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Environmental Consultants

**Prepared for**

**METRO VANCOUVER**

**Metrotower III 4730 Kingsway  
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## **WASTE TO ENERGY FACILITY**

**Emissions Testing Report  
August 2019 3rd Quarter Survey  
Operational Certificate 107051**

## **CERTIFICATION**

The field monitoring for this survey was conducted by certified stack test technicians as required by the British Columbia Ministry of Environment (BC MOE) Field Sampling Manual.

The field crew consisted of:

Mr. S. Harrington (certified), Mr. M. Lanfranco (certified), Mr. C. Lanfranco (certified), Mr. D. Sampson (certified), Mr. M. Goods (certified) and Mr. J. Ching.

The report was prepared by Mr. L. Agassiz using reporting principles and guidelines generally acceptable to Metro Vancouver (MV).

The field crew and A. Lanfranco and Associates Inc. certify that the test methods used were BC MOE/MV approved reference methods for the parameters investigated.

Report reviewed by:

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Mark Lanfranco, CST  
President | Owner

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## SUMMARY

The following table shows the emission results from the three units located at Metro Vancouver's Waste-To-Energy Facility (WTEF) as well as the current emission limits as defined by the Operational Certificate (OC) issued by BC Ministry of Environment & Climate Change Strategy. This compliance survey represents the third quarter of 2019.

**Table 1: Summary Comparison of Emissions Test Results with Limits**

Parameter	Limit	Unit 1	Unit 2	Unit 3	Plant Average
<b>Test Date</b>		Aug. 12-13, 2019	Aug. 13/15, 2019	Aug. 14, 2019	
<b>Particulate</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>9.0</b>	0.60	0.29	2.23	<b>1.04</b>
<b>Hydrogen Fluoride</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>1.0</b>	0.02	0.04	0.01	<b>0.02</b>
<b>Trace Metals - OC Class</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )					
Lead (Pb)	-	0.0033	0.0007	0.0021	<b>0.0020</b>
Arsenic (As)	-	0.0004	0.0003	0.0006	<b>0.0004</b>
Chromium (Cr)	-	0.0013	0.0005	0.0011	<b>0.0010</b>
<b>OC Class Sum</b> (Pb, As and Cr)	<b>0.064</b>	0.0050	0.0016	0.0038	<b>0.0035</b>
<b>Mercury</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>0.02</b>	0.0011	0.0011	0.0008	<b>0.0010</b>
<b>Cadmium</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>0.007</b>	0.0003	0.0001	0.0003	<b>0.0002</b>

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

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## **1.0 INTRODUCTION**

Metro Vancouver (MV) commissioned an emission survey at the Waste-To-Energy Facility (WTEF) in Burnaby BC, as required by the provincially approved Operational Certificate (OC). This report documents the results of a survey on Units 1, 2 and 3 for the third survey of four for the year of 2019. This survey includes particulate matter, trace metals, mercury (Hg), total hydrocarbons (THC), hydrogen fluoride (HF), nitrous oxide (N<sub>2</sub>O) and hexavalent chromium (Cr<sup>+6</sup>). A. Lanfranco and Associates Inc., of Surrey, B.C., conducted the sampling program on behalf of MV. The sampling program consisted of, but was not limited to, the planning, execution, analysis, and reporting of three emission sources located at the WTEF.

This report includes a comparison of emission results to limits established in the OC, detailed emission results, a brief outline of methods employed, equipment used, and a discussion of the survey. All supporting data and appendices are presented under separate cover.

The individual sources that were monitored for compliance are identified as Unit 1, Unit 2 and Unit 3 which represent the three distinct processing lines at the WTEF. Sampling was conducted on August 12-15, and Aug 22, 2019 (hexavalent chromium).

## 2.0 METHODOLOGY

All services provided by A. Lanfranco and Associates Inc. were conducted in accordance with approved reference methods as issued by:

- Metro Vancouver (MV)
- BC Ministry of Environment & Climate Change Strategy (BC MOE)
- Environment Canada (EC)
- US Environmental Protection Agency (EPA)

### 2.1 Sampling and Analytical Methods

The following table lists the test methods used for the different parameters measured. The subsequent paragraphs briefly describe each method.

**Table 2: Reference Methods**

<u>Parameter</u>	<u>Reference Method</u>
Sample and Velocity traverse points	EPS 1/RM/8 A Determination of Sampling Site and Traverse Points
Velocity and flowrate	EPS 1/RM/8 B Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Gas molecular weight (O <sub>2</sub> /CO <sub>2</sub> )	EPS 1/RM/8 C Determination of Molecular Weight by Gas Analysis
Flue gas Moisture	EPS 1/RM/8 D Determination of Moisture Content
Particulate Matter	EPS 1/RM/8 E Determination of Particulate Matter Emissions from Stationary Sources
Trace Metals with Mercury	EPA Method 29 Determination of Metals Emissions from Stationary Sources
Hydrogen Fluoride (HF)	EPS1/RM/1 Reference Method for Source Testing: Measurement of Releases of Gaseous Hydrogen Chloride from Stationary Sources
Nitrous Oxide (N <sub>2</sub> O)	WCB Method 1101 / EPA Method 18
Total Hydrocarbons (THC/VOC)	EPA 203/ALS SOP VOA-TO3C1C6
Hexavalent Chromium (Cr <sup>+6</sup> )	EPA Method 0061 Determination of Hexavalent Chromium from Stationary Sources

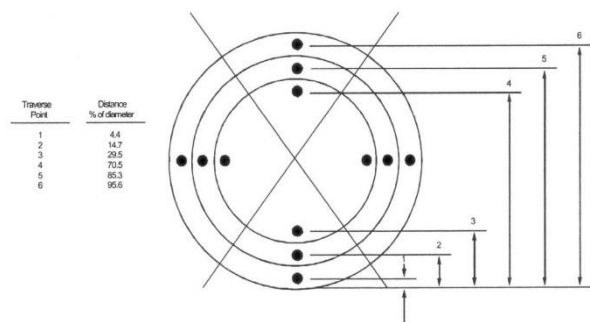
The following section briefly details individual test methods used by the following five individual sampling trains:

- Train 1 – Particulate / Trace Metals
- Train 2 – Hydrogen Fluoride
- Train 3 – Total Hydrocarbons THC/VOC
- Train 4 –  $N_2O$
- Train 5 – Hexavalent Chromium

#### Sampling Site and Traverse Points

Primary: EPS 1/RM/8 Method A  
 Supporting: EPA Method 1

This method is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source. A measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. Traverse points are then located within each of these equal areas.

