Emissions From Mesoscale In-Situ Oil Fires: The Mobile 1991 and 1992 Tests

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Summary

A series of 14 mesoscale burns were conducted in 1991 and six in 1992 to study various aspects of oil burning. These burn tests were sponsored by the U.S. Minerals Management Service and were conducted at the U.S. Coast Guard facility in Mobile, Alabama. Environment Canada and the U.S. Environmental Protection Agency conducted extensive sampling and monitoring of these burns to determine the emissions resulting from the burn. Air samples were taken and analyzed for PAHs. PAHs were found to be lower in the soot than in the starting oil and were consumed by the fire to a large degree. Metals in the oil were found exclusively in the residue and could not be measured in soot samples using conventional industrial hygiene sampling techniques. Particulates in the air were measured by several means and found to be of concern up to 150 metres downwind at ground level. Particulate matter is not a concern past this level. Combustion gases including carbon dioxide, sulphur dioxide and carbon monoxide do not reach levels of concern. These gases are emitted over a broad area from the fire and are not directly associated with the plume trajectory. Volatile organic compounds (VOCs) are extensive from fires, however are less than emitted from a non-burning test spill. Over 50 compounds can be identified and quantified, several at levels of concern up to 200 metres downwind. Water under the burns was analyzed; no compounds of concern could be found at the detection level of the methods. The burn residue was analyzed for the same compounds as the air samples. The residue contains elevated amounts of metals, explaining the fate of these metals. PAHs are at a lower concentration in the residue than in the starting oil, however there is a slight concentration increase in some higher molecular weight species. The overall mass of PAHs including that of the higher-molecular-weight species, is lower after the burn. Overall, indications from these mesoscale trials are that emissions from in-situ burning are low in comparison to other sources of emissions and result in concentrations of air contaminants that are acceptable beyond 500 metres downwind.

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Introduction

In-situ burning has long been a means for dealing with oil spills. Acceptance in certain locals has been poor because of concern over the air emissions associated with the burning process. A series of studies has been started by several groups to address these concerns. In Canada, Environment Canada commissioned several studies to address this issue.[1-3] In the United States the U.S. Minerals Management Service contracted NIST -National Institute for Science and Technology, to study burns.[4-6] These efforts have been coordinated to ensure the maximum use of resources. Studies have been done at laboratory scale to study emissions.[7-9] In 1991, U.S. MMS began the sponsorship, in cooperation with several agencies, of a series of mesoscale burn tests. These tests were designed to measure a series of physical parameters as well as emissions. The facilities of the Fire and Safety Test Detachment at Sand Island situated at upper Mobile Bay,Alabama, were used. There were two preliminary and 12 burn tests each with 2000-5000 gallons of crude. A variety of parameters that might affect burning and smoke production were tested. During each burn, extensive samples were taken from the oil, residue and the smoke plume itself. Besides ground station samplers, airborne samplers were also employed. Environment Canada and the U.S. Environmental Protection Agency cooperated to set up a series of instruments and samplers to monitor all suspect emissions. In 1992, a similar series of experiments was set up to monitor these burns. This paper reports on the data from the 1991 trials and provides preliminary data on the 1992 burns.

Experimental - 1991 Mesoscale Tests

Fourteen experiments were conducted. Parameters for these burn experiments are detailed in Evans, Walton, et. al. [10] The experiments are summarized in Table 1. Figure 1 illustrates the layout and position of the samplers.

Sampling methodologies and target emissions are summarized in Table 2.

SAMPLING

The burn was conducted in a specially-constructed steel pan (51x51 ft) with an outer perimeter filled with water. In a typical burn, a 2000-gallon pool of Louisiana crude was released and floated on about 3 feet of water. The oil was ignited and the burn generally lasted about 15-20 min. Details of each setup of the major sampling apparatus are described below:

Polycyclic Aromatic Hydrocarbons (PAHs): Gilian AirCon 520 air samplers (Gilian Instrument, West Caldwell, NJ.) were used at 50 feet upwind, 100 and 200 feet downwind from the burn pan. The pumps were operated at a nominal flow rate of 7 L/m. Air/smoke was drawn through a 37-mm diameter 2-μm TFPE filter in a plastic filter holder, which was followed by an 8x110-mm size sorbent tube packed with 600/400 mg XAD in the front/back section. A typical burn lasted about 20 min and a typical sample volume was thus 140 L. The inlets/outlets of filter and cartridge samples were capped, placed in whirl bags and labelled. They were shipped in coolers kept cool by freezer bags.

Cumulative samples for PAH analysis were also taken at the same three ground stations. The sampling method and media were the same as the standard PAH collection. The pumps were turned off and the filter inlets were capped until the next burn. The cumulative samples were thus the composites of all 11 tests from May 16 to June 5, 1992. The sample volume was 1311, 1453 and 1312 L for the upwind, downwind #1 and downwind #2 locations respectively.

Aliquots of fresh crude and residue were collected from the burn pan before and after each burn using a disposable turkey baster and stored in 100-ml glass vials. The water in the burn pan was also sampled before and after the burn in 250-ml glass bottles for PAH and metal analyses.

Volatile Organic Compounds (VOCs): Gilian HFS-513 or SKC personal samplers were employed at the same locations as the PAH samplers. Sampling media was a two-stage coconut charcoal tube (8x110 mm, 600/150 mg) at a nominal flow rate of 2 L/m. Typical sample size was 50 L. Again, cumulative samples were taken at three ground locations; sample size was an average 500 L.

Metals: Heavy metals in soot were collected using Gilian personal samplers on a 37-mm, 0.8-μm membrane cellulose ester (MCE) filter again at the same locations. Operated at 2 L/m, the pump collected a typical sample volume of 40 L for a 20-min burn.

Together with the field samples, reagent blanks (unopened tubes) and trip blanks (opened tubes exposed to the atmosphere for the same duration as the samples) were also sent and analyzed with the samples.

Summa VOC (C2-C12): Whole air/smoke samples were taken using 6 L pre-evacuated (to 0.05 mm Hg) stainless steel canisters (Summa canisters, Scientific Instrumentation, Moscow, Idaho) at the 100-ft downwind location. A fixed orifice with an integral stainless steel frit was used to restrict the flow to about 200 mL/min. For a few selected runs, samples were also collected at the 50 feet upwind location to evaluate the non-combustion related emission of VOC.

Polychlorinated dibenzo-p-dioxin/furan (DX/DF): High volume samplers (PS-1, General Metal Works) were employed to collect cumulative samples at upwind and downwind locations. Sampling media were 4 in. glass-fibre filters followed by a 2x3 in. polyurethane foam plug (PUF). Flow rate was nominally at 200 L/m; the cumulative sample volume was an average 70 cubic meters.

Helicopters

The Emergencies Science Division of Environment Canada has pioneered the concept of deploying remote-controlled (RC) helicopters to sample and characterize highly toxic and volatile chemicals above spill sites without endangering the lives of response personnel. This technology was used during this experimental burn.

The initial prototype was designed to collect air samples using an onboard sampling pump, and transmit both video records and real-time pollutant concentrations to a ground control station. Based on experience gained from the prototype, a lighter and simplified version of the RC helicopter had been developed. Based mainly on the GMP/Legend hobby-

style RC helicopter, it was equipped with a Hiller stabilized flybar system and controlled by a Futaba 7-channel proportional radio system. Powered by a 0.6 in^3 Enya glow engine producing 3 hp, it measured 127 cm long, 46 cm high, with a roto span of 147 cm. Air sampling was achieved by a Gilian hi-flow sampler (HFS-513A) drawing a nominal 2 L/min through a metal probe that extended about 60 cm in front of the helicopter to clear the prop wash. Sampling media were either prepacked sorbent tubes (for gaseous samples) or Teflon filters (for particulates). The total weight of the unit including fuel and battery was about 7 kg. Because of its compact size and the reliability of using off-the-shelf components, operation and maintenance are relatively simple.

Although the control radio had a range of up to 1/2 mile, visual limitations usually restricted the normal operating distance to about 500 ft. Flight duration was generally 20 min. Normal operations required a team of two, the pilot and a spotter who directed the flight pattern and warned the pilot of any obstructions or hazards in the vicinity of the flight envelope.

In this burn, a helicopter was deployed to sample the smoke plume at locations up to 600 ft from the fire. Soot collected from these locations was compared with that from the ground sampling stations to determine whether there was any spatial changes in the composition of soot. Wipe samples from the roto blades were also recovered using tared acetone-soaked Kimwipes and extracted to supplement the filter samples.

Tethered blimp

The blimp was operated by a team from the National Institute of Standard and Technology (NIST), and consisted of a 10 cubic meter (5.6 m long by 2.5 m diameter) helium-filled blimp with an instrumentation package suspended below it. The payload of the blimp was about 8 lbs (3.6 kg). For PAH collection on May 23, two blimps were positioned about 100 and 200 ft downwind of the fire and the instrumentation package was centred with respect to the path of the plume. The sampling train consisted of a Gilian pump drawing air through a 36-mm Teflon filter/ XAD tube. The flow rate was 3 L/min and the residence time in the smoke path was 10 min, giving a sample volume of about 30 L.

Sample workup

PAHs:

PAH samples from AirCons were initially extracted ultrasonically in toluene/acetone (95/5%) in accordance with NIOSH method 5510. Front-half and back-half of the XAD tubes were extracted separately to determine the distribution of collected PAH. From the preliminary runs, it was discovered the soot loading was very small and the PAH was below detection. The tube was then extracted as one sample to lessen the work load as well as to improve detectability of such low levels of PAH.

Soxhlet extraction was later used for all filter/XAD and wipe samples from the helicopter run when it was found out the ultrasonic extraction did not recover all the PAH from the sampling media. The filter/XAD was placed in a cellulose thimble and spiked with a mixture of 4 deuterated PAH compounds (10 µg/ml each) and extracted by toluene/acetone in a

Soxhlet overnight. The raw extract was dried over anhydrous sodium sulphate and roto-evaporated and concentrated to 1 ml. A d14-terphenyl internal standard giving a final concentration of 1 µg/ml was added prior to GC/MSD analysis.

Crude and residue sample was first dissolved in cyclohexane to precipitate asphaltenes. An aliquot equivalent to about 50 mg of oil was spiked and subjected to silica column cleanup. The saturates were first eluted with hexane; the aromatic (PAH) fraction was eluted using benzene. This fraction was concentrated down and the column cleanup was repeated to remove the residual oil. An internal standard of d14-terphenyl was added prior to injection.

Water samples were spiked and extracted 3 times by dichloromethane (DM). The extracts were dried, combined and concentrated to 1 ml before instrumental analysis.

VOCs:

The method was based on NIOSH methods 1003,1500 and 1501 for the analysis of VOC having boiling points below 200°C in air samples. The charcoal tubes were extracted ultrasonically with carbon disulphide (CS_2), a mixture of 5 internal standards were added and the extracts analyzed by GC/MSD, using a mixture of 45 native VOC and 5 internal standards for calibration.

Metals:

Samples preparation and analyses were performed by Lab Services Div., Food Production and Inspection Branch, Agriculture Canada, Ottawa. The MCE filter was first spiked with an internal standard of Be and Y at 2 ppm. It was then wet-ashed by a 10-ml mixture of conc. nitric and perchloric acid (4:1) and the digested sample was taken up with 10 ml conc. hydrochloric acid. Final volume was typically 50 ml.

Summa VOCs:

The method used was based on EPA TO-1 in which up to 1 L of air sample was cryogenically trapped at -180°C using liquid nitrogen on the Entec Summa concentrator. The trap was a 30 cm, 0.32 cm OD nickel tube packed with 60/80 mesh glass beads. Perma Pure Dryers were used to dry the sample stream to prevent ice formation in the lines. After trapping for 30 min at a gas flow at 40 ml/min, the trap was heated to 100°C and the non-methane organic compounds were desorbed into a GC/MSD operated in selected ion monitoring (SIM) mode. Two other determinations of each Summa canister were also performed using two GC with optimized columns and conditions to determine C2 and C3-C12 hydrocarbons.

Dioxins/Furans:

The samples were spiked with a mixture of carbon-13 surrogates covering tetra-to octa-chloro DX/DF and extracted by soxhlet using toluene. The raw extract was cleaned up using an acid/base silica column which removed the easily-oxidisable organics. This was followed by an activated alumina column that separated the dioxins/furans from interfering PCBs,

pesticides etc. A typical pre-injection sample volume was 20 µL.

Analysis and Quantitation

PAH analysis was carried out on a Hewlett Packard (HP) HP5890GC/5971A Mass Selective Detector (MSD). A 30-M DB-5 fused silica column (0.25 mm, 0.25-µm film) was used to separate the PAH mixture. It was coupled directly to the MSD operated in Selected Ion Monitoring (SIM) mode. Oven temperature was 90°C/min, ramped to 180°C at the rate 20°C/min and to a final temperature of 285°C and held for 10 min at the rate of 7.5 C/min. A 1-µL aliquot of sample was injected splitless on the GC using an HP 7673 autosampler. A minimum of 2 ions of each PAH was monitored with a dwell time of 50 ms on a PC-based data station using HP1034B software.

Initially a Supelco 610M PAH mixture containing 16 PAH compounds was used as calibration standard. Later on, an expanded list of PAHs was furnished by using a standard reference material SRM-1491 which has 24 compounds covering the methyl-naphthalenes and methyl-phenanthrenes, which are important constituents of crude oils. Area response of the quantitation ion was corrected by that of the terphenyl internal standard; recoveries of the 4 surrogate PAHs spiked onto samples were monitored to assess loss of analytes during sample workup.

Daily calibration was carried out by injecting a diluted solution of SRM 1491 (nominal concentration=0.7 ppm) which contained 26 compounds covering 2- to 6-rings PAH. Daily calibrations were performed to verify the column resolution and MS sensitivity. The response of the internal standard (d14-terphenyl) was used to correct for instrumentation drift and analytical variations.

Instrument detection limit: in SIM mode, 0.1-0.5 ng/µL (ppm) for target PAH.

Method detection limit: 0.2 ppb for 250 ml water; 1 ppm for 25 mg oil; 1-5 µg/m^3 for a 0.1-m^3 air/smoke sample volume; for the cumulative sample, 0.07-0.35 µg/m for an average sample volume of 1.4 m^3.

VOC analysis was performed also on the GC/MSD, using a Restek RTX-5 column (cross-bonded SE-54 phase,30-m X 0.32 mm, 0.5-µm film) for separation of the 45 VOC compounds on the target list. Oven temperature was 30°C/3 min, to 150°C @ 4°C/min and to 220°C/min @ 8°C/min. The MSD was operated in scan mode from 35-360 amu with a scan rate of 1 scan/sec. Characteristic ions were extracted from each analyte peak from an appropriate time window and the area response was corrected with the 5 internal standards co-injected with the sample.

An ARL 3510 ICP (Inductively-Coupled Plasma spectrometer) was used to perform metal analysis. Calibration standard range was from 0-10 ppm.

Summa C2-C12 VOC analysis was performed by Pollution Measurement Division, River Road Environmental Technology Centre, Ottawa. Initially the sample was screened on a HP 5890 GC equipped with a FID and ECD in parallel to determine the concentration of C3-C12. After screening, target analyte analysis was carried out using a HP 5890 GC/5970A MSD. Organic compounds desorbed from the cryogenic trap was

separated on a 50-m HP-1 column (0.32mm ID, 1-μm film). The GC was temperature programmed from -50°C held for 3 min to 280°C at the rate of 8°C/min and held for 8 min. The MSD was operated in the SIM mode by which only the ions specific to the target compounds were monitored, thus maximizing the sensitivity of the MSD. The C2 hydrocarbons were determined separately on a 2 m nickel Hayesept T column (3.2 mm OD) in a Perkin Elmer Sigma 3 GC. The packed column was temperature-programmed from 50°C, held for 5 min to 100°C at 10 °C/min.

Ultra-trace analysis of dioxins/furans was carried out on an HP 5890 GC coupled to the VG 70S, which is a double focusing high resolution mass spectrometer operated in the electron impact mode. The MS was tuned using PKF to achieve a resolution of at least 6000 (10% valley). One μL of sample was injected in the splitless mode on a 60 m DB-5 capillary column, with 0.25-mm ID. and 0.25-μm film thickness. The temperature program was as follows: 70°C for 1 min, 100°C to 200°C @ 40°C/min, 200 °C to 235°C @ 3°C/min and hold for 10 min, 235°C to 310°C @ 8°C and held for 15 min. Injector and interface temperature was at 300°C and 290°C respectively.

The system was calibrated using a standard mixture of all 17 2,3,7,8-substituted DX/DF congeners, the set of C13-labelled surrogates and C13-labelled 1,2,3,4-TCDD and 1,2,3,7,8,9-HCDD congeners which were added to the sample extracts as internal and time reference standards.

Instrument detection limit: 2-10 pg/μl (ppb) operated at 6000 resolution.

Method detection limit: 0.50-3 pg/m^3 for a 70-m^3 sample volume

1991 Mesoscale Tests - Results and Discussion

Results for most analyses are given at locations of upwind, downwind 1 (100 ft) or downwind 2(200 ft). Analysis at other points will be noted. Results are not corrected for surrogate recovery as is standard practice. Recovery efficiencies are noted on those tables where relevant. Values below detection limit are given as less than the detection limit where this is known and can be easily calculated, otherwise these are noted as "LDL" . In some cases the detection limit is noted as "DL".

Results for particulate analysis are given in Table 3. These results show high variability due to the high variability in microscale winds and turbulence. Downwind particulate counts at 100 ft. (downwind 1) are well above the normal acceptable limits of 150 μg/m^3 .[11] The downwind 2 levels of particulates are generally less than half of these values and thus closer to acceptable. Soot was collected at the upwind and downwind sites using conventional industrial hygiene equipment as described above. The sample volume is generally insufficient to yield good PAH results. These results are shown in Tables 4 to 6. A series of cumulative samples was taken for all burns. The PAH analysis for this is shown in Table 7. An accumulation of 7 burns is insufficient sample to yield reliable data for PAH analysis using conventional industrial hygiene sampling techniques at ground level. The sampling for the 1992 trials was performed using high-volume sampling equipment to overcome this problem. The low sample volume at the ground stations is indicative, however, that contaminant levels are less serious than might be expected. Smoke samples were taken from a blimp

and from a remote-controlled helicopter. These results are shown in Table 8. Sampling was not always conducted using the helicopter so that data exist for a few days only. The PAH content of the starting oil was measured from samples taken on different days. These results are summarized in Table 9 The residue was analyzed in similar fashion as shown in Table 10.

A comparison of the concentrations of PAHs in the starting oil, residues and soot at downwind points is shown in Figure 2. This figure is based on the use of average PAH values from the above tables. Examination of these tables shows that the values of PAHs in the various experiments did not differ by more than a factor of two, despite significant variances in experimental parameters. Figure 3 shows the quantity of PAH's in the same regimes as a mass balance. Soot percent is taken as 0.7 % which is the average of several series of lab scale tests by several workers. These figures clearly show that the PAH's are largely consumed by the fire. Furthermore, there is net loss of even the larger PAHs in the smoke. Only in the residue is there an increase in the amount of 5 and 6 ring PAHs by a factor of two. Previous lab trials by the present authors showed that there were some concentration increases in the 5 and 6-ringed compounds in the smoke. The current results would suggest that this was due to discrepancies in sampling or by a difference between combustion conditions in the field and the laboratory.

Table 11 shows the results for the very toxic dioxins and diobenzofurans. The samples were taken by high volume samplers at upwind and two downwind locations. These results show that no dioxins or dibenzofurans are produced by the fire. The levels are within the same error range whether upwind or downwind and all levels are well above detection levels.

Metal analysis was performed using ICP on samples collected by low volume pumps. Results of the air analysis presented in Table 12 shows that there is no detectable levels of metal on the soot at either of the downwind locations. Because the volume of soot taken by the samplers was small, it is not known whether the metals are ever present in the soot. Consequently, the sample volume taken at the 1992 trials was increased by two orders-of-magnitude. Table 13 shows the results of metal analysis in the starting crude oil and in the residue. This shows that the metals concentrate in the residue. The ratio of metals in the residue compared to the starting oil differ and this does appear to correlate somewhat to their volatility. It is suspected that some metal is transported with the soot, but the bulk of it remains at the burn site with the residue. The amount which stays may be dependent on the volatility of the metal in question.

Table 14 shows the sulphur dioxide concentrations at the downwind station number 1. Measurements taken upwind during some of the trials were below detection limits. The levels are far below what would be predicted from plume modelling of the release of sulphur from the starting oil. These low levels confirm the hypothesis that the combustion gases are dispersed over a wide area.

Table 15 shows the corresponding carbon dioxide values at the downwind locations. Upwind data was only taken on certain days, because

of instrument failure. Consequently,insufficient background data are available. These do, however confirm the findings that the background level is about 200 ppm. There are concerns about these data because they are very noisy. The instruments used in these trials were prone to a number of interferences. The data do, however, show that elevated levels of carbon dioxide are found downwind at both stations. This again shows the widespread distribution of carbon dioxide.

The sampling of Volatile Organic Compounds - VOC's, was done using two methodologies, charcoal absorption tubes and grab-sampling using Summa canisters. The data taken during this trial show that the data are comparable and yield similar results, however the Summa canister method is far more sensitive and can yield data on compounds at levels well below the detection level for the charcoal tubes. Table 16 shows cumulative data collected using charcoal tubes. The cumulative samples were collected by using the same absorption tubes throughout the 9 days noted on the table. This was done to ensure that there was enough sample to analyze. This can be compared to Summa canister data as shown in Table 17. The total amount of VOC's is comparable as are the quantities of individual compounds. The Summa canisters were installed only at the downwind 1 location. Table 17 shows that analysis for more compounds is readily possible. This is further illustrated in Tables 18, 19 and 20. These data are the concentrations of the VOC's sampled by individual charcoal tubes on each day. These data show that the sensitivity of this method is very much lower than that of the Summa canister method. By whichever method data are taken, the levels of VOC's close to a burn or fresh release of oil are of serious concern. Many of the levels of the compounds are above normal workplace health maximum values. Data taken by NOAA personnel during an evaporation trial conducted in Mobile in the same time period, show that the levels of volatile compounds may actually be higher if burning is not conducted. Unfortunately, in this series of experiments, the same analytical procedures were not put into place for the evaporation test so that a direct comparison could not be made. This was done in 1992 and these data do show higher VOCs levels if burning does not take place.

