EAST INTERLAKE CONSERVATION DISTRICT: WATERSHED 05OJ RIPARIAN ASSESSMENT SURVEY – WITH EMPHASIS ON THIRD ORDER DRAINS and HIGHER – 2007 and 2008

A Report Prepared
for

by

P. G. Graveline

2008

North/South Consultants Inc.
Aquatic Environment Specialists
83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca
Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

EXECUTIVE SUMMARY

The East Interlake Conservation District (EICD) invited North/South Consultants Inc. to conduct the *Watershed 05OJ – Riparian Assessment Survey.* The primary objective of this survey was to provide the EICD board with a comprehensive overview of riparian and land use conditions affecting Watershed 05OJ. Secondary objectives included the identification of barriers to fish passage and migration; to determine the utilization of recreationally important fish species in the watershed; and to provide a list of potential fisheries-based projects for future works within Watershed 05OJ.

The study area within Watershed 05OJ (third order drains and higher) includes the riparian areas along: Cochrane Creek; Fisher Drain; Gramiak Drain; Grassmere Creek Drain (including Grassmere Creek Drain west); Jackfish Creek; Jennifer Creek; Netley Creek; Parks Creek; Ross Creek; Steele Drain; Tugela Creek; Wavey Creek; Whiskey Ditch; and Norris Lake. Also included in the study area was the shoreline of Netley Marsh (from Chalet Beach approaching the mouth of the Red River).

The Water Quality Management Section, Manitoba Water Stewardship, was queried for water quality records relating to Watershed 05OJ. Library and internet searches were also conducted for existing documentation. With the exception of some existing data on Netley and Wavey creeks, water quality information for Watershed 05OJ was limited.

Existing fisheries records (Manitoba Water Stewardship – Fisheries Branch) and spring/summer investigations conducted by North/South Consultants Inc. identified 39 species of fish within Watershed 05OJ. With the exception of the bigmouth buffalo (special concern), none of the species identified are listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as endangered, threatened, or of special concern.

Spring fisheries investigations (2008), conducted by North/South Consultants Inc., identified a definite barrier to fish passage into the Grassmere Creek Drain. Spring investigations also suggest that adult spawning fish can migrate at least 25 km up the Netley Creek and 28 km up Wavey Creek for spawning purposes.

Approximately 229 km of riparian area within Watershed 05OJ was reviewed for land/use cover and/or classified according to aquatic habitat quality using aerial videography,

groundtruthing, and a review of existing orthophotos. Approximately 125 km was covered by ground while the remaining 103 km was covered by air. The majority of the riparian area throughout Watershed 05OJ, as classified according to land use/cover, was determined to be other agricultural land (47.8%). This was followed by: pasture/grazing (14.4%); cropland (14.3%); mixed forest land (9.1%); other urban or built-up land (5.1%); residential/commercial (3.4%); hayland (3.2%); and non-forested wetland (2.7%).

A review of combined aquatic habitat quality ratings suggests Watershed 05OJ is highly impacted by anthropogenic (i.e., human induced) forces (Class C). With the exception of some 'natural' areas in the lower reaches of Netley and Wavey creeks and along Norris Lake the majority of the watercourses in this watershed have either been channelized or modified by land use/cover. Primarily, the fish habitat reviewed in this watershed was marginal. The exceptions were areas along Netley Creek, Wavey Creek, and Norris Lake. Some of the smaller watercourses, near their confluences, also had limited areas of important fish habitat.

Based on a review of the aerial video, groundtruthing, and existing information, 47 potential rehabilitation sites, prioritized on a scale from 1 to 3, were identified within Watershed 05OJ by North/South Consultants. In addition, 7 other rehabilitation sites were identified by a study conducted in 1996. Rehabilitation efforts will need to be based on a watershed management plan developed by the EICD. Although there are some fish passage issues within this watershed (e.g., Grassmere Creek Drain), rehabilitation efforts may best be focused on improving water quality and maintaining the important fish habitat that currently exists (e.g., Netley and/or Wavey creeks).

ACKNOWLEDGMENTS

Manitoba Water Stewardship Fisheries Branch (Winnipeg) is thanked for conducting a search of the Fisheries Inventory and Habitat Classification System and providing existing information on Watershed 05OJ.

Manitoba Water Stewardship Fisheries Branch (Gimli) and the East Interlake Conservation District are thanked for providing field assistance and support during the spring, 2007, fish utilization component of this study. EICD also assisted with the summer fish utilization component of this project.

Fieldwork described within this report was conducted under Scientific Collection Permit # 42-07 issued to North/South Consultants Inc. by Manitoba Water Stewardship, Fisheries Branch.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

The use of water in Manitoba for such practices as agriculture, urban expansion and development, and recreation has severely taxed this precious resource. Policy developments (The Manitoba Water Strategy, 2003; *Water Protection Act*, proclaimed in 2006) focus on a number of water protection strategies, with a focus on watershed planning and a reduction in nutrient loading to Lake Winnipeg.

With funding obtained through the Manitoba Fisheries Enhancement Initiative and the federal Stewardship in Action fund, the East Interlake Conservation District (EICD) retained North/South Consultants Inc. to conduct the Watershed 05OJ -Riparian Assessment Survey. The primary objective of this survey was to provide the EICD board with a comprehensive overview of riparian and land use conditions affecting 3rd order drains (and higher) within Watershed 05OJ. Specific watercourses included: Cochrane Creek; Fisher Drain; Gramiak Drain; Grassmere Creek Drain (including Grassmere Creek Drain west); Jackfish Creek; Jennifer Creek; Netley Creek; Parks Creek; Ross Creek; Steele Drain; Tugela Creek; Wavey Creek; Whiskey Ditch; and Norris Lake (Figure 1). Also included in the study area was the shoreline of Netley Marsh (from Chalet Beach approaching the mouth of the Red River).

Specific objectives of the assessment included:

- To identify and assess the quality of riparian and aquatic ecosystem habitat;
- To identify barriers to fish passage and migration;
- To identify the extent in which recreationally important fish species utilize the watershed; and
- To provide a list of potential fisheries-based projects for future works within Watershed 05OJ.

This report provides baseline aquatic habitat and riparian conditions pertaining to the watershed. It can act as a resource tool for continued watershed management and water quality improvements.

2.0 METHODS

2.1 REVIEW OF EXISTING INFORMATION

2.1.1 Physical and Hydrological Information

The Environment Canada web page (www.msc.ec.gc.ca/wsc) was reviewed for historical hydrological data throughout Watershed 05OJ.

Using a USGS digital elevation model (DEM), elevation profiles were generated for the Grassmere, Netley, Parks, and Wavey creeks. The profiles were produced by intersecting points along polylines with 90 m Shuttle Radar Topography Mission (SRTM) USGS DEM, using Spatial Analyst extension in ESRI ArcGIS® v.9. Due to the coarse resolution of the DEM (i.e., each pixel is 90 m x 90 m) spikes in the elevation profiles may be exaggerated.

2.1.2 Water Quality

The Water Quality Management Section, Manitoba Water Stewardship (WQMS-MWS 2007), was queried for water quality records relating to Watershed 05OJ. Library and internet searches were also conducted for existing documentation.

2.1.3 Fish Species Utilization

Existing information on fish utilization in Watershed 05OJ was documented by querying the Manitoba Water Stewardship - Fisheries Branch (MWSFB) office in Winnipeg. The MWSFB Fisheries Inventory Habitat Classification System (FIHCS) was also searched by provincial staff. Where possible, interviews were conducted with local landowners and tenants who live within the watershed, and members of the Department of Fisheries and Oceans.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) website was searched for fish species listed as: endangered; threatened; or special concern.

2.2 FIELD SURVEYS

2.2.1 Physical and Hydrological Information

To provide a general understanding of stream morphology and substrates in the various branches of the watershed, a number of sampling locations were selected during groundtruthing investigations. Site selection depended on road access, stream accessibility (i.e., depths and velocity), groundtruthing locations, and/or if fisheries investigations were to be conducted.

Substrate types (i.e., composition) were assessed based on a modified Wentworth classification, as outlined in Bain and Stevenson (1999). Substrate compaction was based on three general criteria (i.e., soft, medium, or hard) and determined by inserting a survey rod into the bottom of the stream bed (where possible). Stream velocities were measured with a Swoffer-Model 2100® velocity meter. Velocities measured in culverts were typically taken near the bottom. Discharges were calculated using the 'mean section method' outlined in Terzi (1981).

2.2.2 Water Quality

In conjunction with groundtruthing and fish utilization surveys, basic water quality parameters were measured *in situ* (i.e., in the field) with a Horiba U-10, YSI-550A, and/or aYSI-63 water quality meter. The parameters measured included: dissolved oxygen; conductivity (measured as specific conductance); temperature; pH; and turbidity. In some locations, water temperature was measured with a hand-held alcohol filled pocket thermometer. Water quality parameters were measured at or just below the water surface.

2.2.3 Fish Species Utilization

2.2.3.1 Summer and Fall 2007

Fish use within Watershed 05OJ was assessed during the summer (August 3 to 10) and fall (October 25 to 26) of 2007. Methods included back-pack electrofishing (Smith-Root Model LR-24), dip netting, and visual surveys. Effort was comparable at each site and was conducted to determine presence/absence and possible extent of spawning migration through capture of young-of-the-year fish species.

Sampling was conducted at sites throughout the watershed where access and/or water was available. All fish collected were identified to species and released. A number of the small-bodied fish were preserved in the field (10% formaldehyde solution) for subsequent identification. Any commercial or recreationally important species captured (i.e., northern pike, white sucker, yellow perch) were measured for fork length (± 1 mm).

2.2.3.2 Spring 2008

It was determined, by consultation with the EICD, that spring fishing efforts be focused on the following watercourses: Grassmere Creek Drain; and Netley, Parks, Ross, and Wavey creeks. The objective of spring fishing in Grassmere Creek Drain and Parks Creek was to determine species utilization. Efforts in Netley, Ross, and Wavey creeks were to determine species composition as well as extent of fish migration.

Fishing locations were based on suitable flow conditions (e.g., minimal spring velocity), depths (<1.5 m), and site accessibility. Efforts were based on water temperatures within the range of 4.0 ^{o}C to 10.0^{o}C.

Oriented to capture fish moving upstream, hoop nets (1.2 m in diameter, constructed of 6.45 cm^2 nylon mesh, and 10.0 m long wings) were deployed between April 14 to 22. All fish captured were identified to species and released. A sub-sample of fish (approximately 25/species/day) were also measured for fork length (± 1 mm) and weight (± 25 g), classified by sex and state of maturity, and released. The duration of each set was approximately 20 to 24 hours.

Where possible, visual inspections for fish presence were conducted along stream reaches.

2.2.4 Groundtruthing

Areas of Watershed 05OJ were groundtruthed for the identification of potential rehabilitation sites and collection of ground-based photographs. This was accomplished by driving along lengths of drain and/or creek (where possible) and observing existing conditions (Figure 1). All sites visited were geolocated with the use of a hand held Global Positioning System (GPS).

For the purpose of groundtruthing, the riparian area was defined as the area of land starting at the channel bank, extending perpendicular by at least one full channel width. Also, bank sides (i.e., left or right) were delineated while looking upstream.

Limitations of ground based reconnaissance usually center on landowner approval, presence of roads, or the ability of the vehicle being used.

2.2.5 Aerial Videography

Between the hours of 10:00 and 12:30, aerial videography was collected from an Airvan® fixed wing plane on October 11, 2007. Videography equipment included: a laptop loaded with ESRI ArcGIS®, ArcView Geographic Information System (GIS) software, a handheld Garmin Etrex® GPS unit, and a Canon Mini-DV digital video recorder. The video was collected at an average airspeed of 80 knots and an altitude between 1,700 to 2,000 feet.

Photo1. Airvan® fixed wing airplane chartered for aerial videography on October 11, 2007.

The flight path was developed to gather information from areas that could not be readily accessed by vehicle or where natural stream sinuosity appeared to occur on map (Figure 1). The aerial video was compiled to assist in the identification of potential rehabilitation sites (Section 2.3.4) and to document existing conditions within Watershed 05OJ.

The collection of video via fixed wing aircraft can limit the effectiveness or resolution of classification. Limitations may include: the aircrafts inability to alter speed or altitude in quick response to a stream course; turbulence impacting the aircrafts stability and thus video clarity; and the inability to fly directly over a stream channel often resulting in the collection of video from only one bank.

2.3 CLASSIFICATIONS

Information collected on Watershed 05OJ (via groundtruthing and aerial video was reviewed for basic land use/cover (Section 2.3.1), areas of detriment to aquatic habitat (e.g., eroding shorelines), and potential barriers to fish migration. The end results were to classify riparian areas within the watershed according to aquatic habitat quality and to develop a prioritized list of potential fisheries-based projects for future works.

Where noted, reaches were bound by obvious changes in classification attributes and extended at least two active channel widths on each side. The active channel width is the stream width at 'bank full' discharge or the flow rate that controls the shape and size of the active channel (USDA 1998).

The following sections outline the rationale behind the land use/cover classifications, the rating system incorporated for aquatic habitat quality and the prioritization methodology employed for each potential rehabilitation site.

2.3.1 Land Use/Cover and General Classifications

Within the boundaries of classification systems, the definition of land use and/or land cover is often interchangeable. However, within this document the accepted definition of land use refers to the direct use of land by humans (e.g., agricultural practices, homesteads, industry) (Clawson and Stewart, 1965 in: Anderson et al. 1976). Although land cover can also refer to human practices (e.g., cropland), within the scope of this document land cover refers to more 'natural' cover types (e.g., mixed deciduous, non-forested wetland).

Land use/cover within Watershed 05OJ was reviewed for eight general categories as outlined below. The categories were developed by North/South Consultants Inc. based on the predominant land use practices found in the region and by implementing classifications described by Anderson et al. (1976). The categories focused on reaches of the watercourses and the predominant land use adjacent to them. Although the reaches classified could incorporate more than one land use/land cover type, classification of each reach was based on the most intensive use within the area.

Residential/Commercial: Anderson et al. (1976) define residential as an area with multiple units (e.g., houses) or houses on lots of more than one acre. Generally, residential strips have uniform size and spacing of structures, linear driveways, and lawn areas. Examples of residential areas are towns or the recently developed 'suburbs' of these small towns. The

commercial classification outlines areas used for the sale or production of goods and services, and may include: warehouses; waste disposal areas; strip developments; junkyards; etc.

Other Agricultural Land: This category is applied when separate land uses cannot be mapped individually and typically involves agricultural practices. This classification may include: farmsteads; holding areas for livestock (i.e., corrals); or structures associated with agricultural practices (e.g., barns, storage silos, etc.). Practices under this category are typically on a small scale.

Other Urban or Built-up Land: Land use within this category is defined as golf courses, parks, cemeteries, and undeveloped land within an urban setting (Anderson et al. 1976).

Crop Land: This category may be defined as land used for the production of food (e.g., wheat crop, legumes, etc.). These areas are generally characterized by coarser textures, linear crop/cultivation features, and yellow to gold colour tones. Land under cultivation or without vegetative cover (e.g., tilled) also falls under this category.

Hayland: This category is defined as land used for the production of forage crops for livestock (e.g., alfalfa, timothy, etc.). Hayland crops are often characterized by hay bales spotting the landscape adjacent to watercourses.

Pasture/Grazing: Areas of land used for livestock operations were classified as pasture/grazing. This land use is generally characterized by a smooth texture resulting from grazed herbaceous cover. Pasture/grazing is often associated with heavily defined linear tracks and, where applicable, fence lines. Pastures in forested areas were identified by a decreased density of trees within the forest stand.

Mixed Forest: This classification includes forested areas where evergreens and deciduous trees are growing, yet neither predominate (Anderson et al. 1976).

Non-forested wetland: This classification is defined as an area where wetland herbaceous vegetation dominants (e.g., *Juncus*, *Typha*, *Carex*, etc.) (Anderson et al. 1976). However, within this document, woody species (e.g., willow, alder, oak) may also be present.

Residential/commercial, other agricultural land, other urban or built-up land, cropland, hayland, and pasture/grazing, were considered to be anthropogenic in origin. Mixed forest land and non-forested wetland are assumed to be in natural states or areas not necessarily altered by anthropogenic means.

2.3.2 Aquatic Habitat Quality and Qualitative Ratings

Aerial video and information collected by groundtruthing were used to classify aquatic habitat conditions within Watershed 05OJ. Streams were classified based on a visual qualitative assessment of conditions in and adjacent to the watercourse. Stream condition assessments were based on the United States Department of Agriculture Stream Visual Assessment Protocol (USDA 1998).

The classification system was based on identifying potential impacts to aquatic habitat as either a 'Positive' or 'Negative' attribute to stream processes. The four criteria selected for the evaluation of impacts were: channel morphology (hydrologic alterations and channelization); bank stability; riparian zone function; and barriers to fish migration. These criteria were chosen based on their relative importance to stream health as described within the USDA Stream Visual Assessment Protocol (1998), and the ability to interpret these criteria using both the quality of the video and the accessibility of the watercourse.

The following sections describe the stream conditions assessed in determining aquatic habitat quality, as well as the classification methods used.

2.3.2.1 Channel Morphology

Bank full flows and flooding are important in maintaining both the shape of a channel and its function (USDA 1998). High flows can redistribute larger sediments and debris to form pool/riffle habitats and increase the habitat diversity of a watershed. Altered channel morphology can limit the scouring effect of high flows, allowing siltation of important spawning areas and habitat zones (USDA 1998; Bain and Stevenson 1999).

Channel morphology was rated based on the following criteria (USDA 1998):

Negative condition(s):

- Dykes or other man-made structures were present that prevented natural flooding of the adjacent floodplain;
- Channel was altered, braided, or contained man-made structures restricting floodplain width. Channel may be incised; or
- Evidence of past channel alteration, but with significant recovery of channel and banks.

Positive condition(s):

- Channel appears to be 'natural' with no structures or dykes. No dams, water withdrawal, dykes or other structures limit stream access to the floodplain.

2.3.2.2 Bank Stability

Stream banks are important transition zones between aquatic and terrestrial systems (Bain and Stevenson 1999). Eroding banks can reduce instream fish cover, reduce water transparency, smother fish eggs and benthic invertebrates with silt, and infill shallow water habitats (Bain and Stevenson 1999). Although some bank erosion is normal in a healthy watershed system, excessive erosion can occur when riparian areas are degraded, hydrology is altered, or when sediment load is increased (USDA 1998).

Assessments of bank stability were based on the potential for detachment of soil from the upper and lower stream banks and the subsequent deposition to the stream channel. Due to the scale and resolution of the aerial video, bank stability was at times difficult to assess visually using videography. Therefore, ratings were primarily based on the application of groundtruthing data and an overall visual assessment of the stream reach being classified.

Bank stability was rated on the following criteria (USDA 1998):

Negative condition(s):

- Bank(s) unstable and typically high. There may be overhanging vegetation at top of a bare bank, trees falling into stream, or a number of slope failures apparent;
- Bank(s) moderately unstable and typically high. Some trees may be falling into the stream and there may be some slope failures apparent; or
- Bank(s) moderately stable and low. A lower amount of eroding surface on outside bends is protected by roots that extend to the base-flow elevation.

Positive condition(s):

- Bank(s) are stable and low. A large amount of eroding surface area on outside bends is protected by roots that extend to the base-flow elevation.

2.3.2.3 Riparian Zone Function

Riparian zone is defined as an area adjacent to a body of water or as the transition zone between aquatic and upland areas; it can also be referred to as riparian buffer zone, buffer strip, or vegetation retention zone (Kipp and Callaway 2003; Williams et al. 1997; Bain and

Stevenson 1999). The health of the riparian zone is fundamental to the well-being of an entire stream ecosystem (USDA 1998). A healthy riparian zone can: buffer the introduction of pollutants and/or organic matter to a stream; regulate instream algal production via shading; decrease erosion by stabilizing stream banks and dissipating energy during flood events; provide a source of cover, food, and microclimate control for fish and invertebrates; and act as a travel corridor for terrestrial animals/birds (Williams et al. 1997; USDA 1998; Bain and Stevenson 1999; Koning 1999).

From an agricultural standpoint, riparian vegetative cover helps regulate soil climate, stimulate soil activity (via biomass production), and acts as a buffer between water courses and fertilizer and pesticide applications (Donat 1995). It has been found that dew formation and soil moisture increase in the vicinity of a well-established riparian zone (Donat 1995). The quality of the riparian zone increases as both the width and complexity of woody vegetation within it increases (USDA 1998).

Riparian zone function was rated based on the following criteria (USDA 1998):

Negative condition(s):

- Natural vegetation/regeneration of vegetation is lacking and the 'filtering' function of the riparian zone is severely or moderately compromised.

Positive condition(s):

- Natural vegetation extends at least two active channel widths on each side and the 'filtering' function of the riparian zone does not appear to be compromised.

2.3.2.4 Barriers to Fish Migration

Barriers to fish movement can be defined as any structure or habitat conditions that create a potential obstacle to fish movements under certain hydrologic conditions (Bain and Stevenson 1999). These barriers can be anthropogenic in origin (e.g., concrete structure, earthen dam, dike, perched culvert) or natural (e.g., beaver dam, debris dam, rapids). Besides limiting/stopping the movement of fishes, barriers can affect the health of a stream via disruption of stream flow, sediment transport, and thermal regimes (Bain and Stevenson 1999).

Barriers, or areas with the potential to impede migration of fish movement, were primarily identified from groundtruthing and, where possible, review of aerial video. Barriers were classified as follows:

1) Beaver dams;
2) Debris – accumulations of natural or man-made debris; and
3) Anthropogenic – dams, fords, or culverts.

- Class A: Stream reaches within this category were minimally impacted and tended to have natural channel morphology. The riparian vegetation, which was typically present on both stream banks, provided a high level of buffering capacity, fish habitat, and bank stability.

- Class B: Stream reaches in this category were moderately impacted, and typically had a more natural channel morphology and hydrologic regime than Class C reaches. Bank stability in this class tended to be moderate. Commonly, a margin of natural vegetation may have remained, increasing bank stability and buffering capacity. Some stream reaches in this category had more 'natural' conditions on one bank and a greater amount of impact on the opposite bank.

- Class C: Stream reaches within this category were highly impacted and generally had altered hydraulic regimes (e.g., channelization, barriers). Bank stability in this class tended to be moderate. Reaches with marginal riparian vegetation may have had a moderate filtering capacity.

- Class D: Stream reaches within this category were severely impacted and generally characterized by altered channels and a heavily altered hydrologic regime. There was a lack of vegetative regeneration within the riparian zone, and because of this the filtering function of the riparian zone may have been severely compromised. The bank was generally unstable within this class.

Typically, drains are constructed to either remove excess water from fields or to supply irrigation water to areas which require water (Evanitski, no date; AAFC-PFRA 2004). Although drains can offer certain agricultural advantages (e.g., earlier planting times) there are environmental concerns associated with them. An accelerated removal of water from fields can place rivers into a flood or near flood stage, increasing the risk of water erosion and bank failure (AAFC-PFRA 2004). Man-made drains are often also associated with marginal riparian zones, which are unable to act as effective buffers resulting in increased introduction of substances deleterious to the aquatic habitat (DFO 1995; AAFC-PFRA 2004).

By definition, drains typically exhibit one or all of the negative conditions associated with degraded aquatic habitat discussed within this document. Therefore, when a watercourse was labelled as 'drain' during the initial land use/cover classification it automatically received a Class C rating. However, segments of the drain may also receive a Class D rating if multiple negative conditions are observed (e.g., linear design, barrier present, slumping bank(s), denuded/removed riparian, agricultural inputs, etc).

2.3.3 Fish Habitat Classification

Upon reviewing existing information, and completing: ground truthing investigations and surveys; land use/cover classifications; and defining stream reaches according to aquatic habitat quality; watercourses within the study area were assessed for their ability to support a fish community. Within this document and for the purpose of developing fisheries based rehabilitation plans, 'fish community' is defined as habitat utilization by commercial or recreational important species. These typically larger bodied fish could be species such as northern pike, walleye, sucker *sp*., channel catfish, freshwater drum, lake whitefish, etc. Although smaller bodied/forage fish species (e.g., brook stickleback, central mudminnow, common shiner, etc.) are not included in this definition, they are still taken into consideration and recognised as an important part of the aquatic ecosystem. Based on a subjective assessment, outlined in Newbury and Gaboury (1993), four standardized classes were utilized:

- Class 1: Water bodies having a high capability for production of fish;
- Class 2: Water bodies having slight limitations to production of fish;
- Class 3: Water bodies having moderate limitations to production of fish; and
- Class 4: Water bodies having severe limitations to production of fish.

In addition to the classes defined above the following three definitions were also considered in assessment of fish habitat within the study area (DFO 1998):

- Critical Habitat: Habitat requiring a high level of protection due to their importance in sustaining subsistence, commercial or recreational fisheries, rareness, high productive capacity, or sensitivity of certain life stages of fish species being supported;
- Important Habitat: Habitat requiring a moderate level of protection, including areas utilized for fish feeding, growth, and migration. These areas are not considered critical, contain a large amount of comparable habitat, and may include areas previously disrupted by human activity; and
- Marginal Habitat: Habitat requiring minimal protection. These areas would have a low productive capacity and marginally contribute to fish production. However, these areas would also have a reasonable potential for enhancement or restoration.

