Appendix B

Assimilative Capacity Feasibility Study and Addendum

Appendix B - 1

Assimilative Capacity Feasibility Study

2018
February 23

Colgan WWTP Alternative Outfall

Assimilative Capacity Feasibility Study

Prepared for:

Township of Adjala-Tosorontio

Submitted by:

Greenland International Consulting Ltd.

Greenland Project No.: 17-G-3670

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1 Introduction

Following submission of the 2014 Draft ACS of Keenansville, Beeton and Bailey Creeks to Support the Colgan MSP and the 2015 Addendum to the report, community engagement prompted the Township to identify an alternative outfall location for further consideration. Greenland Consulting Engineers (Greenland) was retained by the Township of Adjala Tosorontio to review and analyze available data to assess the feasibility of a new outfall option using an assimilative capacity approach.

The new outfall option would discharge to Bailey Creek, within the Innisfil Creek Subwatershed, south of Barrie, Ontario, **Figure 1-1**. This subwatershed drains the southeast part of the Nottawasaga River, into Georgian Bay to the north at Wasaga Beach.

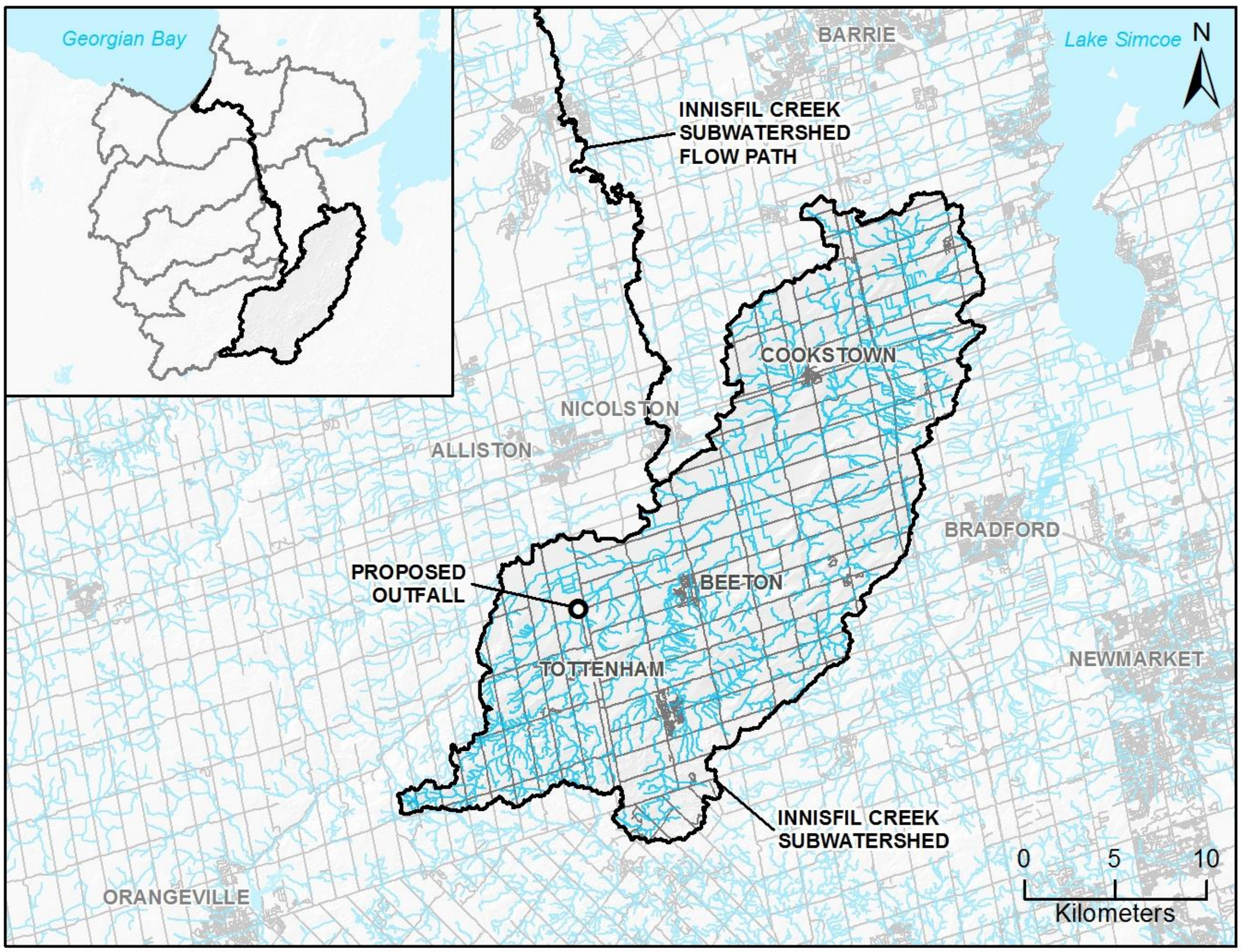


Figure 1-1 Study Region

1.1 Background and Prior Outfall Location Options Considered

Previous assimilative capacity studies for the proposed Colgan wastewater treatment plant considered potential outfall locations on Keenansville Creek at County Road 14 and on Bailey Creek at Keenansville Road. This study considers an alternative outfall to Bailey Creek near the north terminus of Concession Road 8 as shown in **Figure 1-2**.

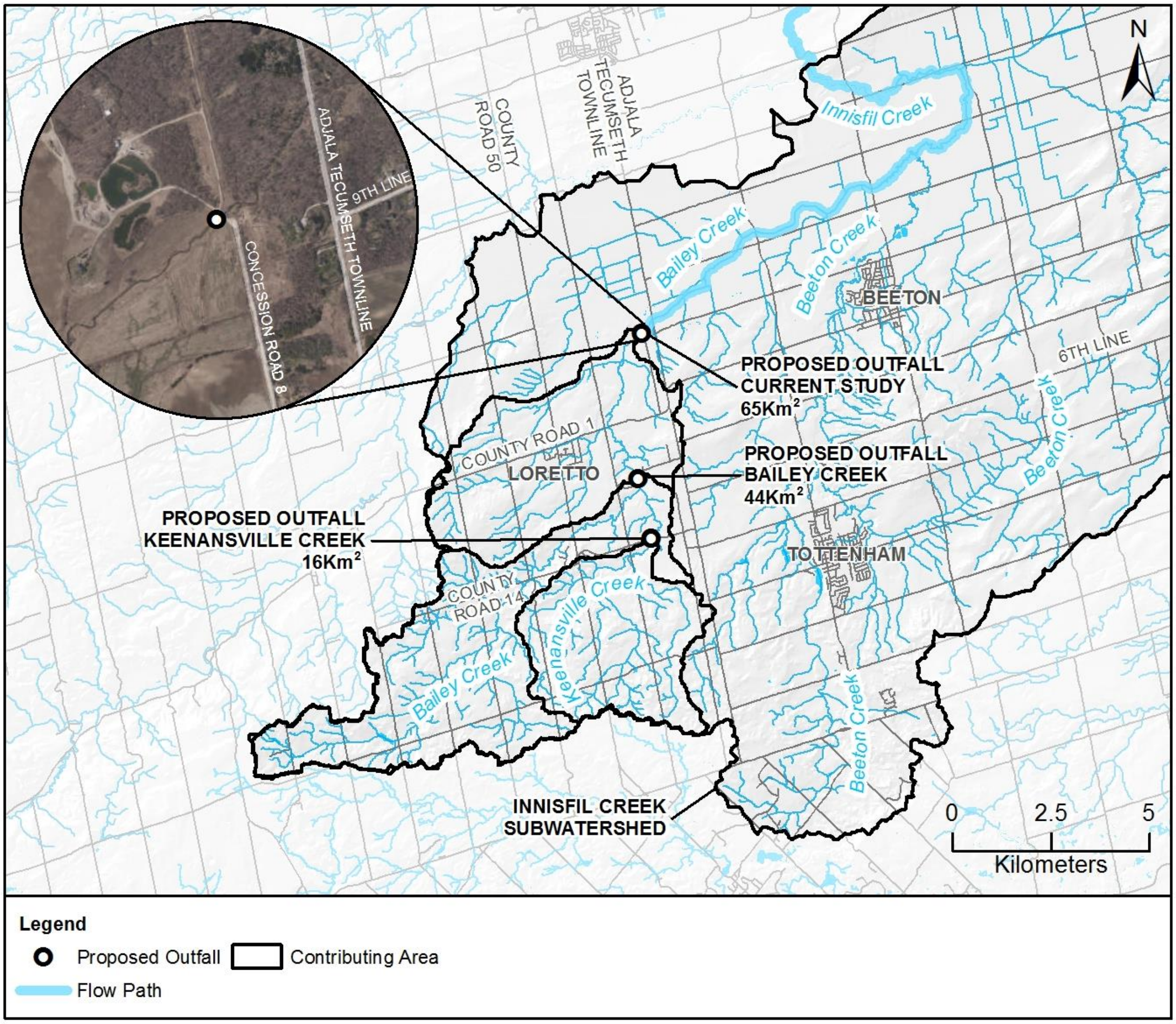


Figure 1-2 Study Area

1.2 Approach for Assessing Concession Road 8 Outfall Option

This analysis assesses ambient in-stream water quality and scaled statistical low flow conditions to evaluate point of discharge mixed concentrations assuming complete instantaneous mixing.

In-stream water quality is assessed using Provincial Water Quality Monitoring Network (PWQMN) data. Low flow conditions are estimated using Water Survey of Canada (WSC) flow monitoring data. Supplemental water quality samples and flow monitoring were obtained at a number of locations from previous studies.

2 Water Quality Characterization and Objectives

The latest Nottawasaga Valley Conservation Authority (NVCA) subwatershed health report card was published in 2013 (NVCA, 2013). It describes the Innisfil Creek subwatershed as the most degraded in the NVCA jurisdiction with a declining trend emphasizing the need for detailed study.

2.1 Assessment of Available Water Quality Monitoring Data

PWQMN data is available downstream of the alternative outfall at stations 03005703102 and 03005703202, **Figure 2-1**. Downstream records have a combined timeframe spanning 1998 to 2014. A limited number of upstream (Bailey Creek & Keenansville Creek) water quality samples were obtained from previous studies in 2009, 2010 and 2014 sampled by Stantec and Greenland, **Figure 2-1**. Water quality plots and tables are presented in **Appendix A**.

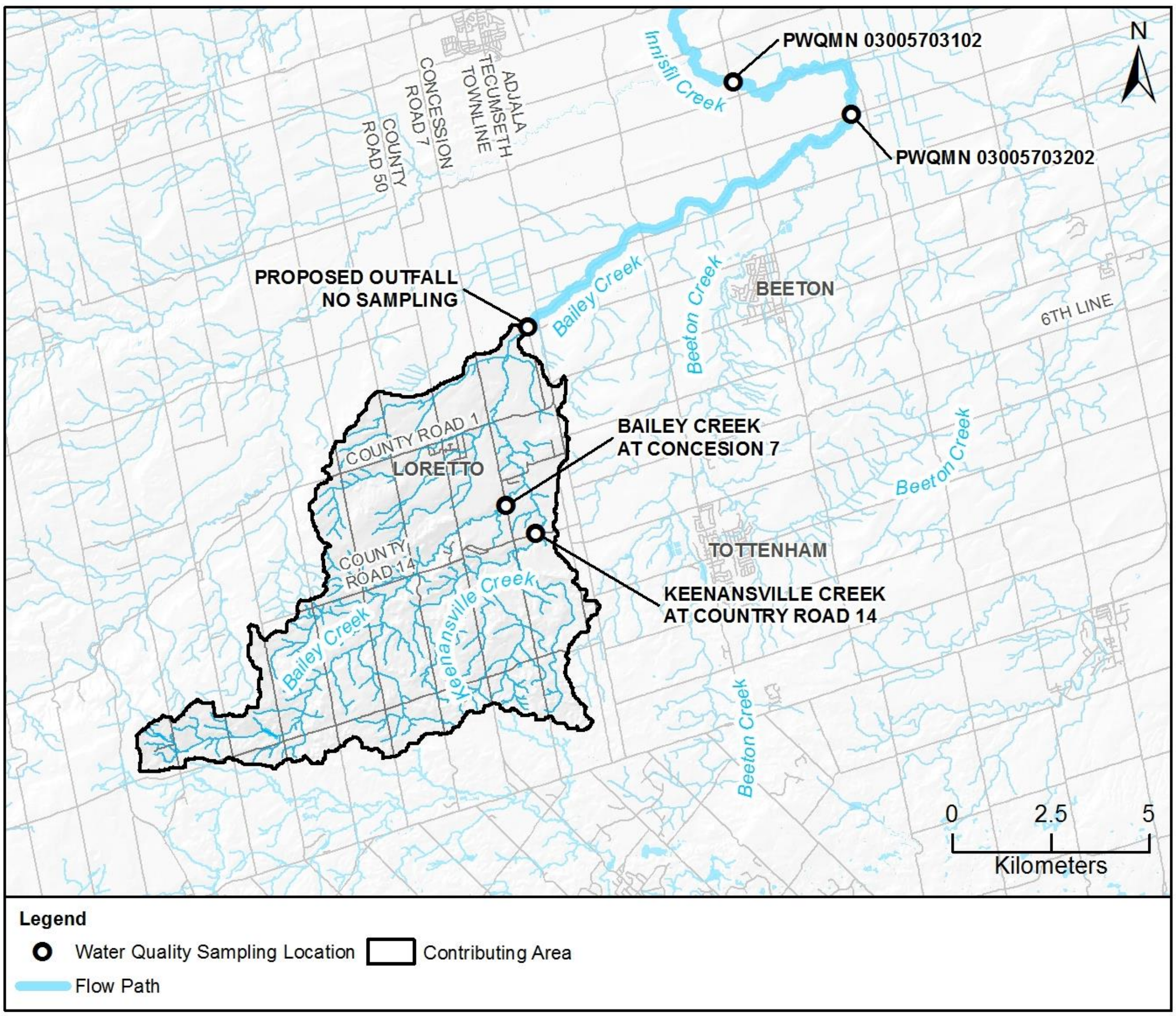


Figure 2-1 Water Quality Record Locations

2.2 Water Quality Objectives and Receiver Policy

The Ministry of the Environment and Climate Change (MOECC) uses the surface water management goals and policies described in MOE (1994) and MOECC (2016) to ensure that the surface waters in the Province are of a quality satisfactory for aquatic life and recreation. Guidelines define Policy 1 and Policy 2 receiving water courses as:

- *<u>Policy '1'</u>: In areas which have water quality better than the Provincial Water Quality Objective (PWQO), water quality shall be maintained at or above the objective (better than the objective).*
- *<u>Policy '2'</u>: Water quality which presently does not meet the PWQOs shall not be further degraded and all practical measures shall be undertaken to upgrade the water quality to the PWQO.*

The Provincial Water Quality Objective (PWQO) for total phosphorus in streams is 0.03 mg/L and un-ionized ammonia 0.02mg/L. There is no PWQO for nitrate so the Canadian Water Quality Guidelines (CWQG) are considered at 3mg/L.

Historical upstream water quality concentrations are assessed using the 75th percentile concentration to determine which policy is applied and to assess capacity for assimilation, **Table 1**. During previous ACS work for earlier Colgan WWTP outfall location options in 2014-2015, MOECC advised including only samples taken during base flow conditions to characterize the upstream watercourse. This results in an upstream designation of Policy 1. Using samples taken during all flow conditions, downstream phosphorus levels exceed PWQO, **Table 1**. Downstream is therefore designated Policy 2.

