

Alternative Low Carbon Fuel Annual Source Testing and Demonstration Trial Results

St Marys Cement Bowmanville Plant

September 5, 2019



St Marys Cement

Alternative Low Carbon Fuels (ALCF Permit) :

96 tonnes/day of woody biomass consisting mainly of wood chips from industrial and post-consumer sources which contains:

- $< 10\%$ non-woody material such as plastic, shingles, laminate, surface coatings and other material
- $< 5\%$ treated wood
- $\leq 1\%$ total halogen content
- $< 25\%$ moisture by weight

ALCFs (Permit for Trial Plastics – Demo Permit):

30% thermal replacement. Residuals derived from industrial and/or post-consumer sources, including plastic polymers, paper fibre and woody materials, received as single streams or blends.

The SMC plant was well below the Performance Objectives, while firing any amount of ALCF.

Parameter	Baseline Results	LCF Results	ECA Limit
Limits in Schedule B of the C of A (0469-9YUNSK)			
Particulate Matter	12.4 mg/Rm ³	7.97 mg/Rm ³	50 mg/Rm ³
Cadmium	0.192 µg/Rm ³	0.215 µg/Rm ³	7 µg/Rm ³
Lead	7.25 µg/Rm ³	5.44 µg/Rm ³	60 µg/Rm ³
Mercury	2.46 µg/Rm ³	2.44 µg/Rm ³	20 µg/Rm ³
Dioxins and Furans	16.6 pg/Rm ³ as ITEQ	14.7 pg/Rm ³ as ITEQ	80 pg/Rm ³ as ITEQ
Hydrochloric Acid	8.78 mg/Rm ³	6.86 mg/Rm ³	27 mg/Rm ³
Opacity	3.8%	3.8%	20%

The result analysis shows that there was no statistically significant difference in kiln stack emissions and POI concentrations of all contaminants as a result of the use of low carbon alternative fuel, relative to baseline conditions.

Results for Contaminants of Interest

Contaminant	CAS Number	Kiln Stack Emission Rate (g/s)		LCF higher than Conventional Fuel?	Updated POI Concentration (ug/m ³)		Averaging Period Emission Rate	Averaging Period POI Concentration	Ministry POI Limit (ug/m ³)	Percent of Ministry POI Limit (%)		Statistically Significant?
		Source Testing Conventional Fuel (Oct 2018)	Source Testing LCF (Oct 2018)		Source Testing Conventional Fuel (Oct 2018)	Source Testing LCF (Oct 2018)				Source Testing Conventional Fuel (Oct 2018)	Source Testing LCF (Oct 2018)	
Mercury	7439-97-6	4.03E-04	3.82E-04	No	n/a	n/a	24 hr	24 hr	2	n/a	n/a	No
TOTAL Dioxin and Furans (TEQ)	CDD	2.74E-09	2.33E-09	No	n/a	n/a	24 hr	24 hr	n/a	n/a	n/a	No
Benzene	71-43-2	2.44E-01	2.68E-01	Yes	3.33E-01	3.73E-01	24 hr	24 hr	100	0.3%	0.4%	No
Benzene	71-43-2	2.44E-01	2.68E-01	Yes	3.33E-01	3.73E-01	24 hr	Annual	4.5	7.4%	8.3%	No
Benzene	71-43-2	2.44E-01	2.68E-01	Yes	6.37E-03	7.22E-03	Annual	Annual	0.45	1.4%	1.6%	No

ALCF Demonstration Schedule and Program Components



SMC is approved to undertake time-limited alternative fuels demonstration projects under their demonstration Environmental Compliance Approvals (ECAs). The purpose of the demonstration is to show that SMC can successfully utilize the ALCFs permitted in their ECAs to offset a portion of conventional fuel.

SMC submitted the Pre-Test Plan to the Ministry of Environment, Conservation and Parks (MECP) on August 30th, 2018. The Pre-test plan was approved on September 18th, 2018.

SMC subsequently conducted an ALCF demonstration project at their Facility, from September 25th, 2018 to October 12th, 2018 (Trial 1 & Baseline) and from November 20th, 2018 to December 10th, 2018 (Trail 2 & Post-Baseline).

