Hutchinson

Environmental Sciences Ltd.

Pine River Receiving Water Assessment – Final Report

Prepared for: Mansfield Ski Club
Job #: J160071

May 17, 2018

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May 17, 2018 HESL Job #: J160071

Finley McEwen
20 Queen Street West, 5th Floor
Toronto, Ontario
M5H 3R4

Dear Mr. McEwen:

Re: Mansfield Ski Club Redevelopment Project – Assimilative Capacity Study – Final Report

We are pleased to submit our Receiving Water Assessment (RWA) in support of a new Sewage Treatment Plant associated with the redevelopment of the Mansfield Ski Club. The RWA is based on field surveys conducted from September 2016 to October 2017 to characterize water quality, flow, aquatic habitat and fish community. These were used to calculate the 7Q20 low flow statistic required by MOECC to model the creek response and to set protective effluent limits using mass-balance and CORMIX modelling. A preliminary RWA was reviewed by MOECC in August of 2017. We provided responses to MOECC (Appendix A) and their comments are addressed in this report.

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

Sincerely,
Per. Hutchinson Environmental Sciences Ltd.

Deborah L. Sinclair

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Signatures

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1. Introduction

Hutchinson Environmental Sciences Ltd. (HESL) was retained by the Mansfield Ski Club (MSC) to prepare a Receiving Water Assessment (RWA) in support of a new Wastewater Treatment Plant (WWTP) associated with the redevelopment of the Mansfield Ski Club (MSC). MSC is located at 628213 Side Rd 15, Mansfield, Ontario, in the Township of Mulmur (Figure 1).

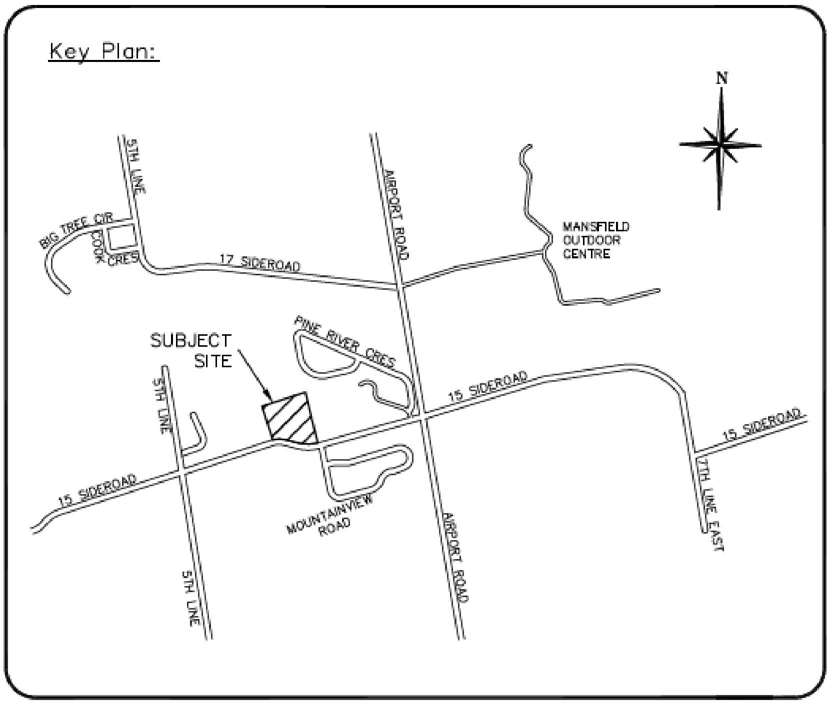


Figure 1. Location of Mansfield Ski Club (from WMI 2017)

A preliminary Receiving Water Assessment (RWA) was completed by HESL in February of 2017 (HESL 2017a; Appendix A). The intent of the preliminary RWA was to provide an overview of the results of the study to date (February 2017). The Preliminary RWA summarized:

1. The proposed wastewater treatment design,
2. Progress of the water quality and flow monitoring program,
3. Low flow analysis,
4. Water quality assessment, and
5. Natural heritage and beneficial use constraints.

Ontario Ministry of the Environment and Climate Change's (MOECC) review of the preliminary RWA (Appendix A) requested that the final RWA include a Dissolved Oxygen (DO) sag assessment, characterization of sensitive aquatic communities and fish habitat near the proposed outfall; and further study regarding the presence of snapping turtles and wetlands.

This report provides an update to the preliminary RWA to include:

- A synthesis and summary of water quality and flow data collected for the Pine River near MSC from September 2016 to August 2017;
- Results of a diurnal dissolved oxygen survey in the Pine River conducted in late summer of 2017 near MSC;
- Mass Balance Modelling to predict fully mixed concentrations of effluent parameters in the receiver, including total phosphorus, ammonia, total suspended solids, nitrate and dissolved oxygen;
- Mixing zone modelling (using CORMIX) to predict the size, shape and characteristics of the mixing zone;
- Characterization of the aquatic habitat and fish community and sensitivity of resident fish species; and.
- Recommended effluent limits and discharge configuration based on the results of receiver water quality, mass-balance and CORMIX modelling, aquatic habitat characteristics, and resident fish community.

Further study regarding the presence of snapping turtles and wetlands was not included in this report, as additional information with respect to snapping turtles, wetlands, and other natural heritage features and functions will be examined during the site plan approval phase as part of an Environmental Impact Study (EIS).

2. Background

The existing MSC operates seasonally from late December to early April. Sanitary servicing for the site (an existing Chalet Building and an Operations Building) is by a private on-site sewage treatment system (Northern Purification System) with subsurface disposal to a leaching bed. The currently proposed redevelopment of the site is to include renovation of the existing Chalet Building, and the Operations Building and new development providing a total of 1,595 m^2 of commercial retail space and a total of 93 residential units for year-round occupancy (WMI 2017).

The Functional Site Servicing and Stormwater Management Report[1] (WMI 2017) for the redevelopment reported that the Total Daily Design Sewage Flow will increase to 1.39 L/s (0.00139 m^3/s) with the proposed redevelopment, which will necessitate a new sanitary sewage treatment system to accommodate the expanded flows (WMI 2017). WMI (2017) proposed a package plant consisting of a Waterloo Biofilter System with UV disinfection and sodium aluminate dosing for phosphorus removal with disposal of the effluent as a continuous discharge to the existing wetland located at the base of the ski hill located in the northeast corner of the MSC property adjacent to 17th Sideroad. From within the wetland effluent would mix with stormwater runoff and be conveyed downstream through a buried pipe prior to discharge to the Pine River near the existing pump house (WMI 2017, Figure 2). The proposed sewage treatment and surface disposal system was designed based on a Total Daily Design Sewage Flow of 1.39 L/s. Further details of the proposed sanitary treatment system can be found in the Functional Site Servicing and Stormwater Management Report (WMI 2017). The system was designed to meet the proposed effluent objectives and limits outlined in Table 1. The RWA will review these proposed effluent limits and advise on the response of the Pine River and any need for revision.

Table 1. Proposed Effluent Objectives and Limits for the MSC WWTP (from WMI 2017)

Effluent Parameter	Objective	Limit
cBOD5	10.0	15.0
Total Suspended Solids	10.0	15.0
Total Phosphorus	0.5	1.0
Total Ammonia	3.0	5.0
E. coli (geometric mean density)	100	200
pH	pH of the effluent maintained between 6.0 and 9.0, inclusive, at all times	

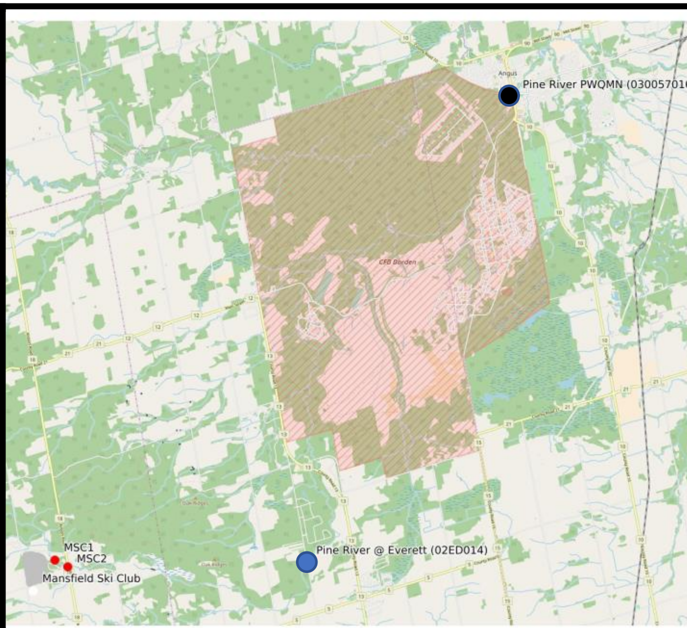
Notes: all concentrations in mg/L except for *E. coli* which is organisms/100 mL

2.1 Study Area

The subject area of the Mansfield Ski Club property proposed for the redevelopment is 4.02 ha. The property is located north of the 15th Sideroad, south of the 17th Sideroad, east of the 5th Line and approximately 600m west of County Road 18 (Airport Road). The property address is 628213 15th Sideroad, P.O. Box 75 RPO Mansfield, Mulmur, ON (Figure 1).

It is proposed that treated effluent from the WWTP be directed to a wetland pond located at the north end of the property, that it combine with stormwater runoff and then be directed via a buried pipe to the Pine River, discharging near the Pump House (Figure 2).

The Pine River is in the Nottawasaga Valley Watershed, west of Lake Simcoe and south of Georgian Bay. The River begins within wetlands southwest of Redickville, flows east through rural/agricultural areas to Horning's Mills. It enters the forests and steep slopes associated with the Niagara Escarpment, where it receives additional flow from many springs. East of the Escarpment, near Airport Road (County Road 18), the Pine River flows through a mix of forested and agricultural lands that extend to CFB Borden before emptying into the Nottawasaga River just downstream of Angus, and ultimately to Georgian Bay (NVCA 2007).



- Water Survey of Canada Station
- Pine River PWQMN Station
- Monitoring Station
- Active Spawning Redds*

*No. represents actively spawning Chinooks Salmon

Figure 2. Mansfield Ski Club Monitoring Locations

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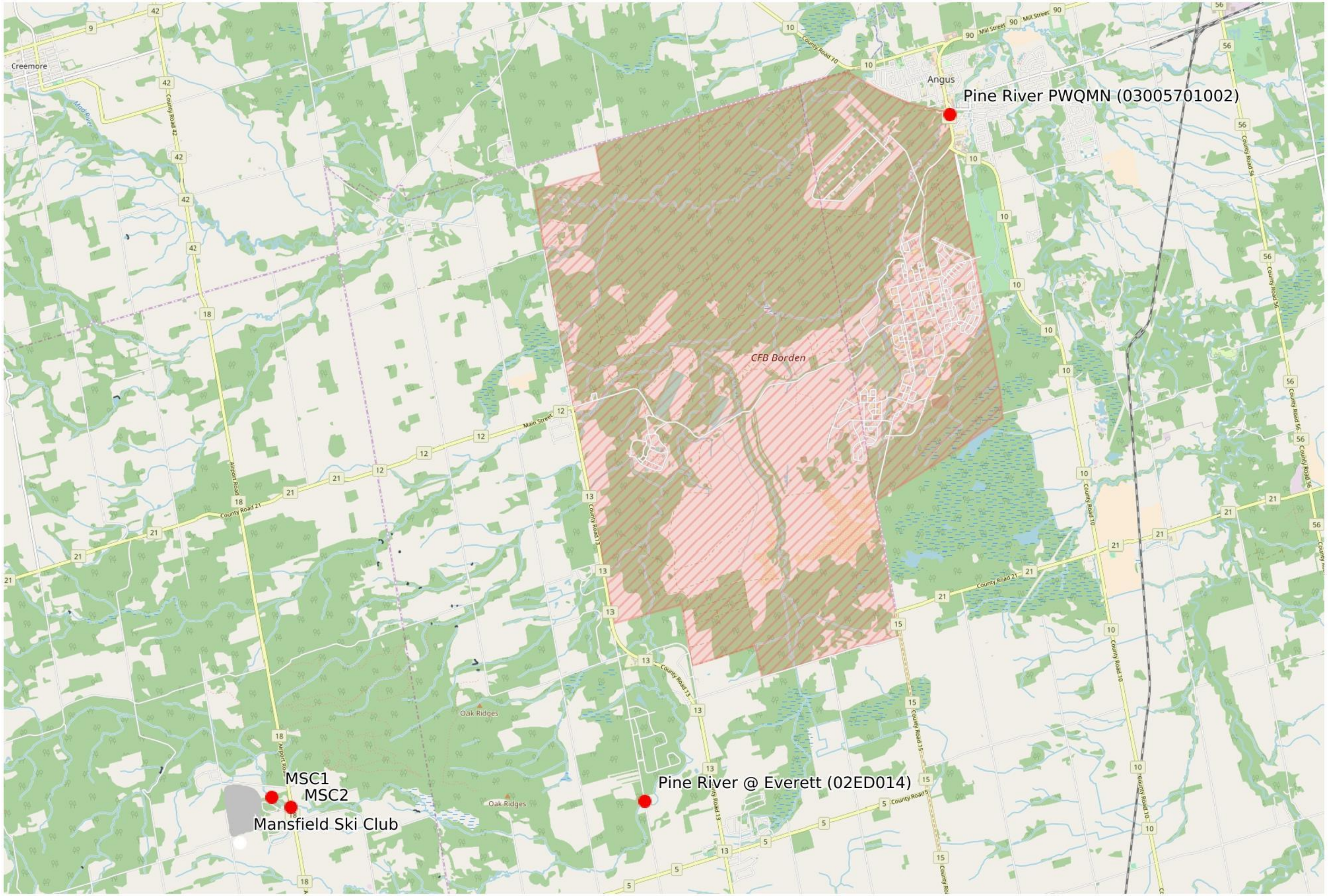

Creemore
Angus
Pine River PWQMN (03005701002)
CFB Borden
Oak Ridges
MSC1
MSC2
Mansfield Ski Club
Pine River @ Everett (02ED014)
County Road 42
County Road 10
County Road 13
County Road 21
County Road 15
County Road 5
County Road 56
Airport Road
Main Street
Mill Street

2.2 Policies

Ontario's Ministry of Environment and Climate Change (MOECC) 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 discharge limits are:

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

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

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

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

3. Methods

3.1 Water Quality

Water quality samples were collected from the Pine River on the following dates to provide a four-season assessment:

- September 14, 2016
- October 24, 2016,
- November 30, 2016,
- December 13, 2016
- January 26, 2017
- February 28, 2017
- March 31, 2017
- April 27, 2017
- June 21, 2017
- July 17, 2017
- August 3, 2017

From September 2 to December 2016 water samples were collected at two locations: immediately downstream of the rock weir near the MSC pump house (MSC-1); and at the crossing of the river at Airport Road (Regional Road 18; MSC-2; Figure 2). From January 2017 to August 2017 water samples were collected at MSC-1 only. The reduction to one sampling station in January 2017 was to account for the redirection of the new proposed discharge location to the pump house, located near MSC-1, and the determination that water quality was similar between the two stations (HESL 2017a).

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

- Total phosphorus (TP);
- Nitrogen species (TAN, NO3, NO2, and total Kjeldahl nitrogen (TKN));
- Total suspended solids (TSS);
- Carbonaceous biochemical oxygen demand (CBOD5); and
- *E. coli*.

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

3.1.1 Diurnal Dissolved Oxygen Survey

Diurnal changes in dissolved oxygen were monitored in the Pine River near the proposed point of discharge. A YSI OMS sonde was deployed in the Pine River near the pump house (Figure 2) on August 28, 2017.

The dissolved oxygen meter was calibrated prior to deployment, and the data sonde programmed to measure dissolved oxygen (mg/L and %) and temperature (ºC) every 0.5 hours. The sonde was retrieved on September 9, 2017. The dissolved oxygen measurements were used to assess aquatic habitat conditions in the Pine River and to provide baseline data to model the effects of the proposed effluent discharge on dissolved oxygen concentrations in the Pine River.

3.2 Stream flow

Stream flow was measured during every sampling event using an OTT MF Pro brand flow meter. Stream velocity was measured at a minimum of 10 points across the stream cross-section. At points where the water depth was less than 0.7 m, the water velocity was measured at 0.6 of the water depth. Where water depths were greater the 0.7 m the velocity was measured at 0.2 and 0.8 of the depth and the mean of these values computed. The area-velocity method was used to calculate stream discharge. Manual streamflow measurements are generally accurate to within 6-19% (Harmel et al. 2006) of the actual flow in the watercourse, with lower flows being less accurate.

3.3 7Q20

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 course. 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.

The Water Survey of Canada maintains a continuous flow gauge on the Pine River near Everett (WSC Station 02ED014), on County Road 4, approximately 8.4 km downstream of MSC. Twenty years (1996-2015) of ccontinuous streamflow data from the WSC Station were used to calculate 7-day average flows. Annual minimum 7-day average flows were then input into HYFRAN-PLUS to estimate one 7Q20 flow (Table 2).

Table 2. Minimum 7-day average flows (m^3/s) for the Pine River at Everett from 1996 to 2015

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Minimum 7-Day Average	0.87	0.9	0.79	0.49	0.47	0.76	0.71	0.55	1.14	0.76
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Minimum 7-Day Average	0.83	0.69	0.79	1.11	0.83	1.12	0.85	1.37	1.3	0.9

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 low flow statistic from 02ED014 was pro-rated for the watershed area at MSC-1 to determine flow statistics at the proposed discharge location near the MSC, as:

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

Where Q_2 is the 7Q20 flow statistic and A_1 is the watershed area at MSC-1, determined using the Ontario Flow Assessment Tool (https://www.ontario.ca/page/watershed-flow-assessment-tool, accessed November 2016), and A_2 is the watershed area at the WSC gauge.

3.4 Modelling

The treated effluent from the STP will be directed to the wetland pond located at the northeast of the property, then directed via a buried pipe to the Pine River, discharging to the River near the pump house (WMI 2017). Mass balance modeling was used to predict the resulting downstream concentrations after complete mixing and the CORMIX model to predict and the size and shape of the effluent plume (the mixing zone prior to complete mixing) in the Pine River. For both modelling approaches, it was conservatively assumed that the effluent water quality (e.g. TP, TAN, TSS and temperature) would remain unchanged throughout the residence time in the wetland and the buried discharge pipe to the Pine River.

3.4.1 Mass Balance

The field studies found that the Pine River at MSC-1 is of high quality, with low concentrations of nutrients (TP and TAN), TSS and bacteria (i.e. all parameters met Policy 1). The 75th percentile concentration of nitrate (3.66 mg/L) exceeds the CCCME of 3.0 mg/L for aquatic life. A mass balance loading analysis was undertaken to determine the effect of WWTP effluent on the river water quality after complete mixing.

Parameters modeled include those regulated by the Environmental Compliance Approval (ECA): total phosphorus, total suspended solids, and total ammonia. Although pH and *E. coli* are also regulated by an ECA, these parameters were not modeled as mass balance analysis is not recommended for these parameters. In these two cases, pH is more influenced by alkalinity reactions than by dilution, and *E. coli* are living organisms, and their numbers may increase or decrease in the receiving environment independent of dilution. The WWTP will incorporate UV disinfection of the effluent prior to discharge to the Pine River. Dissolved oxygen and nitrate were also modeled; to assess the effect of nitrification (biological conversion of ammonia to nitrate) and effluent cBOD concentrations on downstream water quality.

Mass-balance modeling assumes instantaneous and complete mixing of the effluent with the receiver. The modeling does not account for uptake that would reduce phosphorus concentrations, or the removal of ammonia from nitrification processes. It does, however provide a conservative calculation of fully mixed concentrations in the receiver. The mass balance model was completed using 7Q20 flows to represent the conservative assessment of the extreme response of the river to the WWTP discharge. Flows will be higher, and resultant fully mixed concentrations lower, 95% of the time.

The upstream, background loads in the Pine River were estimated by multiplying the 75th percentile concentrations measured at MSC-1 by the 7Q20 flow for the Pine River at MSC-1. Using the 75th percentile concentration, combined with the 7Q20 flow provides a conservative worst-case scenario estimate (low flows coupled with enriched water quality) of background water quality and the response to the proposed discharge.

Loads from the WWTP were estimated by multiplying the effluent limits of 15 mg/L for TSS and cBOD, 1.0 mg/L for TP, and 5 mg/L for TAN (WMI 2017) by the proposed flow rate of 1.39 L/s. Effluent loads were also calculated for the recommended TP and TAN effluent objectives of 0.5 mg/L and 3.0 mg/L respectively (Sections 4.1.2 and 4.4). The WWTP loads were added to the background loads calculated for the Pine River to predict downstream loads and water quality.

The effect of effluent on receiver nitrate concentrations was estimated by assuming complete conversion of effluent TAN to nitrate. Effluent TAN concentrations of 5 mg/L and 3 mg/L (limit and objective) were assumed for nitrate and loads from the WWTP were added to upstream background loads to predict downstream loads and concentrations.

The total oxygen demand (TOD) of the effluent was estimated as four (4) times the TAN ECA limit; NOD load) plus the cBOD ECA limit (15 mg/L), for a TOD of 35 mg/L. The 25th percentile DO concentration (9.34 mg/L) from the diurnal DO survey was used to estimate the dissolved oxygen concentration during periods of low oxygen conditions. The reduction in oxygen in the Pine River downstream of the effluent discharge was estimated by subtracting the effluent TOD load from the DO load in the Pine River.

3.4.2 Mixing Zone (CORMIX)

For an effluent discharge, the MOECC requires that the receiver water quality must be maintained within PWQO (for Policy 1 receivers) except for the volume of water within the mixing zone. From *Deriving Receiving Water Based, Point-Source Effluent Requirements for Ontario Waters* (MOE, 1994b), the mixing zone is defined in one of two ways:

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

The size and characteristics of the mixing zone in the Pine River, as established by the volume of water in which effluent parameters exceed their respective PWQO, were determined using the mixing zone model, CORMIX Version 10.0.

CORMIX (Doneker and Jirka, 2007) is a software system developed by Cornell University for the analysis, prediction, and design of aqueous toxic or conventional pollutant discharges into diverse water bodies. The model classifies the discharge configuration into generic flow classifications and then assembles and executes a sequence of sub-models to simulate the hydrodynamic behaviour of the discharge, calculating the plume trajectory, dilution and maximum centerline concentration.

