Willow Creek Watershed Integrated Watershed Management Plan- Water Quality Report

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Water Quality Investigations and Routine Monitoring:

This report provides an overview of the studies and routine monitoring that have been undertaken by Manitoba Water Stewardship's Water Quality Management Section and the East Interlake Conservation District (EICD) within the Willow Creek watershed.

1. 2005 Investigation:

During the summer of 2005 a short term water quality investigation was undertaken by the Department. Samples were collected on six occasions from Willow Creek at Highway #8. Table 1 illustrates the results from these sampling dates.

Table 1: Water quality results collected in the summer of 2005 from Willow Creek water quality station MB05SBS321 at Highway #8.

Variable	**Units**	**15-Jul**	**18-Jul**	**20-Jul**	**25-Jul**	**27-Jul**	**3-Aug**
Dissolved Ammonia	mg/L	0.05	0.05	0.06	0.04	0.09	0.04
Total Inorganic Carbon	mg/L	64	55	57	63	70	77
Total Organic Carbon	mg/L	19	13	26	20	14	26
Total Carbon	mg/L	83	68	84	83	84	103
Conductivity at 25 C	µS/cm	434	413	438	466	473	506
Total Kjeldahl Nitrogen	mg/L	1.9	1.4	1.9	2.3	1.2	1.2
Dissolved Nitrate and Nitrite Nitrogen	mg/L	L 0.01*	L 0.01	L 0.01	L 0.01	0.01	L 0.01
Dissolved Ammonia	mg/L	0.05	0.05	0.06	0.04	0.09	0.04
Biochemical Oxygen Demand	mg/L	3	2	3	2	2	2
Total Phosphorus	mg/L	0.2	0.124	0.187	0.168	0.136	0.118
Total Ortho Phosphorus	mg/L	0.121	0.101	0.084	0.12	0.085	0.079
Particulate Phosphorus	mg/L	0.065	0.003	0.091	0.041	0.043	0.082
Total Dissolved Phosphorus	mg/L	0.135	0.121	0.096	0.127	0.093	0.036
pH	pH units	7.79	7.82	7.85	7.96	7.96	8.15
Field Water Temperature	Deg C	25	20	20.5	22	20	26
Total Suspended Solids	mg/L	12	15	11	14	12	11

* "L" = Less than detection limit.

This short-term study in Willow Creek showed that both total Kjeldahl nitrogen and total phosphorus levels were relatively high, suggesting that nutrient input from non-point, as well as potential point sources was occurring upstream of sampling locations. Ammonia (a form of nitrogen) levels were low and would not pose any toxicity to aquatic life inhabiting the creek. Conductivity and total suspended solids remained relatively consistent over the three week sampling period.

2. *E. coli* Monitoring in Willow Creek: 2003 – 2009:

Since 2003, Manitoba Water Stewardship (MWS) has been collecting *Escherichia coli (E*. coli) samples from Willow Creek at Highway #9 as part of the routine beach monitoring program. Samples are collected from the Gimli area in order to monitor *E. coli* densities since Willow Creek discharges near some of the recreational beaches on Lake Winnipeg. The results obtained from this monitoring are presented in Figure 1. This figure illustrates that the bacteria levels at this site are usually below the irrigation objective of 1000 *E. coli* per 100 mL, and most often below the body contact recreation objective of 200 *E. coli* per 100 mL. *E. coli* densities in Willow Creek have not been found to correlate with *E. coli* densities obtained from recreational beaches in the area. *E. coli* levels at the beaches have been correlated to *E. coli* present in the wet sands along the beach shorelines (Ralley, 2010; Williamson et. al., 2004). Samples exceeding the irrigation and secondary recreation guideline of 1000 *E. coli* per 100 mL were found once in 2005 and once in 2006.

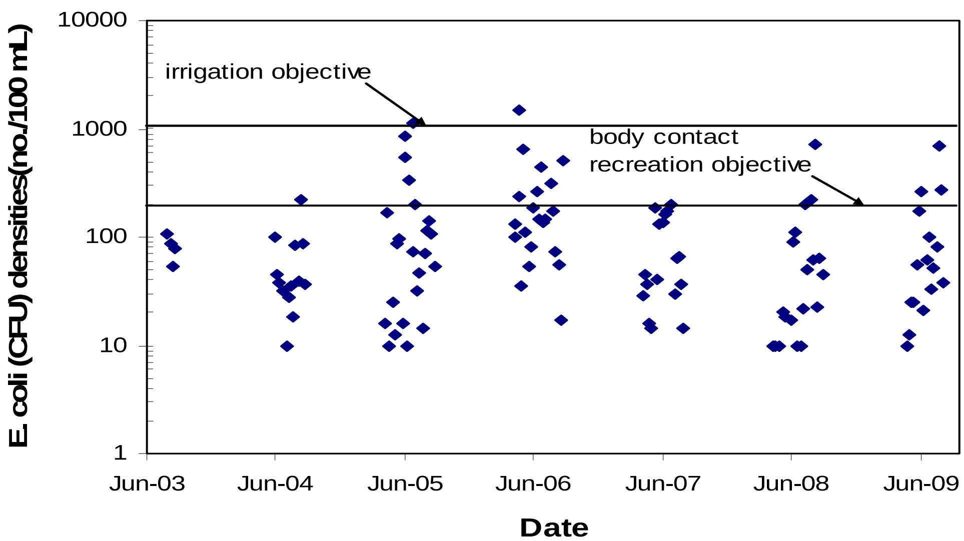

Figure 1: Densities of *Escherichia coli (E*. coli) collected in Willow Creek at Highway #9 between 2003 – 2009.

3. Beach Monitoring:

The Province undertakes an extensive beach monitoring program along the shores of Lake Winnipeg. *E. coli* samples are collected from four locations adjacent to the Willow Creek watershed. These include: Spruce Sands Beach, Gimli Beach, Sandy Hook Beach and Winnipeg Beach. The results of this monitoring are posted on the MWS site and can be retrieved from: http://www.gov.mb.ca/waterstewardship/quality/lake_winnipeg.html

When blooms are present, samples are also collected for algal cell density and algal toxin analysis. Lake Winnipeg beaches are periodically posted with "Algal Advisory" signs when guidelines for cell counts or toxin concentrations are exceeded. The status of algal advisory postings is available at: http://www.gov.mb.ca/waterstewardship/quality/beaches.html

E. coli is a bacteria found in large numbers in all warm-blooded animals including humans, livestock, wildlife, and birds. *E. coli* itself does not generally cause illness, but when it is present in large numbers, the risk of becoming ill from other organisms is elevated. The most common illnesses contracted by bathers are infections of the eyes, ears, nose, and throat as well as stomach upsets. Typical symptoms include mild fever, vomiting, diarrhea and stomach cramps. While water quality at the beaches across Manitoba is generally excellent and safe for swimming, occasionally recreational guidelines are exceeded at these four Lake Winnipeg beaches along the boundary of the Willow Creek watershed (i.e. Spruce Sands Beach, Gimli Beach, Sandy Hook Beach and Winnipeg Beach).

Extensive studies were undertaken by MWS in 2003 to determine the source of occasionally high *E. coli* counts and the mechanism of transfer to Lake Winnipeg beaches. Studies have shown that large numbers of *E. coli* are present in the wet sand of beaches. During periods of high winds, when water levels are rising in the south basin, these bacteria can be washed out of the sand and into the swimming area of the lake. Research has shown that less than 10 percent of the *E. coli* at Lake Winnipeg beaches is from human sources, with the remaining numbers being from birds and animals. Study results significantly enhance the present understanding of water quality in Lake Winnipeg and are available in a Manitoba Water Stewardship Interim Report (Williamson et. al., 2004).

4. Storm Drain Monitoring:

In 2008, the EICD and the R.M. of Gimli monitored the water quality in storm drains in the Gimli region (EICD, 2008). High levels of *E. coli* were observed at some of the storm sewer outfall sites. A report of these results is available at:

http://www.eicd.net/assets/gimli%20storm%20water%20report%202008.pdf . The results of this effort are helping guide sewer and water planning within the R.M. of Gimli.

5. Long-Term Water Quality Monitoring:

The Water Quality Management (WQM) Section maintains a province-wide monitoring program that provides information on long-term trends in surface water quality. There is one long-term monitoring station within the Willow Creek watershed and it is located on Willow Creek at Highway #8. This site was added to the long-term water quality network in 2010. Previously, monitoring at this site was conducted by the EICD. The Conservation District has assumed continued responsibility for monitoring at the Willow Creek site, as well as other sampling sites on tributaries within its jurisdiction. Samples are collected quarterly. Table A1 in Appendix 1 illustrates the water quality data collected from this location since the inception of the monitoring program.

Figure 2 illustrates the phosphorus levels observed in Willow Creek. All samples collected to date show levels at or exceeding the Tier III Manitoba Water Quality Guideline (Williamson, 2002), of 0.05 mg per L. As part of the Lake Winnipeg Action Plan, Manitoba is implementing several strategies to better manage plant nutrients. Part of this Action Plan includes the development of more appropriate site-specific or regional-specific water quality objectives or guidelines for nutrients. In the meantime, the narrative guidelines will be retained for nutrients such as nitrogen and phosphorus until the more site specific objectives are developed. It is generally recognized, however, that the narrative guidelines for phosphorus likely do not apply to many streams in the Canadian prairie region since other factors such as turbidity, stream velocity, nitrogen, and other conditions most often limit algal growth. As well, relatively high levels of phosphorus in excess of the narrative guidelines may arise naturally from the rich prairie soils. It should be noted that most streams and rivers in southern Manitoba exceed this guideline in some cases due to the natural soil characteristics in the watershed and, or due to inputs from human activities.

