Southern Delaware County Air Monitoring Project
Third Interim Report

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Commonwealth of Pennsylvania
Department of Environmental Protection
Bureau of Air Quality

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www.state.pa.us

Summary

In 1994, the United States Environmental Protection Agency (EPA) and the Pennsylvania Department of Environmental Protection (DEP) began to study the environmental risk from toxic air pollutants in the City of Chester. Sampling for volatile organic air pollutants was begun early in 1995 at two locations, one in Chester and the other in Marcus Hook. In February 1997, a third sampling site was added in Swarthmore to provide a comparison site in a less industrialized area. EPA arranged for the Maryland Department of the Environment, Air Management Administration (MDE) to analyze the samples. The methods and equipment used to sample and analyze for volatile organic compounds were described in the December 1996 report.

In February 1997, two more samplers were installed at each site to sample total suspended particulate (TSP) and particulate matter less than 10 microns (PM-10). The DEP Laboratory analyzes the TSP samples for arsenic, beryllium, cadmium, total chromium, lead, nickel and zinc. Previously, TSP samples were also analyzed for hexavalent chromium, a highly toxic form of chromium. An evaluation of filters spiked with hexavalent chromium showed that these results were not valid because this compound is not stable between the times a sample is collected and analyzed.

The goals of this study are to learn more about the air quality in Southern Delaware County – what pollutants are present, how the measured pollutant concentrations compare to other areas, whether there are any trends in pollutant concentrations, and what are the health risks from breathing air containing the pollutants that were measured. The data analysis and conclusions are solely those of DEP and may not reflect the views or opinions of EPA or MDE. Two earlier interim reports were released to the public in December 1996 and April 1999. This third report summarizes all of the air sampling from the start of the study in 1995 through 2000. Some changes were made in the way that the data were analyzed from the first and second interim reports. The estimated cancer risks from inhalation have been updated using the most recent cancer unit risk factors published in EPA's Integrated Risk Information System (IRIS) and in other sources.

The Chester VOC sampler was moved from Front Street and Highland Avenue to Front and Norris Street, on January 7, 1999. This must be considered when examining the data for trends in pollutant concentrations. In September 2000, the Marcus Hook TSP and PM-10 samplers were moved from the roof of Marcus Hook Elementary School to a location behind the school. The average total particulate measured after the samplers were moved increased slightly, apparently due to the lower sampler height.

The second part of this report gives an estimate of the excess lifetime cancer risk due to inhalation of these pollutants. Any estimation of risk is based on assumptions: How well do the air samples represent actual public exposures? How toxic are the chemicals? How long are people exposed? Is the estimated risk for an average person or for sensitive groups? What are the effects of other routes of exposure to these and other chemicals?

The risks are estimates of the additional cancers that may occur in a population exposed continuously to the measured pollutant concentration over a 70-year lifetime. They were

calculated for the average concentrations measured during each calendar year. On a national average, roughly 4,000 out of 10,000 people will develop cancer in their lifetimes. The highest inhalation cancer risks, assuming people were exposed continuously to the annual average concentrations measured in 1995, were 1.6 in 10,000 for Chester and 1.6 in 10,000 for Marcus Hook. Risks, based on the annual average concentrations measured in 2000 were 1.3 in 10,000 for people in Chester, 1.2 in 10,000 for people in Marcus Hook, and 0.8 in 10,000 for people in Swarthmore.

Of the pollutants measured, the four that pose the greatest risk to human health in Chester, Marcus Hook and Swarthmore are 1,3-butadiene, 1,2-dibromoethane, benzene and carbon tetrachloride. Approximately 70% to 90% of the total excess lifetime cancer risk is due to these compounds.

The appendix includes an explanation of scientific notation used to express very large and very small numbers, the equations and factors used in the risk analysis, and definitions of some of the technical terms. The pollutant concentration data that were used to estimate the risks can be obtained from the DEP Southeast Regional Office at (610) 832-6242, and also are on the DEP website at www.dep.state.pa.us (Choose Subjects/Air Quality/Ambient Air Monitoring). The study is continuing, and after new data are verified they are made available to the public through the same sources.

Air Monitoring and Analysis

Overview of Project through December 2000

In 1995, DEP, working with EPA Region III, began measuring the concentrations of certain air pollutants to learn more about the ambient air quality in Southern Delaware County. Interim reports released on December 17, 1996 and April 26, 1999 summarized the air sampling data and assessed the health risk. This report re-evaluates and summarizes all of the data from the start of the study through the end of 2000.

The sampling sites in Chester and Marcus Hook were chosen because they are close to several industrial facilities and near roads with high traffic volumes. DEP started sampling for volatile organic compounds in Chester on January 10, 1995, and in Marcus Hook on April 2, 1995. Sampling at a site in Swarthmore began on January 22, 1997. This location was added to provide a comparison site that is also in Southern Delaware County (the same air basin), but not as close to large industrial sources. In January 1997, DEP also began measuring toxic metals in total suspended particulate matter (TSP) and particulate matter less than 10 microns in size (PM-10) at each site.

The Maryland Department of the Environment, Air Management Administration (MDE) analyzes air samples by GC/MS for EPA Method TO-14 volatile organic compounds and by GC/FID for volatile hydrocarbons. The volatile organic compounds, which are listed in Table 1.1, are targeted primarily because they are toxic and their presence in the ambient air contributes to the inhalation risk. The volatile hydrocarbons, which are listed in Table 1.2, were specified by EPA for the photochemical assessment monitoring sites (PAMS) program because they are associated with emissions that contribute to the formation of ozone and smog.

Of the pollutants measured, those that pose the greatest risk to human health in Chester, Marcus Hook and Swarthmore are 1,3-butadiene, 1,2-dibromoethane, benzene and carbon tetrachloride. The only exception was Chester in 1999 and 2000, where the health risk from 1,2-dichlorethane was higher than the health risk from 1,3-butadiene. Benzene and 1,3-butadiene are common industrial chemicals, and are present in small amounts in gasoline and motor vehicle emissions. They are also emitted from agricultural burning and forest fires. 1,2-dibromoethane has been used as a fumigant and in anti-knock gasoline. Carbon tetrachloride is used as a solvent. It was formerly used as a grain fumigant, refrigerant and in some fire extinguishers.

The annual arithmetic average concentrations are used to estimate the excess lifetime cancer risk resulting from inhalation exposure. The average concentrations reported here are calculated differently than the averages in the first (1996) interim report. In that report, when a chemical was not detected, a concentration of 0.0 parts per billion was used for calculating the average. This report uses one-half of the compound's minimum detection limit (MDL) when it is not detected. This is a more conservative assumption and gives slightly higher average concentrations, thus, slightly greater estimated risks.

The total suspended particulate and PM-10 samples are collected on the same six-day schedule except that the samplers run for a 48-hour period to increase the amount of pollutant

collected thus lowering the detection limit. The DEP laboratory analyzes the TSP filters for arsenic, beryllium, cadmium, chromium, lead, nickel and zinc.

The initial plan for this study was to sample for one year at Chester and Marcus Hook. After reviewing the data from the first nine months of sampling, DEP and EPA decided to continue the study:

- to compare Chester and Marcus Hook to a site in Swarthmore, Pennsylvania;
- to look for trends or changes in pollutant concentrations;
- to better assess the long-term exposures; and
- to measure particulate matter and toxic metals.

Study Participants

The sampling and analysis described in this report is part of a study undertaken by DEP, in cooperation with EPA. The MDE Air Management Administration's laboratory analyzes the canister samples under a cooperative agreement with EPA Region III. The DEP Bureau of Laboratories analyzes the quartz filters for metals and particulates. The conclusions in this report are solely those of DEP and do not reflect the views or opinions of EPA or MDE.

Canister Sampling for Volatile Organic Compounds

The first interim report described the canister sampling method in detail, so only a brief description of the sampling and analytical methods are included in this report. Air samples are collected in SUMMA canisters, which are stainless steel canisters specially treated to create an inert inner surface. The canisters are cleaned and evacuated in the laboratory, then shipped to the sampling site. At each site, a blower continuously draws ambient air through a glass inlet cane and manifold. An Andersen Instruments AVOCS sampling pump connected to the manifold fills the canister at a constant rate to about two atmospheres absolute pressure (approximately 15 pounds gage pressure). Canister samples are collected over a 23-hour, 55-minute period from midnight to 11:55 PM. The filled canisters are then shipped to the laboratory for analysis. During 1995 and 1996, DEP collected canister samples on two days out of three. From January 1997 through April 30, 2000, air samples were collected two days in a row out of every six days. Since April 30, 2000, samples have been collected every sixth day. With this schedule, the same number of samples is collected on each day of the week.

Canister samples are being collected at three sites: Front Street and Norris Avenue in Chester, Eighth and Market Streets in Marcus Hook, and 500 College Avenue in Swarthmore. Prior to January 7, 1999 the Chester canister sampler was located at Front and Highland Streets. Figures 1.1 and 1.2 show the site locations.

Each canister is analyzed by two different methods. First, a method based on EPA Method TO-14[1] is used to analyze for the compounds listed in Table 1.1. The analytical method is gas chromatography/mass spectrometry (GC/MS) in selected ion monitoring (SIM) mode. This method is sensitive and accurate, however, with selected ion monitoring, the GC/MS is

[1] Winberry, William T. , Norma T. Murphy and R. M. Riggin, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA/600/4-89/017, 1988.

programmed to look for the patterns that identify target compounds so other similar compounds that might be present are not detected. The target compounds include common chlorinated and non-polar hydrocarbon solvents and industrial chemicals, aromatic hydrocarbons and chlorofluorocarbons (freons). The laboratory reports the concentrations in parts per billion volume (ppbv). These units were converted to micrograms per cubic meter to calculate the health risk.

The second analysis of each air sample is by gas chromatography with flame ionization detection (GC/FID). The system is calibrated to identify the hydrocarbons listed in Table 1.2, which were specified by EPA for the PAMS program. The flame ionization detector responds to most organic compounds, and the total response to all compounds is reported as total non-methane organic carbon (TNMOC). The laboratory reports the GC/FID concentrations in parts-per-billion carbon (ppbC). These units are equal to ppbv multiplied by the number of carbon atoms in the compound. Chemists use ppbC because the FID response to hydrocarbons is approximately proportional to the number of carbon atoms in the compound. EPA's national database of air quality data, AIRS-AQS, also uses ppbC, so the data in this study can be compared directly to data from AIRS.

Particulate Sampling

Particulate samples are collected at the Commonwealth of Pennsylvania Air Monitoring Station (COPAMS) at Front and Norris Streets in Chester, on the campus of Swarthmore College and at Marcus Hook Elementary School (see Figures 1.1 and 1.2). The Marcus Hook samplers were located on the school roof, about 35 feet above ground, until September 2000, when they were moved to a shelter behind the school with the sampler inlets about 13 feet above ground.

Each site has a GMWL-2000 total suspended particulate sampler and a GMW-321B PM-10 sampler. The samplers are operated and audited following the DEP Bureau of Air Quality's standard operating procedures (SOPs), except that the sampling period is 48 hours rather than 24 hours. This increases the amount of particulate collected on the filter, which lowers the minimum detection limits for metals. When the study started, TSP samples were collected on glass fiber filters. They were changed to quartz fiber filters, which have slightly lower blank levels of metals.

Particulate filters are analyzed for the metals (arsenic, beryllium, cadmium, chromium, lead, nickel and zinc) by inductively coupled plasma mass spectrometry (ICP-MS). The second interim report gave results for hexavalent chromium, measured by ion chromatography, and reported that it had not been detected in any samples. Quality control tests using spiked filters demonstrated that hexavalent chromium changes into other chromium compounds before it can be analyzed, so the results previously reported for hexavalent chromium were invalid. In January 2000, analysis for manganese was added because it is included in the EPA urban air toxics monitoring strategy.