Table 1 Historical Water Quality

		75th Percentile Concentration		
Parameter	**Objective**	**Upstream Base Flows**	**Upstream All Flows**	**Downstream All Flows**
Phosphorus	0.03	0.0238 (18)	0.0292 (24)	0.074 (220)*
NH^3	0.02	0.0044 (7)	0.0049 (13)	0.0044 (143)
NH^3 Warm	0.02	0.0044 (7)	0.0049 (13)	0.0056 (109)
NH^3 Cold	0.02	ID (0)	ID (2)	0.0015 (34)
Nitrate	3	0.6 (10)	0.68 (14)	1.55 (114)

All units mg/L, * Objective Exceeded, ()= sample count, ID = Insufficient Data

PWQO guidance relevant to thermal considerations and dissolved oxygen are as follows:

- *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.*
- *The temperature at the edge of a mixing zone shall not exceed the natural ambient water temperature at a representative control location by more than 10°C.*
- *At a temperature of 25 degrees C, dissolved oxygen must be maintained above minimum levels of 5 mg/L and 4 mg/L for cold and warm water fisheries, respectively.*
- *At 0 degrees C, dissolved oxygen concentrations must be above 8 mg/L and 7 mg/L for cold and warm water fisheries, respectively.*

To address acute toxicity, the unmixed effluent concentration of total ammonia expressed as nitrogen must be maintained below the value determined from **Equation 1** to be non-toxic, where *y* is the maximum allowable ammonia concentration expressed as total ammonia-nitrogen in mg/L, and *pH* is the pH of the effluent (Environment Canada, 2011)

$$y = 306132466.34 \times 2.7183^{(-2.0437 \times pH)} \qquad \textbf{Equation 1}$$

In-stream E coli counts should be maintained below 100 CFU/100ml

CCME (2008) states that induced suspended solids should not exceed 10 mg/L when background suspended solids are equal to or less than 100 mg/L and that induced suspended solids should not exceed 10% of the background concentration where background concentrations are greater than 100 mg/L.

3 Flow Regime Analysis

This section characterizes the design low flow condition where dilution potential is limited.

3.1 Low Flow Conditions

The lowest consecutive 7-day average flow occurring within a 20 year period of record is referred to as the 7Q20 flow condition. This measure is used to compute dilution potential from stream flow under relatively extreme low flow conditions (5% chance of occurrence each year). There is no available flow records to determine 7Q20 directly at the alternative outfall location. Therefore methods available to make this determination are limited. Methods considered to estimate 7Q20 are those provided by the Ontario Flow Assessment Tool (OFAT) and area based scaling of statistically derived 7Q20 flows at other locations with adequate periods of flow data.

3.2 Low Flow OFAT Estimate

OFAT offers two low flow estimation methods, the Graphical Index Method and the Regression Method. The Graphical Index method employs an equation per one of the six regions in Ontario which includes the drainage area and a constant determined by frequency curves for that region. The Regression method applies watershed characteristics, drainage area, length of main channel and mean annual runoff to generate regression equations per region. Results for nearby flow stations are presented in **Table 2** and are contrasted with the statistical 7Q20 values from measured flows at the corresponding WSC station. OFAT provides a valuable starting point, however, it cannot be confidently applied due to variance from measured records in this study region.

Table 2 OFAT Low Flow Estimates

7Q20 Method (m^3/s)	Alternative Outfall	02ED100	02ED026	02ED101	02HC047
Graphical Index	0.237	0.244	0.323	0.442	0.313
Regression	0.229	0.218	0.311	0.406	0.280
Measured Statistical	NA	0.072	0.461	0.716	0.365

3.3 Low Flow Area Based Scaling

Area based scaling is a technique where measured flows (Q) are scaled to an ungauged catchment by the ratio of areas (A) with an optional scaling constant or function (fn), **Equation 2**. This method requires the measured data be from a geographically close catchment with the same climatic regime, similar size, be hydro-geologically similar and be of natural flow (WMO, 2008).

$$Q_{Ungauged} = fn\left(\frac{A_{Ungauged}}{A_{Guaged}}\right)Q_{Guaged} \qquad \textbf{Equation 2}$$

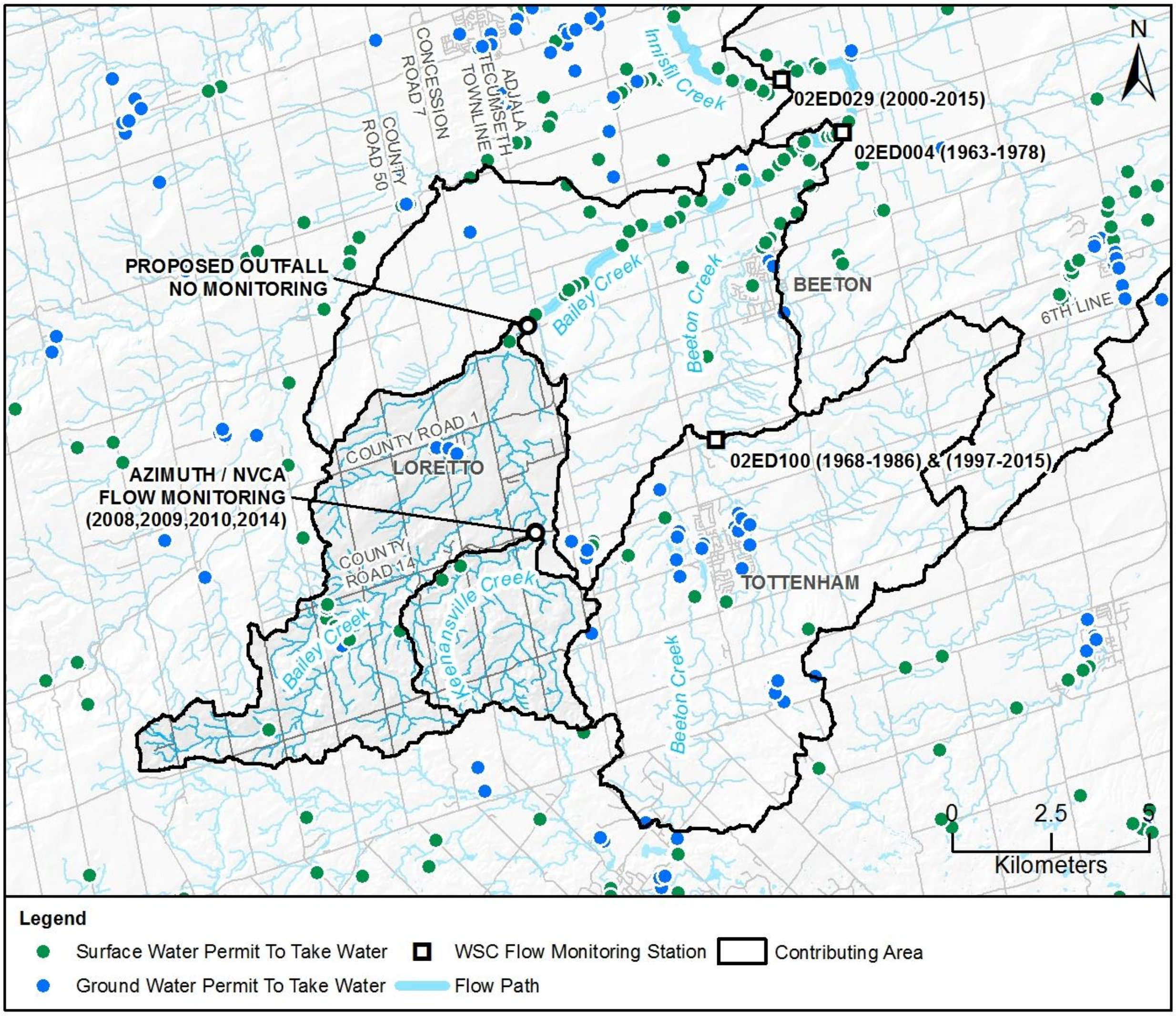


Figure 3-1 Flow Record Locations and Permitted Extractions

Available flow data, hydro-geologic conditions and anthropogenic activities for the subject site present a challenge for area based scaling. Locally there are three WSC flow stations 02ED100, 02ED004 and 02ED029 considered, **Figure 3-1**. The ideal scenario for area based scaling is to scale using a flow record from downstream of the subject area. In this case 02ED004 is a primary candidate however it does not have a recent record. The second candidate, 02ED029, has a recent record but it includes a vast contributing area to the Northeast. To add to these limitations there is potential groundwater recharge and a considerable volume of permitted water extraction from Bailey Creek between the alternative outfall and the WSC flow stations, **Figure 3-1**. The permitted water takings on record between the subject site and the confluence with Beeton Creek, directly upstream of 02ED004 are presented in **Figure 3-2**. The most recent permitted takings allow the extraction of approximately 0.095 m3/s of flow. This may not always occur but in times of drought it would be expected that sod and potato operations draw substantially. Base flow alteration by extraction is present within flow records for 2001, 2002, 2003 and 2005 where flows at 02ED029 are less than flows upstream at 02ED100. **Figure 3-3** demonstrates this flow alteration in 2001. This rules out area based scaling from the primary downstream data sources because the flow record during low flow conditions is altered by extractions.

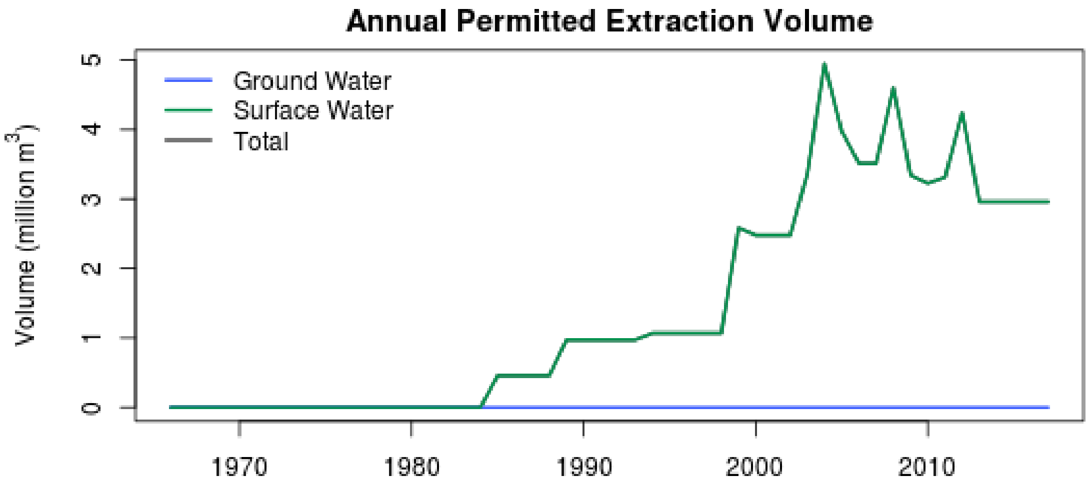


Figure 3-2 Annual Permitted Extraction Volume

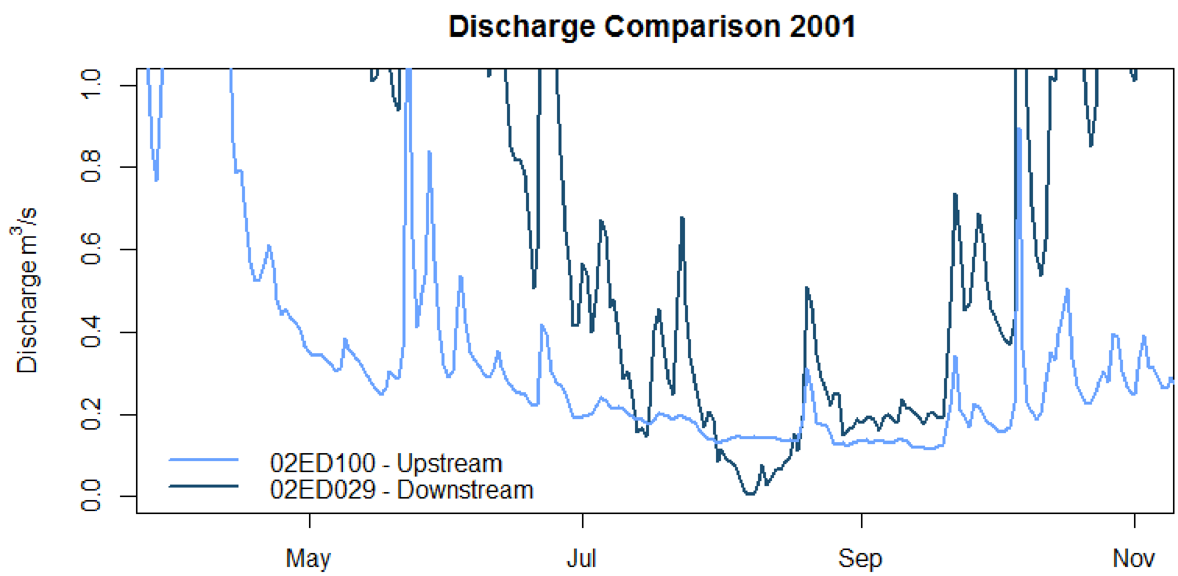


Figure 3-3 Base Flow Alteration by Extraction Example

Since scaling from a downstream flow record has been ruled out, neighboring flow records and conditions are examined for alternatives. The next logical flow record to examine is the contributing area of 02ED100. Performing area based scaling provides a 7Q20 of 0.063 m3/s. Compared to the measured short term flow measurements taken by Azimuth and NVCA on Keenansville Creek this estimate seems low. Statistical results for the short duration record on Keenansville Creek allow the determination of a measured 7Q2 and 7Q5 low flow. Using a common date range to produce a measured 7Q2 and 7Q5 at 02ED100 the difference is apparent, **Table 3**. Keenansville Creek has approximately one fifth the contributing area of 02ED100 yet produces a low flow of approximately half the volume.

Table 3 Short Record Measured 7Q Flow Comparison

Flow Station	7Q2 (m^3/s)	7Q5 (m^3/s)	Contributing Area (km^2)
Keenansville Creek	0.035	0.067	16.2
WSC 02ED100	0.081	0.129	74.5

Appendix A presents relevant tables and figures for watershed characteristic comparisons. Reviewing hydrologic conditions for surrounding watersheds provides clues to the differences in low flow conditions between Keenansville Creek and 02ED100 records, **Figure A-6** and **Figure A-7** in particular. The alternative outfall contributing area appears to be more closely aligned with 02HC047, 02ED101 and 02ED026 for most measures but closer to 02ED100 for others. An average of the scaled records from the four neighboring WSC stations is used as the 7Q20 as there is no effective way to pick one over the other and an average is likely to provide a representative estimate. The average of the scaled 7Q20 estimates from **Table 4** is 0.131m^3/s. Applying an additional 15% safety margin provides a 7Q20 estimate for the alternative outfall of 0.112m^3/s. This estimate is slightly less than a previous estimate for Bailey Creek at Keenansville Road, but it also accounts for some water taking and groundwater recharge potential between these locations.

Table 4 Scaled 7Q20 Estimates for Alternative Outfall Option

WSC Station	Scaled 7Q20 (m^3/s)	Record Length (years)
02HC047	0.147	28
02ED100	0.063	38
02ED101	0.143	31
02ED026	0.172	27

3.4 Downstream Low Flow Conditions

Low flow conditions downstream of the alternative outfall are examined for downstream effluent mixing analysis. Estimating the 7Q20 is straight forward in this case because measured records are available for WSC 02ED004 and 02ED029. 02ED029 was examined for temporal relevance, 2000-2015, where 02ED004 flow records are from 1963-1978 and deemed not temporally relevant. A low flow analysis plot is presented in **Figure 3-4** for 02ED029. The 7Q20 estimate is 0.063m^3/s using the Weibull distribution; lower than the upstream estimate at the alternative outfall. This depressed downstream low flow condition could be caused by extractions and groundwater recharge.

