Town of Erin
Urban Centre Wastewater Servicing
Class Environmental Assessment

Environmental Study Report

FINAL REPORT
Volume 2 of 3

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CONSULTING
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PLANNERS

Appendix - B

Septic System Overview

Town of Erin

Urban Centre Wastewater Servicing
Class Environmental Assessment

Technical Memorandum
Septic System Overview
Final

October 2017

CONSULTING ENGINEERS & PLANNERS

Urban Centre Wastewater Servicing
Class Environmental Assessment

Technical Memorandum
Septic System Overview

Project No. 115157

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The Town of Erin

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1.0 Introduction

This Report has been prepared in support of the Town of Erin Urban Centre Wastewater Servicing Environmental Assessment (UCWWS EA). The majority of properties within the Village of Erin and Hillsburgh are currently serviced by individual private septic systems. The Servicing and Settlement Master Plan (SSMP), completed by B.M. Ross in 2014, selected a communal wastewater collection system for both communities as the preferred alternative solution to deal with issues related to the private systems. The SSMP undertook part of Phase 1 and part of Phase 2 of the Class Environmental Assessment process and the Town is now engaged in completing these two phases and moving on to complete Phase 3 and Phase 4 of the Class EA process.

In order to complete the Class EA process, the Town is seeking to develop a more complete understanding of the existing septic systems in order to clearly define the extent of the planned communal sewage service area. The results of this Technical Memorandum will also assist with the selection of the most appropriate collection system by identifying accurate cost estimates for property owners.

This Technical Memorandum provides an overview of the septic system information collected from all available existing sources and defines the communal sewage service areas and provides rationale for connecting or not connecting each area to a communal collection and treatment system based upon analysis of the available data.

1.1 Objectives

The objective of this memorandum is to review available Septic Tank data, conduct any necessary field work and conduct data analysis and present recommendations for servicing existing properties in the study area.

1.2 Existing Information

Several studies/documents were used to prepare this memorandum. Each of these documents was reviewed for pertinent information related to this project. These documents include (a) Servicing and Settlement Master Plan, (b) Town of Erin Mandatory Septic Re-inspection Program, (c) Building Department Records, (d) GIS data. Relevant codes and standards governing wastewater for private systems including the Ontario Building Code and the Ministry of Environment and Climate Change (MOECC) guidelines were also relied on to develop this report. Information used from these studies/documents is summarised in the following subsections.

1.2.1 Servicing and Settlement Master Plan (SSMP)

In August 2014, BM Ross published the Town of Erin Servicing and Settlement Master Plan (SSMP) Final Report. The SSMP provides a brief overview of the current state of septic systems within the study area and summarises three previously completed reports relevant to the study. In summary, the SSMP found that there are no municipally owned communal sewage systems in Erin. They are generally serviced with Class 4 individual private septic systems, with a smaller portion of Class 6 systems and the commercial areas being serviced by holding tanks. Since 1999, the Town of Erin Building Department has required a permit for any work installing or repairing septic systems, resulting in 484 permits issued for new septic systems and 209 for replacement or alteration from 1999-2014. There are a few shared proprietary septic systems; Centre 2000 in Erin that services the Erin High School and Erin Community Centre. Also The Stanley Park mobile home development and the St. John Brebeuf Catholic School each have their own respective proprietary systems.

There had been past studies done on the septic systems in Erin before BM Ross completed the SSMP. In 1995 the Wellington-Dufferin-Guelph Health Unit performed the Village of Erin Private Sewage System Survey. This helped define the problem for the Class EA because the results indicated that several sewage disposal systems in downtown and on the south end of Main Street are in close proximity to West Credit River, increasing potential for pollution. It also found that many lots in the Village have inadequate space for septic tank replacement that would meet today's design standards under the Ontario Building Code.

The MOECC & West Central Region Technical Support Section Water Unit determined in their 2005 Town of Erin Septic Investigation that septic systems within the Town are a contributor of nutrients to the west branch of the Credit River; however, the impact to receiver was low in 2005. They recommended that older areas of Erin be investigated, as the risk of septic nutrient impact might be higher due to the deterioration of the septic systems.

Lastly, in 2011, there was an Existing Conditions Report for the Erin SSMP Environmental Component to investigate the impact that septic systems had on the West Credit River. It found that the existing municipal water supply wells showed no apparent impact from septic systems and that there was only a slight increase in nitrate concentration over time in the river, downstream of Erin. It also revealed that chloride and mass loading in the West Credit River have increased considerably over the last 20-30 years. Phosphorous levels also have increased over time; however these increases appear to reflect changes in surface runoff rather than impacts from septic systems. In general the report found that there are relatively higher urban impacts (including septic systems) on the reaches of two tributaries, immediately adjacent to Erin when compared to the main branch of the West Credit River. The report further explains that to properly determine the overall sensitivity of the environmental features, functions and linkages within Erin, the results from this report must be combined with other component studies.

The SSMP Final Report also outlines the issues and constraints that the current septic system will face in the future. The report determined that many septic systems in Erin are over 30 years old, while the general lifespan of a septic system is 20-25 years old. This indicates that most systems are in need of being replaced in the immediate future and data shows that only 6 out of approximately 1500 systems within the urban settlements of Erin and Hillsburgh have been replaced since 2004. The need for septic replacement is imminent and the SSMP reports that 54% of properties in Erin and 55% of in Hillsburgh are presently not large enough for a replacement septic and tile bed under the Ontario Building Code.

1.2.2 Septic Re-Inspection Program – WSP Canada 2015 Annual Report

In 2015 WSP conducted a septic re-inspection evaluation on 113 properties in the Town of Erin. This program aims to protect water resources by inspecting septic systems within highly vulnerable municipal well head protection areas every 5 years to ensure that they are operating safely and being maintained. This program was based on the *Draft Source Protection Plan for the Grand River* (March 12th, 2015), which was introduced so that highly vulnerable systems cease to be or never become a significant threat to the water quality in municipal wells.

Following the inspection, 17 of the 113 septic systems were issued remedial action letters based on varying risk factors that were observed. The seven risk factors include: tank size, tank compartments, tank condition, effluent level, leaching bed condition, drinking water source distance, and distance to surface water. Of the 17 remedial action notices, 8 were due to the volume of solids (effluent level) being above the limit or unknown, which requires the tank to be pumped out and 9 were issued to address structural issues such as: missing/cracked/inaccessible lids, inlet or outlet pipe obstruction, and not being watertight. No other remedial action letters were issued, however, the majority (99%) of the inspected septic systems had two or less of the seven risk factors named above. The following is a breakdown of the results for each risk factor:

- Septic Systems with a Tank Size risk: 17%
- Septic Systems with a Tank Compartment risk: 10%
- Septic Systems with a Tank Condition risk: 12%
- Septic Systems with an Effluent Level risk: 17%
- Septic Systems with a Leaching Bed Condition risk: 9%
- Septic Systems with a Drinking Water Source Distance risk: 1%
- Septic Systems with a Distance to Surface Water risk: 1%

1.2.1 Building Department Records (Town of Erin)

As part of this Class EA, in order to further analyse the condition and compliance aspects of the existing septic systems in Erin and Hillsburgh, historical data was obtained from the Town of Erin's Building Department. These records included specific addresses, legal descriptions, owner information, well type and available septic information including: type, tank size, and filter bed size.

The Building Department also provided copies of individual septic related records that included lot property location surveys, septic installation/alteration permits, inspection records, for approximately 1,200 properties in Erin and Hillsburgh. Although the actual data provided by these records was incomplete for each individual property, it was useful in analysing the systems and identifying the approximate age of septic systems throughout each area of Hillsburgh and Erin.

1.2.2 Site Inspections

Also as part of this Class EA, a general site survey was undertaken throughout the Village of Erin and Hillsburgh to verify a sample of septic system records and to identify servicing issues for the main areas of the communities. The results of this survey will be used to identify the cost to connect existing systems to the planned communal collection system.

1.2.3 GIS Data (Town of Erin)

The Town of Erin GIS database provided a property fabric for all lots within the urban boundary. Included in the database was a listing of Parcel ID numbers, Roll Numbers, and lot areas which were attached to spatial reference points. The property area was used as a measure to determine if sufficient space is available for a replacement septic system. The Roll Numbers were used to link existing building department records to the location of the property.

1.2.4 Ontario Building Code

The construction and installation of small individual septic systems (<10,000 L/d) up to a daily design sewage flow of 10,000 litres per day is regulated under the Ontario Building Code (OBC). The OBC regulates the design, construction, operation and maintenance of on-site septic systems for most single family homes, through Part 8 of Division B of the Building Code (O. Reg.350/06) made under the Building Code Act, 1992.

Per Ontario Building Code (Clause 8.2.2.3), the minimum working capacity of a septic tank shall be the greater of 3,600 L and (a) in residential occupancies, twice the daily design sanitary sewage flow or (b) in non-residential occupancies, three times the daily design sanitary sewage flows.

1.2.5 Ministry of Environment and Climate Change (MOECC)

All sewage works with a design capacity in excess of 10,000 L/d, including subsurface disposal systems, are subject to the requirements of Section 53 of the Ontario Water Resources Act (OWRA) administered by the MOECC. Subsurface disposal systems with a design capacity in excess of 10,000L/d are referred to as large subsurface sewage disposal systems (LSSDS). The LSSDS is mainly comprised of two components, a pre-treatment process (i.e., a septic tank or other treatment processes facilities) followed by a soil component (e.g. drain field).

For LSSDS, the working capacity of the septic tank(s) should provide a minimum of 24-hours retention at design peak daily flow. If the LSSDS is proposed to service dry industry, commercial facilities, institutional development, restaurants, office buildings or a larger residential development, it will be necessary to assess both the sewage quality and flow characteristics.

There are some types of wastewater that may not be suitable to be treated with a LSSDS. These may include wastewater from automatic car washes, garage facilities, or some agricultural uses such as egg washing. LSSDS for these types of sewage may require complicated pre-treatment or this type of wastewater may not be suitable for subsurface disposal.

Secondary aerobic biological treatment processes (other than primary septic tanks) for lowering concentrations of BOD and TSS in the effluent are recommended for LSSDS. For flows not substantially larger than 10,000 L/d, the designer should consider the use of pre-engineered (package) aerobic biological treatment units.

The size of LSSDS drain field interface surface may also preclude the use of gravity flow to the drain fields. Part 8 of Division B of the Building Code mandates effluent distribution through dosing for any sewage system having more than 150 m (490 feet) length of distribution pipe. Typically, all LSSDS's fall within this category and should be dosed appropriately.

Evaluation of existing systems was conducted for compliance with MOECC.

2.0 Data Analysis

2.1 Septic System Database

A database was created using the available septic information in order to analyze and to help make decisions on whether certain areas of Erin and Hillsburgh required connection to a communal collection system or whether they should be left to continue using their current septic system. This database combined the data made available through the Town of Erin Building Department Records and the GIS data. This database was used in conjunction with the information and recommendations provided by the SSMP, WSP Canada 2015 Annual Report, Ontario Building Code, and the MOECC to decide whether connection to a communal system for each area of Erin and Hillsburgh was necessary.

2.2 Defining Collection Decision Areas

In deciding whether existing private septic systems can remain as private systems or should be incorporated into a proposed communal system, it is desirable to define "servicing areas" and to decide on an area by area basis as outlined in the SSMP. Constructing a communal wastewater system to service only those systems with proven non-compliance or poor performance issues, while allowing individual lots on the same street or within the same area to remain on private systems, is not a valid approach for the following reasons:

- MOECC will require that wastewater collection systems be designed to service all lots within a specific service area consistent with the planning designation for the area. If an area is to be designated for servicing by a communal wastewater system, then the system must be designed to meet the capacity of all of the properties within this area
- Typically, where a communal wastewater system is to be designed to service an area, Municipalities require all properties to be connected and to contribute their share of the capital and operating costs

For the above reasons, it is necessary to designate specific areas to be serviced by private wastewater systems or by a communal wastewater system. For the purposes of this study, therefore, Erin and Hillsburgh, was split into logical serviceable sections, defined as "decision areas". Decision areas were derived from a combination of factors including location, local topography, drainage areas, proximity to sensitive receivers, and development consistency (lot sizes etc). The decision areas of each of the two communities each have their own unique challenges to be taken into account when planning wastewater collection options.

Having defined the "decision areas", the analysis of existing private systems provides the rationale for whether each area is to be serviced by a communal wastewater system or to continue to be serviced by private wastewater systems.

The decision areas identified are outlined in Table 1.

Table 1 - Collection System Decision Areas in Erin and Hillsburgh

Decision Area Name	Location	Rationale
Erin Industrial Area	North of the Elora Cataract Trailway South of Sideroad 17 Pioneer Drive is included	Primarily industrial and commercial area Natural drainage to the south Contains communal septic system for recreation centre
Erin Town Core 1	South of the Elora Cataract Trailway North of Water St West of Creditview River Road East of Erin Heights Drive	Primarily residential area Consistent lot sizing and building age Several drainage challenges along the river Contains areas of institutional/commercial development
Erin Town Core 2	North of the West Credit River South of Water St A small portion of Highway 124 is included	Primarily residential area Natural drainage area terminating at the West Credit River Consistent lot sizing and building age Contains areas of commercial development
South Erin	Properties along Wellington 124 and Along 8th Line.	Primarily residential area Consistently large lot sizing and newer building age

Erin Heights	Properties along Erin Heights Drive and Sideroad 15	Uniform development Consistent lot sizing and building age Drainage towards river (NE) Separated from Town Core areas by the West Credit River
South East Erin	Bounded by Wellington 124 Road and the south east study area boundary.	Primarily new development with large lot size Natural drainage towards the northwest
North East Erin	Properties along 10th Line including Pine Ridge Road and Credit River Road.	Primarily residential area Consistently large lot sizing and newer building age
Hillsburgh Town Core 1	North of Mill Street East of Trafalgar Road Bounded by north study areas boundary	Primarily Residential Natural drainage towards south end of the decision area Primarily medium sized lots with consistent building age, with larger lots in the North end Contains areas of commercial development
Hillsburgh Town Core 2	North of Station Street South of Mill Street East of Trafalgar Road	Primarily Residential Natural drainage towards west end of the decision area Primarily medium sized lots with consistent building age Contains areas of commercial development
Upper Canada Drive	Properties along Upper Canada Drive and Leader Court	Residential area Single development with

		consistent age and large lot sizes Drainage splits NE and SW creating two drainage areas
George Street	Properties along George Street	Consistent development age and lot sizes Drainage to the west
South Trafalgar Road	Properties along Trafalgar Road south of Station Street	Mixed residential and commercial development Consistent building age Drainage to the south

The drawings in Appendix A provide a visual representation of the collection decision areas in Erin and Hillsburgh.

2.3 GIS Data

The Town of Erin GIS database provided a property fabric for all lots within the urban boundary. Included in the database was a listing of Parcel ID numbers, Roll Numbers, and lot areas which were attached to spatial reference points. The property area was used as a measure to determine if sufficient space is available for a replacement septic system. The GIS data was also used to link existing building department records to the location of the property.

The Ontario Building Code states that a lot must be at least 1,400 m^2 to accommodate a septic system replacement. In an analysis of the property lot sizes, it was found that 49% of Erin properties and 58% of Hillsburgh properties are below 1,400m^2, which excludes them from replacing their septic systems in the future, as shown in Table 2.

Table 2 - Town of Erin Properties <1,400m^2

	Total Properties	Properties <1,400m^2	% Properties < 1,400m2
Erin	1339	650	**49%**
Hillsburgh	512	295	**58%**
Total	1851	945	**51%**

Properties less than 1,400m^2 in Town of Erin and Hillsburgh are shown in Appendix B.

2.4 Building Department Data

The data received from the Town of Erin's Building Depart provided information on existing systems. The Ontario Building code states that a septic system must have a minimum working capacity of 3,600L. The building department provided tank sizes for 548 properties in Erin and 266 in Hillsburgh, representing 44% of properties, as can be seen in Table 3.

Table 3 - Town of Erin Septic Tank Sizes

	Total Property Information Available	Tanks < 3,600L	% Tanks < 3,600L
Erin	548	75	**14%**
Hillsburgh	266	49	**18%**
Total	814	124	**15%**

Within that data, 14% and 18% of septic tanks are below the OBC specified 3,600L limit in Erin and Hillsburgh respectively.

A cross section of the septic records was analyzed from each street in Erin and Hillsburgh to determine the septic system age specific to each individual decision area. To be conservative, the highest septic age found on each street was used to represent the age of each respective street. Table 4 shows the average maximum age of the streets within each decision area.

Table 4 - Average Septic System Ages

Decision Area	Average Max Age (yrs)
Erin	
South East Erin	26
Erin Industrial Area	31
North East Erin	no septic records
South Erin	23
Erin Town Core 1	39
Erin Town Core 2	40
Erin Heights	32
Hillsburgh	
Hillsburgh Town Core 1	33
Hillsburgh Town Core 2	37
Upper Canada Drive	11
George Street	29
South Trafalgar Road	35

2.5 Well Head Protection Program

In December of 2015, the Source Protection Plan (SPP) for the Credit Valley/Toronto and Region/Central Lake (CTC) Source Protection Region in Ontario came into effect to protect current and future sources of municipal drinking water from significant threats. As part of the SPP, the Well Head Protection Program has come into effect and has defined well protection areas within Ontario. There are varying sizes of land that are considered protected for each well and their size depends on the length of time necessary for a contaminant to reach the wellhead by means of ground water. The *Clean Water Act* (2006) required that a circle of 100 metres in diameter be provided around each municipal well. The wellhead protection program uses this as their first protection area for each well (WHPA-A), the second is a representation of 2 years of contaminant travel time (WHPA-B), the third is 5 years of travel time(WHPA-C), the fourth is 25 years(WHPA-D), and the last refers to wells in direct influence of surface water(WHPA-E).

Severity of risk is highest within the first protection area delineation of 100m diameter surrounding the well and tends to decrease as the radius gets larger from WHPA-B to WHPA-D. The SPP also assigns vulnerability scores (1-10) to land within the wellhead protection areas based on the vulnerability of the source water area and the hazard rating of the potential threat. The SPP indicates that establishment, operation, or maintenance of septic systems within the WHPA-A will require a maintenance program to be created and an annual report to be submitted to the MOECC equivalent to Section 65 of O.Reg. 287/07. The report must outline the actions taken in the previous year to achieve outcomes of the source protection policy. According to the SSMP, the maintenance program should be a 5 year mandatory septic system inspection. Septic systems within WHPA-B will have their Environmental Compliance Approvals established or under review to ensure it they do not become a significant threat (vulnerability score = 10) in the near future. However, if the vulnerability score within WHPA-B is currently 10, then the same rules that apply to septic systems within WHPA-A, also apply to WHPA-B.

Hillsburgh has 2 wells within its boundary and Erin has 3, all of which have a risk of contamination from septic systems. Appendices C-1 and C-2 show that in Erin, 13 properties are within a WHPA-A and Appendix C-3 show that there are 25 properties within a WHPA-A in Hillsburgh. In addition, in Appendix C-1 it can be seen that Erin has 102 properties within a WHPA-B that has a vulnerability score of 10, which means that operation, or maintenance of those septic systems requires an inspection program. In total there are 140 properties within the wellhead protection plan that have septic systems that require a 5-year maintenance program to be created and an annual report to be submitted to the MOECC equivalent to Section 65 of O.Reg. 287/07.

Although a vulnerability score of 10 is considered significant threat, a score of 8 indicates that that land's risk is close to being a significant threat to municipal water quality. Since the age of the systems within the areas with a vulnerability score of 8 are past the typical septic system life span of 20-25 years, the integrity of the systems will begin to break down in the immediate future and the risk of contamination will increase, which causes the vulnerability score to rise. In Erin, there are two areas in which there is vulnerability score of 8; a WHPA-C in the south end of Erin and a WHPA-B on the west side of Erin, shown in Appendices C-1 and C-2, respectively. In Hillsburgh, both WHPA-B have a vulnerability score of 8 and they contain 84 properties, as can be seen in Appendix C-3. Table 5 provides a breakdown of the wellhead protection areas and how they affect both Erin and Hillsburgh.

Table 5 - Well Head Protection Data

Well Head Protection Area Type	Erin		Hillsburgh		Total	
	Lots with VS=10	Lots with VS=8	Lots with VS=10	Lots with VS=8	Lots with VS=10	Lots with VS=8
WHPA-A	13	0	25	0	38	0
WHPA-B	101	1	0	84	101	85
WHPA-C	0	23	0	0	0	23
TOTAL	114	24	25	84	**139**	**108**

*VS: Vulnerability Score

2.6 Gap Analysis

A gap analysis was performed to identify properties with missing septic system information.

2.6.1 Unaccounted Information

Septic system information for 1,590 lots within Erin and Hillsburgh was available which accounts for 86% of the 1,851 lots in the urban area of Hillsburgh and Erin. A gap analysis of the available data is shown on Table 6.

Table 6 - Gap Analysis of Available Information

Data	Total		Erin		Hillsburgh	
	# of Lots	% of Properties	# of Lots	% of Properties	# of Lots	% of Properties
Total Lots	1851	100%	1339	100%	512	100%
GIS Data	1851	100%	1339	100%	512	100%
Data from Building Dept.	1590	86%	1088	81%	502	98%
Tank Size	814	44%	548	41%	266	52%
Septic Age	1236	67%	740	55%	496	97%
Type of Septic System	861	47%	575	43%	286	56%

2.6.2 Potential Methods of Unaccounted Information Procurement

To obtain data on Septic Type, Septic Age and Septic Size, a full investigation into each individual septic permit that the Building Department is necessary. There are approximately 1200 entries that have varying historical and incomplete permit information.

A physical survey of each individual property would be necessary to obtain 100% of the septic data. Since it is unlikely that property owners would have detailed information on the extent of their disposal beds or tanks, the collection of this data would involve extensive field work. While it was originally envisaged that most data would need to be collected in the field, the actual data collected from the building department has likely more accurate and useful than information that could be collected from property owners.

For this reason, it is suggested that the information available from the sources outlined in this study be considered sufficient to decide whether each area becomes part of the communal wastewater system or remains as privately serviced.

3.0 Overview of Collection Decision Areas

Using the information presented in this report, rationale was made for the properties of each decision area to either be connected to the future wastewater collection system or to continue with private servicing.

3.1 Wastewater Collection System Rationale

3.1.1 Erin

Erin has been divided into 7 decision areas for wastewater. This section of the report will focus on each area individually and provide rationale as to whether it should be connected to a communal system based on the information provided in Section 2.

Erin Industrial

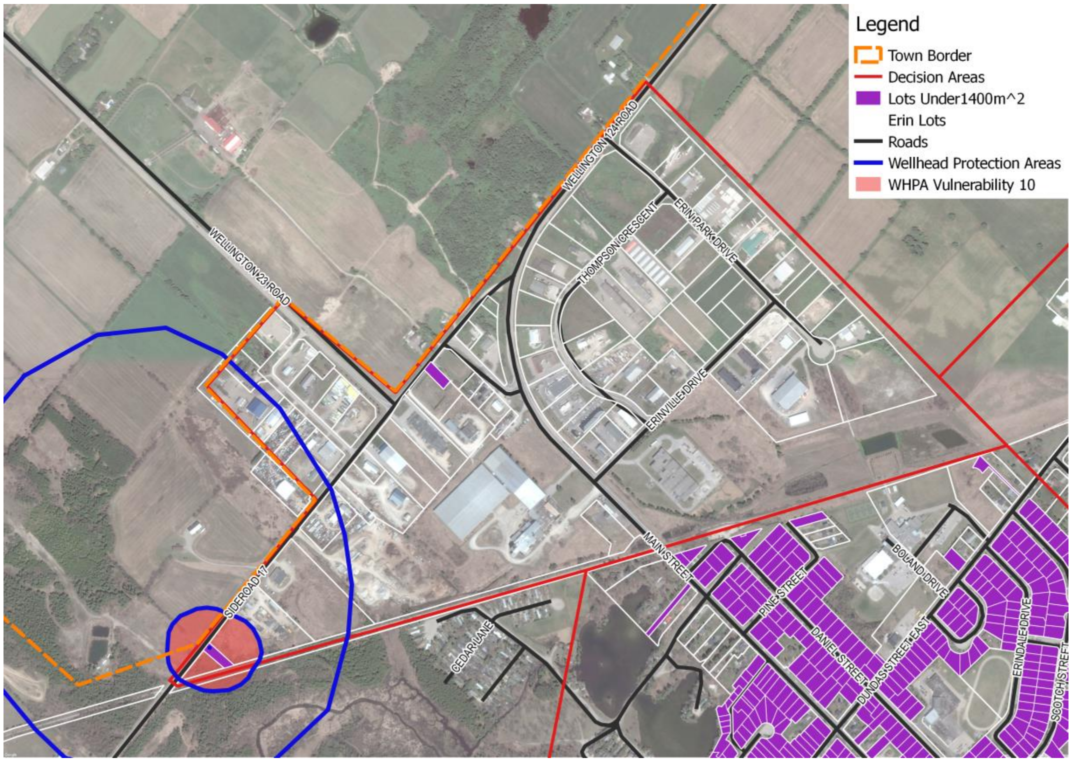


Figure 1 - Erin Industrial

The Erin Industrial area is made up of characteristically large commercial buildings and following a visual inspection, almost no signs of existing septic systems were found. This means that the vast majority of these lots may be using a holding tank or another type of wastewater system that may not comply with the Ontario Building Code.

Based the information provided by the Building Department and on flow calculations, the majority of the lots in this decision area could potentially exceed 10,000L/d. Therefore, the septic systems will likely have to comply with MOECC and not OBC as mentioned in section 1.2.5.

In reviewing the business profile of the area it is apparent that certain properties may have replaced or altered their septic systems due to a change in business operation. It is also apparent that lot sizes presently may not support expansion of some businesses to their full potential. From the available septic records, Table 7 presents the average age of systems within this decision area. The majority of the systems in Erin Industrial are also likely past their typical useful lifespan.

Table 7 - Septic Age within Erin Industrial Area

Street	Approximate Septic Age (yrs)
Erin Park Drive/Erinville Drive	27
Side Road 17	25
Shamrock Road	44
Thompson Crescent	29
Average Age	**31**

Since the majority of the septic systems in this area may not conform to the MOECC guidelines and, the average age of the septic systems may be close to end of their useful lifespan, it is recommended that the Erin Industrial area be connected to the proposed communal wastewater collection and treatment system.

Erin Town Core 1

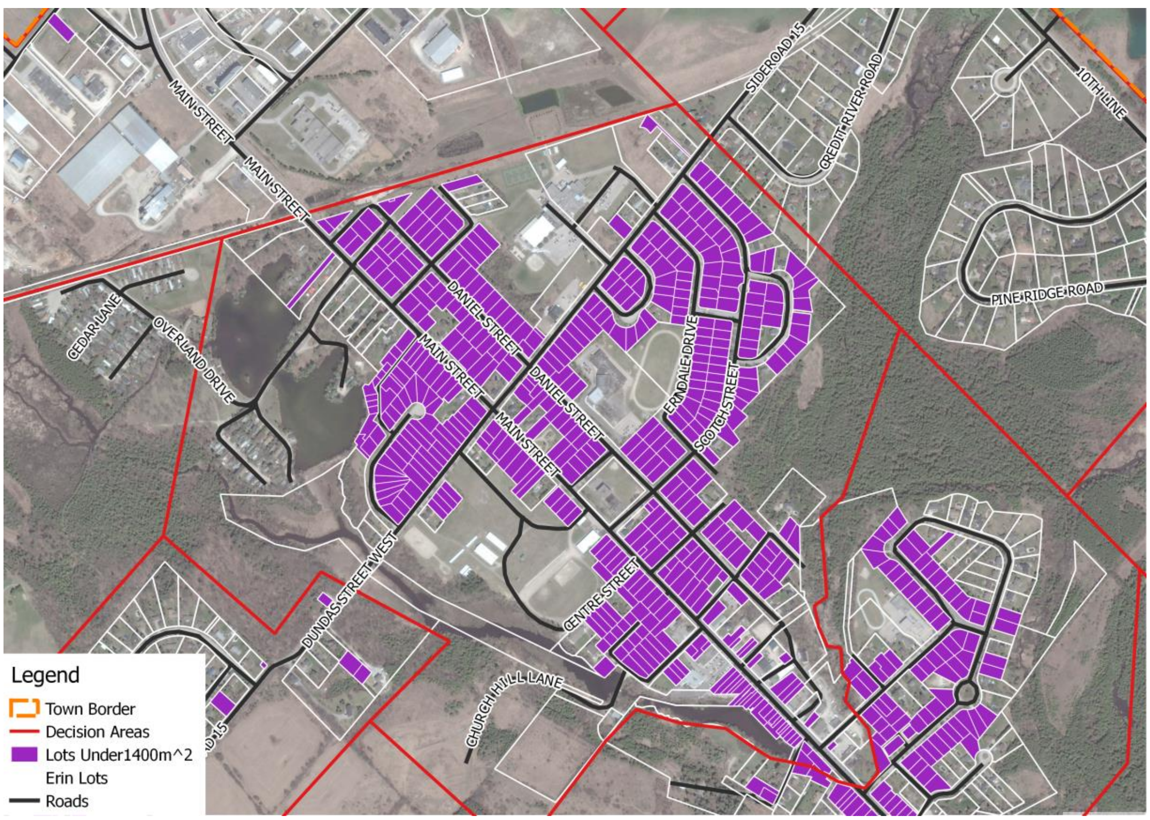


Figure 2 - Erin Town Core 1

The Erin Town Core 1 area contains 521 of the 1,339 lots that are located in Erin, which is the largest decision area in Erin. Of the 521 properties, 449 (86%) are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is available for 228 lots. Of those lots, 22% have septic systems with a tank that is below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC. Within the available septic tank size data, the following streets in Erin Town Core 1 have the highest number of non-compliance sized tanks: Tomwell Cres. (58%), Scotch St. (60%), Erindale Dr. (40%). A portion of properties on the Main St of Erin are using holding tanks as their current septic system. This type of septic system is also in violation of section 8.2.2.3 of the OBC.

Table 8 shows that the average age of the septic systems in this decision area is 39 years old, with the oldest streets being Dundas St E, Main St and Daniel St, which are 55+ years old. A portion of the properties on those streets may have since been replaced or altered their septic systems due to disrepair.

Table 8 - Septic Age within Erin Town Core 1

Street	Approximate Septic Age (yrs)
Daniel Street	56
Ross/Lorne Street	29
Spring Street	39
Pine Street	33
May Street	34
Dundas Street East	62
Tomwell Crescent	44
Centre Street	31
Scotch Street	48
English Street	12
Erindale Drive	44
Erinlea Crescent	27
Church Street/Wheelock St.	44
Church Boulevard	32
Carberry Road	33
Sunnyside Drive	29
Dundas Street West	44
Main Street	64
Average Age	**39**

There are no lots within Erin Town Core 1 that fall within the wellhead protection areas, however, the east and west boundaries of this decision area are in close proximity to the West Credit River and the topography indicates that the decision area drains towards those boundaries. If septic systems are deficient and leaking, they will potentially drain into the West Credit River. Due to the majority of the lots being undersized, the old age of the existing septic systems and the high number of tanks being undersized, this area should be connected to the proposed communal wastewater collection and treatment system.

Erin Town Core 2

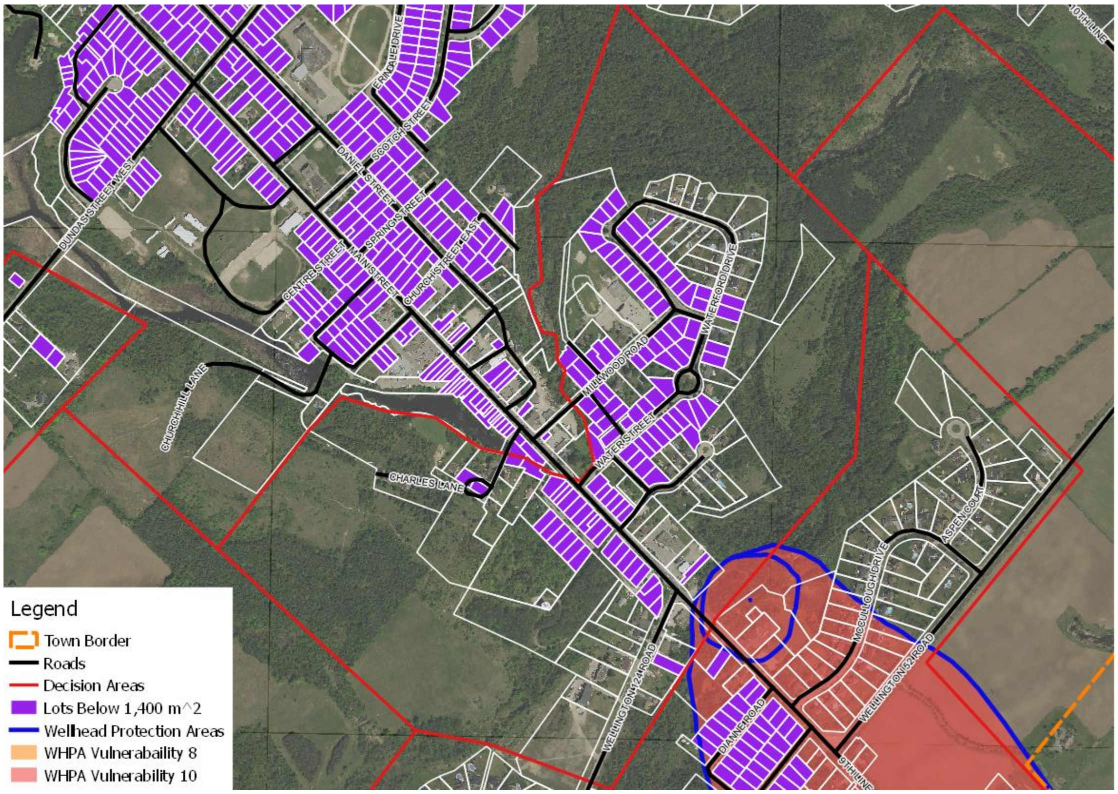


Figure 3 - Erin Town Core 2

The Erin Town Core 2 area contains 174 of the 1,339 lots that are located in Erin. Of these properties, 61% are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is available for 71 lots. Of those lots, 18% have septic systems with a tank that is below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC. Within the available septic tank size data, the following streets in Erin Town Core 2 have the most non-compliance sized tanks: Waterford/Water Dr. (26%) and Scotch St. (43%). A portion of properties on the Main St of Erin are still using holding tanks as their current septic system. This type of septic system is also in violation of section 8.2.2.3 of the OBC.

Table 9 shows that the average age of the septic systems in this decision area is 42 years old, with the oldest streets being Charles St, William St, Waterford/Water Dr, and Millwood Dr, which are 45+ years old. A portion of the properties on those streets may have since replaced or altered their septic systems due to disrepair.

Table 9 - Septic Age within Erin Town Core 2

Street	Approximate Septic Age (yrs)
Waterford/Water Drive	49
Millwood Road	46
Young Street	29
Lions Park Avenue/Hillsview St	34
William Street	51
Charles Street	57
Wellington Road 124	29
Main Street	28
Average Age	**40**

There are 2 lots on the most southern point of Erin Town Core 2 that is within a WHPA-A with vulnerability score of 10 and 1 lot within a WHPA-B with a VS of 10. These lots require a maintenance program to be created and an annual report to be submitted to the MOECC equivalent to Section 65 of O.Reg. 287/07. The report must outline the actions taken in the previous year to achieve outcomes of the source protection policy. According to the SSMP, the maintenance program should be a 5 year mandatory septic system inspection.

The west boundary of this decision area is in close proximity to the West Credit River and east side is in close proximity to a tributary. The topography indicates that the decision area drains towards those boundaries. If septic systems are deficient and leaking, they will potentially drain into the surrounding river.

Due to the majority of the lots being undersized, the old age of the existing septic systems and the high number of undersized septic tanks, this area should be connected to the proposed communal wastewater collection and treatment system.

South Erin

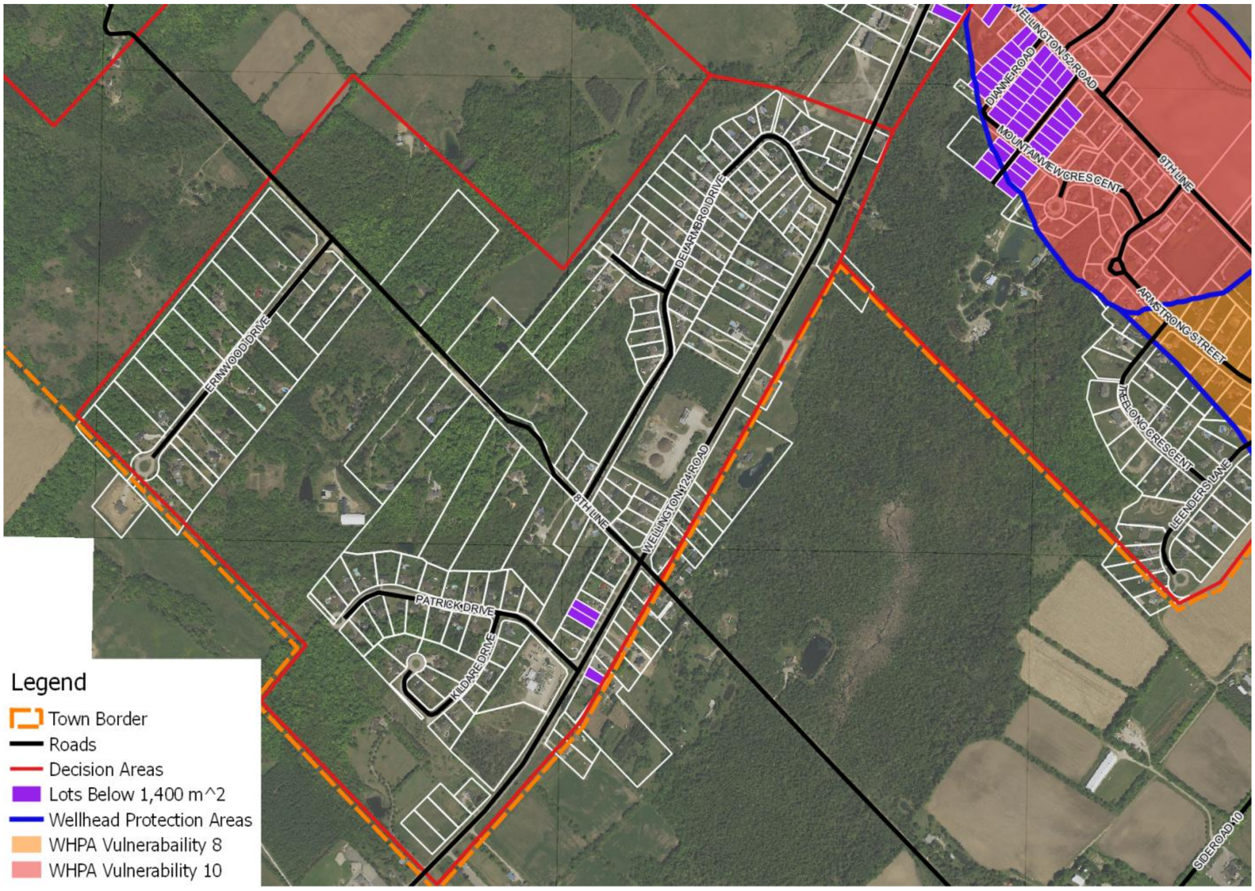


Figure 4 - South Erin

The South Erin decision area contains 163 of the 1,339 lots that are located in Erin. Of these lots, only 2% are below the minimum of 1,400m^2 lot area for septic replacement.

The building department data accounts for only 37 lots (20%) within this decision area.

The septic tank size data is available for only 20 lots. Of those lots, 15% (3 tanks) have septic systems with a tank that are below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC. These non-compliant septic tanks are all on Wellington Road 24.

Table 10 indicates that South Erin is a comparatively new area with an average septic system age of 19 years. Within the Building Department septic records, 8th Line, Erinwood Drive, and Patrick Drive were unavailable.

Table 10 - Septic Age within South Erin

Street	Approximate Septic Age (yrs)
Wellington Road 124	29
Delarmbro Drive	16
8th Line	no permit info
Forest Ridge Road	12
Erinwood Drive	no permit info
Patrick Drive	no permit info
Average Age	**19**

Due to the low number of lots below 1,400m^2 and the relatively young age of the majority of the lots, the recommendation is not to connect this area to the communal wastewater collection and treatment system.

Erin Heights

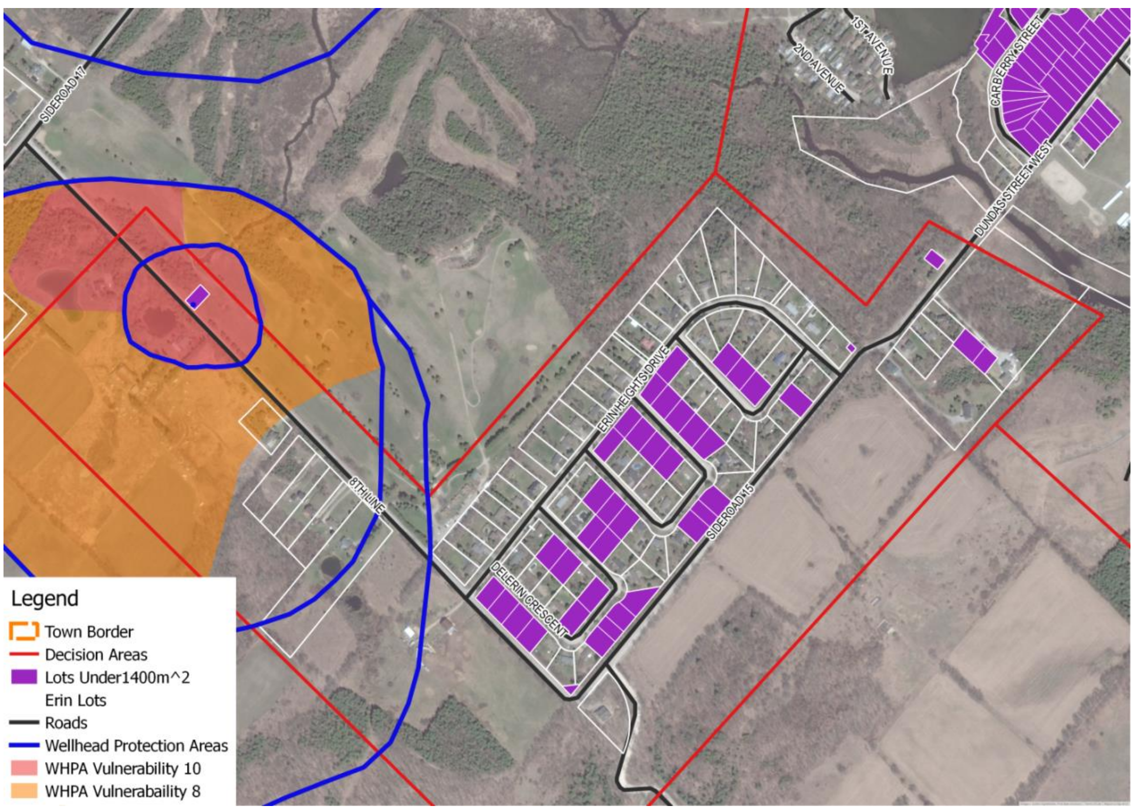


Figure 5 - Erin Heights

The Erin Heights decision area contains 115 of the 1,339 lots that are located in Erin. Of these lots, 38% are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is available for 45 lots. Of those lots, only 2% have septic systems with a tank that are below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC.

There is 1 lot on 8th Line within the Erin Heights that is within a WHPA-A with vulnerability score of 10 which requires an inspection program to support its operation and maintenance under the SPP. In addition there is 1 lot within a WHPA-B with a vulnerability score of 8, increasing the probability that operation and maintenance will require an inspection program under the SPP.

Table 11 shows that the average age of the septic systems in the decision area is 29 years old, with the oldest streets being 40+ years old: Erin Heights Dr, William Rex Cres, and Delerin Cres.

Table 11 - Septic Age within Erin Heights

Street	Approximate Septic Age (yrs)
Erin Heights Drive	40
William Rex Crescent	41
Wesley Crescent	38
Delerin Crescent	41
Dundas Street West	30
8th Line	3
Average Age	**29**

The northeast boundary of this decision area is in close proximity to the West Credit River. The topography indicates that the decision area drains towards that boundary and if septic systems are deficient and leaking, they will potentially drain into the surrounding river.

Due to the high number of undersized lots and the septic ages likely approaching the end of their useful life, it is recommended that this area should be connected to the proposed communal wastewater collection and treatment system.

South East Erin

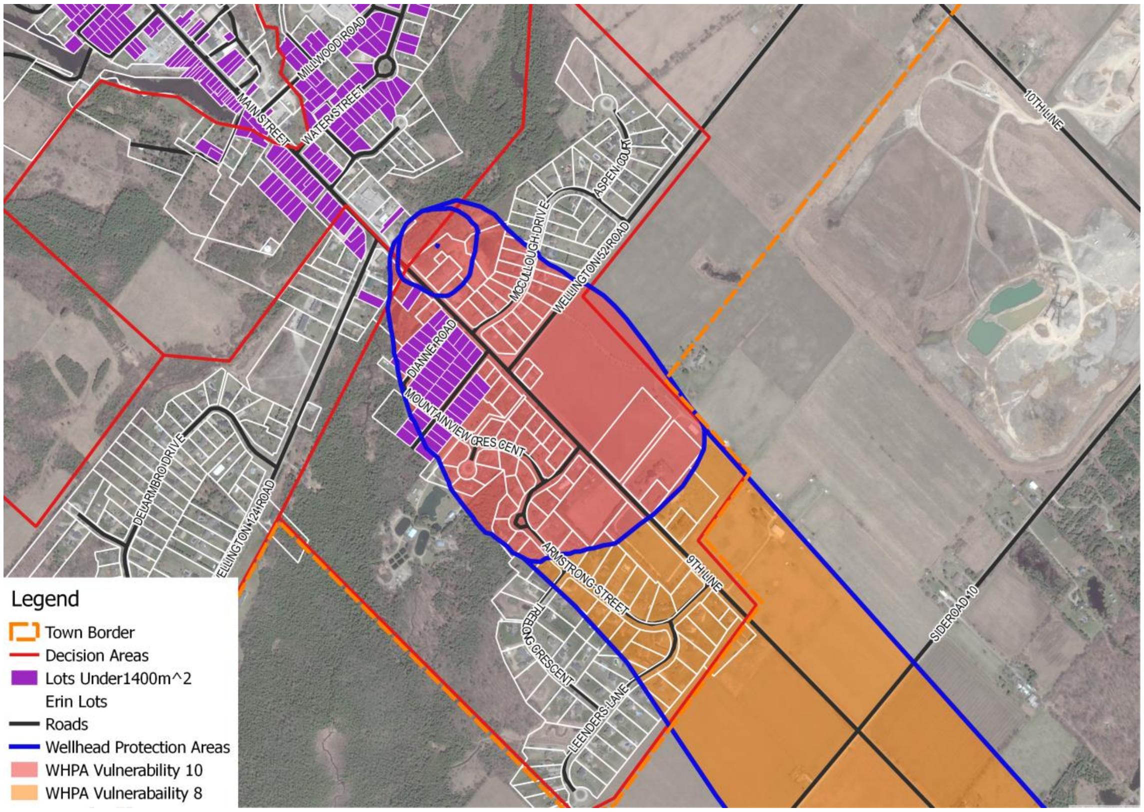


Figure 6 - South East Erin

The South East Erin decision area contains 191 of the 1,339 lots that are located in Erin. Of these lots, 24% are below the minimum 1,400m^2 lot area for septic replacement. The undersized lots are all located primarily on Dianne Rd, Kenneth Ave, and Mountain View Cres.

The septic tank size data is available for 127 lots. Of those lots, only 4% have septic systems with a tank that are below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC.

There are 86 lots within the South East Erin decision area with vulnerability score of 10, five (5) of these lots land within WHPA-A and 81 of these lots land in a WHPA-B. These lots require a maintenance program to be created and an annual report to be submitted to the MOECC equivalent to Section 65 of O.Reg. 287/07. The report must outline the actions taken in the previous year to achieve outcomes of the source protection policy. According the SSMP, the maintenance program should be a 5 year mandatory septic system inspection.

There are also 20 lots that fall within a WHPA-C that has a vulnerability score of 8. The lots with a vulnerability score of 8 are close to a score of 10 and as the age of the septic systems increases, so does their risk of contaminating the groundwater, which increases the vulnerability score of the wellhead protection area that they fall under. This will result in these lots becoming a vulnerability of 10 and inciting the mandatory maintenance and reporting program mentioned above.

Table 12 shows that the average age of the septic systems in the decision area is 27 years old. There are four streets that still have substantial remaining life for their septic systems: Treelong Cres, Leenders Ln and Armstrong St, and Aspen Ct.

Table 12 - Septic Age within South East Erin

Street	Approximate Septic Age (yrs)
Dianne Road	25
9th Line	47
Mountain View Cres.	29
Garden Court	29
Kenneth Avenue	59
Armstrong Street	11
Leenders Lane	11
Aspen Court	18
McCullough Drive	21
Wellington Road 52	32
Treelong Crescent	10
Average Age	**27**

The lots within a wellhead protection area with a vulnerability score of 8 and 10 should be connected to the proposed communal wastewater collection and treatment system. These lots are located on the following streets: 9^{th} Line, Dianne Rd, Kenneth Ave, Mountain View Cres, Armstrong St, Treelong Cres, Leenders Ln, Wellington Road 52. The remaining streets; McCullough Dr and Aspen Ct, have 21 and 11 year old septic systems, however it is anticipated that they would require to be connected to a communal system at some point in the future.

The northwest boundary of this decision area is in close proximity to a tributary of the West Credit River. The topography indicates that the decision area drains towards that boundary. More specifically, if the septic systems on McCullough Dr are deficient and leaking, they will potentially drain into the nearby tributary.

It is recommended to connect this entire area to a communal wastewater system. However this could be re-evaluated following the completion of the ongoing water system Class EA.

North East Erin

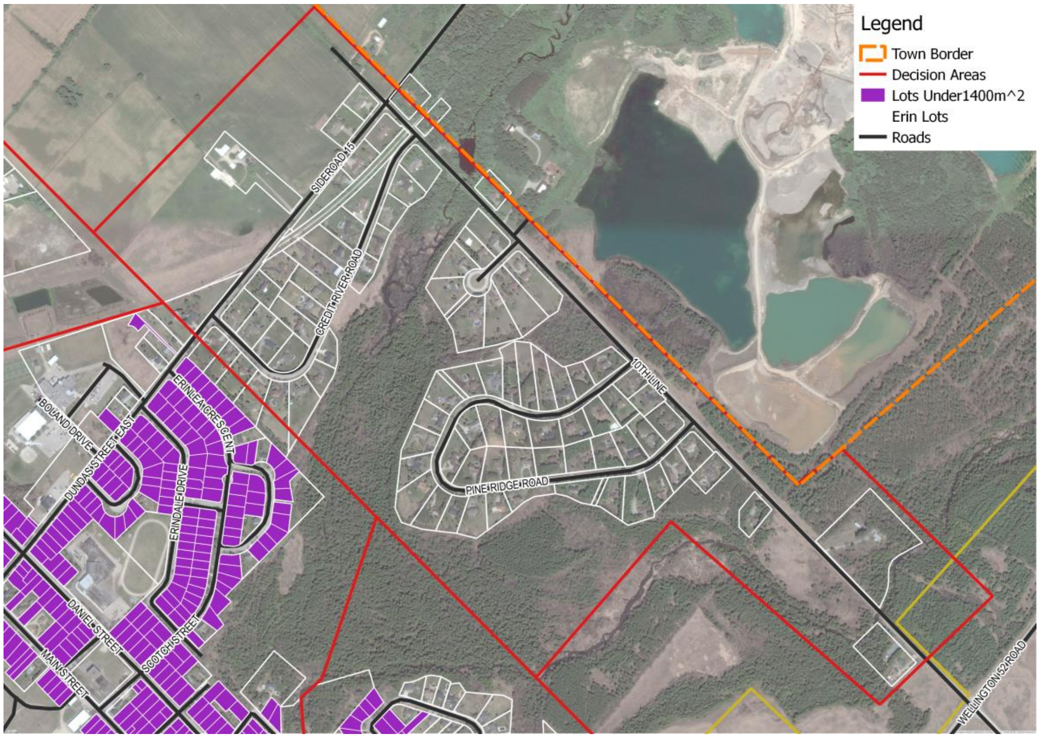


Figure 7 - North East Erin

The North East Erin decision area contains 95 of the 1,339 lots that are located in Erin. The building department data accounts for only 33 lots (20%) within this decision area. None of those lots are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is available for 31 lots. None of those septic systems has a tank that is below 3,600L in working capacity.

There are no lots within this area that fall within well head protection areas.

The Building Department records had no data regarding the age of the septic systems in this area.

The West Credit River runs through the south end of this decision area and the topography indicates that it drains towards the river. If the septic tanks in this decision area were to become deficient and leak, they could potentially contaminate into the West Credit River. However, since these lots were only recently developed, that is unlikely to occur in the near future.

It is recommended that this area not be connected to the proposed communal wastewater collection and treatment system in the immediate future.

3.1.2 Hillsburgh

Hillsburgh has been split into 5 decision areas regarding wastewater collection.

Hillsburgh Town Core 1

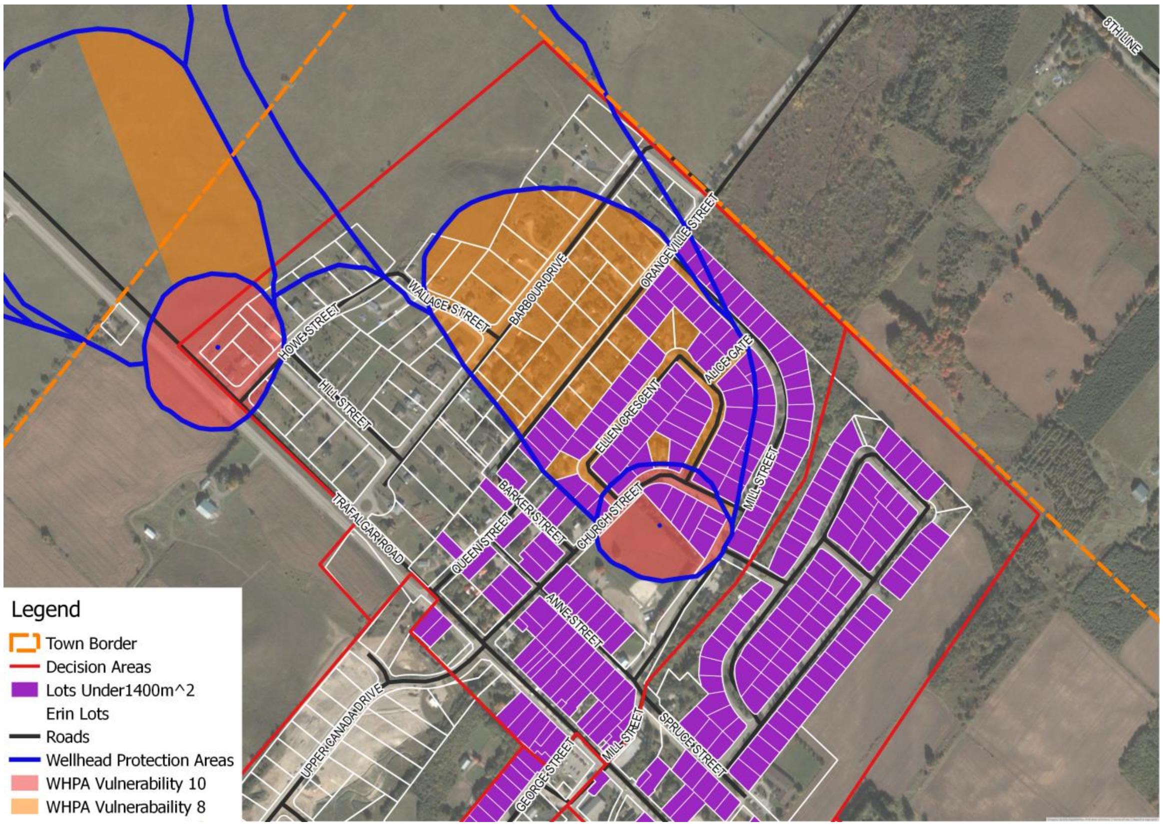


Figure 8 - Hillsburgh Town Core 1

The Hillsburgh Town Core 1 area contains 230 of the 512 lots that are located in Hillsburgh, which is the largest decision area in Hillsburgh. Of the 230 properties, 63% are below the minimum 1,400m^2 lot area for septic replacement. Most of the undersized lots are located south of Orangeville Street, with majority of lots on Mill St., Ellen Cres., Anne St., and Church St. being below 1,400m^2.

The septic tank size data is available for 227 lots. Of those lots, 36% have septic systems with a tank that are below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC. Within the available septic tank size data, the following streets in Hillsburgh Town Core 1 have the most non-compliance sized tanks: Ellen Cres/Alice Gate (94%) and Mill St. (50%).

There are 25 lots within the Hillsburgh Town Core 1 that land within a WHPA-A with vulnerability score of 10. The majority of lots within the two WHPA-A within Hillsburgh Town Core 1 are on Church St and Howe St. The SPP requires these lots to have a maintenance program be created and an annual report to be submitted to the MOECC equivalent to Section 65 of O.Reg. 287/07. The report must outline the actions taken in the previous year to achieve outcomes of the source protection policy. According the SSMP, the maintenance program should be a 5 year mandatory septic system inspection.

There are also 83 lots that fall within a WHPA-B that has a vulnerability score of 8. As can be seen in Appendix C-3, the WHPA-B with vulnerability score of 8 encompasses large portions of lots on Barbour Dr., Orangeville St., Ellen Cr., and Wallace St. These lots are close to a score of 10 and as the age of the septic systems increases, so does their risk of contaminating the groundwater, which would increase the vulnerability score of the wellhead protection area. This will cause the vulnerability scores to reach 10, which will incite the mandatory maintenance and reporting program mentioned above.

Table 13 shows that the average age of the septic systems in the decision area is 33 years old, with the oldest streets being Ellen Cres/Alice Gate, Church St and Trafalgar Rd, which are 45+ years old.

Table 13 - Septic Age within Hillsburgh Town Core 1

Street	Approximate Septic Age (yrs)
Barbour Drive	22
Hill Street	20
Wallace Street	19
Howe Street	23
Anne Street	31
Mill Street	44
Ellen Crescent/Alice Gate	46
Orangeville Street	40
Queen Street	33
Barker Street	23
Church Street	47
Trafalgar Road	45
Average Age	**33**

There is a tributary that runs through the south east section of this decision area, along Mill St. The topography indicates that the decision area drains towards that tributary and if septic systems are deficient and leaking, this could potentially increase the risk of contamination to the surface water.

Due to the majority of the lots being undersized, a high number of undersized septic tanks, a large portion of the area being in wellhead protection areas with vulnerability scores of 8 and 10, the close proximity to nearby surface water and the old age of the septic systems, it is recommended that this area be connected to the proposed communal wastewater collection and treatment system.

Hillsburgh Town Core 2

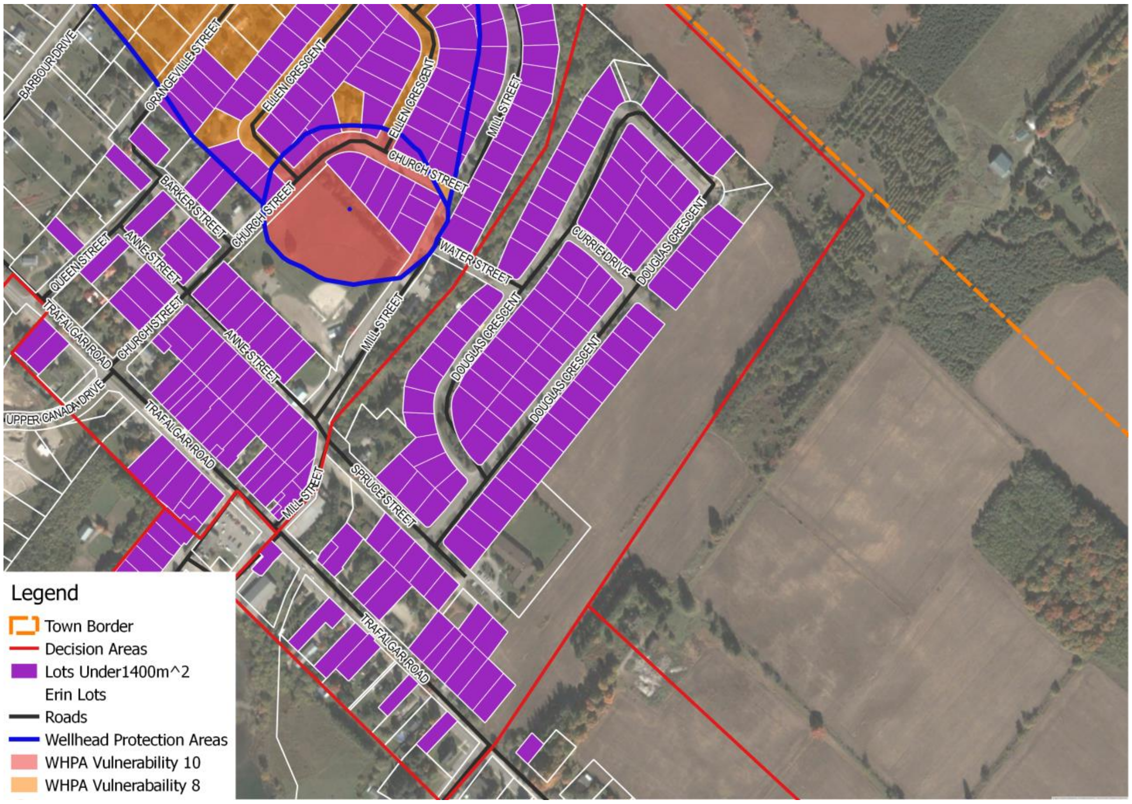


Figure 9 - Hillsburgh Town Core 2

The Hillsburgh Town Core 2 area contains 126 of the 512 lots that are located in Hillsburgh. Of the 126 properties, 85% are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is available for 61 lots. Of those lots, 3% have septic systems with a tank that are below 3,600L in working capacity, which violates section 8.2.2.3 of the OBC.

There are no lots within Hillsburgh Town Core 2 that fall within the wellhead protection areas.

Table 14 shows that the average age of the decision area is 37 years old.

Table 14 - Septic Age within Hillsburgh Town Core 2

Street	Approximate Septic Age (yrs)
Douglas Crescent/Currie Drive	39
Spruce Street	39
Trafalgar Road	32
Average Age	**37**

There is a tributary that runs in close proximity to northwest section of this decision area, along Mill St. The topography indicates that the decision area drains towards that tributary and if septic systems are deficient and leaking, they will potentially contaminate it. There is also a small lake located in close proximity to the south west border of this decision area that also has potential for contamination due to deficient septic systems.

Due to the majority of the lots being undersized, the close proximity to surface water and the old age of the septic systems, it is recommended that this area be connected to the proposed communal wastewater collection and treatment system.

Upper Canada Drive

Figure 10 - Upper Canada Drive

The Upper Canada Drive area contains 46 of the 512 lots that are located in Hillsburgh. Of the 126 properties, none are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is complete for this area and no lot has septic systems with a tank that are below 3,600L in working capacity. There are also no lots within Hillsburgh Town Core 2 that fall within the wellhead protection areas.

Table 15 shows that the average age of the septic systems in the decision area is 11 years.

Table 15 - Septic Age within Upper Canada Drive

Street	Approximate Septic Age (yrs)
Upper Canada Drive/McMurchy Ln	11
Leader Court	10
Average Age	**11**

There is a creek that runs through the north end of this decision area, along Trafalgar Rd and across Upper Canada Dr. The topography indicates that the decision area drains towards that creek and if septic systems are deficient and leaking, they will potentially contaminate it.

There appears to be no issues with the septic systems within this area of Hillsburgh. It is not recommended to be connected to a communal collection system.

George Street

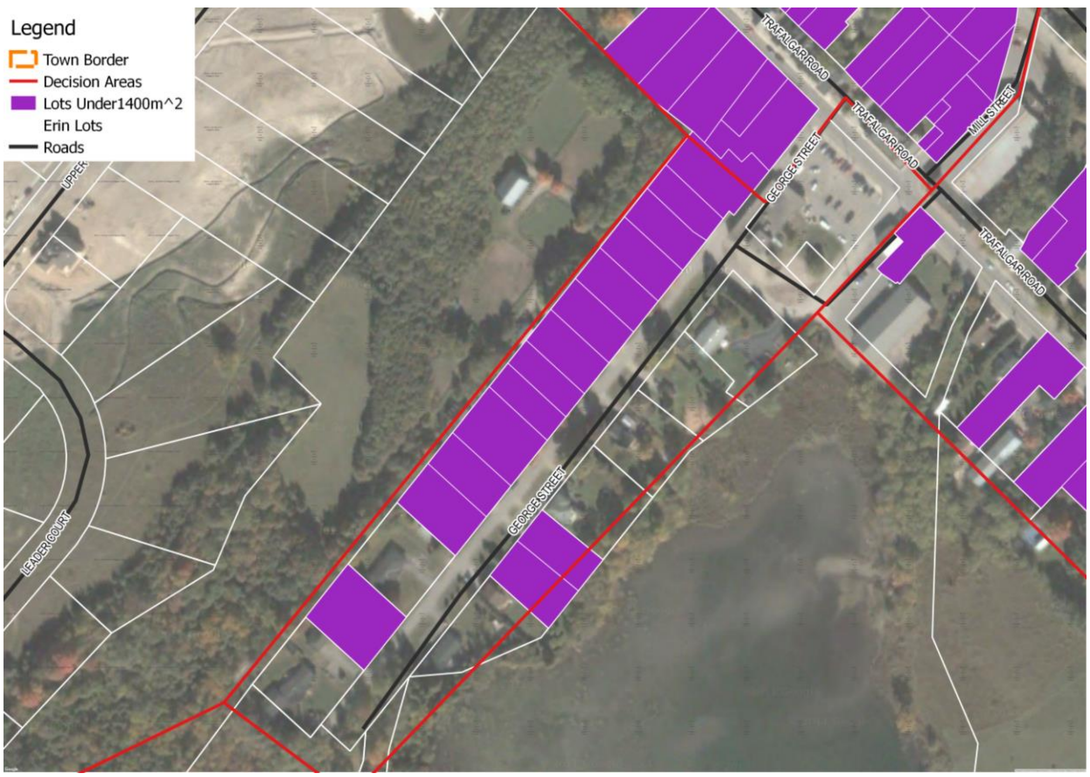


Figure 11 - George Street

The George Street area contains 24 of the 512 lots that are located in Hillsburgh. Of the 24 properties, 67% are below the minimum 1,400m^2 lot area for septic replacement.

The septic tank size data is available for 10 lots. None of those lots have septic systems with a tank that are below 3,600L in working capacity.

There are no lots in this area that fall under a wellhead protection area. Table 16 shows that the average age of the decision area is 29 years old.

Table 16 - Septic Age within George Street

Street	Approximate Septic Age (yrs)
George Street	29
Average	**29**

There is a creek that runs through the north end of this decision area, behind the Hillsburgh library and across George St. The topography indicates that the decision area drains towards that creek and if septic systems are deficient and leaking, they will potentially contaminate it. There is also a small lake located in close proximity to the east border of this decision area that also has potential for contamination due to deficient septic systems.

Due to the majority of the lots being undersized, the close proximity to surface water and the high average age of the septic systems, it is recommended that this decision area be connected to the proposed wastewater collection and treatment system.

South Trafalgar Road

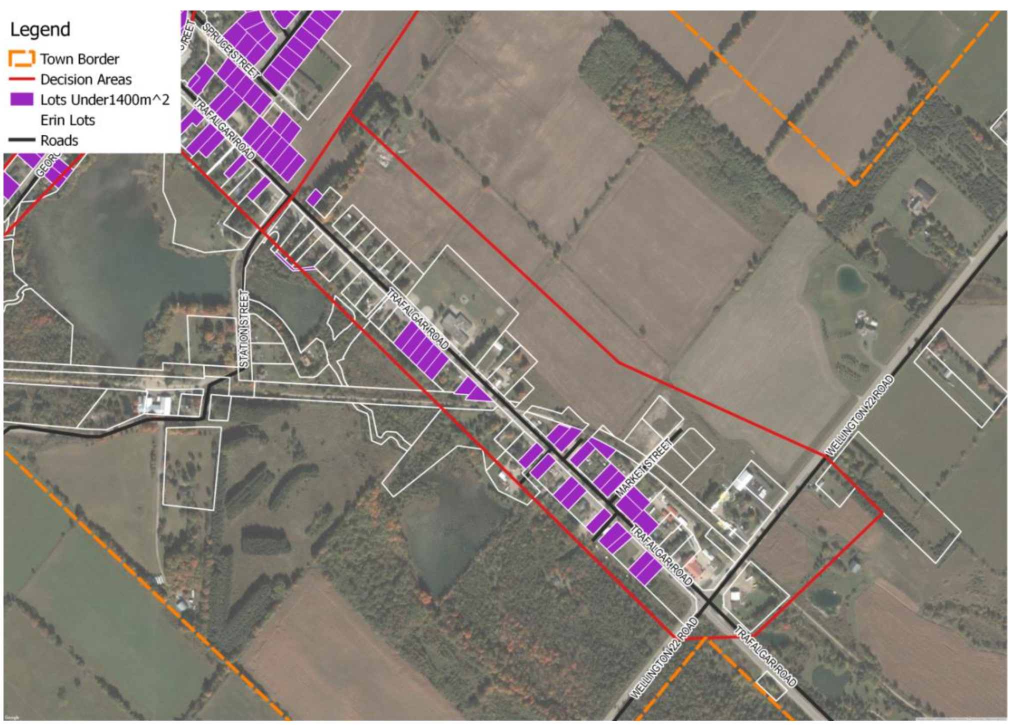


Figure 12 - South Trafalgar Road

The South Trafalgar Road area contains 78 of the 512 lots that are located in Hillsburgh. Of the 78 properties, 35% are below the minimum 1,400m^2 lot area for septic replacement. The majority of those lots are on Trafalgar Rd, with 42% being below 1,400m^2.

The septic tank size data is available for 23 lots. Of those lots, 1 has a septic system with a tank that is below 3,600L in working capacity.

There are no lots in this area that fall under a wellhead protection area.

Table 17 shows that the average age of the septic systems within this decision area is 29 years old.

Table 17 - Septic Age within South Trafalgar Road

Street	Approximate Septic Age (yrs)
Trafalgar Road	50
Station Street	28
Market Street	28
Average	**35**

There is a creek that runs in close proximity to the northwest end of this decision area. The topography indicates that the properties in the northwest end of this decision area drain towards that creek and if septic systems are deficient and leaking, they will potentially contaminate it. There are also a two small lakes located in close proximity to the southwest border of this decision area. These lakes and the creek connecting them also have potential for contamination due to deficient septic systems.

Due to the high number of undersized lots, the close proximity to surface water and the old age of the systems, this area should be connected to the proposed communal wastewater collection and treatment system.

4.0 Conclusion

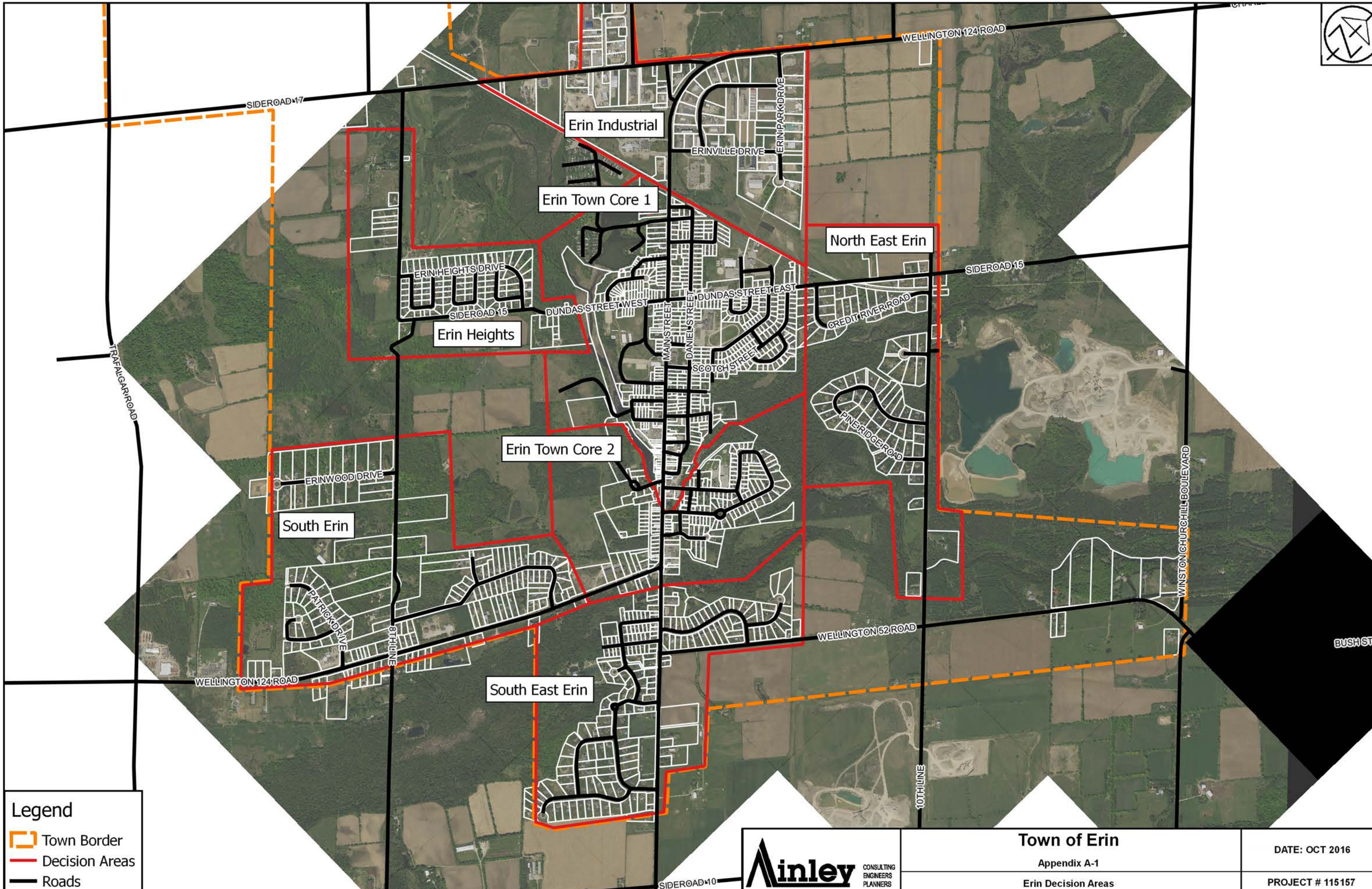
This report has been prepared in support of the Town of Erin Urban Centre Wastewater Servicing Environmental Assessment (UCWWS EA). The majority of properties within the Village of Erin and Hillsburgh are currently serviced by individual private septic systems and this septic system study was carried out to develop a more complete understanding of the existing septic systems to more clearly define the extent of the communal sewage service area. To accomplish this, Erin and Hillsburgh properties were split into separate decision areas based upon property location, local topography, drainage areas, proximity to sensitive receivers, and development consistency. The decision areas in Erin include: Erin Industrial, North East Erin, Erin Town Core 1, Erin Town Core 2, South East Erin, South Erin, and Erin Heights. Hillsburgh decision areas include: Hillsburgh Town Core 1, Hillsburgh Town Core 2, South Trafalgar Road, George Street and Upper Canada Drive. A visual representation of the decision areas can be found in Appendix A.

To determine which decision areas should be connected to the proposed communal wastewater collection and treatment system several studies/documents were analyzed, including: Servicing and Settlement Master Plan, Town of Erin Mandatory Septic Re-inspection Program, Building Department Records, GIS data, CVC Source Protection Plan(SPP), the Ontario Building Code and MOECC guidelines. These documents were analysed to define a number of determining factors for a decision area to connect to a communal sewage system, which include: lot size, septic tank size, septic system age, proximity to surface water and proximity to wellhead protection areas as defined in the SPP. A property lot size lower than 1,400m^2 is considered unable to accommodate a replacement septic system. The typical septic system life is 20-25 years according to the SSMP. If a septic tank is smaller than 3,600L and the property produces less than 10,000 L of sewage per day, it is not in compliance with the Ontario Building Code. If the property produces greater than 10,000 L of sewage per day then the working capacity of the septic tank(s) should provide minimum 24-hours retention at design peak daily flow according to MOECC guidelines. Lastly, if a property is within a wellhead protection area that has a vulnerability score of 10, the SPP requires a maintenance program be created and an annual report to be submitted to the MOECC equivalent to Section 65 of O.Reg. 287/07. The report must outline the actions taken in the previous year to achieve outcomes of the source protection policy. According the SSMP, the maintenance program should be a 5 year mandatory septic system inspection.

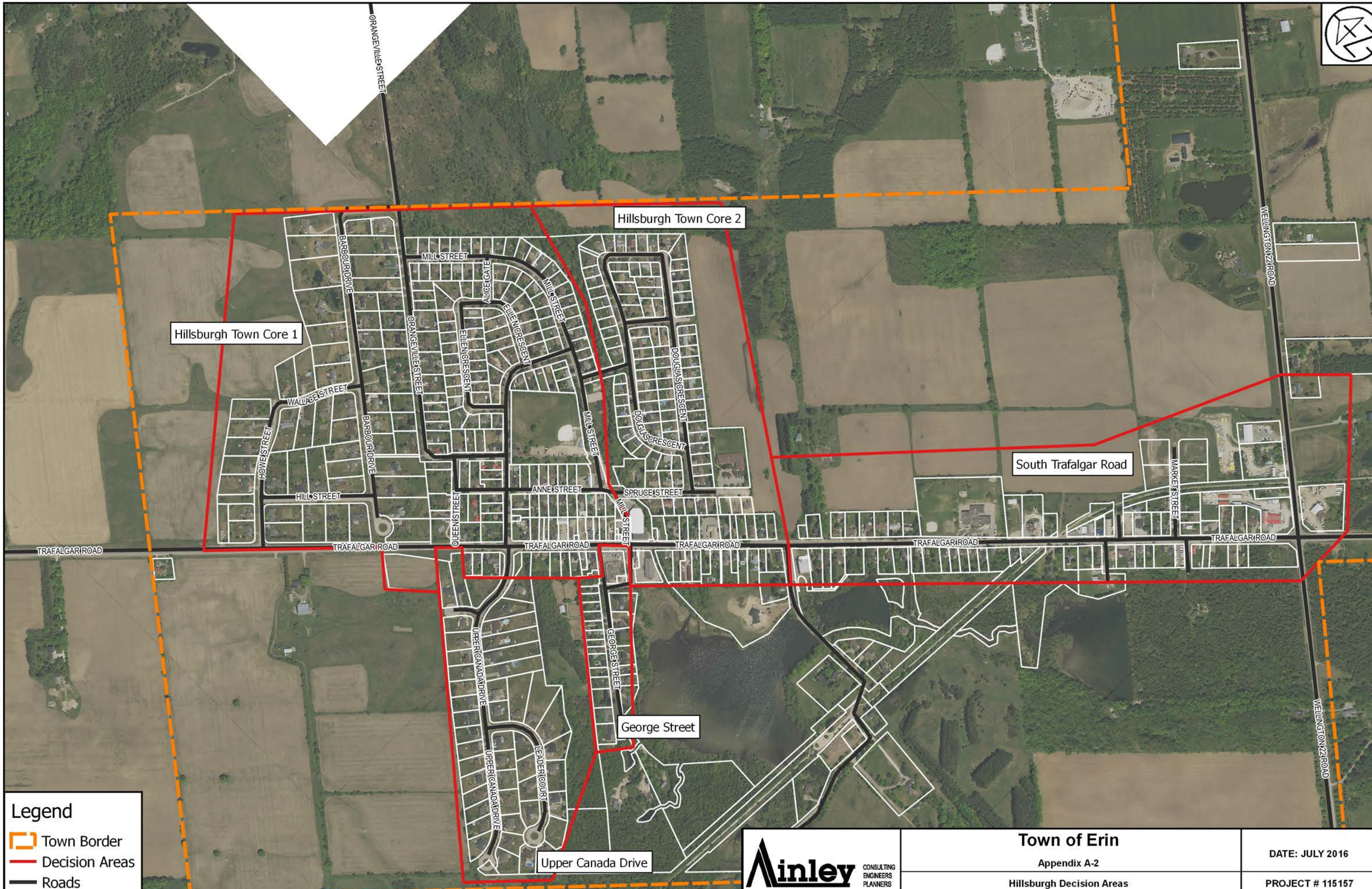
Based on the analysis of the four determining factors it was found that all decision areas in Erin except for Northeast Erin and part of South Erin should be connected to the proposed communal wastewater collection and treatment system, as shown in Appendix D1. In Hillsburgh, all decision areas should be connected except for Upper Canada Drive as shown in Appendix D2. In addition to the four determining factors that were used to decide which areas are to be connected, it should also be recognized that both communities have a high density of septic systems many of which are in close proximity to surface waters.

