

Air Quality Monitoring Audit in Sault Ste. Marie (2008-2009)

A Report Prepared By

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Air Quality Monitoring Audit in Sault Ste. Marie (2008-2009)

Executive Summary

From July 2008 through May 2009, the Technical Support of Northern Region, Ministry of the Environment (MOE) conducted a co-located air quality monitoring audit at the Wallace Terrace station in Sault Ste. Marie (SSM) to investigate the discrepancies between the historical data collected by the MOE and the air quality data submitted by Conestoga-Rovers & Associates (CRA) on behalf of Essar Steel Algoma Inc (Essar). During the co-located audit, samplers of total suspended particulate matter (TSP), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) were installed site by site, and maintained and operated by CRA and MOE, respectively. The purpose of the study was to assess if there are any significant differences between the data collected by CRA and MOE.

The key findings were:

- A strong correlation was found for the TSP data collected by CRA and by MOE. TSP concentrations reported by CRA were close to the corresponding values by MOE: no significant difference between the TSP results.
- Overall, all metals concentrations in TSP were quite low. Correlations between data from CRA and MOE were weak for most of metals. Chromium, vanadium and zinc concentrations reported by CRA were significant lower than those collected by MOE, with the vanadium and zinc concentrations from CRA an order lower than those from MOE.
- VOCs concentrations from CRA were considerable lower than those from MOE according to the correlation analysis. Benzene concentrations reported by CRA were approximately 30-50 per cent of those values reported by MOE. The correlations between VOCs data from CRA and MOE were weak except for benzene and toluene.
- The PAH concentrations from CRA were also consistently lower than those from MOE. On average, benzo(a)pyrene concentrations reported by CRA are about 53 per cent of the corresponding values by MOE. However, correlation analysis indicates a strong linear relationship for most of the PAHs.

1. Introduction

The Essar Steel Algoma Inc. (hereafter Essar) is a steel manufacture facility located on the north shore of the St. Marys River in Sault Ste. Marie, Ontario. Routine air quality monitoring is being conducted in Sault Ste. Marie, which includes a provincial air quality index (AQI) monitoring station to monitoring ambient air quality at regional scale, and several stations to monitor source emissions from the facility of Essar (Figure 1). Table 1 summarizes the on-going routine air quality monitoring stations and parameters near the Essar facility.

The Ministry of the Environment (MOE) had operated the air quality monitoring in Sault Ste. Marie for many years. Ontario industries began taking over the responsibility of operating and maintaining air monitoring stations when the Source Emissions Monitoring (SEM) program was initiated by MOE in 2003. In December 2004, the responsibility for the operation of air quality monitoring stations was transferred to Essar. MOE oversees the monitoring equipment by conducting audits to ensure data quality and integrity.

Previous data analysis indicated discrepancies between historical data collected by MOE and the air quality data submitted by Conestoga-Rovers & Associates (CRA) on behalf of Essar. The analysis showed that values of contaminants submitted by CRA tended to be lower with larger numbers of nondetects than the historical data collected by MOE. The possible sources of data discrepancies include but not limited to sampling techniques, operating procedures, laboratory analytical methodology, and data handling and reporting, etc.

A co-located audit was conducted at the Wallace Terrace station to measure total suspended particulate matter (TSP), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) from July 2008 to May 2009. The objective of this study was to ascertain if there are any significant differences on air monitoring data collected by MOE and CRA.

2. Methodology

A co-located audit study was conducted at the Wallace Terrace station in SSM from July 2008 through May 2009 (Figure 1). The measurements include total suspended particulate matter, volatile organic compounds, and polycyclic aromatic hydrocarbon. CRA operated TSP, VOCs and PAHs samplers on behalf of Essar, while MOE operated their own samplers for TSP, VOCs, and PAHs. All the samplers were installed side by side at the top of a roof (Figure 2), and followed the procedures as specified in the Operations Manual for Air Quality Monitoring in Ontario¹. To eliminate the impacts of sampling methods on air quality monitoring data, CRA and MOE used the same sampling techniques to collect TSP, VOCs and PAHs samples (see below for details).

¹ Operations Manual for Air Quality Monitoring in Ontario. Ontario Ministry of the Environment, Operations Division, Technical Support Section, March 2008.

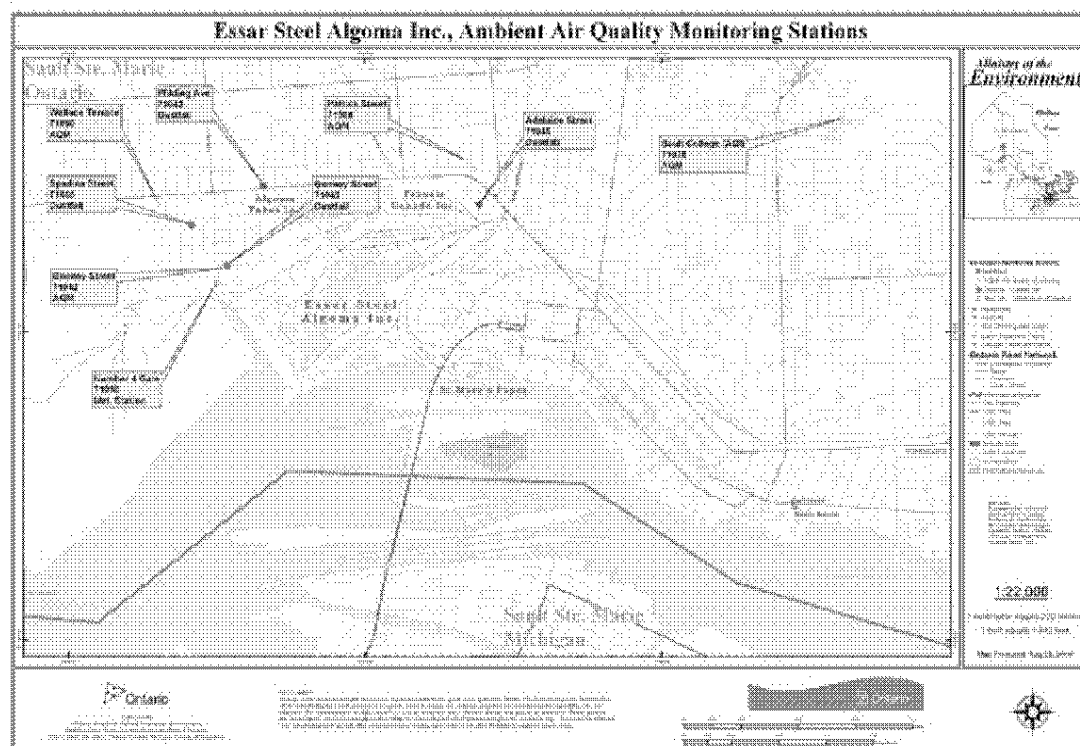


Figure 1: Air quality monitoring stations in Sault Ste. Marie.

Table 1: Summary of routine air monitoring in Sault Ste. Marie in the vicinity of Essar Steel Algoma Inc.

Location	Station No.	Parameters						
		Continuous monitors		Non-continuous monitors				
		PM ₁₀	TRS	Dustfall	TSP	PM ₁₀	VOC	PAH
Spadina	71015			M				
Bonney St.*	71042			M				
Wilding Ave. & Wallace Terrace	71043			M				
Adelaide St.	71045			M				
Patrick St.	71068		H		6D	6D	12D	12D
Wallace Terrace	71090	H	H		6D		12D	12D

* MOE installed a BAM at Bonney St. to monitoring TSP from July 2008.

H = hourly

6D = 1 in 6 days sampling schedule

12D = 1 in 12 days sampling schedule

M = monthly sampling schedule

Total suspended particulate matter was collected using a high volume (hi-vol) sampler which draws a known flow rate of air through a pre-weighted glass fiber filter for 24 hours. The flow rate was approximately 40 cubic feet per minute controlled by a flow controller. TSP concentration was determined according to the particulate weight collected on the filter and the known flow volume for the sampling period. Part of the

filter was also analysed to identify metals concentrations. TSP samplers were collected every 6th day for 24-hr (midnight to midnight), which is consistent with the North American sampling schedule.



Figure 2: TSP, PAHs samplers, and VOCs inlet for the co-located audit at the Wallace Terrace station in Sault Ste. Marie.

Volatile organic compounds in the ambient air were collected onto the thermal desorption tubes at a fixed flow rate of 5 ml min⁻¹. Samples were run for 24 hours (midnight to midnight) every 12th day. The tubes used by CRA and MOE are different in dimensions.

