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COMPARISON OF MEASURED CONCENTRATIONS, TRI EMISSIONS, AND MODELED CUMULATIVE OUTDOOR CONCENTRATIONS OF HAZARDOUS AIR POLLUTANTS IN SOUTHEAST CHICAGO

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Acknowledgments

I. Executive Summary

This report represents a synthesis of three sets of information, developed by the U.S. Environmental Protection Agency (U.S. EPA), that describe the air environment of Southeast Chicago. These data sets include the results of a year long measurement study, the air emissions from the Toxic Release Inventory, and estimates of air toxics from a national effort to assess the health risks of toxics pollutants.

The first of the three data sets represents ambient measurements of air toxics in Southeast Chicago. These data were collected for an Agency for Toxic Substances and Disease Registry (ATSDR) health assessment of the local communities within Southeast Chicago. One of the goals of the health assessment was to identify studies or actions needed to evaluate, reduce, or prevent adverse human health effects. In accordance with this goal, ATSDR requested that the U.S. EPA conduct an ambient air monitoring study for toxic air pollutants in Southeast Chicago in support of the health assessment. In response to this request, the U.S. EPA carried out a monitoring project from May 1994 through April 1995. The U.S. EPA has validated and submitted the ambient air data to ATSDR for the health assessment. The results of the measurement program are reported here.

The second data set is the Toxic Release Inventory (TRI) created for the Emergency Planning and Community Right-To-Know Act of 1986 (TRI reference).[1] One of the goals of this program is to make available to the public, on a community level, detailed information on the release of toxic materials to the environment. The TRI program specifically requires manufacturers to report releases of more than 600 designated toxic chemicals to the environment. The TRI database includes the specific chemicals that are released into the local environment, and the amount of each chemical that is released to the air, water and land on an annual basis. Facilities are required to report toxic emissions if they have ten or more full-time employees, use more than 10,000 pounds of any designated chemical or category, and engage in manufacturing operations specified in Standard Industrial Classification Codes (SIC) 20 through 39. The TRI emissions to the air for the Southeast Chicago region are summarized and evaluated in this report.

The third data set is taken from the U.S. EPA Cumulative Exposure Project (CEP). This project is a national effort to develop initial estimates of 1990 air toxics concentrations for every area, at the census tract level, in the continental United States. The purpose of the study is to characterize the scope and nature of air toxics concentrations across the country and help EPA focus efforts on air toxics that represent the highest potential health risks. This effort has been described in two peer-reviewed publications, "Public Health Implications of 1990 Air Toxics Concentrations across the United States"[2] and "Application of Health Information to Hazardous Air Pollutants Modeled in EPA's Cumulative Exposure Project".[3] Estimated concentrations of hazardous air pollutants for the Southeast Chicago census tracts where the air sampling stations were located are included in this analysis.

The availability of detailed measurements of toxic pollutants in the ambient air of Southeast Chicago collected for the ATSDR study makes possible a systematic evaluation of the TRI emission data as well as the CEP hazardous air pollution estimates for this community. The overall objectives of this report are to summarize the results of the ambient air monitoring study for toxic pollutants in Southeast Chicago, and to compare the information contained in the ambient air concentrations to the emissions oriented TRI data base and the national estimates of hazardous air pollutants.

The Southeast Chicago measurement study contains short-term (24-hour) information on the distribution of air concentrations at the monitoring sites in the study area. The TRI data base contains the locations and rates of emissions for toxic pollutants from industrial facilities. Using a wind trajectory analysis, the emissions of specific toxic chemicals that are released upwind of the air monitors for each measurement period will be correlated against the measured concentrations of the toxic compounds. In this analysis, the daily variability in upwind emissions caused by the changing wind direction will be correlated against the daily variability in measured concentrations. Significant correlations between chemical specific emissions and concentration will validate and support the usefulness of the TRI emissions oriented data base.

In contrast to the TRI data, the national estimates of hazardous air pollutants are designed to provide estimates of annual average concentrations resulting from emissions from point, area and mobile sources of toxic materials. A comparison of the average observed concentrations with these annual estimates will test the completeness of the CEP emission inventory for hazardous air pollutants and the validity of the dispersion model used to transform emissions to ambient concentrations. Because these three data sets are based on fundamentally different methodologies, these comparisons will represent a validation of the emissions oriented TRI and CEP national air toxics data bases. This is of special interest to public agencies and community groups which may rely on TRI data or national estimates of hazardous air pollutants to advocate for and/or support the development of new environmental policy.

For this study, the Southeast Chicago was defined as the Southeast corner of the city of Chicago plus portions of adjoining suburbs. The north/south borders were 87th Street and Sibley Boulevard and the east/west borders were Western Avenue and the Indiana State line, respectively. The total area was 169 square kilometers (65 square miles) with a population of about 393,000 (See Figure 1).

The ambient air monitoring network for the Southeast Chicago project consisted of three sites within the study area and one site south of the study area in Calumet City. Three different types of samplers were used to collected volatile organic compounds, semi-volatile organic compounds and metals. All samplers used 24 hour collection times and sampled from midnight to midnight on a once every twelve (12) day schedule. The particle samples for metals were collected as TSP with standard high volume samplers (Hi-Vol) using quartz fiber filters. The Semi-Volatile Polycyclic Aromatic Hydrocarbons (PAH) were collected on quartz filters and sorbent traps that included polyurethane foam for the first 6 months of the study, and a combination of polyurethane foam and XAD resin for the second six months of the study. Volatile Organic Compounds (VOC) were collected in passivated stainless steel canister samplers. Hi-Vol samples were analyzed for 20 metals using either Atomic Absorption spectroscopy (AA) or Inductively Coupled Argon Plasma spectroscopy (ICAP). Semi-volatile organic samples were analyzed for the concentration of 18 specific PAHs using Gas Chromatography with Mass Spectroscopy detection (GCMS). Volatile organic samples were analyzed for the concentration of 37 specific organics using Gas Chromatography with Mass Spectroscopy detection (GCMS). Samples were collected by the U.S. EPA and sent to contract laboratories for analysis.

Observed concentrations of VOC, PAH and metals are summarized in this report. In general, these observations are consistent with previous observations in the southeast Chicago region. Very few difference were found between mean concentrations at the community monitors and mean concentrations at the Calumet City monitor. Of all VOCs monitored, only bromomethane was significantly higher in the community compared to Calumet City. Crustal elements (aluminum, calcium, iron, and magnesium) were among the elements with the highest concentrations at both the community and Calumet City sites. Of the 20 elements reported, only selenium and zinc were statistically significantly higher at the community monitors compared to the Calumet monitor. In contrast to metals and VOCs, mean concentrations of a number of semi-volatile compounds (anthracene, benzo(a)anthracene, benzo(b+j+k)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene) were all significantly higher in the community compared to the Calumet location.

The wind direction-TRI evaluation found a number of significant relationships. Emissions from paint sources, refineries, car body finishing, the water reclamation plant (WRP) and steel processes were strongly correlated with measured concentrations for a number of the VOCs quantified. Emissions from paint, printing, car body finishing, coke ovens, and steel processes were also significantly correlated with observed concentrations for most elements evaluated. This is consistent with the steel facilities in the region which have coke furnaces and smelting operations known to emit various metals including zinc and lead. It is also interesting to note that refinery emissions of vanadium were strongly correlated with vanadium concentrations, and plastics emissions of zinc were strongly correlated with zinc concentrations. Significant correlations were also found between emissions from steel making processes, coke ovens, auto body finishing, refineries, printing, plastic manufacturing and paint manufacturing and total PAH.

The comparison between CEP modeled concentrations and measured concentrations showed remarkable agreement. In general, the observed mean concentration falls within the CEP predicted range for most compounds. Only four compounds (1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, chloromethylbenzene and hexachloro-1,3-butadiene) were orders of magnitude under predicted by the CEP model. For the semivolatile compounds, excellent agreement is found between measured and modeled naphthalene, and measured total PAH and modeled total Polycyclic Organic Matter (POM is the CEP designation for PAH compounds) concentrations at the Calumet and community sites, respectively.

The major conclusions of this report are:

- Ambient measurements in Southeast Chicago for toxic metals, VOCs and PAH are consistent with previous observations in the region.

- In general, concentrations in the southeast Chicago area are uniform with few significant differences between community and Calumet monitored values.

- The ambient air toxics measurements in Southeast Chicago summarized in this document have been successfully used to validate the accuracy of the national TRI and CEP data sets in the study area. Specifically:

    - Daily variation in the observed concentrations of measured toxic compounds are consistent with the TRI emissions inventory and the variation in hourly wind direction.

    - Measured concentrations are remarkably consistent with CEP predicted mean concentrations. Specifically, for all possible comparisons, 20 out of 24 VOCs and 9 out of 9 metals had measured concentrations within the prediction interval of the CEP's model.

The appendices contain all of the information used in this report. Appendix A shows the distributions of concentrations measured at the S.E. Chicago community monitors, and the Calumet City monitor. Appendix B contains tables of the complete, fully-qualified air monitoring results. Appendix C is the complete TRI inventory for S.E. Chicago that was used in the analysis. Appendix D contains the introduction from the project's QAPP (the complete QAPP is too long to be included here). Appendix E lists the Cumulative Exposure Project Health-Risk Benchmarks, and is included for informational purposes only.

Figure 1 Map of Southeast Chicago Toxic Monitoring Sites. Monitoring sites are shown as triangles, industries are shown as red dots.

II. Introduction and Background

The Southeast Chicago region has had a variety of studies conducted to determine the health risks to humans living the area. In 1989, the USEPA Region 5 published a comprehensive risk assessment entitled "Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southeast Chicago."[4] This study looked at a wide range of source types emitting a broad range of air pollutants. The source categories that contributed significantly to estimated cancer risks included steel mills (particularly the coke ovens), other industrial facilities (including chrome platers), roadway vehicles and consumer-oriented area sources. Background concentrations of formaldehyde and carbon tetrachloride were also important sources of cancer risk.

Following the completion of the risk study, the citizens in the area petitioned the Agency for Toxic Substances and Disease Registry to conduct a comprehensive evaluation of toxic pollutants in the area.[5] One component of this evaluation was a comprehensive air monitoring study in Southeast Chicago to evaluate the exposure of the residents to air pollution in general and air toxics specifically. USEPA Region 5 was asked to conduct the monitoring study of volatile organic compounds, polycyclic aromatic hydrocarbons, and metals concentrations in the targeted area. The focus of this report is to give a summary of the concentrations found in the Southeast Chicago area and to evaluate the consistency of these observations with the region's TRI emission data and the USEPA's CEP modeled estimates of hazardous air pollutant concentrations.

III. Methodology

A. Sampling Locations

The study region was located in southeast Chicago bounded by Calumet City to the south, 103rd Street to the north, I-94 to the west, and the Illinois-Indiana state border on the east (see Figure 1). Four monitoring locations within or directly adjacent to the area sampled volatile organic compounds, metals, and polycyclic aromatic hydrocarbons on a total of 31 sampling periods from May 12, 1994 to April 26, 1995 at approximately 12 day intervals. The four sites were selected to provide data for populated areas near point sources identified as possibly influencing the local air quality. Three community and one upwind site were selected to determine the quality of the air entering the study area as well as assess the contribution of the local point sources.

The community stations were Bright School (which is located in the immediate vicinity of the Acme Steel Company's coke plant where the 1989 USEPA Southeast Chicago risk assessment identified the highest risks), Carver High School, and Washington High School (which is immediately east of the LTV Steel coke plant). In addition to the steel companies, a series of chemical plants, oil refineries, landfills, and other industries are located in the proximity of the three community sampling locations. The upwind monitoring site was located in Calumet City, Illinois. An existing meteorological monitoring station at the Washington Elementary School (across the street from the Washington High-School) was used to record wind direction and wind speed. For days when meteorological data were missing or not measured at the Washington School station, wind direction and speed were obtained from a meteorological station located in Hammond, Indiana which is located approximately ten miles east of the study area.

Table 1 lists the monitoring locations and the sampling equipment which was maintained at each site. Included in the table are the census tracts in which the monitors were located. The high-volume samplers were used to collect Total Suspended Particulate matter (TSP) for metals analysis. The semi-volatile samplers used a polyurethane foam (PuF) trap to collect volatile polycyclic aromatic hydrocarbons (PAH) during the first half of the study, and a combined polyurethane-XAD trap to collect PAH during the second half of the monitoring campaign. Volatile organics were collected in passivated stainless steel canisters (VOCCS). Co-located samplers were used to determine measurement precision.

Table 1: Summary of Monitoring Locations and Sampling Equipment

Sample Location	**Sampling Equipment**
Washington High School (community) 3535 East 114th Street Chicago, Illinois Census tract 520600	2 TSP High Volume Samplers [a] 2 Semi-volatile PuF Samplers [a] 2 Volatile Samplers (VOCCS) [a]
Orville T. Bright Elementary (community) 10740 South Calhoun Chicago, Illinois Census tract 510500	1 TSP High Volume Sampler 2 Semi-volatile Samplers [a] 1 VOCCS Sampler
Carver High School (community) 13100 South Doty Avenue Chicago, Illinois Census tract 540100	1 TSP High Volume Sampler 2 Semi-volatile PuF Samplers [a] 1 VOCCS Sampler
Calumet City-Dept. of Public Works (Calumet) Paxton Ave. & State St. Calumet City, Illinois Census tracts 825801 and 825700	1 TSPHigh Volume Sampler 2 Semi-volatile PuF Sampler [a] 1 VOCCS Sampler
Washington Elementary (community) 3611 East 114th Street Chicago, Illinois Census tract 520600	1 Wind Speed/Wind Direction Monitor (operated by the Cook Co. Department of Environmental Control)

[a] Collocated samplers

B. Target Compounds

To control analytical costs and provide a focus for the sample analysis, the compounds selected for analysis in this project were taken from those specifically identified in the 1989 study as potentially causing significant health risks. Table 2 lists the principal organic compounds and elements that were targeted for analysis during the study.

Table 2: Compounds and Elements Analyzed for During the Southeast Chicago Study

Volatile Organic Compounds	**Semi-volatile Organic Compounds**	**Metals**
m-Dichlorobenzene	Acenaphthene	Aluminum
m,p-Xylene	Acenaphthylene	Antimony
o-Dichlorobenzene	Anthracene	Arsenic
o-Xylene	Benzo (a) anthracene	Titanium
p-Dicholorobenzene	Benzo (a) pyrene	Cadmium
Acetylene	Benzo (b+j+k) fluoranthene	Calcium
Benzene	Benzo (e) pyrene	Chromium
Bromomethane	Benzo (ghi) perylene	Cobalt
Chlorobenzene	Biphenyl	Copper
Chloroethane	Chrysene	Iron
Chloroform	Coronene	Lead
Chloromethane	Dibenz (ah+ac) anthracene	Magnesium
Chloromethylbenzene	Fluoranthene	Nickel
Carbon tetrachloride	Fluorene	Potassium
Dichlorodifluoromethane	Indeno [123-cd] pyrene	Selenium
Ethylbenzene	Naphthalene	Sodium
Hexachloro-1,3-butadiene	Phenathracene	Tin
Methylene Chloride	Pyrene	Vanadium
N-Octane		Zinc
Propylene		
Styrene		
Tetrachloroethylene		
Toluene		
Trichloroethylene		
Trichlorofluoromethane		
Trichlorotrifluoroethane		
1,1-Dichloroethane		
1,1,1-Trichloroethane		
1,2-Dichloroethane		

Table 2: Compounds and Elements Analyzed for During the Southeast Chicago Study		
Volatile Organic Compounds	**Semi-volatile Organic Compounds**	**Metals**
1,2,4-Trichlorobenzene		
1,2,4-Trimethylbenzene		
1,3 Butadiene		
1,3,5-Trimethylbenzene		

C. Ambient Sampling and Analysis Techniques

Metals: Samples were collected using Anderson Model GMWL-20000 Hi Volume TSP samplers equipped with a heavy duty turbine blower with a fixed orifice flow controller. Samples were collected over at 24 hour period from 12 A.M. to 12 A.M. at a flow rate of 1.2 to 1.5 m^3/min. Flows were set using a 90 volt transformer to limit the speed of the motor. Initial and final flow measurements were taken during each sampling using a calibrated flow meter. Continuous flow measurements were also recorded on a Dickson chart flow recorder using a pressure transducer. The sampling time was controlled by a seven day regular timer while an elapsed time meter was used to record the actual total sampling time.

Samples were collected as total suspended particulate on an 8" x 10" quartz filter. A sample saver was employed to cover the filter prior to and after the sampling period. Field blanks were collected at Washington High School by placing a clean preweighed filter into the sampler and not drawing any air through it. Collocated (duplicate) samples were collected at Washington High School on a regular basis to establish sampling variability. Filters were analyzed by the Radian Corporation by Inductively Coupled Plasma (ICP) Spectroscopy or Graphite Furnace Atomic Absorption (GFAA) Spectroscopy.

Semi-Volatile Organics: Semi volatile organic compounds were sampled using Andersen Model GPSI Polyurethane Foam (PuF) Samplers. This sampler was equipped with a by-pass blower motor arranged with an independent cooling fan which allows for long duration sampling at low flow rates without motor failure from overheating. A voltage transformer was used to set the blower motor speed to achieve the desired flow rate. Flow was measured through a calibrated flow venturi using a 0-100" water Magnehelic gauge and was maintained at approximately 0.25 m^3/min during the sampling period. A seven day timer was used to switch the sampler on and off while an elapsed time meter measured how long the sampler ran.

The sampler consisted of an aluminum housing which held a dual media filter. The upper media was a quartz-fiber filter for the collection of particulate matter and the lower filter contained a polyurethane foam plug for the collection of gaseous semi volatile. This specific setup was used for samples collected between May 12, 1994 and September 16, 1994. At this time, the method was amended (on the suggestion of Desert Research Institute) because naphthalene, biphenyl, acenaphthene, acenaphthylene and fluorene were not being retained on the PuF filter (see Section 1.4 of USEPA Method TO-13: The Determination of Benzo(a)Pyrene [B(a)P] and Other Polynuclear Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatographic (GC) and High Performance Liquid Chromatographic (HPLC) Analysis). Method TO-13 recommends using XAD-2 sorbent in combination with PuF which has a higher collection efficiency for semi-volatile compounds than the PuF filter alone. Therefore, beginning with the sample collected on September 26, 1994 through the end of the study on April 26, 1995, the collection media was changed from a single polyurethane foam plug to a cartridge containing XAD-2 resin positioned between two PuF plugs. During the ninth round of sampling, a comparison was made between the two methods and confirmed higher concentrations for naphthalene, biphenyl, acenaphthene, fluorene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, and benzo(ghi)perylene when using the PuF/XAD-2 combination over the solitary PuF plug.[6]

Field blanks were collected at Washington High School. Duplicates were collected at all sites on a regular basis in order to estimate sampling variability. Samples were analyzed by the Desert Research Institute of the University of Nevada according USEPA Method TO-13.

Volatile Organics: A total of 37 volatile organic compounds (VOCs) were detected at least once at the four monitoring locations. This included all 33 target compounds identified in table 2 plus 1,1,2,2-tetrachloroethane, 1,2-dibromoethane, chloroprene and cis-1,2-dichloroethylene. Samples were collected using a Volatile Organic Compound Canister Sampler (VOCCS). This method involves pumping air into an evacuated passivated stainless steel canister with a Viton Diaphragm pump at a flow of approximately 5.0 cm^3/min. Flow was maintained with a mass flow controller. A digital timer was programmed to collect the samples from 12 A.M. to 12 A.M. Central Standard Time. During the 24-hour sampling period, each canister was filled to approximately 15-20 psig absolute. A thermometer was located inside each sampler to record the maximum and minimum temperature during the sampling period.

Prior to sampling, each canister was cleaned and evacuated to approximately 30 mmHg absolute. Blanks were generated using humidified air from a clean air generator by passing zero-air through a canister containing water. Each blank canister was then placed into the sampling apparatus in the field without opening the valve. Duplicates were collected on a regular basis at Washington High School to give an estimate of the sampling variability.

All canister samples were analyzed by the Radian Corporation according to the methodology outlined in the USEPA Method TO-14: Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using SUMMA Passivated Canisters Samplers and Gas Chromatographic Analysis.[7]

D. Analysis Methodology

The data were qualified according to established quality assurance procedures outlined in the Quality Assurance Project Plan (Appendix D) prepared for the study. Data qualifiers represented concentrations less than the detectable limit, values which were less than five times the blank concentration, and suspect values deemed so because filters, PuFs or canisters were analyzed after the established holding time. For this report, all reported concentrations were used regardless of qualifiers placed on individual observations. Concentrations for compounds that were reported as "not found" (no value given) were assumed equal to zero. All other concentrations were taken as reported. We believe that this is the best way to avoid the bias associated with eliminating low, qualified concentrations, or assuming they equal a fixed value between zero and the detection limit. A full listing of all qualified data is included in Appendix B.

Polycyclic aromatic hydrocarbons and metals concentrations were blank corrected using the study-period average mass detected on the field blank filters. Corrected concentrations which were less than zero were treated as zero in the analysis. Volatile organic compound blank canisters had significant contamination from the humidified water source used during the clean-up procedure and were not used to correct the ambient VOC concentrations.

Replicates were analyzed by calculating the mean, standard deviation, and coefficient of variation for each compound. The coefficient of variation is the dimensionless ratio of standard deviation divided by the mean (times 100 to express as a percent) and is a measure of precision.

IV. Results

A. Ambient Measurements

Tables 3 through 5 show summary statistics for each toxic pollutant measured at the community and Calumet sites. The tables contain the location (Calumet or study area), number of detected concentrations, mean, standard deviation, minimum, maximum and median concentrations. Metals and PAH data were field blank corrected. VOC concentrations were not blank corrected due to apparent blank contamination. PAH data collected during the first six months of the study that were adversely affected by not including XAD resin in the sampling train are not included in the summary tables.

Table 6 lists the coefficient of variation for the replicate samples (precision of the measurement) for each of the species measured. The volatile organic compounds had the highest coefficients of variation (lowest precision) while the polycyclic aromatic compounds had the lowest CVs (highest precision). The CVs for the PAHs ranged from 0 to 87% with benzo(a)pyrene, benzo(a)anthracene, benzo(e)pyrene, benzo(ghi)perylene, and indeno[123-cd]perylene having the greatest variability. The volatile organics with high CVs were primarily those compounds which were consistently measured below the limit of detection.

Box plots showing the median, the interquartile range, whiskers representing 1.5 times the interquartile range and dots representing those observations which are outside the range defined by the whiskers were created for all species analyzed during the study. The plots were made for the three community sites and the Calumet (background) site by compound to show the distributional differences between sampling sites for individual species. Box plots for each compound that was detected on a regular basis are included in Appendix A.

The distributions of PAH compounds did not have many observations outside the range designated by the whiskers. This is in contrast to the metals and volatile organic compounds suggesting greater variability for these two categories. Volatile organics and metals also had more observations with concentrations below the detection limits than did the semivolatile organicss. Appendix B includes complete tables of the individual, qualified, daily measured concentrations.

Table 3: Summary Statistics for Metals Collected in Southeast Chicago (all concentrations in µg/m^3)

Location [a]	Parameter	No. of Samples [b]	Mean Concentration	Std. Dev.	Minimum	Median	Maximum
Calumet	Aluminum	30	0.788	0.587	0.0708	0.574	2.3
Calumet	Antimony	30	0.0003	0.0012	0 [c]	0	0.0033
Calumet	Arsenic	30	0.0015	0.0012	0	0.0016	0.0046
Calumet	Cadmium	30	0.0001	0.0011	0	0	0.0043
Calumet	Calcium	30	4.87	3.76	0	4.88	17.5
Calumet	Chromium	30	0.19	0.997	0	0.0075	5.47
Calumet	Cobalt	30	0.0003	0.0014	0	0	0.0055
Calumet	Copper	30	0.0498	0.0222	0.0176	0.0442	0.117
Calumet	Iron	30	1.37	3.88	0	1.61	6.2
Calumet	Lead	29	0.0382	0.0336	0.0079	0.0258	0.163
Calumet	Magnesium	30	4.22	3.01	0.144	3.78	10.8
Calumet	Manganese	30	0.129	0.102	0	0.113	0.39
Calumet	Nickel	30	0.0026	0.0036	0	0.0028	0.0094
Calumet	Potassium	30	0.331	0.197	0	0.302	0.769
Calumet	Selenium	30	0.0018	0.0009	0	0.0018	0.0038
Calumet	Sodium	30	1.54	3	0	0.877	16.6
Calumet	Tin	30	0 [d]	0.0142	0	0	0.0274
Calumet	Titanium	13	0.0225	0.0406	0	0.0132	0.138
Calumet	Vanadium	30	0.0034	0.0027	0	0.0033	0.0108
Calumet	Zinc	30	0.118	0.0813	0.0107	0.0982	0.336
Community	Aluminum	81	0.531	0.423	0	0.393	2.18
Community	Antimony	84	0.0005	0.0012	0	0	0.0041
Community	Arsenic	84	0.0018	0.0016	0	0.0015	0.0088
Community	Cadmium	84	0.0005	0.0013	0	0	0.0076

Table 3: Summary Statistics for Metals Collected in Southeast Chicago (all concentrations in $\mu g/m^3$)

Location[a]	Parameter	No. of Samples[b]	Mean Concentration	Std. Dev.	Minimum	Median	Maximum
Community	Calcium	84	3.57	2.25	0	3.3	9.28
Community	Chromium	84	0.0083	0.0073	0	0.007	0.0325
Community	Cobalt	84	0.0001	0.001	0	0	0.006
Community	Copper	84	0.0564	0.0345	0	0.0455	0.161
Community	Iron	84	1.33	3.69	0	1.54	7.46
Community	Lead	81	0.0759	0.178	0.0029	0.0356	1.58
Community	Magnesium	84	1.26	0.89	0	1.13	4.41
Community	Manganese	84	0.235	0.528	0	0.104	4.48
Community	Nickel	84	0.0645	0.548	0	0.0035	5.03
Community	Potassium	84	0.27	0.208	0	0.274	1
Community	Selenium	84	0.0025	0.0022	0	0.0021	0.0112
Community	Sodium	84	0.723	1.4	0	0.405	8.93
Community	Tin	84	0[d]	0.0131	0	0	0.0485
Community	Titanium	38	0.017	0.0248	0	0.0202	0.0596
Community	Vanadium	84	0.0032	0.0029	0	0.0026	0.0113
Community	Zinc	84	0.263	0.41	0	0.109	2.37

[a] Calumet represents samples collected in Calumet City, Community represents samples collected at Washington, Bright and Carver schools.

[b] Number of samples reported as greater than the detection limit.

[c] Zero was assigned to all concentrations that were reported as not detected, or if the corrected concentration was less than zero.

[d] Average mass of tin on the TSP filters was less than the average mass of tin on the blank filters.

Table 4: Summary Statistics for Volatile Organic Compounds Collected in Southeast Chicago (all concentrations in ppb)							
Location[a]	Parameter	No. of Samples[b]	Mean Concentration	Std. Dev.	Minimum	Median	Maximum
Calumet	1,1,1-Trichloroethane	29	0.242	0.256	0.11	0.18	1.52
Calumet	1,1,2,2-Tetrachloroethane	1	0.04	[d]	0.04	0.04	0.04
Calumet	1,1-Dichloroethane	2	0.0175	0.0035	0.015	0.0175	0.02
Calumet	1,2,4-Trichlorobenzene	13	0.0546	0.03	0.01	0.065	0.1
Calumet	1,2,4-Trimethylbenzene	29	0.257	0.215	0.02	0.2	1.1
Calumet	1,2-Dibromoethane	1	0.005		0.005	0.005	0.005
Calumet	1,2-Dichloroethane	10	0.098	0.111	0.02	0.065	0.41
Calumet	1,3,5-Trimethylbenzene	29	0.0766	0.0646	0.01	0.06	0.34
Calumet	1,3-Butadiene	15	0.0652	0.0714	0.01	0.0375	0.31
Calumet	Acetylene	18	2.84	1.61	0.03	2.42	7.69
Calumet	Benzene	29	0.568	0.533	0.18	0.41	3.02
Calumet	Bromomethane	12	0.0517	0.0205	0.02	0.045	0.1
Calumet	Carbon Tetrachloride	29	0.0727	0.0199	0.0175	0.08	0.1
Calumet	Chlorobenzene	13	0.0235	0.0105	0.01	0.02	0.05
Calumet	Chloroethane	4	0.0975	0.0833	0.045	0.0625	0.22
Calumet	Chloroform	27	0.018	0.0115	0.01	0.015	0.06
Calumet	Chloromethane	29	0.557	0.194	0.04	0.59	1.02
Calumet	Chloromethylbenzene	4	0.0219	0.0188	0.0125	0.0125	0.05
Calumet	Chloroprene	1	0.04		0.04	0.04	0.04
Calumet	Dichlorodifluoromethane	29	0.47	0.171	0.0175	0.44	0.94
Calumet	Ethylbenzene	29	0.215	0.198	0.05	0.18	1.1
Calumet	Hexachloro-1,3-butadiene	7	0.0471	0.0204	0.02	0.05	0.07
Calumet	Methylene Chloride	29	0.18	0.213	0.04	0.12	0.91
Calumet	N-Octane	25	0.0762	0.0896	0.0125	0.05	0.44
Calumet	Propylene	29	0.805	0.849	0.0225	0.53	3.93

Table 4: Summary Statistics for Volatile Organic Compounds Collected in Southeast Chicago (all concentrations in ppb)

Location [a]	Parameter	No. of Samples [b]	Mean Concentration	Std. Dev.	Minimum	Median	Maximum
Calumet	Styrene	28	0.0632	0.0567	0.01	0.045	0.27
Calumet	Tetrachloroethylene	29	0.135	0.156	0.0075	0.08	0.72
Calumet	Toluene	29	1.29	1.31	0.34	0.97	6.58
Calumet	Trichloroethylene	28	0.0304	0.0411	0.01	0.0125	0.18
Calumet	Trichlorofluoromethane	29	0.215	0.0538	0.015	0.23	0.3
Calumet	Trichlorotrifluoroethane	29	0.0742	0.0196	0.0125	0.08	0.12
Calumet	cis-1,2-dichloroethylene	0	0 [c]		0	0	0
Calumet	m,p-Xylene	29	0.628	0.579	0.14	0.45	3.09
Calumet	m-Dichlorobenzene	6	0.0113	0.0115	0.0025	0.0063	0.03
Calumet	o-Dichlorobenzene	11	0.0127	0.0139	0.0025	0.01	0.05
Calumet	o-Xylene	29	0.252	0.227	0.07	0.19	1.19
Calumet	p-Dichlorobenzene	27	0.0324	0.0339	0.0025	0.02	0.17
Community	1,1,1-Trichloroethane	87	0.248	0.159	0.1	0.2	0.96
Community	1,1,2,2-Tetrachloroethane	3	0.03	0.0173	0.01	0.04	0.04
Community	1,1-Dichloroethane	8	0.0163	0.0058	0.01	0.015	0.03
Community	1,2,4-Trichlorobenzene	42	0.0455	0.0238	0.01	0.045	0.1
Community	1,2,4-Trimethylbenzene	87	0.212	0.187	0.0125	0.16	1.2
Community	1,2-Dibromoethane	4	0.0063	0.0025	0.005	0.005	0.01
Community	1,2-Dichloroethane	30	0.212	0.324	0.065	0.0675	1.66
Community	1,3,5-Trimethylbenzene	87	0.0648	0.0667	0.01	0.05	0.51
Community	1,3-Butadiene	46	0.0639	0.0509	0.01	0.0375	0.21
Community	Acetylene	61	2.65	1.5	0.48	2.09	7.79
Community	Benzene	87	0.682	0.735	0.03	0.39	3.74
Community	Bromomethane	39	0.0871	0.0753	0.02	0.045	0.37
Community	Carbon Tetrachloride	87	0.0742	0.0252	0.01	0.08	0.12

Table 4: Summary Statistics for Volatile Organic Compounds Collected in Southeast Chicago (all concentrations in ppb)

Location[a]	Parameter	No. of Samples[b]	Mean Concentration	Std. Dev.	Minimum	Median	Maximum
Community	Chlorobenzene	39	0.0224	0.0457	0.01	0.015	0.3
Community	Chloroethane	12	0.0608	0.0391	0.045	0.045	0.17
Community	Chloroform	81	0.0183	0.0098	0.01	0.015	0.06
Community	Chloromethane	87	0.573	0.182	0.0975	0.56	1.46
Community	Chloromethylbenzene	13	0.0963	0.193	0.0125	0.0125	0.53
Community	Chloroprene	0	0		0	0	0
Community	Dichlorodifluoromethane	87	0.476	0.496	0.0175	0.41	4.95
Community	Ethylbenzene	87	0.179	0.15	0.02	0.13	0.84
Community	Hexachloro-1,3-butadiene	22	0.0477	0.0248	0.01	0.065	0.07
Community	Methylene Chloride	87	0.315	0.579	0.03	0.16	4.6
Community	N Octane	78	0.0585	0.0723	0.01	0.03	0.39
Community	Propylene	87	0.62	0.498	0.0225	0.46	2.87
Community	Styrene	85	0.0624	0.08	0.01	0.03	0.58
Community	Tetrachloroethylene	87	0.0952	0.136	0.0075	0.06	1.21
Community	Toluene	87	0.936	0.816	0.19	0.64	4.11
Community	Trichloroethylene	83	0.0458	0.0763	0.01	0.02	0.52
Community	Trichlorofluoromethane	87	0.265	0.228	0.015	0.23	2.02
Community	Trichlorotrifluoroethane	87	0.0777	0.0207	0.0125	0.07	0.17
Community	cis-1,2-dichloroethylene	1	0.01		0.01	0.01	0.01
Community	m,p-Xylene	87	0.533	0.465	0.06	0.39	2.6
Community	m-Dichlorobenzene	22	0.0091	0.0126	0.0025	0.0025	0.06
Community	o-Dichlorobenzene	35	0.0091	0.0104	0.0025	0.0025	0.05
Community	o-Xylene	87	0.205	0.18	0.02	0.16	1.1
Community	p-Dichlorobenzene	82	0.0175	0.0198	0.0025	0.01	0.13

[a] Calumet samples were collected in Calumet City, Community samples were collected at Washington, Bright and Carver schools.