Appendix - A

Decision Areas

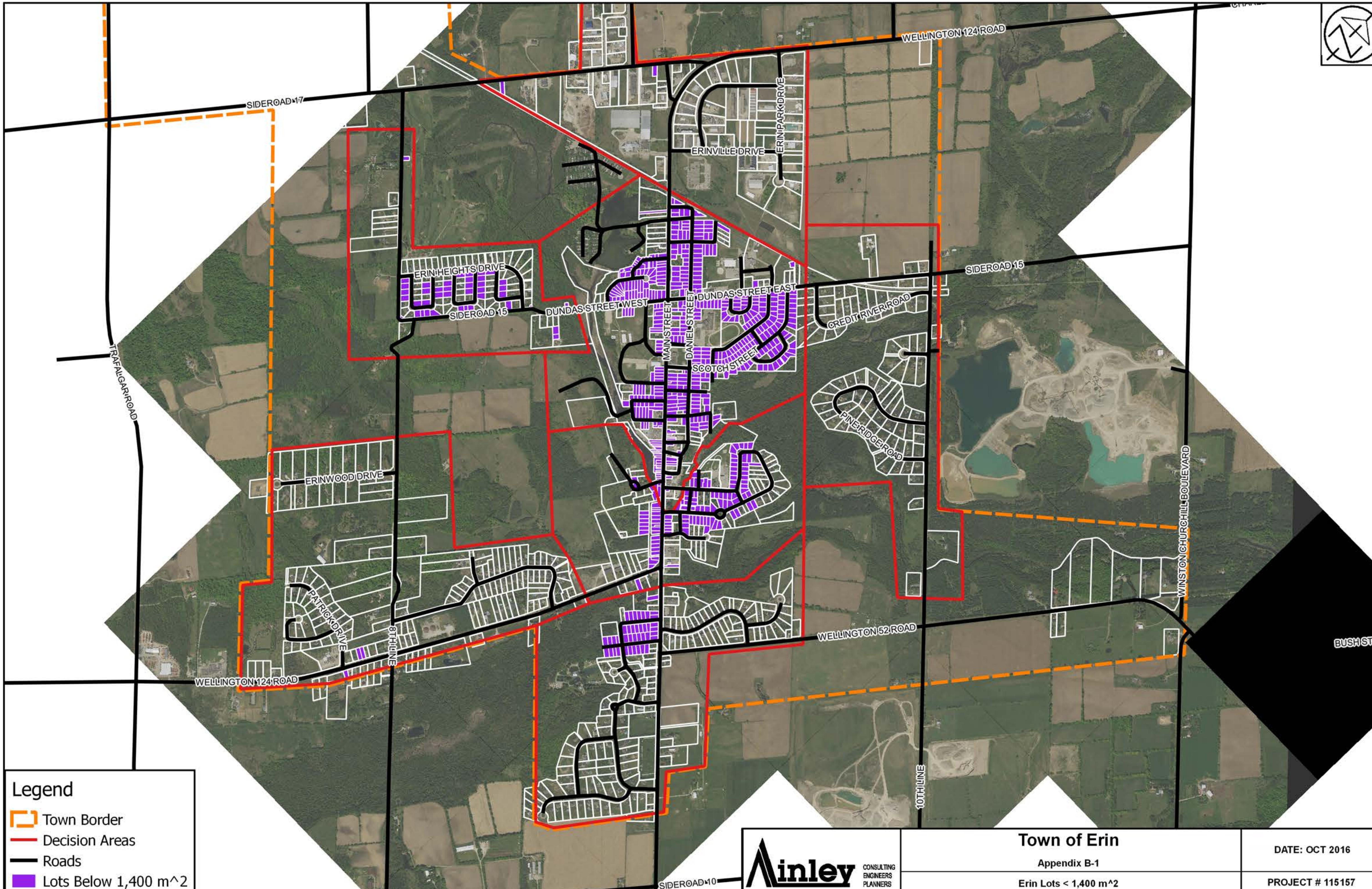


WELLINGTON 124 ROAD
SIDEROAD 17
Erin Industrial
ERINVILLE DRIVE
ERIN PARK DRIVE
Erin Town Core 1
North East Erin
SIDEROAD 15
ERIN HEIGHTS DRIVE
DUNDAS STREET WEST
DUNDAS STREET EAST
SIDEROAD 15
CREDIT RIVER ROAD
Erin Heights
MAIN STREET
DANIEL STREET
SCOTCH STREET
TRAFALGAR ROAD
PINERIDGE ROAD
Erin Town Core 2
ERINWOOD DRIVE
WINSTON CHURCHILL BOULEVARD
South Erin
PATRICK DRIVE
8TH LINE
WELLINGTON 52 ROAD
BUSH STRE
WELLINGTON 124 ROAD
South East Erin
10TH LINE
SIDEROAD 10
Legend
Town Border
Decision Areas
Roads
Ainley CONSULTING ENGINEERS PLANNERS
Town of Erin
Appendix A-1
Erin Decision Areas
DATE: OCT 2016
PROJECT # 115157

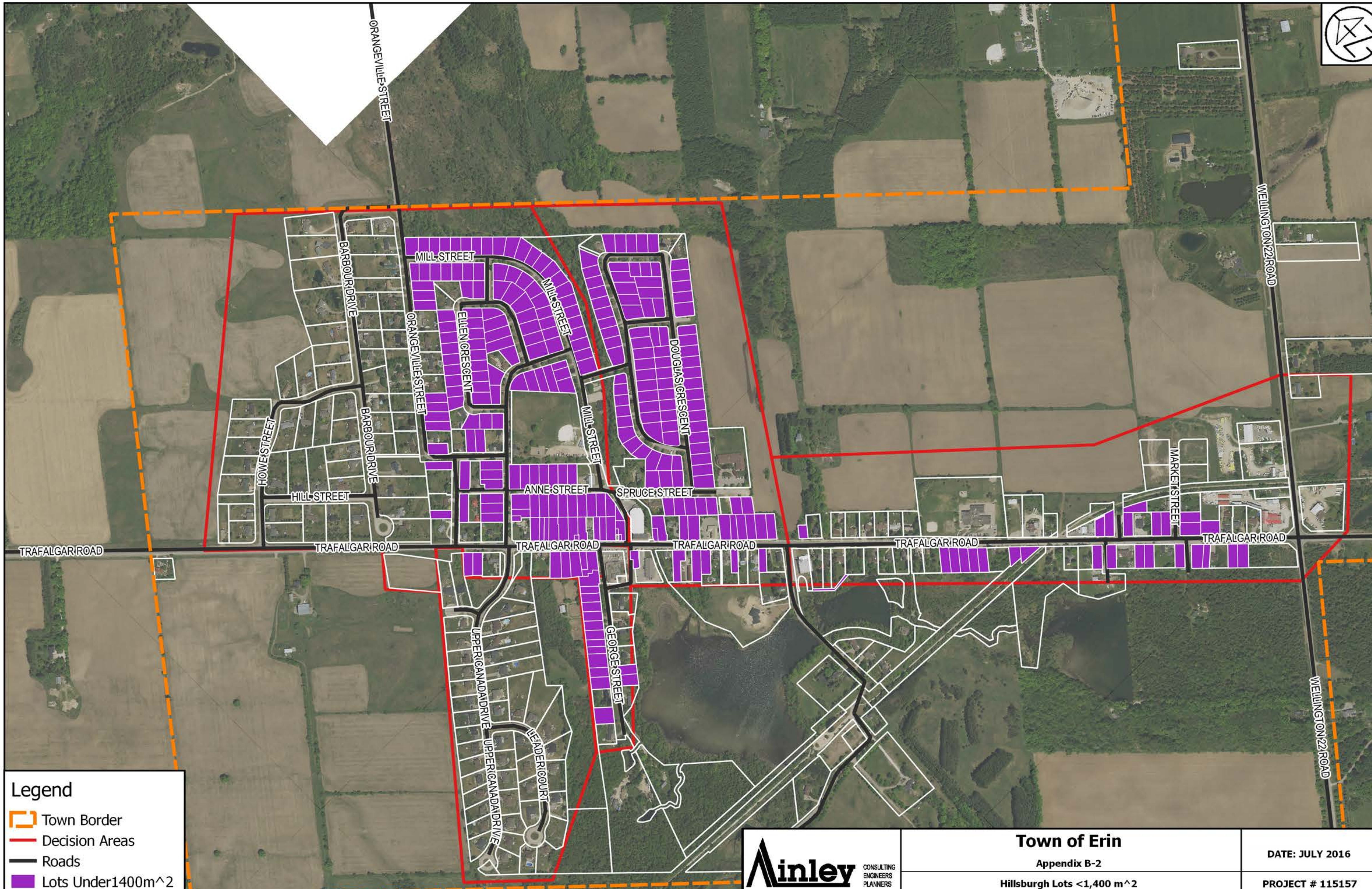

Hillsburgh Town Core 1
Hillsburgh Town Core 2
South Trafalgar Road
George Street
Upper Canada Drive
ORANGEVILLE STREET
MILL STREET
BARBOUR DRIVE
ALICE GATE
ELLEN CRESCENT
DOUGLAS CRESCENT
WALLACE STREET
HOWE STREET
HILL STREET
ANNE STREET
SPRUCE STREET
QUEEN STREET
TRAFALGAR ROAD
MARKET STREET
WELLINGTON 22 ROAD
GEORGE STREET
UPPER CANADA DRIVE
LEADER COURT
Legend
Town Border
Decision Areas
Roads
Ainley
CONSULTING ENGINEERS PLANNERS
Town of Erin
Appendix A-2
Hillsburgh Decision Areas
DATE: JULY 2016
PROJECT # 115157

Appendix - B

Lots Below 1,400m²



Ainley CONSULTING ENGINEERS PLANNERS	Town of Erin	DATE: OCT 2016
	Appendix B-1	
	Erin Lots < 1,400 m^2	PROJECT # 115157



Ainley CONSULTING ENGINEERS PLANNERS

Town of Erin

Appendix B-2

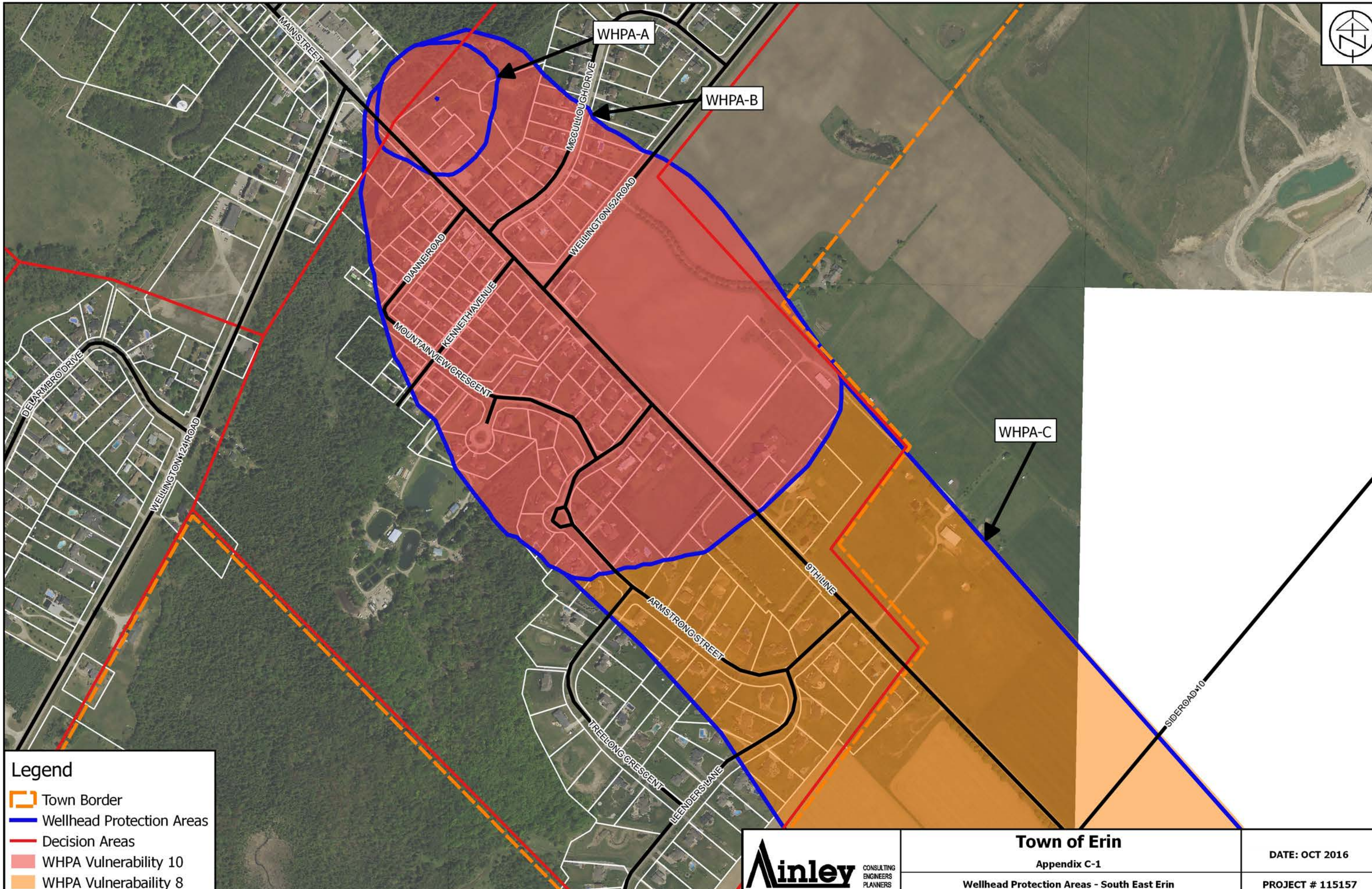
Hillsburgh Lots <1,400 m^2

DATE: JULY 2016

PROJECT # 115157

Appendix - C

Wellhead Protection Areas



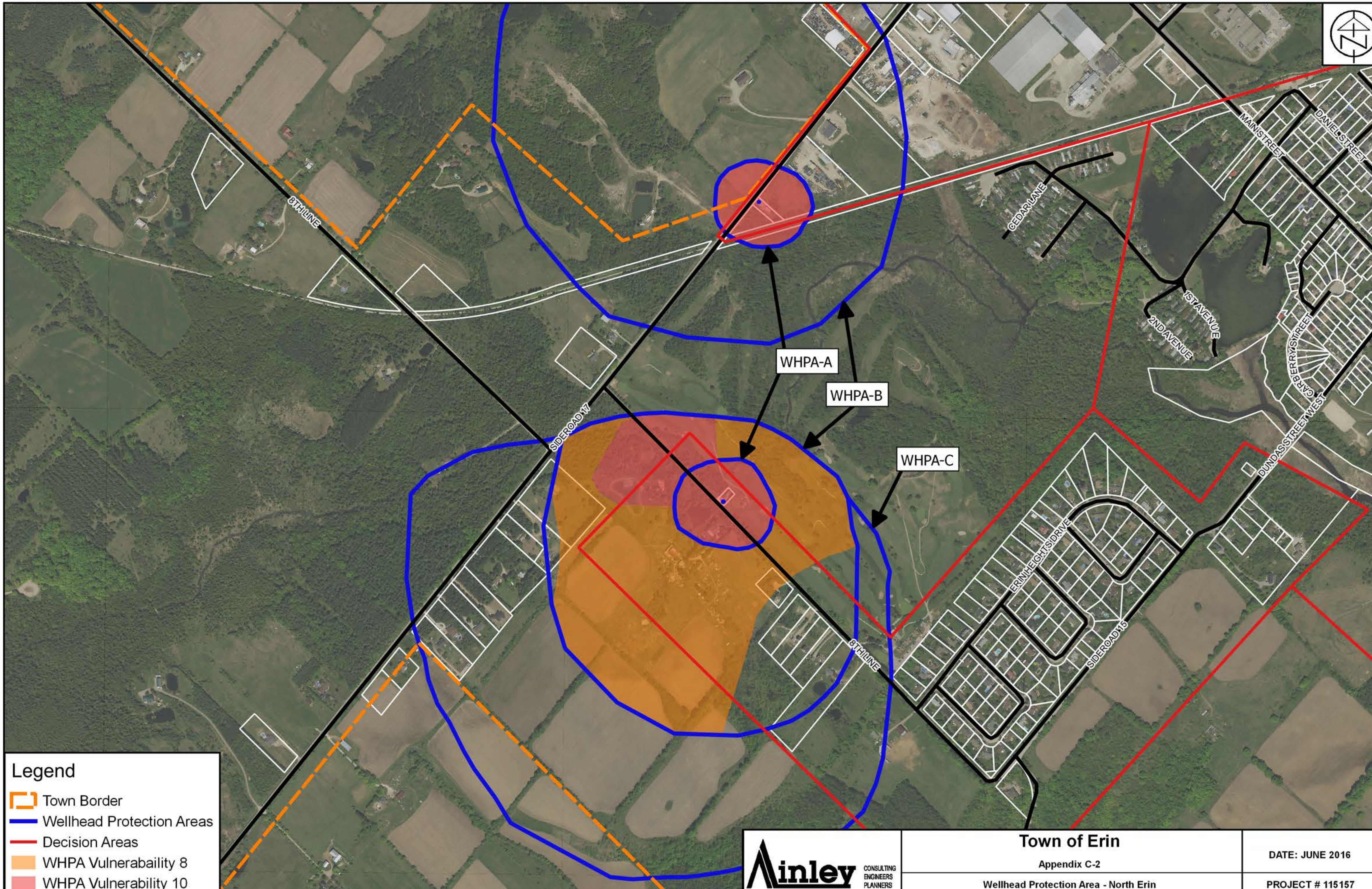
Town of Erin

Appendix C-1

Wellhead Protection Areas - South East Erin

DATE: OCT 2016

PROJECT # 115157



Ainley CONSULTING ENGINEERS PLANNERS

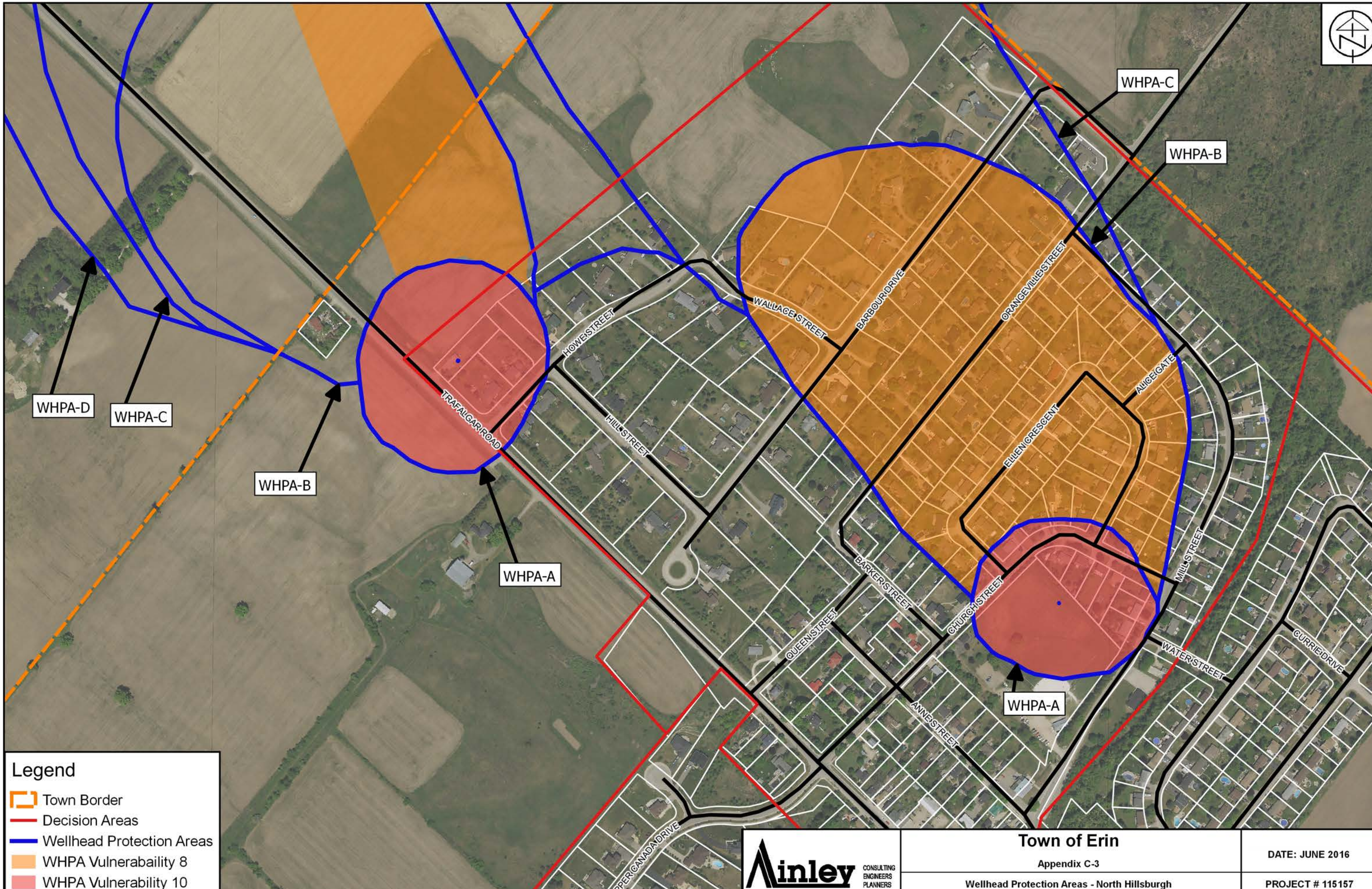
Town of Erin

Appendix C-2

Wellhead Protection Area - North Erin

DATE: JUNE 2016

PROJECT # 115157


WHPA-C
WHPA-B
WHPA-D
WHPA-C
WHPA-B
WHPA-A
WHPA-A
TRAFALGAR ROAD
HOWE STREET
HILL STREET
WALLACE STREET
BARBOUR DRIVE
ORANGEVILLE STREET
ALICE GATE
ELLEN CRESCENT
MILL STREET
CHURCH STREET
BARKER STREET
QUEEN STREET
WATER STREET
CURRIE DRIVE
ANNE STREET
UPPER CANADA DRIVE
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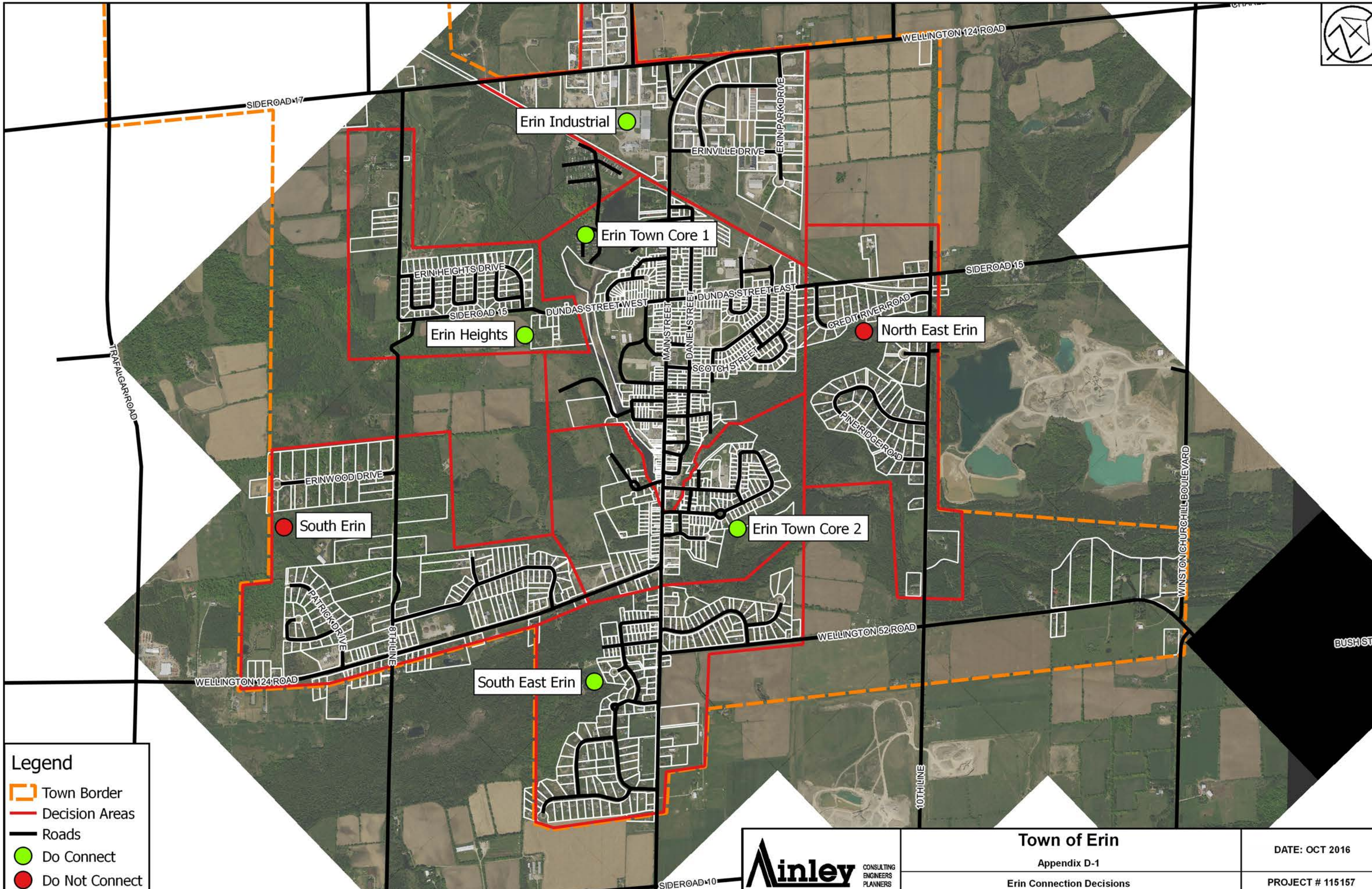
WHPA Vulnerabaility 8
WHPA Vulnerability 10
Ainley CONSULTING ENGINEERS PLANNERS
Town of Erin
Appendix C-3
Wellhead Protection Areas - North Hillsburgh
DATE: JUNE 2016
PROJECT # 115157

Appendix - D

Wastewater Collection Connection Decisions



Ainley CONSULTING ENGINEERS PLANNERS

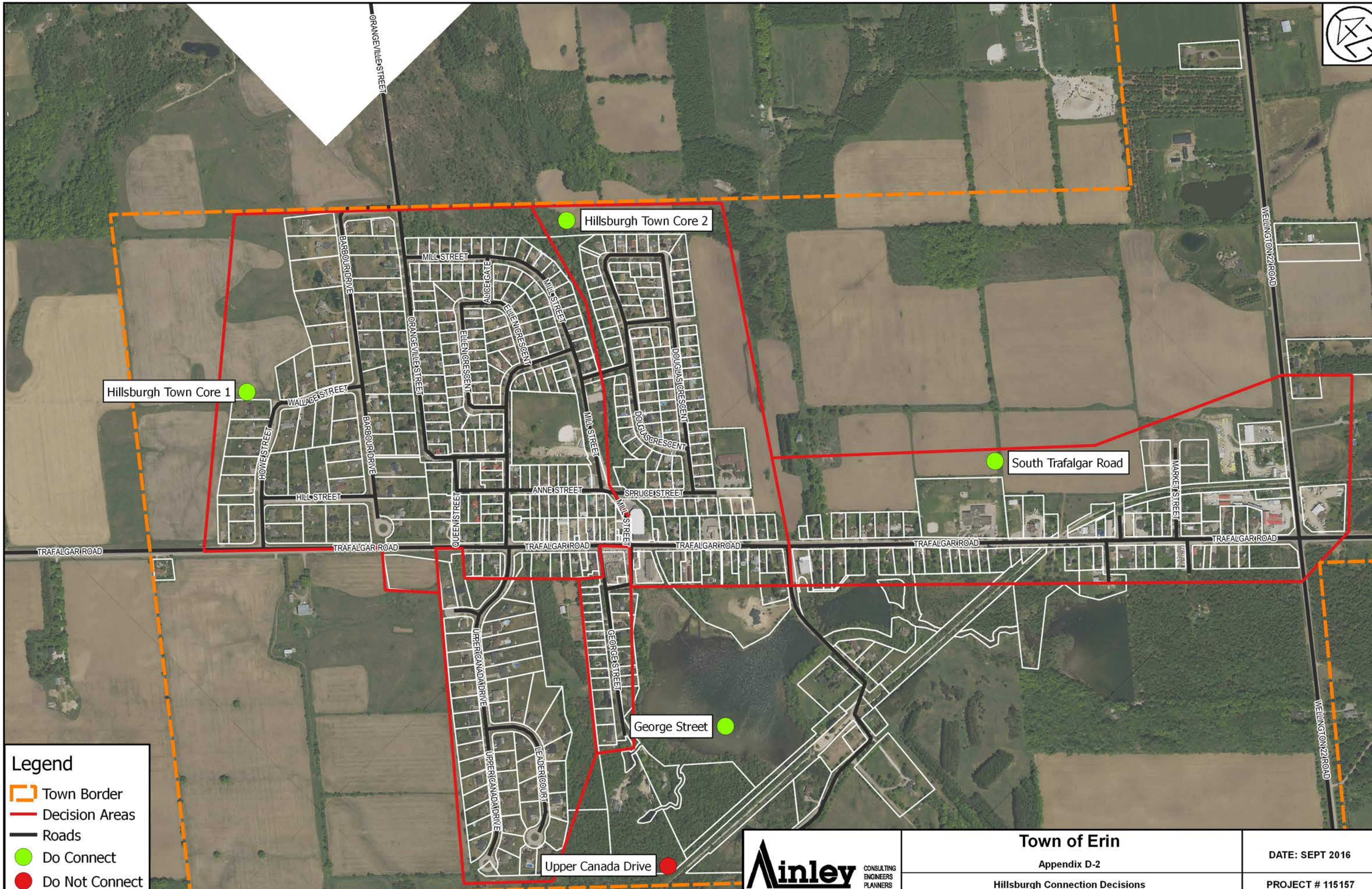
Town of Erin

Appendix D-1

Erin Connection Decisions

DATE: OCT 2016

PROJECT # 115157



Ainley CONSULTING ENGINEERS PLANNERS

Town of Erin

Appendix D-2

Hillsburgh Connection Decisions

DATE: SEPT 2016

PROJECT # 115157

Appendix - C

System Capacity and Sewage Flows

TOWN OF ERIN

Town of Erin

Urban Centre Wastewater Servicing Class Environmental Assessment

Technical Memorandum System Capacity and Sewage Flows *Final*

November 2016

Ainley GROUP
CONSULTING ENGINEERS & PLANNERS

Urban Centre Wastewater Servicing Class Environmental Assessment

Technical Memorandum
System Capacity and Sewage Flows

Project No. 115157

Prepared for:
The Town of Erin

Prepared By:

____
Simon Glass, E.I.T.

Checked by:

____
Gary Scott, M.Sc., P.Eng.

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1.0 Introduction

This Technical Memorandum has been prepared in support of the Town of Erin Urban Centre Wastewater Servicing Environmental Assessment (UCWWS EA). The majority of properties within the Village of Erin and Hillsburgh are currently serviced by individual private septic systems. The Servicing and Settlement Master Plan (SSMP), completed by B.M. Ross in 2014, selected a communal wastewater collection system for both communities as the preferred alternative solution to deal with issues related to the private systems. The SSMP undertook part of Phase 1 and part of Phase 2 of the Class Environmental Assessment process and the Town is now engaged in completing these two phases and moving on to complete Phase 3 and Phase 4 of the Class EA process.

This Technical Memorandum outlines the flow volumes anticipated from each area that has been recommended for connection to the future communal sanitary collection system for the Town. The areas recommended for inclusion or exclusion for the wastewater system are shown in ***Appendix A***. Further, this report will outline the potential discharge volume to the West Credit River on the basis of the revised assimilative capacity report and outlines the amount of growth that the overall system could potentially accommodate.

2.0 Objectives

The objectives of this Technical Memorandum are as follows:

- Identify sanitary sewer flow volumes for each area within the existing urban area of Erin and Hillsburgh.
- Confirm the discharge potential to the West Credit River.
- Establish growth potential for the Town based on the proposed servicing limits for the communal wastewater system.

3.0 SSMP Overview of Flows and Discharge

In 2013, B. M. Ross conducted an Assimilative Capacity Study (ACS) of the West Credit River. The study investigated the impact on the river, as an effluent receiver, under three discharge scenarios: existing population of Erin (3,087 people), existing population of Erin and Hillsburgh (4,481 people), and a Future Population Scenario of 6,000 people. For the purpose of this summary, the impact on the receiver under the “Future Population Scenario” will be discussed.

The report assumed an average water usage rate of 345 litres/capita/day (L/c/d) combined with an inflow and infiltration rate of 90 L/c/d for a total of 435 L/c/d. On the basis of a future population of 6,000 residents the estimated Average Daily Flow (ADF) at 435 L/c/d was therefore 2,610 m^3/d. The ACS reviewed the impact of the discharge on the river at treatment parameter objective concentrations and non-compliance concentrations (summarized in Table 1 below).

Table 1 – SSMP Effluent Parameters

Parameter	Objective	Non-Compliance
TSS (mg/L)	3.0	10
Total Phosphorus (mg/L)	0.1	0.15
Total Ammonia (mg/L)	0.4	2.0
Nitrate-Nitrogen	5	6
TKN (mg/L)	-	3
BOD_5	3.6	7.5

The impact of each parameter on the river was evaluated on a month-by-month basis using monthly 7Q20 flow values developed for the report. Of the parameters considered at the assumed discharge of 2,610 m^3/d, the only concern was a slight exceedance for total nitrate nitrogen compliance limit during the month of February. This assessment was completed on the basis of increasing the phosphorus concentration in the West Credit River up to a limit of 0.03 mg/L corresponding to the Provincial Water Quality Objective (PWQO).

The result of the SSMP was an identified servicing capability of 6,000 persons including the existing population and new growth. While the SSMP identified an existing population of 4,481 persons within the proposed service area, no detailed flow contributions were presented and there was no discussion on “equivalent population” representing flows from institutional, commercial and industrial areas.

3.1 ACS Update Results

As part of this phase of the Class EA process, the Ministry of Environment and Climate Change (MOECC) and the Credit Valley Conservation (CVC) Authority requested updates to the work completed in the SSMP including revisiting the 7Q20 flow values and reevaluating the assimilative capacity of the West Credit River based on updated 7Q20 flows and recommended effluent objective and compliance concentrations of the key effluent parameters. The updated ACS also provides an analysis of all other parameters including dissolved oxygen. The updated ACS is provided as a separate report and the results incorporated into this Technical Memorandum which calculates flow and capacity based on the updated 7Q20 flow.

While the effluent discharge to the West Credit River will be required to meet a full range of compliance limits for various discharge parameters in order to secure MOECC approval, for the purpose of this Technical Memorandum, phosphorus concentration is assumed to be the parameter that limits the amount of treated wastewater effluent that can be discharged to the river. The West Credit River is defined as a Policy 1 stream for management of surface water quality as it has a Total Phosphorus (TP) concentration of between 0.011 – 0.015 mg/L, well below the PWQO of 0.03 mg/L and will have to be managed to remain below the PWQO. While the SSMP assumed a downstream phosphorus concentration of 0.03 mg/L after mixing with the wastewater effluent, discussions with MOECC and CVC throughout the ACS update established that it would be inappropriate to model the wastewater discharge to this limit. Based on this, Hutchinson Environmental Sciences Ltd (HESL) was requested to identify an appropriate downstream phosphorus concentration to ensure that the river remained a Policy 1 receiver while maintaining the appropriate level of water quality. ***Appendix B*** contains HESL's memorandum titled “Recommended Downstream TP Target for West Credit River at Winston Churchill Blvd” which recommends a “Site Specific Target” for Phosphorus downstream of the proposed effluent discharge.

Based on this analysis, it is recommended that a downstream Site Specific Water Quality Objective (SSWQO) of 0.024 mg/L TP be adopted to protect the cold water habitat and water quality in the West Credit River, consistent with Environment Canada and Canada Council of Ministers of the Environment (CCME) guidance. This target aims to maintain the current trophic status of the river. A higher water quality objective is not recommended as the effect of changing the trophic status of the river on brook trout and other aquatic life in the West Credit River is not well understood at this time.

Targeting a fully mixed West Credit River phosphorus concentration of 0.024 mg/L, a range of wastewater effluent scenarios were modeled as outlined in Table 2.

Table 2 – Updated ACS Effluent Discharge Potential (River Concentration 0.024 mg/L)

Effluent Phosphorus Concentration (mg/L)	Discharge Potential (m^3/d)
0.15 mg/L	1,234
0.1 mg/L	2,050
0.07 mg/L	3,380
0.05 mg/L	5,982
0.046 mg/L	7,172

It is noted that the 2,610 m^3/d discharge potential identified in the SSMP associated with a downstream phosphorus concentration of 0.03 mg/L can no longer be achieved at a wastewater effluent concentration of 0.15 mg/L.

4.0 Wastewater Flow Design Basis

4.1 Flows from Existing Developed Communities

In recent years it has been recognized, through changes to the plumbing code and additional efforts to reduce water use; that the wastewater flow rates historically used in Ontario for design of wastewater systems, are high and could result in unnecessary infrastructure spending. More typically, wastewater system capacities are being designed based on lower actual flows. While Erin does not have wastewater flow data available, data for municipal water usage exists and provides a guide for estimating wastewater flow. The current MOECC guidelines for sewage works design suggest a design value of 450 L/c/d for the sizing of wastewater systems. In light of existing water use data, our approach is geared towards optimizing system design by determining a flow estimation value which reflects the actual water use in the existing communities.

The majority of Erin and Hillsburgh planned wastewater service area is presently serviced by municipal water. The water taking records from 2013-2015 were obtained from the Town and the monthly total water demand for this period is summarized in Figure 1. The 3-year average shows the trend of increased water usage during the summer months typically associated with warm weather activities such as lawn/garden watering, car washing, driveway washing, etc. Normally, the increased water usage in the summer is not reflected in increased wastewater flows to municipal systems during that period. Typically a baseline water usage rate exists throughout the year for in-home use including laundry, showers, flushing, dishwashing, etc. and this is reflected in a relatively constant wastewater flow throughout the year.

For Erin, based on the average monthly water usage rates, the baseline overall water usage rate was determined to be 29,500 m^3/month (average of 9 months less June, July, August) which equates to approximately 215 L/c/d considering an existing water service population of approximately 4450 residents. Further, the water taking records reflect the volume of water pumped into the distribution system, not necessarily the volume of water use by residents/businesses/industry in the serviced communities. Typically, water distribution systems have a portion of distributed water unaccounted for through system leaks and operational uses. An efficient system may still have unaccounted for water of up to 10% of distributed water in this manner. Based on this analysis, we can realistically conclude that the Erin per capita wastewater generation rate may be approximately 195 L/c/d. For the purposes of this study it is suggested that a 50% safety factor be used for design over and above this baseflow. It is therefore proposed to use a residential wastewater generation rate of 290 L/c/d. This generation rate is exclusive of flow generated through inflow and infiltration (I&I) sources.

The proposed residential wastewater generation rate is around the mid-range of design standards used by various locations within southern Ontario. Several example locations and their respective rates are outlined in Table 3. Although this will be a completely new wastewater system, the existing residential water use pattern is well established and wastewater flow rates towards the lower end of the range may not be realized. It is therefore prudent to allow for a higher rate of 290 L/c/d.

Table 3 – Sewage Generation Assumptions, Southern Ontario

Design Standard	**Residential Flow Rate**
City of Barrie	225 L/c/d
Region of Halton	275 L/c/d
Region of Peel	303 L/c/d
Region of Waterloo	350 L/c/d
MOECC (design guidelines)	450 L/c/d

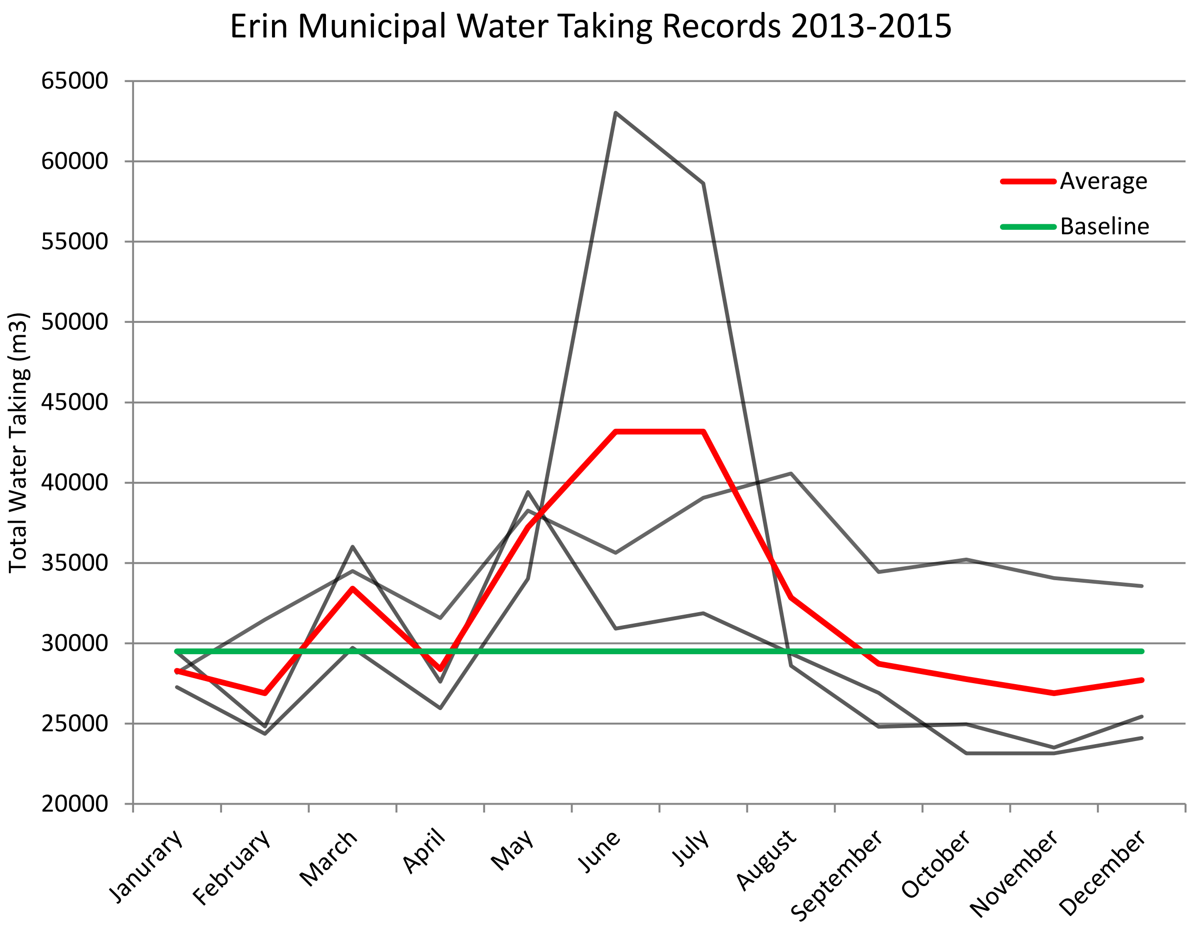


Figure 1 – Erin Municipal Water Taking Records

Table 4 outlines the assumptions used to generate the estimated average daily flow for residential, institutional, commercial and industrial flows as well as inflow and infiltration from the existing properties in Erin.

Table 4 – Flow assumptions for preliminary design

Residential Flow	290 L/c/d
Inflow and Infiltration	90 L/day/capita
School Flow	95 L/student/day
Industrial Flow	9 m^3/ha/d
Commercial Flow	28 m^3/ha/d

The industrial flow assumption has been revised down to 9 m^3/ha/day (from the MOECC standard 28 m^3/ha/day), in light of existing water use data from 2013-2016. This flow allocation is representative of “dry” industries. Future proposals for industrial developments in Erin would likely need to look at the total allocation to industrial/commercial and will also need to look at the nature of the discharge in terms of its effect on treatment and discharge to the West Credit River.

The inflow and infiltration assumption is based on the MOECC design guidelines.

The volume of wastewater generation from the existing developed communities of Erin and Hillsburgh was calculated on an area by area basis using the property database developed for the Septic System Report for those areas recommended to be connected to the communal wastewater system and using the per capita flows established herein. The database includes existing properties serviced by private sewage systems within the communities.

In addition to flows from existing serviced properties, the recommended areas for communal wastewater servicing may also be expected to generate wastewater flows from vacant lots (infill) and from intensification of development on existing serviced lots.

Average daily flows and peak flows were calculated by area. Peak flows were also determined for each community and for both communities combined. Peak flows were calculated using the Harmon Peaking Factor calculation.

4.2 Wastewater Flows from Future Planned Growth Areas

Growth areas are designated in the Town's Official Plan (OP). These areas were confirmed with the County of Wellington and are illustrated in ***Appendix C.*** Also based on discussions with the County of Wellington, the assumed density of residential development is 16 units/ hectare and 2.8 persons per unit. Residential populations are therefore based on this density. Flow contributions from institutional/commercial/industrial growth areas expressed as an equivalent population are determined by calculating the flows based on the flow assumptions in Table 4 and then dividing by the per capita flow contribution of 380 L/C/D. The growth areas considered within the analysis are listed in Table 5 below:

Table 5 – New Growth Areas and Equivalent Population

Identification	Designation	Area (Ha)	Equivalent Population
ER-11	Erin - Residential	14	627
ER-13	Erin - Residential	38	1,702
ER-14	Erin - Residential	18	806
ER-15	Erin - Residential	42	1,882
ER-16	Erin - Residential	3	135
Ind.	Erin - Residential	4.2	188
Ind.	Erin – Industrial	15.3	362
Ind.	Erin – Industrial	15.3	362
Ind.	Erin – Commercial	7.8	575
Erin - Total		157.6	6,639
ER-02	Hillsburgh - Residential	9	403
ER-03	Hillsburgh - Residential	25	1120
ER-04	Hillsburgh - Residential	13	583

ER-05	Hillsburgh - Residential	6	269
ER-06	Hillsburgh - Residential	14	627
ER-07	Hillsburgh - Residential	20	896
ER-45	Hillsburgh - Residential	15	672
Ind.	Hillsburgh – Industrial	7.7	182
Hillsburgh Total		109.7	4,752
Total		267.3	11,391

5.0 Wastewater Flows from Proposed Communal System

5.1 Servicing Existing Developed Communities

The extent of the proposed communal wastewater service area for the existing communities has been identified in the Septic System Survey Technical Memorandum and that technical memorandum includes the rationale for inclusion or exclusion of various sections of the communities on an area by area basis. The results of the study indicate that the entire urban areas of both Erin Village and Hillsburgh should be included in the communal service area except for North East Erin, South Erin, and Upper Canada Drive. The boundaries of the proposed wastewater communal system servicing existing developed communities, are shown in ***Appendix A.*** This Technical Memorandum addresses the flow estimate from only those areas recommended to be in the communal wastewater system.

This section addresses the total wastewater flows from all of the existing developed areas recommended to be serviced by the communal wastewater system. The detailed flow determinations on an area by area basis are shown in ***Appendix D*** for Erin and ***Appendix E*** for Hillsburgh.

In determining wastewater flows from existing developed urban areas it is necessary to determine the flow from existing serviced lots and also to determine the flows from infill development of undeveloped lots. It is also prudent to consider the possibility of intensification as the change from private wastewater systems to communal sewage systems provides the opportunity for properties, especially in downtown core areas, to construct larger commercial properties. For this reason, this Technical Memorandum addresses flows for the proposed existing area in terms of these three components (Existing Lots, Infill Lots and Intensification).

In addition, it is prudent to consider the full build out of existing areas (Existing Lots, Infill Lots and Intensification) when allocating system capacity to the existing communities.

On the basis of the flow assumptions presented in Section 4.0 Wastewater Design Flow Basis, and the detailed area by area flow calculations shown in ***Appendix D*** and ***Appendix E***, the anticipated flow from existing serviced lots in the proposed collection area is presented in Table 6. The ADF flow estimate represents the average daily flow while Peak Day Flow Estimate represents the peak daily flow expected for a gravity system experiencing Inflow and Infiltration. While other collection system alternatives will be considered to eliminate or reduce Inflow and Infiltration, this memorandum considers the worst case in order to establish a minimum potential system capacity.

Table 6 – Sanitary Collection System Flow Estimation – Existing Developed Lots

Location	Equivalent Population[2]	Residential Population	ADF Flow Estimate (m^3/d)	Peak Day Flow Estimate (m^3/d)
Erin	4,852	2,943	1,844	6,006
Hillsburgh	1,513	1,327	575	2,113
Total	6,365	4,270	2,419	7,610[1]

[1] Peak Day Estimates are calculated using the Harmon Peaking Factor and therefore the peak day estimates for each location do not sum to the total.

[2] Equivalent Population (EP) represents Residential Population plus institutional/commercial/industrial wastewater flow sources expressed as the equivalent number of residents, while Residential Population represents the "actual" population exclusive of institutional/commercial/industrial wastewater flows.

It is noted that while the SSMP used an existing population of 4,481, it is not clear whether this represented an equivalent population or simply the existing residential population. None-the-less the estimated equivalent population from the proposed existing communal serviced area is 6,365 which is significantly more than the existing residential population.

It is also noted that the latest available estimated existing residential population of the two urban areas is 4,415 (C N Watson and County Planning). The residential population shown in Table 6 represents the estimated population for the proposed service area while the C N Watson and County Planning estimate is based on the whole urban areas population.

As noted, vacant lots throughout both Erin and Hillsburgh were tallied under the assumption that these lots would be allocated capacity for connection to the proposed sanitary system. The lot tally was conducted using Google Earth images. Vacant lots within industrial areas were assumed to be reserved for industrial development, likewise for residential and commercial areas. The equivalent population and estimated flow rates for the infill lots is presented in Table 7.

Table 7 – Sanitary Collection System Flow Estimation - Infill

Location	Equivalent Population	Residential Population	ADF Flow Estimate (m^3/d)	Peak Day Flow Estimate[1] (m^3/d)
Erin	720	125	273.5	903
Hillsburgh	26	26	10	33
Total	746	151	283.5	935

[1] Peaking Factor assumed to be 3.3 based on the existing population

As the existing communities are on private septic systems it has been difficult for property owners to add to the existing development on their existing lots. There is typically insufficient space to increase the wastewater disposal bed size on most lots. When the communities are serviced with a communal wastewater system, some amount of intensification will likely occur in the core areas where there will be increased opportunity for more commercial activity. For this reason, it is prudent to assume rates of intensification for various areas of Erin and Hillsburgh under the assumption that the communities will further develop on the communal wastewater system. This assumption will help ensure that the design of the proposed system will allow for a moderate amount of intensification to occur without impacting the performance of the system. The equivalent population and estimated flow rates for intensification is presented in Table 8.

Table 8 – Sanitary Collection System Flow Estimation - Intensification

Location	Equivalent Population	Residential Population	ADF Flow Estimate (m^3/d)	Peak Day Flow Estimate (m^3/d)
Erin	333	157	126.6	417.8
Hillsburgh	38	38	14.4	47.5
Total	371	195	141	465.3

[1] Peaking Factor assumed to be 3.3 based on the existing population

Considering the total flow estimate from the existing lots, infill lots and intensification, Table 9 summarizes the total equivalent population and Table 10 summarizes the total estimated wastewater flow needed to service the existing developed areas. It is also noted that the expected residential population for build out of these the existing areas proposed for servicing is 4,616.

Table 9 – Equivalent Population Summary, Servicing Existing Areas

	Existing Equivalent Population	Infill Population	Intensification Population	Total Equivalent Population
Erin	4,852	720	333	5,905
Hillsburgh	1,513	26	38	1,577
Total	6,365	746	371	7,482

Table 10 – ADF Flow Summary, Servicing Existing Areas

	Existing Flow m^3/d	Infill Flow m^3/d	Intensification Flow m^3/d	Total ADF Flow m^3/d
Erin	1,844	273.5	126.6	2,244.1
Hillsburgh	575	10	14.4	599.4
Total	2,419	283.5	141	2,843.5

5.2 Servicing Future Planned Growth Areas

The total potential growth for the communities based on available land designated in the OP as shown in Table 5 is summarized in Table 11. The per capita wastewater flow assumptions outlined in Table 4 were applied to planned growth areas and equivalent populations to establish projected wastewater flows from these areas.

Table 11 – New Growth Areas, Equivalent Population and ADF Estimate

Identification	Designation	Equivalent Population	ADF Estimate (m^3/d)
ER-11	Erin - Residential	627	238.3
ER-13	Erin - Residential	1,702	646.9
ER-14	Erin - Residential	806	306.4
ER-15	Erin - Residential	1,882	715.0
ER-16	Erin - Residential	135	51.1
Ind.	Erin - Residential	188	71.5
Ind.	Erin – Industrial	362	137.7
Ind.	Erin – Industrial	362	137.7
Ind.	Erin - Commercial	575	218.4
Erin - Total		6,639	2,523
ER-02	Hillsburgh - Residential	403	153.2
ER-03	Hillsburgh - Residential	1120	425.6
ER-04	Hillsburgh - Residential	583	221.3
ER-05	Hillsburgh - Residential	269	102.1
ER-06	Hillsburgh - Residential	627	238.3
ER-07	Hillsburgh - Residential	896	340.5
ER-45	Hillsburgh - Residential	672	255.4
Ind.	Hillsburgh – Industrial	182	69.3
Hillsburgh Total		4,752	1805.7
Total		11,391	4,328.7

Table 12 – Sanitary Collection System Flow Estimation – New Growth Areas

Location	Equivalent Population	Residential Population	ADF Flow Estimate (m^3/d)	Peak Day Flow Estimate[1] (m^3/d)
Erin	6,639	5,340	2,523.0	7,316
Hillsburgh	4,752	4,603	1,805.7	5,237
Total	11,391	9,943	4,328.7	12,553

[1] Peaking Factor assumed to be 2.9 based on the total growth population

5.3 Full Build Out Wastewater Flow

Full Build out wastewater flow represents the total estimated wastewater flow that would be generated from the existing developed areas of Erin and Hillsburgh and the total wastewater flow from all planned growth areas identified in the Official Plan. Table 13 shows the full build out flows and Table 14 shows the estimated equivalent population and estimated residential population that would need to be serviced to achieve full build out of the Official Plan. While Equivalent Population includes an allowance for institutional, commercial and industrial flows, the Residential Population represents the actual estimated serviced population. The “Existing Community” in both Table 13 and Table 14 includes infill and intensification.

Table 13 – Full Build Out ADF Flow Summary (m^3/d)

	All Development			Residential Development		
	Erin	Hillsburgh	Total	Erin	Hillsburgh	Total
Existing Community	2,244.1	599.4	2,843.5	1,225.5	528.6	1,754.1
Growth Areas	2,523.0	1,805.7	4,328.7	2,029.2	1,749.1	3,778.3
Total	4,767.1	2,405.1	7,172.2	3,254.7	2,277.7	5,532.4

Table 14 – Full Build Out Population Summary

	Equivalent Population			Residential Population		
	Erin	Hillsburgh	Total	Erin	Hillsburgh	Total
Existing Community	5,905	1,577	7,482	3,225	1,391	4,616
Growth Areas	6,639	4,752	11,391	5,340	4,603	9,943
Total	12,544	6,329	18,873	8,565	5,994	14,559

6.0 Balancing Estimated Wastewater Flows and Effluent Discharge Potential

6.1 Effluent Discharge Scenarios

Using the Updated ACS Effluent Discharge Potential shown in Table 2, the total equivalent population under each phosphorus effluent concentration scenario is outlined in Table 15. The TP effluent discharge concentrations of 0.15 mg/l (used in the SSMP) and 0.10 mg/l have no longer been included because they do not allow the existing community to be serviced.

Equivalent populations are derived from the ADF flows and the per capita flow contribution of 380 L/c/d which is associated with a gravity sewer system and includes an allowance for inflow and infiltration. The residential populations are derived from the previously calculated residential population from the existing areas plus the residential populations from the growth areas at 45 persons per hectare.

Table 15 – Equivalent Population for Discharge Scenario (River Concentration 0.024 mg/L)

Servicing Limits For Flow and TP Discharge Concentration Limits	TP Effluent Discharge Concentration (mg/L)	Equivalent Population Potential	Residential Population	ADF (m^3/d)
Fully Service Existing Community	0.079	7,482	4,616	2,844
Potential Stage 1 Servicing	0.07	8,895	6,029	3,380
Potential Stage 2 Servicing	0.05	15,742	12,876	5,982
Potential Stage 3 Servicing (Full Build Out)	0.046	18,873	14,559	7,172

To service the existing community including infill and intensification would require a wastewater treatment plant to achieve a TP effluent discharge concentration of 0.079 mg/l.

To achieve full build out of the Official Plan (O.P.) including all of the designated growth areas, would require a wastewater treatment plant to achieve a TP effluent discharge concentration of 0.046 mg/l.

The Stage 1, Stage 2 and Stage 3 servicing options are discussed below.

6.2 Treatment Technology Limits for Phosphorus Removal

For the purposes of this Technical Memorandum, it is assumed that meeting the discharge limits for phosphorus into the West Credit River will be the most critical treatment parameter limiting system capacity. As outlined in Section 3 of this Technical Memorandum, it is recommended to adopt a downstream phosphorus concentration of 0.024 mg/l to protect water quality in the river. Phosphorus effluent concentrations from the proposed treatment plant that maintains this downstream level of phosphorus, will therefore dictate the flow that can be discharged and dictate the capacity of the system. Based on this, treatment technologies adopted for phosphorus removal in the treatment plant, will likewise dictate the capacity of the system.

Treatment technologies and overall project phasing will be considered in more detail during Phase 3 and 4 of the Class EA as an implementation plan is developed. Having established the wastewater flows and discharge limits needed to meet full build out of the Official Plan, it is necessary to identify whether it is practical to achieve these limits using available treatment technologies.

Treatment of municipal wastewaters using primary, secondary and tertiary treatment, can reliably achieve an effluent phosphorus concentration below 0.1 mg/l. A range of treatment alternatives including biological phosphorus removal, chemical addition and sand filtration has been used for many decades to achieve this level of removal. In addition to these traditional methods used to remove phosphorus, there are several technologies available that can achieve an effluent concentration below 0.03 mg/l. While at present, 0.03 mg/l may be considered the limit that can reliably be achieved by best available technologies, MOECC appears to have adopted a cautious approach to approval of treatment systems at this limit. While it is considered that the effluent concentration of 0.046 mg/l needed to meet full build out conditions, can be achieved through application of best available technology, it is likely necessary to adopt a staged approach to achieving this limit in order to satisfy MOECC that it can be reliably achieved.

It is therefore suggested that a staged approach could be adopted to achieve full build out condition. This approach would use best available technology combined with a process of treatment plant rerating based on operational results. It should also be noted that, while MOECC issue an approval based on compliance limits, they also set operational objectives to ensure that treatment plants reliably meet their compliance limits. For example, a compliance limit of 0.1 mg/l may also have an objective of 0.08 mg/l that the plant needs to meet.

While phasing will be considered in more detail during Phase 3 and 4 of the Class EA, the following is staging plan is suggested to illustrate the potential for servicing at various Effluent Limits.

6.3 Stage 1 – Effluent Phosphorus Limit 0.07 mg/L

A phosphorus effluent compliance limit of 0.07 mg/L with an operational objective of 0.05 mg/l would provide for the following:

- Equivalent service population limit of 8,895
- Existing lots, infill and intensification can be serviced with 1,413 equivalent population still available for new growth
- Actual residential population could increase to 6,029
- The treatment plant could be operated to demonstrate reliable performance under 0.05 mg/l sufficient to apply for rating to meet Stage 2 limits

6.4 Stage 2 – Effluent Phosphorus Limit 0.05 mg/L

A phosphorus effluent compliance limit of 0.05 mg/L with an operational objective of 0.04 mg/l would provide for the following:

- Equivalent service population limit is 15,742
- Existing lots, infill and intensification can be serviced with 8,260 equivalent population still available for new growth
- Actual residential population could increase to 12,876
- The treatment plant could be operated to demonstrate reliable performance under 0.04 mg/l sufficient to apply for rating to meet full build out limits

6.5 Stage 3 – Effluent Phosphorus Limit 0.046 mg/L

A phosphorus effluent compliance limit of 0.046 mg/L with an operational objective of 0.04 mg/l representative of full build out of the Official Plan, would provide for the following:

- Equivalent service population limit is 18,873
- Existing lots, infill and intensification can be serviced and still allow for 11,391 equivalent population meeting full development of all new growth areas
- Actual residential population could increase to 14,559

7.0 Conclusions and Recommendations

The Servicing and Settlement Master Plan (SSMP) identified an existing communal wastewater serviced population of Erin and Hillsburgh at 4,481 people and a potential future total population of 6,000 based on an estimated wastewater Average Daily Flow (ADF) of 435 L/c/d resulting in a wastewater flow of 2,610 m^3/d discharging to the West Credit River at an effluent phosphorus concentration of 0.15 mg/l to achieve a downstream phosphorus concentration in the West Credit River of 0.03 mg/l corresponding to the Provincial Water Quality Objective for Phosphorus.

The objective of this Technical Memorandum is to:

- More accurately identify predicted wastewater flows from the existing urban areas of Erin and Hillsburgh and from planned growth areas in both of these communities;
- Confirm the discharge potential to the West Credit River based on an updated Assimilative Capacity Study and to confirm the potential to service the urban areas of Erin and Hillsburgh with a communal wastewater system based on the ability to meet discharge limits to the river.

This Technical Memorandum concludes the following:

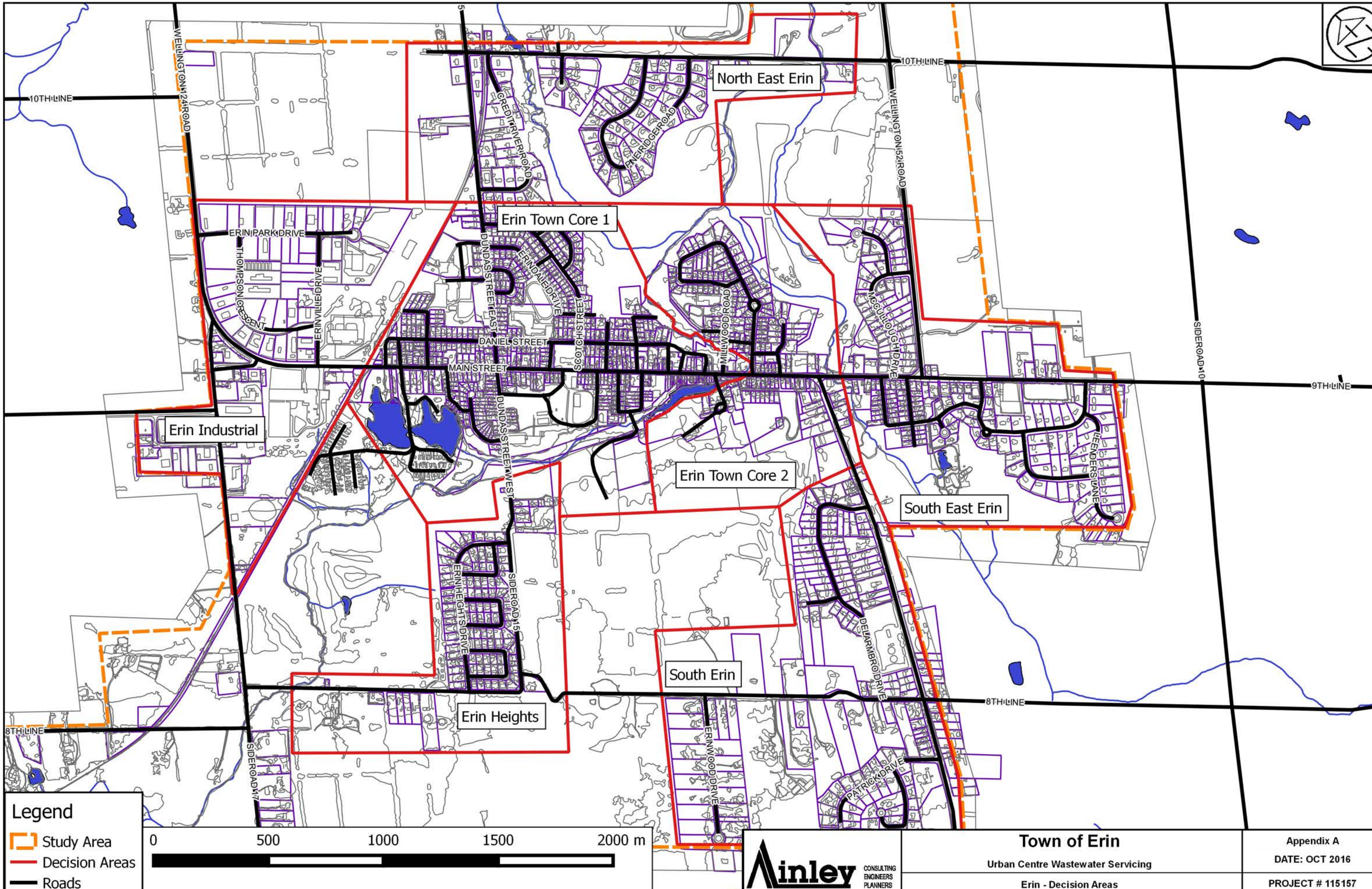
- The SSMP does not represent a realistic wastewater system capacity scenario based on either downstream phosphorus limits in the West Credit River or based on available wastewater treatment technologies for effluent discharge;
- Whereas the SSMP recommended a downstream TP of 0.03 mg/l; a Site Specific Water Quality Objective (SSWQO) of 0.024 mg/l is a more appropriate downstream TP concentration for the West Credit River, in order to protect the cold water habitat and water quality in this Policy 1 receiver;
- To further protect water quality it is recommended that a target of "net zero" increase in phosphorus loading be adopted, such that the cumulative phosphorus loading from municipal wastewater effluent and stormwater runoff must not increase between the pre-development and post-development condition;
- Whereas the SSMP recommended use of an average daily flow of 435 L/c/d; given the level of municipal water consumption in Erin and Hillsburgh, 380 L/c/d is a more appropriate per capita flow contribution for wastewater;
- Whereas the SSMP identified a wastewater flow of 2,610 m3/d to service a population of 6,000; this Technical Memorandum establishes the wastewater flows necessary to service both existing communities and to service all growth areas defined in the Town Official Plan (OP);
- Based on a detailed assessment of the wastewater servicing requirements, the following wastewater flows would result:
  - To fully service Existing Communities with infill growth 2,844 m^3/d
  - To service New Growth Areas Defined in Town Official Plan 4,328 m^3/d
  - Resulting in a total estimated wastewater flow 7,172 m^3/d
- Servicing the existing communities and new growth areas would result in the following residential populations:
  - To fully service Existing Communities with infill growth 4,616 persons
  - To service New Growth Areas Defined in Town Official Plan 9,943 persons
  - Resulting in a total residential population 14,559 persons
- This Technical Memorandum assumes that TP is the limiting parameter for discharge of treated effluent to the West Credit River;
- This Technical Memorandum assumes that the collection system will be a gravity system and makes allowance for inflow and infiltration into the sewers;

- Based on the results of the Assimilative Capacity Study, the following TP effluent Limits would need to be met from a Wastewater Treatment Plant to service the existing communities and new growth:
    - To fully service Existing Communities with infill growth 0.079 mg/l
    - To service Full Build Out of the Town Official Plan 0.046 mg/l
- Treatment technologies will be reviewed and recommended during Phase 3 of this Class EA, however, it is considered that Best Available Technology for phosphorus removal can meet an effluent limit required to achieve full build out of the Town Official Plan;
- It is suggested that the Town of Erin should target a future TP effluent limit of 0.046 mg/l to meet the requirements of full build out of the Town OP;
- It is recognized that additional operating experience with available technologies may need to be demonstrated in order to secure approval from MOECC for an effluent limit of 0.046 mg/l and a staged approach may be necessary in order to achieve this approval in future;
- While it is recommended that a SSWQO of 0.024 mg/l be established to protect water quality in the river, it is recommended that water quality be monitored through phased implementation of wastewater servicing. A relaxation of the SSWQO from 0.024 mg/l to 0.025 mg/l would mean that a treated effluent limit of 0.05 mg/l could achieve full build out of the Town Official Plan;
- While this Technical Memorandum addresses wastewater servicing requirements to meet full build out of the Town OP, it does not address the municipal water requirements to meet full build out of the OP.

Based on the results of this study and the ACS, it is concluded that the Town of Erin can implement a communal wastewater system for the Village of Erin and for Hillsburgh that meets the wastewater servicing requirements of the existing communities including infill and intensification of these areas and can also service all new growth areas identified in the Town Official Plan while protecting water quality in the West Credit River and utilizing “Best Available Technology” for phosphorus removal.

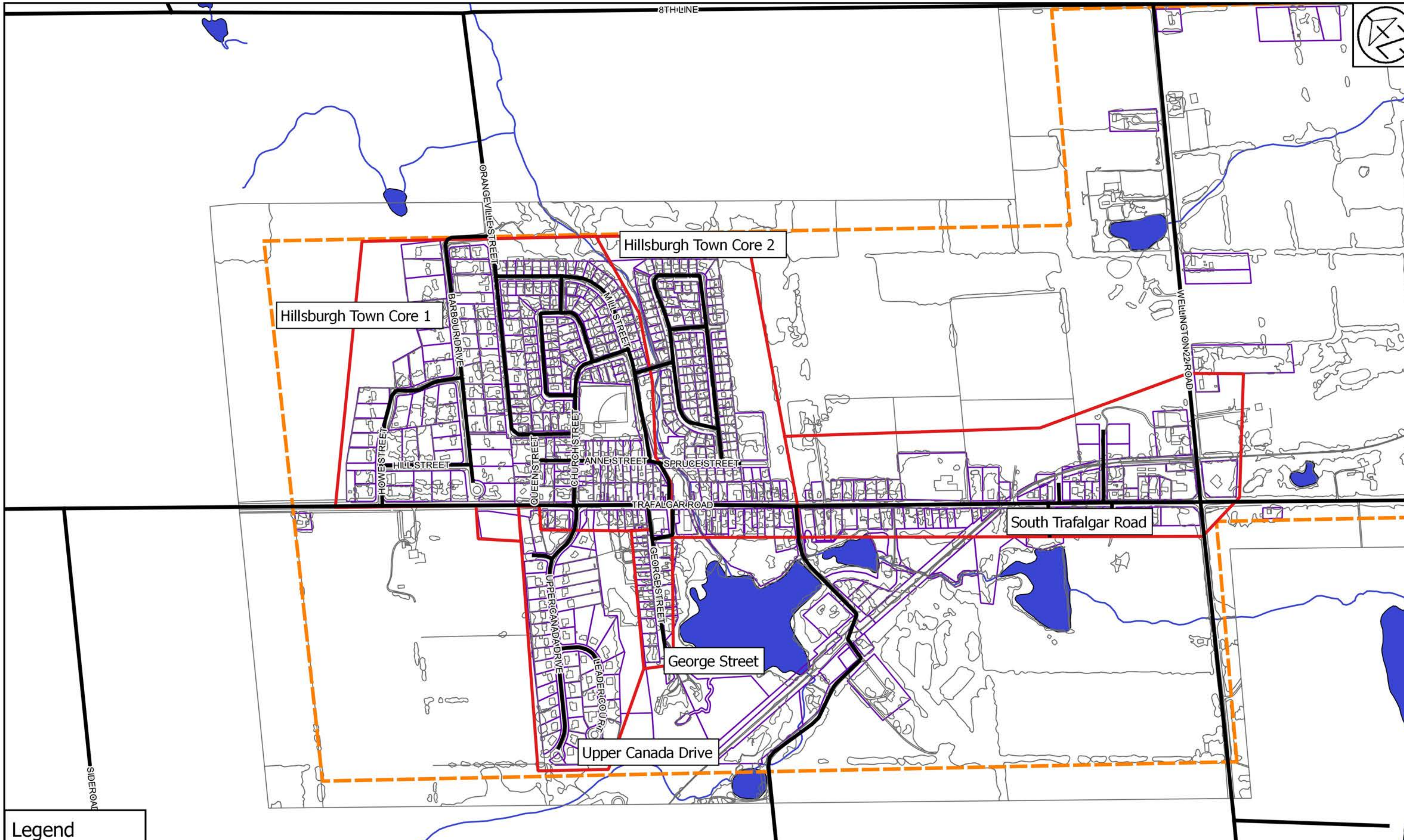
Appendix - A

Decision Areas



Ainley CONSULTING ENGINEERS PLANNERS

Town of Erin	Appendix A
Urban Centre Wastewater Servicing	DATE: OCT 2016
Erin - Decision Areas	PROJECT # 115157



Ainley CONSULTING ENGINEERS PLANNERS

Town of Erin

Urban Centre Wastewater Servicing

Hillsburgh - Decision Areas

Appendix A

DATE: OCT 2016

PROJECT # 115157

Appendix - B

Hutchinson Environmental

Water Quality Memo

Memorandum

Date: **October 20, 2016**

To: **Gary Scott, Ainley Group**

From: **Deborah Sinclair, Neil Hutchinson and Tara Roumeliotis**

Re: **J160005 – Recommended Downstream TP Target for West Credit River at Winston Churchill Blvd.**

The Town of Erin (Town) is currently completing a Schedule C Class EA for a proposed Waste Water Treatment Plant (WWTP) to service the existing population and proposed new growth in Erin and Hillsburgh. The proposed phasing of the plant will eventually accommodate Full Build Out of the Town's official plan with additional capacity for growth. Ainley Group (consultants for the Town) requested that Hutchinson Environmental Sciences Ltd (HESL) recommend a downstream water quality target for Total Phosphorus (TP) for the West Credit River at Winston Churchill Blvd. as input to determining the effluent flow and treatment limits for the proposed WWTP.

The Ontario Ministry of the Environment and Climate Change (MOECC) provides guidance on the management of surface water and groundwater quality and quantity for the Province of Ontario. They have established a Provincial Water Quality Objective (PWQO) of 0.03 mg/L for Ontario rivers and Policy 1 for management of surface water quality which states *"In areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives. Although some lowering of water quality is permissible in these areas, degradation below the Provincial Water Quality Objectives will not be allowed …"*.

This memo provides information and a rationale to support a permissible lowering of water quality in the West Credit River from discharge of treated municipal waste water from the proposed Erin WWTP.

TP Concentrations in West Credit River at 10th Line and Winston Churchill Blvd.

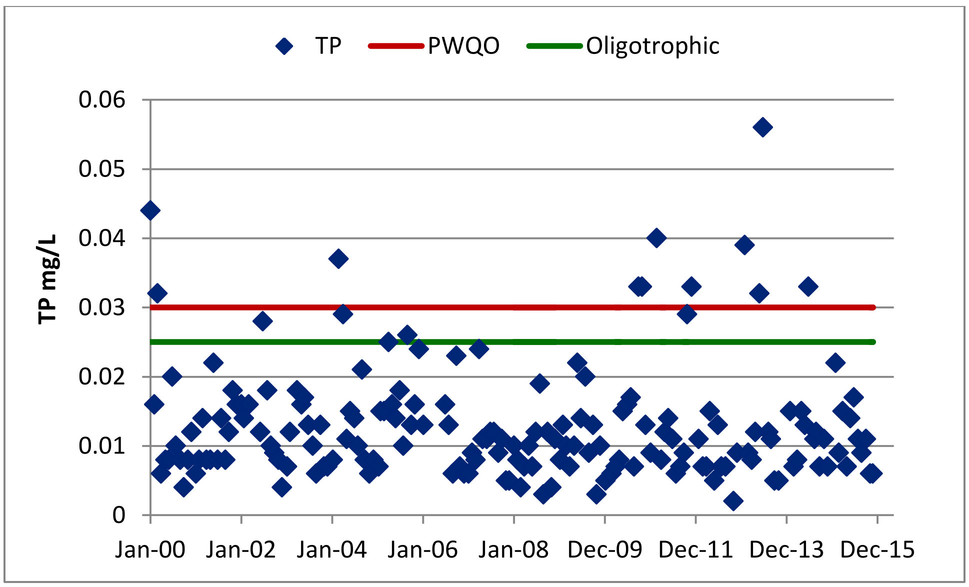
Total phosphorus (TP) concentrations in the West Credit River have been monitored as part of the Ministry of the Environment and Climate Change's (MOECC) Provincial Water Quality Monitoring Network (PWQMN) at Winston Churchill Boulevard since 1975 (station 6007601502). The median (2005 - 2015) and 75th percentile TP concentrations (0.011 mg/L and 0.015 mg/L) are well below the Provincial Water

Quality Objective[1] (PWQO) of 0.03 mg/L. Concentrations are stable; with no apparent increasing or decreasing trend over time (Figure 1).

TP measurements were also collected from the West Credit River upstream of Winston Churchill at 10th Line by Credit Valley Conservation (CVC) in 2007 and 2008 (CVC 2011) and by HESL in 2016 (unpublished data). The median and 75th percentile TP concentrations at 10th Line were also well below the PWQO at 0.014 mg/L and 0.016 mg/L, respectively (based on 15 measurements). The lower TP concentrations, and hence better water quality, at Winston Churchill is due to groundwater discharge to the river between the two stations (CVC 2011).

In 2016, HESL collected chlorophyll "*a*" samples from 10th Line on five occasions. Concentrations ranged from 0.598 µg/L to 3.91 µg/L, with a median of 2.63 µg/L.

Figure 1 Total Phosphorus concentrations measured (2000-2015) in the West Credit River at Winston Churchill Blvd. (PWQMN station 6007601502)



Trophic Status of West Credit River and Implications

Total phosphorus is the key limiting nutrient in plant and algal growth in freshwater systems. Increases in total phosphorus concentrations often results in increased algal biomass (e.g. Dodds et al., 1997). Phosphorus concentrations are therefore commonly used to classify lakes and rivers according to their nutrient ("trophic") status[2] (e.g. oligotrophic, mesotrophic, and eutrophic). Generally oligotrophic systems have low nutrients, low algal biomass, high water clarity, and can support a cold-water fishery. Eutrophic

[1] *The PWQO are numerical and narrative criteria that serve as chemical and physical indicators representing a satisfactory level for surface waters (i.e. lakes and rivers) and where it discharges to the surface, the groundwater of the province of Ontario. The PWQO are set at a level of water quality, which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water (MOEC 1994a).*

[2] *Trophic status – the availability of growth limiting nutrients (Smith et al. 1999) such as total phosphorus or nitrogen.*

systems are nutrient enriched (high nutrient concentrations), have high algal biomass, can have frequent algal blooms, and wide swings in dissolved oxygen (with potential for conditions of no oxygen (anoxia)). Mesotrophic systems have intermediate characteristics (Dodds et al., 1998).

The trophic status classification of the West Credit River between the 10th Line and Winston Churchill Blvd. is oligotrophic using the spot TP data from 10th Line, the long-term PWQMN data and the recent chlorophyll "*a*" data from 10th Line. The oligotrophic classification is based on a trophic status system developed for temperate streams by Dodds et al. (1998; Table 1).

Table 1 Trophic classification boundaries for streams (based on Dodds et al., 1998)

Trophic Level	TP (mg/L)	Suspended Chlorophyll *a* (µg/L)
Oligotrophic	<0.025	<10
Mesotrophic	0.025-0.075	10-30
Eutrophic	>0.075	>30

The West Credit River discharges to the Credit River downstream of Belfountain. The median and 75th percentile (2005-2014) TP concentrations of the Credit River downstream of Belfountain, at Highway 10 (PWQMN station 06007605202) are 0.031 mg/L and 0.052 mg/L respectively; above the PWQO of 0.03 mg/L.

The MOECC provides guidance on the management of surface water and groundwater quality and quantity for the Province of Ontario. In their document: *Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy (MOE 1994a)* two policies relate to the protection of water quality:

> Policy 1 – *In areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives. Although some lowering of water quality is permissible in these areas, degradation below the Provincial Water Quality Objectives will not be allowed …"*
>
> Policy 2 - Water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives.

The West Credit River at Erin is therefore managed under MOECC Policy 1 which allows some degradation of water quality, but flows into the main trunk of the river downstream of Belfountain which is managed under Policy 2 such that no additional degradation is allowed and remediation measures are encouraged. The discharge of effluent from the proposed Erin WWTP must not, therefore, contribute to any additional degradation of the main Credit River downstream.

For the purposes of the Schedule C Class EA, the MOECC stated (Paul Odom, October 3, 2016 Core Management Team Meeting) that the MOECC Policies are guidance statements, and that the Town of Erin may not increase the TP concentration in the West Credit River beyond the PWQO of 0.03 mg/L.