Polycyclic aromatic hydrocarbons were collected through a Teflon-coated glass fibre filter followed by a pair of polyurethane foam (PUF) cartridges to collect both gas phase and particulate bound PAHs at a flow rate of 8 cubic feet per minute, and the sampling was also performed for 24 hours (midnight to midnight) on a 12-day sampling schedule.

TSP, VOCs and PAHs samples collected by CRA were sent to Maxxam Analytics Inc. (hereafter Maxxam) for analysis, while TSP and VOCs samples collected by MOE were analysed by the Laboratory Service Branch (LaSB) of MOE, and PAHs samples were analysed by an organic laboratory of the Environmental Technology Centre (ETC) with Environment Canada (EC).

Metals in TSP from CRA were determined using the inductively coupled plasma atomic emission spectroscopy (ICP-AES) by Maxxam. Metals in TSP from MOE were analysed using a x-ray fluorescence (XRF) method by LaSB. Gas chromatograph/mass spectrophotometer (GC/MS) was used to analyse VOCs samples by Maxxam and LaSB according to United States Environmental Protection Agency's Toxic Organic Method (US EPA Method TO-17). The California Air Resource Board (CARB) Method 429 was used by Maxxam, while a method similar to the US EPA Method TO-13A was used by the ETC to analyse PAH samples. Maxxam is accredited by the Standards Council of Canada (SCC), while LaSB and ETC are accredited through the Canadian Association for Environmental Analytical Laboratories (CAEAL) for the specific air testing. Table 2 presents a summary of the co-located study, including sampling techniques, sampling frequency and duration, site operators and analytical laboratories, etc.

Table 2: Summary of the co-located air audit study at the Wallace Terrace station in SSM.

	Parameter	Sampler	Frequency	Co-located period	Site operator	Analytical laboratory
Essar	TSP	Hi-vol	Every 6 th day	July 2008-May 2009	CRA	Maxxam
	VOCs	Absorbent cartridge	Every 12 th day	July 2008-May 2009	CRA	Maxxam
	PAHs	Filter & PUF cartridge	Every 12 th day	July 2008-May 2009	CRA	Maxxam
MOE	TSP	Hi-vol	Every 6 th day	July 2008-May 2009	MOE	LaSB
	VOCs	Absorbent cartridge	Every 12 th day	July 2008-May 2009	MOE	LaSB
	PAHs	Filter & PUF cartridge	Every 12 th day	July 2008-May 2009	MOE	ETC

Note: please refer the report for the abbreviations.

3. Data Analysis

Statistics and linear regression analyses were used to compare the data collected by CRA and MOE at the Wallace Terrace station during the co-located study period. For the data submitted by CRA, the non-detect TSP, metals, VOCs and PAHs were reported as less

than method detection limits (MDLs), and half of MDL values were substituted for the purpose of performing statistical analyses. LaSB reported the non-detect data with a '<W', and these values were left as is because the W is a fraction of the MDL. ETC reported non-detects as '<0.xxxx' for a MDL of 0.xxxx, and these MDLs were halved to generate statistics.

3.1 Total Suspended Particulate Matter (TSP)

Table 3 summarizes TSP data collected from the co-located audit study from 11 July 2008 to 7 May 2009. The 24-hr average TSP concentrations were $27 \mu\text{g m}^{-3}$ and $31 \mu\text{g m}^{-3}$, with standard deviations of $19 \mu\text{g m}^{-3}$ and $20 \mu\text{g m}^{-3}$ for TSP samples collected by CRA and MOE, respectively. The reported maximum 24-hr average TSP concentrations were $74 \mu\text{g m}^{-3}$ from CRA collected data and $84 \mu\text{g m}^{-3}$ from MOE. No TSP exceedences were recorded during the study period. The wind rose illustrates that the majority of winds during the audit period were from the northeast and northwest, with a lesser amount coming from the southeast and north (Figure 3). The Wallace Terrace station is located in the southeast of the Essar (Figure 1).

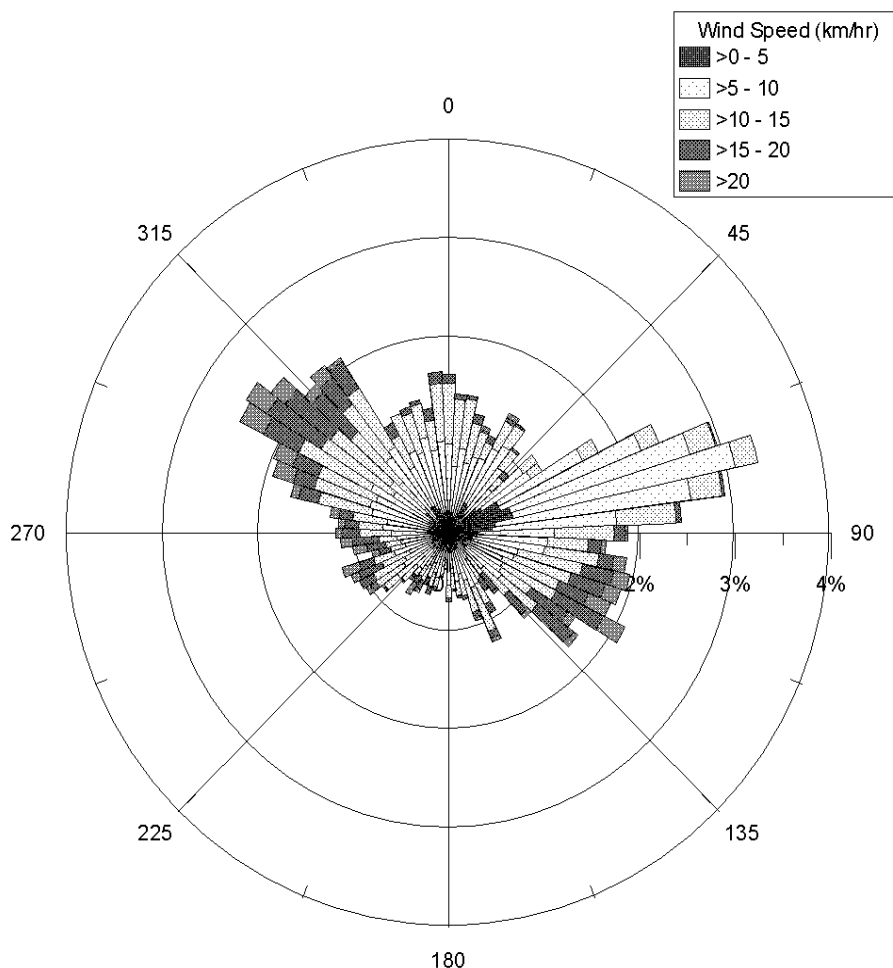


Figure 3: Wind rose showing prevailing wind directions and speeds during the audit period in Sault Ste. Marie (July 2008 – May 2009).

The relationship between 24-hr average TSP concentrations from CRA and MOE during the study period is shown in Figure 4. There is a strong linear relationship between the 24-hr average TSP collected by CRA and MOE with a R-squared value of 0.88. The slope of the regression line was 0.85 with an intercept of 0.61, indicating a good agreement between TSP data from CRA and values from MOE.

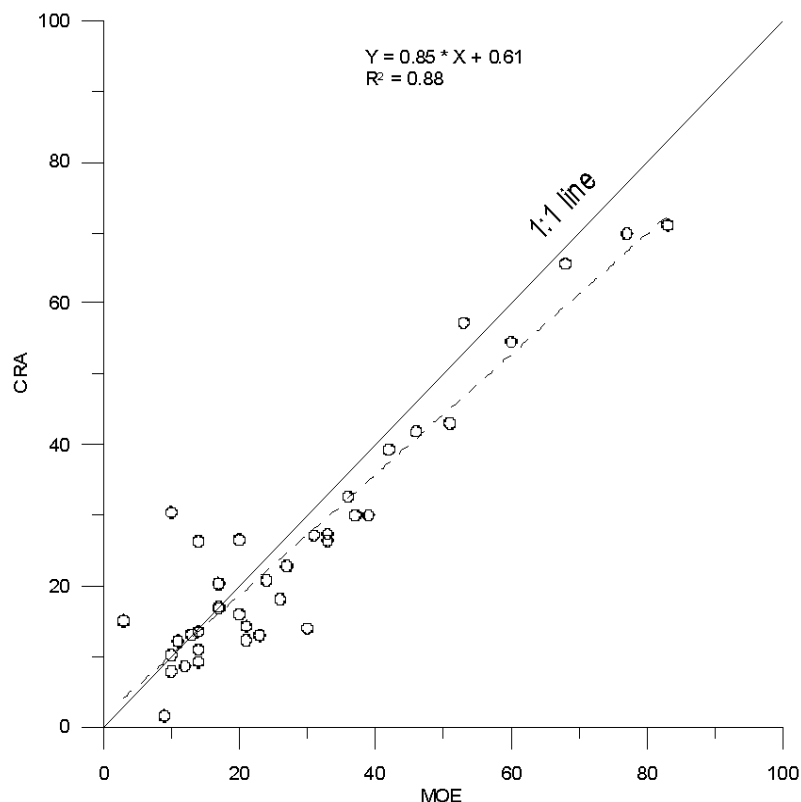


Figure 4: Linear regression between total suspended particulate matter (TSP) data ($\mu\text{g m}^{-3}$) collected by CRA and MOE during the audit period. The solid line indicates 1:1 line through the origin, and the dash line shows the best-fit linear regression line.

