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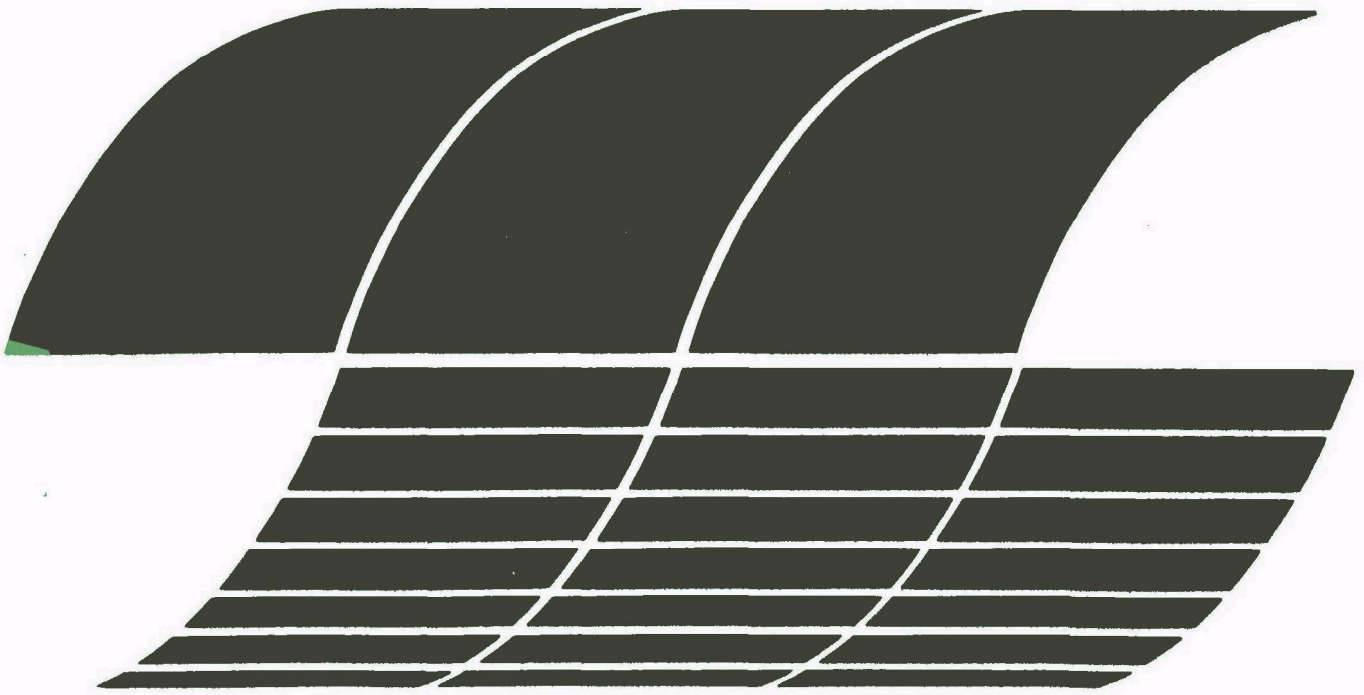
EPA

A Case Study in the Use of Ambient Data for Source Assessment

Interagency Energy/Environment R&D Program Report



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A Case Study in the Use of Ambient Data for Source Assessment

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ABSTRACT

A common objective of regional environmental management is to determine what sources of pollution are the principal determinants of environmental quality in a given area. This report is a case history for such an environmental management study that was conducted for the Allegheny County Health Department, Bureau of Air Pollution Control in Pittsburgh, Pennsylvania. The results of this work were used by Allegheny County as part of their contribution to the State Implementation Plan for achieving air quality standards for total suspended particulate matter (TSP). The techniques that were utilized in this ambient-correlation study include: (1) analysis of present air quality and trends; (2) log-normal distributions; (3) relative frequency of TSP levels; (4) monthly variations in TSP levels; (5) weekday/weekend analysis; (6) wet day/dry day analysis; (7) analysis of pollution roses; (8) wind frequency analysis; (9) isopleth maps; (10) contribution of steel plant emissions by modeling; and (11) particulate identification analysis. The integrated application of these techniques to determine the background traditional and nontraditional components of the ambient TSP levels is described. The results of this environmental management study include estimates of the relative source strengths of particulates, the relative impacts of the sources, and the level of confidence of these results.

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INTRODUCTION

A frequent task in environmental management for a given region or locality is to determine what sources of pollution are the principal determinants of environmental quality in that area. If this determination can be established with a reasonable degree of certainty, then the regulatory decisions necessary to attain compliance with environmental quality goals for the area can be made with minimal risk. In most cases, however, the determination of relative contributions from the multitude of sources is complicated, especially where the pollutant is produced from natural or secondary sources.

Therefore, one objective of the environmental manager is to understand the relationship between ambient environmental quality and the sources which determine that quality. The Environmental Protection Agency (EPA) is interested in analyzing the various methodologies that can be employed in accomplishing this objective. Because any one methodology may not be universally suited to the variety of environmental management problems encountered, it is desired to examine a typical study of ambient-source correlation where the integrated use of several techniques is employed. This report describes an environmental management study that TRC-THE RESEARCH CORPORATION of New England conducted for the Allegheny County Health Department Bureau of Air Pollution Control (BAPC) in Pittsburgh, Pennsylvania, in which a number of analytical techniques were used to estimate the relative contributions from various sources of total suspended particulate (TSP) within the County.

This report discusses this management study in the following manner:

- Section 2 describes the scope of the environmental management study, the results expected, and the users of the study outputs.

- Section 3 describes the methodology used in the management study, including:

  - present situation and trends
  - log-normal TSP distribution analysis
  - relative frequency of TSP levels
  - monthly variations in TSP levels
  - weekday/weekend analysis
  - wet day/dry day analysis
  - pollution roses

- wind frequency analysis
- isopleth maps
- contribution of steel plant emissions to selected monitors by modeling
- particulate identification analysis

The integrated application of these techniques to determine the background, traditional, and non-traditional components of the ambient TSP levels is then discussed.

o Section 4 describes the results of the management study, including the sources of particulates, the relative impacts of the sources, and the level of confidence of the results.

o Section 5 presents a critique of the methodology used in the management study and gives recommendations that would benefit future studies.

SECTION 2

DESCRIPTION OF ENVIRONMENTAL MANAGEMENT STUDY

Allegheny County, Pennsylvania, has been identified by EPA as a nonattainment area for TSP that, under the Clean Air Act of 1977, must submit a revised State Implementation Plan (SIP) to EPA describing how the National Ambient Air Quality Standards (NAAQS'S) for particulate matter will be achieved by 1982. TRC was contracted by the BAPC to organize and manage an effort to develop strategies for the control of traditional and non-traditional sources of suspended particulate matter in Allegheny County. Several organizations participated in various parts of the project, including Carnegie Mellon University, U.S. Steel's Research Center, Energy Impact Associates, and Materials Consultants & Laboratories.

As part of this management study, several years of ambient TSP data as measured by Hi-Volume Samplers in the County were to be analyzed. The objective of the analysis was to use the available data to determine the relative contributions of industrial sources (traditional and non-traditional), non-traditional sources (such as road dust) and background at selected sites in the County that were considered to be indicative of the particulate problem and that could help define strategies for particulate control.