They did note, however, that if the Town of Erin discharge were to increase total phosphorus concentrations in the river to 0.03 mg/L that there would be no remaining assimilation capacity to accommodate other dischargers on this reach of the river or downstream, such as industrial dischargers or other municipalities, or to accommodate stormwater runoff. We note that the MOECC guidance does not encourage dischargers to discharge up to the PWQO, but states "… *some lowering of water quality is permissible in these areas…".* Therefore, MOECC suggested that the study team recommend a downstream objective and rationale for total phosphorus for consideration by MOECC. The downstream objective, because it differs from the MOECC generic PWQO of 0.03 mg/L, would be considered a Site Specific Water Quality Objective (CCME 2003).

The PWQO of 0.03 mg/L represents a two-fold increase over the current 75th percentile TP (0.015 mg/L) concentration and a change in trophic status from oligotrophic to mesotrophic in the West Credit River between 10th Line and Winston Churchill Boulevard. CVC has designated the West Credit River downstream of 10th Line as a cold-water aquatic community due to the presence of brook trout. The most productive brook trout spawning reaches and the best brook trout populations in the West Credit River are located downstream of Erin Village (CVC 2011) and the longest contiguous brook trout habitat in the Credit River watershed is the West Credit River between Erin and Belfountain. The effect of doubling the TP concentration, thus changing the trophic status of the river, on brook trout and other aquatic life in the West Credit River is not well understood but detrimental changes would include increased growth of algae attached to bottom substrate (periphyton) which impairs habitat for fish spawning and benthic invertebrates and increased dissolved oxygen concentrations during the day and decreased concentrations at night in response to increased algal respiration which would stress aquatic life. A cautionary approach to establishing a target downstream TP concentration for the purposes of defining the flow and treatment limits is therefore recommended to protect aquatic life.

The following sections review available guidance to develop a downstream phosphorus objective for the West Credit River that will protect the cold water fishery. We then recommend an effluent TP limit that will meet the objective in the river at the projected effluent flows.

Environment Canada Framework for Managing Phosphorus

Environment Canada (2004) has developed a guidance framework for managing phosphorus concentrations in fresh water systems that is consistent with Canada Council of Ministers of the Environment (CCME) guideline development principles, but permits site-specific management of phosphorus. It was published as part of their *Ecosystem Health: Science-based Solutions* series which is dedicated to the dissemination of information and tools for monitoring, assessing and reporting on ecosystem health to support Canadians in making sound decisions (Environment Canada 2004). The guidance recommends a trigger approach to setting and establishing thresholds for TP concentrations. The framework steps include:

- Set ecosystem goals and objectives (enhance, protect, or restore)
- Define reference/baseline conditions
- Select trigger ranges
- Determine current TP concentrations
- Compare current concentrations and concentrations predicted from an undertaking to the trigger range

- Compare current concentrations and concentrations predicted from an undertaking to the baseline

In this case, the goal is to protect the sensitive brook trout population and maintain a healthy diverse aquatic system, while servicing existing development in Erin Village and Hillsburgh and allowing for new growth in the Town. The reference/baseline conditions in the river are well understood, and in this case represent the current concentrations of total phosphorus, which have not shown any increasing/decreasing trend in the last 15 years.

The Canadian Council of Ministers of the Environment (CCME 2003, p.15) provides the following guidance on setting Site Specific Water Quality Objectives (SSWQOs):

> *Two distinct strategies are commonly used to establish WQOs in Canada, including the antidegradation strategy and the use protection strategy. For water bodies with aquatic resources of national or regional significance, the WQOs are established to avoid degradation of existing water quality. For other water bodies, the WQOs are established to protect the designated uses of the aquatic ecosystem. As long as the designated water uses are protected, some degradation of existing water quality may be acceptable in these water bodies, provided that all reasonable and preventative measures are taken to protect water quality conditions.*

The brook trout population in the West Credit River is of regional significance and the West Credit River is the only portion of the Credit River sustaining Policy 1 oligotrophic waters. Therefore the Site Specific Water Quality Objective should be focused on "antidegradation" to maintain the oligotrophic status of the river.

CCME (2003) identifies four methods for developing a SSWQO; the background concentration procedure, recalculation procedure, water effect ratio procedure, and the resident species procedure. The "background concentration procedure" is appropriate for the West Credit River. *"In the background concentration procedure, the natural background concentrations of a contaminant in water …are determined and these levels are used to define acceptable water quality conditions at the site under consideration. Its use is based on the premise that surface water systems with superior water quality (i.e., relative to the Canadian WQGs) should not be degraded. This approach has been used most commonly to define WQOs for relatively pristine water bodies, including several river systems in Canada (e.g., Dunn 1989; MacDonald and Smith 1990). It has also been used in somewhat contaminated water bodies, such as Burrard Inlet (Nijman and Swain 1989)."* (CCME 2003, p. 19). We used three approaches to define the background concentration and resultant SSWQO for the West Credit River.

Although the natural background concentrations of total phosphorus in the West Credit River are not known, current concentrations are low and exceptional for Southern Ontario and are a reasonable approximation of natural background levels. The background concentration procedure uses the upper limit of the natural background concentration of a contaminant to define acceptable water quality conditions (CCME 2003). In this case the "natural" background concentration is the current stable TP concentration of the receiver, prior to the input from the WWTP. The two examples provided to determine the upper limit are the mean concentration plus two standard deviations and the 90th percentile concentration. For the West Credit River at Winston Churchill Blvd. these values are 0.030 mg/L (mean = 0.012 mg/L, standard deviation = 0.009 mg/L) and 0.024 mg/L respectively. Since the data are highly variable (2 x standard deviation is greater than the mean) this approach is not protective of water quality.

Using the 90th percentile approach to establish the upper limit of the background concentration of 0.024 mg/L is recommended, and recognizes the oligotrophic nature of the receiver.

Therefore, use of the background concentration procedure for derivation of the SSWQO will define the natural background concentration of the West Credit River as the 75th percentile total phosphorus concentration (=0.016 mg/L) with the upper limit defined by the 90th percentile concentration of 0.024 mg/L.

A trigger range is defined as a "desired concentration range for phosphorus; if the upper limit of the range is exceeded, that indicates ***a potential*** environmental problem, and therefore **"triggers" further investigation**. The internationally-accepted Organization for Economic Co-operation and Development (OECD) trophic status values are the recommended trigger ranges (Table 2) for Canadian lakes and rivers (CCME 2004). These trophic values were originally established for lakes and reservoirs (Environment Canada 2004), which is why they differ slightly than those presented in Table 1. Rivers can, however, sustain higher loads of TP than lakes before any observable changes in community composition and biomass (Smith et al. 1999): TP is flushed through the system before it can be taken up and utilized by aquatic plants. Therefore, the United States Environmental Protection Agency (USEPA) has adopted trophic classification for rivers based on the Dodds et al. values (Table 1), which are higher than the OECD values.

Table 2 Recommended trigger ranges for Canadian Lakes and Rivers (CCME 2004)

Trophic Status	TP concentration (µg/L)
Ultra-oligotrophic	< 4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hyper-eutrophic	>100

We recommend using the Dodds et al (1998) trigger ranges as they have specifically been established for rivers in temperate sites. The oligotrophic trophic range is <0.025 mg/L TP (Table 1); therefore a downstream concentration over 0.024 mg/L TP would indicate a potential shift to mesotrophic classification and trigger further investigation.

In addition to the trigger ranges, the Environment Canada guidance also recommends comparing predicted concentrations to baseline conditions, and notes that *"up to a 50% increase in phosphorus concentrations above the baseline level is deemed acceptable"…"If a 50% increase from baseline is not observed, then there is considered a low risk of adverse effects….if the increase is greater than 50%, the risk of observable effects is considered to be high and further assessment is recommended*" (Environment Canada 2004). We established a natural background 75th percentile concentration of 0.016 mg/L in the West Credit River at Erin. A 50% increase above this results in a trigger concentration of 0.024 mg/L.

Use of the Environment Canada guidance of a 50% increase above background supports a total phosphorus concentration of 0.024 mg/L as an upper range to protect the oligotrophic waters of the West Credit River.

We therefore recommend a value of 0.024 mg/L as the SSWQO for total phosphorus in the West Credit River.

Conclusions and Recommendations

We therefore recommend that a downstream SSWQO of 0.024 mg/L TP be adopted to protect the cold water habitat and water quality in the West Credit River, consistent with Environment Canada and CCME guidance. This will maintain the current trophic status of the river. A higher water quality objective is not recommended as the effect of changing the trophic status of the river on brook trout and other aquatic life in the West Credit River is not well understood at this time.

Water quality objectives are developed as guidelines and not as enforced regulatory standards. They are conservative, in that the best scientific information concludes that aquatic life will be protected at concentrations below the objective but this does not mean that the ecosystem will necessarily be impaired if concentrations increase above the objective. Therefore, Environment Canada (2004) states that, if total phosphorus concentrations increase to the SSWQO, the management response is investigation to determine if the changes have been harmful or if further increases can be sustained. This provides the opportunity for adaptive management of discharge from the proposed WWTP at Erin.

During Phase 1 of the WWTP, we recommend that the Town implement a receiver monitoring program for the West Credit River to determine the resultant phosphorus concentration in the river and assess any effects of increased TP loadings on water quality and aquatic communities (e.g. algal, benthos and fish). Effluent monitoring is also required to confirm that the lower effluent limits and objectives required to accommodate future growth can be met. The findings from these monitoring studies can:

a) inform a future application to rerate the Erin WWTP to accommodate a higher wastewater flow at a lower effluent TP concentration if monitoring shows that the plant can be operated at a lower effluent limit,

b) inform a decision to maintain the downstream West Credit River TP objective at 0.024 mg/L at Full Build Out or if it can be relaxed to 0.027 mg/L with no threat to aquatic life to accomodate either a higher population or a higher effluent limit.

Phosphorus Control for New Development

Wastewater discharge will not be the only source of total phosphorus to the West Credit River as the Town of Erin is serviced and grows. New development, infill and intensification of development will increase impervious services in Erin and Hillsburgh, leading to increased runoff of stormwater which will contain phosphorus and other pollutants. Growing recognition of non-point source pollution by urban runoff has lead to increased demands for management of stormwater quality, as well as quantity. New development in the Lake Simcoe and Nottawasaga River watersheds and in the City of Oakville, for example, must set a target of “net zero” increase in phosphorus loading, such that the cumulative phosphorus loading from municipal wastewater effluent and stormwater runoff must not increase between the pre-development and post-development condition. Jennifer Dougherty, of Credit Valley Conservation stated that this was typically required for cases where the receiving waters were Policy 2 but that this would not be required for Erin[3]. Nevertheless, the sensitivity of the West Credit River at Erin may stimulate requests for phosphorus abatement from stormwater as Erin and Hillsburgh are built out.

Decommissioning of septic systems upon completion of the Erin WWTP will reduce one source of phosphorus (and nitrate) loading to the watershed. Development and redevelopment can reduce phosphorus loading in storm water through implementation of improved stormwater management (Best Management Practices) for older areas and Low Impact Development Techniques, particularly infiltration of runoff for new development. Infiltration techniques reduce surface runoff volume, remove particulates and suspended solids from runoff (including particulate phosphorus), encourage adsorption of phosphorus onto mineral surfaces in soils and cool the runoff, all of which will protect the cold water habitat in the West Credit River and help offset the discharge form the new WWTP.

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[3] *October 3, 2016 Core Management Team Meeting)*

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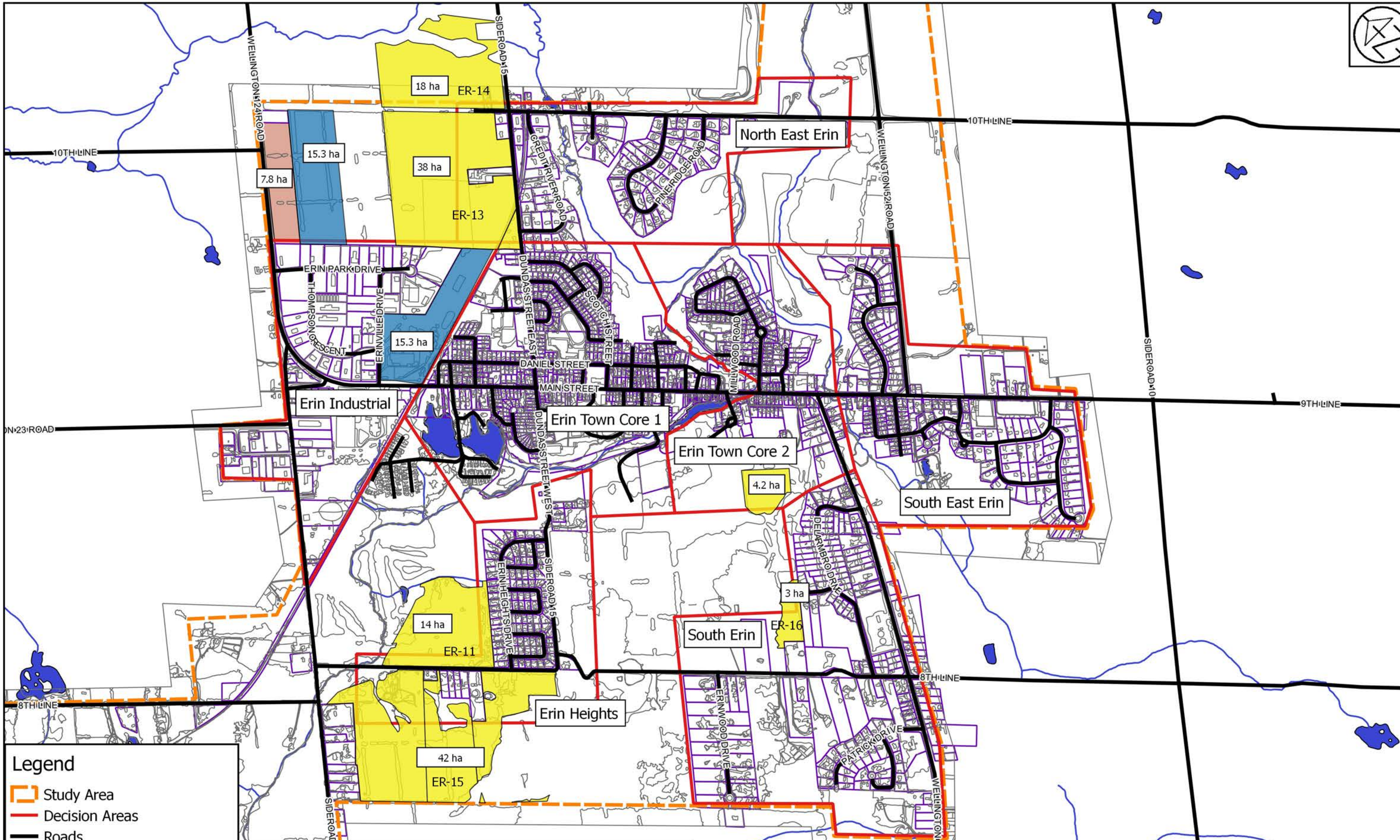
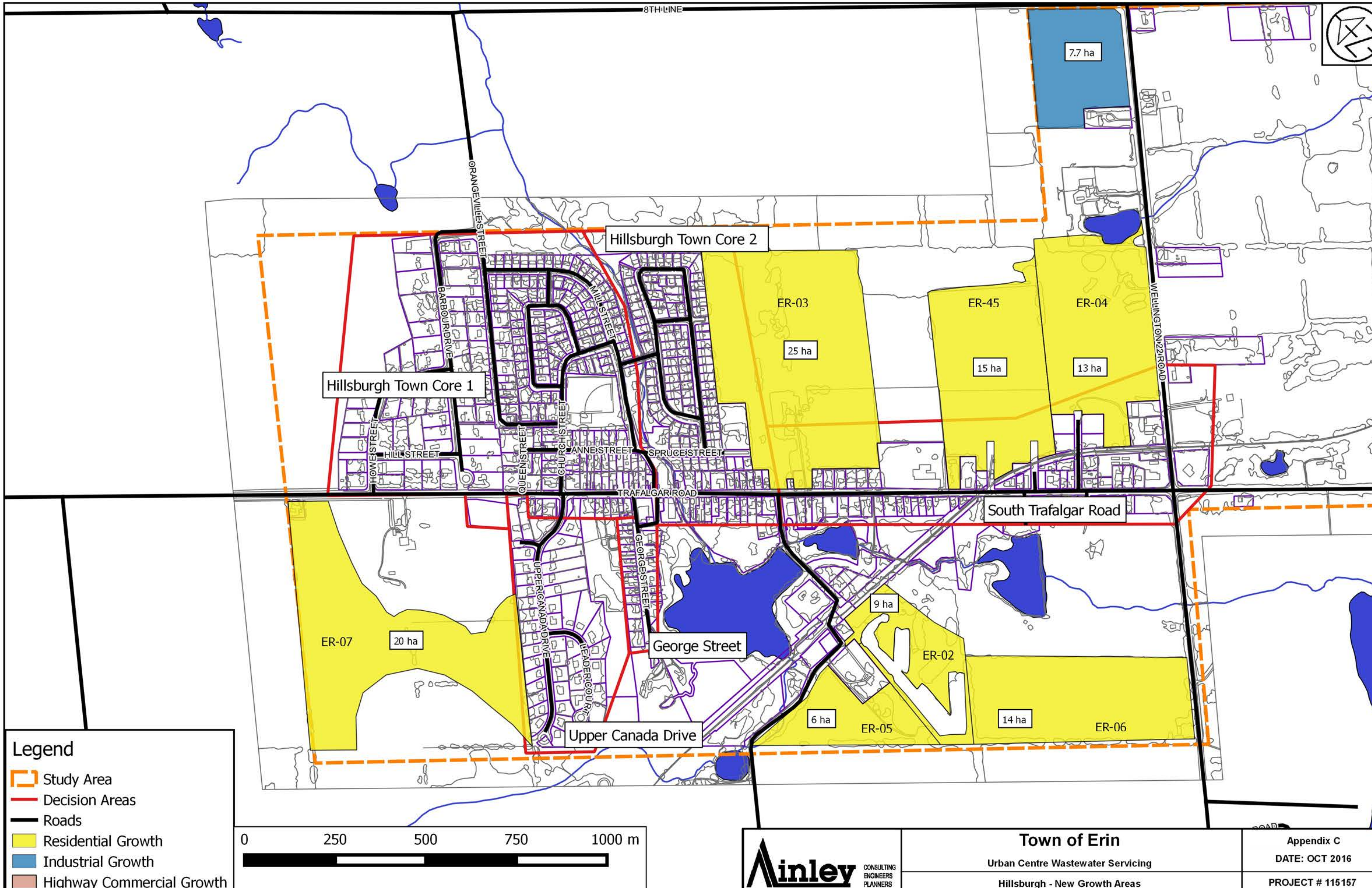
Appendix - C

New Growth Areas



Ainley CONSULTING ENGINEERS PLANNERS

Town of Erin	Appendix C
Urban Centre Wastewater Servicing	DATE: OCT 2016
Erin - New Growth Areas	PROJECT # 115157



8TH LINE
7.7 ha
Hillsburgh Town Core 2
Hillsburgh Town Core 1
ORANGEVILLE STREET
BARBOUR DRIVE
MILL STREET
HOWE STREET
HILL STREET
QUEEN STREET
CHURCH STREET
ANNE STREET
SPRUCE STREET
TRAFALGAR ROAD
WELLINGTON 22 ROAD
ER-03
25 ha
ER-45
15 ha
ER-04
13 ha
South Trafalgar Road
GEORGE STREET
UPPER CANADA DRIVE
LEADER COURT
ER-07
20 ha
George Street
Upper Canada Drive
9 ha
ER-02
6 ha
ER-05
14 ha
ER-06
Legend
Study Area
Decision Areas
Roads
Residential Growth
Industrial Growth
Highway Commercial Growth
0
250
500
750
1000 m
Ainley
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Appendix - D

Erin Wastewater Flow Detail

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1.0 Erin Wastewater Flow by Area

1.1 Industrial Area

The industrial area in Erin is located at the north end of the town and consists of 87 individual lots primarily located along Thompson Crescent, Erinville Drive, Erin Park Drive, and Pioneer Drive. Based on the Town's GIS database, the total combined area of the industrial lots is approximately 72.4 Ha. The current MOECC design standard for sewage flow estimation of industrial areas is 28 m^3/Ha•d. Using the MOECC standard, an estimated 2,026 m^3/d of average day sewage flow would be generated from this area at full buildout. At this time, a number of lots remain vacant and the estimated flow from the established industry is 1,297 m^3/d, shown in Table D1.

Table D1 - Industrial Area Flow Summary, Pre-modification

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Industrial	52	47.0	1,297	3,891

Existing water use data from June 2013 to June 2016 was reviewed for the industrial area. Assuming the maximum yearly consumption of each site, the existing industry uses approximately 84 m^3/d suggesting that the design estimations are much too high and are resulting in an over estimation of actual flows. The *maximum* flow from an industrial property in Erin over the time reviewed was 19.4 m^3/d, in contrast the *average* flow estimate based on MOECC guidelines is 19.5 m^3/d. While the estimates may be excessive for the current use of the area, it is possible that establishing a sanitary network in the town may attract more water intensive industries or will change the habits of the existing users. It is suggested that a compromise between the existing data and design projections be met, the result is shown in Table D2.

In addition to the established industry, a significant amount of land in this area has been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table D2 - Industrial Area Flow Summary, Post-modification

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Industrial – Current Day	52	37.0	334	1,002
Industrial – Infill	35	25.2	227	681
Industrial – Intensification (20%)	-	-	67	201
Industrial – New Growth Areas	-	30.6	275.4	826.2
Commercial – New Growth Areas	-	7.8	215.0	655.2
Residential – New Growth Areas	608	38	647	1,941
Total	995	138.6	1,765.4	5,306.4

1.2 Erin Town Core 1

The area designated as Erin Town Core 1 comprises the majority of the village and is primarily residential and downtown commercial development. The area is bounded at the north end by Elora Cataract Trail and on the south end by the West Credit River. The area has 518 individual lots, including 2 schools, and 32 commercial properties. Based on the Town's GIS database the combined area of the commercial properties is approximately 2.5 Ha. The current MOECC design standard for sewage flow estimation of commercial areas is 28 m^3/Ha•d. Using the MOECC standard, an estimated 70 m^3/d of average day sewage flow would be generated from the commercial portion of this area. For schools, an assumed flow rate of 95 L/student/day is taken. The two schools within this area have a total of 950 students combining for an estimated flow of 90.2 m^3/day. The remaining lots (residential units) combine for an average day flow of 478.1 m^3/d, shown in Table D3.

In addition to the established development, a few hectares of land in this area have been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh. As communities grow it is typical for some amount of intensification to occur in the core areas, for this reason we have assumed a 10% allowance for intensification.

Table D3 – Erin Town Core 1, Flow Summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Residential	484	60.3	478.1	1,769
Commercial	32	2.5	69.0	324.7
Institutional	2	7.7	90.2	333.7
Residential – Infill	30	-	29.6	110.0
Residential – Intensification (10%)	52[1]	-	51.8	191.7
Total	669	71.5	718.7	2,756.1

[1] Equivalent lots.

1.3 Erin Town Core 2

The area designated as Erin Town Core 2 is at the south end of the town and primarily consists of residential development. The area is bounded at the north end the West Credit River and on the south end by Wellington 124 Rd. The area has 161 individual lots, including 3 commercial properties and 1 school. Based on the Town's GIS database the combined area of the commercial properties is approximately 0.95 Ha. Using the MOECC standard, an estimated 26.6 m^3/d of average day sewage flow would be generated from the commercial portion of this area. For schools, an assumed flow rate of 95 L/student/day is taken. The school within this area has 220 students combining for an estimated flow of 20.9 m^3/day. The remaining lots (residential units) combine for an average day flow of 154.4 m^3/d, shown in Table D4.

In addition to the established development, a few acres of land in this area have been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table D4 - Erin Town Core 2, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Flow Estimate (m^3/d)
Residential	157	18.7	154.4	601.1
Commercial	3	0.95	26.6	98.4
Institutional	1	0.94	20.9	83
Residential – Intensification (5%)	8[1]	-	7.8	27
Residential - Infill	6	-	6.0	23.7
Total	175	20.6	215.7	833.2

[1] Equivalent lots.

1.4 South East Erin

The area designated as South East Erin is a primarily residential area with limited commercial properties and covers the properties in Erin along 9th Line south of Wellington 124 Rd. There are 191 lots in this area, 186 of which are single residence lots, 2 commercial lots, as well as a farm, and a cemetery. The total average day flow estimate for the area is 186.3 m^3/d, shown in Table D5.

In addition to the established development, a few acres of land in this area have been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table D5 – South East Erin, Flow Summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Flow Estimate (m^3/d)
Residential	186	50.0	186.3	721.1
Commercial	2	0.4	11.2	43.7
Residential - Infill	11	-	10.9	36
Total	199	50.4	208.4	800.8

1.5 South Erin

The area designated as South Erin is a residential area with a larger average lot size than the surrounding community. There are 176 lots in this area, primarily along Wellington Road 124. The total average day flow estimate for the area is 173.9 m^3/d, shown in Table D6.

In addition to the established development, a few acres of land in this area have been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table D6 – South Erin, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Flow Estimate (m^3/d)
Residential	176	97.6	173.9	694.5
Residential – Growth	118	7.4	126	378
Total	294	105	299.9	1,072.5

1.6 North East Erin

The area designated as North East Erin is a residential area with a larger average lot size than the surrounding community. There are 91 lots in this area, primarily along Credit River Road and Pine Ridge Road. The total average day flow estimate for the area is 89.9 m^3/d, shown in Table D7.

In addition to the established development, a large plot of land in this area has been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table D7 – North East Erin, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Flow Estimate (m^3/d)
Residential	91	44.1	89.9	370.5
Residential – Growth	288	18	306.4	919.3
Total	379	62.1	396.3	1,289.8

1.7 Erin Heights

The Erin Heights area is a residential subdivision which is separated from the downtown by the West Credit River. There are 114 lots within the area, all of which are single residence properties. The total average day flow estimate for the area is 112.6 m^3/d, shown in Table D8.

Two large sections of land have been identified for potential future growth in this area. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table D8 – Erin Heights, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Flow Estimate (m^3/d)
Residential	114	17.7	112.6	451.5
Residential - Growth	896	56	953.3	2,860
Total	1,010	73.7	1,065.9	3,311.5

1.8 Overland Drive

The Overland Drive area is a residential subdivision which is separated from the downtown by a small body of water. There are 98 lots within the area, all of which are single residence properties. The total average day flow estimate for the area is 96.8 m^3/d, shown in Table D9. There is no GIS data for the properties in this location so the total lot area is unknown.

Table D9 – Overland Drive, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Flow Estimate (m^3/d)
Residential	98	-	96.8	397.7

1.9 Erin Summary

Table D10 – Summary of Erin Decision Area Flows

Decision Area	Equivalent Population [Build-out]	Existing ADF Estimate (m^3/d)	Build-out ADF Estimate (m^3/d)
Industrial Area	1,653 [4,655]	628	1,765.4
Erin Town Core 1	1,891 [1,891]	718.7	718.7
Erin Town Core 2	568 [568]	215.7	215.7
South East Erin	548 [548]	208.4	208.4
South Erin	458 [789]	173.9	299.9
North East Erin	237 [1,042]	89.9	396.3
Erin Heights	296 [2,805]	112.6	1,065.9
Overland Drive	255 [255]	96.8	96.8
Total	5,906 [12,554]	2,244	4,767.1

Appendix - E

Hillsburgh Wastewater Flow Detail

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1.0 Hillsburgh Wastewater Flow

1.1 Hillsburgh Town Core 1 and 2

The areas designated as Hillsburgh Town Core 1 and 2 comprise the majority of the village and are primarily residential development, however this area also has the majority of the commercial properties in the town. In total, these areas are bounded at the north end by Howe St., Trafalgar road on the west and on the south end by Douglas Cres. The area has 356 individual lots, including 11 commercial properties. Based on the Town's GIS database the combined area of the commercial properties is approximately 1.4 Ha. Using the MOECC standard, an estimated 39.2 m^3/d of average day sewage flow would be generated from the commercial portion of this area. The remaining lots (residential units) combine for an average day flow of 369.57 m^3/d, shown in Table E1.

In addition to the established development, a significant amount of land in this area has been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table E1 – Hillsburgh Town Core 1 and 2, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Residential	344	56.4	367.2	1,469
Commercial	11	1.4	39.2	155.6
Residential – Infill	10	-	9.9	32.7
Residential – Growth	720	45	766	2,298
Total	1,085	102.8	1,182.3	3,955.3

1.2 George Street

George Street is a short residential street on the south side of Trafalgar Road. In total, there are 27 properties, 26 residential properties, and 1 commercial property. Based on the Town's GIS database the area of the commercial property is approximately 0.3 Ha. Using the MOECC standard, an estimated 2.8 m^3/d of average day sewage flow would be generated from the commercial property in this area. The remaining lots (residential units) combine for an average day flow of 25.7 m^3/d.

In addition to the established development, a significant amount of land in this area has been identified for future growth. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table E2 – George Street, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Residential	26	2.3	25.7	101.6
Commercial	1	0.3	8.4	33.2
Total	27	2.6	34.1	134.8

1.3 South Trafalgar Road

The South Trafalgar Road area has a total of 74 lots and includes the village's local public school. The residential lots in this area combine for an average day flow of 92.4 m^3/d. A summary of the sewage generation for the area is provided in Table E3.

There is a significant amount of land that has been allocated for future growth in this area. Maps have been provided in ***Appendix B*** showing the location of the growth areas and the type of development specified in the Town's Official Plan for Erin and Hillsburgh.

Table E3 – South Trafalgar Road, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Residential	73	74.8	75.1	286.9
Institutional	1	2.3	11.4	46.8
Residential – Intensification (20%)	-	-	14.4	50.5
Residential – Growth	896	56	973.1	2,860
Industrial - Growth	-	7.7	69.3	207.9
Total	970	141	1,143.3	3,452.1

1.4 Upper Canada Drive

The Upper Canada Drive area has a total of 46 residential lots. Through the Septic System Survey this area has been selected for exclusion from the ultimate sanitary system. The residential lots in this area combine for an average day flow of 45.4 m^3/d. A summary of the sewage generation for the area is provided in Table E4.

Table E4 – Upper Canada Drive, flow summary

Development Type	Number of Lots	Lot Area (Ha)	ADF Estimate (m^3/d)	Peak Day Estimate (m^3/d)
Residential	46	12.9	45.4	191.9

1.5 Hillsburgh Summary

Table E5 – Summary of Hillsburgh Decision Area Flows

Decision Area	Equivalent Population [Build-out]	Existing ADF Estimate (m^3/d)	Build-out ADF Estimate (m^3/d)
Hillsburgh Town Core 1 & 2	1,140 [3,111]	433.4	1,182.3
George Street	90 [90]	34.1	34.1
South Trafalgar Road	228 [3,009]	86.5	1,143.3
Upper Canada Drive	119 [119]	45.4	45.4
Total	1,577 [6,329]	599.4	2,405.1

Appendix - D

Assimilative Capacity Study

&

Thermal Impact Assessment

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West Credit River Assimilative Capacity Study

Final Report – December 2017 Update

Prepared for: Ainley Group.
Job #: J160005

December 6, 2017

1-5 Chancery Lane, Bracebridge ON, P1L 2E3 │ 705-645-0021
Suite 202 – 501 Krug Street, Kitchener, ON N2B 1L3 │ 519-576-1711

December 6, 2017 HESL Job #: J160005

Mr. Joe Mullan
550 Welham Road
Barrie, ON
L4N 8Z7

Dear Mr. Mullan:

Re: Assimilative Capacity Study for West Credit River – Final Report – December 2017 Update

We are pleased to submit the final assimilative capacity study final report in support of the Class Environmental Assessment (Class EA) for a communal wastewater and collection system for the Village of Erin and Hillsburgh. We have summarized baseline data on water quality and flow and used the 7Q20 flow value derived by Credit Valley Conservation (CVC) to model effluent limits and flows using CORMIX to estimate near field mixing and QUAL2K to estimate far field assimilation processes. The effluent limits recommended will meet all required water quality objectives in the West Credit River and the mixing zone characteristics modelled meet the regulatory requirements of the MOECC. We have also presented several alternative designs for the effluent outfall itself to accommodate efficient mixing in the near field under Phase 1 and Full Build Out effluent flows. The final report (issued March 2017) incorporated comments received from CVC on the November 2016 draft report. This updated final report incorporates comments received from MOECC on the March 2017 final report. MOECC and CVC comments are provided in Appendix H. Appendix H also contains a Mussel Survey completed in 2017 of the West Credit River in response to MOECC comments.

We thank you for the opportunity to work on this project. If you have any questions, please do not hesitate to contact me.

Sincerely,
Per. Hutchinson Environmental Sciences Ltd.

Deborah L. Sinclair, M.A.Sc.
Deborah.sinclair@environmentalsciences.ca

Signatures

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Neil Hutchinson, Ph.D.
President

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Appendices

1. Introduction

The Town of Erin is currently completing a Class Environmental Assessment (Class EA) for a communal wastewater and collection system for the Village of Erin and Hillsburgh. A Servicing and Settlement Master Plan (SSMP), by B.M.Ross in 2014, completed part of Phase 1 and part of Phase 2 of the Class EA process. The SSMP identified a general area (along Wellington County Road 52) for the location of a wastewater treatment plant (WWTP). The Town is now engaged in completing Phase 1 and Phase 2 of the EA and moving on to complete Phase 3 and Phase 4.

A preliminary Assimilative Capacity Study (ACS) was completed by B.M.Ross (2014) as part of the SSMP. The intent of the preliminary ACS was to assess the feasibility of a wastewater treatment plant (WWTP) with surface water discharge to the West Credit River in the reach between 10th Line and Winston Churchill Blvd. The preliminary ACS demonstrated this was feasible but recommended that the next phases of the EA should include a review of dissolved oxygen and temperature impacts, and potential for effluent storage. The Ontario Ministry of the Environment and Climate Change (MOECC) confirmed that the original ACS be updated to include hydrodynamic modelling and additional stream flow information collected since the ACS was completed.

This ACS report provides an update to the preliminary ACS completed as part of the SSMP to include:

- Recent (2016) water quality data collected for the West Credit River at 10th Line;
- An updated 7Q20 low flow statistic for the West Credit River at 10th Line;
- Mixing zone modelling (using CORMIX) to predict the size and shape of the mixing zone; and
- Hydrodynamic, far-field modelling (using QUAL2K) to predict downstream concentrations of oxygen, temperature, nitrate, and ammonia.

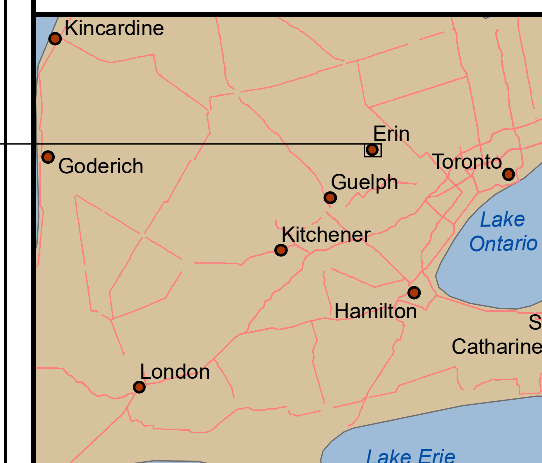
1.1 Study Area

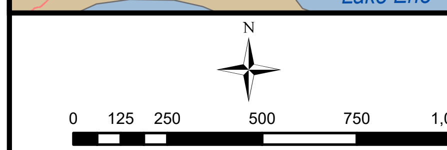
The study area for the ACS is presented on Figure 1. Generally it follows the West Credit River and extends just upstream and downstream of 10th Line and Winston Churchill Blvd., respectively. A large aggregate pit is located to the north-west, and Wellington Road 52 is located to the south-east, along with some residential properties. The study area is located downstream of the Village of Erin.

CVC completed an extensive Existing Conditions Report (CVC 2011) as part of the SSMP, which summarized the hydrogeology, hydrology, geomorphology, aquatic ecology (fish and benthos), water quality, and hydraulics in the study area. Much of the information used for the preliminary ACS was collected from this report, as it provides an excellent baseline of the natural environment in the study area. The West Credit River downstream of 10th Line has been designated as a cold-water aquatic community due to the presence of brook trout. The most productive brook trout spawning reaches and the best brook trout populations in the West Credit River are located downstream of Erin Village (CVC 2011) and the longest contiguous brook trout habitat in the Credit River watershed is the West Credit River between Erin and Belfountain.

Figure 1: Site Location

Stream
Road
Study Area
Waterbody





Prepared by: Eric Dilligeard
Data Source: LIO, HESL, Esri Imagery.
Coordinate System: NAD 1983 UTM Zone 17N

Project Lead: Tara Roumeliotis and Deborah Sinclair
Project: Town of Erin Class EA Wastewater Servicing. Assimilative Capacity Study
Project#: 160005

November 2016

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2. Background

In 2014, B. M. Ross completed an ACS of the West Credit River. The study investigated the impact of three discharge scenarios on the West Credit River: existing population of Erin (3,087 people), existing population of Erin and Hillsburgh (4,481 people), and a future population scenario of 6,000 people. The impact of the WWTP discharge on the West Credit River was estimated using a mass-balance approach with monthly 75th percentile background water quality and monthly 7Q20 flows. Background water quality was based on the long-term Provincial Water Quality Monitoring Network (PWQMN) station located at Winston Churchill Blvd. (station 06007601502). The monthly 7Q20 estimates were calculated by CVC and included a 10% reduction factor for climate change.

B.M.Ross used the effluent objectives and limits outlined in Table 1, and a maximum effluent flow rate of 2,610 m^3/d, and predicted that water quality in the West Credit River met all Provincial Water Quality Objectives (PWQO) with the exception of total phosphorus in September. Total phosphorus concentrations were predicted at 0.0308 mg/L, just slightly above the PWQO of 0.03 mg/L. The report concluded that a surface water discharge with an average daily discharge rate of 2,610 m^3/d (6,000 people) would not negatively impact the stream. The report recommended that dissolved oxygen modelling, thermal impacts, and effluent storage be investigated as part of future stages of the EA (B.M.Ross 2014).

Table 1 Effluent Quality Criteria Proposed by B.M.Ross (2014)

Parameter	Treatment Objectives	Non-Compliance
pH	<7 and >8.6[a]	<7 and >8.6 [a]
Total Suspended Solids (mg/L)	3.0	10
Total Phosphorus (mg/L)	0.1	0.15
Total Ammonia (mg/L)	0.4	2.0
Total Kjeldahl Nitrogen (mg/L)		3.0
Nitrate Nitrogen (mg/L)	5	6
E. coli (org/100 mL)	100	100
Dissolved Oxygen (mg/L)	5 (min)	4 (min)
BOD5 (mg/L)	3.6	7.5
Temperature	17	<8 and >19 [b]

Note: a – this has been interpreted as pH >7 and <8.6; b – this has been interpreted as temperature >8 and <19.

The Ontario Ministry of the Environment and Climate Change (MOECC) confirmed (letter from Ms. Barbara Slattery dated October 31, 2015 to Ms. Christine Furlong, Triton Engineering) that the original ACS be updated to include:

- Mixing zone analysis to include both the lateral and longitudinal plume dimensions;
- Hydrodynamic modelling to predict dissolved oxygen and temperature;

- Worse-case flow scenario should be September (i.e. month with lowest flow); and
- Update ACS to incorporate additional streamflow data (finalize 7Q20 estimate).

HESL used these comments from the CVC and MOECC to prepare an updated work plan (HESL: memo to B. Slattery et al. May 2 2016) for the ACS for review and final approval by the study team.

2.1 Pre-Consultation Meeting with MOECC and CVC

On May 30, 2016, HESL, Ainley Group and Triton Engineering attended a pre-consultation meeting with the MOECC and CVC. The purpose of the meeting was to review the updated ACS work plan with MOCC and CVC and discuss any questions or concerns with the proposed approach (modelling, field investigations and analyses). The group approved the ACS work plan with the following modifications:

1. Water quality modelling will be completed for a 10th Line discharge, as the most conservative location. The West Credit River at Winston Churchill Blvd. is characterized by higher flows and higher water quality than 10th Line as a result of groundwater discharge between the two sites.
2. The dye study and water quality modelling would extend downstream of the study area (i.e. Winston Churchill Blvd.) to capture Winston Churchill Blvd. as a potential discharge location.
3. Stream flow would be measured at Winston Churchill Blvd. to compare with measurements collected at 10th Line.

Minutes from the meeting are presented in Appendix A.

2.2 Policies

Ontario's Ministry of Environment and Climate Change (MOECC) have established policies and guidelines that direct the discharge requirements for waste water treatment plants (WWTPs) in the province. In "*Water Management* Policies*, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy"* (MOE 1994a) the MOE provides direction on the management of surface water and groundwater quality and quantity for the Province of Ontario. The two policies that relate to the determination of WWTP discharges limits are:

> Policy 1 – In areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives.
>
> Policy 2 - Water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives.

The PWQO (Provincial Water Quality Objectives) are numerical and narrative criteria that serve as chemical and physical indicators representing a satisfactory level for surface waters (i.e. lakes and rivers) and where it discharges to the surface, the groundwater of the Province of Ontario. The PWQO are set at a level of water quality, which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water (MOE 1994a).

In Deriving Receiving Water Based, Point-Source Effluent Requirements for Ontario Waters (MOE 1994b), the MOECC provides guidance with regard to the requirements for point-source discharges and the procedures for determining effluent limits. For continuous discharges to streams and rivers, the 7Q20 low-flow statistic is used as a basic design flow to determine the assimilative capacity. The 7Q20 flow represents the minimum 7-day average flow with a recurrence period of 20 years. This value determines the 5% chance of there not being adequate streamflow to properly dilute the point discharge. The 75th percentile concentration is used to determine background water quality when developing receiver-based effluent limits, and is to reflect the existing conditions of the receiver. The 75th percentile background concentrations are also used to determine the Policy status for each of the contaminants expected in the effluent. The following presents MOECC guidance for effluent limits based on receiver Policy Status.

- For Policy 1 receivers, an evaluation is made as to what treatment or other measure is required to maintain water quality at or above the PWQO. Although some lowering of the water quality is permissible, violation of the PWQO is not allowed.
- For Policy 2 receivers no further lowering of water quality is permitted, and all reasonable and practical measures to improve water quality shall be undertaken (MOECC 1994b).

2.3 7Q20 statistic

A Water Survey of Canada (WSC) gauge located in the West Credit River at 8th Line provides a long-term (1983 - present) record of flow. Due to differences in geological conditions between the catchment area of this station and the WWTP study area (i.e., West Credit River between 10th Line and Winston Churchill Blvd.), flows from 8th Line could not be pro-rated for catchment size at 10th Line for the preliminary ACS (B.M.Ross 2014).

A flow gauging station was established at 10th Line in July 2013 by Credit Valley Conservation (CVC). Insufficient data has been collected from this station to determine a reliable 7Q20 low flow statistic; a minimum of 10 years of data are required. Flows measured at this gauge, however, were used by CVC to develop a flow transposition factor between the 8th Line and the 10th Line data. The preliminary ACS used 7Q20 flows for 10th Line as determined by CVC using a transposition factor based on stream flows collected from July to October 2013 at 10th Line. Additional flow data have been collected since the preliminary ACS to refine the transposition factor. In 2016, CVC recalculated the 7Q20 low flow statistic for 10th Line, using data from July 2013 to December 2015 (Appendix B). The new 7Q20 flow statistic for 10th Line of 225 L/s includes a 10% reduction to account for effects on climate change.

3. Approach and Methods

The preliminary ACS (B.M.Ross 2014) used water quality data from the Provincial Water Quality Monitoring Network (PWQMN) station located on the West Credit River at Winston Churchill Blvd. (PWQMN 06007601502) as input to their ACS. This station is located in the study area and has a long-term record of water quality (1975-2015). The updated ACS, however, draws on water quality information collected from the 10th Line, upstream of Winston Churchill Blvd., which was contained in the Existing Conditions Report (CVC 2011), and updated with new data collected as part of this study. Groundwater discharge between the 10th Line and Winston Churchill Blvd. results in improved water quality downstream and so provides a more conservative estimate of background water quality.

A CORMIX water quality model was used to determine the size and shape of the effluent plume and water quality in the mixing zone. Oxygen and temperature modelling of the discharge in the River, as requested by the MOECC and CVC and recommended in the preliminary ACS, was completed using the QUAL2K model. The QUAL2K model was also used to predict the influence of assimilation processes beyond the mixing zone on downstream concentrations of ammonia and nitrate. The QUAL2K model requires a large amount of site-specific physical, chemical and biological information to accurately simulate the effect of the effluent on the receiver. The data to complete the modelling was assembled from the background data and updated with data from the current water quality, quantity and detailed field studies conducted in the summer of 2016. The additional field studies were undertaken as inputs into the ACS included:

- Diurnal Oxygen Surveys - used as input into the QUAL2K model and to determine if oxygen is a limiting factor at night when photosynthesis is low and respiration is high
- Physical Attributes Survey – to define and characterize distinct reaches in the West Credit River within the study area for input into the hydrodynamic model
- Dye Tracer Study – to calculate time of travel and longitudinal dispersion of effluent as input to the Qual2K model

The methods used for the field investigations and ACS are outlined in the following sections.

3.1 Confounding Factors

In early July 2016 the CVC became aware of backwater effects at their 10th Line flow gauge caused by a beaver dam located approximately 20 m downstream of 10th Line. The time of construction of the dam is unknown, but CVC believes that water levels (and hence calculated flows) at 10th Line from approximately May 20, 2016 were impacted by downstream beaver dams (Tim Hurts, CVC personal communication). The presence of beaver dams downstream of the water level gauge at 10th Line caused the pooling of water and flooding of banks upstream of 10th Line. As a result, accurate flow measurements could not be calculated from the CVC gauge from ~ May 2016 onwards.

The presence of the beaver dams should not influence the water quality data collected by HESL in 2016. Water samples were collected at 10th Line from May to July 2016. In August and September 2016 the sampling station was moved 75 m downstream of 10th Line, outside of any influence of the beaver activity. In May, June, and July, stream flows were measured just upstream of 10th Line at the CVC flow gauge. Flows measured during this period may include influence (e.g. backwater effects) from beaver dams located downstream. In August and September, stream flows were measured ~ 75m downstream of 10th Line, to avoid interference from the beaver dam.

A dye tracer study was conducted on August 25, 2016 (Section 3.5). The dye was injected approximately 75 m downstream of 10th Line, downstream of the influence of the beaver dam. The presence of the beaver dam at 10th Line did not influence the dye study, as the study was conducted well outside of its influence.

3.2 Water Quality

Monthly water quality samples were collected from the West Credit River at 10th Line (Figure 2) from May to September 2016 on:

- May 27, 2016

- June 29, 2016
- July 27, 2016
- August 25, 2016
- September 28, 2016

Water samples were collected 75 m downstream of 10th Line during August 25 and September 28 sampling events to avoid the influence of the beaver dam.

During each sampling event grab samples were collected from the centre of the watercourse for analysis of:

- 5-day and ultimate carbonaceous biochemical oxygen demand (CBOD5 and CBODu),
- total phosphorus (TP),
- orthophosphate (PO_4),
- total dissolved phosphorus (TDP)
- total Kjeldahl nitrogen (TKN),
- nitrate (NO3) and nitrite (NO2),
- total ammonia nitrogen (TAN),
- total suspended solids (TSS),
- chlorophyll *a*,
- volatile suspended solids (VSS), and
- chloride (September 2016 sampling event only).

After sample collection, water samples were stored in laboratory-provided coolers containing ice packs and shipped to ALS in Waterloo, Ontario for analysis. Field measurements of pH, dissolved oxygen (DO; mg/L and % saturation), temperature (°C) and specific conductivity (µS/cm) were collected with a water quality multi-parameter meter (YSI 600 QS). Field pH and temperature were used to calculate un-ionized ammonia using the equation from Appendix A of MOE’s document “Water Management” (MOE 1994).

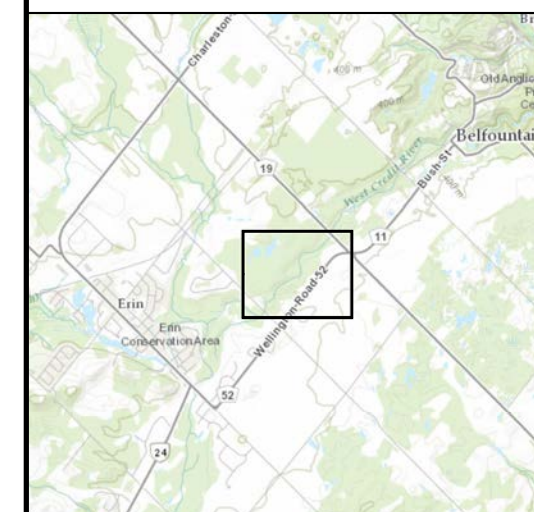
The relationships between these variables are used by the QUAL2K model to predict far-field water quality.

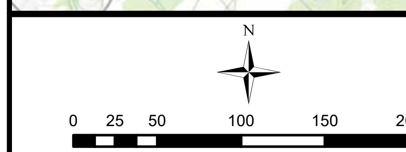
3.2.1 Diurnal DO Surveys

Three dissolved oxygen (DO) loggers (Optical Dissolved Oxygen Loggers, HOBO Model U26-001) were installed in the West Credit River at three locations: 10th Line, Winston Churchill Blvd., and the mid-point between the two stations on June 10, 2016 (Figure 2). The DO loggers were calibrated prior to deployment, and programmed to measure dissolved oxygen (mg/L) and temperature (ºC) every 0.5 hours. The loggers were retrieved on August 25, 2016; the logger between the two stations was likely vandalized and was not retrieved. A DO logger was also installed 75 m downstream of 10th Line from August 25 to September 28, 2016 to assess dissolved oxygen concentrations downstream of 10th Line. The dissolved oxygen measurements were used as input into the QUAL2K model (Section 3.7), and to assess aquatic habitat conditions in the West Credit River.

Figure 2:
Monitoring Locations in
West Credit River Study Area

- Monitoring Site
- PWQMN Station 06007601502
- CVC Flow Station
- HESL DO Logger
- HESL Flow Station
- HESL Water Quality
- Stream
- Road





Prepared by: Eric Dilligeard
Data Source: LIO, HESL, Esri Imagery.
Coordinate System: NAD 1983 UTM Zone 17N

Project Lead: Tara Roumeliotis and Deborah Sinclair
Project: Town of Erin Class EA Wastewater Servicing. Assimilative Capacity Study
Project#: 160005

November 2016

Hutchinson Environmental Sciences Ltd.

3.3 Stream flow

Stream flow was measured at 10th Line and Winston Churchill Blvd. (Figure 2) during each sampling event[1] using an OTT MF Pro brand flow meter. From May to July stream flows were measured just upstream of 10th Line at the CVC flow gauge. Flows measured during this period may include influence (e.g. backwater effects) from the beaver dams located downstream. The August and September flows were measured ~ 75 m downstream of 10th Line to avoid interference from the beaver dam.

Stream velocity was measured at a minimum of 10 points across the stream cross-section. At points where the water depth was less than 0.5 m, the water velocity was measured at 0.6 of the water depth. Where water depths were greater the 0.5 m the velocity was measured at 0.2 and 0.8 of the depth and the mean of these values computed. The area-velocity method was used to calculate stream discharge. Manual streamflow measurements are generally accurate to within 6-19% (Harmel et al. 2006) of the actual flow in the watercourse, with lower flows being less accurate.

3.4 Stream Characterization

On June 10, 2016 a detailed field reconnaissance of the West Credit River between 10th Line and Winston Churchill Blvd. was carried out by HESL scientists. The purpose of the reconnaissance was to develop a better understanding of the proposed receiving environment, identify potential influences on water quality and the assimilation process, and to define and characterize distinct sections (also known as reaches) of the river for the purpose of informing the 1-dimensional river model, QUAL2K.

The QUAL2K model requires spatial segmentation of the river into a series of reaches, which are sections of similar hydrogeometric characteristics, (i.e., depth, cross sectional area, bank slopes, channel slopes, average velocity and average flow), channel pattern, bed materials, bank composition, and influence of riparian and in-stream vegetation on flow. HESL scientists surveyed the longitudinal slope of the river and the left and right bank slopes at eight locations within the study area. In addition, the field reconnaissance made note of any of the following items:

- human contact points
- upstream inputs or modifiers that may affect assimilation such as tile drains or impoundments
- inputs or structures downstream of the discharge such as tributaries, tile drains or impoundments
- Substrate type
- In-stream vegetation (macrophyte growth)
- Large woody debris
- Riparian vegetation
- Tree canopy and percent of shading

HESL field notes from the reconnaissance are attached in Appendix C.

In addition to the reconnaissance conducted by HESL, fluvial geomorphologists from Palmer Environmental Consulting Group (PECG) carried out a comprehensive stream assessment of the West Credit River study

[1] *Stream flow was not measured at Winston Churchill Blvd. during the May27, 2016 event.*

area between 10th Line and 80 m downstream of Winston Churchill Blvd. on June 29, 2016. Although the focus of PECG's assessment was evaluating potential outfall locations, (to be reported in Phase 3 and 4 of the EA), their study observations on channel morphology, bed and bank materials, and existing erosion sites were incorporated into the physical attributes survey results of HESL.

3.5 Dye Tracer Study

Tracer testing was conducted on August 25, 2016 under a low flow of 0.37 m^3/s, as measured by HESL staff on the day of the tracer test at a location approximately 75 m downstream of 10th Line and outside of the influence of the beaver dam. Data gathered during the tracer tests were used to calculate time of travel, velocity, and longitudinal dispersion for use in the far-field 1-dimensional river model (QUAL2K) of the West Credit River and to provide a one-time calibration of the model using the flow and velocity conditions on that date.

Rhodamine WT dye, a fluorescent xanthene dye that is pink in colour, was used as the tracer for the study. Rhodamine WT dye was chosen because it is a stable, non-toxic, and chemically non-reactive dye that is easily measured in the field. The substance is non-carcinogenic, and is safe if it comes into contact with skin. Rhodamine WT dye tracers are also very robust over a variety of different flow regimes.

A slug injection tracer test was carried out whereby a known amount of tracer was added to West Credit River approximately 75 m downstream of 10th Line (Figure 3). This injection location was selected because it was downstream of the zone of influence from the beaver dam near 10th Line.

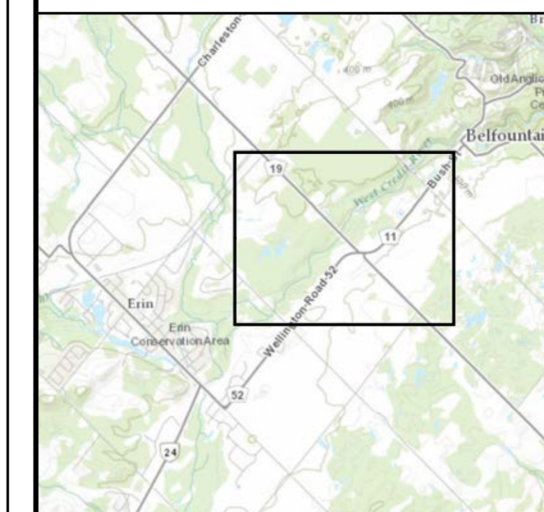
Fluorometers (YSI 600 OMS instruments equipped with Rhodamine WT optical sensors) were placed in the West Credit River at five locations downstream of the tracer injection site, as follows:

- Fluorometer 1 at 105 m downstream of the injection point;
- Fluorometer 2 at 486 m downstream of the injection point;
- Fluorometer 3 at 1,373 m downstream of the injection point;
- Fluorometer 4 at 1,687 m downstream of the injection point; and
- Fluorometer 5 at 2,827 m downstream of the injection point (Figure 3);

The fluorometers were equipped with an optical sensor to determine the concentration of Rhodamine WT in the water, in units of µg/L (ppb), and were set up to collect one measurement every 10 seconds for the duration of the test. The fluorometers were capable of measuring concentrations of Rhodamine WT with a resolution of 0.1 ppb. The Rhodamine WT optical sensors were calibrated in the field on a 2-point scale that included 0 ppb and 100 ppb Rhodamine WT. The 100 ppb solution was mixed in the field from a 20% Rhodamine WT dye solution, which was obtained from a national supplier.

Figure 3:
Dye Tracer Study,
Fluorometer Locations

- Fluorometer Station
- Injection Point
- Stream
- Road



N

0 50 100 200 300 400 m

Prepared by: Eric Dilligeard
Data Source: LIO, HESL, Esri Imagery.
Coordinate System: NAD 1983 UTM Zone 17N

Project Lead: Tara Roumeliotis and Deborah Sinclair
Project: Town of Erin Class EA Wastewater Servicing. Assimilative Capacity Study
Project#: 160005

November 2016

Hutchinson Environmental Sciences Ltd.

To begin the slug injection tracer test, a certain volume of Rhodamine WT 20% dye solution was mixed into a bucket containing 10 L of water collected from the West Credit River. The volume of tracer required was estimated by applying the following empirical equation by Kilpatrick (1989):

$$V_s = 3.79 \times 10^{-5} \frac{QL}{v} C_p$$ Equation (1)

where Vs is the volume of Rhodamine WT 20% dye, in mL;

Q is the flow rate of the West Credit River, in ft^3/s;

L is the length of the measurement reach, in ft;

v is the mean-stream velocity, in ft/s; and

Cp is the peak concentration at the sampling site, in µg/L.

Equation 1 was used to determine the amount of Rhodamine WT 20% dye needed, such that the peak tracer concentration detected at the furthest fluorometer (about 2.8 km downstream) would be detectable by the fluorometer. The 10L bucket containing the Rhodamine WT 20% mixture was then quickly emptied across the width of the river to simulate an instantaneous injection. The time of the injection was recorded. Photograph 1 shows this instantaneous injection, Photograph 2 shows the West Credit River looking downstream of the injection point approximately 10 seconds after the instantaneous injection, and Photograph 3 shows the West Credit River approximately 1 minute after the instantaneous injection. The "parabolic-shaped" velocity profile which is the result of stream velocities that are higher through the centre of the river, and slower along the banks is clearly shown in Photograph 3.

Photograph 1. Rhodamine WT slug test dye injection on the West Credit River (Photo credit: Christine Furlong, Triton Engineering Services Limited)

Photograph 2. Rhodamine WT Dye Plume Approximately 10 seconds after Slug (Instantaneous) Injection

Photograph 3. Rhodamine WT Dye Plume Approximately 1 minute after Slug (Instantaneous) Injection.

The measured Rhodamine WT concentrations versus time were graphed for each of the fluorometer stations, with the time axis, (the x-axis), beginning at the recorded time of the slug injection, as illustrated in the following theoretical example (Figure 4).

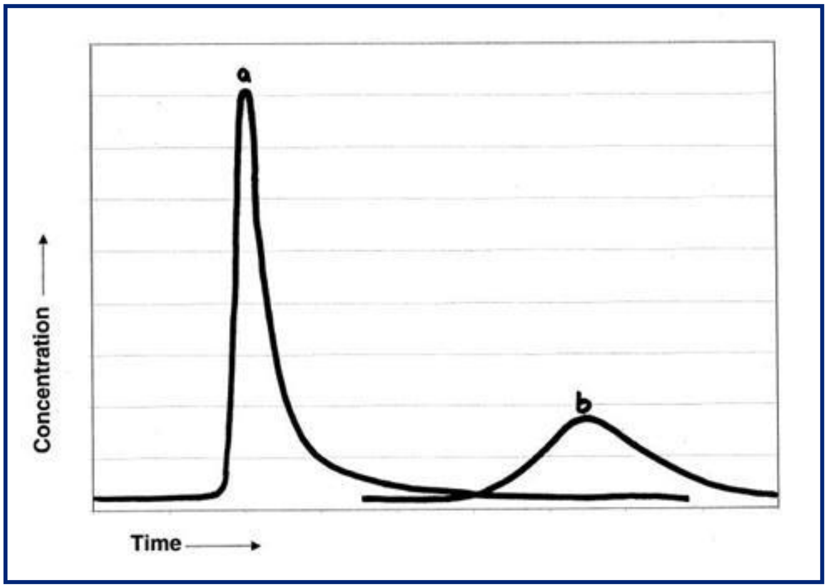


Figure 4. Example Graph of Rhodamine WT Concentration Versus Time for a Slug Injection Test

Figure 4 shows that the fluorometer closest to the injection point (i.e., line a in the figure) would exhibit a tracer peak that was higher and seen sooner than the peak at the other fluorometer station located further downstream (i.e., line b in the figure). The time of travel and longitudinal dispersion were computed by comparing the peak Rhodamine WT concentrations and the time between the slug injection and the peak.

The travel time ($\bar{t}$) between the dye injection point and a given fluorometer station was calculated by the following equation:

$$\bar{t} = \frac{\sum_{i=0}^{n-1} (c_i t_i + c_{i+1} t_{i+1})(t_{i+1} - t_i)}{\sum_{i=0}^{n-1} (c_i + c_{i+1})(t_{i+1} - t_i)} \qquad \text{Equation (2)}$$

where ci is the Rhodamine WT concentration at a given time, in µg/L;

ti is the corresponding time, in minutes elapsed since the time of injection; and

n is the number of data points collected by the fluorometer.

The temporal variance (S_t^2) was calculated from the data collected at each fluorometer by the following equation:

$$s_t^2 = \frac{\sum_{i=0}^{n-1}(c_i t_i^2 + c_{i+1}t_{i+1}^2)(t_{i+1} - t_i)}{\sum_{i=0}^{n-1}(c_i + c_{i+1})(t_{i+1} - t_i)}$$ Equation (3)

The mean velocity (U) between two fluorometer stations was calculated by the following equation:

$$U = \frac{x_2 - x_1}{\overline{t_2} - \overline{t_1}}$$ Equation (4)

where x is the distance between the dye injection point and the fluorometer, in m.

The longitudinal dispersion coefficient (E) between two stations was calculated by:

$$E = \frac{U^2(s_{t2}^2 - s_{t1}^2)}{2(\overline{t_2} - \overline{t_1})}$$ Equation (5)

The calculated times of travel, mean velocities, and dispersion coefficient values between each of the five fluorometer locations were input into the QUAL2K model for the West Credit River.

3.6 Mass Balance Modelling

The potential volume of treated effluent flows from the proposed Erin WWTP are limited by total phosphorus concentrations with respect to both treatment technology limits for TP removal in wastewater and fully mixed TP concentrations in the West Credit River. A mass balance model was used to back-calculate allowable maximum effluent flows based on a range of potential effluent TP concentrations and fully mixed TP concentrations in the river, assuming homogenous concentrations across the river cross-section.

Although there are several processes leading to loss of phosphorus from the water column of a river over the course of a year, these are balanced out by resuspension such that on average, phosphorus is not retained in a river system. The West Credit River was therefore assumed to not act as a net sink for TP and TP was assumed to behave as a conservative parameter. Modelling these processes is difficult using an un-calibrated water quality model and lacking an existing discharge where assimilation processes could be observed in the field. A mass balance model of phosphorus loadings to the West Credit River was therefore used as a conservative estimate of the likely total phosphorus concentrations under a variety of effluent limits.

Determination of the water quality in the West Credit River, at the point of complete and homogenous mixing between the WWTP effluent and the river, was achieved by solving the following mass-balance equation for $C_{d/s}$:

$$Q_{u/s}C_{u/s} + Q_{WWTP}C_{WWTP} = (Q_{u/s} + Q_{WWTP})C_{d/s}$$ (Equation 6)

Where:

$Q_{u/s}$ is the upstream flow in the West Credit River, prior to the proposed WWTP discharge;

$C_{u/s}$ is the upstream West Credit River concentration for the parameter of interest;

Q_{WWTP} is the Erin WWTP effluent flow;

C_{WWTP} is the Erin WWTP effluent concentration for the parameter of interest; and

$C_{d/s}$ is the fully mixed downstream concentration in the West Credit River for the parameter of interest.

The mass balance model does not assume any mixing zone – it is based on the fully mixed river concentrations and treats phosphorus as a conservative parameter – one which does not undergo any assimilation reactions after discharge.

Equation 6 was re-arranged to solve for Q_{WWTP} in order to determine the maximum possible effluent flows under a variety of TP effluent concentrations (Table 2), while maintaining TP concentration in the West Credit River at the site-specific objective of 0.024 mg/L (Appendix D).

$$Q_{WWTP} = \frac{Q_{u/s}(C_{d/s} - C_{u/s})}{C_{WWTP} - C_{d/s}} \qquad \text{(Equation 7)}$$

HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/d and a Full Build Out flow of 7,172 m^3/d for the complete assimilation modelling exercise based on the results of the TP mass balance modelling. These model results are detailed in Section 4.5.

Table 2. Mass Balance Modelling Inputs – Total Phosphorus

Parameter	Value	Rationale
Upstream West Credit River flow ($Q_{u/s}$)	0.225 m^3/s	The 7Q20 value, as calculated by Credit Valley Conservation (*Update of Low Flow Assessment (7Q20) for the West Credit River Assimilative Capacity Study (Erin SSMP),* CVC, June 2016).
Upstream West Credit River TP concentration ($C_{u/s}$)	0.016 mg/L	75th percentile concentrations of HESL (2016) and CVC (2007 & 2008) water quality data collected at 10th Line (15 data points)
WWTP effluent TP concentration (C_{WWTP})	0.15 to 0.04 mg/L	Effluent TP concentrations were varied from 0.15 mg/L (the effluent limit concentration proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*) to 0.04 mg/L (approaching the current limit of treatment technology)
Downstream West Credit River TP concentration ($C_{d/s}$)	0.024 mg/L	Recommended downstream maximum TP concentration based on Environment Canada and CCME guidance. (See Appendix D for additional details).

Mass balance modelling of total ammonia nitrogen (TAN) and nitrate were also completed as a "starting point" in determining effluent limits for these parameters (Equation 6) using the Phase 1 and Full Build Out effluent flows which were derived from the TP mass balance modelling (Equation 7) (Table 3). Since nitrification of TAN (and the generation of nitrate) in the West Credit River would be expected given that the river is well oxygenated (Section 3.1.3), these parameters were further modelled using the far-field longitudinal river model QUAL2K, which accounts for nitrification as well as denitrification. The QUAL2K modelling is discussed in Section 2.5. For the mass balance modelling of TAN, a mass balance to determine downstream temperature and pH was also carried out, and these downstream values then used to calculate fully mixed un-ionized ammonia concentrations.

Table 3. Mass Balance Modelling Inputs – Total Ammonia Nitrogen and Nitrate

Parameter	Value	Rationale
Upstream West Credit River flow ($Q_{u/s}$)	0.225 m^3/s	The 7Q20 value, as calculated by Credit Valley Conservation (*Update of Low Flow Assessment (7Q20) for the West Credit River Assimilative Capacity Study (Erin SSMP),* CVC, June 2016).
Upstream West Credit River concentration for parameter of interest ($C_{u/s}$)	• TAN – 0.055 mg/L • (Temperature – 21.18°C; pH – 8.21)* • Nitrate – 1.9 mg/L	• TAN and nitrate - 75th percentile concentrations of HESL (2016) and CVC (2007 & 2008) water quality data collected at 10th Line (15 data points). • Temperature – 75th percentile of August 2016 HESL temperature logger measurements at 10th Line • pH - 75th percentile of CVC hydrolab data (June and Aug 2008)
WWTP effluent concentration for parameter of interest (C_{WWTP})	• TAN – 0.6 to 1.2 mg/L • Nitrate – 5 to 6 mg/L • (Temperature 19°C; pH – 8.6)*	• Effluent TAN concentrations were varied from 1.2 mg/L (from email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits [Appendix E]) to 0.06 mg/L (the Full Build Out TAN concentration required to meet the PWQO of 0.0164 mg/L for un-ionized ammonia at fully mixed downstream). • Temperature – as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*. • pH – as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*. • Effluent nitrate concentrations were varied from 5 to 6 mg/L, the effluent objective and limit concentrations proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*.
WWTP effluent flow (Q_{WWTP})	Phase 1 – 0.039 m^3/s Full Build Out – 0.083 m^3/s	From results of the TP mass balance modelling, HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/d (0.039 m^3/s) and a Full Build Out flow of 7,172 m^3/d (0.083 m^3/s).

Mass balance modelling of chloride was completed using the Phase 1 and Full Build Out effluent flows (as derived from the TP mass balance modelling) to determine fully mixed, downstream chloride concentrations in the West Credit River. Chloride is a conservative parameter, whose concentrations would be expected to reduce through dilution only. As such, using a mass balance model to predict fully mixed chloride concentrations in the river was most appropriate in examining chloride concentrations in the receiver.

Table 4. Mass Balance Modelling Inputs – Chloride

Parameter	Value	Rationale
Upstream West Credit River flow ($Q_{u/s}$)	0.225 m^3/s	The 7Q20 value, as calculated by Credit Valley Conservation (*Update of Low Flow Assessment (7Q20) for the West Credit River Assimilative Capacity Study (Erin SSMP),* CVC, June 2016).
Upstream West Credit River concentration for chloride ($C_{u/s}$)	48.9 mg/L	75th percentile concentrations of HESL (2016) and CVC (2007 & 2008) water quality data collected at 10th Line (11 data points).
WWTP effluent concentration for chloride (C_{WWTP})	534 and 396 mg/L	Predicted maximum and average effluent chloride concentrations (Appendix D)
WWTP effluent flow (Q_{WWTP})	Phase 1 – 0.039 m^3/s Full Build Out – 0.083 m^3/s	From results of the TP mass balance modelling, HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/d (0.039 m^3/s) and a Full Build Out flow of 7,172 m^3/d (0.083 m^3/s).

3.7 Far-Field Water Quality Modelling (QUAL2K)

QUAL2K is a one-dimensional (1-D) river and stream water quality model, supported by the United States Environmental Protection Agency (US EPA), which is typically used to assess the environmental impact of pollution discharges along rivers. A wide range of water quality parameters and chemical and biological pollutants within the river can be modelled, including temperature, pH, dissolved oxygen (DO), carbonaceous biochemical oxygen demand (CBOD), nitrogen species, phosphorus species, and suspended solids.

Since QUAL2K is a 1-D model, the model assumes that all point source inputs (such as the outfall from the WWTF) are instantaneously mixed laterally and vertically at each particular point in the river. Variation in each water quality parameter modeled occurs only longitudinally (in the x-direction along the length of the river), and is computed as water is transported out of each reach and into the next. The QUAL2K model is known as a far-field model since its water quality predictions apply beyond the point in which the effluent is fully mixed with the river, also known as the far-field. Near-field modelling to the point of complete mixing was carried out using the CORMIX mixing zone model, Section 3.8; however, it is important to note that the QUAL2K model takes into account a larger variety of water quality and physical parameters and processes and thus is both more complex and more precise regarding the fate of pollutants in the river than the mixing zone model, CORMIX.

The outfall for the WWTP is proposed between 10th Line and Winston Churchill Blvd. Thus the West Credit River was modeled using QUAL2K from a point approximately 100 m upstream of the 10th Line to a point approximately 40 m downstream of Winston Churchill Blvd., for a total river model length of about 1.7 km. This 1.7 km stretch was sub-divided into smaller sections called “reaches”, which are sections of the river with similar geomorphologic characteristics (Section 3.4) based on our physical attributes survey, to create an accurate simulation of the river for the model. A total of 6 reaches were identified for the model, denoted as Reach 0 through Reach 5, where Reach 0 is located upstream of 10th Line (Section 4.3, Figure 9).

3.7.1 Model Input

The main input parameters for the QUAL2K model are summarized in Table 5.

The far-field modelling was limited to the summer scenario since it is the most critical season due to increased water temperatures which result in increased speciation of ammonia to its un-ionized form. As such, summer temperatures are reflected in the model inputs.

Table 5. Model Input Parameters for QUAL2K Far-field Assimilation Modelling

Parameter	Value	Rationale
Receiving Water Characteristics (West Credit River at 10th Line)		
pH	8.21	• The 75th percentile of CVC hydrolab data (June and Aug 2008) • Note that 75th percentile of HESL 2016 and CVC (2007-2008) point measurements was 8.11
Water temperature	21.18 ºC	• The 75th percentile of August 2016 HESL temperature logger measurements at 10th Line • Note that the 75th percentile summer temperature (June through August 2016) from the HESL temperature logger was 20.66ºC
Dissolved oxygen	7.72 mg/L	• 25th percentile August 2016 HESL DO logger at 10th Line • 7.93 mg/L – 25% June to August 2016 HESL DO logger
Conductivity	613 µS/cm	• 75th percentile from CVC hydrolab data (June and Aug 2008) • Note that 75th percentile of HESL 2016 and CVC (2007-2008) point measurements was 600 µS/cm
Nutrients	TAN: 0.055 mg/L Nitrate-N: 1.90 mg/L	• 75 percentile of HESL (2016) and CVC (2007 & 2008) data collected at 10th Line (15 data points)

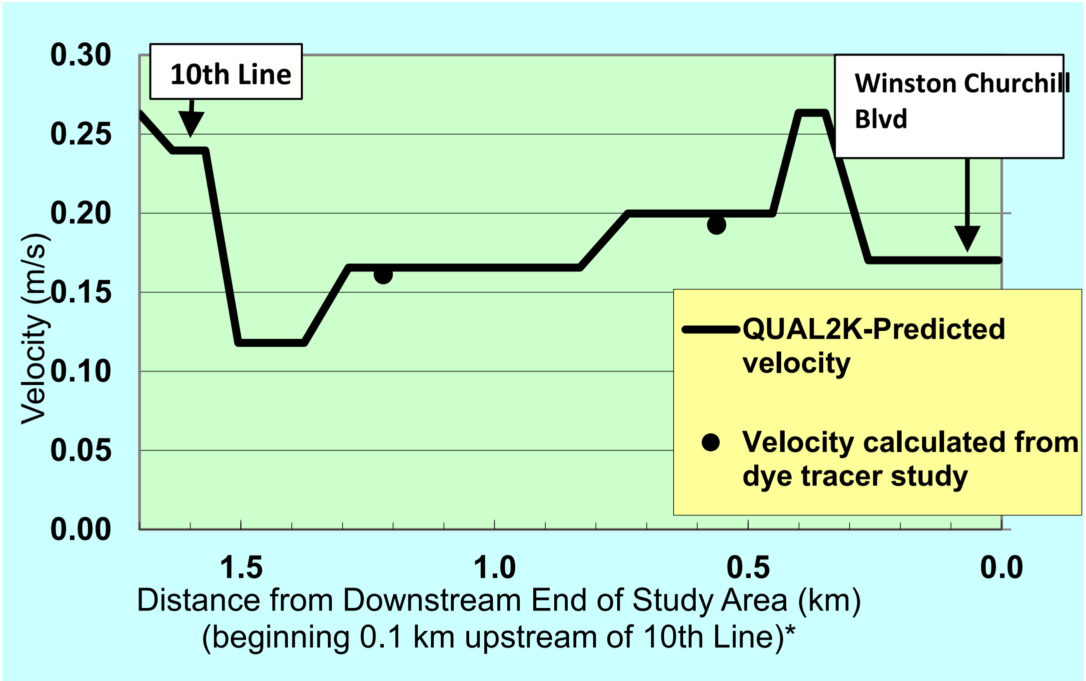
Parameter	Value	Rationale
	TKN: 0.590 mg/L TP: 0.016 mg/L Inorganic P: 0.0081 mg/L Organic P = TP-InorgP Organic N = TKN-TAN	• Organic phosphorus and Inorganic phosphorus – based on 75th percentile of HESL (2016) data collected at 10th Line (5 data points)
Inorganic Solids (ISS)	ISS= TSS-VSS TSS: 3.2 mg/L VSS: <3 mg/L	• 75th percentile of HESL 2016 data collected at 10th Line (5 data points). Did not use CVC data because TSS had high detection limit of 10 mg/L and no VSS data.
$cBOD_{fast}$	2.70 mg/L	• 75th percentile of HESL 2016 cBODu collected at 10th Line (5 data points)
Chlorophyll a	2.72 µg/L	• 75th percentile of HESL 2016 data collected at 10th Line (5 data points)
Alkalinity	281 mg/L	• From May 2011 report by CVC, Aquafor Beech Inc, and Blackport Hydrogeology Inc.: *Erin Servicing and Settlement Master Plan, Phase 1 – Environmental Component – Existing Conditions Report.*
E. coli	160 cfu/100 mL	• CVC 2007-2008 (10 points)
Flow	0.225 m^3/s	• 7Q20 flow at 10th Line, from CVC 2016 report: *Update of Low Flow Assessment (7Q20) for the West Credit River Assimilative Capacity Study (Erin SSMP)* • Accounts for climate change (subtracted 10% from 7Q20 flow)
Manning's n	0.035 – 0.045	• Initially based on June 10, 2016 field reconnaissance, refined through calibration with river velocities computed from dye tracer study
Bottom Algae coverage	15% to 40%	• Based on the June 10, 2016 field reconnaissance
Channel slope	0.0008 to 0.003	• From June 10, 2016 survey, averaged within each reach, refined through calibration with river velocities computed from dye tracer study
Bank slope	0.17 to 0.66	• From June 10, 2016 survey
Air Temperature	21.9°C to 29.7°C	• From Environment Canada's Historic Climate Data records for August 25, 2016 for Georgetown WWTP
Dew Point Temperature	17.7°C to 22.2°C	• From Environment Canada's Historic Climate Data records for August 25, 2016 for Georgetown WWTP
Wind speed	2 m/s	• Recommended for conservative design conditions
Shade	20% to 53%	• From June 10, 2016 survey, averaged within each reach
Effluent Characteristics (Proposed Erin WWTP)		
Flow rate	Phase 1 – 0.039 m^3/s Full Build Out – 0.083 m^3/s	• From results of the TP mass balance modelling, HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/d (0.039 m^3/s) and a Full Build Out flow of 7,172 m^3/d (0.083 m^3/s).

Parameter	Value	Rationale
TAN	Phase 1 – 1.2 mg/L (summer); 2 mg/L (winter) Full Build Out – 0.6 mg/L (summer); 2 mg/L (winter)	• Phase 1 - From email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits (Appendix E), confirmed through mass balance modelling. • Full Build Out - From mass balance modelling: TAN concentration required to meet the PWQO of 0.0164 mg/L for un-ionized ammonia nitrogen at fully mixed downstream.
Temperature	19°C	• Maximum value, as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*.
pH	8.6	• Maximum value, as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*.
Nitrate-N	5 mg/L	• As proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*, confirmed value through mass balance modelling.
TP	Phase 1 – 0.07 mg/L Full Build Out – 0.045 mg/L	• From mass balance modelling, TP effluent concentrations relating to desired effluent flows.
cBOD	5 mg/L	• From email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits (Appendix E).
Dissolved oxygen	4 mg/L	• From email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits (Appendix E), and as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*.
Conductivity	1,000 µS/cm	• Based on measured effluent conductivity from existing WWTPs in southern Ontario (Simcoe WPCP, Delhi WPCP).
TSS	5 mg/L	• From email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits (Appendix E).
E.coli	100 CFU/100 mL	• From email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits (Appendix E), and as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*.
Model Parameters		

Parameter	Value	Rationale
CBOD oxidation rate	2 /d	Set near mid-point of range (0 to 5/d). The West Credit River does not have a high background CBOD concentration; however, oxidation of CBOD requires DO, and therefore to be conservative in our estimates of DO sag concentration in the study area, we set the CBOD oxidation rate at the mid-point of the range instead of at the low end.
Organic nitrogen - hydrolysis	0.1 /d	Conservative estimate. Set at low end of range (0 to 5/d).
Organic nitrogen – settling velocity	0.1 /d	Conservative estimate. Set at low end of range (0 to 2/d).
Nitrification rate	5/d	Set near mid-point of range (0 to 10/d). Literature review of similar streams indicates range of 0.2 to 9/d (EPA 1985). Note that nitrification is at its maximum at pH=8.5 and temperatures between 25 and 35 deg C and is high in shallow streams, thus medium to high rates would be expected for West Credit River. Further downstream TAN concentrations derived by mass balance (Section 4.5) conservatively assume zero nitrification, so the QUAL2K model nitrification rate provides a more realistic scenario.
Denitrification	0.1 /d	Set at low end of range (0 to 2/d). High rates of denitrification would not be expected in the West Credit River study area since it is well oxygenated with low CBOD.
Organic P - hydrolysis Rate	0.1 /d	Conservative estimate. Set at low end of range (0 to 15/d).
Reaeration Model	Tsivoglou-Neal	Default model selection in QUAL2K.

Although no point source currently exists within the West Credit River study area with which to calibrate and validate the water quality predictions of the QUAL2K model, the hydraulic component of the model was calibrated using the river velocities calculated from the dye tracer study conducted on August 25, 2016 (Section 3.3) and the river flow measured on that same day at a location approximately 75 m downstream of 10th Line (and outside the influence of the beaver dam). Manning's n values and channel slopes were varied in order to calibrate the hydraulic model results to those computed from the dye tracer study.

The precision of the hydraulic predictions from the QUAL2K model calibration are presented graphically in Figure 5, where the dye tracer study (i.e., field-calculated) velocities are plotted against the model-predicted velocities. Note that the river velocities computed from the dye tracer study are plotted at the mid-point location between fluorometer stations. The average velocity in the study area, computed through the dye tracer study results, was 0.17 m/s. The QUAL2K average velocity in the study area was 0.177 m/s. Thus the hydraulic results from the QUAL2K model calibrated well to the field results and the model was deemed to be acceptable for use in predicting far-field water quality.