Table 3 summarizes statistics with regard to metals in TSP. All metals concentrations were quite low, and well below the Regulation 419 standards, guidelines or schedule 6 upper risk thresholds (except for iron). There were many samplers in which the metals concentrations were less than method detection limits, especially for nickel, cadmium and lead (see Table A-2 in the Appendix). The comparisons of metals concentrations from MOE and CRA showed that the correlations of metals between CRA and MOE were weak, except for lead, iron, and manganese. Chromium, vanadium and zinc concentrations reported by CRA were significantly lower than those by MOE. The vanadium and zinc concentrations from CRA were an order lower than those from MOE.

It's interesting to note that copper concentrations from CRA were close to the values from MOE from January 2009, even though the copper concentrations reported by CRA were much lower than those from MOE from July 2008 to December 2008. (see Table A-2 in the Appendix for details).

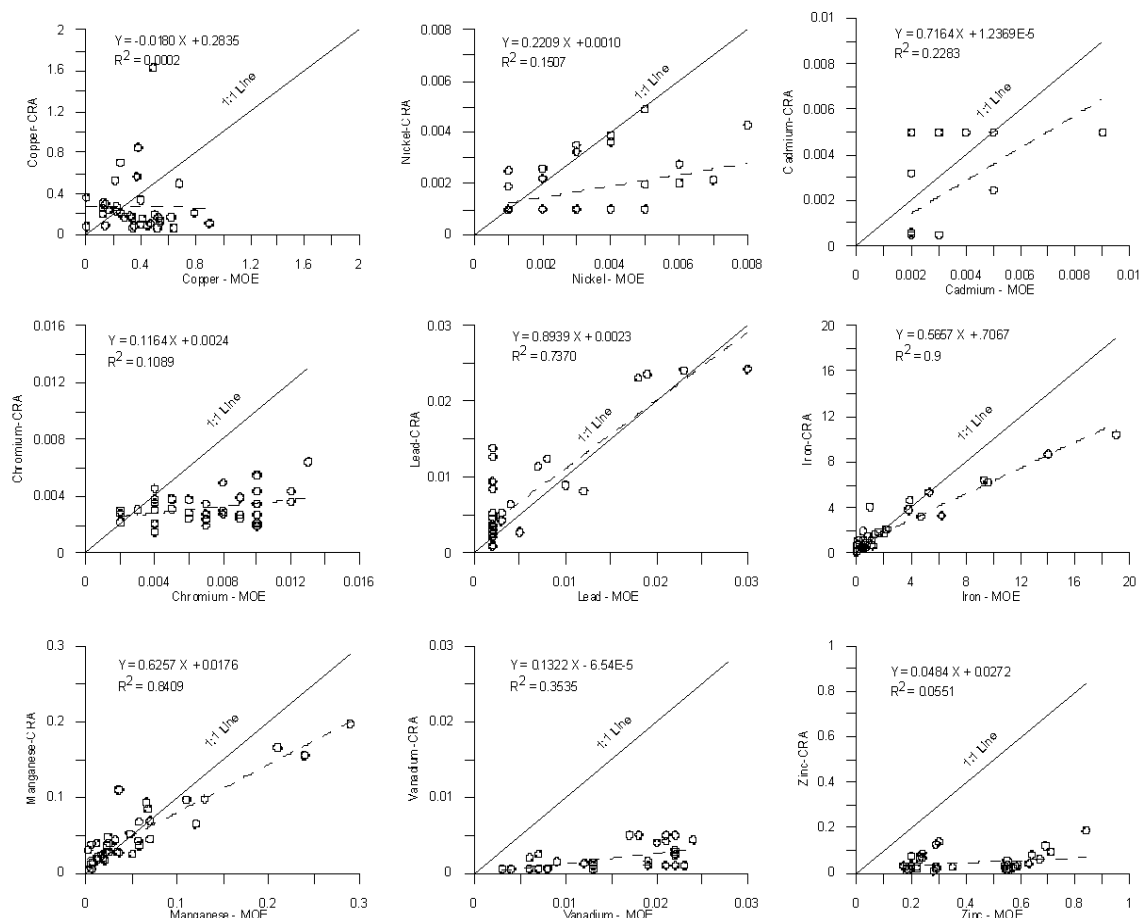


Figure 5: Same as in Figure 4, but for metals concentrations.

3.2 Volatile Organic Compounds (VOCs)

The collected VOC samples were analysed for a suite of 38 VOCs for CRA by Maxxam, and 45 VOCs for MOE by LaSB, respectively. However, only nine VOCs were chosen and compared in this report (Benzene, Toluene, Ethylbenzene, m-/p-xylene, o-xylene, 1,3,5-Trimethylbenzene, 1,2,4-Trimethylbenzene, Carbon tetrachloride, and Naphthalene). Of these nine VOCs, benzene is of the most concern because of its proven toxic effect on human carcinogen.

Table 4 shows the summary statistics of the VOC data, while Figure 6 illustrates the linear relationship between data collected by CRA and MOE during the co-located sampling period. The 24-hr average benzene concentrations were $2.27 \mu\text{g m}^{-3}$ and $5.22 \mu\text{g m}^{-3}$, with standard deviations of $1.85 \mu\text{g m}^{-3}$ and $5.31 \mu\text{g m}^{-3}$ for CRA and MOE measurements, respectively. The maximum benzene concentration was $8.55 \mu\text{g m}^{-3}$ for CRA samples, and $22.90 \mu\text{g m}^{-3}$ for MOE samples.

Table 3: Summary statistics of TSP and metals data for the audit study.

Parameter	Site operator	Valid sample number	Arithmetic Mean ($\mu\text{g m}^{-3}$)	Geomean ($\mu\text{g m}^{-3}$)	Maximum ($\mu\text{g m}^{-3}$)
TSP	CRA	45	27	20	83
	MOE	42	31	25	74
Copper	CRA	45	0.267	0.190	1.630
	MOE	42	0.367	0.250	0.900
Nickel	CRA	45	0.002	0.001	0.005
	MOE	42	0.003	0.003	0.008
Cadmium	CRA	45	0.002	0.001	0.005
	MOE	42	0.002	0.002	0.009
Chromium	CRA	45	0.003	0.003	0.009
	MOE	42	0.007	0.006	0.013
Lead	CRA	45	0.007	0.004	0.024
	MOE	42	0.005	0.003	0.030
Iron	CRA	45	2.187	1.218	10.417
	MOE	42	2.736	0.850	19.000
Manganese	CRA	45	0.056	0.038	0.259
	MOE	42	0.063	0.034	0.290
Vanadium	CRA	45	0.002	0.001	0.007
	MOE	42	0.015	0.013	0.028
Zinc	CRA	45	0.046	0.035	0.186
	MOE	42	0.421	0.373	0.840

Table 4: Summary statistics of VOCs data for the audit study.

