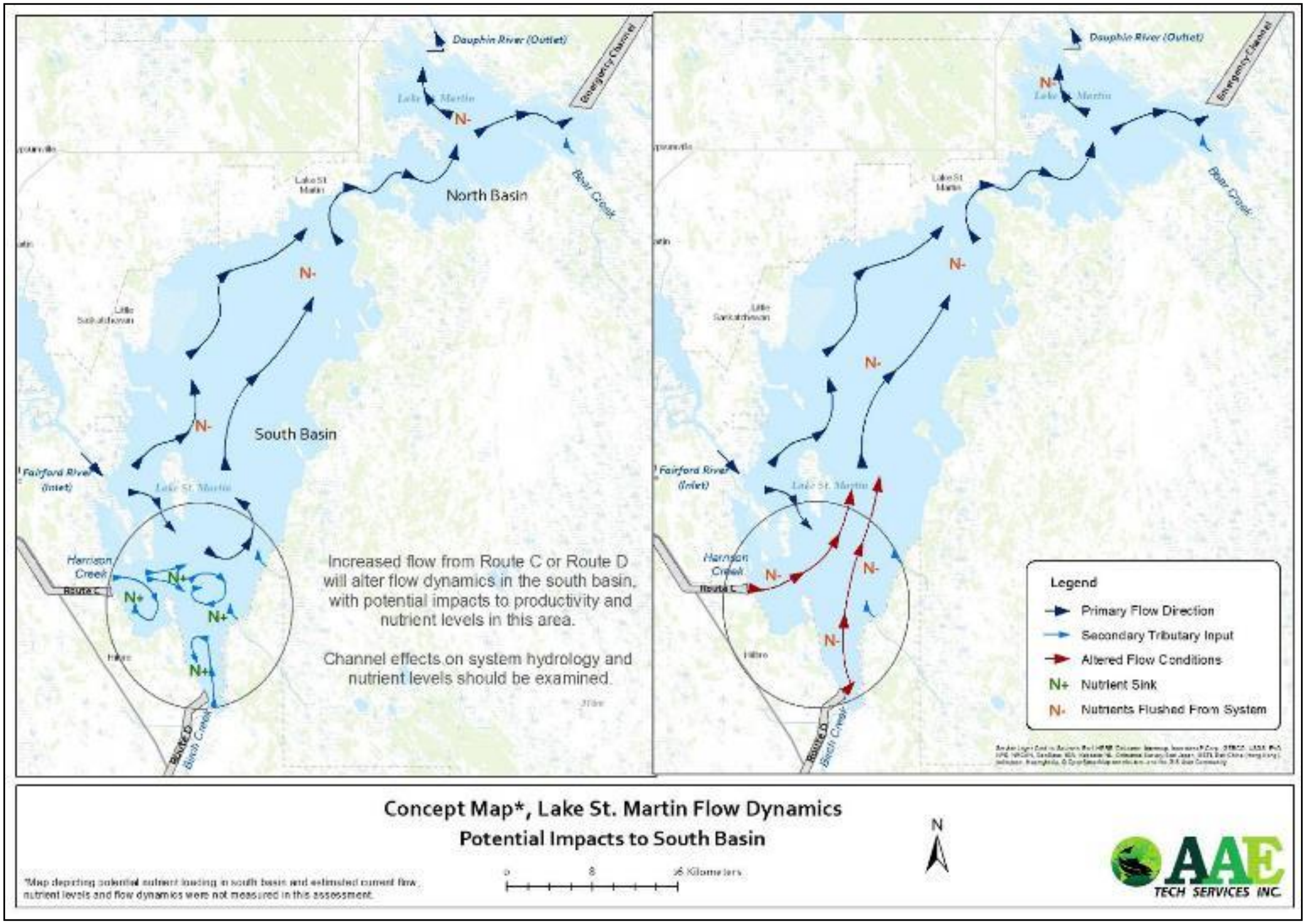


Figure 86. *Concept map of potential impacts of Channel Routes C and D to flow dynamics and nutrient levels of the south basin of Lake St. Martin. The left diagram is of current flow patterns with the proposed channels not in operation; The right diagram illustrates potential flow pattern when channels are in operation*

7.0 SUMMARY

The primary objective of this study was to provide baseline data describing the fisheries and aquatic habitat within the bays of Lake Manitoba and Lake St. Martin, and to evaluate potential environmental impacts by the proposed channels as part of a larger systematic environmental review. Summary documents for each study site are presented in Appendix E.

Through habitat assessment, fish community and benthic invertebrate analysis, and basic water quality measures, it was determined that diverse and healthy fish communities were identified at both sites where the proposed routes will pass. The proposed Route C, however, appears to offer a higher quality fisheries and aquatic habitat than the sites in the proposed Route D as more fish and larval fish were captured along the proposed route in addition to the coastal wetaland situated at the outlet which appears to provide valuable feeding, spawning, rearing and nursery habitats for fish ..

Although the Fairford and Watchorn sites are comparable for fish productivity and species diversity, the Harrison site (Route C) has much higher productivity and species diversity than the Birch Bay site (Route D). The extensive riparian marsh habitat at the Harrison Bay site provides potential nursery and spawning habitat for fish, as evidenced by fish larvae sampling and between-site comparisons of fish communities. The collections at the Harrison Bay site resulted in over 3x the number of adult fish, over 2x the number of larval fish, and 2x the number of fish species than those at the Birch Bay site. The Fairford site (Route C) is also expected to offer better fish spawning habitat with its gravel-sand substrate and higher vegetation cover, in comparison to Watchorn's (Route D) windswept and sandy conditions.

In general, all four sites have good water quality and all water quality measures were consistently within the CCME guidelines for the protection of aquatic life (CCME 1999). However, when examining the results of the benthic invertebrate study, combined with water quality measurements, in particular turbidity and TSS levels, it can be determined that the aquatic habitat within the Route C area of impact (Fairford and Harrison Bay) represents relatively higher quality fish and aquatic habitat.

In general, either route would likely have a greater impact on Lake St. Martin than Lake Manitoba. Both routes would empty into the lake's southern basin, increasing both flow and nutrient mixing throughout the lake. While overall water quality was high at all four sites, benthic invertebrate observations suggest that productivity and nutrient load may be higher within the two Lake St. Martin sites than the Lake Manitoba sites. The southern end of Lake St. Martin may be particularly nutrient-rich due to the influx of nitrogen and other nutrients from agricultural land to the south, although nutrient composition throughout the lake was not explicitly tested in this study. If the southern end of the lake is in fact more productive and nutrient-rich than the northern end, increased flow and mixing from either route could ultimately reduce nutrient concentrations in the south, which may in turn affect productivity. Lower productivity may have impacts on the fishery, for example by reducing the number of benthic invertebrates available for Lake Whitefish and White Sucker and other bottom-feeding species.

In addition to overall effects on Lake St. Martin, each route could have several potential impacts on their respective outlet sites. Harrison Bay (the outlet of Route C) contains quality spawning habitat, healthy and diverse fish and invertebrate communities, and extensive wetland habitat. Spawning fish were observed at the site in both spring and fall sampling periods, and zooplankton tows yielded large numbers of larval fish, potentially using vegetation at the site as nursery habitat. Any of these characteristics could be disrupted by the placement of a route outlet at this site.

Birch Bay also contained substrate suitable for spawning, significant vegetation and adjacent wetland, and diverse fish and invertebrate communities. Fish were found in spawning condition within the bay during both fall and spring sampling conditions, and were seen spawning within Birch Creek during the spring. As in Harrison Bay, larval fish were observed in large numbers during zooplankton tows. In addition to potential impacts on habitat and fish communities within the bay, Route D could also have a large impact on Birch Creek, where fish spawning and commercial fishing was directly observed in this study. The placement of the channel within Birch Creek's watershed would effectively segment the watershed and reduce inflow to the creek itself. The full effect this may have on habitat and water levels within the creek, particularly during spawning seasons, should be investigated.

Baseline results presented in this report provide a snapshot of fish and aquatic habitat conditions within each study site. Further studies will be needed to place the results of this report within the context of natural variability of these water systems. More baseline data on the complexity of the nutrient cycling within the lakes and the impacts of either route on the surrounding watershed would allow greater insight into the potential effects of each proposed channel on the fisheries and aquatic habitat of the two lakes

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APPENDIX A - Site photographs of all Creek study sites.

Appendix A-1. Upstream view of Watchorn Creek at Transect 1.

Appendix A-2. Downstream view of Watchorn Creek at Transect 1.

Appendix A-3. Upstream view of Watchorn Creek at Transect 2.

Appendix A-4. Downstream view of Watchorn Creek at Transect 2.

Appendix A-5. Upstream view of Birch Creek at Transect 1.

Appendix A-6. Downstream view of Birch Creek at Transect 1.

Appendix A-7. Upstream view of Birch Creek at Transect 2.

Appendix A-8. Down-stream view of Birch Creek at Transect 2.

Appendix A-9. Upstream view of Birch Creek at Transect 3.

Appendix A-10. Down-stream view of Birch Creek at Transect 3.

Appendix A-11. Upstream view of Birch Creek at Transect 4.

Appendix A-12. Downstream view of Birch Creek at Transect 4.

Appendix A-13. Upstream view of Birch Creek at Transect 5.

Appendix A-14. Downstream view of Birch Creek at Transect 5.

Appendix A-15. Upstream view of Mercer Creek at Transect 1.

Appendix A-16. Downstream view of Mercer Creek at Transect 1.

Appendix A-17. Upstream view of Mercer Creek at Transect 2.

Appendix A-18. Downstream view of Mercer Creek at Transect 2.

Appendix A-19. Upstream view of Mercer Creek at Transect 3.

Appendix A-20. Downstream view of Mercer Creek at Transect 3.

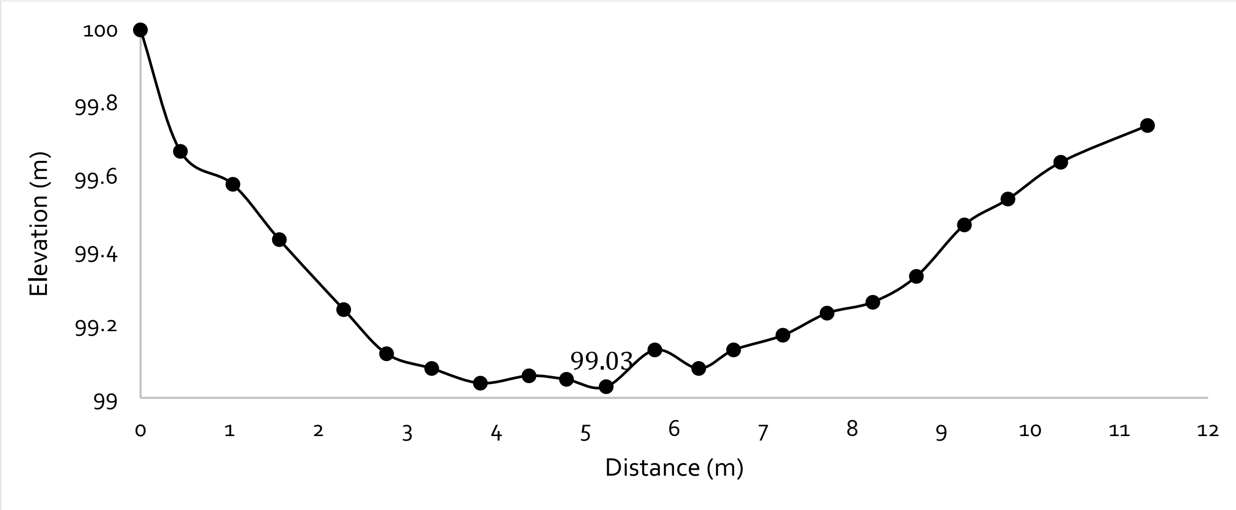
Appendix A-21. Upstream view of Mercer Creek at Transect 4.

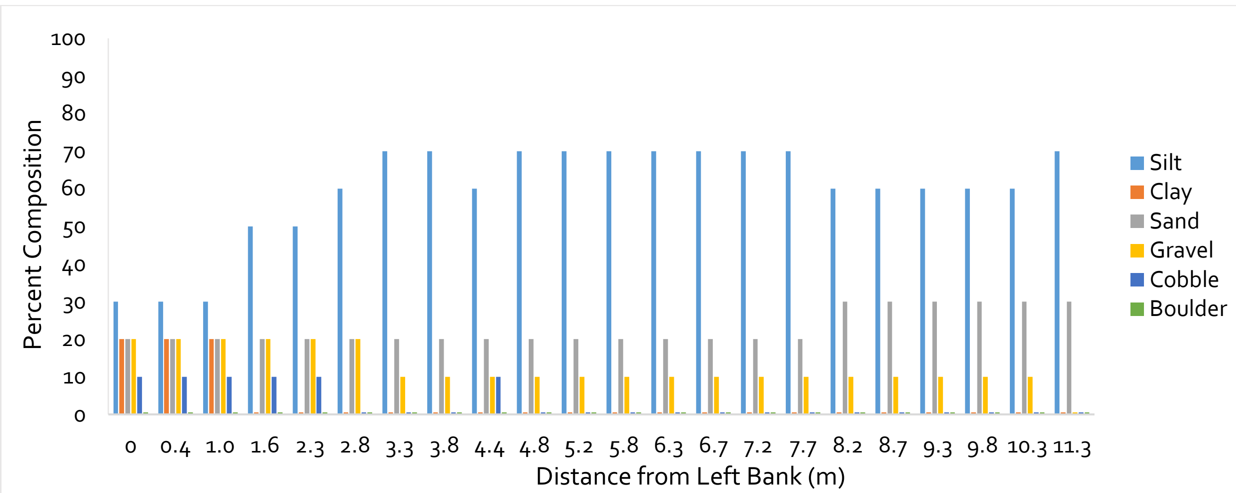
Appendix A-22. Downstream view of Mercer Creek at Transect 4.

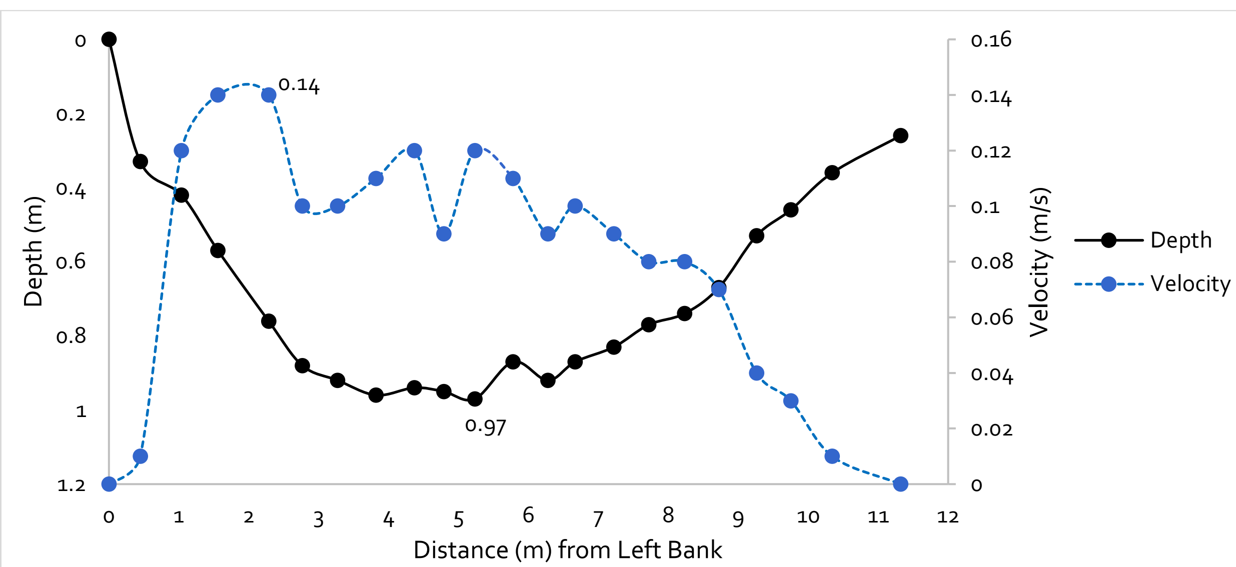
Appendix A-23. Upstream view of Harrison Creek at Transect 1.

Appendix A-24. Down-stream view of Harrison Creek at Transect 1.

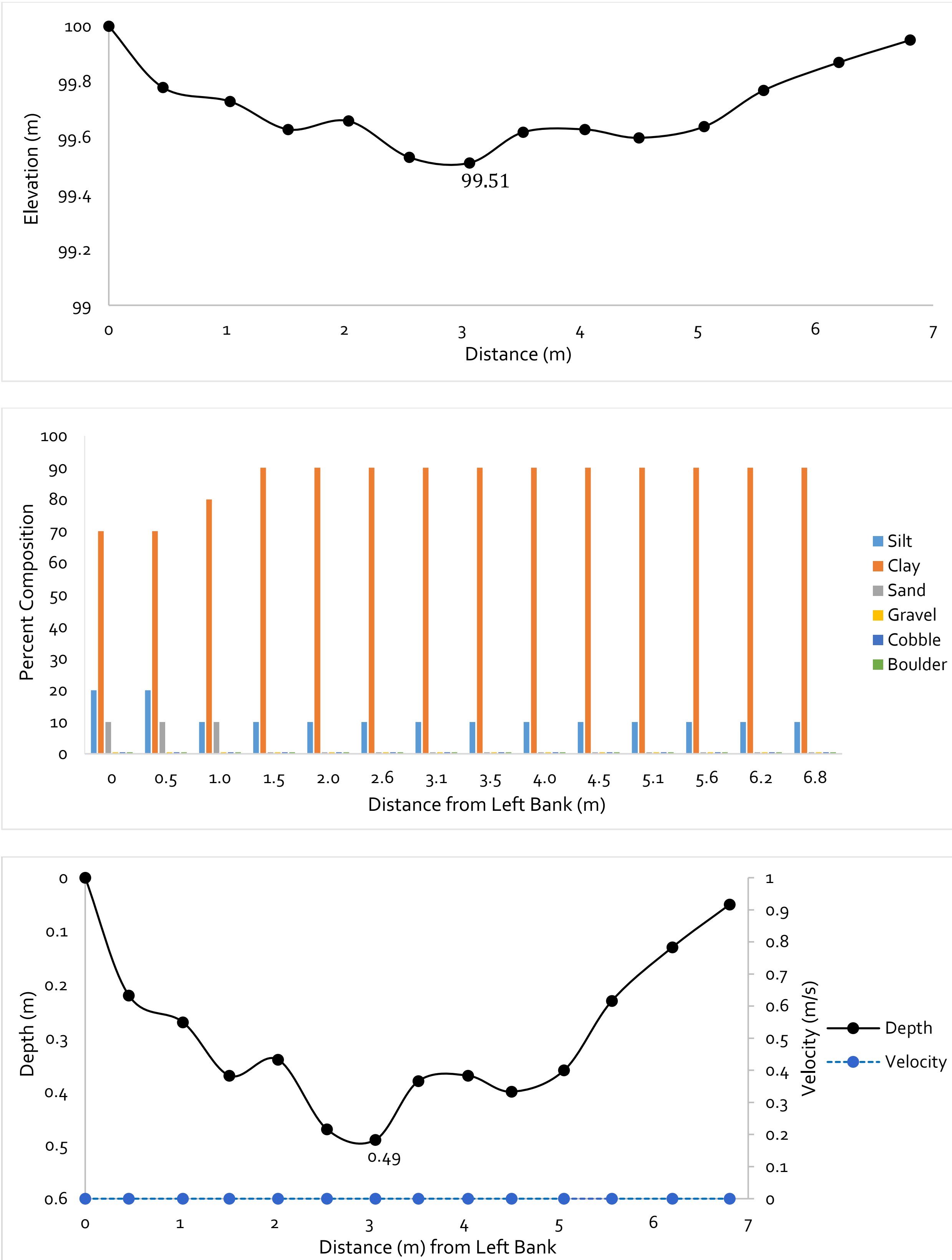
APPENDIX B - Creek Habitat Cross-sectional Profiles



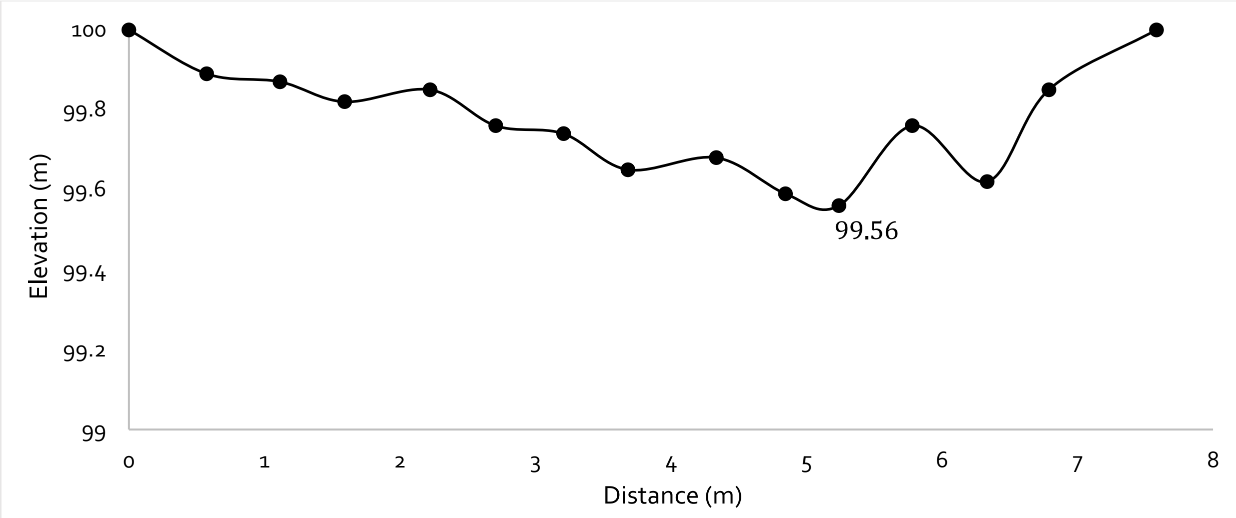


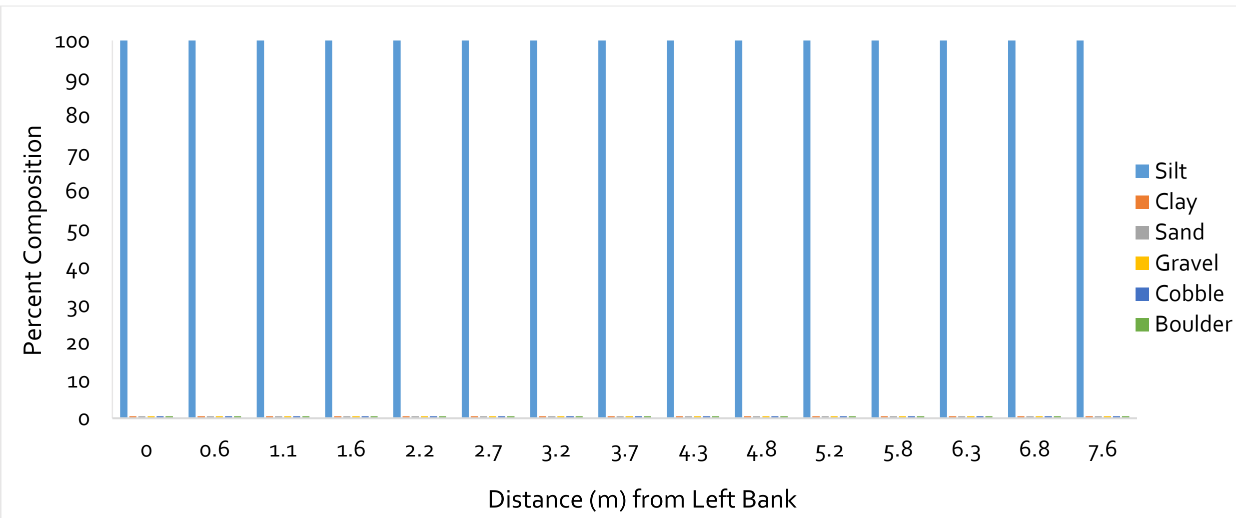


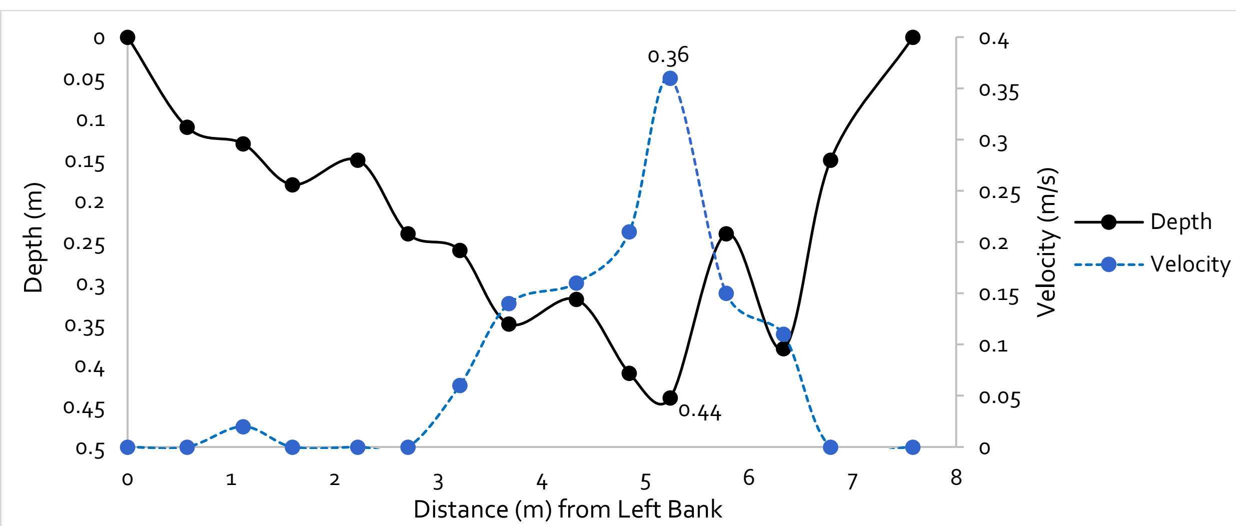
Appendix B-1. Cross-sectional profile of Transect 1 on Watchorn Creek.



