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STATE IMPLEMENTATION PLAN for AIR POLLUTION CONTROL

VOLUME 3: Sulfur Dioxide

Illinois Environmental Protection Agency
Division of Air Pollution Control
2200 Churchill Road
Springfield, Illinois 62706

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(DRAFT)

STATE IMPLEMENTATION PLAN

FOR THE

STATE OF ILLINOIS

VOLUME 3

SULFUR DIOXIDE

Illinois Environmental Protection Agency
Division of Air Pollution Control
2200 Churchill Road
Springfield, Illinois 62706
April 1, 1979

FOREWARD

This document is the third in a series comprising the draft of the State Implementation Plan for the State of Illinois. The intent of this document is to provide information on sulfur dioxide as legally required by the Clean Air Act as amended in 1977. The volumes in this series are:

Volume 1:	General Information for All Pollutants Introduction (Chapter 1) Legal (Chapter 2) Consultation (Chapter 3) Permits (Chapter ~~4~~ 5) Annual Review (Chapter ~~5~~ 4) Miscellaneous (Chapter 6)
Volume 2:	Total Suspended Particulates (Chapter 7)
Volume 3:	Sulfur Dioxide (Chapter 8)
Volume 4:	Nitrogen Oxides (Chapter 9)
Volume 5:	Oxidants (Chapter 10) Transportation Planning (Chapter 11) Inspection and Maintenance (Chapter 12) Carbon Monoxide (Chapter 13)
Volume 6:	Illinois Pollution Control Board Procedural Rules and Regulations
Volume 7:	Illinois Air Pollution Control Rules and Regulations
Volume 8:	Variances and Court Orders

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List of Acronyms and Abbreviations

AQDHS	Air Quality Data Handling System
AQMA	Air Quality Maintenance Area
AQSTM	Air Quality Short-Term Model
CDM	Climatological Dispersion Model
CILCO	Central Illinois Light Company
DAPC	Division of Air Pollution Control
EEI	Electric Energy, Incorporated
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
IPP	Implementation Planning Program
MMA	Major Metropolitan Area
NAAQS	National Ambient Air Quality Standards
ppm	Parts Per Million
RACT	Reasonably Available Control Technology
RFP	Reasonable Further Progress
SAROAD	Storage and Retrieval of Aerometric Data
SCC	Source Classification Codes
SCS	Supplementary Control System
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SMSA	Standard Metropolitan Statistical Area
SO_2	Sulfur Dioxide
SO_3	Sulfur Trioxide
SO_4	Sulfate
TAS	Total Air System
TPY	Tons Per Year
TSP	Total Suspended Particulates
TVA	Tennessee Valley Authority
ug/m^3	Micrograms Per Cubic Meter
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
WBAN	Weather Bureau, Air Force, Navy

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8.0 Sulfur Dioxide (SO_2)

This chapter of the State Implementation Plan (SIP) describes the basic analyses that led the Illinois Environmental Protection Agency (IEPA) to conclude that the existing set of Illinois Pollution Control Board (IPCB) rules and regulations governing sulfur dioxide (SO_2) is necessary and sufficient to achieve the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide.

8.1 Introduction and Overview

8.1.1 Background

8.1.1.1 Federal Activities

The 1970 Clean Air Act Amendments required the Administrator of the U. S. Environmental Protection Agency (USEPA) to promulgate NAAQS for five pollutants. These standards were promulgated in early 1971 and set at levels necessary to protect the public health and welfare.

The 1970 Amendments required states to adopt SIPs by 1972 to attain the NAAQS "as expeditiously as practicable but in no case later than three years after the date of approval of such plan". Subsection (e) of Section 110 authorized the Administrator to extend the attainment date for any national standard for up to two years; thus by mid-1975, or 1977 at the latest, Congress intended that healthful air quality be attained throughout the country. With respect to sulfur dioxide, this goal was achieved in many parts of the nation.

On August 7, 1977, President Carter signed into law new amendments to the Clean Air Act. Section 107(d)(1) of this amended Act required every state to recommend to the USEPA which areas in the state should be designated as attainment, nonattainment, or unclassified areas with respect to the NAAQS. One of the purposes of these designations was to identify those areas requiring study to determine if modifications to the SIP were necessary for the attainment and maintenance of the NAAQS. The USEPA published the official designations for each state in early 1978 (Ref. 52).

Portions of three counties in Illinois were officially designated "nonattainment" for sulfur dioxide. These counties were Peoria and Tazewell Counties in central Illinois and Massac County, which is adjacent to Kentucky, in southern Illinois. Portions of five additional counties were designated "unclassified" because they were located either in highly urbanized industrial areas or areas with high SO_2 emissions. These counties were Bureau, Christian, Cook, Madison, Sangamon, and Will. All other counties were designated as "attainment".

Section 172 of the Clean Air Act as amended in 1977 requires that the SIP provide for attainment of the primary or health related NAAQS as expeditously as possible, but no later than December 31, 1982. The secondary, welfare-related NAAQS are to be achieved in a reasonable time thereafter. The health-related primary standard for SO_2 is 80 micrograms per cubic meter (ug/m^3) measured annually or 365 ug/m^3 measured over a 24-hour period. The welfare or secondary standard for SO_2 is 1300 ug/m^3 measured over a 3-hour period.

8.1.1.2 State Activities

Special SO_2 studies were started in 1976 for the Chicago, Peoria and East St. Louis areas and Massac County. Other SO_2 studies are under way for the areas currently designated as unclassified. These special air quality studies together with existing air monitoring data indicate that the 24-hour primary standard and the 3-hour secondary standard are the most difficult to achieve. If these short-term standards are attained, the annual average air quality standard will likely be achieved by a wide margin in Illinois.

The IEPA studies also show that existing SO_2 air quality problems generally caused by sources which are not in compliance with current IPCB rules and regulations and that once compliance is achieved, the primary NAAQS in Illinois will be attained and maintained. Additionally, only a small portion of one study area, Massac County, has the potential for exceeding the secondary SO_2 standard.

The IPCB SO_2 regulations governing fuel combustion sources in major metropolitan areas have been, and currently are, the subject of challenges upon State procedural grounds in State courts. Among these cases are one decided on September 27, 1978 and one decided on December 14, 1978, each by different districts of the Illinois Appellate Court, in which the regulations were vacated and remanded for reconsideration by the IPCB. A third case touching upon the same matters is currently under consideration by the First District of the Appellate Court. In a fourth case, a Petition for Review was filed in the Third District of the Appellate Court seeking review of an IPCB order by which the compliance dates of the various provisions of Rule 204 were set forth in tabular form. The Illinois Supreme Court has pending on its docket a Petition for Leave to Appeal with respect to the Appellate Court decision dated December 14, 1978.

The IEPA has petitioned the IPCB to re-adopt the remanded regulations so as to ensure that State procedural deficiencies, if any, do not interfere with attainment and maintenance of the NAAQS. The regulations in question remain part of the controlling (current) State Implementation Plan.

8.1.2 Organization of the Sulfur Dioxide SIP

The five portions of the SO_2 SIP development are: 1) nonattainment status evaluation, 2) strategy evaluation, 3) legally enforceable control measures, 4) demonstration of attainment, and 5) reasonable further progress.

Nonattainment status evaluation includes the evaluation of air quality data, development of a point and area source emissions inventory, evaluation of meteorological data, and the accomplishment of detailed dispersion modeling for the area of interest. The output of this process is an analysis indicating the SO_2 air quality in an area and the degree to which additional controls may be required. These detailed analyses are provided in Section 8.2.3.

Strategy evaluation includes the evaluation of alternative regulatory proposals for specific types of stationary point sources and proposals designed to apply to all industry -- statewide. A dispersion analysis was conducted to determine the effect on air quality of various control strategies. In addition to the nonattainment counties, five counties located in urban areas of Chicago and St. Louis were selected for further study: Cook, Lake, Will, Madison and St. Clair. The strategy evaluations are presented in Sections 8.3.1 and 8.3.2. In addition, the effects which sulfur dioxide control will have on health, welfare, economy, society, and energy are discussed in Section 8.3.3.

Legally enforceable control measures include the regulations which will be applicable to improving the sulfur dioxide air quality and are described in Section 8.4.

Demonstration of attainment discusses the current attainment status of each county which was indicated as nonattainment in the initial designation by USEPA. The new status of each area will be discussed based on the recent IEPA studies and monitored air quality levels. Finally, methods which will be used to continue to assess the attainment status of the area are noted in Section 8.5.

Reasonable further progress is the schedule by which emissions reductions will take place, with a goal of achieving significant emissions reductions at regular intervals. This process includes a description of how the IEPA will monitor progress and is described in Section 8.6.

8.1.3 Redesignation of Nonattainment Areas

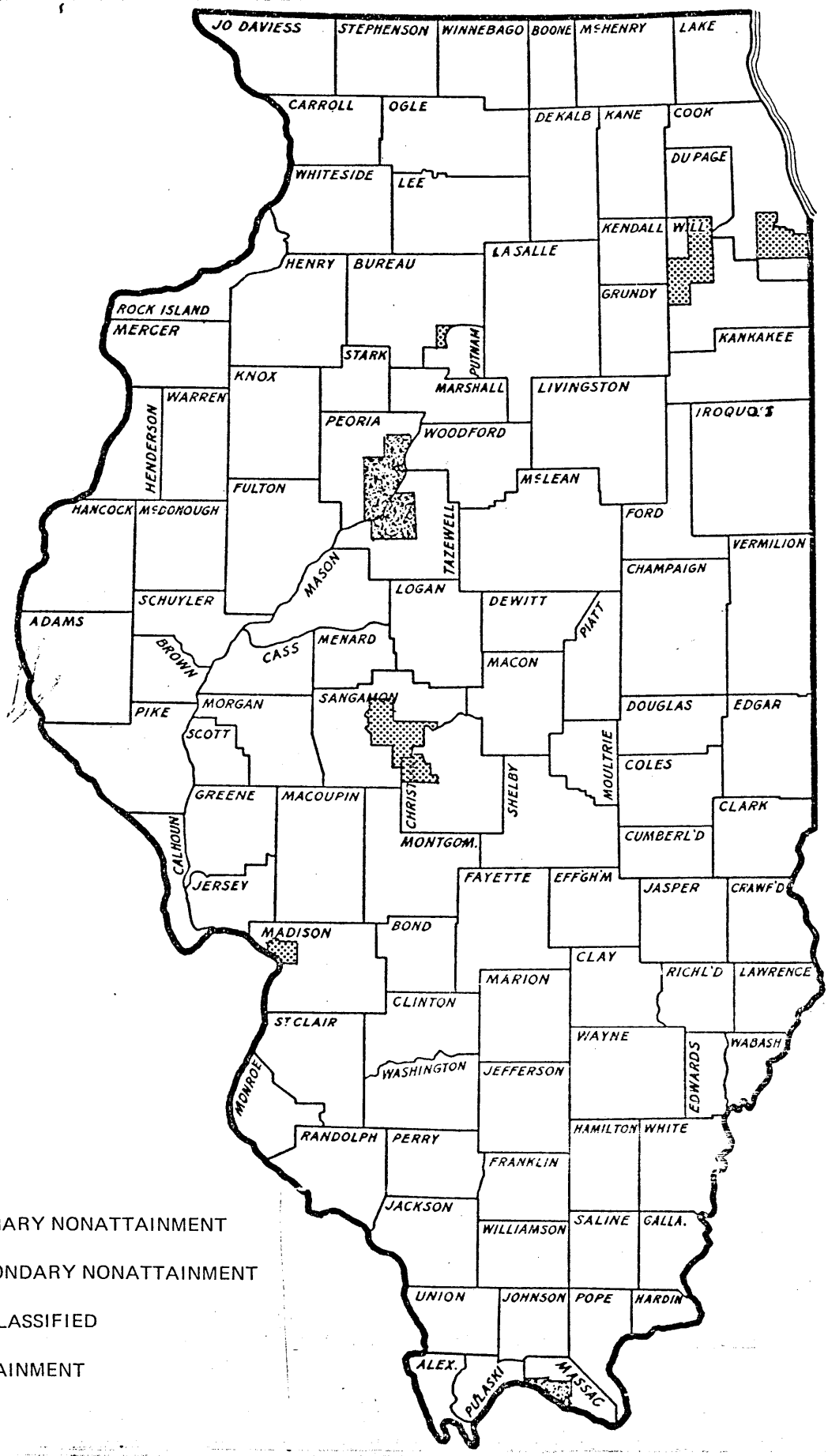
The IEPA has re-evaluated the nonattainment status of Illinois counties based on the most recent IEPA modeling studies and current SO_2 air quality monitoring data. Figure 1 shows the Illinois counties designation status as presented in the October 5, 1978 Federal Register (Ref. 53). The specific nonattainment areas for SO_2 presented in this Federal Register are as follows:

Peoria County - Hollis, Limestone, Medina, Peoria, Kickapoo, and Richwoods Townships

Tazewell County - Cincinnati, Elmgrove, Groveland, and Pekin Townships

Massac County - Grant, Metropolis, and Hillerman Precincts

FIGURE 1
SULFUR DIOXIDE NONATTAINMENT AREAS AS DESIGNATED IN THE OCTOBER 5, 1978 FEDERAL REGISTER



The areas which were unclassified for SO_2 are as follows:

Cook County - Bremen, Calumet, Thornton, and Worth Townships

Will County - Channahon, DuPage, Joliet, Lockport, and Troy Townships

Madison County - Wood River and Alton Townships

Bureau County - Selby Township

Christian County - South Fork Township

Sangamon County - Capitol, Cooper, Cotton Hill, Rochester, and Woodside Townships

All other areas in the state were classified as attainment.

Based on current air quality monitoring data and the most recent air quality studies, the following areas, shown in Figure 2, are recommended by the IEPA as nonattainment for sulfur dioxide:

Peoria County - Hollis, Limestone, Logan, and Peoria Townships

Tazewell County - Cincinnati, Elmgrove (secondary nonattainment only), Pekin, and Groveland Townships

Massac County - All Precincts

No changes have been recommended in the unclassified area for SO_2. All other areas in the state are recommended as attainment areas.

8.2 Nonattainment Status Evaluation

8.2.1. Data Inputs: Acquisition, Processing and Use

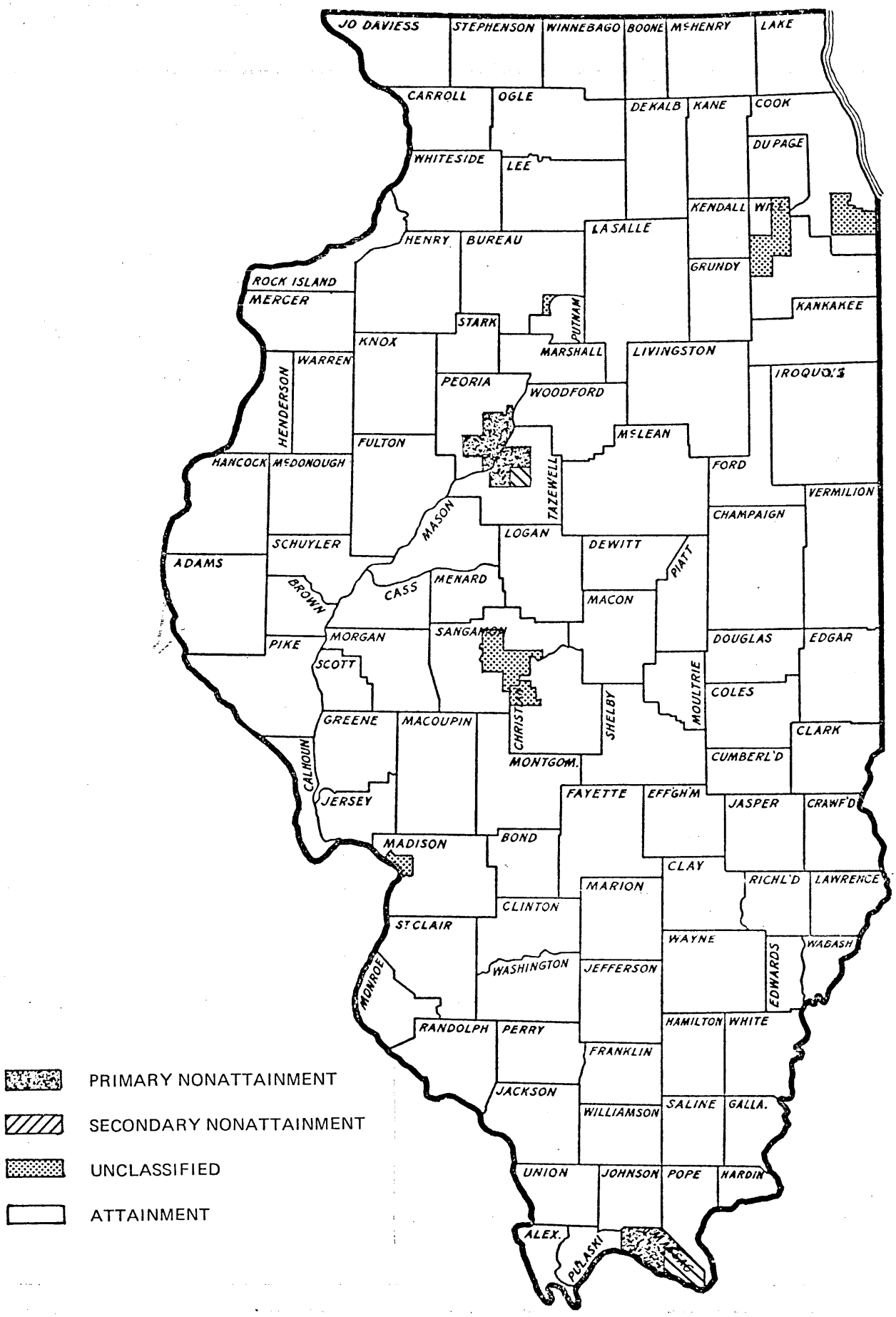
8.2.1.1 Air Monitoring Network

8.2.1.1.1. Description of Network

The Illinois SO_2 monitoring network is designed to represent general population exposure to the maximum SO_2 concentrations (Ref. 1 and 2.)

The three types of monitoring instruments used in the Illinois SO_2 network are: a colorimetric monitor, a coulometric monitor, and a pulsed fluorescent monitor. The colorimetric monitor draws air through an absorbing column where it is continuously mixed with a solution of tetrachloromercurate which absorbs the SO_2. A portion of the solution is mixed with formaldehyde, sulfamic acid and pararosaniline dye and sent through a time delay coil where mixing and chemical reaction between the SO_2 and the analytical reagents take place. The resulting dye complex is spectrophotometrically analyzed using a flow cell colorimeter at a specific wave length. The change in percent transmission of the solution is related to the concentration of SO_2 in the ambient air. This

FIGURE 2
THE RECOMMENDED REDESIGNATION OF THE ILLINOIS SULFUR DIOXIDE NONATTAINMENT AREAS



technique is used to continuously monitor the concentration of SO_2. The reference procedure (eqs - 0775-001) for measuring SO_2 is identical to the above procedure with the exception that an absorbing coil is used to obtain a continuous sample. Both techniques (gas bubbler and continuous monitor) are used in the Illinois network. The second instrument, a coulometric monitor, draws air through an acid solution of bromine and bromide ions. The reaction between SO_2 and bromine results in a shift of electrical equilibrium in the solution. The electrical current required to reform sufficient bromine from the bromide ions to reestablish the original equilibrium is proportional to the SO_2 concentration in the ambient air. The third instrument, a pulsed fluorescent monitor, draws air into a chamber where it is pulse irradiated with ultraviolet light of a specific wave length. The SO_2 molecules present absorb photons of energy from this light. When these excited molecules revert back to their original energy state, they release energy in the form of light and the intensity of the emitted light is measured and converted into a SO_2 concentration. The USEPA has approved monitoring instruments which are based on these techniques, although not all instruments which use one of these techniques have been approved (Ref. 3).

The SO_2 monitoring network in 1977 consisted of 36 continuous analyzers and 70 SO_2 gas bubblers. This was not significantly different than the 1975 network when 32 continuous monitors and 69 gas bubblers were in service. Most of the SO_2 monitoring sites are located in the Chicago major metropolitan area (Ref. 4, 5, 6). The Peoria and St. Louis areas are next. Together, these three metropolitan areas represent 75 percent of the State's population exposure to this pollutant.

8.2.1.1.2 Data Collection and Processing

The SO_2 monitoring instruments used in the Illinois air monitoring network are based on two collection principles. The first type of monitor continuously measures the levels of SO_2 in the air, while the second technique, often called the intermittent technique, collects a 24-hour integrated sample in an absorbing solution. Continuous SO_2 monitors can be connected to a chart recorder, a telemetry system or an on-site data logger. In the Illinois network, most instruments are linked to a telemetry system which transmits data over phone lines to a central computer. All monitors which are not on the telemetry system are connected to chart recorders. As a backup system, most of the telemetered monitors also record the data on strip charts which must be decoded later either manually or electronically with a digitizer to obtain hourly averages. Once the data are reduced from strip chart form, they are then entered to a computer.

