# REPORT FOR CONSULTATION ON THE METROPOLITAN PITTSBURGH INTRASTATE AIR QUALITY CONTROL REGION

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
National Air Pollution Control Administration

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# METROPOLITAN PITTSBURGH

# INTRASTATE AIR QUALITY CONTROL REGION

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
NATIONAL AIR POLLUTION CONTROL ADMINISTRATION
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## PREFACE

The Secretary, Department of Health, Education, and Welfare, is directed by the Air Quality Act of 1967 to designate "air quality control regions" to provide a basis for the establishment of air quality standards and the implementation of air quality control programs. In addition to listing the major factors to be considered in the designation of region boundaries, the Act stipulates that the designation of a region shall be preceded by a consultation with appropriate State and local authorities.

The National Air Pollution Control Administration, DHEW, has conducted a study of the Metropolitan Pittsburgh urban area, the results of which are presented in this report. The boundaries of the Region*, as proposed in this report, reflect consideration of all available and pertinent data; however, the boundaries remain subject to revision suggested by consultation with State and local authorities. Formal designation will be withheld pending the outcome of that consultation.

The Administration is appreciative of assistance received either directly during the course of this study or during previous activities in the metropolitan Pittsburgh area from the Division of Air Pollution Control of the Pennsylvania Department of Health and the Allegheny County Bureau of Air Pollution Control. Useful data was also supplied

*For the purposes of this report, the word region, when capitalized, will refer to the Metropolitan Pittsburgh Intrastate Air Quality Control Region. When not capitalized, unless otherwise noted, it will refer to air quality control regions in general.

by the Southwestern Pennsylvania Regional Planning Commission, the Southwestern Pennsylvania Economic Development District, and the Pennsylvania State Planning Board.

# INTRODUCTION

> "For the purpose of establishing ambient air quality standards pursuant to section 108, and for administrative and other purposes, the Secretary, after consultation with appropriate State and local authorities shall, to the extent feasible, within 18 months after the date of enactment of the Air Quality Act of 1967 designate air quality control regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards. The Secretary may from time to time thereafter, as he determines necessary to protect the public health and welfare and after consultation with appropriate State and local authorities, revise the designation of such regions and designate additional air quality control regions. The Secretary shall immediately notify the Governor or Governors of the affected State or States of such designation."
>
> Section 107(a)(2), Air Quality Act of 1967

## THE AIR QUALITY ACT

Air Pollution in most of the Nation's urban areas is a regional problem. This regional problem demands a regional solution, consisting of coordinated planning, data gathering, standard setting, and enforcement. Yet, with few exceptions, such coordinated efforts are notably absent among the Nation's urban complexes.

Beginning with the Section quoted above, in which the Secretary is required to designate air quality control regions, the Air Quality Act presents an approach to air pollution control involving coordinated efforts by Federal, State, and local governments, as shown in Figure 1. After the Secretary has (1) designated regions, (2) published air quality criteria, and (3) published corresponding documents on control

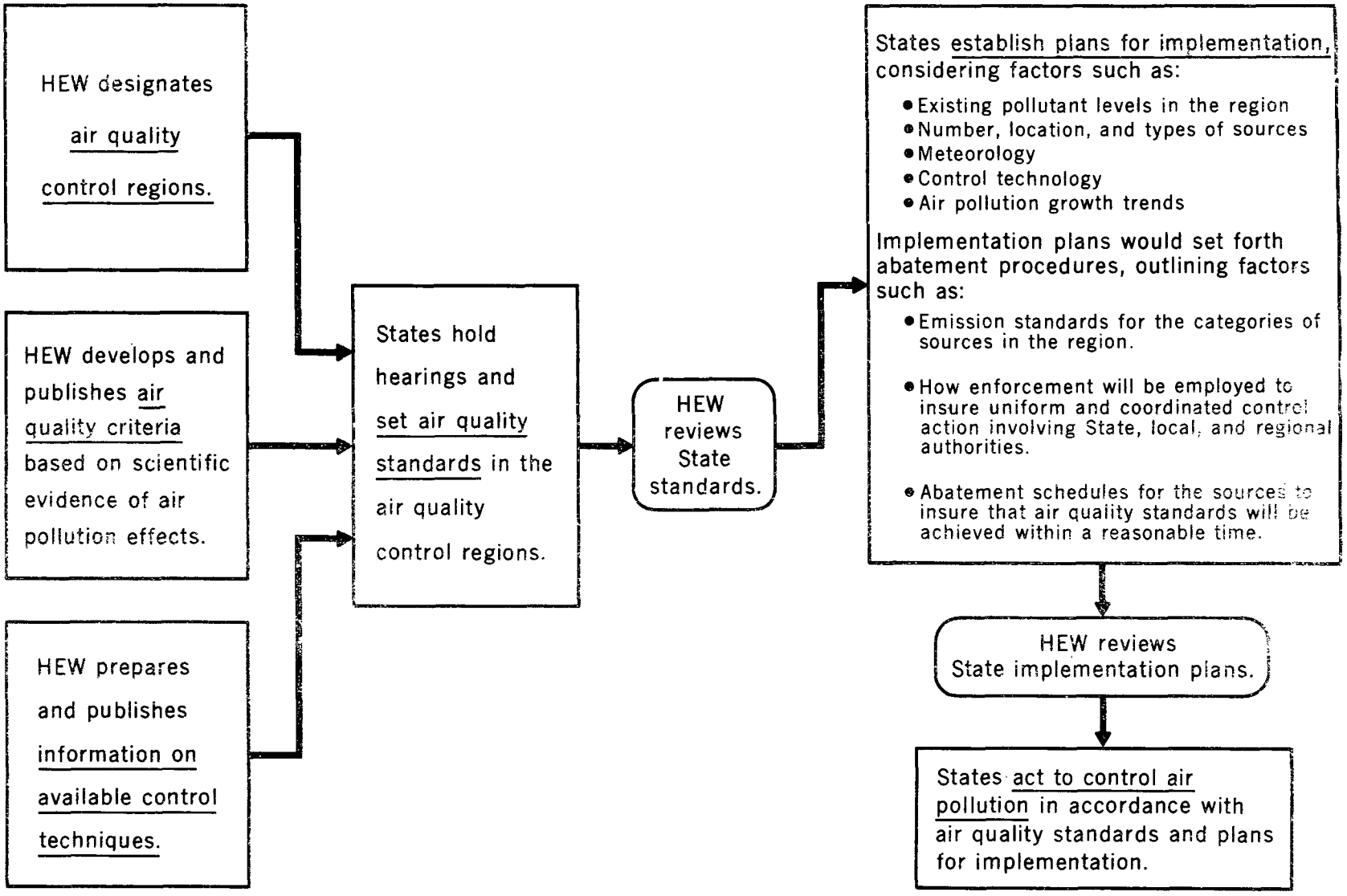


Figure 1. Flow diagram for State action to control air pollution on a regional basis.

technology and associated costs, the Governor(s) of the States(s) must file with the Secretary within 90 days a letter of intent, indicating that the States(s) will adopt within 180 days ambient air quality standards for the pollutants covered by the published criteria and control technology documents and adopt within an additional 180 days plans for the implementation, maintenance, and enforcement of those standards in the designated air quality control region.

The new Federal legislation provides for a regional attack on air pollution and, at the same time, allows latitude in the form which regional efforts may take. While the Secretary retains approval authority, the States(s) involved in a designated region assumes the responsibility for developing standards and an implementation plan which includes administrative procedures for abatement and control. Informal cooperative arrangements with proper safeguards may be adequate in some regions, whereas in others, more formal arrangements, such as interstate compacts, may be selected. The objective in each instance will be to provide effective mechanisms for control on a regional basis.

## THE SIZE OF A REGION

Several objectives are important in determining how large an air quality control region should be. Basically, these objectives can be divided into three separate categories. First a region should be self-contained with respect to air pollution sources and receptors. In other words, a region should include most of the important sources in the area as well as most of the people and property affected by those sources.

In this way, all the major elements of the regional problem will lie within one unified administrative jurisdiction. Unfortunately, since air pollutants can travel long distances, it is impractical if not impossible to delineate regions which are completely self-contained. The air over a region will usually have at least trace amounts of pollutants from external sources. During episodic conditions, such contributions from external sources may even reach significant levels. Conversely, air pollution generated within a region and transported out of it can affect external receptors to some degree. It would be impractical and inefficient to make all air quality control regions large enough to encompass these low-level effects. The geographic extent of trace effects overestimates the true problem area which should be the focus of air pollution control efforts. Thus, the first objective, that a region be self-contained, becomes a question of relative magnitude and frequency. The dividing line between "important influence" and "trace effect" will be a matter of judgement. The judgement should be based on estimates of the impact a source has upon a region, and the level of pollution to which receptors are subjected. In this respect, annual and seasonal data on pollutant emissions and ambient air concentrations are a better measure of relative influence than short term data on episodic conditions.

The second general objective requires that region boundaries be designed to meet not only present conditions but also future conditions. In other words, the region should include areas where industrial and residential expansion are likely to create air pollution problems in the foreseeable future. This objective requires careful consideration

of existing metropolitan development plans, expected population growth, and projected industrial expansion. Such considerations should result in the designation of regions which will contain the sources and receptors of regional air pollution for a number of years to come. Of course, region boundaries need not be permanently fixed, once designated. Boundaries should be reviewed periodically and altered when changing conditions warrant readjustment.

The third objective is that region boundaries should be compatible with and even foster unified and cooperative governmental administration of the air resource throughout the region. Air pollution is a regional problem which often extends across several municipal, county, and even state boundaries. Clearly, the collaboration of several governmental jurisdictions is prerequisite to the solution of the problem. Therefore, the region should be delineated in a way which encourages regional cooperation among the various governmental bodies involved in air pollution control. In this regard, the existing pattern of governmental cooperation on the whole range of urban problems may become an important consideration. Certainly the pattern of cooperation among existing air pollution control programs is a relevant factor. In general, administrative considerations dictate that governmental jurisdictions should not be divided. Although it would be impractical to preserve State jurisdictions undivided, usually it is possible to preserve the unity of county governments by including or excluding them in their entirety. Occasionally, even this would be impractical due to a county's large size, wide variation in level of development, or striking topographical features.

To the extent that any two of the above three objectives lead to incompatible conclusions concerning region boundaries, the region must represent a reasonable compromise. A region should represent the best way of satisfying the three objectives simultaneously.

PROCEDURE FOR DESIGNATION OF REGIONS

Figure 2 illustrates the procedures used by the National Air Pollution Control Administration for designating air quality control regions.

A preliminary delineation of the region is developed by bringing together two essentially separate studies - the "Evaluation of Engineering Factors," and the "Evaluation of Urban Factors."

The "Evaluation of Engineering Factors" considers pollutant source locations and the geographic extent of significant pollutant concentrations in the ambient air. An inventory of air pollutant emissions determines the geographic location and quantities of the various pollutants emitted from the sources in a region. Major quantities of pollution are emitted by automobiles and industry, and from refuse disposal operations, power generation, and space heating. The subsequent effect of the pollution emitted into the atmosphere is determined by measuring ambient air quality. The air quality analysis presented in this report is divided into two major parts. The first part deals with the topography and meteorology of the area and measured air quality based on past studies in southwestern Pennsylvania. It relates how the topography influences the meteorology in the area, and how both these factors affect air quality. The second part of the analysis describes the results of the diffusion model applied to

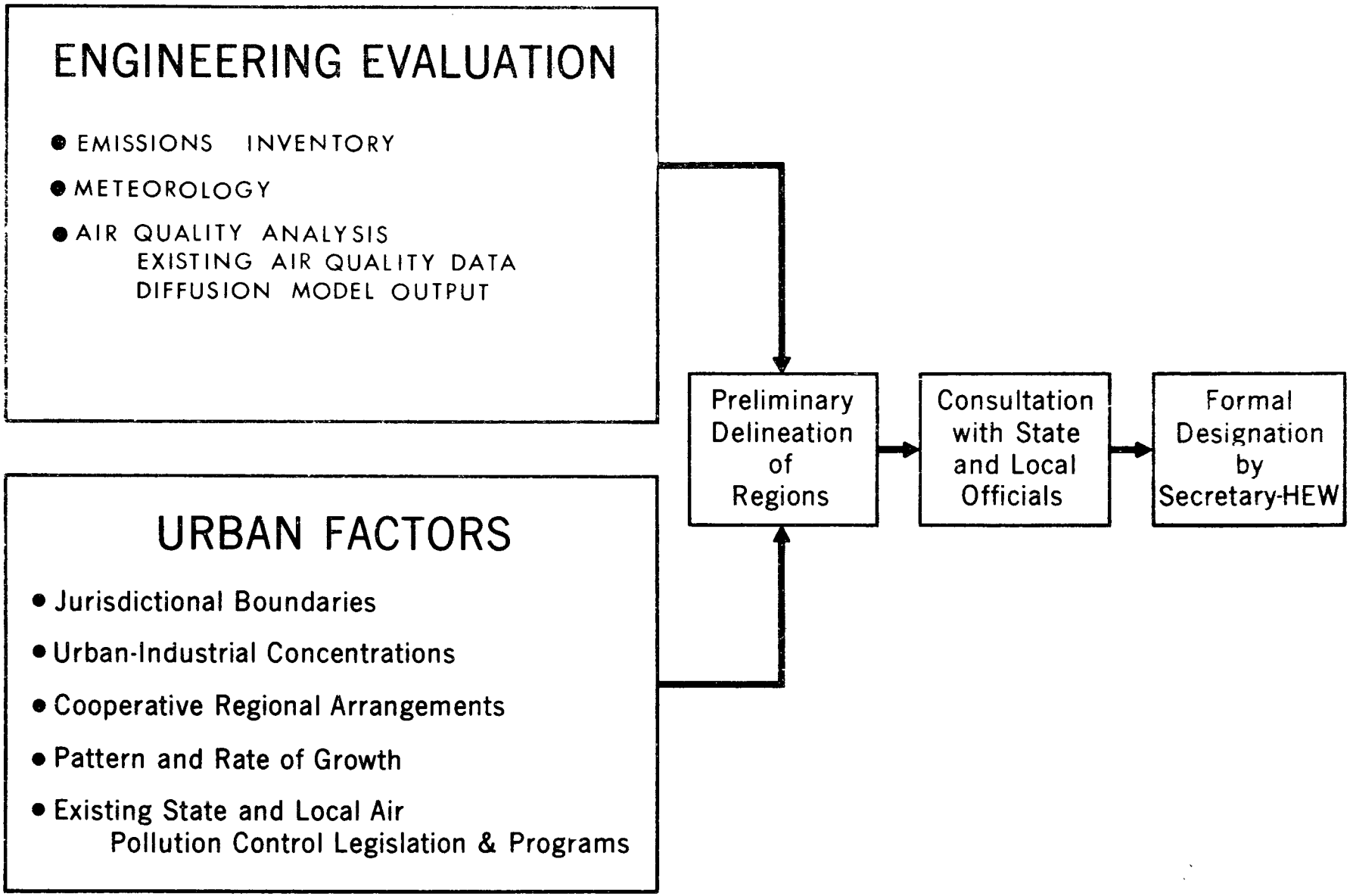


Figure 2. Flow diagram for the designation of air quality control regions.

the Pittsburgh area. It describes some of the limitations of the model in the area of concern. Some of the basic conclusions drawn from the model results, as they relate to the size of the proposed Region, are outlined.

