Town of Saugeen Shores
Southampton WPCP Expansion
Schedule C Class EA
Environmental Study Report
Appendix D

Assimilative Capacity Study Report

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Memorandum

Date: **April 23, 2019**

To: **Shayne Finlay, MECP**

CC: **Gary Scott, Preya Balgobin Ainley Group**

From: **Christine Geiger, Deborah Sinclair, Neil Hutchinson**

Re: **Preliminary ACS Results – Southampton WPCP**

Hutchinson Environmental Sciences Ltd. (HESL) was retained by the Ainley Group to complete a desktop assimilative capacity study (ACS) using existing data in support of the Class Environmental Assessment (Class EA) for expansion of the Southampton Water Pollution Control Plant (WPCP) on behalf of the Town of Saugeen Shores. The current average design flow (ADF) of the Southampton WPCP is 3,042 m^3/day with a peak design flow of 6,084 m^3/day. As part of the Class EA, The Town of Saugeen Shores is considering increasing the WPCP ADF to 5,616 m^3/d, an increase of 2,574 m^3/d or 85% from the existing ADF of 3,042 m^3/d.

The purpose of the desktop ACS is to:

1. Determine the policy status of the Saugeen River (with respect to WPCP effluent parameters);
2. Assess the effect of the WPCP discharge at the currect 75th percentile effluent flow on downstream water quality through mass-balance modelling;
3. Predict the effect of effluent discharge at the proposed ADF through mass-balance modelling; and
4. Recommend effluent limits.

The scope of the desktop ACS is limited to the Saugeen River, and does not include assessing the impact of the WPCP on downstream Lake Huron.

This memorandum summarizes preliminary results from tasks 1 to 3 as a foundation for a meeting with the Ministry of Environment, Conservation and Parks (MECP) to discuss the approach and preliminary modeling results. Based on the review, the ACS will be updated, modelling work completed and effluent limits recommended as input into the Class EA.

1. Regulatory Context

Ontario's Ministry of Environment, Conservation and Parks (MECP) has 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 MECP 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 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 MECP 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. 7Q20 Statistic

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 source discharge over one seven-day period in twenty years.

Continuous river flow data for the Saugeen River was used to calculate the 7Q20. The Water Survey of Canada maintains a continuous flow gauge on the Saugeen River (WSC Station 02FC001) at Concession Rd. 8 W, approximately 11 km upstream of Southampton WPCP. Twenty years (1998-2017) of continuous streamflow data from the WSC Station were used to calculate 7-day average flows (Table 1). The lowest 7-day average flow of 6.56 m^3/s was measured the week of September 6th, 1999. Annual minimum 7-day average flows were then input into HYFRAN-PLUS to estimate one 7Q20 flow statistic.

HYFRAN-PLUS is a hydrological data software package that allows for the fitting of sixteen different statistical distributions to a dataset of extreme values (i.e., either flood or drought events). The software contains a decision support system that provides guidance in selecting the most appropriate distribution or class of distributions to use in fitting a dataset. The goodness of fit to a statistical distribution is then calculated in HYFRAN-PLUS using the Chi-Square test.

The HYFRAN-PLUS software determined that regularly varying distribution functions (i.e., Inverse Gamma, Log Pearson Type 3, Fréchet [Extreme Value 2], and Halphen Type Inverse B) were the most appropriate fit for minimum 7-day flows for the Saugeen River data set. The calculated 7Q20 flows from the different distribution functions are presented in Table 2. Values ranged from 7.01 m^3/s with the Inverse Gamma distribution to 7.21 m^3/s with the Fréchet distribution. The Chi-Square test found that the goodness of fit for the Fréchet and Halphen Type Inverse B were significant at a level of 1%, while the Inverse Gamma and Log Pearson Type 3 were significant at a level of 5%. The confidence interval of the Fréchet function was smaller than the confidence interval for the Halphen Type Inverse B. Therefore, the Fréchet distribution value of 7.21 m^3/s was used as the 7Q20 value.