The intermittent samplers are collected from the monitoring sites and transmitted to a laboratory where the absorbing solutions are analyzed for SO_2. The results of these analyses, expressed as a 24-hour average, are entered to a computer.

All data in the Illinois network are sent to the IEPA. Local contributing agencies send their data to the IEPA on magnetic tape or on data forms. All data from the Illinois network are processed through the computerized Air Quality Data Handling System (AQDHS) (Ref. 7). This system edits the data and provides reports which are reviewed by trained specialists, who look for anomalous data values not captured by the AQDHS editing system. Once the data have been edited and validated, they are ready for submission to the USEPA.

A uniform procedure has been developed for determining whether a sufficient amount of air quality data has been collected by a sensor for use in computing a valid average. This uniform procedure represents a minimum statistical criteria for use in computing 3-hour, 24-hour and annual averages. In order to compute an annual average from a gas bubbler (integrated 24-hour average), a minimum of 20 samples is necessary. Each quarter must contain at least five samples and, within any quarter, if one of the months has no samples, then neither of the other two months can have less than two samples. Continuous monitors require 75 percent of the total data in a year in order to calculate an annual average. In addition, 75 percent of the data in each quarter is required in order to avoid any seasonal bias.

Short-term averages also require a minimum criteria. For 3-hour averages, all three hourly data values are required. To calculate a 24-hour average, a minimum of 18 hourly values is required.

8.2.1.1.3 Quality Assurance Program

The IEPA's Quality Assurance Program for ambient air monitoring was initiated in November, 1974, with a submittal of a role document for quality assurance to the USEPA Region V. In 1975, an operations and procedures manual was prepared to implement the quality assurance program. The program started in January, 1976, with the issuance of an annual inspection schedule for State and local agency air monitoring activities. In March, 1976 the final Quality Assurance Program document was completed and submitted to the USEPA Region V for review and approval.

During the course of 1976, comprehensive inspections of the air monitoring activities of the IEPA and local agencies were performed (Ref. 8-19). These assessments were of multiple benefit, since they provided the IEPA with insight into the actual operating methods used in the various air monitoring programs in the State; permitted operational deficiencies and deviations from Federal Register requirements to be determined; motivated corrective actions, improved methods, and procedural changes; improved coordination between State and local agencies; established credibility and confidence in the objectives and goals of the Quality Assurance Program; and established a guideline for quality assurance activities at the State and local agency levels.

In 1977, the IEPA Quality Assurance Program expanded by adding additional local agency and industrial network monitoring activities to the annual inspection schedule. Increased emphasis was placed on audits of continuous monitoring instruments throughout the State, and new calibration equipment with increased accuracy and reliability was purchased.

In March of 1978, the Illinois EPA submitted a Quality Assurance Policy Statement and the revised Quality Assurance Manual for Ambient Air Monitoring to the USEPA Region V for their approval. These documents were subsequently approved on March 30, 1978.

The IEPA actively pursues a program of routine audits for the SO_2 monitoring system. The Quality Assurance Officer, with an independent SO_2 auditing device, routinely audits SO_2 monitors at sites throughout the state. The results of these audits are documented and are on file at the IEPA's offices in Springfield. The IEPA also participates in the interlaboratory testing program of the USEPA. The results of the USEPA SO_2 Quality Assurance Program are available from either the USEPA or the IEPA (Ref. 20). All of the SO_2 audits conducted to date have shown that the Illinois SO_2 monitoring network is producing accurate and precise data within the limits prescribed by the monitoring technique.

8.2.1.1.4 Data Availability

The IEPA publicizes the statewide SO_2 monitoring results in a variety of forms. An Annual Air Quality Report containing the results from the monitoring network for the previous calendar year is published in June of each year (Ref. 5, 6, 7). This report contains information on air quality standards and episode levels, the health and welfare effects of air pollutants, a description of the air sampling network, and summaries and interpretations of air quality data. Another report containing data summaries for each calendar quarter is issued four times a year. These reports can be obtained by writing to the Springfield office of the IEPA. Mailing lists are maintained for those persons interested in obtaining these reports on a routine basis.

Requests for validated and edited data cannot be filled until approximately two months after the data is collected.

8.2.1.1.5 Interpretation, Summary and Trends

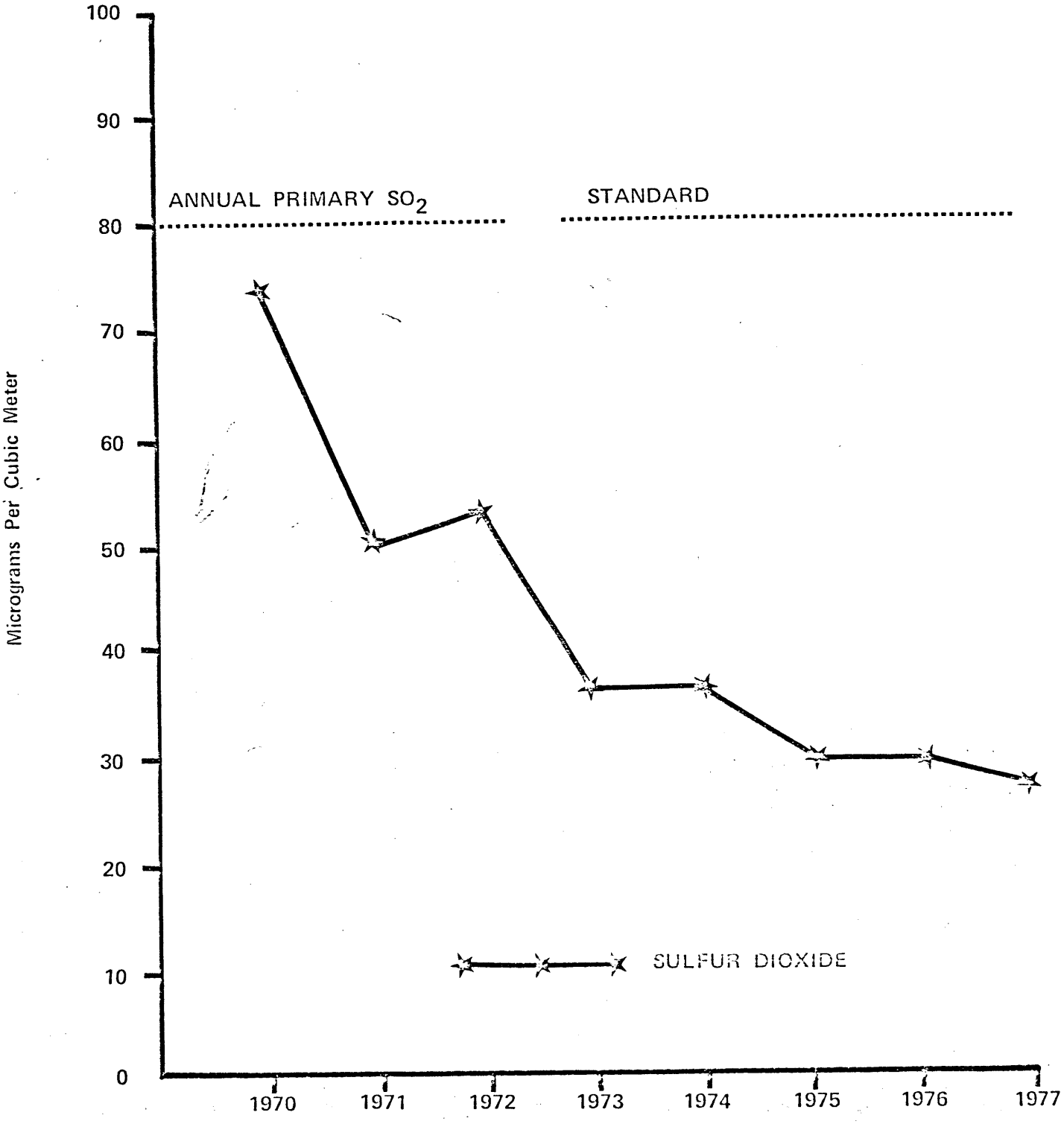
The statewide trend for SO_2 from 1970 through 1977 is shown in Figure 3. The statewide arithmetic average in each year is based on all sites that have valid annual averages for that year. The trend has been definitely downward, with a leveling off since 1975. In 1977, the statewide average was 27 micrograms per cubic meter, well below the primary annual standard of 80 micrograms per cubic meter.

Monitoring sites that have SO_2 values in excess of the primary annual standard generally indicate a pervasive air quality problem. A milestone was reached in 1976 when, for the first time, no violations of the annual SO_2 standard were measured. Again, in 1977, all monitoring sites showed attainment of the annual standard.

Since 1975, violations of the primary 24-hour standard have been measured in Peoria, Pekin, Blue Island, Wood River and Metropolis (Ref. 21). Pekin was the only site in the Illinois network to exceed the 24-hour primary standard in 1977. Industry pollution control programs in Blue Island and Wood River have been related to the elimination of violations in those areas (Ref. 22).

FIGURE 3

STATEWIDE POLLUTION TRENDS FOR SO_2



*Arithmetic average of annual geometric means of all sites which have valid annual averages in each year.

The Pekin and Metropolis areas recorded violations in 1977. Evidence to date is not sufficient to show that violations will not continue to periodically recur in the Peoria, Pekin and Metropolis areas.

8.2.1.2 Emissions Inventory

8.2.1.2.1 Point Source Emissions Inventory

To conduct today's sophisticated air quality analyses, a tremendous amount of data is needed concerning air pollution sources and the pollutants they discharge. The term "emissions inventory" has become the umbrella term for the wide range of information needed for air pollution studies. The data that compose the core of any inventory are the listing of sources and the amounts of air pollutants they discharge to the atmosphere. Other data common to most inventories include type of fuel used, hours of operation, average and maximum throughput and controlled and uncontrolled emission rates.

This information for Illinois air pollution sources is contained in the IEPA data bank called the Total Air System (TAS). The TAS was established to meet a variety of needs: air quality analyses, permit reviews, setting field investigation and enforcement priorities, and special studies.

Any plant for which a permit is required, according to the air pollution rules and regulations, is on file in the TAS. Information about a plant is organized into three basic categories: 1) information concerning an entire plant or facility, 2) information about a specific operation within the facility, or 3) information about an emission source, control system or exhaust point within an operation.

The information concerning an entire facility found in the TAS includes:

- Plant name, address, city, zip code;
- Company name, address, city, state, and zip code;
- Storage and Retrieval of Aerometric Data (SAROAD), county and city codes, major metropolitan area code, federal air quality control region, and DAPC region and district;
- Ownership code, plant Standard Industrial Code (SIC) (Ref. 23), plant lot size, number of employees, and plant Universal Traverse Mercator (UTM) coordinates;
- Episode action plant status and date, names and numbers of persons to be notified during episodes, and major (100 TPY) contaminants;
- Compliance status and date, plant inspection date and engineer's initials, warning letter date, and date plant ceased operation;
- Name of the operation and confidentiality code;
- Date permit received, permit expiration date and analysis engineer's initials;
- Identity of owner(s) and person submitting the application, and number of times processed;
- Record date, number of identical sources, and referenced construction permit number;
- Source code, SCC number, operation SIC and IPP process code, and source equipment name;

- Process weight rate, operating rate, hours of operation, (all maximum and average) and percent annual thruput by quarter;
- Heat input, percent space heat, percent sulfur and ash, and heat content;
- Uncontrolled and allowable emission rates, estimation method, and limiting rule (maximum and average) for each of the five criteria contaminants;
- Control equipment name, control equipment codes and overall efficiency for each of the five criteria contaminants; and
- Stack height (or an effective plume height), diameter, exhaust rate, and temperature, and stack UTM coordinates.

The TAS was originally compiled in 1975 from information supplied to the IEPA in permit applications and from a previous, less comprehensive inventory of sources and their emissions. In 1976, after this project was completed, the field staff was instructed to verify information for major air pollution sources including the source type, size, and location, and to obtain other pertinent emissions data necessary for the air quality studies. Large sources in areas where air quality violations had been measured were given the highest priority. Second highest priority was given to large sources in other areas. The first phase of the verification project was initiated well before the 1977 SIP revision requirements were issued. Although the most recent verification investigations were completed in the fall of 1978, the evaluation and updating of the TAS is a continuous process.

When the TAS was first assembled, much of the data was taken from the permit files. The validity of that data relied not only on the technical competence of the permit applicant and his understanding of the information required, but also on the quality of the standard emission factors in use at that time. During the verification project, source emissions were recalculated using the latest available emission factors. Where appropriate, stack tests and material balances were used.

An important subjective variable in the data check was the field engineer's estimate of the capture efficiency of the control equipment at a plant. Although a particular piece of equipment may have had a high capture rating, a field engineer's observation could significantly decrease the collection efficiency claimed for the controls.

As new emissions factors were officially released by the USEPA, they were evaluated against the factors being used by the IEPA. Recently more accurate factors on metallurgical operations have helped increase the validity of the TAS emission numbers for steel mills.

The latest phase in the evolution of the TAS was an editing check of the source data by field engineers. Prior to the SIP-revision air quality analyses that were conducted in each nonattainment area, the IEPA field staff reviewed the data on each source and facility with the potential to emit 100 tons of SO_2 a year to ensure that the information was accurate and current.

When 1975 point source inventory information was not directly available, the 1978 emissions inventory was used to establish the inventory for base year (1975) modeling. It was initially assumed that the emissions for these years did not differ significantly. However, field engineers evaluated this assumption and supplied estimated 1975 emissions for facilities where the assumption was not appropriate. Base year modeling procedures used the actual amount of air contaminants being emitted to the atmosphere from each emission point.

In the compliance year modeling (the future year when all sources would be in compliance with emission regulations or standards), the amount of emissions modeled was the lesser of the actual vs. the emissions allowed by regulation. The predicted air quality in the compliance year reflects a situation when all sources are either operating at or below compliance emission levels.

Where plant-specific growth information was not available, SO_2 emissions used for the 1985 analysis were obtained by projecting compliance year emissions to 1985 by use of proxy variables related to employment projections for the study area. Base year and future year employment data were obtained by specific Standard Industrial Classification (SIC) categories (Ref. 23). Compliance year emissions were projected to 1985 by multiplying base year emissions by the ratio of 1985 to 1975 employment data for each specific SIC category.

8.2.1.2.2 Area Source Emissions Inventory

Area source pollutants are most accurately described as those pollutants not emitted from a specific, major point source, but rather from a general area. Area source emissions may include the aggregate of numerous point sources too small to be considered individually, such as emissions from residential fuel burning.

The IEPA's first comprehensive area source inventory was compiled in 1975 by the Walden Research Division of Abcor, Inc. (Ref. 24). The base year of this emissions data is 1975. The data are organized by source category and by county for five pollutants: total suspended particulates, sulfur dioxide, nitrogen oxides, hydrocarbons, and carbon monoxide. Generally, the Walden emissions figures were used in the air quality analyses; however for some areas or emission categories, IEPA computed its own area source numbers or refined the Walden figures.

In performing air quality studies, the spatial allocation of area source emissions is as important as the emissions estimates themselves. To use the data in dispersion modeling, the area source emissions must be distributed properly in areas characterized as square grids throughout the study area. Emissions are either assigned to grids in which they are physically known to be, such as an airport, or they are apportioned to many grids based on proxy variables. The USEPA documents, Guidelines for Air Quality Maintenance Planning and Analysis (Ref. 25) suggest the use of several different proxy variables, depending on the emission source category, availability, and the depth of analysis desired. Typical proxy variables for land use are the following: employment, population and earnings. For the air quality studies in large urban areas, this type of information was available from local and regional planning agencies,

usually organized according to traffic zones. Unfortunately, traffic zones are rarely uniform in shape or area, and considerable effort was required to transfer the data to the grid cells. If 25 percent of a traffic zone was in a particular grid, then typically 25 percent of the land use data (dwelling unit, employment, etc.) from the zone was assigned to the master grid. This approach is reasonable since traffic zones usually are designed to encompass areas of uniform land use. The land-use data for all traffic zones coincident with a grid cell were then added to obtain a grid total.

The size of each grid cell varied depending on the type of area under study. In rural areas, grid cells were large because of the homogeneity of the area. In the larger metropolitan areas where detailed land-use data were available by traffic zone, the size of the grid cells was reduced proportionately. Smaller grid cells allow greater resolution of land-use parameters and reflect small-scale changes in land use.

The separate emissions categories were apportioned to the grids on a straight percentage basis. For example, if a particular grid contained four percent of a county's dwelling units, then four percent of the county's total sulfur dioxide emissions from residential fuel combustion was assigned to that grid.

The area source allocation schemes used in the air quality modeling analyses varied because of the different data bases, but generally the allocation factors conformed to an "Order 2" analytical approach in the USEPA document, Guidelines for Air Quality Maintenance Planning and Analysis, Vol. 13: Allocating Projected Emissions to Sub-County Areas (Ref. 26).

8.2.1.2.3 Growth Factors

Thorough statistical evaluations of Illinois point source emissions disclose that a frequency distribution of the number of sources in a class interval based on magnitude of total source emissions is invariably lognormal. Sources having actual total emissions in excess of 100 tons annually account for 92.4 to 99.5 percent of all point source emissions, depending on pollutant and geographical area considered. It can therefore be reasonably assumed that to assess growth adequately, only the growth of sources emitting more than 100 tons per year of at least one pollutant is required. Neglecting the smaller point sources will have only a very minor effect on the results of a growth study.

The technique of direct source interview consisted of asking a plant manager for his assessment of the remaining lifetime, present and future process weight rates, and annual hours of operation for each major process source within the facility. It was assumed that source growth generally would be proportional to facility growth. An overall source growth factor was then used for the projection of industrial fuel combustion emissions. The foregoing method was not used for one class of large point sources - the power generating stations of electric utilities. Growth assessment for the electric utilities was taken from that industry's own carefully compiled growth projections.

For point sources in facilities which were not interviewed or for facilities which did not supply the IEPA with information for the interview and for area sources, emission projections were based on the most appropriate indicators of growth available to the IEPA at the time. This was most frequently population and employment data. The Illinois Population Projections prepared by the Illinois Bureau of the Budget were used extensively (Ref. 27). The area source emissions category most closely linked to population changes is residential fuel combustion.

Most county employment data were obtained from estimates developed by Thomas W. Langford for the IEPA's "208" Water Quality Management Program (Ref. 28). Langford also compiled some data specific to nonattainment areas (Ref. 29). Langford's projections were double-checked with the Illinois Bureau of the Budget's population projections and reviewed for consistency by county and regional planning agencies. Langford's study data are aggregated by industrial groupings, generally at the level of 2-digit Standard Industrial Classification Codes (SIC). The employment for each category was forecast from the year 1975 to the year 2000 in five-year increments. These data were especially suited for projecting point source emissions by matching industry types by SIC number and assuming emissions grow proportionately to the employment in the area of concern. Also, emissions from certain area source categories were grown using Langford's projections (e.g., industrial fuel combustion by overall industrial growth in employment).

Additional growth information came from various local, regional, and state planning and transportation agencies. In some instances the data were developed specifically for the air quality studies. Generally, 1975 was the base year for the data. Growth estimates of population, employment, land use and traffic volumes were given by traffic zones to aid in the spatial allocation of emissions. Because the type and source of growth data varied in each study area, the specific studies should be consulted for an exact understanding of the methodology. As a minimum, the projection procedures generally conform to the "Level 2" analytical approach described in Volume 7 of the Guidelines for Air Quality Maintenance Planning and Analysis series (Ref. 30).

8.2.1.3 Meteorology

Meteorological data used in dispersion modeling studies must be representative of the area being studied. The best way to ensure that the data are representative is to select a meteorological monitoring site near the source or sources being studied. Of course, even a weather station very near a source may not always accurately reflect the dispersion characteristics of a region if that monitor is unduly influenced by local obstructions such as trees or buildings, or if terrain is a significant factor in the region.

These problems were minimized in the IEPA's studies of nonattainment areas by using data from the National Weather Service reporting station closest to the area studied. The National Weather Service operates monitoring stations in all the areas where the IEPA conducted technical studies for sulfur dioxide. Since the weather service has strict guidelines on locating its meteorological instruments, the IEPA was reasonably assured that the data was free from bias due to local obstructions to the wind flow.

Complex terrain is not a significant problem in Illinois SO_2 nonattainment areas. The Peoria area is bisected by a river valley system, but careful analysis indicated that the terrain does not cause substantial alterations to the wind flow. A meteorological station operated by the weather service in Peoria provided the best available data for modeling studies and is the most representative and complete data available.

The stations providing meteorological data for the nonattainment modeling studies are shown in Table 1.

The meteorological variables required by the dispersion models include wind direction and velocity, atmospheric stability and mixing height. For the annual analyses, data from the National Climatic Center, presented in the STAR format, were used. The STAR data present the wind direction, wind speed and atmospheric stability in a joint frequency table, expressing the probability of all three variables occurring jointly as a percent. This is the standard format for the Climatological Dispersion Model (CDM), which was the model used by IEPA in all its annual modeling studies. The average minimum and maximum mixing heights, which are required in the annual modeling, were obtained for each study area from Holzworth's Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution (Ref. 31).