[b] Number of samples reported as greater than the detection limit.

[c] Not detected in any of the samples analyzed.

[d] Standard deviation is not defined for less than one observation.

Table 5: Summary Statistics for Polycyclic Aromatic Hydrocarbons Collected in Southeast Chicago (ng/m^3)

Location[a]	Parameter	No. of Samples	Mean Corrected Conc.	Std. Dev.	Minimum	Median	Maximum
Calumet	Acenaphthene	17	4.48	4.1	0.39	3.2	16
Calumet	Acenaphthylene	17	3.95	3.55	0[b]	2.5	13
Calumet	Anthracene	17	1.37	0.823	0	1	2.6
Calumet	Benzo(a)anthracene	31	0.268	0.307	0	0.2	1.06
Calumet	Benzo(a)pyrene	31	0.468	1.21	0	0.18	6.34
Calumet	Benzo(b+j+k)fluoranthene	31	0.828	1.03	0	0.52	4
Calumet	Benzo(e)pyrene	31	0.518	0.939	0	0.25	5.03
Calumet	Benzo(ghi)perylene	31	0.492	0.423	0	0.41	1.9
Calumet	Biphenyl	17	10.4	5.84	0	10	23
Calumet	Chrysene	31	0.584	0.678	0	0.48	3.75
Calumet	Coronene	31	1.41	5.68	0	0.39	32
Calumet	Dibenz(ah+ac)anthracene	31	0.224	0.427	0	0.012	1.6
Calumet	Fluoranthene	31	3.78	3.63	0	2.89	16.8
Calumet	Fluorene	17	7.1	4.13	0	5.3	14
Calumet	Indeno(123-cd)pyrene	31	0.4	0.576	0	0.22	3.1
Calumet	Naphthalene	17	179	239	0	159	736
Calumet	Phenanthrene	17	11.7	6.82	0	10.8	21.7
Calumet	Pyrene	31	2.37	2.15	0	2.2	9.81
Community	Acenaphthene	52	7.31	8.4	0	5.9	43
Community	Acenaphthylene	52	4.8	7.65	0	1.9	39
Community	Anthracene	52	2.38	2.64	0	1.75	13
Community	Benzo(a)anthracene	92	0.972	2.33	0	0.46	21

Table 5: Summary Statistics for Polycyclic Aromatic Hydrocarbons Collected in Southeast Chicago (ng/m^3)

Location[a]	Parameter	No. of Samples	Mean Corrected Conc.	Std. Dev.	Minimum	Median	Maximum
Community	Benzo(a)pyrene	92	0.907	2.31	0	0.495	21
Community	Benzo(b+j+k)fluoranthene	92	2.28	5.43	0	1.15	50
Community	Benzo(e)pyrene	92	0.842	1.48	0	0.46	10.9
Community	Benzo(ghi)perylene	92	0.688	0.683	0	0.575	3
Community	Biphenyl	52	10.2	8.85	0	9.95	54
Community	Chrysene	92	1.42	2.99	0	0.715	27
Community	Coronene	92	0.431	0.349	0	0.365	1.5
Community	Dibenz(ah+ac)anthracene	92	0.338	0.503	0	0.15	2.2
Community	Fluoranthene	92	7.44	7.44	0	5.3	29
Community	Fluorene	52	9.82	8.96	0	8.15	54
Community	Indeno(123-cd)pyrene	92	0.487	0.496	0	0.36	2.4
Community	Naphthalene	52	328	495	0	179	1800
Community	Phenanthrene	52	17.3	14.5	0	15.9	78.4
Community	Pyrene	92	4.29	4.07	0	3.6	19

[a] Calumet represents samples collected in Calumet City, Community represents samples collected at Washington, Bright and Carver schools.

[b] Not Detected

Table 6. Mean Coefficient of Variation of Replicate Analyses (%).

Compound	Monitoring Site			
	Washington	Bright	Calumet	Carver
Acenaphthene	12	2	37	29
Acenaphthylene	4	32	20	13
Anthracene	8	3	29	48
Benzo(a)anthracene	14	13	10	17
Benzo(a)pyrene	17	50	47	54
Benzo(b+j+k)fluoranthene	15	10	43	2
Benzo(e)pyrene	7	5	8	46
Benzo(ghi)perylene	13	19	13	58
Biphenyl	4	5	4	4
Chrysene	17	12	8	39
Coronene	7	3	4	10
Dibenz(ah+ac)anthracene	43	19	1	12
Fluoranthene	9	5	9	2
Fluorene	0	3	8	4
Indeno(123-cd)pyrene	14	10	59	87
Naphthalene	16	8	8	22
Phenanthrene	5	4	6	3
Pyrene	10	7	15	20
1,1,1-Trichloroethane	28			
1,2-Dibromoethane	47			
1,2-Dichloroethane	75			
1,2,4-Trichlorobenzene	107			
1,2,4-Trimethylbenzene	60			
1,3-Butadiene	76			
1,3,5-Trimethylbenzene	54			
Acetylene	8			
Benzene	7			
Bromomethane	28			
Carbon Tetrachloride	12			
Chlorobenzene	0			
Chloroethane	0			
Chloroform	35			
Chloromethane	37			
Chloromethylbenzene	74			
Dichlorodifluoromethane	37			

Table 6. Mean Coefficient of Variation of Replicate Analyses (%).				
	Monitoring Site			
Compound	Washington	Bright	Calumet	Carver
Ethylbenzene	6			
Hexachloro-1,3-butadiene	75			
m-Dichlorobenzene	120			
Methylene Chloride	32			
m,p-Xylene	5			
N-Octane	23			
o-Dichlorobenzene	85			
o-Xylene	14			
p-Dichlorobenzene	94			
Propylene	46			
Styrene	28			
Tetrachloroethylene	12			
Toluene	15			
Trichloroethylene	18			
Trichlorofluoromethane	7			
Trichlorotrifluoroethane	5			
Aluminum	5			
Antimony	7			
Arsenic	4			
Cadmium	0			
Calcium	8			
Chromium	12			
Cobalt	0			
Copper	18			
Iron	5			
Lead	5			
Magnesium	43			
Manganese	49			
Nickel	5			
Potassium	49			
Selenium	10			
Sodium	5			
Tin	0			
Titanium	0			
Vanadium	13			

Table 6. Mean Coefficient of Variation of Replicate Analyses (%).				
Compound	Monitoring Site			
	Washington	Bright	Calumet	Carver
Zinc	4			

B. TRI Data

TRI emission data were taken from 1995 air emission reports for manufacturing operations (Standard Industrial Classification Codes (SIC) 20 through 39) and petroleum bulk stations and terminals.[8] The TRI source area is shown in figure 2. Table 7 lists the specific measured air toxics that are included in the TRI data base. Table 8 lists the TRI sources and SIC codes that emitted compounds included in Table 7. Table 9 summarizes the toxic emissions of measured compounds from these sources in the TRI study area. Appendix C is a complete listing of all TRI data used in this analysis.

Table 7: Measured Compounds and Elements Included in TRI Inventory

Volatile Organic Compounds	Semi-volatile Organic Compounds	Metals
m,p-Xylene	Anthracene	Aluminum
o-Xylene	Biphenyl	Antimony
Benzene	Naphthalene	Arsenic
Carbon tetrachloride	Phenathracene	Cadmium
Dichlorodifluoromethane	Total PAH	Chromium
Ethylbenzene		Cobalt
Methylene Chloride		Copper
Propylene		Lead
Styrene		Manganese
Toluene		Nickel
Trichloroethylene		Vanadium
1,1,1-Trichloroethane		Zinc
1,2-Dichloroethane		
1,2,4-Trimethylbenzene		
1,3 Butadiene		

Table 8: 1995 Toxic Release Inventory Industries in Southeast Chicago

Standard Industrial Classification	TRI Codes
Aluminum Foundries (1987)	3365
Wet Corn Milling	2046
Commercial Printing, Gravure	2754
Industrial Gases	2813
Inorganic Pigments	2816
Industrial Inorganic Chemicals, NEC	2819
Plastics Materials and Resins	2821

Table 8: 1995 Toxic Release Inventory Industries in Southeast Chicago

Standard Industrial Classification	**TRI Codes**
Soap and Other Detergents	2841
Polishes and Sanitation Goods	2842
Paints and Allied Products	2851
Cyclic Crudes and Intermediates	2865
Industrial Organic Chemicals, NEC	2869
Petroleum Refining	2911
Lubricating Oils and Greases	2992
Custom Compound Purchased Resins (1987)	3087
Plastics Products, NEC (1987)	3089
Clay Refractories	3255
Minerals, Ground or Treated	3295
Nonclay Refractories	3297
Blast Furnaces and Steel Mills	3312
Steel Wire and Related Products	3315
Cold Finishing of Steel Shapes	3316
Steel Pipe and Tubes	3317
Steel Foundries, NEC	3325
Secondary Nonferrous Metals	3341
Aluminum Sheet, Plate, and Foil	3353
Copper Foundries (1987)	3366
Metal Heat Treating	3398
Metal Can	3411
Fabricated Structural Metal	3441
Bolts, Nuts, Rivets and Washers	3452
Plating and Polishing	3471
Steel Springs, Except Wire	3493
Miscellaneous Fabricated Wire Products	3496
Hoists, Cranes, and Monorails	3536
Special Industry Machinery, NEC	3559
Motor Vehicles and Car Bodies	3711
Railroad Equipment	3743
Petroleum Bulk Stations and Terminals	5171
TRI Source Groups	
Paint	2816, 2851
Plastic	3087, 3089, 2821
Steel and Coke Production	3312, 3315, 3316, 3317, 3325, 3341

Table 8: 1995 Toxic Release Inventory Industries in Southeast Chicago

Standard Industrial Classification	TRI Codes
Particulate Matter	3255, 3275, 3295, 3297

Table 9. TRI emissions by SIC code for total VOC, PAH and Metals, tons/yr.

SIC Code	VOC Total	PAH Total	Metals Total
2046: Wet Corn Milling	18,250		
2754: Commercial Printing, Gravure	18,529		
2813: Industrial Gases			
2816: Inorganic Pigments			9,726
2819: Industrial Inorganic Chemicals, NEC	25		913
2821: Plastics Materials and Resins	8,481		
2841: Soap and Other Detergents			
2842: Polishes and Sanitation Goods	24		
2851: Paints and Allied Products	115,538	580	1,428
2865: Cyclic Crudes and Intermediates	27,858		
2869: Industrial Organic Chemicals, NEC	45,991	152	250
2911: Petroleum Refining	697,355	3,330	7,229
2992: Lubricating Oils and Greases			250
3087: Custom Compound Purchased Resins (1987)			1,510
3089: Plastics Products, NEC (1987)	14,827		
3255: Clay Refractories			
3295: Minerals, Ground or Treated			7,714
3297: Nonclay Refractories			255
3312: Blast Furnaces and Steel Mills	117,495	230,205	2,148,039
3315: Steel Wire and Related Products			536
3316: Cold Finishing of Steel Shapes			68
3317: Steel Pipe and Tubes	57,000		3,700
3325: Steel Foundries, NEC			191
3341: Secondary Nonferrous Metals			2,465
3353: Aluminum Sheet, Plate, and Foil			6,640
3365: Aluminum Foundries (1987)			5
3366: Copper Foundries (1987)			
3398: Metal Heat Treating			
3411: Metal Cans	87,240		
3441: Fabricated Structural Metal			750

Table 9. TRI emissions by SIC code for total VOC, PAH and Metals, tons/yr.

SIC Code	VOC Total	PAH Total	Metals Total
3471: Plating and Polishing	18,300		9
3479: Metal Coating and Allied Services			
3493: Steel Springs, Except Wire			
3496: Miscellaneous Fabricated Wire Products			250
3536: Hoists, Cranes, and Monorails	9		5
3559: Special Industry Machinery; NEC			
3711: Motor Vehicles and Car Bodies	401,197		251
3743: Railroad Equipment	36,812		306
3825: Instruments to Measure Electricity			2,500
5171: Petroleum Bulk Stations and Terminals	845	37	
Total	1,665,776	234,304	2,194,990
TRI Source Groups			
Particulate Matter: 3255+3275+3295+3297			7,969
Paint: 2816+2851	115,538	580	11,154
Plastic: 3087+3089+2821	23,308		1,510
Steel/Coke: 3312+3315+3316+3317+3325+3341	174,495	230.205	2,154,999

Figure 2 TRI source area. (Numbers identify the individual facilities listed in Appendix C)

C. CEP Air Toxics Concentrations

Data on outdoor levels of toxic air contaminants have not been available for most communities in the United States making it difficult to assess the potential for adverse human health effects from general population exposures. As part of the EPA's Cumulative Exposure Project, an effort to assess the potential impact of air toxics in the US, emissions data from stationary and mobile sources were used with an atmospheric dispersion model to estimate outdoor concentrations of 148 toxic air contaminants for each of the 60,803 census tracts in the contiguous United States for 1990 conditions.[2,3] The Assessment System for Population Exposure Nationwide (ASPEN) model used for this study is a modified version of the EPA Human Exposure Model (HEM), a standard tool designed to model long-term average concentrations.[9] Long-term average concentrations of HAPs were calculated at the census tract level based on emissions rates of the HAPs and frequencies of various meteorological conditions, including wind speed, wind direction, and atmospheric stability. In addition, the ASPEN model incorporates simplified treatment of atmospheric processes such as decay, secondary formation, and deposition.

The pollutants chosen for modeling were based on the list of 189 Hazardous Air Pollutants (HAP) in section 112 of the 1990 Clean Air Act Amendments. The baseline year of 1990 was initially selected for modeling. Based on the availability of emissions data, 148 HAPs were selected for modeling. Of the specific HAPs modeled, 36 were included in the SE Chicago measurement program. These included 24 VOCs, 9 metals, and 3 PAHs.

A national inventory of HAP emissions was developed for this study as a required input to the dispersion model. For large manufacturing sources, emissions data contained in the EPA's TRI were used. Emissions estimates were developed for other sources, such as large combustion sources, automobiles, and dry cleaners, using HAP speciation data in combination with the EPA's extensive national inventories of 1990 emissions of total volatile organic compounds (VOCs) and particulate matter (PM). The dispersion model accounted for long-term concentrations of HAPs attributable to 1990 anthropogenic emissions within 50 km of each census tract centroid. For 28 HAPs, estimated outdoor concentrations also included a background component attributable to long-range transport, resuspension of historical emissions, and natural sources derived from measurements taken at clean air locations remote from the impact of local anthropogenic sources.

Tables 10 and 11 show the outdoor modeled concentrations for the specific census tracts where the Calumet and community air toxics monitors were located, respectively. The Calumet City monitor was located on the border between census tracts 825801 and 825700 in Cook County, IL. The CEP modeled concentrations for the Calumet monitor in Table 10 are the average predictions for these two census tracts. Table 11 shows the average of predictions for the three census tracts where the community monitors were located; census tract 540100 for Carver, 510500 for Bright and 520600 for Washington.

To represent uncertainty in the model predictions, each modeled concentration is accompanied by a range of concentrations that approximate the 90 percent uncertainty bounds. These uncertainty bounds were derived using statistical techniques intended to provide a 90 percent probability of including the actual 1990 average concentration for each pollutant in each census tract within the estimated bounds. The uncertainty bounds were developed using comparisons of modeled concentrations to actual measured air toxics concentrations. Note that the upper bound values of the uncertainty ranges may be much higher than actual concentrations. This resulted from statistical procedures designed to ensure that the interval between the lower bound and upper bound was wide enough to include the actual concentration in 90 percent of all cases. For two pollutants (methylene chloride and styrene) the calculated lower value of the uncertainty bounds is slightly greater than the model prediction. In other words, the range of values included in the 90 percent uncertainty bounds will not include the model prediction. This unusual outcome is due to the fact that comparison of modeled concentrations to the available monitoring data for these pollutants suggested that the model almost always underestimated concentrations of these pollutants. This implies that emissions for these pollutants are probably underestimated.[2,3]

Tables 10 and 11 also include the average, minimum and maximum measured concentrations. All concentrations in these tables are in $\mu g/m^3$ to facilitate comparisons. (The conversion factors for 1 ppb in $\mu g/m^3$ for VOCs are included in the tables.) For the measurements in S.E. Chicago, tables 10 and 11 show that the CEP modeled concentrations agree very well with the measured concentrations, and in general are not systematically under predicted. Only four compounds (1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, chloromethylbenzene and hexachloro-1,3-butadiene) have measured average concentrations more than one order of magnitude outside of the modeled range.

Because much of the CEP data are older and limited, they can create uncertainties regarding meaningful application. Some of the more critical assumptions and/or limitations include:

> Behavior of air toxics. The **ASPEN** model uses a set of equations to simulate the behavior of air toxics in the atmosphere. These equations address the impact of wind speed and wind direction, breakdown of pollutants in the atmosphere, and deposition of pollutants from the atmosphere. The model is assumed to be applicable for a wide variety of climate and terrain conditions across the United States.
>
> Source characterization. The emissions inventory used for **ASPEN** modeling relies on a mixture of facility-specific emissions estimates for larger sources and county-level estimates for smaller, more numerous sources. Emissions from the small and numerous sources (e.g., gas stations and motor vehicles) are geographically allocated to individual census tracts using data surrogates such as population and roadway miles.
>
> Background concentrations. To derive estimates of ambient air toxics concentrations, EPA estimated not only emissions from mobile and stationary sources, but also the background concentrations that are attributable to natural sources, long-range transport of emissions from other countries, and persistence in the environment of pollutants emitted in past years. For the 1990

characterization. EPA estimated background concentrations for 28 air toxics and assumed that these background concentrations are uniform across the U.S. In reality, background concentrations will likely vary geographically.

<u>Census tract estimation</u>. The model provides estimated air toxics concentrations at the census tract level. Census tracts are geographic areas that vary in size but typically contain about 4,000 residents each. Although the modeled concentrations at the census tract level are useful for providing a general sense of air toxics concentrations across the country, they do not account for many local conditions. The modeled concentrations provide a more reliable representation of air toxics concentrations when aggregated over a large number of census tracts--for example, for urban counties or states. In addition, many of the emission estimates used in the model were derived at the county-level, and it is most often appropriate to present or compare the modeled concentrations at a level no finer than county-level.

Table 10. Comparison of CEP Modeled and Measured Concentrations at the Calumet Monitor (All concentrations in µg/m^3).

Compound	CEP Chemical name	molecular weight	1 ppb in µg/m^3	CEP Modeled Concentrations			USEPA R5 Measured Concentrations		
				Lower Bound	Mean	Upper Bound	Minimum	Mean	Maximum
VOLATILE ORGANIC COMPOUNDS									
1,1,1-Trichloroethane	methyl chloroform	133.4	5.46	1.3	3.7	21.1	0.6	1.32	8.3
1,1,2,2-Tetrachloroethane	tetrachloroethane (1,1,2,2)	167.9	6.87	0.23e-6	0.49e-6	7.4e-6	ND	ND	0.3
1,2,4-Trichlorobenzene	trichlorobenzene (1,2,4)	181.4	7.42	0.84e-6	1.94e-6	26e-6	0.074	0.405	0.74
1,2-Dibromoethane	ethylene dibromide	187.9	7.69	0.0038	0.008	0.12	ND	ND	0.04
1,2-Dichloroethane	ethylene dichloride	99	4.05	0.46	0.99	14.7	0.081	0.397	1.66
1,3-Butadiene	butadiene (1,3)	54.1	2.21	0.058	0.12	1.8	0.022	0.144	0.685
Benzene	benzene	78.1	3.19	0.97	1.9	7.4	0.57	1.81	9.63
Bromomethane	methyl bromide	95	3.89	0.02	0.041	0.62	0.078	0.201	0.39
Carbon Tetrachloride	carbon tetrachloride	153.8	6.29	0.54	0.89	1.81	0.11	0.46	0.63
Chlorobenzene	chlorobenzene	112.5	4.61	0.03	0.066	0.98	0.046	0.108	0.23
Chloroethane	ethyl chloride	64.5	2.64	0.0048	0.01	0.15	0.12	0.26	0.58
Chloroform	trichloromethane	119.4	4.88	0.078	0.088	0.31	0.049	0.088	0.29
Chloromethane	methyl chloride	84.9	3.47	0.6	1.2	18.7	0.14	1.93	3.54
Chloromethylbenzene	benzyl chloride	126.6	5.18	0.2e-6	0.5e-6	7.4e-6	0.065	0.11	0.26
Chloroprene	chloroprene	88.5	3.62	0.005	0.011	0.16	ND	ND	0.14
Ethylbenzene	ethylbenzene	106.2	4.34	0.34	0.41	4.1	0.22	0.93	4.77
Hexachloro-1,3-butadiene	hexachloro-1,3-butadiene	260.7	10.66	0.0009	0.0018	0.027	0.21	0.502	0.75
Methylene Chloride	dichloromethane	84.9	3.47	0.55	0.49	7.4	0.14	0.62	3.16
Styrene	styrene	104.2	4.26	0.13	0.13	4.6	0.043	0.27	1.15
Tetrachloroethylene	tetrachloroethylene	165.8	6.78	0.39	0.62	10.4	0.051	0.91	4.88
Toluene	toluene	92.1	3.77	3.5	4.8	32.4	1.28	4.86	24.8
Trichloroethylene	trichloroethylene	131.4	5.37	0.087	0.66	8.1	0.054	0.16	0.97
m,p, o-Xylene	xylene	106.2	4.34	2.7	5	36.5	0.91	3.81	18.6
p-Dichlorobenzene	p-dichlorobenzene	147	6.01	0.08	0.101	1.55	0.015	0.19	1.02

Table 10. Comparison of CEP Modeled and Measured Concentrations at the Calumet Monitor (All concentrations in µg/m^3).

Compound	CEP Chemical name	molecular weight	1 ppb in µg/m^3	CEP Modeled Concentrations			USEPA R5 Measured Concentrations		
				Lower Bound	Mean	Upper Bound	Minimum	Mean	Maximum
Metals									
Antimony	antimony			0.0003	0.00062	0.00093	0	0.0003	0.0033
Arsenic	arsenic			0.00027	0.00057	0.0086	0	0.0015	0.0046
Cadmium	cadmium			0.00022	0.00047	0.0071	0	0.0001	0.0043
Chromium	chromium			0.0037	0.0078	0.11	0	0.19	5.47
Cobalt	cobalt			0.0001	0.00013	0.0019	0	0.0003	0.0055
Lead	lead			0.0074	0.015	0.23	0.0079	0.0382	0.163
Manganese	manganese			0.0034	0.0071	0.11	0	0.129	0.39
Nickel	nickel			0.0061	0.013	0.19	0	0.0026	0.0094
Selenium	selenium			0.0011	0.0024	0.036	0	0.0018	0.0038
PAH/Polycyclic Organic Matter									
Biphenyl	biphenyl			0.00015	0.00033	0.0049	0	0.0104	0.023
Naphthalene	naphthalene			0.087	0.18	2.7	0	0.179	0.736
total PAH	POM			0.15	0.31	4.7	0.00039	0.229	0.912

Table 11. Comparison of CEP Modeled and Measured Concentrations at the Community Monitors (All concentrations in μg/m^3).

Compound	CEP Chemical name	molecular weight	1 ppb in μg/m^3	CEP Modeled Concentrations			USEPA R5 Measured Concentrations		
				Lower Bound	Mean	Upper Bound	Minimum	Mean	Maximum
VOLATILE ORGANIC COMPOUNDS									
1,1,1-Trichloroethane	methyl chloroform	133.4	5.46	3.5	9.6	54	0.55	1.35	5.24
1,1,2,2-Tetrachloroethane	tetrachloroethane (1,1,2,2)	167.9	6.87	0.3e-6	0.71e-6	7.6e-6	0.07	0.21	0.3
1,2,4-Trichlorobenzene	trichlorobenzene (1,2,4)	181.4	7.42	0.7e-6	1.6e-6	24e-6	0.074	0.34	0.74
1,2-Dibromoethane	ethylene dibromide	187.9	7.69	0.0039	0.0082	0.12	0.04	0.05	0.08
1,2-Dichloroethane	ethylene dichloride	99	4.05	0.41	0.86	12.8	0.26	0.86	6.72
1,3-Butadiene	butadiene (1,3)	54.1	2.21	0.087	0.18	2.8	0.02	0.14	0.46
Benzene	benzene	78.1	3.19	1.2	2.4	9.1	0.096	2.17	11.9
Bromomethane	methyl bromide	95	3.89	0.02	0.041	0.61	0.078	0.34	1.44
Carbon Tetrachloride	carbon tetrachloride	153.8	6.29	0.55	0.9	1.83	0.063	0.47	0.75
Chlorobenzene	chlorobenzene	112.5	4.61	0.07	0.14	2.1	0.46	0.103	1.89
Chloroethane	ethyl chloride	64.5	2.64	0.018	0.037	0.56	0.12	0.16	0.45
Chloroform	trichloromethane	119.4	4.88	0.083	0.094	0.33	0.049	0.089	0.29
Chloromethane	methyl chloride	84.9	3.47	0.6	1.3	18.8	0.34	1.99	5.07
Chloromethylbenzene	benzyl chloride	126.6	5.18	0.7e-6	1.5e-7	22e-6	0.065	0.499	2.74
Chloroprene	chloroprene	88.5	3.62	0.02	0.044	0.65	ND	ND	ND
Ethylbenzene	ethylbenzene	106.2	4.34	0.4	0.48	5.2	0.087	0.78	3.65
Hexachloro-1,3-butadiene	hexachloro-1,3-butadiene	260.7	10.66	0.0009	0.0018	0.027	0.107	0.51	0.75
Methylene Chloride	dichloromethane	84.9	3.47	1.5	1.3	12.8	0.104	1.09	15.9
Styrene	styrene	104.2	4.26	0.16	0.16	5.4	0.043	0.266	2.47
Tetrachloroethylene	tetrachloroethylene	165.8	6.78	0.71	1.08	18.3	0.05	0.64	8.2
Toluene	toluene	92.1	3.77	7.9	10.7	72.2	0.72	3.53	15.5
Trichloroethylene	trichloroethylene	131.4	5.37	0.3	2.3	28.2	0.064	0.246	2.79
m,p, o-Xylene	xylene	106.2	4.34	6	11	80.2	0.35	3.2	16.1
p-Dichlorobenzene	p-dichlorobenzene	147	6.01	0.16	0.2	3.2	0.015	0.105	0.78

Table 11. Comparison of CEP Modeled and Measured Concentrations at the Community Monitors (All concentrations in µg/m³).

Compound	CEP Chemical name	molecular weight	1 ppb in µg/m³	CEP Modeled Concentrations			USEPA R5 Measured Concentrations		
				Lower Bound	Mean	Upper Bound	Minimum	Mean	Maximum
Metals									
Antimony	antimony			0.00057	0.0012	0.018	0	0.0005	0.0041
Arsenic	arsenic			0.00054	0.0011	0.017	0	0.0018	0.0088
Cadmium	cadmium			0.00059	0.0013	0.019	0	0.0005	0.0076
Chromium	chromium			0.0093	0.02	0.29	0	0.0083	0.0325
Cobalt	cobalt			0.0001	0.00019	0.0029	0	0.0001	0.006
Lead	lead			0.0062	0.013	0.2	0.0029	0.0759	1.58
Manganese	manganese			0.0048	0.01	0.15	0	0.235	4.48
Nickel	nickel			0.018	0.041	0.62	0	0.0645	5.03
Selenium	selenium			0.0025	0.0053	0.08	0	0.0025	0.0112
PAH/Polycyclic Organic Matter									
Biphenyl	biphenyl			0.00019	0.0004	0.006	0	0.0102	0.054
Naphthalene	naphthalene			0.093	0.203	3	0	0.328	1.8
total PAH	POM			0.16	0.34	5.1	0	0.4	2.27

D. Evaluation of TRI DATA with Ambient Measurements

Each ambient measurement was scored with respect to upwind TRI emissions. TRI source wind scores were developed by first calculating the orientation of each point source to the individual receptors. The individual differences between latitude and longitude of the sources and receptor locations were converted into scalar distances in miles (x and y) using equations developed by Felis.[10] The results of this conversion were then used to calculate the angle between the direction north and a source with the receptor placed at the coordinate system's origin using the equation:

$$\theta = \tan^{-1} \frac{x}{y}$$

where θ is the angle between the north direction and the source with the origin of the axes centered on the receptor and x and y are the differences in the longitudinal and latitudinal directions, respectively. The sources in relation to each receptor were then grouped into one of eight direction categories: north (337.5 to 22.5°), northeast (22.5 to 67.5°), east (67.5 to 112.5°), southeast (112.5 to 157.5°), south (157.5 to 202.5°), southwest (202.5 to 247.5°), west (247.5 to 292.5°), and northwest (292.5 to 337.5°).

Meteorological data (hourly wind direction) was then merged with the source/receptor orientation information to allow for the calculation of individual source-receptor wind scores. Individual source scores were calculated for each measurement at each monitoring site. Hourly wind direction was used to determine when a receptor site was downwind of a specific TRI source. A score of one was assigned for each hour when the source was in the same wind direction category as the wind direction. The remaining hours, when the source location and wind directions were different, were assigned zeros. Because the ambient air quality measurements were collected over 24 hours, the individual source scores were averaged over the 24 hour period of each sampling day. Based on this wind direction classification, the score for an individual source affecting an individual receptor (monitoring location) can range from 0 (never upwind) to 1 (always upwind). The Toxic Release Inventory reported emissions values for each facility were then multiplied by these wind scores and summed for specific compounds within the Standard Industrial Classification codes. If two or more sources of the same compound were contained within a common wind direction category, the scores from these compounds were added together. This calculation results in an individual estimate of the impact of each pollutant from the TRI categories on each monitor. This evaluation was repeated for each of the 31 measurement days.

TRI emissions impacting the measurement sites were then correlated against measured concentrations at all of the monitoring sites for individual HAPs. Table 12 summarizes the significance of the correlations between measured concentrations and selected TRI categories. The table identifies source emission and measured concentration correlations that range from marginally significant to strongly significant. In table 12, poor represents correlations with p values between 0.15 and 0.10, fair are correlations with p values between 0.10 and 0.05, very

Cumulative Exposure Project Chronic Health Benchmarks Concentrations for Air Pollutants ($\mu g/m^3$) [2, 16]

Chemical Name	CAS Number	One per Million Cancer Risk	Noncancer Chronic Health
Methylene diphenyl diisocyanate	101-68-8		0.02
4,4'-methylenedianiline	101-77-9	0.00217	1.9
Naphthalene	91-20-3		14
Nickel and Compounds	7440-2-0	0.005	0.24
Nitrobenzene	98-95-3		1.7
2-Nitropropane	79-46-9	0.00037	20
Pentachlorophenol	87-86-5	0.0292	0.2
Phenol	108-95-2		45
Phthalic anhydride	85-44-9		7000
Polychlorinated biphenyls	1336-36-3	0.000455	1.2
Propylene dichloride	78-87-5	0.0556	4
Propylene oxide	75-56-9	0.27	30
Selenium and Compounds	7782-49-2		0.5
Styrene	100-42-5		1000
Styrene oxide	96-9-3	0.0217	
1,1,2,2-tetrachloroethane	79-34-5	0.0172	
Tetrachloroethene	127-18-4	1.72	35
Toluene	108-88-3		400
2,4-toluene diamine	95-80-7	0.000909	
o-toluidine	95-53-4	0.0196	
1,1,2-trichloroethane	79-0-5	0.0625	
Trichloroethylene	79-1-6	0.588	640
2,4,6-trichlorophenol	88-6-2	0.323	
Trifluralin	1582-9-8	0.455	
Vinyl acetate	108-5-4		200
Vinyl bromide	593-60-2	0.0313	3
Vinyl chloride	75-1-4	0.0119	26
Vinylidene chloride	75-35-4	0.02	32
Xylenes (mixed)	1330-20-7		300

(2) Caldwell, J.C., Woodruff, T.J, Morello-Frosch, R., and Axelrad, D.A., (1998). "Application of Health Information to Hazardous Air Pollutants Modeled in EPA's Cumulative Exposure Project." Toxicology and Industrial Health 14(3):429-454.