*QUAL2K model calculates using a descending distance from the upstream-most point in the study area. In this case, the model begins at 1.7 km (which corresponds to 100 m upstream of 10th Line) and ends at 0 km (which corresponds to 40 m downstream of Winston Churchill Blvd.).

Figure 5. QUAL2K Velocity Calibration Results

3.8 Mixing Zone Modelling (CORMIX)

The receiver (i.e., West Credit River) water quality must be maintained within PWQO except for the volume of water within the mixing zone. From *Deriving Receiving Water Based, Point-Source Effluent Requirements for Ontario Waters* (MOE, 1994b), the mixing zone is defined two ways:

- The volume of water contiguous to the discharge in which the effluent undergoes physical mixing with the receiver such that dilution by mixing is the dominant process reducing effluent concentrations in the water; or
- The volume of water contiguous to the discharge in which concentrations of effluent parameters exceed their respective PWQOs.

The mixing zone model provided information on effluent plume behaviour and pollutant concentrations in the near-field mixing zone. The mixing zone model focused on the physical component of modelling, where assimilation processes were dominated by mixing and dilution of the effluent with the receiving waters. (Note that in order to model assimilation of pollutants by the complex physical, chemical and biological processes in a river system beyond the point of complete mixing, the far-field water quality model QUAL2K was applied, as detailed in Section 3.7).

The mixing zone modelling focussed on ammonia as the potentially toxic component of the effluent that is assimilated by a) dilution in the near field area through initial mixing with the river and b) nitrification, the biological conversion of ammonia to nitrate. There were two aspects to the assessment of ammonia:

- The requirement that undiluted effluent be non-acutely lethal at the point of discharge. This was calculated without the need for an assimilation model and is based solely on the toxicity of ammonia in the effluent; and
- The determination of the size and characteristics of the mixing zone for ammonia in the West Credit River since this is the volume of water in which concentrations will exceed the PWQO of 0.0164 mg/L of un-ionized ammonia nitrogen (MOE, 1994). The mixing zone is allowed under MOECC surface water quality Policy 5 (MOE, 1994). The size of the mixing zone is determined by modelling the physical mixing of effluent with the river and then setting an ammonia limit for the effluent which will maintain the un-ionized ammonia concentration below the PWQO outside of the mixing zone. For a smaller receiver such as West Credit River, this limit will be lower than that required to maintain non-lethal effluent.

The near-field mixing of the proposed Erin WWTP discharge with the West Credit River was hydrodynamically modeled using CORMIX Version 10.0. CORMIX is a software system developed by Cornell University for the analysis, prediction, and design of aqueous toxic or conventional pollutant discharges into diverse water bodies. The model classifies the discharge configuration into generic flow classifications and then assembles and executes a sequence of sub-models to simulate the hydrodynamic behaviour of the discharge, calculating the plume trajectory, dilution and maximum centerline concentration. CORMIX was used to predict water quality up to and including the point of complete mixing between the effluent and the West Credit River. Downstream of the point of complete mixing, the QUAL2K model was used to predict water quality in the West Credit River, as discussed in Section 3.7.

The basis of the CORMIX model is a flow classification system. The model classifies the discharge configuration into generic flow classifications based on dimensionless length scales (Gomm, 1999). Once the flow has been classified, the model assembles and executes a sequence of sub-models to simulate the hydrodynamic behaviour of the discharge, and calculates the plume trajectory, dilution and maximum centerline concentration. CORMIX uses these different sub-models to predict mixing in both the near-field region and far-field region from the discharge point. The terminology “near-field” and “far-field” in the internal CORMIX usage have no relation to the point of complete mixing – the near-field region refers to the region where the initial jet characteristics, including momentum flux and buoyancy flux, and outfall geometry govern the plume mixing. The “far-field” region is representative of where conditions existing in the ambient environment (such as density current buoyant spreading and passive diffusion within the West Credit River) govern the trajectory and dilution of the plume. The distance to the boundary between the near-field to far-field regions depends on the model input parameters as determined by river characteristics and the scenario modelled (i.e. effluent flow, discharge configuration).

The CORMIX model output displays the predicted centerline concentration moving downstream from the outfall location. The centreline concentration is the maximum concentration and the corresponding x, y and z co-ordinates are returned in the model output (x – longitudinal distance downstream; y – across river width; z – river depth). To compute concentrations laterally outward from the centerline concentration at any given longitudinal point (i.e., x is constant, varying y), the following formula was used:

$$C(n) = C_c e^{-\left(\frac{n}{b}\right)^2}$$ (Equation 8)

Where:

C(n) is the lateral concentration;

C_c is the centreline concentration;

n is the y co-ordinate position measured transversely away from the centreline concentration position y-coordinate; and

b is the plume half-width and the longitudinal position of interest.

Note that this formula can only be applied to the “far-field” predictions of the CORMIX model, which were those areas of the mixing zone governed by buoyant spreading and passive diffusion.

The Erin WWTP discharge to the West Credit River for Phase 1 flows was modeled using CORMIX3, a subsystem which is used for buoyant surface discharges, and schematized as a round pipe located at the water surface level. The Phase 1 flows were also modelled using the CORMIX2 subsystem for multi-port discharges, schematized as a buried 5 m long multi-port diffuser running parallel to the south bank of the West Credit River, with vertical ports located along the river bed. The Full Build Out flows were modelled using the same CORMIX2 system for multi-port discharges.

3.8.1 Model Inputs

Table 6 presents the CORMIX model inputs. Note that the CORMIX model could not be calibrated or validated because no point source currently exists. The rationales for each of the inputs are provided immediately following the table.

Table 6. CORMIX Model Inputs – Total Ammonia Nitrogen

Input Parameter	Effluent Flows		
	Phase 1 – single pipe	Phase 1 – multi-port diffuser	Full Build Out - multi-port diffuser
Effluent Worksheet:			
Conservative/non-conservative pollutant	Non-conservative		
Decay rate (1/d) if non-conservative	5	5	
Discharge Concentration (mg/L)	1.2	0.6	
Discharge excess concentration (mg/L)	1.145	0.545	
Effluent flow rate (m^3/s)	0.039	0.083	
Effluent temperature (°C)	19.0		
Ambient Worksheet:			
Average channel depth (m)	0.4		
Depth at discharge (m)	0.3	0.4	

Input Parameter	Effluent Flows		
	Phase 1 – single pipe	Phase 1 – multi-port diffuser	Full Build Out - multi-port diffuser
Wind speed 2 m above water surface (m/s)	2		
Ambient West Credit River flow rate (m^3/s)	0.225		
Ambient Concentration (mg/L)	0.055		
Bounded width (m)	11		
Bounded appearance	Highly irregular		
Manning's n	0.035		
Ambient temperature (°C)	21.18		
Ambient pH	8.21		
Discharge Worksheet (CORMIX3):			
Discharge bank (looking downstream)	Right	n/a	n/a
Discharge configuration	Flush with bank	n/a	n/a
Horizontal angle (degrees)	90 (pipe enters perpendicular to bank)	n/a	n/a
Discharge pipe diameter (m)	0.2	n/a	n/a
Bottom depth invert (m)	0.2	n/a	n/a
Discharge Worksheet (CORMIX2):			
Discharge bank (looking downstream)	n/a	Right	
Diffuser length (m)	n/a	5	
Distance from bank (m)	n/a	0.5	
Port height above river bottom (m)	n/a	0	
Port diameter (m)	n/a	0.05	
Contraction ratio	n/a	1	
Total # of ports	n/a	10	15
Alignment angle (degrees)	n/a	0 (diffuser is parallel to current)	
Vertical angle of port discharge (degrees)	n/a	90 (vertical, pointing upward)	
Mixing Zone Worksheet:			
PWQO (in mg/L)	0.0164[A]		
Excess concentration for the WQS (mg/L)	0.215		0.195

Notes: A – PWQO for un-ionized ammonia nitrogen; n/a – not applicable

Effluent Worksheet

Parameters may be modeled as either conservative (concentrations are reduced by physical mixing and dilution only) or non-conservative (concentrations are reduced by biological assimilation processes). TAN was modeled as a non-conservative parameter with a rate of decay of 5/d. This is the same nitrification rate used in the QUAL2K model. A literature review of similar streams indicated a range of 0.2 to 9/d (EPA 1985). Note that nitrification is at its maximum at a pH of 8.5, temperatures between 25 and 35°C and in shallow streams, thus medium to high rates would be expected for the West Credit River. TAN concentrations derived for downstream fully mixed by mass balance (Section 3.6) conservatively assumed zero nitrification, so the nitrification rate of 5/d provides a more realistic scenario.

The discharge excess concentration refers to the excess concentration of the effluent above background (i.e., West Credit River at 10th Line) concentrations. The 75th percentile background TAN concentration was 0.055 mg/L (calculated from HESL 2016 and CVC 2007 and 2008 data). For Phase 1 effluent flows, the summer TAN effluent limit is proposed at 1.2 mg/L and for Full Build Out, the TAN summer effluent limit is 0.6 mg/L. Therefore, the discharge excess concentration for Phase 1 was 1.145 mg/L (i.e., 1.2 mg/L – 0.055 mg/L) and for Full Build Out was 0.545 mg/L (i.e., 0.6 mg/L – 0.055 mg/L).

The discharge flows were from results of the TP mass balance modelling: HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/d (0.039 m^3/s) and a Full Build Out flow of 7,172 m^3/d (0.083 m^3/s).

The effluent temperature was the maximum summer value, as proposed in the B.M. Ross 2014 report, *West Credit River Assimilative Capacity Study*.

Ambient Worksheet

The West Credit River flow was assigned the 7Q20 value of 0.225 m^3/s, calculated by CVC (Appendix B). This 7Q20 value includes a 10% reduction as an estimate of future climate change on low flow.

Inputs for the bounded width, and the depth at discharge in the West Credit River near 10th Line were based on measurements collected during the 2016 field events. For the river geometry, CORMIX requires that the cross-section of the river be “schematized” as a rectangular channel. The average depth dimension was calculated based on the depth measurements made 75 m downstream of 10th Line (and outside of the influence of the beaver dam). The depth at discharge was set at 0.3 m for the pipe discharge (Phase 1) since the pipe would be originating from the bank and therefore be a smaller depth than the average depth in the river. For the multi-port diffuser discharge, the depth was set to the full average depth of 0.4 m since the diffuser was modelled as resting on the river bottom.

A wind speed of 2 m/s was used for all scenarios. In the absence of field data, this is the velocity recommended by CORMIX for conservative design conditions.

Manning’s n (describing channel roughness and friction) was set at 0.035 based on hydraulic model calibration completed for the QUAL2K model (Section 3.7). The bounded appearance of “highly irregular” was set based on field observations of the local sinuosity of the river.

The ambient temperature of 21.18°C was the 75th percentile of August 2016 HESL temperature logger measurements at 10th Line.

Discharge Worksheet

Under the “discharge” worksheet, the discharge bank location is the location of the nearest bank to the outfall when facing downstream[2] in the direction of the river flow. For the Erin WWTP outfall, this would be the right bank (i.e., south bank).

For the Phase 1 single pipe discharge scenario:

- The discharge was modelled as being flush with the bank, rather than protruding or co-flowing.
- The horizontal angle was the angle of the discharge channel centreline with respect to the direction of river flow. Since the channel enters perpendicular to the bank, the angle was set to 90°.
- The pipe diameter of 0.2 m and bottom depth invert of pipe of 0.2 m were set based on model runs to minimize the size of the mixing zone.

For the Phase 1 and Full Build Out multi-port diffuser scenarios:

- The diffuser length were set to 5 m, oriented parallel to the bank and river current (i.e., an alignment angle of 0°), at a distance of 0.5 m from the bank. This configuration was set based on model runs to minimize the size of the mixing zone, while allowing for fish passage along the bank opposite to the diffuser.
- The diffuser ports were located along the river bed, oriented vertically upward (i.e., a vertical angle of 90°), with port diameters of 0.05 m. We have proposed 10 ports for the Phase 1 discharge and 15 ports for the Full Build Out discharge. (Therefore five ports would be “closed off” for Phase 1 flows and “opened up” for Full Build Out flows). Recommended pipe discharge velocities are within the range of 3 m/s to 8 m/s (Doneker, 2007). The number of ports and their diameter were based on velocity calculations, and while the resulting velocities at Phase 1 and Full Build Out were on the low end of this range, these smaller velocities prevent the plume from quickly spreading across the width of the river, thereby allowing for fish passage. Detailed modeling of discharge port configuration will be carried out in subsequent project stages.
- The contraction ratio represents the “roundedness” of the discharge port. A ratio of 1 was used to represent a well-rounded port.

Mixing Zone Worksheet

Mixing zone modelling requires calculation of the “excess concentration” for the water quality standard over the upstream (background) concentration, or the amount of additional concentration that could be added to the background concentration to maintain the total concentration below the PWQO.

There is no PWQO for TAN but the PWQO for un-ionized ammonia is 0.0164 mg/L. As such, the maximum excess concentration for TAN in order to remain below the PWQO for un-ionized ammonia was determined by back-calculating TAN from an un-ionized ammonia concentration of 0.0164 mg/L using downstream,

[2] *Note that, conventionally-speaking, bank direction is typically assigned as standing facing upstream. CORMIX assumes facing a downstream direction when assigning bank direction.*

fully mixed pH and temperature values that were derived by mass balance for Phase 1 and Full Build Out flows, and subtracting the upstream TAN concentration of 0.055 mg/L from this concentration (Table 7).

Table 7. Calculated Downstream River pH and Temperature and Maximum Excess Concentration of Total Ammonia Nitrogen in the Effluent, for CORMIX Input

Parameter	Phase 1 (0.039 m^3/s)	Full Build Out (0.083 m^3/s)	Rationale
Upstream West Credit River pH and Temperature	pH – 8.21 Temperature – 21.18°C		• The 75th percentile of CVC hydrolab data (June and Aug 2008) • The 75th percentile of August 2016 HESL temperature logger measurements at 10th Line
WWTP pH and Temperature	pH – 8.6 Temperature – 19°C		• Maximum values, as proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*.
Resulting Downstream pH and Temperature	pH – 8.27 Temperature – 20.86°C	pH – 8.32 Temperature – 20.59°C	• By mass balance
Maximum TAN allowable to meet PWQO for un-ionized ammonia at downstream pH and temperature	0.27 mg/L	0.25 mg/L	• Calculated using equation given in *Water Management* (MOE 1994)
Excess TAN concentration over background	0.215 mg/L	0.195 mg/L	• Subtraction of maximum effluent TAN concentration (row above) from 0.055 mg/L (upstream river TAN concentration)

4. Results

4.1 Water Quality

Water quality results are presented in Table 8. Water quality measurements collected at 10th Line confirmed our understanding of baseline conditions for the West Credit River. In 2016, water quality at 10th Line was very good with low concentrations of suspended sediment (TSS), and nutrients (e.g. nitrate, TKN, TP, and ammonia). Total phosphorus (TP), and un-ionized ammonia nitrogen (UI-TAN) concentrations were well below their PWQO values of 0.03 and 0.0164 mg/L respectively; indicating Policy 1 status for these parameters. Dissolved oxygen concentrations were above the PWQO (temperature dependant), indicating a well oxygenated system. Chloride levels were below the chronic long-term Canadian Water Quality Guideline (CWQG) of 120 mg/L and the acute toxicity guideline of 640 mg/L.

Water samples were also collected at 10th Line in 2007 and 2008 (CVC 2011). This water quality data was used to characterize background water quality to inform the ACS. Water quality from 2016 was similar to water quality data measured in 2007 and 2008 (CVC 2011; Table 8), which the exception of TSS. The detection limit for TSS in 2007 and 2008 (<10 mg/L) was higher than the detection limit (<2 mg/L) and TSS concentrations in 2016, therefore comparisons between these results cannot be made. The 2007, 2008, and 2016 data were used to compute the 75th percentile concentrations for the ACS modelling (as per MOECC guidance, Section 1.4). Due to the differences in TSS detection limits between sampling years, only the 2016 TSS data was used to ensure that background concentrations were not overestimated.

Water quality data collected from the West Credit River at Winston Churchill Blvd. (PWQMN station 06007601502) from 2000-2014 was compared to data collected at 10th Line for 2007, 2008, and 2016. The 75th percentile concentrations computed for Winston Churchill Blvd., are for the most part, similar or lower than the 75th percentile concentrations calculated for 10th Line. The lower concentrations of nutrients at Winston Churchill Blvd. has been attributed (CVC 2011) to the input of groundwater between these two stations. The 10th Line statistics (e.g. 75th percentile, median and average values) are based on 5-15 sampling points collected over 3 years (2007, 2008, and 2016), while the Winston Churchill Blvd. statistics are based on 144-164 sampling points over 14 years (2000-2014). Although the statistics calculated for 10th Line are based on a reduced dataset as compared to Winston Churchill Blvd., the 75th percentile concentrations are more conservative (higher predicted background) than those calculated for Winston Churchill Blvd., and therefore were used as inputs into the water quality models (as recommended by CVC and MOECC).

Table 8. Water Quality of West Credit River

Location	Date	Source	VSS	TSS	TAN	UI-TAN	NO_3-N	NO_2-N	TKN	PO_4	TDP	TP	cBOD	cBODu	Chl a (µg/L)	Cl^-
10th Line	**PWQO/CWQG**					0.02	3	0.06				0.030				120
	27-May-16	HESL	<3	4.8	<0.020	0.0006	1.50	<0.01	0.72	<0.003	0.0059	0.0136	<2	3	3.91	-
	29-Jun-16	HESL	<3	2.4	<0.020	0.0002	1.42	<0.01	0.58	<0.003	0.0062	0.0155	<2	<2	1.97	-
	27-Jul-16	HESL	<3	3.2	0.027	0.0006	1.27	<0.01	0.53	<0.003	0.0113	0.0162	<2	2.7	2.63	-
	25-Aug-16*	HESL	<3	2.0	0.023	0.0016	1.27	<0.01	0.35	<0.003	0.0081	0.0103	<2	<2	2.72	-
	28-Sep-16*	HESL	<3	2.0	<0.020	0.0009	1.58	<0.01	0.39	0.0035	0.0060	0.0088	<2	<2	0.598	50.7
	31-Oct-07	CVC	-	<10	0.030	0.001	2.4	-	0.5	-	-	0.007	<2	-	-	42
	26-Sep-07	CVC	-	<10	0.150	0.011	0.8	-	0.6	-	-	0.030	<2	-	-	23
	26-Nov-07	CVC	-	<10	0.090	0.000	2.3	-	0.4	-	-	0.009	<2	-	-	41
	31-Jan-08	CVC	-	<10	0.070	0.001	2.3	-	0.6	-	-	0.003	<2	-	-	51
	26-Mar-08	CVC	-	<10	0.050	0.000	2.0	-	0.5	-	-	0.014	<2	-	-	52
	29-Apr-08	CVC	-	<10	0.060	0.002	1.5	-	0.5	-	-	0.007	<2	-	-	46
	25-Jun-08	CVC	-	<10	0.010	0.001	1.3	-	0.5	-	-	0.011	<2	-	-	40
	27-Aug-08	CVC	-	<10	0.010	0.000	1.8	-	0.6	-	-	0.015	<2	-	-	47
	30-Sep-08	CVC	-	<10	0.030	0.001	1.7	-	0.5	-	-	0.02	<2	-	-	43
	05-Nov-08	CVC	-	<10	0.030	0.001	1.8	-	0.4	-	-	0.02	<2	-	-	38
	75%		3	3.2	0.055	0.0010	1.9	0.010	0.59	0.003	0.008	0.016	2	2.7	2.72	48.9
	median		3	2.4	0.030	0.001	1.58	0.010	0.50	0.003	0.006	0.014	2	2	2.63	43.0
	n		5	5	15	15	15	5	15	5	5	15	15	5	5	11
Winston Churchill Blvd. (2000-2014)	75%		-	4.0	0.019	0.0003	2.11	0.009	0.43	0.0025	-	0.015	1.0	-	-	-
	median		-	2.3	0.011	0.0002	1.72	0.007	0.36	0.0011	-	0.011	0.6	-	-	-
	n		-	158	164	144	163	164	164	164	-	164	156	-	-	-

*Notes: all values in mg/L unless note;, *water samples collected 75 m downstream of 10th Line; "–" not sampled*

4.1.1 Dissolved Oxygen and Temperature

Diurnal DO and temperature records (June 10 to August 25, 2016) for the West Credit River at 10th Line and Winston Churchill Blvd. are presented on Figures 6 and 7. Dissolved oxygen conditions in the West Credit River were excellent during this period. Concentrations ranged from 6.71 to 12.98 mg/L at 10th Line, and 7.44 to 12.44 mg/L at Winston Churchill Blvd., well above the PWQO of 6 mg/L for water temperatures of 10 ºC or more (Figures 6 and 7). Nighttime maxima for dissolved oxygen indicated supersaturated conditions. Minimum dissolved oxygen concentrations were slightly higher, and maximum concentrations were slightly lower at Winston Churchill Blvd. (Table 9) than 10th Line, indicating lower diurnal fluctuations in dissolved oxygen. Groundwater discharge in this reach reduced the temperature (Table 9) which would increase dissolved oxygen minima.

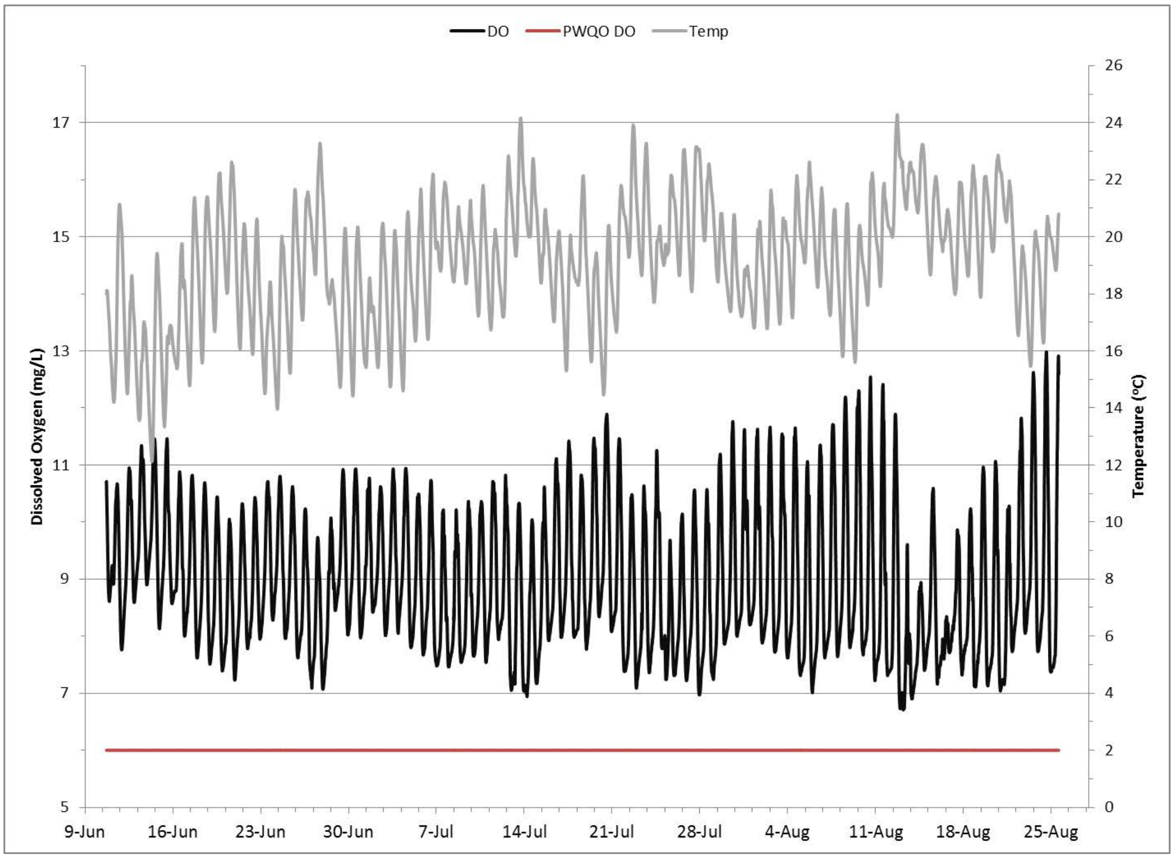


Figure 6 Continuous Dissolved Oxygen and Temperature measurements in the West Credit River at 10th Line (June 10 to August 25 2016)

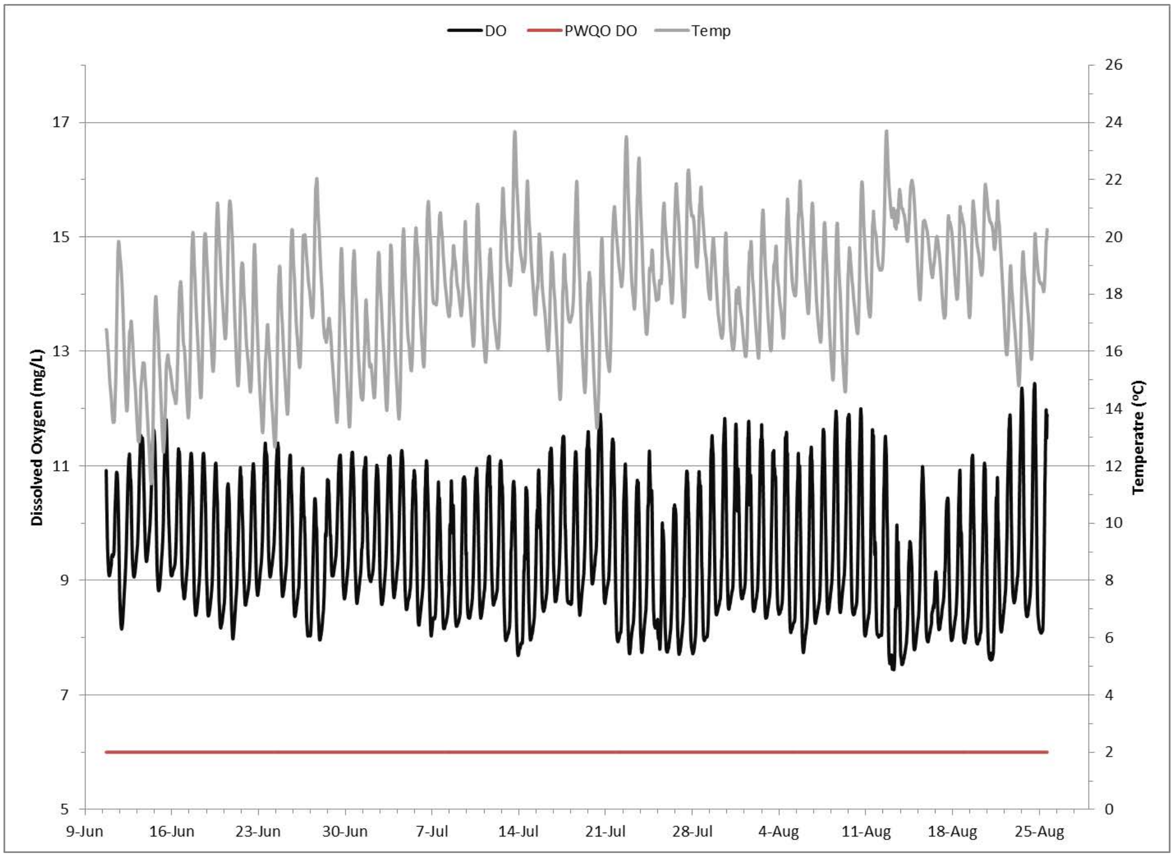


Figure 7 Continuous Dissolved Oxygen and Temperature measurements in the West Credit River at Winston Churchill Blvd. (June 10 to August 25 2016)

Twenty fifth (25th) percentile dissolved oxygen concentrations were calculated (Table 9) for each location as input into the QUAL2K model. Twenty fifth percentile concentrations calculated for 10th Line were lower than those calculated for Winston Churchill Blvd., were and thus a conservative estimate of upstream dissolved oxygen conditions for the ACS.

Table 9 Minima, Maxima, and 25th Percentile Dissolved Oxygen Concentrations (mg/L)

	10th Line			Winston Churchill Blvd.		
	Min	Max	25%	Min	Max	25%
June	7.07	11.46	8.28	7.96	11.81	8.89
Jul	6.94	11.89	7.96	7.69	11.90	8.48
Aug	6.71	12.98	7.72	7.44	12.44	8.29
All Data	6.71	12.98	7.93	7.44	12.44	8.5

Water temperatures ranged from 12.12 to 24.28ºC at 10th Line, and 11.38 to 23.70ºC at Winston Churchill Blvd. The maximum water temperatures were below 26 ºC; below CVC's absolute maximum threshold for coldwater habitat. Minimum and maximum water temperatures were slightly lower at Winston Churchill Blvd. than 10th Line (Table 10). The lower water temperatures at Winston Churchill Blvd are likely from groundwater input cooling the water between the two stations. Seventy-fifth (75th) percentile water temperatures were calculated (Table 8) as input into the QUAL2K model. Seventy-fifth (75th) percentile water temperatures calculated for 10th Line were higher than those calculated for Winston Churchill Blvd., and thus are a conservative estimate of upstream water temperatures for the ACS.

Table 10 Minima, Maxima, and 75th Percentile Water Temperatures (ºC)

	10th Line			Winston Churchill Blvd.		
	Min	Max	75%	Min	Max	75%
June	12.12	23.28	19.66	11.38	22.04	18.18
Jul	14.46	24.16	20.66	13.32	23.68	19.53
Aug	15.46	24.28	21.18	14.58	23.70	20.26
All Data	12.12	24.28	20.66	11.38	23.70	19.58

Dissolved oxygen conditions downstream of 10th Line were monitored in September 2016 (Table 11 and Figure 8). Concentrations were well above the PWQO of 6 mg/L for a water temperature of 10 ºC with a minimum concentration of 7.57 mg/L and maximum concentration of 13.27 mg/L. The diurnal fluctuations in dissolved oxygen decreased around September 7, 2016. At the same time, water temperatures in the river began to show an overall cooling. Minimum and minimum temperatures during this period were 10.08 and 22.36 ºC respectively (Table 11).

Table 11 Summary of Dissolved Oxygen and Water Temperatures 75 m downstream of 10th Line

	DO			PWQO - DO	Temp		
	Min	Max	25%		Min	Max	75%
September	7.57	13.27	8.77	6	10.08	22.36	18.6

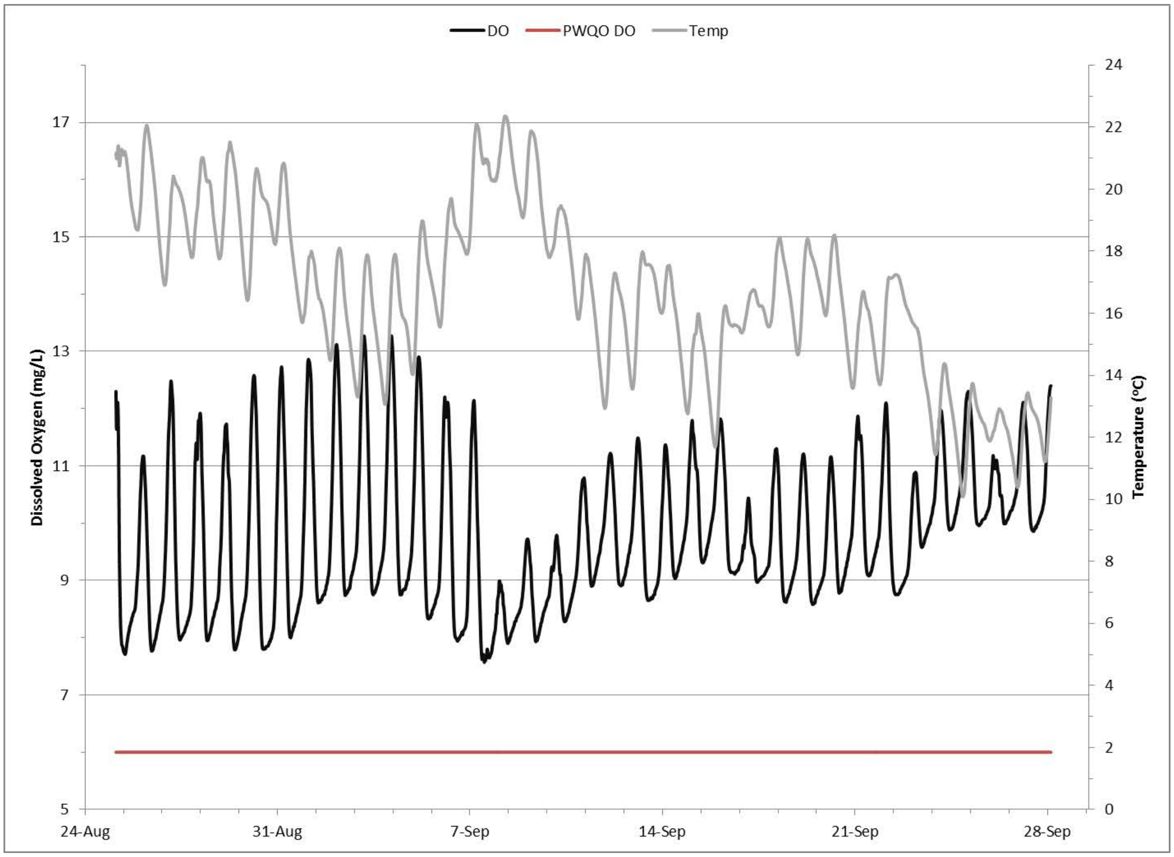


Figure 8 Continuous Dissolved Oxygen and Temperature measured in the West Credit River ~75 m 10th Line (August 25 to September 28, 2016)

4.2 Stream flow

Stream flow was highest in May and decreased throughout the summer months. Flows measured in May, June and July may have been influenced by backwater effects from downstream beaver dam (Table 12). 10th Line flows were greater than the calculated 7Q20 of 225 L/s during each sampling event. The lowest flow of 305 L/s was measured during the August sampling event (downstream of the beaver dam) and was 80 L/s greater than the calculated 7Q20 flow. An increase in flows of 9 to 32% was observed between 10th Line and Winston Churchill Blvd. likely as a result of groundwater inputs.

Table 12 Measured Stream Flows (L/s) in West Credit River

Station	27-May-16	29-Jun-16	27-Jul-16	25-Aug-16	28-Sep-16
10th Line	830 [a]	437 [a]	381 [a]	370 [b]	305 [b]
Winston	N/M	475	502	450	369
% increase	-	9%	32%	22%	21%

Notes: a - downstream beaver dams potentially influencing flow conditions; b – flow measured 75 m downstream of 10th Line; N/M – not measured.

4.3 Stream Characterization

On June 10, 2016 a detailed reconnaissance of the West Credit River study area was undertaken, from 10th Line to Winston Churchill Blvd. A detailed figure showing the river characteristics, distinguishing features such as woody debris, tributary inputs, man-made dams, and the locations of reach breaks (for QUAL2K modelling) was created (Figure 9).

The study area of the West Credit River exhibits an irregular meander pattern. The West Credit River has a relatively moderate trapezoidal cross-section with gentle to steep banks and a bankfull width between approximately 8 m and 12 m within the study area. On the date of the reconnaissance and at all HESL field events (monthly between June and September 2016), the river was easily wadeable.

The water clarity was good, with the river bottom visible. The substrate of the West Credit River in the study area was characterized by fine sediment with some cobbles and rocks. The ratio of fines to rocks/cobbles changed back and forth moving downstream from 10th Line toward Winston Churchill Blvd., but the same combination of substrate was always present (Photograph 4 and 5). A riffle section was noted about 300 m upstream of Winston Churchill Blvd., which was denoted as Reach 5 (Figure 9 and Photograph 6).

The banks were lined with vegetation including tall grasses, shrubs and coniferous trees. Emergent macrophytes were noted along some banks. Bank erosion (under-cutting) was also visible along some bank sections. Beyond the bank vegetation, forest consisting of both coniferous and deciduous trees, lined the north and south banks of river, with the exception of a couple of manicured lawns (residential properties) that were visible on the south river bank.

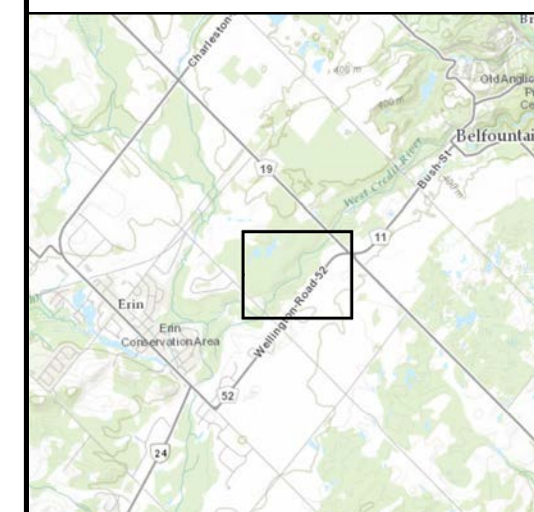
Fallen woody debris altered the river flow in several sections of the West Credit River study area, as identified on Figure 9 (Photograph 7). In some cases, especially in Reach 3 and Reach 4, the woody debris was thick enough that the river could not be walked. While the woody debris was generally naturally occurring as the result of fallen trees in a dynamic system, beaver dams utilizing the fallen woody debris were noted upstream of 10th Line and about 40 m downstream of 10th Line (Photograph 8). (The beaver dam is discussed in Section 3.1).

Occasional growths of submerged aquatic macrophytes were observed in the West Credit River; however, they were not observed in abundance throughout the study area. Attached algae (periphyton) was noted on some cobbles and rocks (Photograph 5).

Man-made dams created out of cobbles were noted at three locations in the study area (Figure 9, Photograph 9). In some cases the dams had been breached in the centre and in all cases the river water level was near the top or above the man-made dam and was not notably altering flows.

Figure 9:
West Credit River Study
Area Characterization

- Intake Pipe
- Man-made Dam
- Culvert
- Tributary Input
- Stream
- Road
- Large Woody Debris
- Reach



N

0 25 50 100 150 200 m

Prepared by: Eric Dilligeard
Data Source: LIO, HESL, Esri Imagery.
Coordinate System: NAD 1983 UTM Zone 17N

Project Lead: Tara Roumeliotis and Deborah Sinclair
Project: Town of Erin Class EA Wastewater Servicing. Assimilative Capacity Study
Project#: 160005

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Three small tributary inputs to the study area were observed on the north bank of the river, in Reach 4 and 5 (Photograph 10). Flows were observed to be low and their influence was captured in the measured increase in flow between 10th Line and Winston Churchill Blvd. (Table 12). The flow contribution from these small tributaries did not have a notable impact on the total flow in the river.

An intake pipe located on the north bank and a culvert located on the south bank were observed, both in Reach 5 in the vicinity of the residential properties. At the time of the reconnaissance, the intake pipe was not drawing water and there was no discharge from the culvert.

The bridge crossings at 10th Line (Photograph 11) and Winston Churchill Blvd. (Photograph 12) represent the only potential human contact points in the West Credit River study area, with the exception of the residences located along the north and south banks in the latter half of the study area. The area near the West Credit River at Winston Churchill Blvd. appears to be a well-visited location and groundwater was flowing from riverbank seeps and drainage pipes to the river (Photograph 13).

Photograph 4. River substrate is mostly fine sediments with few cobbles near 10th Line

Photograph 5. River substrate is fines with cobbles near Winston Churchill Blvd. Note the periphyton on the cobbles

Photograph 6. Riffle section within the West Credit River study area, looking upstream

Photograph 7. Woody debris within the West Credit River study area

Photograph 8. The beaver dam located approximately 40 m downstream of 10th Line, looking upstream

Photograph 9. Breached man made dam within West Credit River study area, looking upstream

Photograph 10. Small tributary entering north bank of West Credit River

Photograph 11. Bridge located at 10th Line, looking downstream

Photograph 12. East side of culvert located at Winston Churchill Blvd., looking upstream

Photograph 13. Groundwater seep at Winston Churchill Blvd

4.4 Dye Tracer Study

Tracer testing was conducted in the West Credit River between 10th Line and Shaws Creek Road (downstream of Winston Churchill Blvd.) on August 25, 2016. The volume of Rhodamine WT 20% dye added to the 10 L bucket of West Credit River water was determined to be 455 mL based on Equation 1.

Figure 10 presents the Rhodamine WT concentration over time, as recorded at each of the fluorometer stations during the slug injection tracer test.

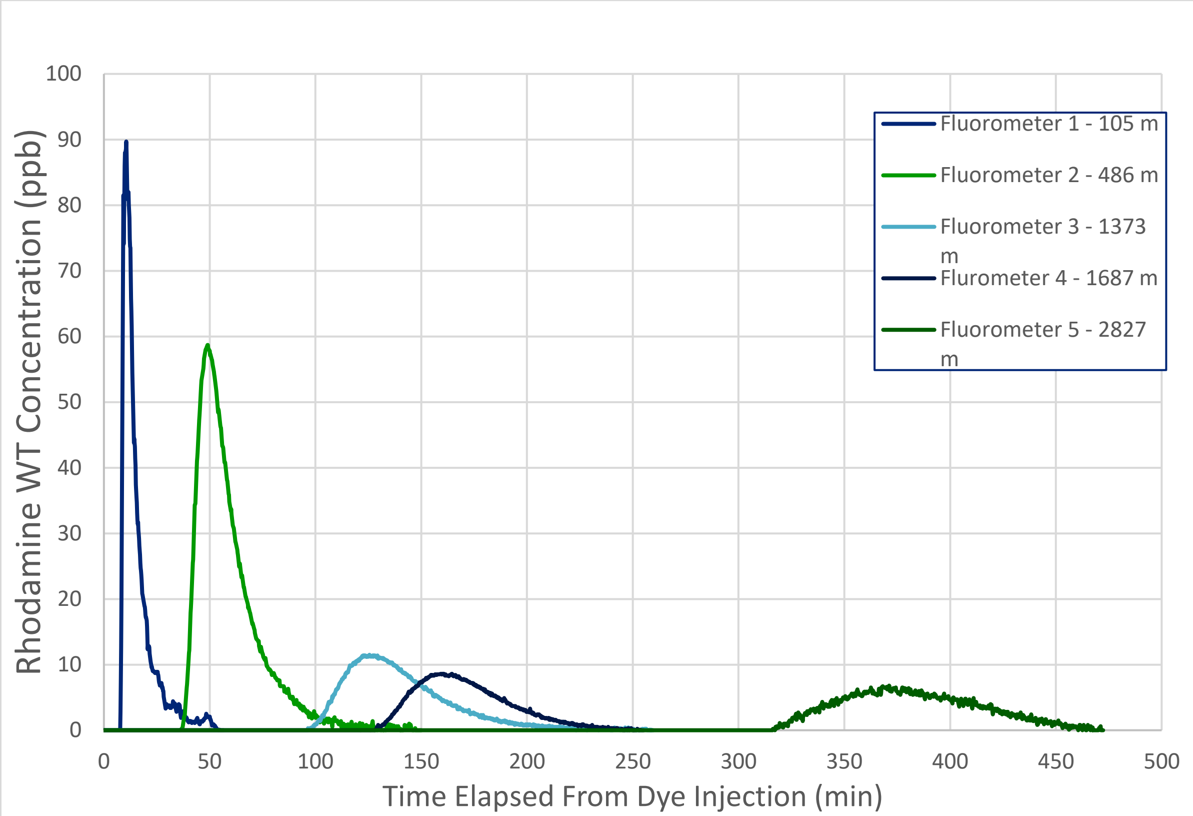

Figure 10 Slug Injection Test Results

The data obtained from the slug injection tests showed that dye dispersion in West Credit River behaved in the expected manner (as per Figure 10) and could therefore be used to determine the time of travel between the dye injection point and each fluorometer station. Data are presented as total travel time (in minutes, Table 13), average velocity (in m/s) between each fluorometer station (Table 14), and longitudinal dispersion (in m^2/min) between each fluorometer station (Table 15).

Table 13. Travel Time Between Fluorometer Stations

Fluorometer	Time of Travel (min)
1 (105 m)	16
2 (486 m)	59
3 (1,373 m)	140
4 (1,687 m)	171
5 (2,827 m)	382

Table 14. West Credit River Velocity (m/s) between Fluorometer Stations

Upstream Fluorometer	Downstream Fluorometer				
	Fluorometer 1	Fluorometer 2	Fluorometer 3	Fluorometer 4	Fluorometer 5
Fluorometer 1	x	0.15	0.17	0.17	0.12
Fluorometer 2	x	x	0.18	0.18	0.12
Fluorometer 3	x	x	x	0.17	0.10
Fluorometer 4	x	x	x	x	0.09
Fluorometer 5	x	x	x	x	x

*Table should be read as the dispersion between the upstream fluorometer (list in 1st column) and the next fluorometer of interest, by reading along the appropriate row.

Table 15. West Credit River Longitudinal Dispersion (m^2/min) between Fluorometer Stations

Upstream Fluorometer	Downstream Fluorometer				
	Fluorometer 1	Fluorometer 2	Fluorometer 3	Fluorometer 4	Fluorometer 5
Fluorometer 1	x	51	139	164	184
Fluorometer 2	x	x	203	222	194
Fluorometer 3	x	x	x	264	158
Fluorometer 4	x	x	x	x	135
Fluorometer 5	x	x	x	x	x

*Table should be read as the velocity between the upstream fluorometer (list in 1st column) and the next flurometer of interest, by reading along the appropriate row.

The average West Credit River velocity for the August 25, 2016 slug injection test was calculated as 0.17 m/s between 10th Line and Winston Churchill Blvd. (Table 14). The data also show that the river moves more slowly downstream of Winston Churchill Blvd., toward Shaws Creek Road.

4.5 Mass Balance Modelling – Total Phosphorus, Total Ammonia Nitrogen and Nitrate

The treated effluent flows from the proposed Erin WWTP are limited by total phosphorus concentrations with respect to both treatment technology limits for TP removal in wastewater and the need to maintain fully mixed TP concentrations in the West Credit River within their site-specific water quality objective of 0.024

mg/L (Appendix D). A mass balance model was used to back-calculate maximum effluent flows based on varying effluent TP concentrations, 7Q20 low flows in the West Credit River, and a fully mixed downstream TP concentrations of 0.024 mg/L in the river (Table 16).

Table 16. Maximum WWTP Effluent Flows Corresponding to Effluent TP Concentrations and a Downstream TP Concentration of 0.024 mg/L

Effluent Total Phosphorus Concentration (mg/L)	Maximum WWTP Effluent Flow (m^3/d)
0.15	1,234
0.1	2,046
0.07	3,380
0.05	5,982
0.045	7,406

Based on the results of the TP mass balance modelling, HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/s and a Full Build Out flow of 7,172 m^3/s corresponding to effluent total phosphorus concentrations of 0.07 and 0.046 mg/L respectively.

Using these Phase 1 and Full Build Out effluent flows, mass balance modelling of TAN and nitrate were carried out to determine appropriate WWTP effluent limits for these parameters. The resulting effluent limits were then confirmed using the far-field QUAL2K model, and in the case of TAN, the near-field (mixing zone) CORMIX model.

The TAN mass balance results are presented in Table 17. The corresponding un-ionized ammonia concentrations were computed using the fully mixed downstream pH and temperature (see Table 6 for particulars on downstream mass balance of pH and temperature), and compared against the PWQO of 0.0164 mg/L un-ionized ammonia nitrogen (Table 18).

Table 17. Fully Mixed Downstream Total Ammonia Nitrogen Concentration (mg/L) for Varying Effluent Concentrations, at Phase 1 and Full Build Out Effluent Flows

Effluent Flow (m3/d)	Effluent Concentration			
	TAN=1.2 mg/L	TAN=1.0 mg/L	TAN=0.8 mg/L	TAN=0.6 mg/L
Phase 1 – 3,381	0.22	0.20	0.17	0.14
Full Build Out – 7,172	0.36	0.31	0.26	0.20

Table 18. Fully Mixed Downstream Un-ionized Ammonia Concentration (mg/L) for Varying Effluent TAN Concentrations, at Phase 1 and Full Build Out Effluent Flows

Effluent Flow (m^3/d)	Effluent Concentration			
	TAN=1.2 mg/L	TAN=1.0 mg/L	TAN=0.8 mg/L	TAN=0.6 mg/L
Phase 1 – 3,381	0.016	0.014	0.012	0.010
Full Build Out – 7,172	***0.028***	***0.024***	***0.020***	0.016

Note: Bold and italicized concentrations represent an exceedance of the PWQO for un-ionized ammonia

As shown in Tables 17 and 18, effluent TAN concentrations were varied from 1.2 mg/L to 0.6 mg/L. At a summer TAN concentration of 1.2 mg/L, which was initially based on email correspondence dated October 3, 2016 from the MOECC providing guidance on effluent limits (Appendix E), un-ionized ammonia concentrations were below the PWQO at fully mixed Phase 1 effluent flows; however, at Full Build Out flows, the PWQO was exceeded. The effluent TAN concentration was decreased until, at a concentration of 0.6 mg/L, the PWQO was met.

As such, summer TAN effluent concentrations of 1.2 mg/L (Phase 1) and 0.6 mg/L (Full Build Out) were carried forward for further examination in the QUAL2K and CORMIX models.

Of note, winter effluent TAN concentrations (of 2 mg/L at both Phase 1 and Full Build Out flows) were also checked to determine the corresponding concentration of un-ionized ammonia. Since speciation of ammonia to its un-ionized state is driven by increasing temperature and pH, un-ionized ammonia at winter temperatures is rarely of concern. In this case, the Phase 1 and Full Build Out flows corresponded with winter un-ionized ammonia concentrations of 0.003 mg/L and 0.006 mg/L, respectively, assuming a water temperature of 4°C. Therefore, the winter effluent TAN concentrations are acceptable.

The nitrate mass balance results are presented in Table 19.

Table 19. Fully Mixed Downstream Nitrate-N Concentration (mg/L) for Varying Effluent Concentrations, at Phase 1 and Full Build Out Effluent Flows

Effluent Flow (m^3/d)	Effluent Concentration	
	Nitrate=6 mg/L	Nitrate=5 mg/L
Phase 1 – 3,381	2.51	2.36
Full Build Out – 7,172	3.00	2.74

At effluent nitrate-N concentrations of 5 and 6 mg/L (which were the effluent objective and limit concentrations proposed in the B.M. Ross, 2014, *West Credit River Assimilative Capacity Study*), the fully mixed downstream nitrate-N concentrations were at or below the CWQG of 3 mg/L nitrate-N for both the Phase 1 and Full Build Out effluent flows. However, nitrification (which would increase the nitrate concentrations in the river) is expected in the West Credit River which is not accounted for in the mass balance model. Given that the effluent nitrate concentration of 6 mg/L results in a fully mixed downstream concentration that is at the CWQG of 3 mg/L, this does not leave any room for the generation of additional nitrate through nitrification. As such, the lower effluent nitrate-N concentration of 5 mg/L was carried forward for further examination in QUAL2K. QUAL2K modelling confirmed that a nitrate concentration of 5 mg/L at Full Build Out flows would maintain the downstream mixed nitrate concentration below the CWQG of 3 mg/L.

4.6 Mass Balance Modelling – Chloride

The current chloride concentrations in the West Credit River are generally low (75th percentile concentration of 48.9 mg/L) and do not vary greatly (median = 43 mg/L). The highest values (50 and 51 mg/L) were observed in January and March, consistent with road salt influence while other potential influences include water softeners and septic systems.

The maximum WWTP effluent chloride concentration was estimated to be 534 mg/L, with average and minimum concentrations of 396 mg/L and 200 mg/L respectively (Appendix D). Predicted chloride levels in the Erin WWTP effluent were developed using data from communities with similar drinking water characteristics to Erin, including the Town of Orangeville, Elora (Wellington County), Arthur (Wellington County) and Mount Forest (Wellington County). Average WWTP effluent average chloride concentrations for these communities was found to be between 197 to 500 mg/L. Maximum WWTP effluent chloride concentrations for these communities ranged between 274 to 713 mg/L. The predicted chloride concentrations in the Erin WWTP effluent was calculated by taking the average of the chloride concentrations in the effluent from the other WWTPs (Appendix D).

The predicted downstream fully mixed chloride concentrations in the West Credit River are 121 mg/L and 180 mg/L for Phase 1 and Full Build Out respectively using the maximum effluent chloride concentration of 534 mg/L and 7Q20 conditions. The Phase 1 concentration is just above the chronic (long-term) CWQG of 120 mg/L, and the Full Build Out concentration of 180 mg/L is 60 mg/L above the chronic CWQG. Using average effluent chloride concentrations, the predicted chloride concentrations in the West Credit River are below the CWQG of 120 mg/L for Phase 1 (100 mg/L, Table 20), and 22 mg/L above the CWQG for Full Build Out (142 mg/L, Table 20). Under both conditions, the predicted receiver concentrations are well below the acute toxicity threshold of 640 mg/L.

Table 20. Fully Mixed Downstream Chloride Concentrations (mg/L) for Varying Effluent Concentrations, at Phase 1 and Full Build Out Effluent Flows

Effluent Flow (m^3/d)	Effluent Concentration	
	Chloride- 534 mg/L	Chloride – 396 mg/L
Phase 1 – 3,381	121	100
Full Build Out – 7,172	180	142

These Cl concentrations were predicted using 7Q20 flows and so do not represent expected concentrations for the long-term indefinite exposures that are relevant to the CCME guideline of 120 mg/L. Exposure to the predicted concentrations (slightly above CCME) would be for brief periods (7 days every 20 years) and aquatic life would be exposed at concentrations well below the short-term exposure CCME guideline of 640 mg/L. We recommend that chloride concentrations in the WWTP influent and effluent be voluntarily monitored by the Town and, if these concentrations approach those used for the mass balance calculations, that the Town consider implementing a public education program focusing on the use of water softeners to mitigate chloride discharge to the sewage system as water softeners are the primary source of chloride levels in wastewater in these areas.

The Town may also consider a road salt and de-icing management and education program. While this would not address chloride source control, it may have a beneficial impact on background chloride concentrations in the West Credit River.

A mussel survey was completed in the WCR from 10th Line to Shaw's Creek Road on October 3, 2017 by Natural Resource Solutions Inc. (NSRI Inc.; Appendix H). The mussel survey was in response to MOECC's comment regarding the projected effect of increased chloride concentrations in the WCR on species at risk (SAR) mussels (Appendix H). The survey found no SAR mussels within the surveyed reach, or review of background information for the WCR. Based on the investigation, the increase in chloride concentrations would not result in impacts to SAR mussels (NSRI 2017 – Appendix H).

4.7 Far-Field Water Quality Modelling (QUAL2K)

Downstream, far-field concentrations of dissolved oxygen, nitrate and un-ionized ammonia, as predicted by the QUAL2K model, were of particular interest. The far-field model results for these parameters are presented in the following sub-sections. All QUAL2K water quality output data can be found in Appendix F. The actual WWTP discharge location has not yet been determined; however, for the purposes of the running the QUAL2K model, the discharge was simulated as entering the West Credit River at 10th Line. This is considered a conservative location since it has been established that water quality in the West Credit River study area improves moving downstream to Winston Churchill Blvd. The choice of the preferred location will also consider the specific ecological sensitivities within this reach of river and factors such as access or cost.

4.7.1 Dissolved Oxygen Far-Field Modelling Results

For the Phase 1 summer low flow scenario, dissolved oxygen concentrations were predicted to decrease by approximately 1 mg/L to a minimum concentration of 6.73 mg/L at a distance approximately 700 m to 1 km downstream of the simulated WWTP discharge location and then begin recovering (Figure 11). As such, dissolved oxygen concentrations were predicted to remain well above the PWQO of 5 mg/L for cold water biota at river temperatures of 20°C and 25°C.

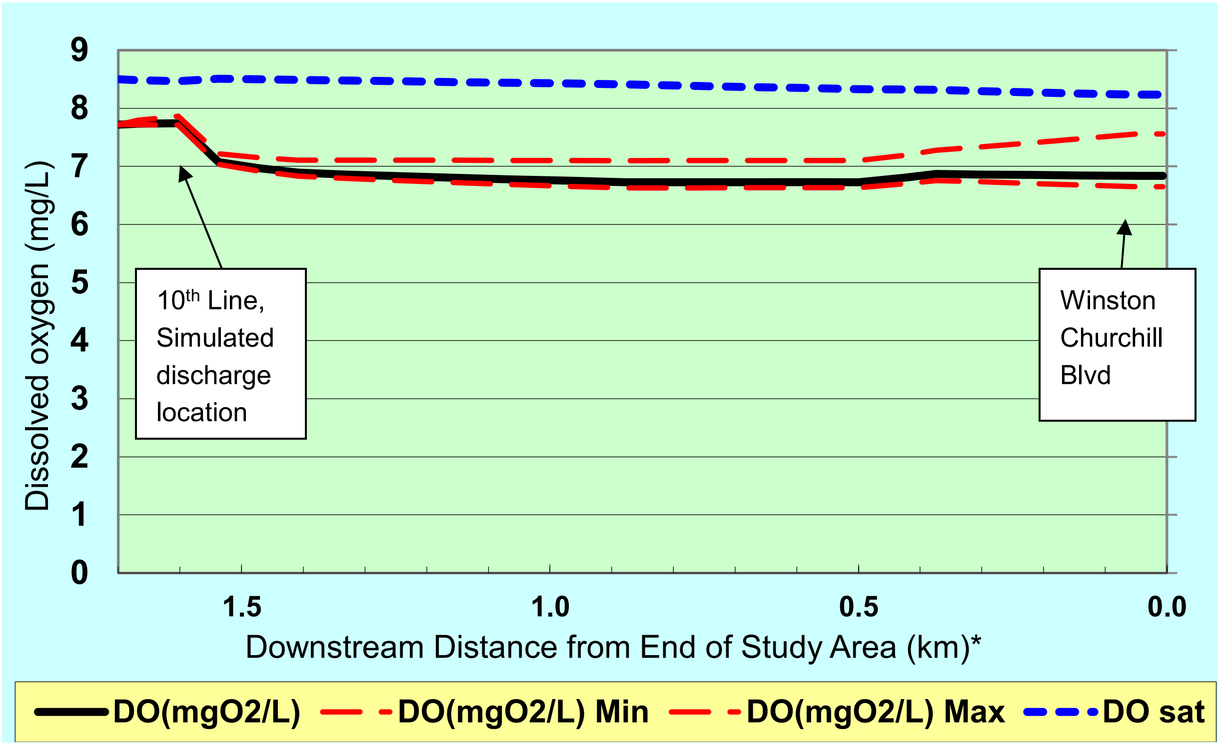

Figure 11. Phase 1: Dissolved Oxygen in the West Credit River Predicted by QUAL2K for Low Summer flow and 5 mg/L Effluent cBOD

*Note: *QUAL2K model calculates using a descending distance from the upstream-most point in the study area. In this case, the model begins at 1.7 km (which corresponds to 100 m upstream of 10th Line) and ends at 0 km (which corresponds to 40 m downstream of Winston Churchill Blvd.).*

For the Full Build Out summer low flow scenario, dissolved oxygen concentrations were predicted to decrease by 1.33 mg/L to a minimum concentration of 6.39 mg/L at a distance approximately 700 m downstream of the simulated WWTP discharge location and then begin recovering (Figure 12). As such, dissolved oxygen concentrations were predicted to remain well above the PWQO of 5 mg/L for cold water biota at river temperatures of 20°C and 25°C.

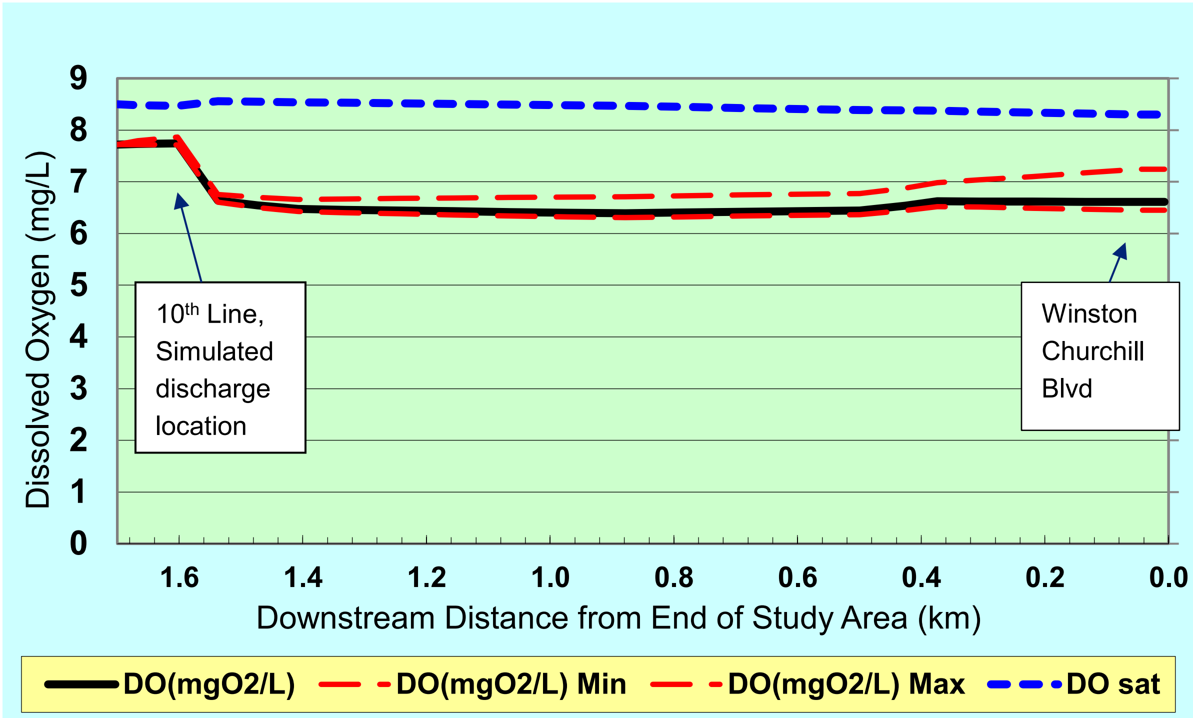

Figure 12. Full Build Out: Dissolved Oxygen in the West Credit River Predicted by QUAL2K for Low Summer flow and 5 mg/L Effluent cBOD

4.7.2 Un-ionized Ammonia Far-Field Modelling Results

For the Phase 1 summer low flow scenario, the maximum un-ionized ammonia concentration beyond the point of complete mixing was predicted at 16.1 µg/L for 1.2 mg/L effluent ammonia (Figure 13), which is below the PWQO of 16.4 µg/L. Un-ionized ammonia concentrations declined to 9.3 µg/L at the downstream edge of the study area.

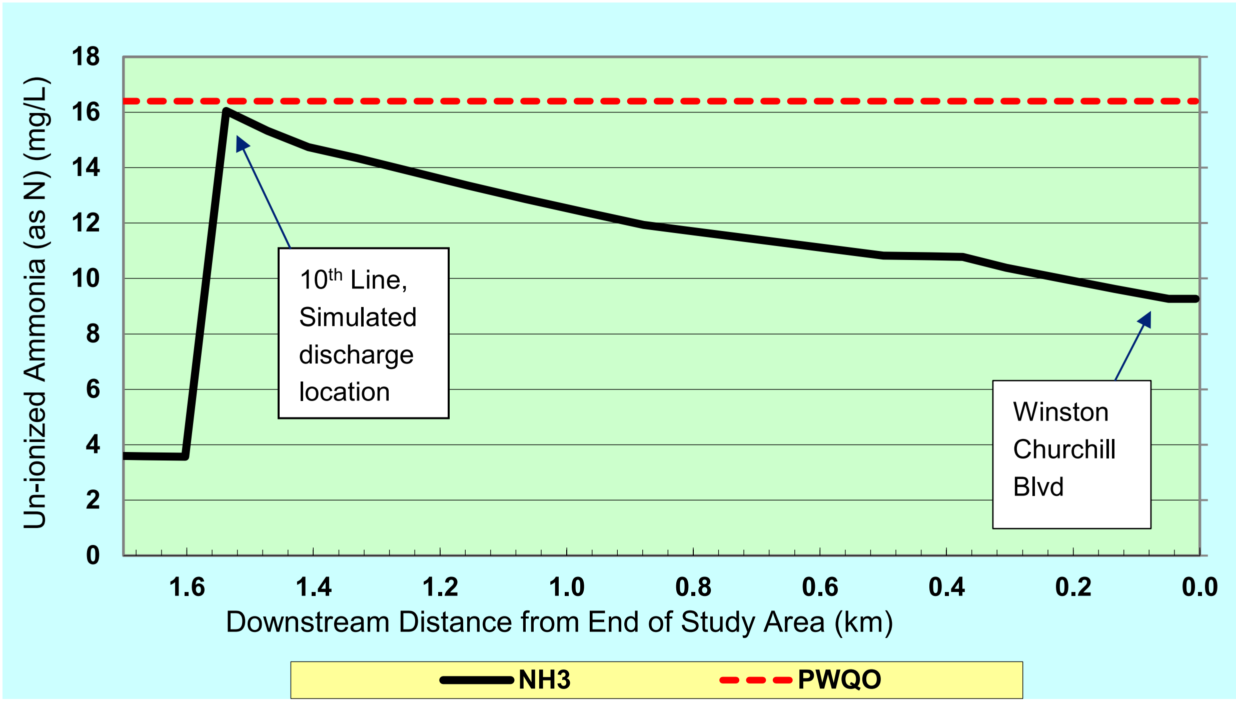

Figure 13. Phase 1: Un-ionized Ammonia in the West Credit River Predicted by QUAL2K for Low Summer flow and 1.2 mg/L Effluent TAN

For the Full Build Out summer low flow scenario, the maximum un-ionized ammonia concentration beyond the point of complete mixing was predicted at 16.1 µg/L for 0.6 mg/L effluent ammonia (Figure 14), which is below the PWQO of 16.4 µg/L. Un-ionized ammonia concentrations declined to 9.9 µg/L at the downstream edge of the study area.

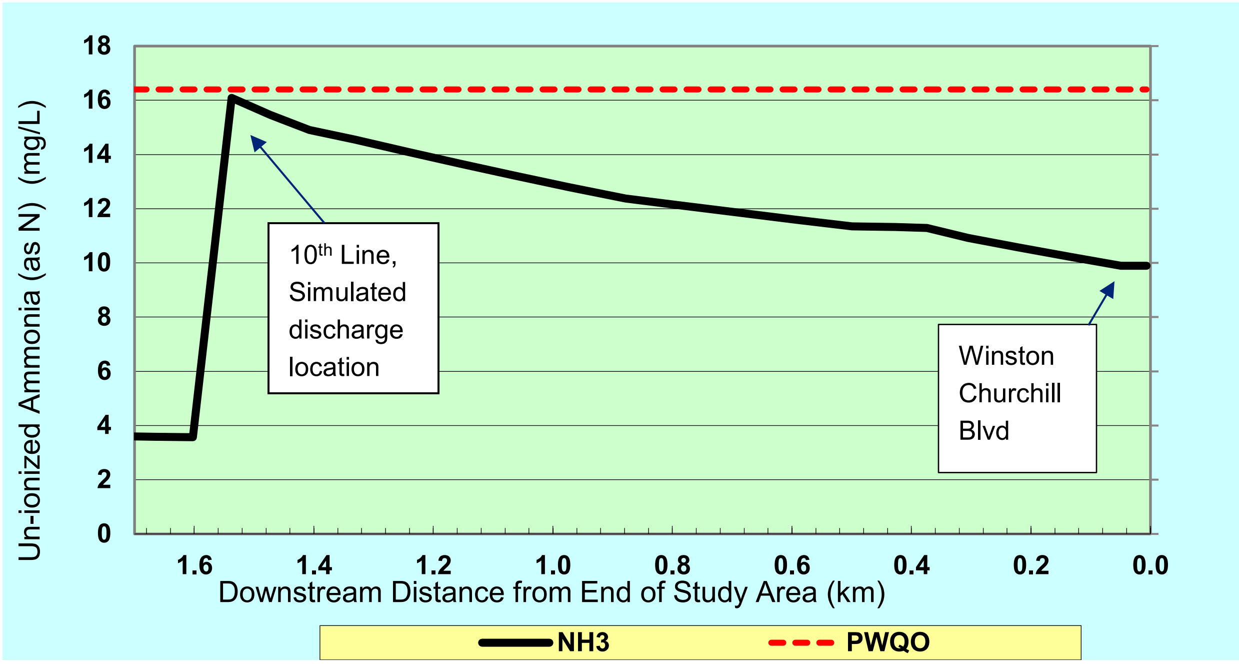

Figure 14. Full Build Out: Un-ionized Ammonia in the West Credit River Predicted by QUAL2K for Low Summer flow and 0.6 mg/L Effluent TAN

4.7.1 Nitrate Far-Field Modelling Results

For the Phase 1 summer low flow scenario, the maximum nitrate concentration beyond the point of complete mixing was predicted to remain below the CWQG of 3 mg/L, with a maximum concentration of approximately 2.4 mg/L (Figure 15).

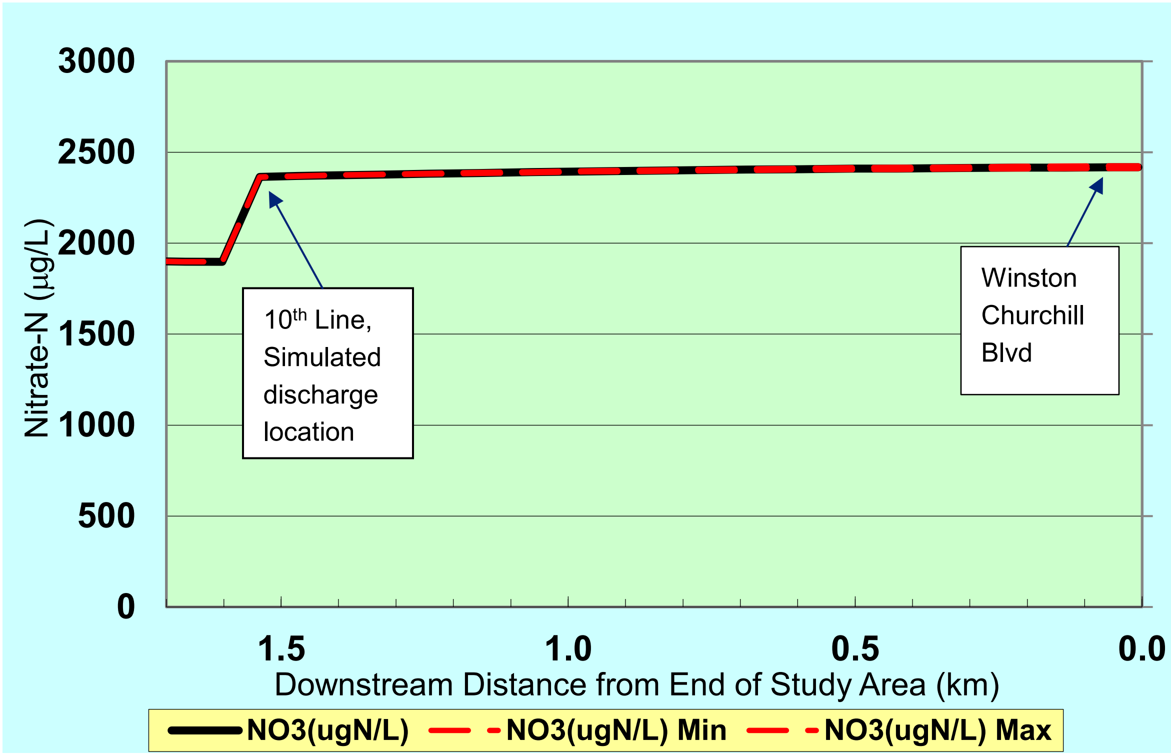

Figure 15. Phase 1: Nitrate-N in the West Credit River Predicted by QUAL2K for Low Summer flow and 5 mg/L Effluent Nitrate-N

For the Full Build Out summer low flow scenario, the maximum nitrate concentration beyond the point of complete mixing was predicted to remain below the CWQG of 3 mg/L, with a maximum concentration of approximately 2.8 mg/L (Figure 16).

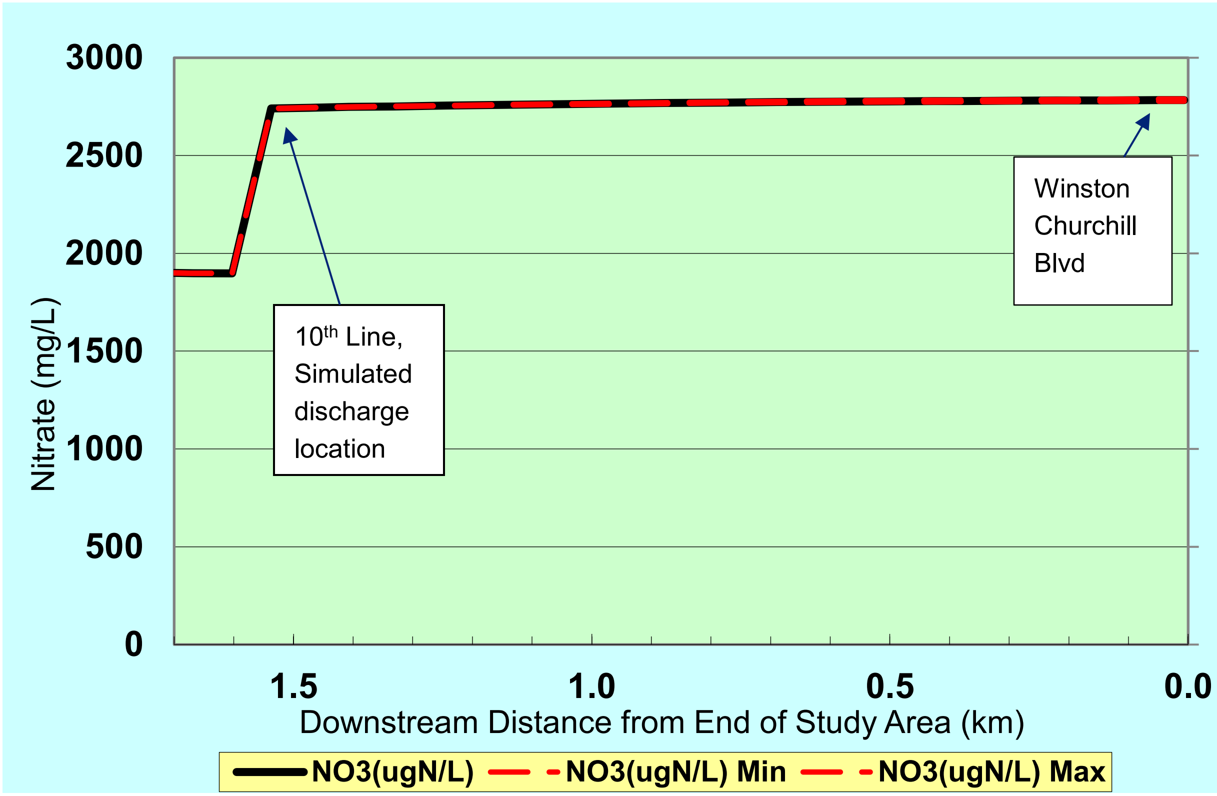

Figure 16. Full Build Out: Nitrate-N in the West Credit River Predicted by QUAL2K for Low Summer flow and 5 mg/L Effluent Nitrate-N

4.7.2 Summary of Far-Field Modelling

The summer low flow Phase 1 and Full Build Out scenarios resulted in dissolved oxygen concentrations above the PWQO at all locations in the West Credit River downstream of the point of complete mixing (Table 21).

Table 21. Overview of QUAL2K Modelling Results for Dissolved Oxygen

Development Phase (Effluent Flow)	CBOD Concentration (mg/L)	Minimum West Credit River Dissolved Oxygen Concentration and Location
Phase 1 (3,380 m^3/d)	5	6.73 mg/L at 0.7 to 1 km
Full Build Out (7,172 m^3/d)		6.39 mg/L at 0.7 km

The summer low flow Phase 1 and Full Build Out scenarios resulted in un-ionized ammonia concentrations below the PWQO at all locations in the West Credit River (Table 22), downstream of the point of complete mixing. The un-ionized ammonia concentrations declined with distance from the outfall and reached concentrations between 9.3 and 9.9 µg/L at the downstream end of the study area (i.e., Winston Churchill Blvd.), 1.5 km from the point of discharge (Table 22). These concentrations are well below the PWQO.

Table 22. Overview of QUAL2K Modelling Results for Un-ionized Ammonia

Development Phase (Effluent Flow)	**Effluent Total Ammonia Concentration (mg/L)**	**West Credit River NH_3 Concentration:**	
		Maximum after discharge (assuming complete mixing, µg/L)	At 1.5 km downstream of outfall (µg/L)
Phase 1 (3,380 m^3/d)	1.2	16.1	9.3
Full Build Out (7,172 m^3/d)	0.6	16.1	9.9

For nitrate-N in both the Phase 1 and Full Build Out summer low flow scenario, the maximum nitrate concentration beyond the point of complete mixing was predicted to remain below the CWQG of 3 mg/L throughout the study area.

Given that the maximum summer water temperature for the WWTP effluent of 19°C is below the 75th percentile West Credit River water temperature of 21.18°C, the input from the WWTP effluent will slightly cool the river temperatures downstream of the outfall.

4.8 Mixing Zone Modelling (CORMIX)

The mixing zone modelling focussed on ammonia as the potentially toxic component of the effluent that is assimilated by a) dilution in the near field area through initial mixing with the creek and b) nitrification, the biological conversion of ammonia to nitrate. There were two aspects to the assessment of ammonia:

- The requirement that undiluted effluent be non-acutely lethal at the point of discharge; and
- The determination of the size and characteristics of the mixing zone for ammonia in the West Credit River.

These two assessment aspects are detailed below.

4.8.1 Effluent characteristics - Non-lethal Effluent Requirement

The MOECC requires that all effluent discharging to surface waters be non-acutely lethal at the end of the pipe. This requires an effluent concentration of 0.27 mg/L or less of un-ionized ammonia (NH_3) as a conservative estimate of the lethal threshold[3]. An effluent pH of 8.6 and temperature of 19°C, were used to estimate un-ionized ammonia concentrations based on recommendations made by B.M Ross (2014). The maximum effluent total ammonia concentration (corresponding to 0.27 mg/L of un-ionized ammonia) was calculated to be 2.1 mg/L. Thus, a total ammonia effluent limit of 2.1 mg/L or less would meet the requirement for non-lethality during the summer discharge period.

4.8.2 Near-Field (Mixing Zone) Model Results – Phase 1

At a Phase 1 effluent flow of 0.039 m^3/s, with the outfall modelled as a pipe discharge at the level of the water surface, pointing perpendicular to the water surface, CORMIX predicted that the plume would immediately attach to the near bank. Mixing was dominated by the initial momentum of the effluent discharge, causing spreading towards the far bank of the river. Following this initial momentum, the cross flow of the West Credit River began to dominate, bending the plume toward the downstream bank. The plume then began to spread laterally (buoyant spreading) while being advected downstream. In the final mixing region, ambient was the predominant mixing process and the plume grew in the vertical and horizontal directions.

The CORMIX model predicted that the plume will encounter the opposite bank at a distance 24 m downstream of the outfall, meet the PWQO of 0.0164 mg/L at 25 m downstream, and become fully mixed at 39 m downstream. Note that although the plume contacts the opposite bank prior to meeting the PWQO, the plume is not homogenously mixed at this point and therefore there is width available for safe passage of aquatic species. Ammonia concentrations laterally across the river at 24 m were computed using Equation 8 to determine the width of the plume that met PWQO at this point (Table 23). The centreline concentration presented in the CORMIX prediction file was located along the nearest river bank.

[3] *The MOECC does not provide formal documented guidance on what levels of un-ionized ammonia are considered acutely toxic. We therefore consulted EPA (2009) which recommends 5 mg/L ammonia nitrogen as a criterion for acute toxicity at pH 8 and 25ºC or, that the average not exceed 4.5 mg/L over any 4 day period. Total ammonia concentrations of 5 and 4.5 mg/L correspond to un-ionized concentrations of 0.27 and 0.24 mg/L respectively at pH 8 and 25ºC. USEPA. 2009. DRAFT 2009 UPDATE AQUATIC LIFE AMBIENT WATER QUALITY CRITERIA FOR AMMONIA – FRESHWATER EPA 822-D-09-001. December 2009. Environment Canada (2009) provide a median LC50 of 0.481 mg/L unionized ammonia (NH_3) for rainbow trout and 1.16 mg/L for the most sensitive daphnid (water flea) species tested. An effluent concentration of 0.27 mg/L or less (as derived using EPA (2009) is therefore a conservative estimate of a concentration that would assure no acute toxicity to test organisms. Environment Canada/Health Canada (2001) Canadian Environmental Protection Act. Ammonia in the Aquatic Environment – Priority Substances List Assessment Report. February 2001. TD195.A44P74 2000.*

Table 23. Total Ammonia Nitrogen Concentrations Laterally Across River at 24 m Downstream (Location where Plume Encounters Opposite Bank) for Phase 1 Pipe Design

Lateral Distance from Centerline Concentration (m)	Total Ammonia Nitrogen Concentration (mg/L)
1	0.269
2	0.264
3	0.256
4	0.244
5	0.231
6	0.215
7	0.199
8	0.182
9	0.166
10	0.150
11	0.134

From Tables 17 and 18, the PWQO for un-ionized ammonia at Phase 1 flows was met at a TAN concentration of 0.27 mg/L. Thus, from Table 23, the PWQO was met at a distance of 1 m from the closest bank (i.e., the location of the centerline concentration). Therefore, there is about 10% of the width of the river available for fish passage.