The "Evaluation of Urban Factors" encompasses all considerations of a non-engineering nature. This evaluation consists of a review of existing governmental jurisdictions, current air pollution control programs, demographic data, current urbanization, and projected patterns of urbanization. The study of urban factors represents an attempt to determine the size of the region that is necessary to include areas where projected urbanization will create increasing air pollution problems.

The findings of the engineering evaluation are combined with the results of the urban factors evaluation, and an initial proposal for the air quality control region is made. As indicated in Figure 2, the proposal is submitted for consultation with State and local officials. After reviewing the official transcript of the consultation proceedings which provides the viewpoints of State and local officials toward the proposal, the Secretary formally designates the region. Formal designation includes a notice in the Federal Register and a notification to the Governor(s) of the State(s) affected by the designation.

The body of this report contains a proposal for the boundaries of the Metropolitan Pittsburgh Intrastate Air Quality Control Region and the engineering and urban factors evaluations supporting the proposal. The report itself is intended to serve as a background document for the formal consultation with appropriate State and local authorities.

# EVALUATION OF ENGINEERING FACTORS

## EMISSION INVENTORY

A quantitative evaluation of air pollutant emissions provides the basic framework for air conservation activities. The compilation of an emissions inventory makes possible the correlation of pollutant emissions with specific geographic locations. This procedure generally results in the identification of the "core" of an air quality control region----that is, the area where the bulk of the pollutant emissions occur. In this study, the emissions inventory results are further utilized as input data to a meteorological diffusion model. In this manner the spatial and temporal distribution of the pollution emitted into the atmosphere can be systematically predicted. For these reasons, a presentation of the emissions inventory results serves as a logical starting point in the engineering evaluation.

The emissions inventory for metropolitan Pittsburgh was conducted by the National Air Pollution Control Administration. The inventory was confined to the four county Pittsburgh Standard Metropolitan Statistical Area. The counties involved are Allegheny, Beaver, Washington and Westmoreland. The 3,054 square mile study area contains the bulk of the population (2,547,100 est. 1967) and urbanization associated with metropolitan Pittsburgh. Though pollutant sources located in counties adjacent to the study area are not considered, it is felt that the role of these outlying areas as receptors of inventoried pollutant emissions will be adequately described, in terms of ambient air quality, by the section entitled "AIR QUALITY ANALYSIS"

beginning on page 18.

The inventory method used, with some modification, for the evaluation of the quantities of the five major pollutants (sulfur oxides*, carbon monoxide, total particulates, hydrocarbons, and oxides of nitrogen) was the Public Health Service rapid survey technique for estimating pollutant emissions.[1] The pollutant emissions were calculated from data representative of the year 1967 using Public Health Service emission factors.[2] These factors represent statistical averages of the rate at which pollutants are emitted from the burning or processing of a given quantity of material (e.g., fuel consumption).

Emission estimates for the survey area were grouped in four general categories. These categories are transportation, refuse disposal, fuel combustion in stationary sources, and industrial process emissions. For the purposes of this report, only sulfur dioxide, carbon monoxide, and total particulate emissions are considered. These three pollutants best represent the spectrum of air pollution sources. Sulfur dioxide emissions best characterize fuel burning activities in stationary sources (77% of total emissions). Carbon monoxide emissions provide the best indication of the impact of the motor vehicle in an area. Ninety-one percent of the total CO emitted in the survey area during 1967 was attributed to the gasoline powered motor vehicle. Total particulate emissions provide an index of the noncombustible components of fuels. All pollution source types contribute

*Sulfur dioxide constitutes the overwhelming majority of sulfur oxide emissions. In this evaluation, sulfur oxide emissions are assumed to be composed entirely of sulfur dioxide. Therefore, $SO_2$ concentrations predicted by the diffusion model, while based on sulfur oxide emissions rather than $SO_2$ emissions, will not be significantly overestimated.

significantly to total particulate emissions, with the largest single source category, power plants, accountable for 34% of the total emissions. Table I provides a breakdown of $SO_2$, CO, and total particulate emissions by county according to source type in each of the four categories.

Geographic locations over the survey area are defined by the use of a grid system based on the Universal Transverse Mercator Projection (UTM). The numbered grid system is shown in Figure 3, superimposed over a map of the study area. Grid squares 5,000 meters on a side are used in the areas of most dense population and industrialization. Grid squares 10,000 meters and 20,000 meters on a side are used in areas of less dense urbanization. In certain instances the outlying portions of counties are not included in the grid zones. In those areas the air pollutant emissions are considered negligible.

Figures 4, 5, and 6 represent emission density maps for $SO_2$, CO, and total particulates respectively, based on the grid system. The density maps are constructed according to the yearly average daily emissions for each pollutant. The densities are computed on the basis of emissions from point sources and area sources within each grid zone. The areas of highest emissions are located within and immediately surrounding the City of Pittsburgh. Also, the Ohio, Allegheny, and Monongahela River valleys are areas of high emissions. This would be expected since most of the large industries in the area are located in these river valleys. Figure 7 shows the location of major pollutant point sources in the Pittsburgh area.

The air quality analysis presented in the next section will aid in defining the bounds of the Region on the basis of the effects of the area-wide pollutant emissions.

TABLE I. SUMMARY OF AIR POLLUTANT EMISSIONS IN THE METROPOLITAN PITTSBURGH STUDY AREA, 1967. (TONS/YEAR)

| | COUNTY | TRANSPORTATION | | | | COMBUSTION OF FUELS, STATIONARY SOURCES | | | | REFUSE DISPOSAL | | IND. PROCESS EMISSIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Road Vehicles | Aircraft | Railroads | Vessels | Industry | Steam-Elec. Utilities | Residential | Comm. & Inst. | Incineration | Open Burning | |
| Sulfur Dioxide | Allegheny | 2,600 | N | 505 | 130 | 49,300 | 137,100 | 4,200 | 9,250 | 450 | 100 | 179,000 |
| | Beaver | 350 | | 15* | | 158,900 | 0 | 4,330 | 7,450 | 20 | 25 | 14,200 |
| | Washington | 500 | | N* | | 163,400 | 76,400 | 7,260 | 8,600 | 5 | 25 | N.A. |
| | Westmoreland | 800 | | N* | | 63,500 | 22,100 | 10,000 | 3,700 | 0 | 50 | 9,000 |
| Total Partic. | Allegheny | 4,400 | 535 | 1,390 | 360 | 22,600 | 83,000 | 3,190 | 3,530 | 1,890 | 790 | 68,400 |
| | Beaver | 620 | | 40* | | 46,000 | 0 | 2,660 | 1,840 | 90 | 220 | 21,500 |
| | Washington | 1,900 | | N* | | 39,800 | 40,700 | 4,430 | 2,170 | 30 | 195 | N.A. |
| | Westmoreland | 1,200 | | N* | | 18,000 | 6,560 | 6,100 | 1,180 | 0 | 370 | 2,050 |
| Carbon Monoxide | Allegheny | 509,800 | 14,490 | 760 | 200 | 1,500 | 900 | 2,520 | 5,790 | 230 | 4,190 | N |
| | Beaver | 2,420 | | 20* | | 5,700 | 0 | 2,650 | 4,650 | 10 | 1,160 | N.A. |
| | Washington | 100,700 | | N* | | 6,110 | 870 | 4,500 | 10,400 | 5 | 1,050 | N.A. |
| | Westmoreland | 145,500 | | N* | | 2,400 | 130 | 6,150 | 3,870 | 0 | 1,970 | N.A. |

N: Negligible
NA: Information Not Available or Not Reported
*: Combined Total for Aircraft, Railroads, and Vessels.

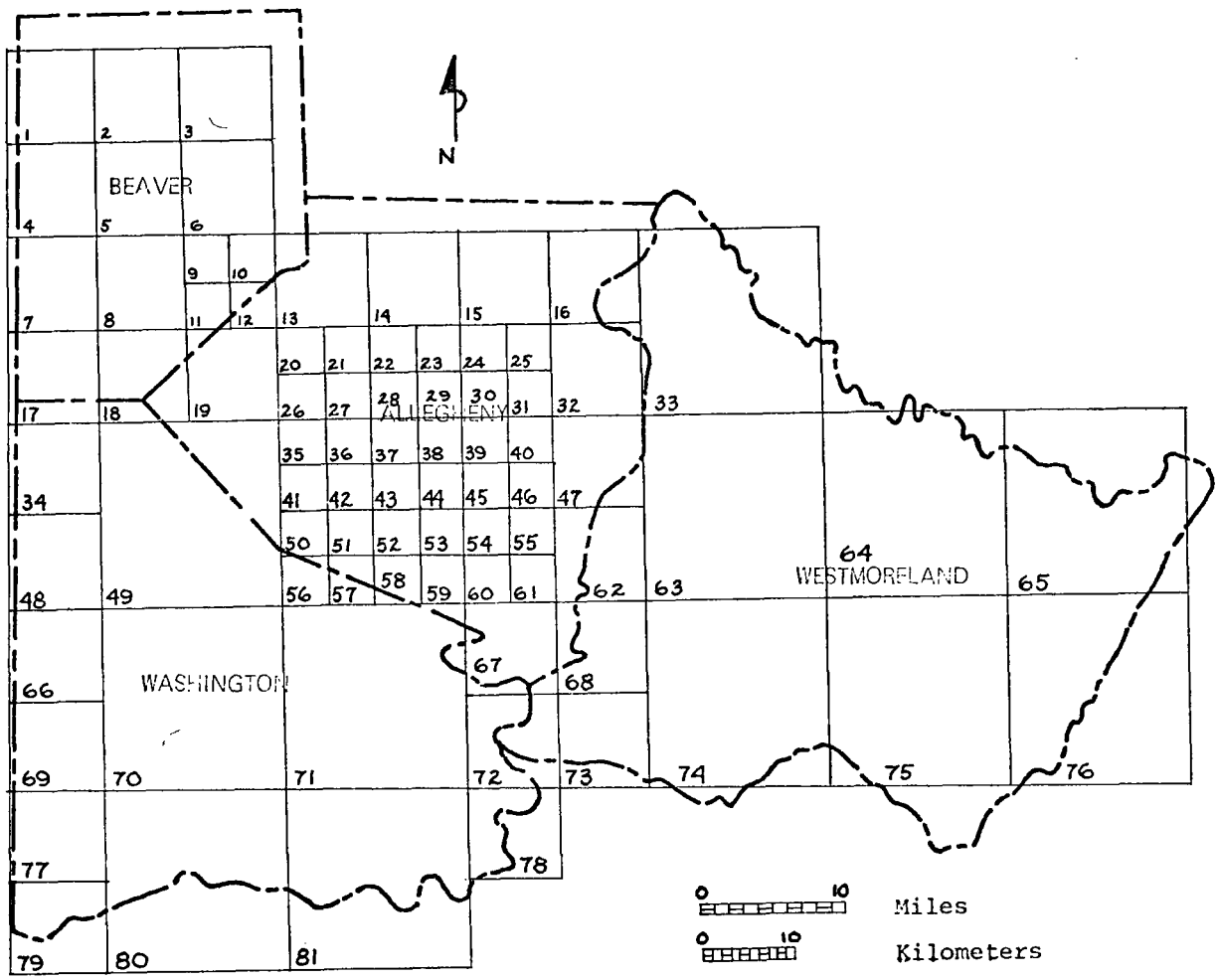


FIGURE 3. EMISSION INVENTORY NUMBERED GRID SYSTEM.

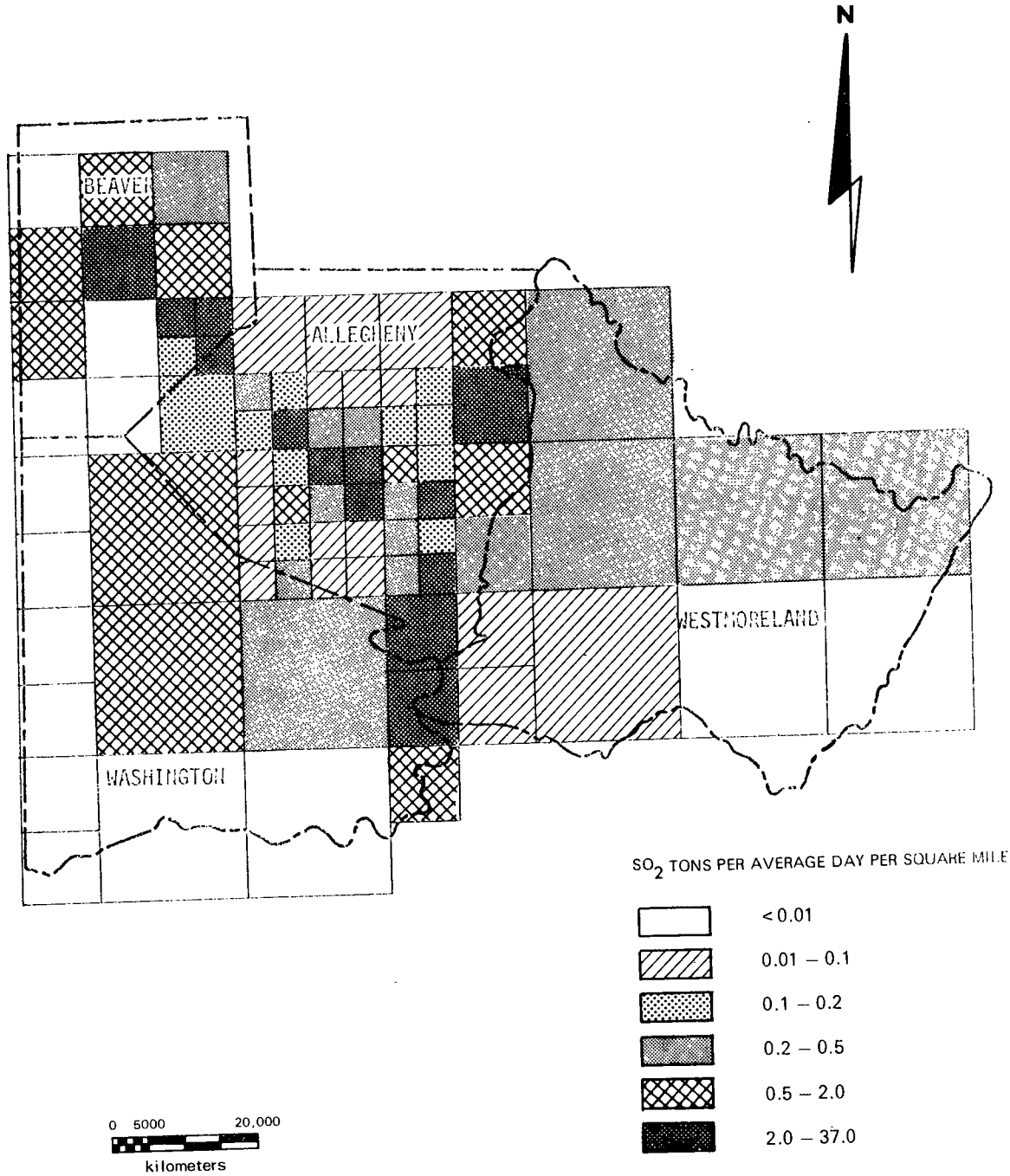


FIGURE 4. SULFUR DIOXIDE EMISSION DENSITIES.