Quality assurance of the analytical methods were done by setting up duplicate samplers at similar locations and sending the samples to Environment Canada and the EPA laboratory (noted as REAC in the tables). This program is essential to ensure that all analytical data is valid and accurate. Differences in data then also reflect:

- differences in sampling
    - flow rates
    - subsequent treatment
- differences in sample position
    - ie. influences of micro-turbulence can affect the data
- differences in extraction procedures and recoveries

and

- differences in analytical procedures and data analysis.

The quality assurance program was designed to define the source of differences. Extracts were exchanged to allow analysis by the other laboratory to compare analytical methods alone. The results of the

methodology checks are shown in Tables 21-23. Table 21 shows a comparison of the analysis of PAHs in the oil and residue. Significant differences exist in the analysis of the crude, however, this was later tracked down to a poor chromatograph run. The results for the residue PAH analysis are very good. Table 22 shows the comparison of data for VOC measurement for charcoal tubes. The results are very similar, considering that the samplers are not necessarily at the same position. Table 23 shows a similar comparison for VOCs. In this case the values are somewhat different, no explanation for these differences were found. Overall, sample comparison showed that the methods of sampling and analysis were in good agreement. Many improvements were incorporated into the 1992 trials, notably the increase in sample volume at the ground stations.

The 1992 Mobile Field Trials

In the fall of 1992 a second round of mesoscale trials was conducted at the U.S. Coast Guard facility at Mobile Alabama. The prime purpose was physical studies and these results will be reported separately by Evans, Walton et. al. The analytical teams from Environment Canada and U.S. Environmental Protection Agency endeavoured to conduct a series of measurements similar to the last trial, but with improvements in the techniques so that adequate sample was obtained. At the time of writing of this paper, the samples are not completely analyzed therefore not all parameters can be reported.

Experimental - 1992 Mesoscale Tests

A wide variety of highly sensitive sampling methods and analytical protocols were used as described below. The experimental method reflects the lessons learned from the 1991 Mobile trials.

Direct sampling

Starting oil and the residuum

Samples of the crude oil prior to ignition and the residuum after the burn were taken. The sampling apparatus, designed by Environment Canada, consisted of a telescopic pole with a variety of attachments such as funnels and netting. The physical characteristics of the oil determined which attachments were used. In general, the residuum had a consistency resembling a highly-weathered crude oil, and consequently had to be picked up by spatula and stored in wide-mouth glass jar with a Teflon-lined cap.

The following parameters and/or compounds in the smoke/air were quantified during the experimental burn: size of particulates, PAH, VOC, metals, carbonyls (aldehydes and ketones), CO_2, CO, SO_2, and NO_2.

The following equipment was used:

Sampler	Item sampled
PS-1 General Metal Works	PAH; dioxins/dibenzofurans

High volume sampler — Total suspended particulates (TSP)

PM-10 — Particulates 10 µ and less; PAH

Specifications:

A PUF sampler collected particulates on a 4-in(10.2 cm) diameter glass-fibre (G/F)filter. This was in tandem with a polyurethane foam plug (PUF) which adsorbed the volatile components of the target analytes. Typical sampling rate was 200 L/min. A typical sampling volume was thus 2 m^3 for a sampling duration of 20 min.

A high volume sampler collected TSP on a tared 8*10 in (20*25 cm) G/F filter. Typical flow rate was 1 m^3/min. After gravimetric determination of TSP, 36-cm discs were cut out using a metal punch and extracted for PAHs.

A PM-10 sampler collected particulates having an aerodynamic equivalency of 10-µm or less on a tared 8*10 in glass-fibre filter. Typical flow rate was 1 m^3/min. After gravimetric determination of <10 µm particulates , 36-cm discs were cut out using a metal punch and extracted for PAH determination.

Summa canister — VOC

Specifications: Summa canisters (6 L) were pre-evacuated to 0.05 mm Hg. A variable flow controller was used to adjust the sample flow rate in the field to typically 200 mL/min (chosen to fill a canister in about 30 min).

Gilian Aircon 2 — Metals

Specifications: Air/smoke was pumped through a 37-mm cartridge with a 0.8-µm mixed cellulose ester (MCE) filter. Flow rate was about 2 L/min.

Gilian 513A pump and DNPH cartridge — Carbonyls

Specifications: Air/smoke was pumped through a DNPH (2,4 dinitrophenylhydrazine)-silica cartridge attached via Tygon tubing to the pump. The cartridge (a Waters Sep-pak) contained 350 mg silica coated with 1.0 mg DNPH. Flow rate was about 2 L/min.

Helicopters

The RC helicopter based mainly on the GMP/Legend hobby-style RC helicopter, was equipped with a Hiller stabilized flybar system and controlled by a Futaba 7-channel proportional radio system. Powered by a 0.6 in^3 Enya glow engine producing 3 HP, it measures 127 cm long, 46 cm high, with a roto span of 147 cm. Air sampling is achieved by a Gilian hi-

flow sampler (HFS-513A) drawing a nominal 2 L/min through a metal probe that extends about 60 cm in front of the helicopter to clear the prop wash. Sampling media were either prepacked sorbent tubes (for gaseous samples) or Teflon filters (for particulates). For this experiment the sampling equipment was modified to incorporate a Teflon filter/PUF sandwich for a more efficient soot collection. Two helicopters were deployed to sample smoke at locations of about 200 ft and 600 ft downwind from the fire. Soot collected from these two locations was compared with that from the ground sampling stations to determine whether there was any spatial changes in the composition of soot. Wipe samples from the roto blades were also recovered using tared acetone-soaked GF filters and extracted to supplement the filter/PUF samples.

Tethered blimp

The blimp was operated by a team from the National Institute of Standard and Technology (NIST), and consisted of 9.0 m long by 2.5 m diameter helium-filled blimp ($30m^3$ volume) with an instrumentation package suspended roughly 60 m below. In each burn, the blimp was positioned about 250 ft downwind of the fire (varied with the plume position); the instrumentation package (weighing up to 30 lbs or 14 kg.) was centred with respect to the path of the plume. The 36-mm Teflon filter samples used for soot yield analysis were weighed in the field and shipped back to ESD lab for PAH analysis. The sampling rate was 4.5 l/min and the residence time in the smoke plume was about 20 min.

Sample preparation and workup prior to chemical analysis

Starting oil and residuum samples

Analytes: Polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH) including bio-markers, and metals.

A 1-g aliquot of oil was diluted in 10 mL hexane to precipitate asphaltenes. An aliquot equivalent to 25 mg of the oil was then spiked with surrogate PAH and bio-marker standards and fractionated on an activated silica column. The hexane and benzene fractions that contained the saturates and aromatics respectively, were then analyzed separately using either GC/MSD or GC/FID. Internal standards for PAHs (d14-terpheny1) and TPH (were added to the final extract before analysis. The pre-injection volume was typically 1 mL.

For ICP analysis of metals, a 50-mg aliquot of oil was digested in a Teflon vessel in a CEM 630-watts microwave oven. Ten ml of nitric acid was added to the oil, which was digested for 10 min using an initial power setting of 50 %. After 10 min, 80% power was used to complete the digestion (total time, 30 min). Final volume was made up to 25 ml(typical) prior to analysis using an ICP spectrometer.

Water samples

Analytes: PAHs, and headspace volatile organics (VOC)

Water samples were stored at 4°C until analyzed. For the determination of PAHs, aliquots of 250 mL were spiked with a mixture of PAH surrogate

standards and extracted three times with dichloromethane. The combined raw extract was then concentrated to a small volume. In preparation for analysis, an internal standard of d14-terphenyl was added and the volume made up to 1 mL.

For headspace analysis, a 10-mL aliquot was placed in a 20-ml capped headspace vial and equilibrated for 30 min at 85°C. A 1-mL aliquot of the headspace was injected via a gas sampling loop into a GC/FID.

Air/smoke samples

Analytes: PAHs, dioxin/furans (DX), metals, Summa VOC, and carbonyls (aldehydes and ketones)

Filter, PUF, PUF/XAD, airborne particulate samples from the blimp and helicopters were individually wrapped in solvent-washed aluminum foil, placed inside a glass jar and were kept cool during transit. They were spiked with surrogate PAH and DX standards and extracted with toluene. The raw extract was concentrated and applied quantitatively to an activated silica column. The first fraction of hexane containing saturates was discarded. The second fraction, containing PAH, was recovered using benzene. This fraction was concentrated, spiked with d14-terphenyl as an internal standard and made to 1 mL before GC/MSD analysis. For a few selected samples the hexane fraction was also retained and examined for the distribution of aliphatics and bio-marker compounds.

The DX samples were spiked with a mixture of carbon-13 surrogates of dioxins/furans and extracted by soxhlet using toluene. The raw extract was cleaned up using an acid/base silica column which removed the easily-oxidizable organics. This was followed by an activated alumina column which separated the dioxins/furans from interfering PCB, pesticides etc. A typical pre-injection sample volume was 20 µL.

For metal analysis on soot samples collected on ground stations, the mixed cellulose ester filters were digested in the same manner as the oil samples.

Up to 1.2 litre of the Summa VOC sample was cryogenically trapped using liquid nitrogen on the Entec Summa concentrator. Perma Pure Dryers were used to dry the sample stream to prevent ice formation in the lines. After trapping for 30 min at a gas flow at 40 mL/min, the trap was heated to 100°C and the non-methane organic compounds were desorbed into a GC/MSD operated in selected ion monitoring (SIM) mode. Two other determinations of each Summa canister were also performed using two GC with optimized columns and conditions to determine C2 and C3-C12 hydrocarbons.

The carbonyl samples collected on the DNPH-silica Sep-pak were wrapped individually and shipped in a capped amber vial and kept cool to minimize degradation. The cartridge was extracted using 5 mL of acetonitrile and analyzed on an HP 1090 HPLC.

Analytical protocols

All organics

An HP 5890 GC was interfaced directly to an HP 5971A MSD. The GC was equipped with an HP 7673 auto sampler. Control of the entire system, data acquisition and data handling was by an HP ChemStation (DOS series). The column used for separation was a DB-5 30-m X 0.25 mm ID capillary column with 0.25-μm film. The GC temperature program used for PAH analysis was as follows: initial, 90°C for 1 min, first temperature ramp, 25°C/min to 180°C, second temperature ramp @ 5°C/min to a final temperature of 290°C for 15 min. A 1-μL aliquot was injected in the splitless mode (purge off: 1 min). Injector, interface and source temperature was 280°C, 300°C and 170°C respectively.

For PAH and bio-marker analysis, the MSD was operated in the SIM mode, monitoring 2-3 ions of each target analyte with a dwell time of 50 millisec for each ion. Autotune was used to tune the MSD daily to ensure day-to-day reproducibility.

Daily calibration was carried out by injecting a diluted solution of SRM 1491 (nominal concentration=0.7 ppm) which contained 26 compounds covering 2- to 6-ringed PAHs. Daily calibrations were performed to verify the column resolution and MS sensitivity. The response of the internal standard (d14-terphenyl) was used to correct for instrumentation drift and analytical variations.

For TPH measurement, the MSD was operated in the scan mode, scanning from 40-450 Daltons with a scan rate of 1 scan/sec. Calibration was by means of an alkane mixture covering the range from C-8 to C-40.

Instrument detection limit: in SIM mode, 0.01-0.05 ng/μL (ppm) for target PAH; in scan mode, 2-5 ppm for TPH components.

Method detection limit: 0.2 ppb for 250 mL water; 1 ppm for 25 mg oil; 0.01 $\mu g/m^3$ for a 1-m^3 air/smoke sample volume.

Dioxins/Furans

Ultra-trace analysis of dioxins/furans was carried out on an HP 5890 GC coupled to the VG 70S, which is a double focusing high resolution MS operated in the electron impact mode. The MS was tuned using PKF to achieve a resolution of at least 10000 (10% valley). One μL of sample was injected in the splitless mode on a 60-m DB-5 capillary column, with 0.25-mm ID. and 0.25-μm film thickness. The temperature program was as follows: 70°C for 1 min, 100°C to 200°C @ 40°C/min, 200°C to 235°C @ 3°C/min and hold for 10 min, 235°C to 310°C @ 8°C and held for 15 min. Injector and interface temperature was at 300°C and 290°C respectively.

The system was calibrated a standard mixture of all 17 2,3,7,8-substituted DX/DF congeners, the set of C13-labelled surrogates and C13-labelled

1,2,3,4-TCDD and 1,2,3,7,8,9-HCDD congeners which were added to the sample extracts as internal and time reference standards.

Instrument detection limit: 0.2-1 pg/μL (ppb) operated at 10000 resolution.

Method detection limit: 50 pg/m^3 for a 1-m^3 sample

Metals

Metals were measured on an ARL 3410 ICP-AE spectrometer. The twelve metals were Mg, Ti, Cr, Ni, Zn, Ba, P, V, Fe, Cu, Mo and Pb. Some typical operating parameters were as follows: incident wattage, 650; reflected wattage, 001; plate volts, 3300; plate current, 496 mA; grid current, 66 mA; drive voltage, 2580; spectrometer profile: zero 76160; Argon, 355.4475 nm.

Calibration standards were made by serial dilutions and combining commercial ICP stock solutions (Leco). Daily calibrations covering a concentration range 0-10 ppm were made to establish the sensitivity and linearity of each metal.

Instrument detection limit: 0.01 ppm for Co (typical);

Method detection limit: 2 μg/m^3 for a 120-L sample volume.

Carbonyls

A Hewlett Packard HP1090 HPLC equipped with a diode-array detector and HPLC Chemstation was used to perform the carbonyl analysis. The monitoring wavelength was 360 nm. Two Zorbax ODS reverse phase columns (25-cm x 0.46-mm ID.) were used for compound separation. A 25-μl aliquot of sample was injected; the elution gradient was 60% to 75% acetonitrile (ACN) in water for 30 min, followed by 75% to 100% ACN in 2 min and held at 100% ACN for 5 min. Solvent flow was 1 mL/min.

Target aldehydes were formaldehyde, acetaldehyde, acrolein, propionaldehyde, benzaldehyde, hexanaldehyde; target ketones were acetone and methylethylketone.

Calibration standards were prepared from ACN from solid DNPH derivatives. Quantitation was by means of an external standard.

Instrument detection limit: 0.1 ppm

Method detection limit: 5 μg/m^3 for a 120-L sample volume.

Headspace VOCs

The headspace analyzer system consisted of a HP 19395A headspace sampler coupled directly to the heated injection port of a HP 5890 GC with FID, via a heated interface. The headspace in each sample vial, kept at 85°C, was swept through a 1-cc internal sample loop. The gas sampling

valve, under the control of the concentrator, was rotated so that the contents of sampling loop was swept into the GC inlet operated in a split mode. The GC was programmed from an initial 30°C (held for 5 min) to a final temperature of 200°C at the rate of 7.5°C/min. Injection and FID temperature were 200°C and 250°C respectively. A 30-m HP-1 capillary column (0.32 mm ID, 1-μm film) was used for compound separation.

A mixture of alkanes, alkenes and aromatics, including benzene, toluene, ethyl benzene o-,p- and m-xylene were used to establish response factors of each class of volatile compounds.

Instrument detection limit: 0.01 ppm.

1992 Mesoscale Tests - Results and Discussion

Results for most analysis are given at locations of upwind, downwind 1 (100 ft) or downwind 2 (150 ft) and downwind 3 (250 ft). For the first burn only, the distances were shortened to 75, 100 and 150 feet, respectively. Analysis at other points will be will be noted. All tables present results that are not corrected for recovery efficiencies as is standard practice. Recovery efficiencies are noted on those tables where relevant. Values below detection limit are given as less than the detection limit where this is known and can be easily calculated, otherwise these are noted as "LDL". In some cases the detection limit is noted as "DL".

Table 24 gives the PAH content of the crude oil. The lesser variability in these data compared to the 1991 reflects improved analytical precision. Table 25 lists the PAH data for the burn residue. This table confirms the findings of the 1991 experiments, namely that there is a small concentration increase in the concentration of 5 and 6-ringed PAHs, but a very sharp decrease in the amount of the smaller homologues. Tables 26 to 29 show the PAH concentrations at the upwind and downwind stations. Table 30 shows the concentrations of PAHs on the filter and PUF/XAD media of downwind station number 1. The filter is capable of retaining particulate material to which the PAHs are adsorbed, but the lower molecular weight products are stripped off and will be trapped by the PUF/XAD resin. Tables 31 and 32 give the results of the helicopter sampling of PAHs at different average heights. Table 33 and 34 gives the results of soot analysis of samples taken by the blimp(s). During some experiments 2 blimps were used to sample the smoke plume at two different locations. The resulting concentration trends are illustrated in Figure 4. Figure 5 shows a mass balance. Soot percent is taken as 0.7 % which is the average of several series of lab scale tests by a number of workers.[12] These figures clearly show that the PAH's are largely consumed by the fire. Furthermore, there is net loss of even the larger PAHs in the smoke. Only in the residue is there an increase in the amount of 5 and 6 ring PAHs and this is about a factor of two. This again confirms the previously noted results that PAHs are consumed in these crude oil fires and not created. This may be attributed to the high temperatures in in-situ fires (about 1500°C) compared to the lower temperatures in PAH-producing processes such as diesel engines and poorly-designed incinerators (500-

900°C).

High-volume samplers were again used to collect soot for Dioxin and Dibenzofuran analysis. The results of these tests are shown in Tables 35 and 36. The results are the same as in the previous year, no generation of Dioxins and Dibenzofurans is evident. Levels of all detectable compounds are as low or lower than background levels.

Carbonyls were collected using DNPH-treated tubes. Subsequent analysis is shown in Tables 37 to 39. These results show a slight increase in the level of formaldehyde and acetaldehyde in the downwind air. The levels are below that for human concern.

Carbon dioxide was measured using electronic instrumentation. Two arrays were used, one directly along the plume line and another perpendicular to this. The latter data are not fully analyzed before this paper was written. However, the levels of carbon dioxide measured around the burn correspond to those measured along the plume line. This shows that the gases are widely diffused from burns. The Carbon Dioxide levels along the plume axis are given in Table 40 and are illustrated in a time series in Figure 6. The data show several trends, first the concentration of CO_2 is highly variable in both time and space, second, peaks in CO_2 occur at about 3 minutes after the start of the burn and a few minutes before the end. The source of the former increase in not known, however, it is suspected to be associated with burn onset. The peak near the end of the burn results from the rapid burning that occurs in the boil-off phase of the burn[8].

Carbon Monoxide data are presented in Table 41. Very little Carbon monoxide is detected and the values are not significantly different from background levels except at the downwind 1 station. The Sulphur Dioxide data are presented in Table 42 and as time series in Figure 7. The values are low and highly variable. Only at the first downwind station are there barely-significant values of the gas. Total aerosol particulates were measured using a real time instrument. These values are shown in Table 43 and as a time series in Figure 8. The values are low and far below concern levels except at the first downwind station. The peaks in particulate matter correspond somewhat to the peaks of carbon dioxide. The rapid-burning phase near the end of the burn results in increased combustion gases as well as particulate matter.

Water samples from the test tank were taken and analyzed for organics. No PAHs could be detected. BTEX and trave levels of TPH were found at 1 ppm or less.

Sample analysis continues and these data should assist in clarifying a number of outstanding points.

CONCLUSIONS

The quantitative analytical data clearly show that the emissions from in-situ oil fires are not a serious concern. All compounds and parameters measured are below health concern levels beyond about 150 metres from the fire. The fate and behaviour of oil components in fires, are still not fully understood and will be the subject of future experiments. Items requiring further study include the specific behaviour of gases, the fate of

metals, further study on organic compound emission and study of the change of all measurements under realistic field conditions.

Several generalizations can be made about the fate, behaviour and quantity of the basic emissions from burning:

Gases - combustion gases are very diffuse and do not have spatial relationship to the plume. A better model would be to view the gas dispersal as following a doughnut-like pattern around the burn. This pattern is deformed by increasing wind velocities. Generally gas concentrations downwind are very low. Gas concentrations, especially in low winds are as high around the fire as down wind.

Particulate Matter/Soot - Particulate matter at ground level is only a matter of concern very close to the fire and under the plume. The concentration of particulates in the smoke plume is not a concern past about 500 metres.

Water Emissions - No compounds have yet been detected in the water of the test tanks.

Organic Compounds - No exotic or highly-toxic compounds are generated as a result of the combustion process. Organic macro-molecules are in lesser concentration in the smoke and downwind than they are in the oil itself. Volatile organic compounds are released in large concentration by fires, but in lesser concentrations than the evaporating slick if not burning.

The following are conclusions relating to specific compound class emissions:

PAHs - Additional Polyaromatic Hydrocarbons are not produced by in-situ oil fires. Oils contain significant quantities of PAHs. These are largely destroyed in combustion. The PAH concentrations in the smoke, both in the plume and the particulate precipitation at ground level are much less than the starting oil. This also includes the concentration of multi-ringed PAHs that are often created in other combustion processes such as low-temperature incinerators and diesel engines. This is very different from that noted in earlier lab experiments. It is suspected that re-precipitation of large soot particles occurs in large-scale tests which does not occur in laboratory tests. These large soot particles are conducive to the production of large multi-ringed PAHs. The burn residue does, however, show a slight increase in the concentration of multi-ringed PAHs. However, when considering the mass balance of the burn, most of the five and six-ringed PAHs are destroyed by the fire.

Dioxins and Dibenzofurans - Tests on particulate matter both upwind and downwind of the fires show that these compounds are not produced during in-situ fires.

Metals - Crude oil contains a number of metals in the ppm range. These metals could not be detected on soot particles using the analytical techniques described here. The burn residue has an elevated metal content - leading to the conclusion that the metals largely remain in the residue.

Carbon Dioxide - The Carbon Dioxide concentration is well below concern levels - even near the fire. The distribution of the gas is very wide-spread, especially with low wind conditions.

Carbon Monoxide - Very little Carbon Monoxide is produced by

large-scale fires. These concentrations are well below concern levels.

Sulphur Dioxide - The concentration of Sulphur Dioxide is far below what is expected from the sulphur content of the oil. This is probably due to the wide dispersal of the gas during the combustion process.

Nitrous Oxides - Tests for Nitric Oxides were performed, however no levels above the background were detected.

Volatile Organic Compounds - The levels of volatile organic compounds are well above concern levels within 200 metres of these size of fires. The levels of these compounds are even greater from an evaporating slick that is not burning.

Carbonyls - Formaldehyde and Acetaldehyde are produced in low concentrations. Their concentrations fall far below concern levels a short distance from the fire.

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References

1. Twardus, E.M., *A Study To Evaluate The Combustibility and Other Physical and Chemical Properties of Aged Oils and Emulsions*, Environment Canada Manuscript Report EE-5, Ottawa, Ontario, 1980.