VOCs	Site operator	Valid sample number	Average ($\mu\text{g m}^{-3}$)	Maximum ($\mu\text{g m}^{-3}$)	Standard deviation ($\mu\text{g m}^{-3}$)
Benzene	CRA	18	2.27	8.55	1.85
	MOE	21	5.22	22.90	5.31
Toluene	CRA	18	12.58	56.22	12.91
	MOE	21	32.07	181.00	45.51
Ethylbenzene	CRA	18	2.86	8.00	2.09
	MOE	21	7.79	47.50	10.82
m-/p-xylene	CRA	18	9.40	23.00	6.20
	MOE	21	26.70	190.00	42.25
o-xylene	CRA	18	3.63	10.00	2.39
	MOE	21	9.93	68.00	15.10
3,5-Trimethylbenzene	CRA	18	1.03	4.00	0.86
	MOE	21	2.67	14.40	3.20
2,4-Trimethylbenzene	CRA	18	2.73	14.00	2.93
	MOE	21	11.40	62.20	13.66
Carbon tetrachloride	CRA	18	0.36	0.89	0.20
	MOE	21	0.51	0.83	0.10
Naphthalene	CRA	18	0.32	2.20	0.57
	MOE	21	3.02	12.50	3.07

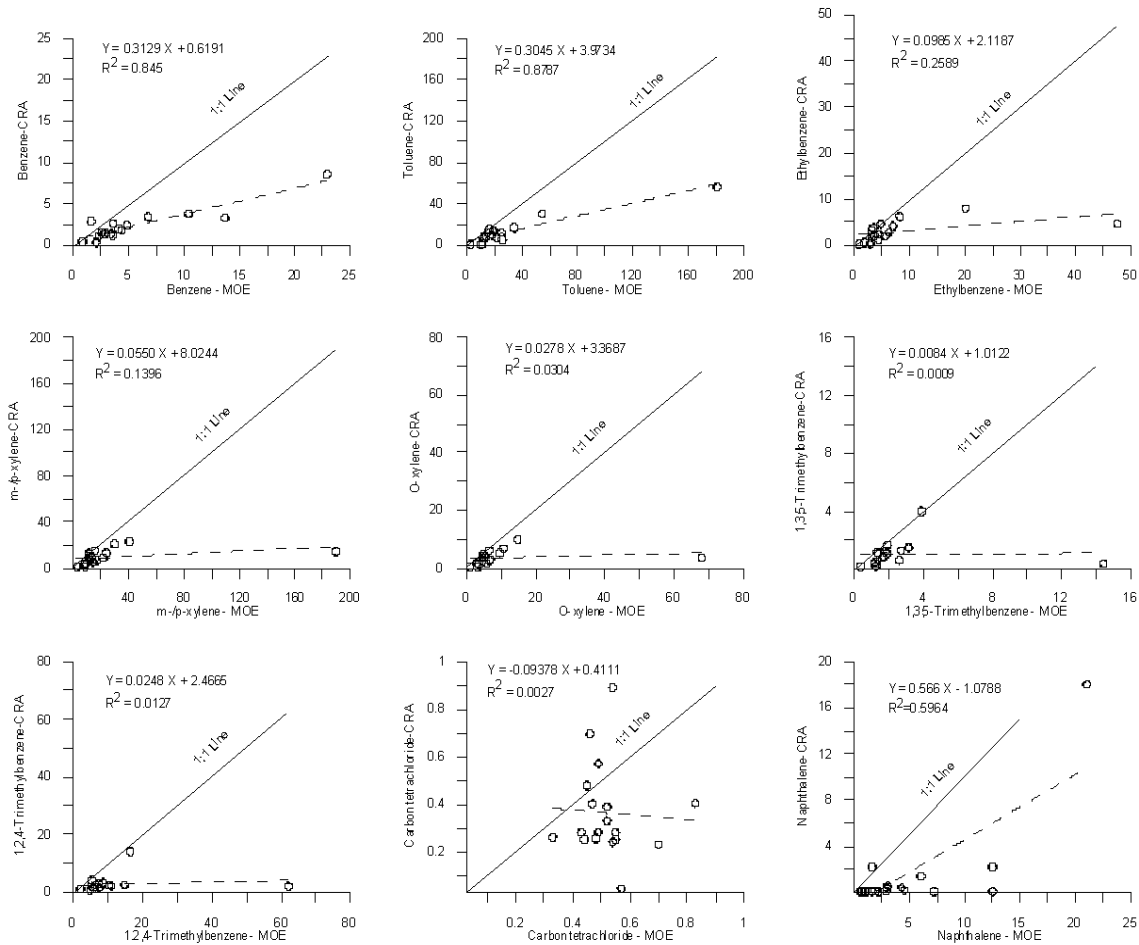


Figure 6: Same as in Figure 4, but for VOCs concentrations

The comparison between CRA and MOE measurements in Figure 6 indicates that VOCs concentrations from CRA collected samplers were consistently much lower than those from MOE collected samplers. On average, benzene concentrations from samples collected by CRA are approximately 30-50 per cent of the values from MOE with a linear correlation coefficient of 0.92 (Figures 6 and 7). Similar trend was found for other VOC components with weak correlation coefficients except for toluene. The complete data sets for VOCs collected by CRA and MOE are given in Table A-3 of the Appendix.

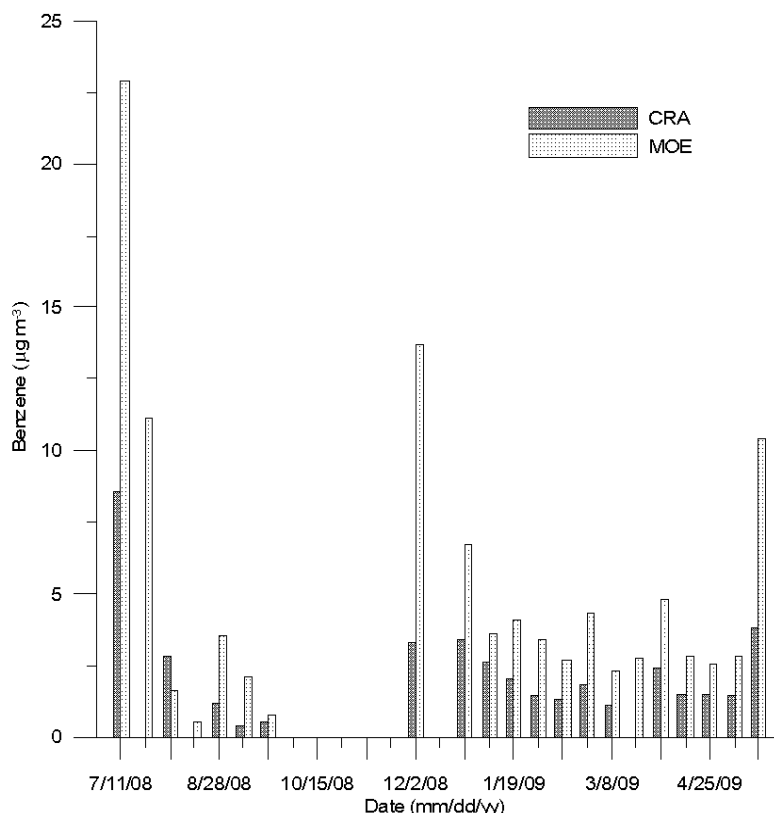


Figure 7: 24-hr average benzene concentrations from samples collected by CRA and MOE during the audit period (July 11, 2008 to May 19, 2009). There is a gap from October through November in 2008 because samples for this period were not collected at the same date by CRA and MOE.