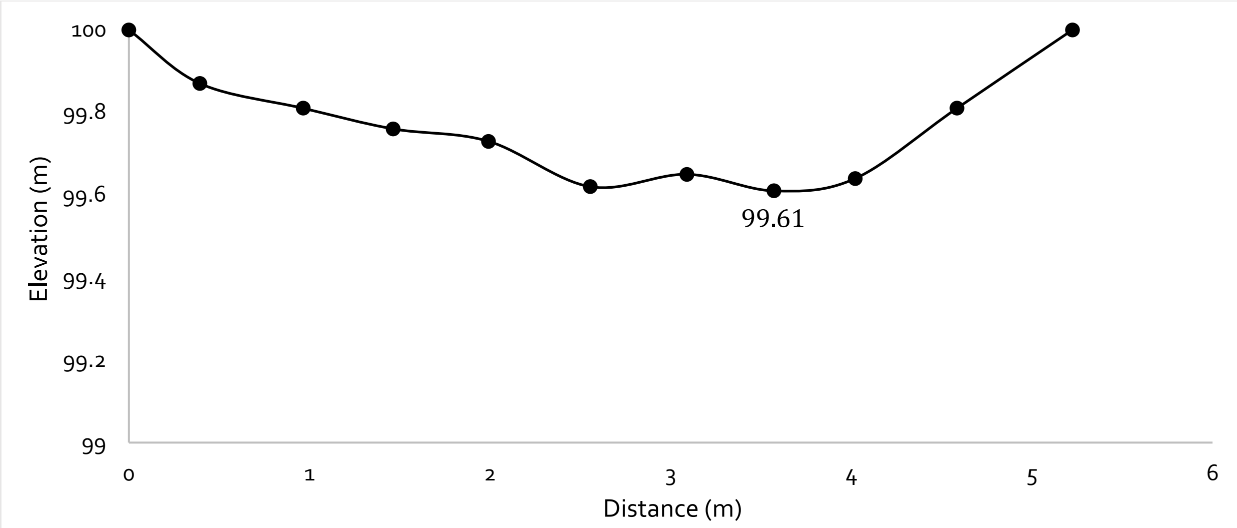
Appendix B-2. Cross-sectional profile of Transect 2 on Watchorn Creek.

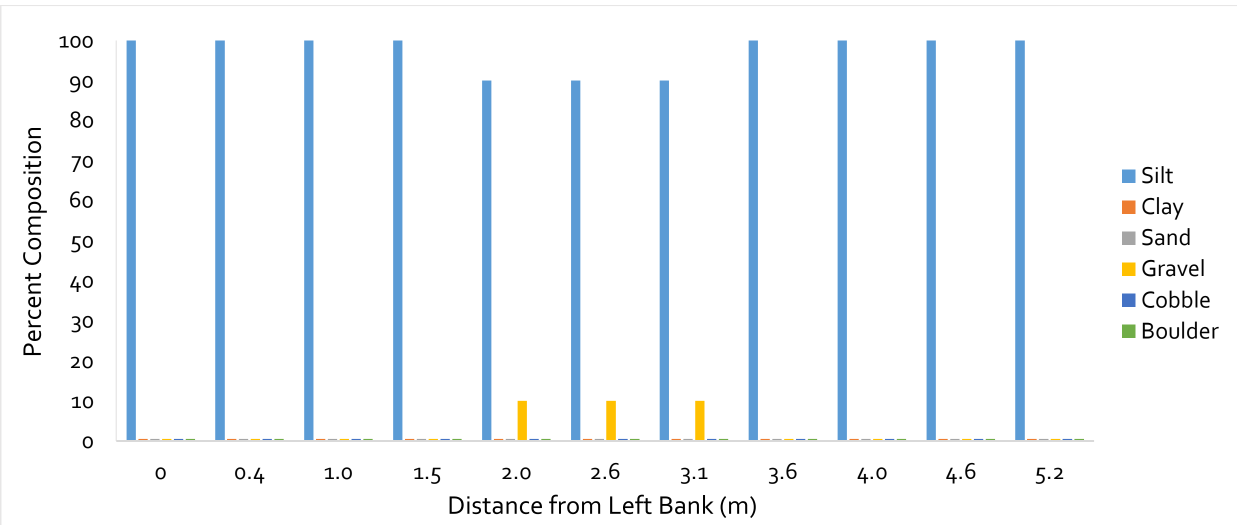


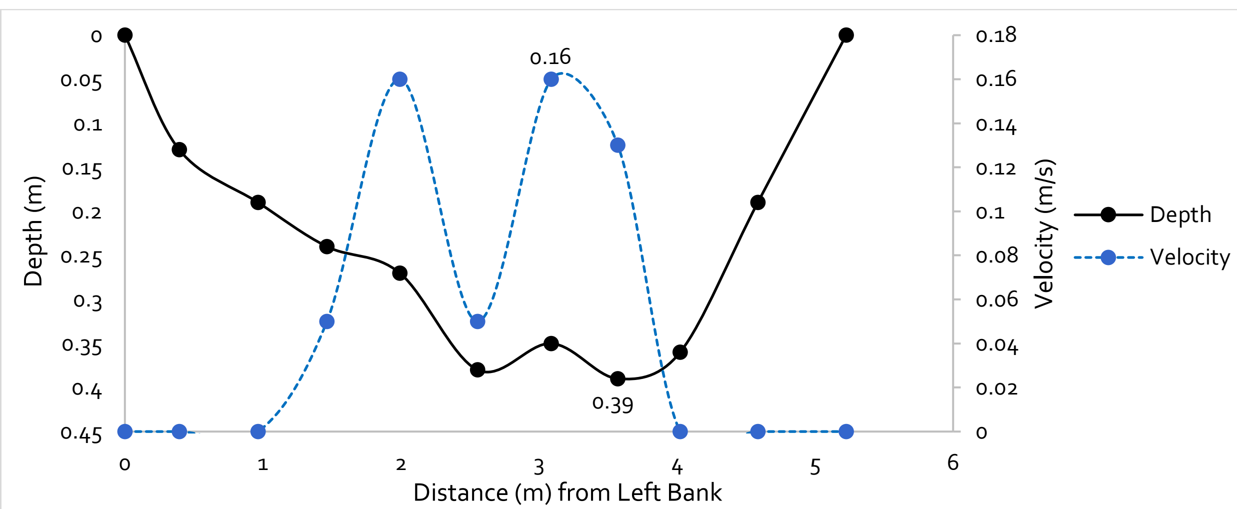




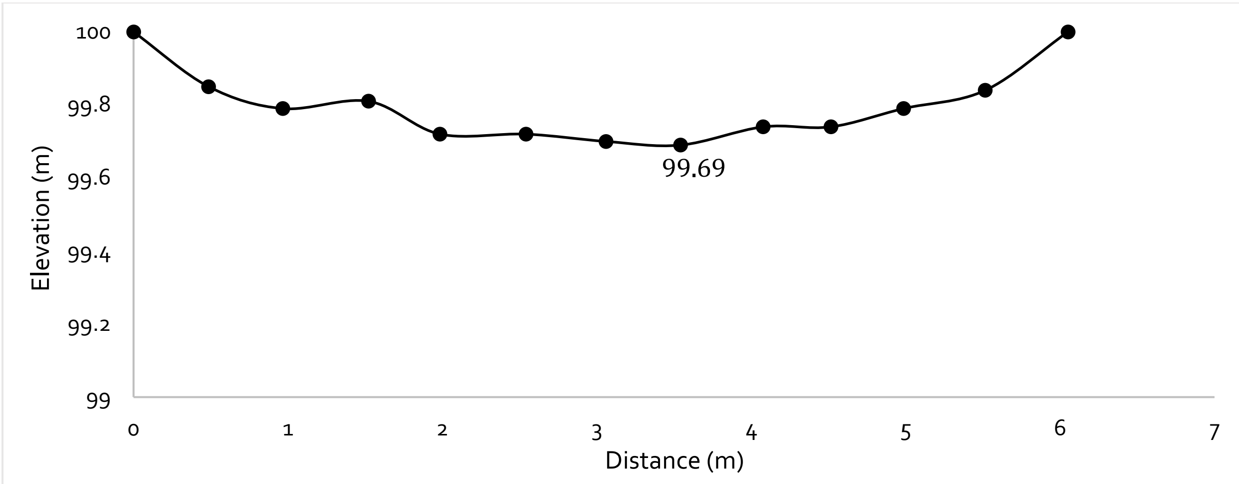
Appendix B-3. Cross-sectional profile of Transect 1 on Mercer Creek.

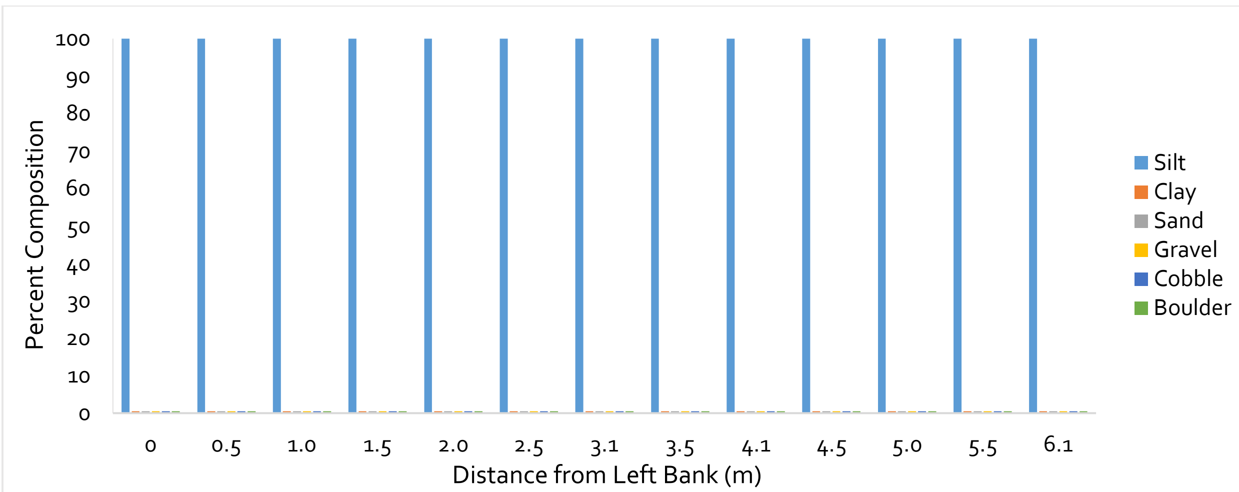


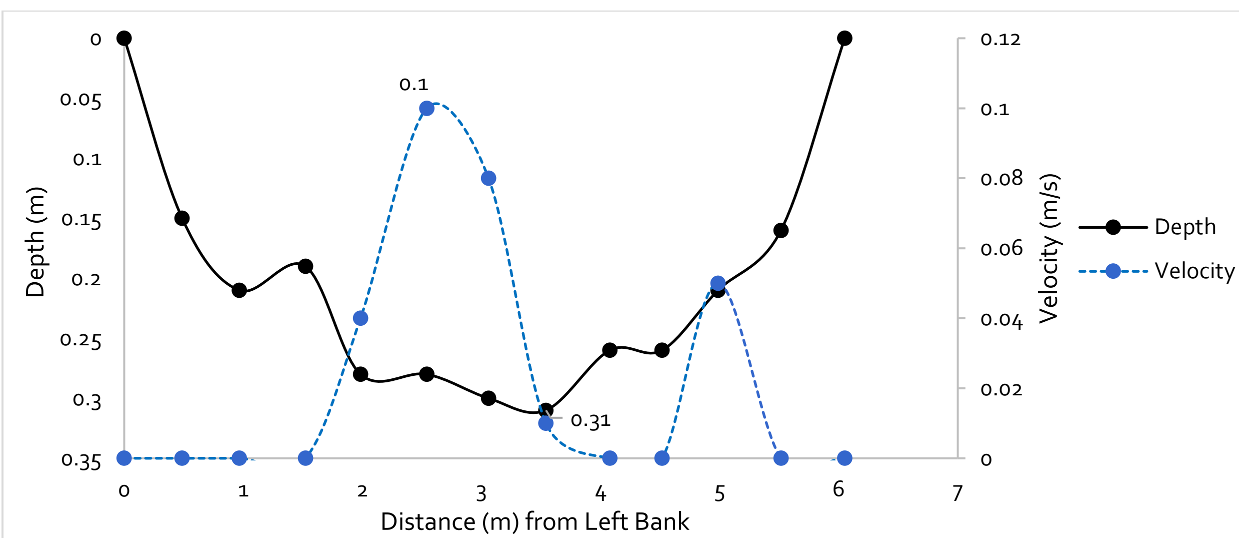




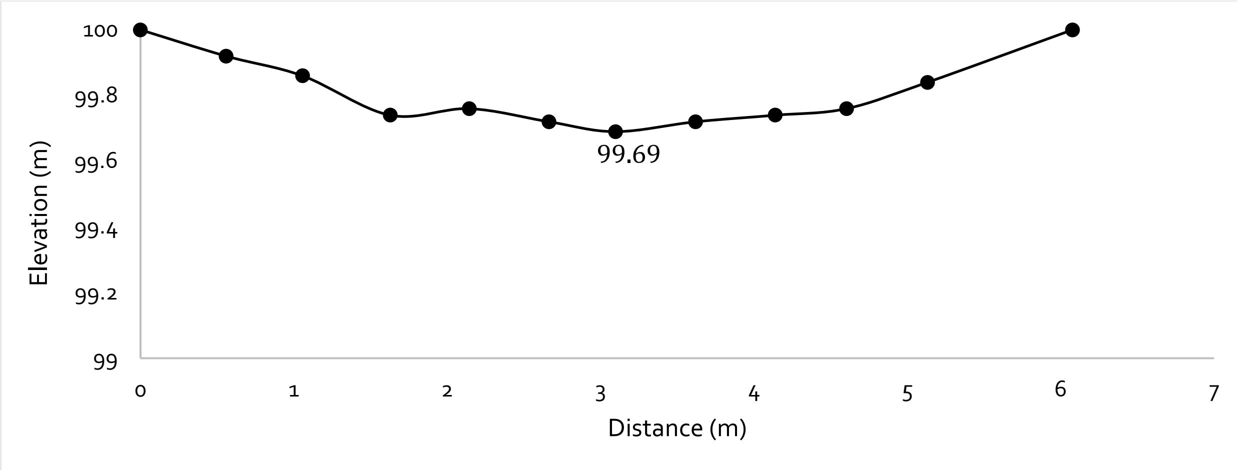
Appendix B-4. Cross-sectional profile of Transect 2 on Mercer Creek.

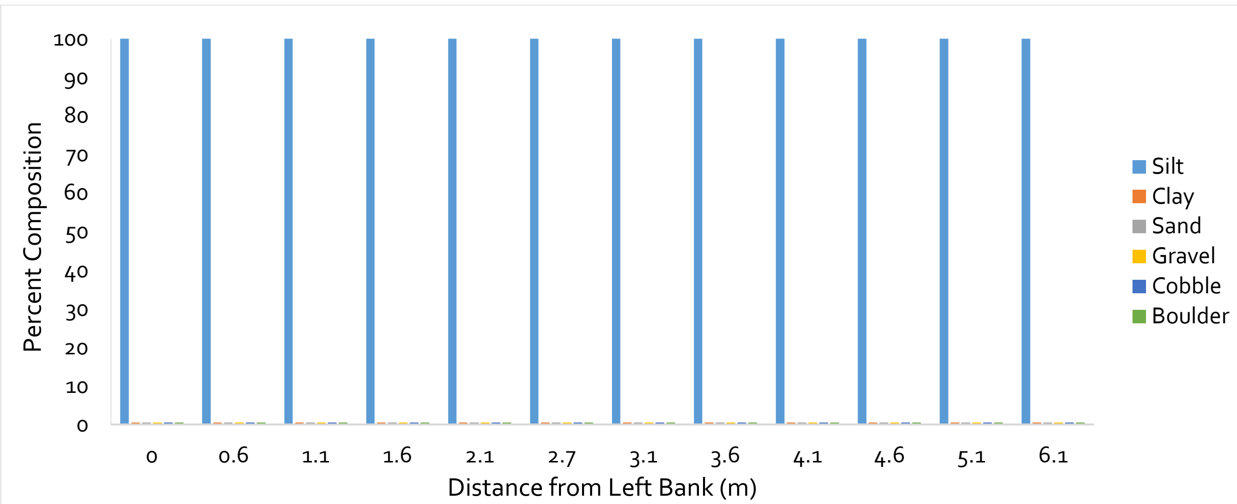


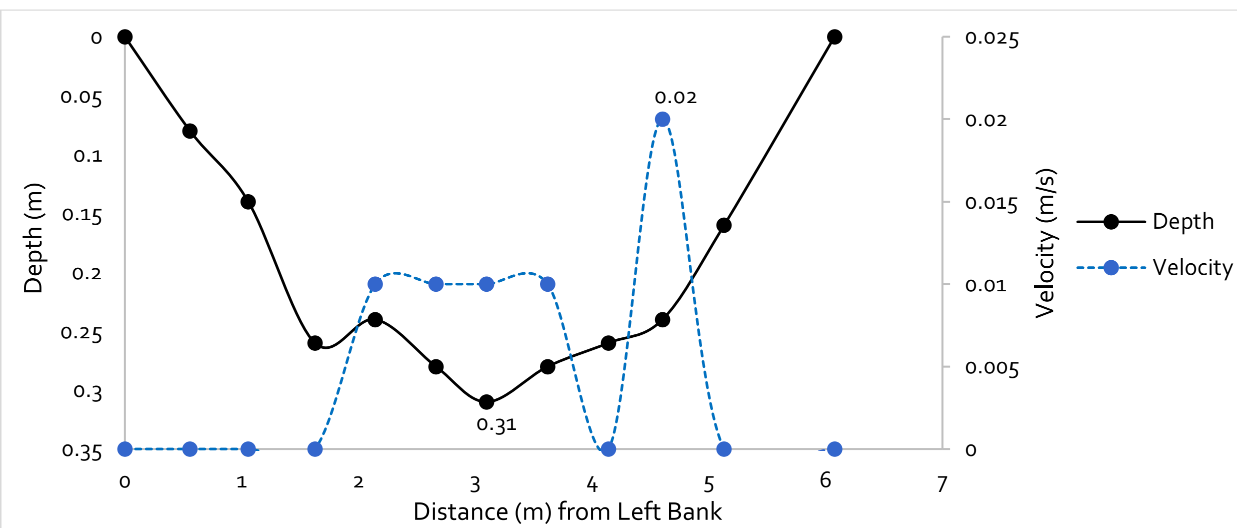




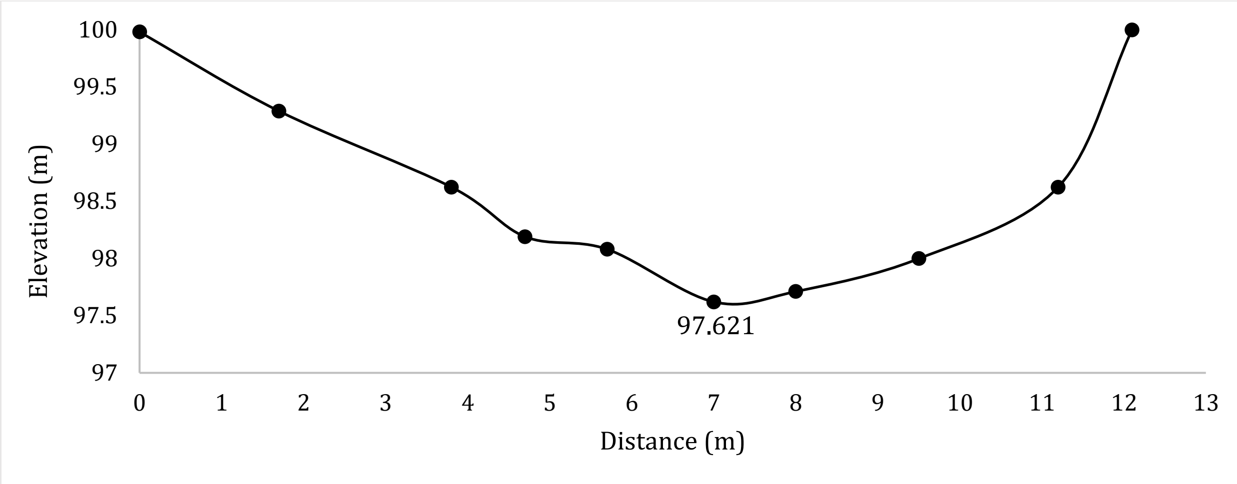
Appendix B-5. Cross-sectional profile of Transect 3 on Mercer Creek.

