ORGANIC AND INORGANIC EMISSIONS FROM A FLUID BED SEWAGE SLUDGE INCINERATOR AT DUFFIN CREEK WATER POLLUTION CONTROL PLANT

Prepared by

Environment Canada

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EXECUTIVE SUMMARY

Emissions from a fluid bed sewage sludge incinerator at the Duffin Creek Water Pollution Control Plant in Pickering, Ontario were studied in October 1986. Sludge feed, ash, scrubber water and stack gas samples were taken and analyzed for dioxins, furans, chlorophenols, chlorobenzenes, PCBs, PAHs and 28 inorganics including heavy metals. The stack gases were continuously monitored for NO_x, CO_2, CO, SO_2, O_2 and THCs (total hydrocarbons).

Dioxins were not found in any samples except sludge feed. Some furans were found in both the sludge feed and the stack gases. No PCBs were found in any samples. Chlorophenols were occasionally found in the sludge feed and not at all in the other samples. Chlorobenzenes and inorganics were found in the sludge and stack gas samples more often than in the other samples.

The study results are compared to emissions from two garbage incinerators, one with no emission controls, and one with electrostatic precipitators.

Through the use of a computer model, stack emissions from the Duffin Creek sewage sludge incinerator were found to meet current and proposed Regulation 308 requirements for metals and particulates.

1 INTRODUCTION

Environment Canada has a continuing mandate to promote the minimization of the release of toxic chemicals to the environment. Incineration has been identified as having the potential to be a major source of toxic emissions particularly with regard to dioxins. In order to investigate toxic emissions from incinerators and to develop strategies for their minimization, the Urban Activities Division (UAD) of the Industrial Programs Branch, Conservation and Protection is implementing a multi-year, multi-million dollar program to test emissions from garbage incinerators. As an extension of this, UAD also has underway a much smaller scale program to test emissions from sewage sludge incinerators for toxics including dioxin.

This report describes a study carried out in October 1986 by Environment Canada in cooperation with the Ontario Ministry of the Environment (MOE) and the Regional Municipality of Durham. The facility to be tested was the fluid bed sewage sludge incinerator at the Duffin Creek Water Pollution Control Plant (WPCP) in Pickering, Ontario, owned by MOE and operated by Durham. UAD provided overall coordination for the study and drew upon the River Road Environmental Technology Centre and the Wastewater Technology Centre for stack sampling and process (non-stack) sampling services.

The Duffin Creek WPCP was, at the time of the study, a 40 MGD (189 250 m^3/d) plant which went into operation in 1980. It is capable of being expanded into 4 stages of 40 MGD each. Sewage at Duffin Creek is treated by the conventional activated sludge treatment process. Treatment includes phosphorus reduction, sludge digestion, sludge dewatering, and incineration of the dewatered sludge in fluid bed incinerators.

A brief description of the sludge processing at Duffin Creek now follows. The combined primary and waste activated sludges are pumped either directly to sludge dewatering or indirectly after treatment by anaerobic digestion. The sludge digestion facilities consist of two primary and two secondary digesters. Raw sludge delivered to the primary digesters is first heated by circulation through straight tube type external heat exchangers and then mixed by internal mixing guns. The sludge then passes from the primary to the secondary digesters. Methane gas collected in the secondary digesters is used as fuel for space heating and any surplus gas is used in the sludge incinerators.

Digested sludge from the secondary digestion tanks is taken to sludge storage tanks prior to dewatering. After passing through macerating devices that cut up the grosser solids the sludge is pumped to membrane filter presses for dewatering. The dewatered sludge cake from the filter presses, containing 30 to 35% solids, is transported to the sludge storage bins by an enclosed screw conveyor. From there it is transported to the incinerators by variable speed sludge screw feeders.

The incineration system is shown in Figure A-1. The sand bed in the incinerator is fluidized by combustion air which has been preheated by the vertical heat exchanger. Sludge entering the incinerator is broken up by the grinding action of the sand and then partially incinerated in the fluid bed. Water vapours from the sludge along with the products of combustion, pass to the top of the incinerator where final combustion occurs. Methane gas from the digester can also be burned in the incinerator.

After passing through the heat exchanger, the combustion gases go to the waste heat boiler where steam is generated to drive the steam turbines that power the combustion air blowers. From the waste heat boiler the gases enter the venturi scrubber where entrained particulate matter is removed and the gas is further cooled as it proceeds through the scrubber's cooling tower section on its way to the 62 metre high stack.

The ash which is removed in the scrubber is transported to the ash thickener tank. From there the ash slurry pump transports the thickened ash to a vacuum filter where the ash is dewatered and loaded onto a truck to be landfilled. The dry ash collection system shown in Figure A-1 consisting of the waste heat boiler ash hopper, dry ash blower, dry ash line and dry ash bin was not operating during the time of the study.

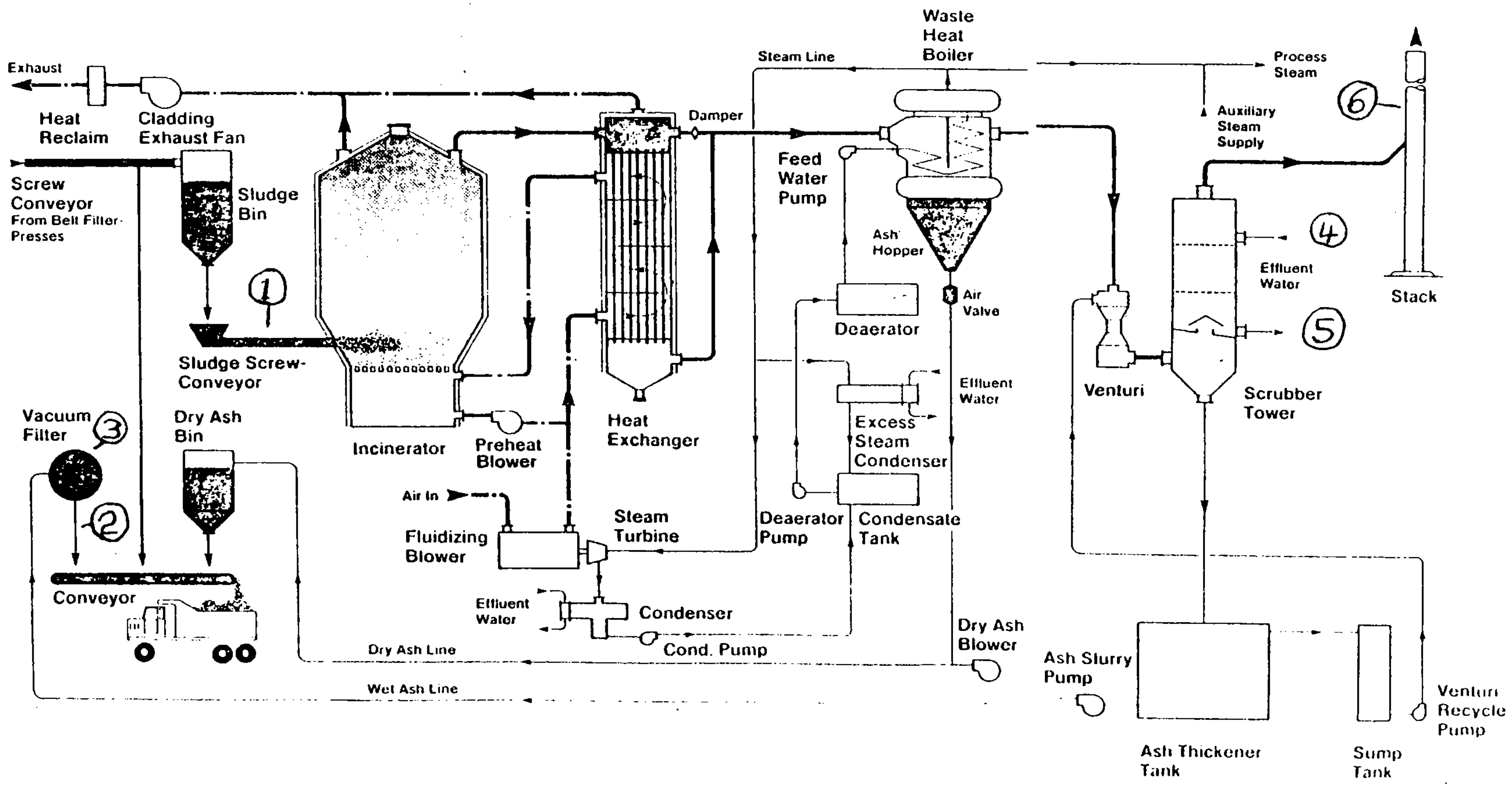


FIGURE A-1 DUFFIN CREEK INCINERATOR SYSTEM

2 GENERAL DESCRIPTION OF THE STUDY

The incinerator system was sampled at six points and the samples analyzed for toxic organics and various inorganic elements including heavy metals. The sample points are shown in Figure A-1 and are described below.

1. dry sludge feed to the incinerator;
2. dewatered incinerator ash taken from the wet ash vacuum filter;
3. filtrate from the wet ash vacuum filter;
4. scrubber water in;
5. scrubber water out;
6. stack gases.

The inorganic elements analyzed for were Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sr, Th, Ti, V, Zn, and Zr. Chlorides, TSS (total suspended solids) and percent moisture/solids were also determined as well as stack gas particulate loadings.

The organics analyzed for were chlorinated dioxins and furans, chlorinated benzenes and phenols, PCBs, and PAHs. In addition the stack gases were sampled by continuous analyzers which monitored on a real-time basis for O_2, CO, CO_2, SO_2, NO_x, and THC (total hydrocarbons).

During the test period the incinerator was run at normal stable operating conditions. Bed temperatures were between 750 and 800°C. It was not possible to get reliable measurements of the sludge feed rate to the incinerator or ash production rates during the testing period. However, the average rates for October 1986 were 1670 kg/h for the sludge feed and 1400 kg/h for the ash off the vacuum filter. The average flow for the "scrubber water in" for the six day test period was 152.7 m^3/h and for the "ash vacuum filter filtrate" was 3.62 m^3/h. The "scrubber water out" flowrate was not measured but was estimated at about 97% of the "scrubber water in" flowrate.

The stack gases were subject to two types of sampling; manual sampling using various sampling trains for inorganics and organics and automatic sampling using continuous analyzers. Both types required the use of sophisticated sampling techniques and equipment. The remaining samples from sampling points 1 to 5 in Figure A-1, were taken on a grab sample basis and are referred to in this report as the "process" samples to distinguish them from the manual stack samples and continuous analyzer stack samples. Aqueous process samples to be analyzed for inorganic elements, except Hg, were preserved with H_2SO_4. Aqueous process samples to be analyzed for Hg were preserved with HNO_3 and $K_2Cr_2O_7$.

The three types of trains used in the manual stack sampling were as follows:

1) a total particulate/heavy metal train to collect samples which were later analyzed for inorganics,
2) a mercury train to collect samples which were later analyzed for mercury,
3) an organic train using the EPA Modified Method 5 (MM5) procedures to collect samples which were later analyzed for organics.

On each day for three days (Oct. 1, 2 and 3) the stack gas was sampled for 4 hours by running two manual stack sampling trains simultaneously (the total particulate/heavy metal train and the mercury train). These sampling runs are referred to in this report as TP/HM-1, TP/HM-2 and TP/HM-3, referring to the three total particulate/heavy metal train runs; and HG-1, HG-2 and HG-3, referring to the three mercury train runs.

On each day for three days (Oct. 4, 5 and 6) the stack gas was sampled for 4 hours by running the organic stack sampling train. These sampling runs are referred to in this report as ORG-1, ORG-2 and ORG-3.

Process samples were taken during each of the stack gas sampling runs and later analyzed for the same parameters as the stack gas samples. During all the runs, stack gases were monitored on a real-time basis by continuous analyzers. A more detailed description of the stack sampling activities now follows.

3 STACK SAMPLING

All manual sampling was carried out at the third level of the incinerator stack (see Figure 1). This sampling location satisfied the site selection criteria specified in Environment Canada's Standard Reference Method for total particulates(4). Multi-point samples were extracted via two 10-cm ports spaced 90° apart.

The sampling location for the continuous gas analyzers was situated at the second level of the stack. The gas samples were extracted via a 10-cm port.

3.1 Manual Sampling Methods

3.1.1 **Total Particulates/Heavy Metals.** The sampling method is a modified version of the Standard Reference Method for total particulates.(4) Stack gas samples were withdrawn isokinetically from traverse points located on two stack diameters. Total particulates were separated from the gaseous constituents by filtration. The particulate weight was determined gravimetrically after the removal of uncombined water. Any particulates and heavy metals escaping the filters were recovered in the two impingers containing aqua regia (see Figure 2).

Upon completion of each run, particulates in the nozzle, the probe, and the front-half of the filter-holder were recovered by washing these train components with acetone. The washings were collected in a clean polypropylene bottle which was then sealed. The filter was removed from its holder and placed in a glass petri-dish. A second polypropylene bottle was used to store the aqua regia solutions and the distilled water rinses of the impingers.

After the field survey, the samples were returned to the PMD for further processing; acetone washings were evaporated to dryness and, together with the filters, desiccated to constant weights. The combined gravimetric results of each set of particulate samples were used to determine the stack particulate concentration. All solid and liquid samples from the particulate/heavy metal runs were sent to a commercial laboratory for the analyses of 27 inorganic elements, viz., Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sr, Th, Ti, V, Zn, and Zr.

3.1.2 **Mercury.** Mercury samples were collected using the same basic techniques outlined previously for total particulates/heavy metals.

