Town of Edson

Receiving Stream Sensitivity Study – REVISED FINAL

Report

Environment AECOM

Town of Edson

Receiving Stream Sensitivity Study – REVISED FINAL

Prepared by:

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Project Number:

60114314 (4193-033-00)

Date:

April, 2012

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April 17, 2012

Dawit Solomon, MSc., P.Eng.
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Dear Mr. Solomon:

Project No: **60114314 (4193-033-00)**

Regarding: Town of Edson Municipal Servicing Plan Update – Receiving Stream Sensitivity Study

We are pleased to submit this revision to our final report on the Town of Edson Municipal Servicing Plan Update – Receiving Stream Sensitivity Study. The revision reflects minor adjustments to calculated values used to describe historical water quality in the McLeod River. The conclusions and recommendations have not changed from those made in the original report.

If you have any questions or require any additional information please call me at (780) 732-9443; or call Mike Yamada at (780) 453-0809.

Sincerely,
AECOM Canada Ltd.

KStLouis

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KSL:blb

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1	C.Prather	October 26, 2010	DRAFT
2	C.Prather	February 22, 2011	FINAL based on comments by AENV
3	S. Kjartanson	April 4, 2012	REVISED FINAL based on internal review

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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Executive Summary

The Town of Edson was required by Alberta Environment to conduct an effluent characterization and risk assessment study of the municipal treated wastewater and discharge to the McLeod River. The effluent characterization program was structured around the Canada Wide Strategy for the Management of Municipal Wastewater Effluent and formed the majority of the study. The second part of the study involved reviewing historical data on the receiving water, collecting new receiving water samples and completing a mixing zone assessment. Results from this study were used to understand the current effluent quality, risk of discharge to the environment and provide some high level treatment and disinfection options for the town.

The effluent characterization study was initiated in May 2009 and final treated effluent samples were collected bi-weekly from May 2009 until May 2010. General chemistry, nutrients and bacteria were analyzed in all samples. In addition, samples were collected once per quarter for analysis of metals, pesticides, polyaromatic hydrocarbons, volatile organic compounds, phenols, polychlorinated biphenyls, anionic surfactants, pathogens (*Cryptosporidium* and *Giardia*) and whole effluent toxicity. Measured effluent quality was compared to technology effluent limits to evaluate how well the facility is functioning. Based on the results, the parameters of concern include total nitrogen, summer ammonia, winter ammonia, total phosphorus, total suspended solids (TSS), anionic surfactants and overall acutely lethal toxicity of effluent. In comparison to expected treatment by technology, the treatment facility is not sufficiently removing nitrogen and phosphorus (on average) or sufficiently removing TSS occasionally.

Total ammonia concentrations in the winter to spring exceeded concentrations known to cause acute toxicity to fish. Un-ionized ammonia concentrations in the spring and one fall sample event were very high. Total phosphorus varied little through the year, but was high in comparison to technology limit. Yearly mean TSS was less the new national performance standard of 25 mg/L, but there were high spikes of TSS in the spring. Anionic surfactants were detected in all of the samples and were highest in the early winter sample. Four samples were collected and analyzed for toxicity. All samples were acutely toxic to trout and one sample (with the highest concentration of anionic surfactants) was also slightly toxic to *Daphnia*. Effluent collected in September produced the best results in the toxicity tests (i.e., highest LC50 for trout and highest IC25 for *Ceriodaphnia* and fathead minnow).

A mixing zone assessment was conducted for September 2010 conditions when samples were collected and for projected low-flow (worst-case) conditions of the river using the 7Q10 flow rate for the river. The model was calibrated using field samples collected in September 2010. The characteristic of the effluent plume under these two conditions was calculated along with concentration of ammonia and phosphorus within the plume and the distance downstream to achieve a water quality objective (WQO). Under higher stream flow conditions, the plume does not fully mix across the river before concentrations of ammonia and phosphorus return to background concentrations (less than WQO). Under the low-flow conditions, the plume mixes across the river by 350 m downstream and is considered fully mixed (lateral and vertical) at 550 m downstream. Ammonia meets the WQO within the mixing zone while TP exceeds the WQO at the end of the mixing zone.

Future steps for this facility should include reducing the toxicity of the effluent in general and in reducing un-ionized ammonia in particular. Additional future steps may include implementing an ambient and effluent monitoring program after discussions with AENV and participating in the Athabasca River rainbow trout recovery team.

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1. Introduction

1.1 Background

The Town of Edson (Edson) has an approval under the Alberta Environment (AENV) Environmental Protection and Enhancement Act (EPEA) for discharge of effluent from the wastewater treatment lagoon (lagoon). Under EPEA approval (640-02-00), there is the requirement for the completion of a sensitivity study and risk assessment. AENV requested Edson to complete an effluent characterization and receiving environment study designed around the Canadian Council for Ministers of the Environment (CCME) Canada Wide Strategy for the Management of Municipal Wastewater Effluent (MWWE) (CCME 2009).

The intent of the MWWE is to ensure that all wastewater treatment facilities, with continuous discharge to surface water, achieve a minimum National Performance Standard, conduct a site-specific risk assessment and develop site-specific Effluent Discharge Objectives (EDO). As part of this strategy, a 12 month effluent characterization program is required. Most of this report focuses on the results of the effluent characterization program. The study area, contributing watersheds and sites for historical data are illustrated in Figure 1-1. At the completion of the effluent characterization program and at the recommendation of AENV, an in-stream sampling program was conducted. The sampling locations used for the field study are illustrated in Figure 1-2. Results from this sampling program are compared to historical receiving environment data and are used to generate a mixing zone assessment of Edson wastewater on the McLeod River.

1.2 Watershed

The Town of Edson discharges effluent into the McLeod River which is a sub-basin and tributary to the upper reaches of the Athabasca River (North/South 2007). The McLeod River enters the Athabasca River above Whitecourt. Above Edson, there are point source inputs from coal mining operations and non-point source inputs from forestry in the watershed. The McLeod River is used for recreational activities such as fishing and canoeing, but also as source drinking water. The major downstream user is the Town of Whitecourt which draw their water from the McLeod River above the confluence with the Athabasca River (Associated Engineering 2004). Along the McLeod River from Edson to the mouth there are other smaller approved water withdrawals. Effluent quality discharged from Edson must not alter water in the McLeod River such that it affects downstream users. The purpose of the study is to evaluate the current effluent quality and if required recommend effluent limits such that there is no impact to aquatic life or downstream users of the receiving water body. Potential downstream users can include municipal or individual drinking water sources, recreation, protection of aquatic life, stock watering, industry, and irrigation.

1.3 Report Organization

This is a supplemental report to the Municipal Servicing Plan Update report and focuses only on the effluent characterization and receiving stream sensitivity study. This report includes:

- Study design, assumptions and calculations.
- A review of available historical data (effluent quantity and quality; river water quantity and quality).
- Review and detailed characterization of current effluent quality (2009-2010).
- Review and characterization of current in-stream water quality (2010).
- Identification of effluent quality parameters of concern.
- Assessment of effluent mixing in the river.
- Interpretations.
- Recommendations.

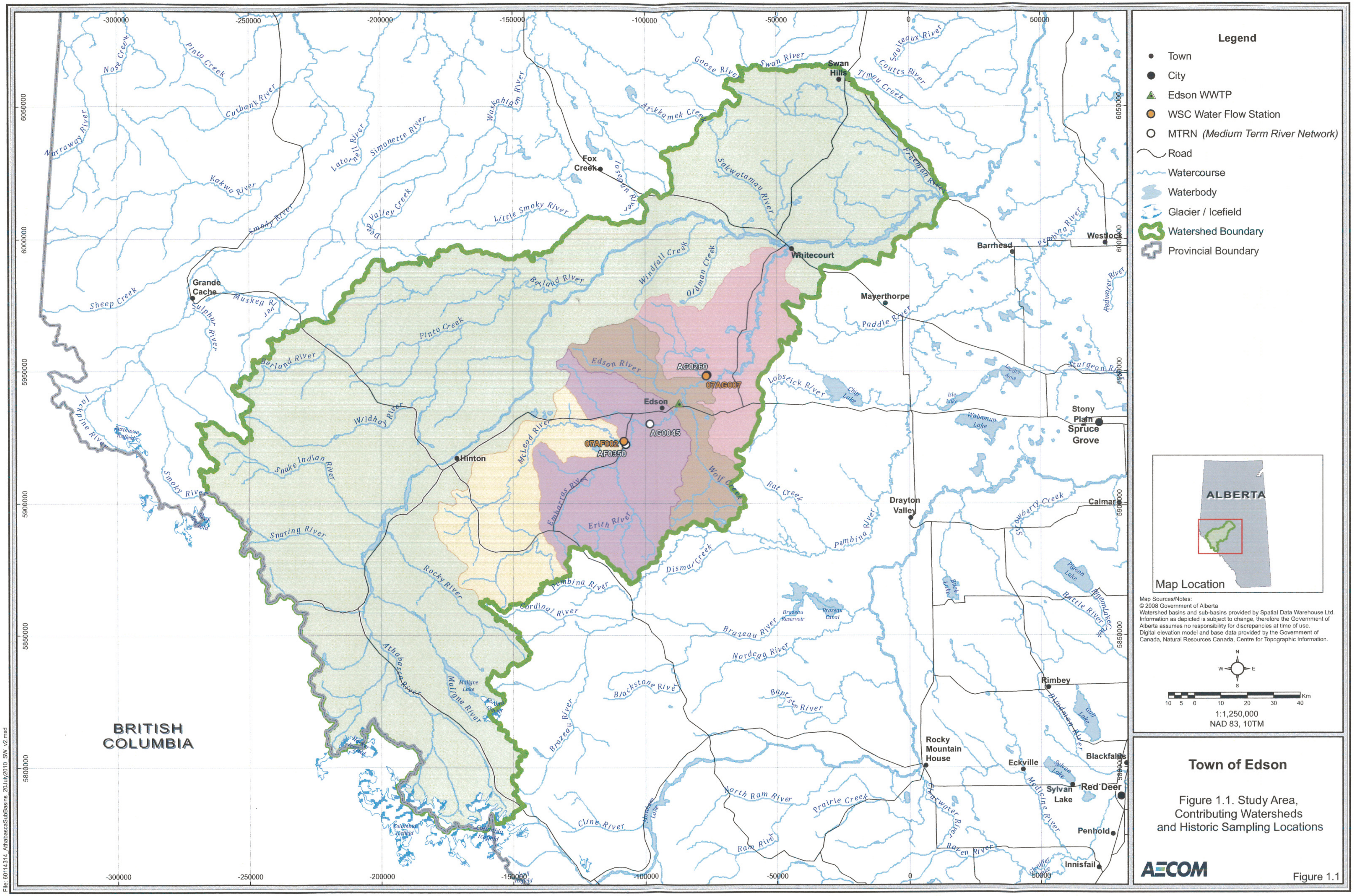

Figure 1.1. Study Area, Contributing Watersheds and Historic Sampling Locations


DS4300-02
DS300-01
DS1000-01
DS1000-02
DS100-01
Outfall
US100-02
TransCanada Highway Yellowhead Route 16
Legend
effluent sample
river water sample
Map Sources/Notes:
Source of color enhancement: GeoBase®
N
W
E
S
m
0 50 100 200 300 400 500
1:7,000
UTM Zone 11N, NAD 83
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Town of Edson
Figure 1-2. McLeod River Sampling Locations
AECOM

2. Study Methods

2.1 Effluent Characterization

Characterization of effluent requires an evaluation of the quantity and quality of treated effluent. As the study was progressing, the focus changed from a basic characterization of effluent and receiving water to a focus on detailed characterization of treated effluent as per the CCME strategy document.

2.1.1 Effluent Quantity

As part of the regular operations at the Edson wastewater facility, daily flows of untreated effluent quantity are measured. There is no flow meter at the outfall point so values from the inflow meter are used as estimates of the daily quantity of treated effluent discharged to the McLeod River. For every day, minimum, maximum and average daily flows (cubic meters per hour [m^3/h]) were recorded. Data from 2008, 2009 and 2010 (up to April) were used to characterize daily, monthly and annual wastewater discharge volume and rates.

The Town of Edson monitors this flow meter and provided the data to AECOM for use in this report.

A review of the raw flow data from 2009 showed some very unusual and elevated readings from July 5 to October 9. Even though these elevated values were recorded every day after July 5, they were not noticed until October. Upon investigation of the flow meter by Edson it was observed that a 200 mm sewer cap was stuck in the flume and caused the elevated readings. This cap was removed October 9. It was determined that these elevated readings were not indicative of the true value because the sewer cap blocked a portion of the flow path and raised the level of water in the flow meter. The flow meter is set to read the height of the effluent above the base and converts it to flows.

Effluent flows are used to calculate loads of treated effluent to the river. Elevated flows would lead to an interpretation of elevated loads to the river. Data from 2008 and 2009 were compared to determine the pattern of readings in one year versus the other (Figure 2-1). It was apparent that flows from 2009 (July 5 to October 9) were on average 150 cubic meters per hour higher than flows on similar dates in 2008 while flows on the other dates were similar between years. A simple correction (subtraction of 150) was used to correct the elevated flows between July 5 and October 9. A more sophisticated correction method could have been used but the corrected value (green line in Figure 2-1) produces a trend that is similar to 2008. These corrected values for 2009 were used in all subsequent calculations involving effluent volume or effluent loads.

Loadings of effluent to the river were calculated as follows:

Load (kg/year) = Effluent Concentration (*kg/L*) x Flow (*L/year*)

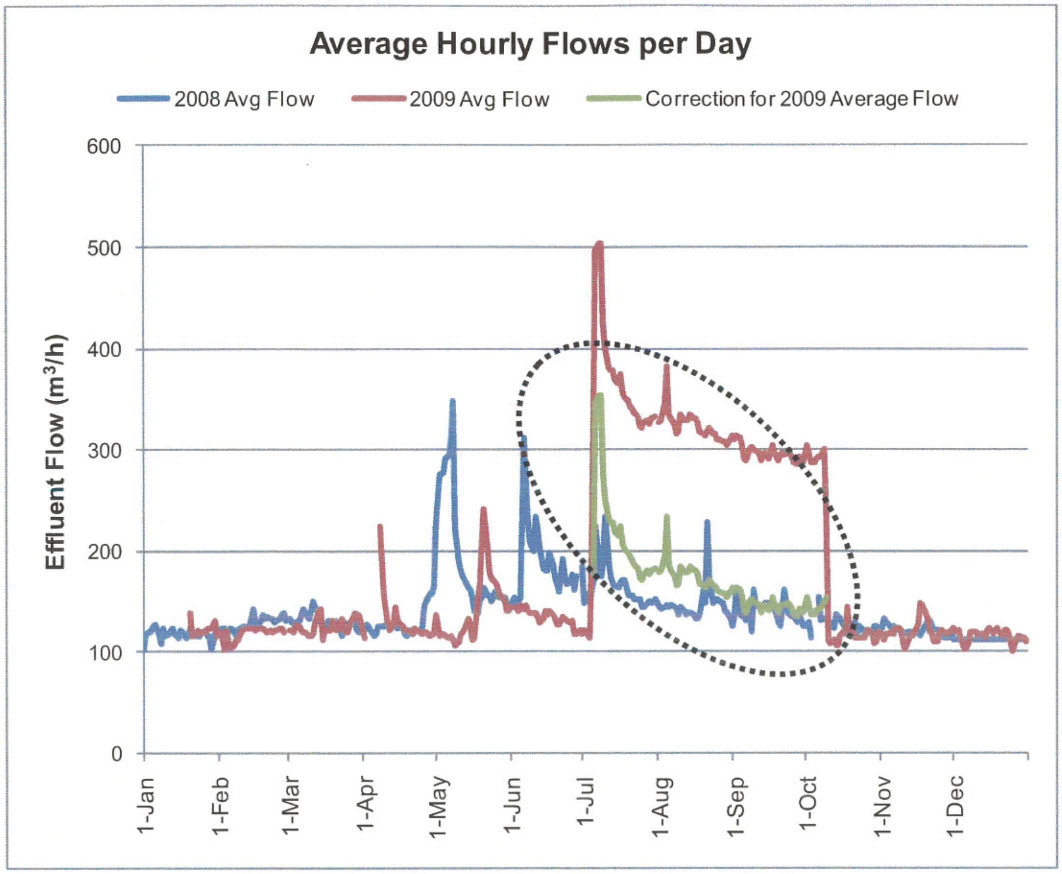


Figure 2-1. Effluent Volume Flow Reconciliation

2.1.2 Effluent Quality

Effluent samples were collected over a 12 month period in order to adequately characterize treated effluent. The structure of this sampling program was developed by following the Canada Wide Strategy (CWS) for the management of municipal wastewater effluent (MWWE) for medium sized municipal wastewater facilities.

Grab samples of final effluent were collected and submitted to ALS Laboratory Group (ALS), a Canadian Association for Laboratory Accreditation (CALA) certified lab, for analysis. At the beginning of the project, AECOM trained staff from Edson on sample collection, data recording and QA/QC procedures. Edson collected the bi-weekly samples after the initial training program. AECOM also assisted Edson with the collection of the quarterly sample set.

Treated, final effluent samples were collected and analyzed biweekly between May 28, 2009 and May 6, 2010 and once again on September 15, 2010 during the field program. Samples were analyzed bi-weekly for three parameter groups including general chemistry, nutrients and bacteria (Table 2-1). These parameter groups included variables such as Total Suspended Solids (TSS), carbonaceous Biological Oxygen Demand (cBOD), total ammonia (NH_4-N), nitrate (NO_3-N), total phosphorus (TP), total dissolved phosphorus (TDP), *E. coli* and fecal coliforms. Samples were also analyzed quarterly for a more intensive list of variables. In addition to the three parameter groups analyzed in the bi-weekly schedule, the samples collected on a quarterly basis were also analyzed for another nine parameter groups (Table 2-1). The raw lab data has been amalgamated and are provided in Appendix A Table A-1. Original lab reports are provided in Appendix D on the CD only.

Table 2-1. Parameter Groups Analyzed in Treated Effluent Samples

Bi-Weekly Parameter Groups	Quarterly Parameter Groups
General Chemistry	Total Metals
Nutrients	Organochlorine Pesticides
Bacteria	Polycyclic Aromatic Hydrocarbons (PAH)
	Volatile Organic Compounds (VOC)
	Phenolic Compounds
	Total Polychlorinated Biphenyls (PCBs)
	Surfactants
	Pathogens (*Cryptosporidium* and *Giardia*)
	Effluent toxicity (acute and chronic)

Supporting data on effluent pH, effluent temperature, ambient weather and general sampling conditions were also collected at the time of sample collection. Field data and field notes have been amalgamated and are provided in Appendix A Table A-2.

Supporting data on effluent pH, temperature and conductivity were also recorded and are provided in Appendix A Table A-2.

As part of the facility operation and the EPEA approval, TSS, cBOD and pH in both the influent and effluent, is monitored weekly. The town provided AECOM with the 2008 and 2009 data for TSS, cBOD and pH to be used as a comparison to the data collected in the detailed effluent characterization program. Final effluent data collected by the town was compared to the final effluent data collected and analyzed as per this study to understand inter-year variability in selected parameters.

2.1.3 Ammonia Calculations

Unionized ammonia (NH_3-N) is a parameter of concern but it is not measured directly in a sample. Rather un-ionized ammonia is a fraction of the total ammonia in a sample. The fraction present in a sample is a function of pH and temperature. As these variables increase, so does the fraction of unionized ammonia. Effluent pH and temperature were used to calculate the amount of unionized ammonia in the sample using the following formula:

$$\text{Unionized ammonia} = \frac{\text{Total ammonia}}{1 + (10^{pKa - pH})}$$

Where

$$pKa = 0.0901821 + 2729.92/T$$

T is temperature in K; Absolute zero = -273.15 °C

$$T\ (\text{in K}) = T\ (\text{in } ^\circ\text{C}) + 273.15$$

Un-ionized ammonia in the receiving environment can directly influence aquatic organisms. The probable concentration of un-ionized ammonia in the immediate receiving environment (i.e., mixing) zone was also calculated. This was calculated by using the total ammonia in the effluent as influenced by the pH and temperature of the receiving environment. The pH and temperature of the receiving environment was estimated from the 75th percentile of long-term data collected from the upstream monitoring station (AB07AG0045).

Concentrations of measured total ammonia in the effluent samples were also compared to a computed value of acutely toxic concentrations of total ammonia using the following formula taken from CCME (2009):

$$\text{Acutely Toxic Ammonia} = 306132466.34 \times (2.7183^{(-2.0437 \times pH)})$$

2.2 Receiving Environment - Historical Data

Data and information on the receiving environment was generated through review and analysis of existing data on water quantity and water quality of the McLeod River.

2.2.1 River Water Quantity

The Edson lagoon discharges treated effluent continuously into the McLeod River. The outfall is on the bank of the river approximately 4 km east of the lagoon. Flow in the McLeod River is monitored daily by two water survey of Canada stations: upstream of Edson above the Embarras River (07AF002) and downstream of Edson near Rosevear (07AG007) (Table 2-2). There is no permanent flow monitoring station on the McLeod River at the point of the wastewater effluent discharge. River flow rates at the point of the outfall were estimated by pro-rating river flows at the downstream station by the contributing watershed area at the lagoon outfall. Pro-rating was a simple function:

$$\text{River flow at outfall (cms)} = \frac{\text{River Flow at 07AG007 (cms)} \times \text{Watershed Area at outfall}}{\text{Watershed Area at 07AG007}}$$

Table 2-2. Flow monitoring stations and contributing watershed areas

Station Number	Station Name	Latitude	Longitude	Watershed Area km²
07AF002	McLeod River above Embarras River	53.47	-116.629	2,551.3
	McLeod River at lagoon outfall			5,477.0
07AG007	McLeod River near Rosevear	53.70	-116.162	7,143.3

Daily data from station 07AG007, 1985 to 2008, were used to calculate minimum and maximum 7 days discharge for different return periods. HEC STATS, USARMY corps of engineering software, was used for statistical analysis of this station.

2.2.2 River Water Quality

In-stream water quality samples have been collected by AENV at various stations on the McLeod River (Table 2-3). This historic data has been used in the risk assessment. Station AB07AG0045 is considered representative of conditions upstream of the Edson effluent discharge while station AB07AG0260 is considered representative of conditions downstream of the outfall. However, it is recognized that there may be other influences on water quality between the outfall and the historical upstream and downstream station. Data from these stations was collected between July 1998 and March 2006 with some parameters (e.g., conductivity and TP) measured up to 42 times. Historical data was used because it was collected over numerous years and can provide some of the expected variability. However, it was last collected in 2006 so a fall 2010 program was initiated (Section 2.3) to collect additional samples to aid in the calibration of the mixing zone model (Section 2.4).

Table 2-3. AENV Water Quality Stations on the McLeod River

Station Number	Description	Latitude	Longitude
AB07AG0045	McLeod River South of Edson	53.53	-116.48
AB07AG0260	McLeod River downstream of Rosevear Ferry-Centre	53.70	-116.16

2.3 Receiving Environment - Current Data

2.3.1 Sampling Stations

A basic field study to collect river water quality and supporting environmental data was conducted in September 2010. A preliminary analysis was done with Cormix to select appropriate locations in which to collect water quality and *in-situ* environmental data. Based on the initial analysis, it was decided to collect samples at:

- Upstream 100 m, centre – US100-02
- Effluent at the outfall – Effluent
- Downstream 100m, left bank[1] - DS100-01[2]
- Downstream 300m left bank - DS300-01
- Downstream 1000m left bank and centre - DS1000-01 and DS1000-02
- Downstream 4300m centre - DS4300-02

Samples identified as left bank were collected at least 10 m away from the bank edge except at station DS100-01 where the river dropped off severely at 4 m. The sample at this station was obtained at approximately 6 m from the bank.

Stations were labelled as detailed in Table 2-4 and Figure 1-2. Lab data is provided in Appendix A Table A-3 while field data is provided in Table A-4. Original lab reports are provided in Appendix D on the CD only. Site photographs are provided in Appendix B.

Table 2-4. River Sampling Stations Used in the September Field Program

Transect	North	West
US 100	53°35.37'	116°20.08'
Outfall	53°35.43'	116°20.10'
DS 100	53°35.51'	116°20.11'
DS300	53°35.58'	116°20.03'
DS1000	53°35.57'	116°19.45'
DS4300	53°35.66'	116°19.01'

Note: Transect coordinates taken at left bank

2.3.2 Water Quality Sample Collection

Field sampling was conducted on September 15, 2010. Water quality samples for laboratory analysis were collected by following recognized sampling protocols and appropriate measures were taken to avoid sample contamination. Nitrile gloves were worn during sample collection. Sample bottles were provided by the laboratory (rinsed in triplicate, rinse water disposed of downstream of the sampling station). In-stream samples were collected by placing the sampling bottles at least 10 cm below the water surface while standing perpendicular to the flow and facing upstream. Collection of surface film was avoided by pushing the bottle down into water quickly before allowing it to fill up. The effluent sample was collected by placing the sampling bottle in the effluent stream at the outfall pipe. When required, samples were preserved using the pre-measured preservative provided by the laboratory. All samples were stored in coolers and kept cool with ice. Chain of custodies were filled out and the samples were delivered to ALS Laboratory Group in Edmonton.

[1] *Left Bank is defined as the river bank on the left side as looking in a downstream direction*

[2] *Station 1 is identified as the station closest to the left bank on the transect upstream or downstream of the outfall; Station 2 is identified as the station closest to the middle of the river on the transect upstream or downstream of the outfall*

Samples were analyzed for:

- General chemistry (pH, conductivity, alkalinity, carbonaceous biochemical oxygen demand [cBOD], BOD, cations, anions, sulphate).
- Nutrients (total phosphorus [TP], total dissolved phosphorus [TDP], nitrite [NO2], nitrate [NO3], ammonia [NH4]).
- Surfactants.

2.3.3 Supporting Environment Parameters

In situ measurements were collected at each station for pH, conductivity (µS/cm), temperature (°C), dissolved oxygen (DO) and water velocity (km/s) using an Oakton pH Testr 2, Oakton ECTestr Low, an OxyGuard Hand Polaris and a Global Water Flow Meter, respectively. Water depth, photographs and GPS coordinates were also collected at each station.

2.4 Mixing Zone Modeling

2.4.1 Background

The near-field mixing of the Edson Wastewater (WW) Lagoon discharge with the McLeod River was hydrodynamically modeled using CORMIX GT Version 6.0. CORMIX is a software system developed by Cornell University for the analysis, prediction, and design of aqueous toxic or conventional pollutant discharges into diverse water bodies, (Doneker *et al.* 2007). CORMIX specializes in analyzing the effluent plume in the mixing zone region (i.e., the region between the lagoon outfall and the point of complete mixing of the plume in the McLeod River).

Effluents do not mix instantaneously when discharged to a receiving environment and the mixing zone is not necessarily the same for each contaminant (CCME 2009). The physical mixing zone is loosely described as the physical area downstream of a discharge point where the effluent is completely mixed laterally and vertically through the river water column. The allocated mixing zone is loosely defined as a zone smaller than the physical mixing zone where there is dilution of an effluent. Typically in-stream water quality objectives (WQO) (either site-specific or generic) must be met at the limit of the allocated mixing zone. The wastewater discharged to a receiving water body must not be acutely toxic to aquatic organisms.

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

The Edson WW Lagoon discharge to the McLeod River was modeled using CORMIX3, a subsystem which is used for positively buoyant surface (shoreline) discharges. This subsystem was chosen due to the fact that the lagoon discharges into a small channel, which then discharges into the McLeod River (Appendix B Photograph 1).

2.4.2 Model Input and Rationale

The CORMIX model was built and calibrated with the flow measurements and water quality data collected during a September 15, 2010 monitoring event at the McLeod River near the Edson WW Lagoon outfall. The model was then used to predict the mixing zone dimensions and resulting water quality in the McLeod River downstream of the Edson WW Lagoon outfall during the summer low-flow "worst-case" scenario. Finally, based on these different model scenarios for both Total Phosphorus and ammonia (calculated un-ionized ammonia) effluent discharge concentrations, as based on the receiving environment assimilation capacity, were derived.

Detailed inputs and results for the Cormix model scenarios are provided in Section 5.

2.5 Descriptive Statistics

Descriptive statistics were calculated to describe the variability of the data. SYSTAT Version 10.2 was used. Prior to any calculations, effluent and water quality data with a reported value of less than the detection limit were replaced with a real value equal to half of the analytical detection limit.

Descriptive statistics were also calculated to better understand the seasonal and yearly variability of the river. Statistics were calculated to describe average discharge per whole year (1985 to 2008) and to describe average discharge per month (combined 1985 to 2008 data).

3. Effluent Characterization

3.1 Effluent Quantity

Effluent flows were recorded in cubic meters per hour, but were converted to cubic meters per second to allow for comparison to recorded flows in the river. Mean yearly effluent flow varies little between years and only slightly between months (Table 3-1). Maximum effluent flows (up to 0.09 m^3/s) were recorded in May through July; however, the average for those months were typically 0.05 m^3/s.

Table 3-1. Descriptive Stats for Effluent Flow 2008 to 2010 (May)

	Average Flow (m^3/s) 2008	Average Flow (m^3/s) 2009	Average Flow (m^3/s) 2010 (to April)
N of Samples	362	339	120
Minimum	0.028	0.022	0.03
Median	0.036	0.035	0.033
Mean	0.039	0.039	0.034
95th Percentile	0.057	0.056	0.038
Maximum	0.096	0.098	0.046
Std. Error	0.001	0.001	0

Note: Effluent flow is daily but occasionally the flow meter was malfunctioning so daily recorded flows were not always available

From the above table it is obvious that data was not recorded every day of the year. For 2008, there were 35 days of missing data. Data was missing for all of December however, for the annual report submitted to AENV, an average daily discharge (2,687.9 m^3) was reported. This estimated average daily discharge value for the month of December was determined from an alternate flow logger which was read every week. Based on the alternate logger, an estimate of daily discharge in December was calculated and reported. By using this total daily value, an estimate was calculated for the average daily discharge in cubic meters per hour (112 m^3/h) and cubic meters per second (0.031 m^3/s). The other four days of missing data were left as blanks and not estimated because they were not estimated in the annual wastewater report to AENV.

For 2009, there were 26 days of missing data. Data was missing from January 1 to 19, April 2 to 7 and July 31. The 2009 annual wastewater report was not available at this time so no assumptions were made to fill in the data for these dates. Instead they were left as blanks in the analyses.

For 2010, data from January to April were used. There were no missing data.

3.2 Effluent Quality

3.2.1 Seasonality and Descriptive Statistics

Samples were collected on a regular schedule from May 2009 to May 2010. On each sampling day indicated, one sample set was collected for the various parameter groups identified in Table 3-2.