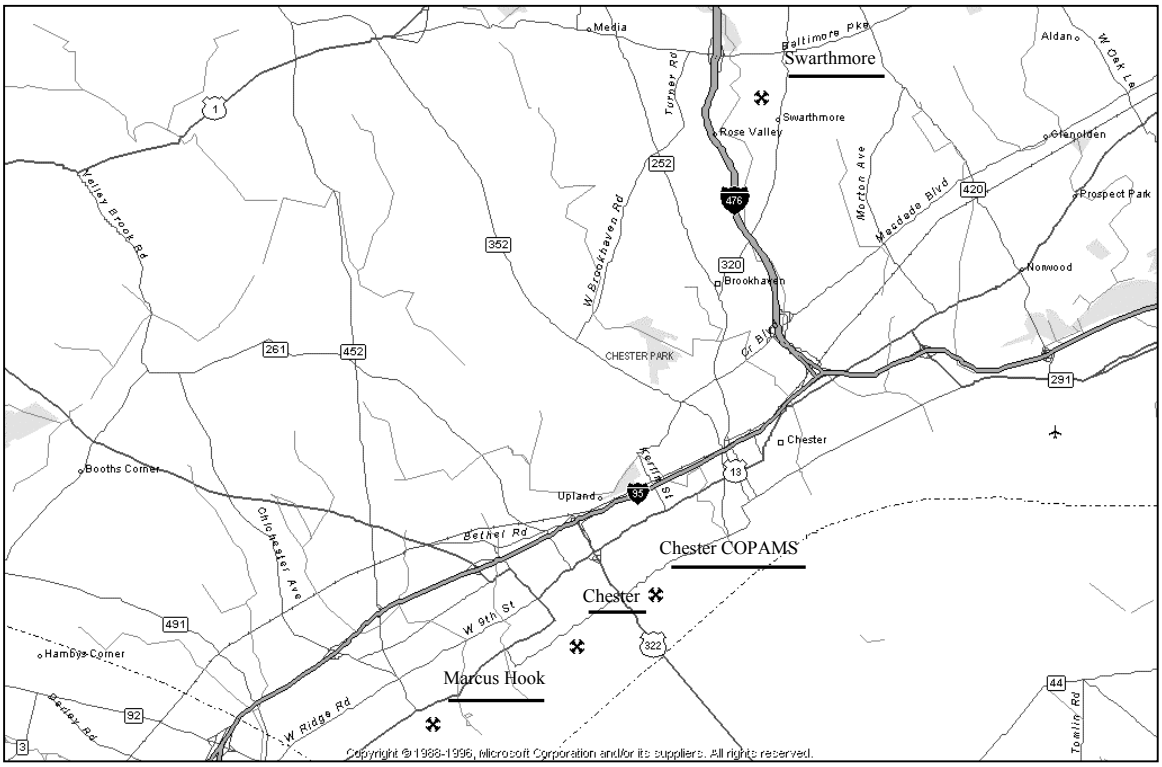

Figure 1.1. Air Sampling Site Locations

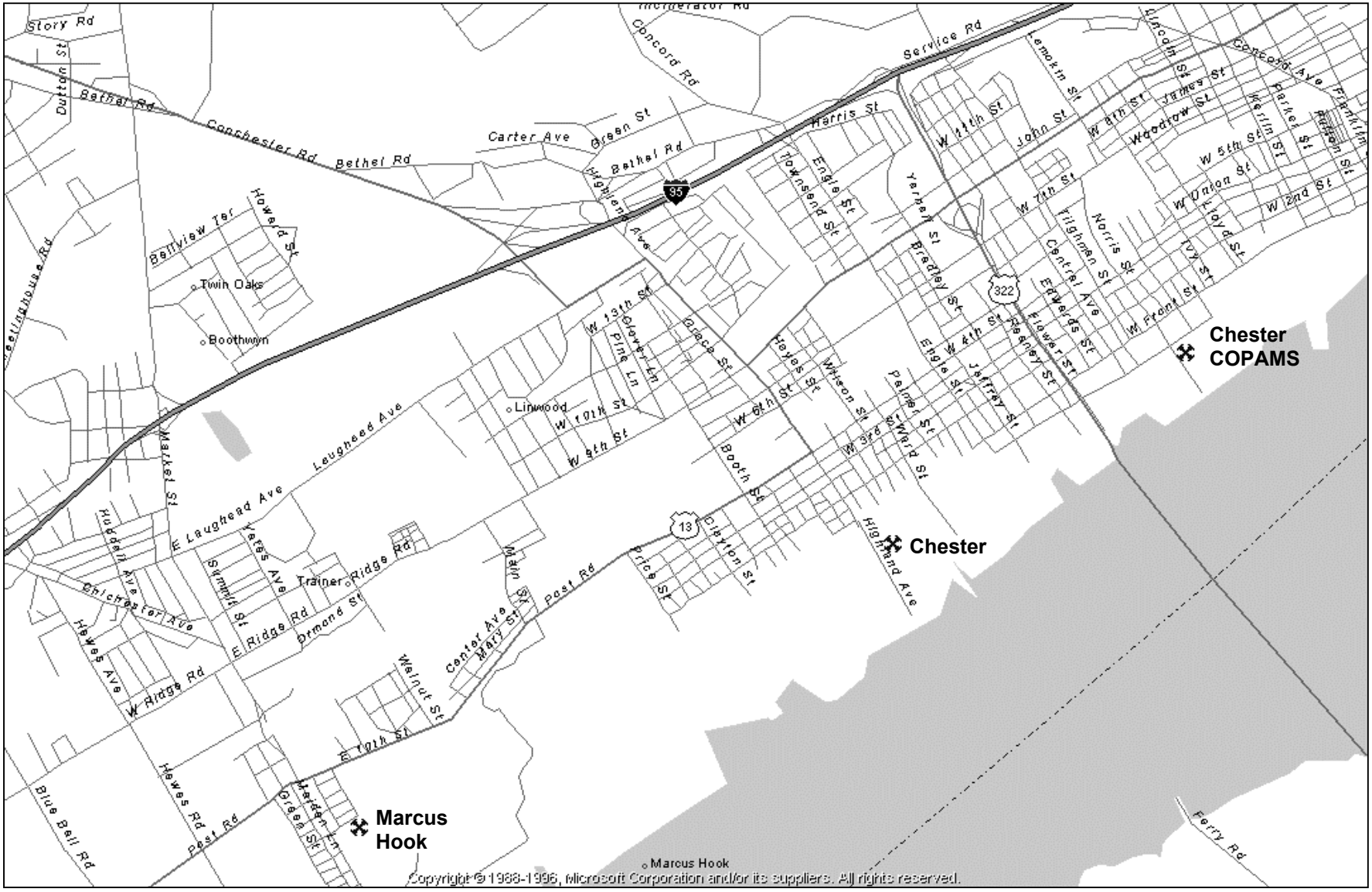

Figure 1.2. Chester and Marcus Hook Air Sampling Site Locations

Table 1.1. Organic Compounds in the Laboratory Calibration Standard

COMPOUND	CAS	MDL	COMPOUND	CAS	MDL
Dichlorodifluoromethane	75-71-8	0.006	trans-1,3-Dichloropropene*	10061-02-6	0.020
Chloromethane	74-87-3	0.030	1,1,2-Trichloroethane	79-00-5	0.020
1,2-Dichloro-1,1,2,2-tetrafluoroethane	76-14-2	0.006	Toluene	127-18-4	0.009
Chloroethene (Vinyl Chloride)	75-01-4	0.020	1,2-Dibromoethane	106-93-4	0.010
1,3-Butadiene	106-99-0	0.060	Tetrachloroethene	127-18-4	0.020
Bromomethane	74-83-9	0.010	Chlorobenzene	108-90-7	0.010
Chloroethane	75-00-3	0.030	Ethylbenzene	100-41-4	0.008
Trichlorofluoromethane	75-69-4	0.009	m & p-Xylene	1330-20-7	0.010
1,1-Dichloroethene	75-35-4	0.009	Styrene	100-42-5	0.020
Methylene chloride	75-09-2	0.010	1,1,2,2-Tetrachloroethane	79-34-5	0.009
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	0.010	o-Xylene	95-47-6	0.010
1,1-Dichloroethane	75-34-3	0.010	1-Ethyl-4-methyl benzene	622-96-8	0.007
cis 1,2-Dichloroethene	156-59-2	0.020	1,3,5-Trimethylbenzene	108-67-8	0.010
Chloroform	67-66-3	0.007	1,2,4-Trimethylbenzene	95-63-6	0.008
1,2-Dichloroethane	107-06-2	0.020	Chloromethylbenzene	100-44-7	0.010
1,1,1-Trichloroethane	71-55-6	0.010	1,3-Dichlorobenzene	95-50-1	0.010
Benzene	71-43-2	0.009	1,4-Dichlorobenzene	106-46-7	0.009
Carbon tetrachloride	56-23-5	0.010	1,2-Dichlorobenzene	541-83-1	0.008
1,2-Dichloropropane	78-87-5	0.020	1,2,4-Trichlorobenzene	95-63-6	0.010
Trichloroethene	79-01-6	0.020	Hexachloro-1,3-butadiene	87-68-3	0.030
cis-1,3-Dichloropropene*	10061-01-5	0.020			

CAS - Chemical Abstract Service Number that uniquely identifies a chemical compound under the Toxic Substances Control Act.

MDL - The analytical laboratory's minimum detection limit in parts per billion by volume.

* cis-1,3-Dichloropropene and trans-1,3-Dichloropropene are reported separately, but are added together for purposes of risk analysis. The CAS number for the mixture is 542-75-6.

Table 1.2. Hydrocarbon Compounds in the Laboratory Calibration Standard

Compound	CAS	Compound	CAS
Ethene	74-85-1	2,3-Dimethylpentane	565-59-3
Ethyne (Acetylene)	74-86-2	3-Methylhexane	589-34-4
Ethane	74-84-0	2,2,4-Trimethylpentane	540-84-1
Propene	115-07-1	n-Heptane	142-82-5
n-Propane	74-98-6	Methylcyclohexane	108-87-2
2-Methylpropane	75-28-5	2,3,4-Trimethylpentane	565-75-3
1-Butene	106-98-9	Toluene	108-88-3
n-Butane	106-97-8	2-Methylheptane	592-27-8
trans-2-Butene	624-64-6	3-Methylheptane	589-81-1
cis-2-Butene	590-18-1	n-Octane	111-65-9
2-Methylbutane	78-78-4	Ethylbenzene	100-41-4
1-Pentene	109-67-1	m & p-Xylene	108-38-3
n-Pentane	109-66-0	Styrene	100-42-5
2-Methyl-1,3-Butadiene (isoprene)	78-79-5	o-Xylene	95-47-6
trans-2-Pentene	646-04-8	n-Nonane	111-84-2
cis-2-Pentene	627-20-3	Isopropylbenzene	98-82-8
2,2-Dimethylbutane	75-83-2	n-Propylbenzene	103-65-1
Cyclopentane	287-92-3	1-Ethyl-3-methylbenzene	620-14-4
2,3-Dimethylbutane	79-29-8	1-Ethyl-4-methylbenzene	622-96-8
2-Methylpentane	107-83-5	1,3,5-Trimethylbenzene	108-67-8
3-Methylpentane	96-14-0	1-Ethyl-2-methylbenzene	611-14-3
2-Methyl-1-pentene	763-29-1	1,2,4-Trimethylbenzene	95-63-6
n-Hexane	110-54-3	n-Decane	124-18-5
Methylcyclopentane	96-37-7	1,2,3-Trimethylbenzene	526-73-8
2,4-Dimethylpentane	108-08-7	1,3-Diethylbenzene	141-93-5
Benzene	71-43-2	1,4-Diethylbenzene	105-05-5
Cyclohexane	110-82-7	n-Undecane	1120-21-4
2-Methylhexane	591-76-4		

CAS – The Chemical Abstract Service Number uniquely identifies a chemical compound under the Toxic Substances Control Act.

Discussion of Results

Organic Compounds

At the start of the study, the MDE laboratory tested the canister samplers for background contamination. They were leak-checked and cleaned, then purged with humidified, ultra-pure air until the canisters had less than 20 ppbC total contaminants. Although the samplers passed the quality control check for total contaminants, it was later determined that two of the samplers at Chester had background contamination of up to a few ppbv for three of the target compounds: styrene, ethylbenzene and 1,3-butadiene. The Chester samplers were replaced in April 1995, which eliminated the contamination problem. In June 1997, after the sampler at Marcus Hook was repaired, it was also later determined that the repair part was contaminated with several target compounds: 1-ethyl-4-methylbenzene, trimethylbenzene isomers, nonane and decane. Data for these compounds were voided for all the samples collected between June 21, 1997, and September 14, 1997. Results for the other compounds were not affected. The first few samples at Swarthmore had higher levels of trichloroethylene than the other sites, which was probably due to sampler contamination.

