

ST. CLAIR RIVER AREA OF CONCERN



Status of the Beach Closings Beneficial Use Impairment

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Executive Summary

In 1987 the International Joint Commission's (IJC) Great Lakes Water Quality Agreement identified "Beach Closings" as a Beneficial Use Impairment (BUI) in the St. Clair River Area of Concern (AOC). The "Beach Closings" BUI is considered "impaired" when water commonly used for swimming exceeds standards, objectives or guidelines developed to protect humans from water-borne illnesses caused by bacterial contamination (IJC, 1991). In Canada, these guidelines focus on the concentration of fecal coliform bacteria such as *Escherichia coli* (*E. coli*) in water samples. The province of Ontario's Provincial Water Quality Objective (PWQO) for *E. coli* is 100 Colony Forming Units (cfu) 100 mL⁻¹ (OMOEE, 1994).

In the St. Clair River AOC the "Beach Closings" BUI was originally deemed "impaired" in the Stage 1 RAP because of frequent bacterial contamination observed at five swimming areas along the waterway – Seager Park, Branton-Cundick Park, Brander Park, Centennial Park, and Willow Park. The BUI remained "impaired" in the Stage 2 RAP report due to continued elevated levels of bacteria from a number of sources, including combined sewer overflow (CSOs), Water Pollution Control Plant (WPCP) effluents, and non-point sources including agricultural runoff.

Various municipal and industrial partners have been working to address actions related to the "Beach Closings" BUI. The *Ontario Water Resources Act* and the *Ontario Environmental Protection Act* as well as municipal and industrial initiatives have resulted in considerable decreases in the concentration and loading of Water Pollution Control Plant discharges since the 1970's. As well, a number of upgrades and expansions to Water Pollution Control Plants along the St. Clair River since the 1990s have further benefitted local water quality. These initiatives are continuing within AOC communities as well as projects aimed at separating combined sewers that discharge to the St. Clair River. Significant progress has also been made in the establishment of riparian buffer projects along St. Clair River tributaries. These buffers will filter, trap and/or absorb runoff from agricultural practices, reducing loads into aquatic environments, thus improving local water quality.

The Ontario Ministry of Health and Long Term Care (MOHLTC) is dedicated to monitoring *E. coli* levels at "official" local beaches through their Beach Management Protocol. An "official" beach is defined under this program as a "beach area owned and/or operated by a municipality which: 1) the general public has direct access to; 2) allows supervised aquatics programs or is staffed by lifeguards, and; 3) meets the requirements of the sampling protocol for sampling sites" (MOHLTC, 2008). Within the St. Clair River AOC the beaches at Mitchell's Bay and Canatara Park are the only two considered official beaches. If levels exceed the PWQO the Ministry will post warnings advising swimmers that the water may be unsafe due to high bacteria levels.

In order for this BUI to be re-designated from "impaired" to "not impaired", delisting criteria developed specifically for the BUI must be met. The criteria states that the "Beach Closings" BUI will be considered "not impaired" when:

1. Less than 20% of the geometric means of water samples collected over the swimming season, at identified beaches within the St. Clair River AOC, exceed the PWQO for *E. coli*, or
2. Results are similar to a suitable non-AOC reference site, when assessed over a period of at least three to five years, or
3. The source of *E. coli* is deemed to be non-anthropogenic (e.g., excessive geese and wildlife) as this would not be considered an AOC issue and the "Beach Closings" BUI could be re-designated to "not impaired" (CRIC Delisting Subcommittee, 2012).

While the delisting criteria applies only to those beaches that are officially recognized by Public Health Units (i.e. Mitchell's Bay and Canatara Park), the CRIC identified and proposed additional sites for sampling along the St. Clair River proper. Beginning in 2011 *E. coli* samples were collected from thirteen additional sites, and repeated in 2012 and 2013.

Annual variations in *E. coli* were observed at the additional sampling sites however the levels were generally below the PWQO (100 cfu/100ml) at the majority of swimming areas along the St. Clair River. Eleven of the 13 sites had less than 20% of samples with *E. coli* greater than the PWQO, while the other two narrowly exceeded the target. Based on the sampling data no significant difference in *E. coli* exceedances was detected between St. Clair River AOC sites and Lake Huron reference beaches.

When the data from the two official beaches in the AOC were examined (Canatara Park and Mitchell's Bay), Canatara Park had consistently good water quality as less than 20% of the total number of samples collected from 2009-15 had *E. coli* levels that exceeded the PWQO. Mitchell's Bay however, slightly exceeded the target as 22.6% of the total number of samples exceeded the PWQO. Higher *E. coli* levels at this location are strongly suspected to be the result of an increased bird population rather than an anthropogenic source. When the frequency of exceedances at the beaches within the AOC are compared to the reference beaches along the Lake Huron shoreline, Canatara Park and Mitchell's Bay have comparable frequencies of *E. coli* PWQO exceedances; meeting delisting criteria #2 and #3 as *E. coli* sources are not anthropogenic.

It is worth noting that the PWQO *E. coli* threshold changed from 100 cfu/100ml to 200 cfu/100ml in January 2018 and if the new threshold was to be applied, delisting criteria #1 would have been met as well.

Based on the findings of the *E. coli* sampling completed, the delisting criteria for this BUI in the St. Clair River Area of Concern has been achieved and therefore, it is recommended that the BUI be re-designated to "Not Impaired".

1.0 Introduction

1.1. The St. Clair River Area of Concern

The St. Clair River flows approximately 64 kilometers connecting Lake Huron to Lake St. Clair and serves as an important shipping channel within the Great Lakes Seaway. Historically, the river was impacted by industrial and municipal point sources originating primarily from Sarnia, Ontario and Port Huron, Michigan. As a result, in 1987, the St. Clair River was designated as one of 43 Areas of Concern (AOC) identified under Annex 1 of the Great Lakes Water Quality Agreement (GLWQA) signed by the governments of Canada and the United States (US). Most recently updated in 2012, the GLWQA commits the two countries to restore and protect water bodies within the Great Lakes Basin. Twelve AOCs were located in Canada, 26 were identified in the US and five AOCs were binational, including the St. Clair River (Figure 1.1).

An AOC is a site where water and the environment were severely degraded by local sources of contamination or development, impacting common uses of the local natural resources. As part of restoring the river, a Remedial Action Plan (RAP) was developed. The Stage 1 RAP report defined the extent and severity of environmental degradation in the St. Clair River (OMOE/MDEQ, 1991) by assessing fourteen criteria known as “Beneficial Use Impairments (BUIs)”. The outcome of these efforts was completed in 1991 and resulted in the identification of 12 environmental challenges needing to be addressed within the AOC. Eight of the beneficial uses were considered “impaired” and four required additional research to determine their status. Two BUIs were deemed “not impaired”.

The Stage 2 RAP report, released in 1995, identified 38 recommended remedial actions to restore the “impaired” beneficial uses in the St. Clair River and undertake further research on those that required it (OMOE/MDEQ, 1995). The goal of the AOC program is to re-designate all BUIs to “not impaired”. Progress has been made in addressing the environmental challenges identified in the AOC with some BUIs already re-designated to “not impaired” (Table 1.1). Once all remedial actions are completed or addressed, an AOC can be removed from the list of AOCs in the Great Lakes Basin; this process is commonly referred to as “delisting”. Presently, three AOCs in Canada and 4 AOCs in the US are no longer designated an AOC.