TABLE 1
SOURCES OF METEOROLOGICAL DATA USED
IN SULFUR DIOXIDE NONATTAINMENT AREA STUDIES

Study Area	Surface Data Base Year	Surface Data Projection Years	Upper Air Data All Years
Peoria MMA	Peoria	Peoria	Peoria
Massac County	Paducah, Ky.	St. Louis*	Salem

* For the projection year studies, the joint frequency table used in CDM was based on five years of meteorological observation. Since five years of data were not available for Massac County, the closest weather station with five years of available data was used.

To calculate short-term air quality, hour-by-hour meteorological data are required. The meteorological data were obtained for the base year (1975) from WBAN reporting forms filled out at the time of observation by each station's meteorologists. The IEPA coded the required WBAN information, including hourly wind speed, wind direction, temperature and cloud cover, from the forms onto computer cards and the data was input to IEPA's version of the STAR program to determine hourly atmospheric stability, based on the classification scheme in Bruce Turner's Workbook of Atmospheric Dispersion Estimates (Ref. 32). The same data were also used in IEPA's Mixing Height Program which interpolates the hourly mixing height from the twice-daily radiosonde observations made at the nearest available upper-air weather observing station. This program uses an algorithm equivalent to that used in the pre-processor program for USEPA's CRSTER and RAM dispersion models.

It is usually preferable to use several years of meteorological data in detailed modeling studies such as those required for the SIP. This allows the proper identification of "worst case" meteorological conditions essential for a conservative modeling study.

IEPA selected 1975 as "base year" for use in its SIP revision process for several reasons. First, obtaining an accurate emissions inventory is a difficult job, even for a single year. The IEPA's field staff spent considerable time and effort defining and verifying the emissions and stack parameters for the numerous industrial sources in the State for 1975. Since modeling information about sources of pollutants can change from year to year, establishing an accurate inventory for several years would be prohibitively difficult and expensive.

Second, hour-by-hour meteorological data for several years was simply not available when the studies were conducted. The last year that hour-by-hour records were kept by the National Climatic Center was 1964. The validation-calibration procedure which should be conducted in any annual modeling study requires meteorological data for the specific year for which the emisssions inventory was developed.

Finally, the costs of using several years of data in a modeling effort as extensive as this one is unnecessary because a "worst case" year can be identified by a carefully designed and less expensive screening procedure. Because meteorological data were not available on an hour-by-hour basis for recent years, a prohibitively extensive and costly coding effort would have been required to get the data into a computer-usable form. Also, the costs associated with the annual analysis would have increased by a factor equivalent to the number of additional years modeled.

Hour-by-hour meteorological data for 1973-77 have recently been made available by USEPA Region V for Chicago (Midway) and Peoria. A study conducted by James Crenshaw of the Mathematics Department of Southern Illinois University-Carbondale, using the meteorological data for both Chicago and Peoria, showed that for emissions released from tall stacks (i.e., power plant stacks) the use of 1975 meteorology resulted in higher ambient ground-level concentrations than did modeling for any of the other years (Ref. 33). This was found to be true for both SO_2 and TSP

regardless of averaging time: annual, 24-hour or 3-hour. Crenshaw also found that the concentrations were not substantially different for any of the years (1973-1977) when modeling short stacks. None of the years between 1973 and 1977 caused significantly higher ground-level concentrations than did 1975 for the short stack study. It was concluded that 1975 was the "worst case" year, as far as the meteorological data are concerned.

8.2.2 Evaluation Process/Modeling

The objectives of the SO_2 nonattainment area studies were to determine: the nature and extent of the annual, 24-hour and 3-hour regional nonattainment problems which existed in 1975; the effectiveness of existing control strategies to solve the nonattainment problems; and, the ability of existing control strategies to maintain the improvements gained to date.

Because there are air quality standards for annual, 24-hour, and 3-hour average SO_2 levels, analytical techniques capable of providing information for all averaging times were used. These techniques involved regional air pollution simulations (dispersion modeling), statistical analyses, and the evaluation of pertinent data by experienced air quality analysts. Since no practicable, finite number of sulfur dioxide samplers can completely document regional air quality, it is necessary to use analytical tools such as simulation modeling in conjunction with air quality, meteorological, and emissions data to yield a more complete understanding of regional air quality levels.

8.2.2.1 Annual Analysis

The computerized atmospheric simulation model, used to define annual average air quality in the SO_2 nonattainment areas, consists of a mathematical description of the transport and dispersion of air contaminants, plus mechanisms for manipulating the necessary input/output data. The simulation model selected for the annual analyses was a modified version of the Climatological Dispersion Model-CDM (Ref. 34-38). This model was used essentially as it was developed for USEPA except for the form of the input and output.

The base year average emissions for the nonattainment counties and meteorological data were used in the CDM to obtain a regional mapping of annual average SO_2 concentrations. SO_2 concentrations were calculated at up to 200 receptor points in some study areas. The grid spacing between receptors ranged from eight kilometers in predominantly rural areas to one kilometer in urban areas. These receptors were supplemented by including actual IEPA monitoring sites. The model results were compared to air quality levels and adjustments to the model output concentrations were made accordingly. This validation process produced a calibration factor which was applied to the model results when the model was used to predict air quality levels.

The model validation element (the comparison of calculated versus observed air quality levels to obtain a calibration factor), accounts for differences in calculated and observed air quality levels which may arise because of (1) an imperfect description of the emissions and meteorological situation in the region; (2) an incomplete knowledge of the magnitude of the long-range transport of SO_2; and (3) the imprecision of the mathematical model in describing the transport process for certain types of sulfur dioxide emission sources.

The model validation process identifies systematic errors in the meteorological or emissions data bases or in the modeling procedure used and develops a "calibration factor". The model validation process consists of a series of analytical steps which include: (1) comparing calculated concentrations with observed values; (2) determining the cause(s) of any discrepancies; (3) correcting and improving data bases, where possible; (4) modifying the model if necessary and practicable; and, (5) developing a statistical relationship between the observed and calculated concentrations which can be applied to all calculated values throughout the region. The statistical relationship is developed by fitting the plot of observed versus calculated values with an appropriate curve. The equation describing the curve is used to "correct" the calculated concentrations and thereby improve agreement with measured (observed) data. When a limited number of observed values are available to determine the appropriate "corrective" equation, a straight-line relationship is normally assumed since: (1) the ideal observed versus calculated concentration relationship would be a straight line with a slope of unity and (2) the choice of a specific non-linear relationship becomes more arbitrary as the number of observations changes.

Optimally, data from 15 to 20 monitors should be available to validate regional dispersion models. These monitors should be located in areas which reflect all types of emissions in the region (e.g., residential, commercial, and industrial). Since data from a variety of sites were not always available for the nonattainment study area analyses, the IEPA staff consulted air quality analysts in government, educational and research institutions, and consulting firms to ensure that validation procedures utilized by the IEPA were consistent with generally accepted practices and the state-of-the-art. These consultations supported the decision to use a straight-line relationship when "calibrating" the annual model.

Once it is determined that a straight-line relationship can be used for calibrating the calculated annual average concentration, there are at least four options: (1) determine the best-fit linear regression equation to describe the calculated versus observed levels without considering emissions from adjoining counties (i.e., make no attempt to calculate any "background" contribution from such sources); (2) use number (1) above but consider the concentration due to emissions from adjoining counties; (3) calculate the calibration (correction) factor by determining the average ratio of calculated versus observed concentrations using data from all the monitors and assume no background

(an assumption that forces the intercept of the correction curve through zero); and (4) use method number (3) above but consider the contribution from adjoining counties to explain part of the "background" concentration expected at the monitors.

The above methods result in an equation $y = mx + b$ where y is the "adjusted" concentration obtained by mathematically "correcting" the model output concentration (x) to more closely fit the actual observed concentrations at the monitoring sites. In the annual air quality assessments for study areas with three or more monitors, the second option was chosen to "calibrate" the computed annual average concentrations because: in general, the least squares fit is a more acceptable technique in model calibration because it incorporates the emissions from adjoining counties and thus defines a portion of the SO_2 concentrations expected at the monitoring sites but not caused by emissions in the study area; and the calculated correction factor approaches the ideal situation (slope equal to unity) where the model calculates the exact concentration as observed. The calibration expression is obtained using data from monitors representing the industrial area; therefore, the expression is only properly applied in that geographical area. Since that area experiences the maximum concentrations, the resulting "calibrated" concentrations are most appropriately represented by the model in the areas of greatest concern; that is, portions of the study areas where the annual air quality standard is being violated.

Once the base year annual air quality was calculated and the model validated and calibrated, a second regional annual air quality determination was made by assuming all sources were in compliance. Two additional analyses were conducted for 1985 and 1995 assuming growth. The growth projections were based on interviews with the major facilities in each area and on growth factors developed in cooperation with local planning agencies. The future air quality studies were conducted to ensure that the ambient SO_2 standards will be maintained after they have been achieved and to identify areas where future growth may endanger those standards.

8.2.2.2 Short-Term Analysis

Three techniques were used to evaluate SO_2 levels which may occur over relatively short periods of time in the nonattainment areas. The first and most beneficial analysis was an evaluation by air pollution meteorologists of SO_2 levels and meteorological data for selected days to develop an understanding of the nature and probable causes (i.e., major contributors) of regional air quality on those days. The days chosen for analysis were the six highest and six lowest concentration days at each monitor. A second statistical analysis (Ref. 39) was used to estimate the maximum and second-highest 24-hour and 3-hour concentrations which occurred in 1975, and to determine the annual average concentration which must be achieved to also attain the short-term standards. Thirdly, a computerized air quality model was used to determine regional air quality for periods of one to 24 hours.

The computer model used in the short-term analyses was the Air Quality Short-Term Model (AQSTM) developed by the IEPA (Ref. 40). The model, based on the well-known Gaussian diffusion equation and plume rise formulae given by Briggs, determines the magnitude and spatial distribution of 3-hour and 24-hour concentrations through applications of appropriate atmospheric diffusion equations.

A complete description of the short-term analyses and the meteorological and air quality data used is included in reports published by IEPA for each study area (Ref. 41, 42).

The analysis by IEPA air quality specialists of the meteorological conditions associated with peak SO_2 concentrations was conducted in several parts. The average values of several meteorological parameters including wind direction, wind speed, temperature, and precipitation on the days when the six highest and six lowest SO_2 levels were observed, were examined to determine how the peak SO_2 levels related to meteorological conditions. Composite wind roses on the highest and lowest days were constructed to determine which wind directions were associated with elevated levels. Pollution roses were also constructed from SO_2 data monitored during the normal 60-day monitoring schedule and also from continuous SO_2 data, when it was available, to determine the average concentrations of sulfur dioxide for each wind direction. Together, these studies enabled the IEPA's air quality specialists to determine what, if any, relationships existed between elevated SO_2 levels and meteorological conditions.

SO_2 air quality is often monitored by non-continuous instruments. However, there are continuous monitors in most areas where SO_2 is a problem. A statistical method formulated by Larsen determines the highest or second highest SO_2 concentrations that would be expected to occur at an intermittent sampler location if the sampler were operated continuously (Ref. 39). The statistical procedure assumes that air quality concentrations in a given location are distributed lognormally. In order to make use of this characteristic of the lognormal distribution, a line whose slope is equal to the observed standard geometric deviation and passes through the annual geometric mean is plotted on log-probability paper. By assuming that the standard geometric deviation is constant with time, one can compute the expected highest or second-highest SO_2 concentrations for either 3-hour or 24-hour averaging times for any year by knowing the geometric mean concentration. This method was used for the base year modeling study, the "compliance year", and 1985 and 1995 projections described in the annual modeling procedures, by using the maximum annual geometric mean concentration computed by CDM. Thus, it was possible to determine the peak 24-hour and 3-hour SO_2 levels expected for those years.

To identify possible violations of the 3-hour and 24-hour standards and the meteorological conditions associated with such violations, the IEPA also used the Air Quality Short-Term Model (AQSTM) in the nonattainment studies.

For the SO_2 nonattainment area studies the "running-average" version of AQSTM was run for all 8760 hours in 1975. The input data for this screening run included emissions from major facilities (i.e., those facilities actually emitting 100 or more tons/year of SO_2). The 3-hour and 24-hour average SO_2 concentrations were calculated to determine the eleven highest concentrations at each receptor for each averaging time. Because Peoria has a major river valley system in it, the terrain option of AQSTM was used in the short-term modeling. Even though the terrain in Peoria does not significantly alter the wind flow, it can be important in determining peak ground-level concentrations because the plume is closer to the ground as it passes over an elevated area. The meteorological conditions causing the 11 highest concentrations at each receptor were evaluated by air pollution meteorologists, and the six worst days for the region were selected.

Once the worst-case days were selected, the short-term modeling analyses were conducted using five basic studies. These studies included a verification of the short-term emissions and of the dispersion model discussed previously.

First, in the verification study, average hourly emission rates were used in conjunction with the meteorological data for the six worst-case days identified from monitoring data in 1975. These worst-case days were selected by air pollution meteorologists from a combined list of the six days at each of the monitoring sites in the study area when the highest ground level SO_2 concentrations were measured. The operators of the major facilities in those areas were interviewed by the field staff to determine whether the sources were operating on the days selected. Only those sources that would be expected to be operating on those days were used in the verification study. The concentrations predicted at each of the monitoring sites were then compared to the measured values on each of the days to see how the model performed. Sulfur dioxide concentrations were computed at receptor points which were spaced one kilometer apart and formed a rectangular grid over all monitor locations. The average difference between the modeled and monitored concentrations was computed to define the background concentration, and this background value was added to the concentration predicted at each receptor. This background level was also added to the modeled results in each of the four subsequent studies accomplished in each study area.

The next study for the base year 1975 assumed that all facilities were operated at the maximum emission rates currently allowed by IEPA regulations. This was done to represent a "worst case" scenario in those regions and to identify any area where current regulations could be inadequate.

The third study assumed that the point sources were operated at their average rates for the base year 1975. This represented a more typical situation and allowed a more realistic assessment of the air quality in the study areas. This study differs from the verification study mentioned previously in that all point sources in the inventory were used instead of just those facilities which indicated that they did operate on

those days. The intent of this study was not to recreate what actually occurred on a specific day as was done in the verification study, but to indicate what the potential air quality would be if those sources operated at their average rate.

The last two studies are projections of air quality in the study areas for 1985 and 1995. These projections were based on 1975 maximum allowable emissions which were increased to anticipate industrial growth in those areas. All analyses described above used a rectangular grid spacing of one to two kilometers.

The results from each of the studies were then used to make composite maps of the air quality in each area. The composite maps show any areas where the 24-hour or 3-hour SO_2 concentrations exceeded the appropriate ambient air quality standard on at least two of the days modeled. Since current standards allow a single excursion of the short-term standard concentrations per year in a given location, the areas shown in the composite maps delineate areas where the modeled results indicate violations (i.e., two or more excursions) of the short-term standards for sulfur dioxide.

8.2.3 Analytical Data For Each Nonattainment Area

8.2.3.1 Peoria AQMA

TABLE 2

PEORIA AQMA
SO_2 ATTAINMENT STATUS AND
MONITORING DATA SUMMARY

ATTAINMENT STATUS

Nonattainment Area (Township)	Exeeeds Primary	Exeeds Secondary	Projected	Modeled	Monitored	SAROAD Site No.(s)
Peoria County						
Hollis	x	x		x		
Limestone	x	x		x		
Medina	x	x		x		6080001
Peoria	x	x		x		6080023 6080024 6080029 6080030 6080031
Kickapoo	x	x		x		
Richwoods	x	x		x		6080027
Tazewell County						
Cincinnati.	x	x		x		
Elmgrove.	x	x		x		
Groveland	x	x		x		
Pekin	x	x		x	x	6060004

MONITORING DATA SUMMARY

SAROAD Site Number	Station (Address)	Annual Ave. (ppm) 75	76	77	Highest 24-Hr. (ppm) 75	76	77	2nd High. 24-Hr. (ppm) 75	76	77
6080001	Peoria (610 NE Jefferson)	.019	.015	*	.056	.058	.043	.039	.050	.016
6080023	Peoria (2711 SE Jefferson)	.015	.008	.006	.105	.031	.028	.043	.023	.027
6080024	Peoria (Hurlburt & McArthur)	.027	.019	.020	.162	.155	.124	.157	.094	.110
6080029	Peoria (407 NE Adams)	-	*	.017	-	.088	.085	-	.080	.070

TABLE 2 (Continued)
MONITORING DATA SUMMARY

SAROAD Site Number	Station (Address)	Annual Ave. (ppm) 75	76	77	Highest 24-Hr. (ppm) 75	76	77	2nd High. 24-Hr. (ppm) 75	76	77
6080030	Peoria (419 Fulton)	*	.009	.012	.035	.029	.062	.034	.027	.042
6080031	Peoria (Glen Oak Park)	-	-	*	-	-	.149	-	-	.041
6080027	Peoria (1604 Detweiller)	.007	.006	.007	.031	.043	.048	.022	.024	.030
6060004	Pekin	.016	.017	.018	.249	.109	.228	.181	.065	.177

TABLE 3

PEORIA AQMA
SO_2 AREA SOURCE EMISSIONS INVENTORY
(Tons Per Year)

Category	1975	1985*	1995**
Residential Fuel Combustion	337	266	279
Commercial/Institutional Fuel Combustion	701	693	729
Industrial Fuel Combustion	721	795	835
Industrial Process Loss	45	36	37
Exhaust and Tire Wear	695	864	908
Military Aircraft	10	16	25
Off-Highway Vehicles	37	37	37
Aircraft	18	27	41
Vessels	25	37	54
Railroads	251	223	234
Solid Waste	62	62	65
Structural Fires	<1	<1	<1
TOTAL	2,901	3,056	3,243

*See Peoria AQMA study for 1985 Growth Factors.
**1995 Growth projections based on population increase from 1985-1995 in the three-county study area using Illinois Bureau of the Budget Population Projections (Ref. 27).

TABLE 4

PEORIA AQMA
SO_2 POINT SOURCE EMISSION INVENTORY
(Tons Per Year)

Facility	ID	Allow	1975	Comp.	1985*	1995*
Libby, McNeil & Libby	179050AAI	57	19	19	18	19
Com. Ed. Powerton Station	179801AAA	53350	183170	53350	97355 **	97355 **
Caterpillar, Morton	179050AAA	116	47	47	59	56
Corn Products Pekin	179060ACA	4226	3560	3560	3435	3504
Caterpillar, E. Peoria	179020AAB	9714	9714	2665	3384	3384
Cilco, Wallace Stn.	179020ABL	6124	12558	5277	2925	2925
Ashland Chemical Co.	143805AAA	800	1832	800	800	858
Pabst Brewing Plt.4	143065AJY	186	117	117	131	143
Pabst Brewing Plt.3	143070AAC	115	115	115	115	124
Celotex Corp.	143065ABD	1448	3433	1448	3918	4466
Caterpillar, Mossville	143801AAG	1222	1211	1211	1299	1247
White School	143065AKV	18	40	18	19	19
Harrison School	143065ACV	18	40	18	19	17
Longfellow School	143065AKQ	18	40	18	19	17
Loucks School	143065AKR	16	35	16	16	17
Tying School	143065AKS	12	27	12	13	13
Von Steuben School	143065AKI	14	32	14	15	15
Roosevelt School	143065AHL	31	69	31	32	33
Whittier School	143065AKW	10	24	10	11	11
Cilco, Edwards Stn.	143805AAG	38248	48650	27412	35684	35684
Jefferson School	143065ADH	20	20	9	9	9
Glen Oak School	143065AKK	14	31	14	15	15
Blain Sumner School	143065AKG	18	40	18	19	19
Calvin Coolidge School	143065AKH	13	28	13	13	14
Columbia School	143065AKI	14	31	14	15	15
Franklin School	143065AKJ	17	38	17	17	18
Lincoln School	143065AKP	10	24	10	11	11
Trwyn School	143065AIY	25	59	25	26	27
Kingman School	143065AKN	13	28	13	13	14
G.E. Koffman & Sons Plt. 1	143065ACN	25	25	25	35	38
Bemis Co., Inc.	143065AAR	1289	1289	1289	1680	1714
Cilco, Keystone Stn.	143004AAF	1050	175	175	184	189
Midland Coal Co.	143803AAA	27	27	27	29	30

TABLE 4 (Continued)

PEORIA AQMA
SO_2 POINT SOURCE EMISSION INVENTORY
(Tons Per Year)

Facility	ID	Allow	1975	Comp.	1985*	1995*
Quaker Oats Co.	179814AAA	34	34	34	26	27
Cilco, Duck Creek Station					51836 ***	51836 ***
+Com. Ed. Powerton Gasification Plant	179801AAA				1290	1302
	TOTALS	118312	266582	97841	204485	205185

*See Peoria AQMA Study for 1985 and 1995 growth factors.
**By 1985 old units will be retired and new ones in operation.
***The CILCO, Duck Creek Station began operation after 1975.
+An anticipated coal gasification unit was assumed in projection years at Powerton. The unit is no longer anticipated, however, its impact on the SO_2 air in Peoria was small.

