Lake St. Martin Outlet Channel Proposed All Season Access Road Fisheries and Aquatic Habitat Assessment

Prepared for

M. Forster Enterprises

For Submission to

Manitoba Infrastructure

Manitoba

Prepared by

AAE Tech Services Inc.

AAE TECH SERVICES INC.

LAKE ST. MARTIN OUTLET CHANNEL
PROPOSED ALL SEASON ACCESS ROAD
FISHERIES AND AQUATIC HABITAT ASSESSMENT

October 2016

Prepared for

M. Forster Enterprises

For Submission to

Manitoba Infrastructure

Prepared by

Mark Lowdon, M.Sc.

Kyle Muirhead, M.Sc.

Jaclyn Oliver, B.Sc.

AAE Tech Services Inc.

AAE Tech Services Inc.
57 First Avenue
La Salle, Manitoba
R0G 0A2

September 23rd, 2016

Ms. Maureen Forster
Principal Consultant/Senior Biologist
M. Forster Enterprises

Dear Ms. Forster:

RE: Lake St. Martin proposed ASR Fisheries and Aquatic Habitat Assessment

AAE Tech Services Inc. is pleased to submit our report summarizing results for the fisheries and aquatic habitat assessment of the Lake St. Martin proposed ASR (Municipal, Forestry and Winter Segments). This report serves as an updated version of the previously submitted report "Lake St. Martin proposed ASR Fisheries and Aquatic Habitat Assessment," to include information on spring use of fish utilizing the watercourse crossing along the proposed ASR that may support a Commercial, Recreational and Aboriginal Fishery.

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.

TABLE OF CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

Manitoba Infrastructure (MI) is currently developing options to address ongoing flood issues in the Assiniboine River and Lake Manitoba watershed basins. As part of this endeavour, MI initiated the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study. This study, which was completed in 2011, included several components. In particular, the "Assiniboine River & Lake Manitoba Basins Flood Mitigation Study Lake Manitoba & Lake St. Martin Outlet Channels Conceptual Design - Stage 1 - Deliverable No: LMB-01" (KGS Group 2014) and the "Assiniboine River & Lake Manitoba Basins - Flood Mitigation Study LMB & LSM Outlet Channels Conceptual Design - Stage 2" (KGS Group 2016) were key to identifying future flood protection initiatives for the Assiniboine River and Lake Manitoba watershed basins.

The Stage 1 and Stage 2 Conceptual Designs prepared by KGS and MI included the three following components:

- further development of the Lake St. Martin Outlet Channel (LSMOC), which involves development of a channel in the area referred to as Reach 2 and completion of the channel referred to as Reach 3;
- construction and operation of a new channel from Lake Manitoba to Lake St. Martin to increase flow capacity and expedite movement of flood waters between these waterbodies; and
- construction and operation of an All Season Road (ASR) in the area of the Lake St. Martin Outlet Channels to facilitate year-round vehicle, crew and equipment access to the Lake St. Martin Outlet Channels.

These three main components formed the overall MI Lake Manitoba and Lake St. Martin Access Road and Outlet Channels Project (the Project) at the time of this writing. This report describes the methods and findings of the baseline fish and aquatic habitat assessment for the proposed ASR component of the Project and was completed in accordance with Standard Fisheries and Oceans Canada Practices and Data Collection Techniques and Report Guidelines. The report begins with identifying the project's scope of work, objectives and methods, followed in Section 5 by defining the project study area and the specific watercourse crossings assessed. In Section 6, a description of fish habitat at each site is presented. In Section 7, the fish community and fish catch data for the study is presented. Section 8 provides a summary of the baseline results collected for the fish and aquatic habitat assessment for the works associated with the proposed ASR. Results of this study will be included as part of baseline investigations to be used in the provincial and federal approvals process for the Project.

2.0 BACKGROUND

As noted above, further development of a Lake St. Martin Outlet Channel (LSMOC) includes the requirement for an ASR in the area of the LSMOC to facilitate year-round vehicle, crew and equipment access. During previous construction and operation of the LSMOC, access to the area was restricted to winter roads extending from the end of Idylwild Road. The Idylwild road is an existing forestry road that runs north from Birch Lake Drive, which is a municipal road located east of the communities of Grahamdale and Spearhill and connects to Dewald Road. In an effort to improve area access, MI plans to construct an ASR on the existing municipal, resource and winter road alignments. The provision of an ASR to access the LSMOC will also require the upgrading and expansion of sections of the municipal road and the Idylwild forestry road. As such, the ASR component of the Project (ASR Project) is defined as the works associated with the upgrading, construction and operation of the affected areas of the municipal road, the Idylwild forestry road, the LSMOC Reach 3 Winter Road Access and the LSMOC Reach 1 proposed ASR Alignment, to an ASR. Figure 1 provides a map of the proposed ASR Project local study area.

3.0 SCOPE OF WORK

This assessment sought to meet the following objectives:

- Collect information on the existing fish and aquatic habitat within the LSMOC proposed ASR to establish the baseline conditions and support the EIA for the project;
- Identify key fish habitat and fish species that are part of Commercial, Recreational or Aboriginal (CRA) fishery that may be affected by the proposed road improvements;
- Identify all creek crossings along the proposed ASR extent where CRA fish species may exist;
- Conduct fall and spring fish surveys at each identified crossing along the proposed ASR to identify fish species at crossing locations, with emphasis on CRA species and Species at Risk (SAR);
- Assess connectivity of watercourse crossings along the proposed ASR to larger waterbodies where fish may overwinter, with special emphasis on CRA and SAR; and
- Describe the aquatic and riparian habitat conditions, including substrate classification, aquatic cover (i.e. woody debris, emergent or submerged vegetation, undercut banks, large boulders, etc.), water quality, and water velocity at each watercourse crossing.

4.0 STUDY AREA

The LSMOC proposed ASR originates approximately 1.5 kilometres (km) north of Spearhill, MB (Figure 1). The proposed ASR includes 20.6 km of municipal road, 48 km of existing forestry road (Idylwild Road) and 48 km of winter road (Lovie 2015, pers. comm.). At its closest point, Lake St. Martin is located approximately 10.0 km to the west of the winter road. The winter road extends northeast where it terminates at Johnson Beach and Willow Point on Lake Winnipeg, approximately 9 km east of Dauphin River FN. The overall landscape has been classified primarily as marsh/wetland habitat, consisting of large extents of standing water or water with no definable flow direction, and extensive, dense vegetation cover.

4.1 SITE SELECTION

On October 6, 2015, an initial site inspection was completed to assess the roadway prior to field investigations. In addition to the initial site survey, an aerial survey was conducted by helicopter on October 9, 2015 to examine the extent of the roadway to be upgraded and to delineate the sampling reaches prior to the commencement of fieldwork, which was to include all creek crossings along the roadway area (municipal, forestry and winter road segments).

Crossings were identified during the aerial survey of the roadway, taking into consideration:

1) Presence of a culvert at or near the potential crossing site;
2) A defined or partially defined creek bed/course identifiable within the landscape surrounding the crossing site; and
3) The apparent or potential connectivity of the water crossing the road to the surrounding creek systems.