Sulfur dioxide and other specific gaseous pollutants can usually be traced to specific sources because they retain their identity from the emission source to the point of measurement in the ambient atmosphere. Analogous tracking of particulate matter from source to receptor is much more difficult, and often not achievable in practice. Particulate matter is ubiquitous. The particles that are captured on the filter of a Hi-Vol can come from a number of sources and arrive at the point of capture after following innumerable routes. Furthermore, the range of physical and chemical properties of particulates are almost limitless, and the use of these properties is not a straightforward means of identifying the sources and routes followed by the collected particles. Therefore, a methodology was developed to determine the relative contributions to total particulate matter measured by broad source or route classifications of particles. Four classifications were considered as follows:

Classification	Definitions & Examples
1. Traditional Sources (Industrial)	"Virgin" (non-resuspended) material arriving at the sampling point directly from point and process fugitive sources within a plant complex.
2. In-Plant Non-Traditional Sources (Industrial)	Fugitive dust from wind blown storage piles and materials handling and resuspended dust from traffic on dusty plant roads.
3. Non-Traditional Sources (Non-Industrial)	Dust from construction and demolition activities. Re-entrained dust from road traffic, playgrounds, parking lots, etc.
4. Background Material	Particulate matter of both natural and anthropogenic origin advected from points outside the County and over which the County has no control.

SECTION 3

METHODOLOGY USED IN MANAGEMENT STUDY

The primary body of data available for the study was that amassed by the BAPC for the years 1975 through 1977. During these years, particulate data were collected essentially continuously at twenty-four sampling stations in the County (Figure 1). These particulate data, together with meteorological data from the Greater Pittsburgh Airport, were used in statistical analyses and manipulations which provided the principal basis for determining the relative contributions of background, non-traditional, and traditional sources of particulates.

DISCUSSION OF INDIVIDUAL ANALYTICAL TECHNIQUES

The individual analytical techniques used in the management study were:

- Present situation and trends
- Log-normal TSP distribution plots
- Relative frequency of TSP levels
- Monthly variations in TSP levels
- Weekday/weekend analysis
- Wet day/dry day analysis
- Pollution roses
- Wind frequency analysis
- Isopleth maps of particulate patterns
- Contribution of steel plant emissions to selected monitors using modeling techniques
- Particulate identification analysis

The above methods are described in the following subsections.

Present Situation and Trends

The development of logical and effective strategies for further control of particulate matter to meet NAAQS's in Allegheny County requires a thorough understanding of trends in both emissions and ambient concentrations of particulate matter. Furthermore, the siting of particulate monitoring stations has an important bearing on the levels of particulate matter measured. Therefore, this analysis consisted of three sub-analyses: a compliance history; an analysis of present ambient particulate levels; and an evaluation of the present particulate air monitoring stations.

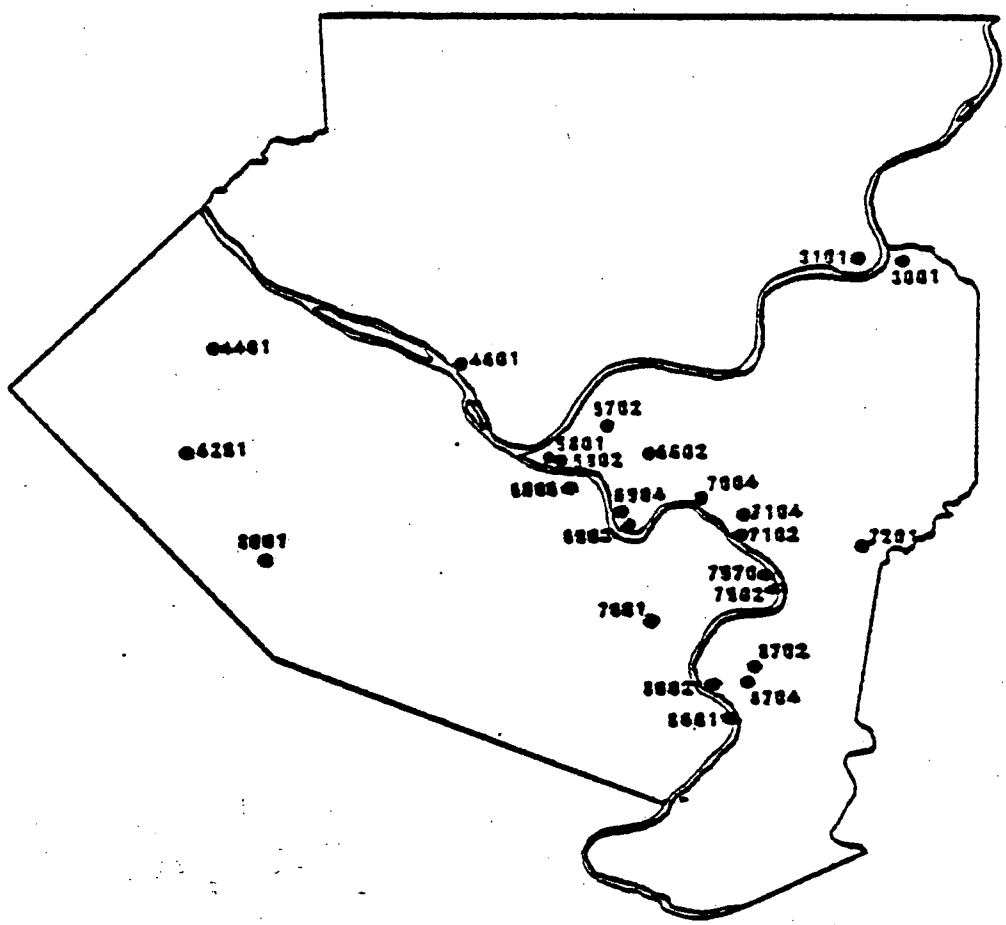

Figure 1. Hi-Vol Montioring Stations for Allegheny County.

Compliance History--

As a first step in developing strategies for the further control of particulate matter, it is mandatory to determine how effective present regulations have been and are likely to be in reducing particulate emissions. Allegheny County has had in force since 1972 a set of regulations for the control of particulate emissions that are as stringent as any in the country.[1] Furthermore, those emission regulations that apply to steel making operations, the principal heavy industry in the County, represent levels of emission control that equal or exceed New Source Performance Standards for applicable processes.

A compliance history was prepared to show the relative amounts of particulate control that have been achieved roughly to the present (1976 is the base year for the emission inventory) and that are expected to be achieved by 1982 by continued enforcement of the requirements of Article XVIII and various consent decrees. The beginning year for this analysis was set as 1971, just before the enactment of Article XVIII.

The changes in emissions over the period 1971-1982 have been and will be the result of installing control devices, varying fuel mixes, varying production levels, phasing out of old processes, the use of new processes, improved maintenance practices, and other changes. The work performed to assemble the compliance history was performed by BAPC personnel.

The compliance history showed that there was a 65 percent reduction in particulate emissions between 1971 and 1976 and that the anticipated reductions in particulate emissions between 1976 and 1982 will be an additional 49 percent.

Air Quality Trends--

Hi-Vol sampling is currently being carried out at 24 locations in Allegheny County. Continuous sampling at each of these stations every 3 or 6 days has been in progress since 1975. Eight of these stations have been in continuous use since 1970. The yearly arithmetic and geometric means at each site were computed and plotted in order to determine whether any large anomalies exist in the air quality trends at any of the monitoring stations.

This analysis technique can provide the following types of information:

- o A large change in the yearly TSP levels at only one site can indicate a local source starting up or shutting down. Such a local source could be a construction site, strip mine, or small industrial source.

[1]Allegheny County Health Department Rules and Regulations Article XVIII, June 1972 and Amendments 1978.

- o A large change in the yearly TSP levels at several sites in a large geographical region can indicate a major TSP source starting up or shutting down or undergoing a major change in operations. Such a major source could be a steel plant.