There were four main components to the project:

1. ALCF sourcing, preparation and inspections;
2. Raw feed and conventional fuel sampling;
3. Kiln stack testing program; and
4. Ambient air monitoring program.

Each component was completed for three operating conditions:

- baseline (conventional fuel only, prior to using ALCF);
- ALCF substitution; and
- post-baseline (conventional fuel only, after using ALCF).

1. ALCF Sourcing, Preparation and Inspections

Fuel Specifications



- Trial 1: woody residuals and post-consumer paper and plastic materials unsuitable for recycling.
- Trial 2: woody residuals from post-consumer sources as well as residual plastic material from an industrial source unsuitable for recycling.

Parameter	Units	Alternative Fuel Used During Demonstration (Average)		Conventional Fuel Used During Demonstration (Average)	
		Trial #1	Trial #2	Baseline & Trial #1	Trial #2 & Post-Baseline
Gross Calorific Value	MJ/kg	18.03	16.47	28.48	27.89
Total Carbon	%	42.34	39.78	68.63	77.76
Sulphur	%	0.15	0.23	3.34	2.8
Halogen	%	0.18	1.36	0.1	0.1

ALCF was introduced into the calciner burner using a dedicated Schenck fuel feed, conveyor and metering system having a maximum feed rate of 12 tonnes per hour.

Trial 1: Average fuel substitution rate was only 3.72 tonnes per hour, with a maximum feed rate of 5.48 tonnes per hour. This did not meet the target substitution rate and adjustments were therefore made to the fuel preparation program and fuel feed system.

Trial 2: Average fuel substitution rate was 8.3 tonnes per hour, with a maximum feed rate of 11.97 tonnes per hour. This met the target substitution rate.

2. Raw Feed and Conventional Fuel Sampling

Program Summary

The purpose was to ensure that the input into the system (i.e. kiln feed, conventional fuel for kiln and conventional fuel for calciner) was consistent so that the effect of introducing alternative fuel could be assessed.

Samples of each material were taken three times during each operating condition. Daily samples were composited and submitted to Maxxam Analytics (Maxxam) for metals (including mercury) and total halogens analyses.

The raw feed and conventional fuel sampling program demonstrated that the input (metals and total halogens) into the system from raw feed and conventional fuel was generally consistent across all operating conditions.

Raw feed analysis for total sulphur input was conducted by SMC and was also determined to be consistent across all operating conditions.



3. Kiln Stack Testing Program

Program Overview



RWDI AIR Inc. (RWDI) conducted the kiln stack testing program for all operating conditions. Triplicate tests were completed for each condition.

Source testing was undertaken for an extensive suite of compounds including:

- Total Particulate Matter (TPM), PM₁₀, PM_{2.5} and Metals;
- Polycyclic Aromatic Hydrocarbons (PAHs), Dioxins and Furans, and Dioxin-like PCBs (D&Fs);
- Hydrogen Chloride (HCl) and Ammonia (NH₃); and
- Volatile Organic Compounds (VOCs) including chlorinated organics.

In addition, continuous emission monitoring (CEM) was undertaken for nitrogen oxides (NO_x), sulphur dioxide (SO₂), carbon monoxide (CO), oxygen (O₂), carbon dioxide (CO₂) and opacity.

While data was collected for both Trial 1 and 2, only Trial 2 data was used for analysis because Trial 1 did not achieve the target substitution rate.

3. Kiln Stack Testing Program

Compliance with Operational Limits and Performance Objectives



The SMC plant fully complied with their Operational Limits and were well below the Performance Objectives, while firing any amount of ALCF.

Parameter	Operational Limit	Compliant?
Raw Material Feed Rate	>250 tonnes/hr	Yes
Quantity of Alternative Fuel	No more than 12 tonnes/hr	Yes
Temperature	>1000 °C at a residence time of >6 seconds in the kiln >850 °C at a residence time of >3 seconds in the calciner	Yes
Residual Oxygen (%)	>1% at the backend of the kiln >3% Residual oxygen at the calciner down comer duct	Yes
Pressure Control	Kiln must be operated under negative pressure	Yes
Operating Conditions	No alternative fuel to be used during start-up, shut-down or upset	Yes