(16) "Cumulative Exposure Toxicity Database Users' Manual," 1998. Prepared for Office of Policy, USEPA by Industrial Economics, Incorporated, Cambridge, MA.

Cumulative Exposure Project Chronic Health Benchmarks Concentrations for Air Pollutants ($\mu g/m^3$) [2, 16]			
Chemical Name	CAS Number	One per Million Cancer Risk	Noncancer Chronic Health
Dimethyl formamide	68-12-2		30
2,4-dinitrotoluene	121-14-2	0.0112	
1,4-dioxane	123-91-1	0.318	400
Epichlorohydrin	106-89-8	0.833	1
1,2-epoxybutane	106-88-7		20
Ethyl acrylate	140-88-5		48
Ethyl benzene	100-41-4		1000
Ethyl carbamate	51-79-6	0.00345	
Ethyl chloride	75-0-3		10000
Ethylene dibromide	106-93-4	0.00455	4.6
Ethylene dichloride	107-6-2	0.0385	95
Ethylene oxide	75-21-8	0.0435	600
Ethylene thiourea	96-45-7	0.0769	
Ethylidene dichloride	75-34-3	0.625	
Formaldehyde	50-0-0	0.0769	3.6
Heptachlor	76-44-8	0.000769	
Hexachlorobenzene	118-74-1	0.00217	2.8
Hexachlorobutadiene	87-68-3	0.0455	
Hexachlorocyclopentadiene	77-47-4		0.24
Hexachloroethane	67-72-1	0.25	
Hexane	110-54-3		200
Hydrazine	302-1-2	0.000204	0.24
Hydrochloric acid	7647-1-0		20
Hydrofluoric acid	7664-39-3		5.9
Lead and Compounds	7439-92-1		1.5
Lindane	58-89-9	0.00263	1
Maleic anhydride	108-31-6		2.4
Manganese and Compounds	7439-96-5		0.05
Mercury and Compounds	7439-97-6		0.3
Methanol	67-56-1		620
Methyl chloride	74-87-3	0.556	105
Methyl chloroform	71-55-6		320
Methyl ethyl ketone	78-93-3		1000
Methyl isocyanate	624-83-9		0.36
Methyl methacrylate	80-62-6		980
Methyl tert-butyl ether	1634-4-4		3000
4,4'-methylene bis(2-chloroaniline)	101-14-4	0.00233	
Methylene chloride	75-9-2	2.13	3000

Cumulative Exposure Project Chronic Health Benchmarks Concentrations for Air Pollutants ($\mu g/m^3$) [2, 16]

Chemical Name	CAS Number	One per Million Cancer Risk	Noncancer Chronic Health
Acetaldehyde	75-7-0	0.455	9
Acetamide	60-35-5	0.05	
Acrolein	107-2-8		0.02
Acrylamide	79-6-1	0.000769	0.7
Acrylic acid	79-10-7		1
Acrylonitrile	107-13-1	0.0147	2
Allyl chloride	107-5-1	0.167	1
Aniline	62-53-3	0.614	1
Anisidine	90-4-0	0.025	
Arsenic and Compounds	7440-38-2	0.000233	0.5
Benzene	71-43-2	0.12	71
Benzotrichloride	98-7-7	0.000269	
Benzyl chloride	100-44-7	0.0206	12
Beryllium and Compounds	7440-41-7	0.000417	0.0048
Bromoform	75-25-2	0.909	
1,3-butadiene	106-99-0	0.00357	
Cadmium and Compounds	7440-43-9	0.000556	3.5
Captan	133-6-2	1.52	
Carbon disulfide	75-15-0		700
Carbon tetrachloride	56-23-5	0.0667	2.4
Chlordane	57-74-9	0.0027	0.02
Chlorinated dibenzo-p-dioxins (as 2,3,7,8-equivalents)	dioxins		3.5E-006
Chlorinated dibenzofurans (as 2,3,7,8-equivalents)	furans		3.5E-006
Chlorobenzene	108-90-7		70
Chloroform	67-66-3	0.0435	35
Chloromethyl methyl ether	107-30-2	0.00145	
Chloroprene	126-99-8		1
Chromium (VI) Compounds	18540-29-9	8.33E-005	0.002
Cresols (mixed)	1319-77-3		180
Cumene	98-82-8		400
p-dichlorobenzene	106-46-7	0.0909	800
3,3'-dichlorobenzidine	91-94-1	0.00778	
Dichloroethyl ether	111-44-4	0.00303	
1,3-dichloropropene	542-75-6	0.0625	20
Dichlorvos	62-73-7	0.0121	0.5

APPENDIX E. Cumulative Exposure Project Health-Risk Benchmarks

Appendix E contains a table of CEP health-risk benchmarks. They were taken from the CEP Toxicity Database (a downloadable searchable database available at a CEP website). Some of these are also reported in the Caldwell et.al. reference (3). Included in the table is the whole CEP list, instead of just the measured chemicals.

HIGH VOLUME AIR SAMPLER CALIBRATION

Unit No.: ______________

Date:

By:

Temp.:

At. Press:

Remarks:

Indicated	True "H_2O	Actual cfm

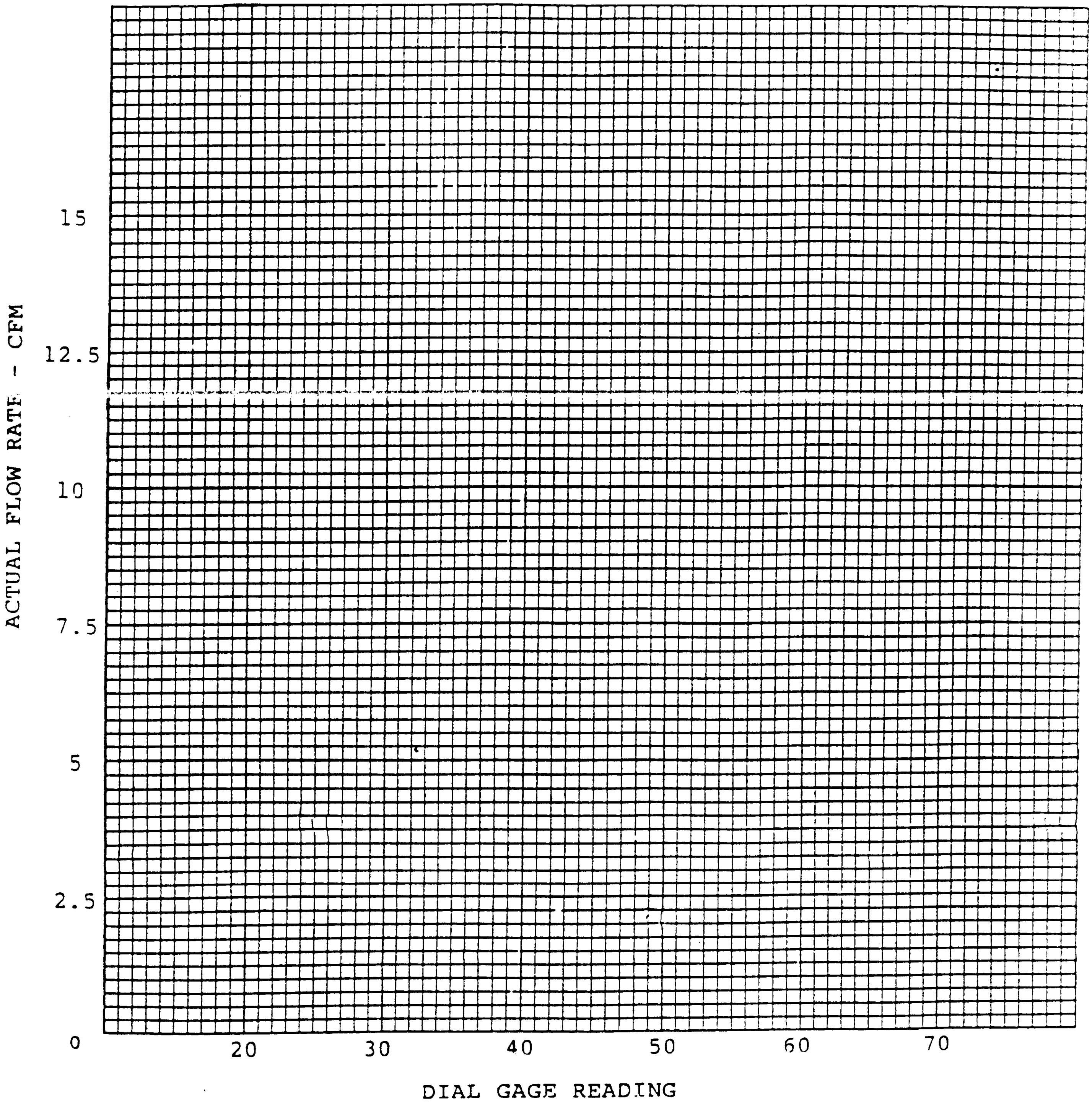


Figure XII

FIGURE XIII

PuF SAMPLER - CALIBRATION DATA SHEET

Mass Flow Controller Calibration

Date: ____________ Ambient Temperature: ____________

Barometric Pressure: ________ Vapor Pressure: ____________

Calibrator: ________ MFC Calibrated: ____________

rret (cc)	Elapsed Volume (cc)	Elapsed Time (sec)	Raw Flow Rate (cc/min)	Calculated Flow Rate (cc/min)	Dial Wheel (/min)	Display (cc/min)	
							AVG.

$$\text{MASS FLOW RATE} = \left[\frac{\text{Vol (cc)}}{\text{Time (sec)}} \times \frac{60\,\text{sec}}{1\,\text{min}} \times \frac{(P_b - P_v)\,\text{in. Hg}}{29.92\,\text{in. Hg}} \times \frac{298\,K}{(273+T)\,K} \right]$$

Vol = Elapsed Volume (cc)
Time = Elapsed Time (sec)
P_b = Barometric Pressure (in. Hg)
P_v = Vapor Pressure of Water (in. Hg)
T = Ambient Temperature (°C)

FIGURE XII

TO-14 - CALIBRATION DATA SHEET

HIGH-VOLUME AIR SAMPLER CALIBRATION DATA SHEET

Station Location ______________________ Date ____________ Time ____________

Sampler Model ______________ S/N ______________ Operator ______________

Pa ______ mm Hg, Ta ______ °C ______K, Unusual conditions: ______________

Ps* ______ mm Hg, Ts* ______ °C ______K, (*seasonal average Ta and Pa)

Orifice S/N ______________________ Orifice Calibration Date ______________________

Orifice calibration relationship: m = ____________ b = ____________ r^2 = ____________

Plate Number	Total ΔH_2O (in.)	X-Axis = Qstd(orifice) flow rate[a] (m^3/min)	I Sampler flow rate indication	Y-Axis $I[(Pa/Ps)(Ts/Ta)]^{\frac{1}{2}}$	Ycal[b]	% Diffe

[a] $Qstd = [[\Delta H_2O(Pa/Pstd)(298/Ta)]^{\frac{1}{2}} - b]/m$

Linear regression of Y on X: $Y = mX + b$

Slope(m) = ________ Intercept(b) = ________ Correlation Coefficient(r) = ______

To determine subsequent flow rate during use: $Qstd = (Y - b)/m$

[b] $Ycal = m\ Qstd + b$

[c] $\%\ Difference = \frac{Y - Ycal}{Ycal} \times 100\%$

Figure X

FIGURE XI

HIGH-VOLUME AIR SAMPLER

CALIBRATION DATA SHEET

ENVIRONMENTAL PROTECTION AGENCY
FOR THE [illegible] METALS

IVISION/BRANCH__________ SAMPLING DATE__________ LAB ARRIVAL DATE__________ DUE DATE__________

U NUMBER__________ DATASET NUMBER__________ STUDY__________ PRIORITY__________ CONTRACTOR__________

ILTER UMBER	SAMPLE DESCRIPTION	Volatiles $\mu g/m^3$	Semi-Volatiles pg/m^3	Metals $\mu g/m^3$		

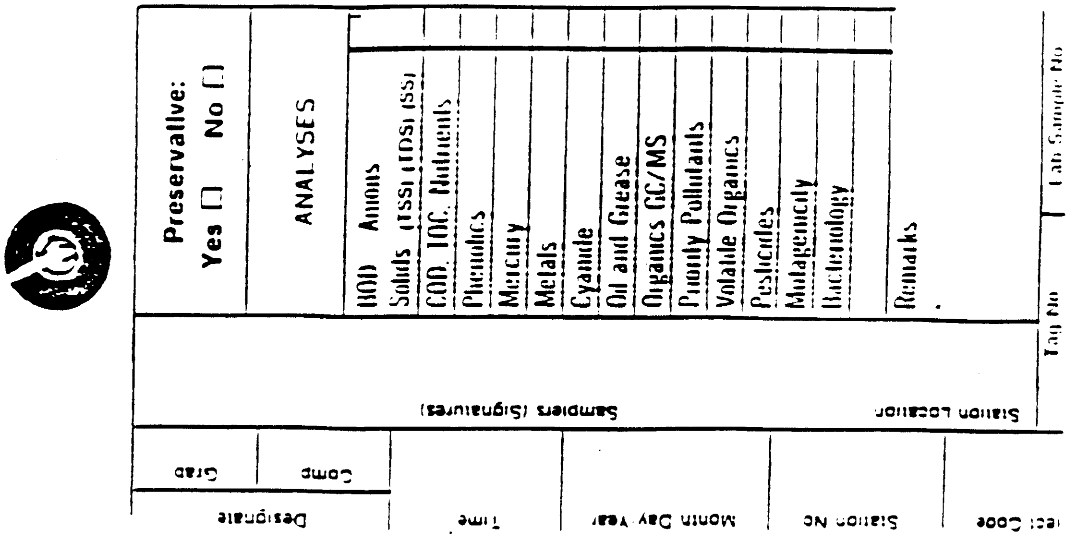
Figure 4

FIGURE X

ANALYSIS REQUEST FORM

FIGURE 3

Sample Tag, Front



Preservative: Yes ☐ No ☐

ANALYSES

BOD Anions
Solids (TSS) (TDS) (SS)
COD, TOC, Nutrients
Phenolics
Mercury
Metals
Cyanide
Oil and Grease
Organics GC/MS
Priority Pollutants
Volatile Organics
Pesticides
Mutagenicity
Bacteriology
Remarks

Lab Sample No
Tag No

Station Location
Samplers (Signatures)

Grab
Comp
Designate
Time
Month Day Year
Station No
ect Code

Sample Tag, Back

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 5
230 South Dearborn Street
Chicago, Illinois 60604

EPA

Cooler Custody Seal

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION V
OFFICIAL SEAL
№ 141320

FIGURE IX

IDENTIFICATION TAG- CUSTODY SEAL

VIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 5
230 South Dearborn Street
Chicago, Illinois 60604

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME	NO. OF CON-TAINERS
AMPLERS: *(Signature)*		

TA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS							REMARKS

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Receive
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks	

Distribution: White — Accompanies Shipment; Pink — Coordinator Field Files; Yellow — Laboratory File

Figure III

FIGURE VIII

CHAIN-of-CUSTODY RECORD

Sampler Site ____________________

Sampler Location ____________________

Date ____________________

	Before	After
Barometric Pressure		
Ambient Temperature		

Site ____________________ Date ____________ Performed By ____________________

Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No.		Sampling Period		Totaling Sampling Time, min.	Pump Timer Hr. Min.	Sampler Flow Check[1]				
			Filter	XAD-2 or PUF	Start	Stop			Manometer ΔH, Inches of Water	Q_{xs}	M	Q_{ms}	Within ± 10%

Checked By ____________________

Date ____________________

FIGURE VII FIELD TEST DATA SHEET.

---

[1] Must Be Performed Before and After Each Sampling Period

FIGURE VII

PuF SAMPLER FIELD DATA SHEET

HIGH-VOLUME AIR SAMPLER FIELD DATA SHEET

Designated/Co-located

Station Location ____________ Date ________ AIRS # ________

Sampler Model ____________ S/N ____________

Filter ID No. ________ Ps or Pav ________ mm Hg, Ts or Tav ________ °C ________ K

Flow Recorder Readings

Mean I ____________

Sampler Calibration Relationship: m = ________ b = ________ r = ________

Qstd ____________ m^3/min Elapsed Time ____________ min

Qstd = (aI - b)/m; a = ________

= ________ I + ________ - simplified

Operator ____________

Comments: ____________

____

____

____

Laboratory Calculations:

Gross weight (Wg) ____________ g

Tare weight (Wt) ____________ g

Net Weight (Wn) ____________ g

Vstd ____________ std m^3

Vstd = ($\overline{Qstd}$) (elapsed time)

TSP Concentration ____________ µg/std m^3

TSP Concentration = (Wn) (10^6)/Vstd

Figure VII-A

FIGURE VII A

HIGH-VOLUME AIR SAMPLER

FIELD DATA SHEET

FIGURE VI

PROJECT ORGANIZATION AND RESPONSIBILITY

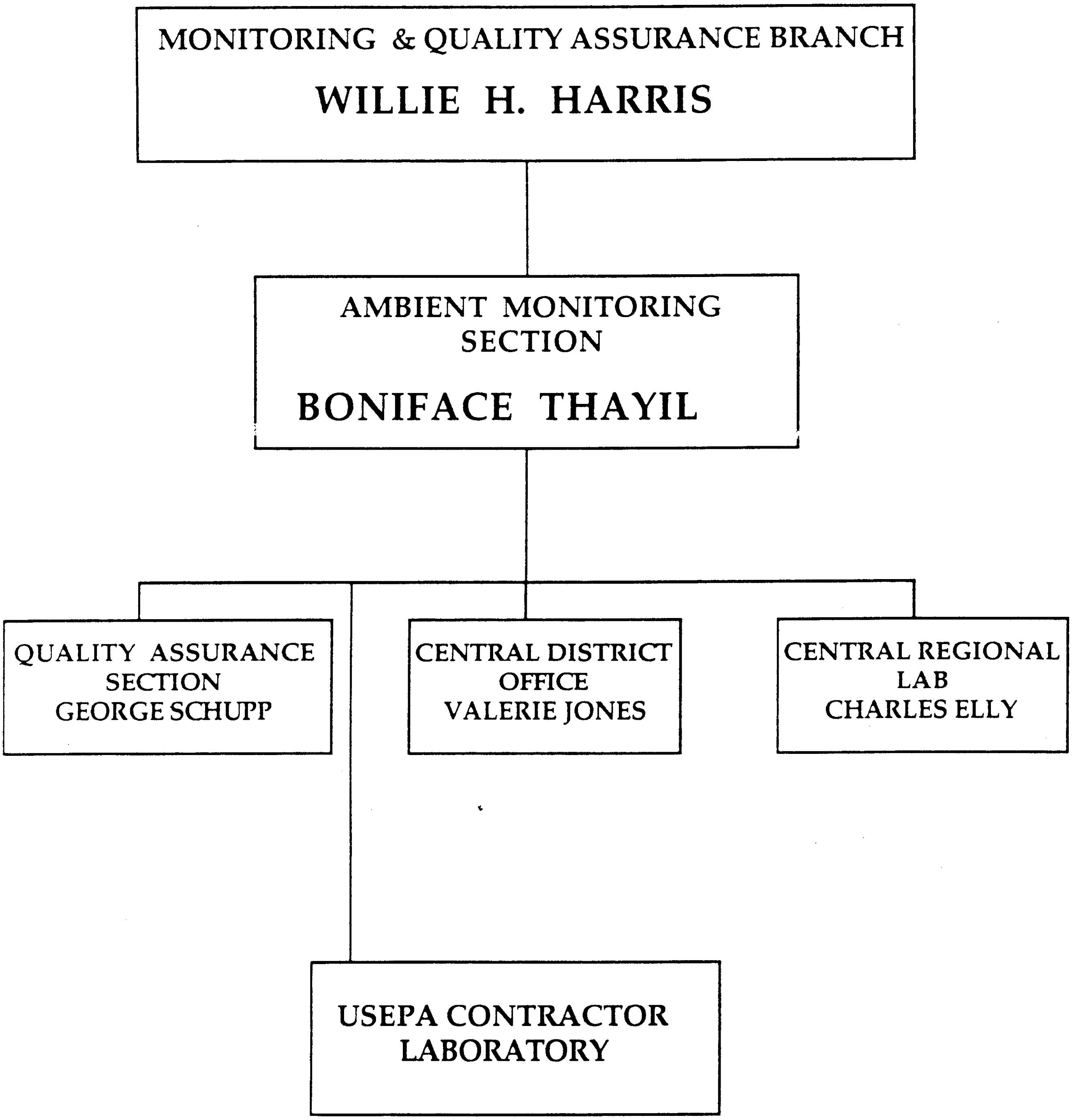


FIGURE VI

PROJECT ORGANIZATION and RESPONSIBILITY

BACKGROUND SITE

CALUMET CITY DEPT. OF PUBLIC WORKS

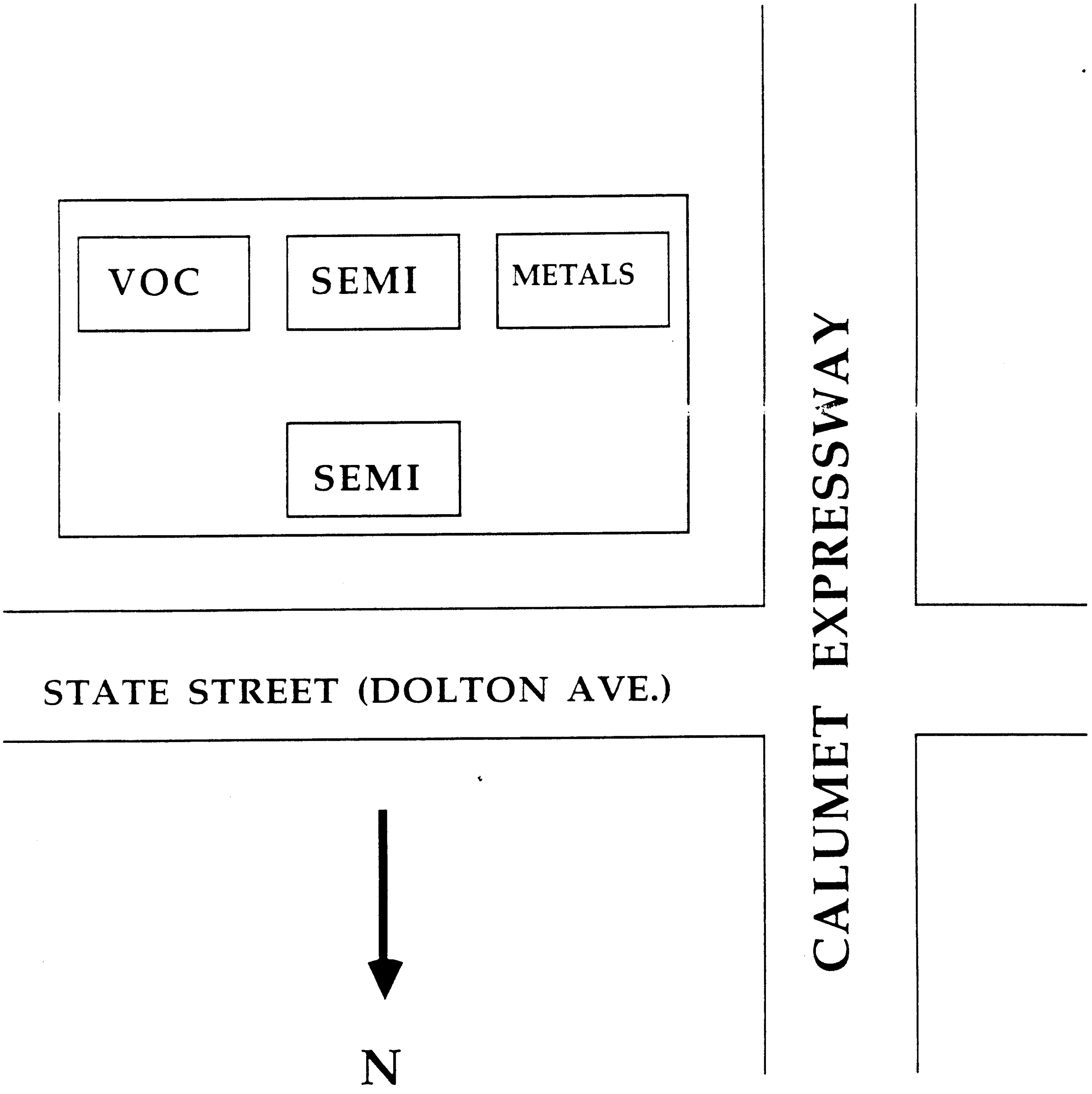


FIGURE V

BACKGROUND MONITORING SITE

FIGURE IV
SITE -C

WASHINGTON ELEMENTARY

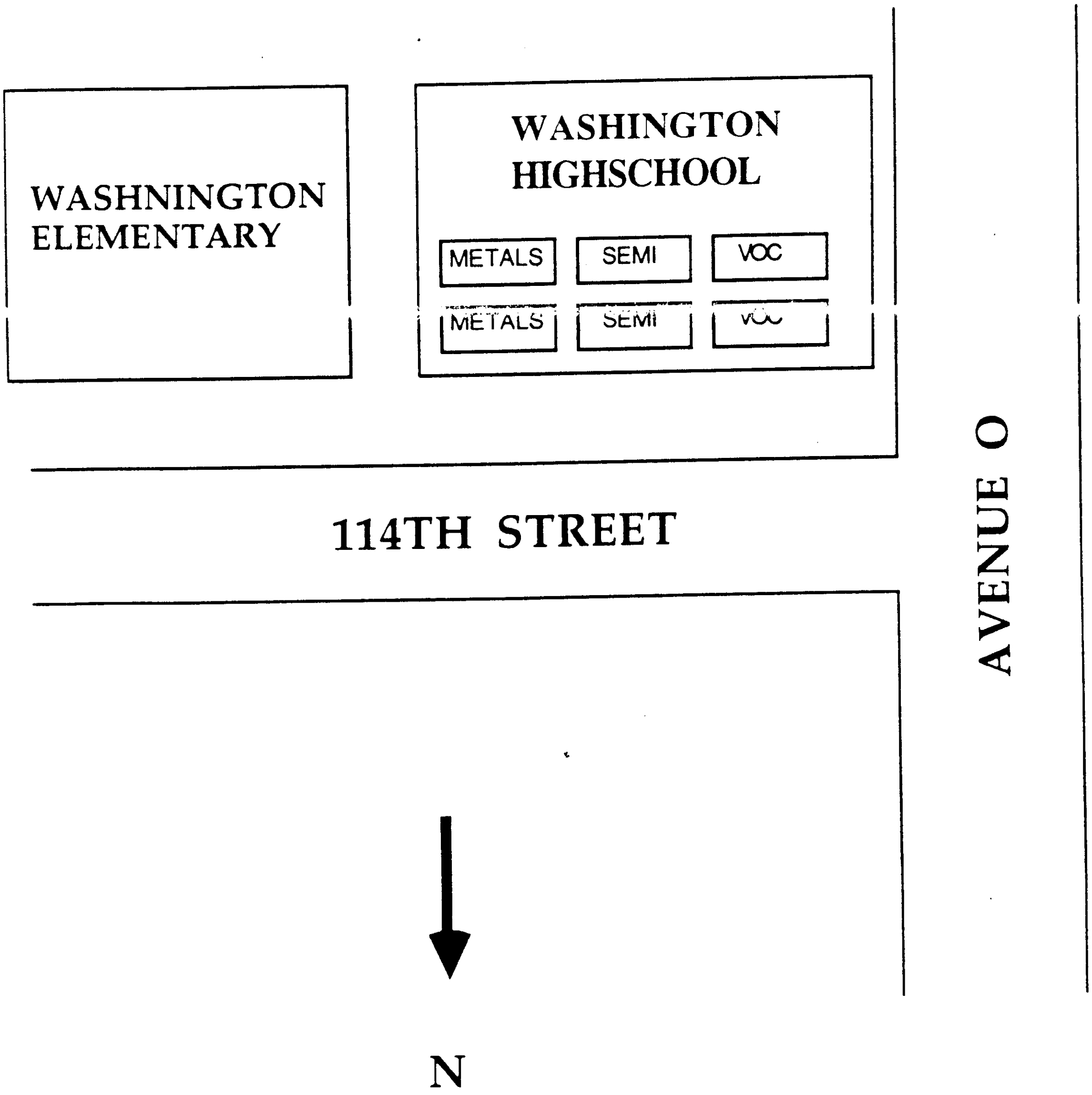


FIGURE IV

MONITORING "C"

FIGURE III
SITE - B
BRIGHT ELEMENTARY

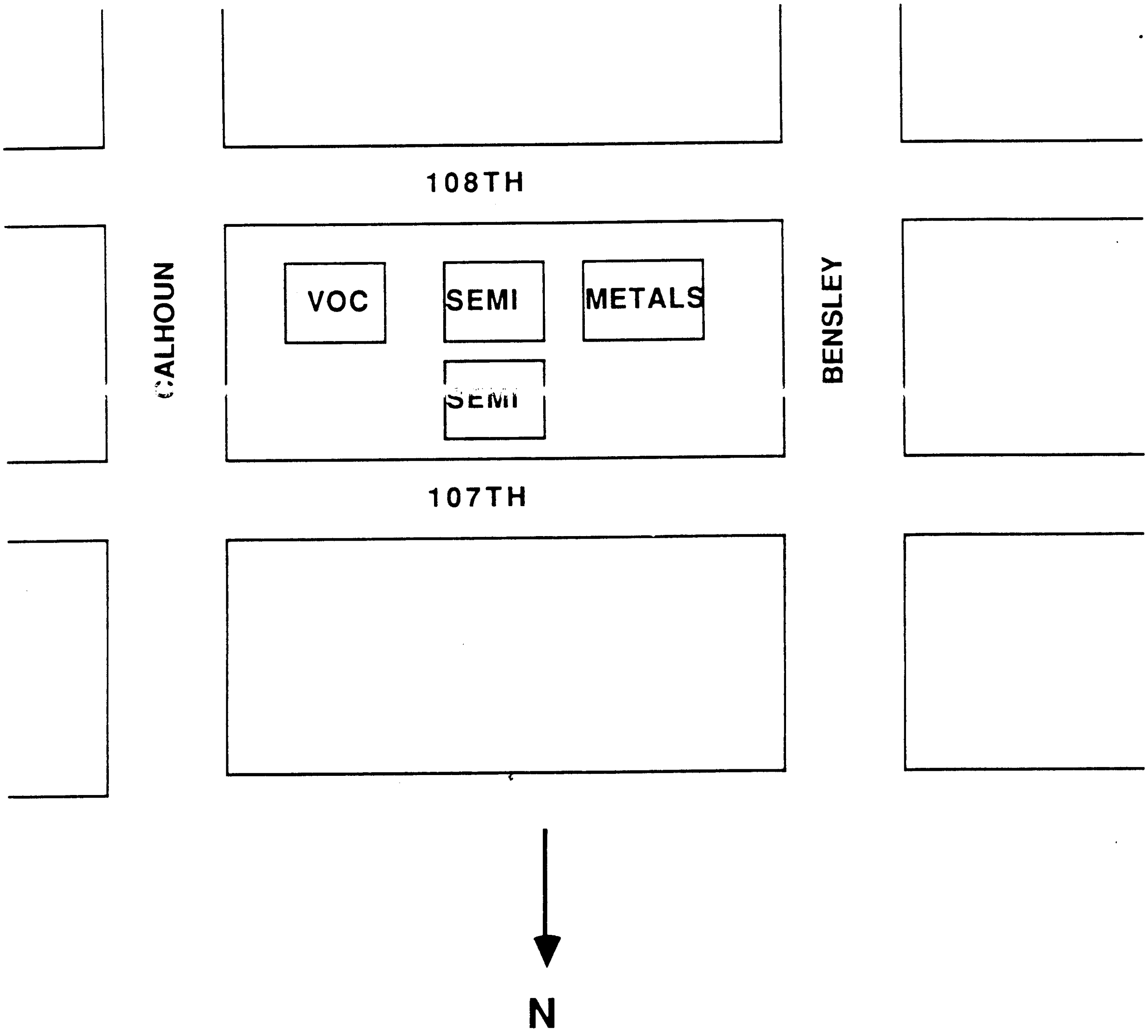


FIGURE III

MONITORING SITE "B"

FIGURE II
SITE - A

CARVER HIGHSCHOOL

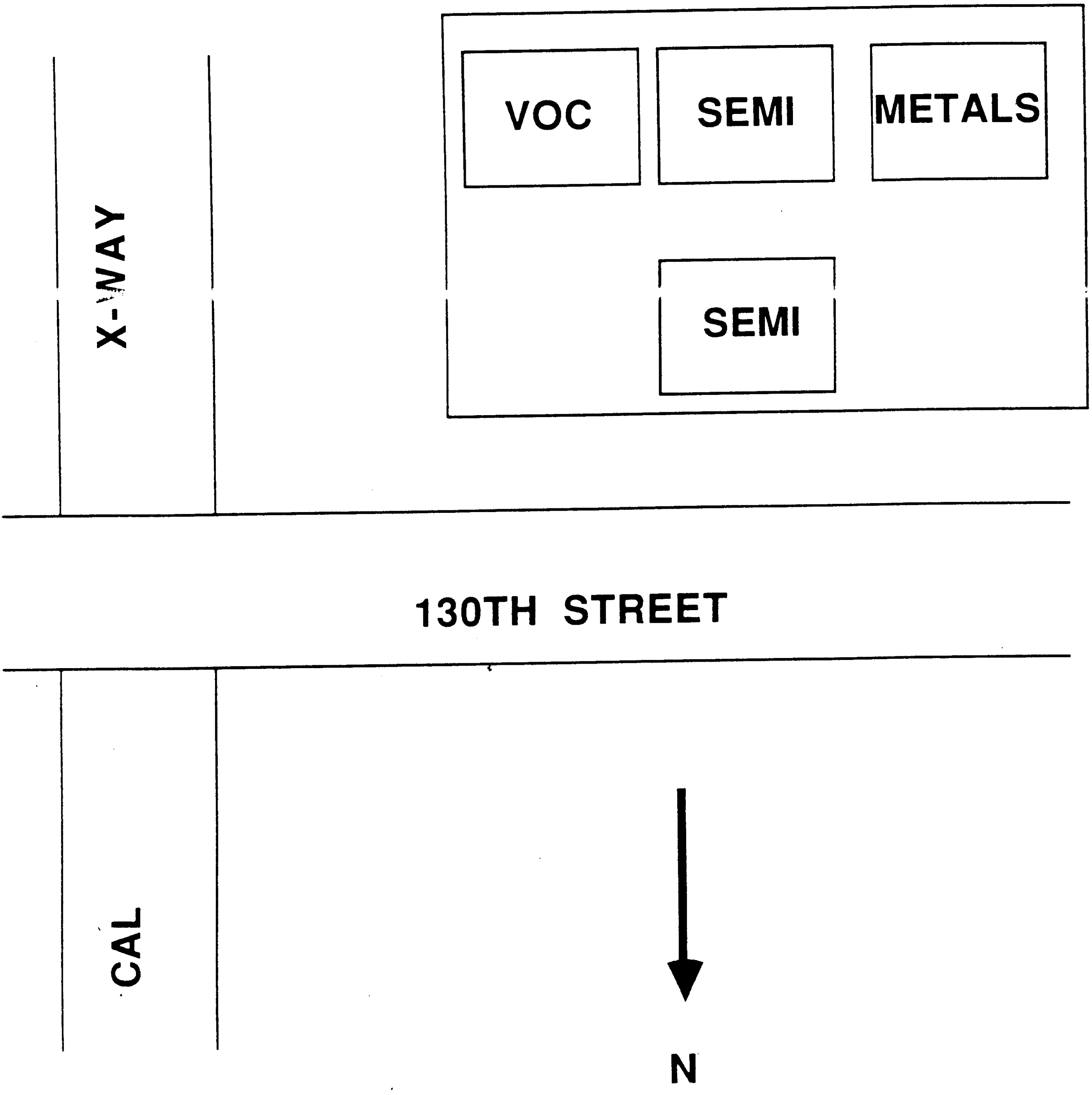


FIGURE II

MONITORING SITE "A"

SOUTHEAST CHICAGO STUDY AREA

Receptor Area

Figure 1b.