- o Gradual changes in the yearly TSP levels at a particular site or several sites can indicate the effectiveness of implemented control measures.

Evaluation of Sampling Sites--

To properly assess the representativeness of the particulate sampling stations to human exposure, an analysis of each site should be performed. These anlayses should examine monitor placement, location of local sources, type of neighborhood, etc. Such an analysis was performed for fifteen of the Allegheny County sampling sites. In addition, micro-inventory site summaries were performed for an additional eight sampling sites.

Another way of examining the representativeness of monitoring sites is by using the Standard Air Monitoring Work Group (SAMWG) guidelines for monitor placement.[2] These guidelines take into account the monitor height, distance from roads, freedom from airflow obstructions, etc. This was done for all of the Allegheny County monitoring stations.

Based on the SAMWG guidelines, observations were made as to the representativeness of the monitoring station sites chosen for use in Allegheny County. Several of the sites were felt to be non-representative of the general TSP levels within the County and were, therefore, not used in the subsequent attainment analysis.

Log-Normal Plots

An analysis method that can be useful in determining the presence of local sources is the log-normal distribution plot in which the percentage of readings over a certian TSP level is plotted versus that TSP level. If a site is subject to large-scale or general influences (i.e., many sources), then its TSP observations should be log-normally distributed. If there is a major local influence, such as a stack or a strong area source in a specific direction from the sampling site or some other source of extreme impact, then the data will either not exhibit log-normality or will deviate from it at the plot extremes. The facilities of the U.S. Steel Research Center were used to produce log-normal plots for each of the 24 monitoring sites for each of the three study years. An example of such a plot is given in Figure 2.

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[2]Air Quality Surveillance Network Design and Siting for State Implementation Plan (SIP) Monitoring.

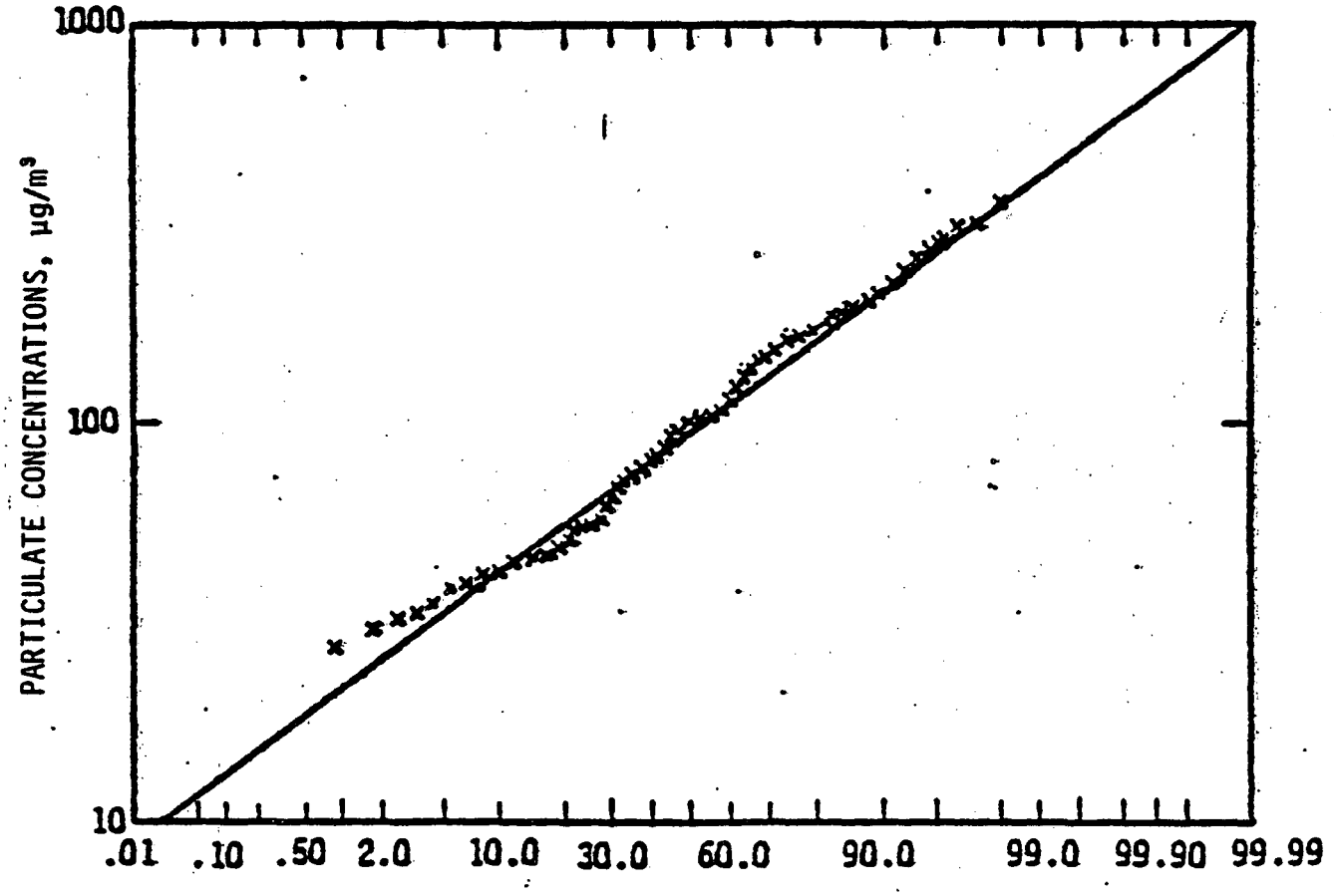

Figure 2. Example of Log-Normal Plot for TSP Data.
(1976 Data For Station 8702-Liberty Boro)

These plots showed that data from all stations appear to be reasonably log-normally distributed which implies that all stations are subject to large-scale influences. This result was not expected since several stations are near to strong point or area sources. The log-normal distribution of data for one station which recently has been influenced by a nearby trucking operation showed only minor deviations from log-normality.

Relative Frequency of TSP Levels

As in the case of log-normal plots, a clue as to whether a monitoring site is affected by a single source can be obtained by inspection of the concentration frequency distribution for that monitor. If the distribution shows extreme values of much larger concentration than the mass of data, then a directionally dependent effect on that monitor or other similar concentrated causes for extreme values may be suspected. Again, with the help of U.S. Steel's Research Center, graphs of relative frequency were prepared for each site for each year of the study period. An example of this type of graph is shown in Figure 3.

In reviewing the frequency distribution graphs, a qualitative judgement was made as to any evidence that extreme values might influence the shape of the distribution curve. We were not able to explain why, over the period of 1975-1977, extreme values appear to have an increasing influence on the pattern of frequency distributions.

Monthly Variations in TSP Levels

The three years of TSP data were averaged by month and plotted to show the monthly and seasonal variations that exist at each of the sites. An abnormally high winter level can be an indication of heavy traffic influence due to the combination of longer morning inversion periods, cars idling while cold, and road sanding/salting operations. A high summer level can be an indication of activity in agriculture or the increased use of school playgrounds.

A variation of this analysis was also performed where the monthly average plots were grouped for stations that are similar in character or in close proximity. This helps to determine whether these groups of stations are influenced by the same source regime. An example of this type of plot is given in Figure 4. Note how the two stations exhibit similar seasonal TSP patterns, indicating the same general source regime; while one station has a higher overall TSP level, indicating a local source influence. These two stations are within one kilometer of each other.