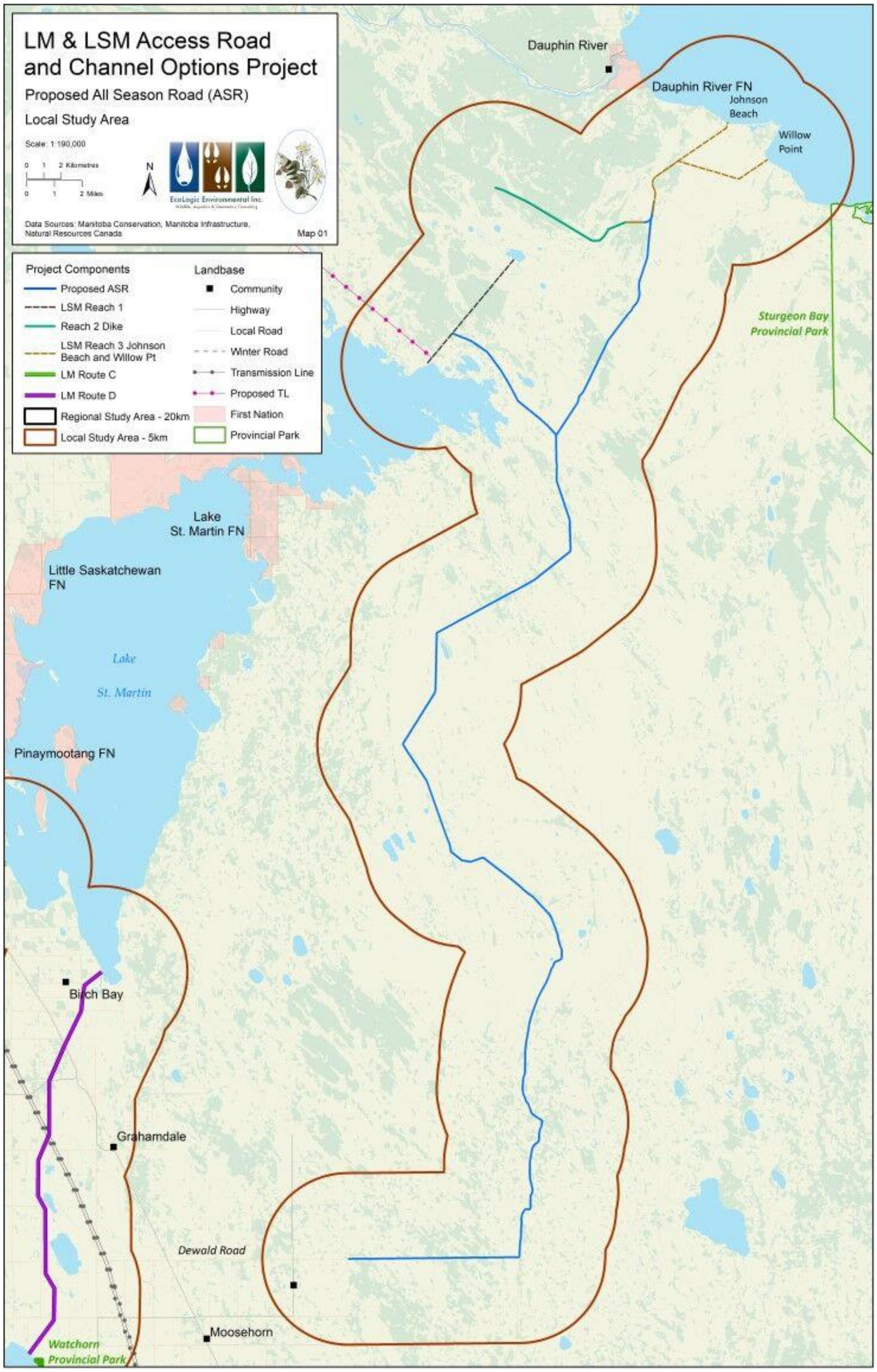

Figure 1. *Lake St. Martin Outlet Channels Proposed ASR Project Local Study Area.*

Using this definition of a true creek crossing, drainage passages installed to manage wetland levels and mitigate roadway flooding were not included in this assessment. The aerial inspection identified three potential fish bearing creek crossings, henceforth referred to as Crossing 1, Crossing 2 and Crossing 3 (Figure 3).

- Crossing 1 (51.392390° -98.145460°) was located approximately 6.9 km north of the intersection of Birch Lake Drive and Ridge Road and crosses Winthers Creek.
- Crossing 2 (51.404130° -98.140520°) was located approximately 1.6 km north of Crossing 1 and also crosses Winthers Creek (Figure 2). A section of creek further downstream of the crossing was accessed via existing recreational vehicle trails, providing an extended area of study for assessment of this site.
- Crossing 3 (51.673674° -98.183877°) was located at the headwaters of Bear Creek, approximately 800 metres (m) from the terminus of the existing forestry road and the beginning of the winter road.

Figure 2. *Crossing 2, view upstream; culvert blockage has resulted in significant water retention.*

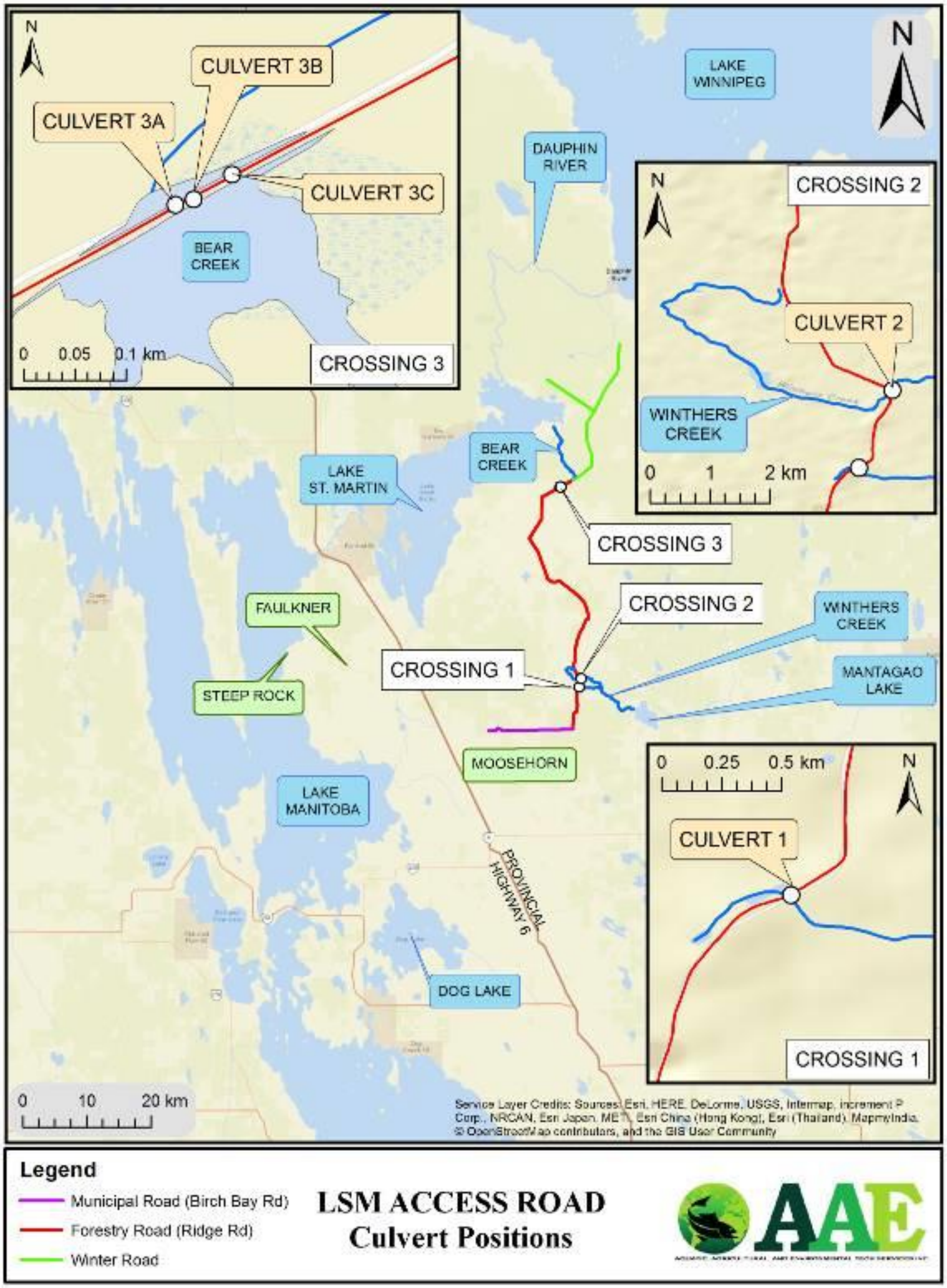

Figure 3. *Extent of existing access road to be upgraded; showing three creek crossings identified for assessment as potential habitat for fish species.*

5.0 METHODS

5.1 DESKTOP STUDY

A desktop study was completed prior to the start of fieldwork to determine those fish species likely to inhabit the creek crossings along the roadway area. Using distribution maps published by Stewart and Watkinson (2007), a list of fish species potentially inhabiting the area was produced (Table 1). Note that habitat requirements and connectivity of the watercourse crossings may affect and limit the presence of the fish species identified in Table 1.

Results of the desktop study identified forty fish species with distribution ranges extending to include the existing LSMOC proposed ASR. More notable CRA fish species with distribution ranges extending to the proposed ASR include, but are not limited to, Yellow Perch (*Perca flavescens*), White Sucker (*Catostomus commersonii*), Northern Pike (*Esox lucius*) and Walleye (*Sander vitreus*). Of the forty species identified in the desktop review, only 11 species occupy similar habitats identified at the three creek crossings. These fish species have been highlighted in Table 1.

5.2 FIELD STUDIES

Various sampling techniques and gear were used to assess and capture fish within the project area at the three creek crossings. Sampling methods described within this report were adapted from Newbury and Gaboury (1993) and Harrelson et al. (1994). The primary sampling methods used were backpack electrofishing, trap netting, and gill netting (Section 7). All methods were performed to minimize harm to captured fish. Sampling locations for all data collection methods are presented in Appendix A.