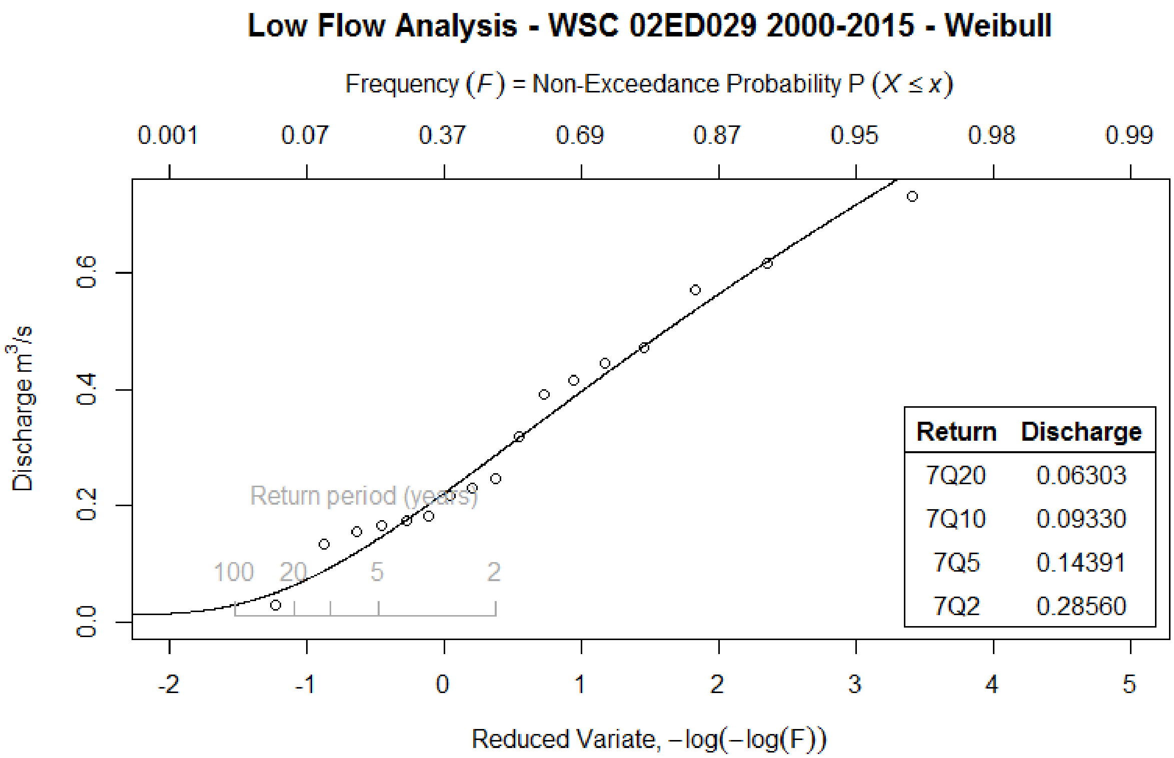


Figure 3-4 Downstream 7Q Plot, WSC 02ED029 2000-2015

4 Point of Discharge and Downstream Concentration Evaluation

Resulting in-stream concentration after effluent of a given flow and concentration are fully mixed is assessed. The mixed in-stream concentration can be determined using **Equation 3**.

$$C_{mix} = \frac{C_{eff}Q_{eff} + C_{amb}Q_{amb}}{Q_{amb} + Q_{eff}}$$ **Equation 3**

Where C_{eff} and C_{amb} are the effluent and ambient in-stream concentrations, respectively and Q_{eff} and Q_{amb} are the corresponding flow rates.

4.1 Point of Discharge Mixed Concentrations

The mixed in-stream concentrations for parameters can be determined by using available data to characterize low flow, water quality conditions, proposed volumes and concentrations of effluent. **Table 5** provides the low flow conditions and the proposed effluent flow rate at the alternative point of discharge. Using 75th percentile historical concentration for each parameter of interest, the effluent concentration that meets the objectives is determined under low flow conditions, **Table 6** and **Table** 7.

Table 5 Assessed Low Flow Conditions and Effluent Discharge Rate

Point of Discharge 7Q20 (Average Scaled w Safety)	0.112 m^3/s
Effluent Flow Rate	7.975 L/s

Table 6 Effluent Mixing Limits: Water Quality Data Corresponding with Higher Flows Omitted

		Point of Discharge (Base Flow WQ Only)		
Parameter	**Objective (mg/L)**	**Ambient Conc. 75th Percentile (mg/L)**	**Effluent Conc. (mg/L)**	**Mixed Conc. (mg/L)**
Phosphorus	0.03	0.0238	0.120	0.030

Table 7 Effluent Mixing Limits: All Available Water Quality Data Included

		Point of Discharge (WQ All Flow Conditions)		
Parameter	**Objective (mg/L)**	**Ambient Conc. 75th Percentile (mg/L)**	**Effluent Conc. (mg/L)**	**Mixed Conc. (mg/L)**
Phosphorus	0.03	0.0292	0.041	0.03
Ammonia Warm	0.02 NH^3	0.060 (TAN)	2.08 TAN	0.02 NH^3
Ammonia Cold	0.02 NH^3	0.060 (TAN)	8.66 TAN	0.02 NH^3
Nitrate	3	0.675	35.5	3

Using concentrations measured during base flow conditions upstream yields some capacity for assimilation of Phosphorus, **Table 6**. Using all historical concentration data leaves little capacity for Phosphorus assimilation and would require an effluent concentration of 0.041 mg/L. There is adequate capacity for un-ionized ammonia and nitrate, **Table 7**.

For ammonia, chronic, in-stream conditions will govern for pH below 9.2. Above, a pH of 9.2 acute toxicity criteria (**Equation 1**) for the unmixed effluent will govern.

Unionized ammonia (NH_3) and ionized ammonia (NH_4^+) exist together in equilibrium in an aqueous solution. Together they are known as total ammonia. Total ammonia nitrogen (TAN) is equal to 0.8224 x total ammonia. MOEE (1994) indicates that the fraction of toxic un-ionized ammonia in an aqueous solution is dependent on temperature and pH according to **Equations [4] and [5]**.

$$f = \frac{1}{10^{pKa-pH} + 1}$$ **[Equation 4]**

Where f is the fraction of the total ammonia that is NH_3 in solution and

$$pKa = 0.09018 + \frac{2729.92}{T + 273.16}$$ **[Equation 5]**

Where T is temperature in degrees Celsius

These equations were applied to determine un-ionized ammonia from total ammonia with a warm in-stream water temperature of 21 degrees and a cool temperature of 5 degrees. Based on available monitoring data, a pH of 8.33 was used in the calculation.

4.2 Consideration for Downstream Effects

The downstream point is more than 10 km downstream of the alternative outfall. Although it has a larger catchment area, there is considerable reduction in the low flow condition (52%) between the alternative outfall and 02ED029 due to water takings and groundwater recharge. Downstream 7Q20 (at WSC station 02ED029) was determine to be 0.063 m^3/s.

This downstream location is considered because the effluent discharge should not result in the water quality objective being exceeded either at the point of discharge (Policy 1) or further downstream (Policy 2). Since, downstream reaches are already impaired, the Colgan discharge cannot further degrade this condition. Station 02ED029 is used because it is the nearest downstream WSC station with a recent and long enough period of record.

Downstream capacity is less than at the alternative outfall due to surface water extractions and potential groundwater recharge coupled with historical concentrations that exceed PWQO for Phosphorus. **Table 8** shows the maximum effluent concentration that meets objectives. For phosphorus the maximum downstream effluent concentration is equal to the ambient concentration in order that the mixed concentration does not increase. Since some of the nutrients would be removed by consumptive water takings or groundwater recharge, this is a somewhat conservative assessment downstream, but if the effluent discharged at the alternative outfall had a higher concentration than the downstream point considered, this could potentially increase the downstream concentration.

Table 8 Effluent Mixing Limits: Downstream

		Downstream		
Parameter	**Objective (mg/L)**	**Ambient Conc. 75th Percentile (mg/L)**	**Effluent Conc. (mg/L)**	**Mixed Conc. (mg/L)**
Phosphorus	0.03	0.074*	0.074*	0.074*
Nitrate	3	1.55	14.5	3

* Objective Exceeded

4.3 Thermal and Dissolved Oxygen Consideration

Thermal regime is defined through in stream water temperature and fishery survey habitat classification. Data available for this region comes from the Aquatic Resource Area (ARA) dataset provided by Ontario Ministry of Natural Resources and Forestry (MNRF) and the NVCA. ARA information classes the thermal regime at the alternative outfall as cool based on water temperature only, **Figure 4-1**. NVCA information classifies temperature logger data and spot measurements as warm but the habitat type as cold, **Figure 4-2**. NVCA identified Rainbow Trout during survey work and classed some reaches as “Spawning/Nursery”. Because of the interpretation of in field conditions by fisheries biologists, the habitat level assessment will take priority over water temperature logging alone. However, the temperature data suggests that the water course might be thermally stressed as a cold water fishery. Therefore, a Policy 2 type approach is indicated whereby the effluent discharge should not raise the ambient temperature.

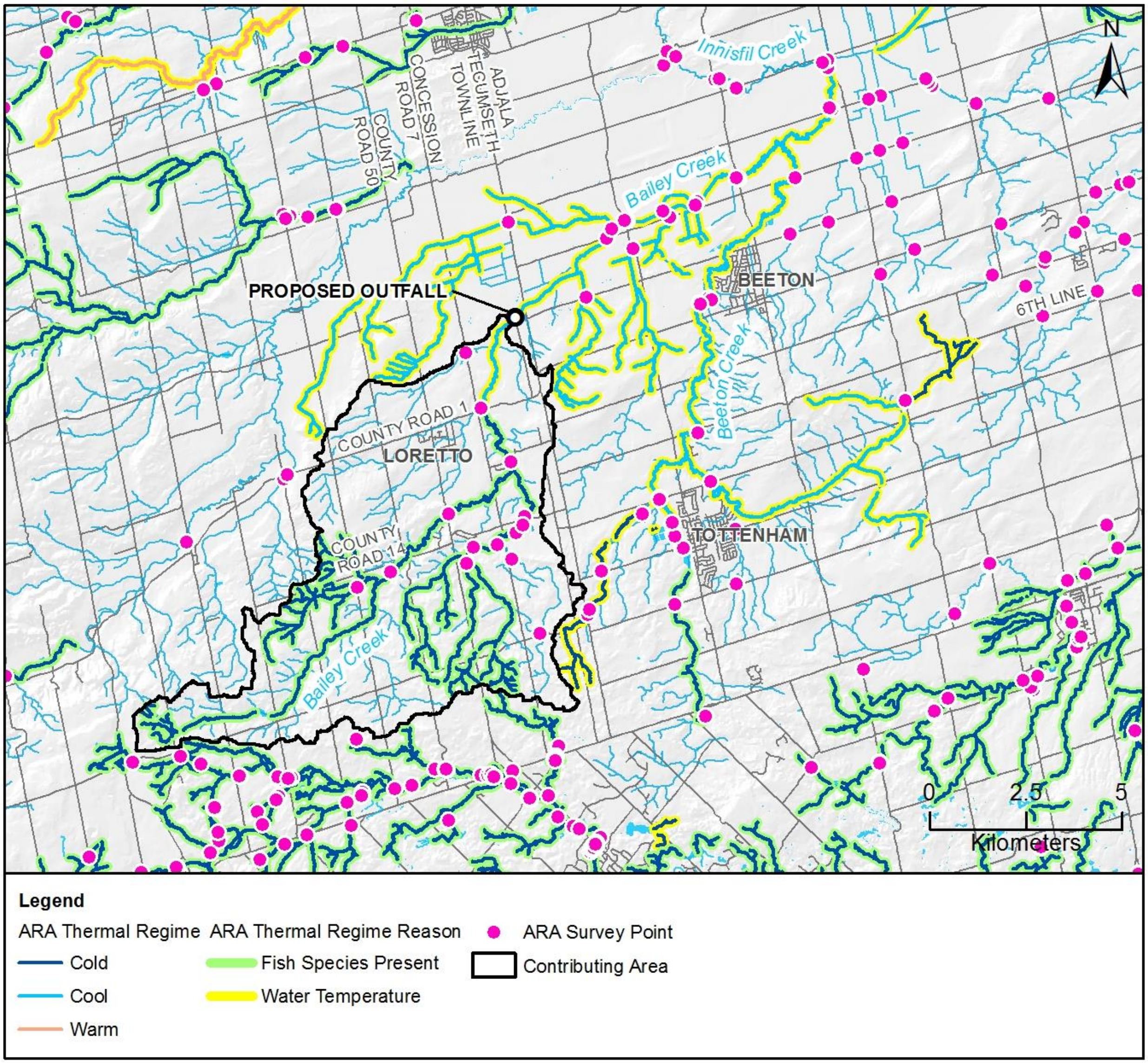


Figure 4-1 Aquatic Resource Area Thermal Regime

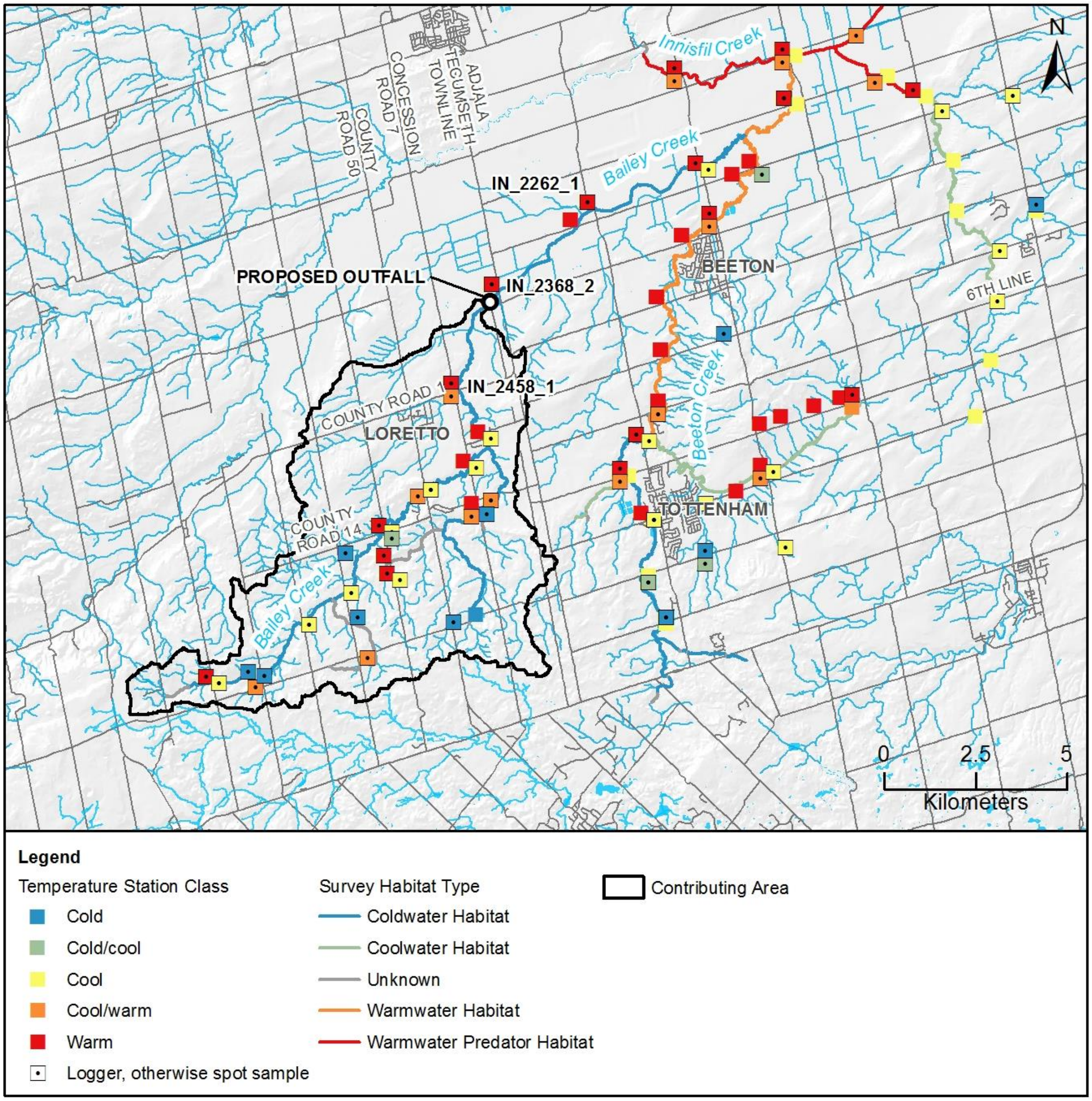


Figure 4-2 NVCA Thermal Regime

In-stream water temperature varies with air temperature, but may be buffered by stable groundwater contributions. A linear model was derived from available data to represent the median water temperature and also the maximum recommended effluent temperature as a function of air temperature, **Equation 4**.

$$T_{Effluent\ Max} = 0.3301 * T_{Air} + 14.2881 \qquad \textbf{Equation 6}$$

This linear model was generated using in-stream water temperature measurements from loggers (IN_2262_1, IN_2368_2 and IN_2458_1) located up and downstream of the alternative outfall, **Figure 4-2**. The logger data was from a limited number of days during warmer months (July and August) in the years 2008, 2009, 2014, 2015, 2016, provided by NVCA.