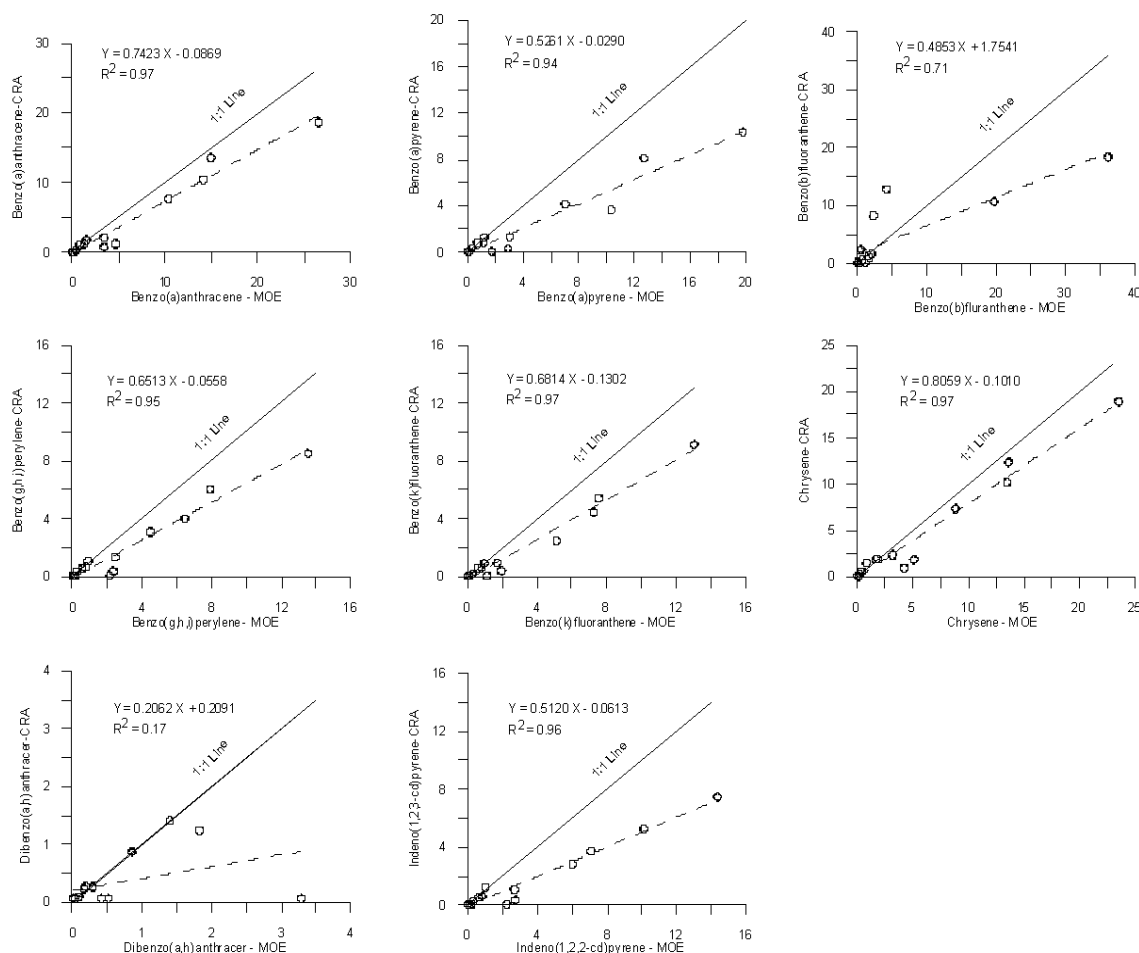
3.3 Polycyclic Aromatic Hydrocarbons (PAHs)

The samples collected by CRA were analysed for a suite of 8 PAH compounds by Maxxam, while the samples collected by MOE were analysed for a suite of 30 PAH compounds by ETC. The Ministry has a guideline of 1.1 ng m^{-3} for benzo(a)pyrene with a 24-hr averaging period.

Table 5 shows a summary statistics of various PAHs for samples collected by CRA and MOE during the co-located sampling period. For benzo(a)pyrene, 6 out of 18 (33.3%) samples exceeded the 24-hr average 1.1 ng m^{-3} for data from CRA, while 10 out of 18 samples (55.6%) for data from MOE. The average benzo(a)pyrene concentration was 1.84 ng m^{-3} for data from CRA, and 3.58 ng m^{-3} for MOE, with a corresponding maximum concentration of 10.37 ng m^{-3} for CRA, and 19.78 ng m^{-3} for MOE.

Table 5: summary statistics of PAHs for the co-located study at the Wallace Terrace station

PAH	Site operator	Valid sample number	Average (ng m ⁻³)	Maximum (ng m ⁻³)	# below MDL	# above AAQC
Benzo(a)anthracene	CRA	18	3.41	18.64	5	
	MOE	18	4.74	26.53	2	
Benzo(a)pyrene	CRA	18	1.84	10.37	6	6
	MOE	18	3.58	19.78	2	10
Benzo(b)fluoranthene	CRA	18	3.61	18.43	3	
	MOE	18	4.31	36.07	2	
Benzo(g,h,i)perylene	CRA	18	1.55	8.52	6	
	MOE	18	2.48	13.53	0	
Benzo(k)fluoranthene	CRA	18	1.52	9.14	6	
	MOE	18	2.39	13.04	2	
Chrysene	CRA	18	3.55	18.89	3	
	MOE	18	4.51	23.49	1	
Dibenzo(a,h)anthracene	CRA	18	0.34	1.42	10	
	MOE	18	0.53	3.29	4	
Indeno(1,2,3-cd)pyrene	CRA	18	1.39	7.47	6	
	MOE	18	2.82	14.34	2	

**Figure 9: Same as in Figure 4, but for PAHs concentrations.**

The comparison between PAHs data from CRA and MOE illustrates an excellent correlation (Figure 9), with all correlation coefficients greater than 0.96 except for benzo(b)fluoranthene ($R^2=0.71$) and dibenzo(a,h)anthracene ($R^2=0.17$). Despite the excellent correlation between the two sets of data, there is a significant difference from a 1:1 relationship (Figure 9). PAHs concentrations from CRA were consistently lower than those from MOE. On average, the benzo(a)pyrene concentrations from CRA's measurements are approximately 53 per cent of those from MOE's measurements (Figures 9 and 10, and Table 5). Similar trend was found for other PAHs (see Figure 9 and Table A-4 for details).

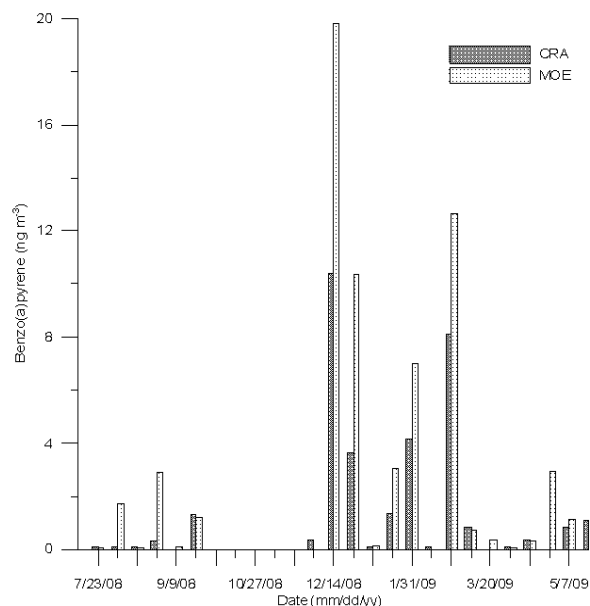


Figure 10: Same as in Figure 7, but for benzo(a)pyrene.

4. Inter-laboratory Comparison Study

To resolve data discrepancies observed in the air samples provided by CRA and collected by MOE, an inter-laboratory comparison study was carried out by a team from the LaSB as requested by the Technical Support of Northern Region, MOE. Three analytical laboratories including the organic lab of ETC with Environment Canada, Maxxam Analytics, LaSB of MOE participated in the inter-laboratory comparison study. A total of two samples were analysed by each laboratory. Below is a summary of the preliminary results from the inter-laboratory comparison study:

For PAHs, the results for Sample 1 are comparable among all three participated laboratories. Results from ETC and LaSB also compared well for Sample 2 with Maxxam producing significantly lower results (Figure 11).

The metals concentrations from LaSB compared well with the designed/expected values, while Maxxam produced lower results for all metals for Sample 1 (Figure 12). The metals results from Sample 2 were not included in the preliminary report due to issues

with that sample analysed by LaSB. For air particulate matter, there was no significant difference between the results analysed by Maxxam and LaSB.

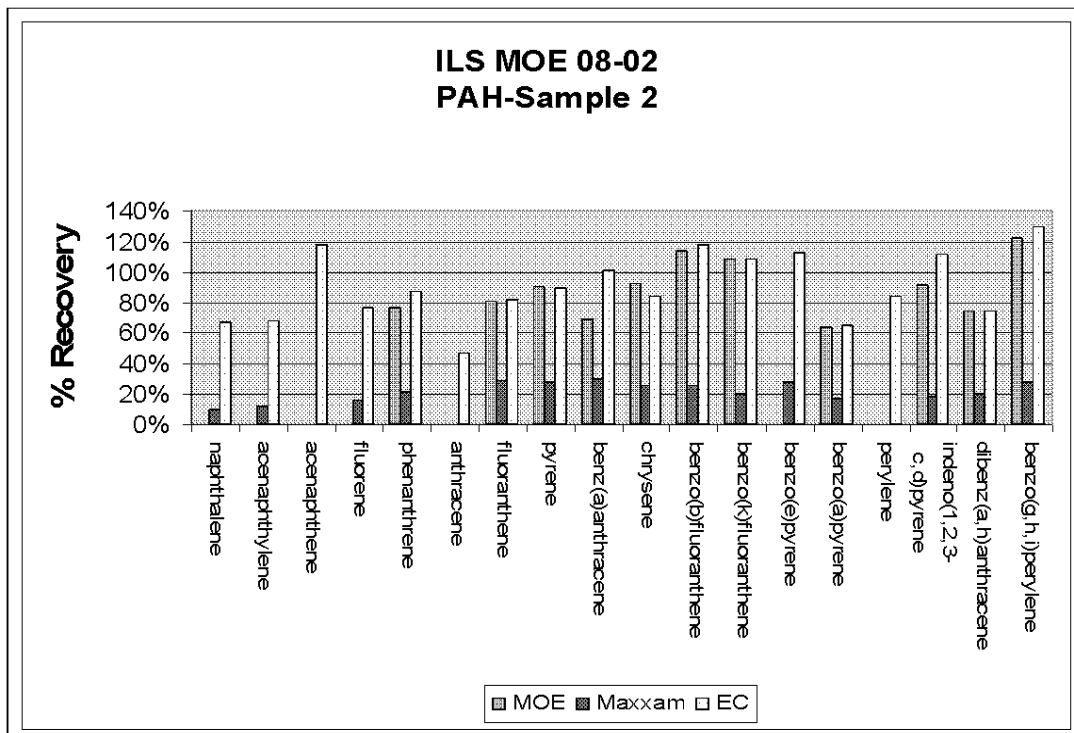


Figure 11: Comparison of PAHs results for Sample 2 analysed by three laboratories: Maxxam, LaSB (MOE) and ETC (EC)