Table 3-2. Summary of Samples Collected for the Effluent Characterization Program

Date Sampled	Season	General Chemistry	Nutrients	Bacteria	Metals, Pesticides, Surfactants	PAH, VOC, PCB	Phenols	*Crypto* and *Giardia*	Toxicity	QA/QC (blank or replicate)
28-May-09		yes	yes	yes						yes
11-Jun-09		yes	yes	yes						yes
25-Jun-09		yes	yes	yes	yes	yes	yes	yes	yes	yes
09-Jul-09		yes	yes	yes						
23-Jul-09		yes	yes	yes						
06-Aug-09	Summer	yes	yes	yes						
20-Aug-09		yes	yes	yes						
03-Sep-09		yes	yes	yes	yes	yes		yes	yes	yes
18-Sep-09		yes	yes	yes						
01-Oct-09		yes	yes	yes						
15-Oct-09		yes	yes	yes						
29-Oct-09		yes	yes	yes						
12-Nov-09		yes	yes	yes						
26-Nov-09		yes	yes	yes						
08-Dec-09		yes	yes	yes	yes	yes	yes	yes	yes	yes
22-Dec-09		yes	yes	yes						
06-Jan-10	Winter	yes	yes	yes						
21-Jan-10		yes	yes	yes						
04-Feb-10		yes	yes	yes						
18-Feb-10		yes	yes	yes						
04-Mar-10		yes	yes	yes						
18-Mar-10		yes	yes	yes						
30-Mar-10		yes	yes	yes	yes		yes	yes	yes	yes
22-Apr-10	Summer	yes	yes	yes						
06-May-10		yes	yes	yes						

Effluent quality data, bi-weekly and quarterly variables, were reviewed and descriptive statistics were calculated as a means to describe the quality of effluent discharged from Edson into the McLeod River. Descriptive stats for the variables analyzed on a bi-weekly basis, using all of the data, are provided in Table 3-3. Most of the variables have a non-skewed or normal distribution. Parameters that have a significantly, positively skewed distribution include TSS, carbonate, sulfate, un-ionized ammonia, nitrate, nitrite, chemical oxygen demand, *E.coli*, fecal coliforms and total cyanide. The distribution for total dissolved phosphorus was negative skewed. For the other variables, the distribution of values around the mean was normal.

The concentration of nitrogen fractions (ammonia, nitrate, and nitrite) in wastewater is altered by microbial action. Microbes are more active in warm water than in cool water. The microbial action also influences the conversion of ammonia to nitrate and nitrite and ultimately denitrification. Based on review of the effluent temperature data it was determined to define summer as the period when effluent temperature was 10°C or greater (mid-April to early October) and winter as the period when effluent temperature was less than 10°C (mid-October to early April). Descriptive statistics for the bi-weekly analyzed effluent quality parameters are provided for the entire data set (Table 3-3), but also for the summer period (Table 3-4) and the winter period (Table 3-5). These seasons are also identified on the various figures presented in Section 3.2.

Table 3-3. Descriptive Statistics for Bi-weekly Analyzed Effluent Quality Variables in Final Treated Effluent (All Samples)

All Samples	Units	DL	No. Samples	Min	Median	Mean	SE	90th Percentile	95th Percentile	Max	Guideline for Protection of Aquatic Life[a]
FIELD VALUES											
pH			25	7.67	8.08	8.11	0.09	8.71	9.225	9.3	6.5-9
Temperature	°C		25	0.3	5	9.26	1.62	20.40	21.45	23.7	
GENERAL CHEMISTRY											
Alkalinity (as $CaCO_3$)	mg/L	5	25	479	561	573.4	14.6	669.0	676	676	
Bicarbonate (HCO_3)	mg/L	5	25	484	662	682.2	21.4	816.0	824.3	825	
Ca-Dissolved	mg/L	0.5	25	25.4	40.4	41.44	2.42	57.20	60.08	61.5	
Carbonate (CO_3)	mg/L	5	25	<5	2.5	9.94	3.58	34.60	55.1	77	
Chloride (Cl)	mg/L	0.5	25	76.1	88.2	89.93	2.14	108.00	109.75	112	600[b]
Conductivity (EC)	µS/cm	0.2	25	1220	1330	1390.8	31.77	1630.00	1650	1650	
Fluoride (F)	mg/L	0.05	24	0.717	1	1.025	0.039	1.31	1.326	1.34	
Hardness (as $CaCO_3$)	mg/L	-	25	91.6	144	148.2	8.2	201.0	208.8	220	
Mg-Dissolved	mg/L	0.1	25	6.17	10.4	10.84	0.54	14.40	14.98	16.1	
pH	pH	0.1	24	7.9	8.27	8.27	0.054	8.62	8.85	9	6.5-9
K-Dissolved	mg/L	0.5	25	9.71	11.8	12.32	0.33	14.70	15.05	16.1	
Na-Dissolved	mg/L	1	25	158	224	226.1	7.4	276.0	278.8	284	
Sulfate (SO_4)	mg/L	0.5	25	28.1	35.2	36.70	2.87	37.60	54.35	104	50-100[b]
TDS (Calculated)	mg/L	-	25	656	739	766.8	15.3	866.0	879.5	911	
TSS	mg/L	3	25	<3	7	12.4	2.387	35.00	38.5	40	
NUTRIENTS											
TN	mg/L	-	25	8.53	26.77	25.72	2.08	38.25	41.15	42.95	
TKN	mg/L	0.2	25	7.85	26.3	24.69	2.24	38.20	41.1	42.9	
NH_4	mg/L	0.05	25	5.67	20.3	21.02	2.09	34.60	34.88	35.4	
NH_3 (Calculated)[d]	mg/L	-	25	0.11	0.23	0.90	0.35	2.35	6.22	6.99	0.019
NH_3 (Calculated)[e]	mg/L	-	25	0.20	0.53	0.56	0.04	0.80	1.05	1.16	0.019
$NO_3 + NO_2$	mg/L	0.071	24	<0.071	0.53	1.06	0.29	3.32	4.09	5.15	
NO_3	mg/L	0.05	24	<0.05	0.43	0.93	0.26	3.08	3.74	4.86	13
NO_2	mg/L	0.05	24	<0.05	0.025	0.15	0.04	0.38	0.52	0.63	0.06
TP	mg/L	0.02	25	3.52	4.57	4.47	0.10	5.03	5.22	5.41	0.05[c]
TDP	mg/L	0.02	25	1.47	4.38	4.03	0.14	4.58	4.69	4.84	
OXYGEN DEMAND											
cBOD	mg/L	2	22	<2	8.85	8.41	1.12	15.38	16.2	16.8	
COD	mg/L	5	22	44.6	73	74.14	5.67	104.54	136.2	144	
BACTERIA											
E. Coli	CFU/100mL	1	22	<1	32.5	175.4	100.5	444.0	1180	2200	
Fecal Coliforms	CFU/100mL	1	23	<1	50	203.0	100.0	548.0	1355	2200	200
TOTAL CYANIDE											
Cyanide	mg/L	0.002	20	<0.002	0.001	0.002	0	0.004	0.004	0.004	

Note: A – Comparison of effluent to in-stream Guidelines for Protection of Aquatic Life (CCME 2007); B – Water Quality Guidelines for British Columbia (BC MOE 2006); C – Alberta Surface Water Quality Guidelines (AENV 1999); D- un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection; E – un-ionized ammonia calculated based on temperature and pH (75th Percentile) of river as per the summer or winter season

Table 3-4. Descriptive Statistics for Bi-Weekly Analyzed Effluent Quality Variables (Summer Period) (April to early October)

Summer	Units	DL	No. Samples	Min	Median	Mean	SE	90th Percentile	95th Percentile	Max	Guideline for Protection of Aquatic Life[a]
FIELD VALUES											
pH			12	7.72	8.12	8.303	0.152	9.23	9.29	9.3	6.5-9
Temperature	°C		12	9.4	16.75	16.97	1.17	21.6	23.4	23.7	
GENERAL CHEMISTRY											
Alkalinity (as $CaCO_3$)	mg/L	5	12	479	501.5	507	7.2	537.9	557.7	561	
Bicarbonate (HCO_3)	mg/L	5	12	484	597	582.7	11.3	617	623	624	
Ca-Dissolved	mg/L	0.5	12	26.5	48.7	46.3	3.7	60.2	61.3	61.5	
Carbonate (CO_3)	mg/L	5	12	<5	6.7	18.0	6.8	56.6	74.1	77	
Chloride (Cl)	mg/L	0.5	12	80.8	87.2	87.6	1.8	95.9	102.0	103	600[b]
Conductivity (EC)	µS/cm	0.2	12	1220	1245	1258.3	11.5	1330	1330	1330	
Fluoride (F)	mg/L	0.05	12	0.72	0.85	0.88	0.03	1.02	1.05	1.05	
Hardness (as $CaCO_3$)	mg/L	-	12	91.6	173.5	163.4	12.5	209.5	218.5	220	
Mg-Dissolved	mg/L	0.1	12	6.17	12.5	11.6	0.9	14.9	15.9	16.1	
pH	pH	0.1	12	8.22	8.36	8.45	0.07	8.85	8.98	9	6.5-9
K-Dissolved	mg/L	0.5	12	9.71	11.25	11.24	0.22	12.1	12.6	12.7	
Na-Dissolved	mg/L	1	12	158	198	198.8	7.0	230	230	230	
Sulfate (SO_4)	mg/L	0.5	12	28.1	31.4	32.5	1.0	37.5	37.8	37.8	50-100[b]
TDS (Calculated)	mg/L	-	12	656	701	701.3	7.8	741.7	747.1	748	
TSS	mg/L	3	12	<3	13.3	17.7	4.5	38.6	39.8	40	
NUTRIENTS											
TN	mg/L		12	8.53	18.22	20.20	2.64	34.00	35.65	35.93	
TKN	mg/L	0.2	12	7.85	14	18.33	2.84	33.72	35.16	35.4	
NH_4	mg/L	0.05	12	5.67	10.85	13.62	2.25	27.38	28.34	28.5	
NH_3 (Calculated)[d]	mg/L	-	12	0.11	0.54	1.62	0.68	6.27	6.89	6.99	0.019
NH_3 (Calculated)[e]	mg/L	-	12	0.34	0.57	0.64	0.07	1.05	1.15	1.16	0.019
$NO_3 + NO_2$	mg/L	0.071	12	<0.071	1.60	1.86	0.48	4.09	5.00	5.15	
NO_3	mg/L	0.05	12	<0.05	1.25	1.602	0.45	3.74	4.7	4.86	13
NO_2	mg/L	0.05	12	<0.05	0.25	0.26	0.05	0.52	0.62	0.63	0.06
TP	mg/L	0.02	12	3.52	4.49	4.42	0.18	5.23	5.38	5.41	0.05[c]
TDP	mg/L	0.02	12	3.49	3.89	3.97	0.12	4.50	4.53	4.54	
OXYGEN DEMAND											
cBOD	mg/L	2	11	<2	2.8	5.9	1.5	13.2	15.0	15.1	
COD	mg/L	5	11	46.4	61.8	75.0	8.8	113.5	141.5	144	
BACTERIA											
E. Coli	CFU/100mL	1	12	<1	6	197.1	182.2	705.5	1986.5	2200	
Fecal Coliforms	CFU/100mL	1	12	<1	8.5	199.3	182.0	709	1987	2200	200
TOTAL CYANIDE											
Cyanide	mg/L	0.002	10	<0.002	0.002	0.002	0	0.004	0.004	0.004	

Note: A – Comparison of effluent to in-stream Guidelines for Protection of Aquatic Life (CCME 2007); B – Water Quality Guidelines for British Columbia (BC MOE 2006); C – Alberta Surface Water Quality Guidelines (AENV 1999); D- un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection; E – un-ionized ammonia calculated based on temperature and pH (75th Percentile) of river in summer period

Table 3-5. Descriptive Statistics for Bi-Weekly Analyzed Effluent Quality Variables (Winter Period) (mid-October to Early April)

Winter	Units	DL	No. Samples	Min	Median	Mean	SE	90th Percentile	95th Percentile	Max	Guideline for Protection of Aquatic Life[a]
FIELD VALUES											
pH			13	7.67	7.85	7.933	0.07	8.28	8.33	8.34	6.5-9
Temperature	°C		13	0.3	1.8	2.15	0.40	4.52	4.91	5	
GENERAL CHEMISTRY											
Alkalinity (as $CaCO_3$)	mg/L	5	13	547	650	634.8	11.3	676	676	676	
Bicarbonate (HCO_3)	mg/L	5	13	662	793	774	14	824.2	824.9	825	
Ca-Dissolved	mg/L	0.5	13	25.4	35.2	37.0	2.8	50.3	54.0	54.8	
Carbonate (CO_3)	mg/L	5	13	<5	2.5	2.5	0	2.5	2.5	2.5	
Chloride (Cl)	mg/L	0.5	13	76.1	89.1	92.1	3.8	109.6	111.6	112	600[b]
Conductivity (EC)	µS/cm	0.2	13	1270	1540	1513.1	34.3	1650	1650	1650	
Fluoride (F)	mg/L	0.05	12	0.956	1.18	1.17	0.04	1.326	1.338	1.34	
Hardness (as $CaCO_3$)	mg/L	-	13	95.9	127	134.1	9.3	181.8	194.25	197	
Mg-Dissolved	mg/L	0.1	13	7.61	9.37	10.16	0.60	13.64	14.42	14.6	
pH	pH	0.1	12	7.9	8.07	8.09	0.04	8.29	8.32	8.32	6.5-9
K-Dissolved	mg/L	0.5	13	10.5	13.5	13.3	0.4	15.0	15.9	16.1	
Na-Dissolved	mg/L	1	13	201	263	251.4	7.6	278.4	283.0	284	
Sulfate (SO_4)	mg/L	0.5	13	32.5	35.3	40.6	5.3	50.9	94.0	104	50-100[b]
TDS (Calculated)	mg/L	-	13	732	832	827.4	14.7	877.4	904.7	911	
TSS	mg/L	3	13	5	7	7.6	0.7	10	13.3	14	
NUTRIENTS											
TN	mg/L		13	14.24	32.23	30.82	2.48	41.03	42.59	42.95	
TKN	mg/L	0.2	13	13.5	32	30.56	2.55	40.98	42.54	42.9	
NH_4	mg/L	0.05	13	11.8	30.1	27.85	2.10	34.84	35.30	35.40	
NH_3 (Calculated)[d]	mg/L	-	13	0.15	0.19	0.24	0.03	0.42	0.49	0.51	0.019
NH_3 (Calculated)[e]	mg/L	-	13	0.20	0.52	0.48	0.04	0.60	0.61	0.61	0.019
NO_3 + NO_2	mg/L	0.071	12	<0.071	0.121	0.264	0.08	0.673	0.734	0.744	
NO_3	mg/L	0.05	12	<0.05	0.12	0.25	0.08	0.65	0.66	0.66	13
NO_2	mg/L	0.05	12	<0.05	0.025	0.03	0.005	0.044	0.08	0.09	0.06
TP	mg/L	0.02	13	3.75	4.65	4.52	0.12	4.92	5.01	5.03	0.05[c]
TDP	mg/L	0.02	13	1.47	4.42	4.09	0.25	4.68	4.81	4.84	
OXYGEN DEMAND											
cBOD	mg/L	2	11	2.7	11	10.9	1.3	16.2	16.8	16.8	
COD	mg/L	5	11	44.6	76.7	73.3	7.6	106.2	128.9	131	
BACTERIA											
E. Coli	CFU/100mL	1	10	7	69	149.4	55.2	460	500	500	
Fecal Coliforms	CFU/100mL	1	11	7	130	207.1	79.0	636	878	900	200
TOTAL CYANIDE											
Cyanide	mg/L	0.002	10	<0.002	0.001	0.001	0	0.002	0.002	0.002	

Note: A – Comparison of effluent to in-stream Guidelines for Protection of Aquatic Life (CCME 2007); B – Water Quality Guidelines for British Columbia (BC MOE 2006); C – Alberta Surface Water Quality Guidelines (AENV 1999); D- un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection; E – un-ionized ammonia calculated based on temperature and pH (75th Percentile) of river in winter period

3.2.2 General Chemistry

TSS was fairly consistent throughout the characterization program and was usually less than 10 mg/L except from late March through early July when it was generally greater than 15 mg/L (Figure 3-1a). Sometimes the higher TSS values are related to algal blooms in the final lagoons but algal blooms would be expected in summer period (July through August) and not necessarily in May. Photos were taken on the first sampling event, and it was observed that the effluent ponds were very green and thus the peak in TSS on the first trip could be attributed to algal blooms. TSS concentrations in samples collected on the same dates as toxicity samples are indicated with an orange box around the value. In the CCME strategy document (CCME 2009) and the draft wastewater regulations (Canada Gazette 2010), a National Performance Standard (NPS) for TSS has been set at 25 mg/L. The CCME document states the criteria as an average concentration of 25 mg/L or less. On average (whole year or by season, Tables 3-3, 3-4 and 3-5) the treated effluent meets this limit, but individual values for 5 of the 25 samples did not meet this limit (Figure 3-1a and Table 3-3).

Conductivity was even more consistent throughout the characterization program ranging between 1,200 and 1,650 µS/cm with higher values in January through March (Figure 3-1b). Conductivity in samples collected on the same dates as toxicity samples are indicated with a blue box around the value. Conductivity, but not TSS was recorded in the September 2010 sample and is included in Figure 3-1b.

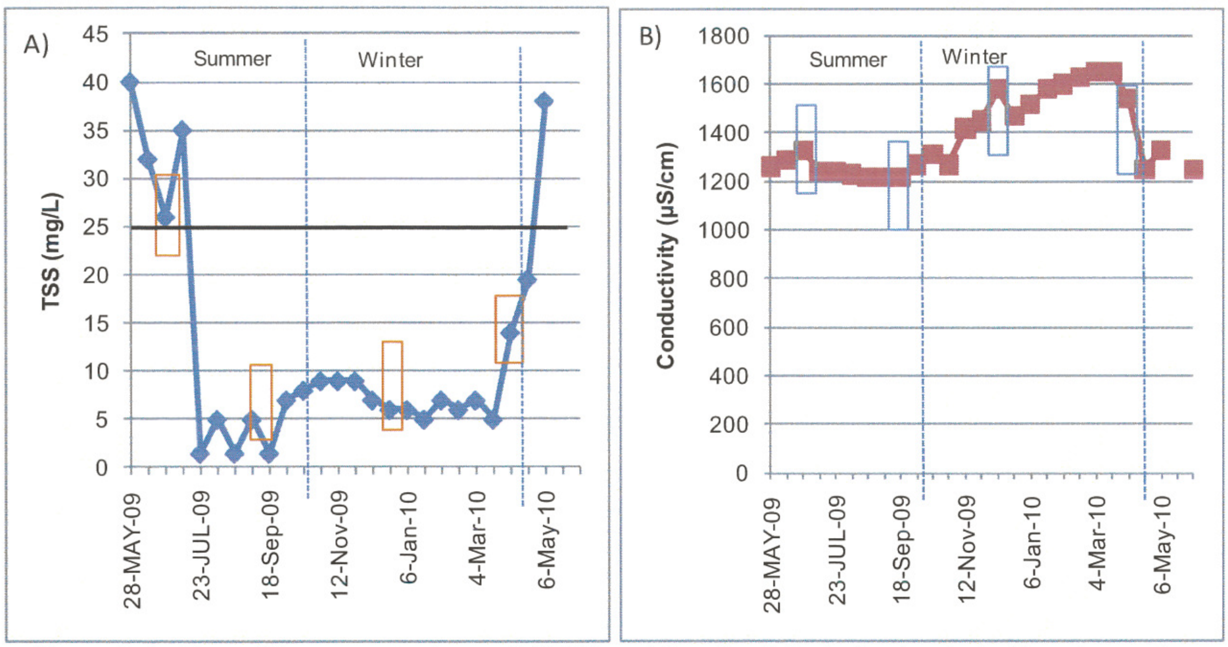


Figure 3-1. Bi-weekly concentrations of a) TSS and Conductivity in the treated effluent samples

Concentration of sulphate was fairly stable over the year except for one spike in December (Figure 3-2 a). Sulphate concentrations in samples collected on the same dates as toxicity samples are indicated with an orange box around the value. One of the toxicity samples was collected on the same date as the spike in sulphate. Elevated sulphate in the effluent could be a parameter that added to the stress of the organisms and thus results of the toxicity tests.

Average cBOD was approximately 8.4 mg/L, but varied between low values of less than the detection limit in July, less than 6 between July and November, generally higher than 12 mg/L from December through approximately March and between 6 and 12 in the other months (Figure 3-2b). The highest recorded value of cBOD was 16.8 mg/L and thus the effluent meets the NPS set out in the CCME strategy document (CCME 2009). This is also the only effluent quality parameter set out in the EPEA approval with a monthly average concentration of 25 mg/L or less. Thus the treated effluent meets the requirements in the EPEA approval and also meets the NPS for cBOD. Concentrations of cBOD in samples collected on the same dates as toxicity samples are indicated with a blue box around the value.

Sulphate and cBOD were analyzed in the September 2010 sample and are included in Figure 3-2a and b.

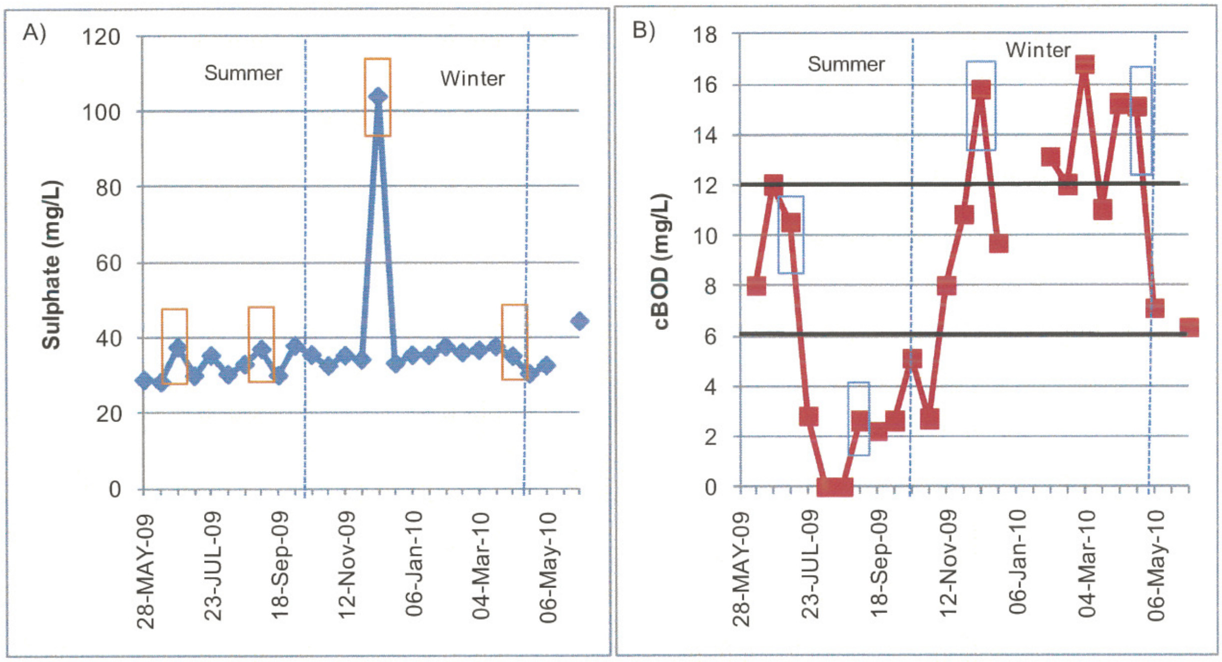


Figure 3-2. Bi-weekly concentrations of a) Sulphate and b) cBOD in the treated effluent samples

A requirement of EPEA approval 640-02-00 is to measure weekly concentrations of TSS, cBOD and pH in the final effluent. Data from the town (2008 and 2009) for these three parameters were compared against data collected as part of this effluent characterization study (Figure 3-3a, b, and c). This was done to understand inter-annual variability in some effluent parameters. These figures illustrate that data collected as part of the effluent characterization study were within the range of expected data.

TSS typically increases from January through July, with highest values in June through July. By August concentrations decrease and then typically remain typically low through to December. There were higher maxima data of TSS in 2008 and 2009 than were captured during sampling for this study. Concentrations of cBOD showed similar trends between the different data sets. Most of the recorded values of cBOD in all datasets were less than 25 mg/L (new CCME limit) with only 2 measured values more than 25 mg/L. The trend in pH values was also similar between datasets, but typically the values recorded as part of the effluent characterization study were higher than what was recorded in 2008 and 2009 by the town. The trend in pH is for lower values in the winter to early spring period and higher values in the summer.

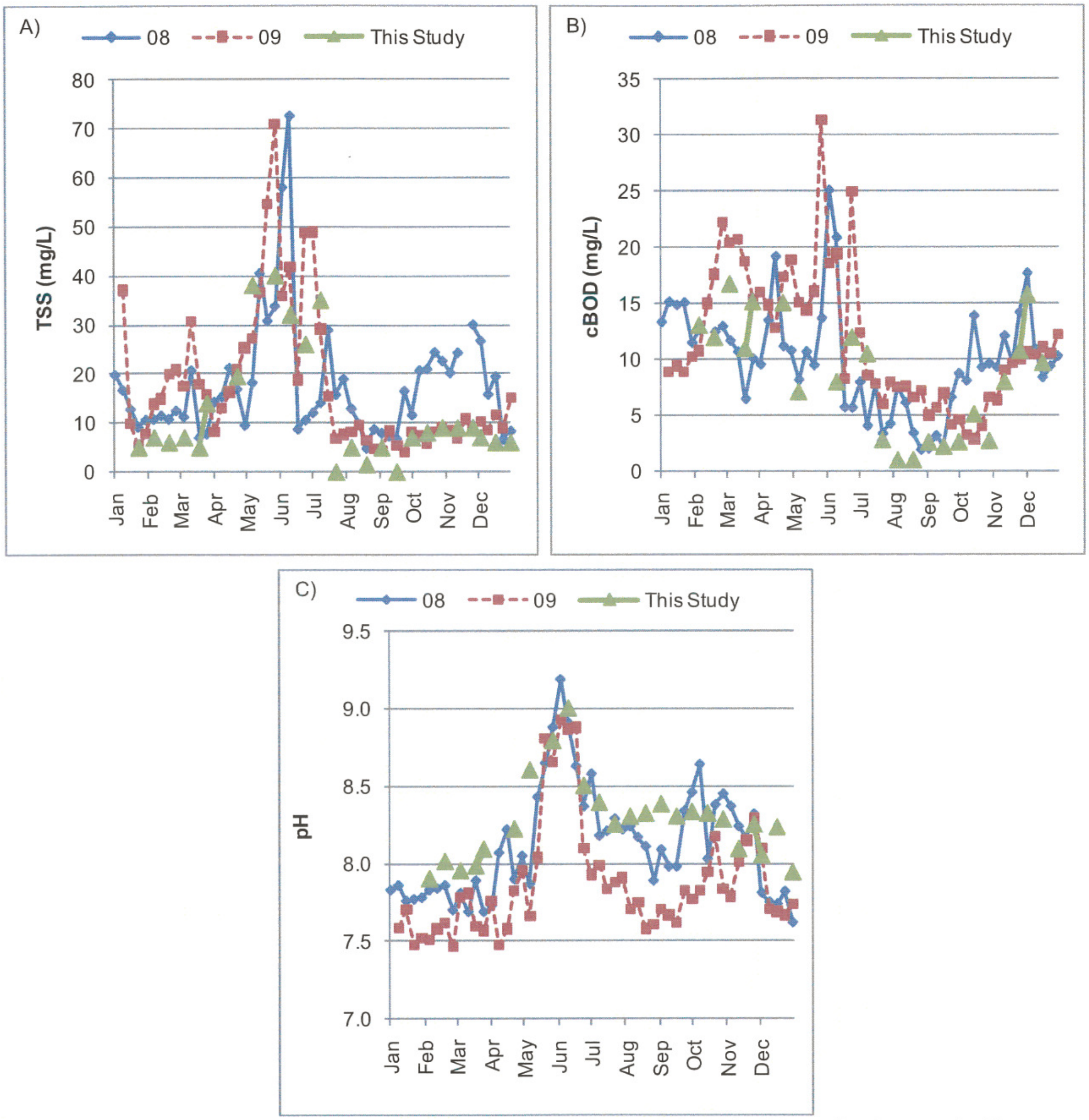


Figure 3-3. Inter-annual variability in a) TSS, b) cBOD and c) pH in Edson final treated effluent

3.2.3 Nitrogen

Concentrations of nitrogen varied widely throughout the 12-month characterization program. TKN, a measure of organic nitrogen and ammonia (total and un-ionized), ranged from 7.9 to 41.1 mg/L and was nearly 100% ammonia-nitrogen (Figure 3-4a). There was a seasonal pattern of ammonia concentrations: < 10 mg/L (summer), > 20 mg/L (winter) and 10 - 20 mg/L (spring and fall). These zones of total ammonia concentrations are indicated with solid black lines. Concentration of total ammonia decreased from late may through mid-September. Total ammonia was less than 10 mg/L in all samples (except 2) from July to early October and then increased in every sample after October through to the end of March. Ammonia and TKN concentrations in samples collected on the same dates as toxicity samples are indicated with an orange box around the values.

Concentrations of nitrate and nitrite, in comparison to ammonia, were very low for most of the year (Figure 3-4a and b). It was only during a very short period from early July to early September when nitrate was at or more than 2 mg/L. Nitrate was less than the detection limit in samples collected from January to April 2010. Nitrite was only at detectable concentrations from late May to mid-October 2009. In all other samples, nitrite was less than the detection limit. Nitrate and Nitrite concentrations in samples collected on the same dates as toxicity samples are indicated with a blue box around the values.