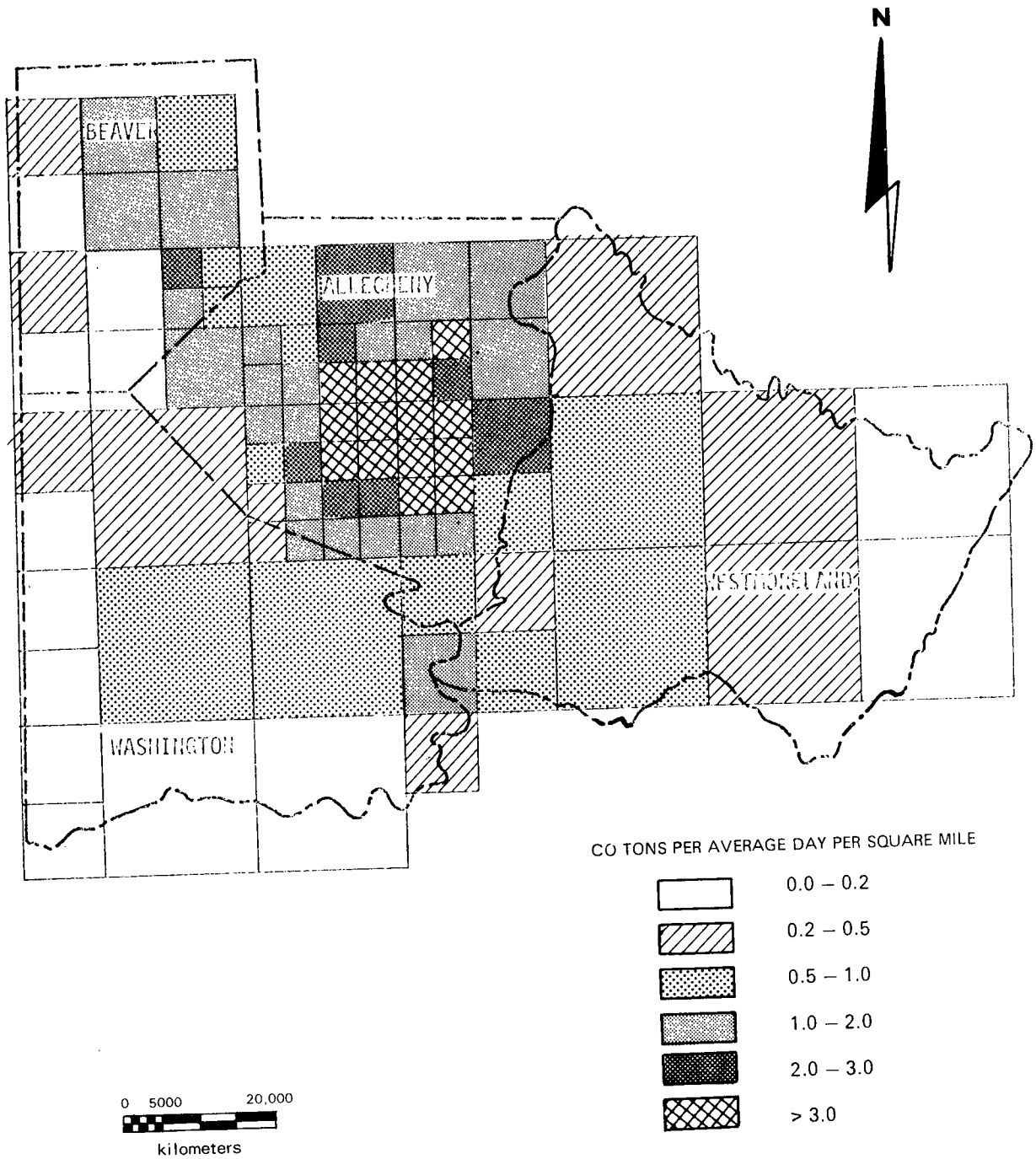


FIGURE 5. CARBON MONOXIDE EMISSION DENSITIES.

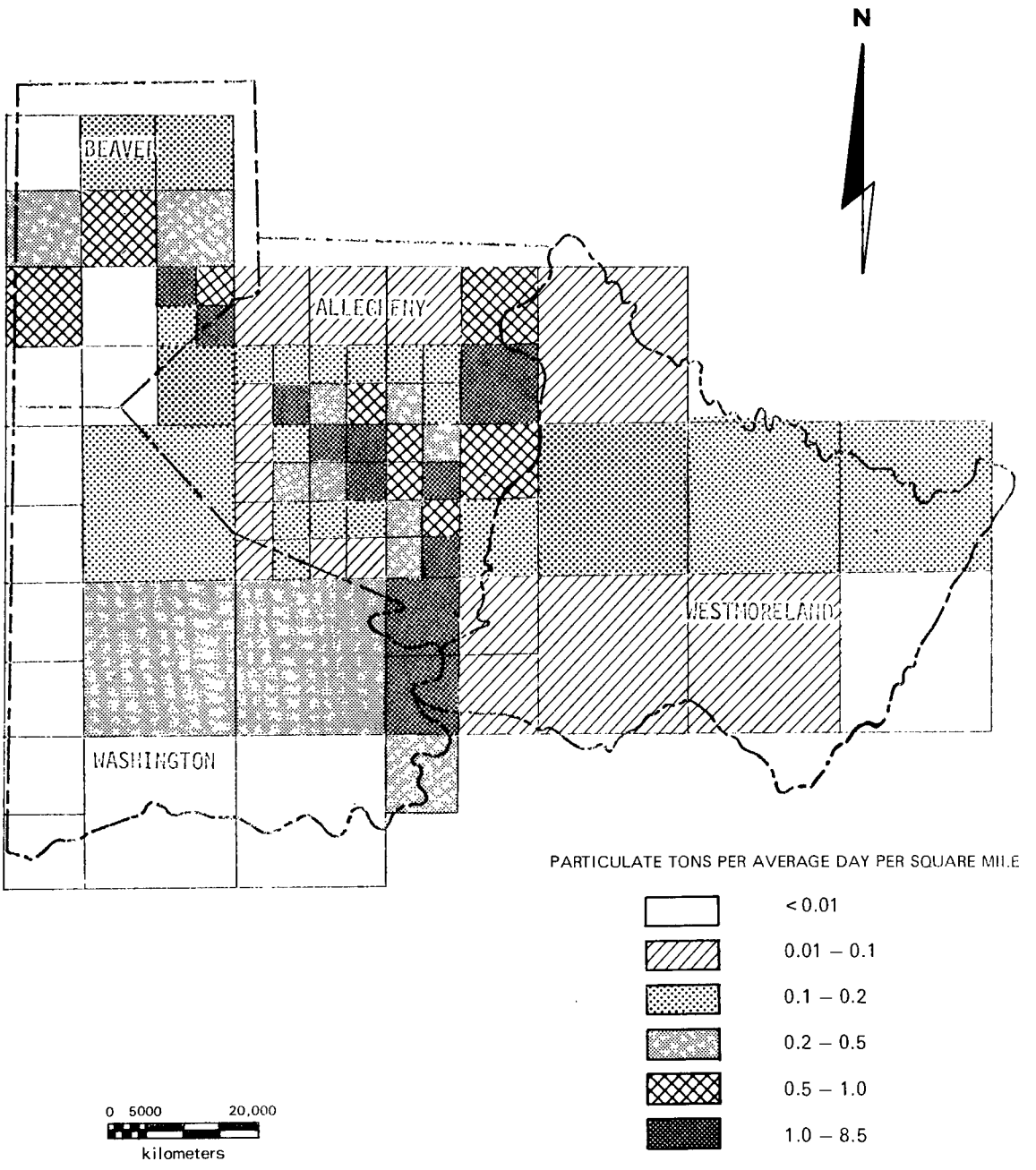


FIGURE 6. TOTAL PARTICULATE EMISSION DENSITIES.

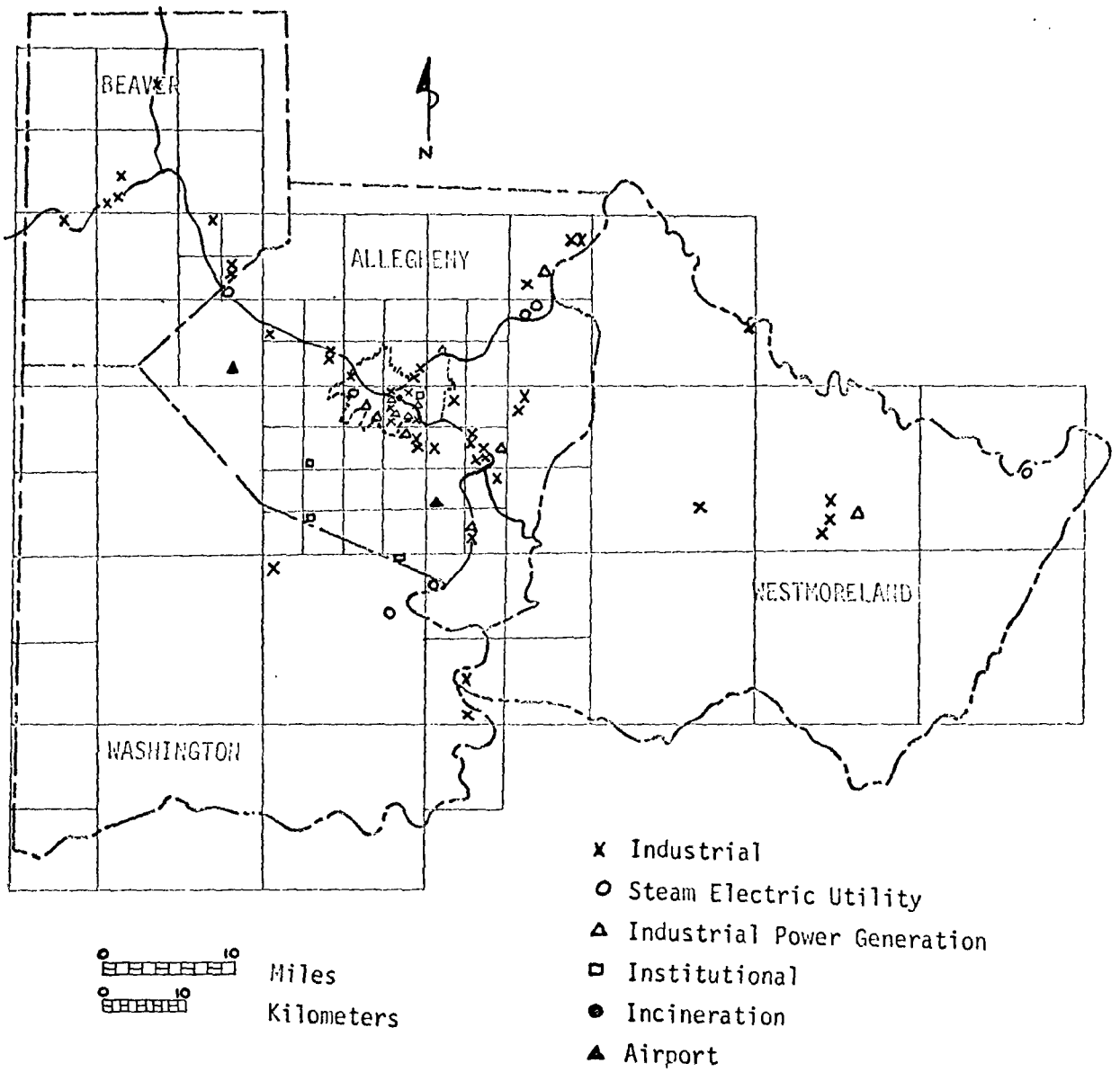


FIGURE 7. LOCATION OF MAJOR POINT SOURCES.

# AIR QUALITY ANALYSIS

## Introduction

The first major condition established prior to the determination of an air quality control region's boundaries is that the regional boundaries should encompass most pollution sources as well as most people and property adversely affected by the source emissions. The core area of a region can be roughly defined on the basis of point source locations and relative emission densities. The above-mentioned condition is not fully satisfied, however, until the bounds of the area significantly affected by the source emissions are determined. Unfortunately, the areal extent of the region, chosen to comply with this condition, cannot be rationally extrapolated from the emissions data alone.

A thorough review of air quality in the Pittsburgh area would make it possible to define the outer bounds of the Region and fully satisfy the source-receptor boundary condition specified above. Two alternatives exist for the determination of air quality in the Pittsburgh region. The first, and most logical approach, is to measure quantitatively the levels of pollutants existing in the ambient air. This approach should also consider the meteorology and topography in the area.

The second approach is to predict ambient air quality in terms of concentrations of individual pollutants. This approach is generallt desirable since existing air sampling networks do not encompass large enough areas, nor have they been in operation over sufficient lengths

of time, that they may be considered reliable and irrefutable guides to the establishing of the Region's limits. Both of these techniques are discussed in the following two sections. Since both approaches contain some drawbacks, the conclusions drawn from each are considered both independently and interdependently. In this manner, the most unbiased review of the pollution problem in Pittsburgh, as it exists today, can be made.