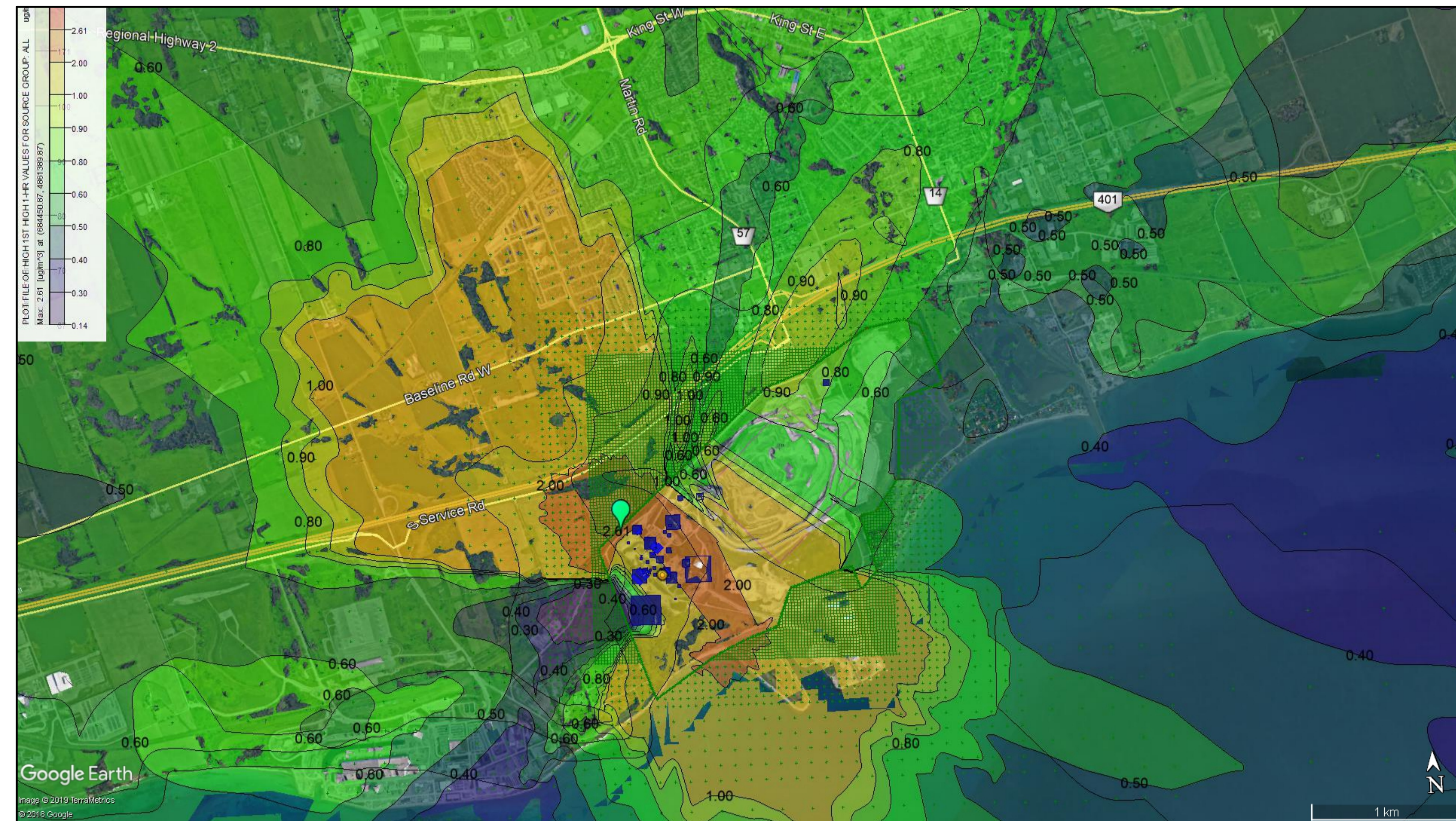
Performance Objective	Units	Emission Limit	Baseline	Trial 1	Trial 2	Post-Baseline
PM	mg/Rm ³	50	12.4	8.2	19	20
D&F	pg ITEQ/Rm ³	80	16.6	20	8.7	9.5
HCl	mg/Rm ³	27	8.8	6.1	7.6	3.0
Cadmium	µg/Rm ³	7	0.192	0.3	0.14	0.16
Lead	µg/Rm ³	60	7.25	5.3	1.4	0.89
Mercury	µg/Rm ³	20	2.46	1.5	1.4	0.86

3. Kiln Stack Testing Program

Compliance with Ontario Regulation 419/05

Air dispersion modelling for all significant contaminants was undertaken for all three operating conditions using the US EPA AERMOD modelling system (AERMOD version 16216r) and site-specific meteorological data provided by the Ministry.