A composite stack gas sample was collected isokinetically from a number of traverse points located on two stack diameters. Mercury present as particulate or

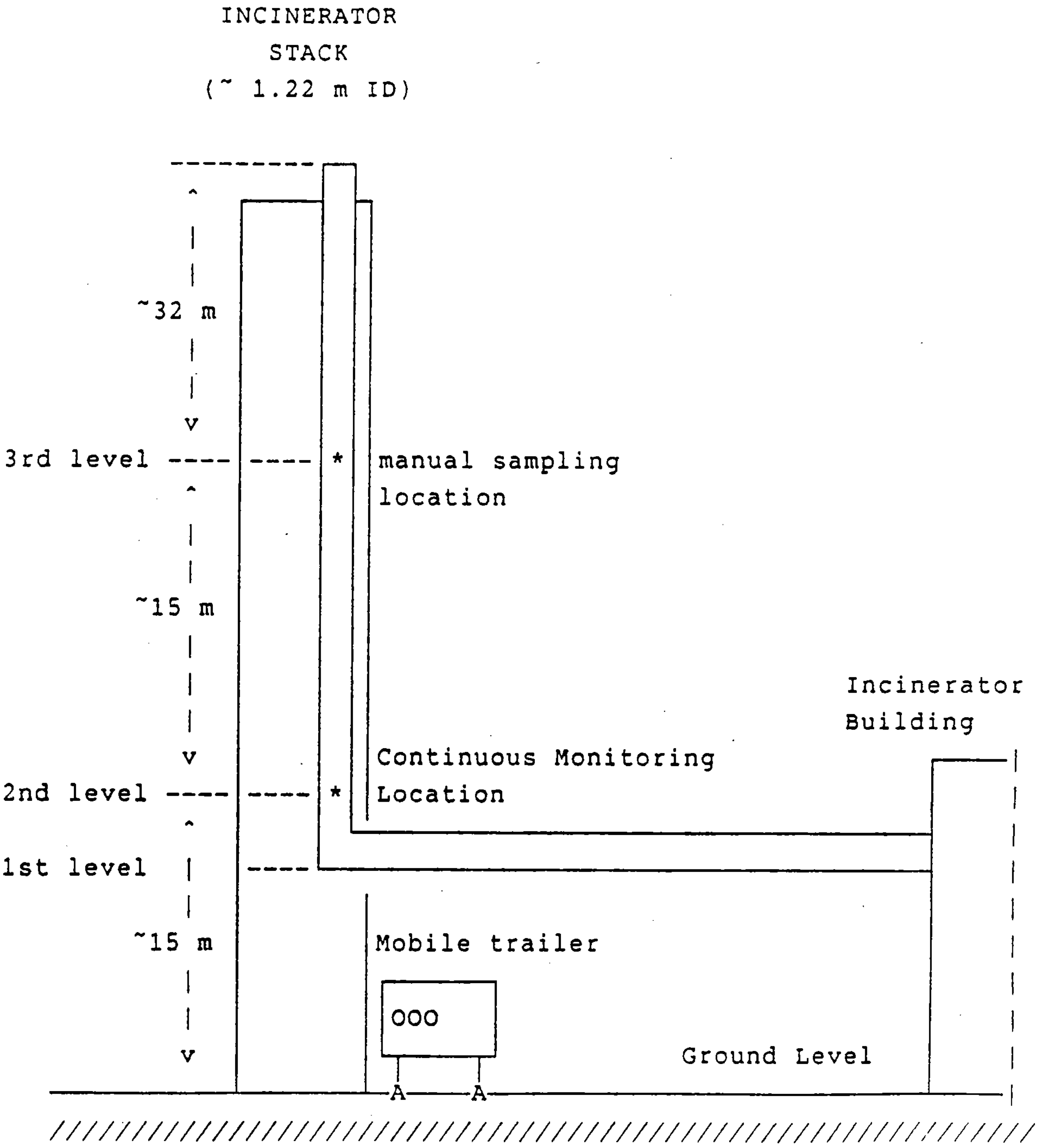
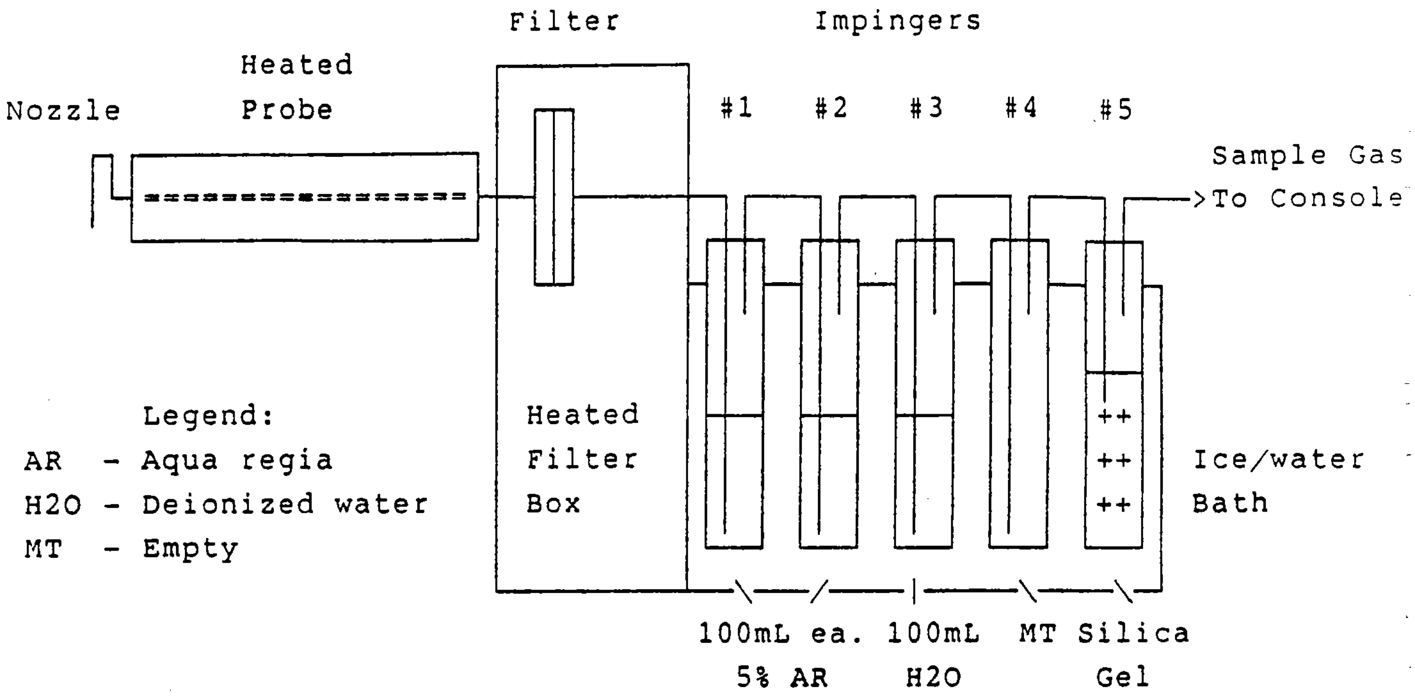


FIGURE 1 SAMPLING LOCATIONS



SAMPLE PARTITIONING AND RECOVERY PROCEDURES - TOTAL PART./HEAVY METAL		
SAMPLE	Train components	Procedures
#1	Nozzle, probe, connector & front-half filter holder	Washed and brushed with acetone into polypropylene bottle
#2	Filter	Stored in a glass petri-dish
#3	Imp#1 and #2, back-half of filter holder and glass connectors	Emptied content into a polypro bottle rinsed glassware with H2O, added 5 mL conc.aqua regia per 100 mL sol'n

Note 1: Moisture gain was determined before sample recovery
Note 2: Contents of Imp. #3, 4, and 5 were discarded

FIGURE 2 TOTAL PARTICULATE/HEAVY METAL TRAIN adhering to particles was collected on a filter while mercury vapour escaping the filter was recovered in a series of ice-cooled potassium permanganate filled impingers (see Figure 3).

Upon completion of a test, samples in the nozzle, probe, and filter were recovered from the train and preserved using a 0.5% acidified dichromate solution. The impinger contents were reduced by hydroxylamine hydrochloride and preserved by a 10% dichromate solution. All samples were forwarded to a commercial laboratory for mercury analysis.

3.1.3 Dioxins, Furans, PCBs, CBs, CPs and PAHs. The basis for the sampling methodology of these organics is the EPA Modified Method 5 (MM5) procedures described in the draft ASME protocol.(5) As with the previous two methods, samples were collected isokinetically from multi-point traverses of two stack diameters. Particulate matter was separated by filtration while the vapour fraction was collected downstream on Amberlite XAD-2 resin (see Figure 4). Some changes from the ASME protocol had been made; for example, ethylene glycol instead of water was used as a back-up collection medium in the impinger located immediately downstream of the Amberlite.

At the end of each run, stack samples were recovered from the MM5 train using the partitioning and recovery procedures summarized in Figure 4.

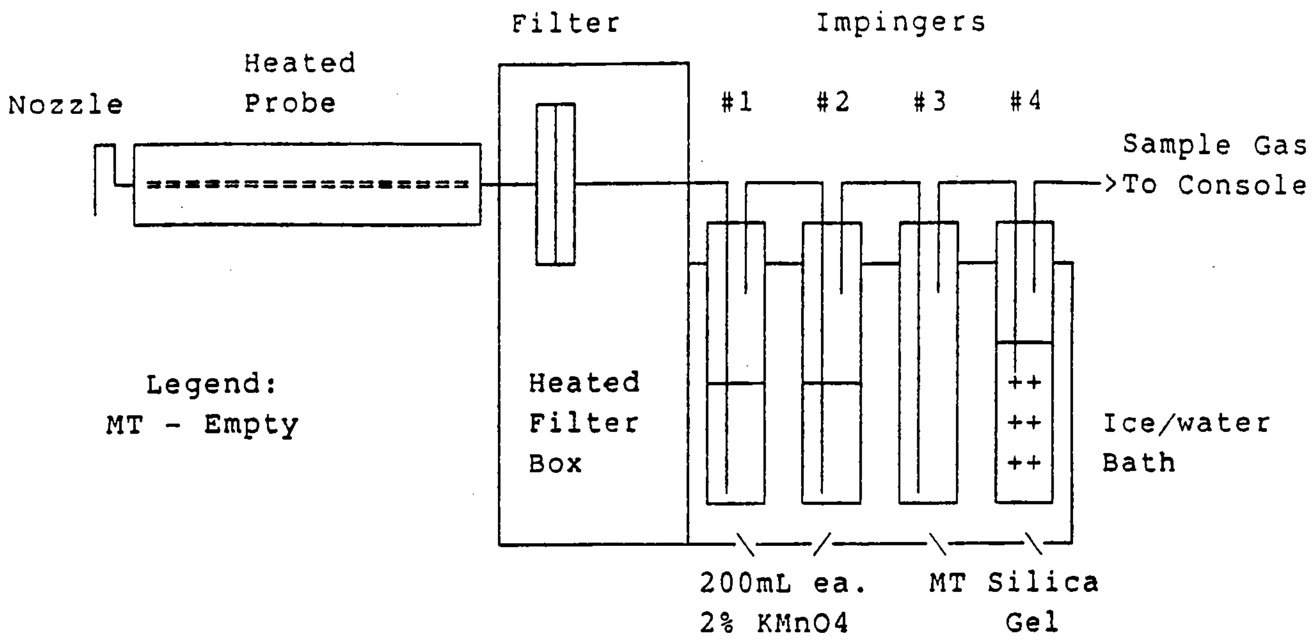
All field samples were stored in ice coolers and shipped to a commercial laboratory for dioxin, furan, PCB, CB, CP, and PAH analyses. To reduce the cost of analyses, the extracts of Samples No. 1a, 2a, and 3a were combined correspondingly with that of 1b, 2b, and 3b. The combined extracts were analyzed and reported in the Result Section as:

- Probe/Filter
- Amberlite XAD-2
- Glycol

3.1.4 Quality Assurance and Quality Control (QA/QC)

3.1.4.1 General QA/QC procedures. A comprehensive QA/QC program was implemented by the Pollution Measurement Division to ensure that all data collected would be representative of the source being tested.