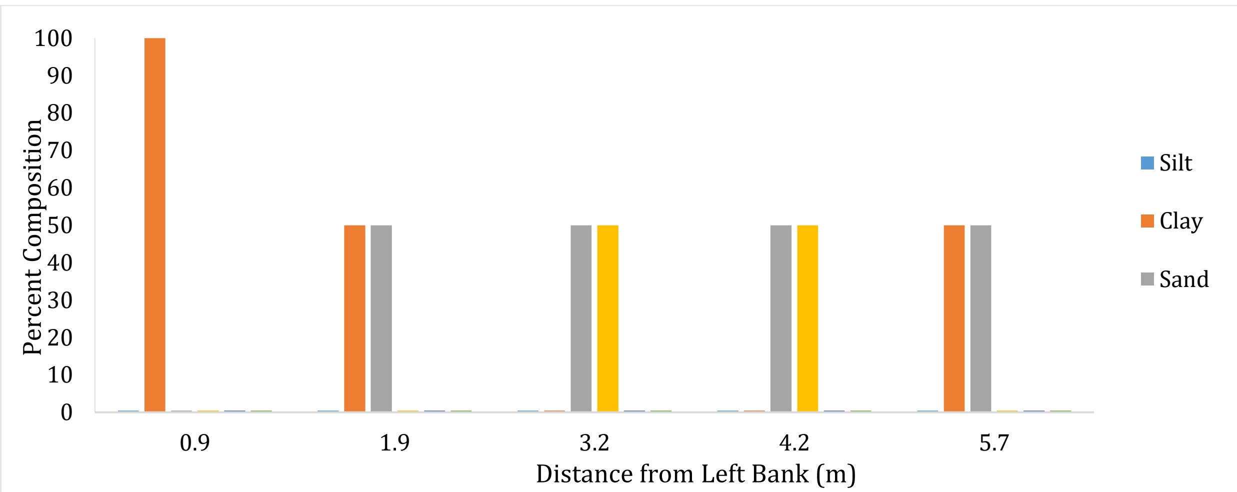


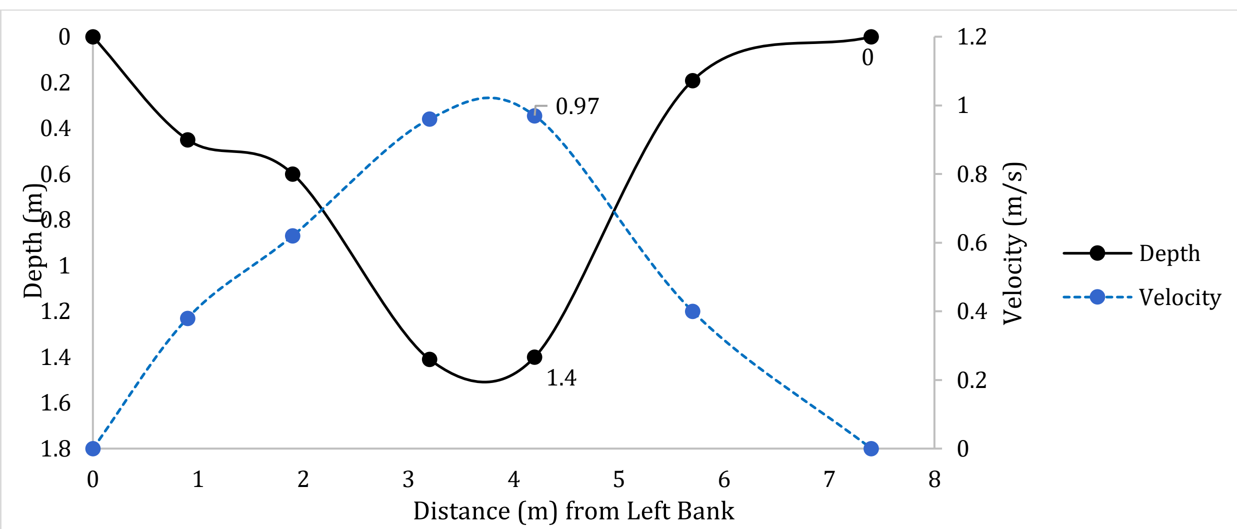




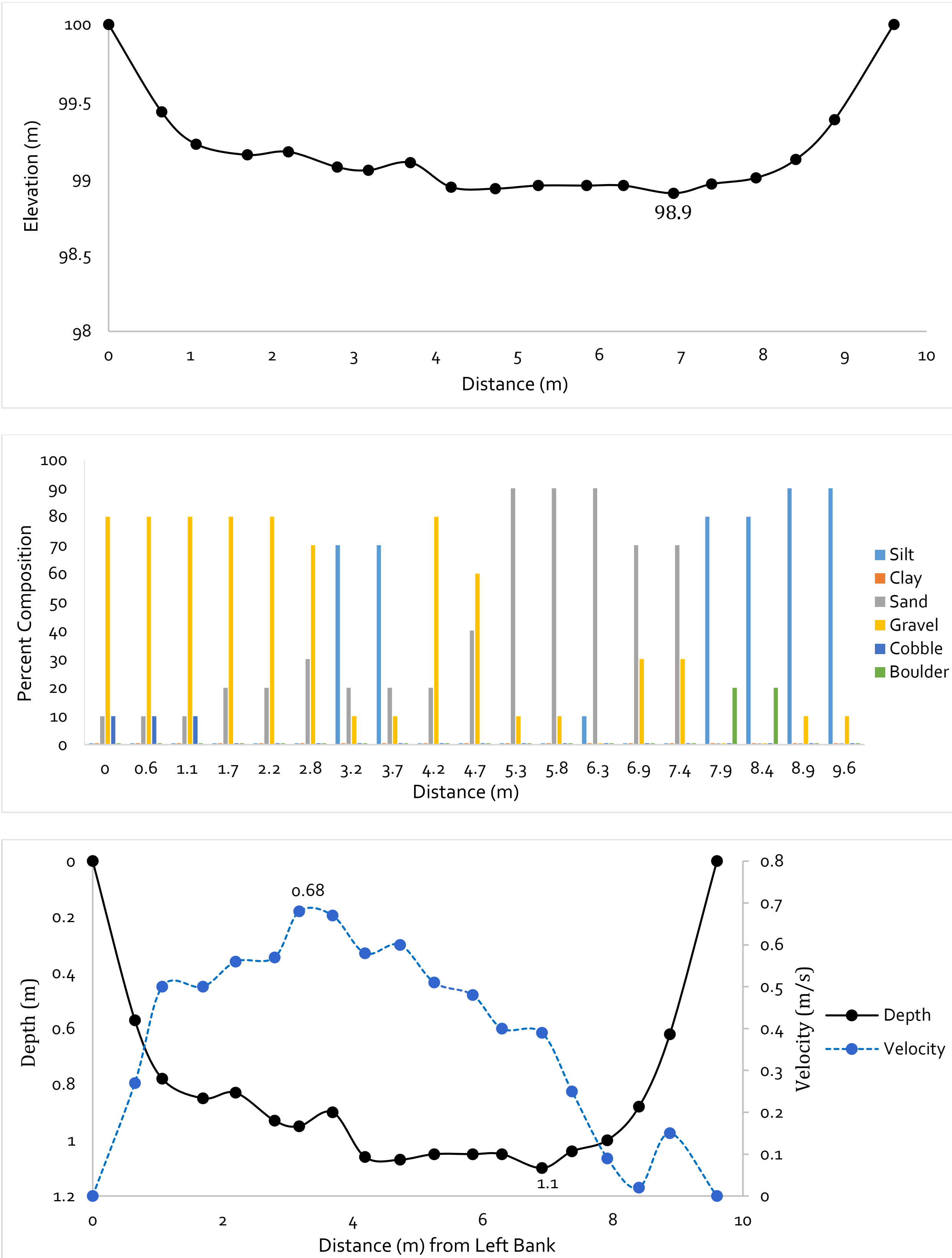
Appendix B-6. Cross-sectional profile of Transect 4 on Mercer Creek.



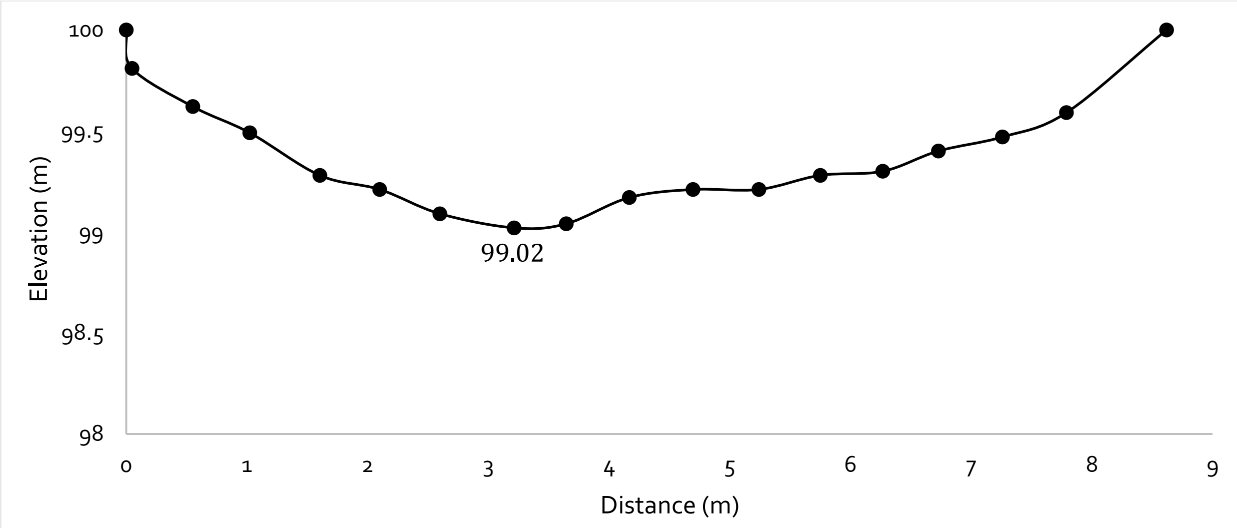


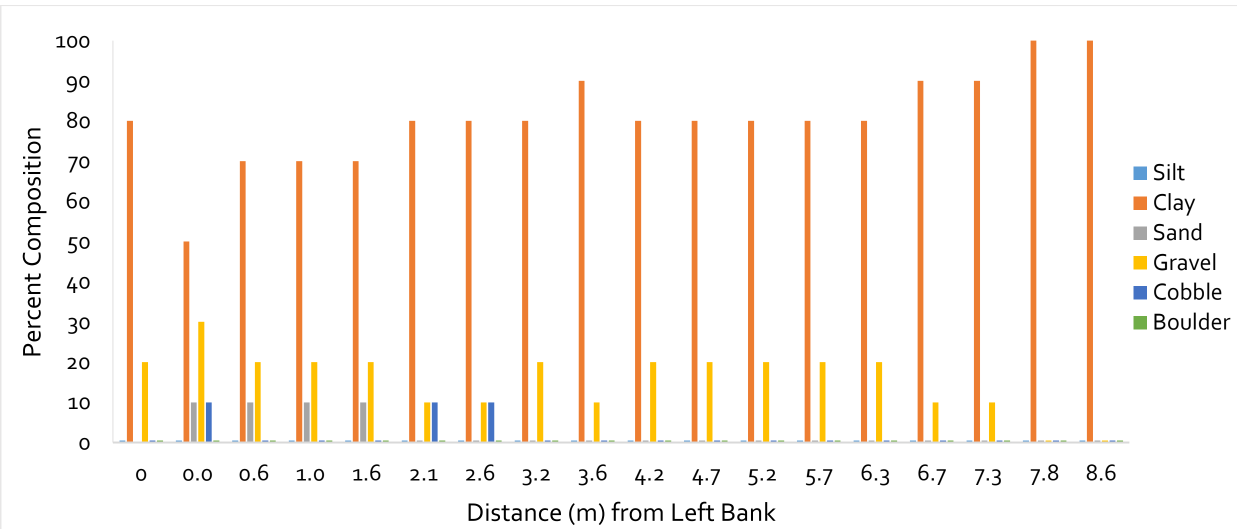


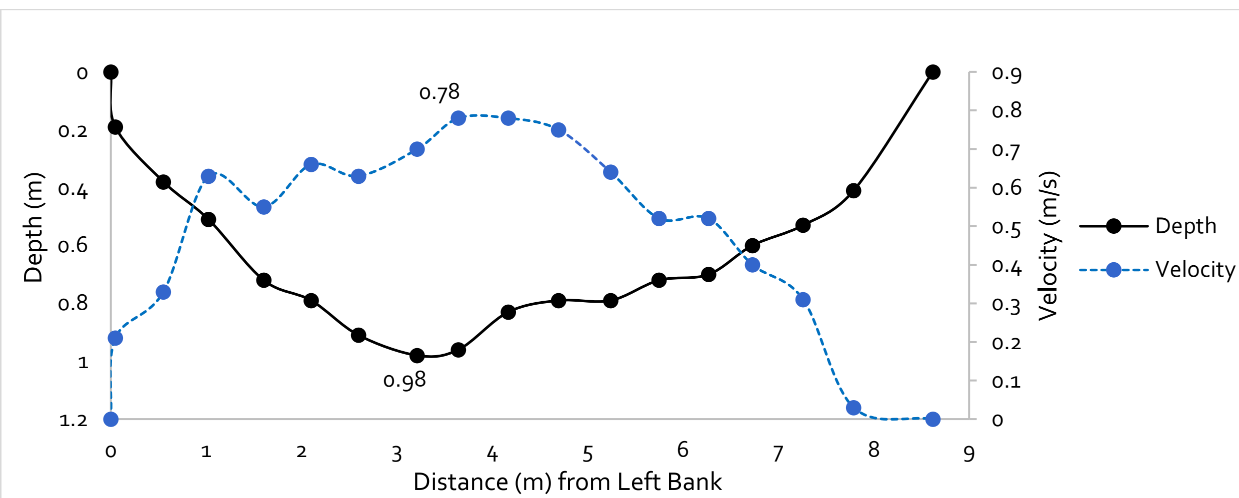
Appendix B-7. Cross-sectional profile of Transect 1 on Harrison Creek.



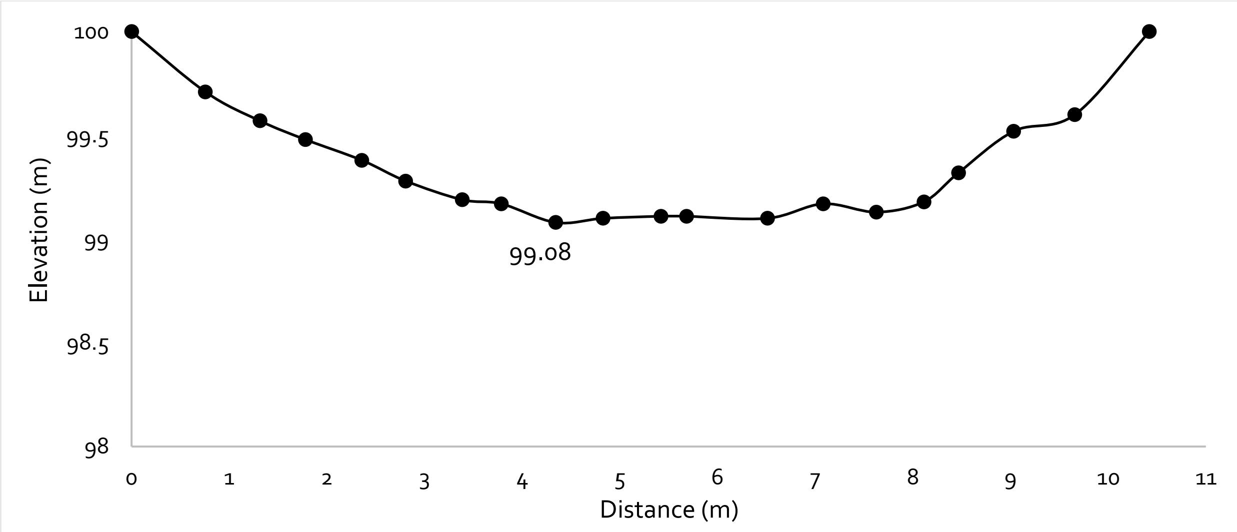
Appendix B-8. Cross-sectional profile, substrate, and velocity of Transect 1 on Birch Creek.

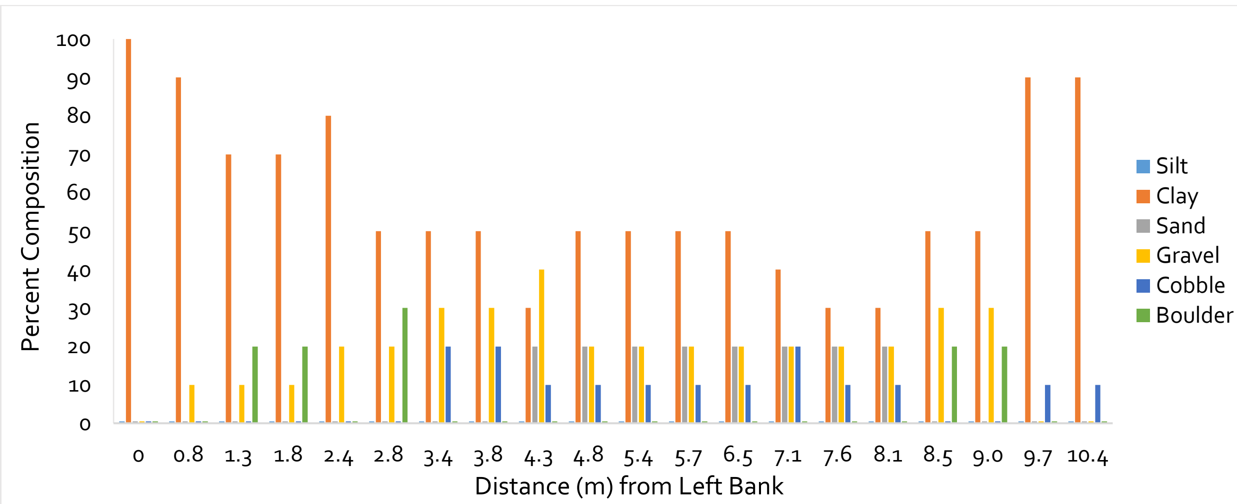


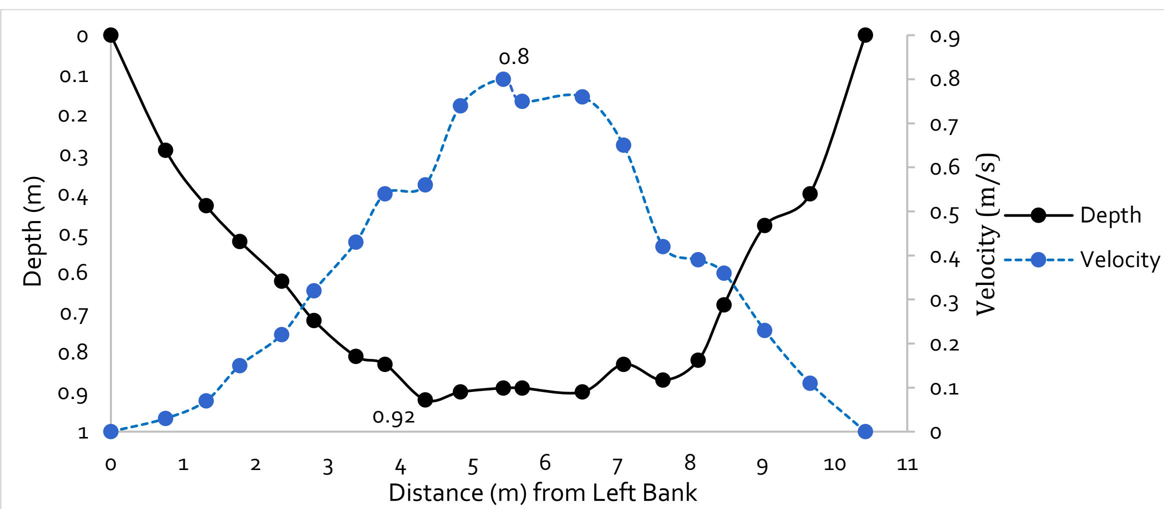




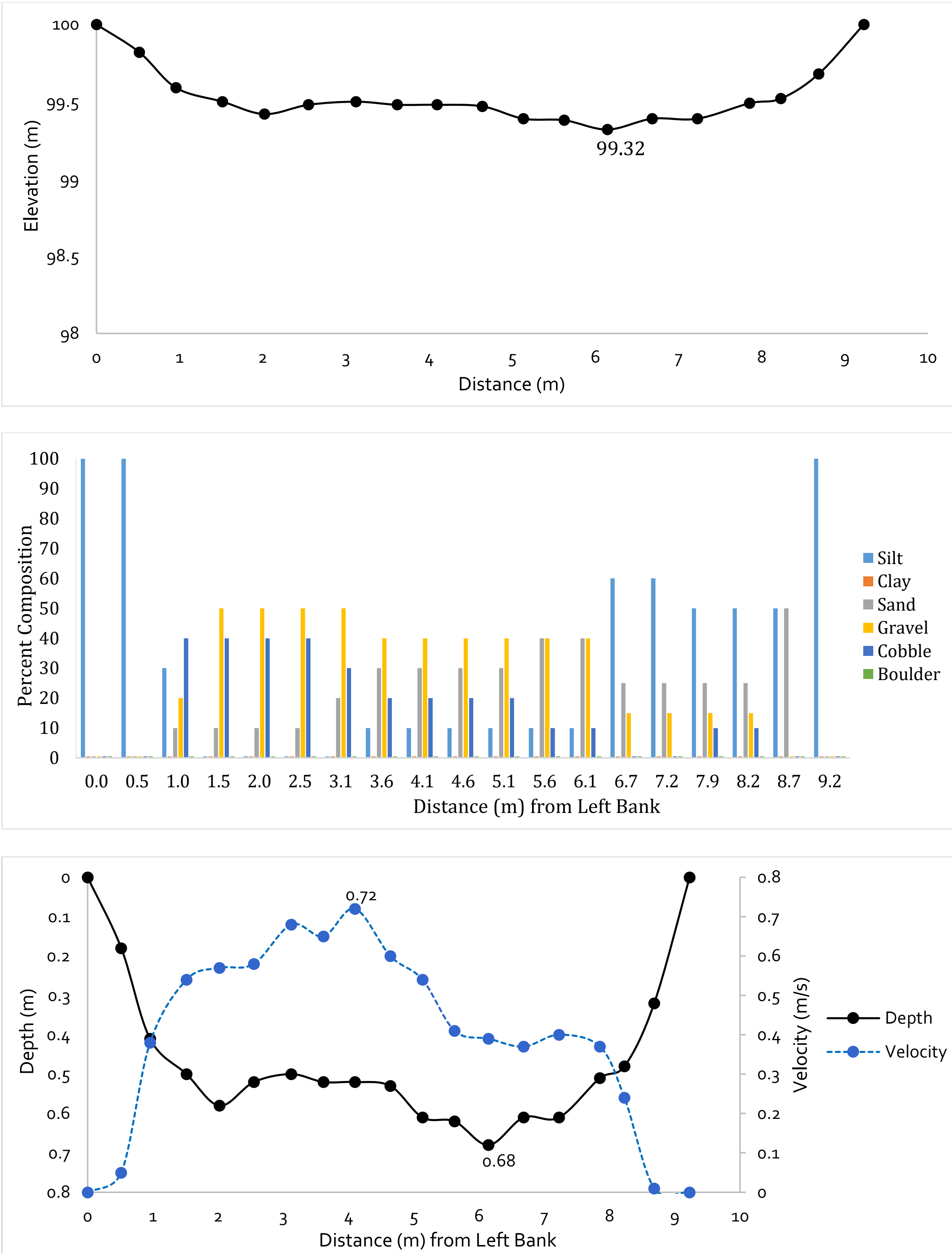
Appendix B-9. Cross-sectional profile, substrate, and velocity of Transect 2 on Birch Creek.