The annual average concentration is the arithmetic average of all the valid 24-hour samples in the calendar year with one-half of the minimum detection limits substituted when the compound was not detected. In a few cases, the laboratory reported concentrations below their usual MDL, and these values were used in calculating the averages. Table 1.1 gives the minimum detection limits for the GC/MS SIM analysis. In the December 1996 interim report, the averages were calculated using 0.00 ppbv for non-detects. The second interim report and this report, use the more conservative assumption of one-half the minimum detection limit in the cases of non-detects. The average concentrations were calculated both ways, and the differences in the overall calculated risks were very small.

DEP used the arithmetic annual average concentrations to calculate the health risks. Sometimes other statistical values are used to estimate the risk, such as the geometric mean or the 95 percent upper confidence limit.

Figures 1.3 and 1.4 show the trends in quarterly average concentrations for compounds that are detected in many of the samples. Other compounds, such as carbon tetrachloride and some of the freons, are not shown because they are at the same concentration, within the analytical accuracy, in almost every sample.

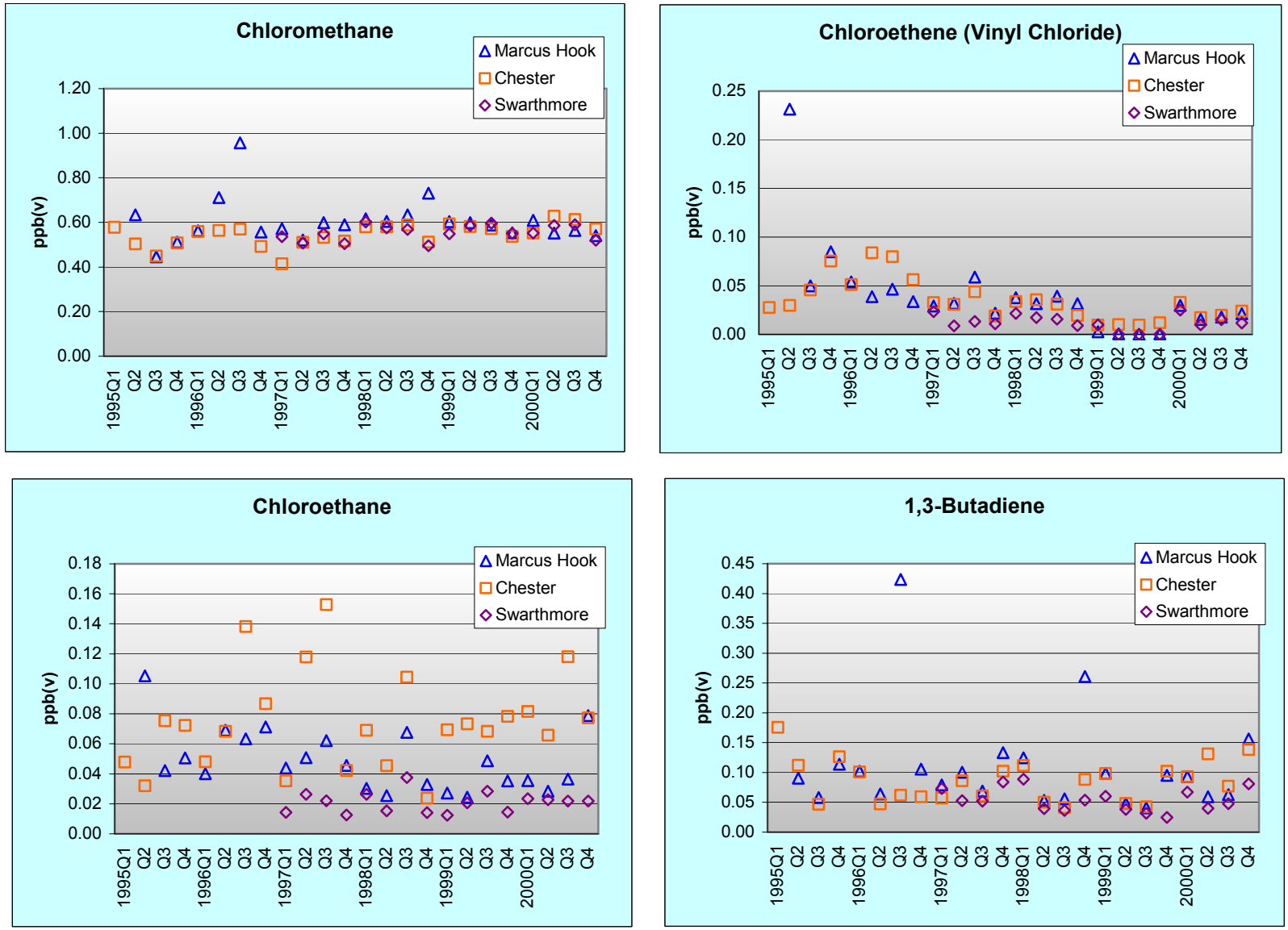

Figure 1.3. Quarterly Average Concentrations

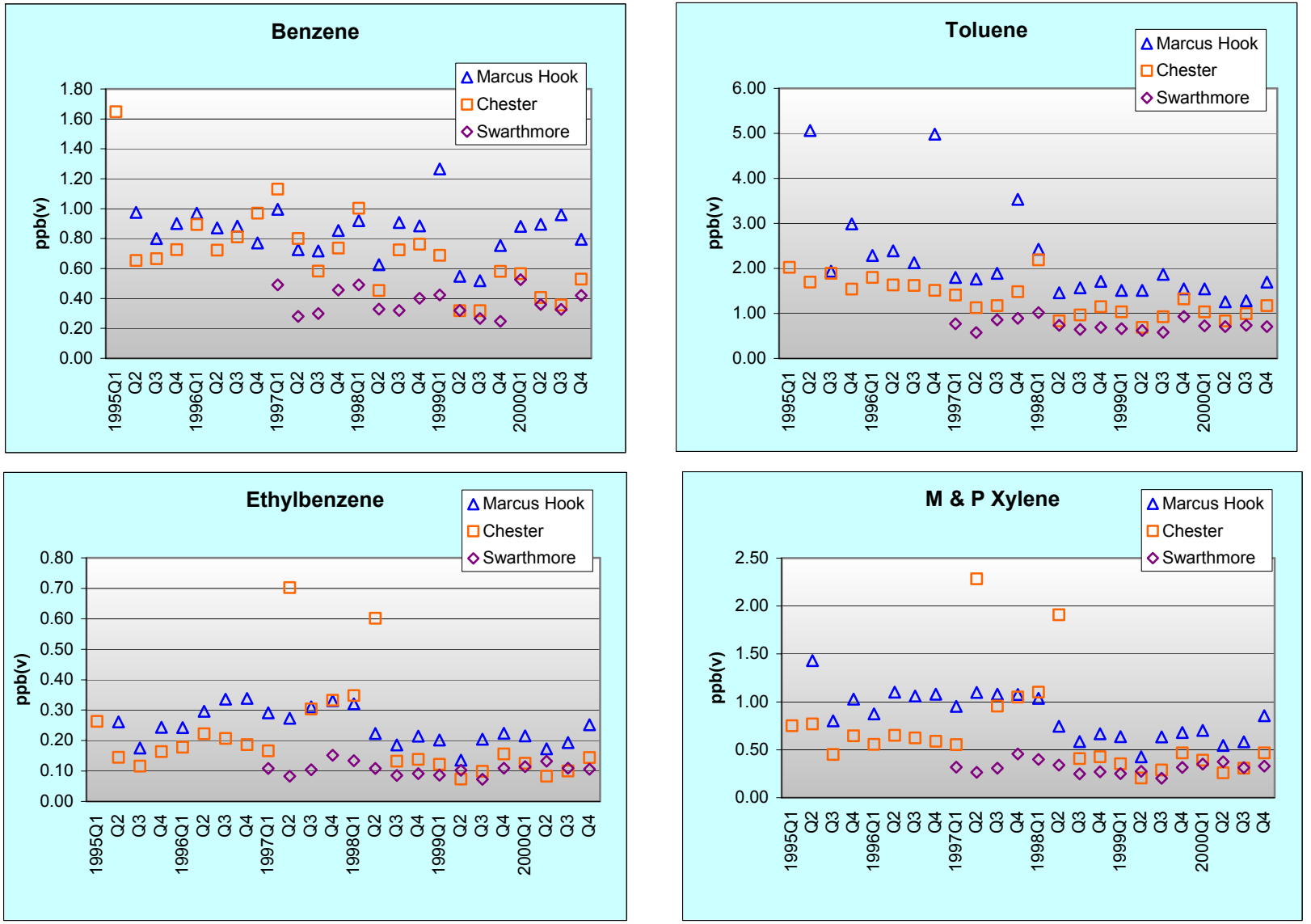

Figure 1.4. Quarterly Average Concentrations

Hydrocarbon Compounds

Table 1.3 summarizes the annual average hydrocarbon concentrations at the three monitoring sites. Figure 1.5 compares the annual average concentrations and annual maximums in ppbC of total non-methane organic carbon (TNMOC). The very high maximum at Marcus Hook that occurred on January 22, 1997 was mostly propane, butane, isobutane and other light alkanes. The 2000 annual average TNMOC concentrations were 390.9 ppbC, 236.1 ppbC and 153.0 ppbC at Marcus Hook, Chester and Swarthmore respectively. Compared to all the 24-hour sites in the entire country that reported 2000 annual averages to AIRS-AQS, the EPA database for air data, Marcus Hook ranks in the 95th percentile, Chester in the 70th percentile and Swarthmore in the 40th percentile. The percentile rank means that the average concentration at the site is equal or higher than the concentration at that percent of the total number of sites reporting. It should be noted that many PAMS sites only operate during the ozone season (typically April to October), which might bias the comparison. Other trends or changes in hydrocarbon concentrations over the course of the study have been noted and they are listed below:

- At all three sites approximately 50% or more of the compounds have been higher in the winter and lower in the summer. Isoprene, which is emitted by plants, is higher in the summer and lower in the winter.
- At the Chester and Swarthmore sites, the concentration of 1-Hexene is higher in the summer and lower in the winter. At the Marcus Hook site, the 1-Hexane concentration is higher in the fall and lower in the spring.
- The Chester site has had a substantial decrease in Ethylbenzene, m & p-Xylene, Styrene, o-Xylene, and Nonane concentrations since 1998.
- Since the Chester site was moved in 1999, it has had a substantial decrease in 2-Methylhexane; 2,3-Dimethylpentane; 3-Methylhexane and Heptane.
- At the Marcus Hook site, there was an episode from September to November 1996 with higher concentrations of 2-Methyl-1-pentene and Toluene. Toluene concentrations were confirmed by the GC/MS analysis.
- All the sites have had sporadic episodes of higher concentrations of 1,2,3-Trimethylbenzene; Chester beginning in 1996, Marcus Hook beginning in 1999 and Swarthmore beginning in 2000.

Several aromatic compounds are on both the organic compound list and the hydrocarbon list. Table 1.4 provides a comparison of the 2000 annual average concentrations as determined by the two analytical methods. The overall agreement was excellent, except for styrene, which was near or below the MDL in many samples. This overall agreement provides confidence that the individual analytical methods are accurate.