PEORIA MODELING RESULTS

A. 1975

Dispersion modeling predicted a small violation of the annual SO_2 standard in 1975 in the industrialized portion of Peoria (Figure 4). The maximum concentration, 91 ug/m^3, was located just north of the Caterpillar Tractor East Peoria plant and the Central Illinois Light Company (CILCO)-Wallace Generating Station. Approximately 71 percent of this violation was due to industrial sources in the region; another 12 percent was due to smaller sources in the region and sources in adjoining counties; and the remaining 17 percent could not be explicitly accounted for in the modeling. The main contributor to the violation, CILCO-Wallace, accounted for 54 percent of the contribution from all industrial sources at the maximum receptor point.

When average emissions were used, the largest 24-hour violation area was located west of Peoria and Pekin; a smaller area was located northeast of Pekin. The Powerton power plant was the major contributor to these violations.

Areas of violation of the 3-hour secondary standard as shown in Figure 5 were generally confined to the Pekin vicinity using average emissions. The Powerton generating station was the major contributor to the violations.

B. Compliance Year

If all sources were in compliance with existing SO_2 emissions limitations, modeling indicates that there would be no violations of the annual standard in the Peoria area (Figure 6). The maximum concentration would be 60 ug/m^3, well within the annual standard of 80 ug/m^3.

FIGURE 4
1975 ANNUAL AVERAGE SULFUR DIOXIDE AIR QUALITY IN THE URBANIZED AREA OF THE PEORIA AQMA (ug/m^3)

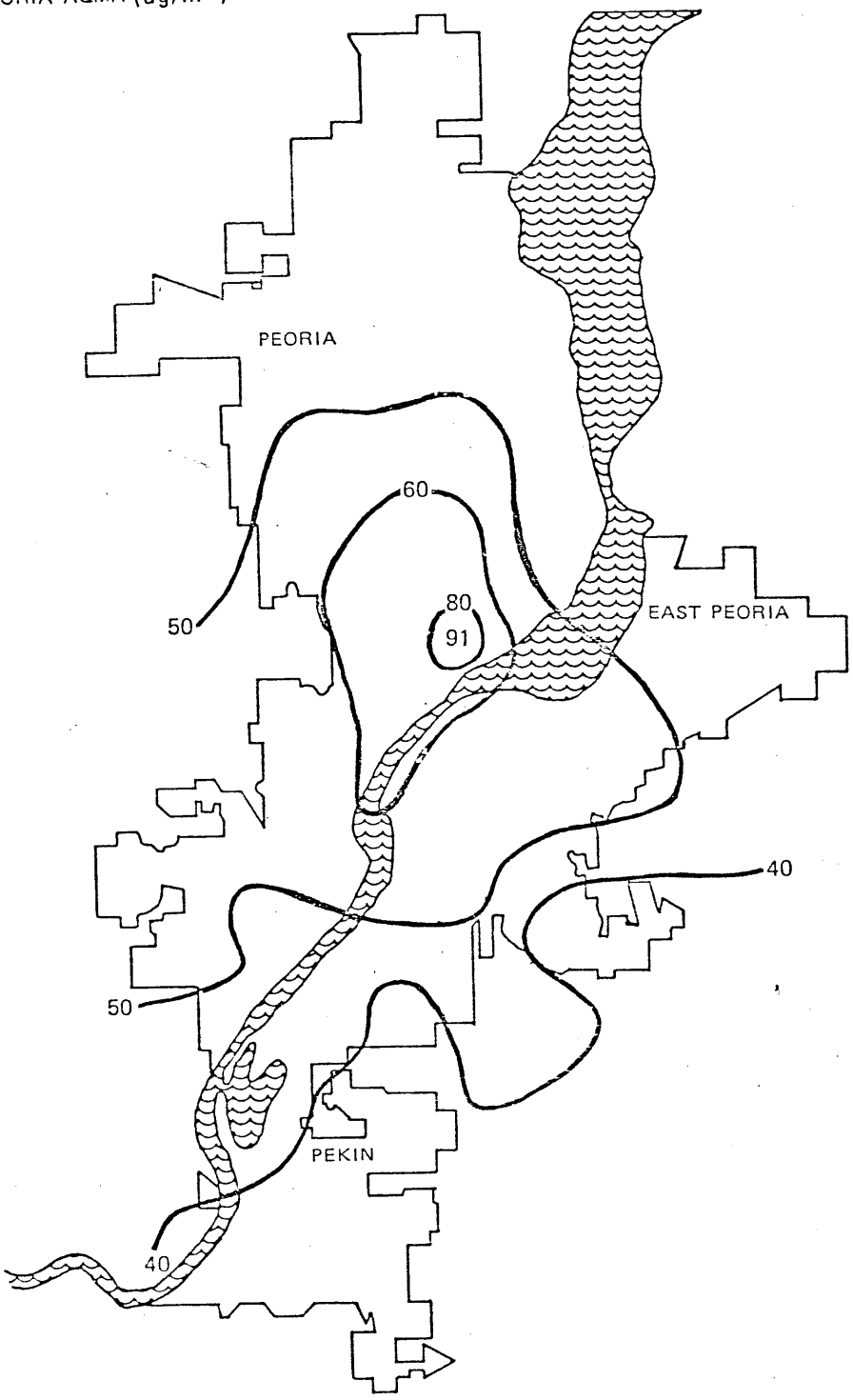


FIGURE 5

AREAS IN PEORIA WHICH EXPERIENCED VIOLATIONS OF THE SO_2 3-HOUR AMBIENT STANDARDS BASED UPON A REGIONAL MODELING ANALYSIS OF SIX DAYS USING AVERAGE 1975 EMISSION RATES.

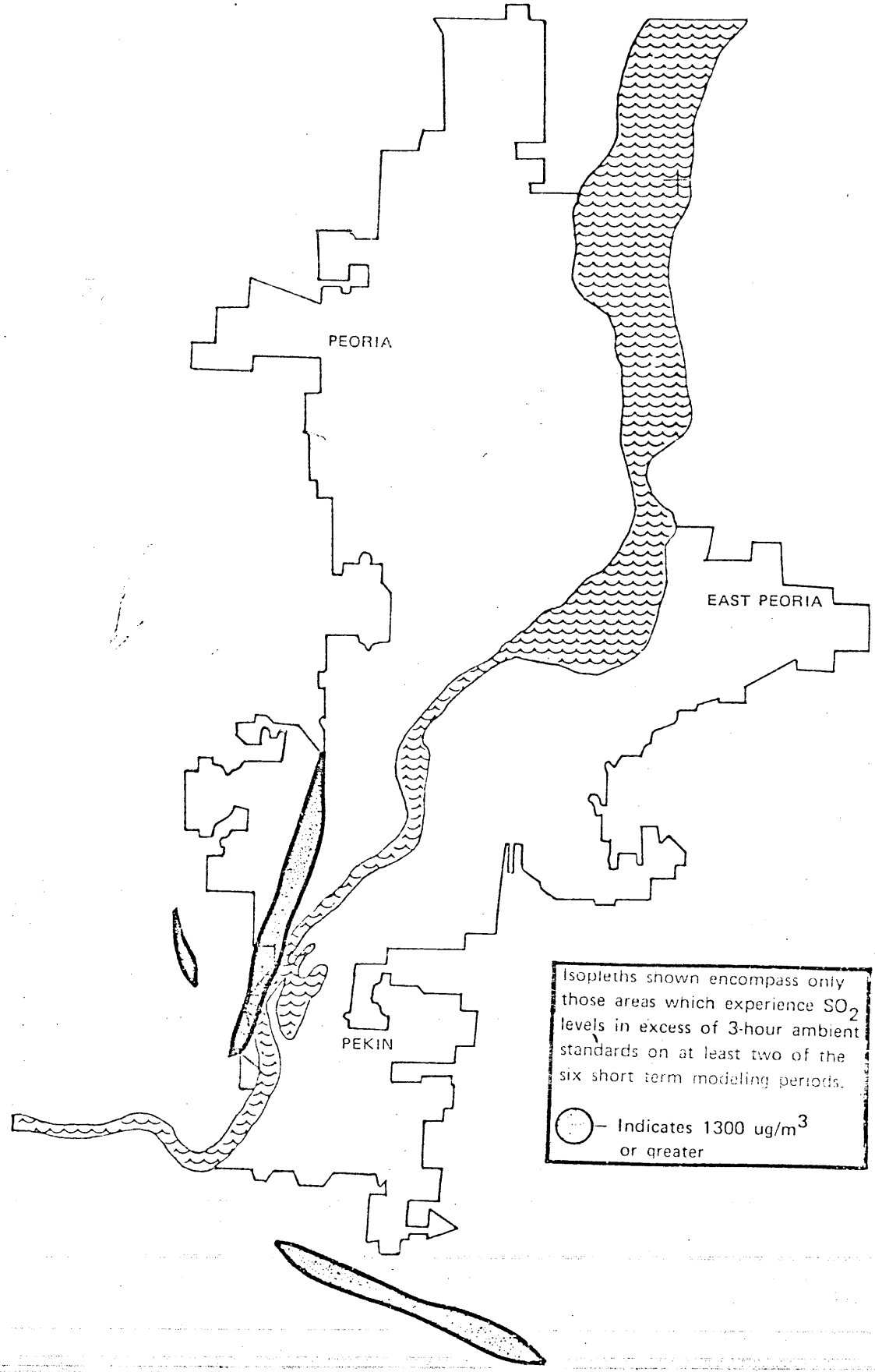
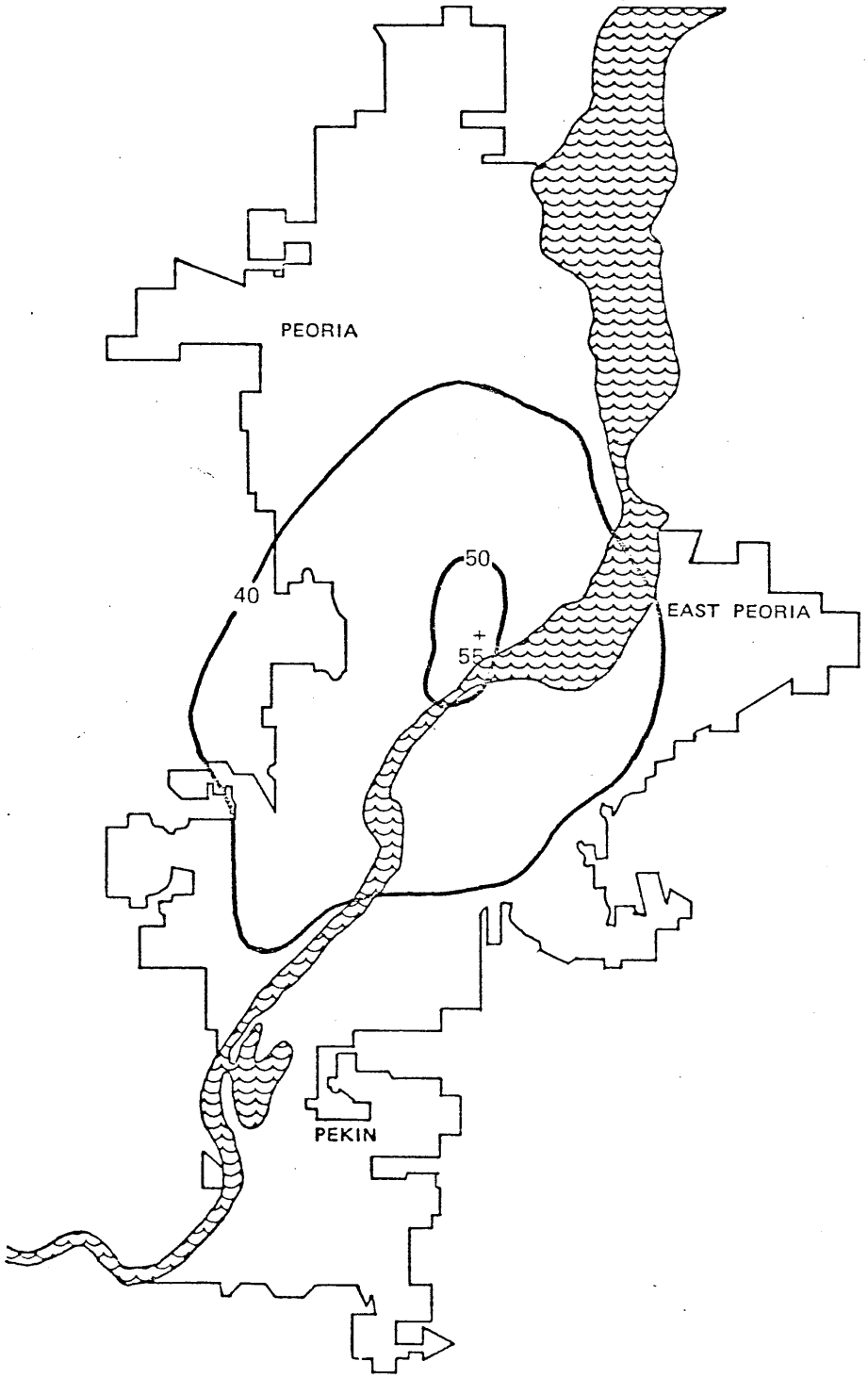


FIGURE 6
ANNUAL AVERAGE SULFUR DIOXIDE AIR QUALITY IN THE URBANIZED AREA OF THE PEORIA AQMA CONSIDERING ALL ANTICIPATED EMISSION REDUCTIONS (ug/m^3)



Using maximum allowable emissions, the modeling predicted a violation of the 24-hour SO_2 standard for 1975 in a small area west of Pekin. This is presented in Figure 7. The major contributor to the violation was the Commonwealth Edison Powerton electric generating plant. The violation areas were larger when average emissions were modeled in place of maximum allowable emissions because several large facilities had emission rates in 1975 that were in excess of their maximum allowed.

Using maximum allowable emissions, a violation of the 3-hour SO_2 standard was predicted in a small area south of Pekin. The major contributor to the violation was the Powerton generating plant (Figure 8).

As with the 24-hour predicted violations, the areas of 3-hour violations were more extensive when average emissions were used.

C. 1985

Taking into account the new emissions which will be added because of anticipated industrial growth in Peoria, the maximum predicted annual SO_2 concentration for 1985 is only 54 ug/m^3 (Figure 9). The modeling also shows no violation areas for the 24-hour standard in 1985. However, a small area of potential violation of the 3-hour SO_2 standard is indicated south of Pekin (Figure 10). The Powerton generating station is the major contributor to the violation.

D. 1995

In 1995, the modeling indicated no danger of an annual violation; however, the 24-hour and 3-hour modeling analyses predicted two small violation areas. The Powerton generating station was the major contributor to both.

CONCLUSIONS

The annual and short-term (24-hour and 3-hour) ambient air quality standards for SO_2 were exceeded in 1975 in the Peoria area; however, based on the results of the analysis techniques used in this evaluation, compliance with the present SO_2 emissions standards and limitations by sources in the study area will likely result in attainment and maintenance of the standards through 1995. Although very small potential violations of the short-term standards are projected by 1995, the IEPA concludes that the SIP is marginally adequate considering the conservative assumptions made in the modeling and the tolerance limits of the model itself.

Considering the marginal nature of the attainment analysis in the Peoria area, the continuation of the assessment of SO_2 air quality is desirable. In this regard, the application of alternate short-term modeling techniques may yield a more definitive picture of the SO_2 attainment status. A re-evaluation of SO_2 air quality in the Peoria area, using alternate modeling approaches such as the USEPA's RAM dispersion model, will be accomplished by the IEPA within approximately one year.

FIGURE 7

AREAS IN PEORIA WHICH EXPERIENCED VIOLATIONS OF THE SO_2 24-HOUR AMBIENT STANDARDS BASED UPON A REGIONAL MODELING ANALYSIS OF SIX DAYS USING MAXIMUM ALLOWABLE 1975 EMISSION RATES.

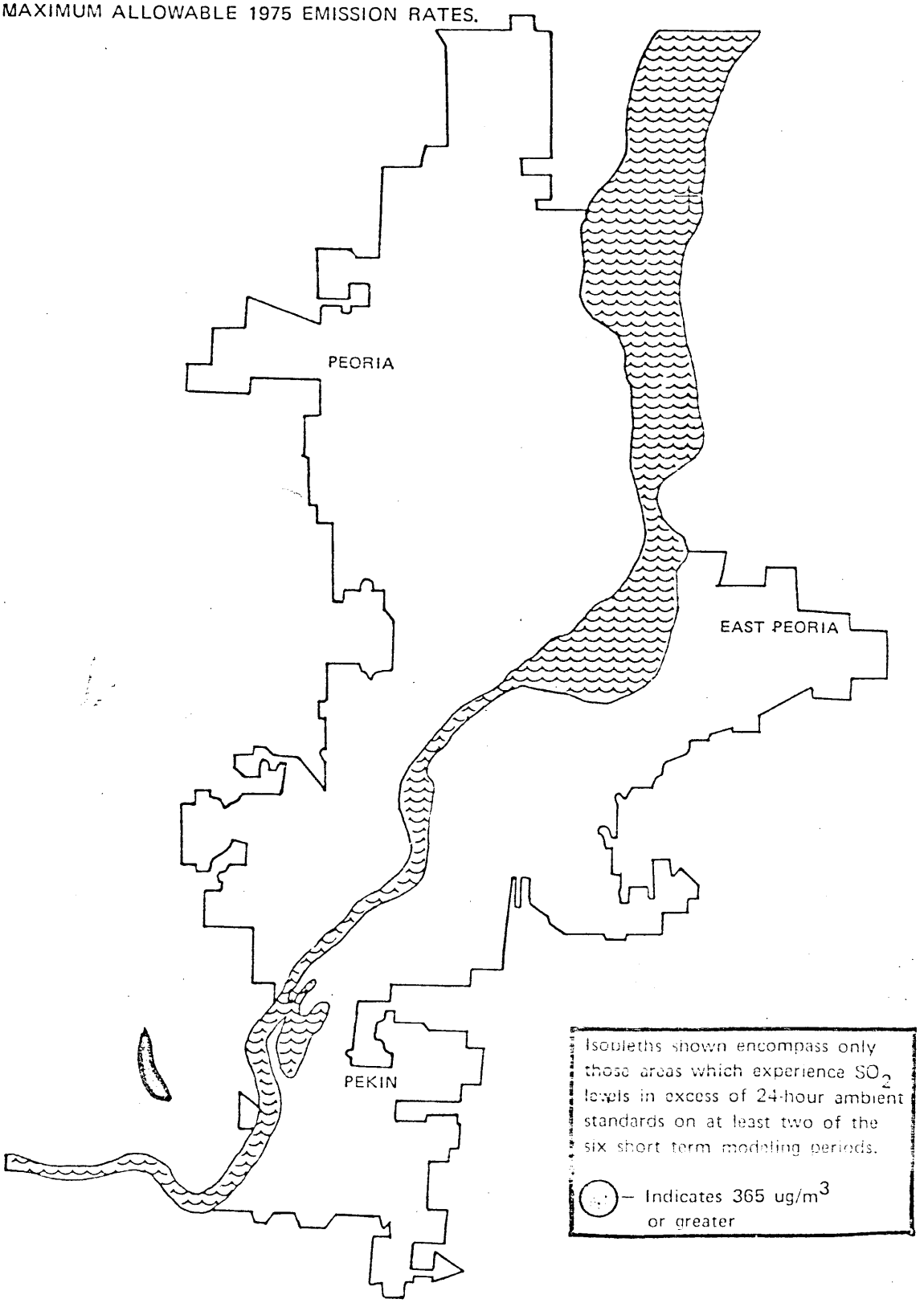


FIGURE 8

AREAS IN PEORIA WHICH EXPERIENCED VIOLATIONS OF THE SO_2 3–HOUR AMBIENT STANDARDS BASED UPON A REGIONAL MODELING ANALYSIS OF SIX DAYS USING MAXIMUM ALLOWABLE 1975 EMISSION RATES.

