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Cootes Paradise: Environmental Impact Evaluation
Hamilton, Ontario

City of Hamilton

April 2020
SLR Project No.: 209.40666.00001

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION

COOTES PARADISE

HAMILTON, ONTARIO

SLR Project No.: 209.40666.00001

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EXECUTIVE SUMMARY

INTRODUCTION

On November 28, 2019, the Ministry of Environment, Conservation and Parks (MECP) issued a Director's Order to the City of Hamilton (the City) in relation to a combined sewage discharge from the Main/King Combined Sewer Overflow (CSO) facility to Chedoke Creek that occurred between January 28, 2014 and July 18, 2018. The Main/King CSO facility discharges to the lower section of Chedoke Creek which in turn outlets at the south shore of Cootes Paradise Marsh.

The Director's Order included requirements for an evaluation of the impacts of the sewage discharge to Cootes Paradise. The City retained SLR Consulting (Canada) Ltd. (SLR) to fulfil these requirements. Specifically, this report addresses the requirements of Item #3 and #4 of the Director's Order. Item #3 specifies that a written assessment of the environmental impact to Cootes Paradise from the sewage discharged between January 28, 2014 and July 18, 2018 should be submitted. The evaluation should include, but not necessarily be limited to:

- Identification of contaminants related to the sewage spill;
- Identification of known environmental impacts from the identified contaminants;
- Identification of anticipated ongoing environmental impacts from the identified contaminants;
- Spatial and environmental evaluation of the contaminants remaining in Cootes Paradise; and
- Proposed remedial actions and recommendations with justification including timelines.

In addition, Item #4 specifies that,

- '*the City shall submit to the Director a written surface water monitoring program for the impacted portion of Cootes Paradise as identified by the work performed in compliance with Item No.3 above and for Chedoke Creek. The surface water monitoring program should be designed to monitor any ongoing environmental impact on the area affected by the sewage spill described in Item No. 3 above*.'

APPROACH

The Environmental Impact Evaluation (EIE) of the Main/King CSO discharge to Cootes Paradise was based on existing information from numerous sources. The information reviewed included reports, research publications, memoranda, emails, data sets, figures and photographs. The impact evaluation focused on four ecosystem components: water quality, sediment quality, aquatic vegetation and fish community. The approach to evaluate impacts was similar for the four components and included comparisons of data, where available, representing conditions before, during and after the Main/King CSO discharge that occurred from 2014 to 2018. Locations in Cootes Paradise were compared with locations near Lower Chedoke Creek as appropriate to evaluate impacts of the CSO discharge on Cootes Paradise.

FINDINGS

Which contaminants were identified as being related to the CSO discharge and how?

Substances deemed to be contaminants of potential concern (COPCs) associated with the CSO discharge were identified by comparing analytical chemistry from surface water samples obtained immediately downstream of the Main/king CSO during the discharge period with applicable surface water quality guidelines and/or local background conditions. Local background concentrations were generally defined as concentrations of COPC (95th percentile) obtained at sampling stations in Chedoke Creek upstream of the Main/King CSO.

The final COPCs included (low) dissolved oxygen (DO), total suspended solids (TSS), un-ionized ammonia, total ammonia as N, nitrate (NO_3) as N, total Kjeldahl nitrogen (TKN), total phosphorus (TP), copper and *E. coli.*

Were impacts on surface water quality in Cootes Paradise identified?

Impacts on surface water quality in Cootes Paradise during the CSO discharge seem to have been limited to *E. coli* and TP (based on annual mean concentrations). The impacts were temporally limited and geographically localized. Concentrations of *E. coli* and TP above pre-discharge conditions were observed in 2018 only and near the mouth of Chedoke Creek and the monitoring station closest to the Bay (CP1). Understanding of the specific inputs from the CSO discharge for other water quality variables (e.g., DO and total ammonia as N) in Chedoke Creek were confounded by ongoing discharges from the former West Hamilton Landfill.

The review of surface water quality data for Chedoke Creek and Cootes Paradise indicated that COPC concentrations after the spill were comparable to concentration before the spill, supporting the conclusion that there is no evidence of long-term impact on Cootes Paradise.

Were impacts on sediment quality in Cootes Paradise identified?

Comparisons of select nutrients and metals concentrations in the sediment samples obtained in Cootes Paradise near the mouth of Chedoke Creek before and after the CSO discharge event did not indicate changes in concentrations resulting from the CSO discharge event. This finding is based on the limited sediment quality data for Cootes Paradise which only includes a few sampling events and to monitoring stations near the mouth of Chedoke Creek. In addition, physical disturbance through wave action and/or bioturbation confound the interpretation of sediment profiles to effectively preclude the time series of contamination in Cootes Paradise that would define the period of the CSO discharge.

Were impacts on aquatic vegetation identified in Cootes Paradise?

The evaluation of impacts on aquatic vegetation considered data collected for Cootes Paradise from 1996 to 2019 and scoped to 11 established aquatic vegetation monitoring stations. To the extent possible, based on available information, percent coverage of aquatic species and vegetation types (submergent, floating and emergent) was compared before, during and after the CSO discharge at locations far from (West End and North Shore – reference stations) and near (potential exposure) Lower Chedoke Creek.

Magnitude of increases and decreases in percent cover for floating and submergent vegetation types during the CSO discharge were similar to, or smaller than fluctuations prior to the CSO discharge at locations both far from, in or near Lower Chedoke Creek, thus within background variation.

Based on observations described above, and consistent with other published sources, assessment of available information does not show impacts on aquatic vegetation in Cootes Paradise associated with CSO discharge, independent from other potential influencing factors.

Were impacts on fish community identified in Cootes Paradise?

Fish community characteristics were compared before, during and after the CSO discharge period at the fishway where Hamilton Harbour and Cootes Paradise join, and at locations in Cootes Paradise far from (background reference) and near (potential exposure) to Lower Chedoke Creek. To facilitate the evaluation of impacts, fish in Cootes Paradise were classified according to four trophic levels as a function of their feeding behaviors and by their tolerance to water quality.

Spatial and temporal patterns of fish species sensitivity to water quality and changes in relative abundance of trophic feeding groups indicate that fish at the fishway, in Cootes Paradise, the vicinity of Lower Spencer Creek, and Lower Chedoke Creek may be influenced by regional factors. Combined, these observations indicate that assessment of available information does not show impacts on fish species relative abundance in Cootes Paradise associated with the CSO discharge, independent from other potential influencing factors.

Were remediation measures recommended?

Options to remediate Cootes Paradise were contingent on the assessment of impacts. Post-discharge levels of contaminants in surface water (except ammonia as N and low DO, which are believed to be components of landfill leachate entering Chedoke Creek) appear consistent with pre-discharge levels. Consequently, no ongoing adverse impacts to Cootes Paradise, as a result of the Main/King CSO discharge, were documented. In addition, the assessment of available information does not show adverse impacts on aquatic vegetation or on the fish community in Cootes Paradise associated with CSO discharge, independent from other potential influencing factors. Thus, remediation is not required to address impacts from the Main/King CSO discharge that occurred from 2014 to 2018, and the '**no action**' alternative was recommended.

Was surface water quality monitoring recommended?

The review of surface water quality data indicates that COPCs concentrations in Chedoke Creek and Cootes Paradise (near the mouth of Chedoke Creek) after the CSO discharge period are comparable to concentrations measured before the discharge event. These findings suggest that there are no persistent, elevated concentrations of COPCs associated with the Main/King CSO discharge remaining in these water bodies. The absence of any long-term impacts in Chedoke Creek and correspondingly within Cootes Paradise due to the discharge event supports the conclusion that there is no evidence of remaining environmental impact. Accordingly, a surface water monitoring program for the area affected by the sewage spill is not required.

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1.0 INTRODUCTION

SLR Consulting (Canada) Ltd. (SLR), with assistance from CanDetec Inc, was retained by the City of Hamilton (the City) to evaluate the environmental impact to Cootes Paradise from the sewage discharged between January 28, 2014 and July 18, 2018. The purpose of this Environmental Impact Evaluation (EIE) was to evaluate the potential impacts of a Main/King Combined Sewer Overflow (CSO) discharge to the receiving environment: Cootes Paradise. The Main/King CSO facility discharges to the lower section of Chedoke Creek which in turn outlets into the south shore of Cootes Paradise Marsh.

1.1 Background

A sewage discharge from the Main/King CSO facility to Chedoke Creek occurred between January 28, 2014 and July 18, 2018.

On November 28, 2019, the Ministry of Environment, Conservation and Parks (MECP) issued a Director's Order to the City. This Order contained items related to the unintended discharge of wastewater from the Main/King CSO tank that included evaluation of potential impacts to Cootes Paradise. This report addresses the requirements of Item #3 and #4 of the Director's Order. Item #3 specifies that a written assessment of the environmental impact to Cootes Paradise from the sewage discharged between January 28, 2014 and July 18, 2018 should be submitted. The evaluation should include, but not necessarily be limited to:

- Identification of contaminants related to the sewage spill;
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In addition, Item #4 specifies that,

- '*the City shall submit to the Director a written surface water monitoring program for the impacted portion of Cootes Paradise as identified by the work performed in compliance with Item No.3 above and for Chedoke Creek. The surface water monitoring program should be designed to monitor any ongoing environmental impact on the area affected by the sewage spill described in Item No. 3 above*.'

2.0 SITE SETTINGS

The following section provides contextual information on Cootes Paradise and its main tributaries: Spencer Creek, Ancaster Creek, Chedoke Creek and Borer's Creek. The Main/King CSO discharged to the lower section of Chedoke Creek (Figure 1, after the text).

2.1 Cootes Paradise Marsh

Cootes Paradise Marsh is part of the Cootes Paradise Nature Reserve owned and managed by the Royal Botanical Gardens (RBG). Cootes Paradise is a Provincially Significant (Class I) Wetland and an Area of Natural and Scientific Interest (ANSI) (City of Hamilton, 2020). In the

Hamilton Region, Cootes Paradise is listed as an Environmentally Sensitive Area (ESA). The Cootes Paradise nature sanctuary contains one of the highest biodiversity of plants per hectare in Canada and the highest biodiversity of plants in the region (City of Hamilton, 2020).

The marsh is a shallow, 320-hectare (ha) river-mouth wetland, discharging at an artificial opening into the west end of the Hamilton Harbour (City of Hamilton, 2020; Leisti et al., 2016). Cootes Paradise is approximately 3.5 kilometres (km) long, with a width ranging approximately 0.5 to 1 km at its widest, and a mean depth of 0.7 metres (m). The maximum surface area and volume of Cootes Paradise are estimated as 2.50 km^2 and $3.57x10^6$ m^3, respectively (Kim et al., 2018). However, the marsh is greatly affected by Lake Ontario water levels such that a 0.75 m change in the average annual water level will expose or cover 65% of marsh (Leisti et al., 2016).

The marsh transitioned from a historically mesotrophic system to a eutrophic system when the surrounding forested areas were converted to agricultural and urban land uses (Kim et al., 2018). Cootes Paradise Marsh has received nutrient inputs from agricultural run-off, urban runoff and multiple urban sources, such as effluent discharges from the Dundas Waste Water Treatment Plant (WWTP) and CSOs from the City of Hamilton (Routledge, 2012). In 1919, with the advancement of urbanization in the watershed, the Dundas WWTP was constructed, which originally discharged primary-treated sewage into Cootes Paradise with subsequent upgrades to secondary and then tertiary treatment in 1962 and 1978, respectively (Leisti et al., 2016). With tertiary treatment, most of the phosphorus is removed from the effluent before it is discharged into the marsh. In 1987, another improvement was implemented that removed sediment from the effluent prior to release. The Dundas WWTP discharges into Cootes Paradise at the Desjardins Canal (Hamilton Conservation Authority (HCA), 2010).

There are four CSO locations within the Cootes Paradise watershed: Ewen, Sterling, Royal, and Main/King. The Royal and Main/King CSOs discharge to Chedoke Creek, the Ewen CSO discharges to Ancaster Creek (a tributary to Spencer Creek), and the Sterling CSO discharges to an intermittent watercourse to Cootes Paradise when capacity of the combined sewer system is exceeded (McCormick Rankin Corporation, 2003). More than 600 km of combined sewers collect both sanitary and storm flows from an area of approximately 52 km (City of Hamilton, 2020). During dry periods and periods of light rainfall, flows are conveyed through the combined sewer system to the Woodward Avenue WWTP for treatment via the Western Sanitary Interceptor and ultimately released into Hamilton Harbour through the Red Hill Creek (McCormick Rankin Corporation, 2003). During large rainfall events, sanitary and storm water inflows exceed the capacity of the combined sewer system and the treatment plant and may overflow into the natural environment. As a result, CSO tanks were constructed in the mid-1980's, with the most recent tank commissioned in 2012, to prevent untreated wastewater from going directly into local receiving waters. The CSO tanks hold the untreated wastewater until the Woodward Avenue WWTP has capacity to treat it (City of Hamilton, 2020).

The hydraulic and nutrient loading of the marsh is predominantly driven by three main tributaries (Spencer, Chedoke and Borer's creeks) from the surrounding watershed (Kim et al., 2018). Spencer Creek accounts for the greatest phosphorus export amongst the three tributaries, contributing approximately 38% of the total annual phosphorus loading. Chedoke Creek was estimated to contribute 12% and Borer's Creek 2% (Kim et al., 2016). The contribution of urban run-off to the total annual phosphorus loading was estimated to be 20% while CSOs were estimated to contribute 14% and the Dundas WWTP 10% (Kim et al., 2016).

2.2 Spencer Creek

Spencer Creek watershed is one of the major Hamilton watersheds. It includes Upper Spencer, Middle Spencer and Lower Spencer watersheds.

Upper Spencer Creek subwatershed is 35.64 km^2 and is composed of seven catchment basins. Middle Spencer Creek subwatershed is 49.36 km^2. It is the largest subwatershed in the Spencer Creek system and comprises 13 catchment basins. Lower Spencer Creek subwatershed is 8.68 km^2 and includes five catchment basins. Lower Spencer is the final subwatershed in the Spencer Creek system before it outlets into Cootes Paradise Marsh. The Lower Spencer Creek subwatershed incorporates the majority of the Cootes Paradise Marsh (HCA, 2010, 2011 and 2012). Land use statistics provided by HCA (2010, 2011 and 2012) are summarized in Table 2-3.

Table 2-1:
Spencer Creek Watershed Land Use Statistics (Sources: HCA 2010, 2011 and 2012)

	Upper Spencer Creek Subwatershed	Middle Spencer Creek Subwatershed	Lower Spencer Creek Subwatershed
Land Use/Descriptor	Area (km^2)	Area (km^2)	Area (km^2)
Area	35.64	49.36	8.68
Agricultural	22.6	23.54	0.28
Commercial	0.7	3.91	0.06
Industrial	0.0008	4.75	0.12
Institutional	0.07	0.3	0.93
Open space	8	5.6	3.27
Residential	1.8	8.96	2.63
Utility	0.6	0.004	0.26
Impervious area (%)	0.01	3.5	68

Upper Spencer Creek is approximately 23 km long, the length of Middle Spencer Creek is approximately 20 km and the length of Lower Spencer Creek is approximately 3.5 km. Lower Spencer Creek outlets into the Desjardins Canal at Cootes Paradise.

HCA (2011) reported that the land use of Lower Spencer Creek subwatershed was predominately urban and that urban runoff captured by storm sewers that outlet into Lower Spencer Creek contributed to the overall input into Lower Spencer Creek, Cootes Paradise and Hamilton Harbour. As indicated earlier, Spencer Creek is estimated to be contributing 38% of the total annual phosphorus loading to Cootes Paradise (Kim et al., 2016).

2.3 Ancaster Creek

Ancaster Creek watershed is a subwatershed of Spencer Creek and covers an area of 13.7 km^2 (HCA, 2008a). Ancaster Creek is a major tributary to the main branch of Spencer Creek (within the Lower Spencer Creek subwatershed upstream of Cootes Drive). Ancaster Creek watershed includes 0.3% wetland and 30% forest (HCA, 2008a). Land use statistics provided by HCA (2008a) are summarized in Table 2-2.

Table 2-2:
Ancaster Creek Subwatershed Land Use Statistics
(Source: HCA, 2008a)

Land Use/Descriptor	Area (km^2)
Area	13.7
Agricultural	2.2
Commercial	0.3
Industrial	0.04
Institutional	1.0
Open space	2.3
Residential	5.6
Transportation	1.86
Utility	0.4
Impervious area (%)	36

Ancaster Creek is a coldwater system (HCA, 2008a). Several water quality concerns have been identified for Ancaster Creek, including the impacts of urban runoff (storm water) and individual and communal septic systems (McCormick Rankin Corporation, 2003).

2.4 Borer's Creek

Borer's Creek watershed is a subwatershed of Spencer Creek. Borer's Creek subwatershed covers an area of 19.5 km^2 and the majority of the subwatershed lies above the Niagara Escarpment (Halton-Hamilton Source Protection, 2017). The Borer's Creek watershed drains into the north side of Cootes Paradise Marsh south of York Road (HCA, 2009). Highways 5 and 6 cross this subwatershed, as does the Canadian National Railway. The northeastern corner of the subwatershed includes a portion of urban Waterdown, while the remainder of the subwatershed is primarily agricultural. Borer's Creek watershed includes 4.8% wetland, 51.6% naturally vegetated streambanks, 15% forest and 29.5% impervious surface (Hamilton Watershed Stewardship Program, non-dated). Land use statistics provided by HCA (2009) are summarized in Table 2-3.

Table 2-3:
Borer's Creek Subwatershed Land Use Statistics
(Source: HCA 2009)

Land Use/Descriptor	Area (km^2)
Area	19.5
Agricultural	9.71
Commercial	0.52
Industrial	0.74
Institutional	0.19
Open space	1.33
Residential	3.9
Transportation	-
Utility	0.05
Impervious area (%)	29.5

Borers Creek is approximately 11.9 km in length from its headwaters to its confluence with Cootes Paradise (HCA, 2009). Borer's Creek is described as a warmwater system above the Escarpment and a coolwater system below the Escarpment (Hamilton Watershed Stewardship Program, non-dated). HCA (2009) reported that results of benthic fauna sampling above the Escarpment, where both urban and agricultural land uses are prevalent, suggested stressed water quality conditions. "*A number of water quality impairments including nutrient and organic enrichment, high suspended solid loads, and variable water temperature and flows, have been identified as the cause of this impaired water quality*" (HCA, 2009). Water quality conditions downstream of the escarpment was noted to improve with groundwater inputs and shade provided by the extensive woodlands around the stream. Rainbow darter (*Etheostoma caeruleum*) have been found in Borer's Creek immediately below the escarpment (HCA, 2009).

2.5 Chedoke Creek

Chedoke Creek watershed covers an area of 25.1 km^2, with the headwaters located above the Niagara Escarpment. Chedoke Creek flows eastward and aligns parallel with Highway 403, within its lower section, before flowing into the south shore of Cootes Paradise Marsh. Chedoke Creek combined with Ancaster Creek and Borer's Creek account for 16% of the total watershed of the Cootes Paradise Marsh (Cootes Paradise Water Quality Group, 2012).

The watershed is predominantly urbanized with more than 70% of impervious surface. HCA (2008b) noted that "*much of the Chedoke Creek subwatershed has been altered over time as a result of intense urban development within the Hamilton area; subsequently the majority of the stream flow directly results from storm water input. Therefore, erosion, sedimentation and insufficient channel sizes occur at the outlet*". HCA (2008b) inventoried 19 storm water outfalls, including two CSOs discharging to Chedoke Creek. Land use statistics provided by HCA (2008b) are summarized in Table 2-4.

Table 2-4:
Chedoke Creek Subwatershed Land Use Statistics
(Source: HCA 2008b)

Land Use/Descriptor	Area (km^2)
Area	25.1
Agricultural	0.001
Commercial	0.7
Industrial	0.6
Institutional	3.2
Open space	3.0
Residential	11.0
Transportation	5.5
Utility	1.1
Impervious area (%)	76

Chedoke Creek is a warmwater system. Much of its length has been straightened and channelized and a significant length of stream is conveyed underground between Main Street, King Street West, and Highway 403. Downstream of Highway 403 and the Main Street Interchange, Chedoke Creek has been straightened and is characterized as a large drainage canal to Cootes Paradise. Chedoke Creek has been assessed as marginal fish habitat due to the highly altered nature of the watercourse.

Water quality in Chedoke Creek indicates contamination with urban sewage and cross connections, and urban runoff with high levels of nitrate, phosphorus and bacteria (*E. coli* and total coliform) commonly observed (Vander Hout et al., 2015). Chedoke Creek is generally considered to have degraded habitat conditions for aquatic life (SNC Lavalin, 2017). Chedoke Creek is estimated to be contributing 12% of the total annual phosphorus loading to Cootes Paradise (Kim et al., 2016).

The waters of Chedoke Creek are reported to "*bypass the majority of Cootes Paradise as it enters the marsh near the outlet to the harbour with minimal impact to the centre of the marsh*" (Theÿsmeÿer as cited in Cootes Paradise Water Quality Group, 2012).

The sections above describe characteristics of contributing catchments to Cootes Paradise providing background context. Detailed evaluation of the study area relies on data from Cootes Paradise and Chedoke Creek to assess potential impacts resulting from the Main/King CSO discharge.

3.0 INFORMATION GATHERING AND REVIEW

Assessment of potential impacts from the Main/King CSO discharge event to Cootes Paradise were assessed based on existing information from numerous sources. Where applicable information was available, surface water quality data, sediment quality data, aquatic vegetation and fish community data were compared with data from before, during and after the CSO discharge that occurred from 2014 to 2018.

3.1 Approach

Available information was gathered from numerous sources, including the following:

- City of Hamilton,
- Royal Botanical Gardens (RBG),
- Hamilton Conservation Authority (HCA),
- Hamilton Harbour Remedial Action Plan (HHRAP), and
- University of Toronto, Scarborough (UTSC).

The information reviewed included reports, research publications, memoranda, emails, data sets, figures and photographs. Each information source was initially assigned a document number and saved in a document library. A preliminary review of each information source was assigned an overall recommendation of the relevance of the information source (i.e., highly relevant, somewhat relevant, perhaps relevant to other disciplines, or not relevant to project). The most relevant information sources were reviewed further using the following criteria:

- Primary subject (e.g., water quality, sediment quality, aquatic vegetation, benthic invertebrates, fish);
- Timing relevant to period of sewage discharge;
- Study area, including sampling locations;
- Parameters related to storm and sanitary discharge;
- Analytical approach (e.g., trends, standards, objectives, guidelines);
- Validity of the information or data; and
- Identification of data gaps.

3.2 Analysis of Information

An extensive review was undertaken with over 93 information sources reviewed and summarized (Appendix A). The most relevant information was synthesized and used to evaluate the potential impacts of the discharge to the receiving environment, Cootes Paradise, including the following:

- Produced study areas from established sampling locations;
- Assessed relative magnitude of concentrations before, during and after discharge period;
- Considered other external factors that made interpretation of the magnitude of impacts difficult (e.g., lake water levels, limited data, other sources of contaminants to Chedoke Creek, other sources to Cootes Paradise);
- Considered data deficiencies or data gaps:
  - Surface water quality,
  - Sediment quality
  - Aquatic vegetation,
  - Benthic invertebrate indices, and
  - Relative abundance of fish species;
- Compared and screened against guidelines and objectives (i.e., water quality); and
- Synthesised and compared results from similar methods to identify potential impacts.

4.0 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

Contaminants of potential concern (COPCs) are substances that occur in environmental media, at concentrations potentially sufficient to cause adverse impacts on ecological receptors, typically as a result of anthropogenic activity. In the current report, substances deemed to be COPCs associated with the sewage discharge that occurred between January 28, 2014 and July 18, 2018 were identified. The COPCs were then carried forward into the evaluation of impacts (Section 5.0). This process was intended to focus efforts on those discharge-related contaminants that potentially caused or may continue to cause adverse impacts to the abiotic or biotic media in Cootes Paradise.

4.1 Approach

The COPC identification (or screening) process comprised the following four steps:

- Step 1: Compilation of dataset;
- Step 2: Compilation of Screening Benchmarks;
- Step 3: Identification of Preliminary COPCs; and
- Step 4: Refinement of COPCs.

4.1.1 Step 1: Compilation of dataset

The environmental medium considered in the COPC identification was surface water because the sources of contaminants was a CSO discharge to surface water. Two sampling stations located immediately downstream of the Main/King CSO were used for COPC identification: STN1 and CP11-outlet (Figure 2, after the text). The available surface water data from sampling events completed at these two locations during the discharge period (January 28, 2014 to July 18, 2018) were included in the dataset used for COPC identification. The dataset included a total of 32 surface samples, including eight field duplicates. The samples were collected between April 16, 2014 and July 18, 2018. The samples included in the dataset were analysed for one or more of the following parameter or group of parameters:

- Total suspended solids (TSS);
- Dissolved Oxygen (DO);
- pH;
- Anions;
- Nutrients;
- Total metals; and
- Bacteria *(E. coli)*

The dataset used for screening of COPCs is summarized in Appendix B.

4.1.2 Step 2: Compilation of Screening Benchmarks

The surface water results were compared to the Provincial Water Quality Objectives (PWQOs) and Interim PWQOs for the Protection of Aquatic Life (MOE[1], 1994 and updates) to identify COPCs. Where PWQOs were unavailable, guidelines and standards from other jurisdictions were selected if methods and protection goals aligned with MECP approaches. Additional sources of screening benchmarks included:

- Canadian Environmental Quality Guidelines (CCME) Water Quality Guidelines (WQG) for the Protection of Aquatic Life (CCME, 2008);
- BC Approved WQG for the Protection of Freshwater Aquatic Life (AWF) Long-term Values (BC ENV, 2019); and
- BC Working WQGs for the Protection of AWF Long-term Values (BC ENV, 2017).

The long-term values were selected, when available.

4.1.3 Step 3: Identification of Preliminary COPCs

Surface water COPCs were identified by comparing the selected screening benchmark to the maximum concentration identified in the dataset representing the discharge period. This approach was used to ensure that all substances potentially adversely affecting aquatic life were identified. If no guideline was available for a parameter, it was retained as an uncertain COPC.

As a summary, substances in surface water were identified as a preliminary COPC ("Yes"), not a COPC ("No"), or an uncertain preliminary COPC ("Uncertain") using the following decision criteria:

- Maximum > Preliminary Screening Benchmark = Yes;
- Maximum < Preliminary Screening Benchmark = No;
- Not detected and maximum detection limit < Preliminary Screening Benchmark = No;
- No screening benchmark = Uncertain.

[1] Now the Ministry of Environment Conservation and Parks (MECP)

4.1.4 Step 4: Refinement of COPCs

To ensure that the impact assessment focused on evaluating the COPCs associated with the CSO discharge event, a COPC refinement process was implemented. COPC refinement was based on comparison to local background concentrations. Local background concentrations are defined, in this report, as concentrations of COPC obtained at sampling stations CC-3 and CC-5 in Chedoke Creek upstream of the Main/King CSO (Figure 2, after the text). Surface water quality data for the upstream samples were available in 2018 during the spill. These data were used to calculate the upper limit of background (95th percentile) during this period. Data were available for TSS, pH, DO, *E. coli* and nutrients. Metal data were not available in Chedoke Creek upstream of the Main/King CSO during the discharge event. For this reason, 95th percentiles for metals were calculated for the location immediately downstream of the CSO (STN1) using data obtained before the discharge event (May 2002- October 2013) (SNC-Lavalin, 2019).

As a summary, a preliminary COPC or an uncertain COPC was retained as a final COPC ("Yes"), or excluded as a COPC ("No"), using the following decision criteria:

- Maximum < 95th percentile during discharge event at local upstream Chedoke Creek Locations = No;
- Maximum < 95th percentile before the discharge event at location STN1 immediately downstream of Main/King CSO = No;
- Maximum > 95th percentile during discharge event at local upstream Chedoke Creek Locations = Yes; and
- Maximum> 95th percentile before the discharge event at location STN1 immediately downstream of Main/King CSO = Yes.

4.2 Findings

The preliminary and final COPC screening results are summarized in Table 4-1 and discussed below the table. Table 1, after the text, provides details on the parameters screened, 95th percentile values and applicable screening benchmarks.

Table 4-1:
Summary of Preliminary and Final COPCs

Parameter or group of Parameters	Preliminary COPCs	Preliminary Uncertain COPCs	Final COPCs
Physicochemical	DO	TSS	DO and TSS
Nutrient	Un-ionized ammonia, nitrate, nitrite, total phosphorus (TP)	Ammonia as N and total Kjeldahl nitrogen (TKN)	Un-ionized ammonia, Ammonia as N, nitrite, TKN and TP
Metals	Boron, chromium, cobalt, copper, iron and zinc	Barium, calcium magnesium, sodium	Copper
Bacteria	*E coli*	-	*E coli*

DO, un-ionized ammonia, nitrate and nitrite as N, total phosphorus, boron, chromium, cobalt, copper, iron, zinc and *E. coli* were selected as preliminary COPCs based on the maximum concentrations exceeding the preliminary screening benchmarks (PWQO or WQGs).

These COPCs, apart from nitrate, boron, chromium, cobalt, iron and zinc, were retained as final COPCs based on the maximum concentrations exceeding the refined screening benchmarks (e.g., 95th percentiles at local upstream background or at STN1 before the discharge event). Nitrate, chromium, cobalt, iron and zinc were not retained as final COPCs because the maximum concentrations during the spill were less or equal to the upper limit of the concentrations (95th percentiles) obtained at STN1 before the discharge event.

The PWQO for boron is an interim objective set for emergency purposes based on the best information readily available and was not subject to peer review and formal publication (MOE, 1994 and updates). All total boron concentrations are less than the CCME long-term WQG for the Protection of Aquatic Life of 1500 µg/L[2]. Boron was therefore not retained as a final COPC in surface water.

TSS, ammonia as N, TKN, barium, calcium magnesium and sodium were identified as preliminary uncertain COPCs based on the lack of screening benchmarks for these parameters. TSS was retained as a final COPC based on the maximum concentration exceeding the 95th percentile at the local upstream background locations. Note that the decision to retain TSS is considered to be conservative as higher TSS values were observed immediately downstream of the Main/King CSO prior to the discharge event (Table 1, after the text). Ammonia as N and TKN were retained as final COPCs based on the maximum concentrations exceeding the 95th percentiles at the local upstream background locations and/or immediately downstream of the CSO prior to the discharge event. Barium, calcium, magnesium and sodium were dismissed as final COPCs because the maximum concentrations were lower than the 95th percentiles obtained immediately downstream of the CSO before the discharge event.

5.0 IMPACTS EVALUATION

5.1 Surface Water

An evaluation of the impacts of the Main/King CSO discharge event on surface water quality in Chedoke Creek and Cootes Paradise was undertaken. This evaluation was undertaken to assess the impact of the discharge on the water quality of Chedoke Creek and subsequently on Cootes Paradise. The COPCs identified in Section 4.2 were used to guide the selection of surface water quality variables considered here.

With respect to surface water quality in Cootes Paradise, only stations proximal to the mouth of Chedoke Creek were considered for direct comparison with the surface water quality of Chedoke Creek. The stations further afield suggested other factors were more likely dominant; nevertheless, an evaluation of surface water quality in Cootes Paradise was undertaken which focused on six monitoring stations selected to represent a spatial gradient from the mouth of Chedoke Creek to the farther shore of Cootes Paradise.

[2] The CCME WQG for boron was developed in 2009 following CCME protocol (CCME, 2009).

5.2 Approach

The evaluation of surface water quality in Chedoke Creek focused on the following components:

1. Evaluation of available data sources that could provide sufficient, comparable data for establishing baseline conditions (before the discharge event), defining conditions during the event (i.e., samples between January 28, 2014 and July 18, 2018) and for assessing whether or not conditions returned to baseline after the event;
2. Assessment of the measured data with respect to their ability to differentiate between wet or storm event samples versus low flow or dry condition samples;
3. Evaluation and analysis of external influences on the quality of Chedoke Creek water;
4. Evaluation of COPCs in Chedoke Creek under before, during and post-discharge event conditions;
5. Evaluation of COPCs in Cootes Paradise proximal to the mouth of Chedoke Creek under before, during and post-discharge event conditions; and,
6. An evaluation of water quality in Cootes Paradise based on six monitoring stations selected to represent a spatial gradient from the mouth of Chedoke Creek to the farther shore of Cootes Paradise.

5.2.1 Surface Water Dataset

5.2.1.1 *Available Data Sources*

Surface water quality data used to support the assessment of surface water conditions in Chedoke Creek and Cootes Paradise were available from the following four main sources:

- West Hamilton Landfill Leachate Collection System Performance Report – 2002-2019 (SNC Lavalin, 2018, 2019 and 2020);
- Hamilton Conservation Authority Tributary Monitoring for Cootes Paradise – 2015, 2018, 2019 (Excel dataset provided by the City of Hamilton);
- Royal Botanical Gardens Cootes Paradise Monitoring – 1994-2019 (Excel dataset provided by the City of Hamilton); and,
- Chedoke Creek Ecological Risk Assessment – 2019 (SLR, 2020.

Table 5-1 summarizes the surface water quality data used in the evaluation of surface water quality. Figure 2, after the text, shows the locations of the surface water sampling stations.

Table 5-1:
Summary of Surface Water Data

Location	Station ID	Year[a]	Parameters[b]	Source
Chedoke Creek Upstream of Main/King CSO	CC-5, CC-5a[c] and CC-3	April 2018-December 2019	TSS, DO, pH, nutrients, *E. coli*,	HCA Excel datasheet[d]
Chedoke Creek Immediately downstream of Main/King CSO	STN1	May 2002 - October 2019	TSS, DO, pH, nutrients, total metals	SNC Lavalin, 2017b and 2019
	CP11-Outlet	June-September 2018	TSS, DO, pH, nutrients, *E. coli*	HCA Excel datasheet
	C-1 West and G-1 Comp	September 2019	TSS, DO, pH, nutrients, *E. coli,* total metals	SLR, 2020

Location	Station ID	Year[a]	Parameters[b]	Source
Chedoke Creek downstream of Main/King CSO	CC1 and CP11	May 2002-October 2019	TSS, DO, pH, nutrients, *E. coli*	HCA Excel datasheet[d]
	STN3, SWC2, STN4, STN7 and STN 9	May 2002 - October 2019	TSS, DO, pH, nutrients, total metals	SNC Lavalin, 2017b and 2019
	C-3 Centre, C-3 West, C-4 West, C-5 east and G-4 Comp	September 2019	TSS, DO, pH, nutrients, *E. coli,* total metals	SLR, 2020
Cootes Paradise	CP11.2, CP1, CP2, CP5 and CP20	May 2002-October 2019	TSS, DO, pH, nutrients, *E. coli*	RBG Excel datasheet[d]
	Boat Launch	September 2019	TSS, DO, pH, nutrients, *E. coli,* total metals	SLR, 2020

a-Sampling dates do not provide full yearly records, limited sampling occurred each year; not all stations were sampled on same dates
b-Not all stations were sampled for all parameters
c- Station CC-5 and CC-5a were combined for statistical analysis.
d-provided by City of Hamilton

Two surface water quality monitoring stations, CP11.2 and C-6 East, were located in Cootes Paradise near the mouth of Chedoke Creek and were considered in association with both the Chedoke Creek and Cootes Paradise stations. Three stations, CP1, CP2 and CP20, were located in the main body of Cootes Paradise. One station, CP5, was located in West Pond (Figure 2, after the text). Station CP11, at the downstream end of Chedoke Creek was also added to the Cootes Paradise dataset to provide a reference for Chedoke Creek water quality discharging into the marsh.

5.2.1.2 *Data Limitations*

Assembling the dataset for Chedoke Creek presented a number of limitations that can be summarized as follows:

- Limited Data – the number of samples vary annually within and between the source datasets. For example, the SNC-Lavalin (2019) data set generally consisted of two to three samples annually throughout the record that extended from 2002 to 2019, whereas the upstream stations sampled by the HCA included as many as 19 samples annually but only in 2018 and 2019 with a few samples prior to those years. CP11-Outlet (located at the downstream end of the Glen Road box culvert) was a temporary location which was only sampled in 2018: three times during the discharge event and five times after it ceased discharging.
- Poor representation of samples over the hydrologic cycle – Neither the RBG dataset nor the SNC-Lavalin (2019) dataset for Chedoke Creek provided documentation regarding stream flow at the time of sampling.
- Surface water quality variables measured were inconsistent; therefore, limiting the pooling of data – The SNC-Lavalin (2019) data set included nutrients, biophysicals and metals but not bacteria, whereas the HCA data included nutrients, biophysicals and *E. coli* but metals were only sampled in 2015.
- Storm flow versus base flow – With the exception of the HCA data, most samples were not differentiated between low or base flow versus storm flows which makes partitioning of storm flow data, when CSO flows should be highest, difficult to impossible especially given the absence of continuous discharge records for Chedoke Creek.