2. Georghiou, P.E. and P.E. Sheppard, *A Study of Mutagenicity of Residue Resulting From The Burning of Crude Oil*, Environment Canada Manuscript Report EE-29, Ottawa, Ontario, 1982.

3. Fingas, M.F. and N. Laroche, "An Introduction To In-Situ Burning of Oil", *Spill Technology Newsletter*, Vol. 13, No. 2, pp. 1-12,1990.

4. Evans, D.D., *Combustion of Oil Spills on Water*, in Technology Assessment and Research Program for Offshore Minerals Operations, OCS Study MMS 88-0057, Reston, Virginia, pp. 169-179, 1988.

5. Evans, D.d., G.W. Mulholland, D. Gross, H. Baum and K. Saito, "Environmental Effects of Oil Spill Combustion", in *Proceedings of the Tenth Annual Arctic Marine Oilspill Program Technical Seminar*, Environment Canada, Ottawa, Ontario, pp. 91-130, 1987.

6. Evans, D.D., "In-Situ Burning of Oil Spills", *Alaska Arctic Offshore Oil Spill Response Technology Workshop Proceedings*, Washington, D.C., pp. 47-55, 1988.

7. Evans, D.D., G.W. Mulholland, J.R. Lawson, E.J. Tennyson, P.A. Tebeau, M.F. Fingas and J.R. Gould, "Burning of Oil Spills", in *Proceedings of the 1991 Oil Spill Conference,* American Petroleum Institute., Washington, D.C., 1991.

8. Benner, B.A. (Jr), N.P. Bryner, S.A. Wise, G.W. Mulholland and D.E. Evans, M.F. Fingas and K. Li, "Emissions of Polycyclic Aromatic Hydrocarbons From The Combustion Of Crude Oil On Water", *Spill Technology Newsletter, Vol 16(1)*, Environment Canada, Ottawa, Ontario, 1991.

9. Evans, D.D., W. Walton, H. Baum, G. Mulholland, J. Lawson, H. Koseki and A. Ghoniem, "Smoke Emission From Burning Crude Oil", *Proceedings of the Fourteenth Annual Arctic Marine Oilspill Program Technical Seminar*, Environment Canada, Ottawa, Ontario, pp. 421-499, 1991.

10. D.D. Evans, W.D. Walton, H.R. Baum, K.a. Notianni, J.R. Lawson, H.C. Tang, K.R. Keydel, R.G. Rehm, D. Madrzykowski, R.H. Zile, H. Koseki and E.J. Tennyson, "In-situ Burning of Oil Spills: Mesoscale Experiments", in *Proceedings of the Fifteenth Annual Arctic Marine Oilspill Program Technical Seminar*
pp. 593-623, 1992

11. *1992-93 Threshold Limit Values,* American Conference of Governmental and Industrial Hygienists, Cincinnati, Ohio, 1992.

12. Brown, N.J., R.L. Dod, F.W. Mowrer, T. Novakov and R.B. Williamson, "Smoke Emission Factors From Medium Scale Fires: Part 1", *Aerosol Science & Technology, Vol. 5*, Elsevier Science Publishing Co. Inc., pp. 2-19, 1989.

Table 1

Experimental Parameters - Mobile 1991

Burn Number	Date	Oil Volume (M^3)	Burn Area (m^2)	Percent Burned	Average Burn Rate ($kg/min.m^2$)	Surface Regression Rate (mm/min)	Air Temperature (C)	Wind Speed (m/s)
1	16-Apr	3.36	37.2	93	2.76	3.24	25.3	1.5
2	17-Apr	1.6	37.2	94	3.12	3.72	24	1.9
3	16-May	1.3	37.2	75	1.14	1.38	27	2.1
4	17-May	2.25	37.2	92	2.52	3	26.3	1.7
5	22-May	3.37	114	96	3.6	4.26	24.3	4
6	23-May	3.31	181	90	2.64	3.12	24.3	5
7	24-May	5.56	170	98	2.52	2.94	25.9	2.4
8	28-May	2.25	72.8	93	3.24	3.84	27.5	1.2
9	29-May	2.31	37.2	91	2.76	3.24	30.1	5
10	30-May	5.8	114	99	2.58	3.06	28.7	3.9
11	31-May	11.8	231	99	2.7	3.24	27.3	0.8
12	3-Jun	7.22	114	99	2.64	3.18	26.4	1
13	4-Jun	6.98	114	96	2.94	3.42	30.2	2.1
14	5-Jun	14.1	231	99	3.06	3.66	30.3	2.1
			Average	94	3	3	27	2

Table 2 **Summary of Analytical Methods**

Sample Taken	Sampler	Measurement Parameter	Secondary Parameter	Additional Parameters
• Soot at Ground	High Volume Sampler	Dioxins and Dibenzofurans	Particulates	PAHs
	Sampling Pump medium volume	PAHs	Particulates	
	RAM	Particulates		
• Soot in Smoke	Sampling Pump low volume	PAHs	Particulates	metals
	both blimp and remote-controlled helicopter			
• Gases	Summa Cannister	Volatile Organic Compounds		
	Sampling Pump low volume	Volatile Organic Compounds		
	CO2 Meter	Carbon Dioxide		
	SO2 Meter	Sulphur Dioxide		
	NO2 Meter	Nitrogen Dioxide		
	CO Meter	Carbon Monoxide		
• Oil		PAHs		
• Burn Residue		PAHs		
• Water under Burn		PAHs	Organics	

Table 3 **Particulates Determined Using Real-Time Aerosol Monitors**

PARTICULATES ANALYSIS **(µg/m³)**

	Day Ap 16	Ap 17	My 16	My 22	My 23	My 24	My 28	My 29	My 30	My 31	Jn 03	Jn 04	Jn 05	**Ave/dy**
Upwind														
Average	LDL	100		20	10	10	30	20	20	1	LDL	10	LDL	25
Maximum	200	1600		30	30	70	70	70	60	2	160	30	50	198
Minimum	LDL	100		10	10	70	10	20	10	1	LDL	LDL	LDL	29
Downwind 1														
Average	100	160	520	1120	3850	70	40	60	2690	500	70	90	500	752
Maximum	2280	16970	22000	19690	21480	1020	120	1950	19460	800	210	1270	9690	8995
Minimum	100	30	20	80	90	50	30	30	500	300	50	60	LDL	112
Downwind 2														
Average			LDL	1500	350	10	10	30	480	100	LDL	30	180	.299
Maximum			100	10900	9690	70	30	2260	5440	100	100	330	4800	3075
Minimum			20	10	LDL	LDL	LDL	10	LDL	LDL	110	20	10	30

Table 4

PAHs On Particulate Matter - Upwind Station

PAH ANALYSIS / AIR / UPWIND (µg/m³)

Day	Ap 16	Ap 17	My 23	My 24	My 28	My 29	My 30	My 31	Jn 04	Jn 05	
Sample Number	5903	5915	6100A	6115A	6116A	5881A	5891A	5896A	6052A	6061A	Ave/dy
Acenaphthylene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Acenaphthene	LDL	LDL	1.1	LDL	LDL	LDL	LDL	LDL	LDL	LDL	1.1
Fluorene	LDL	LDL	2.5	LDL	LDL	LDL	LDL	LDL	LDL	LDL	2.5
Phenanthrene	LDL	LDL	3.5	LDL	LDL	LDL	LDL	LDL	LDL	LDL	3.5
Anthracene	LDL	LDL	0.7	LDL	LDL	LDL	LDL	LDL	LDL	LDL	0.7
3 Rings total	LDL	LDL	7.8	LDL	LDL	LDL	LDL	LDL	LDL	LDL	7.8
Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(a)Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Chrysene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(b)Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(k)Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(a)Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	0.6	0.3	0.4
5 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	0.6	0.3	0.4
Indeno(1,2,3-cd)Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Dibenzo(a,h)Anthracer	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(g,h,i)Perylene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
6 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL PAH / UPWIND	LDL	LDL	7.8	LDL	LDL	LDL	LDL	LDL	0.6	0.3	2.9
Surrogate Recovery, %											
d10-Acenaphthene	100	104	68	64	117	124	97	85	37	89	
d10-Phenanthrene	86	93	110	78	125	126	113	82	106	95	
d12-Benz(a)anthracene	99	112	112	81	174	143	121	118	177	153	
d12-Perylene	99	112	94	87	107	111	108	107	142	147	

DL = 0.5 µg/m³ DL= Detection Limit LDL=below Lower Detection Limit

Table 5

PAHs on Particulate Matter - Downwind 1 Station

PAHs in µg/m³

Day	Ap 16	Ap 17	My 23	My 24	My 28	My 29	My 30	My 31	Jn 04	Jn 05	
Sample Number	5901	5913	6098A	6113A	6117A	5882A	5888A	5894A	6053A	6062A	Ave/dy
Acenaphthylene	LDL	LDL	LDL	LDL	LDL	LDL	15.2	LDL	LDL	0.6	7.9
Acenaphthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Fluorene	LDL	LDL	0.7	LDL	LDL	LDL	0.6	LDL	LDL	LDL	0.7
Phenanthrene	LDL	LDL	4.8	LDL	LDL	LDL	2.1	LDL	LDL	LDL	3.5
Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
3 Rings total	LDL	LDL	5.5	LDL	LDL	LDL	17.9	LDL	LDL	0.6	8.0
Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	0.7	LDL	LDL	LDL	0.7
Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	0.8	LDL	LDL	LDL	0.8
Benzo(a)Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Chrysene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	1.5	LDL	LDL	LDL	1.5
Benzo(b)Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(k)Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(a)Pyrene	LDL	LDL	LDL	LDL	0.8	0.4	LDL	LDL	0.5	LDL	0.6
5 Rings total	LDL	LDL	LDL	LDL	0.8	0.4	LDL	LDL	0.5	LDL	0.6
Indeno(1,2,3-cd)Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Dibenzo(a,h)Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(g,h,i)Perylene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
6 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL PAH	LDL	LDL	5.5	LDL	0.8	0.4	19.4	LDL	0.5	0.6	10.5
Surrogate Recovery, %											
d10-Acenaphthene	99	108	31	106	120	121	80	93	119	81	
d10-Phenanthrene	80	81	78	123	128	129	93	82	122	101	
d12-Benz(a)anthracene	97	83	106	129	127	153	107	114	182	168	
d12-Perylene	97	81	107	134	120	121	109	101	151	160	

DL = 0.5 µg/m³

Table 6

PAHs on Particulate Matter - Downwind 2 Station

PAHs in µg/m³

Day	Ap 16	Ap 17	My 23	My 24	My 28	My 29	My 30	My 31	Jn 04	Jn 05	
Sample Number	5901	5913	6098A	6113A	6117A	5882A	5888A	5894A	6053A	6062A	**Ave/dy**
Acenaphthylene	LDL	LDL	LDL	LDL	LDL	LDL	3.3	LDL	LDL	0.4	1.8
Acenaphthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Fluorene	LDL	LDL	0.8	LDL	LDL	LDL	LDL	LDL	LDL	LDL	0.8
Phenanthrene	LDL	LDL	5.1	LDL	LDL	LDL	LDL	LDL	LDL	LDL	5.1
Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	0.8	LDL	LDL	LDL	0.8
3 Rings total	LDL	LDL	6.0	LDL	LDL	LDL	4.1	LDL	LDL	0.4	5.0
Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(a)Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Chrysene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(b)Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(k)Fluoranthene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(a)Pyrene	LDL	LDL	LDL	LDL	LDL	0.7	LDL	LDL	0.6	LDL	0.6
5 Rings total	LDL	LDL	LDL	LDL	LDL	0.7	LDL	LDL	0.6	LDL	0.6
Indeno(1,2,3-cd)Pyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Dibenzo(a,h)Anthracene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzo(g,h,i)Perylene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
6 Rings total	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL PAH	LDL	LDL	6	LDL	LDL	1	4	LDL	1	LDL	3
Surrogate Recovery, %											
d10-Acenaphthene	106	100	40	115	51	114	82	87	28	87	
d10-Phenanthrene	93	87	88	138	61	120	103	78	103	96	
d12-Benz(a)anthracene	109	112	103	134	91	140	123	115	180	156	
d12-Perylene	112	119	74	136	88	116	129	107	154	151	

DL = 0.5 µg/m³

Table 7

Cumulative PAHs on Particulate Matter

CUMULATIVE PAH ANALYSIS / AIR (µg/m³)

	Upwind	Downwind 1	Downwind 2
Acenaphthylene	LDL	0.55	0.16
Acenaphthene	LDL	0.06	LDL
Fluorene	LDL	0.15	0.04
Phenanthrene	LDL	0.50	0.13
Anthracene	LDL	LDL	LDL
3 Rings total	LDL	1.26	0.33
Fluoranthene	LDL	0.11	LDL
Pyrene	LDL	0.12	0.04
Benzo(a)Anthracene	LDL	LDL	LDL
Chrysene	LDL	LDL	LDL
4 Rings total	LDL	0.23	0.04
Benzo(b)Fluoranthene	LDL	LDL	LDL
Benzo(k)Fluoranthene	LDL	LDL	LDL
Benzo(a)Pyrene	LDL	LDL	LDL
5 Rings total	LDL	LDL	LDL
Indeno(1,2,3-cd)Pyrene	LDL	0.03	LDL
Dibenzo(a,h)Anthracene	LDL	LDL	LDL
Benzo(g,h,i)Perylene	LDL	0.04	LDL
6 Rings total	LDL	0.07	LDL
TOTAL CUMULATIVE PAH	LDL	1.56	0.37
RECOVERY %			
d10-Acenaphthene	124	109	98
d10-Phenanthrene	126	121	114
d12-Benzo(a)Anthracer	109	121	114
d12-Perylene	103	124	118

DL = 0.03 µg/m³

Samples collected May 16, 23, 24, 28, 29, 30, 31, June 04, 05

Table 8 **PAHs on Particulate Matter - Blimp and Helicopter Samples**

PAH ANALYSIS / AIR / BLIMP / HELI (µg/m³)

	Blimp...Downwind 1				Blimp...Downwind 2	Helicopter
	Ap 16	Ap 17	My 23	Ave/dy	My 23	My 28
Acenaphthylene	<2.5	<4	<1.6	LDL	<1.6	<2.5
Acenaphthene	<2.5	<4	5.2	5.2	<1.6	24.0
Fluorene	<2.5	<4	11.9	11.9	2.0	24.5
Phenanthrene	4.3	12.1	4.5	7.0	14.0	16.0
Anthracene	<2.5	<4	<1.6	LDL	<1.6	4.0
3 Rings total	4.3	12.1	21.6	12.7	16.0	68.5
Fluoranthene	<2.5	4.0	<1.6	4.0	<1.6	3.0
Pyrene	<2.5	<4	<1.6	LDL	<1.6	<2.5
Benzo(a)Anthracene	<2.5	<4	<1.6	LDL	<1.6	<2.5
Chrysene	<2.5	<4	<1.6	LDL	<1.6	<2.5
4 Rings total	LDL	4.0	LDL	4.0	LDL	3.0
Benzo(b)Fluoranthene	2.4	4.0	<1.6	3.2	<1.6	<2.5
Benzo(k)Fluoranthene	<2.5	<4	<1.6	LDL	<1.6	<2.5
Benzo(a)Pyrene	3.3	4.0	<1.6	3.7	4.0	<2.5
5 Rings total	5.7	8.0	LDL	6.9	4.0	LDL
Indeno(1,2,3-cd)Pyrene	<2.5	<4	<1.6	LDL	<1.6	<2.5
Dibenzo(a,h)Anthracene	<2.5	<4	<1.6	LDL	<1.6	<2.5
Benzo(g,h,i)Perylene	<2.5	<4	<1.6	LDL	<1.6	<2.5
6 Rings total	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL PAH / AIR	10.0	24.1	21.6	18.6	20.0	71.5
Surrogate Recovery, %						
d10-Acenaphthene			42		36	101
d10-Phenanthrene			67		63	92
d12-Benz(a)anthracene			70		103	25
d12-Perylene			5		86	2

Table 9

PAHs In Crude Oil

PAH ANALYSIS IN CRUDE OIL (µg/g)

		Weathered	Fresh			
Day	Ap 17	My 29	My 29	Jn 04	Jn 05	
Sample Number	0417A	0529A	0529A	0604A	0605A	**Ave/dy**
Naphthalene	291.0	229.0	16.0	10.0	229.0	155.0
2-Methylnaphthalene	110.0	30.0	154.0	368.0	22.0	136.8
1-Methylnaphthalene	64.0	67.0	LDL	258.0	57.0	111.5
Biphenyl	122.0	97.0	127.0	111.0	81.0	107.6
2,6 -Dimethylnaphthalene	341.0	573.0	295.0	597.0	379.0	437.0
4 other isomers Dimethylnaphthalene	1879.0	1927.0	2085.0	1943.0	1941.0	1955.0
2,3,5-Trimethylnaphthalene	333.0	323.0	336.0	326.0	244.0	312.4
1 other isomer Trimethylnaphthalene	1011.0	983.0	624.0	958.0	784.0	872.0
2 Rings total	4151.0	4229.0	3637.0	4571.0	3737.0	4065.0
Acenaphthalene	8.0	4.0	7.0	9.0	7.0	7.0
Acenaphthene	29.0	29.0	25.0	30.0	23.0	27.2
Fluorene	78.0	70.0	75.0	73.0	56.0	70.4
Phenanthene/Anthracene	154.0	155.0	154.0	168.0	128.0	151.8
1-Methylphenanthrene	68.0	69.0	169.0	56.0	75.0	87.4
3 other isomers Methylphenanthrene	655.0	755.0	735.0	766.0	594.0	701.0
3 Rings total	992.0	1082.0	1165.0	1102.0	883.0	1044.8
Flouranthene	4.0	6.0	4.0	4.0	3.0	4.2
Pyrene	9.0	9.0	9.0	9.0	7.0	8.6
Benz(a)anthracene	4.0	0.0	7.0	6.0	4.0	4.2
Chrysene	29.0	32.0	32.0	32.0	25.0	30.0
4 Rings total	46.0	47.0	52.0	51.0	39.0	47.0
Benzo(b,k) flouranthrene	8.0	8.0	8.0	8.0	7.0	7.8
Benzo(e)pyrene	6.0	LDL	LDL	LDL	LDL	6.0
Benzo(a)pyrene	7.0	27.0	7.0	54.0	44.0	27.8
5 Rings total	21.0	35.0	15.0	62.0	51.0	36.8
Perylene	44.0	50.0	50.0	49.0	38.0	46.2
Indenol(1,2,3-cd)anthracene	LDL	LDL	LDL	LDL	LDL	LDL
Dibenz(a,h)anthracene	LDL	LDL	1.0	LDL	LDL	1.0
Benzo(ghi)perylene	LDL	1.0	LDL	LDL	LDL	1.0
6 Rings total	44.0	51.0	51.0	49.0	38.0	46.6
TOTAL PAH IN CRUDE OIL	5254.0	5444.0	4920.0	5835.0	4748.0	5268.9
Surrogate Recovery, %						
d10-Acenaphthene	105	100	83	18	14	
d10-Phenanthrene	75	71	66	69	64	
d12-Benz(a)anthracene	114	11	110	14	109	
d12-Perylene	135	135	130	133	129	

NOTE... May 29 Fresh sample used in calculation of Ave/dy

DL = 1 µg/g

Table 10

PAHs In The Burn Residue

PAH IN OIL RESIDUE (µg/g)

Day	Ap 16	Ap 17	My 16	My 22	My 23	My 24	My 28	My 29	My 30	My 31	My 31	Jn 03	Jn 04	Jn 05	
Sample Number	0416A	0417A	0516A	0522A	0523A	0524A	0528A	0529A	0530A	0531A	0531A	0603A	0604A	0605A	**Ave/dy**
Naphthalene	16.0	7.0	6.0	6.0	8.0	6.0	6.0	4.0	6.0	14.0	4.0	15.0	4.0	4.0	7.6
2-Methylnaphthalene	15.0	11.0	16.0	7.0	11.0	4.0	12.0	3.0	6.0	48.0	12.0	9.0	5.0	2.0	11.5
1-Methylnaphthalene	25.0	26.0	28.0	3.0	9.0	15.0	25.0	7.0	16.0	96.0	17.0	14.0	9.0	3.0	20.9
Biphenyl	2.0	3.0	4.0	4.0	4.0	2.0	3.0	1.0	2.0	16.0	2.0	3.0	2.0	1.0	3.5
2,6 -Dimethylnaphthalene	16.0	17.0	23.0	46.0	34.0	7.0	18.0	4.0	10.0	50.0	13.0	12.0	8.0	10.0	19.1
4 other isomers Dimethylnaphthale	40.0	56.0	56.0	2.0	42.0	28.0	52.0	14.0	34.0	147.0	40.0	29.0	24.0	13.0	41.2
2,3,5-Trimethylnaphthalene	30.0	26.0	29.0	49.0	23.0	11.0	24.0	8.0	15.0	46.0	19.0	26.0	15.0	9.0	23.6
1 other isomer Trimethylnaphthaler	36.0	46.0	37.0	6.0	17.0	20.0	41.0	11.0	8.0	86.0	34.0	24.0	23.0	5.0	28.1
2 Rings total	180.0	192.0	199.0	123.0	148.0	93.0	181.0	52.0	97.0	503.0	141.0	132.0	90.0	47.0	155.6
Acenaphthalene	25.0	13.0	6.0	18.0	9.0	11.0	10.0	8.0	10.0	13.0	6.0	22.0	8.0	7.0	11.9
Acenaphthene	3.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	6.0	1.0	3.0	160.0	1.0	13.6
Fluorene	17.0	11.0	9.0	260.0	10.0	8.0	20.0	6.0	8.0	20.0	7.0	15.0	8.0	6.0	28.9
Phenanthene/Anthracene	86.0	57.0	50.0	111.0	44.0	39.0	48.0	33.0	45.0	70.0	41.0	82.0	46.0	34.0	56.1
1-Methylphenanthrene	155.0	72.0	71.0	65.0	86.0	64.0	56.0	3.0	48.0	44.0	32.0	60.0	32.0	42.0	59.3
3 other isomers Methylphenanthrer	157.0	13.0	132.0	104.0	28.0	92.0	150.0	62.0	144.0	300.0	163.0	190.0	157.0	46.0	124.1
3 Rings total	443.0	168.0	270.0	561.0	179.0	216.0	286.0	114.0	257.0	453.0	250.0	372.0	411.0	136.0	294.0
Flouranthene	22.0	3.0	8.0	25.0	7.0	12.0	8.0	11.0	13.0	12.0	10.0	22.0	12.0	12.0	12.6
Pyrene	32.0	20.0	13.0	48.0	2.0	4.0	17.0	17.0	20.0	24.0	13.0	29.0	16.0	19.0	19.6
Benz(a)anthracene	28.0	20.0	14.0	26.0	17.0	17.0	16.0	14.0	17.0	16.0	13.0	26.0	17.0	16.0	18.4
Chrysene	70.0	54.0	46.0	70.0	42.0	38.0	38.0	34.0	44.0	38.0	35.0	63.0	44.0	16.0	45.1
4 Rings total	152.0	97.0	81.0	169.0	68.0	71.0	79.0	76.0	94.0	90.0	71.0	140.0	89.0	63.0	95.7
Benzo(b,k) flouranthrene	50.0	38.0	27.0	LDL	36.0	36.0	30.0	31.0	33.0	26.0	21.0	36.0	10.0	33.0	31.3
Benzo(e)pyrene	23.0	18.0	14.0	1.0	LDL	16.0	15.0	14.0	16.0	14.0	12.0	20.0	12.0	LDL	14.6
Benzo(a)pyrene	18.0	12.0	8.0	31.0	22.0	LDL	14.0	14.0	17.0	12.0	LDL	LDL	LDL	20.0	16.8
5 Rings total	91.0	68.0	49.0	32.0	58.0	52.0	59.0	59.0	66.0	52.0	33.0	56.0	22.0	53.0	53.6
Perylene	26.0	115.0	97.0	120.0	107.0	86.0	90.0	76.0	86.0	16.0	79.0	124.0	85.0	86.0	85.2
Indenol(1,2,3-cd)anthracene	10.0	6.0	4.0	19.0	11.0	9.0	6.0	8.0	8.0	7.0	4.0	8.0	6.0	10.0	8.3
Dibenz(a,h)anthracene	4.0	LDL	2.0	6.0	4.0	2.0	3.0	LDL	2.0	2.0	LDL	2.0	2.0	4.0	3.0
Benzo(ghi)perylene	12.0	4.0	6.0	26.0	16.0	12.0	9.0	LDL	4.0	8.0	3.0	10.0	7.0	15.0	10.2
6 Rings total	52.0	125.0	109.0	171.0	138.0	109.0	108.0	84.0	100.0	33.0	86.0	144.0	100.0	115.0	105.3
TOTAL PAH IN OIL RESIDUE	918.0	650.0	708.0	1056.0	591.0	541.0	713.0	385.0	614.0	1131.0	581.0	844.0	712.0	414.0	704.1
Surrogate Recovery, %															
d10-Acenaphthene	27	25	28	132	138	28	138	83	68	138	105	83	68	68	
d10-Phenanthrene	25	32	34	142	146	36	146	66	72	146	75	66	72	72	
d12-Benz(a)anthracene	55	58	55	256	248	54	248	110	104	248	114	110	104	104	
d12-Perylene	67	69	64	342	340	62	340	130	126	340	135	130	126	126	