Table 1.3. Annual Average Hydrocarbon Concentrations in ppbC

Annual Average	1995		1996		1997			1998			1999			2000		
COMPOUND	Ches	Marc	Ches	Marc	Ches	Marc	Swar	Ches	Marc	Swar	Ches	Marc	Swar	Ches	Marc	Swar
ETHYLENE	5.6	12.5	6.8	17.1	5.2	17.0	4.0	5.6	17.4	3.8	4.4	13.6	3.5	5.3	17.5	4.3
ACETYLENE	4.1	4.4	4.6	4.7	2.9	3.1	3.0	3.8	3.9	2.9	3.2	3.2	3.5	3.8	3.8	3.0
ETHANE	10.2	17.0	10.5	14.6	9.2	15.0	7.3	9.6	13.5	6.6	9.6	9.2	5.4	11.7	12.3	6.2
PROPENE	6.2	29.9	7.3	27.9	7.9	42.5	3.6	6.9	31.3	3.8	6.6	28.8	3.2	5.3	35.2	4.3
PROPANE	18.0	37.9	19.4	34.2	19.2	69.0	10.7	18.8	33.9	9.7	27.5	24.7	8.5	26.2	31.2	8.7
ISOBUTANE	21.5	33.4	9.8	15.3	9.7	17.5	3.6	11.8	18.5	3.9	4.7	14.3	2.9	5.9	18.0	3.8
1-BUTENE	4.6	6.1	2.9	3.9	1.9	2.7	1.5	1.6	2.2	0.9	0.7	1.4	0.4	1.0	2.3	0.6
BUTANE	21.1	42.9	17.3	29.5	17.7	37.0	7.7	20.1	30.5	7.1	8.5	20.4	6.0	8.8	26.4	5.9
t-2-BUTENE	0.8	2.1	2.0	1.5	0.7	1.4	0.3	0.9	2.0	0.3	0.4	1.3	0.2	0.5	2.5	0.3
c-2-BUTENE	3.2	2.8	1.3	1.8	1.2	1.5	0.6	0.8	1.6	0.4	0.4	1.2	0.3	0.5	1.9	0.3
ISOPENTANE	16.3	37.3	13.5	21.9	14.2	22.1	6.3	15.6	21.8	5.9	5.8	17.0	4.4	6.5	22.1	5.3
1-PENTENE	1.7	3.2	1.0	1.9	1.8	1.3	0.7	0.7	1.0	0.5	0.8	1.0	0.6	0.9	1.0	0.6
PENTANE	13.9	22.3	10.4	12.9	8.1	15.5	3.5	6.6	10.1	3.2	2.9	7.9	2.6	3.8	12.2	3.0
ISOPRENE	1.1	2.9	0.5	2.6	1.0	0.8	1.6	0.6	2.1	1.2	0.8	0.7	1.4	1.4	0.5	1.1
t-2-PENTENE	1.0	2.3	0.7	1.3	0.8	1.2	0.3	0.8	1.3	0.4	0.2	0.9	0.1	0.4	1.3	0.3
c-2-PENTENE	0.6	1.3	0.5	1.3	0.5	1.3	0.2	0.7	1.0	0.3	0.1	0.6	0.1	1.1	0.7	0.2
2,2-DIMETHYLBUTANE	0.7	1.5	0.7	1.1	0.7	1.0	0.4	0.6	1.1	0.5	0.3	0.6	0.2	0.6	1.0	0.4
CYCLOPENTANE	1.1	2.3	1.1	1.6	1.0	1.7	0.5	0.8	1.3	0.5	0.4	1.0	0.5	0.5	1.6	0.4
2,3-DIMETHYLBUTANE	1.7	3.1	1.3	2.1	1.4	2.2	0.8	1.2	2.2	0.8	0.8	1.8	0.7	0.6	2.0	0.6
2-METHYLPENTANE	4.1	9.1	4.2	6.7	3.8	7.6	2.0	3.5	6.3	1.8	2.1	5.0	1.6	2.3	7.4	1.8
3-METHYLPENTANE	10.8	12.8	6.1	10.6	4.8	6.4	1.7	4.5	4.8	2.0	3.3	6.0	2.3	2.4	6.3	1.7
2-METHYL-1-PENTENE	1.9	2.5	0.7	2.1	0.7	0.6	1.2	1.2	1.8	1.2	0.8	1.3	0.7	0.7	0.5	0.4
HEXANE	3.3	7.4	3.4	5.6	3.1	6.6	1.9	2.8	5.2	1.6	2.5	3.8	1.5	2.4	6.2	1.7
METHYLCYCLOPENTANE	2.1	4.7	2.1	3.5	3.3	4.2	1.0	2.5	3.4	1.0	1.2	2.6	0.8	1.3	3.9	0.9
2,4-DIMETHYLPENTANE	0.8	1.4	0.7	1.1	0.7	1.0	0.4	0.7	1.1	0.5	0.3	0.7	0.2	0.6	1.1	0.4
BENZENE	4.8	6.1	5.2	5.0	5.6	5.1	2.4	4.5	5.3	2.3	2.4	4.3	1.7	2.5	5.1	2.2
CYCLOHEXANE	1.5	2.9	1.3	2.2	2.3	3.5	0.7	1.2	2.2	0.6	0.6	1.6	0.3	1.2	3.1	0.6
2-METHYLHEXANE	6.3	3.9	5.2	3.3	4.9	2.6	1.0	3.8	2.9	1.0	1.1	2.3	0.7	1.7	3.2	1.0
2,3-DIMETHYLPENTANE	3.1	2.5	2.6	2.0	2.4	1.4	0.7	1.8	1.8	0.8	0.7	1.2	0.5	0.8	1.4	0.6
3-METHYLHEXANE	9.2	4.5	7.4	3.8	8.3	3.2	1.2	6.8	3.8	1.1	1.4	2.8	0.7	2.2	3.6	1.3

Table 1.3. Annual Average Hydrocarbon Concentrations in ppbC

Annual Average	1995		1996		1997			1998			1999			2000		
COMPOUND	Ches	Marc	Ches	Marc	Ches	Marc	Swar	Ches	Marc	Swar	Ches	Marc	Swar	Ches	Marc	Swar
2,2,4-TRIMETHYLPENTANE	2.9	4.5	2.8	4.0	2.4	3.3	1.5	2.2	4.0	1.6	1.3	2.1	1.0	1.6	2.8	1.3
HEPTANE	9.8	4.7	8.5	4.2	10.7	3.7	1.1	8.3	4.4	1.1	1.6	3.2	0.7	2.2	3.8	0.9
METHYLCYCLOHEXANE	2.7	4.1	3.4	3.2	5.3	4.2	0.7	4.6	3.3	0.7	0.8	2.8	0.6	1.5	4.2	0.7
2,3,4-TRIMETHYLPENTANE	0.9	1.4	0.9	1.3	0.9	1.4	0.5	1.1	2.0	0.7	0.5	0.9	0.4	0.6	1.2	0.5
TOLUENE	14.5	25.8	12.6	34.1	9.5	13.4	5.8	8.7	13.1	5.1	5.7	11.1	4.6	7.1	10.7	4.7
2-METHYLHEPTANE	0.7	1.3	0.7	1.1	0.6	1.2	0.4	0.7	1.1	0.4	0.3	0.8	0.3	0.5	1.2	0.5
3-METHYLHEPTANE	0.6	1.1	0.8	1.1	0.8	1.1	0.4	0.8	1.0	0.5	0.4	0.9	0.3	0.6	1.4	0.7
OCTANE	1.1	2.5	1.1	1.9	1.1	2.2	0.7	1.2	1.5	0.6	0.5	1.1	0.4	1.3	2.0	1.1
ETHYLBENZENE	1.6	2.3	1.7	2.4	3.2	2.3	0.9	2.3	1.9	0.8	0.7	1.2	0.6	0.9	1.6	0.8
m & p-XYLENE	5.4	9.1	5.6	8.4	10.3	7.5	2.7	7.5	6.0	2.4	2.2	4.3	1.9	2.9	5.5	2.6
STYRENE	0.9	1.1	1.0	0.9	0.8	0.9	0.4	0.6	0.7	0.3	0.2	0.4	0.2	0.4	0.6	0.3
o-XYLENE	2.5	3.5	2.5	3.1	3.6	3.0	1.2	2.7	2.4	1.1	0.9	1.3	0.7	0.9	2.1	1.0
NONANE	1.2	1.4	1.3	1.3	1.6	2.2	0.5	1.4	2.0	0.9	0.6	1.0	0.3	0.7	1.1	0.4
ISOPROPYLBENZENE	0.5	0.4	0.5	0.5	0.5	1.4	1.6	0.6	0.4	0.4	0.4	0.3	0.2	0.6	0.6	0.5
PROPYLBENZENE	0.5	0.6	0.7	0.7	0.7	1.0	0.4	0.5	0.6	0.3	0.3	0.3	0.2	0.4	0.4	0.2
1-ETHYL-3-METHYLBENZENE	1.3	1.6	1.5	1.7	1.5	2.3	1.1	1.2	1.4	0.8	0.8	0.8	0.5	1.2	1.2	0.6
1-ETHYL-4-METHYLBENZENE	0.9	1.1	1.3	1.2	1.1	1.5	0.6	0.9	1.2	0.7	0.7	0.7	0.4	0.7	0.7	0.4
1,3,5-TRIMETHYLBENZENE	1.1	1.3	1.3	1.3	1.0	1.3	0.5	0.7	0.9	0.4	0.4	0.5	0.2	0.6	0.7	0.3
1-ETHYL-2-METHYLBENZENE	0.9	1.0	1.0	0.9	1.4	1.7	0.7	0.9	1.2	0.6	0.6	0.7	0.5	0.6	0.6	0.4
1,2,4-TRIMETHYLBENZENE	2.7	3.2	2.7	2.9	2.6	4.6	1.5	2.0	2.7	1.2	1.1	1.3	0.7	1.7	1.9	1.0
DECANE	1.9	1.8	2.0	1.6	2.5	6.2	1.0	1.5	2.3	0.7	0.7	0.9	0.5	1.6	1.3	1.0
1,2,3-TRIMETHYLBENZENE	0.9	1.9	2.8	4.0	25.0	3.6	1.2	10.3	2.1	1.3	6.1	3.1	0.9	11.9	10.5	9.9
m-DIETHYLBENZENE	0.3	0.4	0.4	0.4	0.7	1.1	0.4	0.4	0.5	0.3	0.2	0.2	0.1	0.3	0.3	0.2
p-DIETHYLBENZENE	0.4	0.6	0.6	0.7	0.4	1.1	0.3	0.3	0.5	0.2	0.2	0.3	0.1	0.3	0.4	0.2
UNDECANE	1.3	1.3	1.4	1.1	1.3	15.5	0.8	0.7	1.0	0.4	0.6	0.6	0.3	0.6	0.8	0.4
DODECANE					0.0	0.0	0.0	0.5	0.4	0.3	0.9	0.4	0.3	0.5	0.6	0.3
TNMOC	328.7	541.2	364.3	435.2	402.4	634.6	150.2	285.5	395.1	128.9	202.8	284.8	108.4	236.1	390.9	157.0
PAMSHC	238.8	400.9	209.4	327.0	231.8	365.3	97.7	184.3	283.7	90.2	122.9	221.5	72.2	144.9	293.5	92.9

TNMOC = total non-methane organic compounds
PAMSHC = Sum of Photochemical Assessment Monitoring Sites target compounds

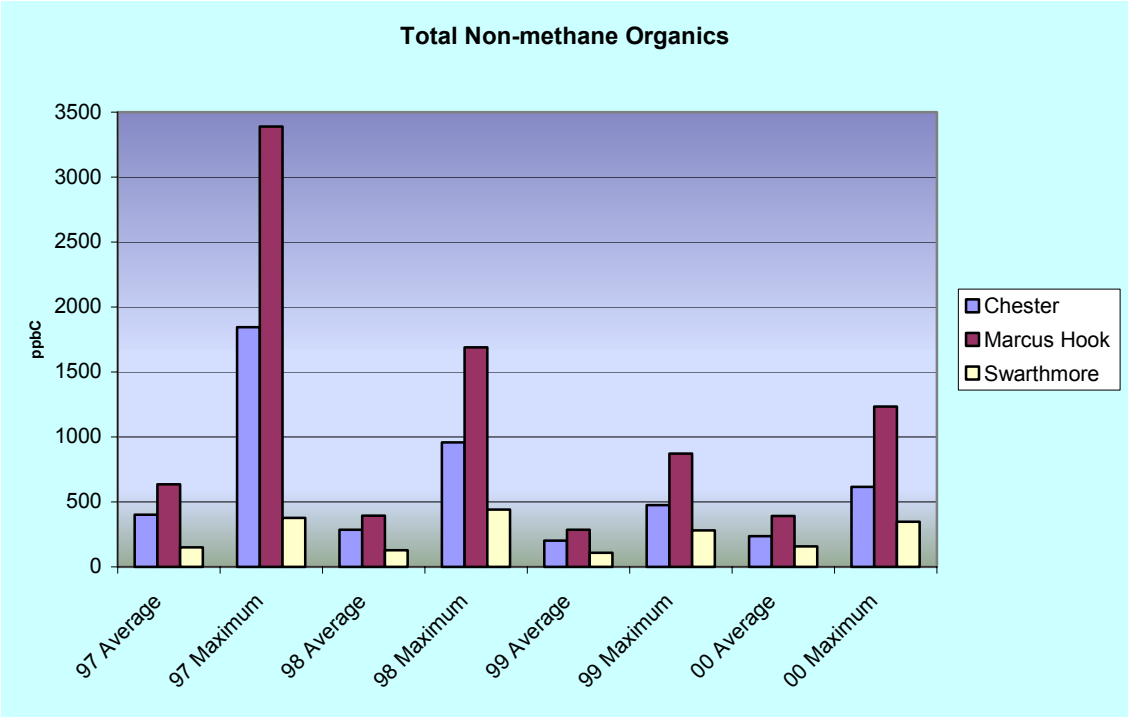

Figure 1.5. Annual Average and Maximum Total Non-Methane Organics in ppbC

Table 1.4. 2000 Annual Average Concentrations by GC/FID Compared to GC/MS SIM

	Chester			Marcus Hook			Swarthmore		
	FID ppbv	SIM ppbv	Percent Difference	FID ppbv	SIM ppbv	Percent Difference	FID ppbv	SIM ppbv	Percent Difference
Benzene	0.92	0.86	6.6	0.87	0.83	5.0	0.39	0.37	6.5
Toluene	1.40	1.38	1.7	2.25	2.26	-0.6	0.82	0.78	5.2
m & p-Xylene	1.23	1.27	-3.5	0.94	1.05	-10.9	0.33	0.34	-2.9
Ethylbenzene	0.39	0.40	-2.2	0.29	0.30	-2.8	0.11	0.11	-0.4
Styrene	0.10	0.05	56.7	0.11	0.07	39.5	0.05	0.03	42.0
o-Xylene	0.43	0.40	7.0	0.37	0.35	5.0	0.16	0.13	16.8