HCA (2019) partitioned their data with respect to wet events and dry or base flow conditions as illustrated in Table 5-2 for station CP11 in Chedoke Creek. The standard deviation for the wet and dry event averages were not provided although the small differences in measured concentrations at CP11 between the dry and wet events would suggest that the concentrations are not statistically different given the natural variability of concentrations of TP, TSS and nitrate in Chedoke Creek which is discussed further below. There may be a statistical difference between wet and dry events for *E. coli.* but without further information this cannot be assessed.

Table 5-2:
Average Concentrations (for Dry or Base Flow, Wet Events, and Total Samples) for Station CP11 in Chedoke Creek (HCA, 2019) for Selected Water Quality Variables

Surface Water Quality Parameter	Dry Flow or Wet Event	Average Concentration CP11
TP (mg/L)	Dry (21 events)	0.506
	Wet (5 events)	0.490
	Total (26 events)	0.497
TSS (mg/L)	Dry Events	19.19
	Wet Events	13.18
	Total Average	17.99
Nitrate (mg/L)	Dry (21 events)	1.70
	Wet (5 events)	0.943
	Total (26 events)	1.492
E. coli (CFU/100mL)	Dry (21 events)	14626.2
	Wet (5 events)	446736.0
	Total (26 events)	19471.0

Based on the wide variability in the selected water quality indicators considered in this report and the other limitations in the data set as noted above, it was determined that the appropriate means to approach the comparison would be to partition the data sets with respect to baseline conditions (before the discharge event), defining conditions during the event (i.e., samples between January 28, 2014 and July 18, 2018) and assessing whether or not conditions returned to baseline after the event (post July 18, 2018). This approach would provide potentially broad characterizations of surface water quality with larger data sets that should provide greater confidence if differences were identified temporally and/or spatially.

Flow data, the calculation of loads and the apportionment of loads to different sources would have provided an alternative assessment. However, a hydrograph could be simulated for Chedoke Creek based on a pro-rated flow model utilizing data from Spencer Creek, Red Hill Creek and Grindstone Creek, all of which have extensive flow records, this effort would have provided limited additional understanding of the impact of the discharge event as there is no data of the volume discharged from the CSO relative to total discharge volume of Chedoke Creek. Thus, the best that could be calculated is total annual loading between the baseline conditions and those of the discharge event. The data limitations noted above, and in particular the absence of quality and quantity data from the CSO, limited any understanding that could be gained from this approach, thus making it a futile exercise.

5.3 Findings - Chedoke Creek

The final COPCs identified in Section 4 were DO, TSS, ammonia (un-ionized), ammonia as N, nitrite, TKN, TP, copper and *E. coli*. Consistent data to evaluate the impact of the CSO discharge were available only for an assessment of DO, TSS, un-ionized ammonia TP and *E coli*. Although *E. coli* data were only available at a limited number of sample stations (CC-5, CC-3, CP11-Outlet, CP11, C6-East in Chedoke Creek and CP11-2 and CP 1 in Cootes Paradise near the mouth of Chedoke Creek). Copper data were only available from the SNC-Lavalin (2019) data set and will only be briefly considered here. The data sets for nitrite and TKN were too limited and will not be considered.

5.3.1 West Hamilton Landfill

As noted, one of the main sources of data for Chedoke Creek was from the receiving water samples collected as part of the landfill leachate monitoring and leachate collection system performance reports that have collected data since 2002 from Chedoke Creek. The former West Hamilton Landfill, now referred to as Kay Drage Park is located north of King Street between the CP Rail Line and Highway 403. The landfill operated from the 1940s through to 1974 although cover and foundry sand continued to be added until 1977 (SNC-Lavalin, 2019). The landfill is located between the natural high bar formed during the post-glacial Lake Iroquois and the current location of Chedoke Creek and Cootes Paradise. This bar, located to the northeast of the landfill, consists of sands and gravels with groundwater distributed between Hamilton Harbour to the northeast and Chedoke Creek and Cootes Paradise to the west.

Chedoke Creek and the landfill are within a valley cut into the Queenston Shale. The post-glacial overburden within the valley consists of alluvial sediments, glacio-fluvial sand and glacio-lacustrine clay, silt and sand that may be in excess of 50 m thick (SNC-Lavalin, 2019).

Peto MacCallum Ltd. (2006) completed 12 boreholes in support of a slope stability study between Highway 403 and Chedoke Creek downstream of Glenn Road. Lake Ontario water levels in June 2006 when these boreholes were completed was 74.89 m above sea level (masl) (http://www.tides.gc.ca/C&A/network_means-eng.html#tabs1_5). Lake Ontario water levels were normal in 2006 with limited variability due to the control of the water levels. The boreholes were completed to elevations generally between 72 and 68 m asl, or up to almost 7 m below the water level of Chedoke Creek. The logs from the boreholes generally showed completion into clay at around 70 masl or over 4 m below the water level in Chedoke Creek at the time. Above the clay there were layers of variable thickness of permeable sand and gravel, sand, silty sand, alluvium and in some cases organic layers with these intermixed with less permeable silty clay to clay layers. In general, permeable strata dominated at comparable elevations to Chedoke Creek.

Urban and Environmental Management Inc. (UEM) (2016) completed a groundwater quality monitoring report covering the period 2009 to 2015. Surface water quality variables measured were inconsistent; therefore, limiting the pooling of data. The SNC-Lavalin (2019) data set included nutrients, biophysicals and metals but not bacteria whereas the HCA data (Excel dataset provided by the City of Hamilton) included nutrients, biophysicals and *E. coli.*

The fill material within the landfill had been described by Gartner Lee (2001) generally as:

- A cover layer of clay/sand about 1 m thick;
- Middle layer: foundry sand between 3 to 5 m thick; and
- Bottom layer: 7 – 10 m of municipal waste.

The municipal waste, as described in the core logs, consisted of mixed plastic, wood, metal, glass, wire and paper and other debris (Gartner Lee, 2001). In general, the landfill extended to about 10 m below ground surface (bgs) and where boreholes continued, interbedded layers of sandy-silt and clayey silt were identified to a depth of 18 m bgs. Leachate from the shallow monitor wells downgradient from the landfill generally showed PWQO exceedances for phenols, un-ionized ammonia, chloride, boron, cadmium, cobalt, copper and zinc (UEM, 2016).

In 2005 a leachate purge well system was installed at a known seep location to Chedoke Creek. The purge well system was replaced in late 2007 and early 2008 with a perforated infiltration pipe along Chedoke Creek and at 300 mm above the general water level. An extension of the original infiltration drain was added to the south between April and October 2017 during which time the leachate collection system was not operated except for some time in July (SNC-Lavalin, 2019).

The purpose of this discussion regarding the landfill was to demonstrate that, as is evident from the leachate assessment reports, the infiltration drain is intercepting substantial quantities of leachate from the landfill. However, there remains the potential for considerable quantities of leachate to reach Chedoke Creek. Groundwater circulation into Chedoke Creek will continue in the approximately 4 m of permeable substrate beneath the infiltration drain. Once groundwater elevation drops below the elevation of the invert of the drain, it will no longer effectively intercept the leachate which will then surface in Chedoke Creek. In contrast, high water levels in Chedoke Creek can result in a reversed gradient with flow from the creek into the drain. This is evidenced in the 2017 monitoring year (SNC-Lavalin, 2018) when the high pump volumes in March and April were attributed to the elevated water level in the creek (Figure 5-1). The pump was generally not operating from April to October as noted above. The reduced pumping volumes in October to December were attributed to lower creek water levels and reduced leachate production due to low precipitation (SNC-Lavalin, 2018). Nevertheless, loadings of leachate to Chedoke Creek, while not quantified, can reasonably be expected to occur at elevations below the drain and the potential impact of this contribution to Chedoke Creek surface water quality must be considered in the context of the discharge event from the CSO between 2014 to 2018.

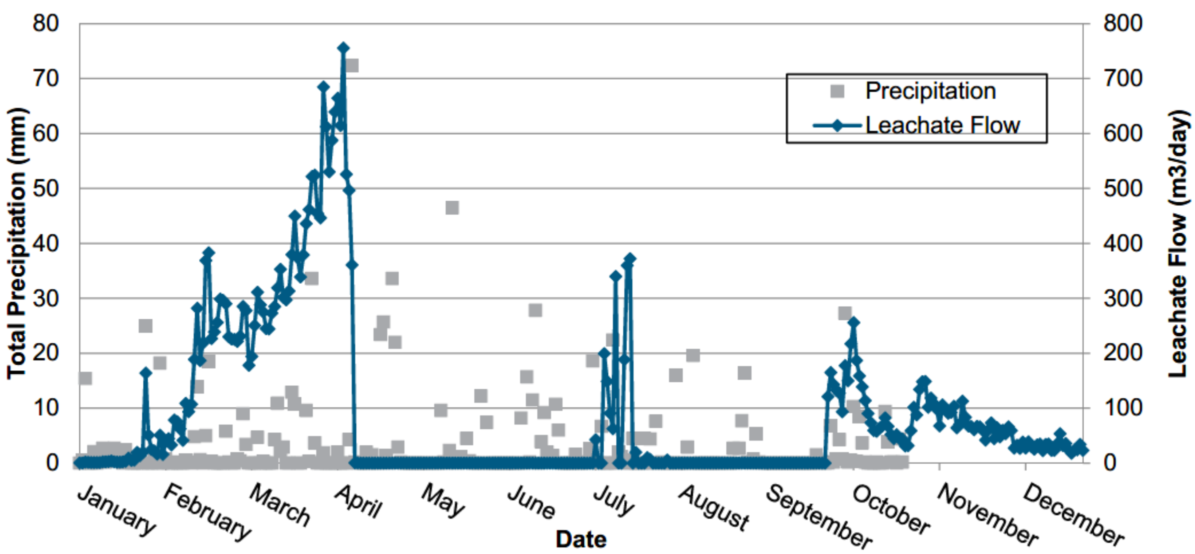

Figure 5-1:
Daily leachate pump volumes from perforated drain and precipitation, 2017 (SNC-Lavalin, 2018)

5.3.2 Chedoke Creek Surface Water Quality

As noted above, the aggregated data sets will be considered for the COPCs with sufficient data to evaluate conditions in Chedoke Creek and in particular to assess whether or not a measurable impact from the January 28, 2014 to July 18, 2018 discharge can be discerned relative to the baseline (pre-2014) and post event quality. Data from the surface water receiver monitoring study of the leachate collection performance reports will also be considered. These data help understand the possible impact of the leachate discharging to Chedoke Creek and provide context to conditions observed in the creek. Statistical summaries of the water quality data are provided in Appendix B.

5.3.2.1 *Dissolved Oxygen (DO)*

The DO pattern in the creek prior to January 2014 was on average relatively stable between 10 and 12 mg/L but with considerable variance as indicated by the 1 standard deviation bars in Figure 5-2. The lowest DO concentration in Chedoke prior to January 2014 was 2.2 mg/L recorded at STN7. Concentrations in Cootes Paradise (CP1) were comparable to concentrations in Chedoke Creek.

During the discharge event, DO concentrations drop by about 7 mg/L between upstream and downstream of the CSO outfall (CP11-Outlet) but tended to recover at STN1, likely because of the drop structure located just upstream of STN 1. This would serve to aerate the water. However, DO drops in Chedoke Creek downstream during the discharge event with average concentrations as low as 6 mg/L at STN 7 and extreme minimums as low as 2.2 mg/L.

Except for CP11, the post July 2018 data set does not return to the DO levels that apparently existed prior to the discharge event. This may be due to the limited number of samples used to characterize conditions post July 2018 (e.g. 6 samples at STN 1 versus 34 samples at CP11).

The increase in DO at CP11 shown on Figure 5-2 for the periods before, during and after the discharge generally reflects the large number of samples taken at this location relative to other sample sites. The additional samples at CP11 provide a better characterization of baseline (n = 97), discharge event (n = 79) and post discharge event (n = 35) over a broader range of conditions as compared to the other sites. By comparison, the DO average concentration for the STN7, immediately upstream, is based on n= 22 for baseline conditions , n = 14 for the discharge event and n = 3 for the post discharge event period. Similarly, the low DO measurements at CP11-Outlet were based on only 3 samples representing the discharge event in 2018 and these three samples do not adequately represent conditions over the four years of the discharge event.

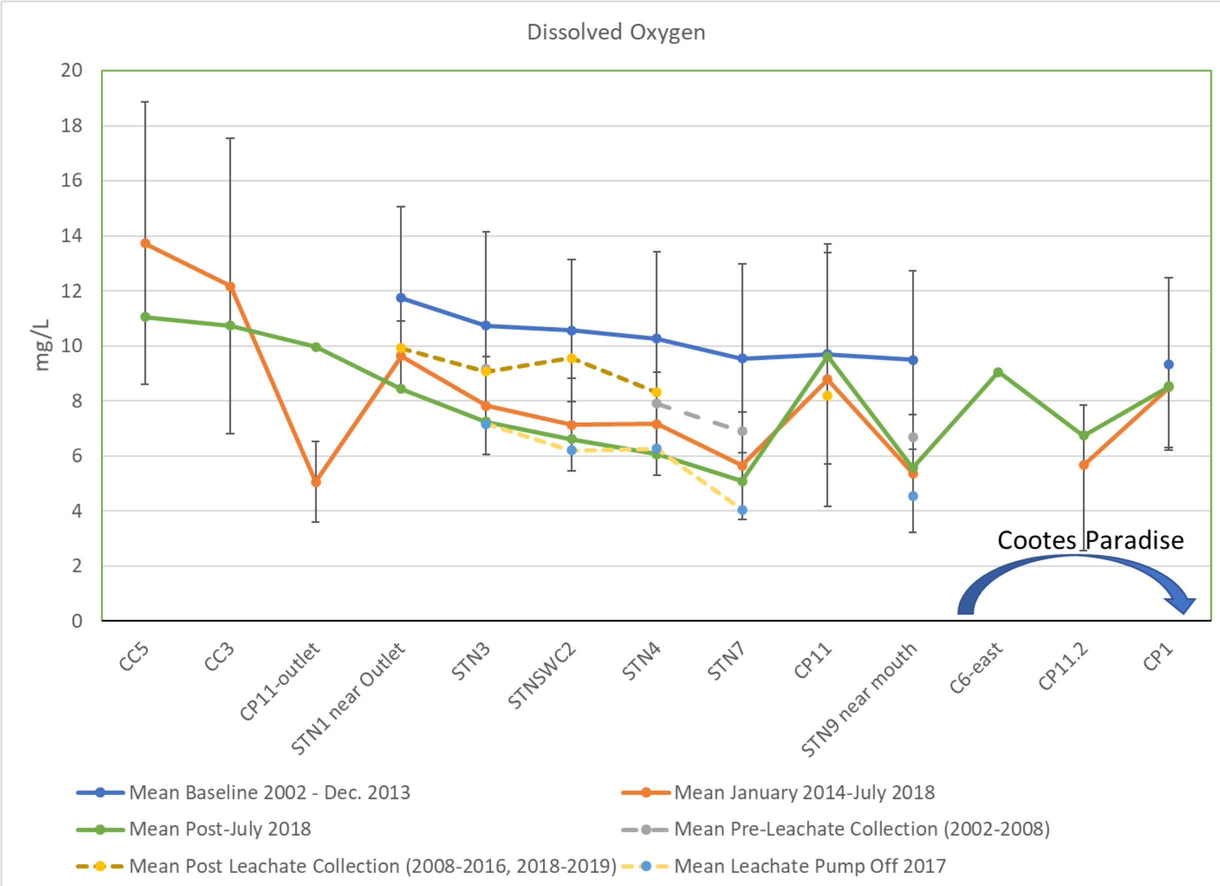

Figure 5-2:
Chedoke Creek and Cootes Paradise dissolved oxygen concentrations

The DO concentrations for the pre-leachate collection period, the mean post-leachate collection period and the period when the leachate pump was off are also illustrated here. UEM (2016) reported quite variable DO concentrations in groundwater from the landfill from 1.4 to 7.8 mg/L. It appears that leachate entering the creek may be causing the DO sag downstream of STN1. This is supported by the post July 2018 data which parallel the DO concentrations measured in 2017 when the leachate pump was shut down which would result in a higher loading of leachate to the creek. The impact of the leachate on DO in Chedoke Creek is less apparent with the more extensive sampling conducted at CP11 and this may be attributable to the sample number differential (n = 6 for post July, 2018 at STN1 versus n = 35 for CP11). When data were available, concentrations of DO rose in Cootes Paradise relative to Chedoke Creek. Sediment samples collected in Chedoke Creek in 2019 by SLR consisted predominantly of sand and silt with low organic matter which would not result in an oxygen demand within the creek itself.

In conclusion, the discharge event appeared to have a short-lived impact on DO in Chedoke Creek, but this was mitigated fully by the aeration achieved at the drop structure. The DO sag in Chedoke Creek downstream of STN1 is probably due to the continuous loading of low DO leachate water into the creek especially during baseflow conditions typified by the SNC-Lavalin data set. Data limitations complicate the interpretation of the data and the differentiation of a cause-effect relationship with respect to the discharge event.

5.3.2.2 *Total Suspended Solids (TSS)*

Average baseline concentrations of TSS (pre-2014) in Chedoke Creek ranged between 15 and 30 mg/L with considerable individual sample variability as evidenced by the 1 standard deviation bars provided in Figure 5-3. Relative to these baseline conditions and the TSS concentrations post-July 2018, the CSO discharge event tended to increase TSS concentration on average by 25 to 40 mg/L. However, this is within the range of the natural variance of TSS at STN1 prior to 2014. Downstream of STN1, TSS ranged from 12 to 31 mg/L through to STN 9 with a high degree of individual sample variability. TSS did rise in Cootes Paradise likely due to factors unrelated to input from Chedoke Creek.

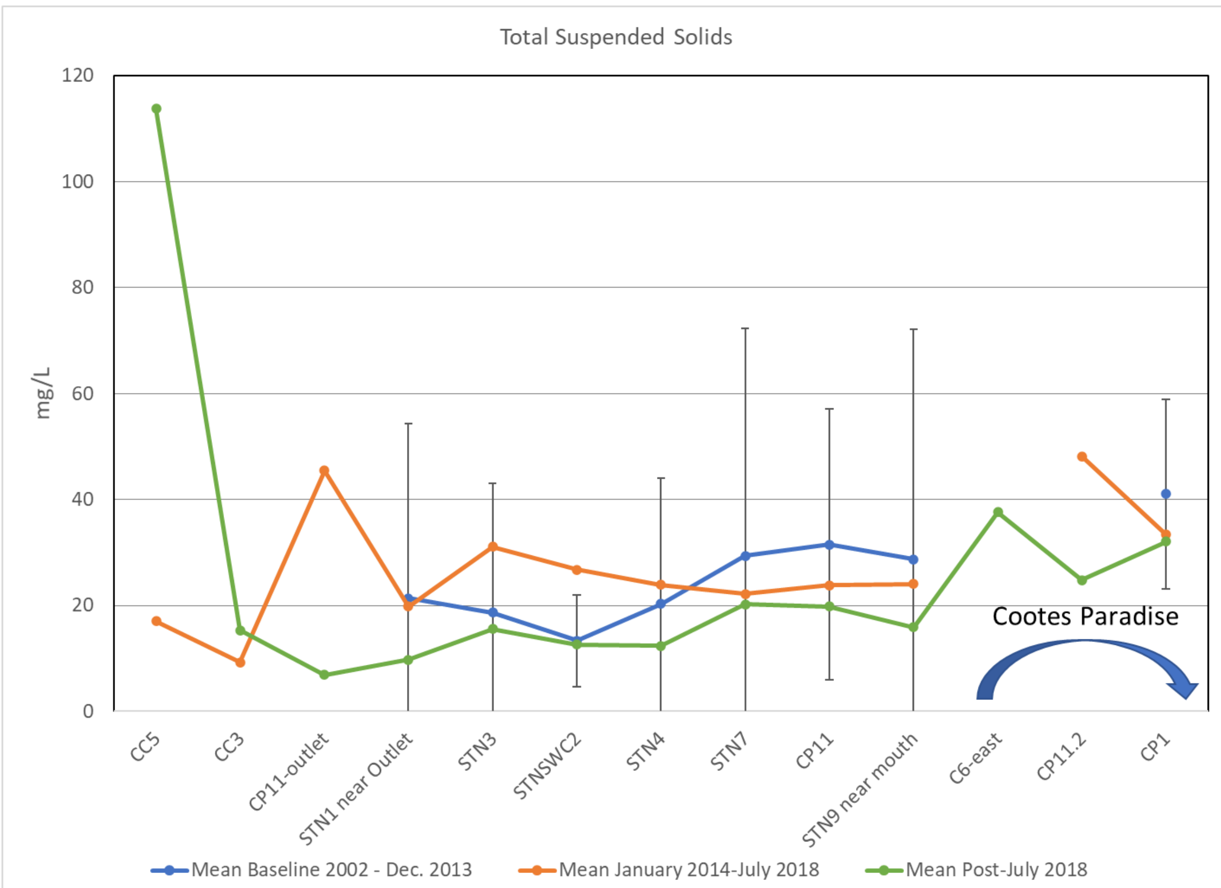

Figure 5-3:
Chedoke Creek and Cootes Paradise total suspended solids concentrations

Groundwater carrying leachate will not contain significant concentrations of particles: therefore, the TSS impact of the leachate will be minimal. In summary, while the discharge event did have some direct impact on TSS in Chedoke Creek, this was quickly assimilated downstream and was not outside of the natural variability of TSS within this section of Chedoke Creek.

5.3.2.3 *Ammonia as N*

Ammonia measured as N baseline concentrations in Chedoke Creek show low levels at Stn. 1 (0.09 mg/L) but concentrations rise consistently downstream peaking an order of magnitude higher at STN4 and STN9 at 0.77 and 0.75 mg/L, respectively (Figure 5-4). These concentrations are very similar to concentrations measured after July 2018. When the stream data for post-leachate collection and with the leachate pump off in 2017 are plotted, it is evident that there is a contribution of ammonia from the leachate both when the pump is operating and especially when the pump was not operating in 2017. Unfortunately, there are no data for CP11 – Outlet although the mean concentrations between January 2014 and July 2018 suggest there is a bump of about 1 mg/L at STN1 with a gradual rise through the system to STN9 at 2.3 mg/L. This increase would appear to be primarily attributable to the unquantified impact of leachate reaching Chedoke Creek. Concentrations in Cootes Paradise near the mouth of Chedoke Creek quickly declined to around 0.01 mg/L during the discharge event.

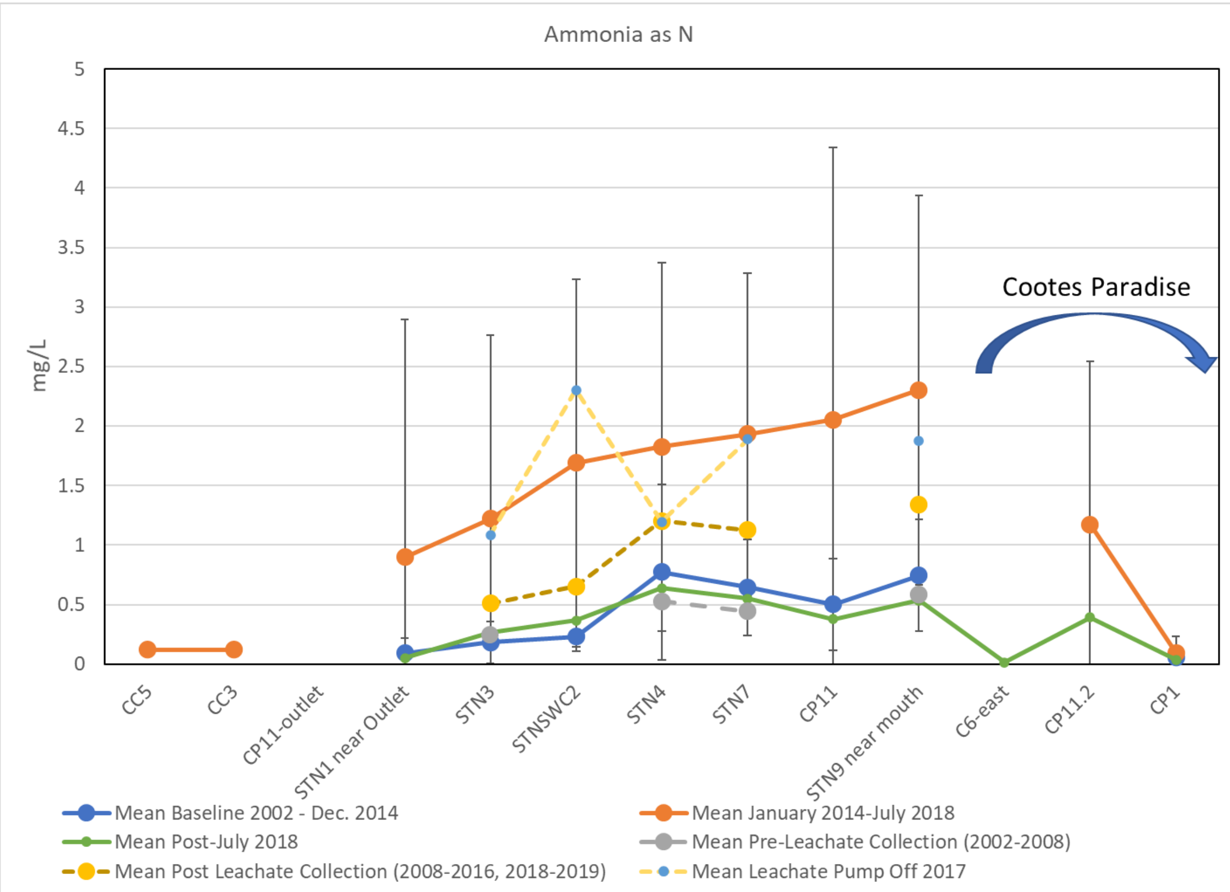

Figure 5-4:
Chedoke Creek and Cootes Paradise ammonia as N concentrations

In conclusion, while there appears to have been some impact on ammonia as N concentrations in Chedoke Creek resulting in an increase in ammonia of about 1 mg/L at Stn. 1, there has been an ongoing influence from leachate reaching the watercourse. The natural variability of ammonia concentrations precludes a conclusion regarding a statistically significant impact of either the discharge event or the leachate.

5.3.2.4 *Un-ionized Ammonia*

Although the data are limited, un-ionized ammonia, not surprisingly, has a similar interpretation to that of ammonia. Upstream concentrations are very low and these increase at STN1 during the 2014 to 2018 period by 0.027 mg/L (Figure 5-5) over upstream and 0.020 mg/L over baseline conditions at STN1. However, the continued increase in un-ionized ammonia downstream appears to be a result of the contribution from leachate or other unquantified sources to Chedoke Creek. Un-ionized ammonia concentrations are highly variable because they are calculated based on total ammonia concentrations and are dependent on water temperature and pH. After July 2018, un-ionized ammonia concentrations in Chedoke Creek are all less than the PWQO. The undifferentiable influence from the discharge event and the leachate; however, have had no identified impact on Cootes Paradise as un-ionized ammonia concentrations at CP11-2 after July 2018 (n = 16) were comparable to upstream baseline concentrations and upstream discharge event concentrations; but all decreased to below the PWQO of 0.02 mg/L at CP1 (n = 14).

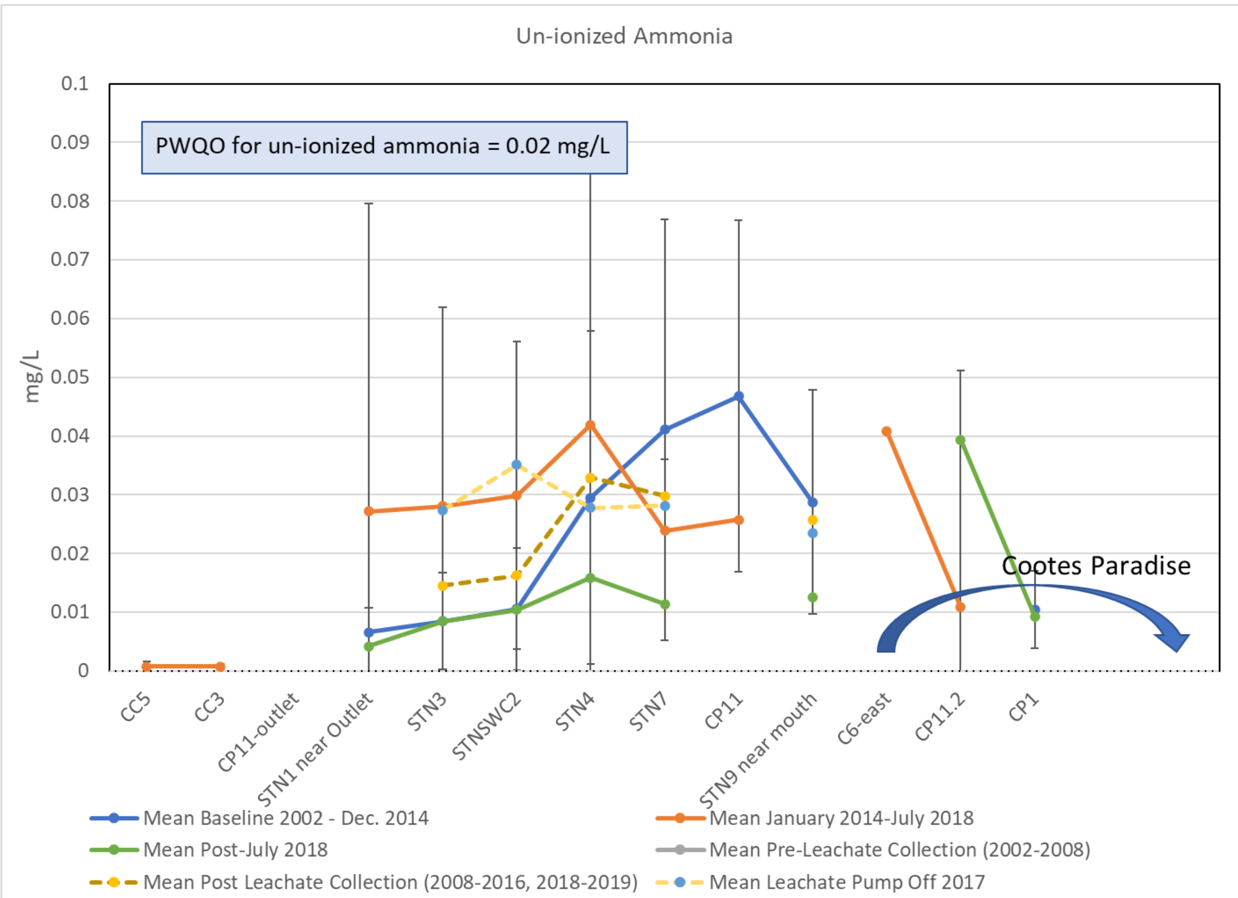

Figure 5-5:
Chedoke Creek and Cootes Paradise un-ionized ammonia concentrations

In summary, the discharge event had no differentiable impact on un-ionized ammonia in Chedoke Creek.

5.3.2.5 *Total Phosphorus (TP)*

The discharge event evidently produced elevated TP concentrations at CP11-Outlet averaging 2.3 mg/L and about 2 mg/L above the upstream concentrations and the baseline concentrations in Chedoke Creek. However, TP concentrations were quickly assimilated in the creek returning to concentrations that were about 0.5 mg/L or double the baseline and post discharge event concentrations (Figure 5-6). TP concentrations vary widely and there is no indication that the average in-stream concentration during the 2014 to 2018 period can be statistically differentiated from background concentrations. TP concentrations in both Chedoke Creek and Cootes Paradise exceed its PWQO (0.03 mg/L).

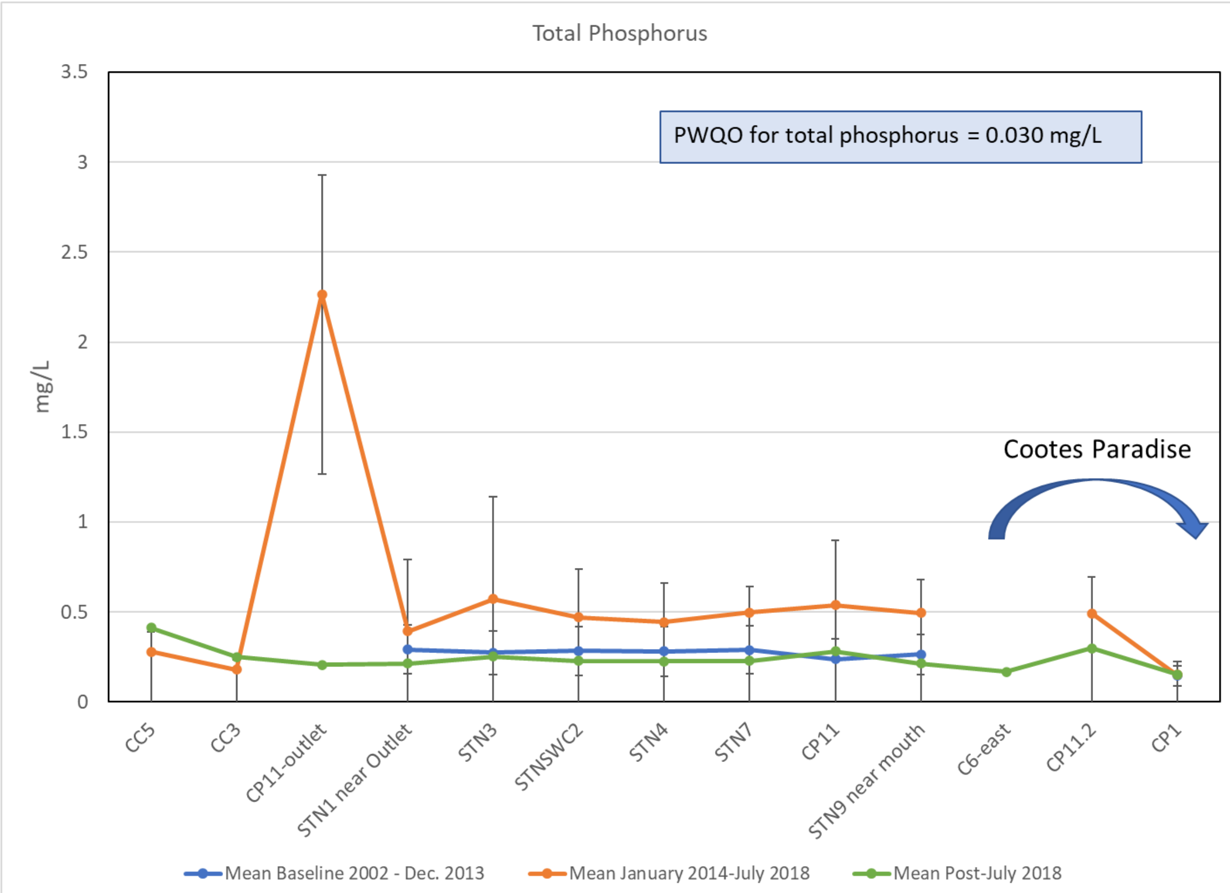

Figure 5-6:
Chedoke Creek and Cootes Paradise total phosphorus concentrations

TP concentrations were not measured in the landfill groundwater (UEM, 2016) and total dissolved phosphorus concentrations were generally near the detection limit of 0.010 mg/L.

In summary, the discharge event contributed TP to Chedoke Creek, but elevated concentrations were quickly assimilated in the creek and the inherently variable concentrations in the creek do not indicate a statistically significant increase over baseline conditions.

5.3.2.6 *E. coliform*

The available *E. coli* data are presented in Figure 5-7. It appears that the discharge event resulted in elevated bacterial measurements at CP11-Outlet. Measurements decreased downstream but there are insufficient data to conclude anything specifically other than that concentrations of *E. coli* were relatively low in Cootes Paradise near the mouth of Chedoke Creek.