The Phase 1 flows were also modelled as discharged from a 5 m long diffuser located parallel to the south bank of the river, with 10 ports opening vertically upward. (The Full Build Out flows were modelled as a diffuser discharge, which is discussed further below. Therefore, for consistency, the Phase 1 flows were also modelled as a diffuser discharge).

With the diffuser design, the CORMIX model predicted that the plume will encounter the opposite bank at a distance 72 m downstream of the outfall, meet the PWQO of 0.0164 mg/L at 100 m downstream, and become fully mixed at 121 m downstream. The low velocities from the individual diffuser ports result in less jet momentum spreading the plume across the width of the river. Therefore, there is less initial mixing with river water and the plume requires a larger downstream distance to meet PWQO.

Ammonia concentrations laterally across the river at 72 m downstream were computed using Equation 8 to determine the width of the plume that met PWQO at this point (Table 24). The centreline concentration presented in the CORMIX prediction file was located along the nearest river bank.

Table 24. Total Ammonia Nitrogen Concentrations Laterally Across River at 72 m Downstream (Location where Plume Encounters Opposite Bank) for Phase 1 Diffuser Design

Lateral Distance from Centerline Concentration (m)	Total Ammonia Nitrogen Concentration (mg/L)
1	0.323
2	0.316
3	0.306
4	0.292
5	0.275
6	0.256
7	0.235
8	0.214
9	0.193
10	0.173
11	0.154

For the Phase 1 diffuser scenario at 72 m downstream, the PWQO was met at a distance of 6.5 m from the closest bank (i.e., the location of the centerline concentration). Therefore, there is about 40% of the width of the river available for fish passage.

4.8.3 Near-Field (Mixing Zone) Model Results – Full Build Out

At a Full Build Out effluent flow of 0.083 m^3/s, and the outfall modelled as a pipe discharge at the level of the water surface, pointing perpendicular to the water surface, CORMIX could not predict the downstream mixing with any degree of certainty because the momentum of the Full Build Out effluent flow in comparison to the 7Q20 West Credit River flow resulted in numerous hydraulic jumps in the vicinity of the outfall. Further, the momentum of the discharge caused the plume to spread very quickly across the width of the river (i.e., within a few meters downstream), thus blocking any means of fish passage around the outfall. For these reasons, a multi-port diffuser was designed and modelled. The diffuser was identical in design to the one described above for the Phase 1 discharge, with the exception that there were 5 additional ports (for 15 ports total).

The CORMIX model predicted that the plume will encounter the opposite bank at a distance 42 m downstream of the outfall, meet the PWQO of 0.0164 mg/L at 152 m downstream, and become fully mixed at 187 m downstream. Since the exit velocity of the discharge from the multi-port diffusers is higher for Full Build Out flows than Phase 1 flows, the additional momentum causes the opposite bank to be encountered more quickly than for the Phase 1 scenario (42 m versus 72 m downstream). However, this opposite bank interaction limits the amount of mixing that can occur, resulting in a longer downstream distance to meet the PWQO.

Ammonia concentrations laterally across the river at 42 m downstream were computed using Equation 8 to determine the width of the plume that met PWQO at this point (Table 25). The centreline concentration presented in the CORMIX prediction file was located along the nearest river bank.

Table 25. Total Ammonia Nitrogen Concentrations Laterally Across River at 42 m Downstream (Location where Plume Encounters Opposite Bank) for Full Build Out Diffuser Design

Lateral Distance from Centerline Concentration (m)	Total Ammonia Nitrogen Concentration (mg/L)
1	0.329
2	0.322
3	0.311
4	0.297
5	0.279
6	0.260
7	0.239
8	0.218
9	0.196
10	0.176
11	0.157

For the Full Build Out diffuser scenario at 42 m downstream, the PWQO is met at a distance of 6.5 m from the closest bank (i.e., the location of the centerline concentration). Therefore, there is about 40% of the width of the river available for fish passage.

A 2-d figure showing a top view (i.e., “bird’s eye view”) of the plume created by the multi-port diffuser at Full Build Out effluent flows is presented in Figure 17. The red-shaded regions (which hug the southern bank) represent areas with the highest TAN concentrations.

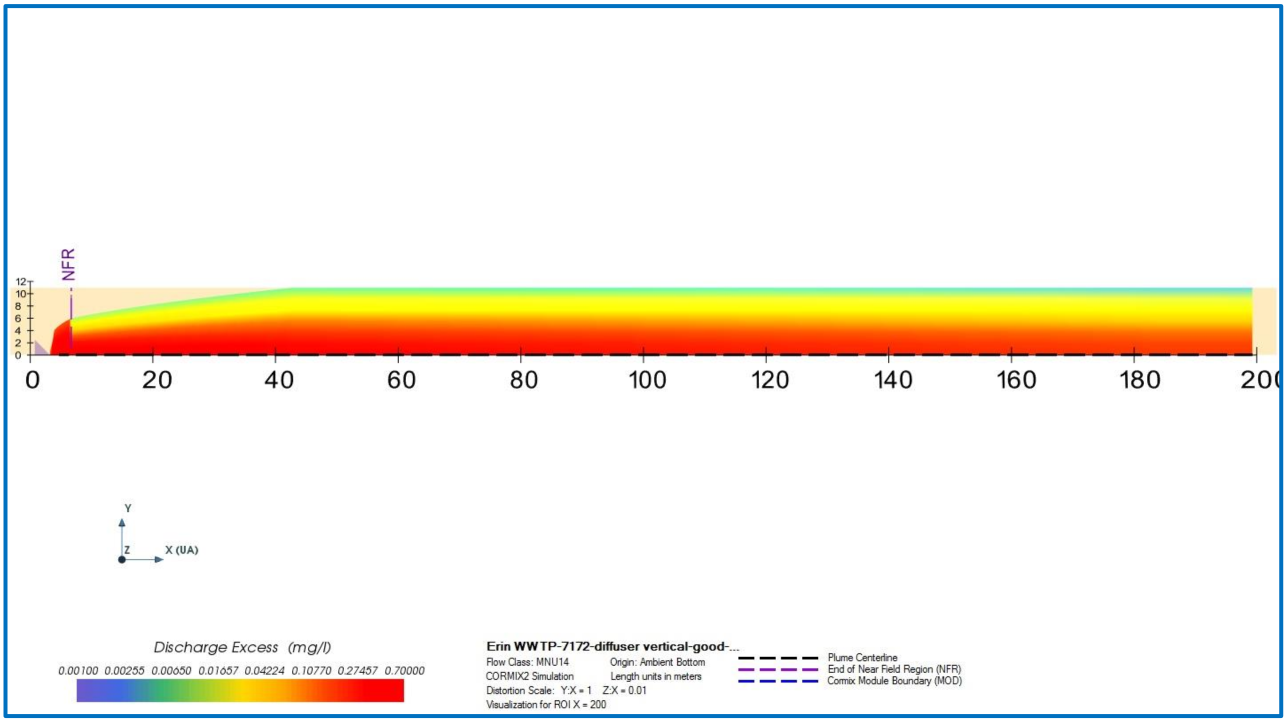

Figure 17. Top View of Full Build Out Discharge Plume for Summer Low River Flow and 0.7 mg/L Effluent Ammonia

4.8.4 Summary of Near-Field CORMIX Modelling

The Phase 1 effluent flow of 0.039 m^3/s was modelled as a pipe discharge at the level of the water surface, pointing perpendicular to the water surface, and also as a multi-port diffuser from a 5 m long diffuser located parallel to the south bank of the river, with 10 ports opening vertically upward. The Full Build Out effluent flow of 0.083 m^3/s was modelled as a multi-port diffuser only, with 15 ports.

The mixing zone results are presented below. CORMIX output results are presented in Appendix G.

Table 26. Summary of CORMIX Mixing Zone Modelling Results

Parameter	Phase 1 Pipe Discharge	Phase 1 Multiport Diffuser	Full Build Out Multiport Diffuser
Distance to Meet PWQO (m downstream of outfall)	25 m	100 m	152 m
Plume Width (% of channel) below PWQO at distance in which plume encounters the opposite bank (representing the narrowest place for safe fish passage)	90%	40%	40%

It is recommended that a detailed design of the outfall pipe or diffuser be carried out prior to construction activities. For example, a staged outfall, with a pipe at bank for Phase 1 and the multiport diffuser for Phase 2 would provide for optimum effluent dispersion, based on results to date.

5. Summary and Recommended Erin WWTP Effluent Limits

This ACS report provides an update to the preliminary ACS completed as part of Class Environmental Assessment (Class EA) for a communal wastewater and collection system for the Villages of Erin and Hillsburgh. It includes:

- Recent (2016) water quality data collected for the West Credit River at 10th Line;
- An updated 7Q20 low flow statistic for the West Credit River at 10th Line;
- Mixing zone modelling (using CORMIX) to predict the size and shape of the mixing zone; and
- Hydrodynamic, far-field modelling (using QUAL2K) to predict downstream concentrations of oxygen, temperature, nitrate, and ammonia; and
- Effluent limit recommendations to meet PWQOs in the West Credit River;

Water Quality

In 2016 water quality at 10th Line was very good with low concentrations of suspended sediments and nutrients (e.g. nitrate, TKN, TP, and ammonia). Total phosphorus, and un-ionized ammonia nitrogen concentrations were well below their PWQO values of 0.03 and 0.0164 mg/L respectively; indicating Policy 1 status for these parameters. Dissolved oxygen concentrations were above the PWQO (temperature dependant), indicting a well oxygenated system. Water quality data collected from the West Credit River at Winston Churchill Blvd. was compared to data collected at 10th Line. The 75th percentile concentrations computed for Winston Churchill Blvd., are for the most part, similar or lower than the 75th percentile concentrations calculated for 10th Line, due to the likely input of groundwater between to two stations.

Low Flow Analysis

CVC recalculated the 7Q20 low flow statistic for 10th Line, using water level and flow data from 8th and 10th Line for July 2013 to December 2015 (Appendix B). The new 7Q20 flow statistic for 10th Line of 225 L/s includes a 10% reduction to account for effects on climate change. Spot flows were measured monthly by HESL from May to September 2016. The lowest flow of 305 L/s was measured during the August sampling event (downstream of the beaver dam) and was 80 L/s greater than the calculated 7Q20 flow.

Site characterization

The study area of the West Credit River, between 10th Line and Winston Churchill Blvd. exhibits an irregular meander pattern. The river is easily wadeable with gentle to steep banks and a bankfull width between approximately 8 m and 12 m within the study area. The water clarity is good, with the river bottom visible. The substrate of the West Credit River in the study area is characterized by fine sediment with some cobbles and rocks. The ratio of fines to rocks/cobbles changed back and forth moving downstream from 10th Line toward Winston Churchill Blvd. The banks are lined with vegetation including tall grasses, shrubs and coniferous trees. Emergent macrophytes were noted along some banks. Bank erosion (under-cutting) was also visible along some bank sections. Fallen woody debris altered the river flow in several sections of the West Credit River study area.

Dye tracer testing

Tracer testing was conducted on August 25, 2016 under a low flow of 0.37 m^3/s. Based on the dye tracer results, the average velocity in the West Credit River in the study area was calculated to be 0.17 m/s on the day of the tracer test, which was used to hydraulically calibrate the far-field QUAL2K model.

Mass balance modelling

The treated effluent flows from the proposed Erin WWTP are limited by total phosphorus concentrations with respect to both treatment technology limits for TP removal in wastewater and fully mixed TP concentrations in the West Credit River. A mass balance model was used to back-calculate maximum effluent flows based on varying effluent TP concentrations, 7Q20 low flows in the West Credit River, and a fully mixed downstream TP concentrations of 0.024 mg/L in the river. Based on the results of the TP mass balance modelling, HESL was directed by Ainley Group to carry forward a Phase 1 WWTP effluent flow of 3,380 m^3/s and a Full Build Out flow of 7,172 m^3/s, based on an effluent TP concentration of 0.07 mg/L (Phase 1) and 0.046 mg/L (Full Build Out).

Mass balance modelling of total ammonia nitrogen (TAN) and nitrate were also completed as a "starting point" in determining effluent limits for these parameters using the Phase 1 and Full Build Out effluent flows which were derived from the TP mass balance modelling. The mass balance modelling found that at summer temperatures, a TAN concentration of 1.2 mg/L (Phase 1) and 0.6 mg/L (Full Build Out) resulted in fully mixed downstream TAN concentrations that equated to un-ionized ammonia concentrations that were below the PWQO for un-ionized ammonia.

Winter effluent TAN concentrations (of 2 mg/L at both Phase 1 and Full Build Out flows) were also checked to determine the corresponding concentration of un-ionized ammonia. Since speciation of ammonia to its un-ionized state is driven by increasing temperature and pH, un-ionized ammonia at winter temperatures is rarely of concern. In this case, the Phase 1 and Full Build Out flows corresponded with winter un-ionized ammonia concentrations of 0.003 mg/L and 0.006 mg/L, respectively, assuming a water temperature of 4°C. Therefore, the winter effluent TAN concentrations are acceptable.

From the mass balance modelling, the resulting downstream fully mixed chloride concentrations in the West Credit River were 121 mg/L and 180 mg/L at Phase 1 and Full Build Out Effluent 7Q20 flows, respectively. Both fully mixed concentrations were above the chronic CWQG of 120 mg/L, but below the acute CWQG of 640 mg/L and not likely to impair aquatic life.

Far-field (QUAL2K) Modelling

QUAL2K is a one-dimensional (1-D) river and stream water quality model, supported by the United States Environmental Protection Agency (US EPA), which is typically used to assess the environmental impact of pollution discharges along rivers. A wide range of water quality parameters and chemical and biological pollutants within the river can be modelled, including temperature, pH, dissolved oxygen (DO), carbonaceous biochemical oxygen demand (CBOD), nitrogen species, phosphorus species, and suspended solids. The QUAL2K model is known as a far-field model since its water quality predictions apply beyond the point in which the effluent is fully mixed with the river, also known as the far-field.

We limited the far-field modelling to the summer scenario since it is the most critical season due to increased water temperatures which result in increased speciation of ammonia to its un-ionized form.

The summer low flow Phase 1 and Full Build Out scenarios resulted in un-ionized ammonia concentrations below the PWQO at all locations in the West Credit River, downstream of the point of complete mixing.

The un-ionized ammonia concentrations declined with distance from the outfall and reached concentrations between 9.3 and 9.9 µg/L at the downstream end of the study area (i.e., Winston Churchill Blvd.), 1.5 km from the point of discharge (Table 22). These concentrations are well below the PWQO.

For nitrate-N in both the Phase 1 and Full Build Out summer low flow scenario, the maximum nitrate concentration beyond the point of complete mixing was predicted to remain below the CWQG of 3 mg/L throughout the study area.

Mixing Zone (CORMIX) Modelling

The mixing zone modelling focussed on ammonia as the potentially toxic component of the effluent. There were two aspects to the assessment of ammonia:

- The requirement that undiluted effluent be non-acutely lethal at the point of discharge. This was calculated without the need for an assimilation model and is based solely on the toxicity of ammonia in the effluent; and
- The determination of the size and characteristics of the mixing zone for ammonia in the West Credit River since this is the volume of water in which concentrations will exceed the PWQO of 0.0164 mg/L of un-ionized ammonia nitrogen (MOE, 1994). The mixing zone is allowed under MOECC surface water quality Policy 5 (MOE, 1994). The size of the mixing zone is determined by modelling the physical mixing of effluent with the river and then setting an ammonia limit for the effluent which will maintain the un-ionized ammonia concentration below the PWQO outside of the mixing zone. For a smaller receiver such as West Credit River, this limit will be lower than that required to maintain non-lethal effluent.

At an effluent pH of 8.6 and temperature of 19°C, [based on recommendations made by B M Ross [2014]), the maximum effluent total ammonia concentration (corresponding to 0.27 mg/L of un-ionized ammonia) was calculated to be 2.1 mg/L. Thus, a total ammonia effluent limit of 2.1 mg/L or less would meet the requirement for non-lethality during the summer discharge period.

The near-field mixing of the proposed Erin WWTP discharge with the West Credit River was hydrodynamically modeled using CORMIX Version 10.0. The Erin WWTP discharge to the West Credit River for Phase 1 flows was modeled using CORMIX3, a subsystem which is used for buoyant surface discharges, and schematized as a round pipe located at the water surface level. The Phase 1 flows were also modelled using the CORMIX2 subsystem for multi-port discharges, schematized as a buried 5 m long multi-port diffuser running parallel to the south bank of the West Credit River, with vertical ports located along the river bed. The Full Build Out flows were modelled using the same CORMIX2 system for multi-port discharges.

The mixing zone results are presented below.

Table 27. Summary of CORMIX Mixing Zone Modelling Results

Parameter	Phase 1 Pipe Discharge	Phase 1 Multiport Diffuser	Full Build Out Multiport Diffuser
Distance to Meet PWQO (m downstream of outfall)	25 m	100 m	153 m
Plume Width (% of channel) below PWQO at distance in which plume encounters the opposite bank (representing the narrowest place for safe fish passage)	90%	40%	40%

It is recommended that a detailed design of the outfall pipe or diffuser be carried out prior to construction activities.

Recommended Erin WWTP Effluent Limits

Based on the results of the ACS, including mass balance modelling, mixing zone modelling, and far-field modelling, the following effluent limits and loadings are recommended for adoption at the proposed Erin WWTP (Table 28 and 29) for Stage 1 (effluent flow of 3,380 m^3/d) and Full Build Out (effluent flow of 7,172 m^3/d). Ainley Group have developed effluent objectives (Table 28) to ensure these effluent limits can be met (in draft). The ACS shows that a discharge at these concentrations and loads, will maintain West Credit River water quality downstream of the proposed outfall the PWQO/CWQG requirements.

Table 28. Proposed Erin WWTP Effluent Objectives and Limits

	Objectives	Limits	
Parameter	Stage 1[a] and Full Build Out[b]	Stage 1[a]	Full Build Out[b]
TSS	3 mg/L	5 mg/L	
TP	0.03 mg/L	0.07 mg/L	0.045 mg/L
TAN - May 15 to October 15	0.3 mg/L	1.2 mg/L	0.60 mg/L
TAN - October 16 to May 14	1 mg/L	2 mg/L	
NO_3-N	4 mg/L	5 mg/L	
DO	5 mg/L	4 mg/L	
$CBOD_5$	3 mg/L	5 mg/L	
pH	6.5 - 8	6.5 – 8.5	
E. coli	100 cfu/100 mL		

Notes: a - at effluent flow of 3,380 m^3/d, b - effluent flow of 7,172 m^3/d

Table 29 Proposed Erin WWTP Effluent Loading Objectives and Limits (in kg/yr)

	Objectives		Limits	
Parameter	Stage 1[a]	Full Build Out[b]	Stage 1[a]	Full Build Out[b]
TSS	3,701	7,853	6,169	13,089
TP	37	79	86	118
TAN - May 15 to October 15	370	785	1,480	1,571
TAN - October 16 to May 14	1,234	2,618	2,467	5,236
NO_3-N	4,935	10,471	6,169	13,089

Notes: a – based on effluent flow of 3,380 m^3/d, b – at effluent flow of 7,172 m^3/d

6. References

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Appendix A. Pre-Consultation Meeting Minutes

Hutchinson
Environmental Sciences Ltd.

Suite 202 – 501 Krug Street, Kitchener, ON N2B 1L3 │ 519-576-1711

Memorandum

Date: **May 2, 2016**

To: **Barbara Slattery and Craig Fowler (Ministry of Environment and Climate Change), Jennifer Dougherty and Tim Mereu (Credit Valley Conservation)**

From: **Deborah Sinclair, Tara Roumeliotis, Neil Hutchinson**

Cc: **Gary Scott and Joe Mullan (Ainley Group), Christine Furlong (Triton Engineering)**

Re: **J160005 – Town of Erin Class EA – Assimilative Capacity Study Update Work Plan**

This memorandum provides an outline of the assimilative capacity study (ACS) update work plan to be completed as part of Phases 1 and 2 of the Town of Erin Class EA.

1. Background and General Approach to Updating the ACS

The intent of the ACS completed as part of the Servicing and Settlement Master Plan (SSMP) was to assess the feasibility of a wastewater treatment facility (WWTF) with surface water discharge to the West Credit River in the reach between 10th Line and Winston Churchill. The preliminary ACS (by B.M. Ross and Associates) demonstrated this was viable; however recommended that the next phases of the EA should include a review of dissolved oxygen and temperature impacts, and potential for effluent storage. The Ontario Ministry of the Environment and Climate Change (MOECC) concurred (in a letter from Ms. Barbara Slattery dated October 31, 2015 to Ms. Furlong, Triton Engineering) that the original ACS be updated to include hydrodynamic modeling and additional stream flow information collected since the preliminary ACS was completed.

The SSMP identified a general area (along Wellington County Road 52, between 10th Line and Winston Churchill Boulevard) for the location of a wastewater treatment plant (WWTP). As part of the next phases of the EA, the ACS will be updated/refined and detailed modeling (mixing zone model and hydrodynamic far-field model) will be completed for three potential outfall locations. The models will be used to predict water temperature, dissolved oxygen, and nutrient loads in the receiver under a range of WWTP discharge scenarios (e.g. low flow, effluent storage and seasonal discharge). The flow rate and discharge criteria used for the modeling will be finalized in consultation with MOECC, Credit Valley Conservation (CVC) and the Town of Erin.

CORMIX will be used to complete the mixing zone modelling of the WWTP effluent and the West Credit River under a variety of flow scenarios. Oxygen and temperature modelling of the discharge in the River, as requested by the MOECC and CVC and recommended in the preliminary ACS, will be completed using the U.S. EPA's QUAL2K model. The QUAL2K model requires a large number of site-specific physical, chemical and biological information to accurately simulate the effect of the effluent on the receiver. The data to complete the modeling will be assembled from the background data and updated with current water quality, quantity and detailed field studies.

Completion of the ACS Update will occur in two-phases in order to provide the EA team (i.e., Town of Erin, Triton Engineering, Ainley Group) with a reasonable estimate of recommended WWTP effluent limits as soon as possible, as follows:

1) A draft ACS Update report will be completed by late spring/early summer. This report will include the updated 7Q20 and water quality data and use estimates in the modelling work where site specific data has not yet been collected. Draft WWTP effluent limits will be calculated and provided; and
2) A final ACS Update report will be completed in the fall. This report will incorporated the summer field investigations and an updated 7Q20 as modelling inputs and to complement the understanding of receiver water quality and quantity. Effluent limits will be finalized based on the site-specific information.

The following tasks will be completed as part of the full ACS update:

1. Review of preliminary ACS
2. Update to water quality and quantity statistics
3. Pre-consultation meeting with MOECC, CVC and the Town of Erin
4. Field investigations including survey of physical attributes of the West Credit River in the study area, water quality sampling, and a dye tracer study
5. Mixing zone modelling (CORMIX) and Far-field modelling (QUAL2K)
6. Derivation of WWTP effluent limits
7. Reporting and Presentations
8. Follow up meetings with MOECC, CVC and the Town of Erin

These tasks are detailed in the sections below.

2. Task 1 – Review Preliminary ACS

The Preliminary ACS completed by B.M. Ross and Associates (2014) will be reviewed to confirm the approach, water quality parameters modeled, 7Q20 derivation, model assumptions, modeling results, and proposed effluent limits.

3. Task 2 - Update Water Quality and Quantity Statistics

The preliminary ACS used water quality data from the Provincial Water Quality Monitoring Network (PWQMN) station located on the West Credit River at Winston Churchill Boulevard (PWQMN 06007601502) as input to the modeling work. This station is located in the study area and has a long-term record of water quality (1975-2015). We will update the monthly water quality summary statistics for this site to include the 2013 through 2015 data. Water quality parameters for the analysis will include 5-day biochemical oxygen demand (BOD_5), dissolved oxygen, Total Kjeldahl Nitrogen (TKN), total ammonia, un-ionized ammonia, nitrite, nitrate, total phosphorus, total suspended solids, pH, temperature, and *Escherichia coli*. Data will be assessed against the most current applicable Provincial Water Quality Objectives (PWQO; MOE 1994a) and Canadian Water Quality Guidelines (CWQG; CCME 2012) to confirm the policy status of the West Credit River at Winston Churchill Boulevard.

Effluent discharge to any receiver requires the determination that the receiver can effectively assimilate or dilute the effluent. In Ontario streams and rivers, the 7Q20 low-flow statistic is used as a basic design flow to determine the assimilative capacity of a stream or river. The 7Q20 flow represents the minimum 7-day average flow with a recurrence period of 20 years. This value determines the 5% chance of there not being adequate streamflow to properly dilute the point discharge.

A Water Survey of Canada (WSC) gauge located in the West Credit River 8th Line provides a long-term (1983 - present) record of flow. Due to differences in geological conditions between the catchment area of this station and the WWTP study area (i.e., West Credit River between 10th Line and Winston Churchill Boulevard), flows could not be pro-rated for the preliminary ACS (BM Ross 2014). Rather, a new gauging station was established at 10th Line in 2013 to develop a flow transposition factor between the 8th Line and the 10th Line. The 7Q20 flows for 10th Line were determined using this factor. CVC have recalculated the transposition factor using the most recent flow data from 8th Line and 10th Line (e.g. 2013 - 2015), and derived updated monthly 7Q20 statistics for 10th Line. CVC will provide this updated 7Q20 data to Hutchinson Environmental Sciences Ltd. (HESL) in spring 2016 for review and use in the draft ACS update. (This 7Q20 will also be reviewed by Blackport Hydrogeology Inc. and the MOECC). CVC will provide a second updated 7Q20 to HESL in fall 2016 (after the low flow period) for use in the final ACS update. The final updated 7Q20 flow statistic should consider the effects on climate change on low flows.

4. Task 3 – Pre-consultation Meeting with MOECC, CVC and the Town

It has been our experience that early and frequent consultation with regulatory agencies encourages successful approval of ACSs by providing agencies the opportunity to review HESL's approach in advance so that refinements can be made. We propose to schedule a pre-consultation meeting after CVC and MOECC have had an opportunity to review this work plan. The purpose of the meeting will be to discuss any questions or concerns with the proposed work plan (including modeling approach, field investigations, and analyses) to ensure that all aspects of the study are adequately addressed.

5. Task 4 – Field Investigations

CVC completed an extensive Existing Condition Report (CVC 2011) as part of the SSMP, which summarized the existing hydrogeology, hydrology, geomorphology, aquatic ecology (fish and benthos), water quality, and hydraulics in the study area. Much of the information used for the preliminary ACS was collected from this report, as it provides an excellent baseline of the natural environment in the study area.

The updated ACS will draw on information contained in CVC's report, and update it with new information collected as part of the next phases of the EA. In particular, water quality and quantity, aquatic ecology (fish and benthos), terrestrial, and geomorphological investigations and inventories will be used to as inputs to the ACS and/or as part of the impact assessment.

The additional investigations required as part of the ACS as input into the models are described below.

5.1 Physical Attributes

The QUAL2K model requires a spatial segmentation of the receiving stream into a series of constant hydrogeometric characteristics, (i.e. depth, cross sectional area, average velocity and average flow). A good understanding of the physical environment is therefore necessary prior to undertaking the modeling exercise. A comprehensive stream assessment of West Credit River will be undertaken by fluvial geomorphologists and aquatic scientists. The primary objective of the investigation is to define and characterize distinct reaches in the West Credit River (within the study area, between 10^{th} Line and Winston Churchill Boulevard) for input into the hydrodynamic model.

Specific reaches will be defined by their characteristic channel pattern, gradient, dimensions, bed material, and bank composition, as well as riparian and aquatic vegetation and in-stream obstructions (e.g., large woody debris). Developing a detailed image of the study area, both within the mixing zone (near-field) and beyond the point of complete mixing of the effluent and River (far-field), is important to provide a better understanding of the receiving environment and other potential influences on water quality and the assimilation process.

5.2 Water Quality

To simulate downstream water quality, the QUAL2K model requires 5-day and ultimate carbonaceous biochemical oxygen demand ($CBOD_5$ and $CBOD_u$), dissolved oxygen (DO), total phosphorus (TP), orthophosphate, inorganic phosphorus, organic phosphorus, Total Kjeldahl nitrogen (TKN), nitrate (NO_3), nitrite (NO_2), total ammonia, total suspended solids (TSS), chlorophyll *a*, and volatile suspended solids (VSS) concentrations. The relationships and reactions between these variables are used by the model to predict far-field water quality. Monthly water quality sampling in the West Credit River at Winston Churchill Boulevard during low flow conditions (May to September) for these parameters will be undertaken to provide a baseline upon which to use for the model. Some of these parameters (i.e., CBODu, orthophosphate, inorganic phosphorus, organic phosphorus, chlorophyll *a* and VSS) are not routinely collected under the PWQMN program and are required for the QUAL2K model. Therefore, the water quality sampling proposed will build a small dataset with which to use for the modelling.

Diurnal oxygen (DO) surveys will be conducted in the West Credit River during summer low-flow conditions (June through September) to determine baseline oxygen conditions in the river, and determine if oxygen is a limiting factor at night when photosynthesis is low and respiration is high. Optical dissolved oxygen probes (HOBO brand) will be deployed at three locations in the West Credit River between 10^{th} Line and Winston Churchill Boulevard. The probes will measure dissolved oxygen and temperature, which will be used as input into the QUAL2K model, and to assess aquatic habitat conditions in the West Credit River at several different locations.

5.3 Dye Study

A dye study under low flow summer conditions will be conducted in the West Credit River to calculate time of travel and longitudinal dispersion, an input requirement into the QUAL2K model. A slug injection test, where a known amount of tracer is instantaneously injected into the river, will be completed at the preferred discharge location. Fluorometers (YSI 600 OMS instruments equipped with Rhodamine WT optical sensors) will be placed in the river at three locations downstream of the proposed discharge location. Rhodamine WT dye, a fluorescent pink xanthene dye, will be used as the tracer for the study. Rhodamine WT dye is a stable, non-toxic, and chemically unreactive dye that is easily measured in the field. The substance is non-carcinogenic, and is safe if it comes into contact with skin. Results of the dye study (i.e., time of travel and dispersion) will be used an input variables into the QUAL2K model.

6. Task 5 – Modeling

6.1 CORMIX

CORMIX is a mixing zone model developed by Cornell University for the analysis, prediction, and design of aqueous pollutant discharges into diverse water bodies. The model simulates the hydrodynamic behaviour of the effluent discharge and calculates the plume trajectory, dilution and maximum centerline concentration in the river. CORMIX will be used to predict water quality up to and including the point of complete mixing between the WWTP effluent and West Credit River.

The CORMIX model will be created with the measurements collected during the field investigations and all available water quality data (i.e., PWQMN and CVC). The CORMIX model will examine total ammonia nitrogen (with un-ionized ammonia concentrations calculated from field pH and temperature) and TP in order to determine concentrations of these parameters between the outfall and the point of complete mixing. The MOECC and CVC will be consulted to determine if any additional parameters should be modelled within the mixing zone. A mixing zone model will be built for three candidate outfall sites. Various outfall configurations (i.e., co-flowing, protruding, etc.) will be modelled to determine the configuration which results in optimal mixing.

6.2 QUAL2K

QUAL2K is a one-dimensional (1-D) river and stream water quality model, supported by the United States Environmental Protection Agency (US EPA), which is typically used to assess the environmental impact of discharges along rivers. A wide range of water quality parameters and chemical and biological pollutants can be modeled, including temperature, pH, DO (including the sag point location), CBOD, nitrogen species, phosphorus species, and suspended solids. QUAL2K assumes instantaneous complete mixing and as such, will be used to predict water quality in the West Credit River beyond the point of complete mixing (i.e., far-field water quality).

The QUAL2K model will be created with the measurements and water quality data collected from the PWQMN Station, CVC monitoring data, and field investigations outlined above. Similar to the CORMIX modelling, the QUAL2K model will be built and run for three different discharge locations on the West Credit River and under a variety of river flows, including the 7Q20 flow.

7. Task 6 – Derivation of WWTP Effluent Limits

The Ontario Ministry of the Environment and Climate Change (MOECC) have three documents that direct the discharge requirements for waste water treatment plants (WWTP). In *Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy* (MOE 1994a) the MOE provides direction on the management of surface water and groundwater quality and quantity for the Province of Ontario. In *Deriving Receiving Water Based, Point-Source Effluent Requirements for Ontario Waters* (MOE 1994b), the MOE provides guidance with regard to the requirements for point-source discharges and the procedures for determining effluent requirements for an Environmental Compliance Approval (ECA). In the Guideline F-5 Series *Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters* (MOE 1994c), the levels of treatment required are described, along with guidance on deriving effluent limits (concentrations and loading).

For the Erin WWTP, effluent limits will be derived from the results of the ACS, and the loading limits will be based on these effluent limits and the design average daily flow for the plant. The MOECC have recommended that best available treatment technology economically achievable (BATEA) be used in the WWTP design. The effluent limits will be cross-referenced with BATEA levels of treatment to determine the feasibility of the recommended effluent limits before they are proposed. The recommended WWTP effluent limits will be verified in writing with the MOECC, CVC and the Town.

8. Task 7 – Reporting and Presentations

A draft ACS Update report will be completed by late spring/early summer. Draft WWTP effluent limits will be provided in this report. A final ACS Update report will be completed in the fall and will include finalized effluent limits based on the site-specific information collected in summer 2016.

A Public Information Centre (PIC) will also be held in conjunction with the completed ACS update report.

9. Task 8 – Follow up Meetings with MOECC, CVC and the Town

A meeting with MOECC, CVC and the Town of Erin will be held after the final effluent limits are calculated and prior to submission of the final ACS Update report in order to discuss agency comments and/or questions regarding the limits. Additional meetings with MOECC, CVC and the Town of Erin will be held as required.

10. Schedule

The tasks to complete the ACS Update are scheduled as follows (Table 1).

Table 1. Schedule for ACS Update, Town of Erin Class EA

Task	Start	End
Review Preliminary Assimilation Capacity Study	1-Apr-16	15-Apr-16
Collect and review CVC 7Q20 and PWQMN data	12-Apr-16	25-Apr-16
Meeting with MOECC and CVC re: work plan	25-Apr-16	29-Apr-16
Derivation of preliminary effluent limits (modeling)	29-Apr-16	12-May-16
Draft Effluent Objectives and Limits	13-May-16	18-May-16
Draft ACS Update report	19-May-16	29-May-16
Field investigations for model inputs and calibration	1-May-16	30-Sep-16
Update ACS model with field data, update draft report	1-Oct-16	31-Oct-16
Meeting with MOECC and CVC re: effluent limits	1-Nov-16	16-Nov-16
Final Reporting – ACS Update	16-Nov-16	1-Dec-16

11. References

BM Ross. 2014. West Credit River Assimilative Capacity Study. File No. 08128. 124 pgs.

Canadian Council of Ministers of the Environment. 2012. Canadian water quality guidelines for the protection of aquatic life: Nitrate. In: Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

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Ontario Ministry of the Environment (MOE). 1994b. Deriving receiving water based point source effluent requirements for Ontario waters. PIBS#3302 Procedure B-1-5.

Ontario Ministry of the Environment (MOE). 1994c. *Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters;* Guideline F-5 Series

Appendix B. Update of Low Flow Assessment (7Q20) for the West Credit River Assimilative Capacity Study - CVC 2016

Watershed Management

To:	**John Sinnige, Sr. Manager, Water Resources and Flood Risk**	**Date:**	**June 13, 2016**
From:	**Alex Pluchik, Hydrologist**	**Subject:**	**Update of Low Flow Assessment ($7Q_{20}$) for the West Credit River Assimilative Capacity Study (Erin SSMP)**
Cc:	**Neelam Gupta, Manager, Hydrology and Hydraulics**	**Our File:**	**Erin SSMP - ACS**
Cc:	**Jennifer Dougherty, Manager, Water Quality Protection**		

Introduction

This memo summarizes the revision of $7Q_{20}$ values for the West Credit River at 10th line to support the update of the West Credit River assimilative capacity study. The initial assessment was completed at the end of 2013 in support of the Town of Erin Servicing and Settlement Master Plan (SSMP) study and was based on stream flows for the period from July to October 2013 at 10th Line. A similar approach was used to update the $7Q_{20}$ values based on stream flows for the period from July 2013 to end of 2015 (refer to Memo from March 14, 2016). The present memo finalizes the results of $7Q_{20}$ value assessment for the West Credit River at 10th line.

The location of the streamflow stations and proposed location of the WWTP effluent discharge are shown in Figure 1.

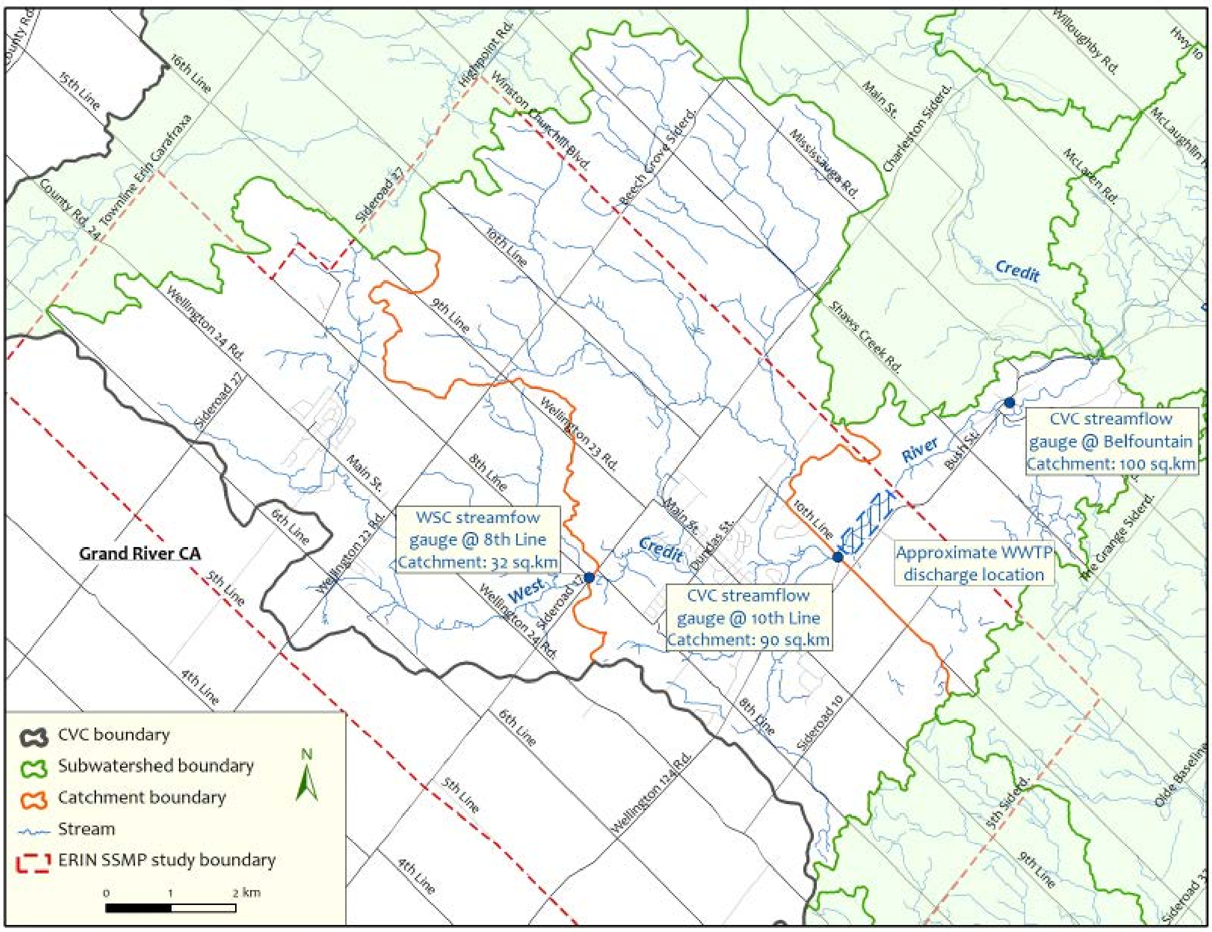

Figure 1: West Credit River watershed relative to the Assimilative Capacity Study limits for the Erin SSMP

Low Flow Analysis

The following methodology was applied to update the $7Q_{20}$ values for the West Credit River at 10^{th} line:

1. Mean daily flow series of the West Credit River at 8^{th} Line (WSC gauge, 1984-2015) were converted to the 7-day mean flows (7-day moving average).
2. Lowest 7-day mean flows for each year of record were collected for the Water Year (October 1-September 30), Summer (July-September), Fall-Winter-Spring (October-June) and for each month of year.
3. Mean daily flow series of the West Credit River at Belfountain (CVC gauge, 2002-2015) were converted to the 7-day mean flows (7-day moving average).
4. Lowest 7-day mean flows for each year of record were collected for the Water Year (October 1-September 30) and Summer (July-September).
5. The CVC real-time streamflow gauge at 10^{th} Line became active and fully operational at the end of July 2013. The development of a rating curve started at the same time. Since then, CVC field staff has measured 20 discharges (16 of them were used for the building of rating curve). The lowest discharges were measured at the end of July 2015; however the 2015 low flows were significantly higher than the low flows of summers 1995-2003 (excepting 1997), 2007 and 2012.

   Continuous water level data (15-min intervals) were converted to a continuous flow record using a rating curve fit equation (Shifted Power Law) developed in the WISKI module SKED (refer to Appendix, Figure A.1).
6. Mean daily and 7-day mean (moving average) flow series for the West Credit River at 10^{th} Line were produced using TSM module of WISKI. 7-day mean flows at the 8^{th} Line (WSC gauge) were paired with corresponding flows at the 10^{th} Line (CVC gauge) for the period of July 2013 – November 2015. These series were sorted by the ratio of 10^{th} Line flows to 8^{th} Line flows in ascending order. To remove outliers, values that lie outside of a band around the mean with a width of two standard deviations were not included for drawing the scatter graph and performing the regression analysis (refer to Appendix A, Figure A.2).
7. Similarly, 7-day mean flows at the Belfountain CVC gauge were paired with corresponding flows at the 10^{th} Line (CVC gauge) for the period of July 2013 – November 2015. These series were sorted by the ratio of Belfountain flows to 10^{th} Line flows in ascending order. Data that was obviously affected by freezing of the CVC Belfountain station were removed. Then values that lie outside of a band around the mean with a width of two standard deviations were not included for drawing the scatter graph and performing the regression analysis (refer to Appendix A, Figure A.3).
8. A regression analysis was executed to explore the relationships between streamflows at 8^{th} Line and 10^{th} Line and also Belfountain and 10^{th} Line. A linear trendline forced to intercept at nil was chosen as the best fit to observed data for both relations (refer to Appendix A, Figures A.2 and A.3). The quality of the regression equations was examined using the following indices: standard deviation of the criterion variable and standard error of estimate, coefficient of determination and F-test. Both regressions were deemed to be significant

given that the computed F-test is greater than F value extracted from the F values distribution table (level of significance = 0.05).

9. The low-flow frequency analysis was performed using the "Low Flow Frequency Analysis Package – LFA" (Environment Canada, September 1988). The program methodology is based on the Gumbel III distribution. This distribution has been recommended by Environment Canada as the best fit for extreme value analysis of low flows in the streams of South Ontario (Condie, Cheng, "Low Flow Frequency Analysis", 1987). Also, the LFA application includes the Cunnane plotting-position formula for estimation the empirical exceedance probability.

10. The low-flow frequency analysis of the West Credit River at 8th Line data was performed for two data sets: 1984-2015 and 2002-2015. Also, the 7-day minimum flows of the West Credit River at Belfountain were processed for period of 2002-2015. The results of calculations ($7Q_{20}$ values) are presented in the Table 1 below and in the Appendix A, Table A.1 and Figures A.4, A.5 and A.6 (Gumbel III and Cunnane frequency curves).

Table 1: $7Q_{20}$ stream flows for the West Credit River gauges of WSC and CVC

(Water Year: Oct 1-Sep 30)

Station location/name	Data Set Period	$7Q_{20}$ (m^3/sec)	$7Q_{20}$ Ratio for 8th Line
8th Line (WSC)	1984-2015	0.123	
8th Line (WSC)	2002-2015	0.172	1.4
Belfountain (CVC)	2002-2015	0.428	

The significant difference between the $7Q_{20}$ values at 8th Line for the different periods (almost 40%) can be explained by the length of analysed data sets. The driest year of the 2002-2015 data set (2003) is positioned at 7th place in 1984-2015 data set, i.e. the 6 years with smallest 7-day minimum flows observed at the 8th Line gauge (flow record from 1981 to 2015) were not measured in the Belfountain gauge (flow record from 2002 to 2015).

11. $7Q_{20}$ values for the West Credit River at 10th Line were computed for period of 2002-2015 using described above two regression equations (one - based on 8th Line data set, second - based on Belfountain gauge data) and are presented in the Table 2 below.

Table 2: 7Q20 stream flows of the West Credit River at 10th line (2002-2015)

Station	$7Q_{20}$ by LFA (m^3/sec)	$7Q_{20}$ at 10th Line by Regression Equation (m^3/sec)	Difference (%)
8th Line (WSC)	0.172	0.350	2.8
Belfountain (CVC)	0.428	0.360	

Comparison of results, which are very close (difference is less than 3%), verifies accuracy of methodology used to calculate streamflow at 10th Line.

12. $7Q_{20}$ values for the West Credit River at 10th Line were computed using the results of the low-flow frequency analysis of 8th Line data for period 1984-2015 and described above regression equation between streamflows at 8th Line and 10th Line (refer to Appendix A, Table A.1). Using this time period, a water year $7Q_{20}$ of 0.250 m^3/sec was calculated, which is very similar to the water year $7Q_{20}$ of 0.246 m^3/sec calculated in the March 2016 memo.

Review of Results

1. A slight increase was found between the $7Q_{20}$ values for the West Credit River at 10th Line computed for Water Year, Summer Season and September and provided in present and previous memos: 1.9%, 5.2% and 5.5 % respectively (refer to Appendix A, Table A.1). However, for the rest of year the $7Q_{20}$ increase is varying from 10% (August and Fall-Winter-Spring Season) to 19% (November, December and May). This increase can be clarified by using more statistically valid approach of selecting data for performing the regression analysis (refer to paragraphs 6 and 7). It allowed developing new linear regression equation between 7-day streamflows at 8th Line and 10th Line. Accuracy of this approach was verified by using streamflow data of Belfountain gauge (refer to paragraph 11).
2. The $7Q_{20}$ values calculated for the West Credit River at 10th Line in the previous memos have included a climate change impact factor. Therefore, the calculated value of $7Q_{20}$ was reduced by 10%. For consistency results the same approach was used to **update the $7Q_{20}$ value for the Water Year at 10th Line, which equals to 0.225 m^3/sec (Table A.1)**, i.e. deviation from the March 2015 value is less than 2%.

APPENDIX A

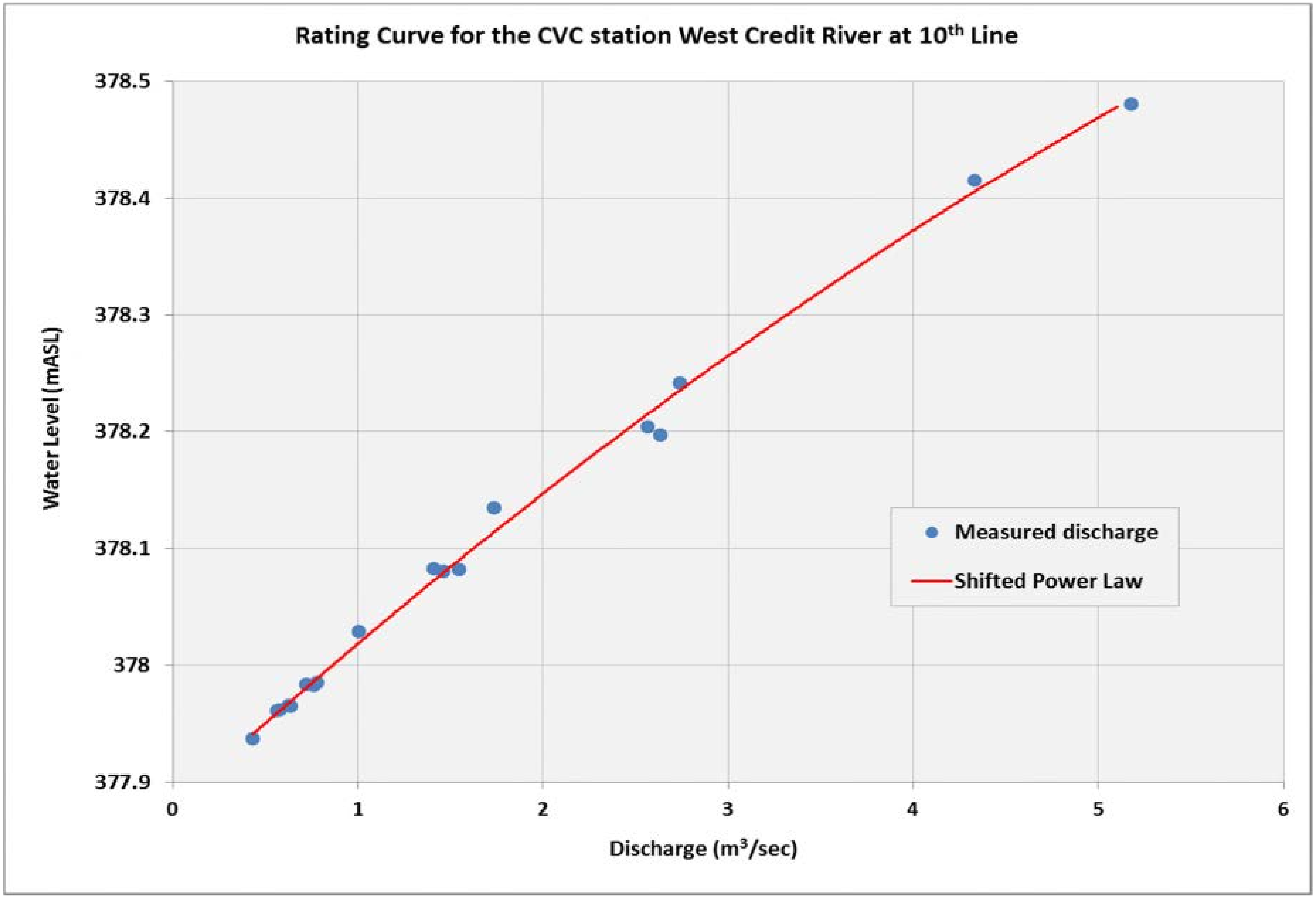

Figure A.1 Rating Curve for the CVC station West Credit River at 10th Line

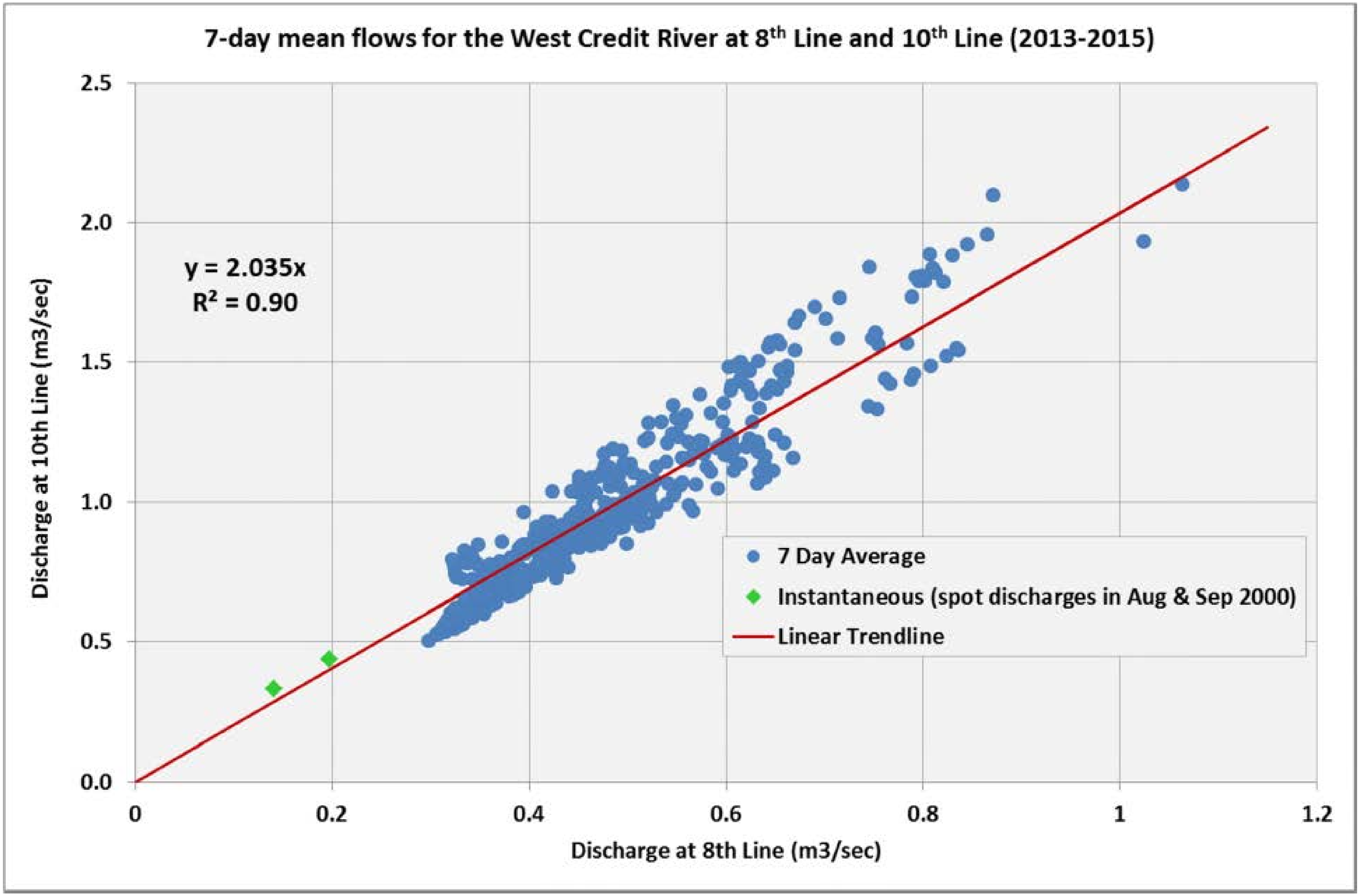

Figure A.2 Scatter graph of 7-day mean flows for the West Credit River at 8 th Line and 10th Line (July 2013 - November 2015)

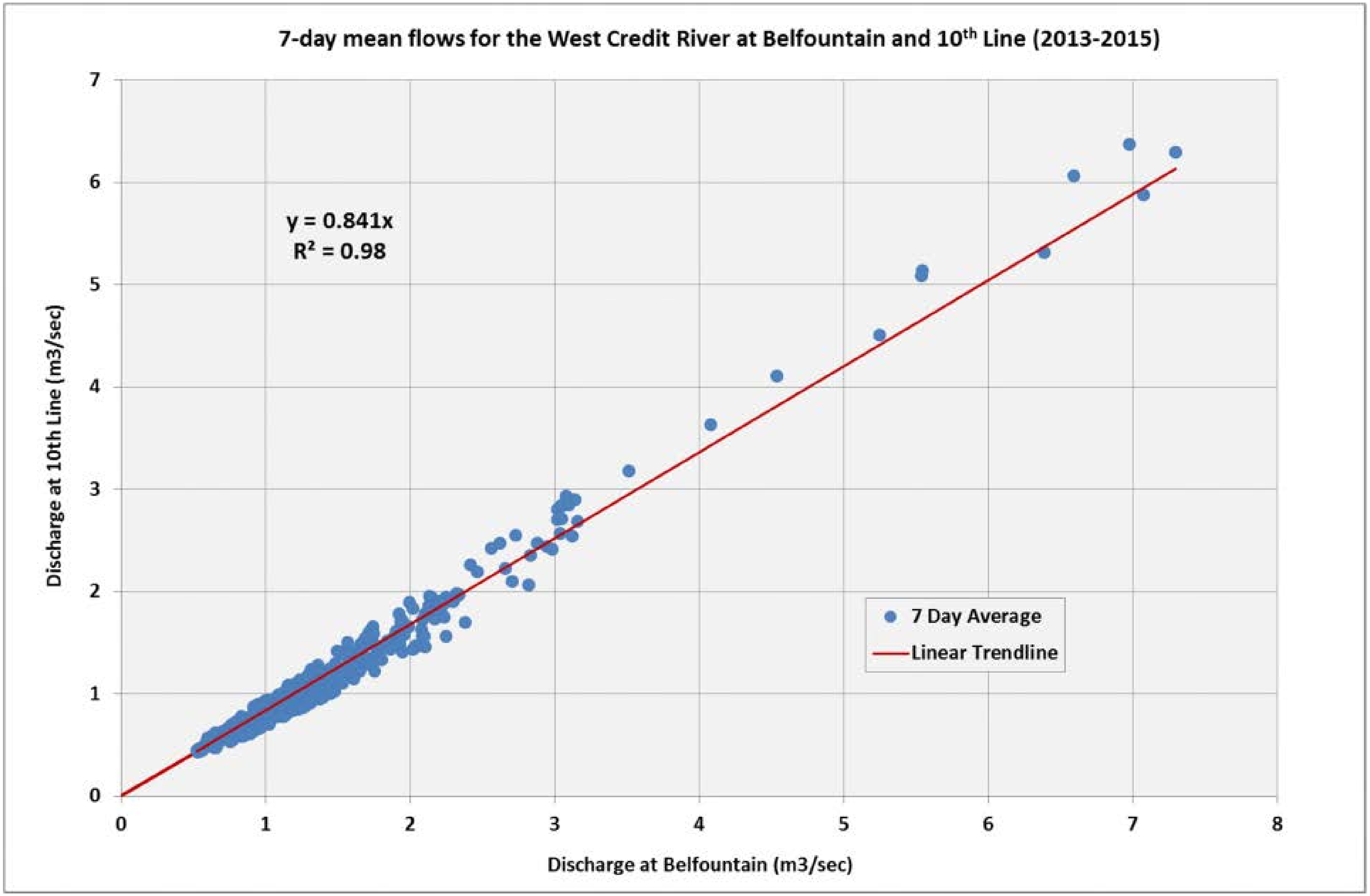

Figure A.3 Scatter graph of 7-day mean flows for the West Credit River at Belfountain and 10 th Line (July 2013 - November 2015)

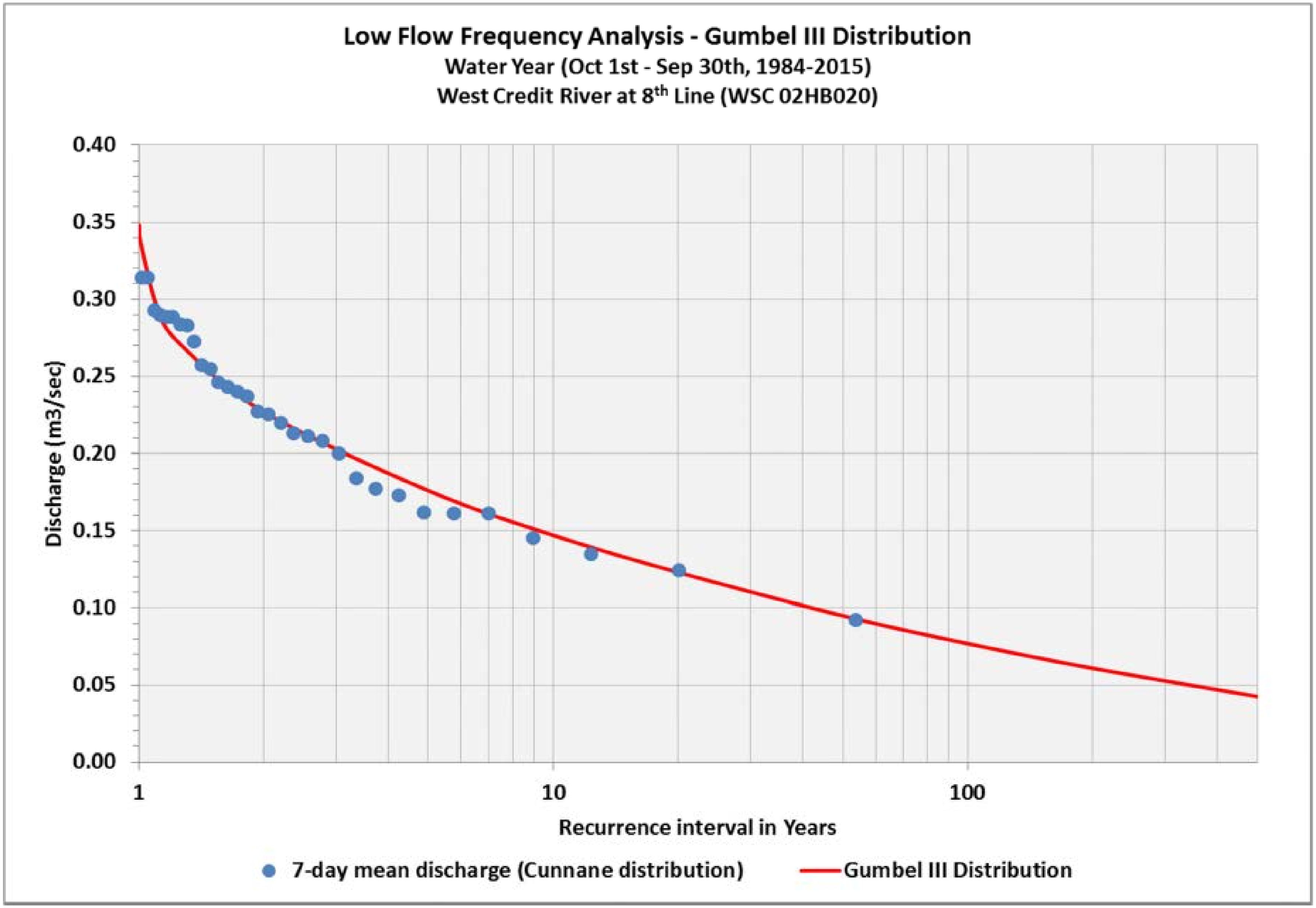

Figure A.4 **Gumbel III and Cunnane frequency distributions of minimum 7-day discharges for the West Credit River at 8 th Line (WSC gauge 02HB020) for Water Year (1984-2015)**

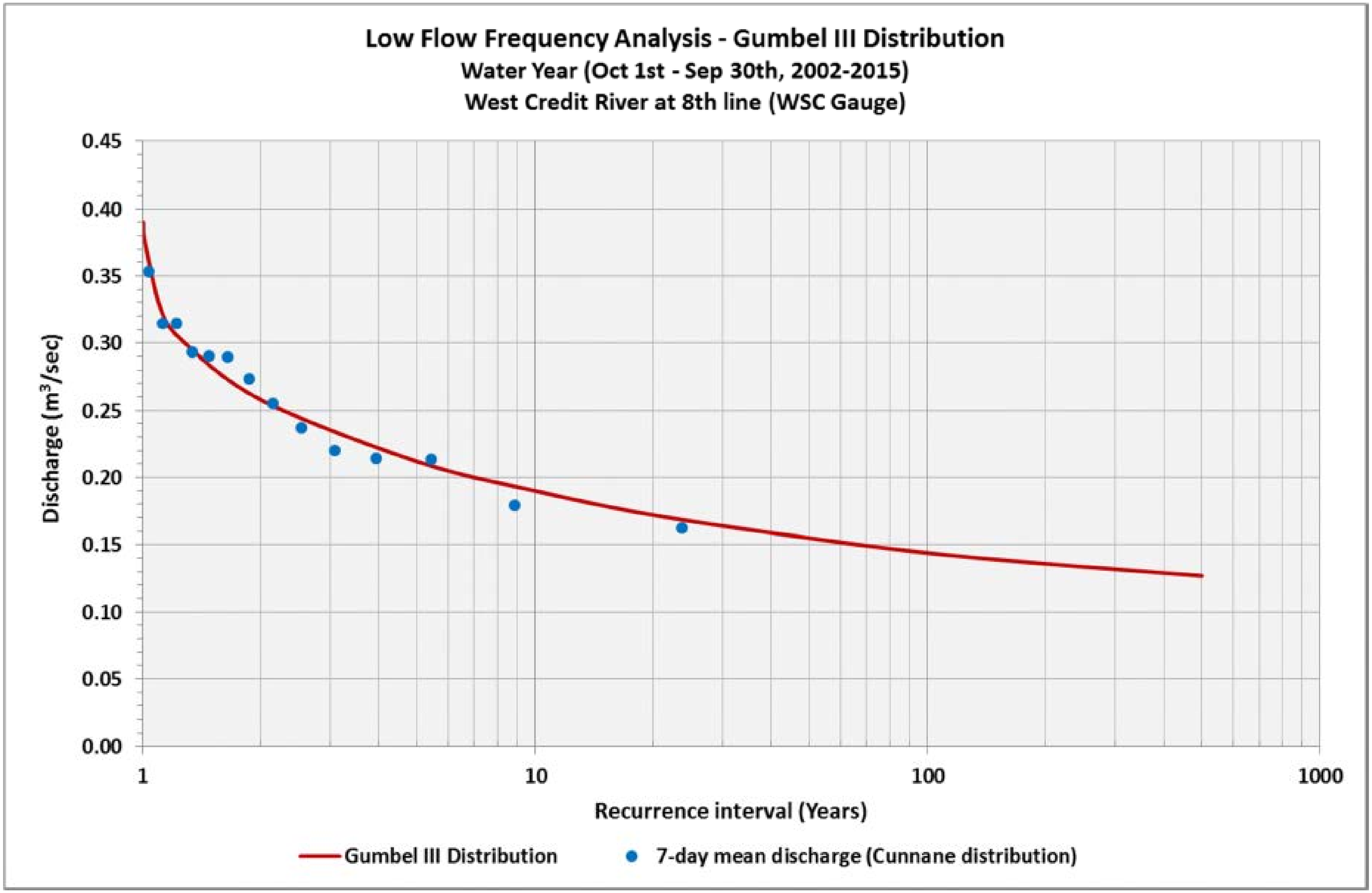

Figure A.5 Gumbel III and Cunnane frequency distributions of minimum 7-day discharges for the West Credit River at 8 th Line (WSC gauge 02HB020) for Water Year (2002-2015)

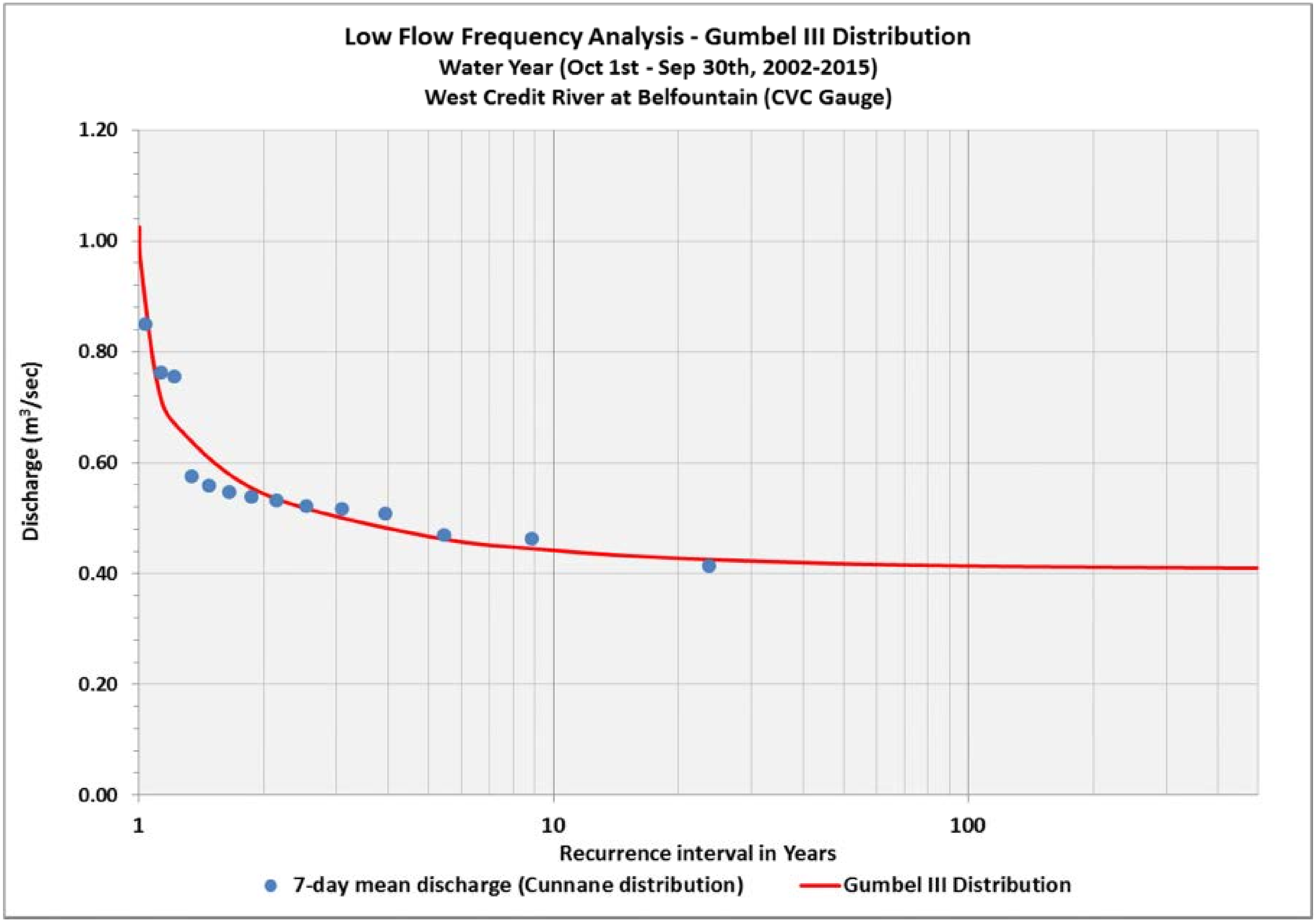

Figure A.6 Gumbel III and Cunnane frequency distributions of minimum 7-day discharges for the West Credit River at Belfountain (CVC gauge) for Water Year (2002-2015)

Table A.1 7Q20 monthly, seasonal and Water Year flows for the West Credit River at 8th Line and 10th Line (m^3/sec) - June 2016

Site/ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Summer Min (Jul-Sep)	Fall-Winter-Spring Min (Oct-Jun)	Water Year Min (Oct 1-Sep 30)	Including 10% CC factor
8th Line (WSC Gauge)*	0.185	0.251	0.253	0.204	0.195	0.253	0.310	0.227	0.167	0.174	0.150	0.133	**0.132**	**0.151**	**0.123**	**0.111**
10th Line (CVC Gauge)**	0.376	0.511	0.515	0.415	0.397	0.515	0.631	0.462	0.340	0.354	0.305	0.271	**0.269**	**0.307**	**0.250**	**0.225**
Difference (%) ***	16.1	19.2	19.1	17.8	17.1	19.1	16.8	18.9	13.6	14.7	10.2	5.5	5.2	10.4	1.9	1.9

Notes:

* 7Q20 low flows (monthly, seasonal and yearly values) at 8th Line were estimated by frequency analysis of long-term streamflow data of the WSC gauge (1984-2015).

** 7Q20 low flows (monthly, seasonal and yearly values) at 10th Line were estimated by linear trendline equation defining relationship between streamflows at 8th Line and 10th Line. The ratio of 10th Line flow to 8th Line flow equal to 2.035.

*** Difference between present 7Q20 values (Jun 2016) and 7Q20 values from the March 14th Memo, calculated for the West Credit at 10th Line.

Table A.2 7Q20 monthly, seasonal and Water Year flows for the West Credit River at 8th Line and 10th Line (m3/sec) - March 2016

Site/ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Summer Min (Jul-Sep)	Fall-Winter-Spring Min (Oct-Jun)	Water Year Min (Oct 1-Sep 30)	Including 10% CC factor
8th Line (WSC Gauge)	0.185	0.251	0.253	0.204	0.195	0.253	0.310	0.227	0.167	0.174	0.150	0.133	**0.132**	**0.151**	**0.123**	**0.111**
10th Line (CVC Gauge)	0.316	0.413	0.416	0.341	0.329	0.416	0.525	0.375	0.294	0.302	0.274	0.256	**0.255**	**0.275**	**0.246**	**0.221**
Ratio (10th Line/ 8thLine)	1.7	1.6	1.6	1.7	1.7	1.6	1.7	1.7	1.8	1.7	1.8	1.9	**1.9**	**1.8**	**2.0**	**2.0**

Appendix C. Physical Attributes Survey Field Notes

★ = channel & bankslope msmt locations.

General notes:

- Bottom is fine sediment w/ some cobbles & rocks. Ratio of fines to rocks/cobbles changes back & forth as you move downstream.

(over)

★ = Channel & bank slope msmt locations

Appendix D. Downstream TP Target Memorandum and Predicted Effluent Chloride Concentrations

Hutchinson
Environmental Sciences Ltd.

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Memorandum

Date: **October 20, 2016**

To: **Gary Scott, Ainley Group**

From: **Deborah Sinclair, Neil Hutchinson and Tara Roumeliotis**

Re: **J160005 – Recommended Downstream TP Target for West Credit River at Winston Churchill Blvd.**

The Town of Erin (Town) is currently completing a Schedule C Class EA for a proposed Waste Water Treatment Plant (WWTP) to service the existing population and proposed new growth in Erin and Hillsburgh. The proposed phasing of the plant will eventually accommodate Full Build Out of the Town's official plan with additional capacity for growth. Ainley Group (consultants for the Town) requested that Hutchinson Environmental Sciences Ltd (HESL) recommend a downstream water quality target for Total Phosphorus (TP) for the West Credit River at Winston Churchill Blvd. as input to determining the effluent flow and treatment limits for the proposed WWTP.

The Ontario Ministry of the Environment and Climate Change (MOECC) provides guidance on the management of surface water and groundwater quality and quantity for the Province of Ontario. They have established a Provincial Water Quality Objective (PWQO) of 0.03 mg/L for Ontario rivers and Policy 1 for management of surface water quality which states *"In areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives. Although some lowering of water quality is permissible in these areas, degradation below the Provincial Water Quality Objectives will not be allowed …"*.

This memo provides information and a rationale to support a permissible lowering of water quality in the West Credit River from discharge of treated municipal waste water from the proposed Erin WWTP.

TP Concentrations in West Credit River at 10th Line and Winston Churchill Blvd.

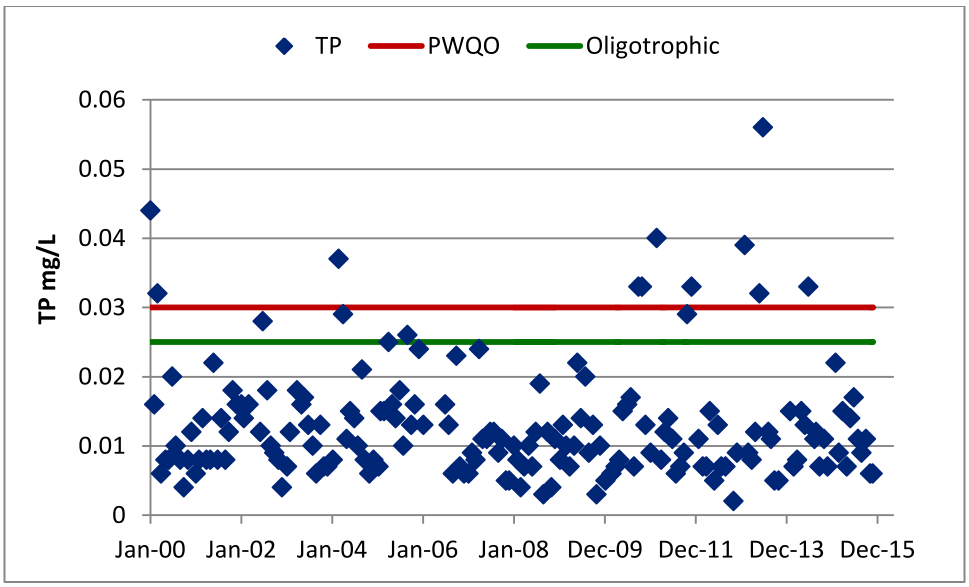
Total phosphorus (TP) concentrations in the West Credit River have been monitored as part of the Ministry of the Environment and Climate Change's (MOECC) Provincial Water Quality Monitoring Network (PWQMN) at Winston Churchill Boulevard since 1975 (station 6007601502). The median (2005 - 2015) and 75th percentile TP concentrations (0.011 mg/L and 0.015 mg/L) are well below the Provincial Water

Quality Objective[1] (PWQO) of 0.03 mg/L. Concentrations are stable; with no apparent increasing or decreasing trend over time (Figure 1).

TP measurements were also collected from the West Credit River upstream of Winston Churchill at 10th Line by Credit Valley Conservation (CVC) in 2007 and 2008 (CVC 2011) and by HESL in 2016 (unpublished data). The median and 75th percentile TP concentrations at 10th Line were also well below the PWQO at 0.014 mg/L and 0.016 mg/L, respectively (based on 15 measurements). The lower TP concentrations, and hence better water quality, at Winston Churchill is due to groundwater discharge to the river between the two stations (CVC 2011).

In 2016, HESL collected chlorophyll *"a"* samples from 10th Line on five occasions. Concentrations ranged from 0.598 µg/L to 3.91 µg/L, with a median of 2.63 µg/L.

Figure 1 Total Phosphorus concentrations measured (2000-2015) in the West Credit River at Winston Churchill Blvd. (PWQMN station 6007601502)



Trophic Status of West Credit River and Implications

Total phosphorus is the key limiting nutrient in plant and algal growth in freshwater systems. Increases in total phosphorus concentrations often results in increased algal biomass (e.g. Dodds et al., 1997). Phosphorus concentrations are therefore commonly used to classify lakes and rivers according to their nutrient ("trophic") status[2] (e.g. oligotrophic, mesotrophic, and eutrophic). Generally oligotrophic systems have low nutrients, low algal biomass, high water clarity, and can support a cold-water fishery. Eutrophic

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[1] *The PWQO are numerical and narrative criteria that serve as chemical and physical indicators representing a satisfactory level for surface waters (i.e. lakes and rivers) and where it discharges to the surface, the groundwater of the province of Ontario. The PWQO are set at a level of water quality, which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water (MOEC 1994a).*

[2] *Trophic status – the availability of growth limiting nutrients (Smith et al. 1999) such as total phosphorus or nitrogen.*

systems are nutrient enriched (high nutrient concentrations), have high algal biomass, can have frequent algal blooms, and wide swings in dissolved oxygen (with potential for conditions of no oxygen (anoxia)). Mesotrophic systems have intermediate characteristics (Dodds et al., 1998).

The trophic status classification of the West Credit River between the 10th Line and Winston Churchill Blvd. is oligotrophic using the spot TP data from 10th Line, the long-term PWQMN data and the recent chlorophyll "*a*" data from 10th Line. The oligotrophic classification is based on a trophic status system developed for temperate streams by Dodds et al. (1998; Table 1).

Table 1 Trophic classification boundaries for streams (based on Dodds et al., 1998)

Trophic Level	TP (mg/L)	Suspended Chlorophyll *a* (µg/L)
Oligotrophic	<0.025	<10
Mesotrophic	0.025-0.075	10-30
Eutrophic	>0.075	>30

The West Credit River discharges to the Credit River downstream of Belfountain. The median and 75th percentile (2005-2014) TP concentrations of the Credit River downstream of Belfountain, at Highway 10 (PWQMN station 06007605202) are 0.031 mg/L and 0.052 mg/L respectively; above the PWQO of 0.03 mg/L.

The MOECC provides guidance on the management of surface water and groundwater quality and quantity for the Province of Ontario. In their document: *Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy (MOE 1994a)* two policies relate to the protection of water quality:

> Policy 1 – *In areas which have water quality better than the PWQO, water quality shall be maintained at or above the objectives. Although some lowering of water quality is permissible in these areas, degradation below the Provincial Water Quality Objectives will not be allowed …"*
>
> Policy 2 - Water quality which presently does not meet the PWQO shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives.

The West Credit River at Erin is therefore managed under MOECC Policy 1 which allows some degradation of water quality, but flows into the main trunk of the river downstream of Belfountain which is managed under Policy 2 such that no additional degradation is allowed and remediation measures are encouraged. The discharge of effluent from the proposed Erin WWTP must not, therefore, contribute to any additional degradation of the main Credit River downstream.