The basis of the CORMIX model is a flow classification system. The model classifies the discharge configuration into generic flow classifications based on dimensionless length scales (Gomm, 1999). Once the flow is classified, the model assembles and executes a sequence of sub-models to simulate the hydrodynamic behaviour of the discharge, and calculates the plume trajectory, dilution and maximum centerline concentration. CORMIX uses these different sub-models to predict mixing in both the near-field region and far-field region from the discharge point. The near-field region refers to the region where the initial jet characteristics (including momentum flux and buoyancy flux) and outfall geometry govern the plume mixing, while the "far-field" region is representative of where conditions existing in the ambient environment (such as density current buoyant spreading and passive diffusion within the Pine River) govern the trajectory and dilution of the plume. The distance to the boundary between the near-field and far-field regions depends on the model input parameters as determined by lake characteristics and the scenario modelled (i.e., effluent flow, discharge configuration).

The mixing zone modelling focussed on ammonia as the potentially toxic component of the effluent that is assimilated by a) dilution in the near field area through initial mixing with the creek to determine the volume of the creek that would exceed the PWQO downstream of the discharge, and b) nitrification, the biological conversion of ammonia to nitrate within the mixing zone.

3.4.2.1 Approach

The proposed MSC discharge to the Pine River was modeled using CORMIX2, a subsystem that is used for positively and negatively buoyant multiport discharges. The multiport configuration represents effluent discharged from a diffuser, and not through a single pipe. A diffuser was modelled to reduce the likelihood of bottom impingement and re-circulation from a bank discharge in the shallow watercourse.

Table 3 provides CORMIX model inputs for the effluent parameter TAN. The rationale for selection of each of the inputs is provided in the following sections.

Table 3 CORMIX Model Inputs

Effluent Worksheet:	
Conservative/non-conservative pollutant	Non-conservative
Decay rate (1/d)	2
Discharge Concentration (TAN in mg/L)	5
Discharge excess concentration (TAN in mg/L)	4.98
Effluent flow rate (m^3/s)	0.00139
Effluent temperature (°C)	22
Ambient Worksheet:	
Channel width (m)	12.1
Bounded appearance	Slight meander
Average channel depth (m)	0.23
Depth at discharge (m)	0.23
Wind speed 2 m above water surface (m/s)	2
Ambient Pine River flow (m^3/s)	0.432

Ambient Concentration (TAN mg/L)	0.02
Manning's n	
Ambient temperature (deg. C)	16.38
Ambient pH	8.33
Discharge Worksheet (CORMIX2):	
Discharge bank (looking downstream)	Right
Diffuser length (m)	1-3
Distance to 1st/2nd endpoint	2-5
Port height (m)	0.02
Port diameter (m)	0.02
Contraction Ratio	1
Total no. of openings	3-15
Alignment (degrees)	90
Vertical angle theta (degrees)	90
Nozzle direction	same
Mixing Zone Worksheet:	
PWQO (TAN in mg/L)	0.27
Temperature used for TAN WQS calculation	16.38
pH used for TAN WQS calculation	8.33
Excess concentration for the WQS (mg/L)	0.25

3.4.2.2 Effluent Worksheet

Parameters may be modelled as either conservative (concentrations are reduced by physical mixing and dilution only) or non-conservative (concentrations are reduced by biological assimilation processes). TAN was modeled as a non-conservative parameter with a rate of decay of 2/d. This rate was conservatively based on a literature review of similar systems that indicated rates between 0.2 and 9/d, and experiences in modelling other surface water bodies in Ontario with low nitrifying activity (HESL, 2016a).

The discharge excess concentration refers to the concentration of a parameter in the effluent above background (i.e., Pine River) concentrations. The Pine River concentrations used in the mixing zone model calculations are summarized in Table 4 along with the rationale for their use.

Table 4. Background Pine River Water Quality for CORMIX Model Input

Parameter	Concentration/Level	Rationale
Total Ammonia Nitrogen	0.02 mg/L	75th percentile of measured TAN concentrations at MSC-1. (method detection limit of 0.02 mg/L, n=11).
Temperature	16.38°C	75th percentile measured temperature concentrations at MSC-1 (n=11). This value is higher than the 75th percentile concentration measured during the DO logger deployment.

pH	8.33	75th percentile measured pH at MSC-1 (n=11).

The discharge excess concentration for TAN was 4.98 mg-N/L (i.e., 5 mg-N/L – 0.02 mg-N/L). An effluent temperature of 22°C was used for the modeling to represent summer effluent temperatures. This conservatively high temperature was based on measured 75th percentile effluent temperature data from the Caledonia and Hagersville WWTPs (HESL, pers. comm.).

An effluent flow rate of 0.00139 m^3/s (1.39 L/s) was used based on the Rated Capacity for the STP.

3.4.2.3 Ambient Worksheet

Inputs for the bounded width, average depth, and the depth at discharge in the Pine River were based on measurements collected during the 2016 -2017 field events. For the river geometry, CORMIX requires that the cross-section of the river be "schematized" as a rectangular channel. The average depth dimension was calculated based on the average depth measurements made at MSC-1 during the lowest flow event (December 2016), then pro-rated for the 7Q20 flow conditions, using the equation provided by CORMIX (Doneker and Jirka, 2007):

$$HA_2 = HA_1 \left[\frac{QA_2}{QA_1} \right]^{3/5}$$

Where HA_1 is the mean ambient water depth measured at MSC-1 (0.31 m), QA_1 is the ambient flow at HA_1 (0.683 m^3/s), QA_2 is the 7Q20 flow (0.432 m^3/s). The mean ambient water depth at 7Q20 conditions (HA_2) was calculated to be 0.23 m. The approach assumes that the ambient width and frictional characteristics of the channel remain the same during a stage change.

The WWTP may discharge in the pool near the pumphouse, approximately 60 m upstream of MSC-1, or downstream near MSC-1. The average depth measured at the pump house on October 5, 2017 was 0.77 m, approximately 0.43 m deeper than at MSC-1 on the same date. The shallower water depth at MSC-1 was used for the depth at discharge, as a conservative measure as this would reduce the volume of water available for mixing. The channel width of 12.1 m was the narrowest width measured during the 2016-2017 field visits, during the November 2016 sampling event.

A wind speed of 2 m/s was used for all scenarios. In the absence of field data, this is the velocity recommended by CORMIX for conservative design conditions. Subsequent sensitivity analyses of the mixing zone model revealed that the model results were insensitive to changes in this input value.

The ambient flow was set to the calculated 7Q20 estimate of 0.432 m^3/s for the Pine River at MSC-1 (Section 4.3). The ambient (i.e., background) concentrations of TAN are described in Table 4.

Manning's n (describing channel roughness and friction) was set at 0.04, which describes a rock, cobble and gravel substrate (LMNO, 2016), as was observed during HESL's site visits.

3.4.2.4 CORMIX Discharge Worksheet

Under the "discharge" worksheet, the discharge location is the location of the nearest bank to the outfall when facing downstream[2] in the direction of the current flow. It was assumed that the diffuser would be located near the MSC pump house. Thus, the discharge location is best described as the right bank.

Six different diffuser configurations were modelled to find the design to optimize nearfield mixing. The diffuser was modelled as 1 m and 3 m long to vary the vertical and lateral mixing, and with 3, 7 and 15 ports to vary the discharge velocity (Table 3). In each scenario the diffuser was oriented perpendicular to the river current (an alignment angle of 90°), 2 m from the bank. This configuration was set so the diffuser was located within the main portion of the channel, for maximum mixing, but proximate to the right bank and not to extend the entire width of the channel to allow for fish passage along the left bank. The ports were oriented upward (vertically angle of 90°) with port height and diameter of 0.02 m each for all scenarios. A contraction ratio of 1 (roundness of the discharge port) was used to represent a round port.

3.4.2.5 Mixing Zone Worksheet

Mixing zone modelling requires calculation of the "excess concentration" of the modelled water quality parameter over the ambient (background) concentration, or the amount of additional concentration that could be added to the background concentration to reach the PWQO.

There is no PWQO for TAN but the PWQO for un-ionized ammonia nitrogen is 0.0164 mg-N/L. As such, the concentration for TAN equating to the PWQO for un-ionized ammonia nitrogen was determined to be 0.27 mg/L TAN using the ambient pH and temperature provided in Table 4. The excess concentration above the water quality standard was 0.25 mg-N/L (0.27 mg-N/L – 0.02 mg-N/L).

3.5 Aquatic Biology

An assessment of aquatic biology was completed to:

1) Inform the determination of appropriate effluent treatment determined through the ACS based on the sensitivity of resident fish species.

2) Minimize impacts to sensitive habitats through selection of the most appropriate outfall location and allow for the development of mitigation measures associated with the installation of the effluent outfall based on sensitivities of resident species and identification of critical habitats.

3) Establish a biological dataset of baseline conditions with which future monitoring results can be compared to determine the presence or absence of impacts associated with the discharge of effluent from the Mansfield Ski Club.

Benthic invertebrates are the most used organism in the bioassessment of freshwater ecosystems and they can provide another layer of information to determine the presence or absence of impacts associated with

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

treated effluent. Benthic invertebrates were not collected as part of this study to inform the selection of the most appropriate effluent outfall location or to characterize baseline conditions because a) the selection of the most appropriate effluent outfall location was informed by the fisheries assessment and characterization of habitat, including quality of benthic habitat for colonization by invertebrates, and b) we do not anticipate that the minor predicted changes in water quality will result in a detectable shift in benthic invertebrate assemblage when natural variability associated with habitat is accounted for.

3.5.1 Aquatic Habitat

Aquatic habitat was characterized in the Pine River between the 17th Sideroad and County Rd. 18 through evaluation of morphology, substrate, riparian vegetation, aquatic vegetation and other cover features. Habitat requirements of resident fish species were compared to habitat found in the study area to determine the presence or absence of critical habitats.

3.5.2 Fisheries

Resident fish assemblages were characterized in the study area based on a background review of sampling conducted by Nottawasaga Valley Conservation Authority and Midhurst District Ministry of Natural Resources and Forestry (MNRF).

HESL received a Licence to Collect Fish for Scientific Purposes (#1087986) from MNRF to collect fish and characterize the resident fish assemblage via backpack electrofishing but spawning activity of Chinook Salmon (*Oncorhnchus tshawytscha*) was observed throughout the study reach so electrofishing was not completed as per Condition #10 of the Licence:

> *10. Due to potential spawning activity by spawning salmonids visual inspection of all sampling area should be done prior to sampling with the electrofisher or seine nets. Should spawning activity or redds be observed all sampling must be stopped in order to prevent disturbance to the fish and habitats.*

A visual spawning assessment of the chinook salmon (*Oncorhynchus tshawytscha*) was completed. Redds were marked via GPS, spawning behaviour was noted, and spawning individuals were counted at each active redd.

The fisheries assessment met the three objectives of the study through the background review, habitat assessment and spawning assessment despite the inability to collect fish via backpack electrofishing as planned. The habitat assessment was used to determine the most appropriate location of the effluent outfall and develop suitable mitigation measures, the background review provided an indication of the resident species assemblage and the ability to assess sensitivities to effluent parameters, and the spawning assessment provided an ecologically important and sensitive measure of baseline conditions and another consideration during the determination of suitable effluent treatment.

4. Results

4.1 Water Quality

Water quality data from the Pine River monitored at MSC-1 and MSC-2 and the nearest Provincial Water Quality Monitoring Network (PWQMN) station (Pine River at Mill Street in Angus, Station 03005701002) was assessed against applicable Provincial Water Quality Objectives (PWQO) to determine the policy status of the river to receive treated effluent in accordance with MOECC policies and guidelines (MOEE 1994):

- 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.

Where available, water quality parameters were also compared against Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG PAL; CCME 2012).

4.1.1 Provincial Water Quality Monitoring Network

The Provincial Water Quality Monitoring Network station (Station 03005701002) is located upstream of the Nottawasaga River at Mill Street, Angus, ON, approximately 25 km downstream of the study site. Long-term data were available from this site for general chemistry and nutrients (1972-2014) and for total metals (2000-2005), which were typically monitored monthly from April to November by the Nottawasaga Valley Conservation Authority (NVCA).

Evaluation of the most recent data from 2000 to 2014 indicated that water in the Pine River at the Mill Street crossing was alkaline (75th percentile pH = 8.48) and with high concentrations of minerals (75th percentile total dissolved solids = 308 mg/L) and some metals (e.g., aluminium, barium, calcium, iron, magnesium, manganese, strontium and zinc) and very hard water (75th percentile hardness = 239 mg/L) that contribute to high specific conductivity (75th percentile = 474 µS/cm)) (Table 5). 75th percentile concentrations of aluminum (190 µg/L), cadmium (0.225 µg/L), cobalt (0.375 µg/L) and iron (376 µg/L) exceeded applicable PWQO and CWQG PAL. The alkaline, hard water and high metal concentrations of the Pine River were consistent with the large natural source of groundwater to the river originating from sedimentary rocks of the Niagara Escarpment and elevated TSS concentrations (metals).

General water quality parameters and nutrient concentrations were all within available PWQO and CWQG PAL except for total phosphorus (75th percentile = 0.038 mg/L), which exceeded the PWQO of 0.03 mg/L for rivers. Total phosphorus concentrations were highly variable over the period of record (Figure 3) and elevated concentrations above the PWQO were generally associated with high concentrations of total suspended solids (Figure 4). Phosphorus-enriched solids likely originated from erosion of soil particles that entered the river with runoff from disturbed areas such as agricultural operations and urban areas, particularly during storm events. High flow events may have also caused erosion and sediment suspension within the river, contributing to periods of high total suspended solids and associated total phosphorus concentrations.

Table 5. Pine River at Mill Street Water Quality Summary (2000-2014, PWQMN Station 03005701002)

Parameter	Units	PWQO/ (CWQG PAL)	Median[3]	75th %ile[3]	N	Values Exceeding Guideline	
						#	%
General							
Alkalinity	mg/L		205	214	55		
Chloride	mg/L	120	17.1	18.2	92	0	0%
Conductivity, specific (@25°C)	µS/cm		453	474	55		
Hardness	mg/L		227	239	49		
Oxygen, dissolved	mg/L	>5 - 8	11.38	12.62	59	0	0%
pH, field	-	6.5 - 8.5	8.38	8.48	61	12	20%
Solids, dissolved	mg/L		296	308	49		
Solids, total suspended	mg/L		12.5	28.3	90		
Temperature	°C		14	17.7	89		
Turbidity	FTU		7.7	18.5	49		
Nutrients							
Ammonia, total (as N)	mg/L		0.009	0.016	91		
Ammonia, unionized (calc.) (as N)[1]	µg/L	16	0.427	1.08	66	0	0%
Nitrate (as N)	mg/L	3	1.7	2.1	89	3	3%
Nitrite (as N)	mg/L	0.06	0.009	0.011	91	0	0%
Nitrogen, total Kjeldahl	mg/L		0.370	0.485	92		
Phosphate	mg/L		0.0022	0.0045	92		
Phosphorus, total	mg/L	0.03	0.024	**0.038**	91	31	34%
Metals (Total) (2000-2005 only)							
Aluminum	µg/L	75	**86.5**	**189**	40	23	58%
Barium	µg/L		35.75	37.8	40		
Beryllium	µg/L	1100	0.0146	0.018	40	0	0%
Cadmium[2]	µg/L	0.2	-0.00163	**0.225**	40	11	28%
Calcium	mg/L		63.8	68.0	49		
Chromium	µg/L	1	0.0188	0.47	40	1	3%
Cobalt	µg/L	0.2	0.107	**0.38**	40	15	38%
Copper	µg/L	5	1.305	1.9	40	0	0%
Iron	µg/L	300	178.5	**376**	40	13	33%
Lead	µg/L	5	0.235	3.2	41	3	7%
Magnesium	mg/L		16.0	16.7	49		
Manganese	µg/L		27.2	55.8	40		
Molybdenum[2]	µg/L	40	-0.618	-0.178	40	0	0%
Nickel	µg/L	25	0.30	0.56	40	0	0%
Potassium	mg/L		1.53	1.63	49		
Sodium	mg/L		8.64	9.04	49		
Strontium	µg/L		151	160	40		
Titanium	µg/L		2.57	4.99	40		
Vanadium	µg/L	6	0.53	1.04	40	0	0%
Zinc	µg/L	20	3.46	5.9	40	1	3%

Notes: [1]Calculated using date-specific field temperature and pH, or the 75th percentile where these parameters were not available (n=4). [2]Laboratory detection is +/- 0.8 µg/L for cadmium, and +/- 1.5 µg/L for molybdenum. [3] Bolded values exceed applicable guideline/objective. Values below laboratory detection limits were set to the detection limit for the calculation.

Figure 3. Total phosphorus concentrations in the Pine River by month (2000-2014, PWQMN Station 03005701002).

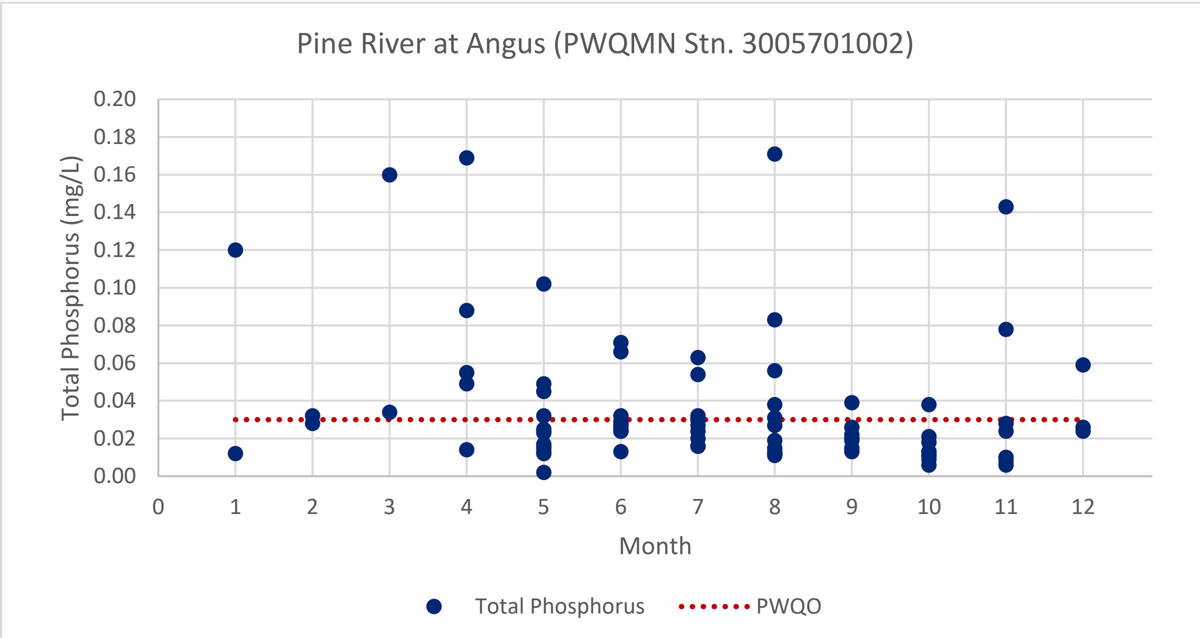
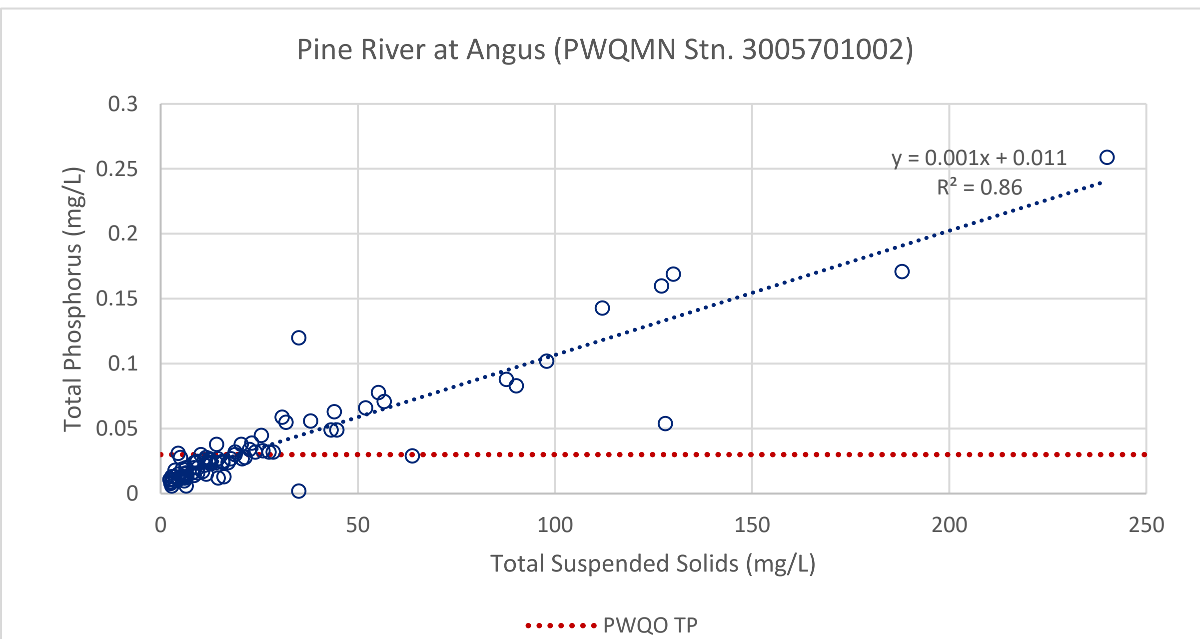


Figure 4. Relationship between total phosphorus and total suspended solids in the Pine River (2000-2014, PWQMN Station 03005701002).



4.1.2 Pine River near Mansfield Ski Club

Water quality in the Pine River near the MSC (Table 6) was sampled at MSC-1 and MSC-2 from September 2016 to January 2017, and from MSC-1 from February 2017 to August 2017. All measured parameters were similar between MSC-1 and MSC-2 (Table B1, Appendix B) and well below applicable PWQO and CWQG PAL (except for pH on the December 13th sampling event), supporting the cessation of MSC-2 sampling in February 2017.