Before the survey, all stack sampling equipment was overhauled and calibrated. Quality assurance results on nozzle diameter measurements, wind tunnel

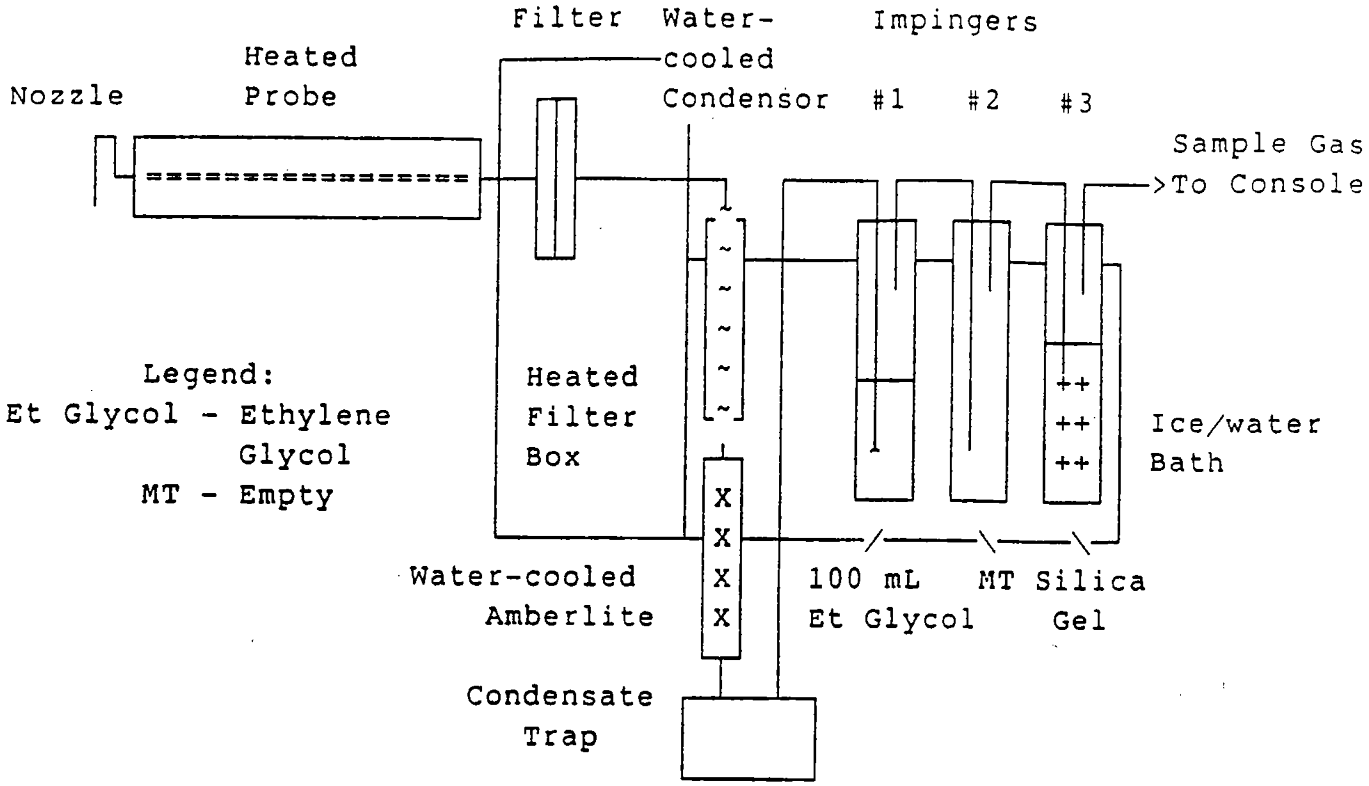


SAMPLE PARTITIONING AND RECOVERY PROCEDURES - MERCURY

Sample#	Train components	Procedures
1	Nozzle, Probe, connector & front-half filter holder Filter	- Washed and brushed w/ 0.5 % $K_2Cr_2O_7$ solution into a glass bottle - Immersed in same solution
2	Impinger #1 Back-half of filter holder and connectors	- Reduced content with 3% $NH_2OH.HCl$, poured sol'n into a vol. flask, rinsed impinger w/ H_2O into same flask - Rinsed with 3% $NH_2OH.HCl$ and deionized water into same flask - Preserved flask content with 10 mL 10% $K_2Cr_2O_7$, made up to volume
3	Impingers #2 and #3 Connectors	- Reduced content with 3% $NH_2OH.HCl$, poured sol'n into a vol.flask, rinsed impinger w/ H_2O into same flask - Rinsed with 3% $NH_2OH.HCl$ and deionized water into same flask - Preserved flask content with 10 mL 10% $K_2Cr_2O_7$, made up to volume

Note 1: Moisture gain was determined before sample recovery
Note 2: Contents of Impinger #4 was discarded

FIGURE 3 MERCURY TRAIN



SAMPLE PARTITIONING AND RECOVERY PROCEDURES - ORGANICS (DIOXINS etc

SAMPLE#	Train components	Procedures
1a	Nozzle, Probe, connector & front-half filter holder	Washed, brushed and rinsed 3X each w/ acetone (A) and hexane (H) into an amber glass bottle
1b	Filter	Placed on pre-cleaned aluminum foil, folded filter in half, sealed foil an stored in a glass petri-dish
2a	Back-half of filter holder, condensor and connectors	Soaked and rinsed 3X each with A and into an amber glass bottle
2b	Amberlite cartridge	Capped ends, wrapped in aluminum foil
3a	Condensate trap, impingers #1 and 2 and connectors	Emptied contents into an amber glass bottle, rinsed each 3X with HPLC wate
3b	All glassware (proof rinse sample)	Rinsed 3X each with A and H into an amber glass bottle

Note 1: Moisture gain was determined before sample recovery
Note 2: Contents of Impinger #3 was discarded
Note 3: All sample containers and teflon lid liners were pre-cleaned
Note 4: One set of A and H blank solutions was taken directly from teflon squeeze bottles

FIGURE 4 MODIFIED METHOD 5 (MM5) TRAIN

calibration of the probe/pitot-tubes/thermocouple assembly, calibration of thermocouples, and calibration of the dry gas meter were documented.

During the survey, all stack sampling trains were leak-checked at the beginning and end of the test and during port change-over. Other QA/QC procedures carried out in the field included the isokinetic analyses of selected field data at the end of each test day and the use of a coding and routing system to keep track of all the samples.

3.1.4.2 Total particulate/heavy metals. In addition to the general QA/QC procedures, special ones were developed for the Total Particulate/Heavy Metal tests. All sampling train glassware and sample bottles were washed with aqua regia and rinsed with deionized water prior to the field survey. In addition to the field samples, reagent and filter blank samples were also collected and sent to the commercial laboratory for inorganic analyses.

3.1.4.3 Mercury. QA/QC procedures for the mercury tests were similar to those for the Total Particulate/Heavy Metals tests, with all the glassware and sample bottles cleaned prior to the tests and reagent and filter blank samples taken during the survey.

3.1.4.4 Dioxins, furans, PCBs, CBs, CPs, and PAHs. Before testing. Prior to the field survey, the following QA/QC procedures for organics were completed:

- All organic train glassware and sample bottles were washed in a dish-washer, rinsed with deionized water, and cleaned with distilled-in-glass grade methylene chloride, hexane, and acetone. All openings of the glassware were sealed with pre-cleaned aluminum foil prior to shipment to the field.
- The Amberlite XAD-2 sorbent was solvent-extracted and proofed approximately one week before the tests.

During testing. During the field survey, the following QA/QC procedures were carried out:

- In order to determine if there was any contamination of the stack samples from the ambient environment, a blank MM5 train identical to the one used for sample collection was set up at the sampling site during the second organic run. Approximately 0.01 m^3 of ambient air was drawn into the blank train to simulate the leak checking of the field train. After the test, samples from the blank train were recovered and analyzed in the same manner as the field train samples.
- One set of field reagent blanks (acetone/hexane, filter, ethylene glycol/distilled water, and Amberlite XAD-2) was collected at the end of the second organic run.

- A field proof rinse of the train glassware was collected prior to the commencement of the third organic run.

Chemical analyses. To ensure accurate organic emission results, QA/QC procedures were also applied to the chemical analysis aspect of the organic tests:

- Surrogate compounds representative of the range of molecular weights or the number of nuclear rings of the target organics under study were introduced quantitatively into the organic samples by the commercial laboratory prior to analyses. The target organics and their corresponding surrogate compounds are shown below:

Target Organics	Surrogate Compounds
Dioxins/Furans	T4CDD, H6CDD, O8CDD, and T4CDF (all 13C12-labelled)
PCBs/CBs/CPs	(dx)-PCB, (d4)CL2-CB, (13C6)CL6-CB, (d3)CL2-CP, and (13C6)CL5-CP
PAHs	d8-Naphthalene, d10-Anthracene, d12-Benzo(a)Pyrene

  The surrogate compounds were analyzed in the same manner as the stack samples and the percentage recovery efficiency of each compound was determined by comparing the amount detected versus the quantity originally injected into the stack sample.

- The extracts of the probe/filter and Amberlite samples of the 6-Oct-86 organic run (ORG-3) were split between the commercial laboratory and the Analytical Services Division. Replicate analyses for dioxins and furans were performed by the laboratories and the results were compared.

3.2 Continuous Monitoring Methods

The concentrations of the stack gases, O_2, CO_2, CO, NO_x, SO_2, and THCs were monitored on a real-time basis using the PMD's continuous monitoring system which consists of three basic units (Figure 5):

- Sample Extraction and Conditioning
- Continuous Analyzers
- Data Logging

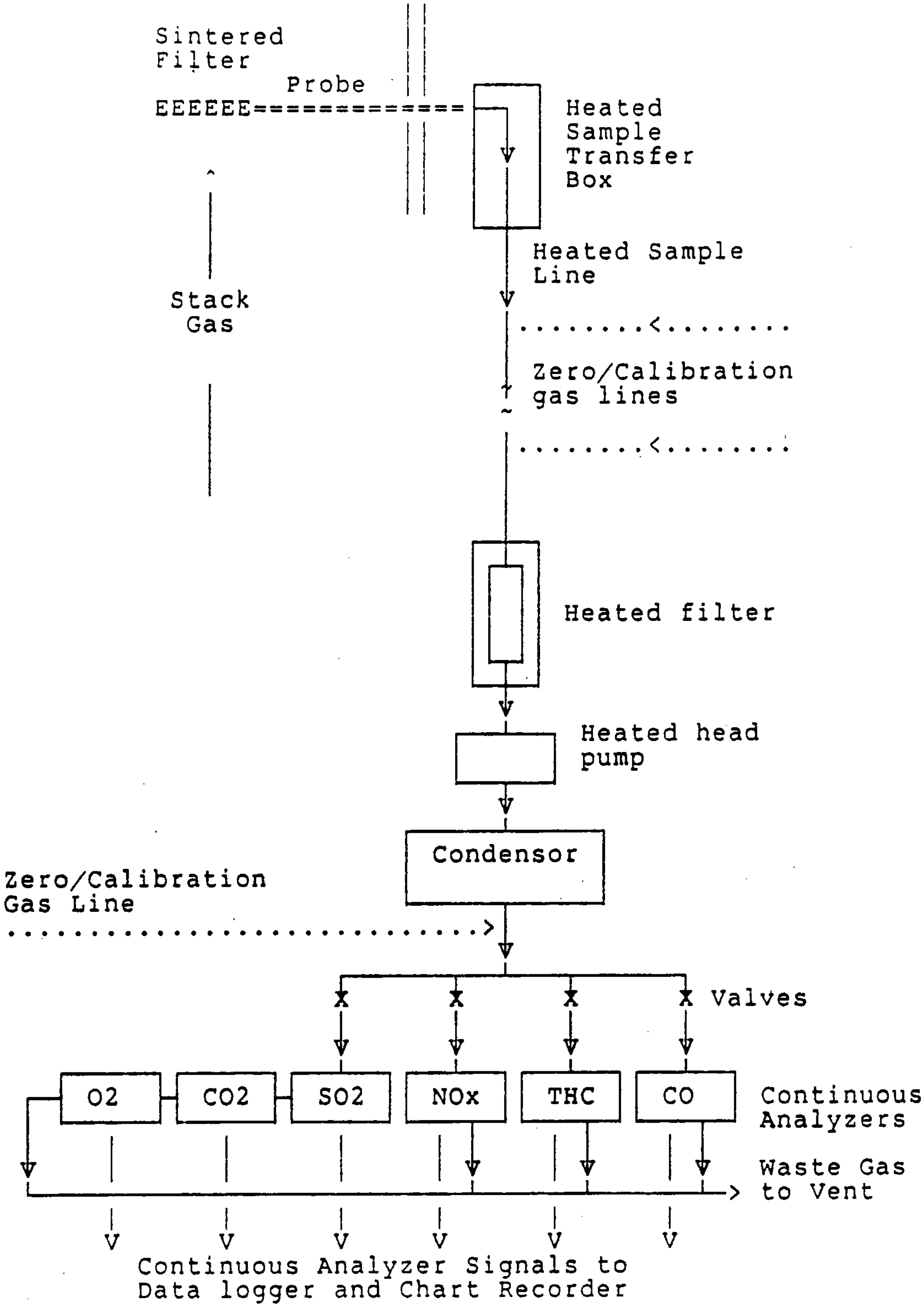


FIGURE 5 CONTINUOUS MONITORING SYSTEM

3.2.1 Sample Extraction and Conditioning. The sample extraction and conditioning unit is designed to extract continuously a representative stack gas sample and to condition the sample so that accurate measurements can be made by the analyzers. The stack gas sample was extracted from a single point near the centre of the stack. After the removal of coarse particulates by a sintered filter, the sample was transported via a heated line to a trailer where a second filter and a condensor removed the fine particulates and moisture in the gas stream. From here, the gas sample was distributed to the various continuous analyzers.

3.2.2 Continuous Analyzers. Six continuous gas analyzers were used at Duffin Creek to measure the stack concentrations of NO_x, SO_2, CO_2, CO, O_2, and THCs. Signals from the analyzers were sent to the Data Logging unit. Table 1 summarizes the types and the principles of operation of these analyzers.

3.2.3 Data Logging/Recording. A computerized data logging system was used to scan the continuous analyzer channels and display the concentration data on a monitor every 20 seconds. A six-pen chart recorder traced the real-time concentration readings and a printer provided hard copies of the 5- and 15-minute average readings.

3.2.4 Quality Assurance/Quality Control. Prior to the survey, all continuous analyzers were overhauled and tested in the RRETC laboratory. The concentrations of the standard gases supplied by the gas companies were verified by wet chemical methods. During the survey, pre- and post-test calibrations of the continuous analyzers were performed using the verified standard gases. Periodic calibrations were also carried out during the test to correct instrument drifts. The calibration gas injection points are shown in Figure 5. The concentrations of the gases used are indicated in Table 1.

Other QA/QC procedures carried out in the field include the pre- and post-test leak tests of the continuous monitoring system at the probe outlet and the heated filter inlet and routine visual inspections of all analyzers and data logging system. All QA/QC information was documented in a field log book.

4 DISCUSSION OF RESULTS

All stack sampling emission data are reported in concentration units corrected to 12% CO_2 (Conc.@12% CO2 = Actual conc. X 12 / %CO2). All gas volumes are expressed on a dry volume basis and at reference conditions of 25 °C and 101.3 kilopascals.

The large differences in the physical and chemical characteristics of the pollutants under study required that a wide variety of sampling and analytical methods be applied to this source. For total particulates, mercury, NO_x, SO_2, CO_2, CO, and O_2, the methods used are well established and are of known accuracy and precision.