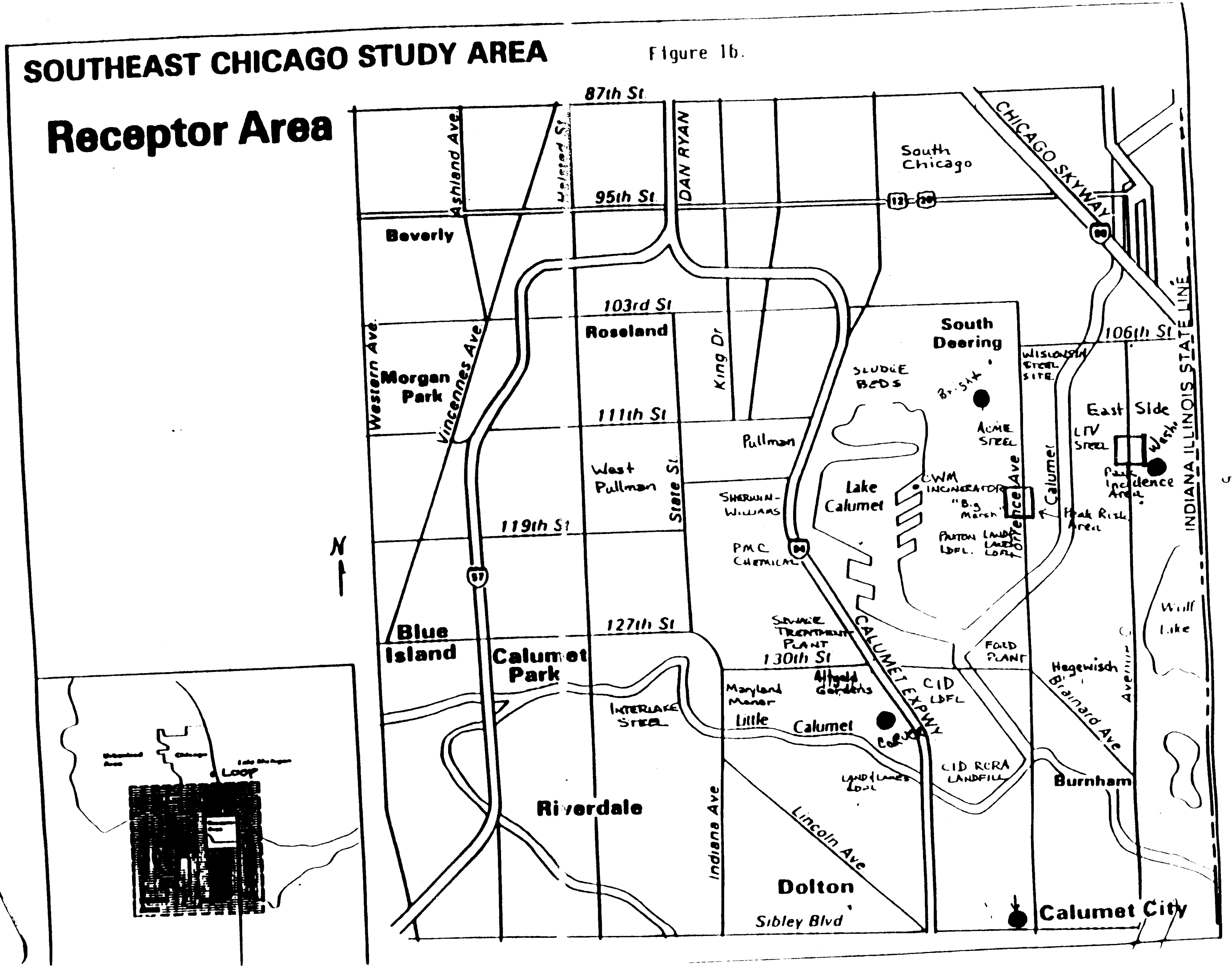


FIGURE 1

SOUTHEAST CHICAGO STUDY AREA

PROPOSED MONITORING SITES

14.0 QUALITY ASSURANCE REPORTS to MANAGEMENT

Quarterly quality assurance reports will be submitted to the ESD Director by the Project Coordinator. The reports will include the following:

- Data for precision, accuracy and completeness
- Results of performance audits and internal quality control checks of flow rate calibration and data processing
- System audit results

13.0 CORRECTIVE ACTION

The need for corrective action during the project may be determined at several points: during field activities, during lab activities, and during data validation & assessment. All corrective action procedures will be documented in the final report.

13.1 Field Corrective Action

Corrective action in the field may be necessary due to quality assurance problems during sampling that were not anticipated in this QAPjP. In general, the need for corrective action will be identified by the field team leader. The US EPA Central District Office field team leader may identify the need for corrective action during an on-going audit. Corrective action should be approved by the Project Coordinator prior to initiation. The Project Coordinator may consult other technical staff (i.e., Contract Lab, US EPA Regional QA Management staff) regarding potential . corrective actions where data quality is an issue.

13.2 Laboratory Corrective Action

All laboratories will follow standard, established procedures. Any deviation from standard procedures should be cleared through the US EPA Quality Assurance Coordinator before execution.

13.3 Corrective Action During DATA Validation and Assessment

The need for corrective action may be identified during the data validation process conducted by the US EPA Region 5 MQAB. If the corrective action requires reanalyzing the sample, the MQAB Team Leaders shall determine whether the samples are within holding time and whether sufficient sample for reanalysis exists, etc. If the lab can rerun or reanalyze samples, the MQAB Data Team Leaders will advise the Lab to do so.

If data are determined to be unusable, results are estimated quantitatively or the data cannot be rerun/reanalyzed, the Project Coordinator will be advised of the situation by the contract laboratory. The Project Coordinator can then determine the feasibility of accepting the limitations of the data.

If for any reason the laboratories must take corrective action, they must contact Willie Harris of MQAB before reanalyzing the samples.

12.0 PROCEDURES for ASSESSING DATA PRECISION, ACCURACY and Completeness

12.1 Procedures for Assessing Data Precision

Precision of VOC, semi-volatiles and metals will be determined by means of collocated samplers, and will be expressed as the percent relative standard deviation (%RSD). The percent RSD should not exceed percentages given in Table I. If it does, an assignable cause should be ascertained and the data flagged.

12.2 Procedures for Assessing Data Accuracy

Accuracy calculation will be made by using the results of performance audits. The procedures for conducting performance audits are given in Section 10.0 of this document. The accuracy goal for this survey is given in Table I. Calculations will be carried out using equations in Section 2.0.8 of Volume II of the QA Handbook.

12.3 Procedures for Assessing Data Completeness

A Data Completeness will be determined by calculation of the number of valid data points divided by the total number of expected data points expressed as a percentage.

12.4 Other Data Assessment Techniques

The data will be provided to ATSDR for Health Assessment purposes.

11.0 PREVENTATIVE MAINTENANCE

11.1 Maintenance Procedures and Frequency for Hi-volume Samplers

The maintenance procedures and frequency are detailed in Section 7.2.7 of Volume II of the QA Handbook. Motor brush replacement and seating procedures for the Model GMWL-2000H are given on Pages 24 and 25 of the GMW operator's manual.

11.2 Maintenance Procedures and Frequency for PuF Samplers

Maintenance procedures and frequency are detailed on Page 8 of the Instruction and Operations Manual.

11.3 Maintenance Procedures and Frequency for Canister Samplers

The sampling equipment will be routinely inspected. Adjustments and Replacement of certain parts as needed, will be carried out by Central District Office personnel.

10.0 PERFORMANCE and SYSTEM AUDITS

Quality Assurance auditing will be an external function performed by Illinois Environmental Protection Agency.

10.1 Performance Audits and Frequency for all Samplers

Quarterly performance flow audits will be conducted on the PuF, Hi-volume and canister samplers. The procedures will be as outlined in the sampling methods manuals for each sampler. The results of the audits shall be documented in a memorandum to all members of the project management and shall be incorporated into the QA section of the final Study Report.

10.2 System Audits

The Illinois Environmental Protection Agency will perform systems audits as they deem appropriate.

9.0 INTERNAL QUALITY CONTROL CHECKS and FREQUENCY

9.1 Field Blank[1] and Duplicate Samples

Field blank samples are incorporated into the project QA program for the purpose of determining whether the compounds detected in the sample are actually contained in the ambient air or are in fact due to system contamination. Field blank samples will be prepared and submitted for analysis with the regular samples.

Duplicate air samples will be collected from collocated monitors. Procedures will be to follow the same sampling techniques used for all other monitors and to use a sample time identical to its collocated sampler. Collocated samplers will be erected within 1 meter of each other for the volatile and semi-volatile samples. Collocated samples will be erected within 2-4 meters of each other for the metal samples.

9.2 Flow Rates

Operational flow checks for the Hi-Vol and PuF samplers will be made every six weeks. The VOCCS sampler will be checked every six months. The procedures are given in the attached methods for each sampler.

9.3 Laboratory

Additional internal QC checks will involve the analysis of method blanks for all analyses and the use of surrogate spikes by the contract laboratory for organic analyses and metal analyses.

9.4 QC Data

Quality Control data will be maintained by the Central District Office and the contractor laboratory

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[1] VOC's - Canister with Laboratory pure air
Semi-VOC's - Take 1 PUF to 1 site each sampling event
Metals - 1 Unused Filter

8.0 DATA REDUCTION, VALIDATION and REPORTING

8.1 Data Reduction, Validation, and Reporting of Metal Data

Metals data will be reduced, and reported using procedures of Section 2.8.6 of Volume II of the QA Handbook. Although these procedures are written for lead, they may also be used for other metals. Results will be reported on a data report form. Data validation will be conducted by MQAB using modified CLP data validation protocols.

8.2 Data Reduction, Validation, and Reporting of Semi-Volatile Organic Compounds

Semi-Volatile Organic data will be reduced, and reported using procedures of Section 17 of EPA's Compendium Method TO-13. Results will be reported on an appropriate data sheet. Data validation will be conducted by MQAB using modified CLP data validation protocols.

8.3 Data Reduction, Validation, and Reporting of Volatile Organic Data

Volatile organic data will be reduced, and reported using procedures described in EPA's Compendium Method TO-14 and approved contractor laboratory procedures. Results will be reported on an appropriate data sheet. Data validation will be conducted by MQAB using modified CLP data validation protocols.

7.0 ANALYTICAL PROCEDURES

Analytical determinations will be made by contractor laboratory. Samples will be analyzed for metals and volatile and semi-volatile organic compounds. SVOC analysis will be TRC/DRI, metals and carbon will be analyzed by Radian Corp. and VOCs will be handled under a national contract coordinated out of QAQPS/RTP. The Analytical Procedures for each are described in Attachment X.

6.0 CALIBRATION PROCEDURES and FREQUENCY

6.1 Calibration Procedures and Frequency for Metal Hi-Vol Samplers

The Calibration procedure is given in 40 CFR 50, Appendix B, Section 9.0 and Section 2.2.2 of Volume II of the QA Handbook (Attachment VIII). The samplers will be calibrated upon receipt and recalibrated as follows: (1) after motor maintenance; (2) anytime the flow rate device is repaired or replaced; and, (3) anytime the difference between the sample flow rate and a one point audit deviates more than 7 percent. Calibration data will be recorded on a sampler calibration worksheet (Figure XI).

6.2 Calibration Procedures and Frequency for Canister Samplers

The calibration Procedure is discussed in EPA Compendium Method TO-14. The mass flow controller will be calibrated once every six months during the Study. A two point calibration will be used for the low and high side of the desired sampling rate. Calibration data will be recorded on an appropriate form (Figure XII).

6.3 Calibration Procedures and Frequency for PS-1 PuF Samplers

The calibration procedure is discussed in EPA Compendium Method TO-13 (Attachment VII). The sampler will be calibrated at the maximum voltage setting of the voltage variator. The quartz filter and PuF plug will be in the Dual Sampling Module during calibration. The samplers will be calibrated upon receipt; after major repairs or maintenance; whenever any audit point deviates from the calibration curve by more than 7%; and when a different sample collection media, other than that which the sampler was originally calibrated to, will be used for sampling. Calibration data will be recorded on an appropriate form (Figure XIII).

5.0 SAMPLE CUSTODY

5.1 **Sample Control and Custody will follow procedures specified in CDO's Procedures Manual, Section 4, Part VII, January 1987 (Attachment VI). Chain-of-Custody will be documented with Region 5's Chain-of-Custody form (Figure VIII) for all samples.**

After the VOC sample is collected, the canister valve will be closed and sealed with a "Custody Seal" (Figure IX), an identification tag will be attached to the canister, and the canister will then be shipped, via overnight courier, with the Chain-of-Custody form to a contractor laboratory for analysis.

Filters used for metal sampling will be removed from the samplers per Paragraph 4.3 of Section 2.2.4 of Volume II QA Handbook. Data required on the outside of the envelope will be entered. The Region 5 Custody Seal will be affixed to the envelope and the filter number will be written on the outside of the envelope. Each set of sample envelopes will be placed in a large envelope with the Chain-of-Custody record. Samples will be shipped, via overnight courier, to a contractor laboratory.

Filters and adsorbent cartridges used to collect semi-volatile organic samples will be removed from the PS-1 PuF sampler with forceps and clean-gloved hands, and immediately placed in an airtight labelled screw-capped container (wide-mouth, preferably glass with Teflon seal or other noncontaminating seal). A Region 5 Custody Seal will be affixed to the cap. The sample along with the Chain-of-Custody record, will be shipped, via overnight courier, to a contractor laboratory.

A laboratory analysis request form will accompany each set of samples shipped to the contractor laboratory (Figure X).

Samples will be collected on high purity quartz fiber filters with Graseby-Andersen High-volume Samplers, Model GMWL2000H. Their operation is described on Pages 12 and 13 of the high-volume sampler operator's manual (Attachment V).

Samples will be collected on an average of every 12 days at each site for a 24-hour period. The samplers will be automatically started and stopped with a Model GMW-800 six day timer/programmer (Attachment II) or by setting the Hi-Vol timer for samplers without the Model GMW-800 Timer.

Flow readings will be recorded with Dixon recorders. The recorders are recording transducers, which are operated according to the instructions on Page 13 of the high-volume sampler operator's manual (Attachment V).

Field duplicates from a collocated monitor, will be obtained at Site "C" 10% of the time. The duplicates will be obtained utilizing the same sampling technique described above for the other Hi-Vol monitors. The sample time will be identical to its collocated sampler. Collocated samplers will be erected within 2-4 meters of each other.

4.3 **Determination of Semi-Volatile Organic Compounds from Ambient Air**

4.3.1 Applicability, Theory of Operation and Apparatus

The applicability, Theory of Operation and Apparatus are given in EPA's Compendium Method TO-13 - "Determination of Benzo(a)pyrene {B(a)P} and other Polynuclear Aromatic Hydrocarbons (PAHs) in Ambient Air using Gas Chromatographic (GC) and High Performance Liquid Chromatographic (HPLC) analysis" June 1988 (Attachment VII).

4.3.2 Sampling Procedure

[illegible] EPA's Compendium Method TO-13 (Attachment VII) Sampling data will be recorded on a field data sheet (Figure VII).

Samples will be collected with a General Metal Works (GMW), Model PS-1 Sampler. Its operation is described on Pages 2 and 3 of the Model PS-1 PuF Sampler Operation Manual (Attachment VII). The sampling media will be either polyurethane foam or a granular solid sorbent.

Samples will be collected on an average of every 12 days at each site for a 24-hour period. The sample time, duration of sample, starting time, volume of air sampled, weather conditions (temperature, wind direction , humidity), and beginning and ending flow rates will be recorded. After collection of samples, they will be immediately placed in sealed containers and stored at 0°C.

Field duplicates, from collocated monitors, will be obtained at all sites 10% of the time. The duplicates will be obtained utilizing the same sampling technique described above for the other Model PS-1 PuF Sampler. The sample time will be identical to its collocated sampler. Collocated samplers will be erected within 1 meter of each other, but must be at least 2 meters from any obstacle to air flow.

4.0 SAMPLING PROCEDURES

4.1 Determination of Volatile Organic Compound in the Atmosphere (Canister Method)

4.1.1 Applicability

The applicability is given in the scope of EPA's Compendium Method TO-14. The Method TO-14 has been reproduced in Attachment I.

4.1.2 Theory of Operation

The Theory of Operation is given in EPA Compendium Method TO-14 (Attachment I)

4.1.3 Apparatus

Apparatus used for sampling and field measurements are prescribed in EPA Compendium Method TO-14.

4.1.4 Sampling Procedure

The sampling procedure is described in EPA's Compendium Method TO-14. The sampling equipment will consist of Anderson Volatile Organic Compound Canister Samplers (VOCCS), and 6-liter Summa® stainless steel canisters into which the sample is collected. Operating procedures for the Anderson Samplers are contained in CDO's Standard Operating Procedures for this Study (Attachment II). Field sampling and Meteorological data collected during the Study will be recorded on a VOCCS Sample Data Sheet (Attachment II).

Sampling will occur on an average of every twelve days at each site for a 24-hour period. Cleaned canisters are shipped to the site under vacuum from the contractor [illegible] After sampling, the final desired pressure in the canister shall be between 15-20 psig.

Field duplicates, from a collocated monitor, will be obtained at Site "C" 10% of the time. The duplicates will be obtained utilizing the same sampling technique described above for the other VOCCS monitors. The sample time will be identical to its collocated sampler. Collocated samplers will be erected within 1 meter of each other. All samples will be shipped by overnight courier to the contractor laboratory.

4.2 Determination of Metals in Suspended Particulate Matter Collected from Ambient Air

4.2.1 Applicability and Theory of Operation

The Applicability and Theory of Operation are given in reference method (40 CFR 50, Appendix G, Section 1.0). This reference method is written for lead in suspended particulate matter; however, it can be used for other metals since ultrasonication extraction with HNO_3/HCl will extract metals other than lead from ambient particulate matter (40 CFR 50 Appendix G, Section 1.4). Appendix G has been reproduced in Attachment III.

4.2.2 Apparatus

The apparatus used for sampling and field measurements are prescribed in 40 CFR 50, Appendix G, Sections 5.0 and 6.0 (Attachment III).

4.2.3 Sampling Procedure

The sampling procedure is given in 40 CFR 50, Appendix G, Section 5.1, which is the same procedure described for TSP in 40 CFR 50, Appendix B. The sampling procedure is described in greater detail in Sections 2.2.4 and 2.8.4 of the QA Handbook - Volume II (Attachment IV). Sampling data will be recorded on a High-Volume Sampler Field Data Sheet (Figure VII-A).

TABLE III

PRIMARY TARGET COMPOUNDS

METHOD	PRIMARY TARGET COMPOUND	OVERALL DETECTION LIMIT	ACTION LIMIT (ug/m3)
TO-13	Benzo (a) pyrene	.1pg/m^3	.000059
TO-14		(ug/m^3)	
	Benzene	.20	1.2
	1,3-Butadiene	4.4	.036
	Trichloroethylene	0.40	5.9
ICAP Metals	Arsenic	0.006	.0023
	Chromium (6)	0.006	.0083
	Cadmium	0.002	.0057

NOTE: 1(pg) picogram=10^{-6} micrograms (ug). Overall detection limits for VOCs were based on the GC/MS in full scan mode using a modified TO-14 procedure.

3.4 Data Completeness

Data completeness will be expressed as the percentage of data generated that is considered valid. The objective is to collect a sufficient quantity of usable data to obtain an adequately reliable representation of concentrations at each location. A data completeness of at least 90 percent will be used to allow for erratic or hard to predict events.

3.5 Representativeness

Project representatives will be achieved by sampling ambient air that are representative of the targeted area. This will be accomplished by using sampling methodologies amenable to VOCs, semi-volatile materials, and metals, appropriate design and siting of the monitoring network, and inclusion of all necessary quality control procedures and methods. Completion of monitoring in accordance with the description in this project proposal is considered to satisfy the objective of representativeness.

3.6 Comparability

Data comparability will be achieved by using the same collection procedures and analytical methods for all samples, and by requiring that all data generated for the project be reported in common units for comparison. Contaminant concentrations will be reported in micrograms per cubic meter (ug/m^3). Sample flow rates will be in cubic meters per minute (m^3/min), corrected to standard temperature and pressure. (See Table II)

3.0 Quality Assurance Objectives for Measurement Data in Terms of Precision, Accuracy, Completeness, Representativeness, and Comparability.

In order to evaluate whether the data to be obtained by this project are of acceptable quality, Data Quality Objectives (DQOs) for this project are given here. Specific Data Quality Indicators (DQIs) to be used in this project will include measures of data accuracy, precision, detection limits, completeness, representattiveness, and comparability. These DQOs are summarized in Table II. The following sections discuss each of these objectives individually.

3.1 Accuracy

For this project, accuracy is defined as the ratio, expressed as a percentage, of a measured value to a true or reference expressed as percent recovery based on the analysis of Performance Evaluation (PE) samples. Based on historical performance of similar sampling techniques, the DQO for accuracy will be within ± 20 percent for this VOC, Semi-Volatiles and Metals. (See Table II)

3.2 Precision

Precision is defined as a measure of agreement among individual replicate measurements of the same property. Precision of VOC, Semi-Volatiles and metals will be determined using duplicate (collocated) samplers and will be expressed as the Percent Relative Standard Deviation (%RSD). The DQOs for precision will be a %RSD less than or equal to 20 percent. (See Table II)

3.3 Detection and Action Limits

ATSDR did not recommend detection limits or action limits for any of the compounds being analyzed. Therefore, EPA selected detection limits based on past experience of detection limits reasonably obtained by the methods planned for use. EPA selected action limits to correspond to estimated cancer risks of 10^{-5}.

EPA, Region 5, will analyze for all compounds in TO-13 and TO-14, as agreed upon by ATSDR. Nevertheless, detection limits and action limits are being established for only a subset of these compounds. Satisfaction of these DQOs will be presumed to indicate that data quality for other similar compounds is also adequate. Conversely, failure to meet these DQOs will be presumed to indicate that data quality for other similar compounds is suspect. Table III presents the specific VOCs, semi-volatile materials, and metals for which quantitative DQOs are being established. This table further indicates the detection limits and the action limits which represent the DQOs for this project.

Action levels were provided by the EPA-Region 5 Office of Health and Environment Assessment. Note that these action levels are based on risk factors reflecting maximum likelihood estimates for benzene, arsenic, chromium, and cadmium, and reflecting 95 percent upper confidence limits for benzo(a)pyrene, butadiene, and trichloroethylene. A further adjustment was then made for benzo(a)pyrene and for chromium.

Conversely, for chromium, an adjustment is necessary to reflect the fact that the monitored parameter includes nonhazardous as well as hazardous material. Specifically, although the measurement method measures all forms of chromium, only the hexavalent form is known to be carcinogenic. As an approximation, it was assumed that 10 percent of total chromium is hexavalent. Consequently, the action level for total chromium was set at a level 10 times higher than a 10^{-5} risk level for hexavalent chromium.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The management, quality assurance, laboratory and field responsibilities are specified below. Figure VI presents the entire project organization. The final product from ESD will be a report that will discuss the sampling, analytical, and quality assurance (QA) procedures used in the Study as well as a summary of the results.

2.1 Management Responsibilities

2.1.1 US EPA, Region 5, Monitoring and Quality Assurance Branch - Willie H. Harris

The US EPA, Region 5, Monitoring and Quality Assurance Branch is responsible for all project activities including review and approval of QAPjP, final data review, and Preparation of Final Report.

2.2 Quality Assurance Responsibilities

2.2.1 US EPA, Region 5, Regional Quality Assurance Manager

The US EPA, Region 5, Regional Quality Assurance Manager is responsible for review and approval of the QAPjP. The Quality Assurance Section (QAS) is responsible for review of the sampling plan, and assisting in field equipment calibration.

2.2.2 Illinois Environmental Protection Agency

The Illinois Environmental Protection Agency (IEPA) is responsible for conducting performance audits of sampling activities (See IEPA QA SOP Attachment XI).

2.2.3 US EPA, Region 5, Central District Office

Staff from the US EPA, Region 5, Central District Office will be responsible for the following:

- Write a quality assurance project plan in concert with the MQAB
- Procure equipment necessary for field activities
- Site Set-up
- Calibrate, operate, and maintain all monitoring/sampling equipment
- Conduct internal quality control checks of sampling activities
- Collect samples for subsequent analysis and ship to laboratory
- Collect weather data from the IEPA (Wind speed and directions only)
- Prepare interim and final Field Reports

2.3 Laboratory Responsibilities

A contractor laboratory will be responsible for analysis of all samples, including field duplicates and blanks, laboratory QA activities, weighing of Hi-Vol filters, cleaning canisters, preparation of the analysis section of the QAPjP, and analysis report. Semi-Volatile analysis will be TRC/DRI, metals and carbon will be analyzed by Radian Corp. and VOCs will be handled under a national contract coordinated out of QAQPS/RTP.

2.4 Field Responsibilities

2.4.1 US EPA, Region 5, Central District Office

Personnel from the Central District Office will be responsible for the field work. This entails equipment calibration, equipment maintenance, site set-ups, and air sampling. A final field report will include CDO's responsibilities during the project, along with all field observations.

1.3 Sample Location and Equipment

Monitoring will be conducted at three sites within Southeast Chicago and at one background site as shown in the table below:

TABLE I

SAMPLE LOCATION and EQUIPMENT

SAMPLE LOCATION	EQUIPMENT
Site A - Carver High School (Altgeld Gardens area) See Figure II	1 - High volume sampler (Hi-Vol) 1 - Semi-volatile PUF Sampler (SVPS) 1 - Collocated SVPS 1 - Volatile Organic Canister Sampler (VOCs)
Site B - Bright Elementary School (Vicinity of Acme Steel Coke Plant) See Figure III	Same as Site A
Site C - Washington High School - (East of LTV Steel - Chicago Coke Plant) See Figure IV	1 - Hi-Vol 1 - Collocated Hi-Vol 1 - SVPS 1 - Collocated SVPS 1 - VOCs 1 - Collocated VOCs
Background Site - Calumet City, Department of Public Works (near Cook County CO Site) See Figure V	Same as Site A

1.4 Sample Collection and Scope

The field work involved in gathering the ambient samples will be completed by personnel from the Central District Office. The methodology will be TO-14 with GC/MS for volatiles, TO-13 with HPLC for semi-volatiles and Hi-vol with atomic absorption and ICAP for metals. Field duplicates will be obtained for QA/QC purposes. There will be one duplicate at one site 10% of the time for volatiles and metals, and one duplicate at all sites 10% of the time for semi-volatiles. Samples will be taken at each site on an average of every 12 days varying between 9 and 15 days. Samples will be picked up from the sites Monday thru Friday. Weather data will be obtained from the Illinois Environmental Protection Agency and sent to EPA's MQAB. Following collection of samples, filters, sorbents and canisters will be delivered to the contract laboratory using CDO Chain-of-Custody procedures.

1.0 PROJECT DESCRIPTION

1.1 Introduction and Background

A variety of studies have identified the Southeast Chicago area (Figure 1) as an area subject to potentially high health risks from environmental exposure to environmental contaminants. In addition to a variety of monitoring studies, a comprehensive risk assessment, performed by Region 5 in 1989, evaluated a broad range of source types emitting a broad range of air pollutants. This study, documented in a September 1989 report entitled Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southeast Chicago, concludes that air pollution in this area may cause relatively high cancer risks. This study further identified subareas with particularly high risks, and identified source types of particular concern. The source type causing the greatest portion of these risks was coke ovens.

Following completion of this study, the citizens of the area petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct a health assessment for this area, to evaluate further whether exposure to environmental contaminants, especially air pollutants, was a probable cause of adverse health impacts to residents of the area. ATSDR in turn has requested that EPA conduct air pollution monitoring in this area which would support such a health assessment. This Southeast Chicago monitoring project is being conducted in response to ATSDR's request.

1.2 Project Objectives

The purpose of this project is to provide concentration data with which to perform a health assessment for residents in the Southeast Chicago area.

The focus of the health assessment will be on areas subject to the greatest potential for adverse impacts due to environmental contaminants. Consequently, this monitoring project is designed in accordance with the results of the 1989 Southeast Chicago risk assessment conducted by Region 5 along with other available information. For example, two of the proposed monitoring sites are in the immediate vicinity of the two coke plants in the area. (A third site is in a relatively high population neighborhood exposure location, and a fourth site is a background site.) As another example, the compounds that EPA has selected for tracking the quality of data collected in this project are compounds identified in the 1989 study as potentially causing particularly significant health risks. In these ways, the monitoring project is intended to provide the best reasonably achievable data base for evaluating the greatest potential health impacts of exposure to air pollutants in the Southeast Chicago area.