## Topography, Meteorology, and Measured Air Quality

Topographically, the Pittsburgh area is classified as "mature." The region consists of a series of dissected plateaus of varying elevations. The area is characterized by flat-topped hills and steep-sided, moderately-wide stream valleys. The tops of the hills are as much as 500 feet above the level of the large rivers, while the average relief is 300 feet. Pittsburgh lies at the foothills of the Allegheny mountains at the confluence of the Allegheny and Monongahela Rivers which form the Ohio River.

Pittsburgh has a humid continental type of climate modified only slightly by its nearness to the Atlantic Seaboard and the Great Lakes. The climatological and topographical influences lead to meteorological conditions conducive to localized air pollution problems. For example, differential heating causes mountain-valley winds. At night radiative cooling of the elevated ground creates density gradients which lead to down-slope and down valley winds. This results in thermal stability conditions , which when coupled with the shielding effect of valley sides, prohibit air exchange. This leads to a build-up of high pollutant

concentration levels in the stagnant air mass at the valley bottom. The combination of these environmental factors, and the fact that most major urban-industrial concentrations in the region occur in the river valleys, has led to severe localized air pollution problems in the southwestern Pennsylvania area.

Extensive air sampling has taken place in southwestern Pennsylvania by the Division of Air Pollution Control of the State Department of Health and by the Allegheny County Bureau of Air Pollution Control. This sampling has occurred either as part of continuous air monitoring activities or as individual studies in areas where particularly severe air pollution problems exist.

The State Division of Air Pollution Control has conducted surveys in the Monongahela Valley, the Beaver Valley, the City of Monessen and the Boroughs of Avalon and Bessemer. With the exception of the Bessemer study, the surveys were primarily concerned with measuring air quality in the river valleys. The Borough of Avalon is adjacent to the Ohio River in Allegheny County while Monessen is situated on the bank of the Monongahela River in Westmoreland County.

The Monessen study, completed in 1962, indicated a high level of suspended particulate pollution. A three month average concentration of 189 $\mu g/m^3$ (during portions of the heating and non-heating season) indicated that Monessen's particulate pollution problem is greater than that of many larger cities. Monessen is located just south of Donora (Washington County), the scene of the nation's first widely publicized air pollution tragedy.

The Borough of Avalon study, conducted in 1959, indicated that the

settleable and suspended particulate pollution in that municipality was as serious as that in the City of Pittsburgh itself. The dustfall measurements averaged 62.5 tons/sq. mile per month, while the average suspended particulate concentration was 163 $\mu g/m^3$. Avalon is not an industrialized community but does lie within the industrialized portion of metropolitan Pittsburgh. The results of this survey indicate that Avalon is the receptor of a great deal of pollution transported from nearby sources.

The Bessemer study (Lawrence County) in 1960 indicated that average suspended particulate concentrations for cities of 3 million or more did not exceed average values for Bessemer whose population numbers approximately 1500. The average suspended particulate level in Bessemer was 284.4 $\mu g/m^3$. Dustfall measurements at selected sites exceeded 80 tons/sq. mile per month.

The Beaver Valley study was conducted in 1961 over a sizeable portion of Beaver and Lawrence Counties. The bulk of the air sampling occurred in the Ohio and Beaver River valleys. These areas were selected for sampling because of the existence of an industrial complex along the rivers and because of the large number of complaints received in the area. High concentrations of suspended and settleable particulate pollution were recorded in New Castle, Bessemer and Ellwood City in Lawrence County. In Beaver County these same high concentrations were recorded in the Beaver Falls area, in Midland, Aliquippa, and at the junction of the Ohio and Beaver Rivers. Significant concentrations of sulfur dioxide pollution were also recorded by the use of lead candles. Evidence suggests that considerable transport of pollution occurs between Lawrence and Beaver Counties along the relatively deep Beaver River valley. The same situation

exists along the Ohio River valley between Allegheny and Beaver Counties.

A study in the Monongahela Valley in the southern portion of Allegheny County and a portion of Washington and Westmoreland Counties indicated that here, too, particulate pollution was excessive. In 1963 a survey in Duquesne, located on the Monongahela River, revealed that sulfur dioxide, and particulate pollution in the immediacy of that city was a major problem.

The Allegheny County Bureau of Air Pollution Control has an extensive sampling network throughout that County. Sampling is for suspended and settleable particulates, sulfation rate, hydrogen sulfide, sulfur dioxide, and carbon monoxide. Measurements over the past few years have indicated that dustfall in Allegheny County averages between 30 and 40 tons/sq. mile per month. Carbon monoxide measurements at one station located within the City of Pittsburgh indicate that occasionally extremely high concentrations occur over short-duration averaging times. Sulfur dioxide measurements at three sites during 1967 indicate abnormally high concentrations averaged over monthly periods. Pollutant levels in Allegheny County show a distinct seasonal variation. Generally, the ambient air contains highest concentrations of sulfur dioxide and suspended particulates during the winter months.

## Diffusion Model Results

The diffusion model has been used to compute sulfur dioxide, suspended particulate and carbon monoxide concentrations in the ambient air at specified receptor points in the Pittsburgh urban area. The model is based on the mathematical treatment of pollutant emissions and meteorological data.* While inherent limitations in the model are recognized, its results have been appropriately modified and interpreted in the past to provide

*See Appendix A for further discussion.

reasonable spatial distributions of long-term (seasonal and annual)* average pollutant concentrations.

It is questionable whether the diffusion model results can be considered valid in southwestern Pennsylvania since topographical and localized meteorological conditions are considerations largely neglected by the model. Thus, the model will not present a true picture of conditions in areas (e.g., river valleys) susceptible to severe air pollution problems. Nevertheless, the model results are presented here to indicate that a definite area-wide pollution problem exists and to indicate patterns of pollutant dispersion assuming minimal topographic and micrometeorological constraints.

Figure 8 shows predicted $SO_2$ concentration contours for the winter.** Greatest $SO_2$ concentrations were predicted by the model for this period. Actual measurements indicate that the greatest $SO_2$ concentrations occur in the winter, while the lowest measurements are recorded during the summer months. The pattern of the contours in Figure 8 indicate greatest predicted concentrations in and near Pittsburgh and in areas of high industrial density generally located along the three major rivers. These high concentration areas may be correlated to some extent with areas of high emissions and with point source locations (Figures 4 and 7). The predicted concentrations indicate a decreased concentration gradient at the .04 ppm contour.

*The averaging times are as follows: the winter averaging time includes the months of December, January, and February while the summer averaging period includes the months of June, July, and August. The annual averaging time includes all 12 months of the year.

**These predicted concentrations are based on a 3-hour $SO_2$ half-life.

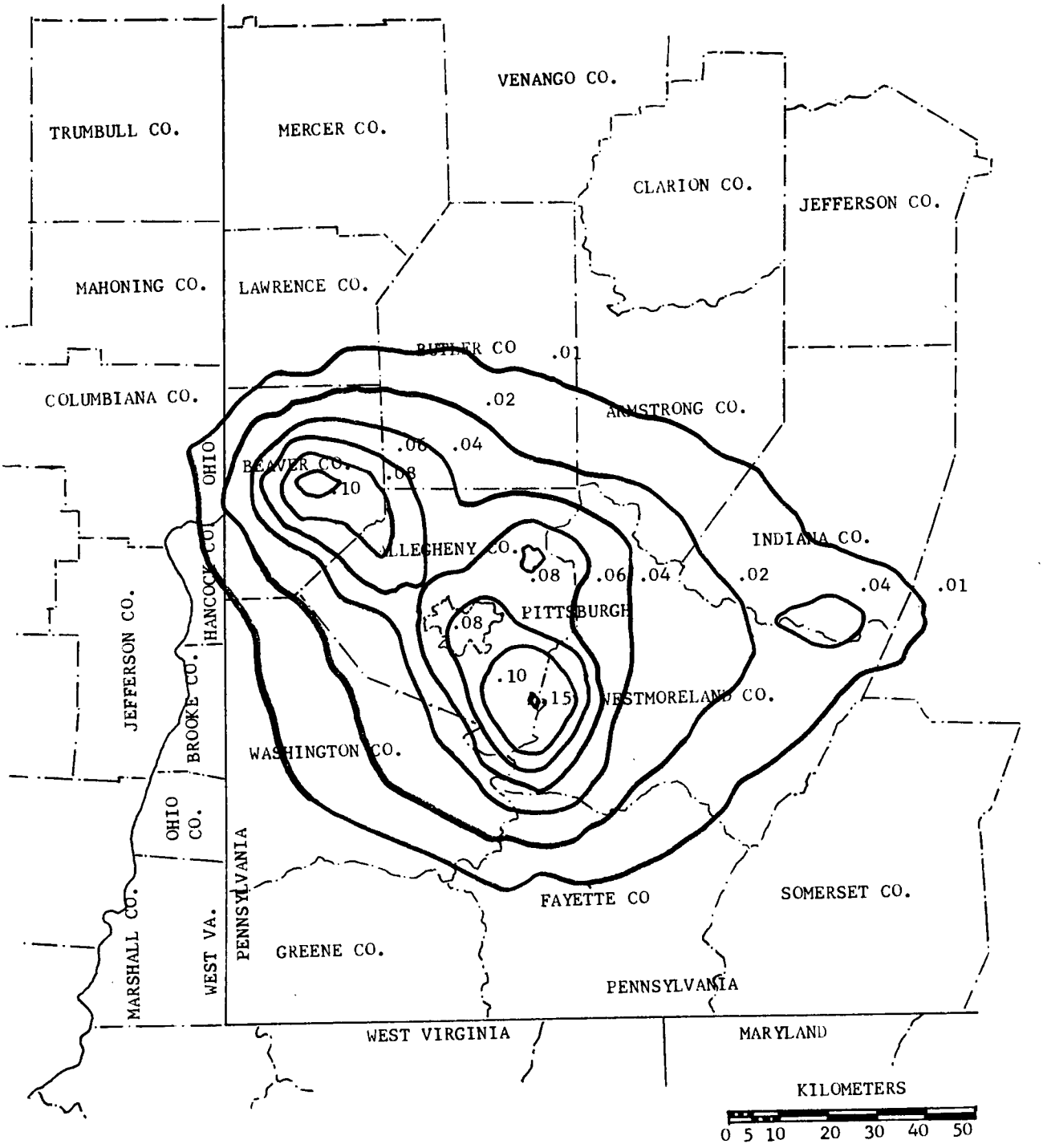


FIGURE 8. THEORETICAL $SO_2$ CONCENTRATIONS IN PPM; WINTER AVERAGE (ASSUMED 3 HR. HALF LIFE).

It can be said that the area enclosed by this contour is that whose ambient air is most seriously affected by the inventoried emissions. This includes most of Allegheny County and portions of Butler, Beaver, Washington, Westmoreland, and Fayette Counties. As indicated previously, it cannot be assumed that the concentrations indicated in Figure 8 are accurate or that the contour patterns are without error in predicting $SO_2$ dispersion characteristics.

Figure 9 shows theoretical suspended particulate concentrations predicted by the model. It is during the space-heating season that particulate emissions, hence suspended particulate concentrations, are the greatest. The concentration gradient decreases significantly at about the 60 $\mu g/m^3$ contour. This contour encloses the bulk of Allegheny County and portions of Beaver, Butler, Armstrong, Indiana, Westmoreland, Fayette, and Washington Counties. The area enclosed by this contour appears to be most affected by the inventoried source emissions. On this basis, the diffusion model indicates that a definite area-wide problem exists with regard to suspended particulate pollution. Actual measurements of particulate pollution, discussed in the previous section, reveal this same basic conclusion. As was true with the $SO_2$ predicted concentrations, it cannot be assumed that the concentrations shown in Figure 9 are precise, though a certain amount of reliance can be placed on the model to predict representative spatial variations in concentration.

Predicted carbon monoxide concentrations are shown in Figure 10. Highest concentrations are predicted for the summer averaging time. This is in agreement with measured data for most urban areas. Allegheny County and portions of Washington and Westmoreland Counties constitute the area most affected by carbon monoxide pollution. The greatest concentrations

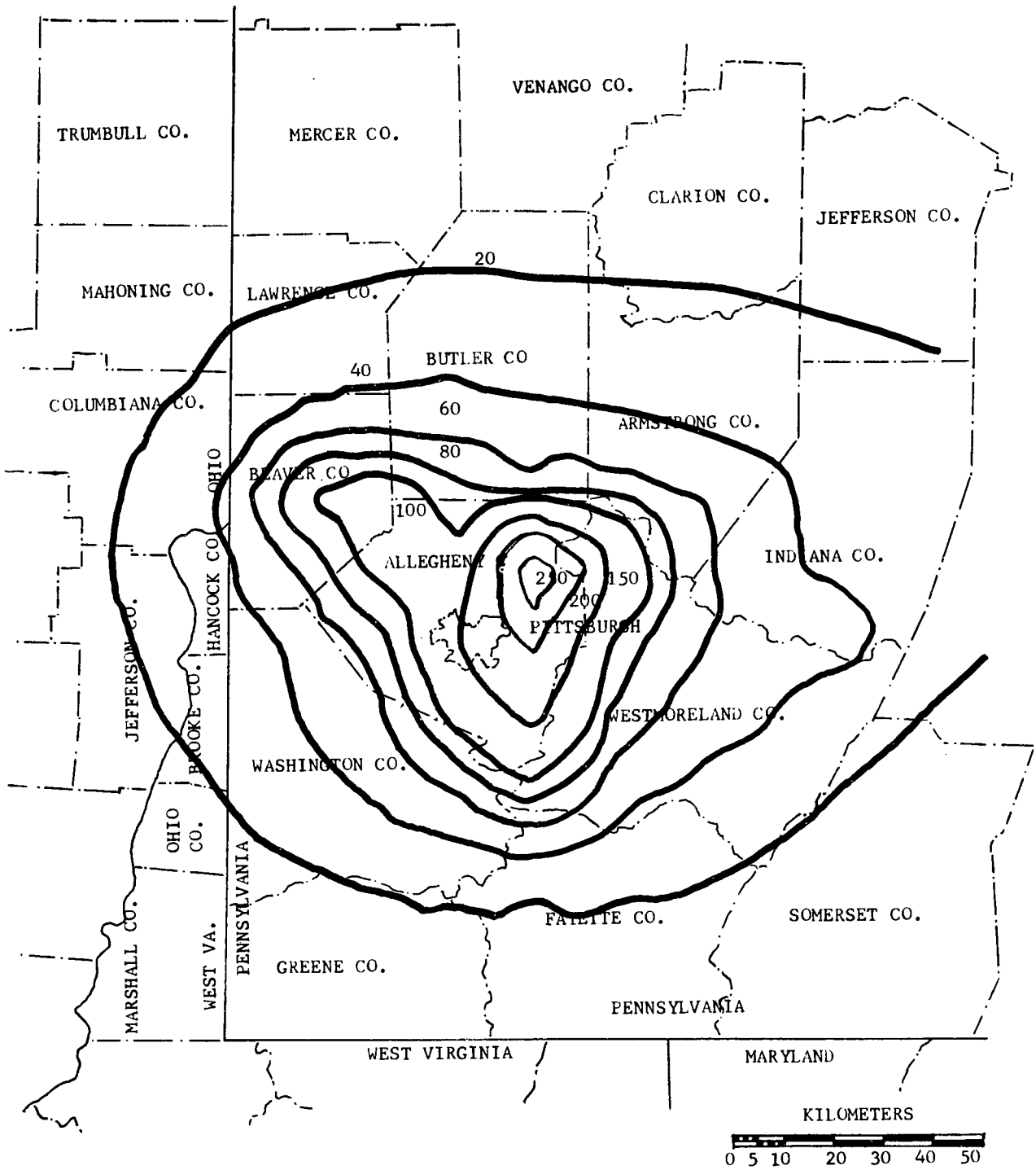


FIGURE 9. THEORETICAL SUSPENDED PARTICULATE CONCENTRATIONS IN $\mu G/M^3$; WINTER AVERAGE.