For over 20 years, there has been significant changes to environmental protection legislation and a collective effort from government, First Nations, industry and other stakeholders to restore AOCs around the Great Lakes. In 2005, the Canadian RAP Implementation Committee (CRIC) was created for the St. Clair River AOC. The mandate of the committee is to coordinate the implementation of remedial activities to restore BUIs and move the St. Clair River AOC towards “delisting”. Due to significant improvements in water quality resulting from implementation of regulations and improvements to industrial and municipal waste water processing and agricultural practices, the CRIC re-assess the status of BUIs initially deemed “impaired”. One of these BUIs is “Beach Closings”.

Table 1.1: The fourteen Beneficial Use Impairments (BUIs) along with their Stage 1 Remedial Action Plan (RAP) status and current status in the St. Clair River Area of Concern (AOC).

| Beneficial Use Impairment | Stage 1 RAP Designation | Current Status (2016) |
|--|------------------------------|-----------------------------|
| Restrictions on Fish and Wildlife Consumption | Impaired | Impaired |
| Tainting of Fish and Wildlife Flavour | Impaired | Not Impaired (2011) |
| Degraded Fish and Wildlife Populations | Requires Further Assessment* | Requires Further Assessment |
| Fish Tumours or Other Deformities | Requires Further Assessment | Requires Further Assessment |
| Bird or Animal Deformities or Reproductive Problems | Requires Further Assessment | Requires Further Assessment |
| Degradation of Benthos | Impaired | Impaired |
| Restrictions on Dredging Activities | Impaired | Impaired |
| Eutrophication or Undesirable Algae | Not Impaired | Not Impaired |
| Restrictions on Drinking Water Consumption or Taste and Odour Problems | Impaired | Impaired |
| Beach Closings | Impaired | Impaired |
| Degradation of Aesthetics | Impaired | Not Impaired (2016) |
| Added Costs to Agriculture or Industry | Impaired | Not Impaired (2012) |
| Degradation of Phytoplankton and Zooplankton Populations | Not Impaired | Not Impaired |
| Loss of Fish and Wildlife Habitat | Impaired | Impaired |

* Requires Further Assessment – Additional research is required to determine whether the BUI is “impaired” or “not impaired”.

1.2. “Beach Closings” Beneficial Use Impairment

The International Joint Commission (IJC) through the 1987 GLWQA identified “Beach Closings” as a common use that could be impacted in AOCs due to degraded water quality. Specifically, the “Beach Closings” BUI is considered “impaired” when waters commonly used for swimming exceed standards, objectives or guidelines developed to protect humans from water-borne illnesses caused by bacterial contamination (IJC, 1991). In Canada and the US, guidelines used to assess recreational beach water focus on the concentration of fecal coliform bacteria such as *Escherichia coli* (*E. coli*) in water samples. The concentration of *E. coli* bacteria serves as an indicator for other potentially harmful pathogens that can cause illnesses such as nausea, diarrhea and ear and throat infections (Lambton Public Health, 2012). The Canadian federal guideline developed by the Canadian Council of Ministers of the Environment (CCME) for *E. coli* is 200 Colony Forming Units (cfu) 100 mL⁻¹ (CCME, 2007) however, the province of Ontario has adopted a more stringent Provincial Water Quality Objective (PWQO) of 100 cfu 100 mL⁻¹ (OMOEE, 1994).

The Ontario Ministry of Health and Long Term Care (MOHLTC) through their Beach Management Protocol monitors *E. coli* at local beaches and posts warnings if levels of *E. coli* exceed the PWQO

(OMOE, 1994; MOHLTC, 2008; Lambton Public Health, 2012) advising swimmers that the water may be unsafe due to high bacteria levels. At some local swimming areas, information (“caution”) signs are installed to educate swimmers of the potential for elevated bacteria levels after heavy rain events and that water conditions should be assessed prior to swimming. In the United States, beaches are considered safe for swimming if geometric means are below the daily target of 300 cfu 100 mL⁻¹ or the 30-day guideline of 130 cfu 100 mL⁻¹ as per the Michigan Public Health Code (MDEQ, 2014).

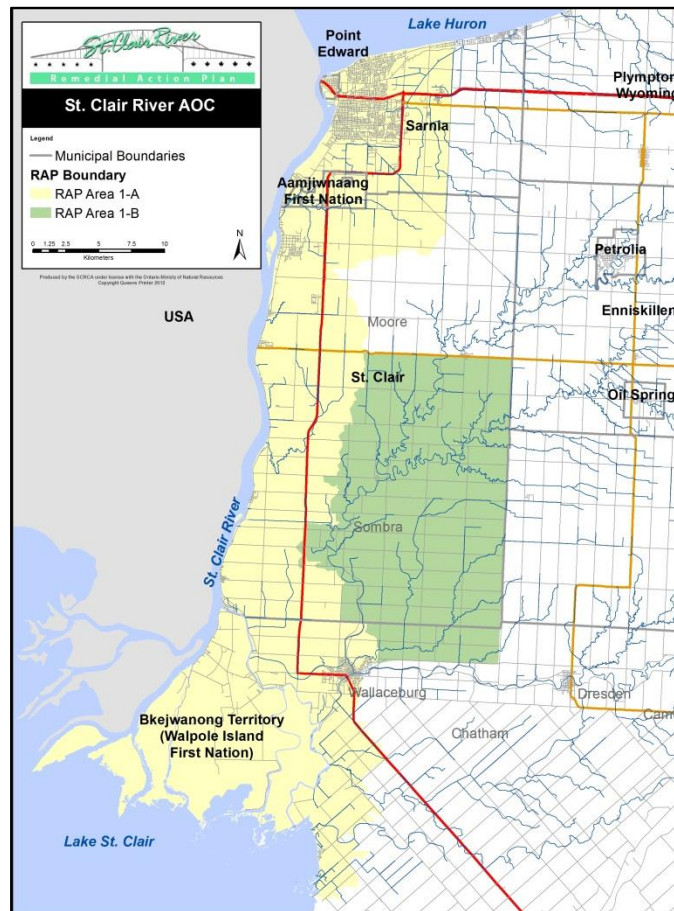


Figure 1.1: Location of the St. Clair River Area of Concern (AOC). The AOC is divided into two areas: Area 1-A (delineated by yellow shading) and Area 1-B (delineated by green shading).



Figure 1.2: Sign advising beach users of potentially high bacterial levels in nearby waters.

The “Beach Closings” BUI was designated as “impaired” in the Stage 1 RAP report because of frequent bacterial contamination observed at five swimming areas along the St. Clair River shoreline. Swimming advisories lasting up to two months were issued for Seager Park, Branton-Cundick Park, Brander Park, Centennial Park and Willow Park in 1990 because *E. coli* levels exceeded the PWQO of 100 cfu 100 mL⁻¹ (Figure 1.2; Table 1.2). The BUI remained “impaired” in the Stage 2 RAP report, with major sources of bacteria identified as combined sewer overflows (CSOs), Water Pollution Control Plant (WPCP) effluents and non-point sources including agricultural runoff.

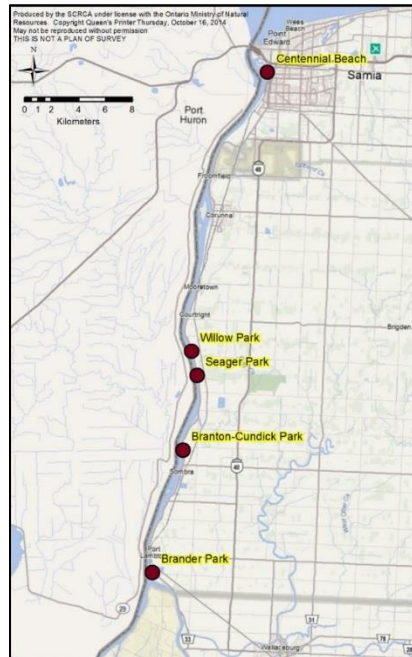


Figure 1.3: The locations of Centennial Park, Willow Park, Seager Park, Branton-Cundick Park and Brander Park in the St. Clair River Area of Concern (AOC). Bacterial contamination at these sites contributed to the “Beach Closings” Beneficial Use Impairment (BUI) being identified as “Impaired”.