TABLE OF CONTENTS

SOUTHEAST CHICAGO AIR TOXICS STUDY

SEPTEMBER 1993

Approved by: ______________________ Date: 5/4/94
Director, Environmental Sciences Division

Approved by: Willie H. Harris Date: 5/4/94
US EPA, Region 5, Regional Quality
Assurance Manager

Approved by: ______________________ Date: 5/4/94
US EPA, Region 5
Chief, Central District Office

QUALITY ASSURANCE PROJECT PLAN

SOUTHEAST CHICAGO AIR

TOXICS STUDY

Prepared by: US EPA, REGION 5, ENVIRONMENTAL SCIENCES DIVISION
MONITORING & QUALITY ASSURANCE BRANCH
CENTRAL DISTRICT OFFICE

APPENDIX D. S.E. Chicago Study Quality Assurance Project Plan.

Round/Batch Number	Sample Collection Date
28	March 18, 1995
29	March 22, 1995
30	April 6, 1995
31	April, 26, 1995

<u>Round/Batch Number</u>	<u>Sample Collection Date</u>
3	June 15, 1994
4	June 28, 1994
5	July 6, 1994
6	July 13, 1994
7	July 21, 1994
8	July 29, 1994
9	August 4, 1994
10	August 10, 1994
11	August 23, 1994
12	August 31, 1994
13	September 7, 1994
14	September 16, 1994
15	September 26, 1994
16	October 4, 1994
17	October 28, 1994
18	November 4, 1994
19	November 28, 1994
20	December 20, 1994
21	December 28, 1994
22	January 5, 1995
23	January 12, 1995
24	January 21, 1995
25	February 8, 1995
26	February 15, 1995
27	February 23, 1995

APPENDIX B. Measured Air Toxics Concentrations.

The following tables are taken from the laboratory data reports for semi-volatile organics, volatile organics and metals. Associated with each report are the data qualifier definitions. For the semi-volatile organic concentrations, B represents a compound that was less than 5 times the blank value, J represents an estimated concentration due to a calibration not meeting the quality control criteria, U indicates a compound that did not match the standard mass spectrum, and N/A is not analyzed.

For the volatile organic compounds, U represents a compound that was analyzed for but not detected, J represents an estimated value for one or more of the following reasons (1: response of the recovery standard is < 50 % of the calibration standard; 2: the sample was not analyzed within 24 hrs of a valid calibration; 3: the sample was analyzed using a calibration that did not meet quality control specifications; 4: the sample was extracted outside of the specified holding time; 5: the response of the compound in the sample is below the lowest calibration standard; and 6: the response of the recovery standard is > 200 % of the calibration standard), UJ indicates that a compound was analyzed for but not detected and the sample quantitation limit listed is estimated for one of the following reasons (1: the response of the recovery standard is < 50 % of the nearest calibration standard; 2: the sample was not analyzed within 24 hrs of a valid calibration; 3: the sample was analyzed using a calibration that did not meet the quality control specifications; and 4: the sample was extracted outside of the holding time), and R indicates that the data result is not usable for one of the following reasons (1: the response of the recovery standard was below 10 % of the nearest calibration standard and the analite was not detected; and 2: the sample was not extracted within fourteen days of sample collection and the analyte was not detected).

Data qualifiers for the metals reports include: U indicates that the analite was analyzed but not detected and the sample quantitation limit is listed; J indicates an estimated result due to blank contamination (less than 5 times the amount in any blank), poor precision (analysis falls outside the appropriate control limit); low bias (recovery is less than 80 %); or high bias (recovery is greater than 120 %); UJ results are estimated due to an elevated detection limit, and R represents data that is unusable. The following table links the round/batch number with the sample collection date for the metals data.

Round/Batch Number	Sample Collection Date
1	May 12, 1994
2	May 25, 1994

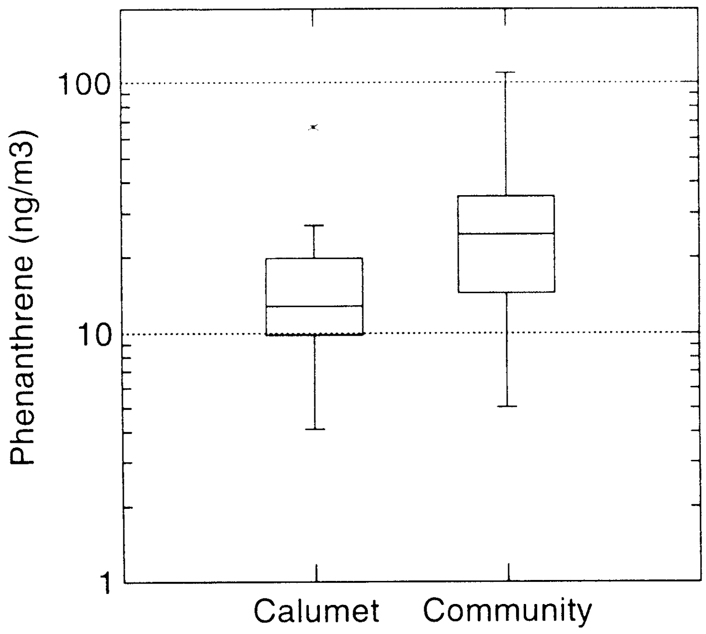

Figure 72 Distribution of Phenanthrene Concentrations.

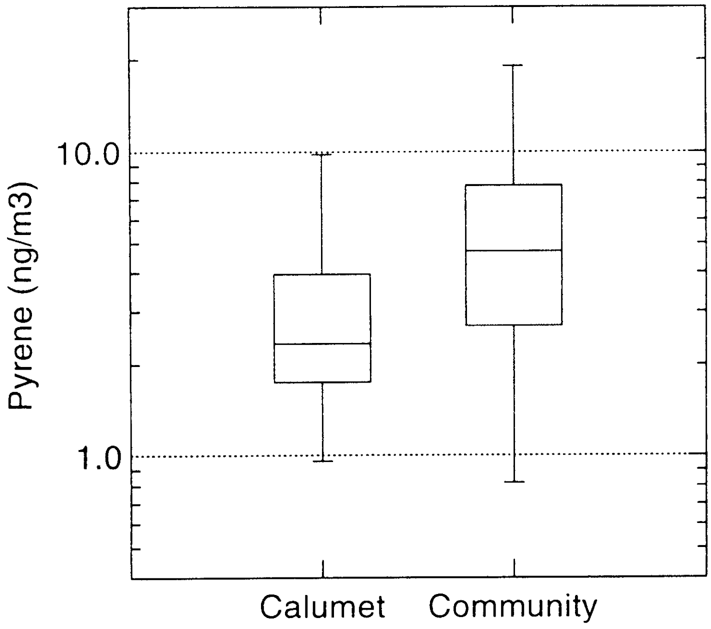

Figure 73 Distribution of Pyrene Concentrations.

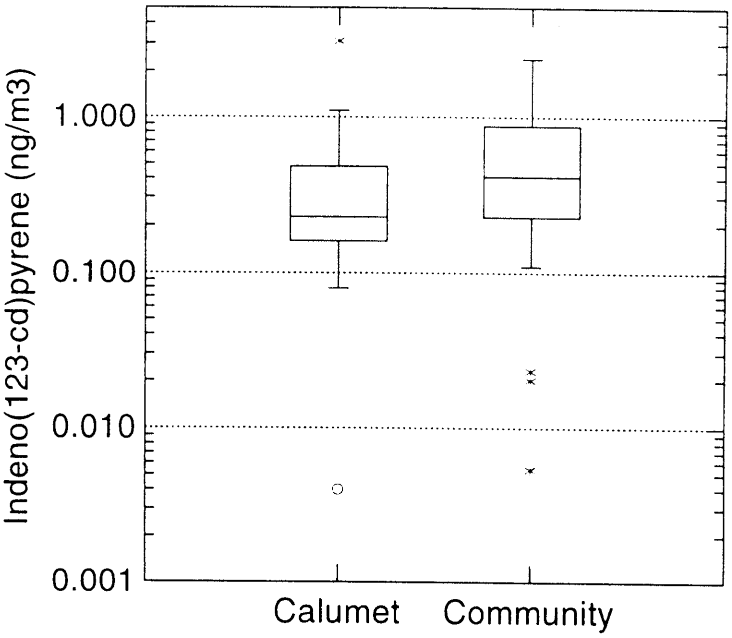

Figure 70 Distribution of Indeno(123-cd)pyrene Concentrations.

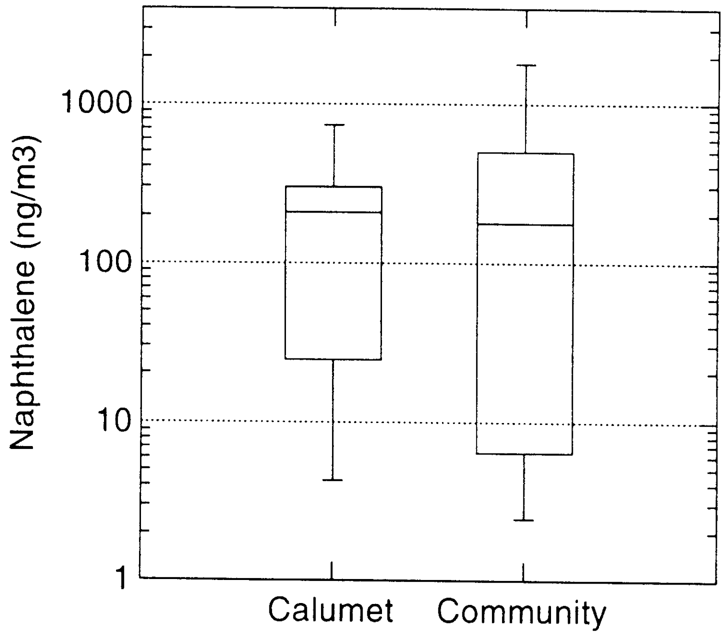

Figure 71 Distribution of Naphthalene Concentrations.

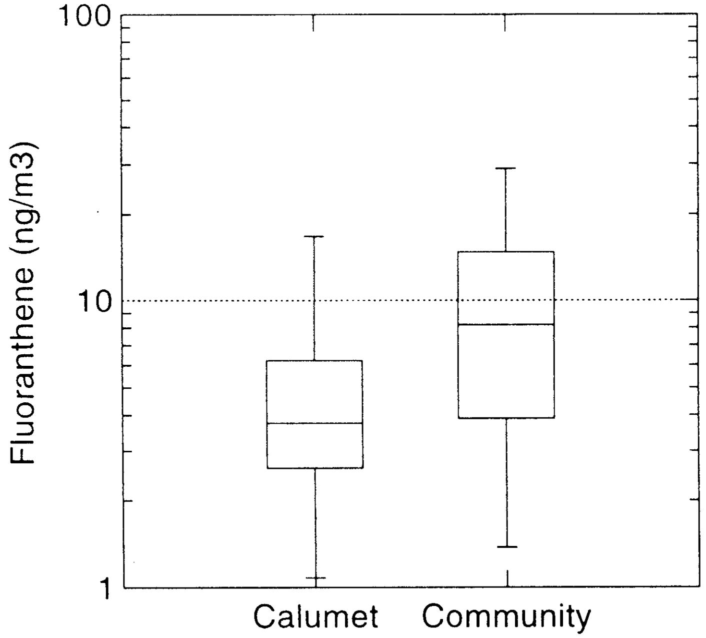

Figure 68 Distribution of Fluoranthene Concentrations.

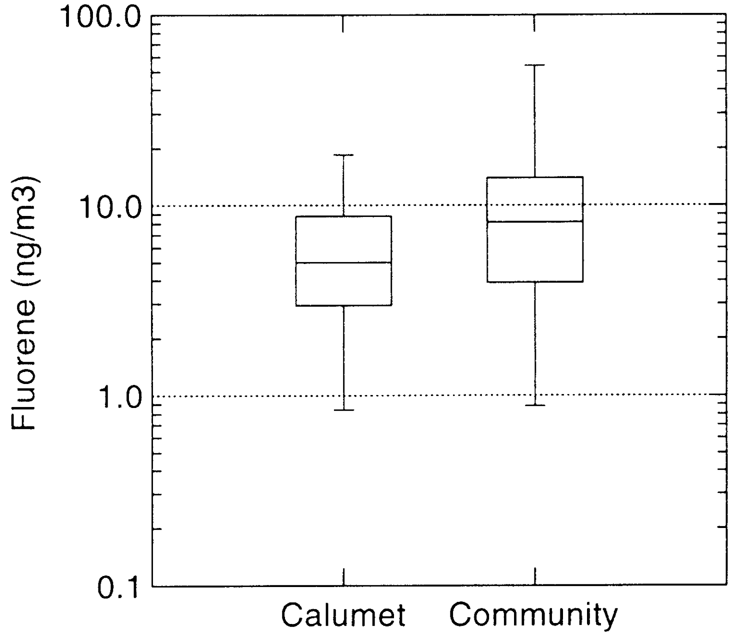

Figure 69 Distribution of Fluorene Concentrations.

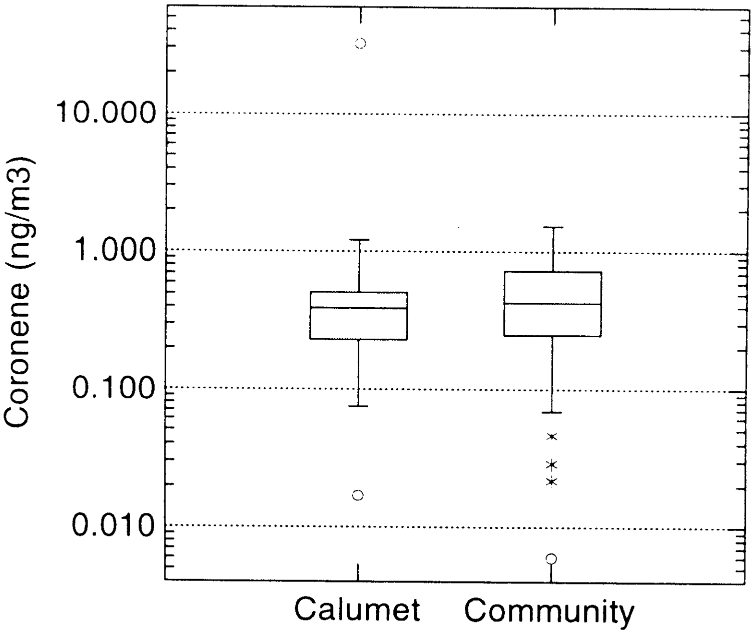

Figure 66 Distribution of Coronene Concentrations.

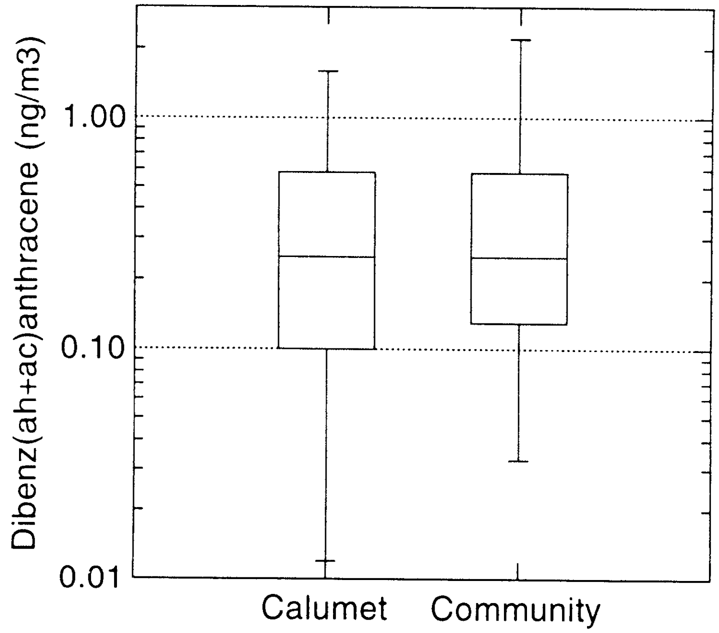

Figure 67 Distribution of Dibenz(ah+ac)anthracene Concentrations.

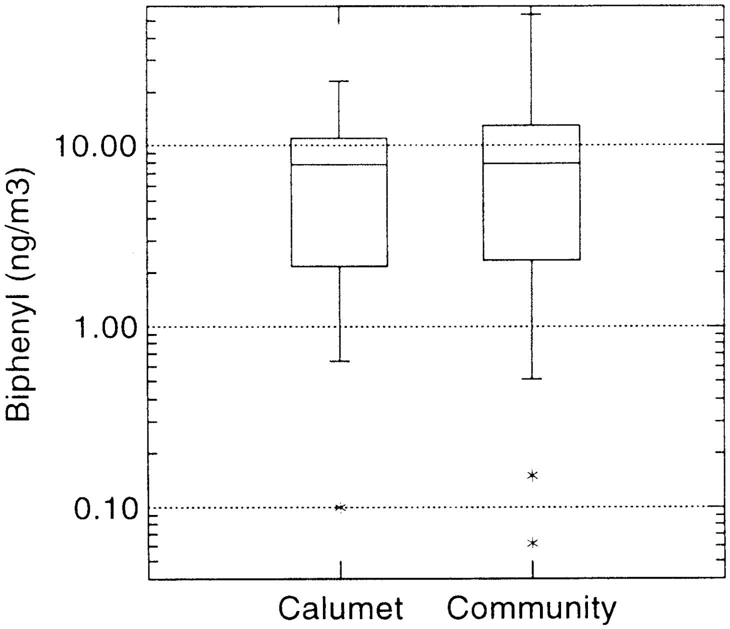

Figure 64 Distribution of Biphenyl Concentrations.

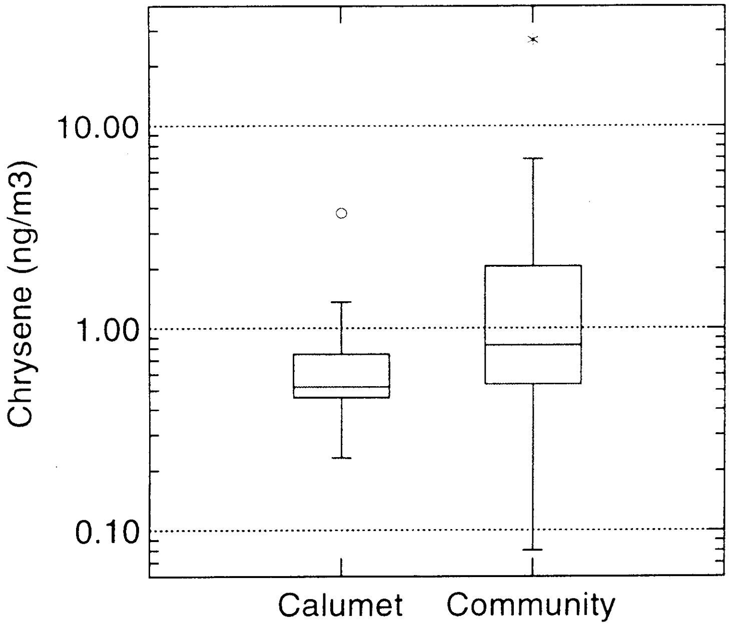

Figure 65 Distribution of Chrysene Concentrations.

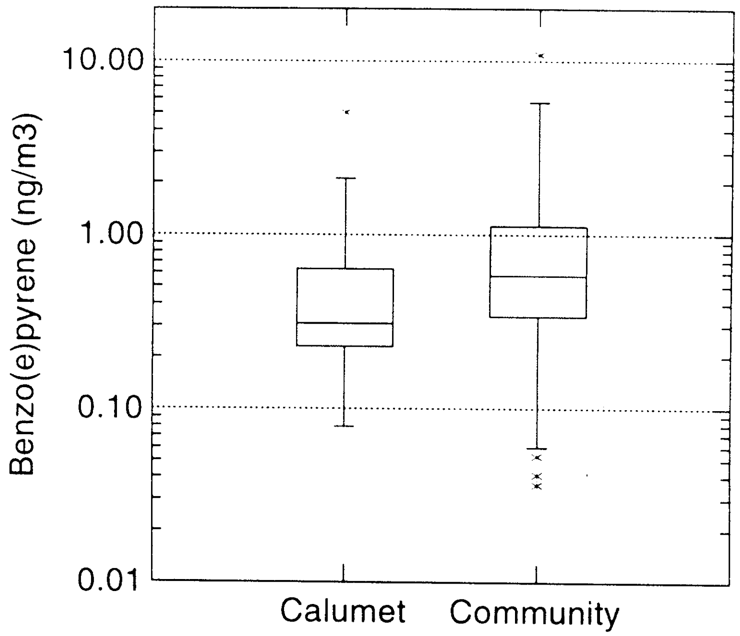

Figure 62 Distribution of Benzo(e)pyrene Concentrations.

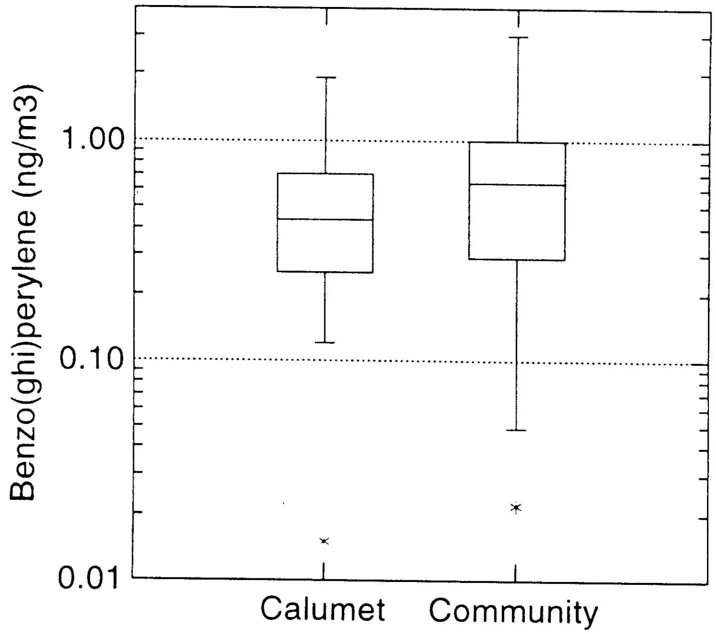

Figure 63 Distribution of Benzo(ghi)perylene Concentrations.

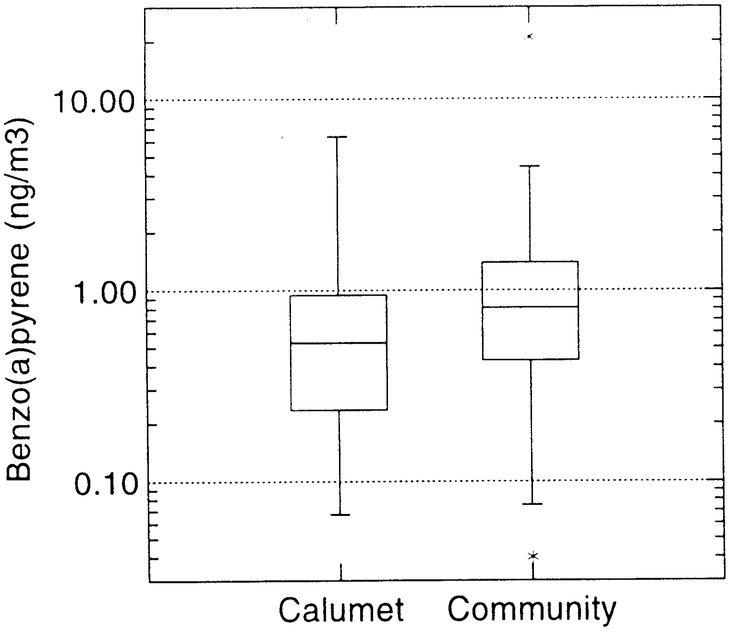

Figure 60 Distribution of Benzo(a)pyrene Concentrations.

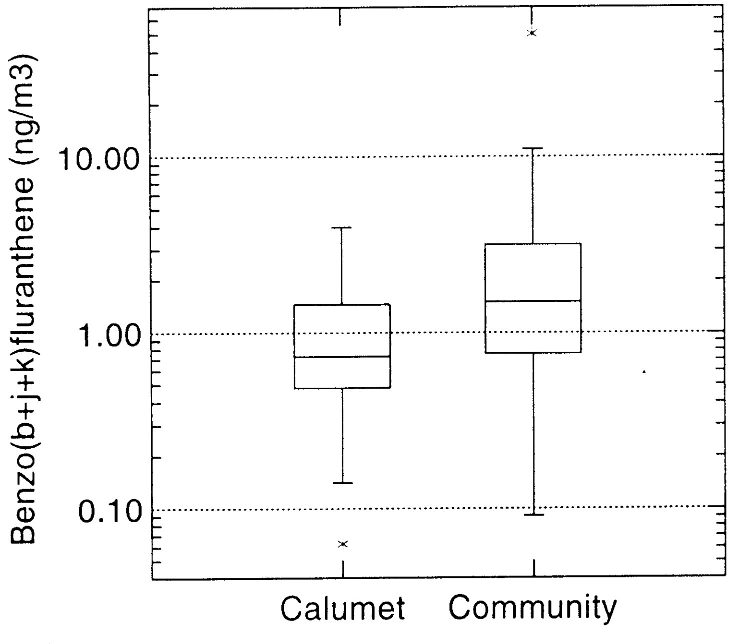

Figure 61 Distribution of Benzo(b+j+k)flouranthene Concentrations.

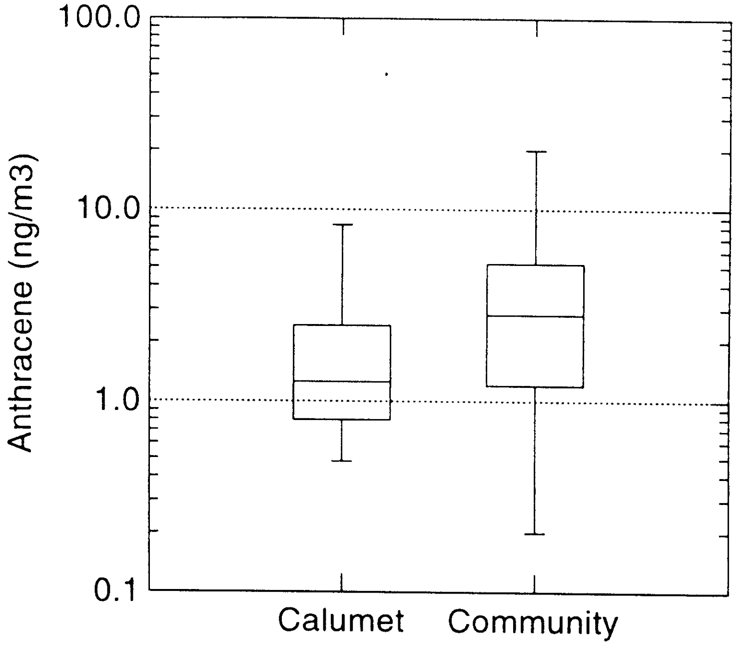

Figure 58 Distribution of Anthracene Concentrations.

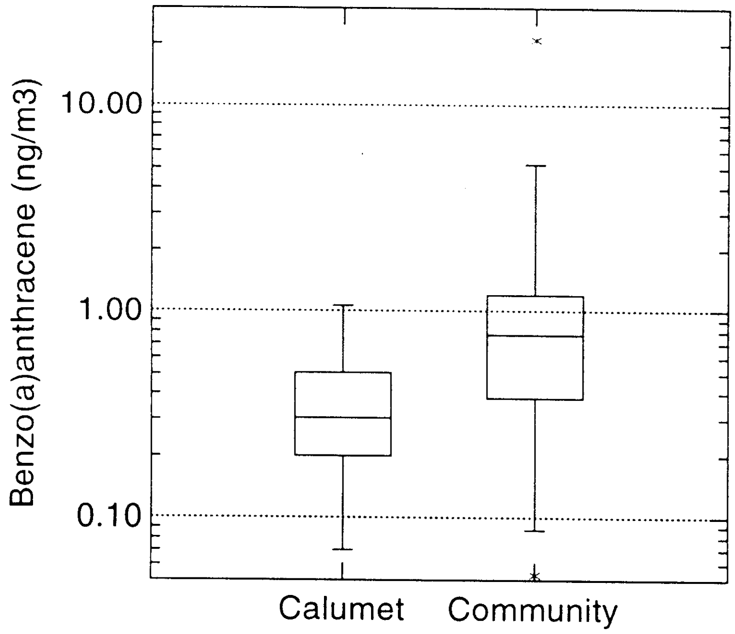

Figure 59 Distribution of Benzo(a)anthracene Concentrations.

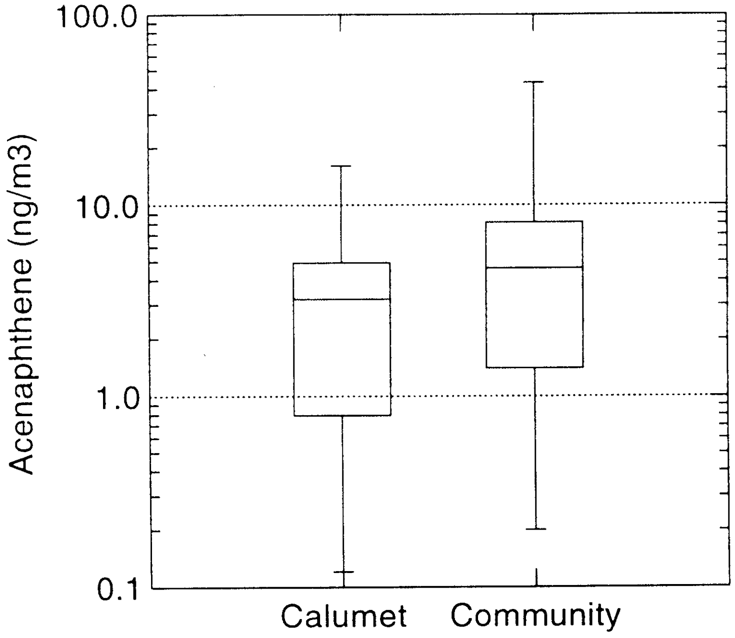

Figure 56 Distribution of Acenaphthene Concentrations.

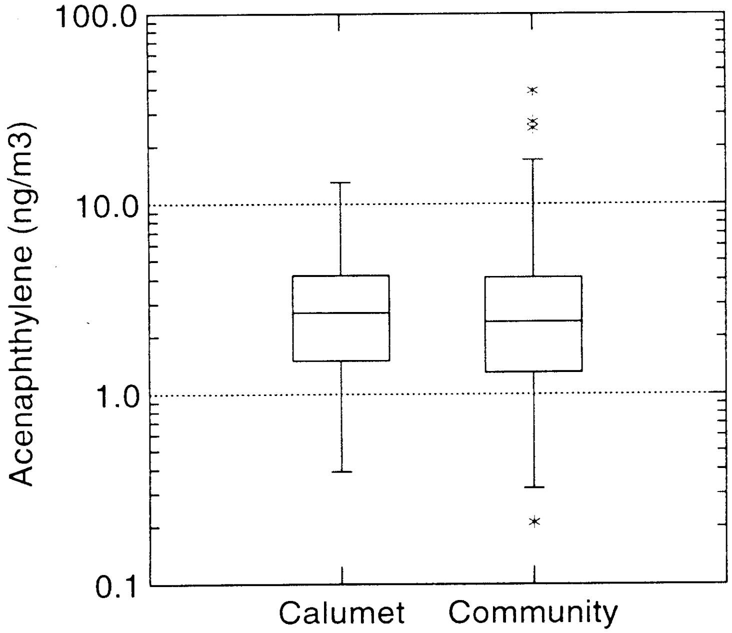

Figure 57 Distribution of Acenaphthylene Concentrations.

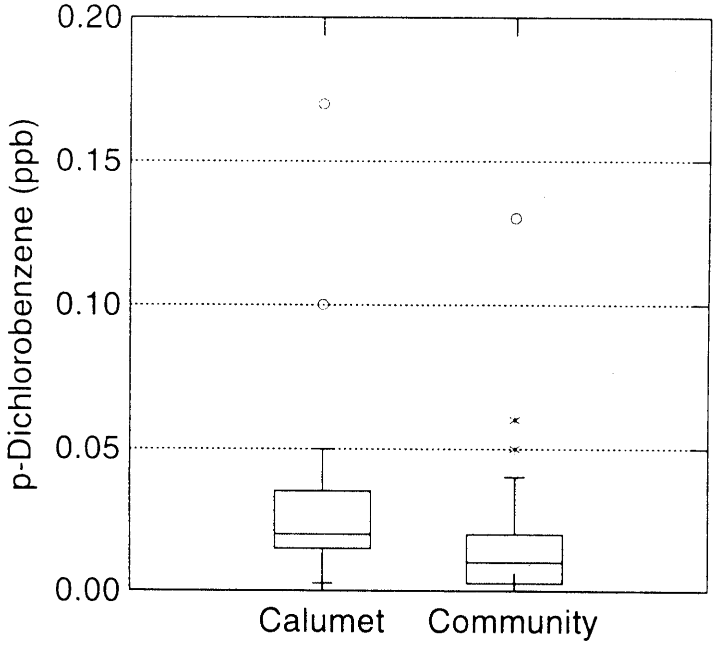

Figure 55 Distribution of p-Dichlorobenzene Concentrations.

