Cornwall
ONTARIO CANADA

CORNWALL WASTEWATER TREATMENT PLANT
ENVIRONMENTAL ASSESSMENT UPDATE

TECHNICAL MEMORANDUM NO. 1B
ASSIMILATIVE CAPACITY ASSESSMENT OF THE ST. LAWRENCE RIVER

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1.0 INTRODUCTION

The Cornwall Wastewater Treatment Plant (WWTP) is owned and operated by the City of Cornwall. The plant provides primary treatment with chemical addition for enhanced treatment and phosphorus removal as well as disinfection. The existing WWTP has a Certificate of Approval (CofA) average day flow (ADF) capacity of 54,432 m^3/d and a peak design capacity of 108,900 m^3/d. Biosolids are treated onsite in an anaerobic digestion process and dewatered using centrifuges prior to disposal in the City's landfill.

The Cornwall WWTP was originally constructed in 1968 and has undergone several expansions since then. The WWTP serves approximately 46,000 people, services commercial and industrial properties, and receives leachate from five waste disposal sites. Plant ownership was transferred to the MOE in 1970, and then to the City of Cornwall in 2000. Plant expansion in 1988 resulted in the current plant layout.

Figure 1 presents and aerial image of the Cornwall WWTP.

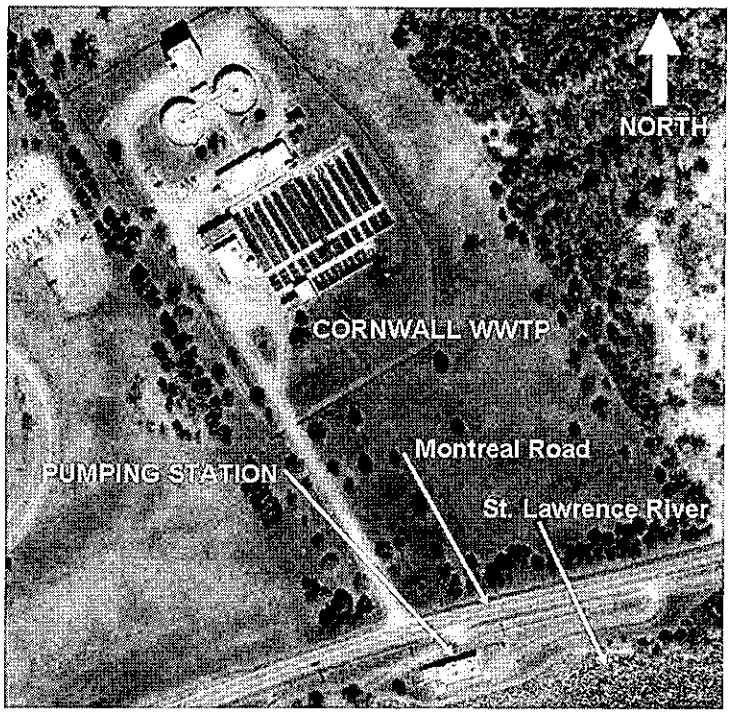


Figure 1 - Satellite photograph of the Cornwall WWTP (courtesy of GoogleMaps)

A Pollution Control Planning (PCP) study was undertaken in 1995 to address concerns raised as part of the Remedial Action Plan (RAP), which stemmed from the designation of the St. Lawrence River as an Area of Concern (AOC) by the Water Quality Board and the International Joint Commission. The PCP is currently being updated to reflect current conditions including a hydraulic assessment of critical sewer infrastructure and determine compliance with MOE Procedure F-5-5. In addition to other recommendations, the RAP recommended the following upgrades to the Cornwall WWTP:

- Upgrading the existing primary treatment plant to the equivalent of secondary treatment
- Achieve phosphorous removal to a compliance limit of 1.0 mg/L, with an objective of 0.5 mg/L
- Increase removal efficiency of other toxic contaminants
- Reduce bacteria levels

Following a plant-wide evaluation for required upgrades in 2003, a Schedule C Class Environmental Assessment (Class EA) for these upgrades was completed in 2005. As a result of the Class EA, a Biological Aerated Filter (BAF) system was recommended for the secondary treatment process upgrade and Ultraviolet (UV) irradiation was recommended for the disinfection system.

In May 2009, the City retained J.L. Richards & Associates Limited, in association with XCG Consultants Ltd and CH2M HILL Canada Limited to update the Class EA completed in 2005. The update is to revisit the preferred treatment technologies identified in the EA based on existing conditions and constraints and to provide updated construction and lifecycle cost estimates.

The purpose of this Technical Memorandum No. 1B (TM1B) is to assess the assimilative capacity of the St. Lawrence River. Other technical memoranda will be prepared to summarize various elements of the overall project. These technical memoranda will form part of the Environmental Study Report Addenda (ESR Addenda), which is anticipated to be the main project deliverable for this project.

1.1 Overview

An analysis of the assimilative capacity of the St. Lawrence River was undertaken to determine appropriate effluent limits for an upgraded City of Cornwall Wastewater Treatment Plant (WWTP), which discharges treated effluent into the St. Lawrence River. The Cornwall WWTP is currently operated by the City of Cornwall, under Ministry of the Environment (MOE) Certificate of Approval (C of A) number 0062-6VJTC, amended December 5, 2006. An upgrade of the WWTP to secondary treatment is proposed and currently a Class Environmental Assessment update is being undertaken.

The existing C of A would require amendment to reflect the changes. The amended C of A would define effluent requirements for the modified WWTP. In order to derive appropriate effluent limits, an assimilative capacity assessment of the receiving water was conducted. This assimilative capacity assessment utilizes available flow and water quality information to establish proposed effluent limits for the WWTP.

The design average day flow (ADF) capacity of the existing WWTP is 54,432 m^3/d. The proposed upgrade would see the ADF capacity increase to 65,318 m^3/d. Effluent from the treatment facility flows through an outfall pipe that extends approximately 610 m into the St. Lawrence River, at a depth of approximately 14.9 m. Effluent is discharged continuously to the river. ***Figure 2*** shows the approximate location of the City of Cornwall WWTP, and the discharge location.

This assimilative capacity assessment provides an analysis of in-stream water quality impacts of the existing WWTP, and for an upgraded WWTP, primarily in terms of un-ionized ammonia, total phosphorus, biochemical oxygen demand (BOD), dissolved oxygen (DO), chlorine residual, E.Coli and suspended solids. Proposed effluent limits for an upgraded system are provided based on results of the assimilative capacity assessment, as well as MOE Guidelines F-5, and the Canadian Environmental Protection Act (CEPA) requirements for ammonia and chlorine in wastewater effluents.