Table 1.2: Geometric mean fecal coliform bacteria for five monitoring locations along the St. Clair River shoreline in 1990 (Lambton Public Health, 1991) constituting impairment of the “Beach Closings” Beneficial Use Impairment (BUI). Bold font indicates exceedances of the Ontario Provincial Water Quality Objective (PWQO) of 100 organisms/100 mL.

| Date | Swimming Area | | | | |
|-----------------|---------------|----------------------|--------------|-----------------|--------------|
| | Seager Park | Branton Cundick Park | Brander Park | Centennial Park | Willow Park |
| June 5 | 27.0 | 94.4 | 52.1 | 30.6 | 30.9 |
| June 11 | 102.4 | 96.7 | 36.8 | 25.7 | 66.1 |
| June 18 | 129.0 | 266.1 | 124.5 | 15.2 | 47.0 |
| June 25 | 29.9 | 325.6 | 41.1 | 268.1 | 46.8 |
| June 28 | n/a | 600.0 | n/a | 600.0 | n/a |
| July 3 | 15.2 | 114.9 | 34.4 | 158.5 | 89.8 |
| July 9 | 55.3 | 246.1 | 299.2 | 110.5 | 34.7 |
| July 11 | n/a | n/a | 218.9 | 159.4 | n/a |
| July 16 | 59.1 | 290.5 | 178.8 | 146.4 | 140.8 |
| July 23 | 316.9 | 515.2 | 188.1 | 160.3 | 296.9 |
| July 25 | 403.5 | n/a | n/a | n/a | 127.5 |
| July 30 | 589.6 | 600.0 | 95.8 | 428.9 | 233.3 |
| August 7 | 185.8 | 600.0 | 165.3 | 133.6 | 128.1 |
| August 13 | 578.5 | 600.0 | 600.0 | 600.0 | 600.0 |
| August 20 | 600.0 | 566.5 | 394.8 | 600.0 | 600.0 |
| August 27 | 505.8 | 600.0 | 439.9 | 127.5 | 130.0 |
| Exceedances (%) | 64 | 86 | 64 | 80 | 57 |

n/a – data not collected

For a BUI to be re-designated from “impaired” to “not impaired”, delisting (“restoration”) criteria developed specifically for the BUI must be met. Delisting criteria are derived locally and are unique to each AOC. For the St. Clair River, delisting targets for BUIs were first published in the 1995 Stage 2 RAP report but in 2010, were revisited and revised where necessary to ensure they were current, achievable and measurable. The original criteria developed in the Stage 2 RAP report stated that “this BUI will be considered restored when there are zero beach closings based on fecal coliform standards regulating beach guidelines over a two-year period” (OMOE/MDEQ, 1995). Upon review the criteria was deemed inconsistent with scientifically recognized guidelines for beach water quality health. As such, the criteria were revised.

The revised delisting criteria states that the “Beach Closings” BUI will be considered “not impaired” when:

- i. Less than 20% of the geometric means of water samples collected over the swimming season, at identified beaches within the St. Clair River AOC, exceed the PWQO for *E. coli*, or
- ii. Results are similar to a suitable non-AOC reference site, when assessed over a period of at least three to five years, or
- iii. The source of *E. coli* is deemed to be non-anthropogenic (e.g., excessive geese and wildlife) as this would not be considered an AOC issue and the “Beach Closings” BUI could be re-designated to “not impaired” (CRIC Delisting Subcommittee, 2012).

The delisting criteria applies to beaches that are officially recognized by Public Health Units (hereafter referred to as “official”). The 20% goal is consistent with the water quality target required for a beach to obtain Blue Flag status; an internationally recognized beach and marina designation signaling good water quality, high safety standards and environmentally sustainability (Foundation for Environmental Education, 2016). Additional locations along the St. Clair River were also sampled in support of this status assessment and are discussed in Section 4.0.

2.0 Purpose of Report

The purpose of this report is to provide an overview of the “Beach Closings” BUI for the St. Clair River AOC and assess its status by providing:

- i. a synopsis of actions implemented since the Stage 1 RAP report to address this issue;
- ii. an analysis of *E. coli* data collected at “official” beaches along the St. Clair River since 2009 and comparing to delisting criteria;
- iii. a summary of monitoring conducted at additional monitoring locations along the St. Clair River in support of this assessment, and;
- iv. recommendations and conclusions regarding re-designation.

3.0 Remedial Actions Completed

The Stage 1 RAP report described environmental degradation while the Stage 2 RAP report recommended remedial actions to address the environmental impairments within the AOC. A work plan for the St. Clair River AOC was published in 2007, building on the actions outlined in the Stage 2 RAP report (CRIC, 2007). The recommended actions relating to the “Beach Closings” BUI were to (i) ensure that WPCPs continue to meet current regulations and do not negatively affect beneficial uses; (ii)

complete programs to eliminate combined sewer overflows and to (iii) establish and implement a riparian habitat and buffering program for the St. Clair River AOC (CRIC, 2007). The following sections provide a brief overview of the programs and projects implemented that have had a direct influence on the “Beach Closings” BUI in the St. Clair River AOC.

3.1. Water Pollution Control Plants

Municipal WPCPs are regulated by the Ontario Ministry of the Environment and Climate Change (OMOECC) under the *Ontario Water Resources Act* and the *Ontario Environmental Protection Act*, where legally enforceable Environmental Compliance Approvals (ECAs) are issued applying limits to municipal discharges. Where non-compliance occurs, a range of abatement and enforcement measures are employed including education, orders, environmental penalties and prosecution. As a result of this legislation and municipal and industrial initiatives, the concentration and loading of WPCP discharges have substantially decreased since the late 1970's (Figure 3.1).

A number of upgrades and expansions to WPCPs along the St. Clair River have further benefitted local water quality. In Point Edward, expansion work completed in the 1990s at the WPCP has resulted in no ECA exceedances recorded in the most recent OMOECC compliance report (2014). In 2013, the Township of St. Clair completed a major \$30 million project that saw the replacement of the Corunna WPCP with a pumping station, conveying sewage to the Courtright treatment facility (Young, 2013). In addition, new storage tanks were installed and the WPCP was expanded to provide sufficient capacity to support future community growth in the area (Young, 2013). No recent ECA exceedances have been observed at either the Port Lambton or Sombra lagoons.

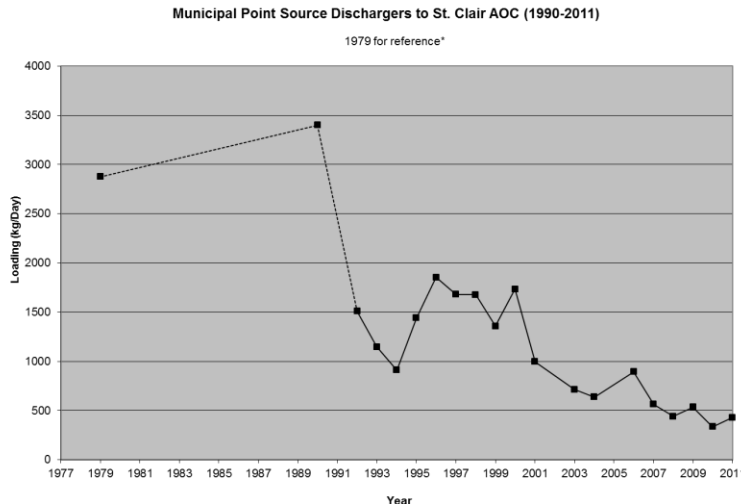


Figure 3.1: Loadings of three parameters (Suspended Solids, Biological Oxygen Demand (BOD5), Total Phosphorus) from seven municipal facilities with point source discharges into the St. Clair River Area of Concern (AOC) between 1990 and 2011 (OMOE, 2014).