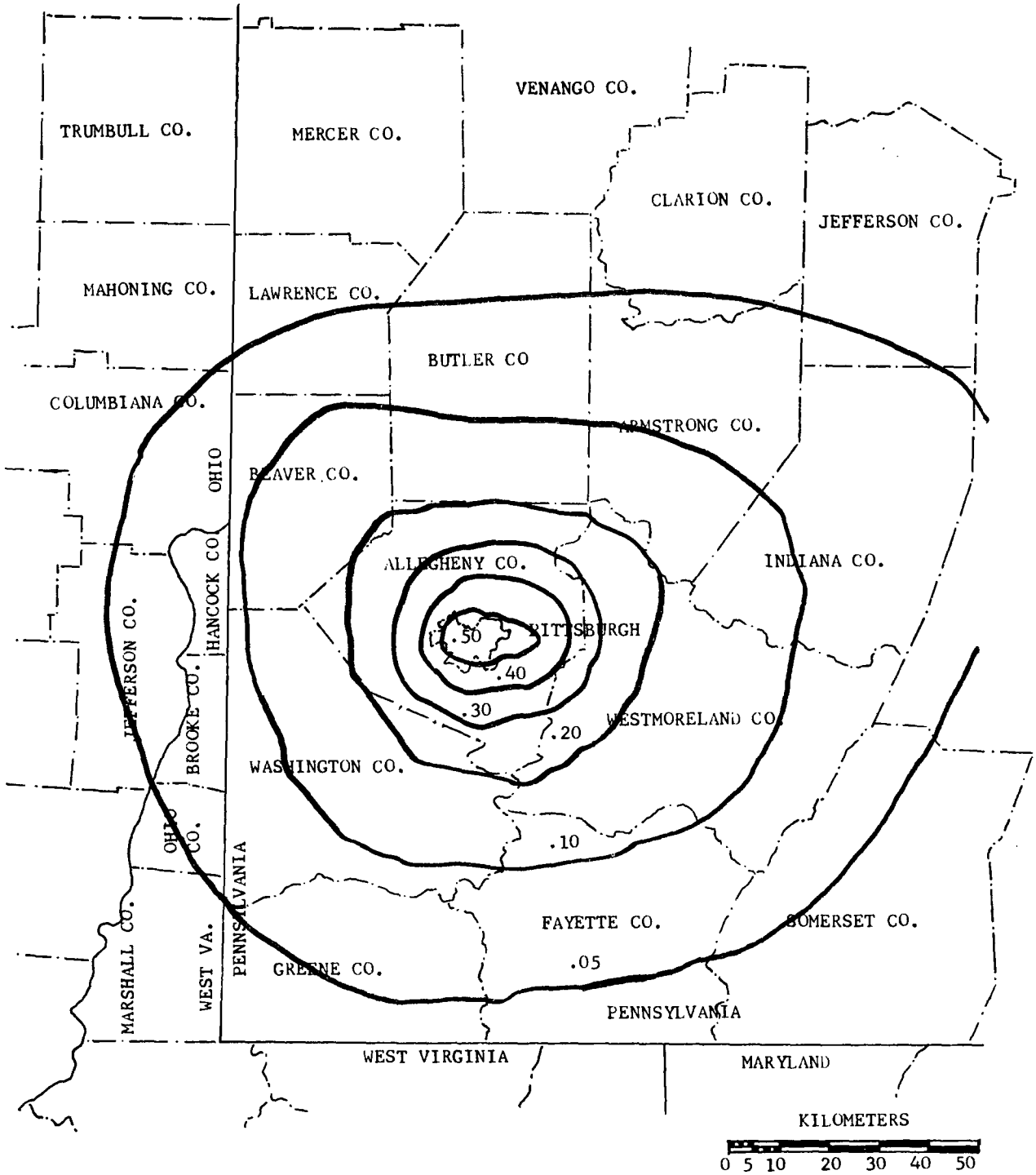


FIGURE 10. THEORETICAL CARBON MONOXIDE CONCENTRATIONS IN PPM; SUMMER AVERAGE.

are predicted to occur in the City of Pittsburgh. This is to be expected since vehicular traffic and subsequently CO emissions (see Figure 5) are greatest in or near Pittsburgh.

## EVALUATION OF URBAN FACTORS

Section 107 (a) (2) of the Air Quality Act of 1967 calls for the designation of air quality control regions "based on jurisdictional boundaries, urban-industrial concentrations, and other factors... necessary to provide adequate implementation of air quality standards." The designation of air quality control regions must be based on a consideration of existing cooperative regional arrangements, existing State and local air pollution control legislation, and patterns and rates of urban growth. These considerations, referred to as "urban factors," lead to the establishing of two chief conditions to be met if an air quality control region is to prove effective as a basic tool to an air resource management program. First, the boundaries of a region should encompass those locations where present and projected urbanization will account for significant air pollution problems in the foreseeable future. Second, the boundaries should be chosen in a way which is compatible with and fosters unified and cooperative governmental administration of the air resource throughout the region.

Existing and potential air pollution problems can be related geographically to areas harboring present or anticipated residential and industrial development. Similarly, population statistics are useful in determining the probable existence of air pollutant emissions since human activity is the basic cause of pollution. Table II shows provisional present and 1980 provisional projected population estimates for Pittsburgh, Allegheny County and its surrounding counties in southwestern Pennsylvania.

The 1980 projections are subject to periodic revision, but nevertheless give some idea of growth trends in the area. These figures indicate that only Butler, Greene, and Westmoreland Counties are expected to increase in population. All other counties listed are expected to experience decreases in population.

TABLE II. PROVISIONAL PRESENT POPULATION AND POPULATION PROJECTIONS

| JURISDICTION | July 1, 1967 Provisional Population | 1967 Pop. Density | 1980 Projected Population | 1980 Projected Pop. Density |
|---|---|---|---|---|
| Pittsburgh City | 544,200 | 989 | n.a.* | n.a. |
| Allegheny Co. | 1,561,600 | 2,140 | 1,402,418 | 1,925 |
| Armstrong Co. | 76,300 | 116 | 65,082 | 99 |
| Beaver Co. | 201,700 | 458 | 190,826 | 433 |
| Butler Co. | 122,300 | 154 | 128,651 | 162 |
| Fayette Co. | 166,400 | 208 | 147,936 | 184 |
| Greene Co | 39,400 | 68 | 40,625 | 70 |
| Indiana Co. | 73,500 | 89 | 61,403 | 74 |
| Lawrence Co. | 109,400 | 298 | 100,363 | 273 |
| Washington Co. | 210,100 | 246 | 201,447 | 245 |
| Westmoreland Co. | 375,100 | 366 | 379,705 | 370 |

*Information not available

Figure 11 shows 1980 population densities from the data in Table II. As expected, the City of Pittsburgh and Allegheny County are and will continue to be the most densely populated areas. Westmoreland, Washington, Beaver, Fayette, Butler, and Lawrence Counties are decreasingly less populous than Allegheny County.

The population densities of these counties vary and are a function of their respective land areas. These density values do not, however, give an adequate or accurate picture of the geographic population distribution.

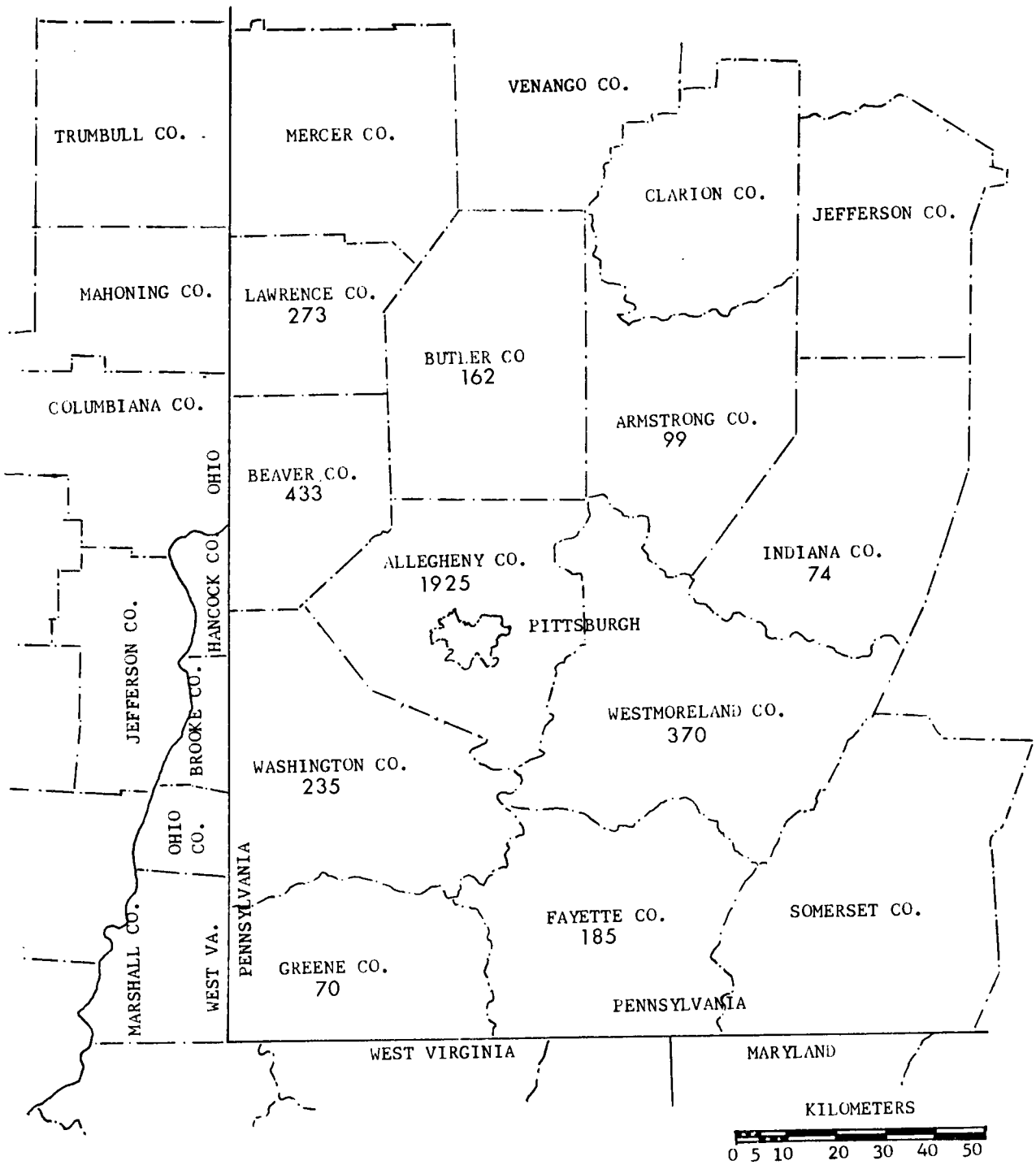


FIGURE 11. 1980 PROJECTED POPULATION DISTRIBUTION
IN SOUTHWESTERN PENNSYLVANIA.

Figure 12 represents a land use map for the six county area under the jurisdiction of the Southwestern Pennsylvania Regional Planning Commission. This map shows commercial, residential, and manufacturing land use patterns, and is based on a 1958 generalized land use map produced by the SPRPC. Figure 12 indicates that in Allegheny County the bulk of the population is located in or closely surrounding the core City of Pittsburgh. Population concentrations toward the outskirts of Allegheny County exist in the valleys of the Monongahela, Allegheny and Ohio Rivers. The same conclusions can be reached with respect to the locations of industry. In the outlying counties residential and industrial land is generally situated along the major rivers or at the intersection of major highways.

A major factor which must be considered further is the role of industrial and manufacturing activities in southwestern Pennsylvania. Not only the relative intensity of industrial development and activity, but also the geographic location of such activity should be considered. As mentioned in the preceeding paragraph, the steel mills and most other industrial plants and complexes are clustered in the river valleys along the three major navigable rivers in southwestern Pennsylvania. Smaller concentrations of industry occur along secondary and tertiary streams. These river valleys possess a unique combination of physical and access advantages which have made them prime locations for industrial development. They provide level building sites and are natural routes for highways and rail lines. Furthermore, the location of industry in these valleys reflects the need for process water and water transportation.