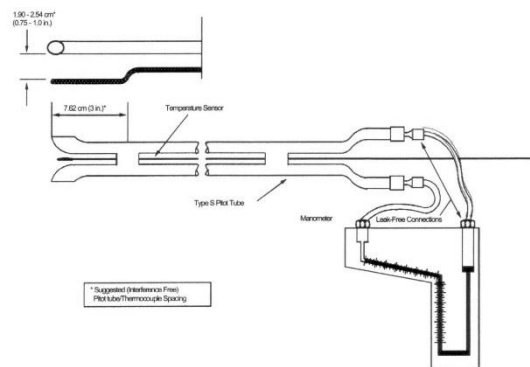


**Figure 1.** Example showing circular stack cross section divided into 12 equal areas, with location of traverse points.

#### Stack Gas Velocity and Volumetric Flow Rate

Primary: EPS 1/RM/8 Method B  
 Supporting: EPA Method 2

The average gas velocity in a stack or duct is determined from the gas density and from the measurement of velocity pressure with an S-type pitot tube. A standard pitot tube may be used where plugging of the tube openings due to particulate matter and/or moisture is not likely to occur. Stack gas volumetric flow rate is determined from measurements of stack gas velocity, temperature, absolute pressure, dry gas composition, moisture content, and stack diameter.



**Figure 2.** Type S Pitot Tube Manometer Assembly

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Molecular Weight by Gas Analysis

Primary: EPS 1/RM/8 Method C  
Supporting: EPA Method 3

An integrated or grab sample is extracted from a single point in the gas stream and analyzed for its components using a Fyrite analyzer, a gas chromatograph, or calibrated continuous analyzers.

Moisture Content

Primary: EPS 1/RM/8 Method D  
Supporting: EPA Method 4

A gas sample is extracted from a single point in the enclosed gas stream being sampled. The moisture is condensed and its weight measured. This weight, together with the volume of gas sampled, enables the stack gas moisture content to be calculated.

Particulate Matter

Primary: EPS 1/RM/8 Method E  
Supporting: EPA Method 5

Particulate matter is withdrawn isokinetically from a number of sampling or traverse points in an enclosed gas stream. The particulate sample is collected in the nozzle, probe, and on a glass fibre filter, all maintained at a temperature of  $120 \pm 14^{\circ}\text{C}$  or such other temperature as is necessary to prevent blinding of the filter from condensation. The particulate weight is determined gravimetrically after removal of uncombined water. Simultaneous determinations of the gas stream moisture content, velocity, temperature, and molecular weight allow calculations of the particulate concentration and the particulate mass emission or release rate to be made.