The City of Sarnia continues to experience decreases in bypass volumes from their WPCP. The City is currently in the middle of a long-term project that will significantly limit inputs to the St. Clair River. In 2013, the Supervisory Control and Data Acquisition (SCADA) project was initiated which allows for better management and mitigation of storm and sewage water flows into the over 60 pumping stations located across the City.

3.2. Combined Sewer Systems

As reported in the Stage 1 RAP report in 1991, combined sewers serviced approximately 540 hectares of Sarnia's city core (Paul Theil Associates Ltd., 1988). Combined sewers collect both storm and household waste water and during high rain events, overflows can occur. These overflows are referred to as Combined Sewer Overflows (CSO). At the time, four outlets were identified that would discharge contaminants and bacteria directly into the St. Clair River during an overflow event. In 1987 alone, monitoring data identified over 100 overflow events (OMOE/MDEQ, 1995). Combined sewers were also identified in the community of Wallaceburg.

Today, work is on-going in Sarnia and Wallaceburg to separate the combined sewers that discharge to the St. Clair River. Presently, 95% of the combined sewer system projects in Wallaceburg have been completed (Robin Dudley, Chatham-Kent PUC, personal communication, 2015). Progress continues in Sarnia and has included the complete separation of the Exmouth and Christina Street combined sewers in 2009 and the East Street Project in 2012 (City of Sarnia Engineering Department, 2014). Between 2007 and 2013, CSO discharges (including WPCP bypasses) were reduced by 40% and no CSO has occurred since 2010. A WPCP (Water Pollution Control Plant) bypass occurs when flow through the system exceeds the capacity of the treatment plant. Of the 39 kilometers of combined sewers in Sarnia, approximately 24 kilometers remain (City of Sarnia Engineering Department, 2014). The implementation of the SCADA project (discussed in Section 3.1) also further reduces the need for overflows to the river.

3.3. Riparian Buffers

In Ontario, 78% of the area that drains into the St. Clair River is used for agricultural purposes (OMOE/MDEQ, 1995). Practices such as manure application and the direct waste from livestock and other domestic animals can contribute nutrients and fecal bacteria to watercourses via surface runoff. Riparian buffers (vegetation planted along shorelines) serve to filter, trap and/or absorb runoff which reduces loads into aquatic environments and improves local water quality.

Between 2007 and 2010, 37 projects were completed that had a riparian component along St. Clair River AOC tributaries, translating into 28 kilometers or 137 hectares of new or enhanced habitat (CRIC, 2012). Based on the most recent analysis of air photographs taken in 2010, approximately 59% of the 1308 kilometer length of St. Clair River tributaries has been buffered by a minimum of 5 meters (Seidler *et al.*, 2012). Almost 36% of the tributary lengths have 30-meter wide riparian buffers (Seidler *et al.*, 2012).

Programs funded by federal, provincial and municipal governments continue to provide financial and technical assistance to landowners wishing to install buffer strips and implement other Best Management Practices (BMPs) on their properties. Examples include the Habitat Stewardship Program, the Species at Risk Stewardship Fund and the Clean Water Program. Most recently, Lambton County adopted the Alternative Land Use Services (ALUS) program that provides direct compensation to landowners that implement BMPs on their properties (Schilz, 2016).

3.4. Implementation Actions on the Michigan Side of the St. Clair River

Similar to Canada, the "Beach Closings" BUI was considered "impaired" on the American side of the St. Clair River as four areas did not support recreational uses due to bacterial contamination. CSOs were identified as major contributors of bacteria on the American side of the river. In the towns of Marysville and St. Clair, all combined sewer separation has been completed (MDEQ, 2013). In the City of Port

Huron, significant progress has been made in separating combined sewers since work began in 1997. As of 2015, the City has seen 1) a 99% reduction in the areas serviced by combined sewers, 2) a 99% decrease in annual overflow volume and 3) the reduction of combined sewer outfalls from 21 to one (Clegg, 2015).

The MDEQ regulates all municipal discharges through the National Pollutant Discharge Elimination System. Shoreline work has been conducted at a number of locations along the St. Clair River including Chrysler Beach in the City of Marysville. These projects have not only improved fish and wildlife habitat within the AOC, but have also reduced the impact non-point sources of contaminants have at beach locations. The “Beach Closings” BUI on the American side of the St. Clair River was re-designated to “not impaired” in 2016.

4.0 *E. Coli* Monitoring at Beaches along the St. Clair River

4.1. Beach Monitoring Locations, Sampling Procedure and Data Analysis

4.1.1. Beach Locations

4.1.1.1. Official Beaches

Under the direction of the MOHLTC, Health Units collect water samples from “official” beaches during the swimming season (June - September) to prevent and reduce the frequency of water-borne illnesses resulting from recreational water use. An “official” beach is defined under this program as a “beach area owned and/or operated by a municipality which: 1) the general public has direct access to; 2) allows supervised aquatics programs or is staffed by lifeguards, and; 3) meets the requirements of the sampling protocol for sampling sites” (MOHLTC, 2008). There are two beaches in the St. Clair River AOC that meet the MOHLTC’s “beach” definition and are monitored under the Ministry’s program accordingly: Mitchell’s Bay and Canatara Park are monitored by Chatham-Kent and Lambton Public Health Units, respectively (Figure 4.1).

4.1.1.2 Additional Sampling Locations

Although there are only two beaches in the St. Clair River AOC defined as “official” beaches as per the Beach Management Protocol, the CRIC identified a number of sites where recreational water use was common but were not monitored by Public Health Units. With the exception of Willow Park, all other sites from the Stage 1 RAP report were included. For these areas, a project separate from the Beach Monitoring Program was proposed. The project saw the collection of *E. coli* samples from a number of additional locations in order to capture locations along the St. Clair River proper. Beginning in 2011, ten locations were sampled during the swimming season by Lambton Public Health with funding and logistical support provided by the OMOECC and the St. Clair Region Conservation Authority. In addition, data from three locations sampled as part of an annual monitoring program on Walpole Island by the Walpole Island Health Centre were provided. This project was repeated in 2012 and 2013. Sample locations included: Blue Water Bridge, Aamjiwnaang Dock, Corunna Dock, Mooretown Dock, Courtright Dock, Seager Park, Terra Beach, Branton-Cundick Park, Port Lambton Dock, Brander Park and Ferry Beach, Roger’s Dock and Smith’s Beach on Walpole Island (Figure 4.1).

Lambton Public Health also monitors *E. coli* levels at Centennial Park in Sarnia. The shoreline was posted with a “no swimming” sign in 2006. Despite not being captured under the “official” beach definition by the MOHLTC, sampling at this location has been on-going due primarily to historical concerns and the

close proximity of a children's playground (Figure 4.1). For informational purposes, results from Centennial Park will be provided in this report (Section 4.3).

4.1.2. E. coli Sampling Procedure and Data Analysis

E. coli samples were collected weekly between June and September during 2012 and 2013 following the MOHLTC Beach Management Protocol (2008). Those sites identified as "official" beaches or deemed sufficient in size had five samples collected on each date with the result reported as the geometric mean of all five samples (Table 4.1). All other locations had one grab sample collected on a weekly basis (Table 4.1). As per MOHLTC Beach Management Protocol, water was collected 15-30 centimeters below the surface in areas reaching a depth of 1 - 1.5 meters using sterile plastic bottles. Samples were kept cool and transported to an accredited laboratory in London, Ontario for microbiological analysis.