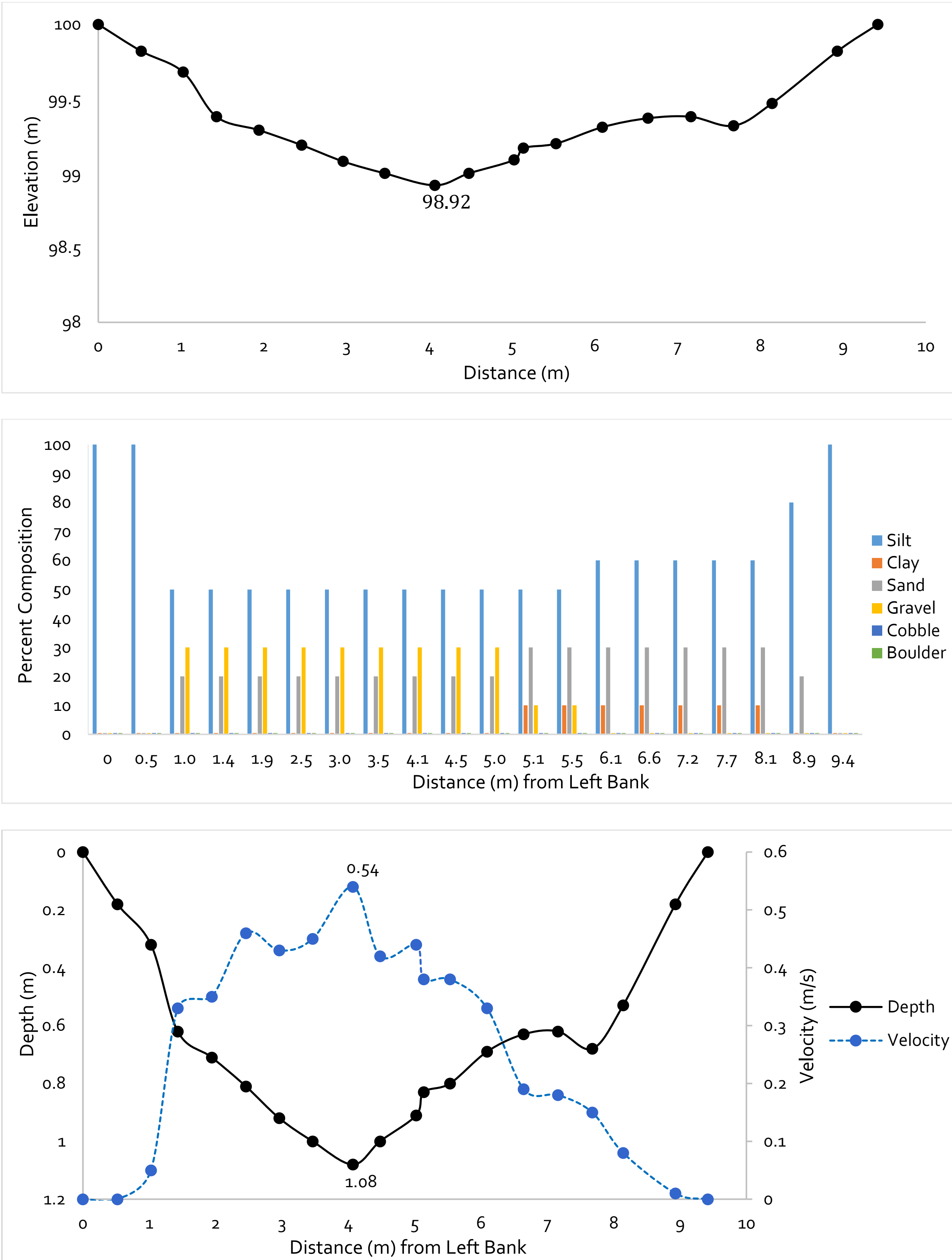




Appendix B-10. Cross-sectional profile, substrate, and velocity of Transect 3 on Birch Creek.



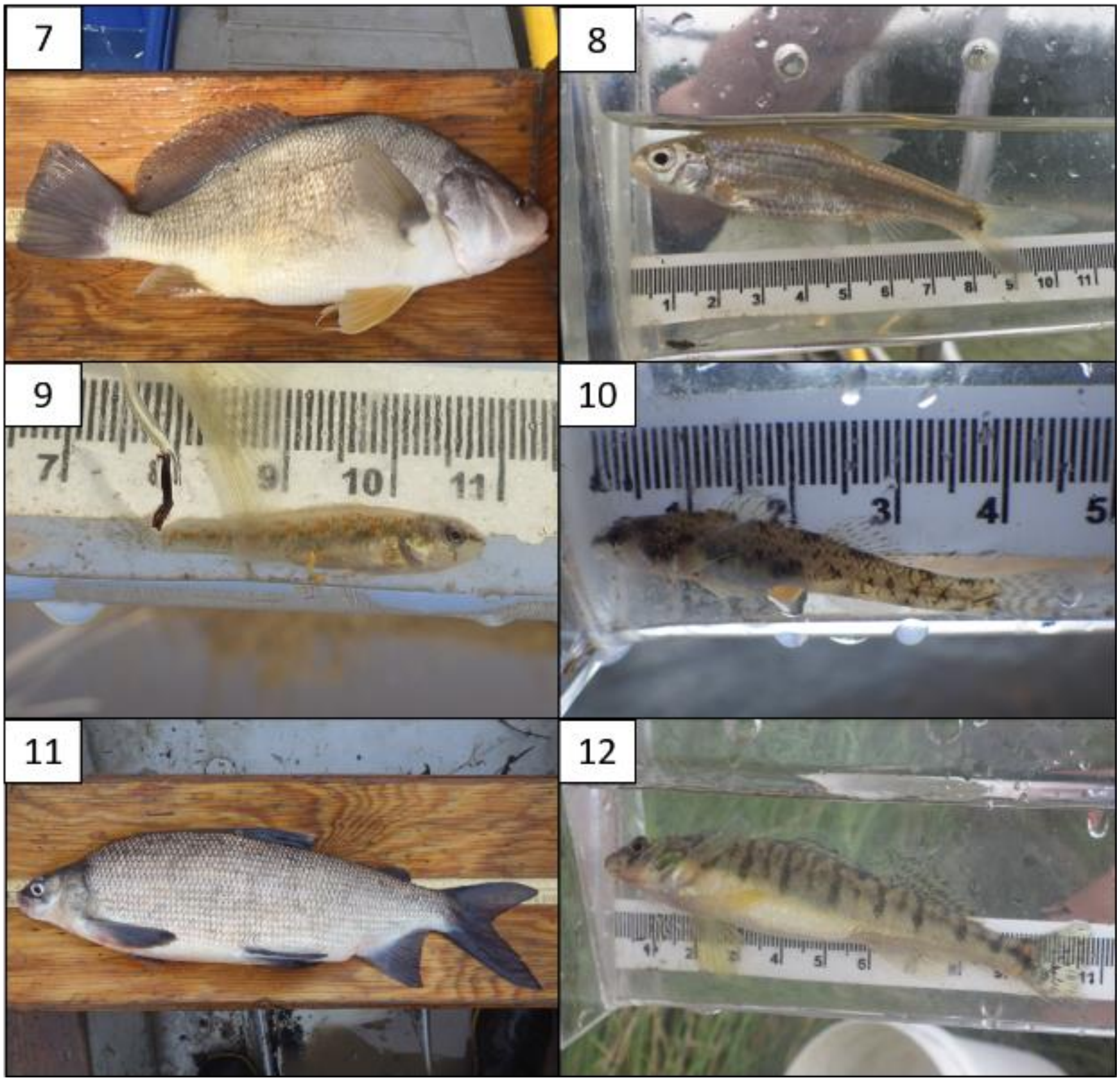
Appendix B-11. Cross-sectional profile, substrate, and velocity of Transect 4 on Birch Creek.



Appendix B-12. Cross-sectional profile of Transect 5 on Birch Creek.

APPENDIX C - Representative photographs of all fish species captured

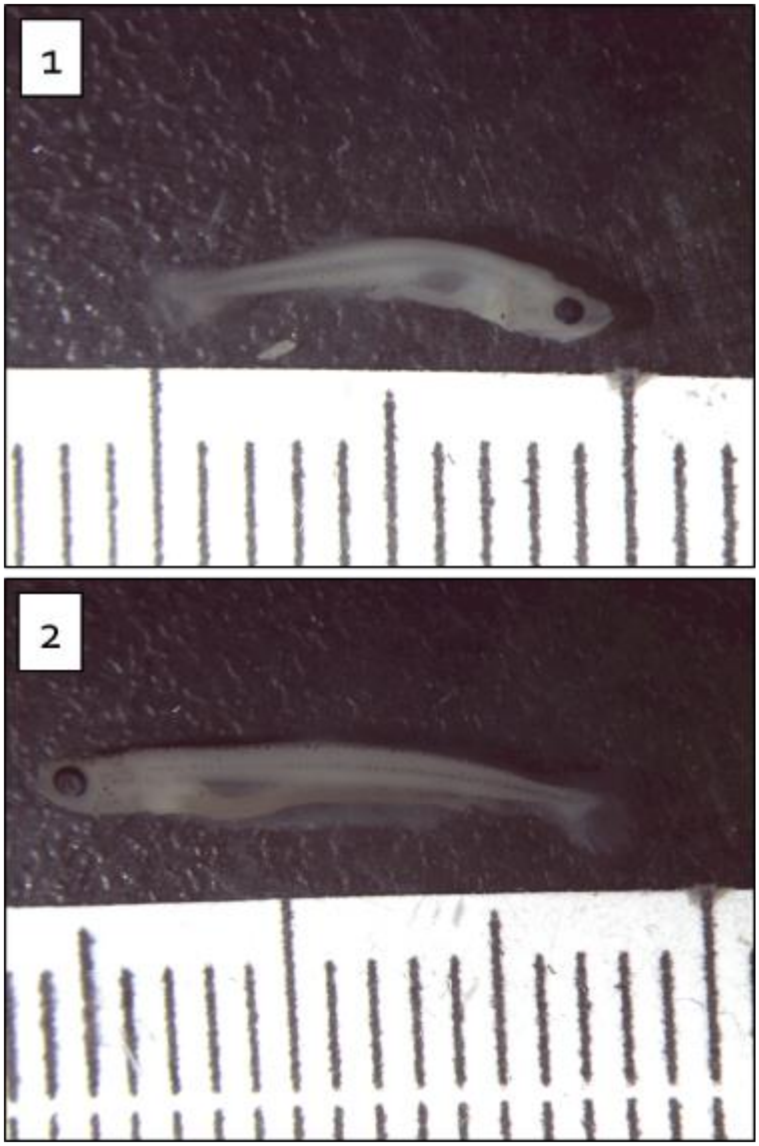
Appendix C-1. Representative photographs of fish species captured in Lake Manitoba and Lake St. Martin. 1 = Black Bullhead, 2 = Emerald Shiner, 3 = Cisco, 4 = Common Carp, 5 = Golder Shiner, 6 = Fathead Minnow.



Appendix C-1. Continued. 7 = Freshwater Drum, 8 = Golden Shiner, 9 = Iowa Darter, 10 = Johnny Darter, 11 = Lake Whitefish, 12 = Logperch.

Appendix C-1. Continued. 13 = Mottled Sculpin, 14 = Northern Pike, 15 = Quillback, 16 = Shorthead Redhorse, 17 = Spottail Shiner, 18 = Troutperch.

Appendix C-1. Continued. 19 = Walleye, 20 = White Sucker, 21 = Yellow Perch.



Appendix C-2. Representative photographs of fish larvae, under 20x magnification. 1 = Walleye; 2 = White Sucker.

APPENDIX D - Representative photographs of collected benthic invertebrate families

Appendix D-1. Representative photographs of benthic invertebrate families collected during sampling on Lake Manitoba and Lake St. Martin. 1 = Belostomatidae, 2 = Caenidae, 3 = Ceratopogonidae, 4 = Chironomidae, 5 = Coenagrionidae, 6 = Corixidae, 7 = Dogielinotidae, and 8 = Dytiscidae.

Appendix D-1. Continued. 9 = Elmidae 10, = Empididae, 11 = Ephemeridae, 12 = Gammaridae, 13 = Helicopsychidae, 14 = Heptageniidae, 15 = Hirudinea, and 16 = Hydrachnidiae.

Appendix D-1. Continued. 17 = Hydrophilidae, and 18 =Hydropsychidae, 19 = Hydroptilidae, and 20 = Leptoceridae 21 = Leptophlebiidae, 22 = Limnephilidae, 23 = Nematoda, and 24 = Phryganeidae.

Appendix D-1. Continued. 25 = Polycentropodidae, 26 = Pyralidae, 27 = Sialidae, and 28 = Tabanidae.

APPENDIX E – Fish and Aquatic Assessment Summary Documents

APPENDIX E-1.1: ROUTE C – LAKE MANITOBA, FAIRFORD STUDY SITE

Location	N 51.5687° W 98.7312° ; 14U 518630.06 5713103.80
Channel Route	Lake Manitoba – Route C
Nearby Tributaries	None

Habitat Assessment

<u>Aquatic Habitat</u>

Bathymetry

- Gently sloping shorelines.
- Maximum observed depth of 2.2 m ~650 m from shore.

Substrate

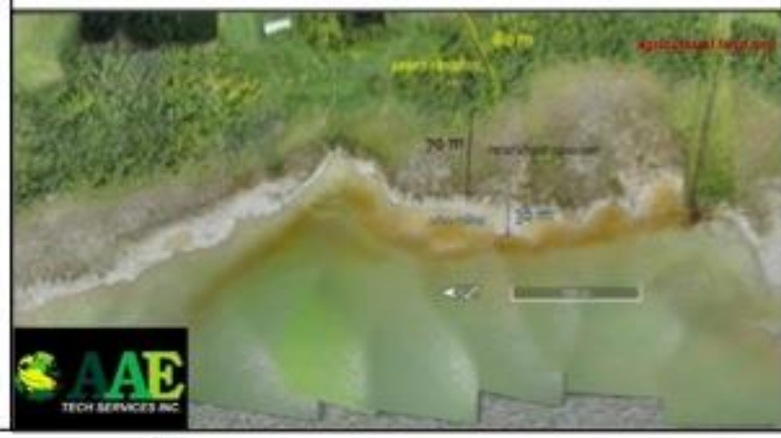
- Three distinct types:
  - 80% gravel 20% sand and cobble, with occasional boulders: <200 m from shoreline to depths <1 m;
  - 50% sand 50% gravel mix: 200-400 m from shoreline at depths of 1.0 - 1.5 m;
  - 80% sand 20% gravel: >400 m from shoreline, at depths >1.5 m.

Aquatic Vegetation

- Aquatic vegetation cover present at 0.5 to 1.5 m depth.
- Plant height limited to 0.5 m.
- Biovolume low throughout most of study area, greatest within ~75 m of north shore.

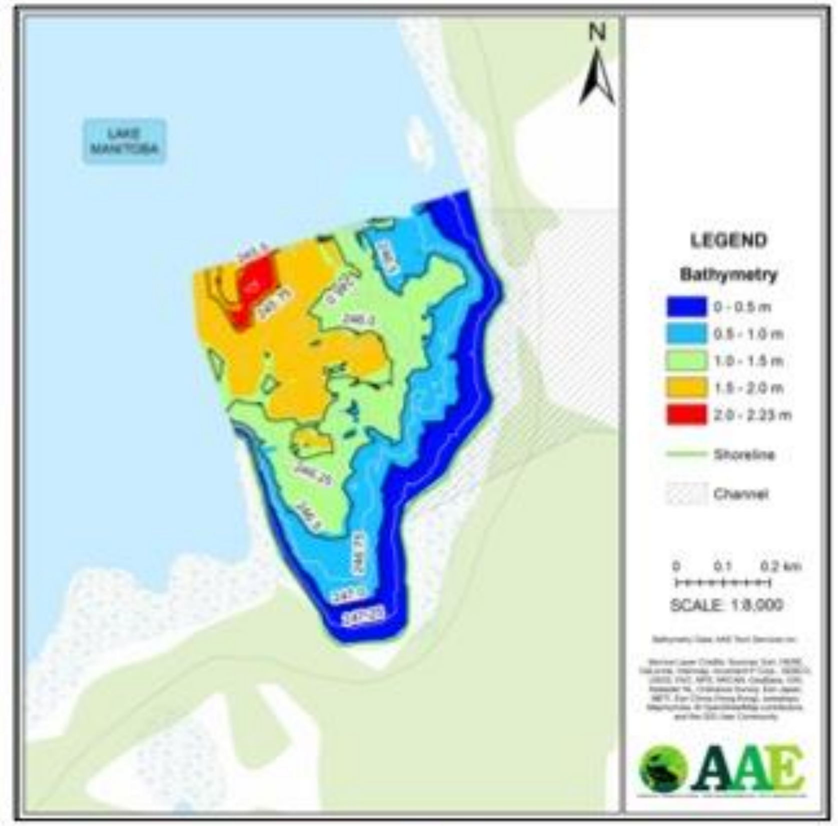
<u>Shoreline and Riparian Habitat</u>

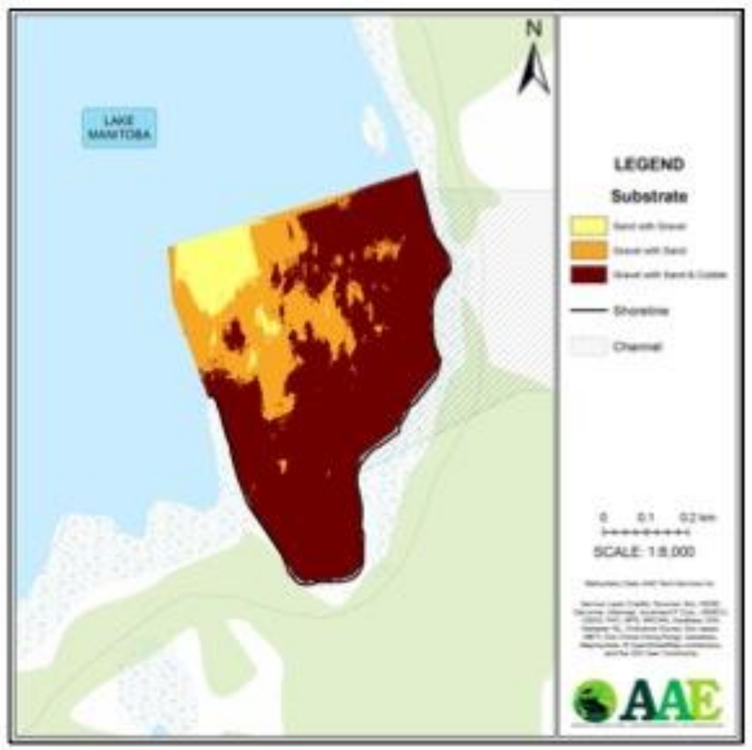
- The rocky shoreline habitat extends back 30 m: gravel-cobble-sand substrate;
- Flood plain extends a further 70 m: open with compacted gravel-cobble substrate and sparse vegetation cover;
- Deciduous trees line shoreline back 80-100 m from waters edge;
- Agricultural land (pasture) beyond.