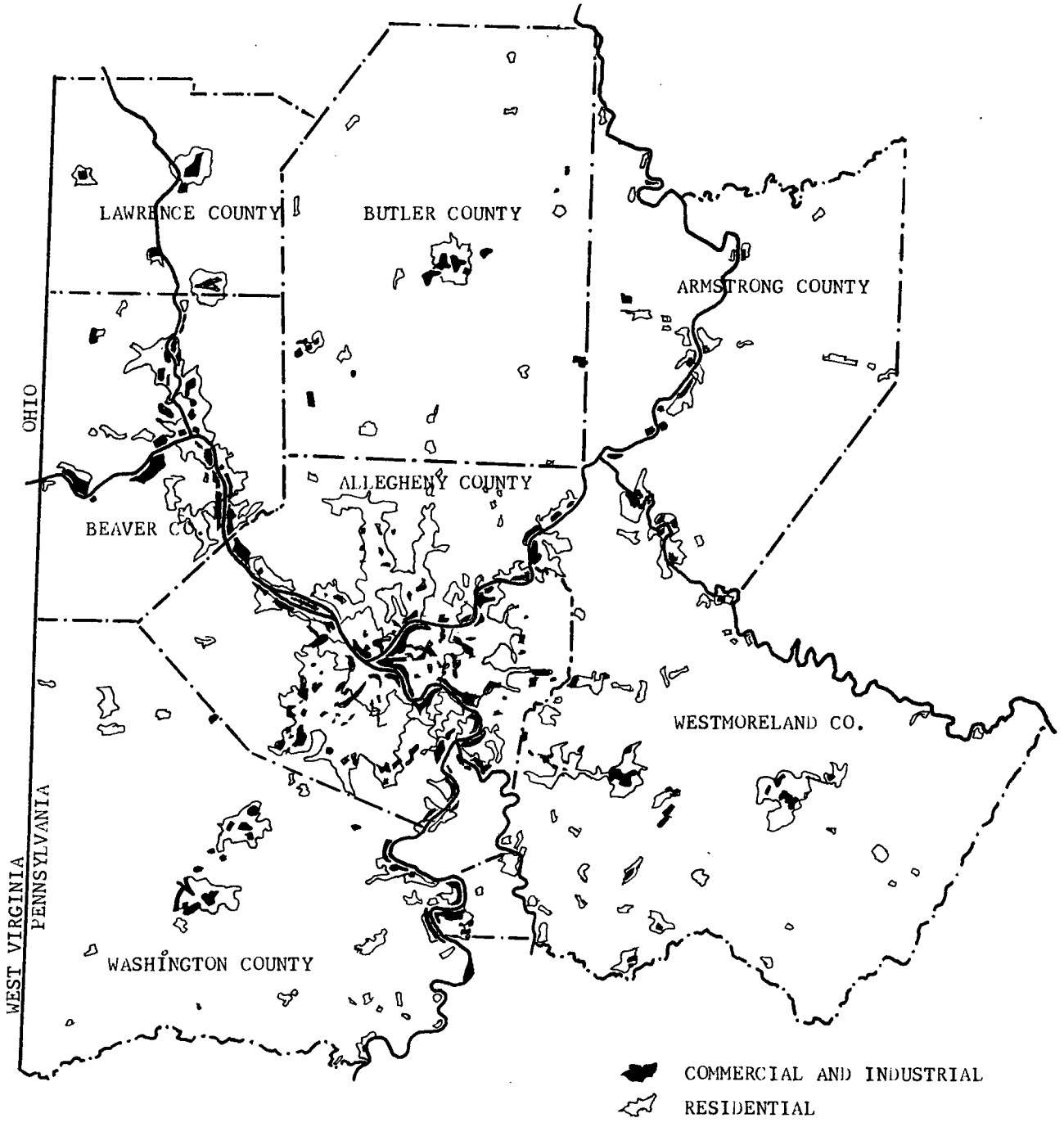


FIGURE 12. LAND USE IN THE PITTSBURGH URBAN AREA.

Table III provides a breakdown of manufacturing employment in southwestern Pennsylvania. Clearly, Allegheny County accounts for the majority of total manufacturing employment in this area. Four of the 5 counties immediately surrounding Allegheny County (excepting Armstrong County) are important areas for manufacturing employment, as is Lawrence County. In southwestern Pennsylvania, Allegheny County is most important as far as steel making capacity is concerned. Beaver County follows in importance, followed by Cambria, Mercer, Washington and Westmoreland. Two other counties producing lesser amounts of steel are Lawrence and Butler Counties.

While manufacturing employment is not expected to increase greatly in the region by 1985 (it may even decrease), the need for additional industrial land will be great. Most of the land demand will be in Allegheny County. However, as prime industrial land becomes scarce the demand for sites in adjacent counties will increase. It is anticipated that these outlying counties will increase in industrial importance by 1985. However, the outermost fringes of these counties have little or no potential for industrial development. This reflects their remoteness from the facilities of the Pittsburgh urban core. This low potential is also a function of the rugged terrain and strip mine devastation characterizing the outer portions of the counties adjacent to and including Allegheny County.

TABLE III. MANUFACTURING EMPLOYMENT IN SOUTHWESTERN PENNSYLVANIA

| JURISDICTION | 1963 | 1966 Estimated | 1963 Value Added by Manufacture |
|---|---|---|---|
| Pittsburgh City | 81,707 | 66,479 | 651,396 |
| Allegheny Co. | 173,097 | 199,053 | 1,718,139 |
| Armstrong Co. | 5,605 | 6,869 | 78,504 |
| Beaver Co. | 43,371 | 53,446 | 526,434 |
| Butler Co. | 11,436 | 15,688 | 176,660 |
| Washington Co. | 16,823 | 21,875 | 179,794 |
| Westmoreland Co. | 38,892 | 47,266 | 454,792 |
| Greene Co. | 1,036* | n.a.** | 3,734 |
| Fayette Co. | 7,459 | n.a. | 66,886 |
| Indiana Co. | 3,988 | n.a. | 43,497 |
| Lawrence Co. | 11,260 | n.a. | 128,130 |

*1960 Figure
**Information not available

Approximately half of the projected requirements for industrial land are expected to depend upon access to highway rather than river and rail transportation. This indicates that new industrial development (those not requiring process water) will locate in areas adjacent to highways, and will not necessarily be confined to the river valleys. However, the existing patterns of development along the major waterways are expected to remain largely unaltered for several years. Due to the influences of topography and frequent inversion conditions, the location of industry in the river valleys poses serious local air pollution problems which are likely to continue sometime into the future.

Figure 13 shows the existing highway network for the core area of Pittsburgh and for surrounding counties. A complete pattern of circumferential and radial highways surrounds the City of Pittsburgh. The major highways extend outward to surrounding counties and serve to integrate

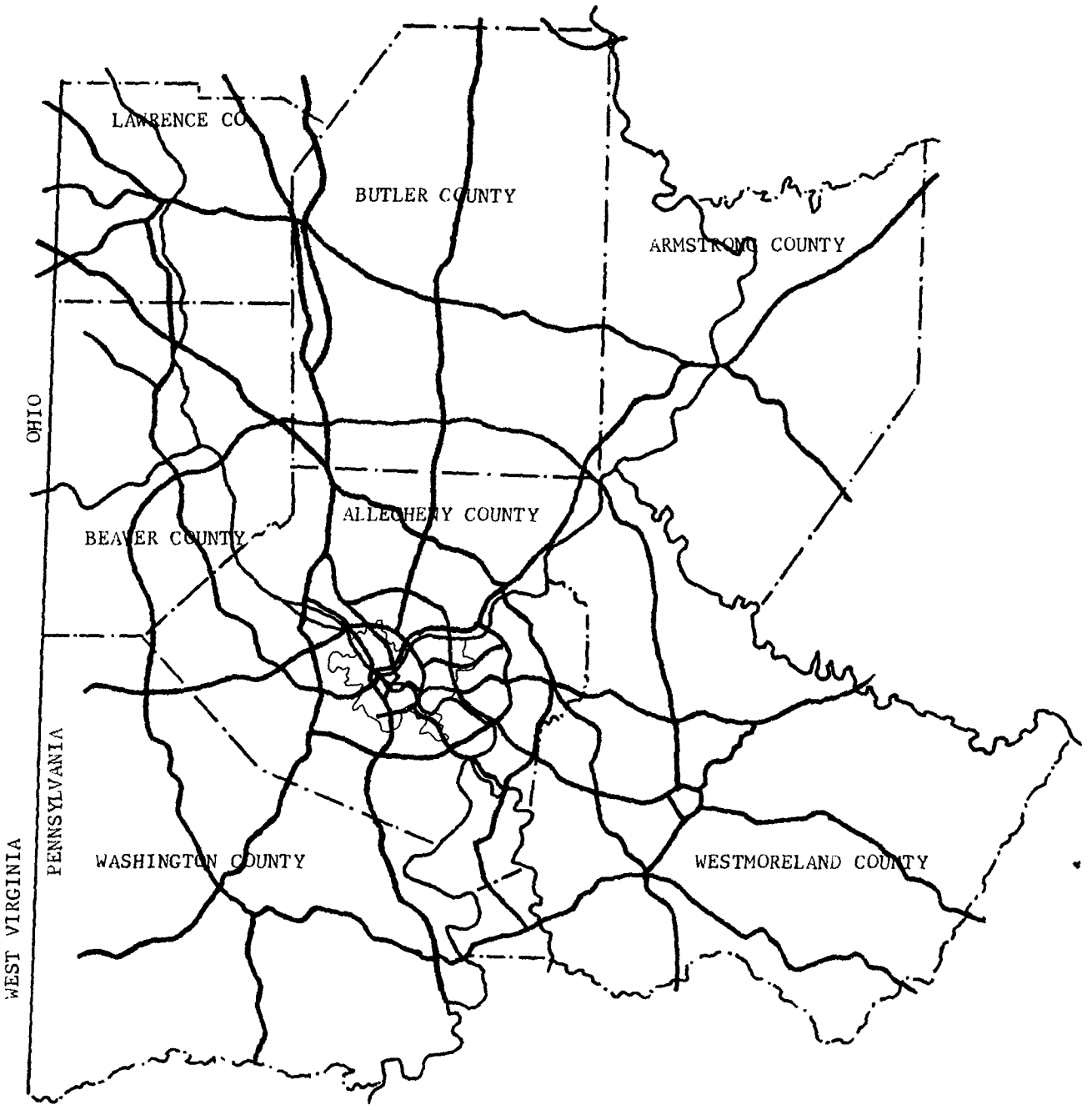


FIGURE 13. EXISTING AND PROPOSED HIGHWAY NETWORK IN SOUTHWESTERN PENNSYLVANIA.

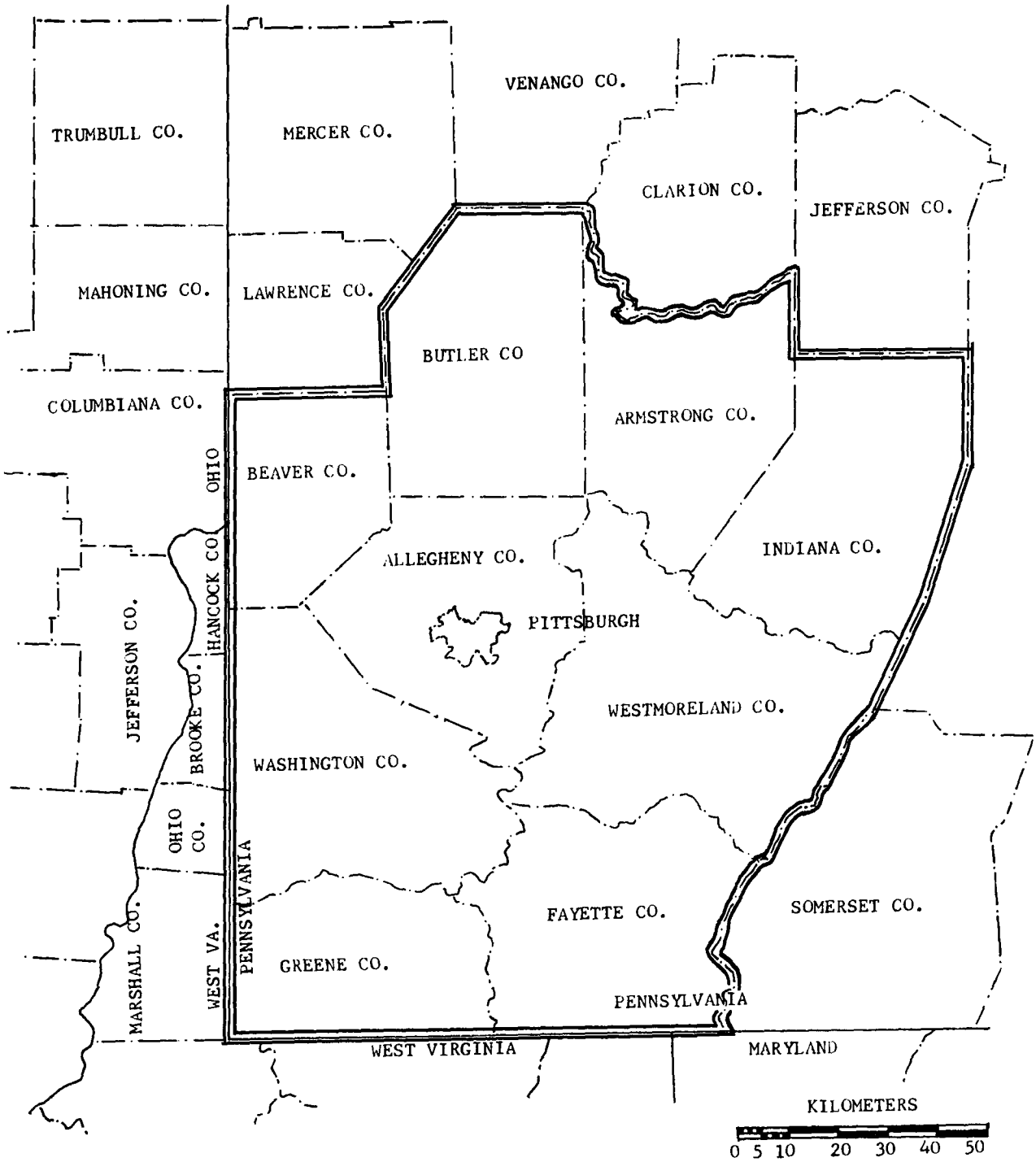


FIGURE 14. STATE PLANNING REGION IN SOUTHWESTERN PENNSYLVANIA.

more closely the metropolitan Pittsburgh area. The relationship of highway location to land use may be observed by comparison of Figures 12 and 13.

In order that the most suitable air quality control region for Pittsburgh might be determined, it is desirable to look beyond present and anticipated patterns of urbanization and industrialization. It becomes necessary to determine the combination of jurisdictions that have developed physically, socially, and economically as a result of regional interaction. Such interaction suggests that these jurisdictions should be included in the Region so that the most effective administration of a regional air resource management program will occur.

In southwestern Pennsylvania, a 9-county area was designated in 1966 by the State Planning Board as a State Planning Region. This Region is shown in Figure 14. The purposes of delineating the State Planning Region were twofold. First, the intent was to "acknowledge the characteristic regional difference in current development trends or problems which will require a varied and individual approach in later work on a State Department Plan."[3] Secondly, it was desirable to "provide a setting for State-local coordination which will acknowledge not only the requirements of State planning, but also the inter-county cooperation most likely to be sought in preparation or coordination of local planning activities."[3]

The Planning Regions were defined on the basis of demographic considerations (with reference to common metropolitan centers, and population growth rates, density, and distribution), topographic considerations (mountain barriers, river valley links), economic similarities, and existing regional industrial and planning organizations. The county unit was retained in delineating Planning Regions since much statistical

information is unavailable for small municipalities and since the county is becoming an increasingly important decision-making level of local government with which the State Planning Board will require close contact.