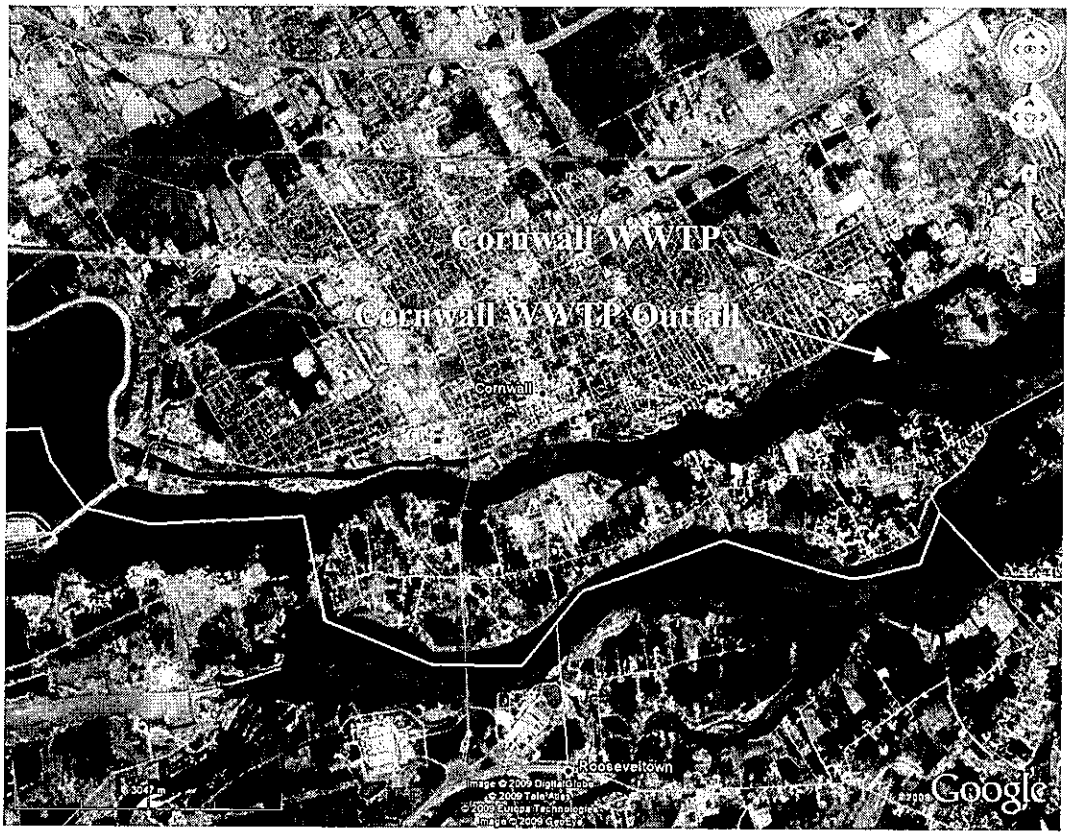


Figure 2 - Location Map of Cornwall WWTP and Outfall

1.2 Objectives

The objectives of this analysis are:

- to determine representative background water quality for the St. Lawrence River in the vicinity of the Cornwall WWTP outfall,
- to determine appropriate low-flow conditions for the St. Lawrence River, and
- to formulate recommendations for effluent limits for the proposed Cornwall WWTP upgrade.

1.3 General Approach

1. *Define Background Water Quality:* Representative background water quality can be defined by examining water quality in the vicinity of the wastewater discharge. For analysis purposes, the 75th percentile threshold is applied to characterize ambient conditions, as recommended by the MOE. The MOE (1994b) states "Normally the 75th percentile is used to determine background quality...".

2. *Define Low Flow:* Low-flow estimates are generated for each month using information obtained from a variety of sources. The flows determined are critical for defining the amount of dilution available.

3. *Assimilative Capacity Analysis:* In-stream water quality impacts are determined for each water quality parameter based on the effluent limits determined to be in compliance with MOE Guideline F-5, in-stream provincial water quality objectives (MOE, 1994c), and CEPA requirements are proposed. The assimilative capacity analysis addresses near and far-field water quality impacts. A mixing model such as the USEPA CORMIX model can be used for detailed assessment of mixing zone characteristics.

4. *Formulation of Recommended Effluent Limits*: Based on the work completed in steps one through three and with consideration to the Remedial Action Plan phosphorus removal related recommendations, effluent limits for the Cornwall WWTP can be generated.

2.0 ANALYSIS OF BACKGROUND DATA

2.1 Ambient Water Quality

Ideally, in establishing ambient water quality for a receiver, there are recent data available at a location in the vicinity of the discharge location. In the case of Cornwall WWTP, there is no single suitable data source for determining the ambient water quality. However, there are several sources of information that when combined form a realistic dataset that characterize the ambient water quality. The data sources that were applied in this study are summarized below in ***Table*** 1.

Table 1 – Flow Design Basis – 2005 ESR

Source	Location Relative to Outfall	Period of Record	Parameters of Interest
US Geological Survey (USGS) St. Lawrence River at Cornwall, Ontario, Near Massena, NY (#04264331)	10 km upstream	1996 - 2009	Dissolved oxygen, total suspended solids and turbidity
Drinking Water Surveillance Program (DWSP) - Cornwall	11 km upstream	1987 - 2009	NH_4, pH, total phosphorus, water temperature and turbidity.
Annual Reports – Cornwall Water Treatment Plant	11 km upstream	2007 - 2008	E. coli
St Lawrence River Institue of Environmental Sciences, *Contribution of E.coli and Other Indicator Bacteria to the Cornwall Water Purification Plant from Strachan Island and Associated Wildlife, June 2005.*	11 – 18 km upstream	2003 - 2004	E. coli and dissolved oxygen

Total Phosphorus

The MOE Provincial Water Quality Objectives (PWQO) state that the interim guideline for streams and rivers is that total phosphorus (TP) should not exceed 0.03 mg/L to prevent excessive plant growth.

The DWSP data source was used to examine ambient TP conditions. The dataset was comprised of just fewer than 100 samples. A review of the time series revealed a single outlier in the dataset; this value was an order of magnitude larger than any other observation and was therefore removed. Sample numbers on a monthly basis ranged from 2 – 11; with such small sample sizes it was deemed necessary to look at TP seasonally rather than monthly in order to gain a better representation of the 75th percentile. The seasonal statistics data are summarized in ***Table 2*** below. The table shows that at the 75th percentile concentrations, TP is below the PWQO and is therefore considered Policy 1 with respect to phosphorus, and the ambient water quality has additional assimilative capacity for this parameter.