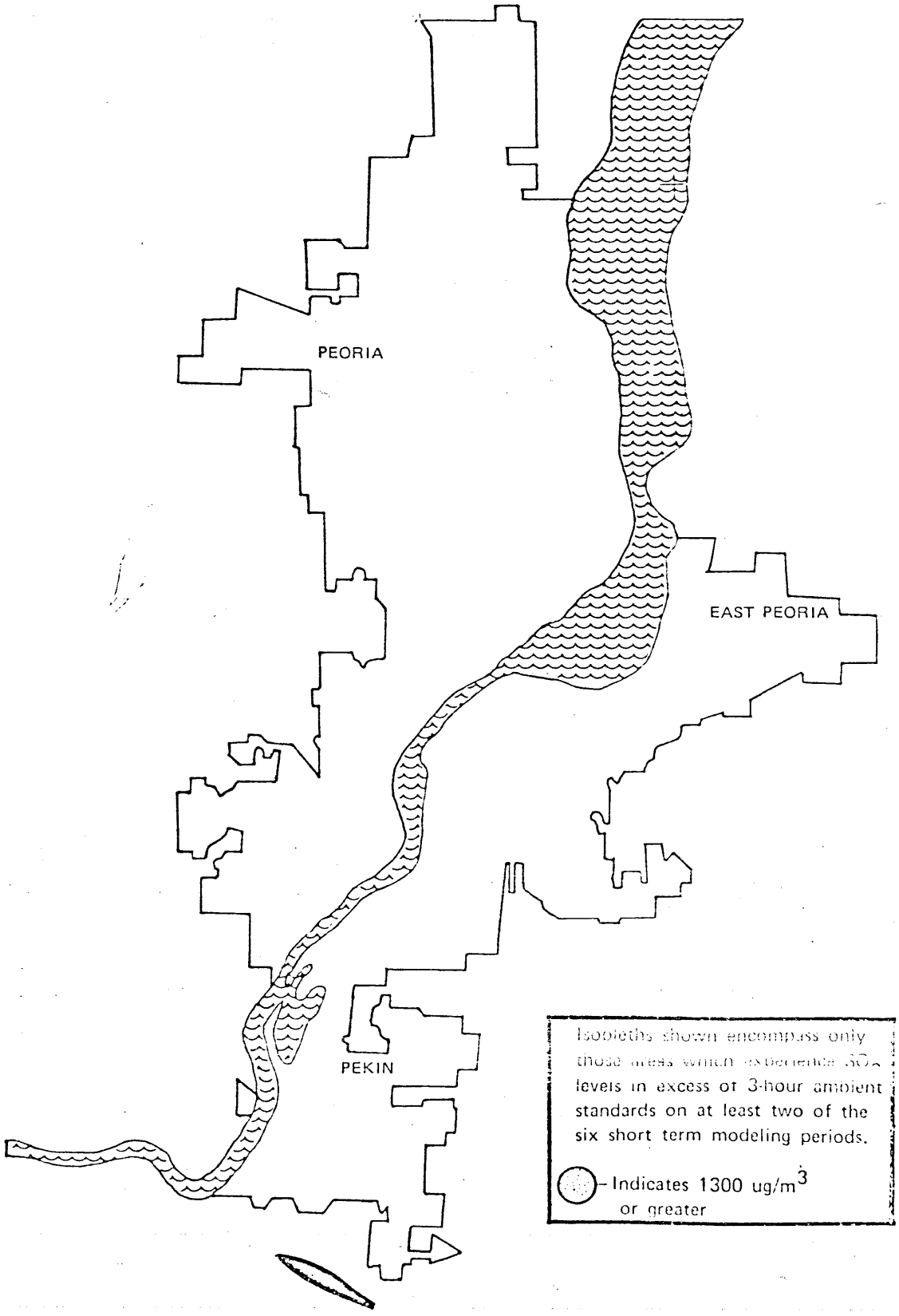


FIGURE 9
1985 ANNUAL AVERAGE SULFUR DIOXIDE AIR QUALITY IN THE URBANIZED AREA OF THE PEORIA AQMA (ug/m^3)

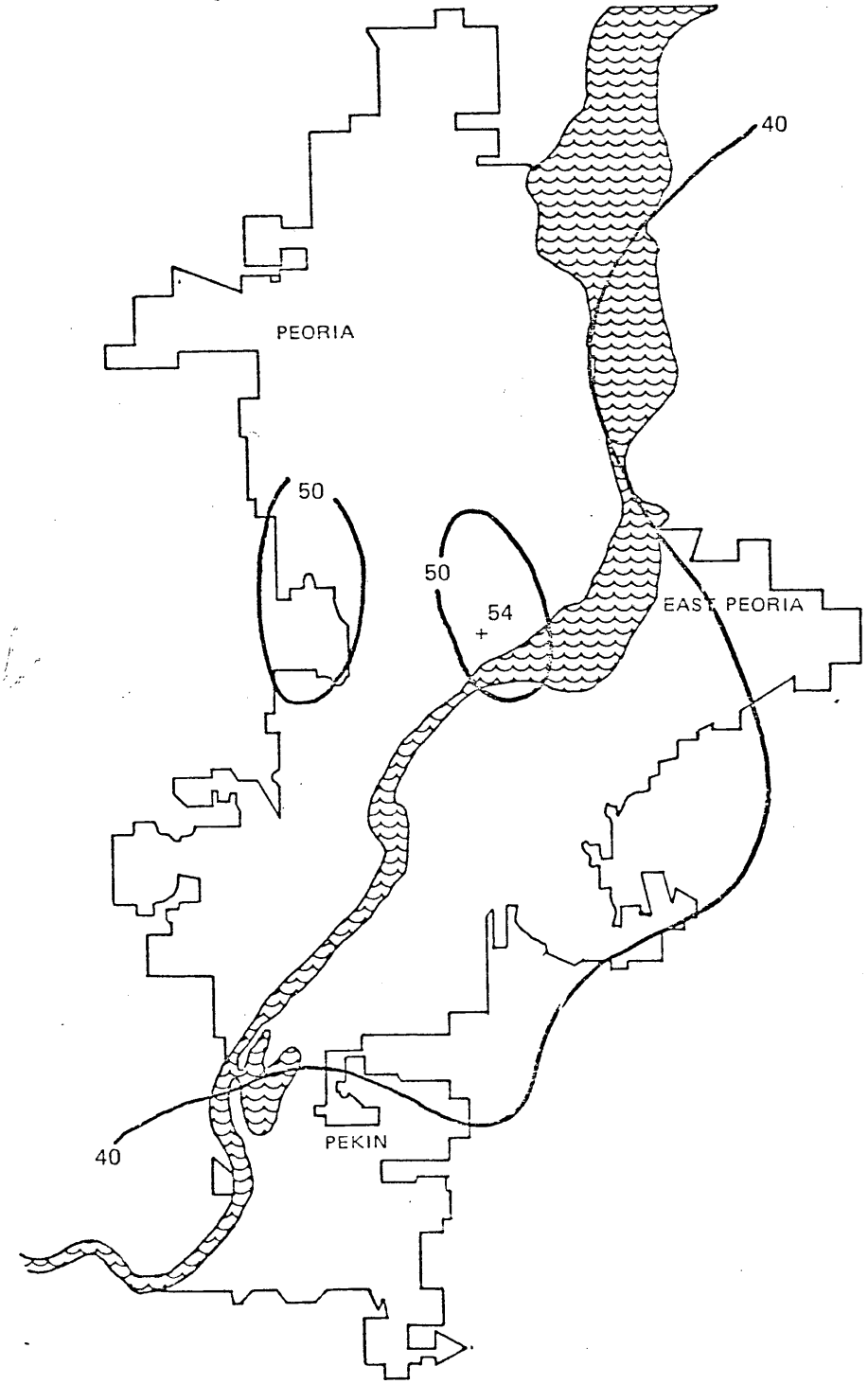
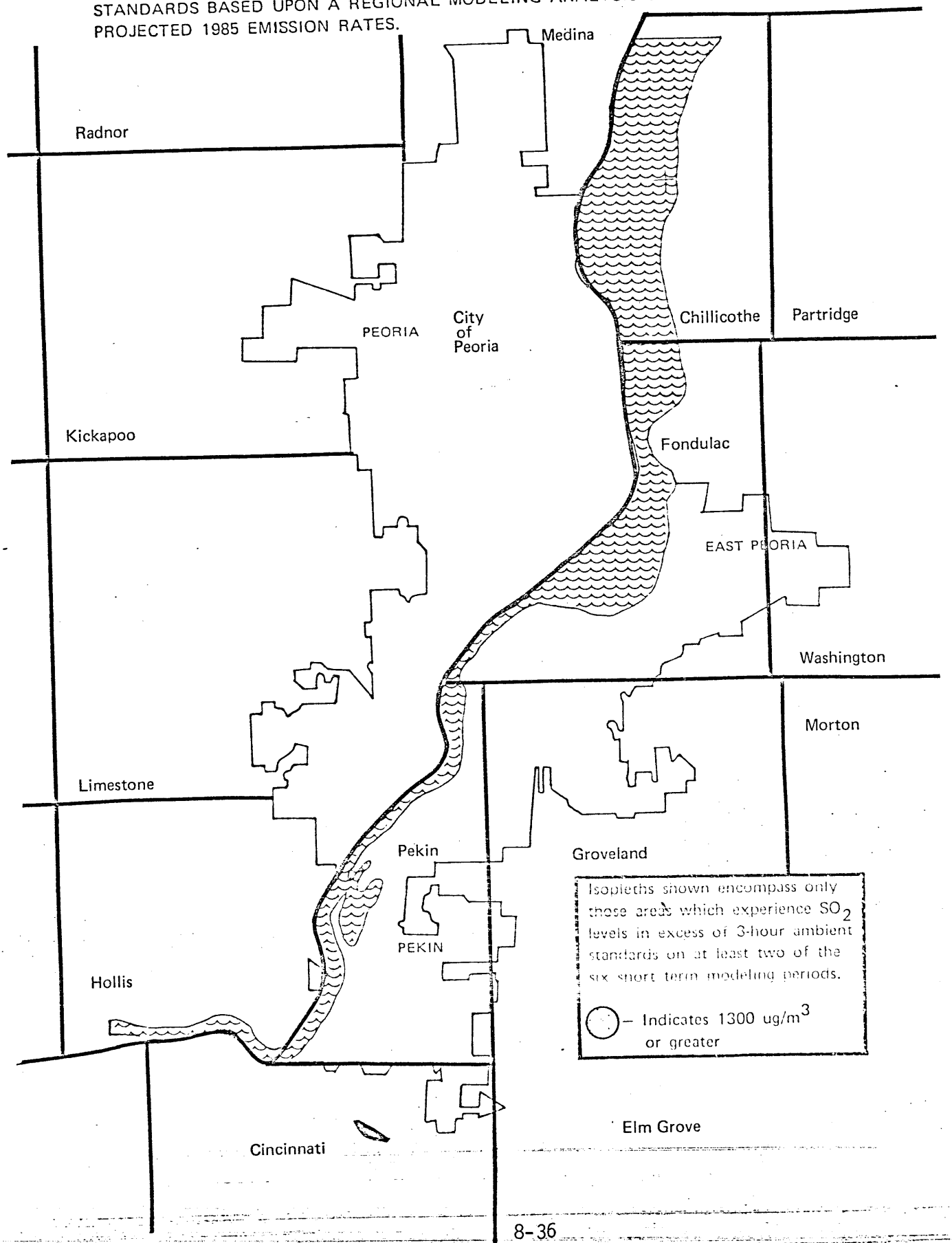


FIGURE 10

AREAS IN PEORIA WHICH EXPERIENCED VIOLATIONS OF THE SO_2 3-HOUR AMBIENT STANDARDS BASED UPON A REGIONAL MODELING ANALYSIS OF SIX DAYS USING PROJECTED 1985 EMISSION RATES.



RECOMMENDED ATTAINMENT STATUS

Based on the preceding analysis, the following SO_2 attainment status is proposed for the Peoria area:

TABLE 5

PEORIA AQMA

ATTAINMENT/NONATTAINMENT DESIGNATION

Geographic Area (Township)	Attainment	Primary	Exceeds Secondary	Primary Unclassified	Monitored	Modeled
Peoria County						
Hollis		X	X			X
Limestone		X	X			X
Logan		X				X
Peoria		X				X
All Other	X				X	X
Tazewell County						
Cincinnati		X	X		X	X
Elmgrove			X			X
Groveland		X				X
Pekin		X				X
All Other	X				X	X

It is anticipated that the above townships will be unclassified, pending further modeling, as soon as the major sources in Peoria achieve compliance with the regulations.

8.2.3.2 Massac County AQMA

TABLE 6

MASSAC COUNTY AQMA
SO_2 ATTAINMENT STATUS AND
MONITORING DATA SUMMARY

ATTAINMENT STATUS

Nonattainment Area (Precincts)	Exeeeds Primary	Exeeds Secondary	Projected	Modeled	Monitored	SAROAD Site No.(s)
Massac County						
Grant Pct.	x	x		x		
Metropolis Pct.	x	x		x	x	5060007
Hillerman Pct.	x	x		x		

MONITORING DATA SUMMARY

SAROAD Site Number	Station (Address)	Annual Ave. (ppm) 75	76	77	Highest 24-Hr. (ppm) 75	76	77	2nd High. 24-Hr. (ppm) 75	76	77
506007	Metropolis (Massac County Hospital)	.027	*	*	.358	.083	.135	.168	.054	.098

TABLE 7

MASSAC COUNTY AQMA
AREA SOURCE EMISSIONS INVENTORY
(Tons Per Year)

Category	1975	1985	1995
Residential Fuel Combustion	133	133	137
Commercial/Institutional Fuel Combustion	31	31	32
Industrial Fuel Combustion	83	83	85
Land Vehicles	56	56	58
Aircraft	<1	<1	<1
Vessels	12	12	20
Solid Waste Disposal	3	3	3
Fires and Open Burning	<1	<1	<1
TOTALS	318	318	327

TABLE 8

MASSAC COUNTY
SO_2 POINT SOURCE EMISSIONS INVENTORY
(Tons Per Year)

Facility Plant ID Number	Allow	1975	Compliance Year	1985	1995
Electric Energy Inc. 127855AAC	161,469	182,193	161,469	161,469	161,469
Missouri Portland Cement 127855AAA	10,707	8,586	9,703	9,703	9,874
Allied Chemical Corporation 127854AAD	71	19	19	19	33
Massac County Totals	172,247	187,798	171,191	171,191	171,376
*TVA Shawnee Power Plant	55,828	249,748	55,828	55,828	59,178

*Plant located in Kentucky

MASSAC COUNTY MODELING RESULTS

A. 1975

Dispersion modeling predicted a violation of the annual SO_2 standard in 1975 covering a large portion of Massac County (See Figure 11). The maximum annual average receptor point was 120 ug/m^3, of which only 16 percent was due to industrial sources within Massac County; one percent due to Massac County area sources; and the remaining 83 percent was due to sources from adjoining counties. The Tennessee Valley Authority (TVA) Shawnee power plant contributed 63 percent of the emissions at the maximum concentration point. The Electric Energy, Incorporated (EEI) Joppa power plant also contributed significantly.

Modeling average 1975 SO_2 emissions, a massive area covering a large portion of the study area was in violation of the 24-hour standard as shown in Figure 12. Although the TVA power plant was the main contributor at the maximum receptor point, other major sources apparently contributed heavily to the violation.

Modeling average emissions indicated that the entire study area had the potential for violation of the 3-hour secondary standard (Figure 13). As with the 24-hour analysis, apparently all the major point sources contributed to the violation.

When 24-hour maximum allowable emissions were modeled, a violation area principally due to the TVA power plant was indicated (Figure 14).

Using maximum allowable emissions, three violation areas of the 3-hour secondary standard were also predicted as shown in Figure 15. One area was located northwest of Metropolis, and the remaining two areas were located west and north of Joppa. The major contributors to the violations were the TVA power plant, the EEI power plant, and the Missouri Portland Cement facility.

B. 1985

After accounting for emission reductions and changes in stack configurations for the two power plants, the modeling for 1985 predicted a maximum annual average concentration for SO_2 of 44 ug/m^3 (Figure 16), well below the annual standard of 80 ug/m^3. Additional modeling indicated no areas in Massac County in violation of the 24-hour standard for 1985; however, one area located west of Joppa was indicated as having the potential for a single violation of the 3-hour secondary standard (Figure 17). The main contributors to the violation are the EEI power plant, and, to a lesser extent, the Missouri Portland Cement facility.

C. 1995

The results of the 1995 analysis were relatively unchanged from 1985.

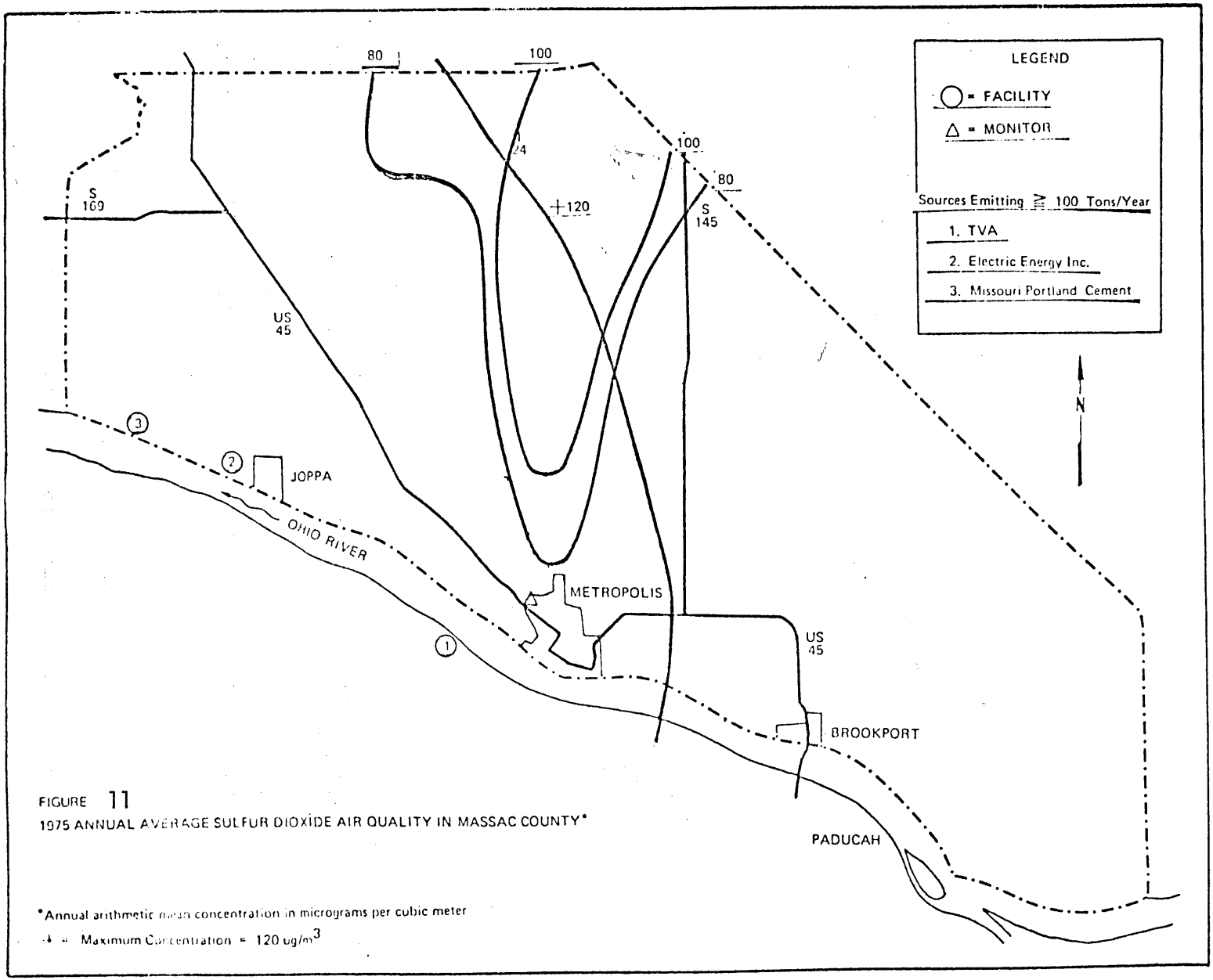


FIGURE 11
1975 ANNUAL AVERAGE SULFUR DIOXIDE AIR QUALITY IN MASSAC COUNTY*

*Annual arithmetic mean concentration in micrograms per cubic meter

+ = Maximum Concentration = 120 ug/m^3

Figure 12

Areas in Massac County Which Experienced Violations of the SO_2 24-Hour NAAQS Based Upon Modeling Analysis Using 1975 Average Emission Rates.