DL = 1 µg/g

Table 11 **Analysis for Dioxins and Dibenzofurans on Particulates**

CUMULATIVE DIOXIN ANALYSIS (pg/m³)

CHLORODIBENZO p-DIOXIN	Upwind	Detection Limit (DL)	Downwind 1 *	DL	Downwind 2	DL
TCDD	<0.01	0.01	<0.03	0.03	<0.03	0.03
P5CDD	<0.03	0.02	<0.03	0.03	<0.03	0.03
H6CDD	<0.04	0.03	<0.05	0.05	<0.06	0.06
H7CDD	0.37	0.07	0.38	0.06	0.30	0.08
OCDD	0.71	0.14	0.72	0.15	0.96	0.16
TOTAL	1.08		1.10		1.26	
CHLORODIBENZO p-FURAN						
TCDF	<0.03	0.03	<0.03	0.03	<0.03	0.03
P5CDF	0.13	0.03	0.10	0.03	<0.03	0.03
H6CDF	0.04	0.04	<0.05	0.05	<0.06	0.06
H7CDF	<0.06	0.06	<0.06	0.06	<0.08	0.08
OCDF	<0.71	0.71	<0.15	0.15	<0.16	0.16
TOTAL	0.17		0.10		LDL	
TOTAL DIOXIN/FURAN	1.25		1.20		1.26	
Recovery %						
13C12-TCDD	78		98		93	
13C12-TCDF	83		90		80	
13C12-P5CDD	49		58		53	
13C12-P5CDF	70		82		74	
13C12-H6CDD	58		59		52	
13C12-H6CDF	62		72		60	
13C12-H7CDD	59		69		59	
13C12-H7CDF	67		71		59	
13C12-OCDD	42		64		50	

samples taken May 16, 23, 24, 28, 29, 30, 31, June 04, 05

* no Puf in high volume sampler, just a particulate filter

Table 12

Metal Analysis of Particulate Material

METAL ANALYSIS IN AIR (µg/m³)

Upwind	My 16	My 16	My 22	My 23	My 24	My 28	My 29	My 31		Jn 03	Jn 05
Cadmium	<1.3	<2.9	<3.5	<5.0	<2.9	<3.0	<2.3	<3.0		<2.9	<2.9
Lead	<21.0	<49.0	<60.0	<85.0	<49.0	<51.0	<39.0	<51.0		<49.0	<49.0
Nickel	<7.5	<17.0	<21.0	<30.0	<17.0	<18.0	<14.0	<18.0		<17.0	<17.0
Cobalt	<2.5	<5.7	<7.1	<10.0	<5.7	<6.0	<4.6	<6.0		<5.7	<5.7
Iron	<4.2	<9.5	<12.0	<17.0	<9.5	<10.0	<7.7	<10.0		<9.5	<9.5
Chromium	<2.5	<5.7	<7.1	<10.0	<5.7	<6.0	<13.0	<6.0		<5.7	<5.7
Magnesium	<38.0	<63.0	<78.0	<110.0	<180.0	<160.0	<100.0	<66.0		<63.0	<63.0
Manganese	<2.5	<5.7	<7.1	<10.0	<5.7	<6.0	<4.6	<6.0		<5.7	<5.7
Vanadium	<8.3	<19.0	<24.0	<33.0	<19.0	<20.0	<1.5	<20.0		<19.0	<19.0
Zinc	<1.3	<2.9	<3.5	<5.0	<2.9	<3.0	<2.3	<3.0		<2.9	<2.9
TOTAL METALS IN AIR	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**	**0.0**
Downwind 1	My 16	My 16	My 22	My 23	My 24	My 28	My 29	My 31	My 31	Jn 03	Jn 05
Cadmium	<1.3	<3.0	<3.2	<4.6	<2.1	<3.8	<2.3	<3.0	<3.3	<3.0	<1.4
Lead	<21.0	<54.0	<54.0	<78.0	<36.0	<64.0	<39.0	<51.0	<57.0	<51.0	<24.0
Nickel	<7.5	<19.0	<19.0	<28.0	<13.0	<23.0	<14.0	<18.0	<20.0	<18.0	<8.6
Cobalt	<5.4	<6.3	<6.3	<9.2	<4.3	<7.5	<4.6	<6.0	<6.7	<6.0	<2.9
Iron	<4.2	<11.0	<11.0	<15.0	<7.1	<13.0	<7.7	<10.0	<11.0	<10.0	<4.8
Chromium	<2.5	<6.3	<6.3	<43.0	<4.3	<7.5	<4.6	<6.0	<6.7	<6.0	<2.9
Magnesium	<28.0	<160.0	<69.0	<100.0	<110.0	<160.0	<140.0	<66.0	<73.0	<66.0	<31.0
Manganese	<2.5	<6.3	<6.3	<9.2	<4.3	<7.5	<4.6	<6.0	<6.7	<6.0	<2.9
Vanadium	<8.3	<21.0	<21.0	<31.0	<14.0	<25.0	<15.0	<20.0	<22.0	<20.0	<9.5
Zinc	<1.3	<6.3	<3.2	<4.6	<2.1	<3.8	<2.3	<3.0	<3.3	<3.0	<1.4
TOTAL METALS IN AIR	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Downwind 2	My 16	My 16	My 22	My 23	My 24	My 28	My 29	My 31	My 31	Jn 03	Jn 05
Cadmium	<1.3	<3.2	<3.5	<4.3	<2.1	<4.0	<2.4	<3.2	<3.2		<1.5
Lead	<21.0	<54.0	<60.0	<73.0	<35.0	<68.0	<41.0	<54.0	<54.0		<25.0
Nickel	<7.5	<19.0	<21.0	<26.0	<12.0	<24.0	<14.0	<19.0	<19.0		<8.8
Cobalt	<2.5	<6.3	<7.1	<8.6	<4.1	<8.0	<4.8	<6.3	<6.3		<2.9
Iron	<4.2	<11.0	<12.0	<14.0	<6.9	<13.0	<8.0	<11.0	<11.0		<4.9
Chromium	<2.5	<6.3	<7.1	<8.6	<4.1	<8.0	<4.8	<6.3	<6.3		<2.9
Magnesium	<28.0	<160.0	<78.0	<94.0	<120.0	<210.0	<120.0	<69.0	<69.0		<32.0
Manganese	<2.5	<6.3	<7.1	<8.6	<4.1	<8.0	<4.8	<6.3	<6.3		<2.9
Vanadium	<8.3	<21.0	<24.0	<29.0	<14.0	<27.0	<16.0	<21.0	<21.0		<9.8
Zinc	<1.3	<3.2	<3.5	<4.3	<2.1	<4.0	<2.4	<3.2	<3.2		<1.5
TOTAL METALS IN AIR	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		**0.0**

Table 13

Analysis of Metals in Oil and Residue

METALS IN OIL ANALYSIS (µg/g)

	CRUDE			RESIDUE		
	Apr 16	Apr 17	Ave/dy	Apr 16	Apr 17	Ave/dy
Cadmium	6.83	4.83	5.83	5.45	10.57	8.01
Mercury	<3.00	<3.00	<3.00	<3.00	<3.00	<3.00
Lead	<5.10	<5.10	<5.10	<5.10	<5.10	<5.10
Nickel	1.80	2.42	2.11	5.71	14.34	10.03
Cobalt	1.14	0.74	0.94	1.06	1.40	1.23
Iron	23.35	24.74	24.05	77.40	92.72	85.06
Chromium	<0.60	<0.60	<0.60	2.50	1.32	1.91
Magnesium	<6.60	<6.60	<6.60	28.21	18.87	23.54
Manganese	1.24	1.41	1.33	2.41	2.16	2.29
Vanadium	2.89	2.75	2.82	5.63	16.13	10.88
Zinc	12.60	8.42	10.51	12.50	23.87	18.19
TOTAL METALS	49.9	45.3	47.6	140.9	181.4	161.1

Table 14 **Sulphur Dioxide Levels at The Downwind 1 Station**

SULFUR DIOXIDE ANALYSIS (ppm)

	Ap 16	Ap 17	My 16	My 22	My 23	My 24	My 28	My 29	My 30	My 31	Jn 03	Jn 04	Jn 05	**Ave/dy**
Downwind 1														
Peak	LDL	LDL	1.60	LDL	0.07	0.10	0.90	0.03	1.20	0.90	0.70	1.20	0.10	0.68

all values represent peak values of Sulphur Dioxide

Table 15 **Carbon Dioxide Data**

CARBON DIOXIDE ANALYSIS (ppm)

day	My 16	My 22	My 23	My 24	My 28	My 29	My 30	My 31	Jn 03	Jn 04	Jn 05	**Ave/dy**
Downwind 1												
Average	1038	147	188	557	369		506	372	804	501	637	512
Maximum	1055	219	400	602	334		582	441	844	525	701	570
Minimum	979	107	126	521	386		450	334	768	488	559	472
Downwind 2												
Average	578	352	392	275	317	315	412	591	485	417	553	426
Maximum	619	415	763	296	410	410	455	625	496	430	583	500
Minimum	511	325	341	244	244	244	386	550	477	405	525	387

Table 16

Cumulative VOC Data Using Charcoal Tubes

CUMULATIVE VOC ANALYSIS (charcoal tubes µg/m³)

	Upwind	Downwind 1			Downwind 2		
	5824B	5826B	5828B	Ave/dy	5829B	5830B	Ave/dy
1,1,1-Trichloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzene	5.0	94.0	87.0	90.5	9.0	11.0	10.0
Carbon tetrachloride	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Cyclohexene	LDL	2.0	2.0	2.0	LDL	LDL	LDL
1,2-Dichloropropane	LDL	5.0	LDL	5.0	LDL	LDL	LDL
Trichloroethene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Heptane	LDL	404.0	444.0	424.0	20.0	18.0	19.0
1,2-Dioxane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Methylcyclohexane	LDL	317.0	347.0	332.0	7.0	16.0	11.5
MIKB	LDL	4.0	4.0	4.0	LDL	LDL	LDL
Toluene	31.0	145.0	145.0	145.0	36.0	40.0	38.0
Octane	1.0	175.0	180.0	177.5	8.0	11.0	9.5
Tetrachloroehtene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Chlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Ethylbenzene	4.0	24.0	24.0	24.0	5.0	7.0	6.0
p-Xylene	24.0	101.0	56.0	78.5	28.0	35.0	31.5
Bromoform	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Styrene	LDL	LDL	1.0	1.0	LDL	LDL	LDL
o-Xylene	6.0	36.0	33.0	34.5	4.0	9.0	6.5
Nonene	LDL	6.0	9.0	7.5	LDL	LDL	LDL
Nonane	LDL	50.0	80.0	65.0	4.0	7.0	5.5
1,1,2,2-Tetrachloroethane	LDL	3.0	4.0	3.5	LDL	LDL	LDL
Cumene	LDL	2.0	4.0	3.0	LDL	LDL	LDL
Mesitylene	4.0	15.0	14.0	14.5	5.0	20.0	12.5
alpha-Methylstyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Decene	LDL	LDL	371.0	371.0	LDL	LDL	LDL
Decane	LDL	17.0	337.0	177.0	2.0	7.0	4.5
1,3-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,4-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzyl chloride	LDL	LDL	LDL	LDL	LDL	LDL	LDL
alpha Terpenene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
d-Limonene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,2-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4-tert-Butyltoluene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Undecene	LDL	LDL	7.0	7.0	LDL	LDL	LDL
Undecane	LDL	4.0	135.0	69.5	LDL	3.0	3.0
Nonanol	LDL	2.0	LDL	2.0	LDL	LDL	LDL
1,2,4-Trichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Naphtalene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Dodecane	LDL	4.0	37.0	20.5	LDL	LDL	LDL
Tridecane	LDL	1.0	17.0	9.0	LDL	LDL	LDL
4-Phenylcyclohexane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Tetradecane	LDL	LDL	5.0	5.0	LDL	LDL	LDL
Pentadecane	LDL	LDL	1.0	1.0	LDL	LDL	LDL
Hexadecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL CUMULATIVE VOC	75.0	1411.0	2344.0	1877.5	128.0	184.0	156.0

samples collected May 16, 23, 24, 28, 29, 30, 31, June 04, 05

Table 17

VOC Analysis By Summa Canister

VOC ANALYSIS (Summa canisters µg/m³)

	Upwind			Downwind 1									
day	Jn 04	Jn 05	Ave/Dy	My 23	My 24	My 28	My 29	My 30	Jn 03	Jn 03	Jn 04	Jn 05	Ave/dy
Propylene	0.38	0.21	0.3	2.33	LDL	1.88	LDL	1.63	LDL	1.93	LDL	1.62	1.9
Propane	4.98	2.48	3.7	37.87	50.40	10.60	LDL	9.28	15.94	12.92	30.25	87.39	31.8
Freon 22	0.73	0.39	0.6	2.29	2.72	9.25	2.08	2.37	2.53	13.34	2.59	2.63	4.4
2-Methylpropane	4.14	0.51	2.3	30.22	41.84	4.00	LDL	6.55	11.93	3.79	20.02	88.03	25.8
Freon 114	0.24	LDL	0.2	LDL	LDL	LDL	LDL	LDL	LDL	0.63	LDL	LDL	0.6
Vinylchloride	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1-Butene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,3-Butadiene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Butane	12.35	1.03	6.7	90.13	121.41	8.75	LDL	9.62	34.88	10.82	55.96	246.82	72.3
trans-2-Butene	LDL	LDL	LDL	LDL	LDL	0.44	LDL	0.36	LDL	0.53	LDL	LDL	0.4
2,2-Dimethylpropane	0.24	0.06	0.2	2.36	2.51	0.27	LDL	0.31	0.95	LDL	1.86	3.82	1.7
1-Butyne	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
cis-2-Butene	LDL	LDL	LDL	LDL	LDL	0.30	LDL	LDL	LDL	0.41	LDL	LDL	0.4
2-Methylbutane	12.23	1.10	6.7	119.31	158.94	11.78	LDL	16.28	50.87	11.43	85.74	329.23	97.9
Freon 11	1.11	0.73	0.9	LDL	LDL	4.02	LDL	4.70	LDL	7.89	LDL	LDL	5.5
1-Pentene	LDL	LDL	LDL	LDL	LDL	0.37	LDL	LDL	LDL	LDL	LDL	LDL	0.4
Pentane	8.30	0.61	4.5	125.84	167.16	13.10	1.03	23.62	56.34	10.38	87.77	351.12	92.9
Isoprene	LDL	3.56	3.6	LDL	LDL	LDL	LDL	0.70	LDL	0.75	LDL	6.49	2.6
1,1-Dichloroethene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	1.21	LDL	LDL	1.2
Dichloromethane	0.25	0.12	0.2	10.69	LDL	8.10	LDL	3.88	2.64	12.52	LDL	LDL	7.6
Freon 113	0.67	0.49	0.6	LDL	LDL	4.28	LDL	1.76	LDL	3.42	LDL	LDL	3.2
2,2-Dimethylbutane	0.50	0.13	0.3	7.20	9.69	8.72	LDL	7.75	1.63	8.30	6.05	20.48	8.7
trans-1,2-Dichloroethylene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,1-Dichloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Cyclopentane	0.27	LDL	0.3	9.83	12.92	0.93	LDL	1.51	1.29	0.65	7.48	28.57	7.9
2,3-Dimethylbutane	0.31	0.14	0.2	12.50	4.97	13.10	LDL	11.74	3.62	12.66	10.38	37.05	13.3
2-Methylpentane	3.78	1.54	2.7	84.32	110.07	46.89	LDL	41.29	37.25	41.66	65.05	241.64	83.5
3-Methylpentane	1.95	0.93	1.4	63.99	84.71	72.22	LDL	63.81	30.20	71.54	52.44	191.10	78.8
1-Hexene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Bromochloromethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Hexane	3.25	0.74	2.0	137.33	147.21	52.48	LDL	47.66	61.40	56.45	101.49	380.65	123.1

Table 17 ctd

	Upwind			Downwind 1									
day	Jn 04	Jn 05	Ave/Dy	My 23	My 24	My 28	My 29	My 30	Jn 03	Jn 03	Jn 04	Jn 05	Ave/dy
Chloroform	2.68	LDL	2.7	LDL	LDL	LDL	LDL	LDL	LDL	LDL	2.61	LDL	2.6
1,2-Dichloroethane	LDL	LDL	LDL	LDL	LDL	0.80	LDL	0.72	LDL	1.48	LDL	LDL	1.0
Methylcyclopentane	0.52	0.35	0.4	36.53	49.35	38.86	LDL	34.07	8.63	38.55	30.60	114.47	43.9
2,4-Dimethylpentane	0.24	LDL	0.2	9.22	10.54	9.94	LDL	8.54	4.98	9.85	7.33	25.46	10.7
1,1,1-Trichloroethane	1.48	0.77	1.1	LDL	LDL	10.94	LDL	7.77	LDL	19.75	LDL	LDL	12.8
2,2,3-Trimethylbutane	0.15	LDL	0.2	2.74	3.01	2.97	LDL	2.20	1.90	2.68	1.89	5.51	2.9
Benzene	1.58	0.37	1.0	42.42	32.63	2.76	LDL	12.06	11.96	5.04	26.70	72.87	25.8
Carbontetrachloride	0.72	0.43	0.6	LDL	LDL	0.85	LDL	0.85	4.98	0.86	LDL	LDL	1.9
Cyclohexane	0.37	0.10	0.2	42.62	60.45	7.78	LDL	7.79	16.49	7.38	39.66	113.00	36.9
2-Methylhexane	1.15	0.34	0.7	37.58	LDL	12.32	LDL	11.11	15.57	10.87	34.54	102.44	32.1
2,3-Dimethylpentane	0.23	LDL	0.2	16.16	22.24	7.01	LDL	6.63	7.82	6.96	14.90	53.49	16.9
3-Methylhexane	1.04	0.35	0.7	46.78	63.99	12.15	LDL	9.62	4.80	10.83	41.34	159.53	43.6
Dibromomethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,2-Dichloropropane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Bromodichloromethane	LDL	LDL	LDL	6.36	LDL	LDL	LDL	LDL	3.36	LDL	5.41	17.49	8.2
Trichloroethane	LDL	LDL	LDL	LDL	LDL	1.20	LDL	1.14	LDL	LDL	LDL	LDL	1.2
2,2,4-Trimethylpentane	0.23	0.08	0.2	1.01	LDL	1.40	LDL	1.07	0.58	2.00	1.14	3.27	1.5
Heptane	0.78	0.11	0.4	80.84	116.13	1.92	LDL	3.51	32.75	2.57	72.99	297.07	76.0
cis-1,3-Dichloropropene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Methylcyclohexane	0.55	LDL	0.6	107.33	146.24	0.86	LDL	3.99	47.88	1.10	100.30	380.06	98.5
2,5-Dimethylhexane	LDL	LDL	LDL	3.26	2.23	LDL	LDL	LDL	LDL	LDL	3.42	12.87	5.4
trans-1,3-Dichloropropene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,1,2-Trichloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
2,3,4-Trimethylpentane	LDL	LDL	LDL	LDL	1.41	0.38	LDL	LDL	LDL	0.55	LDL	3.62	1.5
Toluene	2.17	1.23	1.7	39.37	51.00	159.93	1.38	143.67	16.40	158.60	41.00	150.15	84.6
3-Methylheptane	0.17	LDL	0.2	26.06	17.30	4.09	LDL	3.48	9.32	4.54	28.76	114.47	26.0
Dibromochloromethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
2,2,5-Trimethylhexane	LDL	LDL	LDL	0.80	0.97	0.21	LDL	0.19	LDL	0.25	0.88	2.22	0.8
EDB	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Octane	0.28	0.11	0.2	45.93	LDL	15.18	LDL	14.46	13.56	17.33	52.41	198.92	51.1
Tetrachloroethylene	0.18	LDL	0.2	LDL	LDL	0.65	LDL	0.57	LDL	0.71	LDL	LDL	0.6
Chlorobenzene	0.11	0.14	0.1	4.38	1.50	0.63	LDL	0.51	1.22	0.59	1.33	2.90	1.6
Ethylbenzene	0.32	0.05	0.2	5.21	6.50	2.54	LDL	2.61	1.90	3.31	8.43	22.94	6.7
m,p-Xylene	0.70	0.14	0.4	27.67	34.20	9.18	LDL	10.03	8.98	10.92	50.39	119.65	33.9