Weekday/Weekend Analysis

The arithmetic means for weekday and weekend periods as well as Saturday and Sunday individually were computed for each site for each study year and for

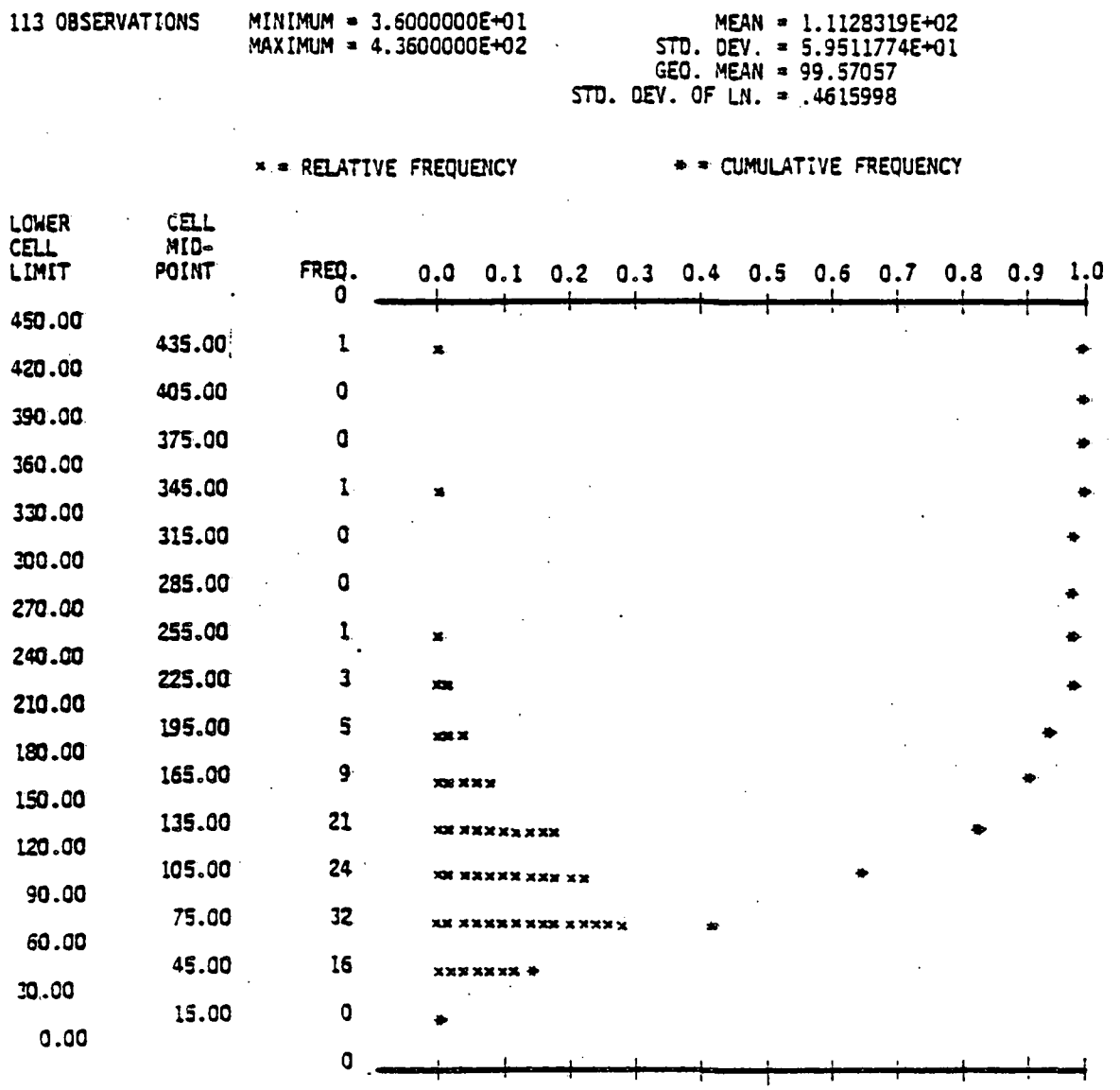

Figure 3. Example of Relative Frequency Plot for TSP Data.
(1977 Data for Station 5801-County Office Building)

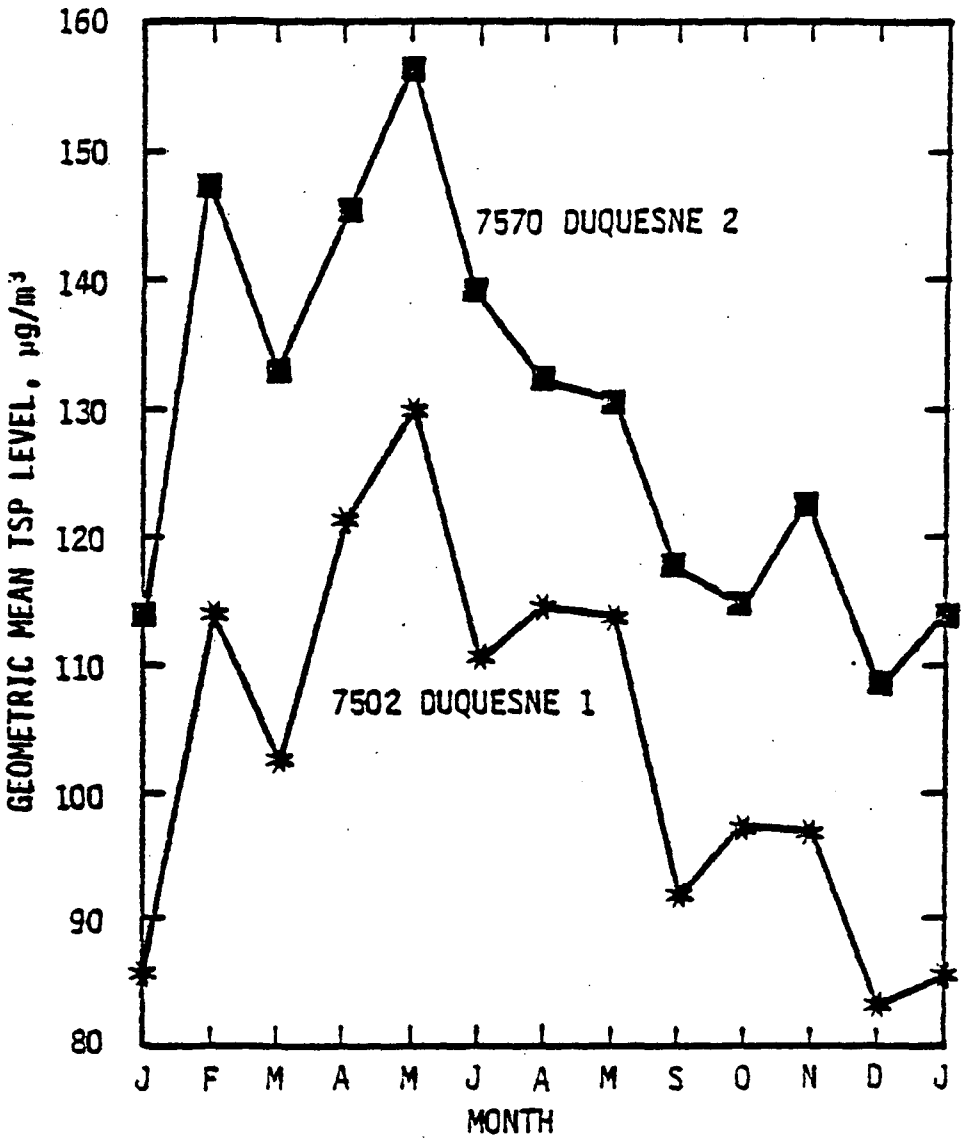

Figure 4. Example of Seasonal Variation Plot for Two Sampling Sites. (1975-1977 Data)

all three study years combined. With only one exception, all of the stations exhibited lower particulate levels on weekends than on weekdays. One might expect that this difference would be caused by a combination of reduced industrial activity (traditional sources) and reduced traffic (non-traditional sources) on weekends. In the Monongahela Valley, which is dominated by steel making operations that operate at a relatively constant level every day, one would expect that the weekend contributions from traditional sources would equal those during weekdays.