Table 1. *List of fish species with distribution ranges extending to include the LSMOC proposed ASR. (Stewart and Watkinson 2007). Species captured from Crossings 1 to 3 are highlighted in blue and species captured in Mantagao Lake are highlighted in orange.*

Common Name	Species	Family	SARA Status	COSEWIC Status
Lake Sturgeon	*Acipenser fulvescens*	Acipenseridae	No Status	Endangered
Goldeye	*Hiodon alosoides*	Hiodontidae	Not Listed	Not Listed
Carp	*Cyprinus carpio*	Cyprinidae	Not Listed	Not Listed
Pearl Dace	*Margariscus margarita*	Cyprinidae	Not Listed	Not Listed
Golden Shiner	*Notemigonus crysoleucas*	Cyprinidae	Not Listed	Not Listed
Emerald Shiner	*Notropis atherinoides*	Cyprinidae	Not Listed	Not Listed
Blacknose Shiner	*Notropis heterolepis*	Cyprinidae	Not Listed	Not Listed
Spottail Shiner	*Notropis hudsonius*	Cyprinidae	Not Listed	Not Listed
Northern Redbelly Dace	*Phoxinus eos*	Cyprinidae	Not Listed	Not Listed
Finescale Dace	*Phoxinus neogaeus*	Cyprinidae	Not Listed	Not Listed
Fathead Minnow	*Pimephales promelas*	Cyprinidae	Not Listed	Not Listed
Longnose Dace	*Rhinichthys cataractae*	Cyprinidae	Not Listed	Not Listed
Quillback	*Carpiodes cyprinus*	Catostomidae	Not Listed	Not Listed
White Sucker	*Catostomus commersonii*	Catostomidae	Not Listed	Not Listed
Silver Redhorse	*Moxostoma anisurum*	Catostomidae	Not Listed	Not Listed
Shorthead Redhorse	*Moxostoma macrolepidotum*	Catostomidae	Not Listed	Not Listed
Black Bullhead	*Ameiurus melas*	Ictaluridae	Not Listed	Not Listed
Channel Catfish	*Ictalurus puntatus*	Ictaluridae	Not Listed	Not Listed
Northern Pike	*Esox lucius*	Esocidae	Not Listed	Not Listed
Muskellunge	*Esox masquinongy*	Esocidae	Not Listed	Not Listed
Central Mudminnow	*Umbra limi*	Umbridae	Not Listed	Not Listed
Cisco	*Coregonus artedi*	Salmonidae	Not Listed	Not Listed
Lake Whitefish	*Coregonus clupeaformis*	Salmonidae	Not Listed	Not Listed
Rainbow Trout	*Oncorhynchus mykiss*	Salmonidae	Not Listed	Not Listed
Arctic Char	*Salvelinus alpinus*	Salmonidae	Not Listed	Not Listed
Brook Trout	*Salvelinus fontinalis*	Salmonidae	Not Listed	Not Listed
Troutperch	*Percopsis omiscomaycus*	Percopsidae	Not Listed	Not Listed
Burbot	*Lota lota*	Gadidae	Not Listed	Not Listed
Brook Stickleback	*Culaea inconstans*	Gasterosteidae	Not Listed	Not Listed
Ninespine Stickleback	*Pungitius pungitius*	Gasterosteidae	Not Listed	Not Listed
Mottled Sculpin	*Cottus bairdii*	Cottidae	Not Listed	Not Listed
Rock Bass	*Ambloplites rupestris*	Centrarchidae	Not Listed	Not Listed
Iowa Darter	*Etheostoma exile*	Percidae	Not Listed	Not Listed
Johnny Darter	*Etheostoma nigrum*	Percidae	Not Listed	Not Listed
Yellow Perch	*Perca flavescens*	Percidae	Not Listed	Not Listed
Logperch	*Percina caprodes*	Percidae	Not Listed	Not Listed
River Darter	*Percina shumardi*	Percidae	Not Listed	Not at Risk
Sauger	*Sander canadensis*	Percidae	Not Listed	Not Listed
Walleye	*Sander vitreus*	Percidae	Not Listed	Not Listed
Freshwater Drum	*Aplodinotus grunniens*	Sciaenidae	Not Listed	Not Listed

6.0 FISH HABITAT

Fish habitat for this report is defined as any habitat that is essential to or acts as spawning ground and nursery, rearing, food supply and/or migration areas on which fish depend directly or indirectly to carry out their life processes (*Fisheries Act* Section 34(1)).

To classify fish habitat at the crossing locations, the Fisheries and Oceans (DFO) classification flowchart for streams and constructed drains through agricultural areas was used as a guide (Milani 2013). The Habitat Type Flow chart classifies habitat based on a combination of fish use and habitat complexity (Figure 4).

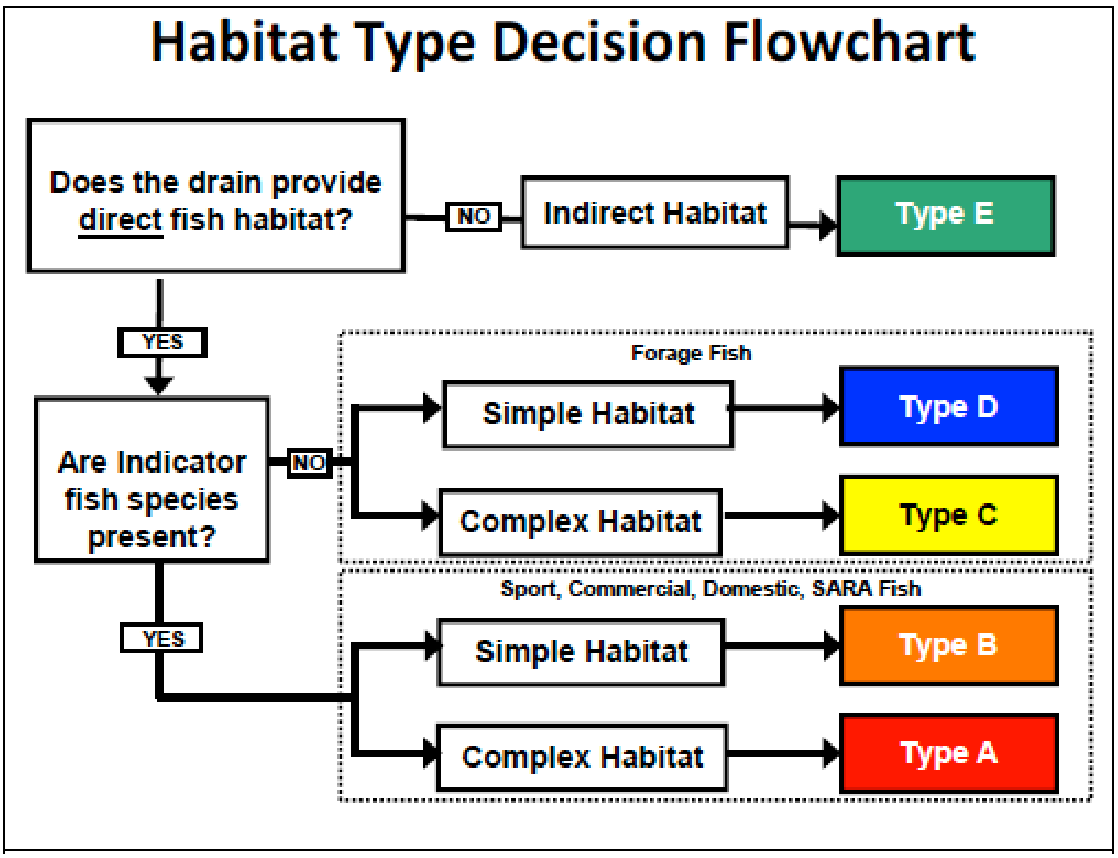

Figure 4. *Fish habitat classification decision flowchart applied to crossing in the study area.*

Where CRA or SARA listed species are present, habitat is classified as Type A or B:

- Type A – Complex habitat, where **one** of the following exists: increased diversity of substrates, cover, or flow regimes; or
- Type B – Simple habitat, with one common substrate type, uniform flow, uniform water depth and low to moderate cover.

Where only forage fish were present, habitat was classified as Type C or D:

- Type C - Complex habitat, where **one** of the following exists: increased diversity of substrates, cover, or flow regimes; or
- Type D - Simple habitat, with one common substrate type, uniform flow, uniform water depth and low to moderate cover.

Where no fish were present, habitat was classified as Type E.

- Type E – Indirect fish habitat, where no fish species are identified.

6.1 HABITAT CLASSIFICATION METHODS

In order to classify fish habitat at the various crossings, a number of parameters were assessed and are described below. Sampling methods described within this report were adapted from Newbury and Gaboury (1993) and Harrelson *et al.* (1994).

Channel Morphology and Habitat Composition

Physical characteristics and habitat structure were qualitatively assessed at each crossing. This qualitative assessment included:

- Cover type (i.e., presence/absence of submerged or emergent vegetation, presence of large boulders, undercut banks, woody debris, etc.),
- Substrate composition of the creek bed (clay, silt, sand, gravel, cobble, boulder, etc.), based on a simplified Wentworth Scale for substrate classification (Wentworth 1922, Table 2), and
- Sinuosity, and habitat type (run, riffle, pool, etc.).

Water Velocity

A Swoffer 2100 current velocity meter was used to measure water velocities immediately downstream of each crossing. An additional velocity profile was also calculated in the distal downstream reach of Crossing 2 (51.405190° -98.137709°).