To determine the status of the “Beach Closings” BUI for the St. Clair River AOC results were compared to the PWQO for *E. coli* to determine if less than 20% of the total number of samples collected at a location exceeded this guideline. In other words, the beaches met the PWQO for *E. coli* 80% of the time during the swimming season. In addition, *E. coli* levels observed in the St. Clair River AOC were compared to upstream reference sites in Lake Huron (Figure 4.2) that are sampled as part of Lambton Public Health’s annual monitoring program.



Figure 4.1: Location of sampling sites in the St. Clair River Area of Concern (AOC). The “official beaches” are highlighted in green.



Figure 4.2: Location of Lake Huron beaches. *E. coli* levels at these reference locations were compared to levels observed at monitoring sites within the boundaries of the St. Clair River Area of Concern (AOC).

Table 4.1: Number of *E. coli* samples collected per sampling day for each of the sites monitored in the St. Clair River Area of Concern (AOC). For those locations where 5 samples were collected, results were presented as the geometric mean of all five sample results as described in the Ontario Ministry of Health and Long Term Care (MOHLTC) Beach Management Protocol (2008). The Stage 1 Remedial Action Plan (RAP) sites are denoted with asterisk (*).

| Location | # of Samples Collected |
|-----------------------|------------------------|
| Canatara Park | 5 |
| Centennial Park* | 5 |
| Blue Water Bridge | 1 |
| Aamjiwnaang Dock | 1 |
| Corunna Dock | 1 |
| Mooretown Dock | 1 |
| Courtright Dock | 1 |
| Seager Park* | 1 |
| Terra Beach | 5 |
| Branton-Cundick Park* | 5 |
| Port Lambton Dock | 1 |
| Brander Park* | 5 |
| Ferry Beach | 1 |
| Roger's Dock | 1 |
| Smith's Beach | 1 |
| Mitchell's Bay | 5 |

4.2. Beach Monitoring Results – Official Beaches

Canatara Park and Mitchell's Bay are the two "official" beaches within the AOC. Canatara Park is located along the shoreline of Lake Huron, just east of the St. Clair River (Figure 4.1). During the timeframe examined for this status assessment (2009-2015), less than 20% of the total number of samples collected had *E. coli* levels that exceeded the PWQO (19.1%; Figure 4.3; Table A-1). The consistently good water quality observed at Canatara Park contributed to the beach being designated a "Blue Flag" beach in 2014 (Morden, 2014). There are only 24 beaches in Canada that hold this designation (Foundation for Environmental Education, 2016).

Mitchell's Bay is located in the southern region of the AOC along the shoreline of Lake St. Clair (Figure 4.1). Between 2009 and 2015, 84 samples were collected and analyzed with 19 exhibiting *E. coli* levels higher than the PWQO (22.6%), slightly exceeding the 20% target outlined in the delisting criteria (Figure 4.3). *E. coli* increases at this location are strongly suspected to be the result of an increased seagull and waterfowl population, as noted by Chatham-Kent Health Unit staff rather than an anthropogenic source. However, comparisons to reference sites along the Lake Huron shoreline suggest that both Canatara Park and Mitchell's Bay have comparable frequencies of *E. coli* PWQO exceedances to those observed at non-AOC locations (Figure 4.4).

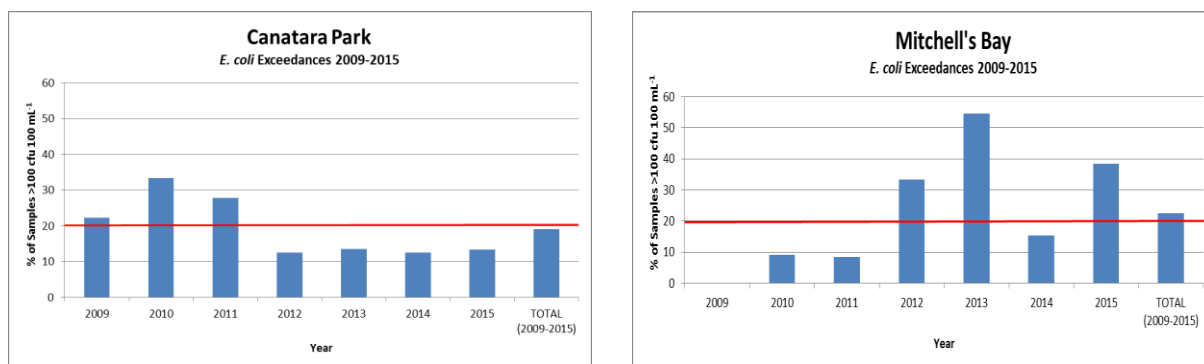


Figure 4.3: The percentage of samples collected from “official” beaches (Canatara Park and Mitchell’s Bay) along the St. Clair River Area of Concern (AOC) that exceeded the Provincial Water Quality Objective (PWQO) for *E. coli*. Annual results are presented as well as the overall percentage when all samples collected between 2009 and 2015 were considered. The 20% criterion is denoted by the red line.

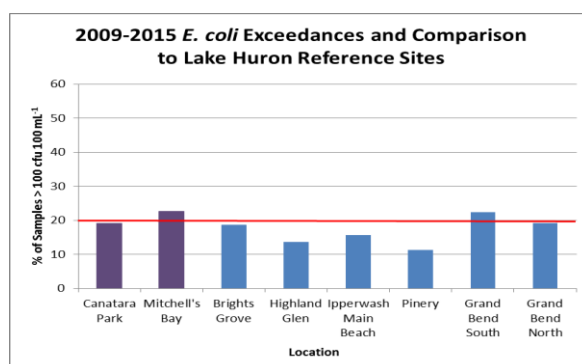


Figure 4.4: The percentage of samples collected between 2009 and 2015 from Canatara Park and Mitchell’s Bay (“official beaches”) in the St. Clair River Area of Concern (AOC; purple) and Lake Huron reference locations (blue) that exceeded the Provincial Water Quality Objective (PWQO) for *E. coli*. The 20% criterion is denoted by the red line.

4.3. Monitoring Results – Additional Monitoring Locations

The additional sites monitored in support of this status assessment were sampled for three years (2011-2013). Annual variations were observed, however low *E. coli* levels were recorded at the majority of swimming areas along the St. Clair River. Eleven of the 13 sites had less than 20% of samples with *E. coli* greater than the PWQO with the other two narrowly exceeding the target (Brander Park – 20.5%; Terra Beach – 25.6%). No exceedances were observed at Aamjiwnaang Dock, Ferry Beach or Rogers Dock during the three-year period (Figure 4.5). Comparisons to Lake Huron reference sites indicate that these additional sites sampled along the St. Clair River have either lower or similar frequencies of exceeding the PWQO for *E. coli* (Figure 4.5).

As there were only two “official” beaches in the St. Clair River AOC, a statistical comparison to Lake Huron reference beaches was not able to be performed. Instead, all AOC sampling sites ($n = 16$) were compared to the Lake Huron reference beaches ($n = 6$) using the non-parametric Mann Whitney U-Test. No significant difference in *E. coli* exceedances was detected between AOC sites (median = 7.7%) and Lake Huron reference beaches (median = 20.2; $U = 23$, $p = 0.07$).