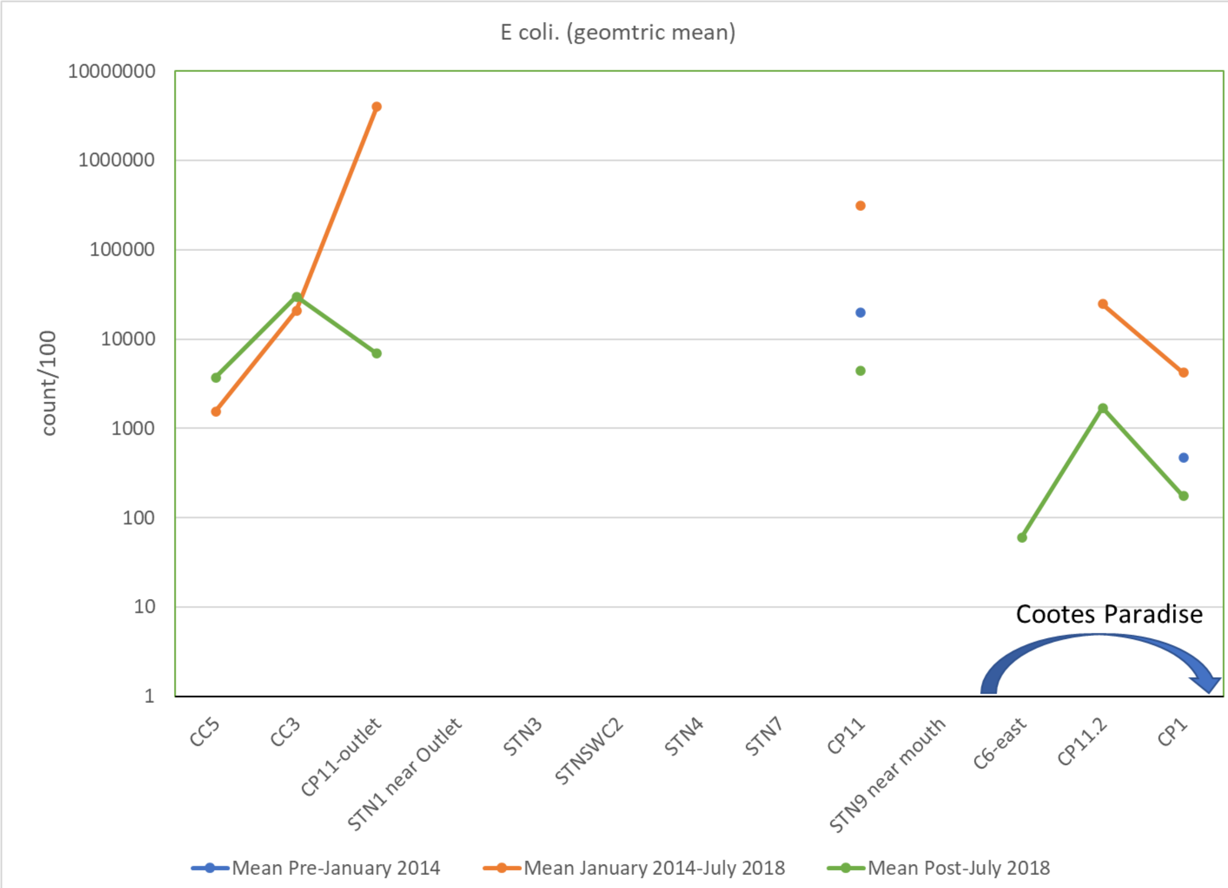

Figure 5-7:
Chedoke Creek and Cootes Paradise *E. coli* measurements

E. coli counts are generally elevated throughout Chedoke Creek subwatershed. *E coli* levels were measured in the study area (CP11) and at the two locations upstream of the Main/King CSO (CC-5, CC3) in 2018. The results are provided in Table 5-3 for two time periods during the discharge and after the discharge. The results show that *E. coli* levels were higher at station CP11 than in the upstream stations during the discharge. However, after the discharge, *E. coli* at station CP11 decreased to levels lower than those observed at the upstream location CC-3. This illustrates the presence of multiple sources of *E. coli* in Chedoke Creek subwatershed.

Table 5-3:
Chedoke Creek E. Coli (Numcount/100mLl) in Surface Water Downstream and Upstream of Main/King CSO in 2018

	CC-5			CC-3			CP11		
	N	Range	Median	N	Range	Median	N	Range	Median
During Discharge	12	130-3600	710	12	200-104000	3900	87	10-3600000	21600
After Discharge	39	170-78000	900	36	120-610000	4100	32	20-35000	1500

5.3.2.7 *Copper*

Copper was identified as a COPC in surface water. The only data available for copper are from the leachate collection performance investigations reported by SNC-Lavalin (2019). Baseline concentrations of copper were 0.006 mg/L at STN1 and rose slightly downstream. During the discharge event, copper concentrations in Chedoke Creek ranged from 0.007 to 0.009 mg/L from upstream to downstream. Concentrations measured in the creek prior to leachate collection (pre-2008) were higher than during the discharge event. It appears that the leachate seeping into Chedoke Creek had a historic impact on copper concentrations and is continuing to add copper to the creek. However, copper concentrations in the groundwater at the landfill was generally low at or near the detection limit of 0.002 mg/L. With the available data, an impact from copper during the discharge event is not evident.

5.4 Findings – Cootes Paradise

The data review was intended to provide an overview of surface water quality and focused on the annual means over the monitoring period ranging from 2011 to 2019. The initial marsh delisting water quality targets for the Hamilton Harbour Remedial Action Plan (HHRAP)[3] and/or the PWQO and federal WQG for aquatic life were used for comparison. As a summary, the review of annual means for the COPCs indicates that, in Cootes Paradise, increases in concentrations due to the discharge event seem to be limited to *E. coli* and TP (limited data) and only for 2018. A potential increase was also noted for nitrite at CP1 and CP2 in 2017; however, the highest nitrite concentrations were obtained in West Pond and do not appear to be related to the discharge event. The observations made based on a review of the annual means for each of the COPCs are summarized below. The COPC discussion does not include total ammonia as data reviewed by SLR did not include total ammonia in Cootes Paradise. For this reason, the discussion regarding ammonia relates to the un-ionized ammonia only. Un-ionized ammonia is the form of ammonia monitored by HCA because it is the form more toxic to fish.

For **DO**, the HHRPA target of 5 mg/L was met at all monitoring stations when annual means are considered at the Cootes Paradise annual routine monitoring station (Bowman, 2019) (Table 5-4).

Table 5-4:
Annual Means for Dissolved Oxygen (mg/L)

HHRPA Target >5 mg/L						
Monitoring Year	CP11	CP11.2	CP1	CP2	CP20	CP5
2011	7	na	6.4	5.9	6.2	6.3
2012	9.4	na	9.4	8.5	7.8	11.3
2013	14	na	8.3	8.6	8.0	9.4
2014	7.8	na	9.5	8.6	9.0	12.2
2015	7.8	na	8.6	6.7	12.2	10.5
2016	9.8	14	na	8.9	8.9	13.9
2017	10.8	7.6	8.3	8.6	7.9	7.6
2018	6.3	6.2	7.8	7.6	5.8	6.2
2019	10.5	7.8	9.0	9.1	8.2	7.8

[3] HHRAP target is reached when 15 of the 17 samples from June to September meet/exceed target levels (Bowman, 2019).

In addition to the annual sampling conducted by RBG, total DO data were available for two Cootes Paradise-wide sampling events, one completed on July 27, 2018 and the other on August 7, 2019. DO was measured at 43 sampling stations in 2018 and at 39 stations in 2019. DO ranged from 3.49 to 11.17 mg/L in 2018 and from 3.77 to 11.2 mg/L in 2019. The mean for all stations was 7.06 g/L in 2018 and 6.96 mg/L for 2019. In 2018, six out of the 43 stations had DO levels below the HHRAP target of 5 mg/L, including three locations at the fishway where Cootes Paradise connects to Hamilton Harbour, one location in West Pond, one in the inlet back of Mac Landing and one in a bay on the north side of Cootes Paradise (BH original outlet) (Figure 3, after the text). In 2019, five out of the 39 locations had DO levels below the HHRAP target of 5 mg/L, including the inlet back of Mac Landing, the station in a Bay on the North side of Cootes Paradise (BH original outlet) and locations in and near Spencer Creek (Figure 4, after the text). In 2018 and 2019, DO was measured at five stations in Cootes Paradise near the mouth of Chedoke Creek and one station in Chedoke Creek. DO concentrations met the targets at these locations for both years. Based on the above observations, the discharge event at Main/King CSO does not seem to have directly affected DO levels in Cootes Paradise.

For **TSS**, the HHRPA target of 25 mg/L was exceeded at most monitoring stations (Table 5-5). Based on the annual means, TSS concentrations do not appear to be related to the Main/King CSO discharge event. Annual means obtained during the period of discharge (2014 to 2018) are comparable or lower than annual means obtained prior to the period of discharge. In addition, the annual means obtained at CP11 in Chedoke Creek are lower than those obtained in Cootes Paradise.

Table 5-5:
Annual Means for TSS (mg/L)

HHRAP Target < 25 mg/L *						
Monitoring Year	CP11	CP11.2	CP1	CP2	CP20	CP5
2011	31	na	35	44	66	36
2012	24	na	50	50	87	59
2013	na	na	24	22	22	33
2014	30	na	33	38	22	18
2015	24	na	28	34	15	18
2016	26	48	na	31	30	18
2017	19	na	34	31	na	21
2018	21	40	43	46	na	21
2019	21	22	27	27	na	14

*Initial HHRAP Target for Cootes Paradise
Bold – Exceed HHRAP initial target

For **un-ionized ammonia,** the monitoring target (CCME WQG of 0.02 mg/L) was met at all stations except for CP11.2 in 2018 (mean of 0.1 mg/L). Note that un-ionized ammonia data for CP11.2 reviewed by SLR were limited to 2016, 2018 and 2019. Un-ionized ammonia data were also limited for CP11 in Chedoke Creek. Based on the annual means at CP11, un-ionized ammonia shows a decrease in concentration since 2012. Based on the data reviewed by SLR the increase in un-ionized ammonia was limited spatially to one station and temporally to 2018 and could not be directly related to the Main/King CSO discharge event. Based on the annual means for monitoring stations in Cootes Paradise, un-ionized ammonia does not appear to be a parameter of concern. A summary of annual means for un-ionized ammonia is provided in Table 5-6.

**Table 5-6:
Annual Means for Un-ionized Ammonia (mg/L)**

Target : ≤0.02 mg/L*						
Monitoring Year	CP11	CP11.2	CP1	CP2	CP20	CP5
2011	na	na	na	na	na	na
2012	**0.05**	na	na	na	na	na
2013	na	na	na	na	na	na
2014	0.043	na	0.004	0.004	0.001	0.004
2015	0.027	na	0.01	0.004	0.002	0.01
2016	0.017	0.02	na	0.002	0.002	0.01
2017	0.01	na	0.01	0.002	na	0.001
2018	0.009**	0.1	0.020	0.005	na	0.01
2019	na	0.002	0.002	0.0010	na	0.001

*CCME WQG used as Target for Cootes Paradise
**n=2
Bold – Exceed HHRAP initial target

For **nitrite,** the target concentration (CCME WQG of 0.06 mg/L) was met at all stations in Cootes Paradise except for CP1 and CP2 in 2017 and CP5 for all years (Table 5-7). The review of annual means indicated, based on annual means at CP11, that the discharge event may have contributed to the increase observed at CP1 and CP2 in 2017 but levels reduced in 2018 and 2019. The discharge event is not considered to be associated with nitrite at CP5 because nitrite has continuously been present at concentrations above the target concentration at this location.

**Table 5-7:
Annual Means for Nitrite (mg/L)**

Target <0.06 mg/L*						
Monitoring Year	CP11	CP11.2	CP1	CP2	CP20	CP5
2011	na	na	0.05	0.05	0.04	**0.13**
2012	na	na	0.03	0.04	0.03	**0.28**
2013	na	na	0.03	0.03	0.03	**0.15**
2014	**0.12**	na	0.02	0.03	0.02	**0.15**
2015	**0.13**	na	0.03	0.03	0.03	**0.16**
2016	**0.14**	0.04	na	0.04	0.03	**0.23**
2017	**0.21**	na	**0.10**	**0.09**	na	**0.13**
2018	**0.14**	na	na	0.04	na	**0.22**
2019	**0.06**	na	na	0.03	na	**0.09**

*CCME WQG used as Target for Cootes Paradise
Bold – Exceed HHRAP initial target

For **TP,** the target concentration (30 µg/L) was exceeded at all stations and for all years considered (Table 5-8). Based on a review of the annual means, an increase of TP above the annual pre-discharge means occurred at CP11.2, CP1 and CP2 in 2018; however, levels decreased in 2019. Based on CP11 data, this increase is likely associated with the discharge.

Table 5-8:
Annual Means for Total Phosphorus (µg/L)

Target <30 µg/L*						
Monitoring Year	CP11	CP11.2	CP1	CP2	CP20	CP5
2011	248	na	110	129	171	186
2012	262	na	160	140	240	250
2013	na	na	91	82	95	127
2014	475	na	120	108	92	100
2015	468	na	117	110	73	140
2016	497	380	na	109	130	120
2017	412	na	133	120	107	160
2018	688	680	227	180	218	170
2019	260	140	108	100	105	130

*PWQO used Target for Cootes Paradise
Bold – Exceed HHRAP initial target

Total phosphorus annual means at stations CP20 and CP5 in 2018 showed an increased compared 2017; however, remain lower than annual means obtained in 2012. The results of TP in Cootes Paradise tributaries for the 2017/2018 season indicated that while the highest magnitude of PWQO exceedances were observed at CP11, "*elevated TP concentrations were observed at all sites, indicating TP impairment throughout the watershed*" (HCA, 2019). The proportion of grab samples that exceeded the PWQO for total phosphorus was 100% for CP11, 64% for CP7 in Spencer Creek and 73.1% for CP18.1 in Borer's Creek. Based on these observations it is likely that inputs from other tributaries also contributed to TP at CP20 and CP5.

For ***E. coli*** the monitoring target for *E. coli* (1000 counts/100 mL) was exceeded in Cootes Paradise at CP11.2 and CP1 in 2018. The annual geometric means at CP11 show an increase during the Main/King CSO discharge (Table 5-9).

Table 5-9:
Annual Geometric Means for *E. coli*

Target <1000 (count/100 mL)*						
Monitoring Year	CP11	CP11.2	CP1	CP2	CP20	CP5
2011	762	na	58	120	82	94
2012	745	na	45	88	55	73
2013	na	na	40	113	65	64
2014	61077	na	96	71	38	21
2015	15734	na	80	42	11	24
2016	5540	192	na	35	13	16
2017	9784	na	219	55	na	46
2018	34858	7717	1041	440	na	35
2019	699	144	19	37	na	30

*Federal Secondary Contact for Recreation Guideline used as Target for Cootes Paradise
Bold – Exceed HHRAP initial target

In 2018 and 2019, two marsh-wide surface water sampling events for *E. coli* were also completed, one on July 27, 2018 and one on August 7, 2019 (as presented above for DO). *E. coli* was analyzed in samples obtained from 43 sampling stations in 2018 and from 39 stations in 2019. E*. coli* counts ranged from 20 to 70,000 CFU/100 mL in 2018 and from 10 to 4,900 CFU/100 mL in 2019. Geometric mean for all stations was 1993 CFU/100 ml in 2018 and 351 CFU/100 mL in 2019. In 2018, most stations (30 out of the 43) had *E. coli* above the target level of 1,000 (Table 2, after the text). In 2019, 13 out of the 39 locations had *E. coli* above the target level (Table 3, after the text). No apparent correlations were observed between *E. coli* numbers and DO levels in 2018 or in 2019. For example, in 2018, the locations with the highest *E. coli* counts also had the highest DO levels (Tables 2 and 3, after the text). The *E. coli* exceedances were mapped for both years (Figures 5 and 6, after the text). Figure 5, after the text shows the contribution of Chedoke Creek to *E. coli* in Cootes Paradise near the mouth of Chedoke Creek. *E. coli* numbers beyond Cootes Paradise near the mouth of Chedoke Creek decrease to below the target for the marsh. Figure 5 shows that elevated E. coli numbers are also present at the west end of Cootes Paradise Marsh in Spencer Creek and Mac Landing. These results point to another source contributing *E coli* to the west side of Cootes Paradise on July 27, 2018. Results for *E. coli* for surface water monitoring stations on Ancaster Creek and Spencer Creek on July 27, 2018 were not available for review by SLR. This information gap precludes further analysis of potential sources of *E. coli* to Cootes Paradise.

Copper was retained as a COPC. Based on the data reviewed, information on metal concentrations in Cootes Paradise Marsh was limited to one sample obtained by SLR from Cootes Paradise near the mouth of Chedoke Creek in 2019. Total copper concentration in this sample was 3.4 µg/L and dissolved copper concentration was 0.5 µg/L and did not exceeded the copper PWQO of 5 µg/L (at a hardness as $CaCO_3$ greater than 20 mg/L). Total copper concentration measured in Chedoke Creek at the furthest downstream station (STN9) are provided in Table 5-10. The summary statistic indicates that copper concentrations at this location are comparable before and during the discharge. Based on this information the discharge event does not seem to have contributed copper to Cootes Paradise in concentrations above those observed prior to the discharge event.

Table 5-10:
Summary Concentration of Total Copper in Chedoke Creek at STN9

	Before Discharge	During Discharge	After Discharge
Number of samples	33	17	2
Min	2	4.9	3.4
Max	30	24.8	9.6
Mean	6.3	10.7	5.6
Standard Deviation	5.0	6.0	5.6
Median	5	7	4.4

5.4.1 Section Summary – Surface Water

The Director's Order requires an evaluation of the environmental impact to Cootes Paradise from sewage discharged between January 28, 2014 and July 18, 2018 including a written assessment of any anticipated ongoing environmental impacts. Further, this assessment is to consider any proposed remedial actions and recommendations with justification. The objective of the surface water quality section was to determine if clear evidence of an impact from the sewage discharge was evident within Chedoke Creek. If the available data do not indicate a sustained impact immediately downstream that is differentiable from background conditions or other influences on Chedoke Creek, then conceivably evidence showing an impact on Cootes Paradise during the discharge event with respect to water quality is lacking. The conclusions resulting from the analysis of water quality data in Chedoke Creek and Cootes Paradise are:

- The discharge event had a short-lived impact on DO in Chedoke Creek, but this was mitigated fully by the aeration achieved at the drop structure. The DO sag in Chedoke Creek downstream of STN1 is probably due to the continuous loading of low DO leachate water into the creek. In Cootes Paradise, the HHRAP target of 5 mg/L was met at all monitoring stations when annual means are considered. Additional marsh-wide sampling completed after the discharge event (on July 27, 2018 and August 7, 2019) indicated that some stations had DO concentrations below 5 mg/L; however, DO concentrations at stations located in Chedoke Creek or Cootes Paradise near the mouth of Chedoke Creek were above 5 mg/L. Based on these observations, the discharge event at Main/King CSO did not directly affected DO levels in Cootes Paradise.
- The discharge event did have some direct impact on TSS in Chedoke Creek but this was quickly assimilated downstream and was not outside of the natural variability of TSS within this section of Chedoke Creek. Annual means for TSS in Cootes Paradise during the discharge event were comparable or lower than annual means obtained prior to the period of discharge. Based on these observations, the discharge event at Main/King CSO did not affect TSS in Cootes Paradise.
- There appears to have been some impact on ammonia as N concentrations in Chedoke Creek resulted in an increase in ammonia of about 1 mg/L at STN1; but there has also been an ongoing influence from landfill leachate reaching the watercourse. The natural variability of ammonia concentrations precludes any conclusion regarding a statistically significant impact of either the discharge event or the leachate.
- The discharge event had no differentiable impact on un-ionized ammonia in Chedoke Creek. Based on the un-ionized ammonia annual means, a slight increase was noted in Cootes Paradise and was limited spatially to one station in Cootes Paradise near the mouth of Chedoke Creek and temporally to 2018. This slight increase could not be directly related to the Main/King CSO discharge event. Based on Chedoke data and the annual means for monitoring stations in Cootes Paradise, un-ionized ammonia does not appear have been a parameter of concern during the discharge event.
- The discharge event contributed TP to Chedoke Creek, but elevated concentrations were quickly assimilated in the creek and the inherently variable concentrations in the creek do not indicate a statistically significant increase of TP over baseline conditions. In Cootes Paradise, based on a review of the annual means, an increase of TP above the annual pre-discharge means occurred at CP11.2, CP1 and CP2 in 2018. It is possible that this relative increase was due to the discharge event. Annual means for TP in 2019 do not show a continuing impact.
- *E. coli* measurements in Chedoke Creek were only available for a limited number of stations (e.g., CP11). The limited data show an increase in *E. coli* counts in Lower Chedoke Creek during the discharge event. Annual geometric means for *E. coli* counts in Cootes Paradise indicated an increase above HHRAP initial target in Cootes Paradise near the mouth of Chedoke Creek at CP11.2 and CP1 in 2018. These increases are likely due to the discharge event (based on the increase *E. coli* counts observed at CP11 downstream of Chedoke Creek during the discharge event).

- Landfill leachate seeping into Chedoke Creek had a historic impact on copper concentrations and is continuing to add copper to the creek. With the available data, an impact from cooper during the discharge event is not evident.

The evaluation of surface water quality indicated that the discharge event contributed to a short-term increase in *E. coli* levels at monitoring stations close to the mouth of Chedoke Creek. A potential short-term localized increase in total phosphorus concentrations was also noted for Cootes Paradise. The surface water quality data reviewed supports the conclusion that there is no evidence of long-term impact on Cootes Paradise based on water quality measurements. Accordingly, proposed remedial actions to address the discharge are unwarranted and a surface water monitoring program for the impacted portions of Cootes Paradise is not required.

5.5 Sediment

5.5.1 Approach

The evaluation of sediment quality follows a before-after comparison approach. Based on the information reviewed to conduct this EIE, only a few locations in Cootes Paradise near the mouth of Chedoke Creek have data characterizing the sediment quality before and after the CSO discharge event.

Sediment grab samples were obtained in Cootes Paradise Marsh and Grindstone Marsh areas as part of the sediment quality monitoring program completed by RBG in 2006 and 2013 (Bowman and Theÿsmeÿer, 2007; Bowman and Theÿsmeÿer, 2014). As part of the 2006 study, grab sediment samples were obtained with an Ekman grab from seven locations including two in Cootes Paradise near the mouth of Chedoke Creek (CC-1 and CC-2). As part of the 2013 study, grab sediment samples were obtained from ten locations including Cootes Paradise near the mouth of Chedoke Creek (CC-1 and CC-2) (Figure 7, after the text). The 2006 and 2013 samples were analysed for nutrients and metals. The sediment samples CC-1 and CC-2 obtained in the 2006 and 2013 studies comprise the dataset characterizing sediment quality before the Main/King CSO discharge event.

Sediment samples were also obtained after the Main/King CSO discharge event. In September 2018, Wood Environmental (Wood) collected sediment core samples in Cootes Paradise near the mouth of Chedoke Creek (station C-6). A total of nine core samples were analysed for nutrients, metals and faecal coliform. In October 2019, SLR collected grab sediment samples from two locations in Cootes Paradise near the mouth of Chedoke Creek (Boat Launch and G-7). A total of two grab samples were also analysed for nutrients, metals and faecal coliforms. Sediment samples collected in Cootes Paradise beyond the stations near the mouth of Chedoke Creek after the discharge event were not found during the preparation of this EIE. Consequently, the before-after sediment quality dataset to evaluate the impact of the discharge event on sediment quality is limited to Cootes Paradise near the mouth of Chedoke Creek sediment samples CC-1, CC-2, C-6 east, C-6 centre and C-6 west, Boat Launch and G-7. Because the sediment samples obtained at location C-6 by Wood consisted of core samples representing various depths, only the surficial core sample (<15 cm) were included in the dataset. However, it is recognized that compiling samples obtained with different methods introduces uncertainty in the dataset.

Other realities of sediment samples further limit the use of this medium to characterizing the impact of the discharge event. These include the following:

- Physical disturbance – shallow environments such as Cootes Paradise are frequently subjected to the disturbance of the surficial sediment layers through wind and wave action resulting in mixing and migration of these sediments with deeper sediments. As a result, sampling shallow layers of sediment (e.g., several centimetres) does not mean that this sediment would for example be relevant to the discharge event considered here. Sediment coring has been developed for application to lakes where cores from depth limit disturbance from physical mixing. This has allowed the development of techniques for verifying the absence of disturbance and the confirmation that the core has successfully sampled the most recent sediments with the use of short half-life radioisotopes (e.g., the presence of Beryllium 7 with a half-life of 53 days confirms that the top of the cores has been recovered). Dating of undisturbed cores is possible but as noted by Wood (2019) "*The irregular channel morphology, minimal water depth and widely varying flows within Chedoke Creek likely result in substantial mixing and transport of especially the fine-grained and organic sediments that retain* ^{210}*Pb. These processes would prevent the formation of interpretable* ^{210}*Pb profiles. For this reason, Wood does not recommend attempts to apply radioisotopic dating methodologies to distinguish sediments deposited prior to, versus during, the 2014 – 2018 discharge event*".
- Bioturbation – sediment invertebrates mix the sediments vertically and common carp (*Cyprinus carpio*) are known to "plough" the surficial sediments while feeding. This has been observed extensively in Cootes Paradise and is believed to result in the loss or sustainability of submergent and emergent aquatic vegetation.

Both of these factors confound the interpretation of sediment profiles to effectively provide a time series of contamination in Cootes Paradise. As a result, sediment quality data discussed below represent mixed conditions aggregating much more than the four years of the discharge event to Cootes Paradise. These limitations must all be kept in mind in the discussion below.

The sediment quality data were compared to the Provincial Sediment Quality Guidelines (PSQGs) Lowest Effect Levels (LELs) and Severe Effect Levels (SELs). The PSQG LEL "*indicates a level of contamination that can be tolerated by the majority of sediment-dwelling organisms*. *Sediments meeting the LEL are considered clean to marginally polluted*". The PSQG SEL "*indicates a level of contamination that is expected to be detrimental to the majority of sediment-dwelling organisms. Sediments exceeding the (SEL) are considered heavily contaminated*" (MOE, 2008).

5.5.2 Findings

Comparisons of nutrients and metals concentrations in the sediment samples obtained in Cootes Paradise near the mouth of Chedoke Creek before and after the discharge event do not point to increases in concentrations resulting from the discharge event. The following sections summarizes the available sediment quality data for nutrients, metals and faecal coliform.

The sediment samples collected in Cootes Paradise and Grindstone Marsh in 2006 and 2013 were analyzed for TKN, ammonia as N and TP. TKN and TP exceeded the PSQG lowest effect levels LEL at all locations in Cootes Paradise and Grindstone Marsh. Total phosphorus also exceeded the provincial PSQG SEL in Desjardin Canal in 2006 and 2013 (Bowman and Theÿsmeÿer, 2014). Comparison of TP and TKN concentrations obtained from Cootes Paradise near the mouth of Chedoke Creek in 2006 and 2013 to concentrations obtained in 2018 and 2019 shows similar TP concentrations and a decrease in TKN concentrations (Table 5-11). Ammonia concentrations in 2019 show high variability which precludes conclusions on potential enrichment from the CSO discharge. Two samples and a duplicate were obtained in 2019. One sample (G-7) had a concentration of ammonia as N of 100 µg/g and the other sample and its duplicate had ammonia as N concertation of 23 µg/g and 32 µg/g, respectively.

**Table 5-11:
Cootes Paradise Before (Historical) and After the Discharge Event - Maximum TKN and TP Concentrations in Surface Sediment**

Nutrient	2006		2013		2018			2019		
	CC-1	CC-2	CC-1	CC-2	C6-East	C6-Centre	C6-West	Boat Launch	Boat Launch Duplicate	G-7
TKN (µg/g)	1250	1010	1390	1330	900	900	1000	55	55	120
Ammonia as N (µg/g)	35	48	<25	<25	na	na	na	23	32	100
TP (µg/g)	1100	1100	1100	920	814	778	809	1030	908	1140

Metal analysis showed that arsenic, cadmium, copper, lead and zinc exceeded the PSQG LELs, but were below the SELs in the sediment samples (CC-1 and CC-2) obtained in 2006 and 2013 in Cootes Paradis near the mouth of Chedoke Creek (Bowman and Theÿsmeÿer, 2014). The 2013 sediment study showed that metals exceeding the PSQG LELs were observed at most locations in Cootes Paradise and Grindstone Marsh, with copper exceeding the LEL at all 10 locations investigated (Bowman and Theÿsmeÿer, 2014). Comparison of metals concentrations obtained in 2006 and 2013 to concentrations obtained in 2018 and 2019 shows similar results, except for copper showing a possible increase (Table 5-12). Note that the maximum copper concentration in West Pond in 2013 was 90.5 µg/g. A study on contaminant loadings and concentrations to Hamilton Harbour reported "*concerns about the concentration levels of copper in the sediments of Cootes Paradise and the Grindstone Creek Estuary*. *The Technical Team hypothesized that sources could include copper pipes and roofs in the area or residue from copper now used in brake pads instead of asbestos*" (Hamilton Harbour Remedial Action Plan Office, 2018).

**Table 5-12:
Cootes Paradise Before (Historical) and After the Discharge Event - Maximum Metal Concentrations in Sediment**

Metals (µg/g)	2006		2013		2018			2019		
	CC-1	CC-2	CC-1	CC-2	C6-east	C6-Centre	C6-West	Boat Launch	Boat Launch D	G-7
Arsenic	6	6	5.6	5.2	3.8	4.1	4.3	5.25	4.98	4.7
Cadmium	2.1	1.5	1	2.1	0.88	0.9	0.96	3.69	3.57	1.0
Copper	73	61	53	55	64	64	76	116	109	100
Lead	62	69	50	48	63	39	63	73.9	67.6	50.9
Zinc	400	320	310	340	285	300	303	571	545	451

Information on bacteria in sediment for the periods prior to and during the discharge event were not located as part of the information reviewed. The sediment samples collected in Cootes Paradise near the mouth of Chedoke Creek in September 2018 were analysed for faecal coliforms. Sediment samples were also collected in Chedoke Creek and analysed for faecal coliforms in 2018. The 2018 results showed that faecal coliforms, human Bacteroidetes and total

Bacteroidetes were only detected in the surface sediment horizon (<15 cm) and that concentrations in Cootes Paradise near the mouth of Chedoke Creek (maximum faecal coliform: 4000 CFU/100g) were generally lower than concentrations in Chedoke Creek. The highest faecal coliform concentrations in Chedoke Creek were found downstream of the Kay Drage Park bridge (43000 CFU/100g) (Wood, 2018). Faecal coliform in Cootes Paradise near the mouth of Chedoke Creek in October 2019 were lower than in 2018 (170 and 790 MNP/100g).

5.5.3 Section Summary - Sediment

Sediment quality data for Cootes Paradise are limited to a few sampling events and monitoring stations. In addition, physical disturbance through wave action and/or bioturbation confound the interpretation of sediment profiles to effectively provide a time series of contamination in Cootes Paradise. As a result, the limited sediment quality data available for 2018 and 2019 represent mixed conditions aggregating much more than the four years of the discharge event to Cootes Paradise.

Keeping these limitations in mind, comparisons of nutrients and metals concentrations in the sediment samples obtained in Cootes Paradise near the mouth of Chedoke Creek before and after the discharge event do not point to increases in concentrations resulting from the discharge event.

Faecal coliforms data were only available for 2018 after the discharge event and for 2019. The results indicated that concentrations in Cootes Paradise near the mouth of Chedoke Creek were generally lower than concentrations in Chedoke Creek. The highest faecal coliform concentrations in Chedoke Creek were found downstream of the Kay Drage Park bridge. The lack of bacteria characterization in Chedoke Creek and Cootes Paradise near the mouth of Chedoke Creek prior to the discharge event precludes any conclusions regarding the impact of the CSO discharge.

5.6 Aquatic Vegetation

5.6.1 Approach

SLR used data collected from 1996 to 2019 by RBG to evaluate existing conditions and potential impacts on aquatic vegetation before, during and after the CSO discharge. The data set contained more than 6,000 records dispersed over 35 monitoring stations. A subset of these records was used for more detailed analysis at 11 monitoring stations. Stations were selected to represent the aquatic communities such as marsh, open water and exposed locations throughout Cootes Paradise (Figure 8, after the text). For example, Figure 8 shows reference locations (B1, G12, M3, M4, O3 and R1) were compared to locations near (potential exposure) Lower Chedoke Creek (C1, C2, M5, B2, and E2). The selected locations represented those with the most complete consistent methodology and complete data sets. Evaluation was considered representative of species types, sampling dates and percent coverage of aquatic vegetation with respect to potential data limitations as outlined below.

A review of the data set revealed several limitations:

- not all sites were surveyed each year;
- personnel conducting the surveys did not remain constant;
- survey effort also may have changed over the sampling period;
- data records were not linked to known variable climate conditions; and
- data records were not linked to monitoring goals or influencing factors.

For example, common carp, invasive vegetation species and their control, aquatic restoration plantings, known excessively high-water levels in Lake Ontario over past few years, early ice off and excessive weather (wind, ice and snow melt) may play important roles in understanding changes over time and aid in the evaluation of potential changes in Cootes Paradise that occurred as a result of the CSO discharge event. These limitations and data variability can introduce uncertainty in the interpretation of results.

In addition to comparing species assemblage, vegetation in the data sets were summarized into three functional groups: submergent, floating and emergent vegetation. These designations were used as a high-level analysis of representation of vegetation types recorded in the dataset.

SLR's approach to the review also considered the species type and typical known nutrients required for growth or growth limitations. For example, nutrient inputs associated with storm water, urban runoff and agricultural runoff which may have contributed to the shift in Cootes Paradise aquatic ecosystem from a mesotrophic, clear water, macrophyte dominated community composition to conditions typical in an eutrophic, relatively turbid, plankton dominated system (Yang et al. 2020). Reduced light penetration favours floating and emergent vegetation coverage over submergent coverage. Nutrients in the Main-King CSO discharge from 2014 to 2018 could have contributed to changes in aquatic vegetation coverage.

5.6.2 Findings

Using spatial and temporal trends in the aquatic vegetation coverage, the data revealed that submergent vegetation within Cootes Paradise is dominated by non-native species including Coontail (*Ceratophyllum demersum),* Eurasian Watermilfoil *(Myriophyllum spicatum)* and Potamogeton species (*P. crispus*). Native submergent species were also frequently observed (for example Canada Pond Weed *(Elodea canadensis)).* For the 11 stations, Duckweed (*Lemna sp.*) was the most observed species in the floating group. Native Waterlilly (*Nymphaea odorata*) were also observed but percent coverage was highly variable from year to year and over the long term. Waterlilies and Cattails (*Typha sp.*) were part of the targeted restoration planting initiatives with Cattails representing the majority of the emergent group. Many of the submergent non-natives were also part of invasive species control programs.

When all the data were reviewed neither a species-specific pattern or trend (increase or decrease) could be linked to the CSO discharge event. Trends in percent cover fluctuated over several years and remained generally within background variation of aquatic species cover before, during and after the event. The following bullets provide a summary of the findings.

- Increases and decreases in percent cover for all three vegetation types observed at Cootes Paradise sites in or near Lower Chedoke Creek (C1, C2, B2, E2 and M5) and stations far from Chedoke Creek (B1, G12, M3, M4, O4, and R1) prior to CSO discharge event (Figure 5-8 and Figure 5-9).
- Submergent vegetation showed decline in percent cover one year prior to CSO discharge and floating vegetation showed decline the first year of the event at locations in or near Lower Chedoke Creek.
- Submergent and floating vegetation showed increases and decreases in percent cover during the CSO discharge period at locations far from Lower Chedoke Creek (Figure 5-8). Emergent vegetation showed an increase in percent cover during the CSO discharge event at the same locations far from Lower Chedoke Creek (Figure 5-8).

- Magnitude of increases and decreases in percent cover for floating and submergent vegetation types during the CSO discharge were similar to, or smaller than fluctuations prior to the CSO discharge at locations both far from, in or near Lower Chedoke Creek, thus within background variation (Figure 5-9).
- This assessment of available information does not show impacts on aquatic vegetation in Cootes Paradise associated with the CSO discharge, independent from other potential influencing factors.

The observed vegetation trends are generally consistent with previous findings reported for Cootes Paradise by Theÿsmeÿer et. al (2016) and Leisti et al (2016). In some instances where emergent, submergent and floating vegetation expanded their coverage this was followed with setbacks due to damage as a result of high-water levels, common carp activity, and periods of eutrophic or hypereutrophic conditions which may occur annually (in late summer). Hypereutrophic conditions can result in algae blooms and declines in plant communities (e.g. submergent group). Other factors potentially influencing percent coverage of aquatic vegetation include the regulation of Lake Ontario water levels, resuspension and inputs of sediment from tributaries along with high nutrient levels which may promote algal blooms thus reducing dissolved oxygen (Leisti et al., 2016). These factors influence aquatic vegetation in Cootes Paradise at a much larger scale than the CSO discharge, were occurring before the CSO event and continue as key issues maintaining degraded conditions in Cootes Paradise (Leisti et al., 2016).