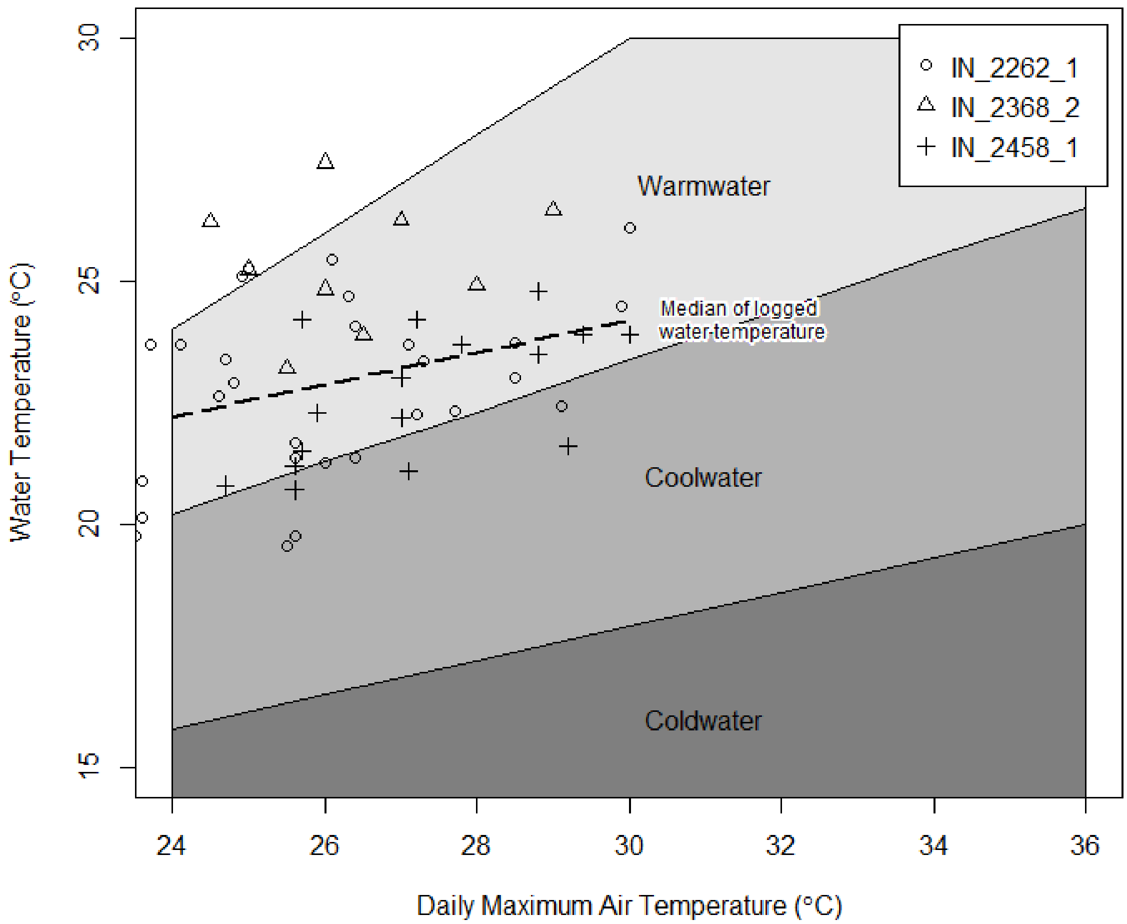
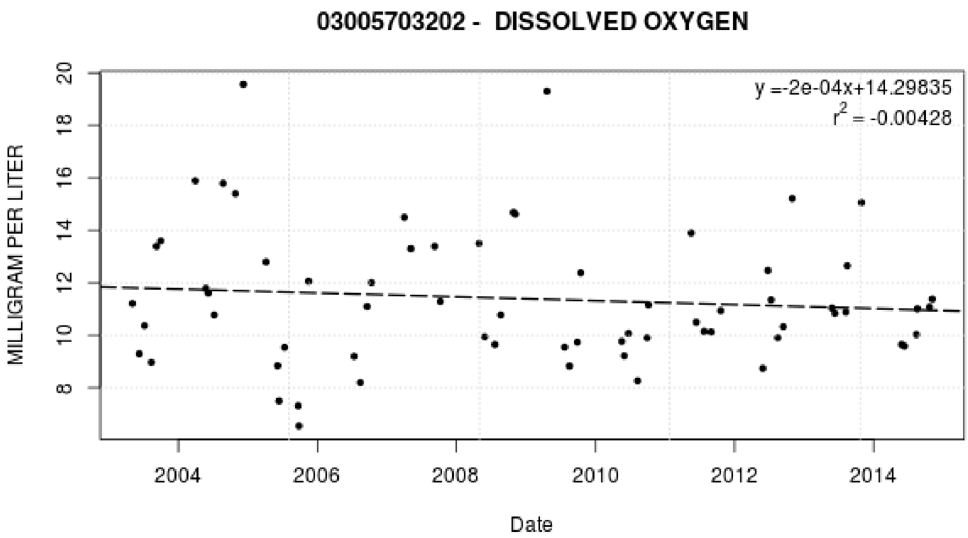


Figure 4-3 Stream Thermal Characteristic Nomogram, Adapted from Stoneman and Jones, 1996 with Overlay of Measured Data

Equation 6 can be used as a guide for design of the outfall and conveyance system. Where the effluent must travel underground to the outfall, there is potential for cooling to occur before reaching the outfall.

Where dissolved oxygen (DO) is inversely related to temperature and is a critical aspect of a viable fishery, the study looked at prevailing dissolved oxygen conditions downstream of the alternative outfall, **Figure 4-4**. The 25th percentile DO occurs in September at approximately 8.5 mg/L from available data. Under warm conditions, this is above the 5 mg/L minimum objective for a cold water fishery, but there is a declining trend line.

Maintaining the thermal regime of the water course, providing adequate removal of BOD in the effluent and designing the conveyance and outfall structures to enhance aeration before discharge may address potential issues related to thermal impacts and ensure DO levels are maintained.



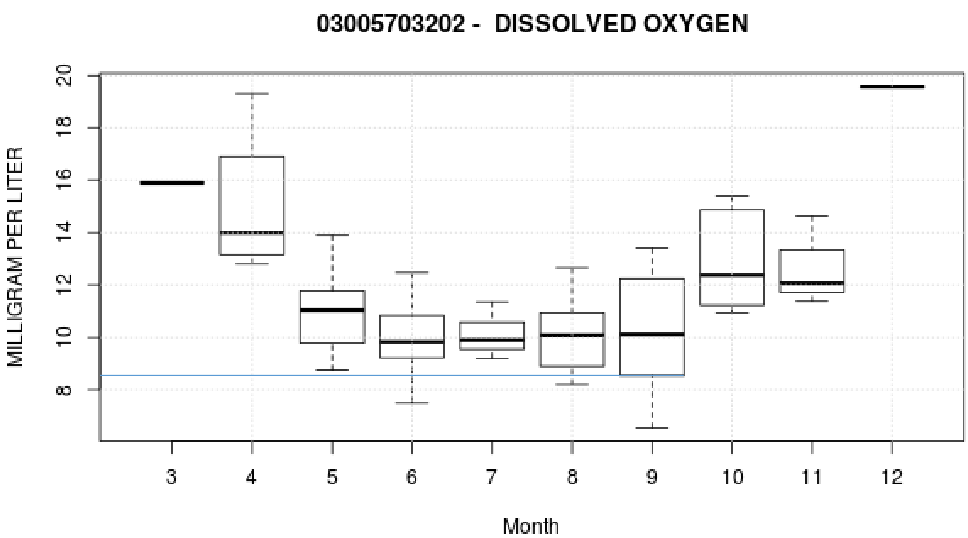


Figure 4-4 Dissolved Oxygen Concentrations Downstream of the Outfall Option

5 Conclusions / Recommendations

The Concession Road 8 discharge location to Bailey Creek appears to be a feasible option. Achieving water quality, thermal and dissolved oxygen objectives downstream of the outfall is possible.

1. Phosphorus is a determining water quality parameter. For the proposed effluent flow rate at the alternative outfall, water quality objects could be met under low flow conditions with an effluent concentration of 0.120 mg/L assessed using water quality data taken during baseflow conditions. Downstream of the alternative outfall the maximum effluent concentration to meet the Phosphorus PWQO is 0.074 mg/L.
2. In-stream chronic ammonia criteria will govern below a pH of 9.1. TAN should be maintained below 2.4 mg/L under summer conditions and below 10.1 mg/L under cool conditions.
3. Low flow conditions are challenging to predict with currently available data. Long term flow measurement should be considered at the alternative outfall. From the approach described herein with a 15% safety factor, a design 7Q20 low flow of 0.112 m^3/s is recommended at the alternative outfall location option. Under these conditions a dilution ratio of 14.5 to 1 is expected. Compared to the Keenansville Road outfall location option, the Concession Road 8 alternative has a similar dilution potential.
4. Available upstream water quality data for this study was limited and downstream stations may be influenced by water takings and groundwater recharge. A long term monitoring program upstream and downstream of the alternative outfall should be considered as part of an adaptive management approach.
5. In stream thermal measurements do not match observed cold water habitat survey results. **Equation 6** can provide a guide for maximum effluent temperature for a given air temperature that would maintain the current thermal regime based on temperature data. The thermal classification at the alternative outfall location at Concession Road 8 is expected to be similar to the Keenansville Road option, although being further downstream, it may exhibit more warming.
6. The monitoring data suggests in-stream dissolved oxygen (DO) levels are currently adequate to sustain cold water fisheries with values ranging from 7 to 19 mg/L.

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Other sources noted with figures.

Appendix A

Supporting Data

Appendix A: Supporting Data

A-1 Upstream Water Quality Results (Past Field Sampling)

Table 9 Upstream Phosphorus Concentrations

Date	Keenansville Creek	Bailey Creek	Flow Type
2009.Sep.11	0.028	0.033	Base
2009.Sep.15	0.025	0.04	Base
2010.Jun.24	0.42	0.17	High
2010.Jul.08	0.017	0.024	Base
2014.Mar.31	0.044	0.014	High
2014.Apr.10	0.018	0.041	High
2014 May.2	0.011	0.011	Base
2014 Jul-10	0.022	0.023	Base
2014 Aug-07	0.02	0.019	Base
2014 Aug-19	0.019	0.014	Base
2014 Sep-08	0.019	0.018	Base
2014 sep-29	0.013	0.009	Base

Table 10 Upstream Un-ionized Ammonia Concentrations (NH3)

	Un-ionized Ammonia (NH^3)		Total Ammonia-N	
Date	Keenansville Creek	Bailey Creek	Keenansville Creek	Bailey Creek
2009.Sep.11	0.001	0.001		
2009.Sep.15	0.001	0.001		
2010.Jun.24	0.008	0.007	0.08	0.07
2010.Jul.08	0.005	0.005	0.05	0.05
2014.Mar.31	0.003	0.003	0.06	0.06
2014.Apr.10	0.002	0.002	0.05	0.05
2014 May.2	0.004		0.08	

TAN results converted to Un-ionized Ammonia using temperature and pH from the closest date/season from PWQMN dataset when field values not present

Table 11 Upstream Nitrate Concentrations

Date	Keenansville Creek	Bailey Creek	Flow Type
2009.Sep.11	0.6	0.6	Base
2009.Sep.15	0.6	0.7	Base
2010.Jun.24	0.7	0.1	High
2010.Jul.08	0.6	0.7	Base
2014.Mar.31	0.7	0.5	High
2014.Apr.10	0.5	0.44	High
2014 May.2	0.37	0.3	Base

A-2 Downstream Water Quality Results (PWQMN)