Particulates and Metals Sampling

Sampling for particulates and metals started on March 5, 1997, so the amount of data used to estimate the 1997 annual average covers less than a full year. The TSP samplers were switched from glass fiber filters to quartz fiber filters on August 2, 1997 because quartz filters typically have slightly lower background levels of metals.

The annual averages used for the risk characterization are the arithmetic average of all valid samples in the calendar year with one-half of the minimum detection limits substituted for non-detects. Because some particles that TSP samplers collect are too large to be inhaled, the inhalation exposures estimates may be conservative (higher than the actual risk.) We chose to analyze for toxic metals in the total particulate rather than just in the respirable particulate, because toxic metals deposited in the environment could expose the public through other exposure routes.

The Chester site is on an industrial property where there were construction and earth-moving activities near the samplers during part of the year 1997. In addition, the Chester sampler inlets are about two meters above ground-level, while the Marcus Hook and Swarthmore samplers are both on buildings rooftops with the inlets between 10 and 15 meters above ground-level. This could bias the results at the Chester site, and account for the slightly higher average TSP and PM10 concentrations. The Swarthmore sampler has consistently been lowest in TSP, PM-10, and all metals.

Table 2.5 on page 26, shows the average TSP and PM10 concentrations for all sites from 1997 through 2000. Chester TSP and PM-10 concentrations have consistently been slightly higher than Marcus Hook's concentrations. However, over the four years, while TSP levels at the Chester site have remained relatively constant, levels at the Marcus Hook site have slightly increased, until they were nearly equal in 2000. Figure 1.6 compares the TSP concentrations at the three sites during 2000.

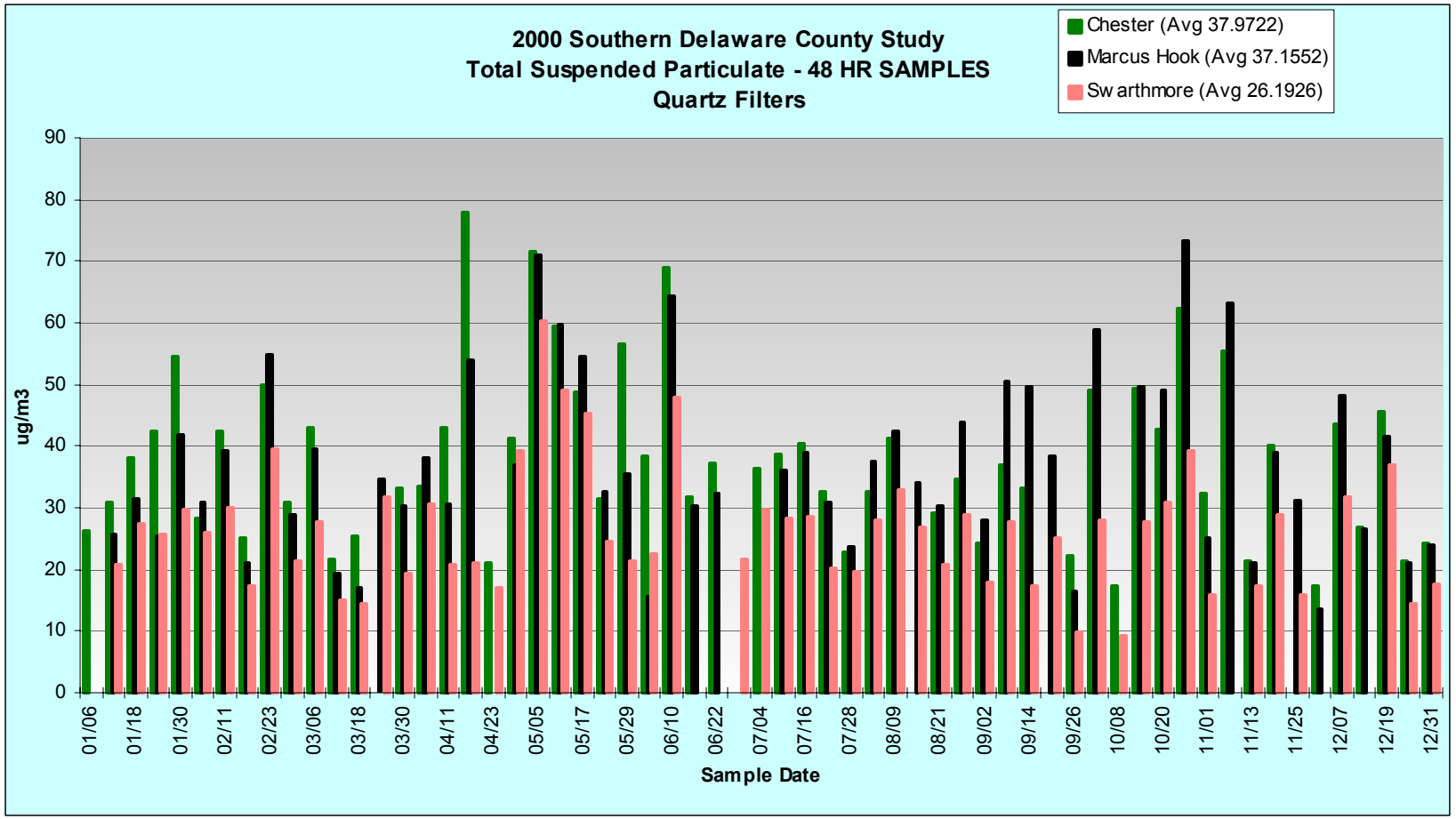

Figure 1.6. Comparison of the Average TSP Concentrations

Toxicity Assessment and Inhalation Risk Characterization

Overview of Risk Factors and Reference Doses

The excess lifetime cancer risk for each of the chemicals was calculated using unit risk factors (URFs), and the risk for non-cancer health effects was calculated using reference air concentrations (RfCs). The URF is a measure of the probability of developing cancer from exposure over a lifetime to a specified concentration of a given chemical. The RfC is the concentration below which no (non-cancer) adverse health affects are expected to occur over a lifetime of continuous exposure. The EPA Region III Superfund Technical Support Section's risk-based concentration (RBC) table was the primary source for the risk factors. In some cases, there were no inhalation risk data for a chemical in the RBC table and other sources, such as the Boilers and Industrial Furnaces (BIF) Regulation, had to be referenced. Table 2.1 gives all of the URFs and RfCs, and summarizes their sources. EPA has revised some of the risk factors since the second interim report was released, and these changes are also listed in the appendix. Of the organic chemicals on the GC/MS target list, 34 had data for either the inhalation reference dose or inhalation cancer potency slope (from which the RfC and URF are derived). Six of the metals had data for either the inhalation reference dose or inhalation cancer potency slope.

The URF and RfC are derived by assuming an adult weighing 70 kilograms (154 pounds) will breathe 20 m^3 (706 ft^3) of air each day for 365 days a year, over a 70-year lifetime of exposure. This is a standard conversion methodology and is detailed in the RBC table. The excess lifetime cancer risk is calculated for each chemical by multiplying its URF by the average concentration of all the valid air samples collected during the year. The individual risks for each chemical are added to get the total excess lifetime cancer risk at that site. Any risk estimate is based on a number of assumptions and some of the assumptions made for this study include the following:

- The measured annual average concentration is the concentration that the individual will be exposed to over a lifetime;
- The concentrations measured at the sampling site are representative of exposures to the population in the area;
- The effects from exposure to multiple chemicals are additive;
- The exposure is based on a typical adult;
- The only excess risk considered in this report is due to inhalation.

The non-cancer risk associated with each of the relevant chemicals is calculated by simply dividing the measured air concentration by the chemical's respective RfC. If this value is less than one, and inhalation is the only source of exposure, then that chemical is not likely to cause adverse non-cancer health affects.

Discussion of Results

Table 2.1 gives the toxicity factors used for the risk analysis and Tables 2.2 through 2.4 summarize the annual average concentrations of volatile organic compounds and the corresponding risks for Chester, Marcus Hook and Swarthmore, respectively. Sampling started

at the Chester site in January 1995, at the Marcus Hook site in April 1995 and at the Swarthmore site in January 1997. Table 2.5 summarizes the average concentrations for particulates and metals, and the associated excess lifetime cancer risks from inhalation.

The four chemicals with the highest estimated excess lifetime cancer risk are 1,3-butadiene, 1,2-dibromoethane, benzene and carbon tetrachloride. The estimated excess lifetime cancer risks associated with the metals in Table 2.5 were less than the risks associated with the top four organic chemicals at all three sites. According to the Agency for Toxic Substances and Disease Registry's Public Health Statement, background carbon tetrachloride concentrations around the world are 0.1 parts per billion. The carbon tetrachloride concentrations at Chester, Marcus Hook and Swarthmore sites are all at background levels.

As was noted earlier, all raw data, including the data used to compile Tables 2.1 through 2.5, are available in Microsoft Excel format.

Table 2.1
Cancer Unit Risk Factors for Inhalation (m3/ug) and Reference Concentrations (ug/m3)

Chemical Name	Unit Risk (m3/ug)	Reference Air Concentration (ug/m3)	Molecular Weight	Source URF[1]	Source RFD[1]
1,3-Butadiene	2.80E-04	----------	54.1	I	
1,2-Dichlorobenzene	----------	----------	147.0		
1,3-Dichlorobenzene	----------	----------	147.0		
1,4-Dichlorobenzene	6.29E-06	8.00E+02	147.0	O	I
1,2-Dibromoethane	2.20E-04	2.00E-01	187.9	I	O
1,1-Dichloroethane	----------	5.00E+02	99.0		O
1,2-Dichloroethane	2.60E-05	5.00E+00	99.0	I	O
1,1-Dichloroethene	5.00E-05	----------	97.0	I	
1,2-Dichloropropane	----------	4.00E+00	113.0		I
1,3-Dichloropropene	4.00E-06	2.00E+01	111.0	I	I
1,1,2,2-Tetrachloroethane	5.80E-05	----------	167.9	I	
1,2,4-Trichlorobenzene	----------	2.00E+02	181.4		O
1,1,1-Trichloroethane	----------	2.20E+03	133.4		O
1,1,2-Trichloroethane	1.60E-05	----------	133.4	I	
1,1,2-Trichloro-1,2,2-Trifluoroethane	----------	3.00E+04	187.4		O
1,2,4-Trimethylbenzene	----------	6.00E+00	120.2		O
1,3,5-Trimethylbenzene	----------	6.00E+00	120.2		O
Benzene	7.80E-06	6.00E+00	78.1	I	O
Bromomethane	----------	5.00E+00	95.0		I
Carbon Tetrachloride	1.50E-05	2.00E+00	153.8	I	O
Chlorobenzene	----------	6.00E+01	112.6		O
Chloroethane	----------	1.00E+04	64.5		I
Chloroethene (Vinyl Chloride)	8.80E-06	1.00E+02	62.5	I	I
Chloroform	2.30E-05	3.00E-01	119.4	I	O
Chloromethane	1.00E-06	9.00E+01	50.5	O	I
Dichlorodifluoromethane	----------	1.75E+02	120.9		O
Ethylbenzene	----------	1.00E+03	106.2		I
Hexachloro-1,3-butadiene	2.20E-05	----------	260.7	I	
Methylene Chloride	4.70E-07	3.00E+03	84.9	I	O
Styrene	----------	1.00E+03	104.2		I
Tetrachloroethylene	5.71E-07	5.00E+02	165.8	O	O
Toluene	----------	4.00E+02	92.1		I
Trichloroethylene	1.71E-06	----------	131.4	O	
Trichlorofluoromethane	----------	7.00E+02	137.4		O
o-Xylene	----------	8.00E+01	106.2		B
m,p-Xylene	----------	8.00E+01	106.2		B
Arsenic	4.30E-03	----------		I	
Beryllium	2.40E-03	2.00E-02		I	I
Cadmium	1.80E-03	2.00E-01		I	O
Chromium	----------	----------			
Chromium +VI	1.20E-02	8.00E-03		I	I
Lead	----------	9.00E-02			B
Manganese	----------	5.00E-02			I
Nickel[2]	2.40E-04	----------		I	
Zinc	----------	----------			
Particulate Matter (TSP)	----------	----------			
PM-10[3]	----------	5.00E+01			O

1. **I** U.S. EPA's Integrated Risk Information System (IRIS), **B** Boiler and Industrial Furnace Regulations (BIF), **O** Other sources
2. The URF is for nickel as refinery dust.
3. The RfC is the annual mean ambient air quality standard.