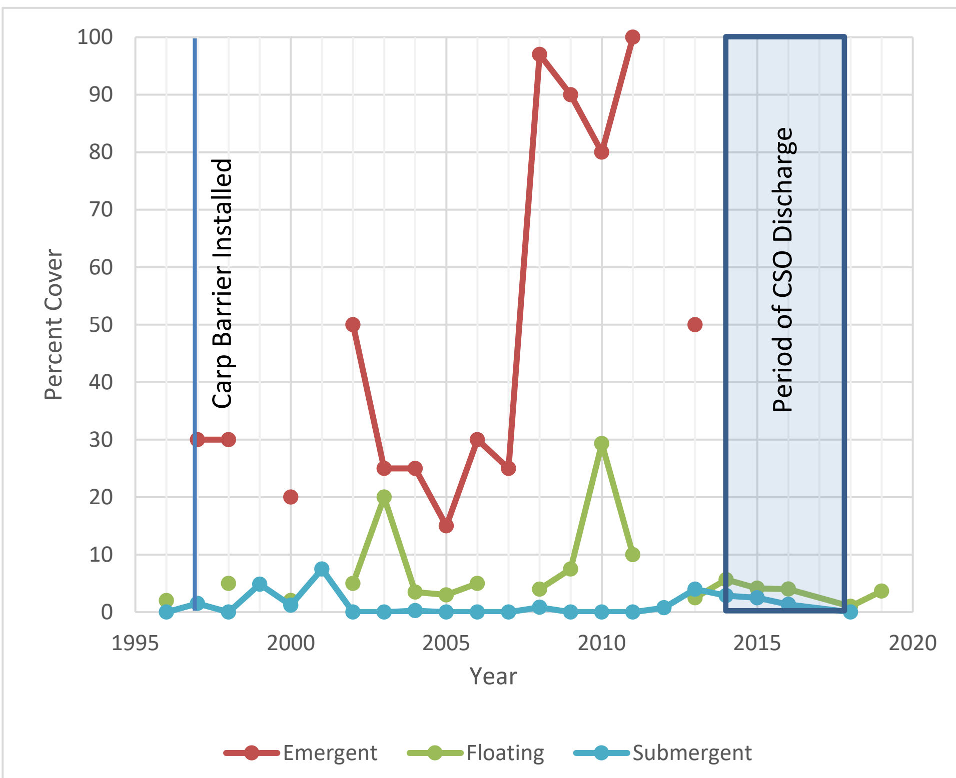

Figure 5-8:
Vegetation Trends for Location in or Near Lower Chedoke Creek

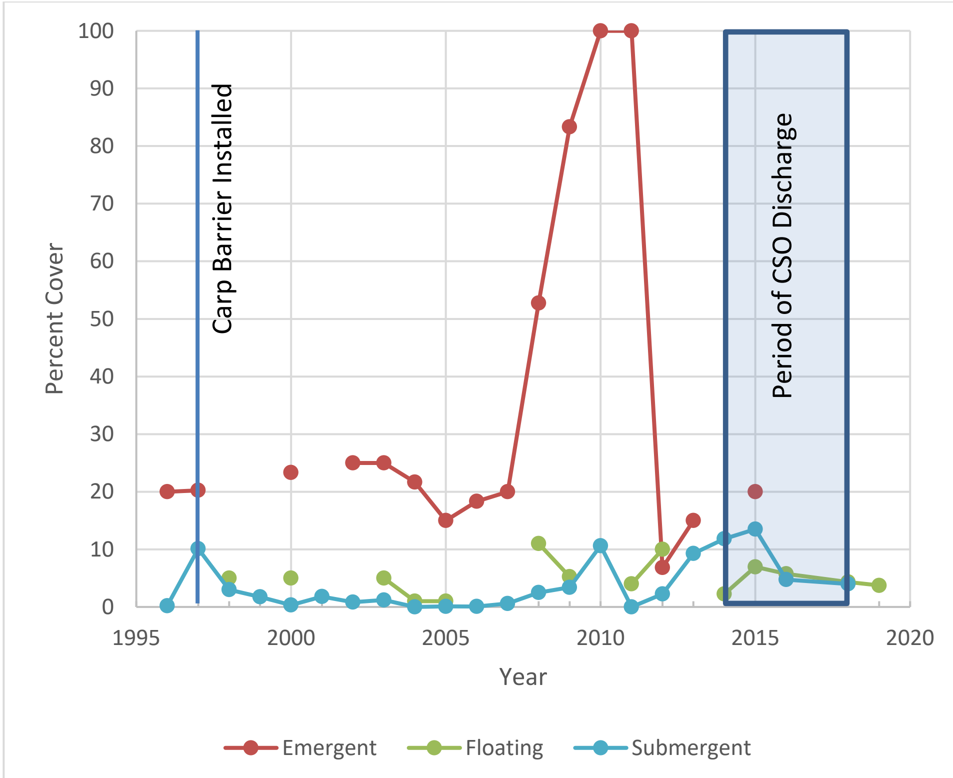

Figure 5-9:
Vegetation Trends for Locations in Cootes Paradise Far From Lower Chedoke Creek

5.6.3 Section Summary – Aquatic Vegetation

Based on observations described above, and consistent with other published sources, assessment of available information does not show impacts on aquatic vegetation in Cootes Paradise associated with the CSO discharge, independent from other potential influencing factors.

5.7 Fish Community

5.7.1 Approach

Fish were used as indicators of potential impacts of the Main-King CSO discharge in Cootes Paradise (sometimes referred to as the marsh) from 2014 to 2018. Fish community characteristics were compared before, during and after the CSO discharge period at locations in Cootes Paradise far from (background reference) and near (potential exposure) to Lower Chedoke Creek (Figure 9, after the text).

Annual Index Fish Community Data and Fishway Data, both received from RBG, were consulted. These datasets appear as a modified continuation of the sampling program initiated in support of a graduate thesis (Theÿsmeÿer, 2000).

Characteristics of the annual index fish community data include:

- Samples collected from 1995 to 2019;
- Fish collections in Cootes Paradise and Lower Chedoke Creek;
- Approximately 25 sampling locations;
- 55 fish species collected in Cootes Paradise; and
- Over 37,000 records.

Characteristics of the fishway data include:

- Samples collected from 1995 to 2019;
- Fish collected during operation of the fishway where Cootes Paradise connects to Hamilton Harbour;
- 36 fish species collected at the fishway; and
- Over 98,000 records.

Over the duration of the fish collection program a total of 69 fish species were captured in the fishway and from Cootes Paradise sampling locations (Table 5-13). Of the total species captured, 14 were captured in the fishway and not Cootes Paradise while 33 were captured in the marsh and not the fishway. Only 22 of 69 species were captured at both the fishway and marsh locations.

Table 5-13:
Comparative Properties of the Fishway and Index Fish Community Datasets

Parameter	Fishway Species	Annual Index Species
Total number of species	36	55
Number of species collected at both locations	22	22
Number of species at one location and not the other	14	33

The rank-order for the 10 most frequently captured fish species in the Fishway and Cootes Paradise datasets are shown in Table 5-14. Only 3 of the 10 most frequently captured fish appeared in both datasets. Brown bullhead (*Ameiurus nebulosus*) and common carp represented 74% of the capture in the fishway dataset while six species represented 77% of the catch in the marsh dataset represented, indicating a reduced species dominance diversity in the fishway capture data.

Table 5-14:
Rank Order of Species Abundance of the Fishway and Index Fish Community Datasets.

Fishway Species: 1996-2019				Cootes Paradise Species: 1996-2019		
Rank Abundance	Species	Percent	Cumulative	Species	Percent	Cumulative
1	Brown Bullhead *Ameiurus nebulosus*	51.1	51.1	Pumpkinseed *Lepomis gibbosus*	29.3	29.3
2	Common Carp *Cyprinus carpio*	23.0	74.1	Bluegill *Lepomis macrochirus*	16.1	45.4
3	White Sucker *Catastomus commersonii*	12.5	86.6	White Perch *Morone americana*	11.9	57.3
4	Gizzard Shad *Dorosoma cepedianum*	4.6	91.2	Common Carp *Cyprinus carpio*	7.5	64.8
5	Channel Catfish *Ictalurus punctatus*	2.7	93.9	Brown Bullhead *Ameiurus nebulosus*	7.4	72.2
6	Goldfish *Carassius auratus*	2.6	96.5	Bluntnose Minnow *Pimephales notatus*	5.3	77.5
7	Freshwater Drum *Aplodinotus grunniens*	2.0	98.5	Spottail Shiner *Notropis hudsonius*	3.5	81.0
8	Rainbow Trout *Oncorhynchus mykiss*	0.4	98.9	Logperch *Percina caprodes*	3.5	84.5
9	Bowfin *Amia calva*	0.3	99.2	Goldfish *Carassius auratus*	3.3	87.7
10	White Perch *Morone americana*	0.1	99.4	Yellow Perch *Perca flavescens*	3.3	91.0

The number of shared species in the two datasets and the difference in species dominance diversity indicate potentially dissimilar habitat, ecosystem conditions and factors influencing community structure in Cootes Paradise and species captured in the fishway. Most of the fish species in the marsh and the fishway likely originated from Hamilton Harbour.

Kim et al., (2016) described Cootes Paradise as a eutrophic system. Yang et al., (2020) described a shift in Cootes Paradise in the 1930s from a clear macrophyte dominated condition to a turbid phytoplankton dominated system as a result of numerous human activities in the catchment. Submergent macrophyte loss is attributed to reduced water clarity from wind-driven sediment suspension, the invasive common carp, nutrient inflows from numerous sources, sewage influent from the Dundas WWTP and CSOs from the City.

These changes from clear water, macrophyte dominated, to a turbid, phytoplankton dominated system reduces the effectiveness of sight feeding for fishes. These conditions could lead to reduced abundance of fish species exploiting sight feeding method in favour of fish species adapted to feeding on plankton, benthic invertebrates and plants, and species tolerant to degraded water quality and habitat.

Surface water COPC focused on parameters including physicochemical, nutrient, inorganics and bacteria (Table 4-1, Section 4.2) commonly associated with CSO discharges. To facilitate the evaluation of potential impacts of the CSO discharge, fish were classified according to four trophic groups as a function of their feeding behaviors and tolerance to water quality. This classification of fish species relates to COPCs associated with CSO discharge, such that changes in the abundance of various trophic feeding groups and water quality sensitive species could be used to assess impacts from the Main/King CSO discharge.

Fish collections from selected locations were assessed for differences in trophic feeding groups and water quality tolerance. Comparing patterns of fish species abundance collected from sampling locations near Chedoke Creek with reference locations in Cootes Paradise far from Chedoke Creek could be used to assess impacts to the fish community from the CSO discharge into Chedoke Creek. Generally, the order of trophic feeding groups from most tolerant to most sensitive to turbid, plankton dominated systems is: Benthic, detritivore, omnivore; Planktivore, herbivore; Planktivore invertivore; and Invertivore carnivore.

Fish species well represented in the fish collection datasets for which trophic feeding and water quality tolerance information was available were used to assess potential impacts from the Main-King CSO discharge.

The 10 species included as indicators from the fishway location represent more than 95% of the individuals captured from that location from 1995 to 2019. Species assignment to trophic feeding classes and sensitivity to poor water quality are shown in Table 5-15.

Table 5-15:
Trophic Class and Species Tolerance to Water Quality, Fishway Location.

Species	Trophic Feeding Groups	SATIWQ[1]
brown bullhead	Benthic, detritivore, omnivore	3
common carp	Benthic, detritivore, omnivore	3
gizzard shad	Planktivore, herbivore	6
Goldfish	Benthic, detritivore, omnivore	3
largemouth bass	Invertivore, carnivore	8
northern pike	Invertivore, carnivore	9
white perch	Invertivore, carnivore	7
white sucker	Benthic, detritivore, omnivore	5
yellow perch	Planktivore, invertivore	7
rainbow trout	Invertivore, carnivore	8

[1]SATIWQ represents species association tolerance to water quality: Dissolved Oxygen Demand, turbidity, habitat disturbance, modified from Wichert and Regier (1998).

The 18 species included as indicators species from the locations in Cootes Paradise and Lower Chedoke Creek represent 98% of the individuals captured form those locations from 1995 to 2019 (Table 5-16).

Table 5-16:
Trophic Class and Species Tolerance to Water Quality, Marsh Locations.

Species	Trophic Class	SATIWQ[1]
Bluegill	Planktivore, invertivore	8
bluntnose minnow	Planktivore, herbivore	4
brown bullhead	Benthic, detritivore, omnivore	3
common carp	Benthic, detritivore, omnivore	3
emerald shiner	Planktivore, herbivore	7
fathead minnow	Planktivore, herbivore	4
gizzard shad	Planktivore, herbivore	6
goldfish	Benthic, detritivore, omnivore	3
green sunfish	Planktivore, invertivore	7
largemouth bass	Invertivore, carnivore	8
Logperch	Planktivore, invertivore	7
northern pike	Invertivore, carnivore	9
pumpkinseed	Planktivore, invertivore	8
round goby	Planktivore, invertivore	6
spottail shiner	Planktivore, herbivore	6
white perch	Invertivore, carnivore	7
white sucker	Benthic, detritivore, omnivore	5
yellow perch	Planktivore, invertivore	7

[1]SATIWQ represents species association tolerance to water quality: Dissolved Oxygen Demand, turbidity, habitat disturbance, modified from Wichert and Regier (1998).

Relative abundance of fish species collected from the fishway location were examined to show trends in relative abundance for fish species passing between Hamilton Harbour and Cootes Paradise. These trends can be used to compare fish community dynamics between the two systems and identify whether consistent responses occur among them.

Comparison of fish community dynamics were conducted at two scales within Cootes Paradise:

- Whole marsh comparing results for fish collection locations near and far from Lower Chedoke Creek outlet to Cootes Paradise; and
- Fish locations in the vicinity of two watercourses discharging into Cootes Paradise: Lower Spencer Creek and vicinity, and Lower Chedoke Creek and vicinity.

As indicated above, nutrients contribute to the development and maintenance of the eutrophic, phytoplankton dominated aquatic ecosystem of Cootes Paradise. Therefore, nutrients from the Main/King CSO discharge could contribute to sustaining the present condition of Cootes Paradise. Examination of patterns and coincident timing of increases and decreases in relative abundance of trophic feeding groups and fish species water quality sensitivity can indicate whether fish at various locations appear influenced by impacts from the CSO discharge in Chedoke Creek or from influencing factors independent of the discharge.

5.7.2 Findings – Fishway Location

Trends in abundance of fish species collected from the fishway location were examined to show patterns in relative abundance for fish species passing between Hamilton Harbour and Cootes Paradise. These trends and patterns can be used to compare fish community dynamics between the two systems and identify whether consistent responses occur among them.

Water Quality Sensitivity

Brown bullhead and common carp comprise 78% of the fish captured at the fishway and assessed here. These species are in the trophic feeding group most tolerant of poor water clarity and are also two of the most tolerant species to poor water quality. High abundance of these species produced a low overall score in terms of species sensitivity to water quality (Figure 5-10). The score showing sensitivity to water quality increased from 1996 to 2000 and then varied slightly around a score of 4 showing no increase or decrease from 2000 through the CSO discharge period to 2019 (Figure 5-10).

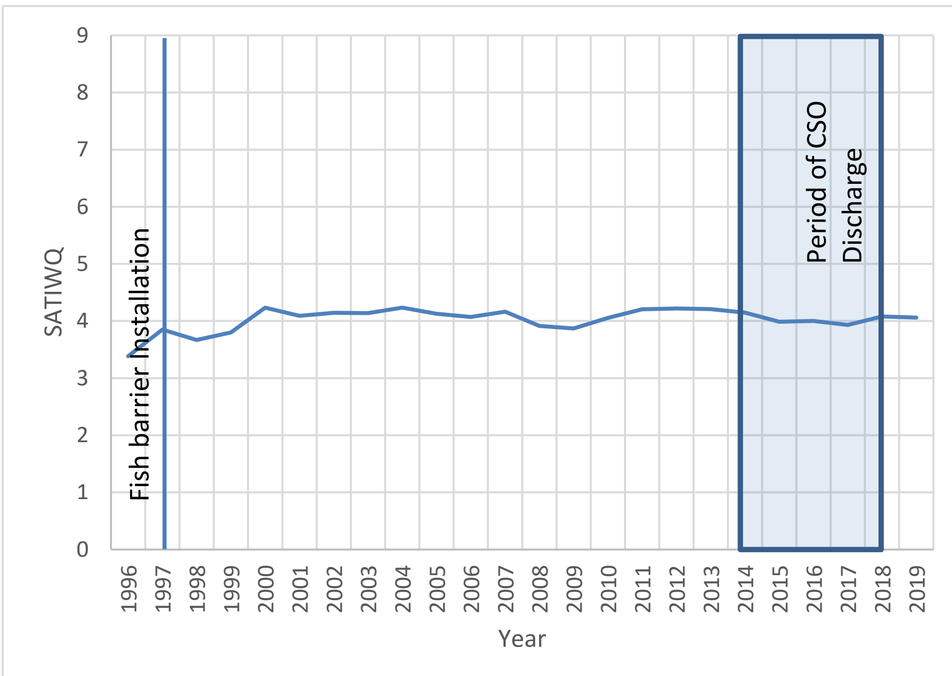

Figure 5-10:
Trend in Water Quality Sensitivity at the Fishway in Cootes Paradise

Trophic Feeding Groups

Benthic-detritivore-omnivore is the numerically dominant trophic feeding group represented at the fishway fish collection location. This group is also the most tolerant of present aquatic ecosystem conditions in Cootes Paradise. Relative abundance of the benthic-detritivore-omnivore group began increasing approximately two years before the CSO discharge period, but this increase is within the range of pre-discharge variation. Relative abundance then decreased during the CSO discharge period to approximate pre-discharge levels (Figure 5-11).

Relative abundance of species more dependent on sight feeding (planktivore-herbivore) showed increased relative abundance approximately two years prior to, but then started declining prior to the CSO discharge (Figure 5-11). Relative abundance of the planktivore-herbivore group started to increase during the discharge period. This increase would not be expected if impacts from the discharge were negatively affecting fish species at the fishway.

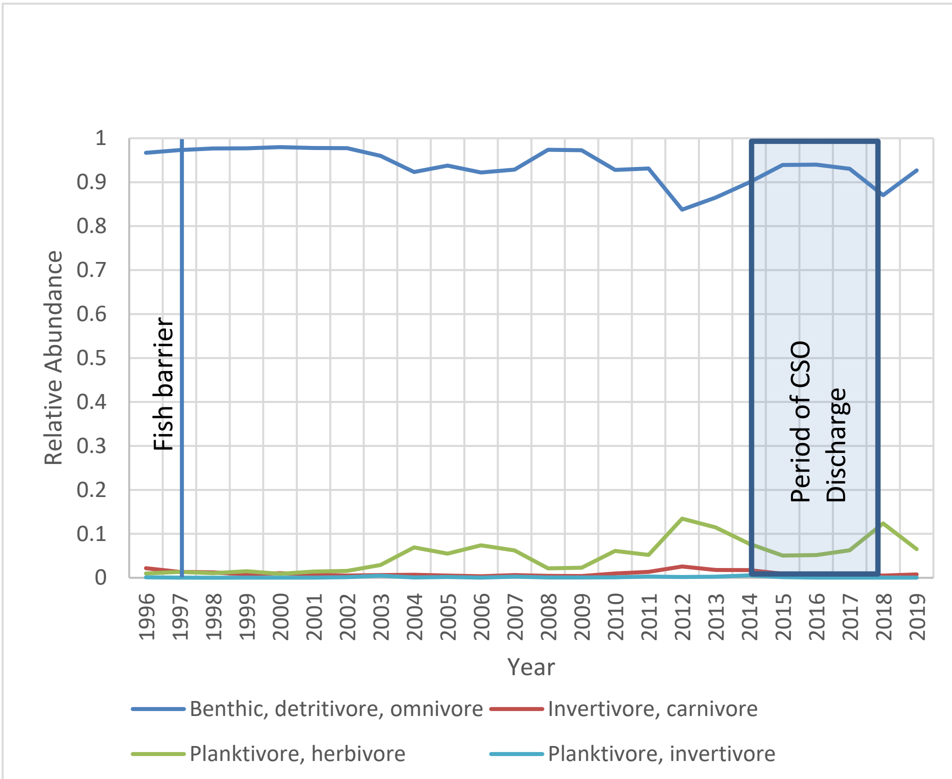

Figure 5-11:
Trends in Trophic Feeding Groups at the Fishway in Cootes Paradise

5.7.3 Findings – Cootes Paradise and Chedoke Creek Locations

Cootes Paradise – Near and Far from Lower Chedoke Creek

Water Quality Sensitivity

Variation in species sensitivity shows a similar pattern at sampling locations in Cootes Paradise near and far from Lower Chedoke Creek. Fish collected from all sites in Cootes Paradise show a decline followed by an increase in water quality sensitivity during the CSO discharge period (Figure 5-12). Similarity in pattern and timing suggest that the fish community in Cootes Paradise does not respond to impacts of the CSO discharge independent of other potential influencing factors.

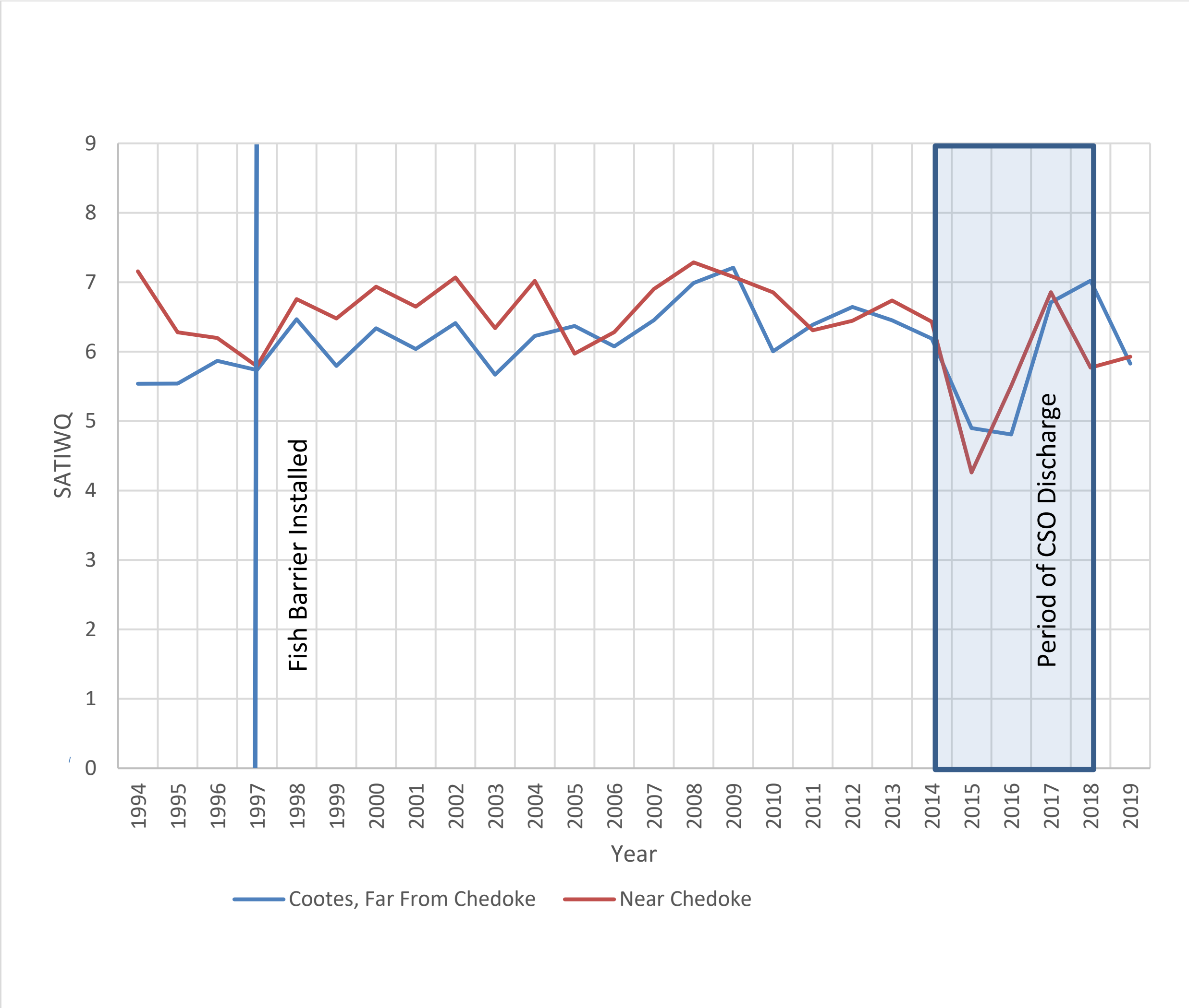

Figure 5-12:
Trends in Water Quality Sensitivity in Cootes Paradise Near and Far From Chedoke Creek Outlet

Trophic Feeding Groups

All trophic feeding groups show variability prior to the period of CSO discharge (Figure 5-13 and Figure 5-14). The invertivore-carnivore group, the group of species with most sight-dependent feeding strategies, showed a decline in relative abundance at locations near Lower Chedoke Creek prior to and extending into the CSO discharge period (Figure 5-13). Fish species in the invertivore-carnivore group collected from locations in Cootes Paradise far from Lower Chedoke Creek showed a similar decline and increase in relative abundance as the near Chedoke locations, but relative abundance does not increase to the same extent at the far locations as for locations near Lower Chedoke Creek (Figure 5-14). All trophic feeding groups showed increases and decreases in relative abundance during the CSO discharge period.

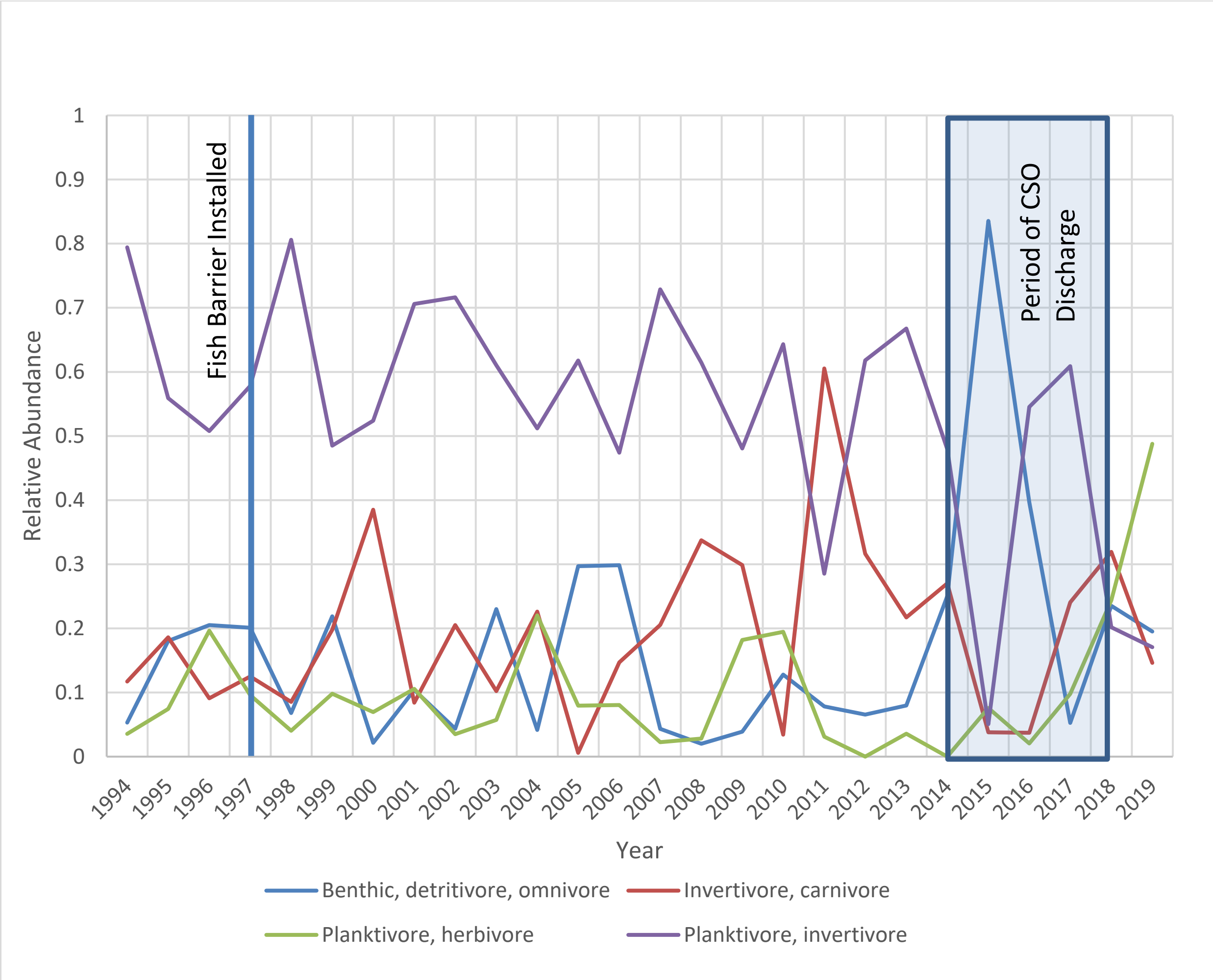

Figure 5-13:
Trends in Water Quality Sensitivity in Cootes Paradise for Locations Near Lower Chedoke Creek

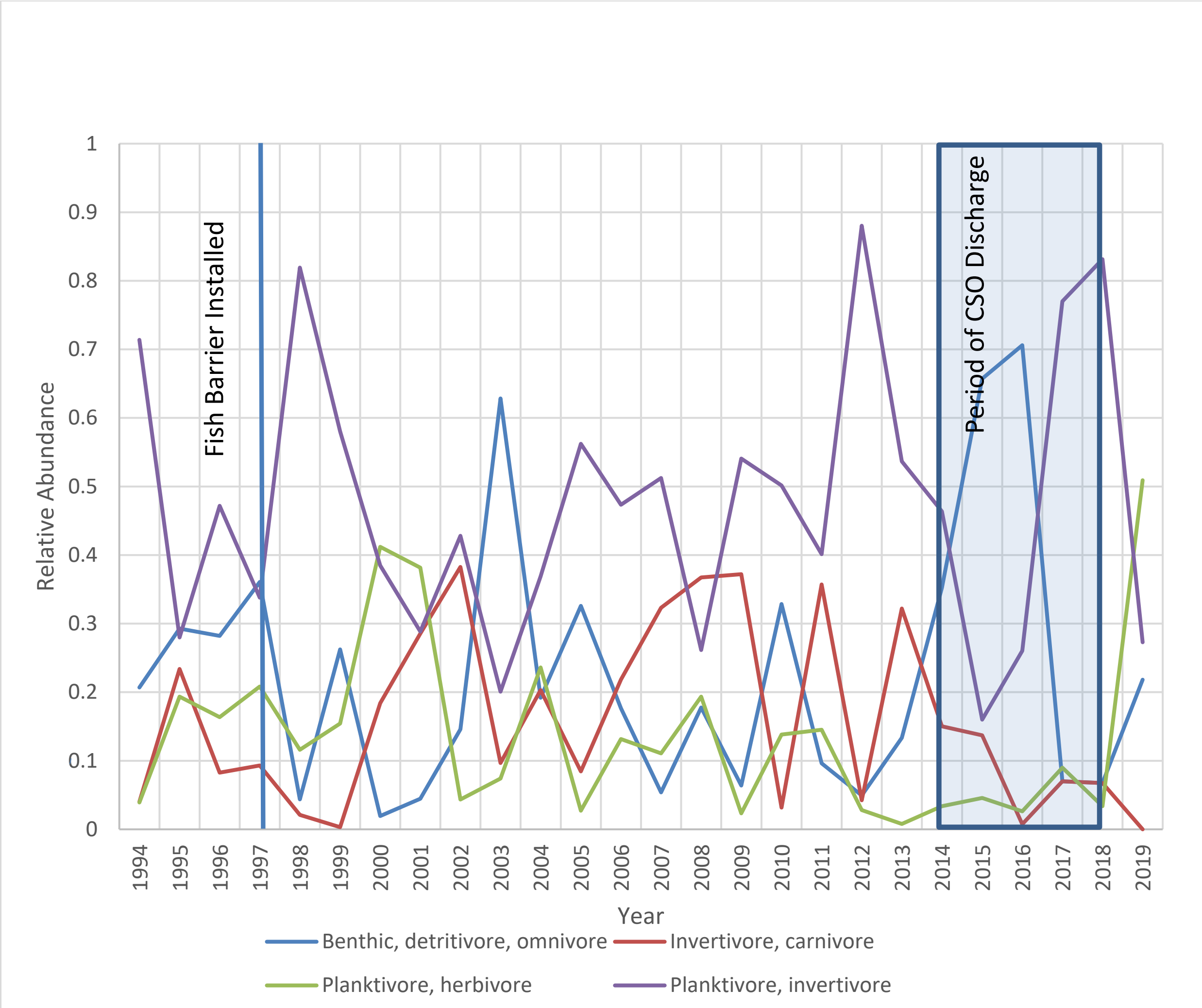

Figure 5-14:
Trends in Trophic Feeding Groups in Cootes Paradise Locations Relatively Far From Chedoke Creek

Lower Chedoke Creek and Lower Spencer Creek and Vicinity

Water Quality Sensitivity

Fish collected from locations in the vicinity of Lower Spencer Creek and Lower Chedoke Creek show a similar pattern of decline followed by an increase in species sensitivity to water quality during the CSO discharge period (Figure 5-15). Similarity in pattern and timing suggest that the fish community in Cootes Paradise does not respond to impacts of the CSO discharge independent of other potential influencing factors. The species sensitivity in the vicinity of Lower Spencer Creek is typically as low or lower than the species sensitivity to water quality for fish species in Lower Chedoke Creek.

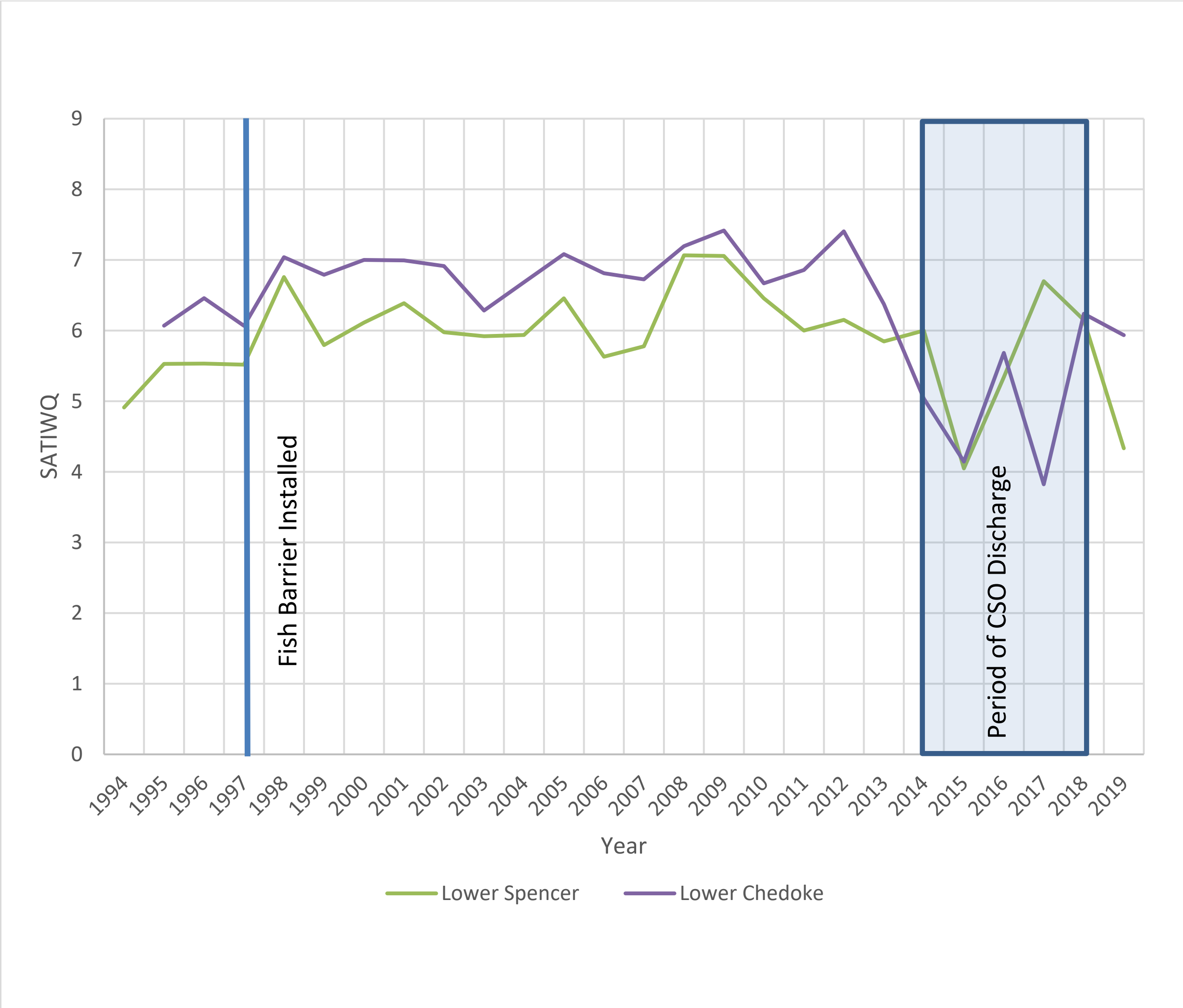

Figure 5-15:
Trends in Water Quality Sensitivity in Lower Spencer Creek and Lower Chedoke Creek

Trophic Feeding Groups

All trophic feeding groups show variability prior to the period of CSO discharge (Figure 5-16 and Figure 5-17). The invertivore-carnivore group, the group of species most sight-dependent feeding strategies, showed a decline in relative abundance at locations in the vicinity of Lower Spencer Creek and Lower Chedoke Creek during the CSO discharge period (Figure 5-16). All trophic feeding groups at Lower Chedoke and Lower Spencer Creek locations showed increased abundance during the CSO discharge period.