2.3.4 Potential Rehabilitation Sites

A compilation of potential rehabilitation sites was developed following completion of groundtruthing, a review of the aerial footage, and an application of the qualitative rating systems discussed above. Once reviewed, sites were prioritized using a scale from 1 to 3. Sites given a priority of 1 were often 'large' in scale, exhibiting multiple environmental issues (e.g., water quality degradation, shoreline erosion, denuded riparian, etc.) that may warrant more immediate attention (i.e., rehabilitation efforts). These sites typically had many direct negative impacts on the health of the watershed. Conversely, sites labelled as priority 3 were often 'smaller' in scale, typically exhibiting only one environmental concern. Sites identified as priority 3 were also areas in which: long-term planning could be required; a return to the sites 'full' potential could not occur within a reasonable time frame; the site may not currently be a detriment to habitat quality, but may become one in the future (USDA 2004).

3.0 RESULTS AND DISCUSSION

For ease of reference, results for watercourses are provided in alphabetical order.

The majority of existing information on Watershed 05OJ was collected through discussions with Manitoba Water Stewardship and, to a lesser extent, conversations with local landowners. The Department of Fisheries and Oceans conducted a number of fisheries based surveys within Watershed 05OJ; however the data is currently in an unpublished stage (Milani 2007).

Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration (AAFC-PFRA 2004b) compiled a summary of resources and land use issues related to riparian areas in the lower Red River watershed. This document could be used for baseline data in the development and refinement of a management plan for Watershed 05OJ.

Distances provided in this document (i.e., length of watercourse, length of reaches defined by land use/cover, and length of reaches defined by aquatic habitat quality) may vary slightly from one identifier to another. This variation stems from the inability to view all portions of a watercourse either from the ground or air and from inferences developed while completing classifications for certain reaches of stream. Therefore, distances provided should be taken as best approximations.

Length of watercourse, distance covered by air and ground, and the percentage of the watercourse classified is provided in Table 1. Table 2 outlines results of the FIHCS search conducted by Manitoba Water Stewardship – Fisheries Branch. Summer/fall 2007 fishing, and spring 2008 fishing conducted by North/South Consultants Inc. are provided in Tables 3 and 4. Land use/cover and aquatic habitat classifications are provided in Tables 5 and 6. Potential rehabilitation sites are outlined in Table 7.

The study area is presented in Figure 1. Elevation profiles are presented in Figures 2 to 4. Land use/cover classifications and groundtruthing sites (i.e., waypoints) are provided in Figures 6 to 8. Aquatic habitat classifications and potential rehabilitation sites are provided in Figures 9 to 11.

Waypoint descriptions are provided in Appendix 1. All stream properties measured (i.e., discharges, depths, substrate composition), in situ parameters measured by North/South Consultants, and biological information recorded during fisheries investigations are provided in Appendices 2.1 to 2.4. Ground and aerial based classifications are provided in Appendix

3 (Appendices 3.1 to 3.15). A summary of detriments to riparian areas and/or aquatic ecosystem health, as well as potential mitigative measures are provided in Appendix 4.

3.1 COCHRANE CREEK

Cochrane Creek primarily flows in an easterly direction for approximately 5 km, before emptying into Lake Winnipeg, south of Chalet Beach (Table 1, Figure 1).

3.1.1 Review of Existing Information

No hydrometric data was found on the Water Survey of Canada website pertaining to Cochrane Creek (ECWSC 2008). The WQMS-MWS (2007) did not have existing information regarding Cochrane Creek.

Brook stickleback are known to inhabit Cochrane Creek (FIHCS search, Manitoba Water Stewardship – Fisheries Branch) (Table 2).

3.1.2 Field Surveys – 2007 and 2008

Cochrane Creek was visited on the ground, where possible, for the collection of ground based photographs. No fisheries investigations were conducted in Cochrane Creek during the summer/fall of 2007 due to limited to non-existent flow conditions (Photo 2). Cochrane Creek was not identified for spring 2008 fisheries investigations.

Photo 2. Looking downstream along Cochrane Creek, Wpt. 85, September 25, 2007.

3.1.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground based classifications for Cochrane Creek are provided in Appendix 3 (Table A3-1). Starting at its headwaters, at least one-half of Cochrane Creek has been channelized (Figure 6, between waypoints 9 and 85). Although not immediately accessible by road, it is assumed that the remainder of this watercourse (from waypoint 85 to its mouth) maintains a natural sinuosity and relatively un-impacted wooded area.

The 3.2 km of Cochrane Creek classified according to land use/cover was determined to be other agricultural land (Table 5). Based on field observations and existing land use practices, the portion of this creek reviewed was given a Class C aquatic habitat rating (Table 6). However, the unobserved/un-classified portions would likely fall into a Class B or A rating.

No potential rehabilitation sites were identified along the sections of Cochrane Creek that were reviewed (Figure 9).

The fish habitat between waypoints 9 and 85 is identified as Class 4, having severe limitations to the production of fish, and consisting of marginal habitat (i.e., uniform channels, minimal to non-existent flows). It is assumed that the fish habitat between waypoint 85 and the mouth of Cochrane Creek would be Class 2 fish habitat, but would remain marginal.

3.2 FISHER DRAIN

The Fisher Drain flows, primarily, in an easterly fashion for approximately 5 km before emptying into Lake Winnipeg (Table 1, Figure 1).

3.2.1 Review of Existing Information

No hydrometric data was found on the Water Survey of Canada website pertaining to Fisher Drain (ECWSC 2008). In addition, the WQMS-MWS (2007) did not have existing water quality information regarding this watercourse.

No information was found regarding fish utilization of the Fisher Drain during the FIHCS search conducted by Manitoba Water Stewardship – Fisheries Branch.

3.2.2 Field Surveys – 2007 and 2008

Fisher Drain was visited on the ground, where possible, for the collection of ground based photographs. No fisheries investigations were conducted in Fisher Drain during the summer/fall of 2007 due to limited to non-existent flow conditions. Low flow conditions also prevented the collection of hydrometric data (Photo 3). Fisher Drain was not identified for spring 2008 fisheries investigations.

3.2.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground based classifications for Fisher Drain are provided in Appendix 3 (Table A3-2).

Over half (58.4%) of the 5.4 km of the Fisher Drain classified according to land use/cover was determined to be other agricultural land. This was followed by mixed forest land (21.1%), cropland (14.4%), and hayland (6.2%) (Table 5, Figure 6).

This highly channelized watercourse was given an aquatic habitat quality rating of Class C (highly impacted) (Table 6, Figure 9). The fish habitat observed (between waypoints 13 and 19) exhibited Class 4 fish habitat (i.e., severe limitations to production of fish) and should be considered as marginal (Figure 6).

Photo 3. Looking downstream on Fisher Drain at Wpt. 17, August 3, 2007.

One potential rehabilitation site was identified on the Fisher Drain (Table 7, Figure 9). Involving bank erosion, this site (#30) was given a priority 3 due to the close proximity of the agricultural practice (i.e., crops).

3.3 GRAMIAK DRAIN

Located near the town of Argyle, the Gramiak Drain primarily flows eastward for approximately 9 km before discharging into the headwaters of the Grassmere Creek Drain (Table 1, Figures 1 and 8).

3.3.1 Review of Existing Information

No hydrometric data was found on the Water Survey of Canada website pertaining to the Gramiak Drain (ECWSC 2008). In addition, the WQMS-MWS (2007) did not have existing water quality information regarding the Gramiak Drain.

No information was found regarding fish utilization of the Fisher Drain during the FIHCS search conducted by Manitoba Water Stewardship – Fisheries Branch.

3.3.2 Field Surveys – 2007 and 2008

Gramiak Drain was visited on the ground, where possible, for the collection of ground based photographs. No fisheries investigations or hydrometric surveys were conducted in Gramiak Drain during the summer/fall of 2007 due to the absence of any water (Photo 4). Gramiak Drain was not identified for spring 2008 fisheries investigations.

3.3.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for the Gramiak Drain are provided in Appendix 3 (Table A3-3).

All (100%) of the 8.8 km of the Gramiak Drain reviewed for land use/cover was determined to be other agricultural land (Table 5). The Gramiak Drain is primarily a 'grassed ditch', channelized (likely) to accelerate the flow of water from agricultural land, and was therefore rated as Class C (highly impacted) (Table 6, Figure 11). In addition, the fish habitat along this drain is considered as Class 4 (severe limitations to fish production) and/or comprising marginal habitat.

No potential rehabilitation sites were observed along the Gramiak Drain.

Photo 4. Looking downstream along Gramiak Drain, Wpt. 35, August 8, 2007.

3.4 GRASSMERE CREEK DRAIN

The Grassmere Creek Drain (including west arm) primarily flows in a south easterly direction for approximately 46 km before emptying into the Red River (Table 1, Figure 1). This drain passes through or in the vicinity of the communities of Grosse Isle (in the west) and West St. Paul (near the Red River and the City of Winnipeg's north perimeter Hwy.). With an average elevation of 238 m, the Grassmere Creek Drain drops only 26 m between its headwaters and its confluence with the Red River (Figures 1 and 2).

3.4.1 Review of Existing Information

Located near Middle Church, archived hydrometric data is available for one station (# 05OJ017; 1963 to 2007) on the Grassmere Creek Drain (ECWSC 2008). A cursory inspection of the data shows peak mean monthly flows occurring in April (4.32 m^3/s), which taper off from May through June (ECWSC 2008). There is a second peak during July (0.654 m^3/s), but the discharge tapers off again through to October (0.053 m^3/s). Typically, flows along the Grassmere Creek Drain are 'slow' and by mid-summer often stagnate. This is likely a result of the gradual drop in elevation from the headwaters of Grassmere Creek Drain to its confluence with the Red River (approximately 26 m over a distance of 46 km) (Table 1, Figures 1 and 2).

The WQMS-MWS (2007) did not have existing water quality information regarding the Grassmere Creek Drain.

A total of 4 species of fish were identified to be utilizing the Grassmere Creek Drain (FIHCS search, MWSFB 2007). These were fathead minnow, northern pike, white sucker, and yellow perch (Table 2).

3.4.2 Field Surveys – 2007 and 2008

Water quality parameters measured in the field (by North/South Consultants Inc.) are provided in Appendix 2 (Table A2-2). Dissolved oxygen measured at waypoint 26 on August 26, 2007 was below the MWQ objective instantaneous minimum of 5.00 mg/L for the protection of cool water aquatic life (i.e., 3.94 mg/L) (Photo 5). However, when measured at Wpt. 26 on October 25 the dissolved oxygen was within the MWQ guidelines (i.e., 11.29 mg/L).

Photo 5. Grassmere Creek Drain at Wpt. 26, August 9, 2007.

Summer/fall fish utilization surveys were conducted at a total of 4 sites throughout the Grassmere Creek Drain (Table 3, Figure 8, Appendix Table A1-1). Twenty fish, representing 4 species were captured, which included: black crappie; brook stickleback;

johnny darter; and pearl dace. A number of forage fish (likely pearl dace) were also observed at Wpt. 26 (Photo 5).

Hoop nets were established at two locations along the Grassmere Creek Drain in the spring of 2008 (Wpts. 87 and 90; Figure 8, Appendix Table A1-1). At Wpt. 87, only one northern pike was captured after five evenings of fishing effort in water temperatures ranging from 3.0 to 11.0^{o}C (Table 4). The fishing effectiveness of this hoop net was impaired by large amounts of debris floating through the Grassmere Drain, specifically grass trimmings and cardboard.

The hoopnet set at Wpt. 90 (located on the downstream side of a sheet pile weir) captured 23 northern pike in less than 24 hours (Photo 6). The majority of these fish were ripe males and/or females ready to spawn in the current year. Under the flow conditions exhibited in the spring of 2008 (i.e., 0.296 m^3/sec on April 23 determined by North/South Consultants) the sheet pile weir located at the mouth of this drain effectively prevented the upstream

Photo 6. Hoop net near the mouth of Grassmere Creek Drain (Wpt. 90), spring 2008.

migration of fish species. In previous years of higher water (i.e., discharges greater than 0.296 m^3/sec) local residents have seen migrations of what appeared to be northern pike and sucker species migrating past their properties (located between Hwys. 8 and 9). This

information suggests that the sheet metal weir near the mouth is not a complete barrier to migration events, although it is likely a deterrent to both upstream and downstream migrations of all life stages.

3.4.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for the Grassmere Creek Drain are provided in Appendix 3 (Table A3-4).

Approximately 41 km of Grassmere Creek Drain were classified by land use/cover (Table 5, Figure 8). Other agricultural land (70.3%) comprised the majority of the classification, followed by: other urban or built-up land (18.2%); hayland (9.2%); and residential/commercial (2.4%).

The nearly 41 km of the Grassmere Creek Drain classified by aquatic habitat was rated as Class C (96.6%), followed by Class D (3.0%), and B (0.5%) reaches (Table 6, Figure 11). With the exception of the small reach of drain that extends from Wpt. 90 downstream to the Red River (rated as Class 2) and the length of drain from Wpt. 90 upstream to Wpt. 26 (Hwy. 9) (rated as Class 3) the entire length of the Grassmere Creek Drain should be considered as Class 4 fish habitat with low productive capacity (i.e., marginal).

A total of 5 potential rehabilitation sites have been identified along the Grassmere Creek Drain (Table 7, Figure 11). Three of these sites (#'s 31, 32, and 33) were identified as Priority 2, relating to the potential to block the passage of fish at low ford crossings and/or culverts. Rehabilitation site #34 related to the slumping of the drain, however reconstruction was already underway along this site. The final rehabilitation site (#46) related to a sheet metal weir which prevented the spring migration of fish in 2008. Given a Priority 1, this site could be reconstructed to allow both the upstream and downstream migration of fish species at any water level.

3.5 JACKFISH CREEK

From its headwaters, nearly one-half of this (approximately 21 km) watercourse flows in a southerly direction prior to heading east and emptying into the headwaters of Wavey Creek (Table 1, Figure 1).

3.5.1 Review of Existing Information

Neither hydrometric data nor water quality information was found pertaining to Jackfish Creek (ECWSC 2008; WQMS-MWS (2007).

Manitoba Water Stewardship-Fisheries Branch (FIHCS search) identified a total of 4 fish species (blacksided darter, central mudminnow, white sucker, and yellow perch) to have utilized Jackfish Creek at some point in time (Table 2).

3.5.2 Field Surveys – 2007 and 2008

No discharge measurements or fisheries investigations were conducted on Jackfish Creek in 2007 due to minimal/non-existent water levels (Photo 7). Jackfish Creek was also not identified for spring fisheries investigations in 2008 .

Photo 7. Looking upstream on Jackfish Creek at Wpt. 38, August 9, 2007.

3.5.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for Jackfish Creek are provided in Appendix 3 (Table A3-5).

Approximately 59% of the 21 km of Jackfish Creek reviewed for land use/cover was determined to be cropland (Table 5, Figure 7). This was followed by pasture/grazing (21.8%), other agricultural land (16.1%), and hayland (2.9%).

The 21 km of Jackfish Creek rated for aquatic habitat quality was either Class C (78.4%) or Class D (21.6%) (Table 6, Figure 10). Although this watercourse maintains some natural sinuosity and channel diversity, its riparian area is typically 'thinned' to accommodate agricultural practices or channelization (east of Hwy. 7). This accounts for the high percentage of highly and severely impacted areas.

The location of this watercourse (i.e., tributary to the headwaters of Wavey Creek), ephemeral nature, impacted aquatic habitat, and existing land/use/cover were all considered when rating the fish habitat of Jackfish Creek as Class 4; having severe limitations to fish production and/or comprising marginal habitat.

Four sites have been identified along Jackfish Creek that may warrant rehabilitation (Table 7, Figure 10). Primarily dealing with agricultural practices (i.e., cattle pasture and hayfield) these sites were rated as Priority 2 (n = 2) and 3 (n = 2).

3.6 JENNIFER CREEK

Jennifer Creek primarily flows in a south easterly direction for approximately 16km before emptying into the headwaters of Wavey Creek (Table 1, Figure 1).

3.6.1 Review of Existing Information

No existing hydrometric or water quality data was located for Jennifer Creek (ECWSC 2008; WQMS-MWS 2007).

No fisheries records were located for Jennifer Creek following an FIHCS search (MWSFB 2007).

3.6.2 Field Surveys – 2007 and 2008

Neither hydrometric nor fisheries investigations were conducted on Jennifer Creek in 2007 due to minimal/non-existent flow (Photo 8).

3.6.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for Jennifer Creek are provided in Appendix 3 (Table A3-6).

Photo 8. Looking upstream on Jennifer Creek at Wpt. 36, August 9, 2007.

Along Jennifer creek, other agricultural land (59.6%) (i.e., cropland and hayland) was the primary land use/cover, followed by pasture/grazing (38.2%), and mixed forest (2.2%) (Table 5, Figure 7). The two reaches of pasture/grazing identified along this creek appear to be extensive and may warrant additional investigation.

With the exception of two reaches of Class D habitat and one reach of Class B, the majority of Jennifer Creek was given a Class C aquatic habitat quality rating (Table 6). While maintaining some natural stream sinuosity (between Wpts. 6 and 36), the upper and lower portions of Jennifer Creek have been channelized (Figure 10). In addition, hayland and cropland appears to extend very close to the creek channel, thus reducing effectiveness of any riparian areas and (likely) increasing erosion.

One potential rehabilitation site was identified (by groundtruthing) on Jennifer Creek (Table 7, Figure 10). This site (# 39) was identified as an area of potentially extensive grazing within the channel of this creek. Although not listed as a rehabilitation site, the second reach of pasture/grazing along this creek should be inspected for potential rehabilitation.

Given its location in Watershed 05OJ (i.e., headwaters of Wavey Creek), lack of natural stream flow (evidenced in 2007), and current land practices, it is unlikely that Jennifer Creek provides either important or marginal fish habitat. However, as a tributary to larger

watercourses rehabilitation efforts (e.g., improvements to water quality) on this creek still warrant consideration.

3.7 NETLEY CREEK

With its headwaters located near Norris Lake, Netley Creek primarily flows in a south easterly direction before emptying into the Red River, a distance of approximately 60 km (Table 1, Figure 1).

3.7.1 Review of Existing Information

Environment Canada - Water Survey of Canada has hydrometric data from two stations located on Netley Creek (ECWSC 2008). Station # 05OJ009, located near Matlock, is discontinued but has 37 years of flow data from 1960 to 1996. Located near Petersfield station # 05OJ008 is still active, providing flow and level data since 1960. Horne and MacDonell (1996) summarized this data providing monthly discharges and an annual flood frequency curve between 1960 and 1994. A review of the more current data indicates flows on Netley Creek still peak during the spring melt, receding into summer. The course of Netley Creek is gradual, dropping only 47 m over a distance of approximately 60 km (Table 1, Figures 1 and 3).

Existing water quality information from 4 separate stations was available for Netley Creek between the years 1994 and 2005 (WQMS-MWS 2007). This data was provided to the EICD manager (electronic copy) for inclusion into their existing water quality database on Netley Creek.

Provincial fisheries records indicated the presence of 27 species of fish within the Netley Creek watercourse (Table 2) (FIHCS search, MWSFB 2007). Some of the economically and recreationally important species of fish (larger bodied) itemized in this watercourse are: carp; channel catfish; goldeye; northern pike; sauger; walleye; white bass; white sucker; and yellow perch.

The FIHCS search also indicated the presence of 20 species of fish within the Netley Marsh (Table 2). Comparable to the list of species found in Netley Creek, additional large bodied species included: bigmouth buffalo; cisco; freshwater drum; and quillback.

The bigmouth buffalo was designated as a species of 'special concern' in April 1989 because it has a 'limited and disjunct distribution in Canada and occurs in low numbers' (COSEWIC 2008). The Species At Risk Act (SARA) defines special concern as 'a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats'. Often misidentified as carp, the bigmouth buffalo is primarily found in the Assiniboine (downstream of Portage La Prairie) and Red rivers, and within the lowermost reaches of tributaries entering the Red River (Stewart and Watkinson 2004). Its preferred habitat is the shallow depths of slow or still waters of larger rivers, oxbows, or reservoirs with a tolerance for turbid water (Scott and Crossman 1979). Despite its designation, Stewart and Watkinson (2004) suggest that there has either been a noticeable increase in the abundance of this species or that more efficient capture techniques (i.e., electrofishing) are being utilized.

Netley Creek is known to support an open water and ice covered recreational fishery. At the mouth of Netley Creek and near the confluence with Wavey Creek, winter catches can include northern pike, walleye, and yellow perch (North/South Consultants Inc., unpublished data).

Horne and MacDonell (1996) completed a fish habitat inventory of Netley Creek for the South Interlake Land Management Association. This report provided a basic stream characterization, potential rehabilitation sites (discussed in Section 3.7.3), and a stream habitat classification summary (discussed in Section 3.7.3).

3.7.2 Field Surveys – 2007 and 2008

Focused in the headwaters of Netley Creek, summer/fall fisheries investigations were conducted at three sites in 2007 (Appendix Table A1-1, Figure 6). A total of 10 fish, representing 2 species (i.e., central mudminnow and lake chub) were captured at Wpt. 46 (Table 3, Figure 6). Although not captured, an undetermined number of 'forage fish' were also observed at Wpts. 45 and 47.

One hoop net was set on Netley Creek in the spring, 2008, west of Hwy. 8 (Wpt. 89; Figure 6, Appendix Table A1-1) (Photo 9). Effectively fishing for three days, 3 species of fish were captured at this site, including: 27 white sucker; two northern pike; and one walleye (Table 4). One northern pike was a female ready to spawn in the current season and the other was a male, preparing to spawn. The walleye was also a male preparing to spawn in the current season. The majority of the white suckers captured were males, either ready to

spawn (n = 12) or preparing to spawn (n = 7) in the current season. Eight female white suckers were captured

Photo 9. Hoop net set on Netley Creek (at Wpt. 89) to capture fish moving upstream, spring 2008.

also preparing to spawn in the current season. The data suggests that, at least with the sucker species, sexually mature (adult) fish can migrate approximately 25 km upstream on the Netley Creek. With suitable flow conditions, these fish would likely continue their migration to the next impassable barrier. This may be as far as the control structure located at the end of Netley Creek and the Norris lake control structure. At this location there have been reports of white sucker and northern pike in the spring. However, on April 21 there was no flow into Netley Creek from the outlet and, subsequently, no fish present at Wpt. 41 (Figure 6).

Also oriented to capture upstream migrating fish, a hoop net was set under the bridge on Hwy. 9 in late April, 2008 (D. Kroeker, MWSFB, pers. comm.). Established by Manitoba Water stewardship – Gimli Fisheries Branch, preliminary results of this hoopnet showed spring fish utilization by white sucker (n = 108), northern pike (n = 8), and walleye (n = 2). The white sucker and walleye captured were preparing to spawn in the current year while the northern pike were in spawning condition.

3.7.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground and aerial classifications for Netley Creek are provided in Appendix 3 (Tables A3-7 and A3-15).

The primary land use/cover along Netley Creek was identified as pasture/grazing (35.7%) (Table 5, Figure 6). This was followed by: other agricultural land (33.0%); nonforested wetland (10.5%); residential/commercial (9.4%); cropland (8.4%); and other urban or built-up land (3.0%).

The aquatic habitat quality along Netley Creek was nearly evenly comprised of Class B (36.0%) and Class C (33.2%) reaches (Table 6, Figure 9). This was closely followed by Class D (20.3%) and, to a lesser extent, Class A (10.5%) reaches.

The fish habitat along Netley Creek, from its mouth upstream to the confluence with Ross Creek (approximately Wpt. 82), is considered as Class 1 and/or important habitat (Figure 6). However, upstream of Wpt. 83 to and including the outlet at Norris Lake, this habitat (through channelization, potential barriers, land/use cover, etc) is reduced to Class 3; being composed of severe limitations to the production of fish and/or having marginal habitat (Figure 6). A Class 3 rating was designated (rather than Class 4) because some natural stream processes are still evident between Wpts. 48 and 45 (Figure 6). These findings were comparable to Horne and MacDonell (1996) wherein Class 1 habitat extended from the mouth of Netley Creek upstream to Hwy. 8, with the remainder of Netley Creek being designated as either Class 3 (i.e., Ross Creek upstream to Provincial Road 225 and from approximately 1 km east of Hwy. 7 upstream for 8km) and Class 2 (i.e., Hwy. 8 upstream to Ross Creek and Provincial Road 225 upstream to the first mile road east of Hwy. 7) habitat.

A total of 24 potential rehabilitation sites were identified along Netley Creek (Table 7, Figure 9). The majority (n = 13) of these sites were identified as Priority 3, followed by Priority 1 (n = 10) and Priority 2 (n = 1). All of the Priority 1 sites were related to livestock and the potential for grazing directly in the creek channel. The Priority 3 sites were related to some impacts within/to the riparian areas, potential barriers to fish migrations, and/or eroding banks. The Priority 2 site also related to agricultural practices and the possibility of grazing and/or the stockpile of manure.

Horne and MacDonell (1996) identified six potential rehabilitation sites along Netley Creek (Table 7, Figure 9). Five of these sites were related to direct access of cattle into the stream while the remaining site dealt with a stream crossing issue. It is unknown if any efforts have been undertaken towards the rehabilitation of these sites.