For the purposes of the Schedule C Class EA, the MOECC stated (Paul Odom, October 3, 2016 Core Management Team Meeting) that the MOECC Policies are guidance statements, and that the Town of Erin may not increase the TP concentration in the West Credit River beyond the PWQO of 0.03 mg/L.

They did note, however, that if the Town of Erin discharge were to increase total phosphorus concentrations in the river to 0.03 mg/L that there would be no remaining assimilation capacity to accommodate other dischargers on this reach of the river or downstream, such as industrial dischargers or other municipalities, or to accommodate stormwater runoff. We note that the MOECC guidance does not encourage dischargers to discharge up to the PWQO, but states "… *some lowering of water quality is permissible in these areas…".* Therefore, MOECC suggested that the study team recommend a downstream objective and rationale for total phosphorus for consideration by MOECC. The downstream objective, because it differs from the MOECC generic PWQO of 0.03 mg/L, would be considered a Site Specific Water Quality Objective (CCME 2003).

The PWQO of 0.03 mg/L represents a two-fold increase over the current 75th percentile TP (0.015 mg/L) concentration and a change in trophic status from oligotrophic to mesotrophic in the West Credit River between 10th Line and Winston Churchill Boulevard. CVC has designated the West Credit River downstream of 10th Line as a cold-water aquatic community due to the presence of brook trout. The most productive brook trout spawning reaches and the best brook trout populations in the West Credit River are located downstream of Erin Village (CVC 2011) and the longest contiguous brook trout habitat in the Credit River watershed is the West Credit River between Erin and Belfountain. The effect of doubling the TP concentration, thus changing the trophic status of the river, on brook trout and other aquatic life in the West Credit River is not well understood but detrimental changes would include increased growth of algae attached to bottom substrate (periphyton) which impairs habitat for fish spawning and benthic invertebrates and increased dissolved oxygen concentrations during the day and decreased concentrations at night in response to increased algal respiration which would stress aquatic life. A cautionary approach to establishing a target downstream TP concentration for the purposes of defining the flow and treatment limits is therefore recommended to protect aquatic life.

The following sections review available guidance to develop a downstream phosphorus objective for the West Credit River that will protect the cold water fishery. We then recommend an effluent TP limit that will meet the objective in the river at the projected effluent flows.

Environment Canada Framework for Managing Phosphorus

Environment Canada (2004) has developed a guidance framework for managing phosphorus concentrations in fresh water systems that is consistent with Canada Council of Ministers of the Environment (CCME) guideline development principles, but permits site-specific management of phosphorus. It was published as part of their *Ecosystem Health: Science-based Solutions* series which is dedicated to the dissemination of information and tools for monitoring, assessing and reporting on ecosystem health to support Canadians in making sound decisions (Environment Canada 2004). The guidance recommends a trigger approach to setting and establishing thresholds for TP concentrations. The framework steps include:

- Set ecosystem goals and objectives (enhance, protect, or restore)
- Define reference/baseline conditions
- Select trigger ranges
- Determine current TP concentrations
- Compare current concentrations and concentrations predicted from an undertaking to the trigger range

- Compare current concentrations and concentrations predicted from an undertaking to the baseline

In this case, the goal is to protect the sensitive brook trout population and maintain a healthy diverse aquatic system, while servicing existing development in Erin Village and Hillsburgh and allowing for new growth in the Town. The reference/baseline conditions in the river are well understood, and in this case represent the current concentrations of total phosphorus, which have not shown any increasing/decreasing trend in the last 15 years.

The Canadian Council of Ministers of the Environment (CCME 2003, p.15) provides the following guidance on setting Site Specific Water Quality Objectives (SSWQOs):

> *Two distinct strategies are commonly used to establish WQOs in Canada, including the antidegradation strategy and the use protection strategy. For water bodies with aquatic resources of national or regional significance, the WQOs are established to avoid degradation of existing water quality. For other water bodies, the WQOs are established to protect the designated uses of the aquatic ecosystem. As long as the designated water uses are protected, some degradation of existing water quality may be acceptable in these water bodies, provided that all reasonable and preventative measures are taken to protect water quality conditions.*

The brook trout population in the West Credit River is of regional significance and the West Credit River is the only portion of the Credit River sustaining Policy 1 oligotrophic waters. Therefore the Site Specific Water Quality Objective should be focused on "antidegradation" to maintain the oligotrophic status of the river.

CCME (2003) identifies four methods for developing a SSWQO; the background concentration procedure, recalculation procedure, water effect ratio procedure, and the resident species procedure. The "background concentration procedure" is appropriate for the West Credit River. *"In the background concentration procedure, the natural background concentrations of a contaminant in water …are determined and these levels are used to define acceptable water quality conditions at the site under consideration. Its use is based on the premise that surface water systems with superior water quality (i.e., relative to the Canadian WQGs) should not be degraded. This approach has been used most commonly to define WQOs for relatively pristine water bodies, including several river systems in Canada (e.g., Dunn 1989; MacDonald and Smith 1990). It has also been used in somewhat contaminated water bodies, such as Burrard Inlet (Nijman and Swain 1989)."* (CCME 2003, p. 19). We used three approaches to define the background concentration and resultant SSWQO for the West Credit River.

Although the natural background concentrations of total phosphorus in the West Credit River are not known, current concentrations are low and exceptional for Southern Ontario and are a reasonable approximation of natural background levels. The background concentration procedure uses the upper limit of the natural background concentration of a contaminant to define acceptable water quality conditions (CCME 2003). In this case the "natural" background concentration is the current stable TP concentration of the receiver, prior to the input from the WWTP. The two examples provided to determine the upper limit are the mean concentration plus two standard deviations and the 90th percentile concentration. For the West Credit River at Winston Churchill Blvd. these values are 0.030 mg/L (mean = 0.012 mg/L, standard deviation = 0.009 mg/L) and 0.024 mg/L respectively. Since the data are highly variable (2 x standard deviation is greater than the mean) this approach is not protective of water quality.

Using the 90th percentile approach to establish the upper limit of the background concentration of 0.024 mg/L is recommended, and recognizes the oligotrophic nature of the receiver.

> **Therefore, use of the background concentration procedure for derivation of the SSWQO will define the natural background concentration of the West Credit River as the 75th percentile total phosphorus concentration (=0.016 mg/L) with the upper limit defined by the 90th percentile concentration of 0.024 mg/L.**

A trigger range is defined as a "desired concentration range for phosphorus; if the upper limit of the range is exceeded, that indicates ***a potential*** environmental problem, and therefore **"triggers" further investigation**. The internationally-accepted Organization for Economic Co-operation and Development (OECD) trophic status values are the recommended trigger ranges (Table 2) for Canadian lakes and rivers (CCME 2004). These trophic values were originally established for lakes and reservoirs (Environment Canada 2004), which is why they differ slightly than those presented in Table 1. Rivers can, however, sustain higher loads of TP than lakes before any observable changes in community composition and biomass (Smith et al. 1999): TP is flushed through the system before it can be taken up and utilized by aquatic plants. Therefore, the United States Environmental Protection Agency (USEPA) has adopted trophic classification for rivers based on the Dodds et al. values (Table 1), which are higher than the OECD values.

Table 2 Recommended trigger ranges for Canadian Lakes and Rivers (CCME 2004)

Trophic Status	TP concentration (µg/L)
Ultra-oligotrophic	< 4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hyper-eutrophic	>100

> **We recommend using the Dodds et al (1998) trigger ranges as they have specifically been established for rivers in temperate sites. The oligotrophic trophic range is <0.025 mg/L TP (Table 1); therefore a downstream concentration over 0.024 mg/L TP would indicate a potential shift to mesotrophic classification and trigger further investigation.**

In addition to the trigger ranges, the Environment Canada guidance also recommends comparing predicted concentrations to baseline conditions, and notes that *"up to a 50% increase in phosphorus concentrations above the baseline level is deemed acceptable"…"If a 50% increase from baseline is not observed, then there is considered a low risk of adverse effects….if the increase is greater than 50%, the risk of observable effects is considered to be high and further assessment is recommended*" (Environment Canada 2004). We established a natural background 75th percentile concentration of 0.016 mg/L in the West Credit River at Erin. A 50% increase above this results in a trigger concentration of 0.024 mg/L.

Use of the Environment Canada guidance of a 50% increase above background supports a total phosphorus concentration of 0.024 mg/L as an upper range to protect the oligotrophic waters of the West Credit River.

We therefore recommend a value of 0.024 mg/L as the SSWQO for total phosphorus in the West Credit River.

Conclusions and Recommendations

We therefore recommend that a downstream SSWQO of 0.024 mg/L TP be adopted to protect the cold water habitat and water quality in the West Credit River, consistent with Environment Canada and CCME guidance. This will maintain the current trophic status of the river. A higher water quality objective is not recommended as the effect of changing the trophic status of the river on brook trout and other aquatic life in the West Credit River is not well understood at this time.

Water quality objectives are developed as guidelines and not as enforced regulatory standards. They are conservative, in that the best scientific information concludes that aquatic life will be protected at concentrations below the objective but this does not mean that the ecosystem will necessarily be impaired if concentrations increase above the objective. Therefore, Environment Canada (2004) states that, if total phosphorus concentrations increase to the SSWQO, the management response is investigation to determine if the changes have been harmful or if further increases can be sustained. This provides the opportunity for adaptive management of discharge from the proposed WWTP at Erin.

During Phase 1 of the WWTP, we recommend that the Town implement a receiver monitoring program for the West Credit River to determine the resultant phosphorus concentration in the river and assess any effects of increased TP loadings on water quality and aquatic communities (e.g. algal, benthos and fish). Effluent monitoring is also required to confirm that the lower effluent limits and objectives required to accommodate future growth can be met. The findings from these monitoring studies can:

a) inform a future application to rerate the Erin WWTP to accommodate a higher wastewater flow at a lower effluent TP concentration if monitoring shows that the plant can be operated at a lower effluent limit,

b) inform a decision to maintain the downstream West Credit River TP objective at 0.024 mg/L at Full Build Out or if it can be relaxed to 0.027 mg/L with no threat to aquatic life to accommodate either a higher population or a higher effluent limit.

Phosphorus Control for New Development

Wastewater discharge will not be the only source of total phosphorus to the West Credit River as the Town of Erin is serviced and grows. New development, infill and intensification of development will increase impervious services in Erin and Hillsburgh, leading to increased runoff of stormwater which will contain phosphorus and other pollutants. Growing recognition of non-point source pollution by urban runoff has led to increased demands for management of stormwater quality, as well as quantity. New development in the Lake Simcoe and Nottawasaga River watersheds and in the City of Oakville, for example, must set a target of “net zero” increase in phosphorus loading, such that the cumulative phosphorus loading from municipal wastewater effluent and stormwater runoff must not increase between the pre-development and post-development condition. Jennifer Dougherty, of Credit Valley Conservation stated that this was typically required for cases where the receiving waters were Policy 2 but that this would not be required for Erin[3]. Nevertheless, the sensitivity of the West Credit River at Erin may stimulate requests for phosphorus abatement from stormwater as Erin and Hillsburgh are built out.

Decommissioning of septic systems upon completion of the Erin WWTP will reduce one source of phosphorus (and nitrate) loading to the watershed. Development and redevelopment can reduce phosphorus loading in storm water through implementation of improved stormwater management (Best Management Practices) for older areas and Low Impact Development Techniques, particularly infiltration of runoff for new development. Infiltration techniques reduce surface runoff volume, remove particulates and suspended solids from runoff (including particulate phosphorus), encourage adsorption of phosphorus onto mineral surfaces in soils and cool the runoff, all of which will protect the cold water habitat in the West Credit River and help offset the discharge form the new WWTP.

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Town of Erin

Urban Centre Wastewater Servicing

Class Environmental Assessment

Phases 3 and 4

Technical Memorandum

Predicted Chloride Levels in Future Erin WWTP Effluent

March 2017

Ainley GROUP
CONSULTING ENGINEERS & PLANNERS

Urban Centre Wastewater Servicing Class Environmental Assessment Phases 3 & 4

Project No. 115157

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____
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1.0 Predicted Chloride Levels

Predicted chloride levels in the Erin WWTP Effluent were developed using data from communities with similar drinking water characteristics to Erin. The hard groundwater sources for Erin drinking water result in consumers using water softeners which add chlorides to the water. The communities in the table below also have high hardness levels in the drinking water and a high incidence of softener use. These communities also already have data on chlorides in their wastewater effluent allowing a comparison to be made with Erin drinking water hardness and a prediction to be made on future WWTP effluent chloride levels.

Parameter	Orangeville	Elora	Arthur	Mount Forest	Erin
Average Hardness in raw drinking water	360 mg/L	400-500 mg/L	345 mg/L	270-300 mg/L	300-400 mg/L
WWTP Effluent Average Chlorides	492.60 mg/L (2012-2016)	500 mg/L (2014-2015)	394.2 mg/L (2010)	197.25 mg/L (2012-2014)	**396 mg/L**
WWTP Effluent Max Chlorides	650 mg/L (2012-2016)	713 mg/L (2014-2015)	499 mg/L (2010)	274 mg/L (2012-2014)	**534 mg/L**
WWTP Effluent Min Chlorides	409 mg/L (2012-2016)	104 mg/L (2014-2015)	272 mg/L (2010)	13.1 mg/L (2012-2014)	**200 mg/L**

On average water hardness in raw drinking water in the Town of Erin ranges from 300-400 mg/L. Data was collected from nearby communities with similar hardness in drinking water including the Town of Orangeville, Elora (Wellington County), Arthur (Wellington County) and Mount Forest (Wellington County).

The hardness level of raw drinking water for these communities was found to between 270-500 mg/L. WWTP effluent average chloride concentrations for these communities was found to be between 197.25 -500 mg/L. WWTP effluent maximum chloride concentrations for these communities was found to be between 274 -713 mg/L.

Whereas the hardness level of drinking water in Erin is within the range of these other communities, there is no real corelation between the hardness and the effluent chloride levels because the % of consumers using softeners also varies and is unknown. For this reason, the predicted chloride concentration in the Erin WWTP effluent was calculated by taking the average of the chloride concentrations in the effluent from the other treatment plants.

Appendix E. Email Correspondence from MOECC on Effluent Limits

Tara Roumeliotis

From: Christine Furlong <cfurlong@tritoneng.on.ca>
Sent: October-03-16 3:21 PM
To: scott@ainleygroup.com
Cc: Simon Glass (glass@ainleygroup.com); 'jdougherty@creditvalleyca.ca'; Noah Brotman (noahbrotman@hardystevenson.com); mullan@ainleygroup.com; Neil Hutchinson; 'garyc@wellington.ca'; Dave Hardy (davehardy@hardystevenson.com); Deborah Sinclair; Tara Roumeliotis; 'Ray Blackport (blackport_hydrogeology@rogers.com)'; Barb Slattery
Subject: FW: Comments on Today's meeting
Attachments: 1160-9ESQPY-14.pdf

Hello Gary

Barb Slattery has provided some comments from MOECC on effluent quality for the Town of Erin WWTP discharge based on the Environmental Compliance Approval (ECA) for the Orangeville WWTP.

Attached is the Orangeville ECA in its entirety from the Access Environment portal.

Christine Furlong, P. Eng

Triton Engineering Services Limited
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Tel - (519) 843-3920 • Fax - (519) 843-1943 • www.tritoneng.on.ca

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From: Slattery, Barbara (MOECC) [mailto:barbara.slattery@ontario.ca]
Sent: October-03-16 2:59 PM
To: Christine Furlong
Subject: Comments on Today's meeting

Hello Christine, would you be so kind as to distribute this email to the rest of the group. As I noted, Paul and Craig wanted to make some comments on Table 4 on page 3 of the slide deck. Here they are:

Using the Orangeville WPCP ECA (2014) for comparison – a plant which discharges to the headwaters of the Credit. Orangeville is currently upgrading (summer 2018 completion) and has current and future numbers (we have used Objective/Limit notation in the following)

a) pH – is this actually meaning pH to be *between* 7 & 8.6. Achieving this is hightly desireable given that this is prime trout rearing habitat. (Orangeville is 6-9.5)
b) TSS – While this is not a PWQO parameter, it it can be designed for 3mg/l, the limit should be 5mg/l (Orangeville is 5/7.5 upgrading to 4/5). The issue is reducing to the maximum extent possible the discharge of solids material to the pools and substrates of one of GTA's prime spawning/rearing habitats.
c) TAN – With an objective of 0.4mg/l, they have proposed a limit of 2mg/l. This difference is likely driven by variations during winter conditions. Limits of 1.3 mg/l (May-October) and 2.0mg/L (November-April) should be readily achievable with a design of 0.4.
d) TKN at 3 mg/l and NO_3 at 5/6 mg/l are OK
e) E Coli at 100 are OK
f) D.O. in the effluent is OK at 5/4 (minimum values)
g) If BOD_5 is $tBOD_5$, OK. If it is $cBOD_5$, the limit should be 5. (Orangeville is 5/7.5 going to 4/5). Most modern facilities achieve $cBOD_5$ <2 (MDL) for most of their analyses (barring upset/spill).
h) Temperature: we presume the values quoted are <17°C objective and 8-19°C limit. Temperature is almost impossible to control within a WPCP; however, influent is usually fairly consistent. In the future, the ministry's review engineer will decide if temperature should be tabulated. Obviously the lower the temperature, the better for both the cold water species and ammonia dissociation.

Thank you

Barb Slattery, EA/Planning Coordinator
Ministry of the Environment and Climate Change
West Central Region
(905) 521-7864

Appendix F. QUAL2K Output Data

Constituent (Average) Summary - Phase 1 Flows (3380 m3/d)

Tributary																	
Label	*Reach Lal*	*x(km)*	*cond (umhos)*	*DO(mgO2/L)*	*ODf (mgO2*	*No(ugN/L)*	*NH4(ugN/L)*	*NO3(ugN/L)*	*Po (ugP/L)*	*Inorg P (ugP/L)*	*ritus (mgD*	*Pathogen*	*Alk*	*pH*	*TP*	*TKN*	*NH3*
main	Mainstem	1.70	613.00	7.72	2.78	535.00	55.00	1900.00	7.90	8.10	0.00	160.00	281.00	8.21	18.72	609.58	3.60
		1.67	613.00	7.73	2.76	533.68	53.89	1898.82	7.70	8.07	0.00	149.99	280.99	8.21	18.45	606.83	3.58
		1.60	613.00	7.74	2.74	532.36	52.80	1897.63	7.51	8.05	0.00	140.87	280.99	8.22	18.19	604.10	3.57
		1.54	670.17	7.08	3.01	702.63	212.36	2363.31	11.29	12.00	0.01	121.98	286.68	8.28	25.48	930.79	16.05
		1.47	670.17	6.98	2.97	701.09	205.69	2368.20	11.09	11.98	0.01	114.09	286.63	8.27	25.24	922.34	15.33
		1.41	670.17	6.90	2.93	699.64	199.70	2372.46	10.91	11.96	0.01	107.53	286.58	8.26	25.01	914.68	14.74
		1.33	670.17	6.87	2.90	698.31	194.85	2375.53	10.74	11.94	0.01	102.58	286.55	8.26	24.79	908.31	14.35
		1.24	670.17	6.84	2.86	696.52	188.47	2379.49	10.51	11.92	0.01	96.57	286.50	8.26	24.50	899.88	13.85
		1.16	670.17	6.82	2.82	694.73	182.28	2383.28	10.29	11.89	0.02	91.16	286.46	8.25	24.22	891.64	13.36
		1.07	670.17	6.79	2.78	692.83	175.88	2387.11	10.06	11.86	0.02	85.93	286.41	8.25	23.92	883.07	12.87
		0.97	670.17	6.77	2.73	690.93	169.68	2390.75	9.83	11.84	0.02	81.19	286.37	8.25	23.63	874.71	12.40
		0.88	670.17	6.75	2.69	689.03	163.67	2394.20	9.61	11.81	0.02	76.89	286.32	8.24	23.34	866.54	11.93
		0.78	670.17	6.75	2.66	687.36	158.76	2396.94	9.42	11.78	0.03	72.84	286.29	8.24	23.10	859.74	11.66
		0.69	670.17	6.75	2.62	685.69	153.95	2399.58	9.24	11.76	0.03	69.20	286.25	8.24	22.86	853.04	11.38
		0.59	670.17	6.75	2.59	684.02	149.24	2402.11	9.06	11.74	0.03	65.89	286.22	8.24	22.62	846.45	11.10
		0.50	670.17	6.75	2.55	682.35	144.64	2404.55	8.88	11.71	0.03	62.87	286.19	8.24	22.39	839.96	10.82
		0.43	670.17	6.82	2.54	681.69	142.01	2405.18	8.79	11.69	0.03	61.67	286.17	8.25	22.26	836.56	10.81
		0.37	670.17	6.89	2.52	681.02	139.42	2405.78	8.70	11.67	0.04	60.51	286.15	8.25	22.14	833.21	10.78
		0.31	670.17	6.88	2.49	679.24	133.73	2407.31	8.48	11.62	0.04	57.38	286.12	8.25	21.84	825.50	10.39
		0.22	670.17	6.88	2.45	677.45	128.18	2408.70	8.27	11.58	0.04	54.50	286.08	8.25	21.55	817.91	10.00
		0.13	670.17	6.87	2.42	675.66	122.82	2409.94	8.06	11.53	0.05	51.84	286.05	8.25	21.27	810.52	9.63
		0.05	670.17	6.86	2.38	673.87	117.66	2411.02	7.86	11.49	0.05	49.38	286.01	8.24	20.99	803.33	9.27
	Terminus	0.01	670.17	6.86	2.38	673.87	117.66	2411.02	7.86	11.49	0.05	49.38	286.01	8.24	20.99	803.33	9.27

Constituent (Average) Summary - Full Build Out Flows (7172 m3/d)

Tributary																	
Label	*Reach Lal*	*x(km)*	*cond (umhos)*	*DO(mgO2/L)*	*ODf (mgO2*	*No(ugN/L)*	*NH4(ugN/L)*	*NO3(ugN/L)*	*Po (ugP/L)*	*Inorg P (ugP/L)*	*ritus (mgD*	*Pathogen*	*Alk*	*pH*	*TP*	*TKN*	*NH3*
main	Mainstem	1.70	613.00	7.72	2.78	535.00	55.00	1900.00	7.90	8.10	0.00	160.00	281.00	8.21	18.72	609.58	3.60
		1.67	613.00	7.73	2.76	533.68	53.89	1898.82	7.70	8.07	0.00	149.99	280.99	8.21	18.45	606.83	3.58
		1.60	613.00	7.74	2.74	532.36	52.80	1897.63	7.51	8.05	0.00	140.87	280.99	8.22	18.19	604.10	3.57
		1.54	717.29	6.64	3.29	844.69	192.74	2738.99	11.31	11.92	0.01	118.57	291.44	8.34	25.12	1051.02	16.09
		1.47	717.29	6.55	3.24	843.01	187.46	2742.67	11.14	11.91	0.01	111.31	291.40	8.33	24.91	1043.87	15.46
		1.41	717.29	6.49	3.20	841.42	182.66	2745.90	10.98	11.89	0.01	105.21	291.37	8.32	24.71	1037.31	14.91
		1.33	717.29	6.48	3.17	839.94	178.73	2748.16	10.83	11.87	0.01	100.57	291.34	8.32	24.52	1031.74	14.56
		1.24	717.29	6.46	3.13	838.01	173.71	2750.99	10.63	11.85	0.01	95.09	291.30	8.31	24.27	1024.59	14.10
		1.16	717.29	6.45	3.09	836.08	168.82	2753.69	10.43	11.83	0.01	90.13	291.26	8.31	24.02	1017.57	13.67
		1.07	717.29	6.44	3.05	834.02	163.74	2756.42	10.23	11.81	0.02	85.32	291.22	8.31	23.77	1010.24	13.23
		0.97	717.29	6.43	3.00	831.97	158.80	2759.02	10.03	11.78	0.02	80.95	291.18	8.30	23.52	1003.05	12.79
		0.88	717.29	6.42	2.96	829.92	153.99	2761.48	9.84	11.76	0.02	76.97	291.15	8.30	23.27	995.99	12.38
		0.78	717.29	6.44	2.92	828.13	150.06	2763.41	9.67	11.74	0.02	73.17	291.12	8.30	23.06	990.09	12.11
		0.69	717.29	6.45	2.89	826.33	146.19	2765.26	9.50	11.72	0.02	69.74	291.09	8.30	22.85	984.26	11.86
		0.59	717.29	6.47	2.85	824.53	142.39	2767.05	9.34	11.70	0.02	66.63	291.06	8.29	22.65	978.49	11.60
		0.50	717.29	6.48	2.82	822.74	138.65	2768.76	9.18	11.68	0.03	63.79	291.03	8.29	22.44	972.79	11.35
		0.43	717.29	6.57	2.80	822.00	136.51	2769.10	9.10	11.66	0.03	62.69	291.01	8.30	22.33	969.83	11.32
		0.37	717.29	6.66	2.79	821.26	134.38	2769.42	9.02	11.64	0.03	61.63	291.00	8.30	22.23	966.89	11.28
		0.31	717.29	6.66	2.75	819.28	129.63	2770.28	8.82	11.60	0.03	58.66	290.97	8.30	21.97	959.96	10.92
		0.22	717.29	6.65	2.71	817.30	125.01	2771.03	8.63	11.57	0.04	55.94	290.94	8.30	21.71	953.18	10.57
		0.13	717.29	6.65	2.68	815.32	120.53	2771.66	8.45	11.53	0.04	53.43	290.91	8.30	21.46	946.54	10.23
		0.05	717.29	6.65	2.64	813.34	116.19	2772.18	8.27	11.49	0.04	51.11	290.88	8.29	21.21	940.04	9.89
	Terminus	0.01	717.29	6.65	2.64	813.34	116.19	2772.18	8.27	11.49	0.04	51.11	290.88	8.29	21.21	940.04	9.89

Appendix G. CORMIX Output Data

```
                       Erin WWTP-3380 bank-good-update.prd
CORMIX3 PREDICTION FILE:
333333333333333333333333333333333333333333333333333333333333333333333333333333333
                       CORMIX MIXING ZONE EXPERT SYSTEM
                Subsystem CORMIX3: Buoyant Surface Discharges
                             CORMIX Version 10.0GT
                     HYDRO3 Version 10.0.0.0 July 2016
---------------------------------------------------------------------------------

---------------------------------------------------------------------------------

CASE DESCRIPTION
 Site name/label:   West Credit River
 Design case:       Erin WWTP - 3380
 FILE NAME:         C:\...rin EA\CORMIX\Erin WWTP-3380 bank-good-update.prd
 Time stamp:        03/14/2017--12:43:54

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     11.00  AS    =      4.40  QA    =      0.23  ICHREG= 2
 HA    =      0.40  HD    =      0.30
 UA    =      0.051 F     =      0.130 USTAR =0.6529E-02
 UW    =      2.000 UWSTAR=0.2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  997.9542

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =      0.00  Configuration: flush_discharge
 SIGMA =     90.00  HDO   =      0.30  SLOPE =    0.00 deg.
 Circular discharge pipe:
 D0    =      0.200 A0    =      0.031
 Dimensions of equivalent rectangular discharge:
 B0    =      0.157 H0    =      0.200 A0    =0.3142E-01  AR    =      1.273
 U0    =      1.241 Q0    =      0.039       =0.3900E-01
 RHO0  =  998.4062  DRHO0 =-.4520E+00  GP0   =-.4442E-02
 C0    =0.1145E+01  CUNITS=  mg/l
 IPOLL =  2         KS    =0.0000E+00  KD    =0.5787E-04

FLUX VARIABLES (metric units)
 Q0    =0.3900E-01  M0    =0.4841E-01  J0    =-.1732E-03
 Associated length scales (meters)
 LQ    =      0.18  LM    =  99999.00  Lm    =      4.30  Lb    =      0.00
 LQ2D  =      0.10  LM2D  =  99999.00  Lm2D  =     61.72

NON-DIMENSIONAL PARAMETERS
 FR0   =  99999.00  FRCH  =  99999.00  R     =     24.28

FLOW CLASSIFICATION
 333333333333333333333333333333333333333333
 3  Flow class (CORMIX3)      =    SA2    3
 3  Applicable layer depth HS =     0.30  3
 3  Limiting Dilution S =QA/Q0=     6.77  3
 333333333333333333333333333333333333333333

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.1145E+01  CUNITS=  mg/l
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2150E+00
 REGMZ =  0
 XINT  =   1500.00  XMAX  =   1500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the WATER SURFACE and at center of discharge
      channel/outlet:      0.00 m  from the RIGHT bank/shore.
```

```
CORMIX2 PREDICTION FILE:
22222222222222222222222222222222222222222222222222222222222222222222222222222222222
222222222222
                         CORMIX MIXING ZONE EXPERT SYSTEM
               Subsystem CORMIX2: Multiport Diffuser Discharges
                               CORMIX Version 10.0GT
                         HYDRO2 Version 10.0.0.0 July 2016
-----------------------------------------------------------------------------------
-----------
-----------------------------------------------------------------------------------
-----------
CASE DESCRIPTION
 Site name/label:   West Credit River
 Design case:       Erin WWTP - 3380
 FILE NAME:         C:\... WWTP-3380-diffuser vertical-good-side-update.prd
 Time stamp:        03/14/2017--12:49:17

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     11.00  AS    =      4.40  QA    =      0.23  ICHREG= 3
 HA    =      0.40  HD    =      0.40
 UA    =      0.051 F     =      0.130 USTAR =0.6529E-02
 UW    =      2.000 UWSTAR=0.2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  997.9542

DIFFUSER DISCHARGE PARAMETERS (metric units)
 Diffuser type:     DITYPE= alternating_parallel
 BANK  =  RIGHT     DISTB =      0.00  YB1   =      0.50  YB2   =      0.50
 LD    =      5.00  NOPEN =   10       SPAC  =      0.56
 D0    =      0.050 A0    =      0.002 H0    =      0.00  SUB0  =      0.40
 D0INP =      0.050 CR0   =      1.000
 Nozzle/port arrangement:   near_vertical_discharge
 GAMMA =      0.00  THETA =     90.00  SIGMA =      0.00  BETA  =     90.00
 U0    =      1.986 Q0    =      0.039 Q0A   =0.3900E-01
 RHO0  =  998.4062  DRHO0 =-.4520E+00  GP0   =-.4442E-02
 C0    =0.1145E+01  CUNITS=  mg/l
 IPOLL =  2         KS    =0.0000E+00  KD    =0.5787E-04

DIFFUSER PARAMETERS WITH IMAGE EFFECTS (metric units)
 The bank/shore proximity effect is accounted for by the following flow
 variables and definitions of length scales and parameters.
 LD    =      5.00  Q0    =      0.078 Q0A    =0.3900E-01

FLUX VARIABLES - PER UNIT DIFFUSER LENGTH (metric units)
 q0    =0.3120E-01  m0    =0.1549E-01  j0    =-.3465E-04  SIGNJ0=     -1.0
 Associated 2-d length scales (meters)
 lQ=B  =      0.016 lM    =     14.54  lm    =     11.85
 lmp   =  99999.00  lbp   =  99999.00  la    =  99999.00

FLUX VARIABLES - ENTIRE DIFFUSER (metric units)
 Q0    =0.7800E-01  M0    =0.7746E-01  J0    =-.1732E-03
 Associated 3-d length scales (meters)
 LQ    =      0.04  LM    =     11.16  Lm    =      7.70  Lb    =      2.59
                                       Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =    475.55  FRD0  =    133.27  R     =     38.84  PL    =  140.00
 (slot)             (port/nozzle)


FLOW CLASSIFICATION
 222222222222222222222222222222222222222222
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 2  Flow class (CORMIX2)      =    MNU14  2
 2  Applicable layer depth HS =     0.40  2
 2  Limiting Dilution S =QA/Q0=     3.88  2
 22222222222222222222222222222222222222222

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.1145E+01  CUNITS=  mg/l
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2150E+00
 REGMZ =  0
 XINT  =    200.00  XMAX  =    200.00

X-Y-Z COORDINATE SYSTEM:
  because of bank/shore proximity, the ORIGIN is located directly
   at the RIGHT bank/shore.
  the bank/shore acts as a plane of symmetry for the predicted
  plume geometry.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 100 display intervals per module
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BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00    0.00     1.0 0.114E+01   0.00     2.50     1.986
.00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
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BEGIN MOD234: UNSTABLE RECIRCULATION REGION OVER LAYER DEPTH

 The MIXING of this alternating diffuser is somewhat REDUCED
   due to its PARALLEL ALIGNMENT.
 INITIAL LOCAL VERTICAL INSTABILITY REGION:
   Bulk dilution (S =   1.41) occurs in a limited region (horizontal extent
   =    3.00 m) surrounding the discharge location.

  Control volume inflow:
       X        Y       Z        S       C       BV       BH         TT
      0.00     0.00    0.00     1.0 0.114E+01   0.00     2.50   .00000E+00

  Control volume outflow:
       X        Y       Z        S       C       BV       BH         TT
      3.00     0.00    0.20     1.4 0.810E+00   0.40     1.00   .00000E+00

END OF MOD234: UNSTABLE RECIRCULATION REGION OVER LAYER DEPTH
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BEGIN MOD234a: UPSTREAM SPREADING AFTER NEAR-FIELD INSTABILITY

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 UPSTREAM INTRUSION PROPERTIES:
        Upstream intrusion length               =       0.26 m
        X-position of upstream stagnation point =       2.74 m
        Thickness in intrusion region           =       0.40 m
        Half-width at downstream end            =       2.86 m
        Thickness at downstream end             =       0.38 m

  Control volume inflow:
       X        Y       Z        S       C       BV       BH        TT
      3.00     0.00    0.20     1.4 0.810E+00   0.40     1.00   .00000E+00

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH      ZU      ZL
TT
      2.74     0.00    0.00  9999.9 0.000E+00   0.00     0.00    0.00    0.00
.28011E+02
      2.77     0.00    0.00     3.1 0.365E+00   0.40     0.41    0.40    0.00
.00000E+00
      2.94     0.00    0.00     1.5 0.783E+00   0.40     0.98    0.40    0.00
.00000E+00
      3.11     0.00    0.00     1.4 0.809E+00   0.38     1.93    0.38    0.00
.20797E+01
      3.27     0.00    0.00     1.4 0.808E+00   0.38     2.10    0.38    0.00
.53212E+01
      3.44     0.00    0.00     1.4 0.805E+00   0.38     2.24    0.38    0.00
.85626E+01
      3.60     0.00    0.00     1.4 0.802E+00   0.38     2.37    0.38    0.00
.11804E+02
      3.77     0.00    0.00     1.4 0.800E+00   0.38     2.48    0.38    0.00
.15045E+02
      3.94     0.00    0.00     1.4 0.798E+00   0.38     2.59    0.38    0.00
.18287E+02
      4.10     0.00    0.00     1.4 0.797E+00   0.38     2.68    0.38    0.00
.21528E+02
      4.27     0.00    0.00     1.4 0.796E+00   0.38     2.78    0.38    0.00
.24770E+02
      4.43     0.00    0.00     1.4 0.795E+00   0.38     2.86    0.38    0.00
.28011E+02
 Cumulative travel time =          28.0112 sec  (    0.01 hrs)
```

END OF MOD234a: UPSTREAM SPREADING AFTER NEAR-FIELD INSTABILITY

** End of NEAR-FIELD REGION (NFR) **

Recall that the plume is symmetric to the bank/shore on which the centerline (X-axis) is located.

BEGIN MOD241: BUOYANT AMBIENT SPREADING

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Profile definitions:

BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
4.43	0.00	0.00	1.4	0.795E+00	0.38	2.86	0.38	0.00	.28011E+02
5.10	0.00	0.00	1.5	0.781E+00	0.37	3.05	0.37	0.00	.39197E+02
5.77	0.00	0.00	1.5	0.768E+00	0.35	3.23	0.35	0.00	.50382E+02
6.45	0.00	0.00	1.5	0.756E+00	0.34	3.40	0.34	0.00	.61568E+02
7.12	0.00	0.00	1.5	0.745E+00	0.33	3.56	0.33	0.00	.72754E+02
7.79	0.00	0.00	1.5	0.735E+00	0.32	3.71	0.32	0.00	.83939E+02
8.46	0.00	0.00	1.6	0.726E+00	0.31	3.86	0.31	0.00	.95125E+02
9.13	0.00	0.00	1.6	0.717E+00	0.30	4.00	0.30	0.00	.10631E+03
9.80	0.00	0.00	1.6	0.708E+00	0.30	4.14	0.30	0.00	.11750E+03
10.47	0.00	0.00	1.6	0.700E+00	0.29	4.27	0.29	0.00	.12868E+03
11.14	0.00	0.00	1.6	0.692E+00	0.28	4.40	0.28	0.00	.13987E+03
11.81	0.00	0.00	1.7	0.684E+00	0.28	4.52	0.28	0.00	.15105E+03
12.49	0.00	0.00	1.7	0.677E+00	0.28	4.64	0.28	0.00	.16224E+03
13.16	0.00	0.00	1.7	0.670E+00	0.27	4.76	0.27	0.00	.17342E+03
13.83	0.00	0.00	1.7	0.663E+00	0.27	4.88	0.27	0.00	.18461E+03
14.50	0.00	0.00	1.7	0.656E+00	0.26	4.99	0.26	0.00	.19580E+03
15.17	0.00	0.00	1.7	0.649E+00	0.26	5.10	0.26	0.00	.20698E+03
15.84	0.00	0.00	1.8	0.643E+00	0.26	5.20	0.26	0.00	.21817E+03
16.51	0.00	0.00	1.8	0.636E+00	0.26	5.31	0.26	0.00	.22935E+03
17.18	0.00	0.00	1.8	0.630E+00	0.25	5.41	0.25	0.00	.24054E+03
17.86	0.00	0.00	1.8	0.623E+00	0.25	5.51	0.25	0.00	.25172E+03
18.53	0.00	0.00	1.8	0.617E+00	0.25	5.61	0.25	0.00	.26291E+03
19.20	0.00	0.00	1.8	0.611E+00	0.25	5.71	0.25	0.00	.27409E+03
19.87	0.00	0.00	1.9	0.605E+00	0.24	5.80	0.24	0.00	.28528E+03

20.54	0.00	0.00	1.9	0.599E+00	0.24	5.90	0.24	0.00	.29647E+03
21.21	0.00	0.00	1.9	0.593E+00	0.24	5.99	0.24	0.00	.30765E+03
21.88	0.00	0.00	1.9	0.587E+00	0.24	6.08	0.24	0.00	.31884E+03
22.55	0.00	0.00	1.9	0.582E+00	0.24	6.17	0.24	0.00	.33002E+03
23.22	0.00	0.00	1.9	0.576E+00	0.24	6.25	0.24	0.00	.34121E+03
23.90	0.00	0.00	2.0	0.570E+00	0.24	6.34	0.24	0.00	.35239E+03
24.57	0.00	0.00	2.0	0.565E+00	0.24	6.43	0.24	0.00	.36358E+03
25.24	0.00	0.00	2.0	0.559E+00	0.23	6.51	0.23	0.00	.37477E+03
25.91	0.00	0.00	2.0	0.553E+00	0.23	6.59	0.23	0.00	.38595E+03
26.58	0.00	0.00	2.0	0.548E+00	0.23	6.68	0.23	0.00	.39714E+03
27.25	0.00	0.00	2.1	0.542E+00	0.23	6.76	0.23	0.00	.40832E+03
27.92	0.00	0.00	2.1	0.537E+00	0.23	6.84	0.23	0.00	.41951E+03
28.59	0.00	0.00	2.1	0.532E+00	0.23	6.92	0.23	0.00	.43069E+03
29.26	0.00	0.00	2.1	0.526E+00	0.23	7.00	0.23	0.00	.44188E+03
29.94	0.00	0.00	2.1	0.521E+00	0.23	7.07	0.23	0.00	.45306E+03
30.61	0.00	0.00	2.2	0.516E+00	0.23	7.15	0.23	0.00	.46425E+03
31.28	0.00	0.00	2.2	0.511E+00	0.23	7.23	0.23	0.00	.47544E+03
31.95	0.00	0.00	2.2	0.505E+00	0.23	7.30	0.23	0.00	.48662E+03
32.62	0.00	0.00	2.2	0.500E+00	0.23	7.38	0.23	0.00	.49781E+03
33.29	0.00	0.00	2.2	0.495E+00	0.23	7.45	0.23	0.00	.50899E+03
33.96	0.00	0.00	2.3	0.490E+00	0.23	7.52	0.23	0.00	.52018E+03
34.63	0.00	0.00	2.3	0.485E+00	0.23	7.60	0.23	0.00	.53136E+03
35.30	0.00	0.00	2.3	0.480E+00	0.23	7.67	0.23	0.00	.54255E+03
35.98	0.00	0.00	2.3	0.475E+00	0.23	7.74	0.23	0.00	.55374E+03
36.65	0.00	0.00	2.4	0.470E+00	0.23	7.81	0.23	0.00	.56492E+03
37.32	0.00	0.00	2.4	0.465E+00	0.23	7.88	0.23	0.00	.57611E+03
37.99	0.00	0.00	2.4	0.461E+00	0.23	7.95	0.23	0.00	.58729E+03
38.66	0.00	0.00	2.4	0.456E+00	0.23	8.02	0.23	0.00	.59848E+03
39.33	0.00	0.00	2.5	0.451E+00	0.23	8.09	0.23	0.00	.60966E+03
40.00	0.00	0.00	2.5	0.446E+00	0.23	8.16	0.23	0.00	.62085E+03
40.67	0.00	0.00	2.5	0.442E+00	0.23	8.23	0.23	0.00	.63203E+03
41.34	0.00	0.00	2.5	0.437E+00	0.23	8.29	0.23	0.00	

									.64322E+03
42.02	0.00	0.00	2.5	0.433E+00	0.23	8.36	0.23	0.00	.65441E+03
42.69	0.00	0.00	2.6	0.428E+00	0.23	8.43	0.23	0.00	.66559E+03
43.36	0.00	0.00	2.6	0.424E+00	0.23	8.49	0.23	0.00	.67678E+03
44.03	0.00	0.00	2.6	0.419E+00	0.23	8.56	0.23	0.00	.68796E+03
44.70	0.00	0.00	2.7	0.415E+00	0.23	8.62	0.23	0.00	.69915E+03
45.37	0.00	0.00	2.7	0.410E+00	0.24	8.69	0.24	0.00	.71033E+03
46.04	0.00	0.00	2.7	0.406E+00	0.24	8.75	0.24	0.00	.72152E+03
46.71	0.00	0.00	2.7	0.402E+00	0.24	8.82	0.24	0.00	.73271E+03
47.39	0.00	0.00	2.8	0.397E+00	0.24	8.88	0.24	0.00	.74389E+03
48.06	0.00	0.00	2.8	0.393E+00	0.24	8.94	0.24	0.00	.75508E+03
48.73	0.00	0.00	2.8	0.389E+00	0.24	9.01	0.24	0.00	.76626E+03
49.40	0.00	0.00	2.8	0.385E+00	0.24	9.07	0.24	0.00	.77745E+03
50.07	0.00	0.00	2.9	0.381E+00	0.24	9.13	0.24	0.00	.78863E+03
50.74	0.00	0.00	2.9	0.377E+00	0.24	9.19	0.24	0.00	.79982E+03
51.41	0.00	0.00	2.9	0.373E+00	0.24	9.25	0.24	0.00	.81101E+03
52.08	0.00	0.00	3.0	0.369E+00	0.24	9.32	0.24	0.00	.82219E+03
52.75	0.00	0.00	3.0	0.365E+00	0.24	9.38	0.24	0.00	.83338E+03
53.43	0.00	0.00	3.0	0.361E+00	0.24	9.44	0.24	0.00	.84456E+03
54.10	0.00	0.00	3.1	0.357E+00	0.25	9.50	0.25	0.00	.85575E+03
54.77	0.00	0.00	3.1	0.353E+00	0.25	9.56	0.25	0.00	.86693E+03
55.44	0.00	0.00	3.1	0.349E+00	0.25	9.62	0.25	0.00	.87812E+03
56.11	0.00	0.00	3.1	0.346E+00	0.25	9.68	0.25	0.00	.88930E+03
56.78	0.00	0.00	3.2	0.342E+00	0.25	9.74	0.25	0.00	.90049E+03
57.45	0.00	0.00	3.2	0.338E+00	0.25	9.80	0.25	0.00	.91168E+03
58.12	0.00	0.00	3.2	0.335E+00	0.25	9.86	0.25	0.00	.92286E+03
58.79	0.00	0.00	3.3	0.331E+00	0.25	9.92	0.25	0.00	.93405E+03
59.47	0.00	0.00	3.3	0.328E+00	0.25	9.98	0.25	0.00	.94523E+03
60.14	0.00	0.00	3.3	0.324E+00	0.25	10.03	0.25	0.00	.95642E+03
60.81	0.00	0.00	3.4	0.321E+00	0.26	10.09	0.26	0.00	.96760E+03
61.48	0.00	0.00	3.4	0.317E+00	0.26	10.15	0.26	0.00	.97879E+03
62.15	0.00	0.00	3.4	0.314E+00	0.26	10.21	0.26	0.00	.98998E+03

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     62.82      0.00     0.00      3.5 0.310E+00   0.26    10.27    0.26    0.00
.10012E+04
     63.49      0.00     0.00      3.5 0.307E+00   0.26    10.32    0.26    0.00
.10123E+04
     64.16      0.00     0.00      3.6 0.304E+00   0.26    10.38    0.26    0.00
.10235E+04
     64.83      0.00     0.00      3.6 0.300E+00   0.26    10.44    0.26    0.00
.10347E+04
     65.51      0.00     0.00      3.6 0.297E+00   0.26    10.50    0.26    0.00
.10459E+04
     66.18      0.00     0.00      3.7 0.294E+00   0.26    10.55    0.26    0.00
.10571E+04
     66.85      0.00     0.00      3.7 0.291E+00   0.27    10.61    0.27    0.00
.10683E+04
     67.52      0.00     0.00      3.7 0.288E+00   0.27    10.67    0.27    0.00
.10795E+04
     68.19      0.00     0.00      3.8 0.285E+00   0.27    10.72    0.27    0.00
.10906E+04
     68.86      0.00     0.00      3.8 0.282E+00   0.27    10.78    0.27    0.00
.11018E+04
     69.53      0.00     0.00      3.9 0.279E+00   0.27    10.84    0.27    0.00
.11130E+04
     70.20      0.00     0.00      3.9 0.276E+00   0.27    10.89    0.27    0.00
.11242E+04
     70.88      0.00     0.00      3.9 0.273E+00   0.27    10.95    0.27    0.00
.11354E+04
     71.55      0.00     0.00      4.0 0.270E+00   0.28    11.00    0.28    0.00
.11466E+04
 Cumulative travel time =        1146.5731 sec  (    0.32 hrs)
 Plume is LATERALLY FULLY MIXED at the end of the buoyant spreading regime.

END OF MOD241: BUOYANT AMBIENT SPREADING
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BEGIN MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.529E-03 m^2/s
  Horizontal diffusivity (initial value) = 0.265E-02 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X        Y        Z        S       C        BV       BH      ZU      ZL
TT
     71.55      0.00     0.00      4.0 0.270E+00   0.28    11.00    0.28    0.00
.11466E+04
     72.83      0.00     0.00      4.0 0.267E+00   0.28    11.00    0.28    0.00
.11680E+04
     74.12      0.00     0.00      4.0 0.264E+00   0.28    11.00    0.28    0.00
.11894E+04
     75.40      0.00     0.00      4.1 0.262E+00   0.28    11.00    0.28    0.00
.12108E+04
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     76.68      0.00     0.00       4.1 0.259E+00   0.29    11.00    0.29    0.00
.12322E+04
     77.97      0.00     0.00       4.2 0.256E+00   0.29    11.00    0.29    0.00
.12536E+04
     79.25      0.00     0.00       4.2 0.254E+00   0.29    11.00    0.29    0.00
.12750E+04
     80.54      0.00     0.00       4.2 0.251E+00   0.29    11.00    0.29    0.00
.12964E+04
     81.82      0.00     0.00       4.3 0.249E+00   0.30    11.00    0.30    0.00
.13178E+04
     83.11      0.00     0.00       4.3 0.246E+00   0.30    11.00    0.30    0.00
.13393E+04
     84.39      0.00     0.00       4.3 0.243E+00   0.30    11.00    0.30    0.00
.13607E+04
     85.68      0.00     0.00       4.4 0.241E+00   0.30    11.00    0.30    0.00
.13821E+04
     86.96      0.00     0.00       4.4 0.238E+00   0.31    11.00    0.31    0.00
.14035E+04
     88.25      0.00     0.00       4.5 0.236E+00   0.31    11.00    0.31    0.00
.14249E+04
     89.53      0.00     0.00       4.5 0.233E+00   0.31    11.00    0.31    0.00
.14463E+04
     90.81      0.00     0.00       4.6 0.231E+00   0.32    11.00    0.32    0.00
.14677E+04
     92.10      0.00     0.00       4.6 0.228E+00   0.32    11.00    0.32    0.00
.14891E+04
     93.38      0.00     0.00       4.6 0.226E+00   0.32    11.00    0.32    0.00
.15105E+04
     94.67      0.00     0.00       4.7 0.223E+00   0.33    11.00    0.33    0.00
.15319E+04
     95.95      0.00     0.00       4.7 0.221E+00   0.33    11.00    0.33    0.00
.15533E+04
     97.24      0.00     0.00       4.8 0.218E+00   0.33    11.00    0.33    0.00
.15748E+04
     98.52      0.00     0.00       4.8 0.216E+00   0.33    11.00    0.33    0.00
.15962E+04
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.215E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     99.81      0.00     0.00       4.9 0.214E+00   0.34    11.00    0.34    0.00
.16176E+04
    101.09      0.00     0.00       4.9 0.211E+00   0.34    11.00    0.34    0.00
.16390E+04
    102.38      0.00     0.00       5.0 0.209E+00   0.35    11.00    0.35    0.00
.16604E+04
    103.66      0.00     0.00       5.0 0.207E+00   0.35    11.00    0.35    0.00
.16818E+04
    104.94      0.00     0.00       5.1 0.204E+00   0.35    11.00    0.35    0.00
.17032E+04
    106.23      0.00     0.00       5.1 0.202E+00   0.36    11.00    0.36    0.00
.17246E+04
    107.51      0.00     0.00       5.2 0.200E+00   0.36    11.00    0.36    0.00
.17460E+04
    108.80      0.00     0.00       5.2 0.197E+00   0.36    11.00    0.36    0.00
.17674E+04
    110.08      0.00     0.00       5.3 0.195E+00   0.37    11.00    0.37    0.00
.17888E+04
    111.37      0.00     0.00       5.4 0.193E+00   0.37    11.00    0.37    0.00
.18103E+04
    112.65      0.00     0.00       5.4 0.190E+00   0.37    11.00    0.37    0.00
.18317E+04
```

```
   113.94      0.00    0.00      5.5 0.188E+00   0.38    11.00    0.38    0.00
.18531E+04
   115.22      0.00    0.00      5.5 0.186E+00   0.38    11.00    0.38    0.00
.18745E+04
   116.50      0.00    0.00      5.6 0.184E+00   0.39    11.00    0.39    0.00
.18959E+04
   117.79      0.00    0.00      5.6 0.182E+00   0.39    11.00    0.39    0.00
.19173E+04
   119.07      0.00    0.00      5.7 0.180E+00   0.40    11.00    0.40    0.00
.19387E+04
   120.36      0.00    0.00      5.8 0.177E+00   0.40    11.00    0.40    0.00
.19601E+04
 Plume interacts with SURFACE.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
   121.64      0.00    0.00      5.8 0.177E+00   0.40    11.00    0.40    0.00
.19815E+04
 Effluent is FULLY MIXED over the entire channel cross-section.
 Except for possible far-field decay or reaction processes, there are
     NO FURTHER CHANGES with downstream direction.
   122.93      0.00    0.00      5.8 0.177E+00   0.40    11.00    0.40    0.00
.20029E+04
   124.21      0.00    0.00      5.8 0.176E+00   0.40    11.00    0.40    0.00
.20243E+04
   125.50      0.00    0.00      5.8 0.176E+00   0.40    11.00    0.40    0.00
.20458E+04
   126.78      0.00    0.00      5.8 0.176E+00   0.40    11.00    0.40    0.00
.20672E+04
   128.07      0.00    0.00      5.8 0.176E+00   0.40    11.00    0.40    0.00
.20886E+04
   129.35      0.00    0.00      5.8 0.176E+00   0.40    11.00    0.40    0.00
.21100E+04
   130.63      0.00    0.00      5.8 0.175E+00   0.40    11.00    0.40    0.00
.21314E+04
   131.92      0.00    0.00      5.8 0.175E+00   0.40    11.00    0.40    0.00
.21528E+04
   133.20      0.00    0.00      5.8 0.175E+00   0.40    11.00    0.40    0.00
.21742E+04
   134.49      0.00    0.00      5.8 0.175E+00   0.40    11.00    0.40    0.00
.21956E+04
   135.77      0.00    0.00      5.8 0.175E+00   0.40    11.00    0.40    0.00
.22170E+04
   137.06      0.00    0.00      5.8 0.174E+00   0.40    11.00    0.40    0.00
.22384E+04
   138.34      0.00    0.00      5.8 0.174E+00   0.40    11.00    0.40    0.00
.22598E+04
   139.63      0.00    0.00      5.8 0.174E+00   0.40    11.00    0.40    0.00
.22812E+04
   140.91      0.00    0.00      5.8 0.174E+00   0.40    11.00    0.40    0.00
.23027E+04
   142.20      0.00    0.00      5.8 0.173E+00   0.40    11.00    0.40    0.00
.23241E+04
   143.48      0.00    0.00      5.8 0.173E+00   0.40    11.00    0.40    0.00
.23455E+04
   144.76      0.00    0.00      5.8 0.173E+00   0.40    11.00    0.40    0.00
.23669E+04
   146.05      0.00    0.00      5.8 0.173E+00   0.40    11.00    0.40    0.00
.23883E+04
   147.33      0.00    0.00      5.8 0.173E+00   0.40    11.00    0.40    0.00
.24097E+04
   148.62      0.00    0.00      5.8 0.172E+00   0.40    11.00    0.40    0.00
.24311E+04
   149.90      0.00    0.00      5.8 0.172E+00   0.40    11.00    0.40    0.00
```

.24525E+04								
151.19	0.00	0.00	5.8	0.172E+00	0.40	11.00	0.40	0.00
.24739E+04								
152.47	0.00	0.00	5.8	0.172E+00	0.40	11.00	0.40	0.00
.24953E+04								
153.76	0.00	0.00	5.8	0.172E+00	0.40	11.00	0.40	0.00
.25168E+04								
155.04	0.00	0.00	5.8	0.171E+00	0.40	11.00	0.40	0.00
.25382E+04								
156.33	0.00	0.00	5.8	0.171E+00	0.40	11.00	0.40	0.00
.25596E+04								
157.61	0.00	0.00	5.8	0.171E+00	0.40	11.00	0.40	0.00
.25810E+04								
158.89	0.00	0.00	5.8	0.171E+00	0.40	11.00	0.40	0.00
.26024E+04								
160.18	0.00	0.00	5.8	0.170E+00	0.40	11.00	0.40	0.00
.26238E+04								
161.46	0.00	0.00	5.8	0.170E+00	0.40	11.00	0.40	0.00
.26452E+04								
162.75	0.00	0.00	5.8	0.170E+00	0.40	11.00	0.40	0.00
.26666E+04								
164.03	0.00	0.00	5.8	0.170E+00	0.40	11.00	0.40	0.00
.26880E+04								
165.32	0.00	0.00	5.8	0.170E+00	0.40	11.00	0.40	0.00
.27094E+04								
166.60	0.00	0.00	5.8	0.169E+00	0.40	11.00	0.40	0.00
.27308E+04								
167.89	0.00	0.00	5.8	0.169E+00	0.40	11.00	0.40	0.00
.27522E+04								
169.17	0.00	0.00	5.8	0.169E+00	0.40	11.00	0.40	0.00
.27737E+04								
170.46	0.00	0.00	5.8	0.169E+00	0.40	11.00	0.40	0.00
.27951E+04								
171.74	0.00	0.00	5.8	0.169E+00	0.40	11.00	0.40	0.00
.28165E+04								
173.02	0.00	0.00	5.8	0.168E+00	0.40	11.00	0.40	0.00
.28379E+04								
174.31	0.00	0.00	5.8	0.168E+00	0.40	11.00	0.40	0.00
.28593E+04								
175.59	0.00	0.00	5.8	0.168E+00	0.40	11.00	0.40	0.00
.28807E+04								
176.88	0.00	0.00	5.8	0.168E+00	0.40	11.00	0.40	0.00
.29021E+04								
178.16	0.00	0.00	5.8	0.168E+00	0.40	11.00	0.40	0.00
.29235E+04								
179.45	0.00	0.00	5.8	0.167E+00	0.40	11.00	0.40	0.00
.29449E+04								
180.73	0.00	0.00	5.8	0.167E+00	0.40	11.00	0.40	0.00
.29663E+04								
182.02	0.00	0.00	5.8	0.167E+00	0.40	11.00	0.40	0.00
.29878E+04								
183.30	0.00	0.00	5.8	0.167E+00	0.40	11.00	0.40	0.00
.30092E+04								
184.59	0.00	0.00	5.8	0.167E+00	0.40	11.00	0.40	0.00
.30306E+04								
185.87	0.00	0.00	5.8	0.166E+00	0.40	11.00	0.40	0.00
.30520E+04								
187.15	0.00	0.00	5.8	0.166E+00	0.40	11.00	0.40	0.00
.30734E+04								
188.44	0.00	0.00	5.8	0.166E+00	0.40	11.00	0.40	0.00
.30948E+04								
189.72	0.00	0.00	5.8	0.166E+00	0.40	11.00	0.40	0.00
.31162E+04								

```
   191.01     0.00    0.00     5.8 0.165E+00   0.40    11.00    0.40    0.00
.31376E+04
   192.29     0.00    0.00     5.8 0.165E+00   0.40    11.00    0.40    0.00
.31590E+04
   193.58     0.00    0.00     5.8 0.165E+00   0.40    11.00    0.40    0.00
.31804E+04
   194.86     0.00    0.00     5.8 0.165E+00   0.40    11.00    0.40    0.00
.32018E+04
   196.15     0.00    0.00     5.8 0.165E+00   0.40    11.00    0.40    0.00
.32232E+04
   197.43     0.00    0.00     5.8 0.164E+00   0.40    11.00    0.40    0.00
.32447E+04
   198.72     0.00    0.00     5.8 0.164E+00   0.40    11.00    0.40    0.00
.32661E+04
   200.00     0.00    0.00     5.8 0.164E+00   0.40    11.00    0.40    0.00
.32875E+04
 Cumulative travel time =        3287.4712 sec  (    0.91 hrs)

 Simulation limit based on maximum specified distance =    200.00 m.
   This is the REGION OF INTEREST limitation.

END OF MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
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CORMIX2: Multiport Diffuser Discharges       End of Prediction File
2222222222222222222222222222222222222222222222222222222222222222222222222222222222
222222222222
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CORMIX2 PREDICTION FILE:
222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222
                    CORMIX MIXING ZONE EXPERT SYSTEM
              Subsystem CORMIX2: Multiport Diffuser Discharges
                          CORMIX Version 10.0GT
                     HYDRO2 Version 10.0.0.0 July 2016
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   West Credit River
 Design case:       Erin WWTP - 7172
 FILE NAME:         C:\... WWTP-7172-diffuser vertical-good-side-update.prd
 Time stamp:        03/14/2017--12:53:32

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     11.00  AS    =      4.40  QA    =      0.23  ICHREG= 3
 HA    =      0.40  HD    =      0.40
 UA    =      0.051 F     =      0.130 USTAR =0.6529E-02
 UW    =      2.000 UWSTAR=0.2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  997.9542

DIFFUSER DISCHARGE PARAMETERS (metric units)
 Diffuser type:     DITYPE= alternating_parallel
 BANK  =  RIGHT     DISTB =      0.00  YB1   =      0.50  YB2   =      0.50
 LD    =      5.00  NOPEN =   15       SPAC  =      0.36
 D0    =      0.050 A0    =      0.002 H0    =      0.00  SUB0  =      0.40
 D0INP =      0.050 CR0   =      1.000
 Nozzle/port arrangement:   near_vertical_discharge
 GAMMA =      0.00  THETA =     90.00  SIGMA =      0.00  BETA  =     90.00
 U0    =      2.818 Q0    =      0.083 Q0A   =0.8300E-01
 RHO0  =  998.4062  DRHO0 =-.4520E+00  GP0   =-.4442E-02
 C0    =0.5450E+00  CUNITS=  mg/l
 IPOLL =  2         KS    =0.0000E+00  KD    =0.5787E-04

DIFFUSER PARAMETERS WITH IMAGE EFFECTS (metric units)
 The bank/shore proximity effect is accounted for by the following flow
 variables and definitions of length scales and parameters.
 LD    =      5.00  Q0    =      0.166 Q0A    =0.8300E-01

FLUX VARIABLES - PER UNIT DIFFUSER LENGTH (metric units)
 q0    =0.6640E-01  m0    =0.4678E-01  j0    =-.7374E-04  SIGNJ0=     -1.0
 Associated 2-d length scales (meters)
 lQ=B  =      0.024 lM    =     26.52  lm    =     35.78
 lmp   =  99999.00  lbp   =  99999.00  la    =  99999.00

FLUX VARIABLES - ENTIRE DIFFUSER (metric units)
 Q0    =0.1660E+00  M0    =0.2339E+00  J0    =-.3687E-03
 Associated 3-d length scales (meters)
 LQ    =      0.04  LM    =     17.52  Lm    =     13.38  Lb    =      5.51
                                       Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =    550.91  FRD0  =    189.09  R     =     55.11  PL    =  140.00
 (slot)             (port/nozzle)


FLOW CLASSIFICATION
 222222222222222222222222222222222222222222
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 2  Flow class (CORMIX2)       =    MNU14  2
 2  Applicable layer depth HS =     0.40  2
 2  Limiting Dilution S =QA/Q0=     2.36  2
 2222222222222222222222222222222222222222

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.5450E+00  CUNITS=  mg/l
 NTOX  =  0
 NSTD  =  1         CSTD  =0.1950E+00
 REGMZ =  0
 XINT  =    200.00  XMAX  =    200.00

X-Y-Z COORDINATE SYSTEM:
  because of bank/shore proximity, the ORIGIN is located directly
   at the RIGHT bank/shore.
  the bank/shore acts as a plane of symmetry for the predicted
  plume geometry.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP = 100 display intervals per module
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S       C       BV       BH       Uc        TT
      0.00     0.00    0.00     1.0 0.545E+00   0.00     2.50     2.818
.00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
BEGIN MOD234: UNSTABLE RECIRCULATION REGION OVER LAYER DEPTH

 The MIXING of this alternating diffuser is somewhat REDUCED
   due to its PARALLEL ALIGNMENT.
 INITIAL LOCAL VERTICAL INSTABILITY REGION:
   Bulk dilution (S =   1.41) occurs in a limited region (horizontal extent
   =    3.00 m) surrounding the discharge location.

  Control volume inflow:
       X        Y       Z        S       C       BV       BH        TT
      0.00     0.00    0.00     1.0 0.545E+00   0.00     2.50   .00000E+00

  Control volume outflow:
       X        Y       Z        S       C       BV       BH        TT
      3.00     0.00    0.20     1.4 0.385E+00   0.40     1.00   .00000E+00

END OF MOD234: UNSTABLE RECIRCULATION REGION OVER LAYER DEPTH
-----------------------------------------------------------------------------------------
```

BEGIN MOD234a: UPSTREAM SPREADING AFTER NEAR-FIELD INSTABILITY

UPSTREAM INTRUSION PROPERTIES:

```
       Upstream intrusion length               =       0.55 m
       X-position of upstream stagnation point =       2.45 m
       Thickness in intrusion region           =       0.40 m
       Half-width at downstream end            =       6.01 m
       Thickness at downstream end             =       0.39 m
```

Control volume inflow:

X	Y	Z	S	C	BV	BH	TT
3.00	0.00	0.20	1.4	0.385E+00	0.40	1.00	.00000E+00

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
2.45	0.00	0.00	9999.9	0.000E+00	0.00	0.00	0.00	0.00	.58745E+02
2.52	0.00	0.00	3.2	0.173E+00	0.40	0.85	0.40	0.00	.00000E+00
2.87	0.00	0.00	1.5	0.372E+00	0.40	2.06	0.40	0.00	.00000E+00
3.22	0.00	0.00	1.4	0.385E+00	0.39	4.06	0.39	0.00	.42412E+01
3.57	0.00	0.00	1.4	0.384E+00	0.39	4.41	0.39	0.00	.11054E+02
3.91	0.00	0.00	1.4	0.383E+00	0.39	4.70	0.39	0.00	.17867E+02
4.26	0.00	0.00	1.4	0.382E+00	0.39	4.97	0.39	0.00	.24680E+02
4.61	0.00	0.00	1.4	0.381E+00	0.39	5.21	0.39	0.00	.31493E+02
4.96	0.00	0.00	1.4	0.380E+00	0.39	5.43	0.39	0.00	.38306E+02
5.31	0.00	0.00	1.4	0.380E+00	0.39	5.63	0.39	0.00	.45119E+02
5.66	0.00	0.00	1.4	0.379E+00	0.39	5.82	0.39	0.00	.51932E+02
6.00	0.00	0.00	1.4	0.379E+00	0.39	6.01	0.39	0.00	.58745E+02

Cumulative travel time =   58.7450 sec (0.02 hrs)

END OF MOD234a: UPSTREAM SPREADING AFTER NEAR-FIELD INSTABILITY

** End of NEAR-FIELD REGION (NFR) **

Recall that the plume is symmetric to the bank/shore on which the centerline (X-axis) is located.

BEGIN MOD241: BUOYANT AMBIENT SPREADING

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Profile definitions:

BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
6.00	0.00	0.00	1.4	0.379E+00	0.39	6.01	0.39	0.00	.58745E+02
6.37	0.00	0.00	1.4	0.377E+00	0.38	6.08	0.38	0.00	.63935E+02
6.73	0.00	0.00	1.4	0.376E+00	0.38	6.15	0.38	0.00	.69124E+02
7.09	0.00	0.00	1.4	0.374E+00	0.38	6.22	0.38	0.00	.74314E+02
7.46	0.00	0.00	1.5	0.373E+00	0.38	6.29	0.38	0.00	.79503E+02
7.82	0.00	0.00	1.5	0.372E+00	0.37	6.36	0.37	0.00	.84693E+02
8.18	0.00	0.00	1.5	0.370E+00	0.37	6.43	0.37	0.00	.89883E+02
8.55	0.00	0.00	1.5	0.369E+00	0.37	6.50	0.37	0.00	.95072E+02
8.91	0.00	0.00	1.5	0.367E+00	0.36	6.56	0.36	0.00	.10026E+03
9.27	0.00	0.00	1.5	0.366E+00	0.36	6.63	0.36	0.00	.10545E+03
9.64	0.00	0.00	1.5	0.365E+00	0.36	6.70	0.36	0.00	.11064E+03
10.00	0.00	0.00	1.5	0.363E+00	0.36	6.76	0.36	0.00	.11583E+03
10.36	0.00	0.00	1.5	0.362E+00	0.36	6.82	0.36	0.00	.12102E+03
10.73	0.00	0.00	1.5	0.361E+00	0.35	6.89	0.35	0.00	.12621E+03
11.09	0.00	0.00	1.5	0.360E+00	0.35	6.95	0.35	0.00	.13140E+03
11.45	0.00	0.00	1.5	0.358E+00	0.35	7.01	0.35	0.00	.13659E+03
11.82	0.00	0.00	1.5	0.357E+00	0.35	7.07	0.35	0.00	.14178E+03
12.18	0.00	0.00	1.5	0.356E+00	0.35	7.13	0.35	0.00	.14697E+03
12.54	0.00	0.00	1.5	0.355E+00	0.34	7.19	0.34	0.00	.15216E+03
12.91	0.00	0.00	1.5	0.353E+00	0.34	7.25	0.34	0.00	.15735E+03
13.27	0.00	0.00	1.5	0.352E+00	0.34	7.31	0.34	0.00	.16254E+03
13.63	0.00	0.00	1.5	0.351E+00	0.34	7.37	0.34	0.00	.16773E+03
14.00	0.00	0.00	1.5	0.350E+00	0.34	7.43	0.34	0.00	.17292E+03
14.36	0.00	0.00	1.5	0.349E+00	0.34	7.49	0.34	0.00	.17811E+03

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     14.72     0.00    0.00     1.6 0.348E+00   0.33     7.55    0.33    0.00
.18330E+03
     15.09     0.00    0.00     1.6 0.347E+00   0.33     7.60    0.33    0.00
.18848E+03
     15.45     0.00    0.00     1.6 0.345E+00   0.33     7.66    0.33    0.00
.19367E+03
     15.81     0.00    0.00     1.6 0.344E+00   0.33     7.71    0.33    0.00
.19886E+03
     16.18     0.00    0.00     1.6 0.343E+00   0.33     7.77    0.33    0.00
.20405E+03
     16.54     0.00    0.00     1.6 0.342E+00   0.33     7.82    0.33    0.00
.20924E+03
     16.90     0.00    0.00     1.6 0.341E+00   0.33     7.88    0.33    0.00
.21443E+03
     17.27     0.00    0.00     1.6 0.340E+00   0.32     7.93    0.32    0.00
.21962E+03
     17.63     0.00    0.00     1.6 0.339E+00   0.32     7.99    0.32    0.00
.22481E+03
     17.99     0.00    0.00     1.6 0.338E+00   0.32     8.04    0.32    0.00
.23000E+03
     18.36     0.00    0.00     1.6 0.337E+00   0.32     8.09    0.32    0.00
.23519E+03
     18.72     0.00    0.00     1.6 0.336E+00   0.32     8.15    0.32    0.00
.24038E+03
     19.08     0.00    0.00     1.6 0.335E+00   0.32     8.20    0.32    0.00
.24557E+03
     19.45     0.00    0.00     1.6 0.334E+00   0.32     8.25    0.32    0.00
.25076E+03
     19.81     0.00    0.00     1.6 0.333E+00   0.32     8.30    0.32    0.00
.25595E+03
     20.17     0.00    0.00     1.6 0.331E+00   0.31     8.35    0.31    0.00
.26114E+03
     20.53     0.00    0.00     1.6 0.330E+00   0.31     8.40    0.31    0.00
.26633E+03
     20.90     0.00    0.00     1.6 0.329E+00   0.31     8.45    0.31    0.00
.27152E+03
     21.26     0.00    0.00     1.6 0.328E+00   0.31     8.50    0.31    0.00
.27671E+03
     21.62     0.00    0.00     1.6 0.327E+00   0.31     8.55    0.31    0.00
.28190E+03
     21.99     0.00    0.00     1.6 0.326E+00   0.31     8.60    0.31    0.00
.28709E+03
     22.35     0.00    0.00     1.6 0.325E+00   0.31     8.65    0.31    0.00
.29228E+03
     22.71     0.00    0.00     1.7 0.324E+00   0.31     8.70    0.31    0.00
.29747E+03
     23.08     0.00    0.00     1.7 0.323E+00   0.31     8.75    0.31    0.00
.30266E+03
     23.44     0.00    0.00     1.7 0.322E+00   0.31     8.80    0.31    0.00
.30785E+03
     23.80     0.00    0.00     1.7 0.321E+00   0.31     8.85    0.31    0.00
.31304E+03
     24.17     0.00    0.00     1.7 0.321E+00   0.30     8.89    0.30    0.00
.31822E+03
     24.53     0.00    0.00     1.7 0.320E+00   0.30     8.94    0.30    0.00
.32341E+03
     24.89     0.00    0.00     1.7 0.319E+00   0.30     8.99    0.30    0.00
.32860E+03
     25.26     0.00    0.00     1.7 0.318E+00   0.30     9.04    0.30    0.00
.33379E+03
     25.62     0.00    0.00     1.7 0.317E+00   0.30     9.08    0.30    0.00
.33898E+03
     25.98     0.00    0.00     1.7 0.316E+00   0.30     9.13    0.30    0.00
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.34417E+03								
26.35	0.00	0.00	1.7	0.315E+00	0.30	9.17	0.30	0.00
.34936E+03								
26.71	0.00	0.00	1.7	0.314E+00	0.30	9.22	0.30	0.00
.35455E+03								
27.07	0.00	0.00	1.7	0.313E+00	0.30	9.27	0.30	0.00
.35974E+03								
27.44	0.00	0.00	1.7	0.312E+00	0.30	9.31	0.30	0.00
.36493E+03								
27.80	0.00	0.00	1.7	0.311E+00	0.30	9.36	0.30	0.00
.37012E+03								
28.16	0.00	0.00	1.7	0.310E+00	0.30	9.40	0.30	0.00
.37531E+03								
28.53	0.00	0.00	1.7	0.309E+00	0.30	9.45	0.30	0.00
.38050E+03								
28.89	0.00	0.00	1.7	0.308E+00	0.30	9.49	0.30	0.00
.38569E+03								
29.25	0.00	0.00	1.7	0.307E+00	0.30	9.53	0.30	0.00
.39088E+03								
29.62	0.00	0.00	1.7	0.306E+00	0.29	9.58	0.29	0.00
.39607E+03								
29.98	0.00	0.00	1.7	0.305E+00	0.29	9.62	0.29	0.00
.40126E+03								
30.34	0.00	0.00	1.7	0.304E+00	0.29	9.67	0.29	0.00
.40645E+03								
30.71	0.00	0.00	1.8	0.304E+00	0.29	9.71	0.29	0.00
.41164E+03								
31.07	0.00	0.00	1.8	0.303E+00	0.29	9.75	0.29	0.00
.41683E+03								
31.43	0.00	0.00	1.8	0.302E+00	0.29	9.80	0.29	0.00
.42202E+03								
31.80	0.00	0.00	1.8	0.301E+00	0.29	9.84	0.29	0.00
.42721E+03								
32.16	0.00	0.00	1.8	0.300E+00	0.29	9.88	0.29	0.00
.43240E+03								
32.52	0.00	0.00	1.8	0.299E+00	0.29	9.92	0.29	0.00
.43759E+03								
32.89	0.00	0.00	1.8	0.298E+00	0.29	9.97	0.29	0.00
.44277E+03								
33.25	0.00	0.00	1.8	0.297E+00	0.29	10.01	0.29	0.00
.44796E+03								
33.61	0.00	0.00	1.8	0.296E+00	0.29	10.05	0.29	0.00
.45315E+03								
33.98	0.00	0.00	1.8	0.295E+00	0.29	10.09	0.29	0.00
.45834E+03								
34.34	0.00	0.00	1.8	0.295E+00	0.29	10.13	0.29	0.00
.46353E+03								
34.70	0.00	0.00	1.8	0.294E+00	0.29	10.17	0.29	0.00
.46872E+03								
35.07	0.00	0.00	1.8	0.293E+00	0.29	10.21	0.29	0.00
.47391E+03								
35.43	0.00	0.00	1.8	0.292E+00	0.29	10.26	0.29	0.00
.47910E+03								
35.79	0.00	0.00	1.8	0.291E+00	0.29	10.30	0.29	0.00
.48429E+03								
36.16	0.00	0.00	1.8	0.290E+00	0.29	10.34	0.29	0.00
.48948E+03								
36.52	0.00	0.00	1.8	0.289E+00	0.29	10.38	0.29	0.00
.49467E+03								
36.88	0.00	0.00	1.8	0.288E+00	0.29	10.42	0.29	0.00
.49986E+03								
37.25	0.00	0.00	1.8	0.288E+00	0.29	10.46	0.29	0.00
.50505E+03								

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     37.61      0.00    0.00     1.8 0.287E+00   0.29    10.50    0.29    0.00
.51024E+03
     37.97      0.00    0.00     1.9 0.286E+00   0.29    10.54    0.29    0.00
.51543E+03
     38.34      0.00    0.00     1.9 0.285E+00   0.28    10.58    0.28    0.00
.52062E+03
     38.70      0.00    0.00     1.9 0.284E+00   0.28    10.62    0.28    0.00
.52581E+03
     39.06      0.00    0.00     1.9 0.283E+00   0.28    10.66    0.28    0.00
.53100E+03
     39.42      0.00    0.00     1.9 0.282E+00   0.28    10.69    0.28    0.00
.53619E+03
     39.79      0.00    0.00     1.9 0.282E+00   0.28    10.73    0.28    0.00
.54138E+03
     40.15      0.00    0.00     1.9 0.281E+00   0.28    10.77    0.28    0.00
.54657E+03
     40.51      0.00    0.00     1.9 0.280E+00   0.28    10.81    0.28    0.00
.55176E+03
     40.88      0.00    0.00     1.9 0.279E+00   0.28    10.85    0.28    0.00
.55695E+03
     41.24      0.00    0.00     1.9 0.278E+00   0.28    10.89    0.28    0.00
.56214E+03
     41.60      0.00    0.00     1.9 0.277E+00   0.28    10.93    0.28    0.00
.56732E+03
     41.97      0.00    0.00     1.9 0.277E+00   0.28    10.96    0.28    0.00
.57251E+03
     42.33      0.00    0.00     1.9 0.276E+00   0.28    11.00    0.28    0.00
.57770E+03
 Cumulative travel time =         577.7041 sec  (    0.16 hrs)
 Plume is LATERALLY FULLY MIXED at the end of the buoyant spreading regime.

END OF MOD241: BUOYANT AMBIENT SPREADING
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BEGIN MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.529E-03 m^2/s
  Horizontal diffusivity (initial value) = 0.265E-02 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X        Y       Z        S       C       BV       BH      ZU      ZL
TT
     42.33      0.00    0.00     1.9 0.276E+00   0.28    11.00    0.28    0.00
.57770E+03
     43.91      0.00    0.00     1.9 0.274E+00   0.28    11.00    0.28    0.00
.60023E+03
     45.48      0.00    0.00     1.9 0.273E+00   0.28    11.00    0.28    0.00
.62275E+03
     47.06      0.00    0.00     1.9 0.272E+00   0.28    11.00    0.28    0.00
.64528E+03
```

48.64	0.00	0.00	1.9	0.271E+00	0.29	11.00	0.29	0.00	.66780E+03
50.21	0.00	0.00	1.9	0.269E+00	0.29	11.00	0.29	0.00	.69032E+03
51.79	0.00	0.00	2.0	0.268E+00	0.29	11.00	0.29	0.00	.71285E+03
53.37	0.00	0.00	2.0	0.267E+00	0.29	11.00	0.29	0.00	.73537E+03
54.94	0.00	0.00	2.0	0.266E+00	0.29	11.00	0.29	0.00	.75790E+03
56.52	0.00	0.00	2.0	0.264E+00	0.29	11.00	0.29	0.00	.78042E+03
58.10	0.00	0.00	2.0	0.263E+00	0.29	11.00	0.29	0.00	.80295E+03
59.67	0.00	0.00	2.0	0.262E+00	0.29	11.00	0.29	0.00	.82547E+03
61.25	0.00	0.00	2.0	0.261E+00	0.29	11.00	0.29	0.00	.84799E+03
62.83	0.00	0.00	2.0	0.259E+00	0.29	11.00	0.29	0.00	.87052E+03
64.40	0.00	0.00	2.0	0.258E+00	0.30	11.00	0.30	0.00	.89304E+03
65.98	0.00	0.00	2.0	0.257E+00	0.30	11.00	0.30	0.00	.91557E+03
67.56	0.00	0.00	2.0	0.256E+00	0.30	11.00	0.30	0.00	.93809E+03
69.13	0.00	0.00	2.0	0.254E+00	0.30	11.00	0.30	0.00	.96061E+03
70.71	0.00	0.00	2.0	0.253E+00	0.30	11.00	0.30	0.00	.98314E+03
72.29	0.00	0.00	2.0	0.252E+00	0.30	11.00	0.30	0.00	.10057E+04
73.86	0.00	0.00	2.0	0.251E+00	0.30	11.00	0.30	0.00	.10282E+04
75.44	0.00	0.00	2.1	0.250E+00	0.30	11.00	0.30	0.00	.10507E+04
77.02	0.00	0.00	2.1	0.248E+00	0.30	11.00	0.30	0.00	.10732E+04
78.60	0.00	0.00	2.1	0.247E+00	0.31	11.00	0.31	0.00	.10958E+04
80.17	0.00	0.00	2.1	0.246E+00	0.31	11.00	0.31	0.00	.11183E+04
81.75	0.00	0.00	2.1	0.245E+00	0.31	11.00	0.31	0.00	.11408E+04
83.33	0.00	0.00	2.1	0.244E+00	0.31	11.00	0.31	0.00	.11633E+04
84.90	0.00	0.00	2.1	0.242E+00	0.31	11.00	0.31	0.00	.11859E+04
86.48	0.00	0.00	2.1	0.241E+00	0.31	11.00	0.31	0.00	.12084E+04
88.06	0.00	0.00	2.1	0.240E+00	0.31	11.00	0.31	0.00	.12309E+04
89.63	0.00	0.00	2.1	0.239E+00	0.31	11.00	0.31	0.00	.12534E+04
91.21	0.00	0.00	2.1	0.238E+00	0.31	11.00	0.31	0.00	.12760E+04
92.79	0.00	0.00	2.1	0.236E+00	0.32	11.00	0.32	0.00	.12985E+04
94.36	0.00	0.00	2.1	0.235E+00	0.32	11.00	0.32	0.00	.13210E+04
95.94	0.00	0.00	2.2	0.234E+00	0.32	11.00	0.32	0.00	.13435E+04
97.52	0.00	0.00	2.2	0.233E+00	0.32	11.00	0.32	0.00	

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.13660E+04
     99.09     0.00     0.00     2.2 0.232E+00   0.32    11.00    0.32    0.00
.13886E+04
    100.67     0.00     0.00     2.2 0.231E+00   0.32    11.00    0.32    0.00
.14111E+04
    102.25     0.00     0.00     2.2 0.229E+00   0.32    11.00    0.32    0.00
.14336E+04
    103.82     0.00     0.00     2.2 0.228E+00   0.32    11.00    0.32    0.00
.14561E+04
    105.40     0.00     0.00     2.2 0.227E+00   0.32    11.00    0.32    0.00
.14787E+04
    106.98     0.00     0.00     2.2 0.226E+00   0.33    11.00    0.33    0.00
.15012E+04
    108.55     0.00     0.00     2.2 0.225E+00   0.33    11.00    0.33    0.00
.15237E+04
    110.13     0.00     0.00     2.2 0.224E+00   0.33    11.00    0.33    0.00
.15462E+04
    111.71     0.00     0.00     2.2 0.223E+00   0.33    11.00    0.33    0.00
.15688E+04
    113.28     0.00     0.00     2.2 0.221E+00   0.33    11.00    0.33    0.00
.15913E+04
    114.86     0.00     0.00     2.3 0.220E+00   0.33    11.00    0.33    0.00
.16138E+04
    116.44     0.00     0.00     2.3 0.219E+00   0.33    11.00    0.33    0.00
.16363E+04
    118.01     0.00     0.00     2.3 0.218E+00   0.33    11.00    0.33    0.00
.16589E+04
    119.59     0.00     0.00     2.3 0.217E+00   0.34    11.00    0.34    0.00
.16814E+04
    121.17     0.00     0.00     2.3 0.216E+00   0.34    11.00    0.34    0.00
.17039E+04
    122.74     0.00     0.00     2.3 0.215E+00   0.34    11.00    0.34    0.00
.17264E+04
    124.32     0.00     0.00     2.3 0.214E+00   0.34    11.00    0.34    0.00
.17490E+04
    125.90     0.00     0.00     2.3 0.213E+00   0.34    11.00    0.34    0.00
.17715E+04
    127.47     0.00     0.00     2.3 0.211E+00   0.34    11.00    0.34    0.00
.17940E+04
    129.05     0.00     0.00     2.3 0.210E+00   0.34    11.00    0.34    0.00
.18165E+04
    130.63     0.00     0.00     2.3 0.209E+00   0.35    11.00    0.35    0.00
.18391E+04
    132.20     0.00     0.00     2.4 0.208E+00   0.35    11.00    0.35    0.00
.18616E+04
    133.78     0.00     0.00     2.4 0.207E+00   0.35    11.00    0.35    0.00
.18841E+04
    135.36     0.00     0.00     2.4 0.206E+00   0.35    11.00    0.35    0.00
.19066E+04
    136.93     0.00     0.00     2.4 0.205E+00   0.35    11.00    0.35    0.00
.19292E+04
    138.51     0.00     0.00     2.4 0.204E+00   0.35    11.00    0.35    0.00
.19517E+04
    140.09     0.00     0.00     2.4 0.203E+00   0.35    11.00    0.35    0.00
.19742E+04
    141.66     0.00     0.00     2.4 0.202E+00   0.36    11.00    0.36    0.00
.19967E+04
    143.24     0.00     0.00     2.4 0.201E+00   0.36    11.00    0.36    0.00
.20192E+04
    144.82     0.00     0.00     2.4 0.200E+00   0.36    11.00    0.36    0.00
.20418E+04
    146.39     0.00     0.00     2.4 0.199E+00   0.36    11.00    0.36    0.00
.20643E+04
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    147.97      0.00    0.00      2.4 0.197E+00   0.36    11.00    0.36    0.00
.20868E+04
    149.55      0.00    0.00      2.5 0.196E+00   0.36    11.00    0.36    0.00
.21093E+04
    151.12      0.00    0.00      2.5 0.195E+00   0.36    11.00    0.36    0.00
.21319E+04
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.195E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
    152.70      0.00    0.00      2.5 0.194E+00   0.37    11.00    0.37    0.00
.21544E+04
    154.28      0.00    0.00      2.5 0.193E+00   0.37    11.00    0.37    0.00
.21769E+04
    155.85      0.00    0.00      2.5 0.192E+00   0.37    11.00    0.37    0.00
.21994E+04
    157.43      0.00    0.00      2.5 0.191E+00   0.37    11.00    0.37    0.00
.22220E+04
    159.01      0.00    0.00      2.5 0.190E+00   0.37    11.00    0.37    0.00
.22445E+04
    160.58      0.00    0.00      2.5 0.189E+00   0.37    11.00    0.37    0.00
.22670E+04
    162.16      0.00    0.00      2.5 0.188E+00   0.37    11.00    0.37    0.00
.22895E+04
    163.74      0.00    0.00      2.5 0.187E+00   0.38    11.00    0.38    0.00
.23121E+04
    165.31      0.00    0.00      2.6 0.186E+00   0.38    11.00    0.38    0.00
.23346E+04
    166.89      0.00    0.00      2.6 0.185E+00   0.38    11.00    0.38    0.00
.23571E+04
    168.47      0.00    0.00      2.6 0.184E+00   0.38    11.00    0.38    0.00
.23796E+04
    170.04      0.00    0.00      2.6 0.183E+00   0.38    11.00    0.38    0.00
.24022E+04
    171.62      0.00    0.00      2.6 0.182E+00   0.38    11.00    0.38    0.00
.24247E+04
    173.20      0.00    0.00      2.6 0.181E+00   0.39    11.00    0.39    0.00
.24472E+04
    174.77      0.00    0.00      2.6 0.180E+00   0.39    11.00    0.39    0.00
.24697E+04
    176.35      0.00    0.00      2.6 0.179E+00   0.39    11.00    0.39    0.00
.24923E+04
    177.93      0.00    0.00      2.6 0.178E+00   0.39    11.00    0.39    0.00
.25148E+04
    179.50      0.00    0.00      2.7 0.177E+00   0.39    11.00    0.39    0.00
.25373E+04
    181.08      0.00    0.00      2.7 0.176E+00   0.39    11.00    0.39    0.00
.25598E+04
    182.66      0.00    0.00      2.7 0.175E+00   0.40    11.00    0.40    0.00
.25824E+04
    184.23      0.00    0.00      2.7 0.174E+00   0.40    11.00    0.40    0.00
.26049E+04
    185.81      0.00    0.00      2.7 0.173E+00   0.40    11.00    0.40    0.00
.26274E+04
 Plume interacts with SURFACE.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
    187.39      0.00    0.00      2.7 0.172E+00   0.40    11.00    0.40    0.00
.26499E+04
 Effluent is FULLY MIXED over the entire channel cross-section.
 Except for possible far-field decay or reaction processes, there are
     NO FURTHER CHANGES with downstream direction.
```

```
   188.96     0.00    0.00     2.7 0.172E+00   0.40    11.00    0.40    0.00
.26724E+04
   190.54     0.00    0.00     2.7 0.172E+00   0.40    11.00    0.40    0.00
.26950E+04
   192.12     0.00    0.00     2.7 0.172E+00   0.40    11.00    0.40    0.00
.27175E+04
   193.69     0.00    0.00     2.7 0.172E+00   0.40    11.00    0.40    0.00
.27400E+04
   195.27     0.00    0.00     2.7 0.171E+00   0.40    11.00    0.40    0.00
.27625E+04
   196.85     0.00    0.00     2.7 0.171E+00   0.40    11.00    0.40    0.00
.27851E+04
   198.42     0.00    0.00     2.7 0.171E+00   0.40    11.00    0.40    0.00
.28076E+04
   200.00     0.00    0.00     2.7 0.171E+00   0.40    11.00    0.40    0.00
.28301E+04
 Cumulative travel time =        2830.1162 sec  (    0.79 hrs)

 Simulation limit based on maximum specified distance =    200.00 m.
   This is the REGION OF INTEREST limitation.