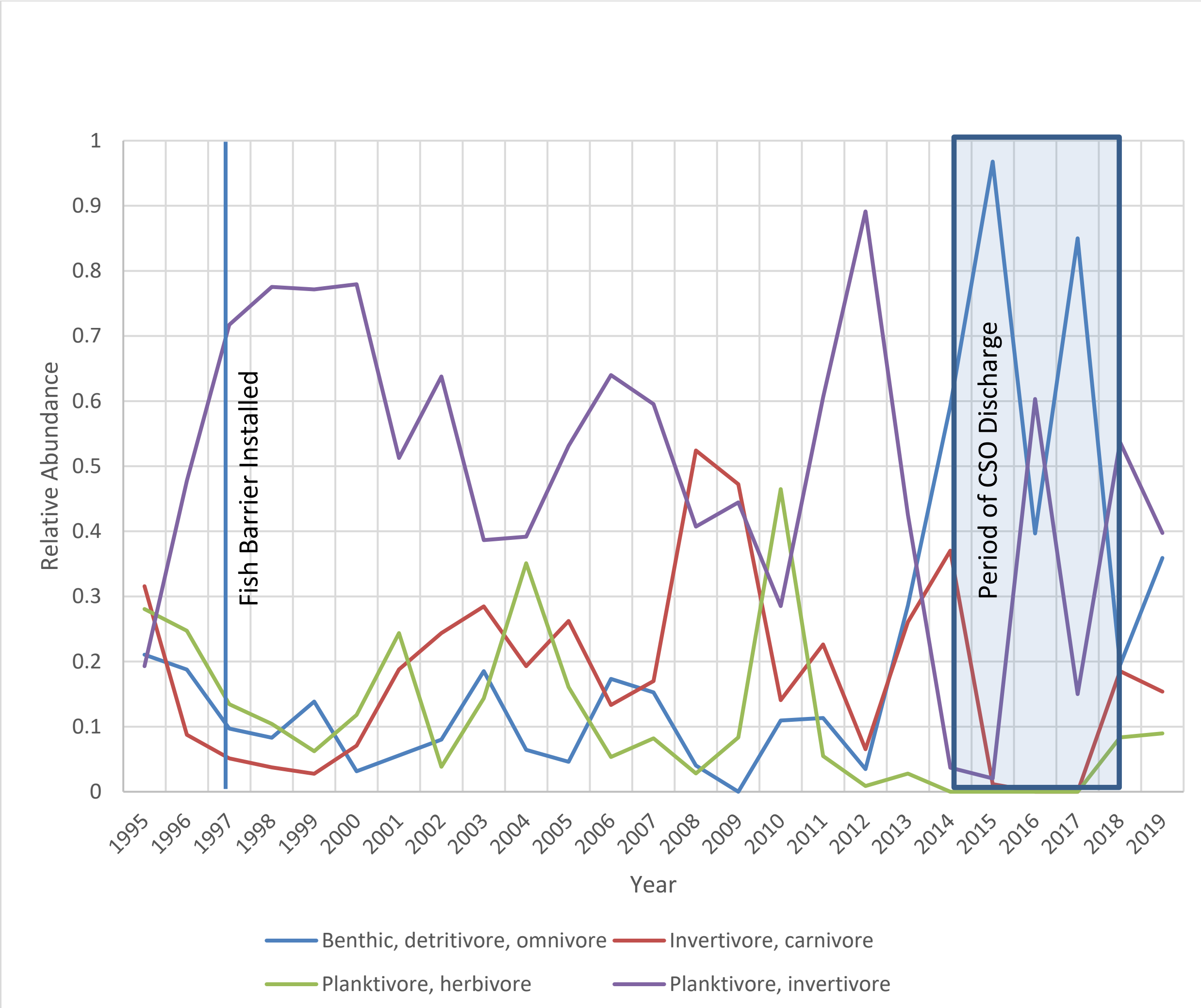

Figure 5-16:
Trends in Trophic Feeding Groups in Lower Chedoke Creek and Vicinity

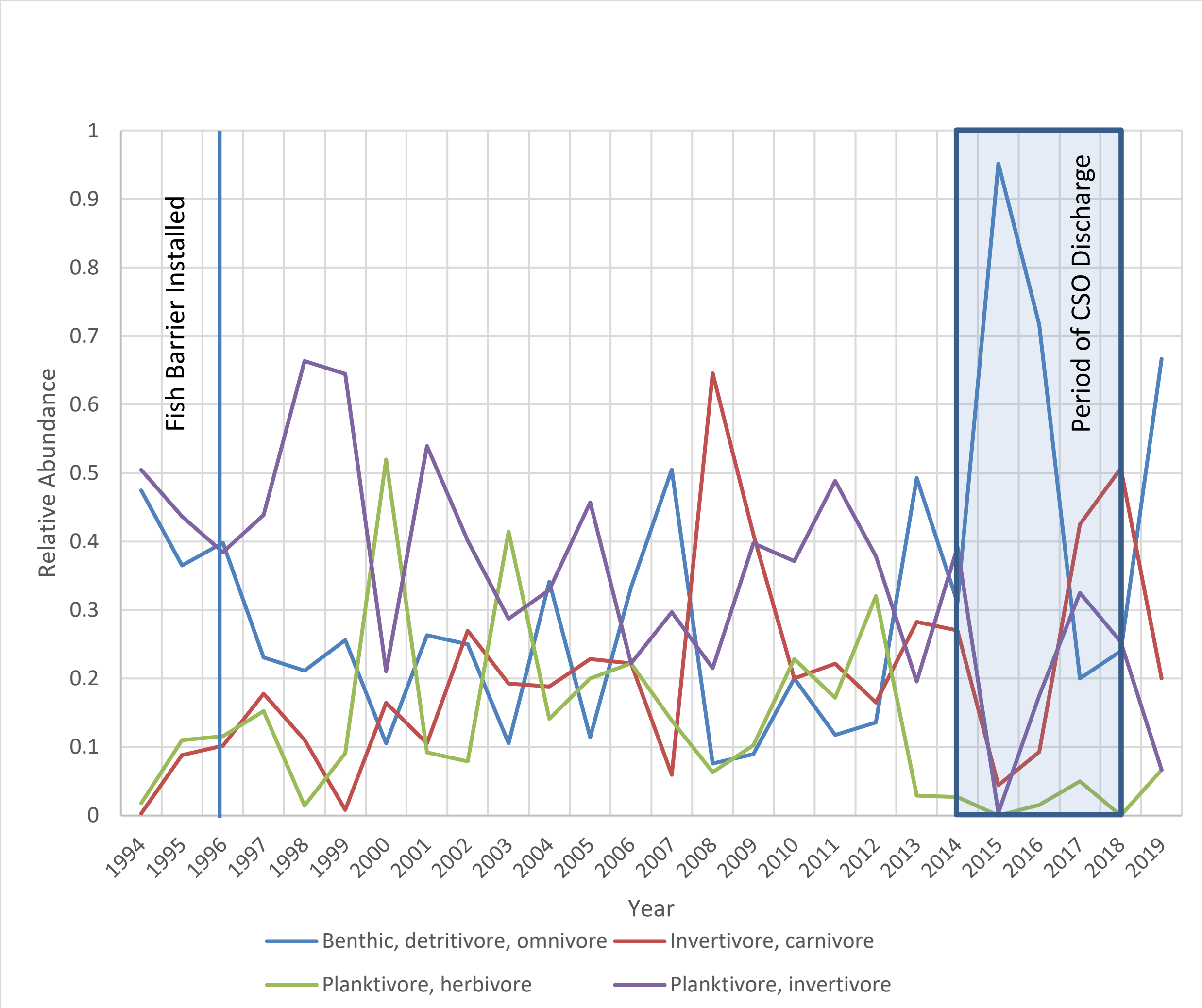

Figure 5-17:
Trends in Trophic Feeding Groups, Lower Spencer's Creek and Vicinity

5.7.4 Section Summary – Fish Community

Spatial and temporal patterns of fish species sensitivity to water quality and changes in relative abundance of trophic feeding groups indicate that fish in Cootes Paradise may be influenced by regional factors independent of the CSO discharge. This conclusion is supported by several observations:

- Sensitivity to water quality scores at the fishway increased from 1996 to 2000 and then varied slightly around a score of 4 showing no increase or decrease from 2000 through the CSO discharge period to 2019.
- Relative abundance of the planktivore-herbivore group at the fishway decreased and increased during the discharge period. This decrease and increase would not be expected if impacts from the discharge were negatively affecting that trophic group at the fishway.

- Decrease in relative abundance of water quality sensitive fish species was observed 1-3 years before the spill period in the vicinity of Lower Spencer Creek and Lower Chedoke Creek.
- Increases in relative abundance of water quality sensitive fish species were observed during the CSO discharge period in Cootes Paradise locations near and far from Lower Chedoke Creek.
- Similar increases and decreases in relative abundance of trophic feeding groups were observed during the CSO discharge period at locations in Cootes Paradise near and far from Lower Chedoke Creek as well as in the vicinity of Lower Spencer Creek and Lower Chedoke Creek.

Combined, these observations indicate that assessment of available information does not show impacts on fish species relative abundance in Cootes Paradise associated with the CSO discharge, independent from other potential influencing factors.

6.0 SUMMARY AND CONCLUSIONS

The purpose of this EIE was to evaluate the potential impacts of a sewage discharge from the Main/King CSO facility to Chedoke Creek on the receiving environment: Cootes Paradise. The discharge occurred between January 28, 2014 and July 18, 2018.

The potential impacts from the Main/King CSO discharge to Cootes Paradise were assessed based on existing information from extensive sources. The information reviewed included reports, research publications, memoranda, emails, data sets, figures and photographs. The impacts assessment focused on four ecosystem components: water quality, sediment quality, aquatic vegetation and fish community. The overall approach followed to evaluate impacts was generally similar for the four components and included comparisons of data obtained before, during and after the Main/King CSO discharge that occurred from 2014 to 2018. Locations in Cootes Paradise were compared with locations near Lower Chedoke Creek as appropriate to evaluate impacts of the CSO discharge on Cootes Paradise.

With respect to the requirement of Item #3 of the Director's Order as identified in this report's Introduction:

- Identification of contaminants related to the sewage spill.

Substances deemed to be COPCs associated with the discharge were identified by comparing analytical chemistry from surface water samples obtained immediately downstream of the Main/King CSO during the discharge to applicable guidelines and/or local background conditions. Final COPCs included (low) DO, TSS, un-ionized ammonia, ammonia as N, nitrite as N, TKN, TP, copper and *E. coli.*

With respect to the requirements of Item #3 of the Director's Order as identified in this report's Introduction:

- Identification of known environmental impacts from the identified contaminants;
- Identification of anticipated ongoing environmental impacts from the identified contaminants; and
- Spatial and environmental evaluation of the contaminants remaining in Cootes Paradise.

Overall the data reviewed indicated that impacts from the CSO discharge were limited to short-term and localized impacts on surface water quality only. The limited sediment quality data reviewed did not indicate that the Main/King CSO discharge event affected sediment quality in Cootes Paradise. The evaluation of aquatic plant and fish community data did not show impacts associated with the CSO discharge, independent from other potential influencing factors. The surface water quality data reviewed supports the conclusion that there is no evidence of long-term impact on Cootes Paradise based on water quality measurements.

Based on annual mean concentrations, changes in surface water quality in Cootes Paradise during the CSO discharge seem to have been limited to *E. coli* and TP. The impacts were temporally limited and geographically localized. Concentrations of *E coli* and TP above pre-discharge conditions were observed in 2018 only, within Cootes Paradise near the mouth of Chedoke Creek and the monitoring station closest to the Bay (CP1). While the discharge event appeared to have contributed TP to Chedoke Creek, the data reviewed indicated that elevated concentrations were quickly assimilated in the creek. Precise determination regarding the contribution of the discharge to TP in Cootes Paradise cannot be made because the inherent variability in concentrations in the creek did not indicate a statistically significant increase of TP over baseline, or pre-CSO discharge, conditions.

In addition, the review of Chedoke Creek water quality data indicated that the Main/King CSO discharge event:

- Had a short-lived impact on DO in Chedoke Creek but this was mitigated fully by the aeration achieved at the drop structure.
- Resulted in an impact on TSS in Chedoke Creek; however, this was quickly assimilated downstream. Post discharge TSS levels appear similar to pre-discharge levels and do not appear outside of the natural variability of TSS within this section of Chedoke Creek.
- Resulted in an increase in ammonia as N of about 1 mg/L at STN1; but this increase cannot be separated from the apparent ongoing influence from landfill leachate reaching the creek. Furthermore, the natural variability of ammonia concentrations precluded any conclusion regarding a statistically significant impact of either the discharge event or the leachate.
- Had no differentiable impact from other possible sources on un-ionized ammonia in Chedoke Creek.

The review indicated that landfill leachate seeping into Chedoke Creek had a historic impact on copper concentrations and appears to be continuing to add copper to the creek. With the available data, an adverse impact from copper during the discharge event is not evident.

Sediment quality data for Cootes Paradise are limited to a few sampling events and monitoring stations. In addition, physical disturbance through wave action and/or bioturbation confound the interpretation of sediment profiles to effectively provide a time series of contamination in Cootes Paradise. Keeping these limitations in mind, comparisons of nutrients and metals concentrations in the sediment samples obtained in Cootes Paradise near the mouth of Chedoke Creek before and after the discharge event do not point to increases in concentrations resulting from the discharge event.

The evaluation of impacts on aquatic vegetation considered data collected for Cootes Paradise from 1996 to 2019 and scoped to 11 established aquatic vegetation monitoring stations. To the extent possible, based on available information, percent coverage of aquatic species and vegetation types (submergent, floating and emergent) was compared before, during and after the

CSO discharge at locations far from (West End and North Shore – reference stations) and near (potential exposure) Lower Chedoke Creek.

Magnitude of increases and decreases in percent cover for floating and submergent vegetation types during the CSO discharge were similar to, or smaller than fluctuations prior to the CSO discharge at locations both far from, in or near Lower Chedoke Creek, thus within background variation.

Based on observations described above, and consistent with other published sources, assessment of available information does not show impacts on aquatic vegetation in Cootes Paradise associated with the CSO discharge, independent from other potential influencing factors.

Spatial and temporal patterns of fish species sensitivity to water quality and changes in relative abundance of trophic feeding groups indicate that fish at the fishway, in Cootes Paradise, the vicinity of Lower Spencer Creek, and Lower Chedoke Creek may be influenced by regional factors. Combined, these observations indicate that assessment of available information does not show impacts on fish species relative abundance in Cootes Paradise associated with the CSO discharge, independent from other potential influencing factors.

7.0 RECOMMENDATIONS

With respect to the requirements of Item #3 of the Director's Order as identified in this report's Introduction:

- Proposed remedial actions and recommendation with justification including timelines.

Options to remediate Cootes Paradise were contingent on the assessment of potential impacts. Given that post-discharge levels of contaminants in surface water (except ammonia as N and DO, which are components of landfill leachate) appear consistent with pre-discharge levels, no remaining adverse impacts to Cootes Paradise as a result of the Main/King CSO discharge persist. In addition, the assessment of available information does not show adverse impacts on aquatic vegetation and the fish community in Cootes Paradise associated with the CSO discharge, independent from other potential factors. Thus, remediation is not required to address impacts from the Main/King CSO discharge that occurred from 2014 to 2018, and the '**no action**' alternative is recommended.

With respect to the requirements of Item #4 of the Director's Order as identified in this report's Introduction:

- *"the City shall submit to the Director a written surface water monitoring program for the impacted portion of Cootes Paradise as identified by the work performed in compliance with Item No.3 above and for Chedoke Creek. The surface water monitoring program should be designed to monitor any ongoing environmental impact on the area affected by the sewage spill described in Item No. 3 above*.

The review of surface water quality data indicates that COPCs concentrations in Chedoke Creek after the discharge event are comparable to concentrations measured before the discharge event. Within Cootes Paradise, ongoing environmental impacts measured by COPC concentrations, were limited to the immediate vicinity of the mouth of Chedoke Creek only during the CSO discharge period, and investigations beyond Cootes Paradise are not justified based on the results of this environmental impact evaluation.

These findings suggest that there are no persistent, elevated concentrations of COPCs associated with the Main/King CSO discharge remaining in these water bodies. The absence of any long-term impacts in Chedoke Creek and correspondingly within Cootes Paradise due to the discharge event supports the conclusion that there is no evidence of ongoing environmental impact. Accordingly, a surface water monitoring program for the area affected by the sewage spill is not warranted.

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9.0 STATEMENT OF LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SLR Consulting (Canada) Ltd. (SLR) for the City of Hamilton referred to as the “Client”. It is intended for the sole and exclusive use of the Client. Other than by the Client and as set out herein, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted unless payment for the work has been made in full and express written permission has been obtained from SLR.

This report has been prepared for specific application to this site and conditions existing at the time work for the report was completed. Any conclusions or recommendations made in this report reflect SLR’s professional opinion based on limited investigations including visual observation of the study area, environmental investigation at discrete locations and depths, and laboratory analysis of specific parameters. The results cannot be extended to previous or future site conditions, portions of the site that were unavailable for direct investigation, subsurface locations which were not investigated directly, or parameters and materials that were not addressed. Substances other than those addressed by the investigation may exist within the study area; and substances addressed by the investigation may exist in areas of the creek not investigated in concentrations that differ from those reported. SLR does not warranty information from third party sources used in the development of investigations and subsequent reporting.

Nothing in this report is intended to constitute or provide a legal opinion. SLR expresses no warranty to the accuracy of laboratory methodologies and analytical results. SLR expresses no warranty with respect to the toxicity data presented in various references or the validity of toxicity studies on which it was based. Scientific models employed in the evaluations were selected based on accepted scientific methodologies and practices in common use at the time and are subject to the uncertainties on which they are based.

SLR makes no representation as to the requirements of compliance with environmental laws, rules, regulations or policies established by federal, provincial or local government bodies. Revisions to the regulatory standards referred to in this report may be expected over time. As a result, modifications to the findings, conclusions and recommendations in this report may be necessary.

The Client may submit this report to the Ministry of Environment Conservation and Parks and/or related Ontario environmental regulatory authorities or persons for review and comment purposes. These agencies may rely on the information contained in this report regarding the study area, as described in this report. These agencies may copy the report as required to fulfil regulatory obligations.

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TABLES

Cootes Paradise: Environmental Impact Evaluation
City of Hamilton
700 Woodward Avenue, North Hamilton, Ontario
SLR Project No.: 209.40666.00001

Table 1: Surface Water Contaminants of Potential Concern (COPC) Screening

Parameter	Units	PWQO[2]	CCME WQG	BC AWQG	95th at location upstream of CSO	95th at locations STN1 before spill	Max Conc. during the spill	Sample ID	Sample Date	Preliminary COPCs	Final COPCs
Bacteria											
E coli		**100**			86750	na	4900000	CP11-outlet	July 4 2018	**YES, max. conc > screening benchmark**	**YES, max. conc > upper limit of background**
Physico-chemical Parameters											
Total Suspended Solids	mg/L	na			16.1	87	75.2	STN-1	April 10 2015	Uncertain	**YES, max. conc > upper limit of background**
pH (Field)	pH	**6.5 - 8.5**			8.4	9.3	7.28-8.63	STN-1	-	No	No
Dissolved Oxygen	mg/L	na	**>5.5**		14.4	15	3.51-11.92	STN-1	-	**YES, min conc < screening benchmark**	**YES, max. conc < upper limit of background**
Nutrients											
Ammonia as N	mg/L	na			0.42	0.31	14.2	CP11-outlet	June 20 2018	Uncertain	**YES, max. conc >upper limit of background**
Ammonia (un-ionized) as NH3	µg/L	20	**20**		na	13.6	220	STN-1	April 23 2018	**YES, max. conc > screening benchmark**	**YES**
Nitrate as N	mg/L	na	**3**		2.7	3.7	3.89	STN-1	April 10 2015	**YES, max. conc > screening benchmark**	No, the maximum concentration at STN1 during the spill is comparable to the 95th percentile at the same location before the spill
Nitrite as N			**0.06**		0.1	na	0.19	CP11-outlet	June 20 2018	**YES**	**YES, max. conc >upper limit of background**
Total Kjeldahl Nitrogen as N	mg/L	na	na	na	na	1.49	14.4	STN-1	April 23 2018	Uncertain	**Yes > 95th percentile before spill**
Total Phosphorus	mg/L	0.03			0.5	0.53	2.8	CP11-outlet	July 4 2018	**YES, max. conc > screening benchmark**	**YES, max. conc >upper limit of background**
Sulphate	mg/L	na		**218**	na	128	116	STN-1	April 24 2017	No < screening benchmark	No
Total Metals											
Barium	mg/L	na	na	na	na	0.07	0.067	STN-1	April 10 2015	Uncertain	No < 95th percentile before spill
Boron	mg/L	0.2	1.5		na	0.24	0.303	STN-1	October 5 2016	**YES**	No < CCME
Calcium	mg/L	na	na	na	na	125	126	STN-1	April 24 2017	Uncertain	No, comparable to pre-spill condition
Chromium (total)	mg/L	**0.001**[a]			na	0.01	0.005	STN-1	April 16 2014	**YES**	No < 95th percentile before spill
Cobalt	mg/L	**0.0009**			na	0.002	0.0012	STN-1	April 10 2015	**YES**	No < 95th percentile before spill
Copper	mg/L	**0.005**			na	0.015	0.0359	STN-1	April 23 2018	**YES**	**Yes > 95th percentile before spill**
Iron	mg/L	**0.3**			na	4.1	2.19	STN-1	April 10 2015	**YES**	No < 95th percentile before spill
Lead	mg/L	**0.025** (Alkalinity >80)			na	0.013	0.0058	STN-1	April 10 2015	No	No < 95th percentile before spill
Magnesium	mg/L	na	na	na	na	31	28.8	STN-1	April 16 2014	Uncertain	No < 95th percentile before spill
Sodium	mg/L	na	na	na	na	202	246	STN-1	April 16 2014	Uncertain	No, comparable to pre-spill condition
Zinc	mg/L	**0.03**			na	0.08	0.091	STN-1	April 16 2014	**YES**	No, comparable to pre-spill condition

Notes:

µg/L – micrograms per litre

mg/L - milligrams per litre

[2] Provincial Water Quality Objectives (PWQO, 1994).

[a] Individual guideline exist for Cr +3 and Cr +6. Reported value represents more stringent guideline.

Table 2: **Cootes Paradise July 27, 2018 - Dissolved Oxygen and E coli One-Time Monitoring Event -RBG Data**

Station 2019	Location	2018 Date	2018 Temp	2018 Turbidity	2018 DO (mg/l)	2018 Ecoli_CFU/100ml	X (Easting)	Y (Northing)	Elevation
1	BH	7/27/2018	24.15	29.01	6.06	210	589498.845	4792908.385	73.602707
2		7/27/2018	24.47	28.53	5.55	50,000	589745.942	4792675.285	73.443481
3	FW	7/27/2018	24.64	26.78	3.93	420	589808.866	4792495.064	73.830353
4		7/27/2018	24.59	34.45	4.76	120	589799.617	4792457.952	74.766411
5		7/27/2018	24.59	31.12	3.67	1,700	589817.474	4792476.297	73.217133
6	Chedoke side of FW WFT	7/27/2018	25.02	32.12	8.52	310	589771.618	4792359.946	74.274666
7		7/27/2018	26.18	62.49	7.86	1,300	589768.983	4792044.13	74.354195
8	Chedoke bridge WFT	7/27/2018	22.2	64.44	5.55	15,000	589765.285	4791851.704	73.923302
9	Chedoke creek	7/27/2018	22.61	72.53	5.32	14,700	589817.226	4791680.006	74.009804
10		7/27/2018	24.6	45.78	5.07	4,800	589617.225	4791816.528	73.822525
11	Chedoke bay PP	7/27/2018	24.41	47.64	5.26	7,400	589590.225	4791931.357	74.119438
12	PPt E side of tip	7/27/2018	25.81	44.96	7.24	4,300	589603.564	4792039.503	74.544113
13		7/27/2018	25.03	29.02	8.56	1,400	589583.79	4792412.224	74.13192
14		7/27/2018	25.19	31.87	8.29	14,200	589462.847	4792192.594	74.877922
15	WI marsh	7/27/2018	25.34	30.74	8.51	1,500	589309.615	4791909.668	74.214447
16		7/27/2018	25.87	31.52	6.31	21,800	589000.047	4791553.378	74.86792
17		7/27/2018	23.9	29.44	8.26	2,000	588914.937	4792027.329	75.421913
18	Double marsh	7/27/2018	25.73	41.98	8.89	1,130	588634.247	4791534.147	73.791481
19	Just E of cattails	7/27/2018	25.69	21.21	10.61	2,400	588076.468	4791448.686	73.581482
20	Mouth of MAC landing	7/27/2018	26.24	41.49	11.17	70,000	587724.122	4791374.48	74.557945
21		7/27/2018	25.7	54.55	9.07	28,900	588024.613	4791673.158	75.189583
22		7/27/2018	25.48	24.97	9.27	310	588337.1	4791821.173	75.213493
23	Spencer creek mouth	7/27/2018	22.81	30.58	5.48	1,500	588558.336	4792120.399	73.672295
24	Spencer creek by N oxbow	7/27/2018	22.78	31.23	6.58	8,000	588061.951	4792085.167	74.204201
25	Old DC near SC1	7/27/2018	20.9	51.27	6.65	8,100	587914.75	4791852.339	77.342216
26	Spencer creek between Sc6 and SC7	7/27/2018	21.66	30.15	6.78	5,400	587371.055	4791878.521	75.331352
27		7/27/2018	20.1	43.12	7.61	14,300	587198.549	4791553.522	76.130127
28	BC at mouth	7/27/2018	21.29	21.61	8.35	3,400	587179.709	4791655.355	75.456955
29		7/27/2018	24.38	20.76	8.89	800	588663.314	4791974.048	74.589165
30	Hickory Bay W	7/27/2018	24.89	41.1	7.02	2,600	588754.015	4792410.976	73.695961
31	Hickory Bay E	7/27/2018	25.08	31.42	6.81	30	588977.532	4792563.519	73.593102
32	DC (CP6)	7/27/2018	23.87	7.46	9.25	220	586333.392	4791174.476	75.348778
33	Specer creek logjam	7/27/2018	19.92	46.69	7.38	9,100	587216.875	4791611.853	74.90802
34	Inner bay far NW end	7/27/2018	26.24	43.58	8.3	450	587597.416	4791582.319	74.323883
35	Inner bay N side	7/27/2018	25.83	31.46	8.59	23,900	587800.56	4791733.124	75.101906
36	PPt W side of tip	7/27/2018	25.45	37.86	7.92	3,900	589494.206	4792073.046	74.550598
37	403 shore	7/27/2018	23.91	25.66	5.24	170	589634.583	4792848.425	73.243576
38	BH original outlet	7/27/2018	24.75	28.39	4.27	60	589478.075	4793092.713	72.993629

Table 2: Cootes Paradise July 27, 2018 - Dissolved Oxygen and E coli One-Time Monitoring Event -RBG Data

Station 2019	Location	2018 Date	2018 Temp	2018 Turbidity	2018 DO (mg/l)	2018 Ecoli_CFU/100ml	X (Easting)	Y (Northing)	Elevation
39	Inlet back of MAC landing	7/27/2018	26.24	15.86	3.49	1,800	587579.955	4791206.005	74.663506
40		7/27/2018	24.66	3.67	4.12	20	586834.622	4791445.334	74.752975
41		7/27/2018	21.19	44.26	6.34	4,900	588444.181	4792080.487	73.290535
42	N side of Cockpit island	7/27/2018	25.77	30.98	8.46	900	589043.463	4791856.517	73.745613
43	CP1-SW	7/27/2018	24.25	28.99	8.25	1,300	589365.816	4792239.186	74.854134

Parameter	Category
DO	Less than initial HHRAP DO target of >5 mg/L
	More than initial HHRAP DO target of >5 mg/L
E coli	Less than target of 1000 num/100ml
	> target but < 2x target
	> 2x target but < 5x target
	> 5x target but < 10 x target
	> 10 x target but < 20 x target
	> 20 x target < 50 x target
	> 50 x target

Source: RBG data provided by City of Hamilton

Table 3: **Cootes Paradise August 7, 2019 - Dissolved Oxygen and E coli One-Time Monitoring Event -RBG Data**

Station 2019	Location	Date	Water Temp	Turbidity	DO (mg/l)	Ecoli_CFU/100ml	Easting	Northing	Elevation
E1	BH original outlet	7-Aug-19	24.4	16.3	4.88	30	589479.052	4793073.735	73.19222
E2	BH	7-Aug-19	24.5	9.6	9.11	10	589472.815	4792931.477	73.18986
E3	403 shore	7-Aug-19	24.6	8.81	9.02	390	589652.953	4792809.454	72.93179
E4	Near O1	7-Aug-19	24.5	9.15	8.56	10	589653.893	4792738.379	72.65328
E5	403 shore by FW	7-Aug-19	24.9	12.2	7.6	2300	589802.055	4792580.392	71.82575
E6	FW	7-Aug-19	24.3	11.22	7.54	430	589795.176	4792486.998	71.42715
E7	Chedoke side of FW WFT	7-Aug-19	25	15.28	6.95	3000	589772.041	4792395.611	71.60945
E8	Mouth of Chedoke WFT	7-Aug-19	25.2	13.5	7.56	870	589750.359	4792194.279	71.23878
E9	Chedoke bridge WFT	7-Aug-19	24.7	15.2	7.3	2000	589779.804	4791809.241	71.52891
E10	Chedoke creek	7-Aug-19	24.6	12.7	9.06	3900	589814.233	4791660.857	71.88013
E11	Inside Chedoke bay	7-Aug-19	24.9	10.2	9.4	1300	589697.937	4791862.584	72.19721
E12	Chedoke bay PP	7-Aug-19	24.9	16.2	8.39	600	589582.940	4791966.584	71.83782
E13	PPt E side of tip	7-Aug-19	25.2	15.8	7.2	600	589573.622	4792057.542	71.85485
E14	CP1-SW	7-Aug-19	25.1	12.55	8.11	30	589409.022	4792230.867	74.40499
E15	PPt W side of tip	7-Aug-19	25.2	18.8	6.64	1000	589460.153	4792046.048	74.34592
E16	WI marsh	7-Aug-19	25.2	16.3	6.28	4000	589348.205	4791919.058	74.48854
E17	N side of Cockpit island	7-Aug-19	25.1	16.8	6.27	30	589130.033	4791846.210	74.4514
E18	SE of Hickory island	7-Aug-19	24.6	8.3	11.2	650	589115.219	4792355.846	74.10172
E19	Hickory Bay E	7-Aug-19	24.7	10.7	9.8	880	588974.338	4792578.365	73.94665
E20	Hickory Bay W	7-Aug-19	24.7	17.6	6.57	60	588659.921	4792419.854	74.19501
E21	Spencer creek mouth	7-Aug-19	25.1	13.3	6.65	300	588558.400	4792115.295	74.46416
E22	Double marsh	7-Aug-19	25.1	18.05	5.05	30	588703.576	4791564.045	75.28707
E23	Middle W of CP2	7-Aug-19	25.1	12.2	7.41	220	588505.094	4791846.911	75.62593
E24	West of E23	7-Aug-19	24.7	17.05	6.24	10	588246.381	4791770.231	75.49037
E25	Inner bay N side	7-Aug-19	25.2	8.8	6.18	150	587792.549	4791718.801	76.39122
E26	Inner bay far NW end	7-Aug-19	25	8.7	6.07	100	587591.545	4791571.807	76.68253
E27	Mouth of MAC landing	7-Aug-19	25.2	10.8	5.31	70	587699.925	4791349.950	76.32878
E28	Inlet back of MAC landing	7-Aug-19	24.9	6.4	3.77	40	587531.929	4791160.066	77.03273
E29	Just E of cattails by	7-Aug-19	25	13.5	4.14	110	587999.912	4791374.939	77.24747
E30	King Fisher bay	7-Aug-19	25.3	15.3	5.77	320	588371.053	4791545.264	77.14645
E31	Spencer creek by N oxbow	7-Aug-19	22.6	15.5	5.26	1000	588047.577	4792079.764	76.85618
E32	Old DC near SC1	7-Aug-19	23.3	18.3	4.32	440	587904.442	4791852.428	77.32198
E33	Spencer creek between Sc6 and SC7	7-Aug-19	21.5	16.3	4	4900	587360.523	4791864.282	77.14144
E34	Spencer creek downstream of WP and BC	7-Aug-19	21.2	15.3	7.01	4500	587249.334	4791675.136	76.82714
E35	Confluence of WP and BC	7-Aug-19	20.8	18.5	7.22	3200	587192.987	4791638.868	77.00849

Table 3: Cootes Paradise August 7, 2019 - Dissolved Oxygen and E coli One-Time Monitoring Event -RBG Data

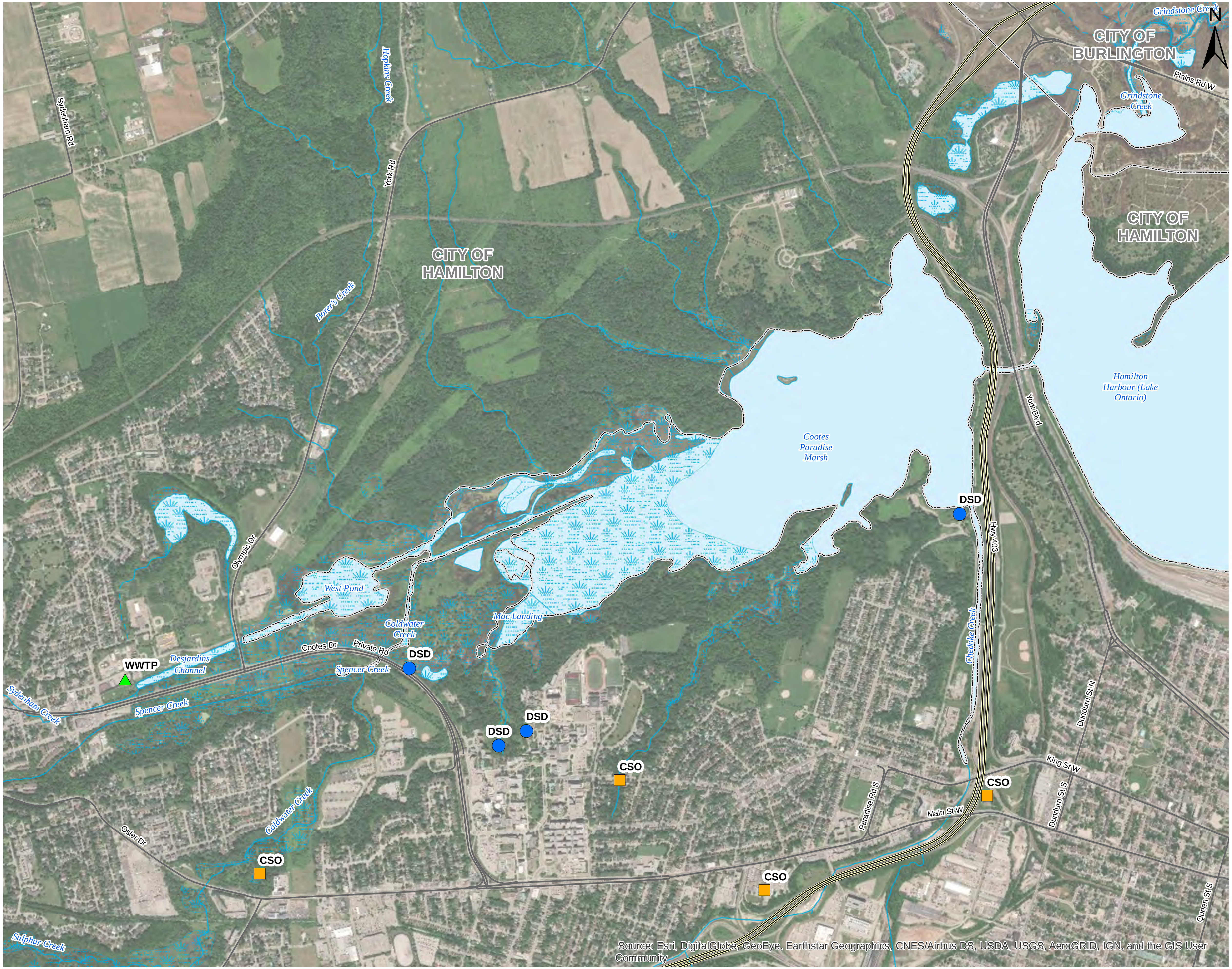
Station 2019	Location	Date	Water Temp	Turbidity	DO (mg/l)	Ecoli_CFU/100ml	Easting	Northing	Elevation
E36	BC at mouth	7-Aug-19	20.3	16.5	7.58	2500	587176.486	4791659.760	76.62929
E37	WP outflow channel	7-Aug-19	21.3	13.5	5.59	1900	587088.293	4791575.322	76.53146
E38	DC (CP6)	7-Aug-19	24.4	3.85	9.38	100	586362.804	4791185.066	75.39981
E39	Specer creek logjam	7-Aug-19	20.8	17.6	7.19	3400	587218.046	4791583.654	75.32508