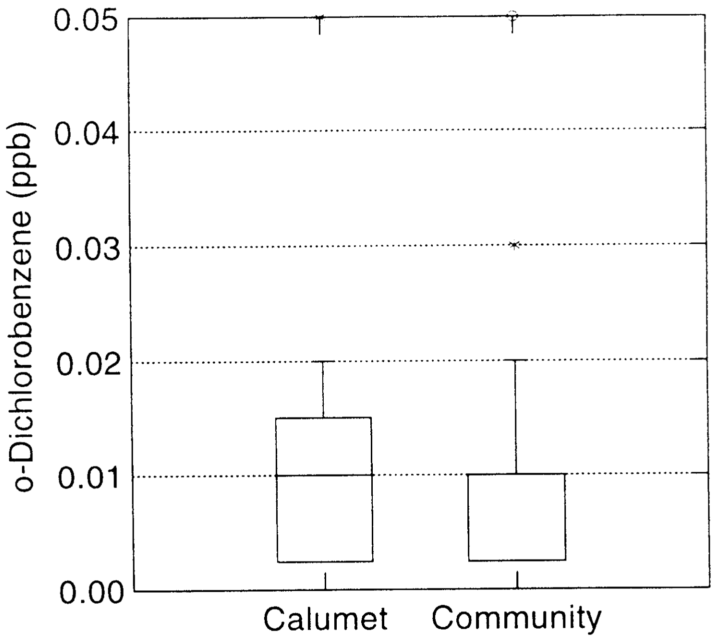

Figure 53 Distribution of o-Dichlorobenzene Concentrations.

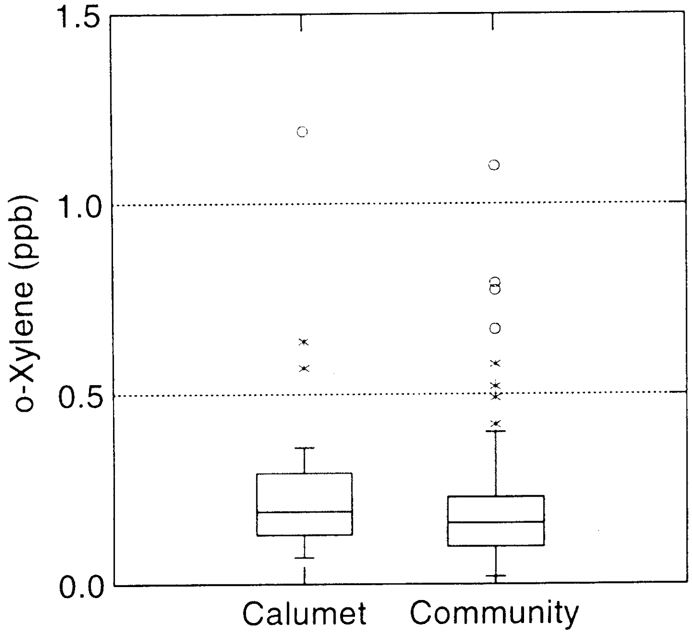

Figure 54 Distribution of o-Xylene Concentrations.

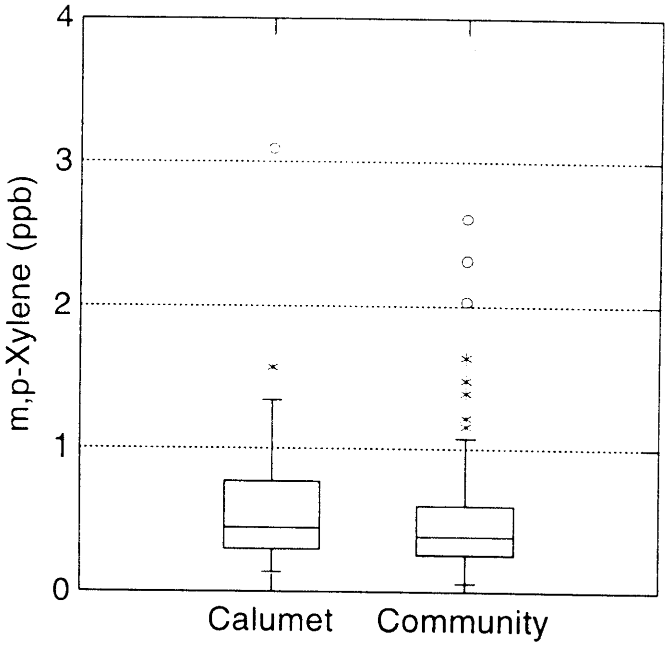

Figure 51 Distribution of m,p-Xylene Concentrations.

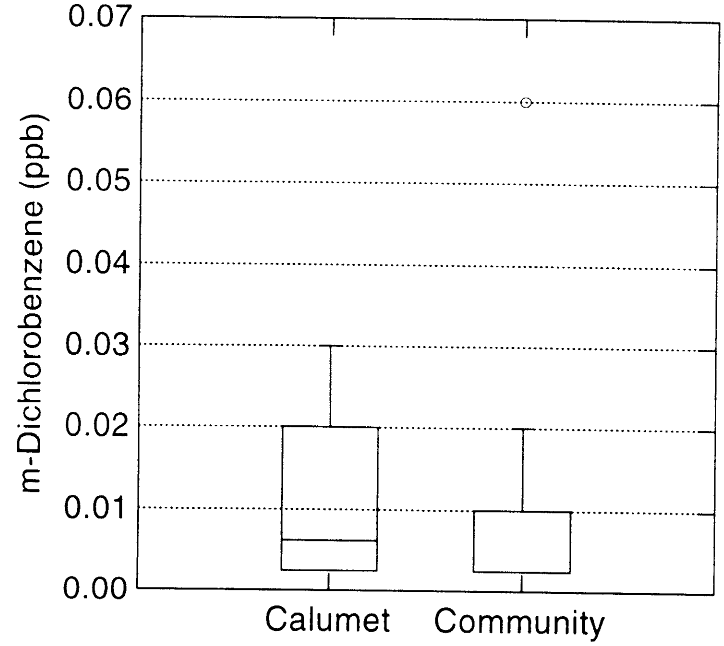

Figure 52 Distribution of m-Dichlorobenzene Concentrations.

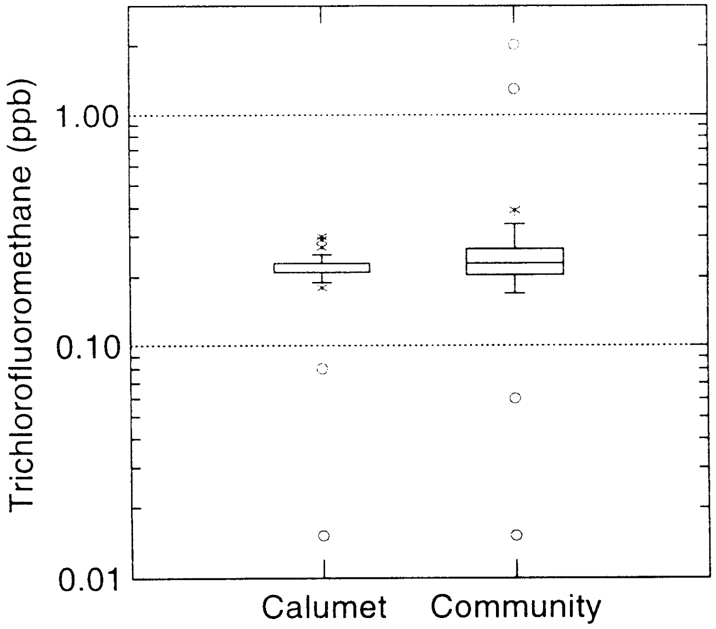

Figure 49 Distribution of Trichlorofluoromethane Concentrations.

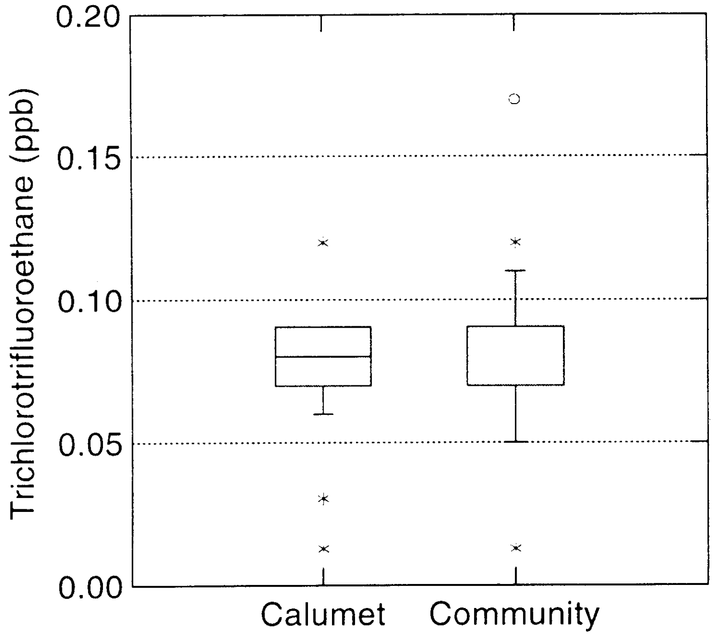

Figure 50 Distribution of Trichlorotrifluoroethane Concentrations.

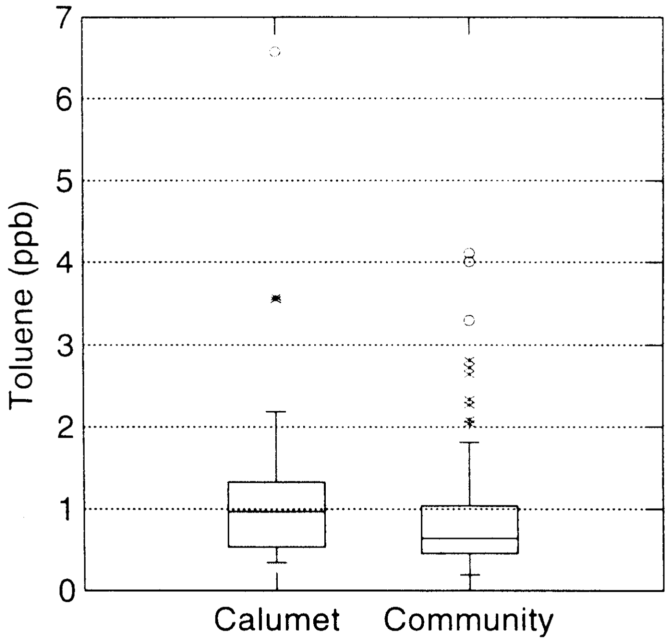

Figure 47 Distribution of Toluene Concentrations.

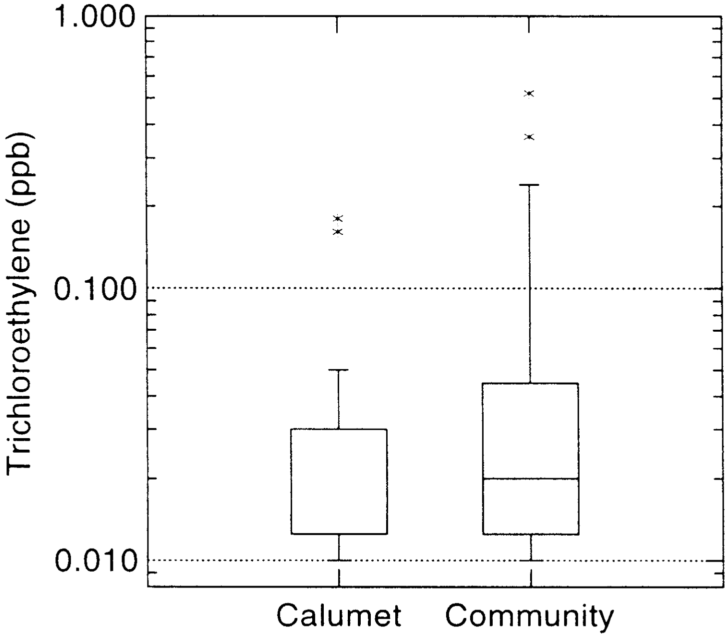

Figure 48 Distribution of Trichloroethylene Concentrations.

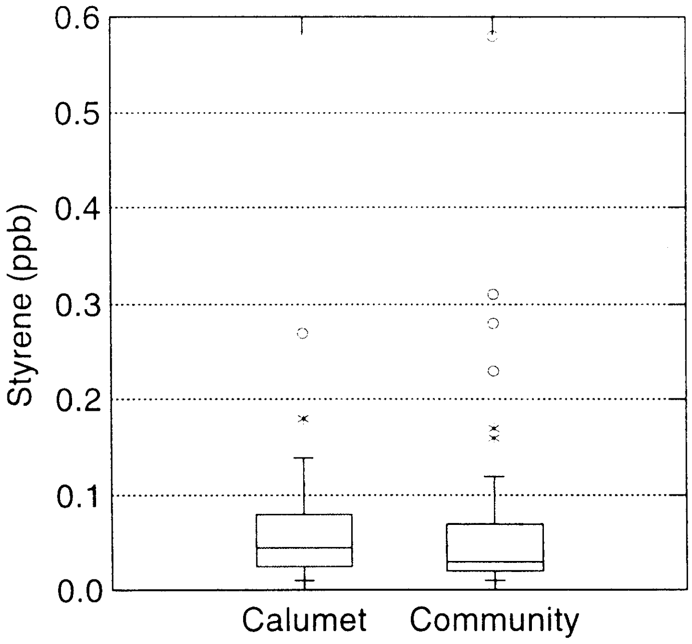

Figure 45 Distribution of Styrene Concentrations.

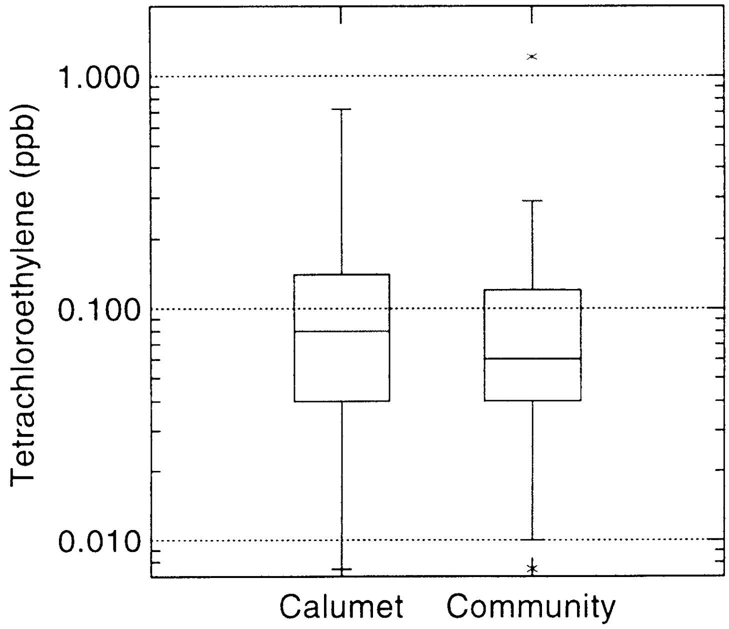

Figure 46 Distribution of Tetrachloroethylene Concentrations.

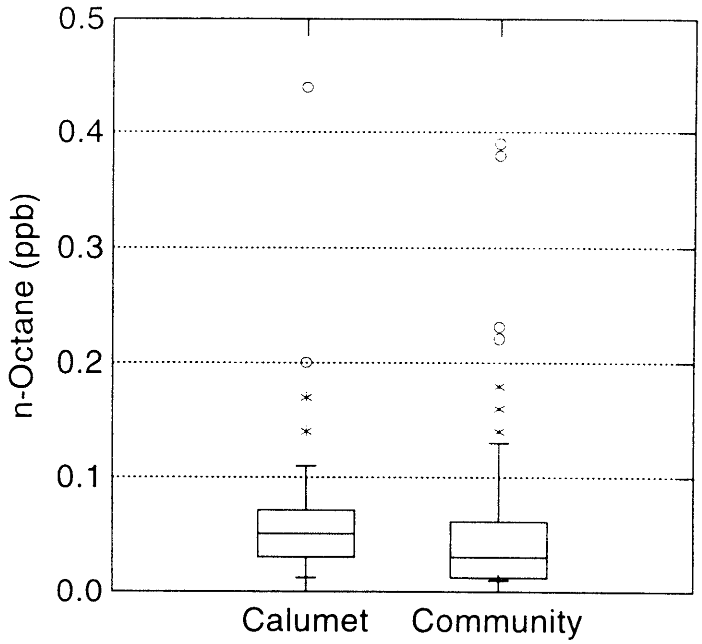

Figure 43 Distribution of n-Octane.

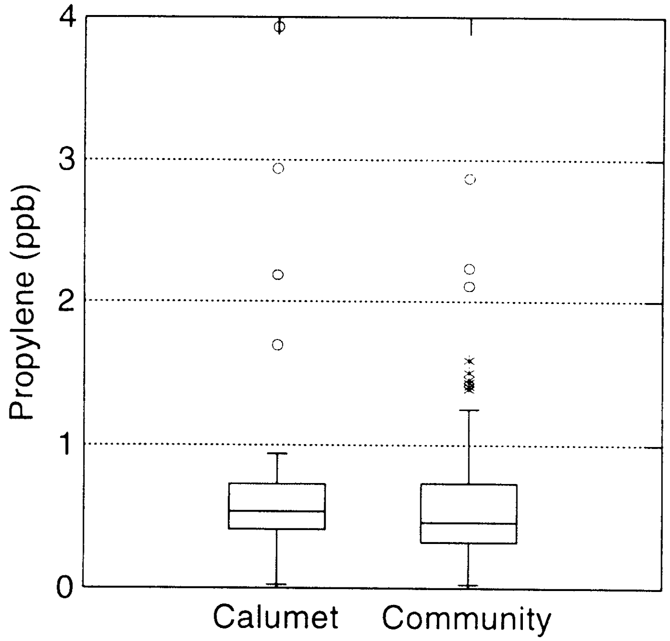

Figure 44 Distribution of Propylene Concentrations.

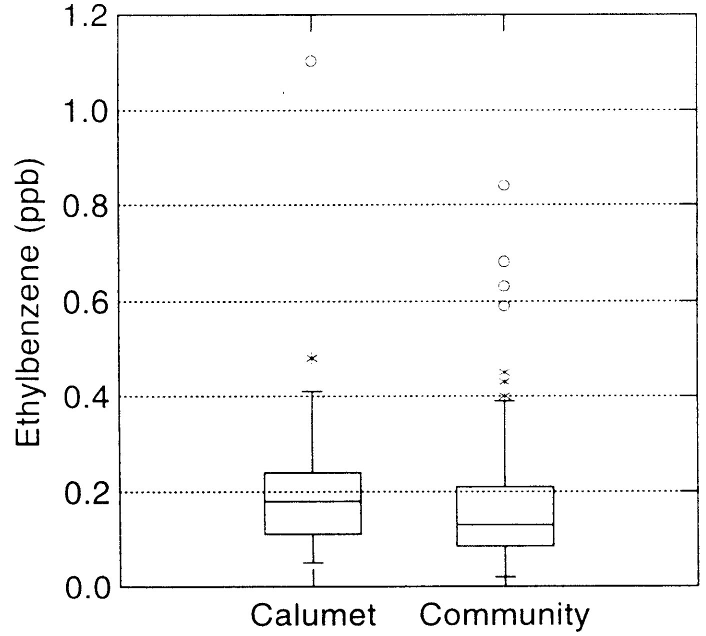

Figure 41 Distribution of Ethylbenzene.

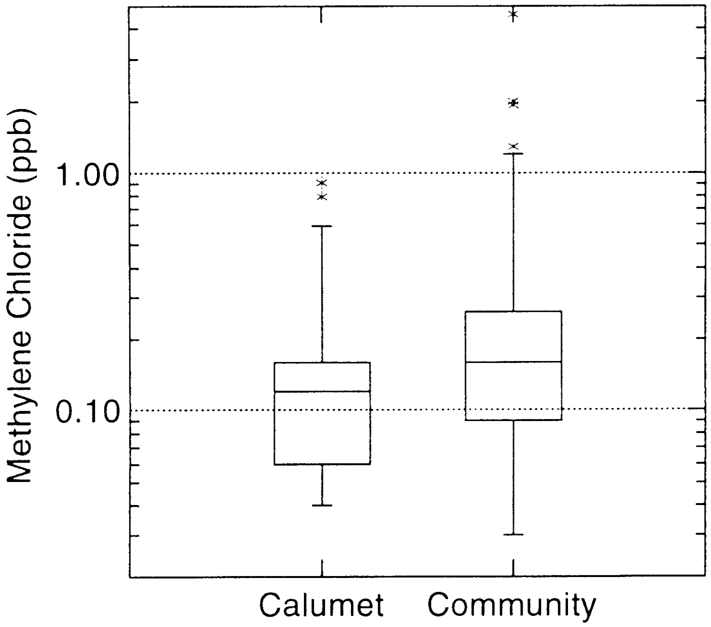

Figure 42 Distribution of Methylene Chloride.

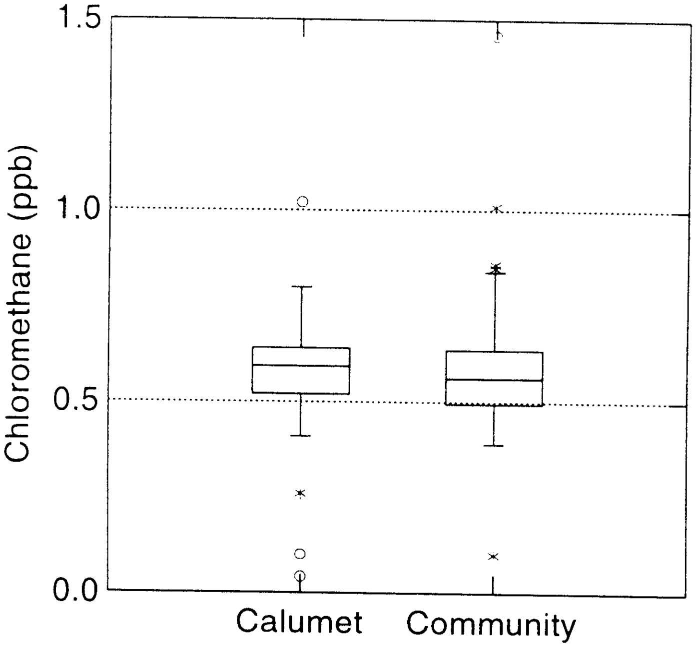

Figure 39 Distribution of Chloromethane.

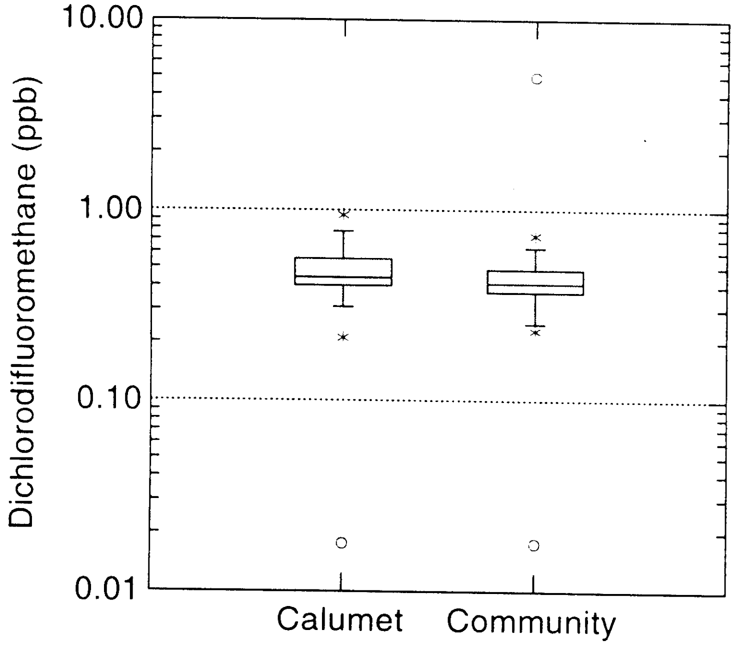

Figure 40 Distribution of Dichlorodifluoromethane.

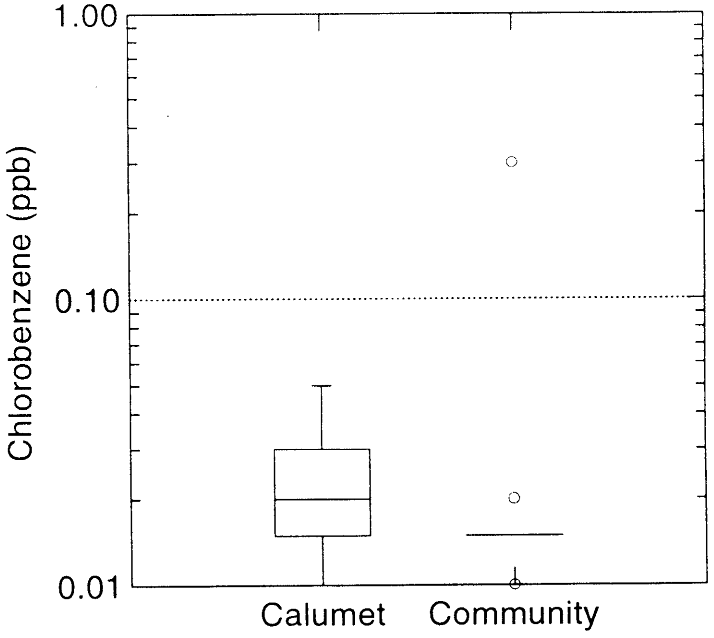

Figure 37 Distribution of Chlorobenzene.

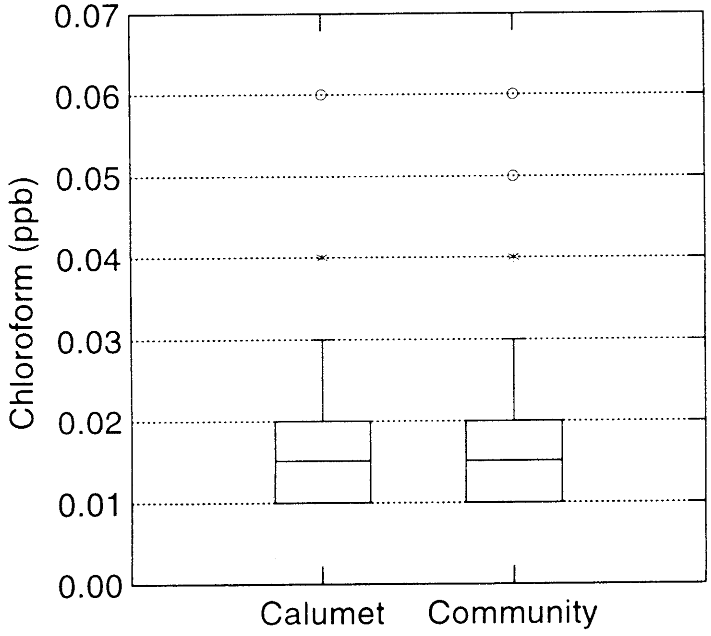

Figure 38 Distribution of Chloroform.

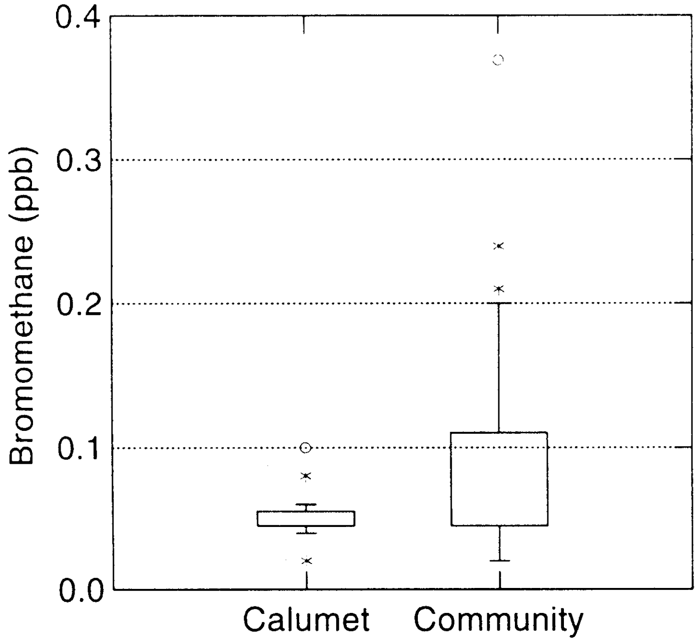

Figure 35 Distribution of Bromomethane.

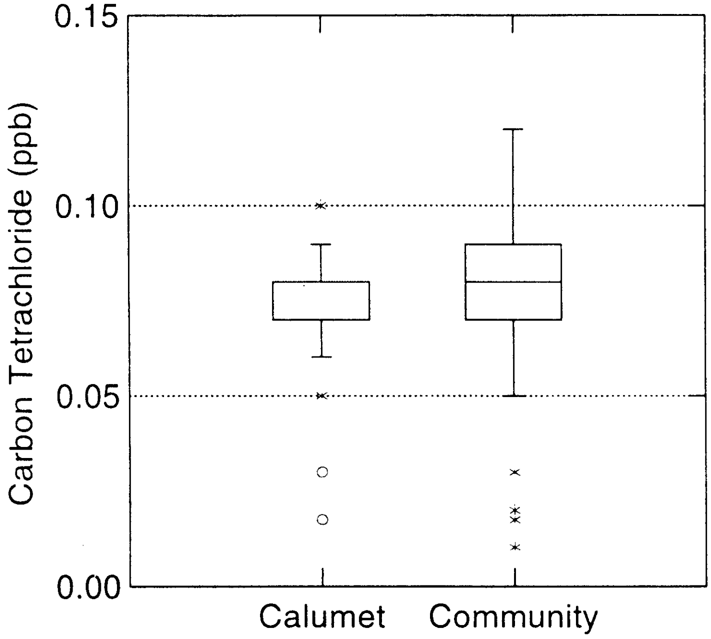

Figure 36 Distribution of Carbon Tetrachloride.

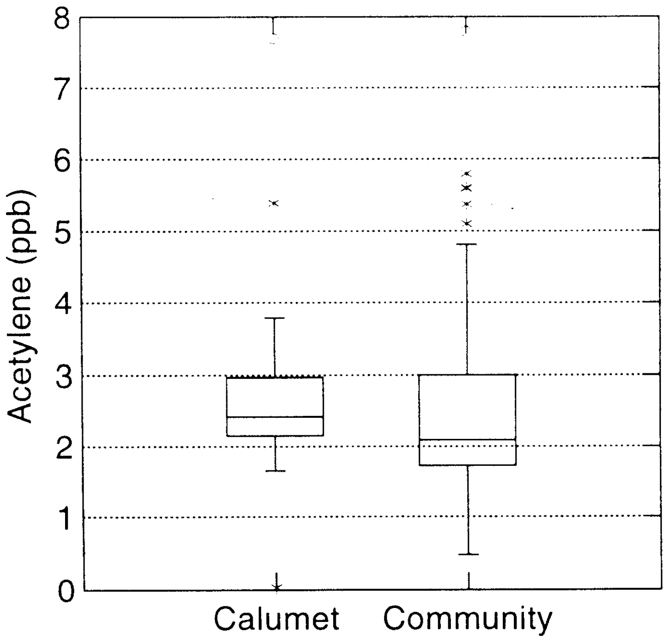

Figure 33 Distribution of Acetylene.