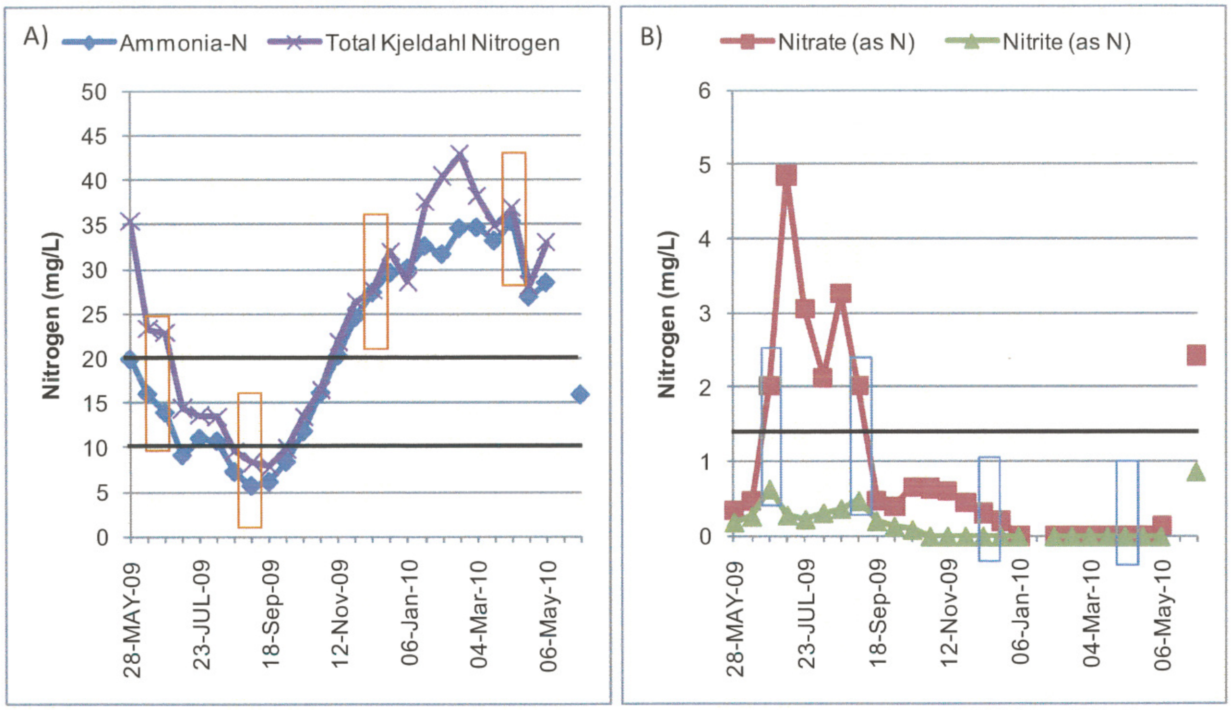
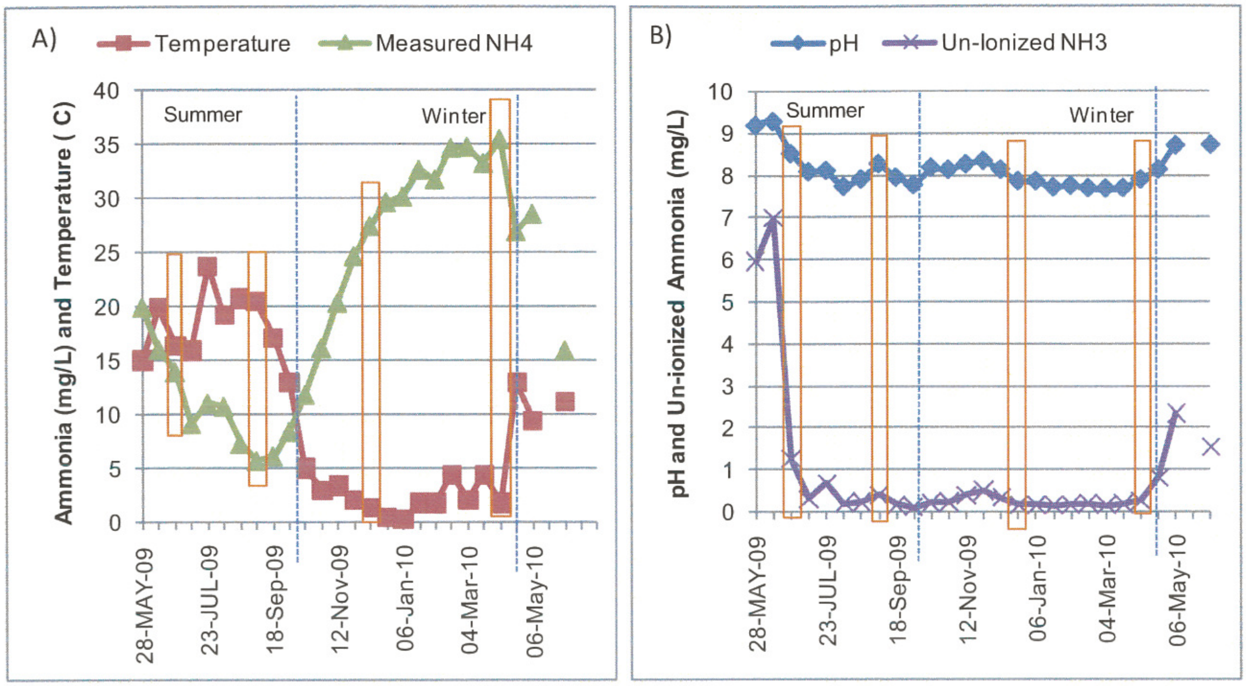


Figure 3-4. Bi-weekly concentrations of nitrogen variables a) total ammonia and TKN and b) nitrate and nitrite in the treated effluent samples

Un-ionized ammonia is a proportion of the total ammonia in a sample. The proportion of total ammonia that is present as un-ionized ammonia is a function of temperature and pH. As these increase, the proportion of un-ionized ammonia in the sample also increases. The expected fraction of un-ionized ammonia in each sample was calculated (by using pH and temperature of effluent at the time of collection) and is illustrated in comparison to total ammonia, temperature and pH (Figure 3-5 a and b). Concentrations of these parameters in samples collected on the same dates as toxicity samples are indicated with an orange box.



Note: un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection

Figure 3-5. Bi-weekly values of a) effluent temperature and total ammonia and b) pH and un-ionized ammonia in the final effluent samples

The draft Federal regulations have identified that effluent can have a maximum concentration of un-ionized ammonia of 1.25 mg/L at a temperature of 15°C. At a pH of 7.5, effluent can have at most 147 mg/L total ammonia and still be in compliance with the regulations. However effluent discharges with those elevated ammonia concentrations would overload most receiving waters. Calculations were made to determine the maximum concentration of total ammonia, at various temperature and pH, which would have no more than 1.25 mg/L of un-ionized ammonia. These calculations were made by using the formula from Section 2.1.3. These results are summarized in Table 3-6.

Table 3-6. Concentrations of total ammonia (with 1.25 mg/L of un-ionized ammonia) as a function of pH and temperature

	Allowable NH_4 by Temperature (for equivalent NH_3 of 1.25 mg/L)						
pH	0°C	5°C	10°C	15°C	20°C	25°C	30°C
6.0	15,375.61	10,162.48	6,816.01	4,635.49	3,194.43	2,229.15	1,574.24
6.5	4,863.05	3,214.51	2,156.27	1,466.73	1,011.02	705.77	498.67
7.0	1,538.69	1,017.37	682.73	464.67	320.57	224.04	158.55
7.5	487.43	322.58	216.75	147.80	102.23	71.70	50.99
8.0	154.99	102.86	69.40	47.59	33.18	23.53	16.98
8.5	49.87	33.38	22.80	15.90	11.35	8.30	6.22
9.0	16.62	11.41	8.06	5.88	4.44	3.48	2.82
10.0	2.79	2.27	1.93	1.71	1.57	1.47	1.41

Note: Total ammonia was back calculated using the formula in Section 2.1.3 and assuming un-ionized ammonia concentration of 1.25 mg/L

The CCME strategy document (CCME 2009) recommends considering ammonia in the effluent as a potential toxicant since it is commonly associated with acute toxicity in municipal wastewater effluent. The concentration of acutely toxic ammonia, as dependent upon pH of the solution, was calculated (equation given in Section 2.1.3) and compared to the measured total ammonia in the effluent samples (Figure 3-6). There were ten effluent samples with total ammonia concentrations greater than the total ammonia value that is considered acutely toxic at the particular pH. There were also another five effluent samples with total ammonia concentrations that were very close to the acutely toxic threshold (Figure 3-7) which is discussed below.

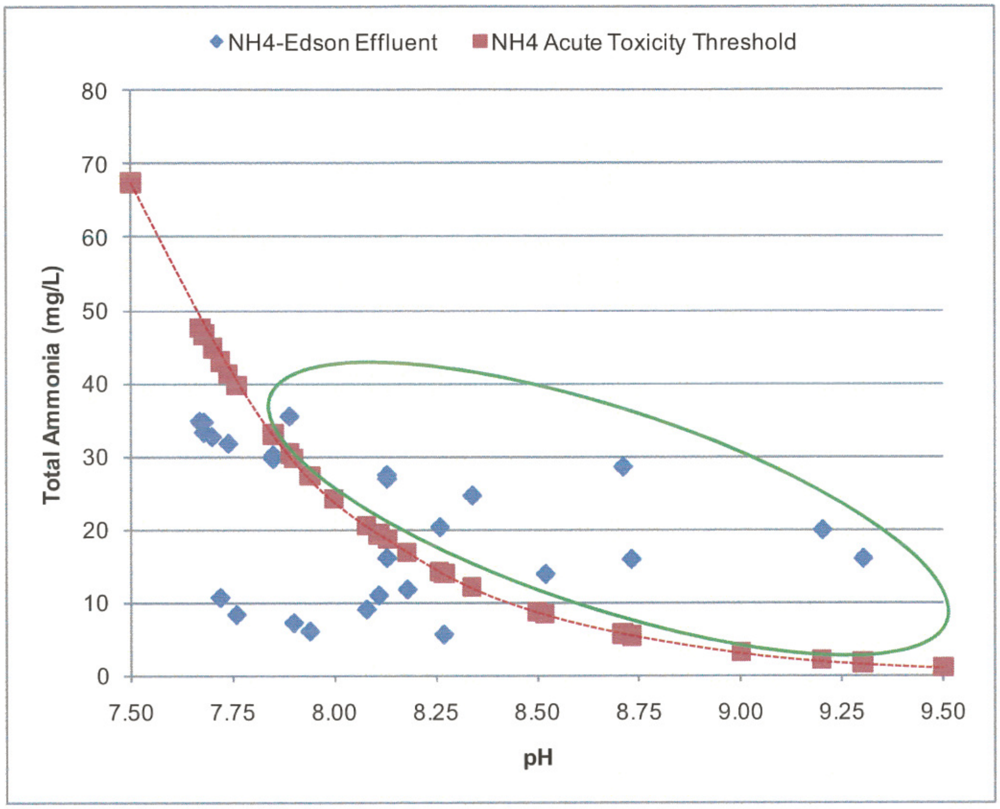
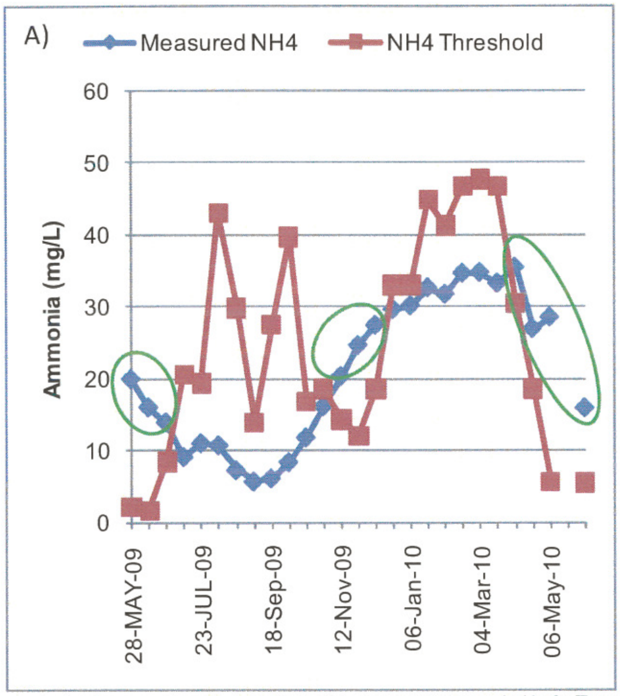


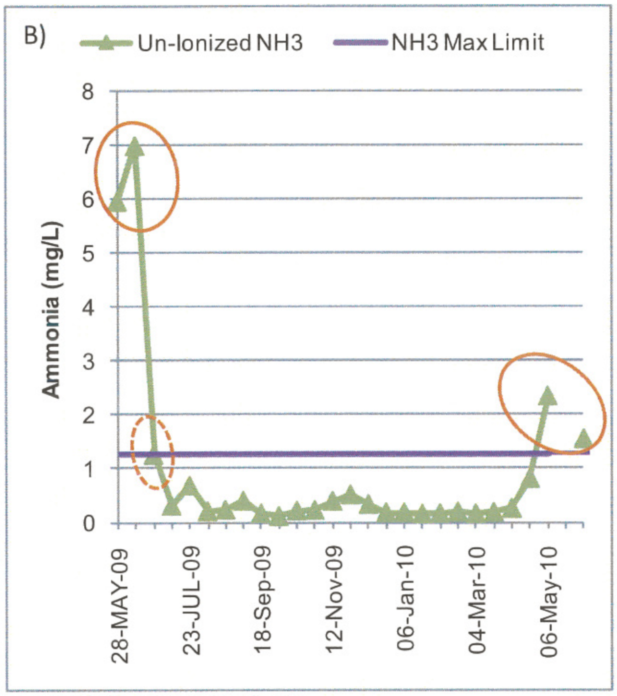
Figure 3-6. Measured Total Ammonia in Edson Effluent and Acutely Toxic Ammonia Versus pH.

Total ammonia averaged 21 mg/L across the 12 month characterization program while un-ionized ammonia averaged 0.9 mg/L (13.6 mg/L and 1.62 mg/L in summer period, respectively; 27.9 mg/L and 0.2 mg/L in winter period, respectively) (Tables 3-3, 3-4 and 3-5). Even though total ammonia in some samples was more than 20, the proportion that was un-ionized ammonia was usually less than 0.3 mg/L (Figure 3-5a and b). The concentration of un-ionized ammonia was very high in samples from late May to early June 2009 and again in early May 2010.

Un-ionized ammonia was less than 1.25 mg/L in all samples except for three samples in 2009 (May 28, June 11 and 25) and two samples in 2010 (May 6 and September 15). Concentrations of un-ionized ammonia presented in Figures 3-6 and 3-7 were calculated using the formula in Section 2.1.3 and pH and temperature of effluent at the time of sample collection. Un-ionized ammonia in the sample from June 25 was 1.26 mg/L. Effluent quality in May, June and September was at its poorest for concentration of un-ionized ammonia. During the other months, effluent quality, based on un-ionized ammonia, was of better quality.

Acutely toxic total ammonia concentrations at the measured pH in a sample were calculated and those samples with measured concentrations greater than the total ammonia toxic threshold are circled (Figure 3-7a). Likewise the concentration of un-ionized ammonia in a sample, based on the pH and temperature of the sample, were calculated and those samples with more than 1.25 mg/L un-ionized ammonia (the limit set in the draft wastewater regulations) are also circled (Figure 3-7b). Between the two calculations, there is agreement that samples collected in May to June 2009 and May and September 2010 contain toxic levels of total or un-ionized ammonia. For the other samples identified in November to early December, the pH levels were higher and thus the ammonia threshold was decreased. For samples in January through April, the pH in the effluent samples was less than 8 so the total ammonia threshold was higher and was above the measured ammonia in the samples.





Note: un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection

Figure 3-7. Bi-weekly concentrations of a) measured total ammonia with acute total ammonia toxicity and b) un-ionized ammonia and proposed wastewater maximum concentration of un-ionized ammonia

3.2.4 Phosphorus

Total Phosphorus (TP) and Total Dissolved Phosphorus (TDP) concentrations were fairly consistent throughout the sampling program. Most of the phosphorus in the effluent is dissolved as opposed to particulate phosphorus (Figure 3-8). The cause for the dip in TDP on November 26 is unknown. Recorded values of phosphorus in samples collected on the same dates as toxicity samples are indicated with an orange box. Concentrations of phosphorus in the sample collected in September 2010 were very low in comparison to those collected earlier in the study. There is also no obvious seasonal trend in the phosphorus parameters.

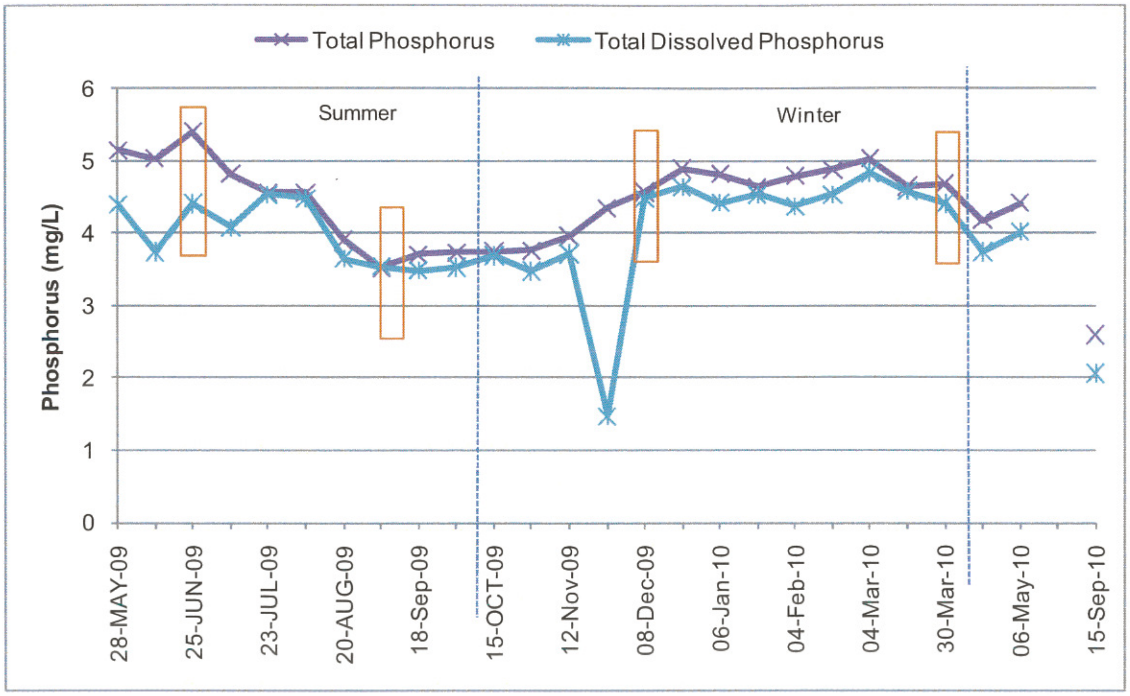


Figure 3-8. Bi-weekly concentrations of total and dissolved phosphorus in the final effluent samples

3.2.5 Metals

Total metals were analyzed in the samples once every quarter. Most metal variables were detectable in at least one sample. The results of the minimum, mean and maximum concentration are summarized in Table 3-7. Beryllium, Cadmium, Chromium, Mercury, Silver and Thallium were not detected in any sample. Antimony, Cobalt, Molybdenum, Selenium and Tin were not detectable in at least one sample. All other metal variables were detectable in all samples.

Table 3-7. Summary of Metal Concentrations in Final Treated Effluent

Total Metals[a]	DL	Min	Mean	Max	Guideline for Protection of Aquatic Life[b]
Aluminum (Al)	0.01	0.05	0.14	0.24	0.1
Antimony (Sb)	0.0004	<DL	0.0005	0.0005	
Arsenic (As)	0.0004	0.0013	0.0017	0.0020	0.005
Barium (Ba)	0.005	0.042	0.061	0.087	
Beryllium (Be)-Total	0.002		<DL		
Boron (B)	0.05	0.27	0.32	0.35	
Cadmium (Cd)	0.0002		<DL		0.000017
Chromium (Cr)	0.005		<DL		0.001
Cobalt (Co)-Total	0.002	<DL	0.001	0.001	
Copper (Cu)	0.001	0.005	0.010	0.020	0.004
Iron (Fe)	0.02	0.28	0.45	0.59	0.3
Lead (Pb)	0.0001	0.0009	0.0010	0.0016	0.007
Manganese (Mn)	0.005	0.098	0.108	0.114	
Mercury (Hg)-Total	0.0001		<DL		0.00026
Molybdenum (Mo)-Total	0.005	<DL	0.004	0.004	0.073
Nickel (Ni)	0.002	0.004	0.004	0.005	0.150
Selenium (Se)	0.002	<DL	0.001	0.001	0.001
Silver (Ag)	0.0004		<DL		0.0001
Sodium (Na)	1	179	216	253	
Strontium (Sr)-Total	0.002	0.221	0.307	0.395	
Thallium (Tl)-Total	0.05		<DL		
Tin (Sn)-Total	0.05		<DL		
Titanium (Ti)-Total	0.001	0.012	0.014	0.015	
Uranium (U)	0.0001	0.0006	0.0010	0.0016	
Vanadium (V)-Total	0.001	0.001	0.002	0.002	
Zinc (Zn)	0.004	0.015	0.022	0.034	0.03

Note: A-All units mg/L and stats are based on 4 samples; B-Instream Guidelines for Protection of Aquatic Life (CCME 2007)

Concentration of total metals in the effluent samples were also compared to the CCME guidelines for protection of aquatic life (CCME 2007). These guidelines relate to measured concentrations in the receiving water and not to measureable concentrations in final effluent. Of those metal parameters with in-stream guidelines, the concentration in the effluent is less than the guideline for Arsenic, Lead, Molybdenum, Nickel and Selenium. Concentrations of Aluminum, Copper and Zinc in the effluent were greater than the in-stream guideline; however, those concentrations are below toxicity levels and would be diluted further once mixed in the river.

3.2.6 Other Analytical Groups

Seven other parameter groups were analyzed once every quarter. For most of the variables in each group, there were no detectable concentrations in any sample. The exceptions for each group are summarized below in Table 3-8 with the minimum, mean and maximum concentration. In the parameter groups of VOC, PAH and Phenolics, there are variables whose concentrations are estimated through analysis of a surrogate variable. For these variables, the results are reported as percent. The important point to consider is that the percent concentration reported for each variable was fairly consistent between sampling events, but also there are no environmental guidelines for these variables so it is not known at this time if these parameters have negative effects on aquatic life. There was one directly measureable parameter in the VOC group, Chloromethane that was detectable in one of the three samples. Chloromethane (also known as Methyl Chloride) is a colourless gas that is soluble in water; there is some information about the toxicity of the gaseous form but not the liquid form (EPA 2000).

Anionic surfactants were measureable in all four samples and were higher in the samples from December and March as compared to the samples from June and September. Results from other studies suggest that surfactants are one of many parameters (ammonia, aluminum, copper, chromium, anionic surfactants and some pesticides) that likely contribute to chronic toxicity of the effluents (Quebec Environment and EC 2001). Surfactants are organic molecules used in domestic and industrial cleaning agents and anionic surfactants were detected in the Quebec study in the range of 0.18 to 2.10 mg/L. There are currently no water quality criteria for surfactants.

The presence of protozoan parasites *Cryptosporidium* and *Giardia* were analyzed in the quarterly samples. *Cryptosporidium* was not detected in any sample while *Giardia* was detected in three of the four samples (June, December, and March). It should be noted that these parasites can be added to the waste stream by waterfowl on the lagoons. The current treatment facility at Edson is not designed to remove these pathogens.

Table 3-8. Summary of Additional Analyses on Final Treated Effluent

Parameter	Units	DL	No. of Samples	Min	Mean	Max
VOLATILE ORGANIC COMPOUNDS						
Chloromethane	mg/L	0.01	3	<DL	0.017	0.017
4-Bromofluorobenzene	%	63-125	3	84	86	87
1,2-Dichloroethane d4	%	77-119	3	108	113.7	124
Toluene d8	%	68-120	3	96	97	98
POLYCYCLIC AROMATIC HYDROCARBONS						
2-Fluorobiphenyl	%	37-123	3	76	81.3	87
Nitrobenzene d5	%	24-132	3	77	81	88
p-Terphenyl d14	%	41-143	3	75	81.3	85
PHENOLICS						
2-Fluorophenol	%	1-91	3	41	66	87
Phenol d5	%	0-94	3	28	47.3	79
2,4,6-Tribromophenol	%	40-132	3	80	95.3	109
POLYCHLORINATED BIPHENYLS						
Decachlorobiphenyl	%	32-152	3	78	84	92
SURFACTANTS						
Anionic Surfactants	mg/L	0.03	4	0.13	0.30	0.44
PARASITES						
Cryptosporidium (oocysts)	# per 19.35 L	0	4	0	0	0
Giardia (cysts)	# per 19.35 L	0	4	0	3	5

3.2.7 Toxicity

Effluent was tested quarterly for acute and chronic toxicity. Effluent was tested for lethal and inhibitory responses at the 25% and 50% population response level. For acute toxicity tests, trout and *Daphnia* test species were used in whole, undiluted effluent while for chronic toxicity tests, *Ceriodaphnia* and fathead minnow test species were used.

Effluent is considered toxic if at 100% effluent, more than 50% of the test organisms are killed (CCME 2009). For each test conducted, test organisms were used in 100% effluent and in diluted effluent series (50%, 25%, 13%, and 6.3%). To address the toxicity question, the results for tests conducted in 100% effluent have been summarized. The length of time for each test varies by test species. The test duration was 2 days, 4 days, 6 days and 7 days for *Daphnia*, trout, *Ceriodaphnia* and fathead minnow, respectively. For each day of the test, pH, conductivity and temperature were recorded. The tests were pH stabilized to avoid pH drift (increase) during the aeration of the tanks. Since ammonia becomes more toxic as pH increases, it is important that the lab stabilizes pH so toxicity results can be attributed to the effluent and not to an increase in pH. The percent mortality at completion of the tests in 100% effluent has been summarized (Figure 3-9). Dissolved oxygen was also monitored during the tests and ranged between 7.0 and 9.1 mg/L across all tests. It was concluded that toxicity was not a result of low dissolved oxygen during the test periods.

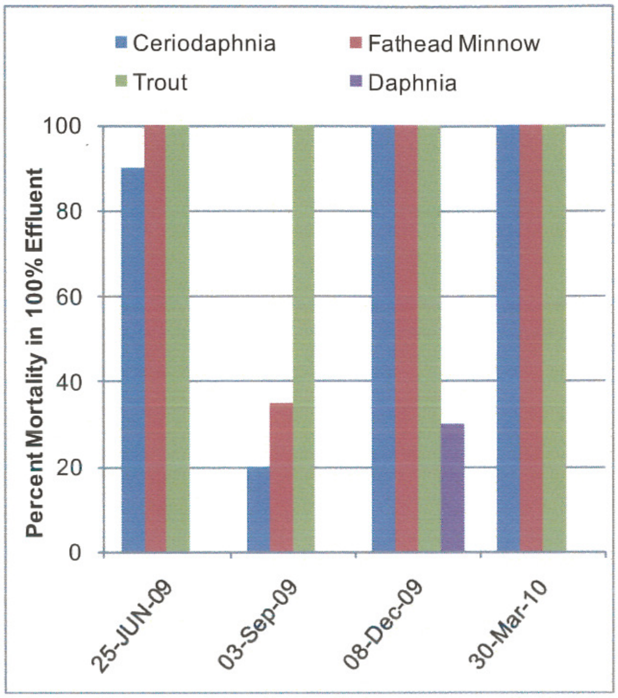


Figure 3-9. Toxicity Test Results: Mortality Rate in 100% Effluent

For *Daphnia*, mortality rate was zero in all samples except December when mortality was 30%. In contrast, mortality rate for trout was 100% in all samples. Mortality of *Ceriodaphnia* and fathead minnow was 90% or greater in three samples. For both of these test organisms, mortality rate was 20% and 35%, respectively, in the September sample. In addition, in the September effluent, trout survived for 3 days, but by day 4, all test organisms were dead. Based on the definition of effluent toxicity, the effluent was never toxic to *Daphnia,* always toxic to trout, and toxic to *Ceriodaphnia* and fathead minnow in three of the four samples (non-toxic in September) (Figure 3-9).

From these tests, the concentration of effluent that is toxic to 50% of the test organisms (LC50) was calculated. As the LC50 value increases, the effluent is considered to be less toxic. LC50 for *Daphnia* was more than 100% effluent in all samples except for the December sample when it was calculated at 85% of whole effluent concentration (Figure 3-10a). Anionic surfactants were highest in the December effluent and it has been suggested that *Daphnia* may be sensitive to surfactants because it may bind with their exoskeletons (Quebec and EC 2001). The concentration of whole effluent that was lethal to 50% of trout (LC50) was less than 50% of whole effluent for all samples except September where an LC50 value of 59% was calculated. That is 59% of whole effluent would not be toxic to 50% of the test organisms. Effluent diluted (or improved) to quality equivalent to 59% or lower of September whole effluent would not be toxic to trout. Trout is the most sensitive species for assessing effects of un-ionized ammonia toxicity (CCME 2000).

Ceriodaphnia and fathead minnow were test organisms used to measure chronic toxicity. Chronic effects are evaluated through the use of IC25 (concentrations of whole effluent inhibitory to 25% of the population). The invertebrate species was more sensitive to effluent concentration than the fish species (Figure 3-10b). IC25 was highest for both *Ceriodaphnia* and fathead minnow in September (27% and 83%, respectively). IC25 was lowest for *Ceriodaphnia* in June 2009 and lowest for fathead minnow in March 2010. Effluent in September was of the best quality and produced fewer inhibitory responses than effluent from the other months.

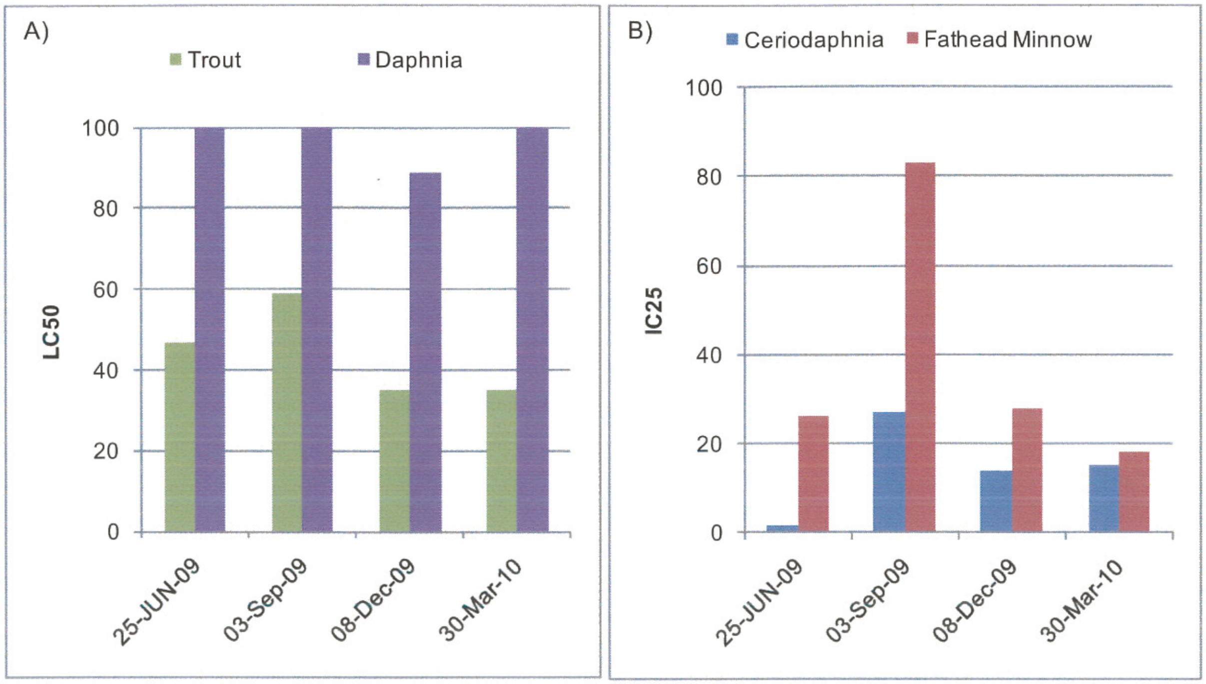


Figure 3-10. Toxicity Test Results: a) LC50 and b) IC25

4. Receiving Environment - Characterization

4.1 Receiving Environment - Historical Data

4.1.1 Quantity

The results for maximum and minimum 7 day discharge for different return periods are summarized in Table 4-1. Typically, for receiving water studies the 7Q10 or 7Q20 statistic is used as the value for low flow periods and to represent water available for dilution of effluent under worst case conditions.