Parameter	Category
DO	Less than initial HHRAP DO target of >5 mg/L
	More than initial HHRAP DO target of >5 mg/L
E coli	Less than target of 1000 num/100ml
	> target but < 2x target
	> 2x target but < 5x target
	> 5x target but < 10 x target
	> 10 x target but < 20 x target
	> 20 x target < 50 x target
	> 50 x target

Source: RBG data provided by City of Hamilton

FIGURES

Cootes Paradise: Environmental Impact Evaluation
City of Hamilton
700 Woodward Avenue, North Hamilton, Ontario
SLR Project No.: 209.40666.00001



LEGEND

- Combined Sewer Overflow (CSO)
- Direct Storm Drain (DSD)
- Waste Water Treatment Plant (WWTP)
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Municipal Boundary

0 125 250 500 Meters

SCALE: 1:17,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

PROJECT AREA

April 17, 2020	Rev	0.0	Figure No.
Project No.	209.40666.00001		1

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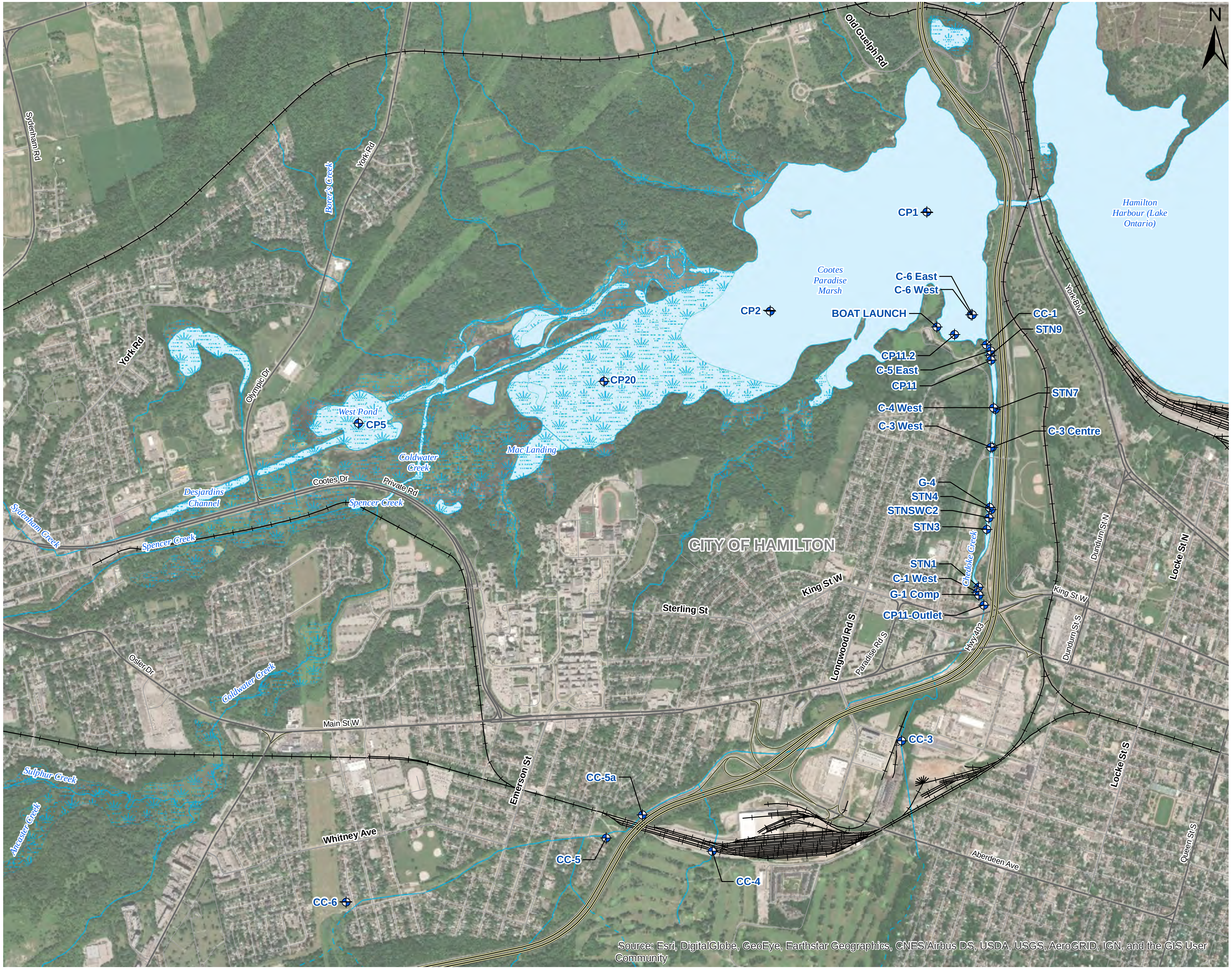

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LEGEND

- Surface Water Stations
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

0 125 250 500 Meters

SCALE: 1:17,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

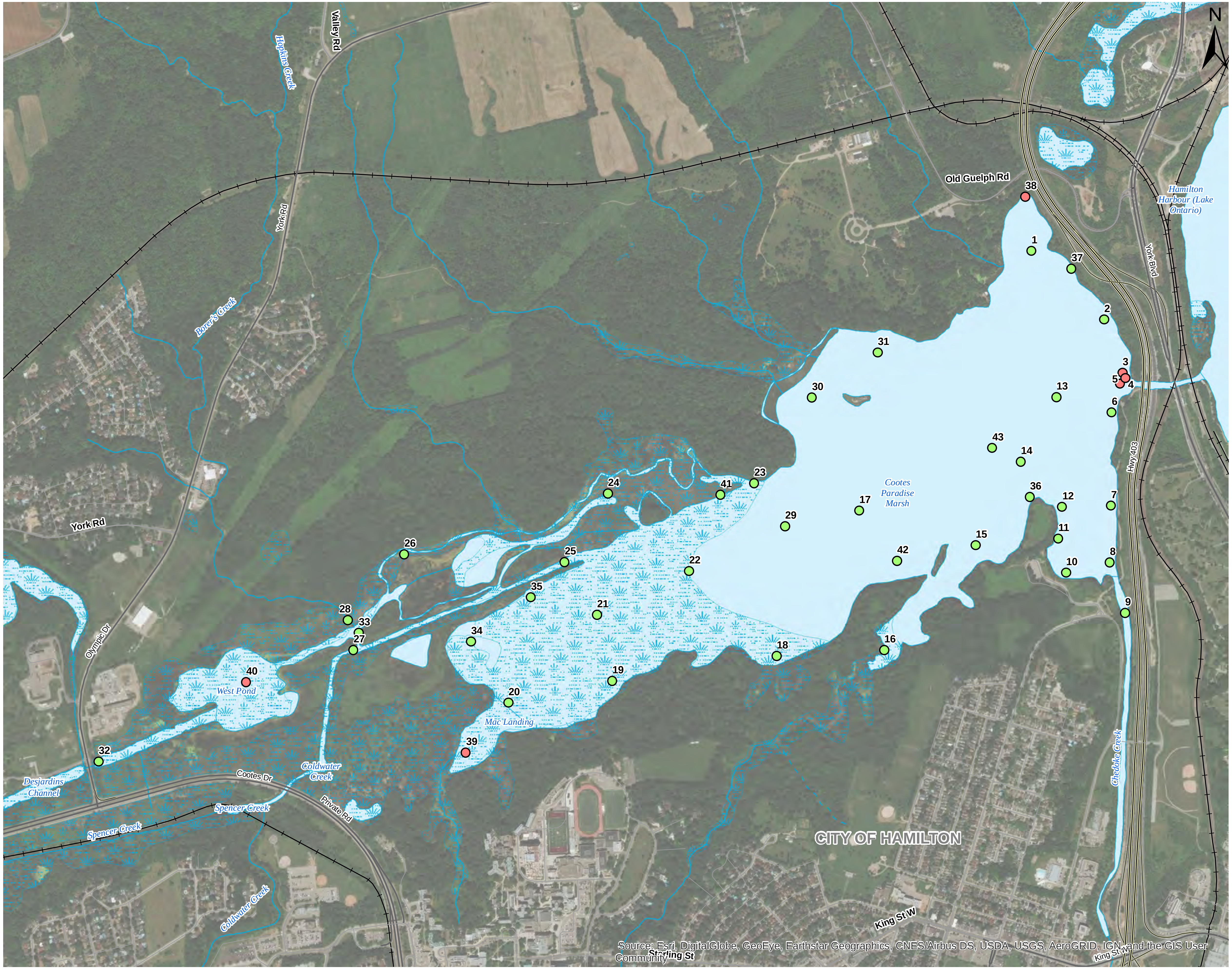
CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

SURFACE WATER STATIONS

April 17, 2020	Rev	0.0	Figure No.
Project No.	209.40666.00001		2

SLR
global environmental solutions



NOTES

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CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

COOTES PARADISE JULY 27, 2018 DISSOLVED OXYGEN COMPARISONS TO HHRAP TARGET

April 17, 2020	Rev	0.0	Figure No.
Project No.	209.40666.00001		3

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global environmental solutions

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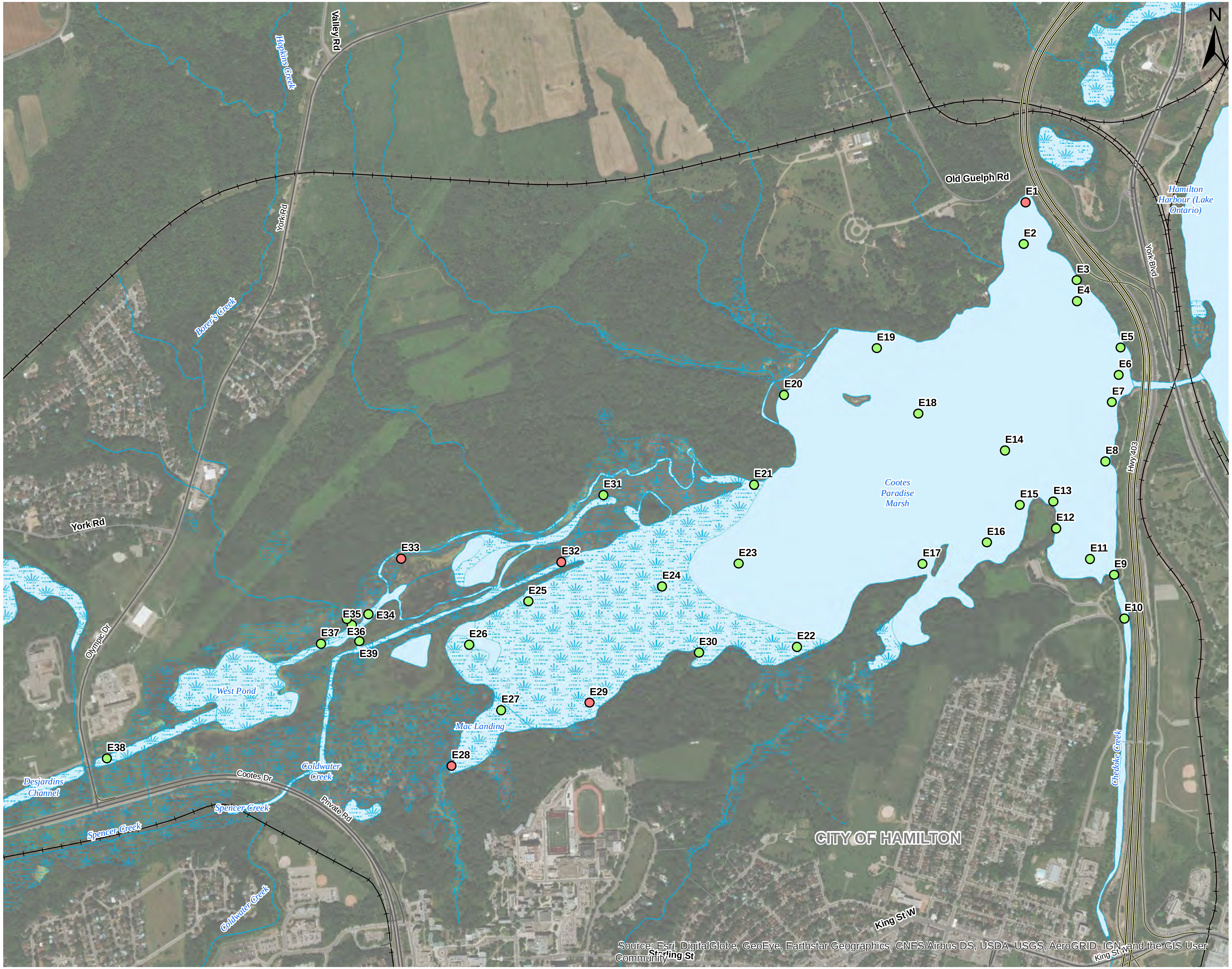

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LEGEND

Surface Water Sampling - July 2019 Results - Dissolved Oxygen

- Less than initial HHRAP DO target of >5 mg/L
- More than initial HHRAP DO target of >5 mg/L
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

SCALE: 1:12,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

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CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

COOTES PARADISE AUGUST 7, 2019 DISSOLVED OXYGEN COMPARISONS TO HHRAP TARGET

April 17, 2020	Rev	0.0	Figure No.
Project No.	209.40666.00001		4

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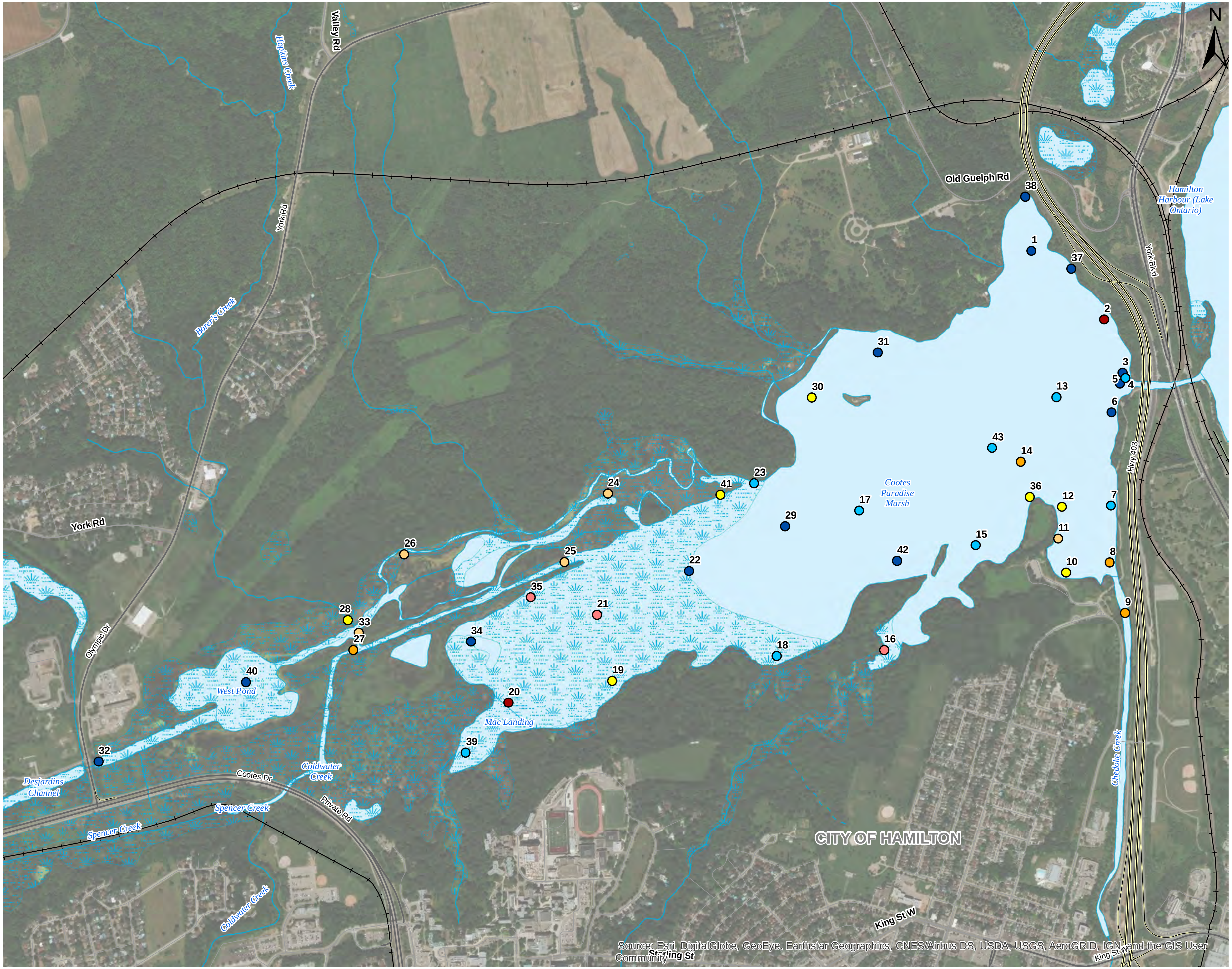

LEGEND

Surface Water Sampling - July 2018 Results - E.coli

- Less than CCME guideline of 1000 counts by 100/ml
- > CCME guideline but < 2x CCME guideline
- > 2x but < 5x CCME guideline
- > 5x CCME guideline but < 10 x CCME guideline
- > 10 x CCME guideline but < 20 x CCME guideline
- > 20 x CCME guidelinebyt < 50 x CCME guideline
- > 50 x CCME guideline
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

0 125 250 500 Meters

SCALE: 1:12,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

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CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

COOTES PARADISE JULY 27, 2018 E COLI COMPARISONS TO HHRAP TARGET

April 17, 2020	Rev 0.0	Figure No. 5
Project No. 209.40666.00001		

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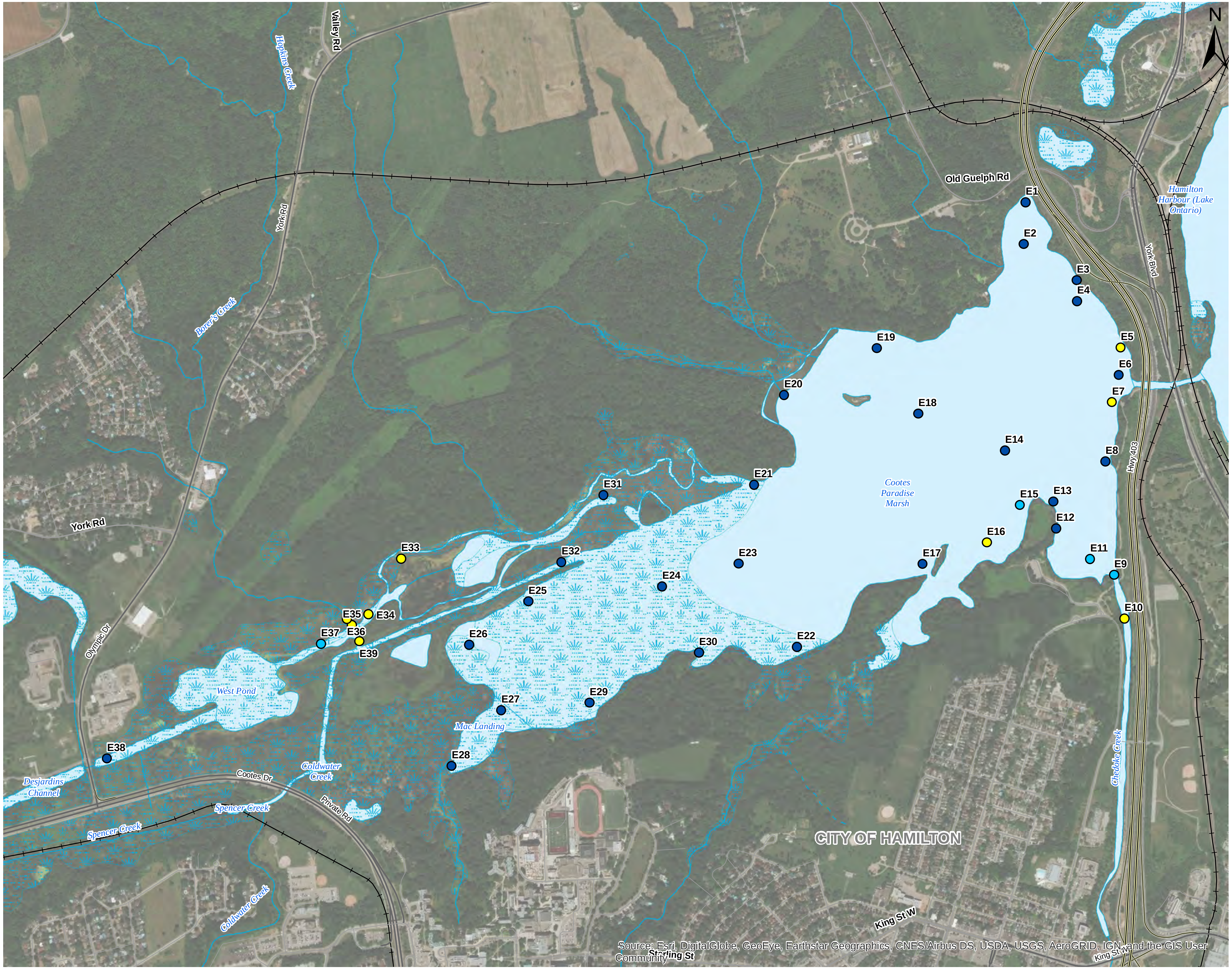

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LEGEND

Surface Water Sampling - July 2019 Results - E.coli

- Less than CCME guideline of 1000 counts by 100/ml
- > CCME guideline but < 2x CCME guideline
- > 2x but < 5x CCME guideline
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

0 125 250 500 Meters

SCALE: 1:12,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

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CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

COOTES PARADISE AUGUST 7, 2019 E COLI COMPARISONS TO HHRAP TARGET

April 17, 2020	Rev	0.0	Figure No.
Project No.	209.40666.00001		6

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LEGEND

- Sediment Sampling Locations
- Waterbodies
- Permanent Watercourse
- Railway

0 25 50 100 Meters

SCALE: 1:2,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

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CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

SEDIMENT SAMPLING LOCATIONS

April 17, 2020	Rev	0.0	Figure No.
Project No.	209.40666.00001		7

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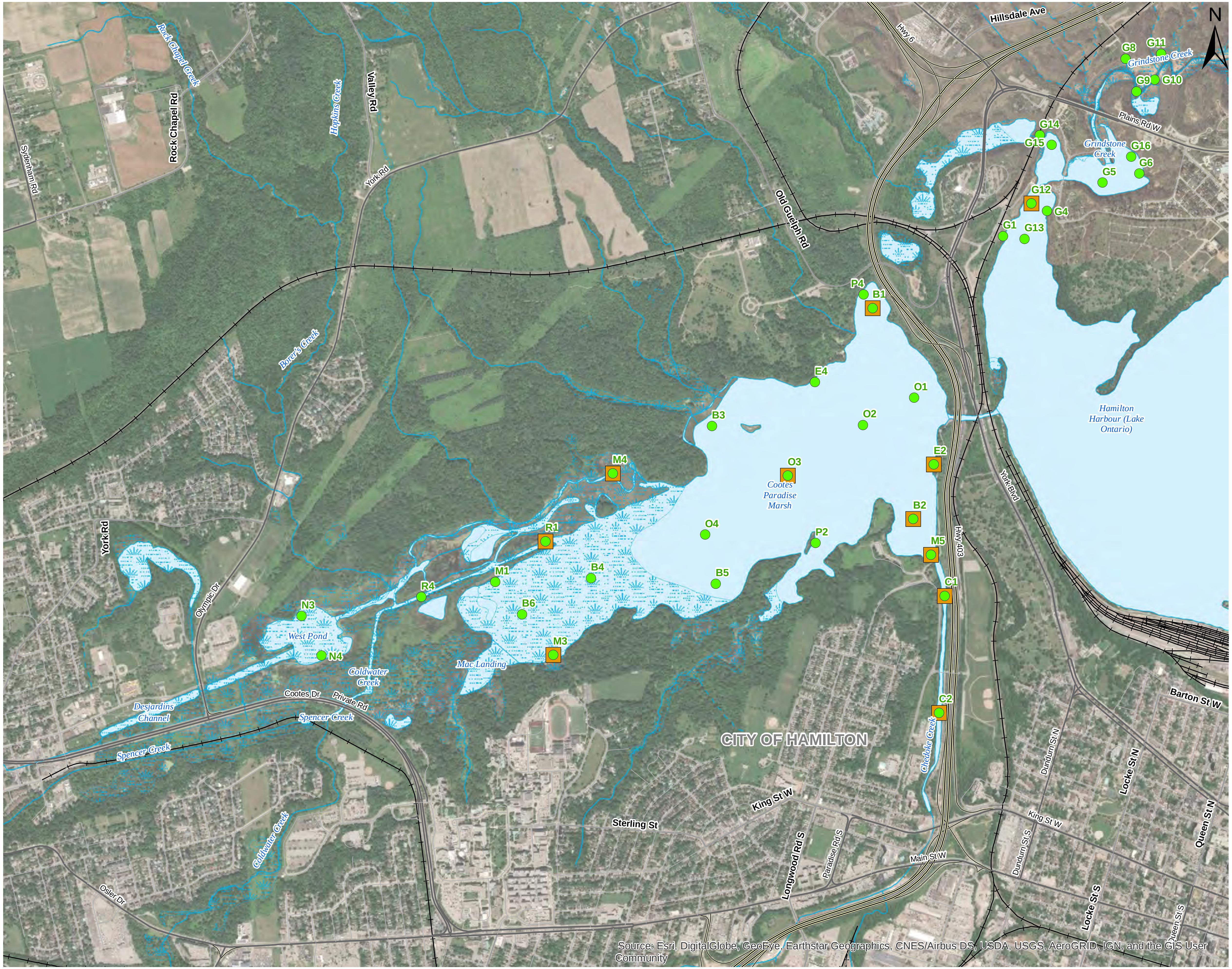

LEGEND

- Vegetation Monitoring Stations Established by RBG (1996 - 2019)
- Vegetation Monitoring Stations used for SLR's review
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

SouStation locations are adapted from Map of RBG Properties (Page 78) of the Harbor RAP Monitoring Catalogue: December 2016, showing Plant Monitoring and Electro-Fishing Transect. Monitoring Stations locations are approximate.

0 125 250 500 Meters

SCALE: 1:17,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

Source: Royal Botanical Garden Aquatic Vegetation Monitoring Stations - Provided to SLR as part of the Data Compilation Package Via City of Hamilton, Hamilton Harbour RAP Monitoring Catalogue: 2016.

CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

EXISTING RBG AQUATIC VEGETATION MONITORING STATIONS

April 17, 2020	Rev	2.0	Figure No.
Project No.	209.40666.00001		8

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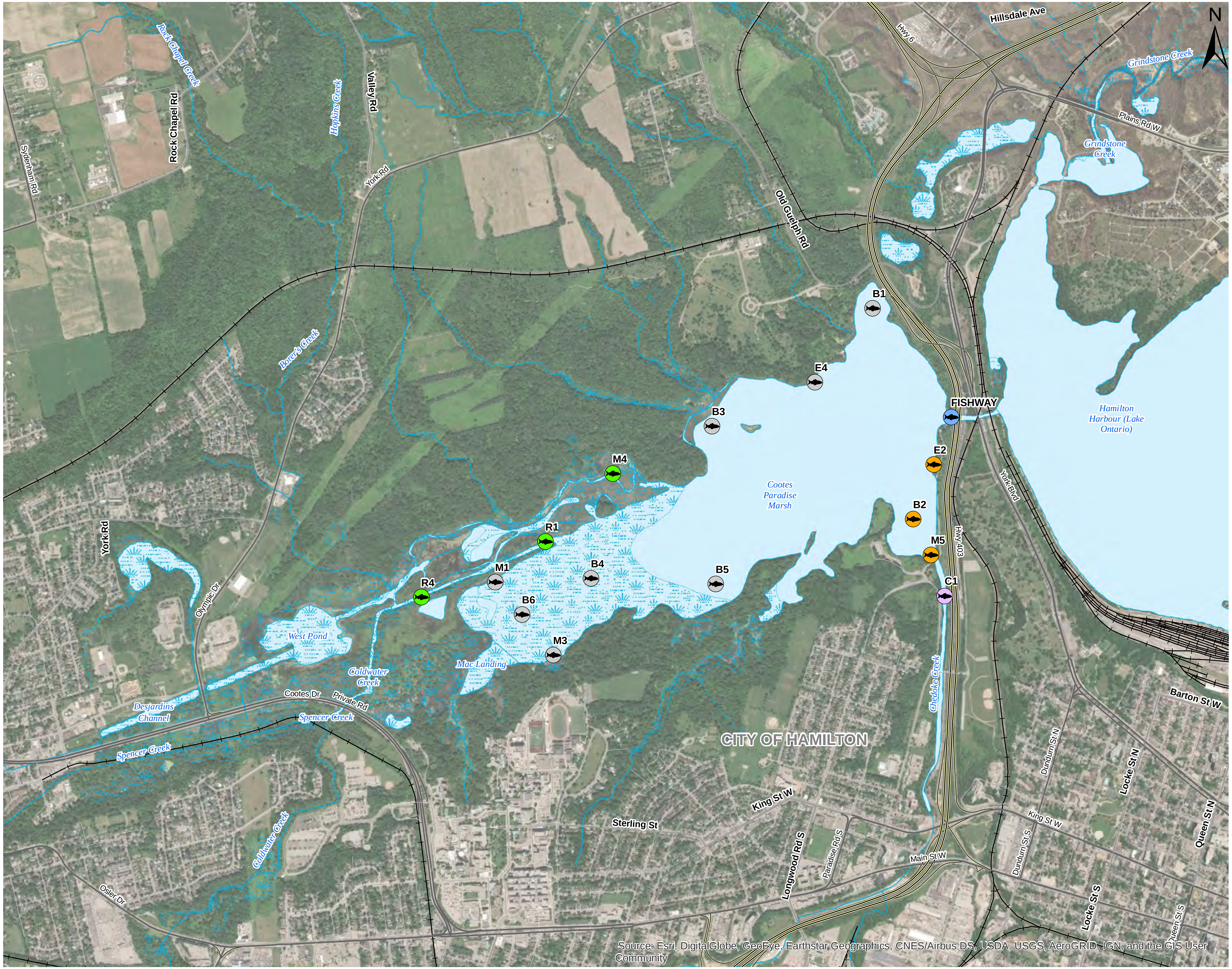

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LEGEND

Fish Sampling Locations

- Fishway
- Far from Lower Chedoke Creek
- Near Lower Chedoke Creek
- Lower Chedoke Creek
- Lower Spencer Creek and Vicinity
- Wetland
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

0 125 250 500 Meters

SCALE: 1:17,500
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 17N

NOTES

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CITY OF HAMILTON

COOTES PARADISE: ENVIRONMENTAL IMPACT EVALUATION
HAMILTON, ONTARIO

EXISTING RBG FISH SAMPLING LOCATIONS

April 17, 2020	Rev **2.0**	Figure No.
Project No. 209.40666.00001		**9**

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APPENDIX A
Information Sources

Cootes Paradise: Environmental Impact Evaluation
City of Hamilton
700 Woodward Avenue, North Hamilton, Ontario
SLR Project No.: 209.40666.00001

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
1	City of Hamilton McCormick Rankin Corporation (MRC)	16	Natural Environment	Ainsilie Wood/Westdale Neighborhoods Class Environmental Assessment Storm Water Management Master Plan	2003	Natural environment	Cootes Paradise, Spencer Creek, Chedoke Creek, Ancaster/Coldwater Creek	The City of Hamilton initiated the Ainslie Wood/Westdale Secondary Plan and Class Environmental Assessment to provide a land use plan and guidelines for development and re-development of lands within the Ainslie Wood/Westdale neighbourhoods. The existing conditions of the Ainslie Wood/Westdale area with respect to the natural environment, drainage and storm water management have been investigated through a review of available background reports, compilation of available digital information and mapping, detailed site reconnaissance, and computer modeling of the drainage system.	McCormick Rankin Corporation (MRC). 2003. City of Hamilton Ainsilie Wood/Westdale Neighborhoods Class Environmental Assessment Storm Water Management Master Plan. Final Report. December 2003.
2	City of Hamilton	66	Water Quality	CSO Tanks Performance Report 2017 Annual Report	2017	Overflow data, water quality	City of Hamilton area	2017 annual performance report for CSO's in the City of Hamilton	City of Hamilton. 2017. CSO Tanks Performance Report 2017 Annual Report
3	City of Hamilton	24	Water Quality	Chedoke Creek Investigation Samples – excel spreadsheet with google map of sample sites	2018	Ammonia + Ammonium as N, Boron, Caffeine, E. Coli, Fluoride, Phosphorus Dissolved total, Phosphorus Total, TSS	Chedoke Creek	at confluence = no info, just E.Coli	
4	City of Hamilton	67	Water Quality	Certificate of Analysis Main and King Influent	2018-09-06	BOD, TSS, E. coli, Metals, Anions, Ammonia, TKN, pH	Chedoke Creek		City of Hamilton. 2018. Certificate of Analysis. Environmental Monitoring and Enforcement. Main and King Influent. Sample Date 2018-09-06.
5	City of Hamilton	72	Water Quality	Certificate of Analysis Main and King Influent	2018-09-07	Ammonia, Field parameters	Chedoke Creek		City of Hamilton. 2018. Certificate of Analysis. Environmental Monitoring and Enforcement. Main and King Influent. Sample Date 2018-09-07.
6	City of Hamilton	68	Water Quality	Appendix B to Report PW19008(f)	Jul – Dec 2018, Aug & Nov 2019	E. coli, DO, Phosphorus, TSS, Ammonia, Boron, Fluoride, Caffeine	Chedoke Creek		Appendix B to Report PW19008(f), Pages 1-6

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
7	City of Hamilton	76	Water Quality	Hamilton Water Quality Data - Influent and Effluent	May, July, Nov, 2019	Metals, BOD, E. Coli, Fecal Coliform, TSS, TKN	Chedoke Creek		Hamilton Water Quality Data - Influent and Effluent, Main King CSO
8	City of Hamilton Rankin Construction Inc. Dillon Consulting UEM	54	Natural Environment	Chedoke Creek Remediation Project, Swana Excellence Award Landfill Management	2010		Chedoke Creek		City of Hamilton. 2010. Chedoke Creek Remediation Project, Swana Excellence Award Landfill Management. April 16, 2010
9	DFO	6	Fish	Letter of Advice – Implementation of mitigation measures to avoid and mitigate serious harm to fish – Chedoke Creek.	2014		Chedoke Creek	Provided follow mitigation measures in plans, the project will not result in serious harm to fish as well as impacts to aquatic species at risk (Eastern Pondmussel and Lilliput) and their habitat.	Fisheries and Oceans Canada. 2014. Letter of Advice. 14-HCAA-00568.
10	DFO	10	Freshwater Mussel	Freshwater Mussel Sampling in Cootes Paradise, Lake Ontario, with emphasis on Eastern Pondmussel *(Ligumia nasuta)*	2015		Cootes Paradise, lower Spencer Creek	Cootes Paradise still maintains a significant mussel community. A large and reproducing population of the Endangered Toxolasma parvum occurs in the area.	Morris, T.J., K. McNichols-O'Rourke, J. VandenByllaardt, and S. Reid. 2015. Freshwater Mussel Sampling in Cootes Paradise, Lake Ontario, with emphasis on Eastern Pondmussel *(Ligumia nasuta)*. Report to the Mollusc Specialist Subcommittee of the committee on the Status of Endangered Wildlife in Canada.
11	Dillon Consulting Limited	11	Erosion, Slope Stability	Chedoke Creek Erosion and Slope Stability Improvements, Municipal Class Environmental Assessment	2006		Chedoke Creek		Dillon Consulting Limited. 2006. Chedoke Creek Erosion and Slope Stability Improvements Municipal Class Environmental Assessment. 06-5921.
12	Dillon Consulting Limited	23	Soil	Chedoke Creek – Soil Sampling Results	2007	Arsenic, beryllium, boron	Chedoke Creek	Certificate of Analysis Soil sampling results Figure of sites	Dillon Consulting. 2007. Chedoke Creek – Soil Sampling Results. Memorandum to City of Hamilton. April 24, 2007

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
13	Dillon Consulting Limited	26	Groundwater, Surface Water quality	Updated West Hamilton Landfill Seepage Assessment Report	2012	Water level, chemical parameters	Chedoke Creek	The initial assessment work and follow-up monitoring program has been completed to evaluate if Seep C2 is influenced by groundwater flow from the West Hamilton Landfill site. The scope of this study did not look to see if the seep influenced the water quality of the creek or if the creek was impacted by the adjacent landfill. The scope was specifically limited to determining if Seep C2 was likely impacted by West Hamilton Landfill.	Dillon Consulting Limited. 2012. Updated West Hamilton Landfill Seepage Assessment Report. Prepared for City of Hamilton. Project No. 12-6961
14	Great Lakes Laboratory for Fisheries & Aquatic Science, RBG	48	Aquatic Vegetation	Aquatic vegetation trends from 1992 to 2012 in Hamilton Harbour and Cootes Paradise, Lake Ontario	2016	Aquatic Vegetation	Cootes Paradise	Using our recent dataset, we tested relationships that had been previously established in the literature between emergent extent and water levels for Cootes Paradise and also the connection between maximum depth of submergent colonization and Secchi depths but simple univariate tests were not significant.	K. E. Leisti, T. Theÿsmeÿer, S. E. Doka & A. Court (2016) Aquatic vegetation trends from 1992 to 2012 in Hamilton Harbour and Cootes Paradise, Lake Ontario, Aquatic Ecosystem Health & Management, 19:2, 219-229
15	Habitat Conservation Authority (HCA)	28	Natural Environment	Chedoke Creek Subwatershed Stewardship Action Plan	2008	Natural history & significant species	Chedoke Creek	Chedoke Creek subwatershed characterization	Hamilton Conservation Authority. 2008. Chedoke Creek Subwatershed Stewardship Action Plan. Endorsed by the Hamilton Conservation Authority Board of Directors April 3, 2008.
16	HCA	26.4	Water quality	2014 Tributary Monitoring for Cootes Paradise to Support the Hamilton Harbour Remedial Action Plan	2014	Total Phosphorus, Orth-phosphate, nitrate/nitrite/ammonia, TSS, E. Coli	Cootes Paradise, Spencer Creek, Chedoke Creek, and Borers Creek, Ancaster Creek.	Monitoring program aimed at understanding water quality contributions from creeks flowing into Cootes Paradise marsh and ultimately Hamilton Harbour.	Hamilton Conservation Authority. 2015. 2014 Tributary Monitoring for Cootes Paradise. To support the Hamilton Harbour Remedial Action Plan. Watershed Planning & Engineering. March 31, 2015.