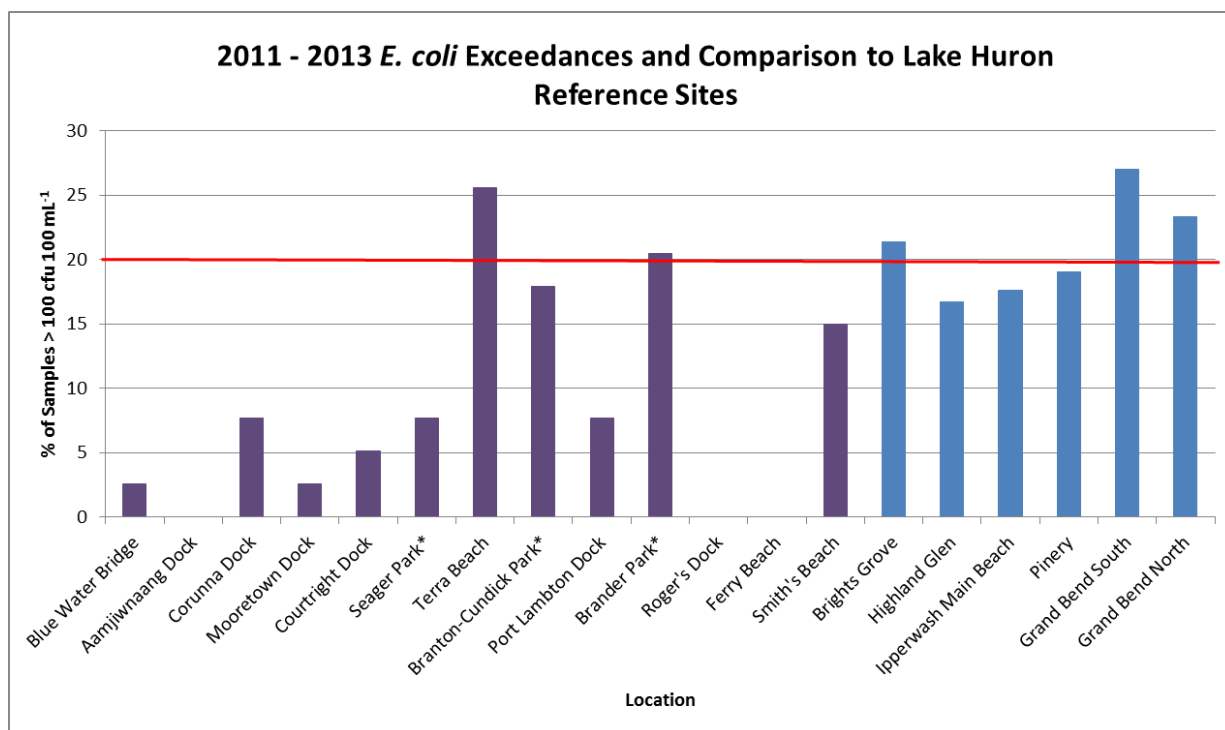


Figure 4.5: The percentage of samples collected between 2011 and 2013 from the additional sites monitored in the St. Clair River Area of Concern (AOC; purple) and Lake Huron reference locations (blue) that exceeded the Provincial Water Quality Objective (PWQO) for *E. coli*. The 20% criterion is denoted by the red line. The Stage 1 Remedial Action Plan (RAP) sites are denoted with asterisk (*).

4.3.1 Centennial Park

The shoreline at Centennial Park is located in Sarnia Bay, east of Sarnia Bay Marina and north of Bayshore Park. *E. coli* levels were consistently elevated during the 2009 – 2015 sampling period (Figure 4.6). As a result, a two-year Microbial Source Tracking study was initiated to examine sources of *E. coli* to Centennial Park more closely.

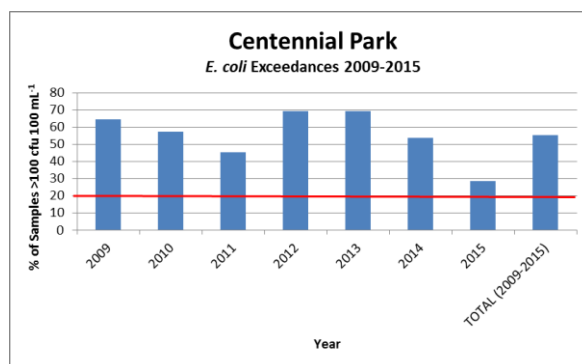


Figure 4.6: The percentage of samples collected from Centennial Park along the St. Clair River Area of Concern (AOC) that exceeded the Provincial Water Quality Objective (PWQO) for *E. coli*. Annual results are presented as well as the overall percentage when all samples collected between 2009 and 2015 were considered. The 20% criterion is denoted by the red line.

4.3.1.1 Microbial Source Tracking at Centennial Park

Microbial Source Tracking (MST) analysis was conducted at Centennial Park in 2012 and 2013. The purpose of the study was to determine what the major source of *E. coli* was to the area and determine if an anthropogenic source remained.

MST analysis allows for the identification of fecal sources in surface water. It involves the relative quantification of bacteriodes (a type of anaerobic bacteria present in the gastro-intestinal system of mammals) by amplifying specific DNA markers through the quantitative real-time Polymerase Chain Reaction (qPCR). The qPCR analysis is capable of identifying genetic markers in bacteriodes specific to the host organism (i.e., geese, human, bovine, etc.; Helix Biological Laboratory, 2014).

Results of the two-year study identified waterfowl (geese and ducks) as the dominant source of *E. coli* to Centennial Park, however an intermittent human signal was detected in close proximity to a storm water outfall (Site 6; Figure 4.7). In response the City of Sarnia investigated the storm water outfall as a possible source of the human signal and discovered a significant build-up of sludge from its historical connection to a combined sewer. The pipe was cleaned out in the fall of 2013. A more detailed account of the methods and results of the MST analysis are available in Appendix B.

Future monitoring of Centennial Park is unclear due to proposed changes to the park's layout. In 2012, the City of Sarnia initiated an environmental and risk assessment of Centennial Park as soil contamination was discovered throughout the park area. The park is scheduled to be remediated and redesigned. Currently, the proposed redesign will have the Centennial Park shoreline replaced with an armour stone wall, eliminating access to the water and likely deterring ducks and geese away from the area. A pollution control barrier (consisting of plants and trees) is also proposed which will intercept storm water. The reconstruction is expected to begin in the summer of 2016. As the project progresses, Lambton Public Health will determine whether *E. coli* monitoring will continue at Centennial Park.



Figure 4.7: Sampling locations at Centennial Park in Sarnia for Microbial Source Tracking (MST) analysis. Samples were collected from all six locations in 2012 but only at site 4 in 2013.

7.0 Discussion

Results from the numerous studies and lines-of-evidence discussed in this status assessment suggest that beach water quality has improved in the St. Clair River AOC. Remedial actions implemented within the AOC has reduced anthropogenic bacterial contributions to the river. Efforts continue, particularly in the City of Sarnia where work to separate the remaining combined sewers is ongoing.

An examination of *E. coli* levels in the St. Clair River AOC yielded positive results. Exceedance of the PWQO for *E. coli* at Canatara Park was below the delisting criteria target of 20% over the 7-year time period (2009-2015). Mitchell's Bay experienced a higher frequency of elevated *E. coli* levels (> 20%) however the number of exceedances were comparable to those observed at Lake Huron reference sites and is strongly suspected to be a result of large waterfowl and seagull populations. As demonstrated in Centennial Park, water birds can be a significant source of *E. coli*.

Impacts of waterfowl to water quality is common throughout the Great Lakes Basin and are a natural (non-anthropogenic) source of *E. coli*. As such, their control is not mitigated under the RAP process. Nonetheless, local communities have implemented actions to divert waterfowl from beach locations such as planting tall grass, using predator decoys or installing fences (OMNR, 2013)

Additional sites monitored along the St. Clair River generally had lower exceedance frequencies than the reference sites and a statistical comparison between AOC locations and Lake Huron sites did not reveal a significant difference. These results may speak to the numerous factors that can drive *E. coli* level variations at beaches throughout the Great Lakes Basin such as wind, rain and the presence or absence of waterfowl.