The WSC gauge is located 11 km upstream of Southampton WPCP. The watershed area draining to the Saugeen River at the WSC gauge is 3,941.35 km^2. The watershed area draining to the Saugeen River at the Southampton WPCP was determined as 3,977.69 km^2 using the Ontario Flow Assessment Tool (https://www.ontario.ca/page/watershed-flow-assessment-tool, accessed November 2016). The 7Q20 statistic was therefore pro-rated for the watershed areas at the Southampton WPCP to determine the low flow statistic in the Saugeen River near the potential discharge location using the equation:

$$Q_1 = Q_2 * A_2^{-1} * A_1,$$

Where Q_2 is the 7Q20 flow statistic (7.21 m^3/s), and A_1 is the watershed area at the Southampton WPCP, (3,977.69 km^2), and A_2 is the watershed area at the WSC gauge (3,941.35 km^2).

Pro-rating of the 7Q20 flow from the Saugeen River near Port Elgin WSC gauging station to Southampton WPCP resulted in a 7Q20 flow of 7.28 m^3/s (7,280 L/s). The minimum 7-day flow in the Saugeen River available for assimilation of the effluent would therefore provide a dilution ratio of 207:1 under 7Q20 flow conditions at the current ADF of 35.2 L/s (3,042 m^3/d) and a dilution ratio of 112:1 for the future ADF of 65 L/s (5,616 m^3/d). River flows will be higher 99.5% of the time; therefore, the resultant fully mixed concentrations will be lower than those predicted over 99.5% of the time.

Table 1 Minimum 7-day average flows (m^3/s) for the Saugeen River near Port Elgin, 1998 to 2017

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Minimum 7-Day Average	9.57	6.56	18.00	11.80	8.54	10.70	11.69	8.63	10.18	8.37
Week of	10-Sep	06-Sep	11-Sep	17-Aug	21-Sep	14-Sep	02-Oct	16-Sep	25-Aug	22-Aug
YEAR	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Minimum 7-Day Average	16.01	11.46	18.93	11.33	7.46	12.54	19.33	12.9	9.87	23.61
Week of	08-Sep	21-Sep	03-Sep	19-Sep	25-Jul	25-Aug	12-Aug	02-Aug	12-Aug	03-Sep

Table 2 Monthly (January to December) 7Q20 values (m^3/s) Saugeen River near Port Elgin

Statistical Distribution	7Q20 value (m^3/s)	Significance Level	**Confidence Interval**	P value
Inverse Gamma	7.01	5%	5.75 – 8.27	0.5319
Log Pearson Type 3	7.05	5%	5.67 – 8.43	0.2466
Fréchet [Extreme Value 2]	7.21	1%	5.98 – 8.44	0.0408
Halphen Type Inverse B	7.17	1%	5.90 – 8.43	0.0302

3. Policy Designation

The effluent limits for the plant are derived based on the 7Q20 flow and the 75th percentile water quality statistics. This minimum flow typically occurs during the late summer when water quality in the river is not influenced by runoff. Although water quality is important in all seasons, the river is most sensitive to effluent discharges during the summer low flow period, when effluent dilution is lowest. The ACS will therefore be informed by the water quality of the river during summer low flow conditions and so summer 75th percentile concentrations were used for Policy designation of the receiver.

Background water quality in the vicinity of the WWTP is required to determine the policy status of a receiver, and as input into deriving receiving water-based effluent limits for WWTPs (MOE 1994b). MECP (Shayne Finlay, March 4th, 2019) and Saugeen Valley Conservation Authority (SVCA; Erik Downing, March 4th, 2019) were contacted for recent (last 10 years) site-specific water quality data. The closest water quality data available to the Southampton WWTP is from the Provincial Water Quality Network (PWQMN) Station (08012303002) located 11 km upstream. In the absence of water quality data closer to the WWTP, the PWQMN data was used to determine the background water quality and hence the policy status of the river.