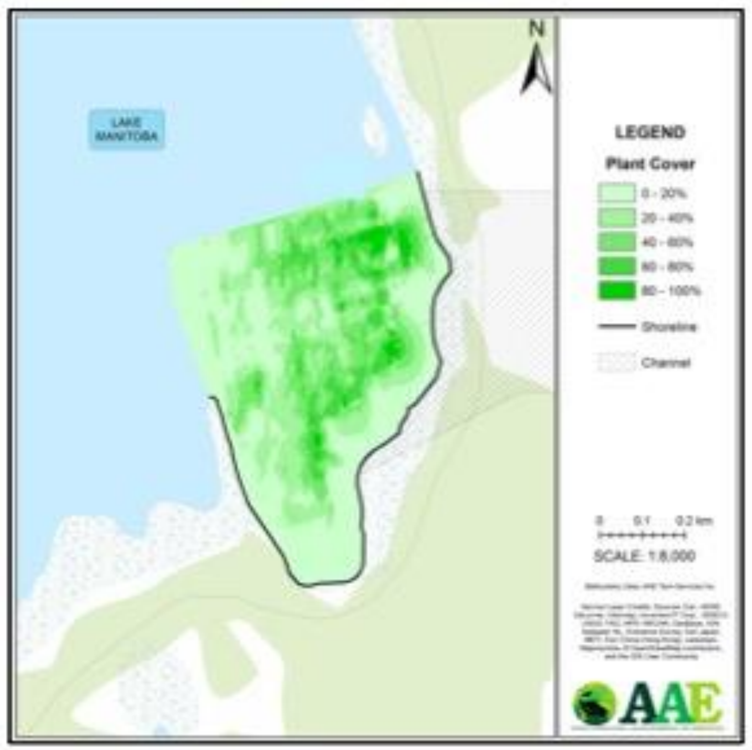


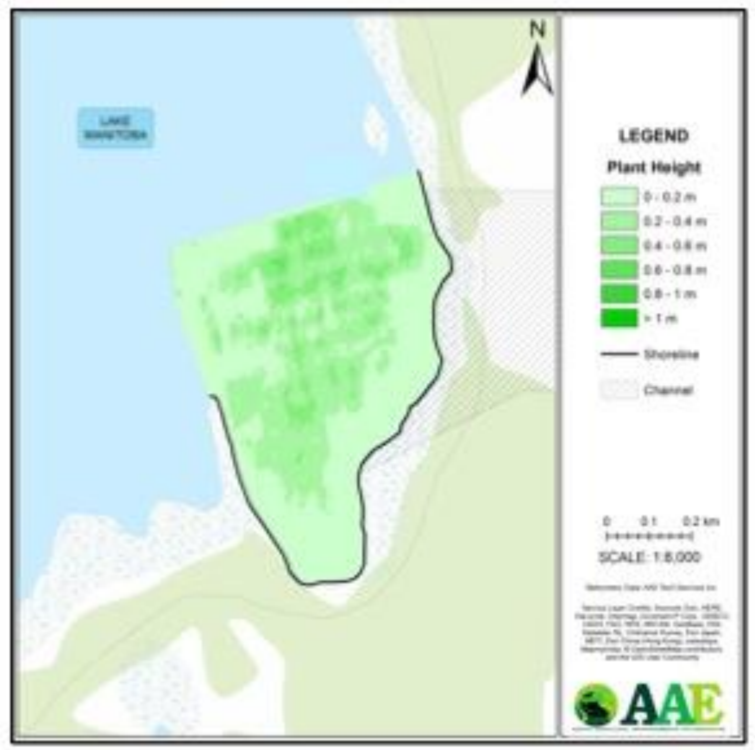
Water Quality Analysis

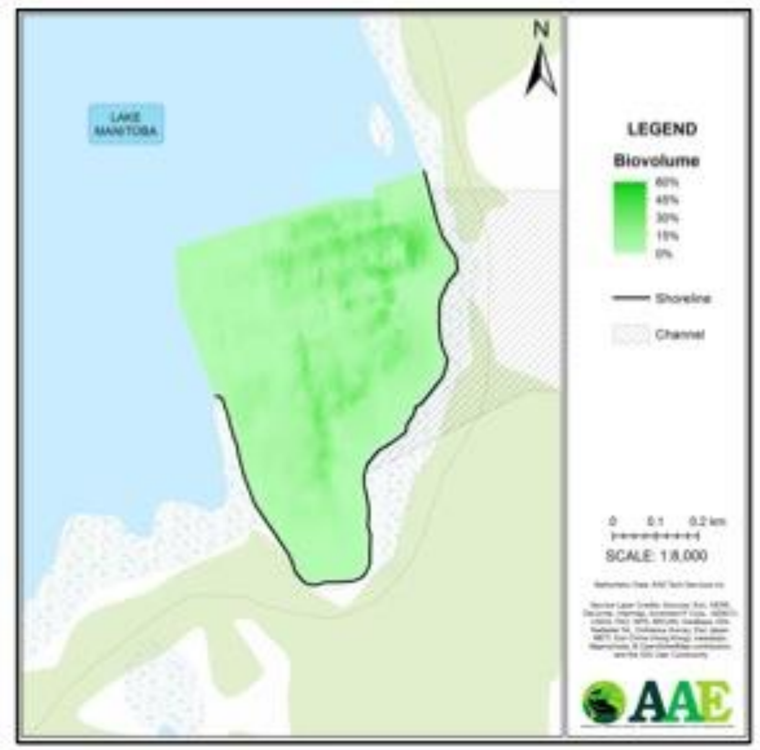
Season	Mean Temperature (°C)	Mean Dissolved Oxygen (mg/L)	Mean pH	Mean Conductivity (µS/cm)	Mean Turbidity (NTU)	Mean TSS (mg/L)
Fall 2015	6.33	10.18	7.09	1160	2.41	10.948
Spring 2016	14.58	8.85	7.30	902	3.02	12.326











APPENDIX E-1.2: ROUTE C – LAKE MANITOBA, FAIRFORD STUDY SITE

Location	N 51.5687° W 98.7312° ; 14U 518630.06 5713103.80
Channel Route	Lake Manitoba – Route C
Nearby Tributaries	None

Aquatic Species Assessment

Fish Species

- White Sucker
- Yellow Perch
- Northern Pike
- Walleye
- Spottail Shiner
- Lake Whitefish
- Emerald Shiner
- Freshwater Drum
- Shorthead Redhorse
- Common Carp
- Fathead Minnow
- Johnny Darter
- Logperch
- Quillback

Comments

- Commercial, Aboriginal and Recreational Fish present
- No SARA species captured

Invertebrate Orders

- Ephemeroptera
- Diptera
- Amphipoda
- Trichoptera
- Trombidiformes
- Coleoptera
- Hirudinea
- Lepidoptera
- Nematoda
- Odonata

Comments

- Invertebrate community diverse
- Signifies a healthy ecosystem

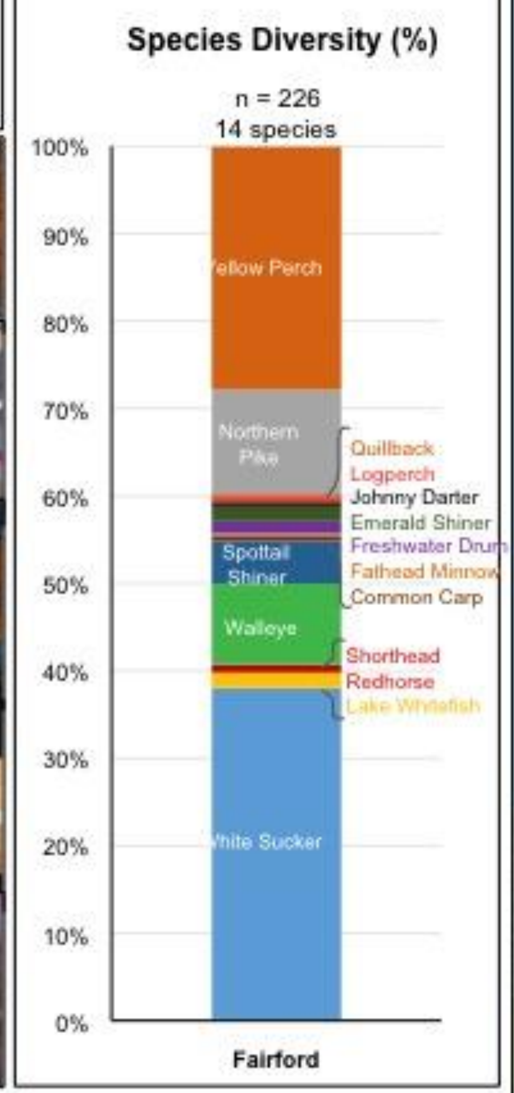
Fish Spawning Activity

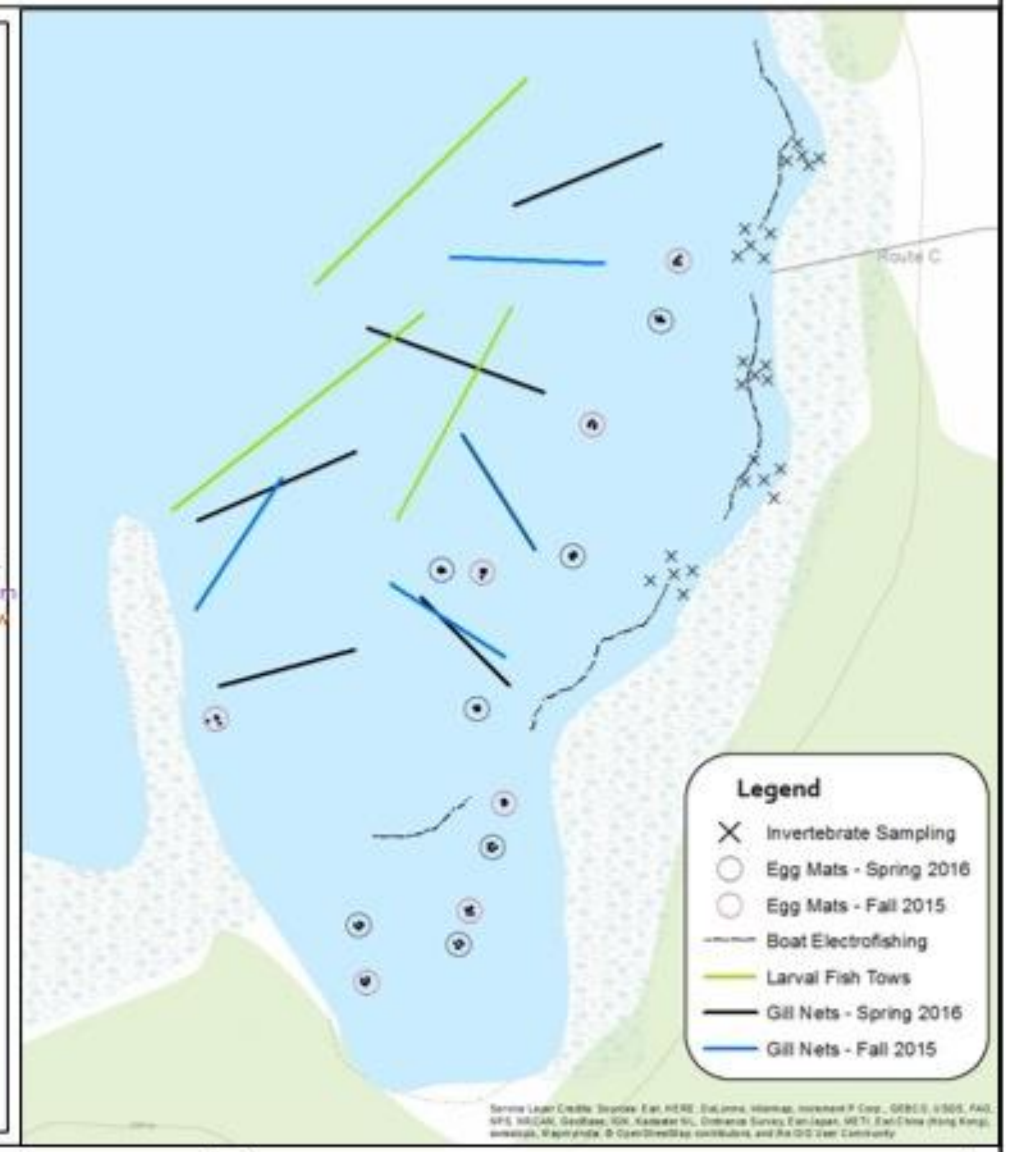
- Adults in spawning condition
  - *Fall: Lake Whitefish (n = 4)*
  - *Spring:*
    Northern Pike (n = 12)
    Walleye (n = 2)
    White Sucker (n = 73)
- Larval fish (Spring)
  - *White Sucker (n = 2)*
  - *Walleye (n = 57)*
- Eggs (Fall and Spring)
  - *No eggs captured*

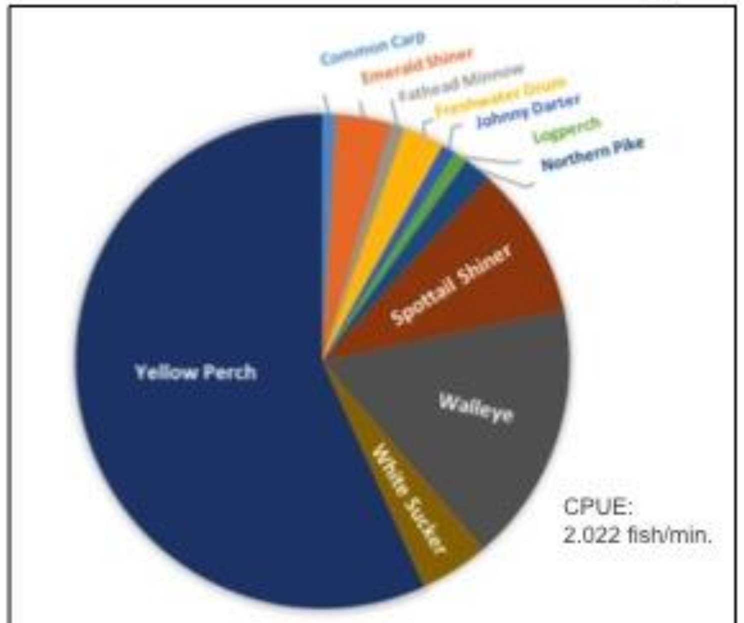
Comments

- Commercial, Aboriginal and Recreational Fish present
- Sheltered Bay with productive invertebrate community
- Shoreline Rocky so will likely be used by fish for spawning
- Not as productive as Lake St. Martin

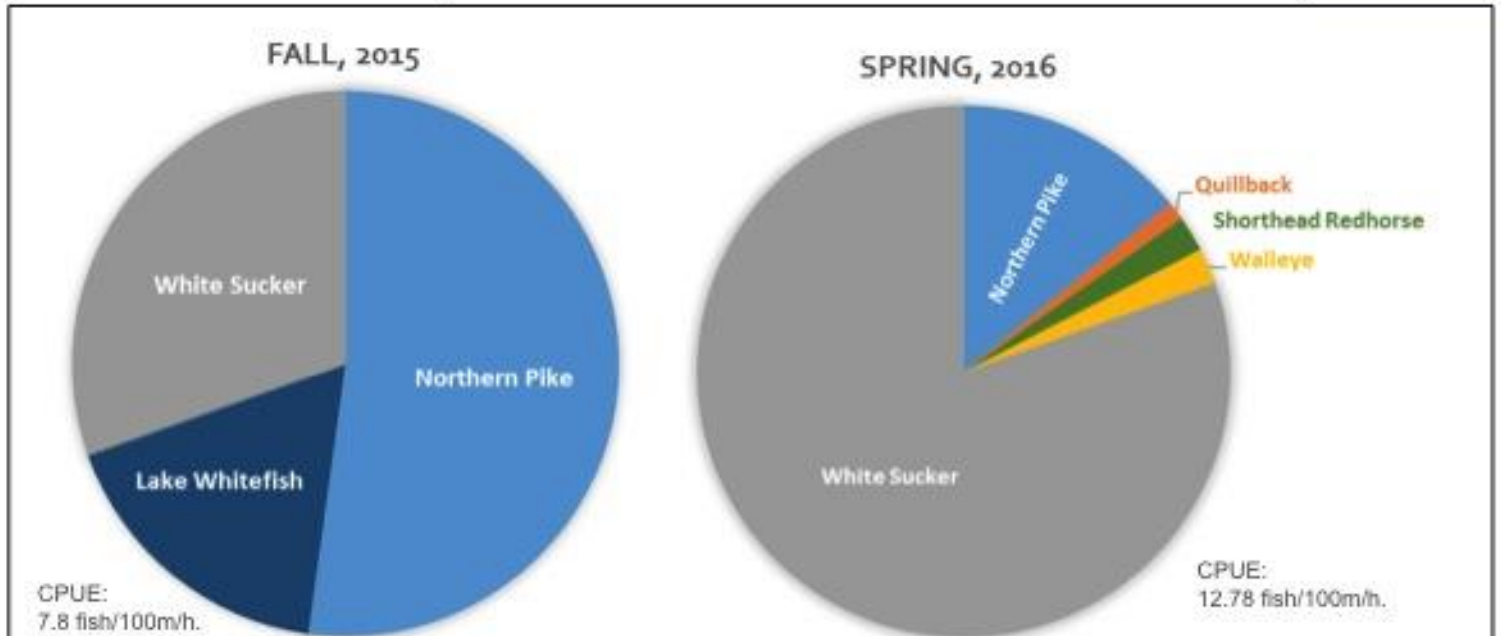
Five Most Commonly Captured Fish Species *(Comprise 92%*



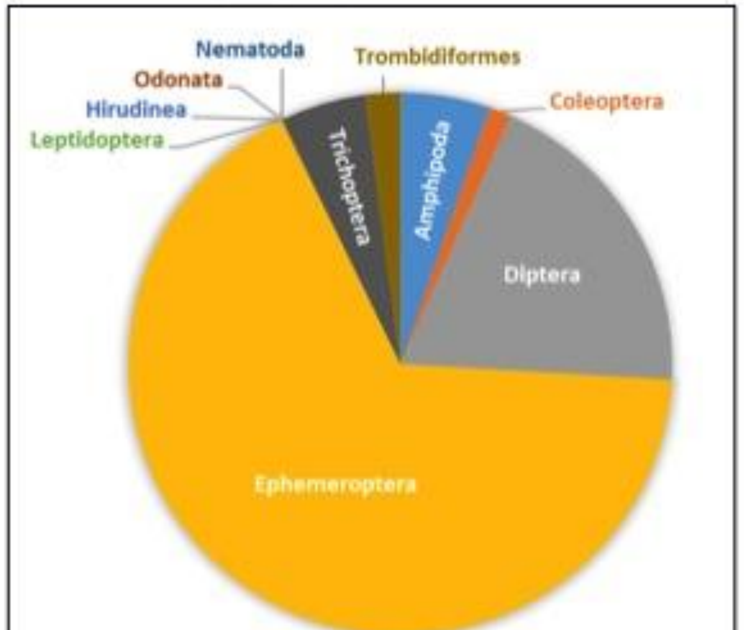




Relative Species Abundance for Fish Captured during Spring Boat Electrofishing



Relative Species Abundance for Fish Captured during Fall and Spring Gill Netting



Relative Species Abundance for Benthic Invertebrates Captured during Fall Sampling

APPENDIX E-2.1: ROUTE D – LAKE MANITOBA, WATCHORN BAY STUDY SITE

Location	N 51.2830° W 98.5694° ; 14U 530030.79 5681384.37
Channel Route	Lake Manitoba – Route D
Nearby Tributaries	Mercer Creek, Watchorn Creek

Habitat Assessment

Aquatic Habitat

Bathymetry

- Gently sloping sandy shorelines.
- Maximum observed depth of 2.7 m ~750 m from shore.

Substrate

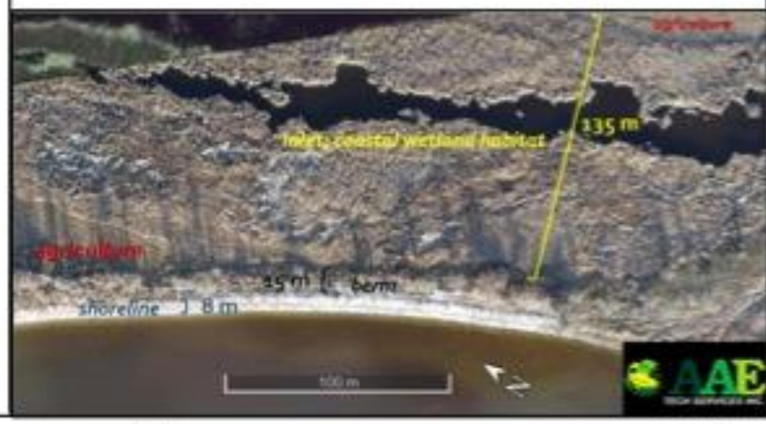
- Three distinct types:
  - 90% sand 10% boulder at depths of 0.5 - 1.5 m;
  - 50% gravel 30% sand 20% silt: >1.5 m depth;
  - 50% coarse sand 50% gravel: pockets at depths >2 m;
  - Occasional boulder fields also observed at all depths across site.

Aquatic Vegetation

- Sparse aquatic vegetation throughout most of site.
- Scattered plant cover >0.5 m, generally at depths >2 m.
- Biovolume low across most of the site.

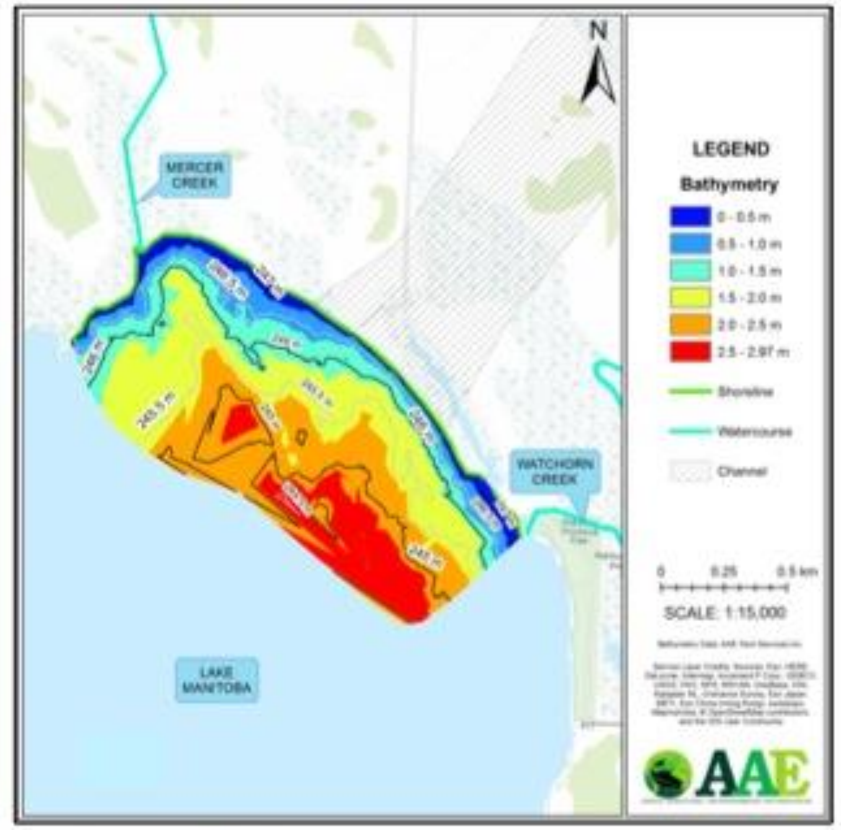
Shoreline and Riparian Habitat

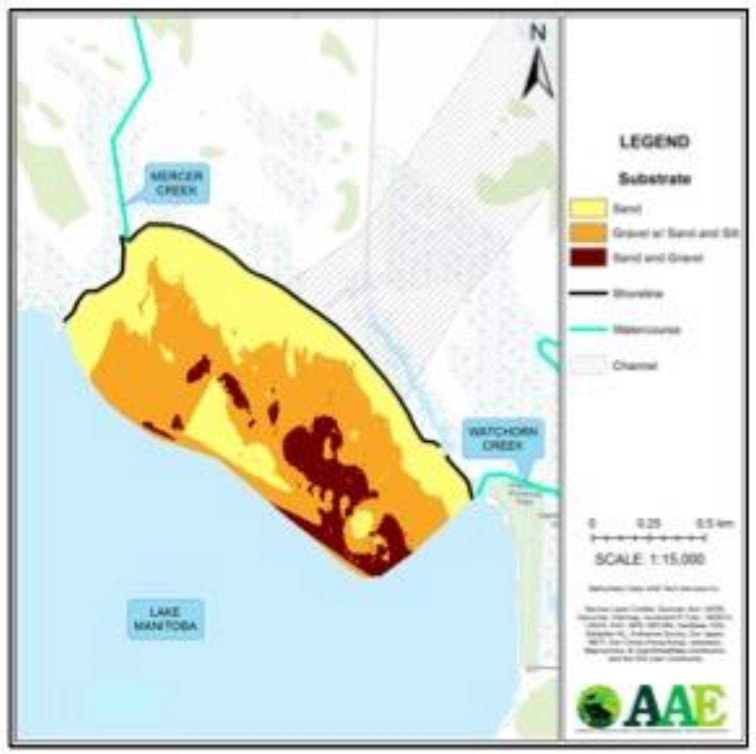
- Narrow band of gravel and sand wrap the shoreline extends back 8-10 m: gravel-cobble-sand substrate with some boulders present.
- Gravel-cobble berm 1.5 m high and 15 m wide observed parallel to shoreline.
- Agricultural land (pasture) beyond berm.
- Floodplain/wetland habitat within and east of the Route D right of way.