Figure 3 illustrates the total nitrogen data in Willow Creek between 2008 and 2010.The narrative objective for total nitrogen states that nitrogen should be limited to the extent necessary to prevent the nuisance growth and reproduction of aquatic rooted, attached and floating plants, fungi, or bacteria, or to otherwise render the water unsuitable for other beneficial uses (Williamson, 2002). Nitrogen along with phosphorus are two essential nutrients that stimulate the growth of algae in Lake Winnipeg and its watershed. Ammonia in its unionized form – can be toxic to aquatic life. This form of nitrogen has not been found in high concentrations within Willow Creek (Table A1 in Appendix 1).

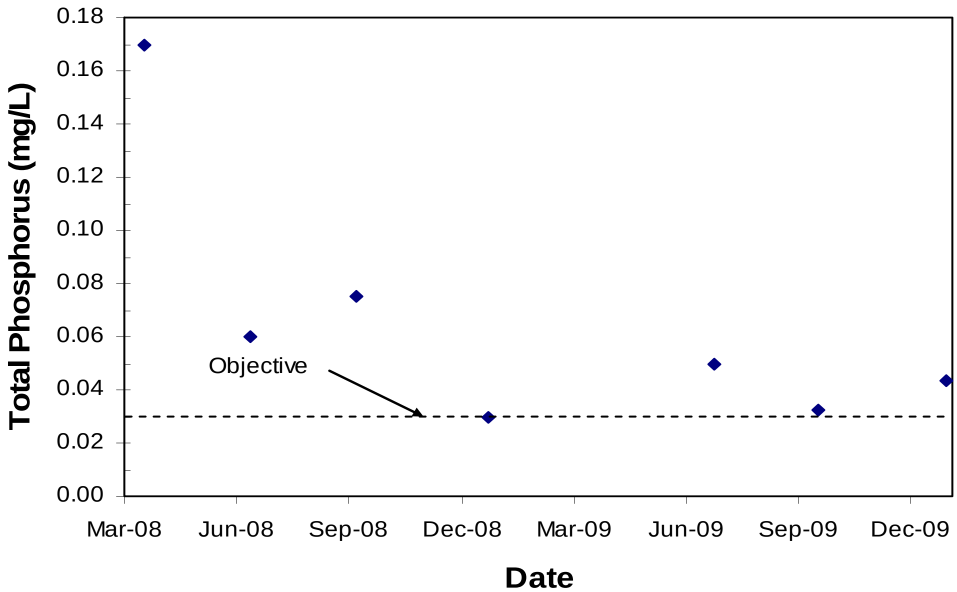

Figure 2: Total phosphorus concentrations between 2008 and 2010 at the long-term water quality monitoring station in Willow Creek at Highway #8.

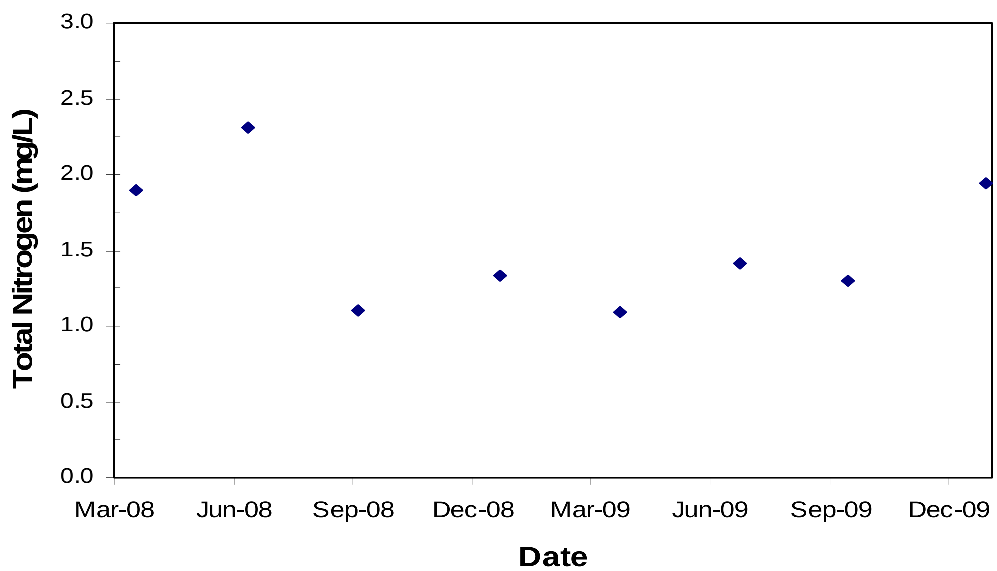

Figure 3: Total nitrogen concentrations between 2008 and 2010 at the long-term water quality monitoring station in Willow Creek at Highway #8.

Maintenance of adequate dissolved oxygen levels is essential to the health of aquatic life inhabiting streams. The monitoring conducted in Willow Creek has demonstrated that dissolved oxygen levels have generally been above the 5.0 mg per L Manitoba objective (Williamson, 2002). However in winter of 2009, oxygen levels were found to be below the objective (Figure 4). Low oxygen levels under ice conditions are not uncommon in small prairie streams, as the decomposition of plant material consumes oxygen from the water.

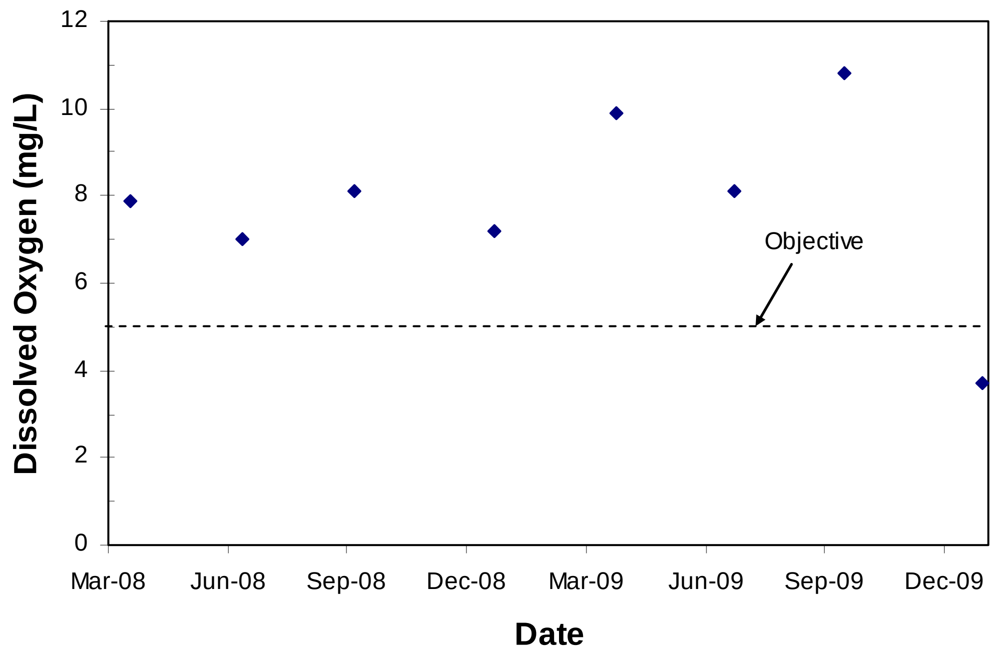

Figure 4: Dissolved Oxygen concentrations between 2008 and 2010 at the long-term water quality monitoring station in Willow Creek at Highway #8.

The results of the analysis of other water quality variables (e.g. metals, pesticides) can be found in Table A1 in Appendix 1. Pesticide concentrations were found to be almost always at the analytical detection limit, or very close to that limit.

6. Comparative Conditions in Willow Creek and Other Steams in the East Interlake Conservation District:

The EICD carries out water quality monitoring on nine tributaries within its jurisdiction. These samples are collected quarterly for a wide range of water quality variables including microbiology, general chemistry, metals and pesticides. Table A2 in Appendix 2 illustrates the comparison of water quality conditions in these nine streams. To compare the water quality of Willow Creek with other streams in the EICD, the average concentrations of several variables were calculated for each of the nine tributaries in the EICD between the sampling period of April 2008 to January 2010. Figure 5 illustrates that Willow Creek has lower phosphorus levels as compared to most of the other streams with only Fish Lake Drain having lower concentrations. Not surprisingly, all sites exceeded the phosphorus objective of 0.05 mg per L. Fish Lake Drain and Willow Creek appear to have lower nutrient loading to their watersheds while Grassmere Creek showed the highest average phosphorus concentrations.