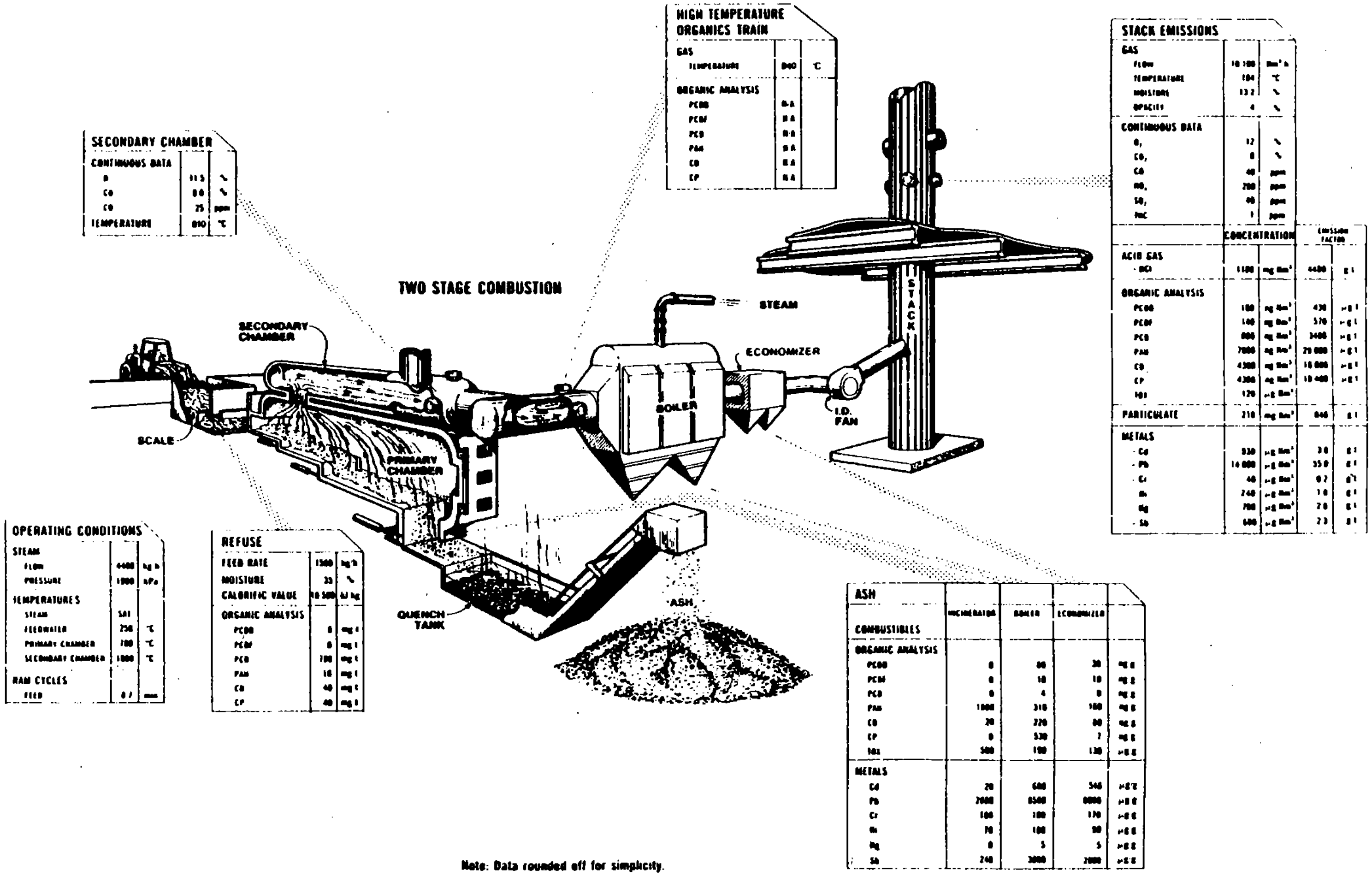
For heavy metals, THCs, and all the trace organics, the methods used are the state-of-the-art, best available techniques recommended by Environment Canada.

Throughout the detailed discussions of the test results contained in the following sections, comparisons will be made between the Duffin Creek study results and data obtained from the recent testing of two garbage incinerators by Environment Canada under the National Incinerator Testing and Evaluation Program (NITEP) (7, 8). Figure 6 summarizes the test results from a two-stage combustion garbage incinerator under normal operating conditions and with no emission controls. Figure 7 shows test results from a mass burn garbage incinerator at normal operating conditions and equipped with an electrostatic precipitator.

4.1 Stack Samples - Particulates and Inorganics

Table 2 shows that particulate concentrations in the incinerator stack, corrected to 12% CO_2, ranged from 105 to 135 mg/m^3 with an average of 117 mg/m^3. By way of comparison, the garbage incinerator with no emission controls emitted 210 mg/m^3 (Figure 6) while the garbage incinerator with the electrostatic precipitator emitted 22 mg/m^3 of particulates.

Stack samples from the three particulate runs were also analyzed for heavy metals and other inorganic elements. The concentration results, based on the total train catch and corrected to 12% CO_2, are shown in Table 3. Of the 27 elements listed, eight have concentrations in the mg/m^3 range. They are, in descending order, Ca, Al, P, Na, Fe, Si, Mg, and K. Concentrations of the remaining 19 elements are in the ug/m^3 level. None of the concentration values have been corrected for filter and aqua regia blank results. For most elements, the amounts detected in the stack samples are at least one order of magnitude higher than those in the blank samples. The exceptions are B, Ba, and



Note: Data rounded off for simplicity.

FIGURE 6 GARBAGE INCINERATOR

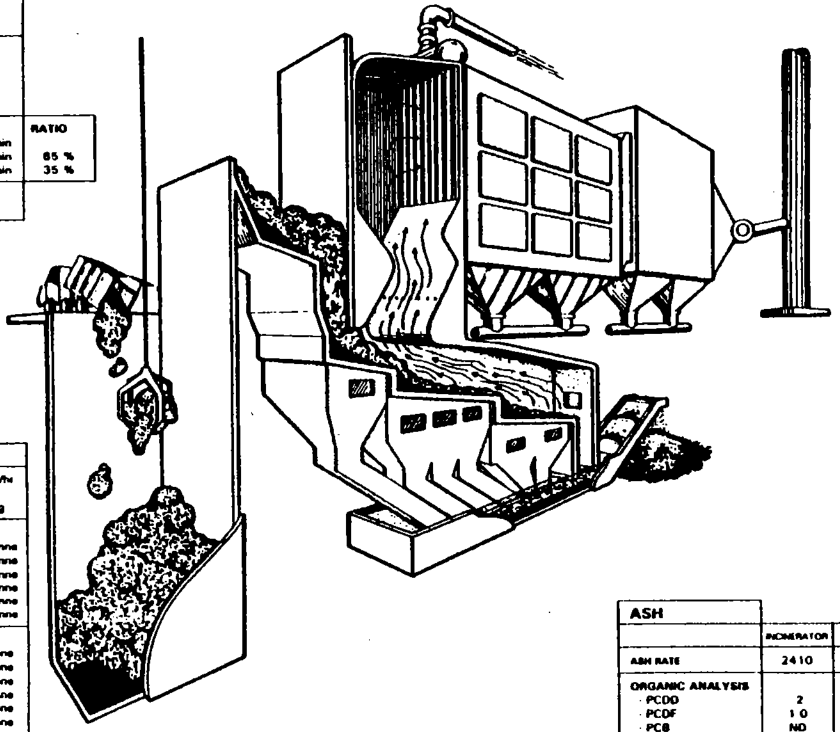


FIGURE 7 GARBAGE INCINERATOR

OPERATING CONDITIONS			
STEAM			
· FLOW	28	tonne/h	
PRESSSURE	4300	kPa	
TEMPERATURE	320	°C	
TEMPERATURES			
LOWER INCINERATOR	1010	°C	
UPPER INCINERATOR	780	°C	
· BOILER INLET	810	°C	
COMBUSTION AIR	34	°C	
AIR FLOW			**RATIO**
· COMBUSTION	550	Am³/min	
· PRIMARY	360	Am³/min	65 %
· SECONDARY	190	Am³/min	35 %
EFFICIENCY			
INPUT/OUTPUT	63 7	%	

REFUSE		
FEED RATE	8 9	tonne/hr
MOISTURE	35	%
CALORIFIC VALUE	2880	cal/g
ORGANIC ANALYSIS		
PCDD	32	mg/tonne
PCDF	3 2	mg/tonne
PCB	45	mg/tonne
· PAH	1660	mg/tonne
· CB	72	mg/tonne
CP	1570	mg/tonne
METALS		
Cd	6 0	g/tonne
Pb	660	g/tonne
Cr	200	g/tonne
Ni	27	g/tonne
Hg	.62	g/tonne
Sb	2 2	g/tonne
As	1 3	g/tonne
Cu	250	g/tonne
Zn	220	g/tonne

STACK EMISSIONS		
GAS		
· FLOW	880	Sm³/min
TEMPERATURE	210	°C
· MOISTURE	15 7	%
· OPACITY	33 3	%
CONTINUOUS DATA		
· O_2	9	%
· CO_2	10	%
· CO	28	ppm
· NO_x	180	ppm
· SO_2	200	ppm
THC	2	ppm
ACID GAS		
· HCl	450	ppm
ORGANIC ANALYSIS		
· PCDD	19	ng/Sm³*
PCDF	44	ng/Sm³*
· PCB	3020	ng/Sm³*
PAH	4030	ng/Sm³*
CB	3100	ng/Sm³*
CP	6080	ng/Sm³*
PARTICULATE	22	mg/Sm³*
METALS		
· Cd	24	ug/Sm³*
· Pb	670	ug/Sm³*
· Cr	7	ug/Sm³*
· Ni	6	ug/Sm³*
· Hg	700	ug/Sm³*
· Sb	38	ug/Sm³*
· As	3	ug/Sm³*
· Cu	33	ug/Sm³*
· Zn	1130	ug/Sm³*

* *Corrected to 12% CO_2*

ASH	INCINERATOR	BOILER	PRECIPITATOR	
ASH RATE	2410	34	57	Kg/h
ORGANIC ANALYSIS				
· PCDD	2	37	580	ng/g
· PCDF	1 0	31	190	ng/g
· PCB	ND	ND	ND	ng/g
· PAH	540	25	110	ng/g
CB	46	380	890	ng/g
CP	16	80	1820	ng/g
METALS				
· Cd	4	210	1060	ug/g
· Pb	1760	7480	21100	ug/g
· Cr	250	300	480	ug/g
· Ni	130	120	110	ug/g
· Hg	0 03	7	72	ug/g
· Sb	16	330	750	ug/g
· As	7	91	170	ug/g
· Cu	2640	630	1480	ug/g
· Zn	1780	17400	60700	ug/g

Na; all had unacceptably high filter blank values. The concentration results of these three elements are therefore questionable.

With the exception of Si, all the elements were found in the front-half (nozzle, probe, and filter) of the particulate sampling train. For Si, approximately 96% of the 2014 ug/m^3 reported in Table 3 was captured in the back-half (aqua regia and water impingers) of the train. It is suspected that the samples might have been contaminated by the silicone grease used to seal the ground glass joints of the impingers.

Metal stack emissions from the garbage incinerator with the electrostatic precipitators (Figure 7) are similar to those found at Duffin Creek. For example at Duffin Creek the stack emissions for Cd, Pb and Cr were 13, 114 and 258 ug/m^3 respectively compared with levels of 24, 670 and 7 ug/m^3 respectively for the garbage incinerator with electrostatic precipitators (Figure 7). The garbage incinerator with no emission controls (Figure 6) emitted Cd, Pb and Cr levels of 930, 14000 and 40 ug/m^3 respectively.

4.1.1 Mercury. Mercury emissio [illegible] lts from the three tests are shown in Table 4. No blank correction was necessary as in [illegible] icant amount of mercury were found in the blank reagent samples.

Mercury concentrations in the [illegible] erator stack gas, corrected to 12% CO_2, varied from 400 to 490 ug/m^3, with an av [illegible] 430 ug/m^3. It appears that mercury compounds in the incinerator stack were a [illegible] aseous since over 99% of the total mercury was found in the back-half ($KMnO_4$ impinge [illegible]) of the sampling train.

The Hg stack emission results from both garbage incinerators (Figures 6 and 7) are in the same order of magnitude as that found at Duffin Creek.

Using a computer model, Proctor and Redfern (10) calculated point of impingement (POI) concentrations using all the metal, mercury and particulate stack emission data from the Duffin Creek tests and compared the calculated POI concentrations to the regulated limits in both the current and proposed versions of the Province of Ontario Regulation 308. The results show that the Duffin Creek sludge incinerator meets all the regulated metal and particulate limits. All calculated POI concentrations were less than 3.5% of the currrent Regulation limits. For the proposed Regulation 308, the highest calculated POI concentration was 15.8% (for total particulates) of the regulated limit. Any pollutant that is less than 30% of the regulated limit is considered to be minor. The results are presented in Table 22. The "percent of regulated maximum" values are calculated by dividing the calculated concentration by the regulated concentration and multiplying by 100.

4.2 Stack Samples - Organics

The stack concentrations of dioxins and furans are given in Table 5. The results were corrected for blank train background values but not for recovery efficiencies.

No dioxin isomers were detected in any of the MM5 train samples. Total furan concentrations, corrected to 12% CO_2, ranged from 340 to 850 pg/m^3, with an average of 650 pg/m^3. The furans were found in the probe/filter samples of Runs ORG-2 and ORG-3 and in the Amberlite XAD-2 samples of all three runs. The isomers identified were T_4CDF and O_8CDF. For the O_8CDF, about 0.49 ng was consistently found in the glycol impinger of every run. However, this amount was excluded from the reported total furan concentration results because the same quantity was also detected in the glycol impinger of the blank train. By comparison, both garbage incinerators had dioxin and furan stack emissions in the ng/m^3 range.