Water quality at MSC-1 was similar to that at the PWQMN Station (03005701002) 10 km downstream with two notable exceptions. The Pine River near MSC-1 had similarly low concentrations of nitrogen species (e.g. ammonia, nitrite, and total Kjeldahl nitrogen; Table 6), however, MSC-1 had much lower concentrations of total suspended solids (75th percentile = 7.6 mg/L, Table 6) and total phosphorus (75th percentile = 0.0073 mg/L, Table 6). Lower total suspended solids at the MSC stations relative to the PWQMN station downstream may be because of the lower erosivity of the geology upstream of the MSC (Escarpment) compared to the downstream reaches; and the absence of major storm events that occurred prior to or during the scheduled sampling events. Lower total phosphorus concentrations at the MSC stations, however, likely reflected lower total suspended solids in the river, but also increased phosphorus loads with distance downstream of the MSC due to increased contributions from agricultural runoff and human activities downstream of CFB Borden, and Angus.

Elevated concentrations of nitrate (3.31 mg/L to 4.45 mg/L, Table B1), above the CCME guideline of 3 mg/L were measured in the Pine River at MSC-1 from February 2017 to June 2017, the 75th percentile concentration of 3.66 mg/L is above the CCME guideline of 3.0 mg/L. High concentrations may be a result of agricultural inputs upstream or inputs from the existing tile fields at MSC.

Table 6 Summary Statistics for Pine River at MSC-1

Parameter	Units	Guideline/ Objective	MSC-1 Summary Statistics				
			N	Min	Max	median	75th %
Field Measurements							
Temperature	°C		11	0.81	18.11	8.64	16.38
pH	pH units	6.5 - 8.5	11	7.78	8.84	8.25	8.33
Specific Conductivity	µS/cm		11	454	529	493	508
Dissolved Oxygen	mg/L	a	11	9.51	14.36	11.53	10.87[b]
	%		11	92	116	101	105
Laboratory Measurements							
Solids, total suspended	mg/L		11	<2.0	9.1	2.9	7.6
Ammonia, total (as N)	mg/L		11	<0.020	0.13	<0.020	<0.020
Nitrate and Nitrite (as N)	mg/L		11	1.84	4.45	2.4	3.66
Nitrate (as N)	mg/L	3	11	1.84	4.45	2.40	3.66
Nitrite (as N)	mg/L	0.06	11	<0.01	<0.01	<0.01	<0.01
Nitrogen, total Kjeldahl	mg/L		11	0.16	0.67	0.4	0.48
Phosphorus, total	mg/L	0.03	11	<0.003	0.0116	0.0063	0.0073

Parameter	Units	Guideline/ Objective	MSC-1 Summary Statistics				
			N	Min	Max	median	75th %
Ammonia, unionized (calc.) (as N)	mg/L	0.0164	11	0.0010	0.0258	0.0048	0.0054
E. coli	CFU/100mL	100	11	<2	120	20	35
Biochemical oxygen demand, carbonaceous	mg/L		11	<2.0	<2.0	<2.0	<2.0

Notes: For summary statistics, if result was <DL, then 1/2 DL was used to calculate statistic. a – PWQO for dissolved oxygen is temperature dependent, b - 25th percentile dissolved oxygen value.

4.1.3 Diurnal Dissolved Oxygen

Dissolved oxygen conditions in the Pine River were excellent from August 29 to September 9, and ranged from 8.41 mg/L to 11.01 mg/L. This is well above the PWQO of 6 mg/L for water temperature of 10ºC (Figure 5). Diurnal variations in oxygen were minimal, and were on average 1.3 mg/L. Dissolved oxygen minima typically occurred near midnight and the early morning, however concentrations were always well above the PWQO. Dissolved oxygen maxima occurred mid-day to mid-afternoon, and reached saturated conditions. The 25th percentile dissolved oxygen concentration of 9.34 mg/L was calculated as input into the DO mass-balance model. This value is also well above the PWQO of 6 mg/L.

Continuous temperature was also monitored during this period. Water temperatures ranged from 10.76 to 23.19ºC.

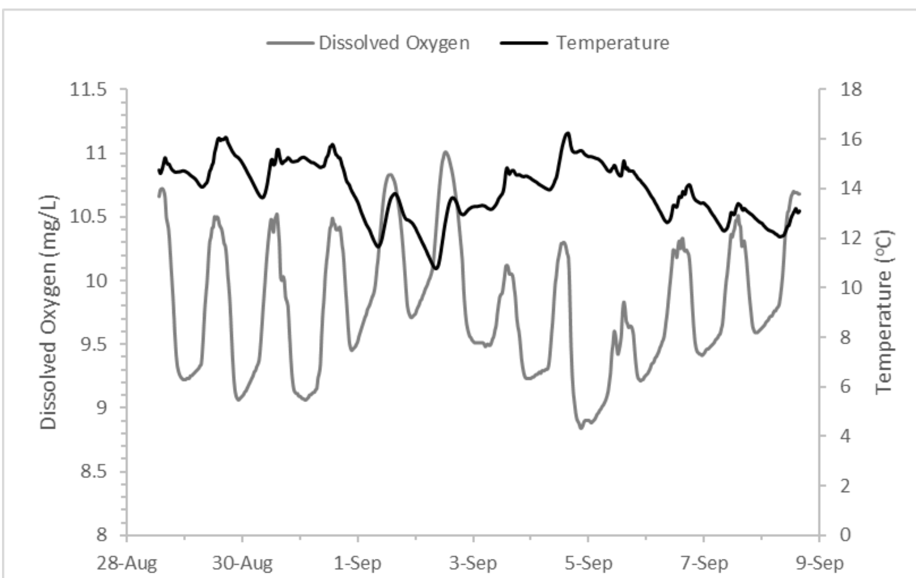


Figure 5. Continuous Dissolved Oxygen and Temperature measurements in the Pine River (August 29 – September 8, 2017)

4.1.4 Summary

In 2016-2017 the water quality in the Pine River near MSC was very good with low concentrations of suspended sediments and nutrients. Total phosphorus (75th percentile = 0.007 mg/L), and un-ionized ammonia nitrogen (75th percentile = 0.0054 mg/L) concentrations were well below their PWQO values of 0.03 and 0.0164 mg/L respectively; indicating Policy 1 status for these parameters. Dissolved oxygen concentrations were above the PWQO of 6 mg/L at 10ºC, indicating a well oxygenated Policy 1 system. Nitrate concentrations were enriched, with 75th percentile concentrations (3.66 mg/L), exceeding the CCME guideline of 3.0 mg/L. Nitrate concentrations exceeded the CCME guideline on four (February to June 2017) of eleven sampling events.

Water quality data collected from the Pine River at MSC-1 was, for the most part, similar to that collected at the PWQMN site near Angus. The downstream site near Angus showed increased total phosphorus concentrations (75th percentile = 0.038 mg/L, Policy 2 status) but had lower nitrate concentrations - the CCME guideline of 3 mg/L was only exceeded on three of 89 sampling events).

Despite the Policy 1 status for total phosphorus in the Pine River near the MSC, efforts to minimize total phosphorus loads from the proposed effluent discharge are recommended considering:

- Phosphorus concentrations are extremely low near the MSC (median total phosphorus = 0.007 mg/L), and exceptional for a river in southern Ontario, and
- Phosphorus concentrations increase downstream of the MSC to levels that often exceed PWQO at Everett.

4.2 Stream Flow

Stream flow was measured in the Pine River at MSC-1 and MSC-2 during every sampling event and showed no consistent increasing or decreasing pattern downstream. Flows differed by -20% to +15% between the two stations, with differences most pronounced under lower flow conditions (Table 7). Differences in measured stream flows were likely related to a combination of measurement accuracy (6-19%, Harmel et al., 2006), inputs from groundwater upwellings (especially during low flow periods), and potential water takings between the two stations.

Stream flows measured in 2016 were much lower than those measured in 2017. From September to December 2016, streamflow ranged from 683 L/s to 903 L/s, and from January 2017 to August 2017 streamflow was almost double, and ranged from 1,429 to 3,186 L/s at MSC-1.

Table 7. Measured Stream Flows (L/s) in Pine River near MSC

	14-Sep-16	24-Oct-16	29-Nov-16	13-Dec-16	26-Jan-17	28-Feb-17
MSC-1	688	723	903	683	1596	3183
MSC-2	794	815	862	549	1473	3023
% change	15%	13%	-5%	-20%	-8%	-5%
	31-Mar-17	**27-Apr-17**	**21-Jun-17**	**17-Jul-17**	**3-Aug-17**	**31-Mar-17**
MSC-1	2210	2865	1956	2219	1429	2210
MSC-2	2357	2475	1971	2067	1437	2357
% change	7%	-14%	1%	-7%	1%	7%

4.3 7Q20

Twenty years (1996-2015) of continuous streamflow data from the WSC Station were used to calculate 7-day average flows. Annual minimum 7-day average flows were then input into HYFRAN-PLUS to estimate the 7Q20 flow. 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. The calculated 7Q20 flows from the different distribution functions are presented in Table 8. Values ranged from 0.508 m^3/s with the Fréchet distribution to 0.528 m^3/s with the Inverse Gamma distribution. The Chi-Square test found that the goodness of fit for the Inverse Gamma distribution was acceptable at p value of 0.07, but only at 0.03 for other two distributions, therefore the Inverse Gamma distribution value of 0.528 m^3/s was used as the 7Q20 value.

Table 8. Monthly (October to April) 7Q20 values (m^3/s) for Maitland River near Harriston

Statistical Distribution	7Q20 value (m^3/s)	Significance Level	P value
Inverse Gamma	0.528	5%	0.0719
Log Pearson Type 3	0.512	1%	0.0302
Fréchet [Extreme Value 2]	0.508	1%	0.0302
Halphen Type Inverse B	N/A		

The WSC gauge is located 8.4 km downstream of MSC. The watershed area draining to the Pine River at the WSC gauge is 190 km^2. The watershed area draining to the Pine River of 156 km^2 at MSC-1 was determined using the Ontario Flow Assessment Tool (https://www.ontario.ca/page/watershed-flow-assessment-tool, accessed November 2016). The 7Q20 statistic was pro-rated for the watershed areas at MSC-1 to determine the low flow statistic in the Pine 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 (0.528 m^3/s), and A_1 is the watershed area at MSC-1, (156 km^2), and A_2 is the watershed area at the WSC gauge (190 km^2).

Pro-rating of the 7Q20 flow from the Everett WSC gauging station to MSC-1 resulted in a 7Q20 flow of 0.432 m^3/s (432 L/s). Flow in the Pine River available for dilution of the effluent would therefore provide a dilution ratio of 311:1 under 7Q20 low flow conditions at the proposed effluent flows of 1.39 L/s.

The minimum spot flow measured by HESL at MSC-1 from 2016 to 2017 was 0.683 m^3/s (683 L/s), well above the 7Q20 value. The spot flow measurements could not be prorated for comparison with the flows measured at Everett, as the 2016/2017 water level and flow data for the gauge were considered to be unreliable by Environment Canada[3]

[3] *(https://wateroffice.ec.gc.ca/report/remarks_e.html?type=h2oArc&stn=02ED014&mode=Graph&reportType=Daily, accessed October 16, 2017).*

4.4 Non-lethal Effluent Requirement

Un-ionized ammonia is the toxic fraction of total ammonia and the proportion of un-ionized ammonia increases as pH and temperature increase. All effluent discharged to surface water must be non-acutely lethal to aquatic life at the point of discharge, prior to any mixing or dilution with the receiver. This is defined as a requirement that 100% effluent pass a 96-hr toxicity test using rainbow trout (*Oncorhyncus mykiss)* and a 48-hr toxicity test using *Daphnia magna*. An effluent concentration of 0.27 mg-N/L or less of un-ionized ammonia is a conservative estimate of the lethal threshold[4].

At the proposed total ammonia concentration of 5 mg/L mg-N/L in the effluent, an effluent temperature of 22°C (75th percentile effluent temperature of Caledonia and Hagersville WWTPs from May to October 2015-2016) and pH of 9.0 (proposed maximum allowable value for the ECA limit), the un-ionized ammonia concentration is 1.57 mg-N/L, and is greater than the 0.27 mg-N/L toxicity threshold. An effluent pH limit of 9 is considered unrealistic for assessment of lethal un-ionized ammonia concentrations for several reasons. The toxicity test results are based on exposures of 48 and 96 hours and so individual spot measurements of pH 9 would not have a great influence on toxicity as long as average exposure conditions were lower. Our experience shows that an average effluent pH above 8 is unlikely in daily operations (75th percentile effluent pH at Caledonia and Hagersville WWTPs for 2015-2016 is 7.2). As such, an average effluent pH of 8.0 represents a conservative scenario for a 48 or 96-hour test. At an effluent pH of 8.0 and temperature of 22°C allows for a TAN effluent limit of 5 mg/L-N/L which provides an un-ionized concentration of 0.21 mg-N/L, well within the toxicity threshold. Effluent temperatures will be cooler than 22°C in the spring, fall and winter months, thereby reducing un-ionized ammonia concentrations at the same pH.

A TAN limit of 5 mg-N/L will meet the non-lethal effluent requirements. At the effluent objective of 3.0 mg-N/L TAN, pH of 8.0, and effluent temperature of 22°C, the un-ionized ammonia concentration is 0.1314, well below the toxic threshold. An upper pH objective of 8.0 is therefore recommended as it is protective of aquatic life.

The current discharge scenario (WMI 2017) proposes to direct the effluent to a wetland pond prior to discharge to the Pine River. Directing the effluent to a wetland prior to the Pine River provides the opportunity for the effluent to warm before discharge to the River, potentially creating lethal effluent at the point of discharge. Mixing of the effluent and the stormwater flows, as proposed may lead to a more complex ECA and effluent quality that is more difficult to control. We therefore recommend that the effluent

[4]*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.*

flow be kept separate from the stormwater flow and that it be discharged directly to the Pine River after treatment.

4.5 Modelling

Mass balance and mixing zone modeling were used to predict the resulting fully mixed downstream concentrations, and the size and shape of the effluent plume in the Pine River. For both modelling approaches, it was conservatively assumed that the effluent water quality (e.g. TP, TAN, TSS, and temperature) would remain unchanged throughout the residence time in the buried pipe to the Pine River.

4.5.1 Mass Balance

A mass balance loading analysis was used to determine the fully mixed concentrations of effluent parameters in the Pine River under the future effluent flow and recommended effluent limits. These calculations assumed instantaneous and complete mixing of the effluent with the Pine River to provide an understanding of downstream water quality under low flow (i.e. worst case) scenarios.

The proposed ECA limits and discharge of 1.39 L/s resulted in slight downstream water quality changes from current conditions. At the effluent limit of 1.0 mg/L for total phosphorus the phosphorus concentrations are predicted to increase to 0.010 mg/L, from 0.007 mg/L (Table 9), well below the PWQO of 0.030 mg/L, and within the range of low concentrations observed for this watercourse. At the proposed operating objective of 0.5 mg/L, the TP concentration will increase to 0.009 mg/L, a nominal increase of 0.002 mg/L.

TSS increased by 0.02 mg/L from 7.55 to 7.57 mg/L. At an effluent limit of 5 mg-N/L the TAN concentration will increase by 0.066 mg-N/L to 0.036 mg-N/L mg-N/L, from <0.020 mg-N/L (Table 9). Using 75th percentile water temperature (16.38ºC) and pH (8.33) field values (Table 6) the calculated un-ionized ammonia-N concentrations increased from 0.0012 mg-N/L to 0.0022 mg-N/L respectively, still well below the PWQO of 0.0164 mg-N/L. At an effluent objective of 3.0 mg-N/L, the TAN and un-ionized ammonia concentration will increase to 0.030 mg-N/L and 0.0018 mg-N/L respectively.

No measurable change to Pine River nitrate concentrations is predicted if effluent TAN is assumed to be completely nitrified in the receiver. At an effluent TAN limit of 5.0 mg-N/L the predicted nitrate concentrations will not change (Table 9).

A small decrease in DO concentrations may occur from the nitrification of ammonia and biological oxygen demand of the effluent. The 25th percentile DO concentration is predicted to decrease by 0.14 mg/L (Table 9). At a TAN effluent limit of 5 mg-N/L, the predicted DO concentration is 9.20 mg/L, well above the PWQO of 7 mg/L for cold water biota at a water temperature of 0ºC.

Table 9 Predicted Changes to Pine River Water Quality

	Pine River Upstream			Effluent			Calculated Pine River Downstream			
	75% Conc.	7Q20	Load	Conc.	STP Flow	STP Load	Load	% Change	Conc.	Conc. Change
	mg/L	m^3/s	kg/d	mg/L	m^3/d	kg/d	kg/d	%	mg/L	mg/L
TP	0.007	0.432	0.27	1[c]	120	0.12	0.39	44	0.010	0.003
	0.007	0.432	0.27	0.5[d]	120	0.06	0.33	22	0.009	0.002
TSS	7.55	0.432	282	15	120	2	284	0.6	7.57	0.02
Ammonia	0.020	0.432	0.75	5 [c]	120	0.60	1.3	81	0.036	0.016
	0.020	0.432	0.75	3 [d]	120	0.36	1.1	48	0.030	0.010
NO_3	3.66	0.432	137	5	120	0.60	137	0.4	3.66	0.004
BOD	2	0.432	75	15	120	2	76	2	2	0.042
Dissolved Oxygen	9.34[a]	0.432	349	35[b]	120	4	344	1.2	9.20	-0.14

Note: a - 25th percentile DO concentration used for Pine River Upstream. b – TOD = 4 5 mg-N/L TAN + 15 mg/L BOD; c – effluent limit; d – effluent objective*

4.5.2 Mixing Zone (CORMIX)

The description of the plume predicted by CORMIX corresponded to flow class MU8, a multiport diffuser with perpendicular alignment discharging into an ambient flow (Appendix B). For this diffuser design the net horizontal momentum flux is zero, so that no significant diffuser-induced currents are produced. The local effect of the discharge momentum flux is strong in relation to the layer depth, and in relation to the discharge buoyancy, so the discharge configuration is hydrodynamically unstable.

The effluent mixing was predicted to consist of the following flow zones:

1. The first zone: the destabilizing effect of the discharge jets produces an unstable near-field zone. For weak cross-flow conditions, a vertical recirculation zone is produced leading to mixing over the full layer depth, however the flow tends to re-stratify outside this zone. For strong cross-flow, as in the Pine River, additional destratification and mixing are produced.
2. The second zone: the plume spreads laterally along the layer boundary while it is being advected by the ambient current. Mixing rate is relatively small.
3. The third zone: passive ambient mixing, background turbulence becomes the dominant mixing mechanism. Plume is growing in depth and width.

The CORMIX model demonstrated that the high flow of the Pine River, even under 7Q20 conditions (0.432 m^3/s or 432 L/s) compared to that of the effluent (0.00139 m^3/s or 1.39 L/s) produced rapid mixing of the effluent in the river and a very small mixing zone. Diffuser design (length and number of ports) had a small effect on the size of the mixing zone, and resulted in rapid mixing in the nearfield and short distances to meet the PQQO of 0.0164 mg-N/L.

The plume was predicted to be vertically mixed in the water column by 1.15 to 3.23 m downstream, and continued to be vertically mixed into the far-field (Table 11). The plume contacted the right bank (discharge bank) between 105 m (1 m diffuser) and 174 m (3 m diffuser) downstream of the discharge (Table 11) and all water quality parameters met PWQO well before this point.

The distance required to meet the PWQO for un-ionized ammonia was predicted to be 0.07 m (3 m diffuser) to 0.67 m (1 m diffuser) from the discharge; therefore, the size of the mixing zone ranged from 1-3 m wide by 0.07 – 0.67 m long depending on the diffuser design. Predicted TAN concentrations 20 m downstream of the diffuser were 0.045 mg-N/L to 0.104 mg-N/L, 2 to 5 times the upstream background concentration of <0.02 mg-N/L. Predicted concentrations 100 m downstream were ~2.7 (0.054 to 0.059 mg-N/L) times the background concentration of <0.02 mg-N/L. Predicted un-ionized ammonia concentrations were well below the PWQO (Table 11).

The dilution of the effluent by the receiver under 7Q20 flow conditions is 311 times, which was reached between 1864 and 2211 m downstream of the outfall (Table 11) depending on the discharge configuration.

Table 10 CORMIX Modelling Results

Diffuser Length	**3 m**			**1 m**		
Number of Ports	**15**	**7**	**3**	**15**	**7**	**3**
Discharge Velocity (m/s)	0.3	0.63	1.48	0.3	0.63	1.48
Distance to PWQO (m)	0.07			0.67		
Distance to Right Bank Attachment (m)	174			105		
Plume Vertically Mixed (m)	1.15			3.23		1.15
Plume Laterally Mixed (m)	1864			2211		
TAN concentration 20 (m) downstream (mg-N/L)	0.045			0.104		
TAN concentration 100 (m) downstream (mg-N/L)	0.054			0.059		
UI-TAN concentration 20 (m) downstream (mg-N/L)	0.0045			0.0033		
UI-TAN concentration 100 (m) downstream (mg-N/L)	0.0063			0.0036		

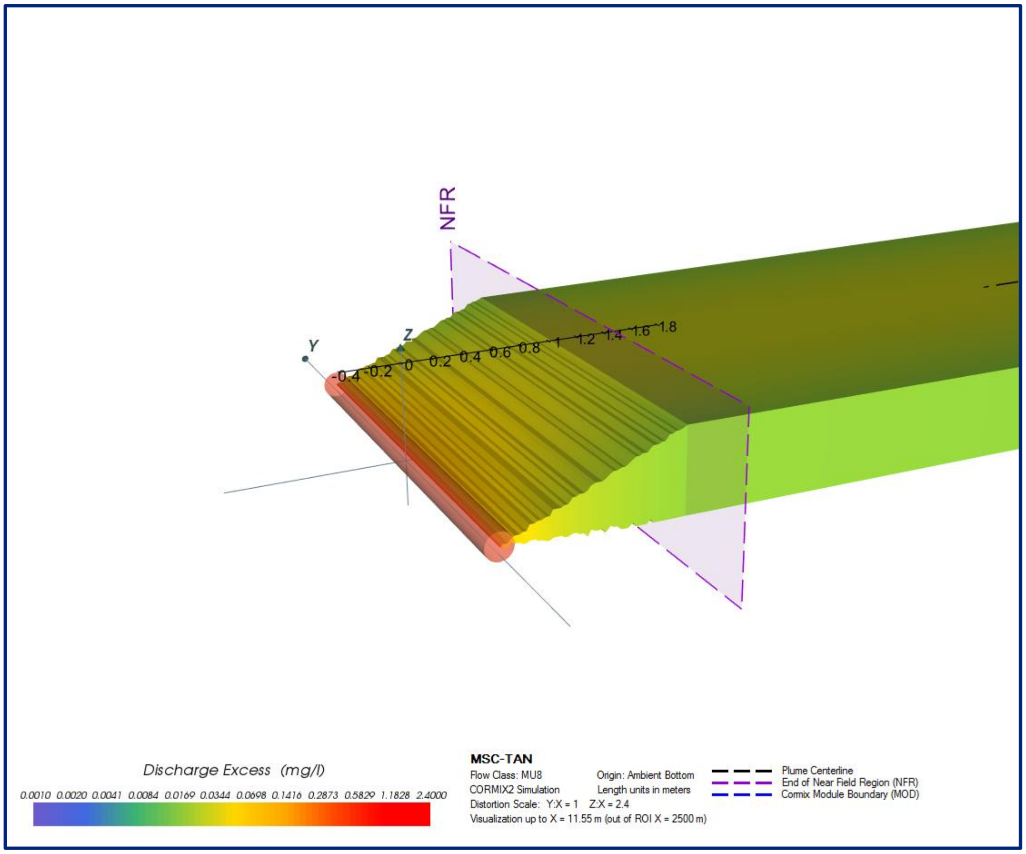


Figure 6. Three-dimensional view of discharge plume. Downstream distance in m.