The 9-county southwestern Pennsylvania Planning Region includes a 6-county (Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland) Pittsburgh-oriented core. Greene and Fayette Counties are not too closely integrated with Pittsburgh at present. Indiana County is linked to Westmoreland and Armstrong Counties in its most populous southern portion by highways and a tributary to the Allegheny River. However, the county is oriented toward the east by its closeness to the City of Johnstown, located in Cambria County. The reason for orientation of Indiana County to the above described 9-county Planning Region was largely a matter of administrative convenience.

Coextensive with the 9-county Planning Region is the Southwestern Pennsylvania Economic Development District. The basic rationale for the determination of the bounds of this economic development district were essentially the same as those of the State Planning Region.

The Pittsburgh Standard Metropolitan Statistical Area (SMSA) consists of the following four counties: Allegheny, Beaver, Washington, and Westmoreland. By definition, SMSA's serve to identify an economically and socially integrated group of communities. They also serve as a geographic base for the gathering of statistical data. In southwestern Pennsylvania, however, a 6-county regional planning agency exists. This agency is the Southwestern Pennsylvania Regional Planning Commission (SPRPC). It has been designated by the Department of Housing and Urban Development as its regional planning commission for the purposes of

Section 204 of the Demonstration Cities and Metropolitan Development Act of 1966. The jurisdiction of the SPRPC includes the four counties of the Pittsburgh SMSA as well as Butler and Armstrong Counties.

There are many reasons why the 6-county area was chosen for the SPRPC. First, the boundaries were established on the basis of economic interdependence. It was seen that the economy of the six counties "constitutes a whole that is far more than the sum of its parts."[4] Secondly, the six counties form a district banking region. In conformance with State law, a bank whose central office is located in Allegheny County would have a financial sphere of interest limited to the six counties of the SPRPC. Thirdly, the 6-county area forms a cohesive trade area. Of the industrial or commercial activities of these six counties, large fractions of the market, of the source of supply, or both, lie within these same counties. Fourth, this multi-county area is a single labor market. Extensive commuting across county lines occurs. However, only a small fraction of the workers within the 6-county area work outside its limits, or vice versa. A substantial proportion of the workers resident in Beaver, Butler, Armstrong, Washington, or Westmoreland Counties have jobs in Allegheny County. This interdependence of work and residence areas is becoming more important with increasing travel facilities. Finally, the 6-county area is appropriate with respect to inter-Regional transportation costs, a factor of high importance in industrial and commercial location and competitive survival.

The third condition to be met by the Region is that it be conducive toward the development of effective governmental administration of a regional air resource management program. The degree of cooperation and the jurisdictional relationship of existing air pollution control programs

is an important factor. Therefore, a review of these existing programs responsible for the control of air pollution in metropolitan Pittsburgh is necessary.

The official air pollution control agency for the City of Pittsburgh is the Bureau of Air Pollution Control of the Allegheny County Health Department. Legal authority for the County air pollution control program is provided through three Pennsylvania enabling acts. Act 315, the Local Health Administration Law, dated August 24, 1951, provides for the establishment of local health services. The second enabling Act, Public Law 723, dated July 28, 1953, enables counties of the second class to regulate smoke and particulate emissions. Allegheny County is the only county of the second class in Pennsylvania.

Article XIII of the Rules and Regulations of the Allegheny County Health Department provides for the mandatory reduction of particulate emissions to the atmosphere from fuel-burning activities and other manufacturing processes, and is adopted under the powers and duties of the Board of Health, as defined in Act 315.* The Allegheny County Board of County Commissioners has adopted an Ordinance identical to Article XIII, and designated the same staff (Bureau of Air Pollution Control) to enforce the Ordinance. This Ordinance permits the Bureau of Air Pollution Control to regulate smoke and particulate emissions in the entire County, including the seven municipalities not covered under Act 315.

*Seven of the 129 municipalities in Allegheny County are not under the jurisdiction of the Allegheny County Health Department, as defined in Act 315. As a result, only 122 municipalities are covered by this Article XIII.

The third enabling Act, Act 199, an amendment to Public Law 723, became effective January 11, 1967. Act 199 authorizes the Bureau of Air Pollution Control to regulate gaseous emissions and all other forms of air contaminants. The Allegheny County Health Department has initiated steps to adopt regulations for the control of gaseous emissions under the new Act.

The Pennsylvania Department of Health, under State legislation of January 1967, has reviewed and approved the Allegheny County Health Department, Bureau of Air Pollution Control program. This approval authorizes the Bureau of Air Pollution Control exclusively, to prevent, abate, and control air pollution from all sources within Allegheny County.

The counties surrounding Allegheny County are under the jurisdiction of the Pennsylvania Department of Health for the control of air pollution. Authority has been granted to this agency by the Air Pollution Control Act, Public Law 2119, of January 8, 1960, and by the rules and regulations promulgated pursuant to the provisions of the Air Pollution Control Act. Four such regulations have since been adopted to prevent and control pollution from a variety of source types. A proposed Regulation V is designed to control air pollution in specifically designated areas of the State. By designating air-basins, any air contamination sources located within these basins will be subject to the provisions of Regulation V and all other regulations of the State Air Pollution Commission.

In the area of concern, an air-basin is proposed in the Beaver Valley. Its bounds extend one mile from each bank of the Ohio River along the course of the river from the Ohio-Pennsylvania State line to the Allegheny-Beaver County line, and extends one mile from each

bank of the Beaver and Shenango Rivers along the course of the river from its junction with the Ohio River to and including the City of New Castle. This basin extends into both Beaver and Lawrence Counties.

The Air Pollution Control Act also provides for cooperation "with the appropriate agencies of the United States or of other States or any interstate agencies with respect to the control, prevention, abatement and reduction of air pollution, and where appropriate formulate interstate air pollution control compacts or agreements...." Initial steps have been taken to establish a regional agreement between the Pennsylvania and Ohio Departments of Health, the West Virginia Air Pollution Commission and the Allegheny County Bureau of Air Pollution Control for the control on a voluntary basis of interstate air pollution. The area to be encompassed by the agreement (counties) has not been determined as yet. In Eastern Pennsylvania the precedent for such an agreement exists between the States of Pennsylvania, New Jersey, and Delaware.

## THE PROPOSED REGION

Subject to the scheduled consultation, the Secretary, Department of Health, Education, and Welfare, proposes to designate an air quality control region for the metropolitan Pittsburgh area, consisting of the following jurisdictions in the State of Pennsylvania:

Allegheny County
Armstrong County
Beaver County
Butler County
Lawrence County
Washington County
Westmoreland County

As so proposed, the Metropolitan Pittsburgh Intrastate Air Quality Control Region would consist of the territorial area encompassed by the outermost boundaries of the above jurisdictions and the territorial area of all municipalities located therein and as defined in Section 302(f) of the Clean Air Act, 42 U.S.C. 1857h(f). Figure 15 shows the boundaries of the proposed Region while Figure 16 indicates the geographic relationship of the Region to surrounding areas.

## DISCUSSION OF PROPOSAL

To implement a successful air resource management program, an air quality control region should be sufficiently large so as to encompass most pollution sources as well as most people and property affected by these sources. The boundaries should also encompass those locations where present and projected urbanization and industrialization will create significant future air pollution problems. Finally, the boundaries chosen should be compatible with and foster unified and cooperative

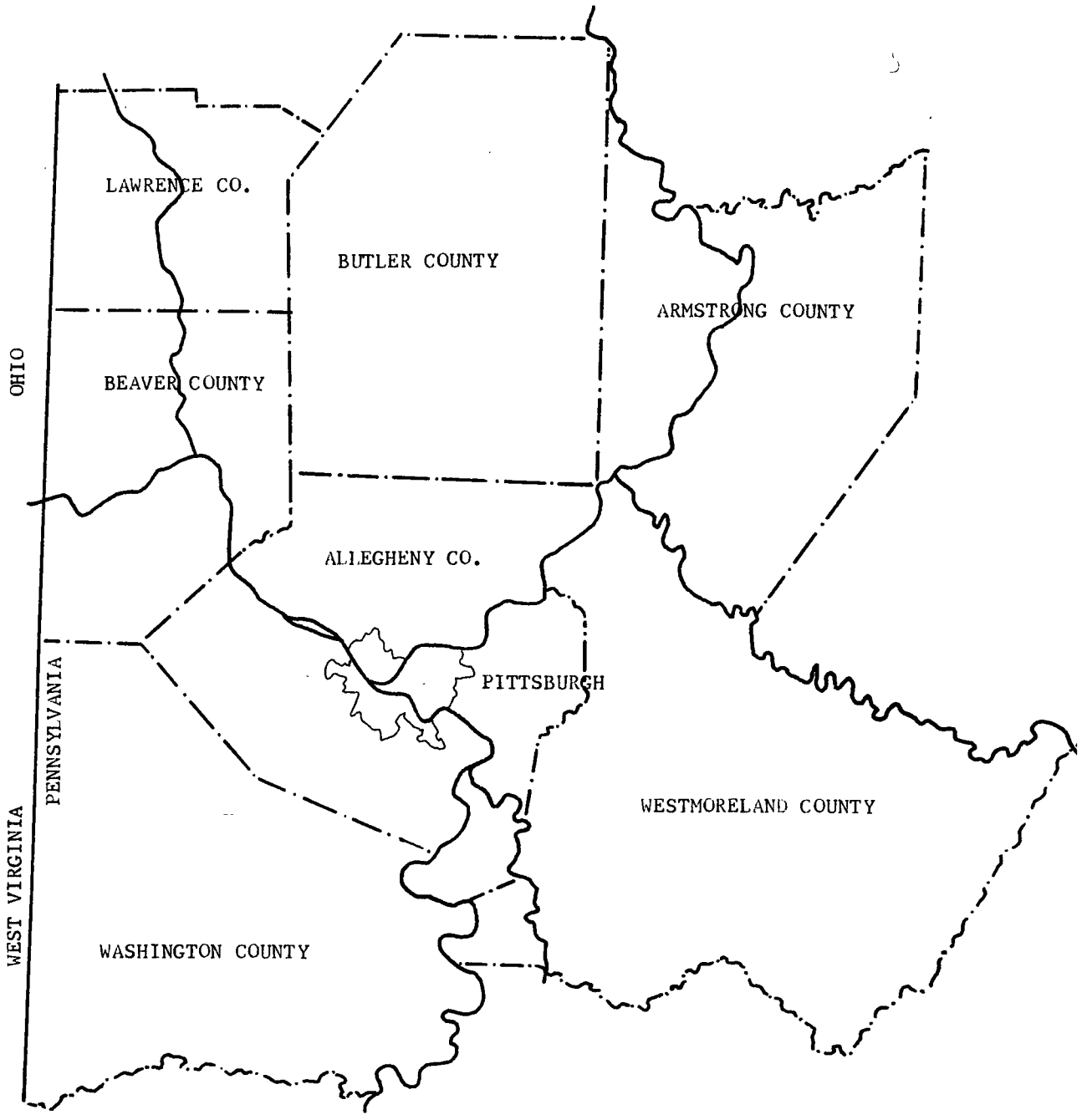


FIGURE 15. PROPOSED METROPOLITAN PITTSBURGH INTRASTATE AIR QUALITY CONTROL REGION.

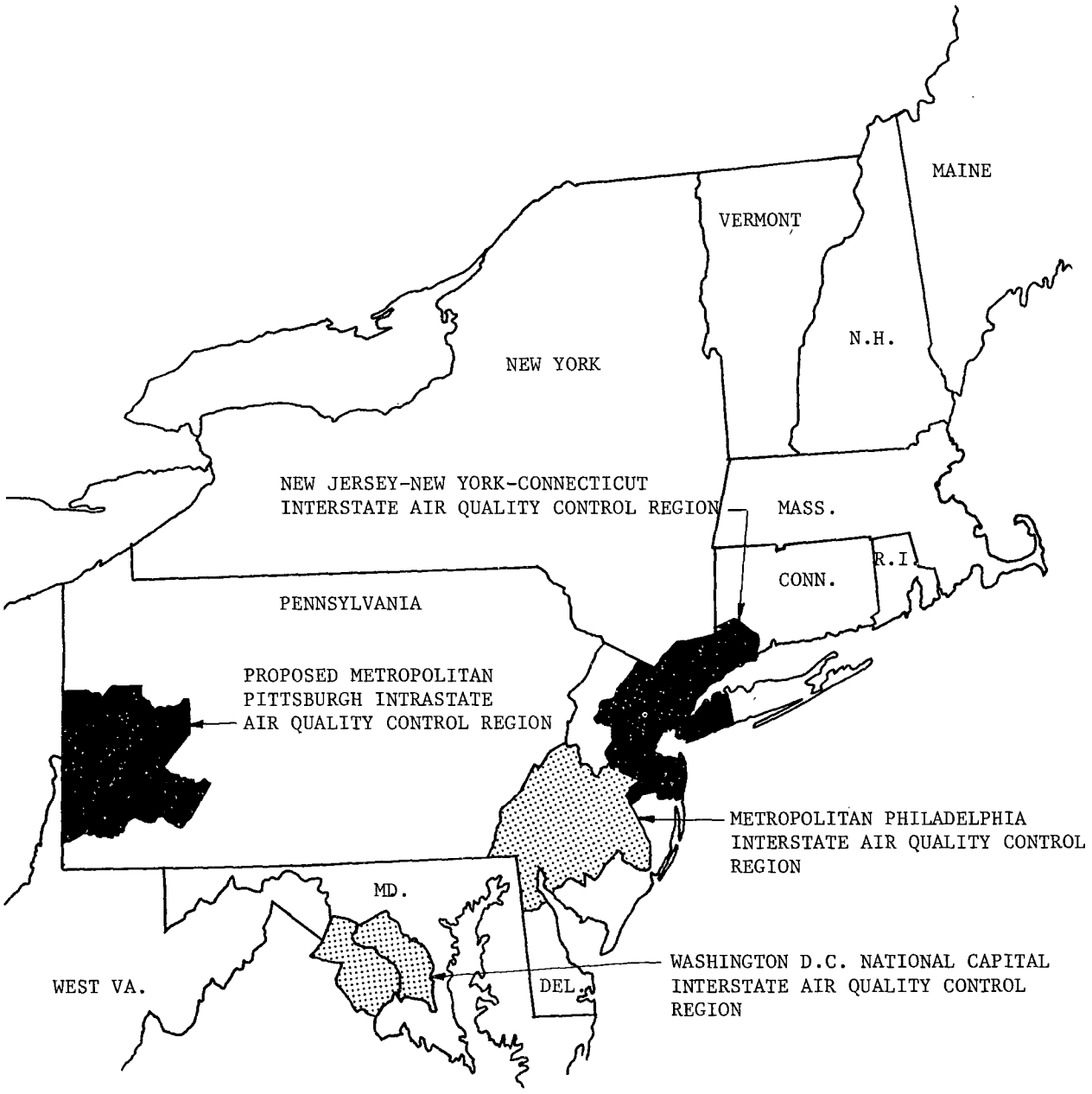


FIGURE 16. RELATIONSHIP OF PROPOSED METROPOLITAN PITTSBURGH INTRASTATE AIR QUALITY CONTROL REGION TO SURROUNDING AREAS.

regional governmental administration of the air resource. The proposed Metropolitan Pittsburgh Intrastate Air Quality Control Region was designed to satisfy these requirements.