It should also be noted that the WWTP discharges into an area of the St. Lawrence River which has special considerations for phosphorus under the Remedial Action Plan (RAP) St Lawrence River (Cornwall) Area of Concern. As such, any recommendations for wastewater effluent phosphorus concentrations must consider the RAP document.

Table 2 - Seasonal St. Lawrence River TP from Cornwall DWSP Data

Season	Mean TP (mg/L)	75th Percentile TP (mg/L)	Number of Observations
Winter (Jan – Mar)	0.009	0.010	24
Spring (Apr – Jun)	0.012	0.013	24
Summer (Jul – Sep)	0.015	0.016	25
Fall (Oct – Dec)	0.010	0.010	19

Note: There were four PWQO exceedances over the period of record

Un-Ionized Ammonia

The MOE PWQO for un-ionized ammonia is 0.02 mg/L (20 µg/L). The monthly or seasonal 75th percentile of the river pH, temperature, and total ammonia levels are required in order to obtain a conservative estimate of in-stream un-ionized ammonia concentrations.

The DWSP data were used to characterize the ambient 75th percentile pH (see ***Table 3***), temperature (see ***Table 4***) and ammonia (see ***Table 5***). Like the TP data there were limited samples on a monthly basis, as such pH and ammonia statistics were calculated on a seasonal basis while temperature was calculated monthly. Temperature was left on a monthly basis in order to generate a conservative temperature estimate for each season. The highest 75th percentile monthly temperature in a season was used to calculate seasonal un-ionized ammonia (see ***Table 6***). ***Table 6*** shows that the 75th percentile concentration for un-ionized ammonia is consistently below the PWQO of 0.02 mg/l by an order of magnitude or more and is therefore Policy 1 with respect to un-ionized ammonia, and the ambient water quality has significant assimilative capacity for ammonia.

Table 3 - Seasonal St. Lawrence River Water pH from Cornwall DWSP Data

Season	Mean pH	75th Percentile pH	Number of Observations
Winter (Jan – Mar)	7.7	7.9	25
Spring (Apr – Jun)	7.8	7.9	24
Summer (Jul – Sep)	7.9	8.0	26
Fall (Oct – Dec)	7.8	7.8	20

Note: pH always fell within PWQO range of 6.5 – 8.5

Table 4 - Monthly St. Lawrence River Water Temperature from Cornwall DWSP Data

Month	Mean Temperature (°C)	75th Percentile Temperature (°C)	Number of Observations
January	1.4	1.4	10
February	1.4	1.9	8
March	1.3	1.7	7
April	3.5	4.0	2
May	10.9	12.0	12
June	14.9	15.9	11
July	20.6	21.0	6
August	24.2	24.8	2
September	18.8	19.6	18
October	13.0	13.5	7
November	8.1	8.8	6
December	3.5	4.5	7

Table 5 - Seasonal St. Lawrence River Total Ammonia from Cornwall DWSP Data

Season	Mean Total Ammonia as N (mg/L)	75th Percentile Total Ammonia as N (mg/L)	Number of Observations
Winter (Jan – Mar)	0.011	0.016	24
Spring (Apr – Jun)	0.013	0.016	22
Summer (Jul – Sep)	0.015	0.016	26
Fall (Oct – Dec)	0.010	0.013	19

Table 6 - Seasonal St. Lawrence River Un-Ionized Ammonia from Cornwall DWSP Data

Season	75th Percentile pH	75th Percentile Temperature (°C)	75th Percentile Total Ammonia as N (mg/L)	75th Percentile Un-ionized Ammonia (mg/L)
Winter (Jan – Mar)	7.9	1.9 (Feb)	0.016	0.000
Spring (Apr – Jun)	7.9	15.9 (Jun)	0.016	0.000
Summer (Jul – Sep)	8.0	24.8 (Aug)	0.016	0.001
Fall (Oct – Dec)	7.8	13.5 (Oct)	0.013	0.000

BOD

There were no data on BOD_5 from any of the data sources examined, however, the levels are expected to be low (<2 mg/L), as such a conservative estimate for BOD_5 would be 2 mg/L.

Dissolved Oxygen

As described in ***Table 1*** there were two available sources of dissolved oxygen data; the USGS station data and the St. Lawrence River Institute data. Both datasets are somewhat limited in that the USGS station has few measurements and the St. Lawrence River Institute data has many measurements at numerous locations but only for a few days. For the purposes of this analysis the two datasets were combined and summary statistics were calculated (see ***Table 7***).

For dissolved oxygen (DO), low concentrations are indications of degraded water quality; therefore 25^{th} percentiles are used, rather than 75^{th} percentiles, to characterize ambient conditions. The PWQO for DO, for warm water fisheries, varies from 4 mg/L during the summer to 7 mg/L during the winter, depending on temperature. The DO concentrations reported in ***Table 7*** show that the 25^{th} percentile concentrations and the minimum observed concentrations are much higher than the PWQO for DO. This indicates that the St. Lawrence River ambient water quality is Policy 1 with respect to DO. The high DO levels are consistent with the low

BOD_5 concentrations that have been assumed to exist in the river (above) and imply that there is significant assimilative capacity for BOD_5 in the river.

Table 7 - Seasonal St. Lawrence River Dissolved Oxygen from USGS and St. Lawrence River Institute Data

Season	Minimum Observed Dissolved Oxygen (mg/L)	25th Percentile Dissolved Oxygen (mg/L)	Number of Observations
Winter (Jan – Mar)	13.2	13.7	4
Spring (Apr – Jun)	9.4	9.9	33
Summer (Jul – Sep)	7.6	9.2	16
Fall (Oct – Dec)	9.2	9.4	15

Total Suspended Solids

The only data available for total suspended solids (TSS) was obtained from the USGS station. The USGS station had a very limited number of data points however, on the days these samples were taken turbidity was also measured. TSS was plotted against turbidity and it was found that TSS could be estimated as 1.5 x turbidity (see ***Figure 3***; note the black line indicates the 1.5 x turbidity envelope).