Table 4-1. Flow Statistics for McLeod River (07AG007)

Return Period (Years)	Maximum 7 Days Discharge (m^3/s)	Minimum 7 Days Discharge (m^3/s)
500	2900	1
200	1970	1
100	1430	1
50	1010	2
20	614	2
10	**465**	**2**
5	430	3
2	268	5

Based on the pro-rating function, the 7Q10 low-flow statistic for the McLeod River at the point of the lagoon outfall was estimated to be 1.545 m^3/s. The pro-rating function was used to convert flows from station 07AG007 to probable flows in the river at the point of effluent discharge. The variability in mean daily river flow per year (Figure 4-1) is much higher than the variability in mean daily river flow per month (Figure 4-2). The 7Q10 statistic was calculated from flow data over the period 1985 to 2008 and thus the same value is used as a characteristic of low flow conditions for yearly river discharge, monthly river discharge or daily river discharge. The 7Q10 statistic is illustrated in Figures 4-1 and 4-2 in comparison to yearly and mean annual river flows and also in comparison to mean monthly effluent discharge (Figure 4-3).

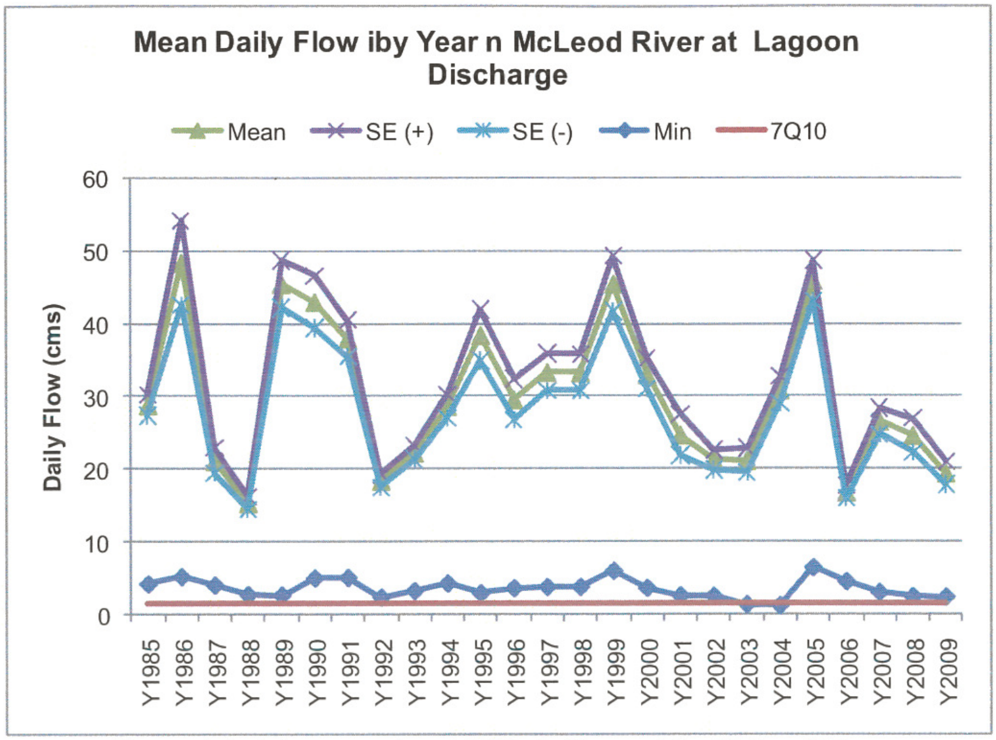


Figure 4-1. Inter-annual variability in flows of the McLeod River

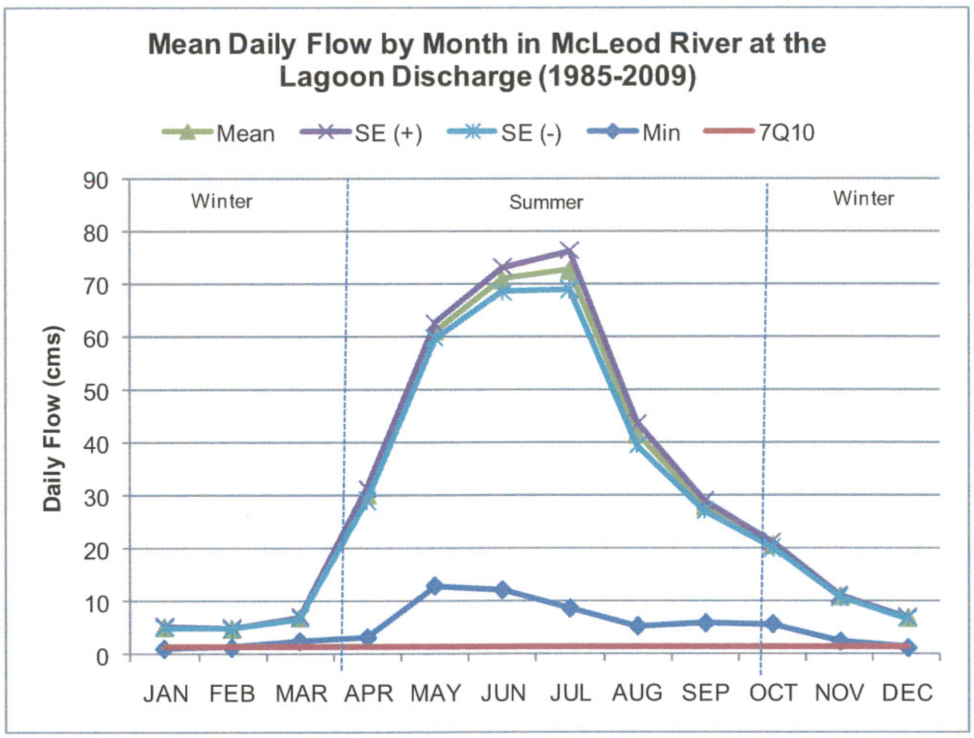


Figure 4-2. Monthly variability in flows of the McLeod River

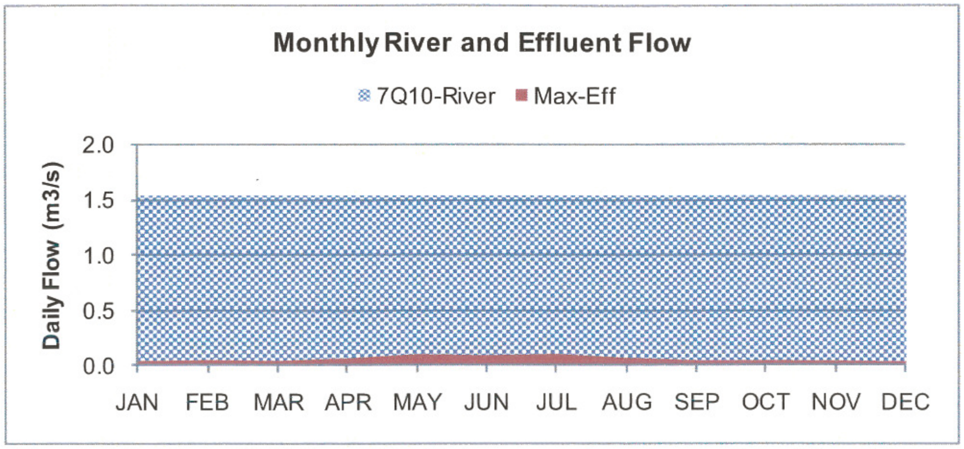


Figure 4-3. River 7Q10 flow statistic in comparison to monthly effluent flows

4.1.2 Receiving Water Quality - Historical

Phosphorus and nitrogen in the McLeod River have been monitored over numerous years at a station upstream (AB07AG0045) and downstream (AB07AG0260) of the Edson wastewater outfall. These stations are located approximately 10 km and 20 km, respectively, away from the outfall. Concentrations of these parameters have been reviewed in an attempt to understand assimilation capacity in the river.

On many sampling dates, TP in the river downstream of the outfall was similar to concentration at the upstream station (Figure 4-4). The proportion of dissolved and total phosphorus both upstream and downstream was also compared. On average, concentrations of TP and TDP are higher downstream as compared to upstream (Tables 4-2 and 4-3), but the proportion of dissolved phosphorus to total phosphorus is slightly higher in the upstream samples (Figure 4-5) as compared to the downstream samples (Figure 4-6). This difference is not significant.

Table 4-2. Descriptive Water Quality Statistics for the McLeod River (AB07AG0045) (upstream of outfall)

Parameter	Unit	n	min	25th	mean	median	75th	max
Alkalinity	mg/L	11	106	138	159	143	183	222
Ammonia-Dissolved	mg/L	41	<0.005	0.003	0.008	0.006	0.009	0.031
Bicarbonate	mg/L	11	130	166	192	172	224	270
DOC	mg/L	41	2.7	3.8	5.8	5.3	6.6	12.8
Chlorophyll *a*	mg/m³	10	0.2	0.3	0.5	0.4	0.6	1.0
Fecal Coliforms	No/100 mL	12	<10	5	12	5	10	60
NO3+NO2 - Dissolved	mg/L	40	<0.006	0.051	0.118	0.115	0.183	0.272
TKN	mg/L	41	<0.05	0.14	0.26	0.20	0.3e0	0.92
DO	mg/L	42	8.30	9.29	10.35	10.03	10.98	13.16
pH		42	7.25	8.05	8.17	8.23	8.41	8.56
TP	mg/L	43	<0.001	0.004	0.025	0.006	0.009	0.296
TDP	mg/L	42	<0.001	0.002	0.003	0.003	0.004	0.013
Residue-filterable	mg/L	6	140	180	210	180	254	300
Residue-nonfilterable*	mg/L	42	<1	1	28	2	4	353
Conductivity	µS/cm	42	147	263	309	300	349	471
Sulphate-dissolved	mg/L	11	17.5	18.7	21.3	21.2	23.7	26.6
Temperature	°C	42	-0.23	2.79	9.68	11.46	15.08	22.48
TDS	mg/L	11	135.0	165.5	193.5	181.0	222.5	260.0
Turbidity	NTU	11	0.21	0.75	1.61	1.20	1.80	5.90

Note: Data collected between July 1998 and March 2006; Seasonality was not separated out when calculated descriptive statistics
** = 24 out of 42 measurements are below the detection limit*

Table 4-3. Descriptive Water Quality Statistics for the McLeod River (AB07AG0260) (downstream of outfall)

Parameter	Unit	n	min	25th	mean	median	75th	max
Alkalinity	mg/L	11	108	140	164	150	186	236
Ammonia-Dissolved	mg/L	41	<0.005	0.003	0.021	0.006	0.018	0.162
Bicarbonate	mg/L	11	131	163	197	182	228	289
DOC	mg/L	41	2.9	4.1	6.5	6.2	7.0	13.0
Chlorophyll a	mg/m³	10	0.5	0.8	1.0	1	1.3	1.6
Fecal Coliforms	No/100 mL	12	<10	5	27	10	20	130
NO3+NO2 - Dissolved	mg/L	40	<0.005	0.018	0.079	0.060	0.108	0.304
TKN	mg/L	41	0.13	0.19	0.30	0.25	0.33	1.30
DO	mg/L	41	6.95	9.16	10.30	10.23	11.29	13.39
pH		41	7.22	8.14	8.24	8.29	8.48	8.64
TP	mg/L	42	0.003	0.007	0.032	0.011	0.020	0.416
TDP	mg/L	41	<0.001	0.003	0.005	0.004	0.005	0.028
Residue-filterable	mg/L	6	160	175	218	195	268	298
Residue-nonfilterable	mg/L	42	<1	2	26	2	5	465
Conductivity	µS/cm	41	141	272	310.3	301	341	519.8
Sulphate-dissolved	mg/L	11	13.9	16.8	19.0	18.1	20.7	25.6
Temperature	°C	41	-0.23	4.18	11.05	12.87	16.82	24.84
TDS	mg/L	11	134.0	164.0	195.6	174.0	219.5	293.0
Turbidity	NTU	11	0.16	0.65	1.29	0.88	1.95	3.30

Note: Data collected between July 1998 and March 2006; Seasonality was not separated out when calculated descriptive statistics

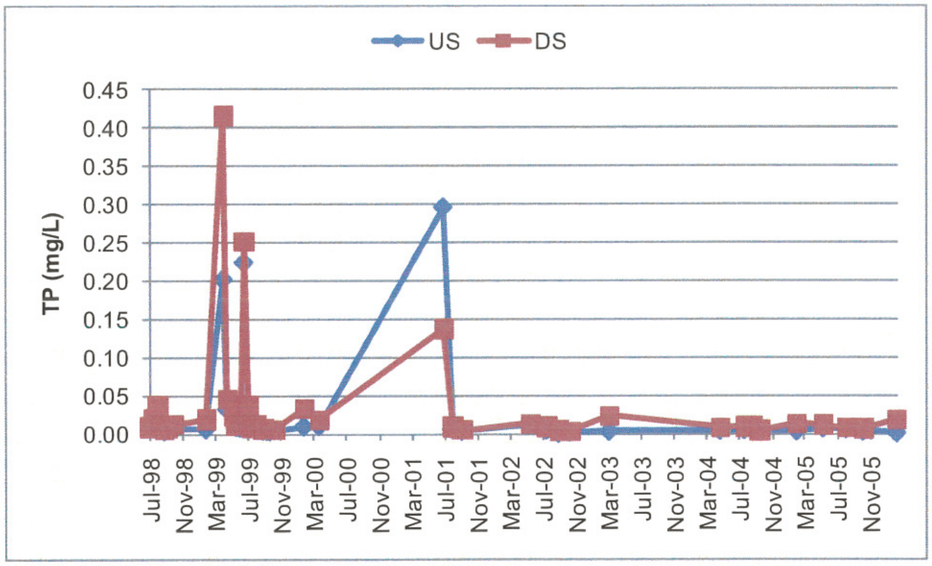


Figure 4-4. Concentrations of TP in the McLeod River Upstream and Downstream of the Edson wastewater outfall.

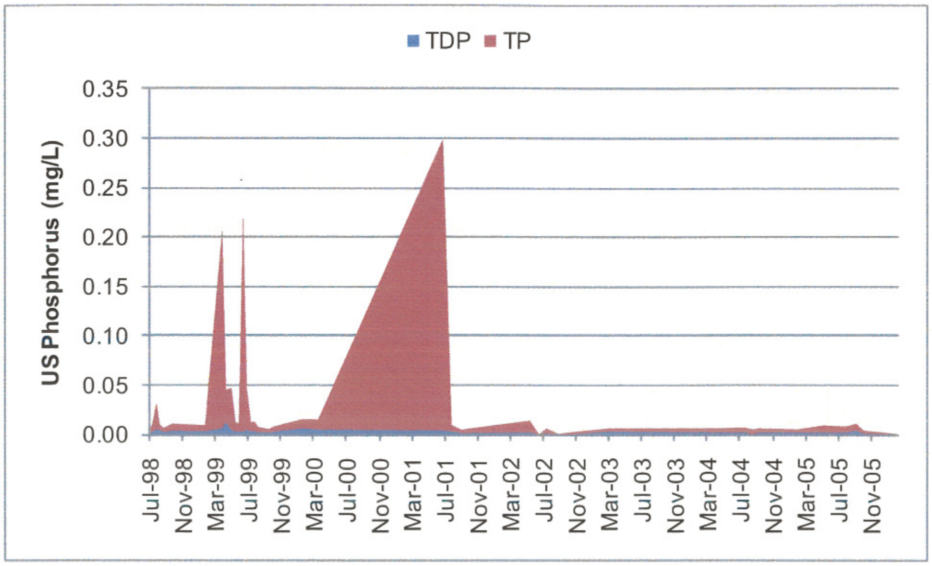


Figure 4-5. Concentrations of Dissolved and Total Phosphorus in the McLeod River upstream of the Edson outfall.

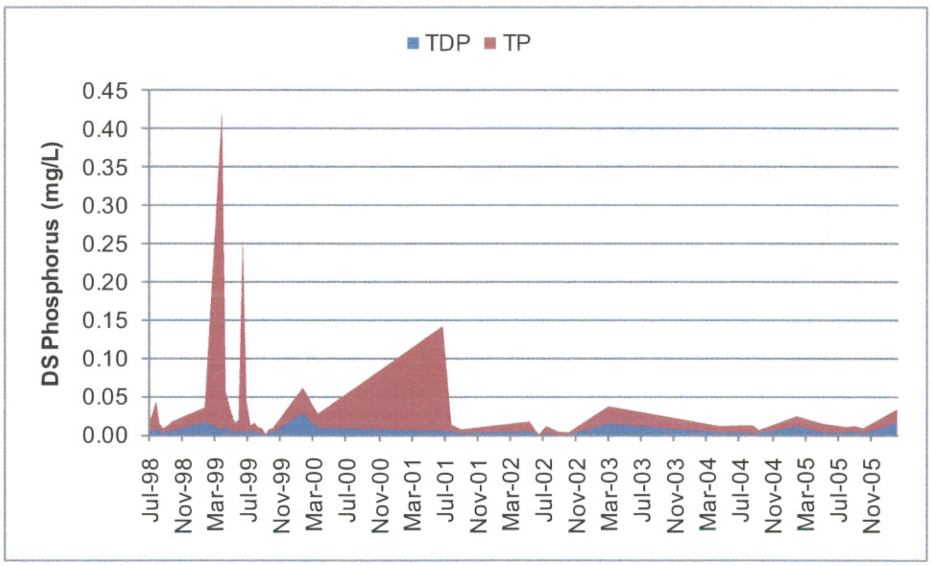


Figure 4-6. Concentrations of Dissolved and Total Phosphorus in the McLeod River downstream of the Edson outfall.

Dissolved ammonia measured both upstream and downstream of the outfall have also been compared (Figure 4-7). The upstream and downstream concentrations are similar except for five samples with concentrations greater than 0.06 mg/L (above the green line). These concentrations were measured in late winter samples and may suggest influence of ammonia loads from the lagoon on the river. Ammonia concentrations were highest in treated effluent samples in late winter because of the lack of biological activity in the lagoons during this portion of the year. The proportion of ammonia and TKN in the river both upstream (Figure 4-8) and downstream (Figure 4-9) of the outfall have been compared. Concentrations of ammonia and TKN are on average higher downstream as compared to upstream and the proportion of ammonia as TKN is higher in the downstream water as compared to the upstream water. This suggests that wastewater effluent contributes or is at least one contributor of ammonia to the river.

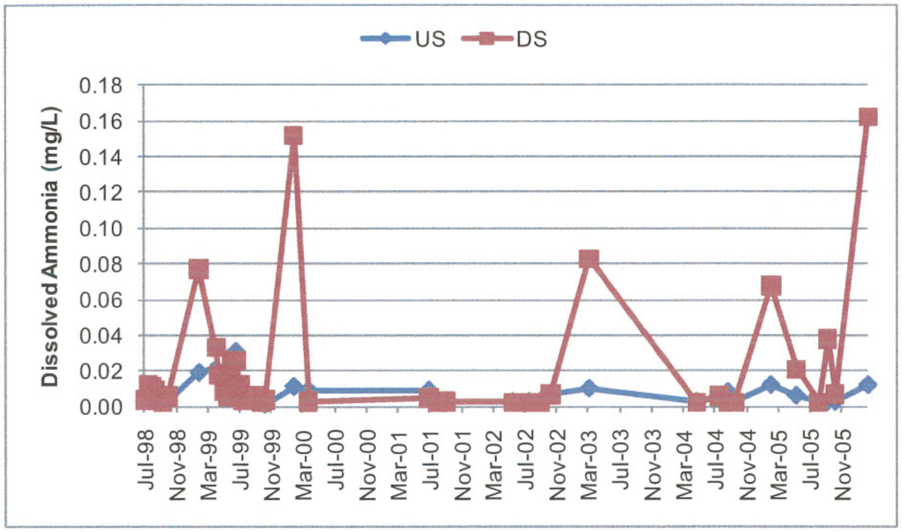


Figure 4-7. Concentrations of dissolved ammonia in the McLeod River Upstream and Downstream of the Edson wastewater outfall.

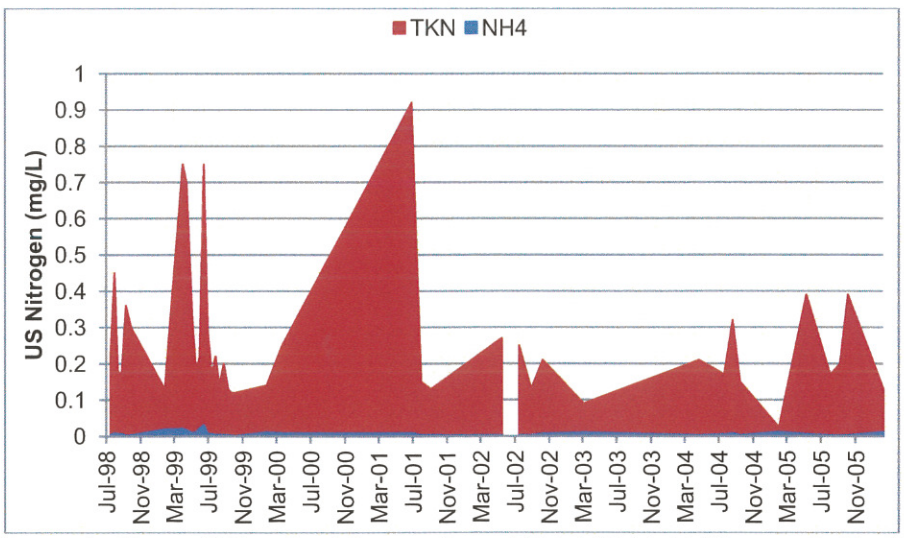


Figure 4-8. Concentrations of Dissolved Ammonia and Total Kjeldahl Nitrogen in the McLeod River upstream of the Edson outfall.

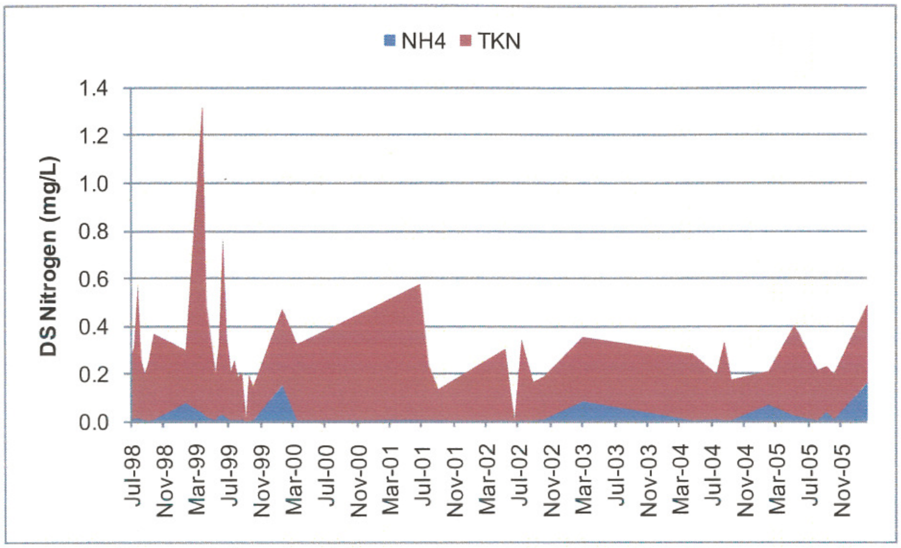


Figure 4-9. Concentrations of Dissolved Ammonia and Total Kjeldahl Nitrogen in the McLeod River downstream of the Edson outfall.

4.2 Receiving Environment - Current Data

4.2.1 Supporting Environmental Data

Supporting environmental data were collected at each sampling station to understand the receiving environment and to assist in the development of the mixing zone model (Table 4-4). While in the field it was observed that the river was quite high. Water survey of Canada discharge data are not yet available for 2010 for use in this report, but a preliminary hydrograph for the station downstream of the town of Edson has been included in Appendix C. Flows in the river at the time of the field sampling program were much higher than long-term historical averages for the month of September. General descriptions of each transect have also been provided (Table 4-5). Upstream of the outfall at around 1000 m to 4300 downstream of the outfall, cobbles make up 70% or greater of the bed texture while at 100 m to 300 m downstream, silty-clay fines make up 90% of the bed texture. The channel is approximately 80 m wide and begins to curve at about 300 m downstream and then again after 1000 m downstream (Figure 1-2). Precise mapping of the bed texture has not been completed but this preliminary analysis would suggest that the river immediately downstream has higher sedimentation rates than other parts of the river along the left bank.

Table 4-4. Supporting environmental data collected September 15, 2010

Station	Water Depth (m)	pH[1]	DO (mg/L)	Conductivity (µS/L)	Temp °C	Distance Station from Shore (m)	WQ Lab Sample Obtained
US100-01	0.59		11.16	323	9	8	No
US100-02	1.06		11.36	299	8.7	42	Yes
Outfall	0.18		7.92	1155	11.2	-8	Yes
DS100-01	1.1		11.54	307	9	4	Yes
DS100-02	Too deep to access						
DS300-01	1.01		11.26	303	9.6	5	Yes
DS300-02	too deep		-	-	-	10	No
DS1000-01	0.71		10.8	300	9.2	8	Yes
DS1000-02	0.73		10.94	303	8.8	35	Yes
DS4300-01	0.33		11.2	315	8.5	8	No
DS4300-02	0.58		11.18	336	8.2	40	Yes

Note: 1: pH meter was malfunctioning and would not calibrate; data did not agree with the lab analyzed results so they are not presented

Table 4-5. Descriptive characteristics of the transects sampled in the 2010 field program

Transect	Bed Texture	Macrophyte Cover	Bank Veg	Notes
US100	80% Cobbles, 18% Fines, 2% Boulders	15% grasses (submerged) and horsetail growing in water	grass and reeds on shore for about 3.5 m then mixed forest (spruce, birch, poplar); very steep bank	Depth undulating. Small amounts of white froth consistent with downstream noted at this location.
Outfall	Not determined.	black, green and grey fungi/algae on rocks in pool.	grasses surrounded by shrubs and invasive/weedy species and fireweed; very steep bank	Flow and depth obtained 0 m fr. shore; bottom past riprap was 40% Cobbles and 60% Fines; semi-veg island noted ***see Appendix B photo 3
DS100	90% Fines (silty clay), 10% gravel	green algae growing on debris/driftwood on bottom	grasses and invasive sp. Surrounded by mixed forest; very steep bank	Sample obtained 6 m from shore; severe drop off after 4 m from shore
DS300	90% Fines (silty clay), 5% Gravel, 5% Boulders	5% sunken grasses <1 m fr. shore	reed grasses to edge of shore; surrounded by mixed forest; very steep bank	Reached with flow metre to obtain readings at 10 m
DS1000	70% Cobbles, 28% Fines, 2% Boulders	none	generally sandy shore with some grass, then mixed forest	Easily accessible - shore flat with quad trail.
DS4300	80% Cobbles, 18% Fines, 2% Boulders	horsetail extending from shore to water	shore flat but vegetated; mixed forest	Easily accessible - shore flat with quad trail.

4.2.2 Analytical Results

In some studies, conductivity and chloride can be used as easy field parameters to identify the effluent plume. Conductivity and chloride have been plotted and it is obvious that even though the conductivity of the effluent (Figure 3-1b) is much higher than in the river (Figure 4-10a and b), a plume based on conductivity and chloride concentrations was not easily detectable in field samples. Effluent flow rates are typically much lower than the river flow rates, but the flows in the river on the day of sampling were quite high and likely diluted the in-stream concentrations. Perhaps it would be possible to distinguish a conductivity or chloride plume during very low flow conditions.

In-steam concentrations of nutrients did show distinct responses due to the effluent loading (Figure 4-11a and b). Concentrations of total ammonia (NH_4) and TP had a significant increase within 100 m of the outfall whereas nitrate and TDP had the highest measureable concentrations at 300 m downstream. To better understand the effect of the effluent load on the river water quality, the ratio of the downstream concentration to the upstream (reference) concentration was calculated for the different nitrogen fractions (total ammonia, un-ionized ammonia, nitrate and nitrite) (Figure 4-12a and b). In-stream concentrations of NH_4 and NH_3 peak dramatically at the first downstream station and slowly decrease down the river. At the final station sampled, NH_4 and NH_3 are 6.4 and 5.9 times greater, respectively, than at the upstream station. Nitrate and nitrite did not increase as much downstream of the outfall but both had the highest concentrations and highest ratio in comparison to upstream concentrations at 300 m downstream as opposed to 100 m downstream (Figure 4-12a and b). In addition, concentration of both parameters returned to upstream conditions by the 1000 m downstream, centre river station. Finally, the in-stream concentration of TP and TDP downstream of the outfall was less than 10 times the concentration upstream of the outfall (Figure 4-13). By 4300 m downstream, TP was 1.5 times higher than the upstream station while TDP had decreased to less than what was measured at the upstream station.