Water Quality

Water turbidity (Nephelometric Turbidity Units (NTU) measured *in-situ*), temperature (°C), conductivity (µS/cm), pH and dissolved oxygen (DO, mg/L) were measured immediately upstream of each crossing during fall and spring sampling. Additional sampling was conducted at Mantagao Lake, the headwaters of Winthers Creek, located approximately 9 km east of the Crossing 2, in the summer of 2016. A La Motte 2020we turbidity meter was used to assess turbidity (NTU) and a YSI multimeter measured remaining water chemistry variables.

Table 2: Modified Wentworth scale for substrate classification.

	size - (mm)	Modified
Clay	<0.0039	clay
Silt	0.0039-0.059	Silt
Sand	0.06-1.99	Sand
VF Gravel	2 - 2.8	Gravel
VF Gravel	2.8 - 4	
Fine Gravel	4 - 5.6	
Fine Gravel	5.6 - 8	
Med. Gravel	8 - 11.3	
Med. Gravel	11.3 - 16	
Coarse Gravel	16 - 22.6	
Coarse Gravel	22.6 - 32	
VC Gravel	32 - 45.3	
VC Gravel	45.3 - 64	
Sm. Cobble	64 - 90.5	Cobble
Sm. Cobble	90.5 - 128	
Lg. Cobble	128 - 181	
Lg. Cobble	181 - 256	
Sm. Boulder	256 - 362	Boulder
Sm. Boulder	362 - 512	
Med. Boulder	512 - 1024	
Lg. Boulder	1024 - 2048	
VL Boulder	2048 - 4096	
Bedrock	>4096	Bedrock

Habitat Connectivity and Fish Passage

Habitat connectivity refers to the level at which the landscape facilitates species movement and other ecological flows within a system (Hanski 1999). In aquatic systems, habitat connectivity includes the ability for water, nutrients, and fish and aquatic invertebrates to move freely within the system. Segmentation of an aquatic system, through natural (e.g. landslides, beaver dams) or artificial (weirs, dams, perched culverts) barriers can result in limitations to connectivity, including the blocking of nutrient flow, or creating barriers to fish passage which can limit or prevent access to spawning, forage, and/or protective habitats

Culverts can play a key role in aquatic habitat connectivity, potentially impacting fish passage and flow dynamics. Perched culverts (base of culvert is above the water line), underside culverts (flow velocity through the culvert is too fast for fish to migrate through it), or damaged/blocked culverts (culvert collapse, blockages, beaver dams) can act as barriers to fish passage. All culverts installed at each crossing were evaluated for characteristics potentially impacting fish habitat and connectivity, including culvert diameter, perching, blockage, and presence/absence of wildlife passage grates.

Riparian Habitat

Riparian habitat was also incorporated into final habitat classifications, specifically in considering vegetative cover (overhanging trees, etc.) and species complexity (simple grasses, grass/shrub/tree cover, etc.). These factors can influence aquatic habitat and ecosystem health through stream bank stability, protective cover, and aquatic habitat characteristics (e.g. undercut banks, woody debris, shoals/riffles, etc.). Analysis of these parameters was combined with the results of the fish community surveys (Section 5) to classify aquatic and riparian habitat upstream and downstream of each crossing using the DFO classification flowchart for streams and constructed drains through agricultural areas (Milani 2013) (Figure 3).

6.2 HABITAT CLASSIFICATION RESULTS

Upstream habitat was similar at all three crossing sites, marked by extensive beaver activity at all three crossings, and across the study area, indicated by the presence of dams and lodges, abundant woody debris along shorelines, and beaver cut stumps. As a result, woody debris and soil have accumulated upstream of all culverts resulting in significant water retention and road washout at all three sites, with little to no flow through the crossings. These watercourses were lined uniformly with silt substrate, which ranged from very soft to firm and was scattered in some areas with woody debris, which provide a low level of instream cover for fish. Emergent vegetation and, within shallower regions (usually < 1 m), submerged vegetation was generally dense along shorelines and provided a moderate degree of cover. Submerged aquatic vegetation was less abundant immediately alongside the proposed ASR at the crossing due to the steeply-sloping banks. Floating aquatic vegetation was abundant upstream of Crossing 1 and provided a high level of instream cover for fish.

Downstream habitat was more variable among sites and often differed from the upstream habitat. At Crossing 1, a very narrow creek extending a short distance (~10m) opened into a large beaver pond. Both the creek and pond were steep sided with no-flow and a silt substrate. Creek depth reached approximately 1 m, while pond depth extended beyond 2 m. The downstream bank was undercut, preventing upstream species passage. Most cover was provided by woody debris and, along shorelines, densely-packed emergent vegetation, grasses and light to moderate tree cover. Unlike upstream, floating vegetation was minimal and was restricted to the pond beyond the narrow creek.

Aquatic habitat downstream of Crossing 2 was different from the large, deep pond observed upstream. Within the proximal downstream reach, water travelled through a narrow, shallow stream (usually < 0.5 m) which branched through dense areas of grasses and woody debris, providing moderate to heavy cover. Substrate was more complex, consisting mainly of silt and sand, transitioning intermittently into gravel/cobble riffles. The upstream boundary of the distal downstream reach was marked by a large beaver dam. Within the distal downstream reach, the creek was shallower and unbranched. Although cover was reduced, with woody debris and submerged vegetation becoming less abundant, substrate was highly complex, including silt, sand, gravel, cobble, and boulder. Riffle habitat was also commonly observed over gravel and cobble substrates within this region.

In the absence of any flow, downstream habitat at Crossing 3 consisted of a small, stagnant pool. The pond, which reached a maximum depth of approximately 1 m, had a very soft silt substrate and very dense submerged aquatic vegetation, providing excellent cover for fish species, especially Central Mudminnow (*Umbra limi*).

6.2.1 WATER VELOCITY

During the fall study period, water velocity measurements were only obtained at Crossing 2 due to the no-flow conditions observed at Crossings 1 and 3 (Table 1). The study took place during a period when routine maintenance of the culverts crossings was being conducted by MI. Grubbing and clearing of the culvert at Crossings 1 and 2 took place October 22, 2015. Average water velocities at Crossing 2 were measured on October 22, 2015 and again October 23, 2015 to document changes in response to the this clearing. Water velocity was 0.28 m/s on October 22, 2015 very shortly after grubbing, and 0.18 m/s the following day once upstream water levels had dropped. Despite cleaning, no observable flow was present at Crossing 1, likely due to beaver activity immediately upstream of the crossing site. All three crossing sites saw zero flow conditions in the spring of 2016, as advanced beaver activity had resulted in the complete blockage of all culverts at all sites. It did not appear as if further grubbing and clearing of any culverts along the proposed ASR had occurred following the noted clearing of Crossing 2.

A cross-section profile of the distal downstream reach of Crossing 2 shows a maximum average velocity of 0.34 m/s within the center of the channel (Figure 5). Substrates within the cross-section included silt, sand, cobble, and boulder. Maximum observed depth was 18 cm.