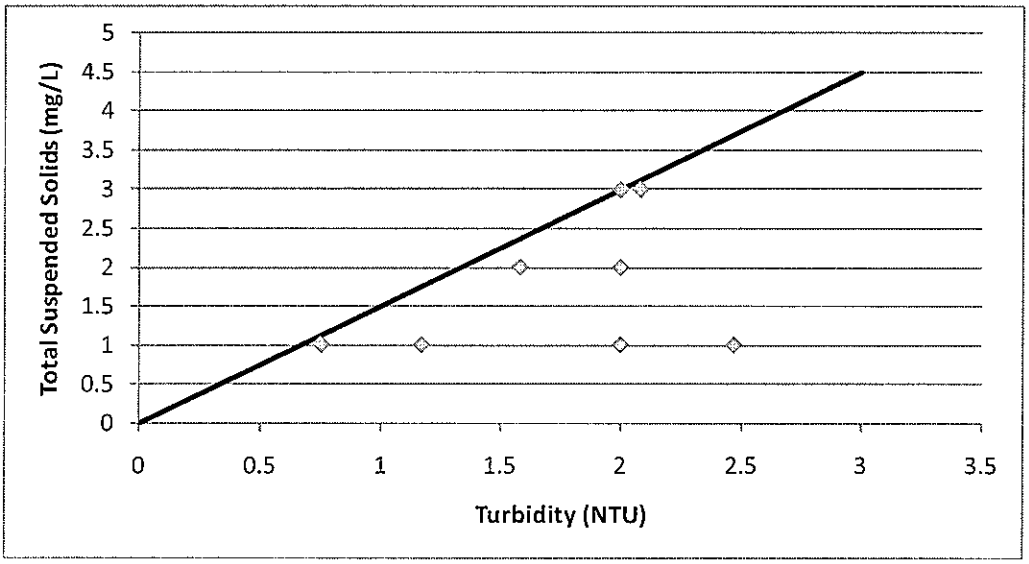


Figure 3 - Relationship between TSS and Turbidity (USGS Station Data)

With this simple ratio defined it was then possible to convert the turbidity values measured in the DWSP dataset to TSS. The newly generated TSS dataset identified a decreasing trend with time. To generate a dataset that was more consistent with existing conditions the dataset was truncated prior to April 1988. The truncated TSS statistics are summarized in ***Table 8*** and show that low concentrations exist. Although there is no PWQO for TSS concentrations, in-stream levels of less than 5 mg/L are generally considered good in streams and rivers.

Table 8 - Seasonal St. Lawrence River TSS from Cornwall DWSP Data

Season	Mean Total Suspended Solids (mg/L)	75th Percentile Total Suspended Solids (mg/L)	Number of Observations
Winter (Jan – Mar)	0.6	0.8	22
Spring (Apr – Jun)	1.4	1.9	24
Summer (Jul – Sep)	2.0	1.8	24
Fall (Oct – Dec)	1.0	1.1	16

Note: note TSS was calculated by multiplying turbidity values by 1.5

E.Coli

Monthly average E.coli data collected from the water treatment plant annual reports for 2007 and 2008 were examined. The raw water E.Coli values reported are consistently below the PWQO of 100 cfu/100 mL. The reports also identify the maximum concentrations observed over each period. For 2007 the range was <1 – 82 CFU/100mL (52 samples) and for 2008 the range was <1 – 45 CFU/100mL (53 samples). These results indicate the St. Lawrence River ambient water quality is Policy 1 for E.coli. This was further confirmed by the sampling completed by the St. Lawrence River Institute where values ranged from 10 – 60 CFU/100 mL.

2.2 River Flow Analysis

Generally, an assimilative capacity analysis is undertaken using low-flow estimates (7Q20 flow) generated for the receiving water at the location of the WWTP discharge. However, the St. Lawrence River is a regulated system, with outflows controlled at Cornwall by the Great Lakes – St. Lawrence River Regulation Office of Environment Canada. Outflows have been regulated since 1960. The immense storage capacity of the Great Lakes, in combination with the restricted outflows, allows the lakes to absorb large variations in water supplies, while maintaining very steady outflows compared with other large rivers. The maximum St. Lawrence River flow is only 2.3 times greater than its lowest rate (Great Lakes Information Network, 2003). Also, high and low water levels in the lakes, and in the St. Lawrence River can persist for a considerable length of time, even when water supplies change significantly. For these reasons, the use of 7Q20 estimates for St. Lawrence River low flows are not appropriate.

An alternative to 7Q20 low flows for the St. Lawrence River are the "M Limit" outflows. Since the International St. Lawrence River Board of Control regulates the outflows with Regulation Plan 1958-D with discretionary authority to deviate when warranted, low flows are defined by the lower limits of the Plan in most instances. These M Limit outflows are defined as the minimum total Lake Ontario outflow at Cornwall to ensure adequate power generation (during the winter months) and to satisfy navigation and riparian needs during the rest of the year (Caldwell, 2003). Although there have been a few instances in recent years when the Board discharged less than the M Limit outflows (as low as 4,800 m^3/s), it is a rare occurrence. Therefore, for the purposes of the Cornwall WWTP assimilative capacity assessment, the M Limit outflows were used as representative of low flow conditions.

Once the river flows through the dam it splits around Cornwall Island. The flow splits with approximately 71% going south and 29% going north[1] past the Cornwall WWTP. As such flows going over the dam are multiplied by 0.29 to be representative in the vicinity near the WWTP.

The monthly M Limit outflows at Cornwall and the estimated flows passing Cornwall WWTP are provided in ***Table 9***.

Table 9 - Monthly Low Flows for the St. Lawrence River

Month	M Limit Outflow at Cornwall (m^3/s)	Estimated Flow Passing Cornwall WWTP (m^3/s)
January	5,950	1,730
February	5,860	1,700
March	5,780	1,680
April	5,320	1,540
May	5,320	1,540
June	5,380	1,560
July	5,470	1,590
August	5,470	1,590
September	5,470	1,590
October	5,470	1,590
November	5,610	1,630
December	5,950	1,730

[1] Morin, Jean, et al., 2000. *Pristine Lake Saint-Francois, St. Lawrence River: Hydrodynamic Simulation and Cumulative Impact.*

3.0 ASSIMILATIVE CAPACITY ANALYSIS

3.1 Analysis of Allowable Discharge Flow

A design average day effluent flow rate for the Cornwall WWTP was adopted as 65,318 m^3/d for assimilative capacity assessment purposes. As shown in ***Table 9*** above, the lowest flows in the St. Lawrence River occur during the months of April through October. Seasonal variability in flow in the St. Lawrence River is very low, however, compared to most other rivers. Even during the low flow months, the St. Lawrence River flow rates are orders of magnitude greater than the WWTP effluent flow.