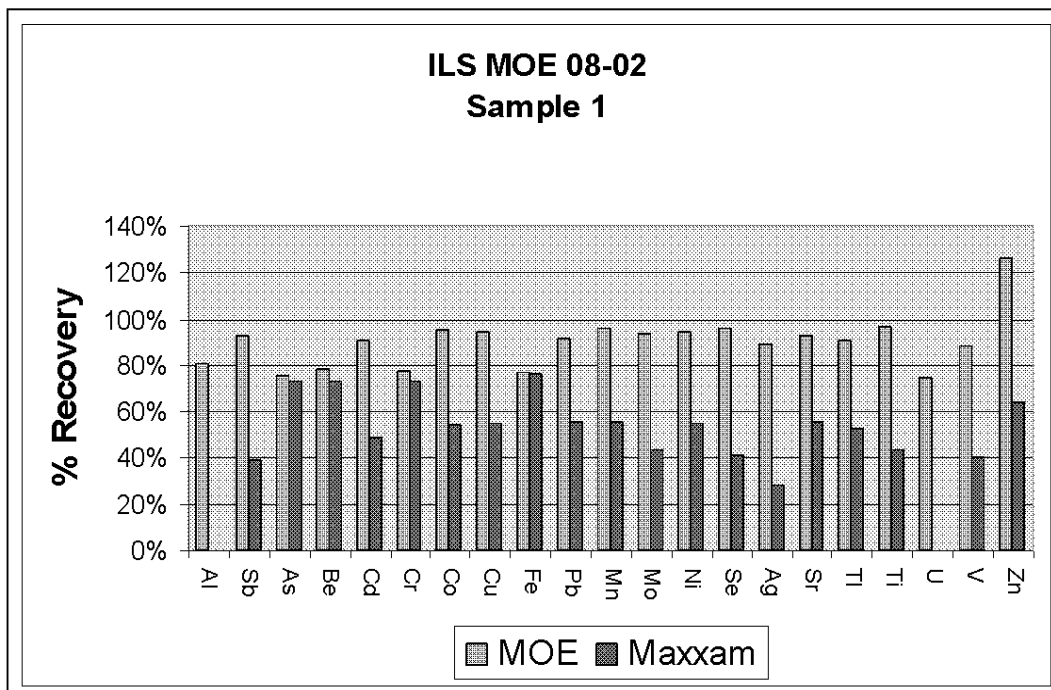


Figure 12: Comparison of metals results for Sample 1 analysed by Maxxam and LaSB (MOE).

5. Conclusions

A co-located air sampling audit was conducted at the Wallace Terrace station in Sault Ste. Marie from July 2008 through May 2009. TSP, VOCs and PAHs were collected by CRA and MOE using the same sampling techniques, and samplers were installed site by site. Samples collected by CRA were analysed by Maxxam analytical Inc, while TSP and VOC samples collected by MOE were analysed by LaSB of MOE, and PAH samples were analysed by the organic laboratory of ETC with EC.

Comparison of the average and maximum TSP data collected by CRA and MOE showed that the TSP concentrations from CRA were in good agreement with those collected by MOE. There was a strong linear relationship between TSP data from CRA and those from MOE, while the correlations between metals in TSP from CRA and MOE were weak for most of metals. There were significant differences in the chromium, vanadium and zinc concentrations between samplers collected by CRA and MOE, and the vanadium and zinc concentrations from CRA were even an order lower than those from MOE.

Concentrations of VOCs from samples collected by CRA were considerable lower than those from MOE. On average, benzene concentrations from CRA were approximately 30-50 per cent of the corresponding values from MOE, with a maximum benzene concentration of $8.55 \mu\text{g m}^{-3}$ from CRA samples, and $22.90 \mu\text{g m}^{-3}$ from MOE samples. The linear correlations were weak for most of selected VOCs except for benzene and toluene.

Comparison of the PAHs concentrations reported by CRA and those by MOE showed that the PAHs concentrations reported by CRA were also consistently lower than the corresponding values by MOE. Benzo(a)pyrene concentrations were only about 52% of those values reported by MOE. However, excellent correlation was found for the PAHs measurements between CRA and MOE, with all correlation coefficients greater than 0.96 except for benzo(b)fluoranthene ($R^2=0.71$) and dibenzo(a,h)anthracene ($R^2=0.18$).

No consistent trend was found for the inter-laboratory comparison study based on the results from two samples: analytical results from one sampler compared well among three laboratories, but not for another sample. It's hard to draw a conclusion from the preliminary results on the inter-laboratory comparison study at this stage.

The reason of consistent lower values reported by CRA than those by MOE remains unexplained, even though the same sampling techniques were used to collect TSP, VOCs and PAHs during the audit period. To identify if the laboratory analysis results in the data discrepancies, it is recommended that in the further, either inter-laboratory comparison with more samples be conducted or co-located samples be analysed by the same laboratory.

Appendix**Table A-1 TSP data ($\mu\text{g m}^{-3}$) from the audit period at the Wallace Terrace station in Sault Ste. Marie.**

Date	CRA	MOE
2008/07/11		38
2008/07/17		46
2008/07/23		
2008/07/29	66	68
2008/08/04		63
2008/08/10	14	14
2008/08/16	21	24
2008/08/22	70	77
2008/08/28	71	83
2008/09/03	13	13
2008/09/09	9	12
2008/09/15	26	14
2008/09/21	27	33
2008/09/27	42	46
2008/10/03	5	
2008/10/09	17	
2008/10/15	14	21
2008/10/21	12	11
2008/10/27	<MDL	9
2008/11/02	58	
2008/11/08	10	10
2008/11/14	10	
2008/11/20	9	14
2008/11/26	12	21
2008/12/02	11	
2008/12/08	20	17
2008/12/14	39	42
2008/12/20	15	3
2008/12/26	43	
2009/01/01	27	31
2009/01/07	8	10
2009/01/13	14	30
2009/01/19	23	27
2009/01/25	17	17
2009/01/31	33	36
2009/02/06	57	53
2009/02/12	17	17
2009/02/18	27	20
2009/02/24	26	33
2009/03/02	18	26
2009/03/08	30	10
2009/03/14	55	60
2009/03/20	74	
2009/03/26		

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2009/04/01		51
2009/04/07	13	23
2009/04/13	43	51
2009/04/19	30	37
2009/04/25	16	20
2009/05/01	11	14
2009/05/07	30	39

Note: <MDL = Less than method detection limit.

Table A-2 Metals in TSP data ($\mu\text{g m}^{-3}$) from the audit period at the Wallace Terrace station in Sault Ste. Marie.