Table 2.2
Summary of Excess Lifetime Cancer Risks from Inhalation
Across Chemicals of Concern for City of Chester, Pennsylvania

	1995		1/1/96 - 9/18/96		1997		1998		1999		2000	
Chemical Name	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk
1,3-Butadiene	0.10	6.4E-05	0.07	4.5E-05	0.08	5.1E-05	0.07	4.6E-05	0.08	4.8E-05	0.11	6.8E-05
1,2-Dichlorobenzene	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.00	----------	0.01	----------
1,3-Dichlorobenzene	0.00	----------	0.00	----------	0.03	----------	0.00	----------	0.00	----------	0.00	----------
1,4-Dichlorobenzene	0.02	9.3E-07	0.03	1.1E-06	0.04	1.4E-06	0.03	1.0E-06	0.02	8.1E-07	0.03	1.2E-06
1,2-Dibromoethane	0.02	3.8E-05	0.01	1.5E-05	0.01	1.1E-05	0.01	8.9E-06	0.00	6.9E-06	0.00	6.2E-06
1,1-Dichloroethane	0.00	----------	0.00	----------	0.01	----------	0.00	----------	0.00	----------	0.00	----------
1,2-Dichloroethane	0.02	2.2E-06	0.03	3.0E-06	0.03	3.1E-06	0.03	3.6E-06	0.09	9.9E-06	0.10	1.0E-05
1,1-Dichloroethene	0.01	2.5E-06	0.00	6.9E-07	0.00	7.3E-07	0.00	5.0E-07	0.00	5.4E-07	0.00	5.0E-07
1,2-Dichloropropane	0.02	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------
1,3-Dichloropropene	0.01	2.1E-07	0.01	1.8E-07	0.01	1.6E-07	0.01	1.6E-07	0.01	1.7E-07	0.01	1.3E-07
1,1,2,2-Tetrachloroethane	0.01	3.0E-06	0.01	2.6E-06	0.01	2.3E-06	0.00	1.8E-06	0.00	1.6E-06	0.00	1.5E-06
1,2,4-Trichlorobenzene	0.00	----------	0.01	----------	0.01	----------	0.01	----------	0.00	----------	0.00	----------
1,1,1-Trichloroethane	0.55	----------	0.16	----------	0.13	----------	0.10	----------	0.08	----------	0.08	----------
1,1,2-Trichloroethane	0.01	7.4E-07	0.01	6.2E-07	0.01	6.5E-07	0.01	6.2E-07	0.01	6.1E-07	0.01	5.1E-07
1,1,2-Trichloro-		----------		----------		----------				----------		----------
1,2,2-Trifluoroethane	0.12	----------	0.09	----------	0.09	----------	0.08	----------	0.09	----------	0.10	----------
1,2,4-Trimethylbenzene	0.16	----------	0.21	----------	0.22	----------	0.17	----------	0.13	----------	0.15	----------
1,3,5-Trimethylbenzene	0.06	----------	0.07	----------	0.07	----------	0.06	----------	0.04	----------	0.05	----------
Benzene	0.92	2.3E-05	0.81	2.0E-05	0.86	2.2E-05	0.74	1.9E-05	0.49	1.2E-05	0.48	1.2E-05
Bromomethane	0.04	----------	0.02	----------	0.02	----------	0.02	----------	0.03	----------	0.03	----------
Carbon Tetrachloride	0.10	1.0E-05	0.11	1.0E-05	0.11	1.0E-05	0.10	9.8E-06	0.11	1.0E-05	0.11	1.1E-05
Chlorobenzene	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------
Chloroethane	0.06	----------	0.08	----------	0.09	----------	0.06	----------	0.07	----------	0.08	----------
Chloroethene (Vinyl Chloride)	0.05	1.0E-06	0.07	1.6E-06	0.03	7.6E-07	0.03	7.0E-07	0.01	2.3E-07	0.02	5.5E-07
Chloroform	0.04	5.0E-06	0.04	4.7E-06	0.05	5.1E-06	0.05	5.9E-06	0.04	4.2E-06	0.04	4.1E-06
Chloromethane	0.51	1.1E-06	0.56	1.2E-06	0.52	1.1E-06	0.57	1.2E-06	0.57	1.2E-06	0.59	1.2E-06
Dichlorodifluoromethane	0.61	----------	0.63	----------	0.57	----------	0.61	----------	0.57	----------	0.59	----------
Ethylbenzene	0.16	----------	0.20	----------	0.40	----------	0.32	----------	0.12	----------	0.11	----------
Hexachloro-1,3-butadiene	0.01	3.0E-06	0.01	2.5E-06	0.00	9.8E-07	0.00	5.9E-07	0.01	1.2E-06	0.00	1.1E-06
Methylene Chloride	0.18	3.0E-07	0.23	3.7E-07	0.28	4.7E-07	0.20	3.3E-07	0.15	2.4E-07	0.16	2.6E-07
Styrene	0.05	----------	0.07	----------	0.05	----------	0.04	----------	0.03	----------	0.04	----------
Tetrachloroethylene	0.07	2.6E-07	0.07	2.8E-07	0.06	2.3E-07	0.06	2.4E-07	0.12	4.6E-07	0.14	5.4E-07
Toluene	1.85	----------	1.69	----------	1.38	----------	1.31	----------	1.02	----------	1.00	----------
Trichloroethylene	0.10	9.1E-07	0.06	5.5E-07	0.05	4.4E-07	0.04	3.9E-07	0.04	3.6E-07	0.06	5.3E-07
Trichlorofluoromethane	0.31	----------	0.33	----------	0.31	----------	0.30	----------	0.30	----------	0.31	----------
o-Xylene	0.22	----------	0.23	----------	0.40	----------	0.33	----------	0.13	----------	0.14	----------
m,p-Xylene	0.63	----------	0.61	----------	1.27	----------	1.00	----------	0.34	----------	0.36	----------
		1.6E-04		1.1E-04		1.1E-04		1.0E-04		9.9E-05		1.2E-04

Notes:

No samples were collected from 9/19/96 to 1/1/97.

Average is the arithmetic mean of all valid samples in the time period with one-half the minimum detection limit substituted for non-detects.

Table 2.3
Summary of Excess Lifetime Cancer Risks from Inhalation
Across Chemicals of Concern for Marcus Hook, Pennsylvania

	4/6/95 - 12/31/95		1996		1/21/97 - 12/31/97		1998		1999		2000	
Chemical Name	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk	Annual Average (ppbv)	Excess Lifetime Cancer Risk
1,3-Butadiene	0.08	5.2E-05	0.14	8.7E-05	0.10	6.0E-05	0.13	8.0E-05	0.07	4.5E-05	0.09	5.6E-05
1,2-Dichlorobenzene	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.00	----------	0.01	----------
1,3-Dichlorobenzene	0.00	----------	0.01	----------	0.02	----------	0.00	----------	0.00	----------	0.00	----------
1,4-Dichlorobenzene	0.02	7.0E-07	0.03	1.2E-06	0.03	1.2E-06	0.02	8.9E-07	0.02	6.5E-07	0.03	1.0E-06
1,2-Dibromoethane	0.02	3.0E-05	0.01	2.2E-05	0.01	1.6E-05	0.01	1.3E-05	0.00	6.6E-06	0.00	6.9E-06
1,1-Dichloroethane	0.00	----------	0.00	----------	0.01	----------	0.00	----------	0.00	----------	0.00	----------
1,2-Dichloroethane	0.02	1.7E-06	0.02	1.8E-06	0.02	1.9E-06	0.02	1.8E-06	0.01	1.4E-06	0.01	1.6E-06
1,1-Dichloroethene	0.01	2.8E-06	0.00	8.5E-07	0.00	7.6E-07	0.00	5.7E-07	0.00	5.1E-07	0.00	6.4E-07
1,2-Dichloropropane	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------
1,3-Dichloropropene	0.01	1.9E-07	0.01	1.8E-07	0.01	1.8E-07	0.01	1.7E-07	0.01	1.7E-07	0.01	1.7E-07
1,1,2,2-Tetrachloroethane	0.01	2.6E-06	0.00	0.0E+00	0.01	2.0E-06	0.00	2.0E-06	0.00	1.8E-06	0.00	1.8E-06
1,2,4-Trichlorobenzene	0.00	----------	0.01	----------	0.01	----------	0.00	----------	0.00	----------	0.00	----------
1,1,1-Trichloroethane	0.21	----------	0.20	----------	0.12	----------	0.09	----------	0.08	----------	0.07	----------
1,1,2-Trichloroethane	0.02	1.5E-06	0.01	7.9E-07	0.01	7.4E-07	0.01	7.3E-07	0.01	6.6E-07	0.01	7.3E-07
1,1,2-Trichloro-		----------		----------		----------		----------		----------		----------
1,2,2-Trifluoroethane	0.14	----------	0.11	----------	0.10	----------	0.09	----------	0.09	----------	0.10	----------
1,2,4-Trimethylbenzene	0.20	----------	0.25	----------	0.22	----------	0.20	----------	0.15	----------	0.18	----------
1,3,5-Trimethylbenzene	0.07	----------	0.08	----------	0.07	----------	0.07	----------	0.05	----------	0.07	----------
Benzene	0.90	2.3E-05	0.81	2.1E-05	0.83	2.1E-05	0.83	2.1E-05	0.76	1.9E-05	0.89	2.2E-05
Bromomethane	0.01	----------	0.02	----------	0.02	----------	0.02	----------	0.03	----------	0.04	----------
Carbon Tetrachloride	0.10	9.8E-06	0.11	1.0E-05	0.11	1.0E-05	0.10	9.7E-06	0.11	1.0E-05	0.11	1.1E-05
Chlorobenzene	0.02	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------	0.01	----------
Chloroethane	0.05	----------	0.05	----------	0.05	----------	0.04	----------	0.04	----------	0.04	----------
Chloroethene (Vinyl Chloride)	0.06	1.4E-06	0.04	9.4E-07	0.04	8.0E-07	0.03	7.9E-07	0.01	2.3E-07	0.02	5.0E-07
Chloroform	0.03	3.5E-06	0.03	3.7E-06	0.03	3.5E-06	0.05	5.6E-06	0.03	3.6E-06	0.03	3.9E-06
Chloromethane	0.53	1.1E-06	0.63	1.3E-06	0.57	1.2E-06	0.65	1.4E-06	0.59	1.2E-06	0.57	1.2E-06
Dichlorodifluoromethane	0.65	----------	0.63	----------	0.58	----------	0.60	----------	0.61	----------	0.63	----------
Ethylbenzene	0.22	----------	0.29	----------	0.30	----------	0.24	----------	0.19	----------	0.21	----------
Hexachloro-1,3-butadiene	0.01	2.6E-06	0.01	2.2E-06	0.01	1.2E-06	0.00	7.2E-07	0.01	1.4E-06	0.01	1.4E-06
Methylene Chloride	0.18	3.0E-07	0.24	4.0E-07	0.25	4.1E-07	0.18	3.1E-07	0.24	3.9E-07	0.21	3.4E-07
Styrene	0.06	----------	0.08	----------	0.07	----------	0.05	----------	0.06	----------	0.07	----------
Tetrachloroethylene	0.05	1.9E-07	0.06	2.4E-07	0.05	2.1E-07	0.05	2.0E-07	0.08	3.1E-07	0.06	2.4E-07
Toluene	3.31	----------	3.90	----------	2.26	----------	1.79	----------	1.61	----------	1.45	----------
Trichloroethylene	0.07	6.1E-07	0.03	2.8E-07	0.03	2.4E-07	0.02	1.6E-07	0.03	2.5E-07	0.03	3.0E-07
Trichlorofluoromethane	0.31	----------	0.34	----------	0.30	----------	0.30	----------	0.30	----------	0.30	----------
o-Xylene	0.33	----------	0.31	----------	0.35	----------	0.26	----------	0.22	----------	0.07	----------
m,p-Xylene	1.08	----------	0.98	----------	1.05	----------	0.76	----------	0.60	----------	0.67	----------
		1.3E-04		1.5E-04		1.2E-04		1.4E-04		9.3E-05		1.1E-04