Using the low flow estimates for the St. Lawrence River passing Cornwall WWTP as described in Section 2, the available dilution ratios of river to effluent flow were calculated on a monthly basis. The prorated St. Lawrence River flows were converted to m^3/d, and then divided by the design average effluent flow rate of 65,318 m^3/d to obtain dilution ratios. Dilution ratios are very high during all months of the year, ranging from 2,000:1 to 2,200:1. Therefore, the assimilative capacity of the river is considerable, even at low flows. The low-flow dilution ratios obtained were used to predict downstream concentrations of the key water quality parameters, un-ionized ammonia, total phosphorus, BOD_5, and TSS.

3.2 Un-Ionized Ammonia

For ammonia limits, it was assumed that current MOE policy requiring a non-toxic effluent would apply. Extensive research by the US EPA and others has demonstrated that a non-toxic limit for un-ionized ammonia ranges between 0.1 and 0.5 mg/L depending on the fish species of interest. Therefore, a conservative non-toxic limit for un-ionized ammonia in the Cornwall WWTP effluent is 0.1 mg/L.

For calculating effluent toxicity, estimates of the pH and temperature of the effluent itself are required. For this purpose, effluent pH and influent temperature data from the Cornwall WWTP from 2006 to 2009 were used. Effluent temperature readings were not available; to create a conservative effluent temperature estimate the influent temperatures were increased by 3°C. It is not anticipated that the addition of secondary treatment would have a significant impact on effluent temperature and pH and therefore the existing effluent data is suitable for ammonia limit determination.

Seasonal un-ionized ammonia concentrations at the end of pipe were estimated by iterating the Non-Acutely Lethal Concentration (NALC) of ammonia in conjunction with the seasonal 75th

percentile pH values and the highest 75th percentile monthly temperature value in a given season (see ***Table 10***).

Canadian Environmental Protection Act (CEPA) requirements for ammonia were considered also. CEPA defines ammonia as "toxic" under Section 64 of CEPA due to its deleterious effect on several species of freshwater organisms, and ammonia appears on the Priority Substances List (PSL). Also, if total ammonia (NH_3 + NH_4^+) in the effluent exceeds 20 mg/L (or 16 mg/L NH_3-N) during the months of June through the end of September, and pH exceeds 7.5, CEPA would require preparation of a pollution prevention plan. These limits are applicable for wastewater flows in excess of 5,000 m^3/d. As shown in ***Table 10***, the limits required for Non-Toxic Effluent for the Cornwall WWTP will meet CEPA requirements.

Table 10 - Proposed Seasonal Ammonia Limits

Season	NALC Total Ammonia as N (mg/L)	75th Percentile pH	75th Percentile Temperature (°C)	75th Percentile Un-ionized Ammonia (mg/L)
Winter (Jan – Mar)	9	7.66	13.0 (Jan)	0.095
Spring (Apr – Jun)	7	7.56	20.0 (Jun)	0.092
Summer (Jul – Sep)	7	7.39	25 (Aug)	0.096
Fall (Oct – Dec)	11	7.29	22 (Oct)	0.097

NALC- Non-Acutely Lethal Concentration (as predicted)

An analysis was conducted to determine the extent of the mixing zone for un-ionized ammonia using the estimated NALCs in ***Table 10***. The results of the mixing zone analysis are discussed in Section 4.

3.3 Total Phosphorus

The Cornwall WWTP discharges into an area of the St. Lawrence River which has special considerations for phosphorous under the Remedial Action Plan (RAP) St. Lawrence River (Cornwall) Area of Concern. One of the issues identified in the RAP is the excessive growth of

nuisance aquatic plants caused, in part, by excessive nutrient availability. The RAP identified in recommendations 28 and 29 that WWTP facilities upstream of Cornwall and Glen Walter (downstream of Cornwall) have a compliance level of 1 mg/L, with an objective of 0.5 mg/L for phosphorous. In keeping with the RAP and discussions with the MOE it is suggested that there be no net increase in phosphorus loading from the Cornwall WWTP. The plant effluent ADF is planned to increase by approximately 20% as such the compliance limit should similarly decrease by 20%. Based on the above, the recommended compliance limit for phosphorous is 0.8 mg/L with a design objective of 0.5 mg/L. It is noteworthy that the resulting TP loading at the proposed rated capacity of 65,315 m^3/d and the objective concentration of 0.5 mg/L, is less than the current effluent TP loading (based on average 2007-8 average operating conditions of 48,071 m^3/d and 0.77 mg/L effluent TP).

3.4 BOD and Dissolved Oxygen

As discussed above, the St. Lawrence River is Policy 1 with respect to DO and significant assimilative capacity is available for BOD_5. The proposed BOD_5 compliance limit is 25 mg/L (MOE Guideline F-5). Using the proposed effluent BOD_5 limit of 25 mg/L, an assumed upstream 75th percentile for BOD_5 of 2.0 mg/L, and the available low-flow dilution ratios, the maximum downstream BOD_5 concentration after mixing is 2.01 mg/L. Therefore the impact of BOD_5 in the effluent on downstream DO levels is minimal during all months of the year.

3.5 Total Suspended Solids

It is proposed that the effluent TSS compliance limit be set at 25 mg/L. Using the proposed effluent, upstream 75th percentile for TSS, and the available low-flow dilution ratios, the TSS are expected to increase by less than 2%. Based on such a small increase it is expected that effluent discharge on TSS levels in the river will be negligible.

3.6 Effluent Disinfection

The current (2004) CEPA effluent total residual chlorine limit is 0.02 mg/L. Based on a brief review of available literature, a de-chlorination system design objective of 0.02 mg/L with a compliance limit of 0.04 mg/L would be appropriate.

Sewage discharges to surface waters can constitute a significant input source of pathogens to the receiving waters. Therefore, to protect the recreational use of the St. Lawrence River in the vicinity of the Cornwall WWTP, it is proposed that a compliance level for E.coli be set at an annual geometric mean of 200 CFU / 100 mL.

4.0 MIXING ZONE ANALYSIS

4.1 Introduction

An analysis was conducted to determine the length of the mixing zone for ammonia in the effluent of the Cornwall WWTP. A mixing zone is defined as an area of water contiguous to a point source where water quality does not comply with one or more PWQOs. A mixing zone must be designed to be as small as possible and is one factor in establishing effluent requirements. Conditions within a mixing zone must not result in toxic conditions or interfere with water supply, recreational or other water uses[2]. The analysis was conducted based on an average day flow (ADF) of 65,318 m^3/d.