Table 17 ctd.	Upwind			Downwind 1									
day	Jn 04	Jn 05	Ave/Dy	My 23	My 24	My 28	My 29	My 30	Jn 03	Jn 03	Jn 04	Jn 05	Ave/dy
Bromoform	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Styrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	0.53	LDL	LDL	0.5
1,1,2,2-Tetrachloroethane	0.16	LDL	0.2	LDL	LDL	0.61	LDL	0.58	LDL	0.68	1.56	2.03	1.1
o-Xylene	0.31	LDL	0.3	6.86	8.29	2.95	LDL	3.10	2.42	3.35	15.46	31.88	9.3
Nonane	0.29	LDL	0.3	21.74	25.26	11.69	LDL	10.99	5.67	10.92	58.94	103.62	31.1
Isopropylbenzene	0.09	LDL	0.1	1.32	1.63	0.67	LDL	0.66	LDL	0.61	2.98	4.45	1.8
n-Propylbenzene	0.11	LDL	0.1	0.99	1.18	1.40	LDL	0.74	LDL	4.28	4.02	4.54	2.5
3-Ethyltoluene	0.16	0.04	0.1	1.91	2.42	1.34	LDL	1.07	0.67	1.62	10.62	10.59	3.8
4-Ethyltoluene	0.11	LDL	0.1	0.94	1.25	0.97	LDL	0.72	LDL	1.53	5.29	4.98	2.2
1,3,5-Trimethylbenzene	0.07	0.06	0.1	2.07	2.79	1.12	LDL	0.80	0.76	1.24	12.18	10.94	4.0
2-Ethyltoluene	0.08	LDL	0.1	0.82	1.02	0.69	LDL	0.59	LDL	0.76	4.47	3.70	1.7
1,2,4-Trimethylbenzene	0.25	LDL	0.3	3.38	3.85	3.04	LDL	2.16	1.03	3.30	27.26	18.70	7.8
Decane	0.27	LDL	0.3	5.88	11.92	11.39	0.72	9.13	1.32	9.92	68.76	38.29	17.5
1,3-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
iso-Butylbenzene	LDL	0.05	0.1	LDL	LDL	LDL	LDL	LDL	LDL	LDL	1.45	0.82	1.1
1,4-Dichlorobenzene	0.15	LDL	0.2	0.98	0.98	0.82	LDL	0.45	LDL	1.40	0.90	1.05	0.9
sec-Butylbenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
p-Cymene	0.12	LDL	0.1	LDL	0.59	1.48	LDL	1.53	LDL	7.63	3.09	2.02	2.7
1,2,3-Trimethylbenzene	0.08	LDL	0.1	0.85	LDL	1.18	LDL	0.76	LDL	0.37	10.39	5.17	3.1
1,2-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	0.44	LDL	LDL	0.4
Indan	0.06	LDL	0.1	LDL	LDL	1.32	LDL	0.85	LDL	1.38	LDL	0.59	1.0
1,3-Diethylbenzene	0.08	LDL	0.1	LDL	LDL	0.18	LDL	0.72	LDL	0.81	1.09	2.96	1.2
1,4-Diethylbenzene	0.11	LDL	0.1	LDL	LDL	0.61	LDL	0.41	LDL	0.59	5.81	2.09	1.9
n-Butylbenzene	0.09	LDL	0.1	0.24	0.40	0.23	LDL	0.15	LDL	0.22	2.57	0.96	0.7
1,2-Diethylbenzene	LDL	LDL	LDL	LDL	LDL	0.21	LDL	LDL	LDL	0.32	0.90	LDL	0.5
Undecane	0.28	LDL	0.3	1.82	2.00	4.00	0.76	2.73	LDL	3.10	45.24	9.07	8.6
1,2,4-Trichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Dodecane	0.15	LDL	0.2	LDL	LDL	0.49	LDL	0.27	LDL	0.41	15.59	2.77	3.9
Naphthlene	0.09	LDL	0.1	LDL	LDL	0.47	0.38	0.88	LDL	0.50	5.20	0.78	1.4
Hexachlorobutane	0.14	LDL	0.1	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Hexylbenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL VOC / SUMMA	74.58	19.49	47.04	1368.28	1597.82	622.89	6.35	580.70	536.42	655.86	1396.88	4251.04	1224.03

Table 18 **VOC Analyses Using Charcoal Tubes - Upwind Data**

VOC ANALYSIS / AIR / UPWIND (charcoal tubes µg/m³)

day	My 16	My 22	My 24	My 29	My 30	Jn 05	
sample number	5875B	6095B	6115B	5881B	5891B	6061B	Ave/dy
1,1,1-Trichloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzene	84.5	65.0	62.0	31.0	8.0	12.0	43.8
Carbon tetrachloride	3.3	6.0	5.0	4.0	LDL	LDL	4.6
Cyclohexene	LDL	LDL	LDL	LDL	LDL	LDL	0.0
1,2-Dichloropropane	LDL	LDL	5.0	LDL	LDL	LDL	5.0
Trichloroethene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Heptane	16.3	LDL	LDL	LDL	LDL	2.0	9.1
1,2-Dioxane	3.3	LDL	5.0	LDL	LDL	LDL	4.1
Methylcyclohexane	LDL	6.0	LDL	LDL	LDL	LDL	6.0
MIKB	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Toluene	263.3	494.0	381.0	223.0	132.0	88.0	263.5
Octane	LDL	12.0	LDL	LDL	LDL	LDL	12.0
Tetrachloroehtene	LDL	LDL	LDL	LDL	LDL	LDL	0.0
Chlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Ethylbenzene	32.5	41.0	62.0	27.0	11.0	5.0	29.8
p-Xylene	91.0	359.0	127.0	146.0	57.0	67.0	141.2
Bromoform	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Styrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
o-Xylene	32.5	47.0	81.0	35.0	11.0	2.0	34.8
Nonene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Nonane	9.8	LDL	14.0	LDL	LDL	LDL	11.9
1,1,2,2-Tetrachloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Cumene	LDL	LDL	5.0	LDL	LDL	LDL	5.0
Mesitylene	3.3	35.0	29.0	23.0	15.0	LDL	21.1
alpha-Methylstyrene	9.8	LDL	LDL	LDL	LDL	7.0	8.4
Decene	LDL	LDL	5.0	LDL	LDL	LDL	5.0
Decane	LDL	6.0	67.0	LDL	LDL	LDL	36.5
1,3-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,4-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzyl chloride	LDL	LDL	LDL	LDL	LDL	LDL	LDL
alpha Terpenene	6.5	6.0	14.0	LDL	LDL	LDL	8.8
d-Limonene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,2-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4-tert-Butyltoluene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Undecene	LDL	LDL	5.0	4.0	LDL	2.0	3.7
Undecane	3.3	LDL	24.0	4.0	4.0	LDL	8.8
Nonanol	3.3	12.0	5.0	4.0	4.0	5.0	5.5
1,2,4-Trichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Naphtalene	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Dodecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Tridecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4-Phenylcyclohexane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Tetradecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Pentadecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Hexadecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL
TOTAL VOC / CHARCOAL	562.3	1089.0	896.0	501.0	242.0	190.0	580.0

Table 19

VOC Analyses At The Downwind 1 Station

VOC ANALYSIS / AIR / DOWNWIND 1 (charcoal tubes µg/m³)

day	My 16	My 16	My 22	My 22	My 23	My 24	My 24	My 28	My 29	My 30	My 31	Jn 03	Jn 04	Jn 05	Av/day
1,1,1-Trichloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzene	418.4	761.9	95.0	116.0	146.0	79.0	75.0	6.0	28.0	79.0	47.0	24.0	57.0	19.0	139.4
Carbon tetrachloride	3.1	3.1	LDL	5.0	LDL	4.0	4.0	LDL	4.0	4.0	LDL	LDL	LDL	2.0	3.7
Cyclohexene	6.2	18.7	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	12.5
1,2-Dichloropropane	3.1	3.1	LDL	5.0	LDL	LDL	4.0	LDL	LDL	LDL	LDL	LDL	LDL	2.0	3.4
Trichloroethene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Heptane	974.2	2641.6	111.0	95.0	246.0	89.0	75.0	69.0	LDL	96.0	53.0	LDL	143.0	LDL	417.5
1,2-Dioxane	3.1	LDL	LDL	5.0	LDL	LDL	4.0	LDL	LDL	LDL	LDL	LDL	LDL	LDL	4.0
Methylcyclohexane	1083.5	2335.6	111.0	105.0	146.0	93.0	89.0	6.0	LDL	92.0	16.0	LDL	86.0	2.0	347.1
MIKB	9.4	25.0	LDL		LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	17.2
Toluene	546.4	996.1	474.0	584.0	677.0	464.0	346.0	556.0	294.0	313.0	337.0	229.0	310.0	133.0	440.7
Octane	434.0	1099.1	16.0	37.0	LDL	21.0	32.0	6.0	LDL	8.0	42.0	14.0	105.0	LDL	164.9
Tetrachloroehtene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Chlorobenzene	3.1	3.1	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	3.1
Ethylbenzene	84.3	168.6	63.0	74.0	39.0	82.0	21.0	8.0	32.0	46.0	16.0	19.0	33.0	10.0	49.7
p-Xylene	371.6	674.4	300.0	163.0	362.0	404.0	225.0	369.0	176.0	233.0	132.0	100.0	186.0	102.0	271.3
Bromoform	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Styrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
o-Xylene	118.7	234.2	LDL	84.0	39.0	107.0	29.0	100.0	44.0	58.0	58.0	24.0	43.0	12.0	73.1
Nonene	12.5	56.2	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	34.3
Nonane	218.6	637.0	LDL	5.0	62.0	50.0	18.0	50.0	LDL	4.0	16.0	LDL	62.0	7.0	102.7
1,1,2,2-Tetrachloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Cumene	6.2	25.0	LDL	LDL	LDL	11.0	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	14.1
Mesitylene	43.7	46.8	32.0	42.0	308.0	139.0	39.0	94.0	24.0	175.0	216.0	29.0	14.0	19.0	87.3
alpha-Methylstyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Decene	162.4	56.2	5.0	LDL	LDL	7.0	4.0	LDL	LDL	LDL	LDL	LDL	LDL	LDL	46.9
Decane	174.9	446.5	5.0	5.0	31.0	71.0	7.0	38.0	32.0	13.0	53.0	5.0	29.0	LDL	70.0
1,3-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,4-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzyl chloride	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
alpha Terpenene	3.1	3.1	5.0	LDL	8.0	LDL	4.0	6.0	LDL	4.0	LDL	LDL	LDL	LDL	4.7
d-Limonene	3.1	6.2	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	4.7
1,2-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4-tert-Butyltoluene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Undecene	3.1	LDL	LDL	LDL	8.0	LDL	LDL	LDL	4.0	LDL	LDL	5.0	LDL	LDL	5.0
Undecane	56.2	9.4	LDL	LDL	23.0	4.0	4.0	6.0	4.0	4.0	26.0	5.0	5.0	LDL	12.3
Nonanol	LDL	LDL	5.0	5.0	23.0	7.0	4.0	13.0	4.0	4.0	11.0	10.0	5.0	2.0	7.8
1,2,4-Trichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Naphtalene	LDL	3.1	LDL	LDL	LDL	4.0	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	3.6
Dodecane	9.4	15.6	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	12.5
Tridecane	LDL	6.2	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	6.2
4-Phenylcyclohexane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Tetradecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Pentadecane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Hexadecane	LDL	3.1	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	3.1
TOTAL VOC / CHARCOAL	4752.4	10279.1	1222.0	1330.0	2118.0	1636.0	984.0	1327.0	556.0	1133.0	1023.0	464.0	1078.0	310.0	2015.2

Table 20

VOC Analyses - Downwind 2 Station

VOC ANALYSIS / AIR / DOWNWIND 2 (charcoal tubes µg/m³)

day	My 16	My 16	My 22	My 22	My 23	My 24	My 24	My 28	My 29	My 30	Jn 04	Jn 05	**Ave/dy**
1,1,1-Trichloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzene	90.0	84.0	112.0	129.0	92.0	45.0	45.0	36.0	40.0	49.0	23.0	20.0	63.8
Carbon tetrachloride	3.0	3.0	6.0	12.0	LDL	7.0	3.0	LDL	LDL	4.0	LDL	2.0	5.0
Cyclohexene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,2-Dichloropropane	LDL	LDL	6.0	LDL	LDL	3.0	LDL	LDL	LDL	4.0	LDL	LDL	4.3
Trichloroethene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Heptane	15.0	15.0	88.0	59.0	131.0	3.0	28.0	7.0	4.0	64.0	14.0	LDL	38.9
1,2-Dioxane	LDL	LDL	6.0	6.0	LDL	3.0	LDL	LDL	LDL	LDL	LDL	LDL	5.0
Methylcyclohexane	18.0	6.0	88.0	41.0	69.0	17.0	14.0	LDL	LDL	53.0	5.0	LDL	34.6
MIKB	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Toluene	249.0	243.0	529.0	565.0	500.0	359.0	303.0	200.0	324.0	273.0	100.0	149.0	316.2
Octane	6.0	9.0	41.0	35.0	35.0	3.0	14.0	7.0	LDL	26.0	5.0	LDL	18.5
Tetrachloroethene	LDL	LDL	6.0	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	6.0
Chlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Ethylbenzene	30.0	30.0	77.0	47.0	31.0	59.0	28.0	36.0	52.0	45.0	9.0	10.0	37.8
p-Xylene	69.0	147.0	382.0	370.0	277.0	303.0	124.0	171.0	288.0	102.0	77.0	102.0	201.0
Bromoform	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Styrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
o-Xylene	15.0	36.0	100.0	94.0	31.0	41.0	66.0	50.0	76.0	30.0	9.0	17.0	47.1
Nonene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	2.0	2.0
Nonane	12.0	3.0	LDL	18.0	54.0	7.0	10.0	7.0	LDL	19.0	5.0	5.0	14.0
1,1,2,2-Tetrachloroethane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Cumene	3.0	3.0	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	3.0
Mesitylene	12.0	9.0	35.0	24.0	246.0	179.0	141.0	21.0	28.0	42.0	9.0	17.0	63.6
alpha-Methylstyrene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Decene	LDL	LDL	LDL	6.0	LDL	3.0	41.0	LDL	LDL	LDL	LDL	LDL	16.1
Decane	9.0	3.0	LDL	LDL	23.0	5.0	48.0	LDL	8.0	45.0	5.0	5.0	16.8
1,3-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
1,4-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Benzyl chloride	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
alpha Terpenene	LDL	LDL	LDL	12.0	8.0	3.0	3.0	LDL	LDL	LDL	5.0	LDL	6.2
d-Limonene	LDL	LDL	LDL	LDL	8.0	LDL	3.0	LDL	LDL	LDL	LDL	LDL	5.5
1,2-Dichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
4 Tert Butyltoluene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Undecene	LDL	LDL	LDL	6.0	LDL	LDL	24.0	LDL	4.0	4.0	LDL	2.0	8.0
Undecane	LDL	LDL	LDL	LDL	LDL	28.0	38.0	LDL	12.0	15.0	LDL	LDL	23.3
Nonanol	12.0	6.0	6.0	12.0	8.0	3.0	83.0	LDL	12.0	8.0	LDL	2.0	15.2
1,2,4-Trichlorobenzene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Naphtalene	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	4.0	LDL	LDL	LDL	4.0
Dodecane	LDL	LDL	LDL	LDL	LDL	LDL	10.0	LDL	LDL	LDL	LDL	LDL	10.0
Tridecane	LDL	LDL	LDL	LDL	LDL	LDL	7.0	LDL	LDL	LDL	LDL	LDL	7.0
4-Phenylcyclohexane	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL	LDL
Tetradecane	LDL	LDL	LDL	LDL	LDL	LDL	10.0	LDL	LDL	LDL	LDL	LDL	10.0
Pentadecane	LDL	LDL	LDL	LDL	LDL	LDL	3.0	LDL	LDL	LDL	LDL	LDL	3.0
Hexadecane	LDL	LDL	LDL	LDL	LDL	LDL	7.0	LDL	LDL	LDL	LDL	LDL	7.0
TOTAL VOC / CHARCOAL	543.0	597.0	1482.0	1436.0	1517.0	1071.0	1053.0	535.0	852.0	783.0	266.0	333.0	872.3

Table 21 Comparison of Data Generated by EPA and EC

PAH ANALYSIS (XAD tubes*, µg/g), Sample collected June 05, 1991

	CRUDE		RESIDUE	
	EC	REAC	EC	REAC
Naphthalene	229	675	15	20
2-Methylnaphthalene	22	601		LDL
1-Methylnaphthalene	57	462		LDL
Biphenyl	81	122		LDL
2,6 -Dimethylnaphthalene	379	610	12	7
Acenaphthalene	7	LDL		21
Acenaphthene	23	LDL	22	LDL
Fluorene	56	74	82	LDL
Phenanthrene	128	217		78
Fluoranthene	3	LDL	22	21
Pyrene	7	LDL	29	45
Benz(a)anthracene	4	LDL		LDL
Chrysene	25	LDL		LDL
Benzo(k)fluoranthene	7	LDL		LDL
Benzo(e)pyrene	LDL	LDL		LDL
Benzo(a)pyrene	44	LDL		62
Indenol(1,2,3-cd)pyrene	LDL	LDL		LDL
Dibenz(a,h)anthracene	LDL	LDL		LDL
Benzo(g,h,i)perylene	LDL	LDL		LDL

* Samples taken by different samplers at same location

Table 22 Comparison of VOC Data Generated by EPA and EC

VOC ANALYSIS (charcoal tubes*, ug/m³), Sample collected May 31, 1991

	Downwind 100'		Downwind 200'	
Sample Number	5894B	5895B	5893B	5892B
	EC	REAC	EC	REAC
1,1,1-Trichloroethane	LDL	LDL	26	LDL
Benzene	47	43	1879	2784
Carbontetrachloride	LDL	LDL	658	1614
Cyclohexene	LDL	LDL	21	719
1,2-Dichloropropane	LDL	LDL	LDL	LDL
Trichloroethene	LDL	LDL	LDL	LDL
Heptane	53	22	2311	1249
1,2-Dioxane	LDL	LDL	LDL	LDL
Methylcyclohexane	16	LDL	774	51
MIKB	LDL	LDL	LDL	LDL
Toluene	337	107	3826	5876
Octane	42	15	1332	464
Tetrachloroethene	LDL	LDL	11	LDL
Chlorobenzene	LDL	LDL	LDL	LDL
Ethylbenzene	16	55	700	670
p-Xylene	132	60	926	2248
Bromoform	LDL	LDL	LDL	LDL
Styrene	LDL	LDL	5	LDL
o-Xylene	58	29	911	912
Nonene	LDL	LDL	LDL	LDL
Nonane	16	18	795	245
1,1,2,2-Tetrachloroethane	LDL	LDL	LDL	LDL
Cumene	LDL	8	142	109
Mesitylene	216	9	100	297
alpha-Methylstyrene	LDL	LDL	LDL	LDL
Decene	LDL	LDL	5	LDL
Decane	53	LDL	395	130

* Samples taken by different samplers at same location

Table 23 Comparison of VOC Data Generated by EPA and EC

VOC ANALYSIS (charcoal tubes*, µg/m³), Sample collected May 23, 1991

	Downwind 100'		Downwind 200'	
	EC	REAC	EC	REAC
1,1,1-Trichloroethane	0	0	0	0
Benzene	146	83	92	63
Carbon tetrachloride	0	0	0	0
Cyclohexene	0	66	0	45
1,2-Dichloropropane	0	0	0	0
Trichloroethene	0	0	0	0
Heptane	246	155	131	108
1,2-Dioxane	0	0	0	0
Methylcyclohexane	146	155	69	93
MIKB	0	0	0	0
Toluene	677	129	500	160
Octane	0	74	39	48
Tetrachloroethene	0	0	0	0
Chlorobenzene	0	0	0	0
Ethylbenzene	39	20	31	27
p-Xylene	362	101	277	143
Bromoform	0	0	0	0
Styrene	0	0	0	0
o-Xylene	39	31	31	42
Nonene	0	0	0	0
Nonane	62	43	54	29
1,1,2,2-Tetrachloroethane	0	0	0	0
Cumene	0	0	0	0
Mesitylene	308	13	246	17
alpha-Methylstyrene	0	0	0	0
Decene	0	0	0	0
Decane	31	22	23	51

* Samples taken by different samplers at same location

Table 24 PAH Analysis of The Starting Crude Oil

PAH ANALYSIS IN CRUDE OIL (µg/g)

day	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/dy
Naphthalene	423.50	398.00	401.50	416.50	402.50	408.40
2-Methylnaphthalene	749.50	714.00	730.50	754.00	733.00	736.20
1-Methylnaphthalene	516.50	496.00	503.50	525.50	506.50	509.60
Biphenyl	138.00	134.00	134.00	140.50	137.50	136.80
2,6 -Dimethylnaphthaler	629.00	627.00	620.00	585.00	581.00	608.40
Dimethylnaphthalenes	1567.00	1564.00	1537.00	1452.00	1441.00	1512.20
2,3,5-Trimethylnaphthale	302.00	303.00	302.00	287.00	284.00	295.60
Trimethylnaphthalenes	979.00	978.00	970.00	919.00	912.00	951.60
2 Rings total	5304.50	5214.00	5198.50	5079.50	4997.50	5158.80
Acenaphthylene	22.85	21.45	22.20	23.05	22.10	22.33
Acenaphthene	12.35	12.05	14.25	12.40	12.05	12.62
Fluorene	56.50	54.00	53.50	58.00	54.50	55.30
Phenanthrene	93.00	90.00	92.00	96.00	90.50	92.30
Anthracene	1.30	1.05	1.35	1.45	1.60	1.35
1-Methylphenanthrene	69.30	70.40	65.70	68.90	60.40	66.94
Methylphenanthrenes	275.00	277.00	273.00	265.00	261.00	270.20
3 Rings total	530.30	525.95	522.00	524.80	502.15	521.04
Fluoranthene	10.90	10.50	10.70	11.40	10.80	10.86
Pyrene	5.45	5.25	5.45	5.85	5.70	5.54
Benz(a)anthracene	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Chrysene	14.65	13.95	14.00	14.30	13.50	14.08
4 Rings total	31.00	29.70	30.15	31.55	30.00	30.48
Benzo(b,k) fluoranthene	5.95	6.05	5.55	7.00	5.80	6.07
Benzo(e)pyrene	2.25	2.10	2.25	2.35	2.15	2.22
Benzo(a)pyrene	5.20	4.55	4.45	5.35	5.15	4.94
5 Rings total	13.40	12.70	12.25	14.70	13.10	13.23
Perylene	41.00	42.45	43.05	46.70	45.80	43.80
Indenol(1,2,3-cd)pyrene	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Dibenz(a,h)anthracene	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Benzo(g,h,i)perylene	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
6 Rings total	41.00	42.45	43.05	46.70	45.80	43.80
TOTAL PAH IN CRUDE OIL	5920.20	5824.80	5805.95	5697.25	5588.55	5767.35