PWQMN Station 08012303002 is located at Bruce Road 3, north of Burgoyne, ON, approximately 11 km upstream of the study site. Long-term data were available from this site for general chemistry, nutrients and total metals for the period 2002-2016 and were typically monitored monthly from April to November by SVCA. Parameters assessed include those regulated by an Environmental Compliance Approval (ECA) and which have a PWQO or Canadian Water Quality Guideline for the Protection of Aquatic life (CWQG; CCME 1999). These included: total phosphorus (TP), un-ionized ammonia (total ammonia regulated by ECA), pH, *E. coli* and dissolved oxygen (BOD regulated by ECA). Nitrate and chloride concentrations were also assessed, as both parameters have a CWQG and can be present at elevated concentrations in effluent. Although they are not typically regulated by an ECA, our experience is that regulatory bodies increasingly request their inclusion in the ACS to assess any threat they may pose. Summary statistics (min, max, median, 75th percentile) for parameters of interest are presented in Table 3.

The 75th percentile of all total phosphorus measurements was 0.028 mg/L which is just below the PWQO (0.03 mg/L). During summer conditions (June to September), the 75th percentile total phosphorus concentration was 0.018 mg/L, well below the PWQO of 0.03 mg/L. The Saugeen River upstream of the Southampton WPCP is therefore Policy 1 for TP, as 75th percentile summer total phosphorus concentrations are well below the PWQO of 0.03 mg/L.

Total ammonia concentrations were low, with a median concentration of 0.022 mg-N/L. The 75th percentile un-ionized ammonia concentration was 0.0022 mg-N/L. The summer 75th percentile concentration of un-ionized ammonia was 0.0028 mg-N/L, indicating that during the summer months, unionized ammonia concentrations increase slightly (likely due to increased water temperatures). Both the annual and summer 75th percentile values are well below the PWQO of 0.0164 mg-N/L; the Saugeen River therefore is considered Policy 1 for un-ionized ammonia.

Table 3 Summary Statistics for Parameters of Interest in the Saugeen River at PWQMN Station 0812303002 from 2002 to 2016

	TP	NO_3-N	TAN	Un-ionized Ammonia	DO	TSS	Cl	pH	Temp	$cBOD_5$
Number	132	128	129	113	118	126	133	120	130	16
Average	0.032	1.37	0.029	0.0016	10.3	22	14.1	8.27	15.7	1.86
Median	0.016	1.12	0.022	0.0012	9.9	9	14.3	8.29	17.2	1.35
75th percentile – All values	0.028	1.49	0.032	0.0022	9.0	16	15.8	8.36	21.5	2.65
75th percentile – Summer[1]	0.018	0.9	0.032	0.0028	8.3	13	16	8.34	23.0	1.0
Min	0.005	0.02	0.002	0.0001	1.0	1	7.9	7.71	0.0	0.70
Max	0.270	7.71	0.233	0.0064	15.9	300	25.8	8.72	27.0	3.80

Notes: all concentrations in mg/L except temperature (°C) and pH (unitless); 1 – June to September values only

The 75th percentile and summer 75th percentile pH were similar; 8.36 and 8.34 respectively. These are within the PWQO range of 6.5 – 8.5, therefore the Saugeen River upstream of the Southampton WPCP is Policy 1 for pH.

The 75th percentile concentrations of chloride were 15.8 mg/L and 16.0 mg/L for all values and just the summer values respectively. Both values are well below their CWQG of 120 mg/L (long-term exposure), and hence the Saugeen River is Policy 1 for chloride.

The summer 75th percentile concentration of nitrate, 0.90 mg-N/L was less than the 75th percentile concentration of 1.49 mg-N/L for all values. The lower summer value may be due to less runoff of fertilizers, and hence nutrients in the summer months. Both concentrations, were well below the CWQG of 3.0 mg-N/L, indicating that the river is also Policy 1 for nitrate.

For dissolved oxygen, the 25th percentile concentration is used to determine Policy status, as this represents a conservatively low concentration in the receiver. The 25th percentile dissolved oxygen concentrations were 9.0 mg/L and 8.3 mg/L for all and summer respectively. The PWQO for dissolved oxygen ranges from 4 to 8 mg/L depending on water temperature and biota present (i.e. cold water or warm water). The 25th summer percentile was well above the PWQO of 5 and 4 mg/L for warm and cold water at 20°C therefore, the Saugeen River is Policy 1 for dissolved oxygen.

4. Southampton WPCP Effluent Quality

Existing effluent limits from the Southampton WPCP was reviewed to establish modelling inputs for assessing the effects of the Southampton WPCP re-rating on Saugeen River water quality. The current ECA limits for the Southampton WPCP are presented in Table 4.