4.2 Methodology

The analysis was conducted using the U.S. Environmental Protection Agency (EPA) mixing zone model Cornell Mixing Zone Expert System CORMIX Version 5.0.3. Since the Cornwall WWTP outfall is a submerged multi-port discharge, CORMIX2 was used to simulate the plume. The model was used to predict the extent of the mixing zone downstream of the discharge for ammonia.

The model was run for a winter scenario (January-March), spring scenario (April-June), summer scenario (July-September) and fall scenario (October-December) at worst-case M Limit outflows passing Cornwall, as discussed in Section 2.2. This conservative estimate of flow was used to determine the mixing zone.

As previously discussed, background ammonia, pH and temperature levels in the St. Lawrence River near Cornwall were based on DWSP data from the station located approximately 11 kilometres upstream of the outfall. However, pH and temperature data used in the un-ionized ammonia calculations were first mixed with current 75th percentile effluent data from the Cornwall System.

[2] Ministry of Environment, 1994. *Water Management – Policies, Guidelines and Provincial Water Quality Objectives.*

[3] Doneker, R.L, and G.H. Jirka, 2007. *A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters.* EPA-823-K-07-001, U.S. Environmental Protection Agency, Washington DC.

The estimated future effluent total ammonia NALC concentrations are 9 mg/L for January to March, 7 mg/L for April to June, 7 mg/L for July to September and 11 mg/L for October to December.

Using monthly ambient river conditions and current effluent discharge concentrations, the total ammonia concentration that would achieve the PWQO of 0.02 mg/L of un-ionized ammonia was calculated. These values were input into CORMIX as the water quality standard for ammonia.

For water temperatures, CORMIX does not allow temperatures below 4°C. Therefore the winter temperature was adjusted upwards to a temperature with the equivalent density (maximum density of water is at 4°C). For winter, a temperature of 6.1°C has the same density as 1.9°C, therefore this was the assumed equivalent temperature.

Drawings provided to XCG (in particular Drawing No. 1-3, Ontario Water Resources Commission Project SP-66-1: City of Cornwall, drawn by Gore and Storrie Limited, March 1967; see **Appendix A**) provided outfall section notes and indicated the high water level as of April 19, 1961. River geometry was obtained from a nautical chart published by the Canadian Hydrographic Service (2008) of the St. Lawrence River at Cornwall. River top width and cross-section were estimated from the chart and this information was used to determine an equivalent rectangular cross-section geometry, required for CORMIX.

This existing outfall consists of a unidirectional multi-port diffuser aligned approximately perpendicular to the shoreline. The original installation drawing indicates that five of the nine diffuser ports are in operation; however, the future scenario was modeled having all nine ports open. The ports are elevated and opened in a unidirectional pattern along the diffuser length. Port openings are 0.203 metres (8 inches) in diameter and extend approximately 0.305 metres (12 inches) above the river bottom. The ports are oriented at 90° to the pipe, facing east, with a horizontal angle of 0°. The mid-point of the diffuser is located 597 m from the shoreline, and is 13.7 m in length. The inputs for the CORMIX analysis are shown in ***Table 11***.

Table 11 - CORMIX Input Values - Cornwall WWTP

Model Input	Winter	Spring	Summer	Fall
Ambient Parameters				
Ambient Flow (m^3/s)	1680	1540	1590	1590
Average depth at discharge (m)	8.0	8.0	8.0	8.0
Ambient River pH (75th percentile)	7.9	7.9	8.0	7.8
Ambient 75th percentile River Temperature (°C) (adjusted value in brackets)	1.9 (6.1)	15.9	24.8	13.5
Ambient 75th percentile Total NH3 (mg N/L)	0.016	0.016	0.016	0.013
Ambient Total NH3 (mg/L) – to meet PWQO of un-ionized ammonia of 0.020 mg/L	2.70	0.87	0.37	1.25
Future Condition Parameters				
Future Effluent Flow (m^3/s)	0.76	0.76	0.76	0.76
Diffuser Length (m)	13.7			
Number of Ports	9			
Port Diameter (m)	0.2032 (8")			
Port Height (m)	0.3048 (12")			
Nozzle Arrangement	Unidirectional			
Diffuser Alignment Angle	90			
Vertical Discharge Angle	90			
Horizontal Discharge Angle	0			
Relative Orientation Angle	90			
Effluent Total NH3 (mg/L) – Proposed future	9	7	7	11

4.3 Results

The CORMIX results for ammonia under future conditions are shown in ***Table 12.***

Table 12 - Results of Mixing Zone Modelling for Un-Ionized Ammonia

Scenario	Mixing Zone Length (m)			
	Winter	Spring	Summer	Fall
Future Conditions	1.4	4.0	26	28

Note: Results presented for Table 12 input values and conditions

At future conditions, the water quality standard for ammonia was reached within the near-field region (NFR, zone of strong initial mixing) in all seasons, thus mixing zones are very small. It is also noteworthy to point out that the model analysis predicts PWQOs for un-ionized ammonia are met well prior to a major river convergence at the east point of Cornwall Island which occurs approximately 1 km downstream of outfall. The river flow and associated available dilution ratios increase significantly at this point.

4.4 Summary

Based on the mixing zone analysis, the proposed limits for ammonia, as shown in ***Table 10*** (Section 3.2), are reasonable in extent.

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Summary of Findings

Key findings of this assimilative capacity assessment analysis are:

- Based on available water quality records for stations near Cornwall, this portion of the St. Lawrence River is MOE Policy 1 with respect to TP, un-ionized ammonia, BOD_5, DO and TSS during all months.

- The St. Lawrence River has the capability to provide assimilative capacity for loadings of all parameters assessed in this study: TP, un-ionized ammonia, BOD_5, DO and TSS from the Cornwall WWTP.

- To be consistent with the governing RAP for the St. Lawrence River (Cornwall) Area of Concern document it has been recommended that there be no net increase in TP loading. To achieve no net increase in loading the recommended compliance limit is 0.8 mg/L with a design objective of 0.5 mg/L.

- There are currently no ammonia limits for the Cornwall WWTP. The predicted Non-acutely lethal concentration (NALC) for effluent ammonia ranges from 7 – 11 based on the season. The NALC was solved iteratively using 75th percentile effluent pH and temperature values to calculate an un-ionized ammonia concentration that approached the criteria of 0.1 mg/L; the resulting NALCs for ammonia are considered conservative. It is proposed that the NALCs be used as the compliance limit for ammonia; with the provision that the discharge be non-acutely lethal.