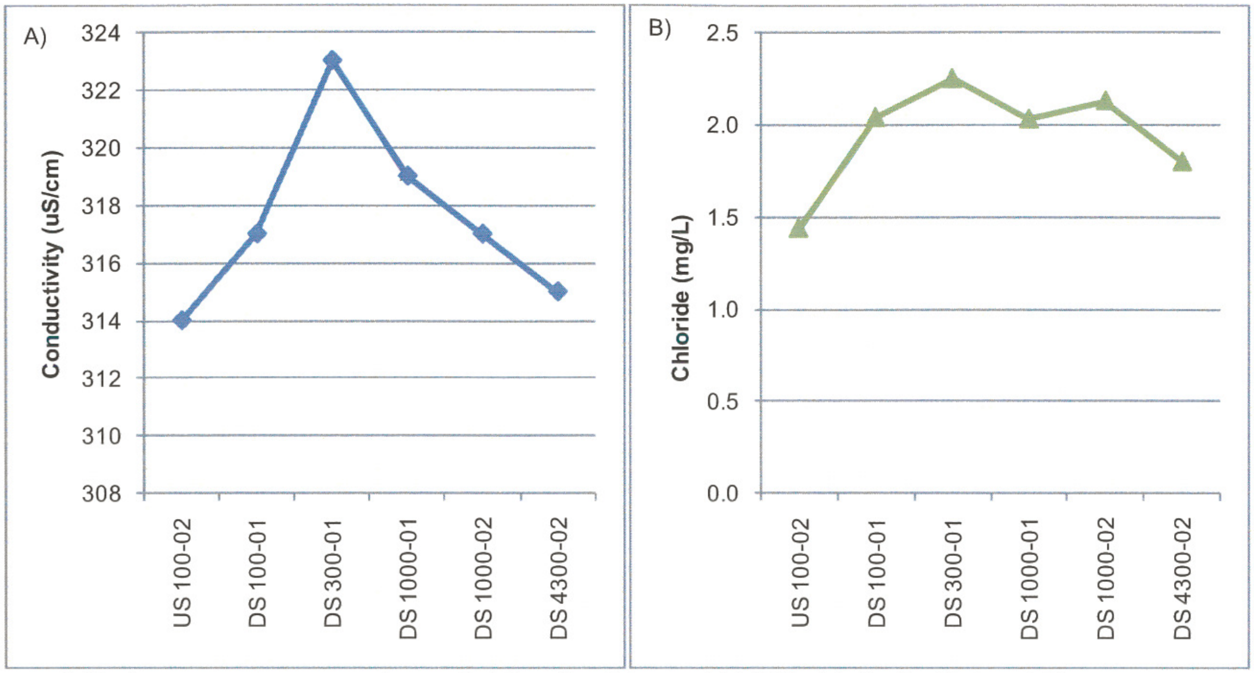


Figure 4-10. In-stream concentrations of a) Conductivity and b) Chloride in the McLeod River upstream and downstream of the outfall

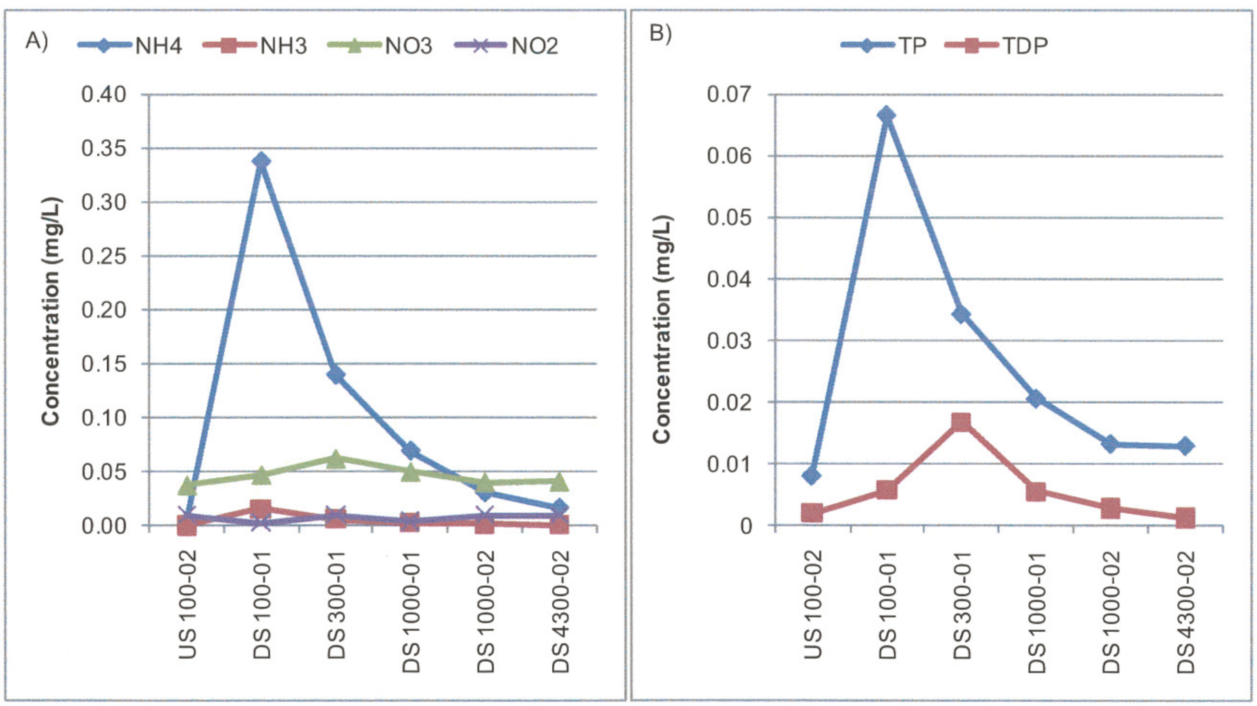


Figure 4-11. In-stream concentrations of a) nitrogen fractions and b) phosphorus fractions in the McLeod River upstream and downstream of the outfall

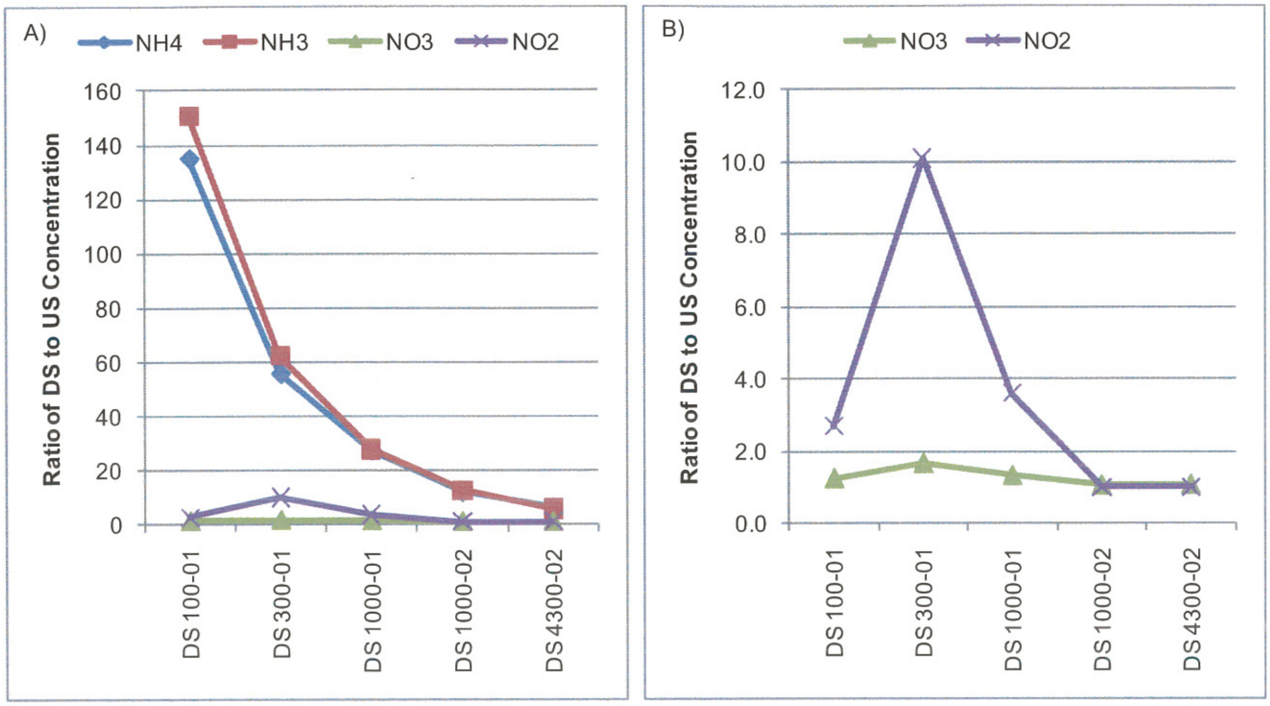


Figure 4-12. Ratio of Downstream Concentrations to Upstream Concentration for a) nitrogen and b) nitrate and nitrite

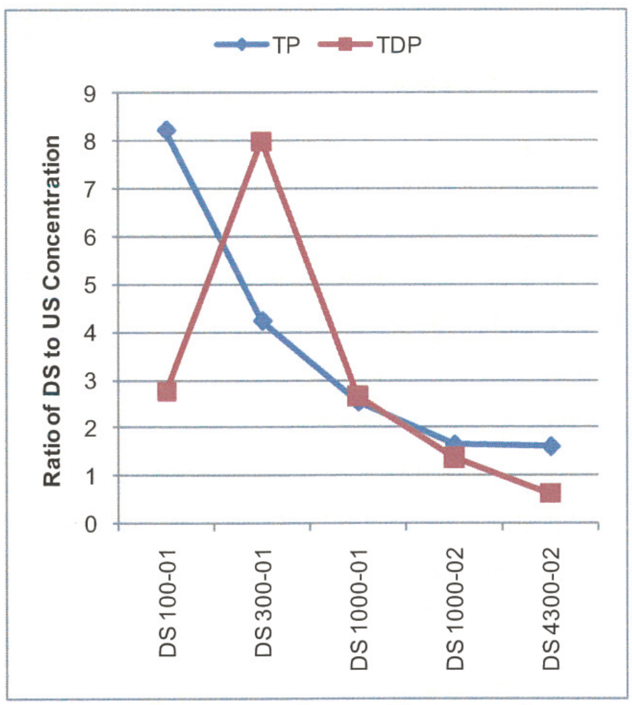


Figure 4-13. Ratio of Downstream Concentrations to Upstream Concentration for Phosphorus

5. Mixing Zone Model Results

5.1 Model Inputs

5.1.1 September 15, 2010 Field Event

Surface water samples and flow measurements were taken at one upstream station (US100-centre) and 4 downstream stations (DS100-left bank, DS300-left bank, DS1000-left bank and centre, DS4300-centre) stations (Table 2-4). CORMIX models were created from the September 15, 2010 field data to simulate total phosphorus concentrations and ammonia concentrations in the McLeod River. Un-ionized ammonia concentrations were calculated from the modeled ammonia concentrations. The CORMIX model inputs for the ammonia and phosphorus scenarios are provided in Table 5-1.

Table 5-1. CORMIX Model Inputs - September 15, 2010 Field Event

Input Parameter	Scenario 1A Total Phosphorus	Scenario 1B Ammonia
Effluent Worksheet:		
Conservative/non-conservative pollutant	Conservative	Non-conservative
Decay rate (1/d) if non-conservative	n/a	31
Discharge excess concentration (mg/L)	2.592	15.898
Effluent flow rate (m^3/s)	0.039	0.039
Effluent density: temperature (°C)	11.2	11.2
Ambient Worksheet:		
Average channel depth (m)	0.8	0.8
Depth at discharge (m)	1.0	1.0
Wind speed 2 m above the water surface (m/s)	2	2
Ambient Elbow River flow rate (m^3/s)	30.8	30.8
Bounded width (m)	75	75
Bounded appearance	Highly Irregular	Highly Irregular
Manning's n	0.017	0.017
Fresh water temperature (deg.C)	8.85	8.85
Discharge Worksheet (CORMIX3):		
Discharge bank location (as seen looking downstream)	Left	Left
Discharge configuration	Flush	Flush
Bottom slope (degrees)	30	30
Horizontal angle sigma (degrees)	90	90
Channel width and depth (m)	2 / 0.5	2 / 0.5
Local depth at discharge outlet (m)	0.5	0.5

Notes: na = No decay rate was used for phosphorus, as it was modeled as a conservative constituent.

Detailed descriptions of the data input for Table 5-1 are provided below.

Effluent Worksheet

Conservative/non-conservative pollutant and **decay rate:**
Under the "effluent" worksheet, the parameter may be modeled as either conservative or non-conservative. Total phosphorus was modeled as a conservative parameter (with no decay coefficient) since it behaves conservatively in the mixing zone. Ammonia was modeled as a non-conservative parameter. The decay rate was determined through calibration with the September 15, 2010 water quality data to be 31 (1/d).

Discharge excess concentration:
The discharge excess concentration refers to the excess concentration of the point source (WW lagoon discharge) above background (i.e., the 100 m upstream station in the McLeod River) concentrations. For total phosphorus, the upstream concentration was 0.0081 mg/L, and the effluent (outfall) concentration was 2.6 mg/L. Therefore, the discharge excess total phosphorus concentration was 2.592 mg/L (i.e., 2.6 mg/L - 0.0081 mg/L).

Similarly for ammonia, the upstream (McLeod River) concentration was <0.005 mg/L and the effluent concentration was 15.9 mg/L. Therefore, the discharge excess ammonia concentration was 15.898 mg/L (i.e., 15.9 mg/L - 0.0025 mg/L). Note that since the upstream concentration was below the laboratory's reportable detection limit, half of the detection limit (0.0025 mg/L) was used in the calculation.

Effluent flow rate:
The effluent flow rate was assumed to be 0.039 m^3/s, which is the average daily discharge rate for the Edson WW Lagoon.

Effluent density (temperature):
The effluent temperature was measured to be 11.2°C on September 15, 2010.

Ambient Worksheet

Ambient McLeod River flow:
The flow in the McLeod River was determined based on data acquired from the WSC flow station located on the McLeod River near Rosevear (07AG007), and pro-rated to reflect flows upstream at the Edson WW Lagoon outfall location. The flow at the Rosevear station was approximately 40 m^3/s on September 15, 2010, resulting in a flow of 30.8 m^3/s at the Edson WW Lagoon.

Average channel depth:
For the river geometry, CORMIX requires that the cross-section of the river be "schematized" as a rectangular channel. McLeod River depths were measured at all surface water stations sampled on September 15, 2010. The average depth was calculated to be 0.8 m based on these measurements.

Depth at discharge:
The depth of the McLeod River at the point in which the outfall channel meets the River was measured to be about 1.0 m.

Bounded width:
From aerial photos, the channel was determined to be 75 m wide in the vicinity of the Edson WW Lagoon outfall.

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

Manning's n:
Manning's n was determined through calibration with the September 15, 2010 field water quality data to be 0.017.

Bounded appearance:
From aerial photos, it was seen that the river immediately downstream of the outfall contains some large meanders. As such, the appearance of the river in CORMIX was denoted as either "slight meander" or "highly irregular", and determined through calibration with the September 15, 2010 data to be "highly irregular".

Fresh water temperature:
The McLeod River water temperature was measured to be 8.85°C on September 15, 2010.

Discharge Worksheet

Discharge bank location:
Under the "discharge" worksheet, the discharge bank location is the location of the nearest bank to the outfall when facing downstream in the direction of the river flow. For the Edson WW Lagoon discharge, this is the left bank.

Discharge configuration:
Since the outfall channel opens into the river, (rather than, for example, protruding into the river), the discharge configuration is considered as "flush".

Bottom slope:
The slope of the outfall channel was estimated to be 30 degrees from field visits and site photographs.

Horizontal angle:
The horizontal angle is the angle between the outfall centreline and the direction of river flow, such that if the discharge is perpendicular to flow in the McLeod River, the horizontal angle is 90 degrees.

Channel width and depth:
The channel width and depth were estimated to be 2 m and 0.5 m, respectively, based on field visits and site photographs.

Local depth at discharge outlet:
The located depth at the discharge outlet was estimated to be the same as the average outlet channel depth, which was 0.5 m.

5.1.2 CORMIX Model Calibration Results

The CORMIX model was built and calibrated with the flow measurements and water quality data collected during the September 15, 2010 field event (Table 4-4; Figures 4-10 to 4-13). The Manning's n value, river appearance, and ammonia decay rate were adjusted in CORMIX in order to fit the model-predicted concentrations to the field concentrations. A comparison of the field measurements and the CORMIX predicted concentrations are provided (Table 5-2).

Table 5-2. Comparison of Field Measured Phosphorus and Ammonia Concentrations to CORMIX Predicted Concentrations

Station Location	Total Phosphorus Concentration (mg/L)		Ammonia Concentration (mg/L)	
	Field	Model	Field	Model
DS100-01	0.0666	0.0659	0.337	0.377
DS300-01	0.0343	0.0381	0.139	0.189
DS1000-01	0.0206	0.0209	0.0686	0.0636
DS4300-02	0.013	0.0104	0.0159	0.00392

There is good agreement between the field measured and modeled concentrations at all stations except for ammonia at the DS4300-02 station. Ammonia concentrations at extended distances are under-predicted as a result of the decay coefficient used in the model; however, the decay coefficient was selected for use in the model because it well describes the ammonia results for the 100 m through 1000 m stations.

5.1.3 Summer Low-Flow "Worst Case" Scenario

The CORMIX model was built and calibrated with the flow measurements and water quality data collected during the September 15, 2010 field event. The Manning's n value, river appearance, and ammonia decay rate were then used to create a model describing a low flow, "worst-case" scenario for the McLeod River at the Edson WW Lagoon outfall. The "worst-case" scenario is described by low flows in the McLeod River, summer temperatures (and therefore greater speciation of ammonia to its toxic form, un-ionized ammonia), 75th percentile water quality concentrations for the McLeod River, 95th percentile flows for the Edson WW Lagoon discharge, and 95th percentile concentrations for the effluent water quality. Using these conditions, the parameters total phosphorus and ammonia were modeled. The CORMIX model inputs for the "worst-case" scenario and the rationale for the model inputs are provided below Table 5-3.

Table 5-3. CORMIX Model Inputs - Summer Low-Flow "Worst Case" Scenario

Input Parameter	Scenario 2A Total Phosphorus	Scenario 2B Ammonia
Effluent Worksheet:		
Conservative/non-conservative pollutant	Conservative	Non-conservative
Decay rate (1/d) if non-conservative	n/a	31
Discharge excess concentration (mg/L)	5.375	28.226
Effluent flow rate (m^3/s)	0.057	0.057
Effluent density: temperature (°C)	23.4	23.4
Ambient Worksheet:		
Average channel depth (m)	0.35	0.35
Depth at discharge (m)	0.4	0.4
Wind speed 2 m above the water surface (m/s)	2	2
Ambient Elbow River flow rate (m^3/s)	1.54	1.54
Bounded width (m)	75	75
Bounded appearance	Highly Irregular	Highly Irregular
Manning's n	0.017	0.017
Fresh water temperature (deg.C)	15.98	15.98
Discharge Worksheet (CORMIX3):		
Discharge bank location (as seen looking downstream)	Left	Left
Discharge configuration	Flush	Flush
Bottom slope (degrees)	30	30
Horizontal angle sigma (degrees)	90	90
Channel width and depth (m)	2 / 0.25	2 / 0.25
Local depth at discharge outlet (m)	0.25	0.25

Notes: na = No decay rate was used for phosphorus. as it was modeled as a conservative constituent.

Effluent Worksheet

Conservative/non-conservative pollutant and decay rate:
Under the "effluent" worksheet, the parameter may be modeled as either conservative or non-conservative. Total phosphorus was modeled as a conservative parameter since it behaves conservatively in the mixing zone. Ammonia was modeled as a non-conservative parameter. The decay rate was determined through calibration with the September 15, 2010 field water quality data to be 31 (1/d).

Discharge excess concentration:
The discharge excess concentration refers to the excess concentration of the point source (WW lagoon discharge) above background concentrations. For total phosphorus, the background concentration was 0.009 mg/L, which was the 75th percentile total phosphorus concentration recorded at the Alberta Environment (AENV) McLeod River Water Quality Station AB07AG0045 located upstream of the Edson WW Lagoon outfall, and south of Edson. The 75th percentile was calculated from 28 summer measurements. The lagoon discharge concentration was 5.384 mg/L, which is the 95th percentile concentration, based on a summer sample set of 12. Therefore, the discharge excess total phosphorus concentration was 5.375 mg/L (i.e., 5.384 mg/L – 0.009 mg/L).

Similarly for ammonia, the background (McLeod River) concentration was 0.007 mg/L based on the 75th percentile value of the AENV McLeod River Water Quality Station AB07AG0045. The 75th percentile was calculated from 26 summer measurements. The lagoon discharge concentration was 28.34 mg/L, which is the 95th percentile concentration, based on a summer sample set of 12. Therefore, the discharge excess ammonia concentration was 28.333 mg/L (i.e., 28.34 mg/L – 0.007 mg/L).

Effluent flow rate:
The effluent flow rate was assumed to be 0.057 m^3/s, which is the 95th percentile daily discharge rate for the Edson WW Lagoon in 2008.

Effluent density (temperature):
The effluent temperature was set at 23.4°C, which is the 95th percentile summer temperature for the lagoon effluent.

<u>Ambient Worksheet</u>

Ambient McLeod River flow:
The low flow in the McLeod River was set at the 7Q10 flow, which represents the minimum 7-day average flow with a recurrence period of 10 years. This flow was computed from data collected at the WSC flow station located on the McLeod River near Rosevear (07AG007). The 7Q10 flow was calculated to be 1.54 m^3/s.

Average channel depth:
The average channel depth under the 7Q10 McLeod River low flow was estimated to be 0.35 m, which was based on an average depth of 0.8 m measured corresponding to a McLeod River flow of 30.8 m^3/s.

Depth at discharge:
The depth of the McLeod River at the point in which the outfall channel meets the River was estimated to be 0.4 m under the 7Q10 McLeod River low flow. This was based on a depth at discharge of 1.0 m measured at a McLeod River flow of 30.8 m^3/s.

Bounded width:
From aerial photos, the channel was determined to be 75 m wide in the vicinity of the Edson WW Lagoon outfall.

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

Manning's n:
Manning's n was determined through calibration with the September 15, 2010 field water quality data to be 0.017.

Bounded appearance:
From aerial photos, it was seen that the river immediately downstream of the outfall contains some large meanders. As such, the appearance of the river in CORMIX was denoted as "highly irregular".

Fresh water temperature:
The McLeod River water temperature was calculated to be 15.98°C, which is the 75th percentile temperature measured for the summer months at the AENV Elbow River Water Quality Station AB07AG0045.

Discharge Worksheet

Discharge bank location:
Under the "discharge" worksheet, the discharge bank location is the location of the nearest bank to the outfall when facing downstream in the direction of the river flow. For the Edson Lagoon WW discharge, this is the left bank.

Discharge configuration:
Since the outfall channel opens into the river, (rather than, for example, protruding into the river), the discharge configuration is considered as "flush".

Bottom slope:
The slope of the outfall channel was estimated to be 30 degrees from field visits and site photographs.

Horizontal angle:
The horizontal angle is the angle between the outfall centreline and the direction of river flow, such that if the discharge is perpendicular to flow in the McLeod River, the horizontal angle is 90 degrees.

Channel width and depth:
The channel width and depth were estimated to be 2 m and 0.25 m, respectively. The channel depth was based on a depth of 0.5 m corresponding to a McLeod River flow of 30.8 m^3/s.

Local depth at discharge outlet:
The located depth at the discharge outlet was estimated to be the same as the average outlet channel depth, which was 0.25 m.

5.2 Model Results

5.2.1 September 15, 2010 Field Event

The discharge plume's shape and flow class were predicted by CORMIX for the September 15, 2010 field event. Mixing characteristics and flow class results are solely influenced by the river flows, discharge flows, and by the river geometry. At present, the model does not account for uptake of modelled parameters by benthic algae.

The discharge plume was classed as "PL2", where the momentum of the lagoon discharge is weak in relation to the McLeod River flow. Initially, the momentum of the discharge will govern the shape of the plume for a very short distance; however, the discharge buoyancy quickly becomes the dominant force since the temperature of the discharge is significantly higher than that of the river. The positive buoyancy causes the plume to rise toward the water surface and spread laterally. Shortly thereafter, the rate of the ambient current (the McLeod River flow) dominates the shape of the plume by strongly deflecting the plume in the downstream direction. As the plume continues to be advected in the downstream direction, there is additional passive mixing with the ambient current. An overhead view of the plume is shown in Figure 5-1.

The plume hugs the nearby bank and does not quickly tend to spread laterally across the river, due to the large flow in the McLeod River (30.8 m^3/s) in comparison to the small flow from the Edson WW Lagoon (0.039 m^3/s) (Figure 5-1). The width of the open water of the river is approximately 75 m and under this scenario the plume only spreads across 30 m by the 4000 m downstream location.

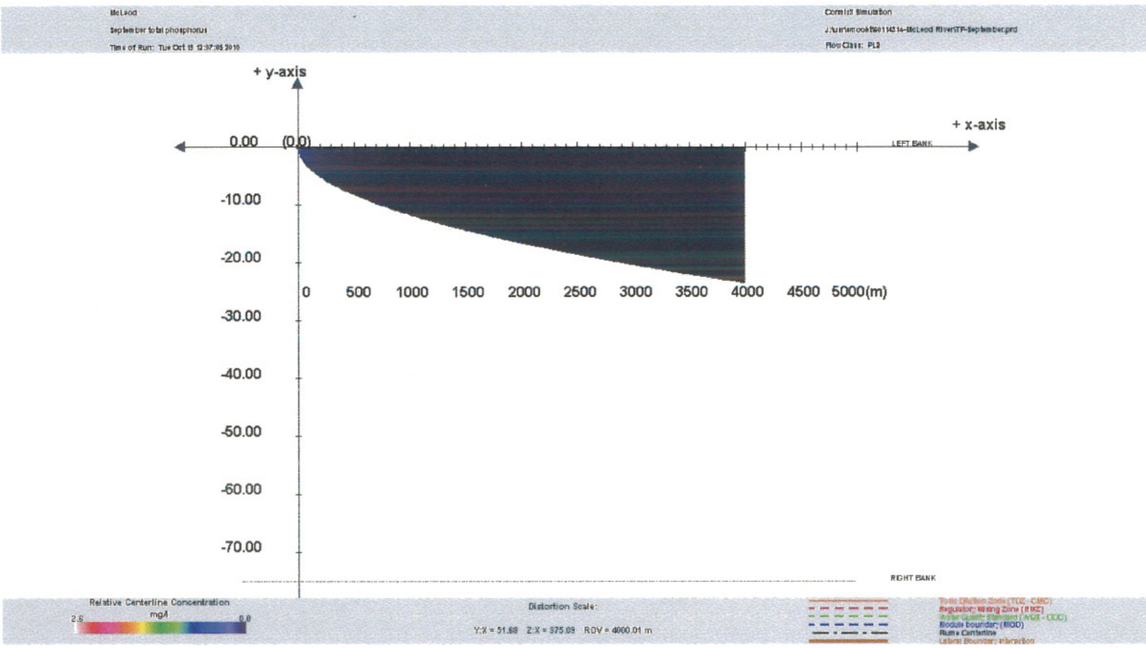


Figure 5-1. September 2010 - CORMIX Overhead Perspective of Edson Wastewater Discharge Plume for Total Phosphorus

<u>Total Phosphorus</u>

In Figure 5-1, the color scale (shown in the bottom left corner of the figure) visually presents the concentrations (of the parameter of interest) in the plume, where red and yellow represents the highest concentrations, green represents average concentrations, and blue to black represent concentrations that are approaching background levels. Due to the scale of the figure, the red, yellow, green, and blue areas are too small to be seen thus the entire figure of the plume appears as black.

Water quality in effluent discharge scenarios is typically evaluated at the edge of the mixing zone. The edge of the physical mixing zone is defined as the point in which the plume is laterally and vertically mixed. However, as seen for the September model results, the plume is strongly advected downstream and does not mix laterally within at least 4 km of the outfall point. However, model predictions and field data show that total phosphorus concentrations began to approach background concentrations (i.e., dropped below 0.02 mg/L) at about 1000 m downstream of the lagoon outfall, such that a water quality signature from the plume would barely be detectable beyond approximately 1000 m.

The Alberta Environment Surface Water Quality Guideline (WQG) for total phosphorus is 0.05 mg/L. In September 2010, this guideline concentration was met at a distance of 180 m from the outfall.

Ammonia

Ammonia behaved differently than phosphorus under these conditions. An overhead view of the discharge plume for ammonia is provided in Figure 5-2. Model predictions and field data show that ammonia concentrations began to approach background concentrations (i.e., dropped below 0.005 mg/L) beyond 4000 m downstream of the lagoon outfall.

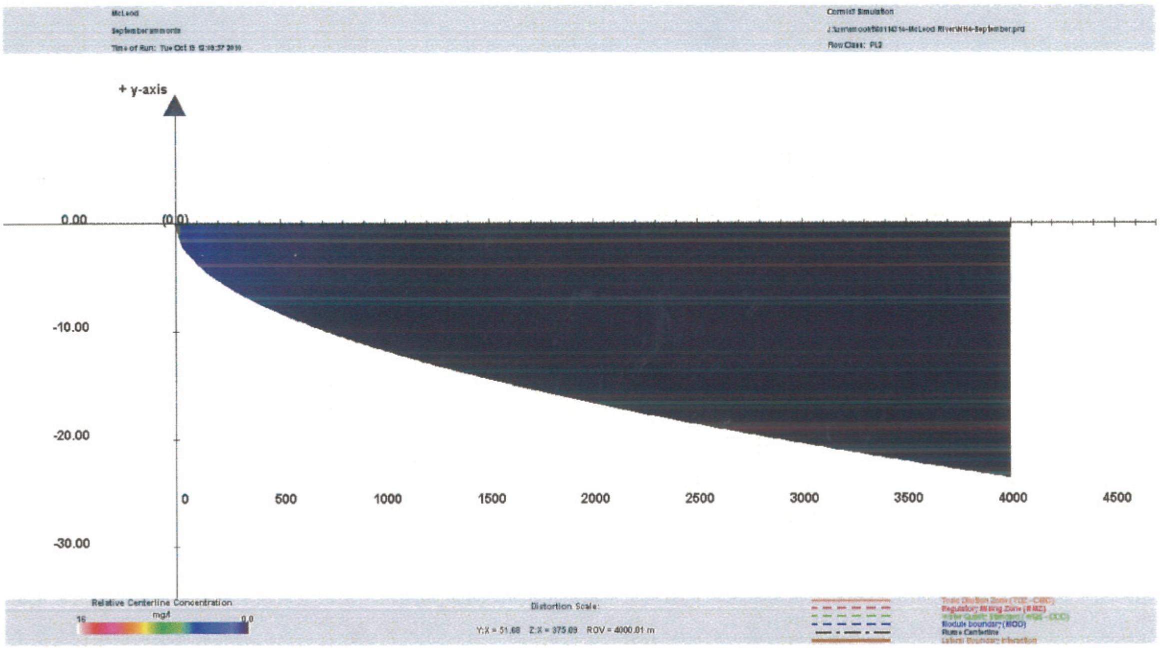


Figure 5-2. September 2010 - CORMIX Overhead Perspective of Edson Wastewater Discharge Plume for Ammonia

Un-ionized ammonia concentrations within the plume in the McLeod River were calculated using a river temperature of 8.85°C and pH of 8.42, which were measured upstream of the lagoon discharge on September 15, 2010. The CCME Canadian Environmental Quality Guideline for un-ionized ammonia is 0.019 mg/L. During the September field event, the un-ionized ammonia guideline was met at a distance of 80 m downstream of the lagoon outfall, corresponding with an ammonia concentration of 0.45 mg/L at this location.