Table 4. Current Effluent Objectives and Limits (3-1216-88-947)

Effluent Parameter	Units	Effluent Objectives (mg/L)	Effluent Limits	
			Monthly Average Concentration (mg/L)	Monthly Average Loading (kg/d)
5-day Carbonaceous biochemical oxygen demand ($CBOD_5$)	mg/L	20	25	76.1
Total Suspended Solids	mg/L	20	25	76.1
Total Phosphorus	mg/L	0.5	1.0	3
E. coli	CFU/ 100 mL	150	200	-
pH	n/a	Between 6.0 and 9.5, inclusive, at all times		

A summary of the 2014-2018 average effluent quality and quantity sampled at the facility (by facility staff) is provided in Table 5. The 75th percentile effluent concentrations were used inputs into the modelling for the ACS.

Table 5 Southampton WPCP Effluent Quantity and Quality Presented as 75th Percentile Values (2014-2018)

Effluent Parameter	Unit	Limit	2014	2015	2016	2017	2018	2014-2018
Flow	L/s	35	23.6	19.6	27.2	30.6	27.6	27.6
$cBOD_5$	mg/L	25	4.5	4.3	4.4	5.1	8.8	4.9
TSS	mg/L	25	5.6	7.4	4.0	3.4	11.0	6.0
TP	mg/L	1.0	0.36	0.36	0.25	0.30	0.34	0.303
TAN as N	mg/L		0.15	0.19	0.10	0.10	0.10	0.10
Nitrate	mg/L		21.60	21.88	21.31	18.93	21.86	21.68
DO	mg/L						4.94	
Temperature	°C						18.38	
pH							7.85	

Note: 75th percentile data based on monthly average concentrations, Data for dissolved oxygen (DO), temperature and pH were only digitally available for 2018. The DO value is the 25th percentile.

From 2014 to 2018 the 75th percentile of annual average WPCP discharge flow ranged from 19.6 in 2015 to 30.6 L/s in 2017. The 75th percentile TSS and cBOD concentrations consistently remained well below effluent limits of 25 mg/L. 75th percentile TSS concentrations ranged from 3.4 to 11.0 mg/L, and 75th percentile cBOD ranged from 4.3 to 8.8 mg/L. The highest concentrations for both parameters were observed in 2018. Total phosphorus concentrations have been well below the limit of 1.0 mg/L, and 75th percentile values ranged from 0.25 to 0.36 mg/L. There is no ECA limit for ammonia but 75th percentile effluent concentrations were low, and ranged from 0.10 mg/L to 0.19 mg/L. Nitrate concentrations were high, reflecting effective nitrification, and ranged from 18.93 to 21.88 mg-N/L.

5. Mass-Balance Modelling

Mass balance modelling was used to:

a) assess the current impact of the Southampton WPCP on Saugeen River water quality (using 75th percentile existing effluent quality and quantity data)[1]; and

[1] *The Southampton WPCP is performing better than its ECA limits. The75th percentile effluent quality and quantity are therefore a reflection of the actual impact of the Southampton WPCP on the Saugeen River, upon which to compare and assess future conditions.*

b) recommended effluent concentrations for the plant expansion, based on downstream (fully mixed) concentrations.

Parameters modelled include total phosphorus, total suspended solids, total ammonia nitrogen (and un-ionized ammonia), nitrate, $cBOD_5$, dissolved oxygen and chloride.

There are several processes (e.g., nitrification, denitrification, settling, uptake by aquatic plants.) that lead to the loss of total ammonia nitrogen, total phosphorus or nitrate from the water course. These are not easily estimated however and vary and so the mass balance model does not account for any losses and thus produces a conservative estimate of the downstream (fully mixed) concentrations.

The mass balance model was completed using the 7Q20 flow and summer 75th percentile background concentrations of the Saugeen River as described above. Results were compared to PWQO or CWQG as appropriate.