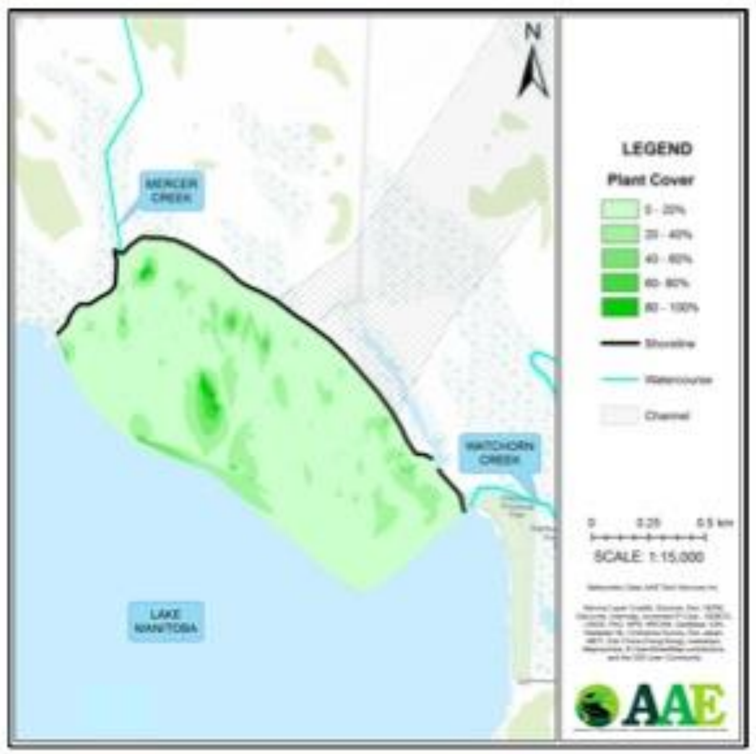


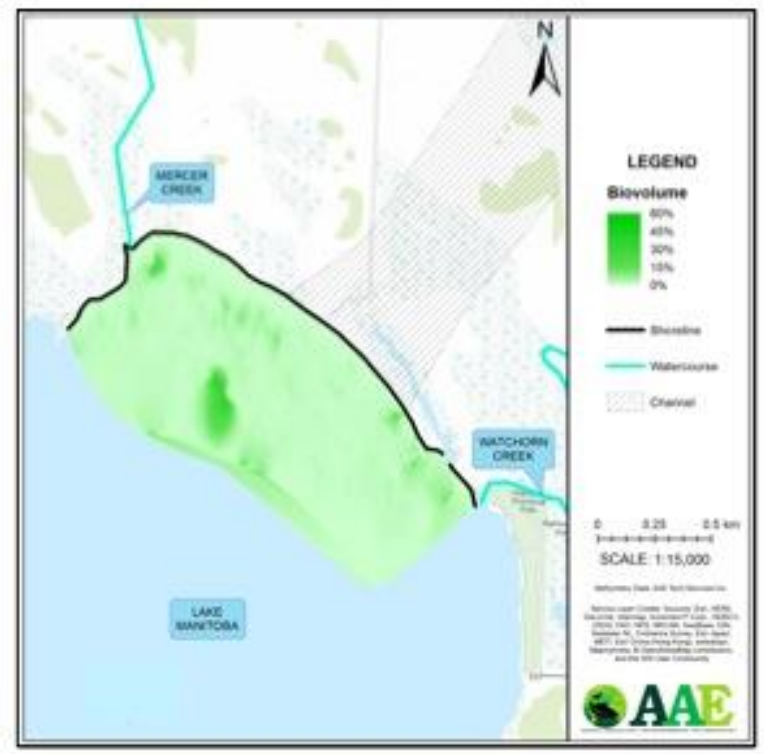
Water Quality Analysis

Season	Mean Temperature (°C)	Mean Dissolved Oxygen (mg/L)	Mean pH	Mean Conductivity (µS/cm)	Mean Turbidity (NTU)	Mean TSS (mg/L)
Fall 2015	6.33	12.30	6.84	823	3.91	14.336
Spring 2016	14.58	8.79	6.60	877	4.05	14.65









APPENDIX E-2.2: ROUTE D – LAKE MANITOBA, WATCHORN BAY STUDY SITE

Location	N 51.2830° W 98.5694° ; 14U 530030.79 5681384.37
Channel Route	Lake Manitoba – Route D
Nearby Tributaries	Mercer Creek, Watchorn Creek

Aquatic Species Assessment

Fish Species

- White Sucker
- Yellow Perch
- Lake Whitefish
- Spottail Shiner
- Common Carp
- Northern Pike
- Fathead Minnow
- Walleye
- Logperch
- Freshwater Drum
- Johnny Darter
- Troutperch

Comments
- Commercial, Aboriginal and Recreational Fish present
- Likely use habitat as migration corridor to move into surrounding tributaries for spawning

Invertebrate Orders

- Ephemeroptera
- Diptera
- Trombidiformes
- Amphipoda
- Nematoda
- Trichoptera
- Coleoptera
- Hemiptera

Comments
- Less diverse invertebrate communities as other sites
- Unstable substrates in shallow bay

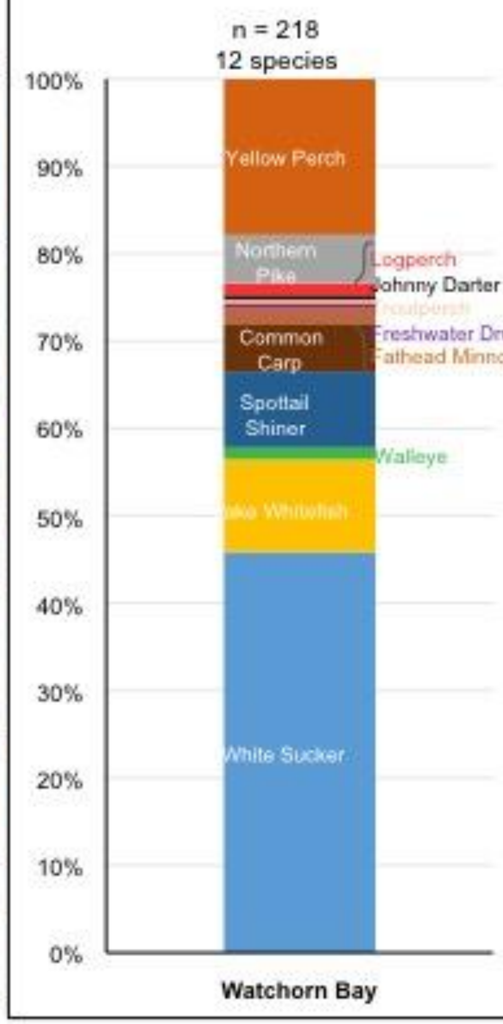
Fish Spawning Activity

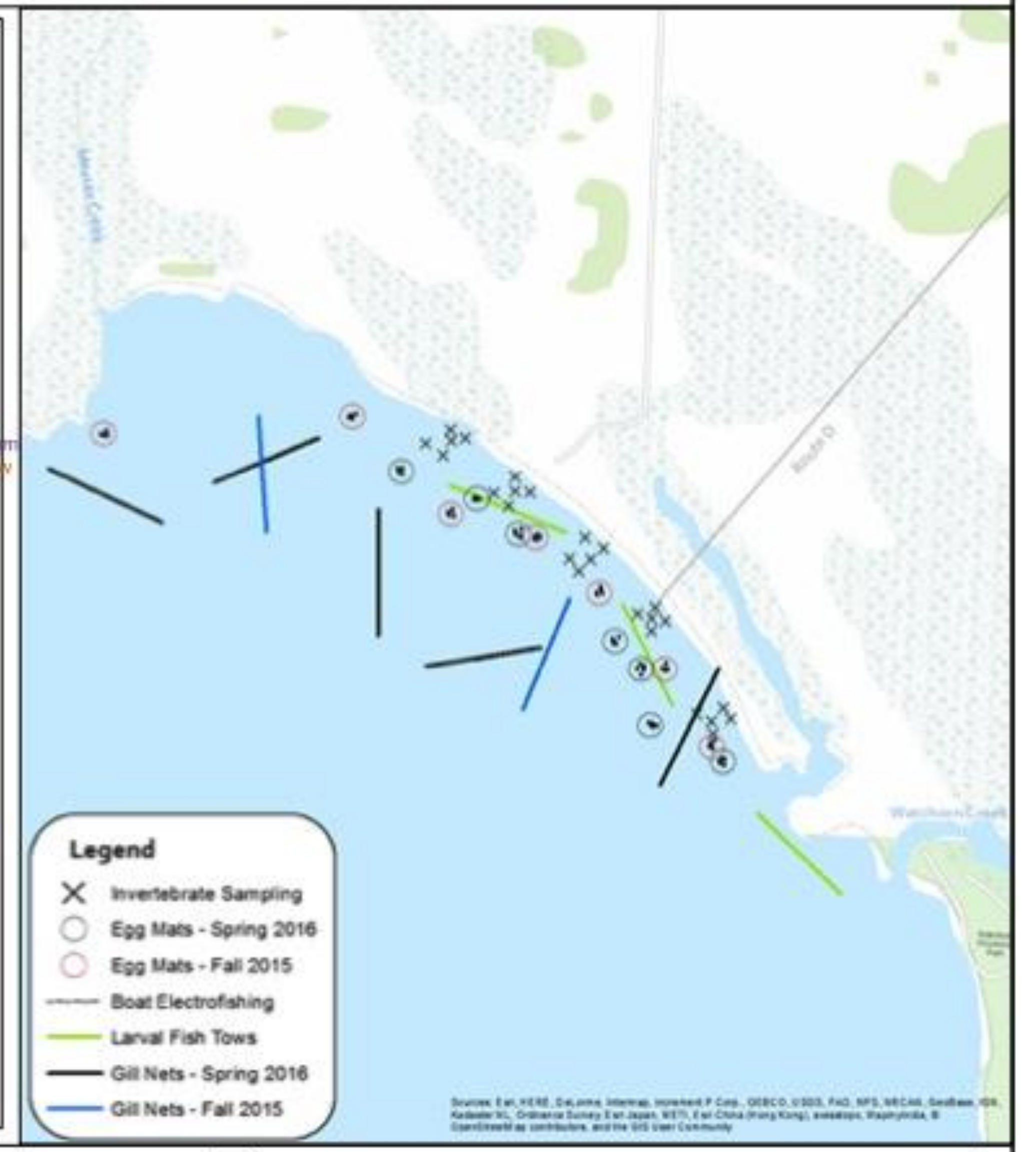
- Adults in spawning condition
  - *Fall: Lake Whitefish (n = 11)*
  - *Spring: Northern Pike (n = 1) Walleye (n = 1) White Sucker (n = 99)*
- Larval fish (Spring)
  - *White Sucker (n = 1)*
  - *Walleye (n = 22)*
- Eggs (Fall and Spring)
  - *Two eggs collected during spring kick sampling; one Catostomidae sp. and one Percidae sp.*

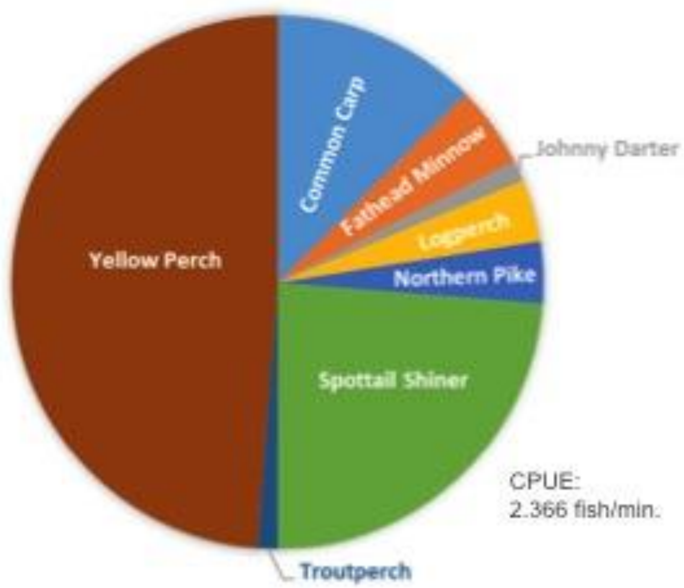
Comments
- Commercial, Aboriginal and Recreational Fish present
- Wind Swept area with shifting substrates, not ideal spawning habitat

Six Most Commonly Captured Fish Species *(Comprise 94% of Total Catch)*

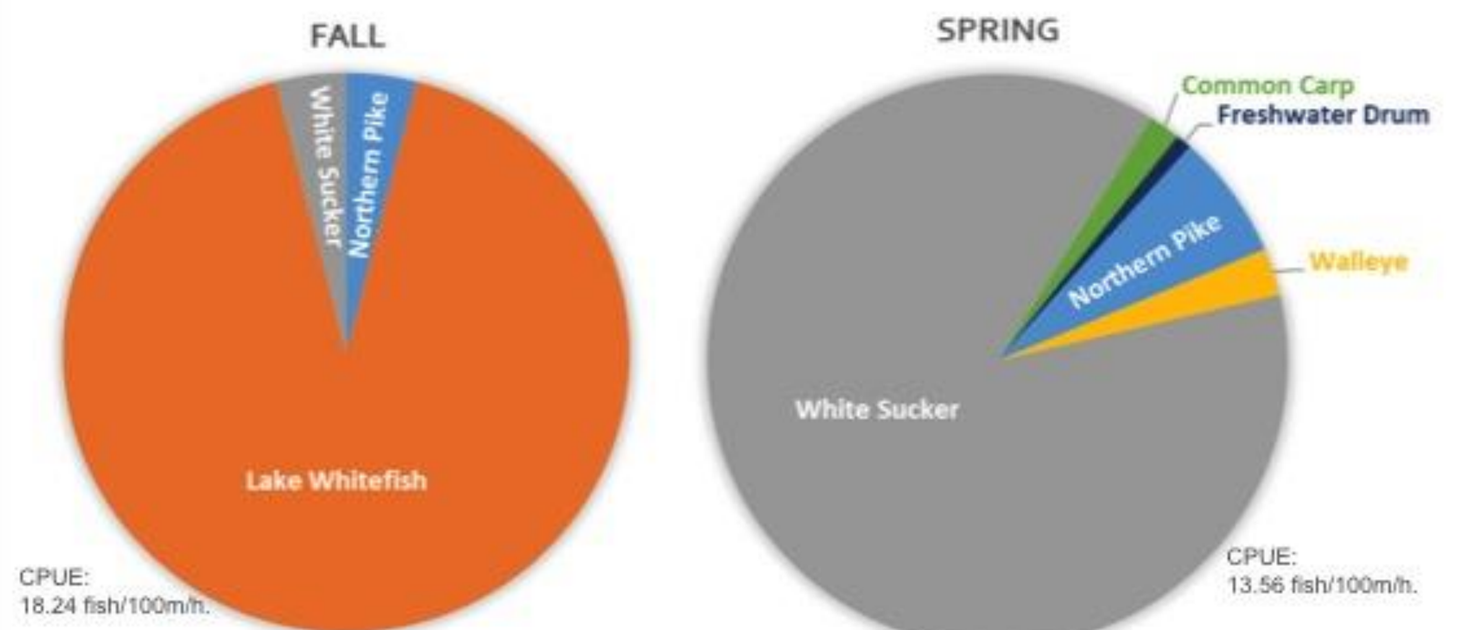
Species Diversity (%)



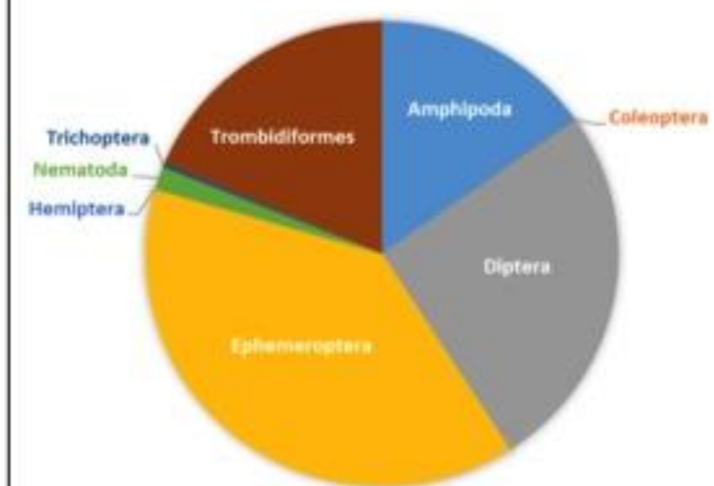




Relative Species Abundance for Fish Captured during Spring Boat Electrofishing



Relative Species Abundance for Fish Captured during Fall and Spring Gill Netting



Relative Species Abundance for Benthic Invertebrates Captured during Fall Sampling

APPENDIX E-3.1: ROUTE C – LAKE ST. MARTIN, HARRISON BAY STUDY SITE

Location	N 51.5389° W 98.5890° ; 14U 528504.29 5709835.43
Channel Route	Lake St. Martin – Route C
Nearby Tributaries	Harrison Creek

Habitat Assessment

Aquatic Habitat

Bathymetry

- Uniform, gentle slope
- Maximum observed depth of 3.25 m ~550 m from shore
- Extensive floodplain/wetland habitat with depths < 1 m.

Substrate

- Three distinct types:
  - 80% sand 20% gravel: at depths <1.5 m;
  - 50% sand 50% gravel: >1.5 m depth;
  - 70% gravel 30% cobble: pockets at 2.5-3.0 m depth.

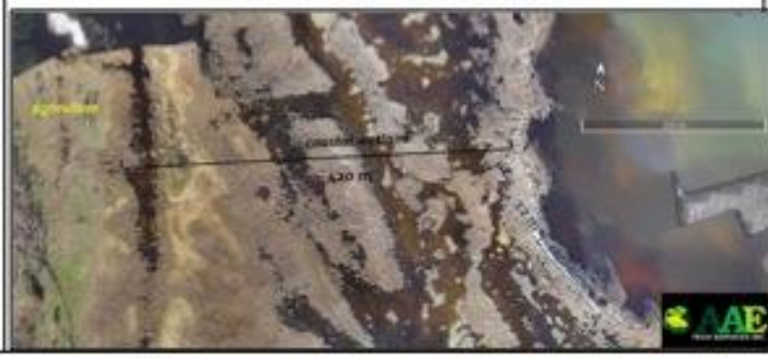
Aquatic Vegetation

- Very dense vegetation in wetland area.
- Low vegetation cover at depths <1.5 m.
- Denser vegetation cover (>60%) beyond depths of 1.5 m, especially in northern half.
- Low plant height (<0.5 m) and biovolume (<30%) outside of wetland area.

Shoreline and Riparian Habitat

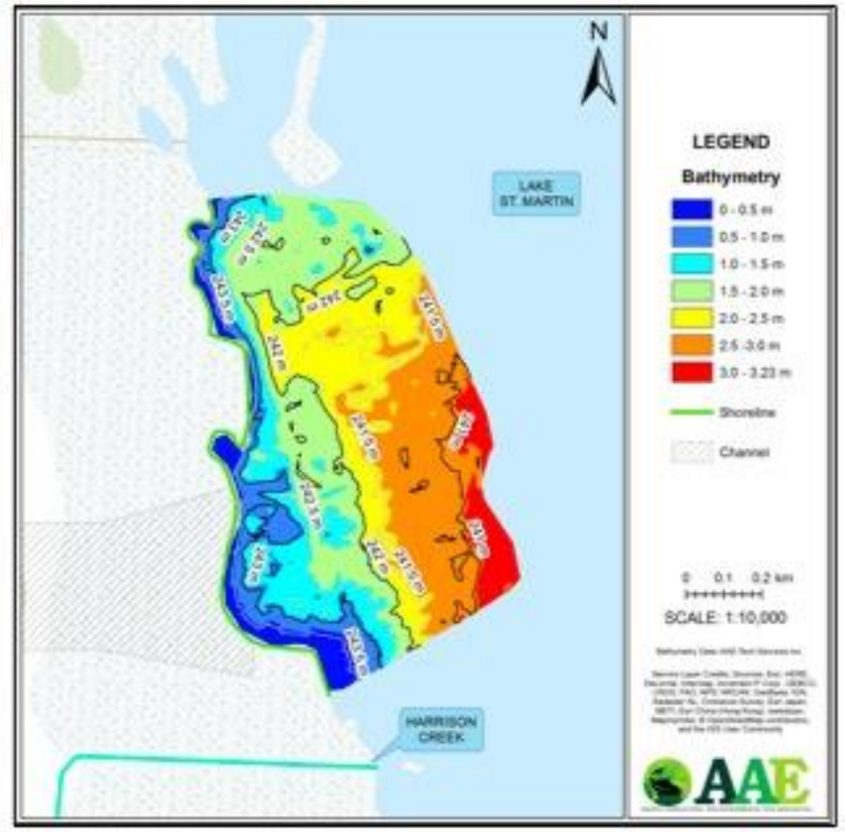
Highly productive wetland habitat surrounding shoreline.

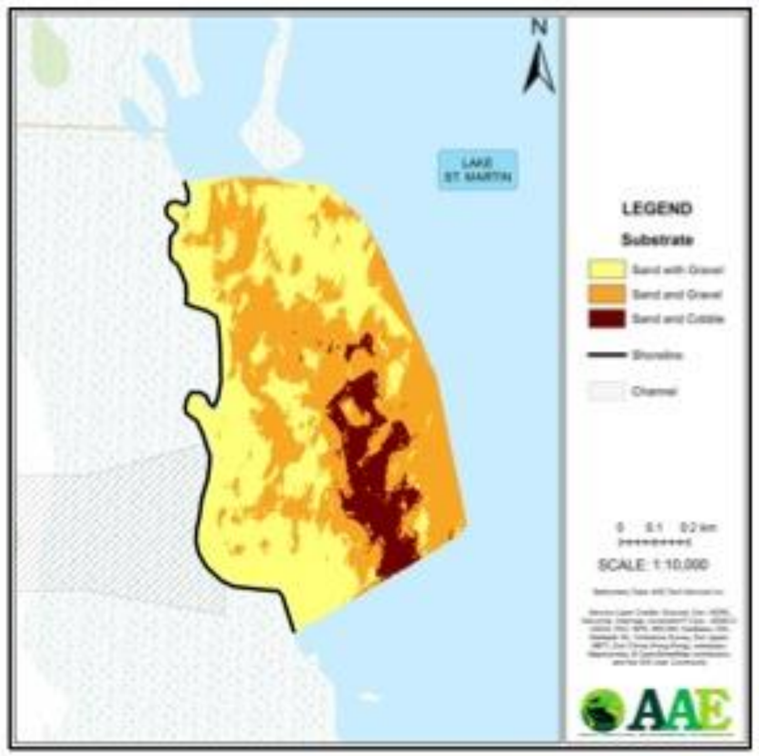
- Rocky shoreline habitat extends back~ 12 m: compacted gravel-sand substrate with scattered cobble and boulders.
- Floodplain/wetland habitat extends 420 m inland: dense emergent vegetation, average depth < 1 m.
  - Gap in shoreline at Route C outlet site creates an inlet into wetland habitat, enabling fish passage between wetland and Lake St. Martin.
  - Excellent spawning habitat for species such as Walleye and Northern Pike.
- Pasture I land (pasture) beyond wetland habitat.