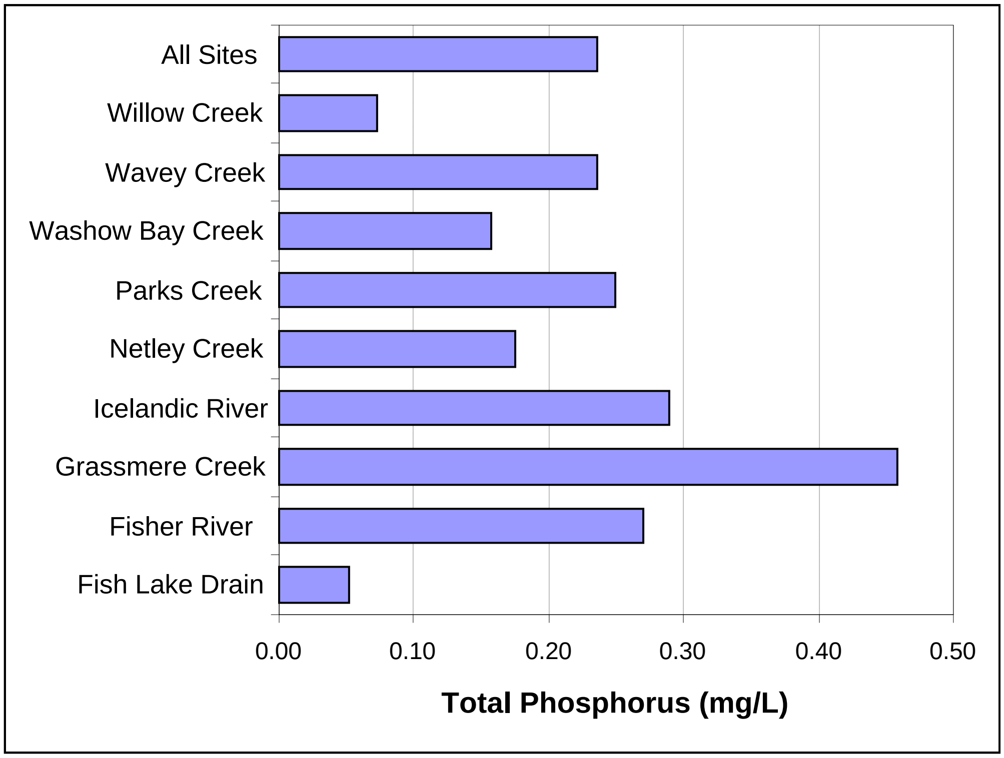

Figure 5: Comparison of mean phosphorus concentrations in nine East Interlake Conservation District streams between April 2008 and January 2010.

Total nitrogen levels in these same streams showed similar trends (Figure 6) with lower nitrogen levels observed in Fish Lake Drain, Willow Creek and also in Netley Creek. Consistent with the phosphorus trends, Grassmere Drain had the highest average nitrogen concentrations, followed closely by the Icelandic River.

Figure 7 illustrates that average oxygen conditions in all nine streams were good and above the 5.0mg per L objective (Williamson, 2002). Oxygen levels were similar between all sampling locations. Maintenance of good oxygen conditions is essential for the health of aquatic life inhabiting these waterways.

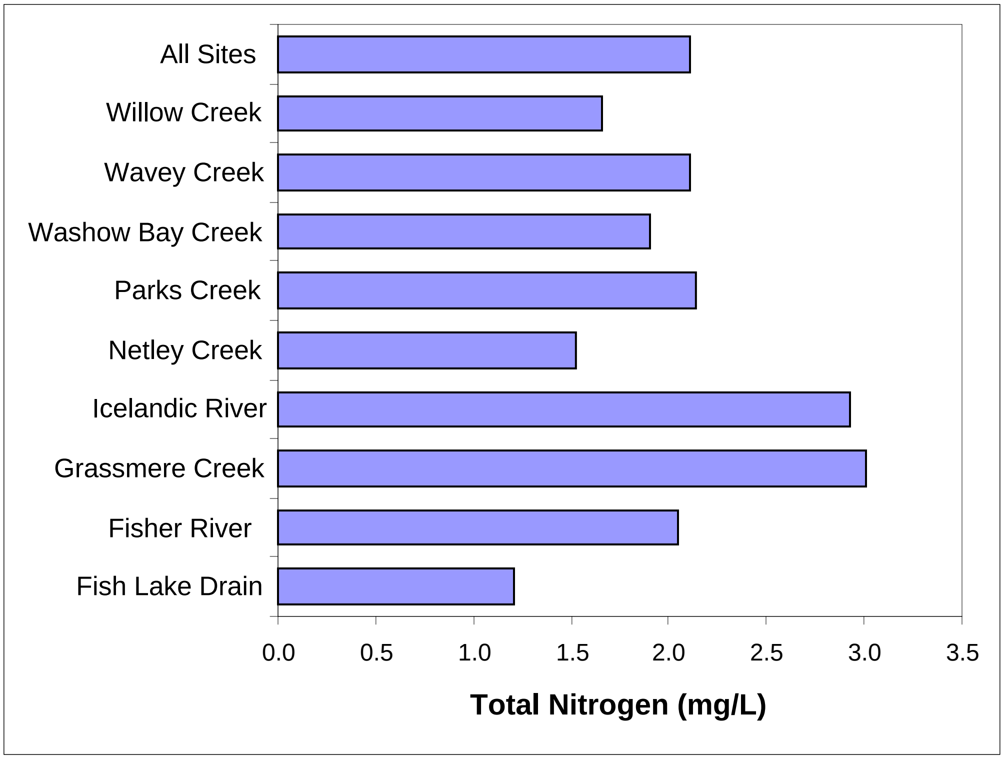

Figure 6: Comparison of mean total nitrogen concentrations in nine East Interlake Conservation District streams between April 2008 and January 2010.

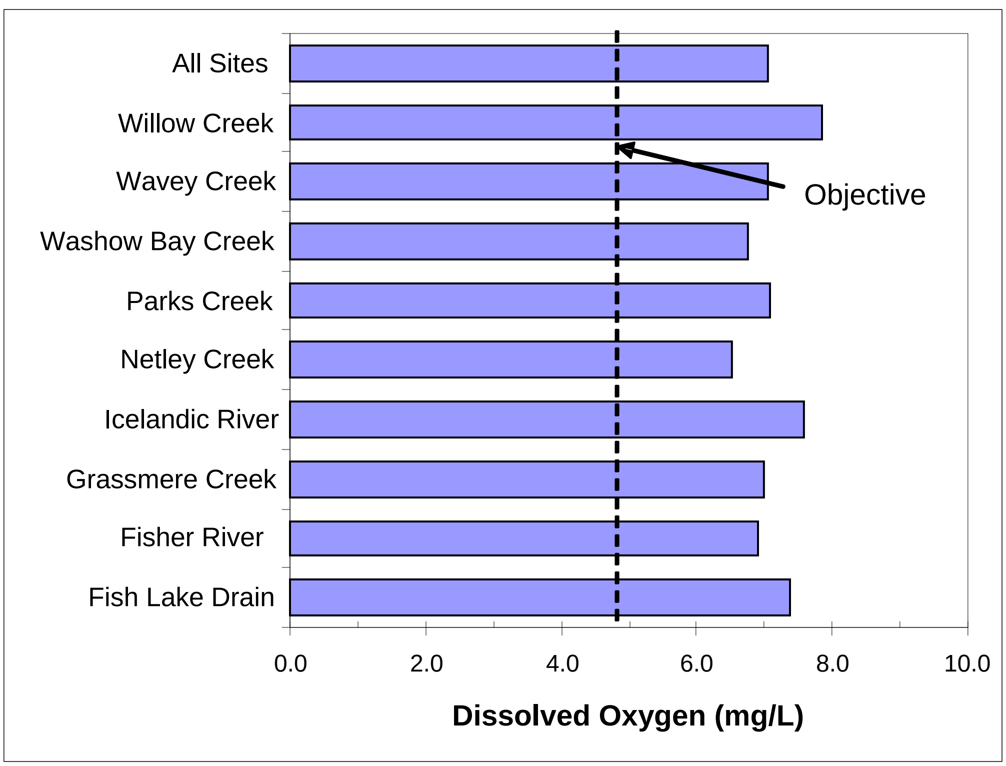

Figure 7: Comparison of dissolved oxygen levels in nine East Interlake Conservation District streams between April 2008 and January 2010.

7. Water Quality Index Calculations:

The Canadian Council of Ministers of the Environment (CCME) Water Quality Index is used to summarize large amounts of water quality data into simple terms (e.g., good) for reporting in a consistent manner (CCME, 2001). In the example below, twenty-five variables are included in the Water Quality Index (Table 2) and are compared with water quality objectives and guidelines contained in the Manitoba Water Quality Standards, Objectives, and Guidelines (Williamson 2002 and Table 2).

Table 2: Example of water quality variables and objectives or guidelines (Williamson 2002) used to calculate Water Quality Index (CCME 2001).