5.1 Existing Conditions – 75th Percentile Effluent Flow of 2,381 m^3/d

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

$$Q_{u/s}C_{u/s} + Q_{WPCP}C_{WPCP} = (Q_{u/s} + Q_{WPCP})C_{d/s} \qquad \text{(Equation 1)}$$

Where:

$Q_{u/s}$ is the upstream flow in the Saugeen River at the WSC station;

$C_{u/s}$ is the upstream Saugeen River (at the PWQMN station) concentration for the parameter of interest;

Q_{WPCP} is the Southampton WPCP effluent flow;

C_{WPCP} is the Southampton WPCP effluent concentration for the parameter of interest; and

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

Inputs for the mass balance model are provided in Table 6.

Table 6 Mass Balance Model Inputs for the WPCP's Existing Performance

Parameter	Value	Rationale
Upstream Saugeen River flow ($Q_{u/s}$)	7.28 m^3/s	7Q20 for the Saugeen River at the Southampton WPCP See Section 2
Upstream Saugeen River concentration for parameter of interest ($C_{u/s}$)	• TP – 0.018 • NO3 – 0.09 • TAN – 0.032 • DO – 8.3 • TSS – 13 • Cl^- - 16 • pH – 8.34 • Temp. – 23 • $cBOD_5$ – 1.0	• Summer 75th percentile concentrations collected at PWQMN Station 0812303002 approximately 11 km upstream of the WPCP between 2002 and 2016 (See Section 2). • Dissolved oxygen summer 25th percentile concentration from PWQMN.
Southampton WPCP effluent flow (Q_{WPCP})	27.6 L/s	The 75th percentile of monthly average effluent flow from 2014 to 2018.
Southampton WPCP effluent concentration (C_{WPCP})	• TP – 0.303 • NO3 – 21.68 • TAN – 0.1 • DO – 5.3 • TSS – 6 • pH – 7.85 • Temp – 18.4 • $cBOD_5$ – 4.9	• 75th percentile concentrations of total phosphorus, nitrate, total ammonia nitrogen, total suspended solids, cBOD5 for the existing plant performance based on monthly average data collected between 2014 and 2018. • 75th percentile concentrations of pH and temperature based on monthly averages from 2018 (data between 2014 and 2017 is currently not available electronically) • The total oxygen demand (TOD) of the effluent was estimated as 4.9 mg/L based on four (4) times the 75th percentile TAN concentration of 0.1 mg/L plus the carbonaceous BOD.

Under 7Q20 conditions concentrations of total phosphorus and nitrate are predicted to marginally increase downstream of the Southampton WPCP, but remain below their respective PWQOs and CWQGs (Table 7). Total phosphorus concentrations will increase from 0.018 mg/L to 0.019 mg/L, below the PWQO of 0.03 mg/L. Nitrate concentrations are predicted to increase from 0.9 mg/L to 1.0 mg/L, but still well below the CWQG of 3.0 mg/L.

TSS and TAN concentrations are predicted to stay the same as upstream background concentrations because the effluent load represents less than 1% of the upstream TSS load, and approximately 1.2% of the upstream TAN load. The downstream un-ionized ammonia-N concentration is 0.0031 mg-N/L, at 23°C and pH 8.34 (Table 7) well below the PWQO of 0.0164 mg-N/L.

A small decrease in dissolved oxygen concentrations downstream of the WPCP may occur from the nitrification of ammonia and biological oxygen demand of the effluent. The summer 25th percentile dissolved oxygen concentration is predicted to decrease by 0.05 mg/L (Table 7). The predicted dissolved oxygen concentration is 8.25 mg/L, well above the PWQO of 5 mg/L for cold water biota and 4 mg/L for warmwater biota at a water temperature of 23ºC.

Based on the mass-balance modelling results, the Southampton WPCP effluent has very little effect on downstream water quality under summer low flow conditions. It should be noted, however, that the model was based on data collected 11 km upstream of the site.

5.1 Future Conditions– ADF of 5,616 m^3/d

The Town of Saugeen Shores would like to increase the ADF from the WPCP to 5,616 m^3/d, an increase of 2,574 m^3/d or 85% from the existing ADF of 3,042 m^3/d. The Saugeen River is Policy 1 for all parameters of concern (TP, TAN, pH, DO, NO_3, and Cl) at the PWQMN station. Water quality downstream of the WPCP discharge must therefore be maintained at or above the PWQO/CWQG, however some degradation of water quality is permissible.