Detection Limit = 1 ppm for a 20-mg aliquot

Table 25 PAH Analyses of The Burn Residue

PAH ANALYSIS IN OIL RESIDUE (µg/g)

	5-Nov	6-Nov	7-Nov	7-Nov reburn	7-Nov tank bot.	9-Nov	10-Nov	10-Nov reburn	Ave/dy
Naphthalene	4.00	11.00	5.00	2.00	5.00	6.00	3.00	2.00	4.75
2-Methylnaphthalene	4.00	25.00	5.00	2.00	5.00	5.00	2.00	1.00	6.13
1-Methylnaphthalene	4.00	17.00	4.00	1.00	4.00	4.00	1.00	1.00	4.50
Biphenyl	1.00	5.00	2.00	1.00	1.00	1.00	1.00	1.00	1.63
2,6 -Dimethylnaphthalene	5.00	25.00	7.00	1.00	5.00	6.00	1.00	1.00	6.38
Dimethylnaphthalenes	15.00	69.00	24.00	4.00	16.00	20.00	4.00	5.00	19.63
2,3,5-Trimethylnaphthalen	9.00	17.00	12.00	2.00	7.00	10.00	3.00	3.00	7.88
Trimethylnaphthalenes	25.00	59.00	35.00	5.00	20.00	29.00	9.00	7.00	23.63
2 Rings total	67.00	228.00	94.00	18.00	63.00	81.00	24.00	21.00	74.50
Acenaphthylene	6.00	5.00	8.00	4.00	5.00	9.00	5.00	3.00	5.63
Acenaphthene	1.00	1.00	1.00	1.00	2.00	1.00	<1.00	1.00	1.14
Fluorene	5.00	5.00	6.00	3.00	4.00	6.00	3.00	2.00	4.25
Phenanthrene	26.00	20.00	37.00	13.00	20.00	32.00	19.00	14.00	22.63
Anthracene	4.00	4.00	8.00	4.00	5.00	6.00	5.00	3.00	4.88
1-Methylphenanthrene	55.00	27.00	63.00	17.00	38.00	57.00	38.00	27.00	40.25
Methylphenanthrenes	56.00	35.00	81.00	22.00	56.00	72.00	43.00	30.00	49.38
3 Rings total	153.00	97.00	204.00	64.00	130.00	183.00	113.00	80.00	128.00
Fluoranthene	12.00	11.00	17.00	10.00	10.00	13.00	10.00	10.00	11.63
Pyrene	18.00	19.00	29.00	17.00	16.00	21.00	18.00	15.00	19.13
Benz(a)anthracene	*	*	*	*	*	*	*	*	*
Chrysene	36.00	23.00	34.00	20.00	21.00	27.00	27.00	20.00	26.00
4 Rings total	66.00	53.00	80.00	47.00	47.00	61.00	55.00	45.00	56.75
Benzo(b,k) fluoranthene	20.00	19.00	25.00	17.00	14.00	16.00	16.00	16.00	17.88
Benzo(e)pyrene	10.00	13.00	19.00	12.00	11.00	15.00	12.00	11.00	12.88
Benzo(a)pyrene	14.00	18.00	24.00	16.00	13.00	16.00	14.00	14.00	16.13
5 Rings total	44.00	50.00	68.00	45.00	38.00	47.00	42.00	41.00	46.88
Perylene	85.00	70.00	129.00	61.00	64.00	111.00	84.00	73.00	84.63
Indenol(1,2,3-cd)pyrene	8.00	18.00	21.00	15.00	12.00	12.00	12.00	13.00	13.88
Dibenz(a,h)anthracene	5.00	11.00	12.00	10.00	9.00	8.00	8.00	8.00	8.88
Benzo(g,h,i)perylene	11.00	24.00	27.00	22.00	16.00	16.00	15.00	16.00	18.38
6 Rings total	109.00	123.00	189.00	108.00	101.00	147.00	119.00	110.00	125.75
TOTAL PAH IN OIL RESIDUE	439.00	551.00	635.00	282.00	379.00	519.00	353.00	297.00	431.88
Surrogate Recovery, %									
d10-Acenaphthene	74	126	122	117	119	117	132	129	
d10-Phenanthrene	83	136	135	125	128	127	140	136	
d12-Benz(a)anthracene	104	166	185	154	158	169	180	171	
d12-Perylene	106	179	200	165	161	170	180	169	

Method Detection Limit = 1 ppm for a 25-gm aliquot

* Benz(a)anthracene unresolved from Chrysene

Table 26 **PAH Analyses - Upwind Station**

PAH ANALYSIS / AIR / UPWIND (µg/m³) (filter + PUF)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/Dy
Naphthalene	0.01	0.03	0.05	0.01	0.09	0.01	0.03
2-Methylnaphthalene	<0.01	0.03	0.04	0.01	0.04	0.01	0.03
1-Methylnaphthalene	<0.01	0.02	0.02	<0.01	0.02	0.01	0.02
Biphenyl	0.04	0.06	0.05	0.03	0.04	0.07	0.05
2,6 -Dimethylnaphthalene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dimethylnaphthalenes	<0.01	<0.01	0.14	0.04	<0.01	<0.01	0.09
2,3,5-Trimethylnaphthalen	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Trimethylnaphthalenes	<0.01	0.05	<0.01	0.03	0.02	0.03	0.03
2 Rings total	0.05	0.19	0.30	0.12	0.21	0.13	0.17
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	<0.01	0.02	0.02	<0.01	0.01	0.01	0.02
Fluorene	<0.01	0.02	0.02	<0.01	0.01	0.01	0.02
Phenanthrene	<0.01	0.03	0.03	0.03	0.02	<0.01	0.03
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
1-Methylphenanthrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methylphenanthrenes	<0.01	0.01	0.02	0.01	0.01	0.01	0.01
3 Rings total	<0.01	0.08	0.09	0.04	0.05	0.04	0.06
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4 Rings total	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02
Benzo(b,k) fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(e)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5 Rings total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Perylene	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	
Indenol(1,2,3-cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
6 Rings total	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.04
TOTAL PAH / UPWIND	0.05	0.27	0.43	0.16	0.26	0.19	0.23
Surrogate Recovery, %							
d10-Acenaphthene	88	84	97	74	99	84	
d10-Phenanthrene	115	105	119	116	143	127	
d12-Benz(a)anthracene	90	90	98	98	108	97	
d12-Perylene	80	79	53	84	101	102	

Method Detection Limit = 0.01 µg/m³ assuming a sample volume of 10 cu m

Table 27 **PAH Analyses - Downwind 1 Station**

PAH ANALYSIS / AIR / DOWNWIND 1 (µg/m³) (filter + PUF)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/Dy
Naphthalene	0.09	0.72	0.55	0.10	0.24	0.10	0.30
2-Methylnaphthalene	0.17	0.94	0.45	0.14	0.53	0.14	0.40
1-Methylnaphthalene	0.17	0.73	0.37	0.11	0.42	0.12	0.32
Biphenyl	0.30	0.58	0.28	0.19	0.26	0.28	0.31
2,6 -Dimethylnaphthaler	0.01	0.04	0.22	0.14	0.06	0.02	0.08
Dimethylnaphthalenes	0.03	0.09	0.85	0.42	0.18	0.04	0.27
2,3,5-Trimethylnaphthale	0.02	0.14	0.06	0.05	0.38	0.06	0.12
Trimethylnaphthalenes	0.17	0.44	0.29	0.20	1.21	0.34	0.44
2 Rings total	0.96	3.68	3.07	1.34	3.28	1.11	2.24
Acenaphthylene	2.63	1.21	0.78	0.53	0.34	0.47	0.99
Acenaphthene	0.05	0.03	0.03	0.02	0.06	0.03	0.04
Fluorene	0.53	0.20	0.15	0.12	0.19	0.12	0.22
Phenanthrene	2.17	0.63	0.57	0.65	0.38	0.32	0.79
Anthracene	0.49	0.10	0.09	0.08	0.04	0.05	0.14
1-Methylphenanthrene	0.09	0.07	0.03	0.02	0.13	0.03	0.06
Methylphenanthrenes	0.30	0.08	0.11	0.10	0.40	0.10	0.18
3 Rings total	6.26	2.32	1.76	1.52	1.54	1.12	2.42
Fluoranthene	1.15	0.32	0.31	0.42	0.07	0.12	0.40
Pyrene	1.10	0.33	0.32	0.43	0.06	0.12	0.39
Benz(a)anthracene	0.41	0.05	0.06	0.06	0.01	0.03	0.10
Chrysene	0.41	0.06	0.07	0.08	0.02	0.04	0.11
4 Rings total	3.07	0.77	0.76	0.99	0.14	0.30	1.00
Benzo(b,k) fluoranthene	0.85	0.15	0.14	0.15	0.01	0.06	0.23
Benzo(e)pyrene	0.38	0.05	0.04	<0.01	<0.01	<0.01	0.16
Benzo(a)pyrene	0.60	0.08	0.07	<0.01	<0.01	<0.01	0.25
5 Rings total	1.83	0.28	0.25	0.15	0.01	0.06	0.43
Perylene	0.09	0.02	0.02	0.02	0.01	0.01	0.03
Indenol(1,2,3-cd)pyrene	0.41	0.08	0.07	0.07	<0.01	0.03	0.13
Dibenz(a,h)anthracene	0.10	0.01	<0.01	<0.01	<0.01	0.01	0.04
Benzo(g,h,i)perylene	0.43	0.11	0.09	0.09	0.01	0.03	0.13
6 Rings total	1.03	0.23	0.17	0.18	0.02	0.08	0.29
TOTAL PAH / DWD 1	13.14	7.28	6.02	4.18	4.99	2.67	6.38
Surrogate Recovery, %							
d10-Acenaphthene	42	85	77	53	98	108	
d10-Phenanthrene	72	106	111	118	136	129	
d12-Benz(a)anthracene	93	104	115	117	112	110	
d12-Perylene	90	111	100	103	103	117	

Method Detection Limit = 0.01 µg/m³ assuming a sample volume of 10 cu m

Table 28 **PAH Analyses - Downwind Station 2**

PAH ANALYSIS / AIR / DOWNWIND 2 (µg/m³) (filter + PUF)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/Dy
Naphthalene	0.08	1.04	0.23	0.04	0.16	0.05	0.27
2-Methylnaphthalene	0.12	1.27	0.22	0.11	0.24	0.04	0.33
1-Methylnaphthalene	0.13	0.94	0.17	0.09	0.18	0.03	0.26
Biphenyl	0.40	0.62	0.11	0.06	0.16	0.19	0.26
2,6 -Dimethylnaphthale	0.01	0.06	0.11	0.07	<0.01	<0.01	0.06
Dimethylnaphthalenes	0.03	0.11	0.41	0.22	0.11	0.02	0.15
2,3,5-Trimethylnaphthal	0.05	0.19	0.04	0.02	0.18	0.02	0.08
Trimethylnaphthalenes	0.14	0.61	0.19	0.08	0.55	0.07	0.27
2 Rings total	0.97	4.83	1.48	0.69	1.58	0.42	1.66
Acenaphthylene	3.50	1.15	0.23	0.12	0.15	0.08	0.87
Acenaphthene	0.07	0.04	0.02	<0.01	0.02	0.01	0.03
Fluorene	0.65	0.20	0.07	0.03	0.09	0.02	0.18
Phenanthrene	2.19	0.60	0.24	0.16	0.17	0.07	0.57
Anthracene	0.50	0.09	0.03	0.02	0.02	0.01	0.11
1-Methylphenanthrene	0.09	0.07	0.03	<0.01	0.05	0.01	0.05
Methylphenanthrenes	0.24	0.15	0.06	0.04	0.18	0.02	0.11
3 Rings total	7.24	2.30	0.68	0.36	0.67	0.23	1.91
Fluoranthene	1.11	0.29	0.10	0.09	0.03	0.03	0.27
Pyrene	1.08	0.30	0.09	0.09	0.02	0.02	0.27
Benz(a)anthracene	0.38	0.05	0.02	0.01	<0.01	<0.01	0.12
Chrysene	0.40	0.06	0.02	0.01	0.01	0.01	0.08
4 Rings total	2.97	0.70	0.23	0.20	0.06	0.06	0.70
Benzo(b,k) fluoranthen	0.79	0.13	0.04	0.03	<0.01	0.01	0.20
Benzo(e)pyrene	0.29	0.06	0.01	0.01	<0.01	<0.01	0.09
Benzo(a)pyrene	0.43	0.08	0.02	0.02	<0.01	<0.01	0.14
5 Rings total	1.51	0.27	0.07	0.06	<0.01	0.01	0.38
Perylene	0.08	0.02	<0.01	<0.01	0.01	<0.01	0.04
Indenol(1,2,3-cd)pyren	0.33	0.06	0.02	0.01	<0.01	<0.01	0.11
Dibenz(a,h)anthracene	0.08	0.01	<0.01	<0.01	<0.01	<0.01	0.04
Benzo(g,h,i)perylene	0.35	0.09	0.03	0.02	<0.01	<0.01	0.12
6 Rings total	0.83	0.19	0.05	0.04	0.01	<0.01	0.22
TOTAL PAH / DWD 2	13.52	8.29	2.50	1.35	2.32	0.71	4.78
Surrogate Recovery, %							
d10-Acenaphthene	67	88	74	55	108	91	
d10-Phenanthrene	87	108	114	118	127	134	
d12-Benz(a)anthracen	106	109	119	112	113	89	
d12-Perylene	101	111	118	101	135	91	

Method Detection Limit = 0.01 µg/m³ assuming a sample volume of 10 cu m

Table 29

PAH Analyses at Downwind Station 3

PAH ANALYSIS / AIR / DOWNWIND 3 (µg/m³) (filter + PUF)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/Dy
Naphthalene	0.05	0.43	0.36	0.03	0.02	0.03	0.15
2-Methylnaphthalene	0.05	0.53	0.21	0.08	0.02	0.02	0.15
1-Methylnaphthalene	0.05	0.38	0.15	0.06	0.01	0.02	0.11
Biphenyl	0.18	0.28	0.11	0.04	0.09	0.06	0.13
2,6 -Dimethylnaphthalene	0.01	0.02	0.11	0.06	<0.01	<0.01	0.05
Dimethylnaphthalenes	0.01	0.05	0.29	0.13	0.01	0.01	0.08
2,3,5-Trimethylnaphthalen	0.03	0.07	0.03	0.01	0.01	<0.01	0.03
Trimethylnaphthalenes	0.07	0.23	0.13	0.06	0.05	0.05	0.10
2 Rings total	0.45	1.98	1.39	0.47	0.20	0.19	0.78
Acenaphthylene	1.20	0.28	0.21	0.05	<0.01	0.02	0.35
Acenaphthene	0.03	0.03	0.02	<0.01	0.01	<0.01	0.02
Fluorene	0.24	0.07	0.05	0.02	0.01	0.01	0.07
Phenanthrene	0.82	0.19	<0.01	<0.01	<0.01	<0.01	0.50
Anthracene	0.17	0.03	0.02	<0.01	<0.01	<0.01	0.07
1-Methylphenanthrene	0.05	0.02	0.02	<0.01	<0.01	<0.01	0.03
Methylphenanthrenes	0.12	0.07	0.04	0.03	0.01	0.02	0.05
3 Rings total	2.63	0.69	0.36	0.09	0.03	0.06	0.64
Fluoranthene	0.39	0.08	0.10	0.05	<0.01	0.01	0.12
Pyrene	0.36	0.07	0.10	0.04	<0.01	0.01	0.12
Benz(a)anthracene	0.10	0.01	0.02	<0.01	<0.01	<0.01	0.04
Chrysene	0.12	0.02	0.02	<0.01	<0.01	<0.01	0.05
4 Rings total	0.97	0.18	0.25	0.09	<0.01	0.02	0.30
Benzo(b,k) fluoranthene	0.22	0.03	0.04	0.01	<0.01	<0.01	0.07
Benzo(e)pyrene	0.09	0.01	0.01	0.25	<0.01	<0.01	0.09
Benzo(a)pyrene	0.10	0.02	0.02	0.05	<0.01	<0.01	0.05
5 Rings total	0.41	0.06	0.07	0.31	<0.01	<0.01	0.21
Perylene	0.02	<0.01	<0.01	0.08	<0.01	<0.01	0.05
Indenol(1,2,3-cd)pyrene	0.08	0.02	0.02	<0.01	<0.01	<0.01	0.04
Dibenz(a,h)anthracene	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Benzo(g,h,i)perylene	0.09	0.02	0.03	<0.01	<0.01	<0.01	0.05
6 Rings total	0.21	0.04	0.04	0.08	<0.01	<0.01	0.10
TOTAL PAH / DWD 3	4.67	2.95	2.10	1.04	0.23	0.27	1.88
Surrogate Recovery, %							
d10-Acenaphthene	61	87	70	47	107	91	
d10-Phenanthrene	87	111	114	105	143	134	
d12-Benz(a)anthracene	86	106	101	92	130	93	
d12-Perylene	80	122	93	71	133	86	

Method Detection Limit = 0.01 µg/m³ assuming a sample volume of 10 cu m

Table 30 **PAH Analyses - Separate PUF and Filter Analyses - Downwind 1**

PAH ANALYSIS / AIR / DOWNWIND 1 (µg/m³) (filter + PUF/XAD)

	3-Nov	3-Nov	5-Nov	5-Nov	6-Nov	6-Nov	7-Nov	7-Nov	9-Nov	9-Nov	10-Nov	10-Nov	Ave/Dy	Ave/Dy
	Filter	PUF/XAD	Filter	PUF/XAD	Filter	PUF/XAD	Filter	PUF/XAD	Filter	PUF/XAD	Filter	PUF/XAD	Filter	PUF/XAD
Naphthalene	0.02	7.22	0.03	3.17	0.01	1.18	0.04	1.10	0.04	0.90	0.02	1.31	0.03	2.48
2-Methylnaphthalene	0.01	1.54	0.01	1.33	<0.01	0.40	<0.01	0.57	0.02	0.55	<0.01	0.44	0.02	0.81
1-Methylnaphthalene	<0.01	1.04	<0.01	0.86	<0.01	0.26	<0.01	0.34	0.01	0.34	<0.01	0.29	0.01	0.52
Biphenyl	0.04	0.72	0.04	0.28	0.02	0.20	0.02	0.21	0.08	0.30	0.02	0.23	0.04	0.32
2,6 -Dimethylnaphthalene	<0.01	0.34	<0.01	0.43	<0.01	0.12	<0.01	0.19	<0.01	0.30	<0.01	0.15	<0.01	0.26
Dimethylnaphthalenes	0.01	0.74	<0.01	0.89	<0.01	0.24	<0.01	0.38	0.02	0.97	<0.01	0.33	0.01	0.59
2,3,5-Trimethylnaphthalene	<0.01	0.09	<0.01	0.14	<0.01	0.04	<0.01	0.06	<0.01	0.23	<0.01	0.07	<0.01	0.11
Trimethylnaphthalenes	<0.01	0.15	<0.01	0.28	<0.01	0.08	<0.01	0.11	0.01	0.38	<0.01	0.13	0.01	0.19
2 Rings total	0.08	11.84	0.08	7.38	0.04	2.52	0.06	2.95	0.19	3.99	0.04	2.95	0.08	5.27
Acenaphthylene	<0.01	4.15	0.01	0.83	<0.01	0.20	0.01	0.36	<0.01	0.14	<0.01	0.22	0.01	0.98
Acenaphthene	<0.01	0.09	<0.01	0.03	<0.01	0.01	<0.01	0.01	<0.01	0.03	<0.01	0.01	<0.01	0.03
Fluorene	<0.01	0.88	<0.01	0.15	<0.01	0.05	<0.01	0.08	<0.01	0.17	<0.01	0.06	<0.01	0.23
Phenanthrene	0.05	2.99	0.05	0.48	0.02	0.14	0.11	0.26	0.04	0.29	0.01	0.16	0.05	0.72
Anthracene	0.01	0.66	0.01	0.07	<0.01	0.02	0.02	0.02	<0.01	0.03	<0.01	0.03	0.01	0.14
1-Methylphenanthrene	<0.01	0.10	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.08	<0.01	0.02	0.02	0.04
Methylphenanthrenes	0.03	0.34	0.06	0.07	0.02	0.02	0.03	0.04	0.04	0.30	<0.01	0.06	0.04	0.14
3 Rings total	0.09	9.21	0.17	1.64	0.05	0.44	0.18	0.79	0.10	1.03	0.01	0.56	0.10	2.28
Fluoranthene	0.57	1.34	0.24	0.12	0.08	0.02	0.26	0.02	0.04	0.04	0.01	0.05	0.20	0.26
Pyrene	0.66	1.18	0.29	0.09	0.09	0.02	0.26	0.01	0.03	0.03	0.02	0.05	0.22	0.23
Benz(a)anthracene	0.58	<0.01	0.06	<0.01	0.02	<0.01	0.04	<0.01	<0.01	<0.01	0.01	<0.01	0.14	<0.01
Chrysene	0.60	<0.01	0.07	<0.01	0.02	<0.01	0.05	<0.01	0.02	<0.01	0.02	<0.01	0.13	<0.01
4 Rings total	2.41	2.52	0.67	0.21	0.21	0.04	0.61	0.03	0.09	0.06	0.06	0.10	0.67	0.49
Benzo(b,k) fluoranthene	1.18	<0.01	0.19	<0.01	0.05	<0.01	0.10	<0.01	<0.01	<0.01	0.03	<0.01	0.31	<0.01
Benzo(e)pyrene	0.39	<0.01	0.06	<0.01	0.02	<0.01	0.04	<0.01	<0.01	<0.01	0.01	<0.01	0.10	<0.01
Benzo(a)pyrene	0.62	<0.01	0.10	<0.01	0.03	<0.01	0.06	<0.01	<0.01	<0.01	0.01	<0.01	0.16	<0.01
5 Rings total	2.19	<0.01	0.35	<0.01	0.10	<0.01	0.20	<0.01	<0.01	<0.01	0.06	<0.01	0.58	<0.01
Perylene	0.11	<0.01	0.03	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01
Indeno(1,2,3-cd)pyrene	0.46	<0.01	0.10	<0.01	0.02	<0.01	0.05	<0.01	<0.01	<0.01	0.01	<0.01	0.13	<0.01
Dibenz(a,h)anthracene	0.09	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01
Benzo(g,h,i)perylene	0.49	<0.01	0.14	<0.01	0.03	<0.01	0.06	<0.01	<0.01	<0.01	0.01	<0.01	0.15	<0.01
6 Rings total	1.16	<0.01	0.28	<0.01	0.06	<0.01	0.12	<0.01	<0.01	<0.01	0.03	<0.01	0.33	<0.01
TOTAL PAH / DWD 1	5.94	23.56	1.55	9.23	0.46	3.01	1.17	3.77	0.37	5.08	0.19	3.61	1.61	8.04
TL PAH / FLT+PUF/XAD		29.50		10.77		3.47		4.94		5.46		3.80		9.66
Surrogate Recovery, %														
d10-Acenaphthene	81	47	106	63	84	108	84	47	127	36	97	68		
d10-Phenanthrene	121	67	154	57	127	129	121	79	184	68	144	83		
d12-Benz(a)anthrac	103	89	110	76	97	110	100	69	94	74	79	105		
d12-Perylene	95	79	122	64	102	117	97	58	117	64	83	100		