Date	Copper (Cu)		Nickel (Ni)		Cadmium (Cd)		Chromium (Cr)		Lead (Pb)		Iron (Fe)		Manganese (Mn)		Vanadium (V)		Zinc (Zn)	
	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE
2008/07/11		0.880		0.003		0.002		0.005		0.002		3.100		0.045		0.014		0.38
2008/07/17		0.480		0.004		0.002		0.010		0.002		3.100		0.220		0.028		0.58
2008/07/23																		
2008/07/29	0.568	0.370	0.003	0.006	<MDL	0.004	0.006	0.013	0.014	0.002	6.250	9.600	0.197	0.290	0.004	0.024	0.093	0.71
2008/08/04		0.350		0.005		0.002		0.012		0.022		10.000		0.190		0.026		0.65
2008/08/10	0.181	0.320	0.005	0.005	<MDL	0.009	0.002	0.010	<MDL	0.002	0.441	0.420	0.027	0.034	<MDL	0.018	0.015	0.56
2008/08/16	0.195	0.500	0.002	0.005	<MDL	0.005	0.003	0.007	0.003	0.002	0.650	1.200	0.045	0.070	0.002	0.022	0.031	0.54
2008/08/22	0.157	0.410	0.004	0.008	<MDL	0.002	0.005	0.008	0.024	0.030	8.701	14.000	0.165	0.210	0.004	0.021	0.186	0.84
2008/08/28	0.165	0.530	0.004	0.004	<MDL	0.003	0.004	0.010	0.013	0.002	10.417	19.000	0.155	0.240	0.004	0.020	0.080	0.64
2008/09/03	0.068	0.340	<MDL	0.004	<MDL	0.003	0.002	0.006	<MDL	0.002	1.146	0.510	0.036	0.022	<MDL	0.017	0.013	0.55
2008/09/09	0.123	0.540	<MDL	0.003	<MDL	0.003	0.002	0.010	<MDL	0.002	0.392	0.380	0.017	0.019	<MDL	0.021	0.016	0.55
2008/09/15	0.101	0.400	<MDL	0.005	<MDL	0.002	0.004	0.012	0.003	0.002	1.955	0.460	0.110	0.036	0.002	0.022	0.021	0.55
2008/09/21	0.216	0.790	0.002	0.007	<MDL	0.002	0.003	0.010	0.009	0.002	3.315	6.200	0.065	0.120	<MDL	0.022	0.060	0.67
2008/09/27	0.172	0.620	<MDL	0.003	<MDL	0.002	0.004	0.009	0.008	0.002	3.235	4.700	0.096	0.110	0.003	0.022	0.041	0.63
2008/10/03	0.076		<MDL		<MDL		0.002		<MDL		0.195		0.007		<MDL		0.015	
2008/10/09	0.105		<MDL		<MDL		0.002		0.005		1.152		0.061		0.002		0.029	
2008/10/15	0.140	0.540	<MDL	0.003	<MDL	0.002	0.002	0.009	0.004	0.002	0.729	1.100	0.036	0.058	<MDL	0.021	0.034	0.55
2008/10/21	0.093	0.450	<MDL	0.005	<MDL	0.003	0.003	0.008	0.002	0.002	0.760	0.082	0.039	0.011	<MDL	0.022	0.031	0.58
2008/10/27	0.111	0.470	<MDL	0.005	<MDL	0.002	0.003	0.008	<MDL	0.002	0.132	0.002	0.006	0.006	<MDL	0.019	0.016	0.55
2008/11/02	0.093		0.003		<MDL		0.005		0.014		5.582		0.143		0.004		0.080	
2008/11/08	0.169	0.340	<MDL	0.005	<MDL	0.002	0.003	0.010	<MDL	0.002	0.567	0.540	0.042	0.057	0.002	0.019	0.015	0.55
2008/11/14	0.142		<MDL		<MDL		0.002		<MDL		0.459		0.024		<MDL		0.020	
2008/11/20	0.085	0.350	0.002	0.006	<MDL	0.003	0.002	0.007	<MDL	0.002	0.289	0.110	0.013	0.005	<MDL	0.019	0.024	0.57
2008/11/26	0.071	0.520	<MDL	0.004	<MDL	0.002	0.003	0.009	0.002	0.002	0.468	0.660	0.017	0.020	<MDL	0.023	0.015	0.55
2008/12/02	0.112		0.002		<MDL		0.002		<MDL		0.410		0.015		<MDL		0.023	
2008/12/08	0.066	0.640	<MDL	0.005	<MDL	0.002	0.002	0.010	0.004	0.002	1.464	0.780	0.025	0.051	<MDL	0.021	0.034	0.59
2008/12/14	0.111	0.900	0.003	0.003	0.00	0.005	0.004	0.012	0.024	0.019	6.434	9.300	0.097	0.130	0.003	0.022	0.119	0.69

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2008/12/20	0.078	0.001	<MDL	0.005	<MDL	0.002	0.002	0.007	0.009	0.002	0.729	0.002	0.030	0.002	<MDL	0.013	0.055	0.55
2008/12/26	0.054		<MDL		<MDL		0.003		0.014		5.227		0.056		<MDL		0.073	
2009/01/01	0.207	0.120	<MDL	0.001	<MDL	0.002	0.003	0.002	0.003	0.002	3.812	3.800	0.044	0.032	0.001	0.013	0.026	0.29
2009/01/07	0.204	0.120	<MDL	0.001	<MDL	0.002	0.003	0.005	0.002	0.002	0.153	0.016	0.004	0.003	<MDL	0.013	0.010	0.28
2009/01/13	0.088	0.140	<MDL	0.002	<MDL	0.002	0.004	0.004	0.002	0.002	0.660	0.730	0.027	0.025	0.001	0.013	0.019	0.29
2009/01/19	0.232	0.220	0.002	0.001	<MDL	0.002	0.004	0.006	0.003	0.002	4.074	0.960	0.047	0.024	0.001	0.012	0.028	0.35
2009/01/25	0.307	0.120	<MDL	0.001	<MDL	0.002	0.002	0.004	0.005	0.002	1.852	1.600	0.018	0.012	<MDL	0.007	0.029	0.22
2009/01/31	0.301	0.140	<MDL	0.001	<MDL	0.002	0.002	0.004	0.024	0.023	5.368	5.300	0.052	0.048	<MDL	0.008	0.127	0.29
2009/02/06	0.259	0.120	0.004	0.004	0.0032	0.002	0.005	0.010	0.023	0.018	4.628	3.900	0.093	0.066	<MDL	0.006	0.137	0.30
2009/02/12	0.245	0.160	<MDL	0.002	<MDL	0.002	0.003	0.004	0.004	0.003	0.534	0.390	0.014	0.008	<MDL	0.006	0.014	0.18
2009/02/18	0.238	0.170	<MDL	0.002	<MDL	0.002	0.004	0.005	0.012	0.008	1.681	1.300	0.039	0.025	<MDL	0.004	0.086	0.24
2009/02/24	0.277	0.220	<MDL	0.003	<MDL	0.002	0.003	0.006	0.011	0.007	1.148	1.100	0.028	0.022	<MDL	0.006	0.069	0.23
2009/03/02	0.705	0.250	<MDL	0.001	<MDL	0.002	0.003	0.002	0.004	0.002	0.537	0.370	0.021	0.012	<MDL	0.003	0.029	0.18
2009/03/08	0.360	0.001	<MDL	0.001	<MDL	0.002	0.003	0.003	0.005	0.003	1.130	0.130	0.038	0.006	<MDL	0.006	0.032	0.17
2009/03/14	0.850	0.380	<MDL	0.001	<MDL	0.002	0.005	0.004	0.006	0.004	1.776	2.000	0.084	0.068	<MDL	0.008	0.073	0.20
2009/03/20	0.913		0.003		<MDL		0.009		0.007		3.529		0.259		0.007		0.048	
2009/03/26																		
2009/04/01		0.200		0.001		0.002		0.009		0.002		1.500		0.120		0.011		0.17
2009/04/07	0.528	0.210	0.003	0.002	<MDL	0.002	0.002	0.007	0.003	0.002	0.575	0.470	0.024	0.017	<MDL	0.007	0.020	0.22
2009/04/13	1.630	0.490	0.003	0.001	<MDL	0.002	0.004	0.005	0.008	0.012	2.100	2.200	0.069	0.070	0.003	0.007	0.061	0.23
2009/04/19	0.216	0.250	0.004	0.003	<MDL	0.002	0.004	0.004	0.009	0.010	2.150	2.100	0.068	0.058	0.002	0.006	0.066	0.24
2009/04/25	0.338	0.400	<MDL	0.001	<MDL	0.002	0.002	0.002	0.003	0.005	0.489	0.400	0.017	0.012	<MDL	0.006	0.030	0.17
2009/05/01	0.174	0.280	<MDL	0.001	<MDL	0.002	0.002	0.004	<MDL	0.002	0.362	0.310	0.019	0.019	<MDL	0.008	0.015	0.19
2009/05/07	0.500	0.680	0.002	0.002	<MDL	0.002	0.004	0.007	0.005	0.002	0.750	1.100	0.027	0.036	0.002	0.009	0.032	0.20

Note: (1) <MDL = Less than method detection limit;
(2) Cells with purple = < T: A measurable trace amount: interpret with caution;
(3) Cells with yellow = <=W: No measurable response (zero): <reported value.