Traffic data could not be obtained at any of the County monitoring stations, but some information on traffic patterns was obtained for the state in general. These results were surprising in that they showed significantly more automobile traffic on weekends than on weekdays. If the vehicular use in Allegheny County is similar to that state-wide, the average daily traffic volume appears to have a negative effect on particulate concentrations. However, assuming that traffic resuspends particulate matter that can affect Hi-Vol readings, there are at least two factors that could make the traffic data not consistent with the particulate data:

1. Weekend contributions from plant generated fugitive dust may be significantly less than for weekdays.

2. Weekend driving patterns are different than those for weekdays.

During weekends, driving is done in the middle of the day when dispersion conditions are at their best. During weekdays, peak driving is done in the early morning (0630-0900) and late afternoon (1500-1800) when dispersion conditions may be poor, thus keeping traffic-suspended particulate matter in the vicinity of the point of generation in a relatively undiluted condition.

We were not able to obtain specific emission inventory data on a weekday/weekend basis, but qualitative reports from the principal steel companies in the County showed that, while steel production was relatively constant throughout the week, certain operations such as shipping, loading, and unloading were at reduced levels over weekends. Such operations are important non-traditional particulate sources.

Wet Day/Dry Day Analysis

In performing this analysis, it was assumed that on days with sufficient snow cover, with greater than 0.5 centimeters of precipitation, or following days with greater than 0.5 centimeters of precipitation, the principal contributions to the TSP levels would be traditional sources, home heating, vehicle exhaust, and material transported from outside the County. The rain and snow would suppress the majority of the local fugitive and reentrained dust. These days were defined as "wet" days and all other days as "dry" days. The meteorological data for the three-year study period were examined and the TSP levels at each site on wet days were then averaged and compared to the average TSP levels on the dry days. The results showed that on wet days total

TSP was from 14 to almost 50 percent less than on dry days. These differences give a first approximation of the non-traditional source component at each of the sampling stations.

Pollution Roses

Pollution roses, which depict the average TSP concentration for various wind directions, were constructed using the computer facilities of the U.S. Steel Research Center for each site for each of the study years. They were based on the sixteen compass points for a wind persistence factor ≥ 0.71.[3] For each site, two plots were constructed for each year: one for wind speeds of 0-3.5 m/sec and one for wind speeds of 3.5-20 m/sec.

To facilitate subsequent analyses, the data were then combined for all wind speeds and a persistence factor ≥ 0.71 and plotted in accordance with the eight cardinal compass directions. An example of this type of plot is presented in Figure 5.

These roses are useful in determining if high TSP levels are associated with a particular wind direction or directions. They are capable of showing the following types of influence from sources:

- Lack of any specific directional effect of sources on background stations.
- Diffuse influence of distant industrial complexes.
- Combination of diffuse influence from distant sources and nearby sources.
- Influence of nearby large sources.

Wind Frequency Analysis

As an aid in performing the analysis, the percent of time the wind blows from a particular direction (persistence ≥ 0.71) was determined from the Greater Pittsburgh Airport wind data. This wind frequency can be combined with the pollution rose information to determine the TSP level contribution from a particular compass sector.

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[3]Wind persistence factor is defined as the ratio of vector average wind to the average wind speed over the 24 hour Hi-Vol sampling period. A factor near 1.0 indicates a wind that blows consistently from one direction during the entire sampling period. A persistence factor ≥ 0.71 is equivalent to an hourly wind direction deviation of 45^{0}.

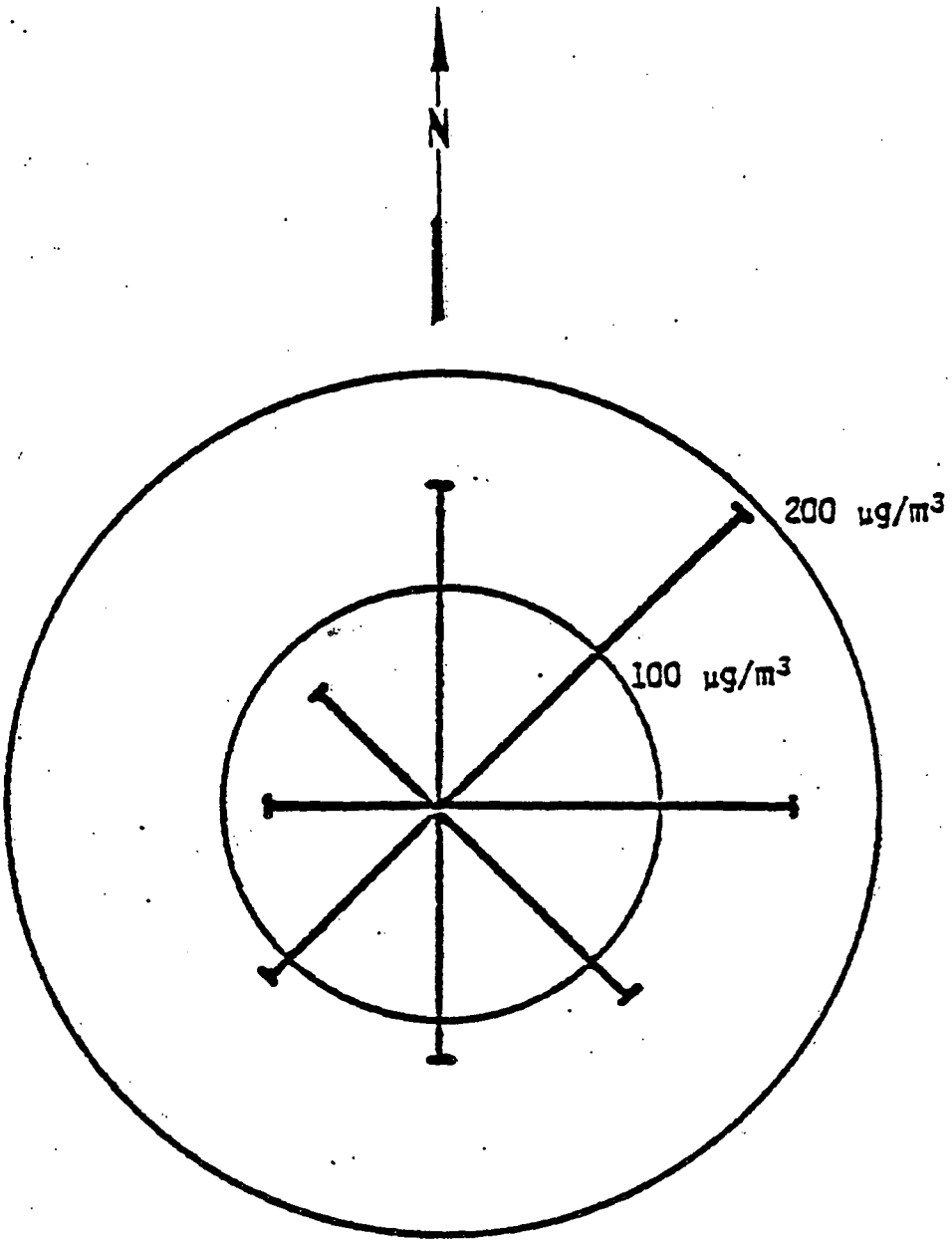

Figure 5. Example of Integrated Pollution Rose for TSP Data.
(1975-1977 Data for Station 8601 - Clairton)