3.8 PARKS CREEK

Parks Creek Primarily flows in a south easterly direction (under Hwys. 8 and 9) for 13 km before emptying into the Red River, north of West St. Paul (Figure 1).

3.8.1 Review of Existing Information

No hydrometric data was found on the Water Survey of Canada website (ECWSC 2008) and WQMS-MWS (2007) did not have existing information pertaining to Parks Creek. The elevation change along Parks Creek is gradual, dropping only 7 meters over a course of approximately 13 km (Table 1, Figures 1 and 4). The majority of this change (i.e., 6 m) occurs between Hwy. 9 and the confluence with the Red River (Photo 10).

An FIHCS search identified 5 species of fish to have inhabited Parks Creek, including: brook stickleback, fathead minnow, johnny darter, northern redbelly dace, and yellow perch (Table 2).

Photo 10. Parks Creek, between the mouth and Hwy. 9, spring 2008.

3.8.2 Field Surveys – 2007 and 2008

A total of 11 fish, representing 3 species (i.e., brook stickleback, northern pike, and pearl dace) were captured at Wpt. 25 during summer/fall fish utilization surveys, 2007 (Table 3, Figure 8). Another site (Wpt. 29) was fished but there was no catch, only the visual observation of forage fish. The northern pike captured at Wpt. 25 was determined to a young-of-the-year, suggesting that this species can utilize Parks Creek for spawning.

One hoop net was deployed on Parks Creek between April 14 and 22, in water temperatures ranging from 3.0 to 10.0 ^{o}C (Wpt. 88; Table 4, Figure 8, Appendix Table A1-1). Effectively covering nearly 100% of the channel and fishing for a total of 5 nights, this hoop net captured 3 northern pike and 1 white sucker (Table 4). The northern pike captured on April 15 was a male preparing to spawn, the remaining 2 northern pike were ripe females. Although water temperatures were within the normal range for spawning of northern pike, walleye, and suckers (the targeted species) very few were captured. With a discharge of 0.282 m^3/sec (taken April 23, 2008) there was apparently enough water in this watercourse to allow fish passage (Appendix Table A2-1) (Photo 10). Also, an inspection of the creek from Wpt. 88 to its confluence with the Red River did not reveal any major barriers to fish migration. With the exception of some restrictions at Hwy. 9 (Wpt. 29) and a few smaller beaver/debris dams passage for some spring migratory species should be possible (Photo 11).

A brief discussion with local landowners at Wpt. 88 revealed that in previous years, with higher water levels, fish species such as northern pike and sucker were observed in Parks Creek. The land owners also suggested that the fish may only travel approximately 100 m upstream from this waypoint due to an instream restriction/barrier.

3.8.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for Parks Creek are provided in Appendix 3 (Table A3-8).

Land use/cover along Parks Creek was determined to be primarily cropland (85.4%), followed by residential commercial (8.4%), and mixed forest land (6.2%) (Table 6, Figure 8).

Aquatic habitat quality along Parks Creek was determined to be primarily Class C habitat (89.0%), followed by: Class B (6.3%) and Class D (4.7%) habitat. From its confluence with the Red River, upstream (just past Wpt. 88), Parks Creek may fall within a Class 3 rating (moderate limitations to production of fish) but be important habitat (Figure 8). However,

Photo 11. Debris on Parks Creek, between Hwy. 9 and the Red River, spring 2008.

upstream of Wpt. 88 the fish habitat within Parks Creek has more severe limitations to the production of fish (i.e., Class 4) comprising 'marginal habitat'.

One potential rehabilitation site (#42) was identified on Parks Creek (Table 7, Figure 11). Located at Hwy. 9 (Wpt. 29), this Priority 3 site exhibited eroding banks likely exacerbated by the presence of a drainage culvert located at the top of the right bank and a formerly cultivated field with denuded riparian. The infrastructure at this site (i.e., bridge) is also failing, depositing large chunks of concrete into the main channel of the creek. It is assumed that the structure and creek banks at this site will be rehabilitated in the near future based on the Manitoba Infrastructure and Transportation proposed fall advertising schedule for the 2008 construction season (www.gov.mb.ca/mit/contracts/capitalprogram/schedule.pdf, Accessed February 2008).

3.9 ROSS CREEK

Ross Creek primarily flows in an easterly direction for 20 km before emptying into Netley Creek (east of Hwy. 8) (Table 1, Figure 1).

3.9.1 Review of Existing Information

Neither hydrometric data nor existing water quality information was found relating to Ross Creek (ECWSC 2008; WQMS-MWS 2007).

Six species of fish have been identified inhabiting Ross Creek, including: brook stickleback; central mudminnow; fathead minnow; northern pike; northern redbelly dace; and white sucker (Table 2) (MWSFB 2007). With the exception of the northern pike and white sucker, these species are considered 'small bodied' and likely to inhabit smaller water bodies. The northern pike and white sucker likely move upstream, into Ross Creek, from Netley Creek during spring migration events.

3.9.2 Field Surveys – 2007 and 2008

No stream properties (i.e., discharges, depths, substrate composition) or summer/fall fish utilization surveys were conducted on Ross Creek in 2007 due to non-existent and/or marginal stream flows (Photo 12).

Although Ross Creek was identified for spring migration studies in 2008 low flow conditions prevented the placement of hoop nets.

Photo 12. Looking upstream along Ross Creek (Wpt. 79), September 19, 2007.

3.9.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for Ross Creek are provided in Appendix 3 (Table A3-9).

Land use/cover along this creek was primarily classified as other agriculture (e.g., a mix of cropland, hayland, and some residences) (87.2%), followed by: mixed forest land 96.6%); and hayland (6.2%) (Table 5, Figure 6).

With the exception of the area near Wpt. 40 (Hwy. 7) (Class A: 6.5%), the majority of this watercourse has been channelized and given a Class C (93.5%) aquatic habitat quality rating (Table 6, Figure 9). Although some fish species may migrate into Ross Creek from Netley Creek under suitable hydraulic conditions; the degree of channelization and ephemeral nature of Ross Creek (including existing land use/cover) suggest this watercourse has severe limitations to the production of fish (i.e., Class 4) and/or has marginal habitat for the production of fish.

No potential rehabilitation sites were identified along Ross Creek.

3.10 STEELE DRAIN

Forming the headwaters of Wavey Creek, the Steele Drain flows northward for approximately 4 km emptying into the headwaters of Wavey Creek (Table 1, Figure 1).

3.10.1 Review of Existing Information

Neither hydrometric data nor existing water quality information was found relating to Steele Drain (ECWSC 2008; WQMS-MWS 2007).

Three species of fish have been identified inhabiting the Steele Drain, including: brook stickleback; fathead minnow; and northern pike (Table 2) (MWSFB 2007). The northern pike likely moved into the Steele Drain, from Wavey Creek, during periods of high flow.

3.10.2 Field Surveys – 2007 and 2008

No stream properties (i.e., discharges, depths, substrate composition) or summer/fall fish utilization surveys were conducted on the Steele Drain in 2007. This drain was dry near

Wpt. 5, but wetted between Wpts. 3 and 4. The water between these waypoints appeared to maintain a constant depth (due to channelization) and did not exhibit any flow (Photo 13).

The Steele Drain was not identified for spring fisheries studies in 2008.

Photo 13. Looking upstream along Steele Drain (Wpt. 4), August 2, 2007.

3.10.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for Steele Drain are provided in Appendix 3 (Table A3-10).

All 4.3 km (100.0%) of the Steele Drain reviewed for land use/cover was determined to be cropland (Table 5, Figure 8).

The Steele Drain is a straight line 'ditch', likely constructed to expedite the removal of water from the surrounding agricultural fields. Riparian cover, natural sinuosity, instream cover, and habitat variability are all lacking along this drain (Photo 13). Therefore, it was given a Class C aquatic habitat quality rating for its entire length (Table 6, Figure 11). With its location in the headwaters of this watershed, degree of channelization, and ephemeral nature, the fish habitat of Steele Drain can be designated as Class 4 (having severe limitations to production of fish) and/or comprising marginal habitat.

No potential rehabilitation sites were identified along the Steele Drain.

3.11 TUGELA CREEK

Tugela Creek flows eastward for approximately 2 km before emptying directly into Lake Winnipeg (Table 1, Figure 1).

3.11.1 Review of Existing Information

No existing information regarding hydrometric data, water quality information, or fisheries records were found relating to Tugela Creek (ECWSC 2008; WQMS-MWS 2007; MWSFB 2007).

3.11.2 Field Surveys – 2007 and 2008

No hydrometric surveys or fisheries investigations were conducted on Tugela Creek in 2007. With the exception of the mouth of this creek, the majority of this watercourse was dry or had ponded sections of water (Photo 14).

Tugela Creek was not identified for spring fisheries investigations in 2008.

3.11.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground classifications for Tugela Creek are provided in Appendix 3 (Table A3-11).

The 2.3 km of Tugela Creek reviewed for land use/cover was primarily hayland (80.0%) and, to a lesser extent, residential/commercial (20.0%) (Table 5, Figure 6) (Photo 14).

The length of Tugela Creek reviewed for aquatic habitat quality received a Class C (i.e., highly impacted with altered hydraulic regimes) (Table 6, Figure 9). This watercourse is primarily channelized, flows through a residential area, is surrounded by hayfields, and maintains minimal flow; it should therefore be designated as having Class 4 fish habitat (severe limitations to production of fish) and/or comprising marginal fish habitat. However

Photo 14. Looking upstream along Tugela Creek (Wpt. 19), August 2, 2008.

it is a direct tributary to Lake Winnipeg and, under certain hydraulic conditions, its mouth could provide some degree of fisheries habitat (e.g., spawning, rearing, feeding).

Two potential rehabilitation sites were identified on Tugela Creek (Table 7, Figure 9). Related directly to residential land use, these Priority 3 sites exhibited manicured lawns with minimal riparian cover and/or buffer strips (Photo 14). As a tributary to Lake Winnipeg, Tugela Creek acts as a direct conduit for potentially deleterious substances (e.g., sediments, nutrients, residential and agricultural herbicides, etc). In the case of these two sites (or as one longer site), the best rehabilitation efforts could start with educational programs extolling the benefits of a healthy riparian zone.

3.12 WAVEY CREEK

With its headwaters located east of the town of Stonewall, Wavey Creek flows in a north east direction for approximately 41 km before discharging into Netley Creek (Table 1, Figure 1).

3.12.1 Review of Existing Information

The elevation of Wavey Creek drops approximately 18 m over a course of 41 km (Table 1, Figures 1 and 5). With the exception of the spring freshet or other high precipitation events, this gradual decline in elevation usually results in slow moving and, sometimes, idle sections

of watercourse. No hydrometric data was located pertaining to Wavey Creek (ECWSC 2008).

In 1995, a relatively intense water quality sampling program (n = 10 stations) was conducted along the Wavey Creek watercourse (WQMS-MWS 2007). A cursory inspection of the data suggest it was collected to determine the effects of field runoff throughout the course of the open water season. The WQMS-MWS data has been provided to the EICD Manager in digital form for inclusion into their Wavey Creek water quality data base.

Up to 17 species of fish have been reported utilizing Wavey Creek (Table 2) (MWSFB 2007). Some of the larger bodied species identified included: carp; channel catfish; freshwater drum; northern pike; walleye; white sucker; and yellow perch. These species likely utilize the lower portions of Wavey Creek migrating upstream from Lake Winnipeg, the Red River, or Netley Creek.

On July 23, 2007, North/South Consultants Inc. (unpublished data) captured 107 fish, representing 13 species {(i.e., black crappie (n = 12); blackside darter (n = 1); brook stickleback (n = 1); fathead minnow (n = 22); johnny darter (n = 7); rock bass (n = 21); sand shiner (n = 10); shorthead redhorse (n = 1); tadpole madtom (n = 1); walleye (n = 1); white sucker (n = 15); and yellow perch (n = 15)} underneath the bridge at Hwy. 9. Six of these species (i.e., black crappie, johnny darter, rock bass, walleye, white sucker, and yellow perch) were represented by young-of-the-year and/or juvenile life stages. This data suggests successful spawning of these species and/or suitable nursery habitat, at least up to this section of creek.

From Hwy. 9 downstream to its confluence with Netley Creek, Wavey Creek supports a relatively active recreational fishery during the open water and ice cover seasons (North/South Consultants Inc., unpublished data). Catches in winter can include walleye, northern pike, and yellow perch. Captured in early spring, the presence of sexually maturing northern pike suggests that, at least, this species is staging in the area with the likelihood of spawning in the current year.

Horne and MacDonell (1996) completed a fish habitat inventory of Wavey Creek for the South Interlake Land Management Association. This report provided a basic stream characterization, potential rehabilitation sites, and a stream habitat classification summary (discussed in Section 3.12.2).

3.12.2 Field Surveys – 2007 and 2008

A total of 24 fish, representing eight species were captured at Wpts. 22 and 84 during summer/fall fish utilization surveys, 2007 (Table 3, Figure 7, Appendix Table A1-1). Primarily small bodied fish, the species captured included: blacknose shiner; blackside darter; golden redhorse; johnny darter; longnose dace; pearl dace; rock bass; and white sucker.

Effectively fishing for three nights and covering 100% of the channel, the hoopnet set at Wpt. 22 captured a total of 7 northern pike, 5 white sucker, and 1 walleye (Table 4, Figure 7). Four of the northern pike captured were ripe females, while the remaining 3 were males preparing to spawn in the current season (Appendix 2 Table A2-4). The 3 female and 1 male white sucker captured were preparing to spawn in the current season. The fifth white sucker was a ripe male. The one walleye captured was a male preparing to spawn in the current season.

Fishing for two nights and covering 100% of the channel, the hoopnet set at Wpt. 78 captured a total of 19 white sucker and 1 northern pike (Table 4, Figure 7) (Photo 15). The majority (n = 14) of the white suckers captured were females preparing to spawn in the current season, while 5 were males preparing to spawn (Appendix 2 Table A2-4). The one northern pike captured was a ripe female. The presence and number of these adult spawning fish suggests that fish passage is possible at least 28 km upstream on Wavey Creek and at a discharge of 1.008 m^3/sec (Appendix 2 Table A2-1).

3.12.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground and aerial classifications for Wavey Creek are provided in Appendix 3 Tables A3-12 and A3-15).

The land use/cover along Wavey Creek was comprised of other agricultural land (66.2%), mixed forest land (30.6%), and pasture/grazing (3.2%) (Table 5, Figure 7).

The aquatic habitat quality along Wavey Creek was determined to be primarily Class C (69.4%), followed by Class A (27.1%) and Class B (3.5%) habitat (Table 6, Figure 10). The relatively high percentage of Class A habitat may be attributable to the remaining natural riparian areas and lack of channelization of this watercourse from its confluence with Netley Creek upstream to Wpt. 22 (Figure 7). With it's natural sinuosity, varying depths and substrates, healthy riparian, etc. this section of Wavey Creek (i.e., confluence to Wpt. 22) can be defined as having Class 1 fish habitat (i.e., high capability for fish production) and/or

Photo 15. Hoop net set on Wavey Creek, just downstream of the control structure at Wpt. 78, spring 2008.

comprising important habitat. Upstream from Wpt. 22 to Wpt. 5, Wavey Creek is primarily channelized having comparable depths, substrate, and (often) minimal riparian. This section of watercourse was therefore identified as having Class 4 fish habitat (i.e., severe limitations to production of fish) and/or marginal fish habitat.

Horne and MacDonell (1996) also suggested that the fish habitat from the mouth of Wavey Creek, upstream to Hwy. 9 was also Class 1. This habitat then declined to Class 2 habitat for a short distance until becoming Class 4 up to the end of their study area (just south of Provincial Road 515).

Five potential rehabilitation sites were identified on Wavey Creek with an additional site identified on a wider tributary entering Wavey Creek (Table 7, Figure 10). Rehabilitation Site 1, located on the extension of Wavey Creek, was designated a Priority 1. Given the extent of grazing/livestock access and proximity to Lake Winnipeg, the possibility of nutrient loading to this waterbody should be addressed. Rehabilitation sites 2 and 3 (both Priority 2) revealed the likelihood of extensive grazing. Rehabilitation sites 4, 5, and 6 (all Priority 3) identified areas of: potential rock barrier; grazing areas; and a barrier at a cement ford; respectively. Although no information was available regarding Site 4, it is possible that this area is the site of previous rehabilitation efforts (e.g., placement of aggregate as

spawning habitat in a riffle sequence or to slow velocities) (Photo 16). Groundtruthing investigations could be warranted at this site during spring migrations. Identified as a low level, concrete and culvert ford, in 2007 Site 6 was unlikely a barrier to upstream fish migration. However, this site should be monitored periodically for accumulations of debris (which could hinder upstream and downstream movements) or washouts (which could cause bank erosion and subsequent sediment loading).

Photo 16. Looking upstream on Wavey Creek (Wpt. 22) towards riffle sequence, spring 2008.

Horne and MacDonell (1996) identified one site on Wavey Creek that warranted rehabilitation (Table 7, Figure 10). This site, identified as high priority, outlined problems associated with direct cattle access (e.g., siltation) and provided remedial options (i.e., fencing, stream crossing, and re-vegetation). It is unknown if rehabilitation efforts were attempted at this site.

3.13 WHISKEY DITCH

Whiskey Ditch flows south to north for approximately 4 km, emptying into an area south of the confluence of Netley Creek and the Red River (Table 1, Figure 1).

3.13.1 Review of Existing Information

Neither hydrometric data nor existing water quality information was found relating to Whiskey Ditch (ECWSC 2008; WQMS-MWS 2007).

An FIHCS search identified three species of fish to inhabiting the Whiskey Ditch ,these were: black bullhead; brook stickleback; and fathead minnow (Table 2) (MWSFB 2007).

3.13.2 Field Surveys – 2007 and 2008

With the exception of ground based photography and aerial reconnaissance, no field inspections (i.e., hydrometric surveys or fisheries investigations) were conducted on Whiskey Ditch in 2007. The area of this ditch that was accessible by road exhibited minimal to non-existent flow conditions (i.e., dry) (Photo 17).

Whiskey Ditch was not identified for spring fisheries investigations in 2008.

Photo 17. Looking downstream along Whiskey Ditch (Wpt. 86), September 25, 2007.

3.13.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground and aerial classifications for Whiskey Ditch are provided in Appendix 3 (Table A3-13).

Land use/cover along Whiskey Ditch was determined to be comprised entirely of other agricultural land (100.0%) (Table 5, Figure 6) (Photo 17).

The entire length of the Whiskey Ditch has been designated as Class C (aquatic habitat quality) (Table 6, Figure 9). With the degree of channelization, minimal riparian, and homogeneous instream habitat it is assumed this ditch would also offer little in the way of beneficial fish habitat (i.e., Class 4 and or marginal fish habitat). However, this may not be the case near the mouth of this ditch (which was not accessible or viewed from the air) which flows northward towards Lake Winnipeg (Figure 9).

No potential rehabilitation sites were identified along the Whiskey Ditch in 2007.

3.14 NORRIS LAKE

3.14.1 Review of Existing Information

Neither hydrometric data nor existing water quality information was found relating to Norris Lake (ECWSC 2008; WQMS-MWS 2007).

An FIHCS search identified 7 species of fish either inhabiting or previously inhabiting Norris Lake (Table 2) (MWSFB 2007). Species accounts included: black bullhead; brook stickleback; brook trout; central mudminnow; fathead minnow; northern pike; rainbow trout; and yellow perch. The Manitoba Water Stewardship – Fisheries Branch website (www.gov.mb.ca/waterstewardship/fisheries/habitat/index) has stocking records from 2002 to 2007. Records for the assumed stocking of Norris Lake with brook and rainbow trout were not available for this period. However, in April 2005, 200 adult northern pike were released into Norris Lake.

Norris Lake supports both a open water and ice-cover fishing season (North/South Consultants Inc., unpublished data). Winter catches on this lake may include both northern pike and yellow perch. Although relatively small in size, these species appeared to be generally healthy and, based on internal and external examination, exhibited varying degrees of sexually reproductive capabilities.

3.14.2 Field Surveys – 2007 and 2008

Field surveys of Norris Lake were limited to the collection of ground based photographs and the collection of some in situ water quality parameters.

3.14.3 Land Use/Cover, Aquatic Habitat and Rehabilitation Sites

Ground and aerial classifications for Norris Lake are provided in Appendix 3 (Table A3-14).

Based primarily on aerial footage the 13.8 km of Norris Lake reviewed for land use/cover consisted of: mixed forest land (58.0%); other urban or built-up land (20.1%); pasture/grazing (20.0%); and other agricultural land (1.9%) (Table 5, Figure 6).

An aerial review of Norris Lake revealed it still maintained a relatively strong percentage (58.0%) of Class A aquatic habitat quality (Table 6, Figure 9). This was followed by Class B (20.1%), Class D (13.2%), and Class C (8.7%) aquatic habitat quality. Although Norris Lake exhibits a relatively healthy aquatic habitat (i.e., Class A) it may still be limited in its capacity to support a 'thriving' fish community (based on recreational standards); nonetheless the fish habitat in Norris Lake would be Class 2 and or important habitat.

3.15 NETLEY MARSH SHORELINE

The Netley Marsh is an important area to maintain and protect for a number of reasons. This area (i.e., Netley-Libau Marsh) was officially dedicated as a Canadian Important Bird Area on October 1st, 2000 and is also a heritage marsh candidate under the Manitoba Heritage Marsh Program (www.ibacanada.com/cpm_netley. accessed June 30, 2008). Although it is beyond the scope of this document to develop mitigative strategies and/or rehabilitation plans for this vast area (24,381-ha of upland and wetland habitat); it is hoped that this document be used to further assist working groups involved in ongoing conservation efforts. For example, Lindgren and The Netley Libau Marsh Foundation Inc. (2001) have compiled information pertaining to this area, associated threats, and conservation goals/objectives.

Classified as non-forested wetland (100.0%), the 17 km of Netley Marsh shoreline was not rated according to aquatic habitat quality. However, it is assumed (based on the absence of development and/or major agricultural practice) this area would be Class A (i.e., minimally impacted with natural morphology). In addition, this area would be Class 1 fish habitat (i.e., high capability for fish production) and/or important.

No potential rehabilitation sites were identified along the Netley Marsh shoreline.

3.16 OVERVIEW OF WATERSHED 05OJ

The comparison of one watershed to another, or even one waterbody to another, is often problematic. A number of factors (e.g., land use practices, size of watershed, population dynamics, soil composition, etc.) all must be considered. With this is mind, the health/integrity of Watershed 05OJ is apparently no worse or better than other watersheds within agro-Manitoba (e.g., a number of watersheds throughout Manitoba are now channelized, which is a major factor in the 'health' rating of these systems). Each watershed is unique and requires the development of independent watershed management plans to deal with specific issues.

The majority of potential rehabilitation sites within watershed 05OJ were identified along the Netley and Wavey creeks (Table 7, Figures 9 and 10). These sites, especially the ones in areas of important fish habitat, could be the focus of mitigative efforts and/or watershed management plans. Maintaining existing 'quality' habitat and rehabilitating damaged areas (e.g., via exclusion fencing, riparian rehabilitation, bank stabilization, etc.) would be important steps towards effective watershed management and a reduction in potentially deleterious substances. Potential detriments to aquatic health, negative impacts, and potential mitigative measures are outlined in Appendix 4.

4.0 REFERENCES

Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration, Prairies East Region (AAFC-PFRA). 2004. Summary of resources and land use issues related to riparian areas in the Icelandic River watershed study area. Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration, Winnipeg.

Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration, Prairies East Region (AAFC-PFRA). 2004b. Summary of resources and land use issues related to riparian areas in the Lower Red River watershed study area. Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration, Winnipeg

Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper: 964.

Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Bain, M.B. and N.J. Stevenson, editors. 1999. Aquatic habitat assessment: Common methods. American Fisheries Society, Bethesda, Maryland.

Bourne, A., N. Armstrong, and G. Jones. 2002. A preliminary estimate of total nitrogen and total phosphorus loading to streams in Manitoba, Canada. Water Quality Management Section. Manitoba Conservation Report No. 2002-04.

CCME. 2005. Canadian environmental quality guidelines. CCME, Winnipeg.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2008. www.cosewic.gc.ca/. Accessed February, 2008.

Department of Fisheries and Oceans (DFO) – Manitoba Natural Resources. 1996. Manitoba stream crossing guidelines for the protection of fish and fish habitat.

Department of Fisheries and Oceans (DFO). 1998. Habitat conservation and protection guidelines. Developed from the *Policy for the management of fish habitat* (1986). Communications Directorate, Fisheries and Oceans Canada, Ottawa, Ontario. Second edition.

Donat, M. 1995. Bioengineering techniques for stream bank restoration: A review of central European practices. Ministry of Environment, Lands, and Parks and Ministry of Forests, British Columbia. Watershed Restoration Project Report No. 2.

Environment Canada, Water Survey of Canada (ECWSC). 2008. www.msc.ec.gc.ca/wsc. Accessed February 18, 2008.

Evanitski, C. no date. The drain primer: A guide to maintaining and conserving agricultural drains and fish habitat. Produced by Drainage Superintendents Association of Ontario and Ontario Federation of Agriculture in association with Fisheries and Oceans Canada.

Horne, B. and D. S. MacDonell. 1996. Fish habitat inventory of Cooks, Netley, Wavey, and Willow creeks in southern Manitoba. A report prepared for the South Interlake Land Management Association. North/South Consultants Inc., Winnipeg, Manitoba.