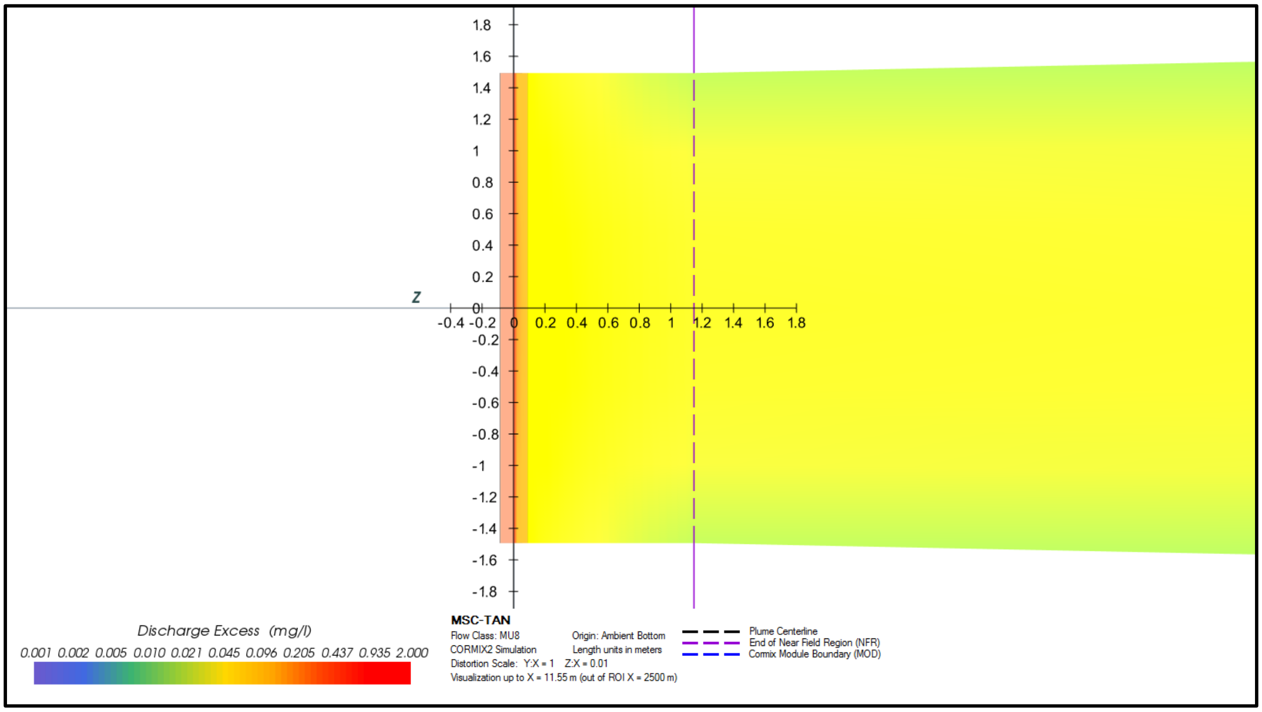


Figure 7. Plan view of discharge plume. Distances in m.

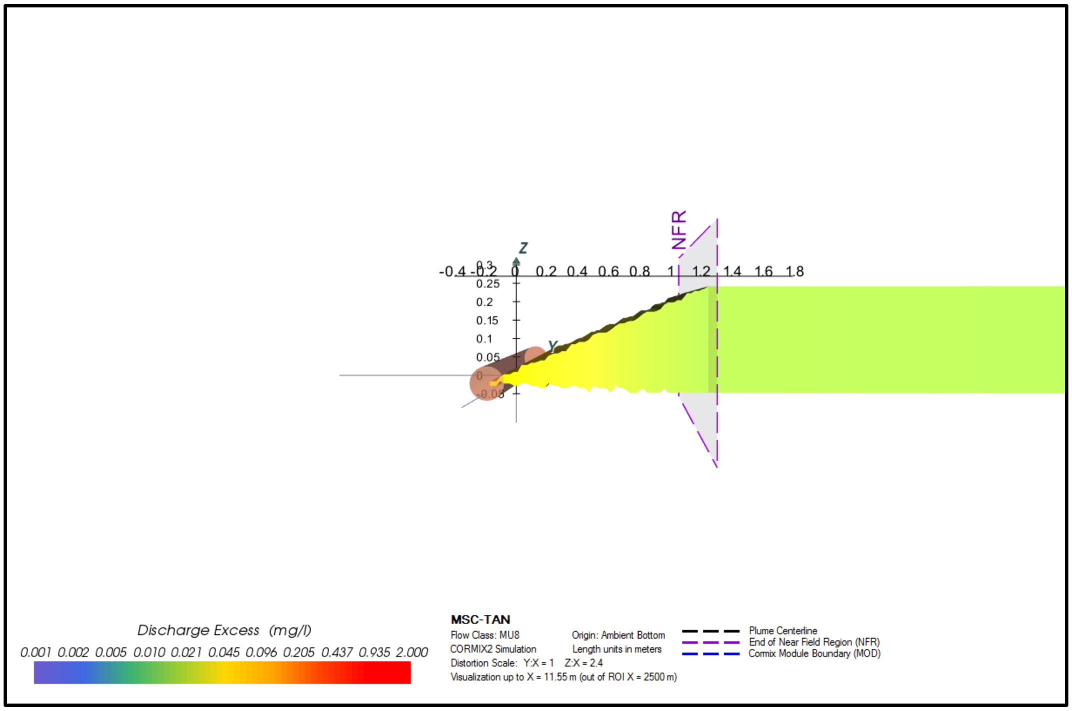


Figure 8. Lateral view of discharge plume, distances in m.

4.6 Aquatic Biology

4.6.1 Aquatic Habitat

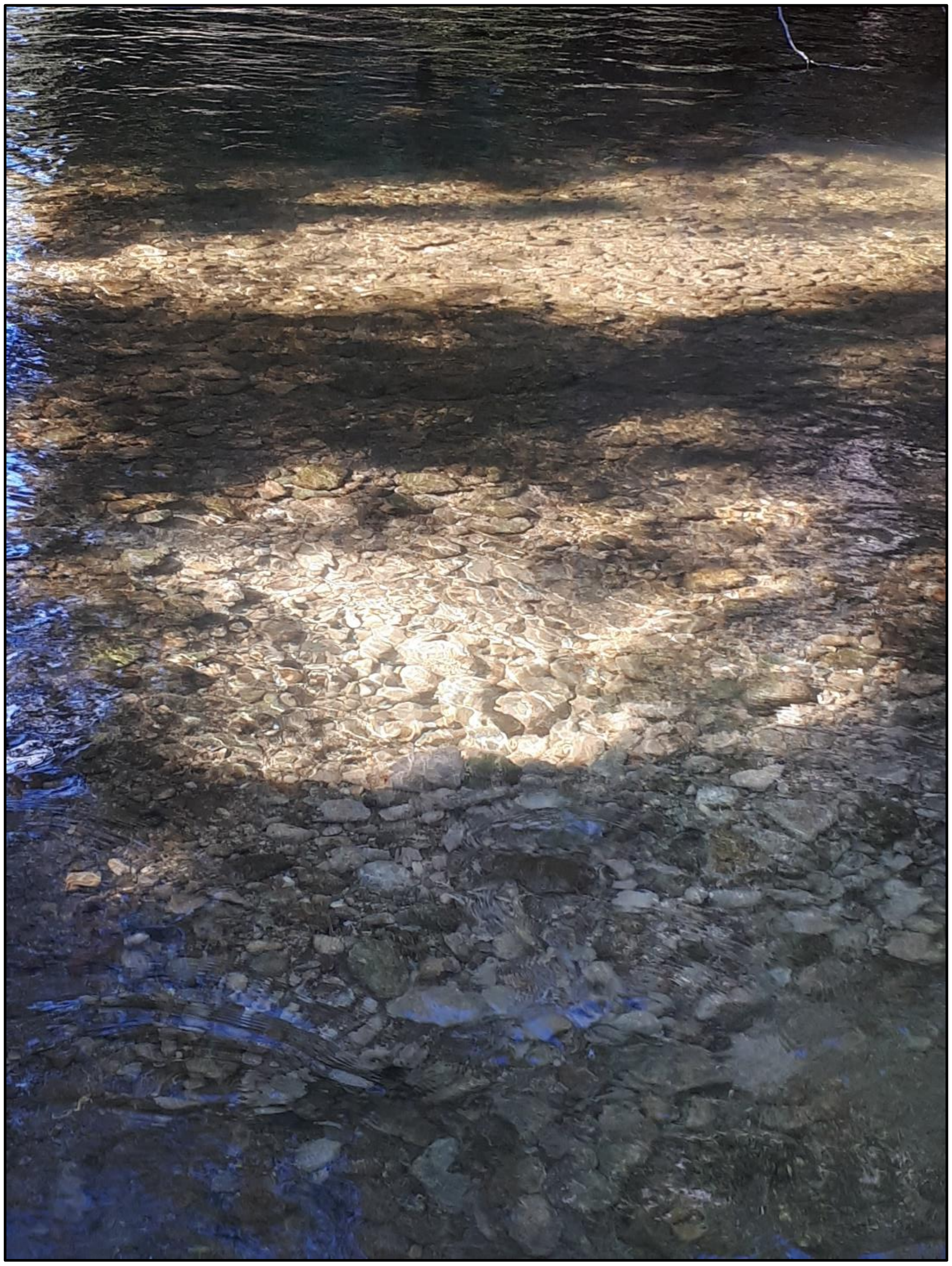
Aquatic habitat was relatively homogeneous between the 17th Sideroad and County Road 18. The Pine River exhibits limited slope and a slightly wandering channel, and has developed plane bed/pool riffle morphology with moderately deep riffles and shallow runs (>0.15 m deep), and deeper runs with shallow pools (<0.80 m deep). Substrates were predominantly rocky (gravel, cobble and some boulders) in the shallower areas and sandy in the deeper, depositional areas. Excavation and placement of large cobble and boulders has resulted in the formation of a deep pool (>1 m) and a step pool/cascade near the pumphouse (Site MSC-1; Photograph 1). The pool contains silty sands predominantly and along the margins substrates are unconsolidated up to 0.2 m depth as a result of depositional hydrology.

Aquatic vegetation was moderately abundant in the upstream part of the study reach near the 17th Sideroad as the result of accumulations of Canada Waterweed (*Elodea canadensis*) and Lake Watercress (*Nasturtium officinale*), which is an indicator of groundwater upwellings and cold-water temperatures (Photograph 2). Smaller accumulations of Canada Waterweed were observed in isolated pockets further downstream. Riparian vegetation was mixed in the upstream reach and provided little overhanging cover while Eastern White Cedar (*Thuja occidentalis*) became dominant and provided considerable overhanging cover in the downstream section of the study reach. Woody debris was sparse throughout much of the study reach because of high flows.

Chinook Salmon redds were observed between the step pool/cascade located adjacent to the pump house and County Road 18 (Figure 2; Photograph 3). Redds were located in rocky substrates within deep riffles/shallow runs. Most redds were occupied by Chinook Salmon exhibiting active spawning behaviour as described in Section 4.6.2.

Photograph 1. The boulder cascade located downstream of the pumphouse.

Photograph 2. View of the Pine River facing north (upstream) in the upper portion of the study reach with the 17th Sideroad located in the distance. Lake Watercress beds and rocky substrates were dominant throughout this reach.



Photograph 3. Chinook Salmon redd located near County Rd. 18 which was occupied by up to 6 individuals on the date of observation.

4.6.2 Fisheries

The Pine River flows from the Horning's Mills area through Terra Nova, Mansfield and eventually Angus before emptying into the Nottawasaga River and ultimately Georgian Bay. A number of spring-fed tributaries flow into Pine River near Terra Nova. The river valley consists of mixed forested and agricultural lands near the study area and a well-forested valley system that extends to Angus (NVCA 2013).

The Pine River supports a wide variety of sportfish and baitfish (Table 12).

Table 11. Fish Species List for the Pine River (MNRF, 2017).

Fish Species	Collected
S- Brook Trout	2009
S- Rainbow Trout	2009
S- Chinook Salmon	2009
S- Burbot	2006
S- Splake	1987
S- Brown Trout	2006
B- Johnny Darter	1997
B- Pearl Dace	1987
B- Longnose Dace	2009
B- Creek Chub	2009
B- Blacknose Dace	2009
B- White Sucker	2009
B- Mottled Sculpin	2006
B- Redhorse Sucker	1987
B- Bluntnose Minnow	2009
B- Brook Stickleback	2000
B- Northern Redbelly Dace	2000
B- Fathead Minnow	2000
B- Central Mudminnow	2000

Notes:
- *S – Sportfish*
- *B – Baitfish*

No blockages to fish migration were observed in the study area on the date of observation but we are not aware of the migratory potential for different species in adjacent reaches of the Pine River and smaller, connected tributaries. As a result, we attempted to determine the resident fish assemblage based on results of the background review that were within or near (i.e. ~2km) the study area to determine a species list for the study area (Table 13).

Table 12. Fisheries Information within 2 km of the Study Area

Species	Date	Age	Number	Size Range (MM)	Source
Rainbow Trout	August 29, 1988	Young-of-the-Year (YOY)	*	*	MNRF 2017
		1+			
Chinook Salmon		YOY			
Brook Trout		YOY			
Cyprinidae spp.		--			
Rainbow Trout	September 12, 1989	YOY			
		1+			
Brown Trout		YOY			
Brook Trout		YOY			
White Sucker					
Sculpin spp.					
Cyprinidae spp.					
Rainbow Trout	August 27, 1990	YOY			
Brook Trout		YOY			
		1+			
		2+			
Sculpin spp.					
Cyprinidae spp.					
Rainbow Trout	August 31, 1992	1+			
Brown Trout		YOY			
Brook Trout		YOY			
		1+			
Chinook Salmon	August 31, 2016	*	3	57-81	NVCA 2017
Rainbow Trout			11	60-175	
Creek Chub			1	152	
Mottled Sculpin			5	56-83	

* *Data not collected*

Chinook Salmon were observed throughout much of the observed reach (Figure 2). 32 individuals displayed active spawning characteristics at 8 active redds. Females were observed constructing and cleaning redds by turning on their sides and performing a series of flexures and slapping their tail on the gravel substrate, and males displaying dominance near redds by biting and butting other males (Figure 2). Probing and quivering were not observed, nor were any roe, but a few recently deceased Chinook Salmon were observed indicating that some spawning had likely occurred, but the majority of egg deposition likely happened shortly after our field investigation (Photograph 4). A number of other Chinook Salmon were observed migrating, and many active spawners likely left redds as a result of our presence so the observations are under representative of actual conditions. A number of smaller fish were also observed which were appeared to be young-of-the-year Rainbow Trout (*Oncorhynchus mykiss*) based on visual observations.

Photograph 4. A recently deceased Chinook Salmon found in the Pine River. Note the black gums which distinguishes this species from similar species.

4.6.3 Critical Habitat

Macrophyte beds, woody debris and the interstitial spaces between large rocky substrates provide rearing habitat where juvenile fish of all species can feed and evade predators. The study area also provides critical spawning habitat for Chinook Salmon as observed during site investigations as well as potential spawning habitat for five other resident species, including both spring and fall spawners (Table 14). Fisheries and Oceans Canada has developed restricted activity timing windows which are often applied to protect fish from impacts of works or undertakings in and around water during spawning migrations and other critical life history stages. The restricted timing windows are also presented in Table 14.

Table 13. Spawning Habitat Requirements of Resident Fish Species

Resident Species	Spawning/Incubation Habitat	Restricted Activity Timing Window (DFO 2013)
Chinook Salmon	Rocky substrates with fast-flowing water.	September 15 to May 31
Rainbow Trout	Spawn from mid-April to late June in gravel, usually in a riffle above a pool (Scott and Crossman 1973; Hickman et al. 1984).	March 15 to June 15
Brook Trout	Groundwater upwellings, riffle areas in the fall.	October 1 to May 31
Brown Trout	Spawn from approximately October 15 – early November in shallow, gravelly headwaters or overtop of groundwater upwellings (Raleigh et al. 1986)	October 1 to May 31
Sculpin Spp.	Spawn in spring under rocks or ledges.	March 15 to July 15
White Sucker	Typically spawn in in May and June over gravel in shallow water.	March 15 to July 15

4.7 Biological Impact Assessment

The potential impacts associated with the proposed construction and operation of the Mansfield Ski Club WWTP were evaluated according to fish species and habitat over the short-term (i.e. construction impacts) and long-term (i.e. preferred site selection and effluent impacts) based on results of the background review and site investigations.

4.7.1 Effluent Site Selection

Two potential effluent outfall locations were evaluated: the pump house and MSC-1 located approximately 25 m downstream. Habitat at the pump house is best defined as deep run habitat with depository substrates along the stream margins and small patches of Canada Waterweed, while MSC-1 provides high quality spawning habitat for Chinook Salmon (Table 15). The pump house is the preferred location for the effluent outfall based on site-specific habitat and ecological requirements of resident species.

Table 14. Habitat Characteristics at the Proposed Outfall Locations

Habitat Characteristics	Pumphouse	MSC-1
Substrates	Silty sand with coarse sand and gravel in the centre of the channel	Gravel and small cobble overtop sands
Aquatic Vegetation	Patches of Canada Waterweed	None
Quality of benthic habitat to support a diverse invertebrate assemblage	Moderate	High
Rearing Habitat Quality	Moderate	Poor
Spawning Habitat Quality	Low	High
Chinook Spawning Observed	Yes, but appeared to be staging for a run further upstream	Yes, active clearing of redds by females and aggressive male activities
Preferred Location	Yes	No

4.7.2 Construction

Construction and installation of the effluent outfall could disturb sediments and temporarily increase turbidity, total suspended solids and associated water quality parameters such as metals which adsorb to suspended materials. Installation of the effluent outfall and diffuser should be completed between July 15 and September 15 to avoid sensitive spawning periods of resident fish species so that any displaced sediment does not cover spawning grounds or developing embryos and short-term changes in water quality do not occur during this critical life stage.

An Erosion and Sediment Control (ESC) Plan should also be developed that minimizes erosion and sediment transport from the areas of construction into the Pine River. An ESC Plan should be developed to:

- Utilize a multi-barrier approach;
- Retain existing vegetation;
- Minimize land disturbance area;
- Slow down and retain runoff to promote settling;
- Divert runoff from problem areas;

- Minimize slope length and gradient of disturbed areas;
- Maintain overland sheet flows and avid concentrate flows; and
- Store/stockpile soil away from watercourses, drainage features, and tops of steep slopes (Certified Inspector of Erosion and Sediment Control Training Manual, 2011).

4.7.3 Treated Effluent

Receiving Water Assessments or Assimilative Capacity Studies typically describe effluent limits sufficient to ensure that effluent is not directly toxic, determine the characteristics of the mixing zone and calculate water quality at the point of complete mixing. Water quality modelling results are compared to PWQOs or CWQGs to determine the potential for any impacts to aquatic biota. Water quality objectives and guidelines are protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to water, and ensure that treated effluent is not directly toxic (MOE 1994a). The study area provides high quality, coldwater habitat for a variety of sensitive fish species at critical life stages such as spawning and so it is appropriate to use conservative water quality guidelines as the basis of the assessment. The results presented above show that aquatic life will be protected at the effluent limits proposed.

5. Summary and Conclusions

5.1 Water Quality

In 2016-2017 the water quality in the Pine River near MSC was very good with low concentrations of suspended sediments and nutrients. Total phosphorus (75th percentile = 0.007 mg/L), and un-ionized ammonia nitrogen (75th percentile = 0.0054 mg/L) concentrations were well below their PWQO values of 0.03 and 0.0164 mg/L respectively; indicating Policy 1 status for these parameters. Dissolved oxygen concentrations were above the PWQO of 6 mg/L at 10ºC, indicating a well oxygenated Policy 1 system. Nitrate concentrations were enriched, with 75th percentile concentrations (3.66 mg/L), exceeding the CCME guideline of 3.0 mg/L. Nitrate concentrations exceeded the CCME guideline on four (February to June 2017) of eleven sampling events and are a likely result of agricultural activities upstream or discharge from the existing tile fields at the MSC. If the latter is the case, then the proposed effluent treatment system will improve baseline nitrate concentrations in the Pine River.

Water quality data collected from the Pine River at MSC-1 was, for the most part, similar to that collected at the PWQMN site near Angus. The downstream site near Angus showed increased total phosphorus concentrations (75th percentile = 0.038 mg/L, Policy 2 status) but had lower nitrate concentrations - the CCME guideline of 3 mg/L was only exceeded on three of 89 sampling events).