Variables	Units	Objective Value	Objective Use
Escherichia coli	**Bacteria/100mL**	**200**	**Recreation**
pH	**pH Units**	**6.5-9.0**	**Aquatic Life Greenhouse**
Conductivity	**uS/cm**	**1000**	**Irrigation**
Total Suspended Solids	**mg/L**	**25 (mid range)**	**Aquatic Life**
Dissolved Oxygen	**mg/L**	**5 (mid range)**	**Aquatic Life**
Total or Extractable Cadmium*	**mg/L**	**Calculation based on Hardness (7Q10)**	**Aquatic Life**
Total or Extractable Copper*	**mg/L**	**Calculation based on Hardness (7Q10)**	**Aquatic Life**
Total Arsenic	**mg/L**	**0.025**	**Drinking Water, Health**
Total or Extractable Lead*	**mg/L**	**Calculation based on Hardness (7Q10)**	**Aquatic Life**
Total or Extractable Nickel*	**mg/L**	**Calculation based on Hardness (7Q10)**	**Aquatic Life**
Total or Extractable Zinc*	**mg/L**	**Calculation based on Hardness (7Q10)**	**Aquatic Life**
Total or Extractable Manganese	**mg/L**	**0.05**	**Drinking Water, Aesthetic**
Total or Extractable Iron	**mg/L**	**0.3**	**Drinking Water, Aesthetic**
Total Ammonia as N	**mg/L**	**Calculation based pH**	**Aquatic Life**
Soluble or Dissolved Nitrate-Nitrite	**mg/L**	**10**	**Drinking Water, Health**
Total Phosphorus	**mg/L**	**0.05 in Rivers or 0.025 in Lakes**	**Nuisance Plant Growth**
2,4 D	**ug/L**	**4**	**Aquatic Life**
MCPA	**ug/L**	**0.025 where detectable**	**Irrigation**

The Water Quality Index (WQI) combines three different aspects of water quality:

- the 'scope,' which is the percentage of water quality variables with observations exceeding guidelines;
- the 'frequency,' which is the percentage of total observations exceeding guidelines; and
- the 'amplitude,' which is the amount by which observations exceed the guidelines.

The basic premise of the WQI is that water quality is excellent when all guidelines or objectives set to protect water uses are met virtually all the time. When guidelines or objectives are not met, water quality becomes progressively poorer. Thus, the Index logically and mathematically incorporates information of water quality, based on comparisons to guidelines or objectives to protect important water uses. The Water Quality Index ranges from 0 to 100 and is used to rank water quality in categories ranging from poor to excellent.

- Excellent (95-100) - Water quality never or very rarely exceeds guidelines
- Good (80-94) - Water quality rarely exceeds water quality guidelines
- Fair (60-79) - Water quality sometimes exceeds guidelines and possibly by a large margin
- Marginal (45-59) - Water quality often exceeds guidelines and/or by a considerable margin
- Poor (0-44) - Water quality usually exceeds guidelines and/or by a large margin

Unfortunately there is not yet sufficient data collected for Willow Creek in order to calculate a water quality index for this site. The CCME guidance document recommends that the WQI should not be run with less than four parameters and four sampling visits per year. Since to date there are only three sampling periods in 2008, four sampling periods in 2009 and one in 2010 – it is not possible to establish a trend over time. As more data is collected, this index can be used as a tool to report on water quality conditions in the streams in the East Interlake Conservation District.

8. Benthic Macroinvertebrate Monitoring:

Benthic macroinvertebrates are a group of organisms found in the bottom substrates of lakes and streams for at least a portion of their life cycle. The prefix “macro” corresponds to the size of these organisms. Usually, macroinvertebrates are captured with mesh between 200 and 500 µm in size. In conjunction with water chemistry information, aquatic macroinvertebrates have increasingly been used as indicators of water quality.

As a biological assemblage, macroinvertebrates are able to respond to the conditions of their habitat. Typically, it is the density, abundance, and diversity of the macroinvertebrate community which are used to evaluate water quality. Measures of richness, abundance, or diversity are referred to as bioassessment metrics. Using the end results obtained from a number of different metrics, one can develop an index value which can qualitatively define water quality. Hilsonhoff's Family Biotic Index was used to define the water quality in Willow Creek.

Macroinvertebrate community data is available from Willow Creek for one year (2006). The EICD, with assistance from North South Consultants, completed a biological assessment using macroinvertebrates of several tributaries. A kick net with 500 µm Nitex© was used to sample five 1.0 m^2 quadrants at three sites along Willow Creek (Figure 8). A kick and sweep methodology was employed to pass over each of the 1.0 m^2 areas at least twice. Sampling took place between mid August and the end of September.

Figure 8: One of the sites on Willow Creek where the macroinvertebrate community was sampled.
Photo courtesy of North/South Consultants Inc.

Two of three monitoring sites on Willow Creek were classified as having fair water quality, while the macroinvertebrate community of the third site yielded a poor ranking (Table 3). A number of other tributaries in the EICD jurisdiction showed a ranking of fair to poor, based on the monitoring sites where macroinvertebrates were collected.

Table 3: Water quality classification based on the Family Biotic Index (FBI) for benthic macroinvertebrates collected in 2006 from tributaries found in the East Interlake Conservation District (North/South Consultants Inc., 2007).

	Water Quality (based on Family Biotic Index)						
Waterbody	**Excellent**	**Very Good**	**Good**	**Fair**	**Fairly Poor**	**Poor**	**Very Poor**
Icelandic River Reach 1							XXXXX
Icelandic River Reach 2			XX	XX			X
Icelandic River Reach 3	XXXXX						
Washow Bay Creek Reach 1						XXXX	X
Washow Bay Creek Reach 2			XXXXX				
Washow Bay Creek Reach 3	X	XXX		X			
Grassmere Creek			X	X	X	XX	
Parks Creek						X	XX
Wavey Creek					X	XXX	
Netley Creek					XX		X
Willow Creek				XX		X	
Fish Lake Drain			XX	X	X		
Fisher River - East Arm					XX	X	

The rankings obtained using Hilsonhoff's Family Biotic Index indicate that water quality in Willow Creek has likely been impacted by various amounts of organic pollution (Table 4). The number of organisms collected at the three sites ranges from 2000 to 6848, although the number of distinct taxonomic groups (taxa richness) remains relatively consistent (Table 5). The number of EPT (Orders Epheroptera, Plectoptera, Trichoptera) is greatest at site 3. The three taxonomic orders that comprise the EPT are generally considered to be more sensitive to deteriorating environmental conditions. Therefore, having more of these taxa in a particular watercourse is advantageous. Chironomid midges (Family Chironomidae) are known to be able to survive in environments where oxygen is limited. Chironomids at site 2 made up 63% of the macroinvertebrate community, likely attributing to the ranking of "very poor". The ranking at site 2 is compounded further by the proportion of aquatic worms (Oligochaeta; 18%) that made up the macroinvertebrate community.

Table 4: The distribution of water quality classifications using Hilsonhoff's Family Biotic Index (Hilsonhoff, 1988).

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very Good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly Poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very Poor	Severe organic pollution likely

Table 5: Bioassessment metric summary for the macroinvertebrate community from Willow Creek.

Monitoring Site	Total # of organisms	EPT[1]	Hilsonhoff's FBI	EPT:Chironomidae	Taxa Richness
Willow 1	2000	40	5.51	8.0	13
Willow 2	3968	48	6.96	52.57	14
Willow 3	6848	4576	5.51	0.20	12

1 Ephemeroptera, Plectoptera, Trichoptera

As with any dataset, particularly where the goal of the program is to evaluate changes in environmental quality, a longer record is advised. The information acquired from sampling the benthic macroinvertebrate community in 2006 supplements existing water chemistry data, however, it only provides a snapshot of the conditions in Willow Creek. Without additional macroinvertebrate data, it is difficult to assess whether the conditions in Willow Creek are the result of environmental changes, or caused by the habitat which was sampled. For example, typically, water chemistry is sampled from a different location than where the benthic community is assessed.

In comparison to the water chemistry data that is available, some variables (such as total phosphorus) frequently exceed the objective that has been established as a benchmark to gauge water quality. Alternatively, dissolved oxygen is, generally, above the provincial objective, suggesting adequate oxygen to support aquatic life. Interpretation of available water chemistry and benthic macroinvertebrate data implies that Willow Creek has water quality that is typical of many small Prairie streams, where fluctuating water levels, as well as land use changes in adjacent catchment areas have a direct impact on the health of the ecosystem.

Discussion

Nutrient enrichment or eutrophication is one of the most important water quality issues in Manitoba. Excessive levels of phosphorus and nitrogen fuel the production of algae and aquatic plants. Extensive algal blooms can cause changes to aquatic life habitat, reduce essential levels of oxygen, clog fisher's commercial nets, interfere with drinking water treatment facilities, and cause taste and odour problems in drinking water. In addition, some forms of blue-green algae can produce highly potent toxins.

Studies have shown that since the early 1970s, phosphorus loading to Lake Winnipeg has increased by about 10 per cent and nitrogen loading has increased by about 13 per cent. A similar phenomenon has also occurred in many other Manitoba streams, rivers, and lakes. Manitobans, including those in the Willow Creek watershed, contribute about 47% of the phosphorus and 44% of the nitrogen to Lake Winnipeg (Bourne *et al.* 2002, updated in 2006).

Approximately 15% of the phosphorus and 6% of the nitrogen entering Lake Winnipeg is contributed by agricultural activities within Manitoba. In contrast, approximately 9% of the phosphorus and 6% of the nitrogen entering Lake Winnipeg from Manitoba is contributed by wastewater treatment facilities such as lagoons and sewage treatments plants.