Isopleth Maps of Particulate Patterns

Data for generating particulate isopleths, or lines of constant concentration, were developed with the help of the U.S. Steel Research Center. The TSP data were stratified into periods when wind conditions over the sampling wind period met certain criteria: wind direction within one of the eight compass sectors on days with persistence ≥ 0.71 and within two wind speed classes (0-3.5 m/sec and 3.5-20 m/sec). The average TSP concentrations for each site, for each wind direction, and for the two wind speed regimes were then combined, based on the number of observations, to give the TSP concentrations for each wind direction for all wind speeds. These values were then used to form isopleth maps representing particulate concentrations associated with winds from each of the compass directions. An example of such a map is presented in Figure 6. Recognizing the general locations of the industrial and urban sources, these isopleth patterns show the effect of wind "smearing" of these emissions downwind of the sources.

Contribution of Steel Plant Emissions to Selected Monitors

Under the sponsorship of the steel companies with plants in Allegheny County, Energy Impact Associates (EIA) of Pittsburgh, Pennsylvania, carried out an indepth assessment of the particulate impact of each of the steel making facilities on selected monitors. The work consisted of the following elements:

- Development of a detailed in-plant particulate source inventory including emission estimates for fugitive sources.
- Development and application of a model for predicting ambient particulate concentrations. The model accounts for particulate loss through deposition.

EIA's calculations were in terms of the yearly arithmetic averages for 1976 and 1982, utilizing Greater Pittsburgh Airport winds. EIA stratified the impact in terms of point, process fugitive, and non-traditional sources from within the plant area. We then adjusted the 1976 averages to the three-year average data base on which our analysis was based by simple ratioing.

Particulate Identification Analysis

A field sampling program was conducted which collected TSP samples using membrane type Hi-Vol filters at 12 different Hi-Vol sites in the County. A total of 50 samples was collected including 33 ambient samples (21 day, 12 night), 15 control samples, and 2 special test filters. The sampling was conducted under carefully specified wind and stability conditions for each sampling group by Denardo and McFarland Weather Service, Inc.

Each ambient and reference filter was analyzed by computer-controlled Scanning Electron Microscopy/Energy Dispersion X-Ray Analysis(SEM/EDAX). This

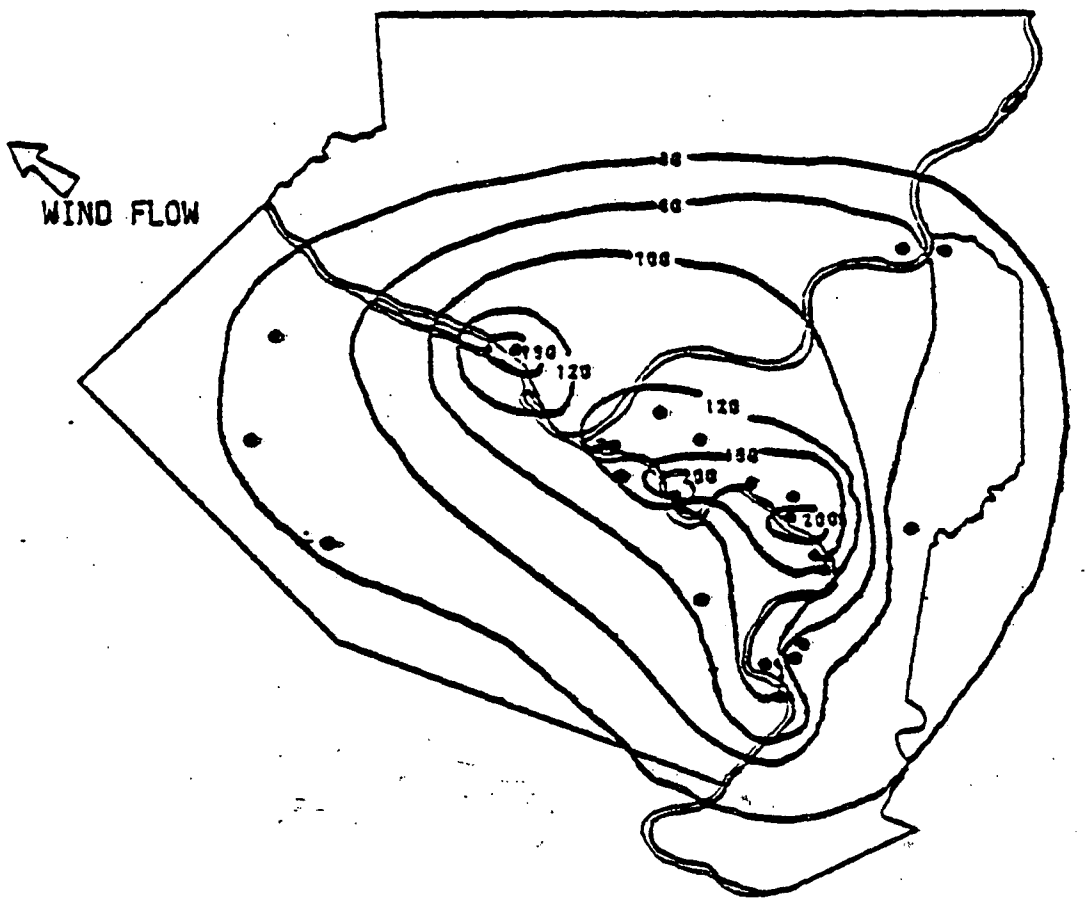

Figure 6. Example of Isopleth Map Showing Pattern of TSP Levels in $\mu g/m^3$. Example is for Southeast Winds.

technique classifies particles into various types. The particles are then classified as being from traditional or non-traditional sources by comparing chemistries, sizes, and shapes of particles on the ambient filters with particles from control samples taken from various industrial processes, as well as from known sources of non-traditional particles such as clay, sand, and street dust. This analysis was performed by Materials Consultants & Laboratories, Inc. (MCL), Monroeville, Pennsylvania. They provided TRC with the following information:

- The distribution of particles by size in terms of 48 different particle chemistries (plus a miscellaneous category) for ambient filters collected under specified meteorological conditions and for 17 reference samples representing various traditional and non-traditional sources.

- The percentage by weight of large particles (>15 μm) and the chemistries of such particles.

- A description of the 49 particle chemistries in terms of most probable sources, both traditional and non-traditional.

TRC carried the MCL description of particle chemistries one step further by estimating the relative percentages of traditional, in-plant non-traditional, and urban non-traditional particulate making up each of the particle chemistries. These estimates were then applied to the results of the filter analyses made by MCL. The estimated percentages were multiplied by the weight percentages for each of the particle chemistries making up essentially all of the total weight of the filter catch. The contributions were then summed and the resulting percentage breakdown of traditional, in-plant non-traditional, and urban non-traditional components were tabulated for each sample.

INTEGRATED APPLICATION OF TECHNIQUES

Using the results of the previously described analyses along with other published information it was possible to determine the approximate background TSP level for the County as well as the approximate non-traditional and traditional components of the mean TSP level at each monitoring site. The following subsections describe the procedures used.