Re-designation Recommendation:

The delisting criteria developed for the St. Clair River AOC states that the "Beach Closings" BUI will be considered "not impaired" when *"less than 20% of the geometric means of water samples collected over the swimming season, at identified beaches within the St. Clair River AOC, exceed the PWQO for E. coli or is similar to a suitable non-AOC reference site, when assessed over a period of at least three to five years"*. In addition, re-designation can also be considered if the major source of *E. coli* originates from non-anthropogenic sources.

Based on the water quality data collected, analyzed and presented in this status assessment the delisting criteria for this BUI have been met as demonstrated by the following findings:

- 1) *E. coli* levels at official beaches were either low based on the delisting target of > 20% of water samples collected exceeding the PWQO for *E. coli* (Canatara Park) or comparable to Lake Huron reference beaches (Mitchell's Bay).
- 2) There is no statistically significant difference between PWQO exceedances for *E. coli* at monitoring sites throughout the St. Clair River AOC when compared to Lake Huron reference beaches.

It is recommended that the “Beach Closings” BUI be re-designated to “Not Impaired” for the St. Clair River Area of Concern.

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Appendix A

E. coli concentration raw data for beach monitoring locations in the St. Clair River Area of Concern (AOC).

Table A-1: Date and *E. coli* levels observed at Canatara Park in the St. Clair River Area of Concern (AOC). Only those *E. coli* readings that exceeded the Provincial Water Quality Objective (PWQO) of 100 cfu 100 mL⁻¹ are presented. Results are based on the geometric mean of five samples as per the Beach Management Protocol (2008).

| Location | Year | Sample Date | <i>E. coli</i> Level (cfu 100 mL ⁻¹) |
|---------------|------|-------------|---|
| Canatara Park | 2009 | July 6 | 111 |
| | | August 24 | 146 |
| | | August 27 | 179 |
| | | August 31 | 204 |
| | 2010 | June 7 | 1784 |
| | | July 13 | 330 |
| | | July 19 | 465 |
| | | July 22 | 115 |
| | | August 9 | 276 |
| | | August 16 | 172 |
| | | August 24 | 262 |
| | 2011 | July 18 | 112 |
| | | August 16 | 102 |
| | | August 18 | 164 |
| | | August 31 | 195 |
| | | September 1 | 360 |
| | 2012 | August 27 | 147 |
| | | August 30 | 123 |
| | 2013 | June 3 | 195 |
| | | July 25 | 228 |
| | | August 22 | 113 |
| | | August 28 | 142 |
| | | August 29 | 228 |
| | 2014 | June 30 | 530 |
| | | August 5 | 856 |
| | 2015 | June 2 | 767 |
| | | June 29 | 414 |

Table A-2: Date and *E. coli* levels observed at Mitchell's Bay in the St. Clair River Area of Concern (AOC). Only those *E. coli* readings that exceeded the Provincial Water Quality Objective (PWQO) of 100 cfu 100 mL⁻¹ are presented. Results are based on the geometric mean of five samples as per the Beach Management Protocol (2008).

| Location | Year | Sample Date | <i>E. coli</i> Level (cfu 100 mL ⁻¹) |
|----------------|------|-------------|---|
| Mitchell's Bay | 2010 | July 20 | 139 |
| | 2011 | June 28 | 299 |
| | 2012 | June 12 | 175 |
| | | June 26 | 265 |
| | | July 17 | 171 |
| | | August 14 | 1999 |
| | 2013 | July 2 | 100 |
| | | July 15 | 173 |
| | | July 22 | 923 |
| | | July 29 | 107 |
| | | August 6 | 170 |
| | | August 12 | 188 |
| | 2014 | July 14 | 188 |
| | | July 28 | 259 |
| | 2015 | June 8 | 280 |
| | | June 22 | 136 |
| | | July 27 | 107 |
| | | August 10 | 920 |
| | | August 24 | 120 |

Table A-3: Date and *E. coli* levels observed at Centennial Park in the St. Clair River Area of Concern (AOC). Only those *E. coli* readings that exceeded the Provincial Water Quality Objective (PWQO) of 100 cfu 100 mL⁻¹ are presented. Results are based on the geometric mean of five samples as per the Beach Management Protocol (2008).

| Location | Year | Sample Date | <i>E. coli</i> Level (cfu 100 mL ⁻¹) |
|-----------------|------|-------------|---|
| Centennial Park | 2009 | June 29 | 408 |
| | | July 6 | 127 |
| | | July 20 | 551 |
| | | July 27 | 287 |
| | | August 4 | 906 |
| | | August 10 | 119 |
| | | August 17 | 1034 |
| | | August 24 | 1092 |
| | | August 31 | 222 |
| | 2010 | June 1 | 162 |
| | | June 21 | 132 |
| | | June 28 | 244 |
| | | July 13 | 454 |
| | | August 3 | 531 |
| | | August 16 | 309 |
| | | August 24 | 380 |
| | | August 30 | 162 |
| | 2011 | July 18 | 1724 |
| | | July 27 | 229 |
| | | August 8 | 983 |
| | | August 23 | 630 |
| | | August 31 | 694 |
| | 2012 | June 18 | 120 |
| | | July 3 | 156 |
| | | July 16 | 443 |
| | | July 23 | 519 |
| | | July 30 | 687 |
| | | August 7 | 723 |
| | | August 13 | 628 |
| | | August 20 | 167 |
| | | August 27 | 560 |
| | 2013 | June 10 | 149 |
| | | June 17 | 126 |
| | | July 15 | 109 |
| | | July 22 | 295 |
| | | July 29 | 151 |
| | | August 6 | 536 |
| | | August 12 | 578 |
| | | August 19 | 593 |
| | | August 26 | 224 |

Table A-3 (continued): Location, date and *E. coli* levels observed at Centennial Park in the St. Clair River Area of Concern (AOC). Only those *E. coli* readings that exceeded the Provincial Water Quality Objective (PWQO) of 100 cfu 100 mL⁻¹ are presented. Results are based on the geometric mean of five samples as per the Beach Management Protocol (2008).

| Location | Year | Sample Date | E. coli Level (cfu 100 mL ⁻¹) |
|-----------------|------|-------------|---|
| Centennial Park | 2014 | June 30 | 598 |
| | | July 7 | 301 |
| | | July 14 | 118 |
| | | July 28 | 329 |
| | | August 11 | 136 |
| | | August 18 | 230 |
| | | August 25 | 140 |
| | 2015 | June 8 | 478 |
| | | August 4 | 134 |
| | | August 10 | 134 |
| | | August 24 | 120 |

Table A-4: Location, date and *E. coli* levels observed at the additional monitoring sites along the St. Clair River Area of Concern (AOC). Only those *E. coli* readings that exceeded the Provincial Water Quality Objective (PWQO) of 100 cfu 100 mL⁻¹ are presented.