Method Detection Limit = 0.01 µg/m³ assuming a sample volume of 10 cu m

Table 31 **PAH Analyses - Helicopter -1**

PAH ANALYSIS / HELI...ERT (µg/g) (150 ft)

	3-Nov Filter	3-Nov Wipe	5-Nov Filter	5-Nov Wipe	6-Nov Filter	7-Nov Filter	7-Nov Wipe	Ave/Dy Filter
Naphthalene	ND	21.56	ND	ND	ND	ND	ND	21.56
2-Methylnaphthalene	ND	4.20	ND	ND	ND	ND	ND	4.20
1-Methylnaphthalene	ND	2.40	ND	ND	ND	ND	ND	2.40
Biphenyl	ND	5.12	ND	ND	ND	ND	ND	5.12
2,6 -Dimethylnaphthal	ND	1.46	ND	ND	ND	ND	ND	1.46
Dimethylnaphthalenes	ND		ND	ND	ND	ND	ND	
2,3,5 Trimethylnaphthc	ND	0.86	ND	ND	ND	ND	ND	0.86
Trimethylnaphthalenes	ND		ND	ND	ND	ND	ND	
2 Rings total		35.60						35.60
Acenaphthylene	ND	19.66	ND	ND	ND	ND	ND	19.66
Acenaphthene	ND	2.08	ND	ND	ND	ND	ND	2.08
Fluorene	ND	6.99	ND	ND	ND	ND	ND	6.99
Phenanthrene	ND	71.92	ND	ND	ND	ND	ND	71.92
Anthracene	ND	10.21	ND	ND	ND	ND	ND	10.21
1-Methylphenanthrene	ND		ND	ND	ND	ND	ND	
Methylphenanthrenes	ND	1.54	ND	ND	ND	ND	ND	1.54
3 Rings total		112.41						112.41
Fluoranthene	ND	44.28	ND	ND	ND	ND	ND	44.28
Pyrene	ND	46.91	ND	ND	ND	ND	ND	46.91
Benz(a)anthracene	ND	4.38	ND	ND	ND	ND	ND	4.38
Chrysene	ND	6.59	ND	ND	ND	ND	ND	6.59
4 Rings total		102.17						102.17
Benzo(b,k) fluoranther	ND	7.46	ND	ND	ND	ND	ND	7.46
Benzo(e)pyrene	ND	3.74	ND	ND	ND	ND	ND	3.74
Benzo(a)pyrene	ND	4.92	ND	ND	ND	ND	ND	4.92
5 Rings total		16.12						16.12
Perylene	ND	2.15	ND	ND	ND	ND	ND	2.15
Indenol(1,2,3-cd)pyrer	ND	1.41	ND	ND	ND	ND	ND	1.41
Dibenz(a,h)anthracen	ND	<0.5	ND	ND	ND	ND	ND	
Benzo(g,h,i)perylene	ND	3.38	ND	ND	ND	ND	ND	3.38
6 Rings total		6.93						6.93
TL PAH / HELI / ERT TOTAL FILTER+WIPE		273.23						273.23
Surrogate Recovery, %								
d10-Acenaphthene	77	77	85	39	29	87	64	
d10-Phenanthrene	78	78	85	58	41	88	77	
d12-Benz(a)anthracen	84	84	88	62	47	72	83	
d12-Perylene	61	61	40	29	25	38	66	

ND denotes non detectable because of non-measurable sample weight

Table 32 PAH Analyses - Helicopter 2

PAH ANALYSIS / HELI...EC (µg/g) (500ft)

	3-Nov Wipe	5-Nov Filter	5-Nov Wipe	6-Nov Filter	6-Nov Wipe	7-Nov Filter	9-Nov Wipe	10-Nov Wipe	Ave/Dy Wipe
Naphthaler lost	14.00	ND	13.20	ND	7.65	ND	2.04	3.20	8.02
2-Methylnaphthalene	4.89	ND	3.55	ND	1.67	ND	0.67	0.70	2.30
1-Methylnaphthalene	2.58	ND	2.07	ND	1.00	ND	0.34	0.35	1.27
Biphenyl	3.99	ND	31.81	ND	1.30	ND	3.63	1.84	8.51
2,6 -Dimethylnaphthaler	1.50	ND	1.35	ND	0.69	ND	0.32	0.19	0.81
Dimethylnaphthalenes		ND		ND		ND			
2,3,5-Trimethylnaphthale	<0.50	ND	0.88	ND	1.81	ND	<0.50	<0.50	1.35
Trimethylnaphthalenes		ND		ND		ND			
2 Rings total	26.96		52.85	0.00	14.13		7.00	6.28	21.45
Acenaphthylene	5.35	ND	5.44	ND	2.37	ND	0.71	2.19	3.21
Acenaphthene	<0.50	ND	0.79	ND	0.59	ND	<0.50	<0.50	0.69
Fluorene	2.00	ND	2.54	ND	1.06	ND	0.38	1.01	1.40
Phenanthrene	22.16	ND	19.88	ND	8.38	ND	4.58	31.76	17.35
Anthracene	3.00	ND	2.10	ND	0.86	ND	0.62	6.98	2.71
1-Methylphenanthrene		ND		ND		ND			
Methylphenanthrenes	1.78	ND	1.41	ND	1.34	ND	0.60	2.25	1.48
3 Rings total	34.30		32.17		14.60		6.89	44.21	26.43
Fluoranthene	17.37	ND	11.31	ND	4.10	ND	3.23	36.73	14.55
Pyrene	5.85	ND	11.48	ND	3.71	ND	3.41	37.08	12.30
Benz(a)anthracene	<0.5	ND	2.74	ND	1.10	ND	1.40	7.85	3.27
Chrysene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	8.46	8.46
4 Rings total	23.22		25.53		8.91		8.05	90.12	31.17
Benzo(b,k) fluoranthene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	12.86	12.86
Benzo(e)pyrene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	5.14	5.14
Benzo(a)pyrene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	9.33	9.33
5 Rings total	<0.50		<0.50		<0.50		<0.50	27.33	27.33
Perylene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	1.92	1.92
Indenol(1,2,3-cd)pyrene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	11.61	11.61
Dibenz(a,h)anthracene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	1.10	1.10
Benzo(g,h,i)perylene	<0.5	ND	<0.5	ND	<0.5	ND	<0.5	8.73	8.73
6 Rings total	<0.50		<0.50		<0.50		<0.50	23	23.35
TOTAL PAH / HELI...EC	159.08		178.23		66.76		36.94	293.67	146.93
TOTAL FILTER+WIPE									
Surrogate Recovery, %									
d10-Acenaphthene	73	57	40	83	76	36	50	51	
d10-Phenanthrene	78	79	61	91	76	69	62	62	
d12-Benz(a)anthracene	74	70	69	78	73	58	64	82	
d12-Perylene	49	42	41	44	43	<0.5	58	74	

Method Detection Limit = 0.5 ppm assuming sample wt = 20mg

ND denotes non detectable because of non-measurable sample weight

Table 33 **PAH Analyses - Blimp at Downwind 2c**

PAH ANALYSIS / Blimp / Downwind 2-C (µg/m³)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/Dy
Naphthalene	0.38	1.40	0.87	1.12	0.57	0.61	0.83
2-Methylnaphthalene	0.53	0.67	0.85	1.29	1.15	0.74	0.87
1-Methylnaphthalene	0.22	0.33	0.37	0.59	0.54	0.35	0.40
Biphenyl	0.44	1.00	0.63	0.82	1.14	1.00	0.84
2,6 -Dimethylnaphthalen	<0.10	<0.10	0.29	0.49	0.65	0.34	0.44
Dimethylnaphthalenes	0.17	<0.10	0.56	0.89	1.11	0.58	0.66
2,3,5-Trimethylnaphthale	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Trimethylnaphthalenes	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
2 Rings total	1.74	3.40	3.57	5.20	5.16	3.62	3.78
Acenaphthylene	0.19	0.43	1.13	1.19	0.29	0.73	0.66
Acenaphthene	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Fluorene	0.18	<0.10	0.26	0.21	<0.10	0.38	0.26
Phenanthrene	6.64	0.85	2.51	2.21	0.67	4.61	2.92
Anthracene	1.32	0.12	0.33	0.28	<0.10	0.64	0.54
1-Methylphenanthrene	0.24	<0.10	0.20	0.18	<0.10	0.21	0.21
Methylphenanthrenes	0.51	<0.10	0.20	0.17	<0.10	0.21	0.27
3 Rings total	9.08	1.40	4.63	4.24	0.96	6.78	4.52
Fluoranthene	7.97	0.72	1.98	1.78	0.74	3.54	2.79
Pyrene	8.11	0.70	1.98	1.79	0.56	3.59	2.79
Benz(a)anthracene	1.82	<0.10	0.17	0.18	<0.10	0.40	0.64
Chrysene	2.10	0.10	0.17	0.17	<0.10	0.43	0.59
4 Rings total	20.00	1.52	4.30	3.92	1.30	7.96	6.50
Benzo(b,k) fluoranthene	3.40	0.13	0.29	0.35	<0.10	0.80	0.99
Benzo(e)pyrene	1.30	<0.10	0.16	0.28	<0.10	0.50	0.56
Benzo(a)pyrene	2.09	<0.10	0.18	0.33	<0.10	0.64	0.81
5 Rings total	6.79	0.13	0.63	0.96	<0.10	1.94	2.09
Perylene	0.58	<0.10	<0.10	0.16	<0.10	0.20	0.31
Indenol(1,2,3-cd)pyrene	1.43	<0.10	<0.10	0.19	<0.10	0.41	0.68
Dibenz(a,h)anthracene	0.29	<0.10	<0.10	<0.10	<0.10	<0.10	0.29
Benzo(g,h,i)perylene	1.86	<0.10	0.15	0.30	<0.10	0.59	0.73
6 Rings total	4.16	<0.10	0.15	0.65	<0.10	1.20	1.54
TOTAL PAH / BLIMP 2C	80.71	9.29	21.88	23.33	10.02	38.04	30.55

Surrogate Recovery, %						
d10-Acenaphthene	54	50	78	67	86	88
d10-Phenanthrene	74	72	115	100	112	124
d12-Benz(a)anthracene	80	74	67	69	71	77
d12-Perylene	72	60	51	61	61	67

Method Detection Limit = 0.1 µg/m³ assuming sample volume of 100L

Table 34 PAH Analyses - Blimp At Downwind 2-d

PAH ANALYSIS / Blimp / Downwind 2-D (µg/m³)

	7-Nov	9-Nov	10-Nov	Ave/Dy
Naphthalene	1.38	0.20	0.22	0.60
2-Methylnaphthalene	1.19	0.21	0.18	0.53
1-Methylnaphthalene	0.52	<0.10	<0.10	0.52
Biphenyl	1.61	1.83	2.03	1.82
2,6 -Dimethylnaphthalene	0.54	0.23	0.24	0.34
Dimethylnaphthalenes	1.27	0.54	0.54	0.78
2,3,5-Trimethylnaphthalene	<0.10	<0.10	<0.10	<0.10
Trimethylnaphthalenes	<0.10	<0.10	0.31	0.31
2 Rings total	6.51	3.01	3.52	4.35
Acenaphthylene	1.06	0.13	0.21	0.47
Acenaphthene	<0.10	<0.10	<0.10	<0.10
Fluorene	0.12	<0.10	0.20	0.16
Phenanthrene	1.86	0.48	0.35	0.90
Anthracene	0.19	<0.10	<0.10	0.19
1-Methylphenanthrene	0.14	<0.10	<0.10	0.14
Methylphenanthrenes	0.11	<0.10	0.30	0.21
3 Rings total	3.48	0.61	1.06	1.72
Fluoranthene	1.33	0.47	2.20	1.33
Pyrene	1.28	0.40	2.21	1.30
Benz(a)anthracene	0.22	<0.10	0.41	0.32
Chrysene	0.23	<0.10	0.53	0.38
4 Rings total	3.06	0.87	5.35	3.09
Benzo(b,k) fluoranthene	0.46	<0.10	0.86	0.66
Benzo(e)pyrene	0.15	<0.10	0.31	0.23
Benzo(a)pyrene	0.19	<0.10	0.34	0.27
5 Rings total	0.80	<0.10	1.51	1.16
Perylene	<0.10	<0.10	<0.10	<0.10
Indenol(1,2,3-cd)pyrene	0.14	<0.10	0.40	0.27
Dibenz(a,h)anthracene	<0.10	<0.10	<0.10	<0.10
Benzo(g,h,i)perylene	0.20	<0.10	0.54	0.37
6 Rings total	0.34	<0.10	0.94	0.64
TOTAL PAH / BLIMP 2D	14.19	4.49	12.38	10.35

Surrogate Recovery, %			
d10-Acenaphthene	94	54	89
d10-Phenanthrene	139	128	146
d12-Benz(a)anthracene	109	110	113
d12-Perylene	100	101	105

Method Detection Limit = 0.1 µg/m³ assuming sample volume of 100L

Table 35 **Dioxin and Furan Analyses - Downwind 1**

DIOXIN ANALYSIS / AIR / DOWNWIND 1 (pg/m³)

	6-Nov	7-Nov	Ave/Dy
CHLORODIBENZO p-DIOXIN			
TCDD	<0.5	<0.5	<0.5
P5CDD	<0.5	<0.5	<0.5
H6CDD	<0.5	<0.5	<0.5
H7CDD	2.7	1.7	2.2
OCDD	3.6	2.4	3
TOTAL DIOXIN	6.3	4.1	5.2
CHLORODIBENZO p-FURAN			
TCDF	<0.5	<0.5	<0.5
P5CDF	<0.5	<0.5	<0.5
H6CDF	<0.5	<0.5	<0.5
H7CDF	<0.5	<0.5	<0.5
OCDF	1.2	<0.5	1.2
TOTAL FURAN	1.2	<0.5	1.2
TOTAL DIOXIN / DWD 1	7.5	4.1	5.8
Recovery %			
13C12-TCDD	76	71	
13C12-TCDF	80	69	
13C12-P5CDD	80	86	
13C12-P5CDF	83	81	
13C12-H6CDD	72	84	
13C12-H6CDF	77	83	
13C12-H7CDD	88	81	
13C12-H7CDF	91	79	
13C12-OCDD	88	74	

Method Detection Limit = 0.5 pg/m³

Table 36 Dioxin Analyses - Downwind 2

DIOXIN ANALYSIS / AIR / DOWNWIND 2 (pg/m³)

	6-Nov	7-Nov	Ave/Dy
CHLORODIBENZO p-DIOXIN			
TCDD	<0.5	<0.5	<0.5
P5CDD	<0.5	<0.5	<0.5
H6CDD	<0.5	<0.5	<0.5
H7CDD	1.7	1.2	1.5
OCDD	1.6	1.4	1.5
TOTAL DIOXIN	3.3	2.6	3.0
CHLORODIBENZO p-FURAN			<0.5
TCDF	<0.5	<0.5	<0.5
P5CDF	<0.5	<0.5	<0.5
H6CDF	<0.5	<0.5	<0.5
H7CDF	<0.5	<0.5	<0.5
OCDF	0.6	<0.5	0.6
TOTAL FURAN	0.6	<0.5	0.6
TOTAL DIOXIN / DWD 2	3.9	2.6	3.3
Recovery %			
13C12-TCDD	65	72	
13C12-TCDF	67	72	
13C12-P5CDD	68	83	
13C12-P5CDF	69	80	
13C12-H6CDD	69	77	
13C12-H6CDF	70	77	
13C12-H7CDD	74	71	
13C12-H7CDF	73	74	
13C12-OCDD	84	61	

Method Detection Limit = 0.5 pg/m³

Table 37 Carbonyl Analyses - Upwind

ALDEHYDE / KETONE ANALYSIS / AIR / UPWIND (µg/m³)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	Ave/Dy
Formaldehyde	36.0	25.0	<5.0	<5.0	<5.0	30.5
Acetaldehyde	36.0	22.0	9.7	33.7	43.2	28.9
Acrolein	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acetone	7.2	6.0	<5.0	20.0	<5.0	11.1
Propinaldehyde	16.8	<5.0	<5.0	17.9	<5.0	17.4
Crotonaldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
MEK etc	62.4	<5.0	21.7	61.1	88.4	58.4
Benzaldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Isovaleraldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Pentanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Valeraldehyde	<5.0	<5.0	<5.0	<5.0	23.2	23.2
o-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
m-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
p-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
MIBK	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexanal	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,5-Dimethyl Butanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
TOTAL ALDEHYDE/UPW	158.4	53.0	31.4	132.7	154.8	106.1

Values reported are blank subtracted
Method Detection Limit = 5 µg/m³ assuming sample volume = 20 L

Table 38 Carbonyl Analyses - Downwind 1

ALDEHYDE / KETONE ANALYSIS / AIR / DOWNWIND 1 (µg/m³)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	Ave/Dy
Formaldehyde	88.0	27.0	110.0	43.8	7.4	55.2
Acetaldehyde	95.2	25.0	60.6	33.3	37.9	50.4
Acrolein	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acetone	33.6	11.0	16.4	<5.0	13.7	18.7
Propinaldehyde	<5.0	20.0	<5.0	23.8	14.7	19.5
Crotonaldehyde	<5.0	<5.0	6.1	<5.0	<5.0	6.1
MEK etc	49.6	62.0	35.2	53.3	48.4	49.7
Benzaldehyde	30.4	<5.0	52.7	<5.0	<5.0	41.6
Isovaleraldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Pentanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Valeraldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
o-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
m-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
p-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
MIBK	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexanal	<5.0	21.0	<5.0	<5.0	<5.0	21.0
2,5-Dimethyl Butanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
TOTAL ALDEHYDE/DWD 1	296.8	166.0	281.0	154.2	122.1	204.0

Values reported are blank subtracted
Method Detection Limit = 5 µg/m³ assuming sample volume = 20 L

Table 39 Carbonyl Analyses - Downwind 2

ALDEHYDE / KETONE ANALYSIS / AIR / DOWNWIND 2 (µg/m³)

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	Ave/Dy
Formaldehyde	51.2	19.0	22.8	<5.0	<5.0	31.0
Acetaldehyde	78.4	43.0	24.4	19.1	24.4	37.9
Acrolein	23.2	<5.0	<5.0	<5.0	<5.0	23.2
Acetone	16.0	19.0	16.1	9.1	27.8	17.6
Propinaldehyde	33.6	<5.0	<5.0	18.2	25.3	25.7
Crotonaldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
MEK etc	48.8	56.0	30.6	57.3	61.1	50.8
Benzaldehyde	22.4	<5.0	<5.0	<5.0	<5.0	22.4
Isovaleraldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Pentanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Valeraldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
o-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
m-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
p-Tolualdehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
MIBK	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexanal	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,5-Dimethyl Butanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
TOTAL ALDEHYDE/DWD 2	273.6	137.0	93.9	103.7	138.6	149.4

Values reported are blank subtracted
Method Detection Limit = 5 µg/m³ assuming sample volume = 20 L

Table 40 Carbon Dioxide Analyses

CARBON DIOXIDE ANALYSIS (ppm) REAC

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/dy
Upwind							
Average	440.8	390.5	388.1	383.2	429.0	402.6	405.7
Maximum	551.0	430.0	547.0	460.0	493.0	477.0	493.0
Minimum	367.0	357.0	246.0	351.0	386.0	361.0	344.7
Downwind 1							
Average	448.6	393.1	397.9	272.1	238.3	318.7	344.8
Maximum	730.0	927.0	598.0	478.0	432.0	484.0	608.2
Minimum	322.0	300.0	302.0	212.0	-16.0	168.0	214.7
Downwind 2							
Average	387.6	419.5	412.4	432.7	327.9	399.3	396.6
Maximum	577.0	625.0	614.0	561.0	434.0	540.0	558.5
Minimum	329.0	346.0	339.0	374.0	155.0	309.0	308.7
Downwind 3							
Average	377.6	405.4	368.7	402.0	273.1	374.6	366.9
Maximum	446.0	482.0	481.0	506.0	406.0	447.0	461.3
Minimum	354.0	355.0	333.0	356.0	162.0	243.0	300.5

Table 41 Carbon Monoxide Analyses

CARBON MONOXIDE ANALYSIS (ppm) REAC

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/dy
Upwind							
Average	0.0	0.8	2.9	6.0	12.6	1.3	3.9
Maximum	0.0	1.0	3.0	6.0	14.0	2.0	4.3
Minimum	0.0	0.0	2.0	6.0	0.0	1.0	1.5
Downwind 1							
Average	6.5	lost	3.7	3.4	7.2	2.0	4.6
Maximum	34.0	lost	25.0	11.0	8.0	8.0	17.2
Minimum	1.0	lost	1.0	2.0	0.0	1.0	1.0
Downwind 2							
Average	1.7	0.0	0.2	0.0	0.0	3.8	1.0
Maximum	16.0	0.0	6.0	0.0	0.0	5.0	4.5
Minimum	0.0	0.0	0.0	0.0	0.0	3.0	0.5
Downwind 3							
Average	1.3	1.0	1.3	1.7	3.7	1.7	1.8
Maximum	5.0	8.0	9.0	23.0	5.0	7.0	9.5
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 42 Sulphur Dioxide Analyses