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
17	HCA	29	Water Quality	HCA Chedoke Creek Water Quality Monitoring Program 2018 – Combined Services for Hamilton Harbour Remedial Action Plan and the City of Hamilton	2014-2018	Ammonia, Nitrate, Nitrite, Phosphorus, TSS, E. coli, turbidity	Ancaster Creek, Chedoke Creek (AC-1, AC-2, AC-3, AC-4, AC-5, CP-7, CP-11, CP-18, CC-3, CC-5, CC-7, CC-9, CC-2, CC-5a, CC-10)	To support the HHRAP, since spring of 2014 the HCA has been taking bi-weekly grab samples in Spencer Creek, Ancaster Creek, Borers Creek and Chedoke Creek in order to gather information on non-point sources of nutrients, sediments and bacteria into Cootes Paradise Marsh and ultimately the Hamilton Harbour. Over the past four years of sampling and data analysis, the program has grown from 7 sampling locations in 2014 to 15 in 2018 – most of these additional locations are located in Chedoke Creek in response to very poor water quality and elevated levels of nutrients and bacteria found near the mouth of the creek (site CP-11).	Excel spreadsheet with data, Project Descriptions, map
18	HCA	28.1	Water quality	Chedoke Creek All Data – 2014 to 2019.xlsx	2014-2019	Ammonia, Nitrate, Nitrite, phosphorus, TSS, E. coli, DO, pH, turbidity	Cootes Paradise, Chedoke Creek CP-11, CC-3, CC-5, CC-7, CC-9 CC-2, CC-5a, CC-10	Chedoke Creek All Data – 2014 to 2019.xlsx	Excel spreadsheet
19	HCA	26.1	Water quality	2015 Tributary Monitoring for Cootes Paradise.	2015	Total Phosphorus, Unionized Ammonia, Nitrate, Nitrite, TSS, VSS, E. Coli.	Ancaster Creek, Sulphur Creek, Borers Creek, Lower Spencer Creek, & Chedoke Creek. 7 surface water sampling locations.	Monitoring program aimed at understanding water quality contributions from creeks flowing into Cootes Paradise marsh and ultimately Hamilton Harbour.	Hamilton Conservation Authority. 2016. 2015 Tributary Monitoring for Cootes Paradise. To support the Hamilton Harbour Remedial Action Plan. Watershed Planning & Engineering. March 31, 2016.
20	HCA	26.2	Water quality	2016/2017 Tributary Monitoring for Cootes Paradise	2016/2017	Total Phosphorus, Unionized Ammonia, Nitrate, Nitrite, TSS, VSS, E. Coli.	In 2015, the monitoring program was further expanded in that storm event samples were taken at site AC-1 using an ISCO automated composite sampler	Monitoring program aimed at understanding water quality contributions from creeks flowing into Cootes Paradise marsh and ultimately Hamilton Harbour.	Hamilton Conservation Authority. 2017. 2016/2017 Tributary Monitoring for Cootes Paradise. To support the Hamilton Harbour Remedial Action Plan. Watershed Planning & Engineering. May 31, 2017.
21	HCA	26.3	Water quality	2017/2018 Tributary Monitoring for Cootes Paradise	2017/2018	Total Phosphorus, Unionized Ammonia, Nitrate, Nitrite, TSS, VSS, E. Coli.	In 2016 the sampling period was lengthened to be year-round at all seven stations.	Monitoring program aimed at understanding water quality contributions from creeks flowing into Cootes Paradise marsh and ultimately Hamilton Harbour.	Hamilton Conservation Authority. 2017. 2016/2017 Tributary Monitoring for Cootes Paradise. To support the Hamilton Harbour Remedial Action Plan. Watershed Planning & Engineering. May 31, 2017.

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
22	HCA	12	Information request	Email re: Chedoke Creek-Additional Information/Data	2018		Cootes Paradise, Chedoke Creek	No dredging projects, HCA permits on file, bedload movement, no previous reports on species presence, no surveys or data for current water depth, hydrology, hydraulics, flood plain mapping	Jonathan Bastien. 2018. Email re: Chedoke Creek-Additional Information/Data. September 14, 2018.
23	HCA	27.1	Fish	RED1009-A1 2019 data for SLR.xlsx	2019	Fish	RED1009-A1	Fish species captured on July 31, 2019	Excel spreadsheet
24	Hamilton Harbour Remedial Action Plan (HHRAP)	31	Water Quality	Cootes Paradise Marsh: Water Quality Review and Phosphorus Analysis.	Prior to 2012	Phosphorus concentrations	Cootes Paradise, Chedoke Creek, Spencer Creek, Grindstone Marsh		Cootes Paradise Phosphorus Budget and Model Sub-Committee. 2012. Cootes Paradise Marsh: Water Quality Review and Phosphorus Analysis. March 2012. Cootes Paradise Water Quality Group Hamilton Harbour Remedial Action Plan.
25	HHRAP	55	Stormwater Management	Urban Runoff Hamilton Report and Recommendations	2016		Cootes Paradise	This report addresses findings related solely to urban stormwater management.	Urban Runoff Hamilton Task Group. 2016. Urban Runoff Hamilton Report and Recommendations.
26	HHRAP	58	Monitoring delisting objectives	2016 Monitoring Catalogue	2016		Hamilton Harbour	This monitoring catalogue has been developed to compile metadata information on monitoring activities occurring throughout Hamilton Harbour in one report. It will help broaden our understanding of what monitoring is happening and identify potential gaps. It has been designed to be updated on an annual basis.	Hamilton Harbour Remedial Action Plan. 2016. Hamilton Harbour Remedial Action Plan Monitoring Catalogue 2016 Season. December 2016
27	HHRAP	47	Monitoring delisting objectives	Hamilton Harbour Remedial Action Plan Monitoring Catalogue 2017 Season	2017		Hamilton Harbour	This monitoring catalogue has been developed to compile metadata information on monitoring activities occurring throughout Hamilton Harbour in one report. It will help broaden our understanding of what monitoring is happening and identify potential gaps. It has been designed to be updated on an annual basis.	Hamilton Harbour Remedial Action Plan. 2018. Hamilton Harbour Remedial Action Plan Monitoring Catalogue 2017 Season. February 2018.

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
28	HHRAP	46	Water quality	Contaminant Loadings and Concentrations to Hamilton Harbour: 2008-2016 Update	2018	Contaminants – TP, TSS, Ammonia, Nitrate, TKN, Fe, Pb, Zn, Phenolics, PAHs	Cootes Paradise	The purpose of this report is to show the relative contributions of contaminants from known sources. It is not a trend analysis. The report does not provide an interpretation of the concentration and loading results.	Hamilton Harbour Remedial Action Plan. 2018. Contaminant Loadings and Concentrations to Hamilton Harbour: 2008-2016 Update. April 2018.
29	Kim et al. 2016 in Aquatic Ecosystem Health & Management	33	Water Quality	Modelling phosphorus dynamics in Cootes Paradise marsh: Uncertainty assessment and implications for eutrophication management.	2016	Phosphorus modelling, nutrient recycling, sediment dynamics, Areas of Concern	Cootes Paradise	Model sensitivity analysis identified the sedimentation of particulate material and diffusive reflux from sediments as two critical processes to characterize the phosphorus cycle in the wetland. Based on the current parameter specification, our model postulates that the sediments still act as a net sink, whereas macrophyte processes respiration rates, nutrient uptake from interstitial water) appear to play a minor role. We conclude by discussing the various sources of uncertainty and additional remedial actions required in Cootes Paradise marsh to realize a shift from the current turbid-phytoplankton dominated state to its former clear-macrophyte dominated state.	Kim, D., T. Peller, Z. Gozum, T. Theÿsmeÿer, T. Long, D. boyd, S. Watson, Y.R. Rao, and G. B. Arhonditsis. 2016. Modelling phosphorus dynamics in Cootes Paradise marsh: Uncertainty assessment and implications for eutrophication management. Aquatic Ecosystem Health & Management 19(4):368-381.
30	Matrix	9	Hydrology	Spencer Creek MIKE-11 Model Expansion and Cootes Paradise Water Level Analysis	2014	Water level, flood level	Cootes Paradise	Subsequent to the completion of the Spencer Creek MIKE-11 model, HCA was interested in understanding how water levels within Cootes Paradise might affect flood levels within the Town of Dundas.	Bellamy, S. 2014. Memorandum Re: Spencer Creek MIKE-11 Model Expansion and Cootes Paradise Water Level Analysis. To J. Bastien, Hamilton Conservation Authority. December 29, 2014.
31	McMaster University	57	Sediment	Potential Contribution of Nutrients and Polycyclic Aromatic Hydrocarbons from the Creeks of Cootes Paradise Marsh	1996	PAH, nutrients	Spencer Creek Chedoke Creek Borer Creek	During the summer of 1994, we compared the physical and nutrient characteristics of the three main tributaries of Cootes Paradise: Spencer, Chedoke and Borer's creeks.	Chow-Fraser, P., B. Crosbie, D. Bryant, and B. McCarry. 1996. Potential Contribution of Nutrients and Polycyclic Aromatic Hydrocarbons from the Creeks of Cootes Paradise Marsh. Water Qual. Res. J. Canada, 1996, Volume 31, No. 3, 485-503.

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
32	Minnesota Pollution Control Agency	62	Sediment	Guidance for The Use and Application of Sediment Quality Targets for The Protection of Sediment-Dwelling Organisms in Minnesota	2007	Sediment quality	Minnesota	Specific indicators (e.g., sediment chemistry) can be used to determine if the designated uses of the aquatic ecosystem are being protected, and where necessary, restored. A suite of sediment quality indicators was developed for the St. Louis River Area of Concern (AOC) in northeastern Minnesota	Crane, J.L. and S. Hennes. 2007. Guidance for The Use and Application of Sediment Quality Targets for the Protection of Sediment-Dwelling Organisms in Minnesota. February 2007.
33	MTE	80.4	Leachate	Final 2012 Annual Leachate Collection System Performance Report	2012	Leachate	Chedoke Creek, Cootes Paradise	MTE Consultants Inc. (MTE) was retained by the City of Hamilton (the City) to complete the 2012 Annual Performance Report for the leachate collection system (LCS) and leachate and surface water monitoring program at Kay Drage Park (former West Hamilton Landfill).	MTE More Than Engineering. 2013. Kay Drage Park (Former West Hamilton Landfill). Final 2012 Annual Leachate Collection System Performance Report. Prepared for City of Hamilton. March 25, 2013.
34	MTE	80.2	Leachate	Final 2013 Annual Leachate Collection System Performance Report	2013	Leachate	Chedoke Creek, Cootes Paradise	MTE Consultants Inc. (MTE) was retained by the City of Hamilton (the City) to complete the 2013 Annual Performance Report for the leachate collection system (LCS) and leachate and surface water monitoring program at Kay Drage Park (former West Hamilton Landfill).	MTE More Than Engineering. 2014. Kay Drage Park (Former West Hamilton Landfill). Final 2013 Annual Leachate Collection System Performance Report. Prepared for City of Hamilton. March 25, 2014.
35	Ontario Ministry of the Environment	50	Water quality, sediment, invertebrate biology	Cootes Paradise Study 1986	1986	Phosphorus, nitrogen, chlorophyll, TSS, BOD, metals, TKN, nutrients & productivity, sediment chemistry, invertebrate biology	Cootes Paradise	By 1979 and 1980 improvements in water quality in Cootes Paradise following expansion of the Dundas Water Pollution Control Plant when compared to 1975. Noteworthy improvement was in TP.	McLarty, A.W. and A. G. Thachuk. 1986. Cootes Paradise Study 1986. Ministry of the Environment.
36	Ontario Ministry of the Environment & Climate Change (OMOECC)	63	Water Quality	An Empirically-Based Regression Method for Estimating TP Loads to Hamilton Harbour from the Four Tributary Inputs	2015	Phosphorus (TP), Discharge data, nutrient	Desjardins Canal, Grindstone Creek, Indian Creek, Red Hill Creek	Presentation Results published in Long, T., C. Wellen, G. Arhonditsis, and D. Boyd. 2014. Evaluation of stormwater and snowmelt inputs, land use and seasonality on nutrient dynamics in the watersheds of Hamilton Harbour, Ontario, Canada. Journal of Great Lakes Research 40 (2014) 964-979.	Long, T. 2015. An Empirically-Based Regression Method for Estimating TP Loads to Hamilton Harbour from the Four Tributary Inputs. Presentation for Nutrient Loading Workshop, January 20, 2015.

Appendix A: Information Sources Reviewed and Saved in the Document Library

Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
37	RBG	43.1.13	Aquatic Vegetation	Cootes Paradise	?	Total phosphorus contamination scale	Cootes Paradise	Two figures, sites for submergent vegetation sites and map of contamination based on level of TP concentrations	Cootes-sedphos - Wild Rice Project 2001 Lakehead.gif
38	RBG	43.1.12	Water quality	Cootes Water Phosphorus Model v5b.STR	?	TP	Cootes Paradise		Cootes Water Phosphorus Model v5b.STR
39	RBG	32	Water Quality Dataset for Cootes Paradise	Excel spreadsheet	1986 – 2017	Ammonia Secchi Chl-a TSS TKN Nitrate (1991 – 1992) TP SRP DO (1993 – Conductivity (1993 - Turbidity (1993 – VSS Org SuspSed (1993 – Inorg Sus Sed (1993 – Tot Nitrogen as N (1993 – TN (1993 – Nitrite (1995 – Nitrate (1995 -	CP 1 CP2 4 & 7 (Spencer Creek) CP5 (West Pond) 5.1 (Delsey Creek) CP 6 (STP Outflow) 8 (Mac Landing) 9 (Mac Landing) 10 (Mac Landing) CP11 (Chedoke Creek) 12 13 14 15 (Mac Landing) CP16 (Westdale Inlet) 17 CP20 (Cootes) CP1.1 (Fishway) CP18 (Borer's Creek)	Water Quality Data Cootes Paradise 1986-2017.xlsx	Water Quality Data Cootes Paradise 1986-2017.xlsx
40	RBG	59	Water Quality in Cootes Paradise	20 Year Trends in Water Quality Cootes Paradise and Grindstone Creek Marsh	1991 – 2011	Secchi (water clarity) TP TSS	Delisting Site (CP1) West Pond (CP5) Spencer Creek (CP7) Westdale Inlet (CP16) Chedoke Creek (~CP11)	Report updates the current state of wetland WQ using ongoing monitoring data, highlighting HHRAP and carp exclusion. WQ indicators summarized include water clarity, phosphorus, suspended sediment, E. coli	Reddick D. & Theÿsmeÿer T. 2012. 20 Year Trends in Water Quality, Cootes Paradise and Grindstone Marsh. Royal Botanical Gardens. Burlington, Ontario.
41	RBG	43.1.6	Fish, Water quality	Fishway Data.xlsx	1996-2003 2004-2019	Species captured Water quality at fishway Incidental Fish (small)	Cootes Paradise, fishway	Fish species captured and water quality at fishway.	Fishway Data.xlsx
42	RBG	4	Fish	Table 1.3 Annual Comparison of Large Fish Caught Entering the Marsh at Cootes Paradise Fishway	1996-2015	Large Fish	Cootes Paradise	Table 1.3 Annual Comparison of Large Fish Caught Entering the Marsh at Cootes Paradise Fishway	RBG. 2016. Project Paradise Season Summary. Carp Barriers.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
43	RBG	43	Water Quality & Fisheries	Cootes Paradise Nature Sanctuary Lower Chedoke Creek Area Water Quality & Fisheries	2001	Ammonia/Nitrates/Nitrites, total Phosphorus, E. coli, TSS	Lower Chedoke Creek, Cootes Paradise		RBG. 2001. Cootes Paradise Nature Sanctuary Lower Chedoke Creek Area Water Quality & Fisheries.
44	RBG	43.1.1	Water quality	WQ Index Monitoring 2003-2018.xlsx	2003-2019	Water quality	Cootes Paradise	Data, Figures - Water quality sampling locations E. coli sample locations 2018 E. colie sample locations 2019 Index Fish Community Monitoring Sample Locations Submerged Aquatic Vegetation Monitoring site map	WQ Index Monitoring 2003-2018.xlsx
45	RBG (JEMSys Software Systems Inc.)	43.1.15	Water quality	Towards A Phosphorus Budget and Model for Cootes Paradise	2005	Phosphorus	Cootes Paradise	The work described here is an attempt to apply to Cootes Paradise the phosphorus budget and modelling work reported by Minns et al. (2000a) and Minns et al. (2000b) for the Bay of Quinte. Its scope is almost entirely limited to implementing the ideas laid out in those publications. It is supported almost entirely by the data-collection effort of Simser (2004) and the hydrology and phosphorus loadings reported by Aquafor Beech (2005). The intent is to move the discussion of phosphorus management in Cootes Paradise beyond static annual estimates of annual loading, bringing together all available information to produce a budget accounting for flushing and seasonal variation.	JEMSys Software Systems Inc. 2005. Towards A Phosphorus Budget and Model for Cootes Paradise

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
46	RBG	22	Sediment	Internal Report: 2006 Cootes Paradise Sediment Quality Assessment	2006	Phosphorus, heavy metals, nutrients	Cootes Paradise	In 2006 a thorough examination of the contamination in the sediment in the Cootes Paradise Marsh areas was undertaken by RBG. The purpose of the report was to determine the amount of contamination in the sediments of the Cootes Paradise Marsh system. The results were intended to provide groundwork for assessing remedial options and establish baseline conditions against which to gauge future trends.	Bowman, J.E., and T. Theÿsmeÿer. 2007. 2006 Cootes Paradise Sediment Quality Assessment. RBG Internal Report No. 2007-02. Royal Botanical Gardens. Hamilton, Ontario.
47	RBG	43.1.16	Water quality	Water Quality Characterization of the Main Tributaries of the Garden's Property Spencer Creek Chedoke Creek Borer's Creek Grindstone Creek 2008/09	2008-2009	TP, water clarity, TSS, Ammonia/Nitrate/Nitrite, TKN	Cootes Paradise	Recommendation # 5 - 1996-2002 Contaminants Loading Report (2004) Water quality samples were taken from these four creeks on biweekly basis over the course of a one year period (May 2008 – May 2009). Sampling focused on basic water quality characteristics (pH, dissolved oxygen and temperature) and various identified parameters limiting water quality recovery in Cootes Paradise Marsh and Hamilton Harbour (nitrogen, phosphorus and suspended sediment). The objective of this study was to provide a more comprehensive characterization of the individual tributaries and their influence on the water quality of Cootes Paradise and Grindstone Creek marshes, and Hamilton Harbour.	T. Theÿsmeÿer, B. Reich, and J.E. Bowman. 2009. Water Quality Characterization of the Main Tributaries of the Garden's Property - Spencer Creek, Chedoke Creek, Borer's Creek and Grindstone Creek, 2008/09, RBG Report No. 2009-06. Royal Botanical Gardens. Hamilton, Ontario.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
48	RBG	34 35 36 37 38 39 40 42 43.1.17	Water Quality in Cootes Paradise	Water Quality Monitoring Season Summary	2011 2012 2013 2014 2015 2016 2017 2018 (lab only) 2018	Secchi (cm) DO (mg/l) Temp (°C) Turbidity (NTU) Chl a (µg/l) TP (mg/l) Nitrate-N (mg/l) Nitrite-N (mg/l) Unionized Ammonia (m/l) TSS (mg/l) E. coli (#100 ml)	CP1 (2011-2018) CP2 (2011-2018) CP5 (2011-2018) CP6 (2011-2013) CP7 (2011-2013) CP10 (2011-2012) CP11 (2011-2012) CP11.2 (2018) CP15 (2011) CP16 (2011-2018) CP18 (2011-2013) CP20 (2011-2018)	Each summary report identifies various lessons realized during each season. Summary of results for Cootes Paradise and long-term trends at delisting stations Summary of WQ in Cootes Paradise at each station with HHRAP targets and WQ guidelines CSO events from monitored locations affecting Cootes Paradise during sample event (each year).	43.1.17 - Bowman, J.E. 2019. Water Quality Season Summary 2018. RBG Report No. 2019-11. Royal Botanical Gardens. Hamilton, Ontario.
49	RBG	45	Water Quality	Water Quality Trends in Cootes Paradise Marsh and Grindstone Creek adapted from the 2012 report by Dave Reddick and Tys Theÿsmeÿer	2012	Precipitation, major infrastructure upgrades, water clarity, TP, TSS, E. Coli	Cootes Paradise, Grindstone Creek	Appears to be questions for a workshop or class.	Water Quality Trends in Cootes Paradise Marsh and Grindstone Creek adapted from the 2012 report by Dave Reddick and Tys Theÿsmeÿer
50	RBG	14 15 13	Natural Environment	Project Paradise Season Summary	2013 2015 2016	• WQ (water clarity, DO, Temp, turbidity, E.coli, TP, TSS, nitrate-N, nitrite-N, unionized ammonia) • Submergent aquatic vegetation (SAV) • Phytoplankton Chl a • Fish • Water level • Invasive Species management • Amphibian monitoring • Bird monitoring • Aquatic mammal monitoring • Fall migratory bird • Benthic (not in 2016)	Cootes Paradise, Spencer Creek Borer's Creek	The Project Paradise seasonal report summarizes the results obtained from all projects undertaken by the aquatic ecology staff of Royal Botanical Gardens' Natural Lands Department during the 2013 season. This report is divided into six sections: carp barriers, water quality, plants, fish, marsh monitoring program and other wildlife. Each section is further divided into Cootes Paradise Marsh and Hendrie Valley Sanctuary based upon the watershed systems. Lists stormwater events for each season of sampling.	

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
51	RBG	21	Sediment	2013 RBG Marsh Sediment Quality Assessment	2013	Metals, nutrients	Cootes Paradise	In 2013 marsh sediment samples were collected as part of the sediment quality monitoring program at RBG. The purposed of this report was to update the sediment status in the Cootes Paradise and Grindstone Creek marsh areas for heavy metal and nutrient contamination, with focus on the west Desjardins Canal and other sites associated with sewage contamination Comparison with results from the 2006 assessment and earlier will provide insight into trends in recovery and highlight potential restoration needs.	Bowman, J.E., and T. Theÿsmeÿer. 2014. 2013 RBG Marsh Sediment Quality Assessment. RBG Report No. 2014-14. Royal Botanical Gardens. Hamilton, Ontario.
52	RBG	77	Natural Environment	Wetlands Conservation Plan 2016-2021 Includes RBG contribution to the HHRAP as it pertains to the restoration of the wetlands	2016-2021	Restoration Plan, Monitoring	Cootes Paradise	This restoration plan summarizes items including the role of RBG in the HHRAP, the strategy looking forward independent of the HHRAP, resources required, partnerships, research opportunities, specific projects and locations. The plan is in parallel with the 2021 expected completion of the Hamilton Harbour Remedial Action Plan (HHRAP), bringing the wetlands to a recovered state.	Theÿsmeÿer T., J. Bowman, A. Court & S. Richer. 2016. Wetlands Conservation Plan 2016-2021. Natural Lands Department. Internal Report No. 2016-1. Royal Botanical Gardens. Hamilton, Ontario.
53	RBG	43.1.7 43.1.9 43.1.10	Water quality	20180704_Chedoke-Scum closeup near 403 Box culvert.jpg	2018	photographs	Chedoke Creek	Photographs & figures 43.1.13	20180704_Chedoke-Scum closeup near 403 Box culvert.jpg
54	RBG	43.1.4	Water quality	20180704_Chedoke water just upstream of Cootes Paradise Marsh.jpg	2018	photographs	Chedoke Creek	Photographs	20180704_Chedoke water just upstream of Cootes Paradise Marsh.jpg

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
55	RBG	3	Benthic Invertebrates	Benthic Invertebrate Assessment of RBG Wetlands 2014 and 2015	2018	Benthic invertebrates	Cootes Paradise, Grindstone marsh	Benthic Invertebrate sampling was completed in Cootes Paradise and Grindstone Marsh during 2014 and 2015. Overall Cootes Paradise had 18 orders found, ranging from sites with 1 order, to samples with several individual to a high of 2,650 Oligochaeta. In Grindstone Marsh 14 orders were found ranging from samples with 1 order and a few individuals to a high of 759 in Diptera (data from 2014 and 2015 combined).	Bowman, J.E. and H. Wilton. 2018. Benthic Invertebrate Assessment of RBG Wetlands 2014 and 2015. RBG Report No. 2018-9. Royal Botanical Gardens. Hamilton, Ontario.
56	RBG	43.1.3	Water quality	20180421_Fishway outflow algae accumulation.jpg	2018	Photographs	Cootes Paradise, fishway	photograph	20180421_Fishway outflow algae accumulation.jpg
57	RBG	43.1.14	Aquatic Vegetation	Submerged Aquatic Vegetation Monitoring.xlsx	2019	Aquatic vegetation species	Hendrie Valley Sanctuary, Cootes Paradise	July 2019 data	Submerged Aquatic Vegetation Monitoring.xlsx
58	RBG – Duplicate #31	43.1.11							
59	Redeemer College	44	Water quality	Water Quality Monitoring of the Chedoke Creek Subwatershed, Subwatersheds of Cootes Paradise, and the Red Hill Watershed	2015	Flow, nitrate, phosphate, chloride, BOD, E. coli, total coliforms, estimate of contaminant load	Cootes Paradise, Chedoke Creek Ancaster Creek Spencer Creek Red Hill Creek	At each sample site, temperature, pH, electrical conductivity, and dissolved oxygen were recorded. Estimates of creek flow rate were determined as well, to allow estimates of total contaminant load. Additionally, three water samples were taken and analyzed for nitrate, phosphate and chloride concentrations in the lab. Single determinations of biological oxygen demand, E. coli and total choliforms were made.	Vander Hout, J., D. Brouwer, and E. Berkelaar. 2015. Water Quality Monitoring of the Chedoke Creek Subwatershed, Subwatersheds of Cootes Paradise, and the Red Hill Watershed. Redeemer University College. May-August 2015.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
60	Redeemer College	27	Water quality	Water Quality Monitoring of the Chedoke Creek Watershed Fall 2016 Analytical Chemistry Class, Redeemer University College, Ancaster, Ontario	2016	Nitrate, phosphate, chloride, BOD, E. coli	Chedoke Creek	As part of a project-based learning approach, the Analytical Chemistry class (CHE242) at Redeemer University College has been carrying out water quality monitoring at several sites in the Chedoke Creek watershed. The results of the Fall 2016 project are presented here and compared to previous work since 2012. Our data show that while most sampling sites have levels of nutrients, organic matter, and bacteria above desirable levels, there are indications of improving water quality at several sites. This is an encouraging result as the City of Hamilton has been remediating a number of cross connections in these catchment areas.	Water Quality Monitoring of the Chedoke Creek Watershed Fall 2016 Analytical Chemistry Class, Redeemer University College, Ancaster, Ontario
61	SLR	2	Benthic invertebrates	Statistical Analysis Benthic ID Contract 2019	2019	Benthic invertebrates	Cootes Paradise	Entomogen Inc. was contracted by SLR Consulting (Canada) Ltd. to analyze benthic identification data. The objectives of this analysis are to (1) calculate the species richness, Shannon diversity, and Simpson diversity, (2) calculate the similarity between all possible pairwise combinations of sites, and (3) identify whether data from the sediment sampling have a strong influence on the explained variance in the data set.	Chedoke Creek 2019 Raw Data and Indices Results.xls Entomogen. 2019. Statistical Analysis Benthic ID Contract 2019. For SLR Consulting (Canada) Ltd. Chedoke Creek 2019 Figures 1-3.pptx Table 3 pg. 7 in report.xlsx
62	SLR	19	Sediment	Freshwater Sediment Toxicity Testing Using Chironomus Dilutus And Hyalella Azteca	2019	Sediment	?	Freshwater sediment samples were collected between October 1st, 2019 and October 2nd, 2019 for testing. The samples arrived at Bureau Veritas Laboratories, in good condition, on October 3rd, 2019. The following freshwater sediment toxicity tests were conducted on the samples; a 10 day survival and growth test with the freshwater midge, Chironomus dilutus, and a 14 day survival and growth test with the freshwater amphipod, Hyalella azteca.	Ecotoxicology Group Bureau Veritas Laboratories. 2019. Freshwater Sediment Toxicity Testing Using Chironomus Dilutus And Hyalella Azteca. Prepared for SLR Consulting, Ltd. November 2019.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
63	SLR	30	Water quality	Sample Collection	2019	BOD, TOC, Metals, TSS, Anions, Phosphate, Ammonia, TKN, E. coli	Chedoke Creek	Certificate of Analysis for samples collection 2019-09-30	209.40666_Certificate of Analysis - City of Hamilton.PDF 209.40666_COC_WO 330748_Chedoke Creek SW.pdf
64	SLR	20	Water quality, sediment quality	SLR ESdat outputs	2019, 2020		Cootes Paradise, Grindstone Creek		191212_PW Chemistry_draft.xlsm 191212_SED 0.15mbg+ Chemistry_draft.xlsm 191212_SED 0-0.15mbg Chemistry_draft.xlsm 191212_SW Chemistry_draft.xlsm 191218_SW Chemistry_draft.xlsm
65	SLR	70	Aquatic Ecological Risk Assessment	Ecological Risk Assessment	2019-2020		Chedoke Creek	SLR Consulting (Canada) Ltd. (SLR) was retained by the City of Hamilton to complete an Aquatic Ecological Risk Assessment (ERA) for the lower section of Chedoke Creek, parallel to Highway 403 between Glen Road and Princess Point	SLR Consulting (Canada) Ltd. 2020. Ecological Risk Assessment. Chedoke Creek, Hamilton, Ontario. February 2020. SLR Project No.: 209.40666.00000.
66	SLR	71	Aquatic Ecological Risk Assessment – Appendices	ERA – Appendices	2019-2020		Chedoke Creek	SLR Consulting (Canada) Ltd. (SLR) was retained by the City of Hamilton to complete an Aquatic Ecological Risk Assessment (ERA) for the lower section of Chedoke Creek, parallel to Highway 403 between Glen Road and Princess Point	SLR Consulting (Canada) Ltd. 2020. Ecological Risk Assessment. Chedoke Creek, Hamilton, Ontario. February 2020. SLR Project No.: 209.40666.00000.
67	SNC Lavalin	78	Leachate	2018 Landfill Leachate Collection System Performance Report				An Amended Environmental Compliance Approval (ECA) Number 0881-A9SQSD was issued May 16, 2016 to include an extension to the leachate collection system, which was completed in 2017. The ECA specifies a monitoring program for surface water and collected leachate.	SNC Lavalin. 2020. Kay Drage Park, Closed West Hamilton Landfill. 2018 Landfill leachate Collection system Performance Report. March 21, 2019.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
68	SNC Lavalin	41	Water Quality	Kay Drage Park, Closed West Hamilton Landfill	2002-2017	WQ – conventional parameters including TP, Nitrate-N, NH3 Total metals	WQ site at confluence of Chedoke Creek & Cootes Paradise	TP – above PWQO of 0.01 mg/L from 2002 – 2017, max of 0.634 mg/L in 2014/10/08, min of 0.098 in 2003/05/26. Between 2002 & 2013 TP ranged between 0.098 – 0.448 mg/L. In 2014/04/16 TP = 0.583. Lowest value between 2014 & 2017/10/03 was 0.305. Ammonia (un-ionized) as NH3 – above PWQO of 20 µg/L in 2009 – 2012 & 2014 – 2017. Total metals above POQO = Boron, Chromium (total), Copper, Iron, Zinc	
69	SNC Lavalin	53	Water quality, aquatic ecosystems Terrestrial ecosystems	City of Hamilton B-Line Light Rapid Transit, Draft Environmental Project Report. Appendix B.1 Natural Heritage Features. Surface Water and Aquatic Ecosystems	2011	Water quality, aquatic ecosystems	Chedoke Creek, Red Hill Creek,	The field investigation study area for the watercourse crossings included the proposed B-Line corridor, plus 50 m upstream and 200 m downstream of the assumed right-of-way of the corridor.	SNC Lavalin. ? City of Hamilton B-Line Light Rapid Transit, Draft Environmental Project Report. Appendix B.1 Natural Heritage Features. Surface Water and Aquatic Ecosystems.
70	SNC Lavalin	8	Leachate	Review of Design for Expansion of Leachate Collection System at the Closed West Hamilton Landfill	2014	hydrogeology	Chedoke Creek	The Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) was retained by the City of Hamilton (City) to provide a 3rd-party review of detailed design documents prepared and submitted by Urban & Environmental Management Inc. (UEM). UEM prepared and submitted these documents to the City under separate contract to identify potential deficiencies or optimizations that may be addressed prior to construction of an expanded leachate collection system at the closed West Hamilton Landfill.	SNC Lavalin. 2014. Re: Hydrogeological Review of Design for Expansion of Leachate Collection System at the Closed West Hamilton Landfill. To: Mr. Alan McKee, City of Hamilton. May 26, 2014.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
71	SNC Lavalin	79	Leachate	DRAFT - 2019 Landfill Leachate Collection System Performance and Groundwater Monitoring and Sampling Report	2019	Hydrogeology Leachate collection Surface water quality Groundwater water quality	Chedoke Creek	An Amended Environmental Compliance Approval (ECA) Number 0881-A9SQSD was issued May 16, 2016 to include an extension to the leachate collection system, which was completed in 2017. The ECA specifies a monitoring program for the leachate collection system and the receiving surface water body. This report has been prepared to fulfill Condition 7 (4) of the ECA.	SNC Lavalin. 2020. Kay Drage Park, Closed West Hamilton Landfill. 2019 Landfill Leachate Collection System Performance and Sampling Report. Prepared for the City of Hamilton. Draft – March 16, 2020. Groundwater Monitoring and Sampling Report
72	Theÿsmeÿer	75	Fish	Seasonal Fish Community Use of the Great Lakes Coastal Marsh Cootes Paradise as Reproductive Habitat	2000	Fish	Cootes Paradise	Master of Science thesis	Theÿsmeÿer, T. 2020 Seasonal Fish Community use of the Great Lakes Coastal Marsh Cootes Paradis as Reproductive Habitat. Master of Science thesis, McMaster University.
73	UEM	80.10	Leachate	Annual Performance Report (2008)	2008	Leachate	Chedoke Creek	The purpose of this report is to fulfill reporting requirements defined in Certificate of Approval Municipal and Private Sewage Works Number 2893-66CTKT (CofA) dated December 16, 2004 (see Appendix A). This CofA has since been revoked and the system described replaced with a new leachate collection system and bank stabilization works. The data herein was collected under the revoked CofA. The period covered in this report is from May 2005 to December 2007.	Urban & Environmental Management Inc. 2008. Kay Drage Park (formerly West Hamilton Landfill) Annual Performance Report. October 2008.
74	UEM	80.3	Leachate	Annual Performance Report (2008-2009)	2008-2009	Leachate	Chedoke Creek	A new leachate collection system was constructed during late 2007 and early 2008 and a new Certificate of Approval (CofA Number 8445-744ND8 dated July 6, 2007 in Appendix A) specifies an updated monitoring program for surface water and collected leachate.	Urban & Environmental Management Inc. 2010. Kay Drage Park (formerly West Hamilton Landfill) Annual Performance Report (2005-2007).
75	UEM	80.1	Groundwater	Kay Drage Park (formerly West Hamilton Landfill). Groundwater Monitoring Report for the period 2009-2015	2009-2015	Groundwater	Chedoke Creek	This report includes a review groundwater quality and elevation data.	Urban & Environmental Management Inc. 2016. Kay Drage Park (formerly West Hamilton Landfill). Groundwater Monitoring Report for the period 2009-2015, 2015 Annual Performance Report

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
76	UEM	80.8	Leachate	Annual Performance Report (2010)	2010	Leachate	Chedoke Creek	A new leachate collection system was constructed during late 2007 and early 2008 and a new Certificate of Approval (CofA Number 6461-7BYQWA dated February 19, 2008) specifies an updated monitoring program for surface water and collected leachate.	Urban & Environmental Management Inc. 2011. Kay Drage Park (formerly West Hamilton Landfill) Annual Performance Report (2010).
77	UEM	80.9	Leachate	Closed West Hamilton Landfill Leachate Quantity Assessment	2012	Leachate	Chedoke Creek	UEM has been asked to provide analyses of issues related to leachate collection system operations at the closed West Hamilton Landfill.	Gall, B. 2012. Re: Closed West Hamilton Landfill Leachate Quantity Assessment. Memorandum. October 17, 2012.
78	UEM	5	Leachate	Request for Review, Chedoke Creek Bank Stabilization Works and Leachate Collection System Improvements Project, Hamilton, Ontario	2014	Leachate	Chedoke Creek	Request for Review, Chedoke Creek Bank Stabilization Works and Leachate Collection System Improvements	Urban & Environmental Management Inc. Request for Review, Chedoke Creek Bank Stabilization Works and Leachate Collection System Improvements Project, Hamilton, Ontario. Prepared for Fisheries and Oceans Canada.
79	UEM	80.6	Leachate	Annual Performance Report (2014)	2014	Leachate	Chedoke Creek	A new leachate collection system was constructed during late 2007 and early 2008 and a new Certificate of Approval (CofA Number 6461-7BYQWA dated February 19, 2008) specifies an updated monitoring program for surface water and collected leachate	Urban & Environmental Management Inc. 2015. Kay Drage Park (formerly West Hamilton Landfill) Annual Performance Report (2014).
80	UEM	80.7	Leachate	Annual Performance Report (2015)	2015	Leachate	Chedoke Creek	A new leachate collection system was constructed during late 2007 and early 2008 and a new Certificate of Approval (CofA Number 6461-7BYQWA dated February 19, 2008) specifies an updated monitoring program for surface water and collected leachate	Urban & Environmental Management Inc. 2016. Kay Drage Park (formerly West Hamilton Landfill) Annual Performance Report (2015).