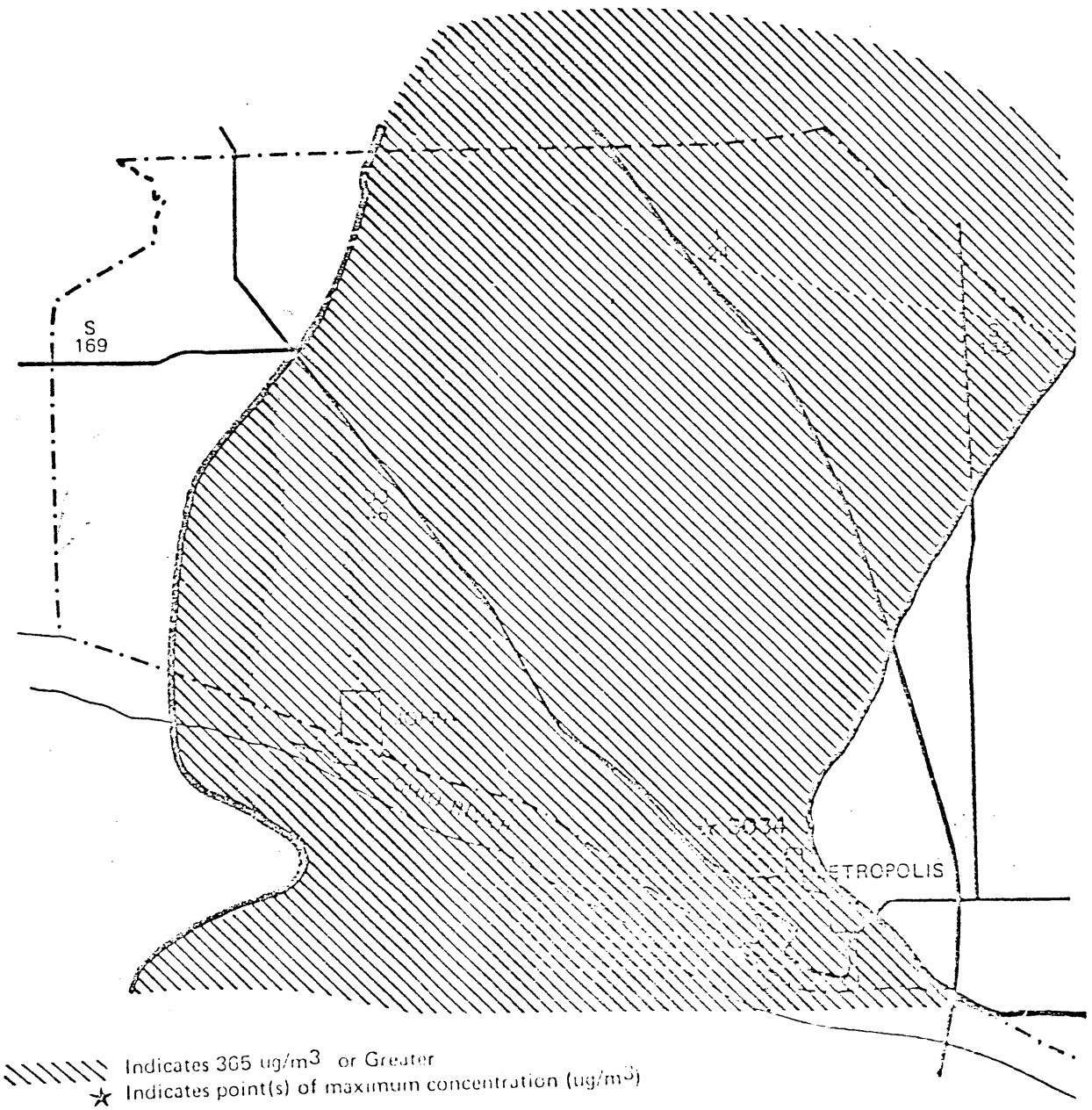


Figure 13

Areas in Massac County Which Experienced Violations of the SO_2 3-Hour NAAQS Based upon Modeling Analysis Using 1975 Average Emission Rates.

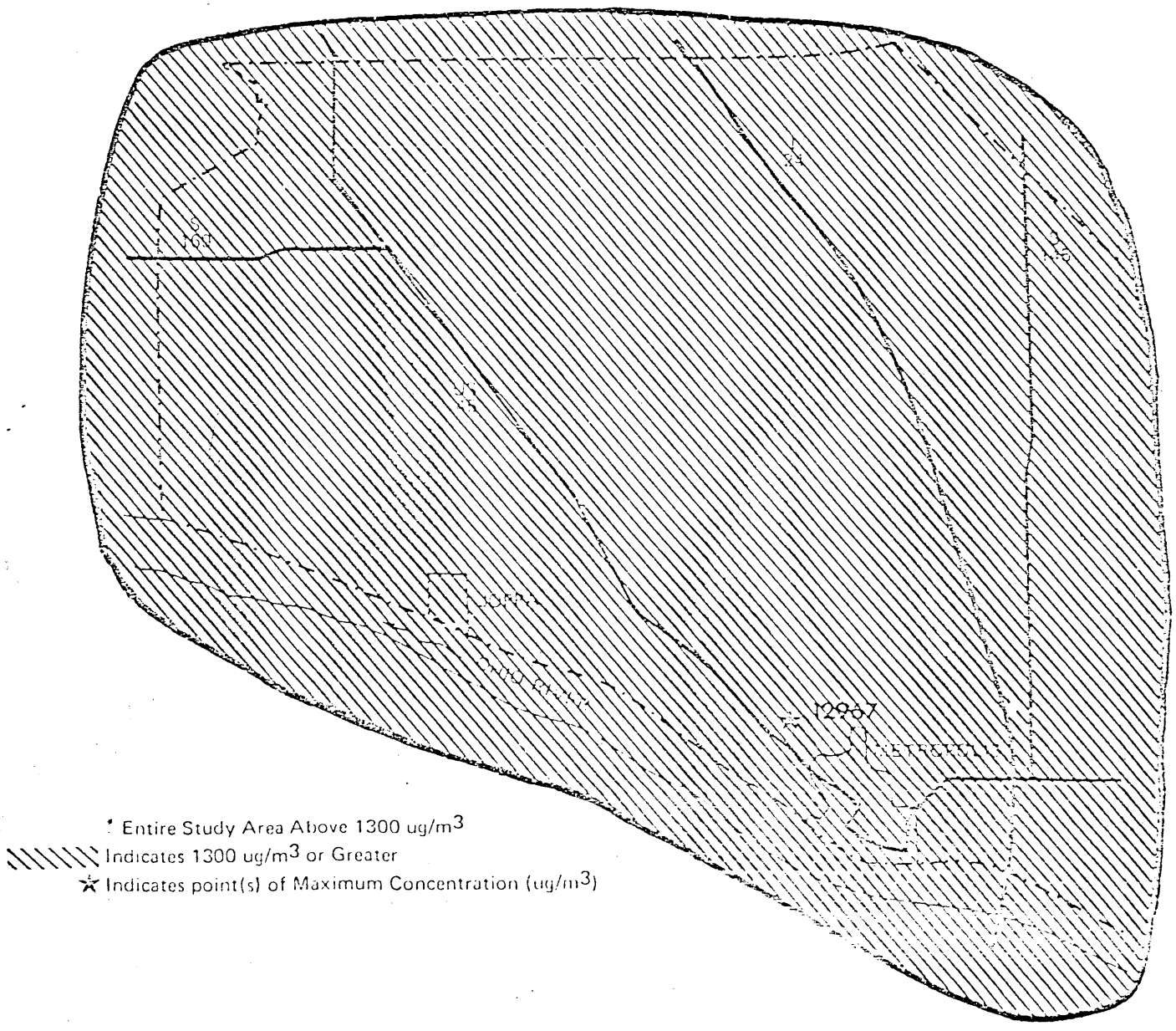


Figure 14: Areas in Massac County Which Experienced Violations of the SO_2 24-Hour NAAQS Based Upon Modeling Analysis using 1975 Maximum Allowable Emission Rates.

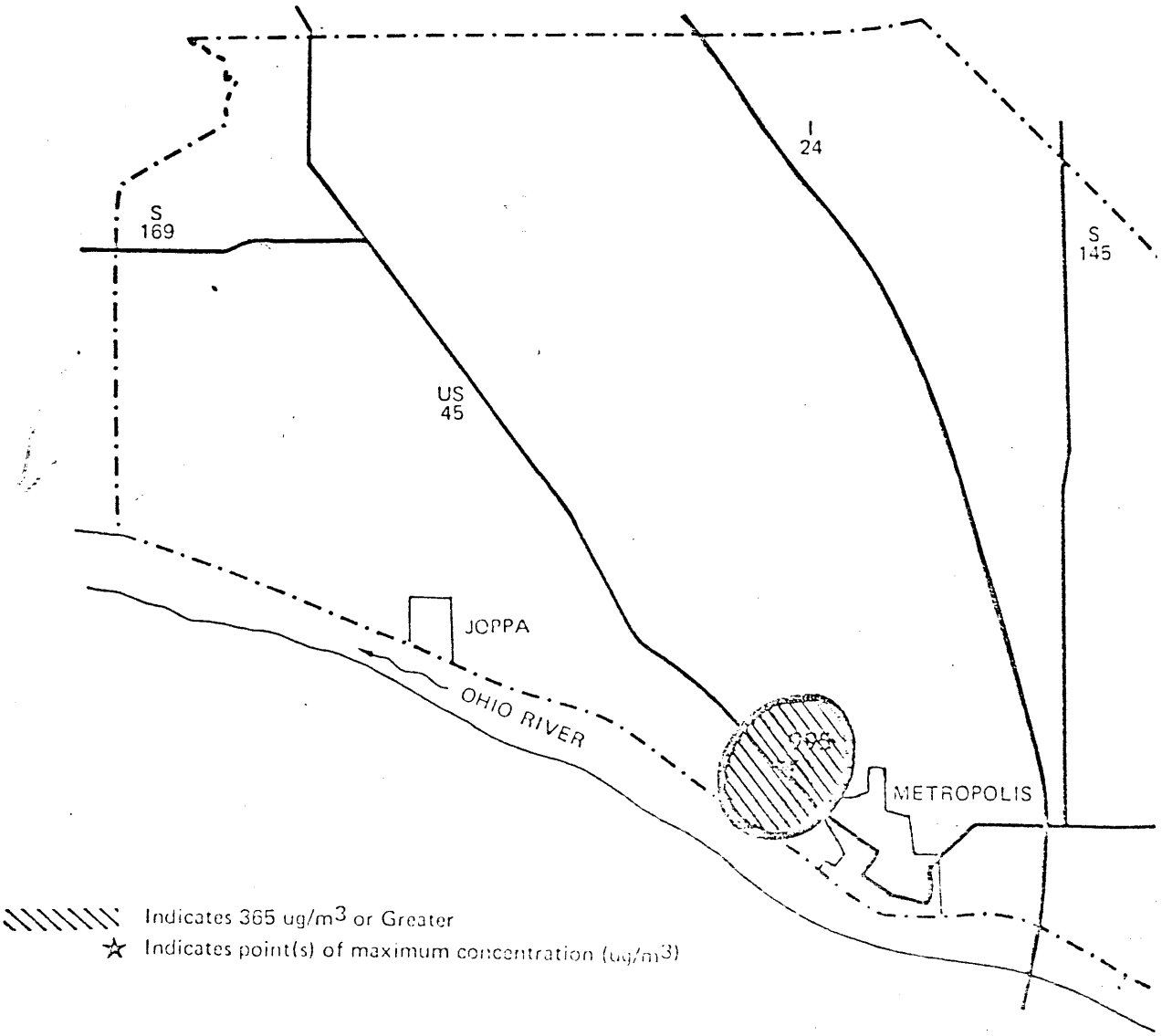
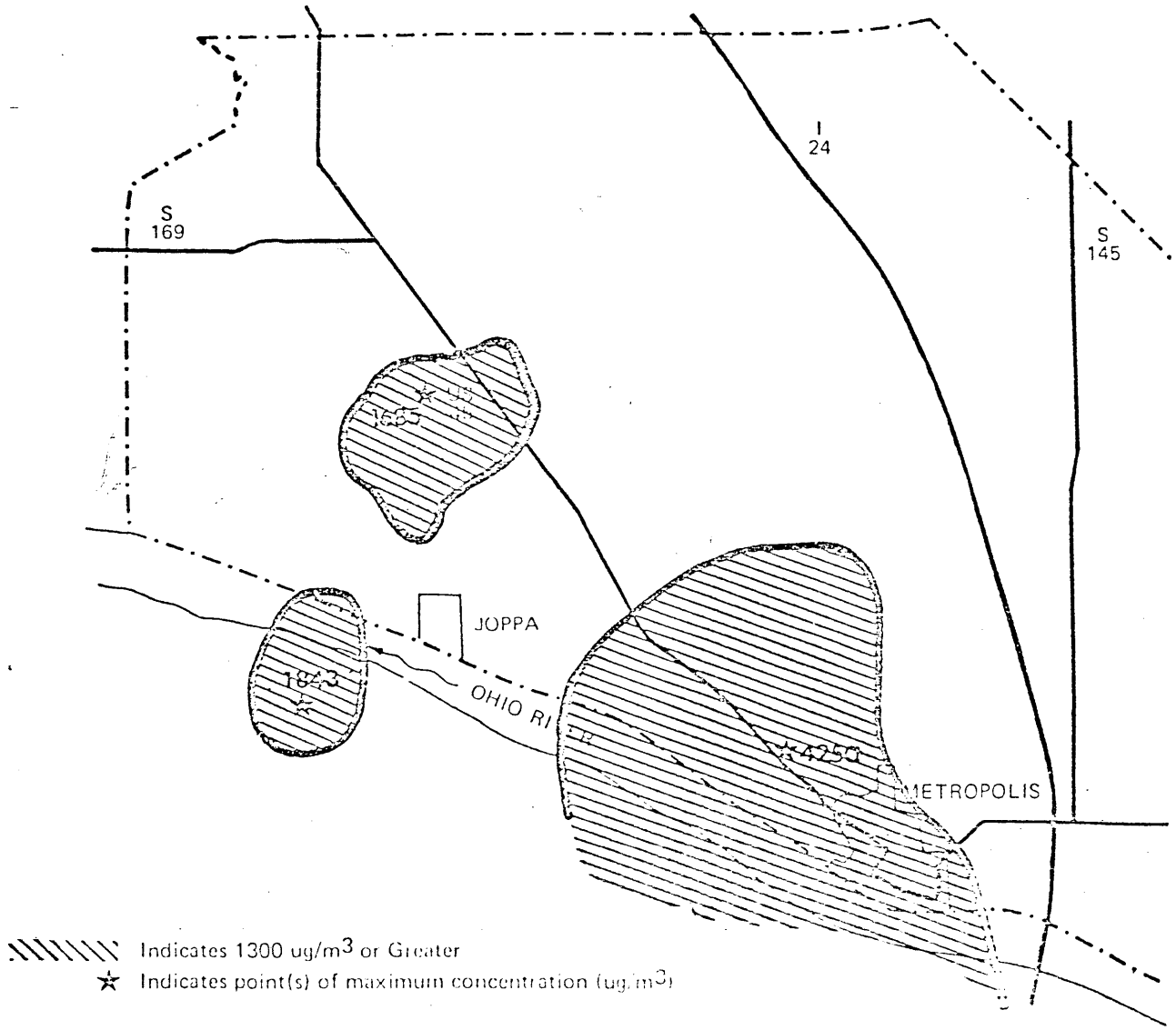


Figure 15 Areas in Massac County Which Experienced Violations of SO_2 3-Hour NAAQS Based Upon Modeling Analysis Using 1975 Maximum Allowable Emission Rates.



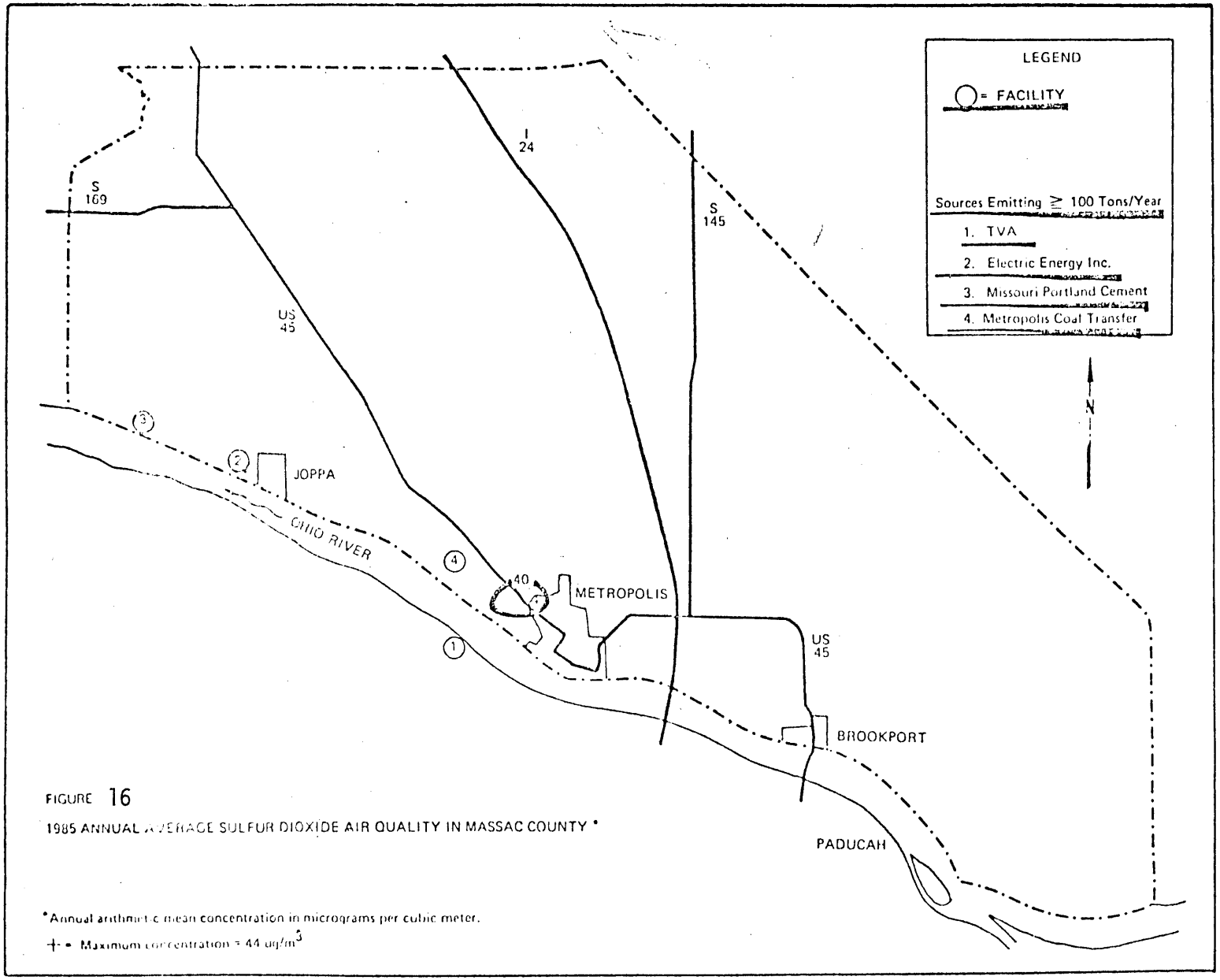


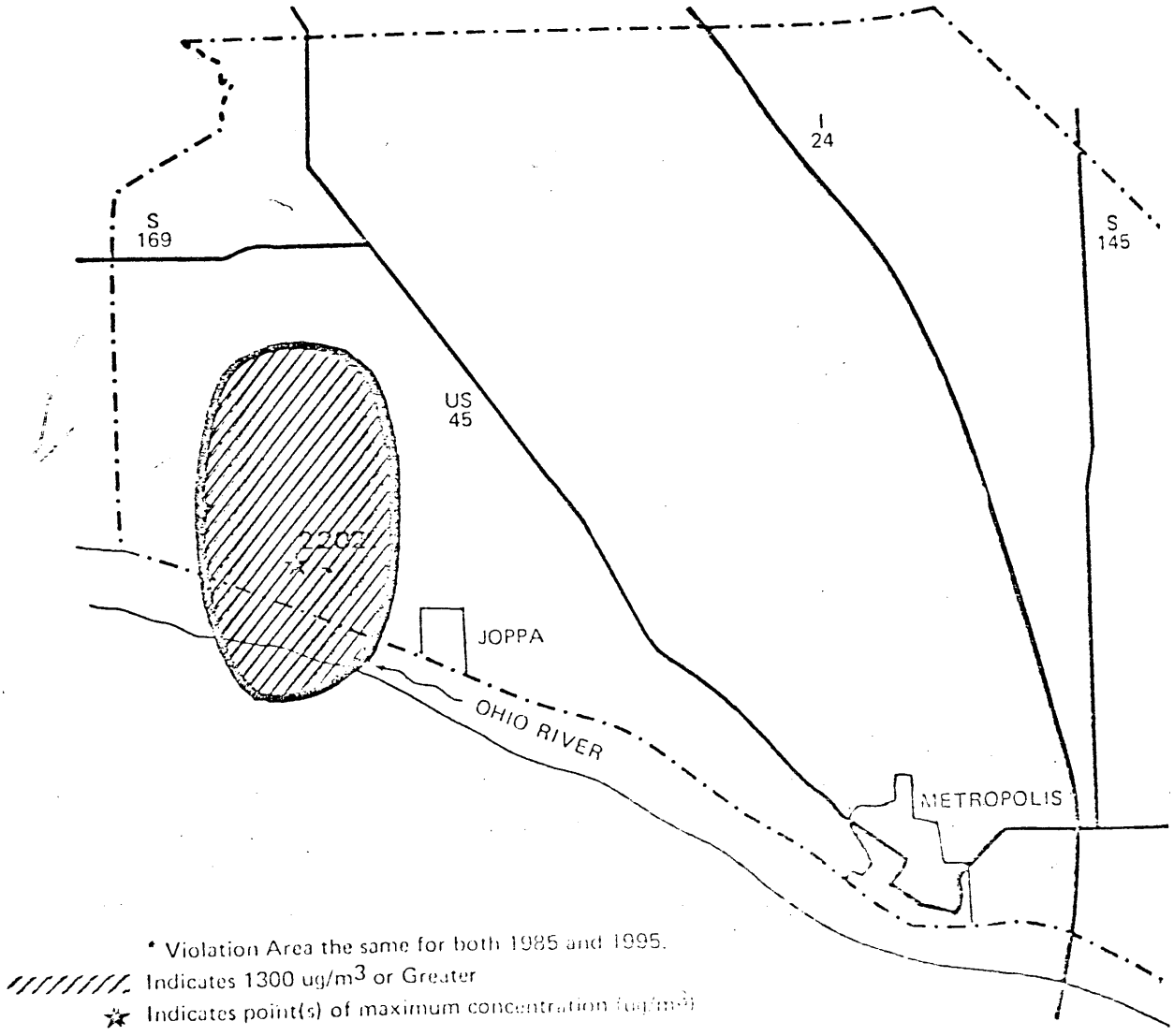
FIGURE 16

1985 ANNUAL AVERAGE SULFUR DIOXIDE AIR QUALITY IN MASSAC COUNTY *

*Annual arithmetic mean concentration in micrograms per cubic meter.