Before discussing the relative contribution of various components of the TSP measurement, consideration must be given as to which of the two standards is the more restrictive: annual geometric mean of 75 $\mu g/m^3$ or the short term standard of no more than one 24-hour value exceeding 260 $\mu g/m^3$. The method used consisted of computing the standard geometric deviation (SGD) for the data from each station and comparing this with the SGD for the standards. The SGD of the primary standards is the slope of the line of a log-probability plot passing through both the 24-hour and annual standard. If the SGD of the monitor data is greater than the SGD of the standard, the short-term standard is more restrictive. Conversely, in the SGD of the monitor is less than that for the standards, the annual standard is more restrictive.

The results of this comparison showed that, with only a few exceptions, the annual standard was the more restrictive and was therefore used as a basis for the further analyses.

Background Component

For purposes of developing a control strategy for particulate matter, background concentrations must be taken into consideration. As used in the study, "background concentration" is that portion of the measured ambient levels of particulate matter which is not attributable to emissions from manmade sources within the County. This is essentially material that is transported into the study area from external sources over which the County has no control and material generated within the County from natural and agricultural sources. The mean background TSP level was established through the use of an "eclectic" particulate rose and the frequency of wind direction.

To remove the impact of Allegheny County sources on TSP levels within the County, only those wind directions not associated with County sources were chosen at two selected monitoring sites located at the far southwest and northeast edges of the County. The TSP concentrations at these sites were then obtained for all days with a wind persistence factor ≥ 0.71. These were classified by wind direction sector and the mean of each data set was calculated. A composite (or "eclectic") particulate rose was constructed utilizing the wind direction dependent values from the two sites associated only with wind directions not associated with County sources. To determine a weighted mean background level, the percent of time the wind blew from each directional sector was used. The mean TSP level for each directional category was multiplied by the frequency of wind from that category and the results were summed for all eight categories in order to give the weighted mean.

The weighted values obtained were assumed to be composed of transported material, home heating, vehicle exhaust, reentrained road dust, tire rubber, and natural and agricultural sources. Since the sites used are located in relatively rural or suburban locations and due to the wind directions chosen, the contributions from home heating and vehicles were assumed to be quite small. Representative values for the emissions from these two sources were chosen using published information. A background TSP level for Allegheny County was thus established. In subsequent analyses, this background level was applied uniformly to data at all sampling sites within the County.

The background level developed for Allegheny County is 51 $\mu g/m^3$ annual average and 48 $\mu g/m^3$ annual geometric mean. These levels are high when compared with other urban areas, but considering the strength of industrial sources to the west and southwest of the County, this level of background is considered reasonable. Other investigators using less rigorous techniques have confirmed that background levels of this order should be expected for Allegheny County.

One other background value was computed in order to provide some information on the transported portion of the background level. It was assumed

that on days with sufficient snow cover, with greater than 0.5 centimeters of precipitation, or following days with greater than 0.5 centimeters of precipitation, the only contributors to the Hi-Vol filter would be home heating, vehicle exhaust, and transported material from outside the County for "eclectic" wind directions. The rain and snow would suppress the fugitive dust sources. The meteorological data for the three-year study period were examined and those days meeting the above criteria and with wind persistence ≥ 0.71 were noted. The TSP levels at the background sites were then obtained for those particular days, sorted by wind direction, averaged and weighted as before.

The value obtained was assumed to consist of home heating, vehicle exhaust, and material transported from outside the County. As before, using published information, the combined effects for home heating and vehicle exhaust were estimated. A value was thus established for the "wet" background level, or amount due to transport, in Allegheny County. This value is 36 $\mu g/m^3$ annual average.

Traditional and Non-Traditional Components

Once the background level has been determined and subtracted from the three-year mean, the remainder will be composed of traditional and non-traditional components. For the purposes of the study, the traditional component was assumed to be composed of industry-related sources (stack, process fugitive, and inplant fugitives) and other fuel combustion sources (home heating) that impact the sampler directly. The non-traditional component was assumed to be composed of vehicle-related emissions (reentrained dust, tire rubber, exhaust, brake linings, etc.), construction-related sources, and other miscellaneous non-industrial sources.

To obtain the approximate component breakdown at each site, a variety of methods was used which encompassed any or all of the analyses described previously along with other published data calculation methods. The details of the evaluation at each site will not be described here since they are quite involved and would require lengthy explanations. However, the general methods used will be discussed and some examples will be given.

Pollution roses were used extensively in the analyses of the sites. The first step was to subtract the values of the background rose from the site-specific rose. The remainder could then be examined in relation to the directions of traditional sources and to the directions of local non-traditional sources (from the site evaluations) and a good indication of the non-traditional and traditional contributions could be obtained.

The results of the EIA study were also used extensively. This study was a rigorous treatment of the impact of steel mill sources on selected monitors and was considered to be a fair representation of the actual conditions. A few of EIA's results were modified where it appeared that part of their contribution was more properly labeled "non-traditional" than "traditional." The MCL results were used as a check of the findings of the EIA near-field modeling study.

Direct, day-by-day comparison of TSP levels at various sites resulted in valuable information on component breakdown. This was particulary useful at sites that were in close proximity or that were in very similar geographical locations. For example, it was seen that for wind directions not associated with the traditional sources, the daily TSP levels at site A were consistently 10-20 $\mu g/m^3$ higher than the levels at a neighboring site B. This indicated that the non-traditional influence was about 15 $\mu g/m^3$ higher at site A.

At several sites, engineering judgements were made as to the effect of traditional sources. For instance, it was assumed that two of the rural sites, located in the western part of the County, would be affected identically by the traditional sources within the County, due to their approximately equal distance from the source locations.

The site evaluations were also of great importance since they indicated the location and size of local fugitive dust sources such as playgrounds and parking lots.

The other analyses, such as the seasonal variations, wet/dry comparisons, weekday/weekend comparisons, etc, were valuable in providing indications of whether the non-traditional or traditional sources predominated.

SECTION 4

RESULTS OF THE MANAGEMENT STUDY

By the procedure outlined in the previous section, the component breakdown at each site was determined. The breakdown was calculated both in terms of arithmetic and geometric means. The final results, in terms of the arithmetic means, are reproduced in Table 1.

An examination of this table reveals the relative contributions of the traditional and non-traditional components of the mean TSP levels at each of the sites within Allegheny County. It can be seen that several sites, such as the Court House (5802) and Pittsburgh Airport (4401), are predominantly affected by traffic and other non-traditional sources, while others, such as the Braddock stations (7102 and 7104), are dominated by traditional sources. These sites are impacted primarily by the Edgar Thompson Works of U.S. Steel. Several stations such as Swissvale (7004) and Hazelwood 2 (6904), are affected fairly evenly by both traditional and non-traditional sources.

It should be noted that the values presented in Table 1 are based on a wide variety of techniques plus a considerable amount of engineering judgement. It is not possible to assign confidence levels in statistical terms to the values. However, we believe that the values are an accurate assessment of the relative contribution of various sources to particulate levels in Allegheny County. Individual values should not be taken as firm figures. The pollution roses were generated using airport winds and these have been shown by EIA to vary considerable from local winds. There are numerous topographical features in Allegheny County that have large effects on airflow patterns. Nevertheless, the patterns of contributions as a whole are a reasonable approximation of the true picture and TRC believes they are an adequate basis for the development of particulate control strategies to meet air quality standards by 1982. Furthermore, we believe that the approach used here, which relies upon a variety of methods and a considerable amount of engineering judgement, is a considerable improvement over the traditional approach of using source inventories together with unvalidated models. To gain further insight as to the exact components and their sources at each site, more detailed studies and measurements are warranted.