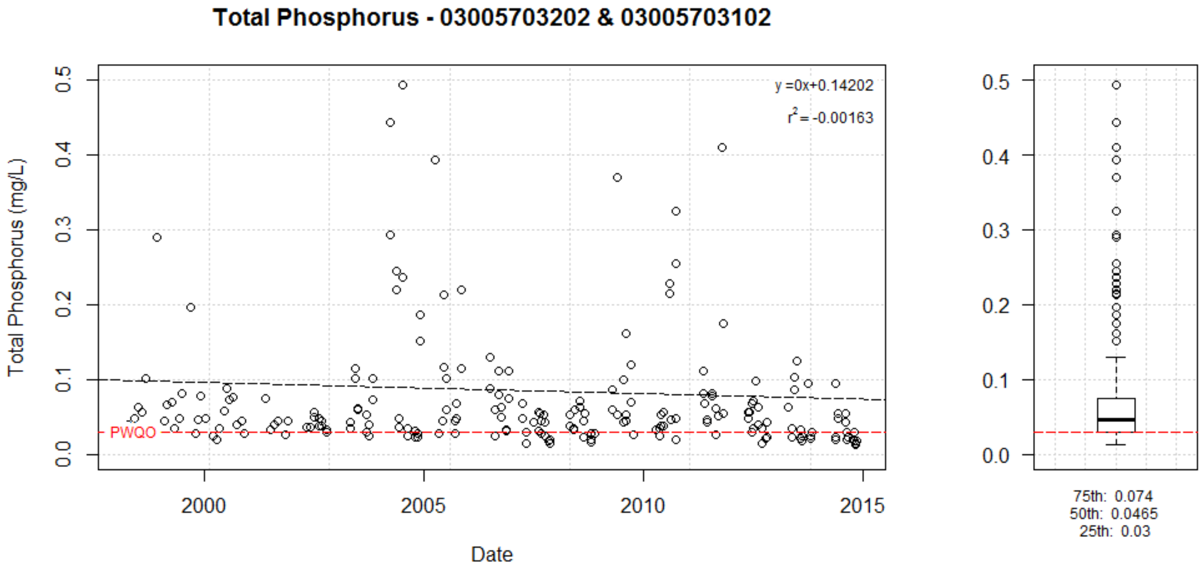

Figure A-1 Downstream Total Phosphorus

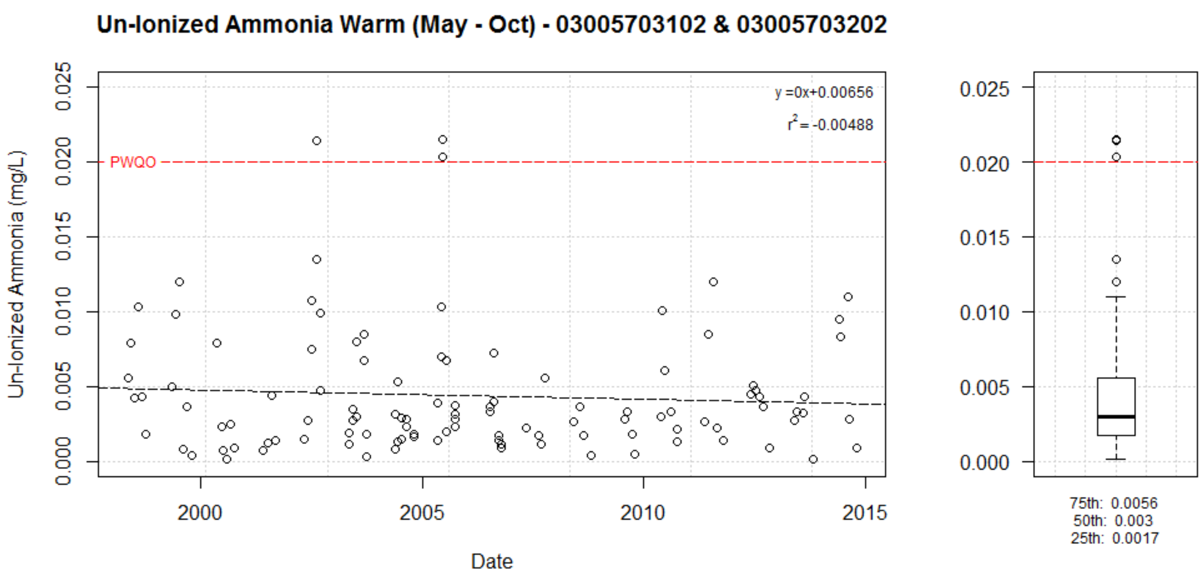

Figure A-2 Downstream Un-Ionized Ammonia Warm

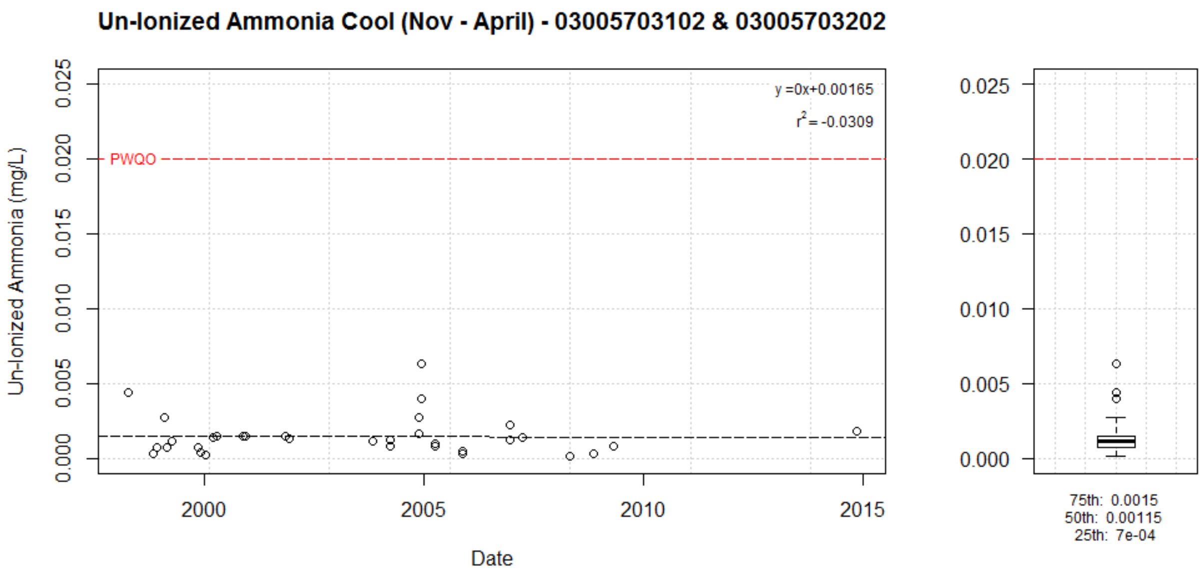

Figure A-3 Downstream Un-Ionized Ammonia Cool

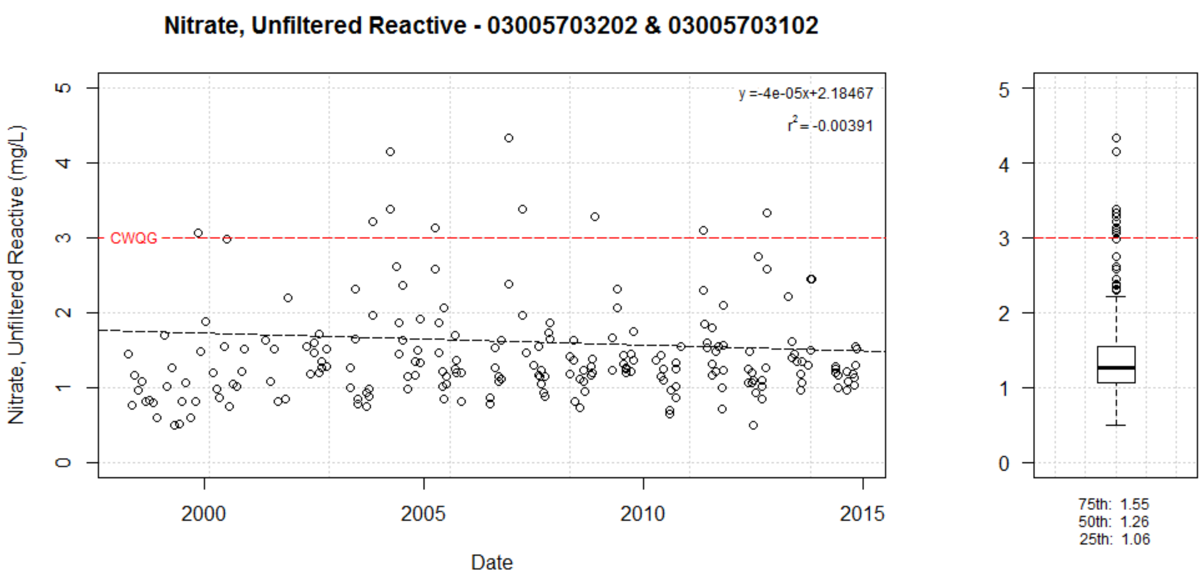

Figure A-4 Downstream Nitrate

A-3 Watershed Characteristics

Table 12 OFAT Generated Characteristics

Measure	Alternative Outfall	02ED100	02ED026	02ED101	02HC047
Drainage Area (km^2)	65.53	74.69	175.97	328.70	163.88
Shape Factor	11.83	6.65	8.88	11.71	10.96
Length of Main Channel (km)	27.84	22.29	39.52	62.04	42.39
Maximum Channel Elevation (m)	426.72	321.61	511.53	511.53	479.38
Minimum Channel Elevation (m)	233.95	230.91	262.24	233.62	257.36
Slope of Main Channel (m/km)	7.28	4.07	6.31	4.64	5.24
Slope of Main Channel (%)	0.73	0.41	0.63	0.46	0.52
Area - Lakes (km^2)	0.15	0.31	0.48	0.98	2.01
% Area Lakes	0.24	0.42	0.27	0.30	1.23
Area - Wetlands (km^2)	3.21	3.34	27.92	40.36	13.41
% Area Wetlands	4.90	4.47	15.87	12.28	8.18
Mean Elevation (m)	286.83	277.07	440.67	394.05	352.62
Maximum Elevation (m)	427.36	386.97	522.09	524.87	489.82
Mean Slope (%)	4.86	4.58	5.06	5.48	5.55
Annual Mean Temperature (°C)	7.10	7.10	6.40	6.63	7.03
Annual Precipitation (mm)	836.00	829.00	896.00	874.00	841.00

Table 13 Drainage Density & WSC Record Duration

WSC Station	Drainage Density	Record Start	Record End	Record Length (years)
02HC047	2.23	1981	2015	28
02ED100	1.79	1968	2015	38
02ED101	1.36	1967	2015	31
02ED026	1.20	1989	2015	27
Prop. Outfall	2.58	NA	NA	NA

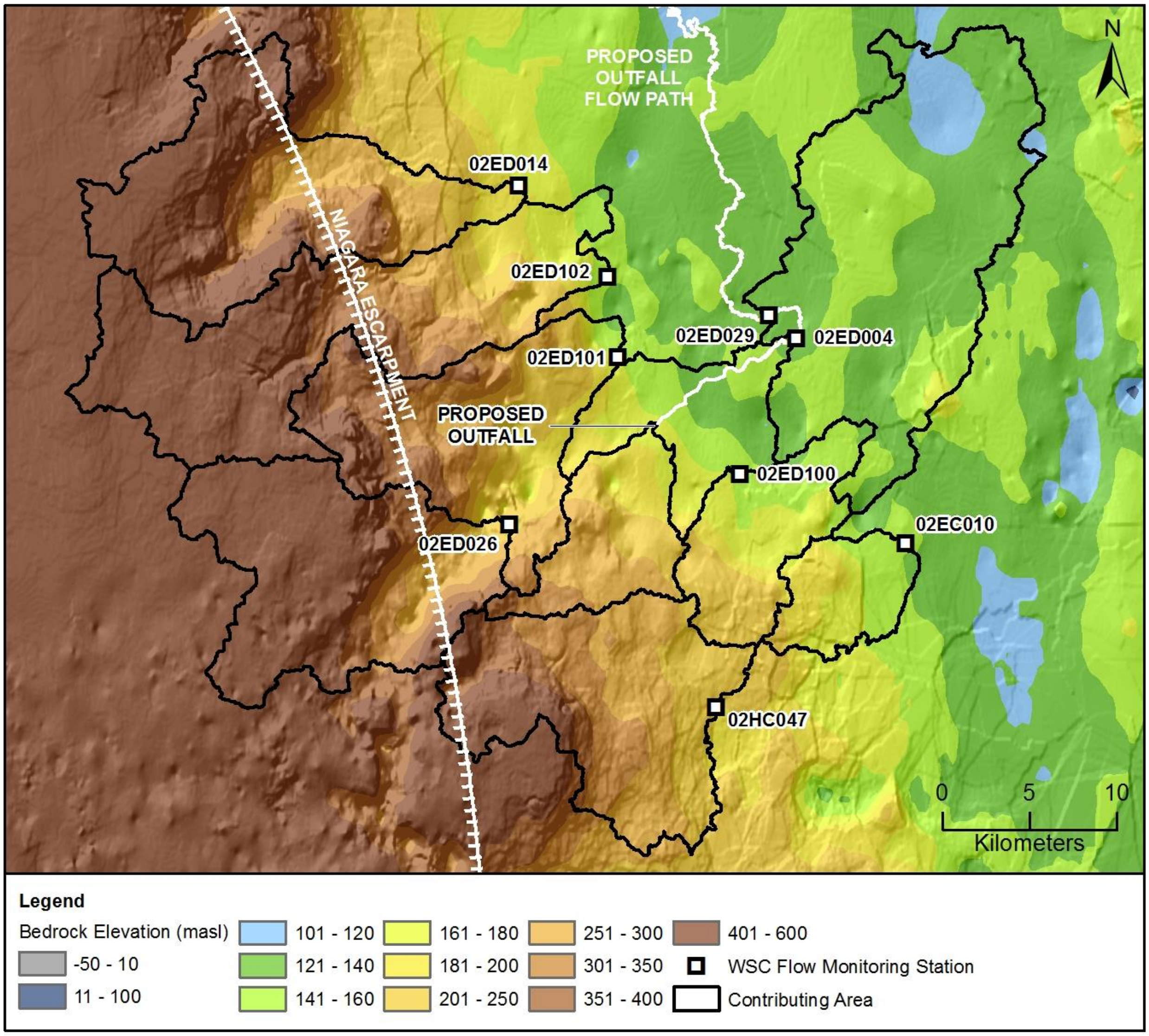

Figure A-5 Bedrock Elevation

Gao, C., Shirota, J., Kelly, R. I., Brunton, F.R., van Haaften, S. 2006. Bedrock topography and overburden thickness mapping, southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 207. ISBN 1-4249-2550-9

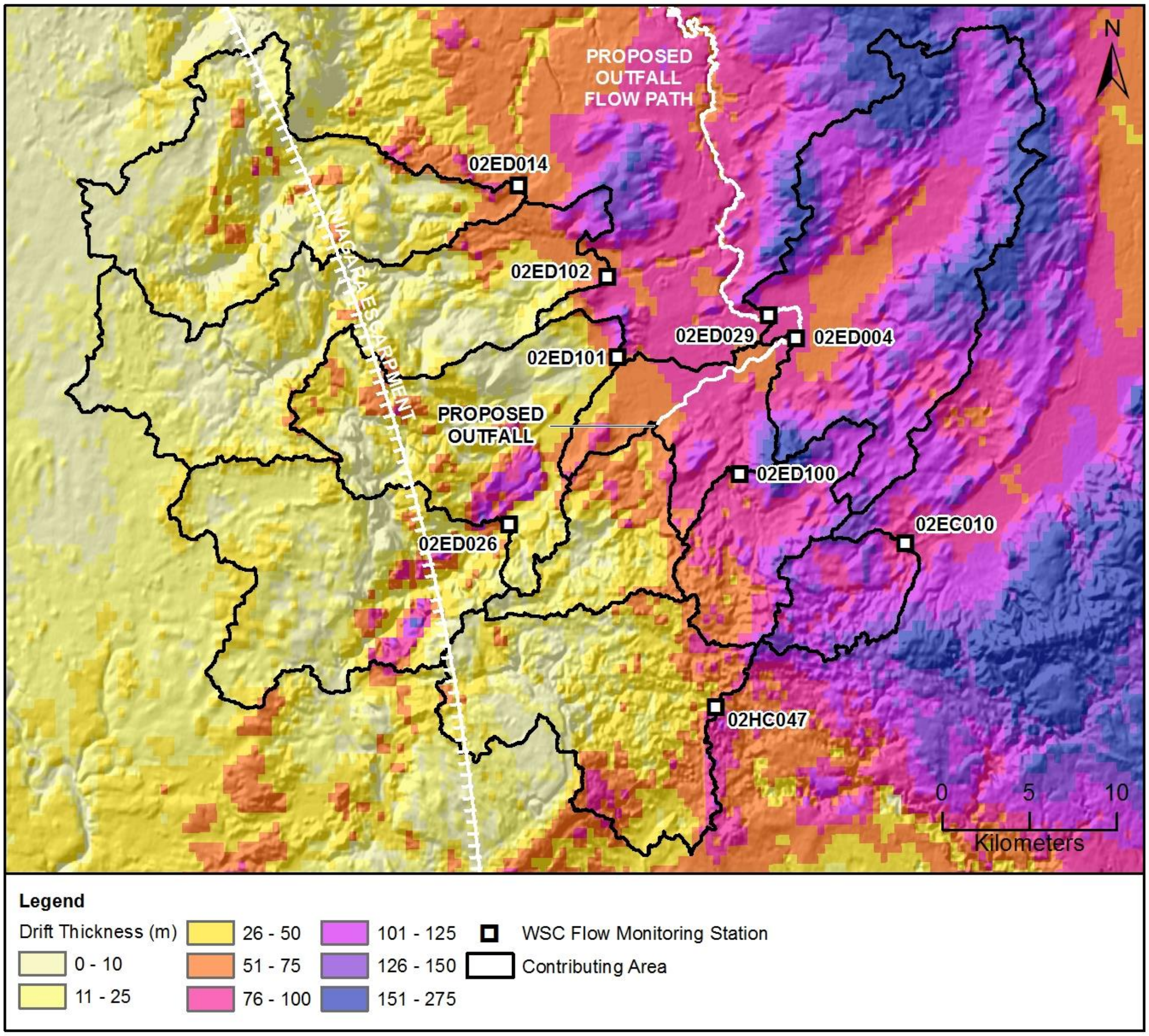

Figure A-6 Drift Thickness

Gao, C., Shirota, J., Kelly, R. I., Brunton, F.R., van Haaften, S. 2006. Bedrock topography and overburden thickness mapping, southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 207. ISBN 1-4249-2550-9