+ = Maximum concentration = 44 ug/m^3

Figure 17 :Areas in Massac County Which Experienced Violations of the SO_2 3-Hour NAAQS Based Upon Upon Modeling Analysis Using 1985 (1995) Maximum Allowable Emission Rates.*



CONCLUSIONS

The annual and short-term (24-hour and 3-hour) ambient air quality standards for SO_2 were exceeded in 1975 in Massac County; however, current SO_2 emission standards and limitations are sufficient to attain and maintain the annual and 24-hour standards through 1995. The TVA Shawnee power plant's current compliance program, which will be completed in late 1981 will remove the potential for future violations. Until then, 24-hour violations may occur.

A limited number of potential violations of the 3-hour secondary standard are projected through 1995. The sources primarily responsible for these modeled violations were the EEI power plant, and to a lesser extent, the Missouri Portland Cement facility. It will be necessary to further examine these potential violations in light of the present SIP regulations to determine the steps necessary to ensure attainment of the secondary standard.

Considering the marginal nature of the attainment analysis in Massac County after all sources achieve compliance, the continuation of the assessment of SO_2 air quality is desirable. In this regard, the application of alternate short-term modeling techniques may yield a more definitive picture of the SO_2 attainment status. A re-evaluation of SO_2 air quality in Massac County, using alternate modeling approaches such as the USEPA's RAM dispersion model, will be accomplished by the IEPA within approximately one year.

RECOMMENDED ATTAINMENT STATUS

Bases on the preceding analyses, the following SO_2 attainment status is proposed for Massac County:

TABLE 9

MASSAC COUNTY AQMA
ATTAINMENT/NONATTAINMENT DESIGNATION

Geographic Area (Township)	Attainment	Exceeds Primary	Exceeds Secondary	Unclassified	Monitored	Modeled
Massac County						
T.15S.-R.6E.			X			X
T.16S.-R.6E.			X			X
T.17S.-R.6E.			X			X
All Other		X	X		X	X

8.3. Strategy Evaluations

In evaluating the status of attainment and maintenance of the NAAQS for SO_2, various options were considered. Some involved the relaxation of emission limitations for existing sources in areas where the standards are being attained; others involved a tightening of existing limitations for selected source categories in order to provide more potential for

industrial growth. Of the SO_2 related strategies evaluated, only the general provision covering maintenance and malfunction of air pollution control equipment is being offered as a new SIP revision at this time. Additionally, the currently remanded SO_2 regulations are considered necessary to ensure attainment and maintenance of the NAAQS. Future analyses may indicate the need for incorporating other control options in the SIP.

8.3.1 Control Options and Modeling Results

8.3.1.1 Control Option 1: Relax Emission Limits for Small Sources in Major Metropolitan Areas

Control Option 1 consists of relaxing the SO_2 emissions standard for coal burning fuel combustion emission sources of less than 250 million BTU per hour rated heat capacity located in the Chicago, Peoria and East St. Louis major metropolitan areas to 6.0 lbs. SO_2 per million BTU. The presently applicable limit is 1.8 lbs. per million BTU. The 6.0 lbs. was chosen because it is identical to the limit that applied to all sizes of coal burning units everywhere else in Illinois at the time that control Option 1 was considered. The 6.0 lbs. per million BTU regulation also included a stack height provision that could yield a lower limit than 6.0 lbs. for certain large facilities. Recently the Illinois Pollution Control Board changed the 6.0 lb. limit to 6.8 lbs., and the stack height formula to one generally more restrictive (i.e., less emissions are allowed).

Option 1 generally was designed to assess a strategy which was proposed by Illinois industry in an official Illinois Pollution Control Board (IPCB) filing, R77-15, as a regulatory strategy to apply to the Peoria area since it would enable the smaller coal burning facilities to burn Illinois coal without the addition of SO_2 control equipment and since the contribution of such facilities to that area's SO_2 emissions was thought to be small. In the Peoria area, 27 out of 33 coal burning units of 250 million BTU per hour or less presently do not comply with the 1.8 lb. rule. By contrast, only 1 of 33 such units in the Chicago and Metro-East areas fail to comply. Compliance in both urban areas is usually affected by burning low sulfur coal; however, in two cases flue gas desulfurization equipment (scrubbers) is used.

The IEPA found in its strategy analysis that the contribution of coal burning fuel combustion emission equipment of 250 million BTU or less to total SO_2 emissions was indeed small. Assuming compliance with the 1.8 lb. limit, the contribution to SO_2 emissions ranged from about 1.5 percent in the Peoria area to 2.5 percent in the Chicago and Metro-East areas. Accordingly, the IEPA considered the application of such strategy to all three areas, even though the strategy might fall short of reasonably available control technology requirements.

Control Option 1 was tested by determining the difference in annual arithmetic mean SO_2 ground level concentration that would result from compliance with a 6.0 lb. of SO_2 per million BTU limit and that concentration which would result with a 1.8 lb. limit (or actual emissions if less than 1.8 lbs.) for all coal burning fuel combustion

emission facilities rated at 250 million BTU per hour or less in each area. The dispersion model CDM was employed to calculate SO_2 concentration values at 195 receptors in a grid centered in areas of high ground-level concentrations in the Peoria and East St. Louis areas and for the counties of Cook, Lake and Will in the Chicago area. Receptors were located at two kilometer intervals, except for Cook County in the Chicago area, where the spacing was four kilometers. The number of sources modeled was 33 in Peoria, 19 in Chicago and 14 in East St. Louis. The relatively small number of sources modeled enabled the IEPA to improve upon the emissions inventory with further verification of its data. The emission rates, coal analyses, and stack parameters from the inventory were double-checked by reference to operating permit data for each facility and then checked a third time by telephone contact with plant managers or similar personnel at the modeled source. This third check concentrated on obtaining the best possible information about annual coal usage, heat content of the coal, and hours of operation.

The modeling results indicated that control Option 1 should not be adopted because its application would cause significant increases in annual ambient levels ranging from 10 ug/m^3 in the Peoria area through 22 ug/m^3 in the East St. Louis area to 32 ug/m^3 in the Chicago area. The most significant factor was the short stacks associated with most boilers of less than 250 million BTU per hour which caused a tremendous increase in low level emissions. Although this increase would not have caused SO_2 air quality violations in all cases, it would have used a substantial portion of allowable growth increments in each of the areas studied.

8.3.1.2 Control Option 2: Tighten Emission Limits on Major Sources in Nonattainment Areas

Control Option 2 consists of tightening allowable SO_2 emission limits for existing coal fired fuel combustion emission sources in nonattainment areas from 1.8 to 1.2 lbs. per million BTU when such sources are rated at more than 250 million BTU per hour. The 1.2 lb. limit represents the current allowable emissions limit for such sources in the Standards of Performance for New Stationary Sources, and therefore represents even more than reasonably available control technology. Such a strategy seems plausible for nonattainment areas since 1.2 lbs. can be met by essentially the same techniques that are now used to meet the current 1.8 lb. standard, namely the burning of low sulfur coal or the use of flue gas desulfurization equipment (scrubbers). Some facilities that are required to meet 1.8 lbs. are actually meeting 1.2 lbs. at the present time. Coal burning fuel combustion emissions units rated in excess of 250 million BTU per hour are responsible for about 36 percent of the Chicago area's point source SO_2 emissions; 12 percent of the East St. Louis emissions; and over 99 percent of the Peoria area emissions. Then too, the improvement of current air quality should be expected because almost all affected facilities, except for those in the Peoria area, are in compliance with the current regulations, thus assuring that present day air quality is usually a reflection of the current regulations.

The same data base and modeling used in analyzing Option 1 were used for studying Option 2. The modeling, however, showed that Option 2 would have a negligible effect on air quality because of (1) the tall stacks

associated with large boilers; (2) the small difference between 1.2 and 1.8 lbs., and (3) a number of such sources are already emitting no more than 1.2 lbs. The strategy lowered the annual average sulfur dioxide concentrations by more than 0.5 ug/m^3 in only 3 of the 5 areas. Even in those areas, the lowering was usually less than 0.5 ug/m^3 and always less than 1.5 ug/m^3.

8.3.1.3 Control Option 3: Reinstate Remanded Rules

Control Option 3 consists of reinstating IPCB Rule 204(c)(1)(A) governing sulfur dioxide emissions from existing fuel combustion sources burning solid fuel in the Chicago, East St. Louis and Peoria metropolitan areas. The rule has been vacated by two Illinois appellate courts and the cause has been remanded to the IPCB for further consideration. Public hearings before the IPCB to readopt the regulations are currently being held. Rule 204(a)(1), governing SO_2 emissions for new sources, was also vacated but its substance is incorporated in the Federal New Source Performance Standards for fossil fuel fired steam generators which was adopted, along with all other current new source and hazardous pollutant regulations, by the IPCB on December 14, 1978.

Rule 204(c)(1)(A) limits existing coal burning fuel combustion emission sources in those three areas to 1.8 lb. sulfur dioxide per million BTU actual heat input. Compliance with this rule is usually achieved by the use of low sulfur coal although in a very few cases flue gas desulfurization equipment (scrubbers) is employed. Historically, compliance was also achieved, especially in the Chicago area, by the conversion of coal burning units to gas or oil. Coal burning units account for about 14 percent of the SO_2 emissions in the Metro-East area; 27 percent in the Chicago area; and over 99 percent in the Peoria area. The limit of 1.8 lbs. per million BTU is considered reasonably available control technology because it is quite close to the New Source Performance Standards for large fossil fuel fired units of 1.2 lbs. per million BTU.

Although Rule 204(c)(1)(A) is not in effect as a matter of State law, compliance with it is relatively good except for the Peoria area. At the time of this writing, 16 of 17 units in East St. Louis and all 34 units in the Chicago area are in compliance, but only 9 of 39 units in the Peoria area comply. (Boilers of less than 1 million BTU per hour capacity were excluded from this count.)

The actual air quality effects of compliance with Rule 204(c)(1)(A) were modeled in 1970 and 1971 just before the strategy was put into effect as an Illinois air pollution control regulation. The modeling was conducted by the Center for Environmental Studies of Argonne National Laboratory. The specific strategy of 1.8 lbs. per million BTU for all coal burning facilities was shown to be necessary to attain the former national secondary standard of 60 micrograms per cubic meter annual arithmetic mean in the Peoria area, when contrasted with a 1.8 lb. limit for power plants and a 6.0 lb. limit for all other facilities in that area. While the 1.8 limit was not specifically modeled for the Chicago and East St. Louis area, it was shown by comparison of the 6.0 limit with other limits in those areas that an emission limit much stricter than 6.0 lbs. was

necessary there as well in order to meet the 60 ug/m^3 standard. While it is true that the 60 ug/m^3 standard is no longer in effect, studies of standard deviation of SO_2 concentration in all three areas indicate that the 60 ug/m^3 annual arithmetic mean is equivalent to the present primary 24-hour standard of 365 ug/m^3 not to be exceeded more than once annually. Although the Illinois emission data base has improved considerably since 1970 and 1971, the preliminary results of recent modeling conducted for at least two of these areas show little room for relaxation since the 24-hour primary standards come quite close to being violated even when all sources are in compliance with a 1.8 lb. limit.

8.3.2 Maintenance Malfunction

In general, the maintenance/malfunction regulation (Appendix) is considered an integral part of the regulatory strategy for each pollutant category. It is designed to help ensure that the benefits of existing and proposed emission regulations will be fully realized.

In developing the SIP for air pollution control, the IEPA has conducted numerous air quality studies to determine the nature and extent of existing or projected air pollution problems throughout the State. Principally, these studies have focused on the urban industrialized areas of the State, although some analyses have been made of rural areas where the NAAQS for various pollutants are not being attained. Several general aspects of the studies are pertinent with respect to their influence on the development of the maintenance/malfunction regulation.

First, air quality problems (i.e., existing or potential violations of NAAQS) do exist in numerous areas of the State. Analyses indicate that, in many cases, industrial point sources contribute significantly to these problems. Additionally, a significant portion of the problems is often attributed to either background or unknown sources within the area of concern.

Secondly, the studies indicate that in selected problem areas, there is significant overcompliance with existing emission regulations, and that if this overcompliance is not maintained, attainment of the NAAQS will be jeopardized.

In performing comprehensive regional air quality studies, an attempt is made to explicitly account for as many of the pollution sources that contribute to the area's problems as possible. When using analytical techniques such as mathematical dispersion modeling, this is particularly important. The contributions of various pollution sources are either accounted for explicitly or implicitly (i.e., source contributions are defined individually as specific inputs to the mathematical model, or they are defined collectively as "background" or unknown contributors on the basis of the difference between air quality levels predicted by the model and those measured at actual monitoring locations). This "background" or "unknown contribution" factor invariably shows up in modeling exercises because it is practically impossible to explicitly define all emission sources in a complex urban industrial setting in a particular time frame. This fact is reflected in the results of the air quality analyses conducted by the IEPA. In general, these analyses show

significant contributions to identified air quality problems from explicitly defined industrial point source emissions, explicitly defined area source emissions, and undefined sources (i.e., background or unknown contributors). Classically, the undefined source emissions are thought to be made up of material transported into the area from sources located at relatively great distances from the study area, and emissions from local point and area sources that are not accounted for in the emissions inventory data input to the analysis. The experience of IEPA field engineers and others leads the IEPA to conclude that a significant portion of the unaccounted for industrial point source emissions may result from malfunctions or maintenance problems associated with air pollution control equipment.

It should be recognized that a precise quantification of the extent to which maintenance/malfunction problems contribute to air quality problems is difficult, if not impossible, given the present data base. The IEPA's belief that a viable maintenance/malfunction regulation is a desirable and necessary part of the SIP is founded on the professional opinion of IEPA staff and others that significant and unresolved maintenance/malfunction problems do exist and that they have the potential for adversely affecting ambient air quality.

A recent review of the IEPA's facility inspection records conducted by the Field Operations staff indicated the following with respect to maintenance/malfunction problems:

1. Approximately 10-15 percent of the facility inspections conducted by IEPA field engineers reveal some type of maintenance/malfunction problem with some air pollution control equipment at the facility.

2. The average collection efficiency of control equipment observed operating during malfunction situations is estimated to range from about 50-90 percent.

These figures were developed on the basis of one year's worth of facility inspection records in the IEPA's East St. Louis area field office; and several years of data for one district of the Chicago area field office. The data are presented not as an attempt to explicitly quantify the nature and extent of maintenance/malfunction problems, but simply as an indication that such problems do exist and that in any particular instance, they have the potential for greatly increasing a source's pollutant emissions. The likely impact of such emission increases are of particular concern in the short-term (i.e., periods of 24-hours or less), even though they might be infrequent. This arises because the short-term National Ambient Air Quality Standards are written in terms of air quality levels that are not to be exceeded more than once a year. Therefore, even a relatively small number of maintenance/malfunction problems could significantly influence the attainment or maintenance of short-term standards.

Given this situation, the fact that air quality problems do exist, and the IEPA's belief that existing point source regulations represent Reasonably Available Control Technology (RACT), it is the IEPA's position that the most rational and least disruptive approach to gaining further

reductions in emissions from point sources at this time is the promulgation of a meaningful regulation designed to reduce maintenance/malfunction problems. It is hoped that in identified problem areas this will minimize, if not eliminate, the need for regulations that require existing sources to go beyond "Reasonably Available Control Technology"; and that it will provide a greater margin for growth in areas where the National Ambient Air Quality Standards are attained.

8.3.3 Health, Welfare, Economic, Social and Energy Impacts

8.3.3.1 Health Effects and Population Exposure

Sulfur dioxide is the predominant sulfur oxide in the atmosphere. It is an acrid, corrosive, toxic gas that is produced mostly by electrical utilities and industrial plants that burn high sulfur coal and fuel oil. Sixty percent of the sulfur oxides in the atmosphere by weight are produced from the combustion of coal; 22 percent from industrial processes that use sulfur; 14 percent from combustion of oil; and 4 percent from miscellaneous sources (Ref. 43).

Gaseous SO_2 is considered a major pollutant, even though few health or environmental effects can be attributed per se. It is hazardous primarily because of its affinity for atmospheric oxidants and water with which it combines to form sulfuric acid mists. The synergistic influence of SO_2 on illness and its destructive environmental actions are directly related to its presence first as sulfur dioxide and then to its conversion to sulfurous and sulfuric acid or to its adsorption by particulate matter. A three to four-fold increase in irritancy occurs when SO_2 is oxidized to sulfuric acid (Ref. 44).

In most natural settings, it is impossible to entirely separate the effects of SO_2 from those of particulates. Some danger has, however, been attributed to persistent high levels of sulfur dioxide. SO_2 alters the mechanical function of the upper and lower airways in humans. The principle effect is to increase pulmonary flow resistance or impair the rate of exhalation (Ref. 45).

Because SO_2 is soluble, most of its absorption during quiet breathing occurs at the bronchiolar and alveolar level (Ref. 46). Hence, with an increased ventilatory rate and mouth breathing, more SO_2 reaches the trachea, where it may cause reflex coughing (Ref. 47).

The odor threshold for SO_2 can be as low as 0.3 ppm (Ref. 48) while throat irritation occurs at 8 to 12 ppm, and cough and eye irritation are produced at 20 ppm (Ref. 48).

Table 10 shows the results of a World Health Organization study (1972) of the health effects of SO_2 (Ref. 49).

TABLE 10
EXPECTED EFFECTS WHEN BOTH SMOKE & SO_2 EXCEED THE VALUES SHOWN

Effect	Visibility and/or Annoyance	Increased Respiratory Symptoms	Exacerbation of Bronchitis and Emphysema	Excess Mortality & Increases in Hospital Admissions
Concentration & Averaging Time	80ug/m3 Annual Geometric Mean	100ug/m3 Annual Arithmetic Mean	250ug/m3 Daily Average	500ug/m3 Daily Average

Note: Measurement methods are as prescribed by the British Ministry of Technology, thus are not directly equivalent to U.S. methods.

Table 11 presents total statewide population exposed to monitored violations of primary standards for the relevant populants sufficient to cause classification of the site as a nonattainment area. Population exposed is based on census counts of population in the county where the violation was monitored.

TABLE 11

TOTAL ILLINOIS POPULATION EXPOSED (1980 Est.)

Pollutant	No.
Ozone	8,800,000
Carbon Monoxide	3,600,000
Sulfur Dioxide	400,000
Total Suspended Particulates	7,500,000

8.3.3.2 Welfare Impact

Material

Corrosion rates of certain materials are higher in those urban and industrial atmospheres with relatively high levels of both particulates (TSP) and sulfur oxides (SO_x).

Paint and zinc have been shown to be the two materials most affected by TSP and SO_2 pollution (Ref. 51). For 1970, the cost due to damage of these materials, in five SMSA's (Chicago; St. Louis, MO-IL; Davenport, IA-IL; Rockford; Peoria) was estimated at $6.986 billion (1977$) (Ref. 50). Table 12 shows the estimated damage functions for zinc and paint (Ref. 50).