TABLE 1. ANNUAL ARITHMETIC AVERAGE COMPONENT BREAKDOWN FOR PARTICULATE MATTER IN ALLEGHENY COUNTY (1975-1977) - $\mu g/m^3$

Site Number	Site Location	3-Year Arithmetic Average	Back-Ground	Traditional		Non-Traditional	
				Stack	Other Trad.	Industrial	Urban
3001	Logan's Ferry	73	51	5	4	8	5
3101	Springdale	71	51	5	3	7	5
4401	Greater Pitt. Airport	81	51	1	2	2	25
4601	Bellevue	110	51	5	7	22	25
5602	Murray Towers	102	51	2	3	7	39
5702	Central Lab	118	51	2	3	7	55
5801	County Office Bldg.	101	51	2	3	7	38
5802	Court House	184	51	2	3	7	121
6201	North Fayette	66	51	1	2	2	10
6903	Hazelwood 1	107	51	3	13	15	25
6904	Hazelwood 2[a]	142	51	5	22	24	40
6905	Kaufmann	81	51	2	3	7	18
7004	Swissvale[a]	150	51	8	25	56	10
7102	Braddock[a]	164	51	7[b]	32[b]	61[b]	13
7104	North Braddock[a]	131	51	7[c]	13[c]	50[c]	10
7201	Wall	81	51	2	4	4	20
7502	Duquesne 1[a]	117	51	8[c]	14[c]	32[c]	12
7570	Duquesne 2	143	51	8	14	32	38
7601	Allegheny Co. Airport	83	51	2	5	5	20
8001	South Fayette	61	51	1	2	2	5
8601	Clairton[a]	110	51	19[d]	7[d]	22[d]	11
8602	Glassport[a]	134	51	19[d]	4[d]	44[d]	16
8702	Liberty[a]	123	51	15[e]	3[e]	20[e]	34
8704	Coursin Hollow[a]	110	51	22[e]	4[e]	20[e]	13

(a) Based on component breakdown for point, other traditional, and industrial non-traditional as computed by EIA.

(b) These values reduced from EIA's values proportionally for a total of 20 $\mu g/m^3$.

(c) These values reduced from EIA's values proportionally for a total of 10 $\mu g/m^3$.

(d) These values reduced from EIA's values proportionally for a total of 5 $\mu g/m^3$.

(e) These values reduced from EIA's values proportionally for a total of 15 $\mu g/m^3$.

SECTION 5

CRITIQUE OF THE METHODOLOGY USED IN THE MANAGEMENT STUDY

As a means of determining the relative contributions of sources for the development of control strategies, the methodology described in this report has been effective. The methods used provided a thorough understanding of the nature of the particulate problem in Allegheny County. The interpretation of the information developed led to the isolation of the contributing sources. In particular, the following analyses should be included in a study of this type:

- Trend analyses
- Site analyses - these must be done in order to identify local influences that could affect the sampler data
- Monthly/seasonal analyses
- Pollution roses
- Filter analyses

The other analyses that were performed were more useful as indicators of whether traditional or non-traditional sources predominated at any particular site, rather than as methods to identify an individual source. These analyses are:

- Log-normal plots
- Weekday/weekend analyses
- Relative frequency plots
- Wet day/dry day analyses
- Isopleth contours

While the methodology was effective, there are several things that should be done to improve its usefulness in future studies. The following items should be considered by environmental managers:

- The overall placement of particulate samplers should be reviewed in relation to sources and human exposure, as a means of truly representing attainment or non-attainment of air quality standards and providing adequate geographical coverage of the entire study area. Usually, large portions of an area are not covered by sampling sites, while there is considerable redundancy of sampling in so-called "hot spots."

- Rather than relying on meteorological data from one location, such as the nearest airport, detailed meteorological measurements should be recorded simultaneously with the sampler data at each site or at least in several different representative locations. The local winds can vary significantly from location to location and the determination of the local wind patterns can greatly help in source identification.

- Continuous TSP data should be obtained at several sampler locations (i.e., daily, rather than every third or sixth day) to allow for the influence of traffic, as well as providing more detailed information on TSP patterns in relation to meteorological influences and variations in source strengths.

- Traffic flow data should be obtained concurrently with the TSP sampling data to allow for the correlation between these two parameters. The data should be stratified by day of the week. This would enable the weekday/weekend analysis to be a more useful analytical technique, and would also allow a slant distance analysis to be performed.[4]

- Information on the mixing depth, or the depth of the low-lying unstable layer of air below a stable inversion layer which limits atmospheric dilution of pollutants, would be very useful in establishing the relationship between inversions and TSP levels.

- More statistical analyses, such as correlation between particulate levels and variables such as wind and other meteorological conditions, could be performed on the data to establish confidence levels.

Two other points to make here that might be of help to the environmental manager are the use of predictive modeling and the use of particle identification studies.

- TRC feels that the state-of-the-art of predictive modeling is inadequate at this time to determine with precision the relative contributions of traditional and non-traditional sources in large urban areas. Attempting to use models in any general way based on the currently available information could lead to erroneous conclusions and ill-conceived strategies for control of particulate matter. This statement is not applicable to situations where

[4]Several published studies (e.g., National Assessment of the Urban Particulate Problem. Volume I. National Assessment. Lynn, D.A., et.al., EPA-450/3-76-024, July, 1976) indicate that there is a direct relationship between the daily TSP concentration and average daily level of traffic and an inverse relationship between TSP and the distance of the Hi-Vol sampler from the traffic, measured by the slant distance.

sources can be specified in detail as to configuration, mechanism of generation, and particle size of emissions; where the model can accept and deal with all of the above inputs plus complex terrain; and where meteorological measurements for application of the model have been made in the near vicinity of sources and receptors. Such a rigorous approach was used in the special near-field study by EIA described earlier in this report.

- In this program, particle identification techniques were used to establish the source origins of various types of particles. While such methods provide information on the mechanisms by which particles are formed, they do not necessarily show the path by which the particles arrived at the samplers. In developing air quality control strategies, the path followed by a particle is an important factor. For example, did the particle arrive directly from a process, or did it deposit on the ground and become entrained? Samples collected for particle identification must be carefully planned, and samples under enough meteorological and source strength conditions must be collected to be able to establish overall contributions of specific sources to a given sampling location.

The objective of our analysis was to use available data to determine the relative contributions of industrial sources (traditional and non-traditional), non-traditional sources, and background at selected sites in the County that we believed to be indicative of the particulate problem and could help lead the way to strategies for particulate control. The methodology described in this report has been effective in obtaining this objective.

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16. ABSTRACT The report is a case history for an environmental management study to determine what pollution sources are the principal determinants of environmental quality in Allegheny County, PA. The study was conducted for the Allegheny County Health Department, Bureau of Air Pollution Control, in Pittsburgh, PA. Results were used as part of Allegheny County's contribution to the State Implementation Plan for achieving air quality standards for total suspended particulate matter (TSP). Techniques used in this ambient-correlation study include: (1) analysis of present air quality and trends; (2) log-normal distributions; (3) relative frequency of TSP levels; (4) monthly variations in TSP levels; (5) weekday/weekend analysis; (6) wet-day/dry-day analysis; (7) analysis of pollution roses; (8) wind frequency analysis; (9) isopleth maps; (10) contribution of steel plant emissions by modeling; and (11) particulate identification analysis. The report describes the integrated application of these techniques to determine the background traditional and nontraditional components of the ambient TSP levels. Study results include estimates of the relative source strengths of the particulates, the relative impacts of the sources, and the level of confidence of these results.

17. KEY WORDS AND DOCUMENT ANALYSIS		
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