As part of Lake Winnipeg Action Plan (LWAP), the Province of Manitoba is committed to reducing nutrient loading in Lake Winnipeg to levels that existed prior to the 1970s. The LWAP recognizes that nutrients are contributed by most activities occurring within the drainage basin and therefore, reductions will need to occur across all sectors. Reductions in nutrient loads across the Lake Winnipeg watershed will benefit not only Lake Winnipeg but also improve water quality in the many rivers and streams that are part of the watershed including Willow Creek. The Lake Winnipeg Stewardship Board's 2006 report "Reducing Nutrient Loading to Lake Winnipeg and its watershed: Our Collective Responsibility and Commitment to Action" (LWSB 2006) provides 135 recommendations on actions needed to reduce nutrient loading to the Lake Winnipeg watershed. However, reducing nutrients loading to the Lake Winnipeg watershed, including the Willow Creek watershed, is a challenge that will require the participation and co-operation of all levels of government and all watershed residents. Ensuring good water quality in the Willow Creek and downstream is a collective responsibility among all living in the watershed.

Water Quality Management Zones

In June 2005 *The Water Protection Act* received royal ascension. This Act is intended to enable regulations to be developed for strengthening adherence to water quality standards; for protecting water, aquatic ecosystems or drinking water sources; and to provide a framework for integrated watershed management planning. The first regulation under *The Water Protection Act*—the *Nutrient Management Regulation (see:* www.gov.mb.ca/waterstewardship/wqmz/index.html) — defines five Water Quality Management Zones for Nutrients to protect water from excess nutrients that may arise from the over-application of fertilizer, manure, and municipal waste sludge on land beyond the amounts reasonably required for crops and other plants during the growing season.

As of January 1, 2009, substances containing nitrogen or phosphorus cannot be applied to areas within the Nutrient Buffer Zone or land within Nutrient Management Zone N4 (Canada Land Inventory Soil Capability Classification for Agriculture Class 6 and 7, and unimproved organic soils). The width of the Nutrient Buffer Zone varies depending upon the nature of the body of water and is generally consistent with those contained in the Livestock Manure and Mortalities Management Regulation (42/98).

The *Nutrient Management Regulation* (MR 62/2008) prohibits the construction, modification, or expansion of manure storage facilities, confined livestock areas, sewage treatment facilities, and wastewater lagoons on land in the Nutrient Management Zone N4 or land in the Nutrient Buffer Zone. Further, the construction, installation, or replacement of an on-site wastewater management system (other than a composting toilet system or holding tank) within Nutrient Management Zone N4 or land in the Nutrient Buffer Zone is prohibited (Part 4: Section 14(1): f). It is recommended that measures are taken to prevent the watering of livestock in any watercourses to prevent bank erosion, siltation, and to protect water quality by preventing nutrients from entering surface water.

No development should occur within the 99 foot Crown Reserve from the edge of any surface water within the rural municipalities. Permanent vegetation should be encouraged on lands within the 99 foot crown reserve to prevent erosion, siltation, and reduce the amount of nutrients entering surface water.

The Nutrient Management Regulation under *The Water Protection Act*, prohibits the application of a fertilizer containing more than 1% phosphorus by weight, expressed as P_2O_5, to turf within Nutrient Management Zone N5 (built-up area such as towns, subdivisions, cottage developments, etc.) except during the year in which the turf is first established and the following year. In residential and commercial applications, a phosphorus containing fertilizer may be used if soil test phosphorus (using the Olsen-P test method) is less than 18 ppm.

The Nutrient Management Regulation (MR 62/2008) under *The Water Protection Act*, requires Nutrient Buffer Zones (set-back distances from the water's edge) be applied to all rivers, streams, creeks, wetlands, ditches, and groundwater features located across Manitoba including within urban and rural residential areas and within agricultural regions (Table A3 in Appendix 3).

Drainage

Although it is recognized that drainage in Manitoba is necessary to support sustainable agriculture, it is also recognized that drainage works can impact water quality and fish habitat. Types of drainage include: the placement of new culverts or larger culverts to move more water, the construction of new drainage channels to drain low lying areas, the draining of potholes or sloughs to increase land availability for cultivation and the installation of tile drainage. Artificial drainage can sometimes result in increased nutrient (nitrogen and phosphorus), sediment and pesticide load to receiving drains, creeks and rivers All types of drainage should be constructed to ensure that there is no net increase in nutrients (nitrogen and phosphorus) to waterways. To ensure that drainage maintenance, construction, and re-construction occurs in an environmentally friendly manner, the following best available technologies and best management practices aimed at reducing impacts to water quality and fish habitat are recommended.

The following recommendations are being made to all drainage works proposals during the approval process under *The Water Rights Act*:

- There must be no net increase in nutrients (nitrogen and phosphorus) to waterways as a result of drainage activities. Placement of culverts, artificial drainage and construction, and operation of tile drains can sometimes result in increased nutrient (nitrogen and phosphorus), sediment and pesticide loads to receiving drains, creeks and rivers.
- Synthetic fertilizer, animal manure, and municipal wastewater sludge must not be applied within drains.

Culverts

- Removal of vegetation and soil should be kept to a minimum during the construction and placement of culverts.
- Erosion control methodologies should be used on both sides of culverts according to the Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat.
- A strip of vegetation 1 to 3 metres wide should be maintained along drainage channels as a buffer. This will reduce erosion of channels and aid in nutrient removal.
- The proponent should revegetate exposed areas along drainage channels.

Surface Drainage

- Surface drainage should be constructed as shallow depressions and removal of vegetation and soil should be minimized during construction.
- Based on Canada Land Inventory Soil Capability Classification for Agriculture (1965), Class 6 and 7 soils should not be drained.
- There should be no net loss of semi-permanent or permanent sloughs, wetlands, potholes or other similar bodies of water in the sub-watershed within which drainage is occurring.
- Erosion control methodologies outlined in Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat should be used where the surface drain intersects with another water body.
- A strip of vegetation 1 to 3 metres wide should be maintained along surface drainage channels as buffers. This will reduce erosion of channels and aid in nutrient removal.

- The proponent should revegetate exposed areas along banks of surface drainage channels.

Tile Drainage

- Discharge from tile drainage should enter a holding pond or wetland prior to discharging into a drain, creek or river.

Manitoba Water Stewardship is working towards the development of an environmentally friendly drainage manual that will provide additional guidance regarding best management practices for drainage in Manitoba.

Conclusions and Recommendations:

1. Relative to other streams in the East Interlake Conservation District, Willow Creek water quality is generally of better quality. However, both nitrogen and phosphorus levels in the stream are likely influenced by both natural and anthropogenic (human induced) activities.

2. Although oxygen levels appear to be within the range necessary to support aquatic life, the 2006 macroinvertebrate monitoring data suggests that water quality conditions are only fair and poor at the three sites monitored. This ranking is consistent with the range of conditions (excellent → very poor) that was determined for other tributaries in the EICD in 2006. Additional monitoring will be necessary to confirm whether the conditions in Willow Creek are the result of degraded habitat.

3. Strategies need to be implemented to protect and enhance the water quality and habitat in Willow Creek. Actions should be taken to reduce nutrient and other contaminant loading to the watershed, and ultimately Lake Winnipeg. Consistent with the interim water quality targets set out in the Lake Winnipeg Action Plan, the EICD could consider setting a goal of reducing nutrient loading in the Willow Creek watershed by about 10%.
The EICD should consider implementing the following actions to improve water quality:
   a. Maintain a natural, riparian buffer along waterways. Natural vegetation slows erosion and helps reduce the amount of nitrogen and phosphorus entering lakes, rivers and streams.
   b. Where feasible, "naturalize" drainage systems to reduce streambed and streambank erosion, and allowing opportunities for nutrients to be assimilated and settled out of the stream.

c. Value and maintain wetlands. Similar to riparian buffers along waterways, wetlands slow erosion and help reduce nutrient inputs to lakes, rivers, and streams. Wetlands also provide flood protection by trapping and slowly releasing excess water while providing valuable habitat for animals and plants.

d. Employ efforts to reduce bacteria and nutrients in stormwater runoff from urban areas. These efforts include: educating residents on eliminating phosphorus based fertilizers on lawns, proper maintenance of private sewage disposal systems, and picking up pet waste. Septic systems should be pumped out regularly and disposal fields should be checked on a regular basis to ensure that they are not leaking or showing signs of saturation.

e. Work with producers to keep livestock out of waterways to reduce soil erosion and vegetation disturbance. This will also prevent animal feces, which are rich in nutrients, from being deposited into waterways.

f. Prevent nutrient rich soil from eroding off urban and rural properties and reaching storm drains or municipal ditches.

g. Evaluate options for potential reduction of nutrients from municipal wastewater treatment systems. Consider options such as effluent irrigation, trickle discharge, constructed wetland treatment, or chemical treatment to reduce nutrient load to the watershed.

h. Review the recommendations in the Lake Winnipeg Stewardship Board 2006 report "Reducing Nutrient Loading to Lake Winnipeg and its Watershed: Our Collective Responsibility and Commitment to Action" with the intent of implementing those that are relevant to the EICD.

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Appendices:

Appendix 1

Table A1: Water quality data collected from the Willow Creek watershed between 2008 and 2010.