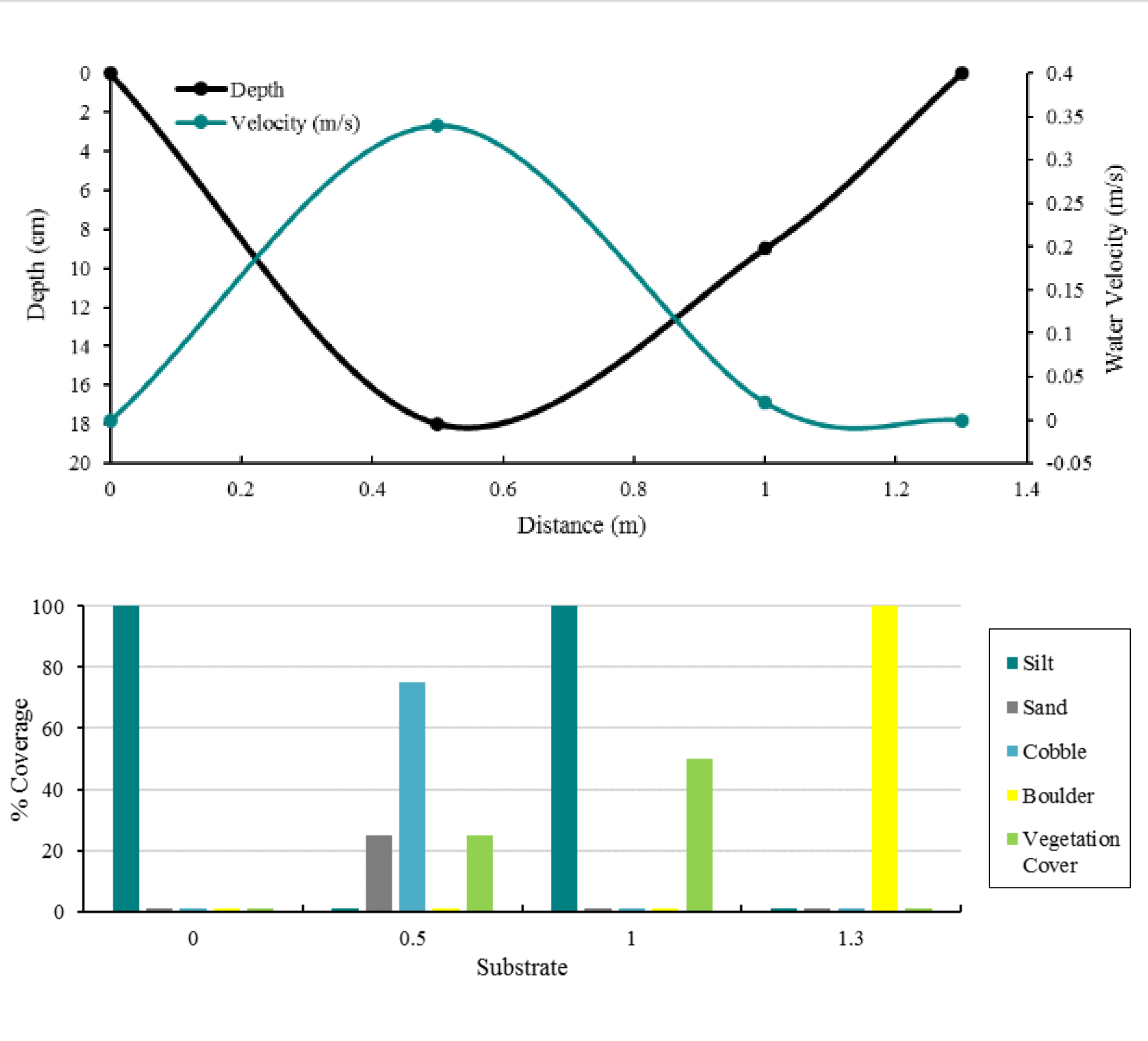

Figure 5. *Cross-section profile for distal downstream reach of Crossing 2, including depth/velocity (top) and substrate composition (bottom).*

6.2.2 WATER QUALITY

Water quality results are presented in Table 3. Water temperatures at the creek crossings ranged between 6.5°C and 7.0°C for the fall assessment and 10.0°C and 12.8°C for the spring assessment, respectively. Additional sampling at Mantagao Lake was carried out in the summer of 2016, which had a higher average water temperature of 24.0°C.

Turbidity measurements taken during the fall showed Crossing 2 as markedly less turbid than Crossings 1 or 3, likely due to culvert clearing and increased flow rates at this site. Subsequent turbidity measurements in the spring showed similar turbidity levels at all three sites. Similar values were observed at Mantagao Lake (Figure 2).

Conductivity and pH levels were similar at all three crossing sites in both the fall and spring field seasons. DO was slightly higher at the Crossing 3 site in both fall and spring seasons, likely due to the large volume of water retained at this site and the associated wave action observed along the roadway where measurements were taken. Wave action at the water surface provides mixing and can increase DO levels.

Table 3. *Water quality measurements at each creek crossing and Mantagao Lake.*

	Water Temperature (°C)		Turbidity (NTU)		Water Velocity (m/s)		Conductivity (µS)	
Crossing	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
1	6.5	11	3.07	1.08	0	0	212	201
2	7	10	0.63	1.14	0.18 - 0.28[a]	0	210	207
3	7	12.8	2.29	0.91	0	0	231	225
Mantagao Lake	-	24	-	1.7 – 3.8[b]	-	-	-	388

	Dissolved Oxygen (mg/L)		pH	
Crossing	Fall	Spring	Fall	Spring
1	9.18	8.88	6.31	6.12
2	9.31	8.94	6.33	6.09
3	9.77	9.10	6.65	6.51
Mantagao Lake	-	8.79	-	8.82

[1]Water velocity was measured prior to and after clearing of the Crossing 2 culvert during the fall assessment
[b]Turbidity was measured both near shore (high turbidity) and off shore (low turbidity) in Mantagao Lake.

6.2.3 HABITAT CONNECTIVITY

Habitat connectivity was found to be limited at all three Crossing sites, as well as across the entire project area. Culvert crossings at all three sites were found to be blocked and/or damaged. While grubbing and cleaning were noted at Crossing 2 in October of 2015 (Section 6.2.1), the culvert was again blocked the following spring, and continued beaver activity had resulted in numerous road washouts and extensive culvert blockage/damage along the extent of the proposed ASR. Blockages at Crossings 2 and 3 resulted in extensive damage (Figure 6) and washout (Figure 7) of the forestry road in the spring of 2016.

Culverts were assessed for any perching, blockages or the presence of any wildlife gates or blockage prevention methods (Table 4). Wildlife gating was observed on some culverts along the forestry road, though none were present at the crossing sites. Photographic documentation of all culverts at each crossing are presented in Appendix B.

Figure 6. *One of three culverts at Crossing 3, exposed across road and completely blocked at upstream end.*

Figure 7. *Washout of existing access road north of Crossing 2 in spring, 2016. Beaver activity had increased between fall and spring field seasons, with the beginnings of beaver dam construction across the existing access road.*

Table 4. *Culvert analysis at each creek crossing as assessed on April 29, 2016. Y = Yes, N = No.*

				Perched		Blocked		Wildlife Gated	
Culvert	Location	Diameter (mm)	Flow (m/s)	Y	N	Y	N	Y	N
1	51.392455° -98.145401°	600	0		X	X			X
2	51.404071° -98.140378°	600	0		X	X			X
3A	51.673877° -98.183027°	600	0		X	X			X
3B	51.673924° -98.182768°	900	0		X	X			X
3C	51.674136° -98.182226°	600	0		X	X			X

6.2.4 HABITAT CLASSIFICATION

Fish habitat was classified for each sampling reach using the DFO classification flowchart for streams and constructed drains through agricultural areas (Figure 3). The presence of forage fish and absence of CRA or SARA listed species within all upstream and downstream reaches indicates that all aquatic habitat assessed was classified as either Type C or Type D habitat, depending on habitat complexity. Simple habitat is defined as habitat with low to moderate cover coupled with uniform substrate type and flow, whereas complex habitat is characterized by increased diversity of either substrate type or flow regime and/or heavy cover. Therefore, habitat with at least one of these characteristics of increased complexity is defined as complex, or Type C habitat. Habitat lacking these characteristics is defined as simple, or Type D habitat. Photographic documentation of all aquatic and riparian habitat immediately upstream and downstream of each crossing site is presented in Appendix C.

Aquatic habitat was similar upstream of all three creek crossings, with a similar uniform silt substrate and no-flow conditions. Crossings 2 and 3 were found to have little to no emergent or submerged aquatic vegetation and minimal woody debris concentrated at beaver lodges set upstream of the crossing sites. Extensive water retention has resulted in significant retention ponds at Crossings 2 and 3, with primarily open water. Riparian habitat was simple at both sites, with predominantly simple grasses and low shrubs. Thus, upstream habitat at Crossings 2 and 3 were classified as Type D (Table 5).

Upstream habitat at Crossing 1 was markedly different, with abundant floating aquatic vegetation, likely due to lack of flow from beaver activity further upstream. Riparian habitat at this site was also more complex, with tall grass, shrub and trees present providing increased cover. Therefore, upstream habitat at Crossing 1 was defined as complex and classified as Type C habitat, whereas upstream habitat at Crossings 2 and 3 was defined as simple and both were classified as Type D habitat (Table 5).

Downstream habitat was more variable among sites than upstream habitat. At Crossing 1, downstream habitat was defined as Type D due to its uniform silt substrate, lack of flow, and simple riparian habitat of low grasses. Downstream of Crossing 2, substrate complexity was significantly higher within both the proximal and distal reaches. Riparian habitat along the proximal reach consists of complex grass, shrub and trees, providing a high level of overhanging cover. Therefore, habitat within both downstream reaches at Crossing 2 was defined as complex and classified as Type C habitat (Table 5). Crossing 3 was determined to have no flow and uniform silt substrate. However, very dense submerged aquatic vegetation was present at this site, likely due to the lack of flow downstream of all culverts. Grass and tall shrubs dominate the riparian habitat downstream providing excellent overhanging cover for fish. This habitat was defined as complex, and classified as Type C habitat (Table 5).

Table 5. Habitat classification at each crossing using the DFO classification flowchart for streams and constructed drains through agricultural areas. Bold cells indicate characteristics determining elevated habitat complexity.