SULFUR DIOXIDE ANALYSIS (ppm) REAC

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/dy
Upwind							
Average	0.0	0.4	1.0	1.4	1.6	0.4	0.8
Maximum	0.0	0.6	1.1	1.4	1.6	0.5	0.9
Minimum	0.0	0.4	0.9	1.3	1.4	0.3	0.7
Downwind 1							
Average	2.9	lost	1.1	1.4	1.9	0.9	1.6
Maximum	14.2	lost	2.1	4.4	2.1	2.4	5.0
Minimum	0.3	lost	0.9	1.1	1.8	0.6	0.9
Downwind 2							
Average	0.6	0.5	1.3	1.1	0.0	0.8	0.7
Maximum	5.0	0.8	1.8	1.7	0.1	1.2	1.8
Minimum	0.0	0.0	1.0	0.9	0.0	0.5	0.4
Downwind 3							
Average	0.0	0.3	2.2	1.1	1.2	0.0	0.8
Maximum	0.4	0.4	2.3	1.4	1.3	0.1	1.0
Minimum	0.0	0.2	2.0	0.9	1.2	0.0	0.7

Table 43 Particulates Analyses

TOTAL AEROSOL PARTICULATES ANALYSIS (mg/m³) REAC

	3-Nov	5-Nov	6-Nov	7-Nov	9-Nov	10-Nov	Ave/dy
Upwind							
Average	0.02	0.00	0.00	0.0	0	0.0	0.0
Maximum	0.02	0.00	0.00	0.0	0	0.0	0.0
Minimum	0.02	0.00	0.00	0.0	0	0.0	0.0
Downwind 1							
Average	7.44	5.00	3.43	4.1	1.04	0.0	3.5
Maximum	19.95	19.95	32.27	32.7	31.94	0.0	22.8
Minimum	0.04	0.01	0.00	0.0	0	0.0	0.0
Downwind 2-A							
Average	0.02	0.05	2.2	0.6	0.16	0.4	0.6
Maximum	0.03	0.08	23.4	0.7	0.35	5.6	5.0
Minimum	0.01	0.03	0.6	0.5	0.08	0.0	0.2
Downwind 2-B							
Average	0.00	0.6	2.9	0.2	0.23	0.2	0.7
Maximum	0.03	8.2	30.6	4.2	1.2	0.8	7.5
Minimum	0.00	0.0	0.4	0.1	0.17	0.1	0.1
Downwind 2							
Average	4.11	3.0	2.0	1.8	0.45	0.3	1.9
Maximum	20.14	20.1	37.8	19.5	10.26	2.5	18.4
Minimum	0.04	0.0	0.0	0.0	0.05	0.0	0.0
Downwind 2-C							
Average	0.01	0.0	0.6	2.2	0.62	0.3	0.6
Maximum	0.01	0.0	4.4	27.7	2.04	3.2	6.2
Minimum	0.01	0.0	0.2	0.3	0.49	0.0	0.2
Downwind 2-D							
Average	0.03	1.2	0.5	1.4	0.29	0.4	0.6
Maximum	1.02	20.0	2.7	12.1	0.37	1.0	6.2
Minimum	0.02	0.1	0.3	0.5	0.25	0.2	0.2
Downwind 3							
Average	0.48	1.3	1.6	2.1	0.19	0.1	1.0
Maximum	6.53	11.1	16.0	9.0	2.84	2.9	8.1
Minimum	0.00	0.0	0.4	1.0	0.08	0.0	0.3

MOBILE BURN SAMPLING

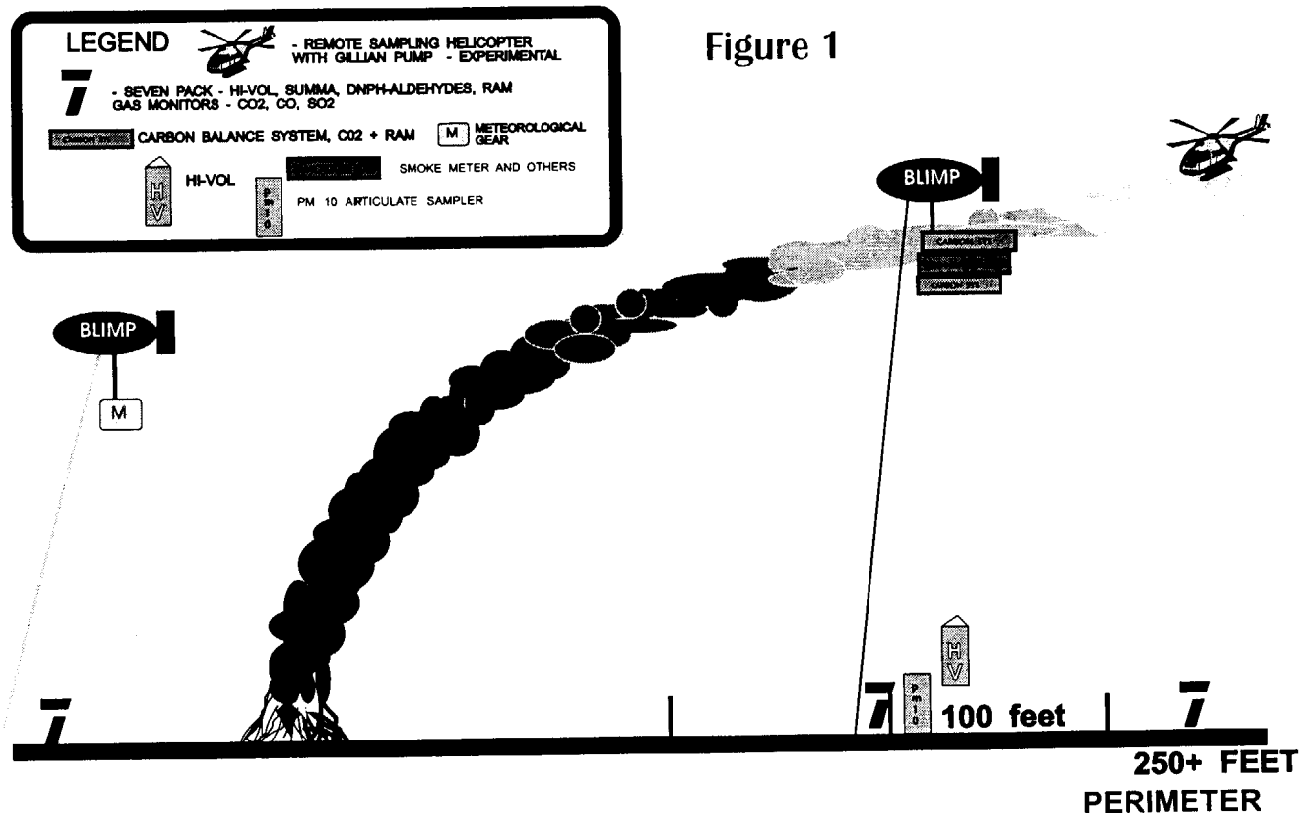
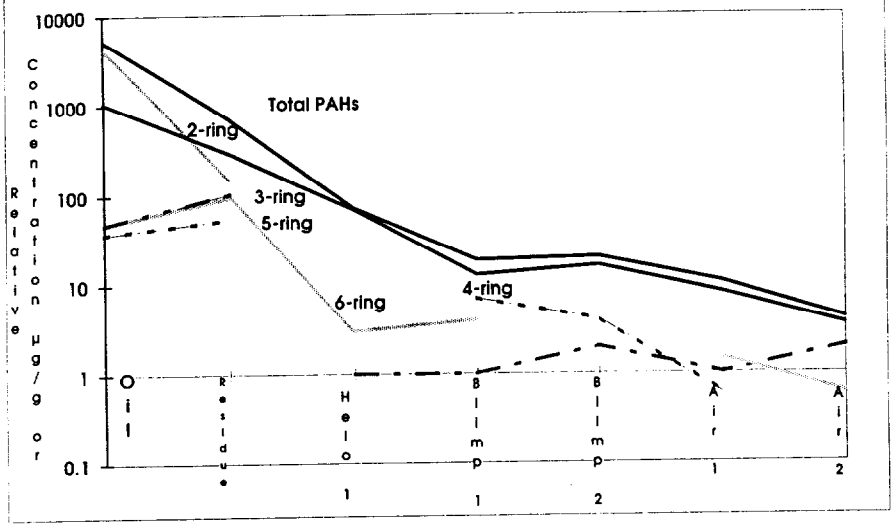


Figure 1

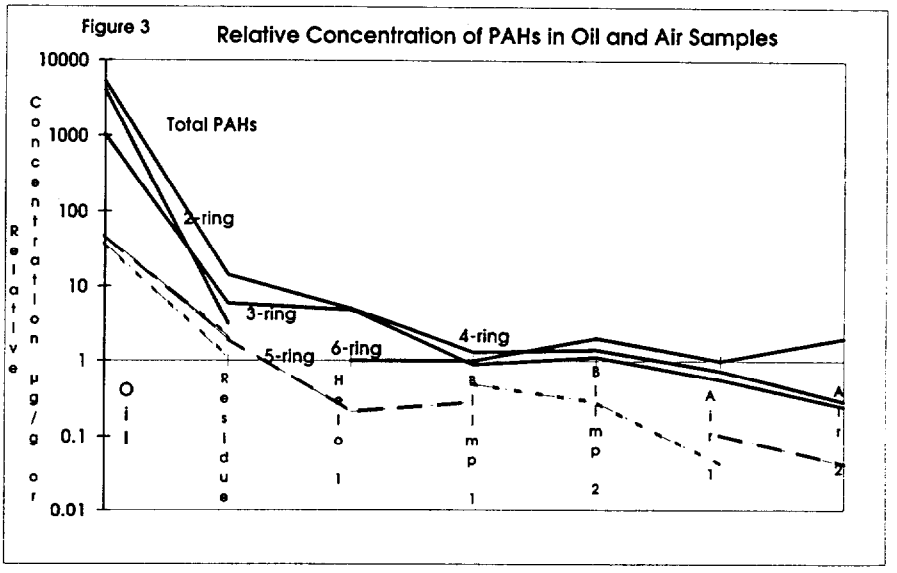
	Crude Oil	Burn Residue	Helo 1	Blimp 1	Blimp 2	Downwind 1	Downwind 2
Total	5268	704	71.5	18.6	20	10.5	4.1
2-ring	4065	156					
3-ring	1044	294	68.5	12.7	16	8	3.5
4-ring	47	96	3	4	0	1.5	0.6
5-ring	37	54	0	6.9	4	0.6	0
6-ring	47	105	0	0	0	0	0

Figure 2 Relative Concentration of PAHs in Oil and Air Samples



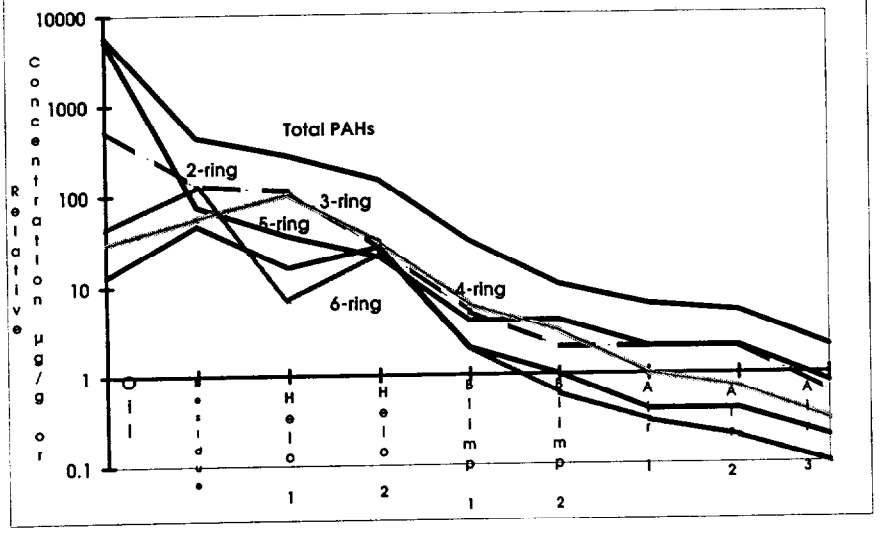
	Crude Oil	Burn Residue	Helo 1	Blimp 1	Blimp 2	Downwind 1	Downwind 2
Total	5268	14.08	5.035	1.302	1.4	0.735	0.287
2-ring	4065	3.12	0	0	0	0	0
3-ring	1044	5.88	4.795	0.889	1.12	0.56	0.245
4-ring	47	1.92	0.21	0.26	0	0.105	0.042
5-ring	37	1.08	0	0.483	0.28	0.042	0
6-ring	47	2.1	0	0	0	0	0

Figure 3 Relative Concentration of PAHs in Oil and Air Samples



	Crude Oil	Burn Residue	Helo 1	Helo 2	Blimp 1	Blimp 2	Downwind 1	Downwind 2	Downwind 3
Total	5767	432	273	147	31	10	6	5	2
2-ring	5159	75	36	21	4	4	2	2	0.8
3-ring	521	128	112	26	5	2	2	2	0.6
4-ring	30	57	102	31	6	3	1	0.7	0.3
5-ring	13	47	16	27	9	1	0.4	0.4	0.2
6-ring	44	126	7	23	2	0.6	0.3	0.2	0.1

Figure 4 Relative Concentration of PAHs in Oil and Air Samples



	Crude Oil	Burn Residue	Helo 1	Helo 2	Blimp 1	Blimp 2	Downwind 1	Downwind 2	Downwind 3
Total	5767	8.64	19.11	10.29	2.17	0.7	0.42	0.35	0.14
2-ring	5159	1.5	2.52	1.47	0.28	0.28	0.14	0.14	0.056
3-ring	521	2.56	7.84	1.82	0.35	0.14	0.14	0.14	0.042
4-ring	30	1.14	7.14	2.17	0.42	0.21	0.07	0.049	0.021
5-ring	13	0.94	1.12	1.89	0.14	0.07	0.028	0.028	0.014
6-ring	44	2.52	0.49	1.61	0.14	0.042	0.021	0.014	0.007

Figure 5 Relative Mass of PAHs in Oil and Air Samples

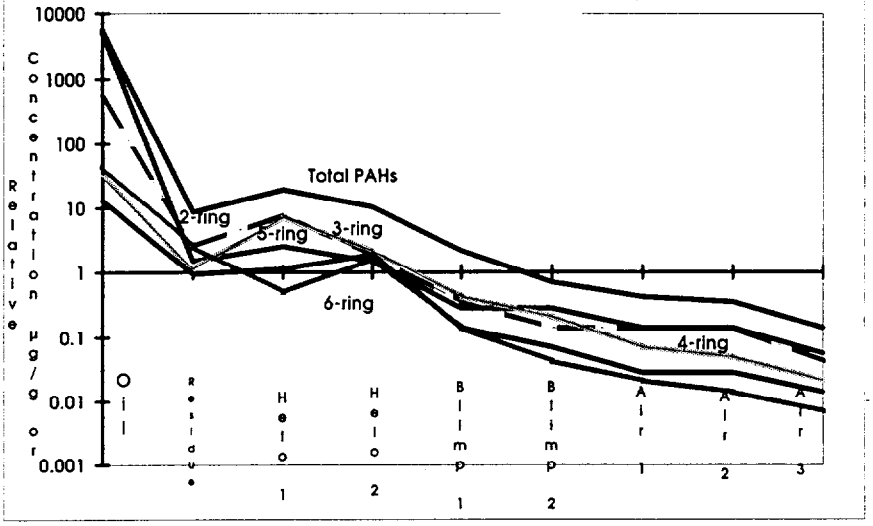


Figure 6 Carbon Dioxide Concentrations - Tests 1 and 2

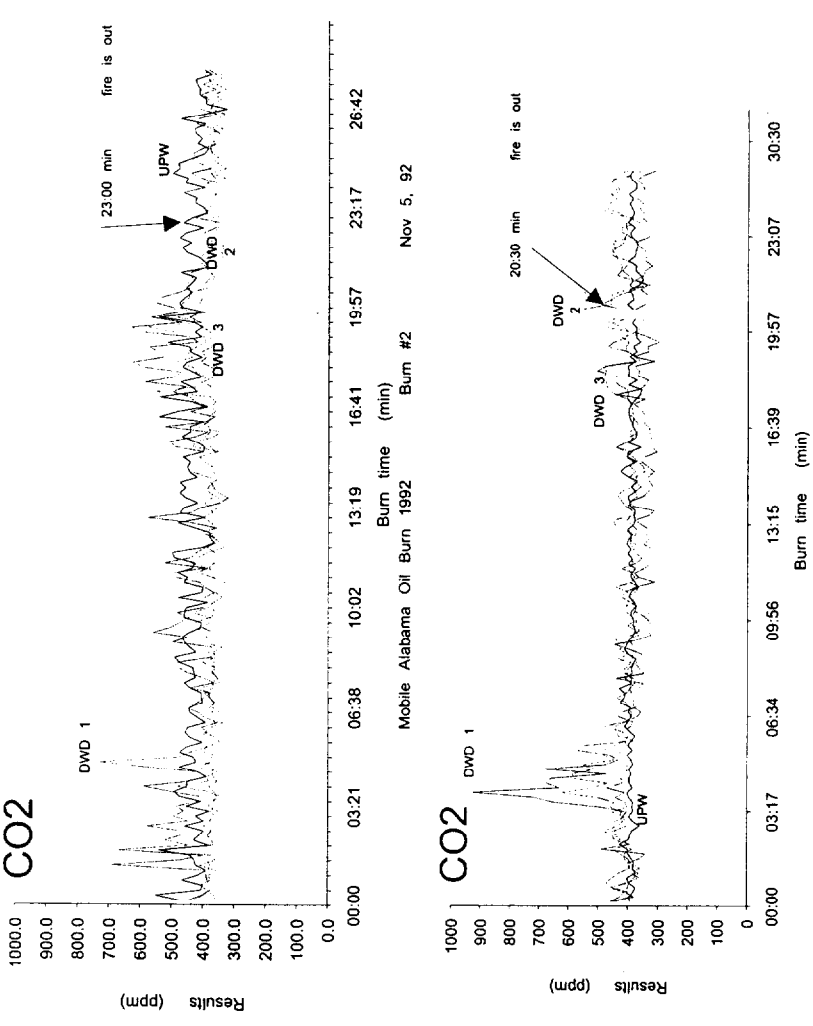


Figure 7 Sulphur Dioxide Concentrations - Tests 1 and 2

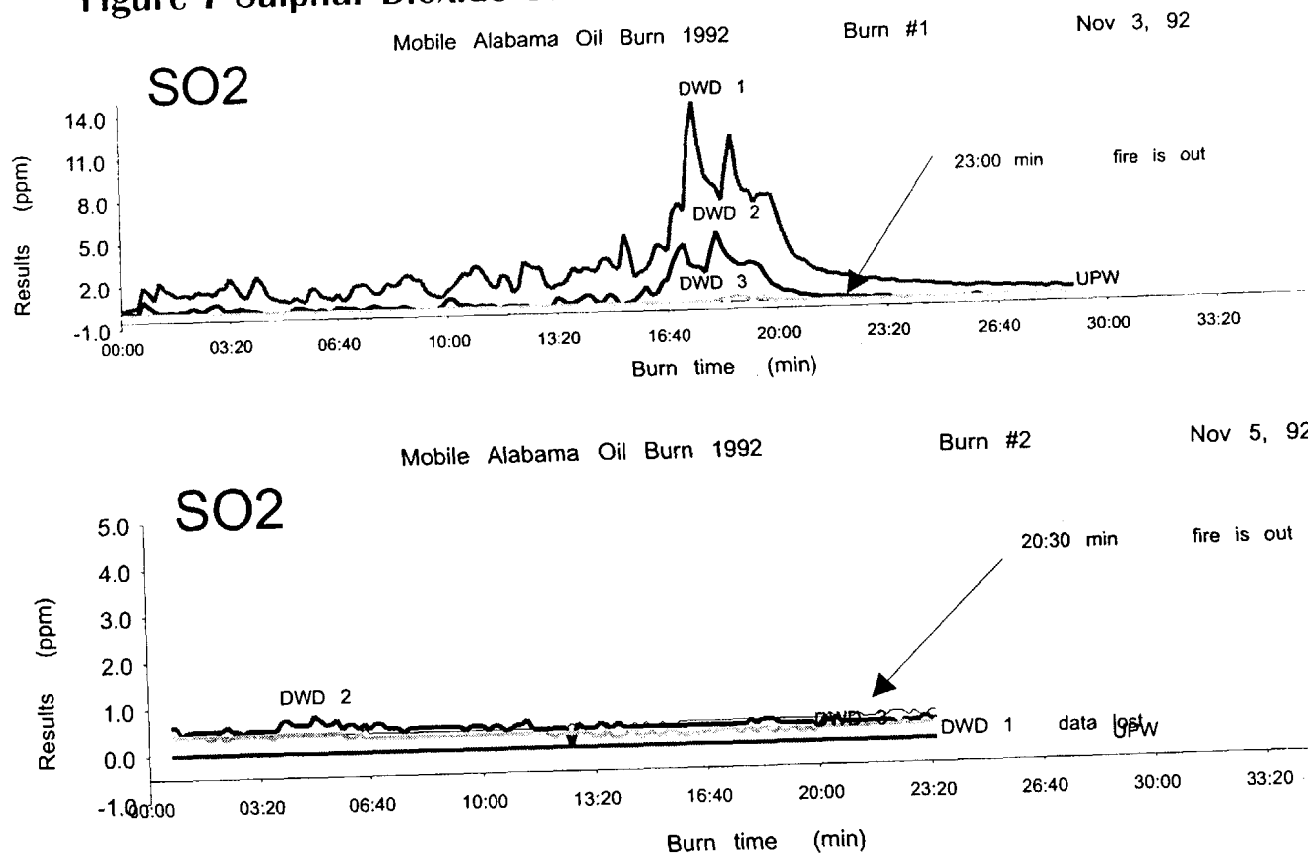


Figure 8 Total Aerosol Particulate Concentrations - Tests 1 and 2