The current effluent limits for total phosphorus, total suspended solids, BOD, pH and *E. coli* need to be reviewed to ensure water quality downstream of the WPCP is maintained.

At the current effluent total phosphorus limit of 0.5 mg/L, downstream total phosphorus summer concentrations would increase to 0.022 mg/L (Table 8), an increase of 0.003 mg/L from existing downstream concentrations (Table 8), and well within the PWQO of 0.03 mg/L.

At the current effluent limit of 20 mg/L and the proposed flow of 5,616 m^3/s, TSS concentrations would only marginally increase (0.1 mg/L) downstream of the effluent discharge (Table 8). The effluent limit is, however, outdated for current treatment standards. The current 75th percentile effluent TSS concentration is 6 mg/L, an effluent concentration of 10 mg/L is therefore likely achievable and would maintain existing TSS concentrations of 13 mg/L in the receiver (Table 8) during summer low-flow conditions.

Table 7 Saugeen River Mass Balance Modelling Results –Existing Conditions

	Saugeen River Upstream			Effluent			Saugeen River Downstream			
	75th Conc	7Q20	Load	75th Conc	Flow	Load	Load	Flow	Conc	Change
	mg/L	L/s	mg/s	mg/L	L/s	mg/s	mg/s	L/s	mg/L	mg/L
TP	0.018	7,276	131	0.303	27.6	8.4	139	7,304	0.019	0.001
TSS	13.0	7,276	94,594	6.0	27.6	165	94,760	7,304	13.0	0.0
TAN	0.032	7,276	233	0.10	27.6	2.8	236	7,304	0.032	0.000
NO_3	0.9	7,276	65,49	22	27.6	598	7,146	7,304	1.00	0.10
BOD	1	7,276	7,276	4.9	27.6	135	7,412	7,304	1.0	0.0
Dissolved oxygen	8.3	7,276	60,395	5.3	27.6	146	60,249	7,304	8.25	-0.05
Temperature	23	7,276	167,359	18.4	27.6	507.12	167,866	7,304	22.98	-0.02
pH	8.34	7,276	60,686	7.85	27.6	216.35	60,902	7,304	8.34	0.00

Note: the 25th% used for DO concentrations and 4*NH3 + BOD used for plant effluent for TOD

Table 8 Saugeen River Mass Balance Modelling Results – Future Conditions

	Saugeen River Upstream			Effluent			Saugeen River Downstream				Change from Current
	75th Conc	7Q20	Load	Conc	Flow	Load	Load	Flow	Conc	Change	
	mg/L	L/s	mg/s	mg/L	L/s	mg/s	mg/s	L/s	mg/L	mg/L	
TP - current limit	0.018	7,276	131	0.5	65.0	32.5	160	7,341	0.022	0.004	0.003
TSS – current limit	13.0	7,276	94,588	20.0	65.0	1,300	95,888	7,341	13.1	0.1	0.1
TSS - 10 mg/L	13.0	7,276	94,588	10.0	65.0	650	95,238	7,341	13.0	0.0	0.0
BOD – current limit	1.0	7,276	7,276	20.0	65.0	1,300	8,576	7,341	1.2	0.2	0.1
BOD – 10 mg/L	1.0	7,276	7,276	10.0	65.0	650	7,926	7,341	1.1	0.1	0.1
TAN - non-toxic	0.032	7,276	233	11.20	65.0	728	961	7,341	0.131	0.099	0.099
TAN - 5 mg/L	0.032	7,276	233	5.00	65.0	325	558	7,341	0.076	0.044	0.044
NO_3	0.9	7,276	6,548	22.0	65.0	1,430	7,978	7,341	1.1	0.2	0.1
Dissolved oxygen	8.3	7,276	60,391		65.0	1,950	58,441	7,341	8.0	-0.3	-0.3
Temperature	23	7,276	167,348	18.4	65.0	1,196	168,544	7,341	23.0	0.0	0.0
pH	8.34	7,276	60,682	7.85	65.0	510	61,192	7,341	8.34	0.00	0.00

Note: the 25th% used for DO concentrations and 4*NH3 + BOD used for plant effluent for TOD

Similar to TSS, a BOD effluent limit of 20 mg/L is outdated for current treatment standards. Given that the 75th percentile effluent concentration is 4.9 mg/L, an effluent concentration of 10 mg/L is achievable and would maintain downstream dissolved oxygen concentrations well above the PWQO[2] (Table 8).