ICF Consulting. 2005. A summary of existing research on low-head dam removal projects. Requested by: American Association of State Highway and Transportation Officials (AASHTO). Prepared by ICF Consulting, Lexington, MA in association with Woodlot Alternatives.

Kipp, S., and C. Callaway. 2003. On the living edge: Your handbook for waterfront living. Saskatchewan/Manitoba Edition. www.livingbywater.ca

Koning, C.W. 1999. Riparian assessment and prescription procedures. Ministry of Environment, Lands, and Parks, Watershed Restoration Program. University of British Columbia. Watershed Restoration Technical Circular No. 6.

Lake Winnipeg Stewardship Board. 2006. Reducing nutrient loading to Lake Winnipeg and its watershed. Our collective responsibility and commitment to action. Report to the Minister of Water Stewardship. December 2006.

Lindgren, C. J. and The Netley Libau Marsh Foundation Inc. 2001. Netley-Libau Marsh important Bird area community conservation plan. Prepared for the Canadian Nature Federation, Bird Studies Canada, Bird Life International and the Manitoba Naturalists Society. Winnipeg, Manitoba. 54 pp.

Manitoba Water Stewardship - Fisheries Branch (MWSFB). 2007. Office located in Winnipeg Manitoba. Fisheries Inventory Habitat Classification System (FIHCS) and library searches.

Manitoba Water Stewardship. 2006. Manitoba Water Stewardship public consultation draft – Nutrient Management Regulation. Nutrient Management Regulation under *The Water Protection Act*. www.gov.mb.ca/waterstewardship/wqmz/nutrient_mgmt_draft_reg2006-11.pdf.

Milani, D.W. 2007. Fish habitat inventory of agro-Manitoba watersheds (2002 – 2006). Fisheries and Oceans Canada. Habitat Management. Winnipeg, MB. Unpublished data.

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. Co-published by Manitoba Natural Resources.

Peake, S. J. 2008. Behaviour and passage performance of northern pike, walleyes, and white suckers in an experimental raceway. North American Journal of Fisheries Management. 28:000-000, 2008.

Scott, W. B. and E. J. Crossman. 1979. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 184.

Stewart, K. W. and D. A. Watkinson. 2004. The freshwater fishes of Manitoba. University of Manitoba Press.

Terzi, R. A. 1981. Hydrometric field manual – measurement of streamflow. Inland Waters Directorate Water Resources Branch. Ottawa, Canada.

United States Department of Agriculture (USDA). 1998. Stream visual assessment protocol. National Water and Climate Center technical note: 99-1.

United States Department of Agriculture (USDA). 2004. Riparian assessment using the NRCS riparian assessment method. United States Department of Agriculture and Natural Resources Conservation Service (NRCS).

Williams, J.E., C.A. Wood, and M.P. Dombeck, editors. 1997. Watershed restoration: Principles and practices. American Fisheries Society, Bethesda, Maryland.

Williamson, D.A. 2002. Manitoba water quality standards, objectives, and guidelines. Manitoba Conservation Report 2002-11. Final Draft: November 22, 2002. 76pp

Water Quality Management Section - Manitoba Water Stewardship (WQMS-MWS). 2007. 123 Main Street, Suite 160. Winnipeg, Manitoba. R3C 1A5.

TABLES AND FIGURES

Table 1. Length of watercourse (determined by the National Topographic Service Base), distances reviewed by ground and air, and percent of each watercourse classified for Watershed 05OJ, 2007.

Watercourse	Length of Watercourse (km)[1]	Distance Covered by Air (km)	Distance Covered by Ground (km)	% of Watercourse Classified
Cochrane Creek	4.9	-	2.4	49.5
Fisher Drain	5.4	-	4.7	87.7
Gramiak Drain	8.8	-	8.2	92.8
Grassmere Creek Drain	45.9	-	41.0	89.3
Jackfish Creek	21.4	-	8.7	40.7
Jennifer Creek	15.7	-	7.6	48.5
Netley Creek	60.4	60.4	-	100.0
Parks Creek	12.8	-	7.0	54.8
Ross Creek	19.9	-	14.5	73.0
Steele Drain	4.3	-	4.2	98.6
Tugela Creek	2.2	-	0.5	22.2
Wavey Creek	41.1	6.8	26.4	80.8
Whiskey Ditch	3.9	3.9	-	100.0
Norris Lake	14.9	15.0	<1.0	100.0
Netley Marsh Shoreline	17.4	17.4	-	100.0
Total (km)	**278.9**	**103.4**	**125.2**	

Total length of watercourses	**278.9**
Total length of watercourses classified	**228.6**
Total percentage of watercourses classified	**82.0**

[1] Source: Department of Natural Resources, Government of Canada; 1:50,000 National Topographic Service Base

Table 2. Fish species known to, or possibly, utilizing watercourses in Watershed 05OJ. Information based on a Fisheries Inventory Habitat Classification System (FIHCS) search conducted by Manitoba Water Stewardship – Fisheries Branch, 2007.

SPECIES	WATERCOURSE										
	Cochrane Creek	**Grassmere Creek Drain**	**Jackfish Creek**	**Netley Creek**	**Netley Marsh**	**Parks Creek**	**Ross Creek**	**Steele Drain**	**Wavey Creek**	**Whiskey Ditch**	**Norris Lake**
Bigmouth buffalo				X	X						
Black bullhead				X						X	X
Black crappie				X	X						
Blackside darter			X	X					X		
Brook stickleback	X			X		X	X	X	X	X	X
Brook trout				X							X
Brown bullhead				X	X				X		
Burbot				X	X						
Carp				X	X				X		
Central mudminnow			X	X			X				X
Channel catfish				X	X				X		
Cisco					X						
Common shiner				X							
Creek chub				X							
Emerald shiner				X	X				X		
Fathead minnow		X		X		X	X	X	X	X	X
Freshwater drum					X				X		
Goldeye				X	X						
Iowa darter				X							
Johnny darter				X		X			X		
Longnose dace									X		
Northern pike		X		X	X		X	X	X		X
Northern redbelly dace						X	X				
Quillback					X						
Rainbow trout											X
River shiner									X		
Rock bass				X	X				X		
Sauger				X	X						

Table 2. Continued.

SPECIES	WATERCOURSE										
	Cochrane Creek	**Grassmere Creek Drain**	**Jackfish Creek**	**Netley Creek**	**Netley Marsh**	**Parks Creek**	**Ross Creek**	**Steele Drain**	**Wavey Creek**	**Whiskey Ditch**	**Norris Lake**
Spottail shiner				X							
Tadpole madtom				X	X				X		
Trout perch					X						
Walleye				X	X				X		
White bass				X	X						
White sucker		X	X	X	X		X		X		
Yellow perch		X	X	X	X	X			X		X

Table 3. Summer and fall fish utilization results, by watercourse and waypoint site (in *italics*) throughout Watershed 05OJ, 2007. Descriptions of waypoints are provided in Appendix 1.1

SPECIES	Netley Creek			Wavey Creek		Parks Creek		Jackfish Creek	Steele Drain	Grassmere Creek Drain				Ross Creek	TOTALS
	46	*45*	*47*	*22*	*84*	*25**	*29***	*78*	*3*	*1***	*26*	*65*	*71*	*81*	
Black crappie	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Blacknose shiner	-	-	-	1	-	-	-	3	-	-	-	-	-	-	4
Blackside darter	-	-	-	3	2	-	-	-	-	-	-	-	-	-	5
Brook stickleback	-	-	-	-	-	1	-	1	-	-	-	7	-	Yes	9
Central mudminnow	1			-	-	-	-	-	-	-	-	-	-	-	1
Golden redhorse	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Johnny darter	-	-	-	4	3	-	-	3	-	-	-	-	3	-	13
Lake chub	9	-	-	-	-	-	-	-	-	-	-	-	-	-	9
Longnose dace	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4
Northern pike	-	-	-		-	1	-	-	-	-	-	-	-	-	1
Pearl dace	-	-	-	2	-	9	-	-	-	-	4	2	3	-	20
Rock bass	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
White sucker	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2
Forage fish (visual)	-	Yes	Yes	-	-	-	Yes	-	Yes	-	Yes	-	-	Yes	-
TOTALS	10	-	-	16	8	11	-	7	-	-	5	9	6	-	72

* young-of-the-year northern pike, August 3, 2007.

** fished in fall but no catch

Table 4. Results of spring fish utilization studies, conducted by North/South Consultants Inc. throughout Watershed 05OJ, 2008.

DATE	Temperature (°C)	Grassmere Creek @ train bridge (Wpt. 87)				Comments
		Northern pike	White sucker	Walleye	TOTALS	
14-Apr-07	3.0	-	-	-	-	Hoop net installed
15-Apr-07	3.0	0	0	0		Hoop net pulled
16-Apr-07	-	-	-	-	-	No fishing
17-Apr-07	-	-	-	-	-	No fishing
18-Apr-07	9.0	-	-	-	-	Hoop re-installed
19-Apr-07	10.0	0	0	0	0	80% cover
20-Apr-07	11.0	1	0	0	0	
21-Apr-08	10.0	0	0	0	0	
22-Apr-08	7.0	0	0	0	0	Hoop pulled
TOTALS		1	0		1	

DATE	Temperature (°C)	Grassmere Creek @ mouth (Wpt. 90)				Comments
		Northern pike	White sucker	Walleye	TOTALS	
21-Apr-08	10.0	-	-	-	-	Hoop net installed
22-Apr-08	7.0	23	0	0	23	Hoop net pulled
TOTALS		23	0	0	23	
14-Apr-07	-	-	-	-	-	Hoop net installed
15-Apr-07	3.0	1	0	0	1	Hoop net pulled
16-Apr-07	-	-	-	-	-	No fishing
17-Apr-07	-	-	-	-	-	No fishing
18-Apr-07	7.0	-	-	-	-	Hoop re-installed
19-Apr-07	9.0	1	0	0	1	100% cover
20-Apr-07	9.0	0	0	0	0	
21-Apr-08	10.0	0	0	0	0	
22-Apr-08	6.0	1	1	0	2	Hoop net pulled
TOTALS		3	1		4	

Table 4. Continued.

DATE	Temperature (°C)	Netley Creek (Wpt. 89)				Comments
		Northern pike	White sucker	Walleye	TOTALS	
19-Apr-07	10.0	-	-	-	-	Hoop net installed
20-Apr-07	9.0	0	27	1	28	
21-Apr-08	8.0	2	0	0	2	
22-Apr-08	7.0	0	0	0	0	Hoop net pulled
TOTALS		2	27	1	30	

DATE	Temperature (°C)	Wavey Creek @ ford crossing (Wpt. 22)				Comments
		Northern pike	White sucker	Walleye	TOTALS	
19-Apr-07	12.0	-	-	-	-	Hoop net installed
20-Apr-07	9.0	1	2	1	4	
21-Apr-08	6.0	0	0	0	0	Large hole in net
22-Apr-08	4.5	6	3	0	9	Hoop net pulled
TOTALS		7	5	1	13	

DATE	Temperature (°C)	Wavey Creek @ control structure (Wpt. 78)				Comments
		Northern pike	White sucker	Walleye	TOTALS	
20-Apr-07	9.0	-	-	-	-	Hoop net installed
21-Apr-08	8.0	1	17	0	18	
22-Apr-08	7.0	0	2	0	2	Hoop net pulled
TOTALS		1	19	0	20	

Table 5. Total number of reaches (by land use/cover), length of watercourse classified, and percentage of reach by land use/cover in Watershed 05OJ, 2007.

LAND USE/LAND COVER	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Cochrane Creek			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	1	3.2	100.0
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Cochrane Creek		3.2	100.0
Fisher Drain			
Hayland	1	0.3	6.2
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	1	0.8	14.4
Other Agricultural Land	1	3.1	58.4
Mixed Forest Land	3	1.1	21.1
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Fisher Drain	6	5.4	100.0
Gramiak Drain			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	1	8.8	100.0
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Gramiak Drain	1	8.8	100.0
Grassmere Creek Drain			
Hayland	1	3.8	9.2
Residential/Commercial	1	1.0	2.4
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	1	28.7	70.3

Table 5. Continued.

LAND USE/LAND COVER	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	1	7.4	18.2
Total along Grassmere Creek Drain	4	40.9	100.0
Jackfish Creek			
Hayland	1	0.6	2.9
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	2	4.7	21.8
Cropland	1	12.6	59.2
Other Agricultural Land	1	3.4	16.1
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Jackfish Creek	5	21.3	100.0
Jennifer Creek			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	2	4.0	38.2
Cropland	0	0.0	0.0
Other Agricultural Land	4	6.3	59.6
Mixed Forest Land	1	0.2	2.2
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Jennifer Creek	7	10.5	100.0
Netley Creek			
Hayland	0	0.0	0.0
Residential/Commercial	1	5.6	9.4
Pasture/Grazing	7	21.1	35.7
Cropland	4	5.0	8.4
Other Agricultural Land	6	19.5	33.0
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	2	6.2	10.5
Other Urban or Built-up Land	1	1.8	3.0
Total along Netley Creek	21	59.2	100.0

Table 5. Continued.

LAND USE/LAND COVER	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Parks Creek			
Hayland	0	0.0	0.0
Residential/Commercial	1	1.1	8.4
Pasture/Grazing	0	0.0	0.0
Cropland	1	10.9	85.4
Other Agricultural Land	0	0.0	0.0
Mixed Forest Land	1	0.8	6.2
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Parks Creek	3	12.8	100.0
Ross Creek			
Hayland	1	0.9	6.2
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	1	12.7	87.2
Mixed Forest Land	1	1.0	6.6
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Ross Creek	3	14.5	100.0
Steele Drain			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	1	4.3	100.0
Other Agricultural Land	0	0.0	0.0
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Steele Drain	1	4.3	100.0
Tugela Creek			
Hayland	1	1.8	80.0
Residential/Commercial	1	0.5	20.0
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	0	0.0	0.0

Table 5. Continued.

LAND USE/LAND COVER	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Tugela Creek	2	2.3	100.0
Wavey Creek			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	1	1.1	3.2
Cropland	0	0.0	0.0
Other Agricultural Land	1	22.0	66.2
Mixed Forest Land	3	10.2	30.6
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Wavey Creek	5	33.2	100.0
Whiskey Ditch			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	1	3.9	100.0
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Whiskey Ditch	1	3.9	100.0
Norris Lake			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	3	2.8	20.0
Cropland	0	0.0	0.0
Other Agricultural Land	1	0.3	1.9
Mixed Forest Land	3	8.0	58.0
Nonforested Wetland	0	0.0	0.0
Other Urban or Built-up Land	2	2.8	20.1
Total along Norris Lake	9	13.8	100.0

Table 5. Continued.

LAND USE/LAND COVER	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Combined			
Hayland	5	7.4	3.2
Residential/Commercial	4	8.1	3.4
Pasture/Grazing	15	33.6	14.4
Cropland	8	33.5	14.3
Other Agricultural Land	19	111.9	47.8
Mixed Forest Land	12	21.2	9.1
Nonforested Wetland	2	6.2	2.7
Other Urban or Built-up Land	4	12.0	5.1
Total combined	69	234.0	100.0
Netley Marsh Shoreline			
Hayland	0	0.0	0.0
Residential/Commercial	0	0.0	0.0
Pasture/Grazing	0	0.0	0.0
Cropland	0	0.0	0.0
Other Agricultural Land	0	0.0	0.0
Mixed Forest Land	0	0.0	0.0
Nonforested Wetland	1	15.9	100.0
Other Urban or Built-up Land	0	0.0	0.0
Total along Netley Marsh Shoreline	1	15.9	100.0

Note: The value(s) for Netley Marsh Shoreline were not included in the total combined, as it is below the total combined cell.

Table 6. Total number of reaches (by habitat quality rating), length of watercourse classified, and percentage of reach by rating in Watershed 05OJ, 2007.

AQUATIC HABITAT CLASSIFICATION	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Cochrane Creek			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	1	3.2	100.0
Class 'D'	0	0.0	0.0
Total along Cochrane Creek	1	3.2	100.0
Fisher Drain			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	1	5.4	100.0
Class 'D'	0	0.0	0.0
Total along Fisher Drain	1	5.4	100.0
Gramiak Drain			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	1	8.8	100.0
Class 'D'	0	0.0	0.0
Total along Gramiak Drain	1	8.8	100.0
Grassmere Creek Drain			
Class 'A'	0	0.0	0.0
Class 'B'	1	0.2	0.5
Class 'C'	1	39.1	96.5
Class 'D'	2	1.2	3.0
Total along Grassmere Creek Drain	4	40.5	100.0
Jackfish Creek			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	3	16.9	78.4
Class 'D'	2	4.7	21.6
Total along Jackfish Creek	5	21.5	100.0

Table 6. Continued.

AQUATIC HABITAT CLASSIFICATION	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Jennifer Creek			
Class 'A'	0	0.0	0.0
Class 'B'	1	0.2	2.3
Class 'C'	3	6.3	59.5
Class 'D'	2	4.0	38.2
Total along Jennifer Creek	6	10.5	100.0
Netley Creek			
Class 'A'	2	6.2	10.5
Class 'B'	4	21.3	36.0
Class 'C'	8	19.6	33.2
Class 'D'	7	12.0	20.3
Total along Netley Creek	21	59.2	100.0
Parks Creek			
Class 'A'	0	0.0	0.0
Class 'B'	1	0.8	6.3
Class 'C'	1	10.9	89.0
Class 'D'	1	0.6	4.7
Total along Parks Creek	3	12.3	100.0
Ross Creek			
Class 'A'	1	1.0	6.5
Class 'B'	0	0.0	0.0
Class 'C'	1	13.6	93.5
Class 'D'	0	0.0	0.0
Total along Ross Creek	2	14.5	100.0
Steele Drain			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	1	4.3	100.0
Class 'D'	0	0.0	0.0
Total along Steele Drain	1	4.3	100.0
Tugela Creek			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	1	2.3	100.0

Table 6. Continued.

AQUATIC HABITAT CLASSIFICATION	# OF REACHES	TOTAL LENGTH OF REACHES (km)	% OF REACHES (km)
Class 'D'	0	0.0	0.0
Total along Tugela Creek	1	2.3	100.0
Wavey Creek			
Class 'A'	2	9.0	27.1
Class 'B'	1	1.2	3.5
Class 'C'	3	23.0	69.4
Class 'D'	0	0.0	0.0
Total along Wavey Creek	6	33.2	100.0
Whiskey Ditch			
Class 'A'	0	0.0	0.0
Class 'B'	0	0.0	0.0
Class 'C'	1	3.9	100.0
Class 'D'	0	0.0	0.0
Total along Whiskey Ditch	1	3.9	100.0
Norris Lake			
Class 'A'	3	8.0	58.0
Class 'B'	2	2.8	20.1
Class 'C'	2	1.2	8.7
Class 'D'	3	1.8	13.2
Total along Norris Lake	10	13.8	100.0
Combined			
Class 'A'	8	24.1	10.3
Class 'B'	10	26.5	11.3
Class 'C'	28	158.4	67.9
Class 'D'	17	24.3	10.4
Total combined	63	233.3	100.0
Netley Marsh Shoreline			
Class 'A'	0	0.0	
Class 'B'	0	0.0	
Class 'C'	0	0.0	
Class 'D'	0	0.0	
Total along Netley Marsh Shoreline	0	0.0	

Table 7. Index of potential rehabilitation sites identified by groundtruthing and aerial footage throughout Watershed 05OJ, 2007.

WATER BODY	WPT. #	GROUND OR AIR SITE #	PRIORITY	REHAB. #	VIDEO TIME	DESCRIPTION
Wavey Creek	-	A	1	1	00:05:03	Possible grazing and dugout area with access to a main channel; structures in area
Wavey Creek	-	A	2	2	00:06:26	Possible pasture (extensive?) in wooded area on both banks
Wavey Creek	-	A	2	3	00:06:32	Possible pasture in wooded area on left bank; continuation from 06:26
Wavey Creek	-	A	3	4	00:06:56	Appears to be riffle (rock) in center channel; not an obvious barrier; spawning project?
Wavey Creek	-	A	3	5	00:07:04	Homestead with out buildings and grazing potential; wooded riparian
Wavey Creek	22	A	3	6	00:07:13	Cement ford with culverts; passage likely; drain with buffer
Netley Creek	-	A	3	7	00:09:56	Netley Golf Course; some beaver dams in area
Netley Creek	-	A	3	8	00:10:22	Apparent beaver dam in river; temporary barrier
Netley Creek	-	A	1	9	00:10:28	Outbuildings; possible grazing and shelter; access to creek? (confirm) (and at 13:00)
Netley Creek	-	A	1	10	00:14:01	Thinning riparian, possible grazing in creek; manure piles present? HWY 8?
Netley Creek	-	A	3	11	00:14:16	Possible grazing area on right bank (could be fenced?)
Netley Creek	-	A	1	12	00:14:59	No apparent blockage at this water level; possible spring barrier; Groundtruth
Netley Creek	-	A	3	13	00:18:57	Appears to be fenced pasture beyond road and drain; Colony in vicinity?
Netley Creek	-	A	1	14	00:20:06	Multiple issues; Grazing, manure piles, access to drain, denuded riparian: mostly LB
Netley Creek	-	A	2	15	00:20:16	On LB, thinned riparian, possible access; manure piles?
Netley Creek	-	A	3	16	00:20:51	Grazing on LB but appears to be beyond the riparian; access limited to nil
Netley Creek	-	A	3	17	00:21:18	Footage is grainy, but grazing with an impacted riparian could result
Netley Creek	-	A	3	18	00:21:28	Possible heavy grazed area with impacted riparian and eroding banks
Netley Creek	-	A	3	19	00:21:42	Possible heavy grazed on both banks; channelized here; fence line unapparent
Netley Creek	-	A	3	20	00:21:52	Homestead on LB with grazing; fenced at this point; See photos from Wpt. 44
Netley Creek	-	A	1	21	00:22:01	Heavy grazing; barns; access to creek; dugout in channel
Netley Creek	-	A	1	22	00:22:45	Heavy grazing; trails into creek; no riparian; dugout; cattle present
Netley Creek	-	A	1	23	00:23:00	Heavy grazing, into and through creek, no riparian, erosion?
Netley Creek	-	A	1	24	00:23:11	Dugout directly in channel; grazing in area likely
Netley Creek	-	A	1	25	00:23:26	Grazing in creek; no riparian; outbuildings; cattle apparent
Netley Creek	-	A	3	26	00:23:34	No blockage apparent (likely no water); from operation at 00:23:26
Netley Creek	-	A	1	27	00:24:10	Dugout in channel (watered); grazing/access in area likely
Netley Creek	89	G	3	47	-	Concrete ford with culverts; low profile
Norris Lake	-	A	1	28	00:26:21	Holding areas; grazing; bales; access to lake and/or grazing shoreline (fenced?). Decent buffer between grazing and shoreline?
Norris Lake	-	A	3	29	00:27:47	Pasture area, but it appears to be fenced and away from the lake; see cattle
Fisher Drain	15	G	3	30	-	Grassed drain extending to crop; erosion
Grassmere Ck.	63	G	2	31	-	Well grassed drain extending to cropland; cement ford with no culverts (flow over); impedes flow; barrier
Grassmere Ck.	64	G	2	32	-	Well grassed drain extending to cropland; cement ford with no culverts (flow over); impedes flow; barrier
Grassmere Ck.	69	G	2	33	-	Well dyked and grassed; hay LB; road RB; flow does not pass through culvert
Grassmere Ck.	70	G	3	34	-	Slumping in area but construction under way upstream
Grassmere Ck.	90	G	1	46	-	Low head, sheet metal weir; barrier to upstream migration
Jackfish Creek	7	G	3	35	-	Fenced area, no immediate creek channel or signs of cattle
Jackfish Creek	7	G	3	36	-	Grassed drain but closely bordered by hayfield
Jackfish Creek	37	G	2	37	-	Riparian but cattle access
Jackfish Creek	38	G	2	38	-	Same pasture as Wpt. 37

Table 7. Continued.