The QA/QC results in Table 6 compare the dioxin/furan levels in the various components of a field train and the blank train, in the various blank reagents and in the pre-test proof rinse of a MM5 train. As reference points, the analytical detection limits of dioxins/furans are also included. The QA/QC results show that:

- Of the 0.48 ng of O_8CDF detected in the field train glycol impinger, 0.15 ng was from the blank glycol reagent and the remaining 0.33 ng was from non-stack sources such as the ambient environment.
- The amounts of dioxins/furans in the field train are mostly below the analytical detection limits. A larger-than-normal stack gas sample (i.e. > 3 m^3) will be required if better quantification of organic emissions from such a low level source is desired.
- Results of the pre-test proof rinse of the MM5 field train indicate that the train glassware were clean prior to the ORG-3 run. The levels of dioxins/furans in the acetone and hexane rinses were at or below the detection limits.

Table 7 shows the recovery efficiencies of the four surrogate dioxin/furan isomers introduced into the samples from: the field trains, the blank train, the blank reagents, and the pre-test proof rinse of the MM5 train. Most of the values are within the Analytical Services Division's in-house guideline limits of 100+-40%(6).* The results infer that all the dioxin and furan isomers, from the tetra to the octa, in the various samples had also been recovered during analyses.

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* The limits on surrogate recovery efficiencies for trace organics such as dioxins/furans, PCBs, CBs, CPs, and PAHs have not been standardized in Canada or the U.S. The 100+-40% guideline limits may be revised as the sampling and analytical methodologies are further refined.

Replicate analyses performed on the extracts of the ORG-3 run probe/filter and Amberlite samples by the Analytical Services Division (ASD) showed that:

- The detection limits provided by ASD were one order of magnitude more sensitive than those by the commercial laboratory.
- The amounts of dioxins/furans in the extract samples were at or below the detection limits.

However, recovery efficiencies were not determined as the surrogates used by the commercial laboratory were unavailable.

The stack concentrations of Polychlorinated Biphenyls (PCBs), Chlorophenols (CPs), and Chlorobenzenes (CBs), corrected to 12% CO_2, are given in Table 8. The concentration results were not corrected for recovery efficiencies or for blank train/blank reagent background values.

No PCBs or CPs were detected in any of the stack samples. By contrast both garbage incinerators (Figures 6 and 7) had PCB and CP stack emissions in the high ng/m^3 to low ug/m^3 range.

Both garbage incinerators (Figures 6 and 7) had CB stack emissions in the low ug/m^3 range. This is similar to the levels found at Duffin Creek where the concentration of total CBs varied from 0.5 ug/m^3 for Run ORG-2 to about 10 ug/m^3 for Runs ORG-1 and ORG-3.

The order-of-magnitude difference in the CB results at Duffin Creek is due to the large quantities of Cl_2CB isomer detected in the Amberlite XAD-2 sample of Runs ORG-1 and ORG-3 and a complete absence of the same isomer in the Amberlite sample of Run ORG-2. The absence could be due to a poor recovery of the Cl_2CB isomer from the Amberlite sample of the second run. A review of the recovery efficiency results in Table 9 shows that, indeed, recovery efficiencies of the surrogate compound $(d_4)Cl_2$-CB for Runs ORG-1 and ORG-3 are 73 and 82% as compared to only 37% for Run ORG-2. However, the two to three times difference in recovery efficiencies still does not explain fully the huge discrepancy in the amounts of Cl_2CB collected. Because of the inconsistency in the concentration results and the poor recovery efficiencies of the Cl_2CB surrogate in general, the CB emission data are considered questionable.

The recovery efficiency results in Table 9 also indicate that:

- The recovery efficiencies of the CP surrogates were unacceptable with most of the values falling outside the guideline limits of 100+-40%. The poor recoveries cast some doubt on the CP emission test results.

- The PCB surrogate recovery efficiencies for most of the samples were within the guideline limits of 100+-40%, infering that all the PCBs in the samples were also recovered during the analyses.

Table 10 compares the levels of PCBs, CPs, and CBs in the samples of a field train, the blank train, blank reagents, and the proof rinse of a MM5 train. The analytical detection limits of these organics are also included as reference points. The results show that:

- PCBs and CPs in the field train were below the analytical detection limits. A larger-than-normal stack gas sample will be required if a more accurate quantification of PCB and CP emissions from such a low level source is desired.
- There were sufficient CBs for analyses in the field trains of Runs ORG-1 and ORG-3, but not ORG-2.
- Background PCB, CP and CB levels were low as indicated by the NDs (or near NDs) in the blank train, blank reagents and the pre-test proof rinse samples.

Of the 15 PAH compounds analyzed, 11 were detected in the incinerator stack samples (see Table 11). All the PAHs were found in the back-half of the sampling train, with the majority in the Amberlite XAD-2 adsorber. Total PAH concentration, corrected to 12% CO_2, varied approximately from 1 to 3 ug/m^3. The emission results had not been corrected for surrogate recovery efficiencies or background (blank train and blank reagents) values.

Stack emission of PAHs from the garbage incinerators were somewhat higher ranging from 4 ug/m^3 from the garbage incinerator with electrostatic precipitators (Figure 7) to 7 ug/m^3 from the garbage incinerator with no emission controls (Figure 6).

Table 12 shows the recovery efficiency results of the three PAH surrogates which were introduced to the various samples by the commercial laboratory prior to analyses. The results were less than satisfactory. Approximately half of the values for the field train and blank reagent samples had exceeded the guideline limits of 100+-40%. Because of the generally poor PAH surrogate recoveries, the PAH emission results are considered questionable.

Table 13 compares the PAH levels in the samples of a field train, the blank train, various blank reagents, and the pre-test proof rinse of a MM5 train. As reference points, the detection limits of the 15 PAH compounds are also given (far right column in Table 13). With the exceptions of fluorene, fluoranthene, pyrene, benzo(b+k)fluoranthene, and benzo(a)pyrene, the amounts of PAHs in the field train were either below or near the detection limits. At such low levels, the amount of PAHs found in the blank train and blank reagents became relatively significant. Naphthalene, in particular, had a blank train value greater than that of the field train; it also accounts for almost 90% by weight of the PAHs found in the blank train. Consistent with the other trace organics, a larger-than-normal stack gas sample will be required if a better quantification of PAH emissions from this source is desired.

4.3 Stack Samples - Continuous Monitoring

Continuous monitoring results of the gases, NO_x, SO_2, CO_2, CO, O_2, and THCs are summarized in Table 14. All gas concentrations are expressed on a dry volume basis and at reference conditions of 25 °C and 101.3 kilopascals. The values were averages of the continuous analyzer readings that were logged over the duration of each manual test (approx. 4 hours). Detailed raw field data, such as the strip-chart readings and the 5- and 15-minute averages, as well as all the QA/QC calibration results, are available, upon request, from the Pollution Measurement Division.

4.4 Process Samples - Inorganics

Tables 19 and 20 show metal concentrations found in the process samples. Also shown in Tables 19 and 20 are metal concentrations in the sludge feed calculated on a fixed solids basis. The metal concentrations in the dry bottom ash should not be significantly higher than the calculated values for the sludge feed on a fixed solids basis, and this is the case for all the metals shown in Tables 19 and 20, with the possible exception of Co. However, due to the very low values of Co found in the dry bottom ash and the sludge feed, the differences between the dry bottom ash concentrations and the sludge feed concentrations calculated on a fixed solids basis is probably not significant. Nevertheless, the Co concentrations in Table 19 should be used with caution.

Metal concentrations in the bottom ash of the garbage incinerators (Figures 6 and 7) are comparable to those found in the bottom ash at Duffin Creek. For example, at Duffin Creek levels of Cd, Pb, Cr and Ni found in the bottom ash were about 40, 1050, 2080 and 460 ppm respectively, while the same metals in the bottom ash from the garbage incinerators ranged from 4 to 20, 1760 to 2600, 100 to 250 and 70 to 130 ppm respectively. The somewhat elevated metal levels in the Duffin Creek bottom ash is not cause for concern however, since a recent study (9) indicates that sewage sludge incinerator bottom ash is very resistant to leaching since most of the metals are speciated as insoluble oxides or silicates.

Table 21 shows some QA/QC results on the inorganic aqueous analyses. The Wastewater Technology Centre made up some aqueous samples spiked with the metals shown in the table and submitted them to the commercial laboratory for analysis. The spiked values are shown as the values under the column heading "True Value", and the "reported values" are the results of the commercial laboratory's analyses. Three samples containing metals in the low mg/l range (samples Nos. 29, 31 and 32) as well as three samples containing metals in the low ug/l range were submitted to the commercial laboratory. The percent recoveries achieved by the commercial laboratory are shown in Table 21 and with the exception of Pb are generally acceptable. It appears that the laboratory could not adequately analyze aqueous samples for Pb where Pb was at levels close to the detection limit. Therefore any such low values of lead reported by the laboratory in aqueous samples are suspect.

4.5 Process Samples - Organics

Tables 15 through 18 show levels of toxic organics found in the process samples, namely dioxins and furans (Table 15); chlorobenzenes and PAHs (Table 16); PAHs (Table 17); and chlorophenols (Table 18). Table 18 also shows total suspended solids (TSS) and moisture data on the process samples.

Low levels of dioxins and furans in the low ng/g range near the detection limit were found in the sludge feed. Dioxins were found only in the sludge feed, not in the other process samples, and only the less toxic hepta and octa dioxins were found. Some furans were found in the bottom ash and "scrubber water out" but at very low levels (low ng/g and ng/l range). By comparison, both garbage incinerators (Figures 6 and 7) show dioxin and furan levels in the low ng/g range in the bottom ash. All the surrogate recoveries reported in Table 15 are within the acceptable range (100% plus or minus 40%), indicating a high degree of confidence in the dioxin furan data reported.

In Table 16 low values, near the detection limits (low ug/g and ug/l range), of chlorobenzenes were found in the process samples and were most frequently found in the sludge feed. No PCBs were found in any of the process samples. By comparison, no PCBs were found in the bottom ash of the garbage incinerators (Figures 6 and 7) either and low ug/g levels of chlorobenzenes were also found in the bottom ash. More than half of the chlorobenzene surrogates are within the acceptable range indicating a fair degree of confidence in the data. All the PCB surrogates are within the acceptable range indicating a high degree of confidence in the PCB data.

Table 17 shows low levels of PAHs in the sludge feed (< 10 ug/g), no PAHs detected in the bottom ash, low levels (< 0.1 ug/l) in the "scrubber water in" and "scrubber water out" and still low levels, but slightly higher (< 0.5 ug/l) in the bottom ash filtrate. By comparison PAHs in the bottom ash of the garbage incinerators range from 540 to 1800 ng/g. More than half of the PAH surrogate recoveries are within the acceptable range indicating a fair degree of confidence in the PAH results.

Table 18 shows only low levels (< 1 ug/g) of chlorophenols detected in the process samples and these were only detected in the sludge feed. A comparison with the garbage incinerators (Figures 6 and 7) shows chlorophenols in the bottom ash ranging from below detection to 16 ng/g. The chlorophenol surrogate recoveries are very poor with most of the recoveries falling outside the acceptable range. This indicates a low degree of confidence in the data.

5 CONCLUSIONS

The results from the Duffin Creek tests indicate that dioxins were found only in the sludge feed and nowhere else. Some furans were found in the sludge feed and in the stack gases. No PCBs were found in any samples.

Chlorinated benzenes were found most commonly in the sludge feed and the stack gases. Chlorophenols were only occasionally detected in the sludge feed and not detected at all in the stack gases or the other process samples. Most of the 15 PAHs reported were found in the sludge feed and in the stack gases. A smaller number were found in the ash and the scrubber water.

The stack emission concentrations of organics at Duffin Creek were found to be significantly less than those found at two garbage incinerators. The concentrations of organics and metals in the bottom ash at Duffin Creek were comparable to those found at the two garbage incinerators. Metal stack emissions from Duffin Creek were found to be comparable to those from a garbage incinerator equipped with an emission control system.

Incinerator stack emissions at Duffin Creek meet both the current and proposed Regulation 308 requirements for Ontario for metals and particulates.

6 RESULTS

6.1 List of Tables

6.2 Data Tables

TABLE 1 CONTINUOUS ANALYZER SPECIFICATIONS

Gas	Continuous Analyzer	Principle of Operation	Analyzer Range	Calibration Gas Conc.
NO_x	Teco 10AR	Chemiluminescent	0-250 ppm	214 ppm NO
SO_2	Western 721-A	NDUV	0-250 ppm	228 ppm
CO_2	Beckman 756	NDIR	0-20 %	18.3 %
CO	Bendix 8501-5BA	NDIR	0-250 ppm	208 ppm
O_2	Beckman 755	Paramagnetic	0-25 %	22.5 %
THCs	Beckman 400	FID (cold)	0-30 ppm	15.2 ppm

NOTES:
NDUV = Nondispersive ultraviolet
NDIR = Nondispersive infrared
FID = Flame ionization ('cold' hydrocarbon analyzer)

TABLE 2 TOTAL PARTICULATE TEST RESULTS

Run number	TP/HM-1	TP/HM-2	TP/HM-3
Date (1986)	OCT 1	OCT 2	OCT 3
Time started	11:45	11:21	09:44
finished	15:55	15:30	13:54
Test duration (min)	240	240	240
SAMPLING DATA			
Sample volume (m3)	3.187	3.214	3.267
Isokineticity (%)	101.2	101.5	101.8
STACK GAS CHARACTERISTICS			
Average Velocity (m/s)	3.46	3.45	3.57
Flow rate (m3/min)	215	216	220
Temperature (deg C)	36.8	35.4	37.5
Moisture (%)	6.90	6.33	7.25
Oxygen (%, dry)	6.8	7.5	5.8
Carbon dioxide (%, dry)	11.8	11.5	13.0
PARTICULATE MATTER COLLECTED			
Front-half (mg)	343.7	416.5	374.1
Back-half (mg)	0.0	0.0	0.0
Total (mg)	343.7	416.5	374.1
PARTICULATE CONCENTRATION			
Uncorr. (mg/m3)	107.8	129.6	114.5
Corrected to 12% CO2 (mg/m3)	109.6	135.2	105.7

NOTE: All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascals.