There is no current effluent limit for TAN. The MECP 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-N/L or less of un-ionized ammonia (NH_3) as a conservative estimate of the lethal threshold[3]. The 75th percentile effluent pH of 7.85 and temperature of 18.4°C were used to calculate the total ammonia concentration of 11.2 mg-N/L that corresponds to an un-ionized ammonia concentration of 0.27 mg-N/L. An effluent concentration of 11.2 mg-N/L would increase downstream concentration to 0.120 mg-N/L (Table 8). At fully mixed receiver pH and temperature of 8.34 and 23°C (Table 8), the calculated un-ionized ammonia concentration would be 0.0115 mg-N/L, below the PWQO of 0.0164 mg-N/L. The WPCP is currently achieving effluent concentrations of TAN below 1 mg/L (Table 5), an effluent concentration of 5.0 mg-N/L or less is reasonable and should be achievable, given the current treatment technology.

The current effluent nitrate concentration of 22 mg-N/L has a marginal effect on downstream nitrate concentrations (Table 7), and maintains water quality well below the CWQG of 3.0 mg-N/L. A nitrate effluent limit is therefore not warranted for the future flow conditions, as effluent concentrations of 22 mg-N/L would only increase downstream nitrate concentrations by 0.2 mg/L (Table 8).

The background chloride concentration in the Saugeen River is low (16 mg/L). Chloride concentrations in the effluent of the Southampton WPCP have not been monitored, but are expected to be low, given that the Town draws their drinking water from Lake Huron. Water softeners, one of the main sources of chlorides in WWTP effluent, are used when groundwater is used as the water source to remove minerals. Based on surface water being the source of drinking water, and the lack of water softeners, we do not see the need to recommend an effluent concentration for chloride.

Based on the current ECA limits effluent values of 6.0 to 9.5 and 200 CFU/100 mL for pH and *E. coli* are recommended.

6. Summary

Based on water quality data summarized from the PWQMN station, the Saugeen River is “Policy 1” for total phosphorus, un-ionized ammonia, dissolved oxygen, nitrate, chloride and pH. The 7Q20 for the

[2] *With an TAN effluent concentration of 5 mg/L or less.*

[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 25°C 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 25°C. 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.*

Saugeen River at the Southampton WPCP was calculated as 7.28 m^3/s providing a dilution ratio of 207:1 for the current ADF, and a dilution ratio of 112:1 for future ADF.

Under the current plant quality and quantity (effluent flow and quality) downstream concentrations of total phosphorus, total suspended solids, total ammonia-nitrogen, and nitrate in the Saugeen River were predicted to increase only slightly and stay well below their PWQOs and CWQGs during summer-low flow conditions.

The Town of Saugeen Shores would like to increase the ADF to 5,616 m^3/d. The following effluent concentrations will maintain receiver concentrations below the PWQO/CWQG meeting Policy 1 designation:

- TP concentration of 0.5 mg/L or less;
- TSS and BOD concentrations of 10 mg/L or less;
- TAN concentration of 5 mg-N/L or less;
- pH values between of 6.0 to 9.5; and
- 200 CFU/100 mL for *E. coli.*

Recommended effluent concentrations for nitrate and chloride are not warranted as mass-balance modeling showed that the WPCP effluent has a marginal influence on downstream concentrations.

This assessment is based on receiver water quality obtained 11 km upstream of the WPCP. The water quality of Saugeen River at the WPCP may differ (i.e. total phosphorus concentrations may be enriched) from that measured at the PWQMN station due to point source discharges and overland runoff between the two sites. Water quality data collected just upstream of the WPCP is required to provide site-specific water quality to accurately determine the Policy status of the receiver, evaluate the effects of WPCP effluent on downstream water quality.

7. References

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