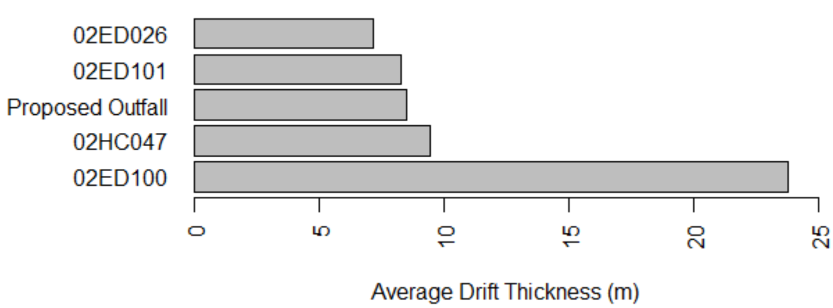

Figure A-7 Average Watershed Drift Thickness

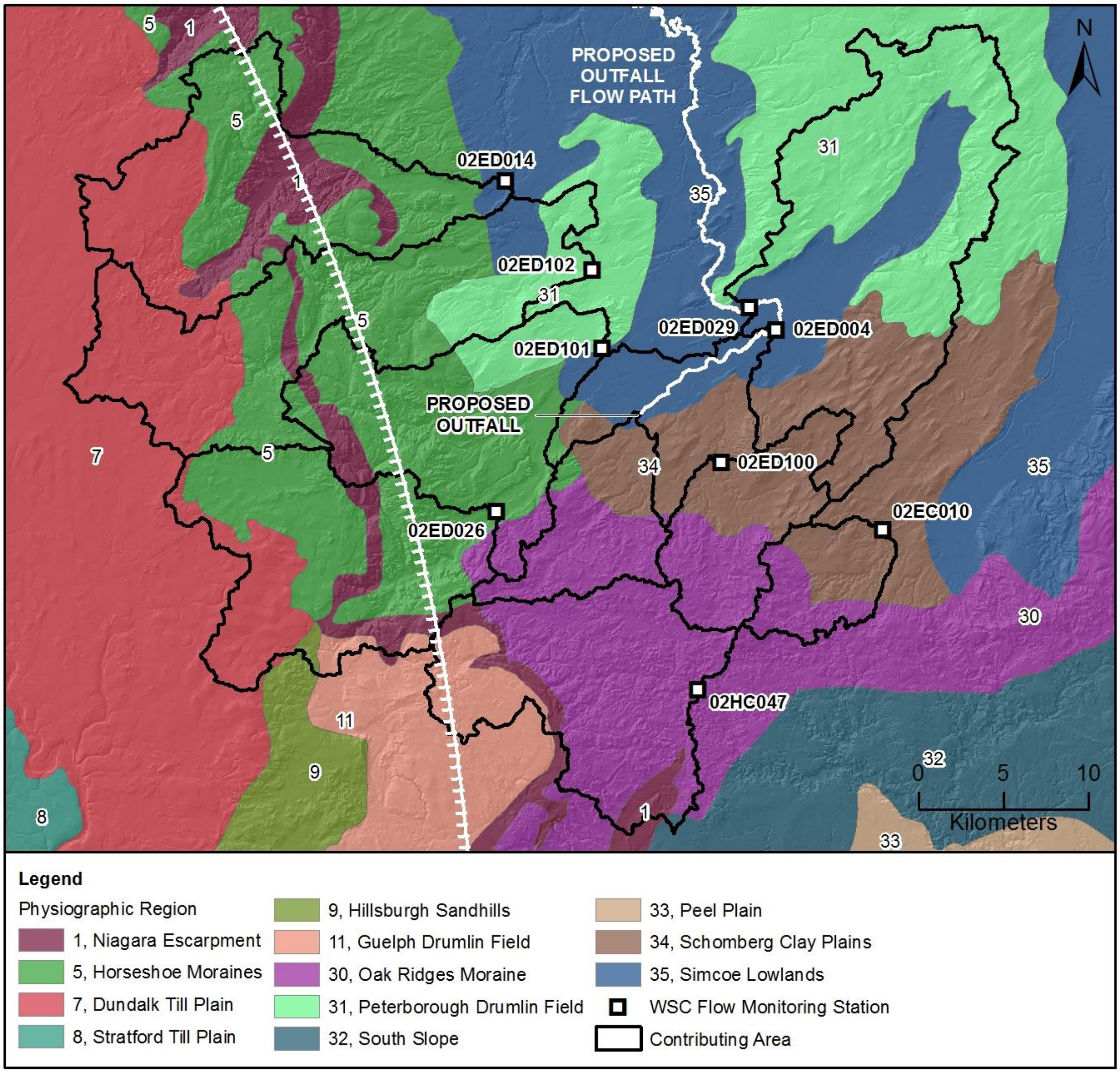

Figure A-8 Physiography

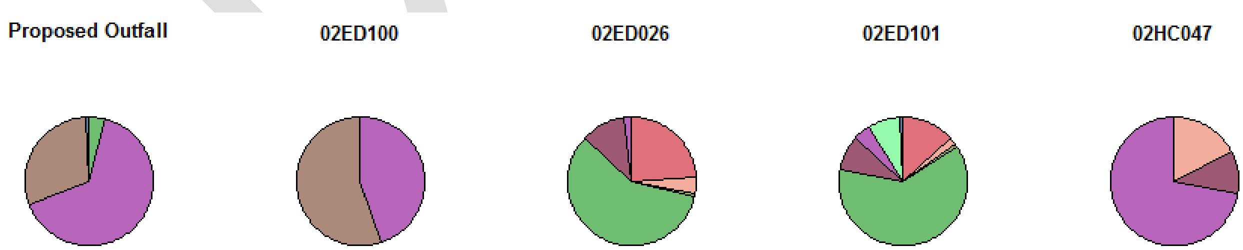

Figure A-9 Physiography by Watershed

Chapman, L.J. and Putnam, D.F. 2007. Physiography of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 228 ISBN 978-1-4249-5158-1

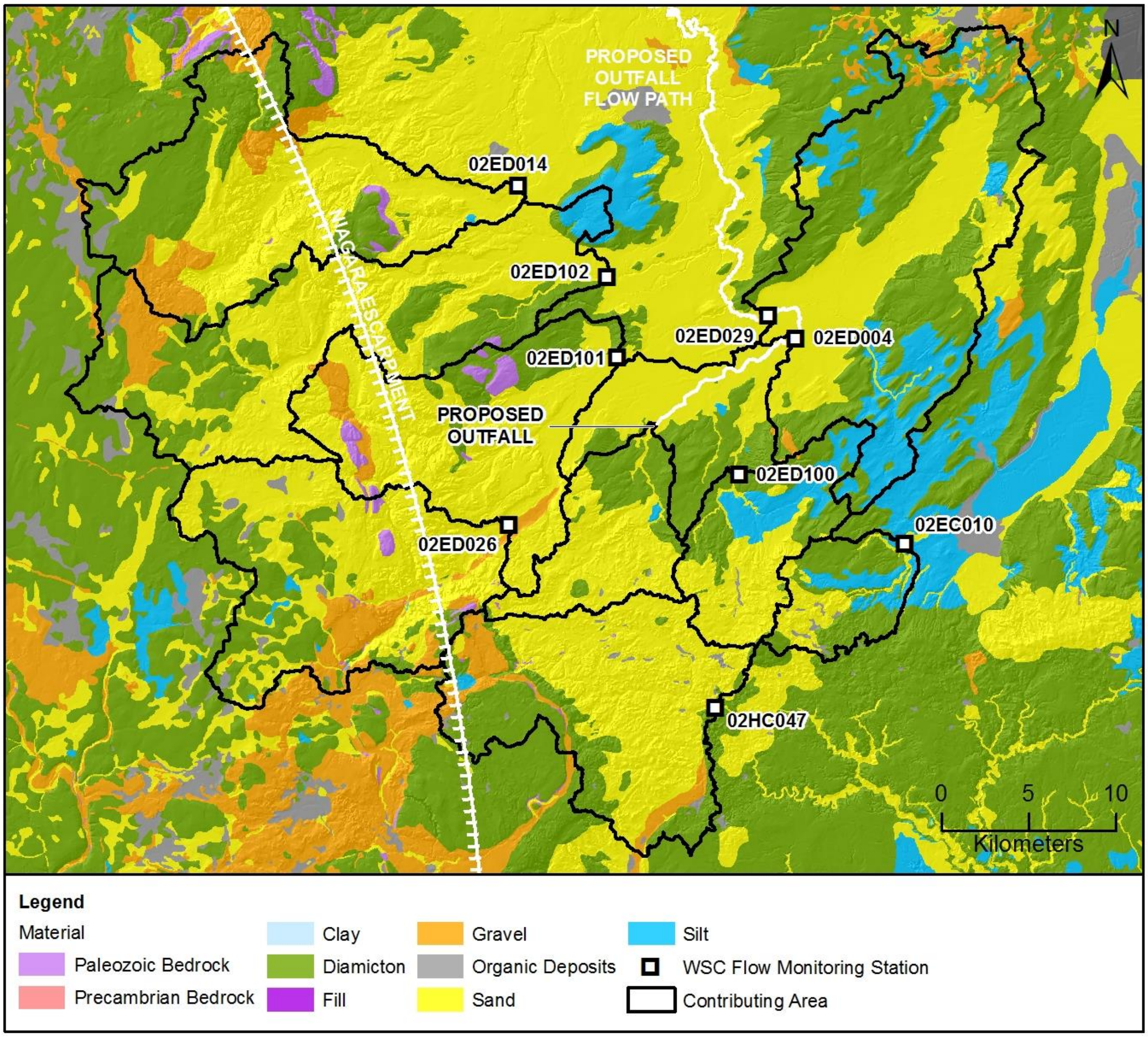

Figure A-10 Surficial Geology

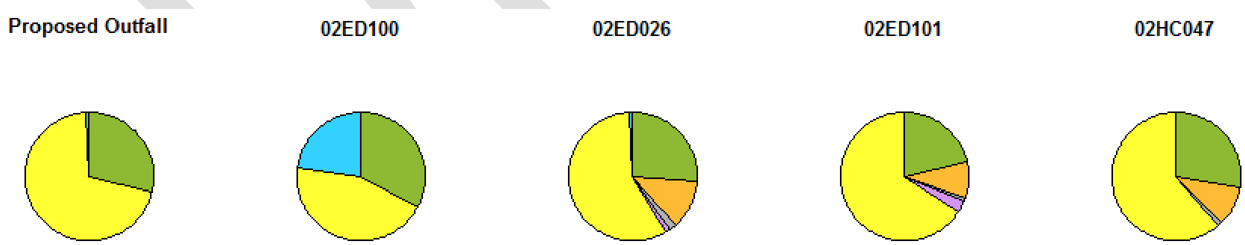

Figure A-11 Surficial Geology by Watershed

Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2482-7

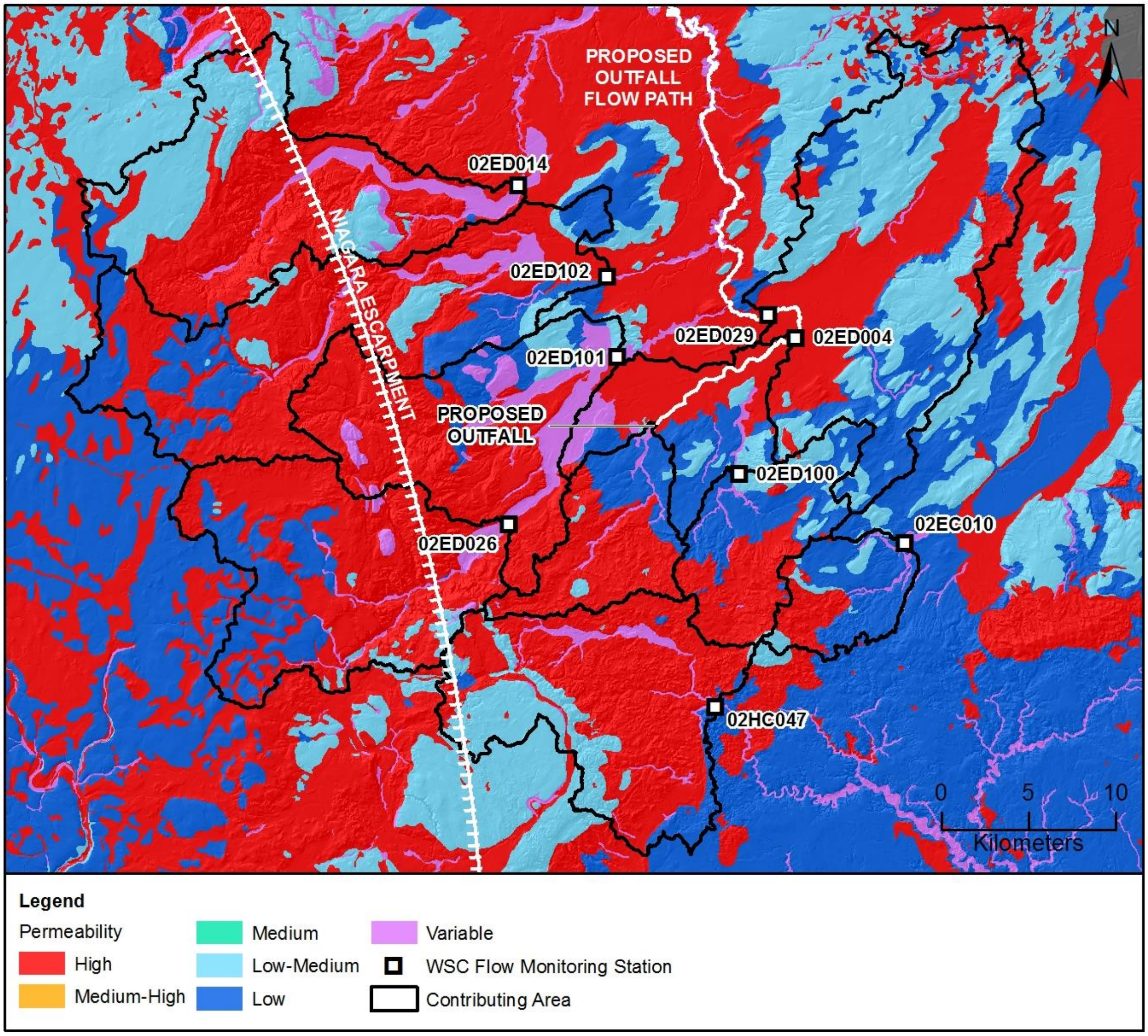

Figure A-12 Surficial Geology Permeability

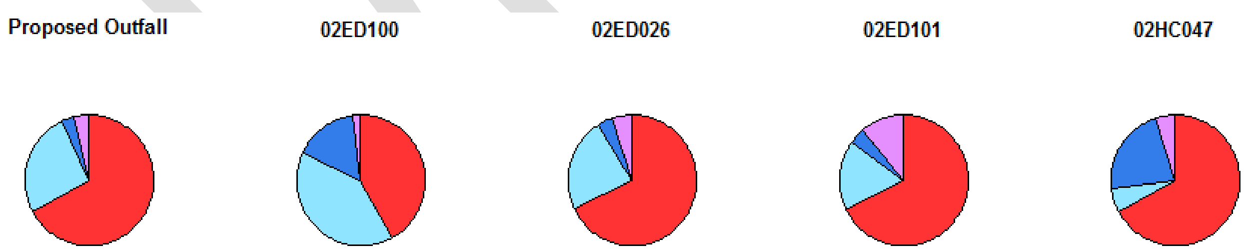

Figure A-13 Surficial Geology Permeability by Watershed

Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2482-7

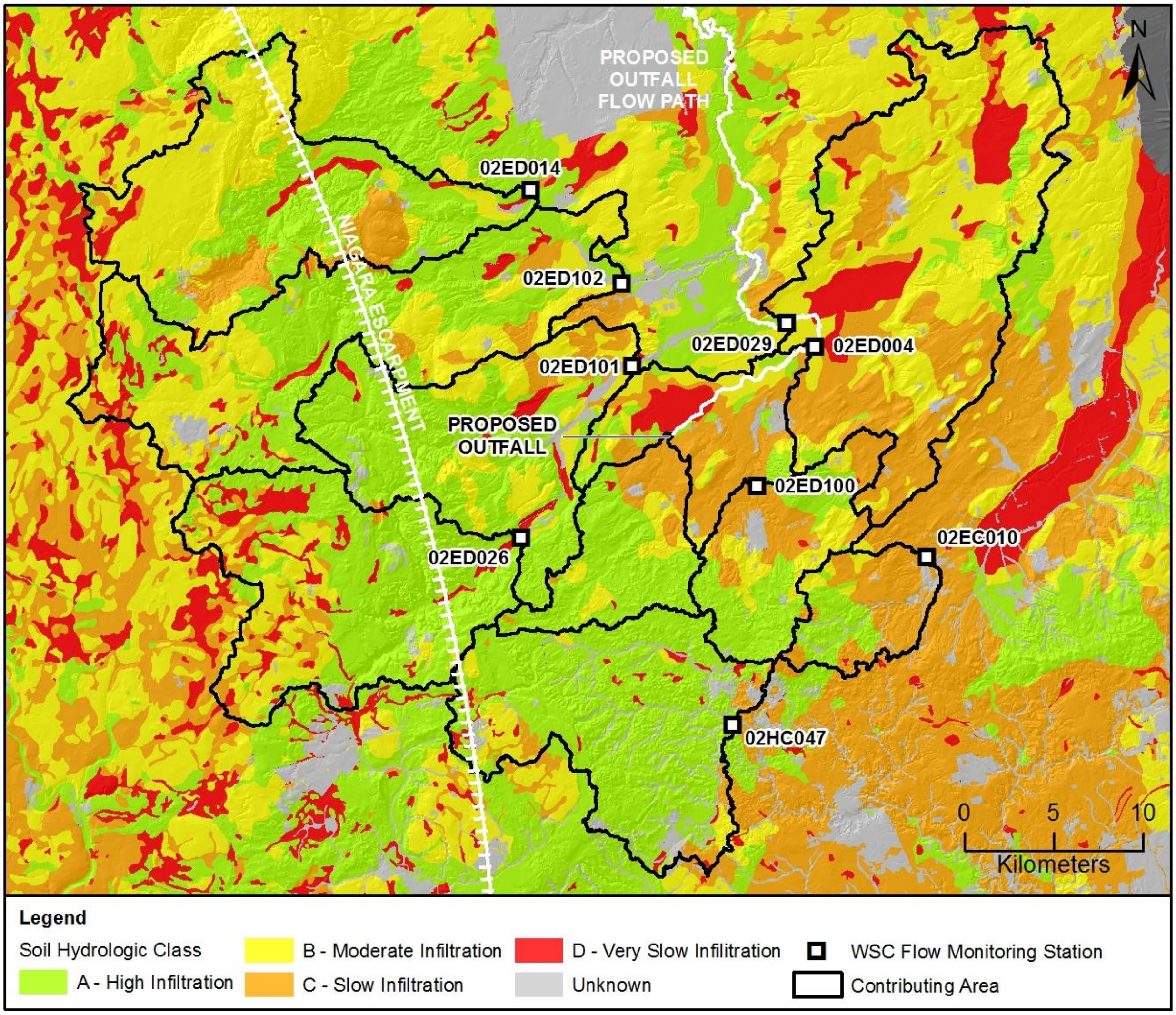

Figure A-14 Soil Hydrologic Class

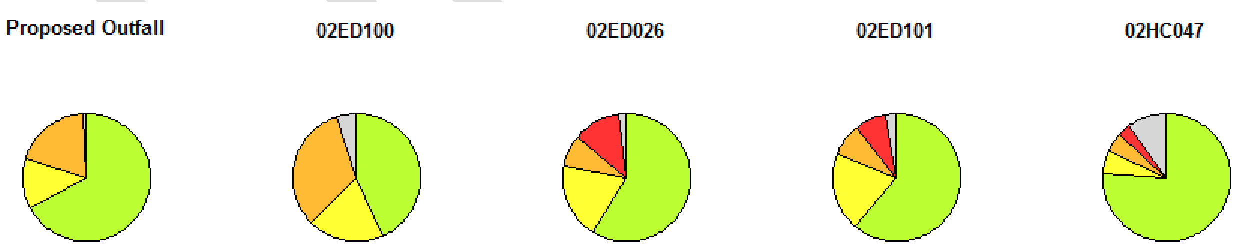

Figure A-15 Soil Hydrologic Class by Watershed

Ontario Ministry of Agriculture, Food and Rural Affairs 2015-11-20. Soil Survey Complex. https://www.javacoeapp.lrc.gov.on.ca/geonetwork/srv/en/main.home?uuid=86302406-ddff-4505-b3af-39c293a6702a