- Mixing zone analysis was conducted for total ammonia for winter, spring, summer and fall scenarios. The results indicated that the predicted seasonal mixing zones are reasonable in extent for proposed future conditions.

Table 13 presents proposed effluent requirements for the Cornwall WWTP, based on the analysis presented in this Technical Memorandum. This Memorandum was submitted to the Surface Water Section of the Ministry of Environment's Eastern Region for review. Agreement with the proposed effluent limits has been confirmed. A copy of the MOE's November 3, 2009 Memorandum in this regard is included in **Appendix B** for reference.

Table 13 - Existing and Proposed Effluent Requirements for Cornwall WWTP

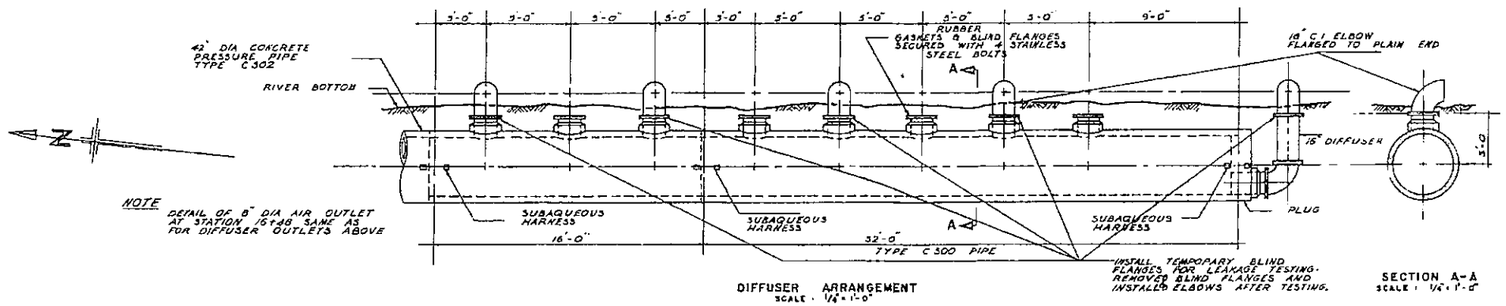
Parameter	Existing C of A		Proposed	
Rated Capacity (ADF)	54,432 m^3/d		65,318 m^3/d	
	Objective	Compliance	Objective	Compliance
$CBOD_5$ (mg/L)	40.0	50.0	15.0	25.0
TSS (mg/L)	30.0	45.0	15.0	25.0
Total Ammonia as N (mg/L)				
January - March	--	--	7.0	9.0
April - September	--	--	5.0	7.0
October - December	--	--	9.0	11.0
			Non-acutely Lethal to Rainbow Trout and Daphnia Magna	
TP (mg/L)	1.0	1.0	0.5	0.8
E. coli. (CFU/100 mL)	200		100	200
Total Residual Chlorine (mg/L) (2010)		1.0	0.02	0.04

Notes: 1) $CBOD_5$, TSS, TP and Total Ammonia Nitrogen based on monthly average concentration.

2) E.Coli based on monthly geometric mean density.

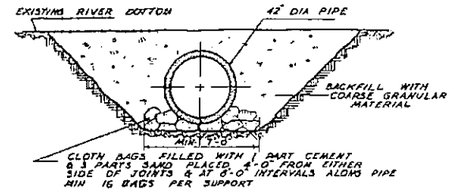
APPENDIX A
OUTFALL DRAWING

703-01



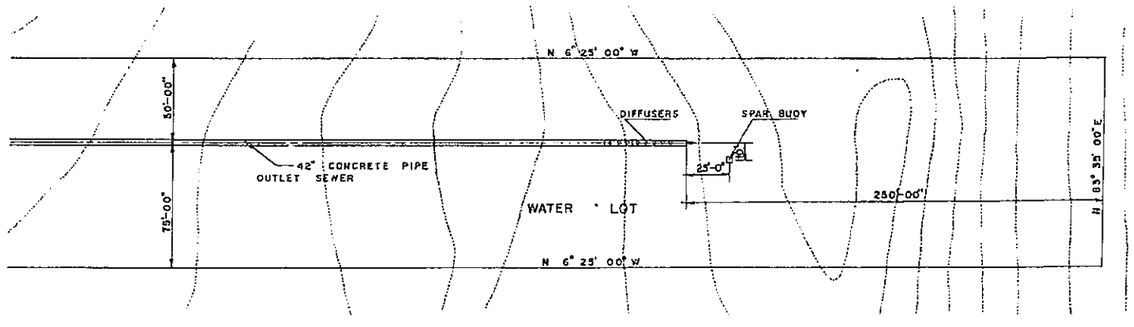
DIFFUSER ARRANGEMENT
SCALE : 1/4" = 1'-0"

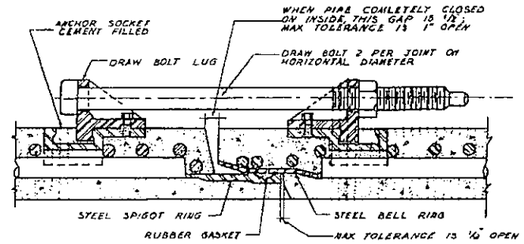
SECTION A-A
SCALE : 1/4" = 1'-0"



SECTION THROUGH TRENCH
SCALE : 1/4" = 1'-0"