Note: Average is the arithmetic mean of all valid samples in the time period with one-half the minimum detection limit substituted for non-detects

Table 2.4
Summary of Excess Lifetime Cancer Risks from Inhalation
Across Chemicals of Concern for Swarthmore, Pennsylvania

Chemical Name	1997 Annual Average (ppbv)	1997 Excess Lifetime Cancer Risk	1998 Annual Average (ppbv)	1998 Excess Lifetime Cancer Risk	1999 Annual Average (ppbv)	1999 Excess Lifetime Cancer Risk	2000 Annual Average (ppbv)	2000 Excess Lifetime Cancer Risk
1,3-Butadiene	0.07	4.4E-05	0.05	3.4E-05	0.05	3.2E-05	0.06	3.7E-05
1,2-Dichlorobenzene	0.01	----------	0.01	----------	0.00	----------	0.00	----------
1,3-Dichlorobenzene	0.02	----------	0.00	----------	0.00	----------	0.00	----------
1,4-Dichlorobenzene	0.03	1.1E-06	0.02	8.6E-07	0.02	6.2E-07	0.02	8.2E-07
1,2-Dibromoethane	0.01	1.3E-05	0.01	1.8E-05	0.00	5.8E-06	0.00	6.3E-06
1,1-Dichloroethane	0.01	----------	0.00	----------	0.00	----------	0.00	----------
1,2-Dichloroethane	0.01	1.6E-06	0.02	1.9E-06	0.01	1.3E-06	0.01	1.5E-06
1,1-Dichloroethene	0.00	7.0E-07	0.00	4.8E-07	0.00	3.9E-07	0.00	5.3E-07
1,2-Dichloropropane	0.01	----------	0.01	----------	0.01	----------	0.01	----------
1,3-Dichloropropene	0.01	1.7E-07	0.01	1.6E-07	0.01	1.6E-07	0.01	1.6E-07
1,1,2,2-Tetrachloroethane	0.02	6.3E-06	0.00	1.5E-06	0.00	1.5E-06	0.00	1.3E-06
1,2,4-Trichlorobenzene	0.01	----------	0.00	----------	0.00	----------	0.00	----------
1,1,1-Trichloroethane	0.14	----------	0.10	----------	0.08	----------	0.07	----------
1,1,2-Trichloroethane	0.01	6.3E-07	0.01	6.1E-07	0.01	4.7E-07	0.01	5.9E-07
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.09	----------	0.08	----------	0.09	----------	0.10	----------
1,2,4-Trimethylbenzene	**	----------	0.12	----------	0.08	----------	0.09	----------
1,3,5-Trimethylbenzene	**	----------	0.04	----------	0.03	----------	0.03	----------
Benzene	0.37	9.3E-06	0.38	9.7E-06	0.38	9.5E-06	0.43	1.1E-05
Bromomethane	0.02	----------	0.03	----------	0.02	----------	0.03	----------
Carbon Tetrachloride	0.11	1.0E-05	0.11	1.0E-05	0.11	1.0E-05	0.12	1.1E-05
Chlorobenzene	0.01	----------	0.01	----------	0.01	----------	0.01	----------
Chloroethane	0.02	----------	0.02	----------	0.02	----------	0.02	----------
Chloroethene (Vinyl Chlorid	0.01	3.4E-07	0.02	3.8E-07	0.01	2.3E-07	0.02	3.5E-07
Chloroform	0.03	3.5E-06	0.05	6.0E-06	0.04	4.0E-06	0.04	4.6E-06
Chloromethane	0.52	1.1E-06	0.57	1.2E-06	0.56	1.2E-06	0.56	1.2E-06
Dichlorodifluoromethane	0.59	----------	0.59	----------	0.56	----------	0.59	----------
Ethylbenzene	0.11	----------	0.11	----------	0.11	----------	0.12	----------
Hexachloro-1,3-butadiene	0.00	1.0E-06	0.00	7.1E-07	0.01	1.2E-06	0.01	1.3E-06
Methylene Chloride	0.19	3.1E-07	0.16	2.6E-07	0.15	2.4E-07	0.15	2.4E-07
Styrene	0.03	----------	0.03	----------	0.03	----------	0.04	----------
Tetrachloroethylene	0.06	2.2E-07	0.06	2.3E-07	0.08	3.0E-07	0.06	2.2E-07
Toluene	0.78	----------	0.78	----------	0.79	----------	0.72	----------
Trichloroethylene	0.25	2.4E-06	0.04	3.7E-07	0.02	2.2E-07	0.03	2.8E-07
Trichlorofluoromethane	0.38	----------	0.39	----------	0.61	----------	0.55	----------
o-Xylene	0.13	----------	0.13	----------	0.12	----------	0.03	----------
m,p-Xylene	0.34	----------	0.32	----------	0.31	----------	0.35	----------
		9.6E-05		8.7E-05		6.9E-05		7.8E-05

Average is the arithmetic mean with one-half the minimum detection limit substituted for non-detects.

** Data invalid

Table 2.5
Summary of Excess Lifetime Cancer Risks from Inhalation for Metals

Chemical Name	Chester 1997 Average ug/m3	Chester 1997 Maximum ug/m3	Chester 1997 Excess Lifetime Cancer Risk	Marcus Hook 1997 Average ug/m3	Marcus Hook 1997 Maximum ug/m3	Marcus Hook 1997 Excess Lifetime Cancer Risk	Swarthmore 1997 Average ug/m3	Swarthmore 1997 Maximum ug/m3	Swarthmore 1997 Excess Lifetime Cancer Risk
Arsenic	1.09E-03	2.49E-03	4.68E-06	9.07E-04	1.62E-03	3.90E-06	8.01E-04	1.84E-03	3.44E-06
Beryllium	4.81E-05	5.52E-05	1.15E-07	4.46E-05	4.80E-05	1.07E-07	4.99E-05	1.06E-04	1.20E-07
Cadmium	2.82E-04	1.34E-03	5.08E-07	2.34E-04	7.26E-04	4.22E-07	1.81E-04	5.62E-04	3.26E-07
Chromium	3.62E-03	1.25E-02	----------	2.29E-03	3.79E-03	----------	1.69E-03	4.16E-03	----------
Lead	1.36E-02	2.71E-02	----------	1.17E-02	2.91E-02	----------	9.16E-03	2.72E-02	----------
Nickel[c]	5.68E-03	1.56E-02	1.36E-06	6.16E-03	3.98E-02	1.48E-06	3.45E-03	9.79E-03	8.27E-07
Zinc	4.46E-02	1.42E-01	----------	4.06E-02	1.64E-01	----------	2.88E-02	1.11E-01	----------
Particulate Matter (TSP)	5.60E+01	1.11E+02	----------	3.08E+01	6.58E+01	----------	2.84E+01	6.02E+01	----------
PM-10[b]	3.16E+01	7.23E+01	----------	2.31E+01	6.22E+01	----------	2.09E+01	5.71E+01	----------
			6.67E-06			5.91E-06			4.72E-06

Chemical Name	Chester 1998 Average ug/m3	Chester 1998 Maximum ug/m3	Chester 1998 Excess Lifetime Cancer Risk	Marcus Hook 1998 Average ug/m3	Marcus Hook 1998 Maximum ug/m3	Marcus Hook 1998 Excess Lifetime Cancer Risk	Swarthmore 1998 Average ug/m3	Swarthmore 1998 Maximum ug/m3	Swarthmore 1998 Excess Lifetime Cancer Risk
Arsenic	8.67E-04	1.55E-03	3.73E-06	8.98E-04	2.01E-03	3.86E-06	7.31E-04	1.59E-03	3.14E-06
Beryllium	4.90E-05	5.89E-05	1.18E-07	5.31E-05	1.99E-04	1.27E-07	5.11E-05	1.14E-04	1.23E-07
Cadmium	2.57E-04	8.29E-04	4.63E-07	2.54E-04	9.64E-04	4.56E-07	1.88E-04	5.92E-04	3.38E-07
Chromium	3.05E-03	2.17E-02	----------	2.27E-03	7.60E-03	----------	1.56E-03	5.85E-03	----------
Lead	1.03E-02	2.25E-02	----------	1.19E-02	6.03E-02	----------	7.86E-03	2.24E-02	----------
Nickel[c]	5.91E-03	1.69E-02	1.42E-06	8.11E-03	3.31E-02	1.95E-06	5.13E-03	1.71E-02	1.23E-06
Zinc	3.31E-02	1.45E-01	----------	4.09E-02	1.24E-01	----------	2.90E-02	1.65E-01	----------
Particulate Matter (TSP)	3.83E+01	6.31E+01	----------	3.42E+01	7.83E+01	----------	2.64E+01	5.90E+01	----------
PM-10[b]	2.63E+01	4.86E+01	----------	2.23E+01	4.65E+01	----------	2.10E+01	4.99E+01	----------
			5.73E-06			6.39E-06			4.84E-06

Chemical Name	Chester 1999 Average ug/m3	Chester 1999 Maximum ug/m3	Chester 1999 Excess Lifetime Cancer Risk	Marcus Hook 1999 Average ug/m3	Marcus Hook 1999 Maximum ug/m3	Marcus Hook 1999 Excess Lifetime Cancer Risk	Swarthmore 1999 Average ug/m3	Swarthmore 1999 Maximum ug/m3	Swarthmore 1999 Excess Lifetime Cancer Risk
Arsenic	8.29E-04	2.62E-03	3.57E-06	7.76E-04	2.03E-03	3.34E-06	5.71E-04	2.08E-03	2.46E-06
Beryllium	5.46E-05	6.13E-05	1.31E-07	5.06E-05	1.00E-04	1.21E-07	4.63E-05	5.20E-05	1.11E-07
Cadmium	2.44E-04	8.46E-04	4.38E-07	2.27E-04	5.52E-04	4.08E-07	1.50E-04	3.04E-04	2.70E-07
Chromium	2.19E-03	8.51E-03	----------	2.44E-03	5.48E-03	----------	1.48E-03	3.66E-03	----------
Lead	1.16E-02	7.08E-02	----------	1.08E-02	3.88E-02	----------	6.34E-03	1.14E-02	----------
Nickel[c]	5.15E-03	2.71E-02	1.24E-06	6.60E-03	1.88E-02	1.58E-06	3.16E-03	9.75E-03	7.59E-07
Zinc	3.41E-02	9.18E-02	----------	4.77E-02	2.00E-01	----------	1.96E-02	5.08E-02	----------
Particulate Matter (TSP)	3.76E+01	6.35E+01	----------	3.49E+01	1.13E+02	----------	2.47E+01	6.14E+01	----------
PM-10[b]	2.49E+01	5.84E+01	----------	2.19E+01	4.97E+01	----------	2.07E+01	4.70E+01	----------
			5.37E-06			5.45E-06			3.60E-06