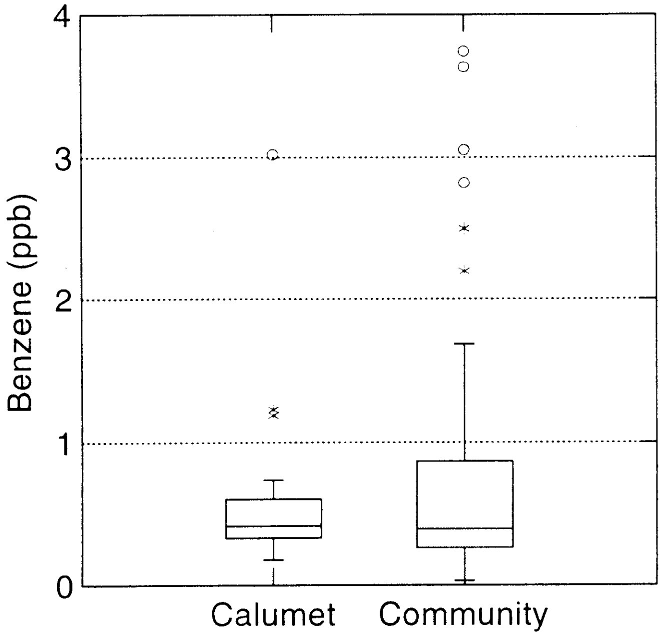

Figure 34 Distribution of Benzene.

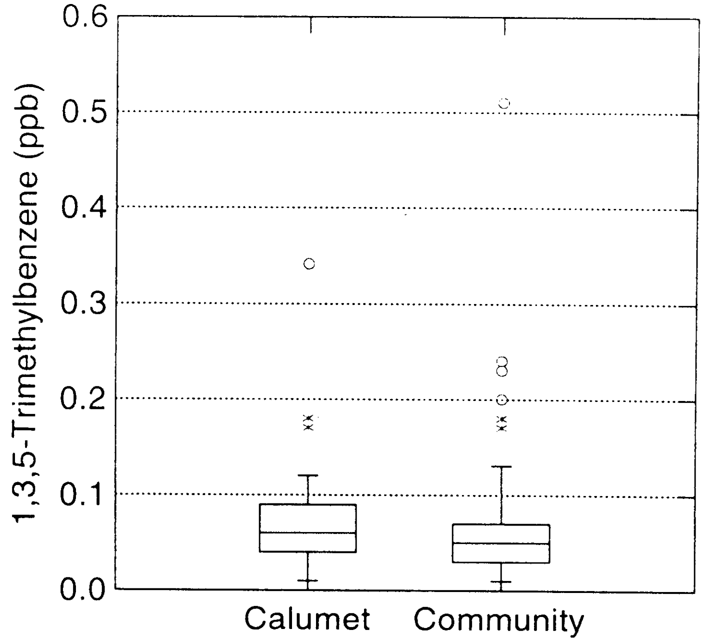

Figure 31 Distribution of 1,3,5-Trimethylbenzene.

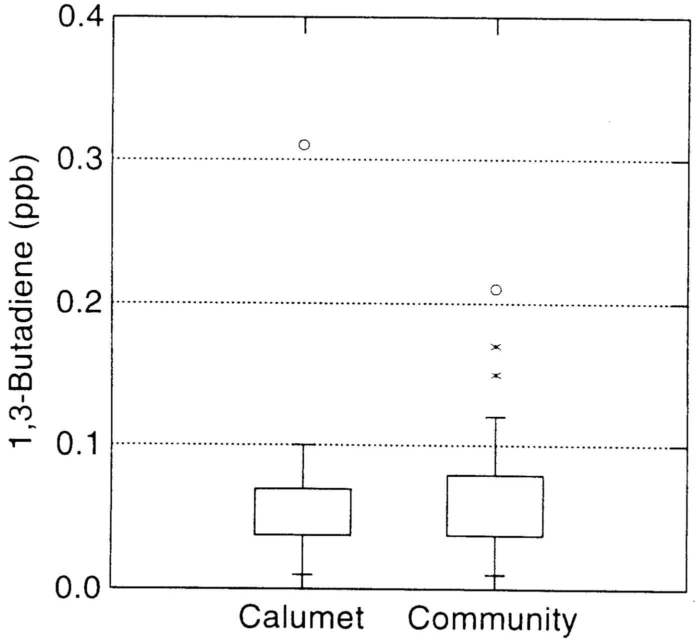

Figure 32 Distribution of 1,3-Butadiene.

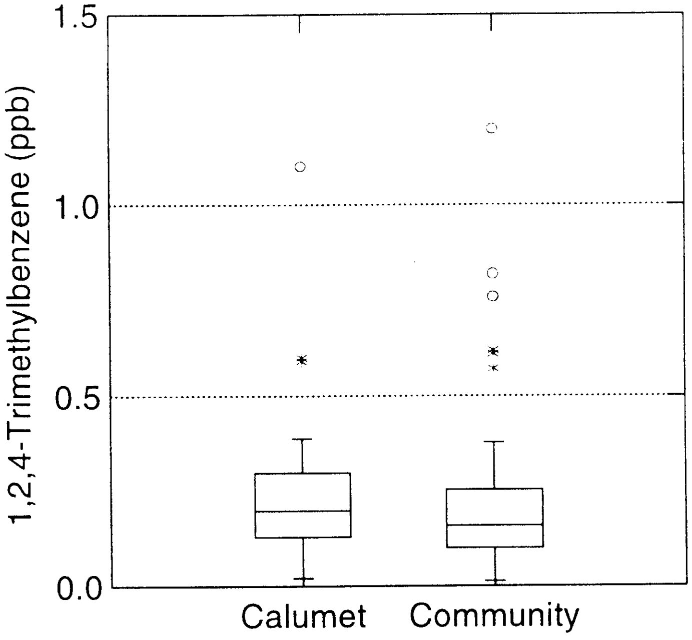

Figure 29 Distribution of 1,2,4-Trimethylbenzene.

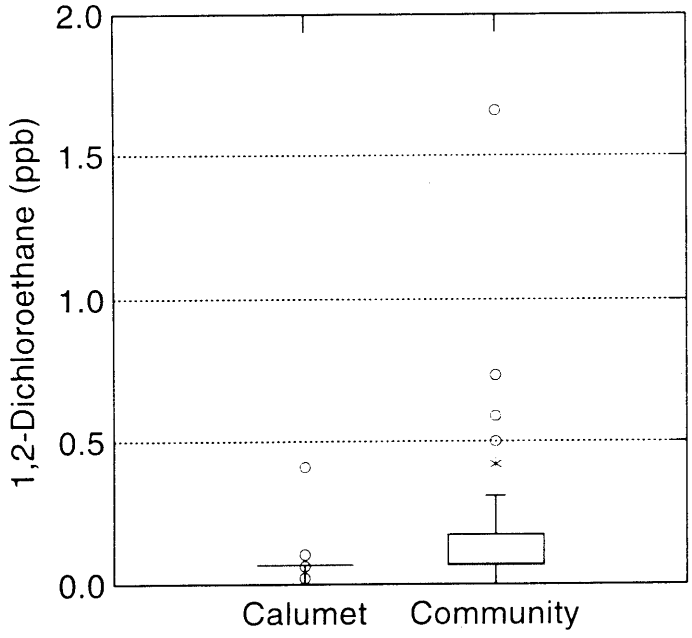

Figure 30 Distribution of 1,2-Dichloroethane.

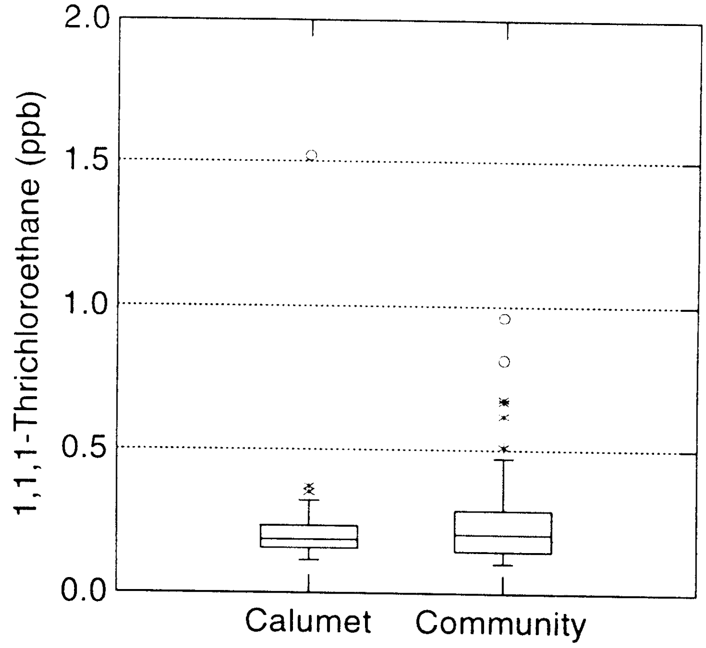

Figure 27 Distribution of 1,1,1-Trichloroethane Concentrations.

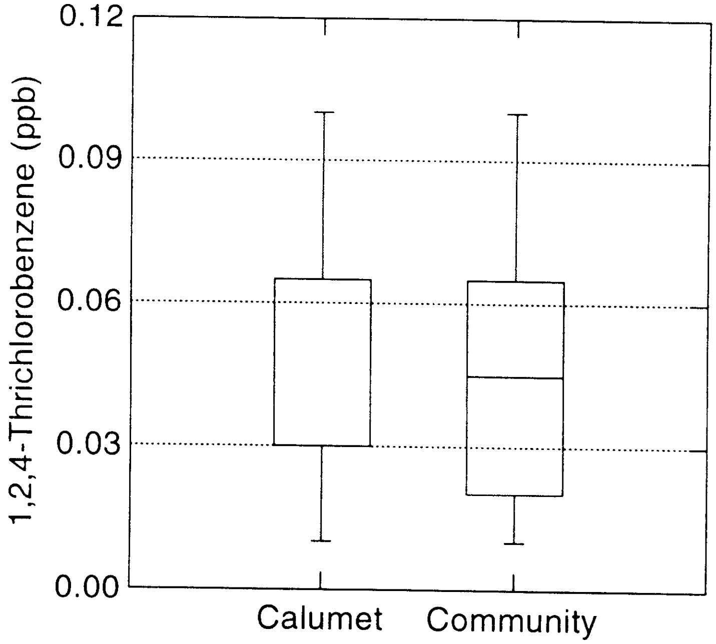

Figure 28 Distribution of 1,2,4-Trichlorobenzene.

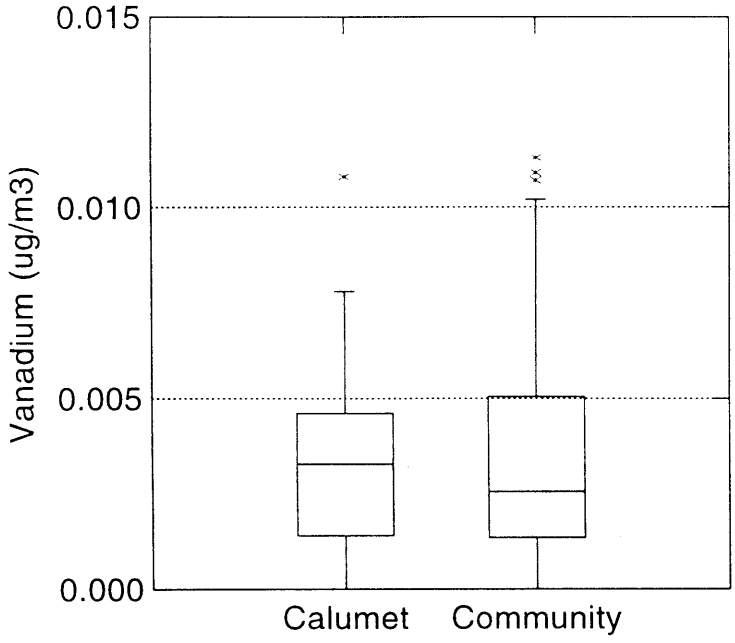

Figure 25 Distribution of Vanadium Concentrations.

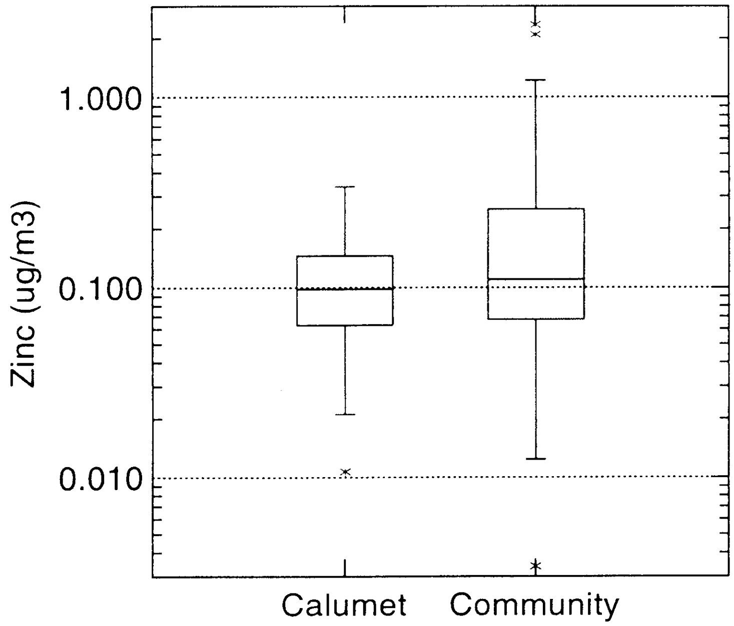

Figure 26 Distribution of Zinc Concentrations.

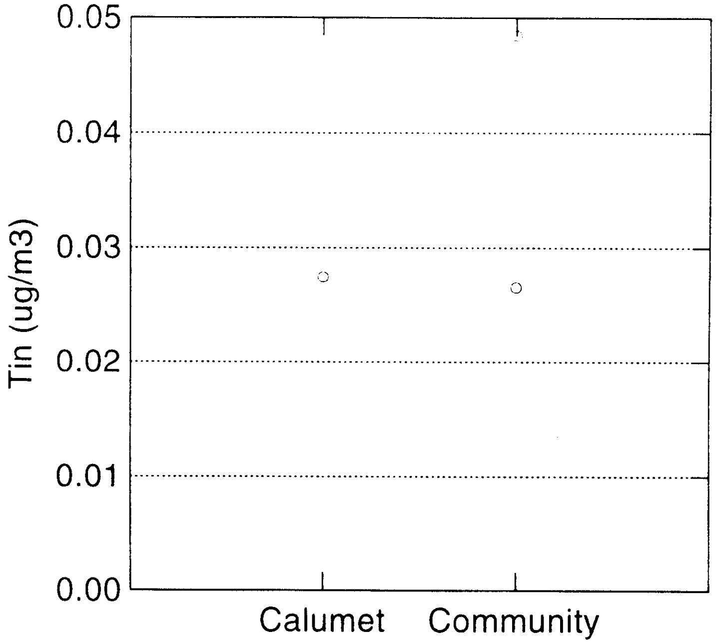

Figure 23 Distribution of Tin Concentrations.

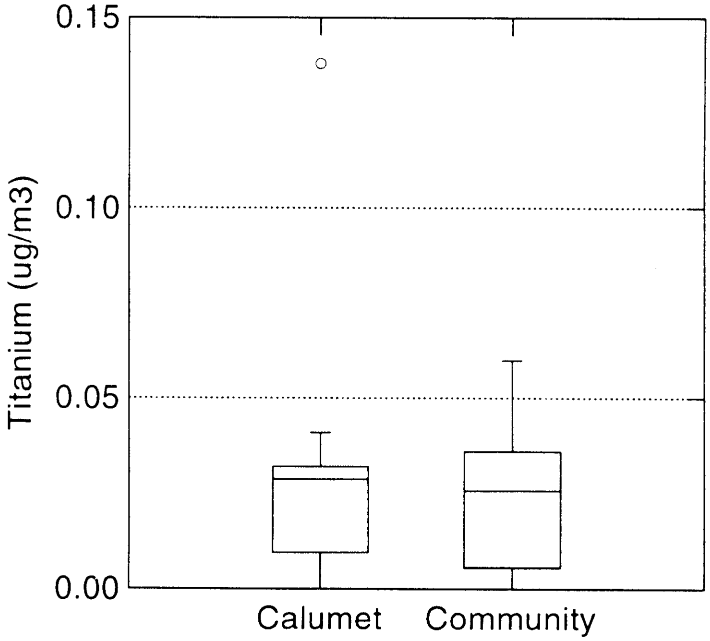

Figure 24 Distribution of Titanium Concentrations.

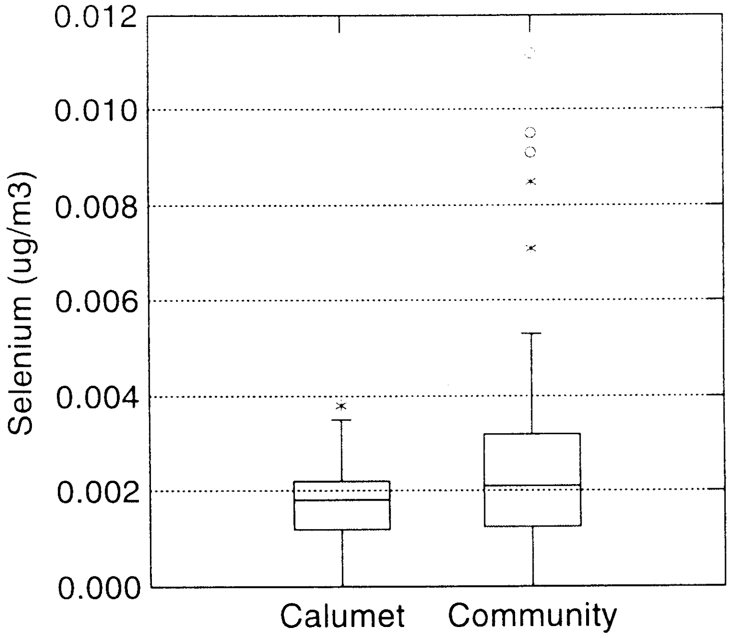

Figure 21 Distribution of Selenium Concentrations.

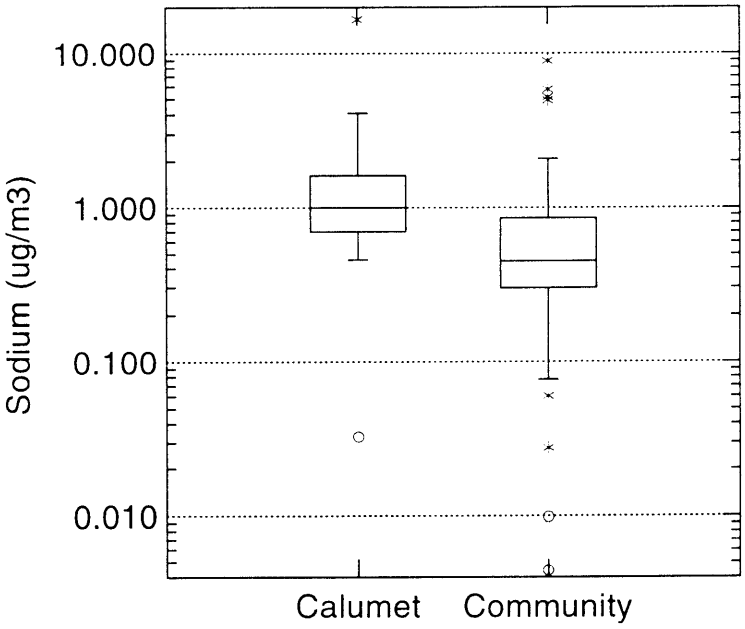

Figure 22 Distribution of Sodium Concentrations.

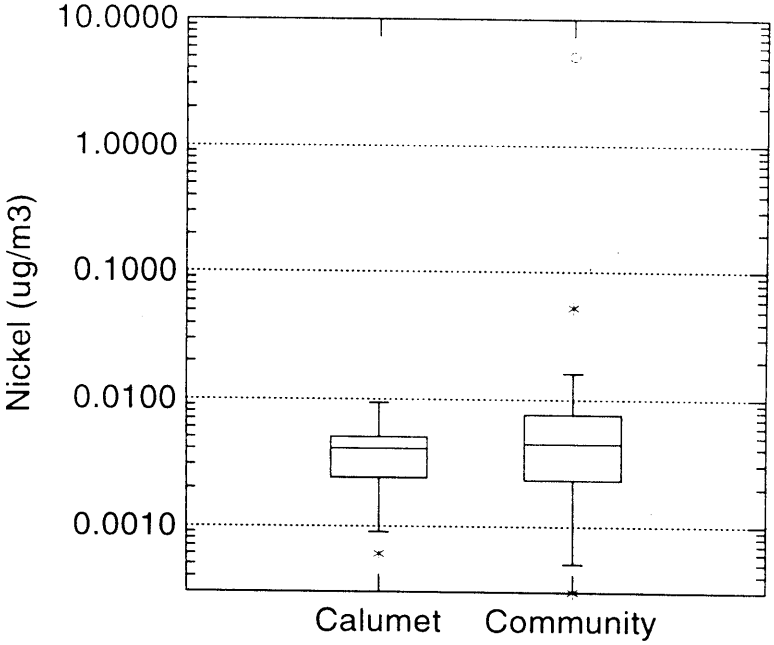

Figure 19 Distribution of Nickel Concentrations.

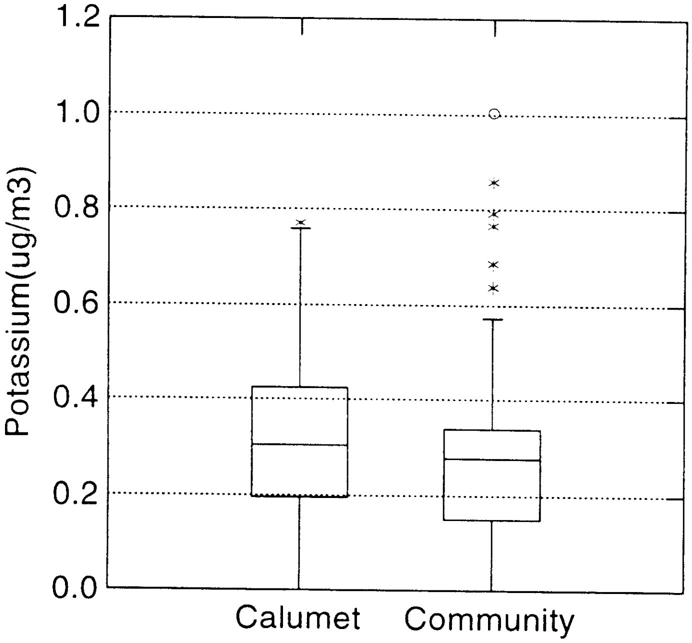

Figure 20 Distribution of Potassium Concentrations.

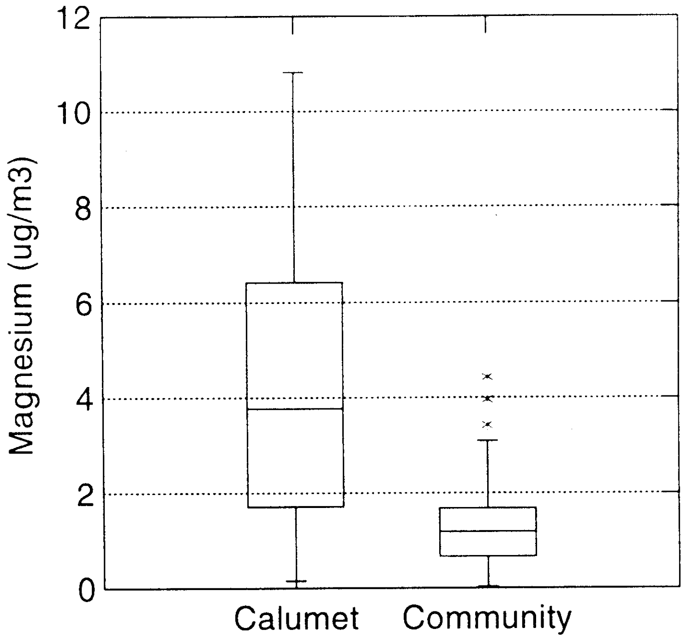

Figure 17 Distribution of Magnesium Concentrations.

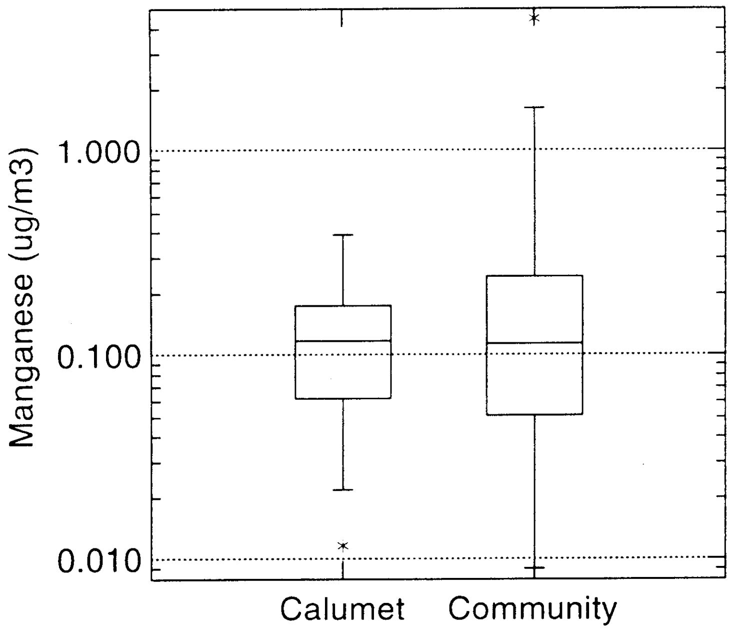

Figure 18 Distribution of Manganese Concentrations.

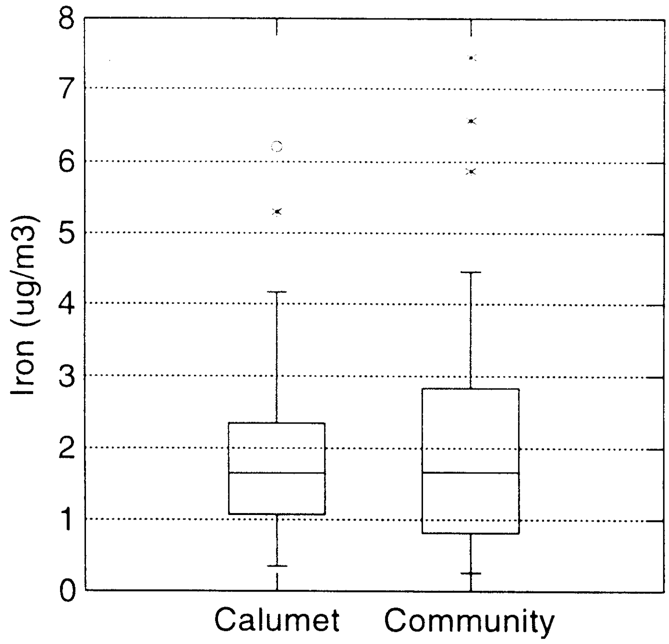

Figure 15 Distribution of Iron Concentrations.

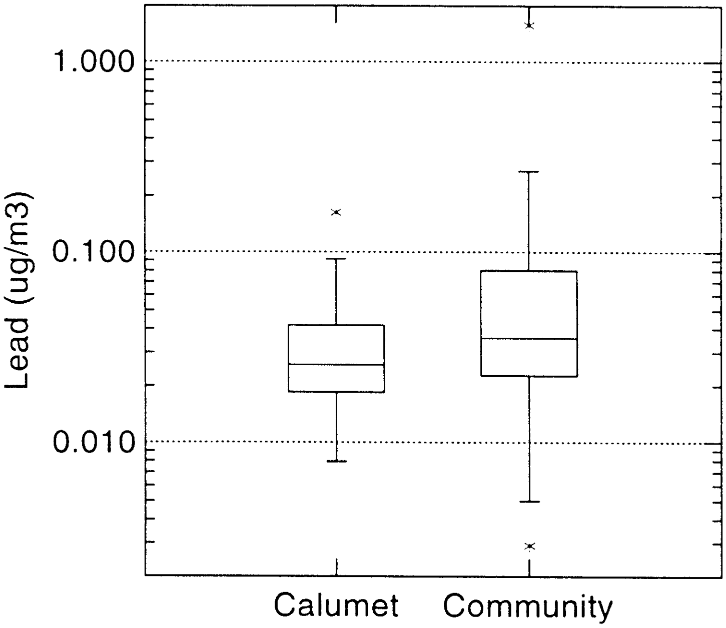

Figure 16 Distribution of Lead Concentrations.

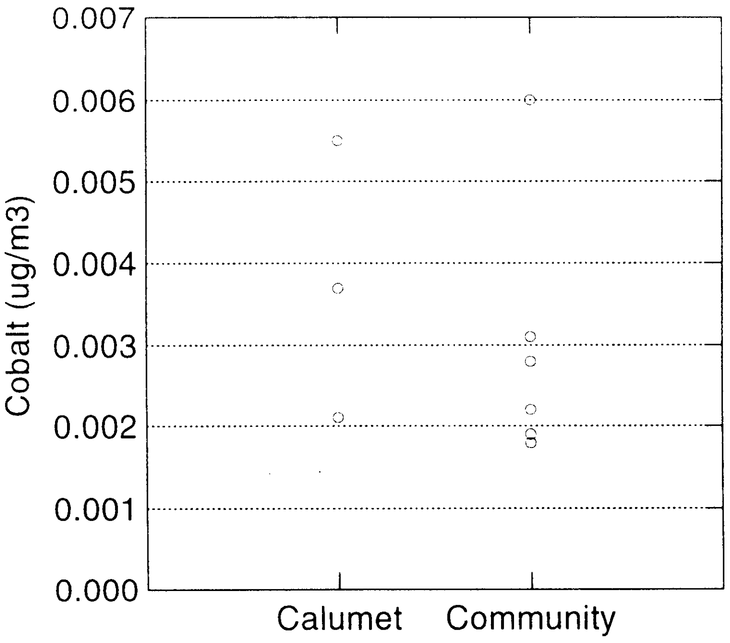

Figure 13 Distribution of Cobalt Concentrations.

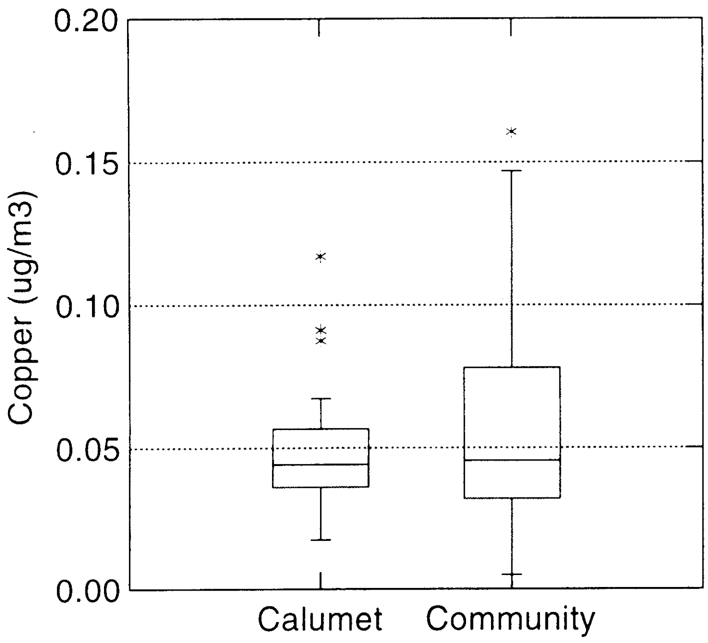

Figure 14 Distribution of Copper Concentrations.

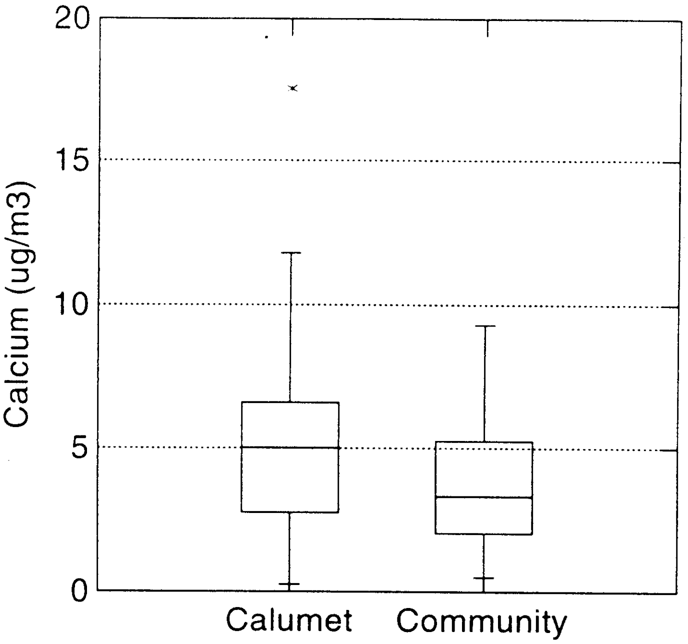

Figure 11 Distribution of Calcium Concentrations.