TABLE 12

ECONOMIC DAMAGE FUNCTIONS ON MATERIALS[a]

Soiling Damage Cost for Zinc

$$= \underset{(19{,}929)}{23{,}328.4} + \underset{(3.4)^*}{43.1\ ME} + \underset{(171.6)^*}{943.3\ SO_2} + \underset{(356.0)^*}{148.1\ TSP} - \underset{(1820.4)}{235.0\ SUN}$$

$$+ \underset{(1{,}750.2)}{2{,}679.3\ RHM} + \underset{(18.0)}{21.9\ YP} \qquad R^2 = 0.64$$

Deterioration Damage Cost for Zinc

$$= \underset{(6{,}460.4)}{7{,}562.2} + \underset{(0.1)^*}{1.4\ ME} + \underset{(5.5)^*}{30.5\ SO_2} + \underset{(11.5)^*}{47.9\ TPS} - \underset{(59.0)}{76.2\ SUN}$$

$$+ \underset{(56.7)}{86.8\ RHM} + \underset{(615.5)}{712.6\ YP} \qquad R^2 = 0.63$$

Soiling Damage Cost for Paint

$$= \underset{(259{,}861.3)}{-141{,}199.7} + \underset{(3.4)^*}{577.2\ HU} + \underset{(2.6)^*}{15.2\ YP} + \underset{(235.3)^*}{911.3\ RHM} + \underset{(23.2)^*}{69.1\ SO_2}$$

$$+ \underset{(245.9)}{305.3\ SUN} \qquad R^2 = 0.995$$

Deterioration Damage Cost for Paint

$$= \underset{(887.2)^*}{-4{,}820.1} + \underset{(0.1)^*}{19.7\ HU} + \underset{(0.08)^*}{0.5\ YP} + \underset{(8.0)^*}{31.1\ RHM} + \underset{(0.8)^*}{2.3\ SO_2} + \underset{(8.4)}{10.4\ SUN}$$

$$R^2 = 0.995$$

a The values below the coefficients are standard errors with * to indicate that the coefficients are significant at the 1 percent level. All coefficients and standard errors are reduced by a factor of 103.

Variable Notation:

- SO_2 = Sulfur dioxide concentration
- TSP = Particulate concentration
- RHM = Relative humidity
- SUN = % of days of sunshine
- YP = Per capita income
- ME = Manufacturing establishments

Vegetation

Sulfur dioxide was one of the first man-made pollutants to cause economic damage to vegetation. It is generally accepted that SO_2 enters the leaves of plants through open stomata (Ref. 51). If SO_2 is not absorbed too rapidly, great concentrations of less-toxic sulfate (SO_4) may accumulate, developing chronic sulfate injury in the plants. If SO_2 is absorbed rapidly, highly phytotoxic sulfate (SO_3) will accumulate, causing acute injury (Ref. 51). Acute injury usually results in the injured tissue changing to an ivory color. Chronic injury leads to pigmentation of leaf tissue; a gradual yellowing (chlorosis) in which the chlorphyll - making mechanism is impeded (Ref. 6). Both acute and chronic injury may be accompanied by the suppression of growth and yield (Ref. 6).

Aesthetics

Once in the atmosphere, some SO_2 can be oxidized (either photochemically or in the presence of a catalyst) to SO_3 (sulfur trioxide). With water vapor present, SO_3 is readily converted to sulfuric acid mist, a corrosive and toxic substance. In addition to this problem, a particularly bothersome attribute of SO_2 is its odor, which can be noticed at low concentrations (0.3 ppm) (Ref. 48).

8.3.3.3 Economic Impact

Codification of over-compliance, as noted in the section on TSP regulations, will not have an effect on capital costs for pollution control equipment, but is likely to raise operating costs of the equipment in place, since more stringent procedures will likely be necessary to maintain the operation of the equipment at a level in excess of compliance.

Control Option 1, discussed in Section 8.3.1.1, presents a reverse cost-benefit problem as it is a relaxation of a rule (e.g., costs may be imposed on the population in the form of increased pollution, while sources would reap the benefits of decreased compliance costs).

Potential Price Impact

A more detailed economic impact statement is presently being conducted on the effects of these regulations. This report will contain the price impact, under the assumption of full cost pass through.

8.3.3.4 Social Impact

The total number of facilities affected, and the impact on employment of the regulations promulgated for control of particulate matter, will also be outlined in the forthcoming economic impact statement.

8.3.3.5 Energy Impact

No SIP SO_2 strategy requires a significant amount of energy, or change in the present mix of energy resources (coal, gas, oil, nuclear, etc.):

1. The maintenance and malfunction regulation will actually save energy since it will generally prohibit operation under conditions of abnormally high energy demand (i.e., during malfunctions).

2. Compliance with the currently remanded sulfur dioxide regulations will generally require some energy (as compared to allowing uncontrolled emissions) only to the extent that compliance is achieved by using flue gas desulfurization equipment (scrubbers) rather than low sulfur coal, although a small amount of energy can be assigned to the transportation of low sulfur coal from sources far removed from the traditional Illinois sources of coal. It is estimated, however, that only about five percent of the fuel burning capacity affected by compliance with the remanded regulations will comply by using scrubbers rather than low sulfur fuel. This will not change the mix of energy sources at all, but will require about three percent more energy per installation. Theoretically, this could be greater for larger units which might also affect the mix by using an additional one percent of energy in the form of fuel oil for reheating a scrubbed plume. At any rate, the increased energy estimate of the strategy is five percent of three percent or only 0.15 percent.

8.4 Control Measures Adopted in Legally Enforceable Form

The IEPA and the Illinois Attorney General's Office are of the opinion that Rule 204(c)(1)(A) remains a part of the SIP for Federal enforcement purposes, as already discussed in 8.1.1.2, State Activities, above. Therefore, although the IEPA is seeking the readoption of this rule by the IPCB, its status as a result of State litigation should not be an issue with respect to the approvability of the Illinois SIP for SO_2.

8.5 Demonstration of Attainment

This section discusses the means by which attainment and maintenance of the NAAQS for SO_2 will be achieved in the Peoria area and in Massac County, the two portions of Illinois designated nonattainment for SO_2. The essential element necessary to achieve attainment and maintenance of the standards in both areas is the compliance of sources that are currently out-of-compliance with the remanded SO_2 regulations. Although compliance with the maintenance/malfunction regulation for SO_2 will also be beneficial, it is difficult to explicitly assess its impact on air quality.

Additionally, a discussion is presented of on-going and proposed air quality studies using different modeling techniques, as well as ambient SO_2 monitoring, to assess air quality as sources reach compliance levels.

8.5.1 Peoria Area

The report, Technical Analysis of the State Implementation Plan for the Attainment and Maintenance of the Suspended Particulate and Sulfur Dioxide Ambient Air Quality Standards in the Peoria Air Quality Maintenance Area (Ref. 41), concludes that compliance with the present

SO_2 emission limitations (i.e., the remanded regulations) by sources in the study area will likely result in the attainment and maintenance of the ambient air quality standards through 1995. The analysis shows that attainment will be achieved when sources that are currently out-of-compliance with existing (i.e., the remanded) regulations achieve compliance.

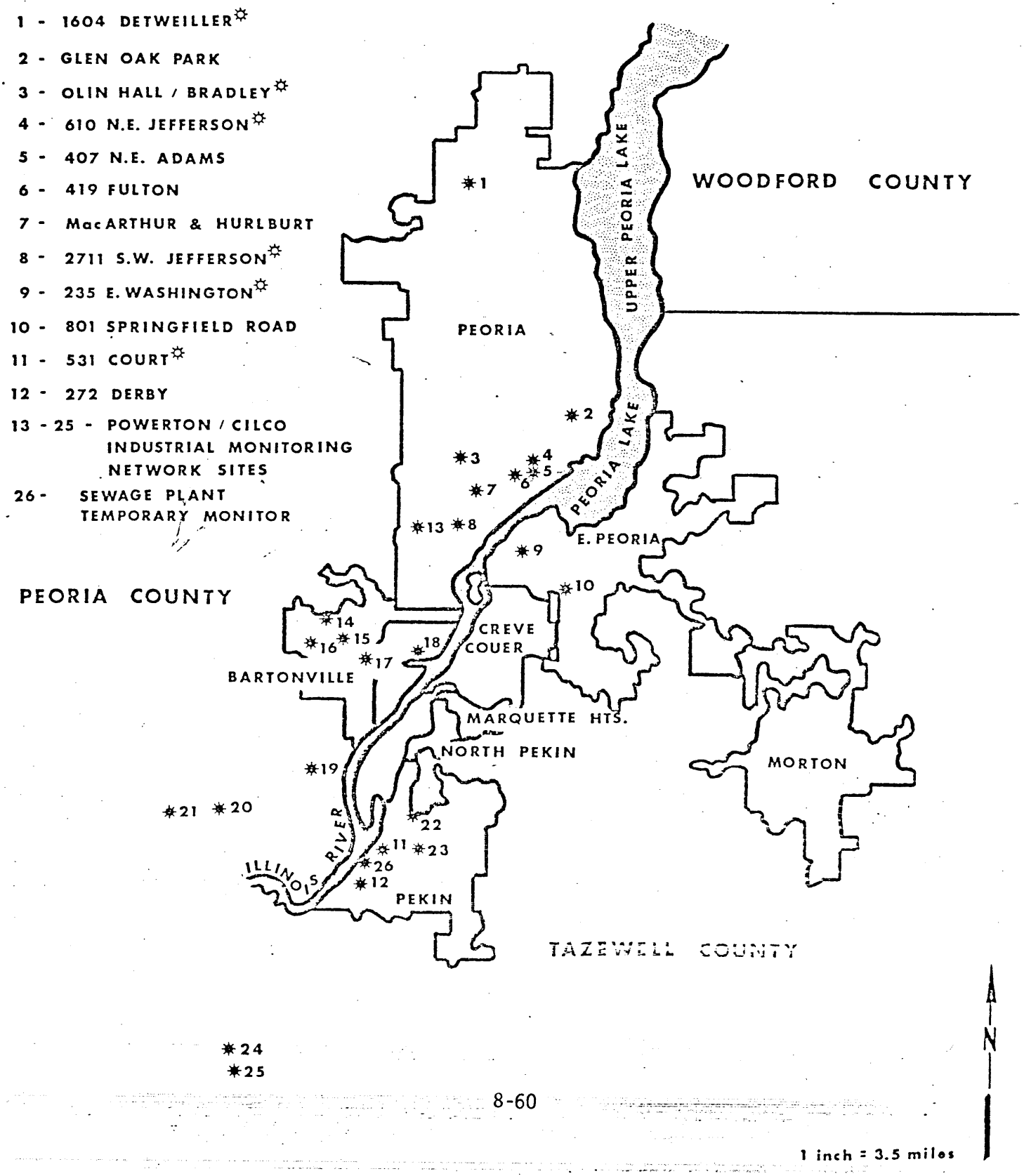
Therefore, the demonstration of attainment for SO_2 in the Peoria area will consist of a demonstration that all sources are in compliance with existing regulations. The mechanism for providing this information to USEPA is explained in Section 8.6. The townships of Peoria and Tazewell Counties noted in Section 8.2.3.1 must be considered nonattainment until all sources come into compliance with existing IPCB rules and regulations or until further analyses indicate the area has achieved attainment status. To continue the assessment of SO_2 air quality in Peoria and Tazewell Counties, particularly in the area of predicted maximum ground level concentration, revised modeling techniques consistent with the USEPA RAM model will be used to re-evaluate the air quality in the vicinity of the Powerton generating station. This will be accomplished by the IEPA as soon as the necessary computer capabilities become available (within approximately one year).

The industrial ambient air monitoring network comprising the Powerton-Edwards Supplementary Control System (SCS) currently blankets the area of maximum predicted SO_2 levels indicated in the Peoria AQMA report (Ref. 41). Figure 18 shows the location of the 13 permanent SO_2 monitors which comprise the SCS system. (There are also numerous mobile monitoring sites not shown.) The IEPA applies quality control to this data consistent with the procedures set forth in the IEPA monitoring guidelines. Additionally, the samplers can be monitored on a real-time basis by IEPA when elevated levels are anticipated or noted. The data for all the SCS monitors is summarized and reported to the IEPA on a monthly basis by Commonwealth Edison.

The IEPA presently maintains nine SO_2 monitors in the Peoria area with one monitor at 272 Derby in Pekin (in the vicinity of the predicted elevated levels) (Figure 18). An additional SO_2 monitor was placed in the western portion of Pekin during 1978 to further define the air quality in the Peoria area (monitor 26). This monitor was in-place for over six months at a location of anticipated elevated SO_2 levels but detected no exceedances of the 24-hour or 3-hour SO_2 standards. If the Powerton-Edwards SCS system is terminated, the IEPA will install additional SO_2 monitors in the area to provide for the continuing assessment of air quality.

In conclusion, the Peoria analysis indicates that the area will achieve compliance with the SO_2 ambient air quality standards when all SO_2 sources come into compliance with the existing emission standards. Portions of Peoria and Tazewell Counties will be nonattainment until additional modeling techniques can be applied to the area anticipated to have elevated SO_2 levels or until all sources come into compliance. In-place SO_2 monitors will be carefully noted, especially those near geographical areas of expected elevated SO_2 levels.

FIGURE 18
AIR QUALITY MONITORS IN THE PEORIA AREA



8.5.2 Massac County

In Massac County, SO_2 levels exceeding the primary and secondary air quality standards have been monitored and are predicted by air quality modeling. Conclusion 3 of the Technical Analysis of the State Implementation Plan for the Attainment and Maintenance of Sulfur Dioxide Ambient Air Quality Standards in the Massac County Air Quality Maintenance Area (Ref. 42) states that current SO_2 emission standards and limitations are sufficient to attain and maintain the primary ambient air quality standards through 1995. Conclusion 4 states that violations of the secondary 3-hour SO_2 standard are projected in 1985 and 1995 even after compliance with existing regulations is achieved.

Attainment of the SO_2 primary standards will be achieved once compliance with existing regulations is reached. Therefore, the demonstration of attainment for SO_2 in Massac County will consist of a demonstration that all sources are in compliance with existing IPCB rules and regulations. The mechanism for providing this information to USEPA is explained in Section 8.6. The precincts in Massac County, noted in Section 8.2.3.1, must be considered nonattainment until all sources come into compliance with existing IPCB rules and regulations or until further analyses indicate the area has achieved attainment status.

The IEPA will be further assessing the adequacy of the SO_2 SIP in Massac County by using other modeling schemes, consistent with the USEPA model RAM. This will be accomplished by the IEPA as soon as the necessary computer capabilities become available (within approximately one year).

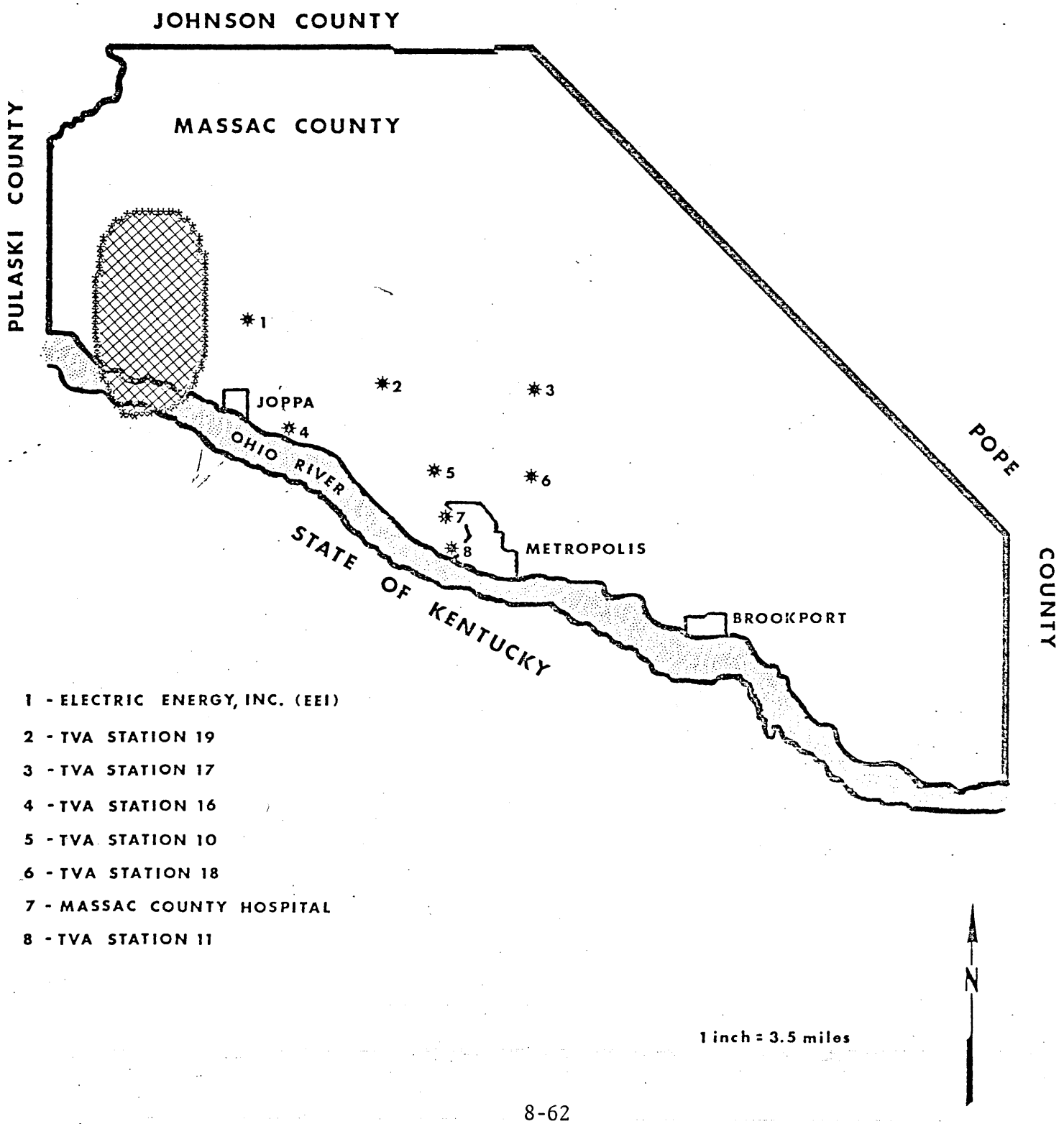
The IEPA currently operates an SO_2 monitor at the Massac County Hospital in Metropolis as shown in Figure 19. The locations of industrial monitors in Massac County are also indicated in Figure 19. When compliance with existing emission regulations is achieved, if the modeling techniques still confirm that violations of the secondary SO_2 air quality standard are expected, additional monitor(s) will be placed in the expected problem areas.

In summary, although existing air quality indicates violations of the primary and secondary SO_2 standards in Massac County, the implementation of anticipated SIP-related control (i.e., at TVA's Shawnee power plant) will result in attainment of the primary SO_2 air quality standard by 1985. To further assess the potential for SO_2 short-term excursions in Massac County, the IEPA will be verifying the existing modeling results by applying different modeling techniques, by carefully analyzing existing SO_2 monitoring data, and by installing additional SO_2 monitors in Massac County.

8.6 Reasonable Further Progress

Reasonable Further Progress (RFP) is an emissions inventory tracking system designed by the USEPA to be used for nonattainment areas. The purpose of the RFP system is to identify any errors in the predictions that the states made concerning the effectiveness of their SIP revisions.

FIGURE 19
AIR QUALITY MONITORS IN MASSAC COUNTY



Compliance with the current IPCB regulations (i.e., the remanded regulations) has been deemed the key element in attainment of the primary SO_2 ambient air quality standards both in the Peoria area and in Massac County. Table 13 has been prepared for Peoria and Tazewell Counties and Table 14 has been prepared for Massac County. These tables provide the base emission rate of all out-of-compliance sources, the estimated 1978 emission rate, the emission rates allowed by current IPCB rules and regulations, and the anticipated date for compliance of sources currently out-of-compliance.

TABLE 13

PEORIA AQMA

MAJOR SOURCES OUT OF COMPLIANCE
WITH SULFUR DIOXIDE REGULATIONS*
(Tons Per Year)

Plant Name	Source Name	1975 Allowable	1975 Actual	1978 Actual	Compliance Schedule
1. Commonwealth Edison Powerton Station 179801AAA	Boilers 51,52	53,350	183,170	317,687	7-1-79
2. Cilco Wallace Station 179020ABL	Boilers 9, 10	6,124	12,558	3,967	In Compliance
3. Cilco Edward Station 143805AAG	Coal Boilers	39,248	48,650	24,516	In Compliance
4. Ashland Chemical 143805AAA	Coal Boilers	800	1,832	1,562	Not on Program
5. Celotex 163065ABD	Coal Boilers	1,448	3,433	1,717	Not on Program

*A major source is one that exceeds 100 tons of SO_2 per year.

TABLE 14

MASSAC COUNTY

MAJOR SOURCES OUT OF COMPLIANCE
WITH SULFUR DIOXIDE REGULATIONS*
(Tons Per Year)

Plant Name	Source Name	1975 Allowable	1975 Actual	1978 Actual	Compliance Schedule
1. Electric Energy Joppa Station	Coal Boilers	55,456**	182,193	145,948	In Compliance
2. TVA Shawnee Station	Coal Boilers	55,828	249,748	-	11-1-81

*A major source is one that exceeds 100 tons of SO_2 per year.

**With the new 550 foot stack, the allowable is 161,470 tons per year using existing IPCB Rule 204(c).

Since a direct measurement or assessment of the air quality improvement due to the IEPA maintenance/malfunction regulation will not be feasible on a year-by-year basis, the assumption will be made that one-third of the benefit will be gained in each year 1980 through 1982.

The IEPA will provide the USEPA with updated Tables 13 and 14 on a yearly basis to demonstrate reasonable further progress. Furthermore, the results of additional air quality monitoring and air quality modeling analyses will be provided as they are accomplished.

SO_2 References

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