Variable / Date Sampled		16-Apr-08	10-Jul-08	2-Oct-08	16-Jan-09	17-Apr-09	16-Jul-09	07-Oct-09	18-Jan-10
Hardness	mg/L	131	253	279	380	128		285	475
Total Dissolved Solids	mg/L	159	298	333	436	142	338	330	562
Total Suspended Solids	mg/L	71	19	9	4	106	15	20	<5.0
Dissolved Chloride	mg/L	4.71	3.82	4.42	8.37	<9.0	<9.0	3.72	6.17
Nitrate and Nitrite N	mg/L	0.4	0.01	< 0.01	0.13	0.013	<0.0050 *	<0.0050 *	0.0278
Dissolved Sulphate	mg/L	8.04	6.75	10.1	13	839	23.6	12.5	14.1
Total Organic Carbon	mg/L	14	32	25	22	14.5	22.5	21.1	32
Total Inorganic Carbon	mg/L	24	51	65	81	23.9	64.5	73.9	127
Total Carbon	mg/L	38	83	90	103	38.5	87	95	159
Ammonia Nitrogen N	mg/L	0.22	< 0.03	0.03	0.17	0.103	0.0530 *	0.0069 *	0.142
Total Kjeldahl Nitrogen	mg/L	1.5	2.3	1.1	1.2	1.08	1.41	1.3	1.91
Total Nitrogen	mg/L	1.9	2.31	1.1	1.33	1.093	1.41	1.3	1.9378
Total Phosphorus P	mg/L as P	0.219	0.072	0.031	0.052	0.178	0.05	0.0321	0.0436
Total Particulate Phosphorus P	mg/L as P	0.129	0.045	0.017	0.03	<0.0010	0.0095	0.0104	0.0112
Total Soluble Phosphorus P	mg/L as P	0.09	0.027	0.014	0.022	0.117	0.0405	0.0217	0.0324
pH, Laboratory	pH units	7.75	8.04	8.24	7.86	8.12	8.44	8.59	7.33
Conductivity	uS/cm	234	433	501	734	199	475	554	859
True Color	CU	106	116	104	57	60	100	60	60
Turbidity	NTU	46	10.8	8	5.5	75	7.9	25	6.6
Total Alkalinity	mg/L	110	225	262	392	104	267	315	506
Bicarbonate Alkalinity	mg/L	134	275	304	478	127	316	361	617
Carbonate Alkalinity	mg/L	< 0.5	< 0.5	7.8	< 0.5	<0.60	4.45	11.9	<0.60
Hydroxide Alkalinity	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	<0.40	<0.40	<0.40	<0.40
Dissolved Oxygen, Winkler	mg/L	7.9	7	8.1	7.2	9.9	8.1	10.8	3.7

Variable / Date Sampled		16-Apr-08	10-Jul-08	2-Oct-08	16-Jan-09	17-Apr-09	16-Jul-09	07-Oct-09	18-Jan-10
Coliform	MPN/dL	-	>200	2200	< 1	220	>200	230	
E. coli	MPN/dL	20	>200	230	< 1	<10	90	230	<1
Total Aluminum	mg/L	1.34	0.42	0.17	0.12	1.84	0.201	0.157	0.206
Total Antimony	mg/L	0.0004	0.0003	< 0.001	0.0004	<0.00020	0.00042	<0.00020	<0.00020
Total Arsenic	mg/L	0.001	0.0014	< 0.001	0.0006	0.00076	0.00106	0.00056	0.00112
Total Barium	mg/L	0.034	0.032	0.033	0.046	0.0349	0.0284	0.0316	0.0547
Total Beryllium	mg/L	< 0.0002	< 0.0002	< 0.001	< 0.0002	<0.00020	<0.00020	<0.00020	<0.00020
Total Bismuth	mg/L	< 0.0002	< 0.0002	< 0.001	< 0.0002	<0.00020	<0.00020	<0.00020	<0.00020
Total Boron	mg/L	0.02	0.05	0.03	0.05	0.015	0.023	0.022	0.025
Total Cadmium	mg/L	< 0.00004	< 0.00004	< 0.0002	< 0.00004	0.000019	<0.000010	<0.000010	<0.000010
Total Calcium	mg/L	25.4	44.4	47.9	61.2		40.4	38.5	61.5
Total Cesium	mg/L	0.0002	< 0.0001	< 0.0005	< 0.0001	0.00017	<0.00010	<0.00010	<0.00010
Total Chromium	mg/L	0.002	0.0009	< 0.001	0.0005	0.0048	<0.0010	<0.0010	<0.0010
Total Cobalt	mg/L	0.0008	0.0004	< 0.001	0.0003	0.00158	0.00024	0.0002	0.00075
Total Copper	mg/L	0.0037	0.0024	0.001	0.0016	0.0034	0.0012	<0.0010	0.0013
Total Iron	mg/L	1.39	0.62	0.27	0.26	1.55	0.218	0.18	0.492
Total Lead	mg/L	0.0008	0.0008	< 0.001	0.0003	0.0012	0.000209	0.000158	0.000334
Total Lithium	mg/L	0.0092	0.01	0.011	0.02	0.00673	0.0102	0.013	0.0143
Total Magnesium	mg/L	16.4	34.5	38.6	55	15.7	35.4	45.8	78.2
Total Manganese	mg/L	0.046	0.022	0.014	0.025	0.0702	0.0184	0.0101	0.441
Total Molybdenum	mg/L	0.0008	0.0003	< 0.0005	< 0.0001	0.00034	<0.00020	<0.00020	<0.00020
Total Nickel	mg/L	0.0031	0.0026	0.001	0.0011	0.0032	<0.0020	<0.0020	<0.0020
Total Phosphorus	mg/L	0.17	0.06	< 0.15	0.03		0.05	0.0321	0.0436
Total Potassium	mg/L	8.57	6.87	6	8.53	6.42	4.43	6.29	14.3
Total Rubidium	mg/L	0.0057	0.0041	0.003	0.0049	0.0057	0.00291	0.00323	0.00413
Total Selenium	mg/L	< 0.0002	0.0005	< 0.001	< 0.0002	<0.0010	<0.0010	<0.0010	<0.0010
Total Silicon	mg/L	6.11	9.23	5.77	10.4				
Total Silver	mg/L	< 0.00005	0.00009	< 0.00025	< 0.00005	<0.00010	<0.00010	<0.00010	<0.00010
Total Sodium	mg/L	3	5.4	5.7	13	1.8	6.03	6.94	13.4
Total Strontium	mg/L	0.04	0.086	0.096	-	0.0363	0.104	0.0826	0.156
Total Tellurium	mg/L	< 0.0002	< 0.0002	< 0.001	< 0.0002	<0.00020	<0.00020	<0.00020	<0.00020

Variable / Date Sampled		16-Apr-08	10-Jul-08	2-Oct-08	16-Jan-09	17-Apr-09	16-Jul-09	07-Oct-09	18-Jan-10
Total Thallium	mg/L	0.00002	< 0.00002	< 0.0001	< 0.00002	<0.00010	<0.00010	<0.00010	<0.00010
Total Thorium	mg/L	0.0002	< 0.0001	< 0.0005	< 0.0001	0.00065	<0.00010	<0.00010	<0.00010
Total Tin	mg/L	< 0.0002	0.0004	< 0.001	< 0.0002	0.00068	0.00079	<0.00060	<0.00060
Total Titanium	mg/L	0.046	0.016	0.009	0.0062	0.0755	0.00986	0.00658	0.00834
Total Uranium	mg/L	0.0008	0.0006	0.0006	0.0006	0.00044	0.00042	0.00037	<0.00020
Total Vanadium	mg/L	0.0038	0.0018	0.001	0.0008	0.00539	0.00133	0.00126	0.00039
Total Zinc	mg/L	0.009	0.028	0.011	0.01	0.0078	0.0069	<0.0050	0.00111
Total Zirconium	mg/L	< 0.002	< 0.002	< 0.01	< 0.002	0.0021	0.00052	<0.00040	0.0152
Total Hexavalent Chromium	mg/L	-	< 0.01	< 0.01	-	<0.010 *	<0.010	<0.010	0.00063
Dissolved Aluminum	mg/L	0.036	0.008	0.02	0.001	0.145	0.0087	0.0085	0.0047
2,4,5-TP	ug/L	-	< 0.05	< 0.05	-	-	-		-
2,4-D	ug/L	-	0.1	< 0.05	-	-	-	<0.050	-
2,4-DB	ug/L	-	< 0.05	< 0.05	-	-	-	<0.050	-
2,4-DP	ug/L	-	< 0.05	< 0.05	-	-	-	<0.050	-
Alachlor	ug/L	-	< 0.2	< 0.2	-	-	-	<0.10	-
alpha-Chlordane	ug/L	-	< 0.01	< 0.01	-	-	-	<0.010	-
Atrazine	ug/L	-	< 0.1	< 0.1	-	-	-	<0.10	-
Atrazine desethyl	ug/L	-	< 0.05	< 0.05	-	-	-		-
Azinphosmethyl	ug/L	-	< 1	< 1	-	-	-		-
Bromacil	ug/L	-	< 0.2	< 0.2	-	-	-	<0.10	-
Bromoxynil	ug/L	-	< 0.02	< 0.02	-	-	-	<0.020	-
Captan	ug/L	-	< 10	< 10	-	-	-		-
Carbofuran	ug/L	-	< 0.2	< 0.2	-	-	-	<0.20	-
Carboxin (Carbathin)	ug/L	-	< 0.1	< 0.1	-	-	-		-
Chlorophyll A	ug/L	-	-	-	-	-	-		-
Chlorpyrifos	ug/L	-	< 0.02	< 0.02	-	-	-	<0.020	-
Chlorpyrifos	ug/L	-	< 0.02	< 0.02	-	-	-		-
Chlorthalonil	ug/L	-	< 0.06	< 0.06	-	-	-		-
Cyanazine	ug/L	-	< 0.5	< 0.5	-	-	-		-
Deltamethrin	ug/L	-	< 0.04	< 0.04	-	-	-		-
Diazinon	ug/L	-	< 0.03	< 0.03	-	-	-	<0.030	-