Crossing	Location	Fish Presence	Substrate	Flow Regime	Cover	Habitat Type	Classification
1	Upstream	Forage	Uniform	No flow	**High**	Complex	Type C
	Downstream	Forage	Uniform	No flow	Low to moderate	Simple	Type D
2	Upstream	Forage	Uniform	No flow	Low to moderate	Simple	Type D
	Proximal Downstream	Forage	**Complex**	No flow	Low to moderate	Complex	Type C
	Distal Downstream	Forage	**Complex**	No flow	**High**	Complex	Type C
3	Upstream	Forage	Uniform	No flow	Low to moderate	Simple	Type D
	Downstream	Forage	Uniform	No flow	**High**	Complex	Type C

7.0 FISH COMMUNITY

7.1 FIELD SAMPLING METHODS

7.1.1 BACKPACK ELECTROFISHING

Backpack electrofishing with a Smith-Root LR24 was used to assess the fish communities at each creek crossing within the study area during the 2015 fall field season, and again in the spring 2016 season, to target both small- and large-bodied fish (Figure 8). As backpack electrofishing is limited to depths of 1.3 m or less, sampling was performed within select areas in upstream and downstream reaches for each crossing, ensuring that all habitat types were studied (Figures 10 - 12). Due to culvert blockage and a subsequently wider upstream sampling area at all three crossings, two upstream transects were performed for each crossing (i.e. one on each side of the culvert) and combined for results. A single downstream transect was performed at Crossing 1 and Crossing 3 whereas, due to easy accessibility, two downstream transects were performed at Crossing 2 to document both proximal and distal downstream fish species. All fish captured were held temporarily in a live well prior to being identified to species, enumerated, measured for fork length and released unharmed into similar habitat from which they were collected. If identification was not possible on site due to similar external morphologies of two species, fish were identified to genus and a small number of representative voucher specimens were preserved in 10% formalin for further analysis in the AAE laboratory.

Figure 8. *Backpack electrofishing, distal downstream reach of Crossing 2.*

7.1.2 TRAP NETTING

As backpack electrofishing is limited to depths of 1.3 m or less, spring investigations focused on the study of fish utilization within the deeper mid-channel areas not assessed during fall sampling, which were suspected to contain large-bodied fish. These deeper areas were assessed using trap netting and gill netting. Trap nets were utilized to capture fish at Crossing 2 and Crossing 3 along the roadway area. One trap net was set downstream of each crossing at a location of sufficient depth to enable effective capture of fish travelling upstream (depth > 0.8 m). Although depths immediately downstream of Crossing 3 enabled setting of trap nets, shallow depths immediately downstream of Crossings 1 and 2 precluded effective trap netting. Consequently, a trap net was instead set immediately downstream of a large beaver dam approximately 50 m downstream of Crossing 2. Trap nets were each 1.2 m in diameter and constructed of 1.85 cm^2 nylon mesh. Two 4.5 m wings were attached to the downstream opening of each net to direct fish into the traps (Figure 9).

To reduce stress on captured fish and to minimize fish mortality, trap nets were set, monitored, and pulled once a substantial number of fish were captured or a maximum set length of eight hours was reached. Fish captured were identified, enumerated, measured for fork length, and released unharmed.

Figure 9. *Trap net installation at Distal Downstream reach of Crossing 2.*

7.1.3 GILL NETTING

In conjunction with trap netting, gill netting investigations focused on the study of fish utilization within the deeper mid-channel areas not assessed during fall sampling. Gill netting was performed immediately upstream of each crossing during the spring field season. One gill net was set upstream of each crossing perpendicular to the creek at a location of sufficient depth to enable effective gill netting (i.e. minimum depth of 0.8 m). The gill nets used during these assessments were 30.0 m in length, with 3½ inch (88.9 mm) stretched mesh designed to target large-bodied fish species. Non-lethal gill net sets were carried out, with a maximum fishing time of 2 hours to reduce stress on those fish captured and to prevent fish mortality. Fish captured were identified to species, enumerated, measured for fork length, and released unharmed.

7.2 FIELD SAMPLING RESULTS

7.2.1 BACKPACK ELECTROFISHING

During fall field investigations, a total of 1,012 fish representing four species and one species hybrid were collected from all creek crossings (Table 6 and Table 7, Figures 8 and 10). Seventy-one percent (n = 720) of the total catch was identified as *Phoxinus* spp. Within this genus, Northern Redbelly Dace (*Phoxinus eos*) and Finescale Dace (*Phoxinus neogaeus*), as well as a small number of hybrids of these two species, were captured. Seventeen percent (n = 167) of the total catch was identified as Brook Stickleback (*Culaea inconstans*). The remaining 12% (n = 125) of the total catch was identified as Central Mudminnow. Visual surveys conducted during the study identified no large-bodied fish at any of the three crossings.

Note that it was not possible to identify each *Phoxinus* spp. specimen captured to species level because Northern Redbelly Dace, Finescale Dace, and hybrids of these two species are difficult to distinguish based on external morphology; identification is typically accomplished by examination of internal organs (e.g. intestine looping direction). To minimize harm to fish while enabling identification to species level, a small number (n = 12) of *Phoxinus* spp. voucher specimens were preserved in formalin and identified in the lab as the species listed above.

Although only four fish species (including hybrids) were determined to be present, distributions varied among crossings. Catch rates were low at Crossing 1, especially upstream, and species distributions appeared segregated; exclusively Central Mudminnow were captured upstream and exclusively Brook Stickleback were captured downstream. Blockage and only minimal flow through the culvert likely contributed to this disparity and separation of the species. All four species were captured at Crossing 2: *Phoxinus* spp. represented the majority of the catch (79%), Brook Stickleback was also common (21%), and a single Central Mudminnow was captured within the distal downstream reach. Catch per unit effort (CPUE) varied at Crossing 2, the highest rate (distal downstream) being nearly 95 times greater than the lowest (proximal downstream). Species distribution at Crossing 3 also differed between the upstream and downstream reaches. Upstream, the majority of fish collected were *Phoxinus* spp. (79%), followed by Brook Stickleback (18%), and a small number of Central Mudminnow (3%). However, downstream CPUE was significantly higher than the upstream CPUE, with exclusively Central Mudminnow captured.

Representative photographs of all fish species captured during this study are presented in Appendix D.

7.2.2 TRAP NETTING

Although visual observations confirmed the presence of small bodied fish during the spring, no large-bodied fish or otherwise were captured at either crossing. Trap net coordinates and set lengths are presented in Appendix A.

7.2.3 GILL NETTING

No large-bodied fish were captured at any of the three crossings. When coupled with the lack of fish captured by trap netting, this result indicates an absence of large bodied fish within Winthers Creek or Bear Creek at the road crossing sites. Gill net coordinates and set lengths are presented in Appendix A.

Table 6. *Backpack electrofishing fish capture data at three creek crossings on proposed ASR. Crossing codes: US = upstream, DS = downstream, PDS = proximal downstream, DDS = distal downstream.*

	# Captured									
	Crossing 1		Crossing 2			Crossing 3		Total	Fork Length	
Species	**US**	**DS**	**US**	**PDS**	**DDS**	**US**	**DS**		**TL Average (mm)**	**TL Range (mm)**
Brook Stickleback	0	0	23	16	18	110	0	167	32.6	18 – 62
Central Mudminnow	3	0	0	0	1	16	105	125	84.7	41 – 114
Phoxinus spp.	0	16	89	4	127	484	0	720	32.5	14 – 64
Total	**3**	**16**	**112**	**20**	**146**	**61**	**105**	**1012**		

Note: Phoxinus eos, Phoxinus neogaeus and hybrids of these two species are difficult to distinguish based on external morphology; identification is typically accomplished by examination of internal organs (e.g., intestine looping direction).

Table 7. *Backpack electrofishing fish counts, effort, and CPUE by crossing.*

Crossing	Location	# Captured	Effort (sec)	CPUE (#/min)
1	Upstream	3	224	0.80
	Downstream	16	158	6.08
2	Upstream	112	793	8.47
	Downstream Proximal	20	2985	0.40
	Downstream Distal	146	230	38.09
3	Upstream	610	1140	32.11
	Downstream	105	60	105
Total		**1012**	**5590**	**10.86**

Figure 10. *Aerial photograph of Crossing 1 taken on October 9th, 2015. Fish sampling reaches indicated in red. Water temperature and turbidity measurements performed at orange point; culvert output flow velocity and turbidity measurements made at blue point.*