Despite the Policy 1 status for total phosphorus in the Pine River near the MSC, efforts to minimize total phosphorus loads from the proposed effluent discharge are strongly recommended considering:

a) Phosphorus concentrations are extremely low near the MSC (median total phosphorus = 0.007 mg/L), and
b) Phosphorus concentrations increase downstream of the MSC to levels that often exceed PWQO at Everett.

5.2 Flow & 7Q20

Twenty years of continuous streamflow data from the WSC Station located on the Pine River near Everett was used to estimate a 7Q20 flow statistic of 0.528 m^3/s at this gauge. The statistic was pro-rated for watershed size to estimate a value of 0.432 m^3/s at MSC-1. Spot flows measured by HESL at MSC-1 could not be correlated or compared to the flows prorated from those measured at Everett to validate the estimate, as the 2016/2017 water level and flow data for is gauge is considered to be unreliable by Environment Canada.

5.3 Non-Lethal Effluent Requirment

All effluent discharged to surface water must be non-acutely lethal at the point of discharge, prior to any mixing or dilution with the receiver. To meet the non-lethal requirement, we recommend th TAN limit of 5 mg-N/L and a maximum pH objective of 8.0.

We also recommend that the effluent be directed and discharged directly to the Pine River after treatment, and not to a wetland pond (as recommended by WMI 2017) to prevent warming of the effluent, and enhanced formation of un-ionized ammonia in the summer.

5.4 Modelling

The provincial guidance (MOE, 1994a, b) and results of the water quality assessment, mass-balance modelling, mixing zone analysis, and non-lethal effluent requirement, were used to assess the proposed WWTP effluent on Pine River water quality.

At the recommended total phosphorus effluent limit of 1.0 mg/L and objective of 0.5 mg/L and design flow of 1.39 L/s, the total phosphorus concentration in the River would increase marginally from 0.007 to 0.010 mg/L and 0.009 mg/L respectively once fully mixed. Phosphorus concentrations in the Pine River near MSC would remain low, well below the PWQO of 0.03 mg/L, and within the oligotrophic trigger range (4-10 µg/L) for Canadian lakes and rivers (CCME 2004). As such, no change in aquatic habitat, such as increased algal or macrophyte growth and subsequent reduction in dissolved oxygen conditions, is expected due to increases in TP concentrations in the receiver near MSC. Baseline total phosphorus concentrations increase downstream and exceed the PWQO at Everett. The Pine River also discharges to the Nottawasaga River, which is nutrient enriched.

The proposed effluent limits of 15 mg/L for cBOD and 5 mg-N/L for TAN would decrease the 25th percentile dissolved oxygen concentration in the River by 0.014 mg/L once fully mixed. Concentrations in the Pine River near MSC would remain high, and well above the PWQO of 7 mg/L at water temperature of 0°C. As such, no change in aquatic habitat from reduced dissolved oxygen conditions is expected due to discharge from the MSC STP.

The concentration of total suspended solids near MSC is low, with 75th percentile concentration of 7.55 mg/L. At a proposed effluent limit of 15 mg/L, the TSS concentration in the Pine River near MSC would increase only marginally, by 0.02 mg/L.

The size and the shape of the effluent plume was modelled with six different diffuser configurations to optimize nearfield mixing. The diffuser was modelled as 1 m and 3 m long with 3, 7, and 15 ports to vary the discharge velocity. Diffuser design (length and number of ports) had a small effect on the size of the mixing zone, and resulted in rapid mixing in the nearfield and short distances to meet the PQQO of 0.0164 mg-N/L. At the recommended effluent limits of 5 mg-N/L the PWQO for un-ionized ammonia nitrogen of 0.0164 mg/L would be met within 0.67 m (67 cm) of the discharge when ambient total ammonia nitrogen concentration is <0.02 mg/L, ambient pH is 8.33, and water temperature is 16.38°C. The plume contacted the right bank (discharge bank) between 105 m and 174 m downstream of the discharge, and was laterally mixed across the channel between 1,864 m and 2,211 m downstream depending on the discharge configuration,

5.5 Fish and Aquatic Habitat

Aquatic habitat was characterized in the Pine River between the 17th Sideroad and County Rd. 18 through evaluation of morphology, substrate, riparian vegetation, aquatic vegetation and other cover features. Habitat requirements of resident fish species were compared to habitat found in the study area to determine the presence or absence of critical habitats. Aquatic habitat was relatively homogeneous between the 17th Sideroad and County Road 18. Substrates are predominantly rocky (gravel, cobble and some boulders) in the shallower areas and sandy in the deeper, more depository areas.

Canada Waterweed (*Elodea canadensis*) and Lake Watercress (*Nasturtium officinale*) was moderately abundant in the upstream part of the study reach near the 17th Sideroad. Riparian vegetation was mixed in the upstream reach and Eastern White Cedar (*Thuja occidentalis*) became dominant and provided cover in the downstream section of the study reach. Woody debris was sparse throughout much of the study reach.

Chinook Salmon redds were observed between the step pool/cascade located adjacent to the pump house and County Road 18. Redds were located in rocky substrates within deep riffles/shallow runs. No blockages to fish migration were observed in the study area on the date of observation. Chinook Salmon were observed throughout much of the observed reach. 32 individuals displayed active spawning characteristics at 8 active redds. A few recently deceased Chinook Salmon were observed indicating that some spawning had likely occurred. A number of smaller fish were also observed which appeared to be young-of-the-year Rainbow Trout (Oncorhynchus mykiss) based on visual observations.

5.6 Biological Impact Assessment

The study area provides coldwater habitat for a variety of sensitive fish species at critical life stages such as spawning. The pump house is the preferred location for the effluent outfall based on site-specific habitat and ecological requirements of resident species. All sensitive species and life stages will be protected at the proposed effluent limits and the small mixing zone provided by the high 7Q20 flows in the Pine River and the proposed discharge configuration.

6. Recommendations

At a design flow of design flow of 1.39 L/s the recommended discharge option for the WWTP effluent is a multiport diffuser located approximatively 2 m from the bank at the pump house. This discharge configuration had good nearfield mixing (met PWQO for un-ionized ammonia within 0.08 m), reduced bottom impingement and resulted in low receiver concentrations, when modelled. This location and discharge configuration is preferred to maintain the high quality of the Pine River at MSC and protect the coldwater habitat that supports critical life stages for a variety of sensitive fish species.

Conservative estimates were used in the assimilative capacity study; however, we recommend the following:

1. Effluent limits of 1.0 mg/L for TP, 15 mg/L for cBOD and TSS, 5 mg-N/L for TAN, and 8.5 for pH. Effluent objectives of 0.5 mg/L TP, 3.0 mg-N/L TAN, and 8.0 pH.
2. The effluent be directed and discharged directly to the Pine River at the pump house after treatment based on the water quality analysis and aquatic habitat requirements of resident species.
3. Considerable groundwater discharges to the Pine River though the Escarpment and so the prorated 7Q20 estimate should be verified by ongoing flow monitoring and comparison to WSC data at Everett when reliable data are available from the WSC.
4. Detailed design of the diffuser be carried out prior to construction activities to further optimize design;
5. The sources of enriched nitrate concentrations in the Pine River at the MSC and potential sources upstream of the pump house and MSC-1 should be investigated and considered in the interpretation of water quality.
6. Additional information with respect to snapping turtles, wetlands, and other natural heritage features and functions should be examined during the site plan approval phase as part of an Environmental Impact Study (EIS).

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Appendix A. Preliminary RWA and Correspondence with MOECC

Hutchinson
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Memorandum

Date: **February 10, 2017**

To: **Finely McEwen, Mansfield Ski Club**

From: **Kris Hadley, Tammy Karst-Riddoch**

Re: **J160071 – Mansfield Ski Club – Receiving Water Assessment for Surface Discharge of Treated Wastewater Effluent to the Pine River**

We are pleased to present the preliminary results of the receiving water assessment that we are completing in support of an application for the discharge of treated wastewater effluent to the Pine River for the Mansfield Ski Club (MSC) re-development project.

The purpose of the receiving water assessment is to determine suitable effluent quality and a discharge location so that the size and quality of the effluent plume in the river meets the guidelines of the MOECC to protect water quality and beneficial uses. The assessment, as described in our work plan dated September 20, 2016, will include:

1. Characterization of the existing water quality and flows of the Pine River at the proposed discharge location and determination of its assimilative capacity to receive treated effluent based on results of monthly monitoring and existing data,
2. Identification of environmental and beneficial usage constraints for the discharge,
3. Recommendation of alternative discharge options (e.g., direct to river or via an existing man-made pond) and locations based on identified constraints,
4. Completion of a mixing zone analysis at the point of effluent discharge to the Pine River to determine the size of the mixing zone and provide recommendations for a discharge configuration to minimize the size of the mixing zone,
5. Recommendations for appropriate treatment objectives and limits based on the assimilative capacity of the river and results of the mixing zone analysis, and
6. Development of a water quality monitoring program to confirm the results of the assessment and to monitor the effects of the discharge on water quality of the Pine River.

Here, we present an overview of the results of the study to date, regarding:

1. The proposed wastewater treatment design,
2. Progress of the water quality and flow monitoring program,
3. Low flow analysis,
4. Water quality assessment, and
5. Natural heritage and beneficial use constraints.

1. Preliminary Wastewater Treatment Design

A preliminary wastewater treatment design plan was completed for the MSC redevelopment, which is to include renovation of the Operations Building and new development providing a total of 1,595 m^2 of commercial retail space and 93 residential units[1]. Sewage flows from the redevelopment were estimated to increase from 14,740 L/day to 116,765 L/day over the operational period of the MSC from December to April. A package plant was proposed as a treatment option to accommodate the expanded sewage flows, consisting of a Waterloo Biofilter System with UV disinfection and sodium aluminate dosing with disposal of the effluent to the Pine River, either directly or via an existing onsite man-made pond as the ultimate receiver.

The initial proposed effluent treatment objectives were 10.0 mg/L for carbonaceous oxygen demand (CBOD5) and total suspended solids (TSS), 0.5 mg/L for total phosphorus (TP), 3.0 mg/L for total ammonia nitrogen (TAN) and a geometric annual mean concentration of 100 organisms/100 mL for *Escherichia coli*. The proposed effluent treatment limits were 15 mg/L for CBOD5 and TSS, 1.0 mg/L for TP, 5.0 mg/L for TAN and a geometric annual mean concentration of 200 organisms/100 mL for *E. coli*.

2. Water Quality and Flow Monitoring Program

The monthly water quality and flow monitoring program was designed and implemented in September 2016. Four sampling events were completed in 2016 (September 14, October 24, November 30, and December 13) at two locations in the river (immediately downstream of the rock weir near the MSC pump house (MSC-1) and at the crossing of the river at Airport Road (Regional Road 18) (MSC-2). Water quality monitoring parameters included:

- Field parameters (pH, temperature, dissolved oxygen, conductivity);
- TP;
- Nitrogen species (TAN, NO3, NO2, and total Kjeldahl nitrogen (TKN));
- Total suspended solids (TSS);
- Carbonaceous biochemical oxygen demand (CBOD5); and
- *E. coli*.

Results of the monitoring from the 2016 sampling events are summarized in Section 3 (flows) and Section 4 (water quality). Monitoring is scheduled to continue on a monthly basis to the end of April, 2017, to span the period of likely discharge, but may continue if MSC wishes to consider extending the operational period of the resort.

3. Low Flow Analysis

Surface effluent discharge to a receiver requires the determination that the receiver can effectively assimilate or dilute the effluent. In Ontario streams and rivers, the 7Q20 low-flow statistic is used as a basic design flow to determine the assimilative capacity of a stream or river. The 7Q20 flow represents the

[1] *WMI & Associates Limited, 2016. Site servicing & stormwater management report. Mansfield Ski Club, Township of Mulmur. Report WMI 15-319. June 2016.*

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 dilute the effluent.

Seasonal flow summary statistics including 7Q20 flows were calculated for the Pine River at the nearest Water Survey of Canada (WSC) station downstream of MSC (Pine River Near Everett, Station 02ED014) using the most recent 20-year data record. Seasons were defined as winter (Dec - Feb), spring (Mar - May), summer (Jun - Aug), and fall (Sept - Nov).

Seasonal flow statistics from 02ED014 were pro-rated for the watershed areas of the two field sampling sites (MSC-1 and MSC-2) to determine flow statistics at possible discharge locations near the MSC, as:

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

> Where Q is the flow statistic and A is the watershed area at sites 1 (MSC-1 or MSC-2) and 2 (O2ED014), determined using the Ontario Flow Assessment Tool (https://www.ontario.ca/page/watershed-flow-assessment-tool, accessed November, 2016).

Measured flows at MSC-1 and MSC-2 were compared to pro-rated flows calculated using observed flows at 02ED014 that occurred over the 1-hour period encompassing the time when flows were measured at the MSC sites (from 14:20 – 15:20 on September 14 and 11:20 – 12:20 on October 24, 2016).

Seasonal flows at the Pine River Near Everett station (watershed area = 190.1 km^2) varied seasonally, with the highest flows occurring in spring and relatively similar flows in summer, fall and winter (Table 1).

Table 1. Seasonal Flow Statistics (m^3/s) at Pine River Near Everett (WSC 02ED014)

Season	Mean	Minimum	Maximum	25th Percentile	7Q20
Winter	1.95	0.44	19.1	1.26	0.579
Spring	3.56	0.58	19.7	2.26	0.883
Summer	1.60	0.51	11.3	1.10	0.630
Fall	1.38	0.48	8.81	0.98	0.565

The watershed area draining to the Pine River was 155.7 km^2 and 156.9 km^2 at MSC-1 and MSC-2, respectively. Due to the small difference in watershed area draining to these sites, pro-rated flow statistics differed between the stations by only 0.02 m^3/s or less (Table 2). Pro-rating of the flows from the Everett station resulted in 7Q20 flows at MSC-1 and MSC-2 that ranged from 0.46 m^3/s to 0.48 m^3/s in fall and winter, and from 0.72 m^3/s to 0.73 m^3/s in spring. Pro-rated summer 7Q20 flow was 0.52 m^3/s at both MSC stations.

Table 2. Pro-Rated Seasonal Flow Statistics (m^3/s) at the Mansfield Ski Club (MSC) Sampling Stations

Site	Season	Mean	Minimum	Maximum	25^{th} Percentile	7Q20
MSC-1 (@ Pump House)	Winter	1.60	0.36	15.63	1.03	0.47
	Spring	2.92	0.47	16.12	1.85	0.72
	Summer	1.31	0.41	9.25	0.90	0.52
	Fall	1.13	0.39	7.21	0.80	0.46
MSC-2 (@ Airport Rd.)	Winter	1.61	0.36	15.76	1.04	0.48
	Spring	2.94	0.47	16.26	1.86	0.73
	Summer	1.32	0.42	9.32	0.91	0.52
	Fall	1.14	0.39	7.27	0.81	0.47

Flow in the Pine River available for dilution of the effluent during the proposed discharge period (fall to spring) would therefore provide a minimum dilution ratio of 342:1 under 7Q20 low flow conditions (0.46 m^3/s) and 835:1 under average flows (1.13 m^3/s) at the proposed effluent flows of 116,765 L/day (0.00135 m^3/s).

Measured flows at the MSC sampling sites were generally similar to prorated flows, but were higher on all sampling events with the exception of MSC-2 on November 29th when flows in the Pine River were highest (Table 3). Differences between measured and prorated flows may result from variability in flow over the course of the day (flows were prorated for the daily flow measured on each sampling date), but also differences in water inputs along the river. Pro-rating assumes equal contribution of water from all areas of the watershed, but higher discharge of groundwater occurs upstream of MSC via extensive springs that emerge from the Niagara Escarpment which could account for the higher measured flows. It is also possible that there is substantial groundwater inputs to the river between MSC-1 and MSC-2 resulting in the greater difference between measured and pro-rated flows at MSC-2 during relatively low flow conditions (14-Sep, 24-Oct, 13-Dec) when there is less contribution of water from surface runoff. Additional monitoring of flows by the MSC monitoring program will help to confirm this observation.

Table 3. Comparison of Measured and Pro-rated Pine River Flows at the Mansfield Ski Club (MSC) Sampling Stations

Station	Flow (m^3/s)			
	14-Sep-16	24-Oct-16	29-Nov-16	13-Dec-16
WSC 02ED014[1]	0.836	0.724	1.525	0.896
MSC-1 (@ Pump House)				
Pro-Rated	0.685	0.593	1.249	0.734
Measured	0.716	0.741	1.255	0.778
% Difference	5%	25%	0%	6%
MSC-2 (@ Airport Rd.)				
Pro-Rated	0.690	0.597	1.259	0.740
Measured	0.803	0.827	0.919	0.836
% Difference	16%	38%	-27%	13%

Notes: [1]Daily flow on MSC sampling date.

4. Water Quality Assessment

Water quality data from the Pine River monitored at MSC-1 and MSC-2 and the nearest Provincial Water Quality Monitoring Network (PWQMN) station (Pine River at Mill Street, Station 03005701002) were assessed against applicable Provincial Water Quality Objectives (PWQO) to determine the policy status of the river to receive treated effluent in accordance with MOECC policies and guidelines (MOEE 1994):

- 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.

Where available, water quality parameters were also compared against Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG PAL; CCME 1999).

4.1 Pine River at Mill Street (PWQMN Station 03005701002)

The PWQMN station (Station 03005701002) is located upstream of the Nottawasaga River at Mill Street, Angus, ON, approximately 10 km downstream of the study site. Long-term data were available from this site for general chemistry and nutrients (1972-2014) and for total metals (2000-2005), which were typically monitored monthly from April to November by the Nottawasaga Valley Conservation Authority (NVCA).

Evaluation of the most recent data from 2000 to 2014 indicated that water in the Pine River at the Mill Street crossing was alkaline (75th percentile pH = 8.48) and with high concentrations of minerals (75th percentile total dissolved solids = 308 mg/L) and some metals (e.g., aluminium, barium, calcium, iron, magnesium, manganese, strontium and zinc) that contribute to high specific conductivity (75th percentile = 474 µS/cm) and very hard water (75th percentile hardness = 239 mg/L) (Table 4). 75th percentile concentrations of aluminum (189.25 mg/L), cadmium (0.225 mg/L), cobalt (0.375 mg/L) and iron (376 mg/L) exceeded applicable PWQO and CWQG PAL. The alkaline, hard water and high metal concentrations of the Pine River were consistent with the large natural source of groundwater to the river originating from sedimentary rocks of the Niagara Escarpment.

General water quality parameters and nutrient concentrations were all within available PWQO and CWQG PAL with the exception of total phosphorus (75th percentile = 0.038 mg/L), which exceeded the PWQO of 0.03 mg/L for rivers. Total phosphorus concentrations were highly variable over the period of record (Figure 1) and elevated concentrations above the PWQO were generally associated with high concentrations of total suspended solids (Figure 2). Phosphorus-enriched solids likely originated from erosion of soil particles that entered the river with runoff, particularly during storm events. High flow events may have also caused erosion and sediment suspension within the river, contributing to periods of high total suspended solids and total phosphorus concentrations.

4.2 Pine River near Proposed Discharge (MSC-1 and MSC-2)

Water quality in the Pine River near the MSC (Table 5) was similar to that 10 km downstream at the Mill Street crossing (PWQMN Station 03005701002) with elevated pH and conductivity and similar concentrations of nitrogen, but had much lower concentrations of total suspended solids (75th percentile = 2 mg/L) and total phosphorus (75th percentile = 0.053 mg/L). All measured parameters were similar between the MSC monitoring stations (MSC-1 and MSC-2) and were well below applicable PWQO and CWQG PAL, with the exception of pH on the December 13th sampling event (mean pH = 8.83).

Lower total suspended solids at the MSC stations relative to the PWQMN station downstream were likely due to lower runoff that typically occurs in late fall and winter, but also due to the fact that there were no major storm events that occurred prior to or during the scheduled sampling events. Lower total phosphorus concentrations at the MSC stations likely reflected lower total suspended solids in the river, but also increased phosphorus loads with distance downstream of the MSC due to increased contributions from agricultural runoff and human activities.

Table 4. Pine River at Mill Street Water Quality Summary (2000-2014, PWQMN Station 03005701002)

Parameter	Units	PWQO/ (CWQG PAL)	Median[3]	75th %ile[3]	N	Values Exceeding Guideline	
						#	%
General							
Alkalinity	mg/L		205	213.5	55		
Chloride	mg/L	120	17.1	18.2	92	0	0%
Conductivity, specific (@25°C)	µS/cm		453	474	55		
Hardness	mg/L		227	239	49		
Oxygen, dissolved	mg/L	>5 - 8	11.38	12.62	59	0	0%
pH, field	-	6.5 - 8.5	8.38	8.48	61	12	20%
Solids, dissolved	mg/L		296	308	49		
Solids, total suspended	mg/L		12.5	28.25	90		
Temperature	°C		14	17.7	89		
Turbidity	FTU		7.7	18.5	49		
Nutrients							
Ammonia, total (as N)	mg/L		0.009	0.016	91		
Ammonia, unionized (calc.) (as N) [1]	µg/L	16	0.427	1.08	66	0	0%
Nitrate (as N)	mg/L	3	1.7	2.1	89	3	3%
Nitrite (as N)	mg/L	0.06	0.009	0.011	91	0	0%
Nitrogen, total Kjeldahl	mg/L		0.370	0.485	92		
Phosphate	mg/L		0.0022	0.0045	92		
Phosphorus, total	mg/L	0.03	0.024	**0.038**	91	31	34%
Metals (Total) (2000-2005 only)							
Aluminium	µg/L	75	**86.5**	**189.25**	40	23	58%
Barium	µg/L		35.75	37.75	40		
Berylium	µg/L	1100	0.0136	0.0184	40	0	0%
Cadmium[2]	µg/L	0.2	-0.00163	**0.225**	40	11	28%
Calcium	mg/L		63.8	68.0	49		
Chromium	µg/L	1	0.0188	0.470	40	1	3%
Cobalt	µg/L	0.2	0.107	**0.375**	40	15	38%
Copper	µg/L	5	1.305	1.913	40	0	0%
Iron	µg/L	300	178.5	**376**	40	13	33%
Lead	µg/L	5	0.235	3.17	41	3	7%
Magnesium	mg/L		16.0	16.7	49		
Manganese	µg/L		27.2	55.8	40		
Molybdenum[2]	µg/L	40	-0.618	-0.178	40	0	0%
Nickel	µg/L	25	0.301	0.558	40	0	0%
Potassium	mg/L		1.53	1.63	49		
Sodium	mg/L		8.64	9.04	49		
Strontium	µg/L		151	160	40		
Titanium	µg/L		2.57	4.99	40		
Vanadium	µg/L	6	0.527	1.035	40	0	0%
Zinc	µg/L	20	3.455	5.923	40	1	3%

Notes: [1]Calculated using date-specific field temperature and pH, or the 75th percentile where these parameters were not available (n=4). [2]Laboratory detection is +/- 0.8 µg/L for cadmium, and +/- 1.5 µg/L for molybdenum. [3] Bolded values exceed applicable guideline/objective. Values below laboratory detection limits were set to the detection limit for the calculation.