The draft wastewater regulations have an un-ionized ammonia limit of 1.25 mg/L for final discharge. The ammonia concentration in the September 15, 2010 discharge was 15.9 mg/L at a temperature of 11.2°C and a pH of 8.73. This corresponds to an un-ionized ammonia concentration of 1.55 mg/L in the outfall, which exceeds the draft wastewater limit.

5.2.2 Summer Low-Flow "Worst Case" Scenario

The discharge plume's shape and flow class were predicted by CORMIX for the summer low-flow scenario to be "SA1". Initially, the discharge flow from the outfall is strong enough (in comparison to the low ambient flow of the McLeod River) that the momentum of the discharge causes spreading of the plume in both the lateral and vertical directions. Shortly thereafter, the flow in the McLeod River beings to dominate, causing the plume to be bent in the downstream direction. The plume has a strong positive buoyancy (due to the large difference in temperatures between the lagoon discharge and the McLeod River), causing the plume to continue to spread laterally across the river. During this time, the plume continues to be advected downstream by the McLeod River flow.

The CORMIX model predicts that under the summer low-flow "worst-case" scenario, the lagoon discharge plume will become fully laterally mixed (i.e., encounter the opposite bank) at a distance of approximately 350 m from the lagoon outfall, and become fully vertically mixed (i.e., encounter the river bottom) at a distance of approximately 550 m from the lagoon outfall. The overhead view for the modeled plume is illustrated in Figure 5-3.

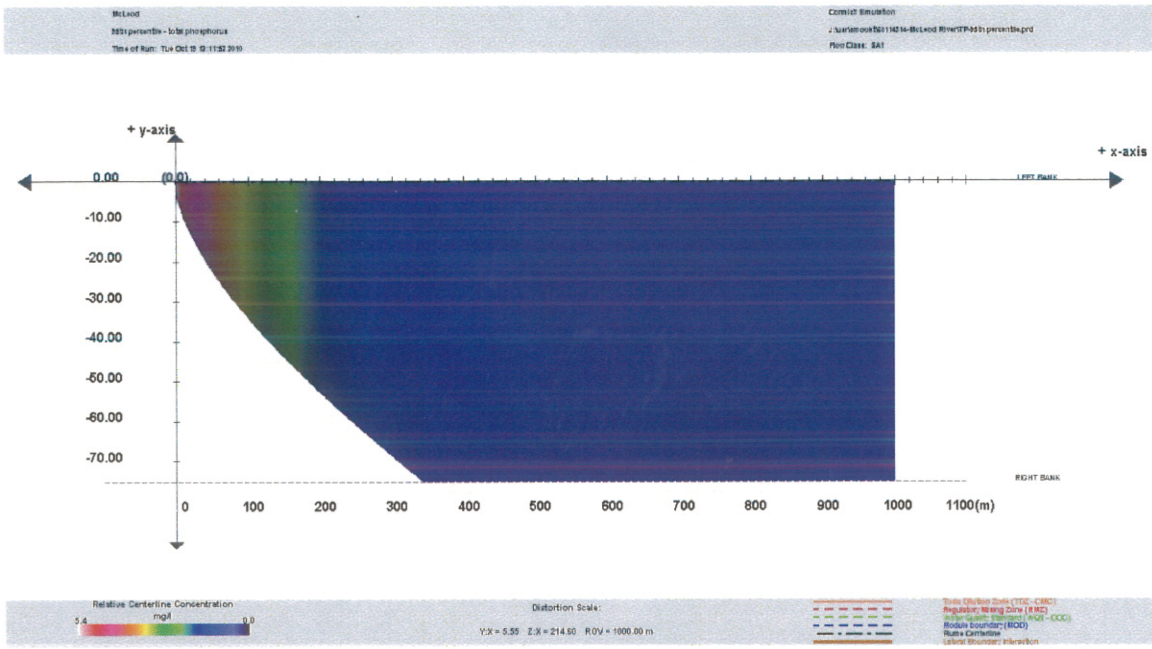


Figure 5-3. "Worst-Case" Scenario - CORMIX Overhead Perspective of Edson Wastewater Discharge Plume for Total Phosphorus Concentrations

<u>Total Phosphorus</u>

The color scale (shown in the bottom left corner of Figure 5-3) visually presents the concentrations (of the parameter of interest) in the plume, where red and yellow represents the highest concentrations, green represents average concentrations, and blue to black represent concentrations that are approaching background levels.

As noted above, the plume becomes completely mixed in McLeod River at a distance 550 m downstream of the lagoon discharge point. The WQG for total phosphorus is 0.05 mg/L, which should be reached at the point of complete mixing. The summer low-flow "worst case" scenario model predicts that total phosphorus concentrations will be 0.19 mg/L at the point of complete mixing, and therefore exceed the WQG.

<u>Ammonia</u>

The overhead perspective of the Edson WW Lagoon discharge plume for ammonia concentrations is illustrated in Figure 5-4. The plume becomes completely mixed in the McLeod River at a distance 550 m downstream of the lagoon discharge point. The CCME Canadian Environmental Quality Guideline for un-ionized ammonia is 0.019 mg/L, which should be reached by the point of complete mixing. Un-ionized ammonia concentrations within the plume in the McLeod River were calculated using a river temperature of 15.98°C and pH of 8.44, which are the 75th percentile summer measurements collected from the AENV McLeod River Water Quality Station AB07AG0045.

The summer low-flow "worst case" scenario model predicts that ammonia concentrations will be 0.0437 mg/L at the point of complete mixing, resulting in an un-ionized ammonia concentration of 0.0032 mg/L, which meets the CCME Guideline. The Guideline for un-ionized ammonia is met at a distance of 320 m downstream of the lagoon outfall, corresponding with an ammonia concentration of 0.26 mg/L.

In the summer low-flow "worst case" scenario, the outfall ammonia concentration is 28.34 mg/L. At a 95th percentile temperature and pH of 23.4°C and 8.98, respectively, this converts to an un-ionized ammonia concentration of 9.17 mg/L that exceeds the draft limit.

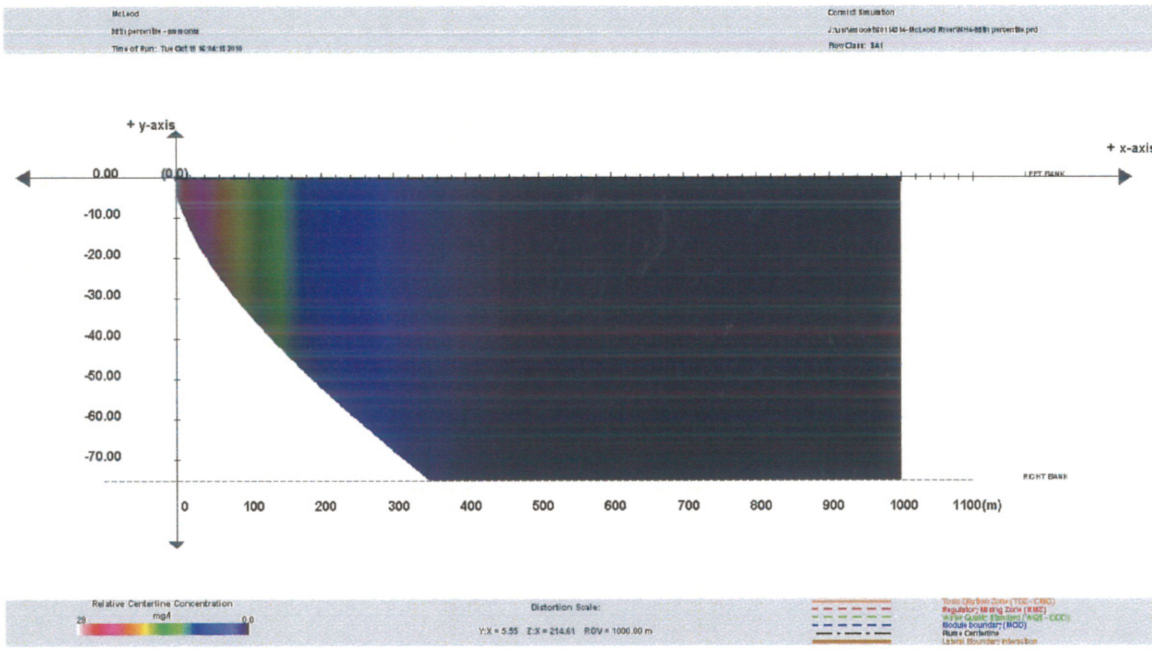


Figure 5-4. "Worst-Case" Scenario - CORMIX Overhead Perspective of Edson Wastewater Discharge Plume for Ammonia Concentrations

5.3 Summary

Results from the September 2010 scenario suggest that the effluent plume tends to hug the nearby left bank and does not spread laterally across the river within the first 4000 m because the flow in the McLeod River is much higher than the flow from the lagoon outfall. Under this model scenario, TP concentrations approached background concentrations by about 1000 m downstream while ammonia concentrations approached background concentrations at about 4000 m downstream (Table 5-4). The WQO for TP was met by 180 m downstream and the WQO for un-ionized ammonia was met by 80 m downstream even though the un-ionized ammonia in the effluent was 1.55 mg/L and above the draft wastewater regulation limit of 1.25 mg/L.

Results from the low-flow model scenario suggest that the flows in the McLeod River are weak enough that the plume is able to quickly spread laterally across the width of the river. Under these conditions, the effluent plume will become fully laterally mixed (i.e., encounter the opposite bank) at a distance of approximately 350 m from the lagoon outfall, and become fully vertically mixed (i.e., encounter the river bottom) at a distance of approximately 550 m from the lagoon outfall (Table 5-5). TP at this point of complete mixing will be 0.19 mg/L and thus exceed the WQO. Under this scenario, the WQO for un-ionized ammonia is reached by 320 m downstream. Also under this scenario, the outfall total ammonia concentration is 28.34 mg/L which converts to un-ionized ammonia of 9.17 mg/L. Thus the un-ionized ammonia at the discharge point exceeds the draft limit but the WQO is still reached within the mixing zone.

The limit of the physical mixing zone, the point at which the plume is fully mixed laterally and vertically, is more than 4000 m downstream of the outfall as predicted in September 2010 conditions (30 m^3/s) or 550 m in low-flow conditions (1.54 m^3/s). The allocated mixing zone, the point at which WQO are achieved, is more than 550 m for TP and 320 m for un-ionized ammonia in low-flow conditions. Phosphorus is not a toxic component but it does cause excessive algal growth. It would be appropriate to set an allocated mixing zone of 320 m for both parameters because toxicity would not be a concern but it would be more conservative to set an allocated mixing zone of 550 m to allow for adequate assimilation of P. In addition, another outfall or intake should be more than 550 m downstream of the Edson outfall as based on current effluent quality and mixing zone estimates, such that there are no additional discharges or water withdrawals within the allocated mixing zone.

Table 5-4. Summary of Model Results – September 2010 Conditions

Scenario – September 2010 Conditions	TP	NH_4	NH_3
Effluent Concentrations (mg/L)	2.6	15.9	**1.55**
Is Effluent Acutely Toxic?	No		**Yes**
Distance downstream (m) to complete mixing (i.e. physical mixing zone and plume mixed laterally and vertically)	>4000		>4000
Concentration at distance of complete mixing (mg/L)	<0.02		<0.005
Distance downstream (m) to achieve WQO (TP=0.05 mg/L; NH_3=0.019 mg/L)	180		80
Allocated Mixing Zone Distance Downstream (m)	180		180
WQO objectives achieved within Allocated Mixing Zone?	Yes		Yes

Table 5-5. Summary of Model Results – Low-flow Worst Case Conditions

Scenario – Low flow Worst Case Conditions	TP	NH_4	NH_3
Effluent Concentrations (mg/L)	5.38	28.34	**9.17**
Is Effluent Acutely Toxic?	No		**Yes**
Distance downstream (m) to complete mixing (i.e. physical mixing zone and plume mixed laterally and vertically	550 m		550 m
Concentration at distance of complete mixing (mg/L)	**0.19 mg/L**		0.0032 mg/L
Distance downstream (m) to achieve WQO (TP=0.05 mg/L; NH_3=0.019 mg/L)	>550 m		320 m
Allocated Mixing Zone Distance Downstream (m)	550 m		550 m
WQO objectives achieved within Allocated Mixing Zone?	**No**		Yes

6. Analysis

6.1 Effluent Quality

This effluent characterization study was completed to provide a detailed characterization of treated effluent quality being released from the Edson wastewater facility. The Edson facility is a mechanical aerated lagoon and as such certain effluent quality, as based on the technology, is assumed (Prince *et al.* 1994). Effluent quality as determined through this characterization program is compared to assumed technology limits for this type of facility (Table 6-1). As discussed above, the facility is functioning and meeting objectives and standards for cBOD and TSS (as based on average concentrations, but not as based on 95th percentile concentrations). In addition, as based on the assumed technology performance for this type of facility, it is not meeting technology limits (based on 95th percentile of measured effluent) for winter ammonia, summer ammonia, total nitrogen, total phosphorus and yearly TSS.

Table 6-1. Effluent Quality - Technology versus Measured Data

Parameter	Units	Technology (Prince *et al.* 1994)	Measured Effluent Quality (Annual Data)			% Different From Technology Standard		
			Mean	90th Percentile	95th Percentile	Mean	90th Percentile	95th Percentile
cBOD	mg/L	25	8.41	15.38	16.2	-66.34	-38.48	-35.20
TSS	mg/L	25	12.4	35.00	38.5	-50.40	**40.00**	**54.00**
TN	mg/L	30	25.721	38.25	41.15	-14.26	**27.50**	**37.17**
TN-Winter	mg/L		30.822	41.03	42.59			
TN-Summer	mg/L		20.195	33.991	35.651			
NH_4			21.019	34.60	34.875			
NH_4-Winter	mg/L	20	27.854	34.84	35.295	**39.27**	**74.20**	**76.48**
NH_4-Summer	mg/L	10	13.615	27.38	28.34	**36.15**	**173.80**	**183.40**
NH_3^a			0.903	2.347	6.217			
NH_3^b			0.558	0.798	1.046			
NH_3^a-Winter			0.241	0.415	0.493			
NH_3^b-Winter			0.482	0.603	0.611			
NH_3^a-Summer			1.62	6.268	6.885			
NH_3^b-Summer			0.641	1.054	1.145			
TP	mg/L	3.7	4.472	5.03	5.215	**20.86**	**35.95**	**40.95**

Note: A- un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection; B – un-ionized ammonia calculated based on temperature and pH (75th Percentile) of river in either summer or winter as defined previously; Winter mid-October to early May (n=13 samples); Summer mid April to early October (n=12 samples)

Based on the effluent quality data results and toxicity testing results, it appears that at least one parameter of concern is the quantity of total ammonia (and estimated un-ionized ammonia) in the effluent. Effluent chemistry in the four samples collected for toxicity testing was evaluated further. Concentration of total and un-ionized ammonia between samples was highly variable (Table 6-2). Likewise concentrations of surfactants was variable between samples and was lowest in the September sample when toxicity, as based on three of the four test organisms, was considered non-toxic (Figure 3-9). Likewise TSS, cBOD and COD were lowest in the September sample. In contrast, sulphate and surfactants were highest in the December sample which corresponds to the only sample set with recorded mortality in *Daphnia* (Figure 3-9).

Temperature and pH were also reported along with the toxicity test results and it was noted that effluent temperature was higher in the toxicity test samples as compared to the temperature and pH recorded at the time of sample collection. Since the proportion of un-ionized ammonia in a sample is a function of pH and temperature, un-ionized ammonia during the toxicity tests was also calculated (Table 6-2). Un-ionized ammonia calculated based on the concentration of total ammonia and pH and temperature of effluent at the time of sample collection is a reasonable estimate of the concentration and load of un-ionized ammonia entering the river. Un-ionized ammonia calculated based on the concentration of total ammonia and pH and temperature of effluent at the time of toxicity testing is a reasonable estimate of the concentration of un-ionized ammonia to which the test organisms were exposed.

Table 6-2. Effluent Chemistry in Toxicity Test Samples

Date Sampled	Units	DL	25-Jun-09	03-Sep-09	08-Dec-09	30-Mar-10
FIELD VALUES						
pH			8.52	8.27	8.13	7.89
Effluent Temperature	°C		16.4	20.4	1.4	1.8
Conditions			normal operations	nice weather, highs over 20	all ponds frozen	finishing pond still frozen; aerated ponds frozen around edges only
CONDITIONS DURING TOXICITY TESTING ON TROUT						
pH			8.3	8.32	8.25	8.0
Temperature	°C		16	15	14.5	15
GENERAL CHEMISTRY						
TSS	mg/L	3	26	5	7.0	14.0
TDS	mg/L	-	748	705	911	804
Conductivity (EC)	µS/cm	0.2	1330	1220	1580	1540
pH	pH	0.1	8.50	8.38	8.05	8.09
Alkalinity	mg/L	5	528	483	661	600
Bicarbonate (HCO_3)	mg/L	5	603	573	806	732
Sulfate (SO_4)	mg/L	0.5	37.4	36.9	104.0	35.0
NUTRIENTS						
NH_4	mg/L	0.05	13.9	5.67	27.4	35.4
NH_3 (Calculated)[a]			1.26	0.40	0.33	0.26
NH_3 (Calculated)[b]			1.01	0.41	0.47	0.61
NH_3 (calculated)[c]			0.76	0.3	1.21	0.93
$NO_3 + NO_2$	mg/L	0.071	2.66	2.50	0.31	<0.071
NO_3	mg/L	0.05	2.03	2.02	0.31	<0.050
NO_2	mg/L	0.05	0.63	0.48	<0.050	<0.050
TKN	mg/L	0.2	22.90	8.34	27.60	36.9
TP	mg/L	0.02	5.41	3.52	4.57	4.69
TDP	mg/L	0.02	4.41	3.54	4.48	4.41
OXYGEN DEMAND						
cBOD	mg/L	2	12.00	2.60	15.8	15.2
COD	mg/L	5	88.50	46.40	131	89.6
Total Metals						
Aluminum (Al)	mg/L	0.01	0.24	0.22	0.0467	
VOLATILE ORGANIC COMPOUNDS						
Chloromethane	mg/L	0.01	<0.010	0.02	<0.010	
SURFACTANTS						
Anionic Surfactants	mg/L	0.03	0.19	0.13	0.44	0.38
TOXICITY TESTS						
Ceriodaphnia-LC50	%		49.00	>100	51.00	21.00
Fathead Minnow-LC50	%		42.00	>100	33.00	33.00
Trout-LC50	%		47.00	59.00	35.00	35.00
Daphnia-LC50	%		>100	>100	89.00	>100

Note: A- un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection; B – un-ionized ammonia calculated based on temperature and pH (75th Percentile) of river in either summer or winter as defined previously; C - un-ionized ammonia calculated based on temperature and pH during toxicity testing on trout

AENV requested Edson to complete an effluent characterization and receiving environment study designed around the CCME MWWE strategy (CCME 2009). The study to meet this condition has been completed. While initial data and information has been gathered through this study on the immediate receiving environment, additional information on the receiving environment will be required if site-specific receiving water objectives need to be determined.

6.2 Parameters of Concern

Based on the results of the wastewater characterization and the receiving water model the identified parameters of concern in the Edson effluent are as follows:

- Total and un-ionized ammonia.
- Total nitrogen.
- Total phosphorus.
- Total suspended solids.
- Anionic surfactants.
- Toxicity of effluent.

6.3 Wastewater Discharge Concentrations

CORMIX was used to model and predict the physical and allocated mixing zones for the Edson wastewater effluent. Worst-case conditions, defined by 7Q10 flow in the river, 75^{th} percentile upstream water quality in the river, 95^{th} percentile effluent quality and 95^{th} percentile effluent flow rate were used. Effluent discharged to a receiving water body should meet two general components: the effluent must not be acutely toxic and in-stream conditions water quality objectives must be met by the end of the allocated mixing zone.

Toxicity of the effluent was determined by results from whole effluent toxicity testing while published in-stream guidelines for TP (ASWQG = 0.05 mg/L) and un-ionized ammonia (CCME = 0.019 mg/L) were used to determine compliance within the mixing zone.

In the low-flow scenario modelling, it was predicted that complete mixing would be achieved by 550 m downstream of the outfall. To meet the WQO for total phosphorus by 550 m downstream of the outfall, the concentration of TP in the effluent would have to be 1.4 mg/L or less. Mean effluent TP over the length of this study was 4.3 mg/L. While this is not acutely toxic, concentrations this high will not allow the WQO to be met within the mixing zone in low-flow conditions. Thus to achieve the condition of meeting the WQO by the end of the mixing zone, effluent TP concentration should be no higher than 1.4 mg/L.

In the low-flow scenario modelling, it was predicted that at the current 95^{th} percentile ammonia concentration in the effluent of 28.34 mg/L (9.17 mg/L un-ionized ammonia), the in-stream concentration would be 0.0032 mg/L at 550 m downstream of the outfall and thus would meet the CCME guideline in the allocated mixing zone. Therefore, based solely on meeting the in-stream guideline, the 95^{th} percentile ammonia concentration in the effluent is adequate. However the 95^{th} percentile ammonia and un-ionized ammonia is acutely toxic to aquatic life, so based on meeting the criteria of not acutely toxic, the effluent fails. The draft wastewater limit for un-ionized ammonia in effluent is 1.25 mg/L. If the final effluent has an un-ionized ammonia concentration of less than 1.25 mg/L, the effluent should be non-toxic and the in-stream criteria for un-ionized ammonia in the mixing zone would be met.

6.4 Monitoring Program

It has been suggested to develop a monitoring program to understand upstream variability in the identified parameters of concern, but also to assist in developing site-specific environmental quality objectives. A monitoring program could also be framed as an impact assessment study, tailored to answer specific questions. An additional benefit of a monitoring program is that the data collected can be used to continually refine the mixing zone assessment under various flow and seasonal conditions to understand potential impacts under different scenarios.

A monitoring program could include sampling at the same stations used in the September field program to capture spatial variability:

- US100
- DS100
- DS300
- DS1000
- DS4300

To capture temporal variability, sampling at the above stations could occur in different seasonal periods (e.g., winter, spring, summer and fall). As identified from the effluent characterization program, ammonia in the effluent loads discharged in the spring and sometimes the fall have the potential to be toxic (Figure 3-7). The total load of ammonia in winter is extremely high and even though it does not appear to be toxic in the released effluent, it may have other effects under the ice in the receiving environment. A temporal sampling program could include collection of samples by:

- Seasons:
  - Winter (e.g., February)
  - Spring (e.g., May)
  - Summer (e.g., August)
  - Fall (e.g., October)

The spatial and temporal monitoring program has been identified above, but the next step is to identify the sampling parameters. A monitoring program could include sampling and analysis for water quality, effluent quality, supporting environmental variables, benthic communities, fish communities and human health.

- Effluent and River Water Analysis:
  - Total Ammonia
  - Total Phosphorus
  - Total Suspended Solids
  - Surfactants
  - River and effluent flow on day of sampling
  - pH, conductivity, temperature and dissolved oxygen
  - Optional additional parameters could include BOD, cBOD and Total Nitrogen
- Benthic Algae
  - Cover
  - Biomass ash-free dry weight and Chlorophyll *a*
- Benthic Invertebrates:
  - Identification to species
  - Community composition and diversity indicators (e.g., diversity, evenness, density, difference between samples)
- Fish Habitat:
  - Map habitat types and quantification of habitat types
  - Habitat suitability
- Fish Community:
  - Fishing during different seasons to assess utilization of the area by different species in comparison to a reference area

A basic monitoring framework for the identified monitoring program components is provided below in Table 6-3.

Table 6-3. Simplified Suggested Sampling Program for a Monitoring Program in the McLeod River

	Where to Sample	When to Sample	What to Sample
Water Quality	Upstream, mixing zone, downstream, final effluent stream	Winter, spring, summer, fall	Effluent and river water for parameters identified above
Benthic Algae	Upstream, mixing zone, downstream	Fall	Survey for coverage assessment, ash-free dry weight, biomass
Invertebrates	Upstream, mixing zone, downstream	Spring or fall	Benthic invertebrate assemblages for identification to lowest taxonomic level
Fish Habitat	Far upstream, upstream, mixing zone, downstream far downstream	During low-flow conditions	Identification and delineation of habitat types
Fish Community	Far upstream, upstream, mixing zone, downstream far downstream	Spring and fall	Capture and release to identify and quantify fish community structure

6.5 Wastewater Treatment and Disinfection Options

6.5.1 Introduction

Based on the receiving water sensitivity modelling that has been conducted, proposed effluent nutrient limits have been established for the wastewater treatment plant. For total phosphorus, a maximum effluent concentration has been set at 1.4 mg/L. Effluent ammonia has been examined based upon an end of pipe toxicity threshold for un-ionized ammonia. Where Alberta does not set a specific effluent un-ionized ammonia target, a range was developed using the established targets from Ontario (0.1 mg/L) and those proposed in the draft Federal W*astewater Systems Effluent Regulations (1.25 mg/L*). Based upon current effluent temperature and pH values, total ammonia under worst case conditions (95th percentile of summer effluent quality) would correspond to 0.31 mg/L (Ontario guideline) and 3.86 mg/L (draft Federal guideline), respectively.

In its existing configuration, the town's wastewater treatment plant would be incapable of meeting these nutrient limits. Therefore, a series of treatment options have been derived to address these limits. The options noted below range from retrofits of the existing system, to implementation of a greenfield solution. Prior to outlining these options, the mechanisms of phosphorus and ammonia reduction will be discussed briefly.

6.5.1.1 Phosphorus Removal

Phosphorus can be reduced in the wastewater by one of two commonly used mechanisms:

- Chemical removal, or
- Biological removal.

Chemical phosphorus removal is accomplished through the additional of metal salts to the wastewater in order to encourage the precipitation of the soluble form of the total phosphorus. Metal salts based on aluminum and iron are the most commonly used precipitation chemicals. Aluminum sulphate (alum) is perhaps the most commonly used chemical for phosphorus reduction. On a weight basis, the ratio of alum to phosphorus removed ranges from approximately 15:1 to 20:1. This chemical is best dosed at the effluent end of an aeration basin, followed by a quiescent settling zone. Depending on the effluent total phosphorus target, filtration can also be used as a physical means of removing the precipitated phosphorus from the effluent stream.

Biological phosphorus reduction requires a two-step reaction that stores excess soluble ortho-PO_4 in the biomass prior to removal in sludge wasting systems. The following summarizes these two biological steps:

- Anaerobic conditions:
  - The first step under anaerobic conditions releases stored soluble ortho-PO_4 from within the phosphorus accumulating organisms (PAOs). Simultaneously the PAOs absorb volatile fatty acids (VFAs) and store this food source as polyhydroxylbutyrate (PHB) or other similar storage compounds; and
- Aerobic and anoxic conditions:
  - In the second step under aerobic/anoxic conditions, the PAOs utilize the stored PHB as a food source for rapid cell growth and then re-absorb the available soluble ortho-PO_4 previously released. If the environmental conditions in both stages are carefully controlled, the PAOs will absorb ortho-PO_4 in excess of the original release, thus creating a net removal mechanism.

Optimizing the process requires control and manipulation of all potential anaerobic, aerobic/anoxic environments within the entire process train as well as provision of an adequate supply of VFA's required to stimulate the release/uptake mechanisms.

6.5.1.2 Nitrogen Removal

Ammonia removal, or nitrification, is a biological reaction occurring as a result of combining NH_4, dissolved oxygen (D.O.), and the right type/number of nitrifying organisms for a controlled period of time. The result is biological oxidation of NH_4-nitrogen (NH_4) to nitrate-nitrogen (NO_3). No net removal of nitrogen is accomplished; the nitrogen compound is simply raised to a higher state of oxidation. In a suspended growth system (e.g. activated sludge) the growth of nitrifying bacteria is a relatively slow process. The time required (days) to grow nitrifying bacteria is normally described as the solids retention time (SRT) or mean cell residence time (MCRT). There are also many environmental factors which affect the nitrifying bacteria growth rate. Presence of NH_4-nitrogen, dissolved oxygen level, soluble BOD present, SRT, wastewater temperature and pH, and trace elements are important environmental factors. With regards to cold climate lagoons, the factors of SRT and temperature are often the dictating parameters with respect to nitrification.

6.5.2 Treatment Options

In terms of the options available to treat effluent to the suggested effluent guidelines noted above, there are two broad categories. These include either retrofitting existing infrastructure, or building a new greenfield facility. The information provided below offers an overview of the technologies; however, it is recommended that this analysis be further refined in the future to determine the best life cycle cost option for the Town.

6.5.2.1 Lagoon Retrofits

In considering a retrofit for the existing aerated lagoon, the main objective is to increase the sludge age to encourage the growth of nitrifying bacteria. There are three configurations that can be considered to accommodate nitrification using the existing infrastructure, which include:

- Media addition to aeration basin.
- Addition of a tertiary nitrification filter.
- Conversion to extended aeration activated sludge.

For all three of the noted retrofit options, the most viable means of phosphorus reduction would be the addition of alum or another metal salt. This is a commonly used practice for lagoon-based systems where biological phosphorus removal may prove to be a challenge.

Media Addition

Media addition to a portion of the aeration lagoon provides additional surface area for the growth of biomass, which in turn encourages the growth of the required nitrifying bacteria. In the context of a lagoon retrofit, the media can be a submerged synthetic packing media (moving bed biofilm reactor), or a suspended rope-like media which creates a baffle or curtain within the basin. For either version of this retrofit, only a portion of the existing aerated lagoon would be required to be modified. In terms of advantages, this option may be the lowest cost of the three retrofit variations. With respect to disadvantages, managing the media within the aerated basin could prove to be an operational challenge.

Tertiary Nitrification

Tertiary treatment can be used as an add-on process to the aerated lagoon to accommodate nitrification. Various proprietary processes exist that utilize this form of nitrification for cold weather ammonia reduction. An example of this technology has been developed by Nelson Environmental (Winnipeg, MB). Their submerged attached growth reactor (SAGR) consists of a linear aeration grid overlaid by a gravel bed, with effluent flowing through the substrate horizontally, vertically upward, or vertically downward. Where upgrades are required, the SAGR can often be installed within the layout of an existing lagoon treatment system. This technology has the advantage of being a proven cold climate nitrification technology. However, the construction of the below grade reactor may be limited to available land and favourable soil conditions.

Extended Aeration Activated Sludge

With the addition of secondary clarification and return sludge pumping, a portion of the aerated lagoon could be converted to an extended aeration activated sludge process. The return sludge stream would allow biomass to be built up in the lagoon/aeration basin increasing solids retention time, and therefore the population of nitrifying bacteria. Of the retrofit options, this may have the highest implementation cost, but would also offer the best opportunity for controlling cold weather nitrification.