| Location | Year | Sample Date | <i>E. coli</i> Level (cfu 100 mL ⁻¹) |
|-----------------------|------|-------------|---|
| Blue Water Bridge | 2011 | August 10 | 231 |
| | 2011 | June 7 | 147 |
| Corunna Dock | 2012 | August 14 | 560 |
| | 2013 | June 11 | 199 |
| Mooretown Dock | 2013 | June 11 | 116 |
| Courtright Dock | 2013 | June 11 | 460 |
| | | July 9 | 111 |
| Seager Park | 2012 | June 26 | 132 |
| | 2013 | June 11 | 146 |
| | | July 9 | 136 |
| Terra Beach* | 2011 | August 2 | 374 |
| | | August 10 | 101 |
| | | June 26 | 108 |
| | 2012 | July 4 | 727 |
| | | July 10 | 526 |
| | | July 31 | 544 |
| | | August 14 | 757 |
| | 2013 | July 9 | 160 |
| | | July 16 | 154 |
| | | August 20 | 179 |
| Branton-Cundick Park* | 2012 | June 12 | 132 |
| | | July 31 | 220 |
| | | August 14 | 691 |
| | 2013 | June 11 | 121 |
| | | July 9 | 593 |
| | | July 16 | 1372 |
| Port Lambton Dock | 2012 | July 4 | 170 |
| | 2013 | June 11 | 179 |
| | | July 9 | 320 |
| Brander Park* | 2011 | August 2 | 128 |
| | | August 10 | 276 |
| | 2012 | June 12 | 100 |
| | | July 31 | 1508 |
| | | August 14 | 102 |
| | 2013 | August 6 | 101 |
| | | August 13 | 156 |
| Smith's Beach | 2012 | August 27 | 104 |
| | | June 11 | 170 |
| | | July 18 | 190 |
| | 2014 | August 1 | 150 |
| | | July 15 | 122 |
| Ferry Beach | 2015 | August 11 | 263 |

* Based on the geometric mean of five samples as per the Beach Management Protocol (2008)

Appendix B

Microbial Source Tracking at Centennial Park, Sarnia, Ontario

As previously discussed, Centennial Park in Sarnia, Ontario was permanently posted with a “no swimming” sign in 2006 due to consistently high *E. coli* levels. Lambton Public Health has continuously sampled the beach as part of their annual monitoring program due to the close proximity of a children’s playground. The “beach” itself is located in Sarnia Bay, east of Sarnia Bay Marina and north of Bayshore Park. The playground was approximately 20 meters from the shoreline which is continually populated with ducks and geese.

In response to the high levels of *E. coli*, the City of Sarnia completed work separating sewage and storm water systems that directly influenced the beach at Centennial Park and Sarnia Bay (CLCHSD, 2011). These efforts resulted in steadily improved water quality until *E. coli* levels increased substantially during mid-summer sampling in 2011 and remained high until the end of the season. As a result, it was recommended that *E. coli* at Centennial Park be examined more closely. In 2012, a study was initiated to identify the major sources of *E. coli* to this area of the St. Clair River AOC.

B.1. 2012 Sampling and Results

Samples were collected from six locations weekly from August 20 until September 24, 2012 and after heavy rain events for MST analysis which allows for the identification of fecal sources in surface waters. This method involves the relative quantification of bacteriodes (a type of anaerobic bacteria present in the gastro-intestinal system of mammals) by amplifying specific DNA markers through the quantitative real-time qPCR. The qPCR analysis is capable of identifying genetic markers in bacteriodes specific to the host organism (i.e., geese, human, bovine, etc.; Helix Biological Laboratory, 2014). The purpose was to examine whether anthropogenic (human) sources (such as CSOs) continue to impact water quality at Centennial Park or if other sources such as ducks and geese were the major contributors of *E. coli*.

Water samples were delivered to the OMOECC laboratory in Toronto, Ontario for analysis. The OMOECC laboratory has DNA markers for bacteriodes originating from human and bovine sources. A human signal was identified at sites 1, 3 and 6 (Table B-1). The percentage of total bacteriodes detected at sites 1 and 3 originating from human sources was low (mean of 0.5% and 1.2%, respectively; Table B-1) implying a primarily non-anthropogenic influence.

Table B-1: Total bacteriodes and percentage of human and bovine markers for Microbial Source Tracking (MST) samples collected in 2012 from Centennial Park in the St. Clair River Area of Concern (AOC). The mean values and ranges are provided.

| Location | | Total Bacteriodes (cfu* 100 mL ⁻¹) | Human (%) | Bovine (%) |
|-----------|-------|---|--------------|---------------|
| All Sites | mean | 113 605 | 7.2 | 27.9 |
| | range | 2400 – 570 000 | 0 – 33 | 0 – 220 |
| Site 1 | mean | 37 000 | 0.46 | 13.6 |
| | range | 15 000 – 74 000 | 0 – 1.5 | 0 – 31 |
| Site 3 | mean | 112 614 | 1.2 | 57 |
| | range | 7900 – 340 000 | 0 – 4.1 | 1.9 – 220 |
| Site 6 | mean | 169 314 | 18 | 8.9 |
| | range | 2400 – 570 000 | 3.9 – 33 | 0.2 – 18 |

* cfu = colony forming units

Human bacteriodes were also observed at site 6 located at the base of a storm water outfall but still constituted a low percentage of the total bacteriodes collected. An average of 18% of the total bacteriodes was linked to human sources (Table B-1). The greatest total number of individual bacteriodes was observed at this site on September 24 (570 000 cfu 100 mL⁻¹), 33% of which were identified as originating from human hosts (Table B-1). Results from the 2012 sampling period also showed the presence of bovine bacteria, possibly carried to the beach on the feet of geese (Table B-1). Because an intermittent human influence was detected but markers for waterfowl were not available, the study was continued in 2013.

B.2 2013 Sampling and Results

In 2013, Helix Biological Laboratory located in Warren, Michigan was sourced to conduct qPCR analysis as they had the capacity to identify bacteriodes originating from a number of different mammals. Nine samples were collected over a 20-week period (late spring, summer and early fall) from one location and were analyzed for geese, duck and human bacteriodes.

Duck and/or geese markers were found in all samples. Duck markers were detected in all nine analyses and geese bacteriodes were present in eight (Table B-2). An intermittent human marker continued to be observed in 2013, with three samples containing human bacteriodes. One sample collected on May 8, 2013 showed human marker levels that were 21 600 times greater than the duck marker (Table B-2). In response to these results, the City of Sarnia investigated the storm water outfall located at site 6 from the 2012 study as the potential source of the human signal. When this pipe was further examined, no cross-connections were found but a significant build-up of sludge was present from its historical connection to a combined sewer system. The storm water pipe was cleaned in the fall of 2013 by the City of Sarnia.

Table B-2: Total bacteriodes, DNA marker detection and “fold-difference” for water samples collected in 2013 from Centennial Park in Sarnia, Ontario located in the St. Clair River Area of Concern (AOC).

| Date | Total Bacteriodes (cfu* 100 mL ⁻¹) | Human | Duck | Goose | Fold-Difference |
|--------------|---|-------|------|-------|---|
| May 8 | 3890 | + | + | + | Human marker 21 600 times higher than duck marker |
| May 28 | 203 | - | + | + | Goose marker 19.84 times higher than duck marker |
| June 26 | 512 | + | + | + | Human marker 1.59 times higher than both duck and goose markers |
| July 8 | 684 | - | + | + | Goose marker 1.19 times higher than duck marker |
| July 23 | 709 | + | + | - | Duck marker 15.45 times higher than human marker |
| August 13 | 665 | - | + | + | Duck marker 5.62 times higher than goose marker |
| August 20 | 650 | - | + | + | Duck marker 3.01 times higher than goose marker |
| September 17 | 405 | - | + | + | Duck marker 13.93 times high than goose marker |
| October 10 | 108 | - | + | + | Goose market 2.14 times high than duck marker |

* cfu = colony forming units

Although no follow-up sampling and analysis has occurred, with the sludge removed from the storm water sewer, it is likely the only major source of *E. coli* to Centennial Park will be that originating from geese and ducks. The issue of waterfowl impacts to water quality is a problem plaguing many locations throughout the Great Lakes Basin and is not unique to AOCs or within the context of the AOC program. There are many actions that can be implemented to divert waterfowl from beach locations such as planting tall grasses, using predator decoys or installing fences (OMNR, 2013).