Figure 1. Total phosphorus concentrations in the Pine River by month (2000-2014, PWQMN Station 03005701002).

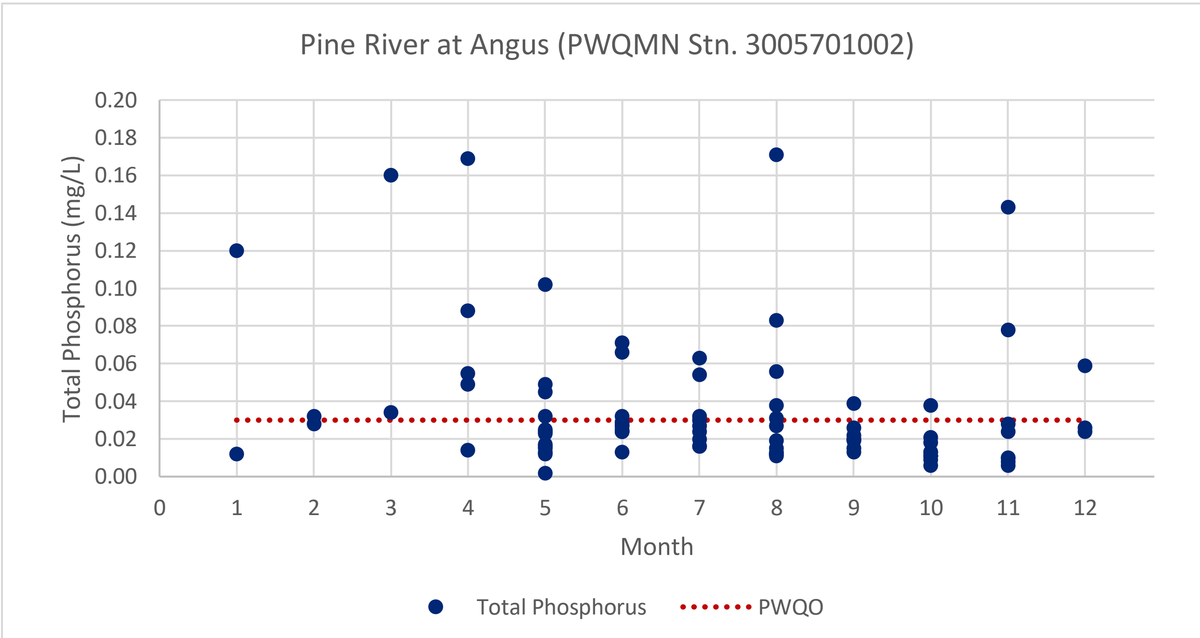


Figure 2. Relationship between total phosphorus and total suspended solids in the Pine River (2000-2014, PWQMN Station 03005701002).

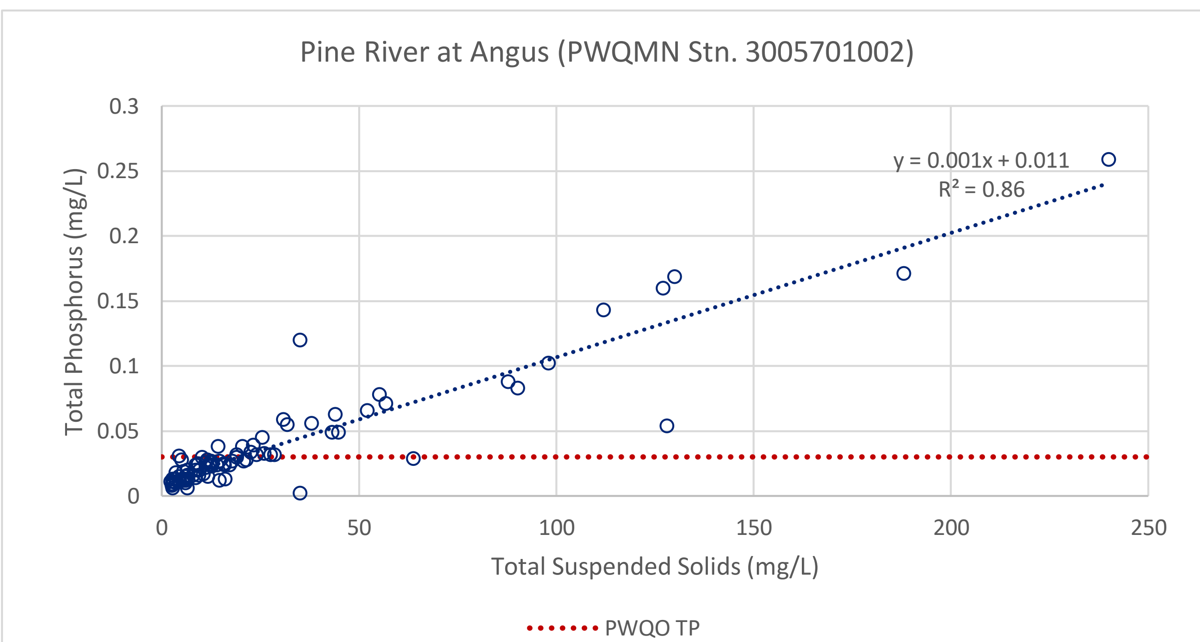


Table 5. Pine River Near Mansfield Ski Club Water Quality Summary

Parameter	LDL	Units	PWQO/ (CWQG PAL)	MSC-1	MSC-2	MSC-1	MSC-2	MSC-1	MSC-2	MSC-1	MSC-2	Median[1]	75th %ile[1]
				14-Sep		24-Oct		29-Nov		13-Dec			
Field Measurements													
Temperature		°C		17.12	16.9	8.64	8.68	5.86	5.86	0.81	0.76	7.25	10.74
pH		pH units	6.5 - 8.5	8.28	8.27	7.78	7.82	8.42	8.41	**8.84**	**8.82**	8.35	**8.52**
Conductivity, specific (@25°C)		µS/cm		454	456	486	486	504	496	529	537	491	510
Oxygen, dissolved		mg/L	>5 – 8	11.12	11.2	11.53	11.22	12.64	13.49	13.06	13.87	12.09	13.17
Physical Tests (Water)													
Solids, total suspended	2.0	mg/L		<2.0	2.4	<2.0	<2.0	3.5	4.5	<2.0	<2.0	1	2
Anions and Nutrients													
Ammonia, total (as N)	0.020	mg/L		<0.020	0.167	<0.020	<0.020	<0.020	<0.020	<0.020	0.024	0.01	0.01
Nitrate (as N)	0.020	mg/L	3	1.86	1.86	1.84	1.83	1.99	1.99	2.32	2.31	1.99	2.32
Nitrite (as N)	0.010	mg/L	0.06	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.005	0.005
Nitrogen, total Kjeldahl	0.15	mg/L		0.40	0.25	0.16	0.21	0.38	0.38	0.26	0.23	0.24	0.35
Phosphorus, total	0.0030	mg/L	0.03	0.0051	0.0069	0.0030	0.0039	0.0070	0.0050	0.0032	<0.0030	0.0050	0.0053
Ammonia, unionized (as N)[2]		µg/L	16	0.57	9.25	0.10	0.11	0.34	0.33	0.58	1.32	0.46	0.76
Bacteriological Tests													
E. coli	10	CFU/100mL	100	20	20	70	50	30	50	<2.0	<2.0	22	45
Aggregate Organics													
Biochemical oxygen demand, carbonaceous	2.0	mg/L		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	-	0.01	0.01

Notes: [1]Values below Laboratory Detection Limits (LDL) were set to half the LDL for calculation of the median and 75th percentile. [2]Calculated using date-specific field temperature and pH, or the 75th percentile where these parameters were not available (n=4). [3]Bolded values exceed applicable guideline/objective.

4.3 Policy Status

Based on measured water quality data collected under the MSC monitoring program in 2016, the Pine River at MSC-1 and MSC-2 would be considered Policy 2 for pH (75th percentile pH = 8.52; PWQO = 5.5 - 8.5) and Policy 1 for all other measured parameters including dissolved oxygen, unionized ammonia nitrogen and total phosphorus.

The Pine River downstream of the MSC at the PWQMN station at Everett (Station 03005701002) would be considered Policy 2 for total phosphorus (75th percentile = 0.038 mg/L; PWQO = 0.030 mg/L) and several metals including:

- Aluminium (75th percentile = 189.25 mg/L; PWQO = 75 mg/L)
- Cadmium (75th percentile = 0.225 mg/L; PWQO = 0.2 mg/L)
- Cobalt (75th percentile = 0.375 mg/L; PWQO = 0.2 mg/L), and
- Iron (75th percentile = 375 mg/L; PWQO = 376 mg/L).

Despite the Policy 1 status for total phosphorus in the Pine River near the MSC, efforts to minimize total phosphorus loads from the proposed effluent discharge are strongly recommended considering:

- Phosphorus concentrations are extremely low near the MSC (median total phosphorus = 0.005 mg/L), and exceptional for a river in southern Ontario, and
- Phosphorus concentrations increase downstream of the MSC to levels that often exceed PWQO at Everett.

5. Natural Heritage and Beneficial Use Constraints

5.1 Natural Heritage Features

5.1.1 Description of Receiving Environment

Upstream of the MSC, immediately to the north of Sideroad 17, the Pine River flows through the Provincially Significant Terra Nova Wetland Complex. This Provincially Significant Wetland (PSW) is primarily swamp, but contains marsh habitat as well. The PSW is recognized for providing nesting habitat for waterfowl and colonial waterbirds, winter cover for deer, and habitat for fish spawning and rearing. The PSW is also part of the Pine River Valley Provincial Earth Science Area of Natural and Scientific Interest (ANSI), which extends northwest of the MSC. According to the Natural Heritage Information Centre (NHIC), there is an unevaluated wetland along part of the Pine River on the property (NHIC 2015).

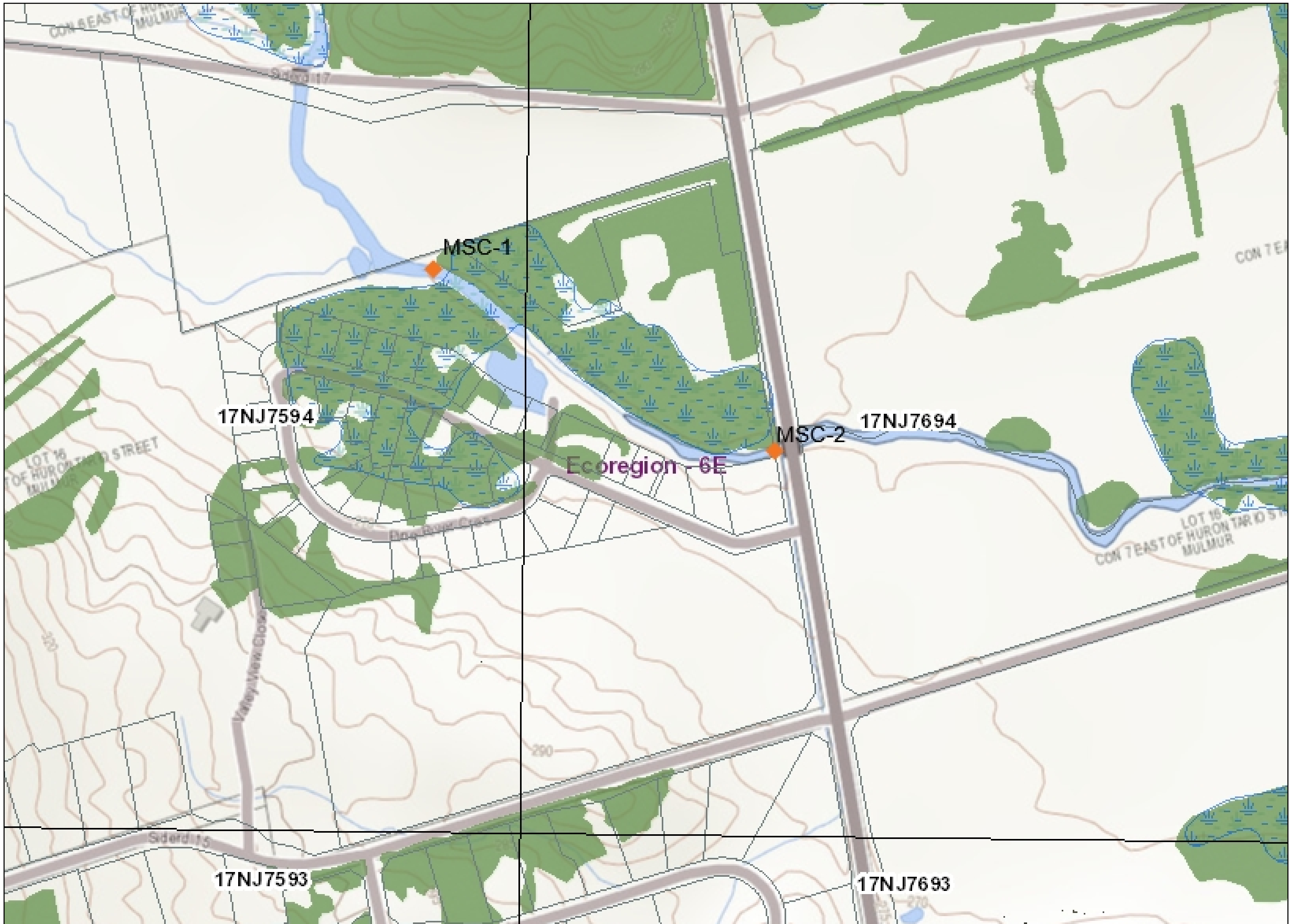
NHIC identifies two species at risk (SAR) which have been recorded in the three 1 km^2 UTM squares that encompass the sections of the Pine River (i) on the property, (ii) immediately upstream and (iii) immediately downstream of the property (NHIC 2015; Figure 3: squares 17NJ7595, 17NJ7594 and 17NJ7694). One of these species, Eastern milksnake (*Lampropeltis triangulum*) is entirely terrestrial and likely would not be affected by effluent discharge to the river. The other, Snapping turtle (*Chelydra serpentina*) is mainly aquatic and inhabits slow-moving waterways characterized by a soft mud bottom and dense aquatic vegetation. Snapping turtles nest in sand or gravel banks along rivers, streams, ponds and wetlands. They hibernate underwater, buried in mud or beneath logs and overhanging banks in waterways with continuously flowing water. Snapping turtles are listed as special concern both federally and in Ontario due to legal and illegal harvesting of adults, persecution, road mortality, predation by racoons and skunks, and decreased reproductive success caused by environmental pollution (Government of Canada 2016).

Ministry of Natural Resources and Forestry

Make-a-Map: Natural Heritage Areas

Figure 3. Pine River Natural Heritage Survey

Notes: 17NJ7595 is north of Sideroad 17, 17NJ7594 is south of 17NJ7595 and includes part of the subject property, 17NJ7694 is east of 17NJ7594 and includes part of the subject property.



Legend

- Assessment Parcel
- Woodland
- Conservation Reserve
- Provincial Park
- Natural Heritage System
- Ecoregion

Wetland

- Provincially Significant Wetland Evaluated
- Non - Provincially Significant Wetland Evaluated
- Unevaluated Wetland

Area of Natural Heritage & Scientific Interest (ANSI)

- Provincially Significant Life Science ANSI
- Provincially Significant Earth Science ANSI

Greenbelt Plan

- Boundary
- River Valley Connections

Land Use Designations

- Protected Countryside
- Towns and Villages
- Hamlets
- Urban River Valley
- Specialty Crop Area

Niagara Escarpment Plan (NEP)

- Boundary
- Parks and Open Space System

Land Use Designations

- Escarpment Natural Area
- Escarpment Protection Area
- Escarpment Rural Area
- Mineral Resource Extraction Area
- Escarpment Recreation Area
- Urban Area
- Minor Urban Centre

Oak Ridges Moraine Conservation Plan (ORM)

- Boundary

Land Use Designations

- Natural Core Area
- Natural Linkage Area
- Countryside Area
- Rural Settlement
- Palgrave Estates Residential Community
- Settlement Area

0.5 0 0.23 0.5 Kilometers

Scale: 1 : 9,027

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Natural Resources and Forestry(OMNRF) shall not be liable in any way for the use of, or reliance upon, this map or any information on this map.

5.1.2 Relevant Policy

The Provincial Policy Statement (PPS) prohibits development[2] and site alteration[3] in PSWs. It prohibits development and site alteration in significant ANSIs and significant wildlife habitat, unless it can be shown that there will be no negative impacts on the natural features or their ecological function. Furthermore, development and site alteration are not permitted on adjacent lands to PSWs, significant ANSIs or significant wildlife habitat, unless it can been shown that there will be no negative impacts on the natural features and their ecological functions (Ministry of Municipal Affairs and Housing 2014).

Snapping turtle wintering and nesting areas qualify as significant wildlife habitat. For wintering habitat, the mapped Ecological Land Classification ecosite area encompassing the site represents significant wildlife habitat. For nesting habitat, the nesting site and a radius of 30-100 m around it (depending on site characteristics such as slope, riparian vegetation and adjacent land use) represents significant wildlife habitat (Ministry of Natural Resources and Forestry 2015). Further study would be required to determine whether Snapping Turtles are present on the property and using habitat within or adjacent to the Pine River.

The Official Plans for Dufferin County and the Township of Mulmer apply the same prohibitions on development and site alteration in PSWs, significant ANSIs, and significant wildlife habitat as the PPS. The Dufferin County Official Plan extends these prohibitions to include unevaluated wetlands as well (i.e., development and site alteration are not permitted within any unevaluated wetland unless it can be shown that there will be no negative impacts on the natural features or their ecological functions; an evaluation of the unevaluated wetland is required to determine its significance). The Township of Mulmer Official Plan prohibits development adjacent to or within 30 m of a non-PSW unless it can be demonstrated that there will be no negative impacts on wetland functions. In most cases, both Official Plans define adjacent land as contiguous land within 120 m of natural heritage features, although the Township Plan defines adjacent land for significant Earth Science ANSIs as within 50 m (Township of Mulmer 2010; Dufferin County 2015).

The Dufferin County Official Plan indicates that the MSC property is within the County's Preliminary Natural Heritage System (Dufferin County 2015: Schedule E1). The property is not within the Greenbelt Area, the Niagara Escarpment Plan Area or the Oak Ridges Moraine Conservation Area.

The Dufferin County Official Plan does not indicate that there is an unevaluated wetland on the property (Dufferin County 2015: Schedule E), although NHIC does (NHIC 2015; Figure 3). The presence of wetlands should be assessed in greater detail by a site investigation and in consultation with the Nottawasaga Valley Conservation Authority.

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[2] The PPS defines development as the creation of a new lot, a change in land use or the construction of buildings or structures requiring approval under the Planning Act.

[3] The PPS defines site alteration as activities, such as grading, excavation, and placement of fill, that change the landform and natural vegetative characteristics of the site.

5.2 Fisheries

Four Rainbow Trout (*Oncorhynchus mykiss*) were observed near the proposed effluent outfall on August 11, 2016 (Figure 4). Rainbow Trout are found in rivers throughout much of Southern Ontario and have specific habitat requirements for each life stage (i.e. adult, embryo, fry and juvenile), but generally require cool to cold water environments (12 - 19°C), high concentrations of dissolved oxygen, silt-free rocky riffles because fines <3mm can impact embryo survival, food production and fill crevice habitat for juveniles, adequate cover and appropriate habitat characteristics for critical life stages such as spawning, embryo and fry development. Table 6 indicates specific habitat requirements for spawning and embryo development.

Figure 4. Rainbow Trout observed in the Pine River near the proposed effluent discharge location for the MSC (August 11, 2016)

Table 6. Spawning and Embryo Habitat Requirements for Rainbow Trout

	Habitat Characteristics for Spawning and Embryo Development					
	Spawning Period	**Optimum Water Temperature**	**Substrates**	**Substrate Size**	**Water Depths**	**Flow**
Rainbow Trout	mid-April to late June[1]	7 – 12°C[1]	Gravel, usually in a riffle above a pool**Error! Bookmark not defined.**	Rocky substrates with a diameter of 1.5 – 6 cm for fish that are ≤50 cm long and 1.5 – 10 cm in diameter for > 50 cm long[2]	15 – 250 cm^2	Optimum flow = 30 – 70 cm/sec; will tolerate 10 – 90 cm/sec[2]

Notes: [1]*Scott, W.B., and E.J. Crossman. 1973. Freshwater Fishes of Canada. Environment Canada. Fisheries Research Board of Canada, Ottawa;* [2]*Hickman, T., Solomon, R.C., and P.C. Nelson. 1984. Habitat suitability information: Rainbow trout, revised. U.S. Fish Wildlife Service. 82(10.60). 64 pp.*

The *Fisheries Act* primarily protects fish populations through the following policies:

- Section 35(1) “No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery, and
- Section 36(3) “No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.”

Additional legislation summarizes substances that are “deleterious” based on toxicity tests, of which Rainbow Trout is a common test subject. The PWQOs provide for water quality that is protective of aquatic life and recreation, including for parameters most commonly impacted by the discharge of treated effluent such as water temperature, dissolved oxygen, ammonia and total phosphorus. Additional policies related to effluent requirements are included in B-1-5 Deriving Receiving Water Based Point Source Effluent Requirements for Ontario Waters:

- 2.4 “A mixing zone is defined as an area of water contiguous to a point source or definable non-point source where the water quality does not comply with one or more PWQO. A mixing zone is, under no circumstances, to be used as an alternative to reasonable and practical treatment. It must be designed to be as small as possible.”
- 2.4(1a) “In order to protect important aquatic communities in the vicinity of the mixing zone, no conditions within the mixing zone will be permitted which are acutely lethal to aquatic life.”