WATER BODY	WPT. #	GROUND OR AIR SITE #	PRIORITY	REHAB. #	VIDEO TIME	DESCRIPTION
Jennifer Creek	6	G	1	39	-	Fenced pasture area with cattle
Netley Creek	45	G	3	40	-	Slight erosion at bank; some rip rap; manicured
Netley Creek	49	G	3	41	-	Slight bank erosion due to cropping close (?)
Parks Creek	29	G	3	42	-	Eroding bank at top and culvert
Tugela Creek	10	G	3	43	-	Manicured drain with minimal buffer and cottages
Tugela Creek	11	G	3	44	-	Manicured drain with minimal buffer and cottages
Norris Lake	42	G	1	45	-	Pasture could extend to banks of lake
Netley Creek[1]	*1*	*A*	*High*	*P1*	-	*14U 622175 5595013; Livestock*
Netley Creek[1]	*2*	*A*	*High*	*P2*	-	*14U 619911 5595776; Livestock*
Netley Creek[1]	*7*	*A*	*Medium*	*P7*	-	*14U 643143 5575207; Livestock*
Netley Creek[1]	*9*	*A*	*Medium*	*P9*	-	*14U 630552 5589815; Stream crossing*
Netley Creek[1]	*10*	*A*	*Low*	*P10*	-	*14U 625663 5592974; Livestock*
Netley Creek[1]	*11*	*A*	*Low*	*P11*	-	*14U 639286 5576716; Livestock*
Wavey Creek[1]	*5*	*A*	*High*	*P5*	-	*14U 644210 5570254; Livestock*

[1] Source data: Horne and MacDonell (1996)

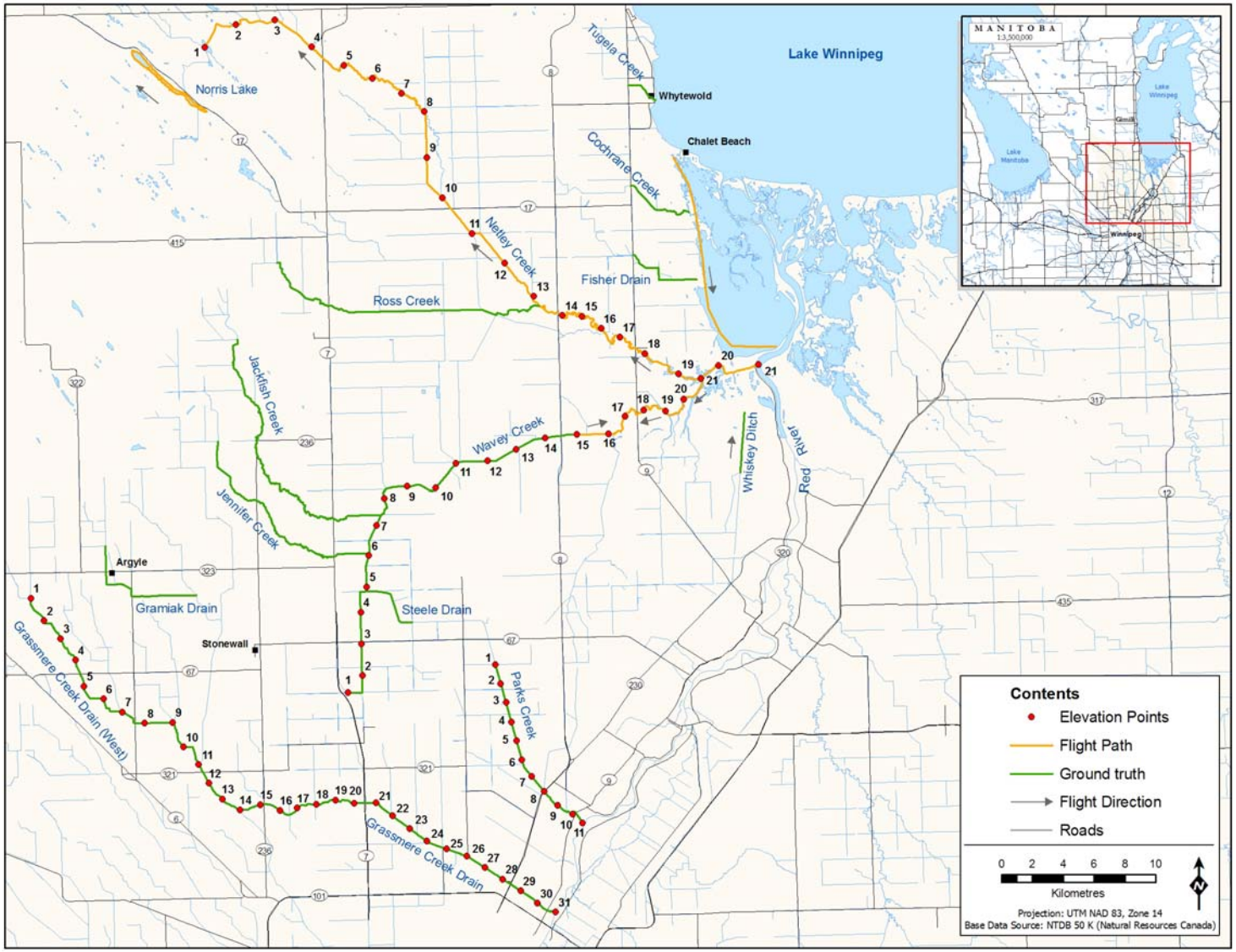

Figure 1. Watershed 05OJ study area, reaches of watercourse viewed by ground and air, and elevation points used to generate selected elevations profiles.

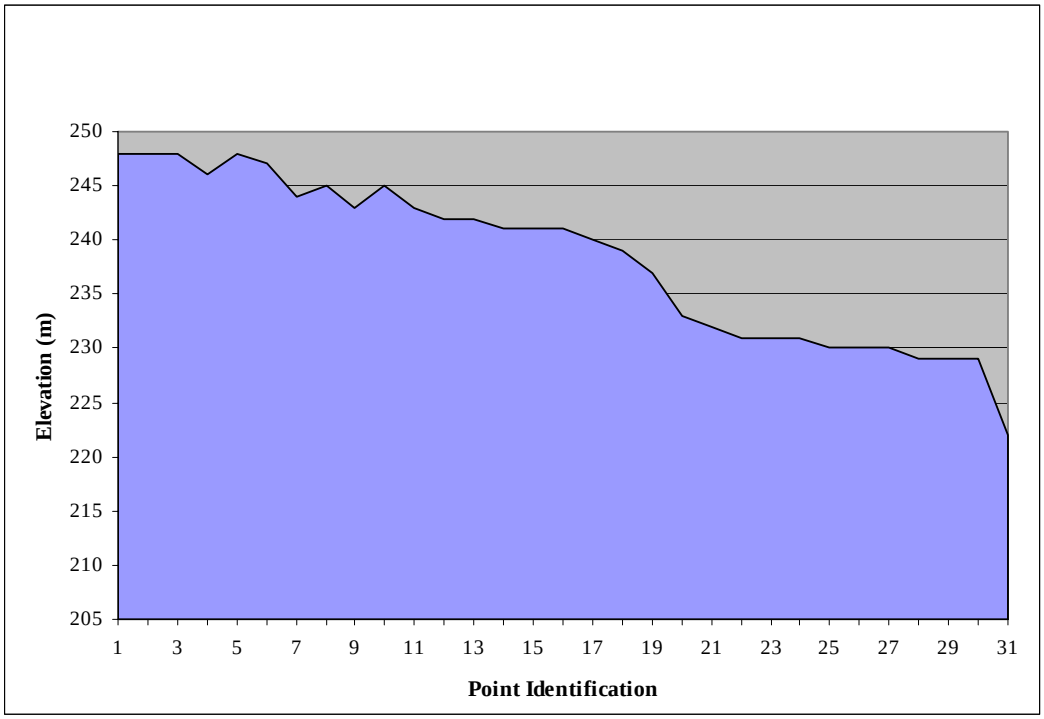

Figure 2. Longitudinal elevation profile (m) along the Grassmere Creek Drain.

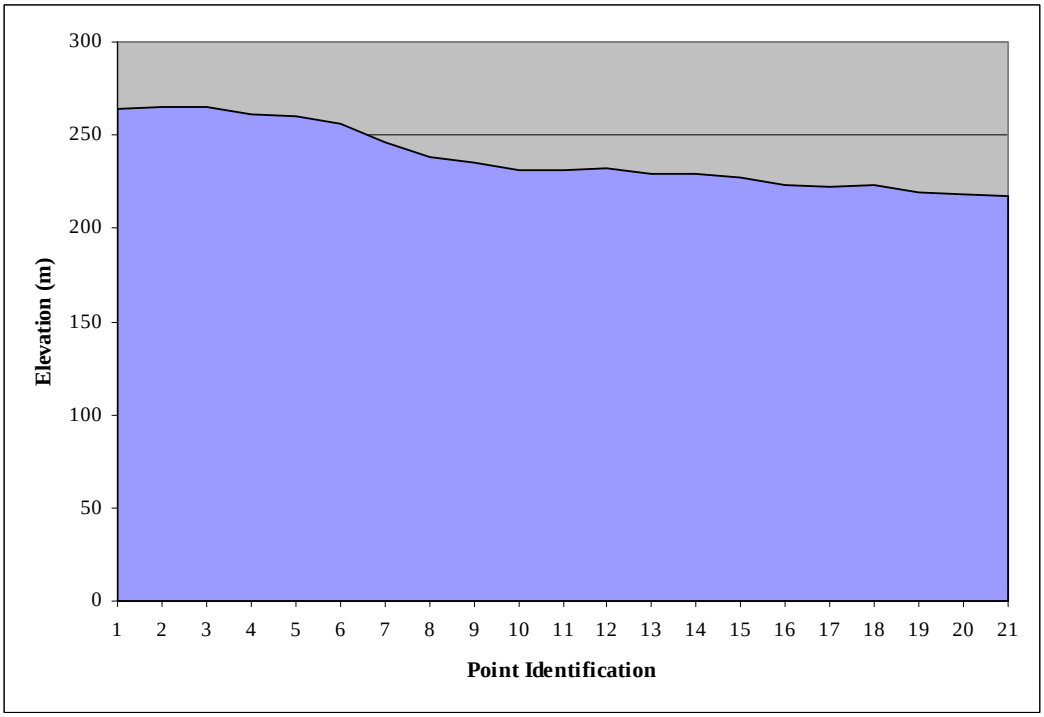

Figure 3. Longitudinal elevation profile (m) along Netley Creek.

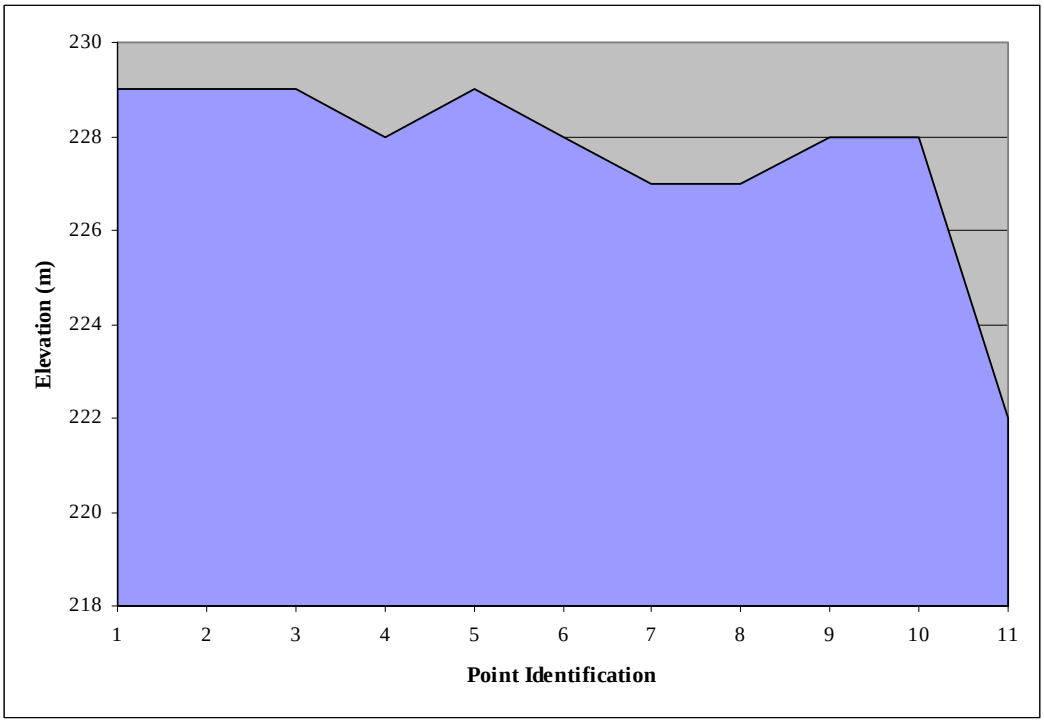

Figure 4. Longitudinal elevation profile (m) along Parks Creek.

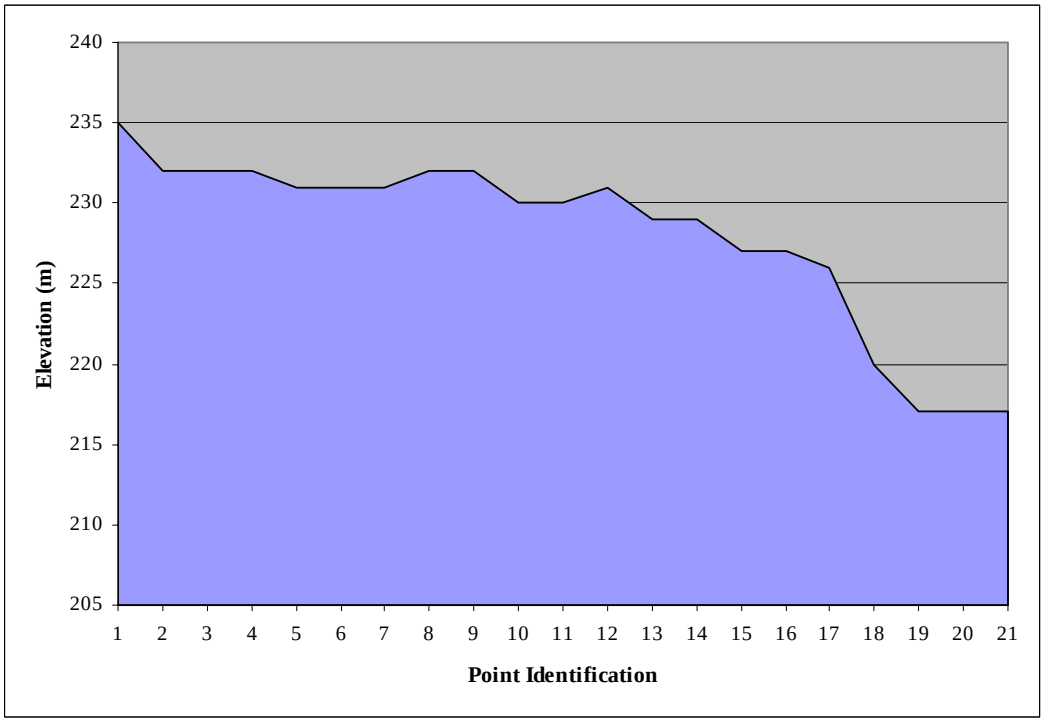

Figure 5. Longitudinal elevation profile (m) along Wavey Creek.

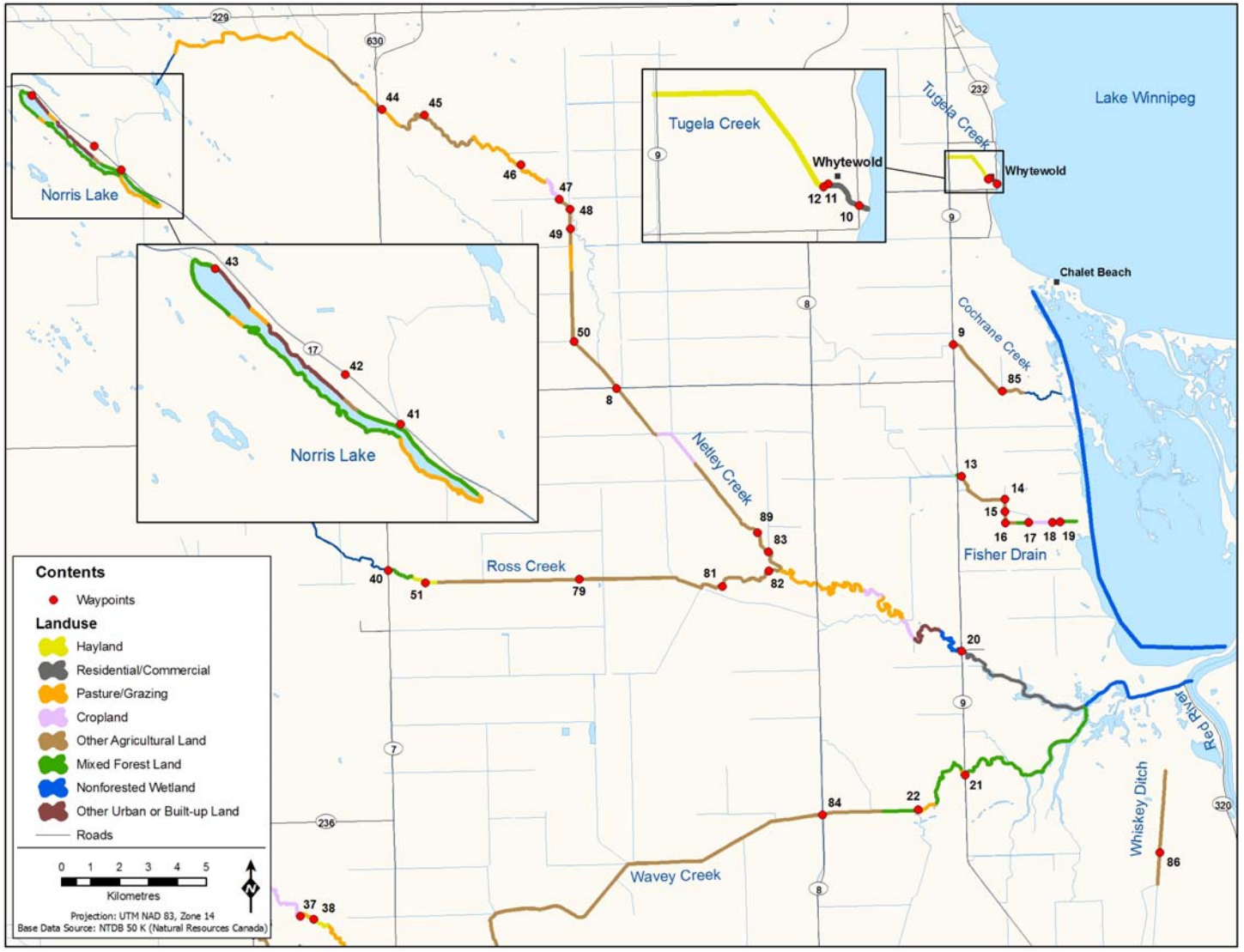

Figure 6. Sites groundtruthed throughout the northern portion of Watershed 05OJ, indicated by waypoint #, and specific land use/cover identified, 2007.

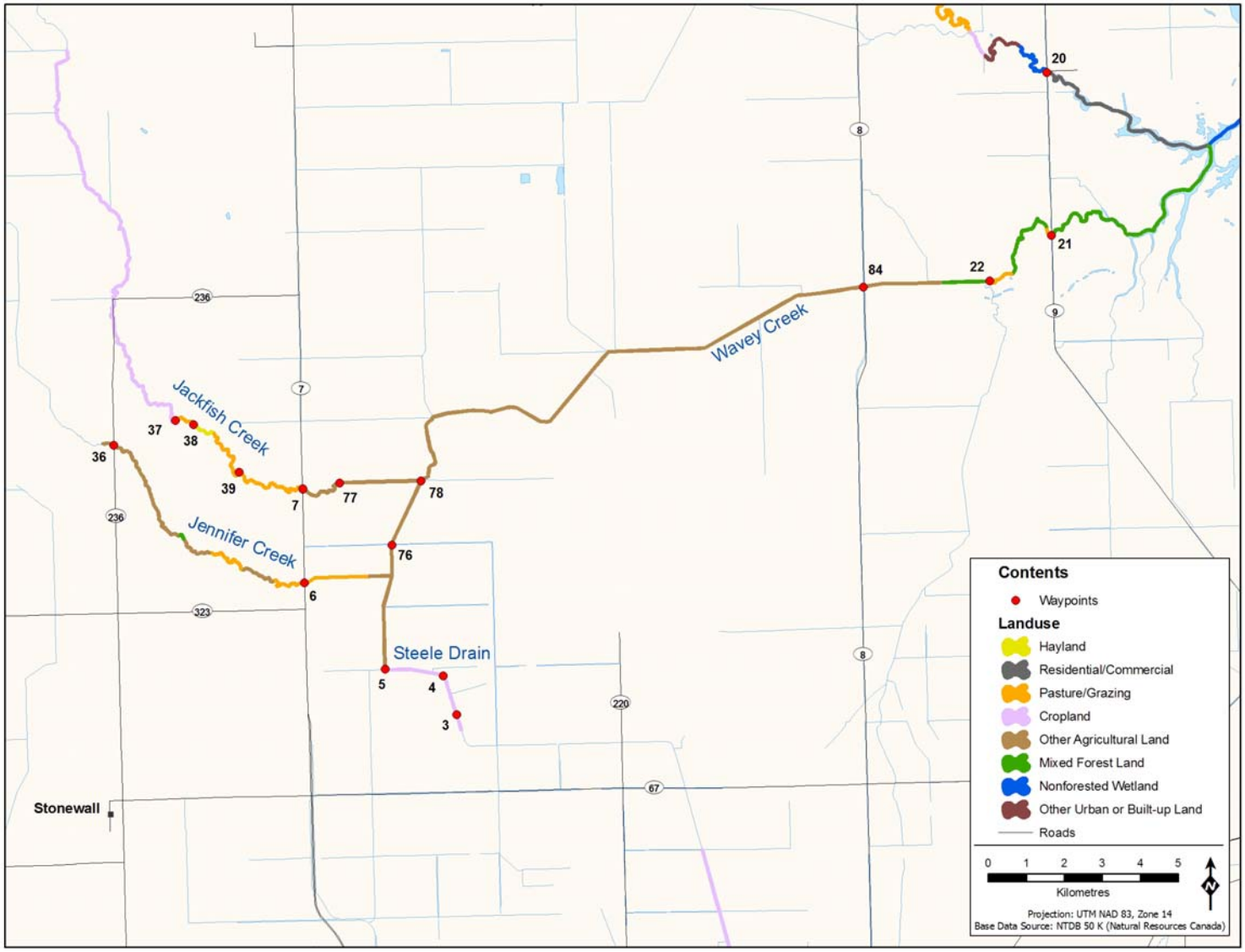

Figure 7. Sites groundtruthed throughout the central portion of Watershed 05OJ, indicated by waypoint #, and specific land use/cover identified, 2007.

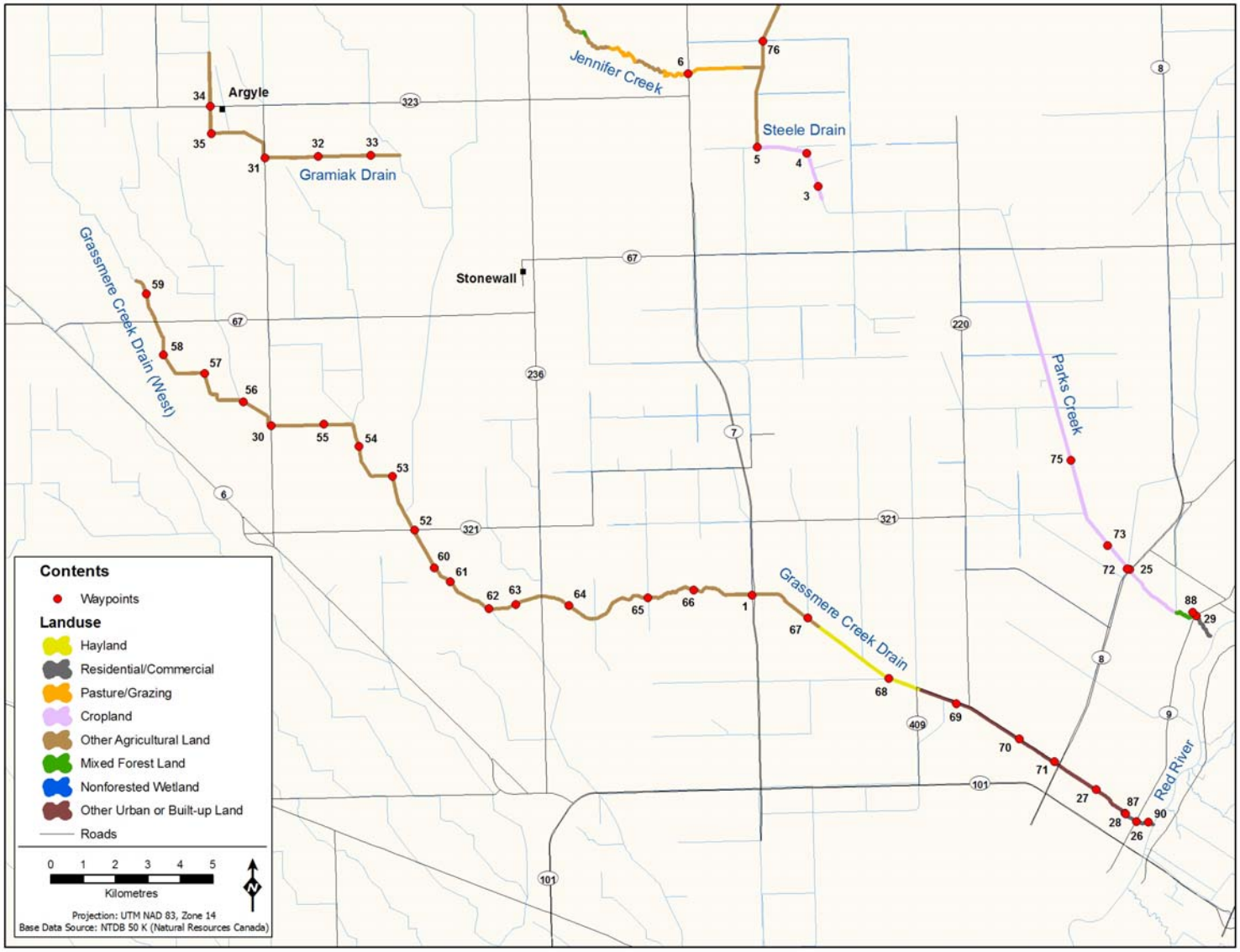

Figure 8. Sites groundtruthed throughout the southern portion of Watershed 05OJ, indicated by waypoint #, and specific land use/cover identified, 2007.