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
81	University of Toronto (UTSC) & RBG	51	Modelling, Water Quality, phytoplankton, macrophytes	Predicting the likelihood of a desirable ecological regime shift: A case study in Cootes Paradise marsh, Lake Ontario, Ontario, Canada	2020	Phosphorus, nutrient loading, phytoplankton, macrophyte	Cootes Paradise	Mechanistic model used to leverage understanding of the major phosphorus biogeochemical pathways in Cootes Paradise. We also develop a network of statistical models that accommodates the spatial heterogeneity of the prevailing water quality conditions in the marsh. Nutrient loading reductions dissipates as move from the marsh's western end to the central area due the presence of confounding factors, such as the hydraulic loading from Spencer Creek, internal nutrient loading, wind resuspension, and bioturbation.	Yang, C., D. Kim, J. Bowman, T. Theÿsmeÿer, G. B. Arhonditsis. 2020. Predicting the likelihood of a desirable ecological regime shift: A case study in Cootes Paradise marsh, Lake Ontario, Ontario, Canada. Ecological Indicators 110 (2020) 105794.
82	Urban & Environmental Management Inc. (UEM)	80.5	Leachate	Annual Monitoring Report (2005-2007)	2005-2007	Leachate	Chedoke Creek	This report includes a review of leachate water quality monitoring data, surface water quality, and groundwater quality and elevation data.	Urban & Environmental Management Inc. 2009. Kay Drage Park (formerly West Hamilton Landfill) Annual Monitoring Report (2005-2007).
83	UTSC	74	Eutrophication management	Eutrophication Management In A Great Lakes Wetland: Examination Of The Existence Of Alternative Ecological States. Ecosphere	?	Eutrophication management	Cootes Paradise	The present modelling study aims to support the restoration and management of Cootes Paradise marsh, one of the most degraded shallow wetlands in Southern Ontario, in response to exogenous nutrient control.	Kim, D. C. Yang, C. T. Parsons, J. Bowman, T. Theÿsmeÿer, G. B. Arhonditsis. Eutrophication Management In A Great Lakes Wetland: Examination Of The Existence Of Alternative Ecological States. Ecosphere.
84	UTSC	52	Water quality	Evaluation of stormwater and snowmelt inputs, land use and seasonality on nutrient dynamics in the watersheds of Hamilton Harbour, Ontario, Canada	2014		Hamilton Harbour	Evaluation of stormwater, snowmelt, land use and seasonality on nutrient dynamics	Long, T., C. Wellen, G. Arhonditsis, D. Boyd. 2014. Evaluation of stormwater and snowmelt inputs, land use and seasonality on nutrient dynamics in the watersheds of Hamilton Harbour, Ontario, Canada. Journal of Great Lakes Research. In press. 16 pp.
85	UTSC	61	Water quality	Modelling phosphorus dynamics in Cootes Paradise marsh: Uncertainty assessment and implications for eutrophication management	2016	Phosphorus, nutrient recycling, sediment dynamics	Cootes Paradise	Modelling phosphorus dynamics in Cootes Paradise marsh: Uncertainty assessment and implications for eutrophication management	Kim, D., T. Peller, Z. Gozum, T. Theÿsmeÿer, T. Long, D. Boyd, S. Watson, Y.R. Rao, and G. B. Arhonditsis. 2016. Aquatic Ecosystem Health & Management, 19(4):368–381.

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Row	Custodian	Document #	Subject	Title	Years	Parameters	Sites/Stations	Data Summary	Reference
86	UTSC	49	Aquatic vegetation	Development of a mechanistic eutrophication model for wetland management: Sensitivity analysis of the interplay among phytoplankton, macrophytes, and sediment nutrient release.	2018	Aquatic vegetation	Cootes Paradise	In this study, we present a wetland eutrophication model that explicitly accounts for the ecological interplay among phytoplankton, macrophytes, and nutrient release from the sediments.	Kim, D., C. Yang, A. Javed, G. B. Arhonditsis. 2018. Development of a mechanistic eutrophication model for wetland management: Sensitivity analysis of the interplay among phytoplankton, macrophytes, and sediment nutrient release. Ecological Informatics 48 (2018) 198-214.
87	UTSC	64	Hydrological cycle	A season-specific, multi-site calibration strategy to study the hydrological cycle and the impact of extreme-flow events along an urban-to-agricultural gradient	2019	Hydrological cycle	Cootes Paradise	Present a season-specific, multi-site calibration framework that accommodates the variability in the hydrological responses induced by the agricultural landscape changes during different periods of the year.	Dong, F, A. Neumann, D. Kim, J. Huang, G. B. Arhonditsis. 2019. A season-specific, multi-site calibration strategy to study the hydrological cycle and the impact of extreme-flow events along an urban-to-agricultural gradient. Ecological Informatics 54 (2019) 100993.
88	UTSC	65	Ecological regime shift	Prediction the likelihood of a desirable ecological regime shift: A case study in Cootes Paradise marsh, Lake Ontario, Ontario, Canada	2020	Ecological regime shift	Cootes Paradise	The overarching goal of the present model study is to offer insights into the restoration and management of Cootes Paradise Marsh, one of the most degraded shallow wetlands in Southern Ontario.	Yang, C., D. Kim, J. Bowman, T. Theÿsmeÿer, G. B. Arhonditsis. 2020. Prediction the likelihood of a desirable ecological regime shift: A case study in Cootes Paradise Marsh, Lake Ontario, Ontario, Canada. Ecological Indicators 110 (2020) 105794.
89	Wood	7	Fish	2018_09_07_Additional_Fisheries_Info_RBG	2001-2018	Fish	Chedoke Creek, Cootes Paradise	Fisheries information collected through electrofishing transects (includes map of locations)	Chedoke Creek RBG Fish 2001-2018.xlsx Electofishingmap2008.bmp
90	Wood	25	Water quality	Wood WQ Data	2009-2018	TP, pH, ammonia, DO. TSS and E.coli	Chedoke Creek, Cootes Paradise	Water quality data from multiple stations on Chedoke Creek and Cootes Paradise	Water_QualityData_ChedokeCreek_Stations.xlsx Water_QualityData_CootesParadise_Stations.xlsx
91	Wood	17	Sediment	C0H_Chedoke-MicrobialInsightsData.zip	2018		Chedoke Creek	Sediment quality data from sites in Chedoke Cr. Analysis completed by Microbial Insights	9)073PI_073PICOC.pdf 073PI-EDD.xls CENSUS-073PI_66044737.pdf
92	Wood	18	Sediment	18. CoH_Chedoke-SGS_SedData.zip	2018		Chedoke Creek	Sediment quality data from sites in Chedoke Cr. Analysis completed by SGS	
93	Wood	1	Benthic Invertebrates	Benthic community data	2018	Benthic invertebrates	Chedoke Creek	Benthic Community data for 7 sites (three replicates each)	Re: Chedoke Creek, ON, EA Invertebrate Identifications 2018

APPENDIX B
Surface Water Data - Statistical Summary

Cootes Paradise: Environmental Impact Evaluation
City of Hamilton
700 Woodward Avenue, North Hamilton, Ontario
SLR Project No.: 209.40666.00001

Appendix B: Table B1 Surface Water Statistical Summary

Location	CC5 & CC5a								CC3						
	Chedoke Creek - Monitoring Stations Upstream of Main/King CSO														
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Nitrite as N (mg/L)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)															
Count (detected)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Minimum (detected)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Maximum (detected)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Standard Deviation	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Median	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
95th percentile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
90th percentile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
75th percentile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
During Discharge (January 28, 2014 to July 18, 2018)															
Count (detected)	4	4	12	12	11	12	1	ND	4	4	12	12	10	12	ND
Minimum (detected)	0.087	0	9.52	0.128	4	130	0.015	ND	0.086	0	7.8	0.111	2.9	200	ND
Maximum (detected)	0.195	0.002	29.19	0.436	73.1	3600	0.015	ND	0.184	0.001	27.7	0.267	25.3	104000	ND
Mean	0.122	0.0008	13.73	0.281	17.0	1549	NC	ND	0.12	0.0008	12.2	0.180	9.3	20872	ND
Standard Deviation	0.044	0.0008	5.12	0.111	18.1	1272	NC	ND	0.039	0.0004	5.4	0.056	6.3	33131	ND
Median	0.103	0.0005	12.86	0.303	12.3	710	NC	ND	0.105	0.001	10.0	0.1575	7.6	3900	ND
95th percentile	0.183	0.002	21.54	0.424	45.2	3380	NC	ND	0.174	0.001	21.0	0.265	20.3	91350	ND
90th percentile	0.172	0.0017	15.27	0.412	17.3	3160	NC	ND	0.164	0.001	15.6	0.264	15.2	75090	ND
75th percentile	0.137	0.001	14.60	0.370	14.7	2800	NC	ND	0.133	0.001	14.0	0.232	10.5	17475	ND
After Discharge (July 19, 2018 onward)															
Count (detected)	ND	ND	40	37	37	39	5	ND	ND	ND	36	36	31	36	ND
Minimum (detected)	ND	ND	8.51	0.135	1.8	170	0.05	ND	ND	ND	8.0	0.07	1.6	120	ND
Maximum (detected)	ND	ND	14.58	3.66	3660.0	78000	0.72	ND	ND	ND	13.4	0.479	136.0	610000	ND
Mean	ND	ND	11.04	0.412	113.8	3722	0.266	ND	ND	ND	10.7	0.252	15.3	29977	ND
Standard Deviation	ND	ND	1.80	0.557	591.4	12546	0.240	ND	ND	ND	1.7	0.125	25.4	100447	ND
Median	ND	ND	10.78	0.306	8.4	900	0.16	ND	ND	ND	10.8	0.238	7.3	4100	ND
95th percentile	ND	ND	14.26	0.6354	81.1	7780	0.634	ND	ND	ND	13.2	0.4525	53.9	72500	ND
90th percentile	ND	ND	13.56	0.4878	41.9	3720	0.548	ND	ND	ND	13.1	0.428	24.7	39000	ND
75th percentile	ND	ND	12.42	0.397	16.7	1705	0.29	ND	ND	ND	12.3	0.363	13.1	20000	ND

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

	Chedoke Creek - Monitoring Stations Immediately downstream of Main/King CSO													
Location	CP11-outlet							STN1						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)														
Count (detected)	ND	ND	ND	ND	ND	ND	ND	33	26	32	37	18	ND	35
Minimum (detected)	ND	ND	ND	ND	ND	ND	ND	0.01	0.001	2.7	0.098	1.8	ND	0.002
Maximum (detected)	ND	ND	ND	ND	ND	ND	ND	0.66	0.014	16.3	0.72	111.0	ND	0.023
Mean	ND	ND	ND	ND	ND	ND	ND	0.091	0.007	11.7	0.292	21.4	ND	0.006
Standard Deviation	ND	ND	ND	ND	ND	ND	ND	0.126	0.004	3.3	0.135	32.9	ND	0.004
Median	ND	ND	ND	ND	ND	ND	ND	0.04	0.006	12.5	0.27	4.5	ND	0.005
95th percentile	ND	ND	ND	ND	ND	ND	ND	0.298	0.014	16.1	0.537	84.6	ND	0.014
90th percentile	ND	ND	ND	ND	ND	ND	ND	0.232	0.013	15.8	0.4846	74.4	ND	0.012
75th percentile	ND	ND	ND	ND	ND	ND	ND	0.1	0.009	13.6	0.331	17.9	ND	0.0065
During Discharge (January 28, 2014 to July 18, 2018)														
Count (detected)	ND	ND	3	3	3	3	ND	21	21	21	21	18	ND	21
Minimum (detected)	ND	ND	3.5	1.33	31.6	3400000	ND	0.01	0.0006	2.7	0.118	1.1	ND	0.003
Maximum (detected)	ND	ND	7.0	2.78	58.0	4900000	ND	8.04	0.22	16.3	1.85	75.2	ND	0.0359
Mean	ND	ND	5.1	2.267	45.5	4033333	ND	0.899	0.027	11.7	0.393	19.8	ND	0.008
Standard Deviation	ND	ND	1.5	0.663	10.8	634210	ND	1.998	0.052	3.3	0.398	23.4	ND	0.007
Median	ND	ND	4.6	2.69	46.8	3800000	ND	0.05	0.0036	12.5	0.227	8.8	ND	0.006
95th percentile	ND	ND	6.8	2.771	56.9	4790000	ND	5.53	0.111	16.1	1.06	74.9	ND	0.017
90th percentile	ND	ND	6.6	2.762	55.8	4680000	ND	1.41	0.0734	15.8	0.717	54.6	ND	0.016
75th percentile	ND	ND	5.8	2.735	52.4	4350000	ND	0.73	0.0225	13.6	0.367	31.7	ND	0.007
After Discharge (July 19, 2018 onward)														
Count (detected)	ND	ND	5	5	5	5	ND	8	8	6	10	9	ND	10
Minimum (detected)	ND	ND	8.6	0.187	4.0	460	ND	0.02	0.0017	7.1	0.146	3.8	ND	0.0027
Maximum (detected)	ND	ND	10.8	0.226	10.2	20000	ND	0.08	0.0088	9.4	0.357	24.4	ND	0.0064
Mean	ND	ND	10.0	0.2072	6.9	6852	ND	0.05	0.0042	8.4	0.214	9.7	ND	0.0048
Standard Deviation	ND	ND	0.8	0.014	2.2	7227	ND	0.025	0.0026	1.0	0.071	7.8	ND	0.001
Median	ND	ND	10.0	0.213	6.2	3300	ND	0.05	0.0033	8.9	0.187	7.4	ND	0.005
95th percentile	ND	ND	10.7	0.2238	9.8	17820	ND	0.08	0.0084	9.4	0.3534	24.1	ND	0.006
90th percentile	ND	ND	10.7	0.2216	9.5	15640	ND	0.08	0.0080	9.4	0.3498	23.8	ND	0.006
75th percentile	ND	ND	10.5	0.215	8.4	9100	ND	0.073	0.0055	9.3	0.199	7.8	ND	0.006

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

Location	Chedoke Creek - Monitoring Stations downstream of Main/King CSO													
	STN3							STNSWC2						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)														
Count (detected)	29	19	26	29	25	ND	29	17	16	16	15	15	ND	17
Minimum (detected)	0.03	0.001	2.5	0.096	2.8	ND	0.003	0.1	0.001	6.6	0.095	1.8	ND	0.003
Maximum (detected)	0.89	0.031	17.8	0.568	126.0	ND	0.024	0.51	0.042	15.6	0.521	28.4	ND	0.008
Mean	0.182	0.008	10.7	0.274	18.6	ND	0.006	0.232	0.011	10.6	0.285	13.4	ND	0.005
Standard Deviation	0.173	0.008	3.4	0.121	24.5	ND	0.004	0.126	0.010	2.6	0.135	8.6	ND	0.001
Median	0.13	0.004	11.6	0.255	11.4	ND	0.005	0.17	0.007	10.7	0.260	9.4	ND	0.005
95th percentile	0.486	0.025	14.8	0.519	46.4	ND	0.014	0.478	0.027	14.8	0.515	27.1	ND	0.008
90th percentile	0.336	0.018	13.8	0.448	29.8	ND	0.011	0.428	0.021	13.7	0.489	25.8	ND	0.0068
75th percentile	0.19	0.011	12.5	0.317	22.4	ND	0.006	0.28	0.016	12.4	0.389	21.5	ND	0.006
During Discharge (January 28, 2014 to July 18, 2018)														
Count (detected)	13	13	13	13	13	ND	13	13	13	13	13	13	ND	13
Minimum (detected)	0.14	0.003	5.0	0.146	3.0	ND	0.003	0.26	0.0029	4.5	0.182	5.2	ND	0.002
Maximum (detected)	6.05	0.131	11.3	2.25	171.0	ND	0.027	5.27	0.0967	10.0	0.988	66.8	ND	0.022
Mean	1.221	0.028	7.8	0.574	31.1	ND	0.008	1.691	0.030	7.1	0.471	26.8	ND	0.008
Standard Deviation	1.543	0.034	1.8	0.566	44.1	ND	0.007	1.543	0.026	1.7	0.266	20.7	ND	0.006
Median	0.75	0.015	7.7	0.302	14.6	ND	0.005	1.03	0.017	6.7	0.371	19.2	ND	0.006
95th percentile	3.974	0.086	10.4	1.656	110.6	ND	0.024	4.712	0.07198	9.6	0.986	63.9	ND	0.020
90th percentile	2.356	0.054	9.7	1.176	64.7	ND	0.019	4.038	0.05492	9.2	0.947	60.1	ND	0.017
75th percentile	1.25	0.036	9.6	0.548	22.0	ND	0.006	2.5	0.0484	8.6	0.492	42.0	ND	0.011
After Discharge (July 19, 2018 onward)														
Count (detected)	5	5	3	5	4	ND	5	5	5	3	5	4	ND	5
Minimum (detected)	0.01	0.002	4.4	0.18	5.8	ND	0.0026	0.06	0.006	3.7	0.12	5.7	ND	0.003
Maximum (detected)	0.94	0.023	9.1	0.377	32.4	ND	0.009	1.15	0.018	8.8	0.357	19.6	ND	0.007
Mean	0.268	0.008	7.2	0.2536	15.6	ND	0.004	0.368	0.010	6.6	0.230	12.7	ND	0.004
Standard Deviation	0.340	0.007	2.1	0.088	10.6	ND	0.002	0.401	0.004	2.2	0.094	5.2	ND	0.001
Median	0.14	0.007	8.3	0.184	12.1	ND	0.004	0.2	0.009	7.4	0.181	12.7	ND	0.0034
95th percentile	0.782	0.020	9.0	0.3704	30.1	ND	0.008	0.984	0.016	8.7	0.351	18.9	ND	0.006
90th percentile	0.624	0.017	8.9	0.3638	27.8	ND	0.007	0.818	0.015	8.5	0.345	18.3	ND	0.005
75th percentile	0.15	0.008	8.7	0.344	20.9	ND	0.004	0.32	0.010	8.1	0.327	16.3	ND	0.004

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

	Chedoke Creek - Monitoring Stations downstream of Main/King CSO													
Location	STN4							STN7						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)														
Count (detected)	31	19	28	32	30	ND	34	24	15	22	26	20	ND	26
Minimum (detected)	0.08	0.001	2.4	0.094	2.0	ND	0.003	0.04	0.0017	2.1	0.124	5.0	ND	0.002
Maximum (detected)	3.57	0.117	17.5	0.642	133.0	ND	0.02	1.55	0.1328	17.1	0.712	210.0	ND	0.018
Mean	0.773	0.030	10.3	0.281	20.3	ND	0.007	0.646	0.041	9.5	0.290	29.4	ND	0.006
Standard Deviation	0.735	0.028	3.2	0.140	23.7	ND	0.004	0.405	0.036	3.4	0.132	42.9	ND	0.004
Median	0.6	0.020	10.8	0.245	14.6	ND	0.006	0.55	0.0339	9.5	0.2465	16.2	ND	0.005
95th percentile	2.16	0.084	14.8	0.597	46.5	ND	0.014	1.448	0.104	14.1	0.508	47.0	ND	0.015
90th percentile	1.88	0.053	13.3	0.451	34.2	ND	0.012	1.275	0.09032	13.6	0.4535	37.3	ND	0.011
75th percentile	0.825	0.041	11.6	0.318	23.0	ND	0.007	0.733	0.04915	11.6	0.339	35.7	ND	0.006
During Discharge (January 28, 2014 to July 18, 2018)														
Count (detected)	13	13	13	13	13	ND	13	14	14	14	14	14	ND	14
Minimum (detected)	0.51	0.004	4.4	0.194	8.4	ND	0.003	0.15	0.004	2.2	0.249	5.1	ND	0.004
Maximum (detected)	6.08	0.188	11.3	0.788	67.5	ND	0.02	4.93	0.044	9.7	0.736	73.2	ND	0.017
Mean	1.825	0.042	7.2	0.445	23.9	ND	0.008	1.933	0.024	5.6	0.499	22.2	ND	0.008
Standard Deviation	1.549	0.046	1.9	0.216	18.5	ND	0.005	1.353	0.012	2.0	0.142	15.9	ND	0.005
Median	1.26	0.027	6.9	0.349	16.9	ND	0.006	1.65	0.024	6.0	0.4815	19.5	ND	0.005
95th percentile	4.976	0.120	10.3	0.769	63.2	ND	0.018	4.404	0.042	8.1	0.733	48.2	ND	0.016
90th percentile	3.868	0.071	9.5	0.752	55.1	ND	0.016	3.874	0.040	7.2	0.716	32.3	ND	0.015
75th percentile	2.05	0.048	8.7	0.731	28.1	ND	0.009	2.425	0.034	6.9	0.566	22.5	ND	0.014
After Discharge (July 19, 2018 onward)														
Count (detected)	4	4	3	5	5	ND	5	5	5	3	5	5	ND	5
Minimum (detected)	0.29	0.013	3.8	0.126	3.2	ND	0.0026	0.01	0.0006	3.1	0.154	8.8	ND	0.003
Maximum (detected)	1.43	0.022	7.5	0.341	22.9	ND	0.0072	0.99	0.0203	6.3	0.311	35.7	ND	0.006
Mean	0.64	0.016	6.1	0.225	12.4	ND	0.004	0.55	0.01134	5.1	0.229	20.2	ND	0.005
Standard Deviation	0.460	0.004	1.6	0.094	8.0	ND	0.002	0.343	0.007	1.4	0.065	10.2	ND	0.001
Median	0.42	0.014	6.9	0.167	12.8	ND	0.0032	0.46	0.011	5.9	0.198	16.0	ND	0.0052
95th percentile	1.285	0.021	7.4	0.340	22.2	ND	0.00648	0.96	0.01924	6.2	0.310	34.2	ND	0.006
90th percentile	1.139	0.020	7.4	0.340	21.4	ND	0.00576	0.93	0.01818	6.2	0.308	32.7	ND	0.006
75th percentile	0.703	0.017	7.2	0.338	19.2	ND	0.0036	0.84	0.015	6.1	0.304	28.3	ND	0.005

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

	Chedoke Creek - Monitoring Stations downstream of Main/King CSO													
Location	CP11							STN9 near mouth						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)														
Count (detected)	133	17	97	132	133	119	ND	30	18	26	30	25	ND	33
Minimum (detected)	0.005	0.008	0.0	0.032	1.5	10	ND	0.04	0.005	2.2	0.098	2.4	ND	0.002
Maximum (detected)	1.95	0.112	21.0	0.81	168.0	560000	ND	1.66	0.068	15.9	0.512	232.0	ND	0.03
Mean	0.503	0.047	9.7	0.238	31.5	19708	ND	0.745	0.029	9.5	0.264	28.7	ND	0.006
Standard Deviation	0.384	0.030	4.0	0.11	25.5	67326	ND	0.470	0.019	3.2	0.113	43.5	ND	0.005
Median	0.44	0.038	10.0	0.21	26.0	540	ND	0.7	0.027	9.6	0.23	19.8	ND	0.005
95th percentile	1.202	0.096	15.2	0.43	75.9	160000	ND	1.582	0.067	14.9	0.482	42.9	ND	0.013
90th percentile	1.01	0.0902	14.0	0.36	54.1	31980	ND	1.303	0.052	11.9	0.451	40.6	ND	0.009
75th percentile	0.74	0.061	13.0	0.281	39.4	3800	ND	1.13	0.042	11.7	0.36	31.8	ND	0.006
During Discharge (January 28, 2014 to July 18, 2018)														
Count (detected)	87	ND	79	87	84	87	ND	17	17	17	17	17	ND	17
Minimum (detected)	0.002	ND	0.4	0.109	2.2	10	ND	0.09	0.004	2.4	0.294	5.8	ND	0.005
Maximum (detected)	13.1	ND	22.2	2.03	104.0	3600000	ND	6.33	0.052	10.3	0.897	84.8	ND	0.0248
Mean	2.05	ND	8.8	0.54	23.8	312349	ND	2.302	0.026	5.4	0.495	24.1	ND	0.011
Standard Deviation	2.287	ND	4.6	0.360	19.6	596671	ND	1.638	0.013	2.1	0.186	17.1	ND	0.006
Median	1.05	ND	9.2	0.466	18.8	21600	ND	2.06	0.022	5.1	0.424	22.4	ND	0.007
95th percentile	6.411	ND	16.3	1.241	57.9	1483000	ND	6.314	0.051	9.4	0.895	41.0	ND	0.023
90th percentile	4.976	ND	14.0	1.04	51.0	900000	ND	4.372	0.046	8.3	0.738	29.8	ND	0.019
75th percentile	2.945	ND	11.4	0.702	30.4	430000	ND	2.56	0.032	6.0	0.599	26.2	ND	0.015
After Discharge (July 19, 2018 onward)														
Count (detected)	34	ND	35	35	35	32	ND	5	5	3	5	5	ND	5
Minimum (detected)	0.01	ND	0.7	0.135	2.9	20	ND	0.01	0.0012	3.3	0.063	4.8	ND	0.003
Maximum (detected)	1.39	ND	22.1	0.935	143.0	35000	ND	1	0.0212	7.7	0.361	27.0	ND	0.010
Mean	0.378	ND	9.6	0.282	19.8	4427	ND	0.534	0.01248	5.6	0.214	15.9	ND	0.006
Standard Deviation	0.331	ND	4.0	0.132	23.7	6727	ND	0.418	0.007	1.8	0.116	7.1	ND	0.002
Median	0.26	ND	10.3	0.261	14.4	1500	ND	0.53	0.0162	5.7	0.171	16.5	ND	0.004
95th percentile	1.154	ND	14.3	0.422	43.8	12750	ND	1	0.02044	7.5	0.356	25.1	ND	0.009
90th percentile	0.768	ND	13.0	0.379	30.0	11110	ND	1	0.01968	7.3	0.352	23.2	ND	0.009
75th percentile	0.46	ND	12.4	0.292	23.3	7225	ND	1	0.0174	6.7	0.338	17.6	ND	0.007

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

	Cootes Paradise - Monitoring Stations													
Location	C6-east[1]							CP11.2						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)														
Count (detected)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Minimum (detected)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Maximum (detected)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Standard Deviation	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Median	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
95th percentile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
90th percentile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
75th percentile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
During Discharge (January 28, 2014 to July 18, 2018)														
Count (detected)	ND	ND	ND	ND	ND	ND	ND	17	17	17	17	17	17	ND
Minimum (detected)	ND	ND	ND	ND	ND	ND	ND	0.01	0.0003	0.8	0.14	11.7	30	ND
Maximum (detected)	ND	ND	ND	ND	ND	ND	ND	5.06	0.154	12.8	0.97	125.0	128000	ND
Mean	ND	ND	ND	ND	ND	ND	ND	1.175	0.041	5.7	0.494	48.1	24713	ND
Standard Deviation	ND	ND	ND	ND	ND	ND	ND	1.369	0.040	3.1	0.203	24.5	42631	ND
Median	ND	ND	ND	ND	ND	ND	ND	0.43	0.019	4.9	0.472	44.2	220	ND
95th percentile	ND	ND	ND	ND	ND	ND	ND	3.396	0.105	10.7	0.831	80.7	112000	ND
90th percentile	ND	ND	ND	ND	ND	ND	ND	2.812	0.085	9.2	0.737	65.8	104400	ND
75th percentile	ND	ND	ND	ND	ND	ND	ND	1.97	0.061	7.5	0.58	55.8	13000	ND
After Discharge (July 19, 2018 onward)														
Count (detected)	1	ND	1	1	1	1	1	16	16	16	16	16	16	ND
Minimum (detected)	0.016	ND	9.1	0.169	37.6	60	0.004	0.005	0.0001	2.2	0.09	12.0	10	ND
Maximum (detected)	0.016	ND	9.1	0.169	37.6	60	0.004	1.9	0.327	12.0	0.92	38.0	16000	ND
Mean	NC	ND	NC	NC	NC	NC	NC	0.392	0.039	6.7	0.299	24.8	1695	ND
Standard Deviation	NC	ND	NC	NC	NC	NC	NC	0.578	0.083	3.2	0.251	8.8	3855	ND
Median	NC	ND	NC	NC	NC	NC	NC	0.09	0.004	7.0	0.1775	25.8	290	ND
95th percentile	NC	ND	NC	NC	NC	NC	NC	1.435	0.185	12.0	0.757	37.7	7150	ND
90th percentile	NC	ND	NC	NC	NC	NC	NC	1.275	0.115	11.4	0.672	36.6	3300	ND
75th percentile	NC	ND	NC	NC	NC	NC	NC	0.375	0.019	8.3	0.461	31.3	1168	ND

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

	Cootes Paradise - Monitoring Stations													
Location	CP1							CP2						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge														
(2002 to January 27, 2014)														
Count (detected)	130	6	93	129	129	130	ND	128	11	93	127	128	128	ND
Minimum (detected)	0.005	0.003	4.0	0.015	4.0	0	ND	0.005	0.0001	3.0	0.026	5.6	1	ND
Maximum (detected)	0.45	0.019	21.0	0.345	124.0	14000	ND	0.21	0.0226	16.0	0.426	175.0	6100	ND
Mean	0.053	0.010	105.9	0.145	41.1	468	ND	0.046	0.004	9.0	0.153	48.9	382	ND
Standard Deviation	0.073	0.007	34.9	0.057	17.9	1789	ND	2.734	0.006	2.7	0.074	28.1	880	ND
Median	0.03	0.010	99.0	0.136	38.6	40	ND	9	0.001	9.0	0.145	43.8	63	ND
95th percentile	0.181	0.019	14.4	0.253	72.7	2255	ND	0.17	0.0156	14.0	0.2907	101.6	2095	ND
90th percentile	0.131	0.018	13.0	0.224	60.2	620	ND	0.113	0.0086	12.8	0.2368	82.5	786	ND
75th percentile	0.06	0.017	12.0	0.173	50.0	145	ND	0.06	0.0043	10.0	0.1915	59.0	295	ND
During Discharge														
(January 28, 2014 to July 18, 2018)														
Count (detected)	40	35	52	52	40	39	ND	94	85	94	94	94	94	ND
Minimum (detected)	0.005	0.0002	4.0	0.05	7.7	0	ND	0.005	0.0001	2.0	0.019	1.0	1	ND
Maximum (detected)	0.67	0.079	15.0	0.386	73.0	62000	ND	0.44	0.035	21.0	0.481	294.0	4400	ND
Mean	0.095	0.011	8.5	0.151	33.4	4187	ND	0.037	0.003	94.6	0.113	32.5	240	ND
Standard Deviation	0.135	0.015	2.2	0.072	14.5	11540	ND	0.058	0.005	3.3	0.075	34.8	561	ND
Median	0.03	0.005	8.7	0.134	30.4	120	ND	0.02	0.008	8.0	0.095	26.4	60	ND
95th percentile	0.382	0.033	12.6	0.313	56.5	17120	ND	0.147	0.009	15.0	0.2472	67.8	1259	ND
90th percentile	0.221	0.026	11.9	0.223	52.8	9600	ND	0.064	0.007	12.7	0.2116	55.9	597	ND
75th percentile	0.143	0.013	9.2	0.170	41.6	1035	ND	0.03	0.003	10.0	0.1478	44.3	145	ND
After Discharge														
(July 19, 2018 onward)														
Count (detected)	14	14	19	19	14	14	ND	21	21	21	21	21	21	ND
Minimum (detected)	0.005	0.00004	2.7	0.065	13.7	5	ND	0.005	0.000001	2.9	0.064	11.6	5	ND
Maximum (detected)	0.14	0.091	15.0	0.233	50.4	1600	ND	0.21	0.010	14.6	0.222	60.0	67000	ND
Mean	0.038	0.009	8.5	0.153	32.1	175	ND	0.043	0.002	8.2	0.133	32.5	3821	ND
Standard Deviation	0.043	0.023	2.8	0.053	10.3	413	ND	0.052	0.003	2.8	0.049	14.4	14225	ND
Median	0.02	0.001	8.2	0.144	32.1	25	ND	0.02	0.001	7.7	0.118	31.5	80	ND
95th percentile	0.14	0.038	12.9	0.230	48.5	872	ND	0.15	0.009	12.2	0.219	55.0	7400	ND
90th percentile	0.113	0.010	12.4	0.224	46.2	381	ND	0.1	0.005	11.7	0.217	52.4	3400	ND
75th percentile	0.038	0.006	10.0	0.205	38.9	40	ND	0.04	0.003	10.5	0.163	44.8	360	ND

Notes:
NC = not calculated
ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

Appendix B: Table B1 Surface Water Statistical Summary

	Cootes Paradise - Monitoring Station						
Location	CP20						
Parameter	Ammonia as N (mg/L)	Ammonia (un-ionized) as NH3 (mg/L)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E Coli (#/100ml)	Copper (mg/L)
Pre-discharge (2002 to January 27, 2014)							
Count (detected)	116	6	82	115	116	116	ND
Minimum (detected)	0.005	0.0002	3.0	0.022	7.1	1	ND
Maximum (detected)	0.37	0.012	17.0	0.793	673.0	5500	ND
Mean	0.038	0.005	8.7	0.197	82.0	249	ND
Standard Deviation	0.053	0.004	2.7	0.130	93.0	793	ND
Median	0.02	0.005	9.0	0.164	51.7	36	ND
95th percentile	0.125	0.010	13.0	0.434	241.0	1325	ND
90th percentile	0.085	0.009	12.9	0.376	176.5	311	ND
75th percentile	0.04	0.007	10.0	0.237	90.0	106	ND
During Discharge (January 28, 2014 to July 18, 2018)							
Count (detected)	34	29	57	57	34	33	ND
Minimum (detected)	0.005	0.0002	2.0	0.005	1.0	1	ND
Maximum (detected)	0.16	0.013	51.0	0.286	84.5	700	ND
Mean	0.017	0.002	9.0	0.116	22.1	54	ND
Standard Deviation	0.027	0.003	6.8	0.081	21.8	125	ND
Median	0.01	0.0008	7.9	0.113	16.2	10	ND
95th percentile	0.037	0.005	17.6	0.251	65.9	180	ND
90th percentile	0.03	0.004	13.2	0.235	55.9	134	ND
75th percentile	0.02	0.002	10.0	0.172	28.4	30	ND
After Discharge (July 19, 2018 onward)							
Count (detected)	ND	ND	19	19	ND	ND	ND
Minimum (detected)	ND	ND	3.3	0.05	ND	ND	ND
Maximum (detected)	ND	ND	12.8	0.297	ND	ND	ND
Mean	ND	ND	7.1	0.162	ND	ND	ND
Standard Deviation	ND	ND	2.5	0.080	ND	ND	ND
Median	ND	ND	6.6	0.142	ND	ND	ND
95th percentile	ND	ND	12.1	0.292	ND	ND	ND
90th percentile	ND	ND	10.7	0.289	ND	ND	ND
75th percentile	ND	ND	8.2	0.226	ND	ND	ND

Notes:
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ND = no data

[1] = one value sampled for the location (i.e. sampled on 9/30/2019)

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