Determination of effluent objectives and a treatment process should consider sensitive aquatic organisms in the receiving environment. A site-specific assessment is therefore recommended to characterize sensitive aquatic communities and fish habitat near the proposed effluent outfall to ensure that impacts are minimized and treatment meets appropriate legislative requirements including: determination of appropriate effluent objectives and minimization of the size of the mixing zone, particularly in sensitive habitats.

In addition, we have made inquiries to the NVCA on the presence fish habitat in the Pine River and on local water quality concerns for the protection of that habitat. We will consider this information in the assimilative capacity assessment report.

5.3 Beneficial Uses

According to the Ministry of Environment and Climate Change (MOECC), there are six permits to take water from the Pine River in the vicinity of the property, including one for the MSC itself and five for agricultural operations downstream of the property (between the property and County Road 13) (Table 7; MOECC 2016). The Nottawasaga Valley Source Protection Area, which encompasses the MSC, has one surface water intake for municipal drinking water, but this is for the Municipality of Collingwood in Simcoe County and thus is not associated with the Pine River (Lake Simcoe Region Conservation Authority et al. 2015).

Table 7. Permits to Take Water from the Pine River in the Vicinity of MSC (MOECC 2016)

Permit Number	Permit Holder	Location (UTM Zone 17 Easting/Northing)	Purpose	Specific Purpose	Max Litres per Day
1637-7V3NT9	Mansfield Ski Club Inc.	581246, 4893739	Commercial	Snowmaking	11,259,500
4230-7Q4KAJ	A. A. W. Hubrecht	583585, 4893490	Agricultural		1,930,910
5214-7DQPKK	P. VanderZaag	586887, 4893861	Agricultural	Field and pasture crops	2,200,000
0468-8UQMU5	D. Matthys Farms Ltd.	587792, 4894925	Agricultural		4,088,160
1301-9REUH9	A. Lang	588057, 4894574	Agricultural	Field and pasture crops	33,600
8838-84YLW8	H. J. Vander Zaag Farms Ltd.	588014, 4895749	Agricultural	Field and pasture crops	4,089,600

The Pine River between MSC-1 and MSC-2 is a popular recreational area that is used for swimming and angling by local residents; both activities were observed by HESL staff during site visits. In addition, there several residential properties along this stretch of the river (Figure 3) that may draw water via private water intakes. Maintaining water quality in the Pine River within PWQO would be protective of aquatic habitat and recreational uses. Untreated water drawn from the river or any other surface or groundwater source should not be used for drinking.

6. Conclusions

Preliminary results of the flow, water quality and natural heritage and beneficial use constraints indicate that:

- Flow in the Pine River available for dilution of the effluent during the proposed discharge period (fall to spring) would provide a minimum dilution ratio of 342:1 under 7Q20 flows (0.46 m^3/s) and 835:1 under average flows (1.13 m^3/s) at the proposed effluent flows of 116,765 L/day (0.00135 m^3/s);
- The Pine River at MSC-1 and MSC-2 would be considered Policy 2 for pH (75th percentile pH = 8.52; PWQO = 5.5 - 8.5) and Policy 1 for all other measured parameters including dissolved oxygen, unionized ammonia nitrogen and total phosphorus, and therefore;
  - Effluent must not increase pH in the Pine River, and
  - The Pine River has assimilative capacity to accommodate a surface discharge of treated effluent from the MSC (for dissolved oxygen, unionized ammonia and total phosphorus)
- Total phosphorus concentration near the MSC is exceptionally low for a river in southern Ontario and therefore this section of the Pine River represents a highly sensitive receiver for phosphorus. Efforts to minimize additional phosphorus loads to the Pine River are therefore recommended to protect the low nutrient status of the river at this location.
- The Pine River downstream of the MSC at the PWQMN station at Everett (Station 03005701002) would be considered Policy 2 for total phosphorus (75th percentile = 0.038 mg/L; PWQO = 0.030 mg/L) and several metals including aluminium, cadmium, cobalt and iron;
- Given the increase in total phosphorus concentration downstream of MSC at Everett to levels above PWQO, efforts to minimize additional phosphorus loads to the Pine River would be beneficial.
- The subject property is not within the Greenbelt Area, the Niagara Escarpment Plan Area or the Oak Ridges Moraine Conservation Area, and as such, policies related to these areas are not applicable;
- The presence of wetlands and Snapping Turtles on the subject property and in the vicinity of the proposed effluent discharge area should be assessed in greater detail by a site investigation and in consultation with the Nottawasaga Valley Conservation Authority to ensure that any works associated with the sanitary servicing meet policy requirements;
- The Pine River near the proposed discharge supports a cold water fishery, and fish habitat should be considered in the selection of a discharge location (and for the mixing zone) to ensure protection of sensitive fish habitat. Field investigations may be required to identify sensitive fish habitat features in the vicinity of the proposed discharge.

7. References

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July 14, 2017

MEMORANDUM

To: Gary Tomlinson
Senior Environmental Officer
Guelph District Office

From: Michael Spencer
Surface Water Group Leader
Technical Support Section

RE: Mansfield Ski Club Redevelopment Project
Preliminary Receiving Water Assessment
Township of Mulmur, Pine River

As requested, I have reviewed the following document for surface water issues:

> February 10, 2017 Memo, Re: Mansfield Ski Club, Receiving Water Assessment for Surface Discharge of Treated Wastewater Effluent to the Pine River, Hutchinson Environmental Sciences Ltd.

<u>Background</u>

The Mansfield Ski Club redevelopment project includes renovation of the Operations Building and a new development including commercial retail and residential. A sewage effluent discharge to the Pine River is proposed. The preliminary Receiving Water Assessment (Feb. 10, 2017) contains the results of the monitoring and the study to date and is based on the September 20, 2016 work plan which was previously reviewed by the Ministry.

<u>Comments</u>

Based on my review of the preliminary Receiving Water Assessment (Feb. 10, 2017), I have the following comments:

1. Based on my July 6, 2017 telephone conversation with Deborah Sinclair, Hutchinson Environmental, it is my understanding that the Mansfield Ski Club is now considering a year round sewage effluent discharge and the monthly water quality sampling program is continuing. As such, the final receiving water assessment should incorporate a monthly assessment in regards to the low flow analysis (ie. monthly 7Q20) and the corresponding

assimilative capacity study. The submitted preliminary Receiving Water Assessment was based on a seasonal assessment period since a seasonal discharge was proposed at the time of writing.

2. Table 4 and 5 listed the PWQO (or CWQG) for un-ionized ammonia as 16 ug/L. The PWQO for un-ionized ammonia is 20 ug/L and the CWQG is 19 ug/L.

3. The need for a DO sag assessment should be determined and included in the final receiving water assessment as needed.

4. The preliminary Receiving Water Assessment identified that further study is required in regards to the presence and habitat of snapping turtles and the presence of wetlands which I concur with.

5. The preliminary Receiving Water Assessment identified that a site specific assessment is recommended to characterize sensitive aquatic communities and fish habitat near the proposed effluent outfall which I concur with.

Michael Spencer
Surface Water Group Leader
Technical Support Section

cc: B. Koblik, TSS

IDS Ref. No.
File H-04-PI-32-01

Limitations: *The purpose of the preceding review is to provide advice to the Ministry of the Environment and Climate Change regarding surface water impacts based on a review of the information provided in the above referenced documents. The conclusions, opinions and recommendations of the reviewer are based on information provided by others, except where otherwise noted. The Ministry cannot guarantee that the information that is provided by others is accurate or complete. A lack of specific comment by the reviewer is not to be construed as endorsing the content or views expressed in the reviewed material.*

Hutchinson
Environmental Sciences Ltd.

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August 22, 2017 HESL Job #: J160071

Finley McEwen
20 Queen Street West, 5th Floor
Toronto, Ontario
M5H 3R4

Dear Mr. McEwen:

Re: Mansfield Ski Club Redevelopment Project – Preliminary Receiving Water Assessment – Response to MOECC Comments

We have reviewed the MOECC's comment on our Preliminary Receiving Water Assessment for the Mansfield Ski Club (MSC). The reviewer (Michael Spencer, Surface Water Group Leader, Technical Support West Central Region) had five (5) comments on the memorandum. We have responded to those comments below:

MOECC Comment #1:

Based on my July 6, 2017 telephone conversation with Deborah Sinclair, Hutchinson Environmental, it is my understanding that the Mansfield Ski Club is now considering a year round sewage effluent discharge and the monthly water quality sampling program is continuing. As such, the final receiving water assessment should incorporate a monthly assessment in regards to the low flow analysis (ie. monthly 7Q20) and the corresponding assimilative capacity study. The submitted preliminary Receiving Water Assessment was based on a seasonal assessment period since a seasonal discharge was proposed at the time of writing.

HESL Response:

The assimilative capacity assessment will be completed using a mass balance modeling approach to determine water quality in the Pine River at the point of complete mixing of the effluent and a CORMIX model to determine the size and shape of the mixing zone. It will consider the annual 7Q20 low flow statistic and the 75th percentile background concentrations of parameters collected as this represents the most conservative estimate of receiver conditions.

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

The Water Survey of Canada (WSC) maintains a flow gauge on the Pine River near Everett (Station 02ED014). We will calculate the 7Q20 flow statistic for the Pine River at the proposed discharge site using the most recent 20-year data record from the WSC Station, pro-rated and for the watershed area upstream of the proposed discharge location and verified with the measured flows from field monitoring.

HESL collected monthly water quality samples (September 2016 to August 2017 except April and May 2017) from the Pine River near the MSC. Samples were analysed for total phosphorus, total Kjeldahl nitrogen, total ammonia, nitrate, nitrite, total suspended solids, carbonaceous biochemical oxygen demand, and *E. coli*. The 75th percentile concentration (September 2016-August 2017) for each parameter will be used as background receiver water quality as input into the assimilative capacity study modelling.

MOECC Comment #2:

Table 4 and 5 listed the PWQO (or CWQG) for un-ionized ammonia as 16 ug/L. The PWQO for un-ionized ammonia is 20 ug/L and the CWQG is 19 ug/L.

HESL Response:

The CWQG for un-ionized ammonia of 19 µg/L is reported as NH_3 (CCME 2010). It is our understanding that the PWQO for un-ionized ammonia of 20 µg/L is also reported as NH_3. Total ammonia concentrations are reported by the laboratory as total ammonia-N. The PWQO and CWQG have been converted to ammonia-N by multiplying the guideline value by a correction factor 0.8224, as per CCME guidance (CCME 2010).

MOECC Comment #3:

The need for a DO sag assessment should be determined and included in the final receiving water assessment as needed.

HESL Response:

The Pine River near the MSC is well oxygenated (dissolved oxygen ranged from 11.12-14.4 mg/L; 92% - 116%). The potential influence of the effluent on the oxygen concentration in the Pine River can be determined by subtracting the total oxygen demand (TOD) of the effluent from the upstream oxygen load of the River. TOD is a sum of the biochemical oxygen demand (BOD) and the nitrogenous oxygen demand (NOD). The NOD is assumed to be four times the concentration of the ammonia in the effluent an represents the mass of oxygen consumed from the river water by the oxidation of effluent ammonia to nitrate.

Based on a daily design flow of 116.8 m^3/d, or 1.35 L/s, and effluent limits of 10 mg/L for cBOD and 3 mg/L for total ammonia, the TOD of the effluent will be approximately 30 mg/s. The upstream oxygen load of the Pine River was estimated as 6,283 mg/s by multiplying the lowest dissolved oxygen concentration measured in the Pine River (11.12 mg/L on September 14, 2016) by the fall seasonal 7Q20 flow estimate of 565 L/s (most conservative). The TOD of the effluent will reduce the oxygen load of the Pine River by less than less 5%, and the resulting dissolved oxygen concentrations downstream will be 11.07 mg/L (0.05 mg/L less than the upstream).

Based on this assessment a detailed DO sag assessment (e.g. QUAL 2K modeling) is not recommended for the final receiving water assessment. A dissolved oxygen logger will be installed in the Pine River for two weeks in August or September 2017 to determine diurnal oxygen conditions in the river, and determine if oxygen is a limiting factor at night when photosynthesis is low and respiration is high. Results will be used to update the mass-balance modeling of effluent oxygen demand to the Pine River in the final assimilative capacity study.

MOECC Comment #4:

The preliminary Receiving Water Assessment identified that further study is required in regard to the presence and habitat of snapping turtles and the presence of wetlands which I concur with.

HESL Response:

Further study with respect to the presence and habitat of snapping turtles, wetlands, and other natural heritage features and functions will be examined during the site plan approval phase.

MOECC Comment #5:

The preliminary Receiving Water Assessment identified that a site-specific assessment is recommended to characterize sensitive aquatic communities and fish habitat near the proposed effluent outfall which I concur with.

HESL Response:

An assessment of fish communities and aquatic habitat will be completed in the Pine River to inform the Assimilative Capacity Study (ACS). The fisheries investigation will be used to a) inform the receiving water assessment both in terms of effluent treatment required to protect resident species and selection of an effluent outfall location that minimizes impacts to critical habitat, and b) establish a baseline dataset with which future monitoring data can be compared to assess the presence or absence of impacts associated with effluent. The investigation will include a background review and field investigations.

The background review will include determination of the fish assemblages in the area based on sampling conducted by Nottawasaga Valley Conservation Authority and Midhurst District Ministry of Natural Resources and Forestry (MNRF). Fish assemblage information will be combined with available habitat information and any management guidelines to best describe the study area prior to sampling.

Sampling will be completed via backpack electrofishing following Ontario Stream Assessment Protocol (Stanfield 2010[1]). Fish collection will require completion of an Application to Collect Fish for Scientific Purposes and approval from the Midhurst District MNRF Office. Fish will be captured, identified to species,

[1] Stanfield, L. 2010. Ontario Stream Assessment Protocol. Version 8.0. Fisheries Policy Section. Ontario Ministry of Natural Resources. Peterborough, Ontario. 376 pages.

measured for length and live released. Catch-Per-Unit-Effort, rarity and sensitivity of captured species will be assessed, used to inform the ACS and act as a baseline for future monitoring efforts.

Aquatic habitat will be characterized through evaluation of features such as substrate, aquatic vegetation, water quality and temperature. Habitat requirements of resident fish species (as determined through the background review and sampling efforts) will be compared to habitat found in the study area to determine the presence or absence of critical habitats such as Rainbow Trout (*Oncorhynchus mykiss*) spawning habitat. The ACS will include an assessment of potential impacts to critical habitats and attempt to minimize impacts by selecting appropriate effluent treatment and a suitable location for the effluent outfall.

If you have any questions please do not hesitate to contact me. We would like to thank Mansfield Ski Club for selecting Hutchinson Environmental Sciences Ltd. for this assignment. We look forward to working with you to bring this project to a successful conclusion.

Sincerely,
Per. Hutchinson Environmental Sciences Ltd.

Deborah L. Sinclair

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

Attach

References

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October 18, 2017

MEMORANDUM

To: Gary Tomlinson
Senior Environmental Officer
Guelph District Office

From: Michael Spencer
Surface Water Group Leader
Technical Support Section

RE: Mansfield Ski Club Redevelopment Project
Response to Ministry Comments July 24, 2017
Preliminary Receiving Water Assessment
Township of Mulmur, Pine River

As requested, I have reviewed the following document for surface water issues:

> August 22, 2017 Memo, Re: Mansfield Ski Club Redevelopment Project – Preliminary Receiving Water Assessment – Response to MOECC Comments, Hutchinson Environmental Sciences Ltd.

<u>Background</u>

The Mansfield Ski Club redevelopment project includes renovation of the Operations Building and a new development including commercial retail and residential. A year round sewage effluent discharge to the Pine River is proposed. My July 24, 2017 review memorandum to yourself provided surface water comments on the Preliminary Receiving Water Assessment (Hutchinson, Feb. 10, 2017). The recently submitted August 22, 2017 memo from Hutchinson Environmental provided a response to my July 24, 2017 comments.

<u>Comments</u>

Based on my review of the response letter (Hutchinson, Aug. 22, 2017) to my July 24, 2017 review memorandum, I have the following comments:

1. The response is acceptable. The letter identified that the annual 7Q20 will be used instead of monthly 7Q20s which may be more conservative but is acceptable.

2. The response in regards to the un-ionized ammonia conversion is acceptable.

3. The response in regards to the oxygen concentration in the Pine River is acceptable.

4. No further comment is necessary in regards to habitat and natural features due to concurrence.

5. No further comment is necessary in regards to the assessment of fish communities and habitat due to concurrence.

Original Signed By

Michael Spencer
Surface Water Group Leader
Technical Support Section

cc: B. Koblik, TSS

IDS Ref. No. 4443-AS8HKC
File H-04-PI-32-01

Limitations: The purpose of the preceding review is to provide advice to the Ministry of the Environment and Climate Change regarding surface water impacts based on a review of the information provided in the above referenced documents. The conclusions, opinions and recommendations of the reviewer are based on information provided by others, except where otherwise noted. The Ministry cannot guarantee that the information that is provided by others is accurate or complete. A lack of specific comment by the reviewer is not to be construed as endorsing the content or views expressed in the reviewed material.

Appendix B. Table B1, Water Quality Results (September 2016 - August 2017)

Table B1. Measured Water Quality at MSC-1 and MSC2 (September 2016-August 2017)

Parameter	Units	Guideline/ Objective	14-Sep-16		24-Oct-16		29-Nov-16		13-Dec-16		26-Jan-17		28-Feb-17	31-Mar-17	27-Apr-17	21-Jun-17	17-Jul-17	3-Aug-17	MSC-1 Summary Statistics				
			MSC-1	MSC-2	MSC-1	MSC-2	MSC-1	MSC-2	MSC-1	MSC-2	MSC-1	MSC-2	MSC-1	MSC-1	MSC-1	MSC-1	MSC-1	MSC-1	N	Min	Max	median	75th %
Field Measurements																							
Temperature	°C		17.12	16.90	8.64	8.68	5.86	5.86	0.81	0.76	2.60	2.70	2.70	3.19	10.61	15.63	17.71	18.11	11	0.81	18.11	8.64	16.38
pH	pH units	6.5 - 8.5	8.28	8.27	7.78	7.82	8.42	8.41	8.84	8.82	8.36	8.38	8.30	8.21	8.20	8.25	8.20	8.19	11	7.78	8.84	8.25	8.33
Specific Conductivity	µS/cm		454	456	486	486	504	496	529	537	493	492	468	511	519	497	486	455	11	454	529	492.8	508
Dissolved Oxygen	mg/L	>5 - 8	11.12	11.20	11.53	11.22	12.64	13.49	13.06	13.87	13.50	13.65	14.36	13.00	11.45	10.38	9.51	10.62	11	9.51	14.36	11.53	10.87[a]
	%		116	116	99	96	101	108	92	97	100	101	106	97	103	105	100	113	11	92	116	101	105
Laboratory Measurements																							
Solids, total suspended	mg/L		<2.0	2.4	<2.0	<2.0	3.5	4.5	<2.0	<2.0	2.1	<2.0	8.4	2.9	6.8	9.1	8.3	2.7	11	<2.0	9.1	2.9	7.55
Ammonia, total (as N)	mg/L		<0.020	0.167	<0.020	<0.020	<0.020	<0.020	<0.020	0.024	<0.020	<0.020	0.128	<0.020	<0.020	<0.020	<0.020	<0.020	11	<0.020	0.13	<0.020	<0.020
Nitrate and Nitrite (as N)	mg/L		1.86	1.86	1.84	1.83	1.99	1.99	2.32	2.31	2.4	2.39	4.45	4.01	4.31	3.31	2.39	2.4	11	1.84	4.45	2.4	3.66
Nitrate (as N)	mg/L	3	1.86	1.86	1.84	1.83	1.99	1.99	2.32	2.31	2.40	2.39	4.45	4.01	4.31	3.31	2.39	2.40	11	1.84	4.45	2.40	3.66
Nitrite (as N)	mg/L	0.06	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	11	<0.01	<0.01	<0.01	<0.01
Nitrogen, total Kjeldahl	mg/L		0.40	0.25	0.16	0.21	0.38	0.38	0.26	0.23	0.18	0.21	0.67	0.61	0.40	0.51	0.34	0.44	11	0.16	0.67	0.4	0.48
Phosphorus, total	mg/L	0.03	0.0051	0.0069	0.0030	0.0039	0.0070	0.0050	0.0032	<0.0030	0.0053	0.0049	0.0110	0.0063	0.0069	0.0075	0.0116	0.0057	11	<0.003	0.0116	0.0063	0.0073
Ammonia, unionized (calc.) (as N)	µg/L	16	0.57	9.25	0.10	0.11	0.34	0.33	0.58	1.32	0.23	0.24	2.58	0.17	0.30	0.48	0.50	0.51	11	0.10	2.58	0.48	0.54
E. coli	CFU/100mL	100	20	20	70	50	30	50	<2.0	<2.0	24	<2	40	2	4	20	120	8	11	<2	120	20	35
Biochemical oxygen demand, carbonaceous	mg/L		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	11	<2.0	<2.0	<2.0	<2.0

Notes: For summary statistics, if result was <DL, then 1/2 DL was used to calculate statistic. A - 25th percentile Dissolved oxygen value presented for DO

Appendix C. CORMIX Output Data

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                                               MSC-TAN
CORMIX2 PREDICTION FILE:
222222222222222222222222222222222222222222222222222222222222222222222222222222222222
22222222222
                        CORMIX MIXING ZONE EXPERT SYSTEM
                Subsystem CORMIX2: Multiport Diffuser Discharges
                              CORMIX Version 10.0GT
                      HYDRO2 Version 10.0.2.0 April 2017
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CASE DESCRIPTION
 Site name/label:   Mansfield Ski Club
 Design case:       TAN
 FILE NAME:         C:\...ACS\Job\Data-analysis\CORMIX\Oct 2017\MSC-TAN.prd
 Time stamp:        11/03/2017--14:07:47