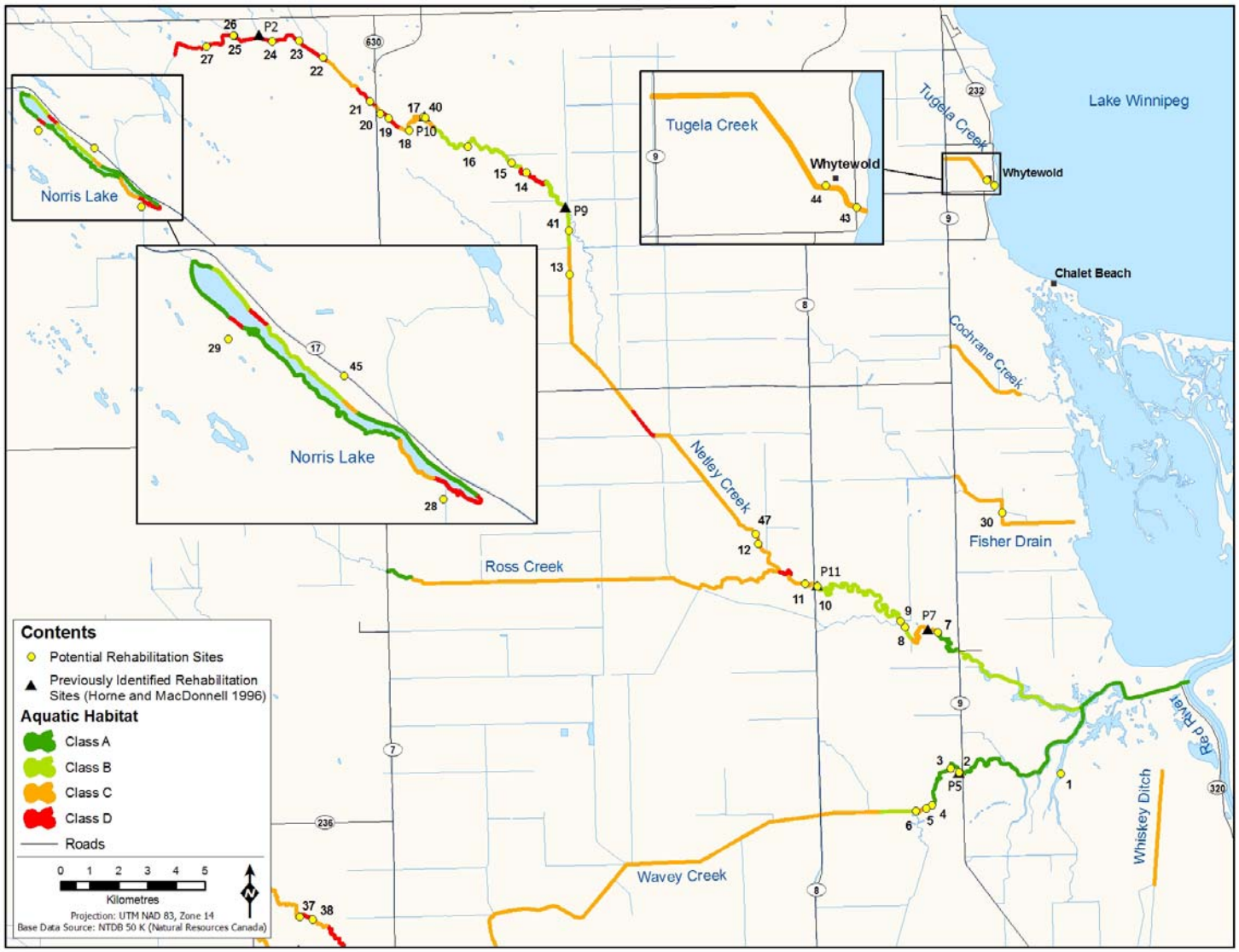

Figure 9. Aquatic habitat quality ratings and potential rehabilitation sites (including previously identified sites) identified throughout the northern portion of Watershed 05OJ, 2007.

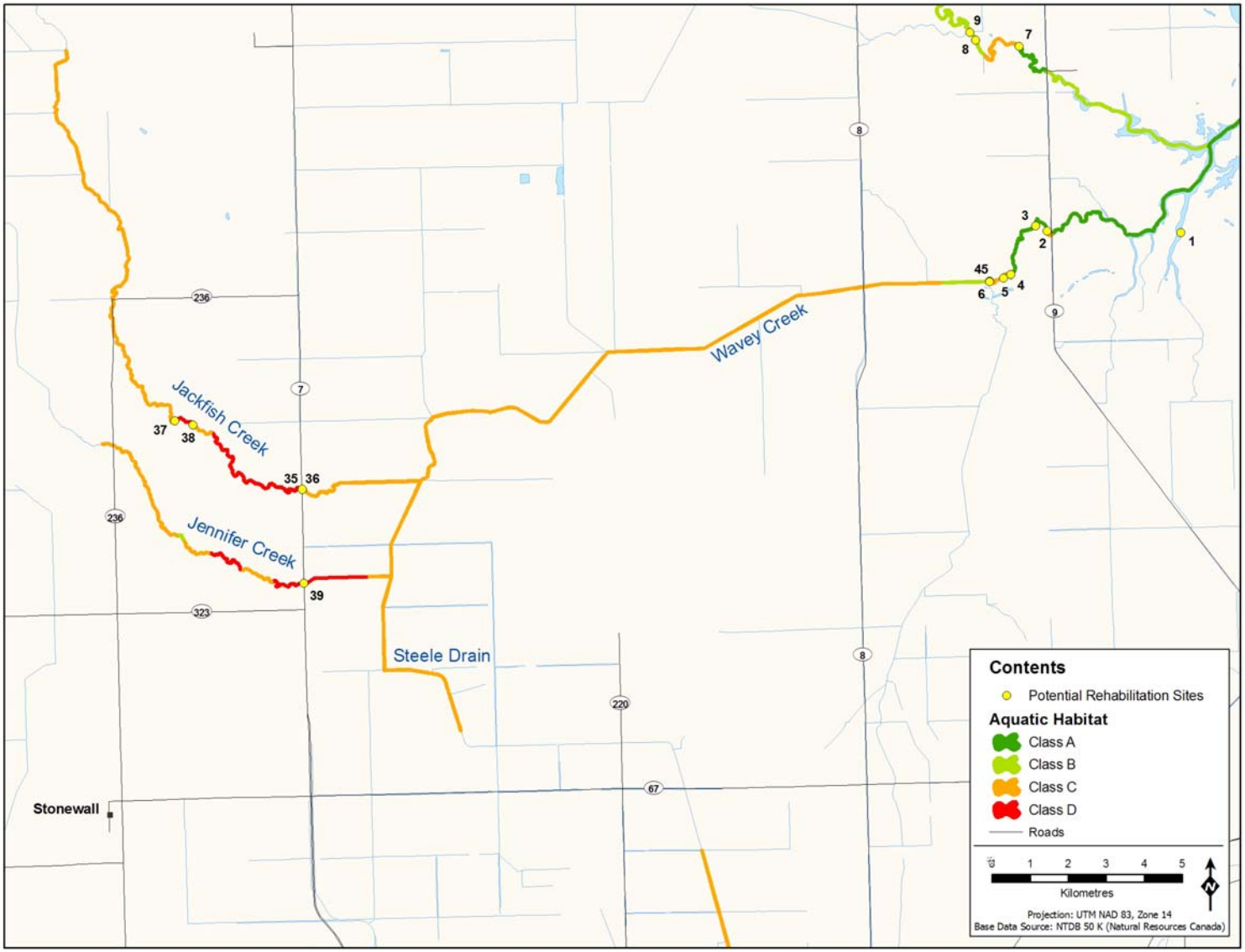

Figure 10. Aquatic habitat quality ratings and potential rehabilitation sites (including previously identified sites) identified throughout the central portion of Watershed 05OJ, 2007.

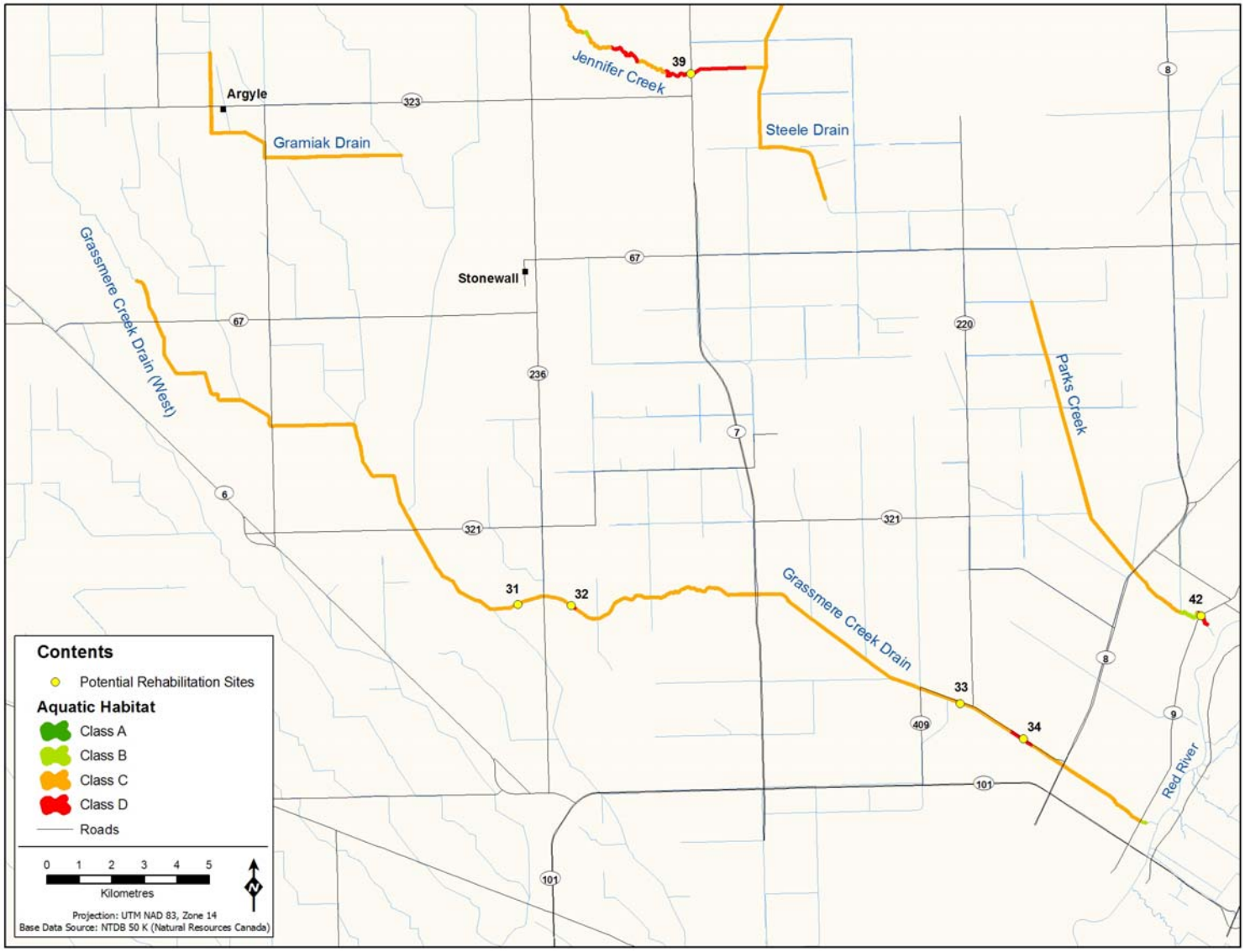

Figure 11. Aquatic habitat quality ratings and potential rehabilitation sites (including previously identified sites) identified throughout the southern portion of Watershed 05OJ, 2007.

APPENDICES

APPENDIX 1.
SITE DESCRIPTIONS AND WORK CONDUCTED BY NORTH/SOUTH CONSULTANTS INC.

Table A1-1. Reference list of sites visited (by Wpt. #), site description, and work conducted by North/South Consultants Inc. throughout Watershed 05SB, 2007 and 2008.

STUDY POINT	Watercourse	Site Description	UTM (14U)		WORK CONDUCTED							
			easting	northing	in situ	hoops	pictures	discharge	velocities	dip net	electro	physical
1	Grassmere Ck. Drain	at Hwy. 7	626667	5544970			Y				Y	Y
3	Steele Drain	Headwaters	628696	5557538			Y					
4	Steele Drain	Corner of drain	628347	5558562			Y					
5	Steele Drain	Road 79N	626826	5558743			Y					
6	Jennifer Creek	at Hwy. 7	624702	5561006			Y					
7	Jackfish Creek	Hwy. 7 (south of Road 82N)	624656	5563473			Y					
8	Netley Creek	Hwy. 17 and Netley Creek	632264	5583499			Y					
9	Cochrane Creek	at Hwy. 9	643922	5585020			Y					
10	Tugela Creek	at Lk. Wpg. (Gimli Road and Grove Ave.)	645428	5590580			Y					
11	Tugela Creek	at tracks	645174	5590760			Y					
12	Tugela Creek	u/s of tracks	645134	5590732			Y					
13	Fisher Drain	Hwy. 9 and Netley Road	644195	5580466			Y					
14	Fisher Drain	at Janisch Road	645697	5579681			Y					
15	Fisher Drain	between Wpts. 14 and 16	645706	5579253			Y					
16	Fisher Drain	Taylor Road and Janisch Road	645718	5578866			Y					
17	Fisher Drain	between Wpts. 16 and 18	646528	5578876			Y					
18	Fisher Drain		647342	5578892			Y					
19	Fisher Drain	furthest pt. accessible by road at Lk. Wpg.	647620	5578901			Y					
20	Netley Creek	at Hwy. 9	644204	5574430			Y					
21	Wavey Creek	at Hwy. 9	644317	5570138			Y					
22	Wavey Creek	Road 85N (and ford)	642703	5568946		Y	Y		Y		Y	Y
25	Parks Creek	at Hwy. 8	638310	5545760			Y				Y	Y
26	Grassmere Ck. Drain	at Hwy. 9 (Middle Church)	638519	5538006	Y		Y	Y			Y	Y
27	Grassmere Ck. Drain	off Grassmere Rd. btw. Hwy. 8 and 9	637282	5538991			Y					
28	Grassmere Ck. Drain	Grassmere Rd. and rail line west of Hwy. 9	638172	5538252			Y					
29	Parks Creek	at Hwy. 9	640357	5544335	Y		Y				Y	Y
30	Grassmere Ck. Drain	Hwy. 322 and Road 74N	611837	5550175			Y					
31	Gramiak Drain	Hwy. 322 and Road 79N	611645	5558417			Y					
32	Gramiak Drain	east on Road 79N	613286	5558456			Y					
33	Gramiak Drain	down Road 79N and 3E	614919	5558485			Y					
34	Gramiak Drain	Meridian Road west of Argyle	609962	5560006			Y					
35	Gramiak Drain	Meridian Road south of Argyle	610002	5559166			Y					
36	Jennifer Creek	Hwy. 236 (south of Road 83N)	619694	5564618			Y					
37	Jackfish Creek	Road 83N and 7E	621320	5565264			Y					
38	Jackfish Creek	Road 83N	621785	5565167			Y					
39	Jackfish Creek	south on Road 8E	622993	5563907			Y					
40	Ross Creek	Hwy. 7	624368	5577226			Y					
41	Norris Lake	Hwy. 17	615119	5591055	Y		Y					

Table A1-1. Continued.

STUDY POINT	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	WORK CONDUCTED in situ	hoops	pictures	discharge	velocities	dip net	electro	physical
42	Norris Lake	Hwy. 17 and Norris Lake Road south	614194	5591876			Y					
43	Norris Lake	boat launch and campground	612031	5593634			Y					
44	Netley Creek	east of Hwy. 7 and Road 100N	624147	5593144	Y		Y					
45	Netley Creek		625619	5592953			Y					
46	Netley Creek	Road 12E	628953	5591240			Y					
47	Netley Creek	Road 98N	630275	5590035			Y					
48	Netley Creek	Road 13E	630646	5589696			Y					
49	Netley Creek	south of Wpt. 48 (Road 13E)	630668	5589017			Y					
50	Netley Creek	Road 95N	630795	5585124			Y					
51	Ross Creek	east of Hwy. 7	625643	5576791			Y					
52	Grassmere Ck. Drain	off Hwy. 321	616264	5546970			Y					
53	Grassmere Ck. Drain		615573	5548614			Y					
54	Grassmere Ck. Drain		614548	5549539			Y					
55	Grassmere Ck. Drain		613467	5550213			Y					
56	Grassmere Ck. Drain		610991	5550904			Y					
57	Grassmere Ck. Drain		609790	5551782			Y					
58	Grassmere Ck. Drain		608514	5552351			Y					
59	Grassmere Ck. Drain		607995	5554222			Y					
60	Grassmere Ck. Drain		616868	5545809			Y					
61	Grassmere Ck. Drain		617364	5545393			Y					
62	Grassmere Ck. Drain		618557	5544553			Y					
63	Grassmere Ck. Drain		619375	5544691			Y					
64	Grassmere Ck. Drain		621015	5544646			Y					
65	Grassmere Ck. Drain		623461	5544893			Y				Y	Y
66	Grassmere Ck. Drain		624875	5545131			Y					
67	Grassmere Ck. Drain		628384	5544276			Y					
68	Grassmere Ck. Drain		630883	5542417			Y					
69	Grassmere Ck. Drain	Gr. Ck. Drain and Grassmere Ck. Rd.	632965	5541633			Y					
70	Grassmere Ck. Drain	at Hwy. 220	634914	5540545			Y					
71	Grassmere Ck. Drain	at Hwy. 8	635987	5539857			Y				Y	Y
72	Parks Creek	west of Hwy. 8	638231	5545783			Y					
73	Parks Creek		637628	5546491								
75	Parks Creek	Parks Creek at Mud Road	636502	5549107			Y					
76	Wavey Creek	Headwaters	627002	5562012			Y					
77	Jackfish Creek	Road 82N and Jackfish Creek	625625	5563618			Y					
78	Jackfish Creek	Jackfish Ck. and confluence at Wavey	627759	5563679		Y	Y				Y	Y
79	Ross Creek	Ross Creek along Road 90N	630982	5576921			Y					
81	Ross Creek	Ross Creek along road	635923	5576671			Y					
82	Ross Creek		637531	5577199			Y					
83	Netley Creek		637518	5577868			Y					
84	Wavey Creek	at Hwy. 8	639384	5568776			Y				Y	Y
85	Cochrane Creek	on Cochrane Road	645607	5583409			Y					

Table A1-1. Continued.

STUDY POINT	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	WORK CONDUCTED in situ	hoops	pictures	discharge	velocities	dip net	electro	physical
86	Whiskey Ditch	and Road 84N	651065	5567466			Y					
87	Grassmere Ck. Drain	Spring 2008 hoop at rail bridge	638177	5538251		Y		Y				
88	Parks Creek	Spring 2008 hoop	640258	5544449		Y		Y				
89	Netley Creek	Spring 2008 hoop	637145	5578524		Y	Y		Y			
90	Grassmere Ck. Drain	Spring 2008 hoop and sheet metal weir	638886	5537991		Y	Y					

Description of Work Conducted:
in situ = water quality parameters measured in the field
hoops = hoop nets set for adult migrating fish
pictures = digital 'still' photos
discharge = hydrologic measurement
velocities = taken near bottom of culverts
dip net = fine mesh dip net used for larval fish
electro = backpack electrofishing unit used to capture small bodied fish
physical = physical parameters recorded (e.g., substrate compaction, composition)

APPENDIX 2.

PHYSICAL PARAMETERS AND BIOLOGICAL INFORMATION OBTAINED THROUGHOUT WATERSHED 05OJ

Table A2-1. Physical information (substrate composition/compaction, water depths, velocities, discharges) collected by North/South Consultants Inc. throughout watershed 05OJ, 2007 and 2008. Definitions provided at end of Table.

DATE	LOCATION	STUDY SITE	SIDE	DISTANCE (m)	WIDTH	DEPTH (m)	SUBSTRATE		AREA	VELOCITY (m/sec)	DISCHARGE (m^3/sec)	Comments
							Compaction	Composition				
9-Aug-07	Grassmere Creek Drain	26	LB	0.00	0.13	0.00	hard	boulder/cobble/gravel	0.00	-	-	
9-Aug-07	Grassmere Creek Drain	26		0.25	0.25	0.20	hard	boulder/cobble/gravel	0.05	0.08	0.004	
9-Aug-07	Grassmere Creek Drain	26		0.50	0.25	0.30	hard	boulder/cobble/gravel	0.08	0.05	0.004	
9-Aug-07	Grassmere Creek Drain	26		0.75	0.25	0.35	hard	boulder/cobble/gravel	0.09	0.07	0.006	
9-Aug-07	Grassmere Creek Drain	26		1.00	0.25	0.42	hard	boulder/cobble/gravel	0.11	0.06	0.006	
9-Aug-07	Grassmere Creek Drain	26		1.25	0.25	0.32	hard	boulder/cobble/gravel	0.08	0.07	0.006	
9-Aug-07	Grassmere Creek Drain	26		1.50	0.25	0.36	hard	boulder/cobble/gravel	0.09	0.03	0.003	
9-Aug-07	Grassmere Creek Drain	26		1.75	0.25	0.33	hard	boulder/cobble/gravel	0.08	0.09	0.007	
9-Aug-07	Grassmere Creek Drain	26		2.00	0.25	0.22	hard	boulder/cobble/gravel	0.06	0.12	0.007	
9-Aug-07	Grassmere Creek Drain	26		2.25	0.25	0.30	hard	boulder/cobble/gravel	0.08	0.13	0.010	
9-Aug-07	Grassmere Creek Drain	26		2.50	0.25	0.20	hard	boulder/cobble/gravel	0.05	0.11	0.006	
9-Aug-07	Grassmere Creek Drain	26		2.75	0.13	0.05	hard	boulder/cobble/gravel	0.01	0.00	0.000	
9-Aug-07	Grassmere Creek Drain	26	RB	2.77	-	0.00	hard	boulder/cobble/gravel	-	-		
											0.058	**Discharge**
25-Oct-07	Grassmere Creek Drain	26				0.55	hard	boulder/cobble/gravel			filamentous algae, minimal flow	
25-Oct-07	Parks Creek	29				0.61	medium	silt/sand/gravel			filamentous algae; aquatic plants; minimal flow	
25-Oct-07	Parks Creek	25				0.60	very soft	silt/mud			some algae and aquatic plants present; no flow	
25-Oct-07	Grassmere Creek Drain	71				0.75	medium	mud/cobble			minimal aquatic plants and/or current	
25-Oct-07	Grassmere Creek Drain	1				0.80	soft	silt/gravel			minimal aquatic plants and/or current	
25-Oct-07	Grassmere Creek Drain	65				0.70	medium	silt/gravel			emergent vegetation; minimal flow	
25-Oct-07	Jackfish Creek	78				0.80	very soft	silt			lots of algae and aquatic plants; no flow	
26-Oct-07	Wavey Creek	84				0.50	soft	cobble/gravel			filamentous algae; emergent vegetation; low flow	
26-Oct-07	Wavey Creek	22				1.00	medium	silt/sand/gravel			some boulders and flow	
22-Apr-08	Wavey Creek	22	RB	0.00	0.5	0.00	hard	mud/cobble	0.00	0.00	0.000	
22-Apr-08	Wavey Creek	22		1.00	1.0	0.20	hard	mud/cobble	0.20	0.40	0.080	
22-Apr-08	Wavey Creek	22		2.00	1.0	0.70	hard	mud/cobble	0.70	0.39	0.273	
22-Apr-08	Wavey Creek	22		3.00	1.0	0.70	hard	mud/cobble	0.70	0.28	0.196	
22-Apr-08	Wavey Creek	22		4.00	1.0	0.55	hard	mud/cobble	0.55	0.29	0.160	
22-Apr-08	Wavey Creek	22		5.00	1.0	0.40	hard	mud/cobble	0.40	0.29	0.116	
22-Apr-08	Wavey Creek	22		6.00	1.0	0.20	hard	mud/cobble	0.20	0.36	0.072	
22-Apr-08	Wavey Creek	22		7.00	1.0	0.25	hard	mud/cobble	0.25	0.33	0.083	
22-Apr-08	Wavey Creek	22	LB	8.00	0.5	0.20	hard	mud/cobble	0.10	0.29	0.029	
											1.008	**Discharge**
22-Apr-08	Wavey Creek	22					culvert diameter 0.5 m; length 7.9 m			1.39		LB culvert at ford
22-Apr-08	Wavey Creek	22					culvert diameter 0.5 m; length 7.9 m			1.52		Center culvert at ford
22-Apr-08	Wavey Creek	22					culvert diameter 0.5 m; length 7.9 m			1.51		RB culvert at ford

Table A2-1. Continued.