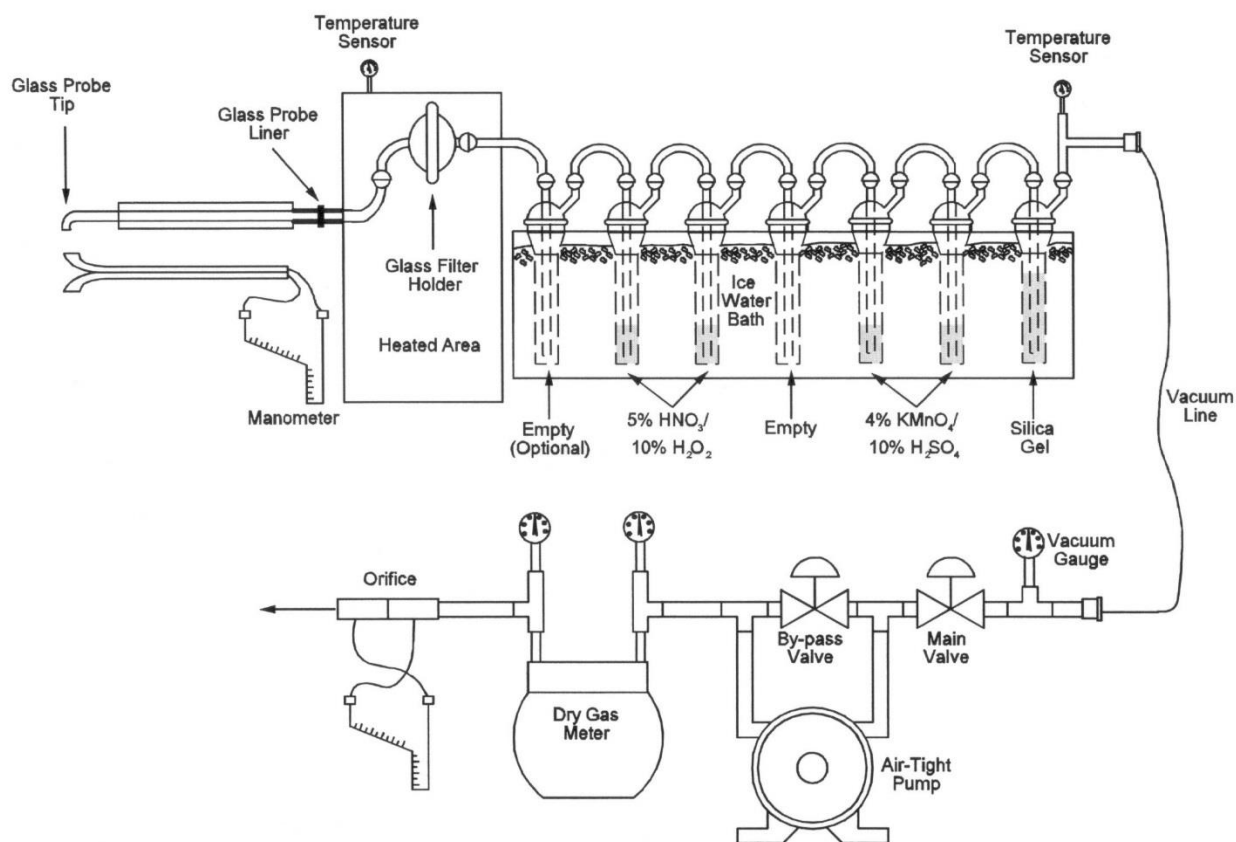
Trace Metal

Primary: EPA Method 29 (modified)

This method is used in conjunction with the above Method 5. A stack sample is withdrawn isokinetically from the source. Particulate emissions are collected in the probe and on a heated filter, and gaseous emissions are then collected in an aqueous acidic solution of hydrogen peroxide (analyzed for all metals including Hg) and an aqueous acidic solution of potassium permanganate (analyzed only for Hg). The recovered samples are digested, and appropriate fractions are analyzed for Hg by cold vapour atomic absorption spectroscopy (CVAAS). The remaining trace metals are analyzed with inductively coupled argon plasma emission spectroscopy (ICAP), atomic absorption spectroscopy (AAS) and graphite furnace atomic absorption spectroscopy (GFAAS).

Figure 3 displays the sample train and its configuration.





**Figure 3.** Particulate / Trace Metals Sampling Train

### Hydrogen Fluoride

Primary: EPS 1/RM/1  
 Supporting: BC Method 7176106 & 7066101

HF is sampled in a four-impinger train consisting of two impingers containing distilled/deionized H<sub>2</sub>O, one empty impinger, and fourth containing silica gel. A sample of the stack gas is extracted from a single point near the centre of the stack over the sample duration at a constant rate. The collected samples are measured for F by ion chromatography at ALS Environmental in Burnaby, BC.

### THC/VOC

THC/VOC samples were collected with evacuated SUMMA canisters. The canisters extract stack samples via a teflon line and are operated for 60 minutes, at which time the initial vacuum of about 28" Hg reduces to about 4" Hg. The samples were analysed by GC FID at ALS specialty lab in Simi Valley, California.

N<sub>2</sub>O

Primary: WCB Method 1101

Three N<sub>2</sub>O samples were collected from each source using evacuated tedlar bag sampling procedures. Each bag was purged and evacuated on-site with small amounts of stack gas, prior to final stack gas collection. Each bag sample was an integrated type sample where stack gases were collected over sixty minute periods. The bag sampling was conducted over about a four hour period.

The samples were analysed at Maxxam Laboratory, Burnaby B.C. N<sub>2</sub>O analysis was conducted within 24 hours of sample collection using WCB Method 1101.

Chromium<sup>+6</sup>

Primary: EPA Method 0061

The Method 0061 sampling train (see Fig. 4) was used to collect samples, where all train components were Teflon or borosilicate glass. A small amount of 0.1 N KOH is re-circulated through the probe and first impinger via peristaltic pump. The impinger components were:

#### Stack Impingers

- 150 ml 0.1 N KOH
- 75 ml 0.1 N KOH
- 75 ml 0.1 N KOH
- Empty
- 200 g silica gel

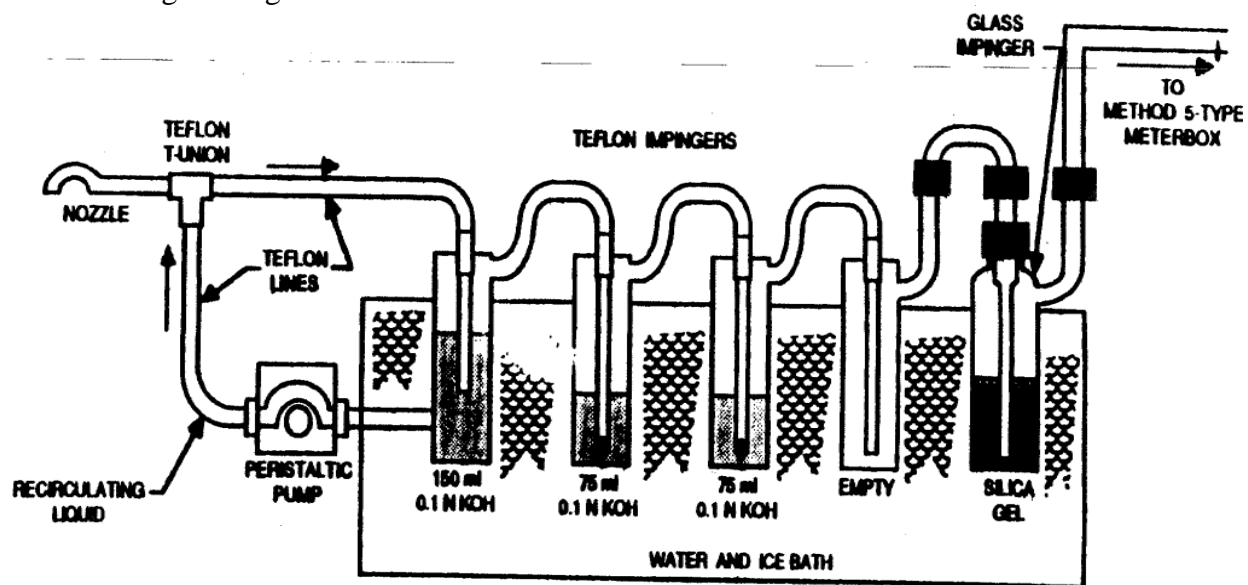


Figure 4. Hexavalent Chromium Sampling Train

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## 2.1 Method Modifications

Three minor method modifications were instituted for this work.