TABLE 3 INORGANICS/HEAVY METALS CONCENTRATIONS
(Concentrations in ug/m^3, corrected to 12% CO_2)

Run number	TP/HM-1	TP/HM-2	TP/HM-3	Average
Date (1986)	OCT 1	OCT 2	OCT 3	
Ag	6	7	0	4
Al	9 349	12 597	9 776	10 574
As	1	1	1	1
B	43	82	106	77
Ba	171	292	294	252
Be	0	0	0	0
Ca	14 703	18 879	14 198	15 927
Cd	12	12	15	13
Co	2	2	2	2
Cr	229	311	235	258
Cu	261	351	252	288
Fe	2 572	3 344	2 469	2 795
K	878	1 243	1 051	1 057
Mg	1 781	2 386	1 858	2 008
Mn	76	94	63	77
Mo	2	0	0	1
Na	2 853	3 766	4 069	3 562
Ni	146	108	83	112
P	7 243	8 506	6 470	7 407
Pb	115	127	102	114
Si	2 365	2 045	1 631	2 014
Sr	62	81	63	68
Th	0	0	0	0
Ti	124	144	120	130
V	3	4	3	4
Zn	392	604	492	496
Zr	3	2	1	2

NOTES:
- All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascals.
- Above results have not been corrected for reagent and filter blank values which are generally low.
- Only B, Ba, and Na have unacceptably high filter blank values.
- All elements except Si are found in the front-half of the total particulate sampling train.

TABLE 4 MERCURY TEST RESULTS

Run number	HG-1	HG-2	HG-3
Date (1986)	OCT 1	OCT 2	OCT 3
Time started finished	11:45 15:55	11:21 15:30	09:44 13:54
Test duration (min)	240	240	240
SAMPLING DATA			
Sample volume (m3)	3.021	3.058	3.099
Isokineticity (%)	100.4	101.0	101.5
STACK GAS CHARACTERISTICS			
Average Velocity (m/s)	3.32	3.31	3.44
Flow rate (m3/min)	206	207	211
Temperature (deg C)	38	37	39
Moisture (%)	6.85	6.34	7.26
Oxygen (%, dry)	6.8	7.5	5.8
Carbon dioxide (%, dry)	11.8	11.5	13.0
MERCURY COLLECTED			
Front-half (ug)	2	4	1
Back-half (ug)	1 447	1 156	1 389
Total Hg (ug)	1 450	1 160	1 390
TOTAL MERCURY CONCENTRATION			
Uncorr. (ug/m3)	480	380	450
Corrected to 12% CO2 (ug/m3)	490	400	410

NOTES:
- All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascals.
- Mercury results have not been corrected for reagent and filter blank values which are negligible.

TABLE 5 DIOXIN/FURAN CONCENTRATIONS
(corrected to 12% CO2)

RUN NO.	ORG-1			ORG-2			ORG-3		
DATE	OCT 4			OCT 5			OCT 6		
ISOMERS	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol
Dioxin Concentrations (pg/m^3 @ 12% CO_2)									
T4CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
P5CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
H6CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
O8CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total	ND	ND	ND	ND	ND	ND	ND	ND	ND
Furan Concentrations (pg/m^3 @ 12% CO_2)									
T4CDF	ND	ND	ND	216	ND	ND	ND	ND	ND
P5CDF	ND	ND	ND	ND	ND	ND	ND	ND	ND
H6CDF	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7CDF	ND	ND	ND	ND	ND	ND	ND	ND	ND
O8CDF	ND	338	ND*	202	350	ND*	391	456	ND*
Total	ND	338	ND	418	350	ND	391	456	ND
		338			768			847	

NOTE 1: All gas volumes are expressed on a dry basis at reference conditions of 25°C an 101.3 kilopascals.

2: ND = Non detectable.

3: * = ND after correcting for the 0.49 ng of O8CDF detected in the glycol impinge of the blank train.

4: For ORG-1, -2, and -3, CO2 Concentrations = 13.4, 12.8, and 12%; stack gas flow - 215, 218, and 209 m3/min.

TABLE 6 COMPARISON OF DIOXIN/FURAN LEVELS IN VARIOUS SAMPLES (ng)

Dioxins/Furans in field train, blank train, blank reagents, and MM5 train proof rinse

SAMPLES	Field Train			Blank Train			Blank Reagents*				Proof
DATE	OCT 5			OCT 5			OCT 5				OCT 6
ISOMERS	Probe/ filter	Amber. XAD-2	Glycol	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane	Filt.	Amber. XAD-2	Glycol	Acet.+ Hexane
T4CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
P5CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H6CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
O8CDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T4CDF	0.74	ND	ND	ND	ND	ND	ND	ND	0.81	ND	0.09
P5CDF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H6CDF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
H7CDF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
O8CDF	0.69	1.20	0.48	ND	ND	0.49	ND	ND	ND	0.15	0.17
Total	1.43	1.20	0.48	ND	ND	0.49	ND	ND	0.81	0.15	0.26

NOTES:
* = Amounts similar to field samples
ND = Non detectable

TABLE 6 COMPARISON OF DIOXIN/FURAN LEVELS IN VARIOUS SAMPLES (ng) (Cont'd)

Dioxins/Furans Detection Limits (ng)

ISOMERS	Probe Filter	Amber.	Glycol
Tetra	0.10	0.20	0.10
Penta	0.20	0.30	0.10
Hexa	0.20	0.30	0.10
Hepta	0.20	0.30	0.20
Octa	0.40	0.40	0.20

TABLE 7 RECOVERY EFFICIENCIES OF 13C12-LABELLED SURROGATE DIOXINS/FURANS (%)

(a) Field Train Samples

RUN NO.	ORG-1			ORG-2			ORG-3		
DATE	OCT 4			OCT 5			OCT 6		
SURROGATE	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol
T4CDD	89	83	89	64	78	74	95	90	75
H6CDD	82	81	91	58	85	92	85	84	79
O8CDD	101	93	95	71	98	92	112	98	73
T4CDF	91	88	90	73	98	88	92	97	78

(b) Samples of Blank Train, Blank Reagents, and Pre-test Proof Rinse of MM5 Train

SAMPLE	Blank Train			Blank Reagents				Proof
DATE	OCT 5			OCT 5				OCT 6
SURROGATE	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane
T4CDD	97	88	101	77	97	102	74	113
H6CDD	84	76	101	71	85	84	90	93
O8CDD	102	102	97	56	100	116	78	84
T4CDF	100	67	103	63	106	94	98	93

TABLE 8 PCBs, CPs, and CBs CONCENTRATIONS

RUN NO.	ORG-1			ORG-2			ORG-3		
DATE	OCT 4			OCT 5			OCT 6		
ISOMERS	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol
PCBs Concentrations (ng/m^3 @12% CO_2)									
PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPs Concentrations (ng/m^3 @12% CO_2)									
CL2-CP	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL3-CP	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL4-CP	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL5-CP	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL		ND			ND			ND	
CBs Concentrations (ng/m^3 @12% CO_2)									
CL2-CB	ND	10 141	51	ND	ND	ND	ND	9 115	62
CL3-CB	ND	200	ND	47	105	ND	ND	781	ND
CL4-CB	ND	451	ND	32	169	ND	ND	221	ND
CL5-CB	ND	59	ND	35	64	ND	ND	39	ND
CL6-CB	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL	ND	10 851	51	114	339	ND	ND	10 156	62
		10 902			453			10 218	

NOTE 1: ND = Non detectable.

2: All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascals.

3: For ORG-1, -2, and -3, CO2 Concentrations = 13.4, 12.8, and 12%; stack gas flows = 215, 218, and 209 m3/min.

TABLE 9 RECOVERY EFFICIENCIES OF SURROGATE PCBs, CPs, and CBs (%)

(a) Field Train Samples

RUN NO.	ORG-1			ORG-2			ORG-3		
DATE	OCT 4			OCT 5			OCT 6		
SURROGATE	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol
(dx)-PCB	120	89	113	75	87	105	98	105	92
(d3)CL2CP	62	70	68	0	50	61	47	8	39
13C6CL5CP	133	390	230	9	275	140	270	277	164
(d4)CL2CB	92	73	35	46	37	49	42	82	18
13C6CL6CB	115	107	90	67	95	82	85	116	69

(b) Samples of Blank Train, Blank Reagents, and Pre-test Proof Rinse of MM5 Train

SAMPLE	Blank Train			Blank Reagents				Proof
DATE	OCT 5			OCT 5				OCT 6
SURROGATE	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane
(dx)-PCB	119	105	80	77	96	215	122	95
(d3)CL2CP	56	37	45	25	39	10	19	5
13C6CL5CP	92	16	86	0	65	0	173	0
(d4)CL2CB	46	58	32	60	42	48	16	62
13C6CL6CB	122	106	74	58	107	123	78	109

TABLE 10 COMPARISON OF PCB, CB, and CP LEVELS in VARIOUS SAMPLES (ug)

PCBs, CPs, and CBs in field train, blank train, blank reagents, and MM5 train proof rinse

SAMPLES	Field Train			Blank Train			Blank Reagents*				Proof
DATE (RUN)	OCT 5 (ORG-2)			OCT 5			OCT 5				OCT 6
ISOMERS	Probe/ filter	Amber. XAD-2	Glycol	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane	Filt.	Amber. XAD-2	Glycol	Acet.+ Hexane
Total PCB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL2CP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL3CP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL4CP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL5CP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total CPs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL2CB	ND	ND**	ND	ND	ND	0.35	ND	ND	ND	0.19	ND
CL3CB	0.16	0.36	ND	0.07	0.05	ND	ND	ND	ND	ND	ND
CL4CB	0.11	0.58	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL5CB	0.12	0.22	ND	ND	ND	ND	ND	ND	ND	ND	ND
CL6CB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total CBs	0.39	1.16	ND	0.07	0.05	0.35	ND	ND	ND	0.19	ND

NOTES:
ND = Non detectable
* = Amount similar to field samples
** = 36 and 28 ug of Cl_2CB were detected in the Oct. 4 (ORG-1) and Oct. 6 (ORG-2) runs

TABLE 10 COMPARISON OF PCB, CB, and CP LEVELS in VARIOUS SAMPLES (ug) (Cont'd)

PCBs/CPs/CBs Detection Limits (ug)

COMPOUNDS	Probe Filter	Amber.	Glycol
PCBs	0.05	0.05	0.05
CL 2-CP	0.50	0.50	0.50
CL3 to CL5-CP	0.02	0.02	0.02
CL 2-CB	0.05	0.05	0.01
CL3 to CL6-CB	0.05	0.05	0.05

TABLE 11 .PAH CONCENTRATIONS

(ng/m^3, corrected to 12% CO_2)

RUN NO.	ORG-1			ORG-2			ORG-3		
DATE	OCT 4			OCT 5			OCT 6		
PAHs	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol
Naphthalene	ND	338	20	ND	12	22	ND	423	15
Acenaphthylene	ND	ND	ND	ND	10	4	ND	ND	ND
Acenaphthene	ND	10	ND	ND	9	ND	ND	88	ND
Fluorene	ND	68	6	ND	158	4	ND	160	ND
Phenanthrene	ND	73	22	ND	16	19	ND	78	ND
Anthracene	ND	79	ND	ND	6	ND	ND	59	ND
Fluoranthene	ND	ND	4	ND	202	3	ND	3	3
Pyrene	ND	ND	11	ND	172	9	ND	8	11
Benzanthracene	ND	ND	ND	ND	ND	ND	ND	14	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND
B(b+k)Fluoranthene	ND	12	ND	ND	1 782	ND	ND	ND	ND
Benzo(a)Pyrene	ND	15	ND	ND	321	ND	ND	ND	ND
Indeno Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
B(ghi)Perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzanthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL	ND	594	63	ND	2 688	63	ND	833	29
		657			2 750			862	

NOTE 1: ND = Non detectable

2: All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascals.

3: For ORG-1, -2, and -3, CO2 Concentrations = 13.4, 12.8, and 12%; stack gas flows = 215, 218, and 209 m3/min.