Table A-3 VOCs data ($\mu\text{g m}^{-3}$) from the audit period at the Wallace Terrace station in Sault Ste. Marie.

Date	Benzene		Toluene		Ethylbenzene		m-/p-xylene		o-xylene		1,3,5-Trimethylbenzene		1,2,4-Trimethylbenzene		Carbon tetrachloride		Naphthalene	
	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE
2008/07/11	8.552	22.9	56.221	181	4.659	47.5	14.316	190	3.519	68	0.389	14.4	1.947	62.2	0.695	0.46	<MDL	12.5
2008/07/23		11.1		147		24.7		95.3		35.1		8.75		36.3		0.41		7.18
2008/08/04	2.843	1.61	5.080	25.7	0.634	1.81	3.156	7.89	1.803	2.93	0.507	1.17	1.550	5.8	0.890	0.54	0.408	4.32
2008/08/16		0.51		5.5		1.1		4.3		1.64		0.75		3.62		0.56		3.53
2008/08/28	1.179	3.55	0.897	10.4	0.254	2.91	1.224	8.43	0.472	3.16	0.227	1.24	1.066	5.97	<MDL	0.57	1.430	6.07
2008/09/09	0.364	2.07	1.240	11.3	0.644	2.97	3.149	9.05	1.259	3.51	0.415	1.22	1.930	5.39	0.402	0.83	0.227	4.53
2008/09/21	0.484	0.8	0.787	2.84	0.223	0.9	1.250	2.66	0.475	0.93	0.191	0.38	1.081	2.05	0.387	0.52	0.396	2.95
2008/12/02	3.29	13.7	13.33	19.9	1.25	4.42	5.12	13.9	1.60	5.73	0.63	2.61	2.03	11	0.48	0.45	<MDL	7.2
2008/12/14																		
2008/12/26	3.43	6.74	15.57	16.3	3.74	3.49	12.68	11.3	4.67	4.65	1.26	1.82	3.21	8.55	0.25	0.48	0.17	2.95
2009/01/07	2.6	3.6	17	34.3	8	20.1	23	40.6	10	14.8	4	3.89	14	16.5	0.57	0.49	2.2	1.66
2009/01/19	2	4.05	12	25.2	4.1	7	13	24	5.2	9.58	1.3	2.71	2.2	10.3	0.25	0.55	<MDL	0.99
2009/01/31	1.4	3.43	7	21.8	2.7	6.31	8.8	21.5	3	6.75	0.77	1.57	1.5	6.47	0.28	0.55	<MDL	1
2009/02/12	1.3	2.71	9.8	18.4	2.1	5.7	6.6	17.1	2.6	6.65	0.86	1.67	2.3	6.71	0.33	0.52	<MDL	0.73
2009/02/24	1.8	4.35	8	13.8	2	3.59	6.1	11.8	2.5	4.67	0.49	1.21	0.69	4.81	0.24	0.54	<MDL	0.68
2009/03/08	1.1	2.26	6.5	12.3	2.3	4.24	7.7	11.4	3.4	4.53	1.2	1.33	4	5.47	0.4	0.47	<MDL	0.66
2009/03/20		2.73		11.9		3.06		10.6		4.18		1.27		5.75		0.46		0.84
2009/04/01	2.4	4.81	14	19.5	4.6	4.8	15	15.7	6.2	6.51	1.7	1.92	3.0	7.46	0.28	0.43	0.080	1.06
2009/04/13	1.5	2.85	12	14.9	3.2	3.11	10	11.3	4.3	4.65	1.1	1.36	1.9	5.24	0.26	0.33	<MDL	0.76
2009/04/25	1.5	2.55	7.6	14.1	2.4	4.59	9.1	13.1	4.0	5.35	1.1	1.86	2.9	7.47	0.28	0.49	<MDL	0.93
2009/05/07	1.4	2.84	9.5	12.8	2.4	3.03	8.0	10.7	3.5	4.64	0.96	1.71	1.4	7.59	0.25	0.44	<MDL	0.7
2009/05/19	3.8	10.4	30	54.6	6.2	8.19	21	30	6.8	10.6	1.5	3.15	2.5	14.7	0.23	0.7	<MDL	2.25

Note: (1) <MDL = Less than method detection limit;

(2) VOCs concentrations from October through November in 2008 were not included in this table because samples were not collected at the same date by CRA and MOE.

Table A-4 PAHs data (ng m⁻³) from the audit period at the Wallace Terrace station in Sault Ste. Marie.

	Benzo(a)anthracene		Benzo(a)pyrene		Benzo(b)fluoranthene		Benzo(g,h,i)perylene		Benzo(k)fluoranthene		Chrysene		Dibenzo(a,h)anthracene		Indeno(1,2,3-cd)pyrene	
	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE	CRA	MOE
2008/07/11																
2008/07/23	<MDL	<0.0226	<MDL	<0.0338	<MDL	<0.0037	<MDL	0.025	<MDL	<0.0197	<MDL	<0.0049	<MDL	<0.0226	<MDL	<0.0199
2008/08/04	0.715	3.402	<MDL	1.739	0.212	1.089	<MDL	2.133	<MDL	1.117	0.957	4.204	<MDL	0.415	<MDL	2.224
2008/08/16	<MDL	<0.0030	<MDL	<0.0405	<MDL	<0.0036	<MDL	0.060	<MDL	<0.0213	<MDL	0.111	<MDL	<0.0321	<MDL	<0.0215
2008/08/28	1.221	4.590	0.322	2.899	1.074	1.764	0.405	2.333	0.420	1.950	1.862	5.104	<MDL	0.520	0.356	2.707
2008/09/09		0.1065		0.09		0.04		0.11		0.0453		0.1346		0.0163		0.0866
2008/09/21	1.702	1.475	1.316	1.198	2.479	0.560	1.092	0.896	0.926	0.963	1.896	1.686	0.273	0.195	1.209	0.988
2008/12/14	18.642	26.535	10.370	19.784	18.426	36.074	8.519	13.530	9.136	13.042	18.889	23.486	<MDL	3.292	7.469	14.338
2008/12/26	10.401	14.102	3.642	10.321	10.741	19.682	4.043	6.456	4.475	7.261	10.216	13.463	1.244	1.826	3.735	7.069
2009/01/07	<MDL	0.136	<MDL	0.117	0.318	0.062	<MDL	0.168	<MDL	0.131	0.347	0.168	<MDL	<0.0213	<MDL	0.188
2009/01/19	2.118	3.397	1.338	3.041	2.264	0.401	1.360	2.443	0.949	1.690	2.389	3.169	0.271	0.297	1.073	2.654
2009/01/31	7.683	10.340	4.159	7.014	8.349	2.357	3.083	4.479	2.511	5.125	7.365	8.845	0.876	0.856	2.816	5.995
2009/02/12	<MDL		<MDL		0.2300		<MDL		<MDL		0.2332		<MDL		<MDL	
2009/02/24	13.599	14.932	8.121	12.679	12.866	4.258	6.051	7.914	5.446	7.539	12.357	13.589	1.420	1.401	5.255	10.104
2009/03/08	1.150	0.769	0.821	0.710	1.319	1.613	0.597	0.557	0.629	0.584	1.489	0.842	0.100	0.098	0.527	0.613
2009/03/20		0.4598		0.3416		1.1061		0.4658		0.4245		0.6443		0.066		0.4396
2009/04/01	<MDL	0.080	<MDL	0.056	<MDL	0.242	<MDL	0.113	<MDL	0.085	<MDL	0.163	<MDL	0.012	<MDL	0.103
2009/04/13	0.390	0.397	0.360	0.304	0.660	0.655	0.370	0.240	0.180	0.278	0.600	0.412	<MDL	0.045	0.280	0.284
2009/04/25		3.3233		2.9165		5.6329		2.0051		2.0052		3.2901		0.333		2.1863
2009/05/07	1.220	1.265	0.850	1.135	1.750	2.061	0.690	0.759	0.650	0.795	1.980	1.797	0.240	0.161	0.620	0.823
2009/05/19	1.610		1.080		3.060		0.860		0.990		2.720		<MDL		0.740	

Note: (1) <MDL = Less than method detection limit;**(2) < = the value is below the detection limit reported;****(3) Sample from MOE on May 19, 2009 was invalidated due to short sampling duration;****(4) PAHs concentrations from October through November in 2008 were not included in this table because samples were not collected at the same dates by CRA and MOE.**