END OF MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
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CORMIX2: Multiport Diffuser Discharges       End of Prediction File
22222222222222222222222222222222222222222222222222222222222222222222222222222222222
222222222222
```

```
    X-axis points downstream
    Y-axis points to left as seen by an observer looking downstream
    Z-axis points vertically upward (in CORMIX3, all values Z = 0.00)
NSTEP = 100 display intervals per module
-----------------------------------------------------------------------------------

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BEGIN MOD301: DISCHARGE MODULE

 Efflux conditions:
      X        Y       Z        S       C       BV       BH        TT
     0.00     0.00    0.00     1.0 0.114E+01   0.20     0.08 .00000E+00

END OF MOD301: DISCHARGE MODULE
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BEGIN MOD302: ZONE OF FLOW ESTABLISHMENT

  Control volume inflow:
      X        Y       Z        S       C       BV       BH        TT
     0.00     0.00    0.00     1.0 0.114E+01   0.20     0.08 .00000E+00

 VERTICAL MIXING occurs in the initial zone of flow establishment.

 Profile definitions:
   BV = Gaussian 1/e (37%) vertical thickness
   BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction efects, if any)
   TT = Cumulative travel time

  Control volume outflow:                                  SIGMAE=     89.52
      X        Y       Z        S       C       BV       BH        TT
     0.00     0.06    0.00     1.0 0.114E+01   0.30     0.09 .51796E-01
 Cumulative travel time =           0.0518 sec  (    0.00 hrs)

END OF MOD302: ZONE OF FLOW ESTABLISHMENT
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BEGIN CORSURF (MOD310): BUOYANT SURFACE JET - NEAR-FIELD REGION

 Surface jet in shallow crossflow with shoreline-attachment.

 Profile definitions:
   BV = water depth (vertically mixed)
   BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction efects, if any)
   TT = Cumulative travel time