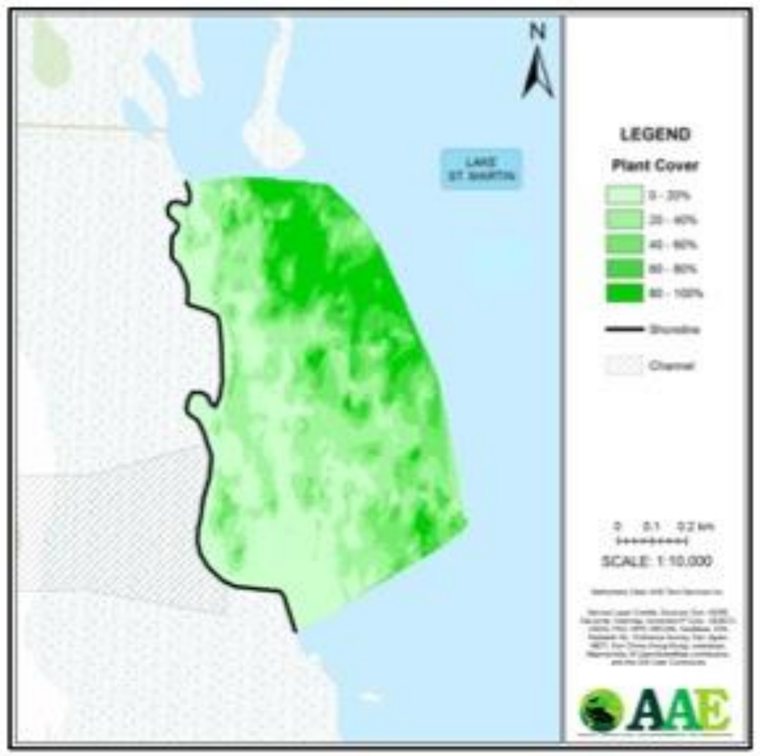


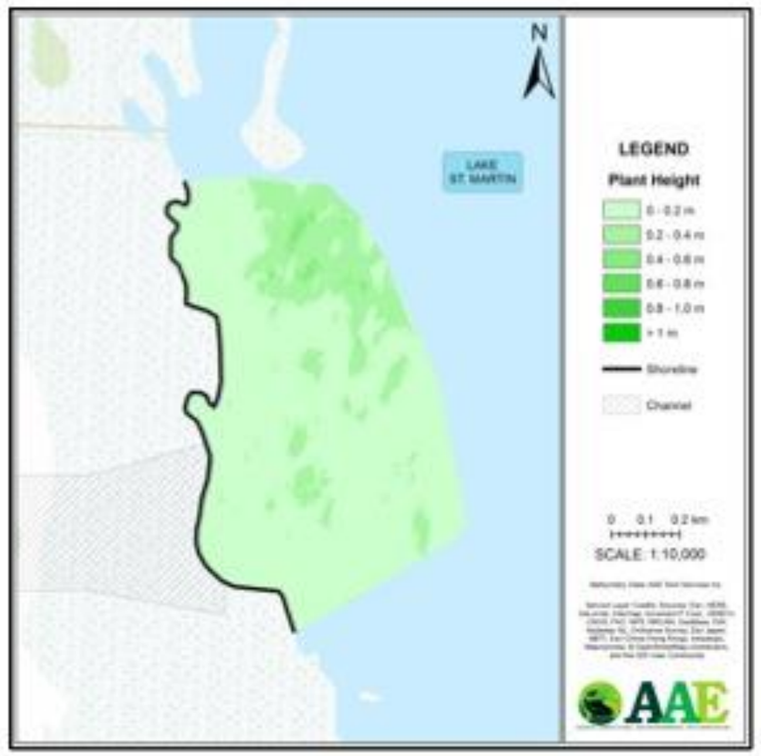
Water Quality Analysis

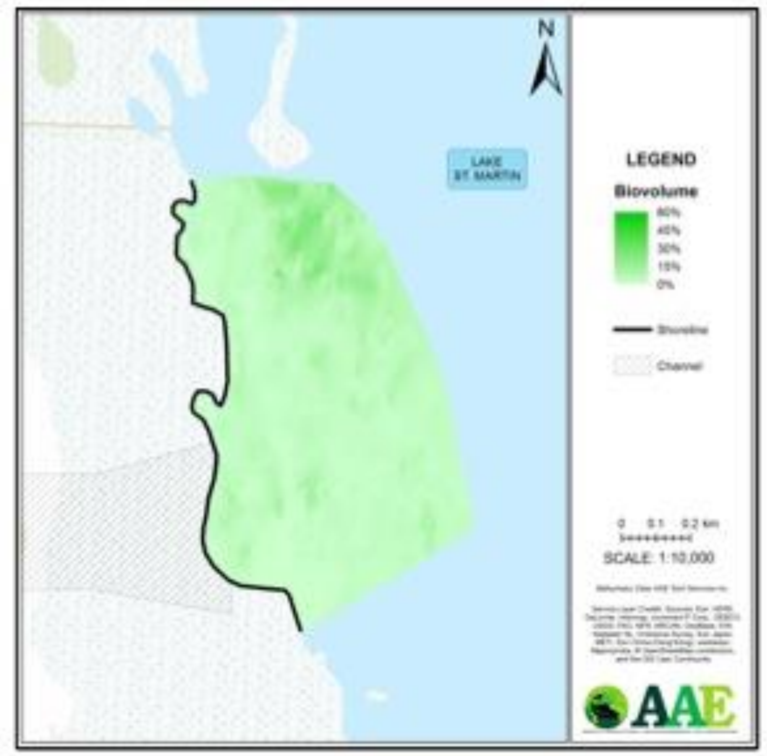
Season	Mean Temperature (°C)	Mean Dissolved Oxygen (mg/L)	Mean pH	Mean Conductivity (µS/cm)	Mean Turbidity (NTU)	Mean TSS (mg/L)
Fall 2015	-	-	-	-	-	-
Spring 2016	13.40	11.61	6.43	393.08	2.49	15.470











APPENDIX E-3.2: ROUTE C – LAKE ST. MARTIN, HARRISON BAY STUDY SITE

Location	N 51.5389° W 98.5890° ; 14U 528504.29 5709835.43
Channel Route	Lake St. Martin – Route C
Nearby Tributaries	Harrison Creek

Aquatic Species Assessment

Fish Species

- White Sucker
- Northern Pike
- Yellow Perch
- Shorthead Redhorse
- Blacknose Shiner
- Lake Whitefish
- Fathead Minnow
- Troutperch
- Walleye
- Freshwater Drum
- Mottled Sculpin
- Spottail Shiner
- Common Carp
- Golden Shiner
- Black Bullhead
- Emerald Shiner

Comments
- Commercial, Aboriginal and Recreational Fish present

Invertebrate Orders

- Ephemeroptera
- Diptera
- Amphipoda
- Trombidiformes
- Odonata
- Trichoptera
- Nematoda
- Hemiptera
- Coleoptera
- Megaloptera

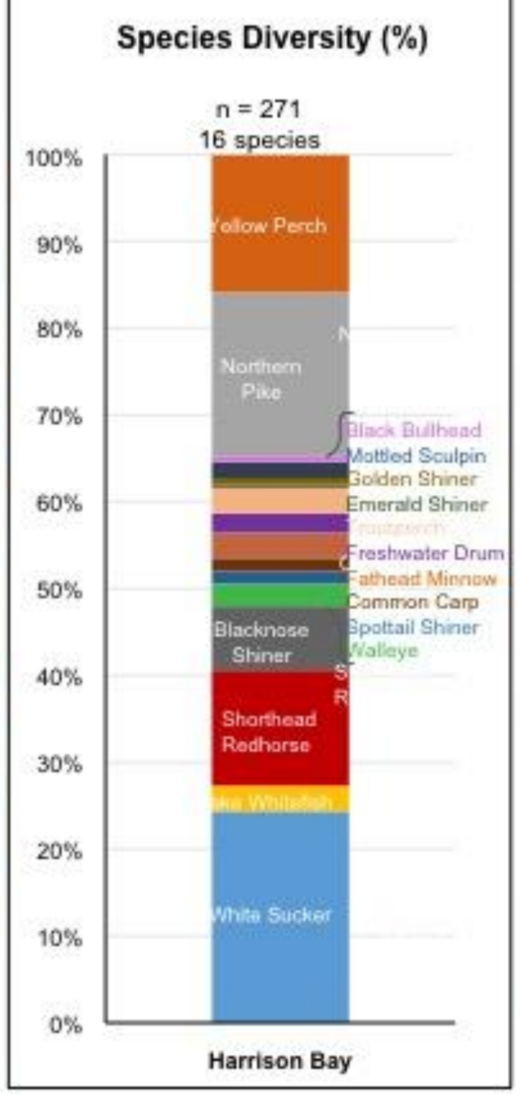
Comments
- Productive Habitat on Lake St. Martin
- Diverse invertebrate community identified
- Fish will use the habitat for spawning, nursery, and feeding
- Wetland habitat

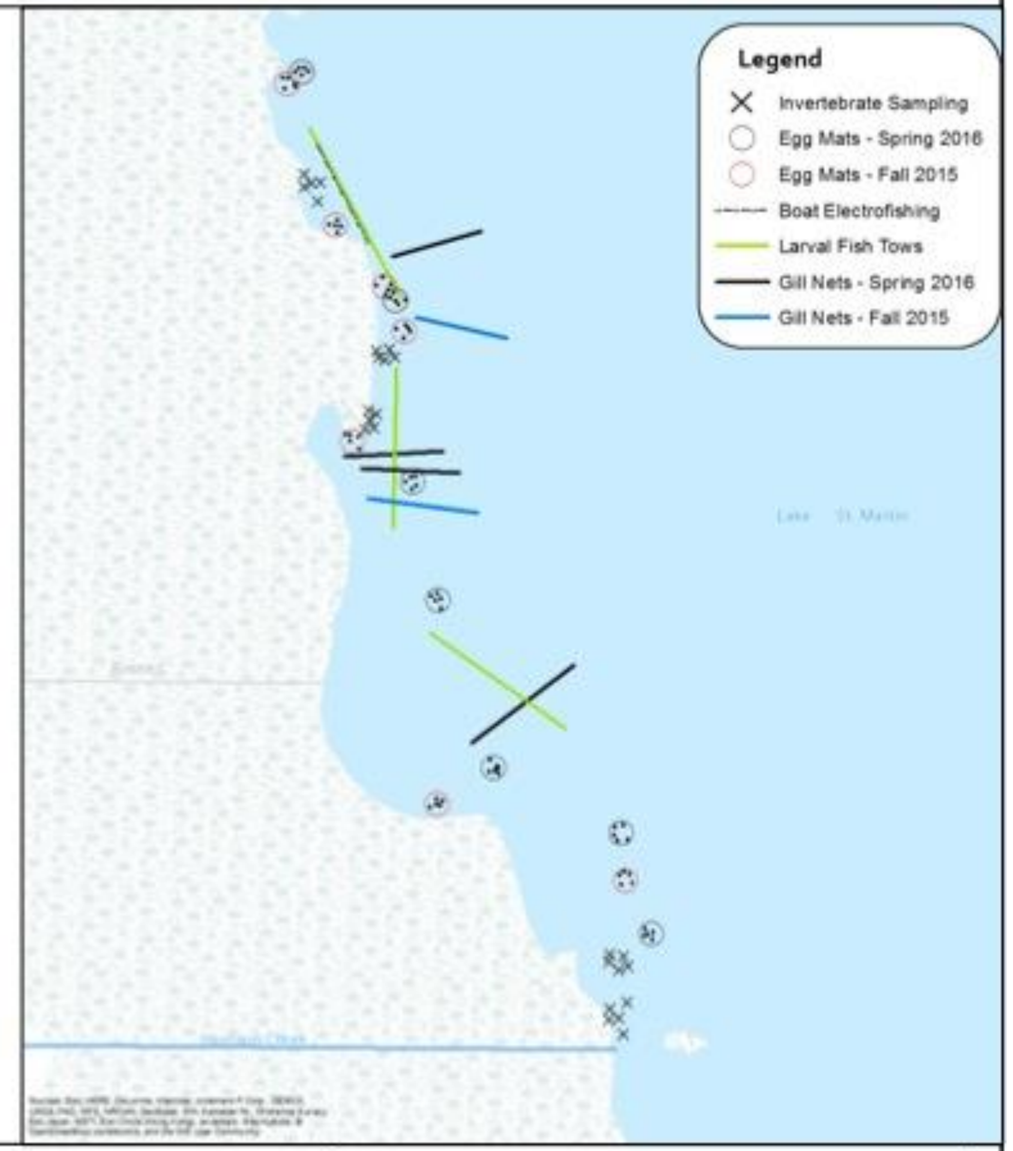
Fish Spawning Activity

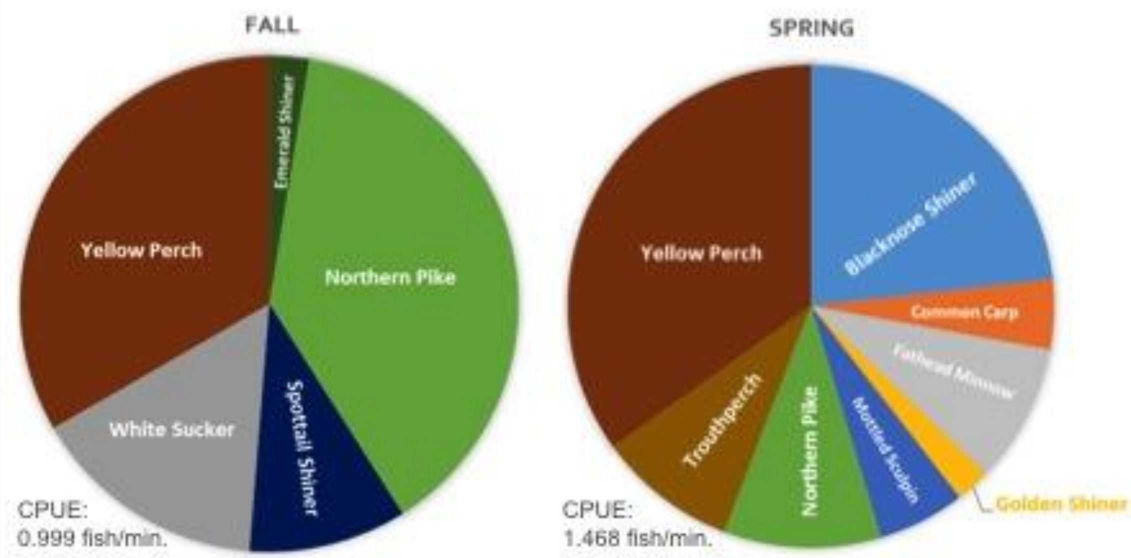
- Adults in spawning condition
  - *Fall: Lake Whitefish (n = 3)*
  - *Spring:*
    Northern Pike (n = 17)
    Walleye (n = 4)
    White Sucker (n = 57)
- Larval fish (Spring)
  - *White Sucker (n = 5577)*
  - *Walleye (n = 267)*
- Eggs (Fall and Spring)
  - No eggs captured

Comments
- CRA Fish species present
- Very Productive area based on Larval Drift tows
- Wetland habitat will likely be used by Northern Pike, Yellow Perch and forage fish for spawning

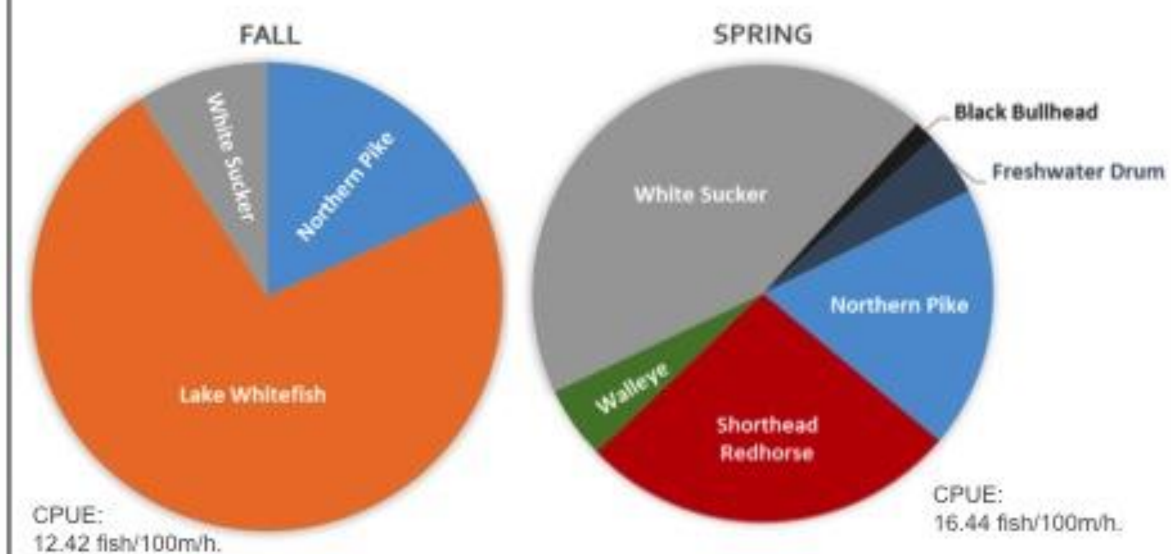
Five Most Commonly Captured Fish Species (*Comprise 80% of Total Catch*)



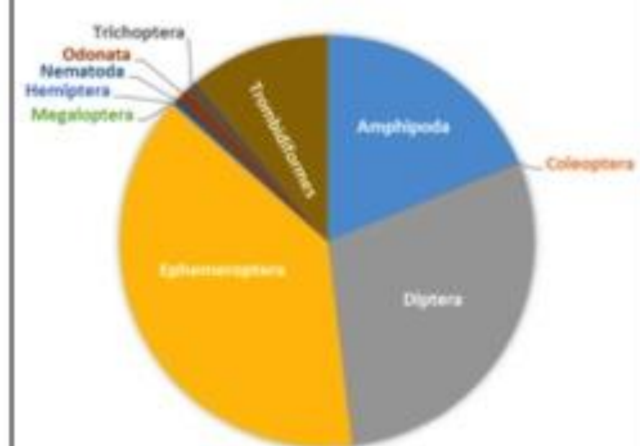




Relative Species Abundance for Fish Captured during Fall and Spring Boat Electrofishing



Relative Species Abundance for Fish Captured during Fall and Spring Gill Netting



Relative Species Abundance for Benthic Invertebrates Captured during Fall Sampling

APPENDIX E-4.1: ROUTE D – LAKE ST. MARTIN, BIRCH BAY STUDY SITE

Location	N 51.4848° W 98.5113° ; 14U 533933.20 5703851.96
Channel Route	Lake St. Martin – Route D
Nearby Tributaries	Birch Creek

Habitat Assessment

Aquatic Habitat

Bathymetry

- Steep slope at Route D outlet, relatively uniform, gentle slope throughout remainder of site
- Maximum depth 3.71 m ~600 m from shore
- Extensive coastal wetland habitat hindered survey

Substrate

- Three distinct types:
  - 70% gravel 30% sand: <2.5 m depth;
  - >90% sand: >2.5 m depth;
  - >90% gravel: pockets at depths >3.0 m.

Aquatic Vegetation

- Vegetation primarily found at depths <2.0 m.
- Low plant height (<0.2 m).
- Plant biovolume highest (>30%) along the eastern shoreline and across the mouth of Birch Creek

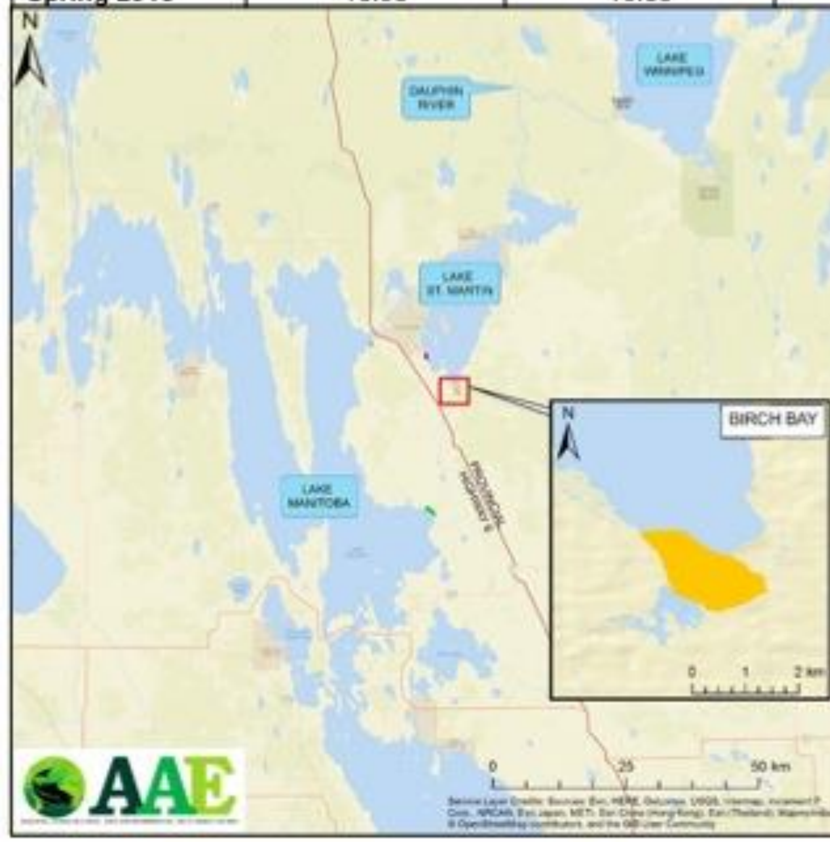
Shoreline and Riparian Habitat

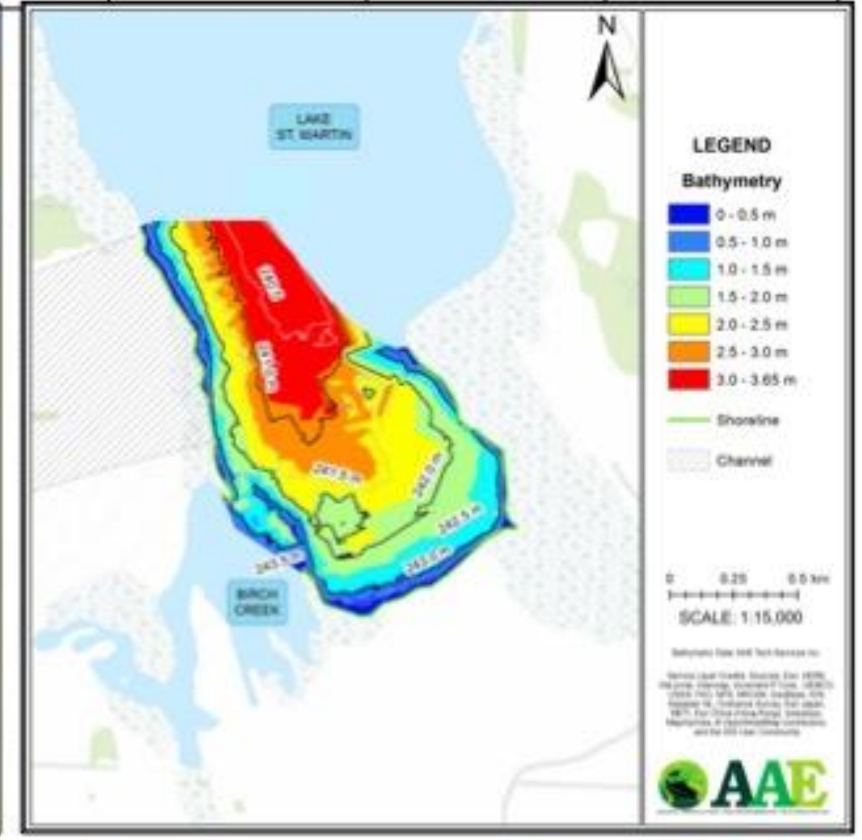
Narrow band of rocky substrates lining shoreline.