The Region as proposed consists of the following seven counties in southwestern Pennsylvania: Allegheny, Armstrong, Beaver, Butler, Lawrence, Washington, and Westmoreland. The determination of the Region involved a consideration of both engineering and urban factors. The boundaries chosen create an inclusive yet cohesive combination of jurisdictions for the administering of a region-wide air resource management program.

On the basis of engineering factors, the Region should be no less in extent than the following five counties: Allegheny, Beaver, Lawrence, Washington, and Westmoreland. A survey of pollutant emissions in the Pittsburgh SMSA revealed that the greatest emission densities occur in or near Pittsburgh. Areas of high emissions also occur along the Allegheny, Monongahela, Ohio, and Beaver Rivers where urban and industrial concentrations are greatest.

A study of air quality was based upon a review of existing measured air quality and upon the application of a diffusion model to southwestern Pennsylvania. It is clear that the influences of topography on meteorology in the area produce stable atmospheric conditions conducive toward the build-up of high pollutant concentrations. Sources located in the river valleys emit pollutants whose dispersion is restricted vertically by atmospheric inversions and laterally by the valley sides.

A study in the Beaver Valley, including portions of Beaver and Lawrence Counties, revealed that in certain areas suspended and settleable particulate pollution represents a definite problem. Most of the sampling

occurred adjacent to the Ohio and Beaver Rivers near the industrial and population centers. It is likely that considerable transport of pollution occurs down valley between Lawrence and Beaver Counties and Beaver and Allegheny Counties.

A past survey of the Monongahela Valley in the southern portion of Allegheny County, and Washington and Westmoreland Counties, indicated that particulate pollution was, and no doubt remains, at high levels. Studies in Bessemer (Lawrence County), Avalon and Duquesne (Allegheny County) and Monessen (Westmoreland County) indicated that in these communities, suspended particulate pollution exceeded those levels typical of much more populous areas. The same situation exists for settleable particulate pollution.

A continuing program of air monitoring in Allegheny County both within and without the City of Pittsburgh indicates that many areas of the County experience high levels of particulate pollution. Carbon monoxide levels in the City of Pittsburgh at times reach high levels whether averaged over monthly or hourly periods. Sampling at three locations in Allegheny County have revealed high concentrations of sulfur dioxide, based on monthly averages.

The application of the mathematical diffusion model to the Pittsburgh urban area is questionable due to the Region's topography. The model essentially neglects to consider the variable elevation of sources and receptors and the effect of topography on localized meteorology. The model results presented through the use of concentration contour maps may be considered as crude estimates of the spatial distribution of pollutants. The absolute concentration values predicted cannot be considered accurate.

Assuming that the shapes of the predicted contours and their relationship to one another are reasonably correct, it appears that Beaver, Allegheny, Washington, and Westmoreland Counties are most affected by the pollutant emissions. Since other counties were not included in the emissions inventory, it is not expected that the model would predict accurately their air quality except through the geographic proximity of pollutant sources which emit large amounts of pollution. In addition, inter-county pollution transport is likely to depend greatly on local topographical and meteorological considerations in many areas. Finally, diffusion model results are not inclusive of pollutant background concentrations.

On the basis of urban factors it is concluded that the Region should consist of the following seven counties: Allegheny, Armstrong, Beaver, Butler, Lawrence, Washington, and Westmoreland.

Allegheny, Armstrong, Beaver, Butler, Washington, and Westmoreland Counties are members of the six-county Southwestern Pennsylvania Regional Planning Commission (SPRPC). All but Armstrong and Butler Counties are members of the Pittsburgh SMSA. The boundaries of the SPRPC were established on the basis of economic interdependence. These six counties form a distinct banking region, a cohesive trade area, and a single labor market. A great deal of commuting occurs across county lines. Only a small proportion of persons residing outside this six-county area work within its limits and vice-versa.

Of these six counties, Armstrong County and Butler County contain the lowest population and lowest manufacturing employment. However, a substantial proportion of residents living in these two counties work

in Allegheny County. On the basis of the factors mentioned in the previous paragraph, it is not recommended that these two counties be excluded from the Pittsburgh Region.

Beaver, Allegheny, Washington, and Westmoreland Counties contain areas of high population density and industrialization. These areas generally occur as clusters along the major rivers. In Lawrence County the bulk of its population lies in the New Castle and Ellwood City urban areas. Ellwood City lies on the border of Lawrence and Beaver Counties near the Beaver River. The Beaver Valley and several major highways connect Lawrence County to Beaver County and metropolitan Pittsburgh.

The reasons for proposing the inclusion of Lawrence County in the Region are not so apparent as they were for the proposed inclusion of the other six counties. Lawrence County has not been included with Allegheny, Beaver, Butler, Armstrong, Washington, or Westmoreland Counties in the past in overall planning efforts. Considerations given to industrial and residential locations indicate that Lawrence County shares and will continue to share pollution problems with Beaver County. For this reason its inclusion in the Region is a logical step toward regional air resource management, particularly in regard to the lessening of pollutant transport boundary conditions.

The State Department of Planning has designated nine counties in southwestern Pennsylvania as a Planning Region. These are Allegheny, Armstrong, Beaver, Butler, Fayette, Greene, Indiana, Washington, and Westmoreland Counties. These same nine counties form an Economic Development District. Fayette, Greene, and Indiana Counties have not been proposed for inclusion in the Region.

Greene County has not been integrated with Pittsburgh in the past for planning purposed, nor is it vitally dependent on Pittsburgh economically. Industry does not play an important role in her economy nor is population projected to increase greatly by 1980. Fayette County's population is generally located in its western section and along a northeast-southwest axis through the center of the county. Industrial development along the Monongahela River has been limited because of lack of access to the river. Most of the land use in Fayette County is residential. Its population is projected to decrease by 1980. Greene and Fayette Counties were included in the State Planning Region chiefly because they belonged in no other such district. For these reasons greene and Fayette Counties have been omitted from the proposal.

Indiana County is another peripheral county which has been excluded from the proposal. It possesses low population density and industrialization and was included in the State Planning Region chiefly on the basis of administrative convenience. Otherwise, it has no strong connections with the Pittsburgh urban area, economic or otherwise.

As is true of most efforts to draw boundaries around an area to differentiate it from surroundings, there is always the likelihood of boundary conditions existing or developing. In the case of the air quality control regions, such a boundary condition would exist where sources of pollution on one side of the region affect air quality on the other side of the boundary. Relocating the boundary would only rarely provide relief from this condition. The solution is to be found in the way in which control efforts are implemented following the designation

of an air quality control region. Consonant with the basic objective of providing desirable air quality within the problem area being designated as an air quality control region, the implementation plan that follows the designation should have provisions for the control of sources located close to but beyond the region boundaries. The level of control for such sources would be a function of the degree to which emissions from source areas cause air quality levels to exceed the standards chosen for application within the air quality control region.

The boundaries of the Pittsburgh Region were selected so as to minimize the pollutant transport boundary problems mentioned above.

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## APPENDIX A. DESCRIPTION OF DIFFUSION MODEL.

The diffusion model is based on the Gaussian diffusion equation, described by Pasquill[1,2] and modified for long-term averages[3,4] for application to the multiple-source situation typical of an urban complex. The basic equation assumed that the concentration of a pollutant within a plume has a Gaussian distribution about the plume centerline in the vertical and horizontal directions. The dispersion of the plume is a function of the emission rate, effective source and receptor heights, atmospheric stability and the distance from the source. The plume is assumed to move downwind according to the mean wind.

The model was used to predict concentrations of $SO_2$, and CO, and total suspended particulates. The averaging times were the summer and winter seasons and the year. In order that the theoretical pollutant levels could be determined, it was necessary to evaluate certain meteorological input parameters. These parameters are wind direction and frequency of occurrence in each direction, effective wind speeds for each direction, and mixing depths for various averaging times.

Figure I-A shows the wind roses for the summer, winter, and year for the Pittsburgh area*. They represent graphically the frequency of occurrence of the wind from the various compass directions. This data, along with effective wind speeds for the respective compass directions

*U.S. Weather Bureau Data for Greater Pittsburgh Airport, 1951 through 1960.

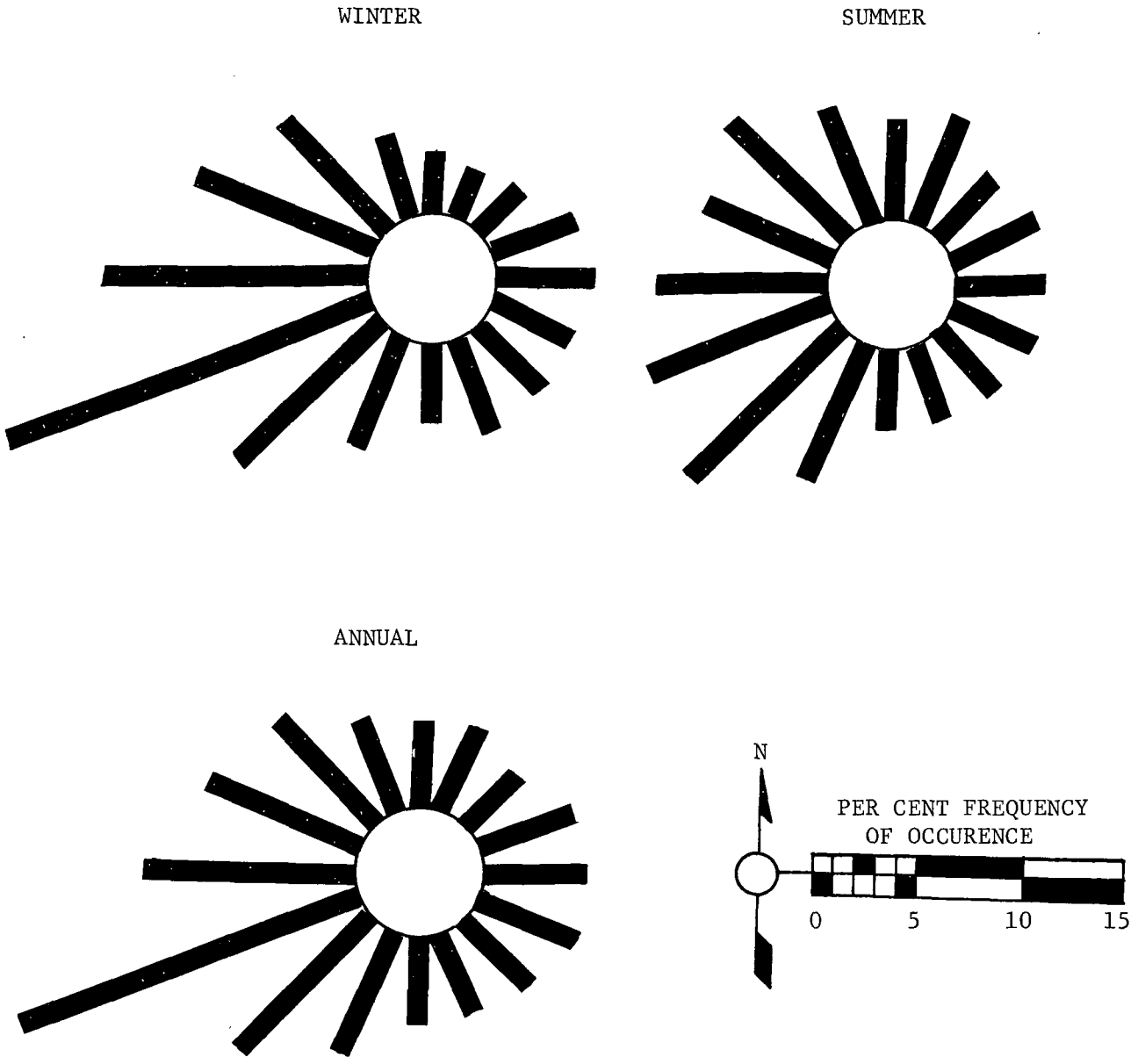


FIGURE 1-A. WIND DIRECTION PER CENT FREQUENCY OF OCCURENCE FOR VARIOUS AVERAGING TIMES.

was used as input data to the computerized model. The characteristic prevailing wind directions for each of the averaging times as depicted by the length of the wind rose radials, produce a direct influence over the dispersion of pollutants.

Table I-A shows average mixing depths for the winter, summer, and annual averaging periods*. A significant diurnal variation in the mixing depth is indicated. These mixing depths define the volume of air above the surface through which pollutants are allowed to mix, and are assumed to have no spatial variation (i.e., mixing depth is constant) over the receptor grid system.

Table I-A.

Average Mixing Depths for Pittsburgh by Season and Time of Day (meters).

| Season | Morning Average | Afternoon Average | Average, Morning and Afternoon |
|---|---|---|---|
| Winter | 419 | 811 | 615 |
| Summer | 333 | 1794 | 1064 |
| Annual (four seasons) | 390 | 1431 | 911 |

*Computed mixing depths documented by Holzworth[5,6] and by recent tabulations furnished to the Meteorological Program, NAPCA, by the National Weather Record Center, ESSA.

The diffusion model was used to compute the ground level concentrations of pollutants at 225 receptor points. Their locations were defined by an orthogonal grid system with mesh points 15 kilometers apart. This grid, 210 km. on a side, was centered in the City of Pittsburgh. An effective source height of 75 meters was assumed for all pollutant point sources, while topographical features were neglected for area-source emissions and for the 225 receptor points.

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