      X        Y       Z        S       C       BV       BH        TT
     0.00     0.06    0.00     1.0 0.114E+01   0.30     0.09 .51796E-01
     0.08     0.29    0.00     1.3 0.912E+00   0.30     0.12 .27976E+00
     0.24     0.48    0.00     1.4 0.814E+00   0.30     0.14 .54407E+00
     0.31     0.53    0.00     1.5 0.788E+00   0.30     0.15 .63949E+00
     0.45     0.62    0.00     1.5 0.744E+00   0.30     0.17 .84063E+00
     0.60     0.69    0.00     1.6 0.706E+00   0.30     0.19 .10549E+01
     0.84     0.79    0.00     1.7 0.660E+00   0.30     0.21 .13998E+01
```

0.92	0.81	0.00	1.8	0.647E+00	0.30	0.22	.15208E+01
1.08	0.86	0.00	1.8	0.623E+00	0.30	0.24	.17717E+01
1.33	0.92	0.00	1.9	0.592E+00	0.30	0.26	.21695E+01
1.41	0.94	0.00	2.0	0.582E+00	0.30	0.27	.23077E+01
1.57	0.98	0.00	2.0	0.565E+00	0.30	0.29	.25925E+01
1.82	1.02	0.00	2.1	0.542E+00	0.30	0.31	.30400E+01
1.99	1.05	0.00	2.2	0.528E+00	0.30	0.33	.33517E+01
2.07	1.06	0.00	2.2	0.522E+00	0.30	0.34	.35115E+01
2.23	1.09	0.00	2.2	0.510E+00	0.30	0.36	.38389E+01
2.40	1.11	0.00	2.3	0.498E+00	0.30	0.37	.41767E+01
2.65	1.15	0.00	2.4	0.483E+00	0.30	0.40	.47027E+01
2.82	1.17	0.00	2.4	0.474E+00	0.30	0.42	.50660E+01
2.90	1.18	0.00	2.4	0.469E+00	0.30	0.42	.52515E+01
3.07	1.19	0.00	2.5	0.461E+00	0.30	0.44	.56299E+01
3.24	1.21	0.00	2.5	0.453E+00	0.30	0.46	.60183E+01
3.49	1.24	0.00	2.6	0.442E+00	0.30	0.48	.66195E+01
3.66	1.25	0.00	2.6	0.435E+00	0.30	0.50	.70326E+01
3.82	1.27	0.00	2.7	0.428E+00	0.30	0.52	.74555E+01
3.91	1.27	0.00	2.7	0.425E+00	0.30	0.52	.76706E+01
4.16	1.29	0.00	2.8	0.416E+00	0.30	0.55	.83305E+01
4.24	1.30	0.00	2.8	0.413E+00	0.30	0.56	.85554E+01
4.41	1.31	0.00	2.8	0.408E+00	0.30	0.57	.90123E+01
4.66	1.33	0.00	2.9	0.400E+00	0.30	0.60	.97157E+01
4.75	1.33	0.00	2.9	0.397E+00	0.30	0.61	.99550E+01
5.00	1.35	0.00	2.9	0.390E+00	0.30	0.63	.10687E+02
5.08	1.36	0.00	2.9	0.388E+00	0.30	0.64	.10936E+02
5.25	1.37	0.00	3.0	0.384E+00	0.30	0.66	.11441E+02
5.50	1.38	0.00	3.0	0.377E+00	0.30	0.68	.12216E+02
5.58	1.39	0.00	3.0	0.375E+00	0.30	0.69	.12479E+02
5.84	1.40	0.00	3.1	0.369E+00	0.30	0.71	.13283E+02
5.92	1.40	0.00	3.1	0.368E+00	0.30	0.72	.13555E+02
6.09	1.41	0.00	3.1	0.364E+00	0.30	0.74	.14107E+02
6.34	1.42	0.00	3.2	0.359E+00	0.30	0.76	.14953E+02
6.42	1.43	0.00	3.2	0.357E+00	0.30	0.77	.15240E+02
6.68	1.44	0.00	3.2	0.352E+00	0.30	0.79	.16114E+02
6.76	1.44	0.00	3.3	0.351E+00	0.30	0.80	.16411E+02
6.93	1.45	0.00	3.3	0.348E+00	0.30	0.82	.17010E+02
7.18	1.46	0.00	3.3	0.343E+00	0.30	0.84	.17926E+02
7.26	1.46	0.00	3.3	0.342E+00	0.30	0.85	.18236E+02
7.52	1.47	0.00	3.4	0.338E+00	0.30	0.87	.19181E+02
7.60	1.47	0.00	3.4	0.336E+00	0.30	0.88	.19501E+02
7.85	1.48	0.00	3.4	0.333E+00	0.30	0.90	.20473E+02
8.02	1.49	0.00	3.5	0.330E+00	0.30	0.92	.21133E+02
8.11	1.49	0.00	3.5	0.329E+00	0.30	0.93	.21467E+02
8.27	1.50	0.00	3.5	0.326E+00	0.30	0.94	.22140E+02
8.53	1.50	0.00	3.5	0.323E+00	0.30	0.97	.23169E+02
8.69	1.51	0.00	3.6	0.321E+00	0.30	0.98	.23866E+02
8.86	1.51	0.00	3.6	0.319E+00	0.30	1.00	.24572E+02
8.95	1.52	0.00	3.6	0.318E+00	0.30	1.01	.24929E+02
9.11	1.52	0.00	3.6	0.315E+00	0.30	1.02	.25649E+02
9.37	1.53	0.00	3.7	0.312E+00	0.30	1.04	.26747E+02
9.53	1.53	0.00	3.7	0.310E+00	0.30	1.06	.27491E+02
9.62	1.53	0.00	3.7	0.309E+00	0.30	1.07	.27866E+02
9.79	1.54	0.00	3.7	0.308E+00	0.30	1.08	.28623E+02
9.95	1.54	0.00	3.7	0.306E+00	0.30	1.10	.29390E+02
10.21	1.55	0.00	3.8	0.303E+00	0.30	1.12	.30557E+02
10.38	1.55	0.00	3.8	0.301E+00	0.30	1.13	.31346E+02
10.46	1.55	0.00	3.8	0.301E+00	0.30	1.14	.31745E+02
10.63	1.56	0.00	3.8	0.299E+00	0.30	1.16	.32548E+02
10.80	1.56	0.00	3.8	0.297E+00	0.30	1.17	.33360E+02
11.05	1.56	0.00	3.9	0.295E+00	0.30	1.19	.34596E+02
11.22	1.57	0.00	3.9	0.293E+00	0.30	1.21	.35432E+02
11.30	1.57	0.00	3.9	0.293E+00	0.30	1.22	.35853E+02

11.47	1.57	0.00	3.9	0.291E+00	0.30	1.23	.36702E+02
11.64	1.57	0.00	3.9	0.290E+00	0.30	1.25	.37560E+02
11.89	1.58	0.00	4.0	0.287E+00	0.30	1.27	.38864E+02
12.06	1.58	0.00	4.0	0.286E+00	0.30	1.28	.39745E+02
12.14	1.58	0.00	4.0	0.285E+00	0.30	1.29	.40189E+02
12.31	1.58	0.00	4.0	0.284E+00	0.30	1.30	.41084E+02
12.48	1.59	0.00	4.0	0.283E+00	0.30	1.32	.41988E+02
12.73	1.59	0.00	4.1	0.280E+00	0.30	1.34	.43360E+02
12.90	1.59	0.00	4.1	0.279E+00	0.30	1.35	.44287E+02
12.98	1.59	0.00	4.1	0.278E+00	0.30	1.36	.44753E+02
13.15	1.59	0.00	4.1	0.277E+00	0.30	1.38	.45693E+02
13.32	1.60	0.00	4.1	0.275E+00	0.30	1.39	.46642E+02
13.57	1.60	0.00	4.2	0.273E+00	0.30	1.41	.48083E+02
13.74	1.60	0.00	4.2	0.272E+00	0.30	1.42	.49054E+02
13.82	1.60	0.00	4.2	0.271E+00	0.30	1.43	.49543E+02
13.99	1.60	0.00	4.2	0.269E+00	0.30	1.45	.50528E+02
14.16	1.60	0.00	4.3	0.268E+00	0.30	1.46	.51522E+02
14.41	1.60	0.00	4.3	0.265E+00	0.30	1.48	.53030E+02
14.58	1.61	0.00	4.3	0.264E+00	0.30	1.49	.54046E+02
14.66	1.61	0.00	4.3	0.263E+00	0.30	1.50	.54558E+02
14.83	1.61	0.00	4.4	0.261E+00	0.30	1.51	.55587E+02
15.00	1.61	0.00	4.4	0.259E+00	0.30	1.53	.56626E+02
15.25	1.61	0.00	4.4	0.257E+00	0.30	1.55	.58200E+02
15.42	1.61	0.00	4.5	0.255E+00	0.30	1.56	.59261E+02
15.50	1.61	0.00	4.5	0.254E+00	0.30	1.57	.59795E+02
15.67	1.61	0.00	4.5	0.252E+00	0.30	1.58	.60869E+02
15.93	1.61	0.00	4.6	0.250E+00	0.30	1.60	.62497E+02
16.09	1.61	0.00	4.6	0.248E+00	0.30	1.61	.63593E+02
16.26	1.61	0.00	4.6	0.246E+00	0.30	1.63	.64698E+02
16.43	1.61	0.00	4.7	0.244E+00	0.30	1.64	.65811E+02

Maximum lateral extent of recirculation bubble.

16.51	1.61	0.00	4.7	0.243E+00	0.30	1.65	.66372E+02

End of RECIRCULATION BUBBLE for shoreline-attached jet motion.
Dilution in recirculation bubble = 5.5
Corresponding concentration = 0.207E+00
Cumulative travel time = 66.3715 sec (0.02 hrs)

END OF CORSURF (MOD310): BUOYANT SURFACE JET - NEAR-FIELD REGION

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH/THICKNESS VALUE in the next far-field module will be CORRECTED by a factor 2.31 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and INTERNAL HYDRAULIC JUMPS.

Some lateral bank/shore interaction occurs at end othe near-field.

In the next prediction module, the jet/plume centerline will be set to follow the bank/shore.

BEGIN MOD341: BUOYANT AMBIENT SPREADING

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Profile definitions:
BV = top-hat thickness,measured vertically
BH = top-hat half-width, measured horizontally from bank/shoreline
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	TT
16.51	0.00	0.00	4.7	0.243E+00	0.40	7.62	.66372E+02
16.59	-0.00	0.00	4.7	0.243E+00	0.40	7.66	.67636E+02
16.67	-0.00	0.00	4.7	0.243E+00	0.40	7.70	.68900E+02
16.74	-0.00	0.00	4.7	0.242E+00	0.40	7.73	.70164E+02
16.82	-0.00	0.00	4.7	0.242E+00	0.39	7.77	.71428E+02
16.89	-0.00	0.00	4.7	0.242E+00	0.39	7.81	.72692E+02
16.97	-0.00	0.00	4.7	0.241E+00	0.39	7.84	.73957E+02
17.04	-0.00	0.00	4.7	0.241E+00	0.39	7.88	.75221E+02
17.12	-0.00	0.00	4.7	0.241E+00	0.39	7.92	.76485E+02
17.20	-0.00	0.00	4.7	0.240E+00	0.39	7.95	.77749E+02
17.27	-0.00	0.00	4.8	0.240E+00	0.39	7.99	.79013E+02
17.35	-0.00	0.00	4.8	0.240E+00	0.39	8.03	.80278E+02
17.42	-0.00	0.00	4.8	0.239E+00	0.38	8.06	.81542E+02
17.50	-0.00	0.00	4.8	0.239E+00	0.38	8.10	.82806E+02
17.58	-0.00	0.00	4.8	0.239E+00	0.38	8.14	.84070E+02
17.65	-0.00	0.00	4.8	0.238E+00	0.38	8.17	.85334E+02
17.73	-0.00	0.00	4.8	0.238E+00	0.38	8.21	.86599E+02
17.80	-0.00	0.00	4.8	0.238E+00	0.38	8.24	.87863E+02
17.88	-0.00	0.00	4.8	0.237E+00	0.38	8.28	.89127E+02
17.95	-0.00	0.00	4.8	0.237E+00	0.38	8.32	.90391E+02
18.03	-0.00	0.00	4.8	0.237E+00	0.37	8.35	.91655E+02
18.11	-0.00	0.00	4.8	0.236E+00	0.37	8.39	.92920E+02
18.18	-0.00	0.00	4.8	0.236E+00	0.37	8.42	.94184E+02
18.26	-0.00	0.00	4.8	0.236E+00	0.37	8.46	.95448E+02
18.33	-0.00	0.00	4.8	0.236E+00	0.37	8.49	.96712E+02
18.41	-0.00	0.00	4.8	0.235E+00	0.37	8.53	.97976E+02
18.49	-0.00	0.00	4.8	0.235E+00	0.37	8.57	.99240E+02
18.56	-0.00	0.00	4.9	0.235E+00	0.37	8.60	.10050E+03
18.64	-0.00	0.00	4.9	0.234E+00	0.37	8.64	.10177E+03
18.71	-0.00	0.00	4.9	0.234E+00	0.36	8.67	.10303E+03
18.79	-0.00	0.00	4.9	0.234E+00	0.36	8.71	.10430E+03
18.87	-0.00	0.00	4.9	0.233E+00	0.36	8.74	.10556E+03
18.94	-0.00	0.00	4.9	0.233E+00	0.36	8.78	.10683E+03
19.02	-0.00	0.00	4.9	0.233E+00	0.36	8.81	.10809E+03
19.09	-0.00	0.00	4.9	0.233E+00	0.36	8.84	.10935E+03
19.17	-0.00	0.00	4.9	0.232E+00	0.36	8.88	.11062E+03
19.24	-0.00	0.00	4.9	0.232E+00	0.36	8.91	.11188E+03
19.32	-0.00	0.00	4.9	0.232E+00	0.36	8.95	.11315E+03
19.40	-0.00	0.00	4.9	0.232E+00	0.36	8.98	.11441E+03
19.47	-0.00	0.00	4.9	0.231E+00	0.35	9.02	.11567E+03
19.55	-0.00	0.00	4.9	0.231E+00	0.35	9.05	.11694E+03
19.62	-0.00	0.00	4.9	0.231E+00	0.35	9.09	.11820E+03
19.70	-0.00	0.00	4.9	0.230E+00	0.35	9.12	.11947E+03
19.78	-0.00	0.00	4.9	0.230E+00	0.35	9.15	.12073E+03
19.85	-0.00	0.00	4.9	0.230E+00	0.35	9.19	.12200E+03
19.93	-0.00	0.00	5.0	0.230E+00	0.35	9.22	.12326E+03
20.00	-0.00	0.00	5.0	0.229E+00	0.35	9.26	.12452E+03
20.08	-0.00	0.00	5.0	0.229E+00	0.35	9.29	.12579E+03
20.15	-0.00	0.00	5.0	0.229E+00	0.35	9.32	.12705E+03
20.23	-0.00	0.00	5.0	0.229E+00	0.35	9.36	.12832E+03
20.31	-0.00	0.00	5.0	0.228E+00	0.34	9.39	.12958E+03
20.38	-0.00	0.00	5.0	0.228E+00	0.34	9.42	.13085E+03
20.46	-0.00	0.00	5.0	0.228E+00	0.34	9.46	.13211E+03
20.53	-0.00	0.00	5.0	0.228E+00	0.34	9.49	.13337E+03

20.61	-0.00	0.00	5.0	0.227E+00	0.34	9.53	.13464E+03
20.69	-0.00	0.00	5.0	0.227E+00	0.34	9.56	.13590E+03
20.76	-0.00	0.00	5.0	0.227E+00	0.34	9.59	.13717E+03
20.84	-0.00	0.00	5.0	0.226E+00	0.34	9.63	.13843E+03
20.91	-0.00	0.00	5.0	0.226E+00	0.34	9.66	.13969E+03
20.99	-0.00	0.00	5.0	0.226E+00	0.34	9.69	.14096E+03
21.06	-0.00	0.00	5.0	0.226E+00	0.34	9.72	.14222E+03
21.14	-0.00	0.00	5.0	0.225E+00	0.34	9.76	.14349E+03
21.22	-0.00	0.00	5.0	0.225E+00	0.33	9.79	.14475E+03
21.29	-0.00	0.00	5.0	0.225E+00	0.33	9.82	.14602E+03
21.37	-0.00	0.00	5.1	0.225E+00	0.33	9.86	.14728E+03
21.44	-0.00	0.00	5.1	0.224E+00	0.33	9.89	.14854E+03
21.52	-0.00	0.00	5.1	0.224E+00	0.33	9.92	.14981E+03
21.60	-0.00	0.00	5.1	0.224E+00	0.33	9.95	.15107E+03
21.67	-0.00	0.00	5.1	0.224E+00	0.33	9.99	.15234E+03
21.75	-0.00	0.00	5.1	0.224E+00	0.33	10.02	.15360E+03
21.82	-0.00	0.00	5.1	0.223E+00	0.33	10.05	.15486E+03
21.90	-0.00	0.00	5.1	0.223E+00	0.33	10.08	.15613E+03
21.98	-0.00	0.00	5.1	0.223E+00	0.33	10.12	.15739E+03
22.05	-0.00	0.00	5.1	0.223E+00	0.33	10.15	.15866E+03
22.13	-0.00	0.00	5.1	0.222E+00	0.33	10.18	.15992E+03
22.20	-0.00	0.00	5.1	0.222E+00	0.33	10.21	.16119E+03
22.28	-0.00	0.00	5.1	0.222E+00	0.32	10.25	.16245E+03
22.35	-0.00	0.00	5.1	0.222E+00	0.32	10.28	.16371E+03
22.43	-0.00	0.00	5.1	0.221E+00	0.32	10.31	.16498E+03
22.51	-0.00	0.00	5.1	0.221E+00	0.32	10.34	.16624E+03
22.58	-0.00	0.00	5.1	0.221E+00	0.32	10.37	.16751E+03
22.66	-0.00	0.00	5.1	0.221E+00	0.32	10.41	.16877E+03
22.73	-0.00	0.00	5.1	0.220E+00	0.32	10.44	.17004E+03
22.81	-0.00	0.00	5.1	0.220E+00	0.32	10.47	.17130E+03
22.89	-0.00	0.00	5.2	0.220E+00	0.32	10.50	.17256E+03
22.96	-0.00	0.00	5.2	0.220E+00	0.32	10.53	.17383E+03
23.04	-0.00	0.00	5.2	0.220E+00	0.32	10.57	.17509E+03
23.11	-0.00	0.00	5.2	0.219E+00	0.32	10.60	.17636E+03
23.19	-0.00	0.00	5.2	0.219E+00	0.32	10.63	.17762E+03
23.26	-0.00	0.00	5.2	0.219E+00	0.32	10.66	.17888E+03
23.34	-0.00	0.00	5.2	0.219E+00	0.32	10.69	.18015E+03
23.42	-0.00	0.00	5.2	0.218E+00	0.31	10.72	.18141E+03
23.49	-0.00	0.00	5.2	0.218E+00	0.31	10.75	.18268E+03
23.57	-0.00	0.00	5.2	0.218E+00	0.31	10.79	.18394E+03
23.64	-0.00	0.00	5.2	0.218E+00	0.31	10.82	.18521E+03
23.72	-0.00	0.00	5.2	0.218E+00	0.31	10.85	.18647E+03
23.80	-0.00	0.00	5.2	0.217E+00	0.31	10.88	.18773E+03
23.87	-0.00	0.00	5.2	0.217E+00	0.31	10.91	.18900E+03
23.95	-0.00	0.00	5.2	0.217E+00	0.31	10.94	.19026E+03
24.02	-0.00	0.00	5.2	0.217E+00	0.31	10.97	.19153E+03
24.10	-0.00	0.00	5.2	0.216E+00	0.31	11.00	.19279E+03

Cumulative travel time = 192.7918 sec (0.05 hrs)

Plume is LATERALLY FULLY MIXED at the end of the buoyant spreading regime.

END OF MOD341: BUOYANT AMBIENT SPREADING

BEGIN MOD361: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

Vertical diffusivity (initial value) = 0.529E-03 m^2/s
Horizontal diffusivity (initial value) = 0.132E-02 m^2/s

Profile definitions:
BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
= or equal to water depth, if fully mixed

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   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction efects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X        Y       Z        S       C       BV       BH        TT
     24.10     0.00    0.00     5.2 0.216E+00   0.31    11.00 .19279E+03
** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.215E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
     38.86     0.00    0.00     6.8 0.165E+00   0.40    11.00 .43877E+03
 Effluent is FULLY MIXED over the entire channel cross-section.
 Except for possible far-field decay or reaction processes, there are
   NO FURTHER CHANGES with downstream direction.
     53.62    -0.00    0.00     6.8 0.163E+00   0.40    11.00 .68476E+03
     68.38    -0.00    0.00     6.8 0.160E+00   0.40    11.00 .93074E+03
     83.13    -0.00    0.00     6.8 0.158E+00   0.40    11.00 .11767E+04
     97.89    -0.00    0.00     6.8 0.156E+00   0.40    11.00 .14227E+04
    112.65    -0.00    0.00     6.8 0.154E+00   0.40    11.00 .16687E+04
    127.41    -0.00    0.00     6.8 0.151E+00   0.40    11.00 .19147E+04
    142.17    -0.00    0.00     6.8 0.149E+00   0.40    11.00 .21607E+04
    156.93    -0.00    0.00     6.8 0.147E+00   0.40    11.00 .24066E+04
    171.69    -0.00    0.00     6.8 0.145E+00   0.40    11.00 .26526E+04
    186.45    -0.00    0.00     6.8 0.143E+00   0.40    11.00 .28986E+04
    201.21    -0.00    0.00     6.8 0.141E+00   0.40    11.00 .31446E+04
    215.97    -0.00    0.00     6.8 0.139E+00   0.40    11.00 .33906E+04
    230.73    -0.00    0.00     6.8 0.137E+00   0.40    11.00 .36366E+04
    245.48    -0.00    0.00     6.8 0.135E+00   0.40    11.00 .38825E+04
    260.24    -0.00    0.00     6.8 0.133E+00   0.40    11.00 .41285E+04
    275.00    -0.00    0.00     6.8 0.131E+00   0.40    11.00 .43745E+04
    289.76    -0.00    0.00     6.8 0.129E+00   0.40    11.00 .46205E+04
    304.52    -0.00    0.00     6.8 0.128E+00   0.40    11.00 .48665E+04
    319.28    -0.00    0.00     6.8 0.126E+00   0.40    11.00 .51125E+04
    334.04    -0.00    0.00     6.8 0.124E+00   0.40    11.00 .53584E+04
    348.80    -0.00    0.00     6.8 0.122E+00   0.40    11.00 .56044E+04
    363.56    -0.00    0.00     6.8 0.121E+00   0.40    11.00 .58504E+04
    378.32    -0.00    0.00     6.8 0.119E+00   0.40    11.00 .60964E+04
    393.07    -0.00    0.00     6.8 0.117E+00   0.40    11.00 .63424E+04
    407.83    -0.00    0.00     6.8 0.115E+00   0.40    11.00 .65884E+04
    422.59    -0.00    0.00     6.8 0.114E+00   0.40    11.00 .68343E+04
    437.35    -0.00    0.00     6.8 0.112E+00   0.40    11.00 .70803E+04
    452.11    -0.00    0.00     6.8 0.111E+00   0.40    11.00 .73263E+04
    466.87    -0.00    0.00     6.8 0.109E+00   0.40    11.00 .75723E+04
    481.63    -0.00    0.00     6.8 0.108E+00   0.40    11.00 .78183E+04
    496.39    -0.00    0.00     6.8 0.106E+00   0.40    11.00 .80643E+04
    511.15    -0.00    0.00     6.8 0.105E+00   0.40    11.00 .83102E+04
    525.91    -0.00    0.00     6.8 0.103E+00   0.40    11.00 .85562E+04
    540.66    -0.00    0.00     6.8 0.102E+00   0.40    11.00 .88022E+04
    555.42    -0.00    0.00     6.8 0.100E+00   0.40    11.00 .90482E+04
    570.18    -0.00    0.00     6.8 0.987E-01   0.40    11.00 .92942E+04
    584.94    -0.00    0.00     6.8 0.974E-01   0.40    11.00 .95402E+04
    599.70    -0.00    0.00     6.8 0.960E-01   0.40    11.00 .97861E+04
    614.46    -0.00    0.00     6.8 0.946E-01   0.40    11.00 .10032E+05
    629.22    -0.00    0.00     6.8 0.933E-01   0.40    11.00 .10278E+05
    643.98    -0.00    0.00     6.8 0.920E-01   0.40    11.00 .10524E+05
    658.74    -0.00    0.00     6.8 0.907E-01   0.40    11.00 .10770E+05
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673.50	-0.00	0.00	6.8	0.894E-01	0.40	11.00	.11016E+05
688.25	-0.00	0.00	6.8	0.881E-01	0.40	11.00	.11262E+05
703.01	-0.00	0.00	6.8	0.869E-01	0.40	11.00	.11508E+05
717.77	-0.00	0.00	6.8	0.856E-01	0.40	11.00	.11754E+05
732.53	-0.00	0.00	6.8	0.844E-01	0.40	11.00	.12000E+05
747.29	-0.00	0.00	6.8	0.832E-01	0.40	11.00	.12246E+05
762.05	-0.00	0.00	6.8	0.821E-01	0.40	11.00	.12492E+05
776.81	-0.00	0.00	6.8	0.809E-01	0.40	11.00	.12738E+05
791.57	-0.00	0.00	6.8	0.798E-01	0.40	11.00	.12984E+05
806.33	-0.00	0.00	6.8	0.786E-01	0.40	11.00	.13230E+05
821.09	-0.00	0.00	6.8	0.775E-01	0.40	11.00	.13476E+05
835.84	-0.00	0.00	6.8	0.764E-01	0.40	11.00	.13722E+05
850.60	-0.00	0.00	6.8	0.753E-01	0.40	11.00	.13968E+05
865.36	-0.00	0.00	6.8	0.743E-01	0.40	11.00	.14214E+05
880.12	-0.00	0.00	6.8	0.732E-01	0.40	11.00	.14460E+05
894.88	-0.00	0.00	6.8	0.722E-01	0.40	11.00	.14706E+05
909.64	-0.00	0.00	6.8	0.712E-01	0.40	11.00	.14952E+05
924.40	-0.00	0.00	6.8	0.702E-01	0.40	11.00	.15198E+05
939.16	-0.00	0.00	6.8	0.692E-01	0.40	11.00	.15444E+05
953.92	-0.00	0.00	6.8	0.682E-01	0.40	11.00	.15690E+05
968.68	-0.00	0.00	6.8	0.672E-01	0.40	11.00	.15936E+05
983.44	-0.00	0.00	6.8	0.663E-01	0.40	11.00	.16182E+05
998.19	-0.00	0.00	6.8	0.654E-01	0.40	11.00	.16428E+05
1012.95	-0.00	0.00	6.8	0.644E-01	0.40	11.00	.16674E+05
1027.71	-0.00	0.00	6.8	0.635E-01	0.40	11.00	.16920E+05
1042.47	-0.00	0.00	6.8	0.626E-01	0.40	11.00	.17166E+05
1057.23	-0.00	0.00	6.8	0.617E-01	0.40	11.00	.17412E+05
1071.99	-0.00	0.00	6.8	0.609E-01	0.40	11.00	.17658E+05
1086.75	-0.00	0.00	6.8	0.600E-01	0.40	11.00	.17904E+05
1101.51	-0.00	0.00	6.8	0.592E-01	0.40	11.00	.18150E+05
1116.27	-0.00	0.00	6.8	0.583E-01	0.40	11.00	.18396E+05
1131.03	-0.00	0.00	6.8	0.575E-01	0.40	11.00	.18642E+05
1145.78	-0.00	0.00	6.8	0.567E-01	0.40	11.00	.18888E+05
1160.54	-0.00	0.00	6.8	0.559E-01	0.40	11.00	.19134E+05
1175.30	-0.00	0.00	6.8	0.551E-01	0.40	11.00	.19380E+05
1190.06	-0.00	0.00	6.8	0.543E-01	0.40	11.00	.19626E+05
1204.82	-0.00	0.00	6.8	0.535E-01	0.40	11.00	.19871E+05
1219.58	-0.00	0.00	6.8	0.528E-01	0.40	11.00	.20117E+05
1234.34	-0.00	0.00	6.8	0.520E-01	0.40	11.00	.20363E+05
1249.10	-0.00	0.00	6.8	0.513E-01	0.40	11.00	.20609E+05
1263.86	-0.00	0.00	6.8	0.506E-01	0.40	11.00	.20855E+05
1278.62	-0.00	0.00	6.8	0.499E-01	0.40	11.00	.21101E+05
1293.37	-0.00	0.00	6.8	0.492E-01	0.40	11.00	.21347E+05
1308.13	-0.00	0.00	6.8	0.485E-01	0.40	11.00	.21593E+05
1322.89	-0.00	0.00	6.8	0.478E-01	0.40	11.00	.21839E+05
1337.65	-0.00	0.00	6.8	0.471E-01	0.40	11.00	.22085E+05
1352.41	-0.00	0.00	6.8	0.464E-01	0.40	11.00	.22331E+05
1367.17	-0.00	0.00	6.8	0.458E-01	0.40	11.00	.22577E+05
1381.93	-0.00	0.00	6.8	0.451E-01	0.40	11.00	.22823E+05
1396.69	-0.00	0.00	6.8	0.445E-01	0.40	11.00	.23069E+05
1411.45	-0.00	0.00	6.8	0.439E-01	0.40	11.00	.23315E+05
1426.21	-0.00	0.00	6.8	0.432E-01	0.40	11.00	.23561E+05
1440.97	-0.00	0.00	6.8	0.426E-01	0.40	11.00	.23807E+05
1455.72	-0.00	0.00	6.8	0.420E-01	0.40	11.00	.24053E+05
1470.48	-0.00	0.00	6.8	0.414E-01	0.40	11.00	.24299E+05
1485.24	-0.00	0.00	6.8	0.409E-01	0.40	11.00	.24545E+05
1500.00	-0.00	0.00	6.8	0.403E-01	0.40	11.00	.24791E+05

Cumulative travel time = 24791.1406 sec (6.89 hrs)

Simulation limit based on maximum specified distance = 1500.00 m.
This is the REGION OF INTEREST limitation.

END OF MOD361: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

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CORMIX3: Buoyant Surface Discharges                       End of Prediction File
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Appendix H. CVC Comments, MOECC Comments, Mussel Survey Report

January 31, 2017

Town of Erin
5684 Trafalgar Road
RR2 Hillsburgh, ON
N0B 1Z0

Attention: Dina Lundy, Clerk (by email only)

Re: Draft West Credit River Assimilative Capacity Study

Through the SSMP there was no determination of appropriate location for discharge of surface flows from a proposed Waste Water Treatment Plant. However, recognizing that there is an increase in flows and groundwater discharge downstream of the Village of Erin, CVC has no objection to the proposed location for the new Waste Water Treatment Plant below 10th Line.

Staff of Credit Valley Conservation (CVC) have had an opportunity to review the following documents:

1. West Credit River Assimilative Capacity Study. Hutchinson Environmental Sciences Ltd. Black Creek Assimilative Capacity Study – Draft – November 14, 2016
2. Correction to West Credit River Assimilative Capacity Study Draft Report. Hutchinson Environmental Sciences Ltd. - November 30, 2016

Overall CVC has no objection to the West Credit River Assimilative Capacity Study report subject to the correction with respect to revised unionized ammonia guideline being included in the final report. Additionally, in the minutes of the May 2nd, 2016 Technical committee meeting (where we discussed the Terms of Reference for the Assimilative Capacity Study) it is documented that CVC requested that the water quality parameter of concern chloride be including in the modelled parameters for the impact assessment.

Upon review it was found that chloride was not analysed in the November ACS report. CVC recommends that this parameter be included in the analysis, specifically mass balance analysis to understand mixed instream chloride concentration changes downstream of the WWTP discharge location. This has been a concern in other assimilative capacity studies occurring in small receivers in our watershed (Orangeville and Acton).

It is recommended that the CORMIX model results also be updated with the PWQO (0.0165 mg/L NH4-N) and table 24 be updated accordingly.

Credit Valley Conservation 1255 Old Derry Road, Mississauga, Ontario L5N 6R4
Phone (905) 670-1615 Fax (905) 670-2210

Please do not hesitate to contact the undersigned if you have any questions.

Yours truly,

Liam Marray
Senior Manager Planning Ecology

Cc: Triton Engineering Services Limited
105 Queen Street West, Unit 14
Fergus, ON N1M 1S6
Attn: **Christine Furlong**
cfurlong@tritoneng.on.ca (by email only)

MOECC
West Central Region
Ellen Fairclough Bldg
119 King St W, 12th Flr
Hamilton, ON L8P 4Y7
Attn: **Barb Slattery**
EA/Planning Coordinator
Barbara.slattery@ontario.ca (by email only)

Hutchinson Environmental Sciences Ltd.
Suite 202, 501 Krug Street
Kitchener ON N2B 1L3
Attn: **Deborah Sinclair, M.A.Sc. I Senior Aquatic Scientist**
Deborah Sinclair Deborah.Sinclair@environmentalsciences.ca (by email only)

Ainley Group
2 County Court Blvd., 4th Floor
Brampton, ON L6W 3W8
Attn: **Gary Scott, M. Sc., P. Eng.**
Vice President, Water Business
scott@ainleygroup.com (by email only)

CREDIT VALLEY CONSERVATION

May 10, 2017

Town of Erin
5684 Trafalgar Road
RR2 Hillsburgh, ON
N0B 1Z0

Attention: Dina Lundy, Clerk

Re: West Credit River Assimilative Capacity Study
Hutchinson Environmental Services Ltd.
March 29, 2017

Staff of Credit Valley Conservation (CVC) have had an opportunity to review and find satisfactory the above-noted report. We provide the following comments for your consideration.

Although CVC has no further concerns with the methodology for the mass balance modeling of the water quality parameters of concern, the results show that under full build out instream chloride concentrations will exceed aquatic guidelines for chronic exposure. At present, it is not technically feasible to remove chloride in the treatment process; therefore, CVC recommends that emphasis should be placed on controlling the input of chloride at the source. Recognizing water softeners are a significant source of chloride/salts in the wastewater stream specifically in areas where groundwater is used for drinking water, 0ne method to reduce chloride is to use high efficiency water softeners.

Therefore, Erin Urban Centre Wastewater Servicing Class Environmental Assessment Environmental study should include recommendations such as:

- New Developments:
  - That Subdivision Agreements include conditions to require the installation of high efficiency water softeners for all new residences.
- Existing Developments:
  - That funding sources be made available to residents for high efficiency water softeners when they tie into the new sewer lines.
  - That an education program be developed for the residents of Erin on how they can minimize their environmental impacts on their own property including the installation of high efficiency water softeners.

Please do not hesitate to contact me, if you have any additional questions.

Yours truly,

Liam Marray
Senior Manager Planning Ecology

Cc: (email only)

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August 3, 2017

Ms Deborah Sinclair
Hutchinson Environmental Sciences Ltd.
(via email only)

Ms. Christine Furlong
Triton Engineering
(via Email only)

Please be advised that we have completed our review of the *West Credit River Assimilative Capacity Study (*Hutchinson Environmental Ltd.'s Report of March 29, 2017) prepared in support of the Class EA for a communal wastewater system intended to service Erin, Hillsburgh and some additional development. Comments provided by the Credit Valley Conservation Authority were taken into consideration and staff of the ministry's Standards Development Branch were also consulted. Overall the study and supporting analysis were found satisfactory. However, a few concerns listed below should be resolved to finalize the effluent criteria.

(1) Design objectives and loadings should be included for the proposed effluent parameters and included in the effluent criteria;

(2) Effluent temperature should be included as an additional parameter to protect the most productive brook trout spawning habitat immediately downstream of the proposed discharge. A compliance limit and a design objective for effluent temperature to protect cold water fishery downstream should be proposed;

(3) No information was provided as to how the effluent would be disinfected. If chlorine is planned to be used as a disinfectant, 'total chlorine residual' shall be included as an effluent parameter with a compliance limit and design objective concentrations. Please provide information on the proposed plan of effluent disinfection, and propose a compliance limit and design objective of the residual disinfectant;

(4) Total Ammonia Nitrogen criteria have been proposed for summer and winter. Please define summer and winter by calendar dates in the recommendation section of the report (i.e., in section 5);

(5) (a) Chloride may be a parameter of concern as predicted effluent chloride concentration appears to be high (396 - 534 mg/L). The source of this chloride to

the municipal waste water is the water softener used at household level to reduce hardness of the groundwater.

(b) Once that effluent mixes with the receiving water, the predicted fully mixed downstream chloride concentration for the full build out effluent flow scenario is estimated to be 142 mg/L (average), and 180 mg/L (maximum). These concentrations are well below the short-term benchmark concentration for chloride of 640 mg/L, which is an estimator of severe effects to the aquatic ecosystem, and is intended to give guidance on the impacts of severe, but transient, situations. However, both concentrations do exceed the long-term CWQG for chloride of 120 mg/L, which is derived to be protective of all aquatic organisms, for all life stages, during indefinite exposure periods.

(c) According to our review, the predicted concentrations of chloride would have no impact on brook trout present at the site however, there is the potential to impair freshwater mussels.

(d) For most organisms used in aquatic toxicity testing, exposures to assess long-term (chronic) effects are at least 7 days in duration, with the exception of testing conducted with larval life stage of freshwater mussels. Looking to the aquatic toxicity data set used to derive the chronic CWQG, the most sensitive organisms are freshwater mussels, specifically the early (larval) life-stage. Testing conducted with a COSEWIC species of special concern (*Lampsilis fasciola*, wavy-rayed lampmussel) and a COSEWIC endangered species (*Epioblasma torulosa rangiana*, northern riffle shell) resulted in a no effect concentration (EC10, or effect concentration resulting in 10% mortality of test organisms) of 24 and 42 mg/L, respectively. These exposures were 24 hours in duration, due to the fact that the larval life stage is short, and die off is rapid if the larvae (glochidia) are unable to attach to a host fish and continue metamorphosis to a juvenile life-stage. Chloride exposure prevents the glochidia from closing their valves, which is required in order to clamp onto a host fish gill, thereby resulting in their mortality.

(e) If a species of special concern, or an endangered species, is present at a site of interest (in this case the West Credit River), then a Protection Clause is invoked. The protection clause may be invoked if an acceptable single (or geometric mean) no-effect or low-effect level endpoint (e.g., ECx for growth, reproduction, survival, or behavioural) for a species at risk (as defined by the Committee on the Status of Endangered Wildlife in Canada [COSEWIC]) is lower than the proposed guideline (i.e., is below the 5th percentile intercept to the fitted curve), then that endpoint becomes the recommended guideline value. In this case, if an endangered freshwater mussel species is present, the site-specific chloride CWQG could be lowered to 24 or 42 mg/L.

(f) We spent some time to find if any freshwater mussel survey data was available for the West Credit River, it appears Credit River Conservation did not have any data but DFO provided us with some information which is limited to only two species identified **(Lasmigona compressa,** creek heelsplitter and *Strophitus undulates*, squawfoot). Of the information provided, none of the species listed are found on the Canadian Species at Risk Public Registry.

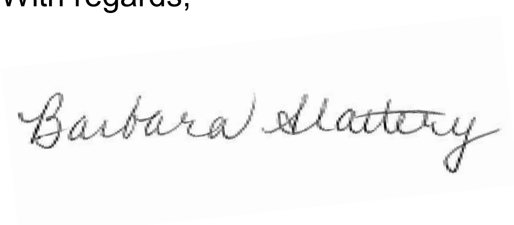
(g) However, it is suggested that a survey be considered, in order to confirm that no species of special concern or species at risk freshwater mussels are present at the site of interest. If the survey finds no presence of that species, the predicted chloride concentration in the effluent would be acceptable to us and no chloride criterion will be included in the effluent parameters. On the other hand, if survey finds presence of that species, an effluent criterion (design objective and compliance limit) for chloride should be proposed to protect fresh water mussels.

(6) The proposed effluent discharge must not be acutely lethal as defined by meeting a 96 hour LC_{50} whole effluent toxicity test using Rainbow Trout and *Daphnia Magna*. This requirement shall be included in the form of an Effluent Limit and shall be monitored through sampling and analysis once in every three months once an ECA is issued.

(7) Details as to the outfall configuration, effluent and receiving water monitoring will be finalized at the permitting stage when an ECA application will be submitted.

Should you have any questions or wish to discuss the specifics of these comments, please contact Sajjad Khan directly either by calling (905) 521-7607 or by email at mohammad.khan@ontario.ca

With regards,



Barbara Slattery
EA/Planning Coordinator

cc. Liam Murray, CVC (via email)
Rick Neubrand, MOECC-DWMD (via email)
S. Khan, MOECC (via email)

Table H1 Response to MOECC August 3, 2017 Comments

No.	MOECC Comment	Response
1	Design objectives and loadings should be included for the proposed effluent parameters and included in the effluent criteria	Ainley Group are recommending design objectives as part of their Technology Review Technical Memorandum (in draft) as part of Phase 3 of the Class EA. These objectives, in addition to loading limits have been provided in Section 5, Table 28 of the ACS.
2	Effluent temperature should be included as an additional parameter to protect the most productive brook trout spawning habitat immediately downstream of the proposed discharge. A compliance limit and a design objective for effluent temperature to protect cold water fishery downstream should be proposed	The Municipal Water Systems for the Urban areas of Erin and Hillsburgh are supplied by groundwater which exhibits an even temperature year-round. It is recognized that hot water use and storage tank exposure to sunlight will increase the temperature of the water. In addition, exposed treatment tanks in the WWTP could also increase the temperature. There is no economically feasible means to adjust effluent temperature. The temperature increases can be mitigated to some extent by using in-ground storage and covered tanks at the WWTP site, by the ~ 2km of buried forcemain between the plant and the river which will be exposed to groundwater temperatures to help attenuate any temperature increases and by the 2.7X dilution available between the 7Q20 flow and the effluent flow at full build out The recommended location for the outfall to the river has been moved downstream to Winston Churchill Boulevard where the river water is cooler and there is a longer exposure of the forcemain to groundwater temperatures.
3	No information was provided as to how the effluent would be disinfected. If chlorine is planned to be used as a disinfectant, 'total chlorine residual' shall be included as an effluent parameter with a compliance limit and design objective concentrations. Please provide information on the proposed plan of effluent disinfection, and propose a compliance limit and design objective of the residual disinfectant;	Ainley group are recommending UV for disinfection of the effluent. This will be outlined in Technology Review Technical Memorandum being prepared by Ainley Group (in draft) as part of Phase 3 of the Class EA.
4	Total Ammonia Nitrogen criteria have been proposed for summer and winter. Please define summer and winter by calendar dates in the recommendation section of the report (i.e., in section 5);	Summer and winter dates have been defined as May 15 – October 15 and Oct 16-May 14 respectively. Table 28 (Section 5) has been updated to reflect summer and winter calendar dates.
5 (g)	However, it is suggested that a survey be considered, in order to confirm that no species of special concern or species at risk freshwater mussels are present at the site of interest. If the survey finds no presence of that species, the predicted chloride concentration in the effluent would be acceptable to us and no chloride criterion will be included in the effluent parameters. On the other hand, if survey finds presence of that species, an effluent criterion (design objective and compliance limit) for chloride should be proposed to protect fresh water mussels.	NSRI completed a mussel survey of the WCR on October 3, 2017 (report appended). The survey found no SAR mussel species in the reach downstream of 10th Line to Shaw's Creek Road. No criterion for effluent chloride concentrations have been proposed. Results of mussel survey have been incorporated into report section 4.6 Mass Balance Modelling - Chloride
6	The proposed effluent discharge must not be acutely lethal as defined by meeting a 96 hour LC50 whole effluent toxicity test using Rainbow Trout and Daphnia Magna. This requirement shall be included in the form of an	Our ACS (Section 4.8.1) recommends effluent limits for TAN to maintain non-acutely lethal effluent

	Effluent Limit and shall be monitored through sampling and analysis once in every three months once an ECA is issued.	
7	Details as to the outfall configuration, effluent and receiving water monitoring will be finalized at the permitting stage when an ECA application will be submitted	Comment acknowledged. The outfall was modelled as 5 m long multi-port diffuser running parallel to the south bank of the West Credit River, with vertical ports located along the river bed. (See Table 6 in ACS). Any alternative configuration can be modelled as required, and monitoring details finalized at the ECA submission stage.

Memo

Project No.2001

To: **Deborah Sinclair, Hutchinson Environmental Science Ltd.**

From: **Gina MacVeigh, Natural Resource Solutions Inc.**

Date: **December 6, 2017**

Re: **West Credit River Freshwater Mussel Survey, Town of Erin Ontario**

Introduction

NRSI was retained by Hutchinson Environmental Science Ltd. to complete a SAR mussel survey and habitat assessment associated with a Class EA for a new WWTP for the Town of Erin that is to discharge to the West Credit River. The Ministry of Environment and Climate Change (MOECC) requested the mussel survey in response to a CCME guideline for chloride and the concerns to SAR mussels in south western Ontario. NRSI conducted a survey and habitat assessment in the West Credit River near the Town of Erin, Ontario on October 3, 2017 to determine the suitability of the habitat for Species at Risk (SAR) mussels. The assessments were done for two proposed outfall alternatives, shown on Map 1a and 1b in Appendix I, and are as follows:

1. West Credit River – downstream of 10th Line at Erin to Winston Churchill Boulevard.
2. West Credit River – Downstream of Winston Churchill Boulevard for 1km.

Collection and Review of Background Information

Background information on the West Credit River within the two proposed outfall alternative locations was requested from the Credit Valley Conservation Authority (CVC) and the Ministry of Natural Resources and Forestry (MNRF) Aurora District. CVC provided mussel occurrence records on November 6, 2017 (email from A. Ockenden). As of November 22, 2017, no response from the MNRF has been received. NRSI also reviewed the DFO's distribution mapping of fish and mussel SAR (DFO 2017a) and the MNRF's Natural Heritage Information Centre (NHIC) (MNRF 2017a) within the West Credit River which indicates that there is no record of SAR mussels present within the West Credit River.

Field Survey Methodology

Two aquatic biologists, one of which is considered a Freshwater Mussel Specialist, conducted a field survey for mussels and mussel habitat within the two proposed outfall alternative locations. The method for the examination of features followed the informal sampling design described in A Guide to Sampling Freshwater Mussel Populations (Smith and Strayer 2003). As SAR mussels were not expected within these sections of the West Credit River, a quantitative survey to determine presence/absence was not conducted, but instead a timed search was done at each of the two locations. Based on the guide, a timed search of five person hours was completed at each of the two locations (2.5 hours per aquatic biologist per location). Water levels at the time of the assessment were average to below average for the time of year and clear water conditions provided high visibility for viewing the substrates. The survey included walking in an upstream direction utilizing view finders to conduct visual searches within habitat that was suitable for mussels. Additional effort was spent looking for shells along the banks of the river to add to the species information. Surveys for mussels, including SAR, are usually conducted before temperatures drop below 16ºC, as mussels become less active and start to bury deep into the substrate (Mackie et al. 2008). As the survey was conducted in October, the water temperature was below the recommended 16 ºC; however, the West Credit River is a cool-cold water river, which means that the mussel species present are likely to be more tolerant to cooler water temperatures. The weather leading up to the survey had been warmer than average for the end of September. There had been no precipitation during the previous few days prior to the survey.

Mussel Habitat and Species

Information regarding the mussel species present within the West Credit was received from CVC. There are limited observations, dating back to 2006, and spread out throughout the West Credit subwatershed, and no SAR mussel observations have been made. Mussel species that have previously been found within the West Credit River, their status, preferred habitat, and condition they were found in are below in Table 1.

Table 1. Mussel Species from the West Credit River

Common name	Scientific Name	SRANK[1]	ESA[2]	SARA[3]	Preferred Habitat[1]	Condition
Creek Heelsplitter	*Lasmigona compressa*	S5	N/A	N/A	Small streams and the headwaters of small to medium-sized rivers in fine gravel or sand.	Weathered shells have been found within the West Credit River.
Creeper	*Strophitus undulatus*	S5	N/A	N/A	Small to medium-sized streams or occasionally large rivers in mud, sand or fine gravel in a range of flow conditions.	Weathered shells have been found in different locations within the West Credit River.
Cylindrical Papershell	*Anodontoides ferussacianus*	S4	N/A	N/A	Small, slow-moving stream and the headwaters of large streams in silt or mud or sometimes sand.	Weathered shells have been found within the West Credit River. An alive specimen, freshly dead shells and weathered shells have been found within a tributary to the West Credit River.
Giant Floater	*Pyganodon grandis*	S5	N/A	N/A	Small streams to large rivers in backwaters with little or no current in clay silt or mud.	A weathered shell has been found within the West Credit River.

[1]Metcalfe-Smith et al. 2005, [2]MNRF 2017b, [3]Government of Canada 2017b

Reach 1 - Upstream of Shaw's Creek Road to Winston Churchill Blvd

Aquatic biologists conducted a visual mussel survey and habitat assessment for approximately 1km within the West Credit River. The survey started upstream of Shaw's Creek Road at 0930hrs and was conducted to the culvert crossing at Winston Churchill Boulevard, ending at 1215hrs. Water quality parameters were taken upstream of Shaw's Creek Road within the surveyed area. At 0930hrs water temperature was 10.3ºC while air temperature was 9ºC. The air temperature increased throughout the survey to 14.5ºC at 1215hrs. Recorded water quality parameters at 0930hrs include: pH of 8.26, dissolved oxygen of 11.30mg/L and 107%, conductivity of 600µS (microsiemens), and total dissolved solids of 3.0 parts per million (ppm). A turbidity tube was also utilized and was greater than 90cm which means it had a turbidity of less than 5 NTU's (very clear).

Throughout this reach the West Credit River is primarily undeveloped, with the majority of the river having a good flood plain and treed valley (conifers and poplars). The substrates throughout this section consist of primarily sand, gravel, and cobble, with areas of silt, muck and detritus along some of the edges. A few boulders are also present throughout. Filamentous algae were present on the larger cobble and boudlers. Remnants of an old dam and corresponding elevation change are present within this section (Map 1a). Immediately upstream of the old dam, the substrates are comprised more so of silt and detritus overtop of a firmer bottom. Overhanging trees and submerged wood was also abundant. Areas of pure sand were noted within the river. These areas are indicative of ground water upwelling. Watercress, which is also a groundwater indicator, was also very abundant throughout this section. Groundwater seeps were observed along the valley, under the conifer trees. Brook Trout (*Salvalinus fontinalis*) of various sizes were observed during the survey. Brook Trout are considered a cold-water indicator species preferring clear, cool-cold water habitat to complete its life cycle and reproduce. Two partial shells of Cylindrical Papershell were found during the mussel survey. These shells were weathered but still had distinguishing features. No additional live mussels or mussel shells were observed within Reach 1.

Reach 2 – Winston Churchill Blvd to 10th Line

Aquatic biologists conducted a visual mussel survey and habitat assessment for approximately 1km within the West Credit River. The survey started at the upstream edge of the culvert under Winston Churchill Boulevard at 1245hrs and was conducted to the culvert crossing at 10th Line, ending at 1520hrs. Water quality parameters were taken upstream of Winston Churchill Boulevard, just upstream of the culvert. At 1245hrs water temperature was 10.3ºC while air temperature was 14.5ºC. The air temperature increased throughout the survey to 16.5ºC at 1430hrs. Additional water quality parameters recorded at 1245hrs include; pH of 8.29, dissolved oxygen of 12.77mg/L and 112.8%, conductivity of 600µS (microsiemens), and total dissolved solids of 3.1 part per million (ppm). A turbidity tube was also utilized and was greater than 90cm which means it had a turbidity of less than 5 NTU's (very clear).

Similar to the first reach, the West Credit River is primarily undeveloped, with only a few residential properties or areas where there is clearing right to the water's edge. A small section of the river also appears to have been influenced by humans or children, with a manicured lawn right to the river and larger substrates removed from the river and placed into a small rock dam across the river (Map 1b). The majority of the river has a good flood plain and treed valley (conifers and poplars). The substrates are very similar to the previous reach consisting of sand, gravel, and cobble, with areas of silt, muck and detritus along some of the edges. Algae was also observed on the substrate within this section. Overhanging trees and submerged wood was also abundant. Watercress and areas of pure sand were noted in excess throughout this reach. A large number of Brook Trout, of various sizes, were observed during the survey and assessment. A partial and very weathered Cylindrical Papershell was also found within this reach. No additional live mussels or mussel shells were observed within Reach 2.

Overall Habitat for Mussels

In general, the permanently wetted habitat within both reaches of the West Credit River would provide suitable habitat for a number of mussel species, including the four common species in the above table. There were pool, riffle and run habitats, which all had suitable substrates required for mussels to burrow and survive within. The limited abundance and diversity of mussels within this reach is most likely driven by the cooler water temperatures and the location being within the Niagara escarpment. The smaller diversity of fish would also limit the number of mussel species present, as a large number of mussels use fish hosts that prefer warm water habitats. Photos of the West Credit River are provided within Appendix II.

Summary Review of Mussels

None of the species that were found during the survey or previously observed within the background information are listed as SAR under the provincial *Endangered Species Act* or the federal *Species at Risk Act*. The Creeper, Creek Heelsplitter, and Giant Floater each have a S-Rank of S5 (Very common and demonstrably secure within Ontario), and the Cylindrical Papershell has an S-Rank of S4 (Common and apparently secure within Ontario) (MNRF 2015).

Non-SAR mussels do not receive protection under the *ESA* or the *SARA*, but as they are considered fish under the *Fisheries Act*, they are afforded protection and require consideration and projects should avoid causing serious harm to them.

No SAR mussels were observed within the West Credit River in the vicinity of either alternative for new WWTP for the Town of Erin. Due to the lack of SAR mussel presence, chloride (under the new CCME guideline) will not result in impacts to SAR mussel as a result of the new WWTP.

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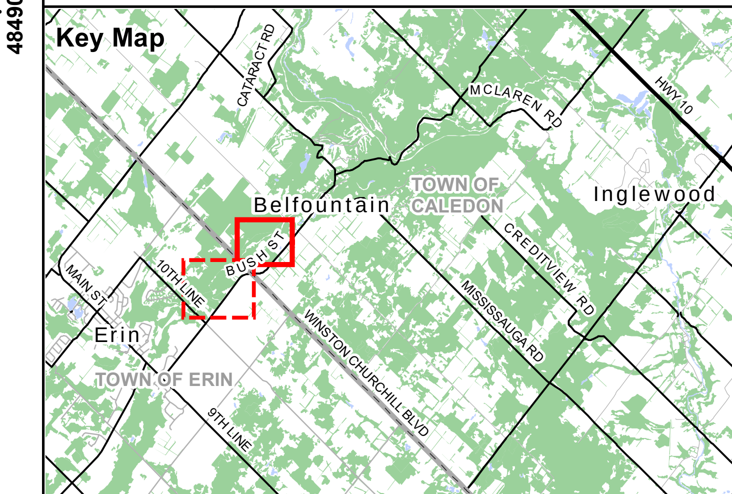
APPENDIX I
Map

Map 1a

Town of Erin WWTP Outfall Alternatives

West Credit River Mussel Survey

Key Map



Legend

- Reach 1
- Reach 2
- Remnant Dam
- Permanent Watercourse
- Intermittent Watercourse

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Project: 2001 Date: November 21, 2017	NAD83 - UTM Zone 17 Size: 11x17" 1:3,500

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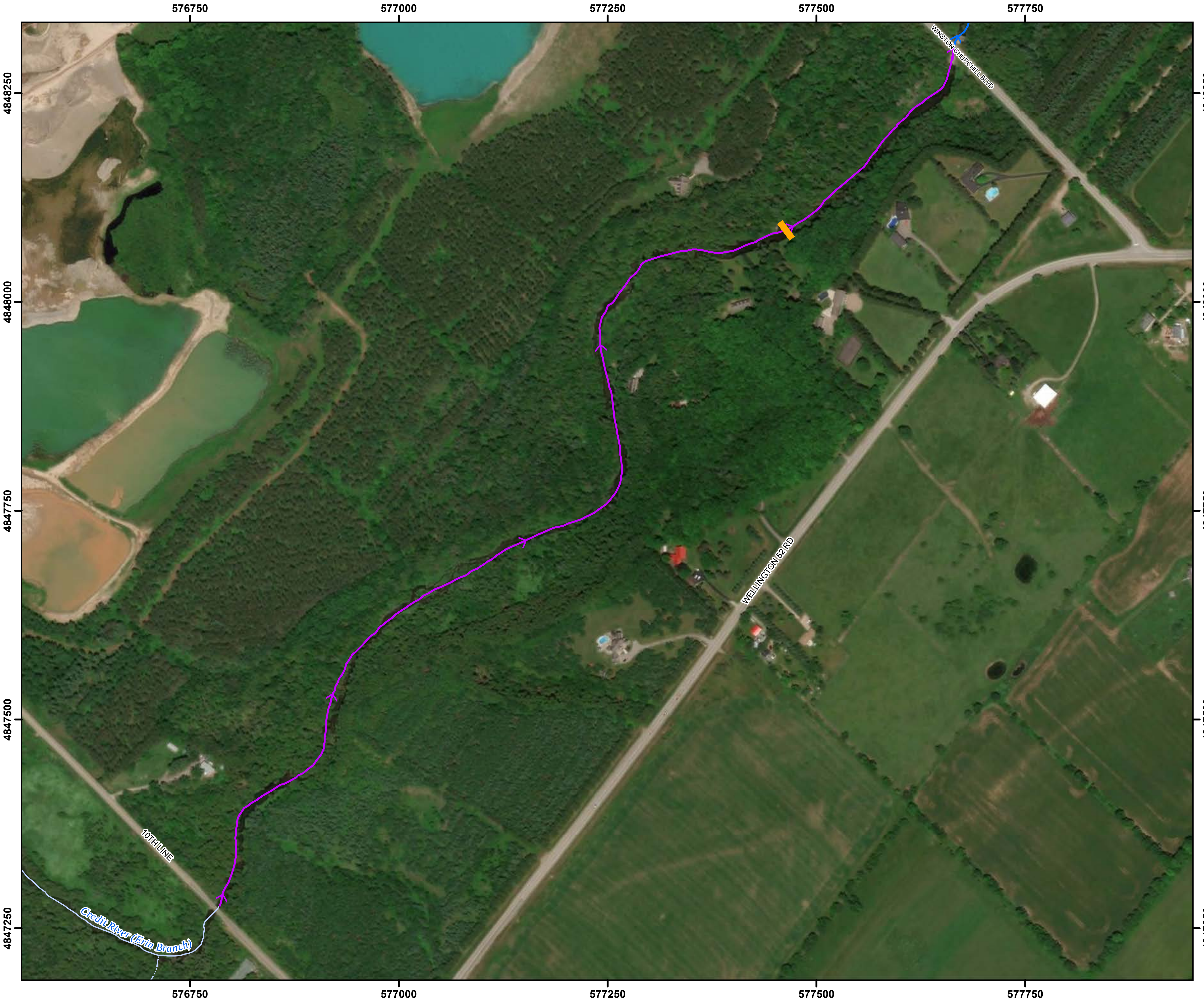
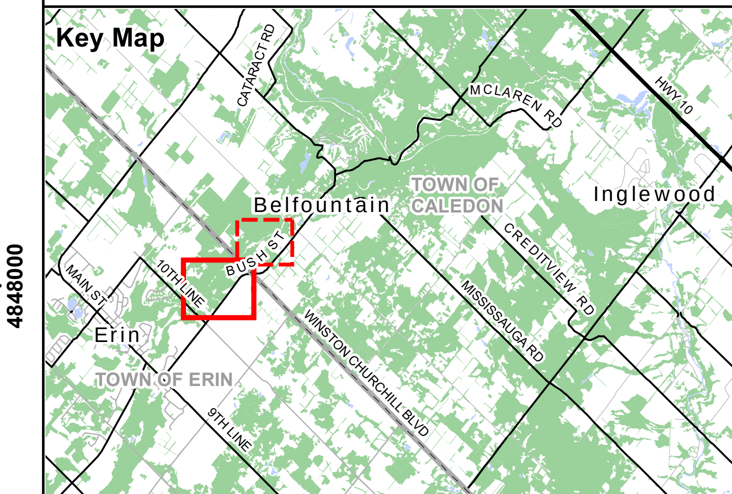
Map 1b

Town of Erin WWTP Outfall Alternatives

West Credit River Mussel Survey



Key Map



Legend

- Reach 1
- Reach 2
- Rock Dam
- Permanent Watercourse
- Intermittent Watercourse

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Project: 2001
Date: November 21, 2017

NAD83 - UTM Zone 17
Size: 11x17"
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APPENDIX II
Photos

Reach 1 – Shaw's Creek Road to Winston Churchill Blvd


Photo 1: Downstream view at downstream extent.

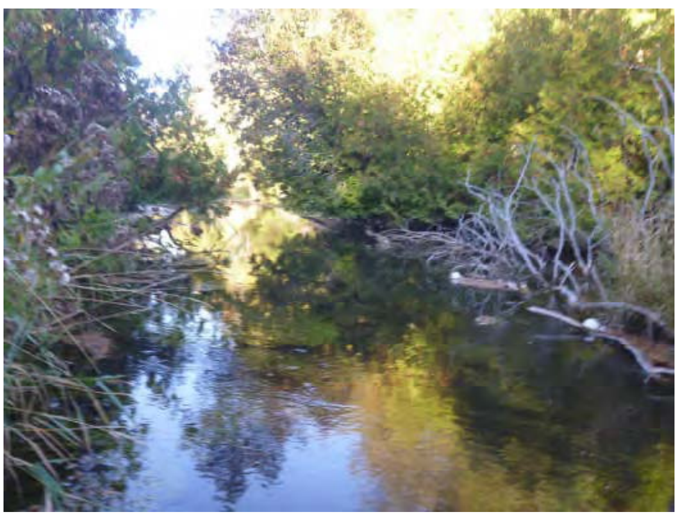
Photo 2: Upstream view at downstream extent.


Photo 3: Gravel and cobble substrates, clear water.


Photo 4: Upstream view with substrates and showing clear water good bank vegetation.


Photo 5: Downstream view. Good flow, clear water.


Photo 6: Watercress, algae on substrates.

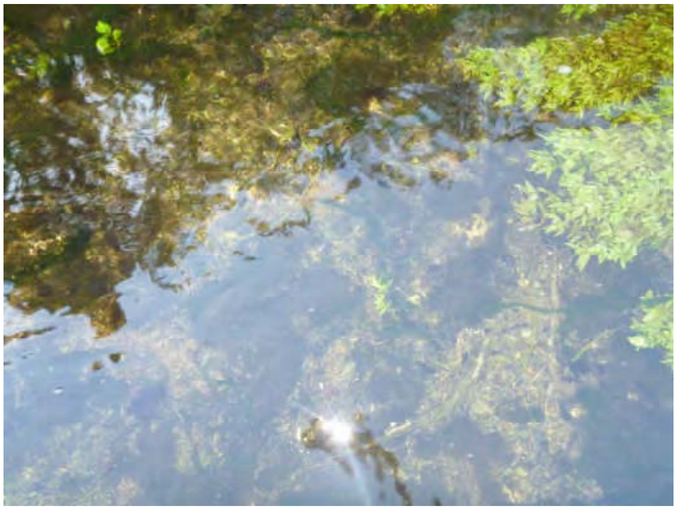

Photo 7: Substrates – sand, gravel, algae.

Photo 10: Side channel with abundant watercress, cobble and gravel substrates.

Photo 8: Downstream view within reach. Good flow, clear water.

Photo 11: Upstream view showing remnant dam.

Photo 9: Upstream view of riffle. Cobble substrates. Overhanging cedar trees.

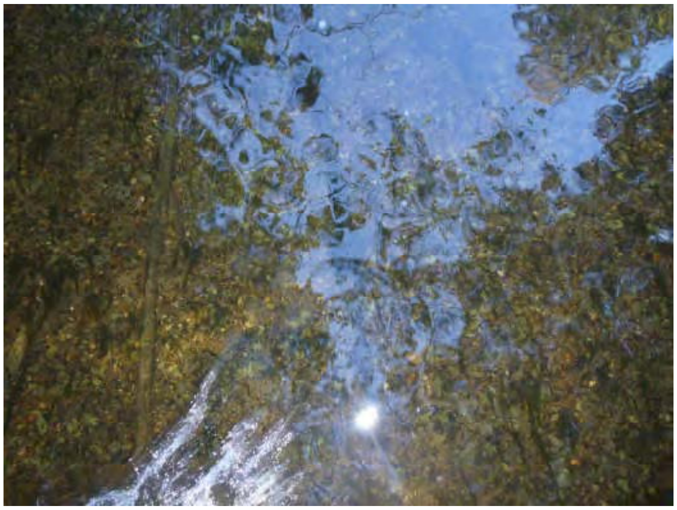

Photo 12 – Downstream of remnant dam. Gravel and sand substrates.


Photo 13: Remnant Dam. Boulders and elevation change.


Photo 16: Upstream view upstream of the soft substrates.


Photo 14: Downstream view looking towards remnant dam. Showing silt substrates, slower flow.


Photo 17: Substrates back to gravel, cobble and sand just downstream from Winston Churchill Blvd.


Photo 15: Looking across river upstream of remnant dam. Aquatic vegetation and soft silt substrates.


Photo 18: Culvert at Winston Churchill Blvd.

Reach 1 –Winston Churchill Blvd to 10th Line


Photo 19: Upstream view immediately upstream of Winston Churchill Blvd.


Photo 20: Cobble substrates upstream of Winston Churchill Blvd.


Photo 21: Across the West Credit at Winston Churchill Blvd.


Photo 22: Upstream view towards rock dam. Sand, gravel and cobble substrates.

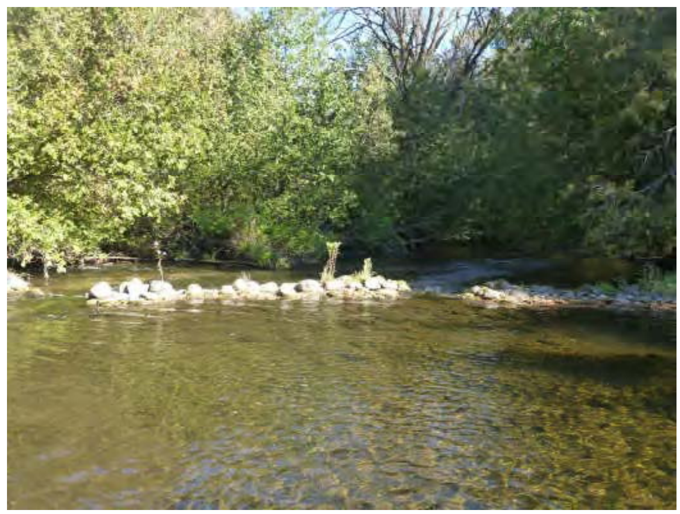
Photo 23: Downstream view at rock dam.


Photo 24: Upstream view of a side channel. Sand and gravel substrates. Overhanging cedar trees.


Photo 25: Upstream view of watercress, some silt on substrates.


Photo 28: Upstream view showing substrate and watercress.


Photo 26: Upstream view within reach.


Photo 29: Abundant amount of watercress, sand and upwelling of ground water.


Photo 27: Algae on boulders and large cobble throughout reach.


Photo 30: Upstream near upstream extent showing abundant algae.


Photo 31: Woody debris present in water throughout West Credit.


Photo 32: Watercress and algae on substrates.


Photo 33: Upstream view of 10th Line Bridge.


Photo 34: Upstream view upstream of 10th Line.

Appendix A – West Credit River Temperature Assessment

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Memorandum

Date: **April 4, 2018**

To: **Gary Scott, Ainley Group**

From: **Brent Parsons, Deborah Sinclair and Neil Hutchinson**

Re: **HESL J160005 – Thermal Assessment of Erin WWTP on West Credit River**

The reach of the West Credit River between 10th Line and Winston Churchill Blvd. contains a cold-water thermal regime and aquatic habitat that supports a robust population of sensitive coldwater fish species and critical Brook Trout spawning habitat (HESL 2017a). The purpose of this technical memorandum is to provide an assessment of the potential effect of the Erin WWTP effluent on water temperatures in the West Credit River during all times of the year for both Phase 1 (near term) and Full Build Out ((FBO) 20-year horizon) of the Wastewater Treatment Plant (WWTP) project to assess potential impacts to Brook Trout.

Temperature Thresholds for Brook Trout in West Credit River

Brook Trout are ranked as the most sensitive fish species in Toronto-area streams (Wichert and Regier 1998), they are the indicator species for coldwater habitat in the Credit River watershed (MNR and CVC 2002) and were therefore selected as the sentinel species to assess potential impacts of the Erin WWTP effluent on water temperature in the West Credit River. Temperature thresholds for various life stages were reviewed and two temperature “thresholds” (optimum and upper tolerance) associated with spawning, egg development and adult behaviour (i.e. growth) were defined (Table 1). Optimum water temperatures for spawning, egg development and general adult behaviour were defined as 10.7°C, 6.1°C and 14.2°C, respectively, as reported in Key Ecological Temperature Metrics for Canadian Freshwater Fishes (Hasnain et al. 2010). Upper tolerance temperatures for spawning, egg production and adult behaviour were defined as 16°C (Hokanson et al. 2001), 11.7°C (Hokanson et al. 2001) and 19°C (various citations – Table 1), respectively.

Table 1. Water Temperature Considerations for Brook Trout at Various Life Stages. Note that bold values are carried forward into the assessment.

Life Stage	Water Temperature Considerations
Spawning	- Ovulation and spawning occur at **16°C** or lower (Hokanson et al. 2001) - Optimal spawning temperature = **10.7°C** (Hasnain et al. 2010)
Egg Development	- Optimum egg development temperature = **6.1°C** (Hasnain et al. 2010) - Egg viability decreases above **11.7°C** (Hokanson et al. 2001)

Adult	- Optimum growth temperature = **14.2°C** (Hasnain et al. 2010) - Optimum growth rate at 14 °C (Baldwin 1951) - Brook Trout do poorly in streams where water temperatures exceed 20°C for extended periods (McAfee 1966) - Brook Trout are sensitive to changes in water temperature because they do not tolerate water temperatures greater than **19°C** - 20°C for long (Creaser 1930; Burton and Odum 1945; Gibson 1966) - A general upper tolerance of **19°C** - 20°C is evident throughout the literature (Kerr 2000). - **19°C** is critical as temperatures above this are considered suboptimum (Hokanson et al. 1973) - When temperatures reach 20°C non-indigenous Brown Trout will outcompete Brook Trout (Taniguchi et al. 1998)

Brook Trout life stages and associated water temperature thresholds are presented for each month in Table 2. In the West Credit River, growth occurs throughout the year, with spawning in October/November (active spawning was observed on November 1, 2016 (HESL 2017a)), and egg development from November through to March of the following year. Egg development has the lowest temperature preference, so these values were applied as thresholds for November to March, spawning temperatures were applied to October, and growth temperatures were applied as thresholds for the rest of the year (April to September), when spawning and egg development are not occurring (Table 2).

Temperature thresholds were compared to continuous water temperature data collected by CVC at Winston Churchill Blvd. from 2009-2015 (station 501150002; Table 2, Figure 1). Existing 75th percentile and maximum water temperatures exceed the optimal temperature preference of 14.2°C for Brook Trout growth from May to September (Table 2, Figure 1) and the 10.7°C optimal temperature preference for spawning in October. Maximum recorded water temperatures also exceeded the upper tolerance thresholds of 19°C for growth from May to September, and the upper tolerance threshold for spawning of 16°C in October. The 75th percentile July temperature of 19.3°C also exceeds the upper tolerance threshold for growth.

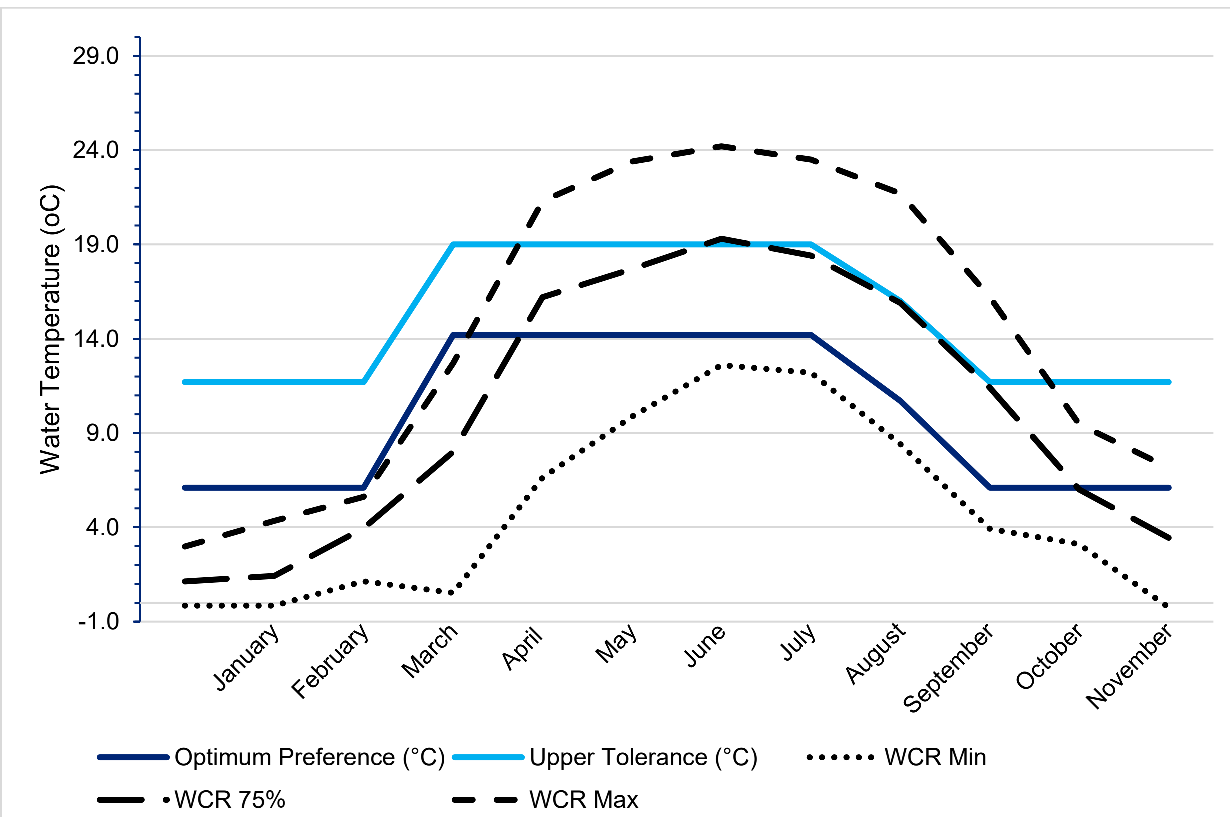
Table 2. Monthly Temperature Thresholds for Brook Trout in the West Credit River.

Month	Life Stage with Lowest Temperature Requirement	Optimal Temperature Preference (°C)	Upper Tolerance Temperature (°C)	Existing West Credit River Temperatures (°C)		
				Minimum	75th Percentile	Maximum
January	Egg Development	6.1	11.7	-0.2	1.1	3.0
February				-0.2	1.4	4.4
March				1.1	4.0	5.6

April	Growth	14.2	19	0.5	8.0	12.7
May				6.6	16.2	**21.3**
June				9.9	17.7	**23.4**
July				12.6	**19.3**	**24.2**
August				12.2	18.4	**23.5**
September				8.42	15.9	**21.7**
October	Spawning	10.7	16	3.9	11.4	**16.2**
November	Egg Development	6.1	11.7	3.1	6.0	9.5
December				-0.3	3.4	7.2

Notes: There was no temperature data for the months of January, February and December at station 501150002. Values for these months are based on continuous water temperatures collected at Belfountain at station 14526010 by CVC (Correlation between Belfountain and Winston Churchill data: r = 0.99; p<0.001). Shaded values exceeded optimal temperature preference values and bold values exceed upper tolerance temperatures.

Figure 1. Brook trout temperature requirements and water temperatures of West Credit River at Winston Churchill (2009-2015)



The Brook Trout population in the West Credit River near Winston Churchill Blvd. appeared to be thriving based on numbers of fish and spawning redds observed during surveys (HESL 2017a) even though existing 75th percentile water temperatures exceed optimal temperature preference for growth and spawning becase:

1. Water temperature is only one habitat component of many required to support robust populations;
2. Brook Trout commonly seek out thermal refugia within streams (Ebersole et al. 2001);
3. Different Brook Trout strains have acclimatized to the water temperatures of their environment (Stitt et al. 2014), so it is challenging applying reported thermal tolerances of assemblages in the West Credit River when the studies were not completed on these populations; and
4. Groundwater upwellings are ubiquitous in the study area and they provide a consistent source of cold, oxygen-rich water for egg and sac-fry development.

Therefore, for the purposes of the temperature assessment, upper threshold water temperatures were used to assess any effects of the Erin WWTP on the Brook Trout life stages in the West Credit River.

Approach

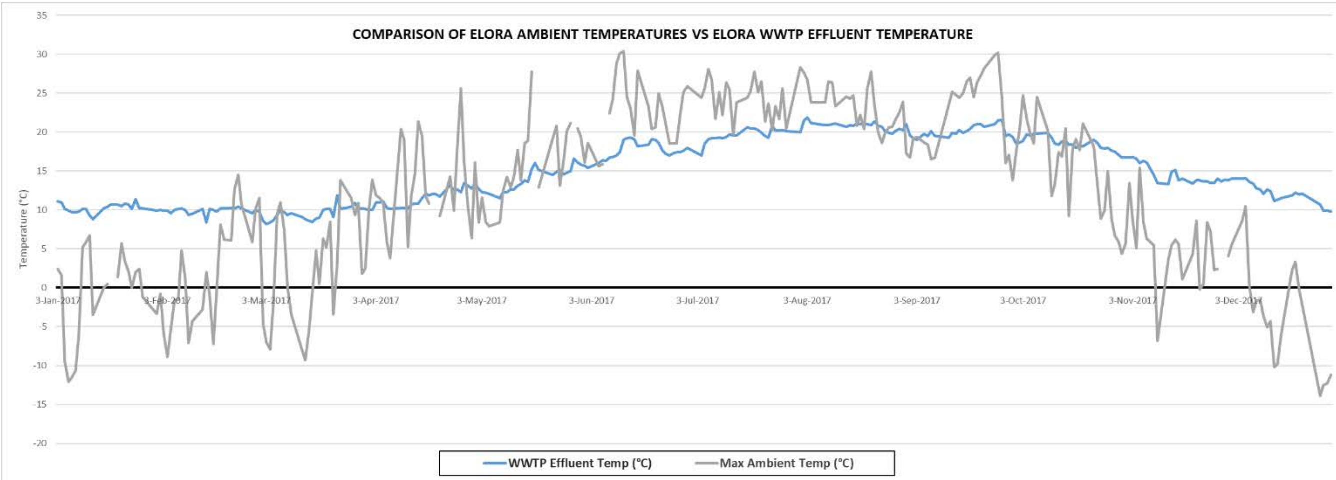
The effect of the Erin WWTP effluent on water temperatures in the West Credit River was calculated using:

1. A mass balance model (i.e., conservative approach) to estimate water temperatures after complete mixing of effluent within the creek; and
2. A CORMIX model to predict the size and shape of the thermal mixing zone.

Water temperature data for the West Credit River were obtained from CVC's station located at Winston Churchill Blvd (2009 through 2015 data; station 501150002), which was supplemented with water quality data collected by CVC at Belfountain (station 14526010). The 75th percentile, minimum and maximum water temperatures were calculated for each month (Table 2) as input into the models.

Monthly 75th percentile effluent temperatures were provided by Ainley Group (Preya Balgobin pers. communication, March 13, 2018) based on 2017 effluent temperatures for the Elora WWTP. The Elora WWTP effluent temperatures were used as it is close to Erin, and similar water sources and climate would result in similar effluent temperatures. It should be noted however that the Elora WWTP uses an extended air process which has higher retention time and longer exposure to ambient air temperatures compared to the treatment process that is proposed at Erin, which means that the use of Elora WWTP effluent temperatures represents a conservative approach of higher effluent temperatures than will likely be recorded at the Erin WWTP. These values were corrected for heat loss through the 1.7 km forcemain between the WWTP and the outfall to the West Credit River. Except for May, it is predicted that effluent will always be warmer than the creek (Table 3). Figure 2 presents ambient air temperatures in Elora compared to Elora WWTP effluent temperatures. The ambient temperatures show much greater fluctuations than the WWTP effluent temperature. The WWTP effluent temperatures gradually increase in warmer weather, and slowly decrease in cooler weather, and are not affected by swings in ambient air temperature.

Figure 2. Comparison of Elora Ambient Air Temperatures with Elora WWTP Effluent Temperatures.



Monthly 7Q20 flows for the West Credit River at 10th Line were the same as those used in the ACS (HESL 2017b). They were calculated by CVC (CVC 2016) and corrected for climate change (10% reduction as per the annual 7Q20 estimate by CVC) and used as input into the models. The lowest 7Q20 value occurs in September, followed by the other summer monthly flows (August, June and July). Highest 7Q20 values occur in the spring (April and March) and late fall/early winter (December/November; Table 3).

Models were run for both Phase 1 (39 L/s) and Full Build Out (83 L/s) effluent flows. It should be noted that Phase 1 is predicted to occur in the near term (next 3 to 5 years), and Full Build Out conditions will not occur for 20 or more years. Therefore, Full Build Out predictions may be validated and refined with future site-specific data (e.g. Erin WWTP effluent temperatures).

The CORMIX model inputs were those detailed in the *West Credit River Assimilative Capacity Study* (HESL 2017b) with addition of a surface heat exchange coefficient for modelling temperature. The CORMIX user manual (Doneker and Jirka 2014) suggests that, for conservative models, a value of 10 W/m^2,°C be used at low water temperatures and a value of 20 W/m^2,°C be used at high water temperatures. These values correspond to a wind speed of 0-2 m/sec - heat exchange would be greater at higher wind speeds. Following this, a surface heat exchange coefficient of 20 W/m^2,°C was used for the months of June through August, and a coefficient of 10 W/m^2,°C was used for all other months.

Mass Balance Model Results

The resulting water temperatures in the West Credit River downstream of the proposed WWTP discharge as calculated by the mass balance (at both Phase 1 and Full Build Out effluent flows of 39 L/s and 83 L/s) are presented in Table 3.

Table 3. Monthly Fully-Mixed Water Temperatures in West Credit River by Mass Balance Modelling

Month	75th Effluent Temp (°C)	75th % West Credit River Temp (°C)	Monthly 7Q20 (L/s)	Phase 1 Mixed Temp (°C)	Phase 1 Temp Increase (°C)	Full Build Out Mixed Temp (°C)	Full Build Out Temp Increase (°C)	Upper Tolerance Temperature (°C)
January	10.8	1.1	374	2.0	0.9	2.9	1.8	11.7
February	10.3	1.43	357	2.3	0.9	3.1	1.7	11.7
March	10.3	4.0	464	4.4	0.5	4.9	1.0	11.7
April	12.2	8.0	568	8.3	0.3	8.5	0.5	19.0
May	14.8	16.2	416	16.1	-0.1	16.0	-0.2	19.0
June	18.0	17.7	306	17.7	0.0	17.8	0.1	19.0
July	19.6	19.3	319	19.3	0.0	19.4	0.1	19.0
August	20.3	18.4	275	18.6	0.2	18.8	0.4	19.0
September	20.0	15.9	244	16.5	0.6	16.9	1.0	19.0
October	18.4	11.4	338	12.1	0.7	12.8	1.4	16.0
November	15.7	6.0	460	6.8	0.8	7.5	1.5	11.7
December	12.7	3.4	464	4.2	0.7	4.8	1.4	11.7

Note: Shaded values exceed both 75th percentile background and upper tolerance threshold for Brook Trout

During Phase 1, fully mixed 75th percentile water temperatures are predicted to decrease in May by 0.1ºC, not change in June and July, and increase between 0.2 to 0.9ºC in August to April. The largest increase in water temperatures will be in the late fall (November) and winter (December, January and February), with water temperature increases of 0.7 to 0.9ºC. Except for July, water temperatures will remain below their upper tolerance thresholds for the various life stages. The existing 75th percentile water temperature in July (19.3ºC) is above the upper tolerance threshold for growth (19ºC). Under Phase 1 effluent flows, July water temperature is predicted to stay the same (i.e. 19.3ºC), therefore, there is no predicted change from current conditions. Fully mixed water temperatures during the sensitive periods for Brook Trout spawning (October) and egg development (November through to March) will remain well below the upper tolerance temperatures (Table 3) although groundwater inflows will isolate eggs from the changes.

During Full Build Out, fully mixed 75th percentile water temperatures are predicted to decrease in May by 0.2ºC and increase between 0.1 to 1.8ºC between June and April. Except for July, water temperatures will remain below their upper tolerance thresholds for the various life stages. In July, the 75th percentile water temperature is predicted to be 19.4ºC, above the threshold of 19ºC, but only 0.1ºC above the existing 75th percentile water temperature of 19.3ºC.

CORMIX Model Results

During Phase 1, the upper tolerance threshold temperatures are met at the diffuser from January to June. In July, background 75th percentile West Credit River water temperatures exceed the upper tolerance threshold value of 19ºC (see mass-balance modeling results), therefore the threshold will not be met downstream. From August to December the distance to the point where effluent temperature declines to the upper tolerance threshold ranges from -2.5 m (backflow from diffuser) to 32 m. These distances are within the 152 m size of the mixing zone predicted for other water quality parameters in the effluent (HESL 2017b).

Table 3 Distance (m) to meet Upper Tolerance Thresholds in West Credit River.

Month	Effluent Temp (°C)	75th % WCR Temp (°C)	Monthly 7Q20 (L/s)	Upper Tolerance Temperature (°C)	Distance (m) downstream to Upper Tolerance - Phase 1	Distance (m) downstream to Upper Tolerance - Full Build-Out
January	10.8	1.13	374	11.7	0	0
February	10.3	1.43	357	11.7	0	0
March	10.3	3.95	464	11.7	0	3
April	12.2	8.00	568	19.0	0	0
May	14.8	16.20	416	19.0	a	
June	18.0	17.70	306	19.0	0	0
July	19.6	19.30	319	19.0	b	
August	20.3	18.40	275	19.0	32	84
September	20.0	15.90	244	19.0	3	3
October	18.4	11.40	338	16.0	3	715
November	15.7	6.00	460	11.7	7	12
December	12.7	3.44	464	11.7	-2.5	3

Notes: a – effluent is cooler than West Credit River, therefore the Upper Tolerance Threshold is never exceeded; b – existing 75th percentile West Credit River water temperatures exceed the Upper Tolerance Threshold

During Full Build Out, the upper tolerance threshold temperatures are met at the diffuser in January, February, April, and June. Again, in July, background 75th percentile West Credit River water temperatures exceed the upper tolerance threshold value of 19ºC, therefore the threshold will not be met downstream. In March, September, November, and December, the distance for temperature to decrease to the upper tolerance threshold ranges are less than 40 m. In August and October, the distance to upper tolerance threshold temperatures are 84 and 715 m respectively. We note that the large increase in October is an artifact that relates to the transition from a growth tolerance temperature of 19ºC to a spawning tolerance of 16ºC, which will not occur on October 1 but will depend on when fish actually spawn. The actual affected distance in the river will be much less than the 715 m predicted. At 35 m downstream of the diffuser, water temperatures are predicted to be 19.2ºC and 16.2ºC for August and October respectively. This is only 0.2ºC greater than the upper tolerance thresholds for spawning and egg development.

Thermal Impact on Fish and Other Aquatic Species

The proposed effluent outfall diffuser will be placed approximately 2 m upstream (i.e. south) of the large culvert that transmits flows beneath Winston Churchill Blvd. The culvert is approximately 45 m long and represents degraded habitat because it is permanently shaded, doesn't permit macrophyte growth and limits the form of the stream bed and width of the channel.

The predicted increases in temperature in the West Credit River downstream of the outfall as predicted through mass balance modeling are minimal. In the short-term (Phase 1), fully mixed water temperatures are predicted to stay the same (July) or increase by 0.9ºC. Fully mixed water temperatures during Brook Trout spawning (October) and egg development (November to March) will remain well below their upper tolerance temperatures.

In the longer-term (Full Build Out, > 20 years), fully mixed water temperatures are predicted to increase by a maximum of 1.7ºC. Except for July, water temperatures will remain below their upper tolerance thresholds for the various life stages. The nominal increase (0.2ºC) in July water temperature is not expected to affect the growth life stage of the local Brook Trout population for the following reasons:

1. Brook Trout in this reach have acclimatized to water temperatures up to 24.3ºC (maximum water temperature of Winston Churchill),
2. Brook Trout routinely experience water temperatures of 19.3ºC in the study area,
3. Temperature predictions are conservative since they are focused on 7Q20 flows (which are exceeded 99.5 to 99.9% of the time; Pyrce 2004) and 75th percentile water temperatures,
4. Brook Trout commonly seek out thermal refugia (Ebersole et al. 2001),
5. Seasonal temperature cycles provide an acclimatization period for Brook Trout (Raleigh 1982), and
6. Fully mixed water temperatures during sensitive spawning (October) and egg growth development (November to March) life stages will remain well below their upper tolerance temperatures.

The maximum predicted distance to upper threshold temperatures in the West Credit River downstream of the outfall during Phase 1 as predicted through CORMIX modeling is 32 m in August so increased temperatures will be constrained to degraded habitat located in the culvert. Predicted distances to upper threshold temperatures during Full Build Out are 84 m in August and 715 m in October but, the October distance of 715 m is considered artificially high. By 35 m downstream of the diffuser (within the culvert) water temperatures are predicted to be 19.2ºC and 16.2ºC for August and October, respectively. This is only 0.2ºC greater than the upper tolerance thresholds for spawning and egg development. Any effects on Brook Trout populations will be partially mitigated in August by their ability to seek out thermal refugia, and from November - March egg and sac-fry development will not be impacted because Brook Trout commonly spawn overtop of rocky substrates and groundwater upwellings, and eggs develop within the interstitial spaces of the substrates. Groundwater inputs will not be impacted by the WWTP effluent and therefore water temperatures near these spawning and development areas and within the interstitial spaces between rocky substrates are not likely to change. Water temperature modelling is focused on the assimilation of effluent throughout the water column and not on water temperatures within or adjacent to sediments, so the prediction of impacts on spawning habitat represents a very conservative assessment of the change to water temperatures.

There are several qualifications mentioned throughout this assessment that made it conservative. Qualifications include:

1. These predictions were made for 7Q20 low flow conditions as a conservative estimate of change - flows will be higher and temperature changes smaller 99.5% of the time,
2. Seasonal temperature cycles from summer highs to winter lows provide an acclimatization period to temperature extremes for Brook Trout (Raleigh 1982),
3. Brook Trout commonly seek out thermal refugia within streams (Ebersole et al. 2001),
4. Different Brook Trout strains have acclimatized to the water temperatures of their environment (Stitt et al. 2014), so it is challenging applying reported thermal tolerances of assemblages in the West Credit River when the studies were not completed on these populations, and
5. Most importantly, Brook Trout commonly spawn overtop of rocky substrates and groundwater upwellings, and eggs develop within the interstitial spaces of the substrates. Groundwater inputs will not be impacted by the WWTP effluent and therefore water temperatures near these spawning areas and within the interstitial spaces between rocky substrates are not likely to change. Water temperature modelling is focused on the assimilation of effluent throughout the water column and not on water temperatures within or adjacent to sediments, so the prediction of impacts on spawning habitat represents a very conservative assessment of the effect of change to water temperatures.

Conclusions

The Provincial Water Quality Objective for water temperature is, "The natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed." (MOE 1994). Based on the results of the thermal assessment on Brook Trout, including the various conservative qualifications, we predict that the temperature changes resulting from the WWTP discharge will not "significantly change the distribution and abundance of plant and animal life" per the Provincial Water Quality Objective.

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Appendix - E

Two Treatment Plants Alternative

Town of Erin
Urban Centre Wastewater Servicing
Class Environmental Assessment

Technical Memorandum
Two Treatment Plants Alternative
(One Hillsburgh and One Erin)

FINAL

June 2017

Urban Centre Wastewater Servicing Class Environmental Assessment

Technical Memorandum
Two Treatment Plants Alternative
(One Hillsburgh and One Erin)

Project No. 115157

Prepared for:
The Town of Erin

Prepared By:

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Executive Summary

Overview/Objectives

- This Technical Memorandum looks at the viability of a surface water discharge of treated effluent in Hillsburgh in support of a “Two-Plant Solution” for Hillsburgh and Erin.
- Based on the results of this review, the Technical Memorandum recommends whether to further study the two-plant solution or whether to proceed with the preferred alternative solution identified in the Servicing and Settlement Master Plan (SSMP)
- The review looks at available water quality data and river flow data to determine the viability of a surface water discharge in Hillsburgh and compares the cost of a two-plant solution with the single plant solution proposed in the SSMP

SSMP Approach to Establishing the Preferred Discharge Location

- The SSMP collected water quality data on the river from Hillsburgh through to south of Erin and based on this, recommended a preferred discharge south of Erin for the entire service area
- The preferred discharge location identified in the SSMP was supported by MOECC and CVC
- Subsequent to the SSMP, the current Class EA (UCWS EA) has established effluent limits and flows capable of supporting full build out of the urban areas at this location

Ability of the West Credit River to Assimilate Wastewater Effluent

- Based on this review, there is insufficient water quality data and insufficient river flow data available to support an assimilative capacity study to be able to define effluent limits and obtain MOECC/CVC approval for a discharge of treated effluent within the Hillsburgh area.
- No additional water quality or flow data has been collected for the West Credit River through Hillsburgh since the SSMP.
- Establishing whether river water quality can support a treated effluent discharge within Hillsburgh would require collection of additional data over several years
- Establishing a 7Q20 river flow, needed to determine whether the river through Hillsburgh could accept a discharge from the community, cannot be completed based on available data and would take several years of flow measurement to confirm viability and as much as 10 years to support an approval from MOECC/CVC. As such, it is not known whether the river can support full build out population for Hillsburgh or even the existing population.
- Collection of all required flow and quality data and completion of an assimilative capacity study for a surface water discharge in Hillsburgh would cost in excess of $500,000

Cost of Two Treatment Plants Compared to One Treatment Plant

- This Technical Memorandum also addresses the economic viability of using a two plant solution versus a one plant solution. Implementation plans were developed for both alternatives and the capital and operating costs were developed for each alternative on the basis of full build out of the communities and for each of the existing communities separately. The following has been established from this review:

- There is an industry focus on reduction of operational and compliance costs

- The Net Present Value of 50 year capital, operation and maintenance costs of the single plant solution is 32% cheaper for the full build-out scenario and 27% cheaper for the existing community scenario.

- The following represents the costs to full build out:

Inflation Adjusted Costs	One Plant	Two Plants
Capital Cost	$60,669,310	$98,348,076
Operation and Maintenance Costs	$75,113,136	$100,118,368
Total	$135,782,445	$198,466,444
Present Value Cost	**$70,497,472**	**$104,250,255**

- The following represents the costs to service just the existing community:

Inflation Adjusted Costs	One Plant	Two Plants
Capital Cost	$ 30,904,188	$42,910,949
Operation and Maintenance Costs	$31,707,382	$41,826,759
Total	$62,611,569	$84,737,708
Present Value Cost	**$36,810,320**	**$50,655,454**

- Even when the cost to convey the wastewater between Hillsburgh and the proposed WWTP site, is taken into account, the capital and operating costs of the two plant solution remains significantly more expensive than the single plant alternative.

- Subject to development of a cost sharing plan with developers, the full build out cost allocation to the existing community could substantially reduce the per capita cost to existing residents.

Conclusion and Recommendation

Based on the results of this review, it is recommended that the preferred alternative solution identified in the SSMP with a single treatment plant discharging to the West Credit River south of Erin Village, remain the preferred alternative.

Table of Contents

List of Tables

List of Abbreviations

ACS	-	Assimilative Capacity Study
CVC	-	Credit Valley Conservation
ECA	-	Environmental Compliance Approval
ECR	-	Existing Conditions Report
GTA	-	Greater Toronto Area
MOECC	-	Ministry of Environment and Climate Change
NPV	-	Net Present Value
PLC	-	Programmable Logic Controllers
PWQO	-	Provincial Water Quality Objectives
SCADA	-	Supervisory Control and Data Acquisition
SSMP	-	Servicing and Settlement Master Plan
UCWS EA	-	Urban Centre Wastewater Servicing Class EA
WSC	-	Water Survey of Canada
WWTP	-	Wastewater Treatment Plant

1.0 Introduction and Background

To date, the Erin Urban Centre Wastewater Servicing Class EA (UCWS EA) has proceeded with developing and evaluating alternative solutions for wastewater servicing of the urban areas of Erin Village and Hillsburgh based on a single treatment plant solution servicing both communities in keeping with the recommendations of the Servicing and Settlement Master Plan (SSMP) completed by BM. Ross in 2014 and the established terms of reference for the UCWS EA study. The preferred alternative solution established in the SSMP is to establish a municipal wastewater system for the study area; to collect all wastewater from the study area and to treat these flows and discharge treated effluent to the West Credit River. A review of available data on river water flows and quality established that the preferred discharge location for the treated effluent was between 10th Line and Winston Churchill Boulevard south of Erin Village. Having reviewed the discharge capabilities of the river throughout the study area based on available data and having established a preferred location for that discharge, a single treatment plant solution with a discharge at the preferred location, was identified as the preferred alternative solution.

An assimilative capacity study (ACS, BM Ross 2014) was completed for a discharge to the river within the preferred reach between 10th Line and Winston Churchill Boulevard and agreement was obtained for this solution from the Ministry of Environment and Climate Change (MOECC) and from Credit Valley Conservation (CVC). The terms of reference for the UCWS EA provided for a refinement of the ACS completed during the SSMP and this was completed during the initial phase of the UCWS EA and effluent criteria for the discharge are now accepted by MOECC and CVC. Although the ACS completed during the SSMP established effluent limits capable of treating wastewater flows from a population of 6,000 persons, the ACS completed during the UCWS EA, has established effluent limits capable of supporting a discharge from a population of 14,500 persons. This discharge would be capable of servicing all of the development lands identified in the present Town of Erin Official Plan.

In closing out Phase 2 activities, the UCWS EA has established servicing limits, system capacity and required effluent limits for the study area and the results are planned to be presented to the public in an upcoming Public Information Centre (PIC).

After the study team had developed the system capacity and effluent limits for a single surface water discharge, on March 2, 2017 Council requested the study team to address concerns expressed by members of the Public Liaison Committee that a solution based on decentralised treatment was being overlooked. To address this, the study team prepared a Technical Memorandum on the potential for Subsurface Disposal of treated effluent. This study was presented to Council on May 17, 2017 and concluded that the preferred solution established under the SSMP, was still valid. It is also noted that the Subsurface Disposal Technical Memorandum (Ainley May 2017) also looked at a two plant scenario for Hillsburgh and Erin (based on subsurface disposal) and concluded that it was more expensive than the single plant alternative.

At the May 2, 2017 Council Meeting, the following resolution was passed:

“Be it resolved that Council would like to determine why a two smaller sewage treatment plants option (one Hillsburgh and one Erin) has not been pursued; And that the Mayor direct our engineering consultants to put a short summary report on the potential feasibility of this option, requesting the MOECC (Ministry of Environment and Climate Change) and CVC (Credit Valley Conservation) to comment".

Based on this resolution, the intent of this Technical Memorandum is to review the alternative of a "two-plant solution" with separate surface water discharges and either, confirm selection of the preferred alternative solution established through the Servicing and Settlement Master Plan (SSMP) or to recommend further study of the two-plant approach with a surface water disposal alternative during Phase 3 of the UCWS EA."

1.1 Objectives of Technical Memorandum

The main objective of this technical memorandum is to review and establish the viability of collecting and treating wastewater in two separate systems for Hillsburgh and Erin Village with separate surface water discharges. As such, this technical memorandum:

- Provides an overview of the SSMP approach to identifying a discharge point for treated effluent to the West Credit River
- Summarises and re-presents the surface water quality and quantity information for the West Credit River through the study area gathered during the SSMP augmented with up to date available information on water quality and river flow.
- Outlines the activities required to conduct an Assimilative Capacity Study (ACS) for a discharge to the river in Hillsburgh.
- Identifies and compares conceptual level capital and operating costs for the single plant and two-plant solutions.

2.0 SSMP Approach to Establishing a Preferred Discharge Location

The SSMP provided a rationalisation for limiting surface water discharge to a location between 10th Line and Winston Churchill Boulevard in Erin Village. The surface water discharge limitation provided justification of the SSMP conclusions to establish a single wastewater treatment facility in Erin discharging to the West Credit River. The SSMP provides significant rationale for the single surface water discharge location and the decision was supported by the conclusions of the CVC "Environmental Component – Existing Conditions Report" which stated the following:

"The surface water quality in the upper portion of the study area [Hillsburgh] is fair in terms of impact to the health of aquatic biota. This lower ranking is the result of elevated levels of bacteria, total phosphorus, and nitrate-nitrogen. In addition, the West Credit River through Hillsburgh is a losing stream, thus reducing its assimilative capacity. In the mid-portions of the study area, the water quality ranking improves as downstream stations with significant groundwater discharge contribute to higher flows, which increase the streams ability to assimilate contaminant inputs. In the Villages of Hillsburgh and Erin, the influence of roads, septic systems and urban land use with higher population density is apparent because median concentration of total phosphorus, bacteria and nitrate are higher than in rural areas. Downstream of the Village of Erin, at 10th Line, the water quality improves once again as a result of significant groundwater discharge into the West Credit River. This indicates that

throughout this sub-watershed the quantity of groundwater discharges contribute significantly to improving the surface water quality."

The very clear conclusion of the SSMP was to establish a single plant with surface water discharge downstream of Erin Village and this was based on an evaluation of all available data on the river between Hillsburgh and Erin Village. In addition, work completed during this UCWS EA has established effluent limits for a surface water discharge between 10^{th} Line and Winston Churchill that can support a population up to 14,500 from a single tertiary wastewater treatment plant. This single surface water discharge is a valid solution for both urban areas.

3.0 Surface Water discharge in Hillsburgh

3.1 Summary of Available Surface Water Quality Data

Surface water quality data was collected and presented in the "Phase 1 – Environmental Component – Existing Conditions Report" (ECR) completed in 2011, authored by the CVC, Aquafor Beech, and Blackport Hydrogeology. The data was gathered between 2007 and 2008 and covered a range of water quality indicators for chemical, microbiological and physical condition of the water and sediment in the West Credit River. Water quality information was collected from a series of locations along the West Credit River as well as from some tributaries. A map of the sampling locations is provided, see Figure 1.

Overall, water quality within the study area was determined to be fair-good based on the rankings of each station under the Water Quality Index scoring system. The primary parameters affecting the score of each station were total phosphorus, nitrate nitrogen and elevated bacterial levels. For the upper portions of the study area through Hillsburgh, water quality was fair in terms of the impact to the health of aquatic biota. A general trend of improving water quality exists through the mid-potions of the study area as significant groundwater discharge adds higher flows, increasing the streams ability to assimilate contaminants. The influence of urban land use is apparent; measurements at the sampling locations surrounding both of the urban areas show increases in total phosphorus, nitrate and bacterial concentrations.

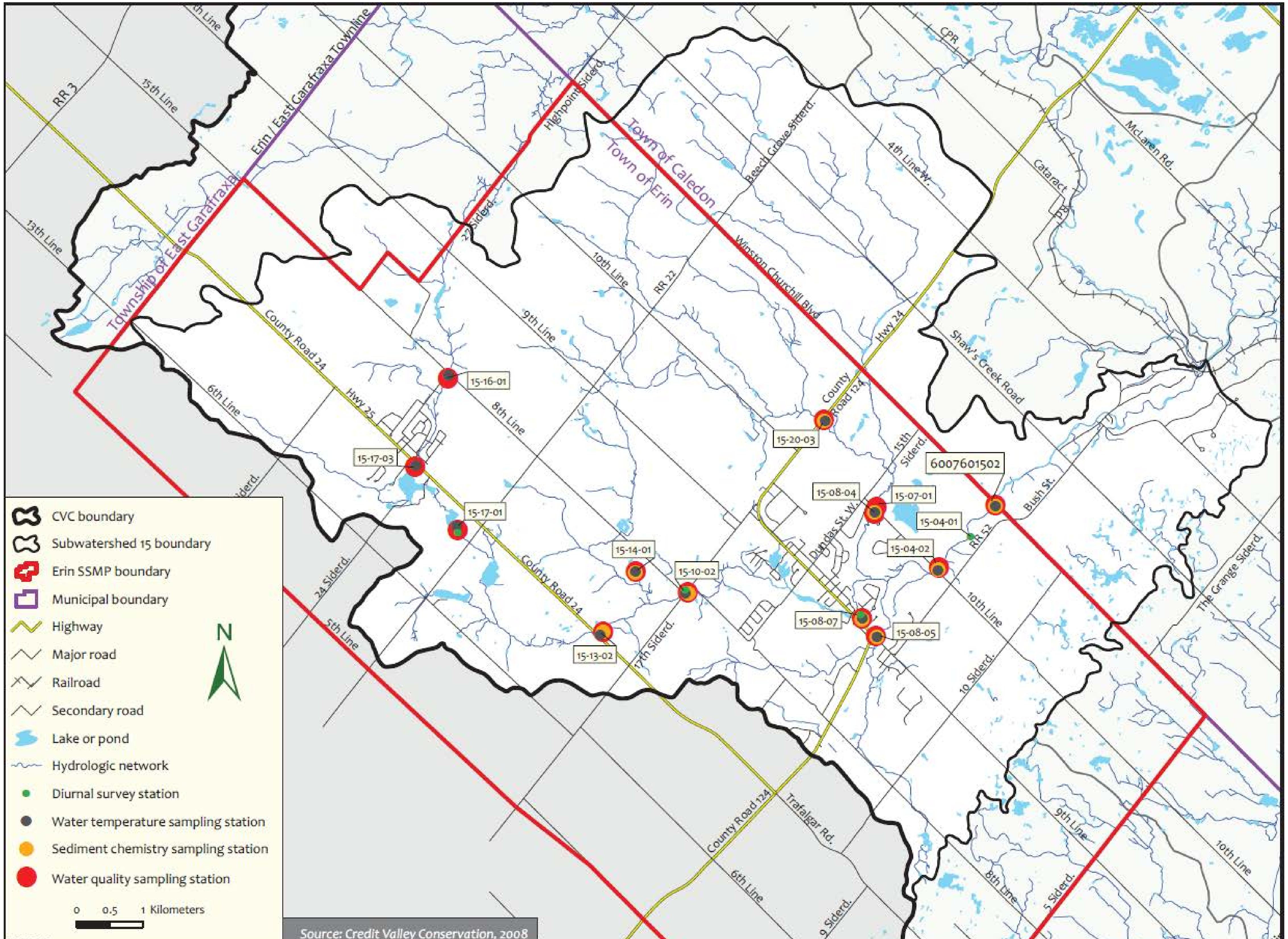

Figure 1 – Sampling Location Reference Map

The key parameters affecting the quality of treatment that will be required at the treatment facility and the volume of effluent that may be discharged to the receiver are, in this case, total phosphorus and nitrate-nitrogen. Discharge volumes are typically limited by available flow in the river (based on the 7Q20 flow statistic) and the capacity of the treatment facility to remove these nutrients from the wastewater before discharge to the river in order to keep the concentrations in the river below the provincial water quality objectives (PWQO). The PWQO limits are provided in Table 1.

Table 1 – PWQO Nutrient Limits of Concern

Nutrient Parameter	Limit (mg/L)
Total Phosphorus (MOECC 1994)	0.03
Nitrate-Nitrogen (CCME 2012)	3.0

A box-and-whisker plot of the total phosphorus data collected at each monitoring location is provided in Figure 2. For the purposes of comparison with the PWQO, the 75th percentile (upper quartile in Figure 3) value is used. Figure 3 is provided as a quick reference guide for understanding box-and-whisker plots.

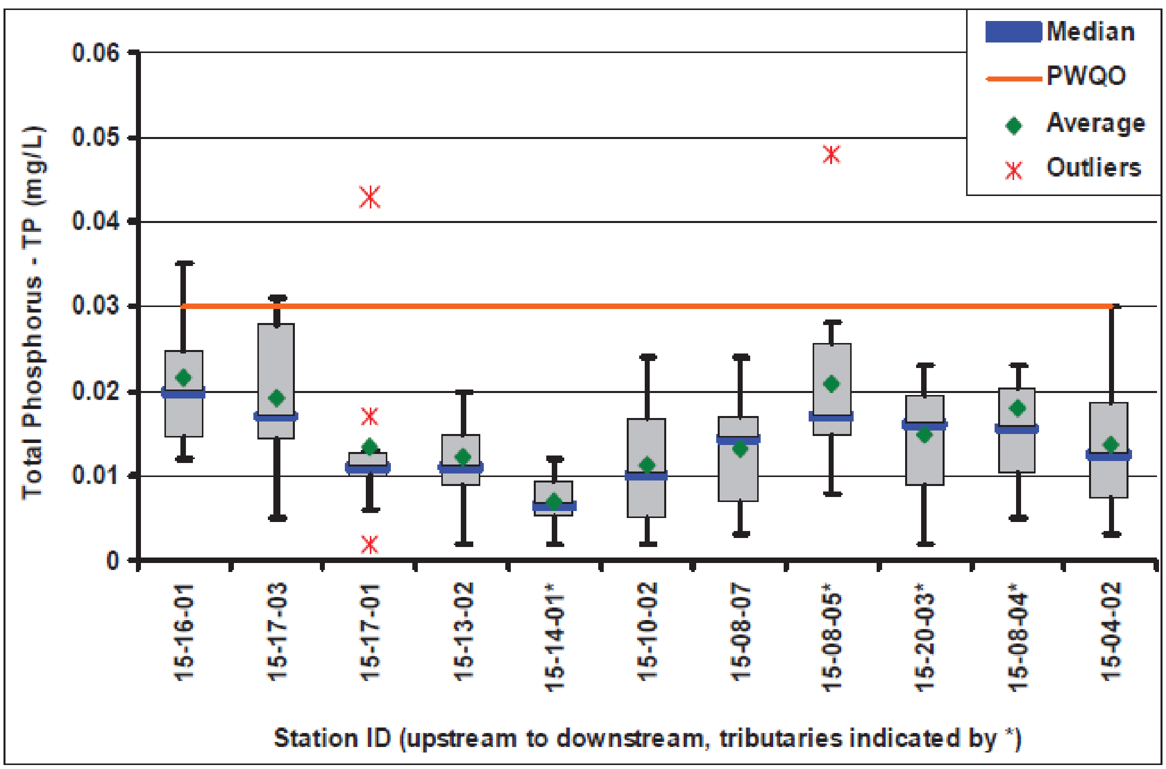

Figure 2 – Total Phosphorus Box-and-Whisker Plots (SSMP)

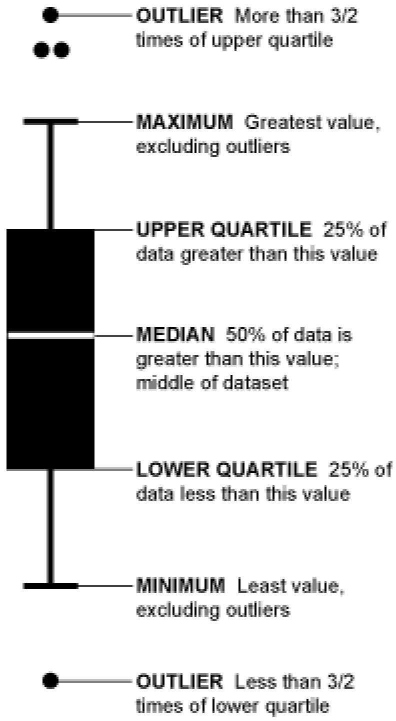

Figure 3 – Box-and-Whisker Plot Description

A box-and-whisker plot of the nitrate-nitrogen data collected at each monitoring location is provided in Figure 4.

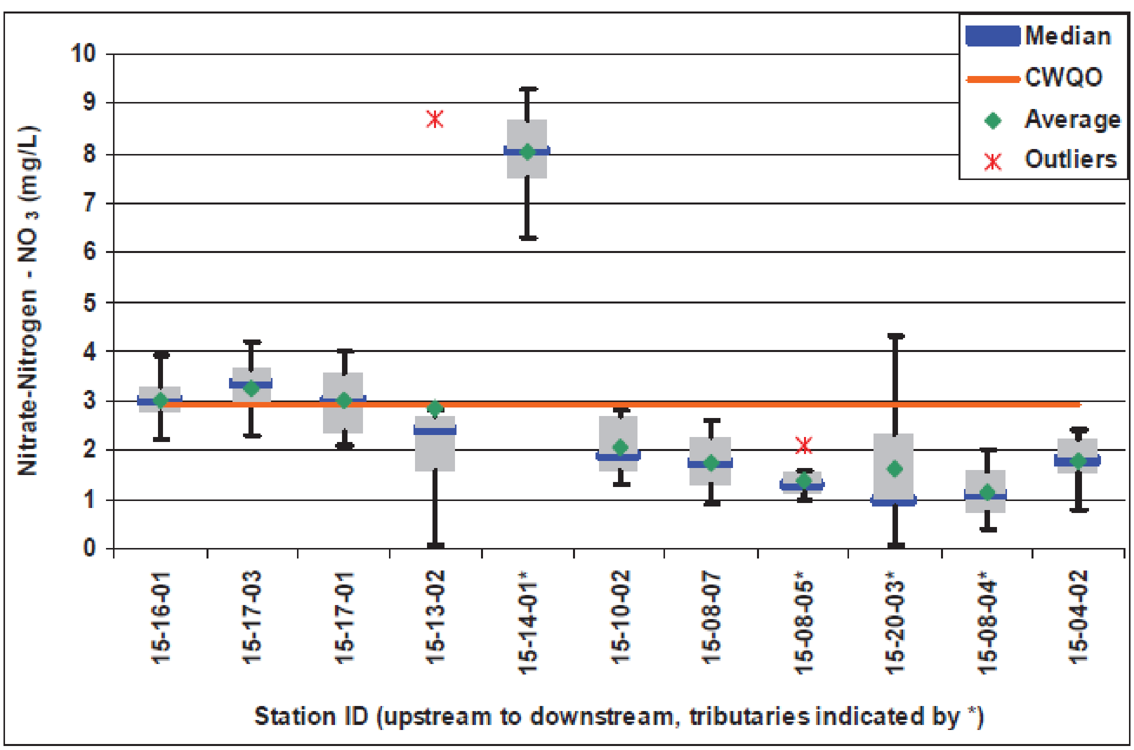

Figure 4 – Nitrate-Nitrogen Box-and-Whisker Plots (SSMP)

The station which is located closest to the planned discharge location in Erin Village is Station 15-04-02. This station is located at the intersection of the West Credit River and 10th Side Road and the following characteristics have been documented:

- 75th percentile total phosphorus concentration of 0.018 mg/L (ECR, 2007/08 data)
- Slight improvement of phosphorus levels over time, a 75th percentile phosphorus concentration of 0.016 mg/L (ACS Update, 2016 data)
- 75th percentile nitrate-nitrogen concentration of 2.3 mg/L (ECR, 2007/08 data)
- Slight improvement of nitrate-nitrogen levels over time, a 75th percentile nitrate-nitrogen concentration of 1.9 mg/L (ACS Update, 2016 data)
- 7Q20 flow rate of 225 L/s

Two monitoring locations exist at the south end of Hillsburgh. Based on the topography, the better discharge location would likely be between the two stations (15-17-03 and 15-17-01). The station closest to Hillsburgh is 15-17-03; this station has reduced water quality due to the proximity to the urban area, there is a general improvement of water quality downstream towards station 15-17-01. Based on the findings of the Existing Conditions Report (ECR):

- 75th percentile total phosphorus concentration of 0.028 mg/L at station 15-17-03.
- 75th percentile nitrate-nitrogen concentration of 3.6 mg/L at station 15-17-03.
- 75th percentile total phosphorus concentration of 0.013 mg/L at station 15-17-01.
- 75th percentile nitrate-nitrogen concentration of 3.5 mg/L at station 15-17-01.

While the total phosphorus concentrations measured show a significant improvement from station 15-17-03 to station 15-17-01, it should be noted that this is based on a limited dataset and there are significant outliers at the downstream station. Based on the tributary and impoundment network in the area it is not possible to reliably predict river water quality in the area. The nitrate-nitrogen concentrations remain relatively consistent from 15-17-03 to 15-17-01. The 75th percentile concentration of 3.5 mg/L exceeds the PWQO limits and would be a major limiting factor in obtaining approval for discharge at this location. The MOECC requires no further degradation of water quality in rivers and streams where water quality parameters have been exceeded.

There is insufficient site specific water quality data available to support an assimilative capacity study and to be able to define effluent limits and obtain MOECC approval for a discharge. Since completion of the SSMP, there is no additional water quality data available for the river through Hillsburgh. It is possible that the level of nitrates in the river would limit any approval for a discharge or require costly denitrification of the effluent to avoid any additional degradation of water quality.

3.2 River Flow Rate and 7Q20 Flow Data

A Water Survey of Canada (WSC) gauge located in the West Credit River at 8th Line provides a long-term (1983 - present) record of flow. Due to differences in geological conditions between the catchment area of this station and the WWTP study area (i.e., West Credit River between 10th Line and Winston Churchill Blvd.), flows from 8th Line could not be pro-rated for catchment size at 10th Line for the preliminary ACS (B.M.Ross 2014).

A flow gauging station was established at 10th Line in July 2013 by Credit Valley Conservation (CVC). Insufficient data had been collected from this station to determine a reliable 7Q20 low flow statistic; a minimum of 10 years of data is typically required. Flows measured at this gauge, however, were used by CVC to develop a flow transposition factor between the 8th Line and the 10th Line data. The preliminary ACS used 7Q20 flows for 10th Line as determined by CVC using a transposition factor based on stream flows collected from July to October 2013 at 10th Line. Additional flow data have been collected since the preliminary ACS to refine the transposition factor. In 2016, CVC recalculated the 7Q20 low flow statistic for 10th Line, using data from July 2013 to December 2015. The new 7Q20 flow statistic for 10th Line of 225 L/s includes a 10% reduction to account for potential effects of climate change.

Only minimal flow data is currently available for the span of river downstream of Hillsburgh. During the ECR a spot measurement of flow was taken in Hillsburgh at the same time as a measurement at 10^{th} Line in Erin village. Based on the spot measurement, flow through Hillsburgh is approximately 26% of the flow at 10^{th} Line, however, clearly there is insufficient data to be able to establish a 7Q20 flow that would be required to support approval for a discharge of treated wastewater effluent through Hillsburgh. It would take several years of flow data to support an assimilative capacity study for Hillsburgh and perhaps as much as 10 years before CVC and MOECC would be able to approve a discharge. CVC have indicated that they have no need or intent to establish a gauging station through Hillsburgh.

3.2.1 Conclusions on Discharge Potential to the West Credit River in Hillsburgh

There is insufficient water quality data and insufficient river flow data available to support an assimilative capacity study and to be able to define effluent limits and obtain MOECC/CVC approval for a discharge of treated effluent within the Hillsburgh area. It is possible that the level of nitrates in the river would limit any approval for a discharge.

No additional water quality or flow data has been collected for the West Credit River through Hillsburgh since the SSMP.

Establishing whether river water quality can support a treated effluent discharge within Hillsburgh would require collection of data over several years. Establishing a 7Q20 river flow that would be needed to determine whether the river could accept a discharge from the community, would take several years of flow measurement to even confirm viability and as much as 10 years to support an approval from MOECC/CVC. As such, it is not known whether the river can support full build out population for the community or even the existing population.

Since CVC have no plans to construct a gauging station to measure river flows in Hillsburgh, the cost of this station and the annual monitoring and analysis of all the flow and quality data over several years would become a cost to the ECWS Class EA. Once sufficient data had been collected, an assimilative capacity study could be undertaken. It is likely that the total cost of all data collection and the ACS will be in excess of $500,000.

4.0 Overview of Wastewater Collection and Treatment Planning

The planned wastewater system for the urban areas of Erin and Hillsburgh represents a small system and the overall area serviced will still be significantly smaller than the systems of many medium and large urban areas. The water and wastewater industry in Ontario is highly regulated to protect the health of its citizens and to protect the environment. In particular, effluent discharge limits are becoming stricter and the operational requirements for testing, monitoring and reporting to ensure compliance with MOECC Environmental Compliance Approvals (ECA) represent a significant operational cost for wastewater treatment plants. In many jurisdictions municipalities are looking to reduce the number of treatment plants in order to reduce operations cost. Decisions by municipalities over the last 20 years reflect the trend towards a lower number of larger treatment facilities in order to lower operational cost. The following are offered as a few examples:

- District of Muskoka is presently intending to eliminate one of its two Wastewater Treatment Plants in Huntsville, primarily to reduce operations cost.
- Clearview Township (Stayner) decided to pump its wastewater to Wasaga Beach rather than expand/upgrade its lagoon
- The Town of Tecumseth decided to pump its wastewater to Windsor rather than expand/upgrade their own plant
- York Region eliminated septic systems in King City and connected the wastewater system to the large York-Durham system rather than construct a smaller local treatment plant in King City
- The Town of Georgina decided to collect wastewater from all of the shoreline communities between Sutton and Keswick and pump all wastewater to the Keswick WWTP south of Keswick rather than build a more central treatment facility

Due to compliance issues and operational costs, the tendency is clearly towards elimination of smaller plants and to constructing larger systems which are less costly on a per capita basis.

5.0 Implementation Plan for Treatment Plant Alternatives

In order to compare the two-plant alternative with the single plant alternative, an implementation plan for each alternative was developed through to full build out of the growth areas identified in the system capacity technical memorandum. Cost scenarios for full build out and for each of the existing communities alone have been developed based on these implementation plans.

The final implementation plan will depend on many factors including:

- Revision and approval of the Town Official Plan to define growth;
- Limits for the urban areas; and
- Funding for the portion required to service the existing population.

The implementation plan used in this technical memorandum is purely for comparative analysis to illustrate cost differences between plant scenarios. Implementation phasing was developed with consideration of the following:

- The need to service the existing community in the first phase;
- The need to provide for a level of growth in the first phase; and
- Making best use of the scale effect where in larger capacity plants cost less on a per capita basis thus offsetting some cost for the existing communities.

For the purpose of evaluation, a two-phase approach was selected with allocation to growth in Phase 1 representing 33% of the overall treatment capacity. In addition to identifying full build out phasing, the analysis identifies the cost of a plant to service the existing community. The costing excludes the cost of treatment for septic wastes from rural communities in the town. It is assumed that this waste would be processed at only one plant.

It is noted that the implementation plan is significantly different from the scenario identified in the SSMP wherein the system was primarily aimed at servicing the existing community with a small growth allocation (up to a population of 6000). Based on work completed to date within this study, it is possible to service population greater than 14,500. In order to provide a meaningful comparison with the single plant solution developed as part of the UCWS EA, the implementation plans are for full build out to a service population of 14,500.

Within the discussion of alternatives it is assumed that all plants are designed to meet the effluent limits established under the assimilative capacity study undertaken as part of this project.

The alternatives considered are as follows:

- Alternative 1 – A single treatment facility for both communities with phased implementation
- Alternative 2 – Separate treatment facilities for each community with phased implementation

5.1 Alternative 1 – Single Plant Servicing Erin & Hillsburgh

Under Alternative 1, implementation is based on a two phase approach with a single plant designed for the population and flow capacities presented in Table 2.

Table 2 – Populations and Flows for Erin and Hillsburgh

Erin & Hillsburgh	Population	Capacity (m^3/d)
Existing Population	4,616	2,844
Growth	9,943	4,329
Total	14,559	7,173

The phasing plan is presented in Table 3. The table presents the plant size required to service the existing community in addition to a two-phase plant implementation plan with the capacity associated with each implementation phase.

Table 3 – Single Treatment Plant Phasing

Phase	Capacity (m^3/d)	Allocation to Existing	Allocation to Growth	Year Built
Existing Only	2,844	100%	Zero	2020-2022
Phase 1	4,300	66%	34%	2020-2022
Phase 2	2,873	Zero	100%	2028-2030

5.2 Alternative 2 – Two Plants Servicing Erin & Hillsburgh

Under Alternative 2, implementation is based on a two phase approach with separate treatment plants for Erin and Hillsburgh. Under this scenario, the population and flow capacities for Erin are presented in Table 4.

Table 4 – Populations and Flows for Erin

Erin	Population	Capacity (m^3/d)
Existing Population	3,225	2,244
Growth	5,340	2,523
Total	8,565	4,767

The phasing strategy is presented in Table 5. The table presents the plant size required to service the existing community in addition to a two-phase plant implementation plan with the capacity associated with each implementation phase.

Table 5 – Independent Treatment for Erin, Plant Phasing

Phase	Capacity (m^3/d)	Allocation to Existing	Allocation to Growth	Year Built
Existing Only	3,244	100%	Zero	2020-2022
Phase 1	3,400	66%	34%	2020-2022
Phase 2	1,367	Zero	100%	2028-2030

The population and flow capacities for Hillsburgh are presented in Table 6.

Table 6 - Populations and Flows for Hillsburgh

Hillsburgh	Population	Capacity (m^3/d)
Existing Population	1,391	599
Growth	4,603	1,806
Total	5,994	2,405

The phasing strategy is presented in Table 7. The table presents the plant size required to service the existing community in addition to a two-phase plant implementation plan with the capacity associated with each implementation phase.

Table 7 - Independent Treatment for Hillsburgh, Plant Phasing

Phase	Capacity (m^3/d)	Allocation to Existing	Allocation to Growth	Year Built
Existing Only	599	100%	Zero	2020-2022
Phase 1	900	66%	34%	2020-2022
Phase 2	1,505	Zero	100%	2028-2030

6.0 Cost Implications for a two Treatment Plant Solution

6.1 Capital Costs

The capital cost of the process components at each facility proposed was developed based on the cost estimation curve presented in Figure 5. Costing curves were originally developed for individual wastewater treatment processes as part of a Ministry of Infrastructure study (Water and Wastewater Asset Cost Study, Ministry of Public Infrastructure Renewal R J Burnside and Associates). The combined curve presented in Figure 5 was developed for full tertiary treatment process components and was supplemented with additional construction cost information for facilities constructed in Ontario over the past 10 years. Additional costs for individual facilities were included in the NPV calculation for land purchase, site works and operations buildings.

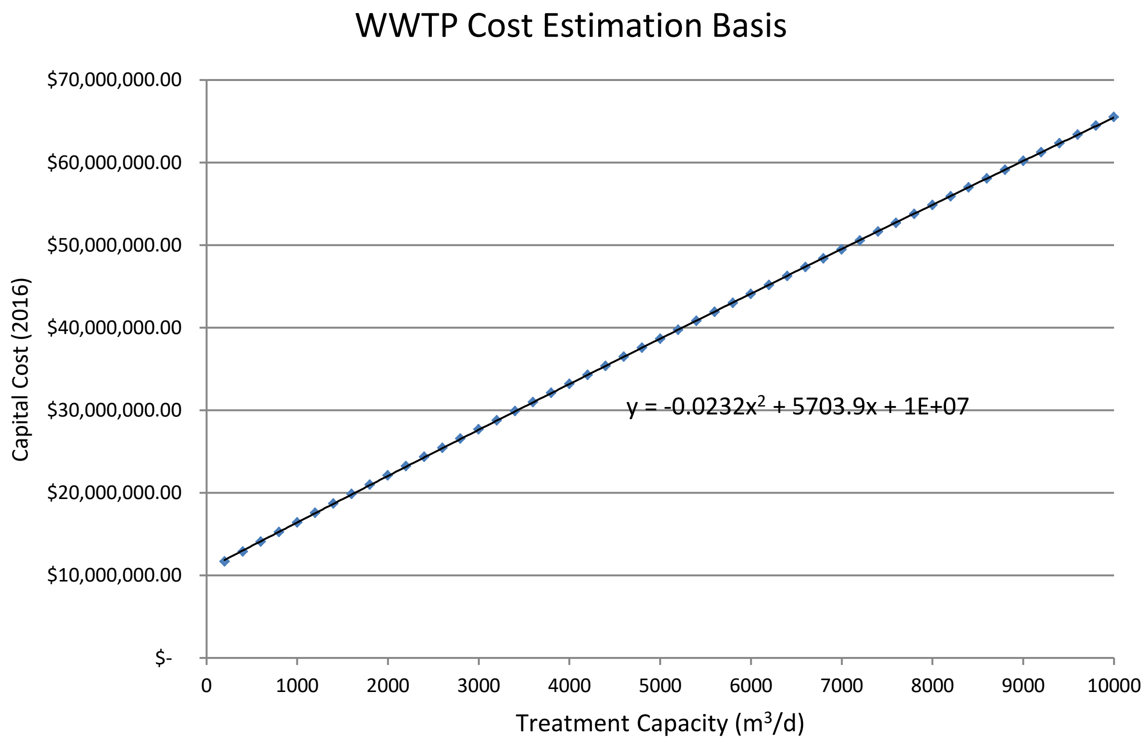

Figure 5 – Cost Basis for Process Aspects of Wastewater Treatment

6.2 Operation and Maintenance Costs

The cost of operating Municipal Wastewater Treatment Plants varies widely depending on the type of treatment, size and number of facilities operated by the particular municipality. Small communities with facultative lagoon type treatment represent low cost treatment and this approach has been used for many small communities throughout Ontario. However, as regulations change and these communities experience the need for growth, these lower cost systems are being replaced by more complex treatment plants needed to meet stricter discharge criteria. For example the Village of Havelock recently replaced their lagoon at a cost of $8.7 million resulting in a substantial increase in treatment cost.

Generally, the larger GTA Municipalities and Cities, such as City of Hamilton, City of Waterloo, City of Ottawa etc. have the lowest operating cost per cubic metre processed. Other larger municipalities with multiple facilities such as District of Muskoka, Township of Springwater and Kawartha Lakes for example, have operating costs of 1.7 to 1.8 times larger than Region/City plants. Smaller communities with advanced treatment plants have even higher operating costs.

In preparing this technical memorandum, we have reviewed the operations budgets of a number of municipalities. Based on this and discussion with operating authorities, we have compared operating cost components for both a single treatment plant and two treatment plants. Costs are expressed in terms of $/m^3 of installed plant capacity per day.

6.2.1 Personnel Costs

A comparison was conducted between the Phase 1 Single Plant and Phase 1 Two Plants. Discussions were held with operating authorities regarding personnel costs. For the single plant, three staff will be required on a part time basis for a total of 2,100 hours, while two plants would require around 3,700 hours of operation and maintenance per year. Typically more time is required for operation of the collection system than the treatment system and staff can be integrated to some degree, however, it is likely that two treatment plants would require a higher number of staff overall. Based on our assessment of the hours required to operate these plant alternatives, we anticipate that the personnel cost would be 70% more for two plants, versus one plant.

Translating this to the operating cost of similar plants gives a cost of $0.12/m^3 of installed capacity per day for a single plant versus $0.20/m^3 for two plants.

6.2.2 Power / Chemicals / Consumables

Two Plants would require duplication of building space for administration functions and larger overall building space for electrical, mechanical equipment and maintenance facilities. Power costs associated with lighting and heating for the larger space will be increased for two plants. Two plants will also require a higher number of process trains requiring a larger number of pumps, process equipment and control equipment and this will increase the overall power consumption. Chemicals used in wastewater are typically used in proportion to flow and so total chemical use for two plants should be similar to the one plant solution. Other consumables such as water, cleaning materials and transportation etc. will be significantly higher for the two plant scenario. Overall, our analysis indicates that two plants would cost some 20% more for power, chemicals and consumables.

Translating this to the operation cost of similar plants gives a cost of $0.25/m^3 of installed capacity per day for a single plant versus $0.30/m^3 of installed capacity for two plants.

Compliance with the MOECC ECA requires on-going monitoring of flows and water quality collected through instrumentation and automatic sampling devices. All of this work would be doubled for two plants versus one plant. Annual reporting and plant administration would also be doubled for two plants versus one plant.

6.2.3 Plant Maintenance

Although each of the two plants will have a smaller capacity than the larger single plant and therefore smaller pumps, motors and process equipment, the actual number of pieces of equipment will be double in the two plant scenario. Again, while parts for smaller equipment will cost less, it is likely that equipment maintenance costs will still be higher for the two plant alternative.
Modern wastewater treatment plants use advanced automation systems to control many plant functions. The entire automation (SCADA) and instrumentation system would be doubled for two plants versus one plant and maintenance costs associated with instruments, controllers (PLC), computers, and control software will be double with the two plant scenario. Likewise, a great deal of the electrical systems including the motor control centres would be doubled in two plants, versus one plant again leading to increased maintenance. Overall, it is considered that maintenance costs will be 20% more for the two plant scenarios.

Translating this to the operation cost of similar plants gives a cost of \$0.10/m^3 of installed capacity per day for a single plant versus \$0.12/m^2 for two plants.

6.2.4 Operations Cost Summary

Based on the above analysis, the daily Operations and Maintenance Costs are summarized in the Table 8.

Table 8 – Cost of Operations for Wastewater Treatment

Category	\$ / m^3 of Installed Capacity per day Single Plant	Two Plants
Personnel	\$ 0.12	\$ 0.20
Power / Chemicals / Consumables	\$ 0.25	\$ 0.30
Maintenance Materials	\$ 0.10	\$ 0.20
Total	\$ 0.47	\$ 0.62

It is therefore anticipated that two plants will be some 32% more expensive to operate and maintain as compared to a single plant.

6.3 Net Present Value (NPV) Assessment

Four NPV calculations were completed evaluating the Alternatives discussed in Section 4.0. The scenarios evaluated include:

- A single treatment plant with phased implementation to service the full build-out population
- Separate treatment plants for Erin and Hillsburgh to service the full build-out population
- A single treatment plant to service the existing population
- Separate treatment plants for Erin and Hillsburgh to service the existing population

The net present value calculations assumed a 1% yearly inflation rate and a 4% interest rate. A reduction in the spread between inflation and interest rate will increase the NPV difference. All of the costs presented are calculated to 2016 as the base year. The results of the NPV calculations are summarised in Table 9 and Table 10. The calculation sheets for each scenario are provided in ***Appendix A.***

Table 9 – Full Buildout Servicing, Cost Comparison of Alternatives

Inflation Adjusted Costs	One Plant	Two Plants
Capital Cost	$60,669,310	$98,348,076
Operation and Maintenance Costs	$75,113,136	$100,118,368
Total	$135,782,445	$198,466,444
Present Value Cost	**$70,497,472**	**$104,250,255**

Table 10 – Existing Community Servicing, Cost Comparison of Alternatives

Inflation Adjusted Costs	One Plant	Two Plants
Capital Cost	$ 30,904,188	$42,910,949
Operation and Maintenance Costs	$31,707,382	$41,826,759
Total	$62,611,569	$84,737,708
Present Value Cost	**$36,810,320**	**$50,655,454**

Based on the NPV calculations providing servicing utilising a single plant is a better solution from a capital and operational cost basis. Over the 50-year life calculated the single plant solution is 32% cheaper for the full build-out scenario and 27% cheaper for the existing community scenario.

It should further be noted that whereas the existing residents would pay the full $ 30.9 million for a single plant with no growth, they would be liable to pay approximately one third of the $ 60.7 million cost of the full build out plant to a population of 14,500 or $ 20.2 million, provided an implementation plan can be devised that equally apportions costs. Likewise the operational burden on the existing residents would also be reduced for a full build out population of 14,500.

The calculations for NPV did not take into account the cost of constructing a forcemain between Hillsburgh and Erin or the required oversizing of gravity sewers through Erin to accommodate pumped waste from Hillsburgh. The associated costs for the additional collection system requirements to support the single plant solution have been estimated to be as follows:

- Forcemain/sewer from Hillsburgh to Erin (Elora Cataract Trail – 4.7 km) - $3.75 million
- Increase in trunk sewer diameter through Erin (approx. 1.4 km) – $200,000
- Increased forcemain diameter to plant (approx. 2.25 km) - $250,000
- Increased SPS capacity at 2 sites - $1.00 million

Considering that the additional collection system costs of over $5.0 million to convey wastes to a single treatment plant does not offset the additional capital cost of constructing two plants and considering that the operational costs associated with two treatment plants is higher, the single plant solution remains superior in terms of economic feasibility.

7.0 Conclusions and Recommendations

The approach taken in the SSMP was to evaluate water flows and water quality based on available data and additional water quality data collected for the river from Hillsburgh through to south of Erin in an effort to identify the best possible use of the West Credit River as a discharge for treated effluent. Based on this evaluation a recommended preferred discharge location was identified south of Erin Village for the entire service area.

Additional work within this UCWS EA study has confirmed that the preferred discharge location and effluent limits and flows are capable of supporting full build out of the urban areas and this has been accepted by MOECC and CVC as a valid solution.

Based on this review, it is apparent that there is insufficient water quality data and insufficient river flow data available to support an assimilative capacity study to be able to define effluent limits and obtain MOECC/CVC approval for a discharge of treated effluent within the Hillsburgh area.

No additional water quality or flow data has been collected for the West Credit River through Hillsburgh since completion of the SSMP.

In order to establish whether river water quality could support a treated effluent discharge within Hillsburgh it would require collection of data over several years.

In order to establish a 7Q20 river flow to determine whether the river could accept a discharge from the community, it would take several years of flow measurement to even confirm viability and as much as 10 years to support an approval from MOECC/CVC.

As such, it is not known whether the river can support a discharge from the existing population or even the full build out population for the community. Completing an assimilative capacity study for a surface water discharge in Hillsburgh could cost in excess of $500,000 and could take up to 10 years to complete.

This Technical Memorandum also addresses the economic viability of using a two plant solution versus a one plant solution. Implementation plans were developed for both alternatives and the capital and operating costs were developed for each alternative on the basis of full build out of the communities and for the existing communities alone. The following has been established from this review:

- The industry trend is towards less and larger treatment plants in order to reduce operational and compliance costs
- The Net Present Value of 50 year capital, operation and maintenance costs of the single plant solution is 32% cheaper for the full build-out scenario and 27% cheaper for the existing community scenario.
- The following represents the costs to full build out:

Inflation Adjusted Costs	One Plant	Two Plants
Capital Cost	$60,669,310	$98,348,076
Operation and Maintenance Costs	$75,113,136	$100,118,368
Total	$135,782,445	$198,466,444
Present Value Cost	**$70,497,472**	**$104,250,255**

- The following represents the costs to service just the existing community:

Inflation Adjusted Costs	One Plant	Two Plants
Capital Cost	$ 30,904,188	$42,910,949
Operation and Maintenance Costs	$31,707,382	$41,826,759
Total	$62,611,569	$84,737,708
Present Value Cost	**$36,810,320**	**$50,655,454**

- Even when the cost to convey the wastewater between Hillsburgh and the proposed WWTP site, is taken into account, the capital and operating costs of the two plant solution remains significantly more expensive than the single plant alternative.

- Subject to development of a cost sharing plan with developers, the full build out cost allocation to the existing community could substantially reduce the per capita cost to existing residents.

Based on the results of this review it is recommended that the preferred alternative solution identified in the SSMP with a single treatment plant discharging to the West Credit River south of Erin village, remain the preferred alternative.

Appendix - A

Net Present Value Calculations

Erin Urban Centre Wastewater Servicing Class EA
Single Plant - Full Build Out

Discount Rate: **4%**
Inflation Rate **1%**

Asset Description	Phase 1 - Annual Value in Constant Year 2016 Dollars	Phase 2 - Annual Value in Constant Year 2016 Dollars	NPV Total	2019	2020	2021	2022	2023	2028	2029	2030	2031	2068	2069
1) Capital Cost														
Treatment Process Components				$ 1,000,000	$ 15,000,000	$ 15,000,000	$ 6,600,000		$ 1,000,000	$ 11,000,000	$ 1,000,000			
Operations Building / Site Works					$ 4,500,000									
Land Cost				$ 150,000										
Engineering				$ 30,000	$ 450,000	$ 450,000	$ 198,000		$ 30,000	$ 330,000	$ 30,000			
Current Year Sub-total				$ 1,180,000	$ 19,950,000	$ 15,450,000	$ 6,798,000	$ -	$ 1,030,000	$ 11,330,000	$ 1,030,000	$ -	$ -	$ -
Inflation Adjusted				$ 1,215,755	$ 20,760,050	$ 16,238,105	$ 7,216,214	$ -	$ 1,160,630	$ 12,894,597	$ 1,183,958	$ -	$ -	$ -
NPV			$ 47,028,990	$ 1,080,802	$ 17,745,778	$ 13,346,539	$ 5,703,079	$ -	$ 724,926	$ 7,744,161	$ 683,706	$ -	$ -	$ -
2) O&M Costs														
Personnel	$ 188,340	$ 315,360						$ 188,340	$ 188,340	$ 188,340	$ 315,360	$ 315,360	$ 315,360	$ 315,360
Power/ Chemicals / Consumables	$ 392,375	$ 657,000						$ 392,375	$ 392,375	$ 392,375	$ 657,000	$ 657,000	$ 657,000	$ 657,000
Equipment Maintenance	$ 156,950	$ 262,800						$ 156,950	$ 156,950	$ 156,950	$ 262,800	$ 262,800	$ 262,800	$ 262,800
Current Year Sub-total								$ 737,665	$ 737,665	$ 737,665	$ 1,235,160	$ 1,235,160	$ 1,235,160	$ 1,235,160
Inflation Adjusted								$ 790,877	$ 831,219	$ 839,532	$ 1,419,785	$ 1,433,982	$ 2,072,214	$ 2,092,936
NPV			$ 23,468,482					$ 601,001	$ 519,177	$ 504,201	$ 819,890	$ 796,240	$ 269,588	$ 261,812
Total Costs (Infrastructure and O&M Costs)			$ 105,162,255	$ 1,180,000	$ 19,950,000	$ 15,450,000	$ 6,798,000	$ 737,665	$ 1,767,665	$ 12,067,665	$ 2,265,160	$ 1,235,160	$ 1,235,160	$ 1,235,160
Inflation Adjusted			$ 125,522,943	$ 1,215,755	$ 20,760,050	$ 16,238,105	$ 7,216,214	$ 790,877	$ 1,991,849	$ 13,734,128	$ 2,603,743	$ 1,433,982	$ 2,072,214	$ 2,092,936
PV Costs (Infrastructure and O&M Costs)			**$ 70,497,472**	$ 1,080,802	$ 17,745,778	$ 13,346,539	$ 5,703,079	$ 601,001	$ 1,244,103	$ 8,248,362	$ 1,503,597	$ 796,240	$ 269,588	$ 261,812

Erin Urban Centre Wastewater Servicing Class EA

Single Plant - Existing Community

Discount Rate:	**4%**
Inflation Rate	**1%**

Asset Description	**Phase 1 - Annual Value** in Constant Year 2016 Dollars	**NPV Total**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2048**	**2049**	**2066**	**2067**	**2068**	**2069**
1) Capital Cost															
Treatment Process Components			$ 1,000,000	$ 15,900,000	$ 10,000,000										
Operations Building / Site Works				$ 1,750,000											
Land Cost			$ 150,000												
Engineering			$ 30,000	$ 477,000	$ 300,000	$ -									
Current Year Sub-total			$ 1,180,000	$ 18,127,000	$ 10,300,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Inflation Adjusted			$ 1,215,755	$ 18,863,029	$ 10,825,404	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NPV		$ 26,102,691	$ 1,080,802	$ 16,124,196	$ 8,897,693	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2) O&M Costs															
Personnel	$ 124,567					$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567
Power/ Chemicals / Consumables	$ 259,515					$ 259,515	$ 259,515	$ 259,515	$ 259,515	$ 259,515	$ 259,515	$ 259,515	$ 259,515	$ 259,515	$ 259,515
Equipment Maintenance	$ 103,806					$ 103,806	$ 103,806	$ 103,806	$ 103,806	$ 103,806	$ 103,806	$ 103,806	$ 103,806	$ 103,806	$ 103,806
Current Year Sub-total						$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888
Inflation Adjusted						$ 517,903	$ 523,082	$ 528,313	$ 533,596	$ 670,817	$ 677,526	$ 802,396	$ 810,420	$ 818,525	$ 826,710
NPV		$ 10,707,629				$ 409,306	$ 397,499	$ 386,033	$ 374,898	$ 191,222	$ 185,706	$ 112,907	$ 109,650	$ 106,487	$ 103,416
Total Costs (Infrastructure and O&M Costs)		$ 50,586,193	$ 1,180,000	$ 18,127,000	$ 10,300,000	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888	$ 487,888
Inflation Adjusted		$ 58,559,066	$ 1,215,755	$ 18,863,029	$ 10,825,404	$ 517,903	$ 523,082	$ 528,313	$ 533,596	$ 670,817	$ 677,526	$ 802,396	$ 810,420	$ 818,525	$ 826,710
PV Costs (Infrastructure and O&M Costs)		**$ 36,810,320**	$ 1,080,802	$ 16,124,196	$ 8,897,693	$ 409,306	$ 397,499	$ 386,033	$ 374,898	$ 191,222	$ 185,706	$ 112,907	$ 109,650	$ 106,487	$ 103,416

Erin Urban Centre Wastewater Servicing Class EA

Two Plants - Full Build Out

Discount Rate: 4%

Inflation Rate 1%

Asset Description	Phase 1 - Annual Value in Constant Year 2016 Dollars	Phase 2 - Annual Value in Constant Year 2016 Dollars	NPV Total	2019	2020	2021	2022	2028	2029	2030	2031	2068	2069
1) Capital Cost													
Treatment Process Components - Erin				$ 1,000,000	$ 20,000,000	$ 8,900,000		$ 1,000,000	$ 16,700,000	$ 1,000,000			
Treatment Process Components - Hillsburgh				$ 1,000,000	$ 13,850,000	$ 1,000,000		$ 1,000,000	$ 17,300,000	$ 1,000,000			
Operations Building / Site Works - Erin					$ 2,600,000								
Operations Building / Site Works - Hillsburgh					$ 1,480,000								
Land Cost - Erin				$ 150,000									
Land Cost - Hillsburgh				$ 150,000									
Engineering				$ 60,000	$ 1,137,900	$ 297,000	$ -	$ 60,000	$ 1,020,000	$ 60,000	$ -	$ -	$ -
Current Year Sub-total				$ 2,360,000	$ 39,067,900	$ 10,197,000	$ -	$ 2,060,000	$ 35,020,000	$ 2,060,000	$ -	$ -	$ -
Inflation Adjusted				$ 2,431,510	$ 40,654,213	$ 10,717,149	$ -	$ 2,321,260	$ 39,856,027	$ 2,367,917	$ -	$ -	$ -
NPV			$ 72,475,473	$ 2,161,604	$ 34,751,392	$ 8,808,716	$ -	$ 1,449,852	$ 23,936,497	$ 1,367,413	$ -	$ -	$ -
2) O&M Costs													
Personnel	$ 313,900	$ 525,600					$ 313,900	$ 313,900	$ 313,900	$ 525,600	$ 525,600	$ 525,600	$ 525,600
Power/ Chemicals / Consumables	$ 470,850	$ 788,400					$ 470,850	$ 470,850	$ 470,850	$ 788,400	$ 788,400	$ 788,400	$ 788,400
Equipment Maintenance	$ 188,340	$ 315,360					$ 188,340	$ 188,340	$ 188,340	$ 315,360	$ 315,360	$ 315,360	$ 315,360
Current Year Sub-total							$ 973,090	$ 973,090	$ 973,090	$ 1,629,360	$ 1,629,360	$ 1,629,360	$ 1,629,360
Inflation Adjusted							$ 1,032,955	$ 1,096,502	$ 1,107,467	$ 1,872,907	$ 1,891,636	$ 2,733,559	$ 2,760,895
NPV			$ 31,774,782				$ 816,359	$ 684,872	$ 665,116	$ 1,081,557	$ 1,050,359	$ 355,627	$ 345,369
Total Costs (Infrastructure and O&M Costs)			$ 155,577,220	$ 2,360,000	$ 39,067,900	$ 10,197,000	$ 973,090	$ 3,033,090	$ 35,993,090	$ 3,689,360	$ 1,629,360	$ 1,629,360	$ 1,629,360
Inflation Adjusted			$ 184,932,633	$ 2,431,510	$ 40,654,213	$ 10,717,149	$ 1,032,955	$ 3,417,762	$ 40,963,494	$ 4,240,824	$ 1,891,636	$ 2,733,559	$ 2,760,895
PV Costs (Infrastructure and O&M Costs)			**$ 104,250,255**	$ 2,161,604	$ 34,751,392	$ 8,808,716	$ 816,359	$ 2,134,724	$ 24,601,613	$ 2,448,970	$ 1,050,359	$ 355,627	$ 345,369

Erin Urban Centre Wastewater Servicing Class EA

Two Plants - Existing Community

Discount Rate: **4%**

Inflation Rate **1%**

Asset Description	Phase 1 - Annual Value in Constant Year 2016 Dollars	Phase 2 - Annual Value in Constant Year 2016 Dollars	NPV Total	2019	2020	2021	2022	2023	2026	2037	2041	2042	2043	2044	2068	2069
1) Capital Cost																
Treatment Process Components - Erin				$ 1,000,000	$ 17,000,000	$ 5,500,000										
Treatment Process Components - Hillsburgh				$ 1,000,000	$ 12,100,000	$ 1,000,000										
Operations Building / Site Works - Erin					$ 1,400,000											
Operations Building / Site Works - Hillsburgh					$ 750,000											
Land Cost - Erin				$ 150,000												
Land Cost - Hillsburgh				$ 100,000												
Engineering				$ 60,000	$ 937,500	$ 195,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Current Year Sub-total				$ 2,310,000	$ 32,187,500	$ 6,695,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Inflation Adjusted				$ 2,379,995	$ 33,494,442	$ 7,036,512	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NPV			$ 36,530,496	$ 2,115,807	$ 28,631,189	$ 5,783,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2) O&M Costs																
Personnel	$ 207,612	$ 525,600					$ 207,612	$ 207,612	$ 207,612	$ 207,612	$ 207,612	$ 207,612	$ 207,612	$ 207,612	$ 207,612	$ 207,612
Power/ Chemicals / Consumables	$ 311,418	$ 788,400					$ 311,418	$ 311,418	$ 311,418	$ 311,418	$ 311,418	$ 311,418	$ 311,418	$ 311,418	$ 311,418	$ 311,418
Equipment Maintenance	$ 124,567	$ 315,360					$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567	$ 124,567
Current Year Sub-total							$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597
Inflation Adjusted							$ 683,191	$ 690,023	$ 710,932	$ 793,164	$ 825,370	$ 833,623	$ 841,960	$ 850,379	$ 1,079,756	$ 1,090,553
NPV			$ 14,124,957				$ 539,936	$ 524,361	$ 480,280	$ 348,067	$ 309,610	$ 300,679	$ 292,006	$ 283,582	$ 140,473	$ 136,421
Total Costs (Infrastructure and O&M Costs)			$ 68,867,180	$ 2,310,000	$ 32,187,500	$ 6,695,000	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597	$ 643,597
Inflation Adjusted			$ 79,391,853	$ 2,379,995	$ 33,494,442	$ 7,036,512	$ 683,191	$ 690,023	$ 710,932	$ 793,164	$ 825,370	$ 833,623	$ 841,960	$ 850,379	$ 1,079,756	$ 1,090,553
PV Costs (Infrastructure and O&M Costs)			**$ 50,655,454**	$ 2,115,807	$ 28,631,189	$ 5,783,500	$ 539,936	$ 524,361	$ 480,280	$ 348,067	$ 309,610	$ 300,679	$ 292,006	$ 283,582	$ 140,473	$ 136,421

Appendix - F

Subsurface Disposal Alternative

Town of Erin
Urban Centre Wastewater Servicing
Class Environmental Assessment

Technical Memorandum
Subsurface Disposal Alternative
Final

May 2017

Urban Centre Wastewater Servicing Class Environmental Assessment

Technical Memorandum Subsurface Disposal Alternative

Project No. 115157

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