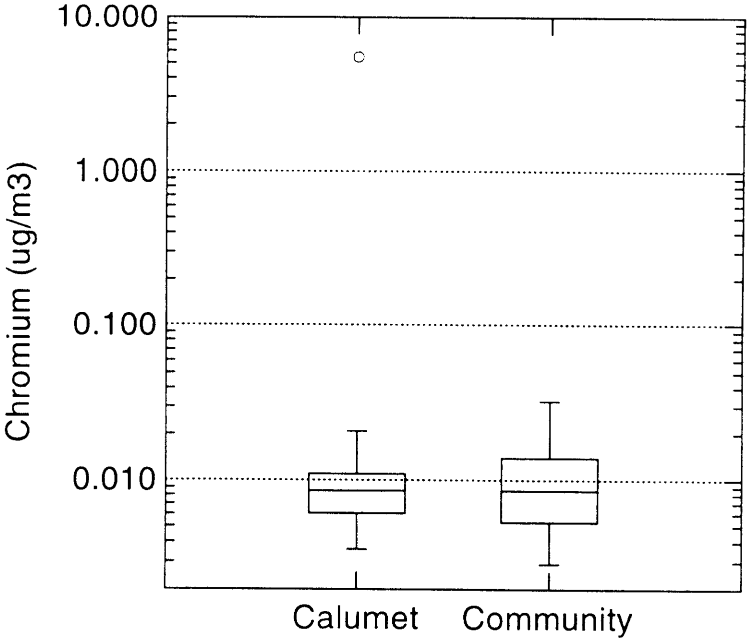

Figure 12 Distribution of Chromium Concentrations.

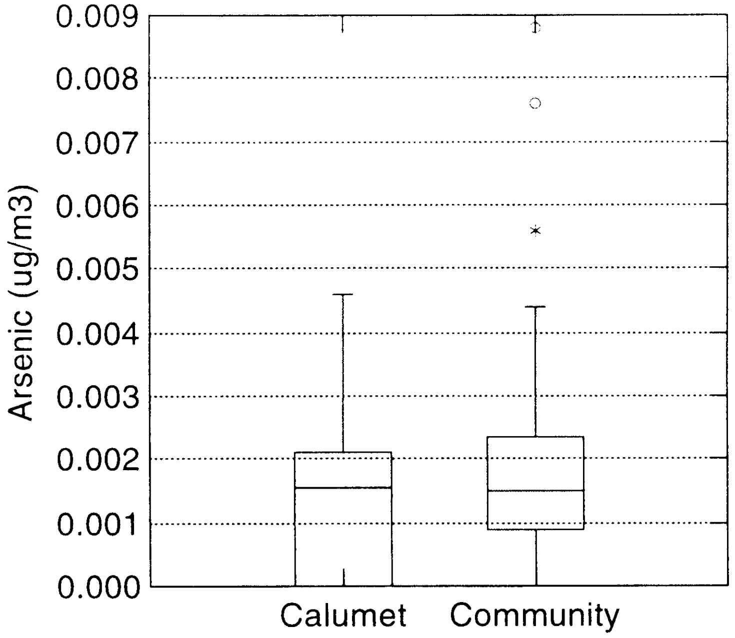

Figure 9 Distribution of Arsenic Concentrations.

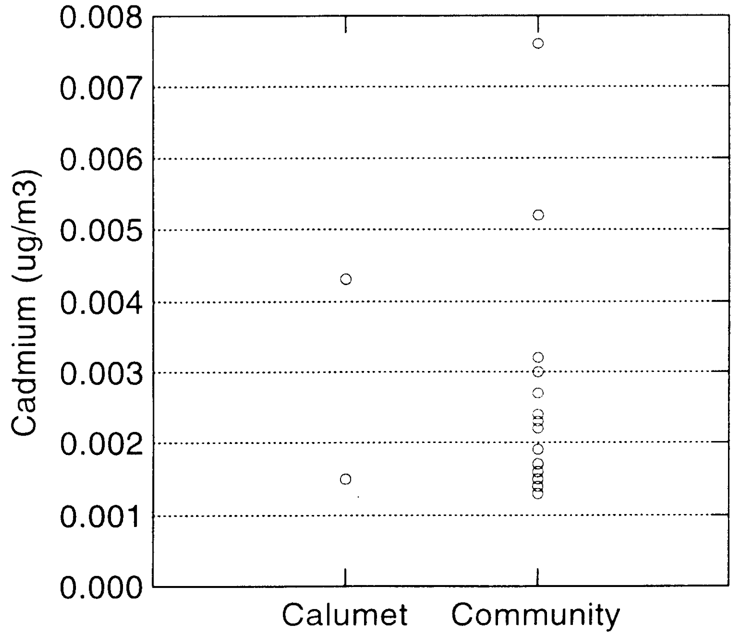

Figure 10 Distribution of Cadmium Concentrations.

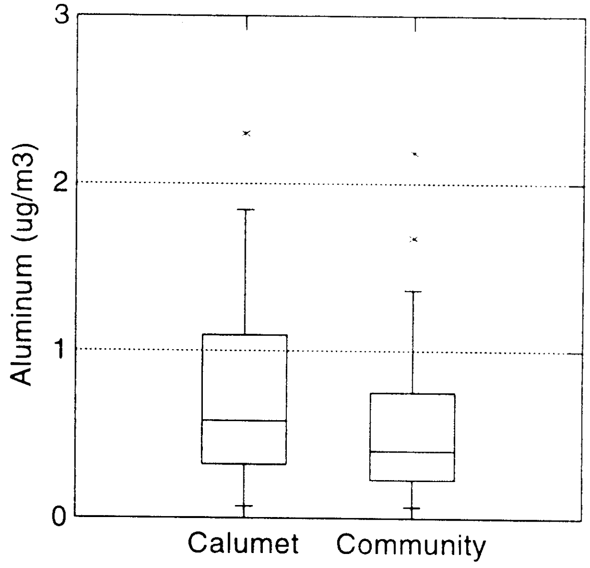

Figure 7 Distribution of Aluminum Concentrations.

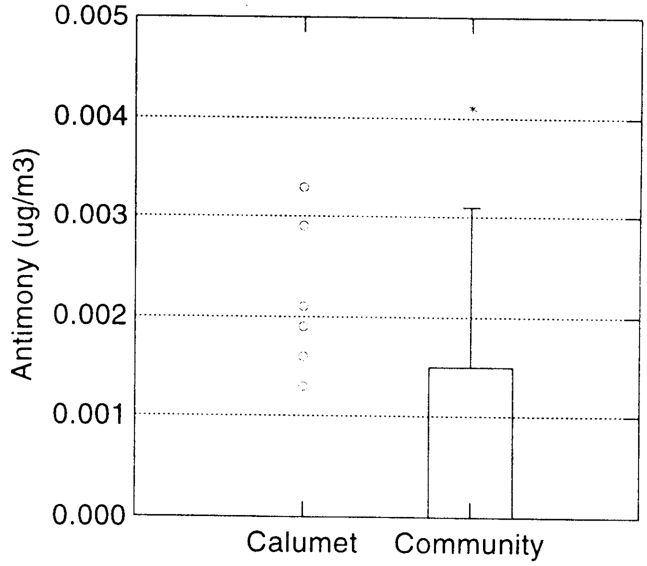

Figure 8 Distribution of Antimony Concentrations.

APPENDIX A: Box Plots of Ambient Concentrations.

Figures 7 through 73 show the distribution of concentrations of toxic air pollutants observed in S.E. Chicago. The plots show separate distributions for (1) the Calumet City monitor and (2) the study area monitors. The plots show: the median (horizontal line in the middle of the box); the range (height of the box shows the interquartile range within which the central 50% of the values fall), the upper and lower inner fences (vertical lines showing the range of values within 1.5 times the interquartile range); and outside values (values between 1.5 and 3 times the interquartile range are plotted with asterisks, and values beyond 3 times the interquartile range are plotted with open circles).

VIII. Appendices

A. Box Plots of Measured Concentrations for Community and Calumet Monitors

B. Measured Air Toxics Concentrations

C. TRI Emission Inventory for S.E. Chicago

D. S.E. Chicago Study Quality Assurance Project Plan

E. Cumulative Exposure Project Health-Risk Benchmarks

14. Northeast States for Coordinated Air Use Management. Letter to Mr. Robert Perciasepe, Assistant Administrator, Office of Air and Radiation, U.S. EPA, January 21, 1999, Attachments 1 and 2.

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VII. References

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6. USEPA Method TO-13: The Determination of Benzo(a)Pyrene [B(a)P] and Other Polynuclear Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatographic (GC) and High Performance Liquid Chromatographic (HPLC) Analysis.

7. USEPA Method TO-14: Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using SUMMA Passivated Canisters Samplers and Gas Chromatographic Analysis.

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13. Sweet, C.W., Vermette, S.J., and Landsberger, S.: Toxic elements in urban air in Illinois. Environ. Sci. and Technol. 27:(12), 2502-2510, 1993.

- The ambient air toxics measurements in Southeast Chicago summarized in this document have been successfully used to validate the accuracy of the national TRI and CEP data sets in the region.

The comparison of CEP modeled mean concentrations and observed average concentrations for metals showed remarkable agreement. Figure 3 shows that the range of predicted concentrations include, or are very close to, the y = x perfect fit line. Of all elements modeled, only manganese and lead measured concentrations were greater than predicted CEP predictions. This is shown in figure 4. Figure 4 also shows that the Calumet monitor for chromium was substantially higher than CEP prediction. Note, however, that this is the result of a single very high observation (see Figure 12), and the median chromium at this site was 0.0075 $\mu g/m^3$, very close to the CEP prediction.

C. Polycyclic Aromatic Hydrocarbons

PAH concentrations are summarized in Table 5. In general, these concentrations are consistent with previous observations in the region.[12] In contrast to metals and VOCs, mean concentrations of anthracene, benzo(a)anthracene, benzo(b+j+k)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene were all significantly higher in the community compared to the Calumet location (two sample t-test with separate variances).

Comparison of measured concentrations with TRI emissions found significant correlations between emissions from steel making processes, coke ovens, auto body finishing, refineries, printing, plastic manufacturing and paint manufacturing and total PAH (see table 12). Tables 10 and 11 show excellent agreement between measured and modeled naphthalene, and measured total PAH and modeled total POM concentrations at the Calumet and community sites, respectively.

VI. Conclusions

- Ambient measurements in Southeast Chicago for toxic metals, VOCs and PAH are consistent with previous observations in the region.
- In general, concentrations of metals and VOCs in the study area are uniform with few significant differences between community and Calumet monitored values. A number of PAH compounds were systematically higher at the community monitors.
- Daily variation in the concentrations of measured toxic compounds are consistent with the TRI emissions inventory and the variation in hourly wind direction.
- Average measured concentrations are consistent with CEP predicted mean concentrations. This evaluation is similar to comparisons with measured data in Vermont and New York,[14] and in the Mid-Atlantic States (including Philadelphia, New Brunswick and Baltimore).[15]

V. Discussion

A. Volatile Organic Compounds

VOC concentrations are summarized in Table 4. In general, these concentrations are consistent with previous observations in the region.[11, 12] This table shows that in general, there is very little difference between concentrations at the community monitors and concentrations at the Calumet monitor. Of all compounds monitored, only bromomethane was significantly higher in the community compared to Calumet (two sample t-test with separate variances). Note, however, that bromomethane was detected in less than half of the samples making this comparison very tentative.

The wind direction-TRI evaluation found a number of significant relationships. Emissions from paint sources, refineries, car body finishing, WRP and steel processes were strongly correlated with measured concentrations of number of the VOCs quantified. For example, Table 12 shows that paint sources are strongly correlated with observed concentrations of trimethylbenzene, benzene, ethylbenzene, xylene, styrene and toluene.

The comparison between CEP modeled concentrations and measured concentrations showed remarkable agreement. Figure 5 and tables 10 and 11 show that the observed mean concentration falls within the predicted range for most compounds. Of the 24 VOCs in tables 10 and 11, only four compounds (1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, chloromethylbenzene and hexachloro-1,3-butadiene) were significantly under predicted by the CEP model.

B. Metals

The concentrations of metals in the study area are consistent with previous observations.[12, 13] Crustal elements (aluminum, calcium, iron, and magnesium) are among the elements with the highest concentrations at both the community and Calumet sites. Table 3 shows that there is little difference between the concentrations at the community and Calumet sites. In general, concentrations were not statistically different between Calumet and community monitoring locations. Only selenium and zinc were statistically significantly higher at the community monitors compared to the Calumet monitor (two sample t-test with separate variances).

The Southeast Chicago study area contains several steel facilities which have operating coke furnaces and smelting operations which emit various metals such as zinc and lead. The wind direction analysis of the TRI data set (table 12) showed that emissions from Paint, Printing, Car Body Finishing, Coke Ovens, and Steel Processes were significantly correlated with observed concentrations for most elements evaluated. It is also interesting to note that refinery emissions of vanadium were strongly correlated with vanadium concentrations, and plastics emissions of zinc were strongly correlated with zinc concentrations.

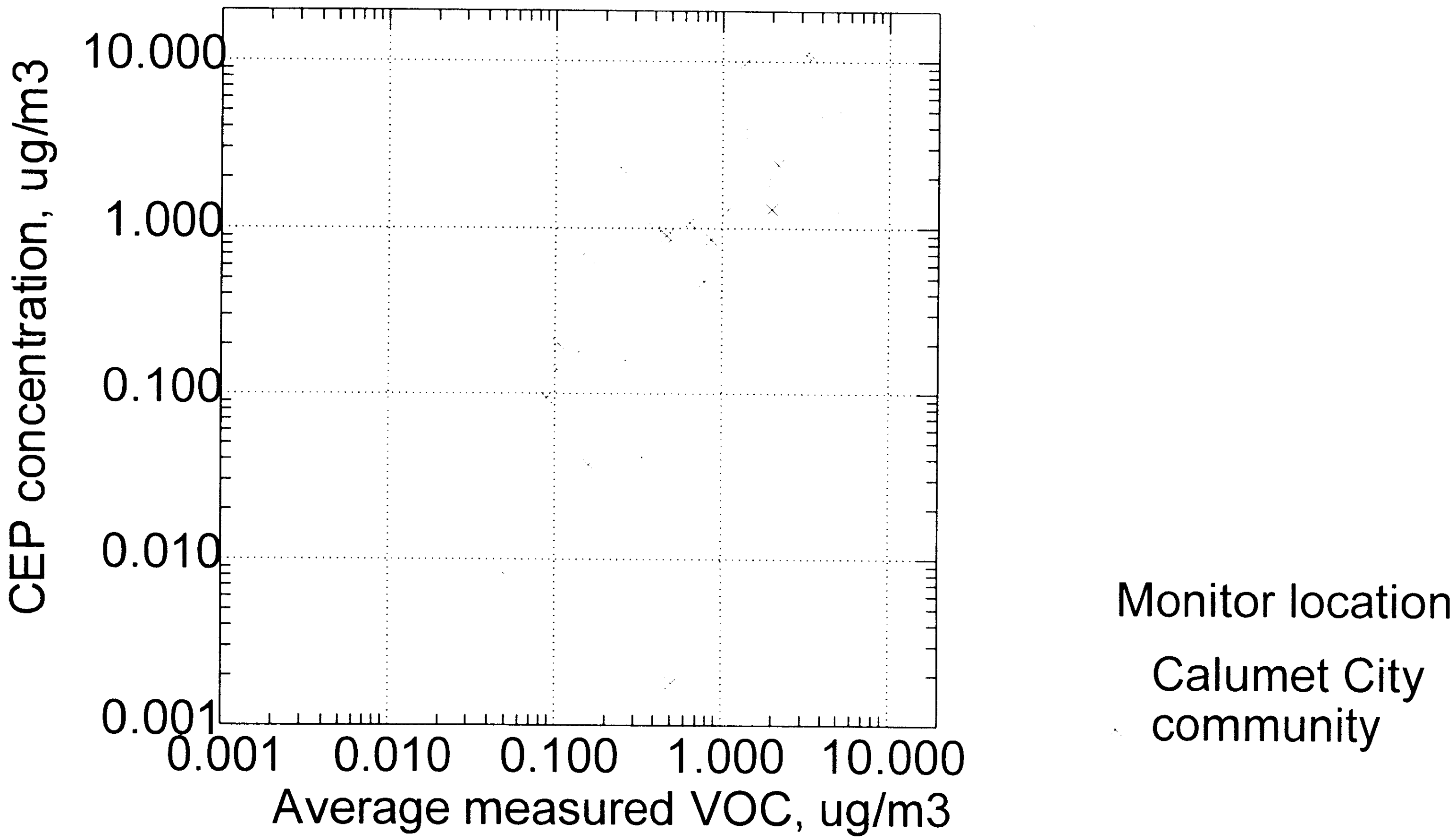

Figure 6 Comparison of CEP predicted and measured VOC concentrations.

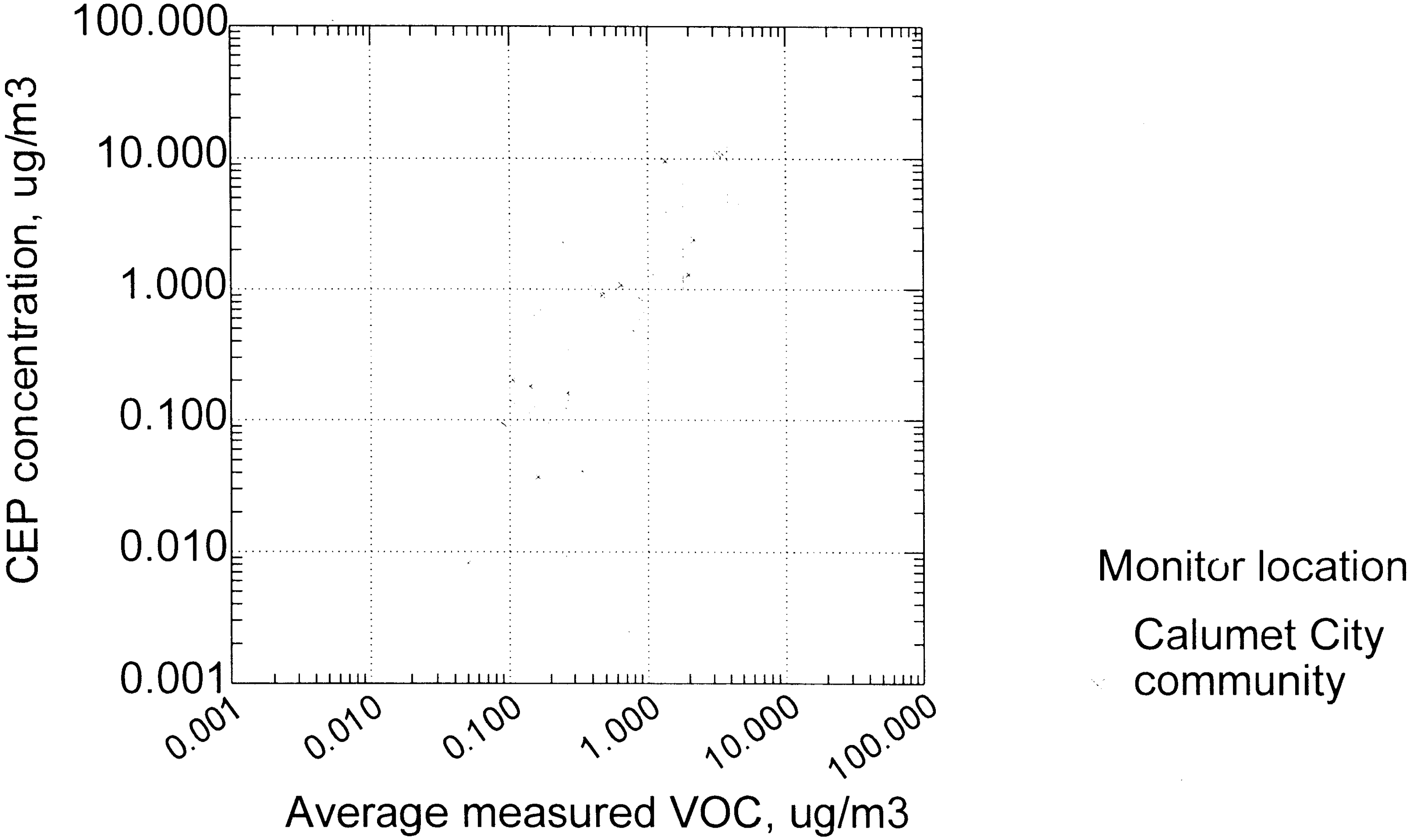

Figure 5 Comparison of CEP predicted and measured VOC concentrations. Vertical lines represent CEP prediction intervals.

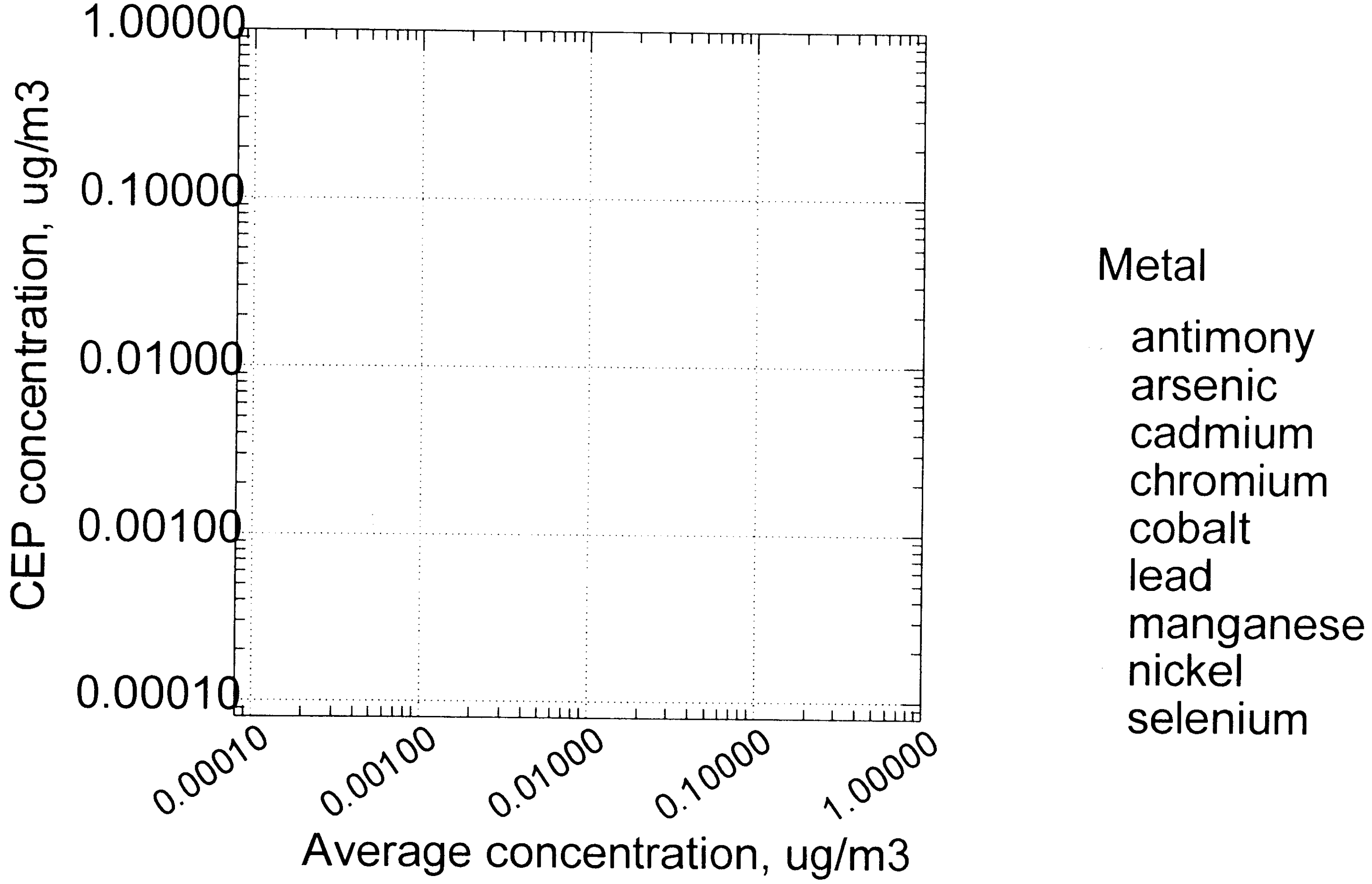

Figure 4 Comparison of CEP predicted and measured metals concentrations.

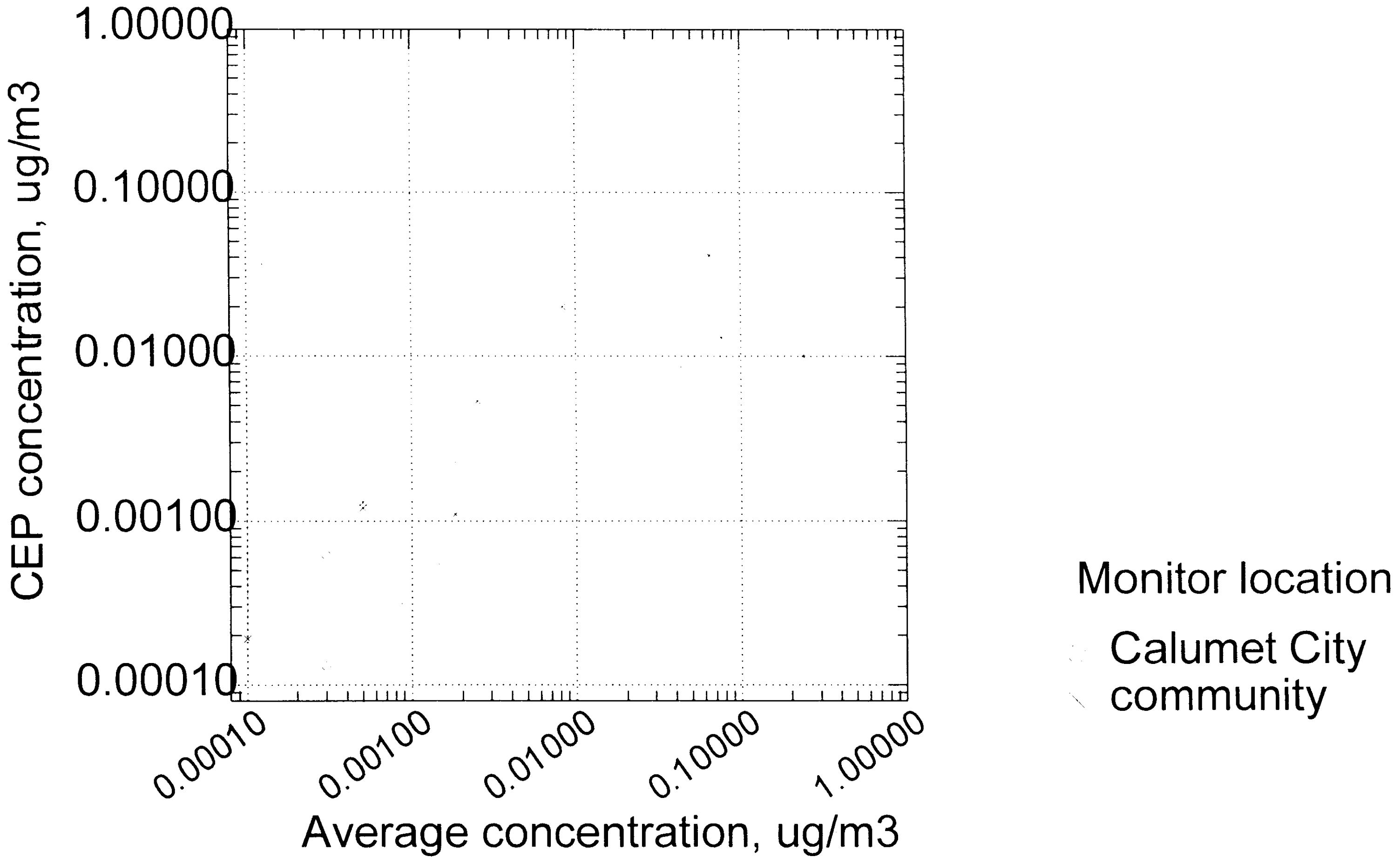

Figure 3 Comparison of CEP predicted and measured metals concentrations. Vertical lines represent CEP prediction intervals.

E. Evaluation of CEP Estimates of Toxic Air Pollutants with Ambient Measurements.

The CEP is an effort to assess the potential impact of air toxics in the US. The model incorporates emissions data from stationary and mobile sources to estimate outdoor concentrations of 148 toxic air contaminants for each of the 60,803 census tracts in the contiguous United States for 1990.[2] Long-term average concentrations of HAPs were calculated at the census tract level based on emissions rates of the HAPs and frequencies of various meteorological conditions, including wind speed, wind direction, and atmospheric stability. In addition, the model incorporates simplified treatment of atmospheric processes such as decay, secondary formation, and deposition.

Tables 10 and 11 show the modeled and measured HAP concentrations for the Calumet and community monitor census tracts, respectively. Included in these tables are the lower-bound and upper-bound estimates of the modeled concentrations defined as the 90 percent confidence interval of the prediction, and the average, minimum and maximum observed concentrations in S.E. Chicago. These tables show remarkable consistency between the mean predictions and measurements for most compounds. For all 36 compounds included in this analysis, only four compounds (1,1,2,2-tetrachloroethane, 1,2,4-trichlorobenzene, chloromethylbenzene and hexachloro-1,3-butadiene) were more than an order of magnitude different between the modeled and measured concentrations. In almost all other cases, the observed mean concentrations were within, or close to, the 90 percent confidence interval of the predicted CEP means.

Figure 3 is a high-low-close plot showing the relationship,between the average measured concentration (x-axis) and the CEP upper-bound, lower-bound and mean predicted concentrations for 9 metals (y-axis) for the community monitors and Calumet monitor. This figure shows that for all cases, the range between the upper and lower bound predicted concentrations cross, or are very close to, the y = x line. Figure 4 is a scatter plot of the mean CEP predicted (Y-axis) and measured (x-axis) concentrations of the 9 metals. The individual metals are identified on this figure. Note that the higher of the two points for chromium on this figure is for the Calumet monitor and is the result of a single extremely high observation in the Calumet city data set (see figure xx in appendix A). The median measured value for chromium at this site (0.0075 μg/m^3) is very close to the CEP predicted mean of 0.0078 μg/m^3.

Figure 5 is a high-low-close plot of the CEP predicted (y-axis) and EPA measured VOC concentrations (x-axis). Note that because of very low predicted concentrations, 1,1,2,2-Tetrachloroethane, 1,2,4-Trichlorobenzene and Chloromethylbenzene are not included in this figure. As with the metals, except for the compounds not included in the figure, all of the plotted ranges are within, or close to, the y = x line. Figure 6 is a scatter plot of the mean predicted and measured concentrations of the individual VOCs. This figure shows that in most cases shown, the CEP modeled average concentration is within an order of magnitude of the average measured concentration.

Table 12. Summary of the Correlations between Measured Concentration (all sites) and TRI Source Scores

(*=poor, **=fair, ***=very good, ****=excellent)

HAP	TRI source category									
	Paint	Plastic	PM	Printing	Organic Chemicals	Refineries	Car Body Finishing	Coke Ovens	WRP	Steel Processes
o-Xylene	****	***				**	****	***	**	***
Propylene		*			****	****		**	****	**
Styrene	***					*				
Toluene	****	*				*	***		***	
Trichloroethylene	*									
PAHs										
Anthracene	****									
Naphthalene	****					*	****	****		
Phenanthrene	****			***			***			
Total PAH	****	****		****		****	****	****	**	****

Table 12. Summary of the Correlations between Measured Concentration (all sites) and TRI Source Scores

(*=poor, **=fair, ***=very good, ****=excellent)

HAP	TRI source category									
	Paint	Plastic	PM	Printing	Organic Chemicals	Refineries	Car Body Finishing	Coke Ovens	WRP	Steel Processes
Metals										
Aluminum					**			****	****	
Antimony	****			***		**		***		
Arsenic		**					****	**		**
Cadmium	***		****			*	***	*	****	**
Copper	****	**	****	****			****	****	***	****
Lead	****	*		***			****	***		***
Manganese	****						****	****		***
Vanadium	****			***		****	****	****		****
Zinc	****	****	*	****		**	****	****	*	****
VOCs										
1,1,1-Trichloroethane	***					****		*	****	
1,2,4-Trimethylbenzene	****	*				****	****	***	***	**
1,2-Dichloroethane			****		**	****		***	****	****
1,3-Butadiene	***				**		**		****	
Benzene	***	*		**		****	****			**
Carbon Tetrachloride										
Ethylbenzene	****	***				**	****	***	*	***
Methylene Chloride										

good are correlations with p values between 0.05 and 0.01, and excellent are correlations with p values less than 0.01. Note that non-parametric Spearman correlations were used in this analysis.