1. Reagent blanks for metals trains were made to the same volumes as all samples. In other words, exactly 100 ml of the various reagents used to recover samples was NOT done, as some sample components (probe washing for example) required more than 100 ml to adequately clean and rinse the probe. Instead, sample recovery was conducted with however much rinsing was deemed adequate. In the laboratory, the blanks and samples were made up with the appropriate reagent so that all samples and blanks were the same volume.

2. Filter and residue weighing were not conducted with the six-hour interval technique. Instead the sample filters and beakers were conditioned with cooling and desiccation and then weighed on two separate laboratory scales after 24 hours. Duplicate or triplicate Blank samples were carried through the gravimetric analysis, and the sample results were adjusted with the Blank data to determine the net filter and probe wash residue weight gain. This is the Environment Canada approved modified approach for weighing probe wash residue.

3. For the purposes of calculating a result, all parameters were given the value of  $\frac{1}{2}$  the detection limit when the analysis yielded 'non-detect' results.

All results are expressed using the metric system and corrected to standard conditions of 20°C and 101.325 kPa, dry gas (unless otherwise noted).

## 2.2 Calculations

The following sections show the equations and define the variables that were used for this survey. The equations are organized in three sections. Equations 1-11 were used to calculate parameter concentration at standard conditions on a dry basis. Equations 12-26 were used to sample within the  $100 \pm 10\%$  isokinetic variation and to confirm that sampling meets this isokinetic variation threshold. Equations 27-29 were used to calculate the volumetric flowrate of the stack flue gas.

### 2.2.1 Parameter Concentration Calculations

$$c = \frac{m}{V_{std}} \quad \text{Equation 1}$$

$$m_{part} = m_{filter} + m_{pw} \quad \text{Equation 2}$$

$$m_i = m_{ana,i} - m_{blank} \quad \text{Equation 3}$$

$$m_{HF} = \frac{20.006}{18.998} (m_F - m_{blank}) / 1000 \quad \text{Equation 4}$$

$$V_{std} = \frac{V_{std(imp)}}{35.315} \quad \text{Equation 5}$$

$$V_{std(imp)} = \frac{V_{samp} \times y \times P_m \times (T_{std} + 459.67)}{P_{std} \times (T_{m(ave)} + 459.67)} \quad \text{Equation 6}$$

$$V_{samp} = V_{final} - V_{init} \quad \text{Equation 7}$$

$$P_m = P_B + \frac{\Delta H_{ave}}{13.6} \quad \text{Equation 8}$$

$$\Delta H_{ave} = \frac{1}{n} \sum_{i=1}^n \Delta H_{i(act)}, \text{ where } n = \text{the number of points} \quad \text{Equation 9}$$

$$OC = \frac{20.9 - \%O_{2c}}{20.9 - \%O_{2m}} \quad \text{Equation 10}$$

$$\%O_{2m} = \frac{1}{n} \sum_{i=1}^n \%O_{2i}, \text{ where } n = \text{the number of } O_2 \text{ measurements} \quad \text{Equation 11}$$

Where,

$c$	= Parameter concentration
$m$	= Parameter mass
$m_i$	= Net analytical mass (mg, ng, or $\mu\text{g}$ )
$m_{ana,i}$	= Analytical mass (mg, ng, or $\mu\text{g}$ )
$m_{blank}$	= Blank analytical mass (mg, ng, or $\mu\text{g}$ )
$m_{part}$	= Total particulate mass (mg)
$m_{filter}$	= Net particulate gain from filter (mg)
$m_{pw}$	= Net particulate gain from probe wash (mg)
$m_{HF}$	= Net mass of HF (mg)
$m_F$	= Net mass of F ( $\mu\text{g}$ )
$V_{std(imp)}$	= Sample volume at standard conditions ( $\text{ft}^3$ )
$V_{std}$	= Sample volume at standard conditions ( $\text{m}^3$ )
$V_{smp}$	= Sample volume at actual conditions ( $\text{ft}^3$ )
$V_{final}$	= Final gas meter reading ( $\text{ft}^3$ )
$V_{init}$	= Initial gas meter reading ( $\text{ft}^3$ )
$T_{std}$	= Standard temperature (68 °F)
$T_m$	= Gas meter temperature (°F)
$T_{m(ave)}$	= Average gas meter temperature (°F)
$P_m$	= Absolute meter pressure (inches of Hg)
$P_B$	= Barometric pressure (inches of Hg)
$P_{std}$	= Standard barometric pressure (29.92 inches of Hg)
$\Delta H_{ave}$	= Average of individual point orifice pressures (inches of $\text{H}_2\text{O}$ )
$\Delta H_{i(act)}$	= Individual recorded point orifice pressures (inches of $\text{H}_2\text{O}$ )
$OC$	= Oxygen correction factor (dimensionless)
$\%O_{2c}$	= Oxygen concentration to correct to (% dry basis)
$\%O_{2i}$	= Individual oxygen measurements (% dry basis)
$\%O_{2m}$	= Average measured stack gas oxygen concentration (% dry basis)

Equation 1 is the general concentration calculation used for all parameters. The mass,  $m$ , is the net analytic mass for the given parameter. For particulate,  $m$  is the sum of the mass contributed from probe washing and filter particulate.

For trace metals and Hg,  $m$  is the blank corrected (Equation 3) analytical result (Appendix 1) for each metals species and run. If the analytical result was below the detection limit, half of the detection limit (DL) was used for  $m$  in Equation 1.

The HF concentration was calculated from analytic results. Equation 4 was used to convert the F mass to HF, and this result was used as  $m$  in equation 1. As with the trace metals, half the detection limit was substituted for results that were non-detectable.