Variable / Date Sampled		16-Apr-08	10-Jul-08	2-Oct-08	16-Jan-09	17-Apr-09	16-Jul-09	07-Oct-09	18-Jan-10
Dicamba	ug/L	-	< 0.02	< 0.02	-	-	-	<0.0060	-
Diclofop-methyl	ug/L	-	< 0.1	< 0.1	-	-	-	<0.10	-
Dimethoate	ug/L	-	< 0.2	< 0.2	-	-	-	<0.10	-
Dinoseb	ug/L	-	< 0.05	< 0.05	-	-	-	<0.050	-
Eptam	ug/L	-	< 0.2	< 0.2	-	-	-	<0.20	-
Ethafluralin	ug/L	-	< 0.02	< 0.02	-	-	-		-
Fenoxaprop	ug/L	-	< 0.1	< 0.1	-	-	-		-
gamma-BHC (Lindane)	ug/L	-	< 0.01	< 0.01	-	-	-	<0.010	-
gamma-Chlordane	ug/L	-	< 0.01	< 0.01	-	-	-	<0.010	-
Malathion	ug/L	-	< 0.2	< 0.2	-	-	-	<0.10	-
MCPA	ug/L	-	< 0.05	< 0.05	-	-	-	<0.025	-
MCPP	ug/L	-	< 0.05	< 0.05	-	-	-		-
Methoxychlor	ug/L	-	< 0.04	< 0.04	-	-	-	<0.010	-
Methyl Parathion	ug/L	-	< 0.2	< 0.2	-	-	-		-
Metribuzin	ug/L	-	< 0.2	< 0.2	-	-	-	<0.20	-
Metribuzin	ug/L	-	< 0.2	< 0.2	-	-	-		-
Parathion	ug/L	-	< 0.2	< 0.2	-	-	-		-
Pentachlorophenol	ug/L	-	-	-	-	-	-	<0.020	-
Pheophytin A	ug/L	-	-	-	-	-	-		-
Picloram	ug/L	-	< 0.2	< 0.2	-	-	-	<0.20	-
Propachlor	ug/L	-	< 0.2	< 0.2	-	-	-		-
Propanil	ug/L	-	< 0.2	< 0.2	-	-	-	<0.20	-
Propoxur	ug/L	-	< 0.2	< 0.2	-	-	-	<0.20	-
Quizalofop	ug/L	-	< 0.1	< 0.1	-	-	-	<0.10	-
Simazine	ug/L	-	< 0.1	< 0.1	-	-	-	<0.10	-
Tebuthiuron	ug/L	-	< 2	< 2	-	-	-		-
Terbufos	ug/L	-	< 0.5	< 0.5	-	-	-	<0.10	-
Triallate	ug/L	-	< 0.1	< 0.1	-	-	-	<0.10	-
Trichlopyr	ug/L	-	< 0.05	0.12	-	-	-	<0.050	-
Trifluralin	ug/L	-	< 0.03	< 0.03	-	-	-	<0.030	-

< = less than detection limit

Appendix 2: Water Quality Data – EICD

Table A2: Comparison of water quality conditions in Willow Creek to other stream in the East Interlake Conservation Districts. Mean values were calculated for eight sampling periods between April 2008 and January 2010.

Variable	Units	Fish Lake Drain	Fisher River	Grassmere Creek	Icelandic River	Netley Creek	Parks Creek	Washow Bay Creek	Wavey Creek	Willow Creek	All Sites
Apr 08-Jan 10		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	**Mean**	**Mean of Means**
Hardness	mg/L	290	302	705	320	347	393	246	372	**277**	**372**
Total Dissolved Solids	mg/L	307	371	953	377	360	474	282	446	**325**	**446**
Total Dissolved Solids	mg/L	44	42	47	44	34	42	21	39	**31**	**39**
Dissolved Chloride	mg/L	4.9	4.1	122.1	6.8	11.4	29.9	2.8	26.0	**5.0**	**26.0**
Nitrate and Nitrite N	mg/L	0.048	0.529	0.682	1.097	0.347	0.541	0.586	0.547	**0.074**	**0.547**
Dissolved Sulphate	mg/L	155.82	27.66	220.88	37.18	72.82	102.87	177.74	113.56	**115.89**	**113.56**
Total Organic Carbon	mg/L	16.67	27.64	16.00	28.11	16.46	20.98	15.26	20.16	**22.89**	**20.16**
Total Inorganic Carbon	mg/L	51.64	50.94	97.86	56.78	69.50	65.34	55.48	63.93	**63.79**	**63.93**
Total Carbon	mg/L	68.24	78.44	113.99	84.98	85.99	86.33	70.78	84.10	**86.69**	**84.10**
Ammonia Nitrogen N	mg/L	0.120	0.125	0.548	0.209	0.100	0.220	0.228	0.221	**0.092**	**0.221**
Total Kjeldahl Nitrogen	mg/L	1.114	1.176	2.084	1.444	1.226	1.409	1.176	1.376	**1.475**	**1.376**
Total Nitrogen	mg/L	1.206	2.048	3.013	2.925	1.523	2.143	1.908	2.109	**1.661**	**2.109**
Total Phosphorus	mg/L as P	0.0627	0.3705	0.5950	0.2461	0.1797	0.2908	0.1820	0.2752	**0.0847**	**0.2752**
Total Particulate Phosphorus	mg/L as P	0.0308	0.0606	0.2135	0.0834	0.0571	0.0891	0.0424	0.0824	**0.0316**	**0.0824**
Total Soluble Phosphorus	mg/L as P	0.0318	0.3081	0.3815	0.1847	0.1226	0.2057	0.1397	0.1963	**0.0456**	**0.1963**
pH, Laboratory	pH units	8.051	7.986	8.204	8.119	8.035	8.079	7.874	8.050	**8.046**	**8.050**
Conductivity	µS/cm	497	552	1434	594	570	730	445	689	**499**	**689**
True Color	CU	74	73	64	68	73	71	66	70	**83**	**70**
Turbidity	NTU	25.49	38.16	44.89	49.78	29.04	37.47	16.19	34.43	**23.10**	**34.43**
Total Alkalinity	mg/L	264	284	442	292	292	315	231	303	**273**	**303**
Bicarbonate Alkalinity	mg/L	320	344	515	348	350	375	281	362	**327**	**362**
Carbonate Alkalinity	mg/L	1.301	1.563	12.638	4.188	3.514	4.641	0.950	4.113	**3.188**	**4.113**
Hydroxide Alkalinity	mg/L	0.23	0.23	0.23	0.25	0.23	0.23	0.23	0.23	**0.23**	**0.23**
Dissolved Oxygen, Winkler	mg/L	7.4	6.9	7.0	7.6	6.5	7.1	6.8	7.0	**7.8**	**7.0**
E. coli	MPN/dL	20.79	68.20	362.43	14.00	34.13	99.91	16.25	87.96	**81.64**	**87.96**