DATE	LOCATION	STUDY SITE	SIDE	DISTANCE (m)	WIDTH	DEPTH (m)	SUBSTRATE		AREA	VELOCITY (m/sec)	DISCHARGE (m^3/sec)	Comments
							Compaction	Composition				
22-Apr-08	Netley Creek	89					culvert diameter 0.35 m; length 12.0 m			0.45		LB culvert at ford
22-Apr-08	Netley Creek	89					culvert diameter 0.4 m; length 12.0 m			0.61		Center culvert at ford
22-Apr-08	Netley Creek	89					culvert diameter 0.2 m; length 12.0 m			0.62		RB culvert at ford
23-Apr-08	Grassmere Creek Drain	87	LB	0.00	0.25	0.00	medium	grassed	0.00	0.00	0.000	
23-Apr-08	Grassmere Creek Drain	87		0.50	0.50	0.35	medium	silt/gravel	0.18	0.31	0.054	
23-Apr-08	Grassmere Creek Drain	87		1.00	0.50	0.38	medium	silt/gravel	0.19	0.47	0.088	
23-Apr-08	Grassmere Creek Drain	87		1.50	0.50	0.35	medium	silt/gravel	0.18	0.23	0.040	
23-Apr-08	Grassmere Creek Drain	87		2.00	0.50	0.25	medium	silt/gravel	0.13	0.41	0.051	
23-Apr-08	Grassmere Creek Drain	87		2.50	0.50	0.25	medium	silt/gravel	0.13	0.38	0.048	
23-Apr-08	Grassmere Creek Drain	87		3.00	0.50	0.20	medium	silt/gravel	0.10	0.12	0.012	
23-Apr-08	Grassmere Creek Drain	87	RB	3.50	0.25	0.15	medium	silt/gravel	0.04	0.08	0.003	
											0.296	**Discharge**
23-Apr-08	Parks Creek	88	LB	0.00	0.25	0	hard	grassed	0.00	0	0.000	
23-Apr-08	Parks Creek	88		0.50	0.50	0.55	medium	silt/sand	0.28	0.22	0.061	
23-Apr-08	Parks Creek	88		1.00	0.50	0.58	medium	silt/sand	0.29	0.26	0.075	
23-Apr-08	Parks Creek	88		1.50	0.50	0.60	medium	silt/sand	0.30	0.27	0.081	
23-Apr-08	Parks Creek	88		2.00	0.50	0.50	medium	silt/sand	0.25	0.22	0.055	
23-Apr-08	Parks Creek	88	RB	2.50	0.25	0.28	medium	silt/sand	0.07	0.15	0.010	
											0.282	**Discharge**

Side = Left (LB) or Right (RB) bank
Distance = Distance (m) from either the left or right bank
Width = Distance between two vertical points of measurement.
Area = Width x Depth

Table A2-2. Water quality data collected in situ (i.e., in the field) by North/South Consultants Inc. throughout Watershed 05OJ, open water season, 2007 and 2008.

DATE	LOCATION	SITE	Dissolved Oxygen[1]	Temperature (°C)			pH[2]	Turbidity[3]
			YSI-550A	Horiba	YSI-550A	YSI-63	YSI-63	(NTU)
9-Aug-07	Grassmere Creek Drain	26	3.94	20.2	20.2	20.2	8.91	2
9-Aug-07	Parks Creek	29	8.62	20.7	21.4	20.9	8.84	39
9-Aug-07	Norris Lake	41	8.61	25.2	25.0	26.8	8.43	49
9-Aug-07	Netley Creek	44	7.64	-	23.8	27.9	8.46	58
25-Oct-07	Grassmere Creek Drain	26	11.29	-	6.1	-	8.24	-
25-Oct-07	Parks Creek	29	12.22	-	5.1	-	8.05	-
25-Oct-07	Parks Creek	25	11.90	-	6.8	-	8.02	-
25-Oct-07	Grassmere Creek Drain	71	13.51	-	7.0	-	8.37	-
25-Oct-07	Grassmere Creek Drain	1	15.45	-	7.0	-	8.65	-
25-Oct-07	Grassmere Creek Drain	65	12.58	-	7.7	-	8.47	-
25-Oct-07	Jackfish Creek	78	-	-	7.8	-	8.44	-
26-Oct-07	Wavey Creek	84	-	-	7.2	-	8.50	-
26-Oct-07	Wavey Creek	22	-	-	6.2	-	8.50	-
14-Apr-08	Grassmere Creek Drain	87	-	-	-	3.0	-	-
14-Apr-08	Parks Creek	88	-	-	-	3.0	-	-
15-Apr-08	Grassmere Creek Drain	87	-	-	-	3.0	-	-
15-Apr-08	Parks Creek	88	-	-	-	3.0	-	-
18-Apr-08	Grassmere Creek Drain	87	-	-	-	9.0	-	-
18-Apr-08	Parks Creek	88	-	-	-	7.0	-	-
19-Apr-08	Grassmere Creek Drain	87	-	-	-	10.0	-	-
19-Apr-08	Parks Creek	88	-	-	-	9.0	-	-
19-Apr-08	Wavey Creek	22	-	-	-	9.0	-	-
19-Apr-08	Netley Creek	89	-	-	-	10.0	-	-
20-Apr-08	Grassmere Creek Drain	87	-	-	-	11.0	-	-
20-Apr-08	Parks Creek	88	-	-	-	9.0	-	-
20-Apr-08	Wavey Creek	22	-	-	-	9.0	-	-
20-Apr-08	Netley Creek	89	-	-	-	10.0	-	-
21-Apr-08	Grassmere Creek Drain	87	-	-	-	10.0	-	-
21-Apr-08	Parks Creek	88	-	-	-	10.0	-	-
21-Apr-08	Wavey Creek	22	-	-	-	6.0	-	-
21-Apr-08	Netley Creek	89	-	-	-	8.0	-	-
21-Apr-08	Norris Lake	41	-	-	-	4.0	-	-
21-Apr-08	Wavey Creek	78	-	-	-	8.0	-	-
22-Apr-08	Grassmere Creek Drain	87	-	-	-		-	-
22-Apr-08	Parks Creek	88	-	-	-	6.0	-	-
22-Apr-08	Wavey Creek	22	-	-	-	4.5	-	-
22-Apr-08	Netley Creek	89	-	-	-	7.0	-	-
22-Apr-08	Grassmere Creek Drain	90	-	-	-	7.0	-	-

[1]MWQ objective instantaneous minimum of 5 mg/L for the protection of cool water (>5°C) aquatic life.

[2]MWQ guidelines for: Recreation (5.0-9.0); Protection of Freshwater Aquatic Life (6.5-9.0); and Drinking Water Aesthetic Objectives (6.5-8.5).

[3] Collected with Horiba meter

Table A2-3. Fish species (common name and code used) identified throughout Watershed 05OJ and definitions of sex and maturity codes outlined in Table A2-4.

FAMILY	COMMON NAME	ABBREVIATION	GENUS	SPECIES
Ictaluridae	Black bullhead	BLBL	*Ameiurus*	*melas*
Gasterosteidae	Brook stickleback	BRST	*Culaea*	*inconstans*
Ictaluridae	Brown bullhead	BRBL	*Ameiurus*	*nebulosus*
Cyprinidae	Carp	CARP	*Cyprinus*	*carpio*
Umbridae	Central mudminnow	CNMD	*Umbra*	*limi*
Cyprinidae	Emerald shiner	EMSH	*Notropis*	*atherinoides*
Cyprinidae	Fathead minnow	FTMN	*Pimephales*	*promelas*
Sciaenidae	Freshwater drum	FRDR	*Aplodinotus*	*grunniens*
Percidae	Iowa darter	IWDR	*Etheostoma*	*exile*
Percidae	Johnny darter	JHDR	*Etheostoma*	*nigrum*
Cyprinidae	Longnose dace	LNDC	*Rhinichthys*	*cataractae*
Esocidae	Northern pike	NRPK	*Esox*	*lucius*
Cyprinidae	Northern redbelly dace	NRDC	*Phoxinus*	*eos*
Percidae	Sauger	SAUG	*Sander*	*canadensis*
Cyprinidae	Spottail shiner	SPSH	*Notropis*	*hudsonius*
Percidae	Walleye	WALL	*Sander*	*vitreus*
Moronidae	White bass	WHBS	*Morone*	*chrysops*
Catostomidae	White sucker	WHSC	*Catostomus*	*commersoni*
Percidae	Yellow perch	YLPR	*Perca*	*flavescens*
Catostomidae	Bigmouth buffalo	BGBF	*Ictiobus*	*cyprinellus*
Centrarchidae	Black crappie	BLCR	*Pomoxis*	*nigromaculatus*
Percidae	Blackside darter	BLDR	*Percina*	*maculata*
Salmonidae	Brook trout	BRTR	*Salvelinus*	*fontinalis*
Salmonidae	Rainbow trout	RNTR	*Oncorhynchus*	*mykiss*
Cyprinidae	River shiner	RVSH	*Notropis*	*blennius*
Centrarchidae	Rock bass	RCBS	*Ambloplites*	*rupestris*
Ictaluridae	Tadpole madtom	TDMD	*Noturus*	*gyrinus*
Percopsidae	Trout perch	TRPR	*Percopsis*	*omiscomaycus*
Gadiformes	Burbot	BURB	*Lota*	*lota*
Ictaluridae	Channel catfish	CHCT	*Ictalurus*	*punctatus*
Cyprinidae	Pearl dace	PRDC	*Margariscus*	*margarita*
Salmonidae	Cisco	CISC	*Coregonus*	*artedi*
Cyprinidae	Lake chub	LKCH	*Couesius*	*plumbeus*
Cyprinidae	Common shiner	CMSH	*Luxilus*	*cornutus*
Cyprinidae	Creek chub	CRCH	*Semotilus*	*atromaculatus*
Catostomidae	Golden redhorse	GLRD	*Moxostoma*	*erythrurum*
Hiodontidae	Goldeye	GOLD	*Hiodon*	*alosoides*
Catostomidae	Quillback	QUIL	*Carpiodes*	*cyprinus*
Cyprinidae	Blacknose shiner	BLSH	*Notropis*	*heterolepis*

Sex and Maturity Codes Used:

F = Female

F2 = Female preparing to spawn in the current year

F3 = A female, ripe and ready to spawn in the current year

F4 = A female that has spawned in the current year (spent)

M = Male

M7 = Male preparing to spawn in the current year

M8 = A male, ripe and ready to spawn in the current year

M9 = A male that has spwaned in the current year (spent)

Table A2-4. Spring fishing results and biological information collected from fish captured by North/South Consultants Inc. throughout Watershed 05OJ, 2008. Fish species codes and sex/maturity ID are outlined in Table A2-3.

Waterbody	Wpt. #	Total Count	Fish Species	Check Date (y/m/d)	Check Time (h:m)	Fork Length (mm)	Weight (g)	Sex ID	Maturity ID	Comments
Parks Creek	88	1	NRPK	15-Apr-08	12:00	535	1450	M	7	
Grassmere Creek Drain	87	0	-	15-Apr-08	11:30					
Grassmere Creek Drain	87	0	-	19-Apr-08	10:45					
Parks Creek	88	1	NRPK	19-Apr-08	11:15	430	600	F	3	
Grassmere Creek Drain	87	1	NRPK	20-Apr-08	10:30	-	-	-	-	Not sampled
Parks Creek	88	0	-	20-Apr-08	10:50					
Wavey Creek	22	1	WALL	20-Apr-08	11:50	478	1300	M	7	
Wavey Creek	22	1	NRPK	20-Apr-08	11:50	526	1200	F	3	
Wavey Creek	22	1	WHSC	20-Apr-08	11:50	390	900	F	2	
Wavey Creek	22	1	WHSC	20-Apr-08	11:50	430	1100	M	7	
Netley Creek	89	1	WALL	20-Apr-08	12:50	485	1500	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	478	1600	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	480	1650	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	487	1500	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	425	1150	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	406	900	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	452	1400	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	432	1350	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	460	1700	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	545	2600	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	461	1200	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	517	2400	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	540	2700	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	451	1400	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	450	1600	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	415	1200	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	450	1500	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	510	2000	F	2	

Table A2-4. Continued.

Waterbody	Wpt. #	Total Count	Fish Species	Check Date (y/m/d)	Check Time (h:m)	Fork Length (mm)	Weight (g)	Sex ID	Maturity ID	Comments
Netley Creek	89	1	WHSC	20-Apr-08	12:50	513	2200	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	450	1500	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	445	1400	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	447	1650	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	441	1300	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	451	1600	F	2	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	445	1400	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	443	1550	M	8	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	387	1050	M	7	
Netley Creek	89	1	WHSC	20-Apr-08	12:50	456	1650	M	7	
Grassmere Creek Drain	87	0	-	21-Apr-08	8:30					
Parks Creek	88	0	-	21-Apr-08	8:55					Hole in net
Wavey Creek	22	0	-	21-Apr-08	9:30					Net vandalized
Netley Creek	89	1	NRPK	21-Apr-08	10:25	384	350	M	7	
Netley Creek	89	1	NRPK	21-Apr-08	10:25	709	3600	F	3	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	499	2000	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	438	1400	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	438	1300	F	2	
Wavey Creek	78	1	NRPK	21-Apr-08	11:45	610	1750	F	3	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	450	1225	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	448	1450	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	468	1675	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	413	1050	M	7	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	405	1000	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	464	1500	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	365	800	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	463	1500	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	439	1200	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	500	2250	F	2	

Table A2-4. Continued.

Waterbody	Wpt. #	Total Count	Fish Species	Check Date (y/m/d)	Check Time (h:m)	Fork Length (mm)	Weight (g)	Sex ID	Maturity ID	Comments
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	431	1100	M	7	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	430	1325	M	7	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	442	1300	F	2	
Wavey Creek	78	1	WHSC	21-Apr-08	11:45	373	700	M	7	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	640	2500	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	624	2300	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	735	3450	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	560	1450	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	435	600	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	559	1500	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	264	100	M		
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	395	475	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	250	100	M		
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	292	200	F	3	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	422	450	M	8	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	290	100	M	8	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	300	200	M	7	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	314	200			
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	270	125			
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	275	150	M	8	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	284	150			
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	320	300			
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	271	100			
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	260	150	M		
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	273	100	M	8	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	272	100	M	7	
Grassmere Creek Drain	90	1	NRPK	22-Apr-08	9:25	268	150	M	7	
Parks Creek	88	1	NRPK	22-Apr-08	11:00	400	-	F	3	
Parks Creek	88	1	WHSC	22-Apr-08	11:00	200	-			
Wavey Creek	22	1	NRPK	22-Apr-08	11:30	545	1150	F	3	

Table A2-4. Continued.

Waterbody	Wpt. #	Total Count	Fish Species	Check Date (y/m/d)	Check Time (h:m)	Fork Length (mm)	Weight (g)	Sex ID	Maturity ID	Comments
Wavey Creek	22	1	NRPK	22-Apr-08	11:30	492	700	M	7	
Wavey Creek	22	1	NRPK	22-Apr-08	11:30	528	1100	F	3	
Wavey Creek	22	1	NRPK	22-Apr-08	11:30	539	1000	M	7	
Wavey Creek	22	1	NRPK	22-Apr-08	11:30	494	850	M	7	
Wavey Creek	22	1	NRPK	22-Apr-08	11:30	910	5400	F	3	
Wavey Creek	22	1	WHSC	22-Apr-08	11:30	393	1000	M	8	
Wavey Creek	22	1	WHSC	22-Apr-08	11:30	483	2000	F	2	
Wavey Creek	22	1	WHSC	22-Apr-08	11:30	520	2500	F	2	
Netley Creek	89	0	-	22-Apr-08	13:30					
Wavey Creek	78	1	WHSC	22-Apr-08	14:15	435	-	F	2	
Wavey Creek	78	1	WHSC	22-Apr-08	14:15	360	-	M	7	

APPENDIX 3.

GROUND AND AIR CLASSIFICATIONS FOR WATERCOURSES THROUGHOUT WATERSHED 05OJ

Table A3-1. Results of ground based classification, by waypoint, along Cochrane Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
9	2-Aug-07	Cochrane Creek	Hwy. 9 and Cochrane Ck.	643922	5585020	Upstream	Left	Yes	Drain	Homestead with coniferous and grass buffer
							Right	Yes	Drain	Either hay or crop land
						Downstream	Both	Minimal	Drain	Grassed drain and dykes extending to hay
85	25-Sep-07	Cochrane Creek	Cochrane Rd.	645607	5583409	Upstream	Both	No	Drain	Well grassed; some crop beyond
						Downstream	Both	Pool	Drain	Well grassed; some crop beyond

Table A3-2. Results of ground based classification, by waypoint, along Fisher Drain, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
13	3-Aug-07	Fisher Drain	Hwy. 9 and Netley Rd.	644195	5580466	Upstream	Both	No	Drain	Grassed drain with hay on right
						Downstream	Both	No	Drain	Grassed drain; likely hay
14	3-Aug-07	Fisher Drain	Janisch Rd.	645697	5579681	Upstream	Left	No	Drain	Grassed drain extending to crop
							Right	No	Drain	Grassed drain extending to hay (?)
						Downstream	Left	No	Drain	Grassed drain extending to crop
							Right	No	Drain	Grassed drain bordered by road
15	3-Aug-07	Fisher Drain	Janisch Rd.	645706	5579253	Upstream	Left	No	Drain	Grassed drain extending to crop; erosion
							Right	No	Drain	Grassed drain bordered by road
						Downstream	Left	No	Drain	Grassed drain bordered by road
							Right	No	Drain	Grassed drain extending to hay
16	3-Aug-07	Fisher Drain	Taylor and Janisch Rd.	645718	5578866	Upstream	Both	No	Drain	See Wpt. 15 photo
						Downstream	Left	No	Drain	Grassed drain bordered by road
							Right	No	Drain	Grassed drain extending to hay
17	3-Aug-07	Fisher Drain	on Taylor Rd. (?)	646528	5578876	Upstream	Left	No	Drain	Grassed drain bordered by road
							Right	No	Drain	Grassed drain extending to full riparian
						Downstream	Left	No	Drain	Grassed drain bordered by road
							Right	No	Drain	Grassed drain extending to hay
18	3-Aug-07	Fisher Drain	on Taylor Rd. (?)	647342	5578892	Upstream	Both	No	Drain	Grassed drain
						Downstream	Left	No	Drain	Grassed drain bordered by road
							Right	No	Drain	Grassed drain extending to hay
19	3-Aug-07	Fisher Drain	towards Lk. Wpg.	647620	5578901	Downstream	Both	No	Drain	Fully grassed and heavy riparian

Table A3-3. Results of ground based classification, by waypoint, along Gramiak Drain, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
31	9-Aug-07	Gramiak Drain	Hwy. 322 and Rd. 79N	611645	5558417	Upstream	Left	No	Drain	Well grassed extending to fenced yard and crop
							Right	No	Drain	Well grassed extending to road
						Downstream	Left	No	Drain	Well grassed extending to road
							Right	No	Drain	Well grassed extending to crop
32	9-Aug-07	Gramiak Drain	Rd. 79N (east on)	613286	5558456	Upstream	Left	No	Drain	Well grassed extending to road
							Right	No	Drain	Well grassed extending to hay
						Downstream	Left	No	Drain	Well grassed extending to dyke top
							Right	No	Drain	Well grassed extending to crop
33	9-Aug-07	Gramiak Drain	Rd. 79N and 3E	614919	5558485	Upstream	Left	No	Drain	Well grassed extending to road
							Right	No	Drain	Well grassed extending to dyke top and full riparian
						Downstream	Left	No	Drain	Well grassed extending to dyke top
							Right	No	Drain	Well grassed extending to fenced pasture
34	9-Aug-07	Gramiak Drain	Meridian Rd. (west Argyle)	609962	5560006	Upstream	Left	No	Drain	Well grassed extending to crop
							Right	No	Drain	Well grassed extending to road
						Downstream	Left	No	Drain	Well grassed extending to hay
							Right	No	Drain	Well grassed extending to road
35	9-Aug-07	Gramiak Drain	Meridian Rd. (south Argyle)	610002	5559166	Upstream	Left	No	Drain	Well grassed extending to crop
							Right	No	Drain	Well grassed extending to road
						Downstream	Left	No	Drain	Well grassed
							Right	No	Drain	Well grassed

Table A3-4. Results of ground based classification, by waypoint, along Grassmere Creek Drain, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
1	2-Aug-07	Grassmere Ck.	Hwy. 7	626667	5544970	Upstream	Both	Yes	Drain	Well grassed drain with cropland beyond both banks
26	9-Aug-07	Grassmere Ck.	Hwy. 9 (Middle Church)	638519	5538006	Upstream	Both	Yes	Creek	Riffle sections and thick riparian
						Downstream	Both	Yes	Creek	Riffle sections and thick riparian; cobble substrate
27	9-Aug-07	Grassmere Ck.	off Grassmere Rd.	637282	5538991	Upstream	Left	Yes	Drain	Well grassed drain extending to hayed dyke
							Right	Yes	Drain	Well grassed drain extending to Grassmere Rd.
						Downstream	Left	Yes	Drain	Well grassed drain extending to hayed dyke
							Right	Yes	Drain	Well grassed drain extending to Grassmere Rd.
28	9-Aug-07	Grassmere Ck.	off Grassmere Rd.	638172	5538252	Upstream	Left	Yes	Drain	Well grassed drain extending to crop
							Right	Yes	Drain	Well grassed drain extending to homes
						Downstream	Both	Yes	Drain	Well grassed drain with homes on both sides
30	9-Aug-07	Grassmere Ck.	Hwy. 322 and Rd. 74N	611837	5550175	Upstream	Both	No	Drain	Well grassed and hayed
						Downstream	Both	Yes	Drain	Well grassed and hayed
52	19-Sep-07	Grassmere Ck.	off Hwy. 321	616264	5546970	Upstream	Both	No	Drain	Well grassed and hayed immediately
						Downstream	Both	Yes	Drain	Well grassed and hayed
53	19-Sep-07	Grassmere Ck.	along drain	615573	5548614	Upstream	Left	No	Drain	Grassed drain extending to road
							Right	No	Drain	Grassed drain extending to hayfield
						Downstream	Both	No	Drain	Grassed drain extending to cropland
54	19-Sep-07	Grassmere Ck.	along drain	614548	5549539	Upstream	Both	No	Drain	Well grassed and dyked drain with crop/stubble fields
						Downstream	Both	No	Drain	Well grassed drain extending to cropland
55	19-Sep-07	Grassmere Ck.	along drain	613467	5550213	Upstream	Both	No	Drain	Grassed and dyked up to mixed deciduous riparian
						Downstream	Both	No	Drain	Grassed and dyked up to mixed deciduous riparian

Table A3-4. Continued.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
56	19-Sep-07	Grassmere Ck.	along drain	610991	5550904	Upstream	Both	No	Drain	Well grassed drain extending to cropland
						Downstream	Both	No	Drain	Well grassed drain immediately hayed
57	19-Sep-07	Grassmere Ck.	along drain	609790	5551782	Upstream	Left	No	Drain	Grassed drain extending to road
							Right	No	Drain	Grassed drain extending to hay
						Downstream	Both	No	Drain	Well grassed drain likely hayed
58	19-Sep-07	Grassmere Ck.	Rd. 1W	608514	5552351	Upstream	Left	No	Drain	Grassed drain extending to road
							Right	No	Drain	Grassed drain extending to hay
						Downstream	Both	No	Drain	Well grassed drain likely hayed
59	19-Sep-07	Grassmere Ck.	along drain	607995	5554222	Upstream	Both	No	Drain	Grassed drain; dykes not high; cultivated fields
							Both	No	Drain	Grassed drain; dykes not high; cultivated fields
60	19-Sep-07	Grassmere Ck.	along drain	616868	5545809	Upstream	Both	Yes	Drain	Well dyked and grassed extending to hay
						Downstream	Both	Yes	Drain	Well dyked and grassed extending to hay
61	19-Sep-07	Grassmere Ck.	along drain	617364	5545393	Upstream	Both	Yes	Drain	Well grassed drain extending to cropland
						Downstream	Both	Yes	Drain	Well grassed drain extending to cropland
62	19-Sep-07	Grassmere Ck.	along drain	618557	5544553	Upstream	Both	Yes	Drain	Well grassed drain extending to cropland
						Downstream	Both	Yes	Drain	Well grassed drain extending to cropland
63	19-Sep-07	Grassmere Ck.	along drain	619375	5544691	Upstream	Both	Yes	Ford	Well grassed drain extending to cropland; cement ford with no culverts (flow over); impedes flow; barrier
						Downstream	Both	Yes	Drain	