### 2.2.2 Isokinetic Variation Calculations

$$\Delta H_i = \frac{2.62 \times 10^7 \times c_p \times A_n \times (1 - B_{wo}) \times M_D \times (T_m + 459.67) \times \Delta p_i}{k_o \times M_w \times (T_{stk} + 459.67)} \quad \text{Equation 12}$$

$$R_m = 85.49 \times c_p \times \sqrt{\Delta p_i} \times \sqrt{\frac{(T_{stk_i} + 459.67)}{M_w \times P_B}} \times 60 \times A_n \times \frac{(T_{m_i} + 459.67) \times (1 - B_{wo})}{(T_{stk_i} + 459.67) \times y} \quad \text{Equation 13}$$

$$A_n = \pi \left( \frac{d_n}{24} \right)^2 \quad \text{Equation 14}$$

$$M_w = M_D \times (1 - B_{wo}) + 18 \times B_{wo} \quad \text{Equation 15}$$

$$M_D = 0.44 \times \%CO_2 + 0.32 \times \%O_2 + 0.28 \times (100 - \%CO_2 - \%O_2) \quad \text{Equation 16}$$

$$T_{stk} = \frac{1}{n} \sum_{i=1}^n T_{stk_i}, \text{ where } n = \text{the number of points} \quad \text{Equation 17}$$

$$B_{wo} = \frac{V_{cond}}{V_{cond} + V_{std(imp)}} \quad \text{Equation 18}$$

$$V_{cond} = 0.04707 \times V_{gain} \quad \text{Equation 19}$$

$$Iso = \frac{1}{n} \sum_{i=1}^n Iso_i, \text{ where } n = \text{the number of points} \quad \text{Equation 20}$$

$$Iso_i = \frac{v_{nzi}}{v_i} \quad \text{Equation 21}$$

$$v_i = 85.49 \times c_p \times \sqrt{\Delta p_i} \times \sqrt{\frac{(T_{stk_i} + 459.67)}{(P_{stk} \times M_w)}} \quad \text{Equation 22}$$

$$v_{nzi} = \frac{(V_i - V_{i-1}) \times y \times (T_{stk_i} + 459.67) \times (P_B + \frac{\Delta H_{i(act)}}{13.6})}{A_n \times t_i \times 60 \times (T_{m(i)} + 459.67) \times P_{stk} \times (1 - B_{wo})} \quad \text{Equation 23}$$

$$P_{stk} = P_B + \frac{P_g}{13.6} \quad \text{Equation 24}$$

$$v_{stk} = \frac{1}{n} \sum_{i=1}^n v_i, \text{ where } n = \text{the number of points} \quad \text{Equation 25}$$

$$v_{nz} = \frac{1}{n} \sum_{i=1}^n v_{nzi}, \text{ where } n = \text{the number of points} \quad \text{Equation 26}$$

Where,

$A_n$	= Nozzle area (ft <sup>2</sup> )
$d_n$	= Diameter of nozzle (inches)
$C_p$	= Pitot coefficient (dimensionless)
$\Delta p_i$	= Individual point differential pressures (inches of H <sub>2</sub> O)
$T_{stk}$	= Average flue gas temperature (°F), second subscript i, indicates individual point measurements
$T_m$	= Average gas meter temperature (°F), second subscript i, indicates individual point measurements
$k_o$	= Gas meter calibration constant (dimensionless)
$y$	= Gas meter calibration factor (dimensionless)
$\Delta H_{i(act)}$	= Calculated individual point orifice pressures (inches of H <sub>2</sub> O)
$P_g$	= Stack Static pressure (inches of H <sub>2</sub> O)
$P_{stk}$	= Absolute stack pressure (inches of Hg)
$M_w$	= Wet gas molecular weight (g/gmol)
$M_D$	= Dry gas molecular weight (g/gmol)
%CO <sub>2</sub>	= Stack gas carbon dioxide concentration (% dry basis)
%O <sub>2</sub>	= Stack gas oxygen concentration (% dry basis)
$B_{wo}$	= Stack gas water vapour, proportion by volume
$V_i$	= Gas meter reading at individual point(ft <sup>3</sup> )
$t_i$	= Sample time at each point (minutes)
$V_{cond}$	= Total volume of water vapor collected, corrected to standard conditions (ft <sup>3</sup> )
$V_{gain}$	= Condensate gain of impinger contents (mL)
$P_{std}$	= Standard pressure (29.92 inches of Hg)
$V_{stk}$	= Average flue gas velocity (ft/sec)
$V_i$	= Individual point flue gas velocity (ft/sec)
$V_{nz}$	= Average velocity at nozzle(ft/sec)
$V_{nzi}$	= Individual point velocity at nozzle(ft/sec)
$ISO_i$	= Individual point isokinetic variation (%)
$ISO$	= Average isokinetic variation (%)
$R_m$	= Isokinetic sampling rate (ft <sup>3</sup> /min)

## 2.2.3 Volumetric Flowrate Calculations

$$Q_S = Q_A \times \frac{(T_{Std} + 459.67)}{(T_{Stk} + 459.67)} \times \frac{P_{Stk}}{P_{Std}} \quad \text{Equation 27}$$

$$Q_A = \frac{v_{stk} \times 60 \times A_{stk}}{35.315} \quad \text{Equation 28}$$

$$A_{stk} = \pi \left( \frac{d}{24} \right)^2 \quad \text{Equation 29}$$

Where,

$Q_A$  = Actual flowrate ( $Am^3/min$ )  
 $Q_S$  = Flowrate ( $m^3/min$ ) at standard conditions on a dry basis  
 $A_{stk}$  = Area of stack ( $ft^2$ )  
 $d$  = Diameter of stack (inches)



### 3.0 DETAILED TEST RESULTS

Most of the results of stack emissions were calculated using a “STACK” computer program developed by A. Lanfranco and Associates for BC MOE requirements.