6.5.3 Greenfield WWTP

A final treatment option would involve the construction of a greenfield biological nutrient removal (BNR) plant. This variant of the activated sludge process can be designed to reduce ammonia and phosphorus concentrations in the effluent using a combination of anaerobic, anoxic and aerobic environments (mechanisms described earlier in this section). Typical results achievable by a cold climate BNR process are as follows:

- Total P < 0.5 mg/L (without filtration)
- Total Nitrogen < 6 mg/L (including total ammonia < 1 mg/L)
- BOD and TSS removals to < 10 mg/L

A typical BNR process configuration is outlined in Figure 6-1. This is a similar process that is used at the Jasper, Goldbar, and Alberta Capital Region WWTPs.

This process would offer the best effluent quality during both summer and winter conditions; however, it would have the highest capital cost and would require a higher level of operator qualification.

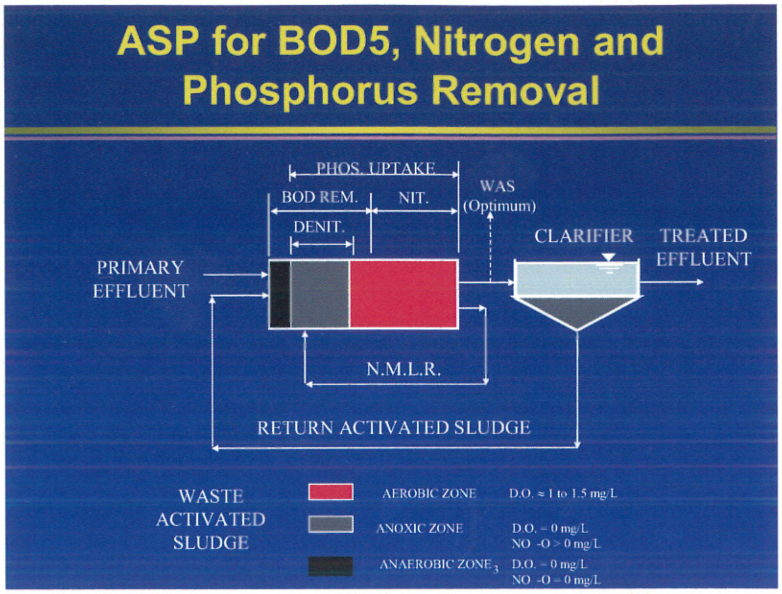


Figure 6-1. Typical BNR Process Configuration

6.5.4 Outfall Options

A wastewater facility may need to consider a new outfall if the current structure cannot meet outflow demands or if enhanced mixing of effluent in the river is required. To determine various outfall options, site-specific information on conditions of the McLeod River in the vicinity of the outfall will be required. Site-specific information needs to cover the entire cross section of the river for a certain distance upstream (e.g., 100 m) and downstream (e.g., 300 m) of the proposed outfall. Some of the site-specific information that will be required for this area includes:

- Fish habitat and fish usage.
- Substrate composition.
- Water flow and velocity (all seasons).
- Water depth (all seasons).
- Ice thickness.

General categories of outfall structure that could be considered are side-bank discharge and submerged effluent diffuser. The general positives and negatives of these are listed below in Table 6-4. Once various conceptual designs have been developed and additional site-specific information has been gathered, the design options should be reviewed with the various regulatory authorities (e.g., AENV, Department of Fisheries and Oceans Canada, Transport Canada) for their input and to develop the preferred option for this location.

Table 6-4. General Outfall Configuration Positives and Negatives

Outfall Type	Positives	Negatives
Side-bank	• Easier installation and maintenance • Minimal impact to fish habitat • No or minimal navigation hazard • Low susceptibility to damage from ice floes	• Aesthetics • More potential for foaming and visibility of effluent plume • Less mixing than for a submerged diffuser
Submerged Diffuser	• Enhanced mixing of effluent in the river • Not directly obvious to public	• Difficult to install and maintain • Safety concerns around thin ice in the winter • Damage due to ice scour or extremely low river levels • Require a minimal water depth year round • Potential for significant alteration or impact to fish habitat

7. Summary

7.1 Conclusions

The effluent characterization program and sensitivity study as per the CWS requirements and EPEA approval requirements is complete. The effluent characterization program, though a time consuming and costly process, produced some very useful results on the current functioning of this wastewater facility and provided an opportunity to quantify loads of effluent to the river. Some of the main results of the effluent characterization program are summarized as follows:

- Effluent flows are relatively consistent between months and years.
- Effluent concentration of TP and TDP was fairly consistent between samples.
- Effluent concentration of total and un-ionized ammonia was not consistent between samples and was very high in the winter and spring.
- Concentration of cBOD met the approval and NPS limits but was highly variable between samples.
- Concentration of anionic surfactants was variable between samples and may be a parameter of concern.
- *Cryptosporidium* was not detected in any samples while *Giardia* was detected in three of four samples; however, this facility is not designed to remove these pathogens.
- The effluent was always toxic to trout.
- The initial mixing zone assessment suggested that under moderate flow conditions:
  - Distance downstream to complete mixing was more than 4000 m but that TP and ammonia were less than the WQO and upstream concentrations
  - WQO for TP are met within 180 m and within 80 m for un-ionized ammonia
- The mixing zone assessment suggested that under extreme low flow conditions:
  - Distance downstream to complete mixing was 550 m un-ionized ammonia was less than the WQO, but TP was more than the WQO
  - The WQO for ammonia is met with 320 m downstream of the outfall

7.2 Recommendations

Based on the results of this study, the following recommendations for follow-up work are made:

- Effluent quality should be improved to reduce concentrations of total ammonia.
- Effluent quality should be improved to reduce concentrations of un-ionized ammonia to meet draft guidelines of 1.25 mg/L or less.
- Effluent quality should be improved to the extent that it is not acutely lethal.
- Effluent quality should be improved so that TSS can meet the NPS of 25 mg/L (typically effluent does not meet this limit for the period May to July).
- Effluent quality needs to be improved to decrease concentration of TP.
- Options were provided on ways to improve effluent quality and a follow-up feasibility study to cost out various upgrade, treatment options or outfall upgrade options should be completed.

A framework for a monitoring program has been developed. This should be discussed with AENV for development of an *Ambient and Effluent Quality Improvement Plan*. Effects monitoring of benthic invertebrates, fish and potential risk to human health could be included as part of this plan.

AENV provided comment that the Town of Edson will participate as an active member of the Athabasca Rainbow Trout Recovery Implementation Team. Details of this team and the involvement of the town need to be discussed and confirmed.

8. References

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A

Appendix A

Table A1. Analytical Data

Table A2. Field Notes

Table A3. September 2010 Analytical Data

Table A4. September 2010 Field Notes

Table A1. Edson Effluent Characterization and Risk Sensitivity Study - Analytical Data

Project
Report To
ALS File No.
Date Sampled
RESULTS OF ANALYSIS

Sample ID	Units	DL	DL	EFFLUENT-1	EFFLUENT-2	EFFLUENT-3	EFFLUENT #1	EFFLUENT #2	EDSON LAGOON EFFLUENT	TRAVEL BLANK	EFFLUENT	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1
ALS File No.				L770125	L770125	L770125	L777089	L777089	L783503	L783503	L790170	L796643	L802299	L808595
Date Sampled				29-May-09	29-May-09	29-May-09	12-Jun-09	12-Jun-09	25-Jun-09	25-Jun-09	10-Jul-09	24-Jul-09	7-Aug-09	21-Aug-09
Date Sampled	**Units**	All Dates Except as Noted	3-Sep-09	**28-MAY-09**	**28-MAY-09**	**28-MAY-09**	**11-JUN-09**	**11-JUN-09**	**25-JUN-09**	**25-JUN-09**	**09-JUL-09**	**23-JUL-09**	**06-AUG-09**	**20-AUG-09**
Time Sampled				11:00	11:00	11:00	13:50	13:50	00:00	00:00	14:15	00:00	00:00	13:00
ALS Sample ID				L770125-1	L770125-2	L770125-3	L777089-1	L777089-2	L783503-1	L783503-2	L790170-1	L796643-1	L802299-1	L808595-1
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests														
Total Suspended Solids	mg/L	3		40	47	43	32		26		35	<3.0	5	<3.0
Anions and Nutrients														
Alkalinity, Total (as CaCO3)	mg/L	5		524	522	522	525		528		479	486	496	479
Ammonia-N, total	mg/L	0.05		19.9			16	15.7	13.9		9.09	11	10.7	7.25
Un-ionized Ammonia[1]				5.9595			6.9878	6.8567	1.2552		0.3049	0.6801	0.2033	0.2297
Un-ionized Ammonia[2]				0.3444			1.1601	1.1384	1.0079		0.6591	0.7976	0.7758	0.5257
Un-ionized Ammonia[3]									0.7625					
Bicarbonate (HCO3)	mg/L	5		542	538	535	484		603		564	593	601	575
Carbonate (CO3)	mg/L	5		47.8	48.6	49.9	77		20.7		10	<5.0	<5.0	<5.0
Chloride (Cl)	mg/L	0.5		90.70	87.50	89.80	92.90		103.00		86.20	90.10	82.30	82.20
Conductivity (EC)	uS/cm	0.2		1260.00	1270.00	1270.00	1290.00		1330.00		1240.00	1240.00	1230.00	1220.00
Fluoride (F)	mg/L	0.05		0.99	1.08	1.08	0.92		0.87		0.79	0.84	0.72	0.74
Hardness (as CaCO3)	mg/L	-		115.00	109.00	114.00	129.00		148.00		153.00	196.00	205.00	194.00
Hydroxide (OH)	mg/L	5		<5.0	<5.0	<5.0	<5.0		<5.0		<5.0	<5.0	<5.0	<5.0
Ion Balance	%	-		103.00	89.70	90.00	97.40		93.50		94.70	102.00	94.90	90.40
Nitrate and Nitrite as N	mg/L	0.071		0.53	0.59	0.60	0.75		2.66		5.15	3.29	2.44	3.63
Nitrate (as N)	mg/L	0.05		0.34	0.39	0.40	0.48		2.03		4.86	3.06	2.13	3.26
Nitrite (as N)	mg/L	0.05		0.19	0.20	0.21	0.27		0.63		0.29	0.23	0.31	0.37
Total Kjeldahl Nitrogen	mg/L	0.2		35.40			23.30	22.40	22.90		14.40	13.60	13.50	9.58
pH	pH	0.1		8.79	8.80	8.81	9.00		8.50		8.39	8.25	8.30	8.32
Phosphorus, Total	mg/L	0.02		5.15			5.03	4.83	5.41		4.82	4.56	4.56	3.91
Phosphorus, Total Diss.	mg/L	0.02		4.40			3.75		4.41		4.08	4.54	4.48	3.65
TDS (Calculated)	mg/L	-		720.00	706.00	710.00	714.00		748.00		684.00	710.00	671.00	656.00
Sulfate (SO4)	mg/L	0.5		28.70	29.50	29.60	28.10		37.40		29.80	35.20	30.20	32.90
Cyanides														
Cyanide, Total	mg/L	0.002		<0.0020	<0.0020	<0.0020	<0.0020		0.00		0.00	<0.0020	0.00	0.00
Bacteriological Tests														
MF - E. Coli	CFU/100mL	1		20			65		2	<1	2200	3	8	8
MF - Fecal Coliforms	CFU/100mL	1		30			70		2	<1	2200	9	11	8
Crypto and Giardia see below		-							See Below					
Dissolved Metals														
Calcium (Ca)-Dissolved	mg/L	0.5		32.80	31.30	32.70	36.50		41.70		42.60	56.40	59.60	54.80
Magnesium (Mg)-Dissolved	mg/L	0.1		8.00	7.58	7.93	9.29		10.60		11.40	13.50	13.60	13.80
Potassium (K)-Dissolved	mg/L	0.5		12.70	12.50	12.30	11.20		11.60		10.90	11.80	10.60	9.71
Sodium (Na)-Dissolved	mg/L	1		230.00	222.00	222.00	217.00		214.00		192.00	196.00	166.00	158.00
Aggregate Organics														
Biochemical Oxygen Demand	mg/L	2		74.70	49.30	70.50								4.50
BOD Carbonaceous	mg/L	2					8.00		12.00		10.50	2.80	<2.0	<2.0
Chemical Oxygen Demand	mg/L	5		144.00	147.00	149.00	90.80		88.50		84.90	55.80	61.20	61.80
Bacteriological Tests-continued														
Cryptosporidium (oocysts)	# per 19.35 L	0							0.00					
Giardia (cysts)	# per 19.35 L	0							5.00					
Chronic Toxicity Tests	**Definition**				**Unit**									
Ceriodaphnia-LC25	effluent concentration lethal to 25% of population				% of whole effluent				21.00					
Ceriodaphnia-LC50	effluent concentration lethal to 50% of population				% of whole effluent				49.00					
Ceriodaphnia-IC25	effluent concentration inhibitory to 25% of population				% of whole effluent				<1.6					
Ceriodaphnia-IC50	effluent concentration inhibitory to 50% of population				% of whole effluent				2.70					
Fathead Minnow-LC25	effluent concentration lethal to 25% of population				% of whole effluent				n.a.					
Fathead Minnow-LC50	effluent concentration lethal to 50% of population				% of whole effluent				42.00					
Fathead Minnow-IC25	effluent concentration inhibitory to 25% of population				% of whole effluent				26.00					
Fathead Minnow-IC50	effluent concentration inhibitory to 50% of population				% of whole effluent				36.00					
Acute Toxicity Tests	**Definition**				**Unit**									
Trout-LC25	effluent concentration lethal to 25% of population				% of whole effluent				n.a.					
Trout-LC50	effluent concentration lethal to 50% of population				% of whole effluent				47.00					
Daphnia-LC25	effluent concentration lethal to 25% of population				% of whole effluent				>100					
Daphnia-LC50	effluent concentration lethal to 50% of population				% of whole effluent				>100					
Daphnia-EC25	Effective effluent concentration lethal to 25% of popu				% of whole effluent				>100					
Daphnia-EC50	Effective effluent concentration lethal to 50% of popu				% of whole effluent				>100					

Sample ID	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	Travel Blank	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT 1	EFFLUENT 2 (TRAVEL BLANK)
ALS File No.	L814376	L814376	L814376	L814376	L820162	L825837	L830508	L835472	L839732	L843885	L846996	L846996
Date Sampled	3-Sep-09	3-Sep-09	3-Sep-09	3-Sep-09	18-Sep-09	2-Oct-09	16-Oct-09	30-Oct-09 0	13-Nov-09 C	27-Nov-09	8-Dec-09	8-Dec-09
Date Sampled	**3-Sep-09**	**3-Sep-09**	**3-Sep-09**	**3-Sep-09**	**18-Sep-09**	**1-Oct-09**	**15-OCT-09**	**29-OCT-09**	**12-Nov-09**	**26-Nov-09**	**8-Dec-09**	**8-Dec-09**
Time Sampled							13:30	14:00	13:30	13:20		
ALS Sample ID	L-814376-1	L-814376-2	L-814376-3	L-814376-4	L820162-1	L825837-1	L830508-1	L835472-1	L839732-1	L843885-1		
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water		
Physical Tests												
Total Suspended Solids	5				<3.0	7	8.0	9.0	9.0	9.0	7.0	<3.0
Anions and Nutrients												
Alkalinity, Total (as CaCO3)	483				500	520	547	571	610	653	661	<5.0
Ammonia-N, total	5.67	5.58	5.38		6.11	8.36	11.8	16.1	20.3	24.6	27.4	-
Un-ionized Ammonia[1]	0.3959	0.3896	0.3756		0.1636	0.1099	0.2157	0.2236	0.3910	0.5108	0.3339	
Un-ionized Ammonia[2]	0.4111	0.4046	0.3901		0.4430	0.6062	0.2042	0.2786	0.3513	0.4258	0.4742	
Un-ionized Ammonia[3]	0.3025										1.2095	
Bicarbonate (HCO3)	573				606	624	662	697	744	796	806	<5.0
Carbonate (CO3)	8.3				<5.0	5.1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (Cl)	89.10				80.80	84.00	83.00	76.10	79.70	79.70	77.50	<0.50
Conductivity (EC)	1220.00				1220.00	1270.00	1310.00	1270.00	1420.00	1450.00	1580.00	<0.20
Fluoride (F)	0.84				0.82	1.05	0.99	0.96	1.14	1.00	1.08	<0.050
Hardness (as CaCO3)	220.00				200.00	201.00	197.00	178.00	173.00	158.00	133.00	<1.0
Hydroxide (OH)	<5.0				<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Ion Balance	101.00				104.00	91.00	98.40	97.50	98.10	97.20	94.90	Low TDS
Nitrate and Nitrite as N	2.50				0.68	0.54	0.74	0.64	0.61	0.45	0.31	<0.071
Nitrate (as N)	2.02				0.48	0.41	0.66	0.64	0.61	0.45	0.31	<0.050
Nitrite (as N)	0.48				0.20	0.13	0.09	<0.050	<0.050	<0.050	<0.050	<0.050
Total Kjeldahl Nitrogen	8.34	8.56	7.85		7.85	9.90	13.50	16.50	21.90	26.30	27.60	-
pH	8.38				8.30	8.33	8.32	8.28	8.09	8.25	8.05	5.91
Phosphorus, Total	3.52	3.51	3.54		3.71	3.74	3.75	3.76	3.96	4.35	4.57	-
Phosphorus, Total Diss.	3.54	3.53	3.53		3.49	3.53	3.69	3.48	3.72	1.47	4.48	-
TDS (Calculated)	705.00				697.00	692.00	732.00	735.00	783.00	817.00	911.00	<1.0
Sulfate (SO4)	36.90				29.90	37.80	35.40	32.50	35.20	34.10	104.00	<0.50
Cyanides												
Cyanide, Total	0.00				0.00	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Bacteriological Tests												
MF - E. Coli	<1	1	<1		4	1	200	7	45	130	60	
MF - Fecal Coliforms	<1	1	<1		6	1	200	7	60	130	130	
Crypto and Giardia see below	See Below											
Dissolved Metals												
Calcium (Ca)-Dissolved	61.50				57.20	56.60	54.80	49.20	48.50	45.30	37.9	<0.50
Magnesium (Mg)-Dissolved	16.10				14.00	14.40	14.60	13.40	12.70	10.80	9.37	<0.10
Potassium (K)-Dissolved	10.70				11.00	11.10	11.00	10.50	12.70	13.10	11.3	<0.50
Sodium (Na)-Dissolved	189.00				200.00	173.00	201.00	207.00	224.00	239.00	272	<1.0
Aggregate Organics												
Biochemical Oxygen Demand												
BOD Carbonaceous	2.60				2.20	2.60	5.10	2.70	8.00	10.80	15.8	<2.0
Chemical Oxygen Demand	46.40				46.50	51.50	44.60	49.60	48.60	52.00	131	15.4
Bacteriological Tests-continued												
Cryptosporidium (oocysts)	0.00										0.00	
Giardia (cysts)	0.00										3.00	
Chronic Toxicity Tests												
Ceriodaphnia-LC25	>100										n.a.	
Ceriodaphnia-LC50	>100										51.00	
Ceriodaphnia-IC25	27.00										14.00	
Ceriodaphnia-IC50	63.00										24.00	
Fathead Minnow-LC25	91.00										n.a.	
Fathead Minnow-LC50	>100										33.00	
Fathead Minnow-IC25	83.00										28.00	
Fathead Minnow-IC50	>100										34.00	
Acute Toxicity Tests												
Trout-LC25	45.00										n.a.	
Trout-LC50	59.00										35.00	
Daphnia-LC25	>100										>100	
Daphnia-LC50	>100										89.00	
Daphnia-EC25	>100										>100	
Daphnia-EC50	>100										89.00	

Sample ID	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	Travel Blank	Effluent	Effluent	Outfall
ALS File No.	L850619	L852728	L856730	L859779	L863236	L866913	L870507	L873283	L873283	L879869	L884108	L932044-1
Date Sampled	23-Dec-09	7-Jan-10	25-Jan-10	5-Feb-10	19-Feb-10	5-Mar-10	19-Mar-10	30-Mar-10	30-Mar-10	22-Apr-10	6-May-10	15-Sep-10
Date Sampled	**22-Dec-09**	**6-Jan-10**	**21-Jan-10**	**4-Feb-10**	**18-Feb-10**	**4-Mar-10**	**18-Mar-10**	**30-Mar-10**	**30-Mar-10**	**22-Apr-10**	**6-May-10**	**15-Sep-10**
Time Sampled												
ALS Sample ID												
Matrix												
Physical Tests												
Total Suspended Solids	6.0	6.0	5.0	7.0	6.0	7.0	5.0	14.0	-	19.5	38.0	
Anions and Nutrients												
Alkalinity, Total (as CaCO3)	676	676	669	646	650	650	643	600	-	503	561	503
Ammonia-N, total	29.6	30.1	32.6	31.7	34.6	34.7	33.2	35.4	<0.050	26.9	28.5	15.9
Un-ionized Ammonia[1]	0.1766	0.1766	0.1537	0.1638	0.1929	0.1566	0.1851	0.2579		0.8087	2.3469	1.5522897
Un-ionized Ammonia[2]	0.5123	0.5210	0.5642	0.5486	0.5988	0.6006	0.5746	0.6127		0.4656	0.4933	
Un-ionized Ammonia[3]								0.9298				
Bicarbonate (HCO3)	825	824	816	789	793	793	785	732	-	613	614	503
Carbonate (CO3)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	<5.0	34.6	54.3
Chloride (Cl)	80.20	89.1	99.7	105	108	112	109	098	-	82.0	88.2	78.7
Conductivity (EC)	1470.00	1520	1580	1600	1630	1650	1650	1540	-	1250	1330	1250
Fluoride (F)	1.14	1.28	1.34	1.26	1.22	1.31	1.32		-	1.01	1.00	0.897
Hardness (as CaCO3)	144.00	127	116	115	112	98.6	95.9	96.0	-	91.6	108	165
Hydroxide (OH)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	<5.0	<5.0	<5.0
Ion Balance	96.10	92.7	97.6	103	102	98.3	99.5	105.0	-	104	100	96.8
Nitrate and Nitrite as N	0.21	<0.071		<0.071	<0.071	<0.071	<0.071	<0.071	-	<0.071	0.136	3.3
Nitrate (as N)	0.21	<0.050		<0.050	<0.050	<0.050	<0.050	<0.050	-	<0.050	0.136	2.43
Nitrite (as N)	<0.050	<0.050		<0.050	<0.050	<0.050	<0.050	<0.050	-	<0.050	<0.050	0.867
Total Kjeldahl Nitrogen	32.00	28.6	37.5	40.5	42.9	38.2	34.9	36.9	<0.20	28.2	33.0	
pH	8.23	7.94		7.90	8.01	7.95	7.98	8.09	-	8.22	8.60	8.73
Phosphorus, Total	4.89	4.82	4.64	4.79	4.88	5.03	4.65	4.69	-	4.18	4.42	2.6
Phosphorus, Total Diss.	4.64	4.42	4.54	4.38	4.54	4.84	4.58	4.41	<0.020	3.75	4.02	2.07
TDS (Calculated)	828.00	832	858	869	866	862	859	804	-	679	739	701
Sulfate (SO4)	33.10	35.3	35.3	37.6	36.0	36.6	37.6	35.0	-	30.3	32.5	44.3
Cyanides												
Cyanide, Total	<0.0020	<0.0020	<0.0020	<0.0020				0.002	-			
Bacteriological Tests												
MF - E. Coli	500			8		420	78	46	-	4	50	
MF - Fecal Coliforms	900			9	196	460	136	50	-	4	50	
Crypto and Giardia see below												
Dissolved Metals												
Calcium (Ca)-Dissolved	40.40	35.2	31.0	30.9	29.8	26.0	25.4	25.9	-	26.5	29.6	46.1
Magnesium (Mg)-Dissolved	10.40	9.48	9.32	9.08	9.22	8.18	7.89	7.61	-	6.17	8.19	12.2
Potassium (K)-Dissolved	13.50	13.0	14.3	14.0	16.1	14.7	14.7	14.1	-	11.7	11.9	10
Sodium (Na)-Dissolved	243.00	243	266	284	276	273	277	263	-	220	230	192
Aggregate Organics												
Biochemical Oxygen Demand					16.8	24.3						47.8
BOD Carbonaceous	9.70			13.1	12.0	16.8	11.0	15.2	-	15.1	7.1	6.3
Chemical Oxygen Demand	69.30	78.0	76.7	82.1		84.9		89.6	-		93.2	
Bacteriological Tests-continued												
Cryptosporidium (oocysts)								0				
Giardia (cysts)								4				
Chronic Toxicity Tests												
Ceriodaphnia-LC25								11.00				
Ceriodaphnia-LC50								21.00				
Ceriodaphnia-IC25								15.00				
Ceriodaphnia-IC50								25.00				
Fathead Minnow-LC25								n.a.				
Fathead Minnow-LC50								33.00				
Fathead Minnow-IC25								18.00				
Fathead Minnow-IC50								30.00				
Acute Toxicity Tests												
Trout-LC25								n.a.				
Trout-LC50								35.00				
Daphnia-LC25								>100				
Daphnia-LC50								>100				
Daphnia-EC25								>100				
Daphnia-EC50								>100				

Table A1. Edson Effluent Characterization and Risk Sensitivity Study - Analytical Data

Project
Report To

ALS File No.				L770125	L770125	L770125	L777089	L777089	L783503	L783503	L790170	L796643	L802299	L808595	L814376	L814376	L814376	L814376	L820162	L825837	L830508	L835472	L839732	L843885	L846996	L846996	L850619	L852728	L856730	L859779	L863236	L866913	L870507	L873283	L873283	L879869	L884108	L932044-1
Date Sampled				29-May-09	29-May-09	29-May-09	12-Jun-09	12-Jun-09	25-Jun-09	25-Jun-09	10-Jul-09	24-Jul-09	7-Aug-09	21-Aug-09	3-Sep-09	3-Sep-09	3-Sep-09	3-Sep-09	18-Sep-09	2-Oct-09	16-Oct-09	30-Oct-09 0	13-Nov-09 (	27-Nov-09	8-Dec-09	8-Dec-09	23-Dec-09	7-Jan-10	25-Jan-10	5-Feb-10	19-Feb-10	5-Mar-10	19-Mar-10	30-Mar-10	30-Mar-10	22-Apr-10	6-May-10	15-Sep-10
RESULTS OF ANALYSIS																																						
Sample ID	Units	DL	DL	EFFLUENT-1	EFFLUENT-2	EFFLUENT-3	EFFLUENT #1	EFFLUENT #2	EDSON LAGOON EFFLUENT	TRAVEL BLANK	EFFLUENT	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	Travel Blank	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT 1	EFFLUENT 2 (TRAVEL BLANK)	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	Travel Blank	Effluent	Effluent	Outfall
Date Sampled	Units	All Dates Except as Noted	3-Sep-09	28-MAY-09	28-MAY-09	28-MAY-09	11-JUN-09	11-JUN-09	25-JUN-09	25-JUN-09	09-JUL-09	23-JUL-09	06-AUG-09	20-AUG-09	3-Sep-09	3-Sep-09	3-Sep-09	3-Sep-09	18-Sep-09	1-Oct-09	15-OCT-09	29-OCT-09	12-Nov-09	26-Nov-09	8-Dec-09	8-Dec-09	22-Dec-09	6-Jan-10	21-Jan-10	4-Feb-10	18-Feb-10	4-Mar-10	18-Mar-10	30-Mar-10	30-Mar-10	22-Apr-10	6-May-10	15-Sep-10
Total Metals																																						
Aluminum (Al)	mg/L	0.01	0.005						0.24	-					0.22			<0.0050							0.0467									0.0488	-			
Antimony (Sb)	mg/L	0.0004							<0.00040	-					0.00			<0.00040							<0.00040									0.00047	-			
Arsenic (As)	mg/L	0.0004							0.00	-					0.00			<0.00040							0.00196									0.00126	-			
Barium (Ba)	mg/L	0.005							0.09	-					0.07			<0.0050							0.0490									0.0421	-			
Beryllium (Be)-Total	mg/L	0.002	0.001						<0.0020	-					<0.0010			<0.0010							<0.0010									<0.0010	-			
Boron (B)	mg/L	0.05							0.31	-					0.27			<0.050							0.333									0.354	-			
Cadmium (Cd)	mg/L	0.0002							<0.00020	-					<0.00020			<0.00020							<0.00020									<0.00020	-			
Chromium (Cr)	mg/L	0.005							<0.0050	-					<0.0050			<0.0050							<0.0050									<0.0050	-			
Cobalt (Co)-Total	mg/L	0.002							<0.0020	-					<0.0020			<0.0020							0.00095									<0.010	-			
Copper (Cu)	mg/L	0.001							0.00	-					0.00			<0.0010							0.0092									0.0204	-			
Iron (Fe)	mg/L	0.02							0.59	-					0.52			<0.020							0.278									0.414	-			
Lead (Pb)	mg/L	0.0001							0.00	-					0.00			<0.00010							0.00090									0.00158	-			
Manganese (Mn)	mg/L	0.005							0.11	-					0.11			<0.0050							0.114									0.0976	-			
Mercury (Hg)-Total	mg/L	0.0001							<0.00010	-					<0.00010			<0.00010							<0.00010									<0.00010	-			
Molybdenum (Mo)-Total	mg/L	0.005							<0.0050	-					<0.0050			<0.0050							0.00353									0.00387	-			
Nickel (Ni)	mg/L	0.002							0.00	-					0.00			<0.0020							0.0051									0.0037	-			
Selenium (Se)	mg/L	0.002	0.0004						<0.0020	-					0.00			<0.00040							<0.0020									0.00045	-			
Silver (Ag)	mg/L	0.0004							<0.00040	-					<0.00040			<0.00040							<0.00040									<0.00040	-			
Sodium (Na)	mg/L	1							212.00	-					179.00			<1.0							220									253	-			
Strontium (Sr)-Total	mg/L	0.002							0.34	-					0.40			<0.0020							0.272									0.221	-			
Thallium (Tl)-Total	mg/L	0.05							<0.050	-					<0.050			<0.050							<0.00010									<0.20	-			
Tin (Sn)-Total	mg/L	0.05							<0.050	-					<0.050			<0.050							0.00048									0.00065	-			
Titanium (Ti)-Total	mg/L	0.001							0.01	-					0.01			<0.0010							0.0149									0.0123	-			
Uranium (U)	mg/L	0.0001							0.00	-					0.00			<0.00010							0.00092									0.00058	-			
Vanadium (V)-Total	mg/L	0.001							0.00	-					0.00			<0.0010							0.00108									<0.0050	-			
Zinc (Zn)	mg/L	0.004							0.02	-					0.02			<0.0040							0.0218									0.0336	-			
Volatile Organic Compounds																																						
Benzene	mg/L	0.0005							<0.00050	<0.00050					<0.00050										<0.00050									<0.00050	-			
Benzene	mg/L	0.001							<0.0010	<0.0010																												
Bromobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Bromochloromethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Bromodichloromethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Bromoform	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Bromomethane	mg/L	0.01							<0.010	<0.010					<0.010										<0.010													
n-Butylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
sec-Butylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
tert-Butylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Carbon tetrachloride	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Chlorobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Dibromochloromethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Chloroethane	mg/L	0.01							<0.010	<0.010					<0.010										<0.010													
Chloroform	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Chloromethane	mg/L	0.01							<0.010	<0.010					0.02										<0.010													
2-Chlorotoluene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
4-Chlorotoluene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2-Dibromo-3-chloropropane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2-Dibromoethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Dibromomethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2-Dichlorobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,3-Dichlorobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,4-Dichlorobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Dichlorodifluoromethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1-Dichloroethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2-Dichloroethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1-Dichloroethene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
cis-1,2-Dichloroethene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
trans-1,2-Dichloroethene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Methylene chloride	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2-Dichloropropane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,3-Dichloropropane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
2,2-Dichloropropane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1-Dichloropropene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
cis-1,3-Dichloropropene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
trans-1,3-Dichloropropene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
EthylBenzene	mg/L	0.0005							<0.00050	<0.00050					<0.00050										<0.00050									<0.00050	-			
Ethylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010																							
Hexachlorobutadiene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Isopropylbenzene	mg/L	0.001							<0.0010	<0.0010															<0.0010													
p-Isopropyltoluene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Naphthalene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
n-Propylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Styrene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1,1,2-Tetrachloroethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1,2,2-Tetrachloroethane	mg/L	0.005							<0.0050	<0.0050					<0.0050										<0.0050													
Tetrachloroethene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Toluene	mg/L	0.0005							<0.00050	<0.00050					<0.00050										<0.00050									<0.00050	-			
Toluene	mg/L	0.001							<0.0010	<0.0010																												
1,2,3-Trichlorobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2,4-Trichlorobenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1,1-Trichloroethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,1,2-Trichloroethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Trichloroethene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Trichlorofluoromethane	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,2,3-Trichloropropane	mg/L	0.002							<0.0020	<0.0020					<0.0020										<0.0020													
1,2,4-Trimethylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
1,3,5-Trimethylbenzene	mg/L	0.001							<0.0010	<0.0010					<0.0010										<0.0010													
Vinyl chloride	mg/L	0.02							<0.020	<0.020					<0.020										<0.020													
o-Xylene	mg/L	0.001							<0.0010	<0.0010																								<0.00050	-			
m+p-Xylenes	mg/L	0.001							<0.0010	<0.0010																								<0.00050	-			
Xylenes	mg/L	0.0005							<0.00050	<0.00050					<0.00050										<0.00050									<0.0010	-			
F1(C6-C10)	mg/L	0.1							<0.10	<0.10					<0.10										<0.10									<0.10	-			
F1-BTEX	mg/L	0.1							<0.10	<0.10					<0.10										<0.10									<0.10	-			
4-Bromofluorobenzene	%	63-125							84.00	84.00					87.00										87.00													
1,2-Dichloroethane d4	%	77-119							124.00	120.00					108.00										109.00													
Toluene d8	%	68-120							97.00	98.00					96.00										98.00													