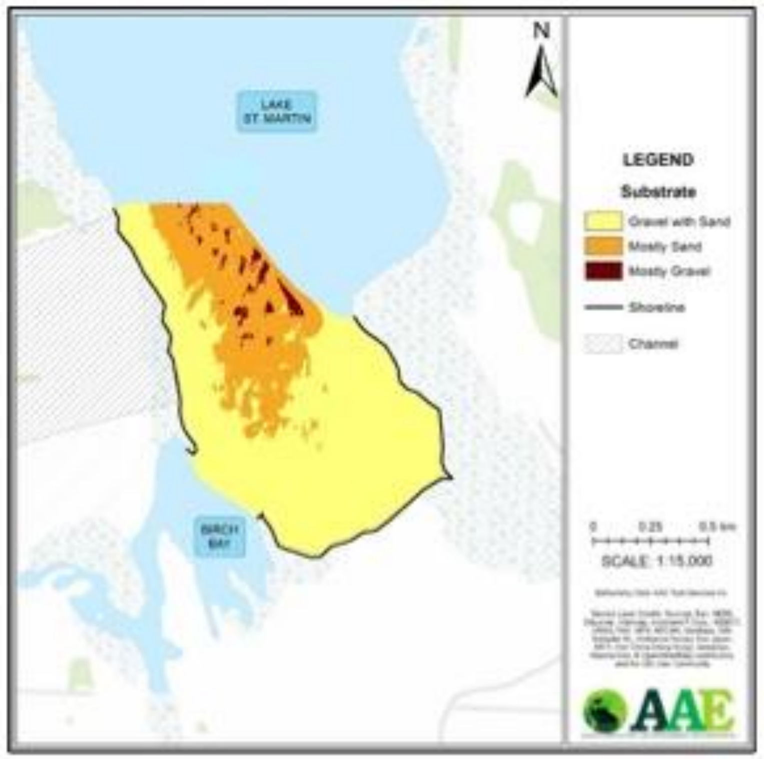
- Shoreline extends back ~10 m: compacted gravel-cobble substrate with scattered boulders.
- Cattails extends back between 62 and 127 m from the shoreline: flood plain/wetland habitat with long grass and cattail vegetation cover, and areas of standing water.
- Agricultural land (cultivated) beyond riparian habitat

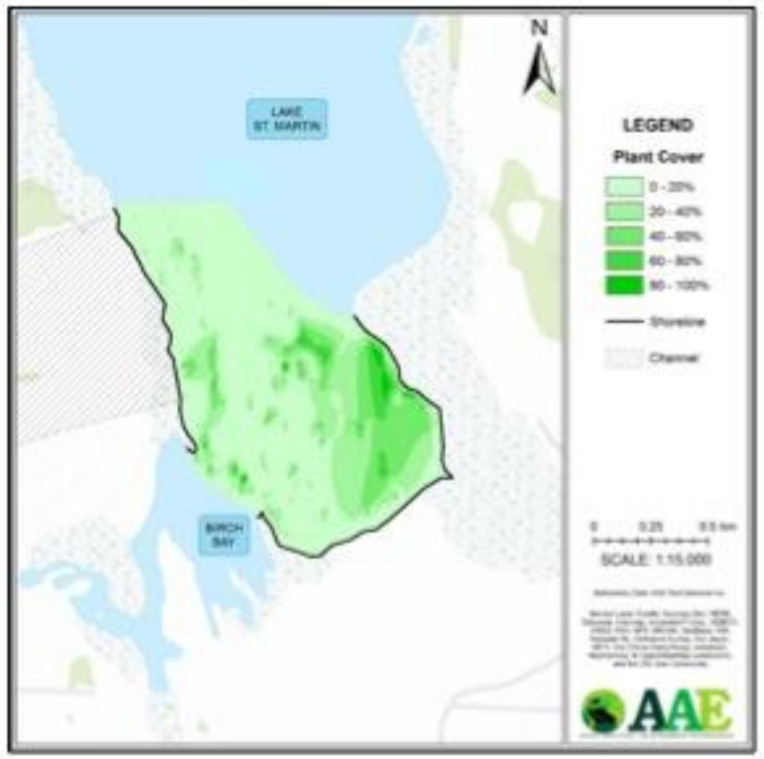
Water Quality Analysis

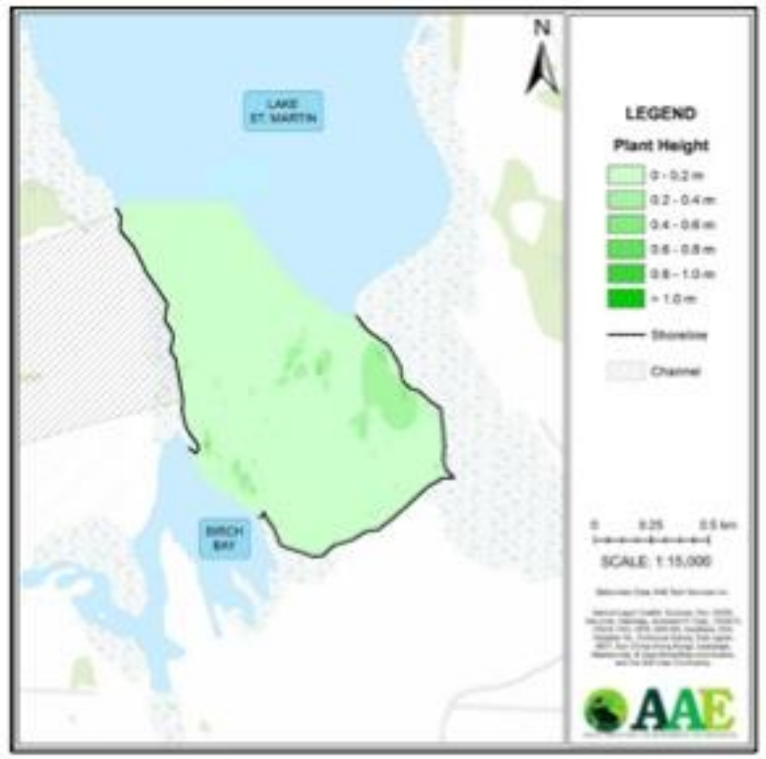
Season	Mean Temperature (°C)	Mean Dissolved Oxygen (mg/L)	Mean pH	Mean Conductivity (µS/cm)	Mean Turbidity (NTU)	Mean TSS (mg/L)
Fall 2015	5.52	10.57	6.88	683	3.20	16.486
Spring 2016	16.95	10.83	6.72	494.7	3.68	17.172

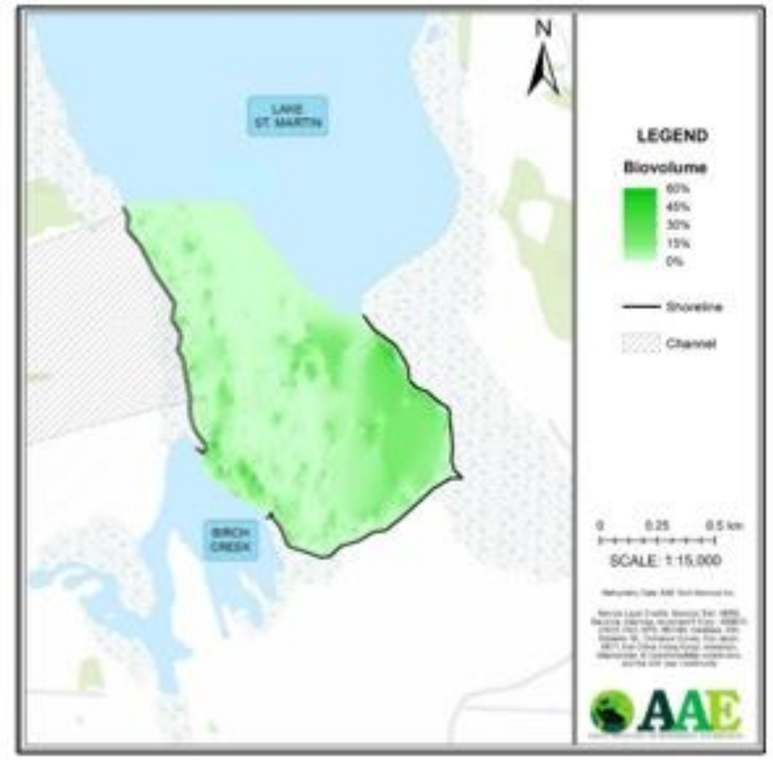












APPENDIX E-4.2: ROUTE D – LAKE ST. MARTIN, BIRCH BAY STUDY SITE

Location	N 51.4848° W 98.5113° ; 14U 533933.20 5703851.96
Channel Route	Lake St. Martin – Route D
Nearby Tributaries	Birch Creek

Aquatic Species Assessment

Fish Species

- Northern Pike
- White Sucker
- Lake Whitefish
- Common Carp
- Shorthead Redhorse
- Yellow Perch
- Cisco
- Walleye

Comments
- Commercial, Aboriginal and Recreational Fish present
- Lake Whitefish Commercial Fishery on Lake
- Northern Pike and White Sucker most abundant species captured

Invertebrate Orders

- Diptera
- Ephemeroptera
- Amphipoda
- Trombidiformes
- Hemiptera
- Odonata
- Trichoptera
- Hirudinea
- Coleoptera
- Megaloptera
- Nematoda

Comments
- Productive Habitat on Lake St. Martin
- Diverse invertebrate community identified
- Likely support Lake Whitefish within Lake as they feed primarily on benthic invertebrates

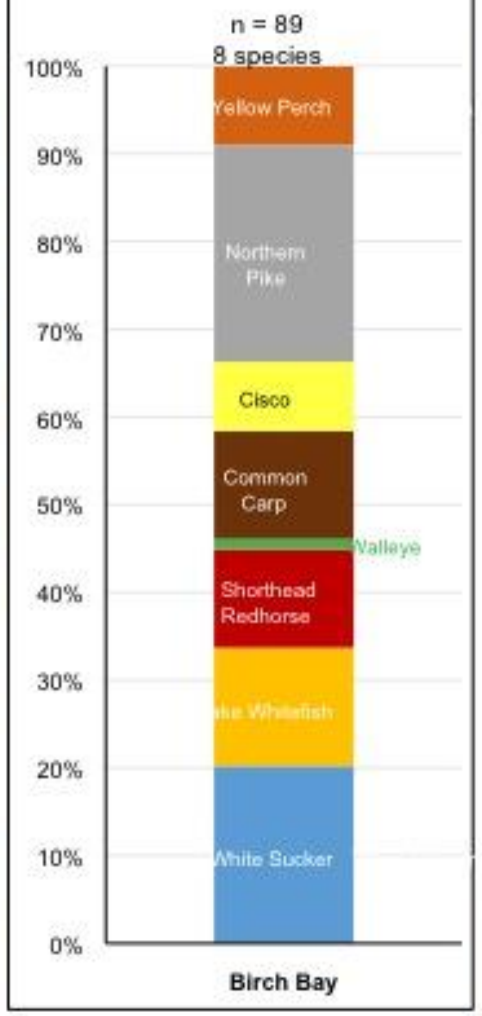
Fish Spawning Activity

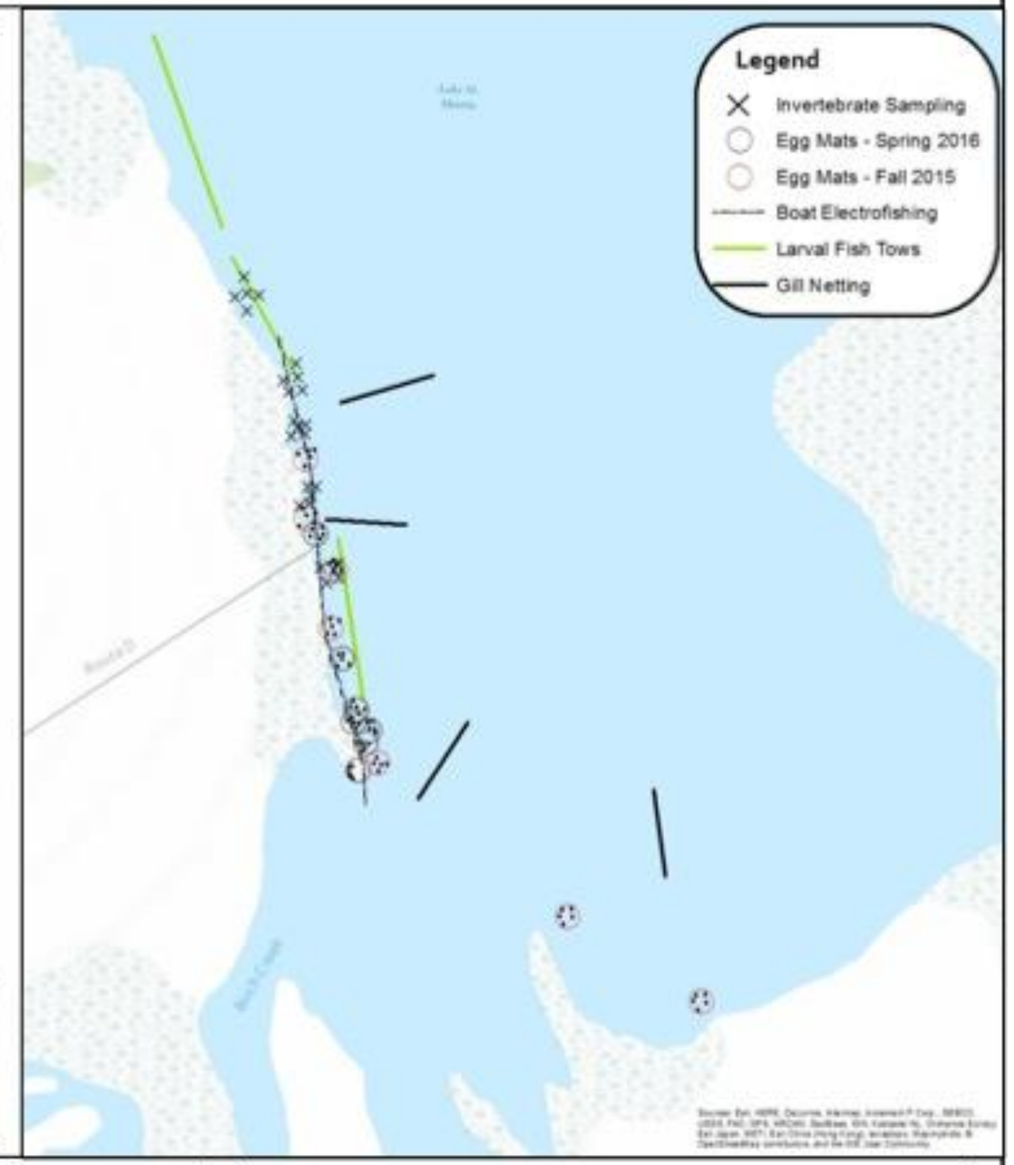
- Adults in spawning condition
  - *Fall: Lake Whitefish (n = 11)*
  - *Spring: Northern Pike (n = 12) Walleye (n = 1) White Sucker (n = 13)*
- Larval fish (Spring)
  - *White Sucker (n = 2665)*
  - *Walleye (n = 187)*
- Eggs (Fall and Spring)
  - No eggs captured

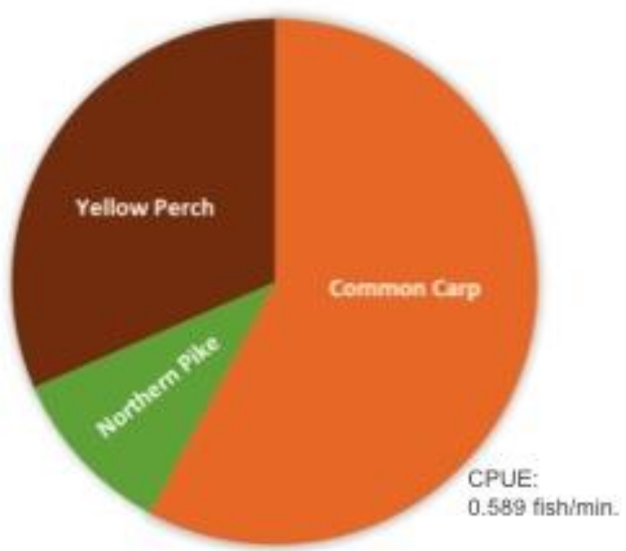
Comments
- CRA Fish species present
- Productive area based on Larval Drift tows
- Likely use habitat as migration corridor to Birch Creek
- Carp visually observed spawning along shoreline

Five Most Commonly Captured Fish Species *(Comprise 82%*

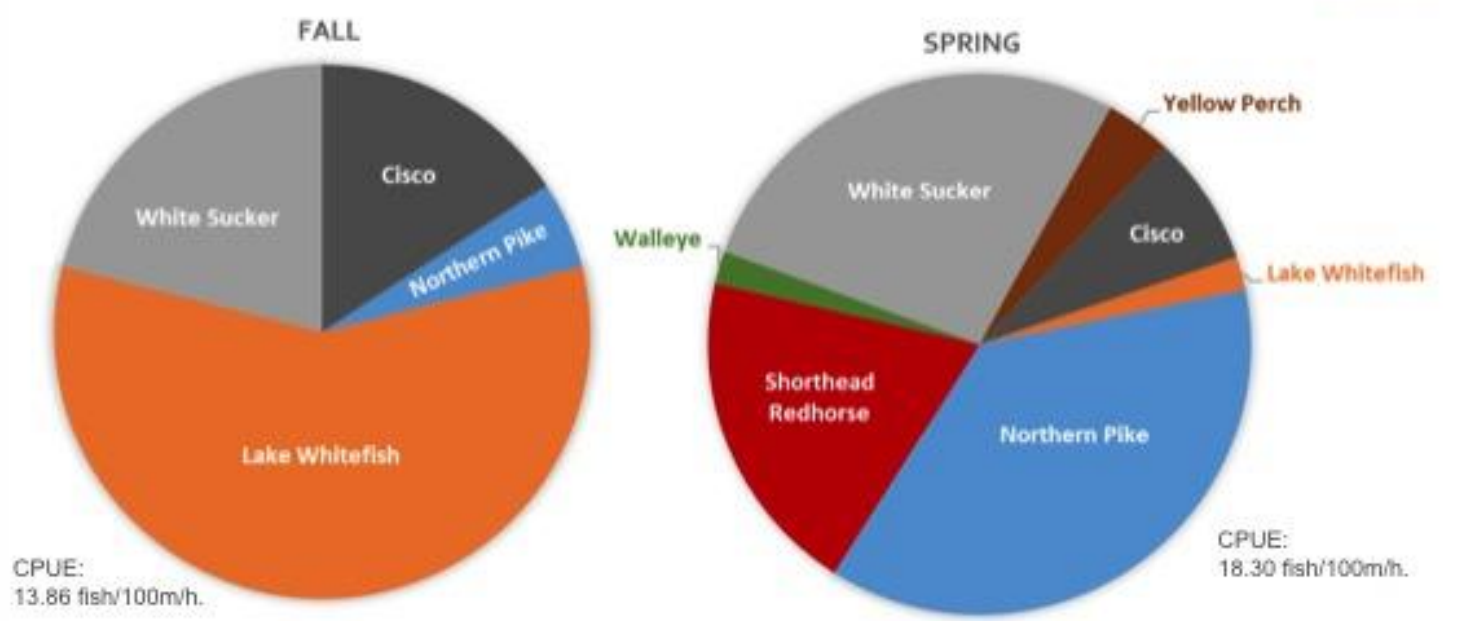
Species Diversity (%)



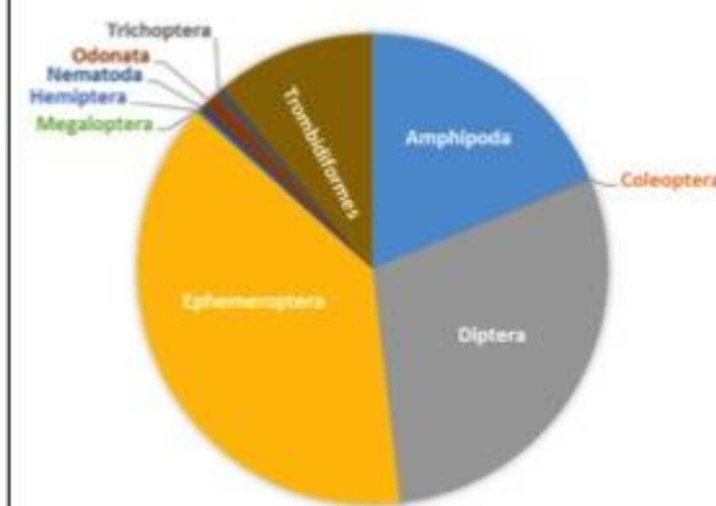




Relative Species Abundance for Fish Captured during Spring Boat Electrofishing



Relative Species Abundance for Fish Captured during Fall and Spring Gill Netting



Relative Species Abundance for Benthic Invertebrates Captured during Fall Sampling