Tables 3-12 present the detailed results of all emissions parameters tested for each of the units. Additional data and the computer outputs can be found in the accompanying Appendices.

**Table 3: Unit 1 Summary of Emission Test Results**

Parameter	Run 1	Run 2	Run 3	Average
Test Date - Particulate/Metals	12-Aug-19	13-Aug-19	13-Aug-19	
Test Time - Particulate/Metals	11:10 - 13:15	09:02 - 11:05	11:25 - 13:27	
Duration - Minutes	120	120	120	
Test Date - Acid Gases	13-Aug-19	13-Aug-19	13-Aug-19	
Test Time - Acid Gases	09:15 - 10:15	10:30 - 11:30	11:45 - 12:45	
Duration - Minutes	60	60	60	
Stack Temperature (°C)	152	151	156	153
Average Gas Velocity (m/s)	14.6	14.4	15.1	15
Dry Flow Rate (m³/min)	1268	1245	1297	1270
Moisture (Vol. %)	13.8	14.5	14.0	14.1
Oxygen (Vol. %)(dry basis)	10.5	10.0	10.0	10.2
Carbon Dioxide (Vol. %)(dry basis)	9.5	10.0	10.0	9.8
<b>Particulate</b> (mg/m³ @ 11% O₂)	0.46	1.11	0.24	<b>0.60</b>
<b>Hydrogen Fluoride</b> (mg/m³ @ 11% O₂)	0.014	0.017	0.017	<b>0.016</b>
<b>Nitrous Oxide</b> (mg/m³ @ 11% O₂)*	6.9	8.3	8.7	<b>8.0</b>
<b>Total Hydrocarbons</b> (mg/Sm³ @ 11% O₂)	3.4	12.2	9.5	<b>8.4</b>
<b>Trace Metals - Operational Certificate List (mg/m³ @ 11% O₂)</b>				
<b>OC Class</b> (Pb, As and Cr)	0.00351	0.00826	0.00314	<b>0.00497</b>
<b>Aluminum</b> (mg/m³ @ 11% O₂)	0.01066	0.00305	0.00825	0.00732
<b>Cadmium</b> (mg/m³ @ 11% O₂)	0.00013	0.00065	0.00007	0.00028
<b>Lead</b> (mg/m³ @ 11% O₂)	0.00120	0.00789	0.00081	0.00330
<b>Mercury</b> (mg/m³ @ 11% O₂)	0.00150	0.00091	0.00100	0.00114
<b>Phosphorus</b> (mg/m³ @ 11% O₂)	0.00148	0.00076	0.00074	0.00099
Isokinetic Variation ( % )	109	103	102	105

\*N₂O was sampled on Aug 12, 2019

THC test times can be found in the accompanying Appendices

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 4: Unit 1 Trace Metals Emissions (OC Class)**

Metal	Test 1 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 2 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 3 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Average (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
<b>OC Class</b>				
Pb	0.00120	0.00789	0.00081	0.00330
As	0.00044	0.00031	0.00044	0.00040
Cr	0.00187	0.00006	0.00188	0.00127
Sum of OC Class	0.00351	0.00826	0.00314	0.00497
<b>Other</b>				
Al	0.01066	0.00305	0.00825	0.00732
Cd	0.00013	0.00065	0.00007	0.00028
P	0.00148	0.00076	0.00074	0.00099
Hg	0.00150	0.00091	0.00100	0.00114

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 5: Unit 1 Detailed Trace Metals Emissions**

Metal	Test 1 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 2 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 3 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Average (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
Pb	0.00120	0.00789	0.00081	0.00330
Sb	0.00156	0.00076	0.00074	0.00102
Cu	0.00048	0.00008	0.00100	0.00052
Mn	0.00385	0.00165	0.00041	0.00197
V	0.00030	0.00031	0.00029	0.00030
Zn	0.00619	0.00125	0.00304	0.00349
As	0.00044	0.00031	0.00044	0.00040
Cr	0.00187	0.00006	0.00188	0.00127
Co	0.00016	0.00008	0.00007	0.00010
Ni	0.00121	0.00048	0.00186	0.00118
Se	0.00031	0.00046	0.00158	0.00078
Te	0.00059	0.00061	0.00059	0.00060
Tl	0.00022	0.00023	0.00044	0.00030
Cd	0.00013	0.00065	0.00007	0.00028
Hg	0.00150	0.00091	0.00100	0.00114

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 6: Unit 2 Summary of Emission Test Results**

Parameter	Run 1	Run 2	Run 3	Average
Test Date - Particulate/Metals	13-Aug-19	15-Aug-19	15-Aug-19	
Test Time - Particulate/Metals	13:30 - 15:33	08:30 - 10:32	10:45 - 12:47	
Duration - Minutes	120	120	120	
Test Date - Acid Gases	15-Aug-19	15-Aug-19	15-Aug-19	
Test Time - Acid Gases	08:45 - 09:45	10:00 - 11:00	11:18 - 12:18	
Duration - Minutes	60	60	60	
Stack Temperature (°C)	161	159	162	161
Average Gas Velocity (m/s)	14.0	13.3	13.9	14
Dry Flow Rate (m³/min)	1139	1076	1119	1111
Moisture (Vol. %)	17.5	18.4	18.4	18.1
Oxygen (Vol. %)(dry basis)	9.0	9.6	9.3	9.3
Carbon Dioxide (Vol. %)(dry basis)	10.5	10.4	10.8	10.5
<b>Particulate</b> (mg/m³ @ 11% O₂)	0.60	0.19	0.08	<b>0.29</b>
<b>Hydrogen Fluoride</b> (mg/m³ @ 11% O₂)	0.033	0.029	0.065	<b>0.042</b>
<b>Nitrous Oxide</b> (mg/m³ @ 11% O₂)*	7.7	9.2	9.2	<b>8.7</b>
<b>Total Hydrocarbons</b> (mg/Sm³ @ 11% O₂)	5.0	6.1	3.7	<b>4.9</b>
<b>Trace Metals - Operational Certificate List (mg/m³ @ 11% O₂)</b>				
<b>OC Class</b> (Pb, As and Cr)	0.00162	0.00150	0.00160	<b>0.00158</b>
<b>Aluminum</b> (mg/m³ @ 11% O₂)	0.00916	0.00404	0.00913	0.00745
<b>Cadmium</b> (mg/m³ @ 11% O₂)	0.00008	0.00008	0.00008	0.00008
<b>Lead</b> (mg/m³ @ 11% O₂)	0.00084	0.00051	0.00084	0.00073
<b>Mercury</b> (mg/m³ @ 11% O₂)	0.00095	0.00139	0.00086	0.00106
<b>Phosphorus</b> (mg/m³ @ 11% O₂)	0.00366	0.00084	0.00274	0.00242
<b>Hexavalent Chromium</b> (mg/Sm³ @ 11% O₂)*	0.00009	0.00008	0.00009	<b>0.00009</b>
Isokinetic Variation ( % )	108	108	107	108