The maximum Point-of-Impingement (POI) concentrations for each contaminant for each applicable averaging period under all operating conditions is below its respective Ministry POI limit. Only combustion gasses and particulate matter are more than 20% of the Ministry POI limits.



Location of Maximum Offsite Concentration from Kiln Stack

Ministry POI limits are air quality limits developed to protect human health and the environment.

They are conservatively set using safety factors and consider the most significant limiting effect (e.g. human health, odour, environment)

3. Kiln Stack Testing Program

Analysis of Statistically Significant Changes



There was no statistically significant difference in kiln stack emissions and POI concentrations of all contaminants as a result of the use of alternative fuel, relative to baseline conditions, with the exception of NO_x, SO₂ and HCl.

- NO_x – Emission rate and maximum POI concentration was lower during the use of alternative fuels.
- SO₂ – The change in SO₂ emissions and POI concentrations were determined to be a result of fluctuations in kiln operating conditions rather than a function of either raw feed or any fuel types.
- HCl – An analysis of chlorine content in the raw feed, conventional fuel and alternative fuel indicates that the emission rate is more closely related to the chlorine content in raw feed than in fuel. A review of SMC’s historical source testing data for HCl confirms that the emission rates for HCl under all operating conditions are within the normal range.

Results for Contaminants of Interest

Contaminant	CAS Number	Kiln Stack Emission Rate (g/s)			Are the Alt Fuel Emissions Within the Baseline Range? (Yes/No)	Updated POI Concentration (ug/m ³)			Averaging Period Emission Rate	Averaging Period POI Concentration	Ministry POI Limit (ug/m ³)	Percentage of Ministry POI Limit based on Maximum Sitewide Emissions			Statistically Significant?
		Baseline (Oct 2018)	Alt Fuel (Dec 2018)	Post Baseline (Dec 2018)		Baseline (Oct 2018)	Alt Fuel (Dec 2018)	Post Baseline (Dec 2018)				Baseline (Oct 2018)	Alt Fuel (Dec 2018)	Post Baseline (Dec 2018)	
Mercury	7439-97-6	4.03E-04	3.06E-04	< 1.73E-04	Yes	6.10E-04	4.80E-04	3.00E-04	24 hr	24 hr	2	0.03%	0.02%	0.02%	No
Dioxins, Furans and Dioxin-like PCBs	CDD	2.74E-09	1.89E-09	1.93E-09	No	3.80E-09	2.62E-09	2.67E-09	24 hr	24 hr	0.0000001	3.80%	2.62%	2.67%	No
Benzene	71-43-2	2.44E-01	2.48E-01	2.77E-01	Yes	3.38E-01	3.44E-01	3.84E-01	24 hr	24 hr	100	0.34%	0.34%	0.38%	No
Benzene	71-43-2	2.44E-01	2.48E-01	2.77E-01	Yes	6.47E-03	6.58E-03	7.35E-03	24 hr	Annual	4.5	0.14%	0.15%	0.16%	No
Benzene	71-43-2	2.44E-01	2.48E-01	2.77E-01	Yes	6.47E-03	6.58E-03	7.35E-03	Annual	Annual	0.45	1.44%	1.46%	1.63%	No

4. Ambient Air Monitoring Program

Program Overview

RWDI was retained by SMC to conduct ambient air monitoring in the vicinity of the Bowmanville Facility.

Ambient monitoring took place throughout the use of alternative fuel in October and December 2018, and on the days of the baseline and post-baseline source tests.