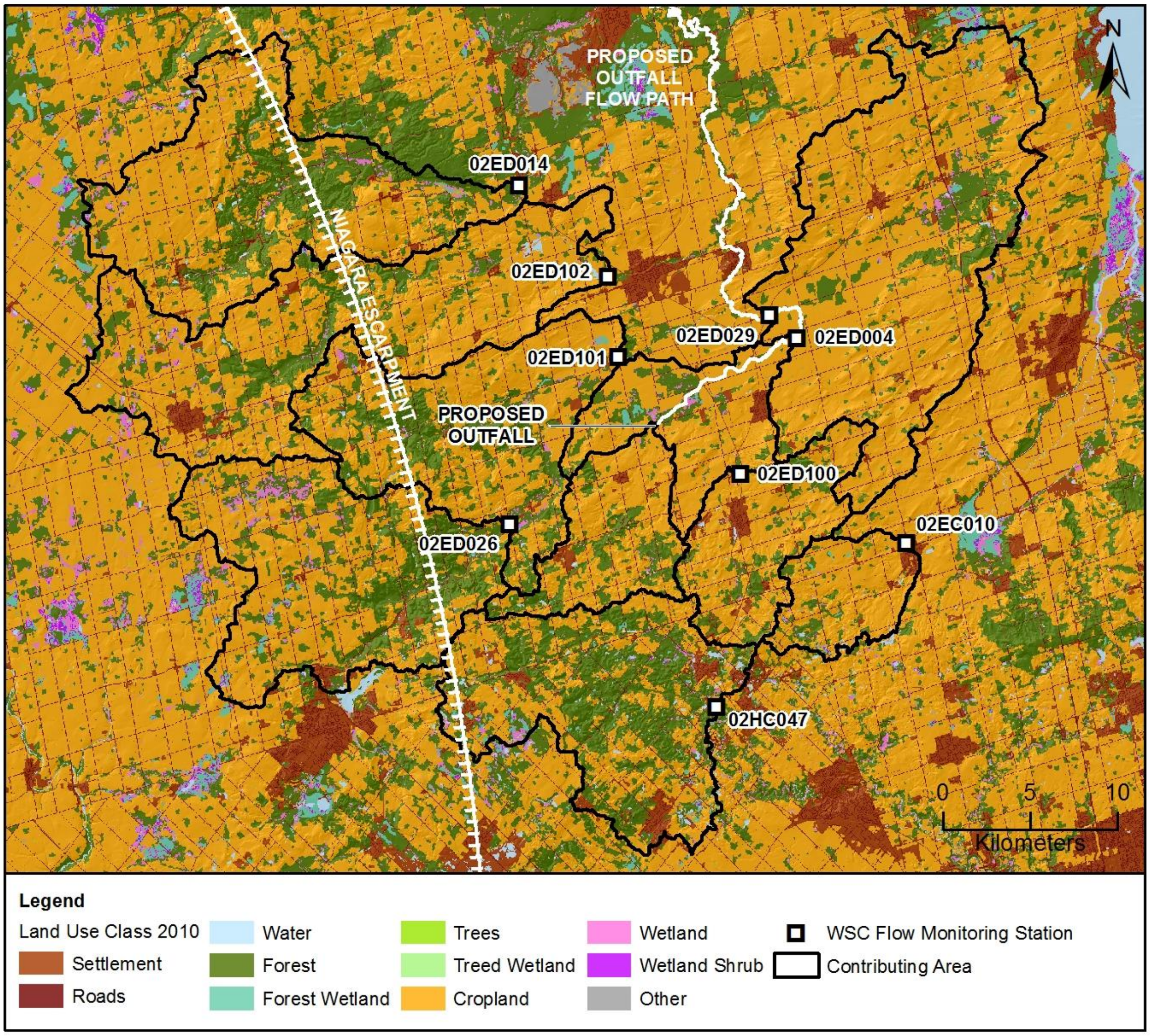

Figure A-16 Land Use 2010

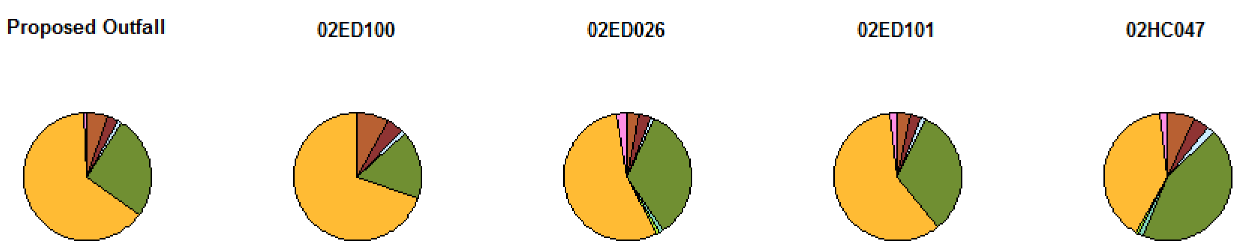

Figure A-17 Land Use 2010 by Watershed

Agriculture and Agri-Food Canada 2015-01-01, Land Use 2010.

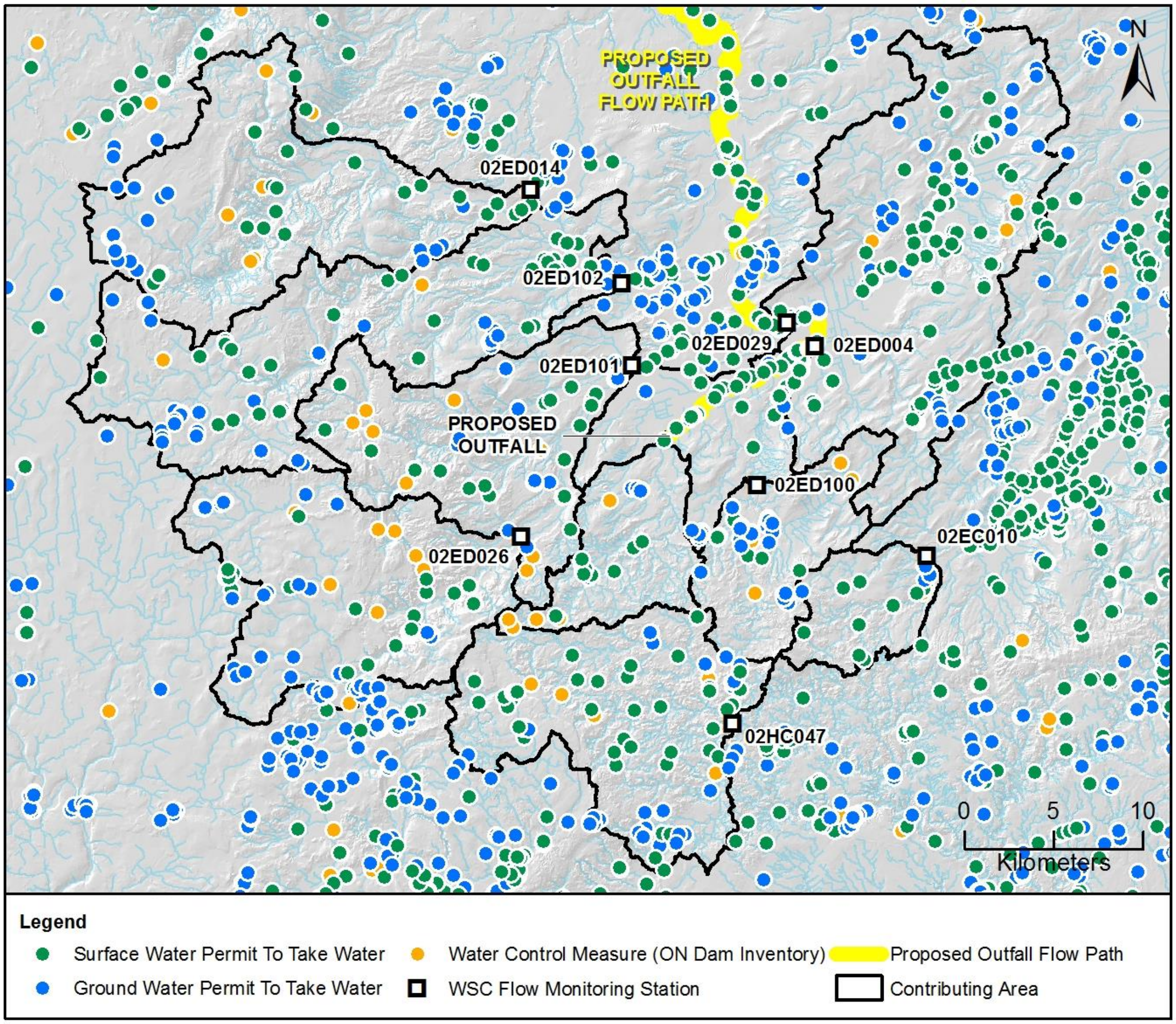

Figure A-18 Extractions and Control Measures

Ontario Ministry of Environment and Climate Change, 2013-11-16. Permit to take water.

Ontario Ministry of Natural Resources and Forestry, 2014-09-09. Ontario Dam Inventory.

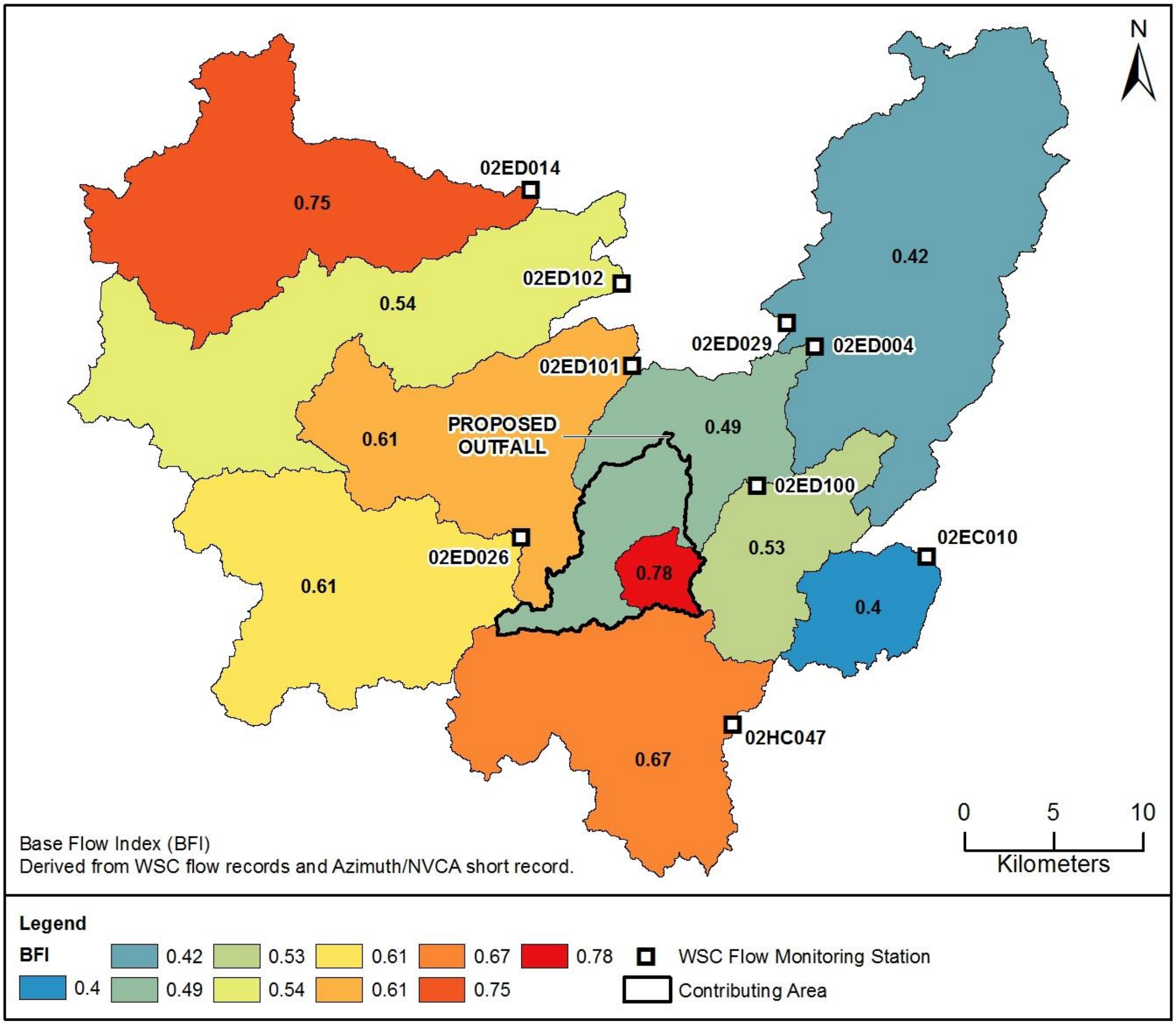

Figure A-19 Measured Base Flow Index

Water Survey of Canada, 2017. HYDAT database.