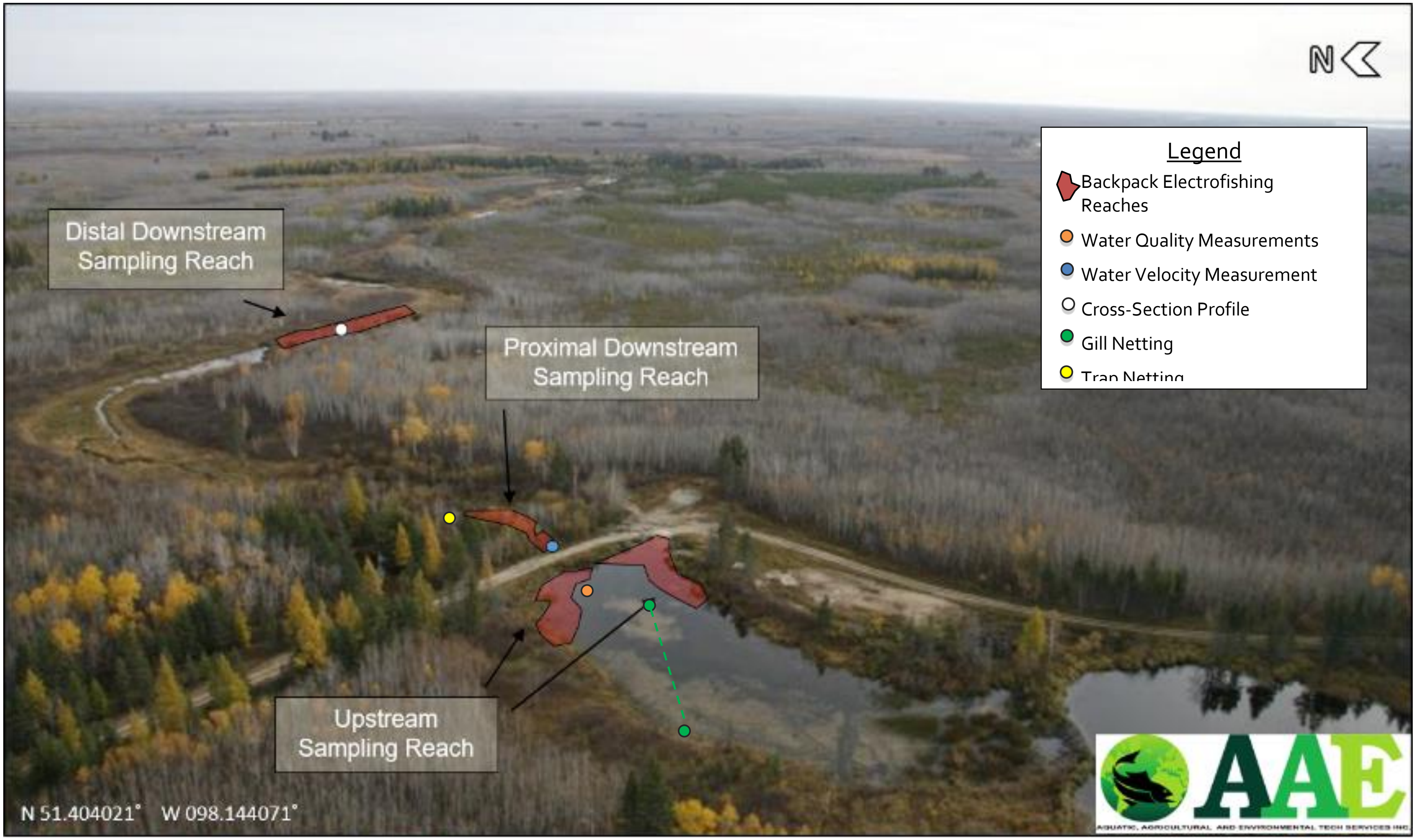

Figure 11. *Aerial photograph of Crossing 2 taken on October 9, 2015. Fish sampling reaches indicated in red. Water temperature and turbidity measurements performed at orange point; culvert output flow velocity and turbidity measured at blue point; velocity and substrate profile measured at white point; gill netting performed at green point; trap netting performed at yellow point.*

Figure 12. *Aerial photograph of Crossing 3 taken on October 9, 2015. Fish sampling reaches indicated in red. Water temperature and turbidity measurements performed at orange point; culvert output flow velocity and turbidity measured at blue point; gill netting performed at green point; trap netting performed at yellow point.*

8.0 MANTAGAO LAKE

To study fish species composition within the headwaters of Winthers Creek (referred to as "Sucker Creek" in KGS 2016), and thus establish a more complete assessment of fish species composition within the watershed system as a whole, boat electrofishing using a Smith-Root 2.5 GPP was performed on Mantagao Lake in the summer of 2016. Sampling was performed along the shoreline at depths of approximately 1.3 m. Fish captured were identified to species, enumerated, fork length measured, and released unharmed. Start and end points of each transect are presented in Appendix A.

A total of sixty-nine fish representing seven species were captured during two transects (combined effort of 2197 seconds) of boat electrofishing on Mantagao Lake (Tables 8 and 9). The most abundant species captured was Yellow Perch (*Perca flavascens*), which accounted for 44.9% of the total catch (n = 31). The second most abundant species captured was Blacknose Shiner (*Notropis heterolepis*), which accounted for 29.0% of the total catch (n = 20). The remaining 26.1% of the catch was comprised of Walleye (*Sander vitreus*, n = 6), Fathead Minnow (*Pimephales promelas*, n = 4), Golden Shiner (*Notemigonus crysoleucas*, n = 4), Northern Pike (*Esox lucius*, n = 3), and Emerald Shiner (*Notropis athineroides*, n = 1). It was observed that most species were distributed relatively evenly throughout the sampling area, and catch-per-unit-effort was very similar between the two transects. However, all six Walleye were captured within the eastern half of Transect 2, suggesting that Walleye distribution may be selective within the lake.

Table 8. *Number of fish captured and length by species for boat electrofishing on Mantagao Lake.*

	# Captured			Fork Length	
Species	**Transect 1**	**Transect 2**	**Total**	**TL Average (mm)**	**TL Range (mm)**
Blacknose Shiner	15	5	20	50	42-60
Emerald Shiner	0	1	1	83	83
Fathead Minnow	3	1	4	59	37-71
Golden Shiner	1	3	4	63	56-68
Northern Pike	1	2	3	434	331-550
Walleye	0	6	6	215	125-280
Yellow Perch	13	18	31	113	54-172
Total	**33**	**36**	**69**		

Table 9. *Number of fish captured, effort, and catch-per-unit-effort by transect for boat electrofishing on Mantagao Lake.*

Transect	# Captured	Effort (sec)	CPUE (#/min)
1	33	1000	1.98
2	36	1197	1.80
Total	**69**	**2197**	**1.88**

9.0 DISCUSSION

The overall risk to fisheries resources associated with upgrading the current road network to the proposed ASR was considered to be low. The fish species identified at each crossing do not support either a commercial, recreational or aboriginal fishery, as there appears to be no connectivity within the system to allow passage of large-bodied fish. Fish habitat immediately adjacent to each crossing is considered Type C or D habitat, and at present is dominated by forage fish species. Lack of connectivity, resulting from a combination of beaver activity and damaged, failing or blocked culverts, is at present preventing the migration of large-bodied species into this system, although Type C habitat present at all three crossing sites would provide suitable habitat for these species if connectivity between upstream and downstream areas was improved.

While at present no large-bodied CRA fish species are expected to be found at these crossings, efforts should be made to limit impacts to the very productive forage fish communities currently present at all three crossing sites, which contribute to the diversity and health of this ecosystem. It is recommended that, in any instance where isolation and de-watering of an area is required for construction, a fish salvage be completed to remove the potentially large volume of small-bodied fish present, as required by DFO regulations/reviews pertaining to construction projects. Spawning windows and habitat/behavior preferences for all fish species identified in this study are presented in Appendix E.

Grubbing and clearing of the culvert at Crossing 2 was noted on October 22, 2015 and resulted in significant drops in upstream water levels (approximately 0.25 m within 24 hours). However, this effect on water flows and levels was short lived, and complete blockage of all three creek crossings resulted in the retention of a significant amount of water during the spring sampling period. Additional beaver activity noted in the spring of 2016 created additional barriers within the creek system, as well as several washouts along the forestry road (Figure 9). Future drainage of these sites, while not expected to impact the fish communities identified, could alter the aquatic and riparian habitat upstream of these culvert crossings, at least temporarily. Changes could include alterations to standing water surface area, increase in flow rates, and improvements to system connectivity. At Crossing 3 where water retention is greatest, increased connectivity could enable fish passage from Bear Creek to the north, which flows into Lake St. Martin. This connectivity could have implications to fish utilization and species composition at the Crossing 3 site, especially if drainage and connectivity are maintained with the proposed road upgrades.

The extensive beaver activity observed upstream and downstream of all three sites provides insight into the absence of large-bodied fish within the crossings. Beaver dams and lodges, and associated culvert blockages along Winthers Creek and Bear Creek, currently act as barriers to fish passage, completely excluding the entry of large-bodied fish into the region of the crossings.

Although the prevalence of beaver dams throughout the area effectively disrupts connectivity among the creek headwaters and the crossings along the roadway area, dam removal may be sufficient to enable fish passage. Preliminary conversations with local stakeholders and land users confirmed that one such headwater source, Mantagao Lake, located approximately 9 km east of the existing access road (Figure 2), is actively used as a recreational and commercial fishery. The results of this examination of Mantagao Lake demonstrate that CRA fish species such as Walleye, Yellow Perch and Northern Pike are present in the headwaters of the creeks crossing the ASR. If connectivity within this system is restored before ASR construction is completed and these CRA species regain access to this area, further assessment will be required to reevaluate fish species composition and habitat classification.