Table A3-4. Continued.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
64	19-Sep-07	Grassmere Ck.	along drain	621015	5544646	Upstream	Both	Yes	Ford	Well grassed drain extending to cropland; cement ford with no culverts (flow over); impedes flow; barrier
						Downstream	Both	Yes	Drain	
65	19-Sep-07	Grassmere Ck.	along drain	623461	5544893	Upstream	Both	Yes	Drain	Well grassed drain extending to hayfield
						Downstream	Both	Yes	Drain	Well grassed drain extending to cropland/hayfield
66	19-Sep-07	Grassmere Ck.	along drain	624875	5545131	Upstream	Both	Yes	Drain	Well grassed drain likely extending to hay/crop
						Downstream	Both	Yes	Drain	Well grassed drain
67	19-Sep-07	Grassmere Ck.	along drain	628384	5544276	Upstream	Both	Yes	Drain	Well grassed drain likely extending to hay/crop
						Downstream	Both	Yes	Drain	Well grassed drain likely extending to hay/crop
68	19-Sep-07	Grassmere Ck.	along drain	630883	5542417	Upstream	Both	Yes	Drain	Well dyked and grassed extending to hay
						Downstream	Both	Yes	Drain	Well dyked and grassed extending to hay
69	19-Sep-07	Grassmere Ck.	Grassmere Creek Road			Upstream	Left	Yes	Drain	Well dyked and grassed extending to hay
							Right	Yes	Drain	Well grassed drain extending to Grassmere Rd.
						Downstream	Left	Yes	Drain	Well dyked and grassed; hay LB; road RB; flow does not pass through culvert
							Right	Yes	Drain	
70	19-Sep-07	Grassmere Ck.	Hwy. 220	634914	5540545	Upstream Downstream	Both	Yes	Drain	Slumping in area but construction under way upstream
71	19-Sep-07	Grassmere Ck.	Hwy. 8	635987	5539857	Upstream	Both	Yes	Drain	Well grassed and dyked drain; buffered
						Downstream	Both	Yes	Drain	Well grassed and dyked drain; buffered
87	14-Apr-08	Grassmere Ck.	hoop net and railway	638177	5538251	Upstream	Both	Yes	Drain	Well dyked and grassed
						Upstream	Both	Yes	Drain	Well dyked and grassed
90	21-Apr-08	Grassmere Ck.	near Red River	638886	5537991	Upstream	Both	Yes	Creek	Rip rap and sheet metal weir; residential
						Upstream	Both	Yes	Creek	Rip rap and sheet metal weir; residential

Table A3-5. Results of ground based classification, by waypoint, along Jackfish Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	Direction	Bank	Water	Use	Comments
7	2-Aug-07	Jackfish Creek	Hwy. 7., south of Rd 82N	624656	5563473	Upstream	Both	No	Pasture	Fenced area, no immediate creek channel or signs of cattle
						Downstream	Both	No	Drain	Grassed drain but closely bordered by hayfield
37	9-Aug-07	Jackfish Creek	Rd. 83N and 7E	621320	5565264	Upstream	Both	No	Crop	Grassed along drain but cropped close
						Downstream	Both	Some	Pasture	Riparian but cattle access
38	9-Aug-07	Jackfish Creek	Rd. 83N	621785	5565167	Upstream	Both	Some	Pasture	Same pasture as Wpt. 37
						Downstream	Left	No	Hay	Hay in area but also some grazing (?)
							Right	No	Hay	Grassed drain but hayed
39	9-Aug-07	Jackfish Creek	Rd. 83N and 8E	622993	5563907	Upstream	Both	No	Creek	Heavy riparian
						Downstream	Both	No	Creek	Heavy riparian
77	19-Sep-07	Jackfish Creek	Rd. 82N	625625	5563618	Upstream	Both	No	Creek	Grassed drain; some riparian and fields
						Downstream	Left	No	Drain	Grassed drain extending to road
							Right	No	Drain	Grassed drain extending to fenced pasture
78	19-Sep-07	Jackfish Creek	near confluence with Wavey	627759	5563679	Upstream	Left	Yes	Drain	Grassed drain extending to road
							Right	Yes	Drain	Grassed drain bordered by crop

Table A3-6. Results of ground based classification, by waypoint, along Jennifer Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	Direction	Bank	Water	Use	Comments
6	2-Aug-07	Jennifer Creek	Hwy. 7	624702	5561006	Upstream	Both	No	Pasture	Fenced pasture area with cattle
						Downstream	Both	No	Drain	Grassed drain extending to hayfield
36	9-Aug-07	Jennifer Creek	Hwy. 236	619694	5564618	Upstream	Both	No	Drain	Grassed field and drain
						Downstream	Left	No	Hay	Hayfield
							Right	No	Hwy.	Transportation

Table A3-7. Results of ground based classification, by waypoint, along Netley Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	Direction	Bank	Water	Use	Comments
8	2-Aug-07	Netley Creek	Hwy. 17 and Netley Creek	632264	5583499	Upstream	Both	Yes	Drain	Grassed drain and dykes with hay
						Downstream	Both	Yes	Drain	Grassed drain and dykes with hay
20	3-Aug-07	Netley Creek	Hwy. 9	644204	5574430	Upstream	Left	Yes	Creek	Natural creek with reeds and deciduous
							Right	Yes	Creek	Natural creek with grass and deciduous
						Downstream	Both	Yes	Creek	Natural creek with grass and deciduous; some manicuring
44	9-Aug-07	Netley Creek	Rd. 100N (east of Hwy. 7)	624147	5593144	Upstream	Left	Yes	Creek	Grassed area extending into mixed deciduous
							Right	Yes	Creek	Grassed creek extending to fenced pasture
						Downstream	Left	Yes	Pasture	Grassed creek extending to fenced pasture
							Right	Yes	Hay	Grassed creek extending to hayfield
45	9-Aug-07	Netley Creek		625619	5592953	Upstream	Left	Yes	Creek	Grassed creek
							Right	Yes	Hay	Grassed creek extending to hayfield
						Downstream	Left	Yes	Creek	Apparent natural grass area
							Right	Yes	Homestead	Slight erosion at bank; some rip rap; manicured
46	9-Aug-07	Netley Creek	Rd. 12E	628953	5591240	Upstream	Left	Pools	Creek	Grassed/riparian with fenced pasture beyond
							Right	Pools	Creek	Heavy riparian
						Downstream	Left	Pools	Creek	Grassed and mixed deciduous
							Right	Pools	Creek	Grassed and mixed deciduous
47	9-Aug-07	Netley Creek	Rd. 98N	630275	5590035	Upstream	Both	Yes	Creek	Grassed and mixed deciduous
						Downstream	Both	Yes	Creek	Mixed riparian with apparent crop beyond
48	9-Aug-07	Netley Creek	Rd. 13E	630646	5589696	Downstream	Left	No	Drain	Grassed drain and heavy riparian into field?
							Right	No	Drain	Grassed drain and Road 13E

Table A3-7. Continued.

Wpt. #	Date	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	Direction	Bank	Water	Use	Comments
49	9-Aug-07	Netley Creek	south of Wpt. 48	630668	5589017	West	Left	No	Crop	Slight bank erosion due to cropping close (?)
50	9-Aug-07	Netley Creek	Rd. 95N	630795	5585124	Upstream	Left	No	Crop	Grassed drain extending to crop
							Right	No	Drain	Grassed drain and road
						Downstream	Both	Pools	Drain	Grassed drain extending to crop/hay
83	19-Sep-07	Netley Creek		637518	5577868	Upstream	Both	Yes	Drain	Grassed drain and dykes
						Downstream	Both			Grassed drain and dykes; crop beyond LB
89	19-Apr-08	Netley Creek	Hoop net at ford	637145	5578524	Upstream	Both	Yes	Drain	Grassed drain extending to hay; ford in area
						Downstream	Both	Yes	Drain	Grassed drain extending to hay

Table A3-8. Results of ground based classification, by waypoint, along Parks Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
25	3-Aug-07	Parks Creek	Hwy. 8	638310	5545760	Upstream	Both	Some	Drain	Well grassed drain extending to hayfields
						Downstream	Both	No	Drain	Well grassed drain extending to hayfields
29	9-Aug-07	Parks Creek	Hwy. 9	640357	5544335	Upstream	Left	Some	Creek	Well grassed with thick deciduous
							Right	Some	Creek	Well grassed with some deciduous and homes
						Downstream	Left	Yes	Creek	Grassed bank with some riparian
							Right	Yes	Creek	Eroding bank at top and culvert
72	19-Sep-07	Parks Creek	west of Hwy. 8	638231	5545783	Upstream	Both	Yes	Drain	Well grassed drain extending to crop
						Downstream	Both	Yes	Drain	Well grassed drain
75	19-Sep-07	Parks Creek	Mud Rd. (?)	636502	5549107	Upstream	Both	No	Drain	Well grassed drain extending to crop
						Downstream	Both	Pool	Drain	Well grassed drain extending to crop or hay
88	18-Apr-08	Parks Creek	Hoop net	640258	5544449	Upstream	Both	Yes	Creek	former bank stabilization in area
						Downstream	Both	Yes	Creek	former bank stabilization in area

Table A3-9. Results of ground based classification, by waypoint, along Ross Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
40	9-Aug-07	Ross Creek	Hwy. 7	624368	5577226	Upstream	Both	No	Creek	Heavy riparian of mixed deciduous
						Downstream	Both	No	Creek	Heavy riparian of mixed deciduous
51	10-Aug-07	Ross Creek	east of Hwy. 7 (drain)	625643	5576791	Upstream	Both	No	Drain	Grassed drain with hay in immediate vicinity
						Downstream	Left	No	Drain	Grassed drain extending to road way
							Right	No	Drain	Grassed drain extending to hayfield
79	19-Sep-07	Ross Creek	along Rd. 90N	630982	5576921	Upstream	Both	Pool	Drain	Well grassed/reeds; cultivated field/hay
						Downstream	Both	No	Drain	Well grassed; stubble fields beyond
81	19-Sep-07	Ross Creek		635923	5576671	Upstream	Left	Yes	Drain	Grassed drain and field beyond
							Right	Yes	Drain	Grassed drain to deciduous riparian and homestead
82	19-Sep-07	Ross Creek		637531	5577199	Upstream	Both	Yes	Drain	Grassed drain with some deciduous riparian; cultivated field RB
						Downstream	Both	Yes	Drain	Grassed drain and dykes

Table A3-10. Results of ground based classification, by waypoint, along Steele Drain, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
2	2-Aug-07	Steele Drain	Steele Drain off Hwy. 67	628138	5555524	Downstream	Both	No	Drain	Grassed/reed drain bounded by road and hayfield
3	2-Aug-07	Steele Drain	Headwaters of drain	628696	5557538	Upstream	Both	Yes	Drain	Grassed dyke bounded by cropland on both sides
						Downstream	Both	Yes	Drain	Grassed dyke bounded by cropland on both sides
4	2-Aug-07	Steele Drain		628347	5558562	Upstream	Left	Yes	Drain	Grassed dyke topped with dirt roadway
						Upstream	Right	Yes	Drain	Grassed drain extending to crop
						Downstream	Left	Yes	Drain	Grassed dyke topped with dirt roadway
						Downstream	Right	Yes	Drain	Grassed drain extending slight mixed deciduous

Table A3-11. Results of ground based classification, by waypoint, along Tugela Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U) easting	UTM (14U) northing	Direction	Bank	Water	Use	Comments
10	2-Aug-07	Tugela Creek	Lake Wpg. and Tugela Ck.	645428	5590580	Upstream	Both	Yes	Cottages	Manicured drain with minimal buffer and cottages
						Downstream	Left	Yes	Access point	Manicured bank with access to pier
							Right	Yes	Buffer	Full riparian
11	2-Aug-07	Tugela Creek	upstream at train tracks	645174	5590760	Upstream	Both	Minimal	Cottages	Manicured drain with minimal buffer and cottages
						Downstream	Both	Minimal	Cottages	Manicured drain with minimal buffer and cottages
12	2-Aug-07	Tugela Creek	upstream of train tracks	645134	5590732	Upstream	Left	No	Drain	Grassed drain extends to hay
							Right	No	Drain	Grassed drain into heavy riparian

Table A3-12. Results of ground based classification, by waypoint, along Wavey Creek, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
21	3-Aug-07	Wavey Creek	Hwy. 9	644317	5570138	Upstream	Both	Yes	Creek	Natural creek with grassed banks and mixed deciduous
						Downstream	Both	Yes	Creek	Natural creek with grassed banks and mixed deciduous
22	3-Aug-07	Wavey Creek	Rd. 85N	642703	5568946	Upstream	Both	Yes	Ford	Cement ford with culverts; passage likely; drain with buffer
						Downstream	Both	Yes	Ford	Cement ford with culverts; passage likely; creek with buffer
76	19-Sep-07	Wavey Creek		627002	5562012	Upstream	Both	Yes	Drain	Grassed drain extending to cultivated fields
						Downstream	Both	Yes	Drain	Grassed drain extending to fields
84	19-Sep-07	Wavey Creek	Hwy. 8	639384	5568776	Upstream	Both	Yes	Drain	Well grassed drain and dykes
						Downstream	Both	Yes	Drain	Well grassed drain and dykes

Table A3-13. Results of ground based classification, by waypoint, along Whiskey Ditch, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
86	25-Sep-07	Whiskey Ditch	Rd. 84N	651065	5567466	Upstream	Left	Minimal	Drain	Grass and road beyond
							Right	Minimal	Drain	Grass and full deciduous riparian
						Downstream	Left	No	Drain	Grass and mud road
							Right	No	Drain	Grass extending to crop

Table A3-14. Results of ground based classification, by waypoint, along Norris Lake, 2007.

Wpt. #	Date	Watercourse	Site Description	UTM (14U)		Direction	Bank	Water	Use	Comments
				easting	northing					
41	9-Aug-07	Norris Lake	Hwy. 17	615119	5591055	at lake	Both	Yes	Lake	Appears to have well buffered banks
42	9-Aug-07	Norris Lake	Hwy. 17 and Norris Lk. Rd. S	614194	5591876		n/a	n/a	Pasture	Pasture could extend to banks of lake
43	9-Aug-07	Norris Lake	Norris Lake boat launch	612031	5593634	north	Both	Yes	Boat launch	Appears to be well buffered
						south	Both	Yes	Boat launch	Appears to be well buffered

Table A3-15. Results of aerial based classification, by video time, along Wavey Creek, Netley Creek, and Norris Lake, 2007.

AREA	TYPE	COMPOSITION	COMMENT	VIDEO TIME
Wavey Creek	Grazing	Left Bank	Possible grazing and dugout area with access to Wavey Creek; structures in area	00:05:03
Wavey Creek	Grazing	Pasture	Possible pasture (extensive?) in wooded area on both banks	00:06:26
Wavey Creek	Grazing	Pasture	Possible pasture in wooded area on left bank; continuation from 06:26	00:06:32
Wavey Creek	Barrier	Riffle	Appears to be riffle (rock) in center channel; not an obvious barrier; spawning project?	00:06:56
Wavey Creek	Homestead	Mixed	Homestead with out buildings and grazing potential; wooded riparian	00:07:04
Wavey Creek	Ford	Cement/gravel	Confirm Wpt. 22 ground photos; not likely a barrier to passage (noted for observation)	00:07:13
Netley Creek	Golf course	Golf course	Netley Golf Course; some beaver dams in area	00:09:56
Netley Creek	Barrier	Beaver dam?	Apparent beaver dam in river; temporary barrier	00:10:22
Netley Creek	Homestead	Medium	Outbuildings; possible grazing and shelter; access to creek? (confirm) (and at 13:00)	00:10:28
Netley Creek	Homestead	Multiple	Thinning riparian, possible grazing in creek; manure piles present? HWY 8?	00:14:01
Netley Creek	Pasture	Grazing	Possible grazing area on right bank (could be fenced?)	00:14:16
Netley Creek	Ford	Gravel (culvert?)	No apparent blockage at this water level; possible spring barrier; Groundtruth	00:14:59
Netley Creek	Grazing	Pasture	Appears to be fenced pasture beyond road and drain; Colony in vicinity?	00:18:57
Netley Creek	Operation	Medium	Multiple issues; Grazing, manure piles, access to drain, denuded riparian: mostly LB	00:20:06
Netley Creek	Grazing	Pasture	On LB, thinned riparian, possible access; manure piles?	00:20:16
Netley Creek	Grazing	Pasture	Grazing on LB but appears to be beyond the riparian; access limited to nil	00:20:51
Netley Creek	Homestead	Small	Footage is grainy, but grazing and riparian impacts could be occurring	00:21:18
Netley Creek	Grazing	Pasture	Possible heavy grazed area with impacted riparian and eroding banks	00:21:28
Netley Creek	Grazing	Pasture	Possible heavy grazed on both banks; channelized here; fence line unapparent	00:21:42
Netley Creek	Homestead	Small	Homestead on LB with grazing; fenced at this point; See photos from Wpt. 44	00:21:52
Netley Creek	Operation	Medium	Heavy grazing; barns; access to creek; dugout in channel	00:22:01
Netley Creek	Homestead	Medium	Heavy grazing; trails into creek; no riparian; dugout; cattle present	00:22:45
Netley Creek	Grazing	Pasture	Heavy grazing, into and through creek, no riparian, erosion?	00:23:00
Netley Creek	Dugout	Dugout	Dugout directly in channel; grazing in area likely	00:23:11
Netley Creek	Homestead	Grazing	Grazing in creek; no riparian; outbuildings; cattle apparent	00:23:26
Netley Creek	Crossing	Culvert	No blockage apparent (likely no water); from operation at 00:23:26	00:23:34
Netley Creek	Dugout	Dugout	Dugout in channel (watered); grazing/access in area likely	00:24:10
Norris Lake	Operation	Larger	Holding areas; grazing; bales; access to lake and/or grazing shoreline (fenced?). There appears to be a decent buffer between grazing and shoreline	00:26:21
Norris Lake	Grazing	Pasture	Pasture area, but it appears to be fenced and away from the lake; see cattle	00:27:47

APPENDIX 4.

A SUMMARY OF DETRIMENTS TO RIPARIAN AND/OR AQUATIC ECOSYSTEM HEALTH, NEGATIVE IMPACTS, AND POTENTIAL MITIGATIVE MEASURES. REFERENCE SECTION PROVIDED AT END OF APPENDIX.

PRESENCE OF LIVESTOCK IN THE RIPARIAN ZONE:

Negatives[1, 3, 8]:

- Not only is it a detriment to aquatic health the well being of livestock is also threatened via direct access to water bodies (e.g., foot rot and/or mastitis, water becomes contaminated with livestock waste providing a transfer medium for other diseases; cattle drink less water if dirty resulting on lower beef production);
- Livestock trample shorelines and destroy aquatic vegetation (erosion and sedimentation are increased);
- Stream flow is more variable which increases bank instability.

Potential Mitigative Measures[1]:

- Completely restrict access by fencing;
- Provide off site watering systems;
- If access is required limit it with on-site fencing or install erosion ramps (e.g., cattle crossings);
- If possible, initiate a rotational grazing system;
- A 'best possible scenario' would involve complete livestock exclusion with a (fenced) 9 to 10 m buffer strip along the waters edge.

Potential Benefits (gains) of Mitigative Measures[1]:

- Reduced risk of infection and disease (e.g., less bacteria);
- Cleaner water via reduced sedimentation;
- Less nutrient loading and potential algal growth;
- Protected and potentially improved habitat for fish and other aquatic organisms.

Note[6] – The real issues of livestock within a riparian area are not the animals themselves but rather the poor management issues associated with this practice (i.e., overgrazing, continuous grazing, poor water access and crossings, pasture overstocking, and proximity of feedlots to stream sides).

REMOVAL OF RIPARIAN VEGETATION (LACK OF BUFFER STRIPS):

The removal of riparian vegetation can be a result of overgrazing by livestock, deforestation to allow for agricultural practices, or as a result of urban expansion.

Negatives[2]:

- Fields cropped to close to watercourses may not be able to slow runoff, resulting in erosion and bank failure;
- Without buffer strips or riparian areas detriments to aquatic health (e.g., sediments, fertilizers, pesticides, pathogens) are not filtered/stopped before the enter the stream;
- Increased levels of nitrogen and phosphorus entering streams (if not trapped by riparian vegetation) can result in toxic conditions (e.g., algal blooms);
- Ground water may also be affected by the leaching of nitrates.

Potential Mitigative Measures[2, 4, 5]:

- Re-establish buffer strips and riparian vegetation where it is needed;
- If buffer strips have been reduced as a result of livestock, include exclusion fencing;
- Buffer strips can be allowed to regenerate naturally or can be assisted with bio-engineering practices (e.g., plantings of willow, grasses or other naturally occurring hardy species);
- The recommended width of a buffer strip is at least 10 m, however 30 m is more ideal.

Potential Benefits (gains) of Mitigative Measures[2, 5]:

- Dense buffer strips slow the rates of spring runoff and flood water. The result is a reduction in soil erosion and potential groundwater recharge (e.g., vegetated banks can withstand up to three times the flow of an un-vegetated bank);
- Vegetation traps sediments and organic matter, thus enriching soils;
- Less leaching of nitrates and phosphates into the water system occurs;
- There is a direct improvement to water quality and (often) clarity;
- Diverse plant communities in riparian and or buffer strip areas can reduce weed invasion;
- Water temperatures can be kept cooler as a result of overhanging vegetation. The result is an increase in oxygen for aquatic organisms and a reduction in the effects of pollution (which are magnified by warmer water).

URABAN ENCROACHMENT AND RECREATIONAL OVERUSE/ABUSE:

Human-induced (i.e., anthropogenic) disturbances related to land use can have the greatest impact on water bodies and can include crop and livestock production (discussed above), urban practices (e.g., waste matter, construction activities, concrete drains and roads, channelization), industry (e.g., mining, forestry, assembly and production), and recreational use/abuse (e.g., parks, golf courses, marinas) [6].

Negatives[6, 7, 8]:

- Recreational development can reduce species diversity, result in compaction of soils, and disrupt wildlife.
- Manicured lawns in areas such as parks, golf courses, and/or private properties are often directly to the edge of water bodies. This can result in: a reduction in species diversity; the direct input of deleterious substances (e.g., fertilizers, lawn trimmings, brush); or bank failure.
- Marinas can result in oil/gas spills or leaks, direct nutrient loading via improperly functioning privies or improperly disposed waste material, bank failure due to excessive/un-checked vessel activity; or the introduction of invader species (e.g., zebra mussels).
- Urbanization can: increase runoff that is potentially polluted (e.g., drains and ditches or paved roadways); result in the clearing of riparian areas; and increase the number of stream crossings in an area.

Potential Mitigative Measures[6, 7, 8]:

- Avoid riparian areas and increase buffer widths along water bodies;
- Plan for a reduction in impervious cover (e.g., roofs, roads, parking lots, etc);
- Limit the disturbance and, subsequent, erosion of soils;
- Treat storm water runoff;
- Initiate buffer widths in urban areas, especially along water courses;
- Reduce or ban the use of lawn fertilizers and chemicals used in the home;
- Enforce regulations to prevent the illegal dumping of material into watercourses;
- Educate the public on how they can make a difference.

Potential Benefits (gains) of Mitigative Measures:

- Increased riparian areas which serve a filtering function and act towards erosion control;
- Improved riparian areas are aesthetically pleasing;
- Treating storm water runoff can improve water quality;
- A reduction of lawn fertilizers and chemicals should reduce the amount of phosphates and nitrates entering a water body, thus improving water quality.

IMPROPERLY DESIGNED STREAM PASSAGE:

Improperly designed stream passage can take a number of forms, including: improperly sized culverts; the use of fords; bridges, or lack of complete structure.

Negatives[9]:

- Improperly designed stream crossings can cause washouts and increase erosion within a stream channel.
- Stream crossings can act as barriers to fish migration. For example, culverts may be perched, act as velocity barriers, or become clogged with debris;
- If not properly maintained, crossings can become blocked by debris (e.g., logs, silt, gravel, etc). These blockages can result in washouts or act as barriers to fish migration;
- Through construction activities sediments entering the stream may increase. These sediment loads could destroy or alter fish habitat and reduce water quality;
- Construction activities can also result in altered or destroyed riparian areas.

Potential Mitigative Measures[9]:

- All road crossing should be designed properly and maintained;
- New road crossings should follow all applicable construction guidelines and guidelines for the protection of fish and aquatic habitat;
- Crossings determined to be detriments to aquatic health should be replaced.

Potential Benefits (gains) of Mitigative Measures:

- Properly designed and maintained crossing should allow for the passage of fish;
- Properly designed and maintained crossings should not increase sedimentation or result in erosion;
- Properly designed crossings are cost effective if they do not result in washouts and subsequent repairs.

References:

1. www.agr.gc.ca/pfra/land/gft14.htm (accessed August 16, 2005)
2. www.agr.gc.ca/pfra/land/stream/streamf1.htm (accessed August 16, 2005)
3. www.agr.gc.ca/pfra/land/stream/streamf3.htm (accessed August 16, 2005)
4. www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/guidelines-conseils/factsheets (accessed August 16, 2005)
5. www.agr.gc.ca/pfra/land/shorelds.htm (accessed August 19, 2005)
6. McIver, Serena. 2004. Using off-stream water sources as a beneficial management practice in riparian areas- a literature review. Agriculture and Agri-Food Canada Prairie Farm Rehabilitation Administration.
7. Fischenich, J. C. and H. Allen. 1999. Stream Management. Prepared for US Army Corps of Engineers, Ft. Worth District under Water Operations and Technical Support Program. Working document, June 1999.
8. Bentrup, G. and J. C. Hoag. 1998. The practical streambank bioengineering guide: users guide for natural streambank stabilization techniques in the arid and semi-arid great basin and international west. USDA Natural Resources Conservation Service, Plant Materials Center. Aberdeen, Idaho.
9. Fisheries and Oceans and Manitoba Natural Resources. 1996. Manitoba stream crossing guidelines for the protection offish and fish habitat.