Ambient monitoring was undertaken for an extensive suite of compounds including:

- Metals;
- PAHs and D&Fs; and
- VOCs

4. Ambient Air Monitoring Program

Analysis of Statistically Significant Changes



Suite of Compounds	Results
Metals	<ul style="list-style-type: none">17 out of 27 metals – not statistically significant (Method 1).All remaining metals – not statistically significant (Method 2).
D&F	<ul style="list-style-type: none">Most individual D&Fs – not statistically significant (Method 1).Total D&Fs – not statistically significant (Method 2).
PAHs	<ul style="list-style-type: none">Most PAHs – not statistically significant (Method 1).Naphthalene – not statistically significant (Method 3).Benzo(a)pyrene (BaP) – measurements exceeded the AAQC on 5 days. These elevated ambient levels were a result of generally elevated levels in the Southern Ontario as verified by reviewing the ambient measurements from other ambient monitoring stations.
VOCs	<ul style="list-style-type: none">Most VOCs – not statistically significant (Method 1).For those contaminants that were detected – not statistically significant (Method 2 and 3).

Methodology – Not a statistically significant change if concentrations:

- 1.Are at or below the detection limit;
- 2.At upwind and downwind stations are within the ambient concentration range for the background stations;
- 3.For all stations under all operating conditions are within 1% of the AAQCs

4. Ambient Air Monitoring Program

Results of Contaminants of Interest

Date	Test	Total Dioxins and Furans (pg TEQ/m³)			Benzene (µg/m³)			Mercury (µg/m³)		
		OPG	Cove	Beach	OPG	Cove	Beach	OPG	Cove	Beach
24 hour AAQC		0.1			2.3			2		
Sept 30	Baseline	*	0.0434	0.0420	1.95	0.36	0.40	*	Below D.L.	Below D.L.
Oct 1	Baseline	0.0439	0.0397	*	0.42	0.22	0.3	Below D.L.	Below D.L.	*
Oct 2	Baseline	0.0370	0.0378	0.0384	0.35	0.3	0.31	Below D.L.	Below D.L.	Below D.L.
Oct 3	Alt Fuel	0.0379	0.0372	0.0399	0.31	0.33	0.16	Below D.L.	Below D.L.	Below D.L.
Oct 4	Baseline	0.0399	0.0380	0.0414	0.24	0.24	0.73	Below D.L.	Below D.L.	Below D.L.
Oct 10	Alt Fuel	0.0359	0.0347	0.0355	0.46	0.27	0.62	Below D.L.	Below D.L.	Below D.L.
Oct 11	Alt Fuel	0.0304	0.0297	0.0313	0.22	0.24	0.24	Below D.L.	Below D.L.	Below D.L.
Oct 12	Alt Fuel	0.0281	0.0316	0.0320	0.23	0.24	0.41	Below D.L.	Below D.L.	Below D.L.
Dec 4	Alt Fuel	0.0402	0.0455	0.0414	0.56	0.62	0.73	Below D.L.	Below D.L.	Below D.L.
Dec 5	Alt Fuel	0.0336	0.0329	0.0329	0.62	0.86	*	Below D.L.	Below D.L.	Below D.L.
Dec 6	Alt Fuel	0.0483	0.0351	0.0391	0.49	0.53	0.51	Below D.L.	Below D.L.	Below D.L.
Dec 7	Baseline	0.0356	0.0347	0.0347	0.44	0.40	0.40	Below D.L.	Below D.L.	Below D.L.
Dec 8	Baseline	0.0326	0.0326	0.0372	0.58	0.51	0.55	Below D.L.	Below D.L.	Below D.L.

* Power outage/stolen samples; **Dark blue** – Source testing dates for Demonstration Trial 1 and Trial 2; Detection limit for mercury is 0.002 µg/m³

- A maximum alternative fuel consumption rate of approximately 12 tonnes per hour was achieved during the demonstration project.
- The raw feed and conventional fuel sampling program demonstrated that the input (metals and total halogens) into the system from raw feed and conventional fuel was generally consistent across all operating conditions.
- The SMC plant fully complied with their Operational Limits, their Performance Objectives, and with Reg 419 while firing any amount of ALCF.
- The data obtained from the source testing program demonstrated that, there was no statistically significant difference in kiln stack emissions and POI concentrations of all contaminants as a result of the use of alternative fuel, relative to baseline conditions.
- The data obtained from the ambient monitoring program demonstrated that there was no statistically significant difference in ambient air concentrations of any contaminant as a result of the use of ALCF, relative to baseline conditions.