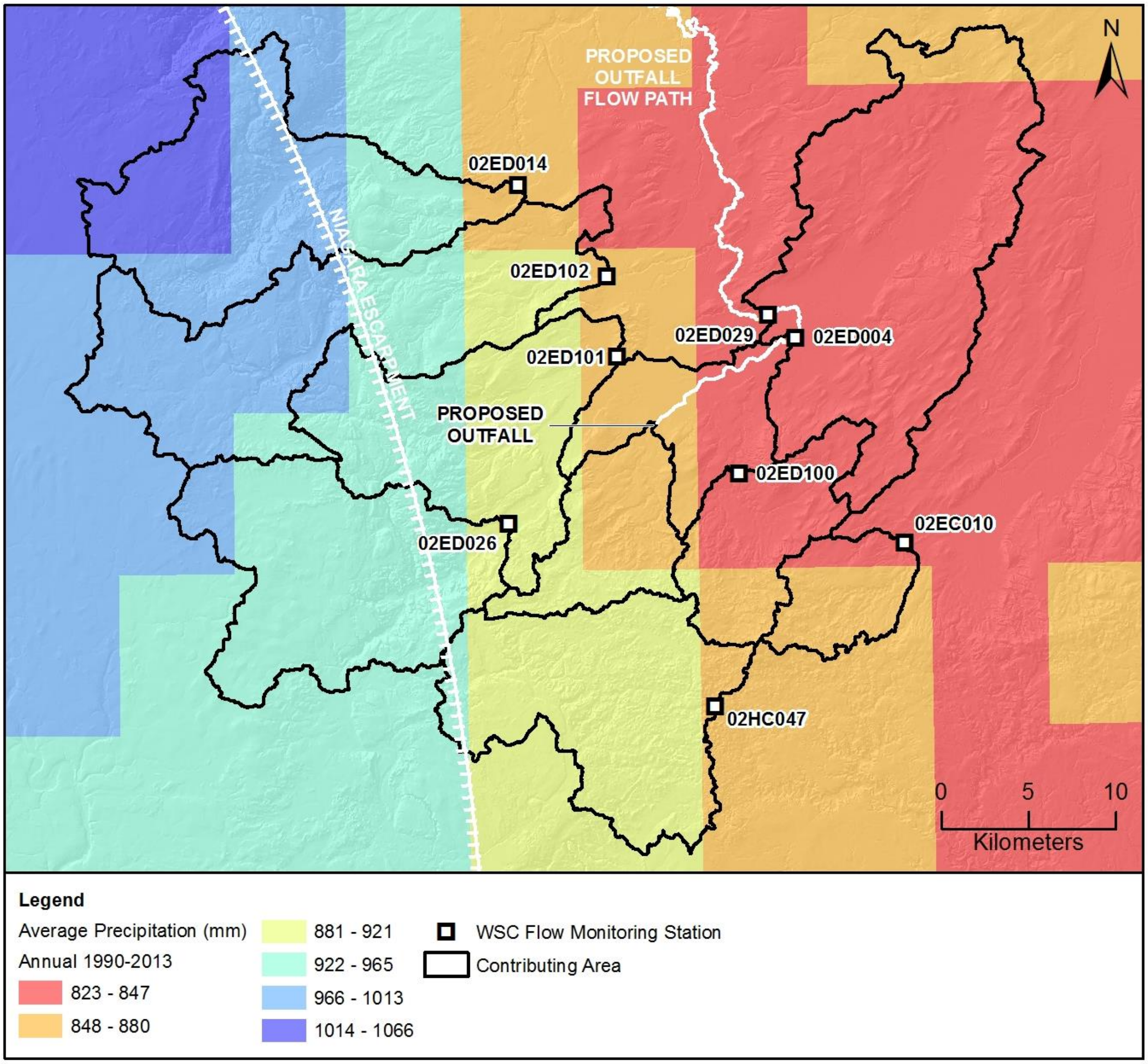

Figure A-20 Average Annual Precipitation 1990-2013

Natural Resources Canada, 2013. Regional Climate Modeling ANUSPLIN Gridded Daily
https://cfs.nrcan.gc.ca/projects/3/4

A-4 Mixing Analysis Calculation Details

Phosphorus

Point of Discharge (Using upstream baseflow WQ data only)			Point of Discharge (Using all available upstream WQ data)	
SCALED 7Q20	0.131	m3/s	0.131	m3/s
Safety factor	15%		15%	
7Q20 less safety factor	0.112	m3/s	0.112	m3/s
7Q20 less safety factor	112	l/s	112	l/s
Ambient 75th Percentile TP - (Low Flow Samples Only)	0.0238	mg/l	0.0293	mg/l
Effluent concentration	**0.120**	mg/l	**0.041**	mg/l
Effluent Flow to River	689.00	m3/day	689.00	m3/day
Effluent Flow to River	7.97	l/s	7.97	l/s
Annual loading rate	30	kg/yr	10	kg/yr
Mixed Conc.	0.030	mg/L	0.030	mg/L
PWQO (Policy 1)	0.030	mg/L	0.030	mg/L

Downstream		
7Q20 Flow 02ED029 Measured 2000-2015	0.06303	m3/s
Safety factor	0%	
7Q20 less safety factor	0.06303	m3/s
7Q20 less safety factor	63.03	l/s
Ambient 75th Percentile TP 102&202	0.074	mg/l
Effluent concentration	**0.074**	mg/l
Effluent Flow to River	689	m3/day
Effluent Flow to River	7.97	l/s
Annual loading rate	18.6	kg/yr
Mixed Conc.	0.074	mg/L
PWQO (Policy 2)	0.074	mg/L

Water quality can't realistically meet objective downstream
Policy 2 downstream means the effluent cannot excees downstream ambient concentration

Ammonia

Point of Discharge Mixing Analysis	Warm Condition		Cool Condition	
SCALED 7Q20	0.131	m3/s	0.131	m3/s
Safety factor	15%		15%	
7Q20 less safety factor	0.112	m3/s	0.112	m3/s
7Q20 less safety factor	112	l/s	112	l/s
75th Percentile Ambient In-stream TAN	0.0600	mg/l	0.0600	mg/l
Max Effluent concentration TAN	**2.086**	mg/l	**8.657**	mg/l
Effluent Flow to River	689.00	m3/day	689.00	m3/day
Effluent Flow to River	7.97	l/s	7.97	l/s
Annual loading rate	525	kg/yr	2177	kg/yr
Mixed Conc. Total Ammonia -N (TAN)	0.195	mg/L	0.634	mg/L
Mixed Conc. Total Ammonia (TAN/0.8224)	0.237393884	mg/L	0.770619333	mg/L
In-stream 75th percentile pH	8.33		8.33	
In-stream Temperature (Warm Condition)	21.3	C	5	C
pKa	9.36111873		9.90438975	
Fraction of un-ionized ammonia in Total Ammonia	0.085158343		0.025953151	
In-stream mixed Un-ionized Ammonia	0.020	mg/L	0.020	mg/L
PWQO (Policy 1) Un-ionized Ammonia	0.020	mg/L	0.020	mg/L

Nitrate

Mixing Analysis	Point of Discharge		Downstream	
CWQG	3	mg/L	3	mg/L
SCALED 7Q20	0.131	m3/s	0.063	m3/s
Safety factor	15%		0%	
7Q20 less safety factor	0.112	m3/s	0.063	m3/s
7Q20 less safety factor	112	l/s	63.0	l/s
Ambient 75th Percentile Nitrate	0.675	mg/l	1.55	mg/l
Effluent concentration	**35.5**	mg/l	14.5	mg/l
Daily discharge	689	m3/day	689.000	m3/day
Effluent Flow to River	7.97	l/s	7.975	l/s
Annual loading rate	170	kg/yr	390	kg/yr
Mixed Conc.	3.00	mg/L	3.00	mg/L

Appendix B - 2

Addendum to Assimilative Capacity Feasibility Study

Flow Regime Analysis – High Flow Considerations

Water Survey of Canada (WSC) flow stations 02ED004 and 02ED029 (Figure 1) were used for high flow consideration because they are located downstream of the Alternative Outfall location; their drainage area contains the Alternative Outfall location and they have adequate periods of record to assess high flows and frequency of occurrence. Although in close proximity to each other, these WSC stations have no over-lapping record period and 02ED029 has a much larger drainage area that includes contributions from the eastern portion of the watershed. Discontinuous flow records measured in 2008, 2009, 2010 and 2014 at County Road 14 were also considered. These records were only taken between May and October and therefore do not include flows from the spring freshet that would normally be associated with spring flooding conditions. As a result, the 95th percentile flows determined from this monitoring location are lower than they would otherwise be with a longer continuous record.

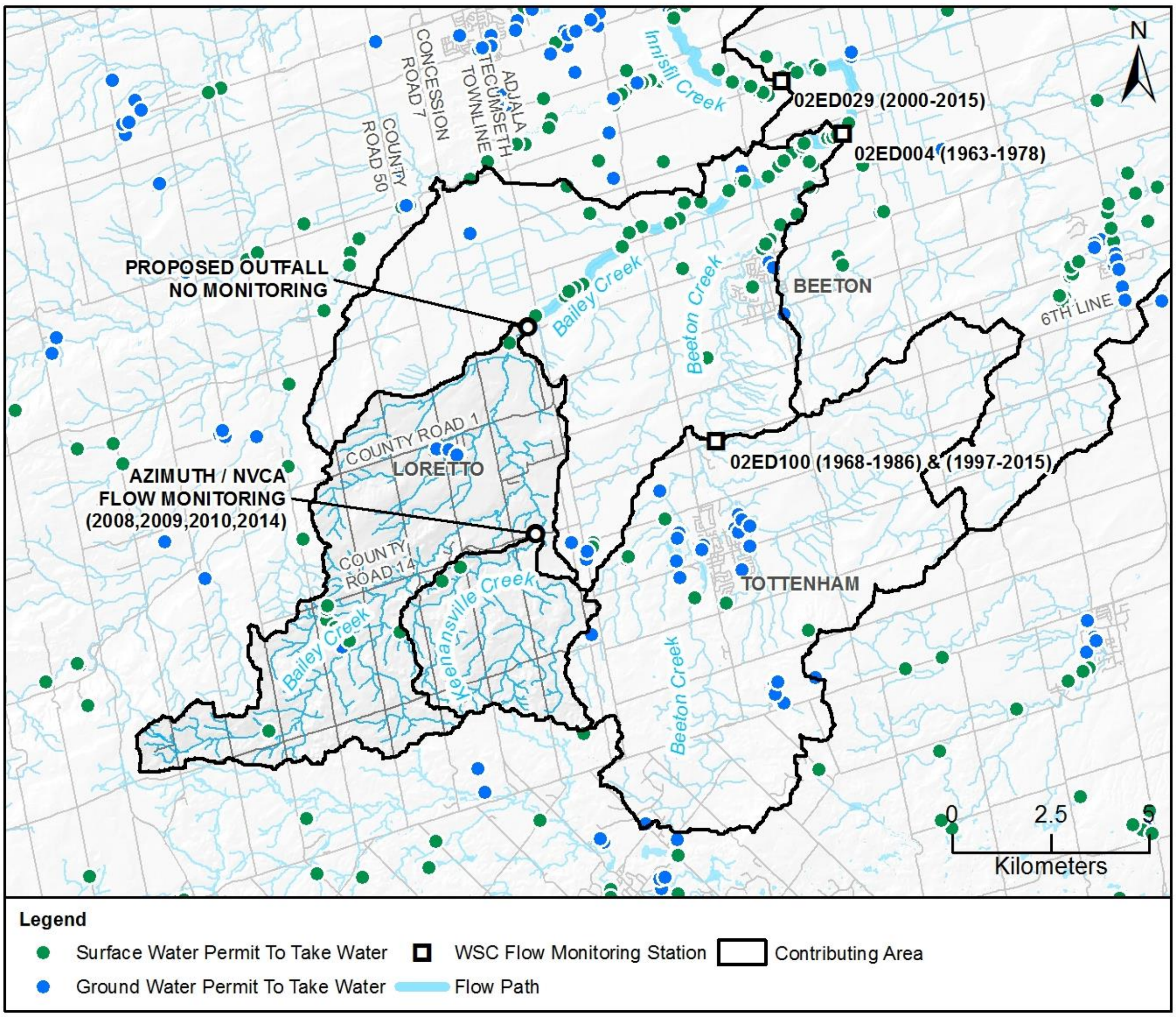

Figure 1 Catchment areas, water takings and Water Survey of Canada stations

As we do not know the exact locations of concern or the level of flow that produces flooding conditions, this assessment will serve as an indicator only.

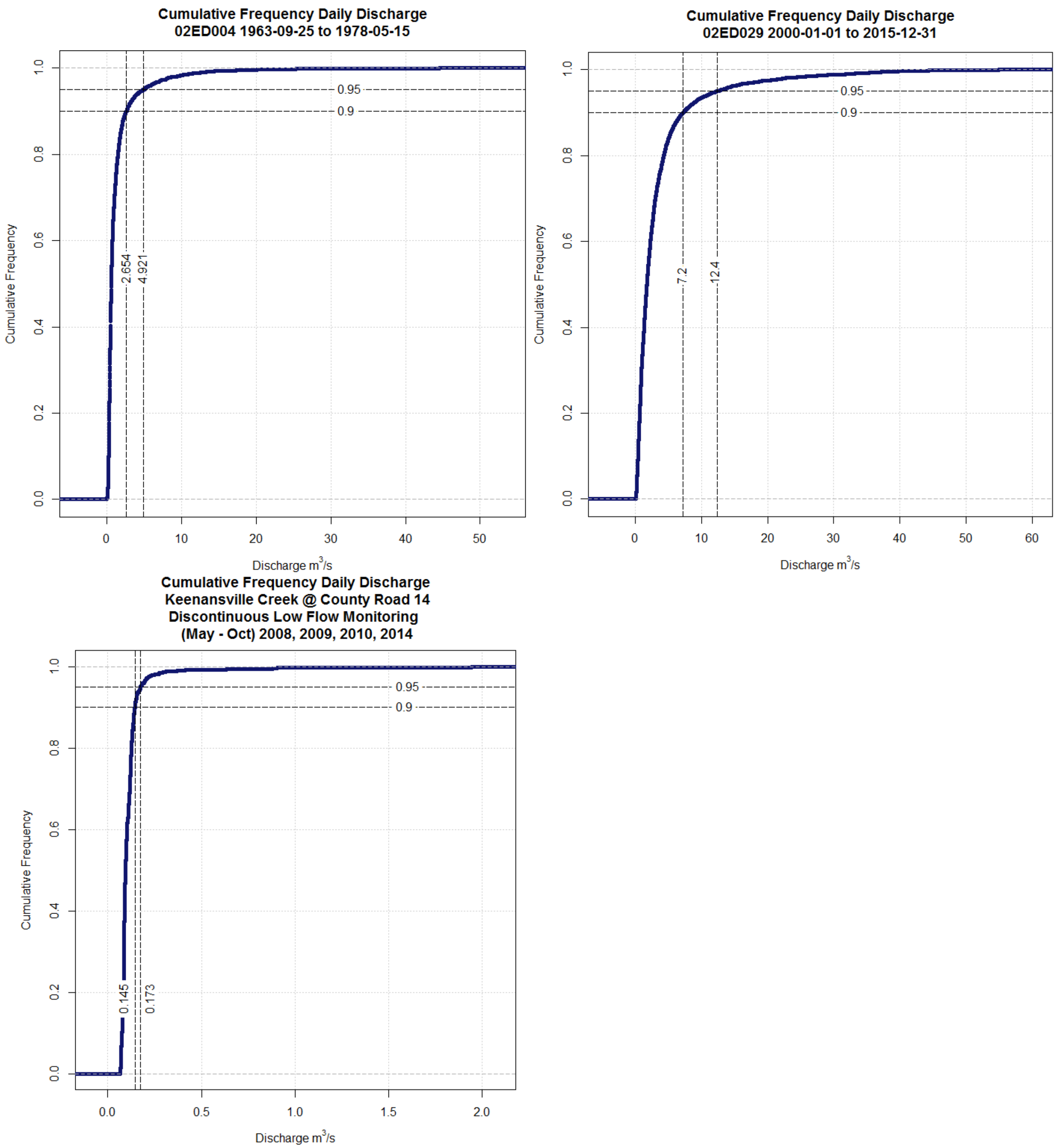

Figure 2 Cumulative frequency of discharge at WSC station 02ED004 (top left) and 02ED029 (top right), discontinuous low flow monitoring at County Road 14 (bottom).

Using the 95th percentile of flows from these stations, presented in Figure 2, Table 1 shows the relative contribution of the WWTP to total stream flow.

Table 1 Summary of flows and relative contribution of the WWTP

WSC Gauge	95th Percentile (High) Flow (m^3/s)	WWTP Contribution to Flow (m^3/s)	Percent of WWTP Flow in Cumulative Flow
02ED004	4.92	0.0078	0.15%
02ED029	12.40	0.0078	0.06%
Temporary Flow Station at CR14	0.173	0.0078	4.3%

From this assessment, it is evident that effluent flow from the proposed WWTP at the Alternative Outfall location will not likely contribute more than 4.3% percent of the flow under high flow conditions. The actual 95th percentile flow at this location would likely be higher with a longer, continuous flow record, therefore this is a conservative estimate. The highest flows measured by the temporary CR14 flow station did not likely coincide with flooding conditions. Under higher flow the WWTP contribution will be a lower percentage of the total flow.