TABLE 12 RECOVERY EFFICIENCIES of SURROGATE PAHs (%)

(a) Field Train Samples

RUN NO.	ORG-1			ORG-2			ORG-3		
DATE	OCT 4			OCT 5			OCT 6		
SURROGATE	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol	Probe/ filter	Amber. XAD-2	Glycol
d8-Naphthalene	69	53	47	35	27	44	43	65	21
d10-Anthracene	69	97	87	11	103	85	90	21	73
d12-Benzo(a)Pyrene	133	274	107	4	193	124	336	19	170

(b) Samples of Blank Train, Blank Reagents, and Pre-test Proof Rinse of MM5 Train

SAMPLE	Blank Train			Blank Reagents				Proof
DATE	OCT 5			OCT 5				OCT 6
SURROGATE	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane
d8-Naphthalene	52	53	46	67	44	34	19	89
d10-Anthracene	86	108	84	81	100	42	90	88
d12-Benzo(a)Pyrene	78	126	140	91	185	66	135	148

TABLE 13 COMPARISON OF PAH LEVELS in VARIOUS SAMPLES (ug)

PAHs in field train, blank train, blank reagents, and MM5 train proof rinse

SAMPLES	Field Train			Blank Train			Blank Reagents*				Proof	Detection Limits (ug)
DATE (RUN)	OCT 5 (ORG-2)			OCT 5			OCT 5				OCT 6	
PAHs	Probe/ filter	Amber. XAD-2	Glycol	Filter	Amber. XAD-2	Glycol	Acet.+ Hexane	Filt.	Amber. XAD-2	Glycol	Acet.+ Hexane	
Naphthalene	ND	0.04	0.08	ND	1.30	0.09	ND	ND	0.58	0.12	ND	0.05
Acenaphthylene	ND	0.03	0.02	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Acenaphthene	ND	0.03	ND	ND	0.03	ND	ND	ND	0.05	ND	ND	0.01
Fluorene	ND	0.54	0.02	ND	0.02	ND	ND	ND	0.16	ND	ND	0.01
Phenanthrene	ND	0.05	0.07	ND	ND	0.07	ND	ND	ND	0.06	ND	0.01
Anthracene	ND	0.02	ND	ND	ND	ND	ND	ND	ND	0.02	ND	0.01
Fluoranthene	ND	0.69	0.01	ND	ND	0.02	ND	ND	ND	0.01	ND	0.01
Pyrene	ND	0.59	0.03	ND	ND	0.04	ND	ND	ND	0.04	ND	0.01
Benzanthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
B(b+k)Fluoranthene	ND	6.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Benzo(a)Pyrene	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Indeno(123cd)Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
B(ghi)Perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Dibenzanthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
TOTAL	ND	9.19	0.23	ND	1.35	0.23	ND	ND	ND	ND	ND	

NOTES: ND = Non detectable
* = Amount/similar to field samples

TABLE 14 CONTINUOUS MONITORING RESULTS

(Average gas concentrations over the duration of each manual test)

	OCT 1	OCT 2	OCT 3	OCT 4	OCT 5	OCT 6
GAS	Run TP/HM-1 Run HG-1	Run TP/HM-2 Run HG-2	Run TP/HM-3 Run HG-3	Run ORG-1	Run ORG-2	Run ORG-3
NOx (ppm)	33	29	17	13	10	24
SO2 (ppm)	7	7	12	7	7	8
CO2 (%)	12	12	13	13	13	12
CO (ppm)	<1	5	1	1	2	1
O2 (%)	7	8	6	5	6	7
THCs (ppm)	9	7	4	2	2	2

NOTE:
- All gas concentrations are expressed on a dry volume basis and at reference conditions of 25°C and 101.3 kilopascals.
- Duration of each manual test was approx. 4 hours.
- Cold THC analyzer was used.

TABLE 15 DUFFIN CREEK - PROCESS SAMPLES - ORGANIC RUNS - DIOXINS AND FURANS - OCT. 4, 5, 6, 1986

Sample Description	Units	Polychlorinated Dibenzo-p-dioxins					Polychlorinated Dibenzofurans					Surrogate Recoveries (%)			
		T4CDD	P5CDD	H6CDD	H7CDD	OCDD	T4CDF	P5CDF	H6CDF	H7CDF	OCDF	13C12-OCDD	13C12-T4CDF	13C12-T4CDD	13C12-H6CDD
												Percent Recovery			
Run ORG-1 - Oct. 4/86															
Sludge feed	ng/g	ND(0.3)	ND(0.5)	ND(2.0)	4.8	12	ND(0.3)	ND(0.5)	ND(0.5)	ND(1.0)	0.5	78	105	101	72
Bottom ash-dry	ng/g	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	0.13	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	106	101	130	107
Bottom ash - filtrate	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.2)	ND(0.1)	ND(0.02)	ND(0.2)	86	125	125	106
Scrubber water in	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.2)	ND(0.1)	ND(0.2)	ND(0.2)	77	87	97	91
Scrubber water out	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.2)	ND(0.1)	ND(0.2)	ND(0.2)	95	98	111	101
Run ORG-2 - Oct. 5/86															
Sludge feed	ng/g	ND(0.3)	ND(0.5)	1.6	5.5	14	ND(0.3)	ND(0.5)	ND(0.5)	0.57	0.57	77	112	106	67
Bottom ash-dry	ng/g	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	ND(0.05)	99	96	122	100
Bottom ash - filtrate	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	78	73	79	87
Scrubber water in	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	71	88	81	90
Scrubber water out	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	0.19	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	84	100	106	109
Run ORG-3 - Oct. 6/86															
Sludge feed	ng/g	ND(0.3)	ND(0.5)	ND(3.0)	5.1	12	ND(0.3)	ND(0.5)	ND(1.0)	ND(0.5)	ND(0.5)	84	82	79	62
Bottom ash-dry	ng/g	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	ND(0.05)	105	104	118	105
Bottom ash - filtrate	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	79	91	98	62
Scrubber water in	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	90	98	107	96
Scrubber water out	ng/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.2)	ND(0.2)	1.37	ND(0.1)	ND(0.1)	0.23	0.23	91	98	98	105

TABLE 16 DUFFIN CREEK - PROCESS SAMPLES - ORGANIC RUNS -CHLOROBENZENES & PCBs - OCT. 4, 5, 6, 1986

Sample Description	Units	Chlorinated benzenes and polychlorinated biphenyls						Surrogate Recovery (%)		
		CL-2 Benzene	CL-3 Benzene	CL-4 Benzene	CL-5 Benzene	CL-6 Benzene	PCB	(d4) CL-2 Benzene	(13C6) CL-6 Benzene	(dx)-PCB
								Percent Recovery		
Run ORG-1 - Oct. 4/86										
Sludge feed	ug/g	0.21	ND(0.05)	0.082	0.060	0.036	ND(0.2)	63	138	62
Bottom ash-dry	ug/g	ND(0.05)	ND(0.05)	ND(0.002)	ND(0.002)	ND(0.002)	ND(0.005)	58	105	106
Bottom ash - filtrate	ug/L	0.21	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	64	98	77
Scrubber water in	ug/L	1.3	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	89	114	112
Scrubber water out	ug/L	0.31	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	61	86	91
Run ORG-2 - Oct. 5/86										
Sludge feed	ug/g	0.13	ND(0.05)	0.075	0.066	0.043	ND(0.2)	35	134	99
Bottom ash-dry	ug/g	ND(0.05)	0.008	ND(0.002)	ND(0.002)	ND(0.002)	ND(0.005)	62	107	105
Bottom ash - filtrate	ug/L	0.13	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	71	106	101
Scrubber water in	ug/L	0.83	0.078	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	101	105	108
Scrubber water out	ug/L	0.21	0.014	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	75	94	100
Run ORG-3 - Oct. 6/86										
Sludge feed	ug/g	0.044	ND(0.05)	0.063	0.053	0.025	ND(0.2)	29	77	74
Bottom ash-dry	ug/g	ND(0.05)	0.007	ND(0.002)	ND(0.002)	ND(0.002)	ND(0.005)	47	104	78
Bottom ash - filtrate	ug/L	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	61	106	104
Scrubber water in	ug/L	0.45	0.025	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	52	100	111
Scrubber water out	ug/L	ND(0.02)	0.015	ND(0.02)	ND(0.02)	ND(0.02)	ND(0.05)	74	105	75

TABLE 17 DUFFIN CREEK - PROCESS SAMPLES - ORGANIC RUNS - PAHs - OCT. 4, 5, 6, 1986

Sample Description	Units	Polyaromatic Hydrocarbons									
		Napthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzanthracene	Chrysene
Run ORG-1 - Oct. 4/86											
Sludge feed	ug/g	0.35	0.025	0.20	0.56	2.0	0.17	0.51	0.64	unknown	0.11
Bottom ash-dry	ug/g	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)
Bottom ash - filtrate	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.086	0.081	0.033	0.044
Scrubber water in	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
Scrubber water out	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.015	0.033	ND(0.05)	ND(0.05)
Run ORG-2 - Oct. 5/86											
Sludge feed	ug/g	0.39	0.030	0.26	0.69	2.6	0.28	0.61	0.68	unknown	0.12
Bottom ash-dry	ug/g	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)
Bottom ash - filtrate	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.057	0.051	0.018	0.028
Scrubber water in	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.038	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
Scrubber water out	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.082	ND(0.05)	0.11	0.13	ND(0.05)	ND(0.05)
Run ORG-3 - Oct. 6/86											
Sludge feed	ug/g	0.36	0.030	0.23	0.67	2.8	0.30	0.80	0.74	unknown	0.11
Bottom ash-dry	ug/g	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)
Bottom ash - filtrate	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.082	ND(0.05)	0.11	0.13	ND(0.05)	ND(0.05)
Scrubber water in	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
Scrubber water out	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.083	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)

TABLE 17 DUFFIN CREEK - PROCESS SAMPLES - ORGANIC RUNS - PAH (Continued) - OCT. 4, 5, 6, 1986

Sample Description	Units	Polyaromatic hydrocarbons (cont'd)					Surrogate Recovery (%)		
		Benzo (b+k) fluoranthene	Benzo (a) pyrene	Indeno (1,2, 3-c,d)pyrene	Benzo (g,h,i) perylene	Dibenz-anthracene	d8-Naptha-lene	d10-Anthra-cene	d12-Benzo(a) pyrene
							Percent Recovery		
Run ORG-1 - Oct. 4/86									
Sludge feed	ug/g	0.12	0.06	ND(0.01)	ND(0.01)	ND(0.01)	54	108	22
Bottom ash-dry	ug/g	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	41	94	123
Bottom ash - filtrate	ug/L	ND(0.05)	0.054	ND(0.05)	ND(0.05)	ND(0.05)	59	104	168
Scrubber water in	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	73	100	118
Scrubber water out	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	60	102	84
Run ORG-2 - Oct. 5/86									
Sludge feed	ug/g	0.10	0.065	ND(0.01)	ND(0.01)	ND(0.01)	75	138	19
Bottom ash-dry	ug/g	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	41	93	106
Bottom ash - filtrate	ug/L	0.036	0.033	ND(0.05)	ND(0.05)	ND(0.05)	63	106	123
Scrubber water in	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	81	85	102
Scrubber water out	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	51	98	82
Run ORG-3 - Oct. 6/86									
Sludge feed	ug/g	0.15	0.084	ND(0.01)	ND(0.01)	ND(0.01)	55	107	27
Bottom ash-dry	ug/g	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	ND(0.01)	39	93	98
Bottom ash - filtrate	ug/L	0.089	0.12	ND(0.05)	ND(0.05)	ND(0.05)	63	84	100
Scrubber water in	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	73	102	163
Scrubber water out	ug/L	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	57	92	95

TABLE 18 DUFFIN CREEK - PROCESS SAMPLES - ORGANIC RUNS - PHENOLS, TSS and MOISTURE - Oct. 4, 5, 6, 1986

Sample Description	Units	Polychlorinated phenols				Surrogate Recovery (%)			
		CL-2 Phenol	CL-3 Phenol	CL-4 Phenol	CL-5 Phenol	(d3) CL-2 Phenol	(13C6) CL-5 Phenol	TSS mg/L	Moisture (%)
						Percent Recovery			
Run ORG-1 - Oct. 4/86									
Sludge feed	ug/g	0.11	ND(0.05)	ND(0.05)	0.15	103	24	NA	67.1
Bottom ash-dry	ug/g	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	20	36	NA	34.4
Bottom ash - filtrate	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	46	325	3660	NA
Scrubber water in	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	68	201	17.6	NA
Scrubber water out	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	72	250	37.5	NA
Run ORG-2 - Oct. 5/86									
Sludge feed	ug/g	ND(0.05)	ND(0.05)	ND(0.05)	0.30	ND	32	NA	66.1
Bottom ash-dry	ug/g	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	14	28	NA	33.9
Bottom ash - filtrate	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	72	310	349	NA
Scrubber water in	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	81	101	20.3	NA
Scrubber water out	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	58	84	299	NA
Run ORG-3 - Oct. 6/86									
Sludge feed	ug/g	0.11	ND(0.05)	ND(0.05)	0.15	103	24	NA	68.3
Bottom ash-dry	ug/g	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	25	15	NA	33.5
Bottom ash - filtrate	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	143	207	1010	NA
Scrubber water in	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	56	210	8.9	NA
Scrubber water out	ug/L	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	54	119	30.5	NA

TABLE 19 DUFFIN CREEK - PROCESS SAMPLES - PARTICULATE/HEAVY METAL RUNS - OCT. 1, 2, 3, 1986 - PART 1

Sample Description	Units	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr
Run TP/HM-1 - Oct. 1/86											
Sludge feed	ppm	83.9	58700	5.0	not anal.	not anal.	0.63	61800	36.1	<3	1220
Bottom ash-dry	ppm	106	98200	11.6	not anal.	not anal.	1.08	103000	50.0	11	2080
Bottom ash - filtrate	mg/L	<0.005	0.895	0.0014	0.202	0.030	<0.0005	93.5	<0.01	<0.05	0.040
Scrubber water in	mg/L	<0.005	1.88	0.0011	0.209	0.045	<0.0005	93.5	<0.01	<0.05	0.063
Scrubber water out	mg/L	<0.005	25.7	0.0082	0.462	0.020	<0.0005	226	0.027	<0.05	0.475
Sludge feed (Fixed solids basis)	ppm	132	92400	7.9	not anal.	not anal.	0.99	97300	56.9	<5	1920
Run TP/HM-2 - Oct. 2/86											
Sludge feed	ppm	83.2	60200	5.0	not anal.	not anal.	0.63	65200	36.5	<3	1270
Bottom ash-dry	ppm	103	97400	11.6	not anal.	not anal.	0.89	108000	49.6	10	2090
Bottom ash - filtrate	mg/L	<0.005	0.873	0.0023	0.222	0.038	0.0011	87.6	<0.01	<0.05	0.071
Scrubber water in	mg/L	<0.005	2.15	0.0018	0.228	0.043	<0.0005	90.2	<0.01	<0.05	0.078
Scrubber water out	mg/L	<0.005	28.6	0.0078	0.642	0.02	0.0005	269	0.031	<0.05	0.525
Sludge feed (Fixed solids basis)	ppm	129	93000	7.7	not anal.	not anal.	0.97	101000	56.4	<5	1960
Run TP/HM-3 - Oct. 3/86											
Sludge feed	ppm	81.1	58900	5.0	not anal.	not anal.	0.65	63900	32.1	<3	1230
Bottom ash-dry	ppm	148	96700	12.5	not anal.	not anal.	1.12	108000	49.4	8	2060
Bottom ash - filtrate	mg/L	<0.005	1.11	0.0007	0.228	0.022	<0.0005	84.5	<0.01	<0.05	0.039
Scrubber water in	mg/L	<0.005	1.81	0.0008	0.213	0.038	<0.0005	81.7	<0.01	<0.05	0.046
Scrubber water out	mg/L	<0.005	47.5	0.010	0.977	0.023	0.0005	428	0.035	<0.05	0.823
Sludge feed (Fixed solids basis)	ppm	125	90600	7.7	not anal.	not anal.	1.0	98300	49.4	<5	1890