Chemical Name	Chester 2000 Average ug/m3	Chester 2000 Maximum ug/m3	Chester 2000 Excess Lifetime Cancer Risk	Marcus Hook 2000 Average ug/m3	Marcus Hook 2000 Maximum ug/m3	Marcus Hook 2000 Excess Lifetime Cancer Risk	Swarthmore 2000 Average ug/m3	Swarthmore 2000 Maximum ug/m3	Swarthmore 2000 Excess Lifetime Cancer Risk
Arsenic	9.86E-04	3.00E-03	4.24E-06	1.02E-03	3.18E-03	4.37E-06	8.00E-04	2.54E-03	3.44E-06
Beryllium	5.20E-05	5.59E-05	1.25E-07	4.97E-05	5.66E-05	1.19E-07	4.99E-05	5.52E-05	1.20E-07
Cadmium	2.41E-04	6.20E-04	4.34E-07	2.74E-04	7.20E-04	4.94E-07	2.11E-04	9.13E-04	3.80E-07
Chromium	2.20E-03	5.96E-03	----------	2.50E-03	6.26E-03	----------	1.64E-03	3.25E-03	----------
Lead	9.78E-03	2.26E-02	----------	1.10E-02	3.23E-02	----------	7.34E-03	1.65E-02	----------
Manganese	1.20E-02	3.52E-02	----------	1.76E-02	4.72E-02	----------	8.10E-03	2.08E-02	----------
Nickel[c]	4.91E-03	1.44E-02	1.18E-06	6.59E-03	2.51E-02	1.58E-06	3.07E-03	1.26E-02	7.36E-07
Zinc	3.80E-02	9.31E-02	----------	4.88E-02	1.08E-01	----------	2.79E-02	8.65E-02	----------
Particulate Matter (TSP)	3.80E+01	7.79E+01	----------	3.72E+01	7.33E+01	----------	2.62E+01	6.02E+01	----------
PM-10[b]	2.67E+01	6.50E+01	----------	2.35E+01	5.15E+01	----------	1.95E+01	4.73E+01	----------
			5.98E-06			6.56E-06			4.68E-06

Appendix

Explanation of Scientific Notation

Scientific notation is used throughout this study to express numbers smaller than zero. For example,

1.00 E-01 = 1.00×10^{-1} = 0.1 (one in ten)
1.00 E-02 = 1.00×10^{-2} = 0.01 (one in a hundred)
1.00 E-03 = 1.00×10^{-3} = 0.001 (one in a thousand)
1.00 E-04 = 1.00×10^{-4} = 0.0001 (one in ten thousand)
1.00 E-05 = 1.00×10^{-5} = 0.00001 (one in a hundred thousand)
1.00 E-06 = 1.00×10^{-6} = 0.000001 (one in a million)
1.00 E-07 = 1.00×10^{-7} = 0.0000001 (one in ten million)
1.00 E-08 = 1.00×10^{-8} = 0.00000001 (one in a hundred million)
1.00 E-09 = 1.00×10^{-9} = 0.000000001 (one in a billion)

Using the above conversions, 1.98 E-06 is equivalent to 0.00000198 (1.98 in a million).

Definitions

Air basin — A geographic area of the Commonwealth of Pennsylvania as defined in 25 PA Code § 121.1. The Southeast Pennsylvania air basin includes the counties of Bucks, Chester, Delaware, Montgomery and Philadelphia.

AIRS —Aerometric Information and Retrieval System is EPA's national database of air quality information. The Air Quality Subsystem (AQS) contains data on ambient air measurements.

Blank – Sampling materials and chemicals analyzed without collecting a sample to test for contaminants that might interfere with the analysis. The analytical protocol specifies acceptable blank levels and how these values are used in calculating the results.

Chronic — Occurring over a long period of time. Cancer is the primary health effect considered when evaluating the risk from chronic exposure to a chemical compound.

Excess risk — The increased risk of disease above the normal background rate.

Halogenated compound — An organic compound bonded with one of the five halogen elements (astatine, bromine, chlorine, fluorine, and iodine).

Mean — The arithmetic average. For example, (2.2 +2.6 +4.8)/3 = 3.2.

Micron — A unit of length equal to one millionth of a meter or about 0.0000394 inches. Its symbol is the Greek letter u.

Microgram — A microgram is one millionth of a gram weight. (The symbol ug is commonly used for microgram) Ambient air concentrations are commonly expressed in micrograms per cubic meter of air (ug/m^3). Because air expands and contracts with changes in temperature and pressure, the cubic meter volume must be referenced to a specific temperature and pressure. Standard conditions for ambient air measurements are 25° C (77° F) and one atmosphere (29.92 inches of mercury).

Milligram — One thousandth of a gram weight.

Nanogram — One billionth of a gram weight. Very low ambient air concentrations are expressed in nanograms per cubic meter of air (ng/m^3).

PAMS — Photochemical Assessment Monitoring Stations measure certain compounds that react in sunlight leading to the formation of ground-level ozone.
Particulate matter — A material except uncombined water, which is or has been airborne and exists as a solid or liquid at 70° F and standard atmospheric pressure.
ppbC — Parts per billion Carbon are the concentration units specified by EPA for reporting hydrocarbon pollutants in ambient air. To convert ppbv to ppbC, the concentration in ppbv is multiplied by the number of carbon atoms in the compound.
ppbv — Parts per billion by volume are the concentration units commonly used for gaseous pollutants in ambient air. These units do not have any meaning for non-gaseous pollutants.
PM-10 — Particulate matter with an effective aerodynamic diameter of less than or equal to a nominal 10 micron body as measured by the applicable reference method or an equivalent method. For practical purposes, these are the particles in the air that are small enough to be inhaled. Recent EPA regulations also cover PM-2.5, even smaller particles that can penetrate deeper into the lungs.
Unit Risk Factor (URF) — A measure of the probability of an individual developing cancer as a result of exposure to a specified unit ambient concentration of a specific chemical. In air, the unit concentration is 1.0 microgram per cubic meter. For example, an inhalation URF of 3.0E-04 implies that if 10,000 people breathe that chemical for 70 years at a concentration of 1.0 ug/m^3, three of the 10,000 may develop cancer as a result of the exposure.
Volatile Organic — A chemical containing carbon that can exist in the atmosphere as a gas at normal temperatures. Generally, these are chemicals with vapor pressures greater than 0.1 mmHg (0.0001316 atmospheres) at 20° C (approx. 70° F).

Acronyms and Abbreviations

AIRS	the previous EPA database for air data
AQS	Air Quality Subsystem, the new EPA database for air data
AVOCS	Name of the manufacture's the sampling pump
BIF	Boilers and Industrial Furnaces
C	Celsius
CPSi	Inhalation Cancer Potency Slope
COPAMS	Commonwealth of Pennsylvania Air Monitoring Station
DEP	Pennsylvania Department of Environmental Protection
EPA	United States Environmental Protection Agency
GC/FID	gas chromatograph/flame ionization detection
GC/MS	gas chromatography/mass spectrometry
GMW-321B	PM-10 particulate monitor made by Tisch Environmental Inc.
GMWL	Particulate monitor made by Tisch Environmental Inc.
HEAST	Health Effects Assessment Summary Tables
ICP-MS	inductively coupled plasma mass spectrometry
IRIS	EPA's Integrated Risk Information System
NCEA	EPA Regional Support Provisional Value
MDE	Maryland Department of the Environment, Air Management Administration
Ppbv	parts per billion volume. Parts per billion Carbon are the concentration units specified by EPA for reporting hydrocarbon pollutants in ambient air. To convert ppbv to ppbC, the concentration in ppbv is multiplied by the number of carbon atoms in the compound.
PpbC	parts-per-billion carbon. Parts per billion by volume are the concentration units commonly used for gaseous pollutants in ambient air. These units do not have any meaning for non-gaseous pollutants.
PM-10	Particulate Matter less than 10 microns
PM-2.5	Particulate Matter less than 2.5 microns (small particles that can penetrate deeper into the lungs)
RfC	reference air concentration
RBC	risk-based concentration
SIM	selected ion monitoring
SOP	standard operating procedure
SUMMA	stainless steel cans that are specially treated internally for low concentration monitoring
TNMOC	total non-methane organic carbon
TO-14	EPA's Toxics Organic Compendium of Method Number 14(A) for the determination of volatile organic compounds in outside air, see: http://www.epa.gov/ttn/amtic/airtox.html
TSP	Total Suspended Particulate
URF	unit risk factor
VOC	Volatile Organic Compound

Site Locations

Approximate locations taken from U. S. Geological Survey 7.5° Quadrangles

Chester	N 39° 49' 45", W 75° 23' 18"
Marcus Hook	N 39° 49' 04", W 75° 24' 51"
Swarthmore	N 39° 53' 49", W 75° 21' 14"
Chester COPAMS	N 39° 50' 08", W 75° 22' 22"

Risk Calculation

The excess lifetime cancer risk for each of the chemicals was calculated by using EPA's unit risk factors (URFs). The EPA Region III Superfund Technical Support Section has established a risk-based concentration (RBC) table for nearly 500 chemicals. Four different chronic toxicological constants are examined for each chemical compound: 1) Oral Reference Dose (RfDo); 2) Inhalation Reference Dose (RfDi); 3) Oral Cancer Potency Slope (CPSo); and 4) Inhalation Cancer Potency Slope (CPSi). The sources of the toxicological constants are: 1) the Integrated Risk Information System (IRIS); 2) Health Effects Assessment Summary Tables (HEAST); 3) HEAST Alternate; 4) EPA-NCEA Regional Support Provisional Value; and 5) other EPA documents. For this study, only the RfDi and CPSi were used. In some cases, there were no inhalation risk data for the chemicals in the RBC table, so other sources, such as the Boilers and Industrial Furnaces (BIF) Regulation, had to be referenced.

The URF and the reference air concentration (RfC) are derived from the CPSi and RfDi, respectively, by assuming that an adult weighing 70 kilograms (154 pounds) will breathe 20 m^3 (706 ft^3) of air a day for 365 days a year, over a 70-year lifetime of exposure. This is a standard conversion methodology and is detailed on page two of the "Contents, Uses, and Limitations of the RBC Table" section of the RBC table. From this standard 70-year exposure scenario for an adult, excess lifetime cancer risk is calculated for each chemical by multiplying the measured air concentrations by their respective URFs. The individual risks for each chemical are added to get the total excess lifetime cancer risk at that site. The non-cancer risk associated with each of the relevant chemicals is calculated by simply dividing the measured air concentration by the chemical's respective RfC.

The conversion from CPSi to URF is carried out as follows:

$$(\text{kg-day})/\text{mg} \times (1/70\ \text{kg}) \times (20\ m^3/\text{day}) \times (\text{mg}/1000\ \text{ug}) = m^3/\text{ug}$$

The conversion from RfDi to RfC is carried out as follows:

$$\text{mg}/(\text{kg-day}) \times (70\ \text{kg}) \times (\text{day}/20\ m^3) \times (1000\ \text{ug}/\text{mg}) = \text{ug}/m^3$$

Changes in Unit Risk Factors and Reference Concentrations

Compound	Change	Source
1,2-Dichlorobenzene	R_fC deleted	Change in EPA-NCEA
1,3-Dichlorobenzene	R_fC deleted	Change in EPA-NCEA
1,1-Dichloroethane	R_fC corrected	
1,3-Dichloropropene	URF changed from 3.71E-05 to 4.00E-06	Change in IRIS
1,1,1-Trichloroethane	R_fC changed from 1.00E+03 to 2.20E+03	Change in EPA-NCEA
Benzene	URF changed from 8.30E-6 to 7.80E-06	Change in IRIS
Chlorobenzene	R_fC changed from 1.75E+01 to 6.00E+01	Change in EPA-NCEA
Chloroethene	URF changed from 8.57E-05 to 8.80E-06	Change in IRIS
Chloroethene	R_fC added	Change in IRIS
Cholormethane	URF changed from 1.80E-06 to 1.00E-06	Change in EPA-NCEA
Chloromethane	added	Change in IRIS
Tetrachloroethene	URF changed from 5.80E-07 to 5.71E-07	Change in EPA-NCEA
Trichloroethylene	R_fC deleted	
Cadmium	R_fC added	Change in EPA-NCEA
Hex Chromium	R_fC changed from 3.50E-04 to 8.00E-03	Change in IRIS
Manganese	Compound added to study, R_fC	IRIS