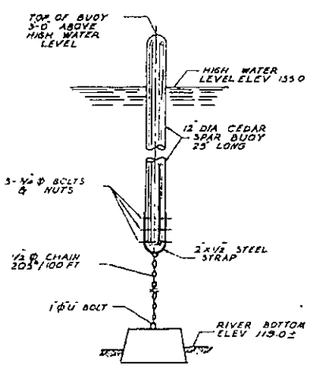
ST. LAWRENCE RIVER



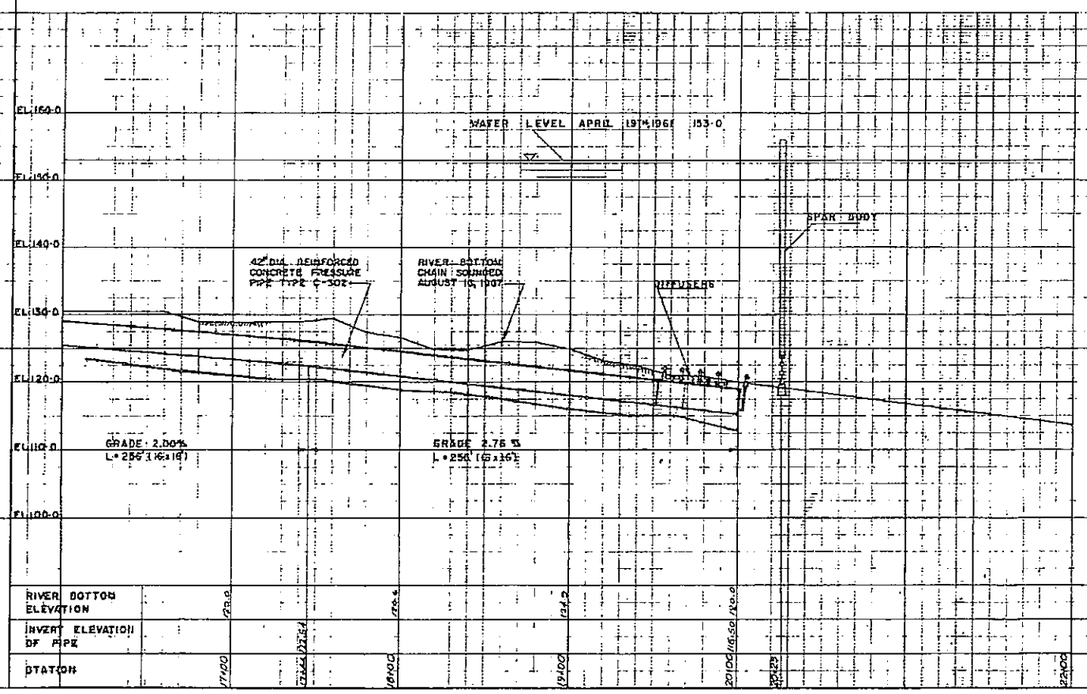


TYPICAL JOINT ON SUBAQUEOUS CONCRETE PIPE
NOT TO SCALE

NOTE: PROFILE CORRECTED TO ACTUAL DEPTHS OF RIVER BOTTOM, CONTOUR LINES LEFT UNCHANGED.



SPAR BUOY
SCALE : 1/4" = 1'-0"



ONTARIO WATER RESOURCES COMMISSION
PROJECT: SP-66-1

CITY OF CORNWALL

CONTRACT 8

42 INCH DIAMETER OUTLET PIPE

PLAN & PROFILE

GORE & STORRIE LIMITED
CONSULTING ENGINEERS
TORONTO ONTARIO

SCALE: HORIZONTAL 1" = 40'-0"
VERTICAL 1" = 8'-0"

DATE: MARCH, 1967 DWG. NO. 3

REVISED AS CONSTRUCTED JANUARY, 1968

FILE: No 348-6-0-7010

703-01

APPENDIX B

MOE RESPONSE TO PROPOSED EFFLUENT OBJECTIVES AND LIMITS FOR THE CORNWALL WWTP

Ministry of the Environment

P.O. Box 22032
Kingston, Ontario
K7M 8S5
613/549-4000 or 1-800/267-0974
Fax: 613/548-6908

Ministère de l'Environnement

C.P. 22032
Kingston (Ontario)
K7M 8S5
613/549-4000 ou 1-800/267-0974
Fax: 613/548-6908

Ontario

MEMORANDUM

November 3, 2009

TO: Vicki Mitchell
Environmental Assessment Coordinator
Technical Support Section
Eastern Region

FROM: Victor Castro
Surface Water Scientist
Technical Support Section
Eastern Region

RE: Cornwall Wastewater Treatment Plant
Environmental Assessment Update
Draft Technical Memorandum No. 1B
Assimilative Capacity Assessment of the St. Lawrence River

J. L. Richards & Associates Limited was retained by the City of Cornwall to complete an assimilative capacity study of the St. Lawrence River near Cornwall. The main purpose of the study was to determine the receiving water-based effluent limits and objectives for the proposed expansion of the Cornwall Water Pollution Control Plant.

In 2005, the MOE provided a Regional clearance on the proposed effluent limits and objectives contained in the 2005 ESR. However, as a result of some inconsistencies in the original ESR and the time lapsed since the ESR was completed, the consultants wanted to re-assess the original limits and objectives based on an assessment of the assimilative capacity of the St. Lawrence River at Cornwall.

The main changes to the original 2005 effluent limits and objectives are related to total phosphorus and total ammonia-N. The proposed revised effluent limits for the Cornwall WPCP are as follows:

Rated Capacity	65,318 m^3/day average daily flow		
Parameter	**Objective (mg/L)**	**Compliance (mg/L)**	**Loading (kg/day)**
$CBOD_5$	15.0	25.0	1,633
TSS	15.0	25.0	1,633
Total Ammonia-N			
January – March	7.0	9.0	588
April – September	5.0	7.0	457
October - December	9.0	11.0	718
		Non-acutely lethal to Rainbow Trout and Daphnia Magna	
Total Phosphorus	0.5	0.8	52
E. Coli (counts/100 ml)	100	200	n/a
Total Residual Chlorine	0.02	0.04	2.6

Notes: 1) $CBOD_5$, TSS, TP and Total Ammonia-N based on monthly average concentration.
2) E. Coli based on monthly geometric mean density

I have added the fourth column above related to loadings.

The Method Detection Limit for total chlorine residual is 0.01 mg/L, therefore a limit of 0.04 mg/L should be sufficiently elevated above the MDL to be reasonably confident in the test results. Total chlorine residual should be monitored continuously with a feedback loop controlling the application of a dechlorination agent. This limit for total chlorine residual would obviously not be applicable if the sewage works upgrade includes UV irradiation as the preferred method of disinfection.

To confirm that the final effluent is non-acutely lethal, the Region requires a condition in the C of A to test the effluent using Daphnia Magna and rainbow trout in accordance with the most current procedures published by Environment Canada. For plants with design flows in excess of 5000 m^3/day, the testing should be carried out on a monthly basis, and can be reduced to quarterly testing following 12 consecutive months of successfully demonstrating non lethality. In the event of failure of any test, the owner would be required to investigate the possible causes of the toxicity based on sampling data and monitoring, and upon determination of the cause or source of lethality determine appropriate control measures.

The Regional office is in agreement with the proposed effluent limits noted above, and I am satisfied that the final effluent quality will not pose any significant impairment issues to the receiving waters.

If you have any questions regarding these comments, please contact me at (613) 540-6862.

Victor Castro
VC/gl

bc: L. Chalmers
J. Ryan
File SW-05-11 (City of Cornwall WPCP)