To address the issue of potential blockage of water flow and fish passage, following the clearing/maintenance of culverts along the forestry road, wildlife deterrents such as culvert grates, beaver deceivers, or similar devices could be installed, especially at the three watercourse crossings identified in this study, to reduce the likelihood of blockage and help to maintain water levels at these sites.

If removal of or modification to beaver dams along the creeks is required for ASR construction, a reevaluation of fish species present will be necessary. As the dams currently act as a barrier to large-bodied fish passage, changes to these dams may enable passage of additional fish species, including those that are part of Commercial, Recreational or Aboriginal (CRA) fisheries.

10.0 LITERATURE CITED

COSEWIC, Committee on the Status on Endangered Wildlife in Canada. 2010. (http://www.cosewic.gc.ca/)

Government of Canada – Fisheries Act, RSC 1985, c F-14. Last amended April 5, 2016. 69 pp.

Government of Canada - Species at risk public registry. http://www.sararegistry.gc.ca (accessed 2 November, 2015)

Hanski, I. 1999. Habitat connectivity, habitat continuity, and metapopulations in dynamic landscapes. Oikos. 87(2): 209-219.

Harrelson, Cheryl C; Rawlins, C. L.; Potyondy, John P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 pp.

KGS Group. 2014. Assiniboine River & Lake Manitoba Basins Flood Mitigation Study Lake Manitoba & Lake St. Martin Outlet Channels Conceptual Design - Stage 1 - Deliverable No: LM-01. Prepared for Manitoba Infrastructure and Transportation. KGS Group Report 12-0300-011. February 2014.

KGS Group. 2016. Assiniboine River & Lake Manitoba Basins - Flood Mitigation Study LM & LSM Outlet Channels Conceptual Design - Stage 2. KGS Group Project 12-0300-011. Final report. January 2016.

Lovie, Mark. 2015. Manitoba Infrastructure, Provincial Roads Construction Supervisor.

Milani, D.W. 2013. Fish community and fish habitat inventory of streams and constructed drains throughout agricultural areas of Manitoba (2002-2006). Can. Data Rep. Fish. Aquat. Sci. 1247: xvi + 6,153 pp.

Newbury, R.W. and M.N. Gaboury. 1993. Stream Analysis and Fish Habitat Design: A Field Manual. Newbury Hydraulics Ltd. and the Manitoba Habitat Heritage Corporation. 262 p.

Scott, W. B., & Crossman, E. J. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin, 184 pp.

Stewart, K.W. and D.A. Watkinson. 2007. The freshwater fishes of Manitoba. University of Manitoba Press, Winnipeg, MB. 276 pp.

Wentworth, C. K. 1922. A Scale of Grade and Class Terms for Clastic Sediments. J. Geology. 30: 377-392.

APPENDIX A – Field sampling location summary tables

Table A-1. *Start and end point coordinates for fall backpack electrofishing sampling.*

Crossing	Transect	Start Point	End Point
1	Upstream Southwest	51.392429° -98.145836°	51.392419° -98.145623°
	Upstream Northeast	51.392465° -98.145557°	51.392574° -98.145630°
	Downstream	51.392379° -98.145429°	51.392220° -98.145256°
2	Upstream Southeast	51.403802° -98.140803°	51.404009° -98.140454°
	Upstream Northwest	51.404042° -98.140521°	51.403970° -98.140984°
	Downstream Proximal	51.404490° -98.139888°	51.404087° -98.140310°
	Downstream Distal	51.405110° -98.137141°	51.405339° -98.137900°
3	Upstream West	51.673319° -98.184861°	51.673571° -98.184155°
	Upstream East	51.674225° -98.182022°	51.673942° -98.182961°
	Downstream	51.673674° -98.183971°	51.673744° -98.183977°

Table A-2. *Coordinates and set lengths for spring trap nets.*

Crossing	Coordinates	Location Description	Set Length (hr:min)
2	51.404619 -98.139799	Immediately downstream of beaver dam	6:30
3	51.673723 -98.183907	Immediately downstream of crossing	2:40

Table A-3. *Coordinates and set lengths for spring gill nets.*

Crossing	Start Point	End Point	Location Description	Set Length (hr:min)
2	51.403920 -98.140405	51.404075 -98.140707	Immediately upstream of crossing	7:15
3	51.673688 -98.183724	51.184020 -98.184020	Immediately upstream of crossing	3:30

Table A-4. *Start and end point coordinates for summer boat electrofishing at Mantagao Lake.*

Transect	Start Point	End Point
1	51.353452 -98.019008	51.349033 -98.022506
2	51.347852 -98.022357	51.345958 -98.013863

APPENDIX B – Photographic documentation of all culvert crossings

Figure B-1. Upstream (left) and downstream (right) views of Culvert 1 shortly after clearing.

Figure B-2. Upstream (left) and downstream (right) views of Culvert 2 shortly after clearing.

Figure B-3. Upstream (left) and downstream (right) views of Culvert 3A. The culvert was buried deep in the ground.

Figure B-4. Upstream (left) and downstream (right) views of Culvert 3B. The upstream side was completely buried in woody debris and the downstream side was somewhat damaged.

Figure B-5. Upstream (left) and downstream (right) views of Culvert 3C. The upstream side was blocked by debris and vegetation; blockage resulted in water flowing across the road.

APPENDIX C – Representative photographs of aquatic and riparian habitat upstream and downstream of creek crossings

Figure C-1. Upstream reach of Crossing 1.

Figure C-2. Floating aquatic vegetation from the upstream reach of Crossing 1.

Figure C-3. Downstream reach of Crossing 1.

Figure C-4. Narrow section of the downstream reach of Crossing 1.

Figure C-5. Narrow channel connecting culvert pool to larger downstream pond.

Figure C-6. Pond downstream of Crossing 1.

Figure C-7. Access road at Crossing 2. Road was washed out prior to clearing and grubbing of culvert.

Figure C-8. Upstream reach of Crossing 2.

Figure C-9. Culvert at Crossing 2 shortly after clearing and grubbing.

Figure C-10. Overview of proximal downstream reach of Crossing 2.

Figure C-11. Within proximal downstream reach of Crossing 2.

Figure C-12. Downstream boundary of distal downstream reach of Crossing 2. Note beaver activity present.

Figure C-13. Cross-section profile conducted within distal downstream reach of Crossing 2.

Figure C-14. Beaver dam marking the upstream boundary of distal downstream reach of Crossing 2.

Figure C-15. Upstream reach of Crossing 3.

Figure C-16. Plugged culvert at Crossing 3.

Figure C-17. Aquatic vegetation within upstream reach of Crossing 3.

Figure C-18. Overview of downstream reach of Crossing 3.

Figure C-19. Mantagao Lake Transect 1 facing north-east.

Figure C-20. Mantago Lake Transect 1 facing south-east.

APPENDIX D – Representative photographs of fish species captured at creek crossings and Mantagao Lake

Figure D-1. Central Mudminnow (*Umbra limi*).

Figure D-2. Brook Stickleback (*Culaea inconstans*).

Figure D-3. Northern Redbelly Dace (*Phoxinus eos*).

Figure D-4. Finescale Dace (*Phoxinus neogaeus*).

Figure D-5. Redbelly x Finescale Dace hybrid (*Phoxinus sp.*)

Figure D-6. Northern Pike (*Esox lucius*)

Figure D-7. Walleye (*Sander vitreus*)

Figure D-8. Yellow Perch (*Perca flavescens*)

Figure D-9. Golden Shiner (*Notemigonus crysoleucas*)

Figure D-10. Fathead Minnow (*Pimephales promelas*)

Figure D-11. Blacknose Shiner (*Notropis heterolepis*)

Figure D-12. Emerald Shiner (*Notropis athineroides*)

APPENDIX E – Spawning behavior and timing information for fish species captured at creek crossings and Mantagao Lake

Table E-1. *Spawning behavior and timing of fish species captured within creek crossings and at Mantagao Lake. Information provided by Stewart and Watkinson (2007), Scott and Crossman (1973), Newbury and Gaboury (1993), and Holm et. al. (2009).*

Common Name	Spawning Behaviour and Habitat	Spawning Calendar
Blacknose Shiner	Adhesive eggs broadcast over sand or vegetation	June to mid-August
Brook Stickleback	Builds nests out of organic detritus and filamentous algae	June
Central Mudminnow	Spawn in ponds or marshes	Early May
Emerald Shiner	Offshore, at night, in midwater	Late June to early August
Fathead Minnow	Nests on soft substrates such as sand and/or mud	Spring
Finescale Dace	Under woody debris on clean substrate surfaces	April
Golden Shiner	Eggs broadcast over submerged vegetation	Mid- to late June (>20°C)
Northern Pike	Broadcast spawners over vegetation	Early April after ice-off
Northern Redbelly Dace	Spawn in masses of filamentous algae	May to August
Walleye	Broadcast over gravel and rocky substrates	April after ice-off
Yellow Perch	Eggs expelled in a thick pleated strand, usually adhere to vegetation	Spring and summer (18°C)