Variable	Units	Fish Lake Drain	Fisher River	Grassmere Creek	Icelandic River	Netley Creek	Parks Creek	Washow Bay Creek	Wavey Creek	Willow Creek	All Sites
Total Aluminum	mg/L	0.64	1.31	1.34	1.10	0.90	1.06	136.99	20.48	**135.83**	**20.48**
Total Antimony	mg/L	0.000320	0.000250	0.000353	0.000319	0.000313	0.000311	0.000301	0.000309	**0.000290**	**0.000309**
Total Arsenic	mg/L	0.000896	0.001336	0.003371	0.001676	0.001176	0.001691	0.000766	0.001559	**0.000875**	**0.001559**
Total Barium	mg/L	0.046486	0.046238	0.080725	0.055500	0.046838	0.055157	0.032275	0.051888	**0.036825**	**0.051888**
Total Beryllium	mg/L	0.000214	0.000100	0.000150	0.000100	0.000150	0.000143	0.000200	0.000151	**0.000150**	**0.000151**
Total Bismuth	mg/L	0.000229	0.000100	0.000150	0.000100	0.000150	0.000146	0.000200	0.000153	**0.000150**	**0.000153**
Total Boron	mg/L	0.028571	0.056375	0.106625	0.056375	0.060125	0.061614	0.014750	0.054919	**0.029375**	**0.054919**
Total Cadmium	mg/L	0.000040	0.000024	0.000040	0.000024	0.000027	0.000031	0.000035	0.000032	**0.000024**	**0.000032**
Total Calcium	mg/L	44.46	51.58	79.89	53.25	47.98	55.43	53.43	55.14	**43.06**	**55.14**
Total Cesium	mg/L	0.000154	0.000143	0.000963	0.000134	0.000121	0.000303	0.000119	0.000277	**0.000109**	**0.000277**
Total Chromium	mg/L	0.001586	0.002225	0.002500	0.001950	0.001825	0.002017	0.001325	0.001918	**0.001275**	**0.001918**
Total Cobalt	mg/L	0.000714	0.000771	0.001600	0.000986	0.000910	0.000996	0.000528	0.000929	**0.000596**	**0.000929**
Total Copper	mg/L	0.001943	0.003063	0.003925	0.003214	0.002350	0.002899	0.001350	0.002678	**0.001888**	**0.002678**
Total Iron	mg/L	0.792	1.255	1.547	1.203	0.959	1.151	0.460	1.052	**0.623**	**1.052**
Total Lead	mg/L	0.00061	0.00159	0.00092	0.00100	0.00063	0.00095	0.00064	0.00090	**0.00054**	**0.00090**
Total Lithium	mg/L	0.01269	0.01751	0.05494	0.01936	0.01626	0.02415	0.00729	0.02174	**0.01180**	**0.0217**
Total Magnesium	mg/L	41.20	42.13	106.73	45.50	44.58	56.03	25.18	51.62	**39.95**	**51.62**
Total Manganese	mg/L	0.09498	0.08761	0.58440	0.04454	0.05184	0.17267	0.05845	0.15636	**0.08084**	**0.156355**
Total Molybdenum	mg/L	0.00033	0.00084	0.00257	0.00101	0.00049	0.00105	0.00066	0.00099	**0.00026**	**0.00099**
Total Nickel	mg/L	0.00219	0.00278	0.00460	0.00279	0.00220	0.00291	0.00136	0.00269	**0.00175**	**0.0027**
Total Phosphorus	mg/L	0.05	0.27	0.46	0.29	0.18	0.25	0.16	0.24	**0.07**	**0.24**
Total Potassium	mg/L	6.07	6.64	12.33	7.43	7.82	8.06	3.87	7.46	**7.68**	**7.46**
Total Rubidium	mg/L	0.00445	0.00545	0.00478	0.00492	0.00414	0.00475	0.00280	0.00447	**0.00421**	**0.004471**
Total Selenium	mg/L	0.00039	0.00041	0.00116	0.00045	0.00035	0.00055	0.00040	0.00053	**0.00040**	**0.0005**
Total Silicon	mg/L	7.69	7.59	5.37	6.04	7.83	6.90	5.06	6.64	**7.88**	**6.64**
Total Silver	mg/L	0.000102	0.000033	0.000053	0.000032	0.000060	0.000056	0.000069	0.000058	**0.000061**	**0.000058**
Total Sodium	mg/L	6.48	9.64	88.39	11.00	13.13	25.73	2.84	22.46	**6.91**	**22.46**
Total Strontium	mg/L	0.082	0.132	0.303	0.136	0.132	0.157	0.093	0.148	**0.086**	**0.148**
Total Tellurium	mg/L	0.00021	0.00010	0.00015	0.00010	0.00015	0.00014	0.00020	0.00015	**0.00015**	**0.00015**
Total Thallium	mg/L	0.00004	0.00004	0.00008	0.00004	0.00004	0.00004	0.00004	0.00004	**0.00004**	**0.00004**

Variable	Units	Fish Lake Drain	Fisher River	Grassmere Creek	Icelandic River	Netley Creek	Parks Creek	Washow Bay Creek	Wavey Creek	Willow Creek	All Sites
Total Thorium	mg/L	0.00030	0.00028	0.00032	0.00030	0.00032	0.00031	0.00023	0.00029	**0.00017**	**0.00029**
Total Tin	mg/L	0.00118	0.00020	0.00036	0.00027	0.00037	0.00047	0.00037	0.00046	**0.00040**	**0.00046**
Total Titanium	mg/L	0.0278	0.0533	0.0510	0.0469	0.0376	0.0433	0.0267	0.0409	**0.0222**	**0.0409**
Total Uranium	mg/L	0.0007	0.0020	0.0096	0.0020	0.0014	0.0031	0.0011	0.0029	**0.0005**	**0.0029**
Total Vanadium	mg/L	0.0023	0.0042	0.0084	0.0042	0.0047	0.0048	0.0018	0.0043	**0.0021**	**0.0043**
Total Zinc	mg/L	0.0065	0.0083	0.0091	0.0071	0.0067	0.0075	0.0061	0.0073	**0.0113**	**0.0073**
Total Zirconium	mg/L	0.0023	0.0012	0.0027	0.0014	0.0023	0.0020	0.0019	0.0020	**0.0014**	**0.0020**
Total Hexavalent Chromium	mg/L	0.0050	0.0071	0.0050	0.0071	0.0050	0.0059	0.0050	0.0057	**0.0050**	**0.0057**
Dissolved Aluminum	mg/L	0.0459	0.1196	0.0377	0.0249	0.0266	0.0509	0.0378	0.0491	**0.0290**	**0.0491**
2,4,5TP	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0250**	**0.0250**
2,4D	ug/L	0.0250	0.0429	0.3833	0.0286	0.0467	0.1053	0.0250	0.0938	**0.0500**	**0.0938**
2,4DB	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0250**	**0.0250**
2,4DP	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0250**	**0.0250**
Alachlor	ug/L	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	**0.08**	**0.08**
alphaChlordane	ug/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	**0.0050**	**0.0050**
Atrazine	ug/L	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	**0.0500**	**0.0500**
Atrazine desethyl	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0250**	**0.0250**
Azinphosmethyl	ug/L	0.50	0.63	0.50	0.63	0.50	0.55	0.50	0.54	**0.50**	**0.54**
Bromacil	ug/L	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	**0.08**	**0.08**
Bromoxynil	ug/L	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	**0.01**	**0.01**
Captan	ug/L	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	**0.50**	**0.50**
Carbofuran	ug/L	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	**0.10**	**0.10**
Carboxin (Carbathin)	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.05**
Chlorpyrifos	ug/L	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	**0.010**	**0.010**
Chlorpyrifos	ug/L	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	**0.010**	**0.010**
Chlorthalonil	ug/L	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	**0.030**	**0.030**
Cyanazine	ug/L	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	**0.250**	**0.250**
Deltamethrin	ug/L	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	**0.020**	**0.020**
Diazinon	ug/L	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	**0.015**	**0.015**
Dicamba	ug/L	0.008	0.009	0.008	0.007	0.008	0.008	0.008	0.008	**0.008**	**0.008**

Variable	Units	Fish Lake Drain	Fisher River	Grassmere Creek	Icelandic River	Netley Creek	Parks Creek	Washow Bay Creek	Wavey Creek	Willow Creek	All Sites
Diclofopmethyl	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.050**
Dimethoate	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.050**
Dinoseb	ug/L	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	**0.025**	**0.025**
Eptam	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Ethafluralin	ug/L	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	**0.010**	**0.010**
Fenoxaprop	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.050**
gammaBHC (Lindane)	ug/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	**0.0050**	**0.0050**
gammaChlordane	ug/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	**0.0050**	**0.0050**
Malathion	ug/L	0.083	0.075	0.083	0.075	0.083	0.080	0.083	0.080	**0.083**	**0.080**
MCPA	ug/L	0.0217	0.0625	0.0533	0.0241	0.0217	0.0366	0.0217	0.0345	**0.0217**	**0.0345**
MCPP	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0250**	**0.0250**
Mecoprop	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0250**	**0.0250**
Methoxychlor	ug/L	0.0150	0.0900	0.0150	0.0900	0.0150	0.0450	0.0150	0.0407	**0.0150**	**0.0407**
Methyl Parathion	ug/L	0.100	0.040	0.100	0.040	0.100	0.076	0.100	0.079	**0.100**	**0.079**
Metribuzin	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Metribuzin	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Parathion	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Pentachlorophenol	ug/L	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	**0.010**	**0.010**
Picloram	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Propachlor	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Propanil	ug/L	0.100	0.094	0.100	0.094	0.100	0.098	0.100	0.098	**0.100**	**0.098**
Propoxur	ug/L	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	**0.100**	**0.100**
Quizalofop	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.050**
Simazine	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.050**
Tebuthiuron	ug/L	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	**1.000**	**1.000**
Terbufos	ug/L	0.183	0.164	0.183	0.150	0.183	0.173	0.183	0.174	**0.183**	**0.174**
Triallate	ug/L	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	**0.050**	**0.050**
Trichlopyr	ug/L	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	**0.0567**	**0.0250**
Trifluralin	ug/L	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	**0.0150**	**0.0150**

Appendix 3:

Table A3. The Nutrient Buffer Zone widths as outlined in the Nutrient Management Regulation (MR 62/2008) under *The Water Protection Act*.

Water Body	**A** [(1)]	**B** [(1)]
o a lake or reservoir designated as vulnerable	30 m	35 m
o a lake or reservoir (not including a constructed stormwater retention pond) not designated as vulnerable o a river, creek or stream designated as vulnerable	15 m	20 m
o a river, creek or stream not designated as vulnerable o an order 3, 4, 5, or 6 drain or higher o a major wetland, bog, swamp or marsh o a constructed stormwater retention pond	3 m	8 m

([1]) Use column A if the applicable area is covered in permanent vegetation. Otherwise, use column B.

A healthy riparian zone is critical to river ecosystem health providing shade, organic inputs, filtering of nutrients and habitat creation (falling trees). Preserving space along rivers gives the river freedom to naturally meander across the landscape and buffers the community from flooding impacts. Reference to the Nutrient Buffer Zone and its significance can be coupled with **Section 3.1.8 – Environmental Policies** which identifies the goals of enhancing surface water and riverbank stability, and the importance of respecting setbacks.