\*N₂O was sampled on Aug 12, 2019. Hexavalent Chromium was sampled on Aug 22, 2019

Cr6+ and THC test times can be found in the accompanying Appendices

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 7: Unit 2 Trace Metals Emissions (OC Class)**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
<b>OC Class</b>				
Pb	0.0008	0.0005	0.0008	0.0007
As	0.0003	0.0003	0.0003	0.0003
Cr	0.0005	0.0007	0.0005	0.0005
Sum of OC Class	0.0016	0.0015	0.0016	0.0016
<b>Other</b>				
Al	0.00916	0.00404	0.00913	0.0074
Cd	0.00008	0.00008	0.00008	0.0001
P	0.00366	0.00084	0.00274	0.0024
Hg	0.00095	0.00139	0.00086	0.0011

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 8: Unit 2 Detailed Trace Metals Emissions**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
Pb	0.00084	0.00051	0.00084	0.00073
Sb	0.00076	0.00084	0.00129	0.00097
Cu	0.00034	0.00109	0.00065	0.00069
Mn	0.00223	0.00158	0.00027	0.00136
V	0.00031	0.00034	0.00030	0.00032
Zn	0.00223	0.00212	0.00149	0.00195
As	0.00031	0.00034	0.00030	0.00032
Cr	0.00048	0.00066	0.00046	0.00053
Co	0.00010	0.00011	0.00008	0.00009
Ni	0.00092	0.00125	0.00069	0.00095
Se	0.00115	0.00202	0.00046	0.00121
Te	0.00061	0.00067	0.00061	0.00063
Tl	0.00046	0.00079	0.00148	0.00091
Cd	0.00008	0.00008	0.00008	0.00008
Hg	0.00095	0.00139	0.00086	0.00106

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 9: Unit 3 Summary of Emission Test Results**

Parameter	Run 1	Run 2	Run 3	Average
Test Date - Particulate/Metals	14-Aug-19	14-Aug-19	14-Aug-19	
Test Time - Particulate/Metals	09:40 - 11:42	11:56 - 13:58	14:13 - 16:15	
Duration - Minutes	120	120	120	
Test Date - Acid Gases	14-Aug-19	14-Aug-19	14-Aug-19	
Test Time - Acid Gases	08:58 - 09:58	10:43 - 11:43	11:56 - 12:56	
Duration - Minutes	60	60	60	
Stack Temperature (°C)	151	162	159	157
Average Gas Velocity (m/s)	13.4	14.5	13.6	13.8
Dry Flow Rate (m³/min)	1145	1191	1125	1154
Moisture (Vol. %)	15.4	16.8	17.0	16.4
Oxygen (Vol. %)(dry basis)	10.3	9.3	8.6	9.4
Carbon Dioxide (Vol. %)(dry basis)	9.8	10.5	10.9	10.4
<b>Particulate</b> (mg/m³ @ 11% O₂)	2.19	1.19	3.32	<b>2.23</b>
<b>Hydrogen Fluoride</b> (mg/m³ @ 11% O₂)	0.014	0.002	0.014	<b>0.010</b>
<b>Nitrous Oxide</b> (mg/m³ @ 11% O₂)*	5.5	11.0	10.9	<b>9.1</b>
<b>Total Hydrocarbons</b> (mg/Sm³ @ 11% O₂)	2.6	2.6	3.2	<b>2.8</b>
<b>Trace Metals - Operational Certificate List (mg/m³ @ 11% O₂)</b>				
<b>OC Class</b> (Pb, As and Cr)	0.00526	0.00164	0.00453	<b>0.00381</b>
<b>Aluminum</b> (mg/m³ @ 11% O₂)	0.00606	0.00364	0.01174	0.00714
<b>Cadmium</b> (mg/m³ @ 11% O₂)	0.00018	0.00033	0.00030	0.00027
<b>Lead</b> (mg/m³ @ 11% O₂)	0.00279	0.00109	0.00227	0.00205
<b>Mercury</b> (mg/m³ @ 11% O₂)	0.00082	0.00079	0.00070	0.00077
<b>Phosphorus</b> (mg/m³ @ 11% O₂)	0.00135	0.00073	0.00088	0.00098
Isokinetic Variation ( % )	104	105	105	<b>105</b>

\*N₂O was sampled on Aug 14, 2019

THC test times can be found in the accompanying Appendices

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 10: Unit 3 Trace Metals Emissions (OC Class)**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
<b>OC Class</b>				
Pb	0.00279	0.00109	0.00227	0.00205
As	0.00084	0.00029	0.00073	0.00062
Cr	0.00163	0.00026	0.00152	0.00114
Sum of OC Class	0.00526	0.00164	0.00453	0.00381
<b>Other</b>				
Al	0.00606	0.00364	0.01174	0.0071
Cd	0.00018	0.00033	0.00030	0.0003
P	0.00135	0.00073	0.00088	0.0010
Hg	0.00082	0.00079	0.00070	0.0008