TABLE 19 DUFFIN CREEK - PROCESS SAMPLES - PARTICULATE/HEAVY METAL RUNS - OCT. 1, 2, 3, 1986 - PART 2 (Cont'd)

Sample Description	Units	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb
Run TP/HM-1 - Oct. 1/86											
Sludge feed	ppm	1180	17000	7930	7950	361	<10	5640	275	29100	575
Bottom ash-dry	ppm	2010	28700	13000	11900	648	<10	9370	480	49800	1020
Bottom ash - filtrate	mg/L	0.114	3.46	6.7	15.6	0.090	<0.2	103	0.14	2.9	0.15
Scrubber water in	mg/L	0.09	2.97	6.6	15.4	0.096	<0.2	102	0.22	3.7	0.05
Scrubber water out	mg/L	0.886	7.04	17.8	44.7	0.368	0.3	73.0	0.20	19.5	0.20
Sludge feed (Fixed solids basis)	ppm	1860	26800	12500	12500	569	<16	8880	433	45800	906
Run TP/HM-2 - Oct. 2/86											
Sludge feed	ppm	1220	17800	7800	8330	371	<10	5660	275	29300	600
Bottom ash-dry	ppm	1990	29200	12700	12400	642	<10	9310	471	49600	1070
Bottom ash - filtrate	mg/L	0.160	4.87	7.6	15.8	0.089	<0.2	115	0.12	3.7	<0.05
Scrubber water in	mg/L	0.089	3.05	8.0	15.9	0.094	<0.2	116	0.12	3.9	<0.05
Scrubber water out	mg/L	0.975	8.57	26.4	60.6	0.460	0.4	84.6	0.21	22.0	0.25
Sludge feed (Fixed solids basis)	ppm	1890	27500	12100	12900	573	<15	8750	425	45300	927
Run TP/HM-3 - Oct. 3/86											
Sludge feed	ppm	1210	17300	7760	8120	370	<10	5780	271	28800	625
Bottom ash-dry	ppm	2000	28800	12500	12700	648	<10	9060	457	49300	1100
Bottom ash - filtrate	mg/L	0.095	1.74	7.6	15.4	0.071	<0.2	118	0.11	2.4	0.20
Scrubber water in	mg/L	0.082	1.37	7.2	14.9	0.072	<0.2	113	0.13	3.0	<0.05
Scrubber water out	mg/L	1.41	15.1	44.4	101	0.686	0.6	94.2	0.29	37.2	0.25
Sludge feed (Fixed solids basis)	ppm	1860	26600	11900	12500	569	<15	8890	417	44300	962

TABLE 19 DUFFIN CREEK - PROCESS SAMPLES - PARTICULATE/HEAVY METAL RUNS - OCT. 1, 2, 3, 1986 - PART 3 (Cont'd)

Sample Description	Units	Si	Sr	Th	Ti	V	Zn	Zr
Run TP/HM-1 - Oct. 1/86								
Sludge feed	ppm	not anal.	327	2.6	2260	33.4	1370	87
Bottom ash-dry	ppm	not anal.	531	4.1	4200	60.4	2360	123
Bottom ash - filtrate	mg/L	6.53	0.309	<0.05	0.005	<0.005	0.178	<0.05
Scrubber water in	mg/L	7.71	0.316	<0.05	0.018	<0.005	0.202	<0.05
Scrubber water out	mg/L	30.5	0.604	<0.05	0.268	0.10	0.476	<0.05
Sludge feed (Fixed solids basis)	ppm	not anal.	515	4.1	3560	52.6	2160	140
Run TP/HM-2 - Oct. 2/86								
Sludge feed	ppm	not anal.	335	<0.5	2360	37.3	1360	98
Bottom ash-dry	ppm	not anal.	523	<0.5	4250	68.2	2300	124
Bottom ash - filtrate	mg/L	6.30	0.310	<0.05	0.013	<0.0005	0.199	<0.05
Scrubber water in	mg/L	8.29	0.306	<0.05	0.065	0.006	0.212	<0.05
Scrubber water out	mg/L	36.4	0.726	<0.05	0.317	0.142	0.527	<0.05
Sludge feed (Fixed solids basis)	ppm	not anal.	518	<0.8	3650	57.7	2100	150
Run TP/HM-3 - Oct. 3/86								
Sludge feed	ppm	not anal.	325	<0.5	2330	32.2	1330	96
Bottom ash-dry	ppm	not anal.	530	<0.5	4380	59.1	2300	125
Bottom ash - filtrate	mg/L	6.22	0.293	<0.05	0.009	<0.005	0.167	<0.05
Scrubber water in	mg/L	6.23	0.287	<0.05	0.020	<0.005	0.178	<0.05
Scrubber water out	mg/L	49.6	1.16	<0.05	0.486	0.208	0.854	0.05
Sludge feed (Fixed solids basis)	ppm	not anal.	500	<0.8	3580	49.5	2050	150

TABLE 20 DUFFIN CREEK - PROCESS SAMPLES - MERCURY RUNS, Cl, TSS, %Solids, % Volatiles - OCT. 1, 2, 3, 1986

Sample Description	Units	Hg	Cl	TSS	Solids (%)	Volatiles (%)
Run TP/HM-1 - Oct. 1/86						
Sludge feed	ppm	3.74	N/A	N/A	35.4	36.5
Bottom ash-dry	ppm	1.36	N/A	N/A	66.3	
Bottom ash - filtrate	mg/L	9.4×10^{-5}	13.1	37.6	N/A	
Scrubber water in	mg/L	4.00×10^{-3}	12.9	43.9	N/A	
Scrubber water out	mg/L	7.60×10^{-3}	12.3	317	N/A	
Sludge feed (Fixed solids basis)	ppm	5.89				
Run TP/HM-2 - Oct. 2/86						
Sludge feed	ppm	4.22	N/A	N/A	35.2	35.3
Bottom ash-dry	ppm	1.62	N/A	N/A	65.4	
Bottom ash - filtrate	mg/L	3.30×10^{-4}	14.7	47.0	N/A	
Scrubber water in	mg/L	3.33×10^{-3}	14.4	42.4	N/A	
Scrubber water out	mg/L	2.56×10^{-2}	14.6	359	N/A	
Sludge feed (Fixed solids basis)	ppm	6.52				
Run TP/HM-3 - Oct. 3/86						
Sludge feed	ppm	3.18	N/A	N/A	34.8	35.0
Bottom ash-dry	ppm	0.46	N/A	N/A	65.3	
Bottom ash - filtrate	mg/L	1.3×10^{-4}	14.9	42.3	N/A	
Scrubber water in	mg/L	5.00×10^{-3}	14.4	38.8	N/A	
Scrubber water out	mg/L	8.33×10^{-3}	20.0	644	N/A	
Sludge feed (Fixed solids basis)	ppm	4.89				

N/A = not applicable

TABLE 21 DUFFIN CREEK - PROCESS SAMPLES - INORGANIC QA/QC

Metals of Interest	True Value (mg/l)	Reported Values No. 29 (mg/l)	 No. 31 (mg/l)	 No. 32 (mg/l)	AVG	STD DEV	% Recovery
Cd	0.50	0.47	0.47	0.48	0.47	0.01	94.67
Cr	0.50	0.46	0.45	0.45	0.45	0.01	90.67
Cu	0.50	0.49	0.47	0.49	0.48	0.01	96.67
Ni	0.10	0.09	0.09	0.09	0.09	0.00	90.00
Pb	0.10	<0.05	<0.05	<0.05	<0.05	0.00	Nil
Zn	0.10	0.09	0.09	0.09	0.09	0.00	90.00
P	8.05	6.55	6.36	6.55	6.49	0.11	80.58

Metals of Interest	True Value (ug/l)	Reported Values No. 5 (ug/l)	 No. 6 (ug/l)	 No. 8 (ug/l)	AVG	STD DEV	% Recovery
Hg	0.50	0.62	0.63	0.69	0.65	0.04	129.33
As	10.00	6.91	9.45	9.45	8.60	1.47	86.03

TABLE 22 DUFFIN CREEK - REGULATION 308 ASSESSMENT (10)

			Current Reg. 308				Proposed Reg. 308			
Element	Avg. Conc. Over 4 hr (ug/m3)	Emission Rate (g/sec)	Calc'd Max. Conc (ug/m3)	Regulated Conc @POI 1/2 hr Avg (ug/m3)	% of Regulated Maximum	Element Regulated As	Calc'd Max. Conc (ug/m3)	Regulated Ambient Air Std Conc (ug/m3)	Avg Time	% of Regulated Maximum
Silver	4	1.45X10^{-5}	1.08X10^{-4}	3	0.004		3.25X10^{-4}	1	24 hr	0.033
Aluminum	10,574	3.82X10^{-2}	2.85X10^{-1}	-	-	oxide	8.60X10^{-1}	35	24 hr	2.457
Arsenic	1	3.62X10^{-6}	2.69X10^{-5}	75	0.000		8.13X10^{-5}	0.3	24 hr	0.027
Boron	77	2.78X10^{-4}	2.07X10^{-3}	100	0.002		6.26X10^{-3}	35	24 hr	0.018
Barium	252	9.11X10^{-4}	6.79X10^{-3}	-	-		2.05X10^{-2}	10	24 hr	0.205
Beryllium	0	0.00	0.00	0.03	0.000		0.00	0.01	24 hr	0.000
Calcium	15,927	5.76X10^{-2}	4.29X10^{-1}	27	1.589	hydroxide	1.30	13.5	24 hr	9.596
						oxide		10	24 hr	12.955
Cadmium	13	4.70X10^{-5}	3.50X10^{-4}	5	0.007		1.06X10^{-3}	2	24 hr	0.053
Cobalt	2	7.23X10^{-6}	5.39X10^{-5}	-	-		1.63X10^{-4}	-	-	-
Chromium	258	9.33X10^{-4}	6.95X10^{-3}	30	0.023		2.10X10^{-2}	1.5	24 hr	1.399
Copper	288	1.04X10^{-3}	7.76X10^{-3}	100	0.008		2.34X10^{-2}	50	24 hr	0.047
Iron	2,795	1.01X10^{-2}	7.53X10^{-2}	10	0.753		2.27X10^{-1}	4	24 hr	5.684
Potassium	1,057	3.82X10^{-3}	2.85X10^{-2}	-	-	hydroxide	8.60X10^{-2}	14	24 hr	0.614
Magnesium	2,008	7.26X10^{-3}	5.41X10^{-2}	100	0.054	oxide	1.63X10^{-1}	100	24 hr	0.163
Manganese	77	2.78X10^{-4}	2.07X10^{-3}	100	0.002		6.26X10^{-3}	10	24 hr	0.063
Molybdenum	1	3.62X10^{-6}	2.69X10^{-5}	-	-		8.13X10^{-5}	-	-	-
Sodium	3,562	1.29X10^{-2}	9.59X10^{-2}	-	-	hydroxide	2.90X10^{-1}	10	24 hr	2.897
Nickel	112	4.05X10^{-4}	3.02X10^{-3}	5	0.060	reviewing	9.11X10^{-3}	2	24 hr	0.455
Phosphorus	7,407	2.68X10^{-2}	1.99X10^{-1}	100	0.199	P205	6.02X10^{-1}	100	24 hr	0.602
Lead	114	4.12X10^{-4}	3.07X10^{-3}	10	0.031		9.27X10^{-3}	5	24 hr	0.185
								2	30 d	0.464
Silicon	2,014	7.28X10^{-3}	5.42X10^{-2}	-	-	silica-	1.64X10^{-1}	5	24 hr	3.276
Stronium	68	2.46X10^{-4}	1.83X10^{-3}	-	-		5.53X10^{-3}	-	-	-
Thorium	0	0.00	0.00	-	-		0.00	-	-	-
Titanium	130	4.70X10^{-4}	3.50X10^{-3}	100	0.004		1.06X10^{-2}	35	24 hr	0.030
Vanadium	4	1.45X10^{-5}	1.08X10^{-4}	5	0.002		3.25X10^{-4}	2	24 hr	0.016
Zinc	496	1.79X10^{-3}	1.34X10^{-2}	100	0.013		4.03X10^{-2}	100	24 hr	0.040
Zirconium	2	7.23X10^{-6}	5.39X10^{-5}	-	-		1.63X10^{-4}	-	-	-
Particulate	116,833	4.23X10^{-1}	3.15	100	3.147	< 44	9.50	120	24 hr	7.919
						microns		60	1 yr	15.838
Mercury	433	1.50X10^{-3}	1.12X10^{-2}	5	0.224		3.38X10-2	2	24 hr	1.689

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