Table A1. Edson Effluent Characterization and Risk Sensitivity Study - Analytical Data

Project
Report To

Sample ID	Units	DL	DL	EFFLUENT-1	EFFLUENT-2	EFFLUENT-3	EFFLUENT #1	EFFLUENT #2	EDSON LAGOON EFFLUENT	TRAVEL BLANK	EFFLUENT	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	Travel Blank	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT 1	EFFLUENT 2 (TRAVEL BLANK)	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	Travel Blank	Effluent	Effluent	Outfall
ALS File No.				L770125	L770125	L770125	L777089	L777089	L783503	L783503	L790170	L796643	L802299	L808595	L814376	L814376	L814376	L814376	L820162	L825837	L830508	L835472	L839732	L843885	L846996	L846996	L850619	L852728	L856730	L859779	L863236	L866913	L870507	L873283	L873283	L879869	L884108	L932044-1
Date Sampled				29-May-09	29-May-09	29-May-09	12-Jun-09	12-Jun-09	25-Jun-09	25-Jun-09	10-Jul-09	24-Jul-09	7-Aug-09	21-Aug-09	3-Sep-09	3-Sep-09	3-Sep-09	3-Sep-09	18-Sep-09	2-Oct-09	16-Oct-09	30-Oct-09 0	13-Nov-09 C	27-Nov-09	8-Dec-09	8-Dec-09	23-Dec-09	7-Jan-10	25-Jan-10	5-Feb-10	19-Feb-10	5-Mar-10	19-Mar-10	30-Mar-10	30-Mar-10	22-Apr-10	6-May-10	15-Sep-10
RESULTS OF ANALYSIS																																						
Date Sampled	**Units**	**All Dates Except as Noted**	**3-Sep-09**	**28-MAY-09**	**28-MAY-09**	**28-MAY-09**	**11-JUN-09**	**11-JUN-09**	**25-JUN-09**	**25-JUN-09**	**09-JUL-09**	**23-JUL-09**	**06-AUG-09**	**20-AUG-09**	**3-Sep-09**	**3-Sep-09**	**3-Sep-09**	**3-Sep-09**	**18-Sep-09**	**1-Oct-09**	**15-OCT-09**	**29-OCT-09**	**12-Nov-09**	**26-Nov-09**	**8-Dec-09**	**8-Dec-09**	**22-Dec-09**	**6-Jan-10**	**21-Jan-10**	**4-Feb-10**	**18-Feb-10**	**4-Mar-10**	**18-Mar-10**	**30-Mar-10**	**30-Mar-10**	**22-Apr-10**	**6-May-10**	**15-Sep-10**
Polycyclic Aromatic Hydrocarbons																																						
Acenaphthene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Acenaphthylene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Anthracene	mg/L	0.00001							<0.000010	-					<0.000010										<0.000010													
B(A)P Total Potency Equivalent	mg/L	0.00001							<0.000010	-					<0.000010										<0.000010													
Benzo(a)anthracene	mg/L	0.00001							<0.000010	-					<0.000010										<0.000010													
Benzo(a)pyrene	mg/L	0.00001							<0.000010	-					<0.000010										<0.000010													
Benzo(b&j)fluoranthene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Benzo(g,h,i)perylene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Benzo(k)fluoranthene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Chrysene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Dibenzo(a,h)anthracene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Fluoranthene	mg/L	0.00002							<0.000020	-					<0.000020										<0.000020													
Fluorene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Indeno(1,2,3-cd)pyrene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
1-Methylnaphthalene	mg/L	0.00001							<0.000010	-					<0.000050																							
2-Methylnaphthalene	mg/L	0.00001							<0.000010	-					<0.000050																							
Naphthalene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Phenanthrene	mg/L	0.00005							<0.000050	-					<0.000050										<0.000050													
Pyrene	mg/L	0.00002							<0.000020	-					<0.000020										<0.000020													
2-Fluorobiphenyl	%	37-123							87.00	-					76.00										81.00													
Nitrobenzene d5	%	24-132							88.00	-					77.00										78.00													
p-Terphenyl d14	%	41-143							75.00	-					84.00										85.00													
Phenolics																																						
4-Chloro-3-methylphenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2-Chlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
3-Chlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
4-Chlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
Total Cresols	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
2,3-Dichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,4 & 2,5-Dichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,6-Dichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
3,4-Dichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
3,5-Dichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,4-Dimethylphenol	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
2,4-Dinitrophenol	mg/L	0.01							<0.010	-															<0.010									<0.010	-			
4,6-Dinitro-2-methylphenol	mg/L	0.01							<0.010	-															<0.010									<0.010	-			
o-Cresol	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
m-Cresol	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
p-Cresol	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
2-Nitrophenol	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
4-Nitrophenol	mg/L	0.005							<0.0050	-															<0.0050									<0.0050	-			
Pentachlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
Phenol	mg/L	0.001							<0.0010	-															<0.0010									<0.0010	-			
2,3,4,5-Tetrachlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,3,4,6-Tetrachlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,3,5,6-Tetrachlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,3,4-Trichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,3,5-Trichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,3,6-Trichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,4,5-Trichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2,4,6-Trichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
3,4,5-Trichlorophenol	mg/L	0.0005							<0.00050	-															<0.00050									<0.00050	-			
2-Fluorophenol	%	1-91							41.00	-															87.00									70	-			
Phenol d5	%	0-94							28.00	-															79.00									35	-			
2,4,6-Tribromophenol	%	40-132							97.00	-															109.00									80	-			

Table A1. Edson Effluent Characterization and Risk Sensitivity Study - Analytical Data

Project
Report To

Sample ID	Units	DL	DL	EFFLUENT-1	EFFLUENT-2	EFFLUENT-3	EFFLUENT #1	EFFLUENT #2	EDSON LAGOON EFFLUENT	TRAVEL BLANK	EFFLUENT	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	EFFLUENT 1	Travel Blank	EFFLUENT 1	EFFLUENT	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT 1	EFFLUENT 2 (TRAVEL BLANK)	EFFLUENT	EFFLUENT STUDY	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	EFFLUENT	Travel Blank	Effluent	Effluent	Outfall
ALS File No.				L770125	L770125	L770125	L777089	L777089	L783503	L783503	L790170	L796643	L802299	L808595	L814376	L814376	L814376	L814376	L820162	L825837	L830508	L835472	L839732	L843885	L846996	L846996	L850619	L852728	L856730	L859779	L863236	L866913	L870507	L873283	L873283	L879869	L884108	L932044-1
Date Sampled				29-May-09	29-May-09	29-May-09	12-Jun-09	12-Jun-09	25-Jun-09	25-Jun-09	10-Jul-09	24-Jul-09	7-Aug-09	21-Aug-09	3-Sep-09	3-Sep-09	3-Sep-09	3-Sep-09	18-Sep-09	2-Oct-09	16-Oct-09	30-Oct-09 0	13-Nov-09 C	27-Nov-09	8-Dec-09	8-Dec-09	23-Dec-09	7-Jan-10	25-Jan-10	5-Feb-10	19-Feb-10	5-Mar-10	19-Mar-10	30-Mar-10	30-Mar-10	22-Apr-10	6-May-10	15-Sep-10
RESULTS OF ANALYSIS																																						
Date Sampled	**Units**	All Dates Except as Noted	3-Sep-09	28-MAY-09	28-MAY-09	28-MAY-09	11-JUN-09	11-JUN-09	25-JUN-09	25-JUN-09	09-JUL-09	23-JUL-09	06-AUG-09	20-AUG-09	3-Sep-09	3-Sep-09	3-Sep-09	3-Sep-09	18-Sep-09	1-Oct-09	15-OCT-09	29-OCT-09	12-Nov-09	26-Nov-09	8-Dec-09	8-Dec-09	22-Dec-09	6-Jan-10	21-Jan-10	4-Feb-10	18-Feb-10	4-Mar-10	18-Mar-10	30-Mar-10	30-Mar-10	22-Apr-10	6-May-10	15-Sep-10
Polychlorinated Biphenyls																																						
Aroclor 1016	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1221	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1232	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1242	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1248	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1254	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1260	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1262	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Aroclor 1268	mg/L	0.00001							<0.000010	-					<0.000010	<0.000010	<0.000010								<0.000010													
Total PCBs	mg/L	0.00005							<0.000050	-					<0.000050	<0.000050	<0.000050								<0.000050													
Decachlorobiphenyl	%	32-152	1						82.00	-					78.00	86.00	82.00								92	86												
Organochlorine Pesticides																																						
Aldrin	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
alpha-BHC	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
beta-BHC	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
gamma-BHC (Lindane)	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
cis-Chlordane	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
trans-Chlordane	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
p,p'-DDD	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
p,p'-DDE	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
p,p'-DDT	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Dieldrin	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Endosulfan I	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Endosulfan II	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Endrin	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Heptachlor	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Methoxychlor	mg/L	0.0002							<0.00020	-					<0.00020										<0.00020									<0.00020	-			
Mirex	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Nonachlor	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Oxychlordane	mg/L	0.0001							<0.00010	-					<0.00010										<0.00010									<0.00010	-			
Quintozene (PCNB)	mg/L	0.0001							<0.00010	-					<0.00010																			<0.00010	-			
Miscellaneous																																						
Anionic Surfactants	mg/L	0.03							0.19	-					0.13										0.44	0.20								0.38				0.03
XNo class																																						
2,4-DD5	%	25-175							74.00	-																												
Toxaphene	mg/L	0.0005	0.0015						<0.00050	-					<0.00050										<1.5	<1.5												

Note

1 - un-ionized ammonia calculated based on temperature and pH of effluent at time of effluent sample collection;
2 - un-ionized ammonia calculated based on temperature and pH (75th Percentile) of river in either summer or winter as defined previously;
3 - un-ionized ammonia calculated based on temperature and pH during toxicity testing on trout

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Table A2. Edson Effluent Characterization and Risk Sensitivity Study - Field Notes

Collection Date	Time	Associated Lab Results	Samplers	Current Weather	Previous Week's Weather	pH	Temprature	Flow (cms)	Toxicity Sample (Y/N)	Comments
28-May-09	11:00 AM	L770125	TH, CP, Melanie, Darren	sunny, calm, warm, 15C	sunny, minimal rain	9.2	15	0.0433	N	Normal operating conditions, photos taken
11-Jun-09	1:50 PM	L777089				9.3	19.9	0.0387	N	Normal operating conditions
25-Jun-09	12:12 PM	L783503	S. Spencer, M. Simard	n/a	n/a	8.52	16.4	0.0357	Y	
9-Jul-09	2:15 PM	L790170	Melanie and Sean	cloudy, 15C	July 7 - 5.0 cm rain, 10C ; July 8 - 3.5 cm heavy rain, 13C; July 9 - 2.0 and showers, 13C	8.08	15.9	0.0763	N	heavy rain for the past few days, effluent lighter in colour
23-Jul-09		L796643	Melanie and Sean	hot, 29°C	hot, high 20's to 30°C; no rain	8.11	23.7	0.0505	N	
6-Aug-09	2:30 PM	L802299	Sean	sunny, 17C	cloudy, rain, 13C	7.72	19.2	0.0501	N	slight odour, little algae, normal summer appearance
20-Aug-09	1:00 PM	L808595	Melanie and Wayne	nice, sunny, cool wind, 21C	nice, no rain, average 20C	7.9	20.7	0.0453	N	pigging water lines
3-Sep-09	10:15 AM	L814376	Jessica and Ken	sunny, 15C, slight breeze	showers Sept 2 in the afternoon, otherwise sunny and hot	8.27	20.4	0.0448	Y	effluent in ponds had a slight amber colour; very little smell; red bugs swimming
17-Sep-09	2:00 PM	L820162	Sean	drizzle, no rain at sample collection	no precipitation, 25oC, sunny	7.94	17.1	0.0406	N	normal, no strong smell, very little algae, effluent almost clear
1-Oct-09	3:00 PM	L825837	Sean and Melanie	sunny, 12C, light breeze	cool, windy, low -3C high 12C, trace precipitation	7.76	13	0.0426	N	slightly murky, less water bugs, increased algae
15-Oct-09	1:30 PM	L830508	Melanie	over cast, trace snow, rain, -1	Oct 13th low of -5 trace snow; Oct 14th low of -8, 3-4 cm snow	8.18	5	0.0323	n	calm, no wind
29-Oct-09	2:00 PM	L835472	Melanie	cool wind, -3C, overcast, going to snow	Oct 28 average + 8C afternoon, -5 mornings; Oct 27 trace snow	8.13	3	0.0302	N	
12-Nov-09	1:30 PM	L839732	Melanie	cold, sunny, windy	cold mornings, no precipitation, average low -8, high +5	8.26	3.4	0.0309	N	aeration ponds starting to freeze around edges
26-Nov-09	1:25	L843885	Melanie	light rain, 0C, cool,slight wind	average low approx -5, high approx 3, no precipitation	8.34	2.1	0.0336	N	aeration ponds frozen around edges, polishing ponds is frozen
8-Dec-09	10:30 AM	L846996	Tiffany	overcast, some snow, -20C	unseasonably cold; -30C; some snow, overcast	8.13	1.4	0.033	Y	samples freezing slightly; all ponds frozen, samples icing over rapidly, small red organisms in effluent (Daphnia?)
23-Dec-09	2:00 PM	L850619	Melanie	snowing, -12C, slight wind	lots of snow, highs -3C lows -18C	7.85	0.5	0.0338	N	ponds frozen, more smelly
6-Jan-10	1:00 PM	L852728	Wayne	minus 21C, clear	yesterday -20, no precip; 2 days ago -17, no precip	7.85	0.5	0.0317	N	ponds frozen
21-Jan-10	1:00 PM	L856730	Melanie	minus 9C, overcast, slight snow and wind	last 2 days approx lows -14C, highs -4C; yesterday overcast	7.7	0.3	0.0314	n	first aeration pond not frozen over completely, second pond completely frozen over; effluent colour slightly brown
4-Feb-10	1:30 PM	L859779	Melanie	minus 5C, overcast, slightly foggy	low -14C, high -5 (overcast) last 2 days; trace snow overcast yesterday	7.74	1.8	0.032	n	slight brown tint in effluent, first aeration pond open (not completely frozen),, second pond frozen over
18-Feb-10	2:00 PM	L863236	Melanie	sunny, calm, -2C	low -14C, high -1C (snow overnight), Wed high 1, low -5	7.68	4.4	0.035	n	first aeration poind almost completely open, second frozen over
4-Mar-10	2:00 PM	L866913	Sean	sunny, no precip, 8C to 11C		7.67	2.1	0.0353	n	
18-Mar-10	1:30 PM	L870507	Melanie	low -2C, cold, windy, trace snow	Tuesday: high +14/low -2 warm and sunny; Wednesday: high 10/low -2, extreme wind with sunny breaks	7.71	1.6	0.0384	n	finishing pond has visual spots of green showing through ice; first aeration pond still completely open/second pond starting to thaw, some open spots; geese at ponds
30-Mar-10	11:15 AM	L873283	Tiffany and Evan	very windy	varied from -3.5C to 14.3C, no precipitation	7.89	1.8	0.0363	y	strong odour, dark green, high flow; finishing pond still frozen across, aerated ponds frozen around edges only
22-Apr-10	3:00 PM	L879869	Sean	cloudy, 8C	sunny, hot, 25 and 27C	8.13	12.9	0.0313	n	algae present/moderate; smell ok, not too strong
6-May-10	1:15 PM	L884108	Melanie	slight wind, +3, overcast, snow flakes, cool	Tuesday: high +1/low -2, extreme wind, trace snow; Wednesday: high 2/low -2, trace snow	8.71	9.4	0.0334	n	effluent is green

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Table A3. Edson Effluent Characterization and Risk Sensitivity Study - September 2010 Analytical Data

	US 100-02	DS 100-01	DS 300-01	DS 1000-01	DS 1000-02	DS 4300-02	OUTFALL	Field Blank
ALS ID	L932045-2	L932045-1	L932045-3	L932043-2	L932043-1	L932043-3	L932044-1	L932044-2
Date Sampled	9/15/2010 2:10:00 PM	9/15/2010 3:00:00 PM	9/15/2010 2:45:00 PM	9/15/2010 11:30:00 AM	9/15/2010 12:15:00 PM	9/15/2010 10:30:00 AM	9/15/2010 2:25:00 PM	9/15/2010 3:30:00 PM

	Units	DL	US 100-02	DS 100-01	DS 300-01	DS 1000-01	DS 1000-02	DS 4300-02	OUTFALL	Field Blank
Alkalinity, Total (as CaCO3)	mg/L	5	139	143	144	142	143	140	503	<5.0
Ammonia-N	mg/L	0.005	<0.0050	0.337	0.139	0.0686	0.03	0.0159	15.9	<0.0050
Un-ionized NH3	mg/L		0.00010432	0.01570909	0.00648729	0.0029082	0.00131822	0.00061107	1.55228965	
Bicarbonate (HCO3)	mg/L	5	160	161	163	160	159	159	503	<5.0
Carbonate (CO3)	mg/L	5	5.1	6.4	6.4	6.8	7.9	6	54.3	<5.0
Chloride (Cl)	mg/L	0.5	1.44	2.04	2.25	2.03	2.13	1.8	78.7	<0.50
Conductivity (EC)	uS/cm	0.2	314	317	323	319	317	315	1250	0.83
Fluoride (F)	mg/L	0.05	0.078	0.088	0.089	0.081	0.073	0.095	0.897	<0.050
Hardness (as CaCO3)	mg/L	n/a	139	144	138	140	138	137	165	<1.0
Hydroxide (OH)	mg/L	5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Ion Balance	%	n/a	102	105	100	101	98.2	99.3	96.8	Low TDS
Nitrate+Nitrite-N	mg/L	0.006	0.037	0.0494	0.0719	0.053	0.04	0.0405	3.3	<0.0060
Nitrate-N	mg/L	0.006	0.037	0.0467	0.0618	0.0494	0.04	0.0405	2.43	<0.0060
Nitrite-N	mg/L	0.002	<0.0020	0.0027	0.0101	0.0036	<0.0020	<0.0020	0.867	<0.0020
pH	pH	0.1	8.42	8.46	8.44	8.41	8.44	8.4	8.73	6.5
Phosphorus, Total	mg/L	0.001	0.0081	0.0666	0.0343	0.0206	0.0133	0.013	2.6	<0.0010
Phosphorus, Total Dissolved	mg/L	0.001	0.0021	0.0058	0.0168	0.0056	0.0029	0.0013	2.07	<0.0010
TDS (Calculated)	mg/L	n/a	170	176	176	174	173	171	701	<1.0
Sulfate (SO4)	mg/L	0.05	22.1	22.2	22.2	22.8	22.7	23.1	44.3	<0.050
Calcium (Ca)-Dissolved	mg/L	0.5	38.7	40.2	38.8	39.1	38.8	38.4	46.1	<0.50
Magnesium (Mg)-Dissolved	mg/L	0.1	10.2	10.6	10.1	10.3	10.1	10.1	12.2	<0.10
Potassium (K)-Dissolved	mg/L	0.1	0.69	0.77	0.78	0.66	0.52	0.45	10	<0.10
Sodium (Na)-Dissolved	mg/L	0.5	12.9	14.2	14.6	14	13	12.9	192	<0.50
Biochemical Oxygen Demand	mg/L	2	4.1	3.6	3.2	<2.0	<2.0	<2.0	47.8	-
BOD Carbonaceous	mg/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	6.3	<2.0
Surfactants	mg/L	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	-

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Table A4. Edson Effluent Characterization and Risk Sensitivity Study - September 2010 Field Notes

	Actual Coordinates				Flow (km/s)												
Transect	N	W	Elevation (m)	Station	0.05 m	0.2 m	0.5 m	Depth of Water (m)	DO (mg/L)	EC (µS/L)	Temp °C	Distance from Shore (m)	WQ Lab Sample Obtained	Bed Texture	Macrophyte Cover	Bank Veg	Notes
US 100	N53°35.3673'	W116°20.0822'	856.9	US100-01	7.99	6.84	6.04	0.59	11.16	323	9	8	No	80% Cobbles, 18% Fines, 2% Boulders	15% grasses (submerged) and horsetail growing in water	grass and reeds on shore for about 3.5 m then mixed forest (spruce, birch, poplar); very steep bank	Depth undulating. Small amounts of white froth consistent with downstream noted at this location.
				US100-02	10.7	9.71	9.16	1.06	11.36	299	8.7	42	Yes	80% Cobbles, 18% Fines, 2% Boulders	none	same	
Outfall	N53°35.4255'	W116°20.1007'	847.3	Outfall	2.35	-	-	0.18	7.92	1155	11.2	-8	Yes	Not determined.	black, green and grey fungi/algae on rocks in pool.	grasses surrounded by shrubs and invasive/weedy species and fireweed; very steep bank	Flow and depth obtained 0 m fr. Shore; bottom past riprap was 40% Cobbles and 60% Fines; semi-veg island noted***see photo 7089
DS 100	N53°35.5073'	W116°20.1111'	866.5	DS100-01	2.78	2.45	2.17	1.1	11.54	307	9	4	Yes	90% Fines (silty clay), 10% gravel	green algae growing on debris/driftwood on bottom	grasses and invasive sp. Surrounded by mixed forest; very steep bank	Sample obtained 6 m from shore; severe drop off after 4 m from shore
				DS100-02	Deep To Access									Not determined.	none		
DS300	N53°35.5838'	W116°20.0290'	856.7	DS300-01	4.98	4.63	3.21	1.01	11.26	303	9.6	5	Yes	90% Fines (silty clay), 5% Gravel, 5% Boulders	5% sunken grasses <1 m fr. Shore	reed grasses to edge of shore; surrounded by mixed forest; very steep bank	Reached with flow metre to obtain readings at 10m
				DS300-02	6.12	5.23	4.84	too deep				10	No		none		
DS1000	N53°35.5691'	W116°19.4471'	855.7	DS1000-01	10.68	8.78	7.73	0.71	10.8	300	9.2	8	Yes	70% Cobbles, 28% Fines, 2% Boulders	none	generally sandy shore with some grass, then mixed forest	Easily accessible - shore flat with quad trail.
				DS1000-02	11.61	12.1	8.63	0.73	10.94	303	8.8	35	Yes	70% Cobbles, 23% Fines, 7% Boulders	none		
DS4300	N53°35.6629'	W116°19.0149'	849	DS4300-01	8.16	42 at 0.25 m		0.33	11.2	315	8.5	8		80% Cobbles, 18% Fines, 2% Boulders	horsetail extending from shore to water	shore flat but vegetated; mixed forest	Easily accessible - shore flat with quad trail.
				DS4300-02	15.66	14.71	10.82	0.58	11.18	336	8.2	40	Yes	80% Cobbles, 18% Fines, 2% Boulders	none		

B

Appendix B

Photographs

Photograph 1. Edson outfall towards McLeod River (May 2009)↑

Photograph 2. McLeod River (US100) left bank, downstream view (September 2010)↑

Photograph 3. McLeod River Outfall on left bank (September 2010)↑

Photograph 4. McLeod River (DS100) left bank, upstream view (September 2010)↑

Photograph 5. McLeod River (DS300) left bank, downstream view (September 2010)↑

Photograph 6. McLeod River (DS1000) left bank, downstream view (September 2010)↑

Photograph 7. McLeod River (DS4300) left bank, upstream view ↑

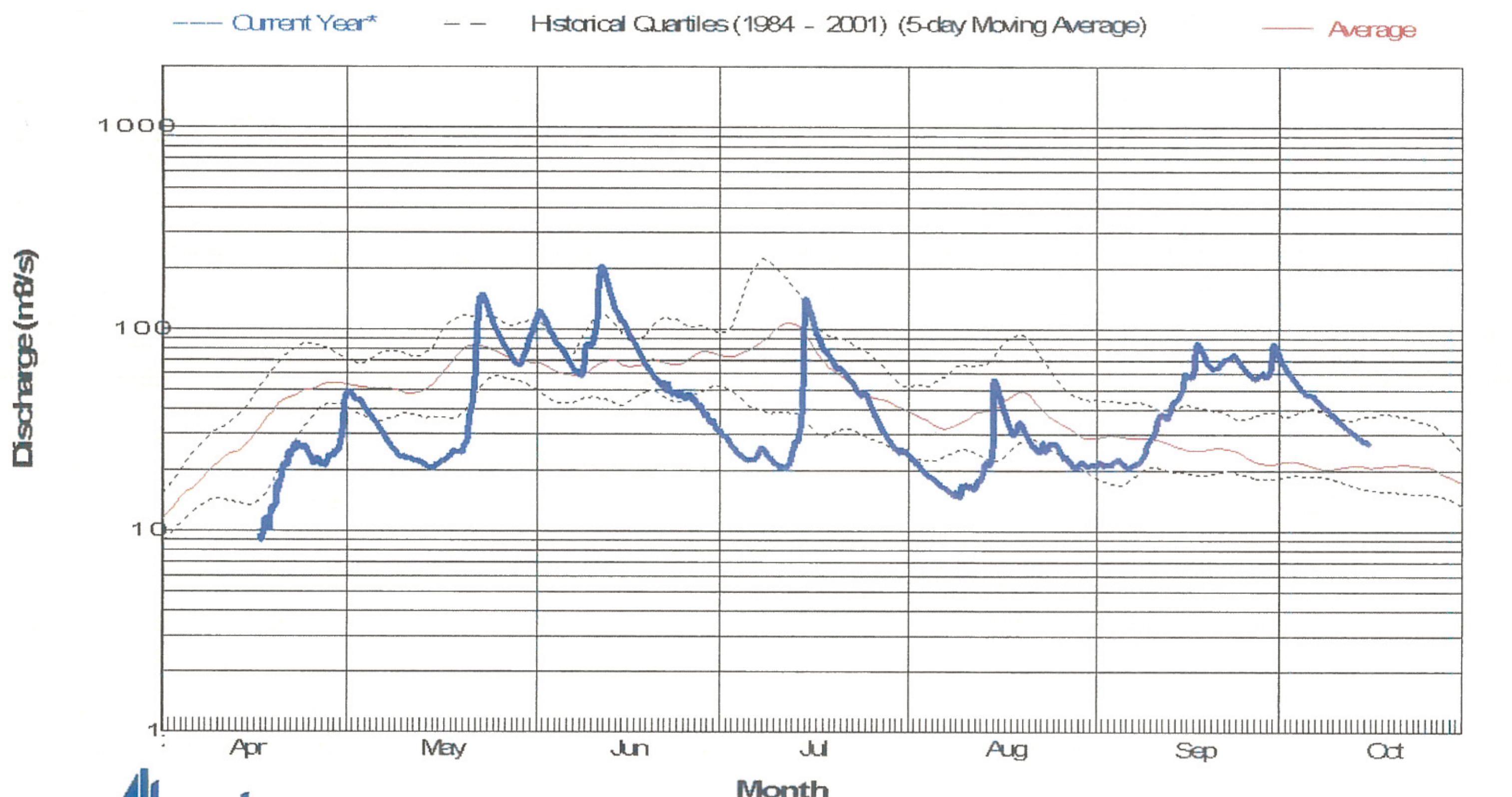
C

Appendix C

Hydrograph of McLeod River (Preliminary 2010 Discharge)

Mcleod River Near Rosevear

(07AG007 - RMCLROSE - 20043.1)



Evaluation and Reporting Section
Environmental Monitoring and Evaluation Branch

* Preliminary Data Subject to Revision

18/10/2010 @ 07:02

D

Appendix D

Original Lab Reports (on CD Only)