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =     12.10  AS    =      2.78  QA    =      0.43  ICHREG= 2
 HA    =      0.23  HD    =      0.23
 UA    =      0.155 F     =      0.205 USTAR =0.2484E-01
 UW    =      2.000 UWSTAR=0.2198E-02
 Uniform density environment
 STRCND=  U         RHOAM =  998.8818

DIFFUSER DISCHARGE PARAMETERS (metric units)
 Diffuser type:     DITYPE= alternating_perpendicular
 BANK  =  RIGHT     DISTB =      3.50  YB1   =      2.00  YB2   =      5.00
 LD    =      3.00  NOPEN =    7       NRISER=    7       SPAC  =      0.50
NPPERR =    1
 D0    =      0.020 A0    =      0.000 H0    =      0.02  SUB0  =      0.21
 D0INP =      0.020 CR0   =      1.000
 Nozzle/port arrangement:   near_vertical_discharge
 GAMMA =     90.00  THETA =     90.00  SIGMA =      0.00  BETA  =     90.00
 U0    =      0.633 Q0    =      0.001 Q0A   =0.1393E-02
 RHO0  =  997.7714  DRHO0 =0.1110E+01  GP0   =0.1090E-01
 C0    =0.1980E+01  CUNITS=  mg/l
 IPOLL =  2         KS    =0.0000E+00  KD    =0.2315E-04

FLUX VARIABLES - PER UNIT DIFFUSER LENGTH (metric units)
 q0    =0.4643E-03  m0    =0.2521E-03  j0    =0.4339E-05  SIGNJ0=      1.0
 Associated 2-d length scales (meters)
 lQ=B  =      0.001 lM    =      0.95  lm    =      0.01
 lmp   =  99999.00  lbp   =  99999.00  la    =  99999.00

FLUX VARIABLES - ENTIRE DIFFUSER (metric units)
 Q0    =0.1393E-02  M0    =0.7563E-03  J0    =0.1302E-04
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 Associated 3-d length scales (meters)
 LQ    =      0.02  LM    =      1.26  Lm    =      0.19  Lb    =      0.00
                                       Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =    242.04  FRD0  =     42.90  R     =      4.08  PL    =   18.27
 (slot)             (port/nozzle)


FLOW CLASSIFICATION
 222222222222222222222222222222222222222222
 2  Flow class (CORMIX2)      =    MU8    2
 2  Applicable layer depth HS =     0.23  2
 2  Limiting Dilution S =QA/Q0=   311.13  2
 222222222222222222222222222222222222222222

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.1980E+01  CUNITS=  mg/l
 NTOX  =  0
 NSTD  =  1         CSTD  =0.2700E+00
 REGMZ =  0
 XINT  =   2500.00  XMAX  =   2500.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and the diffuser mid-point:
         3.50 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  50 display intervals per module
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BEGIN MOD201: DIFFUSER DISCHARGE MODULE

 Due to complex near-field motions:  EQUIVALENT SLOT DIFFUSER (2-D) GEOMETRY

 Profile definitions:
   BV = Gaussian 1/e (37%) half-width, in vertical plane normal to trajectory
   BH = top-hat half-width, in horizontal plane normal to trajectory
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   Uc = Local centerline excess velocity (above ambient)
   TT = Cumulative travel time

       X        Y       Z        S        C       BV       BH       Uc        TT
      0.00     0.00    0.02     1.0 0.198E+01   0.00     1.50     0.633   .00000E+00

END OF MOD201: DIFFUSER DISCHARGE MODULE
```


BEGIN MOD277: UNSTABLE NEAR-FIELD ZONE OF ALTERNATING PERPENDICULAR DIFFUSER

Because of the strong ambient current the diffuser plume of this crossflowing discharge gets RAPIDLY DEFLECTED.

A near-field zone is formed that is VERTICALLY FULLY MIXED over the entire layer depth. Full mixing is achieved at a downstream distance of about five (5) layer depths.

Profile definitions:

BV = layer depth (vertically mixed)
BH = top-hat half-width, measured horizontally in Y-direction
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	TT
0.00	0.00	0.02	1.0	0.198E+01	0.00	1.50	.00000E+00

** WATER QUALITY STANDARD OR CCC HAS BEEN FOUND **

The pollutant concentration in the plume falls below water quality standard or CCC value of 0.270E+00 in the current prediction interval.

This is the spatial extent of concentrations exceeding the water quality standard or CCC value.

0.02	0.00	0.02	11.8	0.169E+00	0.01	1.50	.29586E+00
0.05	0.00	0.02	16.2	0.122E+00	0.01	1.50	.59172E+00
0.07	0.00	0.03	19.6	0.101E+00	0.01	1.50	.88758E+00
0.09	0.00	0.03	22.5	0.880E-01	0.02	1.50	.11834E+01
0.12	0.00	0.03	25.0	0.791E-01	0.02	1.50	.14793E+01
0.14	0.00	0.03	27.3	0.724E-01	0.03	1.50	.17752E+01
0.16	0.00	0.03	29.4	0.672E-01	0.03	1.50	.20710E+01
0.18	0.00	0.04	31.4	0.630E-01	0.04	1.50	.23669E+01
0.21	0.00	0.04	33.3	0.595E-01	0.04	1.50	.26627E+01
0.23	0.00	0.04	35.0	0.566E-01	0.05	1.50	.29586E+01
0.25	0.00	0.04	36.7	0.540E-01	0.05	1.50	.32544E+01
0.28	0.00	0.04	38.2	0.518E-01	0.06	1.50	.35503E+01
0.30	0.00	0.04	39.8	0.498E-01	0.06	1.50	.38462E+01
0.32	0.00	0.05	41.2	0.480E-01	0.06	1.50	.41420E+01
0.35	0.00	0.05	42.6	0.464E-01	0.07	1.50	.44379E+01
0.37	0.00	0.05	44.0	0.450E-01	0.07	1.50	.47337E+01
0.39	0.00	0.05	45.3	0.437E-01	0.08	1.50	.50296E+01
0.41	0.00	0.05	46.6	0.425E-01	0.08	1.50	.53255E+01
0.44	0.00	0.06	47.9	0.414E-01	0.09	1.50	.56213E+01
0.46	0.00	0.06	49.1	0.403E-01	0.09	1.50	.59172E+01
0.48	0.00	0.06	50.3	0.394E-01	0.10	1.50	.62130E+01
0.51	0.00	0.06	51.4	0.385E-01	0.10	1.50	.65089E+01

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      0.53     0.00    0.06    52.6 0.377E-01   0.11     1.50 .68047E+01
      0.55     0.00    0.07    53.7 0.369E-01   0.11     1.50 .71006E+01
      0.58     0.00    0.07    54.8 0.362E-01   0.12     1.50 .73965E+01
      0.60     0.00    0.07    55.8 0.355E-01   0.12     1.50 .76923E+01
      0.62     0.00    0.07    56.9 0.348E-01   0.12     1.50 .79882E+01
      0.64     0.00    0.07    57.9 0.342E-01   0.13     1.50 .82840E+01
      0.67     0.00    0.08    58.9 0.336E-01   0.13     1.50 .85799E+01
      0.69     0.00    0.08    59.9 0.331E-01   0.14     1.50 .88758E+01
      0.71     0.00    0.08    60.9 0.325E-01   0.14     1.50 .91716E+01
      0.74     0.00    0.08    61.8 0.320E-01   0.15     1.50 .94675E+01
      0.76     0.00    0.08    62.8 0.315E-01   0.15     1.50 .97633E+01
      0.78     0.00    0.08    63.7 0.311E-01   0.16     1.50 .10059E+02
      0.81     0.00    0.09    64.6 0.306E-01   0.16     1.50 .10355E+02
      0.83     0.00    0.09    65.5 0.302E-01   0.17     1.50 .10651E+02
      0.85     0.00    0.09    66.4 0.298E-01   0.17     1.50 .10947E+02
      0.87     0.00    0.09    67.3 0.294E-01   0.17     1.50 .11243E+02
      0.90     0.00    0.09    68.1 0.291E-01   0.18     1.50 .11538E+02
      0.92     0.00    0.10    69.0 0.287E-01   0.18     1.50 .11834E+02
      0.94     0.00    0.10    69.8 0.283E-01   0.19     1.50 .12130E+02
      0.97     0.00    0.10    70.7 0.280E-01   0.19     1.50 .12426E+02
      0.99     0.00    0.10    71.5 0.277E-01   0.20     1.50 .12722E+02
      1.01     0.00    0.10    72.3 0.274E-01   0.20     1.50 .13018E+02
      1.04     0.00    0.11    73.1 0.271E-01   0.21     1.50 .13314E+02
      1.06     0.00    0.11    73.9 0.268E-01   0.21     1.50 .13609E+02
      1.08     0.00    0.11    74.7 0.265E-01   0.22     1.50 .13905E+02
      1.10     0.00    0.11    75.5 0.262E-01   0.22     1.50 .14201E+02
      1.13     0.00    0.11    76.3 0.260E-01   0.23     1.50 .14497E+02
      1.15     0.00    0.12    77.0 0.257E-01   0.23     1.50 .14793E+02
 Cumulative travel time =          14.7929 sec  (    0.00 hrs)
   Plume centerline may exhibit slight discontinuities in transition
     to subsequent far-field module.

END OF MOD277: UNSTABLE NEAR-FIELD ZONE OF ALTERNATING PERPENDICULAR DIFFUSER
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** End of NEAR-FIELD REGION (NFR) **
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BEGIN MOD241: BUOYANT AMBIENT SPREADING

 Discharge is non-buoyant or weakly buoyant.
   Therefore BUOYANT SPREADING REGIME is ABSENT.

END OF MOD241: BUOYANT AMBIENT SPREADING
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BEGIN MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

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  Vertical diffusivity (initial value)   = 0.114E-02 m^2/s
  Horizontal diffusivity (initial value) = 0.286E-02 m^2/s

 The passive diffusion plume is VERTICALLY FULLY MIXED at beginning of region.

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
```

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
1.15	0.00	0.23	77.0	0.257E-01	0.23	1.50	0.23	0.00	.14793E+02
4.62	0.00	0.23	80.4	0.246E-01	0.23	1.57	0.23	0.00	.37054E+02
8.08	0.00	0.23	83.6	0.237E-01	0.23	1.63	0.23	0.00	.59314E+02
11.55	0.00	0.23	86.6	0.228E-01	0.23	1.69	0.23	0.00	.81575E+02
15.02	0.00	0.23	89.6	0.220E-01	0.23	1.75	0.23	0.00	.10384E+03
18.48	0.00	0.23	92.5	0.213E-01	0.23	1.80	0.23	0.00	.12610E+03
21.95	0.00	0.23	95.3	0.207E-01	0.23	1.86	0.23	0.00	.14836E+03
25.42	0.00	0.23	98.0	0.201E-01	0.23	1.91	0.23	0.00	.17062E+03
28.88	0.00	0.23	100.7	0.196E-01	0.23	1.96	0.23	0.00	.19288E+03
32.35	0.00	0.23	103.2	0.191E-01	0.23	2.01	0.23	0.00	.21514E+03
35.82	0.00	0.23	105.7	0.186E-01	0.23	2.06	0.23	0.00	.23740E+03
39.28	0.00	0.23	108.2	0.182E-01	0.23	2.11	0.23	0.00	.25966E+03
42.75	0.00	0.23	110.6	0.178E-01	0.23	2.16	0.23	0.00	.28192E+03
46.22	0.00	0.23	113.0	0.174E-01	0.23	2.20	0.23	0.00	

.30418E+03	49.68	0.00	0.23	115.3	0.171E-01	0.23	2.25	0.23	0.00
.32644E+03	53.15	0.00	0.23	117.5	0.167E-01	0.23	2.29	0.23	0.00
.34870E+03	56.62	0.00	0.23	119.7	0.164E-01	0.23	2.34	0.23	0.00
.37096E+03	60.08	0.00	0.23	121.9	0.161E-01	0.23	2.38	0.23	0.00
.39322E+03	63.55	0.00	0.23	124.0	0.158E-01	0.23	2.42	0.23	0.00
.41549E+03	67.02	0.00	0.23	126.1	0.155E-01	0.23	2.46	0.23	0.00
.43775E+03	70.48	0.00	0.23	128.2	0.153E-01	0.23	2.50	0.23	0.00
.46001E+03	73.95	0.00	0.23	130.2	0.150E-01	0.23	2.54	0.23	0.00
.48227E+03	77.42	0.00	0.23	132.2	0.148E-01	0.23	2.58	0.23	0.00
.50453E+03	80.88	0.00	0.23	134.2	0.146E-01	0.23	2.62	0.23	0.00
.52679E+03	84.35	0.00	0.23	136.1	0.144E-01	0.23	2.66	0.23	0.00
.54905E+03	87.82	0.00	0.23	138.1	0.142E-01	0.23	2.69	0.23	0.00
.57131E+03	91.28	0.00	0.23	139.9	0.140E-01	0.23	2.73	0.23	0.00
.59357E+03	94.75	0.00	0.23	141.8	0.138E-01	0.23	2.77	0.23	0.00
.61583E+03	98.22	0.00	0.23	143.6	0.136E-01	0.23	2.80	0.23	0.00
.63809E+03	101.68	0.00	0.23	145.5	0.134E-01	0.23	2.84	0.23	0.00
.66035E+03	105.15	0.00	0.23	147.3	0.132E-01	0.23	2.87	0.23	0.00
.68261E+03	108.62	0.00	0.23	149.0	0.131E-01	0.23	2.91	0.23	0.00
.70487E+03	112.08	0.00	0.23	150.8	0.129E-01	0.23	2.94	0.23	0.00
.72713E+03	115.55	0.00	0.23	152.5	0.128E-01	0.23	2.98	0.23	0.00
.74940E+03	119.02	0.00	0.23	154.2	0.126E-01	0.23	3.01	0.23	0.00
.77166E+03	122.48	0.00	0.23	155.9	0.125E-01	0.23	3.04	0.23	0.00
.79392E+03	125.95	0.00	0.23	157.6	0.123E-01	0.23	3.07	0.23	0.00
.81618E+03	129.42	0.00	0.23	159.3	0.122E-01	0.23	3.11	0.23	0.00

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.83844E+03
    132.88     0.00     0.23    160.9 0.121E-01    0.23     3.14     0.23     0.00
.86070E+03
    136.35     0.00     0.23    162.5 0.119E-01    0.23     3.17     0.23     0.00
.88296E+03
    139.82     0.00     0.23    164.1 0.118E-01    0.23     3.20     0.23     0.00
.90522E+03
    143.28     0.00     0.23    165.7 0.117E-01    0.23     3.23     0.23     0.00
.92748E+03
    146.75     0.00     0.23    167.3 0.116E-01    0.23     3.26     0.23     0.00
.94974E+03
    150.22     0.00     0.23    168.9 0.115E-01    0.23     3.29     0.23     0.00
.97200E+03
    153.68     0.00     0.23    170.4 0.114E-01    0.23     3.32     0.23     0.00
.99426E+03
    157.15     0.00     0.23    171.9 0.112E-01    0.23     3.35     0.23     0.00
.10165E+04
    160.62     0.00     0.23    173.5 0.111E-01    0.23     3.38     0.23     0.00
.10388E+04
    164.08     0.00     0.23    175.0 0.110E-01    0.23     3.41     0.23     0.00
.10610E+04
    167.55     0.00     0.23    176.5 0.109E-01    0.23     3.44     0.23     0.00
.10833E+04
    171.02     0.00     0.23    177.9 0.108E-01    0.23     3.47     0.23     0.00
.11056E+04
    174.48     0.00     0.23    179.4 0.108E-01    0.23     3.50     0.23     0.00
.11278E+04
 Cumulative travel time =        1127.8271 sec  (    0.31 hrs)

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 Plume Stage 2 (bank attached):
       X         Y        Z         S        C        BV        BH       ZU       ZL
TT
    174.48    -3.50     0.23    179.4 0.108E-01    0.23     7.00     0.23     0.00
.11278E+04
    220.99    -3.50     0.23    184.3 0.104E-01    0.23     7.19     0.23     0.00
.14265E+04
    267.50    -3.50     0.23    189.0 0.101E-01    0.23     7.37     0.23     0.00
.17251E+04
    314.01    -3.50     0.23    193.6 0.976E-02    0.23     7.55     0.23     0.00
.20238E+04
    360.52    -3.50     0.23    198.1 0.947E-02    0.23     7.73     0.23     0.00
.23225E+04
    407.04    -3.50     0.23    202.5 0.920E-02    0.23     7.90     0.23     0.00
.26211E+04
    453.55    -3.50     0.23    206.8 0.895E-02    0.23     8.07     0.23     0.00
.29198E+04
```

500.06	-3.50	0.23	211.0	0.871E-02	0.23	8.23	0.23	0.00	.32184E+04
546.57	-3.50	0.23	215.1	0.848E-02	0.23	8.39	0.23	0.00	.35171E+04
593.08	-3.50	0.23	219.2	0.827E-02	0.23	8.55	0.23	0.00	.38158E+04
639.59	-3.50	0.23	223.2	0.807E-02	0.23	8.71	0.23	0.00	.41144E+04
686.10	-3.50	0.23	227.1	0.787E-02	0.23	8.86	0.23	0.00	.44131E+04
732.61	-3.50	0.23	230.9	0.769E-02	0.23	9.01	0.23	0.00	.47117E+04
779.12	-3.50	0.23	234.7	0.751E-02	0.23	9.16	0.23	0.00	.50104E+04
825.63	-3.50	0.23	238.4	0.734E-02	0.23	9.30	0.23	0.00	.53091E+04
872.14	-3.50	0.23	242.1	0.718E-02	0.23	9.45	0.23	0.00	.56077E+04
918.65	-3.50	0.23	245.7	0.703E-02	0.23	9.59	0.23	0.00	.59064E+04
965.16	-3.50	0.23	249.3	0.688E-02	0.23	9.73	0.23	0.00	.62050E+04
1011.67	-3.50	0.23	252.8	0.674E-02	0.23	9.86	0.23	0.00	.65037E+04
1058.18	-3.50	0.23	256.2	0.660E-02	0.23	10.00	0.23	0.00	.68023E+04
1104.69	-3.50	0.23	259.6	0.647E-02	0.23	10.13	0.23	0.00	.71010E+04
1151.20	-3.50	0.23	263.0	0.634E-02	0.23	10.26	0.23	0.00	.73997E+04
1197.71	-3.50	0.23	266.3	0.622E-02	0.23	10.39	0.23	0.00	.76983E+04
1244.22	-3.50	0.23	269.6	0.610E-02	0.23	10.52	0.23	0.00	.79970E+04
1290.73	-3.50	0.23	272.9	0.599E-02	0.23	10.65	0.23	0.00	.82956E+04
1337.24	-3.50	0.23	276.1	0.588E-02	0.23	10.77	0.23	0.00	.85943E+04
1383.75	-3.50	0.23	279.3	0.577E-02	0.23	10.90	0.23	0.00	.88930E+04
1430.26	-3.50	0.23	282.4	0.567E-02	0.23	11.02	0.23	0.00	.91916E+04
1476.77	-3.50	0.23	285.5	0.557E-02	0.23	11.14	0.23	0.00	.94903E+04
1523.28	-3.50	0.23	288.6	0.547E-02	0.23	11.26	0.23	0.00	.97889E+04
1569.79	-3.50	0.23	291.6	0.538E-02	0.23	11.38	0.23	0.00	.10088E+05

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   1616.30    -3.50    0.23   294.6 0.528E-02   0.23    11.49    0.23    0.00
.10386E+05
   1662.81    -3.50    0.23   297.6 0.520E-02   0.23    11.61    0.23    0.00
.10685E+05
   1709.32    -3.50    0.23   300.5 0.511E-02   0.23    11.73    0.23    0.00
.10984E+05
   1755.84    -3.50    0.23   303.4 0.503E-02   0.23    11.84    0.23    0.00
.11282E+05
   1802.35    -3.50    0.23   306.3 0.494E-02   0.23    11.95    0.23    0.00
.11581E+05
   1848.86    -3.50    0.23   309.2 0.486E-02   0.23    12.06    0.23    0.00
.11880E+05
 The passive diffusion plume becomes LATERALLY FULLY MIXED over the channel
     width during the current prediction interval.
 The x-coordinate of bank attachment is    1864.15 m.
   1895.37    -3.50    0.23   312.0 0.479E-02   0.23    12.10    0.23    0.00
.12178E+05
 Effluent is FULLY MIXED over the entire channel cross-section.
 Except for possible far-field decay or reaction processes, there are
     NO FURTHER CHANGES with downstream direction.
   1941.88    -3.50    0.23   310.1 0.478E-02   0.23    12.10    0.23    0.00
.12477E+05
   1988.39    -3.50    0.23   310.1 0.475E-02   0.23    12.10    0.23    0.00
.12776E+05
   2034.90    -3.50    0.23   310.1 0.472E-02   0.23    12.10    0.23    0.00
.13074E+05
   2081.41    -3.50    0.23   310.1 0.468E-02   0.23    12.10    0.23    0.00
.13373E+05
   2127.92    -3.50    0.23   310.1 0.465E-02   0.23    12.10    0.23    0.00
.13672E+05
   2174.43    -3.50    0.23   310.1 0.462E-02   0.23    12.10    0.23    0.00
.13970E+05
   2220.94    -3.50    0.23   310.1 0.459E-02   0.23    12.10    0.23    0.00
.14269E+05
   2267.45    -3.50    0.23   310.1 0.456E-02   0.23    12.10    0.23    0.00
.14567E+05
   2313.96    -3.50    0.23   310.1 0.453E-02   0.23    12.10    0.23    0.00
.14866E+05
   2360.47    -3.50    0.23   310.1 0.449E-02   0.23    12.10    0.23    0.00
.15165E+05
   2406.98    -3.50    0.23   310.1 0.446E-02   0.23    12.10    0.23    0.00
.15463E+05
   2453.49    -3.50    0.23   310.1 0.443E-02   0.23    12.10    0.23    0.00
.15762E+05
   2500.00    -3.50    0.23   310.1 0.440E-02   0.23    12.10    0.23    0.00
.16061E+05
 Cumulative travel time =       16060.7783 sec  (    4.46 hrs)
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 Simulation limit based on maximum specified distance =   2500.00 m.
   This is the REGION OF INTEREST limitation.

END OF MOD261: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
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CORMIX2: Multiport Diffuser Discharges       End of Prediction File
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