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 11: Unit 3 Detailed Trace Metals Emissions**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
Pb	0.00279	0.00109	0.00227	0.00205
Sb	0.00109	0.00095	0.00015	0.00073
Cu	0.00108	0.00020	0.00097	0.00075
Mn	0.02296	0.00076	0.00044	0.00805
V	0.00034	0.00029	0.00029	0.00031
Zn	0.02064	0.01565	0.01863	0.01830
As	0.00084	0.00029	0.00073	0.00062
Cr	0.00163	0.00026	0.00152	0.00114
Co	0.00004	0.00007	0.00003	0.00005
Ni	0.00098	0.00039	0.00103	0.00080
Se	0.00126	0.00044	0.00044	0.00071
Te	0.00067	0.00058	0.00059	0.00061
Tl	0.00050	0.00044	0.00044	0.00046
Cd	0.00018	0.00033	0.00030	0.00027
Hg	0.00082	0.00079	0.00070	0.00077

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 12: Units 1, 2, 3 Summary of Speciated VOC Results**

Sample Date:	13-Aug-19 Unit 1			15-Aug-19 Unit 2			14-Aug-19 Unit 3		
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
<b>Test Times:</b>	09:10 - 10:10	10:14 - 11:14	11:25 - 12:25	09:07 - 10:07	10:14 - 11:14	11:27 - 12:27	08:45 - 09:45	10:07 - 11:07	11:23 - 12:23
<b>Acetylene (ppm)</b>	0.21	0.21	0.21	0.20	0.27	0.34	0.20	0.20	0.22
<b>Methane (ppm)</b>	1.20	1.10	1.10	1.40	1.50	1.80	1.20	1.20	1.40
<b>Ethane (ppm)</b>	0.25	0.25	0.25	0.24	0.32	0.41	0.24	0.24	0.26
<b>Ethene (ppm)</b>	0.25	0.25	0.25	0.24	0.32	0.41	0.24	0.24	0.26
<b>C3 as Propane (ppm)</b>	3.30	20.00	15.00	5.20	6.90	0.70	2.10	1.10	1.60
<b>C4 as n-Butane (ppm)</b>	0.42	1.40	1.30	0.40	0.55	0.70	0.39	0.40	0.43
<b>C5 as n-Pentane (ppm)</b>	0.42	0.41	0.41	0.40	0.55	0.70	0.39	0.40	0.43
<b>C6 as n-Hexane (ppm)</b>	0.42	0.41	0.41	0.40	0.55	0.70	0.39	0.40	0.43
<b>C6+ as n-Hexane (ppm)</b>	0.85	0.80	0.80	0.80	1.05	1.35	0.80	0.80	0.85
<b>Acetylene (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.14	0.14	0.14	0.13	0.18	0.23	0.13	0.13	0.14
<b>Methane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.80	0.73	0.73	0.93	1.00	1.20	0.80	0.80	0.93
<b>Ethane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.17	0.16	0.16	0.16	0.21	0.27	0.16	0.16	0.17
<b>Ethene (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.17	0.16	0.16	0.16	0.21	0.27	0.16	0.16	0.17
<b>C3 as Propane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	2.20	13.34	10.01	3.47	4.60	0.47	1.40	0.73	1.07
<b>C4 as n-Butane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.28	0.93	0.87	0.27	0.37	0.47	0.26	0.26	0.29
<b>C5 as n-Pentane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.28	0.27	0.27	0.27	0.37	0.47	0.26	0.26	0.29
<b>C6 as n-Hexane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.28	0.27	0.27	0.27	0.37	0.47	0.26	0.26	0.29
<b>C6+ as n-Hexane (mg/m<sup>3</sup> as CH<sub>4</sub>)</b>	0.57	0.53	0.53	0.53	0.70	0.90	0.53	0.53	0.57
<b>Total mg/Sm<sup>3</sup> @11% O<sub>2</sub> as CH<sub>4</sub></b>	3.41	12.16	9.52	4.97	6.09	3.72	2.56	2.60	3.24

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

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## 4.0 DISCUSSION

All emissions from all Units were within limits as set out in the OC.

The testing of Unit 2 for particulate and trace metals began the afternoon of August 13; however, due to an operational issue overnight, the testing did not continue on Unit 2 until August 15. The results show negligible difference in emissions between the two days.

For 2019, the manual measurement of total hydrocarbons was reduced to once annually. This survey represents that annual test and also includes the annual test for hexavalent chromium. This year, Unit 2 was chosen for the hexavalent chromium testing.

As stated in Section 2.1, EPA Method 5/29 was modified slightly to accommodate performance based analytical protocols utilized in B.C. for trace metals sampling and analysis. The analytical modification consists of using volumes of recovery reagents different than the method stipulates. In order to validate (ie performance-based QA) the modification, sample Blanks and all samples were made up to the same volume, so that subtraction of the Blank data, was done on equivalent sample sizes. In addition, special Hg spiking of blank filters and peroxide solutions was conducted. This spiking is referred to as a “matrix spike” and is reported in Appendix B, Quality Control for mercury, where the recovery of spiked mercury was calculated to be an acceptable 85 to 115%. It should be noted that independent front half/back half analysis of all trace metals was conducted for this survey. In addition, individual quartz filter blanks were analyzed for each unit.

Sampling was conducted in accordance with their respective reference methods (EPA 29 except as discussed) and passed all appropriate quality assurance and quality control criteria.

All sampling was conducted/supervised by certified emission testing personnel, using calibrated source sampling equipment and quality controlled reagents. It is therefore



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stated that the survey and this report complies with the MV's WTEF compliance testing requirements for this third survey in 2019.